**ON A/C ALL

77–00–00–001

ENGINE INDICATING, GENERAL

Introduction

The purpose of the indicating system is to provide data on vital engine parameters for use by the flight crew and maintenance personnel to monitor engine health and performance. These parameters are: High Pressure Rotor Speed (NH), Low Pressure Rotor Speed (NL), Propeller Speed (NP), Torque (Q), Air Intake Temperature (T1.8), and Inter–Turbine Temperature (ITT).

General Description

Refer to Figures 1 and 2.

The engine parameters collected by the sub–systems are shown on the Engine Display. The parameters are also sent to the EMU for use by the maintenance personnel when they access the maintenance screen on the ARCDU or the CDS on the laptop.

The function of the indicating system is performed by the:

- Power indicating sub–system
- Temperature indicating sub–system
- Analyzers.

High Pressure Turbine Speed (Nh) Sensors

The engine is fitted with two High Pressure Turbine (Nh) probes. Each probe provides the signals from two sensors to each channel of the Full authority Digital Electronic Control (FADEC). One signal is used for engine control and indication, the other signal is used for independent overspeed protection.

Low Pressure Turbine Speed (Nl) Sensors

The engine is fitted with one Low Pressure Turbine Speed (Nl) probe. The probe has two sensors, each sensor provides a signal to a channel of FADEC. The FADEC uses this signal for controlling the Handling Bleed Off Valves (HBOVs) and for indication.

Propeller Speed Sensors

The propeller system is fitted with a Propeller Speed (Np) sensor. This sensor provides a 7 pulses/rev signal to the Propeller Electronic Control (PEC), and this signal is also sent to FADEC for reference only. The PEC uses this signal for propeller speed governing, sycchrophasing and balancing.

Engine Torque/Power Turbine Speed (Q/Npt) Sensors

The engine is fitted with two Torque/Power Turbine Speed probes. Each probe has two sensors. One sensor provides a signal to FADEC, the other provides a signal to the propeller control system. The two signals are sent to FADEC, one to each channel and are used for computing torque and power turbine speed. Both parameters are required for control and indication.

Air Inlet Temperature (T1.8) Sensor

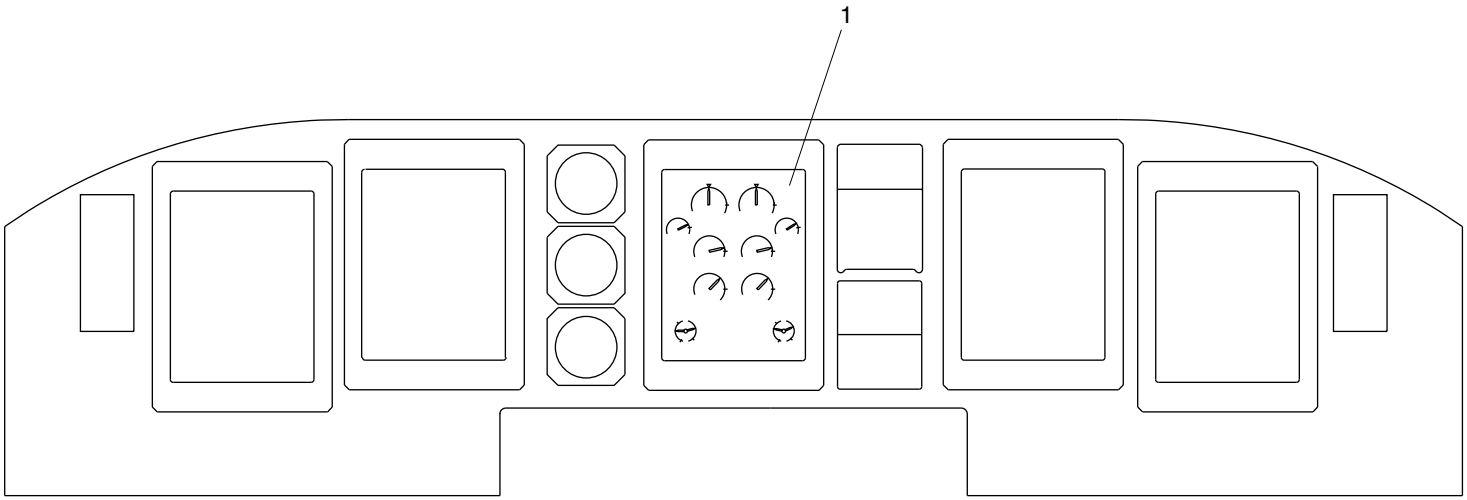
The engine is fitted with an air inlet temperature probe. The probe has two sensors, each sensor provides a signal to a channel of FADEC. The FADEC uses this signal for several functions including setting of thermal rated power. The T1.8 sensor is the reference signal for ambient temperature.

Inter–Turbine Temperature (ITT)

The engine is fitted with an annular ring of eight temperature probes. Each probe has three thermocouples at different radial positions in the gas path. All 24 thermocouples are connected in parallel to the dual sensor Main Oil Temperature probe. FADEC uses the signal from the MOT probe as a cold junction reference for the measurement and calculation of the Exhaust Gas Temperature (EGT). EGT is used by the FADEC for temperature limiting during engine start and is displayed in the flight compartment as ITT.

LEGEND

1. Engine Display.



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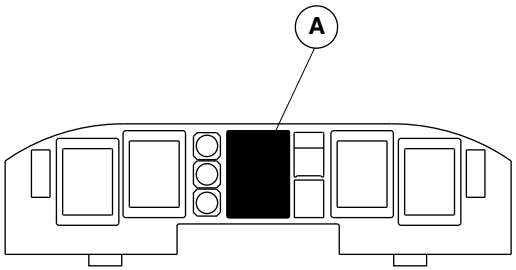
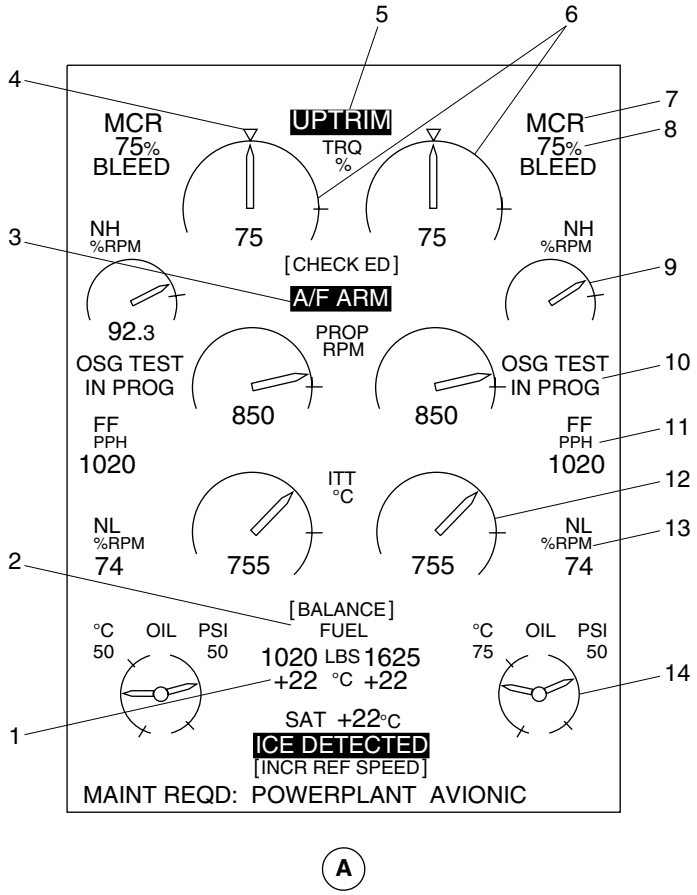
Engine Indicating Location
Figure 1



MAIN INSTRUMENT PANEL



LEGEND

1. Fuel Quantity and Fuel Temperature Indications.
2. Balance Message Indicating Fuel Imbalance.
3. Autofeather Armed Indication.
4. Torque Bug.
5. Uptrim In Operation.
6. Left/Right Torque Indication.
7. Engine Mode Indication.
8. Torque Bug Digital Readout.
9. High Pressure Gas Generator Speed.
10. Overspeed Governor Test In Progress.
11. Fuel Flow In Pounds Per Hour.
12. Indicated Turbine Temperature.
13. Low Pressure Gas Generator Speed.
14. Oil Pressure and Temperature Indications.

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Engine Indicating Details
Figure 2

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**ON A/C ALL

77–10–00–001

POWER INDICATING

Introduction

The Power Indicating System provides data on the engine high pressure rotor speed (NH), torque (Q), and low pressure rotor speed (NL).

General Description

Refer to Figure 1.

The NH, Q, and NL sensors provide signals which are passed to the Full Authority Digital Electronic Control (FADEC) by the controls, electrical wiring harness. Each FADEC display channel (channel not in control) sends the signals on an ARINC 429 bus direct to the Engine Display.

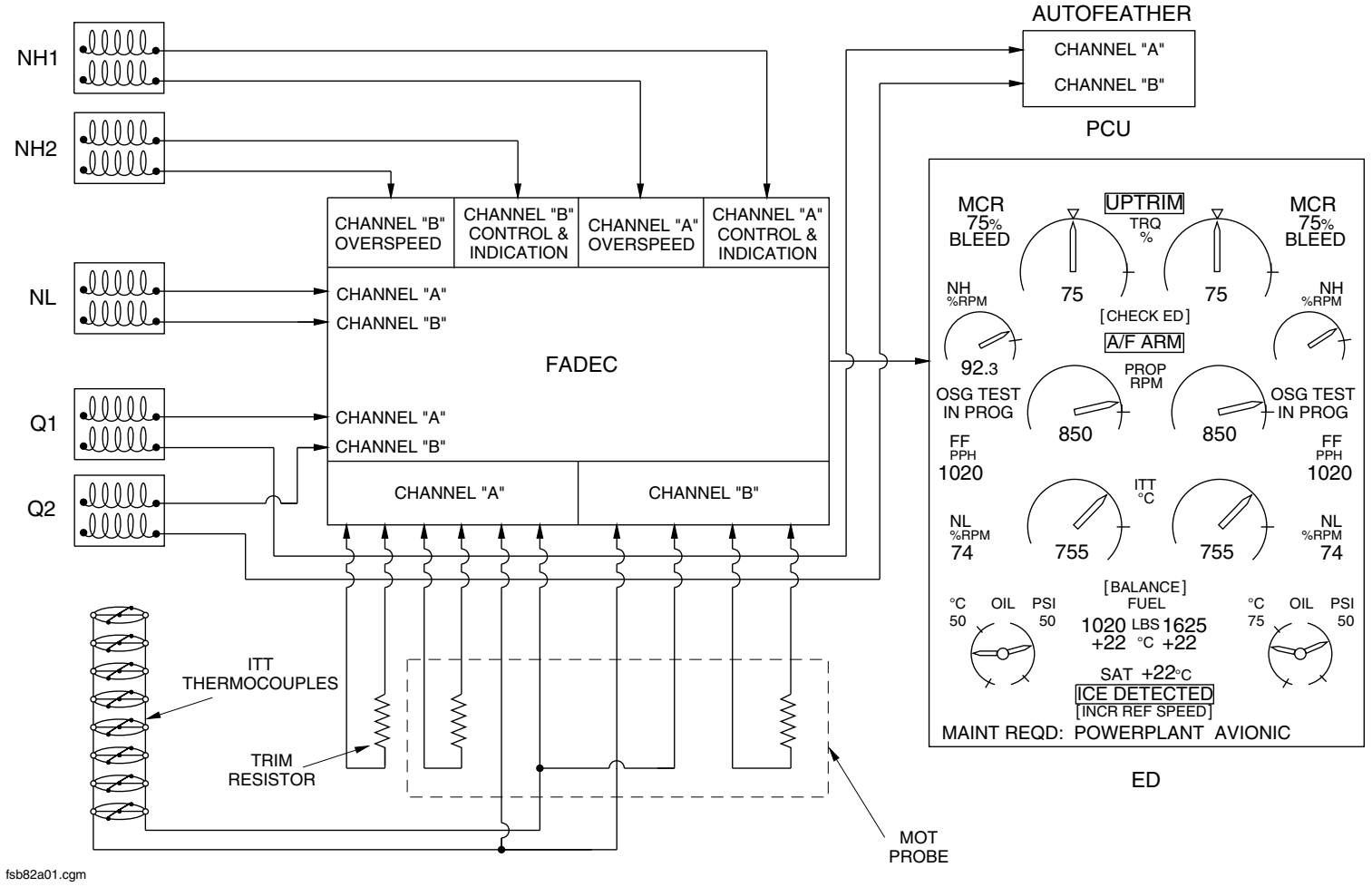
The power indicating system has the components that follow:

- High Pressure Rotor Speed Sensors
- Torque Sensors
- Low Pressure Rotor Speed Sensor

The engine parameters collected by the sub–systems are shown on the Engine Display. The parameters are also sent to the Engine Monitoring Unit (EMU) for use by the maintenance personnel when they access the maintenance screen on the Audio Radio Control Display Unit (ARCDU) or the Central Diagnostic System (CDS) on the laptop.

Training Information Points

OBEY ALL THE ELECTRICAL/ELECTRONIC, AND ELECTROSTATIC DISCHARGE SAFETY PRECAUTIONS.



Engine Power Indicating Schematic
Figure 1

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**ON A/C ALL

77–11–00–001

ENGINE POWER INDICATING

Introduction

The purpose of the power indicating system is to provide data on the speed of the major rotating assemblies and the torque output. These speeds and torque are monitored by magnetic pulse pickup probes at various locations on the engine.

General Description

Refer to Figure 1.

The function of the power indicating system is performed by the:

- High Pressure Rotor Speed (NH) sensors (77–11–01)
- Torque sensors (Q) (77–11–06)
- Low Pressure Rotor Speed (NL) sensor (77–11–11)
- Instrumentation Wiring Harness (77–11–13)

Detailed Description

The speeds of the major rotating assemblies are monitored by magnetic pulse pick–up probes installed at various locations on the engine. High pressure rotor speed (NH), Low pressure rotor speed (NL), and propeller speed (NP) are sensed by these probes. Power turbine rotor speed (NPT) is sensed by the torque sensor and derived to propeller speed (NP). Electromagnetic pulses are generated when associated gear teeth or lugs pass through the magnetic field created at the probe or sensor tip. The pulse frequency is transmitted to the Full Authority Digital Electronic Control (FADEC) and Propeller Electronic Control (PEC) and then to the Central Diagnostic System (CDS).

High Pressure Rotor Speed (NH) sensor

Refer to Figure 2.

There are two NH sensors located on top of the Accessory Gearbox (AGB). Each NH sensor is a sealed unit consisting of two coils. The sensors pick up high pressure rotor speed signals from the fuel pump and PMA gearshaft teeth. One coil is used to provide a NH speed signal to the FADEC for use in the control logic, the other is used to provide a NH speed signal for use in the overspeed logic. There are two sensors on each engine, therefore control and overspeed functions are independent for channel A and B.

Torque Sensor (Q)

Refer to Figure 3.

There are two torque sensors located on the air inlet case. The two torque sensors take their signal from torque shafts in the reduction gearbox. Correction of torque shaft stiffness caused by temperature change is provided to FADEC and PEC by the Main Oil Temperature (MOT) probe on top of the front inlet case. Each sensor consists of two coils which are used to sense Torque (Q) and Power Turbine Speed (NPT). Each sensor supplies a Torque and NPT speed signal to the FADEC and Engine Display, and Propeller Electronic Controller (PEC) using one coil for each. This means that there are independent Torque and NPT speed signals for channel A and B of both the FADEC and PEC. The Torque and NPT speed signals are

used in the FADEC control logic. The FADEC provides processed Torque and NPT speed for flight compartment indication. In the PEC they are used for Autofeather logic processing.

Low Pressure Rotor Speed Sensor (NL)

Refer to Figure 4.

There is one Low Pressure Rotor Speed Sensor located on top of the front inlet case next to the MOT probe. The NL sensor is a sealed unit consisting of two coils. The sensor picks up low pressure rotor speed from a toothed sleeve against the no. 2.5 bearing. Each coil supplies a NL speed signal to channel A and B of the FADEC respectively. NL speed is used for controlling the Interstage and Intercompressor bleed valves, flight compartment indication and in the FADEC LP Rotor Overspeed Detection.

Instrument Wiring Harness

The harness connects the sensors, the bleed valve, the PMA and the Fuel Metering Unit (FMU) to the FADEC.

Refer to Figures 5 , 6 , 7 , 8 and 9.

The pin/socket arrangement for the connectors of the Instrument Wiring Harness is shown in table 1. The receiving connector on the end device is keyed to make sure that the installation of the electrical wiring harness is correct.

Table 1, pin/socket arrangement

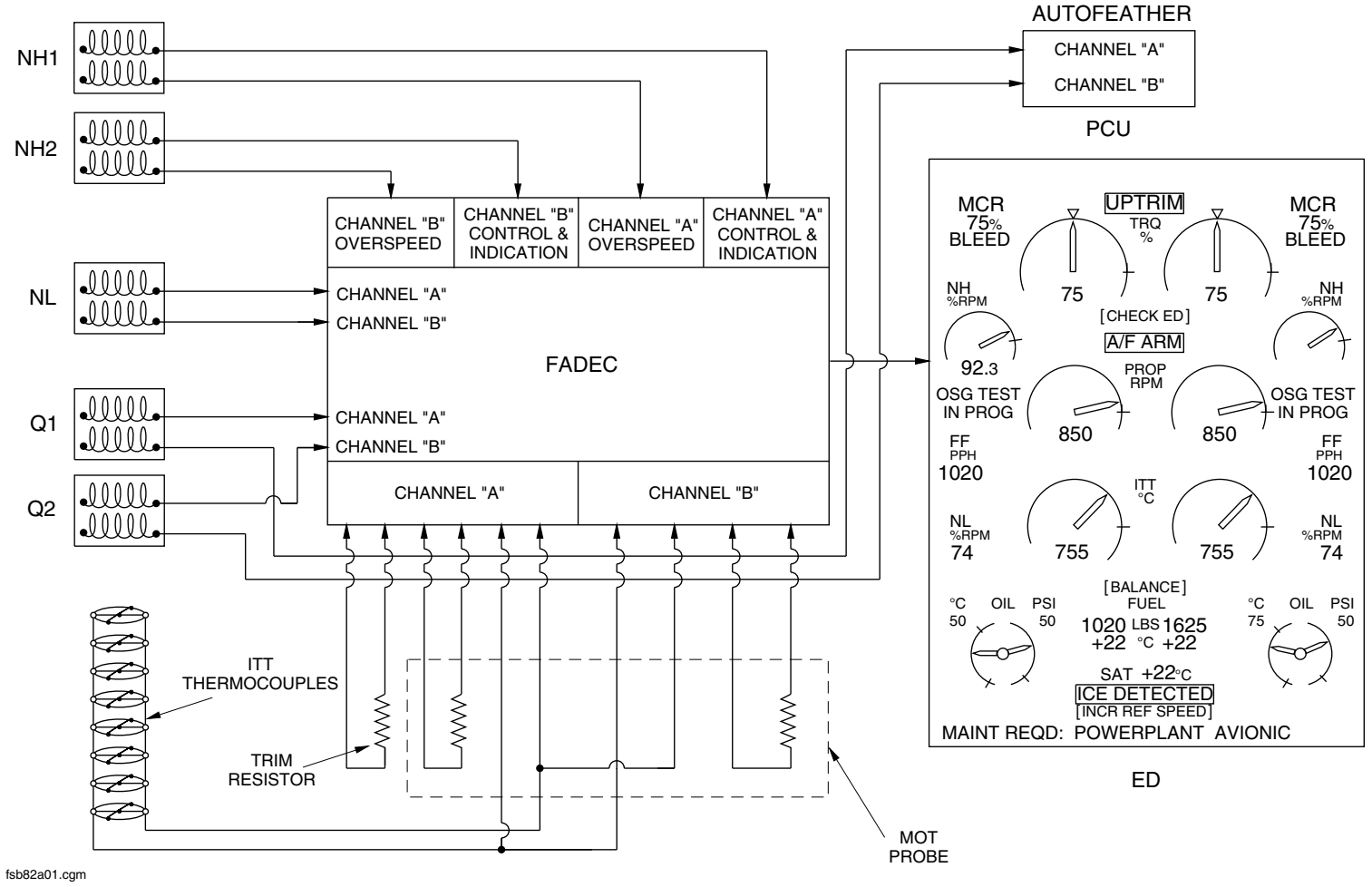
- P41, Fuel Filter Differential Indicator
- P42, AC Generator Chip Detector
- P43, T/M Chip Detector
- P44, Low Fuel Pressure Indicator
- P45, Ignition Exciter
- P46, LOP
- P47, Oil Filter Differential Indicator
- P48, RGB Chip Detector
- P49, Oil Scavenge Differential indicator
- P55, MOP

Refer to Figures 10 , 11 , 12 , 13 , 14 , 15 and 16.

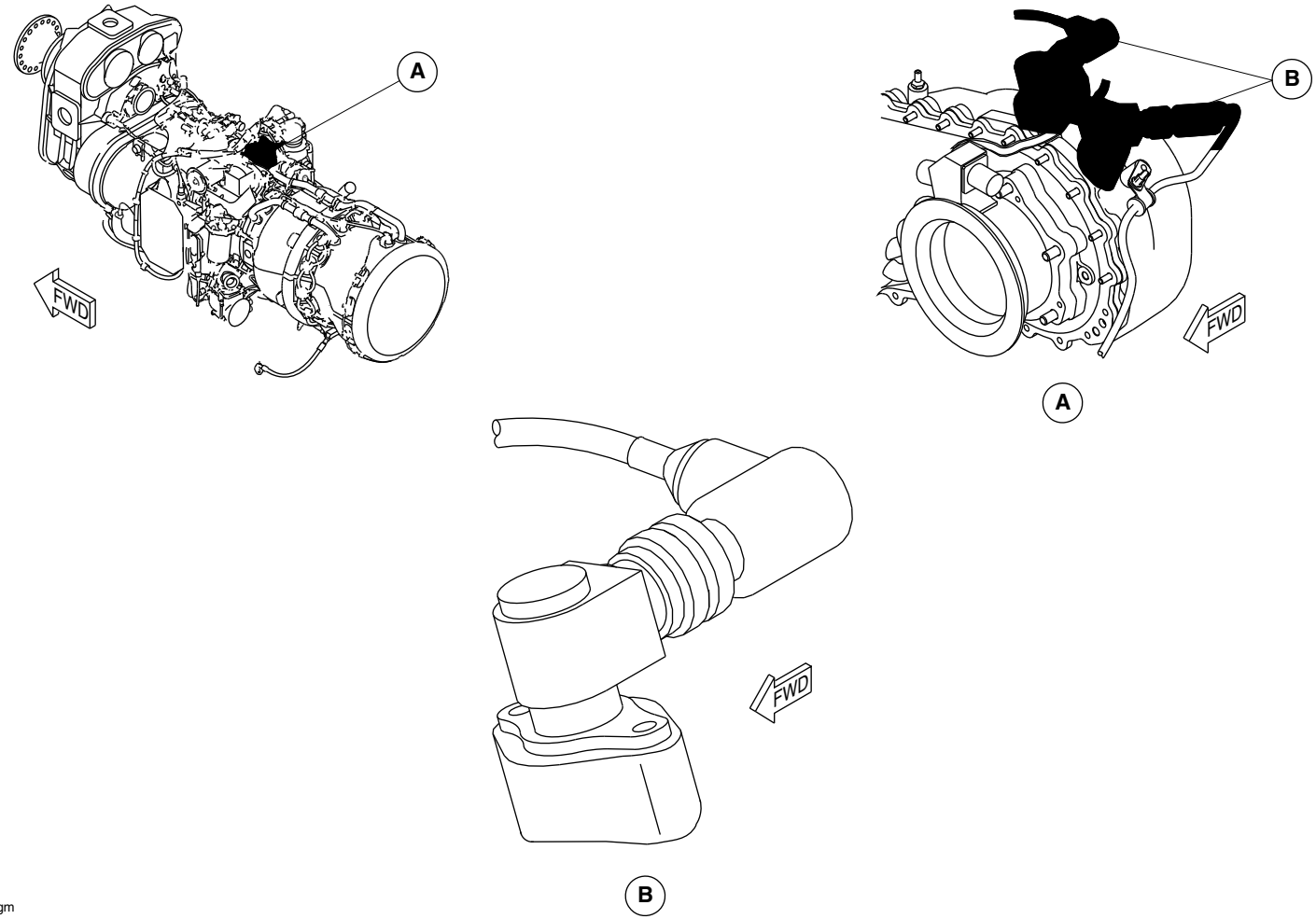
The integral engine electrical wiring harness provides interconnection of all engine mounted instrumentation components. The electrical wiring harness is assembled from single and multicolor cables, each cable having integral EMI shielding. All connectors conform to MIL–C–38999 series III to provide durable self–locking moisture–proof connections. The connectors are made from titanium. EMI shielding is provided by continuous connection of cable shields through connector backshells and bodies. Screens are grounded at both ends to provide protection from induced lightning transients. The backshells also provide mechanical support for the conductors at their interface with the connector.

Training Information Points

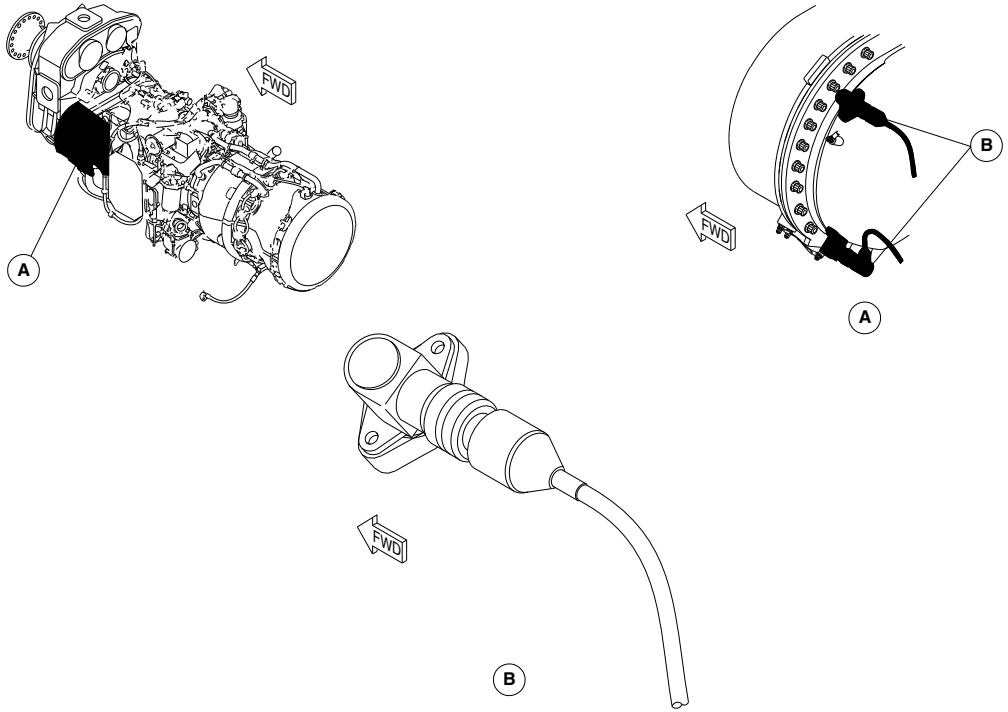
OBEY ALL THE ELECTRICAL/ELECTRONIC, AND ELECTROSTATIC DISCHARGE SAFETY PRECAUTIONS.



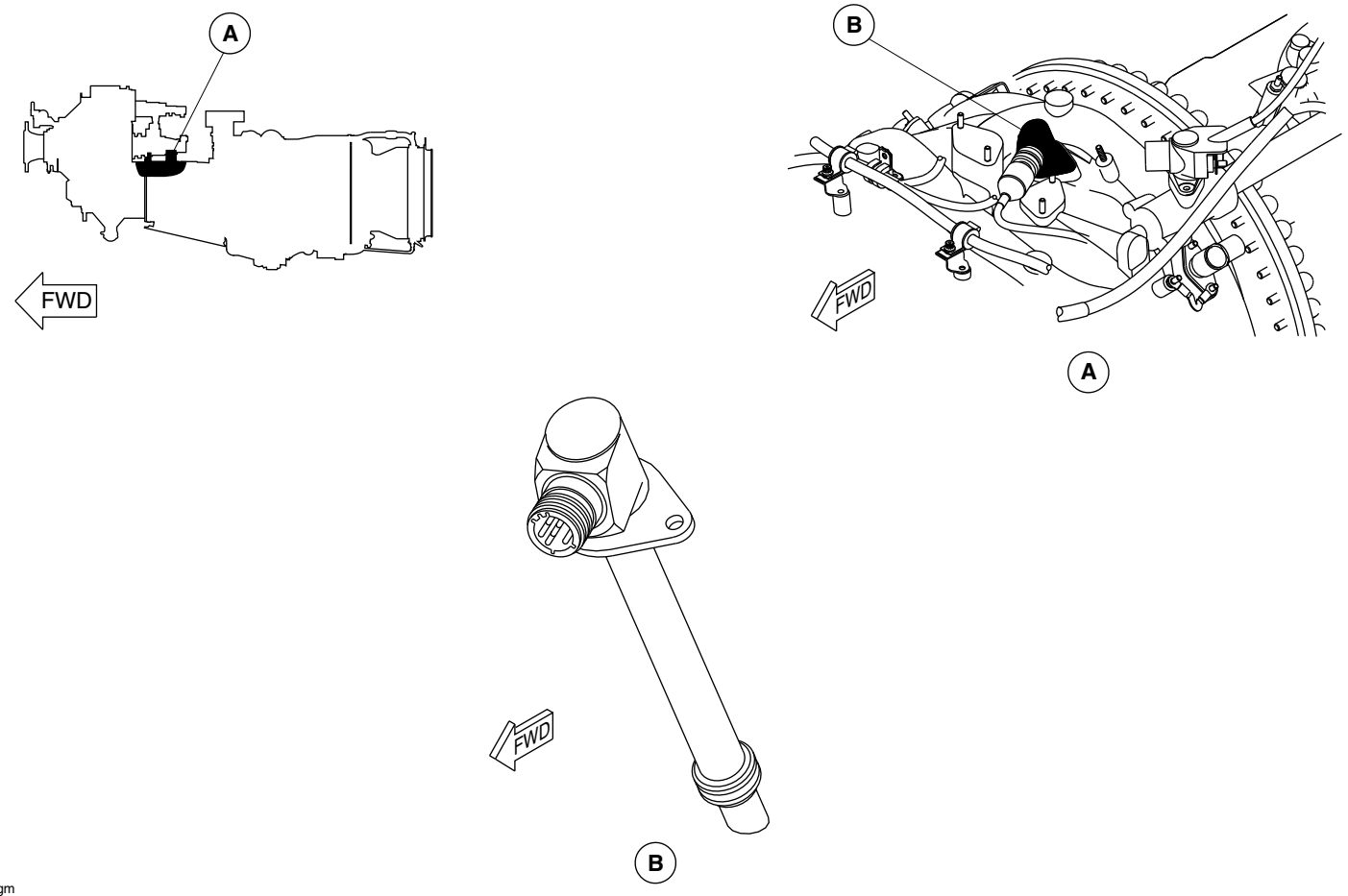
Engine Power Indicating Schematic
Figure 1



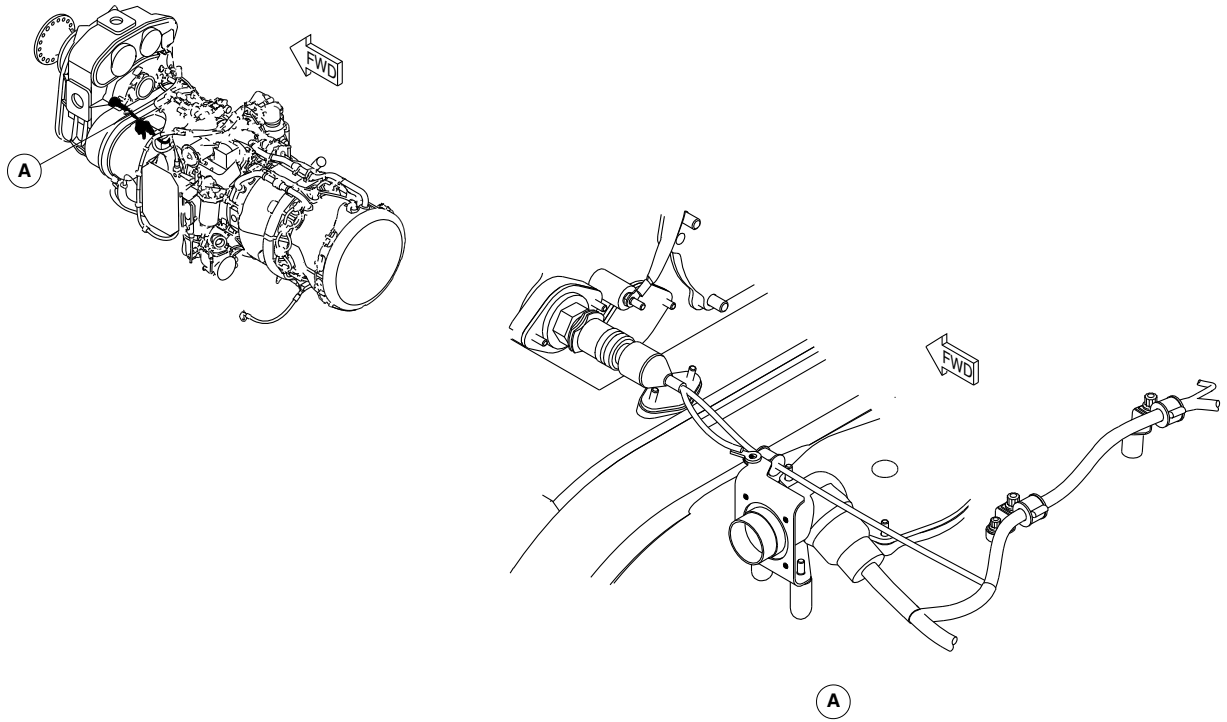
NH sensors
Figure 2



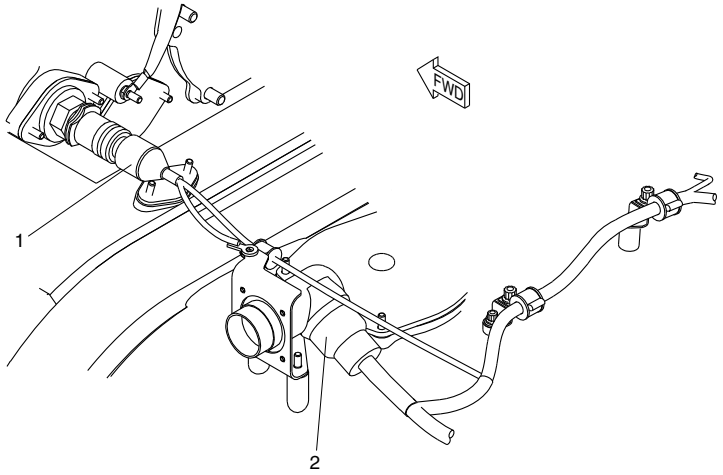
Torque sensors
Figure 3



NL sensor
Figure 4



Instrumentation Wiring Harness Page 1
Figure 5



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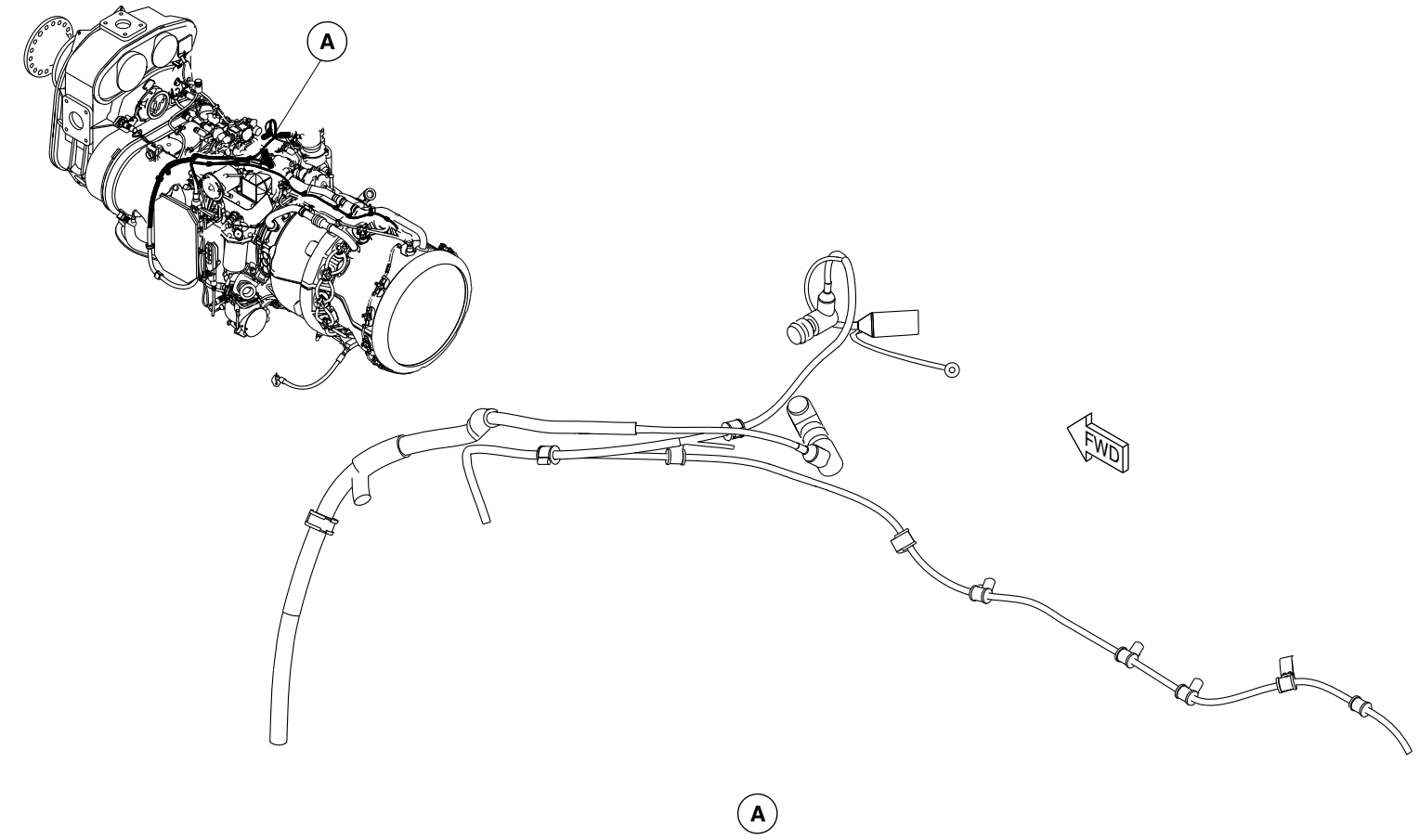
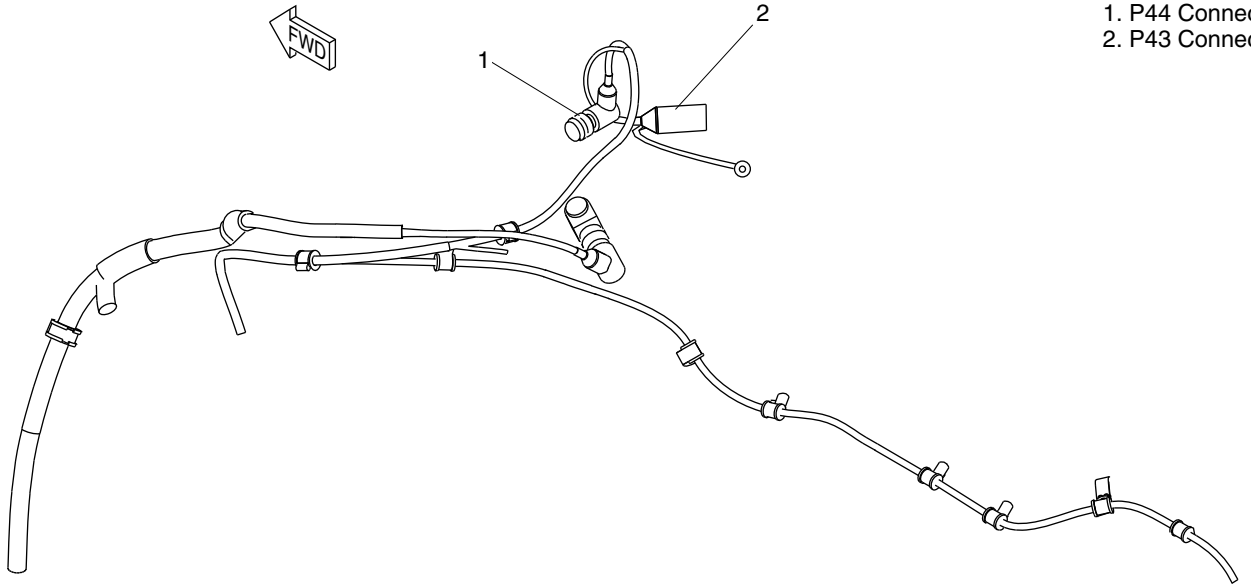
LEGEND

1. P42.
2. J54.

Instrumentation Wiring Harness Page 2
Figure 6



Instrumentation Wiring Harness Page 3
Figure 7



LEGEND

1. P44 Connector.
2. P43 Connector.

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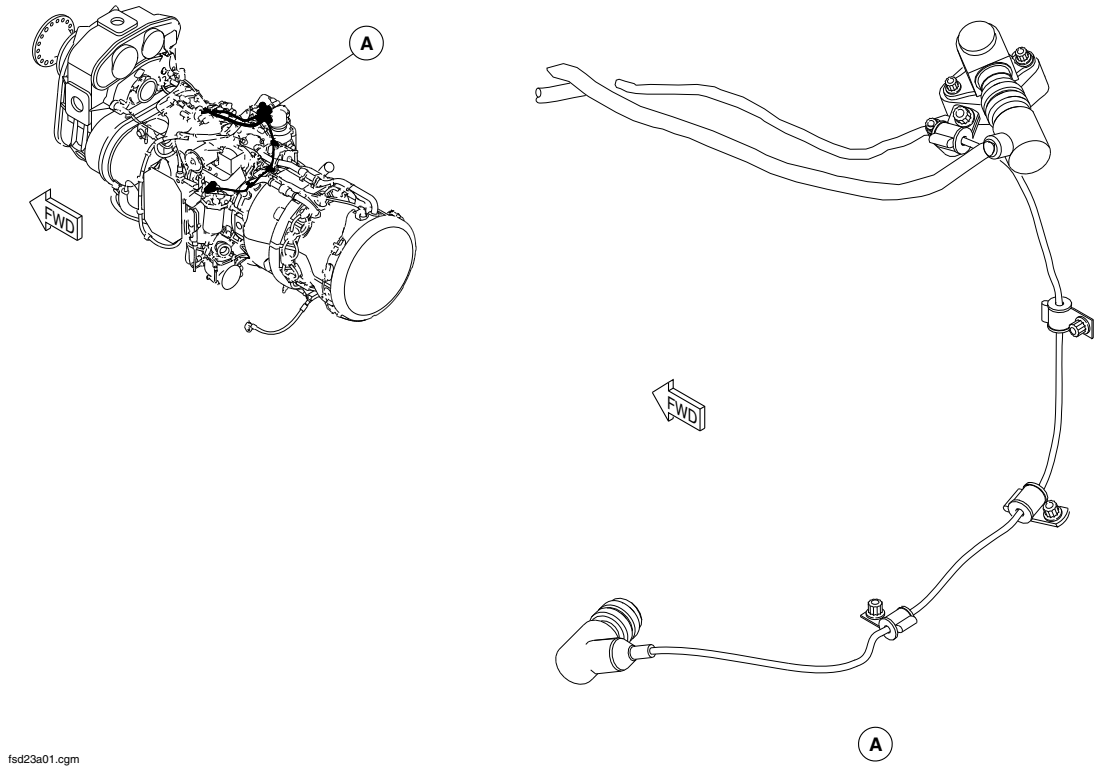
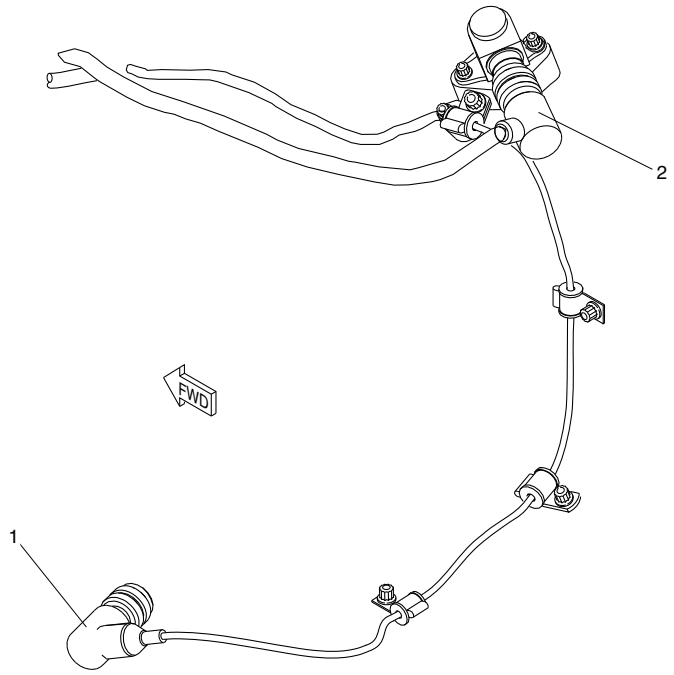
Instrumentation Wiring Harness Page 4
Figure 8



Instrumentation Wiring Harness Locator Page 1
Figure 9



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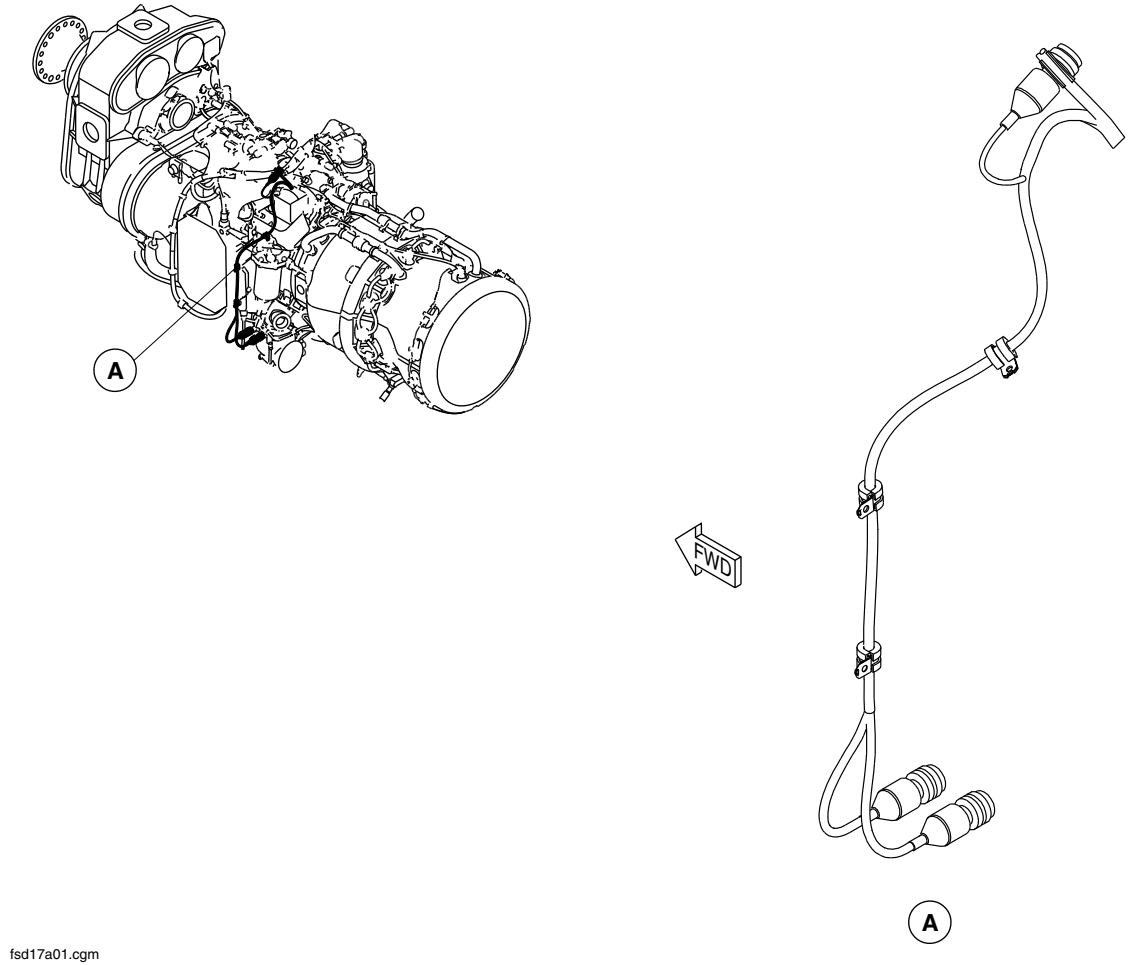
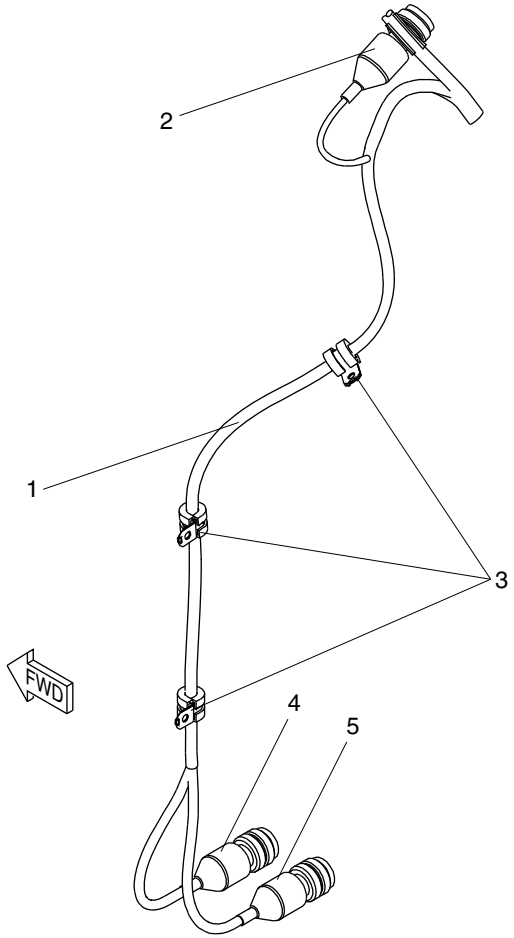
LEGEND

1. P47 Connector.
2. P4 Connector.

Instrumentation Wiring Harness Detail Page 1
Figure 10



Instrumentation Wiring Harness Locator Page 2
Figure 11



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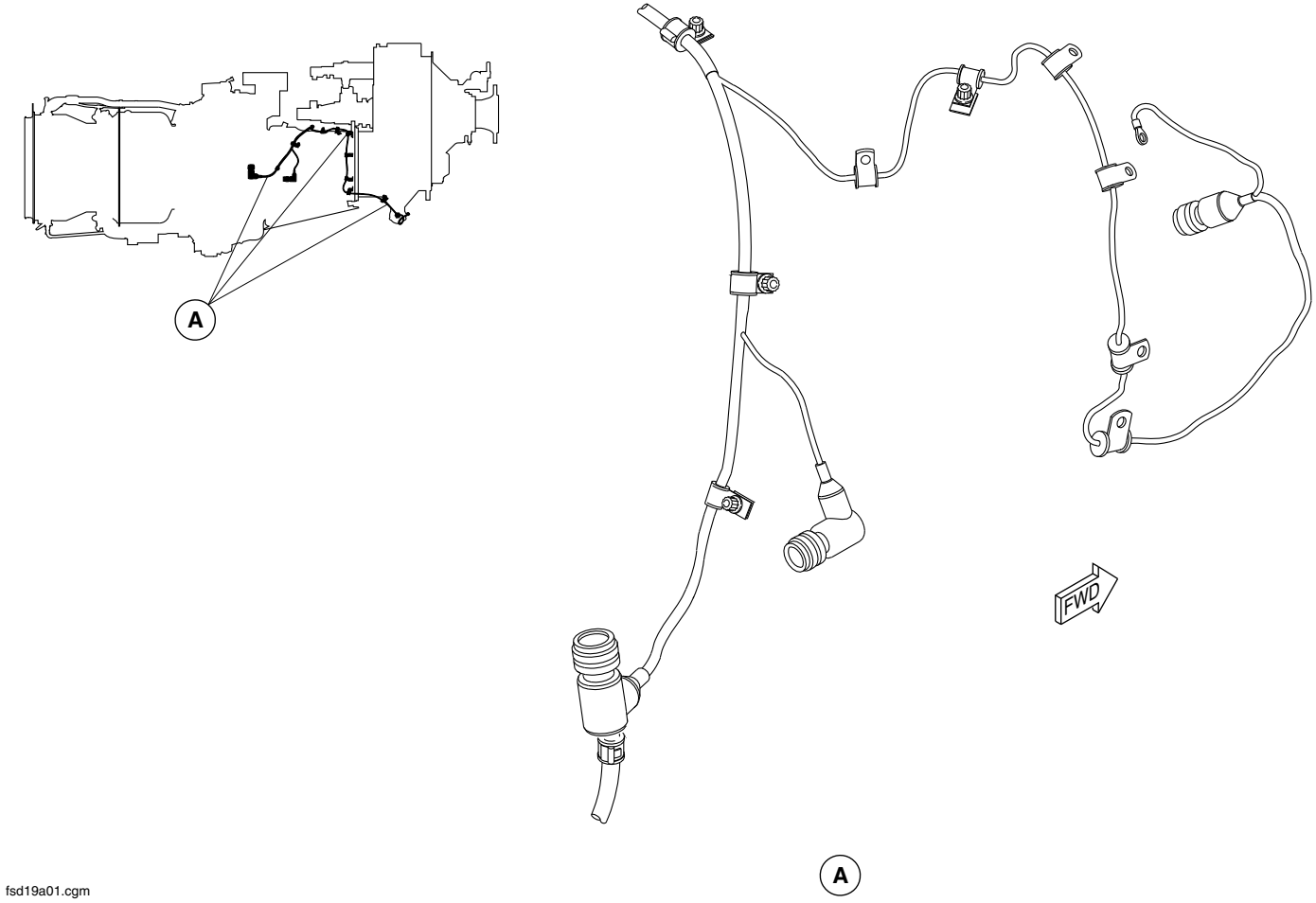
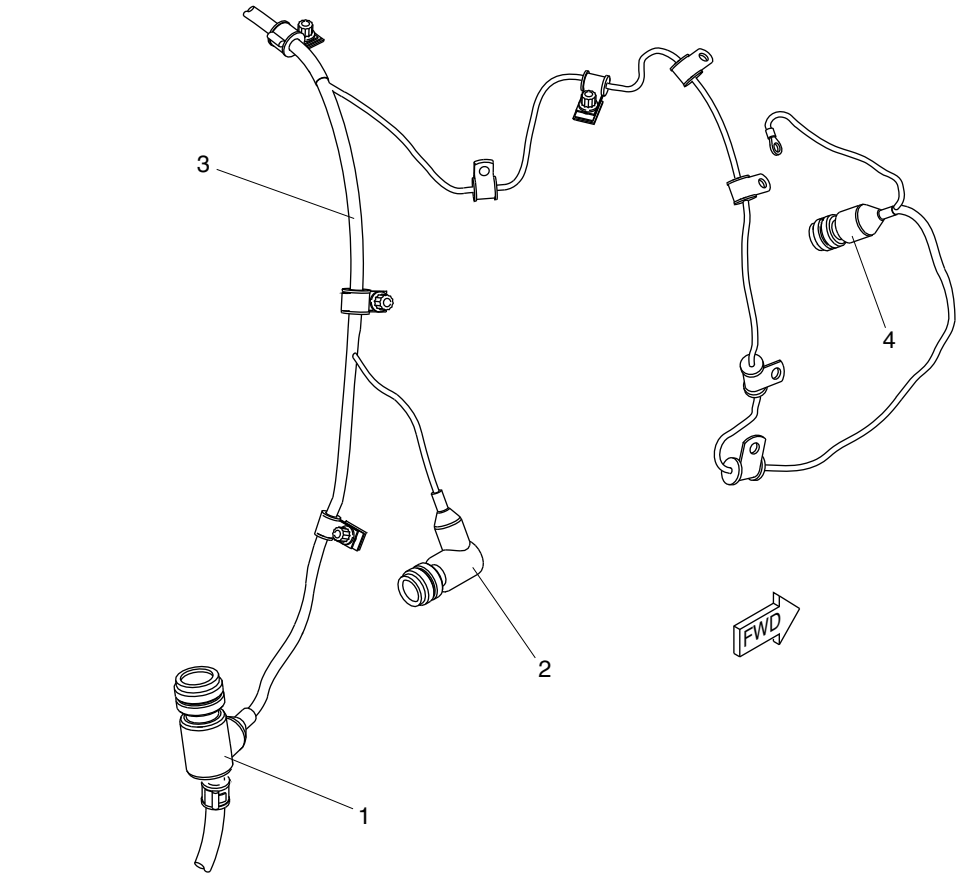
LEGEND

1. Instrumentation Wiring Assembly.
2. P41 Connector.
3. Wiring Harness Mounting Clamps.
4. P46 Connector.
5. P55 Connector.

Instrumentation Wiring Harness Detail Page 2
Figure 12



Instrumentation Wiring Harness Locator Page 3
Figure 13



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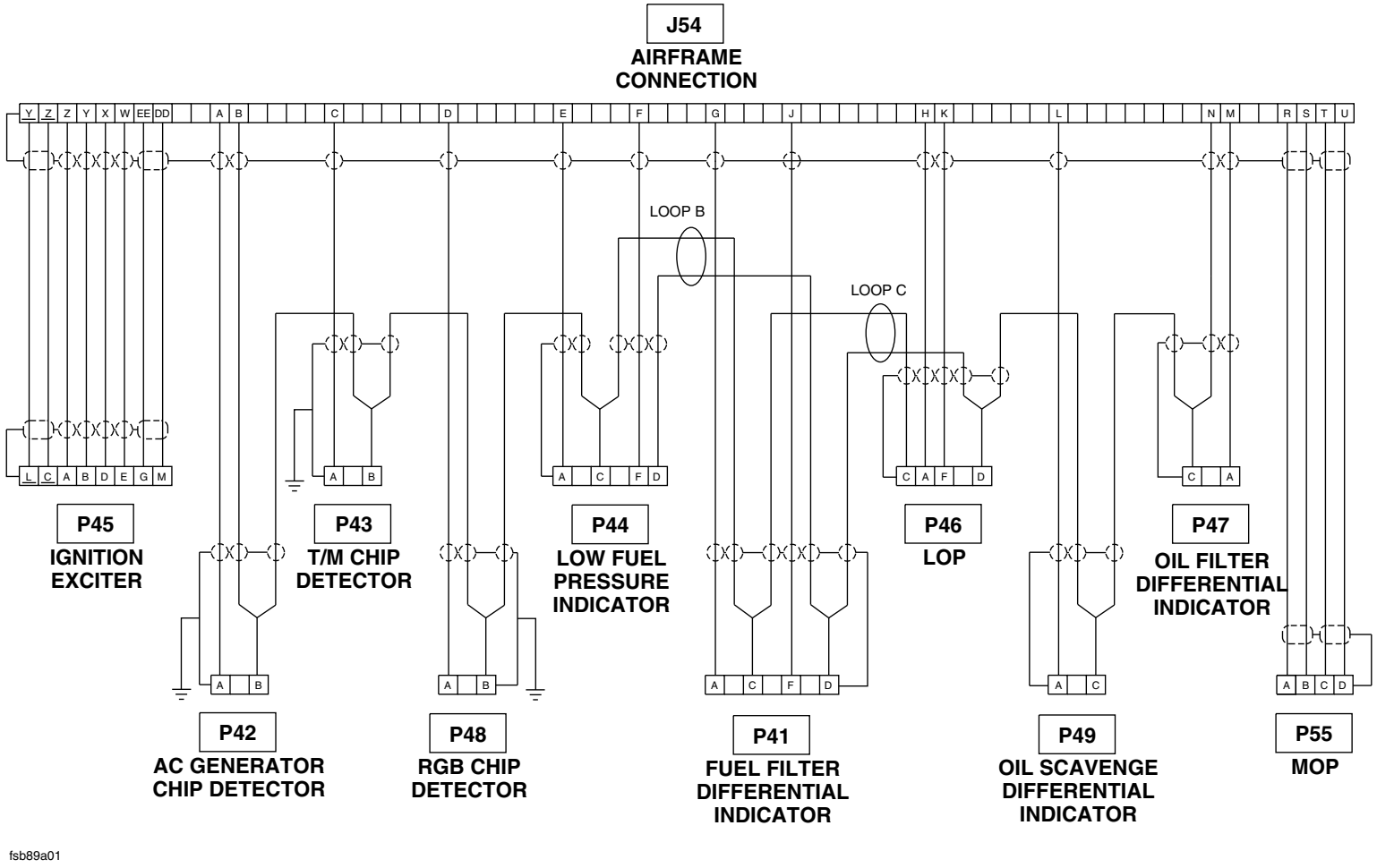
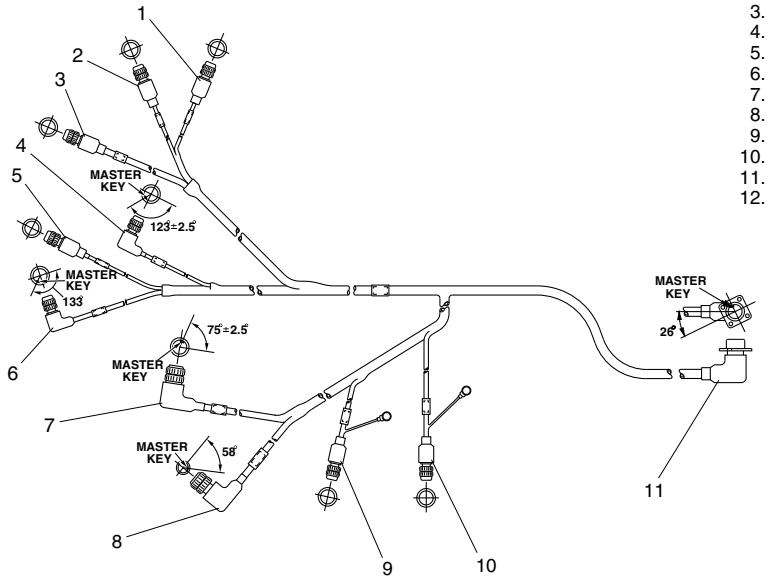
LEGEND

1. P45 Connector.
2. P49 Connector.
3. Right Side Instrumentation Wiring Harness Assembly.
4. P48 Connector.

Instrumentation Wiring Harness Detail Page 3
Figure 14



Typical Connector
Figure 15



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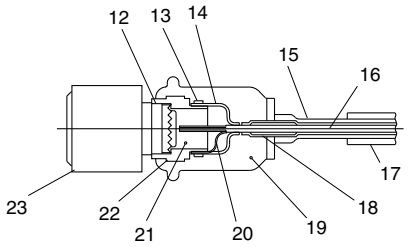
LEGEND

1. P55.
2. P46.
3. P41.
4. P47.
5. P43.
6. P44.
7. P45.
8. P49.
9. P48.
10. P42.
11. J54.
12. THD Sealant.
13. GND Band or Crimp Ring.
14. NI/CU Braid or Alpha Braid.
15. Coating, Viton, Gray, 1st Coat; Coating, Viton, Black, 2nd Coat.
16. RTV Sealant.
17. Ident.
18. Fiberglass Tape.
19. Compound Epoxy.
20. Inner Shield.
21. Potting.
22. Adapter.
23. Connector.



TYPICAL CONNECTOR / CABLE CONSTRUCTION

Wiring Diagram
Figure 16

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**ON A/C ALL

77–20–00–001

TEMPERATURE INDICATING

Introduction

The Temperature Indicating System is used to monitor engine performance.

General Description

The temperature indicating system supplies data on internal engine temperatures at certain engine stations. These temperatures are : Air Intake Temperature (T1.8), and Inter–Turbine Temperature (ITT).

The function of the Temperature Indicating System is performed by the:

- Total–inlet temperature (T1.8) sensor (77–21–02)
- Inter–turbine temperature probes (77–21–01)

Detailed Description

The T1.8 sensor and T6 (ITT) probes provide signals which are passed to the Full Authority Digital Electronic Control (FADEC) by the controls electrical wiring harness and the T6 wiring harness. Each FADEC display channel (channel not in control) sends the signals on an ARINC 429 bus direct to the Engine Display.

T1.8 Temperature Sensor

Refer to Figure 1.

A dual platinum resistance temperature device located in the intake just upstream of the first stage low pressure compressor. The sensor is used to measure air intake temperature. That temperature is used to calculate engine ratings. Calculated engine ratings are used to automatically set maximum rated power and display maximum rated torque in the flight deck.

Intake temperature measured by the T1.8 sensor is used by the local FADEC and transmitted to the opposite FADEC. The two values are averaged in each FADEC to ensure that Rated Torque displayed in the flight compartment, on the Engine Display (ED), is the same for both engines. T1.8 is the primary source of intake temperature to the FADEC. The maximum allowable difference between local and opposite T1.8 is ±2 °C. The secondary source of intake air temperature is provided by the Air Data Unit (ADU).

The FADEC also monitors the ADU Static Air Temperature (SAT) from both channels. The SAT from the ADU could be used as primary source depending on the rating selected.

Indicated Turbine Temperature (ITT) Probe

Refer to Figure 2.

Eight probes consisting of three temperature sensing elements provide 24 measurement points for comprehensive gas temperature measuring. The sensing elements are located to provide sufficient coverage in order to calculate an accurate ITT. The probes are equi–spaced around the circumference at station 6 of the engine which is downstream of the 2nd Power Turbine.

Refer to Figure 3.

ITT measurement is done by 24 sensing elements which are Chromel–Alumel thermocouples connected by the ITT wiring harness in parallel. The total signal is connected at a junction located at the rear of the engine. The junction is connected to a wiring harness which goes to the Main Oil Temperature/Cold Junction sensor. Before being processed by the FADEC, the raw ITT is trimmed by the lug mounted resistor. The trimmed ITT and Main Oil Temperature (MOT) are processed by the FADEC and output to the flight compartment over ARINC 429. ITT is also sent to the Engine Monitoring Unit (EMU).

ITT Trim Resistor (79–32–01)

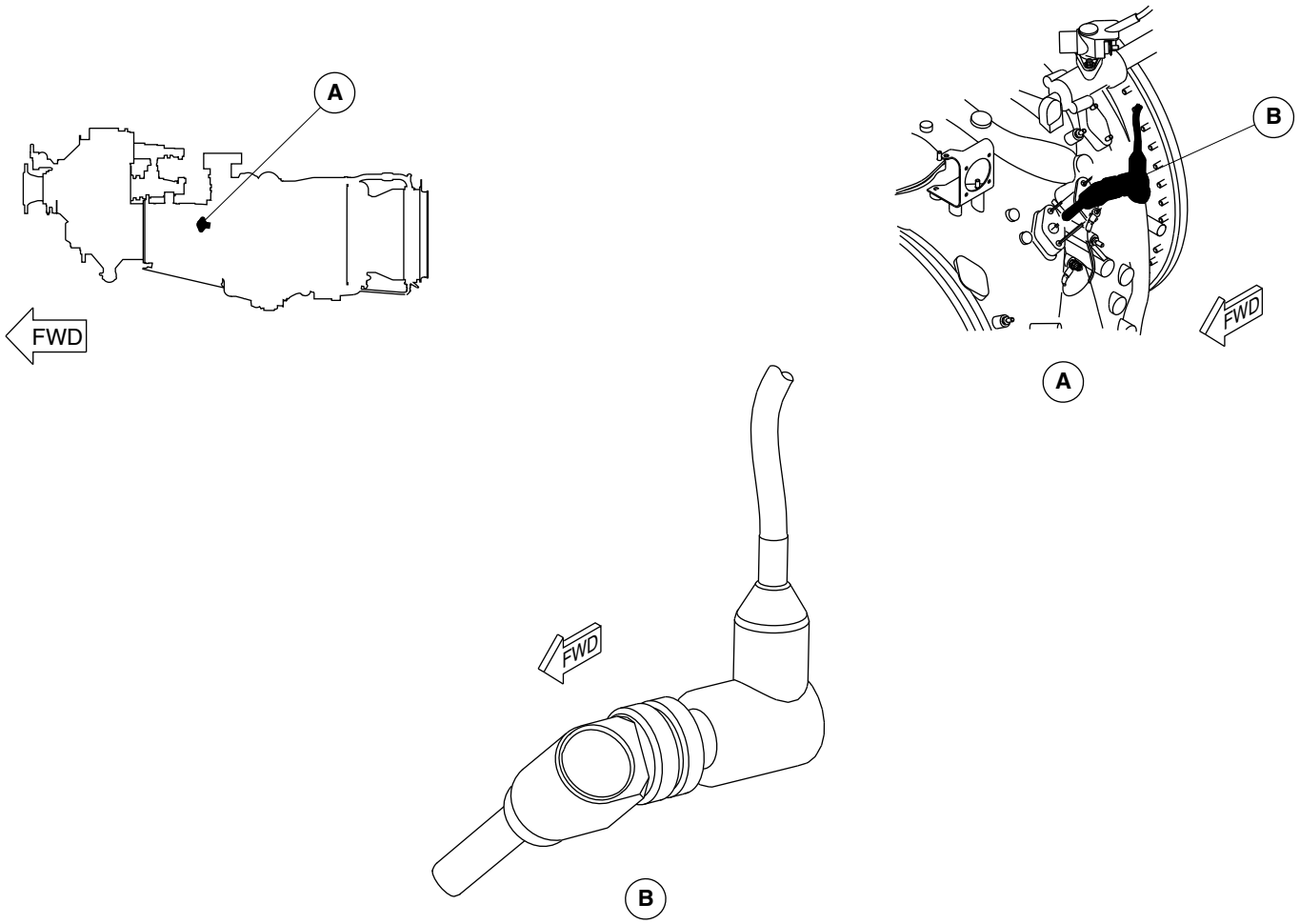
Refer to Figures 4 and 5.

The ITT Trim Resistor is located on two stud terminals on the Main Oil Temperature/Cold Junction Sensor. ITT is produced from a system of 24 Chromel–Alumel thermocouples (eight sensors of three thermocouples each) arranged in parallel. The average signal (by virtue of parallel arrangement) is routed through the ITT Trim Resistor and the cold junction reference before being received and processed by the FADEC. The ITT Trim Resistor is used to provide compensation to the raw ITT signal. The value of the resistor is set during engine pass off testing at the manufacturer or approved overhaul facility.

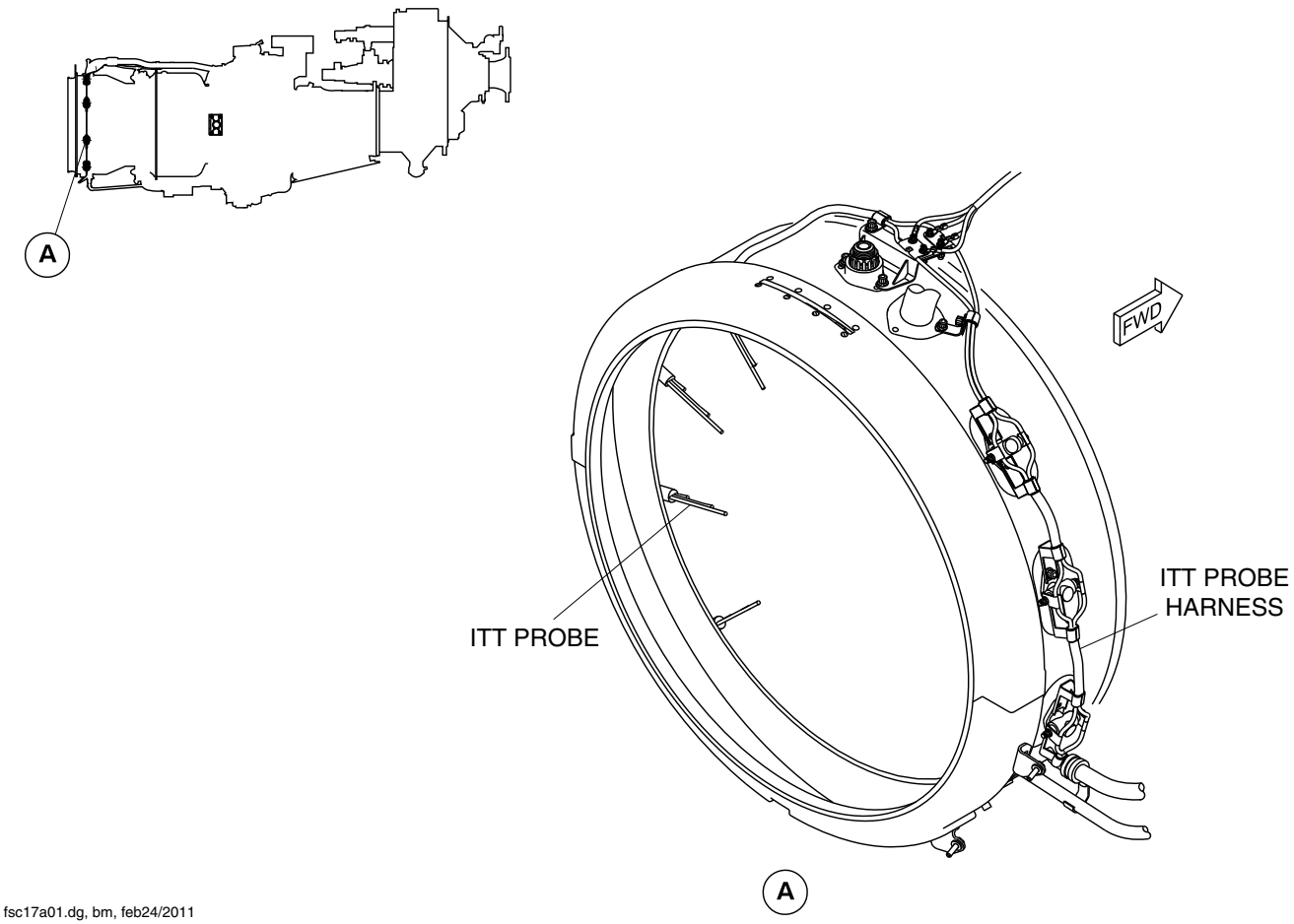
Training Information Points

Replace failed Lug Mounted Resistors before replacement of the FADEC. The new FADEC will immediately ignore a failed resistor and use the trim value stored in its memory. This value will not be the correct value for the engine. Engine performance will be compromised.

OBEY ALL THE ELECTRICAL/ELECTRONIC, AND ELECTROSTATIC DISCHARGE SAFETY PRECAUTIONS WHEN HANDLING THE FADEC.



T1.8 Temperature Sensor
Figure 1



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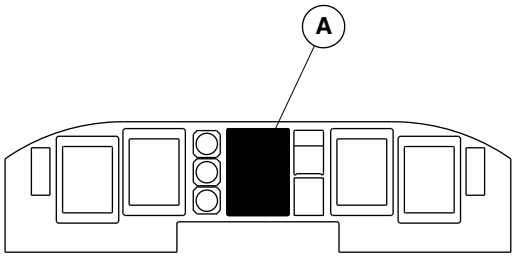
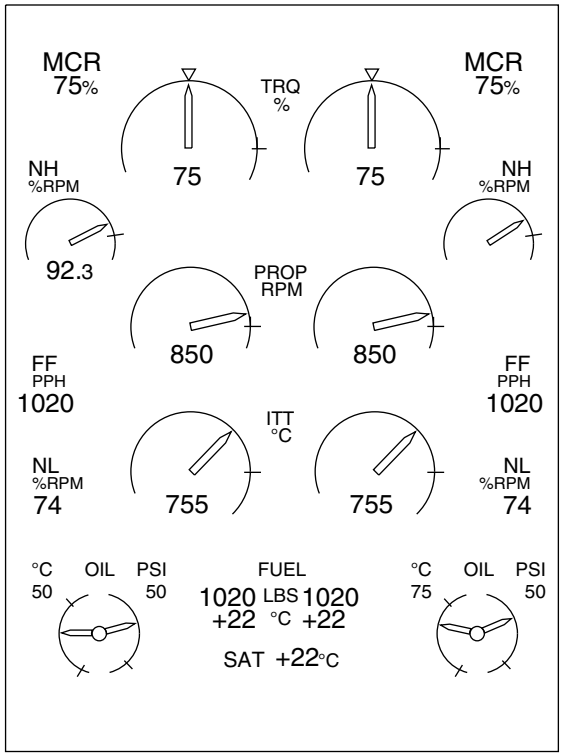
ITT Probes
Figure 2



MAIN INSTRUMENT PANEL



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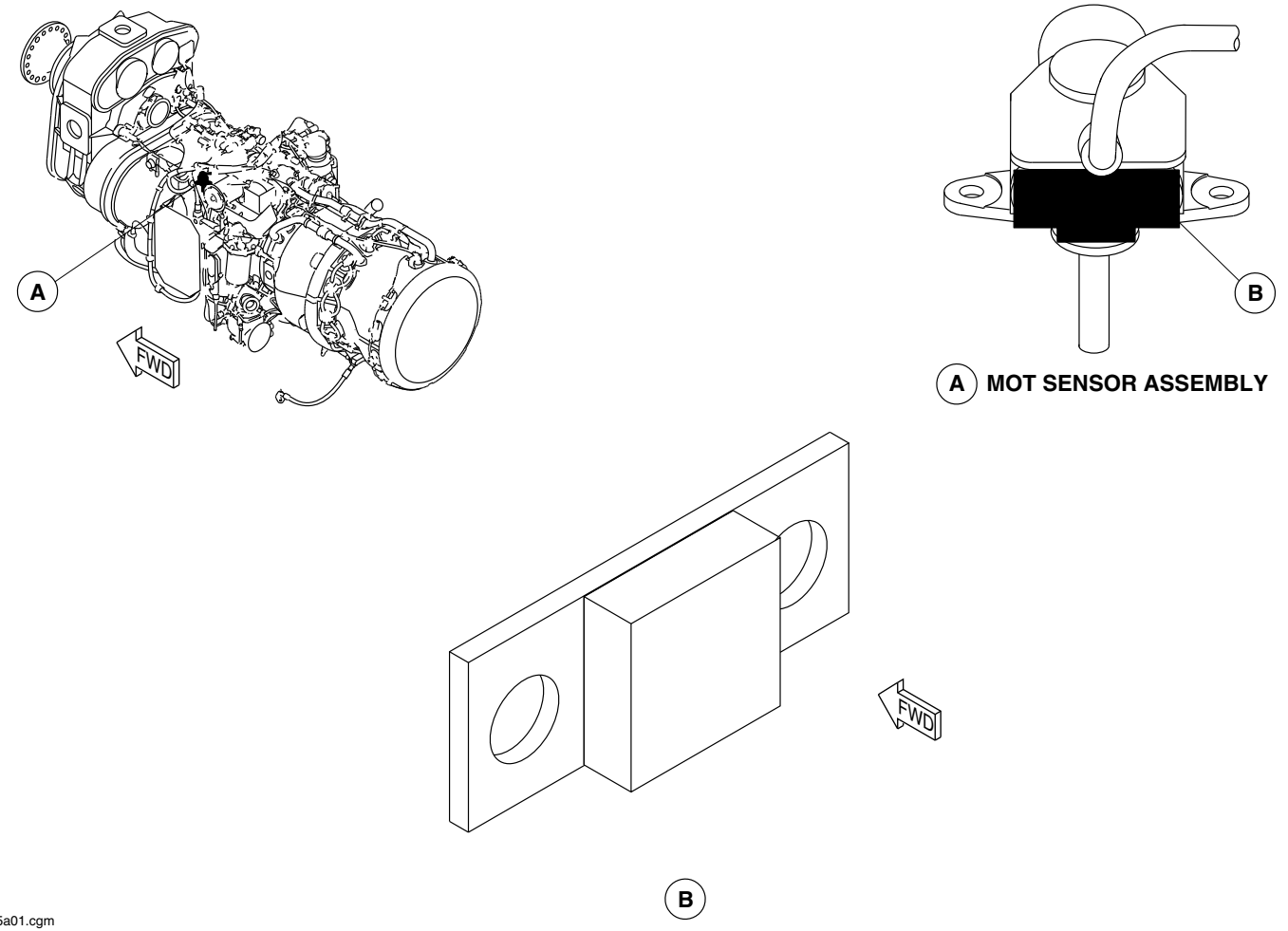
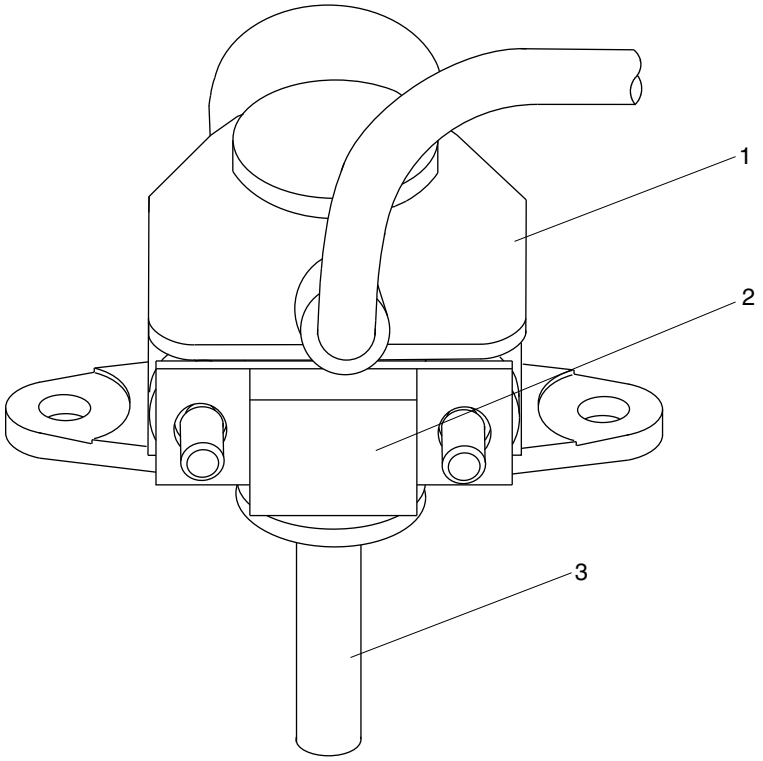
Engine Display (ED)
Figure 3



Main Oil Temperature Sensor and ITT Trim Resistor Locator
Figure 4



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LEGEND

1. Main Oil Temperature (MOT) Sensor.
2. ITT Trim Resistor.
3. MOT Sensor Probe.

Main Oil Temperature Sensor and ITT Trim Resistor Detail
Figure 5

**ON A/C ALL

77–30–00–001

ANALYZERS

Introduction

This system is used to display most of the engine parameters, plus discrete indications, in the Flight Compartment.

General Description

Refer to Figure 1.

The analyzers record, display and download the information that follows:

- FADEC and PEC fault and condition codes.
- Engine Condition Trend Monitoring (ECTM) data.
- Power assurance requirements and data.
- Powerplant limit exceedance data.
- Snapshot and transient powerplant and aircraft data to help troubleshooting.
- Powerplant and aircraft flights, cycles and hours.

Detailed Description

Refer to Figure 2.

The function of the analyzers is performed by the Engine Monitoring System (EMS) and the FADEC ARINC 429 System

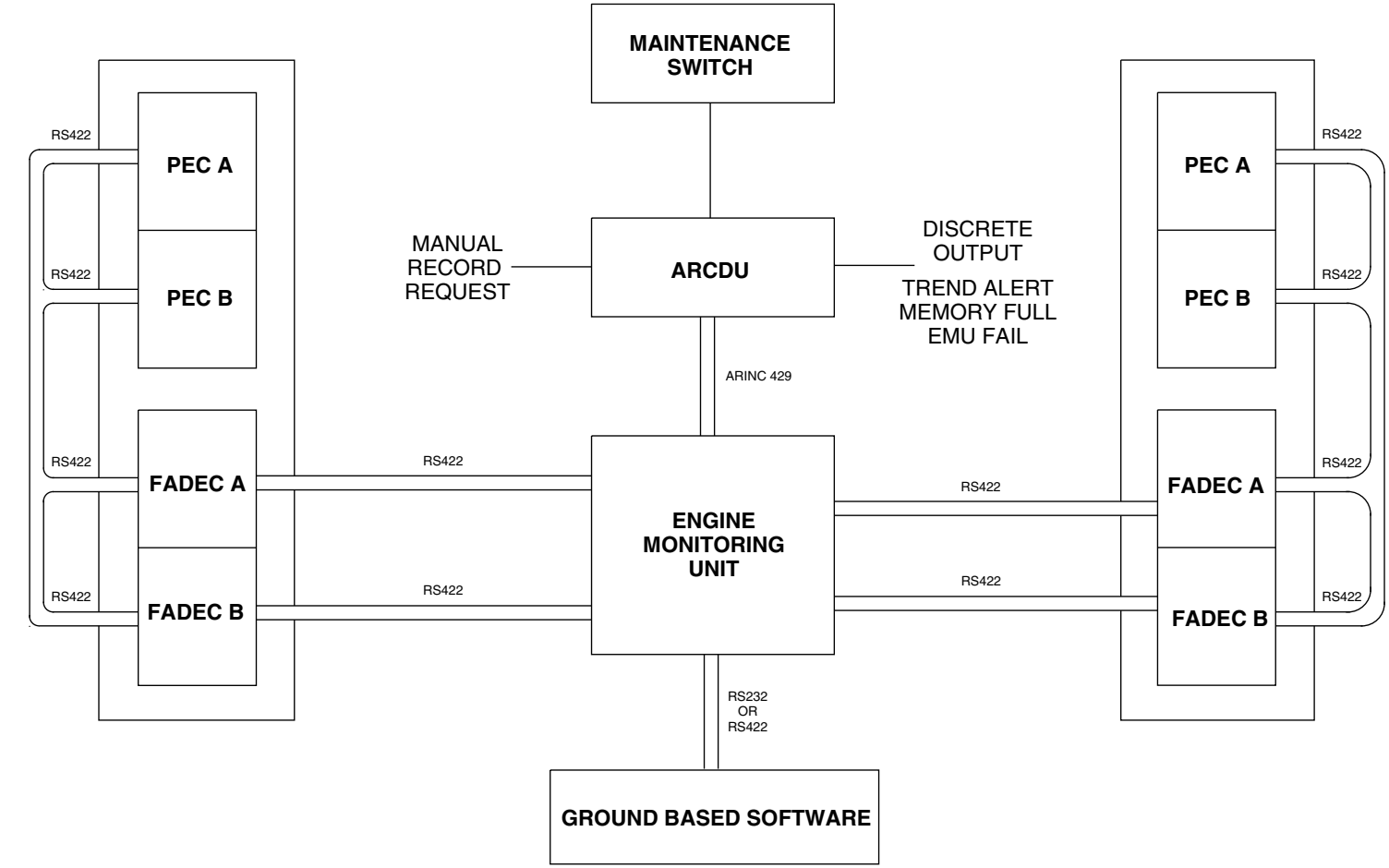
Each FADEC display channel (channel not in control) sends signals on an ARINC 429 bus direct to the Engine Display (ED). The FADEC information is also sent to the Integrated Flight Cabinet (IFC) for processing and retransmission to the Digital Flight Data Recorder (DFDR).

The following parameters and discretes are sent to the Flight Compartment independent of the FADEC ARINC system:

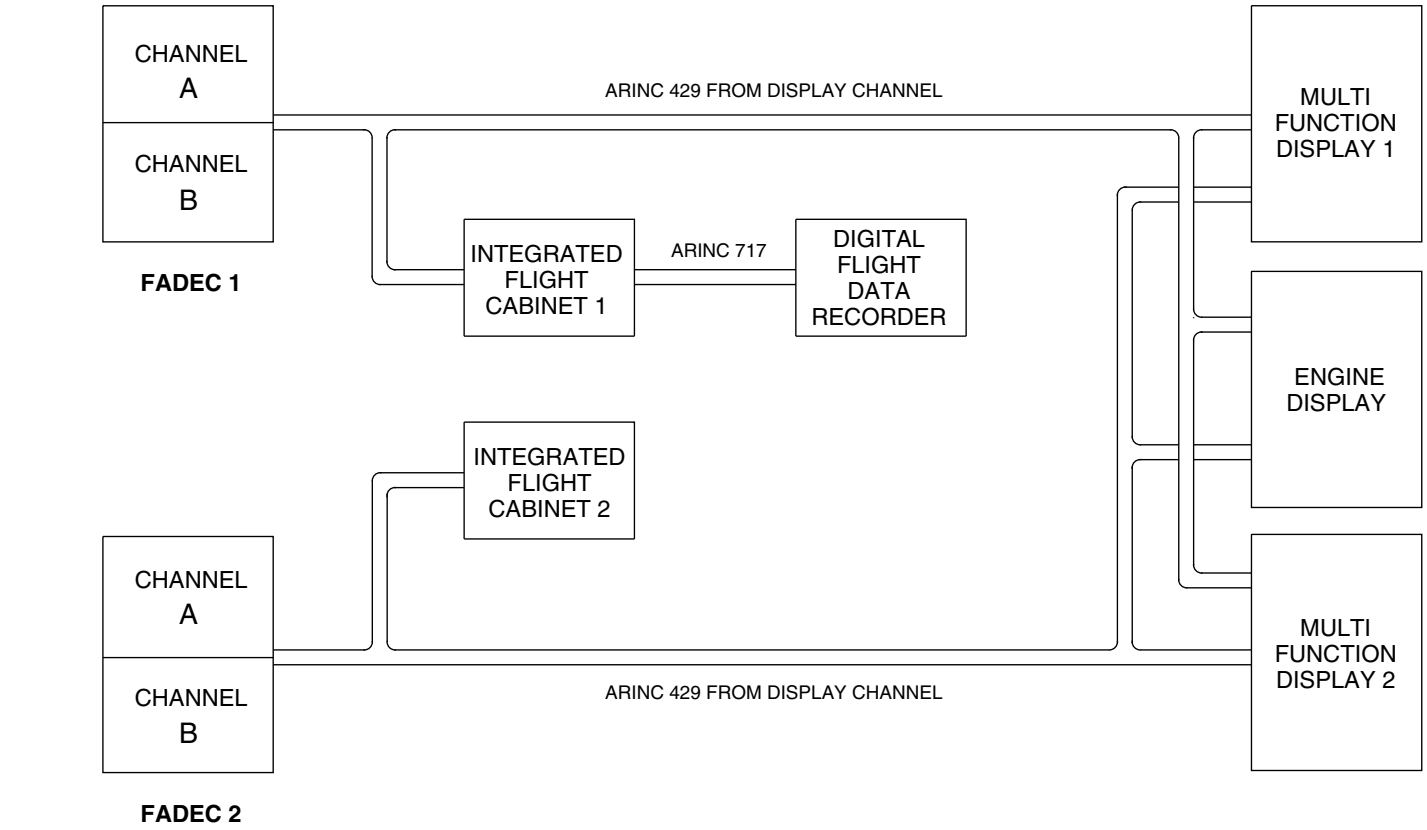
- FADEC Caution, Fail and PEC Caution as discretes are sent directly to the Caution and Warning Panel.
- Propeller Ground Range as a discrete to the Advisory Display Unit (ADU) and then to the lights on the glareshield panel.
- Main Oil Pressure, Fuel Flow and Fuel Temperature from the engine–mounted sensors as analog signals to the IFC, and from there to the ED on an ARINC 429 DATA bus.

Training Information Points

Obey all the electrical/electronic, and electrostatic discharge safety precautions.



EMS Block Diagram
Figure 1



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FADEC ARINC 429 Indicating System
Figure 2

**ON A/C ALL

77–31–00–001

ENGINE MONITORING SYSTEM

Introduction

The Engine Monitoring System collects data on every significant event that occurs during the operation of the engine.

General Description

Refer to Figures 1 and 2.

The data collected by the EMS can be accessed in the aircraft through the Audio and Radio Control and Display Unit (ARCDU) screen. The data can also be downloaded to the laptop PC based Ground Based System (GBS).

The function of the Engine Monitoring System is performed by the:

- Engine Monitoring Unit (EMU) (77–31–00)
- Ground Based System (GBS) (77–31–00)

The EMU is located in the flight compartment, on the side wall behind and below the First Officer's seat. The ARCDU is located in the Flight Compartment, one each side of the console behind the control quadrant.

Detailed Description

The Engine Monitoring System uses:

- The FADEC
- The Propeller Electronic Control (PEC)
- The Centralized Diagnostic System (CDS)
- The ARCDU

The EMS has the following functions:

- Snapshot and/or Trace recording in response to an engine significant event (fault code, exceedance, etc.). Where a snapshot is a recording taken at the instant of the event and consists of approximately 79 parameters generated by the FADEC/PEC. Where a Trace is a recording initiated at the instant of the event and consists of approximately 49 parameters generated by the FADEC/PEC going back two minutes prior to the event and one minute after the event. Resolution is one set of parameters every 80 msec near either side of the event and 800 msec everywhere else. A snapshot and trace can be initiated by the Flight Crew by pressing a button labelled "EVENT MARKER" on the ENGINE CONTROL PANEL.
- Logging of Fault Codes generated by the FADEC and PEC.
- Recording of Engine Condition Trend Monitoring (ECTM) conditions automatically. Averaging of ECTM conditions for the previous Flight Hours and alert to Maintenance if the trend deviates from the norm. Recording of time to spooldown for high and low pressure spools. Alert to Maintenance if the spooldown time reduces below a minimum value significantly.
- Monitoring of Engine parameters and logging any exceedance beyond operating limitations (Ref. AMM 05–10–00). These parameters include: ITT, Torque, NH/NL/NP, Oil Pressure, Oil Temperature.

- Monitoring of Engine Health discretes, and logging any change in state. These discretes include: Chip Detectors, Low Oil Pressure, Oil Filter Impending Bypass, Low Fuel Pressure, and Fuel Filter Impending Bypass.
- Step by step Power Assurance procedure. Detailed results are available following successful completion.
- Live feedback of Flight Deck engine switch state. The position of any switch which provides an input to the FADEC or PEC will be displayed. This enables the circuit to be tested quickly and easily.
- Instructions to check the operation of Engine Health Discretes.
- Confirmation of powerplant trims: Torque Gain and Bias, ITT, configuration, BETA Feedback and Power Lever Angle (PLA) Feedback.
- Review of data stored in EMU memory. This feature allows the operator to view the date/time of each recording in memory, type of recording, and Flight Deck parameters at the time of the recording.
- Summary of aircraft and FADEC configuration. Aircraft Registration, Owner and Operator can be uploaded manually. Aircraft S/N is automatically uploaded from the CMS. FADEC, PEC, and EMU S/N are logged automatically. hours and cycles accumulated on the above is available. EMU memory usage is available.

Flight Compartment Display

Refer to Figure 2.

EMU functions can be displayed in the flight compartment using the ARCDU. The normal mode for the ARCDU is to allow the crew to manage radio communications functions. However, in Maintenance Mode, the ARCDU becomes a display screen for the CDS.

To access the Maintenance Mode on the ARCDU, the following conditions must be satisfied:

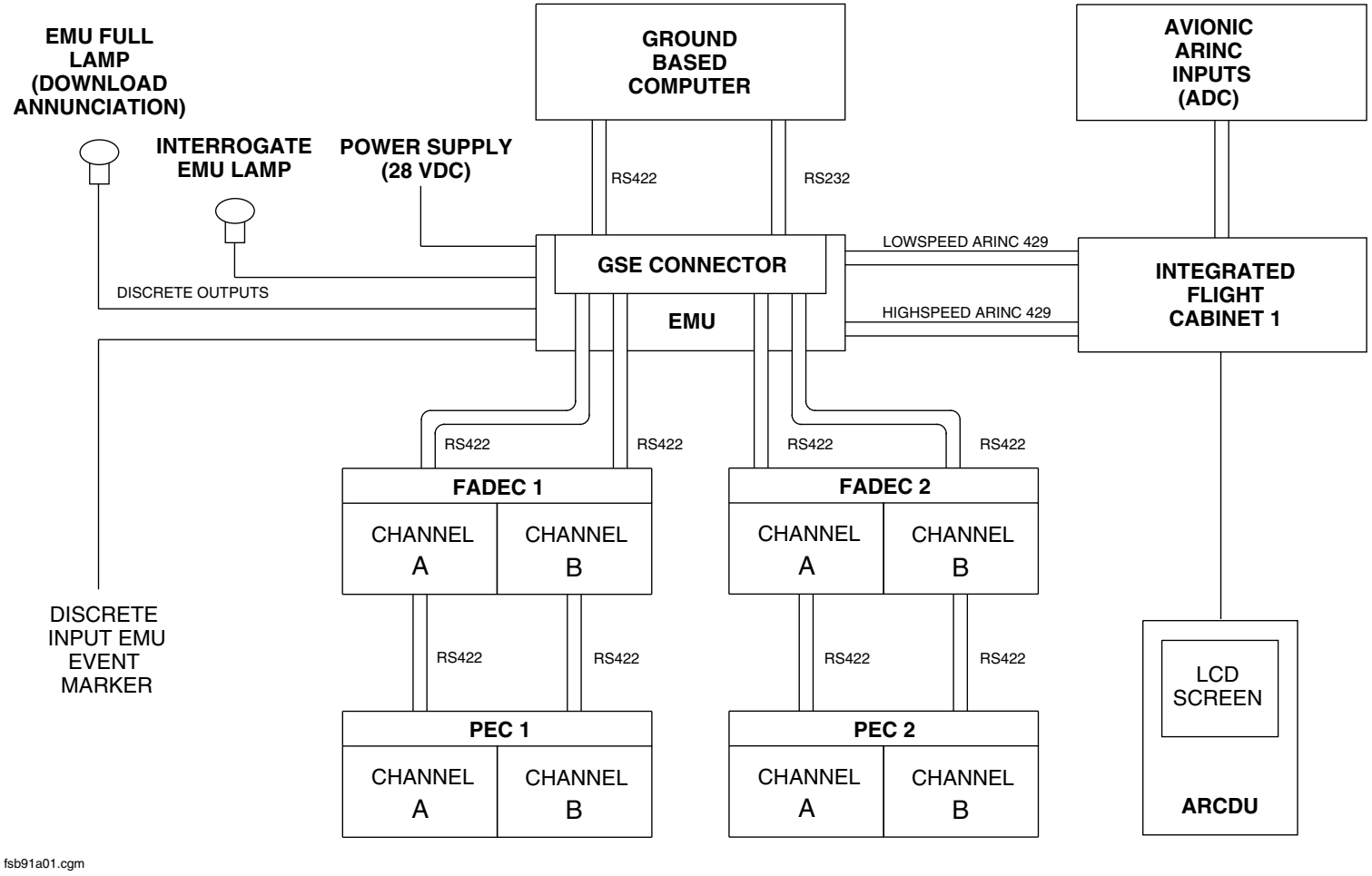
- The aircraft is static (airspeed <50 knots (93 km/h))
- Weight is on wheels
- ARCDU GND MAINT on Central Maintenance Panel in wardrobe is selected.
- MAINT key on either or both ARCDU screens selected.

When Maintenance Mode is selected, the CMS Main Menu is displayed. The ARCDU screen has eight soft keys and three navigation keys which can be used to select menu items. To select the Engine Monitoring Unit, press the key adjacent to “EMU” on the screen.

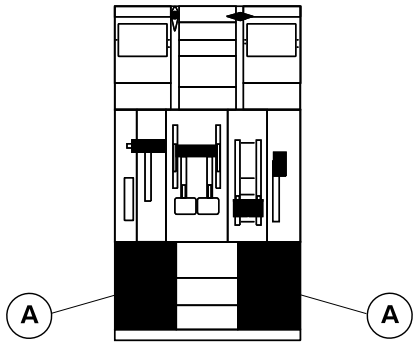
When EMU is selected, the main menu is displayed and any EMU function can be accessed. Note that where there is an active message waiting, the menu item colour is amber rather than white. This convention is carried through the sub–menus, the sub–sub–menus, and so on.

Training Information Points

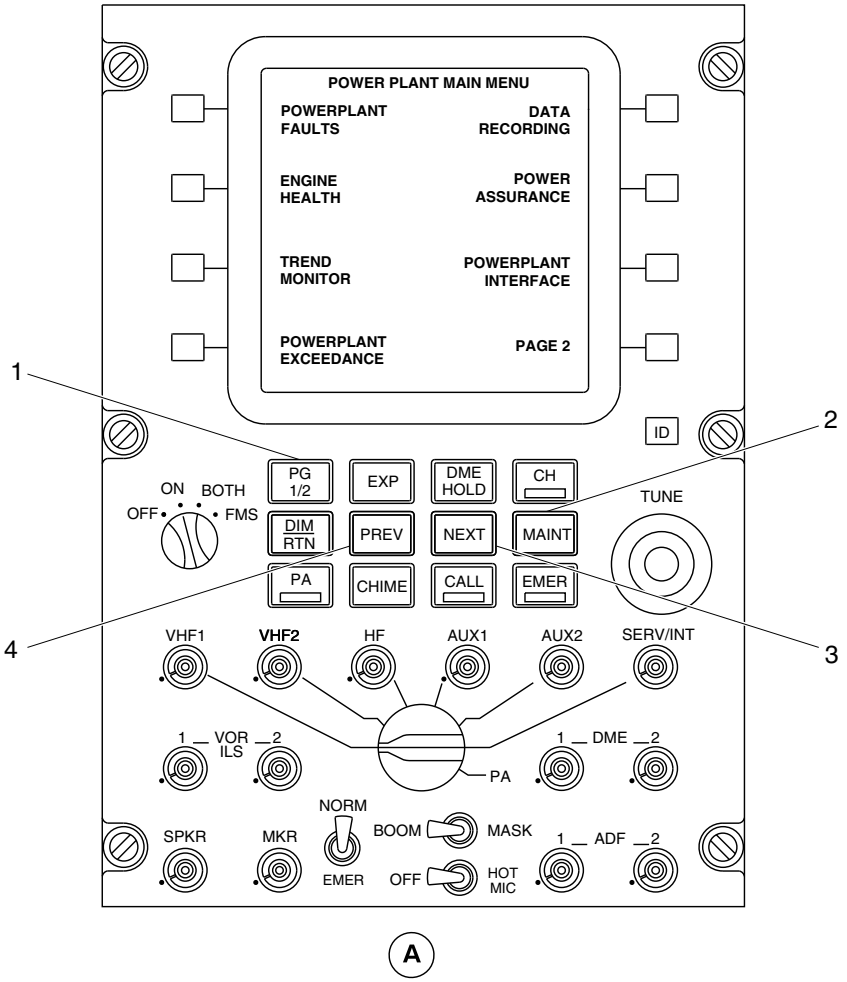
OBEY ALL THE ELECTRICAL/ELECTRONIC, AND ELECTROSTATIC DISCHARGE SAFETY PRECAUTIONS.



Engine Monitoring System Schematic
Figure 1



CENTER CONSOLE



LEGEND

1. Page select key.
2. Maintenance systems select key.
3. Next page key.
4. Previous page key.

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Engine Monitoring System, ARCDU
Figure 2

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