**ON A/C ALL

73–00–00–001

ENGINE FUEL AND CONTROL, GENERAL

Introduction

The fuel system supplies fuel at the correct pressure and flow to the fuel nozzles, throughout the full operating range of the engine.

General Description

The engine fuel system has the components that follow :

- Fuel Heater (AMM Chapter 73–11–01)
- Full Authority Digital Electronic Control (FADEC) (AMM Chapter 73–21–01)
- Fuel Metering Unit (FMU) with integrated fuel pumps (AMM Chapter 73–21–06)
- Fuel nozzle adapters (AMM Chapter 73–11–06)
- Flow divider valve and ecology tank (AMM Chapter 73–11–11)
- Fuel manifolds (AMM Chapter 73–11–26)
- Fuel tubes (AMM Chapter 73–11–16 and 73–11–21)
- Fuel filter (AMM Chapter 73–11–31)
- Electrical wiring harness (AMM Chapter 73–21–11)
- Characterization plug (AMM Chapter 73–21–16)
- Permanent Magnet Alternator (PMA) (AMM Chapter 73–21–21)
- Low fuel–pressure–switch (AMM Chapter 73–21–21)
- Fuel filter impending–bypass switch (AMM Chapter 73–31–06)

Detailed Description

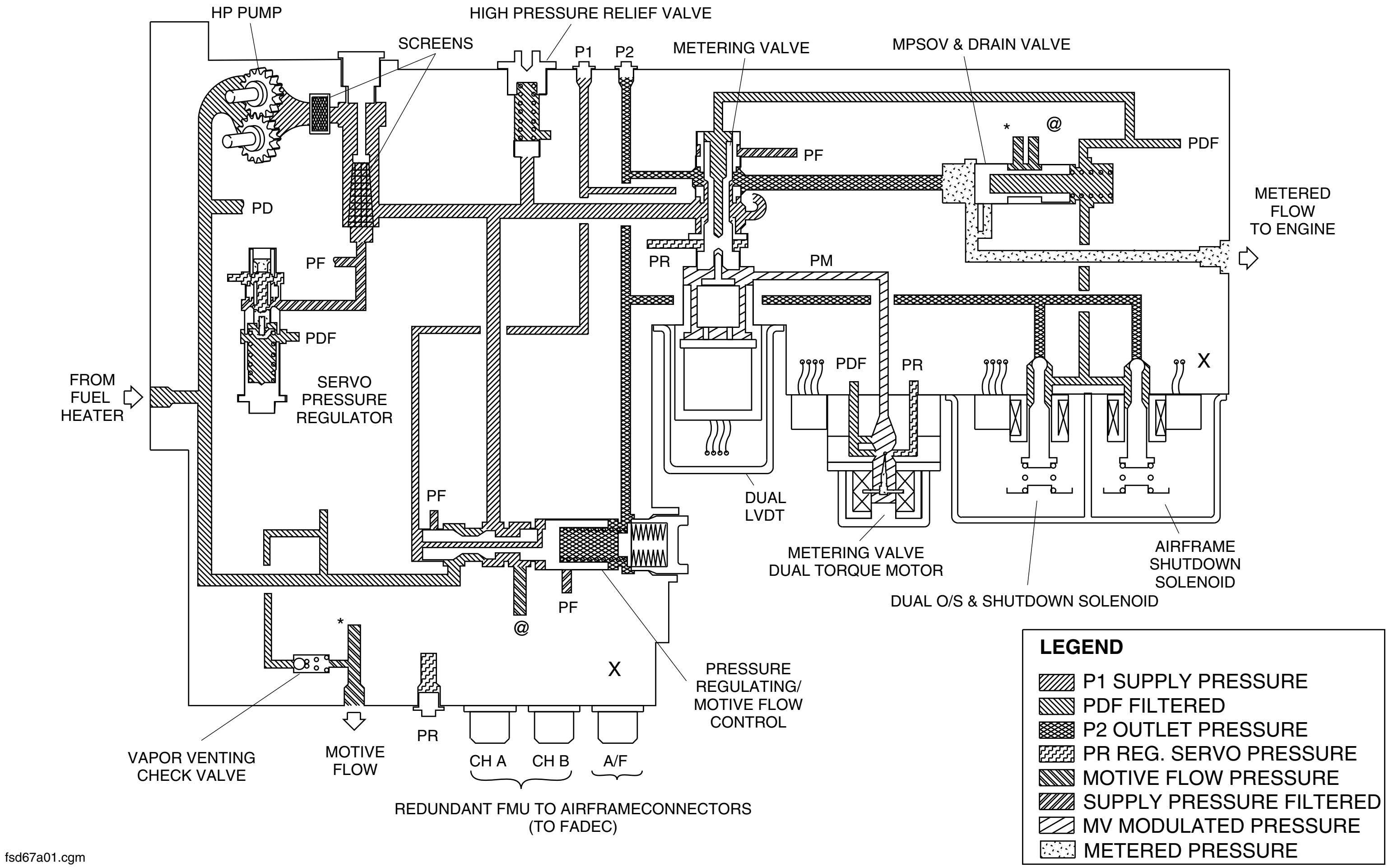
Refer to Figure 1.

The fuel is received by the Fuel Metering Unit (FMU) at the regenerative fuel–pump inlet–port from the airframe fuel pumps. The regenerative fuel pump then supplies fuel to the fuel heater. In the fuel heater, the fuel is heated (if necessary), filtered and returned to the FMU for metering.

The FMU controls the fuel flow supplied to the engine based on demand, through the Full Authority Digital Electronic Control (FADEC). The FADEC calculates the adequate amount of fuel to supply based on various engine sensory inputs like Nh, Nl, Np, engine temperature at various locations and torque calculations. The FADEC acts on the metering valve in the FMU to control the fuel flow. The metered fuel is then routed to the airframe–supplied flowmeter and to the flow divider valve through external tubes. Some of the metered fuel is also returned to the airframe fuel tanks to activate the main ejector pump.

The flow divider valve takes metered fuel and distributes the fuel between the primary and secondary fuel manifolds. When the fuel pressure coming from the FMU is low, only the primary manifold is supplied with fuel. As the fuel pressure increases, the secondary manifold is also supplied with fuel. The flow divider valve also recuperates the remaining fuel in the manifolds on engine shutdown. This fuel is then used on the next engine start.

The fuel manifolds take the fuel from the flow divider valve and supply the twelve fuel nozzle adapters. All fuel nozzle adapters are duplex units and have both primary and secondary passages.



Engine Fuel System Schematic
Figure 1

**ON A/C ALL

73–10–00–001

FUEL DISTRIBUTION SYSTEM

Introduction

The engine fuel distribution system supplies clean fuel to the engine to support combustion.

General description

The engine receives fuel from the airframe fuel system. The fuel passes through the Fuel Heater and is pumped by an integrated fuel pump located in the Fuel Metering Unit (FMU). The fuel is then metered by the FMU. The metered fuel goes to the Flow Divider Valve which separates it into Primary and Secondary for delivery to the Fuel Nozzles through the Fuel Manifolds.

The fuel distribution system consists of the following components:

- Fuel Heater (AMM Chapter 73–11–01)
- Fuel nozzle adapters (AMM Chapter 73–11–06)
- Flow Divider Valve (FDV) (AMM Chapter 73–11–11)
- Fuel tubes (AMM Chapter 73–11–16 and 73–11–21)
- Fuel manifolds (AMM Chapter 73–11–06)
- Fuel filter (AMM Chapter 73–11–31)

Detailed Description

Fuel for the engine passes through the oil to fuel heater to prevent ice forming in the fuel. From the fuel heater, the fuel passes through the fuel filter to remove any contaminant particles. The fuel then passes to the flow divider where it is directed to the primary and secondary fuel manifolds. The manifolds deliver the fuel to the nozzles, where it is atomized and sprayed into the combustor.

Fuel Heater

Refer to Figures 1 and 2.

The purpose of the fuel heater is to heat the fuel to prevent the formation of ice crystals. The fuel heater is an integral assembly made of aluminium castings consisting of a heater assembly and a filter assembly. Both assemblies are welded together and reinforced with struts.

The fuel heater is installed on the left side of the engine on the LP compressor case. It is connected to the FMU through two transfer tubes located on the forward face of the fuel heater. Two transfer tubes located at the bottom of the heater connect it to the main oil–filter–housing.

The heat transfer matrix has an aluminium plate/fin that has separate oil and fuel passages. Heat from the oil is conducted through the walls of the passages and heats the fuel that flows through the adjacent fuel passages.

An impending bypass switch reads the pressure drop across the whole unit and sends a signal to the Caution and Warning panel in the flight compartment when one of the filtration components needs to be replaced. The switch indicates an impending bypass when the pressure differential is 18 to 21 psid (124.1 to 145 kPad).

A 150 micron absolute strainer is installed upstream of the heat transfer matrix. It is sized to prevent contamination of the matrix while being resistant to freezing of the water contained in the fuel. This strainer is protected by a bypass valve equipped with a bypass indicator.

The fuel heater incorporates an oil bypass valve on the oil side of the unit which is both pressure and temperature controlled. The oil bypass valve is pressure sensitive and will bypass oil when the oil pressure reaches 28 ±3 psid (193 ±21 kPad). This protects the fuel heater in the event that oil passages are blocked in the fuel heater, or if the oil pressure becomes too high. The oil bypass valve is also equipped with a thermal sensor on the fuel side. The thermal sensor keeps the valve fully opened when the fuel temperature is below 90 °F (32 °C). As the fuel temperature increases above 90 °F (32 °C), the thermal sensor starts closing the oil bypass valve. When the fuel temperature reaches 120 °F (49 °C), the valve is fully closed and the oil bypasses the heater. The unit also has a fuel temperature probe in the port at the fuel filter outlet. Refer toSDS73–30–00 for a detailed description of the engine fuel temperature sensor.

Fuel Nozzle Adapters

Refer to Figures 3 and 4.

The purpose of the fuel nozzle adapters is to deliver fuel to the combustion chamber, mix it with air and atomize it for combustion. The twelve fuel nozzle adapters are installed on the turbine support case. The nozzle part of the adapter is inserted in the turbine support case and is directed towards the front of the engine. The nozzle portion of the adapters protrudes into the combustion chamber through holes in the dome portion of the combustion chamber outer–liner. Fuel manifolds connect the fuel nozzles together.

All twelve fuel nozzle adapters are duplex units that have both primary and secondary orifices. The primary fuel orifice is located in the center of the nozzle and the secondary fuel orifices surround the primary orifice. The primary fuel orifices are supplied with fuel by the primary fuel manifold and the secondary orifices are supplied by the secondary fuel manifold.

Flow Divider Valve

Refer to Figures 5 and 6.

The purpose of the flow divider valve (FDV) is to divide the fuel flow between the primary and secondary fuel manifolds for starting and steady state operation.

The flow divider housing is made of cast aluminum and is installed on a bracket located at the bottom of the gas generator case. Two fuel manifolds, left and right, are connected to the FDV. Each fuel manifold has two connections to the FDV; one for the primary fuel flow and one for the secondary fuel flow. A fire shield is mounted around the ecology reservoir for fire resistance purposes.

During start, fuel from the FMU flows into the FDV and starts to feed the divider valve. A pressure regulator is used to maintain primary fuel pressure 125 psi (862 kPa) above the secondary fuel pressure. The excess fuel flow is bled to the secondary manifold through the regulator. Fuel stored in the ecology reservoir is also returned to the manifolds through the action of the ecology piston. A restricted orifice in the ecology circuit makes sure of a slow transition of the piston, so as not to affect the fuel nozzle operation during start.

At low fuel flow conditions, fuel is routed to both the primary and secondary manifolds, while the pressure regulator maintains a constant pressure differential between them. As fuel flow increases, the FDV equalizes the pressure between primary and secondary to limit the maximum pressure of the system. Equalization is maintained up to the maximum flow condition.

When the engine is shut down, the fuel remaining in the fuel manifolds is collected in an ecology reservoir integral to the FDV by the action of a piston and a spring. This fuel is used on the next engine start.

Fuel Tubes

Refer to Figure 7.

Two fuel tubes are used to route the fuel from the FMU to the fuel nozzle adapters. One goes from the FMU to the fuel flowmeter and another from the flowmeter to the FDV.

The FMU to flowmeter tube is attached to the FMU on the left side of the engine. It then runs across to the right side and forward, above the inlet case, and down on the left side where it connects to the flowmeter.

About half the length of the FMU to flowmeter tube has a braided flexible portion starting at the FMU. This is used for fire protection. The remaining portion of the tube is made of a titanium alloy. The tube is held to the FMU with two bolts. The other end of the tube is attached to the flowmeter with a self–locking Moeller type nut.

The flowmeter to FDV fuel tube is a plain titanium alloy tube. It goes towards the rear of the engine from the flowmeter to the FDV. It is attached to the flowmeter with a Moeller type nut and to the FDV with two bolts.

Fuel Manifolds

Refer to Figure 8.

The purpose of the fuel manifolds is to deliver fuel to the fuel nozzle adapters. There are two manifolds on the engine; one on the left side and one on the right side. Each fuel manifold connects six fuel nozzle adapters to the FDV.

Each fuel manifold consists of six manifold adapters that are equally spaced. Manifold adapters are interconnected by two flexible hoses, one for the primary fuel path and one for the secondary fuel path.

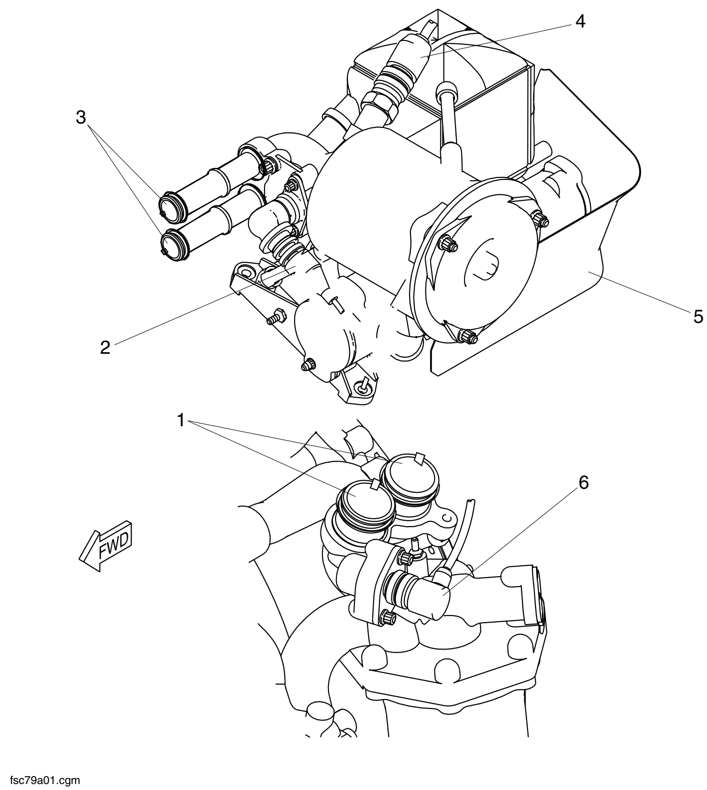
The manifold adapters are made of stainless steel and have a dual bore main section, a mounting flange and welded–on fittings where the flexible hoses are crimped. The flexible hoses are surrounded by metallic braiding for strength. They are covered with a silicon–rubber fire sleeve on the outside for fire resistance.

Fuel Filter

Refer to Figure 9.

The filter is located downstream of the heat transfer matrix and supplies filtered fuel to the engine. The fuel filter bowl and filter element are an integral part of the fuel heater installed on the left side of the engine on the LP compressor case.

The fuel filter is a 10 micron nominal / 25 micron absolute unit and is located downstream of the heat transfer matrix. Particles between the 10 to 25 micron sizes may pass through the filter, but particles above 25 micron in size will not. The filter is protected by a bypass valve and a bypass indicator. The filter is of the non–cleanable type.



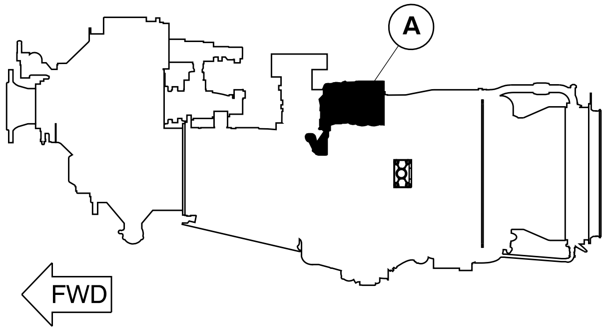
LEGEND

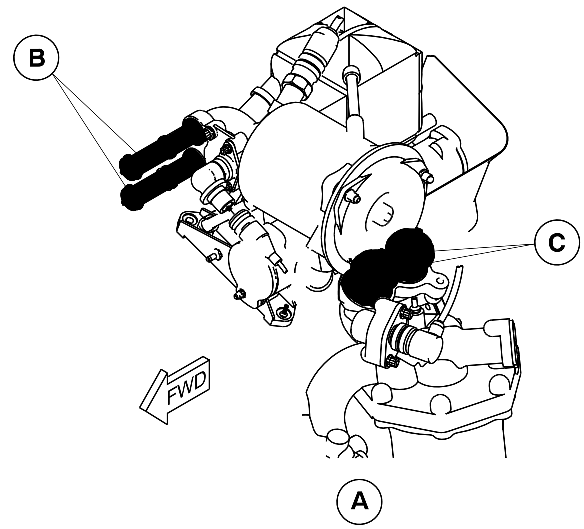
1. Transfer Tubes.
2. P41.
3. Transfer Tubes.
4. P67.
5. Fuel Heater.
6. P47.

NOTE

Fuel Heater separated from engine for clarity.

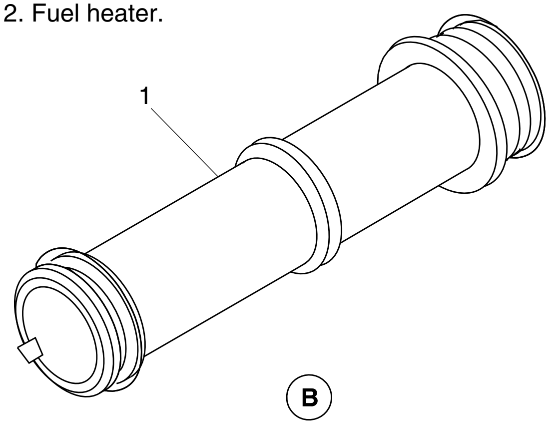
Fuel Heater and Transfer Tubes
Figure 1





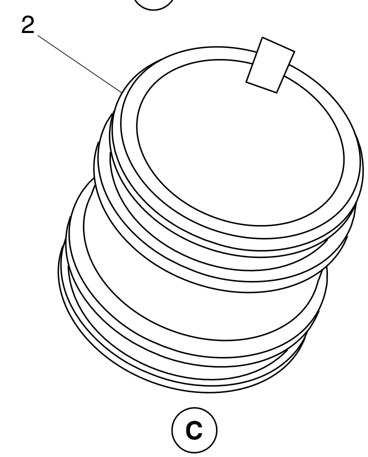
LEGEND

1. Transfer tube assembly.
2. Fuel heater.



NOTE

One transfer tube of each pair shown, other tubes similar.



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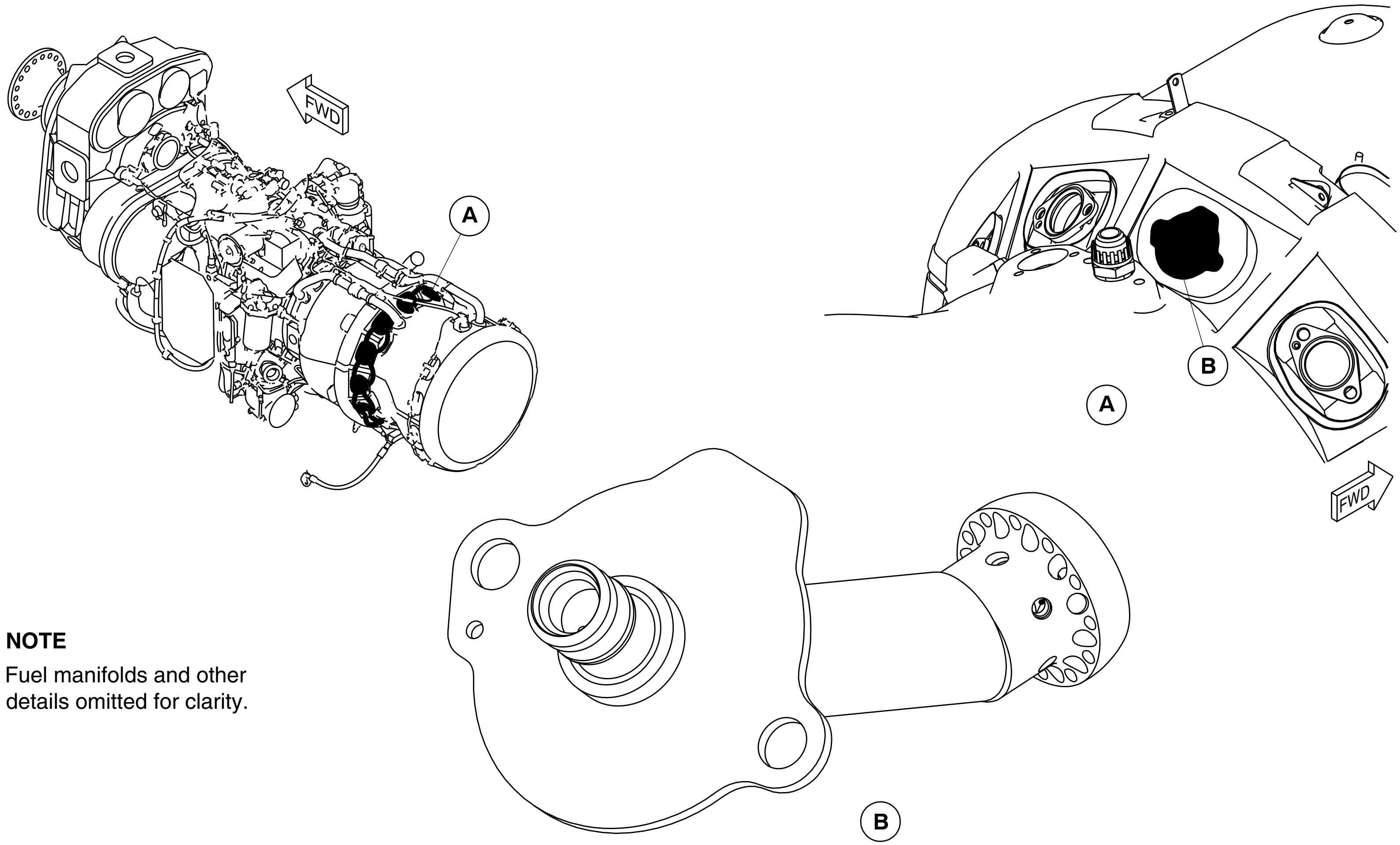
Fuel Heater and Transfer Tubes Detail
Figure 2



NOTE

Fuel manifolds and other details omitted for clarity.

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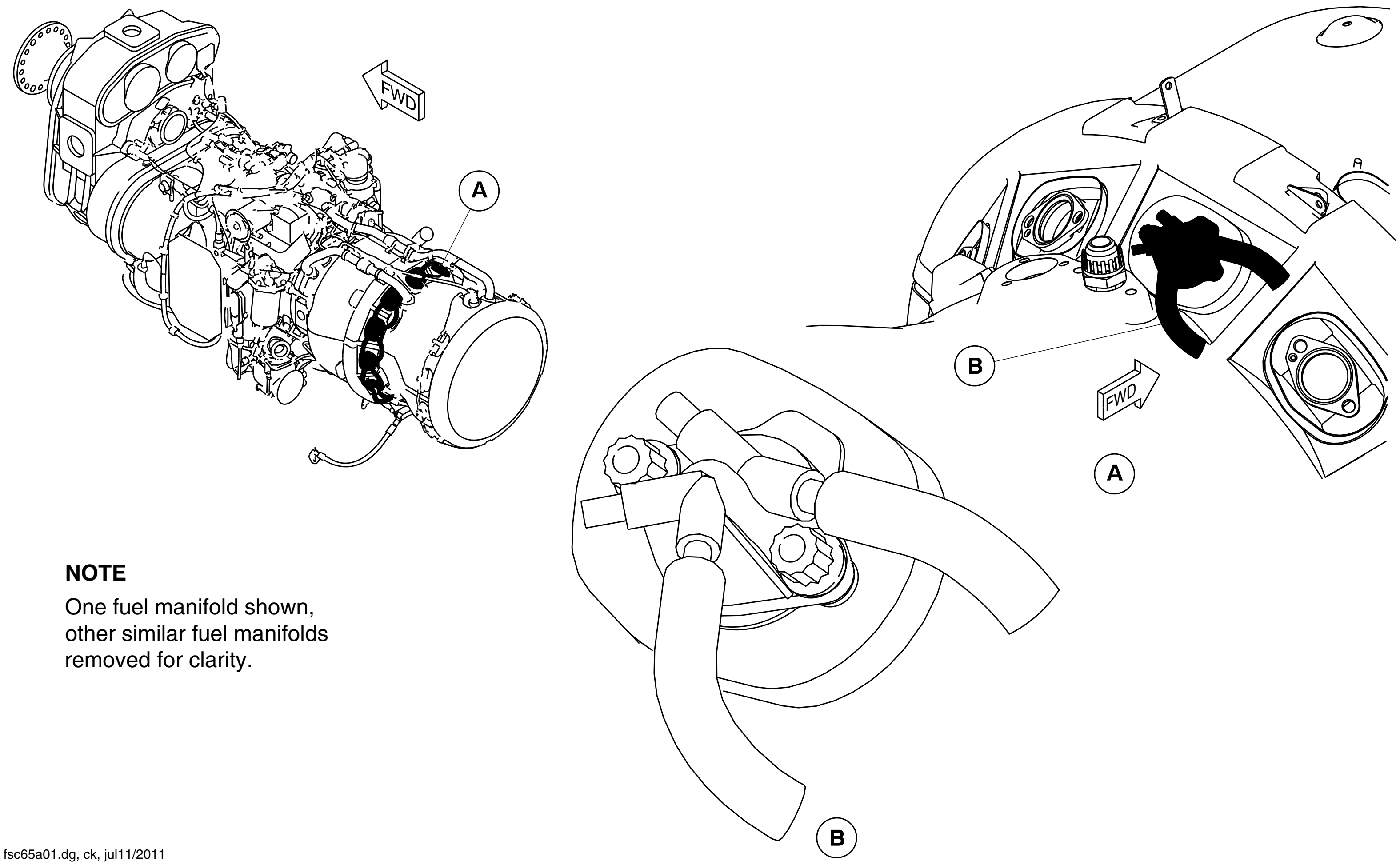
Fuel Nozzle Adapter
Figure 3



NOTE

One fuel manifold shown, other similar fuel manifolds removed for clarity.

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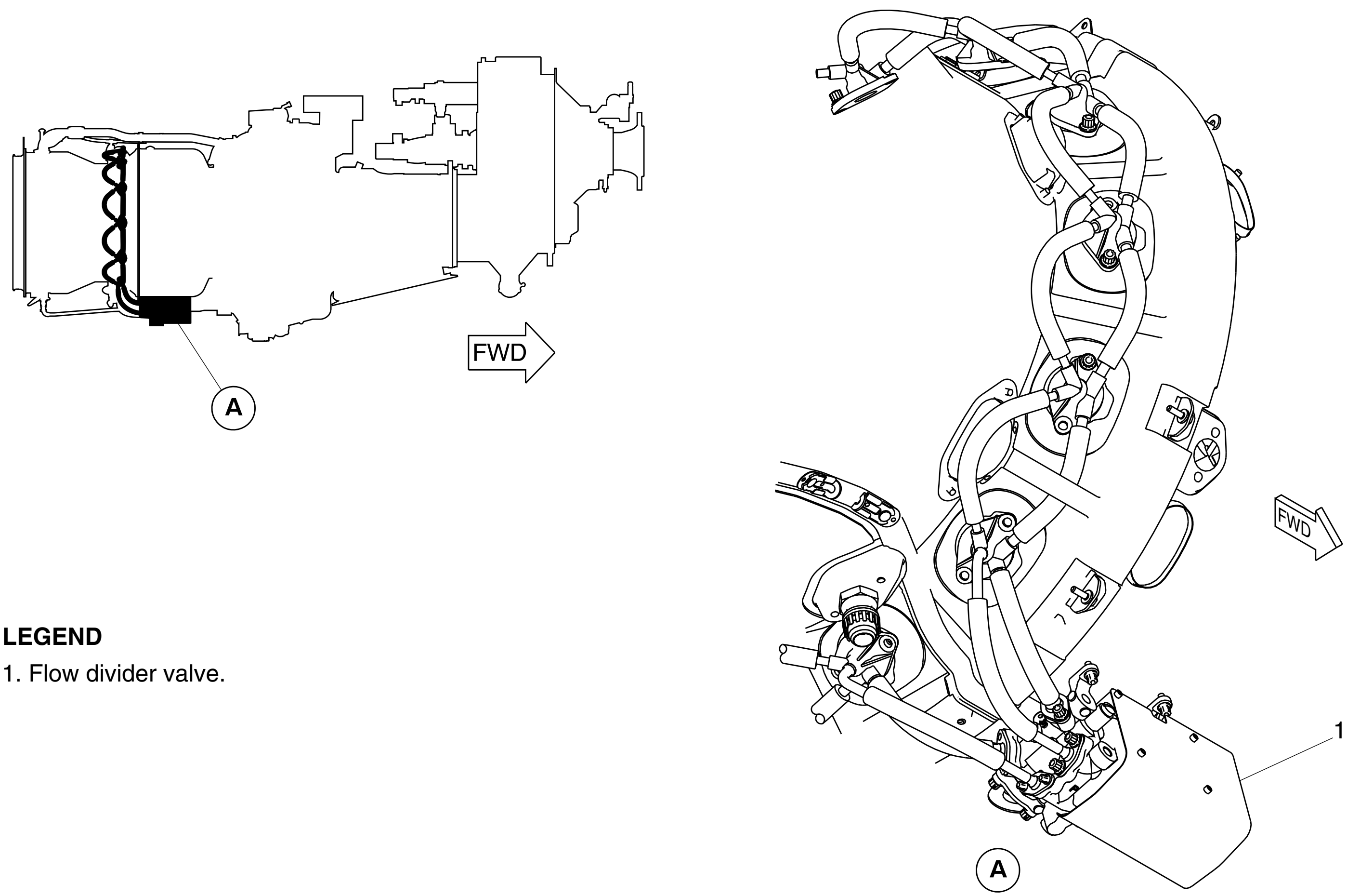
Fuel Nozzle Adaptor and Manifold
Figure 4



LEGEND

1. Flow divider valve.

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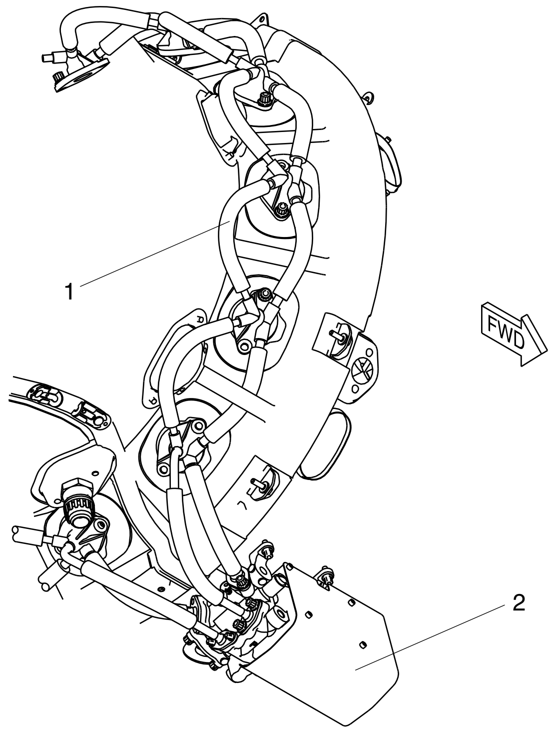
Flow Divider Locator
Figure 5

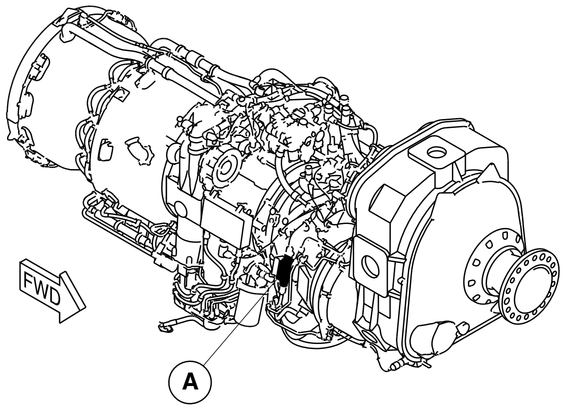


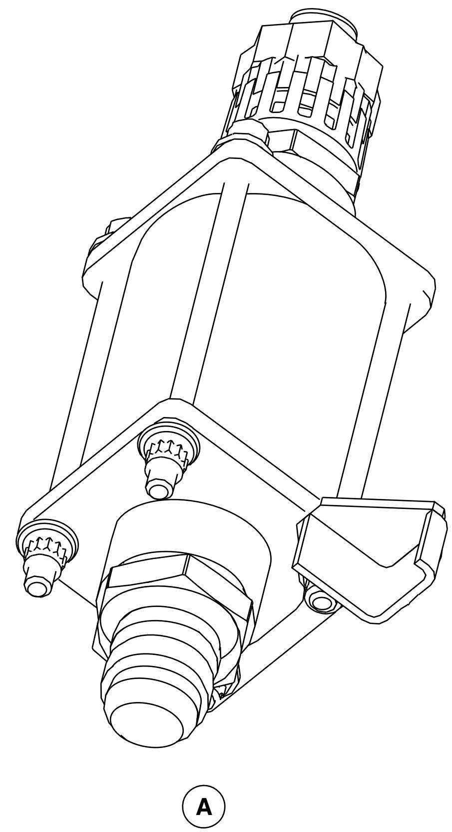
LEGEND

1. Right Side Fuel Manifold.
2. Flow Divider Valve.

fsd58a01.cgm

Flow Divider Detail
Figure 6





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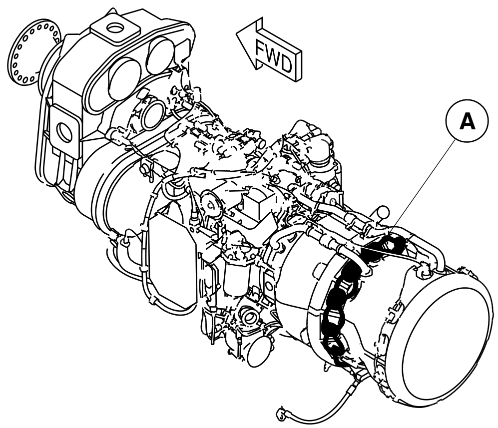
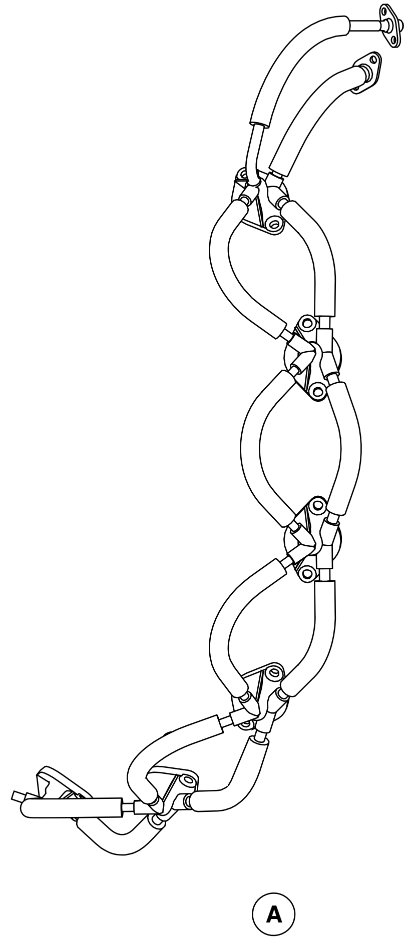
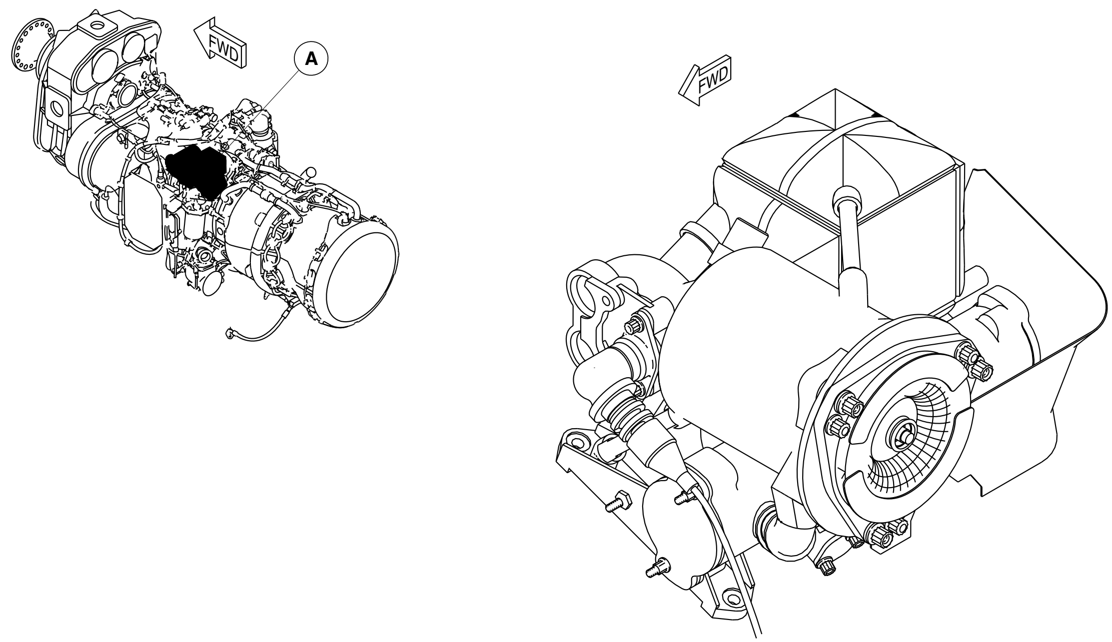
Fuel Flowmeter Locator
Figure 7





fsc53a01.cgm

Fuel Manifolds
Figure 8



Fuel Filter
Figure 9

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73–20–00–001

ENGINE FUEL CONTROL SYSTEM

Introduction

The engine fuel control system manages the engine powerplant by supplying fuel flow, scheduled as a function of the selected Power Lever Angle (PLA), engine ratings, measured torque, and speed. The fuel flow is controlled by the Fuel Metering Unit (FMU).

General Description

Refer to Figure 1.

The Fuel Control function is performed by the:

- Full Authority Digital Electronic Control (FADEC) (AMM Chapter 73–20–01)
- Fuel Metering Unit (FMU) (AMM Chapter 73–21–06)
- Fuel Control Electrical–Wiring–Harness (AMM Chapter 73–21–11)
- Characterization Plug (AMM Chapter 73–20–16)
- Permanent Magnet Alternator (PMA) (AMM Chapter 73–21–21)

Full Authority Digital Electronic Control (FADEC)

The purpose of the FADEC is to perform various control functions and provide signals to the Electronic Instrument System (EIS) for flight compartment indication.

Fuel Metering Unit (FMU)

The purpose of the FMU is to control the fuel flow to the engine in response to command signals from the FADEC. It also provides fuel motive flow for all engine operating conditions within the aircraft flight envelope.

Fuel Control Electrical–Wiring–Harness

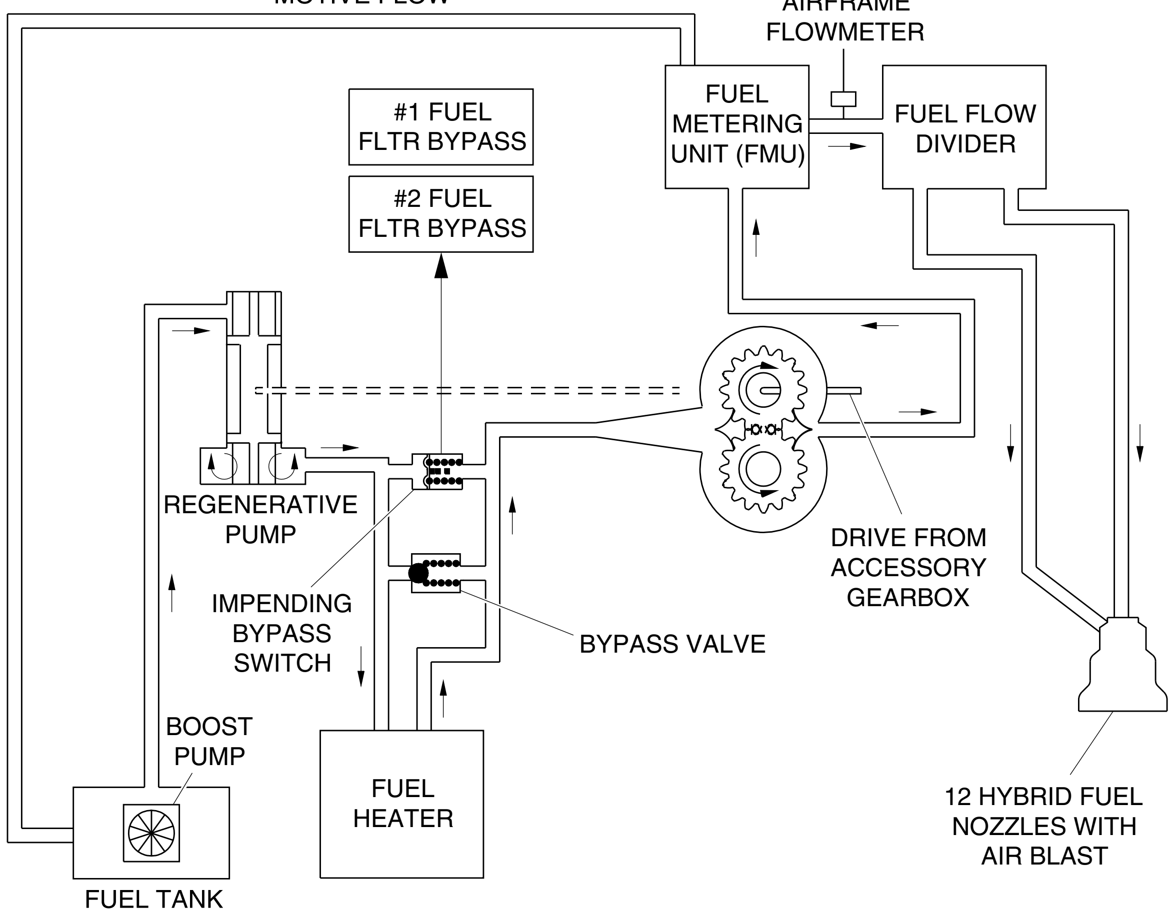
The purpose of the Fuel Control Electrical Wiring Harness is to connect the sensors, FMU, PEC, and airframe components to the FADEC.

Characterization Plug

The purpose of the characterization plug is to provide trim values for torque calculations and to identify the engine model to the FADEC.

Permanent Magnet Alternator (PMA)

The purpose of the PMA is to supply dedicated electrical power to the FADEC and the PEC.



Engine Fuel Control System
Figure 1

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73–21–00–001

ENGINE FUEL CONTROL SYSTEM

Introduction

The engine fuel control system supplies fuel at the required pressure and flow to control the engine power.

General Description

Refer to Figure 1.

The engine fuel control system has the components that follow:

- Full Authority Digital Electronic Control (FADEC) (AMM Chapter 73–21–01)
- Fuel Metering Unit (FMU) (AMM Chapter 73–21–06)
- Fuel Control Electrical–Wiring–Harness (AMM Chapter 73–21–11
- Characterization Plug (AMM Chapter 73–21–16)
- Permanent Magnet Alternator (PMA) (AMM Chapter 73–21–21)

Detailed Description

The engine fuel control system manages the engine powerplant by supplying fuel flow, scheduled as a function of the selected Power Lever Angle (PLA), engine ratings, measured torque, and speed. The fuel flow is controlled by the Fuel Metering Unit (FMU).

Full Authority Digital Electronic Control (FADEC)

Refer to Figure 2.

The FADEC supplies an electrical signal to the Fuel Metering Unit (FMU) to control engine power. This signal controls the fuel flow to the engine as a function of the selected Power Lever Angle (PLA), engine ratings, measured torque and measured speeds. In addition to controlling the FMU, the FADEC also does the following:

- Controls the opening of the P2.7 Handling Bleed Valve (HBV) during handling to prevent an engine surge
- Controls the opening of the P2.2 intercompressor bleed valve at low power to prevent a compressor stall
- Prevents an engine overspeed
- Supervises engine starts and engine shutdowns by controlling the ignition box
- Supplies voltage to the Propeller Electronic Control (PEC) (above 40% NH speed)
- Detects and indicates faults
- Communicates to other units through the UART and ARINC interfaces. Also communicates with the Engine Monitoring Unit (EMU) or a laptop computer (in maintenance mode).

The FADEC is installed on the right side of the inlet case and mounted on vibration–resistant bushings. Five connectors on the back of the FADEC give connection points for the engine and airframe components that interface with FADEC. The connectors are as follows:

- J1: Connects the engine components to the FADEC channel A
- J2: Connects the engine components to the FADEC channel B
- J3: Connects the characterization plug to the FADEC channel A
- J40: Connects the airframe components to the FADEC channel A
- J50: Connects the airframe components to the FADEC channel B.

The FADEC is a dual–channel microprocessor–based controller. Each channel has identical hardware and software. The hardware in each channel incorporates a central processor, an Input/Output (I/O) gate array, appropriate I/O interfaces and a fully independent overspeed system. Hardware discretes, utilized for channel control, and a cross talk serial bus are the only links between channels.

The independent overspeed protection system uses redundant NH signals from the engine to command a fuel shut off in the event of an NH overspeed. The overspeed trip is set at 108% NH. The overspeed circuitry is tested each time the engine is shut down.

The FADEC calculates the maximum rated power available for each rating from the inputs that follow:

- Altitude
- Airspeed data from the Air Data Computer (ADC)
- Outside air temperature from the T1.8 sensor located in the engine inlet
- Selected bleed mode
- Selected rating

From these inputs, and in conjunction with the propeller speed, the FADEC displays the torque target on the Engine Display (ED). The FADEC then increases or decreases the fuel flow through the FMU to match the indicated torque to the target torque.

The FADEC accommodates and reports detected faults depending on their effect on the system. The FADEC classifies a new fault into one of three fault classes:

- Critical fault
- Cautionary fault
- Advisory fault.

A critical fault may cause either, a power stabilization to flight idle or ground idle, or an engine shutdown. For this fault class, the FADEC automatically accommodates the fault without any pilot action. On the cockpit display, the FADEC FAIL light is turned on.

A cautionary fault needs immediate pilot action. Cautionary faults are detected faults that result in either:

- Power levers that may have to be in asymmetric positions to obtain symmetric power/thrust
- Rapid power levers movement that may cause an engine surge

For this fault class, the FADEC caution light is turned on.

An advisory fault is automatically accommodated and is not classified as either critical or cautionary. The FADEC transmits the fault code (or LRU code) to the Engine Monitoring Unit (EMU) and to the Engine Display (ED).

Power Management

The control software provides closed loop control of the engine in response to inputs from the pilot and other aircraft systems. Control of engine power is achieved by deriving a fuel flow request from the main, or outer governing loops after applying various transient and steady state engine limits.

The Power Request Logic uses the primary pilot inputs that follow:

- PLA
- CLA
- ECS bleed selection
- Engine derate

The ambient conditions that follow:

- Altitude
- Airspeed
- Temperature

and an UPTRIM signal from the remote PEC, under failure conditions, to calculate the requested engine power.

During Power Governing, the power request and the power feedback is used to command the fuel flow required to achieve and maintain the requested engine power. Power governing is the primary mode of control during flight (takeoff, climb and cruise) and in reverse.

During Power Turbine Speed Underspeed Governing, the fuel flow request is computed from the following:

- Power turbine speed (NPT) underspeed schedule
- NPT feedback signal

This loop is used to control engine power as a function of propeller speed during low power operation on the ground.

Steady State Limit Loops ensure that the thermal and mechanical limits of the engine are not exceeded, as a result of the requested setting from the outer governing loops. These limits apply to the speed of the engine spools, NH, NL and NPT and engine torque. In addition, the control system is prevented from requesting fuel flows that exceed the hydromechanical limits of the Fuel Metering Unit (FMU).

Transient Limit Loops limit the change in requested gas generator speed, derived from the governing loops. This protects the engine from the following:

- Surge
- Flameout
- Overtorque

A fuel flow rate limit is also used to limit fuel flow commands to within the capabilities of the FMU.

Power Setting Logic

The power setting logic determines the requested power as a function of engine rating, pilots inputs, remote engine failure and ambient conditions. These inputs effect requested power as follows:

INPUT TYPE	INPUT	EFFECT ON POWER REQUEST
Pilot Activated	PLA	Schedules % of rated power as a function of PLA
	CLA	Selects engine power rating and propeller governing speed for normal operation
	Rating Discretes	Allows the selection of power ratings that differ from the standard mode of operation
	ECS Bleed Selection	Biases the rated power downward to compensate for the effect of requested bleed on the engine thermal rating. Also used to discriminate between Maximum Continuous and Maximum Takeoff ratings
	Power Derate Selection	Biases the takeoff rated power downward in the decrements of 2% to a limit of 10%
Automatic Takeoff Power Control System	Uptrim Command	Automatically changes power rating from Normal to Maximum Takeoff upon receipt of the Uptrim discrete from the remote PEC
Ambient Conditions	Ambient Temperature Ambient Pressure Delta Pressure (Airspeed)	Used to determine the thermal rated power of the engine.

Power Setting with the Power Lever

The power lever allows the pilot to modulate power request from Full Reverse to Rated Power. Ground handling is achieved at PLAs below 35°. Above 35°, the power request increases linearly with increasing PLA until the Rated power detent, where there is a flat between 77.5° and 82.5°.

Moving the power lever in the overtravel region, results in an increase in requested power up to 125% of maximum takeoff rating. It also results in an increase of engine software limits. In this region the propeller control system will automatically set propeller speed to 1020 Np.

Rating Selection with the Condition Lever

Rating selection occcurs concurrently with propeller speed selection, when the condition lever is moved to the detent positions. The propeller control converts the Condition Lever Angle (CLA) to a position and transmits this, as discrete information, to the FADEC across the PEC/FADEC serial data buses.

For all condition lever positions, the Rated Power is achieved when PLA is in the rating detent (77.5° to 82.5°). When the PLA is reduced below the detent position, the power request for all positions converge to a single point at 55°. In the PLA overtravel region, the power request for all ratings converge to 125% maximum power at 95°.

Selection of Alternate Power Rating and Propeller Speed Combinations

Alternate combinations of propeller speed and engine power rating can be set by using the MTOP, MCL and MCR Rating Discretes in the flight compartment. These discretes, transmitted to the FADEC by the Engine Cockpit Interface Unit (ECIU), override the rating normally selected as a function of CLA under certain conditions.

When the MTOP discrete is activated, the Maximum Take–Off Power (MTOP) is selected by FADEC whenever the condition lever is in the 1020 RPM position. The MTOP rating is defined as the maximum available power certified for take–off operation.

When CLA is in the 900 RPM position and the MCR discrete is selected, the Maximum Climb (MCL) rating normally associated with this propeller speed is overridden by the Maximum Cruise (MCR) rating. The MCL rating discrete is a momentary switch, so any movement of the CLA will base engine rating selection on the new CLA position. Alternatively, the MCL rating can be recovered, at the same CLA position, by selecting the MCL discrete.

Selection of MCL at a CLA of 850 RPM is also possible using the MCL rating discrete. The MCL discrete is also a momentary switch.

Environmental Control System (ECS) Bleed Selection

The power requested, at a given power rating, is a function of the ECS bleed selected when the engine is operating on the thermal limit. The ECS bleed selection is translated in bleed levels, used for thermal power rating calculations. Higher amounts of ECS bleed results in less thermal rated power. This may reduce the power requested for a given power rating, depending on the ambient conditions.

Bleed Setting If local engine ECS On	Altitude (ft)	Single Engine Bleed (lb/min)	Dual Engine Bleed (lb/min)
MIN	0	38	19
MIN	25k	38	19
MIN	35k	38	19
NORM	0	38	38.3
NORM	10.175k	38	26.5
NORM	35k	38	26.5
MAX	0	38	45.8
MAX	25k	38	33.8
MAX	35k	38	33.8

The FADEC discriminates between single and dual ECS bleed by using the following logic. Dual engine level is used unless the power rating is MTOP, demanded by Uptrim only, or ECS is selected OFF on the remote engine.

The ECS bleed selection is also used by FADEC to distinguish between MTOP and Maximum Continuous Power (MCP).

BLEED	MTOP/MCP
OFF	MTOP
MIN	MTOP
NORMAL	MCP
MAX	MCP

Power Derate

Before take–off the power can be reduced for take–off in the NTOP rating using the power derate function. To derate the requested power, the Power Derate discrete is pressed, with the CLA at the 1020 RPM position and PLA below the rated power detent. Selection of the Power Derate discrete momentary switch, decreases the NTO requested in steps of 2% to a limit of 10%. Selection of the Power Derate Reset discrete, at any time, resets the derate to 0%.

A Power Derate is permitted only when it is confirmed, through cross powerplant communication, that both FADEC channels of each powerplant, have received a Power Derate command

The Power Derate function cannot be activated in MTOP or MCP rating.

If an Uptrim is commanded from the remote powerplant, the requested derate will apply to the MTOP requested power.

Automatic Take–Off Power Control System

During take–off, an Automatic Take–off Power Control System (ATPCS), increases the power of the engine, in the event of loss of power in the opposite engine. This function is referred to as Uptrim, or, Automatic Take–Off Thrust Control System (ATTCS). The local engine's FADEC will respond to the Uptrim signal from the remote Propeller Electronic Control/Autofeather (PEC/AF) unit by changing from NTOP to MTOP/MCP.

The ATPCS is active during take–off and go around manoeuvres. The local ATPCS is armed when:

- Both local and remote PLAs are high
- Local engine torque is high.

If the local engine fails, indicated by low torque, an Uptrim signal is commanded by the local PEC to the remote FADEC. An Uptrim condition is indicated in the flight compartment by:

- Uptrim indication
- Change in engine rating from NTOP to MTOP/MCP
- Change in the torque bug from NTOP to MTOP/MCP

Mechanical and Thermal Power Limits

The engine power limit logic is selected as, the lowest value between the mechanical power limit and the thermal power limit, for the selected rating.

The mechanical power limit is set as a function of the engine rating.

Rating Selected	Mechanical Power SHP
MTOP/MCP	5071
NTOP	4580
MCL	4058
MCR	3947

The thermal power rating is set as a function of:

- Rating selected
- Ambient temperature
- Aircraft altitude
- Aircraft speed
- ECS bleed air extraction
- Power turbine shaft speed.

Engine Control Logic

The control logic is structured into the three loops that follow:

- Outer contol loop
- Intermediate control loop
- Inner control loop.

Outer Control Loop

There are two parallel outer control loops as follows:

- Power governing loop
- Power turbine underspeed (NPT U/S) loop

Power Governing Loop

The power governing loop is active in the reverse power lever quadrant and the forward power quadrant. The power governing loop will govern the engine to a requested power.

The philosophy of the PW150A is to close loop on power and the principal control loop is the power governing loop. The actual engine power is measured using the Torque/NPT sensors and compared to the requested power. FADEC attempts to eliminate the difference between requested power and actual power. The power control loop will determine the gas generator speed required (NHHP), to obtain the requested power and deliver the requested NH.

The authority of the power loop is restricted by mechanical and operational limits in the NH. These limits are built into the gas generator limiting loop.

NPT Underspeed Governing Loop

The NPT U/S function is primarily for ground taxiing manoeuvres and maintains a minimum propeller speed (NHNPU/S).

The control system closes loop on propeller speed and determines the NH to set the required NPT. Thrust is then controlled through the minimum blade angle schedule in the PEC, which gives a direct relationship between PLA and propeller blade angle.

This loop is normally active during ground handling and taxiing. high power, high torque or high airspeed will cancel the NPT U/S governing loop. the loop will also be cancelled ifnthe PEC determines that the propeller control system is unable to control through the PEC/FADEC RS422 digital communication bus.

Gas Generator Limiting

The NH limiting logic in FADEC prevents NH exceeding a given threshold, which is determined as a function of PLA and ambient conditions. The limits, NHmax and NHmin, are derived from operational and mechanical restrictions. The upper bound, NHmaxLimit, is determined by operational restriction required on the power loop.

The NHmaxLimit, NHmax and NHmin bound the powerv loop at PLA greater than 40° and PLA below 10°. The authority of the Power Governing Loop is large in the forward and reverse power regimes.

The lower limit of the Gas Generator Limiting Loop is determined as follows.

The Ground Idle (GI) point, PLA = 20° is determined as the minimum self–sustaining speed of the engine. This value is 64% or 20000 RPM.

The Flight Idle (FI) speed is a variable NH to maintain zero thrust in flight. The Flight Idle speed is varied as a function of ambient pressure and ambient temperature.

The schedule between GI and FI is a straight line extrapolation between the points.

The fan out points, found at approximately 10° and 40° PLA, are set above the GI and FI speeds respectjively to allow for smooth transition on to the Power Governing Loop. NHmax loop above 40° PLA rises quickly, to not restrict the power loop until it intercepts the maximum NH limit allowed. The lower limit rises by always maintaining a positive power gradient with respect to PLAand without interferring with the Power Governing Loop authority.

In reverse similar criteria are used to determine the upper and lower bounds of the Gas generator Limit Loop.

NPT O/S Limiting

The NPT Overspeed Control Limit in the FADEC prevents the power turbine speed from exceeding a given threshold (NHNPTO/S). This is set as a function of PLA and ambient conditions.

This logic calculates a gas generator speed request value, based on the power turbine overspeed reference and the power turbine speed feedback.

The propeller control system includes independent mechanical overspeed protection, to coarsen propeller blade angle when NPT exceeds 104%. This NPT O/S governor is locked out in reverse and the FADEC NPT O/S Governing loop becomes the primary means of protection. The propeller overspeed governor set point, when not locked out, is below the FADEC NPT O/S schedule.

Torque Limiting

The torque limiting logic in FADEC prevents engine torque from exceeding a given threshold, which is a function of PLA and ambient conditions. The logic calculates a gas generator speed request value based on, the torque limit reference and the torque feedback

Transient Overtorque Limiting

The Torque Limiting Logic in FADEC prevents any torque from exceeding a fixed steady state threshold. In the event of a spurious feathering of the propeller at high power, The transient overtorque can exceed this threshold. FADEC uses anticipation in this control loop to rapidly reduce NH to prevent overtorque in exceedance of 150%.

Fuel Metering Unit (FMU)

Refer to Figure 3.

The FMU modulates the engine fuel flow over the entire operational envelope of the engine in response to signals sent by the FADEC.

The FMU is installed on the Permanent Magnet Alternator (PMA) on the LP compressor case. It is attached to the PMA with a V–band clamp. It has a fuel inlet port connected to the airframe fuel supply and a fuel outlet port connected to the fuel flowmeter. It also has fuel heater inlet and outlet ports. The FMU has electrical connections for the engine and airframe harnesses.

The FMU has two integral fuel pumps. A low pressure pump and a high pressure pump. Both pumps are engine–driven. Fuel from the low pressure pump is routed to the fuel heater. From the fuel heater, fuel is then routed to the inlet of the high pressure pump. From there, it enters the metering portion of the FMU.

Intermediate Control Loop. NH Speed Governing Loop

The Outer Control Loop and Outer Control limiting Loops derive a selected NH request speed. FADEC will attempt to eliminate the difference between the requested NH speed and the actual NH. The Gas Generator Loop will determine the requested gas generator speed fuel flow, WFNH.

Intermediate Control Limiting Loops. Acceleration and Deceleration.

The engine is limited in rate of acceleration and deceleration by the acceleration and deceleration limits, WFACC and WFDEC. These limits calculate a fuel flow request, to limit the engine on the programmed acceleration or deceleration schedule. The NH Accel or Decel Limiting Schedule provides compensation as a function of NH and ambient conditions. This ensures that the system meets the required transient accel and decel, including slam manoeuvres, without causing engine surge or flameout.

NL Limiting

The NL Overspeed Control Logic in the FADEC prevents the low pressure turbine speed from exceeding a given threshold. This is a function of PLA. The logic calculates a fuel flow request value, WFNL, based on the NL limit reference and the NL feedback

Wf/P3 Acceleration Rate Limiting

The Wf/P3 Accel Rate Limit scheduling, WF/P3 ACC, becomes active after an engine surge is detected and controls the fuel flow to the engine. FADEC recognizes a surge by an abrupt reversal the two parameters that follow:

– Rate of change of P3, P3dot
– Rate of change of NHdot, NHdotdot.

The Wf/P3 Accel limiting Loop is active for a maximum of 1.5 seconds and lags the Wf increase that results from a rapid P3 increase. This is due to the abrupt decreases and increases of P3 during surge.

Fuel Flow Inner Loop

The fuel flow requested by the Intermediate Control Loop, is limited in rate of acceleration, by the fuel flow rate limiter. The Wfdot accel limit avoids the fuel flow limits that follow:

– Engine acceleration limits, Wfdot NHMAX/MIN
– FMU hardware rate limitations, Wfdot FMU MAX/MIN

At all operating conditions, the fuel flow is limited by the WFdot limit, to a value below the FMU hardware limitation.

In addition to the above limits, 'soft' fuel flow limits are set in the FADEC software as follows:

– To not request more fuel flow than the FMU can deliver, WfMAX
– To not request a fuel flow less than the engine requires to maintain a flame, WfMIN.

The fuel flow requested by the Intermediate Control Loop, after being rated and range limited, passes through a selection process. The selection process is between the start fuel flow, WFSTART and the run fuel flow,WFREQ, as a function of engine mode selection.

The fuel flow is then converted into a metering valve position. The fuel flow effector minor loop, compares the FMU metering valve position request with the measured metering valve position. The measured metering valve position signal is provided by the FMU metering valve LVDT. The system closes loop, to give the desired metering valve position and control the fuel flow to the engine.

The feedback metering valve position is then converted into a feedback fuel flow, WFFB, and compared with the requested Intermediate Control Loop fuel flow.

Fuel Control Electrical Wiring Harness

Refer to Figures 4 , 5 and 6.

The Fuel Control Electrical Wiring Harness connects the sensors, the FMU, and the PEC to the FADEC. The harness has the connectors that follow :

– P1, FADEC A
– P2, FADEC B
– P4, NH sensor A
– P5, NH sensor B
– P6, HP Handling Bleed Off Valve (HBOV)
– P7, FMU A
– P8, LP HBOV B
– P9, LP HBOV A
– P10, FMU B
– P11, Torque sensor A
– P12, Torque sensor B
– P13, NL sensor
– P14, T1.8 sensor
– P15, P3 sensor
– P16, MOT/T6 sensor

- P17, PMA A
- P18, PMA B
- P19, Propeller Electronic Control Unit

Characterization Plug

The characterization plug gives trim values for torque calculations and identifies the engine model to the FADEC.

The characterization plug is installed on the FADEC at the J3 connector. The plug is physically connected to the FADEC channel A only. The trim values are passed to channel B by the FADEC internal communication bus.

The plug is attached to the turbomachinery with a lanyard. This is to make sure that the plug remains with the turbomachinery if the FADEC is removed from the engine. The characterization plug can only be replaced with a plug of the same class. The trim values of the plug are marked on the reduction gearbox data plate.

Inside the plug there are connections for four resistors. Two are used for the torqueshaft gain (slope) and bias (offset) trim values and a third one is used for the engine model identification. The fourth resistor location is unused. The value of each resistor is determined during the engine test and can only be done by a qualified overhaul facility. A sealing compound is put on the resistors after their installation in the plug.

When it is assembled, a torqueshaft almost always has differences in the spacing of the teeth used to generate a signal for the torque sensor to read. These physical spacing differences require electrical trimming for a correct torque indication. The bias trim resistor is used to compensate for these differences.

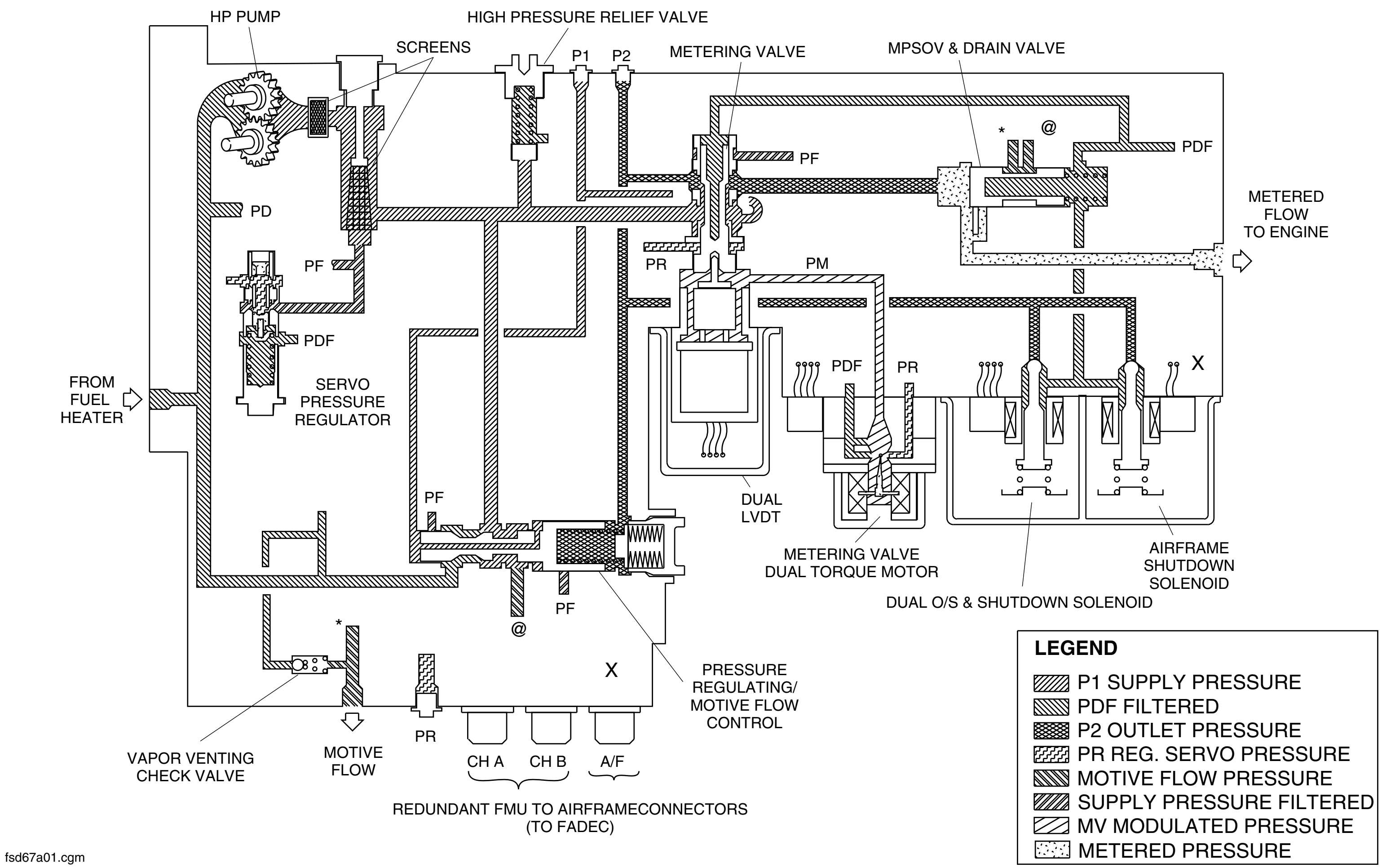
It is also necessary to compensate for the material characteristics of the torqueshaft. These characteristics include things such as the effect of temperature on the metal elasticity of the torqueshaft material. The gain resistor compensates for that.

Permanent Magnet Alternator (PMA)

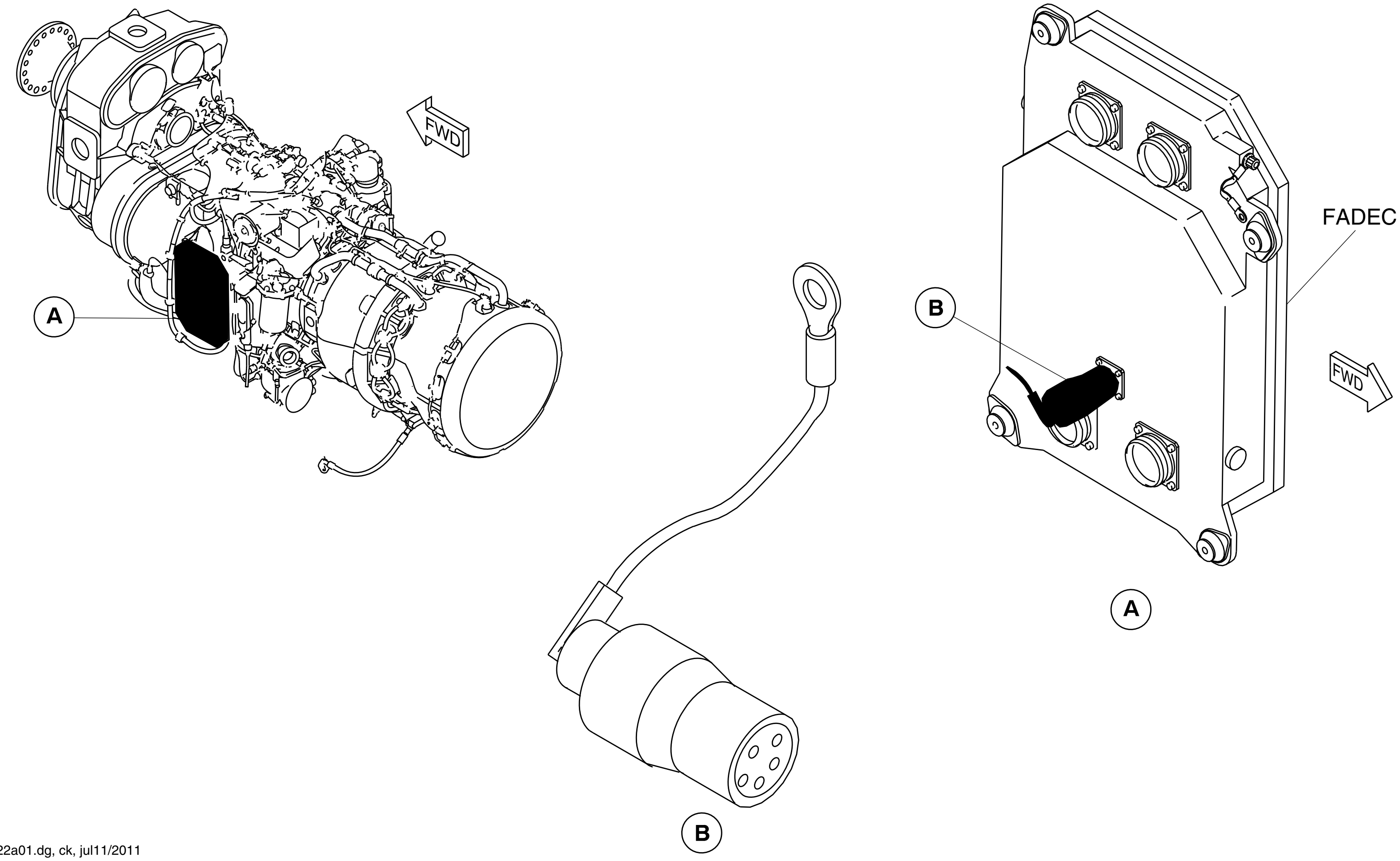
Refer to Figures 7 and 8.

The PMA supplies electrical power to the FADEC and the Propeller Electronic Control (PEC).

The PMA is an integral part of the Fuel Metering Unit (FMU) and is driven by the Accessory Gearbox (AGB). The PMA features a rotor and a stator. The rotor is supported by the AGB bearings and the fuel pump bushings.



Engine Fuel Control System Schematic
Figure 1



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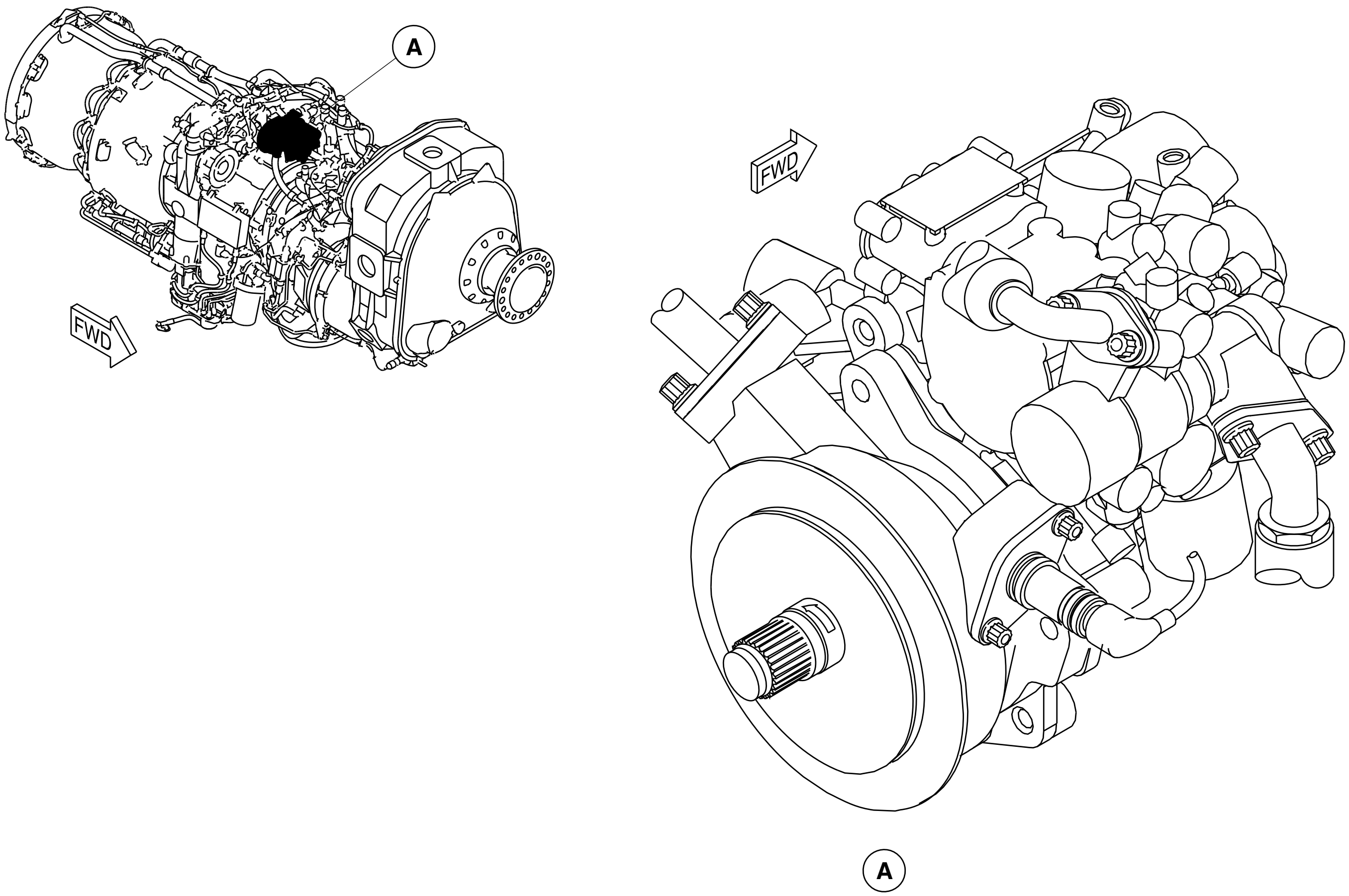
Characterization Plug FADEC
Figure 2



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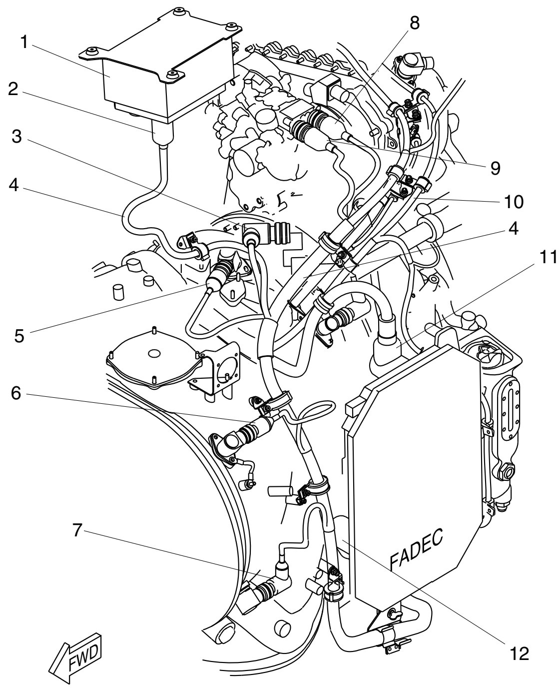
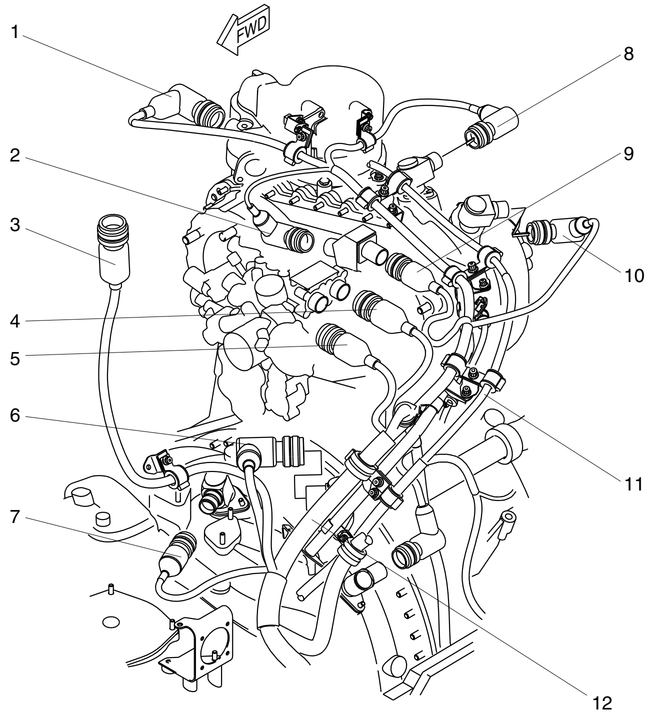
Fuel Metering Unit (FMU)
Figure 3



LEGEND

1. Propeller Electronic Control Unit.
2. P19.
3. P13.
4. Control Wiring Harness.
5. P16.
6. P12.
7. P11.
8. P10.
9. P7.
10. Instrumentation Wiring Harness.
11. P2.
12. P1.

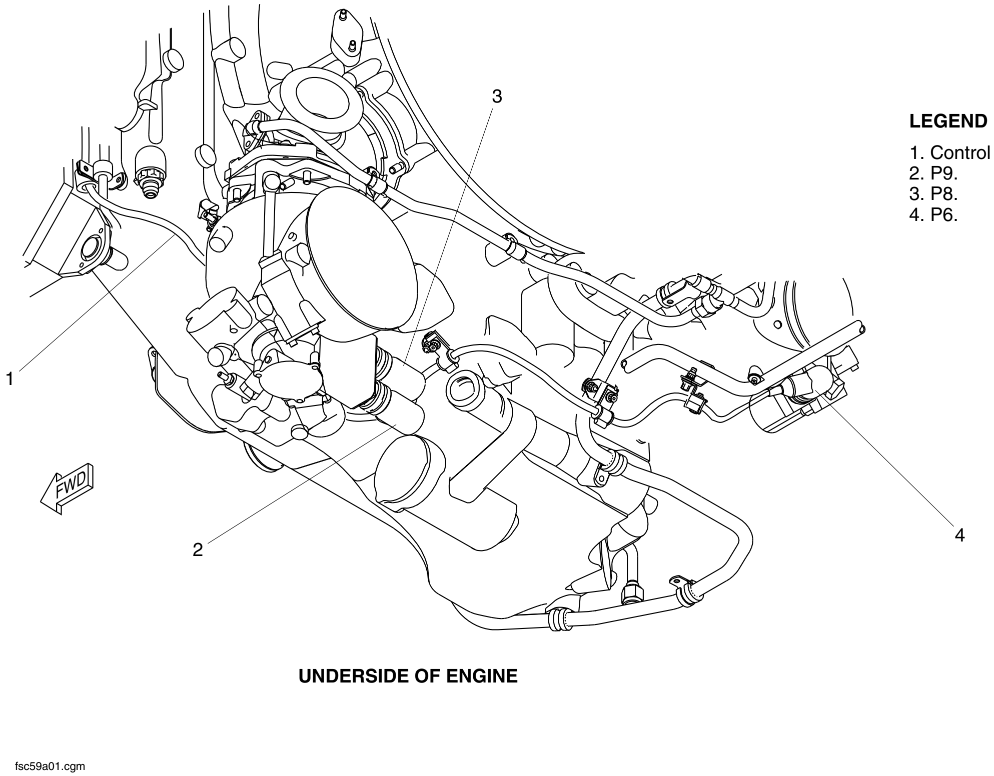
Fuel Control Electrical–Wiring–Harness Page 1
Figure 4



LEGEND

1. P15.
2. P17.
3. P19.
4. P10.
5. P7.
6. P13.
7. P16.
8. P5.
9. P18.
10. P4.
11. Instrumentation Wiring Harness.
12. Control Wiring Harness.

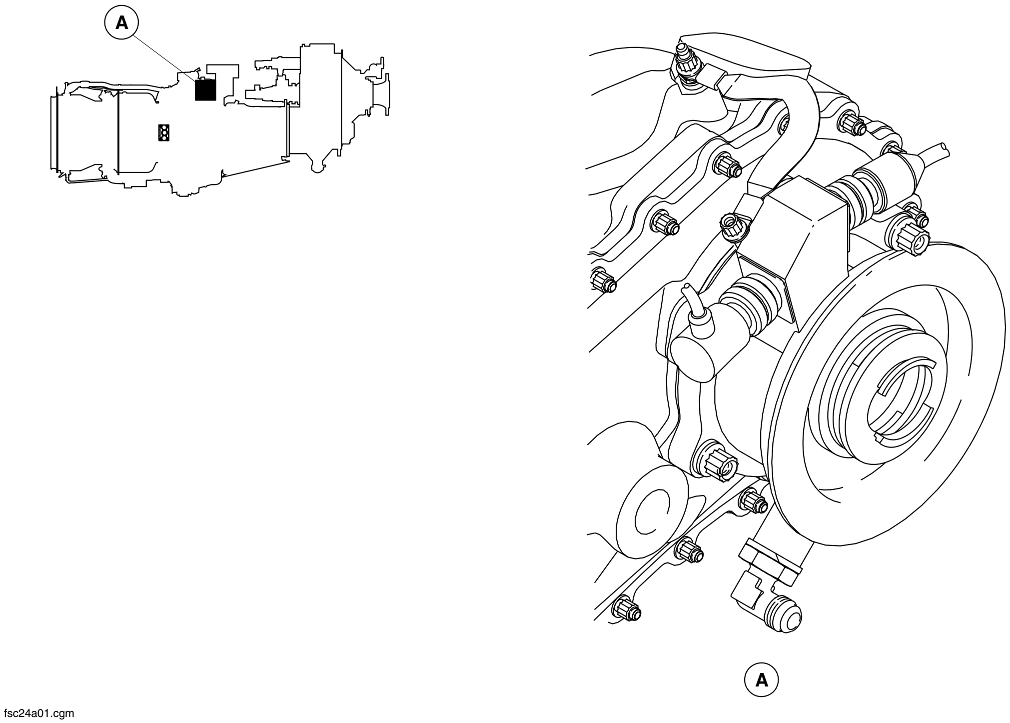
Fuel Control Electrical–Wiring–Harness Page 2
Figure 5



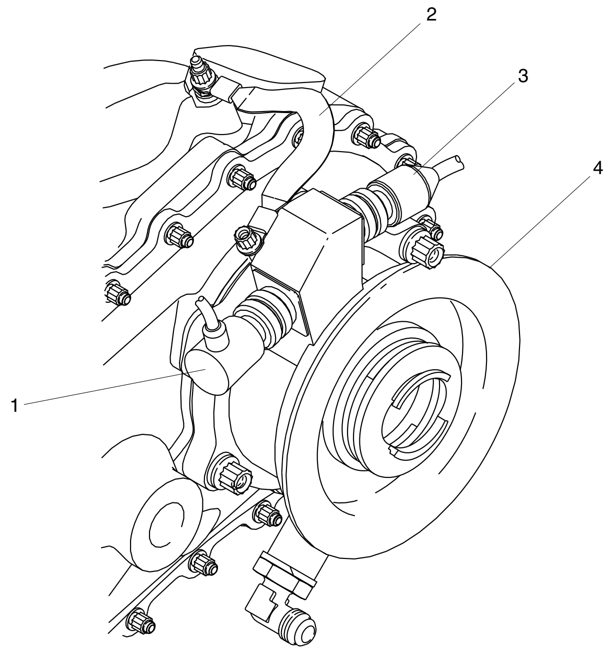
LEGEND

1. Control Wiring Harness.
2. P9.
3. P8.
4. P6.

Fuel Control Electrical−Wiring−Harness Page 3
Figure 6



Permanent Magnet Alternator (PMA) Locator
Figure 7



LEGEND

1. P17.
2. Bonding Strap.
3. P18.
4. PMA Housing.

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Permanent Magnet Alternator (PMA) Detail
Figure 8

**ON A/C ALL

73–30–00–001

ENGINE FUEL INDICATING SYSTEM

Introduction

The engine fuel indicating system provides the flight crew with information on the fuel system status.

General Description

Refer to Figures 1 and 2.

The fuel indicating system uses signals from switches to indicate Fuel System status.The signals from the switches are processed in the Full Authority Digital Electronic Control (FADEC). The processed signals are sent to the Engine Cockpit Interface Unit (ECIU).

Refer to Figure 3.

The ECIU provides the following discrete outputs to the caution lights on the Caution and Warning panel in the flight compartment:

- #1 ENG FUEL PRESS (Engine 1 Low Fuel Pressure)
- #2 ENG FUEL PRESS (Engine 2 Low Fuel Pressure
- #1 FUEL FLTR BYPASS (Engine 1 Fuel Filter Impending Bypass)
- #2 FUEL FLTR BYPASS (Engine 2 Fuel Filter Impending Bypass)

The fuel indicating system has the following components:

- Low Fuel Pressure Switch (AMM Chapter 73–31–01)
- Fuel Filter Impending Bypass Switch (AMM Chapter 73–31–06)

Detailed Description

The low fuel pressure switch and the fuel filter impending bypass switch each provide independent signals to the two FADEC channels. The signals are then sent to the ECIU, and from there to the flight compartment for indication.

The low fuel pressure switch is adjusted to operate on increasing pressure at 8 psig (55.2 kPag). On decreasing pressure, the switch is adjusted to operate at 5.5 ±0.8 psig (38 ±5.5 kPa).

The fuel filter impending bypass switch is adjusted to operate on increasing pressure at 19 ±2 psid (131 ±14 kPad). On decreasing pressure, the switch is adjusted to operate by 13 psid (90 kPad).

Low Fuel Pressure Switch

Refer to Figure 4.

The purpose of the low fuel pressure switch is to indicate low fuel pressure at the outlet of the fuel pump, It sends signal to the FADEC when the fuel pressure gets below 5.5 ± 0.8 psig (38 ± 5 kPa). The low fuel pressure switch is installed on the Fuel Metering Unit (FMU).

The switch has a pressure port, four filtered vents, a switch, a spring and piston assembly, a receptacle and body assembly.

The Low Fuel Pressure Switch consists of a pressure plate and a dual channel electrical switch. When fuel pressure applied on the pressure plate is above a preset value, the electrical switch contacts are held open (resistance >10 kΩ). When the fuel pressure drops below the preset value, the electrical switch contacts relax to a closed state (resistance < 200 mΩ). This sends a signal to the FADEC, then to the ECIU and flight compartment for indication.

Fuel Filter Impending Bypass Switch

Refer to Figure 5.

The purpose of the Fuel Filter Impending Bypass Switch is to send an indication of an impending bypass of unfiltered fuel, It sends a signal to the FADEC when the fuel filter impending bypass differential pressure gets to 18 to 21 psid (124.1 to 144.8 kPad). The Fuel Filter Impending Bypass Switch is installed on the fuel heater.

The switch has a high pressure port, a filtering screen, a low pressure port, a switch, a spring and piston assembly, and a receptacle and body assembly.

The Fuel Filter Impending Bypass Switch consists of a differential pressure sensor and dual channel electrical switch. The switch contacts are normally opened. When the differential pressure across the fuel filter is below a preset value, the electrical switch contacts are relaxed to a closed state (switch resistance < 200 mΩ). If the differential pressure across the filter rises above a preset value, the electrical switch contacts are moved to the open state (switch resistance > 10 kΩ). This sends a signal to the FADEC, then to the ECIU and flight compartment for indication.

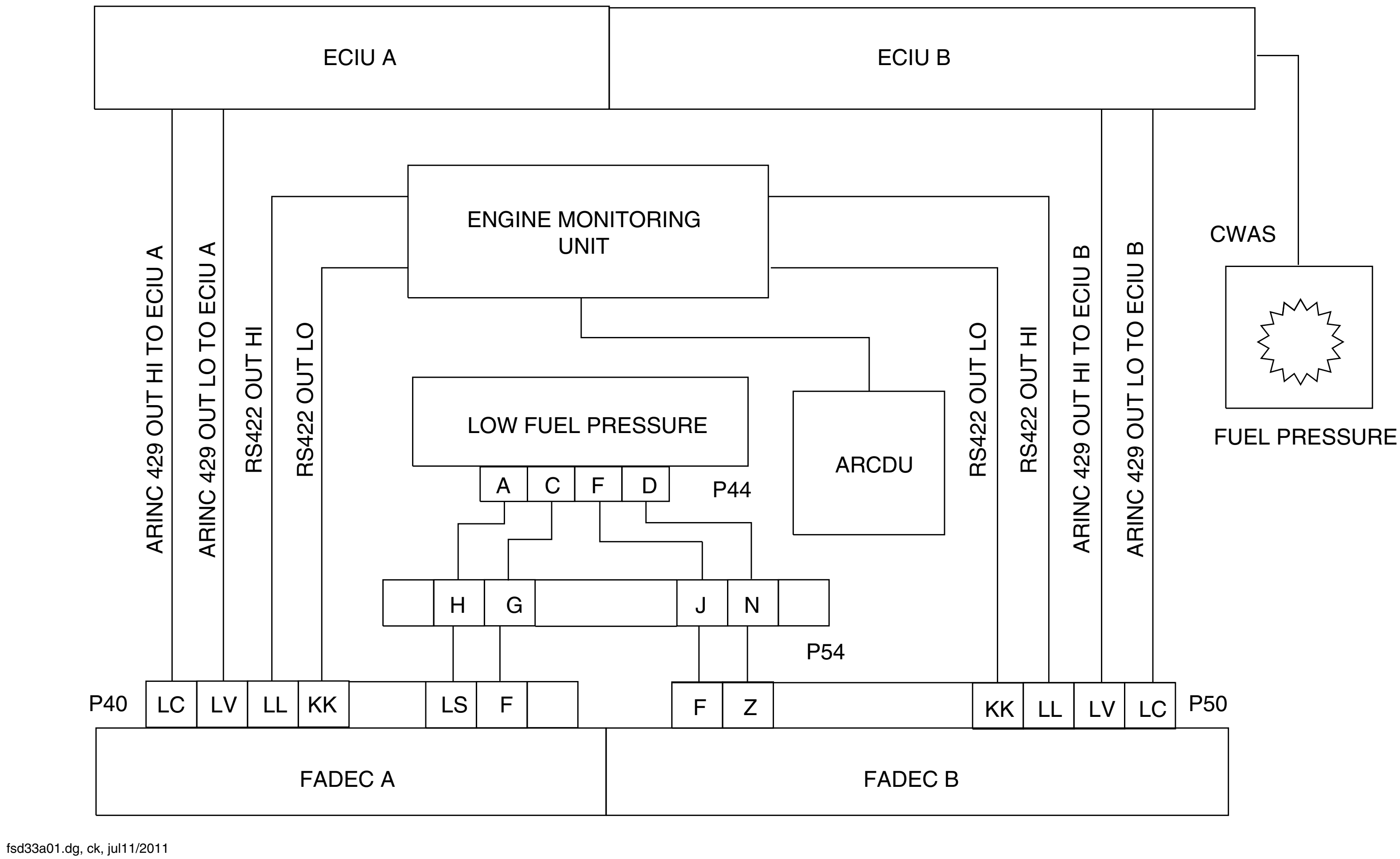
Fuel Temperature Sensor

Refer to Figure 6.

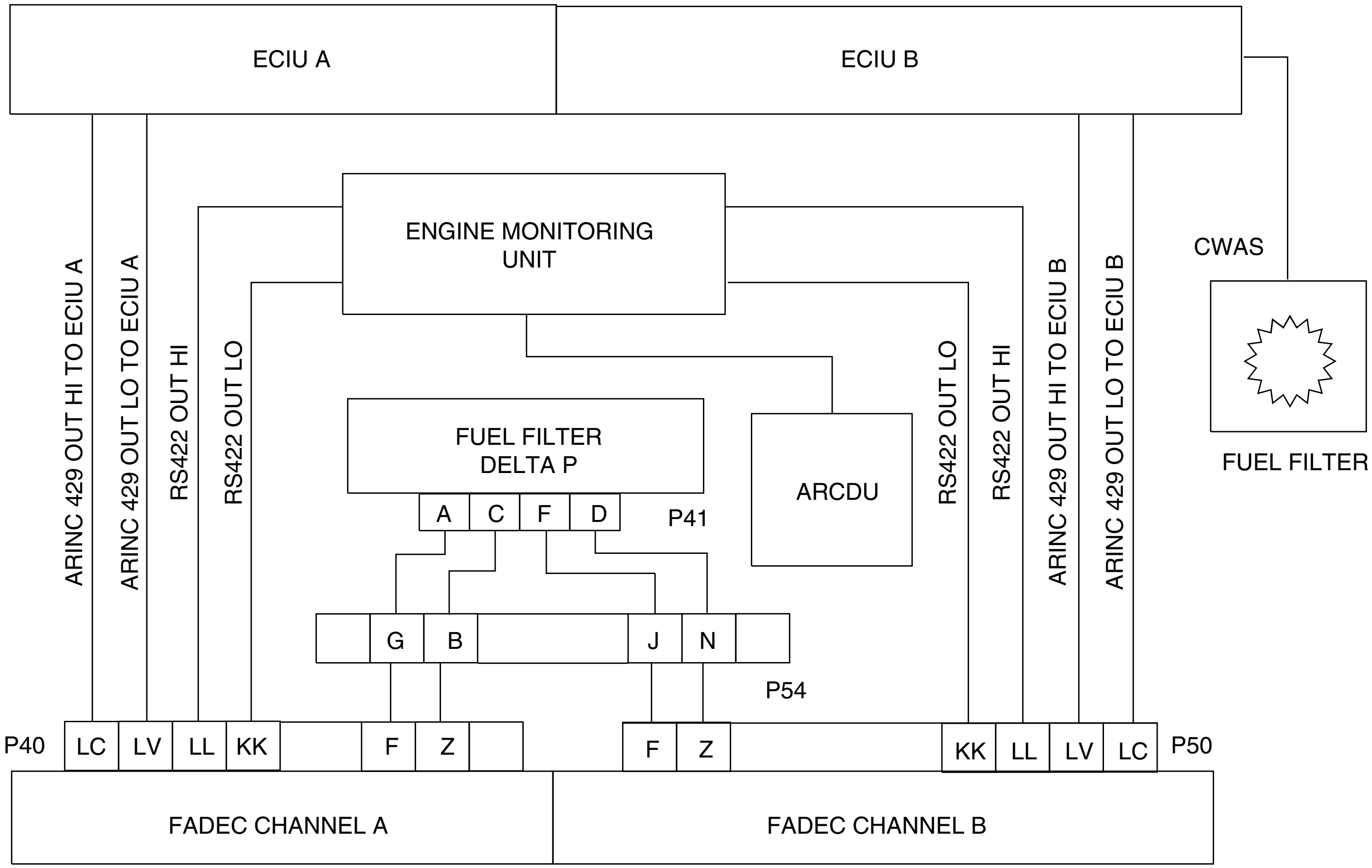
Fuel temperature sensor is a resistive temperature device, which changes the resistance as per the fuel temperature. The sensor installed on the fuel heat exchanger and this fuel heat exchanger is installed on the low pressure compressor case of the left and right engines. The fuel temperature sensor supplies fuel temperature data to the Engine Display (ED), which displays fuel temperature on the fuel page of the Engine Display (ED). Ambient temperature for the fuel temperature sensor is between –65.2 °F and 249.8 °F (–54 °C and 121 °C) and can resist continuous temperature of 302 °F (150 °C) for 2 minutes.

On aircraft without SB84–73–05 or ModSum 4–113817 incorporated, the fuel temperature sensor is not provided with an integral connector.

On aircraft with SB84–73–05 or ModSum 4–113817 incorporated, the fuel temperature sensor is provided with an integral connector attached to a hermetically sealed harness.



Low Fuel Pressure Indication Block Diagram
Figure 1



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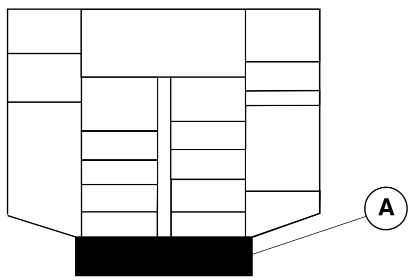
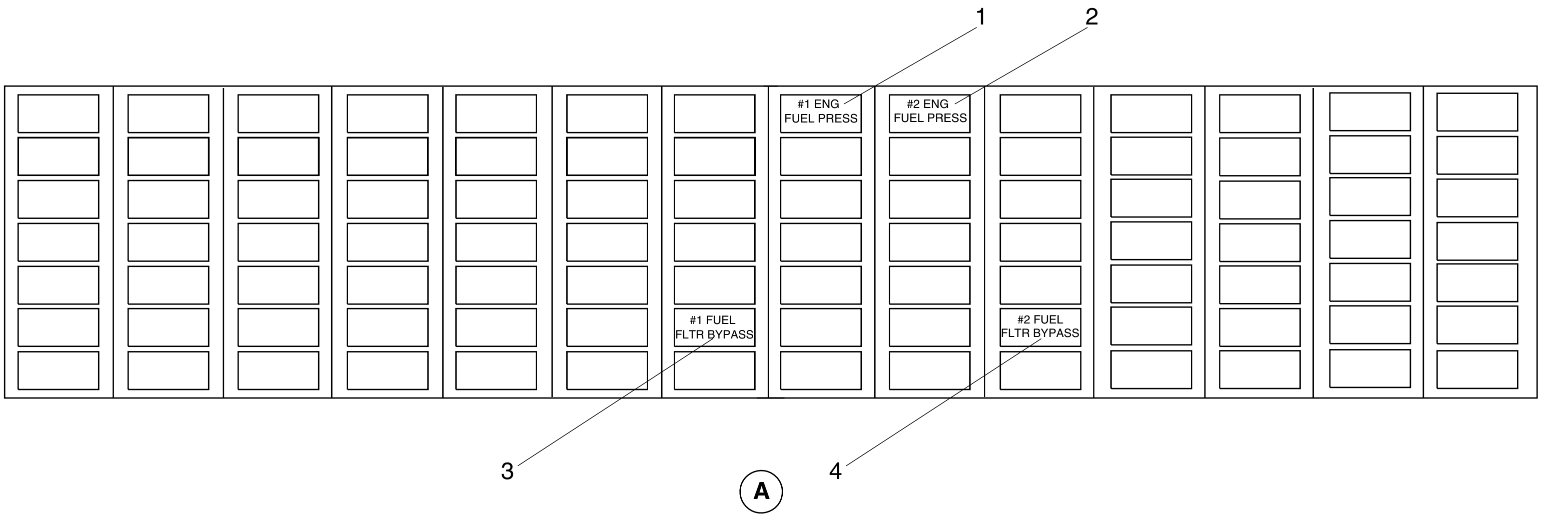
Fuel Filter Impending Bypass Indication Block Diagram
Figure 2



OVERHEAD CONSOLE

LEGEND

1. Engine # 1 Fuel Pressure Low (Amber).
2. Engine # 2 Fuel Pressure Low (Amber).
3. Fuel Filter # 1 Bypass Condition (Amber).
4. Fuel Filter # 2 Bypass Condition (Amber).



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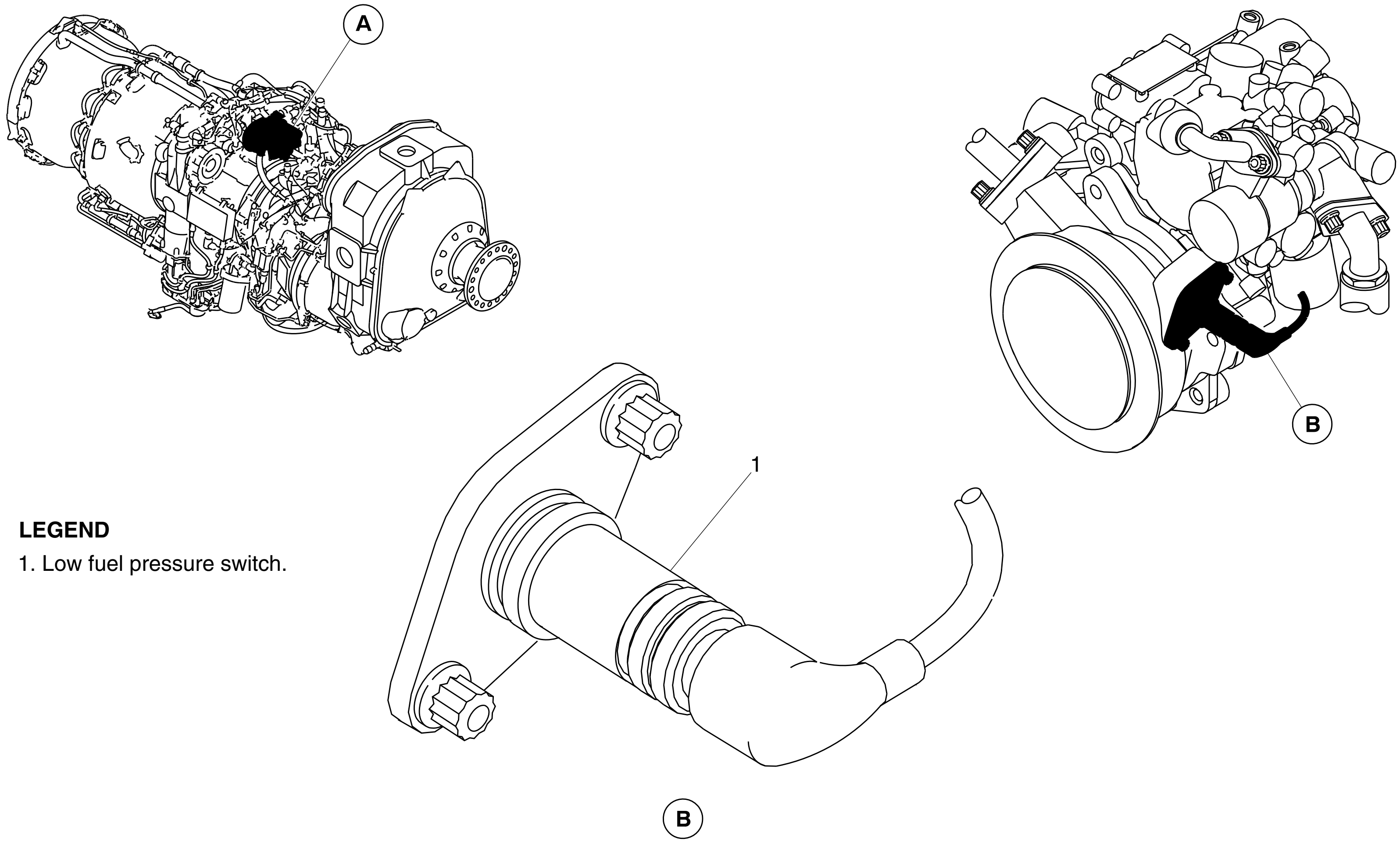
Caution and Warning Panel Fuel Cautions
Figure 3



LEGEND

1. Low fuel pressure switch.

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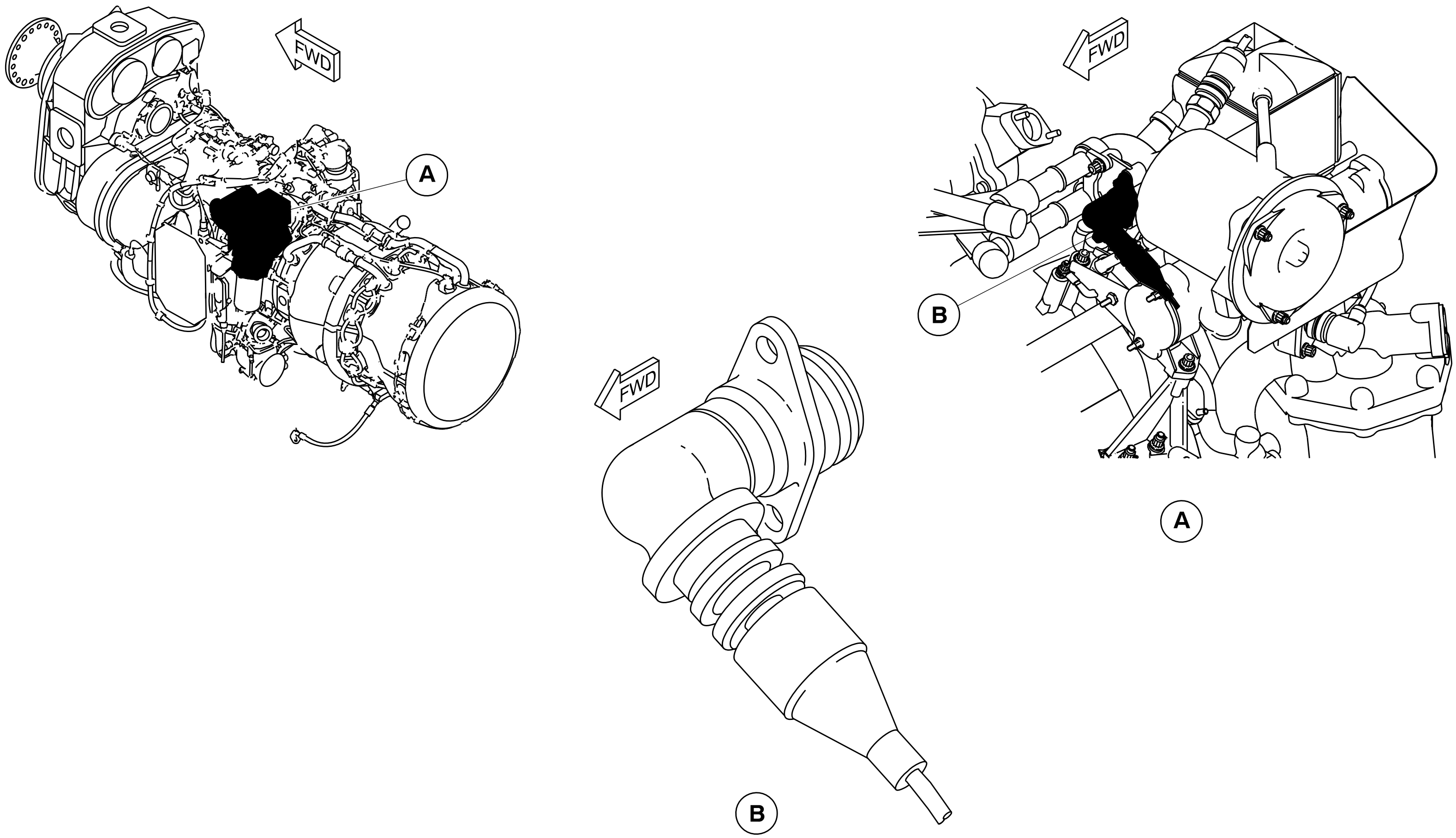
Low Fuel Pressure Switch
Figure 4



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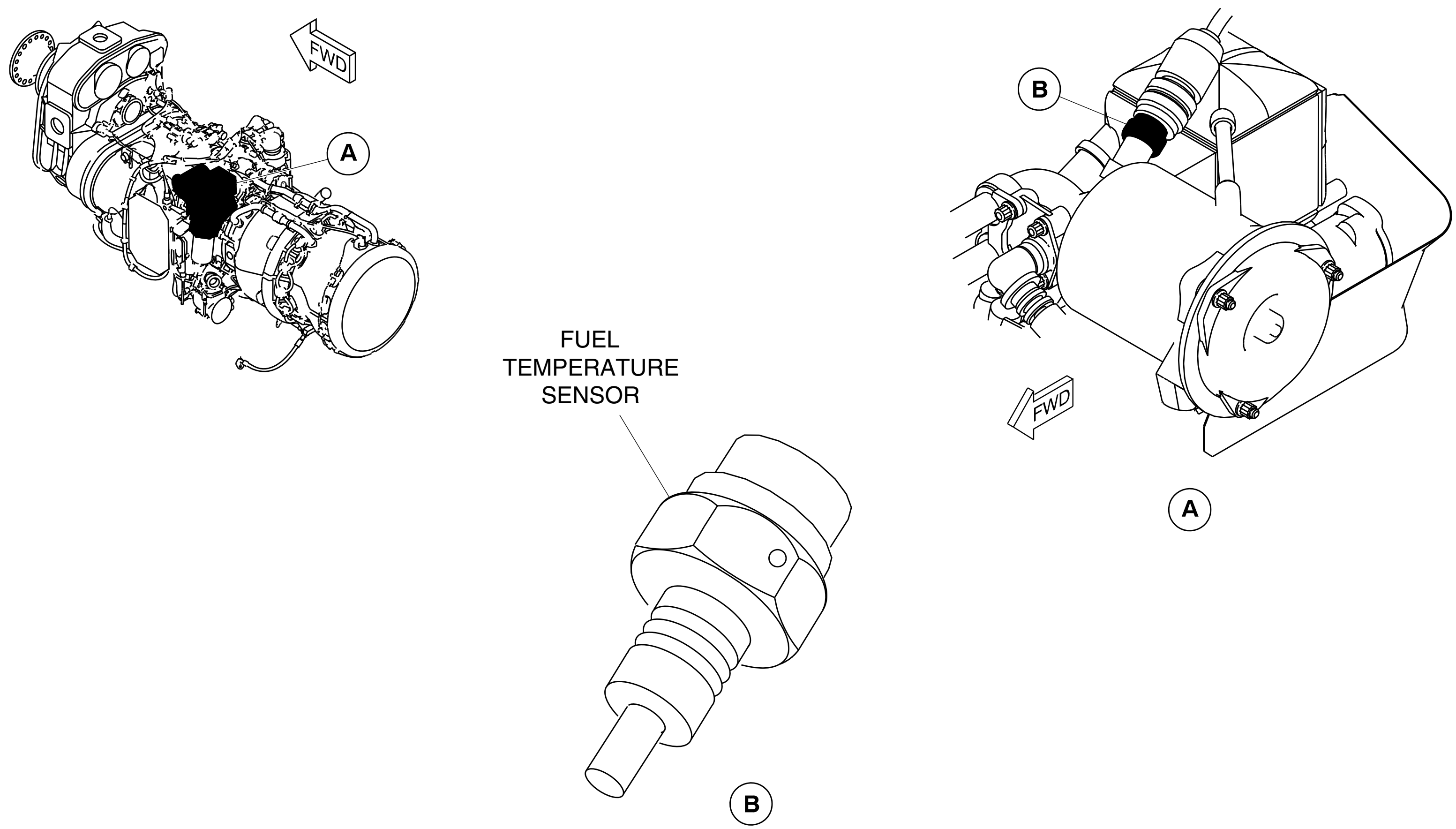
Fuel Filter Impending Bypass Switch
Figure 5



PRE SB84–73–05
PRE MODSUM 4–113817

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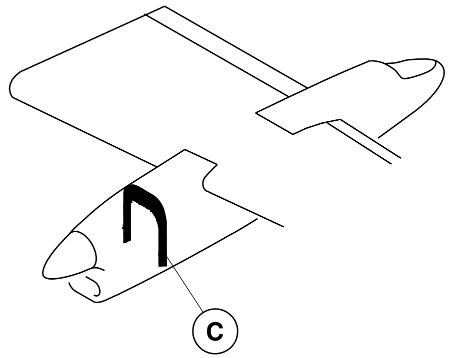
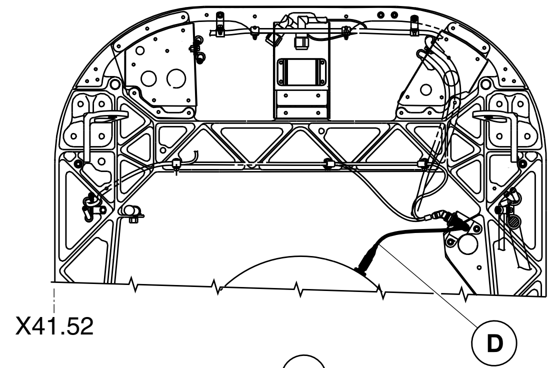
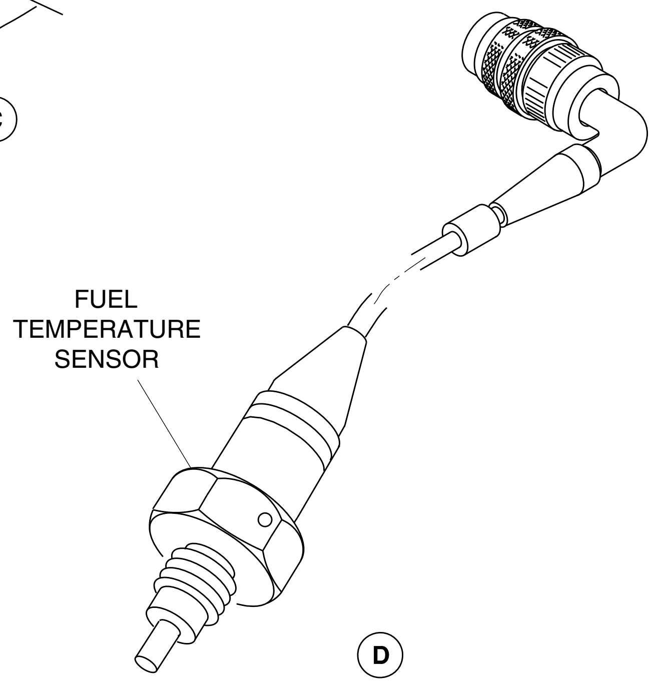
Engine Fuel Temperature Sensor
Figure 6 (Sheet 1 of 2)





C
**VIEW LOOKING AFT ON
NACELLE MID FRAME ENGINE**



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**POST SB84–73–05
POST MODSUM 4–113817**

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Engine Fuel Temperature Sensor
Figure 6 (Sheet 2 of 2)