**ON A/C ALL

49–00–00–001

AUXILIARY POWER UNIT (APU), GENERAL

Introduction

The APS 1000–C12 Auxiliary Power Unit (APU) is a turbine–powered system used to give auxiliary electrical power and pneumatic power.

General Description

The APU engine and its associated components are installed in the aft section of the tail cone. Consisting of a gas turbine engine driving a starter/generator, the APU gives bleed air to the air conditioning pack and 28 Vdc to the left main feeder bus. The APU is installed for ground use only and cannot be operated in flight.

The APU has a control system, an air induction system, an exhaust system, a gearbox, accessories, an electrical generator. The APU includes the following:

- • Powerplant (49–10–00)
- • Engine (49–20–00)
- • Engine Fuel and Control (49–30–00)
- • Ignition and Starting (49–40–00)
- • Air (49–50–00)
- • Engine Controls (49–60–00)
- • Indicating (49–70–00)
- • Oil (49–90–00)

Detailed Description

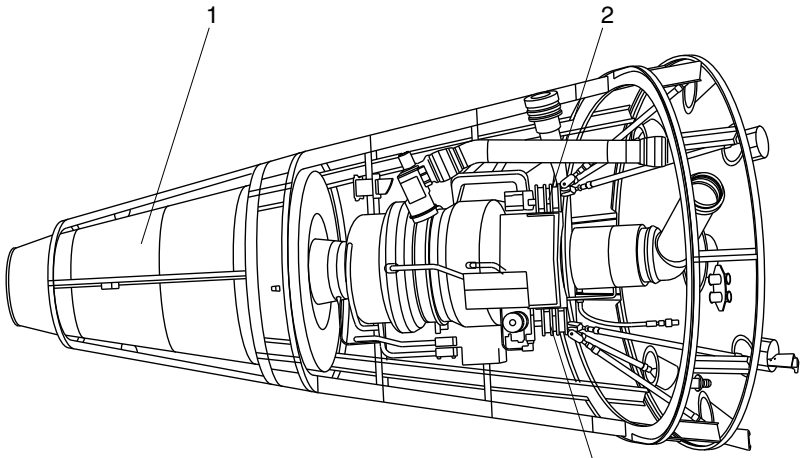
The APU control consists of a Full Authority Digital Electronic Controller (FADEC) and various valves, and sensors. The FADEC controls, monitors and diagnoses all phases of the APU system operation through these valves and sensors. The FADEC also communicates with the aircraft system through an ARINC link. The FADEC controls the APU start, acceleration to 100% speed, the starter motor, the exciter and fuel flow. The FADEC monitors engine speed, EGT, oil temperature, oil pressure, and inlet pressure.

During operation, the APU rotor speed is kept at a constant speed. Abnormal conditions during operation are recorded as faults in the FADEC Non Volatile Memory. The FADEC provides the necessary hardware and software for control sequencing, condition monitoring, fault detection, fault isolation and protection of the APU System. The FADEC also performs the interface functions between the aircraft and the APU.

The air induction system consists of an air inlet system located in the aircraft tail cone. The air induction system provides outside air to the APU compressor, which compresses the air. Some of the compressed air is bled off the APU and delivered to the aircraft Environmental Control System. A bleed control valve controls the flow of air.

The remaining compressed air is heated in a combustor using fuel provided by the APU fuel system, the combustion products then drive the turbine wheel. The energy released drives the compressor and the gearbox with its mounted accessories. The exhaust gases exit the APU through the exhaust system.

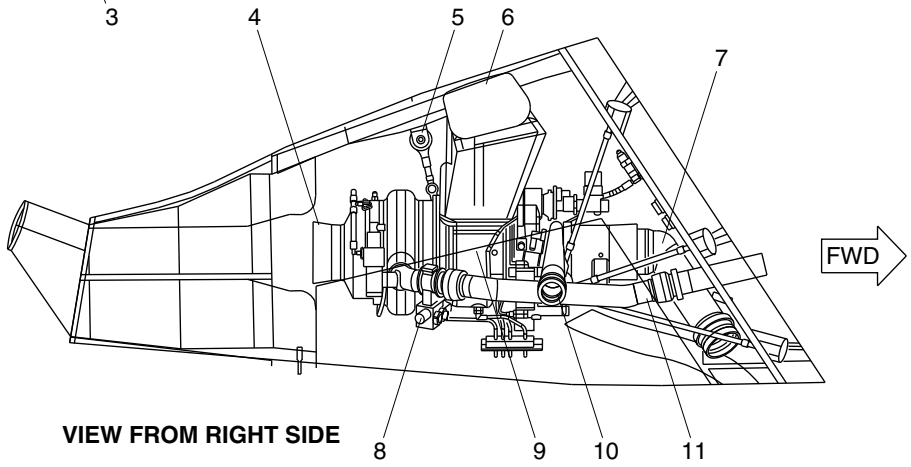
The gearbox mounted electrical generator provides electrical power used by the aircraft systems. The gearbox also drives the following accessories: an oil pump for lubrication, a fuel control which provides fuel to the combustor.



VIEW FROM BELOW

LEGEND

1. Exhaust Silencer.
2. Right Side Mount.
3. Left Side Mount.
4. APU Exhaust.
5. Rear Mount.
6. Inlet Duct.
7. Generator Inlet Duct.
8. Bleed Valve.
9. Access Door Hinge.
10. Generator Outlet Duct.
11. Bleed Air Duct.



VIEW FROM RIGHT SIDE

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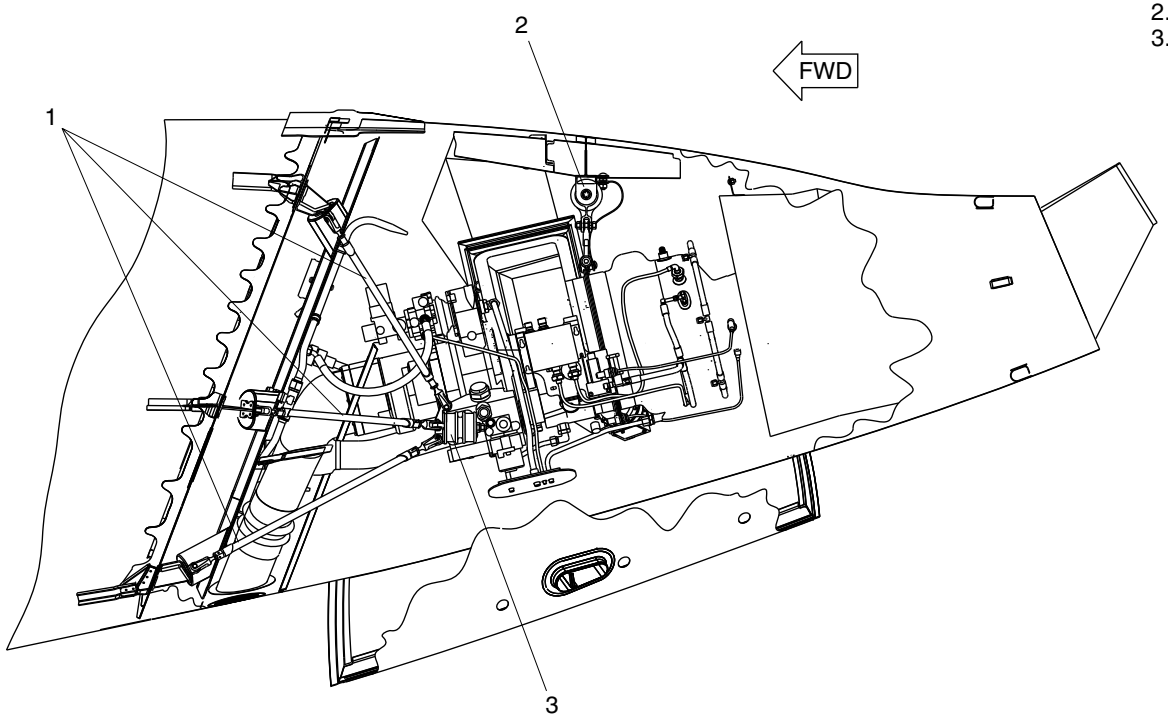
APU Locator Page 1
Figure 1

LEGEND

1. Side Mount Struts.
2. Rear Mount.
3. Left Side Mount.



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APU Locator Page 2
Figure 2

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49–10–00–001

POWERPLANT

Introduction

The Auxiliary Power Unit gives electrical power to the aircraft left main bus, and air conditioning to the Environmental Control System, when the aircraft is in the ground. The APU powerplant is installed in a compartment that provides interfaces for the APU fuel line, electrical connections, air inlet assembly, exhaust, starter/generator duct system, fire detection and the fire extinguishing system.

General Description

Refer to Figures 1 and 2.

The Auxiliary Power Unit (APU) is located in a fireproof titanium compartment in the tail cone of the aircraft. Access to the APU is through two hinged doors that are part of the tail cone structure.

The APU is installed to the tail cone structure by three mounts. The two forward mounts are attached to the gearbox mounts and the rear strut is attached to the APU rear mount. A fish pole hoist is used to install and remove the APU. The hoist is attached to a lug in the APU compartment and uses quick connects to the APU front and rear lifting brackets.

The APU includes the components that follow:

- Harness, Electrical–APU (49–10–06)
- Harness, Electrical–Interconnect (49–10–09)
- Mounts, Side (49–12–01)
- Mounts, Aft (49–12–04)
- Duct, Inlet (49–16–11)
- Drain, Exhaust (49–17–00)
- Vent, Gearbox (49–17–04)
- Drain, Fuel Pump (49–17–07)
- Drain, Inlet (49–17–10)
- Drain, Combustor (49–17–13)

Detailed Description

The Auxiliary Power Unit mounting system is designed to be failsafe. Limit flight loads will be supported with any single component failure.

The mounting system includes the components that follow:

- Six main struts
- Two gearbox mounts
- One aft mount

Harness, Electrical–APU

The engine control harness assembly consists of 15 electrical connectors and associated connecting wires. When installed on the APU engine assembly, the engine control harness assembly gives the electrical interface between the electrical components and the connection at the tailcone firewall bulkhead.

Harness, Electrical–Interconnect

The electrical inter–connect harness carries the electrical interface from the connection point on the tailcone firewall bulkhead, to the APU Full Authority Digital Electronic Control (FADEC) which is installed in the air conditioning bay in the tailcone.

Mounts, Side

Refer to Figure 3.

The two APU side mounts provide two, of the three vibration isolated, failsafe supports for the APU in the tailcone structure. Each mount has three strut assemblies in a tripod arrangement, a strut bracket, two part vibration isolator, gearbox isolator mount and isolator snubbing washer.

Mount, Aft

Refer to Figure 4.

The aft APU mount is the third, of the three, vibration isolated, failsafe supports for the APU. The lower end of the aft mount is attached to the APU at the uppermost point of the turbine combustor flange. The upper end of the aft mount is attached to the lower side of the centre upper beam in the tailcone structure.

Duct, Inlet

The duct interfaces with the aircraft air inlet system to supply ambient air to the APU compressor. The duct is made of molded phenolic resin and is installed around the APU air inlet housing. A mesh screen is installed inside the inlet duct and is attached to the air inlet housing.

APU Drains

Refer to Figure 5.

Drain connections are supplied for:

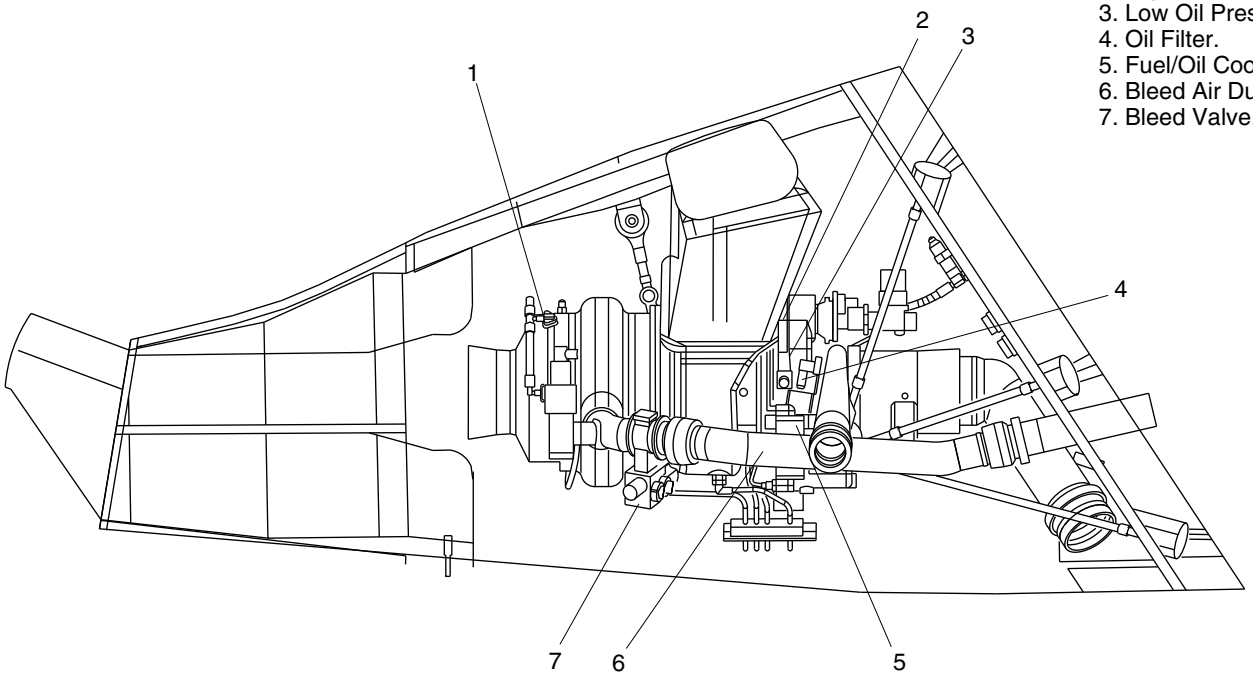
- Fuel pump drive
- Inlet plenum
- Combustor housing.

These connections have stainless steel tubes to connect them to the drain mast. The drain mast is titanium, aerofoil shaped and protrudes through the left door of the tailcone. The mast has a separator plate to segregate the inlet plenum (front) drain from the other drains to prevent ingress of flammable fluids into the inlet. The combustor housing drain valve is threaded into the combustor drain boss. The valve is closed during engine operation by air pressure in the combustor housing. The valve is spring–loaded open when the engine is shut down, to let any accumulation of fuel in the combustor drain into the combustor drain system.

All intercostals and frames in the tailcone and doors have drain cutouts or holes at the lowest point to prevent the accumulation of liquids.

LEGEND

1. Fuel Nozzle (Typical).
2. High Oil Temperature Switch.
3. Low Oil Pressure Switch.
4. Oil Filter.
5. Fuel/Oil Cooler.
6. Bleed Air Duct.
7. Bleed Valve.



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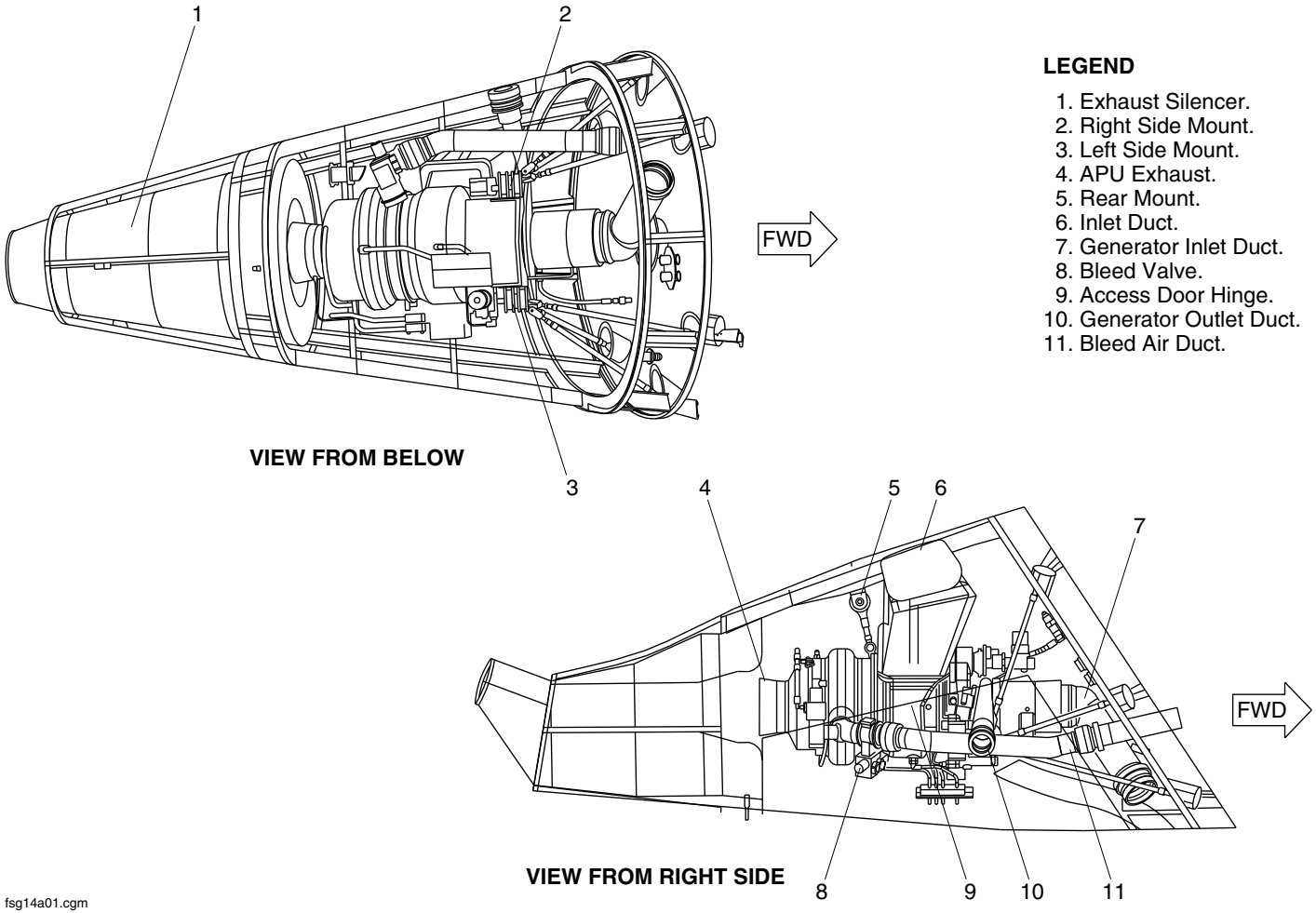
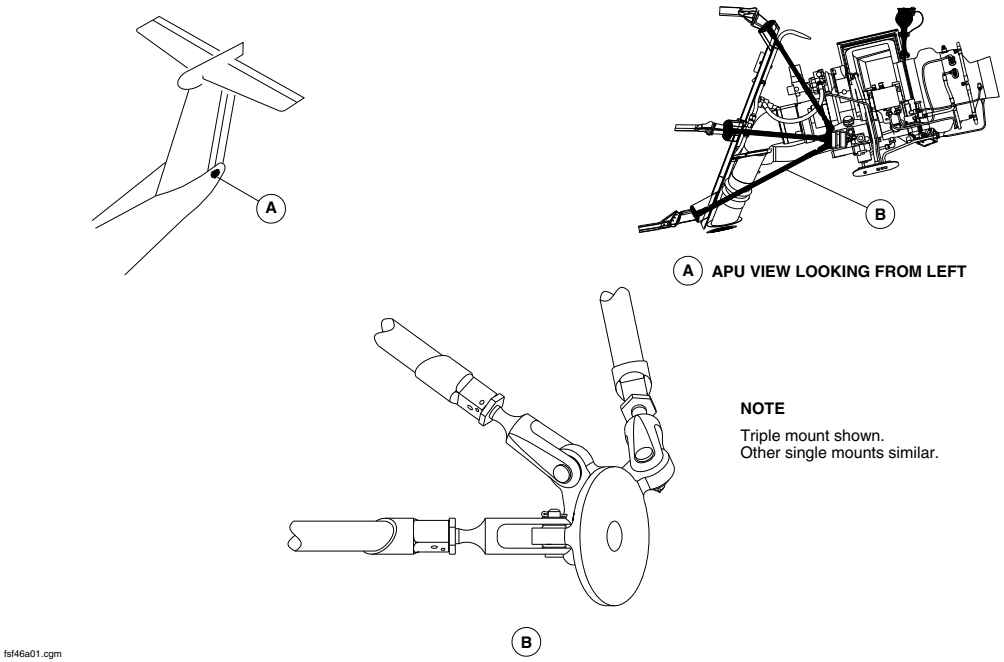
APU Right Side View
Figure 1



LEGEND

1. Exhaust Silencer.
2. Right Side Mount.
3. Left Side Mount.
4. APU Exhaust.
5. Rear Mount.
6. Inlet Duct.
7. Generator Inlet Duct.
8. Bleed Valve.
9. Access Door Hinge.
10. Generator Outlet Duct.
11. Bleed Air Duct.

APU Left Side View
Figure 2



A APU VIEW LOOKING FROM LEFT

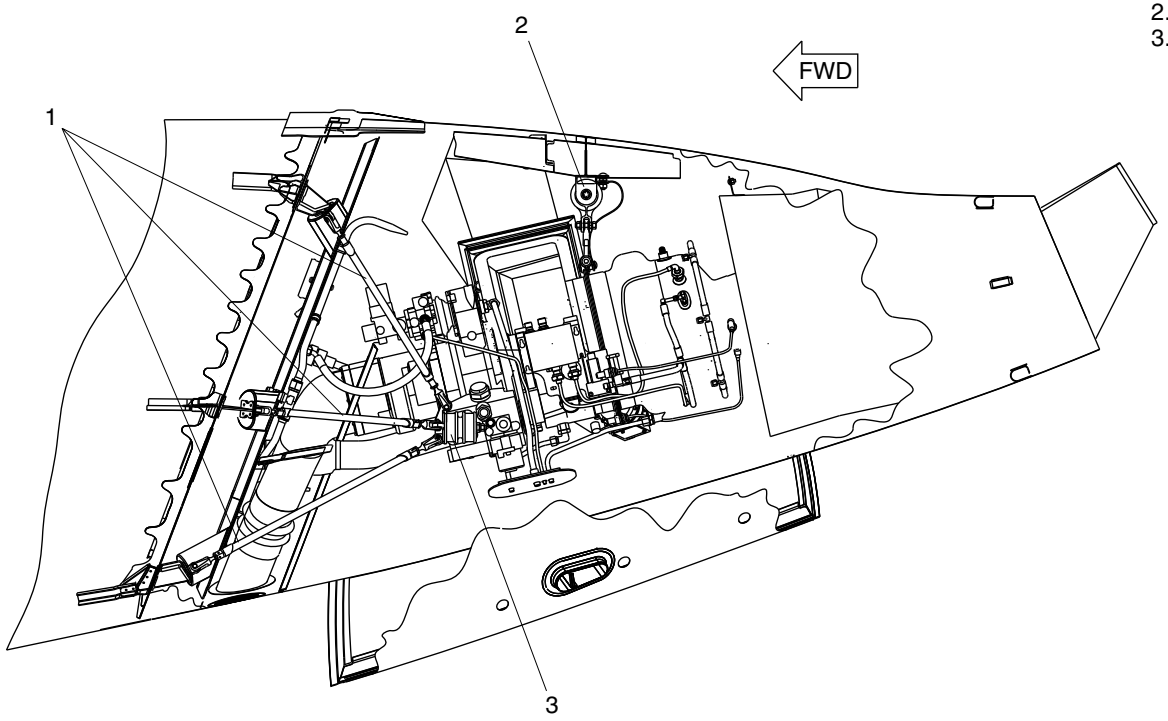
NOTE

Triple mount shown.
Other single mounts similar.

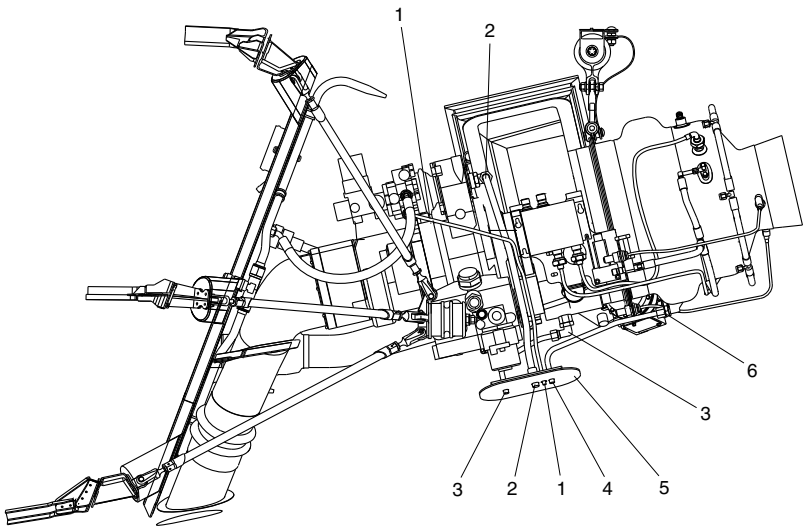
APU Side Mounts
Figure 3

LEGEND

1. Side Mount Struts.
2. Rear Mount.
3. Left Side Mount.



APU Side and Rear Mounts
Figure 4



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LEGEND

1. Fuel Pump Drain.
2. Gearbox Breather.
3. Inlet Muff Drain.
4. Combuster Drain.
5. Drain Mast Bracket.
6. Combustor Drain Valve.

APU Drains
Figure 5

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49–20–00–001

ENGINE

Introduction

The engine assembly of the APU supplies shaft power to operate the Direct Current (DC) Generator, and bleed air to the Environmental Control System (ECS).

General Description

The Engine Assembly is a centrifugal compressor, gas turbine engine. A Full Authority Digital Electronic Controller (FADEC) controls operation of the Engine Assembly.

- Assembly, Engine (49–20–01)

Detailed Description

The engine assembly has two modules that follow:

- Turbine Assembly
- Combustor Assembly

Turbine Assembly

The turbine assembly has the component that follows:

- Air Inlet Housing
- Rotor Assembly
- Turbine Nozzle/Containment Assembly

Air Inlet Housing

Refer to Figure 1.

The APU Air Inlet Housing assembly interfaces with the aircraft air inlet system to supply ambient air to the APU compressor. The Air Inlet Assembly is constructed of molded phenolic resin and is installed around the APU air inlet housing. A mesh screen is located inside the Air Inlet Assembly and is attached to the air inlet housing. The mesh screen is installed to prevent Foreign Object Damage (FOD).

The Air Inlet Housing supplies air to the compressor and gives a rigid support between the Gearbox and Combustor Assembly. The housing also has an internal attachment and support for the Rotor Assembly, Diffuser and Turbine Nozzle Containment Assembly. The housing also provides containment for the Compressor wheel of the Rotor Assembly.

Rotor Assembly

The single stage rotor is a balanced assembly that has an overhung radial Compressor Wheel and Turbine Wheel positioned on a two–bearing shaft system. The bearings are located in the air intake housing. A stationary segmented seal plate between the Compressor and Turbine Wheel prevents compressor discharge air from bypassing the Combustor.

Turbine Nozzle/Containment Assembly

The Nozzle/Containment assembly has a containment ring and a Turbine Nozzle. The Turbine Nozzle is attached to the containment ring by seven radial pins. Four bolts that pass through the diffuser and the air intake housing secure the complete assembly by fasteners on the forward side of the air intake housing. Inside the

turbine nozzle are 21 vanes, which direct the high velocity gas stream to the turbine wheel. Hot gas flows through the wheel and discharges axially through the turbine exhaust. Rotational energy derived from the hot gas flow stream by the turbine wheel drives the compressor and the shaft loads imposed by the generator and APU.

Combustor Assembly

The combustor assembly includes the components that follow:

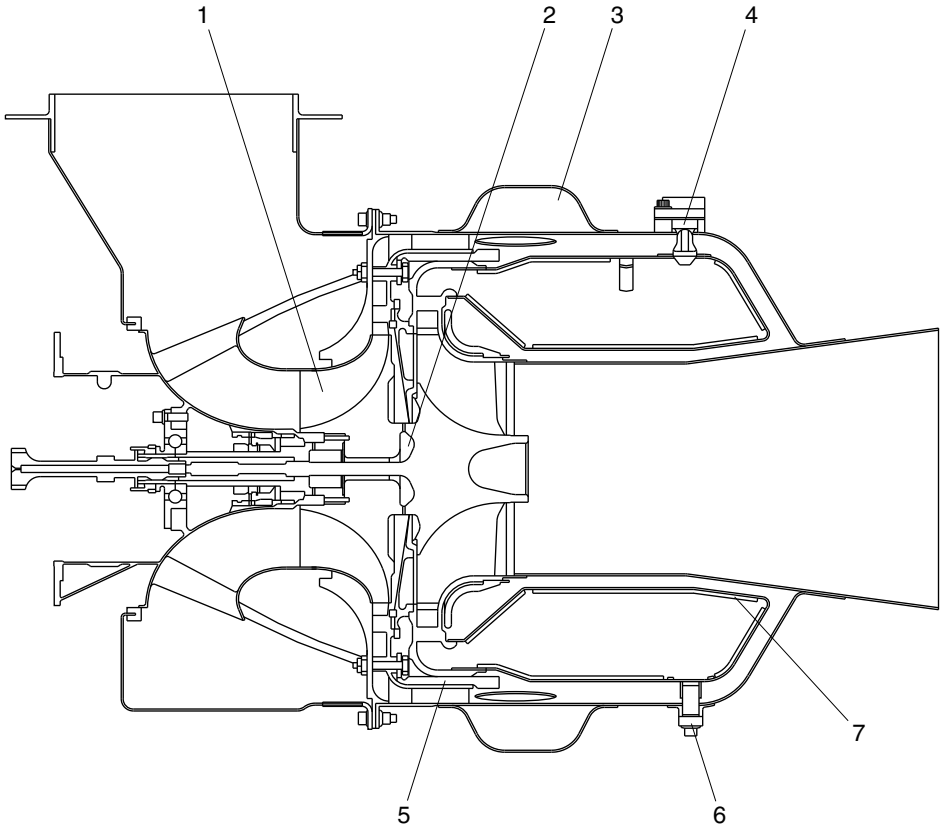
- Combustor Housing
- Combustor Chamber

A bleed port is supplied on the combustor housing for the extraction of bleed air.

The combustor housing is attached to the air inlet housing with bolts. Compressor air is discharged into the combustor housing which forms a plenum surrounding the combustor chamber. Bleed air is ducted off this plenum when required, and the remainder of the air enters the combustor chamber through dilution holes. Six air atomizing fuel injectors directed circumferentially into the combustor chamber provide for complete combustion, thorough mixing, and uniform temperature distribution of the hot gas entering the turbine nozzle. The combustor housing itself is a one–piece flow–formed outer housing.

The combustor drain valve is threaded into the combustor drain boss. The valve is closed during engine operation by air pressure in the combustor housing. The valve is spring loaded open when the engine is shut down, to let any accumulation of fuel in the combustor drain into the combustor drain system.

The combustor chamber is an annular combustor and is located inside the combustor housing. Two start nozzles, six air atomizing fuel injectors and two ignitors go through the combustor chamber. Combustion takes place inside the chamber near the fuel injectors. Dilution air is added downstream where a thorough mixing of fuel and air occurs to produce a uniform hot gas stream. The chamber walls are film cooled by air introduced from behind multiple cooling strips that distributes the air over the inner surface of the chamber.



LEGEND

1. Air Intake Housing.
2. Rotor Assembly.
3. Combustor Housing.
4. Fuel Nozzle.
5. Turbine Nozzle Containment Assembly.
6. Igniter Boss.
7. Combustor Lining.

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Combustor and Turbine Assemblies
Figure 1

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49–30–00–001

ENGINE FUEL AND CONTROL

Introduction

The Engine Fuel and Control system monitors and supplies the fuel to the Auxiliary Power Unit (APU). The system automatically compensates for altitude and APU operations.

General Description

Fuel delivery to the APU electronic fuel control and pump assembly (Fuel Control) is supplied by the aircraft fuel system. The Electronic Control Unit (ECU) supplies the signals that operate the fuel control.

The system has the components that follow:

- Assembly, Fuel Control (49–30–06)
- Valve, Fuel–Start (49–30–11)
- Valve, Fuel–Main (49–30–16)
- Check Valve, Combustor Drain (49–30–21)
- Divider, Flow (49–30–26)
- Check Valve, Purge (49–30–31)
- Nozzle, Fuel–Start (49–30–41)
- Nozzle, Fuel–Main (49–30–46)
- Manifold, Fuel–Start (49–30–46)
- Manifold, Fuel–Main (49–30–51)
- Assembly, Fuel Filter (49–30–56)
- Element, Fuel Filter (49–30–61)

Detailed Description

Refer to Figures 1 , 2 and 3.

The gearbox driven fuel control receives fuel from the aircraft fuel system. Fuel flows through the low pressure centrifugal fuel pump to the fuel/oil cooler, fuel filter, high pressure fuel pump, the fuel servo valve and to the fuel solenoid manifold assembly. Excess fuel is circulated through the relief valve across the high pressure fuel pump. A differential pressure valve is in parallel with the fuel servo valve to maintain a constant differential pressure across the fuel servo current command from the Full Authority Digital Electronic Control (FADEC).

The FADEC controlled fuel flow provides efficient starting and operation of the APU.

The start sequence begins with the servo valve energized open at start up.

The start fuel valve is energized open at 3% gas generator (Ng) speed and fuel flows to the two start nozzles and is ignited by the ignitors. When 25% Ng speed is reached the main fuel valve is energized open and fuel flows to six additional main fuel nozzles. A flow divider valve that is located in the fuel solenoid manifold assembly opens when fuel pressure reaches 300 psid (2068.4 kPad). The valve makes sure proper fuel pressure is maintained to the start nozzles.

The start fuel valve stays open to 70% Ng speed and then is de–energized closed. At this time, the start fuel check valve, located down stream of the start fuel valve, opens to remove residual fuel from the Start Fuel manifold and nozzles. The start fuel check valve is opened by APU compressor air pressure (PCD) when fuel pressure is no longer present. The valve gives a continuous PCD air flow through the nozzles during APU operation.

Assembly, Fuel Control

Refer to Figures 4 and 5.

The electronic fuel control assembly is located on the fuel pump. The assembly contains a fuel servo valve and a differential pressure valve.

The servo valve is energized open at start up. The fuel servo receives milliamp signals from the FADEC to maintain 100% Ng speed during all APU load conditions. In the shutdown sequence FADEC maintains current to the fuel servo valve for 0.5 seconds and then de–energizes the valve.

The differential pressure valve is in parallel with the fuel servo valve to maintain a constant differential pressure across the fuel servo valve. This results in a fuel flow linear relationship to the servo current command from the FADEC.

Valve, Fuel–Start

Refer to Figures 6 and 7.

The start fuel valve is installed on the fuel solenoid manifold assembly. The valve is energized open at 3% Ng speed and fuel flows to the two start nozzles and is ignited by the ignitors. The valve stays open to 70% Ng speed and then is de–energized closed.

Valve, Fuel–Main

The main fuel valve is installed on the fuel solenoid manifold assembly. The valve is energized open when 25% Ng speed is reached and the fuel flows to the six main fuel nozzles. The valve stays open during engine acceleration and throughout engine operation.

Check Valve, Combustor Drain

Refer to Figure 8.

The valve is threaded into the combustor drain boss and is closed, during engine operation, by air pressure in the combustor housing. The valve is spring loaded open when the engine is shut down, to let any accumulation of fuel in the combustor drain into the combustor drain system.

Divider, Flow

The flow divider valve is located in the fuel solenoid manifold assembly. The valve opens when fuel pressure reaches 300 psid (2068.4 kPad) to make sure proper fuel pressure is maintained to the start nozzles.

Check Valve, Purge

The valve is located down stream of the start fuel valve and opens to purge residual fuel from the start fuel manifold and nozzles. It is opened by APU compressor air pressure when fuel pressure is no

longer present. The valve supplies a continuous air flow through the nozzles during APU operation.

Nozzle, Fuel–Start

Refer to Figures 9 and 10.

The two start fuel nozzles are threaded into individual nozzle assemblies and installed in the combustor housing with bolts.

Nozzle, Fuel–Main

Refer to Figures 11 and 12.

The six fuel nozzle assemblies are installed in the combustor housing with bolts.

Manifold, Fuel–Start

The flexible start fuel manifold is located on the engine combustor housing and supplies fuel to the two start fuel nozzles.

Manifold, Fuel–Main

The main fuel manifold is flexible and is located around the engine combustor housing. The manifold supplies fuel to the six fuel nozzle assemblies.

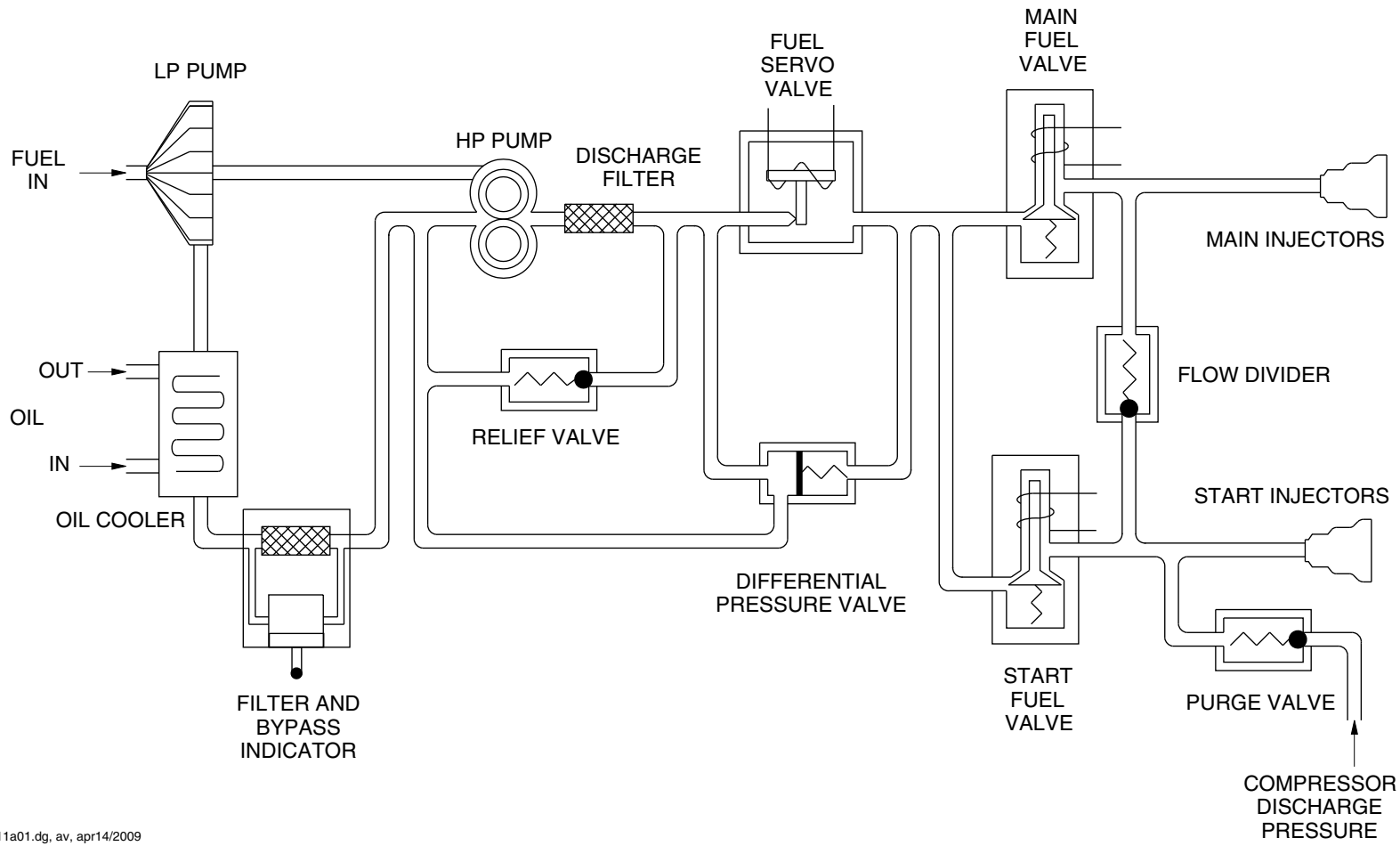
Assembly, Fuel Filter

Refer to Figures 13 and 14.

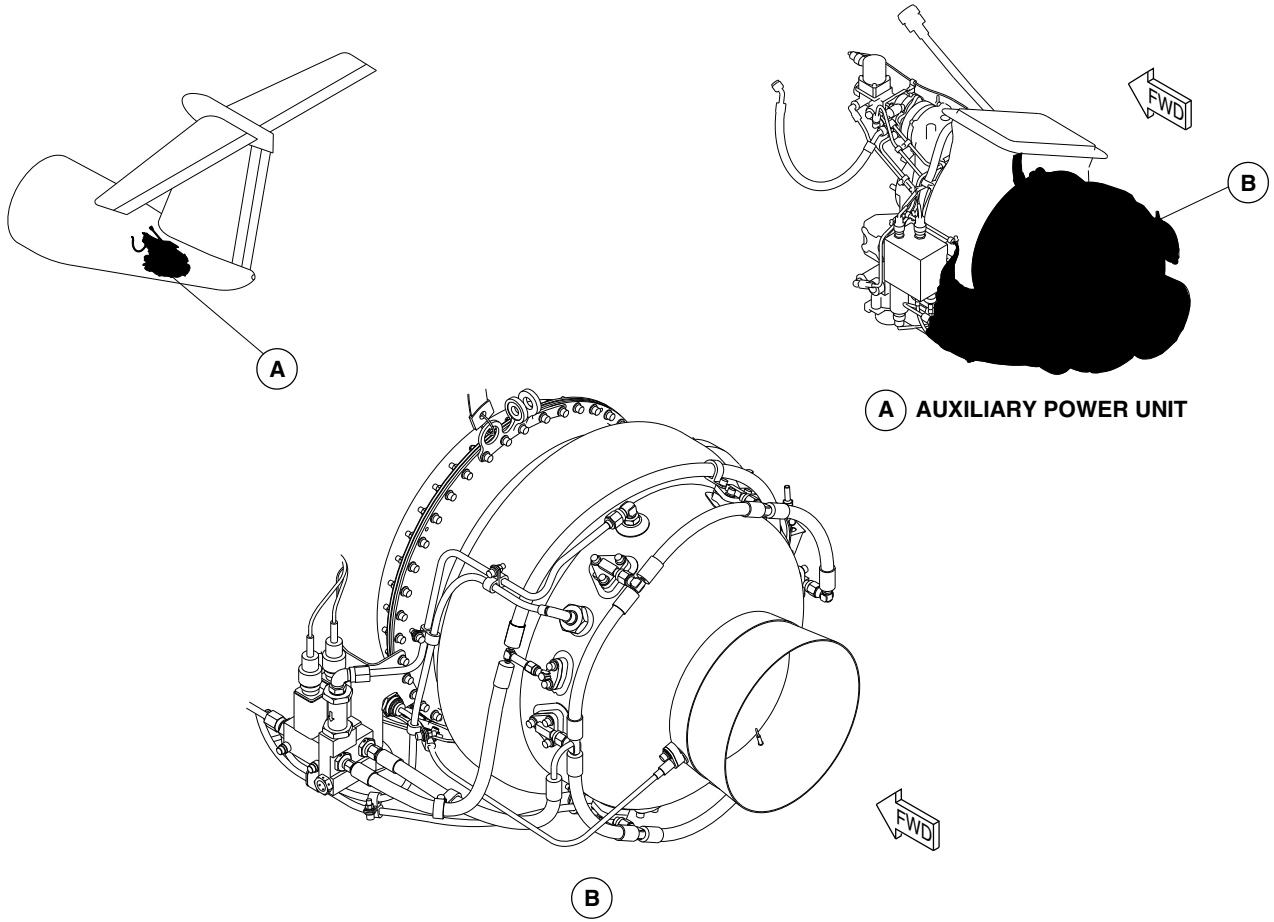
The low–pressure fuel filter protects the fuel control from contamination. The filter differential pressure indicator and bypass valve are located on the side of the filter housing. The impending bypass indicator gives a visual warning when fuel flow through the filter becomes restricted and a pressure differential of 1 to 2 psid (6.89 to 13.8 kPad) occurs. The filter bypass valve will open at a pressure differential of 7 psid (48.3 kPad) to let fuel bypass the filter and maintain flow through the system.

Element, Fuel Filter

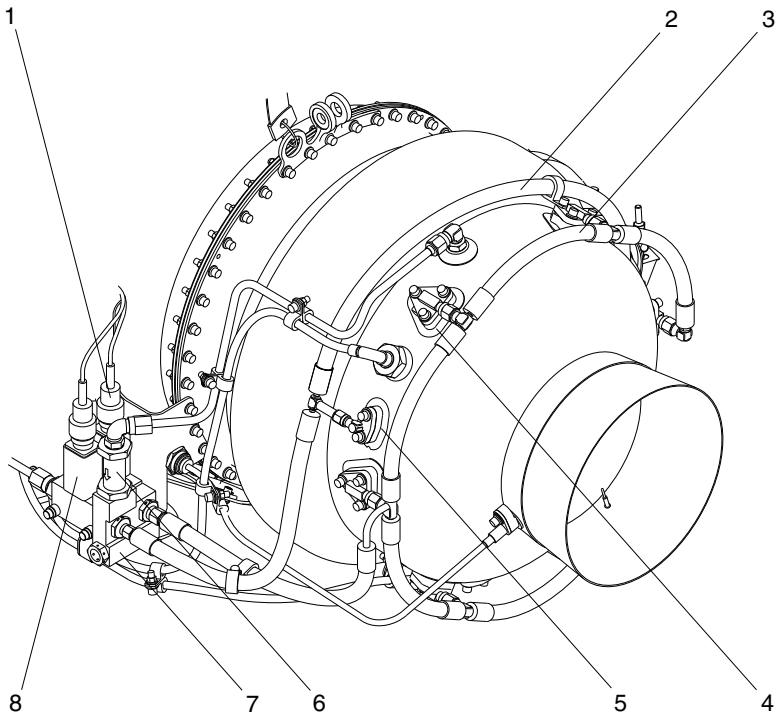
The filter is a full flow type with a replaceable 10–micron filter element.



APU Fuel System Schematic
Figure 1



APU Fuel System Location
Figure 2



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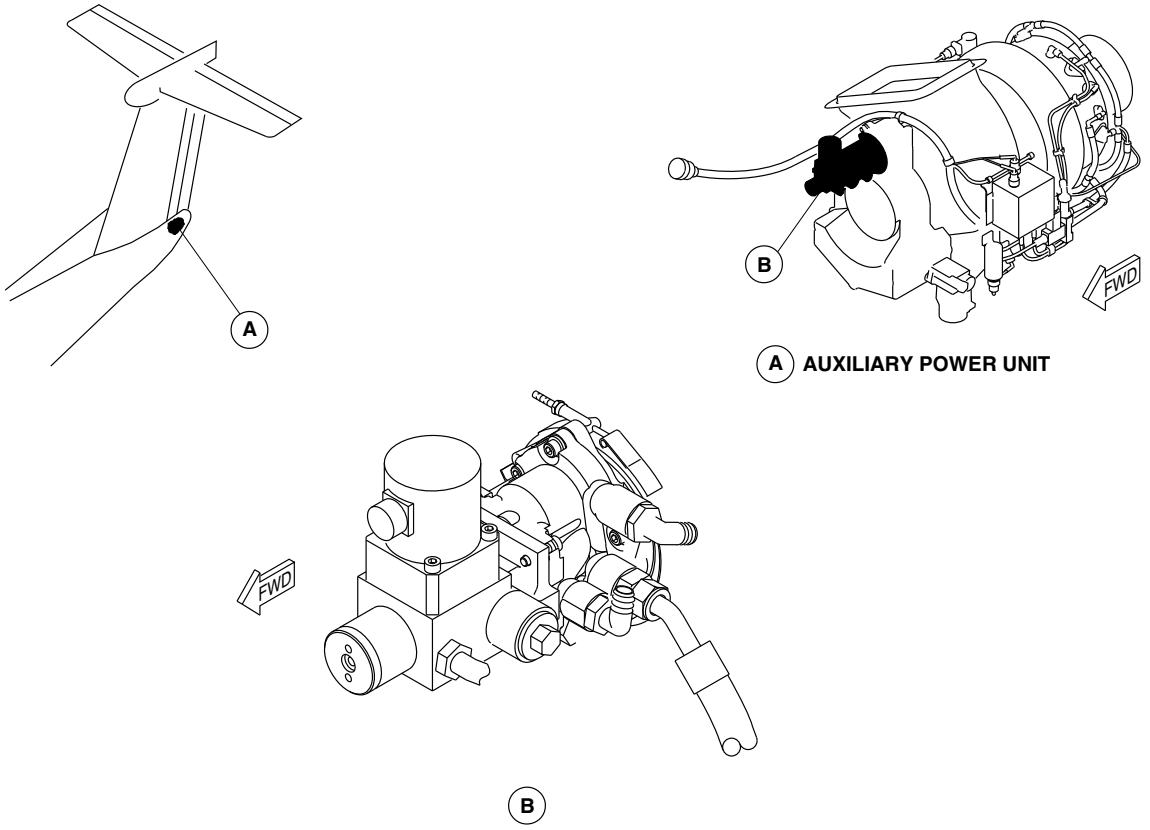
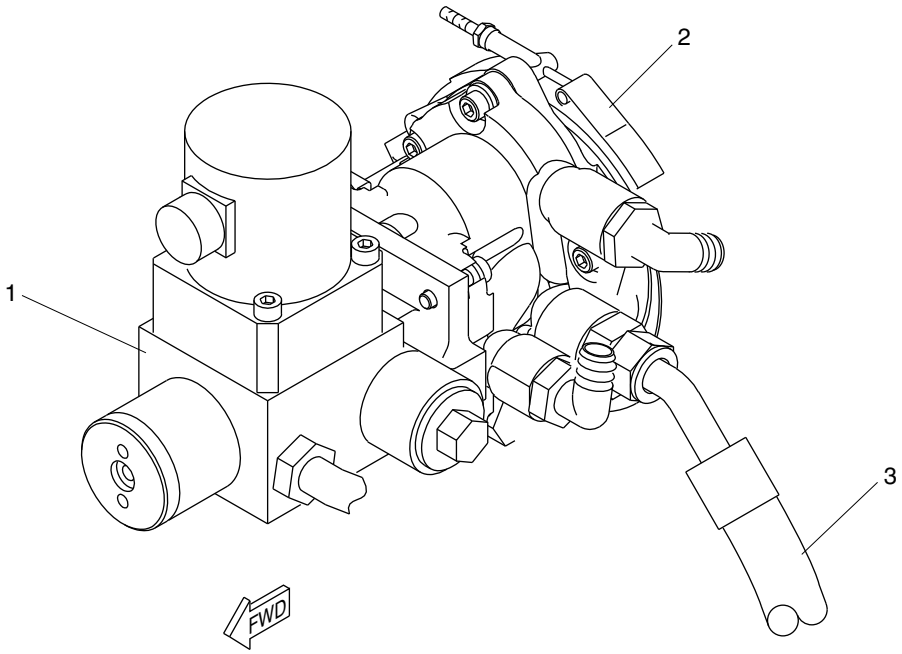
LEGEND

1. Main Fuel Solenoid Valve.
2. Start Fuel Manifold.
3. Main Fuel Manifold.
4. Main Fuel Nozzle.
5. Start Fuel Nozzle.
6. Start Fuel Check Valve.
7. Fuel Solenoid Outlet Manifold Block Assembly.
8. Start Fuel Solenoid Valve.

APU Fuel System Detail
Figure 3



APU Fuel Control Assembly Location
Figure 4



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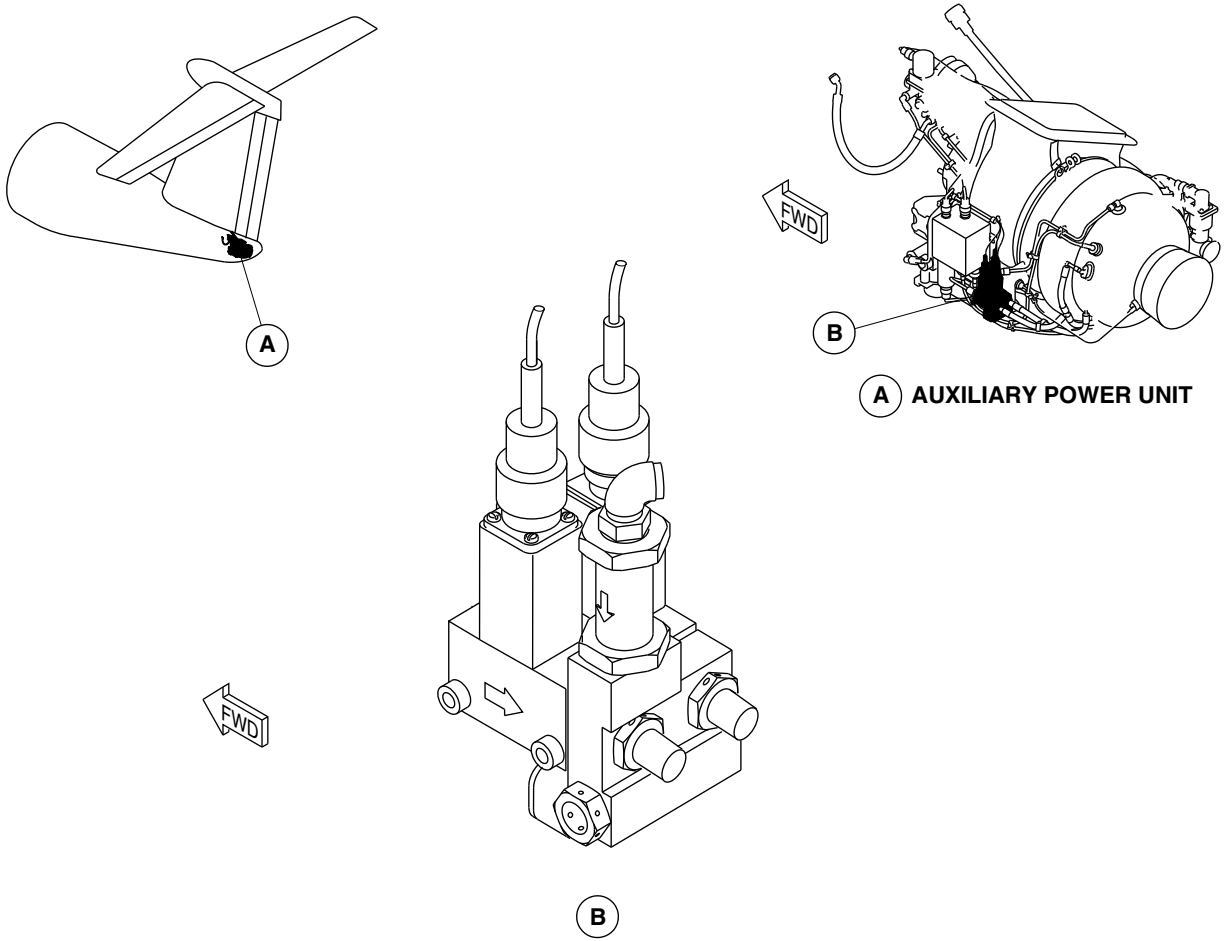
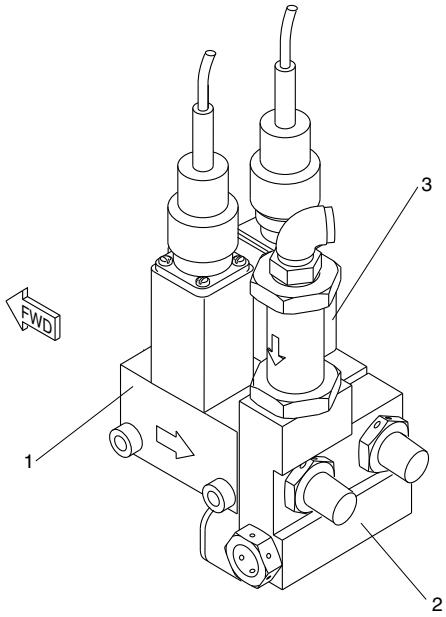
LEGEND

1. Fuel Control Assembly.
2. V–Band Clamp.
3. Fuel Hose.

APU Fuel Control Assembly Detail
Figure 5



APU Start Fuel Valve Locator
Figure 6



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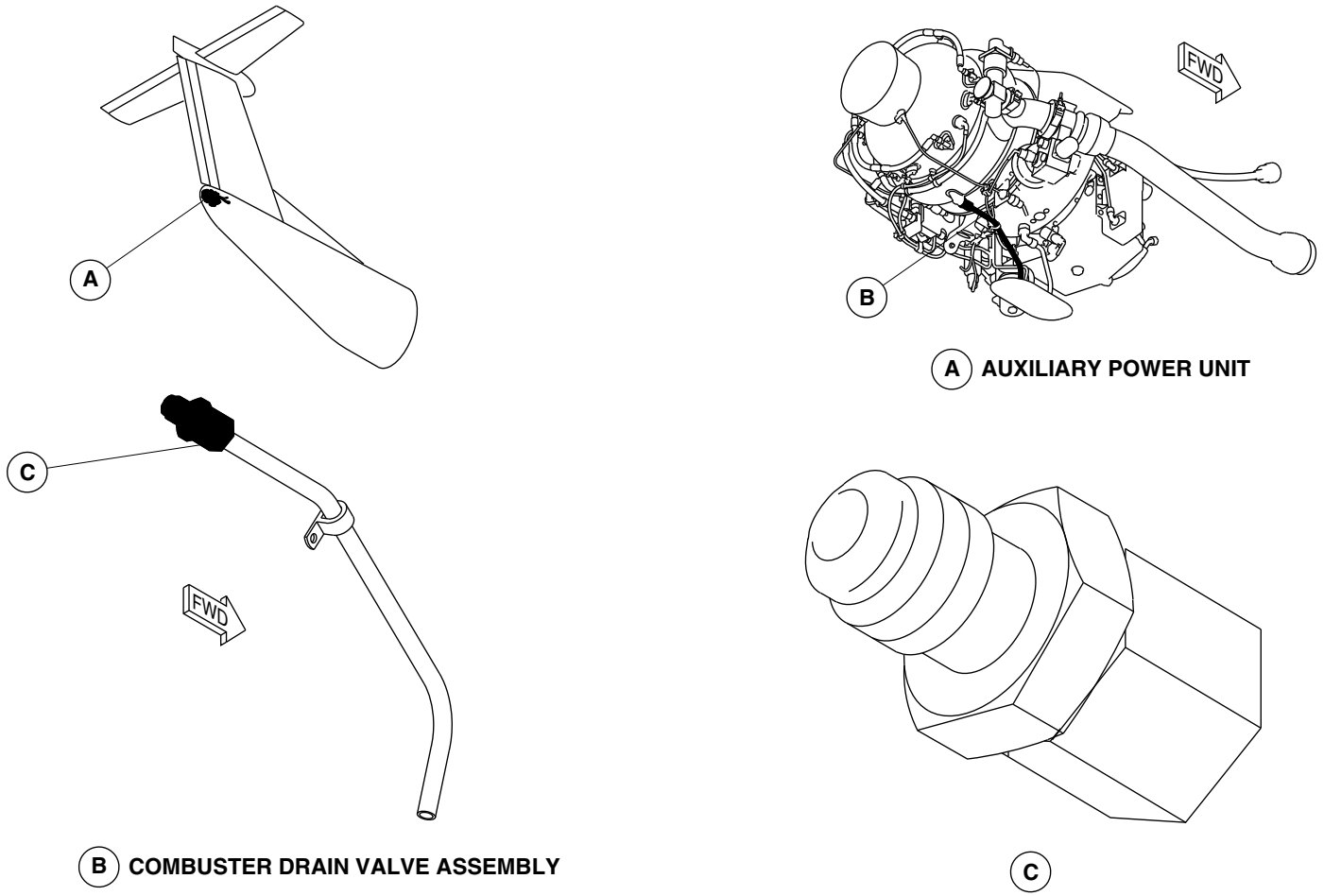
LEGEND

1. Start–Fuel Solenoid Valve.
2. Fuel–Solenoid Outlet Manifold–Block.
3. Main–Fuel Solenoid Valve.

APU Start Fuel Valve Detail
Figure 7



A AUXILIARY POWER UNIT

B COMBUSTER DRAIN VALVE ASSEMBLY

C

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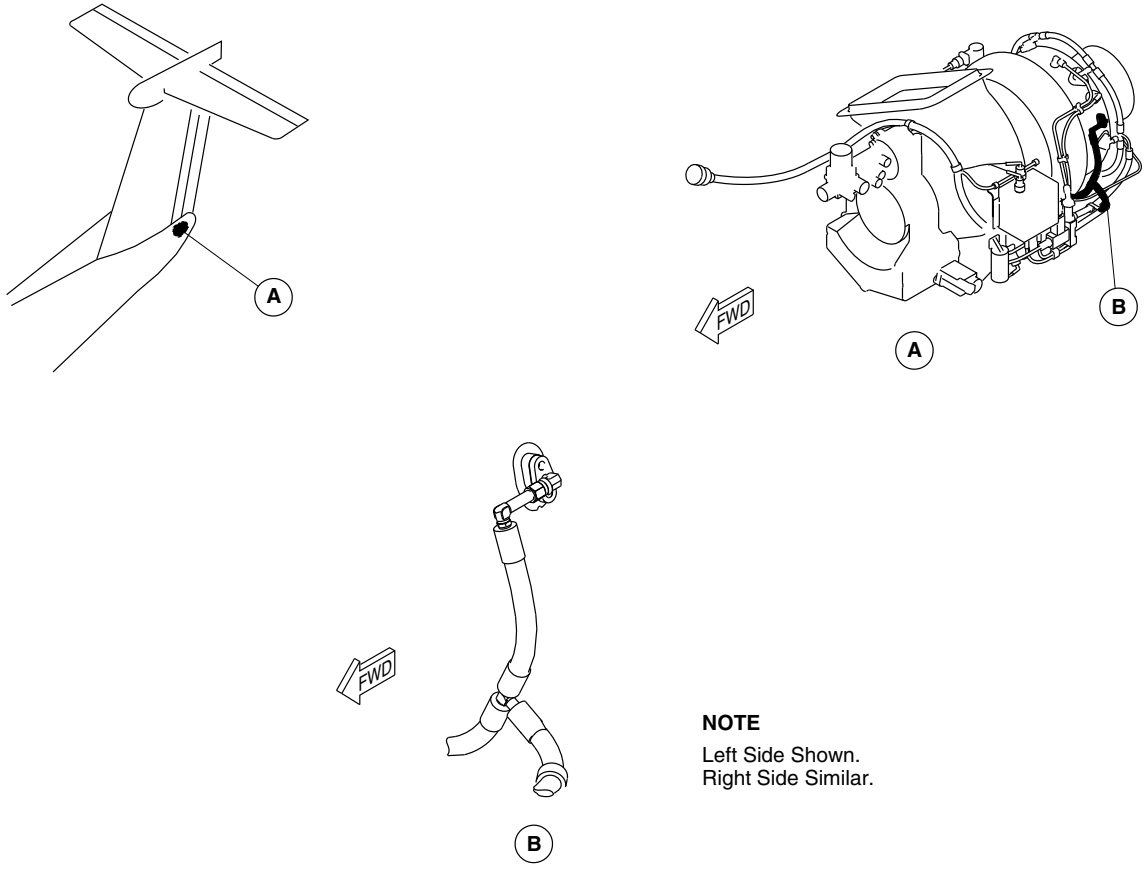
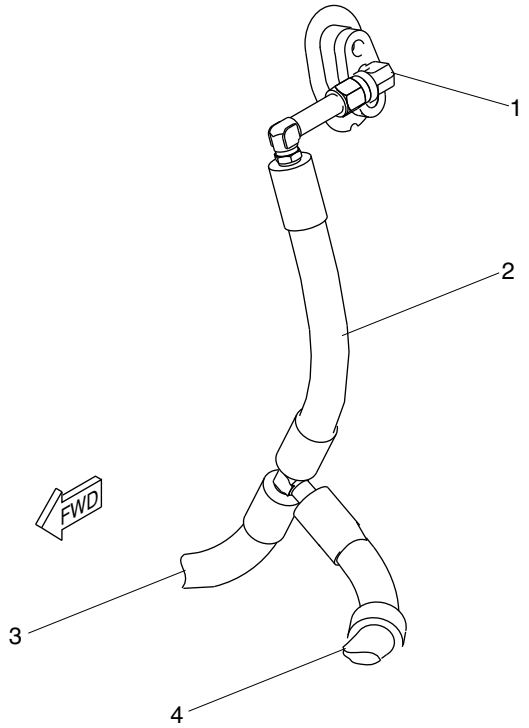
Combustor Drain and Check Valve
Figure 8



NOTE

Left Side Shown.
Right Side Similar.

Start Fuel Manifold and Nozzles Locator
Figure 9



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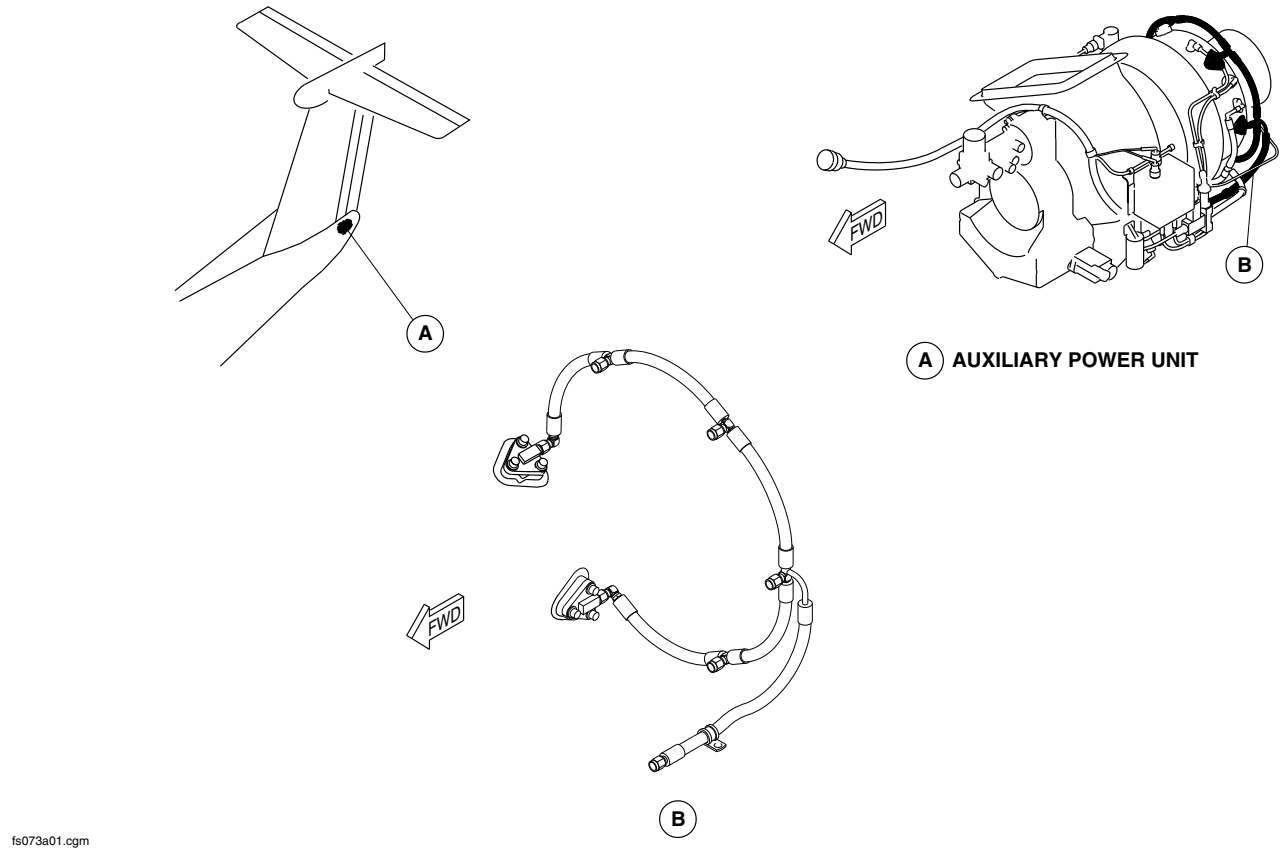
LEGEND

1. Start–Fuel Nozzle Assembly.
2. Start Fuel Manifold.
3. Fuel Line to the Right Side Start Fuel Nozzle Assembly.
4. Fuel Line from the Start Fuel Valve.

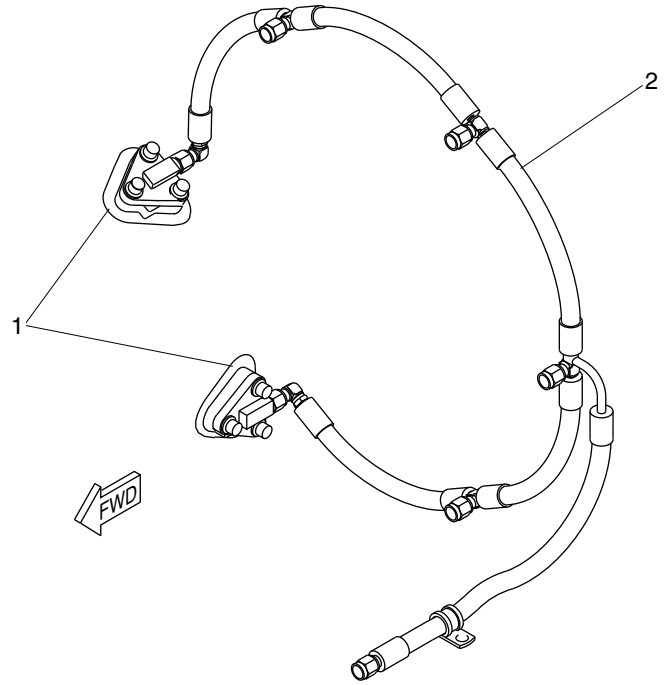
NOTE

Left Side Shown.
Right Side Similar.

Start Fuel Manifold and Nozzles Detail
Figure 10



Main Fuel Manifold and Nozzles Detail Page 1
Figure 11



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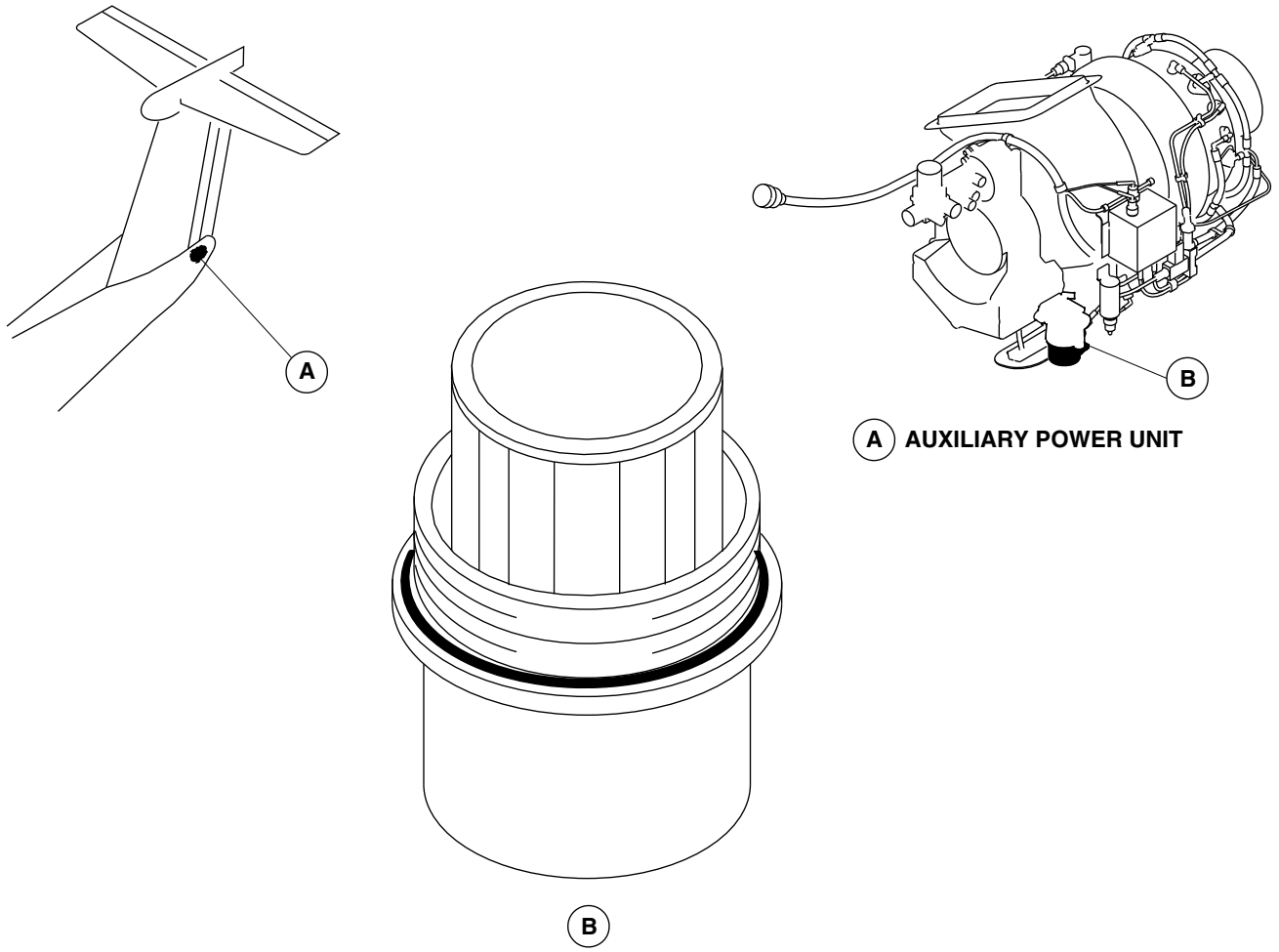
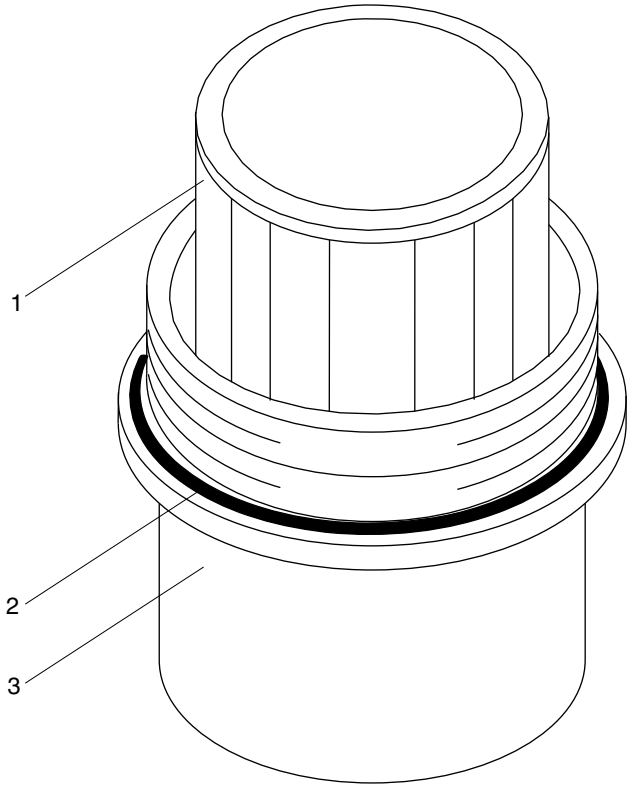
LEGEND

1. Fuel Nozzles.
2. Main Fuel Manifold.

Main Fuel Manifold and Nozzles Detail Page 2
Figure 12



Fuel Filter Locator
Figure 13



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LEGEND

1. Fuel Filter Element.
2. O–Ring.
3. Filter Bowl.

Fuel Filter Detail
Figure 14

**ON A/C ALL

49–40–00–001

IGNITION AND STARTING

Introduction

The starting and ignition system includes the controls, indicators and switches for automatic starting, acceleration, operation and monitoring of the APU.

General Description

The system includes the components that follow:

APU Control Panel

Starter/generator

Ignition Exciter

Ignitor Plugs

Detailed Description

Refer to Figures 1 and 2.

The APU is started by selecting the START switch on the APU control panel. The start sequence and operating sequence are then automatically controlled by the APU Full Authority Digital Electronic Control (FADEC).

APU Control Panel

The APU control panel is installed on the right hand side of the flight compartment overhead panel. Four switches and an annunciator are installed next to each other in one row. The panel is supplied with 5 Vdc background lighting when selected. The START switch is a momentary switch, the other switches are alternate actuation switches.

Selecting the power (PWR) switch applies 28 Vdc power to the FADEC, enabling APU functions and the control panel advisory lights. Pressing the START switch starts the auto start sequence. FADEC signals the Generator Control Unit to begin the start sequence.

After the APU has started and the RUN advisory light on the PWR switch has come on, the GEN ON switch selects the generator and BL AIR selects bleed air on.

Pushing the PWR switch, when the APU is operating, will close the fuel valves and shut down the APU. This is a normal shut down and will not turn on the advisory or caution lights.

GEN OHT turns on when the generator is hot.

FAIL turns on for any detected failure of the APU or APU control functions.

Starter Generator

The air–cooled 28 Vdc, 400 A starter generator is installed on the APU gearbox at the front of the APU. The starter generator functions as a starter and a generator. During the start sequence it is energized by 28 Vdc from the aircraft electrical system. At 50% speed the starter is de–energized. When the APU reaches 95%

speed plus 3 seconds the generator function is available. The generator gives electrical power to the aircraft left main bus and has the same generating capacity as the aircraft main generators. The Generator Control Unit regulates the generator output and controls the starter/generator contactor.

Ignition Exciter

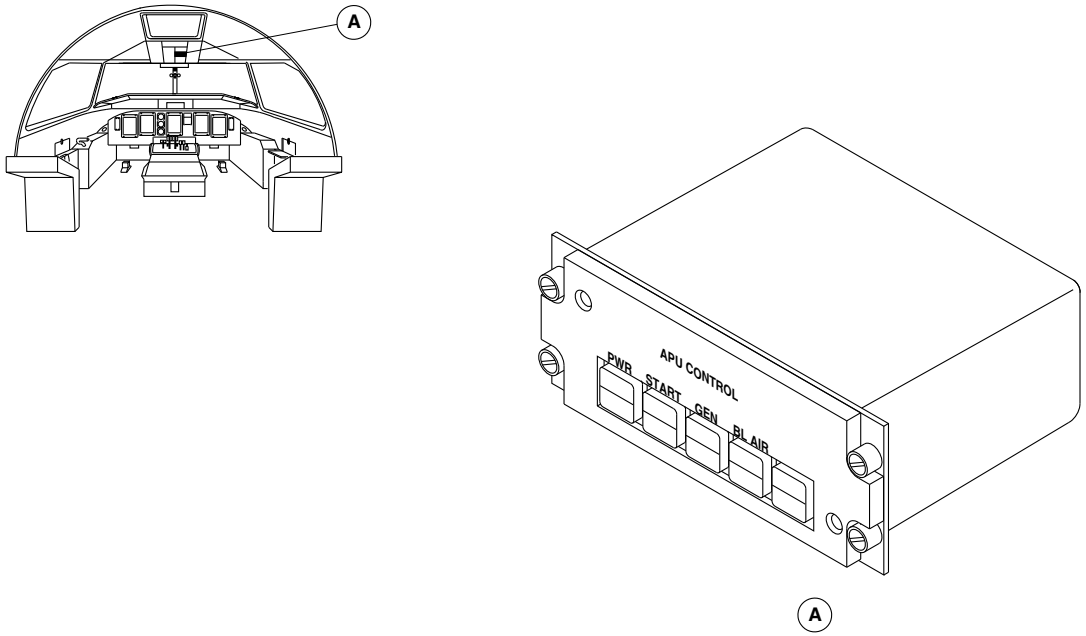
Refer to Figures 3 and 4.

The ignition exciter is installed on the left side of the engine. The exciter is a capacitor discharge unit that uses 28 Vdc to give intermittent high voltage to the ignitor plugs.

The exciter gives high voltage outputs and can be dangerous. When replacing the ignition exciter, be sure electrical power is removed from the exciter for a minimum of 5 minutes. Disconnect ignitor cables from the ignitor plugs. Discharge the exciter by touching the ignitor cable ends to the ignitor plug shells. Be sure exciter is fully discharged before removing the ignitor cables and exciter.

Ignitor Plugs

Two ignitor plugs are installed, one on the left side and one on the right side of the engine. The ignitor plugs are threaded into the engine combustor housing. The 10 milllimeter, gap type ignitors give a high voltage intermittent spark that ignites the fuel–air mixture in the combustor. The ignitors are connected to the Ignition Exciter by two separate shielded ignition cables.



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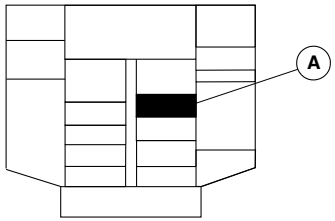
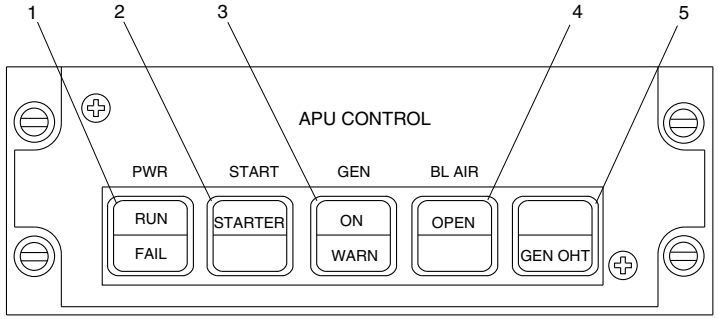
APU Control Panel Locator
Figure 1



OVERHEAD CONSOLE



LEGEND

1. Power Run\Failure Pushbutton Annunciator Switch.
2. Starter Pushbutton Annunciator Switch.
3. Generator On\Warning Pushbutton Annunciator Switch.
4. Bleed Air Open Pushbutton Annunciator Switch.
5. Generator Overheat Annunciator Light.

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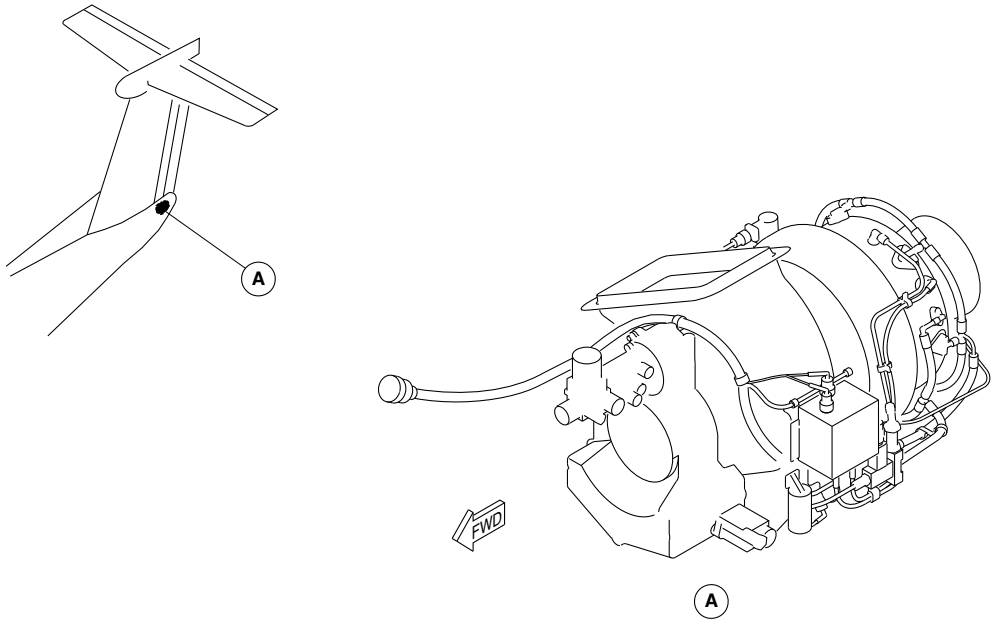
APU Control Panel Detail
Figure 2



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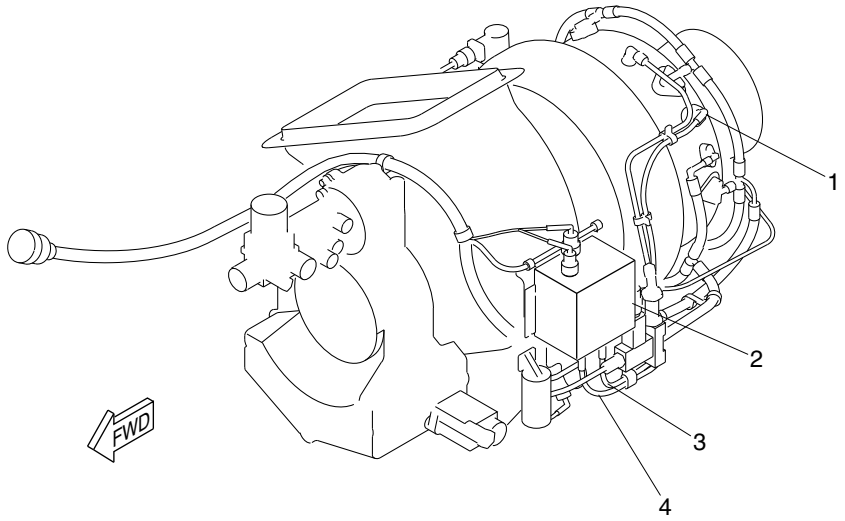
APU Ignition System Locator
Figure 3



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LEGEND

1. Igniter Plug.
2. Ignition Exciter.
3. Ignition Cable (B).
4. Ignition Cable (A).

APU Ignition System Detail
Figure 4

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**ON A/C ALL

49–50–00–001

AIR

Introduction

The APU bleed air system supplies compressed air for air conditioning and other aircraft pneumatic requirements.

General Description

The aircraft air inlet supplies the air to the APU air inlet assembly that is then compressed by the APU compressor. The compressed air is used in the operation of the APU and to supply air to the aircraft pneumatic systems.

Detailed Description

Refer to Figure 1.

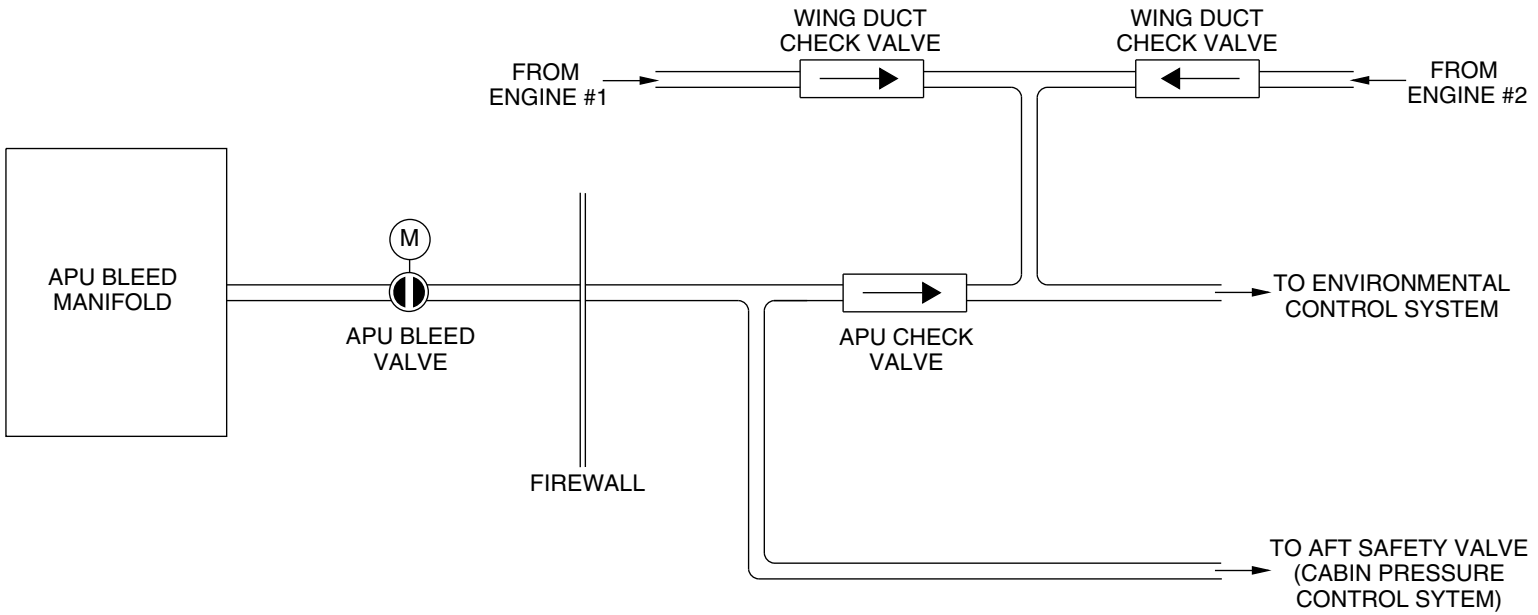
The APU bleed air system supplies compressed air for air conditioning and other aircraft pneumatic requirements.

APU Bleed Valve

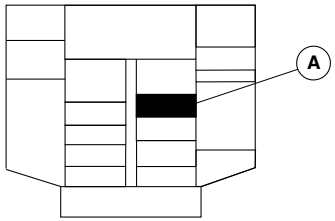
Refer to Figures 2 , 3 and 4.

The bleed valve is an electro–pneumatic butterfly valve that is normally closed. The valve is located on the APU combustor housing bleed air duct and controlled by the FADEC. FADEC receives a signal from the BL AIR switch on the APU control panel.

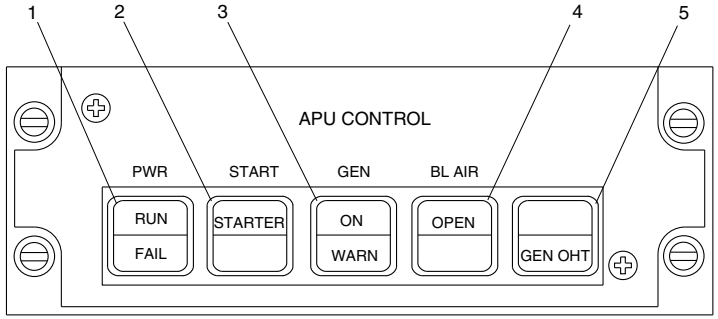
The FADEC uses signals from the APU exhaust thermocouples to control the Bleed Valve during bleed air delivery. If the APU exhaust gas temperature (EGT) reaches 692 °C the Bleed Valve will be modulated to reduce bleed air flow. This gives maximum air flow delivery without exceeding the APU exhaust gas temperature limits. Modulating bleed air flow in response to exhaust gas temperature limits lets generator loads have priority over bleed air delivery.



APU Bleed Air Schematic
Figure 1



OVERHEAD CONSOLE



LEGEND

1. Power Run\Failure Pushbutton Annunciator Switch.
2. Starter Pushbutton Annunciator Switch.
3. Generator On\Warning Pushbutton Annunciator Switch.
4. Bleed Air Open Pushbutton Annunciator Switch.
5. Generator Overheat Annunciator Light.

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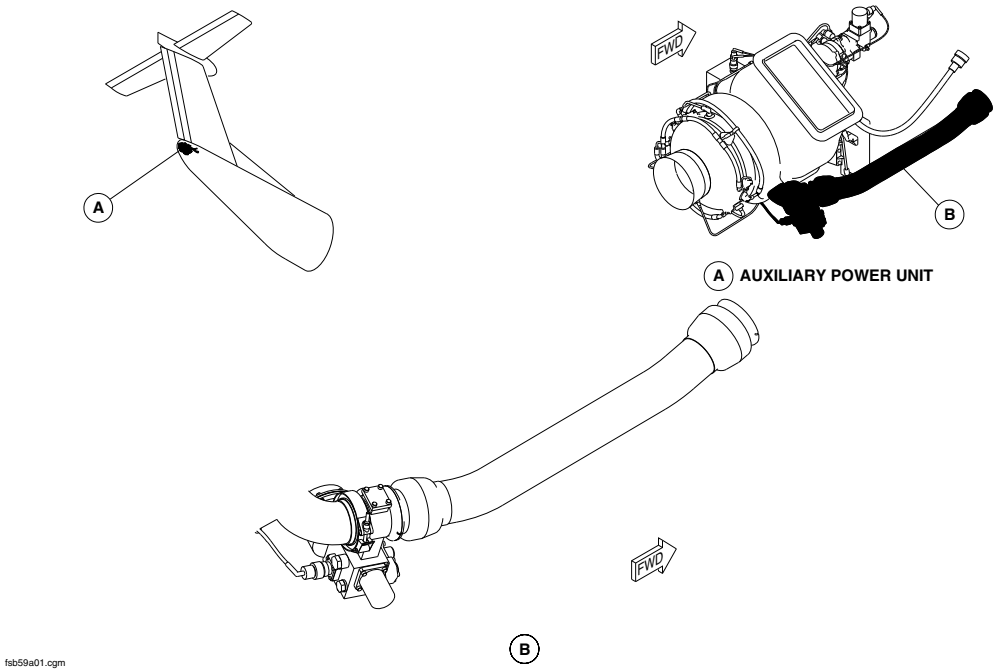
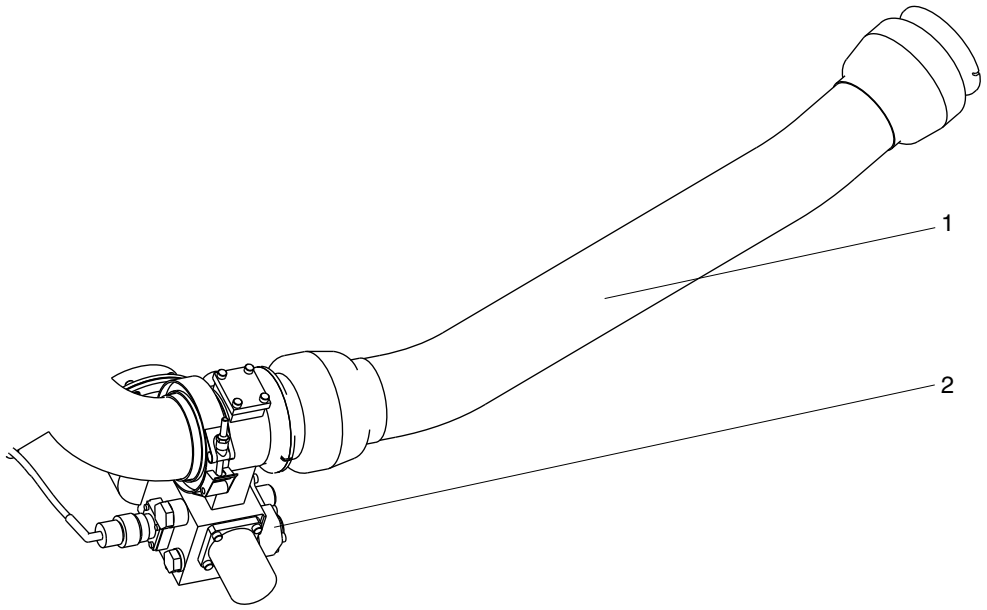
APU Control Panel and BL AIR Switch
Figure 2



Bleed Valve Locator
Figure 3

LEGEND

1. Bleed Duct.
2. Bleed Valve.



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Bleed Valve Detail
Figure 4

**ON A/C ALL

49–60–00–001

ENGINE CONTROLS

Introduction

The Auxiliary Power Unit engine control system controls the operation of the APU. The system also records all operations of and events associated with the APU.

General Description

The engine controls include the components that follow:

- APU Control Panel
- Full Authority Digital Electronic Control (FADEC)

Detailed Description

Refer to Figure 1.

The APU Control Panel is located in the flight compartment and installed in the center overhead panel.

PWR SWITCHLIGHT (alternate action)

- PUSH – arms APU start circuits and opens the APU fuel valve, APU FUEL VALVE OPEN light (green) shown on the APU fire protection panel – only arms aircraft on ground, no fire detected, and EXTG switch not selected
- RUN segment (green) – APU is at operating speed after the START switchlight is pushed
- PUSH – RUN segment (blank) – closes APU fuel valve, APU FUEL VALVE CLOSED light (white) shown on the APU fire protection panel, to stop APU
- FAIL – a failure is detected and the APU automatically stops.

START SWITCHLIGHT (alternate action)

- PUSH – STARTER segment (amber) – starts automatic APU start sequence
- STARTER segment (blank) – APU start sequence complete or stopped

GEN SWITCHLIGHT (alternate action)

- PUSH – ON segment (green) – APU starter–generator is supplying DC power
- PUSH – ON segment (blank) – selects APU generator off line
- WARN segment (amber) – APU starter–generator off line.

BL AIR SWITCHLIGHT (alternate action)

- PUSH – OPEN segment (green) – APU bleed air valve open– APU bleed air supplies air to the ECS if engine bleed air is off
- PUSH – OPEN segment (blank) – APU bleed air valve is closed – selects APU bleed air off

GEN OHT ADVISORY LIGHT

- GEN OHT segment (amber) – APU starter–generator overheat condition – APU automatically shuts down

When the Power (PWR) switch is selected, 28 Vdc electrical power is supplied to the FADEC, enabling APU functions and the control panel advisory lights.

The START button is pushed to begin the auto start sequence. The FADEC commands the generator control unit to begin the start sequence.

After the APU is started and the RUN advisory is displayed on the PWR button, the generator can be set to ON by the generator button and bleed air can be selected, by pressing OPEN on the BL AIR button.

The FAIL light on the PWR button shows that a malfunction or failure has been sensed in the APU system.

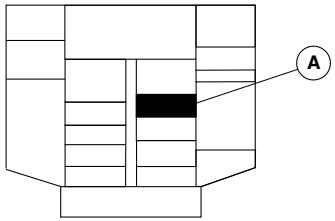
The WARN light on the GEN button shows that the APU generator is not on line.

The GEN OHT light on the APU control panel comes on to warn of a generator overheat. The APU caution light in the flight compartment will also come on in this situation.

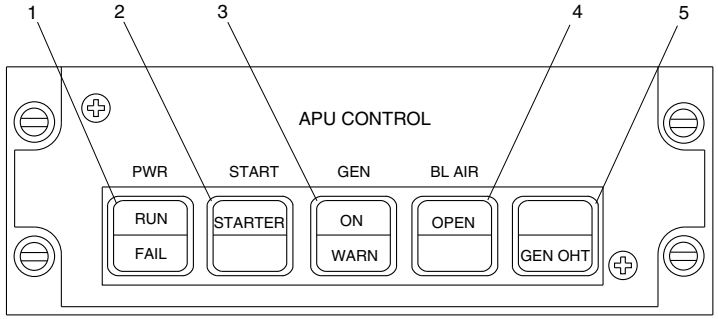
Full Authority Digital Electronic Control (FADEC)

Refer to Figure 2.

The Full Authority Digital Electronic Controller (FADEC) is a microprocessor based controller. The FADEC has the necessary functions for control sequencing, condition monitoring, fault detection, fault isolation and protection of the APU system. The FADEC also transmits fault and maintenance data to the aircraft Centralized Diagnostic System (CDS) through the ARINC 429 data link. This data is used to provide APU maintenance information.



OVERHEAD CONSOLE



LEGEND

1. Power Run\Failure Pushbutton Annunciator Switch.
2. Starter Pushbutton Annunciator Switch.
3. Generator On\Warning Pushbutton Annunciator Switch.
4. Bleed Air Open Pushbutton Annunciator Switch.
5. Generator Overheat Annunciator Light.

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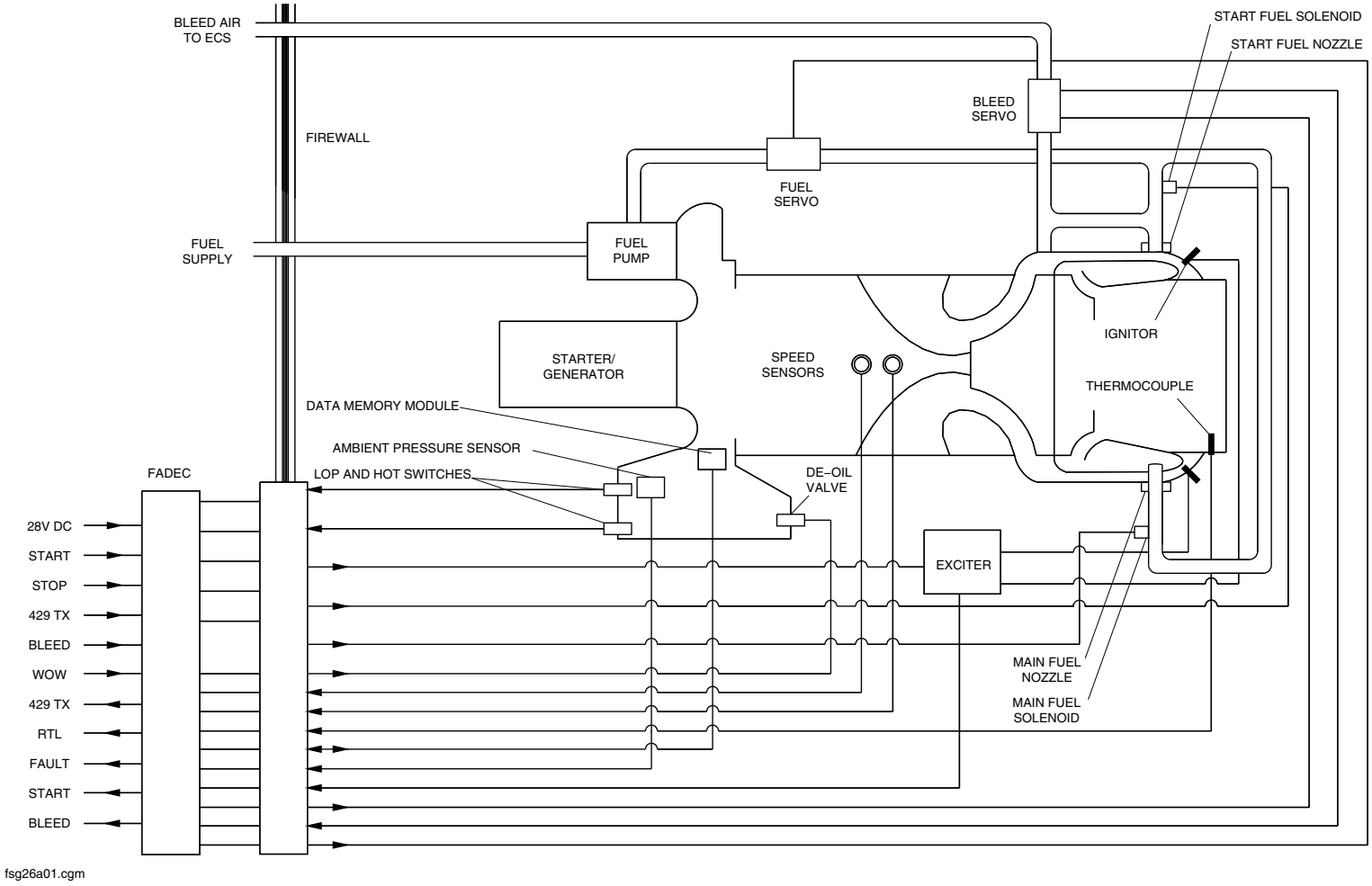
APU Control Panel Page 1
Figure 1



APU Control Panel Page 2
Figure 2

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49–70–00–001

INDICATING

Introduction

The Indicating System supplies the engine operating parameters to the Full Authority Digital Electronic Control (FADEC) for APU engine monitoring and control.

General Description

The Indicating System has the components that follow:

- Sensor, Ambient Pressure (49–70–01)
- Sensor, Speed (49–70–06)
- Thermocouple (49–70–11)
- Hourmeter (49–70–16)
- Counter, Start (49–70–21)
- Switch, High Oil Temperature (49–70–26)
- Switch, Low Oil Pressure (49–70–31)
- Data Memory Module

Detailed Description

At start initiation, the FADEC records the Exhaust Gas Temperature (EGT). This EGT value is used for reference during the start sequence where specific rises in EGT need to occur before the start sequence can continue. During the start sequence FADEC uses signals from the:

- Ambient pressure sensor
- Speed sensor
- Thermocouples,

to schedule fuel flow and initiate and monitor the start sequence.

Sensor, Ambient Pressure

Refer to Figures 1 and 2.

The sensor is located at the left side of the APU. The sensor supplies ambient pressure information to the FADEC prior to start. This information is used for altitude compensation of the fuel during start and operation of the APU. A loss of the ambient pressure signal results in an advisory fault and the FADEC will default to sea level ambient pressure.

Sensor, Speed

The sensor is installed to the air inlet housing. The sensor is a single–probe, dual coil device. The magnetic probe extends through the air inlet housing and aligns with the lobes on the quill shaft. The dual coils give redundant speed signals. The sensor generates redundant sinusoidal signals, which are transmitted to the FADEC and used for start sequencing and speed sensing (overspeed and underspeed). The two signals are averaged by FADEC to give the rated speed. If the difference between the two signals exceeds 5%, the FADEC will use the higher value. Failure of one signal will result in an advisory fault. Loss of both signals will cause an automatic APU shutdown.

Thermocouple

The two single–element, closed end, chromel/alumel thermocouples are located on the APU exhaust flange and extend into the exhaust gas stream. The thermocouples are installed 90 degrees apart, at the five and eight o'clock positions and supply millivolt signals that are used by FADEC for exhaust gas temperature sensing. The FADEC averages the two signals to give the exhaust gas temperature. If the difference between the two thermocouples is greater than 200 °F (93.3 °C), the FADEC will use the higher value. An open or short failure of one thermocouple will result in an advisory message. Failure of both thermocouples will cause an APU shutdown.

Hourmeter

see Data Memory Module section

Counter, Start

see Data Memory Module section

Switch, High Oil Temperature

Refer to Figures 3 and 4.

The switch is located on the forward face of the gearbox assembly. The switch is normally open and closes if the oil temperature exceeds 275 °F (135 °C). A closed switch will result in the FADEC shutting down the APU.

Switch, Low Oil Pressure

The switch is located on the forward face of the gearbox assembly and senses oil pressure, downstream of the oil filter. The normally closed switch opens when oil pressure exceeds 35 psig (241 kPag), the switch will close when oil pressure decreases below this value during APU operation. Prior to start, the FADEC checks the position of the switch. During operation the FADEC begins checking for low oil pressure after Ready To Load (RTL). An open switch prior to start (failed switch), or a closed switch during operation (failed switch or low pressure) will result in the FADEC automatically shutting down the APU.

Data Memory Module

The Data Memory Module (DMM) is a solid state device located on the engine assembly. The DMM contains a mirror image of the data contained in the non–volatile memory (NVM) within the FADEC. Data stored in the DMM includes:

- APU operating hours and starts
- APU and FADEC fault history, 50 shutdown and 50 advisory faults
- FADEC, APU and DMM serial numbers.

FADEC updates the DMM at the same time the data is updated in the FADEC NVM. This feature enables hours/cycles and fault history to be resident on the engine assembly.

The DMM can communicate directly with a laptop PC for interrogation either on–wing or at a repair station. Should the FADEC or DMM be replaced on–wing, the data is automatically copied to the newly replaced item, controlled by software without technician intervention.

After ready to load, which occurs at 95% speed plus 3 seconds, ambient pressure is used by FADEC to set the minimum and maximum fuel set points. The speed sensor signal is used by

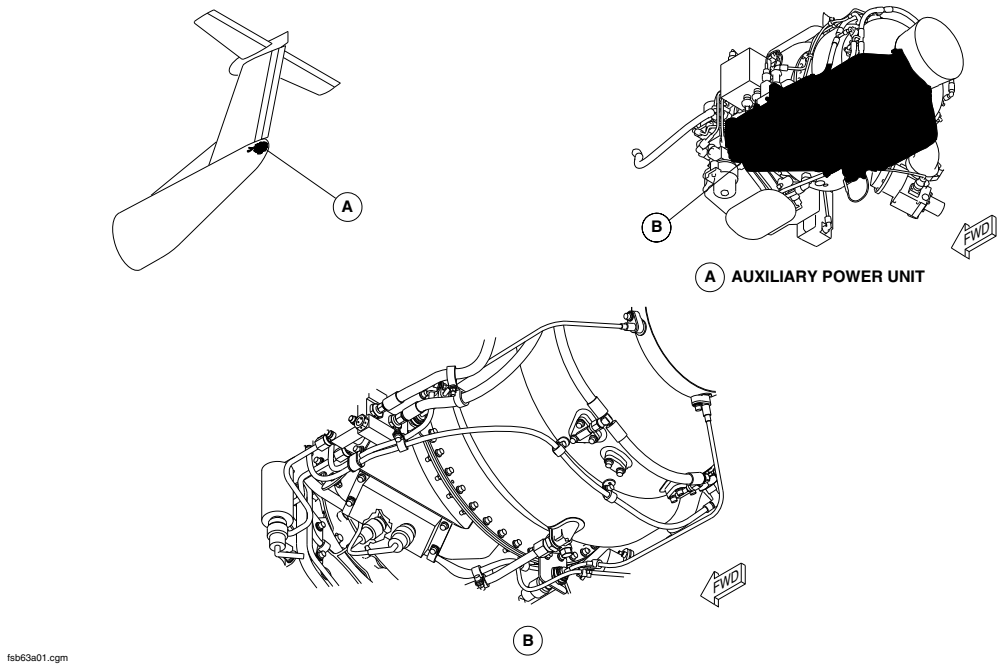
FADEC, to ensure 100% speed is maintained by increasing or decreasing fuel flow through the fuel servo valve. The signal is also used to monitor for overspeed and underspeed conditions.

During operation FADEC also monitors the:

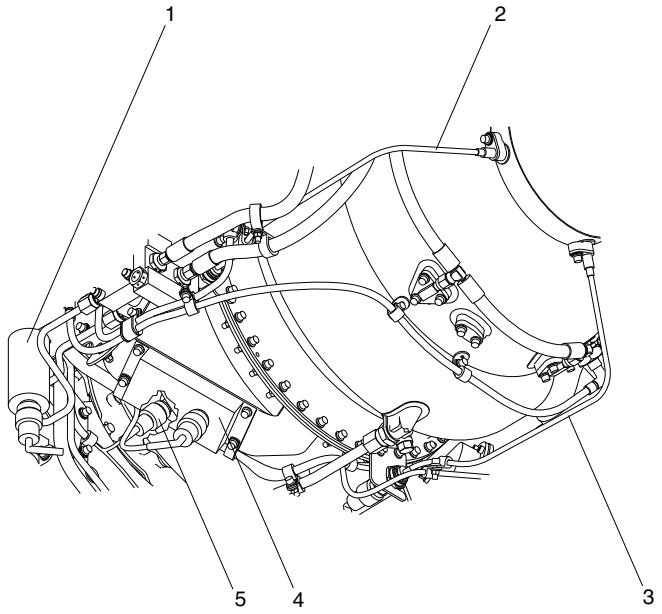
- Exhaust gas temperature
- Oil pressure
- Oil temperature

The conditions that follow will cause an automatic APU shutdown:

- Low oil pressure below 35 psig (241 kPag)
- High oil temperature above 275 °F (135 °C)
- Overtemperature EGT above 1890 °F (1032 °C) during start, 1324°F (718 °C) during run
- Underspeed less than 95%
- Overspeed 105%



APU Sensors Location
Figure 1



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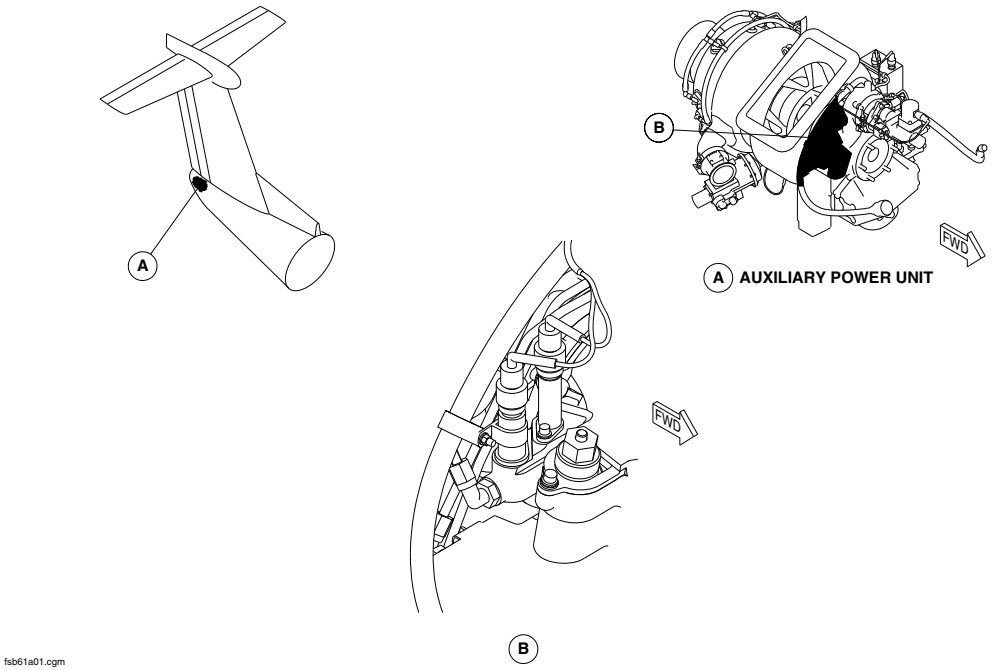
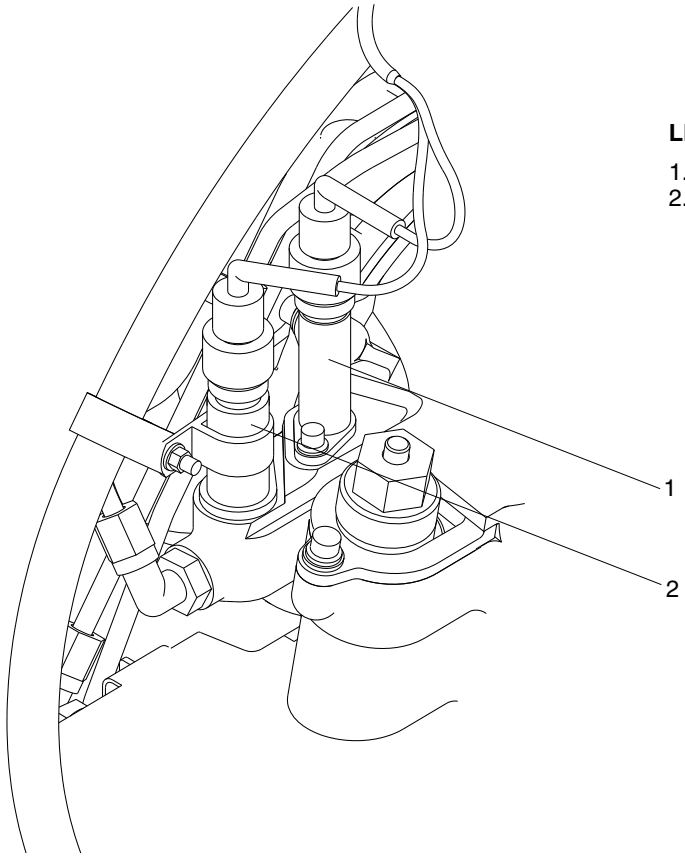
LEGEND

1. Ambient Pressure Sensor.
2. Thermocouple 1.
3. Thermocouple 2.
4. Data Memory Module.
5. Speed Sensor.

APU Sensors Detail
Figure 2



APU High Oil Temperature and Low Oil Pressure Sensors Location
Figure 3



LEGEND

1. High Oil Temperature Switch.
2. Low Oil Pressure Switch.

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APU High Oil Temperature and Low Oil Pressure Sensors Detail
Figure 4

**ON A/C ALL

49–80–00–001

EXHAUST AND TAILCONE VENTILATION

Introduction

Refer to Figure 1.

The APU exhaust system vents the exhaust gases from the APU to the environment, and the ventilation system cools the APU.

General Description

The APU exhaust system consist of an exhaust nozzle and a silenced exhaust duct. This setup also assists in the ventilation of the APU. The ventilation is achieved through a cut out located on the bottom center line on the tailcone.

Detailed Description

The APU exhaust nozzle and the silenced exhaust duct are not connected but arranged to form an ejector system. The exhaust gas is discharged from the duct through an upwards pointing outlet at the aft end of the duct.

NOTE

The exhaust nozzle is removed as part of the APU. The exhaust duct is easily removed after you remove the APU.

The APU and the tailcone are kept cool by the exhaust flow. This exhaust flow, drives the ejector system which cools the APU by ventilation.

Ambient air enters the tailcone through a 4 inch diameter cutout. This is located at the bottom centerline of the tailcone between the firewall and the access door. The cutout is protected by a stainless steel 1/4 inch mesh screen. The mesh screen is located between a riveted titanium doubler and the tailcone skin.

The air is ducted from the cutout by a tube to the area immediately in front of the oil sump to assist in oil cooling. The air then flows around the APU and finally it is ejected into the ejector gas flow.

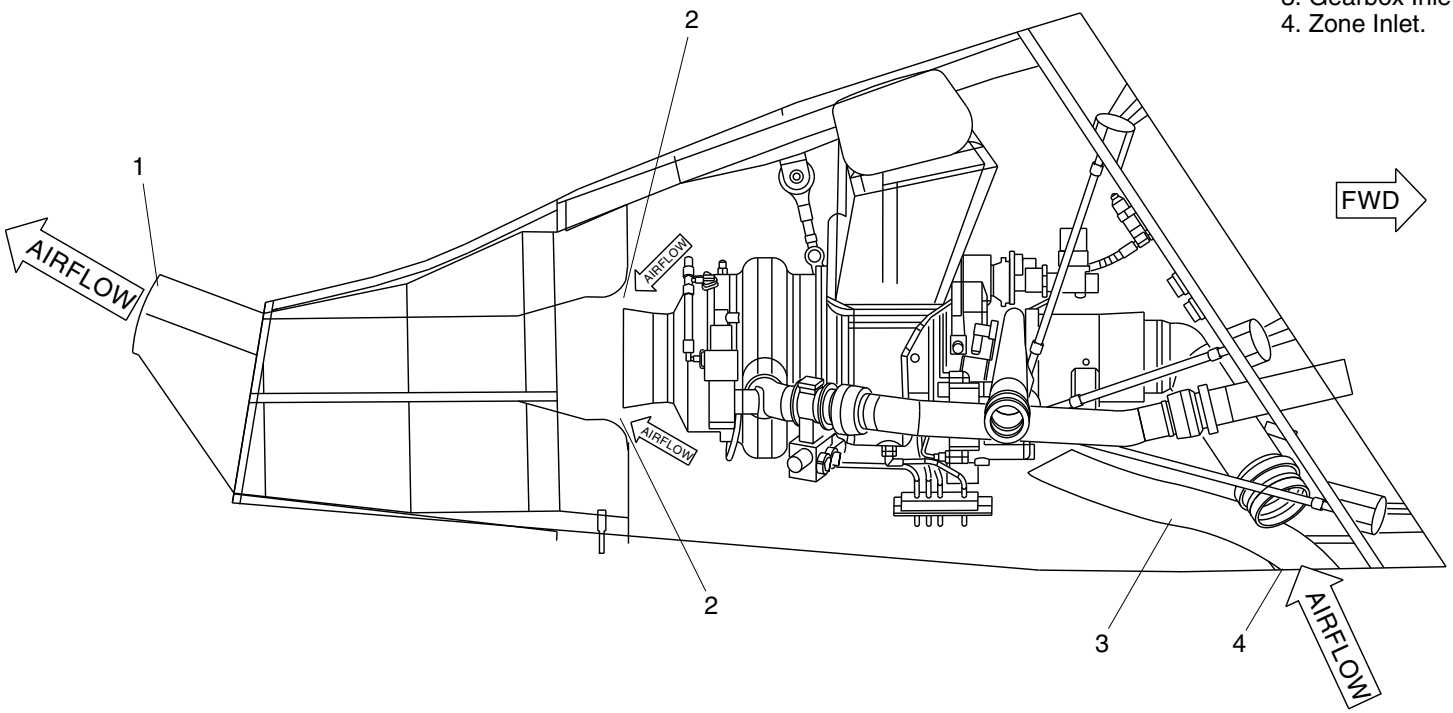
After shut down, the APU and the surrounding area is cooled by soak back cooling. This is done by convective flow primarily through the normal ventilation system. The principles of convective flow is to have the exhaust duct outlet at the highest point of the system. This is supplemented by flow around the outside of the exhaust duct, which has a diametrical clearance with the tailcone structure.

NOTE

If you operate the APU with the access doors open, it may result in an oil overheat automatic shutdown

LEGEND

1. Exhaust Outlet.
2. Ejector Inlet.
3. Gearbox Inlet Duct.
4. Zone Inlet.



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APU Exhaust and Tailcone Ventilation
Figure 1

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49–90–00–001

OIL

Introduction

The APU oil system supplies pressurized oil to the gearbox and the engine rotor assembly to lubricate and cool the gears and the bearings.

General Description

Refer to Figure 1.

A positive displacement gear type oil pump is located inside the gearbox and supplies oil flow to the system. The oil pump supplies oil to the gearbox and the engine rotor assembly through the fuel/oil cooler where the oil is cooled by fuel. If oil flow is restricted through the cooler, a cooler bypass valve opens at 65 to 70 psig (448 to 483 kPag). The valve is located in the gearbox. The oil is filtered through a 10 micron replaceable filter and then flows into the oil system.

The oil pressure relief valve, located between the oil filter and the gearbox oil jets, maintains the system oil pressure of 60 psig (414 kPag). The valve is a non–adjustable component.

High oil temperature and low oil pressure switches monitor the oil system. If either low oil pressure or high oil temperature condition occurs, the APU will shutdown.

The gears and bearings are lubricated and cooled by oil jets and oil mist that is generated by the rotating gears. The oil/air separator is part of the fuel control gear and separates the oil from the air inside the gearbox. The oil returns by gravity to the oil sump and the air is vented overboard through the drain mast vent.

Lubrication and cooling of the rotor bearings is supplied by the gearbox oil pressure system. Oil is injected into the hollow pinion shaft that is splined into the rotor shaft. The pinion shaft delivers oil to the passages located inside the rotor shaft. During engine operation, centrifugal force lets the oil flow through the internal passages to the ball and roller bearings. Oil return from the rotor bearings is accomplished by gravity flow to the gearbox oil sump.

The oil system contains the components that follow:

- Gear type pump
- De–prime valve
- Fuel/oil cooler
- Fuel/oil cooler bypass valve
- Filter
- Pressure relief valve
- High temperature switch
- Low pressure switch
- Oil/air separator
- Carbon seal drain
- Labyrinth seal
- Oil filler port
- Sight glass
- Magnetic drain plug

Detailed Description

The detailed description of the Auxiliary Power Unit oil system is as follows:

Oil Pump

A positive displacement gear type oil pump is located inside the gearbox and supplies oil flow to the system.

Deprime Valve

Refer to Figures 2 and 3.

The deprime valve is a solenoid operated valve and is located on the lower, right side of the gearbox. The valve is energized open to prevent the oil pump from supplying oil during engine startup and shutdown. Above 50% engine speed the deprime valve is de–energized closed and the oil pump produces oil flow. During engine shutdown the deprime valve is energized open for 16 seconds, to prevent oil pump output and to let the oil remaining in the system drain back into the sump.

Fuel/Oil Cooler

The Fuel/Oil cooler is located on the lower, right side of the gearbox. The cooler is a fuel/oil heat exchanger that uses fuel from the fuel control to supply cooling of the oil.

Fuel/Oil Cooler Bypass Valve

The valve is located in the gearbox. In the event the oil flow is restricted through the cooler, the cooler bypass valve opens at 65 to 70 psig (448 to 483 kPag).

Oil Filter

Oil filtration is supplied by a disposable 10 micron filter. The oil filter bypass valve assembly includes a visual impending by pass indicator and a bypass valve. The indicator is visible when differential pressure across the filter reaches 60 to 80 psid (414 to 552 kPad). The bypass valve opens when the differential pressure across the filter reaches 105 to 125 psid (724 to 862 kPad).

Oil Pressure Relief Valve

The oil pressure relief valve, located between the oil filter and the gearbox oil jets, maintains the system oil pressure of 60 psig (414 kPag). The valve is a non–adjustable and non–replaceable component.

High Oil Temperature Switch

Refer to Figures 4 and 5.

The high oil temperature switch is a normally open switch and closes if the oil temperature is more than 275 ±5 °F (135 ±3 °C). A closed switch will result in the APU shutting down.

Low Oil Pressure Switch

The Low Oil pressure Switch senses oil pressure downstream of the oil filter. The normally closed switch opens when oil pressure is more than 35 ±5 psig (241 ±34.5 kPag) and remains open during normal operation of the APU. Oil pressure is not monitored until the APU has reached 100% speed and the switch has been closed for 12 seconds. A closed switch will initiate a shutdown of the APU.

Oil Air Separator

The oil/air separator is part of the fuel control gear and separates the oil from the air inside the gearbox. The oil returns by gravity to the oil sump and the air is vented overboard through the drain mast vent.

Carbon Seal

The carbon face seal prevents oil in the bearing area from entering the compressor. The stationary seal gives a leak proof seal between the rotating inner race of the roller bearing and the carbon face seal.

Carbon Seal Drain

A drain system lets any oil that may leak past the carbon seal vent back to the gearbox.

Labyrinth Seal

The Labyrinth Seal is pressed on to a machined shoulder located on the hub of the compressor wheel. The seal uses engine compressor air to give a non–contact air seal between the Labyrinth Seal and the Bearing Area. The air across the seal is vented into the carbon seal drain passage. If oil leaks through the carbon face seal, the Labyrinth Seal prevents oil from entering the compressor.

Oil Filler Port

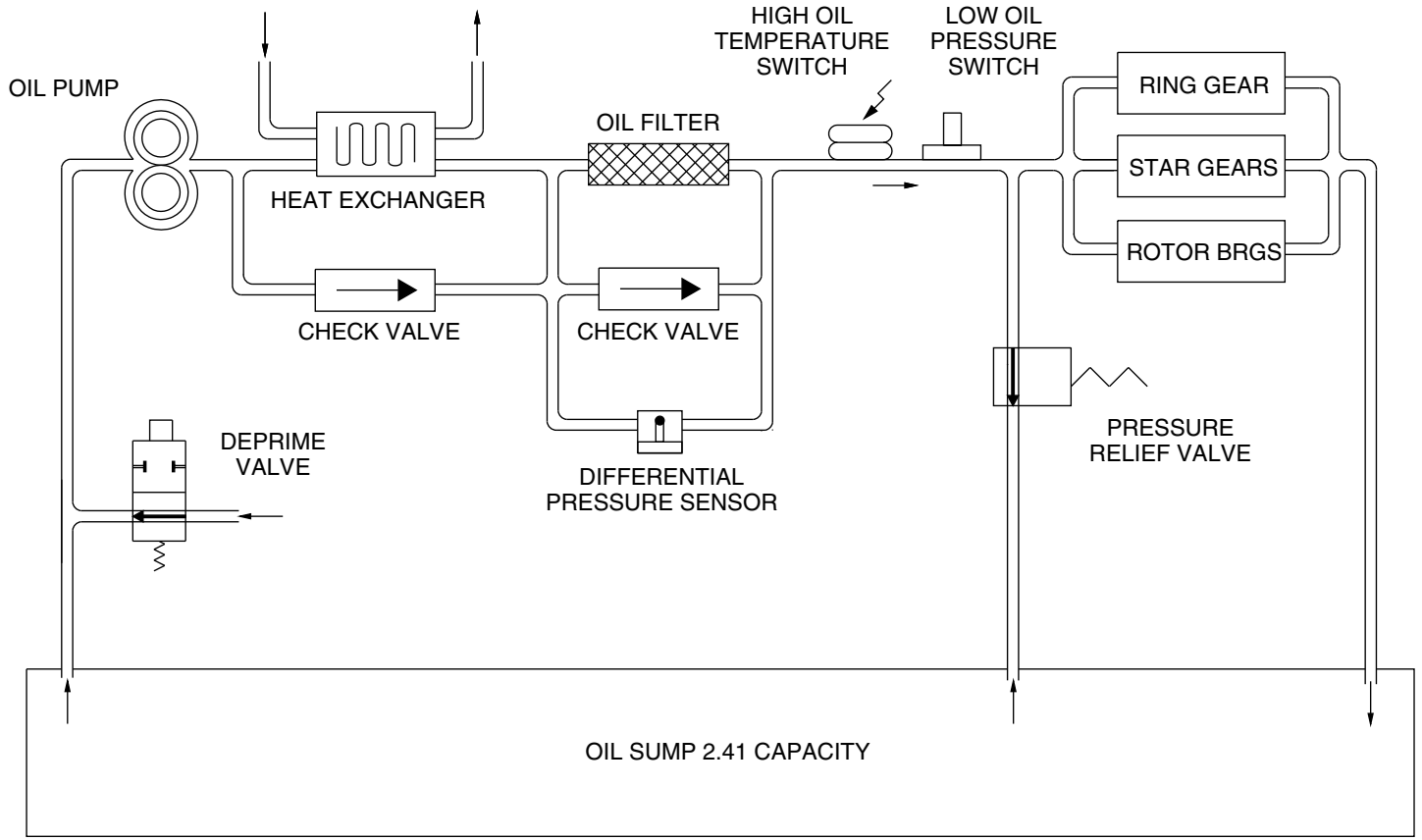
The oil system is serviced through the oil filler port. The locking cap is removed and oil is poured into the filler port. The locking cap has a dip stick that is marked ADD and FULL.

Oil Sight Glass

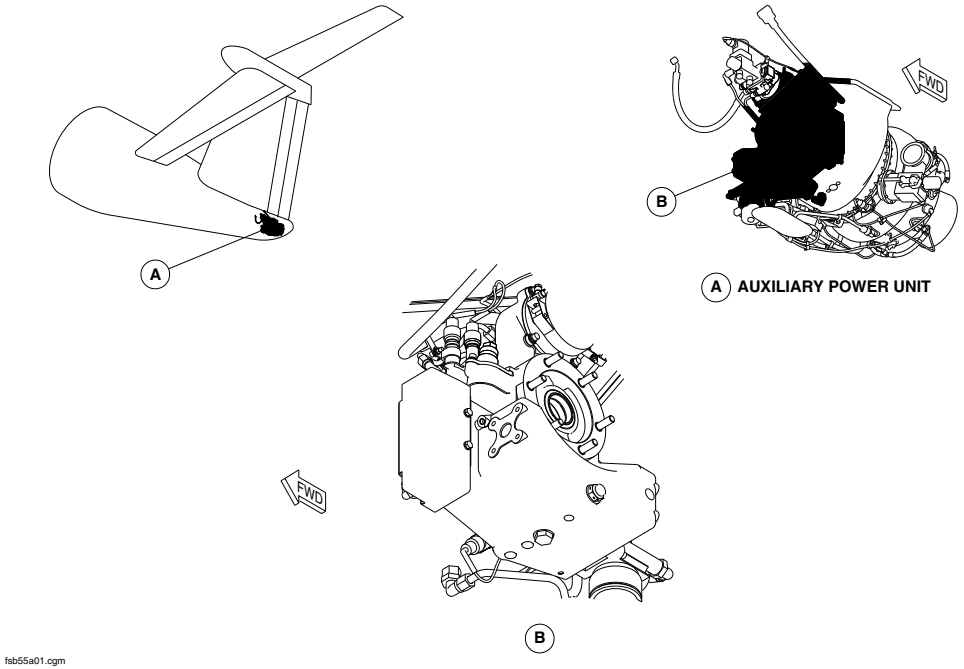
The Oil Sight Glass is located below the Oil Filler Port and gives a visual indication of the oil level in the gearbox oil sump. Proper servicing of the oil system is done by monitoring the sight glass and the dip stick.

Magnetic Drain Plug

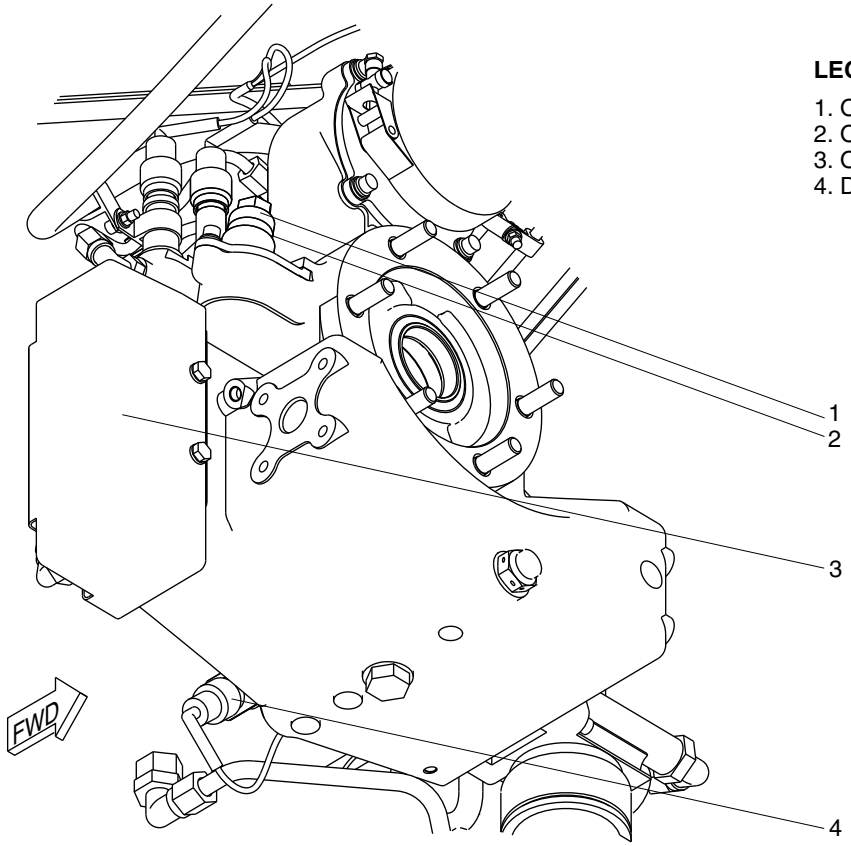
A magnetic drain plug is located on the lower, front side of the gearbox housing. When the plug is removed, oil is drained from the oil sump. The drain plug has a magnetic chip detector that attracts ferrous metal particles in the oil. The detector may be removed, inspected, and installed without draining the oil sump. A check valve located inside the drain plug prevents oil from draining when the chip detector is removed.



Oil System Schematic
Figure 1



Oil System Components Location
Figure 2



LEGEND

1. Oil Filter Bypass Valve.
2. Oil Filter Element.
3. Oil Cooler.
4. Deprime Solenoid Valve.

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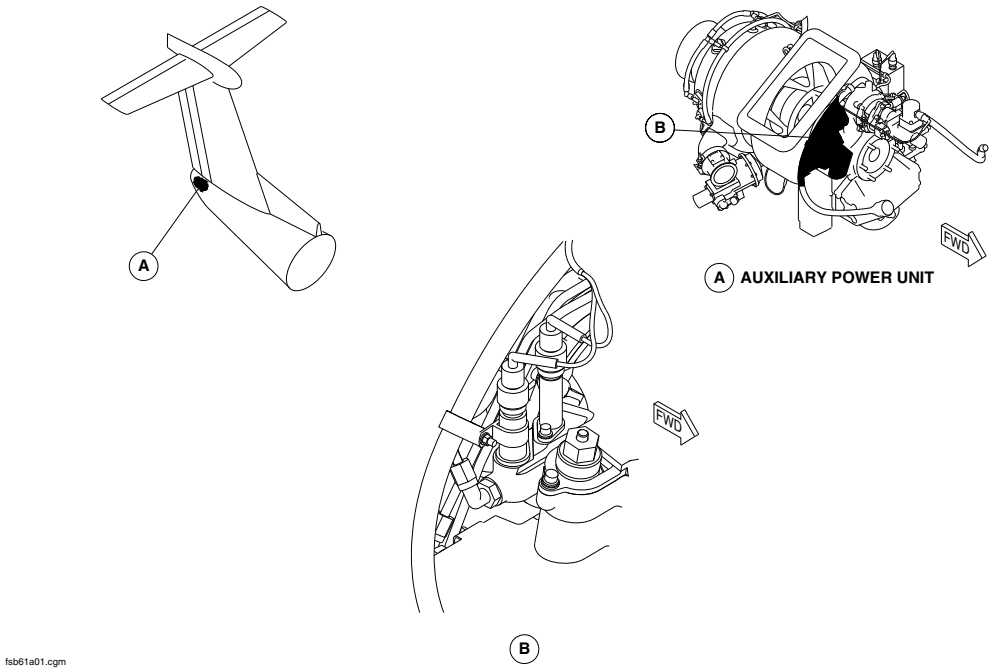
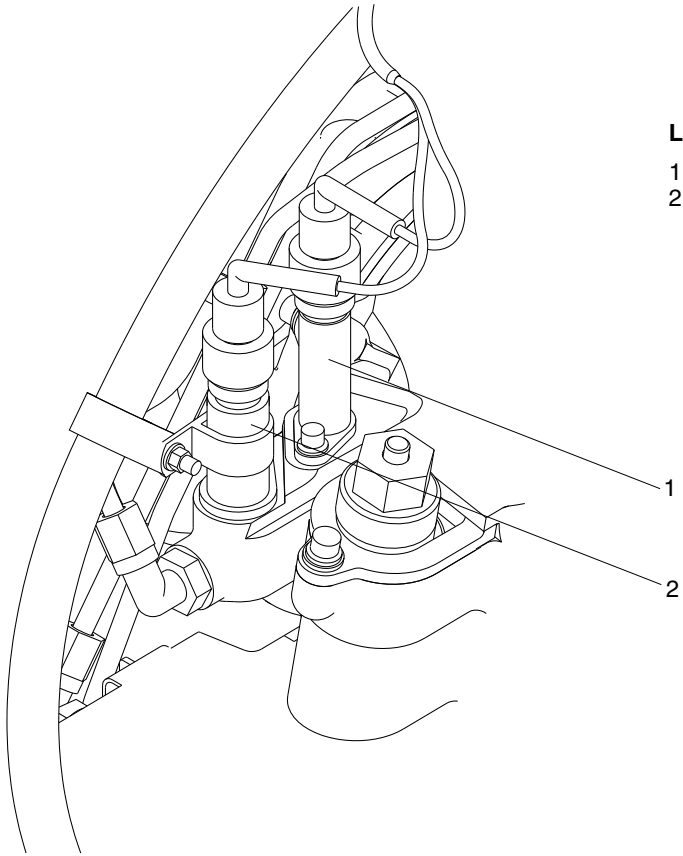
Oil System Components Detail
Figure 3



Oil System Switches Location
Figure 4



LEGEND

1. High Oil Temperature Switch.
2. Low Oil Pressure Switch.

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Oil System Switches Detail
Figure 5

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