CHAPTER

36

Pneumatic

CHAPTER 36
PNEUMATIC

Subject/Page	Date	COC
36-EFFECTIVE PAGES		
1 thru 2	Sep 15/2023	
36-CONTENTS		
1	Sep 15/2021	
2	May 15/2022	
36-00-00		
1	Sep 15/2021	
2	Sep 15/2021	
3	Sep 15/2021	
4	May 15/2022	
5	May 15/2022	
6	Sep 15/2021	
7	Sep 15/2021	
8	Sep 15/2021	
9	Sep 15/2021	
10	BLANK	
36-10-00		
1	Sep 15/2021	
2	Sep 15/2021	
3	Sep 15/2021	
4	BLANK	
36-11-00		
1	Sep 15/2021	
2	Sep 15/2021	
3	Sep 15/2021	
4	Sep 15/2021	

Subject/Page	Date	COC
36-11-00 (cont.)		
5	Sep 15/2021	
6	Sep 15/2021	
7	Sep 15/2021	
8	Sep 15/2021	
9	Sep 15/2021	
10	Sep 15/2021	
11	Sep 15/2021	
12	Sep 15/2021	
13	Sep 15/2021	
14	May 15/2022	
15	Sep 15/2021	
16	Sep 15/2021	
17	Sep 15/2021	
18	Sep 15/2021	
19	Sep 15/2021	
20	Sep 15/2021	
21	Sep 15/2021	
22	BLANK	
36-12-00		
1	Sep 15/2021	
2	Sep 15/2021	
3	Sep 15/2021	
4	Sep 15/2021	

A = Added, R = Revised, D = Deleted, O = Overflow, C = Customer Originated Change

36-EFFECTIVE PAGES

CHAPTER 36
PNEUMATIC

Subject/Page	Date	COC
36-12-00 (cont.)		
5	Sep 15/2021	
6	Sep 15/2021	
7	Sep 15/2021	
8	Sep 15/2021	
9	Sep 15/2021	
10	BLANK	
36-13-00		
1	Sep 15/2021	
2	May 15/2022	
3	May 15/2022	
4	Sep 15/2021	
5	Sep 15/2021	
6	Sep 15/2021	
7	Sep 15/2021	
8	Sep 15/2021	
9	Sep 15/2021	
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36-20-00		
1	Sep 15/2021	
2	May 15/2022	
3	Sep 15/2021	
4	May 15/2022	
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36-EFFECTIVE PAGES

CHAPTER 36
PNEUMATIC

36-CONTENTS

CHAPTER 36
PNEUMATIC

36-CONTENTS

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PNEUMATIC - INTRODUCTION

Purpose

The pneumatic system supplies compressed air to the airplane user systems.

General Description

These are the sources of pneumatic power:

- Engine 1 bleed air system
- Engine 2 bleed air system
- Auxiliary Power Unit (APU) bleed air system
- Pneumatic ground air connection.

The pneumatic manifold collects the compressed air from the sources and supplies it to the user systems.

Valves in the manifold do these:

- Control the flow of bleed air into the manifold
- Isolate the manifold into left and right sides
- Control the flow of manifold air into the user systems.

These are the airplane systems that use pneumatic power:

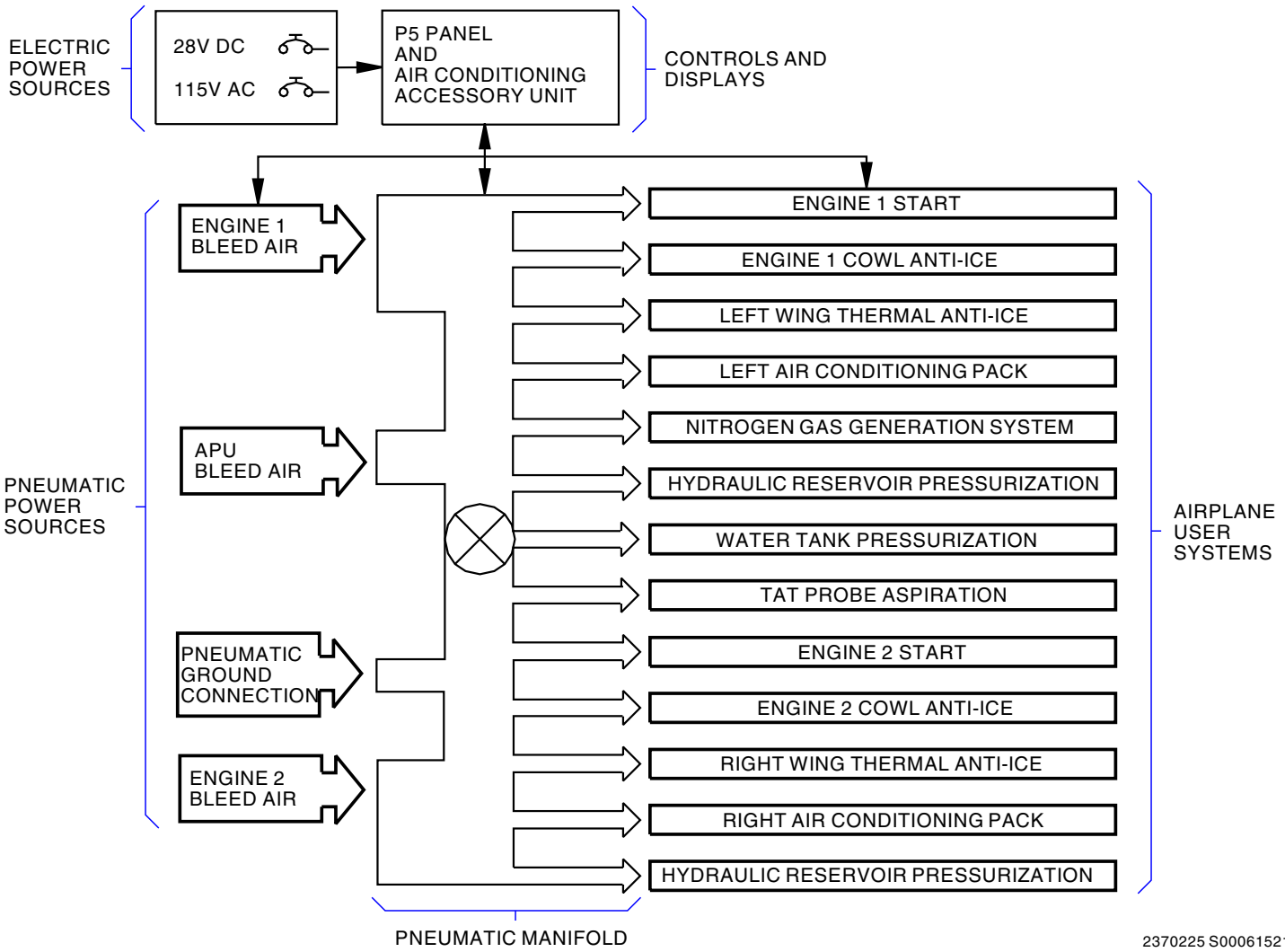
- Engine start systems
- Air conditioning and pressurization systems
- Engine inlet cowl anti-ice systems
- Wing thermal anti-ice systems
- Water tank pressurization system
- Inert gas system
- Hydraulic reservoir pressurization system.

Pneumatic system controls and indications are on the P5-10 air conditioning panel. The controls and indications use 28v dc and 115v ac.

Abbreviations and Acronyms

- ACAU - Air Conditioning Accessory Unit
- ACMS - Airplane Conditions Monitoring System
- ASC - Air Supply Controller
- ASCS - Air Supply Control System
- DFDAU - Digital Flight Deck Acquisition Unit
- EAI - Engine Anti-Ice
- FAMV - Fan Air Modulating Valve
- HPSOV - High Pressure Shutoff Valve
- IASC - integrated air system controller
- IPCV - Intermediate Pressure Check Valve
- OMS - Onboard Maintenance System
- NGS - nitrogen generating system
- PFTC - pack flow / temperature controller
- PI - pressure - intermediate
- PM - pressure - manifold
- PRSOV - Pressure Regulator And Shutoff Valve
- TM - Temperature - Manifold
- XFER - Transfer
- XMTR - Transmitter
- WAI - Wing Anti-Ice

PNEUMATIC - INTRODUCTION



PNEUMATIC - INTRODUCTION

PNEUMATIC - COMPONENT LOCATIONS

Engine Bleed Air

The engine bleed system components are on the engine compressor cases and in the engine struts.

Pneumatic Manifold

The manifold is in these areas:

- The engine struts
- The wing leading edges along the front spars
- The forward air conditioning bays below the center wing - crossover duct
- The keel beam between the air conditioning bays.

Left Side Manifold

The left side of the pneumatic manifold has these interfaces and parts:

- Engine 1 bleed air system
- Engine 1 start system
- APU bleed air system
- Left air conditioning system
- Left wing anti-ice system
- Hydraulic reservoir pressurization tap
- Water pressurization tap

Right Side Manifold

The right side of the pneumatic manifold has these interfaces and parts:

- Engine 2 bleed air system
- Engine 2 start system
- Right air conditioning system
- Right wing anti-ice system
- Hydraulic reservoir pressurization tap

APU Bleed Air

The APU and the APU bleed system components are in a torque box in the 48 section.

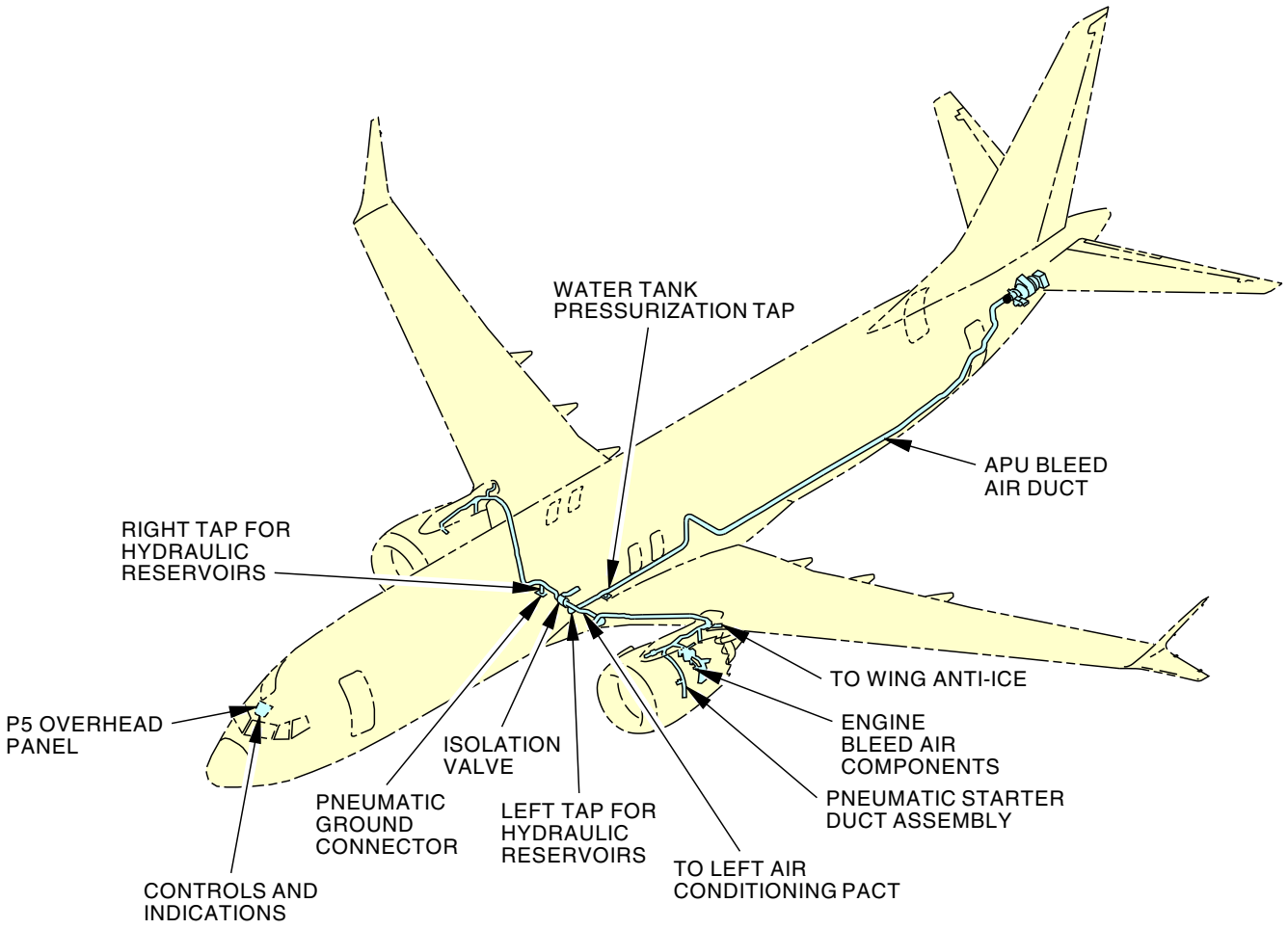
The APU bleed air duct is in these areas:

- Along the right side of the APU torque box
- Through section 48 and the aft pressure bulkhead
- Along the left side and forward bulkhead of the aft cargo compartment

Controls and Indication

The pneumatic system controls and indications are on the air conditioning/bleed air controls panel in the flight compartment.

PNEUMATIC - COMPONENT LOCATIONS



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PNEUMATIC - COMPONENT LOCATIONS

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PNEUMATIC - FUNCTIONAL DESCRIPTION

General

The pneumatic system supplies hot, high pressure air to the systems on the airplane that use air.

These are the sources of pneumatic power:

- Engine bleed air
- APU
- Ground source.

Engine Bleed Air

There is one bleed air system for each engine. The engine bleed system controls bleed air temperature and pressure.

Engine bleed air comes from the 4th and 10th stages of the high pressure compressor. A High Pressure Shutoff Valve (HPSOV) controls the flow of 10th stage bleed air. An Intermediate Pressure Check Valve (IPCV) prevents reverse flow into the 4th stage.

At low engine speed, 4th stage air is not sufficient for the pneumatic system demands, and the 10th stage supplies bleed air. At high engine speed, the HPSOV closes, and only the 4th stage supplies bleed air. The Integrated Air Systems Controller (IASC) controls the HPSOV with inputs from the Intermediate Manifold Pressure (PI) sensor.

A pressure regulator and shutoff valve (PRSOV) controls the flow of bleed air to the pneumatic manifold. The PRSOV is controlled by the IASC with inputs from the manifold pressure (PM) sensor and manifold temperature (TM) sensor. The PRSOV enable/disable solenoid is controlled by a relay in the air conditioning accessory unit (ACAU). The engine bleed switch OFF position is directly wired to the disable solenoid in the PRSOV.

Engine Bleed Air Precooler System

The precooler system controls the engine bleed air temperature. The fan air modulating valve controls the flow of fan air to the precooler.

APU Bleed Air

The APU supplies bleed air to the pneumatic manifold. An APU check valve protects the APU from engine bleed air flow.

Pneumatic Manifold

The pneumatic manifold gets high pressure air from the source systems and supplies it to the user systems. The pneumatic manifold has these features:

- An isolation valve separates the manifold into left and right sides
- Two manifold pressure (PM2) sensors for left and right manifold pressure indication
- A ground pneumatic connector with a check valve (for an external source of pneumatic power)
- Pressure taps and interfaces for user system valves.

Controls and Indications

The air conditioning/bleed air controls panel has control switches and lights to control and monitor the pneumatic system.

The DUAL BLEED light is an amber light that comes on when the APU bleed valve is open and one of these conditions is present:

- Number 1 engine bleed switch on, or
- Number 2 engine bleed switch on and the isolation valve is open.

The dual duct pressure indicator shows the pressures in the left and right pneumatic manifolds.

The isolation valve switch has these three positions:

- CLOSE - isolates left and right pneumatic manifold
- AUTO - the valve opens automatically if a pack or engine bleed switch is put in the OFF position
- OPEN - connects left and right pneumatic systems.

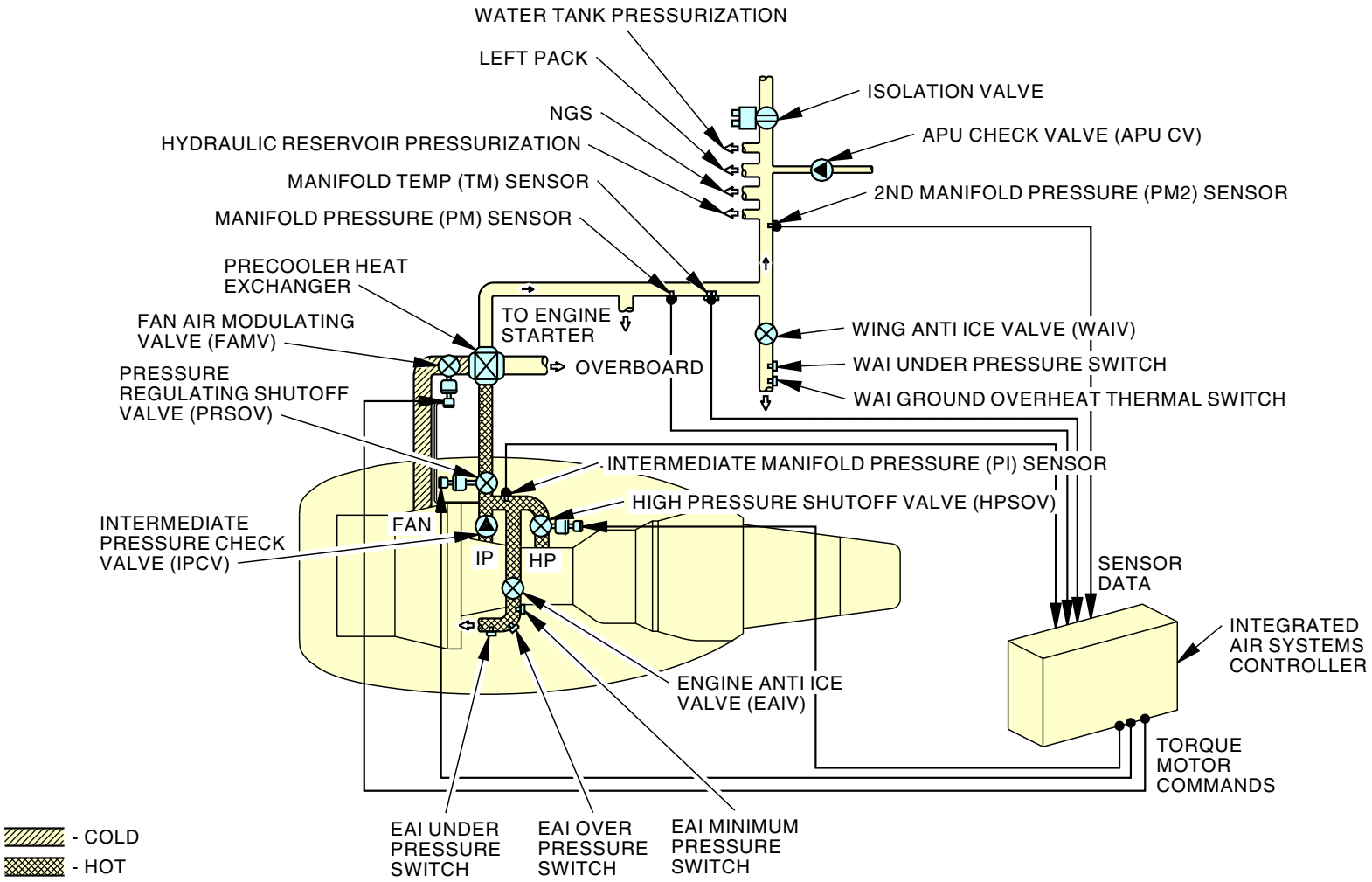
The engine bleed switch has these two positions:

- OFF - closes the PRSOV
- ON - opens the PRSOV.

The APU bleed switch has these two positions:

- OFF - closes the APU bleed valve
- ON - opens the APU bleed valve.

PNEUMATIC - FUNCTIONAL DESCRIPTION



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PNEUMATIC - FUNCTIONAL DESCRIPTION

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PNEUMATIC - DISTRIBUTION - INTRODUCTION

Purpose

The pneumatic distribution system supplies compressed air to the user systems.

General Description

The distribution system has these subsystems:

- Engine bleed air system
- APU bleed air system
- Pneumatic ground air connection
- Pneumatic manifold system.

Engine Bleed Air System

There are two engine bleed air systems, one for each engine.

Engine bleed air is from the 4th and 10th stages of the engine high pressure compressors. At low engine speeds, bleed air comes from the 10th stage. At high engine speeds, bleed air comes from the 4th stage.

APU Bleed Air System

The APU load compressor supplies bleed air on the ground and in the air.

Pneumatic Ground Air Connection

The pneumatic ground air connection provides for the connection of a ground pneumatic cart. The pneumatic cart can supply bleed air for engine start and ground use of the air conditioning system.

Pneumatic Manifold System

The pneumatic manifold system gets bleed air from the engines, APU, or pneumatic ground cart.

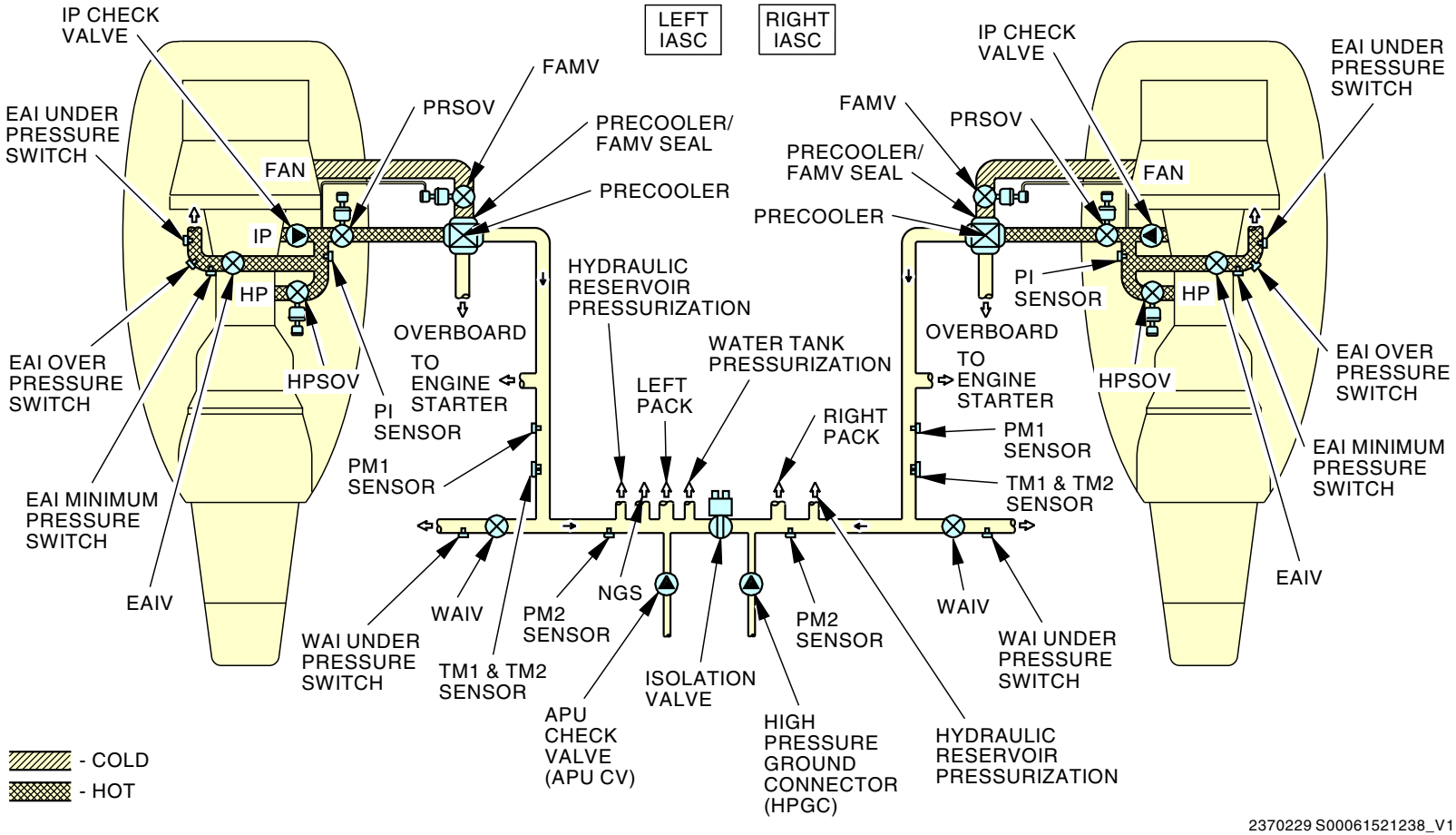
A bleed air isolation valve divides the pneumatic manifold into left and right sides. The normal position of this valve is closed. Because of this, a single duct failure cannot cause a loss of pressure to the whole pneumatic manifold.

The pneumatic manifold has two pressure transmitters. One transmitter is on the right side of the manifold and the other is on the left side. They measure the manifold pressures. Pressure indication is on the air conditioning panel.

The right side of the manifold has a pneumatic ground air connector.

Valves on the pneumatic manifold control the flow of air to the user systems. The user systems control the operation of these valves.

PNEUMATIC - DISTRIBUTION - INTRODUCTION



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PNEUMATIC - DISTRIBUTION - INTRODUCTION

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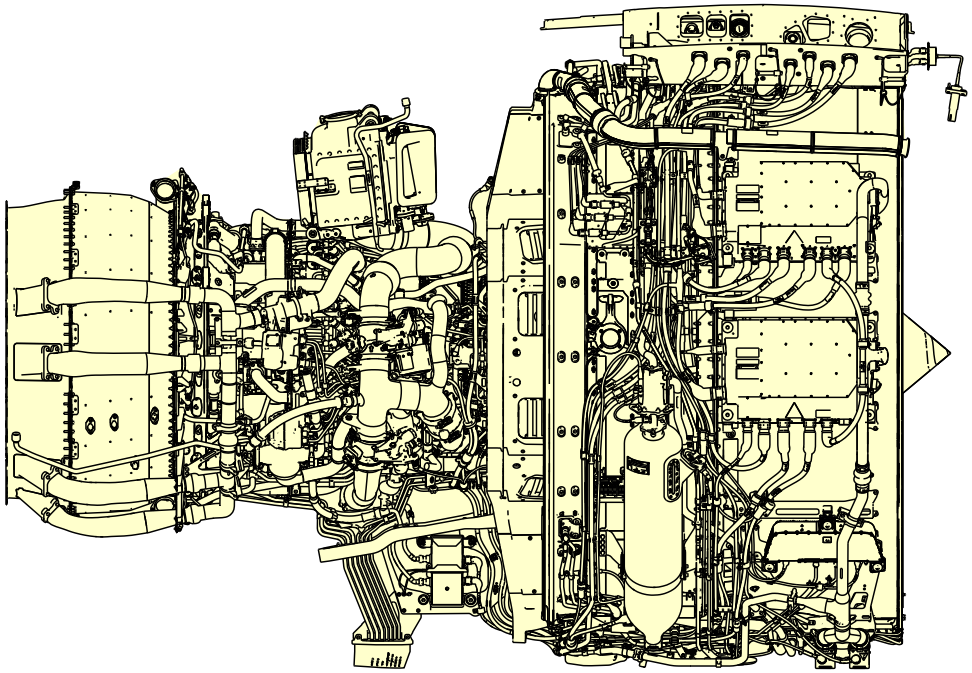
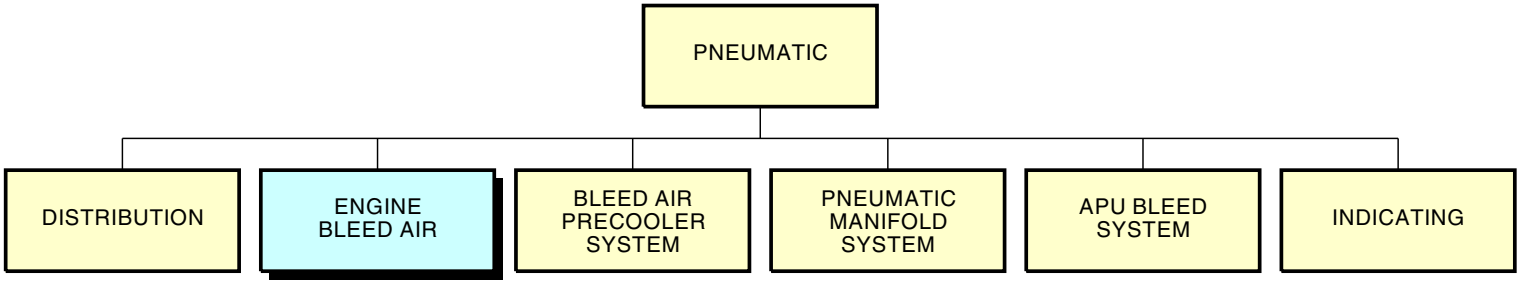
PNEUMATIC - ENGINE BLEED AIR - INTRODUCTION

Purpose

The engine bleed air system supplies pressure regulated air to the pneumatic manifold.

PNEUMATIC - ENGINE BLEED AIR - INTRODUCTION





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PNEUMATIC - ENGINE BLEED AIR - INTRODUCTION

PNEUMATIC - ENGINE BLEED AIR - GENERAL DESCRIPTION

Purpose

The engine bleed air distribution system supplies pressure regulated air to the pneumatic manifold.

General Description

Bleed air comes from the 10th and 4th stages of the engine high stage compressors. At low engine speed, the pneumatic system uses 10th stage bleed air. At low engine speed, the 4th stage air is not sufficient for pneumatic system demands.

At low engine speed, the High Pressure Shutoff Valve (HPSOV) controls the pressure of the engine bleed air. The Intermediate Pressure Check Valve (IPCV) prevents reverse flow.

At high engine speed, the HPSOV valve closes and the IPCV opens to supply bleed air to the Pressure Regulating Shutoff Valve (PRSOV). The PRSOV now controls the engine bleed pressure.

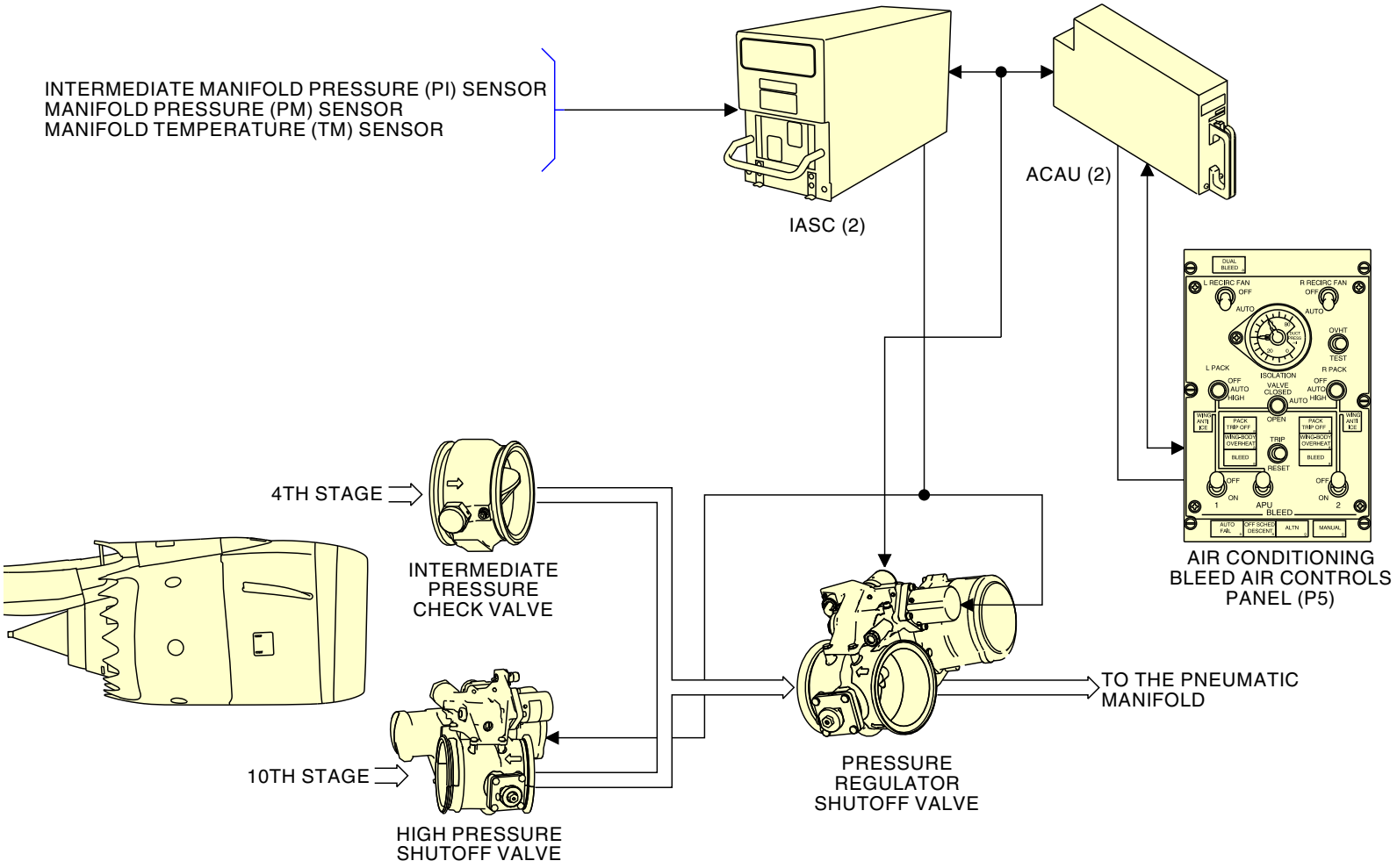
The air conditioning bleed air controls panel has engine bleed switches for solenoid control of the PRSOVs. The HPSOVs and PRSOVs are torque motor controlled by the Integrated Air System Controller (IASC). The IASCs get inputs from the pressure sensors and make adjustments to the HPSOVs and PRSOVs depending on pneumatic system demands.

The Intermediate Manifold Pressure (PI) sensor and the Manifold Pressure (PM) sensor give inputs to the IASC. If the pressure in the manifold is excessive, the IASC will close the HPSOV and PRSOV, and turn on the amber BLEED light on the air conditioning bleed air controls panel.

The Manifold Temperature (TM) sensor gives inputs to the IASC. If the temperature in the manifold is excessive, the IASC will close the HPSOV and PRSOV, and turn on the amber BLEED light on the air conditioning bleed air controls panel.

The Air Conditioning Accessory Unit (ACAU) is an interface between the IASC, air conditioning bleed air controls panel, and the PRSOV.

PNEUMATIC - ENGINE BLEED AIR - GENERAL DESCRIPTION



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PNEUMATIC - ENGINE BLEED AIR - GENERAL DESCRIPTION

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PNEUMATIC - ENGINE BLEED AIR - INTEGRATED AIR SYSTEMS CONTROLLER (IASC)

Purpose

The Integrated Air System Controller (IASC) combines air conditioning pack control functions and engine bleed air supply control functions into a single controller.

There are two identical IASCs (L IASC/R IASC). Each IASC is assigned to manage its respective engine bleed system and air conditioning system.

Location

The IASCs are located in the EE compartment on the E3-3 rack.

General Description

There are two independent controllers inside each IASC. An Air Supply Controller (ASC) and a Pack Flow and Temperature Controller (PFTC). The two ASCs are part of the Air Supply Control System (ASCS).

Each ASC provides control and indication for bleed air management for one engine through:

- Engine bleed port selection (4th or 10th stage)
- Manifold air pressure control
- Manifold air temperature control
- Manifold air flow control
- Engine bleed air cooling.

ASCs primary system control is achieved through closed loop electronic control of these valves:

- High Pressure Shutoff Valve (HPSOV)
- Pressure Regulator Shutoff Valve (PRSOV)
- Fan Air Modulating Valve (FAMV).

The ASCs use these sensor inputs for bleed air management:

- Intermediate Manifold Pressure (PI) sensor
- Manifold Pressure (PM1) sensor
- Manifold Temperature (TM) sensor
- Manifold Pressure (PM2 - Duct Pressure Transducer) sensor.

Physical Description

The IASC is segregated into two distinct parts – the Air Supply Control (ASC) and Pack Flow/Temperature Control (PFTC). The ASC and PFTC subsystems are housed in a common chassis but are largely independent, with separate primary control CCAs, backup control CCAs, power supplies, input/outputs, etc.

The controller housing is a lightweight sheet aluminum box consisting of a U-shaped chassis, top cover, plenums, as well as front and rear covers that have been designed to meet any natural combination of the environments specified.

Functional Description

The ASC subsystem manages the engine bleed systems, including bleed port selection, pressure and temperature regulation, system fault detection, and reconfiguration. Pressure and temperature sensors facilitate system control. Backup control within each controller ensures that manifold temperature can be maintained as normal in the event of a failure.

The PFTC subsystem manages the mass flow through the ECS pack. It also controls pack outlet temperature, as well as flight deck and cabin temperatures to meet the consumer demands depending on airplane and bleed operating conditions.

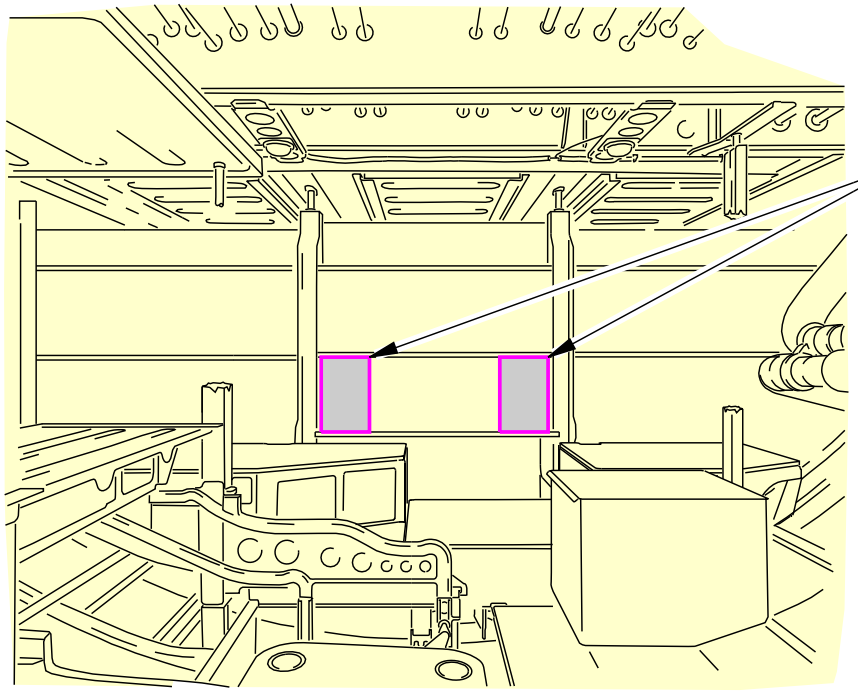
The complete system also includes anti-ice components that prevent the formation of ice on the aircraft engines and wings. The anti-ice system includes Wing Anti-Ice Valves (WAIV), Engine Anti-Ice Valves (EAIV), and pressure switches that monitor WAIV and EAIV operation.

The 737 MAX Integrated Air Supply Controller (IASC) digitally controls the output of 4th and 10th stage pneumatic air in response to bleed system demands; therefore, faults captured in the Onboard Maintenance Function (OMF) should be relied on for troubleshooting purposes rather than observed flight deck effects such as duct pressure needle splits or erratic movement.

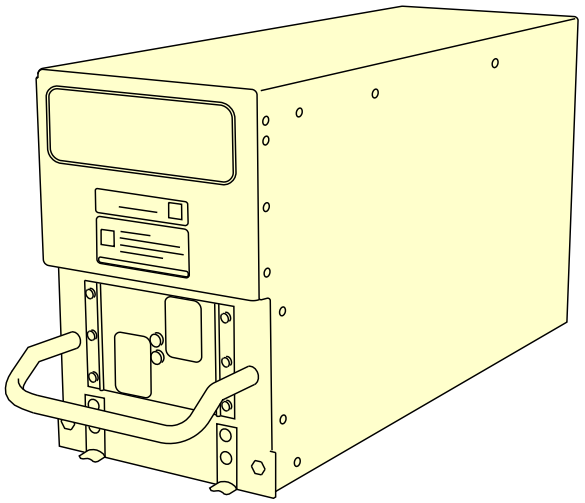
For example, the pneumatic system uses a digital controller that incorporates underpressure protection and Post Flight BIT (PFBIT) of the PRSOV solenoid. After landing, the IASC performs a PFBIT. This causes duct pressure to split after landing, and the left and right needles will move on the air conditioning/bleed air control panel.

During PBIT the observation of split duct pressure is normal and no fault messages are present because the system is operating per design.

PNEUMATIC - ENGINE BLEED AIR - INTEGRATED AIR SYSTEMS CONTROLLER (IASC)



ELECTRONIC EQUIPMENT RACKS, E2, E3 AND E4



INTEGRATED AIR SYSTEMS CONTROLLER (IASC)

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PNEUMATIC - ENGINE BLEED AIR - INTEGRATED AIR SYSTEMS CONTROLLER (IASC)

PNEUMATIC - ENGINE BLEED AIR - INTERMEDIATE PRESSURE CHECK VALVE (IPCV)

Purpose

The intermediate pressure check valve (IPCV) prevents the 10th stage bleed air flow into the 4th stage bleed port.

Physical Description

The IPCV is a split-flapper check valve.

Location

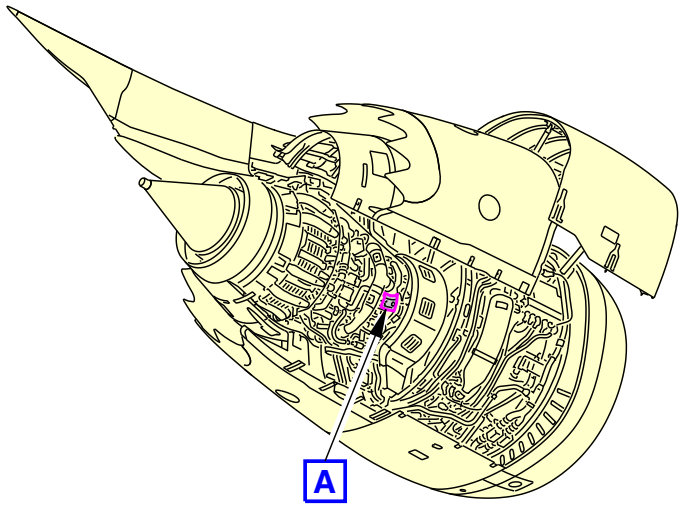
The IPCV is part of the engine bleed air manifold. It is on the right side of the engine high pressure compressor case.

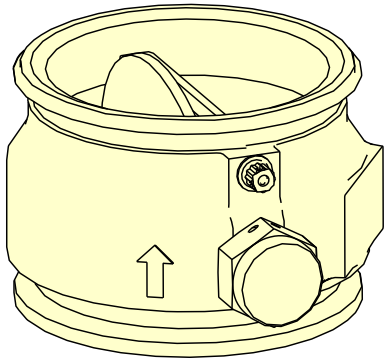
Functional Description

The valve lets air flow go in the direction of the arrow. It stops air flow in the opposite direction.

Two semicircular flappers control air flow. Normal airflow opens the flappers. Reverse airflow closes the flappers.

PNEUMATIC - ENGINE BLEED AIR - INTERMEDIATE PRESSURE CHECK VALVE (IPCV)





INTERMEDIATE PRESSURE CHECK VALVE (IPCV)

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PNEUMATIC - ENGINE BLEED AIR - INTERMEDIATE PRESSURE CHECK VALVE (IPCV)

PNEUMATIC - ENGINE BLEED AIR - HIGH PRESSURE SHUTOFF VALVE (HPSOV)

Purpose

The High Pressure Shutoff Valve (HPSOV) controls the flow of bleed air from the 10th stage engine bleed air manifold.

The integrated air systems controller controls the HPSOV.

Location

The HPSOV is on the engine core area at the 4:00 o'clock position.

Physical Description

The HPSOV is a pneumatically-actuated, electrically-controlled, variable pressure regulating and shutoff valve. The valve has these parts:

- Pneumatic actuator
- Electrical connector
- Reference pressure regulator
- Torque motor
- Test port
- Filter (optional)
- Valve body with direction of flow arrow
- Manual override and position indicator.

Operation

The HPSOV is controlled by the Air Supply Controller (ASC) in the Integrated Air System Controller (IASC).

When the intermediate manifold pressure is insufficient to meet the bleed system user demands, the HPSOV is open and controlled to a target pressure setpoint using the Intermediate Manifold Pressure (PI) sensor. The pressure setpoint is between 35 psig (241 kPa) - 65 psig (448 kPa).

When the intermediate manifold pressure is sufficient, the HPSOV is commanded closed, and the ASC maintains duct pressure through PRSOV regulation. This includes higher throttle settings, takeoff, climb, and all cruise conditions.

When the ASC is not controlling the HPSOV torque motor, the valve will self-regulate to 65 psig (448 kPa). This is referred to as pneumatic or back-up regulation.

The ASC monitors the bleed system configuration and closes the associated HPSOV if there is a potential reverse flow condition. For example, if both engines are running, left and right BLEED switches are ON (HPSOVs are open) and the isolation valve is open, then the ASC will close one of the HPSOVs based on a comparison of left and right Intermediate Manifold Pressure (PI) sensor readings.

Other potential reverse flow conditions are as follows:

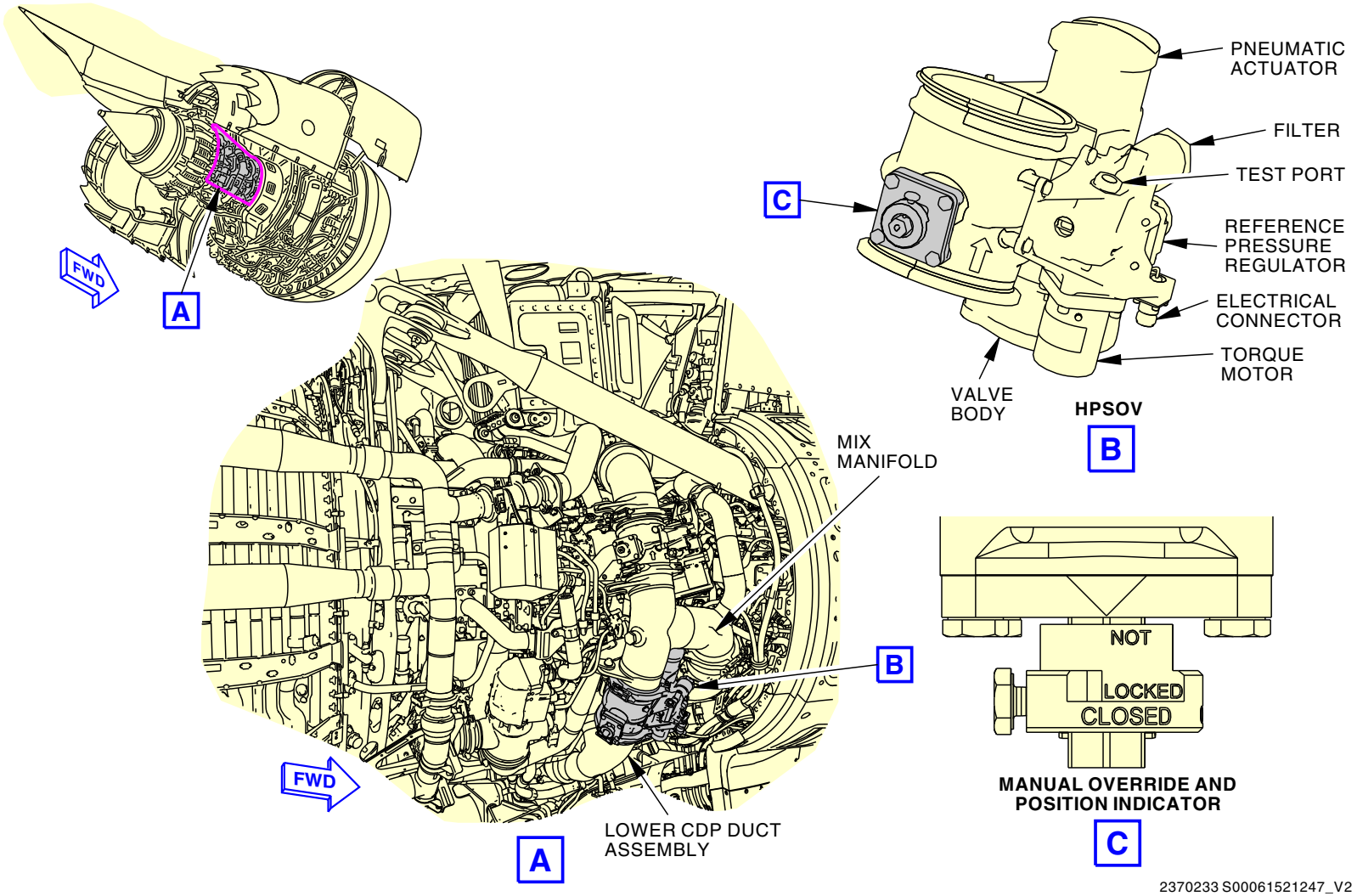
- Left HPSOV open and APU bleed valve open
- Right HPSOV open, APU bleed valve open, and isolation valve open
- High pressure ground air is connected with right HPSOV open
- High pressure ground air is connected with left HPSOV open and the isolation valve is open.

The HPSOV is spring-loaded closed with the loss of electrical and pneumatic power.

The HPSOV enters pneumatic regulation mode if any of the following conditions are met:

- When ENG 1 and 2 are ON, EAI is ON, altitude is less than 22,500 ft (6858 m), Total Air Temp (TAT) less than 50°F (10°C), altitude rate of change is less than 200 ft/min.
- Primary Air Supply Control card failure
- Intermediate pressure (PI) sensor failure
- Loss of compressor outlet pressure (PS3) and compressor outlet temperature (TS3)
- HPSOV torque motor failure
- IASC not healthy.

PNEUMATIC - ENGINE BLEED AIR - HIGH PRESSURE SHUTOFF VALVE (HPSOV)



PNEUMATIC - ENGINE BLEED AIR - HIGH PRESSURE SHUTOFF VALVE (HPSOV)

PNEUMATIC - ENGINE BLEED AIR - PRESSURE REGULATING SHUTOFF VALVE (PRSOV)

Purpose

The Pressure Regulating Shutoff Valve (PRSOV) controls the flow of bleed air from the engine 4th and 10th stages. These are the PRSOV control functions:

- Shutoff of the engine bleed air
- Pressure regulation of the engine bleed air
- Limit of the engine bleed air temperature (450°F (232°C)).

Location

The PRSOV is at the 3:00 o'clock position on the engine core area and below the precooler.

Physical Description

The PRSOV is an electrically-controlled, pneumatically-actuated, variable pressure regulating and shutoff valve. The valve has these parts:

- Pneumatic actuator
- Torque motor
- Solenoid
- Reference regulator
- Filter
- Valve body
- Test port
- Manual override and position indicator.

Operation

The PRSOV gets electrical control by signals from these devices:

- Engine BLEED air switch
- Torque motor control through the Integrated Air System Controller (IASC).

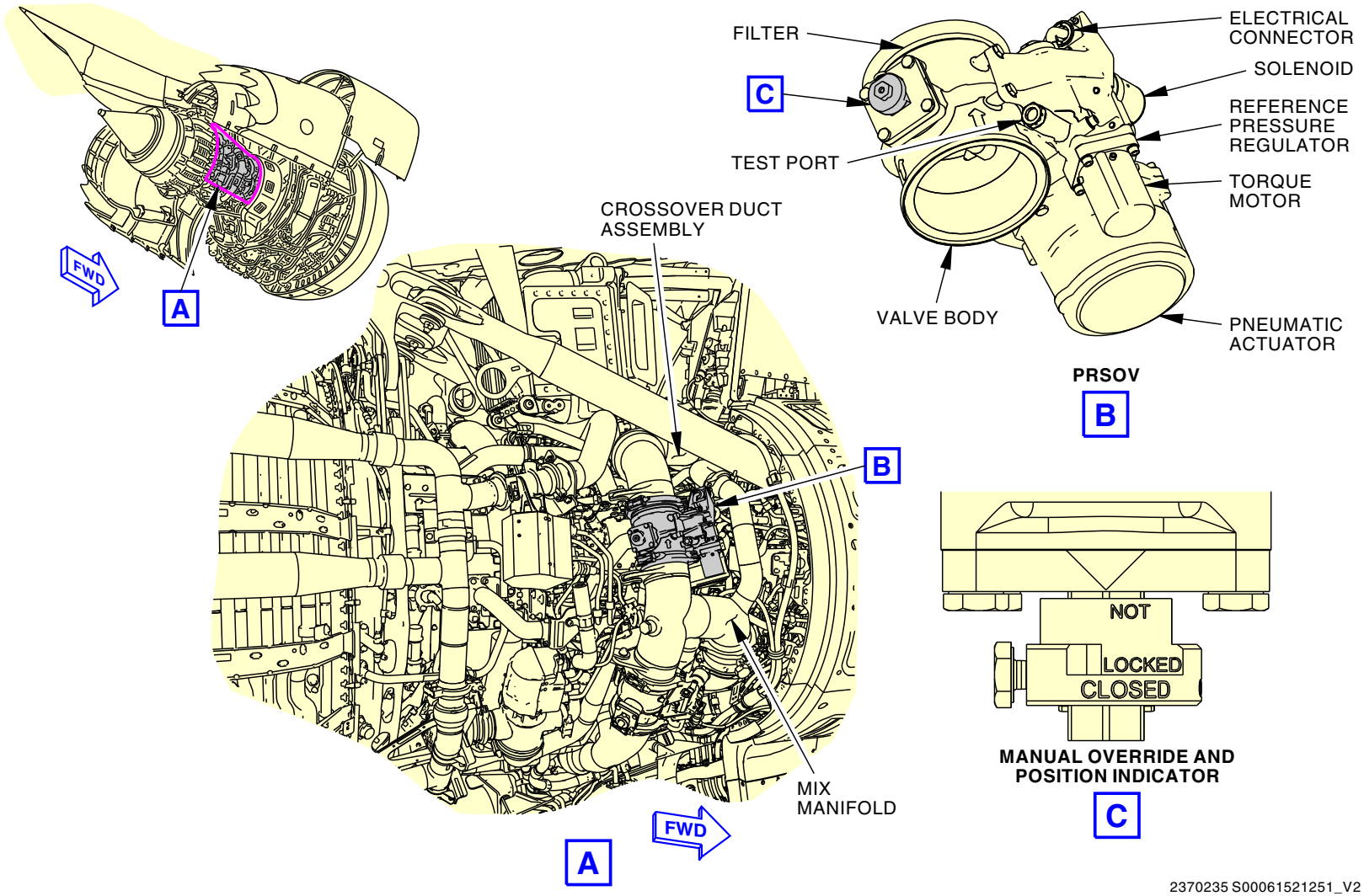
During normal operation, when you set the engine BLEED switch to ON, a signal goes through the Air Conditioning Accessory Unit (ACAU) and energizes the enable solenoid to open the PRSOV. When you set the engine BLEED switch to OFF, a signal goes to the disable solenoid to close the PRSOV.

When the intermediate pressure is sufficient to meet the bleed system user demands, the HPSOV is closed, and the PRSOV regulates the manifold pressure at the PM sensor (45 +/-5 psig). When the intermediate manifold pressure is not sufficient, the PRSOV goes to pneumatic regulation, air is supplied from the 10th stage, and the HPSOV regulates the bleed air supply based on inputs from the Intermediate Manifold Pressure (PI) sensor.

Relays in the ACAU control the PRSOV disable solenoid for these conditions:

- Engine not running
- Engine fire switch pulled (fire condition)
- Dual bleed
- IASC not healthy
- Engine bleed trip over-temperature conditions; 490°F (254°C) overheat for 20 seconds
- Engine bleed trip overpressure conditions; 170 psi for 5 seconds from the PI sensor.
- Engine bleed trip underpressure conditions; less than 13 psi from the PM sensor with the engine running and with the PRSOV commanded to pneumatic regulation.

PNEUMATIC - ENGINE BLEED AIR - PRESSURE REGULATING SHUTOFF VALVE (PRSOV)



PNEUMATIC - ENGINE BLEED AIR - PRESSURE REGULATING SHUTOFF VALVE (PRSOV)

EFFECTIVITY

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PNEUMATIC - ENGINE BLEED AIR - PRESSURE SENSORS

Purpose

The Intermediate Manifold Pressure (PI) sensor detects the hot bleed air pressure upstream of the Pressure Regulating Shutoff Valve (PRSOV).

The manifold pressure sensors (PM1 and (PM2 or Duct Pressure Transducer)) detect the hot outlet air pressure downstream of the precooler.

Location

The PI sensor is located on the engine fan case at the 7:00 o'clock position.

The PM1 sensors is located in the engine struts.

The PM2 sensors are located on the forward bulkheads of the air conditioning bays near the pneumatic crossover duct.

Physical Description

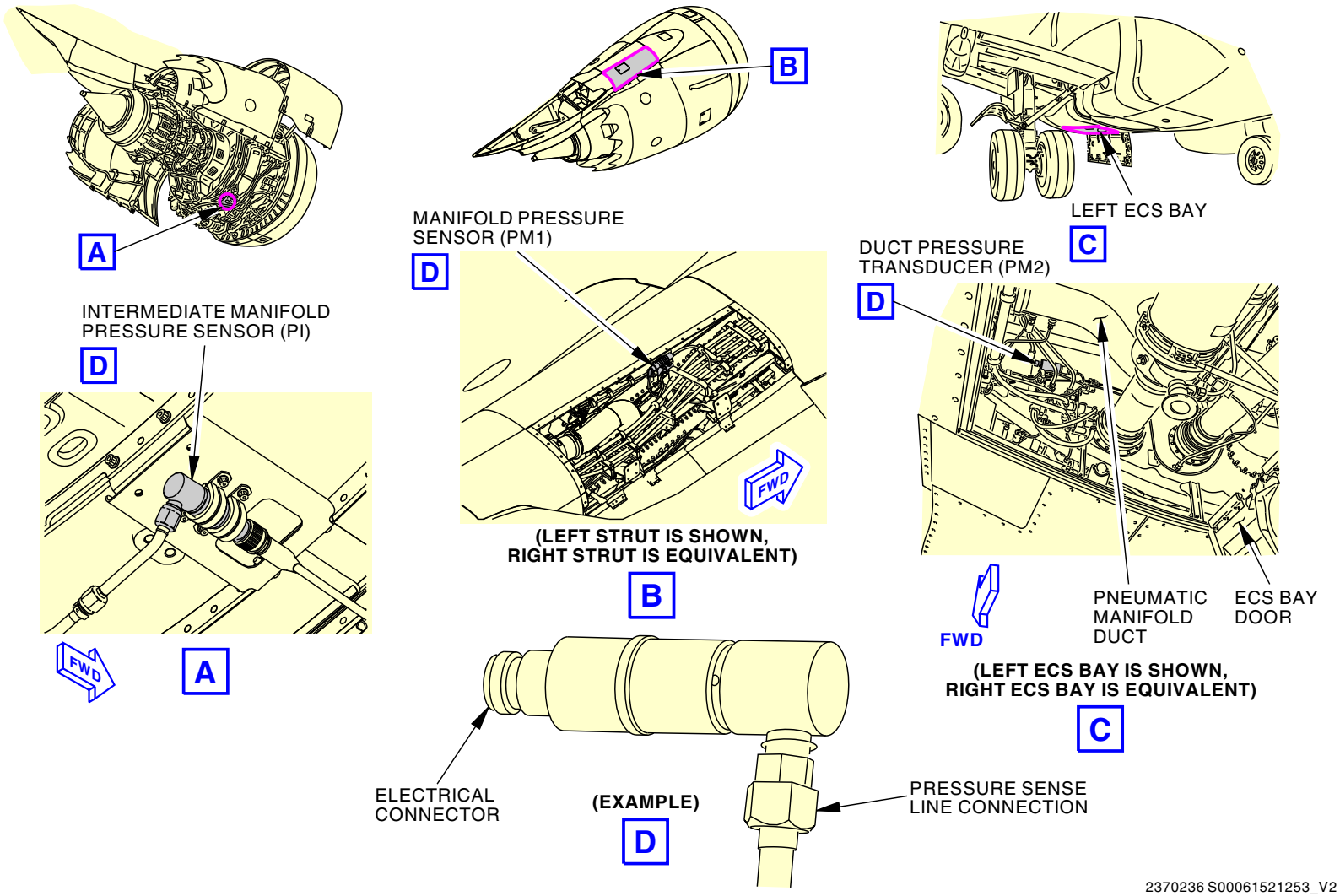
Each is a gauge pressure sensor consisting of a pressure-sensing element with an integral electronics assembly contained within a stainless steel housing. The housing provides protection from both the environment and from electromagnetic interference.

Functional Description

The PI sensor sends pressure signals to the Integrated Air System Controller (IASC). The IASC uses these inputs for the HPSOV regulation and to detects overpressure conditions in the intermediate manifold. If the intermediate manifold pressure exceeds 170 psig for 5 seconds, the IASC closes the HPSOV and PRSOV. The BLEED light on the air conditioning bleed air controls panel and master caution comes on to alert the flight crew.

The PM1 sensor sends pressure signals to the primary ASC channel of the IASC. The PM2 sensor sends pressure signals to the backup ASC channel of the IASC. The IASC uses these inputs for PRSOV pressure regulation. The PM2 sensor is used as a backup for manifold pressure control. The PM2 sensor drives the analog pressure gauge on the flight deck.

PNEUMATIC - ENGINE BLEED AIR - PRESSURE SENSORS



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PNEUMATIC - ENGINE BLEED AIR - PRESSURE SENSORS

PNEUMATIC - ENGINE BLEED AIR - DUCT VENT VALVE

Purpose

The Duct Vent Valve (DVV) prevents a bleed system overpressure shutdown during a “no-bleeds takeoff”.

Location

The DVV is located on the engine turbine case at approximately the 3 o'clock position.

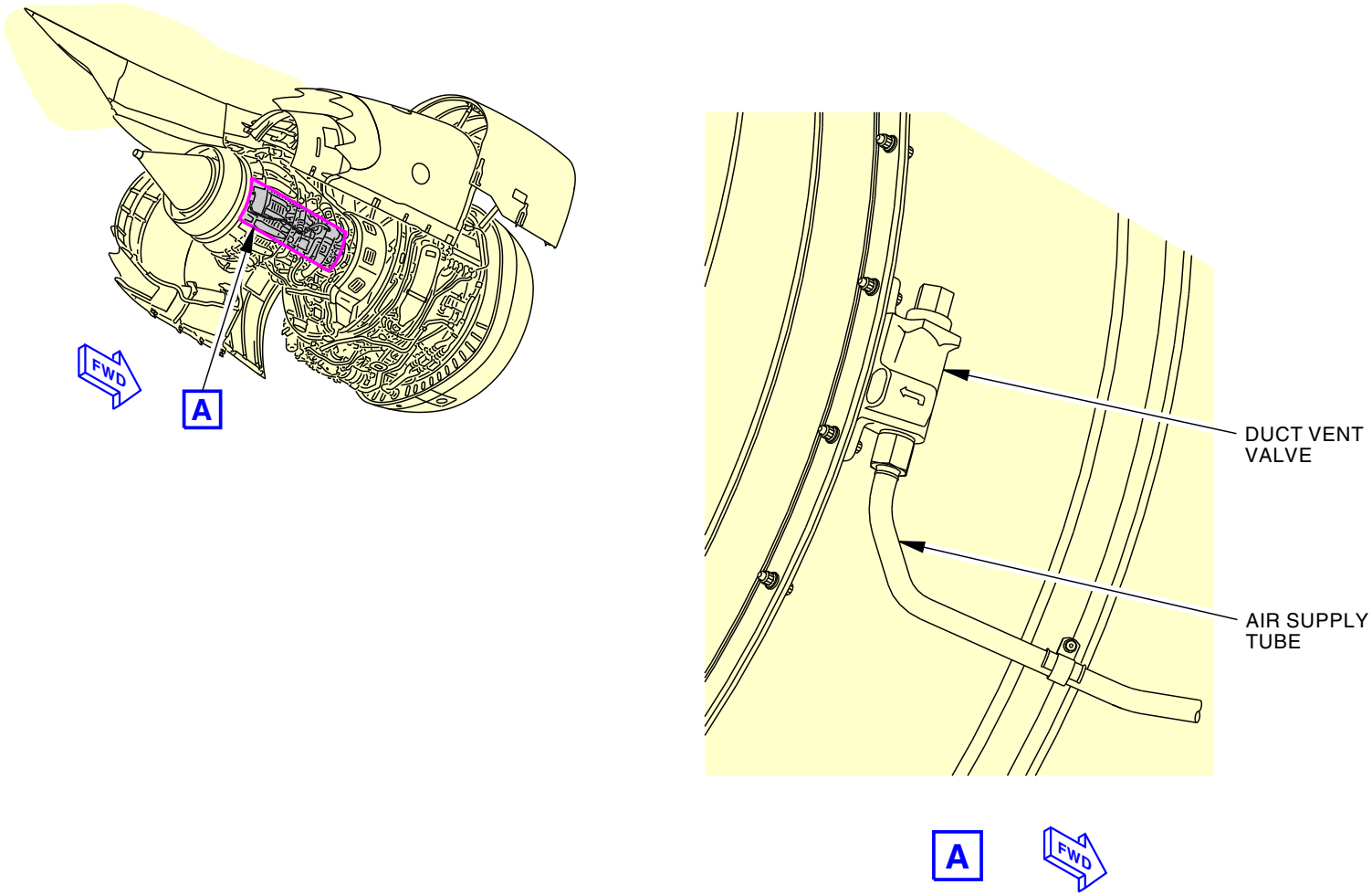
Physical Description

The DVV is a spring loaded closed, pneumatically actuated pressure relief valve.

Functional Description

The function of the duct vent valve is to prevent over pressurization of the bleed manifold during operating conditions where engine bleed supply is active but the Pressure Regulating Shutoff Valve (PRSOV) is closed. In particular, during a “No Bleeds take-off”, the PRSOV is commanded closed during aircraft take-off, to limit bleed extraction and preserve engine thrust. The DVV vents pressure into the engine compartment to maintain bleed manifold pressure within design limits.

PNEUMATIC - ENGINE BLEED AIR - DUCT VENT VALVE



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PNEUMATIC - ENGINE BLEED AIR - DUCT VENT VALVE

PNEUMATIC - ENGINE BLEED AIR - BLEED AIR CONTROL - FUNCTIONAL DESCRIPTION

General

The engine bleed air control and indication circuits use 28 VDC.

With the engine fire handle down (normal condition), the K20 relay stays de-energized the system operates normally. If the handle is up (fire condition), the K20 energizes and disables the Pressure Regulating Shutoff Valve (PRSOV) solenoid valve.

With the engine BLEED switch OFF, the control signal disables the PRSOV solenoid valve. With the engine BLEED switch ON, the control signal goes through the de-energized K20 relay (normal conditions) in the Air Conditioning Accessory Unit (ACAU). This enables the PRSOV solenoid valve.

The relays in the ACAU protect the bleed air system during these conditions:

- Engine start operations
- Engine bleed air overpressure
- Engine bleed air overtemperature.

The K20 PRSOV disable relay energizes during these conditions:

- K9 eng bleed air trip relay energized
- K5 Integrated Air System Controller (IASC) health relay de-energized
- PRSOV disable signal from the IASC
- Fire handle on P8 pulled to the up (fire) position
- R564 eng running relay de-energized (engine off)
- Dual bleed.

The K9 eng bleed air trip relay energizes when there is a bleed trip off condition. These conditions cause the BLEED light to come on:

- Overpressure in the intermediate manifold (sensed by Intermediate Manifold Pressure (PI) sensor)
- Overtemperature downstream of the precooler (sensed by the Manifold Temperature (TM) sensor).
- Underpressure in the bleed air manifold, downstream of the PRSOV (sensed by the Manifold Pressure (PM) sensor).
- Reverse flow fault.
- TM sensor failure (TM1 and TM2 elements).
- IASC failure (Primary and Backup channels failed).
- Backup sensors and Primary channel failed.
- BLEED switches 1 and 2 are not set to ON 45 seconds after takeoff (the two BLEED lights come on).

The contacts of an energized K9 eng bleed air trip relay cause these operations:

- K20 relay energizes and disables the PRSOV solenoid valve - BLEED light comes on
- P7 MASTER CAUTION and AIR COND annunciator lights come on
- Holding circuit makes a connection to the air conditioning panel TRIP RESET button.

To get control of the engine bleed system after a bleed trip off, push the TRIP RESET button

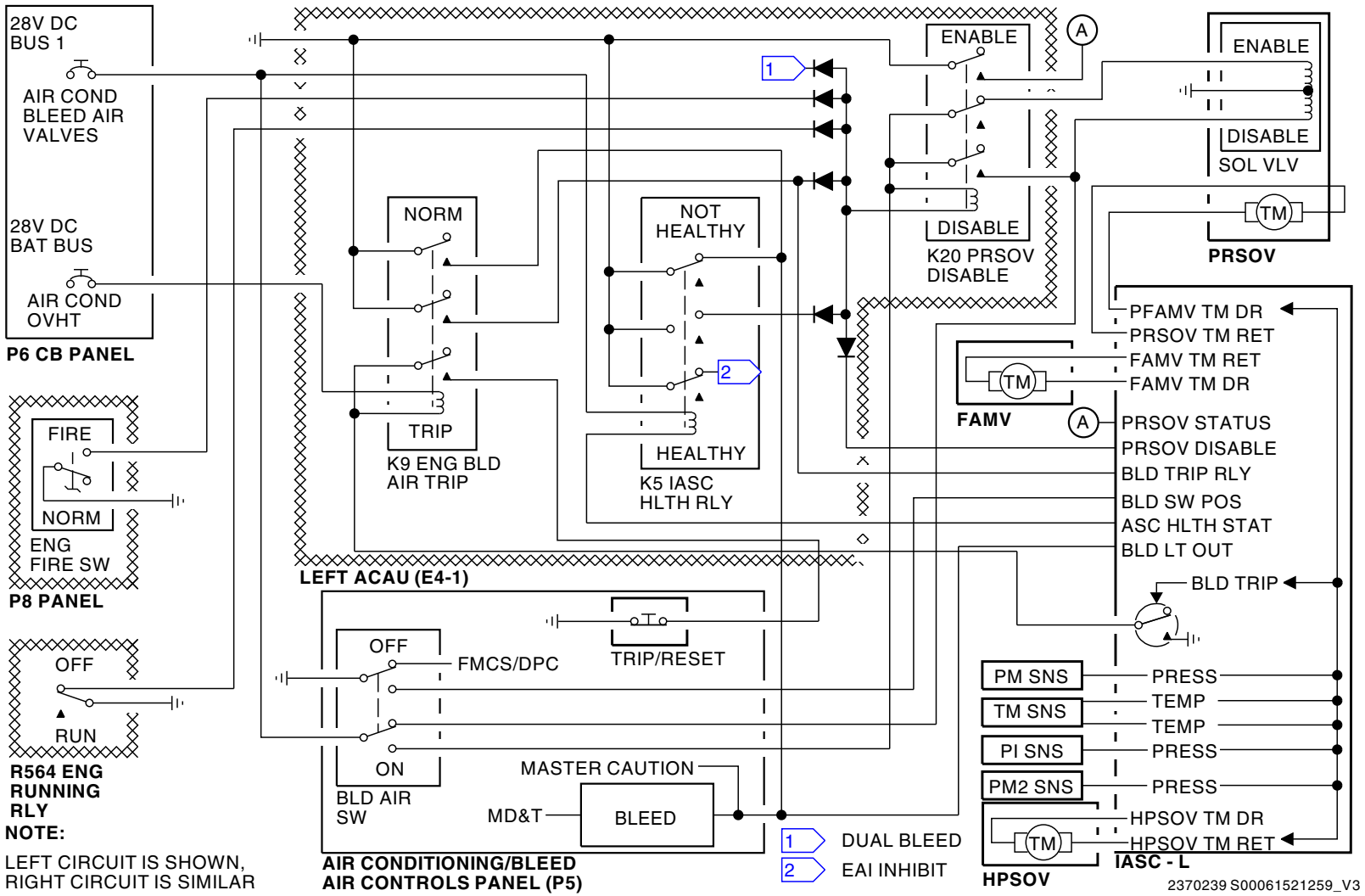
- TRIP RESET button opens the holding circuit.
- Some system faults cannot be reset with the TRIP RESET button.

NOTE: If the two BLEED lights come on because of an incorrect bleed configuration (the two BLEED switches were not turned on within 45 seconds after takeoff), it is possible to set one BLEED switch to ON to extinguish the two BLEED lights.

The engine BLEED switch has multiple poles. One set of poles controls the PRSOV solenoid valve circuit. A different set of poles supplies discrete signals to the Flight Management Computer (FMC) and Display Processing Computer (DPC).

The enable and disable coils on the PRSOV solenoid valve are constant duty coils. When there is a loss of electric power, the solenoid valve stays in the last position given by an electrical command.

PNEUMATIC - ENGINE BLEED AIR - BLEED AIR CONTROL - FUNCTIONAL DESCRIPTION



PNEUMATIC - ENGINE BLEED AIR - BLEED AIR CONTROL - FUNCTIONAL DESCRIPTION

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PNEUMATIC - BLEED AIR PRECOOLER SYSTEM - INTRODUCTION

Purpose

The precooler cools the engine bleed air before it goes into the pneumatic manifold.

General Description

The precooler system in each engine is an air to air heat exchanger.

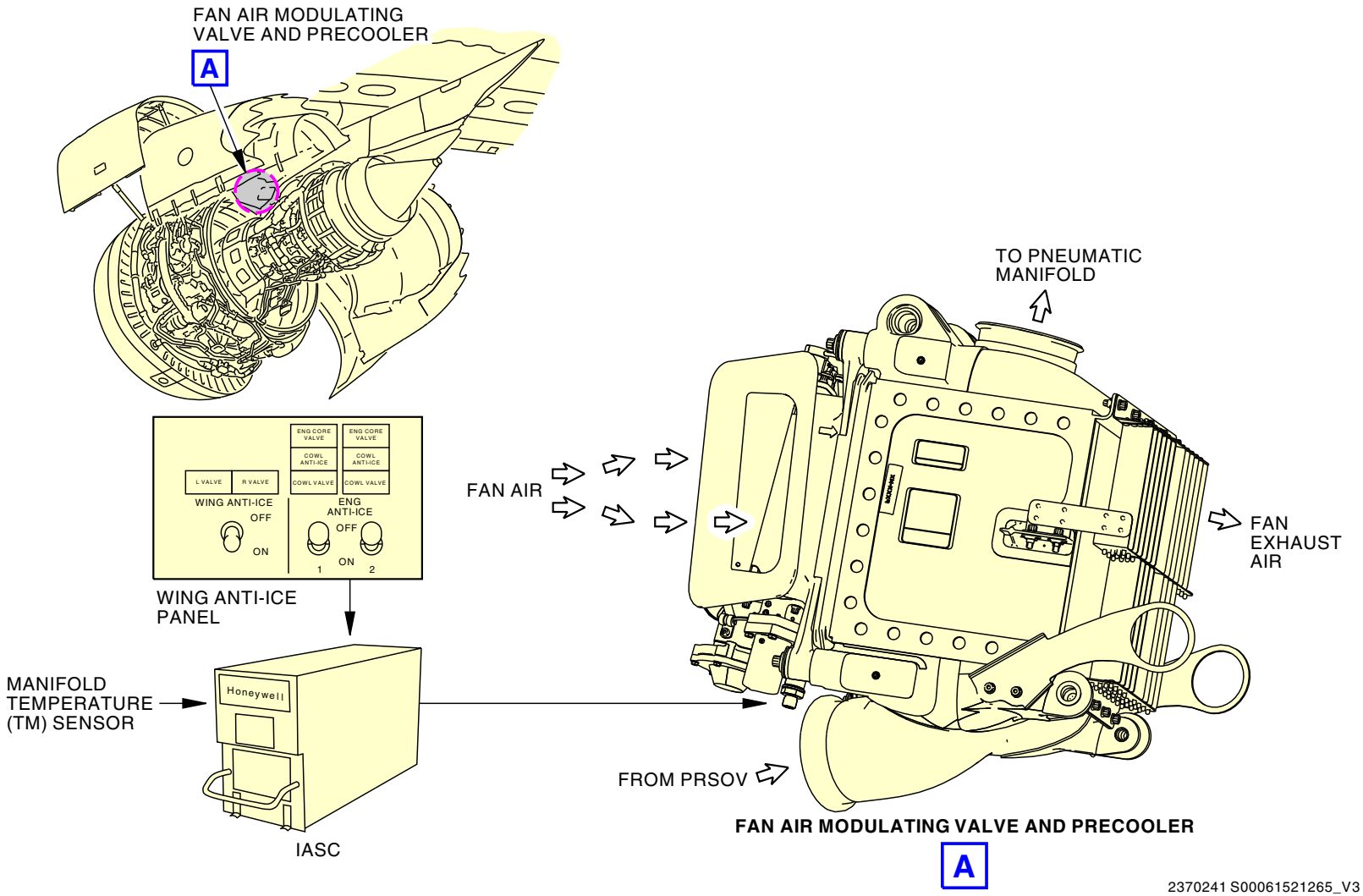
A Fan Air Modulating Valve (FAMV) controls the amount of fan air that flows through the precooler. The FAMV is controlled by the Integrated Air System Controller ((IASC). The IASC gets input from the manifold temperature sensor. The IASC adjusts the FAMV to control the precooler outlet temperature to 415°F (213°C).

When the Pressure Regulating Shutoff Valve (PRSOV) is open, bleed air goes through the precooler to the pneumatic manifold. While the bleed air goes through the precooler, fan air removes the heat and goes out as fan exhaust air. The fan exhaust air flows over the engine core.

If precooler outlet temperature reaches 440°F (227°C), the PRSOV will restrict bleed air flow (temperature topping). The PRSOV is commanded closed when precooler exit temperature reaches 490°F (254°C) for 20 seconds.

Operation of the precooler systems is automatic.

PNEUMATIC - BLEED AIR PRECOOLER SYSTEM - INTRODUCTION



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PNEUMATIC - BLEED AIR PRECOOLER SYSTEM - INTRODUCTION

PNEUMATIC - BLEED AIR PRECOOLER SYSTEM - PRECOOLER

Purpose

The precooler heat exchanger uses fan air to cool the engine bleed air to acceptable outlet conditions.

Physical Description

The precooler is an air to air heat exchanger. It has these parts:

- Fan air inlet and outlet
- Engine bleed air inlet and outlet

Location

The precooler is on the top of the engine high pressure compressor case at the 12 o'clock position. The Fan Air Modulating Valve (FAMV) is mounted to the front of the precooler.

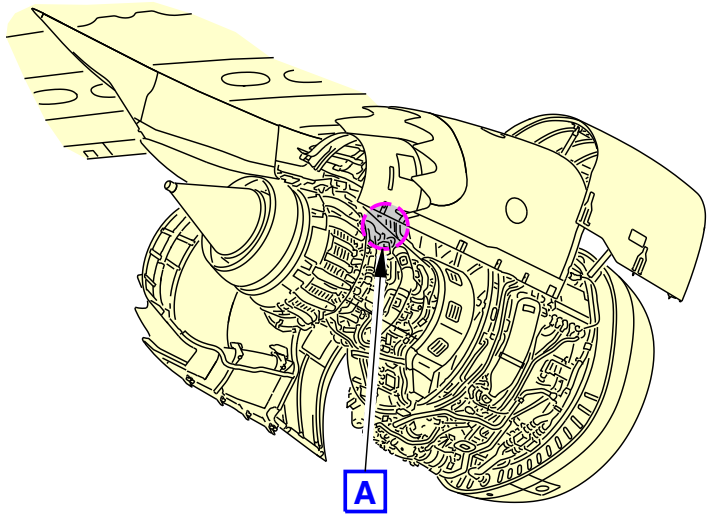
Functional Description

The precooler supplies a large surface area for efficient heat transfer from the bleed air to the fan air.

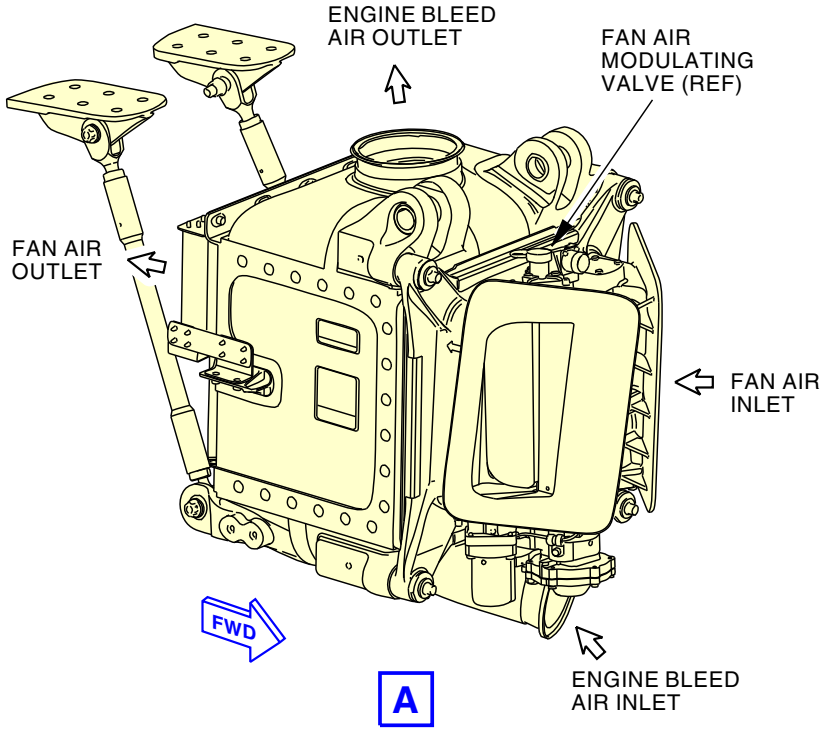
As the engine bleed air moves through the precooler, the bleed air gives up heat to the walls of the precooler. The walls are made of plates and fins and serves as a heatsink. Engine fan air that goes through the precooler on the other side of the walls, removes the heat and carries it away. Heat transfer goes from the bleed air, to the precooler walls, to the fan air. The fan air then flows over the engine case and overboard through the case vents.

A Fan Air Modulating Valve (FAMV) upstream of the precooler in the fan air circuit modulates the amount of cooling air provided to control the bleed air outlet temperature.

PNEUMATIC - BLEED AIR PRECOOLER SYSTEM - PRECOOLER



ENGINE - RIGHT SIDE



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PNEUMATIC - BLEED AIR PRECOOLER SYSTEM - PRECOOLER

PNEUMATIC - BLEED AIR PRECOOLER SYSTEM - FAN AIR MODULATING VALVE (FAMV)

Purpose

The fan air modulating valve (FAMV) controls the flow of fan air to the precooler.

Location

The FAMV is on top of the engine at 12 o'clock. It is attached to the forward side of the precooler.

Physical Description

The FAMV is a butterfly valve, spring loaded to the open position. The valve is pneumatically operated and electrically controlled by the IASC. The FAMV has these parts:

- Left and right flapper
- Torque motor
- Pneumatic actuator
- Pneumatic lock plug.

Pneumatic Lock Plug

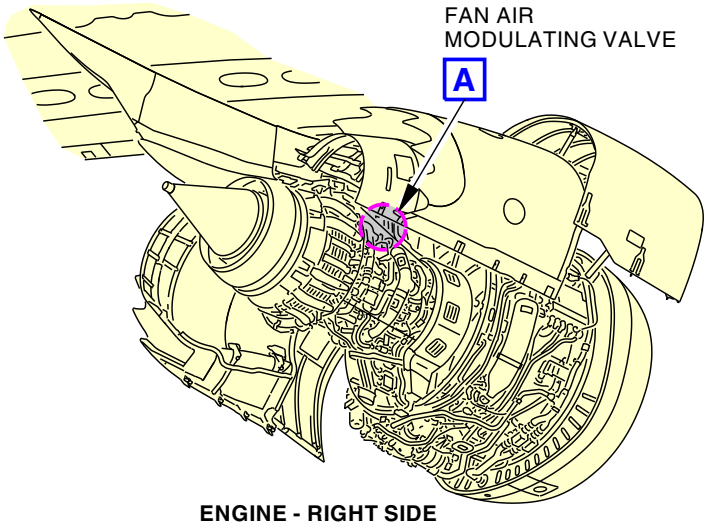
The pneumatic lock plug is a hex bolt with lock (L) and unlock (U) position indications. The pneumatic lock plug has threads on each side of the hex surfaces. The lock plug has a lanyard.

In the unlock (U) position, the FAMV operates normally. If the FAMV fails, you can use the pneumatic lock plug to lock the FAMV in the open position. In the lock (L) position, the long hex bolt shaft blocks valve control pressure from the reference regulator to the valve actuator and the FAMV goes to the full open position.

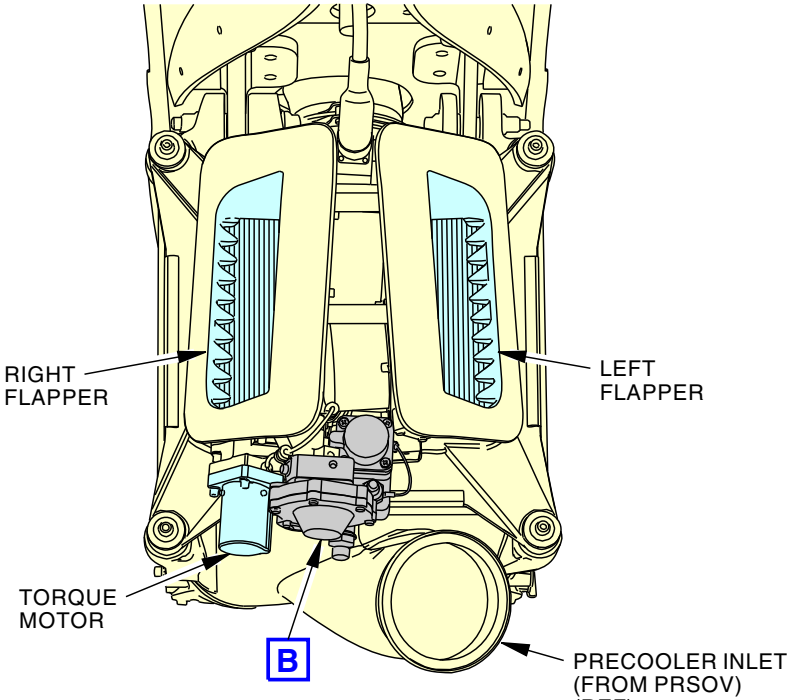
Functional Description

The FAMV controls fan air flow across the precooler to keep the temperature set-point, at the precooler outlet, to a nominal 415°F (213°C). If the Wing Anti-Ice (WAI) is ON, the set-point is lowered to 385°F (196°C).

PNEUMATIC - BLEED AIR PRECOOLER SYSTEM - FAN AIR MODULATING VALVE (FAMV)

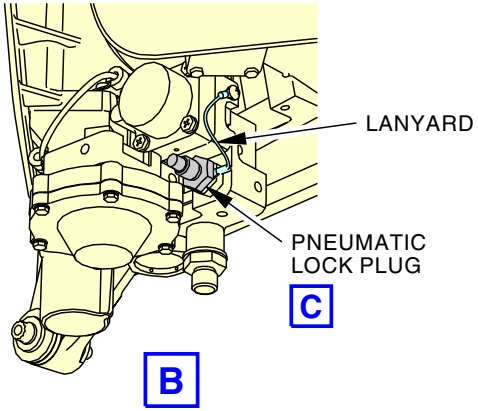


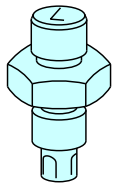
ENGINE - RIGHT SIDE



FAN AIR MODULATING VALVE
(VIEW IN THE AFT DIRECTION)

A





PNEUMATIC
LOCK PLUG

C

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PNEUMATIC - BLEED AIR PRECOOLER SYSTEM - FAN AIR MODULATING VALVE

PNEUMATIC - BLEED AIR PRECOOLER SYSTEM - MANIFOLD TEMPERATURE SENSOR

Purpose

The manifold temperature (TM) sensor senses the bleed air temperature from the precooler.

Physical Description

The TM sensor has these parts:

- Wrench flats
- Electrical connector.

Location

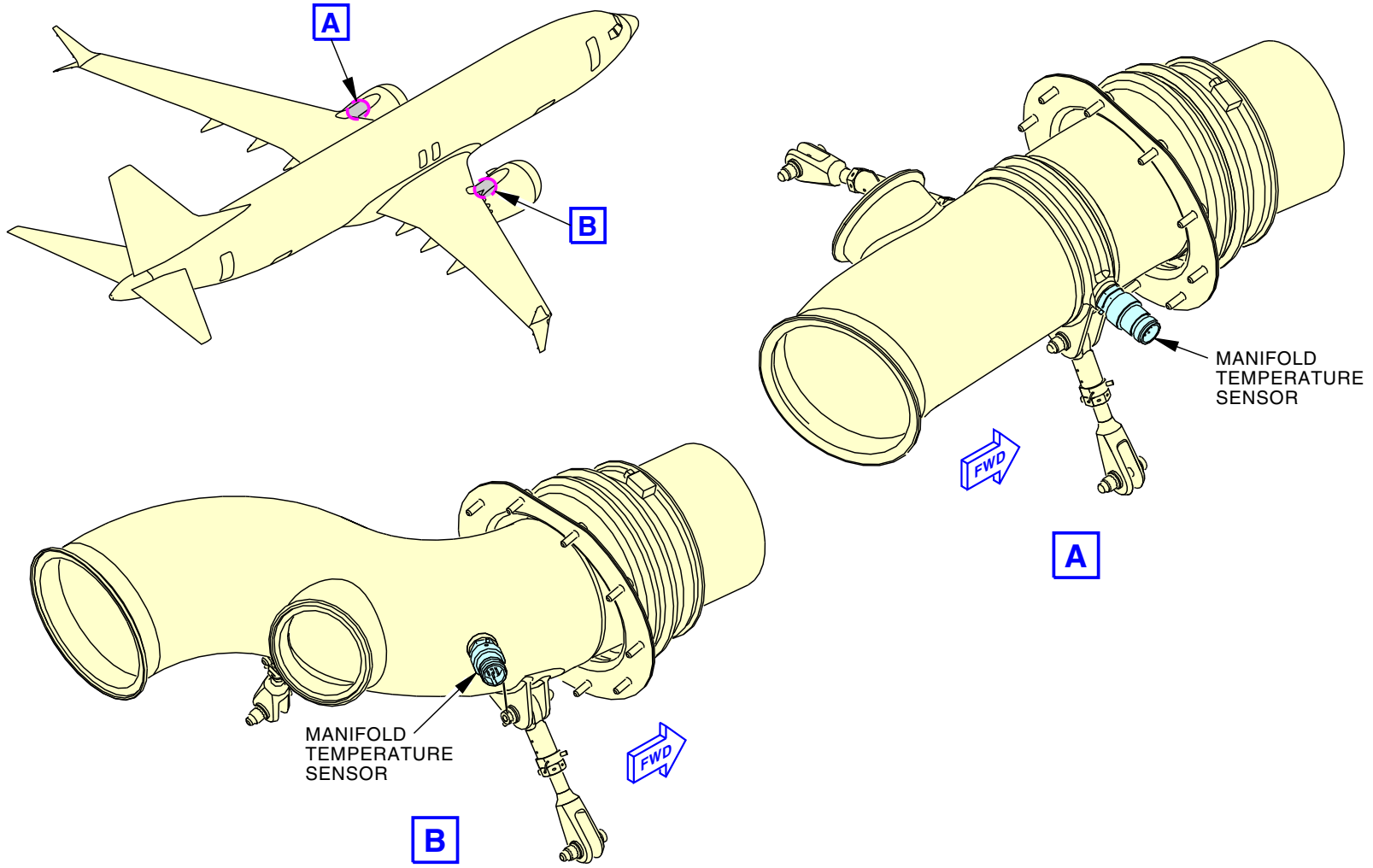
The TM sensor is located in the engine bleed air strut duct downstream of the precooler. Access is through a strut access panel.

Functional Description

The TM sensor gives temperature information to the Integrated Air System Controller (IASC). The IASC controls the FAMV. Bleed air temperature is controlled to 415°F (213°C) nominal through modulation of the FAMV cooling airflow to the precooler. If bleed air temperature reaches 490°F (254°C) for 20 seconds, the system will protect from the overheat as follows:

- The PRSOV will close.
- The HPSOV will close if the engine anti-ice is off.
- The air conditioning/bleed air controls panel BLEED light will come on.
- The P7 MASTER CAUTION and AIR COND annunciator will come on.
- The latching circuit will connect through the air conditioning panel TRIP RESET push-button switch.

PNEUMATIC - BLEED AIR PRECOOLER SYSTEM - MANIFOLD TEMPERATURE SENSOR



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PNEUMATIC - BLEED AIR PRECOOLER SYSTEM - MANIFOLD TEMPERATURE SENSOR

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PNEUMATIC - MANIFOLD SYSTEM - INTRODUCTION

Purpose

The pneumatic manifold has these purposes:

- Sends compressed air from the pneumatic sources to the user systems
- Supplies a valve to isolate the manifold into two separate systems (left and right)
- Supplies a connection for a ground source of pneumatic power.

General Description

The pneumatic manifold ducts are made of strong, corrosion-resistant, light-weight tubing. The pneumatic ducts are supported in tension.

An isolation valve in the center of the crossover duct divides the pneumatic manifold into a left and right side. The right side of the pneumatic manifold has these interfaces/features:

- Engine 2 bleed air system
- Engine 2 start system
- Ground pneumatic connector check valve
- Right air conditioning system
- Right wing thermal anti-ice system
- Hydraulic reservoir pressurization tap
- Isolation valve.

The left side of the pneumatic manifold has these interfaces/features:

- Engine 1 bleed air system
- Engine 1 start system
- APU bleed air system
- Left air conditioning system
- Left wing thermal anti-ice system
- Hydraulic reservoir pressurization tap
- Nitrogen gas generation system tap
- Isolation valve.

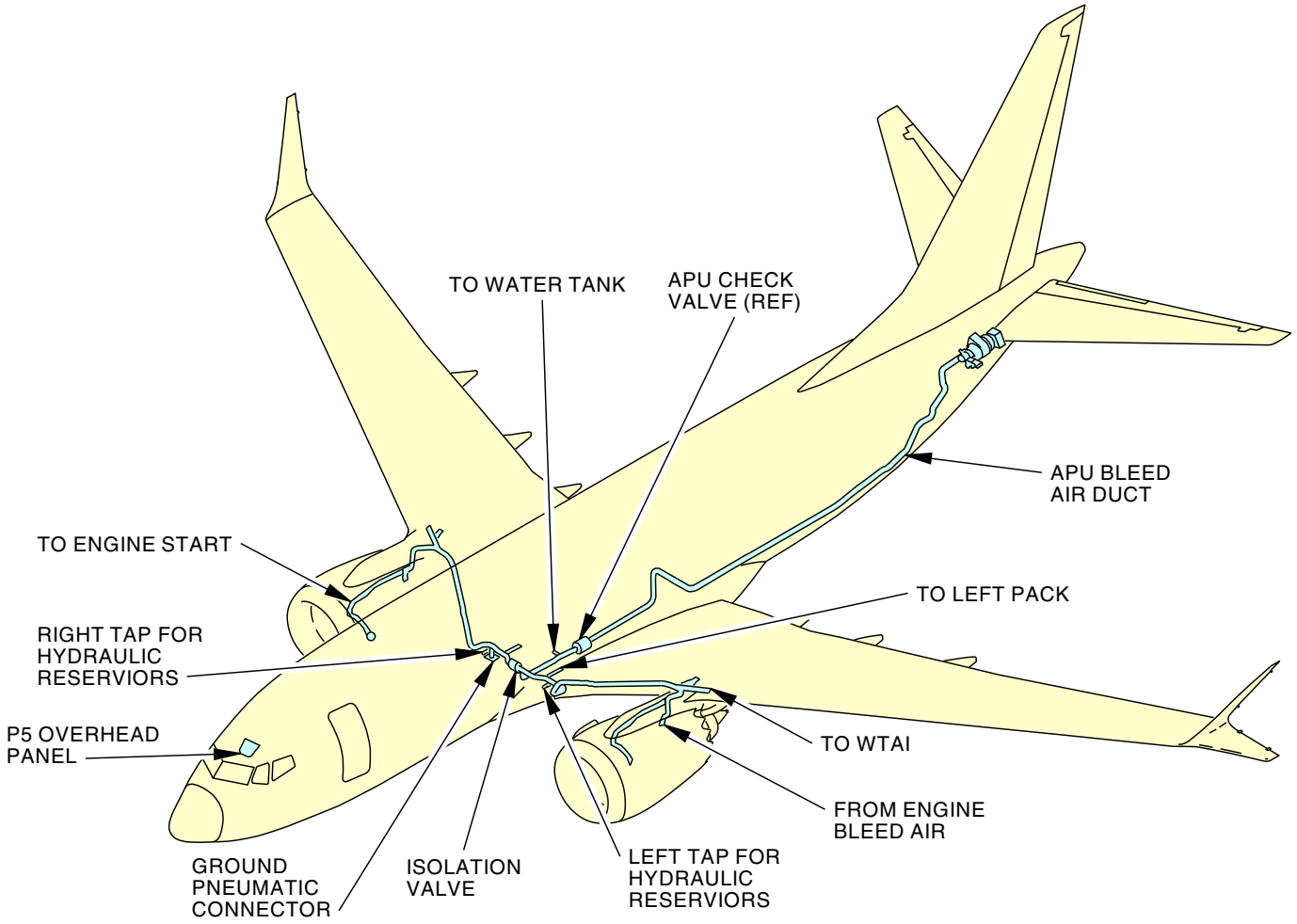
Location

The manifold is in these areas of the airplane:

- Engine struts
- Wing leading edges, along the front spars
- Forward air conditioning bays below the center wing (crossover duct)
- Keel beam between the air conditioning pack bays.

Controls and indications for the pneumatic manifold are on the air conditioning bleed air controls panel.

PNEUMATIC - MANIFOLD SYSTEM - INTRODUCTION



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PNEUMATIC - MANIFOLD SYSTEM - INTRODUCTION

PNEUMATIC - MANIFOLD SYSTEM - DUCT

Purpose

The pneumatic manifold sends hot, compressed air through the pneumatic system.

Physical Description

The pneumatic ducts are thin-walled tubes. The ducts have flanges at their ends and join with flange clamps.

The duct sections are made short in length. This lets ducts expand when hot air flows through them. This is thermal expansion.

Tension force holds the ducts between their structural mounts.

Some ducts have a gold coating. The coating has these functions:

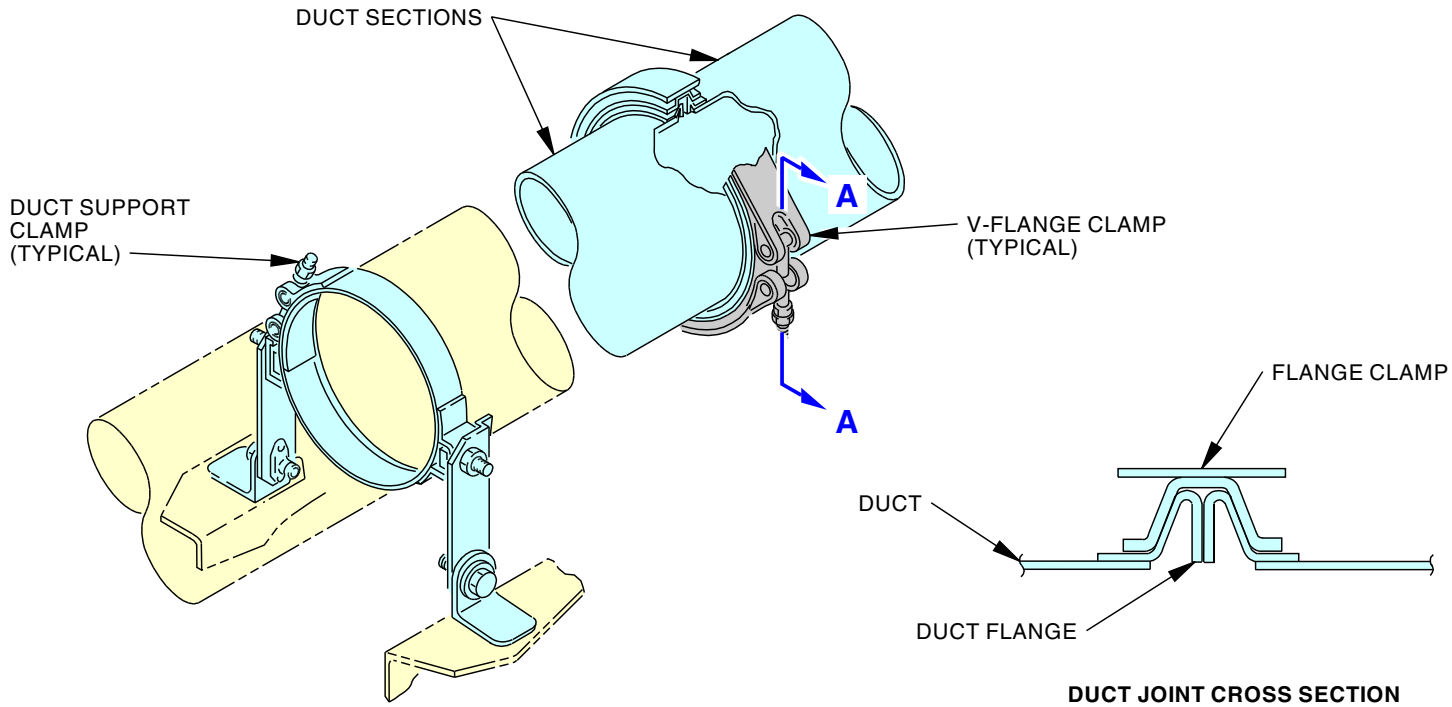
- Protects the ducts from the effects of hydrocarbon contamination (hydrogen embrittlement)
- Reduces heat transfer.

Insulation blankets cover some ducts to reduce heat transfer.

Location

Pneumatic ducts are in these areas of the airplane:

- Pneumatic manifold
- Pneumatic systems.



PNEUMATIC DUCT (TYPICAL)

DUCT JOINT CROSS SECTION A-A

2370248 S00061521281_V2

PNEUMATIC - MANIFOLD SYSTEM - DUCT INSULATION

Purpose

The pneumatic manifold duct insulation decreases the heat flow from the ducts to the adjacent area.

General Description

There are two types of pneumatic insulation on the airplane:

- Soft insulation
- Hard shell insulation.

Soft insulation is a soft, precut, fiberglass pad insulation that is wrapped with a cover and held with tie straps.

Hard shell insulation is a hard, preformed, fiberglass lay-up, air gap insulation that is pre-shaped to fit snugly around the contour of a duct section. The hard shell insulation unit comes in two halves and attaches to the duct section with band clamps or wire lace.

Location

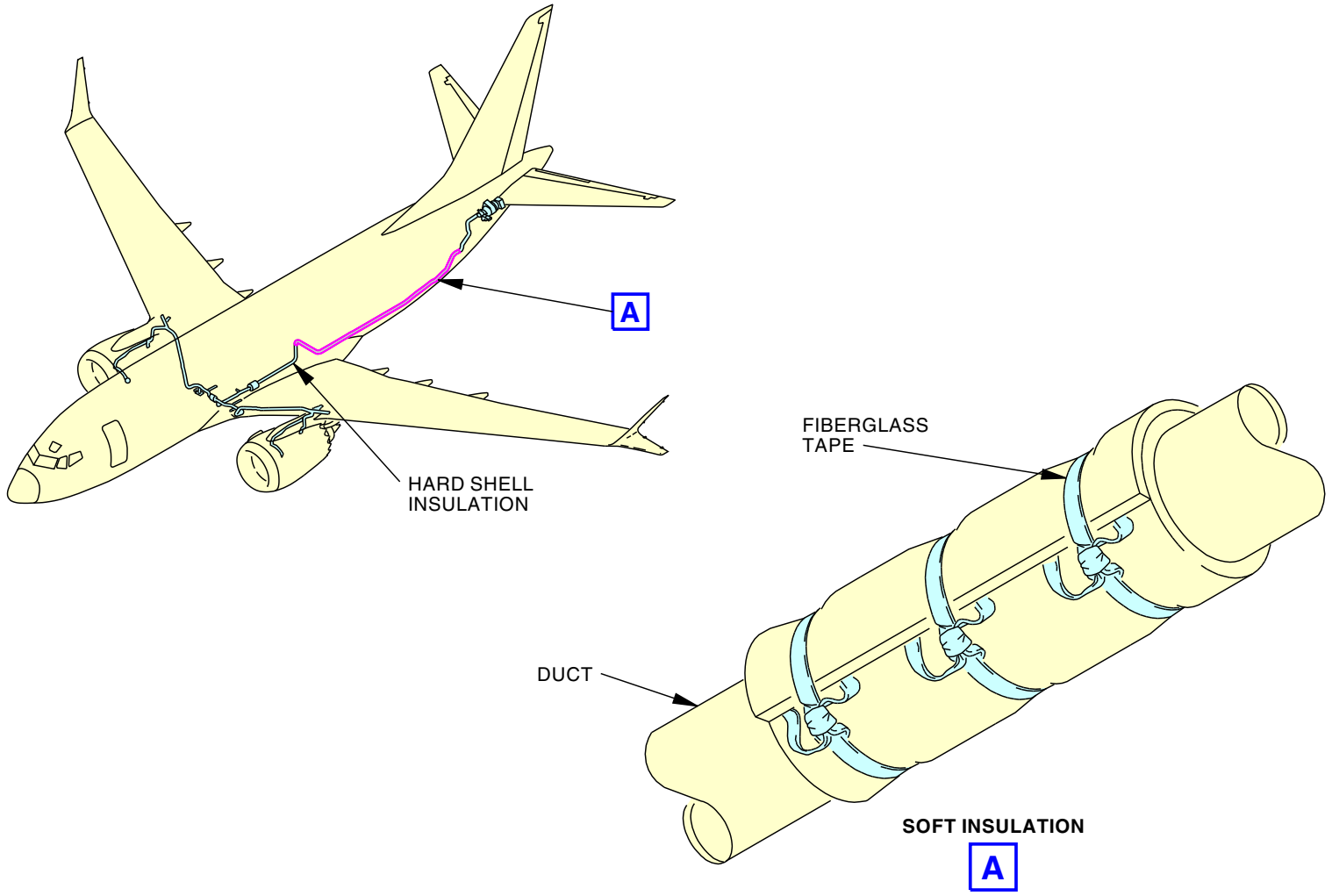
The soft insulation is on the APU duct in the aft cargo compartment areas. The APU duct and soft insulation are behind the sidewall panels in the aft cargo compartments.

The hard shell insulation is on the pneumatic ducts in the keel beam of the airplane.

Functional Description

The duct insulation decreases the heat flow from the ducts they cover. This protects the airplane structure, wiring, and components adjacent to the ducts.

PNEUMATIC - MANIFOLD SYSTEM - DUCT INSULATION



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PNEUMATIC - MANIFOLD SYSTEM - DUCT INSULATION

PNEUMATIC - MANIFOLD SYSTEM - GROUND PNEUMATIC CONNECTOR CHECK VALVE

Purpose

The ground pneumatic connector check valve lets you connect an external source of compressed air to the pneumatic manifold. It prevents flow out of the manifold, and lets flow into the manifold.

General Description

The check valve is a spring-loaded closed split flapper type check valve. Also, it has a standard quick disconnect nipple-type fitting.

The ground pneumatic connector check valve has these parts:

- 3-inch (8-cm) quick disconnect nipple
- Internal check valve.

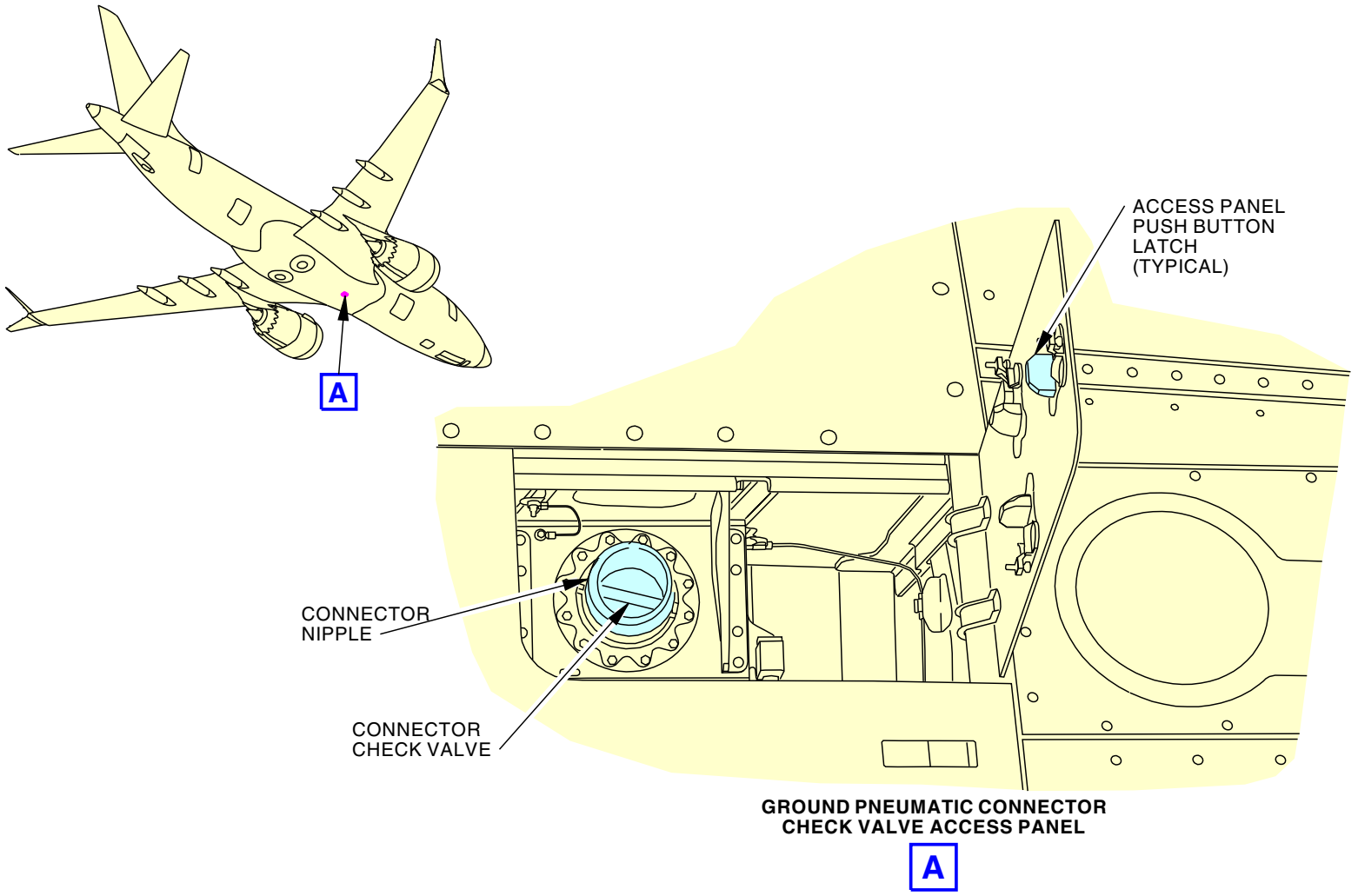
Location

The ground pneumatic connector check valve is on the right side of the pneumatic manifold crossover duct. Access is through the small panel on the forward outboard corner of the right air conditioning bay access door.

Functional Description

When an external source is pressurizing the pneumatic manifold, the force of the airflow is more than the spring force and the check valve opens. The check valve springs and manifold pressure close the valve when there is no external source. This prevents leakage from the manifold.

PNEUMATIC - MANIFOLD SYSTEM - GROUND PNEUMATIC CONNECTOR CHECK VALVE



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PNEUMATIC - MANIFOLD SYSTEM - GROUND PNEUMATIC CONNECTOR CHECK VALVE

PNEUMATIC - MANIFOLD SYSTEM - BLEED AIR ISOLATION VALVE

Purpose

The bleed air isolation valve has these functions:

- Separates the pneumatic manifold into right and left sides
- Connects the right and left sides of the pneumatic manifold for cross bleed operation.

Physical Description

The isolation valve is a 115-volt, single-phase, motor operated butterfly valve. The bleed air isolation valve has a valve body and an actuator assembly. The actuator assembly has these parts:

- An electric motor and drive assembly
- A manual override handle/position indicator.

Location

The bleed air isolation valve is part of the crossover duct. It is in the keel beam, in the forward area of the air conditioning bays.

Functional Description

The bleed air isolation valve is a butterfly shutoff valve. A 115v ac, single phase motor operates the valve. It is reversible in transit.

The valve has a manual override handle that lets you manually set the position of the valve. The manual override handle is also a position indicator. A flange in front of the lever shows OPEN and CLOSED.

Indications

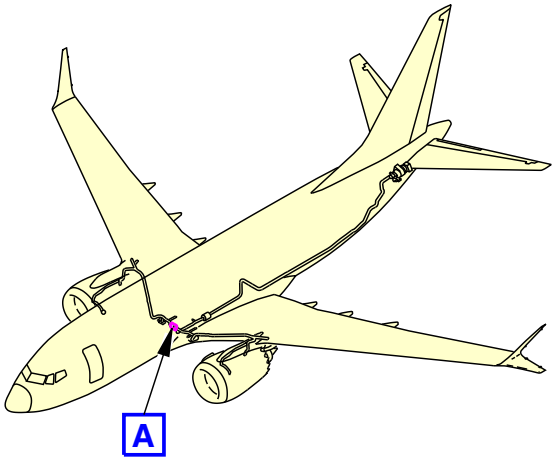
A visual position indicator on the valve shows the valve position.

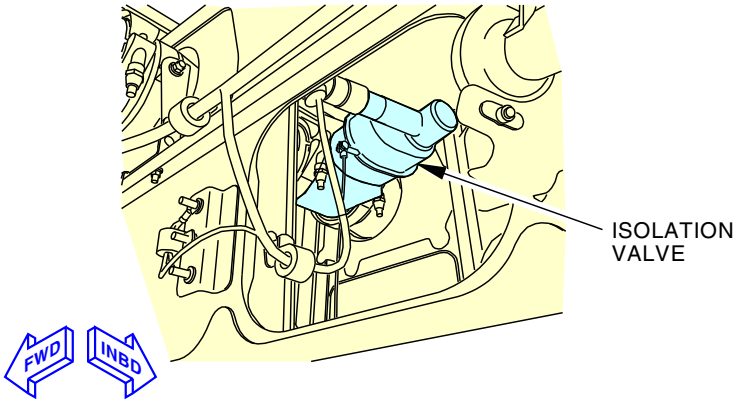
Operational Controls

A three-position toggle switch on the air conditioning bleed air controls panel controls the bleed air isolation valve. These are the switch positions:

- OPEN - The valve opens to connect the right and left sides of the bleed air manifold
- AUTO - The aircraft switch position logic controls the valve to open and close as necessary for aircraft operations
- CLOSE - The valve closes to separate the right and left sides of the bleed air manifold.

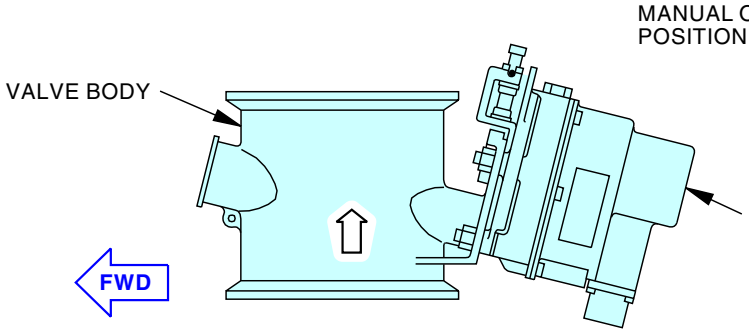
PNEUMATIC - MANIFOLD SYSTEM - BLEED AIR ISOLATION VALVE



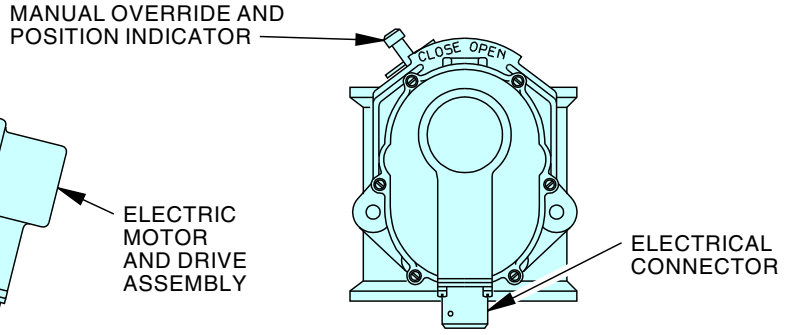


ISOLATION VALVE
(LOOKING FROM LEFT AIR CONDITIONING COMPARTMENT)

A



BLEED AIR ISOLATION VALVE
(VIEW IN THE DOWN DIRECTION)



BLEED AIR ISOLATION VALVE
(VIEM IN THE FORWARD DIRECTION)

2370251 S00061521287_V2

PNEUMATIC - MANIFOLD SYSTEM - BLEED AIR ISOLATION VALVE - FUNCTIONAL DESCRIPTION

Purpose

The bleed air isolation valve is in the center of the crossover duct to separate the left and right pneumatic systems or to connect them when necessary.

Functional Description

A three-position toggle switch on the air conditioning/bleed air controls panel controls the valve motor and valve position.

When the bleed air isolation valve switch is in the AUTO position, the control of the isolation valve comes from these air conditioning panel switches:

- R PACK switch
- L PACK switch
- ENG 1 BLEED switch
- ENG 2 BLEED switch.

When the isolation valve switch is in AUTO, these switches supply the logic to control the bleed air isolation valve position.

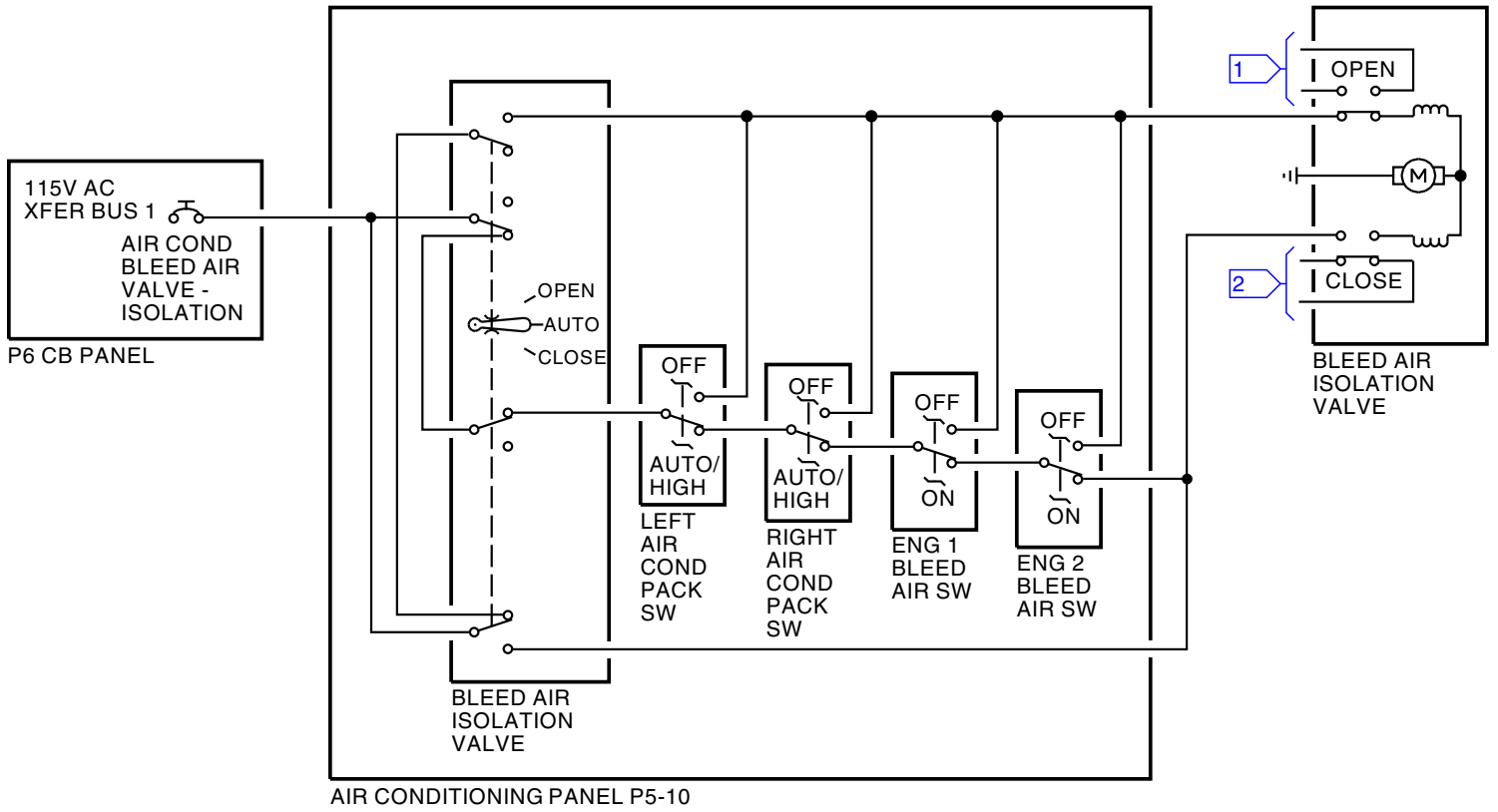
When all the toggle switches are in the AUTO, HIGH, or ON positions, the valve closes.

The control circuit shows a typical cruise condition. The bleed air isolation valve will remain closed. In this configuration, the pneumatic manifold divides into a left and right side. This prevents a single pneumatic duct failure from loss of pressure to all of the manifold.

When any one of the pack or engine bleed switches is in the OFF position, the valve opens.

A trip off condition closes a pack or bleed valve, but does not change the position of its air conditioning panel control switch. The circuit uses switch position logic, not valve position logic.

PNEUMATIC - MANIFOLD SYSTEM - BLEED AIR ISOLATION VALVE - FUNCTIONAL DESCRIPTION



1 TO DUAL BLEED CIRCUIT
2 TO FMCS

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PNEUMATIC - MANIFOLD SYSTEM - BLEED AIR ISOLATION VALVE - FUNCTIONAL DESCRIPTION

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PNEUMATIC - APU BLEED SYSTEM - INTRODUCTION

Purpose

The APU bleed air system supplies bleed air to the pneumatic manifold:

- On the ground
- In the air (up to 17,000 feet).

The APU can supply bleed air to these systems:

- Engine start systems
- ECS systems.

Location

The APU and bleed air valve are in the APU compartment.

The air conditioning/bleed air controls panel is in the flight compartment.

The APU bleed air duct is in these areas:

- APU compartment
- Section 48 stabilizer compartment
- Left side and forward bulkhead of the aft cargo compartment
- Inside the keel beam.

The APU check valve is in the keel beam, between the forward air conditioning bays.

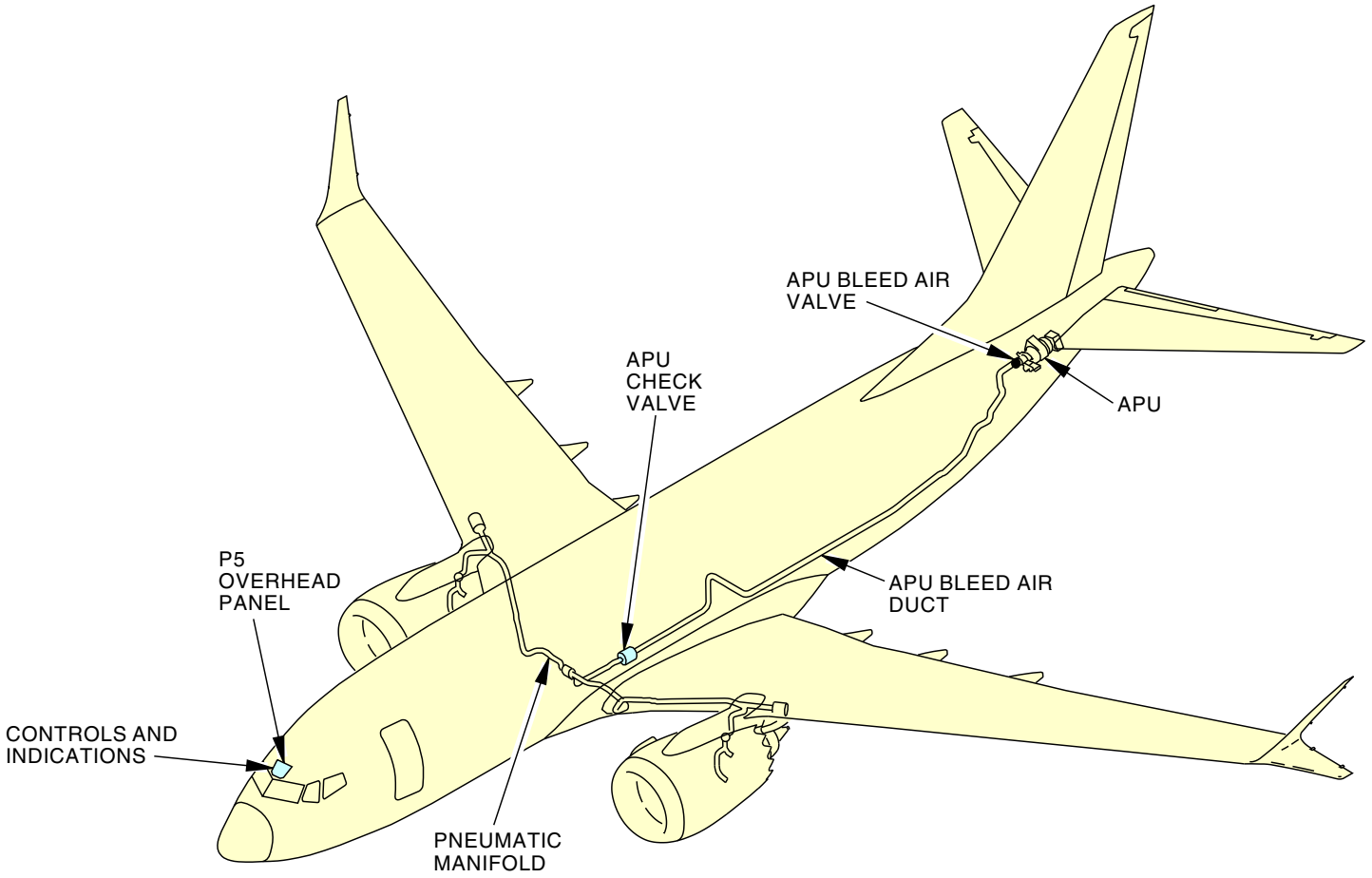
General Description

The APU supplies bleed air to the pneumatic manifold. The APU bleed air duct connects the APU bleed air valve to the pneumatic manifold.

An APU check valve is in the APU duct. This valve protects the APU from engine bleed air flow.

See the APU chapter for more information on the APU bleed air pressure control (SECTION 49-50).

PNEUMATIC - APU BLEED SYSTEM - INTRODUCTION



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PNEUMATIC - APU BLEED SYSTEM - INTRODUCTION

PNEUMATIC - APU BLEED SYSTEM - APU CHECK VALVE

Purpose

The APU check valve prevents engine bleed air flow into the APU load compressor.

Physical Description

The valve is a split flapper type check valve. Two semicircular flappers restrict the air flow.

The bleed air check valve body has a flow direction arrow on it.

Two clamps hold the valve in place.

Location

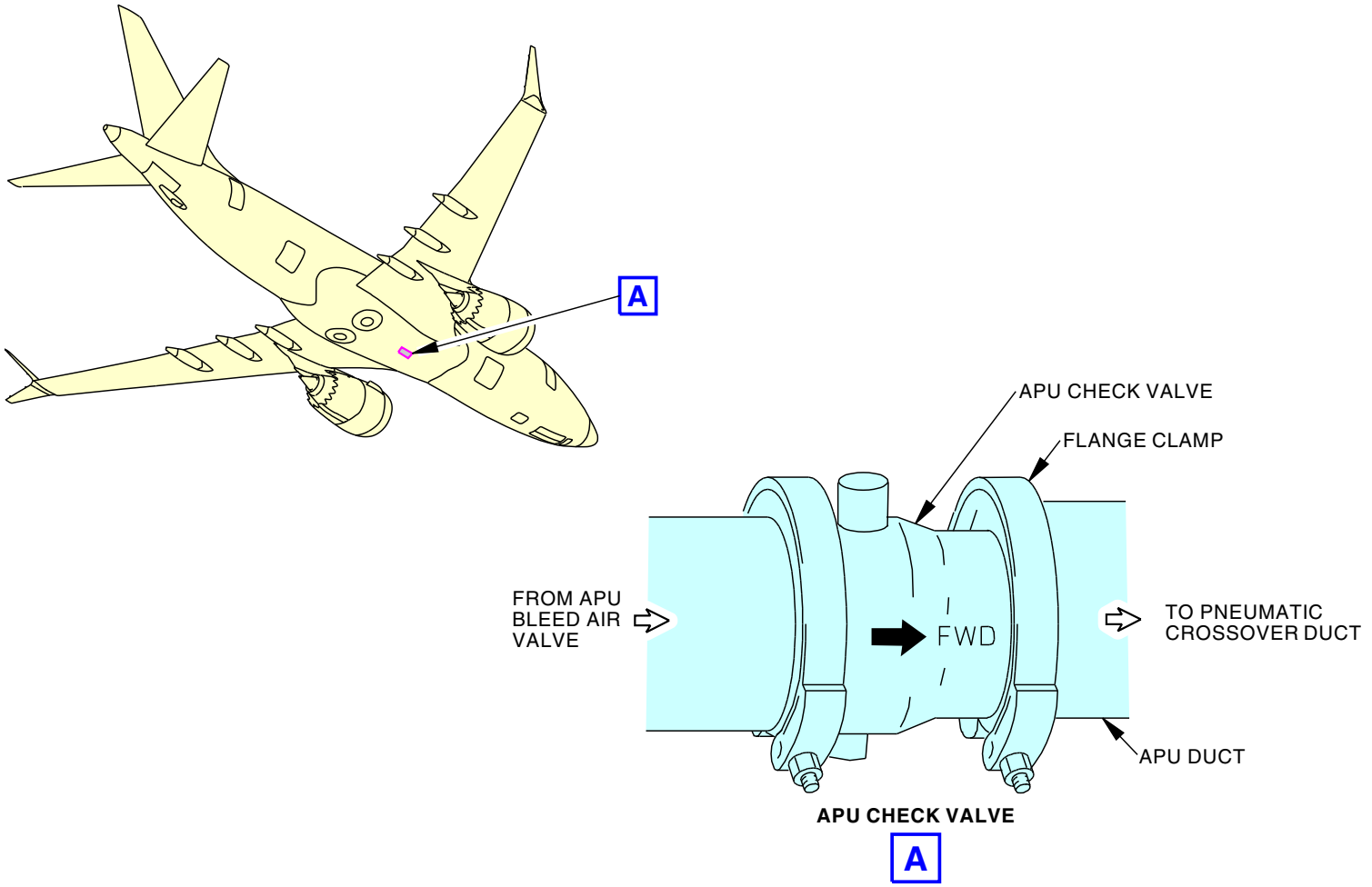
The APU check valve is part of the APU bleed air duct. It is in the keel beam between the air conditioning compartments. Access is through a lightening hole in the keel beam in the left air conditioning compartment.

Functional Description

The valve lets air flow in the direction of the arrow and prevents air flow in the opposite direction.

Normal airflow opens the flappers, reverse airflow closes the flappers.

PNEUMATIC - APU BLEED SYSTEM - APU CHECK VALVE



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PNEUMATIC - APU BLEED SYSTEM - APU CHECK VALVE

PNEUMATIC - APU BLEED SYSTEM - DUAL BLEED LIGHT - FUNCTIONAL DESCRIPTION

Purpose

The DUAL BLEED light does these things:

- Tells the crew that an engine (or engines) and the APU both supply pressure to the pneumatic manifold at the same time.
- Reminds the crew to put the thrust levers to the idle position during DUAL BLEED conditions.

Functional Description

The DUAL BLEED indication circuit uses 28v dc electrical power.

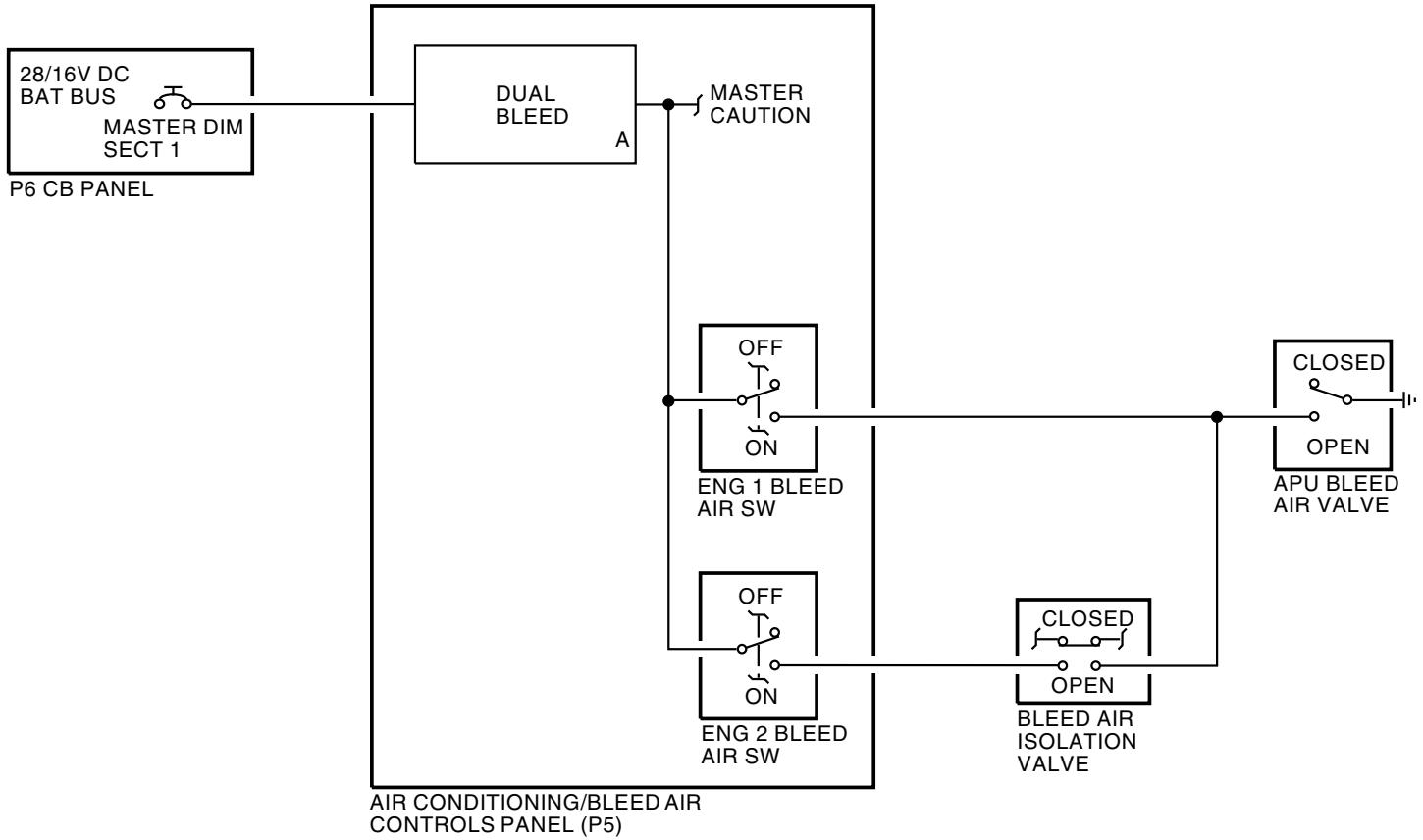
Power goes to the light when the bus has power. When airplane logic supplies a ground to the circuit, the light comes on. The circuit has two paths to ground. Both paths rely on switch and valve position logic.

The DUAL BLEED light comes on for either of these conditions:

- Engine 1 BLEED switch ON and the APU bleed air valve open
- Engine 2 BLEED switch ON, the isolation valve OPEN, and the APU bleed air valve open.

The DUAL BLEED light can make sure that the APU bleed air valve is in the close position. When the APU bleed valve is open and the engine 1 BLEED switch is ON, the DUAL BLEED light shows the valve is not in the close position. When the APU BLEED switch is OFF and the engine 1 BLEED switch is ON, the DUAL BLEED light goes off when the APU bleed air valve closes.

PNEUMATIC - APU BLEED SYSTEM - DUAL BLEED LIGHT - FUNCTIONAL DESCRIPTION



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PNEUMATIC - APU BLEED SYSTEM - DUAL BLEED LIGHT - FUNCTIONAL DESCRIPTION

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PNEUMATIC - INDICATING - INTRODUCTION

Purpose

The indicating system gives the flight crew displays of the pneumatic system status. The displays show this information:

- Right and left pneumatic manifold pressures
- DUAL BLEED conditions.

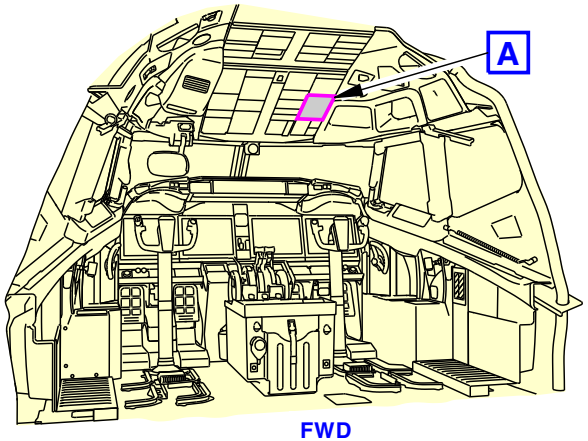
General Description

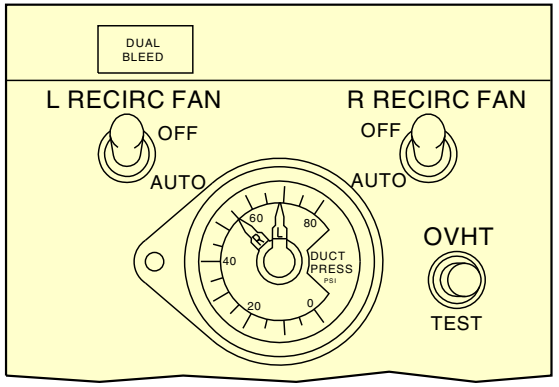
Pneumatic system indications are on the air conditioning/bleed air controls panel.

A dual needle (right and left) pressure indicator shows the pressure in the right and left sides of the pneumatic manifold.

A DUAL BLEED light comes on when pneumatic manifold pressure supply comes from the Auxiliary Power Unit (APU) and one or both engine bleed systems.

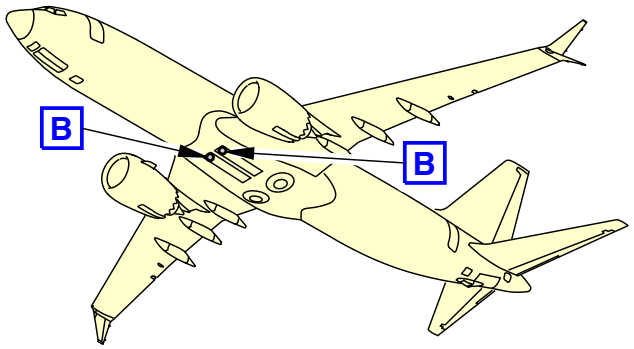
PNEUMATIC - INDICATING - INTRODUCTION



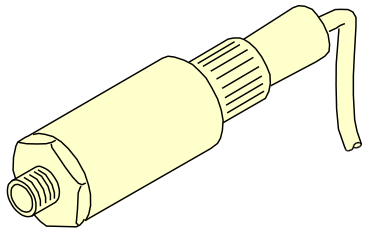


AIR CONDITIONING/BLEED AIR CONTROLS PANEL (TYPICAL)

A



AIRPLANE ACCESS - AIR CONDITIONING BAYS



DUCT PRESSURE TRANSMITTER 2

B

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PNEUMATIC - INDICATING - INTRODUCTION

PNEUMATIC - INDICATING - DUCT PRESSURE TRANSDUCER

Purpose

The duct pressure transmitter supplies pneumatic pressure signals to the P5-10 air conditioning panel pressure gage.

Location

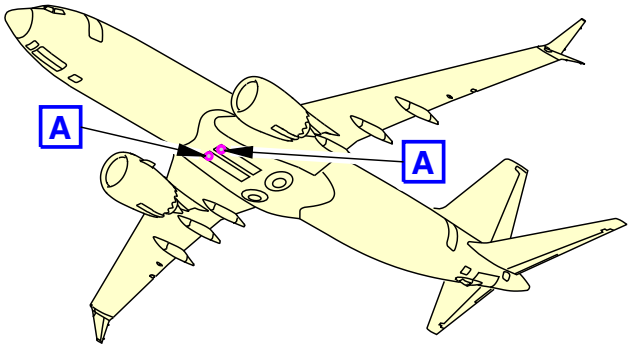
There are two pressure transmitters. One for each side (left and right) of the pneumatic manifold.

The pressure transmitters are on the forward bulkheads of the air conditioning bays near the pneumatic crossover duct.

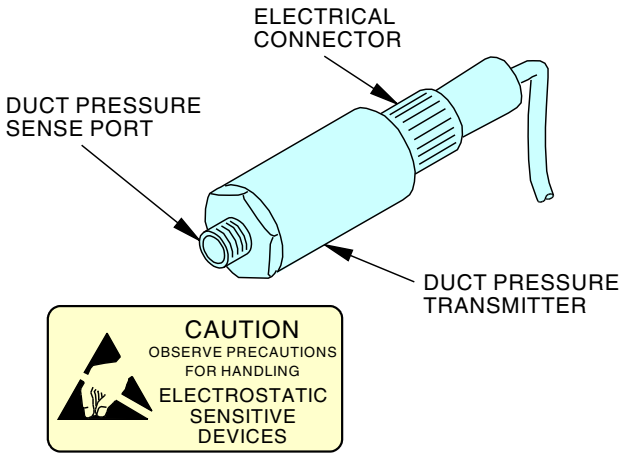
Physical Description

The pressure transmitters have a pneumatic sense port on one end and an electric connector on the other.

PNEUMATIC - INDICATING - DUCT PRESSURE TRANSDUCER



AIRPLANE ACCESS - AIR CONDITIONING BAYS



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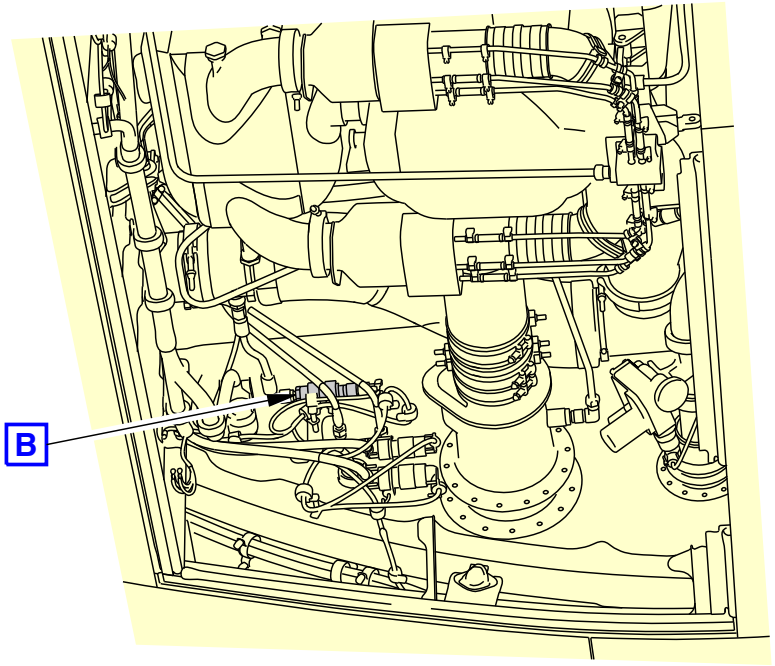

AIR CONDITIONING BAY FWD BULKHEAD

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PNEUMATIC - INDICATING - DUCT PRESSURE TRANSDUCER

PNEUMATIC - INDICATING - DUAL DUCT PRESSURE INDICATOR

Purpose

The pneumatic duct pressure indicator gives indication of these things:

- Left pneumatic duct pressure
- Right pneumatic duct pressure.

Location

The pneumatic duct pressure indicator is on the air conditioning/bleed air controls panel.

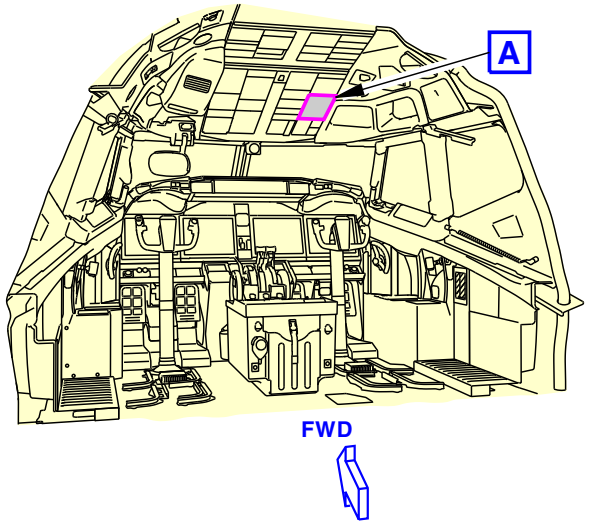
Physical Description

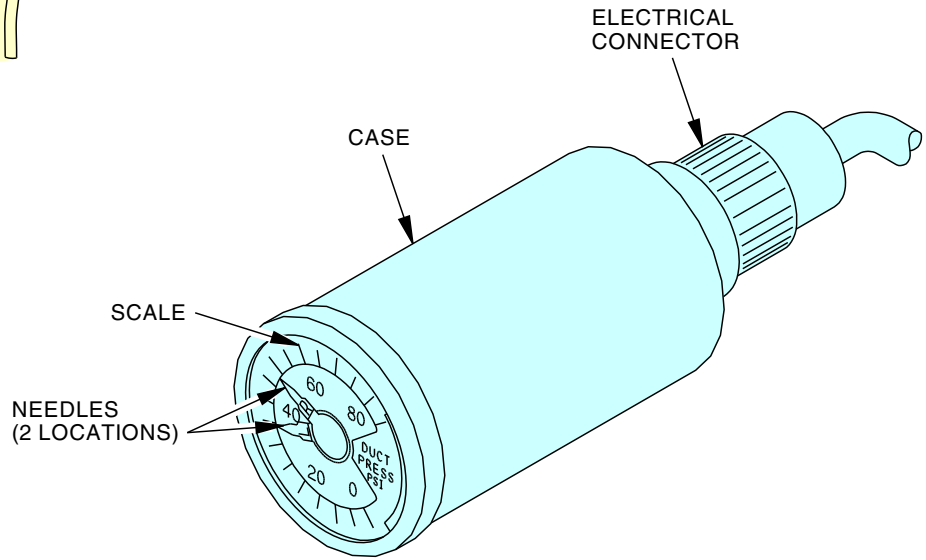
The pressure indicator has two independent needles (L and R), and a single scale (0-80 psi). Integral lamps light the indicator scale. The indicator has a single electrical connector.

Training Information Point

The pressure indicator contains integrated circuits and is an electrostatic discharge sensitive device.

PNEUMATIC - INDICATING - DUAL DUCT PRESSURE INDICATOR





PNEUMATIC DUCT PRESSURE INDICATOR

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PNEUMATIC - INDICATING - DUAL DUCT PRESSURE INDICATOR

PNEUMATIC - INDICATING - FUNCTIONAL DESCRIPTION

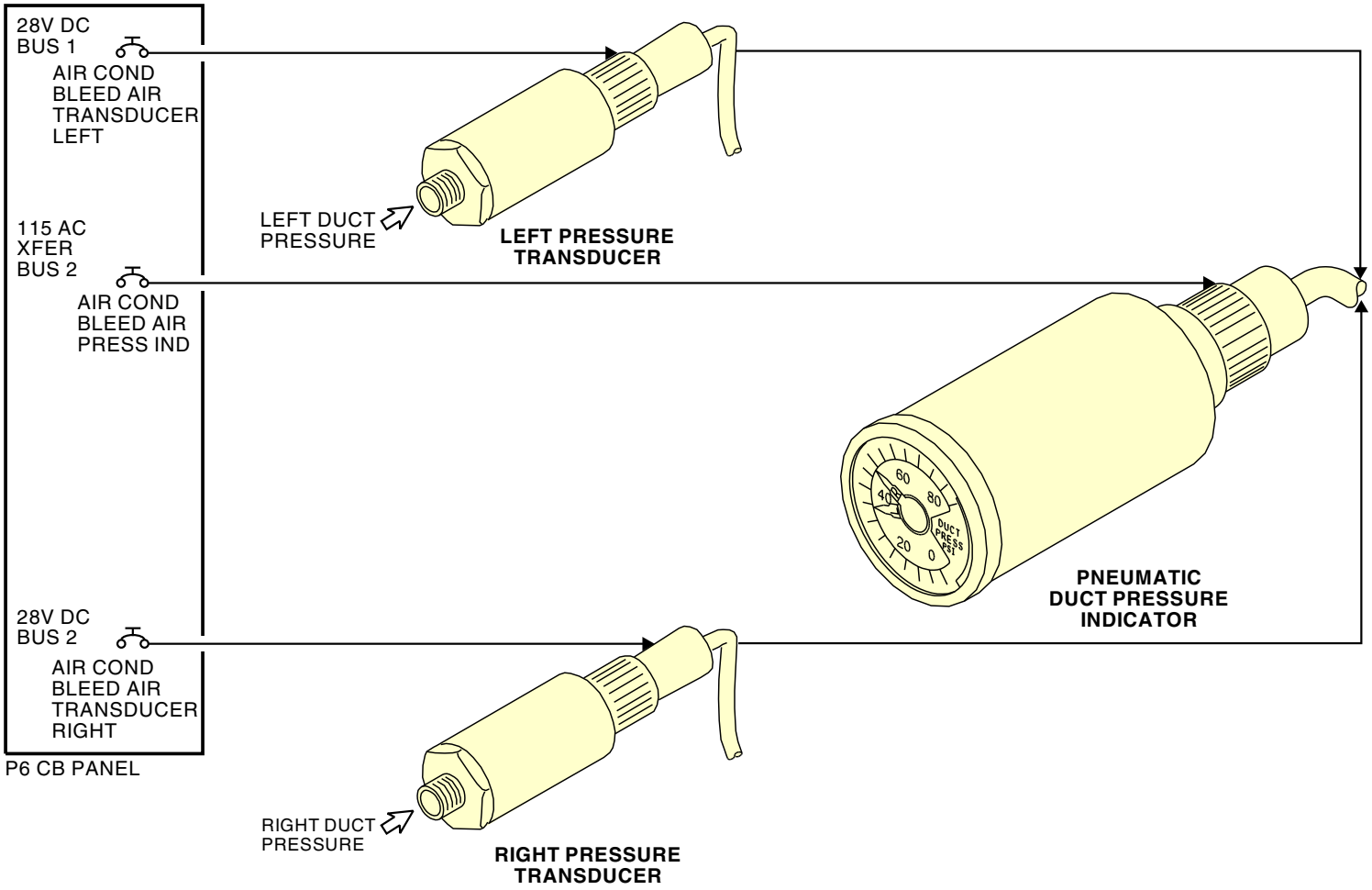
Purpose

The pressure indicating system gives an indication of the pneumatic manifold pressure.

Functional Description

The duct pressure transducers use 28v DC and pneumatic pressure to provide a signal to the pneumatic duct pressure indicator on the air conditioning/bleed air controls panel.

PNEUMATIC - INDICATING - FUNCTIONAL DESCRIPTION



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PNEUMATIC - INDICATING - FUNCTIONAL DESCRIPTION