**ON A/C ALL

75–00–00–001

AIR SYSTEM, GENERAL

Introduction

The engine air system is designed to control the performance of the engine compressors during different flight regimes so as to prevent engine surging and stalling. It also provides compressed air to aircraft services and for sealing internal engine components.

General Description

The purpose of the Air System is to provide compressed air for:

- Cabin pressurization
- Cooling of hot engine components
- Bearing sealing
- P2.2 bleed valve operation
- P2.7 bleed valve operation
- Reference air pressure for the pressure relief valve
- Scavenging of various bearing cavities
- P3 signal to the FADEC
- Airframe services

Detailed Description

The air system is a critical system for the operation and performance of the engine.

Refer to Figure 1.

Refer to Figure 2.

The function of the air system is performed by the:

- Cooling and distribution system
- Compressor control system
- Air indicating system

Cooling and Distribution System

The purpose of the cooling and distribution system is to distribute air to the areas of the engine that require it and to cool the hot section components. This air is also used for sealing and scavenging of the engine bearing oil cavities.

Compressor Control System

The purpose of the compressor control system is to control the performance of the compressor and to deliver compressed air for aircraft services. The system uses two pneumatic valves controlled by the FADEC to prevent compressor surging and stalling.

Air Indication System

The purpose of the air indication system is to sense compressor discharge pressure at the exit from the HP compressor (P3). This air pressure signal is then used in the compressor stall logic, flameout

logic and NL decouple logic of the engine control system and environmental control system.

FADEC

The Full Authority Digital Electronic Control (FADEC) is a dual–channel microprocessor–based controller which controls two Shutoff Valves (SOVs) on the engine for surge avoidance during normal steady state and transient operation.

The FADEC will set the low pressure and high pressure HPSOVs. Command signals from the FADEC to the valve's torque motors control the two SOVs operations. The FADEC commands along with an electrical feedback to the FADEC through a Linear Variable differential Transducer (LVDT), is used to close the feedback control loop

Environmental Control System (ECS)

The ECS provides automatic control of engine conditioned outflow air. The ECS consists of 3 sub–systems which the Bleed Air System (BAS) is one of them. The BAS automatically controls bleed air pressure, flow and temperature. The BAS controls the collection and distribution of compressed air from the engine by controlling the HPSOV and the nacelle SOV.

Handling Bleed–Off Valves (HBOV)

The HBOVs bleed engine air from the main gas path to provide increased surge margin for engine handling during starting, steady state and transient operation. The engine has two shut off valves; one at the engine station 2.2, to bleed low pressure compressor inlet air and the other located at engine station 2.7, to bleed high pressure compressor inlet air. Each FADEC channel commands an independent coil of a torque motor mounted inside the HBOVs.

Precooler

The precooler is a two–part plate and fin, cross flow, air to air heat exchanger which uses low temperature (P2.2) bleed air to cool high pressure bleed air. The precooler is installed near the top of the engine. The main heat exchanger cools the temperature of the high pressure (P3.0) bleed air before it is supplied to the ECS. The small heat exchanger cools either the high pressure (P3.0) or the low pressure (P2.7) bleed air before it is supplied to the deice system.

Nacelle Shutoff Valve

The nacelle shutoff valve (nacelle SOV) is a pneumatically operated, torque motor actuated butterfly valve. The nacelle shutoff valve is installed in line with the precooler outlet duct and the wing ducting. The valve has a wire mesh filter upstream of the torque motor to protect the servo from contamination.

P2.2 Shutoff Valve

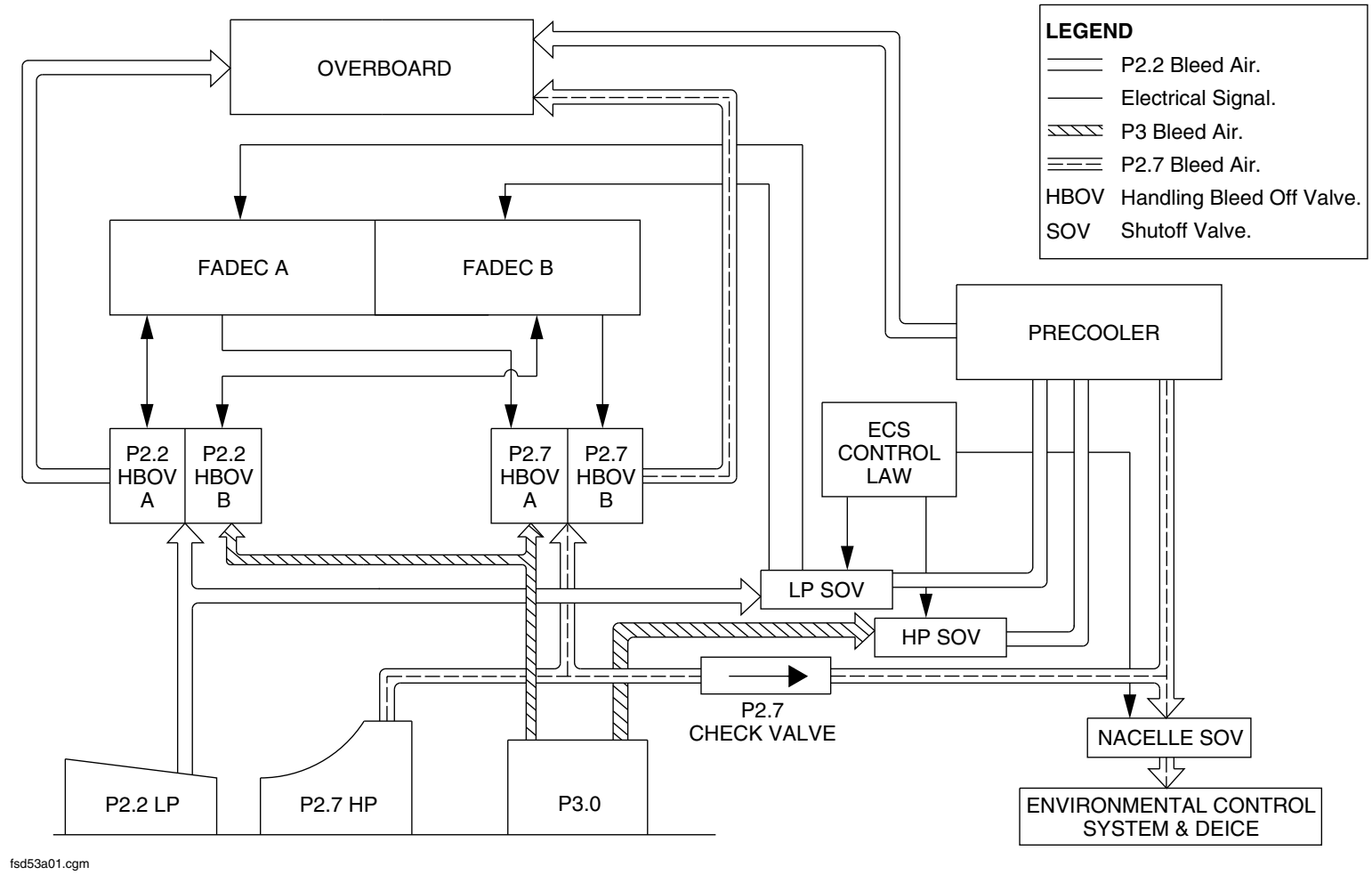
The P2.2 shutoff valve (LPSOV) is a pneumatically operated, torque motor actuated butterfly valve. The valve has a wire mesh filter upstream of the torque motor to protect the servo from contamination. The P2.2 shutoff valve is installed in line with the P2.2 low pressure ducting and the P2.2 inlet at the bottom of the precooler. It opens to supply cooling air through the precooler. The precooler temperature switch controls its operation. The valve has two closed position switches to supply valve position information to the ECU and to FADEC.

High Pressure Shutoff Valve

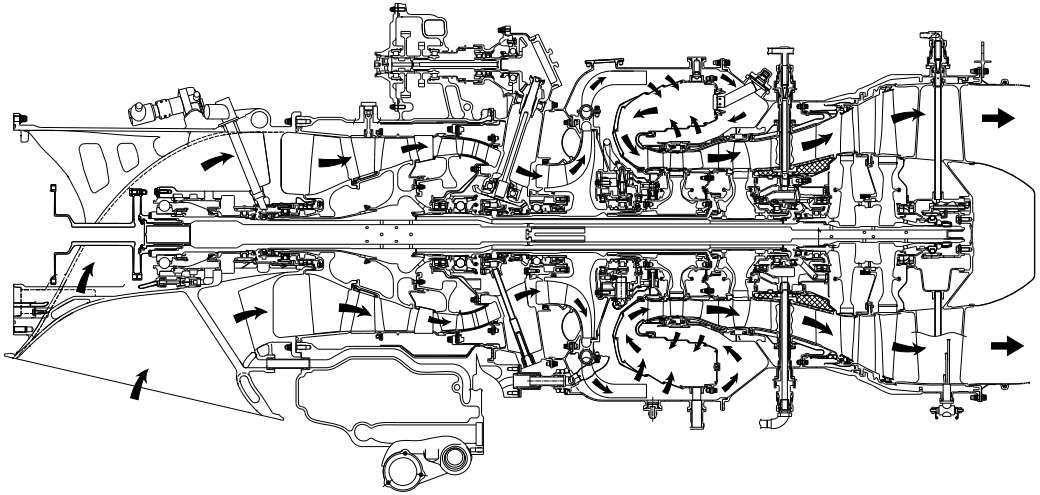
The high pressure shutoff valve (HPSOV) is a pneumatically operated, torque motor actuated butterfly valve. The valve has a wire mesh filter upstream of the torque motor to protect the servo from contamination. The HPSOV is installed in line with the high pressure ducting between the engine (P3.0) bleed air port and the precooler.The HPSOV opens to allow P3.0 air to flow through to the precooler to supply the ECS and/or the deice systems.The ECU opens the HPSOV at low engine power settings. The HPSOV has a closed position switch which informs the ECU of the status of the valve. The bleed stage pressure switch can open the HPSOV independently from the ECU to supply bleed air to the deice system.

P2.7 Check Valve

At higher engine power settings, the ECU closes the HPSOV to select the low stage (P2.7) bleed air. With the HPSOV closed, the P2.7 bleed air pressure opens the P2.7 check valve. This allows P2.7 bleed air to flow directly through to the ECS.



Air System General
Figure 1



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Engine Airflow
Figure 2

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75–20–00–001

COOLING

Introduction

The air distribution system provides air for cooling of hot section components, bearing oil cavity sealing, scavenging, and aircraft services. The purpose of the Cooling System is to cool the hot engine components. Also, this cooling air is used to scavenge and seal the bearing cavities, for compressor control and by the environmental control system.

General Description

Refer to Figure 1.

The Cooling and Distribution System is a critical system for the operation and performance of the engine. During engine operation air is drawn into the engine and compressed. Some of this air is diverted through internal passages and external tubes. This air is used to cool engine components, seal and scavenge bearing oil cavities and for aircraft services through the environmental control system. Engine cooling is a critical system for the operation and performance of the engine. The engine Cooling System is designed to control the temperature of critical engine components. It also provides air for engine sealing and aircraft services.

The function of the distribution system is performed by the:

- Internal air passages
- Intercompressor Case (ICC) to Turbine Support Case (TSC) cooling air tube

Detailed Description

The engine air distribution system is designed to control the temperature of critical engine components. It also serves to provide air for engine sealing and aircraft services.

Internal Air Passages

Internal air passages direct air flow to seal and scavenge the bearing and seal oil cavities. This air is also used to cool internal engine components.

Refer to Figure 2.

The axial flow compressor is cooled internally using P2.5 air. the P2.5 air leaks into the compressor disc after the last stage of stator blades. From the compressor disc the P2.5 cooling air flows through drilled passages into the turbine shaft and then flows aft to the power turbines. The air also leaks across the carbon seals at No.2 and No. 2.5 bearings to prevent the lubricating oil from leaking away from the bearings.

Refer to Figure 3.

The High Pressure (HP) and Low Pressure (LP) turbines are cooled by P3 air flowing in through the blade tips. This P3 air is from the cooling airflow of the combustion chamber liner. P2.5 air flowing through passages from the drive shaft is used to seal the bearing

cavities of No. 3, 4 and 5 bearings. P2.5 air is also used to cool the front face of the LP turbine and the rear face of the LP turbine.

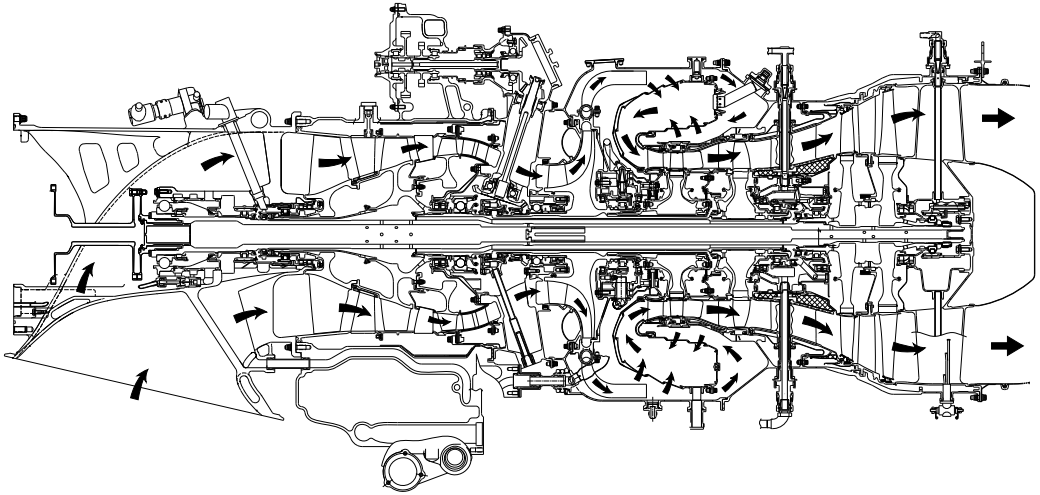
Refer to Figure 4.

P2.5 air flowing from the turbine shaft is used to cool the discs and the roots of the blades of the power turbines. P2.7 air is used to cool the power turbine blades internally.

Intercompressor Case to Turbine Support Case Cooling Air Tube

Refer to Figure 5.

The intercompressor case to turbine support case cooling air tube carries bleed air to the turbine support case to cool the interturbine vane. If the turbine support case is not cooled, its material properties are adversely affected to the point where it is possible that subsequent failure of a turbine blade may result in uncontained debris.



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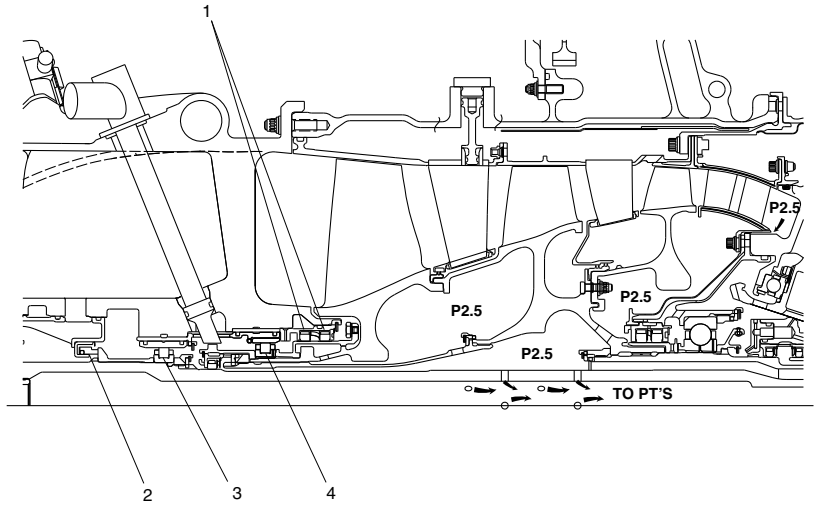
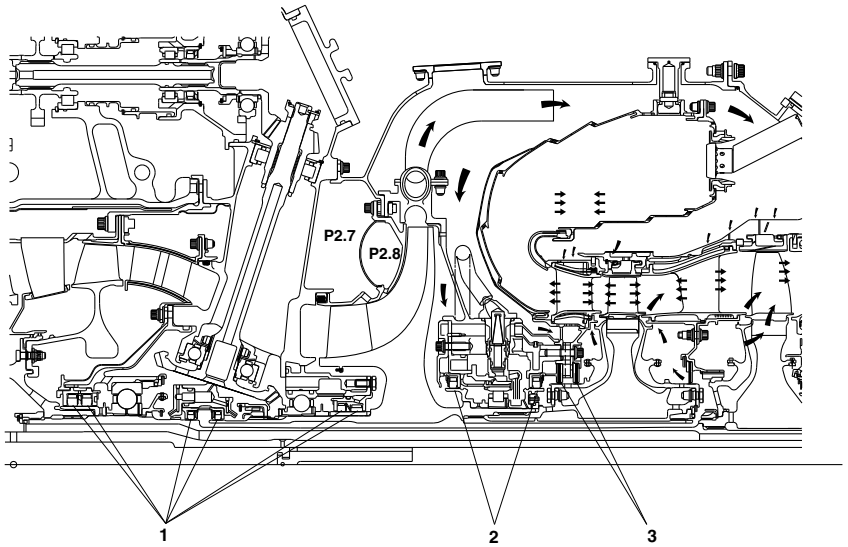
Airflow General
Figure 1



LEGEND

1. Double Carbon Seal Ring.
2. Face Carbon Seal.
3. No. 2 Bearings.
4. No. 2.5 Bearings.

Distribution to No. 2 & 2.5 Bearing Cavity
Figure 2



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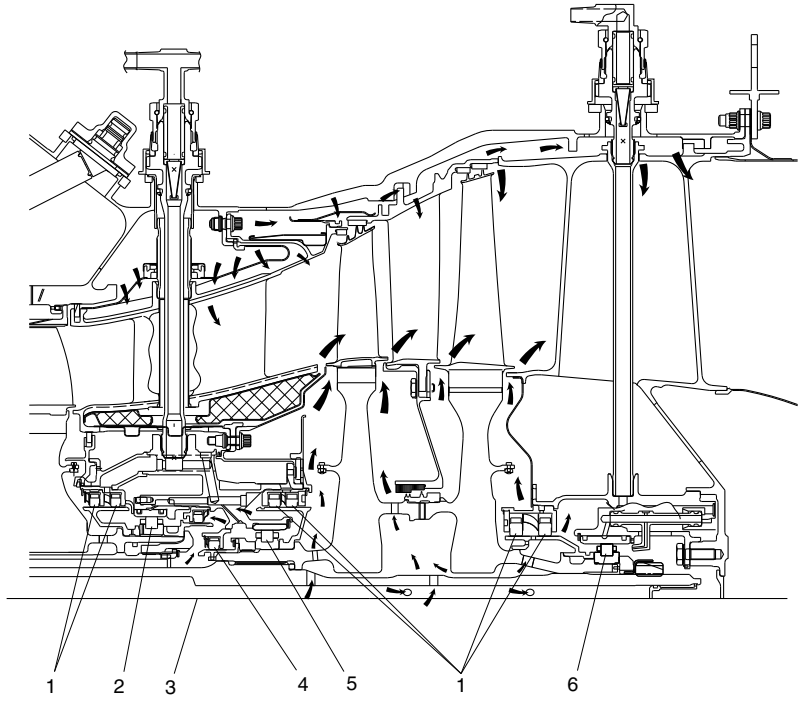
LEGEND

1. Double Carbon Seal Ring.
2. Single Carbon Seal Ring.
3. Brush Seals.

No. 3, 4 & 5 Bearing Cavity
Figure 3



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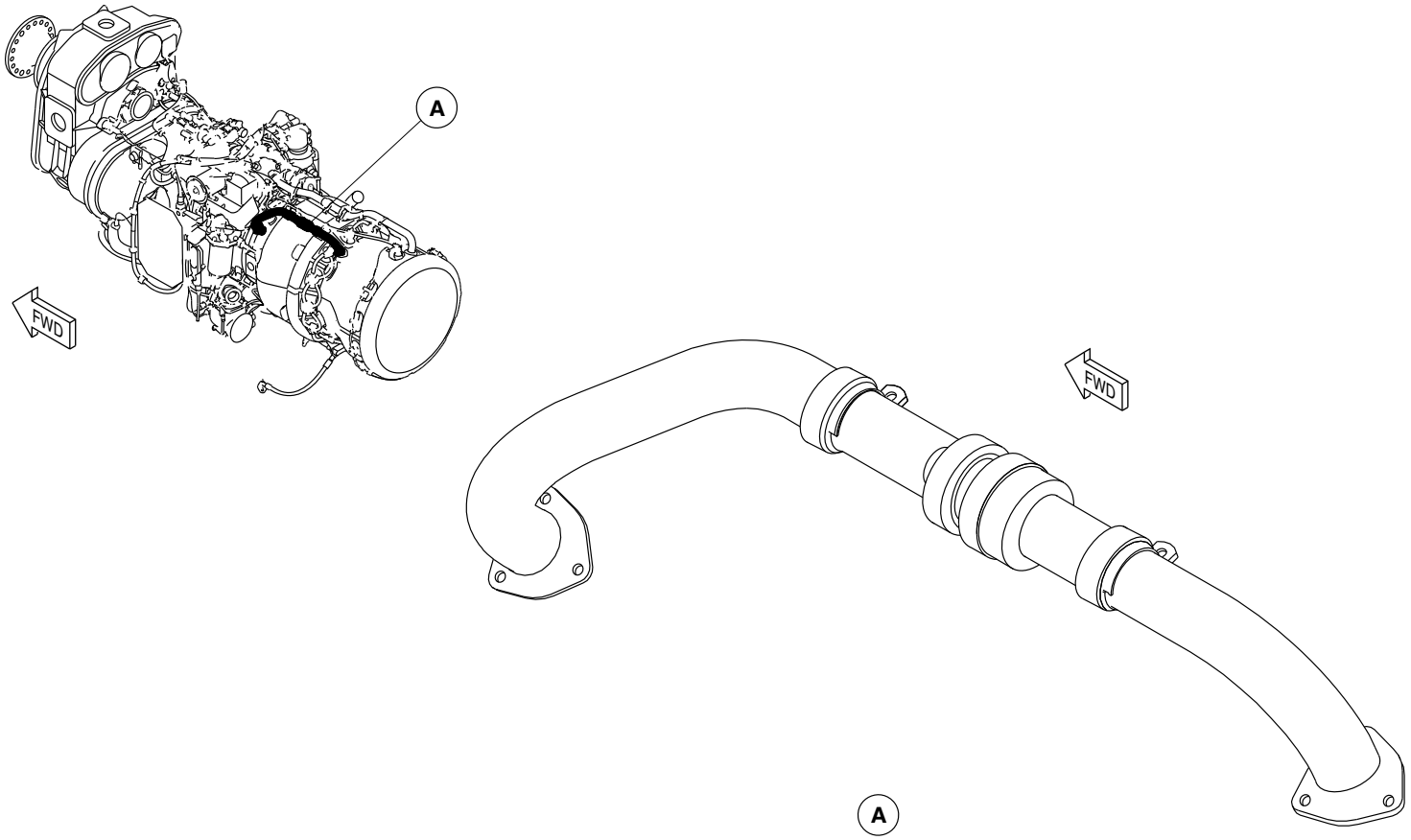
LEGEND

1. Double Carbon Seal Ring.
2. BRG. No. 6.
3. P2.5.
4. Single Carbon Seal Ring.
5. BRG. No. 6.5.
6. BRG. No. 7.

No. 6, 6.5 & 7 Bearing Cavity
Figure 4



Intercompressor Case to Turbine Support Case Cooling Air Tube
Figure 5

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75–30–00–001

COMPRESSOR CONTROL

Introduction

The purpose of the Air Compressor Control system is to control the performance of the compressor and to deliver air for aircraft services:

General Description

The function of the Air Compressor Control system is performed by the:

- P2.2 Interstage Bleed Valve (75–31–11)
- P2.7 Handling Bleed Valve (75–31–01)
- P2.7/P3 Check Valve (75–31–06)
- P3 Air Separator (75–31–16)
- P3 Air Separator to P2.2 Bleed Valve Air Tube (75–31–26)
- P3 Air Separator to P2.7 Bleed Valve Air Tube (75–31–31)
- Gas Generator Case to P3 Separator Air Tube (75–31–21)

Detailed Description

Refer to Figure 1.

The air compressor control system uses two pneumatic valves for compressor control. They are located on the left and right sides of the engine. They use P3 air for actuation. An electrical signal from the FADEC controls the P3 air.

P2.2 Interstage Bleed Valve

Refer to Figures 2 and 3.

The P2.2 interstage bleed valve is a normally open, dual coil torque motor, modulating in–line valve. It has an inlet, outlet, flange mounted servo port and a Linear Variable Differential Transducer (LVDT) connected to the valve poppet. There is an electrical connector hard mounted to the torque motor. The P2.2 valve is located on the left side of the low pressure compressor case.

During engine start the valve is positioned to maximum bleed. During normal engine operation the valve is modulated in the closing position according to a FADEC schedule. The valve is positioned by a command signal from the FADEC to the valve's torque motor. This signal moves the flapper rod, which changes the control pressure to the valve, upsetting the force balance and moving the valve. When the FADEC receives the LVDT position feedback signal which correlates to its schedule, it commands the torque motor back to the null flapper rod position. This balances the forces on the valve and it remains stationary in its new position until the next FADEC command is received. During engine shutdown the valve is commanded back to the full open position.

The P2.2 valve is designed to provide redundancy in the event of a failure. The torque motor and LVDT each have 2 coils that are handled through 2 separately wired channels. Also, in the event of a power loss to the torque motor, its null bias will cause the valve to open to its full bleed position. The valve is also designed to fully open if there is a loss of servo supply pressure.

P2.7 Handling Bleed Valve

Refer to Figures 4 and 5.

The P2.7 handling bleed valve is a normally open, dual coil torque motor, on–off in–line valve. It has an inlet, outlet, and flange mounted servo port. There is an electrical connector hard mounted to the torque motor. The P2.7 valve is located on the right side of the intercompressor case.

During engine operation the valve is positioned open or closed by a command signal from the FADEC. The signal is fed to either coil of the torque motor which then closes the servo supply pressure (P3) and increases the vent area causing the control pressure to drop. The compressor bleed pressure (P2.7) pushes on the underside of the valve poppet and opens the valve. When the current to the torque motor is reduced, the vent is closed. This increases the control pressure (P3) and closes the valve. During engine shutdown, a compression spring will open the valve to the full open position.

In the event of a loss of electrical power to the torque motor the valve will fail to the closed position.

P2.7/P3 Check Valve

Refer to Figures 6 and 7.

The P2.7/P3 check valve is part of the environmental control system. The environmental control system uses either P2.7 or P3 air as supply. If the P3 air is being used, the P2.7/P3 check valve will prevent backflow into the high pressure compressor.

P3 Air Separator

Refer to Figure 8.

In order to prevent contamination damage of the P3 servo inlet port, a centrifugal separator is used to remove dirt and dust from the P3 air.

P3 Air Separator to P2.2 Bleed Valve Air Tube

Refer to Figure 9.

This tube supplies P3 air to the P2.2 bleed valve torque motor servo port. This air is used to modulate the position of the P2.2 bleed valve.

P3 Air Separator to P2.7 Bleed Valve Air Tube

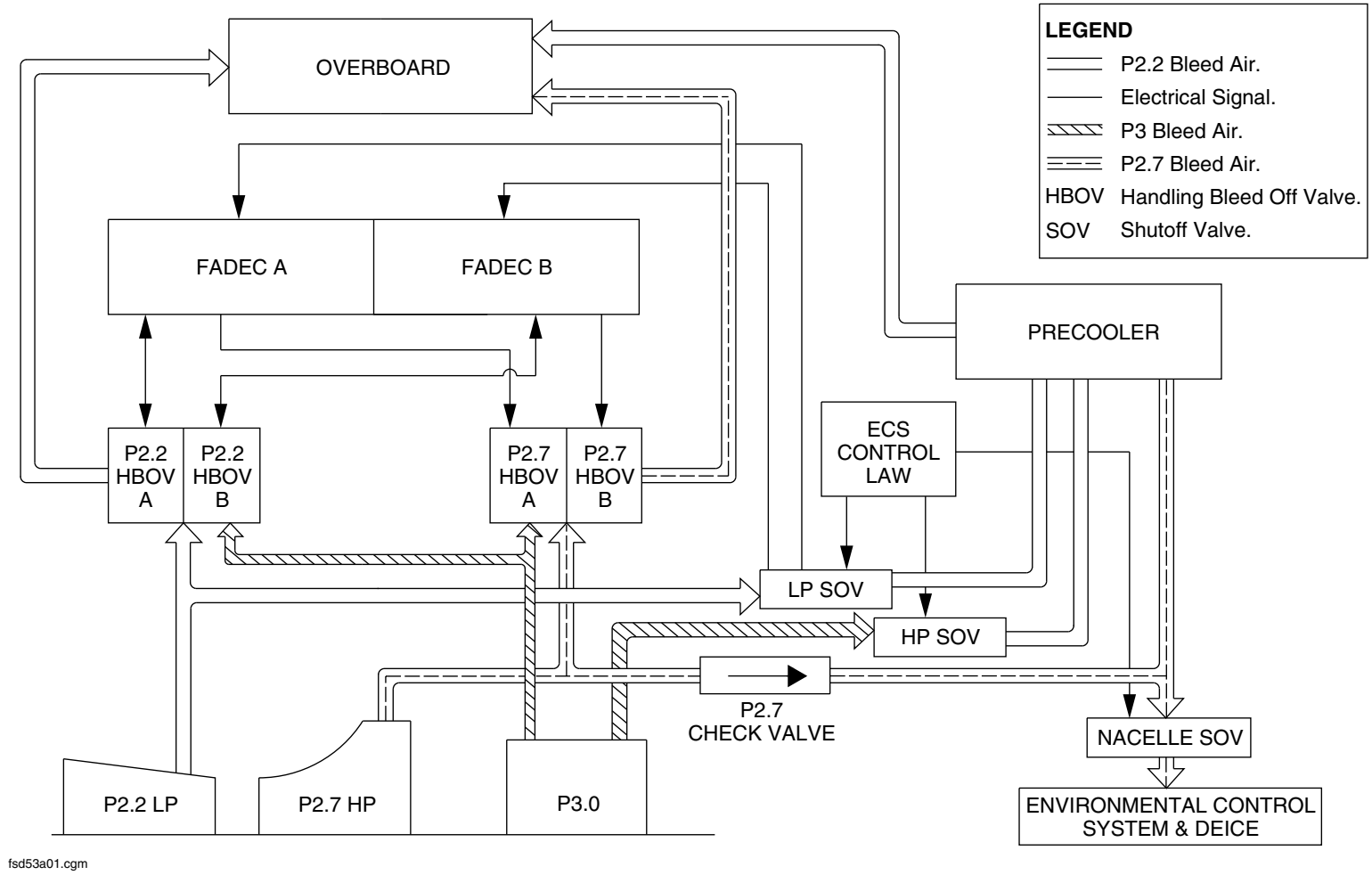
Refer to Figure 10.

This tube supplies P3 air to the P2.7 bleed valve torque motor servo port. This air is used to modulate the position of the P2.7 bleed valve.

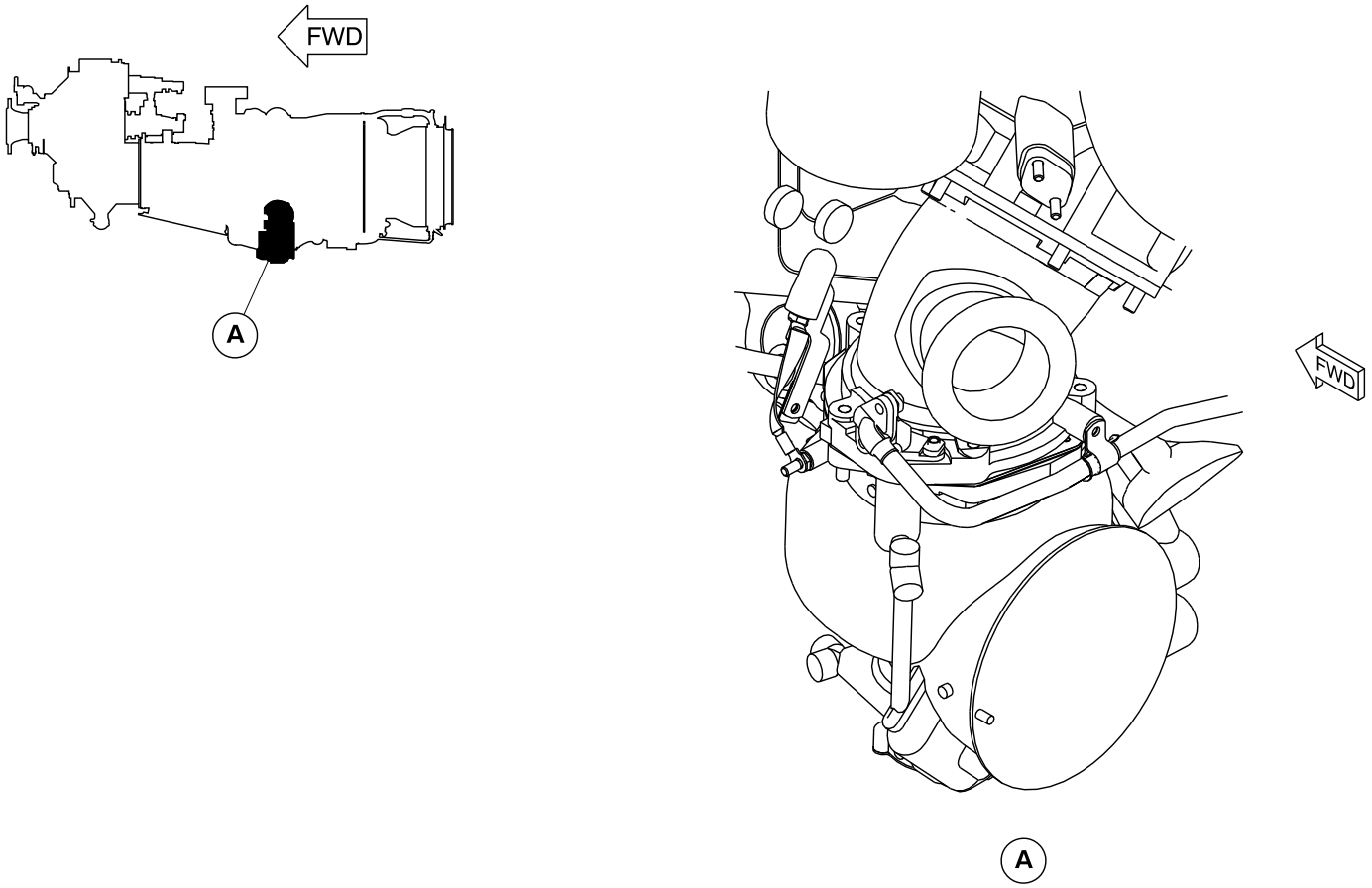
Gas Generator Case to P3 Separator Air Tube

Refer to Figure 11.

This tube carries P3 air from the gas generator case to the P3 separator.



Compressor Control Schematic
Figure 1



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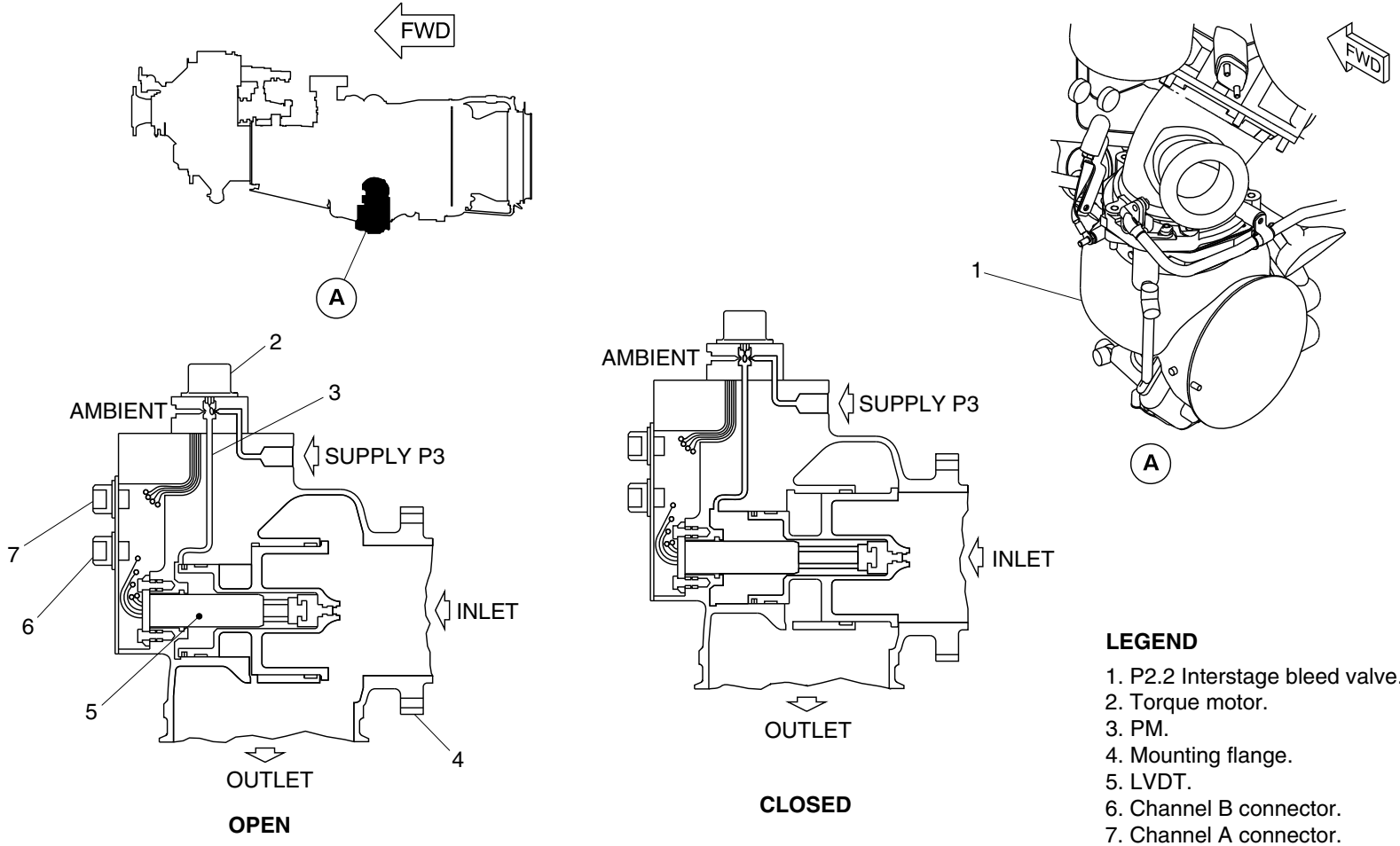
P2.2 Interstage Bleed Valve Locator
Figure 2



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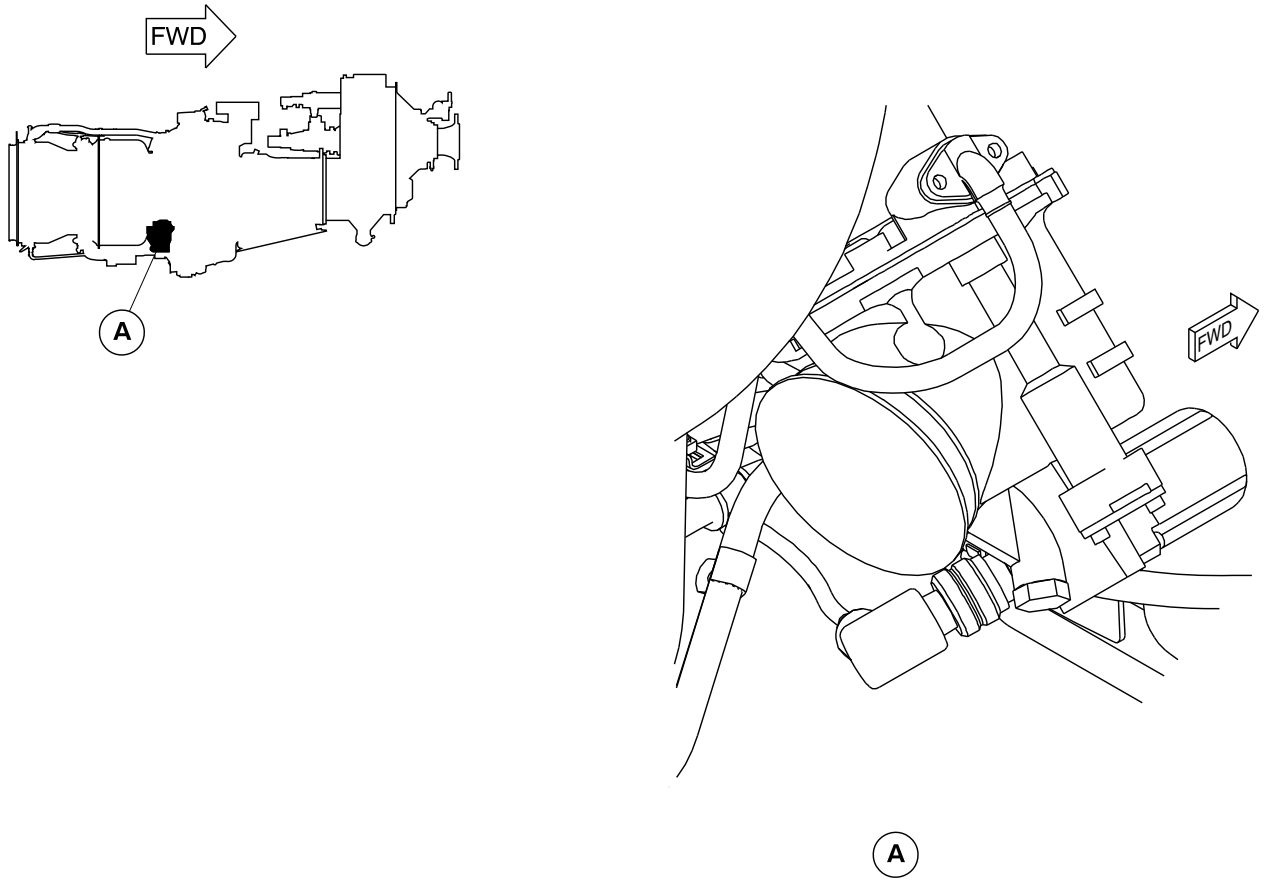
P2.2 Interstage Bleed Valve Detail
Figure 3



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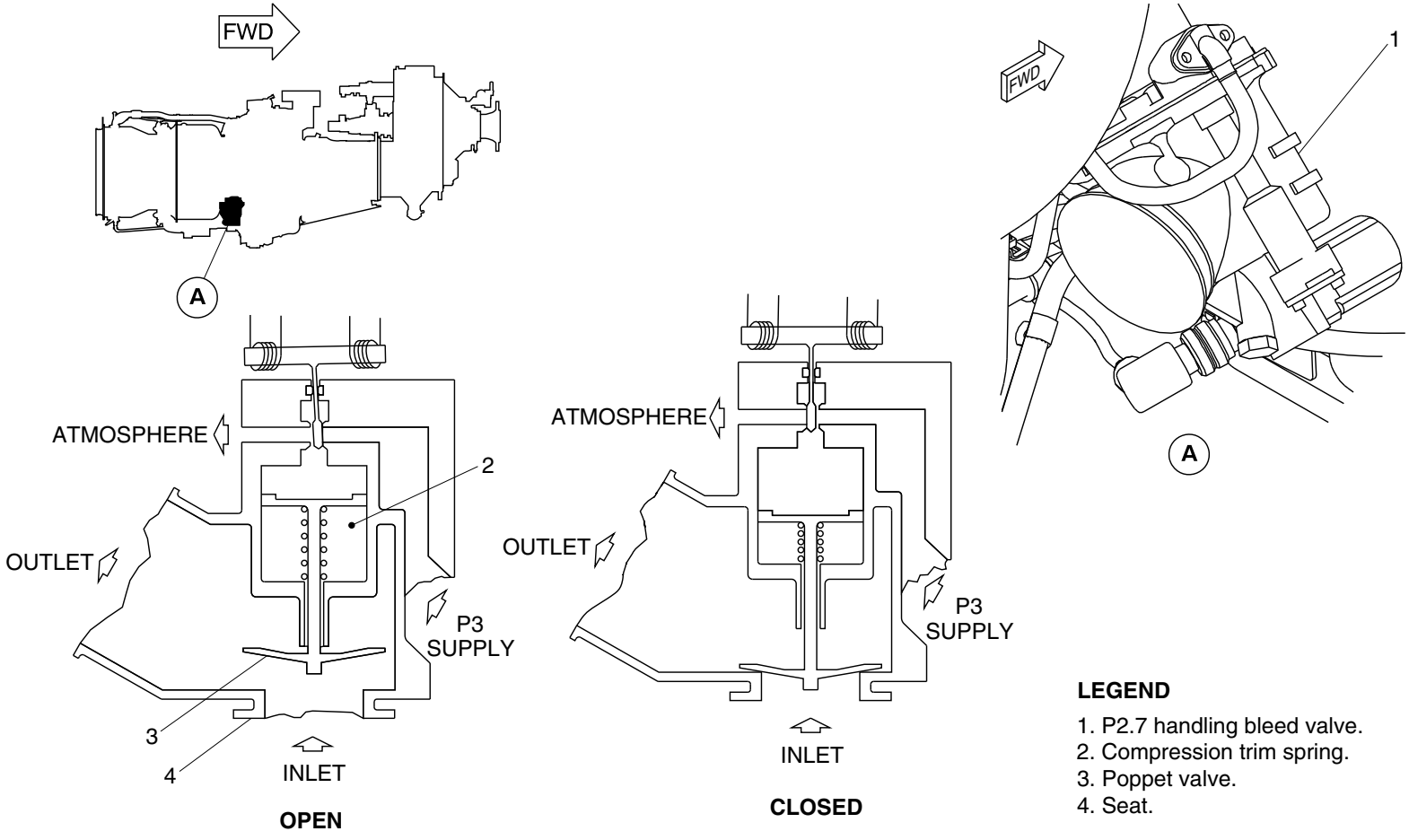
P2.7 Handling Bleed Valve Locator
Figure 4



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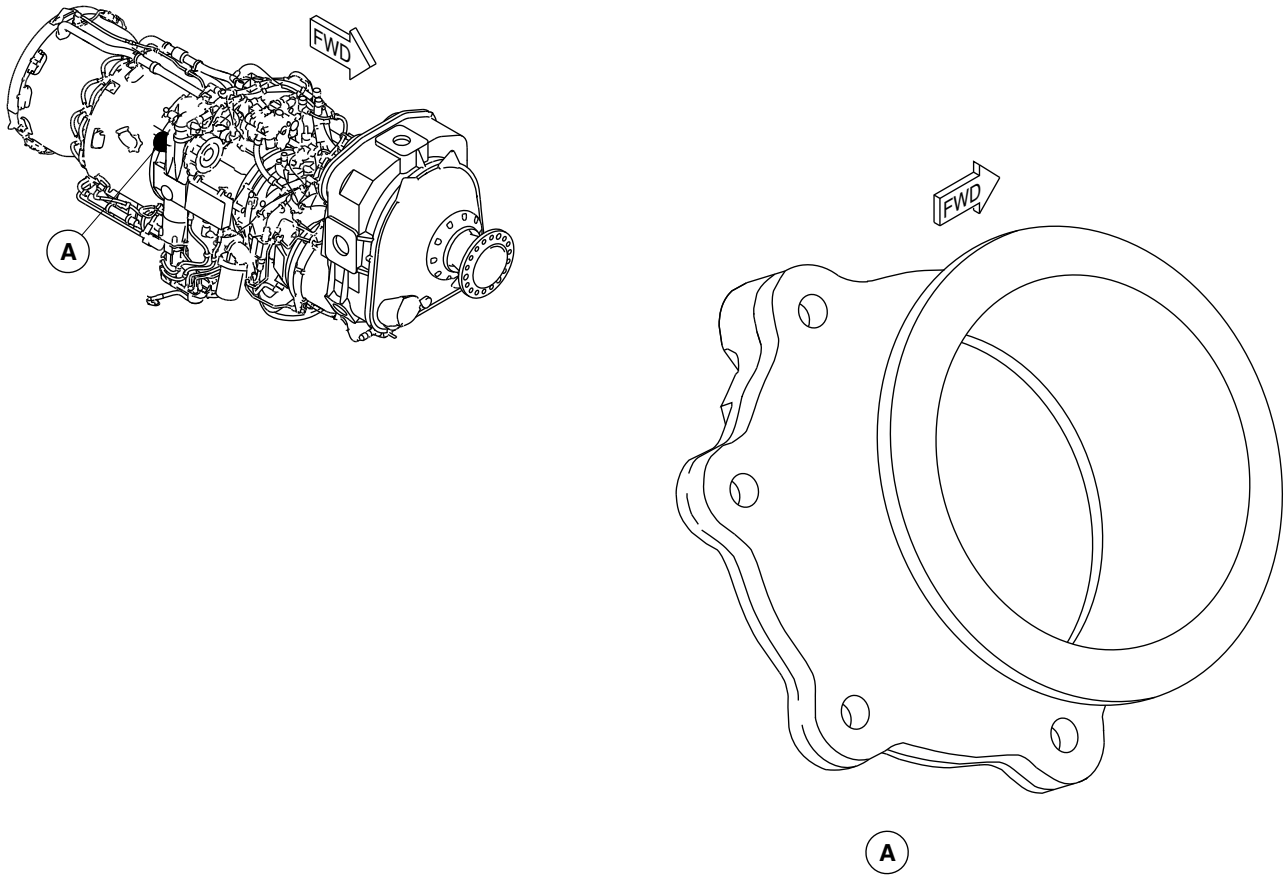
P2.7 Handling Bleed Valve Detail
Figure 5



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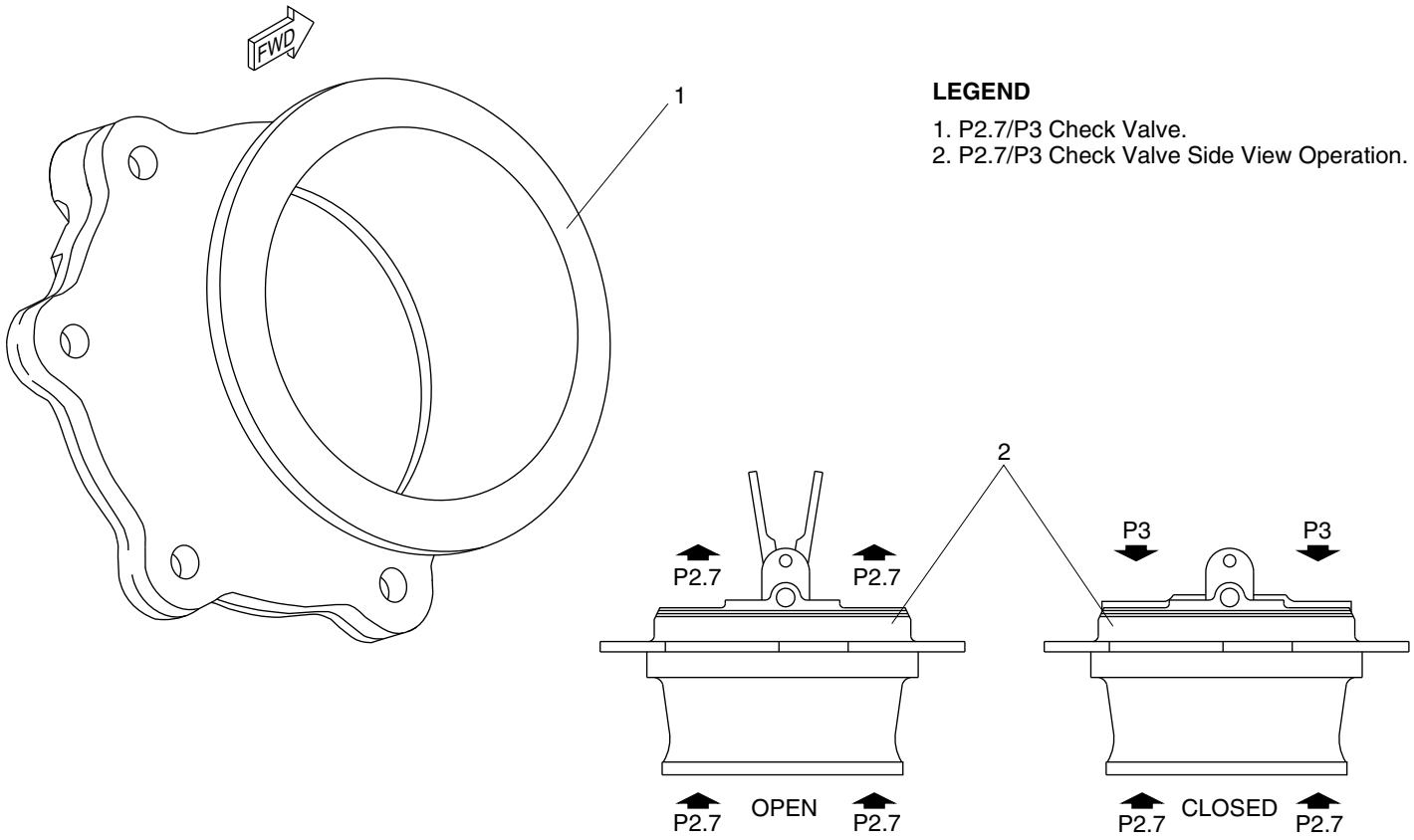
P2.7/P3 Check Valve Locator
Figure 6



LEGEND

1. P2.7/P3 Check Valve.
2. P2.7/P3 Check Valve Side View Operation.

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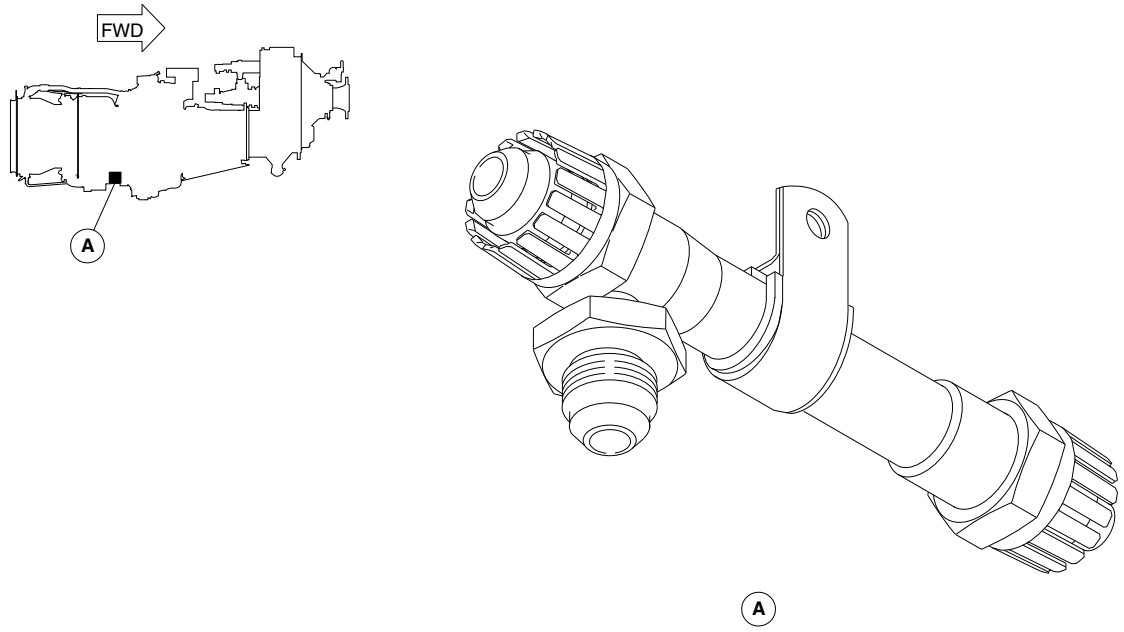
P2.7/P3 Check Valve Detail
Figure 7



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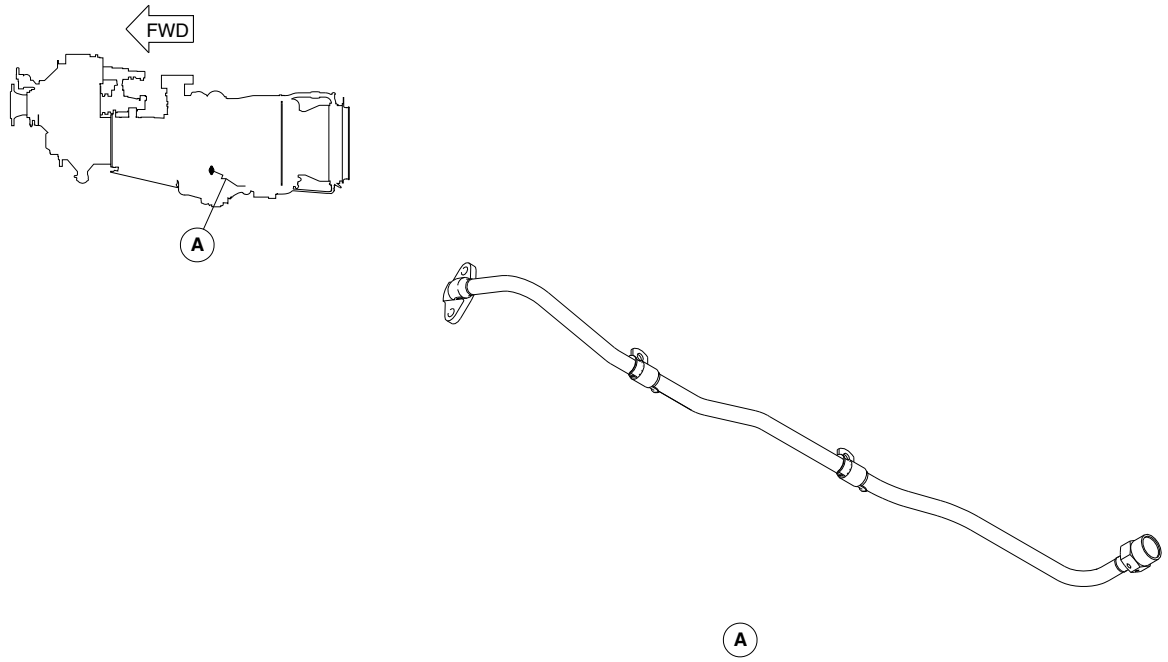
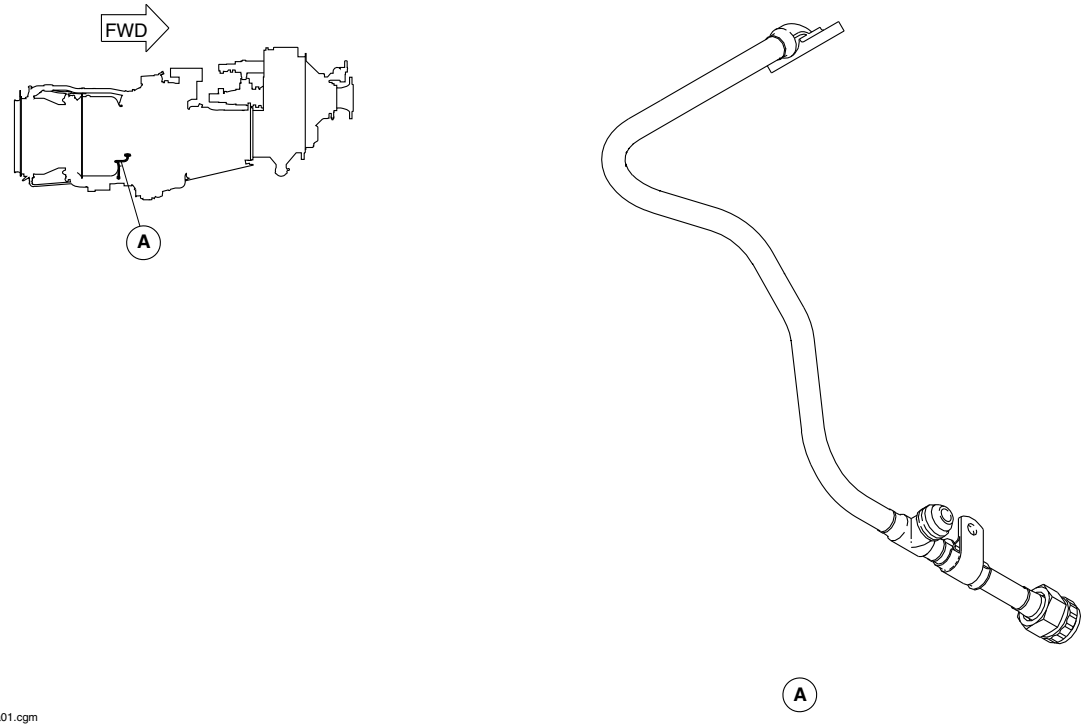
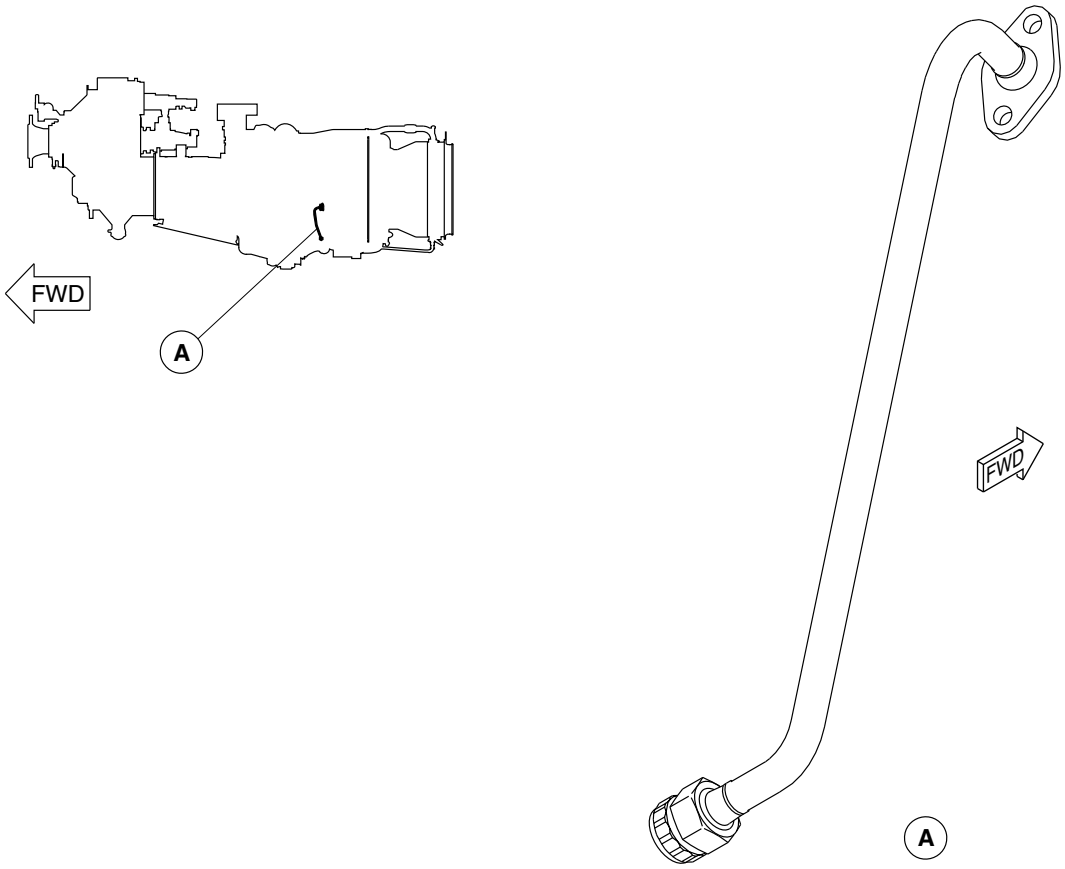
P3 Air Separator
Figure 8



P3 Air Separator to P2.2 Bleed Valve Air Tube
Figure 9



P3 Air Separator to P2.7 Bleed Valve Air Tube
Figure 10



Gas Generator Case to P3 Separator Air Tube
Figure 11

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75–40–00–001

INDICATION

Introduction

The Air Indication system senses compressor discharge pressure at the exit from the HP compressor and transmits this pressure, as an electrical signal, to the related FADEC. This signal is used for engine control.

General Description

Refer to Figure 1.

A transducer receives P3 air pressure and converts this pressure to a proportional electrical signal that is then sent to the FADEC. The FADEC uses this signal to control the bleed valves.

The function of the Air Indication system is performed by the:

- P3 Pressure Transducer (75–41–06)
- P3 Transducer to Gas Generator Case Air Tube (75–41–01).

Detailed Description

The Air Indication system uses a transducer to convert P3 pressure to an electrical signal that the FADEC uses to control bleed valve operation.

P3 Pressure Transducer

Refer to Figure 2.

The transducer is located adjacent to the rear of the accessory gearbox and is connected to the gas generator case by a stainless steel tube and to the FADEC through an electrical wiring harness.

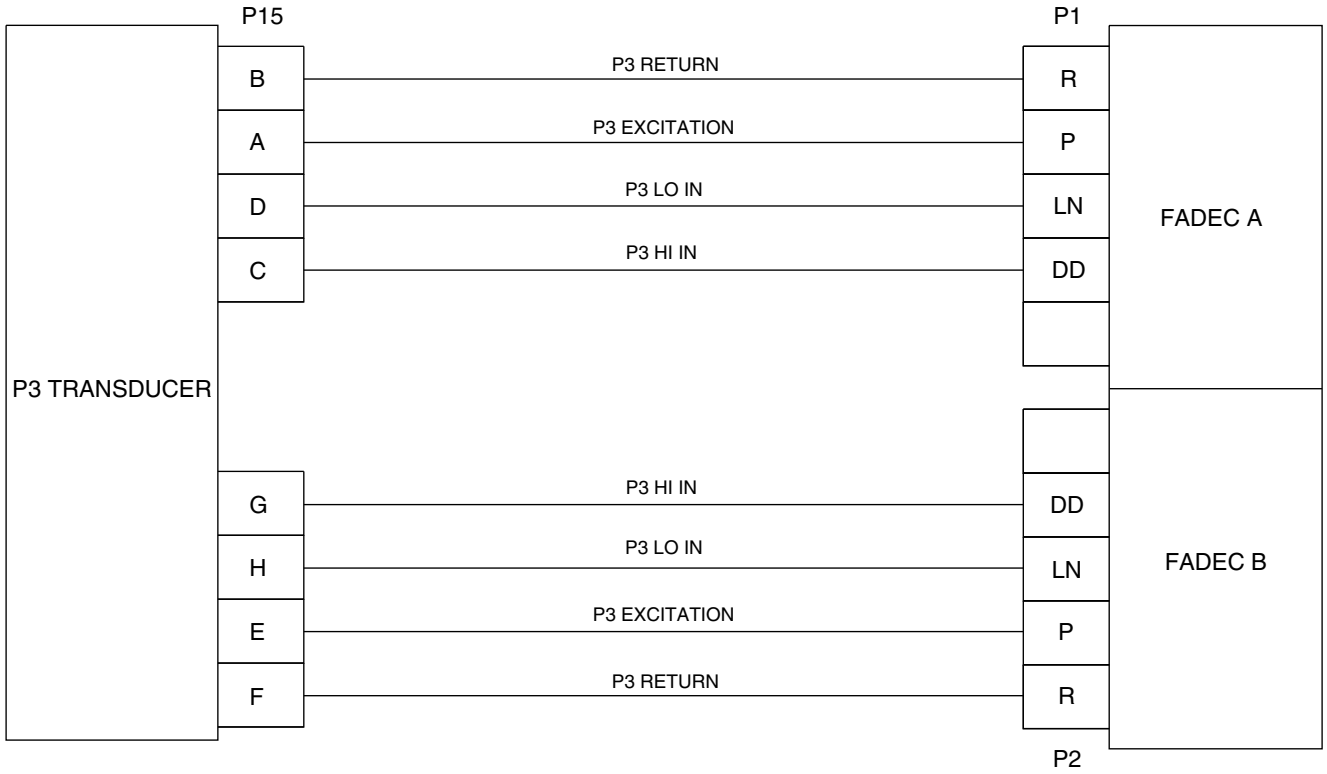
The P3 transducer senses compressor discharge pressure at the exit from the HP compressor. The P3 transducer converts this pressure into a proportional electrical signal and sends it to the FADEC. The FADEC uses this signal to control the bleed valves.

The P3 transducer is a 2 channel device and in the event one channel fails the other channel can fully provide the signal to the FADEC.

P3 Transducer to Gas Generator Case Air Tube

Refer to Figure 3.

This tube supplies P3 air to the P3 transducer. This air supply is used by the FADEC for engine control.



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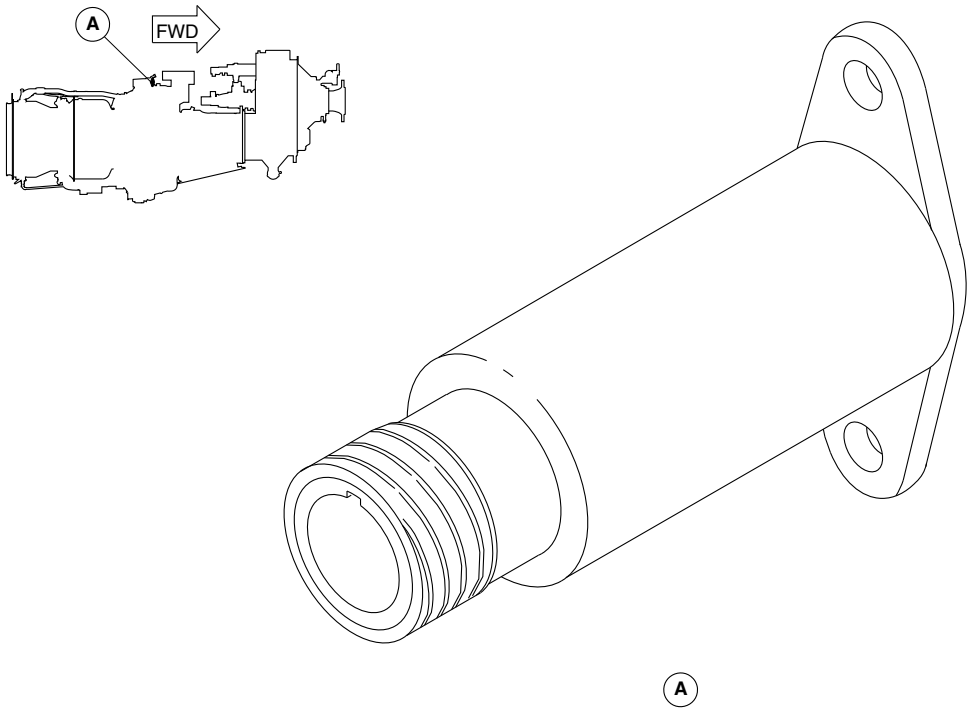
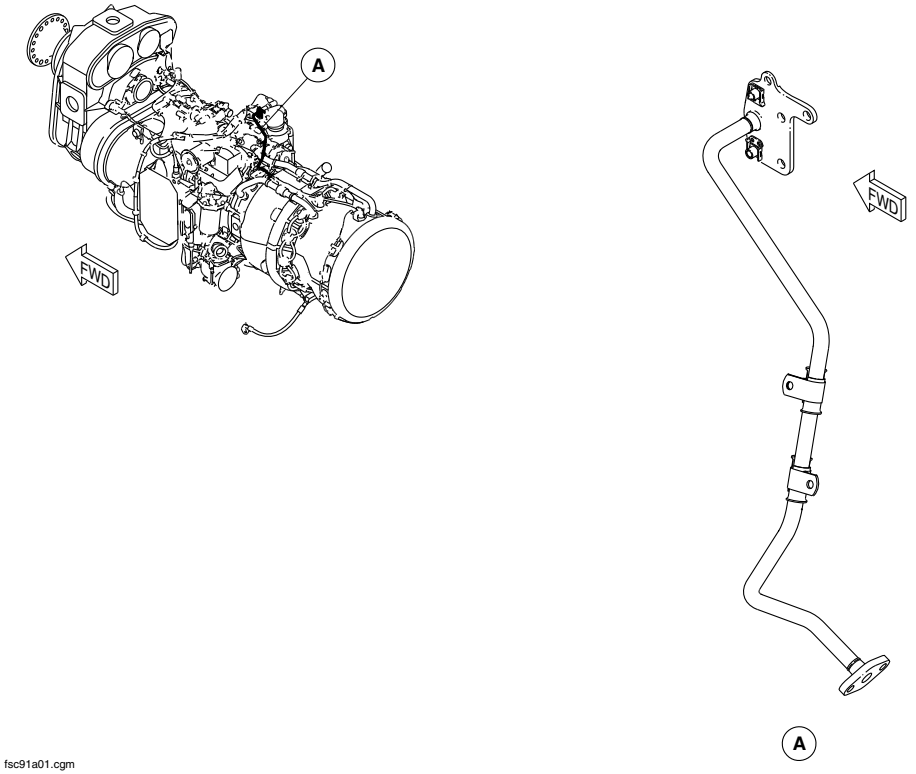
Air Indication System Schematic
Figure 1



P3 Pressure Transducer
Figure 2



P3 Transducer to Gas Generator Case Air Tube
Figure 3

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