United States Army Warfighting Center
Fort Rucker, Alabama
OCTOBER 2006

STUDENT HANDOUT

TITLE: CH-47D POWER PLANT (714)

FILE NUMBER: 011-0341-6

PROPONENT FOR THIS STUDENT HANDOUT IS:

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CH-47D POWER PLANTS (714) (AQC/IPC/MOI/FEIC/IERW)

STUDENT HANDOUT

TERMINAL LEARNING OBJECTIVE (TLO):

Action: Describe components, operational characteristics, functions, limitations, malfunctions, and emergency procedures of the CH-47D T55-GA-714A Power Plant.

Conditions: In a classroom environment, given a student handout.

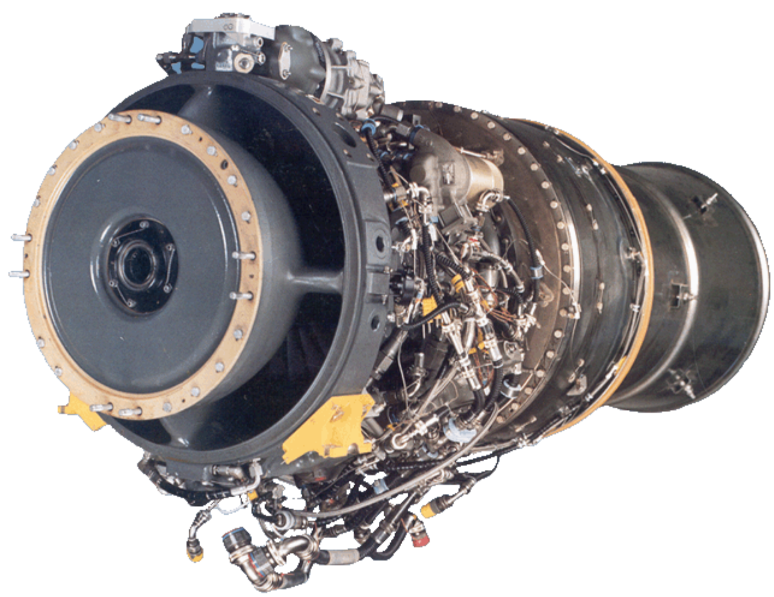
Standards: Correctly answer in writing, without reference, eleven of sixteen questions pertaining to components, operational characteristics, limitations, functions, malfunctions, and emergency procedures of the CH-47D T55-GA-714A Power Plant, In Accordance With (IAW) TM 1−1520−240−10 and the student handout.

Safety Requirements: None.

Risk Assessment Level: Low.

Environmental Considerations: None.

Evaluation: Each student will be evaluated on this block of instruction during the second written examination. This will be a criterion type examination requiring a GO on each scored unit. You will have 90 minutes for the exam.



1. Learning Step/Activity 1−List a general description of the power plant.

a. Type, model, and series; (T55-GA-714A.)

(1) Type –Turbine 55 series.

(2) Manufacture – Honeywell. (Engine, DECU, HMA)

(3) Model - 714A.

(4) Two engines installed per airframe.

(5) Each engine has an engine transmission mounted on the forward end which provides the transition of power to the combining transmission.

T55-GA-714A CHARACTERISTICS

DIMENSIONS	
OVERALL LENGTH	46.53 INCHES
OVERALL LENGTH (TAILCONE INSTALLED)	77.53 INCHES
NOMINAL DIAMETER	24.25 INCHES
WEIGHT (LESS ENG. TRANSMISSION AND TAILCONE)	832 POUNDS
COMBUSTION CHAMBER	EXTERNAL ANNULAR
COMPRESSION RATIO	9.32 TO 1
HORSEPOWER	(MAX RATED) 4,867 (10 MINUTES) EMERGENCY 5,069 (2.5 MINUTES)
MAXIMUM ALTITUDE	25,000 FEET
POWER LEVEL	N1 100% = 18,720 RPM
POWER LEVEL	N2 100% = 15,333 RPM

b. Abbreviations associated with the 714 Engine.

(1) (FADEC) Full Authority Digital Electronic Control.

(2) (DECU) Digital Electronic Control Unit.

(3) (HMA) Hydro mechanical Metering Assembly.

(4) (HMU) Hydro mechanical Metering Unit.

(5) (FPU) Fuel Pump Unit.

(6) (RDPS) Ratio Detector Power Supply.

(7) (PRI) Primary operation for the FADEC system.

(8) (REV) Reversionary (backup) operation for the FADEC system.

(9) (CONT) Contingency Power.

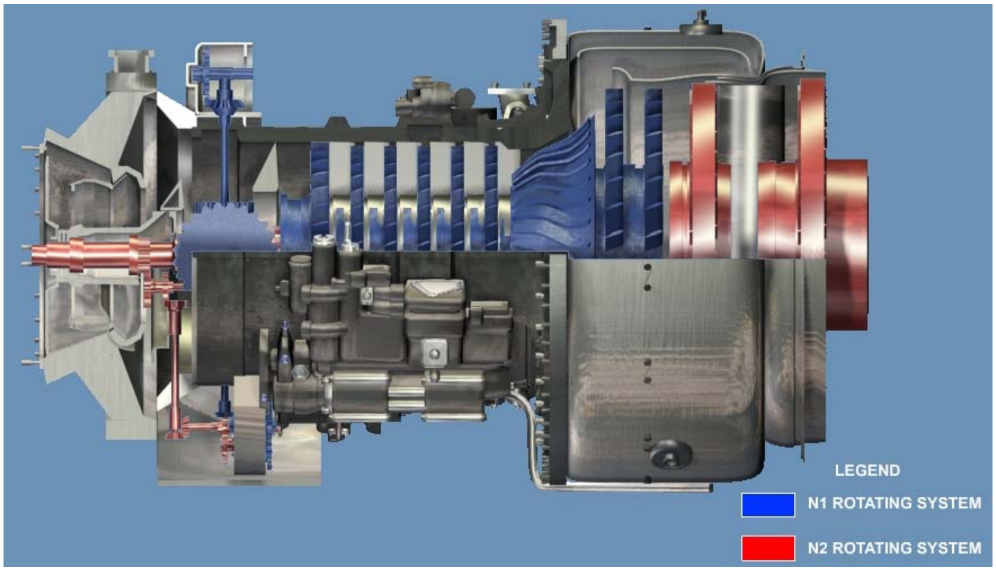
(10) (GP) Gas Producer.

(11) (PT) Power Turbine.

(12) (PTIT) Power Turbine Inlet Temperature.

(13) (AGB) Accessory Gear Box.

c. Systems associated with the 714 Engine.



(1) N_1 Indicating system.

(2) N_2 system.

(3) Oil system.

(4) Fuel system.

(5) Electrical system.

(6) Temperature indicating system.

(7) Torque indicating system.

(8) Fire detection system.

(9) Fire extinguishing system.

(10) Water wash system.

(11) Primary.

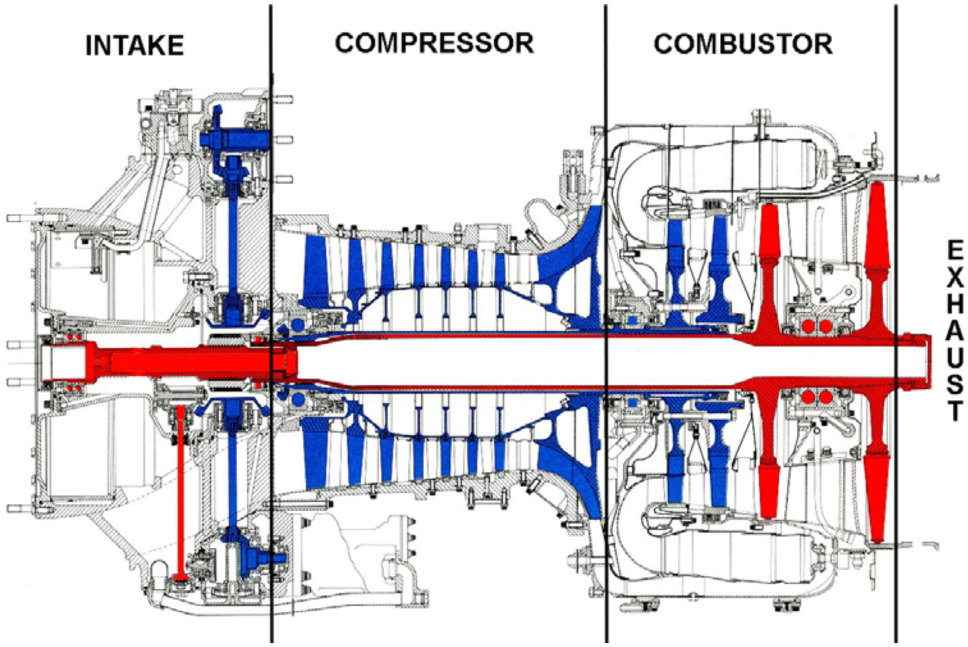
(12) Reversionary.

d. Shaft Horsepower (SHP).

(1) Max rated shaft horsepower 10 minutes: 4,867.

(2) Contingency SHP for actual emergencies 2.5 minutes: 5,069.

e. Major sections of the engine.



(1) Intake section.

(2) Compressor section.

(3) Combustor section.

(4) Exhaust section.

f. Engine component locations (Stations).

(1) Locations on the engine schematic are assigned station numbers

(a) The entrance to the inlet is station 1.

(b) The exit of the inlet, which is the beginning of the compressor, is labeled station 2.

(c) The compressor exit and combustor entrance is station 3.

(d) The combustor exit and turbine entrance is station 4.

(e) The exit of the turbine is station 5.

(2) Station numbers are assigned to simplify the language used when describing the operation of a gas turbine engine. With this numbering convention, we can refer to the "power turbine inlet temperature" as simply "T4.5", or the "compressor exit pressure" as "P3".

(a) Temperature (T).

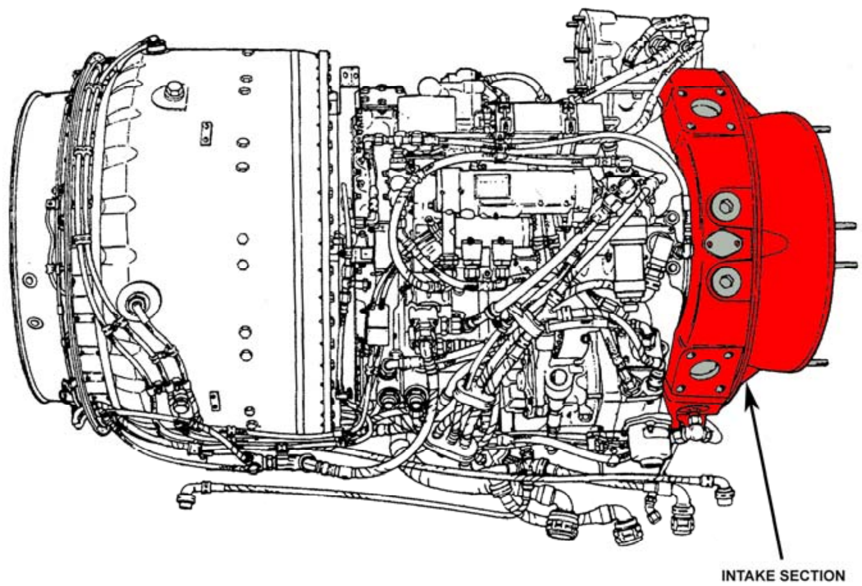
(b) Pressure (P).

(3) In a gas turbine engine the stations correspond to the beginning and the end of thermodynamic processes in the engine

g. Major components of the 714 engine.

(1) Intake Section.

(a)



Air inlet housing assembly.

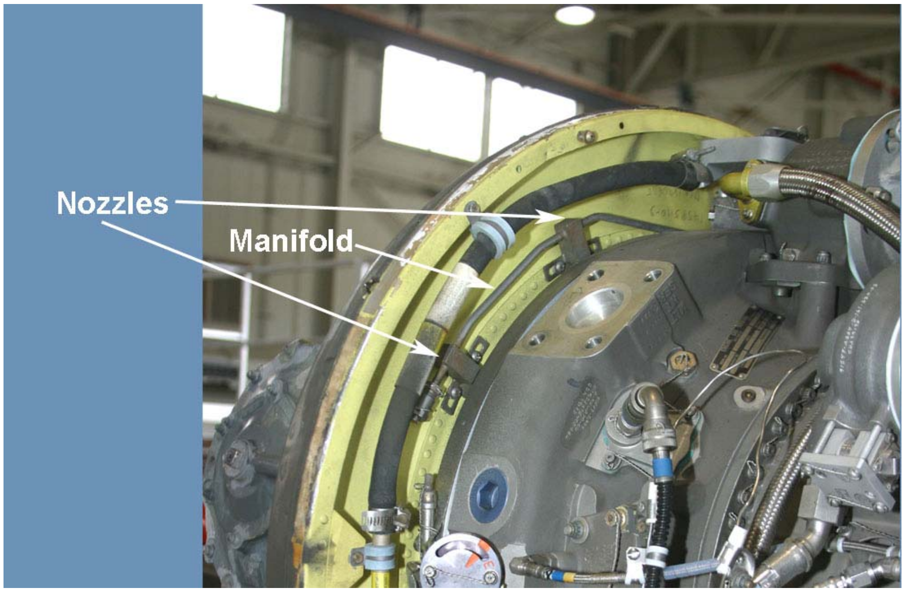
1. Located at the front of engine.

2. One-piece aluminum casting forming an inner and outer housing joined by four hollow struts.

3. Contains engine oil supply tank.

4. Externally provides mounting pads for the starter drive assembly, oil filler assembly, torque sensor, T_1 temperature sensor, and oil level indicator.

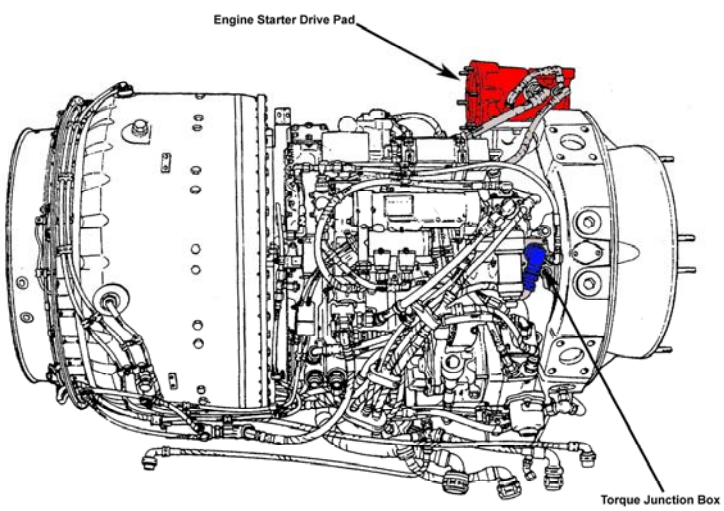
(b) Water wash manifold and nozzles.



1. Manifold mounted and routed around the inside of the engine inlet cowling.

2. Eight nozzles spray cleaning solution or water into the intake of the engine for cleaning and rinsing.

(c) Engine Starter.



1. Located at the Twelve O'clock position on the inlet housing.

2. Mounted to the starter drive pad.

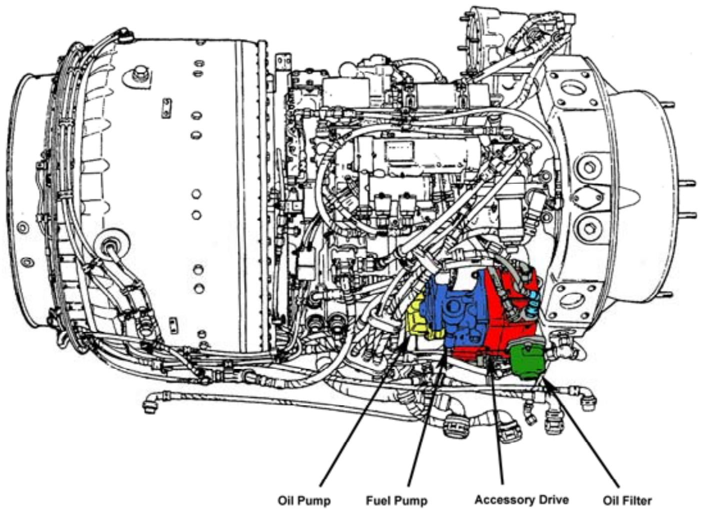
3. Internally connects to a shaft which is connected by gearing to the compressor rotor.

(d) Torque meter junction box.

1. Mounted at the Nine O'clock position on the air inlet housing.

2. Provides the connection between the torque system's engine mounted components and the airframe mounted components.

(e) Accessory gearbox assembly.



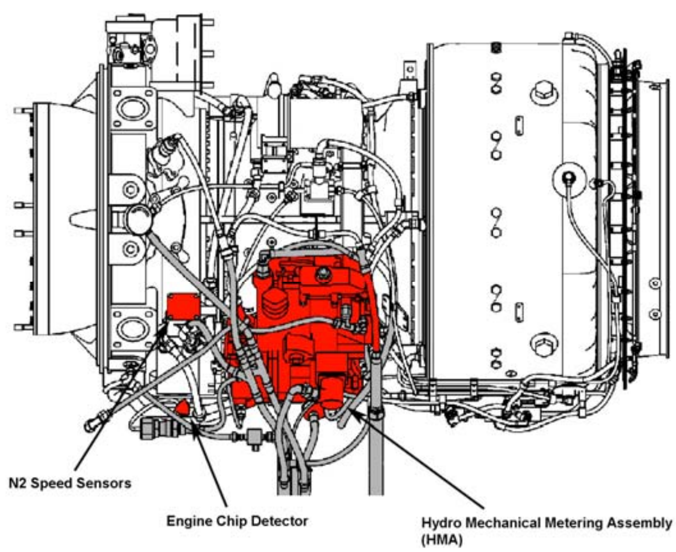
1. Mounted on the air inlet housing.

2. Contains drive gears and provides mounting pads for:

   a. Engine driven fuel boost pump.

   b. Main oil pump and Gas Producer (GP) speed sensor.

   c. Main engine oil filter

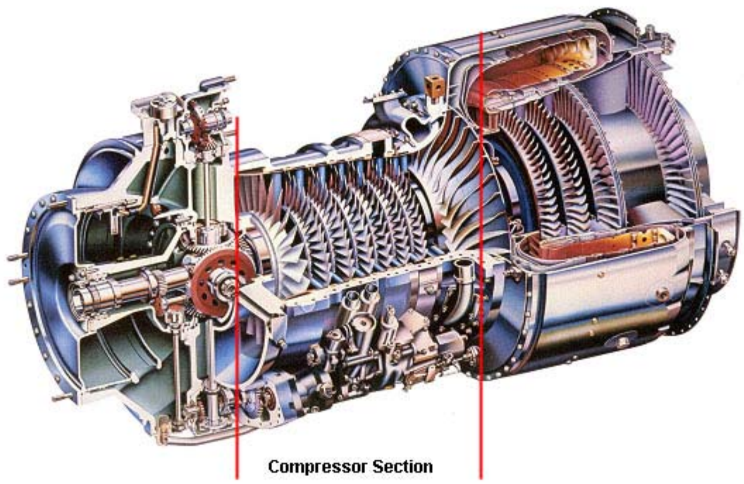


d. Oil temperature sensor.

e. Self-sealing chip detector.

f. Hydro Mechanical Metering Assembly (HMA).

g. Power Turbine (PT) speed pickups.



(2) Compressor section.

(a) Compressor housing assembly.

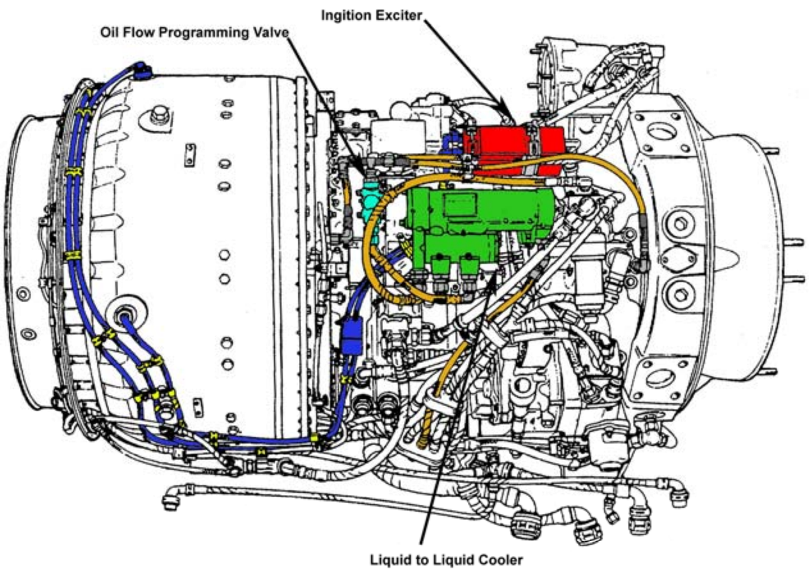
1. Consists of two halves that fit around the compressor rotor assembly.

2. Secures to the front of the inlet housing assembly, and to the rear of the air diffuser assembly.

(b) Compressor rotor assembly.

1. Seven axial stages of compression.

2. One centrifugal impeller.



(c) Oil flow programming valve.

1. Mounted to the left hand end of the liquid to liquid cooler.

2. Reduces oil flow at low power setting (N_1).

(d) Liquid to liquid cooler.

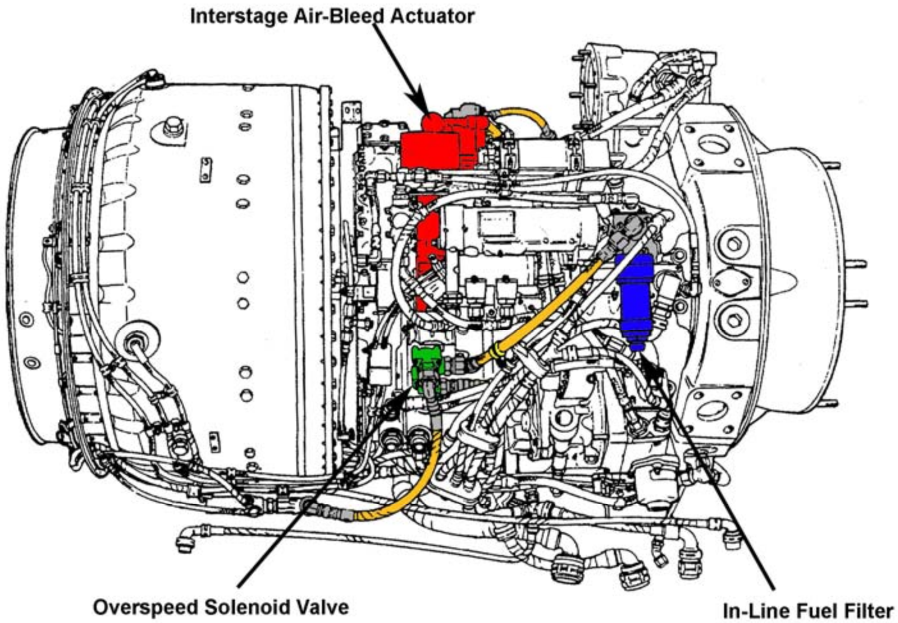
1. Uses fuel to cool engine oil prior to use in the bearings.

2. Uses oil to heat fuel prior to combustion.

(e) Ignition exciter.

1. Mounts on brackets secured to compressor housing.

2. Connected electrically to four spark igniters by coil and cable assembly, providing the spark for ignition.



(f) Overspeed solenoid valve.

1. Mounted below the liquid to liquid cooler.

2. Activated by excess N_2 speed, and controlled by the DECU.

(g) Interstage air-bleed actuator (bleed band actuator).

1. Pneumatic device that mounts on the compressor housing between the sixth and seventh stage of compression.

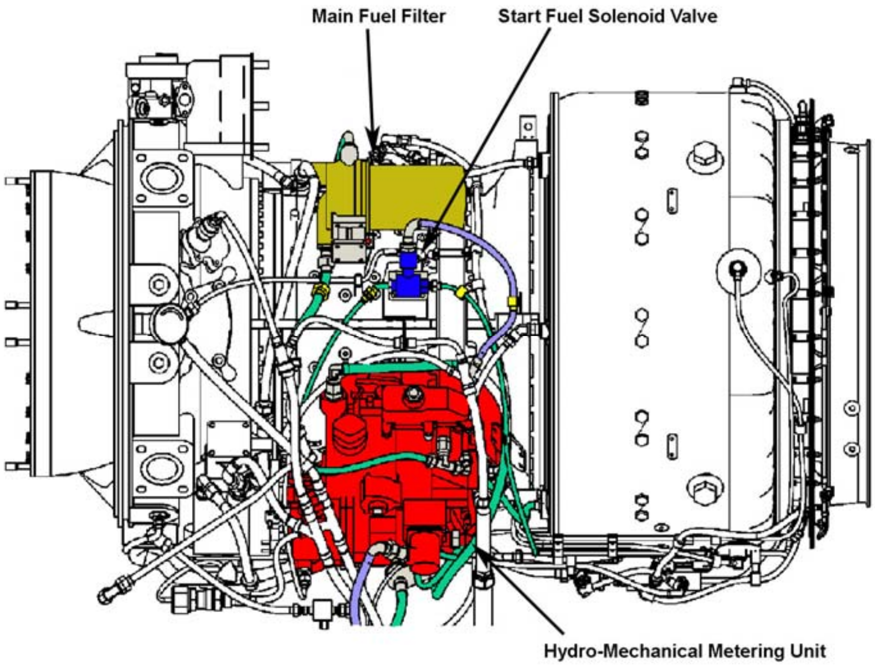
2. Opens and closes bleed band on input signal from the HMA.

(h) In-line fuel filter.

1. Mounts on bracket on inlet housing.

2. Provides final fuel filtering prior to delivery to the main fuel manifolds.

3. Provides a visual indication of filter contamination prior to bypassing the filter element.



(i) Main fuel filter.

1. Filters fuel prior to delivery to the HMA.

2. Provides a visual indication of filter contamination prior to bypassing the filter element.

(j) Hydro Mechanical Metering Assembly (HMA).

1. Mounted to the accessory drive.

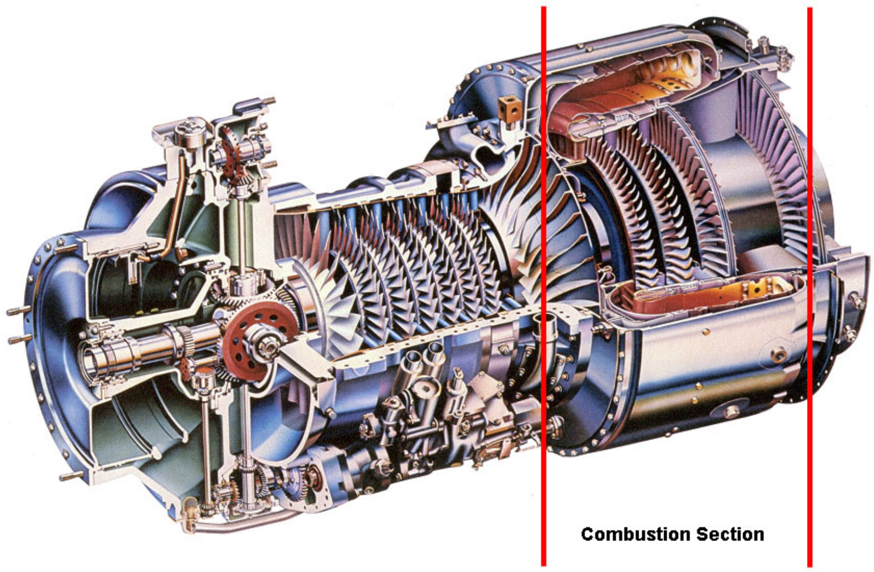
2. Divided into the HMU and the FPU.

3. Supplies fuel to the main fuel nozzles for engine operation.

(k) Starting fuel solenoid valve.

1. Controls fuel flow to the start fuel nozzles.

2. Activated by DECU after N_1 reaches 10%.



(3) Combustion section.

(a) Air diffuser assembly.

1. Mounts on the rear of the compressor housing.

2. Internal vanes cut down on air swirl and directs compressor air to combustion section.

(b) Combustor assembly.

1. Mounts on the air diffuser assembly.

2. Provides an area for combustion and expansion of gases.

(c) Gas Producer (GP) turbine section.

1. Mounted on rear of compressor rotor shaft.

2. Provides the driving force for self- sustainment for engine operation.

3. Consist of two separate turbine disc assemblies.

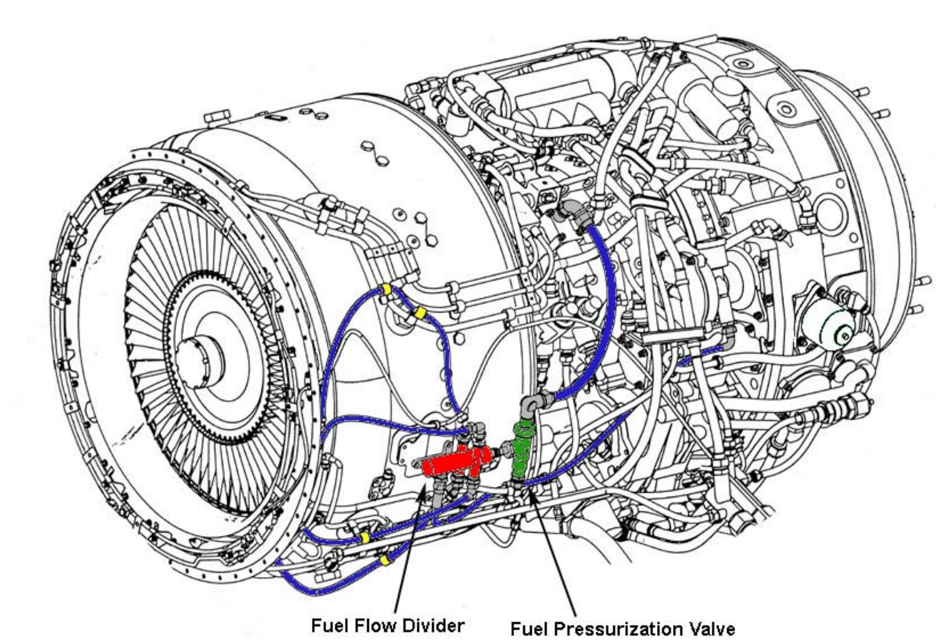
(d) Power Turbine (PT) assembly.

1. Mounted on rear of power turbine shaft.

2. Provides the driving force to turn the rotor systems for flight.

3. Consist of two separate turbine disc assemblies.

(e) Flow divider (fuel flow divider).



1. Mounted at the bottom of the combustion section.

2. Divides fuel flow into primary and secondary flows for the 28 nozzles.

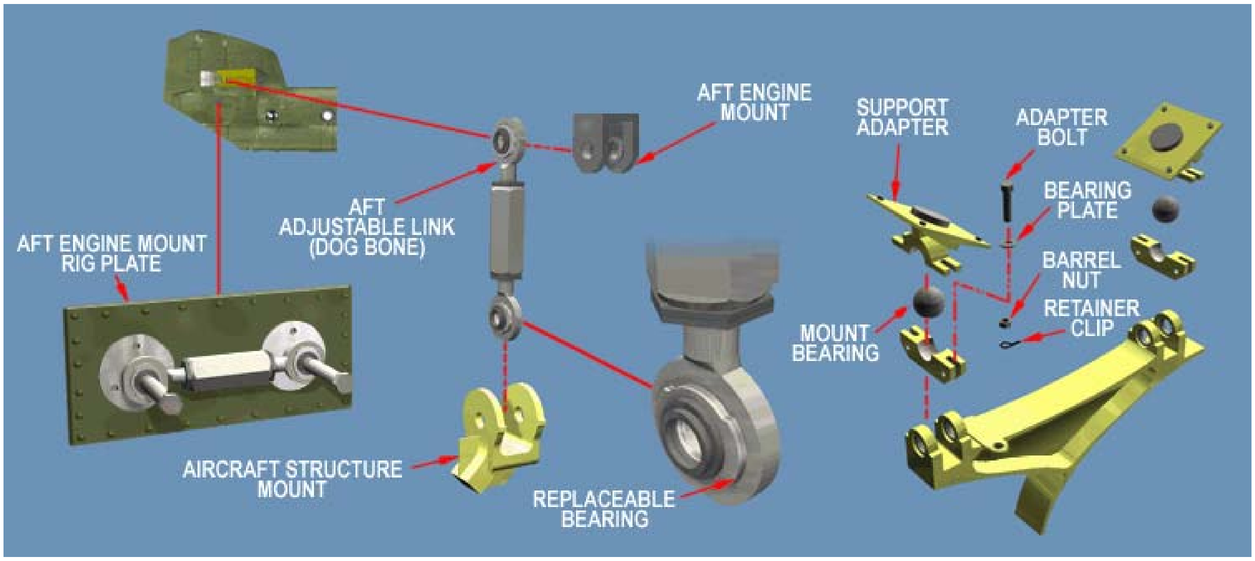
(4) Exhaust section.

(a) Tailpipe (tailcone) assembly.

1. Mounted on the rear of engine.

2. Directs exhaust gases overboard.

h. Engine mounting.



(1) Three point mounting system, two on the forward end and one on the aft end.

(a) The forward mounts support the engine laterally and allow for proper alignment of the engine transmission to the combining transmission.

(b) The Aft mount.

1. Adjustable link with replaceable bearings.

2. Link is labeled with an arrow indicating proper installation direction, serial numbered for the specific aircraft and specific side (i.e. No. 1 or No. 2) with the adjustable rod ends being safetied.

3. Link is adjusted to ensure proper alignment of the engine drive shaft to the combing transmission.

(2) Drag strut (Drag brace).

(a) Provides forward support and holds forward mounting structure in the case of a hard landing.

(b) Forged steel strut that is 20” long with a 2° bend.

(3) Rig plate is installed on the fuselage of the aircraft just below the engine and is used to check the aft engine link prior to installation.

2. Learning Step/Activity 2−Describe the major sections of the power plant.

a. Intake section, made from a one piece aluminum casting.

(1) Engine air inlet fairing.

(a) A circular U-section outer fairing that guides air into the intake.

1. Air flowing into the intake is used to aid in cooling of the engine oil, by passing air over the oil reservoir.

2. Provides the mounting for the engine water wash system

a. Series of eight spray nozzles are installed on the aft side of the engine air inlet fairing.

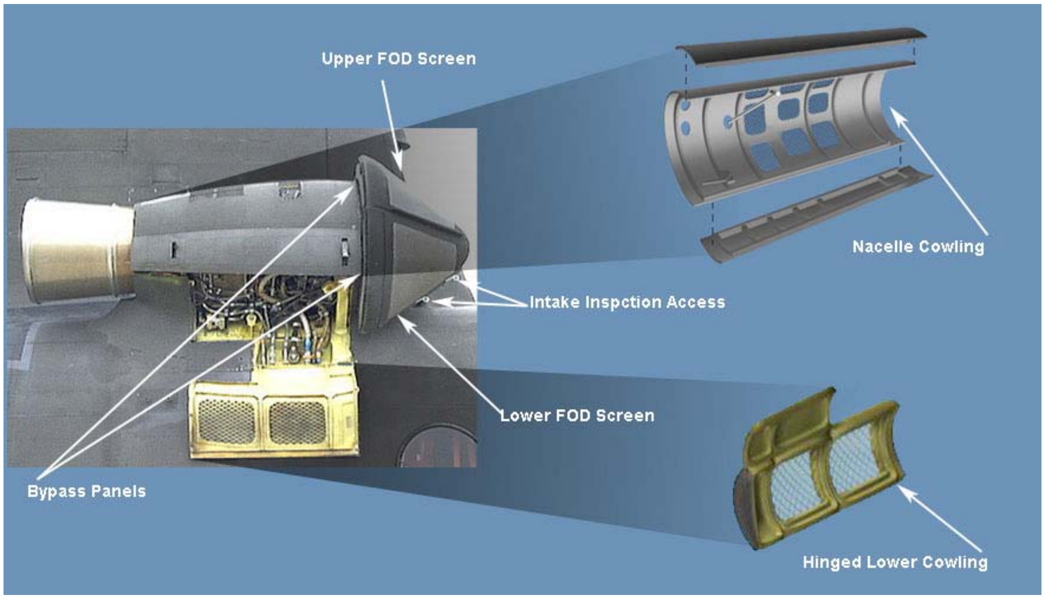
b. During engine wash operations cleaning fluids and rinsing water will be sprayed through the eight spray nozzles into the inlet for cleaning the engine.

c. Liquid and air connections are externally mounted behind each of the engine work platforms.

d. Air connection is used to close the bleed band actuator during the engine wash procedure forcing the cleaning fluids through the entire engine.

(b) Provides mounting holes for the upper and lower portions of the Foreign Object Damage (FOD) screens.

(2) Air Inlet screen assembly (FOD Screens)



(a) Two piece cone shaped screen assembly.

(b) Mounted to the air inlet fairing.

1. T-locks fit into groves on the inlet fairing

2. Tabs of locks must be down and locked.

(c) Secured together with quick release fasteners along the outboard edge, and on each side of the engine driveshaft on the inboard edge.

(d) Lower outboard section is hinged to permit inspection of the engine air inlet, and the first stage compressor blades.

(e) Bypass panels are installed on the rear of the FOD screens.

1. Consist of two panels, an upper and a lower.

2. Removed when outside air temperature drops below +4°C.

(3) Engine transmission fairing.

(a) One piece assembly used to protect the engine transmission and provides for proper alignment of the FOD screens.

(b) Access to the engine driveshaft is provided through two hinged doors.

(4) Nacelle cowling.(Engine fairing)

(a) Engine fairing serves as a protective housing for each engine.

(b) Each fairing consists of three sections.

1. Upper cover assembly.

   a. Hinged to two brackets and attached to the upper part of the intake.

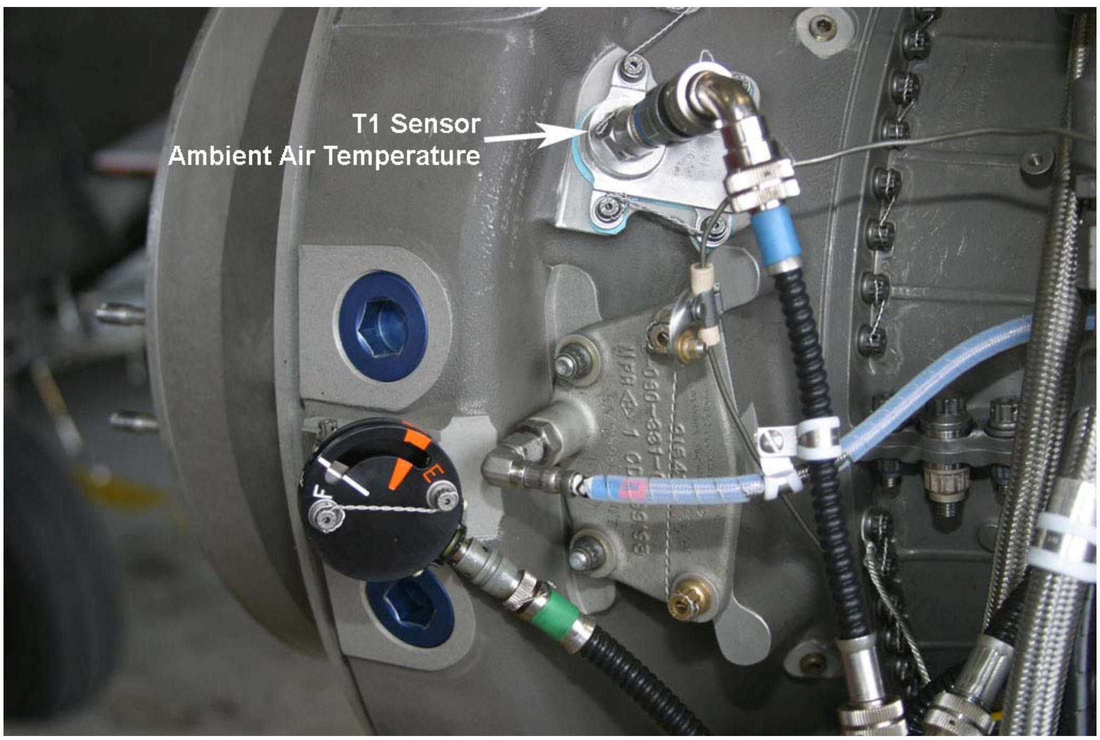
   b. Cowling can be held in the open position by a strut that locks into a mount at the end of the compressor section.

2. Two side cover assemblies.

   a. Provide access to the outboard side of the engine for maintenance or inspections.

   b. Doors can be locked in the up position by the use of a quick release pin that is installed on the aft hinge of the door.

(5) Ambient air temperature sensor (T_1 sensor).

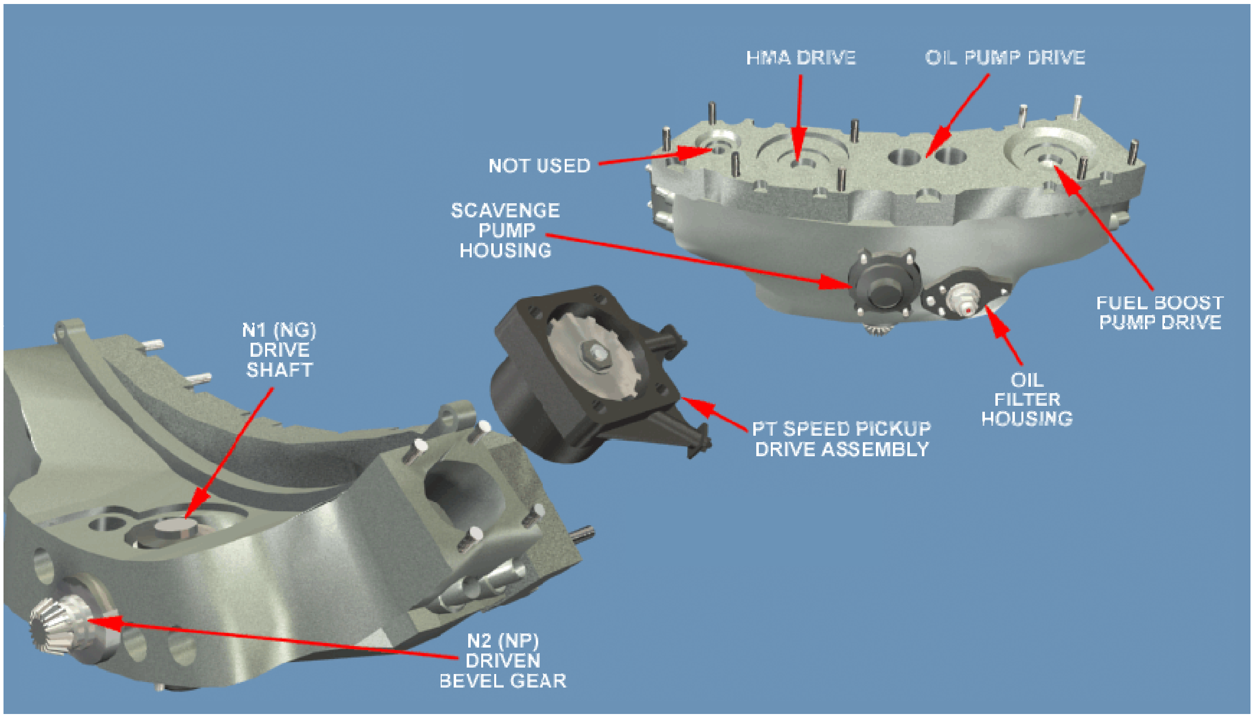


(a) Mounted externally at the Ten O'clock position, with the probe extending into the intake of the engine.

(b) Measures outside air temperature and sends data to the DECU.

(c) Used to calculate Ground Idle speed and make fuel calculations.

b. Accessory Drive.



(1) Mounted on the bottom of the inlet housing.

(2) Consists of N_1 and N_2 gears.

(a) N_1 gears are driven by the engine starter while motoring or by the compressor rotor during operation, via the accessory gear assembly.

1. Drives main fuel pump.

2. Drives oil pump and N_1 speed sensor.

3. Drives a portion of the HMA.

(b) N_2 gears are driven by the power output shaft.

Provides the gear for the N_2 speed sensors.

(3) Contains a scavenge oil pump to “suck” oil from the dual element chip detector.

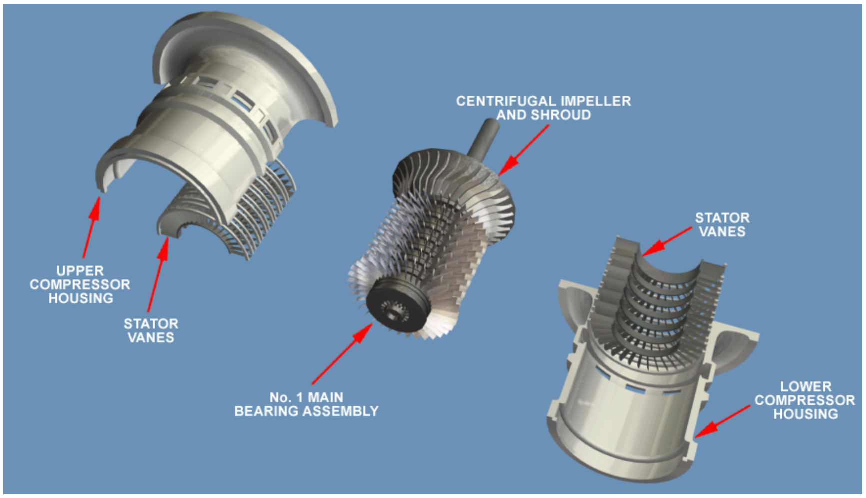
(4) Contains oil chip detector.

(5) Contains oil filter with a visual indicator.

(6) Provides a mounting surface for the HMA, and is driven by the N_1 and N_2 gears.

c. Compressor section.

(1) Compressor halves.

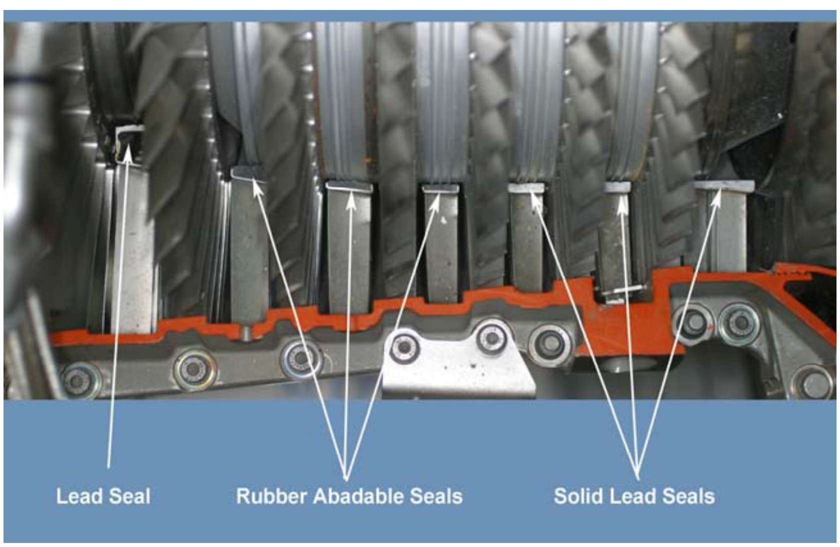


(a) Consist of an upper and a lower half, which can be removed for maintenance.

(b) Constructed of a stainless steel alloy that has four times the strength of the previous engine, making it virtually corrosion resistant.

(c) Bolted to the upper and lower compressor halves are seven, two-piece stainless steel stator vanes.

1. Stator vanes direct the compressed air so that it hits the next set of compressor blades at the best angle for the most efficient operation.



2. Inner portion of the first set of stators is lined with a lead seal that fit against the compressor rotor, and is cut by the compressor rotor upon installation for a close tolerance fit.

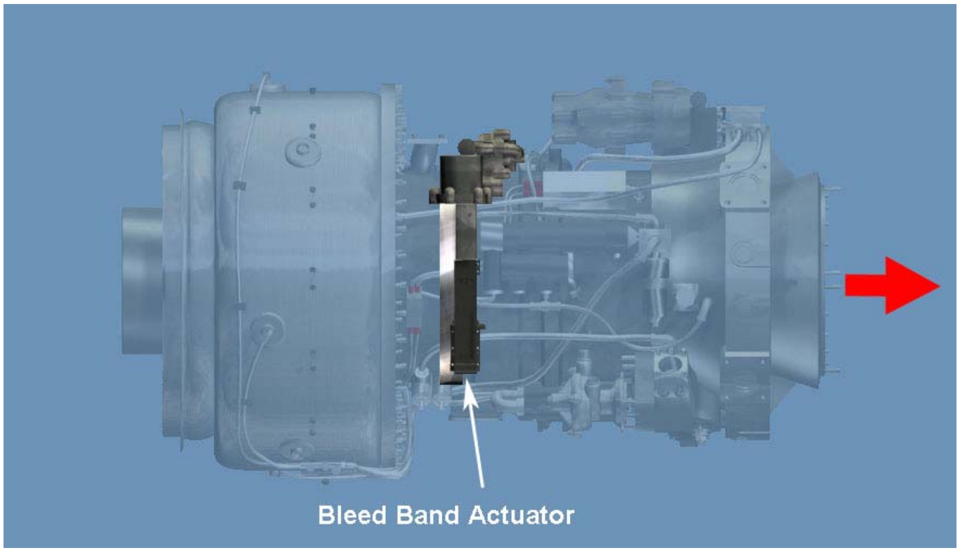
3. Inner portion of the second, third and fourth set of stators is lined with a soft rubber abradable seal that forms an airtight seal against the compressor rotor.

4. Inner portion of the stators (fifth through seventh) are lined with solid lead seals that are cut by the compressor rotor for a close tolerance fit.

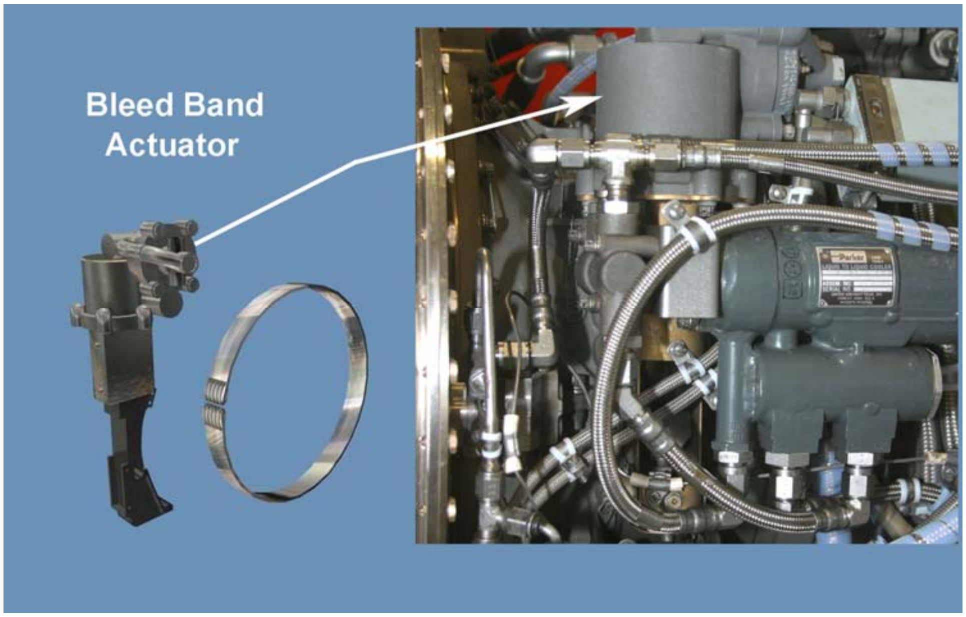
5. Installed over the sixth and seventh set of stators is the bleed band actuator.

(d) Provide the support (backbone) for the engine.

(2) Interstage air bleed system.



(a) Bleed band actuator installed to facilitate rotor acceleration



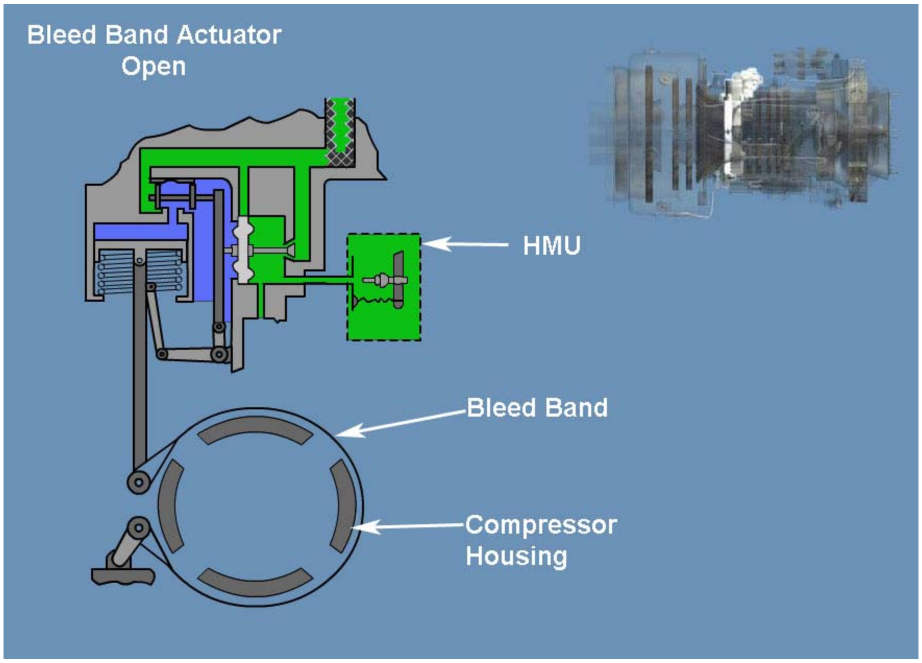
1. Pneumatically operated.

2. Installed over a series of bleed holes through the compressor at the 6^{th} stage of compression.

3. Operated off of P_3 air from the Ten O'clock position on the diffuser, controlling the air flow by tightening or loosening the metal band that encompasses the compressor, allowing a more rapid acceleration of the compressor.

NOTE: P = Pressure, 3 = Location on the engine.

4. Controlled by HMA.



(b) HMA (Hydro Mechanical metering Assembly).

1. Primary mode

a. HMA uses P3 pressure as the controlling medium to determine when the bleed band will open or close.

b. Bleed band will "snap" open and closed in the primary mode.

2. Reversionary mode.

a. The HMA uses fuel pressure as the controlling medium, to determine when the bleed band will open or close.

b. Bleed band will "modulate" or slowly open or close in the reversionary mode.

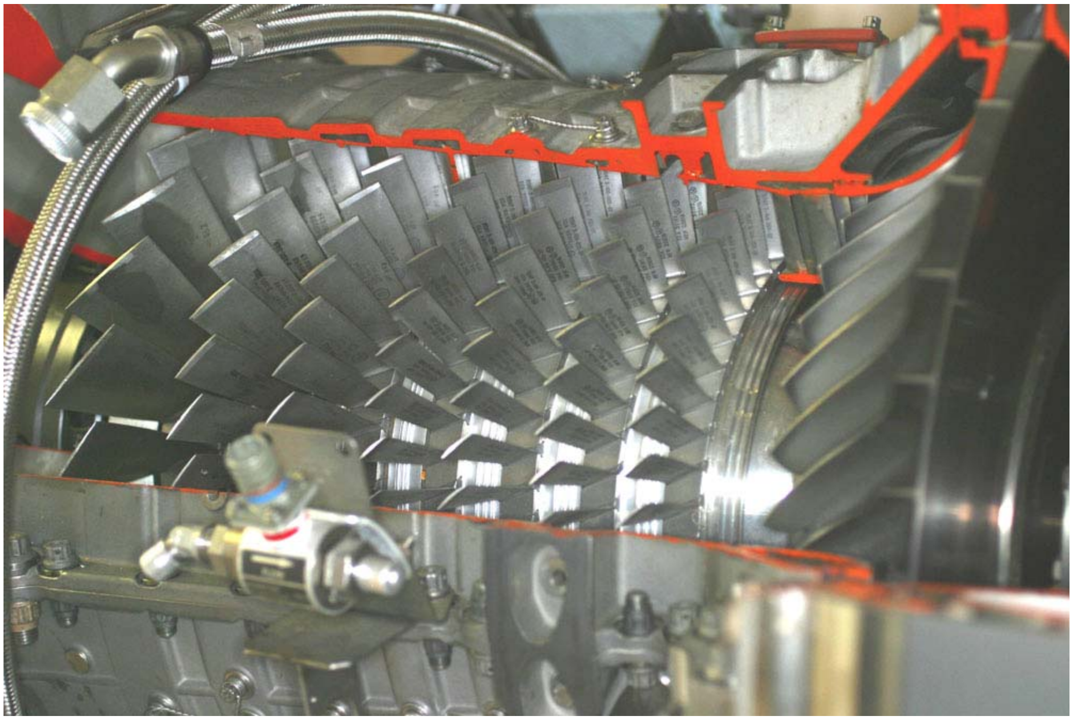
c. Modulation of the bleed band may induce bleed band popping.

(1) Indicated by fluctuations in torque, PTIT and noise.

(2) Normally occurs at N_1 settings between 81% to 86%.

(3) To reduce or eliminate bleed band popping, adjust the power setting of the aircraft.

(3) Compressor rotor assembly.



(a) Seven stages of axial compression.

1. Compressor rotor blades are:

a. Solid dovetail axial blades.

b. Retained in the disk by spring loaded pins.

c. Replaceable in pairs, 180° out from one another.

(b) Designed to compress the air raising the pressure level as it passes through each stage of the compressor.

(c) One single stage centrifugal compressor impeller.

1. Two piece assembly made from titanium, fitted onto the compressor rotor shaft.

2. Designed to further compress and direct air through the air diffuser assembly.

3. Overall compression ratio is 9.32:1.

(d) Compressor rotor has raised ridges that cut grooves into the stators for a tighter fit.

(e) Driven by two gas producer rotors in the combustion section.

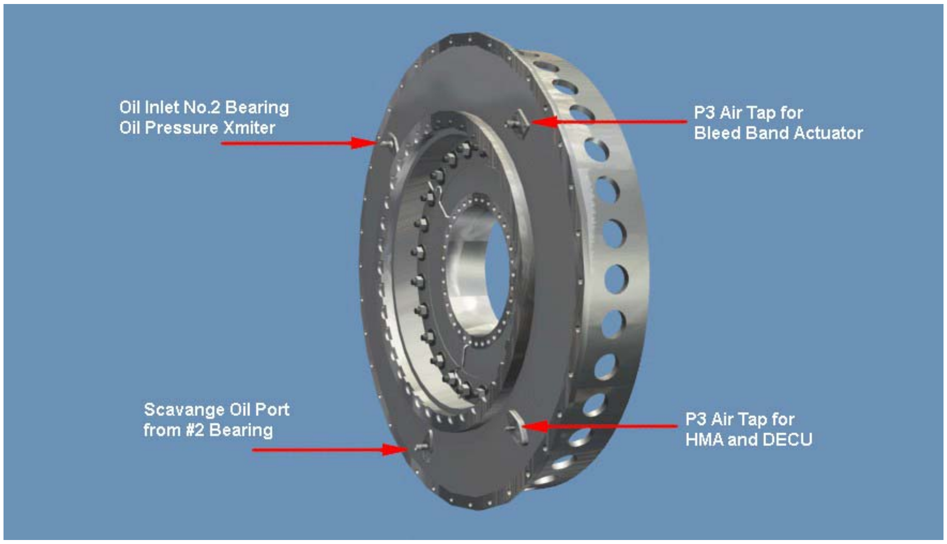
(f) Compressor rotor shaft is supported by:

1. No. 1 bearing package on the forward end.

2. No. 2 bearing package on the aft end (hot end bearing).

(g) Rotates in a counter-clockwise direction, providing an anti-torque effect to the engine.

(4) Air diffuser assembly.



(a) Vanes on the backside of the diffuser reduces air turbulence (swirl effect) and direct the air into the combustion chamber.

(b) Provides support for combustor assembly and non-rotating parts.

(c) Mounting surface for the No. 2 bearing package that supports the aft end of the compressor rotor shaft.

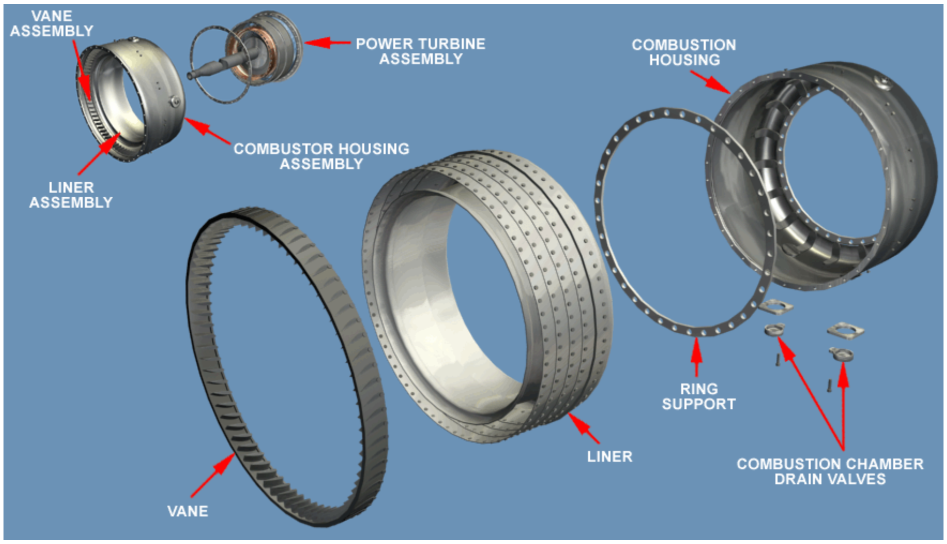
(d) Internal oil supply and scavenge tubes provide lubrication for the No. 2 bearing package.

(e) P3 Compressor Discharge Pressure (CDP) ports provide:

1. Air pressure for the bleed band actuator operation.

2. Air pressure for the HMA and DECU.

d. Combustor assembly.



(1) Combustion chamber housing.

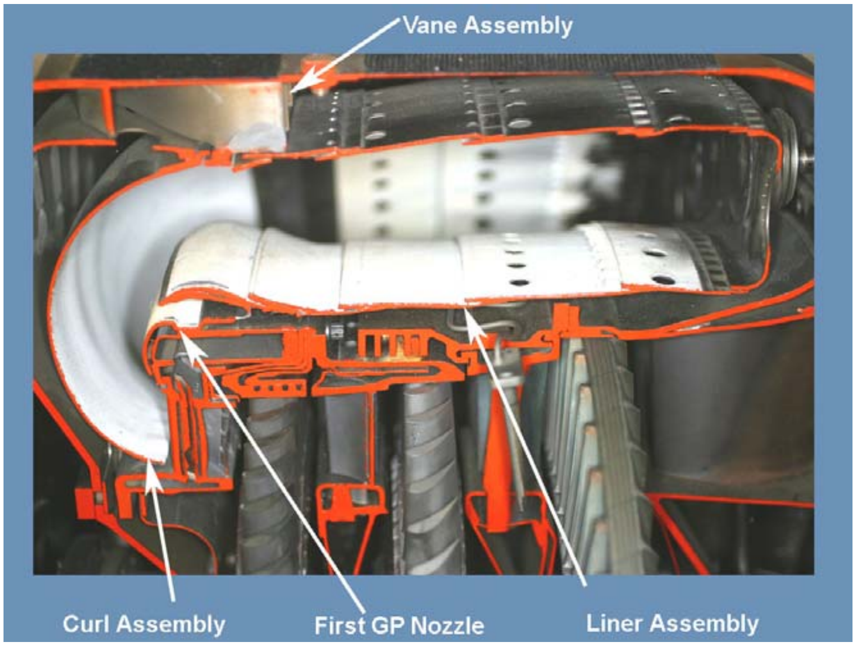
(a) Mounts on the diffuser assembly.

(b) Encircles the power turbine and provides an area for combustion and air expansion.

(c) Provides mounting structure for the fuel manifold, fire shield, fuel flow divider, spark igniters and start fuel nozzles.

(d) Chamber is a reverse flow external annular combustor. This folded design permits maximum utilization of space reducing gas producer and power turbine shaft lengths, reducing engine thrust.

(2) Vane assembly.



(a) Mounts inside the combustor chamber housing.

(b) Work with the straightening vanes in air diffuser assembly to remove air swirl and distribute air properly in the combustion chamber.

(3) Liner assembly.

(a) Mounts inside the combustor chamber housing.

(b) Holes are arranged to control the air for cooling and combustion.

(c) Fuel is fed into the liner assembly where the combustion takes place.

(d) Ceramic coated to provide a higher tolerance to heat.

e. Turbine section contains:

(1) Curl assembly.

(a) Located behind the air diffuser.

(b) Forms the outer wall of the path for the hot gases leaving the combustor section.

(c) Smoothly changes direction of hot gasses and guides them to the first gas producer nozzle.

(d) Ceramic coated to provide a higher tolerance to heat.

(2) Integral shaft assembly.

(a) Include a power shaft and the first power turbine disc assembly that are welded together.

(b) Splined output shaft at the front of the engine for installation of the power output shaft.

(c) Shaft transverses through the compressor rotor shaft.

(d) Supported on each end by:

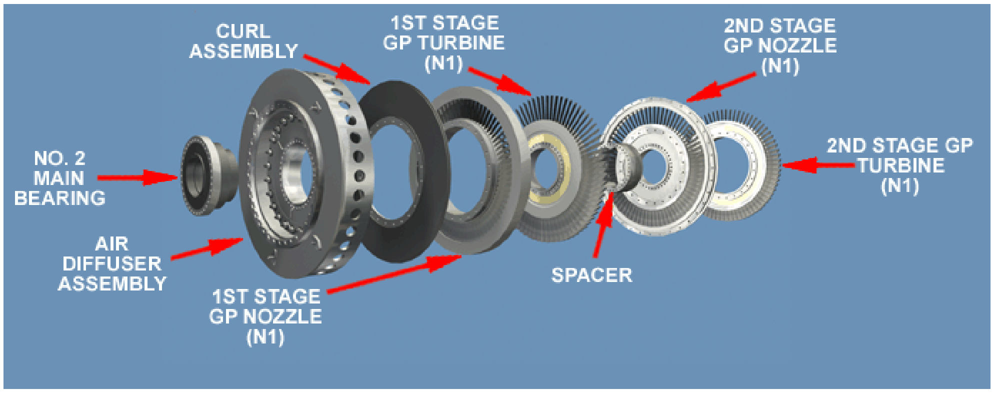
1. No. 3 bearing package at the forward end.

2. No. 4 and No. 5 bearing package at the aft end (hot end bearings).

(e) As the hot gases leave the curl assembly they hit the blades of the power turbine disc, causing the output shaft to turn.

(f) Shaft rotates clockwise providing an anti-torque effect to the engine.

(3) Gas Producer (GP) section.



(a) First gas producer nozzle.

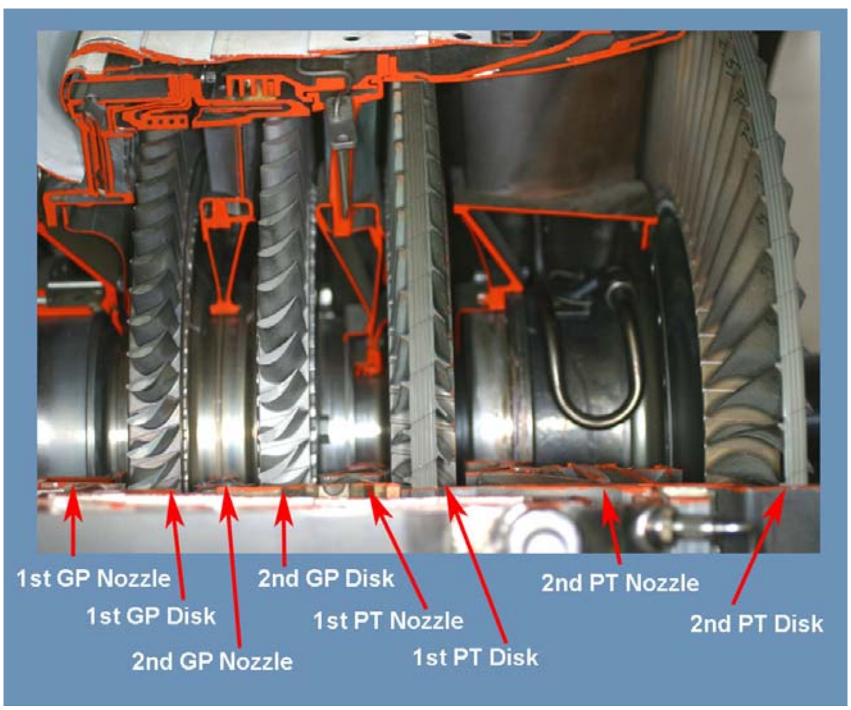
1. Located aft of the curl assembly and forward of the first gas producer disc assembly.

2. Outer portion forms the inner wall of the path for the hot gases leaving the combustion chamber.

3. Air cooled, and ceramic coated.

4. Nozzle vanes direct the hot gases so they hit the first gas producer disc blades at the most efficient angle.

(b) Second gas producer nozzle.



1. Located between the first and second gas producer disc assemblies.

2. Air cooled.

3. Nozzle vanes direct the hot gases leaving the first turbine disc assembly so they hit the second gas producer blades at the most efficient angle.

(c) Gas producer disc assemblies.

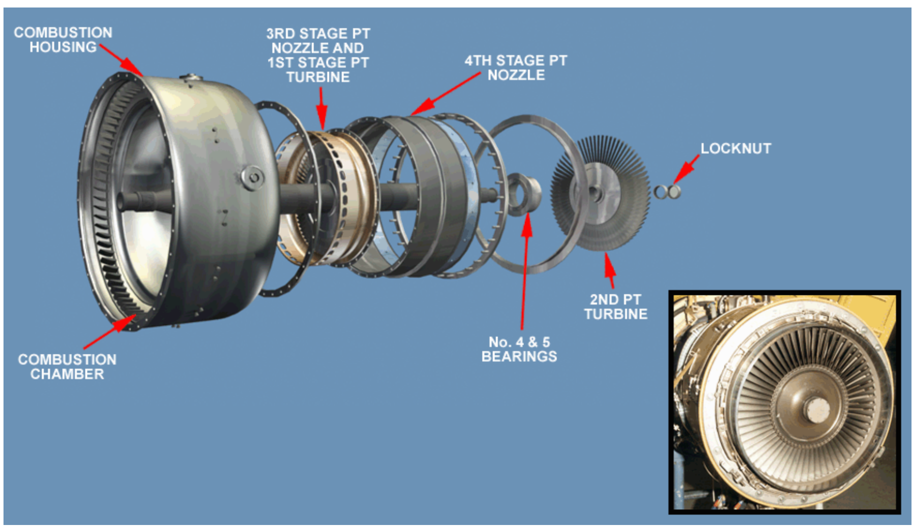
1. Coupled to the compressor rotor assembly.

2. As hot gases hit the disc assemblies, the disc assemblies turns causing the compressor to turn.

3. The turning of the compressor provides the air so that the engine will be able to self sustain operation.

4. Blades are air cooled.

(4) Power Turbine (PT) section.



(a) First power turbine nozzle.

1. Located between the second gas producer disc assembly and the first power turbine disc.

2. Provides mounting for the thermocouple harness assembly.

3. Air cooled.

4. Directs the hot gases so they hit the first set of power turbine blades at the most efficient angle.

(b) Second power turbine nozzle.

1. Provides the main support for the power turbine assembly.

2. Provides the mount for the No. 4 and No. 5 bearing package, and the exhaust cone.

3. Fits inside and mounts to the combustion section.

4. Air cooled.

5. Directs the hot gases so they hit the second set of power turbine blades at the most efficient angle.

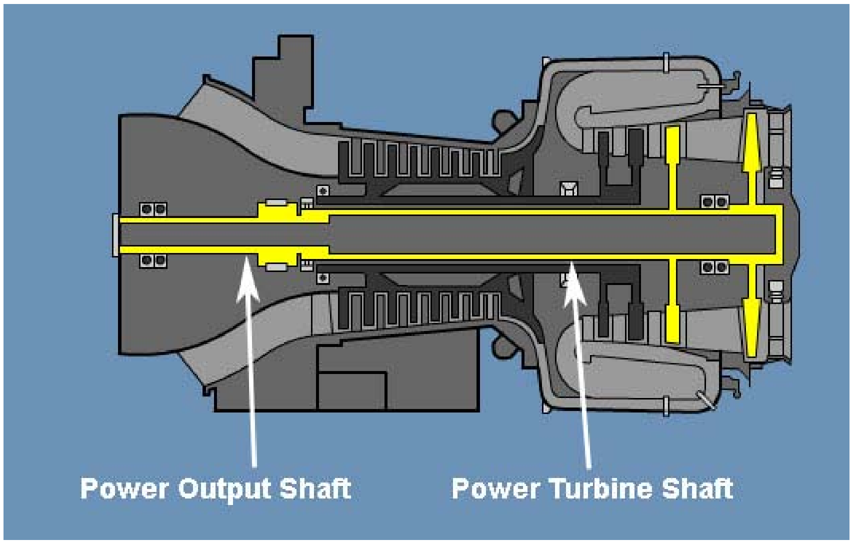
(c) Second Power turbine disc assembly.

1. Mounts on the rear of the power turbine shaft assembly.

2. Turned by the hot gases leaving the second power turbine nozzle assembly

3. Provide the power in conjunction with the first power turbine disc assembly to turn the power output shaft which drives the rotor system.

(5) Power output shaft.



(a) Located at the front of the engine, and is contained within the inlet housing assembly.

(b) Splined directly to and installed in, the end of the power turbine shaft.

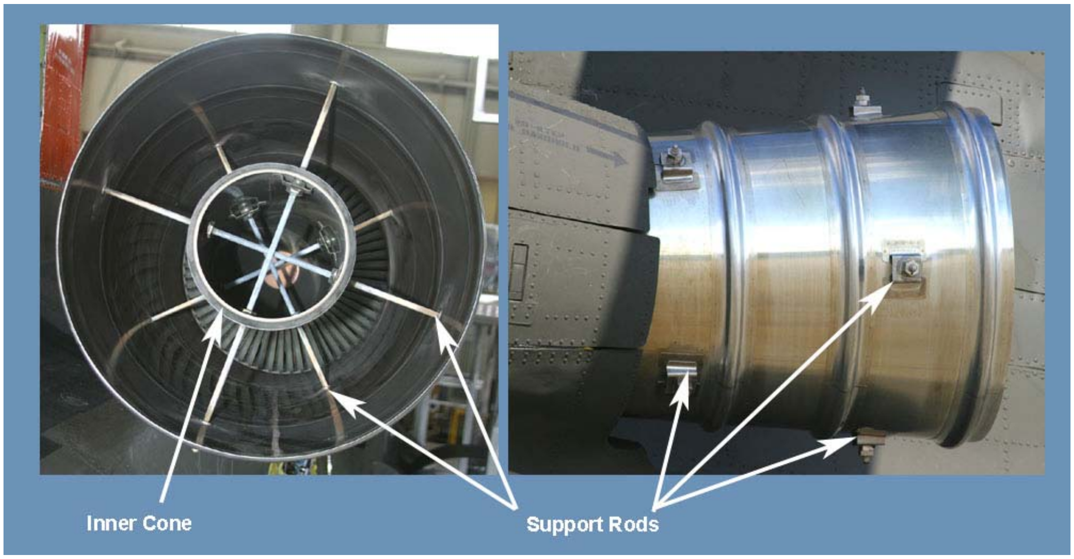
(c) Provides internal splines at the forward end for the installation of the engine transmission "quill" shaft.

(d) Provides the drive for the N_2 section of the accessory drive.

(e) Provides a torque reference for the torque indicating system.

(f) Supported by the No. 6 and No. 7 bearing package.

f. Exhaust section (Tail Cone).



(1) Mounts to the rear of the engine, directly to the second power turbine nozzle assembly.

(2) Outer cone.

(a) Contain a restrictor ring at the mounting end to contain disintegrating turbine wheels in case of engine failure.

(b) Canted approximately 8° up and 8° out from the aircraft to prevent exhaust heat damage to the skin of the aircraft.

(3) Four support rods maintain the position of the inner cone.

(4) Inner cone.

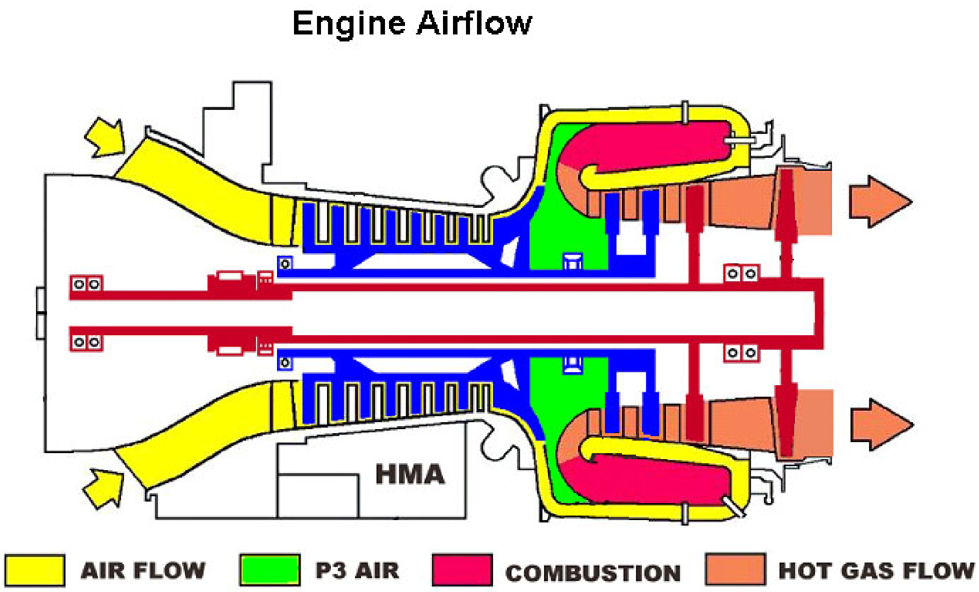
(a) Reduces swirling of the exhaust gases.

(b) Allows the exhaust gases to exit from the engine at a high rate of speed in a more uniform flow.

(5) Reduces exhaust gas temperatures and diverts them overboard.

(6) Can be used on either engine by aligning the index marks for the appropriate engine.

g. Engine Airflow.



(1) Air enters through the inlet housing and is directed into the compressor section.

(2) The air is compressed by the seven stage axial compressor rotor and the centrifugal compressor impeller.

(3) The compressed air flows through the diffuser and into the combustion chamber.

(4) Part of the air is used for internal cooling of the engine.

(5) The rest of the air is mixed with fuel from the two start fuel nozzles and 28 main fuel nozzles, forming a combustible mixture.

(6) Four spark igniters provide spark and ignite the mixture.

(7) The hot expanding gases are discharged through the turbine section.

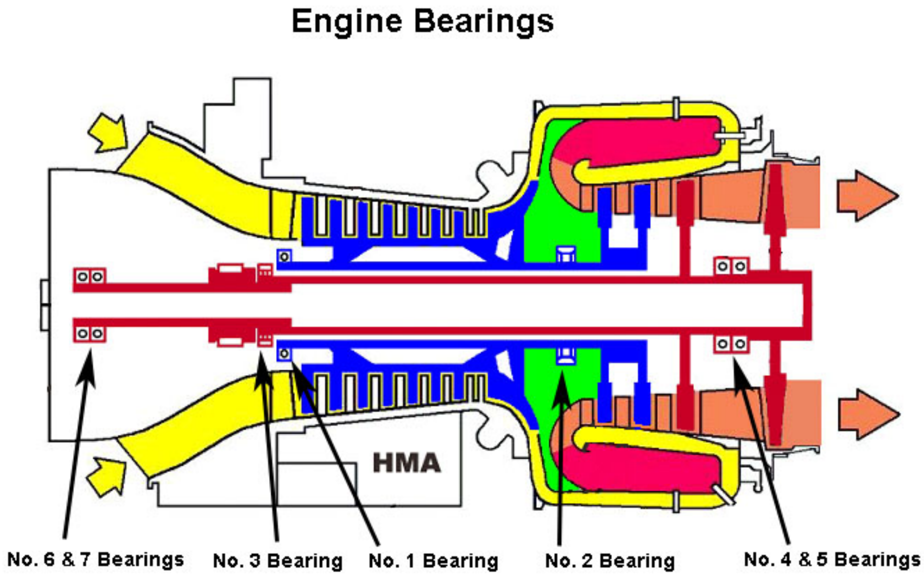
(8) Some of the energy from the hot gases drives two gas producer turbine discs which drive the compressor rotor.

(9) The remaining energy drives two power turbine discs, which drive the rotor system via the output shaft.

(10) As the engine comes up to speed the Hydro mechanical Metering Assembly (HMA) and fuel flow divider allow metered fuel to flow to the 28 main fuel nozzles.

(11) As the air leaves the last power turbine disc, it is exhausted through the tail cone assembly.

h. Engine internal bearings



(1) No. 1 bearing.

(a) Supported in the bearing housing which is supported by the inlet housing.

(b) Supports the forward end of the compressor rotor assembly.

(2) No. 2 bearing.

(a) Supported in the bearing housing which is supported by the air diffuser assembly.

(b) Supports the aft end of the compressor rotor assembly.

(3) No. 3 bearing.

(a) Supported by the power shaft bearing support which is supported by the inlet housing.

(b) Supports the forward end of the power turbine shaft assembly.

(4) No. 4 and 5 bearing package.

(a) Supported by the fourth turbine nozzle assembly.

(b) Supports the rear end of the power turbine shaft assembly.

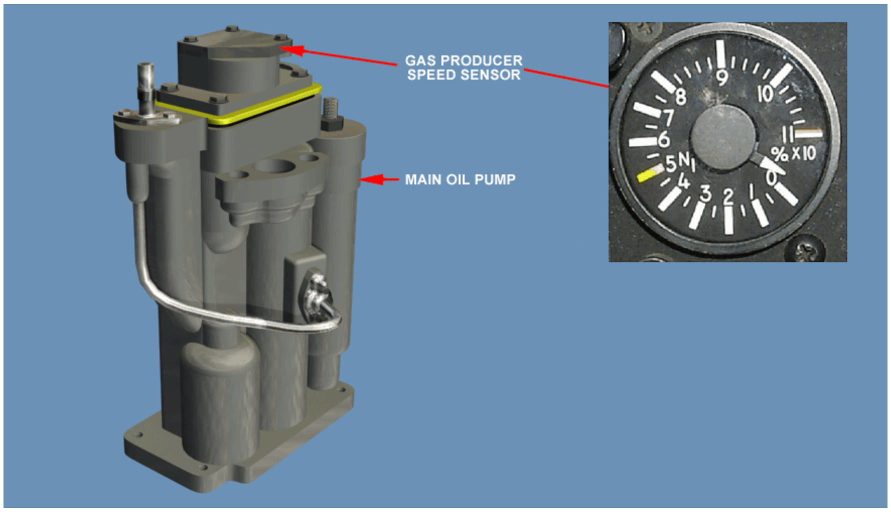
(5) No. 6 and 7 bearing package.

(a) Supported by the output shaft support assembly.

(b) Supports the forward end of the output shaft.

3. Learning Step/Activity−3-Describe operational characteristics, functions, and limitations of the engine subsystems.

a. Gas producer (N_1) tachometer.



(1) Indicates the gas producer speed in percent.

(a) Scale 0% to 80% in increments of 5%.

(b) Scale 80% to 110% in increments of 2%.

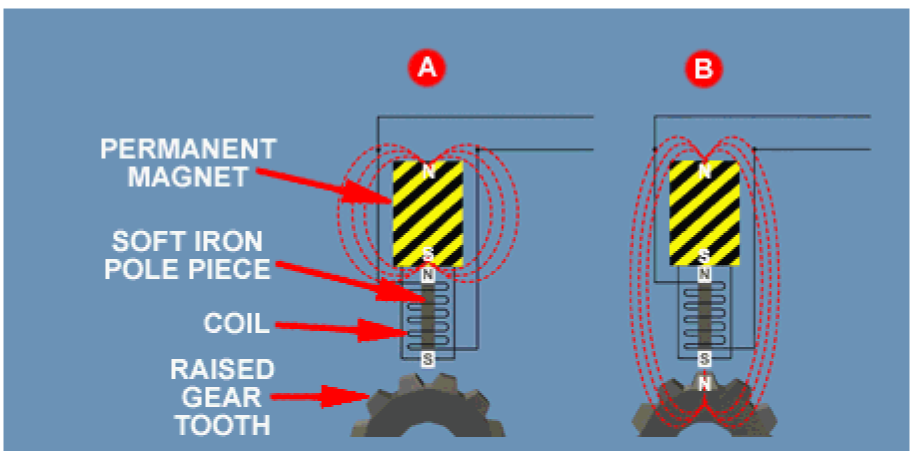
(2) N_1 magnetic pickup.

(a) Mounted on the rear of the engine mounted oil pump.

(b) Driven by the gearing in the oil pump.

(c) Supplies an AC frequency signal proportional to N_1 speed to the instrument.

(d) Does not interface with FADEC, only gauge in cockpit.



NOTE: A magnetic sensor consists of a cylindrical permanent magnet and a wire-wrapped soft iron core. A ferrous metal interrupter (cylinder with symmetrically raised segments around its circumference), driven by the gearing of the oil pump the cylinder rotates in close proximity to the end of the sensors at a speed relative to the gas producer system.

The magnetic lines of flux generated by the magnet are low while a raised segment of the interrupter is positioned away from the end of the magnetic sensor. When a raised segment of the interrupter is passed across the end of the magnetic sensor, the lines of magnetic flux are strengthened and drawn in-ward.

The magnetic flux lines passing across the wire coil will induce a voltage proportional to the rate of change of the lines of flux. The speed signal transmitted to the gauge in the cockpit is proportional to the speed at which the raised segments of the interrupter pass across the end of the magnetic sensor. The function of the magnetic sensor is the same for all engine speed sensors (i.e. HMA speed sensor, APU speed sensor, and dual pick-up power turbine speed sensors).

(3) N_1 Over speed.

(a) When 110% is exceeded.

(b) May cause an over temperature and / or over-torque.

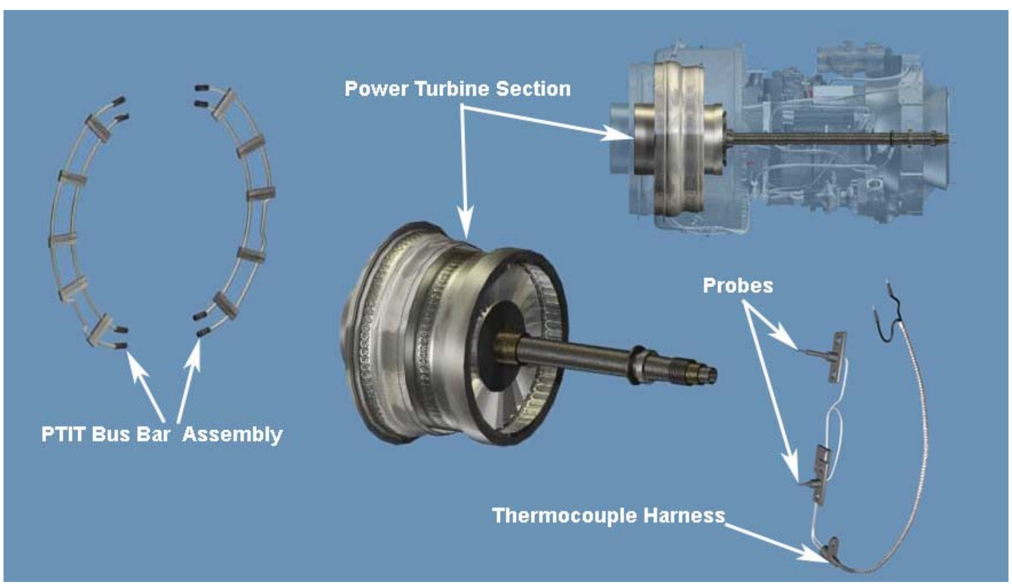
(4) Ground idle speed: Minimum of 50%.

(a) N_1 = 50% Cold day (-54°C)

(b) N_1 = 55% Standard day (15°C)

(c) N_1 = 59% Hot day (57°C)

b. PTIT (Power Turbine Inlet Temperature) indicating system.



(1) Thermocouple harness assembly.

(a) Five assemblies, with two probes each.

(b) One long probe and one short probe per assembly.

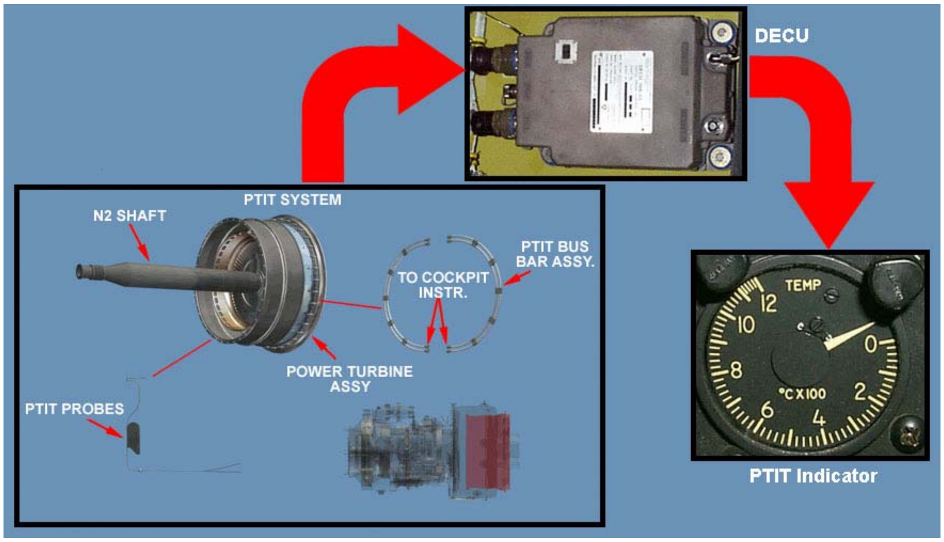
(c) Probes are made of dissimilar metals that when heated generate a proportional voltage to the temperature.

(d) Installed at the inlet of the power turbine section of the combustor, i.e. Power Turbine Inlet Temperature (PTIT).

(e) The ten probes attach to the externally mounted left and right hand thermal bus bar assemblies, where the voltages from the 10 probes are combined and averaged.

(f) This average is sent to the DECU, and the DECU sends the average to the cockpit indicator which is calibrated in centigrade.

(2) PTIT indicator.



(a) Indicator on the center console measure temperature in increments of 20°C.

(b) Scale ranges from 0°C to 1200°C.

(c) Markings are provided to indicate power range or time limited operations. The pilot must keep track of all times and temperatures above 816°C to ensure that no time limit range is exceeded.

1. Continuous range 400°C to 815°C.

2. 30 Minute range 815°C to 855°C.

3. 10 Minute range 856°C to 900°C.

4. 2.5 Minutes Contingency power range 900°C to 930°C.

5. 12 Seconds Maximum 931°C to 940°C, (Never to Exceed) 940°C.

(d) Used in the calculation for load sharing PTIT.

(e) Provides signal for PTIT limiting during the start and operation of the engine.

NOTE: A -13-1 entry is required when any Chapter 5 limitation has been exceeded, noting the limit or limits exceeded, range, time above limits, and any additional data that would aid maintenance personnel.

(3) Electrical power is supplied through the No.1 and No.2 DC buses.

(4) Contingency power system.

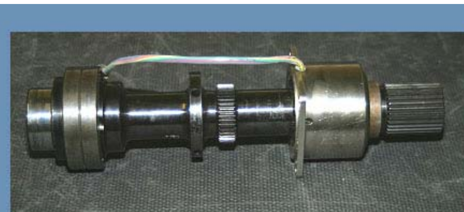
(a) To be used only during actual emergency conditions.

(b) The engine will be in the contingency power range anytime the PTIT above 900°C.

OPERATOR'S MANUAL- CAUTION: To prevent damage, monitor torque and the PTIT indicators when operating with contingency power. Failure to observe these indicators could result in serious damage to the drive train and engines.

c. Torque measuring system.

Torque Meter



Power Output Shaft/Head Assembly

Junction Box

Ratio Detector Power Supply (RDPS)

(1) Engine mounted components.

(a) Power output shaft.

1. A sleeve is welded to the power output shaft.

2. Engine force applies torsion to the shaft.

(b) The non-rotating head assembly.

1. Mounted to intake assembly and fits around the power output shaft sleeve.

2. Primary coil generates a constant magnetic field.

3. Secondary coils measure the torsion and compression on the shaft creating an AC output voltage.

4. Signal from the head assembly is sent to the junction box.

(c) Junction box.

1. Mounted to the right side of the inlet housing.

2. Converts the output of the secondary coils of the head assembly to a DC voltage.

3. Provides the electrical signal for operation of the torque indicator and sends it to the RDPS.

(2) Airframe mounted components.

(a) Ratio Detector Power Supply (RDPS).

1. Inverter/power supply, converts aircraft DC power to AC power for the primary coils in the head assembly.

2. Signal condition, received the DC signals from the junction box.

3. Provides a torque signal to the DECU.

4. Provides a torque signal to the cockpit indicators.

(b) Torquemeter indicator.

1. One torquemeter is installed on the Pilots and one on the Co-Pilots instrument panel.

2. There is a pointer for each engine and torque is measured in percent.

3. Indicator measures torque in 5% up to 110% and 2% increments up to 150%.

4. Scale ranges from 0% to 150%.

5. Torque limits.

a. Dual engine 100% torque.

b. Single engine 123% torque.

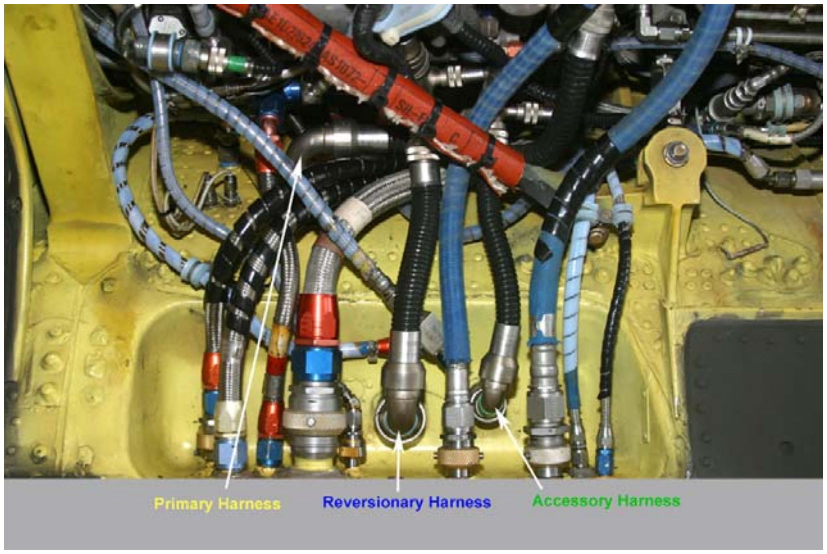
(3) Electrical power.

(a) No.1 and No.2 AC busses.

(b) No.1 and No.2 DC busses.

d. Electrical system provides circuitry for starting, ignition, and for all electrical accessories.

(1) Electrical cable connections consist of three major harness assemblies.



(a) Primary harness assembly.

1. Identified by the yellow bands on the harness.

2. Provides the circuitry for the HMA, N_2A speed pickup, start fuel valve, and torque junction box.

(b) Reversionary harness assembly.

1. Identified by the blue bands on the harness.

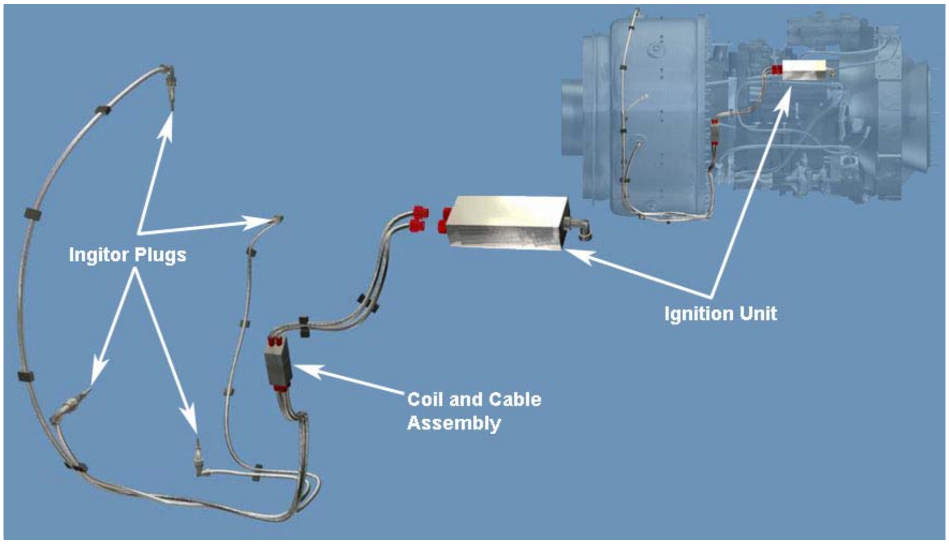
2. Provides circuitry for the T_1 sensor, overspeed solenoid valve, N_2B speed pickup, HMA and backup for primary harness circuitry.

(c) Accessory harness assembly.

1. Identified by the green bands on the harness.

2. Provides circuitry for the oil pressure, oil temperature, oil level low indication, engine chip detector, ignition exciter, and the N_1 speed pickup.

(2) Engine ignition system.



(a) Ignition unit.

1. Located on the upper right side of the compressor housing, directly in front of the bleed band actuator, and above the liquid to liquid cooler.

2. Vibrator transformer within the ignition unit converts a 24 volt DC input to 2500 volts.

3. Voltage is sent through the coil and cable assembly.

(b) Ignition coil and cable assembly.

1. Provides shielded high voltage ignition wiring from the ignition unit to the four igniter plugs in the combustor chamber.

2. The coil (spark splitter) is mounted to the right side of the diffuser and distributes an equal amount of high voltage to each of the four igniter plugs.

(c) Igniter plugs.

1. Four igniter plugs are installed in receptacles in the aft end if the combustion chamber at approximately the Three, Six, Nine and Twelve O'clock positions.

2. The igniter plugs provide the gap for high voltage sparks to ignite the fuel mixture in the combustion chamber.

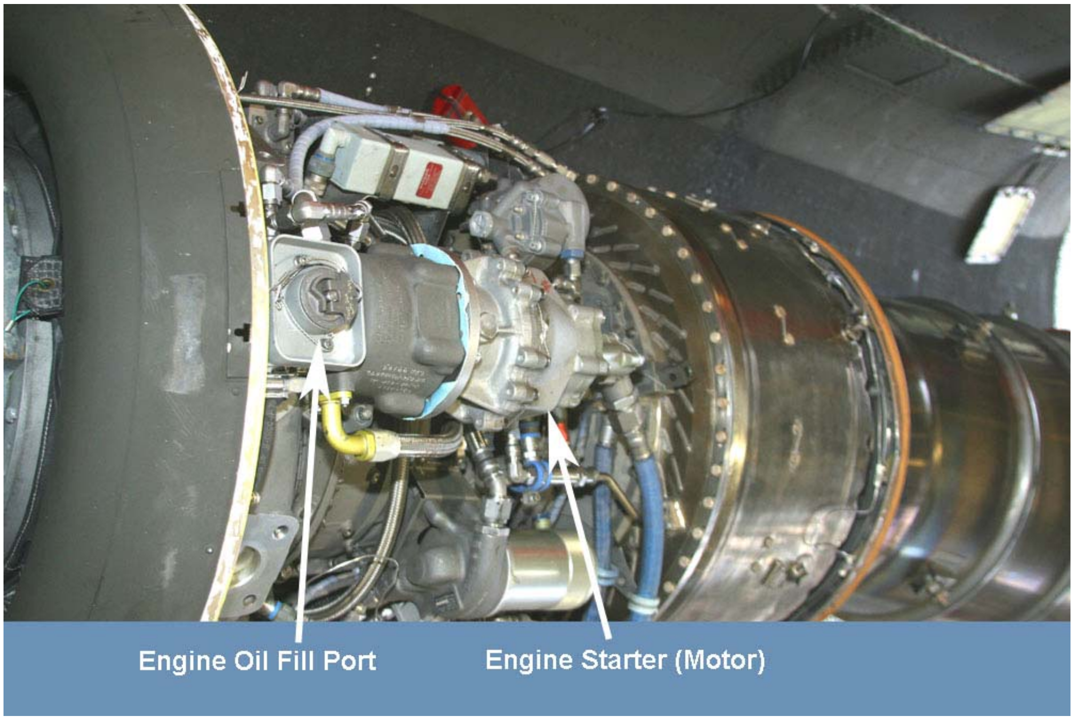
(3) Digital Electronic Control Unit (DECU)

(a) Dual channel airframe mounted component.

(b) Contains a Primary (PRI) channel and a backup Reversionary (REV) channel in the event the primary channel becomes inoperative.

NOTE: The DECU will be described later in the FADEC system operation.

e. Hydraulic engine starter (Motor).



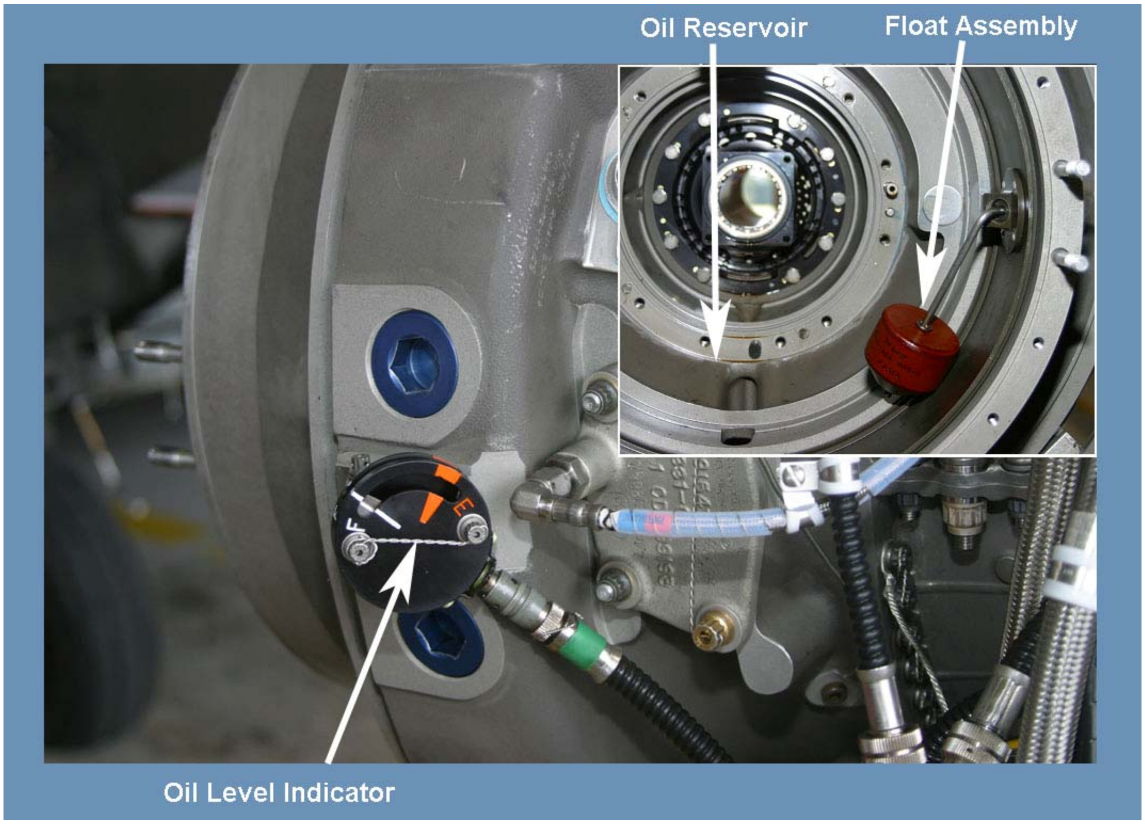
(1) Located at the Twelve O'clock position at the front of the compressor section.

(2) Hydraulic power is provided by the utility hydraulic systems, APU motor/pump which produces the 3350 PSI required to start the engines..

(3) Turns the compressor and drives the N_1 section of the accessory drive.

(4) Contains a sprag clutch that allows the engine N_1 section to decouple from the engine motor when the engine N_1 speed exceeds the maximum motor speed.

f. Lubrication system.



(1) Integral oil tank.

(a) The tank is located in the inlet housing.

1. A one piece aluminum casting.

2. Outer section forms the outer wall of the engine air inlet.

3. Inner section is supported by four hollow support struts which forms the inner wall of the engine air inlet.

4. Engine oil supply tank is contained within the center cavity of the inner section. This arrangement aids in cooling of the engine oil, as the airflow over the inner section will reduce oil temperature as the oil returns to the oil tank.

(b) Oil system is filled via the fill port located at the Twelve O'clock position in the air intake.

1. Oil tank capacity is 12 quarts, leaving room for expansion.

2. System capacity is 15 quarts, which include the cooler, lines and filters.

3. Types of oil used in the engine:

a. MIL-L-23699, (Green can) when temps are above -32° C.

b. MIL-L-7808, (Silver can) when temps are below -32° C.

c. If the oils are mixed, the system must be flushed within six hours of operation, an oil sample taken, and a -13-1 entry made.

4. Access door has three quick release fasteners which lock it in the closed position. On the inside of the door is an “L” bracket which is used to hold down the filler cap tab.

5. Check that the filler cap is secure and the tab is positioned aft, and down.

(c) Oil level indicating system.

1. System consists of a float assembly, indicator, and caution/advisory panel light.

2. Float assembly.

a. Located inside of the inlet housing oil tank.

b. Float is constructed of high density foam that is connected to a metal arm.

3. Indicator assembly.

a. Located on the left side of the engine inlet section.

b. Contains a micro switch.

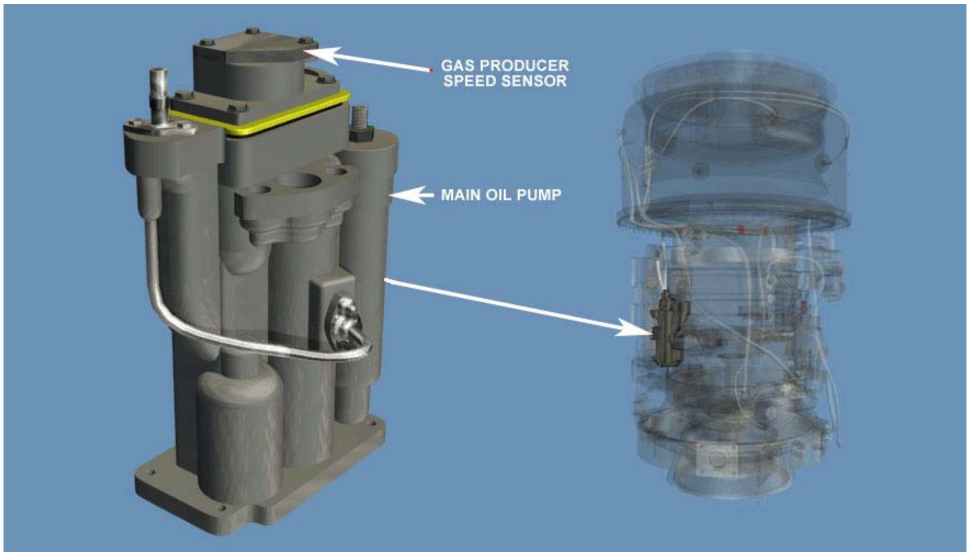
(1) Activated by the float assembly when the oil in the tank reaches two usable quarts.

(2) Micro switch is connected to the associated ENG OIL LVL light on the master caution/advisory panel.

4. If the oil level is low and the engine has been shutdown for more than 24 hours, run it up, shut down, and recheck prior to servicing the engine.

5. Powered by the essential DC bus.

(2) Oil pump.



(a) The pump is mounted on the Accessory Gear Box (AGB).

(b) Driven by the engine N_1 section.

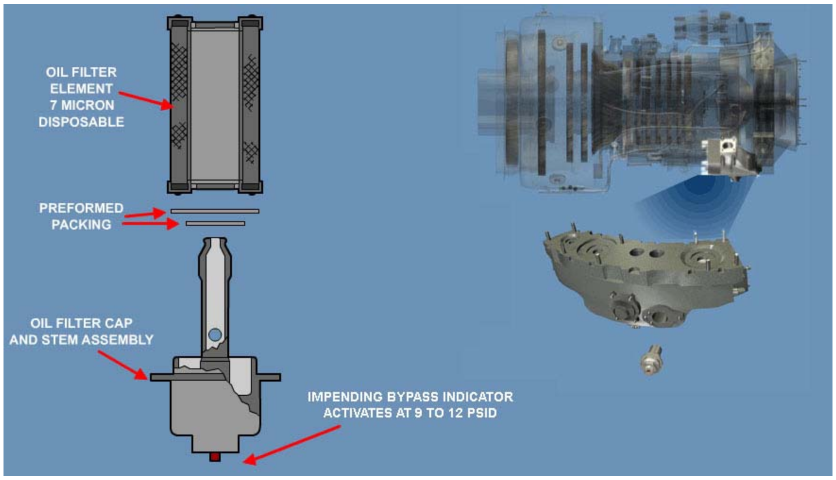
(c) The pump contains one pressure and two scavenge (sucking) elements.

1. The pumping element provides 50 to 90 Pounds per Square Inch (PSI) during normal engine operation.

2. One of the scavenge elements pulls the oil up from the accessory gearbox and returns it to the oil tank.

3. One of the scavenge elements pulls the oil out of the No. 4 and 5 bearing package.

(3) Main oil filter.



(a) Located on the AGB.

(b) A seven micron disposable filter.

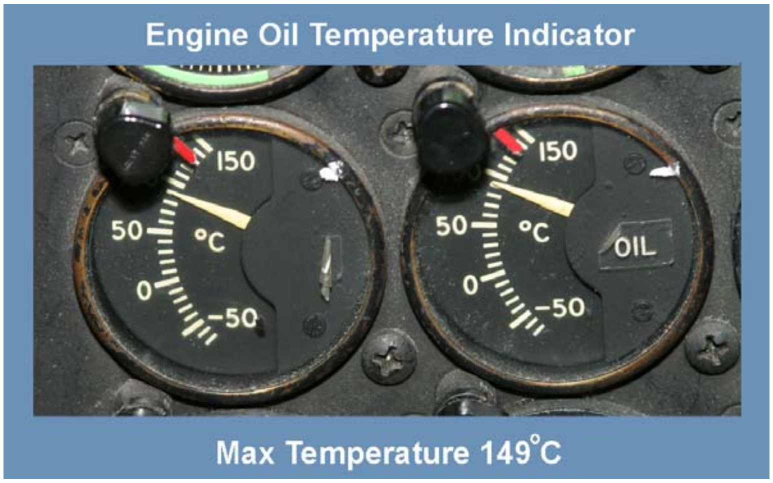
(c) Contains an impending bypass indicator (red button).

1. Activates at 9 to 12 Pounds per Square Inch Differential (PSID).

2. Button has a temperature sensitive spring that prevents the button from extending at oil temperatures below 65°C.

(d) Contains a bypass valve will begin to open at 14 to 16 PSID and is fully open at 19 to 21 PSID, allowing the oil to bypass a clogged filter.

(4) Oil temperature system.



(a) Indicator on the center console measures temperature in increments of 5°C.

(b) Scale ranges from -70°C to 150°C.

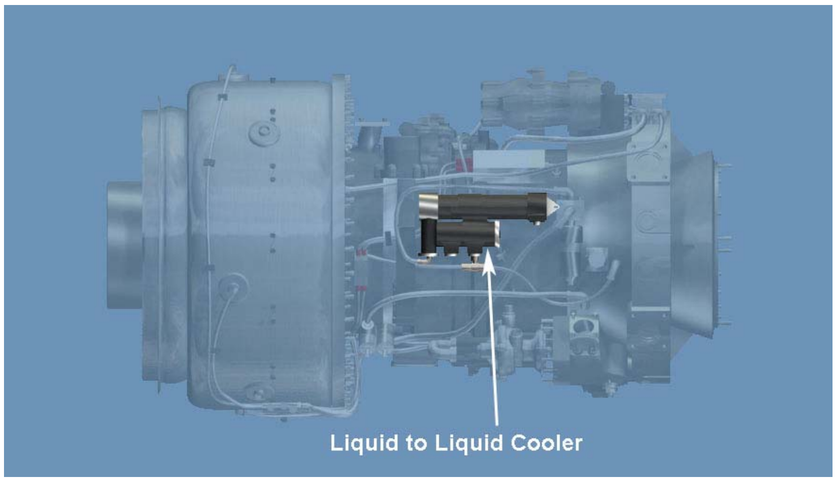
(c) Measured by a temperature transmitter on the right side of the engine located in the AGB.

(d) Temperature is measured prior to cooling by the liquid to liquid cooler and transmitted to the gauge in the cockpit.

(e) Maximum oil temperature is 149°C.

(f) Power comes from the No. 1 and No. 2 DC buses.

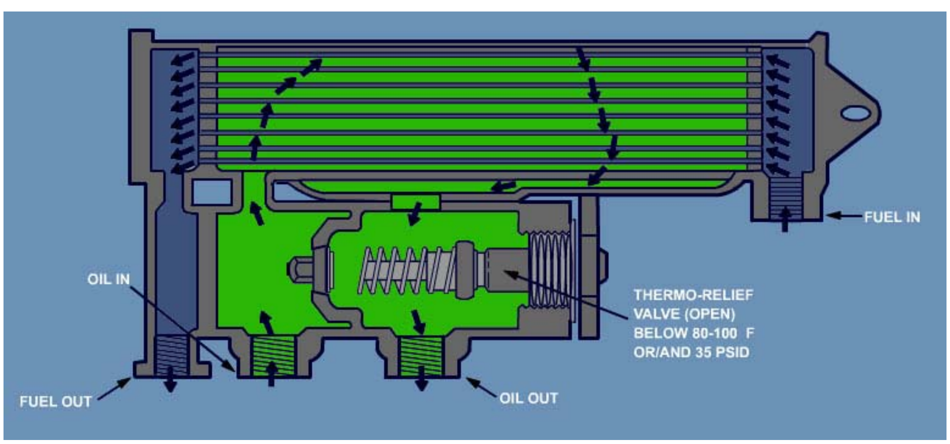
(5) Oil cooler.



(a) Mounted on the right side of the compressor section of the engine.

(b) Provides a means of lowering the oil temperature, and is the primary method of cooling the oil.

(c) Cools the oil and heats the fuel that passes through.



1. Contains many small diameter aluminum tubes (fuel flow) running lengthwise.

2. Oil entering will flow around the small tubes transferring the oils heat to the fuel.

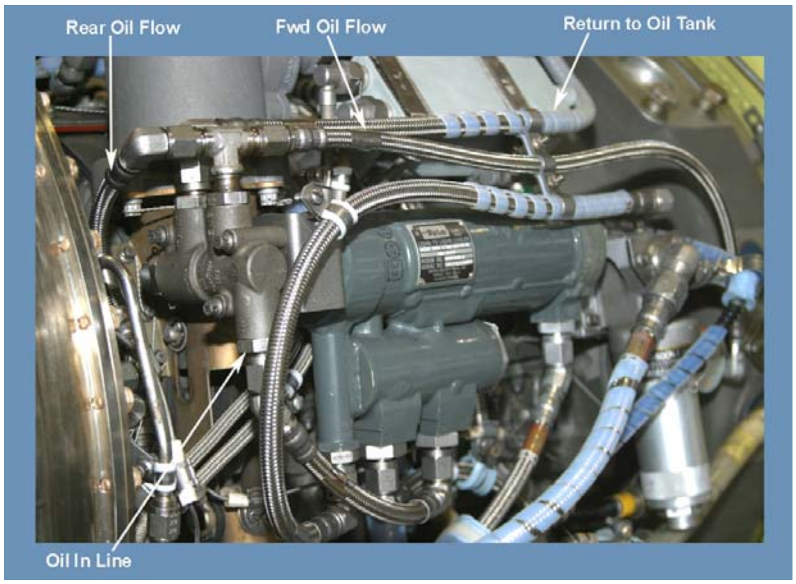
3. Results in a higher fuel temperature and a lower oil temperature.

(d) Oil cooler thermo-relief valve.

1. Installed to allow cold oil to bypass the cooler until the oil temperature reaches (80°F to 100°F) or (26°C to 38°C).

2. If the cooler becomes clogged the valve will begin to open at 35 PSID to allow the oil to bypass the cooler.

(6) Oil flow programming valve.



(a) Mounted on the aft end of the liquid to liquid cooler.

(b) Used to regulate oil flow in accordance with engine demand.

(c) Prevents oil from coking the bearing cavities, increasing engine life.

NOTE: "Coke" is the solid residue remaining when oils undergo severe oxidative and thermal breakdown at extreme engine temperatures. The higher the temperature, the harder, blacker and more brittle the residue. Deposits are not desirable, but if they do form, you want them to stay where they are. Coke shedding can cause blockage of filters and engine oil system passageways. Coke formation increase dramatically as local metal contact temperatures exceed 225°C.

(7) Forward oil flow path.

(a) Provides oil to the gears in the accessory drive.

(b) Provides oil to the No. 1, 3, 6 and 7 bearing packages.

(c) Filtered by knife edge filters prior to the bearings.

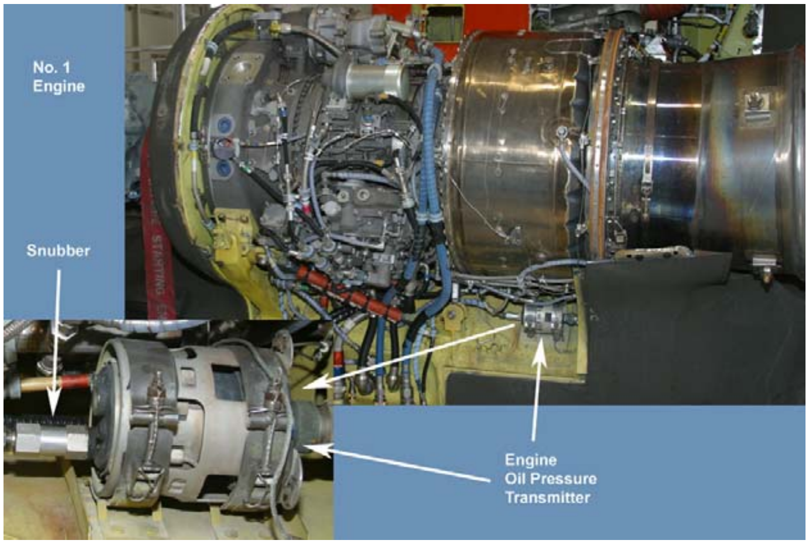
(8) Aft oil flow path.

(a) Provides oil to the No. 2, 4 and 5 bearing packages.

(b) Filtered by knife edge filters.

(c) Provides oil pressure to the engine oil pressure transducer, via the No. 2 bearing.

(9) Oil pressure system.



(a) Oil pressure transmitter is located below the engine combustor section, mounted on the engine deck (airframe).

1. The pressure transmitter sends the pressure reading to the cockpit indicator.

2. Snubber is installed to reduce surges in oil pressure indications.

(b) Oil pressure indicator

1. Scale ranges from 0 to 200 PSI in increments of 10 PSI.

2. Oil pressure limitations:

a. 5 PSI minimum pressure at ground idle 50% N_1.

b. 35 PSI minimum pressure at 80% to 95% N_1.

c. 50 PSI minimum at 95% N_1 or above.

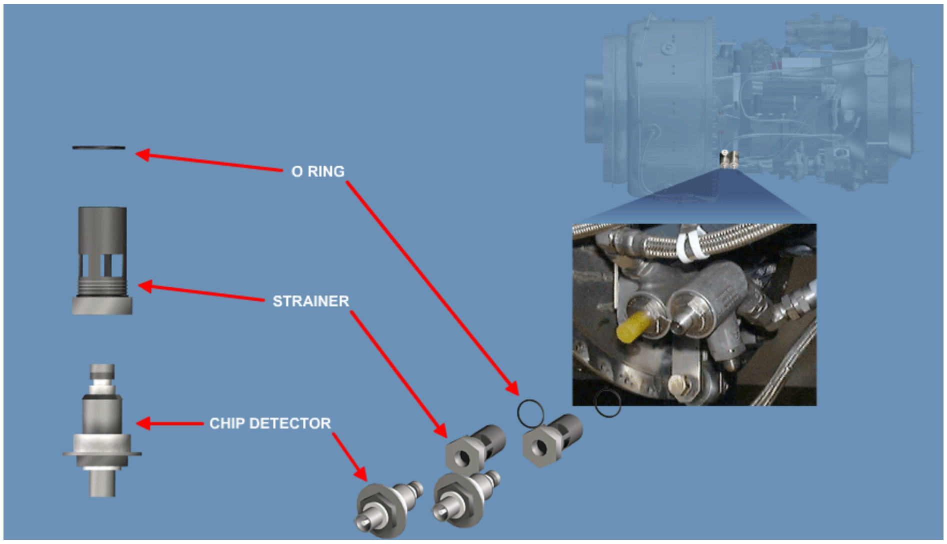
d. 35 to 90 PSI minimum normal operating pressure range.

e. 110 PSI maximum pressure for contingency power.

f. 150 PSI maximum pressure for cold weather starts.

(c) Electrical power is from the 26 volts AC (VAC) instrument buses.

(10) Dual element chip detector.



(a) Mounted on the right side of the compressor section at the Five O'clock position.

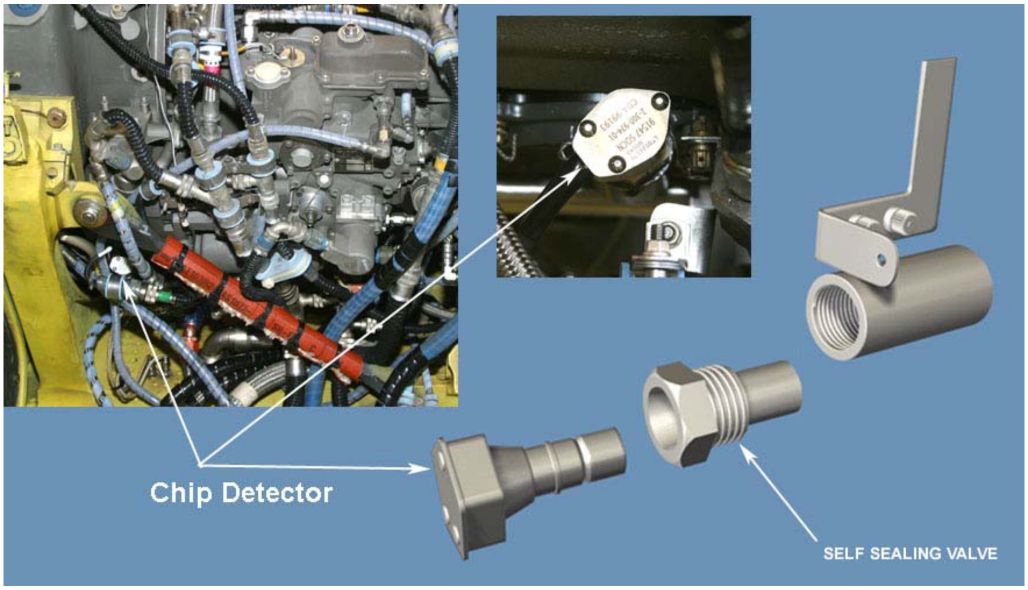
(b) Provides a means to filter and detect metal contamination originating in the No. 2 or No. 4 and 5 bearing areas.

(c) Contains two separate plug assemblies surrounded by a small mesh filter.

(d) Contamination can be detected by a resistance check or by a visual inspection.

(e) Will not provide any indication of contamination to the pilot.

(11) Engine gearbox chip detector.



(a) Mounted on the left side of the compressor section in the accessory gearbox, at the Seven O'clock position.

(b) Provides a means to detect metal contamination in the accessory gearbox.

(c) Contains a magnetic plug and a self sealing housing, which allows the plug to be removed without loss of engine oil.

(d) Center post is the positive post surrounded by a magnet, both of which are encased by the housing which is grounded.

1. Magnet attracts ferrous particles.

2. When a ferrous particle breaches the positive post and the grounded housing, it will attempt to light the master caution/advisory light.

(e) The fuzz burn off module.

1. Located on the right side of the ramp area, just below the maintenance panel.

2. Will attempt to burn the particle in half (like a fuse) prior to lighting the master caution light.

3. The fuzz burner system can burn off particles up to 0.002 of an inch in size.

4. If unable to burn off the fuzz, the chip will activate the associated ENG 1 or ENG 2 CHIP DET light on the master caution/advisory panel, along with the associated latch on the maintenance panel.

(f) Two lights located on the master caution/advisory panel, one for each engine.

1. The lights will illuminate if chips are detected in the engine or the engine transmission.

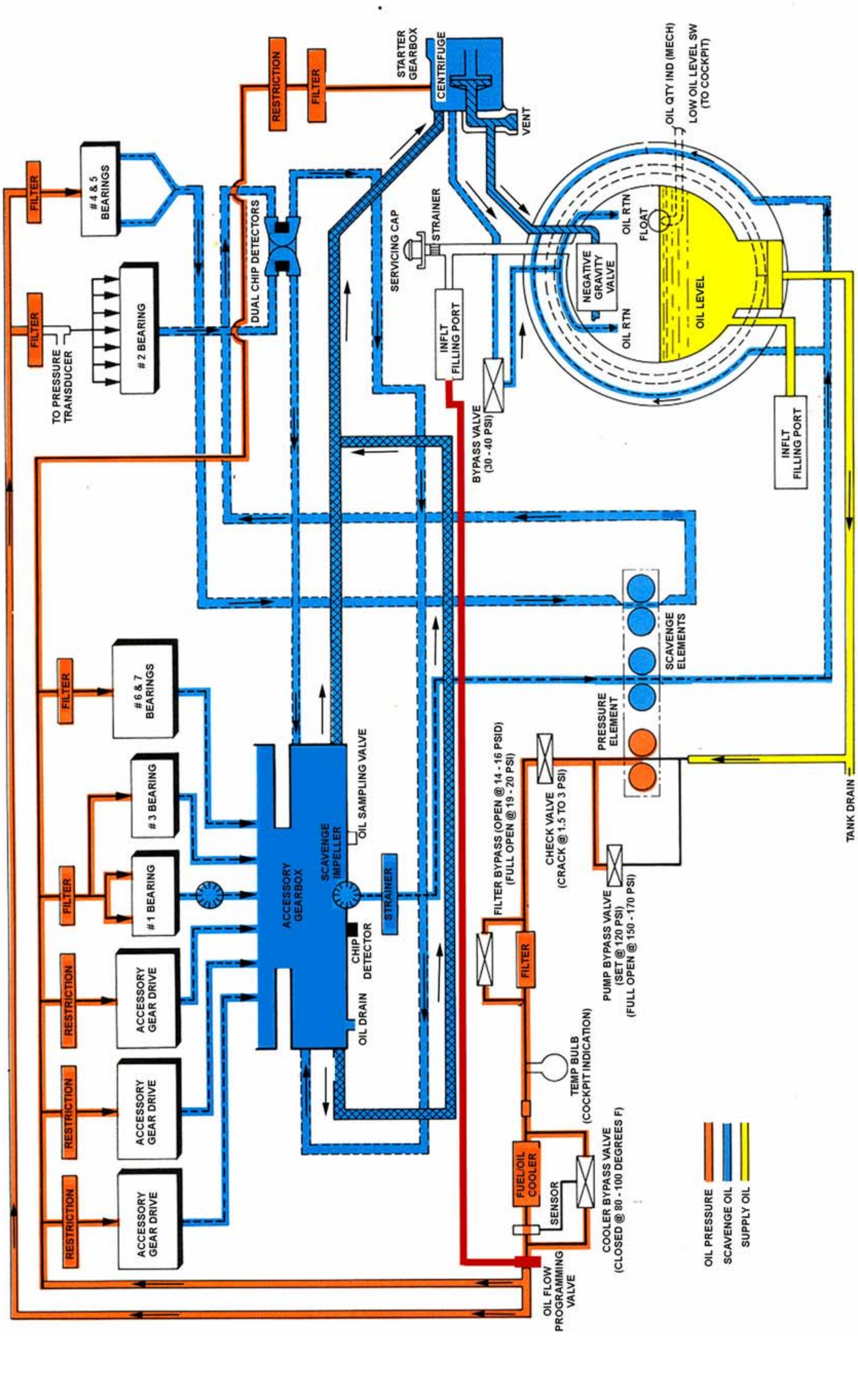
2. Magnetic latch indicators.

a The latch indicators are on the maintenance panel.

b Indicates the location of metal particles (engine or engine transmission).

c Crew member will identify chip location (engine or engine transmission).

(12) Oil flow.



RESTRICTION
FILTER
STARTER GEARBOX
CENTRIFUGE
VENT
OIL QTY IND (MECH)
LOW OIL LEVEL SW (TO COCKPIT)
FILTER
4 & 5 BEARINGS
FILTER
TO PRESSURE TRANSDUCER
2 BEARING
DUAL CHIP DETECTORS
SERVICING CAP
STRAINER
OIL RTN
FLOAT
NEGATIVE GRAVITY VALVE
OIL RTN
OIL LEVEL
INFLT FILLING PORT
BYPASS VALVE (30 - 40 PSI)
INFLT FILLING PORT
FILTER
6 & 7 BEARINGS
SCAVENGE ELEMENTS
PRESSURE ELEMENT
3 BEARING
FILTER
1 BEARING
OIL SAMPLING VALVE
ACCESSORY GEARBOX
SCAVENGE IMPELLER
STRAINER
CHIP DETECTOR
FILTER BYPASS (OPEN @ 14 - 16 PSID) (FULL OPEN @ 19 - 20 PSI)
CHECK VALVE (CRACK @ 1.5 TO 3 PSI)
TANK DRAIN
RESTRICTION
ACCESSORY GEAR DRIVE
RESTRICTION
ACCESSORY GEAR DRIVE
RESTRICTION
ACCESSORY GEAR DRIVE
OIL DRAIN
FILTER
PUMP BYPASS VALVE (SET @ 120 PSI) (FULL OPEN @ 150 - 170 PSI)
TEMP BULB (COCKPIT INDICATION)
FUEL/OIL COOLER
SENSOR
COOLER BYPASS VALVE (CLOSED @ 80 - 100 DEGREES F)
OIL FLOW PROGRAMMING VALVE
OIL PRESSURE
SCAVENGE OIL
SUPPLY OIL

(a) Oil leaves the integral oil tank through the bottom of the inlet housing and flows through an external line to the oil pump.

(b) Oil from the pump pressure element flows through a check valve and main oil filter, past the temperature transmitter, through the liquid to liquid cooler assembly, and the flow programming valve. The main oil pump, filter, and cooler assembly contain bypass valves.

(c) Three flow paths exit the flow programming valve.

   1. The first path flows to the rear of the engine to lubricate the No. 2 and No. 4 and 5 bearings.

   2. The second path flows to the front of the engine to lubricate the accessory drive gears and bearings, starter drive gears and bearings, and the No. 1, 3, 6 and 7 bearings.

   3. The third path returns any excess oil from the programming valve back to the oil tank.

(d) Oil flows through a knife edge filter to the No. 2 bearing, then to the dual element chip detector and to the accessory gearbox assembly.

(e) Oil flows through a knife edge filter to the No. 4 and 5 bearings, where it is scavenged back through the oil pump, and then sent through the dual element chip detector, and to the accessory gearbox assembly.

(f) Oil exiting the accessory drive gears and bearings and the No. 1, 3, 6 and 7 bearings, flows through internal paths to the accessory gearbox assembly.

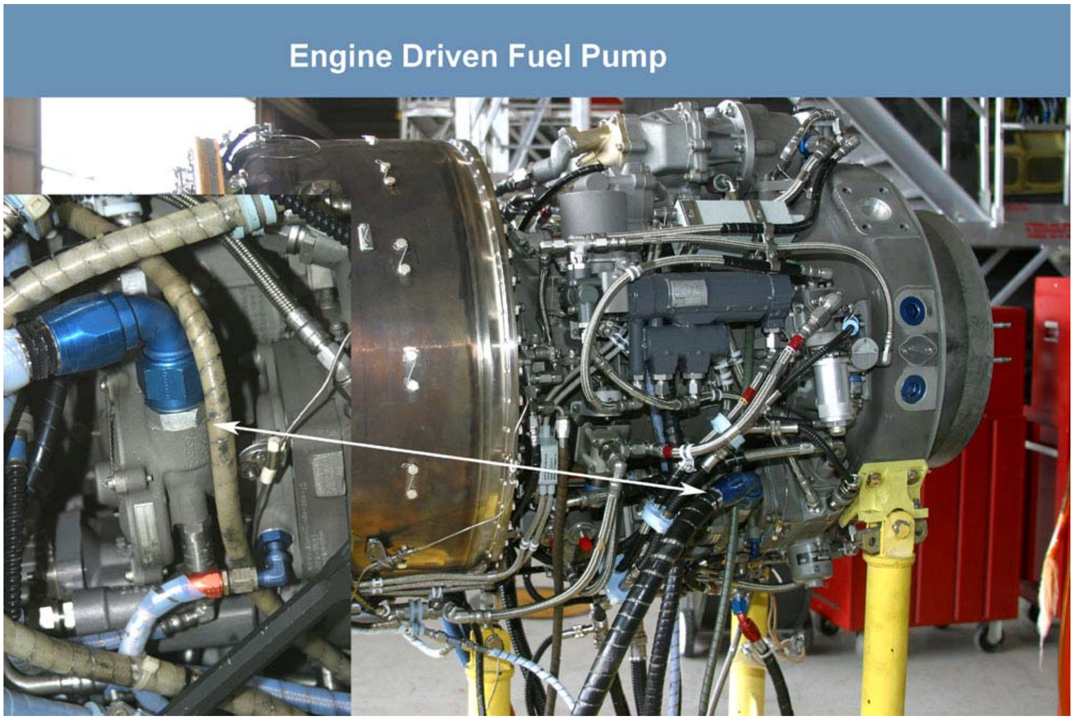
(g) Oil exits the accessory gearbox assembly through a strainer and main scavenge element in the main oil pump and returns to the inlet housing.

(h) Oil flow in the inlet housing is through two passages that surround the integral oil tank. The passages are located in the inner diameter of the inlet housing, next to the inlet air passage; heat transfer takes place by the oil heating the inlet air, as the air cools the oil temperature. Oil flow then returns to the oil tank.

(i) Oil is removed from the oil tank by opening a drain valve.

g. Engine fuel system.

(1) Engine driven fuel pump.



(a) Located on the right hand drive pad of the accessory drive gearbox assembly adjacent to the main oil pump.

(b) A single centrifugal impeller pump driven by the N_1 accessory gear box.

(c) Draws fuel from the main fuel tank below 6,000 feet PA, if the main fuel tank boost pumps fail

(d) Increases fuel pressure by 10 to 20 PSI, by raising the fuel pressure up to 35 PSI dependent upon engine speed.

(e) Fuel pump ports.

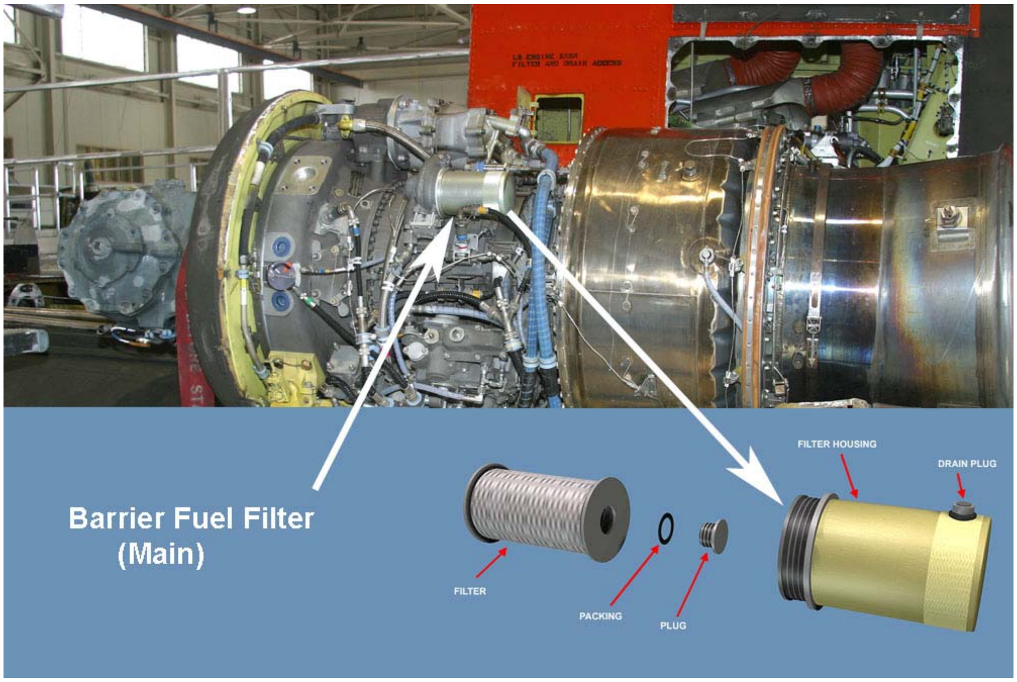
1. Fuel-in port (large) received fuel from the aircraft fuel supply.

2. Fuel-out delivers fuel through the main fuel filter to the HMA.

3. Seal drain, in case of internal seal failure fuel will be discharged overboard.

4. Fuel-in port (small) receives excess fuel from the fuel flow divider.

(2) Barrier fuel filter, (Main fuel filter).



(a) Located on the left side of the engine directly above the start fuel solenoid valve, just below the engine starter.

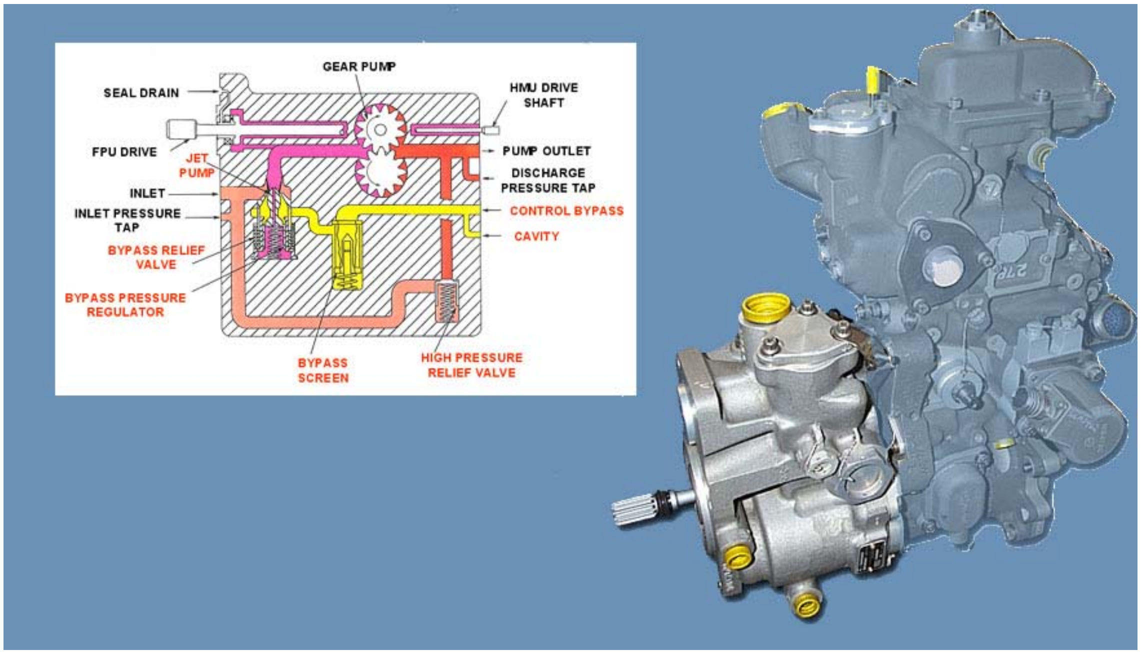
(b) Bowl assembly contains the 7 micron filter which is a replaceable paper type cartridge.

(c) Head assembly:

1. Contains an impending bypass indicator (red button) will extend at 3.6 PSID.

2. Contains bypass valve that opens at 5.5 PSID if the filter becomes clogged.

(3) Fuel Pump Unit (FPU).



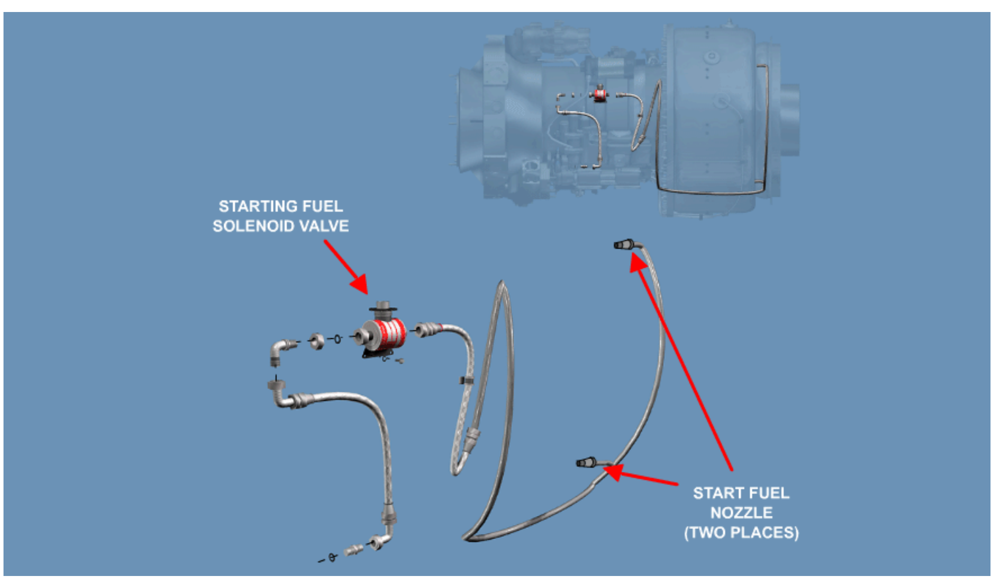
(a) Provides fuel under high pressure for engine operation and provide fuel under pressure to be used as the hydraulic medium for the operation and cooling of the components with-in the HMU.

(b) Mounted to the engine accessory gearbox, driven by the N_1 gears.

(c) Pump increases fuel pressure to 750 PSI

(d) Fuel flow is separated into a start fuel flow, and a main fuel flow.

(4) Start fuel solenoid valve.



(a) Mounted on the compressor housing at the Nine O'clock position.

(b) Electrically opened, normally closed valve.

(c) Controlled by the DECU.

(d) Sends fuel to two start fuel nozzles.

(5) Start fuel nozzles.

(a) Two nozzles mounted at the Six and Nine O'clock positions in the aft end of the combustor.

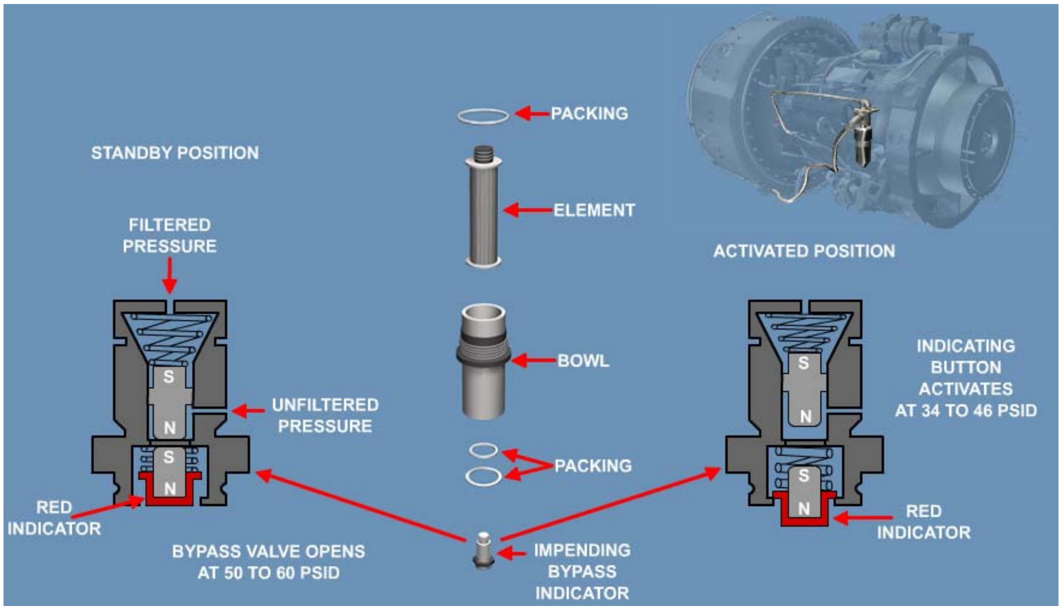
(b) Each one is mounted adjacent to an igniter plug.

(6) Liquid to liquid cooler.

(a) Oil flowing around the fuel tube heats the fuel.

(b) Fuel flowing in the tube in the oil path cools the oil.

(7) The inline fuel filter.



(a) Mounted at the Two O'clock position on each engine.

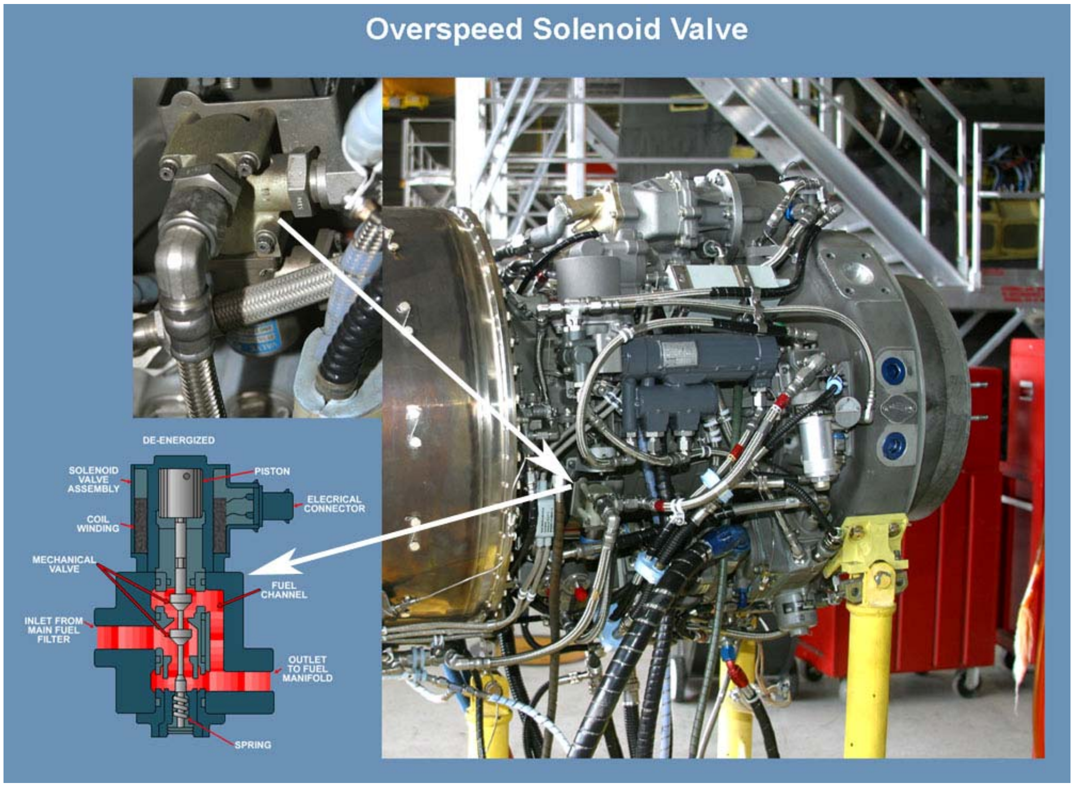
(b) Bowl assembly that contains the filter which is a 7 micron replaceable paper type element.

(c) Head assembly:

1. Contains an impending bypass indicator (red button) will extend at 34 to 46 PSID.

2. Contains bypass valve that opens at 50 to 60 PSID if the filter becomes clogged.

(8) Overspeed solenoid valve.



(a) Located on the right side of the compressor.

(b) In-line between the liquid to liquid cooler and the fuel flow divider.

(c) Controlled by the DECU:

1. If a power turbine overspeed is detected (114.8% N_2) the DECU will activate the overspeed solenoid valve reducing fuel flow to 310 Pounds Per Hour (PPH).

2. Solenoid valve can be held open to maintain the engine at ground idle.

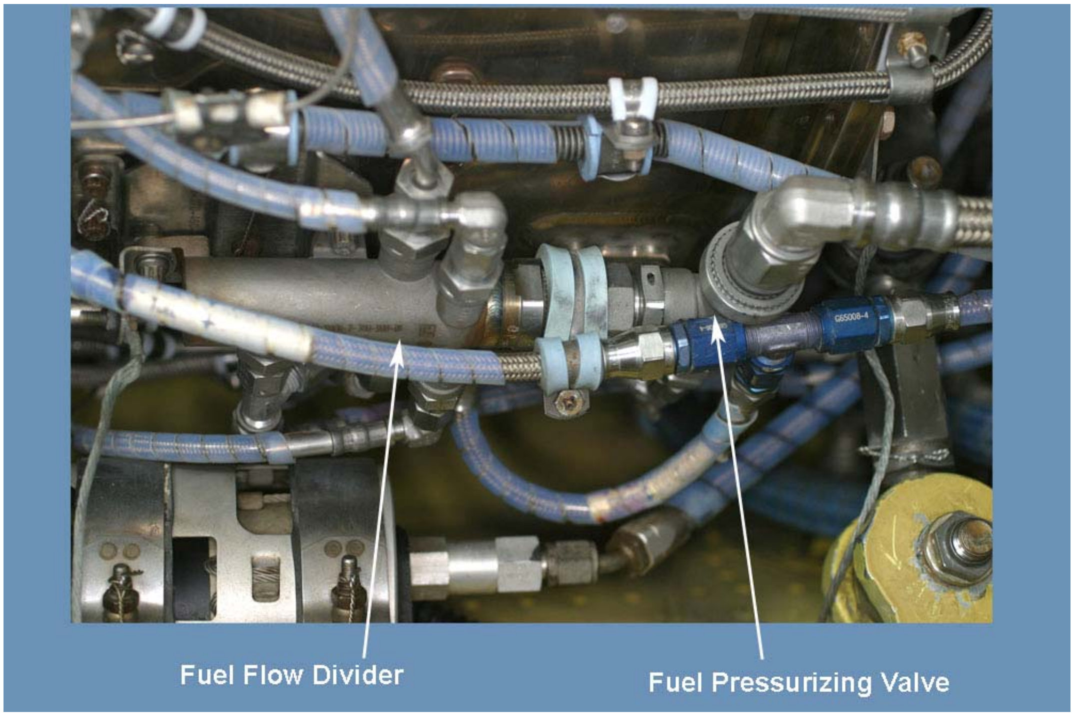
(9) Fuel Pressurizing Valve.

(a) Located in line after the overspeed solenoid valve and prior to the fuel flow divider.

(b) Prevents post shutdown burning caused by fuel expanding in the liquid to liquid cooler and flowing into the combustor.

(c) Valve closes when fuel supply pressure is less than 40 PSI and routes excess fuel volume to the boost pump inlet.

(10) Fuel flow divider.



(a) Located at the Five O'clock position on the bottom of the combustor.

(b) Primary fuel is delivered to the two fuel manifolds at 8% to 12 % N_1 speed.

(c) Secondary fuel is delivered to the two fuel manifolds at 30% to 32 % N_1 speed.

(d) Unused fuel or seepage from the manifold is routed back to the engine driven fuel pump inlet.

(e) Fuel flow divider closes upon engine shutdown preventing fuel from entering the combustion chamber.

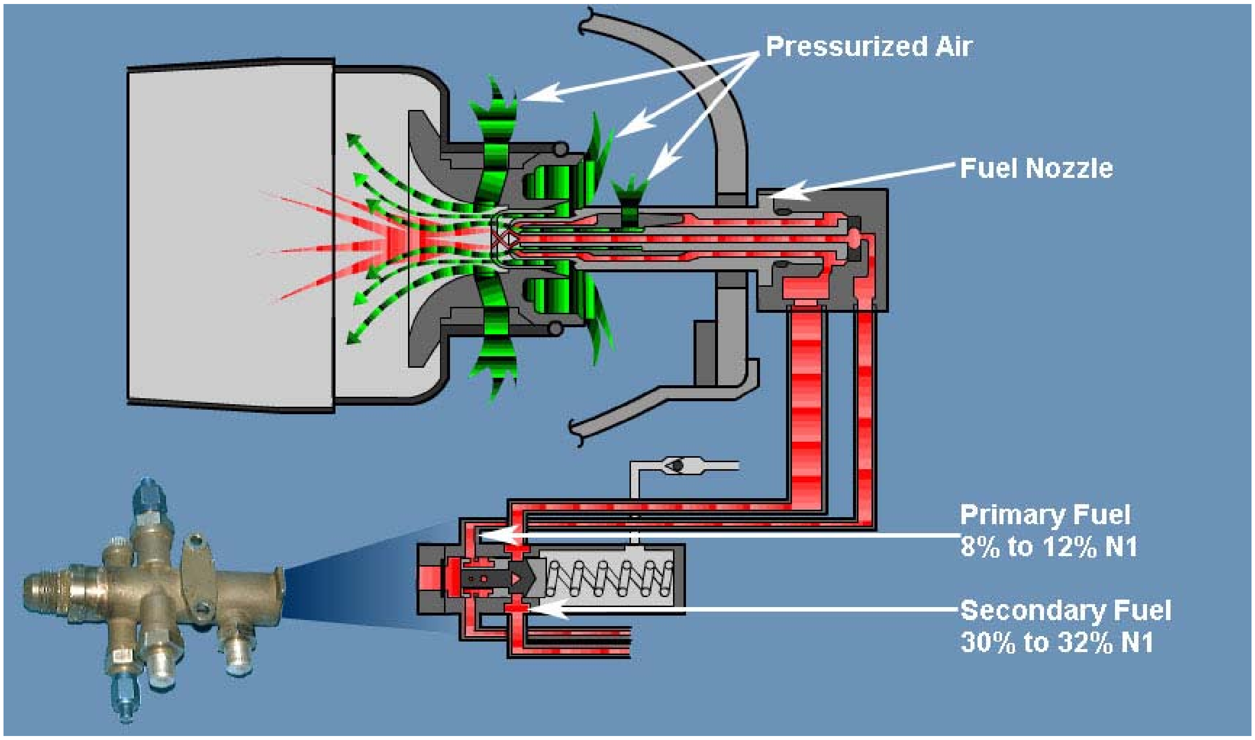
(11) Fuel manifold.

(a) Consists of two halves of 14 fuel nozzles each for a total of 28 nozzles.

(b) Dual fuel passageways are provided within the fuel manifold, a primary and secondary.

(c) Nozzles insert through holes in the combustor section and into the combustion area.

(12) Fuel Nozzles.



(a) 28 individual injector nozzles.

(b) Provide both primary and secondary fuel flows to the combustor.

(c) Fuel is mixed with air using primary and secondary air blast holes and the swirl cups that are installed inside of the combustor liner.

(d) The fuel mixed with the blast air atomizes the fuel spray for better combustion.

(13) Combustor drain valves.

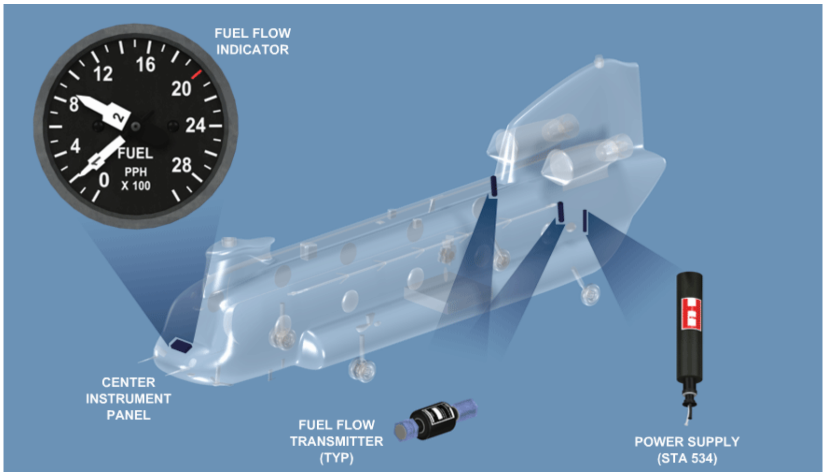
(a) Two, mounted on the bottom of the combustor chamber housing.

(b) Internal spring holds the valve open.

(c) With the engine running, the internal engine pressure from combustion pushes the valve closed.

(d) When the engine stops, the valve opens back up and allows the fuel in the combustor section to drain overboard, preventing a post shutdown fire.

(14) Fuel flow indicating system.

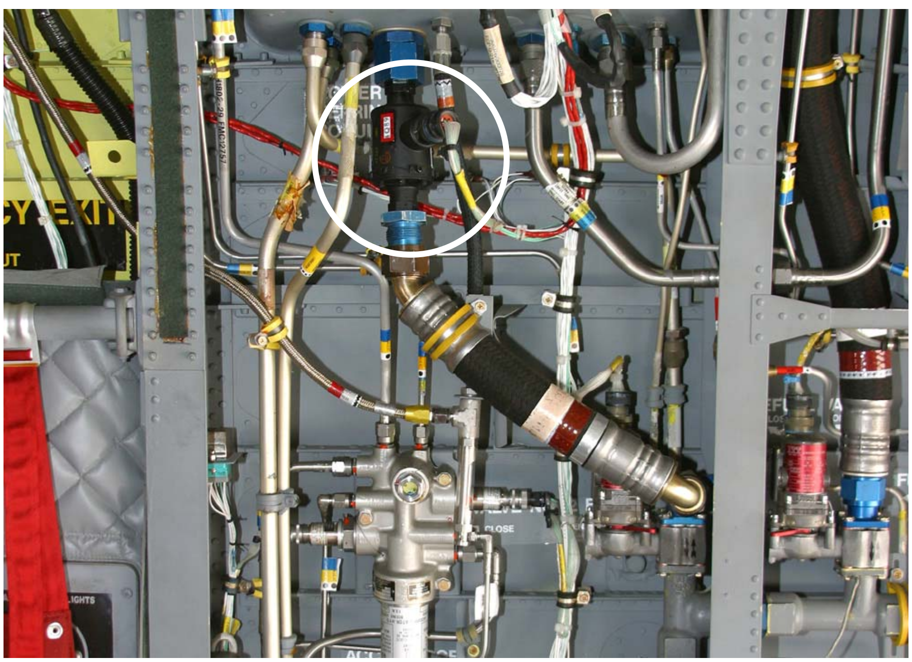


(a) Fuel flow power supply.

1. Located on the left side of the ramp area, Sta. 534.

2. Sends 115V (single phase) AC to both fuel flow transmitters.

(b) Fuel flow transmitter.



1. Located in both main fuel lines for each engine below the quick disconnect shelf, and above the engine fuel shutoff valve at station 490.

2. Contains a constant speed motor which contains 24 cylindrical tubes, which redirect the flow of fuel onto the turbine.

3. The turbine is connected to a synchro transmitter restrained by a spring which transmits the fuel flow rate to the gauge in the cockpit.

(c) Fuel flow indicator.

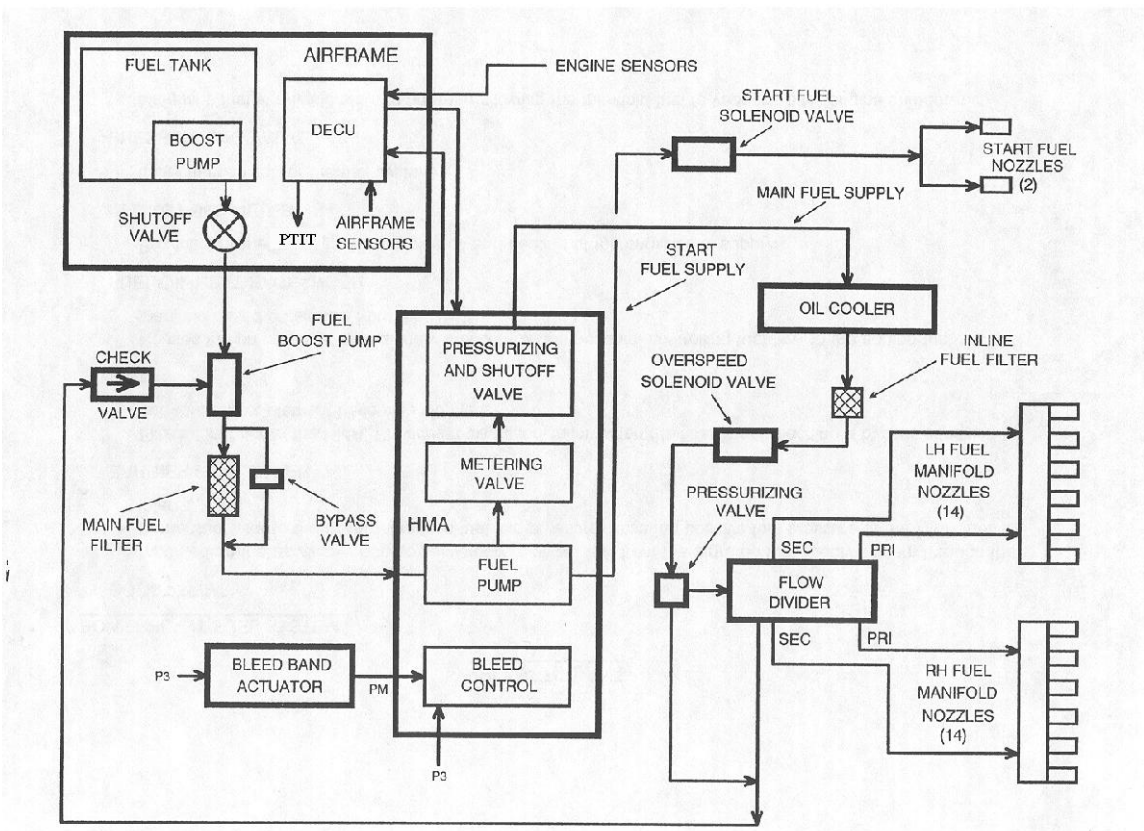
1. Located on the center instrument panel

2. Scale is from 0 to 3000 PPH in 100 pound increments.

2. Contains a numbered pointer for each engine.

4. Receives signal from the fuel flow transmitters.

(15) Fuel system flow.



(a) Fuel from the aircraft main tanks enters the engine through the fuel boost pump.

(b) Fuel is then piped to the main fuel filter and then the HMA where it is discharged through two lines;

1. One routes fuel from the HMA into the starting system.

a. Starting fuel flows from the HMA to a starting fuel solenoid valve that controls flow to the starting fuel system.

b. Energizing the starting fuel switch opens the starting fuel solenoid valve, allowing fuel from the HMA to flow to the starting fuel primer tube.

c. From the starting fuel primer tube, fuel enters the combustion chamber through two nozzles, one located at the Six O'clock position, and the other at the Nine O'clock position in the aft end of the combustor. Two of the four equally spaced igniter's plugs are mounted adjacent to each of the tow starting fuel nozzles to initiate combustion. Starting fuel nozzles are self-purged when not in use.

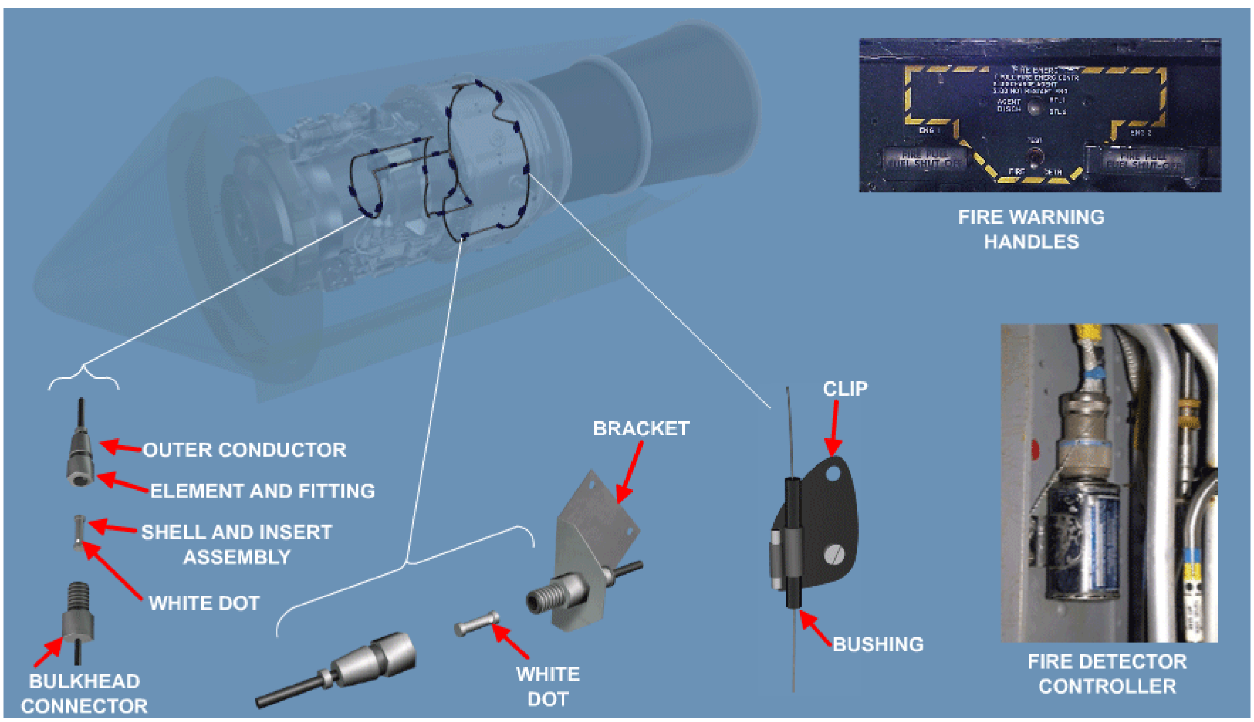
2. The other routes metered fuel from the HMA into the main fuel system.

a. After metered main fuel leaves the HMA, it passes through the liquid to liquid cooler mounted on the right side of the engine.

b. Fuel flow from the oil cooler to an inline fuel filter, an overspeed solenoid valve, a pressurizing valve, and then to a flow divider.

c. The flow divider provides primary and secondary fuel flows to a dual passage fuel manifold, incorporating 28 dual orifice atomizing fuel nozzles for introducing fuel into the combustor.

h. Engine fire detection system.



(1) Detection Elements.

(a) Consists of three individual elements connected together.

(b) Routed around the compressor and combustor sections of the engine.

(c) The engine fire detection system is designed to detect fires in the engine compartment only, and not internal engine fires.

(d) The elements consist of a thin metallic tube with a wire mounted in and isolated from the tube with a salt embedded in a ceramic matrix.

(e) Activated at 300°C to 350°C the salt begins to melt and grounds the inner wire to the metal tube.

(f) The central wire is connected to a control unit.

(2) Fire detection control unit.

(a) Two control units are located at Sta. 482, left and right side of the ramp area, just above the engine fuel shutoff valves.

(b) Each control unit utilizes 115V AC for monitoring and detecting fires.

(c) Each control unit utilizes 28V DC off the essential buses for testing of the system.

(3) FIRE DETR switch.

(a) A two-position switch labeled FIRE DETR and TEST.

(b) Checks the continuity of the entire circuit through the control units.

(c) Four lights, two per fire pull handle should illuminate when the switch is placed to the TEST position.

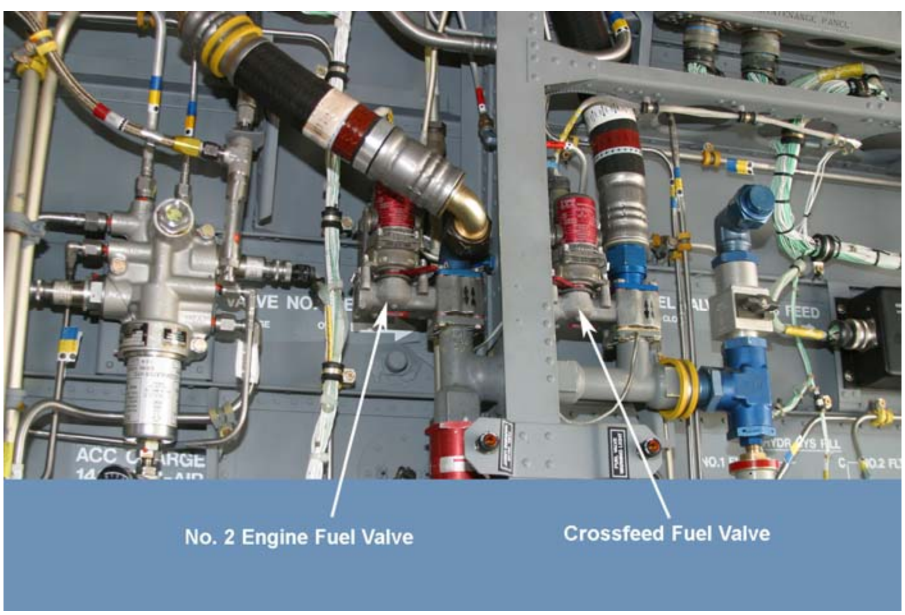
(d) False indications can be caused by, moisture in the element or chaffing of the element, or tight bends in the element.

(4) Fire pull handles.

(a) Two handles located on the top center of the center instrument panel.

(b) Contains two warning lights per handle that indicate the presence of fire in the engine compartment.

(c) Each fire pull handle, when pulled, closes that engine's fuel shutoff valve.



(d) Each fire pull handles, when pulled, arms the AGENT DISCH switch.

(e) The handle, when pulled, selects the engine to receive the agent, by arming one charging squib on each engine fire bottle.

(f) If both handles are pulled:

1. Both fuel valves will close.

2. Both squibs on both engine fire bottles will be armed.

(g) Power is from the DC switched battery bus.

NOTE: Do not push the handle back in after a fire is extinguished. If the handles are pushed back in, fuel will be allowed to flow back to the hot engine possibly resulting in another fire.

OPERATOR'S MANUAL- CAUTION: If there is a fire in both engine compartments, do not pull both FIRE PULL handles simultaneously.

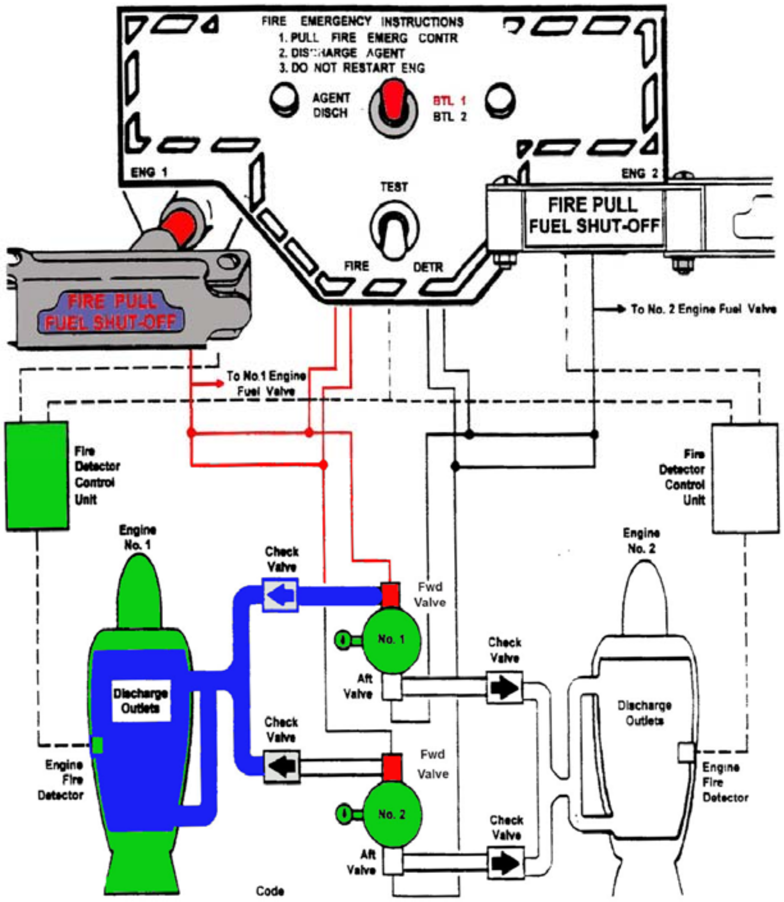
(5) AGENT DISCH switch.

(a) Located on the center instrument panel.

(b) A three position switch labeled: BTL 1, neutral, and BTL 2.

(c) Used to select which bottle is to be used to extinguish the fire.

i. Engine fire extinguishing system.



(1) Extinguishing agent containers.

(a) The containers are located on the overhead structure at Sta. 482 and 506.

(b) Allows the pilot to extinguish a fire in either engine compartment it is not designed to extinguish internal engine fires.

(c) The agent – MONOBROMOTRIFLUOROMETHANE, (CBrF3 or CF3BR) is stored under pressure by nitrogen.

(d) The gauge should be checked on preflight in accordance with page P-10 of the Check List minimum indication.

(e) There are two electrically activated discharge valves per container (squibs).

(f) Agent can be directed to one or both engines via tubing to each engine compartment.

(g) Selection of the container discharged is made by using the agent discharge switch.

(h) Containers must be weighed within 12 months. Check the log book.

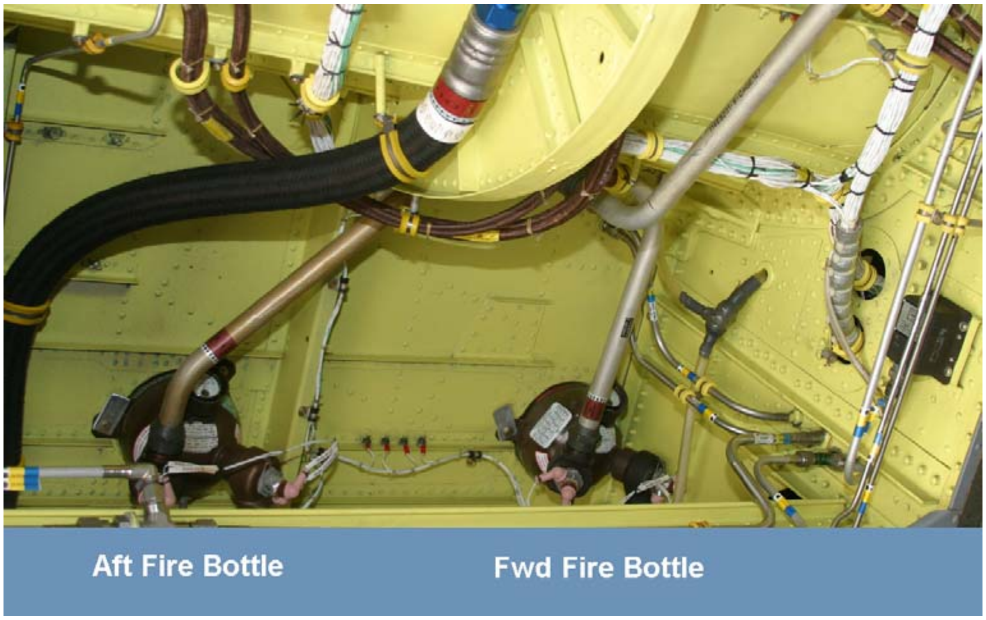
(2) Engine fire extinguishing agent nozzles.

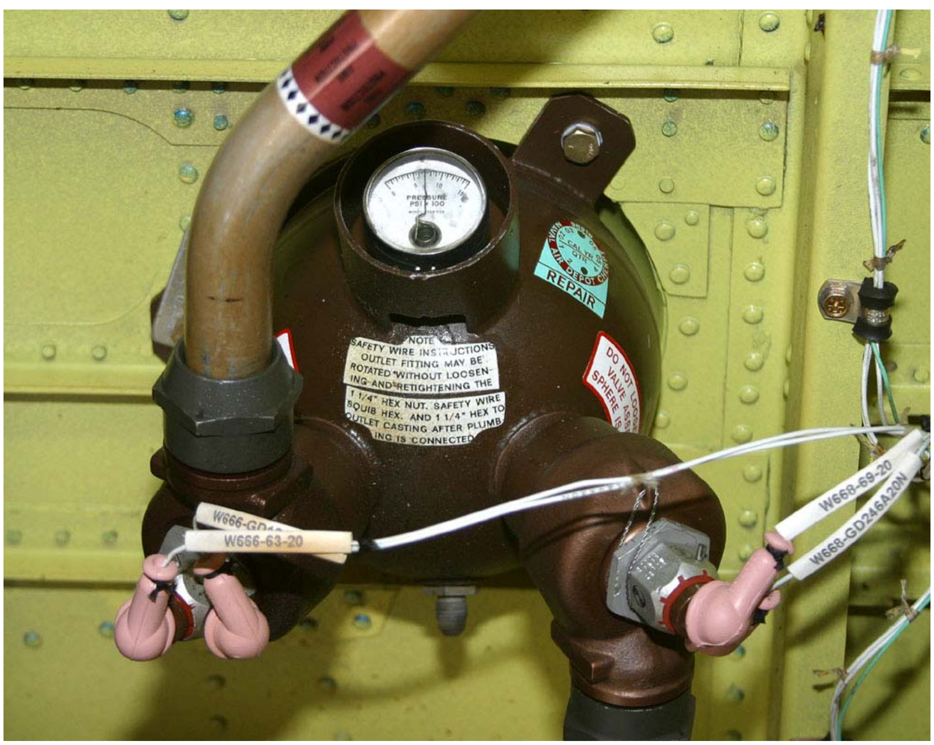
(a) Two nozzles located on the deck below the engine.

1. Forward nozzle located under the compressor section.

2. Aft nozzle located under the combustor section.

(b) Both nozzles are connected to a single feed line.





4. **Learning Step/Activity 4 – Provide a system description of the Full Authority Digital Electronic Control (FADEC).**

   a. The Full Authority Digital Electronic Control (FADEC) system replaces the Hydro-Mechanical engine control system.

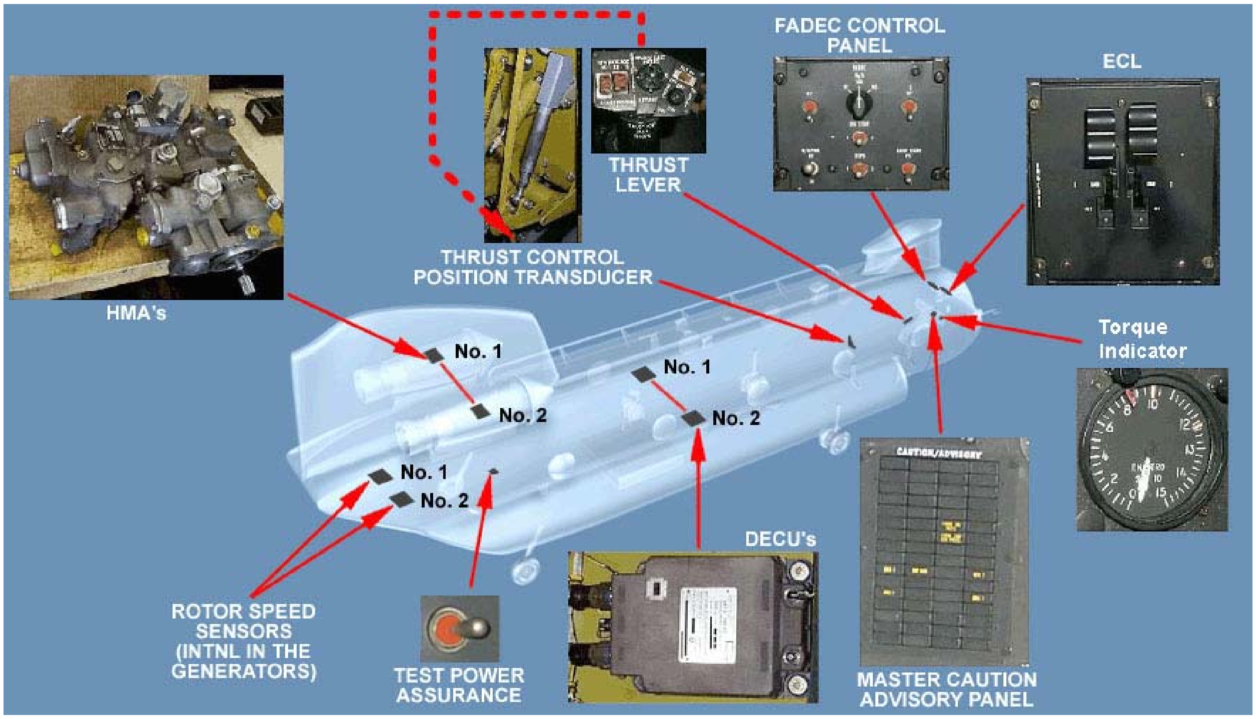
   b. The FADEC system is designated model EMC-32T-2.

   c. The DECU includes a microcomputer-based primary control channel with an independent microcomputer-based electronic reversionary back-up channel.

   d. The DECU tracks the primary channel operation allowing a smooth switch-over when the reversionary channel is selected, or the primary channel fails.

   e. The FADEC system utilizes many of the existing engine and aircraft sensors and controls (i.e., PTIT, P_3, start fuel solenoid, bleed band actuator, and engine condition levers (ECLs).

   f. The components of the FADEC system are:



      (1) Digital Electronic Control Unit (DECU) manufactured by Goodrich Pump and Engine Control Systems.

      (2) Hydro-Mechanical Metering Assembly (HMA).

         (a) Manufactured by Goodrich.

         (b) The HMA is divided functionally into two sections:

            1. Hydro mechanical Metering Unit (HMU).

2. Fuel Pump Unit (FPU).

(3) Master caution/advisory panel.

(4) Engine Condition Levers (ECL).

(5) INC/DEC switches.

(6) Thrust Control Position Transducer (CPT).

(7) FADEC control panel.

g. The FADEC system installed will provide technical features that were not available with the hydro-mechanical control system used on the earlier engine installations. FADEC advantages include: (TM 1-1520-240-10 Pg 2-3-29)

(1) Automatic start scheduling.

(2) No. 1 and No. 2 engine load sharing.

(3) Power turbine speed governing.

(4) Transient load anticipation (using rotor speed and collective pitch rates).

(5) Transient torque smoothing (using N_2 rates).

(6) Contingency power capability to meet aircraft demands.

(7) Acceleration and deceleration control.

(8) Engine temperature limiting throughout the operating range.

(9) Surge avoidance.

(10) Compressor bleed band scheduling.

(11) Fuel flow limiting.

(12) Engine fail detection

(13) Power assurance test.

(14) Engine history, start/component cycle and limit exceedence recording.

(15) Engine-to-engine communication (DECU to DECU).

(16) Automatic switch-over to an independent back-up control system

(17) Control system self-test, self-diagnosis and fault identification.

(18) Accurate torque matching.

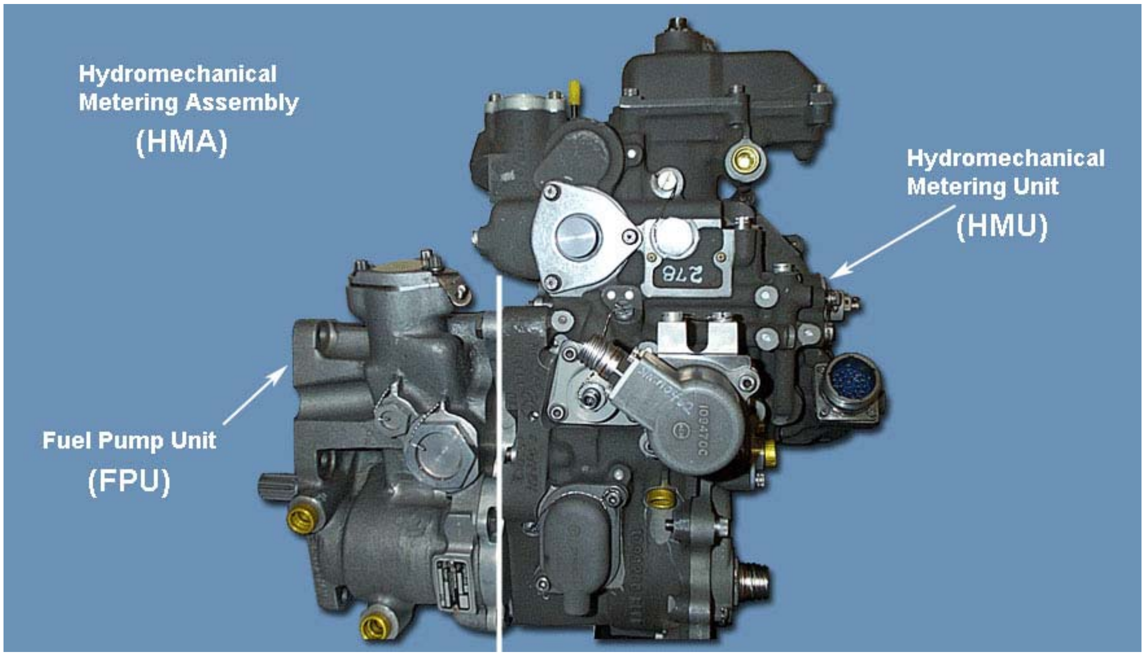
(19) No field level, system adjustments.

(20) On-condition maintenance.

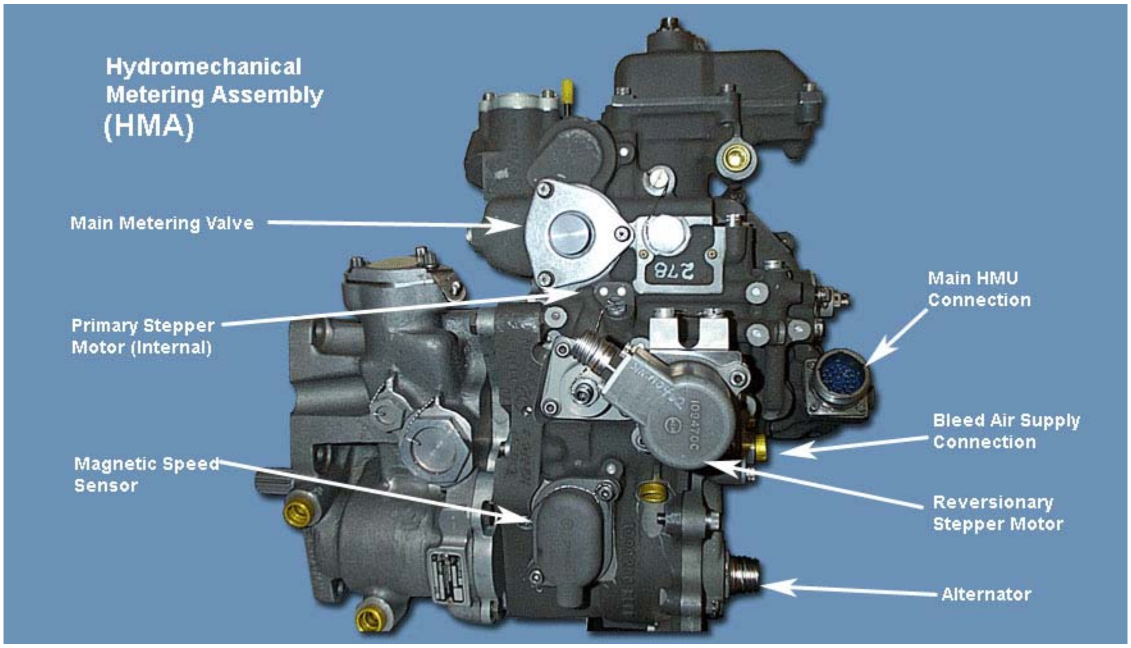
5. Learning Step/Activity 5 - Describe components and operational characteristics of the Full Authority Digital Electronic Control (FADEC).

a. Hydro Mechanical Metering Assembly.

(1) Hydro mechanical Metering Unit (HMU).



(a) Within the HMU is the fuel metering components which support primary and reversionary fuel metering.



1. Primary mode is the primary operating mode of the FADEC system

a. Primary stepper motor:

(1) Rotates the main metering valve shaft.

(2) Positions the metering valve wiper over the metering valve orifice.

(3) Full travel is approximately 55°.

(4) Capable of 500 steps a second.

(5) Full travel of the metering valve takes approximately one second.

b. Metering valve feedback.

(1) Provides the DECU with the metering valve position.

(2) Creates a closed loop system.

2. Reversionary mode is the back up system if the primary system fails.

a. Reversionary stepper motor:

(1) Shadows the operation of the primary stepper motor.

(2) Positions the Wf/P3 servo contour valve in response to commands from the DECU.

b. Power Lever Angle (PLA) feedback potentiometer.

(1) The reversionary stepper motor shaft directly drives the PLA feedback potentiometer.

(2) Provides the DECU with the reversionary stepper motor position.

(b) Contains a built-in alternator:

(a) Provide electrical power to the systems primary channel electronics

(b) Provides a redundant N_1 speed signal to the DECU primary and reversionary channel.

(c) Provides 30 Volts of DC power to the FADEC system.

(c) Primary and reversionary compressor bleed system controls.

(d) Magnetic speed sensor provides the N_1 speed signal for the primary channel in the DECU.

(2) Fuel Pump Unit (FPU).

(a) The FPU contains the jet pump, gear pump, pressure regulator, bypass screen, and relief valve.

(b) A splined shaft from the accessory gearbox drives the FPU.

(c) A second splined shaft between the FPU and HMU provides drive power to the HMU components.

(d) The FPU delivers pressurized fuel to the HMU flat plate-metering valve and metering head regulator. Fuel flow and pressure are determined by pump speed.

(e) The gear pump is a positive displacement; pressure loaded pump capable of delivering a maximum flow of 26 GPM at 4200 RPM.

(f) A high-pressure relief valve is adjusted to limit the gear pump discharge pressure to 750 PSI.

(g) A mesh screen filters HMU bypassed fuel prior to the jet pump.

(h) A jet pump utilizes bypassed fuel from the HMU metering head regulator to increase the gear pump inlet pressure.

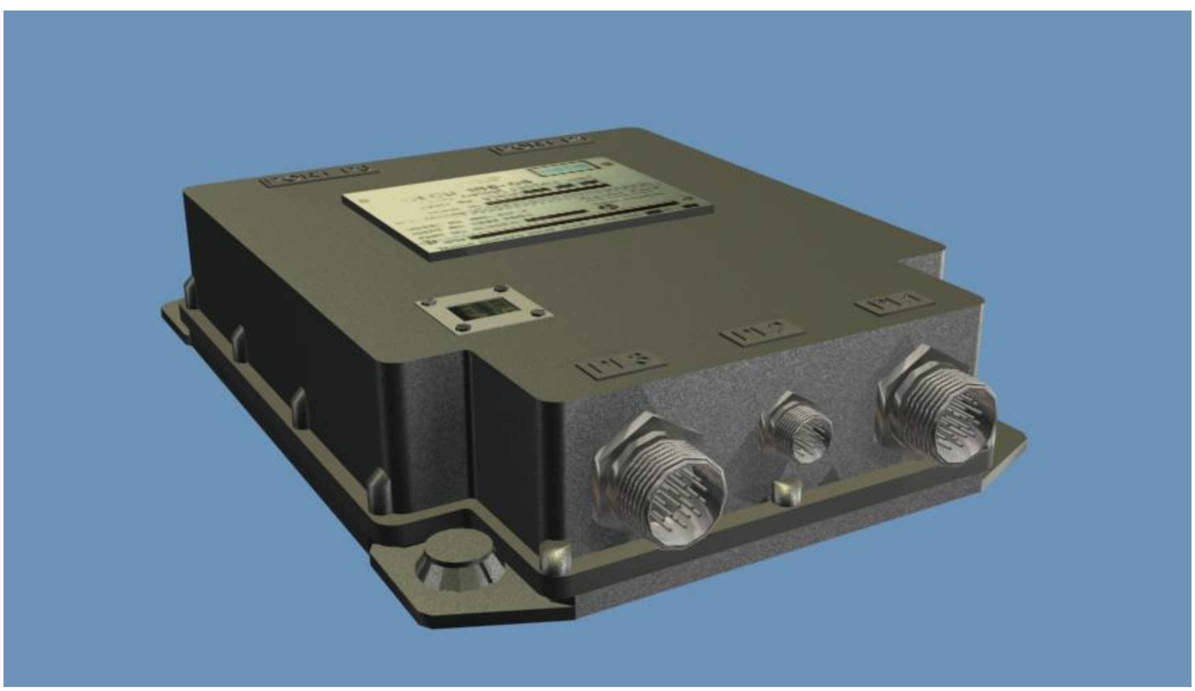
1. A pressure regulator built into the jet pump controls the jet pump output pressure by varying the nozzle area of the jet.

2. Fuel flow in excess of the engine requirement is bypassed back to the FPU to be utilized by the jet pump.

3. Contains a bypass relief valve that will bypass the screen at 15 PSID, should the screen become clogged.

(i) An output shaft between the gear pump and the HMU provides drive power to the HMU internal components.

b. Digital Electronic Control Unit (DECU).



(1) Mounted to the ceiling of the cabin, just aft of the center cargo hook access door, Sta. 400.

(2) Cast aluminum housing, protecting the internal operation from Electromagnetic Interference (EMI), Radio Frequency Interference (RMI), and Electromagnetic Pulse (EMP).

(3) Dual channel digital controller with independent primary and reversionary channels providing control of the fuel used for engine operation.

(4) Mean time between failure is approximately 10,000 hours.

(5) DECU stores information related to engine limit exceedance.

(6) DECU Components include:

(a) Hexadecimal display.

1. Displays fault codes for system failures.

2. Used to verify system operation during the DECU bit check.

NOTE: The DECU fault code matrix (TM 1-1520-240-10, Page 2-35 through page 2-40) will be consulted when anything other then 88 is displayed on the DECU Hexadecimal display during the DECU pre-start, start, or shutdown BIT checks.

3. Significant character (First Digit) is used to identify the source of the faulty component.

a. F Fluid controller (HMU).

b. A Airframe sensor.

c. D, 1, or B DECU fault.

d. E Engine sensor.

e. C Communications between the DECU's.

4. Least significant character (Second digit) is used to identify the specific fault.

5. Soft Faults.

a. A Failure that does not impact the normal control of the engine.

b. Soft faults are not indicated in the cockpit.

c. Pilot action is not required.

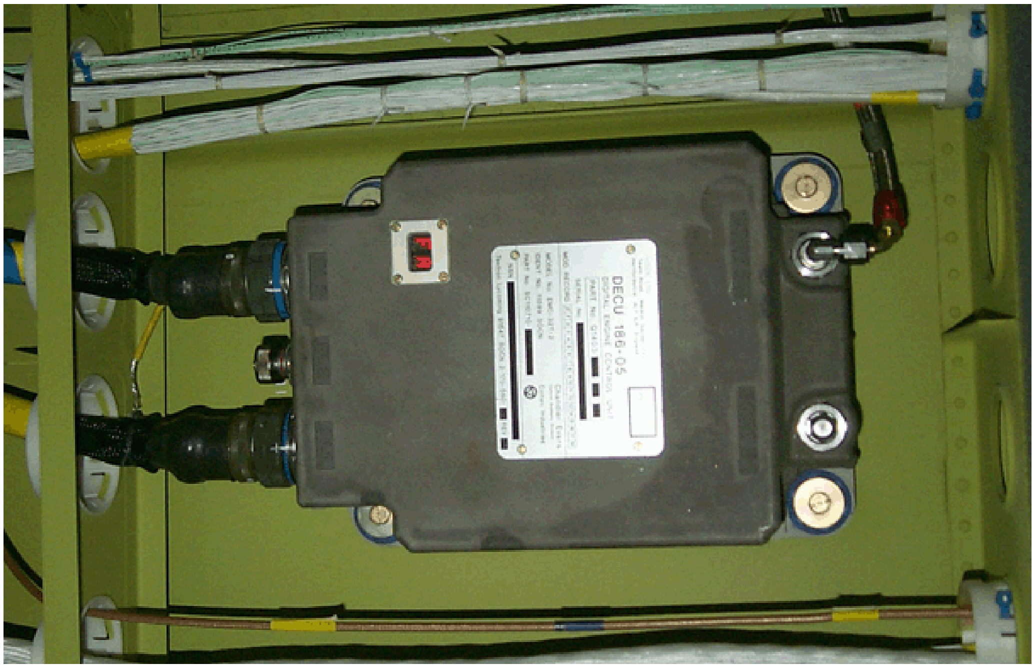
6. Hard Faults.

a. Faults that could cause unacceptable engine and/or aircraft performance.

b. Hard faults are detected through software fault limit monitoring or if the primary channel fails.

c. FADEC 1/2 or REV 1/2 lights will be displayed based on what system(s) failed.

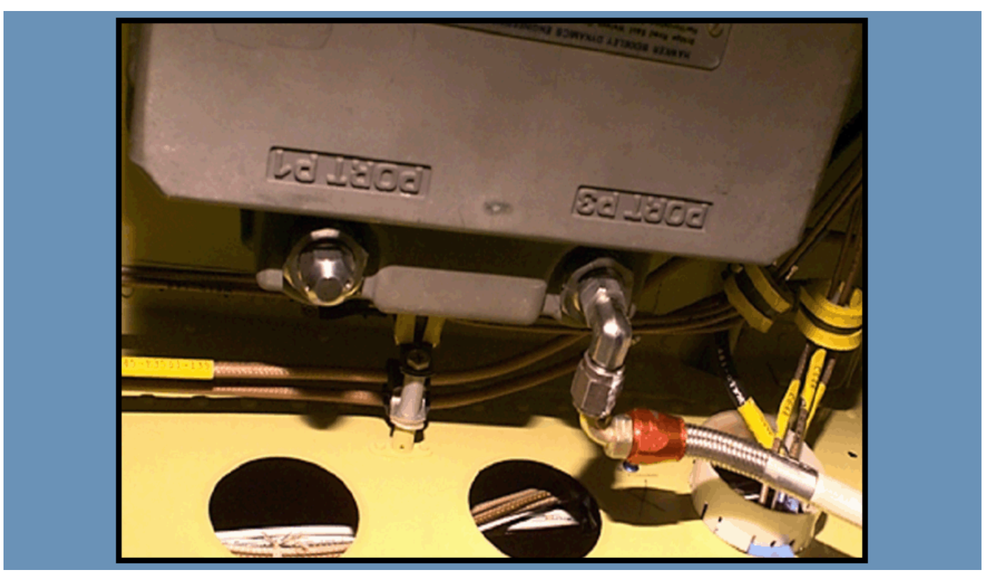
(b) Electrical connections.



1. PL1 and PL3 connector used for input and output of power and information through the DECU.

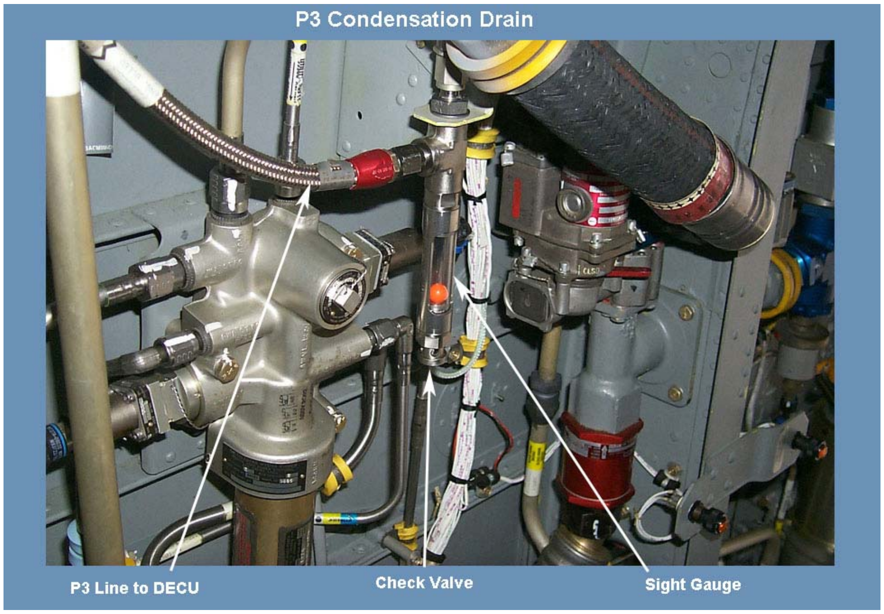
2. PL2 connector is used for connection of the SPORT computer or any laptop with appropriate software installed.

(c) P_1 Atmospheric pressure port measures ambient air pressure in the cabin.



(d) P_3 Compressor Discharge Pressure (CDP) measures air pressure from the diffuser section of the respective engine.

(e) P_3 Condensation drain.



1. Located on the left and right sides of the ramp adjacent to the engine fuel shutoff valves.

2. Drains the P_3 system of accumulated moisture.

3. Lexan tube with a spring loaded valve provides visual indication of accumulated moisture.

CAUTION: Do not press the spring loaded valve with the engines operating.

c. Master caution/advisory panel.

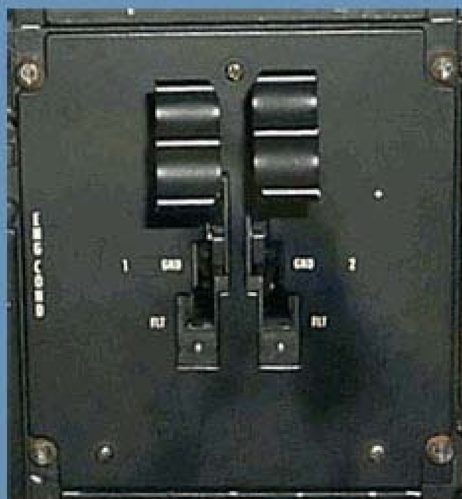
(1) Located on the center instrument panel.

(2) A 4 light by 16 light panel, consisting of 64 lights of which 20 are blank spares.

(3) Divided into a master caution panel with orange or yellow lights and an advisory panel with green lights.

(4) Advisory lights will not light the master caution segment lights on the pilot and co-pilots instrument panel.

d. Engine Condition Levers (ECL).



Engine Condition Levers

(1) Located on the overhead panel.

(2) Three positions which are sent to the DECU.

(a) STOP which will shutdown the engine using both the primary and reversionary modes.

(b) GND (Ground) brings the engine up to an N_1 speed that is above 50% (ground idle).

(c) FLT (Flight) brings the engine up to 100% RRPM.

(3) Positions between ground and flight can be selected, but will affect the FADEC system operation.

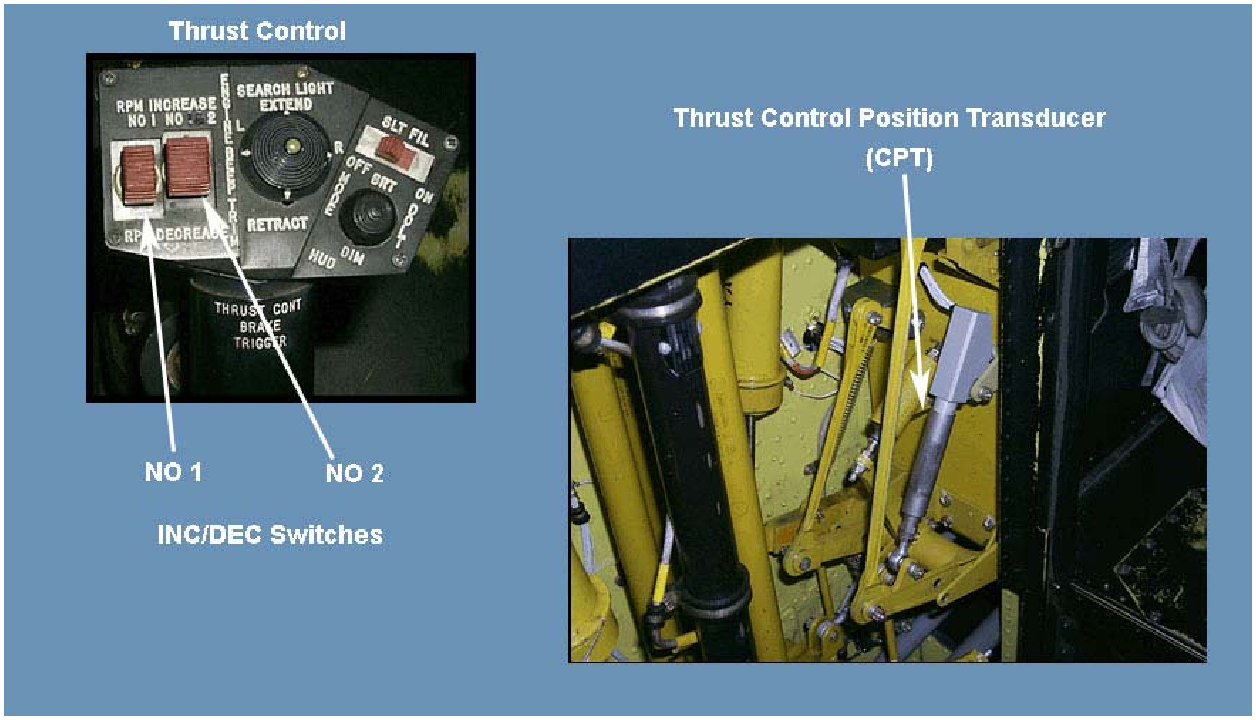
(4) ECL control box contains a micro-switch that when an ECL is moved from the stop position disables the AFCS computer BITE switch.

(5) ECL Friction Brake.

(a) Provides resistance when moving the ECL's.

(b) Requires 4 to 5 pounds of pressure to move the ECL's.

e. INC/DEC switches.



(1) Located on the pilot and co-pilots thrust grips.

(2) Inoperative in the primary mode.

(3) In the reversionary mode they are used to fine tune the engine N_2 speed.

(4) Used to set the rotor RPM, match torque indications or both.

f. Thrust Control Position Transducer (CPT).

(1) Located at the bottom of the flight control closet (forward right corner) level with the companion way floor, directly under the thrust ILCA.

(2) Transducer send a signal to the DECU relative to the thrust position, (load scheduling) in Primary and Reversionary modes.

(3) Transducer sends a signal to the DECU relative to the rate of movement of the thrust, (load anticipation) in Primary mode, thereby anticipating a required rate of acceleration or deceleration to precisely maintain the engines N_2 speed.

g. FADEC control panel.

(1) Located on the overhead switch panel, just forward of the ECL's.

(2) NR% Selector.

(a) A rotary switch which provides variable rotor rpm control, when operating in the primary mode.

(b) The labeled positions are 97%, 100%, and 103%. With the engine condition levers (ECL's) in the FLT position, NR% will be maintained at the selected speed.

(c) The selector is detented at the 100% position only.

(d) Rotor speed selection can be set from 97% to 103%.

(3) 1 and 2 PRI/REV select switches.

(a) Two switches labeled PRI, and REV provides control of the primary and reversionary modes of operation.

(b) In the REV position, electrical power is removed from the primary channel.

(4) ENG Start switch.

(a) A three position switch, spring loaded to the center position, labeled 1 and 2.

(b) This switch is used to initiate the start sequence, or motor the selected engine.

(5) Load share switch.

(a) A two position switch used to select either Torque or PTIT as the parameter.

(b) Used by the DECU as the basis for engine load matching.

(6) B/U PWR (Back-up power) Switch controls the airframe power (Essential DC bus 1 or 2) to the FADEC system primary channel.

(7) OSPD (Overspeed) switch is a two position switch (1 or 2).

(a) The switch is used to perform the engine N_2 overspeed system test.

(b) Operates in the range of 78% to 80%, or 79% +/-1 (MTP Only.)

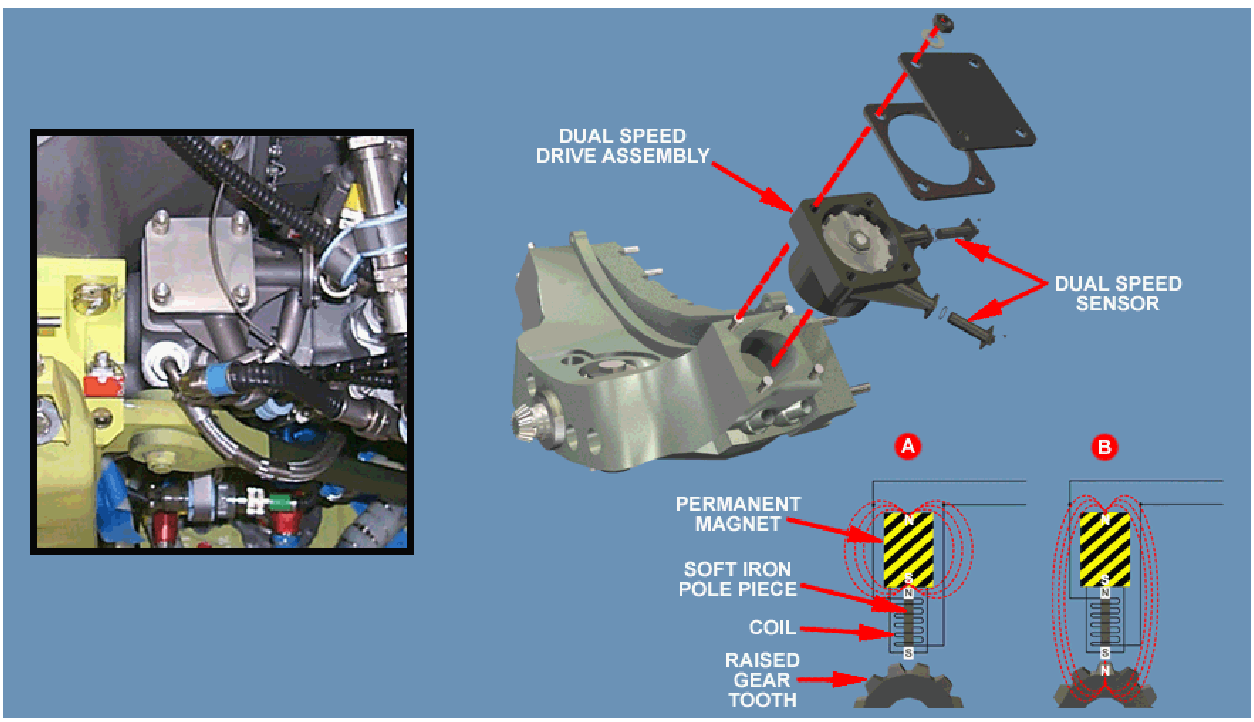
h. Power Assurance Test (PAT) Switch.

(1) Located on the right side of the ramp just below the maintenance panel, Station 523.

(2) Two position switch (1 or 2) which when activated test the engine using, PTIT, Torque, T1, P1 to compute the temperature margin. The engine fails if the calculated PTIT in the logbook is less then the sensed PTIT.

(3) The results of the test are displayed in the DECU BIT window.

i. Power turbine speed sensors.



(1) Mounted on the left side of the engine, at the Nine O'clock position on the accessory gearbox.

(2) Consists of two identical magnetic speed sensors which function like the speed sensor for the N_1 indicator on the back of the oil pump.

(3) Used in conjunction with the overspeed solenoid valve.

(4) Each channel operates using separate pickups N_2A and N_2B.

(5) An overspeed condition must be indicated by both channels, and the other engine must not be experiencing an overspeed in order for the overspeed solenoid valve to be activated.

(a) If a power turbine overspeed is detected (114.8% N_2) the DECU will activate the overspeed solenoid valve reducing fuel flow to 310 Pounds Per Hour (PPH).

(b) The maximum trip point is reduced by 1% per every 10%/sec of N_2 acceleration.

(c) The solenoid valve will remain open until the overspeed condition no longer exists, and will reactivate should another power turbine overspeed occur.

(d) Solenoid valve can be held open to maintain the engine at ground idle.

j. General Operation

(1) Twin engine load sharing.

(a) In non FADEC controlled aircraft the pilots monitor the load share requirements and adjust the engines through a process called beeping, where the engine outputs (torque, PTIT, or N_1) are matched to equalize the engine workloads.

(b) With the FADEC system torque, PTIT can be selected to automatically control the engine load sharing requirements.

(c) If the selected system fails the system is designed to default to N_1 load sharing. If the selected load share signal is loss between the DECU's or one of the two FADEC systems is in the reversionary mode, load sharing is disabled.

(d) Load sharing is accomplished by bringing up the low performing engine, by adjusting the demanded power turbine speed and reducing the output of both engines simultaneously until the desired power output is shared by both engines.

(e) The load sharing circuits are by design slow acting so as not to create an unstable engine condition.

(2) Engine starting.

(a) Set the ECL to the GND position.

(b) Hold start switch until N_1 > 10%.

1. Primary channel will automatically control the start sequencing of the:

a. Starter.

b. Fuel flow to start fuel nozzles.

c. Ignition.

d. Fuel flow to main nozzles.

2. Temperature limiting (After light off PTIT > 760°C).

a. Reduces fuel flow to 100 PPH minimum.

b. Over temperature during start (Abort start).

c. Fuel shutoff if PTIT > 816°C.

d. Associated ENG 1/2 FAIL indication.

e. ECL to STOP resets the start mode.

(c) In flight restart procedures are the same as for a ground start.

(3) Engine shutdown.

(a) ECL moved to GND to allow normal engine cool down.

(b) ECL moved to STOP.

(c) Primary system closes the metering valve to the 40 PPH position.

(d) Reversionary mode will affect complete shutoff of fuel when ECL is moved to STOP.

(e) The shutoff feature is the only function of the reversionary mode that impacts the primary mode.

(4) Rate of Change is directly proportional to the demanded engine fuel flow. Different values of Rate of Change are computed by each of the following functions.

(a) Acceleration (Thrust CPT).

(b) Deceleration (Thrust CPT).

(c) Temperature Limiting (Abort Start).

(d) Power turbine speed (N_2 Overspeed).

6. Learning Step / Activity 6 - Describe malfunctions and emergency procedures.

NOTE: The instructor will explain the current -10 procedures.

a. **EMER ENG Shutdown** (Para 9-3d).

NOTE: The term EMER ENG SHUTDOWN is defined as engine shutdown without delay. Engine shutdown in flight is usually not an immediate action unless a fire exists. Before executing an engine shutdown, identify the affected engine by checking indications of torque, RRPM, N_1, PTIT, engine oil pressure and ENG FAIL Caution.

CAUTION: When in-flight shutdown of a malfunctioning engine is anticipated positive identification of the malfunctioning engine must be accomplished to avoid shutting down the wrong engine.

(1) **ENG COND** lever — **STOP.**

(2) **FIRE PULL** handle—**PULL** (Engine fire only).

(3) **AGENT DISCH** switch — **As required**. (Engine fire only)

(4) Perform single-engine failure procedure.

NOTE: This Procedure is not verbatim TM 1-1520-240-10

b. **Abort Start.** (Para 9-3e).

NOTES: The term ABORT START is defined as engine shutdown to prevent PTIT from exceeding limits or whenever abnormal operation is indicated. If high PTIT was indicated, the engine must be monitored to decrease PTIT below 260°C.

Monitor temperatures during shutdown. If the temperature rises above 350°C, motor engine immediately until the temperature decreases below 260°C.

(1) **ENG COND** lever — **STOP**.

(2) **ENG START** switch — **MTR** (If high PTIT is indicated).

NOTE: To motor the 714 engine you must have the ECL in the STOP position, then hold the engine start switch to the appropriate engine until completed.

c. **Engine Failures:** Indications and procedures.

(1) Dual engine failure (Para 9-10).

(a) **AUTOROTATE.**

(b) **External cargo — Jettison.**

(c) **ALT** switch — **Disengage**.

CAUTION: Jettison external cargo as soon as possible after engine failure. This will help to prevent damage to the helicopter during touchdown and will reduce weight and drag, thereby improving autorotational performance.

CAUTION: The helicopter must be maneuvered into the autorotation approach corridor prior to landing to assure a safe outcome of the maneuver.

(2) **Single Engine Failure** (Para 9-12).

(a) ENG 1 FAIL or ENG 2 FAIL.

(b) The ENG 1 or ENG 2 FAIL caution is illuminated whenever the engine failure logic within the DECU recognizes any of the following:

1. Power turbine shaft failure. N_2 is greater than RRPM by more than 3%.

2. N_1 underspeed.

3. Engine flameout.

4. Over temperature start abort (Primary mode only).

5. Primary system fail freeze (Primary and Reversionary mode hard faults, FADEC caution is illuminated).

6. During normal shutdown as the N_1 RPM goes below 48% the ENG 1 FAIL or ENG 2 FAIL caution is illuminated and then turned off 12 seconds after the N_1 RPM drops below 40%.

(3) **Single Engine Failure** — Low Altitude/Low Airspeed and Cruise (Para 9-13)

(a) Continued flight *is* possible:

1. **Thrust control — Adjust** as necessary to maintain RRPM.

2. **712** **Engine beep trim switch – RPM Increase** as required.

2. **External cargo — Jettison** (If required).

3. **ALT switch — Disengage.**

4. Land as soon as practicable.

5. **EMER ENG SHUTDOWN** (When conditions permit).

NOTE: If S/E flight can be maintained, an attempt to restart the inoperative engine may be made if there is no evidence of fire or obvious mechanical damage.

(b) Continued flight *is not* possible:

1. **Land as soon as possible**.

2. **EMER ENG SHUTDOWN** (When conditions permit).

(4) **Engine restart during flight** (Para 9-14).

WARNING: Fire detector and extinguishing systems are not provided for the APU. Crewmember must monitor APU area for fire.

CAUTION: If abnormal indications are present during the restart, shut down the engine immediately.

(a) APU — Start.

(b) ENG COND lever (inoperative engine) — STOP, then GND.

(c) FIRE PULL handle — In.

(d) All FUEL PUMP switches — ON.

(e) XFEED switch — As required.

(f) Starting engine — Perform.

(g) APU — OFF

d. **ENG OIL LOW or ENG CHIP DET** caution. (Para 9-30)

(1) **Engine Oil** — Low Quantity/High Temperature or Low Pressure.

(a) A low engine oil quantity condition will be indicated by the lighting of the NO. 1 ENG OIL LOW or NO. 2 ENG OIL LOW caution light.

(b) When either one or both of these caution lights come on, about two quarts of usable oil remain in the respective oil tank.

(c) If one or both of the caution lights come on, check oil temperature and oil pressure indicators (affected engine) for abnormal indications.

(d) If the indication on the oil temperature indicator is high or the indication on the oil pressure indicator exceeds limits, high or low, perform the following:

1. If engine power is required for flight:

Land as soon as possible.

2. If engine power is not required for flight:

a. **EMER ENGINE SHUTDOWN — (Affected Engine)**

b. Refer to single-engine failure emergency procedures.

(2) **Engine Chip Detector** Caution Light ON. (Para 9-31).

If either NO. 1 or NO. 2 ENG CHIP DET caution light comes on, perform the following:

1. If engine power is required for flight:

Land as soon as possible.

2. If engine power is not required for flight:

a. **EMER ENGINE SHUTDOWN — (Affected Engine)**

b. Refer to single-engine failure emergency procedures.

e. **Engine Shutdown Condition lever failure** (Para 9-28)

<u>NOTE:</u> Should the engine condition level fail to shut down or control an engine, use the following procedure for engine shutdown.

(1) FIRE PULL handle (affected engine) Pull.

(2) Normal shutdown Perform.

f. **Torque Measuring System Malfunctions** (Para 9-40)

<u>NOTE</u>: Malfunctions in the torque measuring system can appear on the torquemeter as fluctuations, zero torque indication, sluggish movement, indications that are out of phase, or a stationary indication. If this occurs, proceed as follows:

N_1 and PTIT indicators — Check.

(a) N_1s and PTITs <u>not</u> matched.

<u>1</u>. LOAD SHARE switch — PTIT.

<u>2</u>. PTIT indicators — Check.

(b) N_1s and PTITs <u>are not</u> matched.

Land as soon as practicable.

(c) N_1s and PTITs <u>are</u> matched.

AC and DC Torque and Engine circuit breakers — IN.

g. **Fire** (Para 9-1-41)

(1) **Engine Hot Start.** (Para 9-43)

<u>NOTE:</u> A hot start will be detected by a rapid and abnormal rise in PTIT and/or by observing flames and black smoke coming from the engine tail cone. Complete the following on the affected engine.

<u>ABORT START</u>

(2) **Residual Fire During Shutdown.** (Para 9-44)

<u>NOTE:</u> A residual engine fire may occur during shutdown. It is caused by residual fuel igniting in the combustion chamber.

(a) **<u>ABORT START.</u>**

(b) **<u>FIRE PULL handle (affected engine) — Pull.</u>**

(3) **Engine or Fuselage Fire - Flight**. (Para 9-46)

<u>NOTE:</u> Visible flames, smoke coming from the engine or the lighting of the respective FIRE PULL handle:

(a) **<u>Land as soon as possible.</u>**

(b) **<u>Confirm Fire</u>**. (Flight Engineer).

(c) **<u>EMER ENG SHUTDOWN (affected engine)</u>**.

After landing:

<u>EMER ENG SHUTDOWN</u>.

h. **Primary System FADEC Failures**. (Para 9-18).

<u>NOTE:</u> In some cases a failure may occur without illuminating the FADEC, REV, and/or ENG FAIL light(s) and the only indication of a failure will be from engine indications. In these cases the pilot must exercise prudent judgment and perform actions as required. Those actions may include increasing the thrust for a runaway engine, manual ECL control, manually selecting FADEC control panel switches, or engine shutdown for a fail fixed position.

(1) **FADEC 1 or FADEC 2 Caution**. (Para 9-19).

(a) **<u>FADEC INC-DEC beep switches (affected engine) — Adjust</u>** as required.

(b) Reduce rate of Thrust CONT lever changes.

(2) **FADEC 1 and FADEC 2 Cautions.** (Para 9-20).

(a) **<u>FADEC ENG 1 and ENG 2 INC-DEC beep switches — Beep to 100 percent, match TQs.</u>**

(b) Reduce rate of THRUST CONT lever changes.

(c) Land as soon as practicable.

(3) **<u>Engine Fluctuations without FADEC 1/2 Light</u>**. (Para 9-21).

<u>NOTE:</u> The FADEC system may fail without illuminating the FADEC 1/2 light. This will be indicated by power fluctuations (TQ, N_1, Fuel Flow, Rotor RPM, and PTIT indications) with a set thrust position. Proceed as follows:

Load share switch — Select PTIT.

(a) If engine power flucations <u>are not</u> corrected.

<u>1</u>. Load share switch — TQ.

<u>2</u>. No. 1 engine FADEC switch — REV.

(b) If engine power flucations <u>are not</u> corrected.

<u>3</u>. No. 1 engine FADEC switch — PRI.

<u>4</u>. No. 2 engine FADEC switch — REV.

(c) If engine power flucations <u>are not</u> corrected.

<u>5</u>. No. 2 engine FADEC switch — PRI.

6. Land as soon as practicable.

i. **Reversionary System FADEC Failures**. (Para 9-22).

CAUTION: The aircrew should be alert to the possibility of abrupt NR changes when opening the FADEC in single or dual engine REV mode(s).

NOTES: When operating in the reversionary mode and the reversionary mode sustains a hard fault, REV 1 or REV 2 caution illuminates, a failed fixed fuel flow condition may exist, The ENG COND lever may be inoperative, therefore unable to modulate engine N1. The indications may be a change in sound, vibration absorbers may detune causing vibration and a possible increase in NR when the THRUST CONT lever is reduced.

The Reversionary may also fail without illuminating the REV light. In this case, the Reversionary beep switches may become inoperative but the ENG COND lever may be operative.

Two different reactions can occur depending if the engine with the failed FADEC went into fixed fuel flow at a high fuel flow or a low fuel flow.

In a high fuel flow situation, the FADEC on the non malfunctioning engine may cause the non malfunctioning engine to drop off line in an effort to maintain 100% RRPM (since the failed engine has a high fixed fuel flow).

Conversely, if the failure occurred at a low power setting, the malfunctioning engine will provide little or no power upon demand. These indications must be confirmed by observing the engine instruments display since the normal function engine could have low or high torque in comparison to the fixed fuel flow engine.

This fixed fuel flow condition may cause an increase in NR when THRUST CONT lever is reduced. Another indication would be a split in TQ with upward or downward THRUST CONT applications.

This fixed fuel condition may be capable of providing partial power at THRUST CONT application depending on the power that was required when the system sustained the hard failure.

Failure of the REV engine control system to a fixed fuel flow may require the engine to be shutdown at some point before landing to prevent NR overspeed. Once the decision is made to shut down the engine and prior to pulling the T handle with the ENG COND lever in the FLT position, the pilot may attempt to regain control of the FADEC by toggling the FADEC switch from PRI to REV and back to PRI without hesitation between switch positions.

(1) **REV 1 and/or REV 2 (WITHOUT) ASSOCIATED FADEC LIGHT(s) ON.** (Para 9-23).

CAUTION: Do not manually select reversionary mode on affected engine as un-commanded power changes may occur.

(2) **REV 1 or REV 2 (WITH) Associated FADEC LIGHT ON**. (Para 9-24).

NOTE: The FADEC of the non affected engine will attempt to maintain 100% RRPM. If engine shutdown is required, positively identify the affected engine by observing engine instruments.

(a) **Land as soon as possible**.

(b) **EMER ENG SHUTDOWN — As required.**

(3) **714 REV 1 and REV 2 (WITH) Associated FADEC LIGHTS ON.** (Para 9-25).

NOTE: With both FADEC and REV lights illuminated, no engine or RRPM control will be provided by the FADEC. The decision to shutdown the engine(s) should be based on RRPM and fixed power output, keeping in mind the power required for touchdown.

(a) **Land as soon as possible.**

(b) EMER ENG SHUTDOWN — As required

NOTES: Always refer to a current operators manual for the current emergency procedures.

Backup all emergency procedures with the checklist.

Appendix C - Practical Exercises and Solutions

CH-47D POWERPLANT T55-GA-714A

PRACTICAL EXERCISE

1. P3 air is provided to 3 components, what are the three components?

2. What component is installed in the flight control closet for the purpose of eliminating rotor droop?

3. The HMA is divided into two sections, what are they?

4. List the components of the Torque Indicating System?

5. What are the engine oil pressure limitations?

6. List the components of the Fuel Flow Indicating system?

7. What component provides oil pressure to the gauge in the cockpit?

8. What constitutes an N_1 overspeed?

9. What does the load share switch on the FADEC control panel allow for?

10. What does the Oil Flow Programming Valve prevent?

11. What is mounted on the rear of the engine mounted oil pump?

12. What is the contingency power PTIT range and how long may it be used per occurrence?

13. The Bleed Band operates in what FADEC modes of operation?

14. What is the maximum oil temperature?

15. What three engine mounted components have impending bypass indicators that are required to be checked on pre-flight?

16. What does the abbreviation PTIT stand for?

17. What are the ranges of time limited operation for the PTIT system.

18. What are the engines Torque limits (Dual/Single)?

19. What component drives the compressor section during an engine start?

20. What are the two functions of the Liquid to Liquid cooler?

21. The engine chip light on the Master caution/advisor panel can indicate a chip in two locations, what are the two locations?

22. Below 6000 feet pressure altitude, what component can draw fuel out of the main tank if the main tank boost pumps fail?

23. If a power turbine overspeed (N_2) is detected the DECU will activate what valve to reduce fuel flow to the engine?

24. Agent from the #1 (forward) Fire bottle can be directed to which engine(s)?

25. If the FADEC system is operating properly, what specific component on the HMA, provides power to the Primary Channel?

26. A FAULT detected by the DECU that does not impact the normal control of the engine is a ______ Fault.

27. An engine FAULT that could cause unacceptable engine or aircraft performance is a ________ Fault.

28. What does the pilot use to adjust the N1 speed of the engine.

29. With a FADEC 1 or FADEC 2 failure, what does the pilot use to control the N2 speed of the engine?

30. How will the engine be shutdown with an ECL failure?

CH-47D POWERPLANT T55-GA-714A

PRACTICAL EXERCISE SOLUTIONS

1. Bleed Band Actuator, HMA, DECU

2. CPT (Control Position Transducer)

3. HMU (Hydro-mechanical Metering Unit) and FPU (Fuel Pump Unit)

4. Torque Gauge, Power output shaft, Head assembly, Junction Box, RDPS (Ratio Detector Power Supply)

5. 5 PSI Minimum pressure at ground idle (50% N_1)
   35 PSI Minimum at 80% to 95% N1
   50 PSI Minimum at 95% N_1 or above
   35 to 90 PSI Minimum normal operating pressure range
   110 PSI Maximum pressure for contingency power
   150 PSI Maximum pressure for cold weather starts

6. Fuel Flow Meter, Fuel Flow Transmitter, Fuel Flow Power Supply

7. Engine Oil Pressure Transmitter

8. 110% N_1

9. Selection of Torque Matching or PTIT Matching

10. Coking of the bearings in the combustor section

11. N_1 Speed Sensor, N_1 Magnetic Speed Sensor

12. 900°C to 930°C for 2.5 Minutes

13. Both Primary and Reversionary Modes

14. 149°C

15. Main Fuel Filter (Barrier), Inline Fuel filter, Oil Filter

16. Power Turbine Inlet Temperature

17. Continuous range 400°C to 815°C.
30 Minute range 815°C to 855°C.
10 Minute range 856°C to 900°C.
2.5 Minutes Contingency power range 901°C to 930°C.
12 Seconds Maximum 931°C to 940°C, (Never to Exceed) 940°C.

18. Dual Engine 100% Torque
Single Engine 123% Torque

19. Engine Starter (Motor)

20. To cool the engine oil and heat the fuel.

21. Engine or Engine Transmission

22. Engine driven fuel pump

23. Overspeed Solenoid Valve

24. Either the #1 or #2

25 The alternator on the HMA.
If the FADEC system is operating properly, what provides power to the Primary Channel?

26. Soft Fault

27. Hard Fault

28. The ECL's

29. The INC/DEC Switches on the trust control lever.

30. Pull the Fire Pull handle.