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SEPTEMBER 2004

STUDENT GUIDE

FOR

UH-60 AUXILIARY POWER UNIT

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SEPTEMBER 2004

AUXILIARY POWER UNIT

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SECTION I. - INTRODUCTION

TERMINAL LEARNING OBJECTIVE:

At the completion of this lesson you will:

ACTION: Identify the characteristics of the Auxiliary Power Unit (APU) system.

CONDITIONS: As a UH-60 maintenance test pilot.

STANDARD: IAW TM 55-2835-208-23 and TM 55-2835-209-23

SAFETY REQUIREMENTS: Remove all watches, rings and other jewelry before operating, or maintaining electronic equipment.

RISK ASSESSMENT LEVEL: Low

ENVIRONMENTAL CONSIDERATIONS: There are no environmental concerns for this lesson.

EVALUATION: Evaluation will be accomplished with performance exam at the end of this module of instruction.

SECTION II. - PRESENTATION

A. ENABLING LEARNING OBJECTIVE ELO No. 1

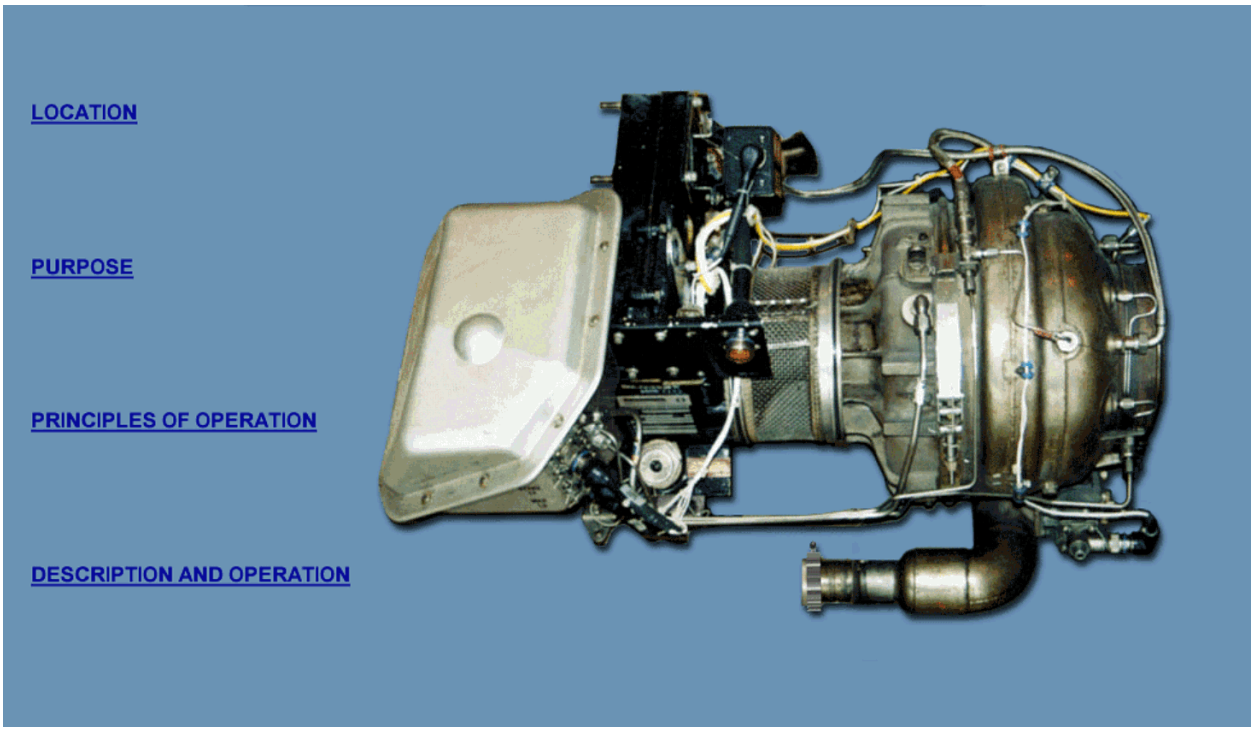
ACTION: Identify the location and function of the APU.

CONDITIONS: As a UH-60 maintenance test pilot.

STANDARD: IAW TM 55-2835-208-23 and TM 55-2835-209-23

a. MENU

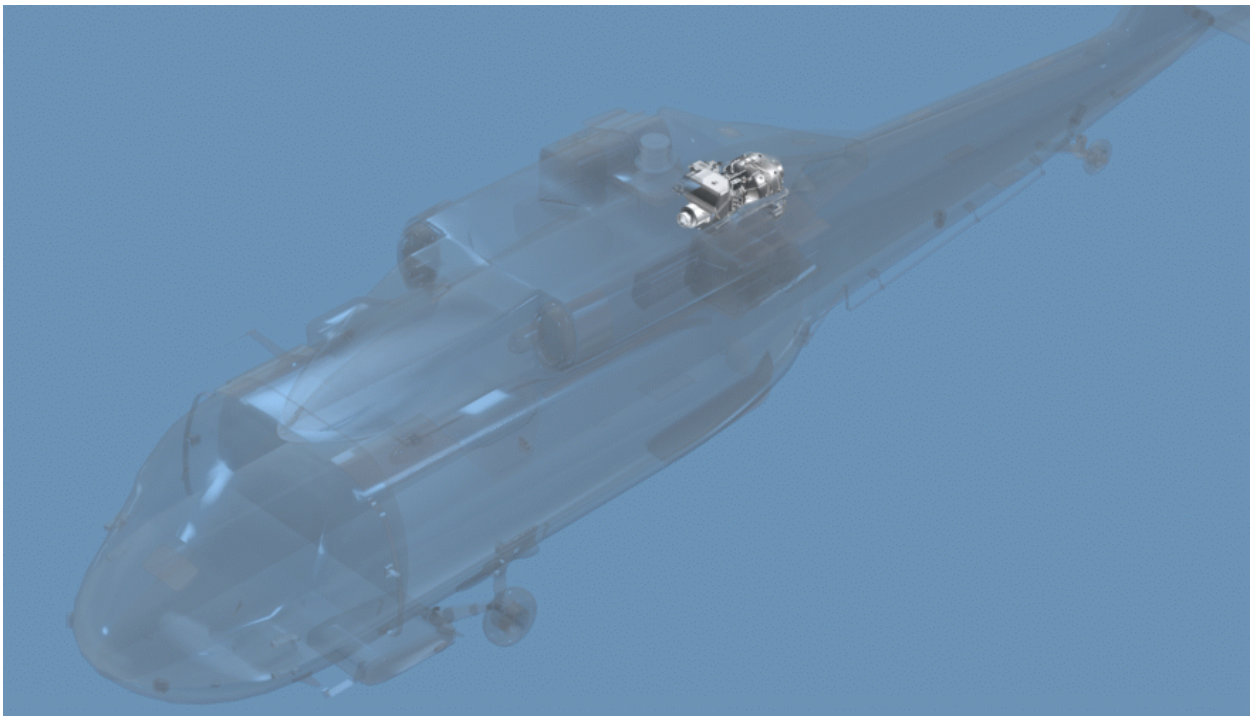
Frame #0022 (MENU)



(1) The APU location and function can be broken down into the four categories listed above.

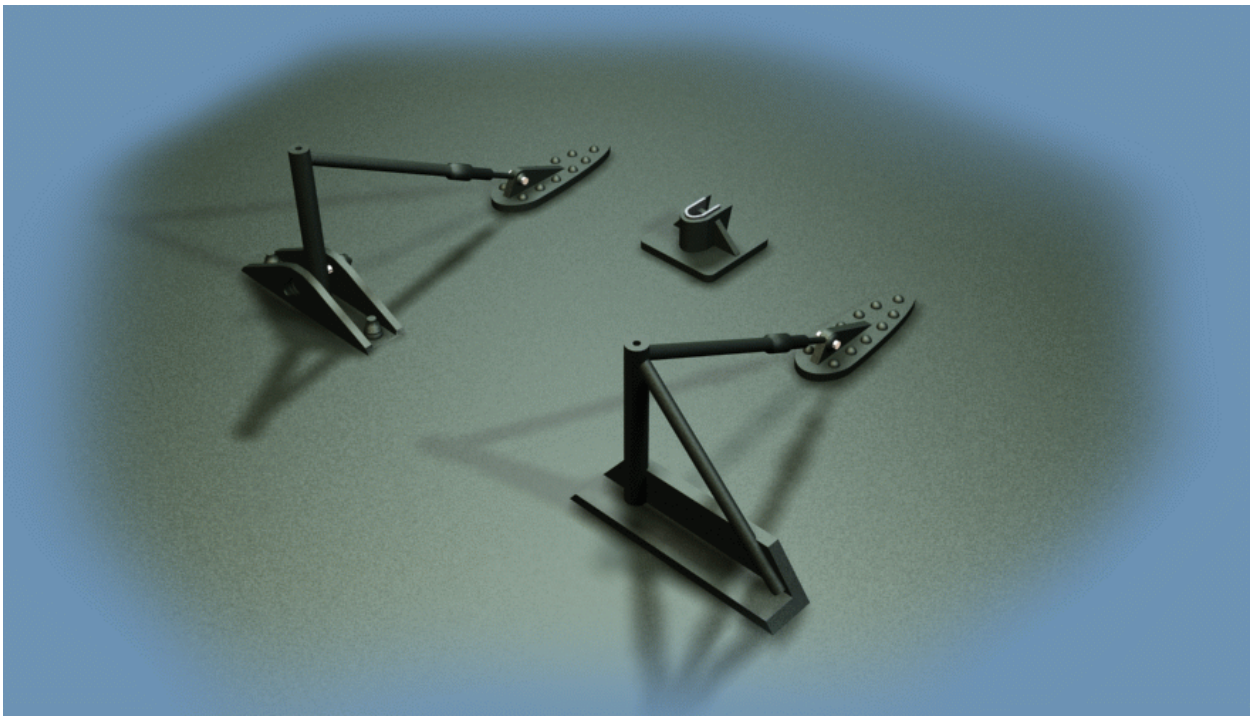
b. Location

Frame #0025 (APU Location)



(1) The APU is located on the upper deck, aft of the oil cooler compartment on the left hand side of the aircraft.

Frame #0030 (APU Mounts)



(2) The APU is mounted to the deck on three support mounts.

(a) The two front supports are adjustable and connect to the forward end of the APU reduction drive assembly.

(b) The aft support is nonadjustable, and connects to the lower, aft end of the APU reduction drive assembly.

c. Purpose

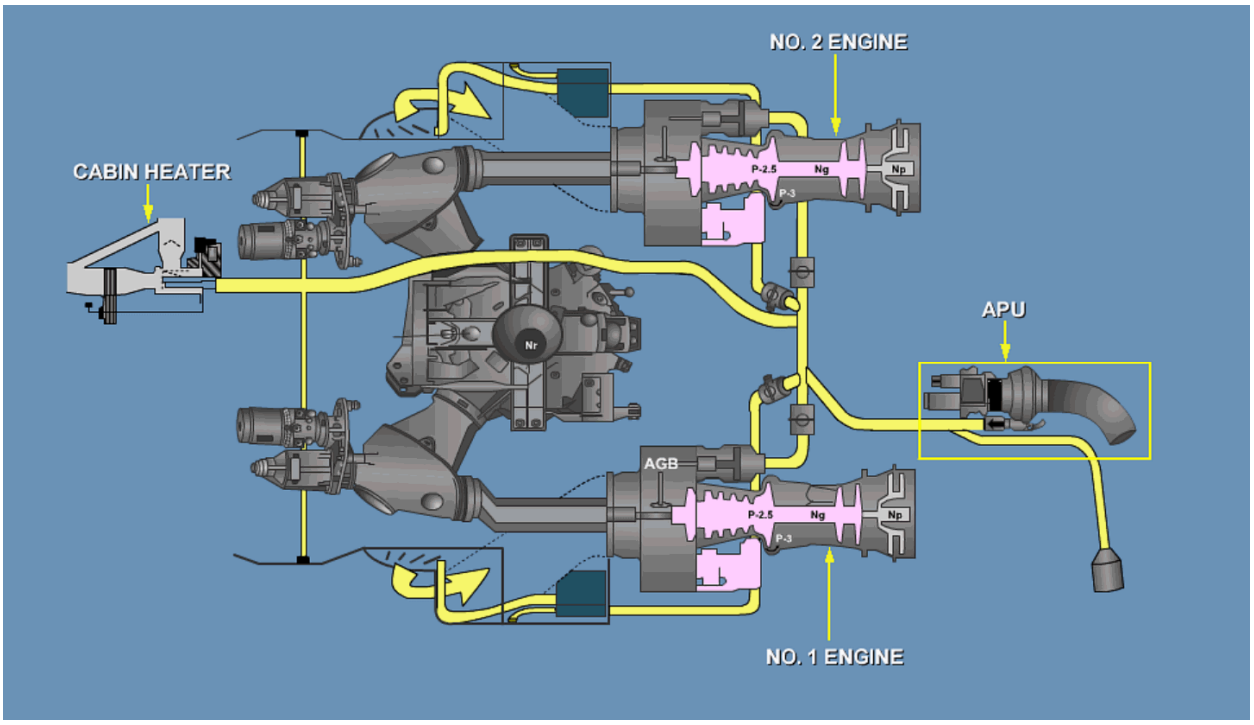
Frame #0035 (Primary Purpose)

(1) The APU has two primary purposes:

(a) Providing a pneumatic air source

(b) An electrical power source

Frame #0040 (APU Air Flow FLASH)



(2) Once the APU is started and online, it provides the air source for cabin heating and the pneumatic start system for the engines.

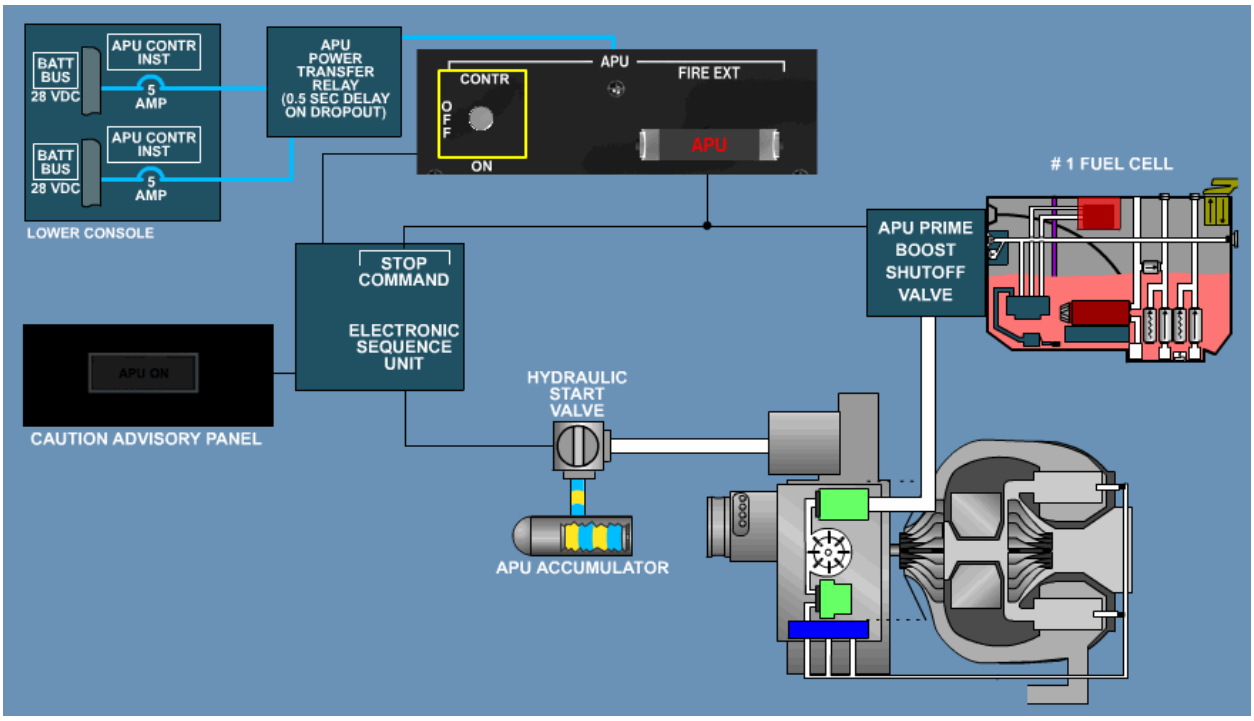
(3) The APU provides sufficient pneumatic air, enabling the pilot to perform engine starting.

Frame #0045 (Secondary Purpose)

(4) Electrical power for ground operations, and in-flight emergencies is provided by the APU generator.

d. Principles of Operation

Frame #0055 (Principles of Operation FLASH)



(1) Power (28 vdc) is already applied to the APU control switch.

(2) When the APU control switch is placed in the ON position, electrical power flows to the Electronic Sequence Unit (ESU).

(3) The ESU sends a signal that opens the hydraulic start valve, releasing the hydraulic accumulator charge to the hydraulic start motor.

(4) The hydraulic start motor turns the accessory drive section, which turns the APU compressor, and the fuel pump.

(5) Air is drawn in by the compressor, compressed, and directed to the combustion chamber via the diffuser.

(6) The fuel shutoff valve opens, and air, fuel is mixed, and ignited by a single spark plug at 5% speed.

(7) At 14% speed, the main fuel is added, producing increased hot gas flow.

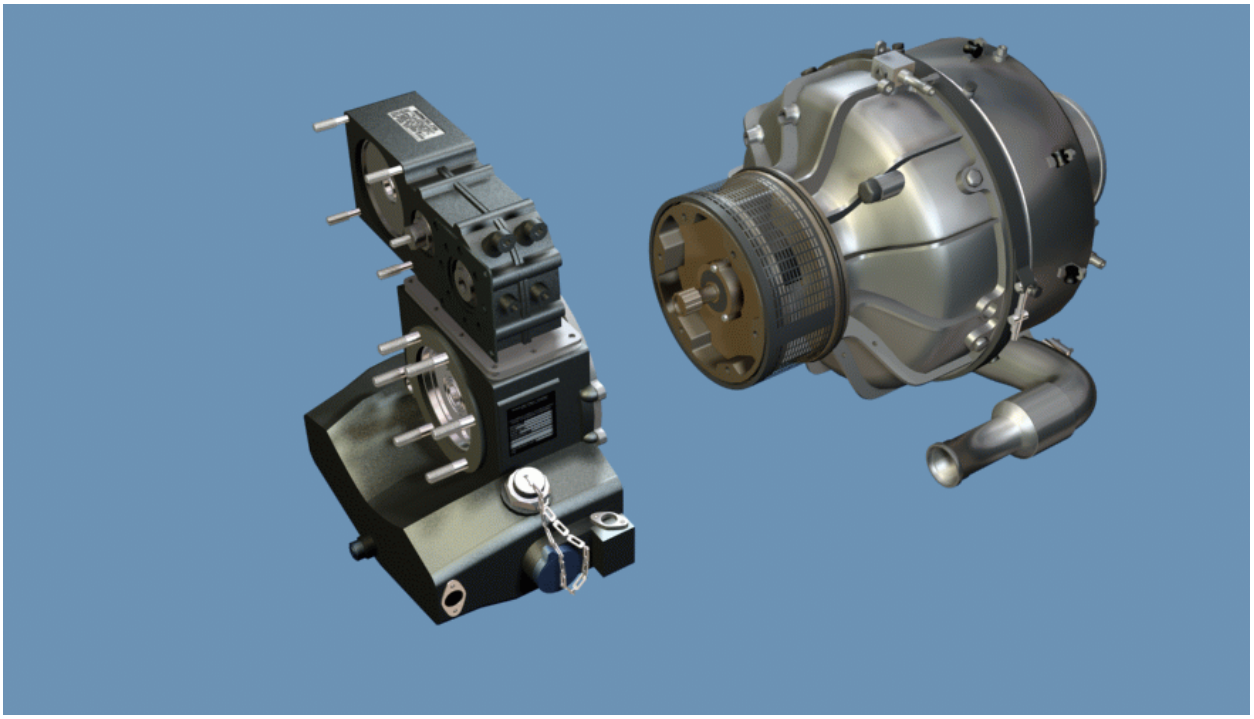
(8) The hot gases drive the turbine wheel and compressor, exiting through the exhaust.

(9) Ignition, and start fuel cut off at 70% speed. Main and maximum fuel results in APU self sustained combustion.

(10) The APU advisory light comes on in the cockpit at 90% speed + 1.5 seconds.

e. Description and Operation

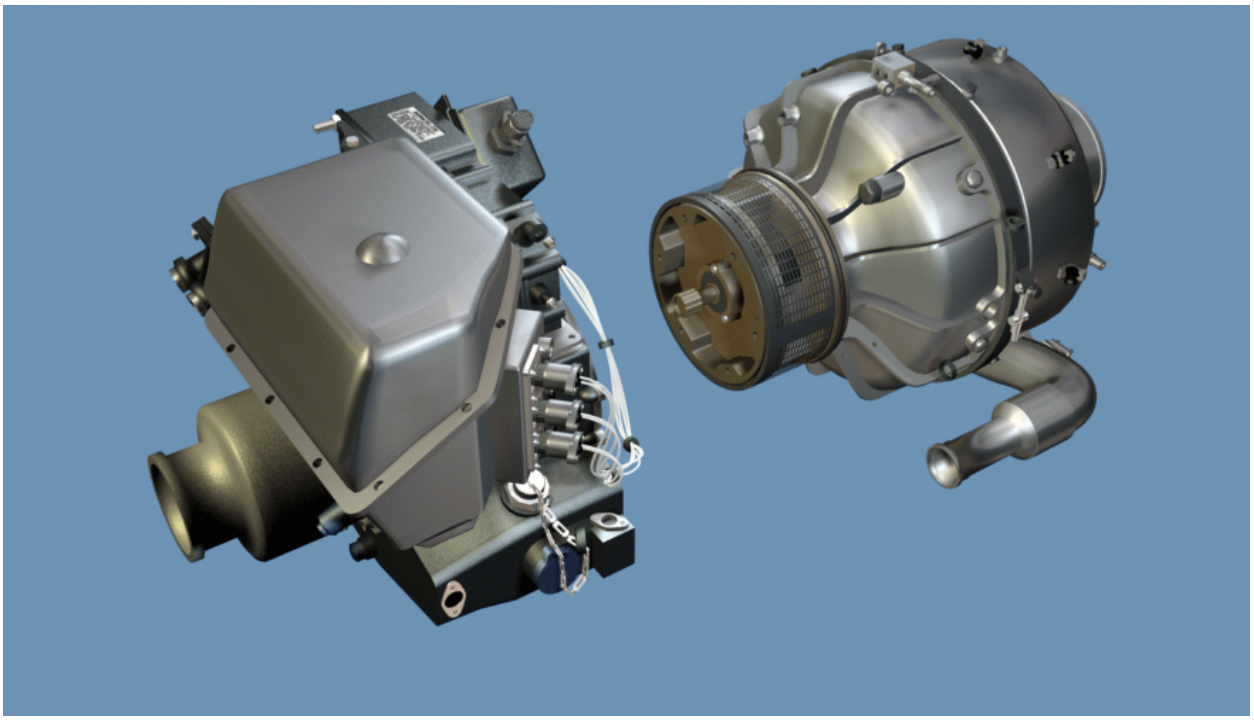
Frame #0060 (Description and Operation)



(1) The T62T-40-1 Titan APU, consists of: a gas turbine power section, reduction drive, and other applicable accessories.

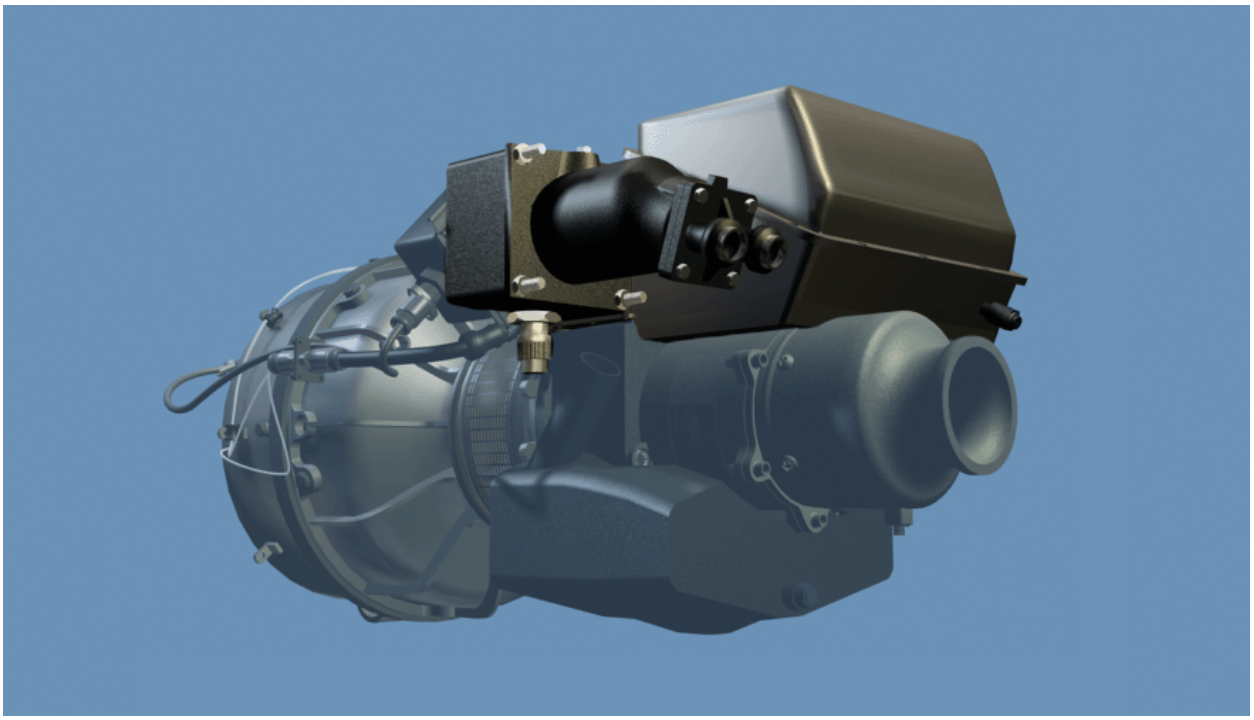
(a) Reduction Drive

Frame #0062 (Reduction Drive)



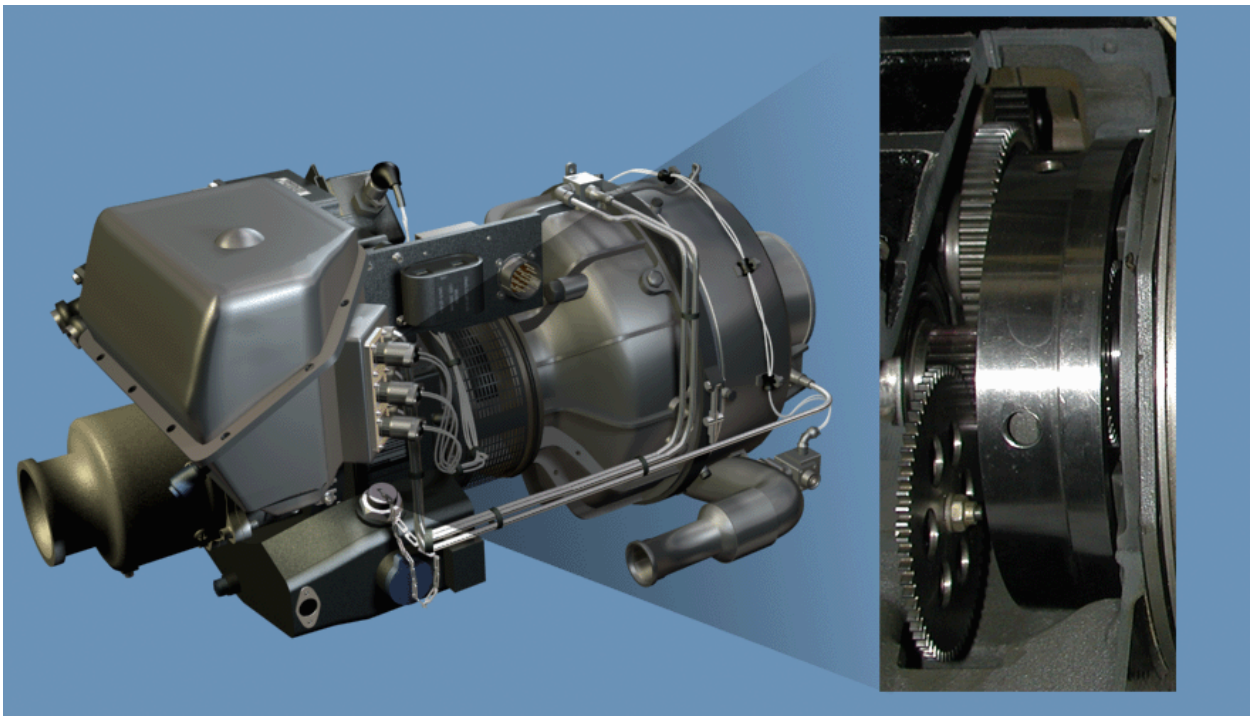
1) The high-speed shaft, from the turbine power section, powers the reduction gear drive, which drives an AC generator and accessory gear drive.

Frame #0063 (Reduction Drive Mounting)



2) Mounted on the accessory gear drive are the hydraulic start motor, magnetic pickup, and the fuel control.

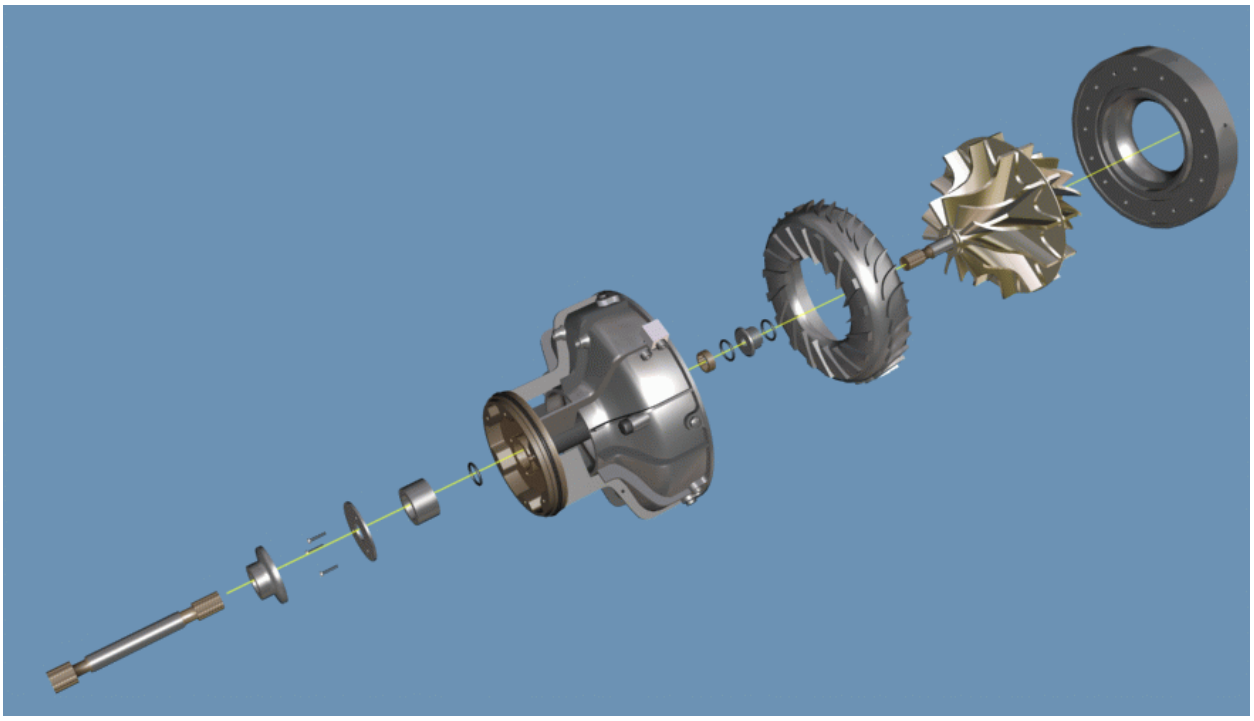
Frame #0066 (Integral Oil System)



3) An integral oil system, housed in the reduction gear drive, provides lubrication for the APU.

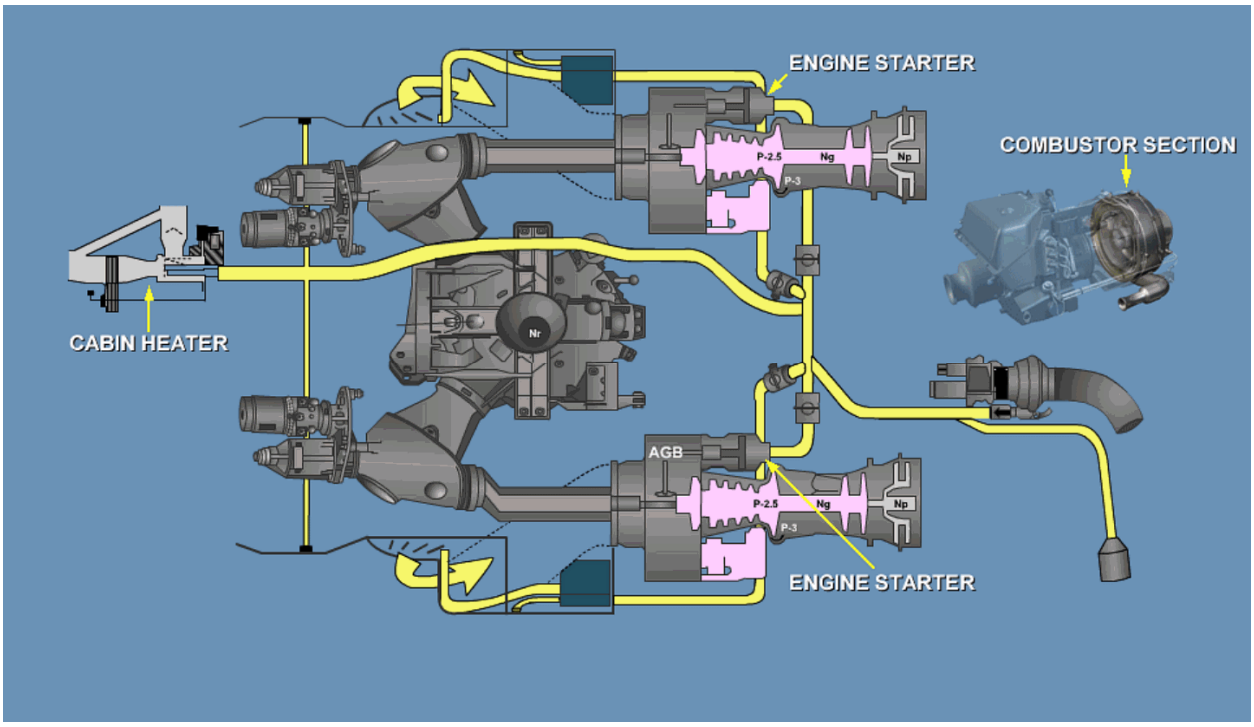
(b) Gas Turbine Power Section

Frame #0061 (Gas Turbine Power Section)



1) The gas turbine power section uses a single centrifugal compressor and a single-stage radial inflow turbine wheel, mounted back to back on a common high speed shaft.

Frame #0064 (Pneumatic Air Flow)

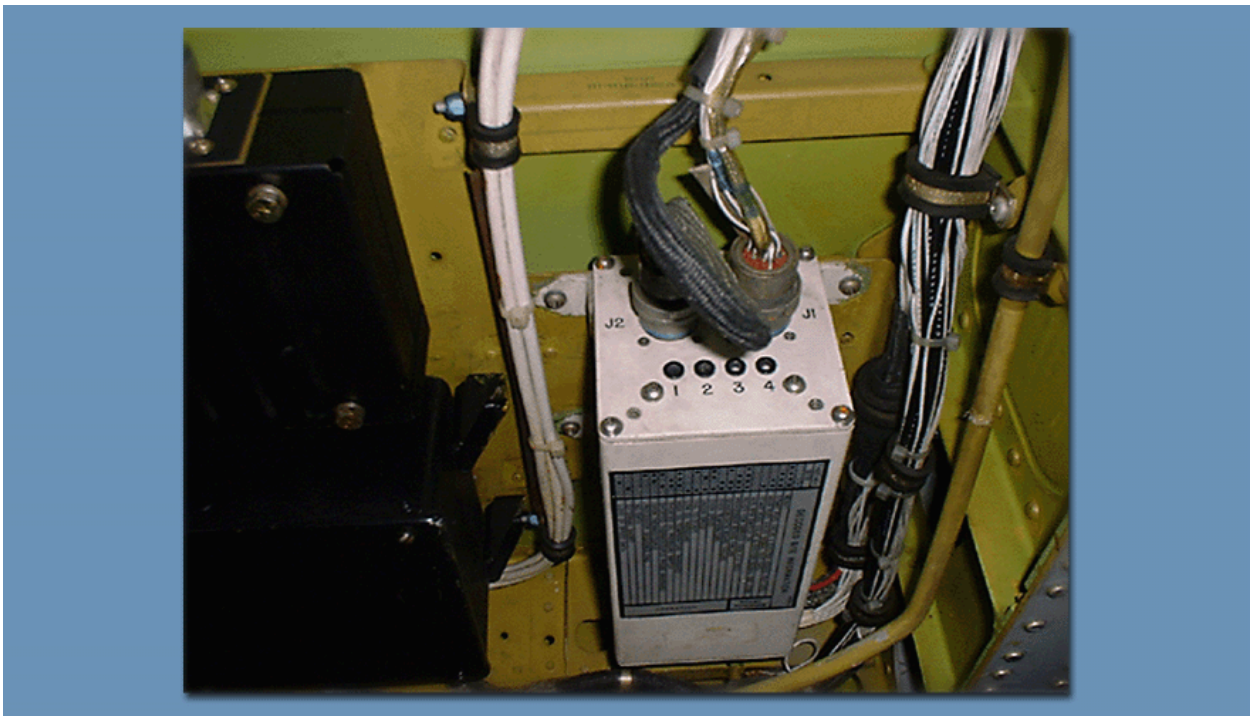


2) Pneumatic air is extracted from the combustor section and routed to the main engines for starting, and to the heater assembly for cabin heating.

Frame #0065 (Electrical Power and Fuel Components)

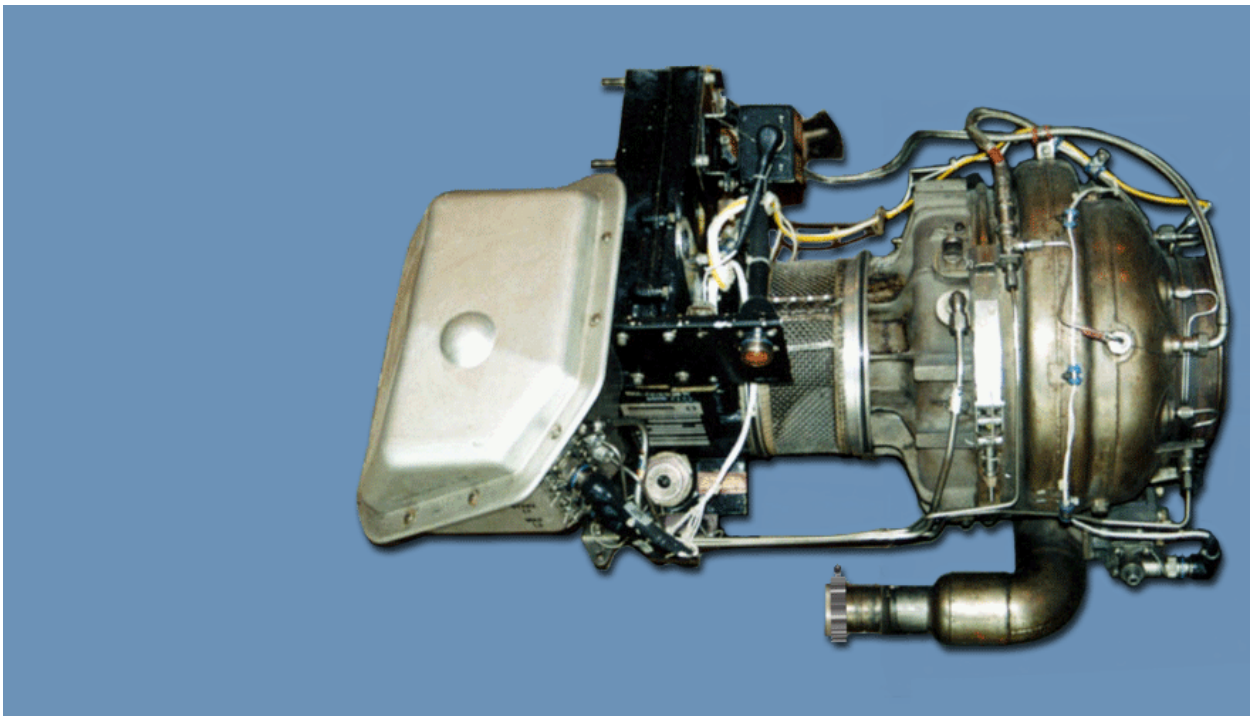
(2) Electrical power and fuel required for operation of the APU is accomplished through an interface with the aircraft electrical and fuel systems.

Frame #0067 (ESU)



(3) The ESU electrically monitors fault conditions and sequences the operation of the APU.

(a) If a fault condition exists, the ESU will automatically shut down the APU and provide the pilot and maintenance personnel with visual indicators, Built-In-Test-Equipment (BITE), and appropriate caution panel lights.



(4) The APU weighs 92 lbs, with a maximum rotational speed of 61,565 rpm, and an axial pad output shaft speed of 12,000 rpm.

(a) Output

1) At a maximum steady state of operation, the Exhaust Gas Temperature (EGT) is 649 ºC.

2) The output shaft horsepower is:

a) 90.0 Shaft Horse Power (SHP) at 0.0 Pounds Per Minute (PPM) bleed flow

b) 60.0 SHP at 52.6 PPM bleed flow

c) 40 SHP at 60.0 PPM bleed flow

d) 20.0 SHP at 66.0 PPM bleed flow

e) 0.0 SHP at 72.0 PPM bleed flow.

(b) Fuel

1) Fuel consumption at the operational rated speed is 150 Pounds Per Hour (PPH), which is supplied from the No. 1 fuel cell only.

a) Acceptable fuels to be used with the APU are Jet Petroleum (JP) 4, JP 5, or JP 8.

b) The primary difference between the APU fuel system and the main engine fuel system is that the APU fuel line is not self-sealing and the engine fuel lines are self-sealing.

(c) Lubrication

1) In the lubrication system, the APU uses either Military Lubricant (MIL-L) 23699, or MIL-L 7808.

a) MIL-L 23699 is used to service the APU when the temperature is -29 ºF (-34 ºC) and above.

b) MIL-L 7808 is used to service the APU when the temperature is below -29 ºF (-34 ºC).

c) When servicing the APU, do not mix the two types of oil in the system. This is due to high detergent additives used in processing the lubricating oils.

d) If the oils are mixed, the system must be drained and reserviced with the proper oil.

CHECK ON LEARNING

1. One purpose of the APU is to provide_____.

2. Which component sends a signal to open the hydraulic start valve?

3. APU operation is monitored for fault conditions, and sequenced by the _____?

SECTION III. -SUMMARY

1. REVIEW/SUMMARIZE:

You have completed the location and Function topic of the APU.
The key points to remember are:

- The APU is secured by three mount lugs, located on the upper deck, aft of the oil cooler, on the left hand side.
- The primary purposes of the APU are: pneumatic air sources for cabin heating, main engine starting, electrical power sources for in-flight emergencies, and ground operations.
- Electrical and fuel requirements for operating the APU are supported by the aircraft electrical and fuel systems.
- An integral oil system is located in the reduction gear drive of the APU.
- The APU may use JP 4, JP 5, or JP 8 for operation.
- Two types of oil are authorized for use with the APU: MIL-L 23699 and MIL-L 7808.
- The accumulator releases the hydraulic charge to the APU start motor after the hydraulic start valve receives a signal from the ESU, beginning the start sequence.
- Driven by the hydraulic start motor, the accessory drive turns the compressor and fuel pump.
- Compressed air is drawn in by the compressor, and routed to the combustion chamber through the diffuser, where fuel and air are mixed for ignition.
- Air and fuel mixing, combustion, and exhaust occur in the gas turbine section.

B. ENABLING LEARNING OBJECTIVE ELO No. 2

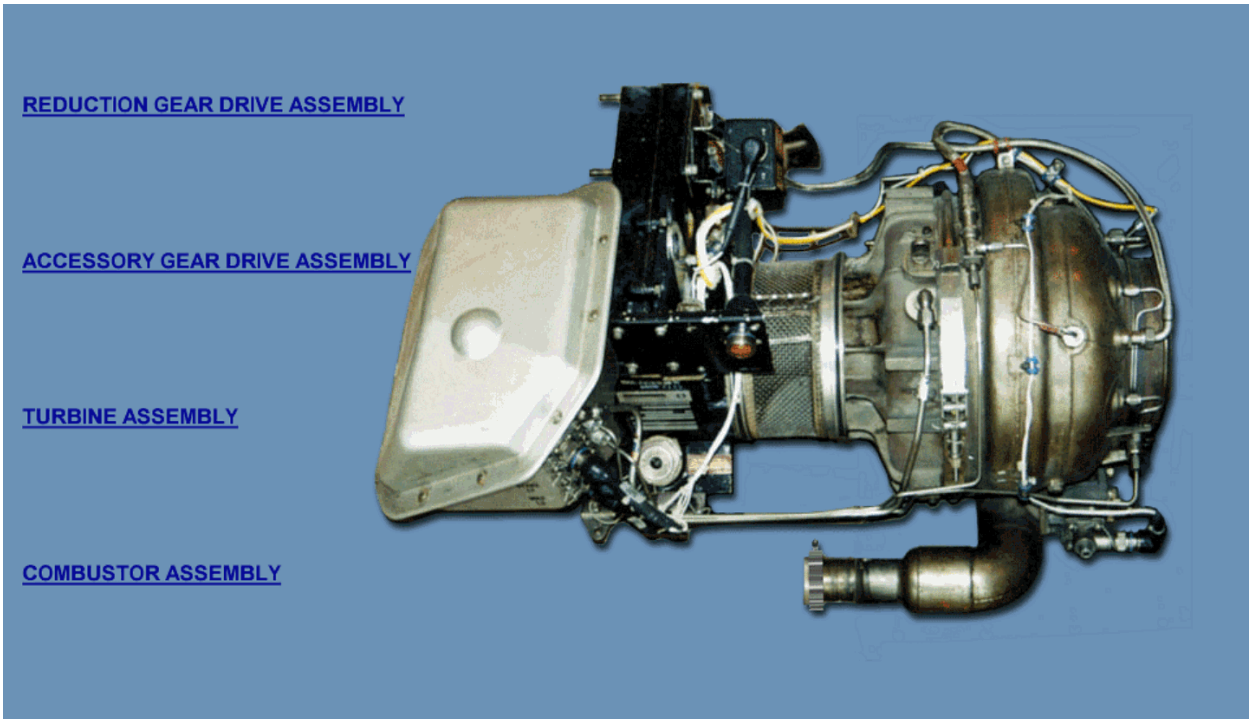
ACTION: Identify the major components of the Auxiliary Power Unit.

CONDITIONS: As a UH-60 maintenance test pilot.

STANDARD: IAW TM 55-2835-208-23 and TM 55-2835-209-23

a. MENU

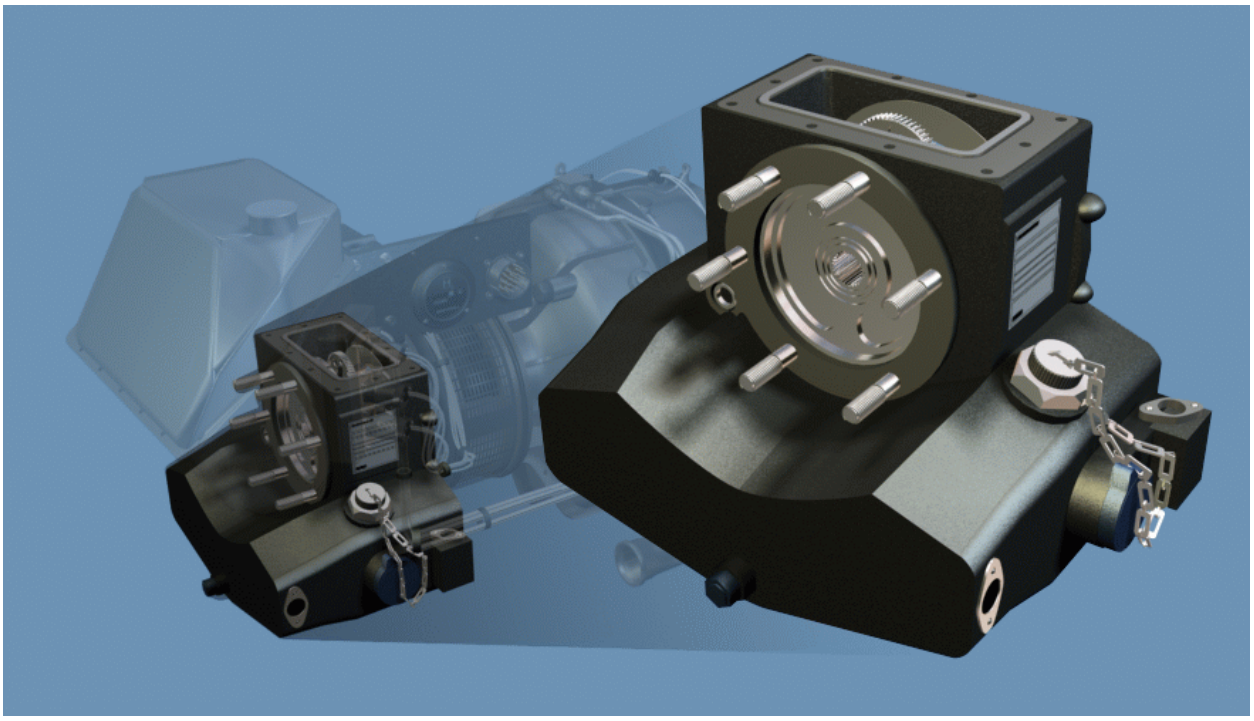
Frame #0505 (MENU)



(1) The APU is composed of four major subassemblies: the reduction gear drive, accessory gear drive, turbine, and combustor.

b. Reduction Gear Drive Assembly

Frame #0510 (Reduction Gear Drive Assembly)



(1) The reduction gear drive assembly reduces the rotational speed of the turbine to the speeds necessary to drive the engine accessories and driven equipment.

(2) The reduction gear drive assembly consists of cast magnesium housing, which serves as an oil sump, holding 3 U.S. quarts.

(3) The internal components include the oil system components (oil pump), and a planetary gear train.

(a) The three planetary gears that are mounted inside, that are driven by the input pinion of the turbine assembly.

(b) The planetary gears drive an internally splined ring gear, mounted on a splined output shaft.

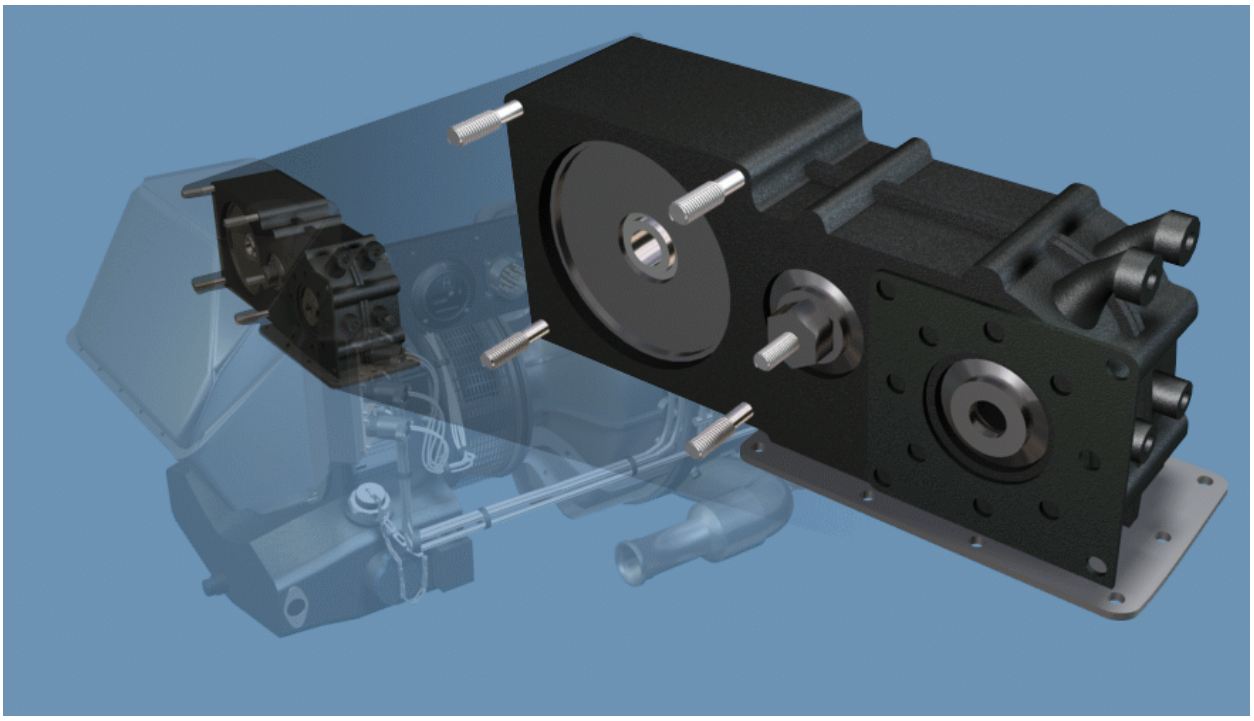
(c) The output shaft drives the oil pump gear, and idler gear.

(d) The idler gear drives the accessory drive.

(4) External power takeoff pads are provided for the AC generator, and an accessory gear drive.

c. Accessory Gear Drive Assembly

Frame #0515 (Accessory Gear Drive Assembly)



(1) The accessory gear drive assembly is mounted on the reduction gear drive assembly.

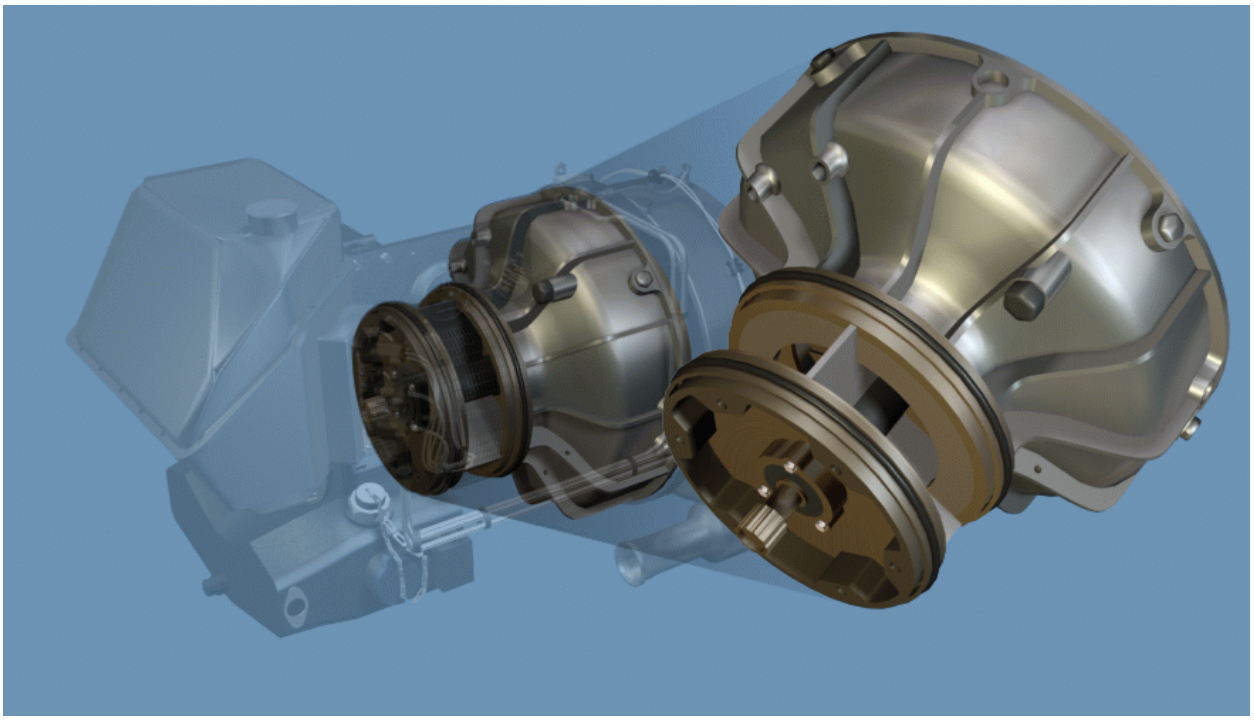
(2) The accessory gear drive assembly has a cast magnesium housing with internal gearing.

(3) The accessory gear drive assembly provides a mounting platform, drive for the fuel pump, hydraulic start motor, and the magnetic pickup.

(4) An ignition exciter is externally mounted on the aft side of the accessory drive, and provides a forward mount for the fuel control enclosure cover and accessories.

d. Turbine Assembly

Frame #0520 (Turbine Assembly)

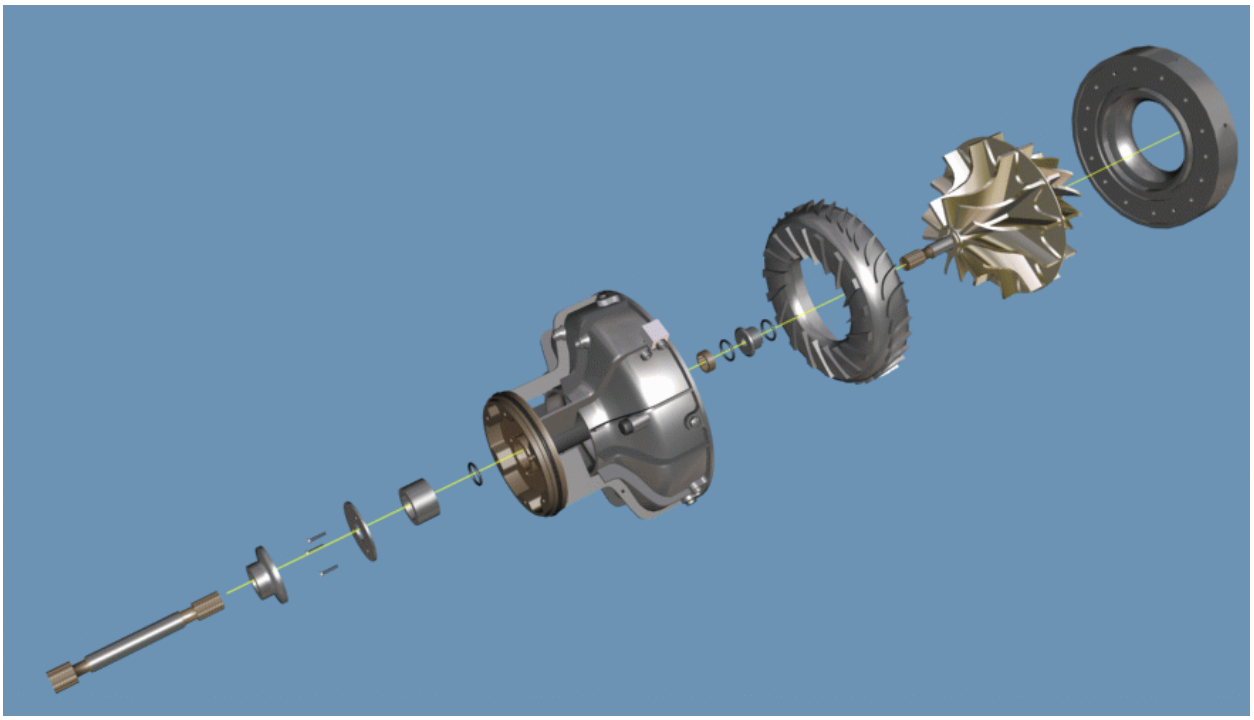


(1) The turbine assembly is a contoured air inlet housing.

(2) The turbine assembly serves as a support between the reduction gear drive and the combustor assembly.

(3) The turbine assembly is bolted to the reduction drive, and a V-band clamp secures it to the combustor assembly.

Frame #0525 (Turbine Assembly Exploded View)



(4) The turbine assembly houses a single-stage, centrifugal compressor wheel.

(5) The radial inflow turbine wheel is mounted back-to-back on the same shaft as the compressor wheel.

(6) The diffuser directs the air and reduces the speed of the centrifugal impeller airflow.

(7) As speed decreases, pressure increases, and the diffuser directs the airflow to the combustor assembly.

(8) The turbine nozzle directs hot gases produced in the combustor assembly to the turbine wheel.

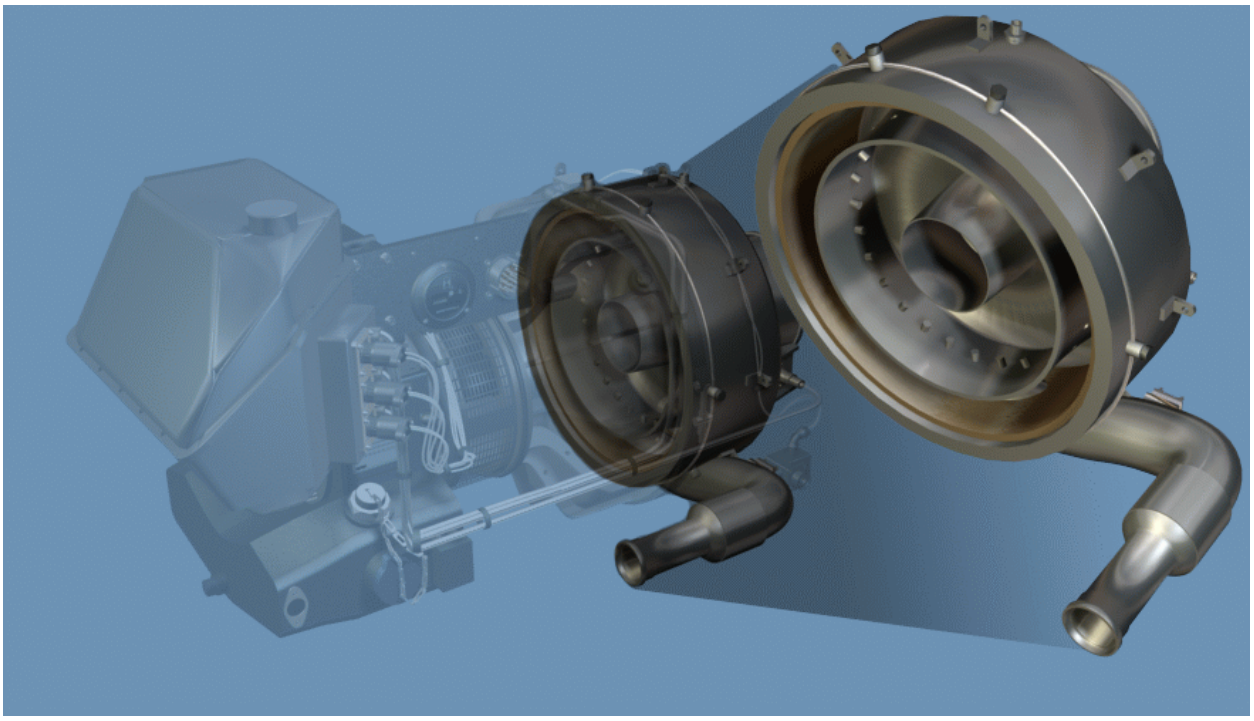
(9) Hot gases continue to turn the compressor, and input pinion of the turbine assembly.

(10) The input pinion is splined to the rotor shaft and to the reduction drive gear assembly.

(11) The compressor turbine support is at the forward end of the rotor shaft and is supported by a ball bearing (radial and axial); the aft end is supported by a roller bearing (radial).

e. Combustor Assembly

Frame #0530 (Combustor Assembly)

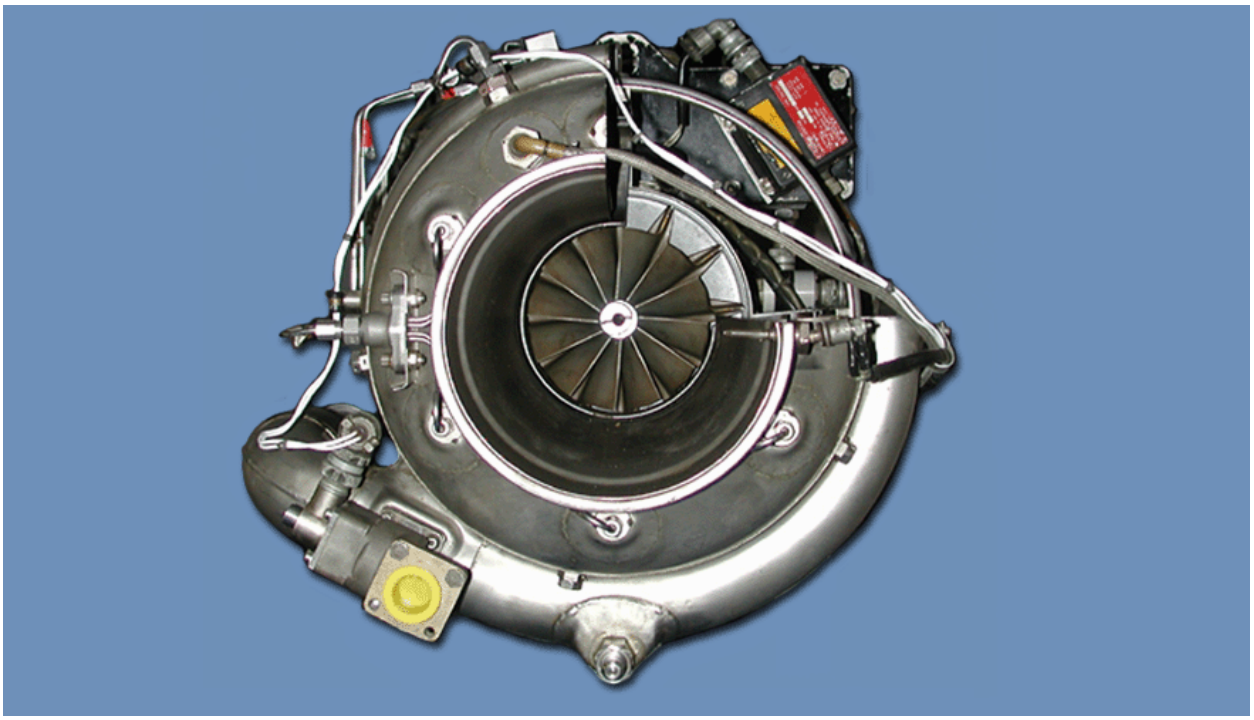


(1) The combustor assembly is where diffused air from the turbine assembly, and atomized fuel are ignited, and burned to drive the turbine wheel, providing self-sustaining operations.

(2) The combustor assembly consists of the outer housing and annular combustion liner.

(3) The annular combustion liner is mounted inside the outer combustor housing, providing space between the liner and the housing for cooling airflow.

Frame #0535 (Outer Housing)



WARNING: Be extremely careful when handling combustor assembly internal parts. These items have been exposed to tetra-ethyl lead, which is HIGHLY poisonous. Use caution, avoid inhalation or contact with open wounds.

(4) The outer housing provides internal mounting for the annular combustion liner and an external mount for the start fuel nozzle, spark plug, main fuel manifold, injectors, thermocouple, combustor drain valve, and the start bypass valve.

CHECK ON LEARNING

1. The four major assemblies of the APU are the reduction gear drive, accessory gear drive, turbine and the _____.

2. Which assembly contains the planetary gear train and oil system?

3. The fuel pump, hydraulic start motor, and magnetic pickup are mounted to which assembly?

4. The purpose of the diffuser of the turbine assembly is to _____.

5. Diffused air and atomized fuel are ignited to provide hot gases for self-sustaining operations of the APU in which component?

SECTION IV. -SUMMARY

1. REVIEW/SUMMARIZE:

You have completed the Major Components topic of the APU.
The key points to remember are:

- There are four major assemblies of the APU: the reduction gear drive, accessory gear drive, turbine, and the combustor.
- The oil system and a planetary gear train are located in the reduction gear drive assembly.
- The accessory gear drive assembly provides mount pads for the fuel pump, hydraulic start motor, and the magnetic pickup.
- The ignition exciter is externally mounted on the aft side of the accessory gear drive assembly.
- A single-stage compressor wheel, with a radial inflow turbine wheel, are mounted back-to-back on a compressor shaft inside the turbine assembly.
- The purpose of the diffuser is to direct air and reduce the speed of the centrifugal impeller airflow.
- An input pinion, from the turbine assembly, is splined to the rotor shaft to drive the reduction gear drive assembly.
- Air is diffused and atomized fuel is ignited to provide hot gases for self-sustaining operations of the APU in the combustor assembly.
- The annular combustion liner, mounted inside the outer combustor housing, provides space for the cooling of the airflow.

C. ENABLING LEARNING OBJECTIVE ELO No. 3

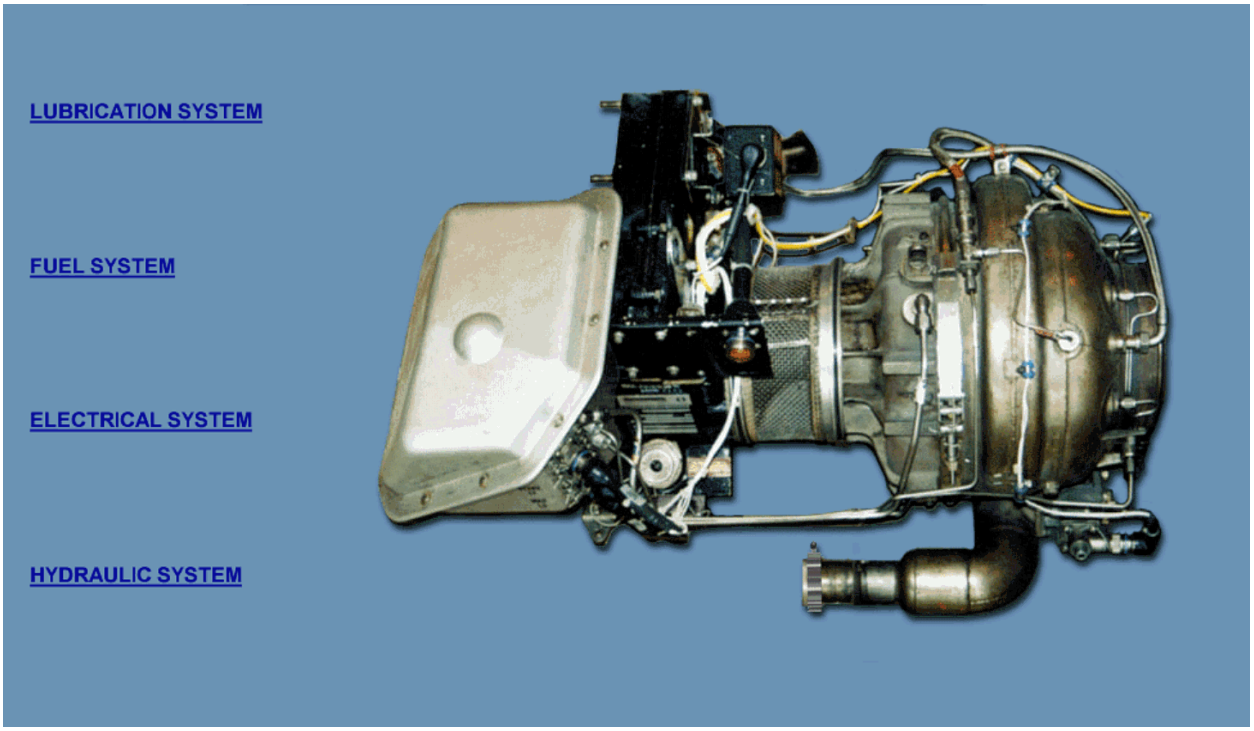
ACTION: Identify the subsystems of the Auxiliary Power Unit.

CONDITIONS: Using TM 55-2835-208-23 and TM 55-2835-209-23

STANDARD: IAW TM 55-2835-208-23 and TM 55-2835-209-23

a. MENU

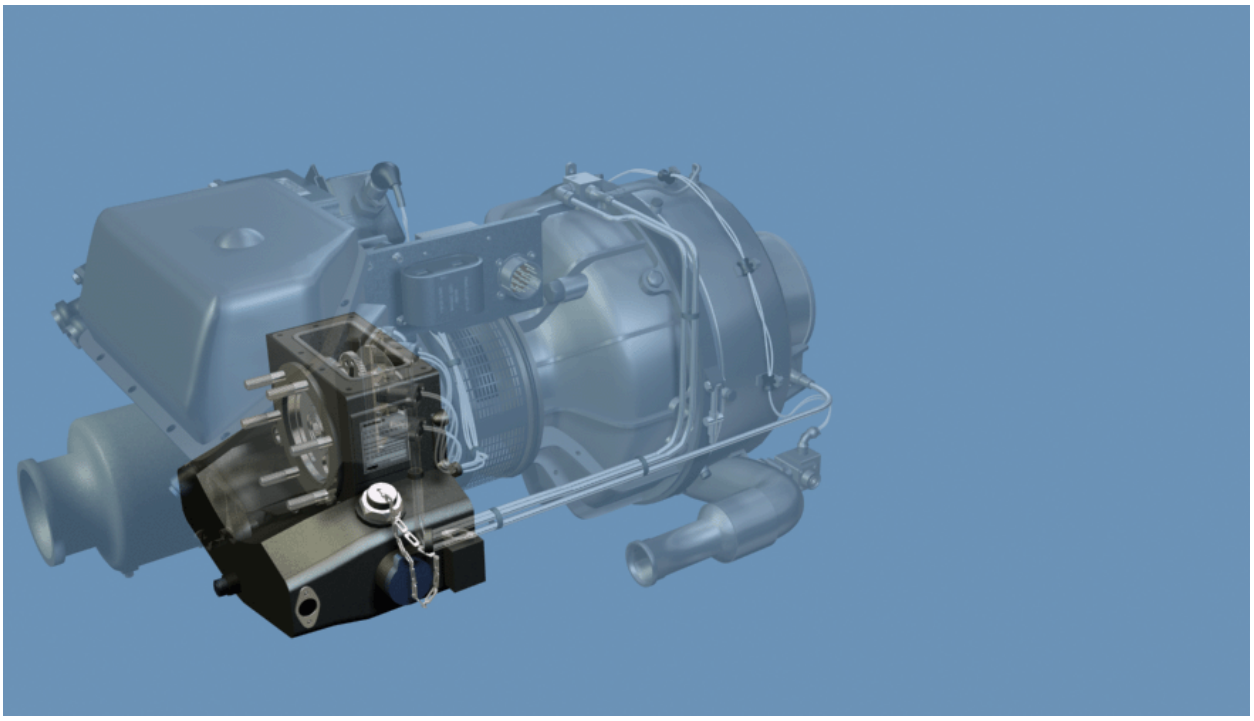
Frame #1005 (MENU)



(1) The subsystems of the APU are broken down into four major systems: lubrication, fuel, electrical, and hydraulic.

b. Lubrication System

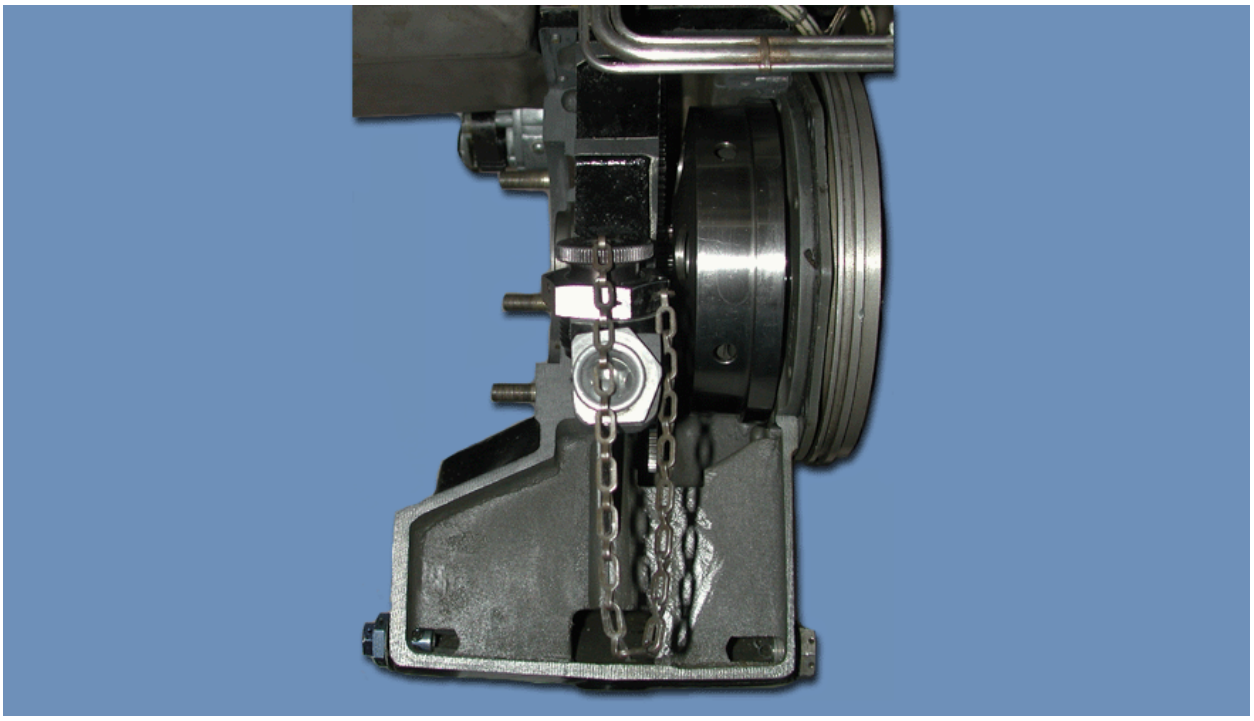
Frame #1010 (Lubrication System)



(1) The lubrication system provides lubrication and cooling oil to the internal components of the APU power turbine, reduction, and the accessory drive sections.

c. Servicing

Frame #1011 (Lubrication System Servicing)



(1) Servicing requirements for the lubrication system can be found in TM 1-1520-237-23-1.

(2) The lubrication system contains an oil filler cap (dipstick), and a sight glass for visual verification of proper servicing.

(3) There are two types of lubricants (oils) authorized for the system, MIL-L 23699 and MIL-L 7808.

(a) MIL-L 23699 (NATO Code O-156) is the primary oil, and is applicable in climates –29 ºF (–34 ºC) and above.

(b) MIL-L 7808 (NATO Code O-148) is the alternate, and is applicable in climates below –29 ºF (–34 ºC).

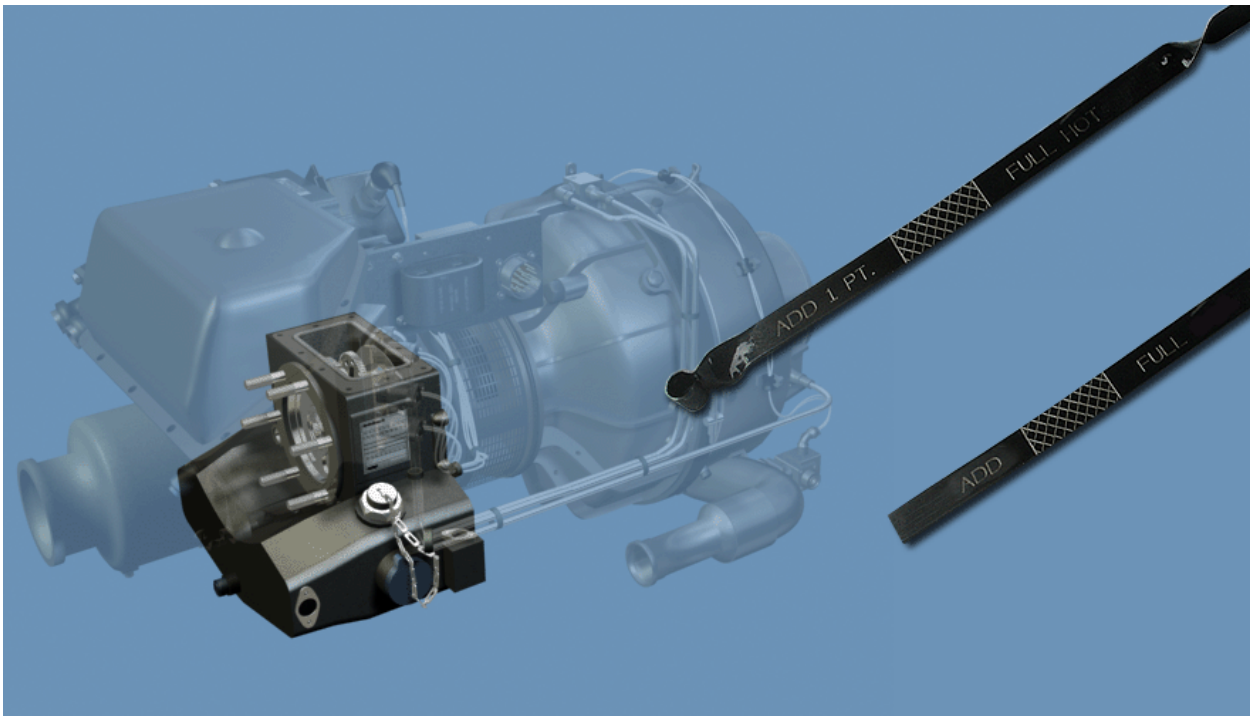
(4) When servicing the APU, the oil sump holds three U.S. quarts of oil.

(5) Do not mix oils for cold weather operations.

(6) However, mixing of oil types is authorized in emergency conditions only.

(7) If the oils are mixed, the sump must be drained, and refilled with the applicable oil as soon as possible.

Frame #1012 (APU Dipstick)



(8) When servicing or checking the APU, wait one hour after operation; this allows for cooling of the oil and will aid in avoiding injury to personnel.

(9) Check the oil level by using the filler cap (dipstick).

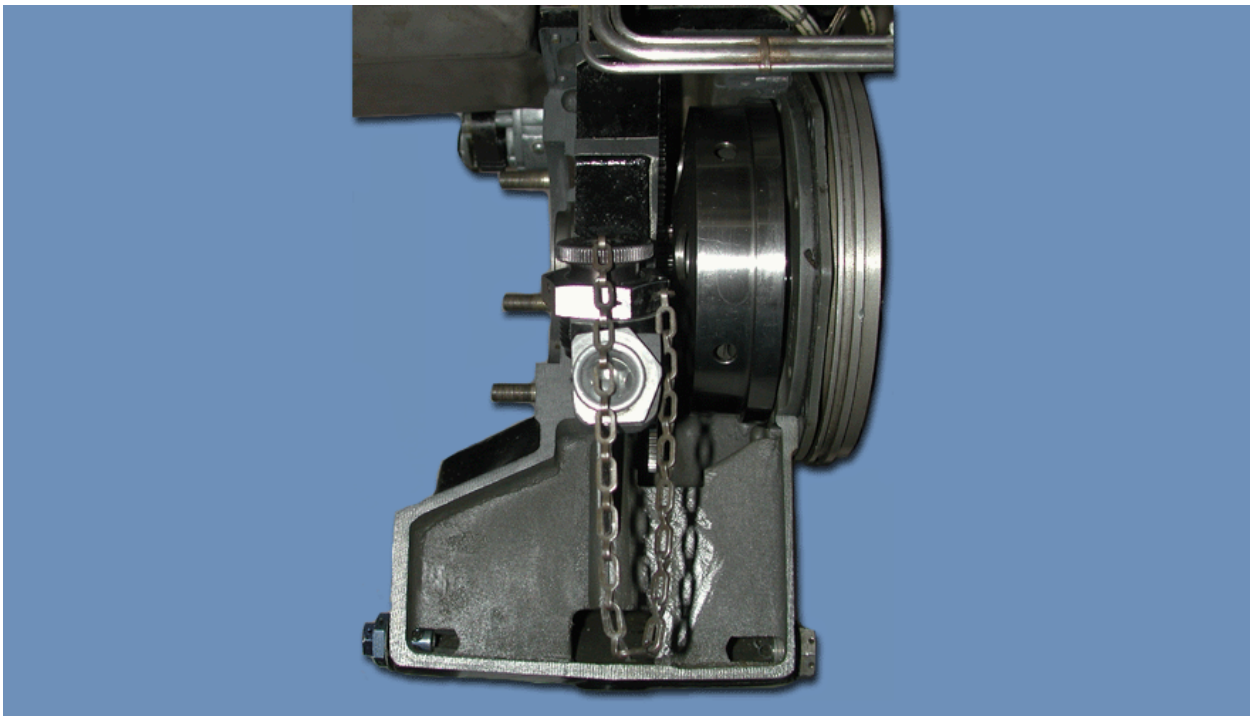
(10) A fully serviced sump should be 1/4 inch below the FULL mark, IAW TM 55-2835-208-23.

(11) When using the modified dipstick, servicing of the APU will be to the indicated full mark on the dipstick.

(12) Over servicing will result in foaming of the oil, causing low oil pressure, and high oil temperatures.

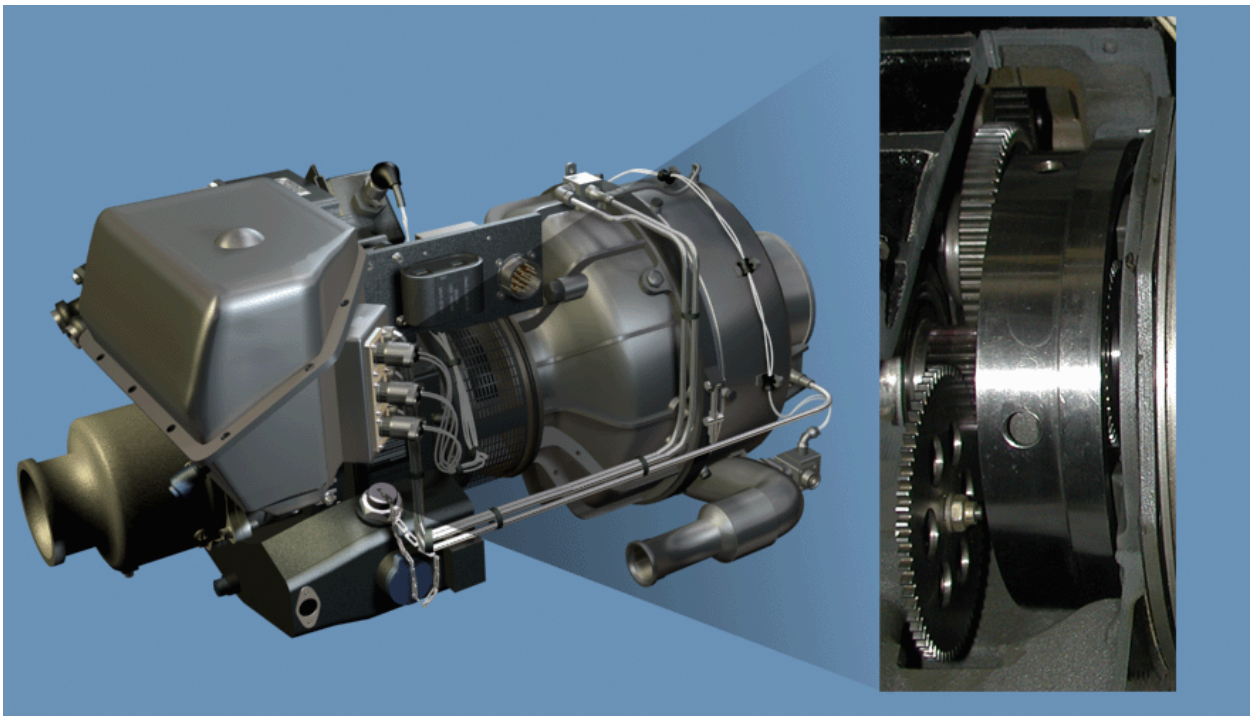
d. Components

Frame #1020 (Lubrication System Components)



(1) The dipstick is used for servicing and checking the oil level of the APU, and is located on the outboard side of the reduction gear drive.

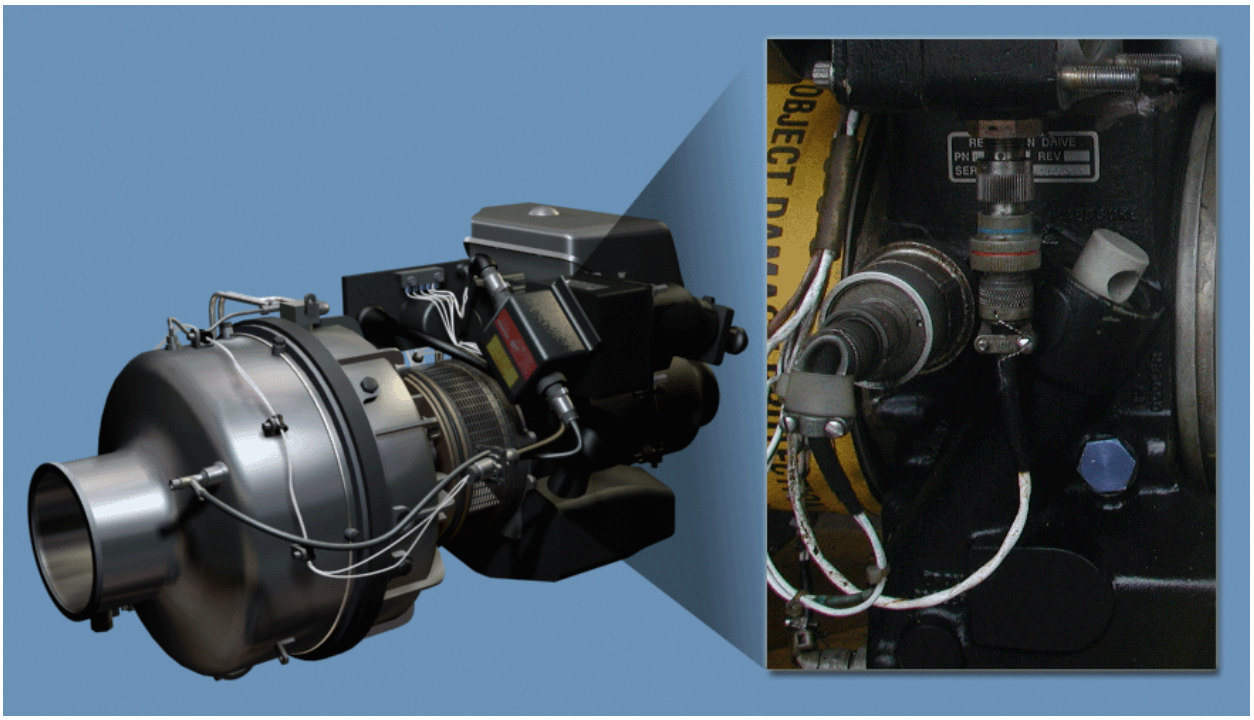
Frame #1025 (Oil Pump)



(2) The oil pump, a gear-type pump, is bolted inside the reduction gear drive.

(a) Driven by an internal planetary gear train, the oil pump draws oil from the oil sump, and pumps it through drilled passages to the oil filter.

Frame #1030 (Oil Filter)



(3) The oil filter is a disposable, 10 micron paper-type filter, mounted in the right side of the reduction drive housing.

(a) Oil filtration occurs as oil passes from the outside to the inside of the filter element.

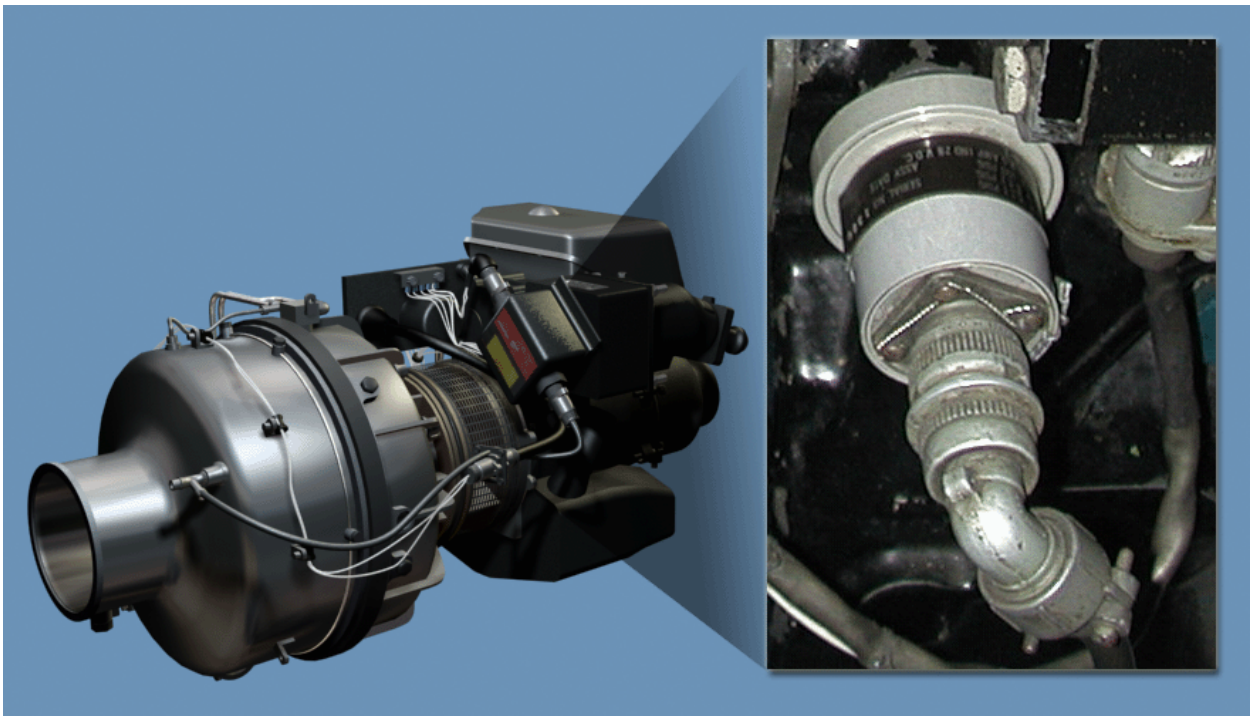
(b) Incorporated with this filter is a bypass valve, which has a differential pressure of 15 - 25 psi.

(c) Located in the housing that serves as a filter cap, is the spring-loaded, ball-type bypass relief valve.

(d) If the filter becomes clogged, and the bypass relief valve is activated, there will be no indications to the pilots.

(e) Only at the 100 hour oil sample and phase, will the oil filter be changed.

Frame #1035 (Oil Low Pressure Switch)



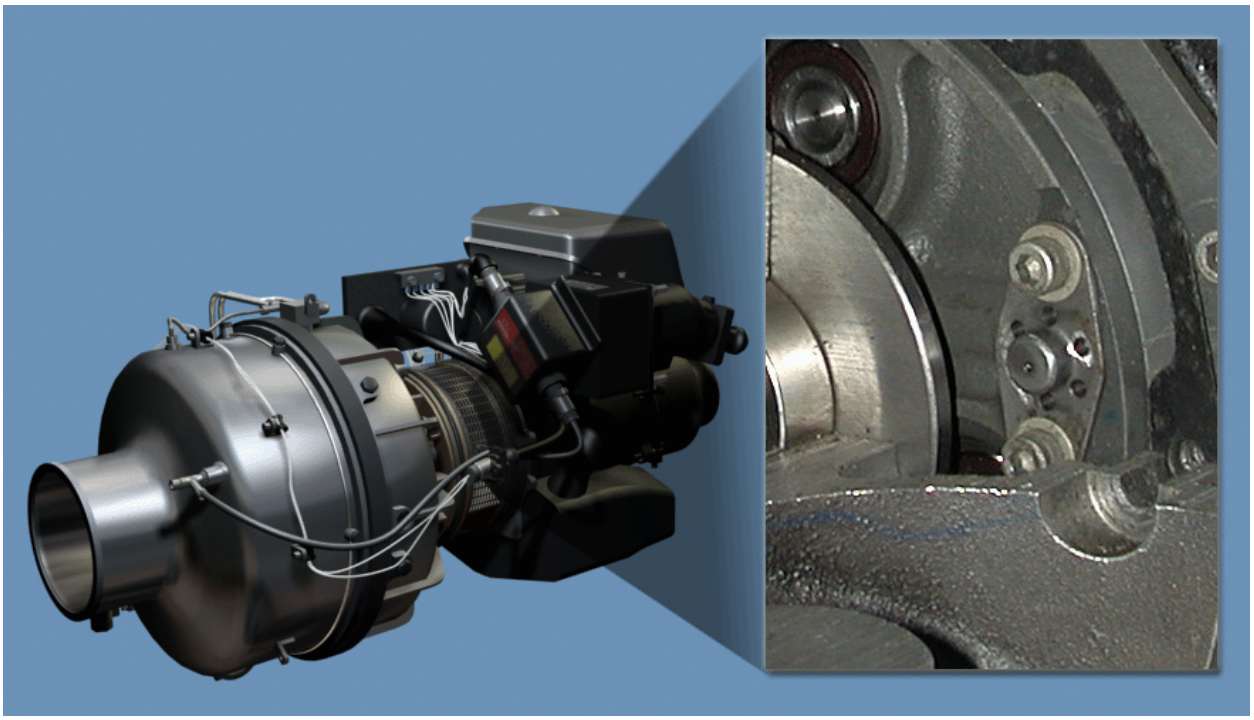
(4) A low oil pressure sensitive switch is located on the right side of the reduction drive housing.

(a) The pressure switch sends a signal to the ESU, which monitors all oil pressure.

(b) The pressure switch is not active up to 70% operating speed. After 70%, if the pressure drops to 6 PSI, ± 1 psi, the ESU will shutdown the APU.

(c) If the APU is shutdown due to low oil pressure, a BITE indication will be visible on the ESU BITE indicators.

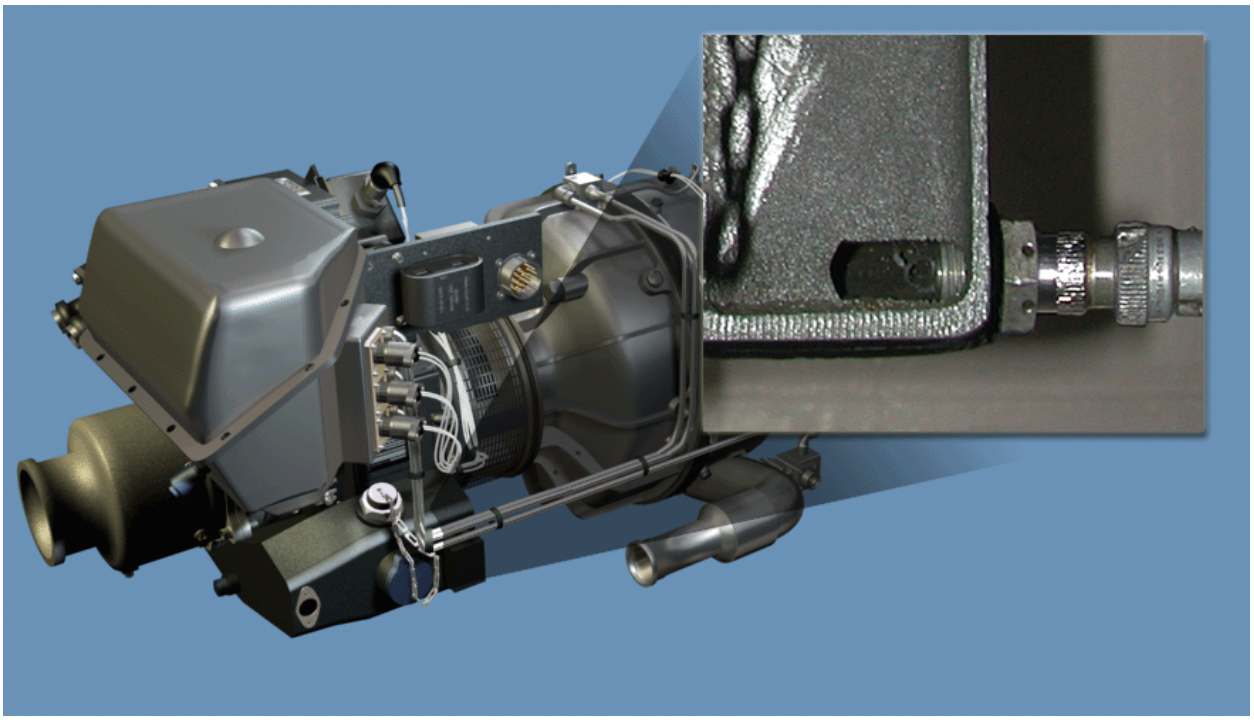
Frame #1040 (Oil Pressure Relief Valve)



(5) The oil pressure relief valve is a spring-loaded, ball type valve, and is located in the main oil gallery, downstream of the oil filter.

(a) The relief valve regulates pressure in the oil system to 15-40 psi, and bypasses excess pressure to the oil sump.

Frame #1045 (Oil Temperature Switch)



(6) Normally a closed contact, the oil temperature switch is temperature sensitive.

(a) Temperatures above 149 ºC will open the contact, sending a signal to the ESU.

(b) The ESU will send a signal to the caution advisory panel, illuminating the APU OIL TEMP HIGH caution light, if the APU is above 90% for more than 1.5 seconds.

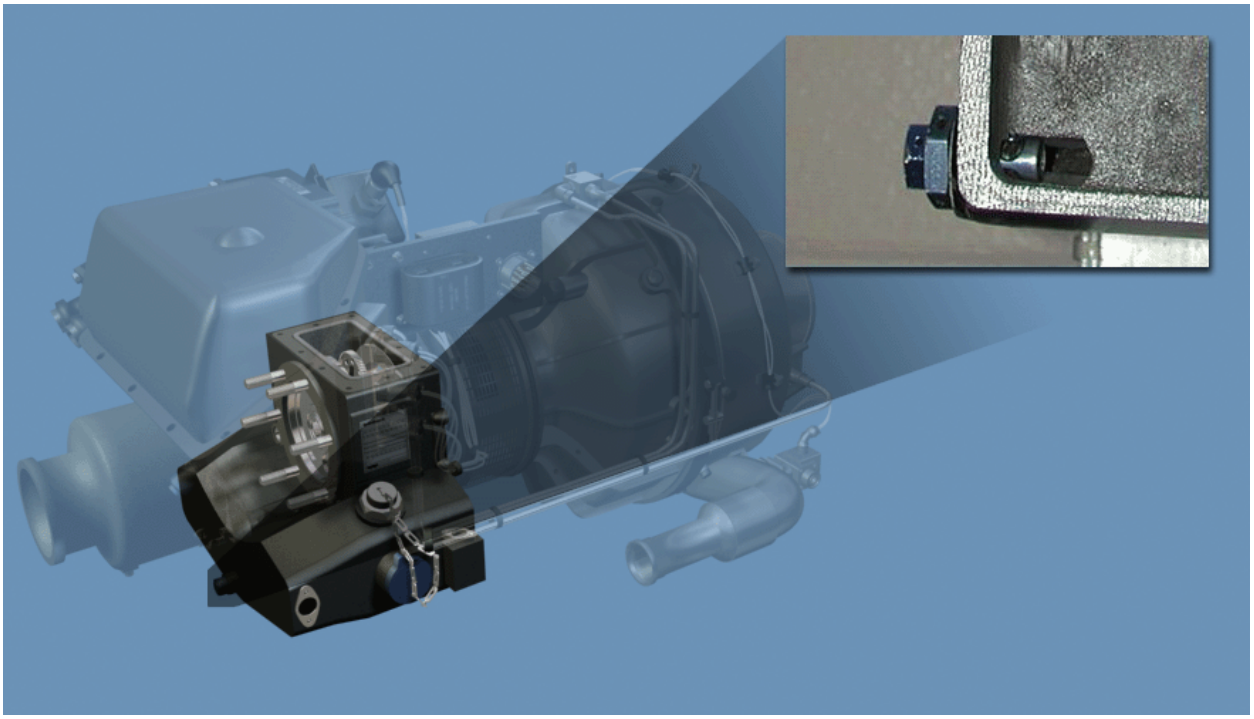
(c) This will not result in a shutdown of the APU, but only give the indication on the caution advisory panel.

(d) To shutdown the APU, a manual shutdown would have to take place.

(e) However, this will prevent a restart of the APU.

(f) Cooling of the oil is accomplished by the oil gravity return to the oil sump, which flows down the inlet wall.

Frame #1050 (Magnetic Chip Detector)



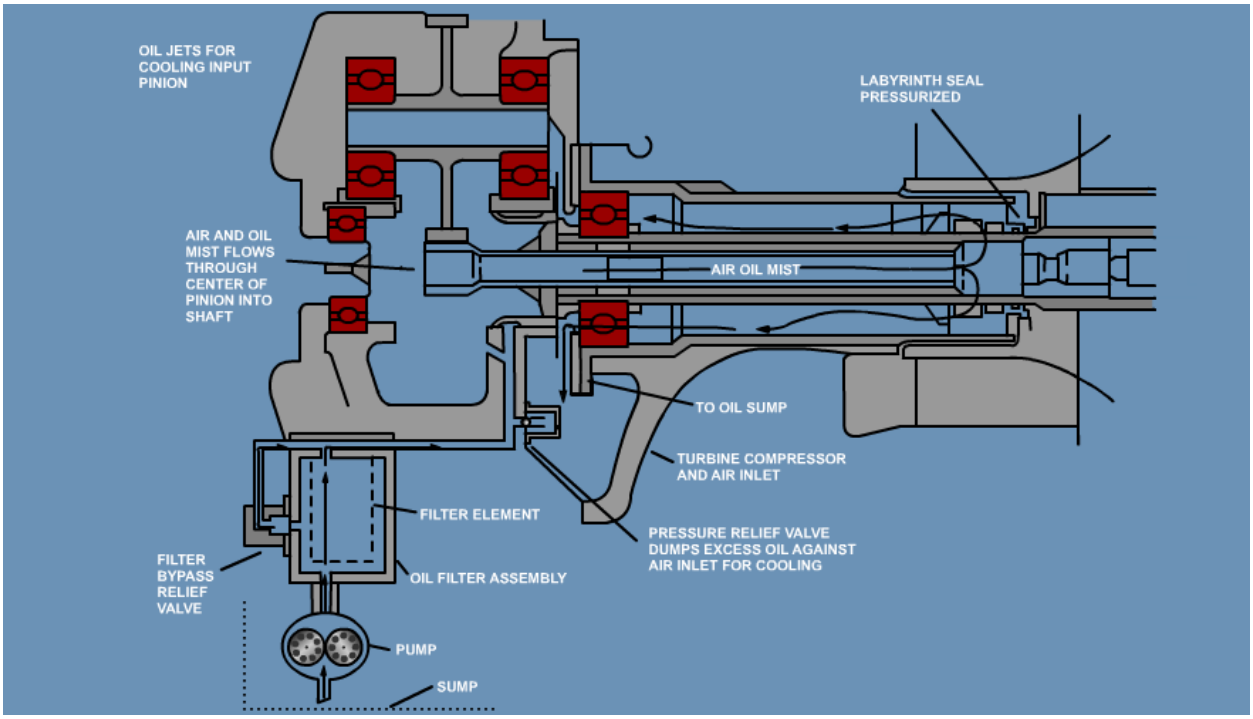
(7) A two-part plug, the magnetic chip detector and plug are mounted in the forward end of the reduction gear drive.

(a) Used to drain oil, and detect magnetic chips in the lubrication system from wear and tear of moving parts, they provide no indications to the cockpit.

(b) Contamination criteria for the lubrication system can be found in the appropriate TM.

e. Function

Frame #1055 (Lubrication System Function FLASH)



(1) The oil pump takes oil from the sump, pushing it into the filter.

(2) At the filter, the oil passes through the outside to the inside of the filter. Should the filter become clogged, the bypass valve is activated when the oil pressure reaches 15-25 psid.

(3) As the oil passes the pressure relief valve, should the oil pressure reach 15-40 psid, the relief valve is activated, allowing excess oil to flow down the inlet wall for cooling back into the sump.

(4) Oil passes to three jet rings, spraying at the junction of the input pinion and the three planetary gears. A fourth jet deflects oil into the hollow shaft of the input pinion.

(5) Air and oil mist flows out the aft end of the shaft through two holes, over the shaft to the roller bearing, ending back inside the drive housing.

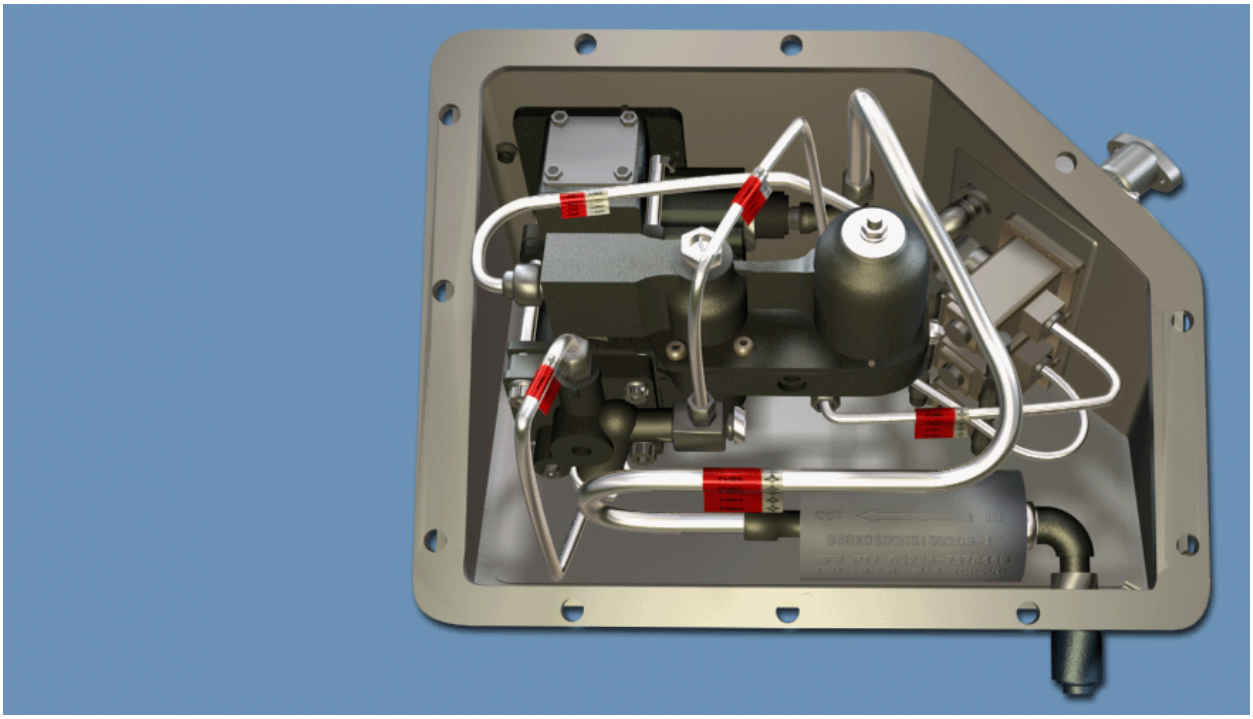
(6) The remaining gears are lubricated by splash oil from the planetary gears and pinion rotation.

(7) When starting the APU, as oil pressure increases to 6 ± 1 psi, the normally closed pressure switch contacts and de-energizes the low oil pressure circuitry to avoid premature shutdown.

(8) If the APU speed is above 70%, the oil pressure circuitry is open, sending a signal to the ESU if the pressure drops to 6 ± 1, shutting the APU down.

f. Fuel System

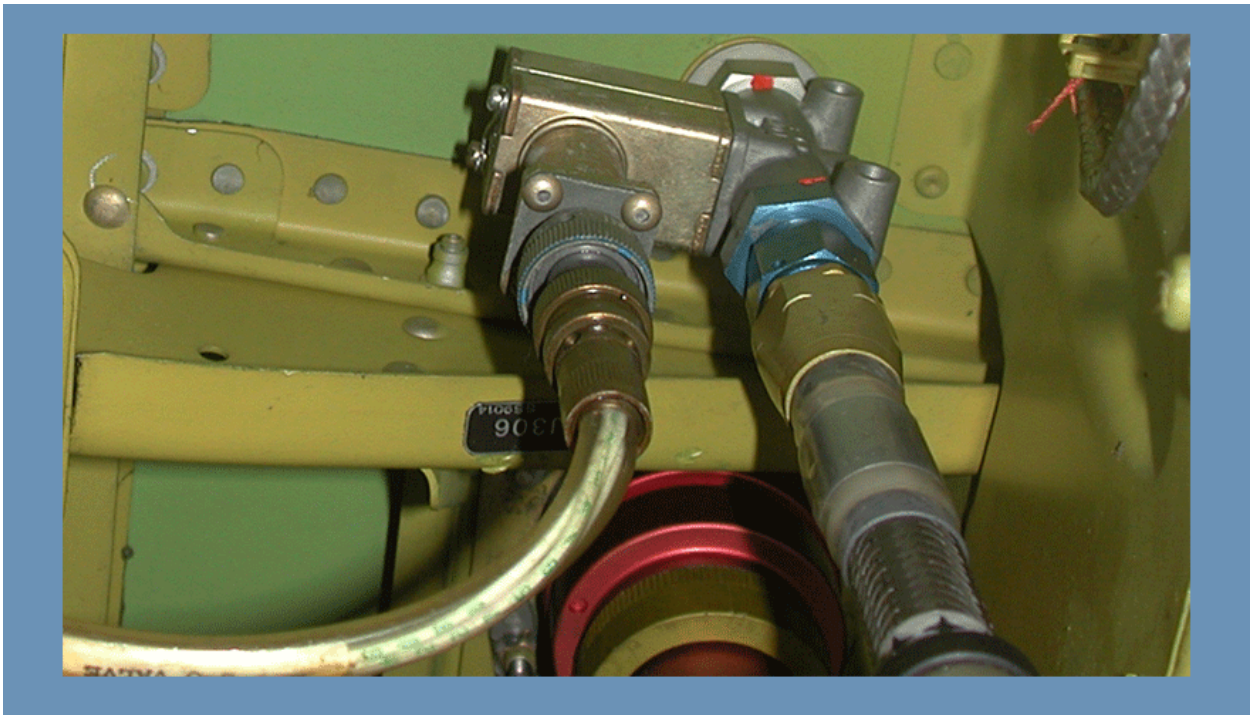
Frame #1100 (Fuel System)



(1) The APU fuel system functions automatically to provide proper engine acceleration, and maintain a near constant operating speed of 61,565 rpm under all operating conditions.

(2) Fuel System Components

Frame #1105 (APU Fuel Shutoff Valve)



(a) APU Fuel Shutoff Valve

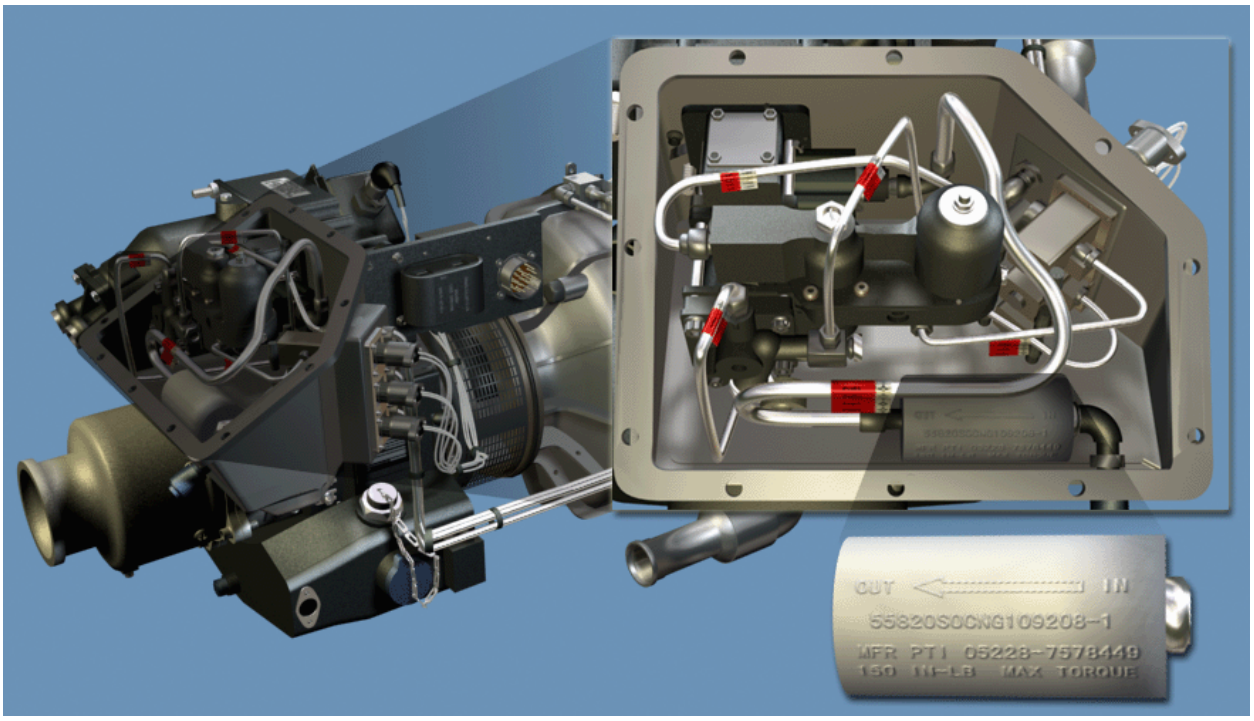
1) The APU shutoff valve is mounted on the ceiling, above the fuel cells, and is electrically opened through the ESU when the APU control switch is placed in the on position.

2) When the valve is open, fuel flows to the fuel inlet filter from the No. 1 fuel cell, and through the fuel line directed through the deck.

3) The shutoff valve is pressurized by the main fuel system prime boost pump.

(b) Fuel Filter

Frame #1110 (Fuel Filter)



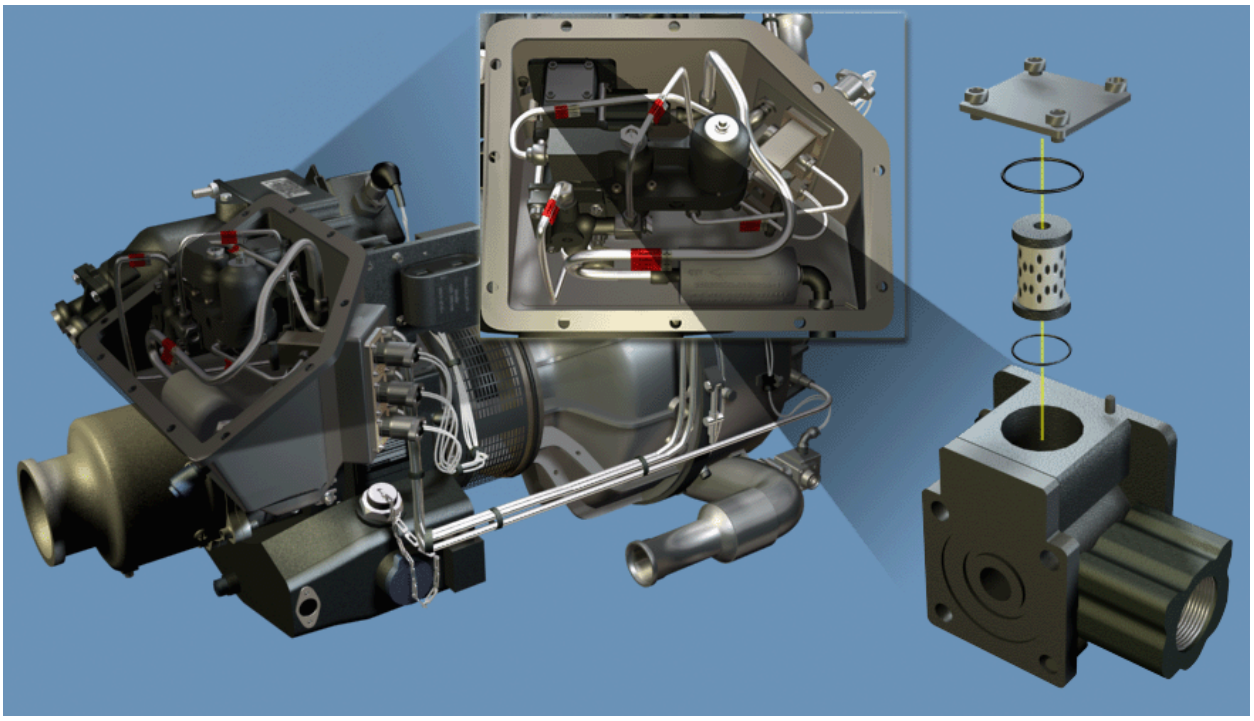
1) Once fuel has passed the APU shutoff valve, it passes through a disposable 10-micron pressure fluid filter located in the APU fuel control.

2) Should the APU fail to start, check the filter.

3) The fuel inlet filter is replaced during a 500 hour inspection.

(c) Fuel Pump

Frame #1115 (Fuel Pump)



1) The fuel pump, one of two components, is a gear type pump, driven by the accessory gear drive.

2) The pump produces 400 PSI at rated speed, and contains a 25-micron, cleanable filter.

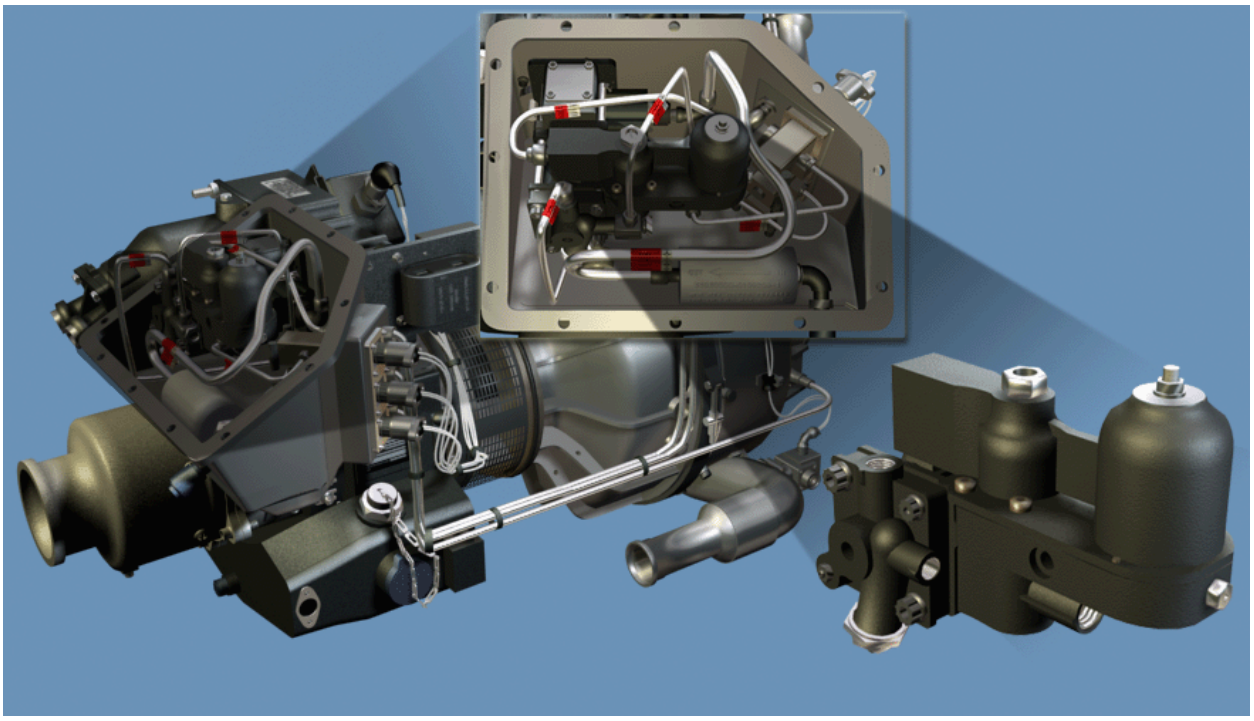
3) Internal pressure regulating valves maintain the outlet pressure of 350 - 400 PSI.

4) If metal particles are found, or the filter is clogged, replace the pump.

5) Scheduled replacement, or cleaning of the fuel filter is done during the phase inspection.

(d) Acceleration Control Assembly

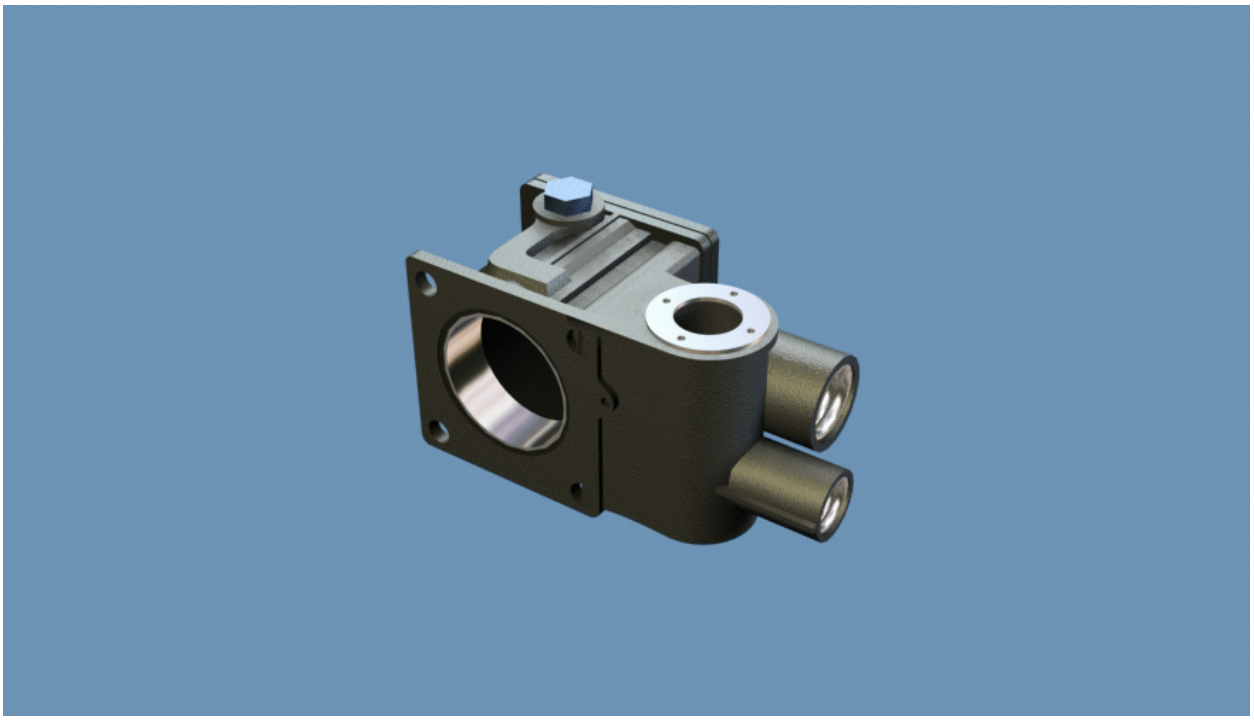
Frame #1120 (Acceleration Control Assembly)



1) The acceleration control assembly is mounted to the front of the fuel pump, and controls the amount of fuel supplied to the fuel nozzles.

(e) Governor Housing

Frame #1121 (Governor Housing)

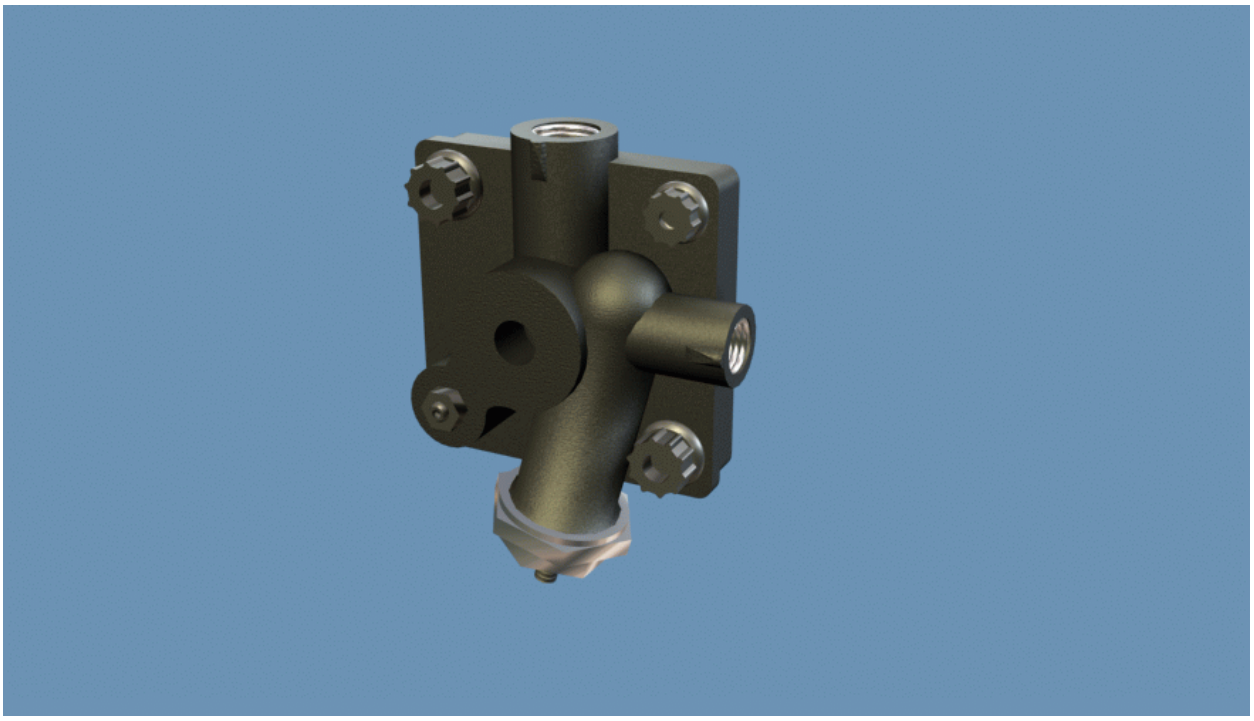


1) The governor housing is driven by the fuel pump, incorporating a differential pressure-regulating valve that maintains a differential pressure (proportional to Compressor Discharge Pressure[PCD]) across a fuel-metering valve.

2) The governor housing works in combination with a flyweight-actuated metering valve (function of rpm) controlling the fuel flow to the combustor.

(f) Fuel Control Housing

Frame #1122 (Fuel Control Housing)

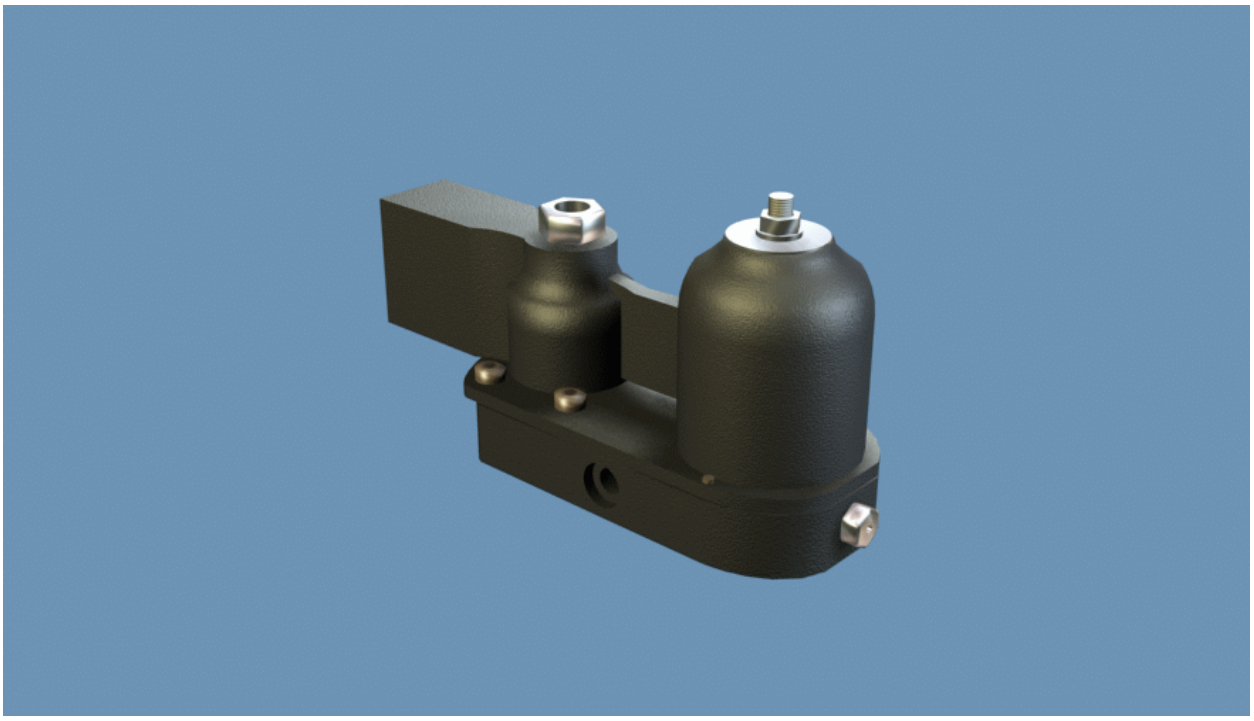


1) Secured to the forward face of the governor housing, the fuel control housing contains a fuel metering valve assembly, and a minimum flow orifice.

2) The fuel metering valve assembly is controlled by the governor housing, while the minimum flow orifice controls the fuel flow during a sudden loss of compressor discharge air.

(g) Bellows Cover Assembly

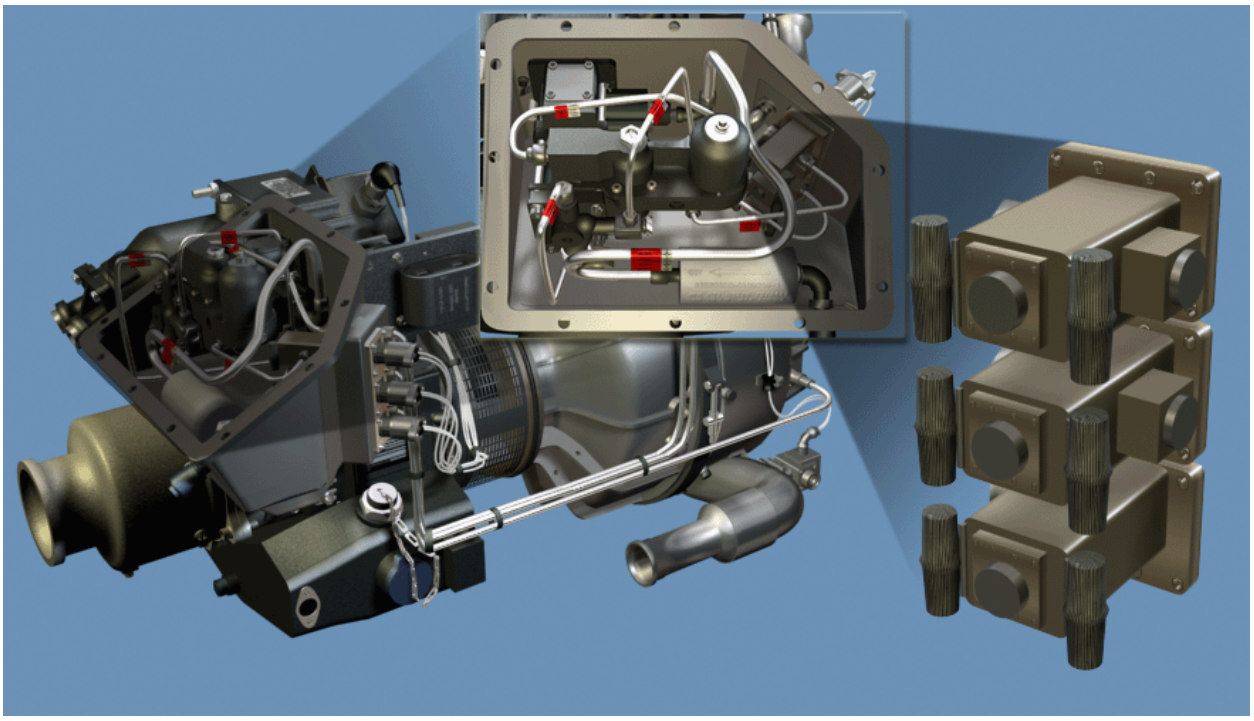
Frame #1123 (Bellows Cover Assembly)



1) The bellows cover assembly contains a sealed altitude compensator bellows and a differential pressure bellows that mechanically controls the governor fuel-metering valve in relation to changes in the compressor discharge pressure.

(h) Fuel Solenoid Valves

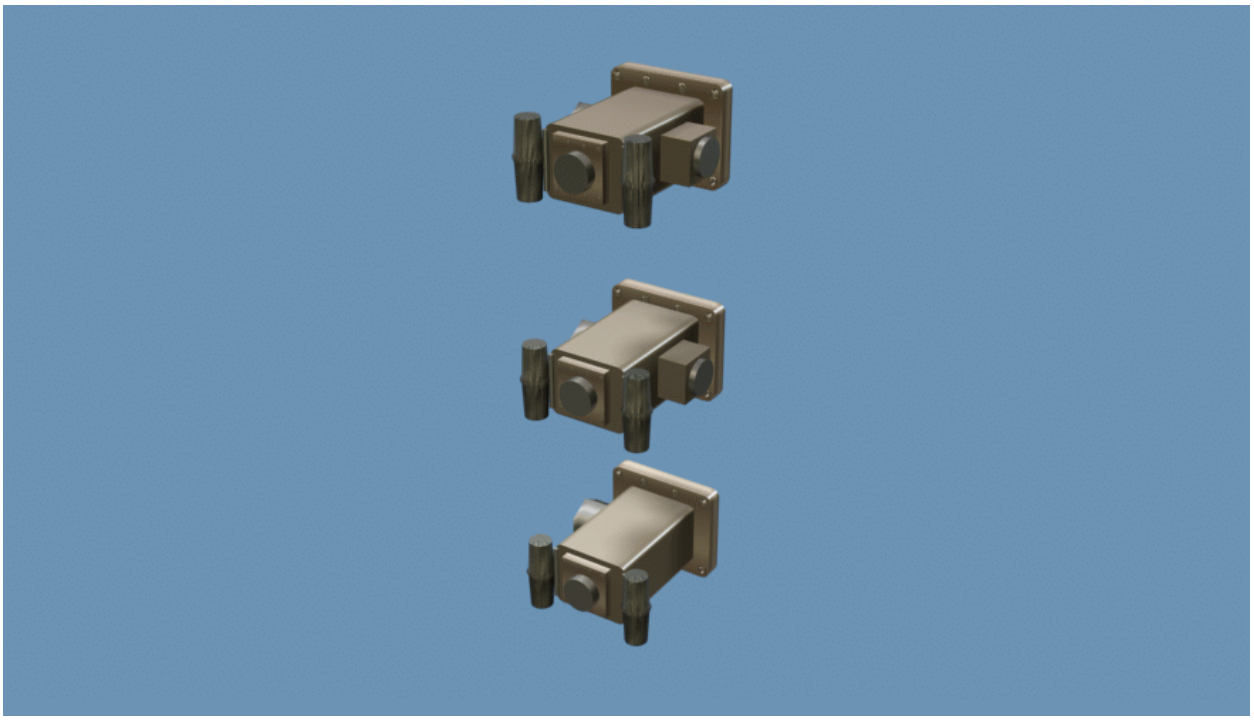
Frame #1125 (Fuel Solenoid Valves)



1) There are three fuel solenoid valves: main, start, and maximum, controlled by the ESU.

(i) Fuel Solenoids

Frame #1126 (Fuel Solenoids)



1) The start fuel solenoid valve opens at 5% rate of speed to allow fuel to flow to the start nozzle, and closes at 70% rate of speed.

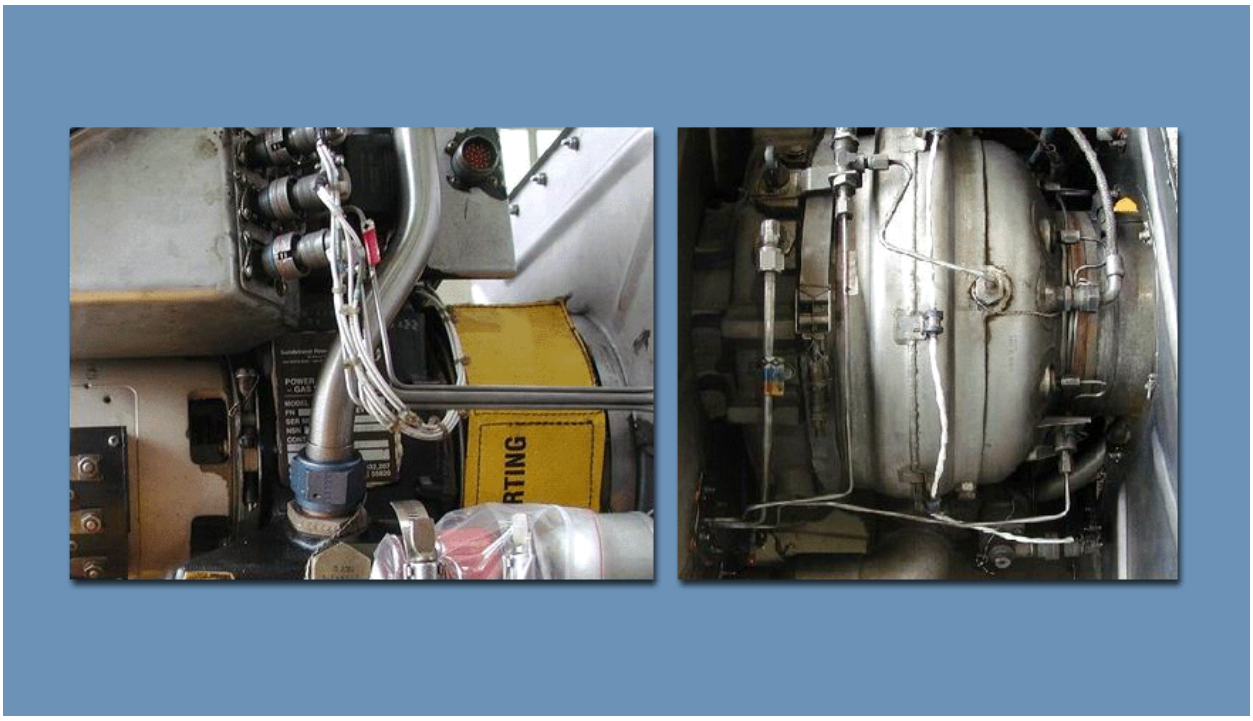
2) The main fuel solenoid valve opens at 14% rate of speed to allow fuel to flow to the fuel manifold, and closes when the APU control switch is turned to the OFF position.

3) The maximum fuel solenoid valve opens at 90% rate of speed, ±5 seconds, and closes when the APU control switch is turned to the OFF position.

4) When open, fuel bypasses the acceleration adjustment needle. The fuel flows through the same plumbing as the main fuel to the fuel manifold.

(j) Fuel Lines

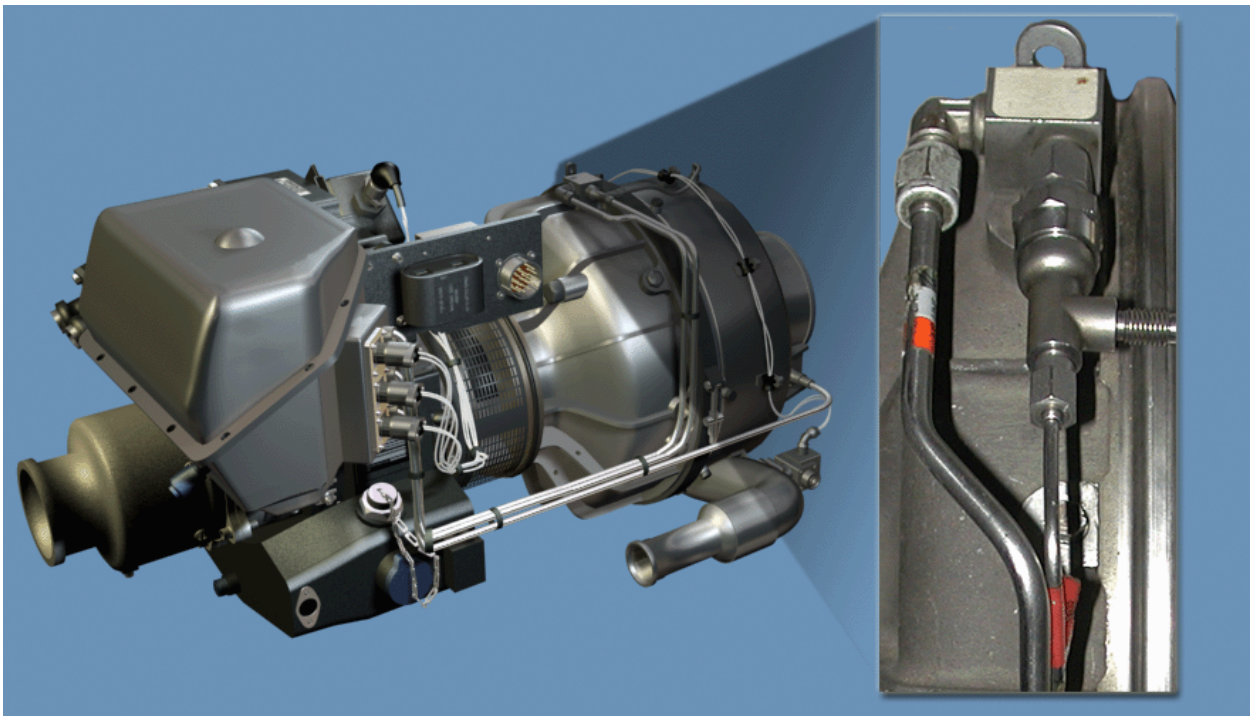
Frame #1130 (Fuel Lines)



1) The start, and main fuel lines are steel rigid tubing that supply fuel from the fuel solenoid valves to the start nozzle, and the fuel injectors.

(k) Fuel Purge Valve Assembly

Frame #1135 (Fuel Purge Valve Assembly)



1) The purge valve assembly prevents the build up of varnish at the start nozzle.

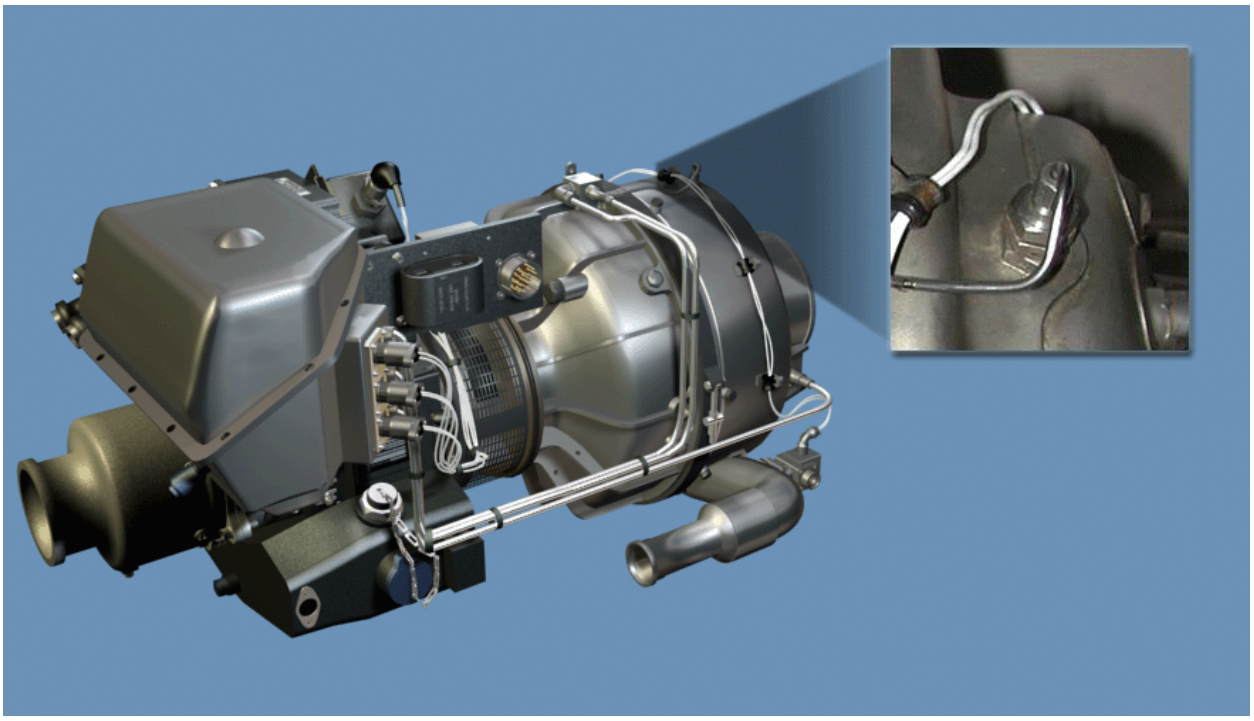
2) The build up of varnish is created from evaporating fuel on the start fuel nozzle during the operation mode of the APU.

3) During the APU operation mode fuel is not flowing to the start fuel nozzle.

4) PCD air passes through the start fuel nozzle, purging residual fuel, and cooling the nozzle.

(l) Start Fuel Nozzle

Frame #1140 (Start Fuel Nozzle)

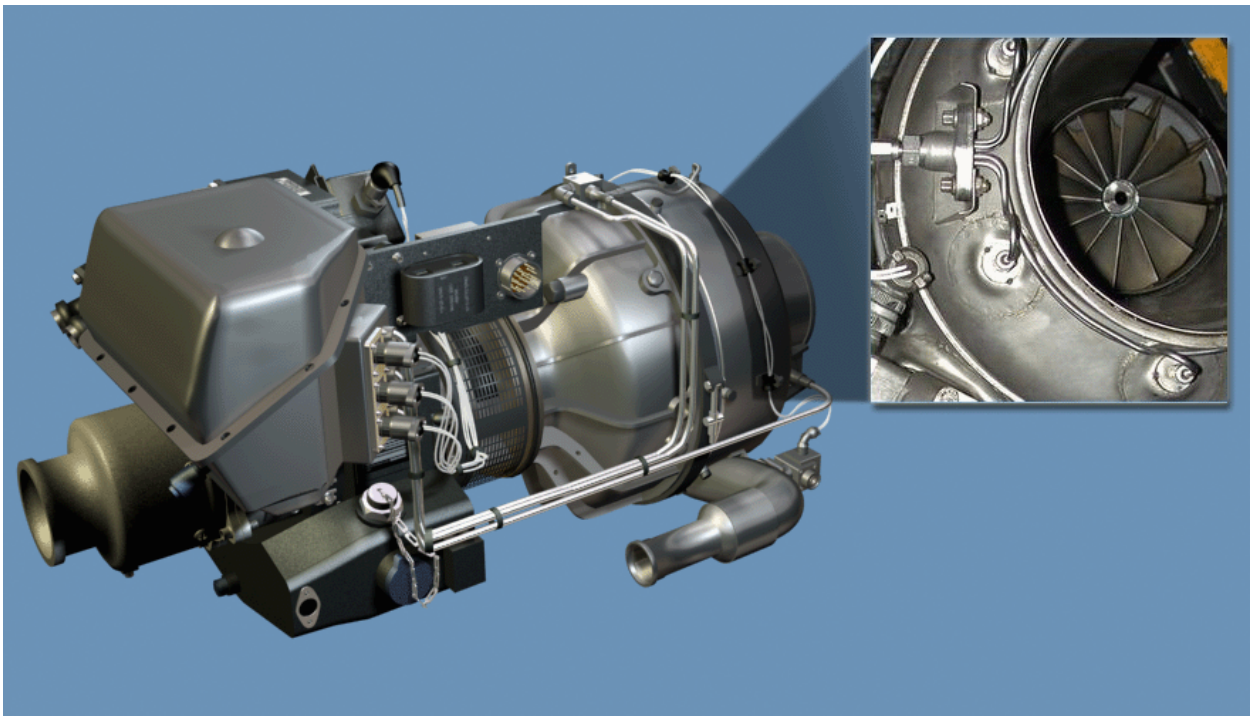


1) During the APU start sequence, the start fuel nozzle sprays atomized fuel into the combustor in line with the spark plug at 5% rate of speed.

2) At 70% rate of speed, the fuel supply to the start fuel nozzle shuts down.

(m) Main Fuel Manifold

Frame #1145 (Main Fuel Manifold)



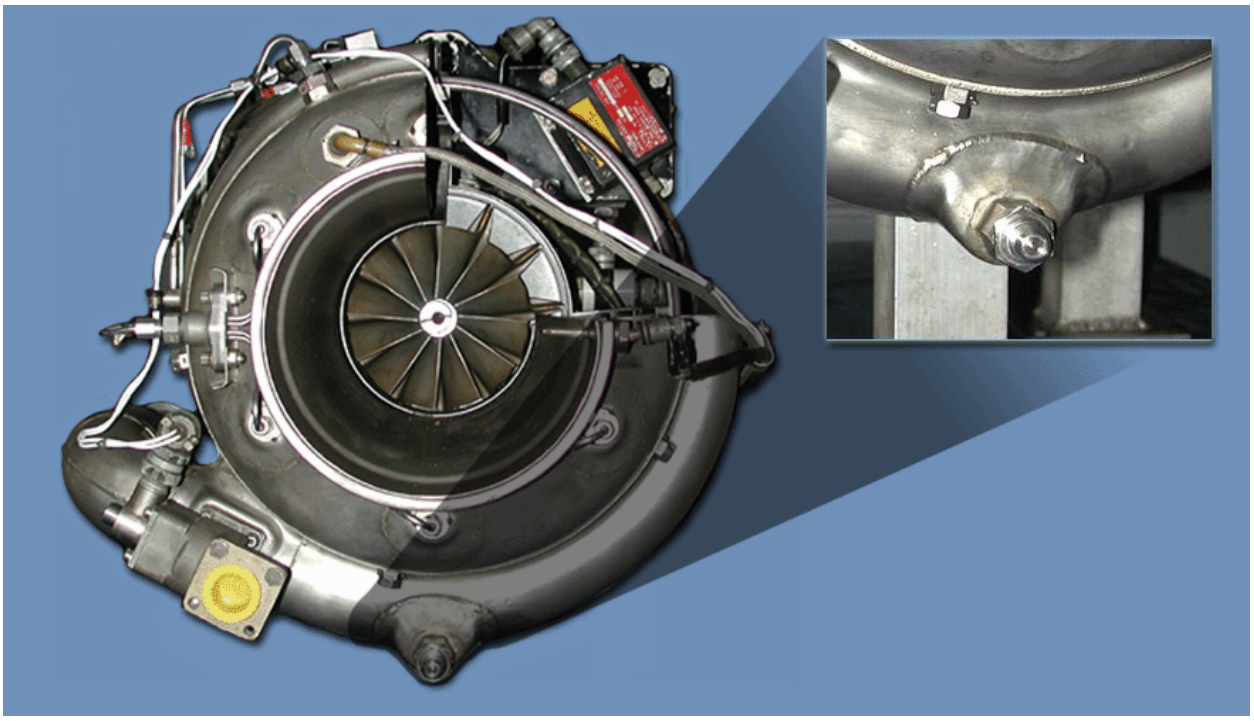
1) The main fuel manifold and injectors are located on the combustor assembly.

2) There are a total of six injectors that begin to spray fuel into the combustor assembly at 14% rate of speed, during the start sequence, and continue till APU shutdown.

3) The six injectors are each connected to a single fuel line by six separate fuel lines, forming the main fuel manifold.

(n) Combustor Drain Valve

Frame #1150 (Combustor Drain Valve)

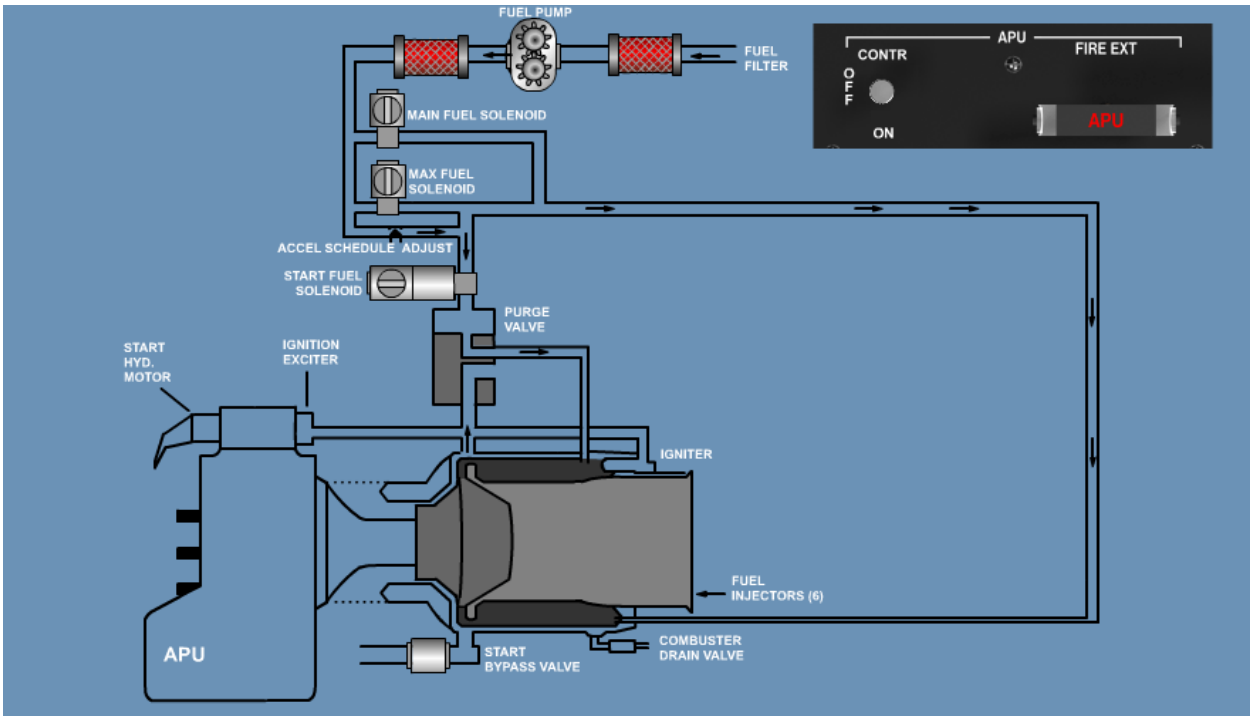


1) Located at the lowest point of the combustor assembly is the combustor drain valve.

2) This valve drains residual fuel from the combustor during shutdown, preventing pooling of fuel.

g. Fuel System Operation

Frame #1155 (Fuel System Operation FLASH)



(1) When the APU control switch is placed in the ON position, electrical power is applied to the APU shutoff valve.

(2) The APU shutoff valve opens, allowing fuel, under pressure, to flow to the APU fuel control assembly.

(3) Fuel is pressurized by the fuel pump, and supplied to the acceleration control assembly.

(4) The ESU determines when fuel will be allowed to pass to the combustor for ignition, by controlling the operation of the fuel solenoid valves (start, main, and maximum).

(5) Once the ESU opens these valves, fuel is regulated by the acceleration control assembly, which uses PCD to determine fuel demand.

(6) Fuel supply is removed for shutdown by placing the APU control switch to OFF, by ESU control of the solenoid valves in the event of an APU malfunction, or by the APU FIRE T-handle.

h. Electrical System

Frame #1200 (Electrical System)

(1) The electrical system consists of several engine-mounted components, an interface utilizing airframe electrical power sources, and components, including switches and indicating lights.

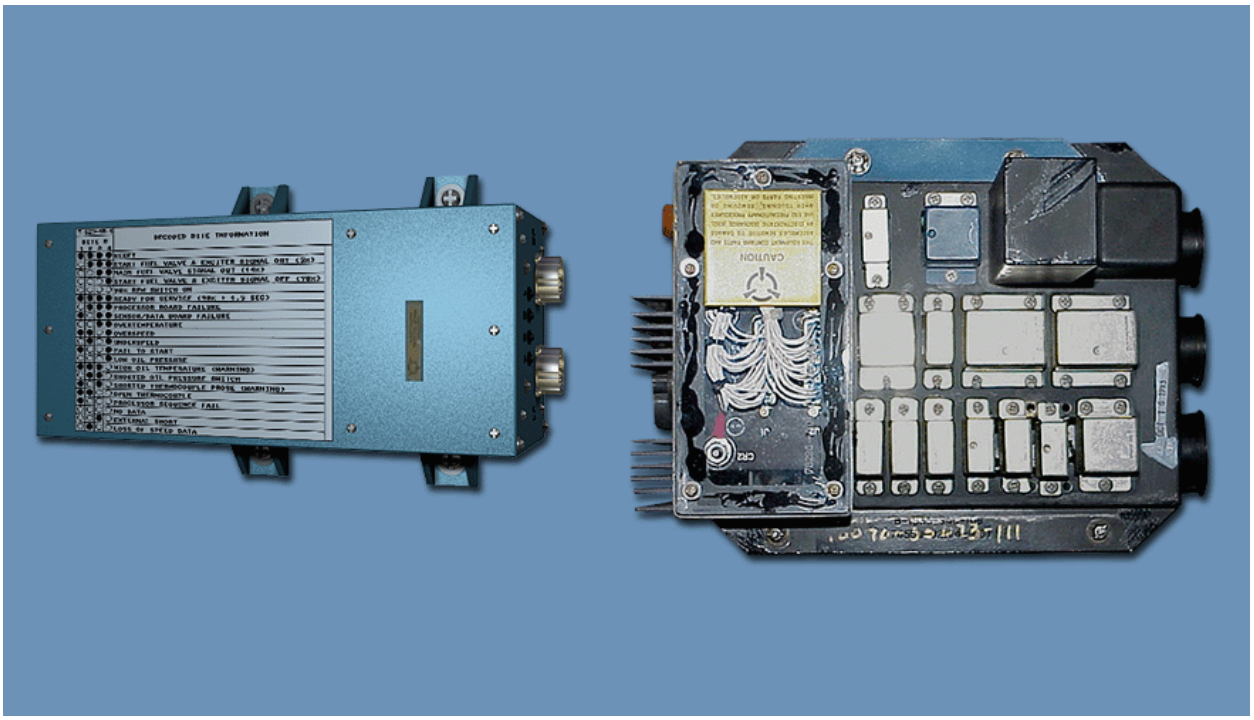
(a) Airframe Power Sources

Frame #1205 (Airframe Power Sources)

1) Airframe power sources provide 14 - 30 vdc, which is required for starting, and normal operation of the APU.

2) The primary source of the APU electrical system is the battery bus, while the backup power source is the battery utility bus.

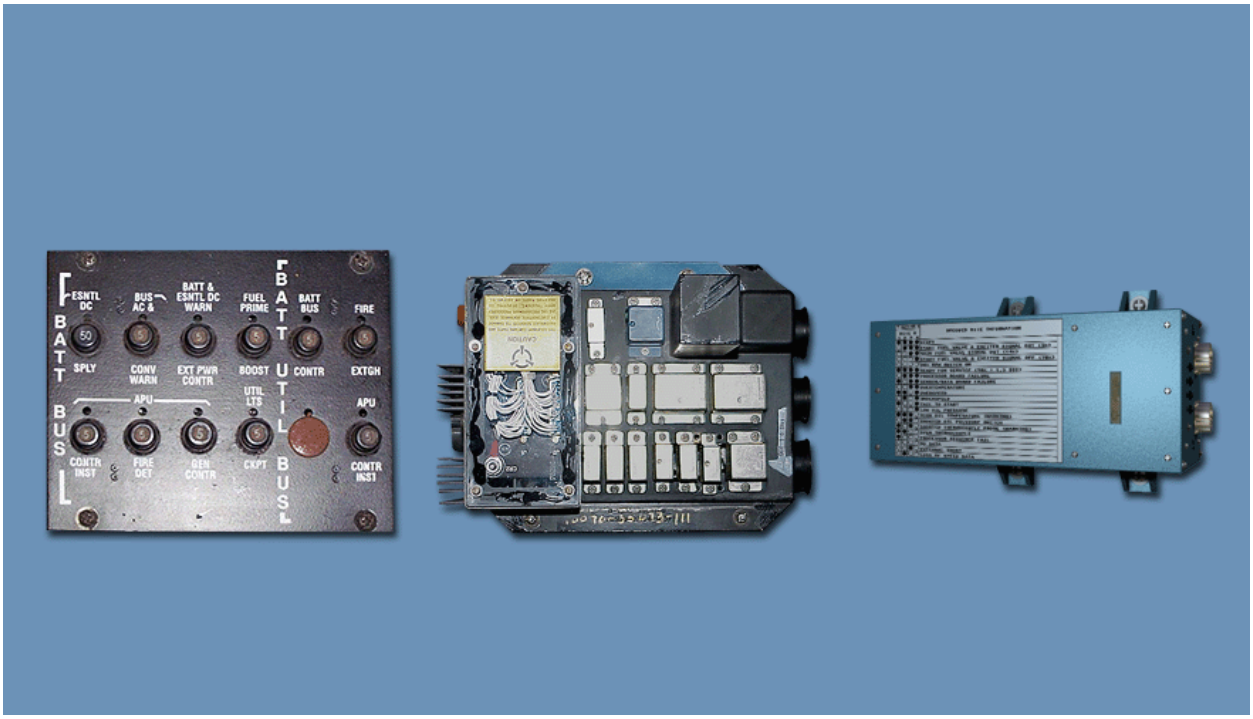
Frame #1210 (Power Transfer System)



3) The power transfer system is utilized by the electrical system to ensure a continuous power supply to the ESU.

4) The power transfer system consists of a K47 relay (APU power transfer relay), located in the left hand relay panel, dc power sources, and associated electrical wiring.

Frame #1211 (Battery Bus/Left Hand Relay/ESU)

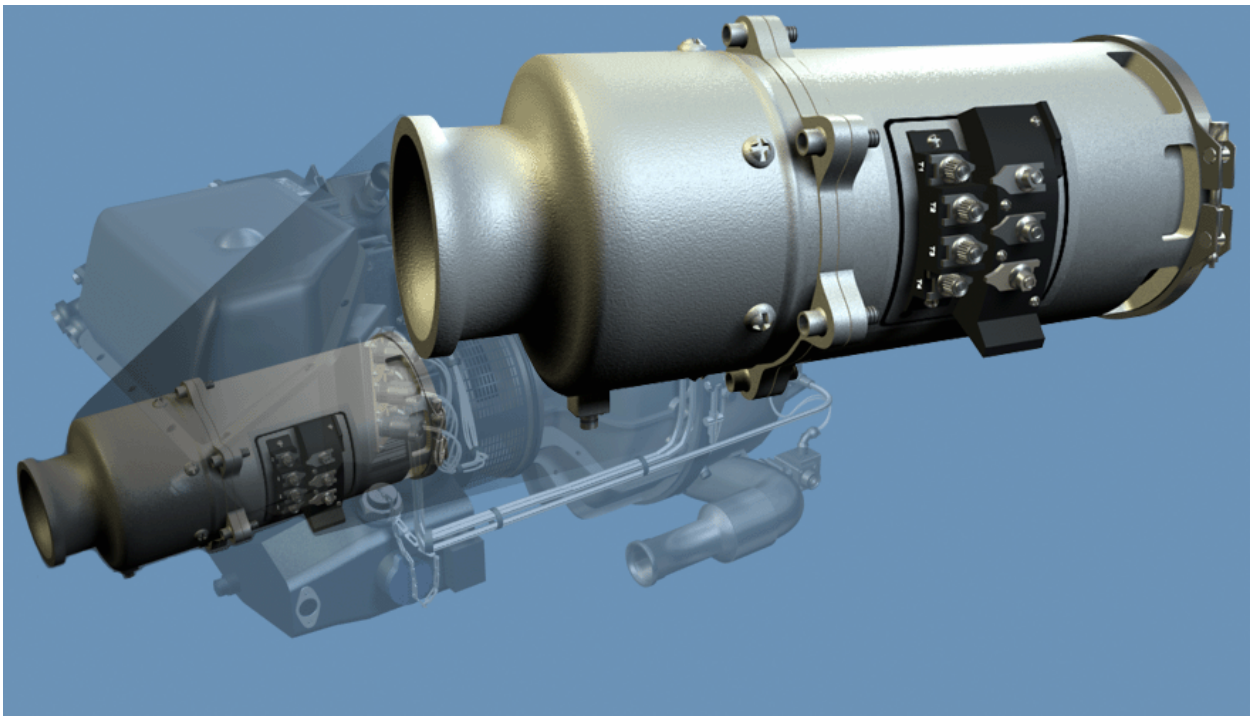


5) During normal operation, the battery bus provides 28 vdc to energize the K47 relay, and power to the ESU.

6) To avoid shutdown, the K47 relay, also known as the 0.5 second time delay relay, utilizes the battery utility bus power to ensure uninterrupted power to the ESU, while holding itself closed for approximately 0.5 second.

(b) APU Mounted Components

Frame #1215 (APU Generator)



1) The APU generator (an air cooled, brushless style generator) is mounted to the reduction drive assembly of the APU, and is driven whenever the APU is operating.

2) The APU generator is rated at 20/30 Kilovolt-Ampere (KVA) at 115/200 volts.

3) It comes equipped with a four wire output, utilizing a grounding neutral, and a three phase alternating current.

4) The APU generator is shaft driven by the reduction drive assembly.

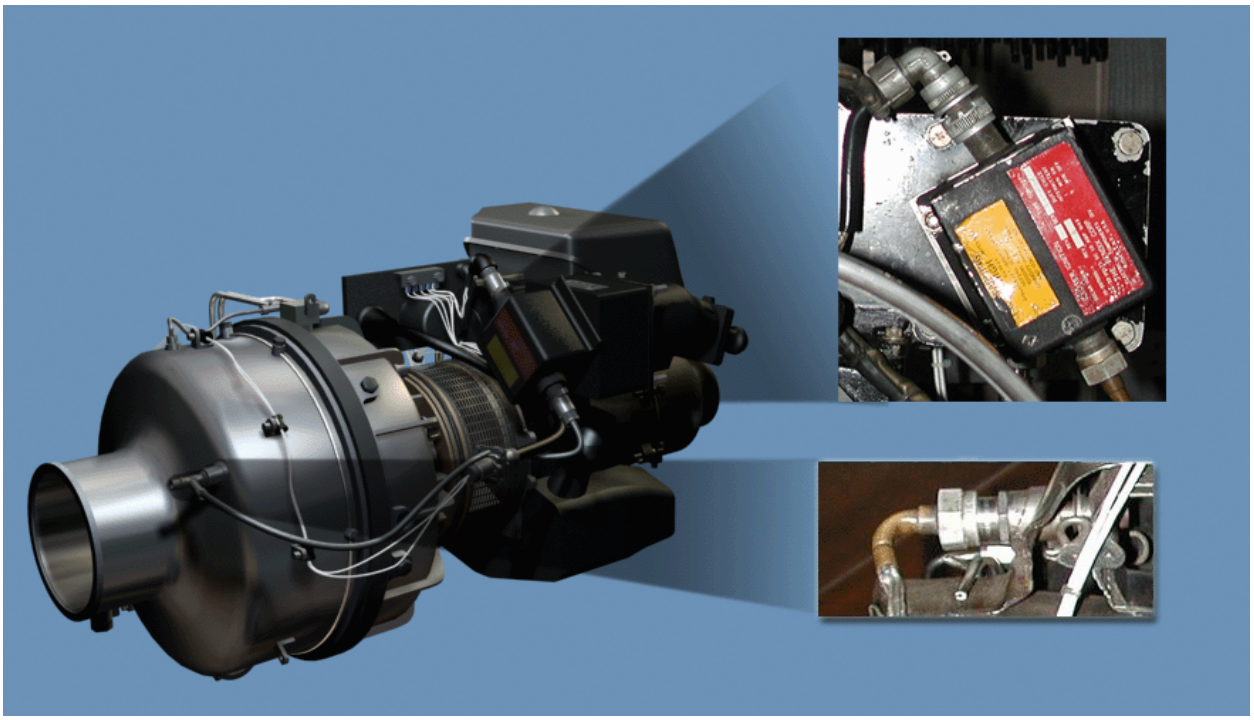
5) Connected by a spline adapter, it normally operates at 12,000 rpm to maintain an output frequency of 400 Hz.

6) The APU generator is cooled by drawing air in at the forward end, and exhausting it at the drive end.

Frame #1219 (Generator Control Unit)

7) APU generator output voltage is regulated by a voltage regulator within the APU Generator Control Unit (GCU).

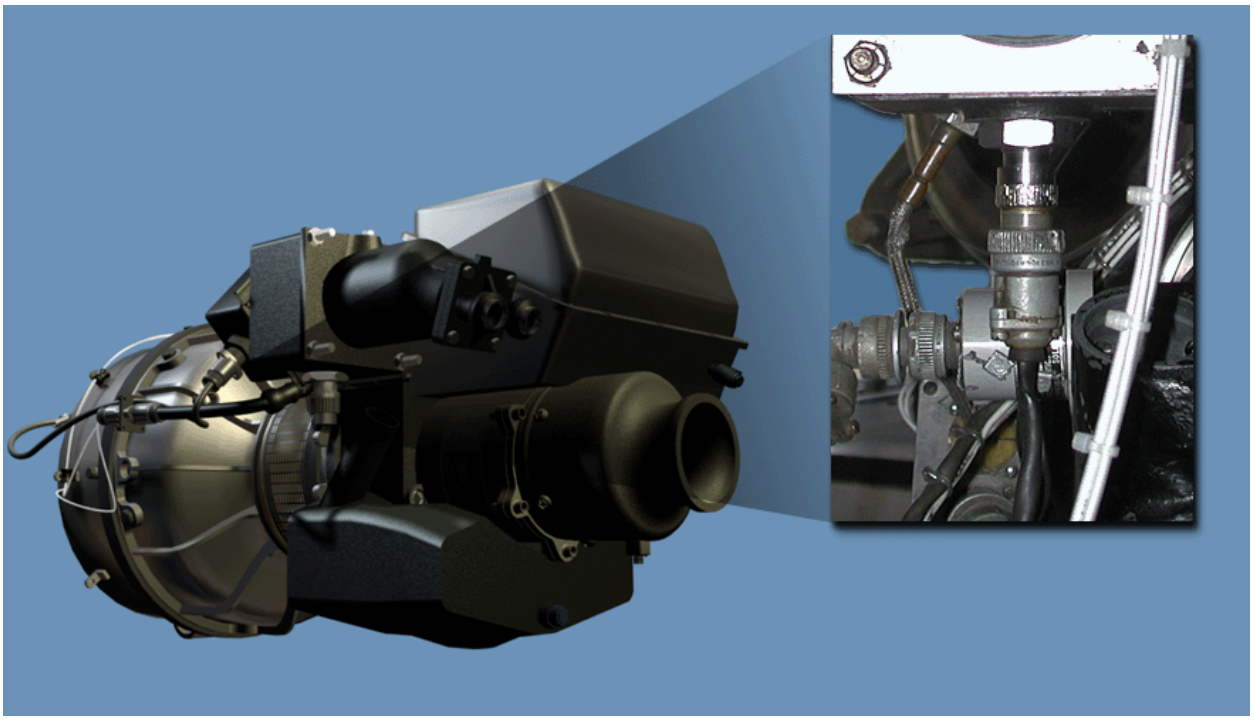
Frame #1220 (Ignition Exciter/Spark Plug)



8) The ignition exciter, a capacitor discharge type exciter, converts DC input into high energy AC to the spark plug.

9) The spark plug, a shunted surface, gap type igniter, is used to produce a spark to ignite fuel during the start sequence.

Frame #1225 (Magnetic Pickup)

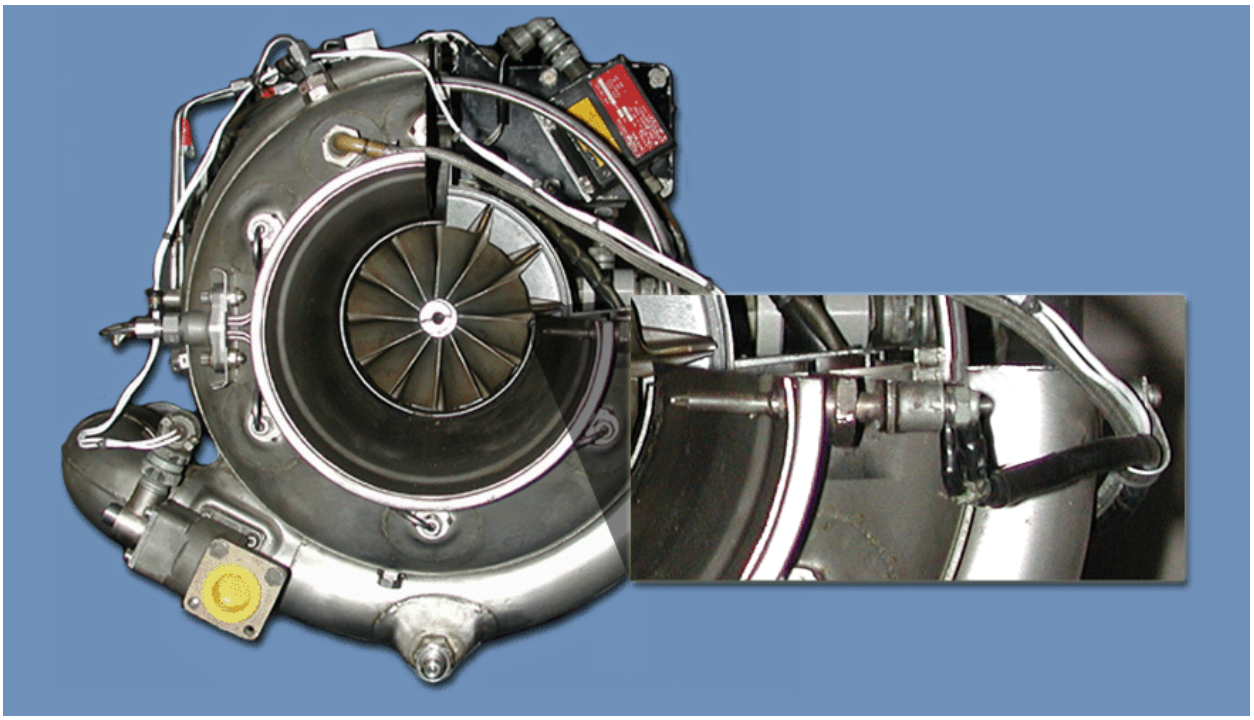


10) The magnetic pickup generates a magnetic field, which is broken by the gears turning in the accessory drive assembly.

11) As the gears pass the magnetic pickup, the speed at which they pass sends a speed signal to the ESU.

12) The speed signal is used to control the APU functions, and interprets the signal into compressor speed (Ng) rpm.

Frame #1230 (Thermocouple)

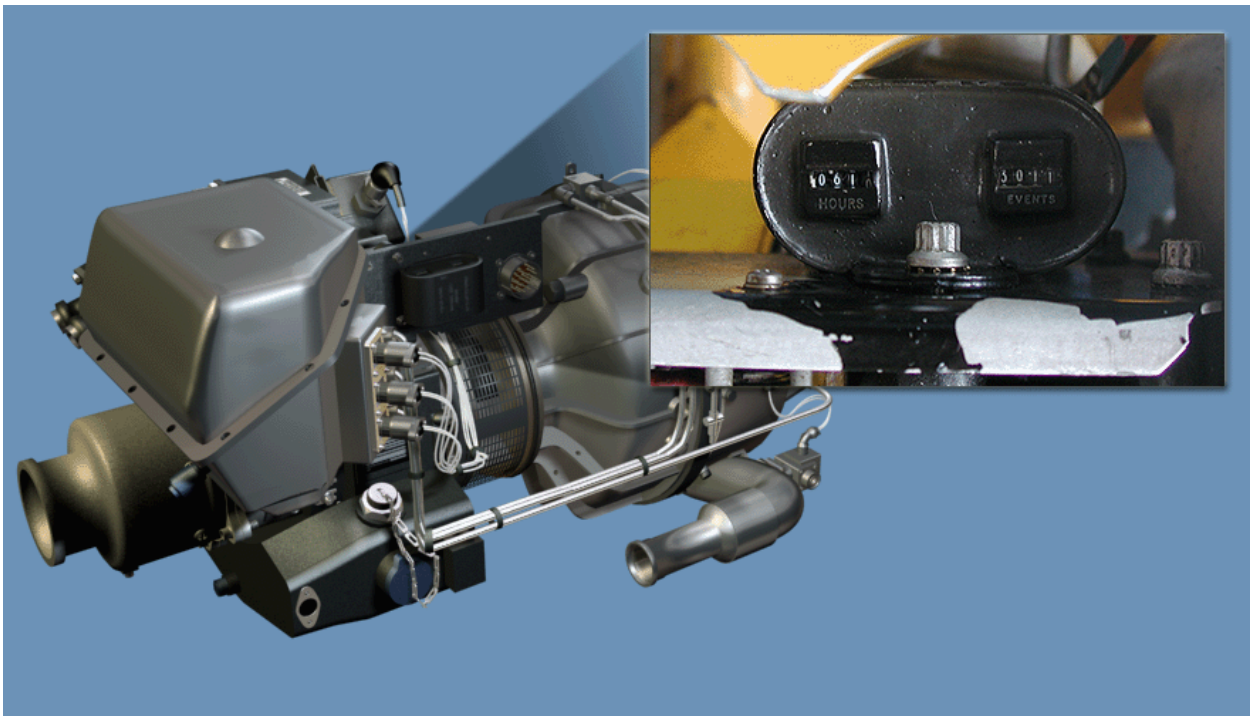


13) The thermocouple is a single element, chrome/aluminum, and is part of the electrical harness.

14) The thermocouple senses the Exhaust Gas Temperature (EGT), and provides the signal to the ESU.

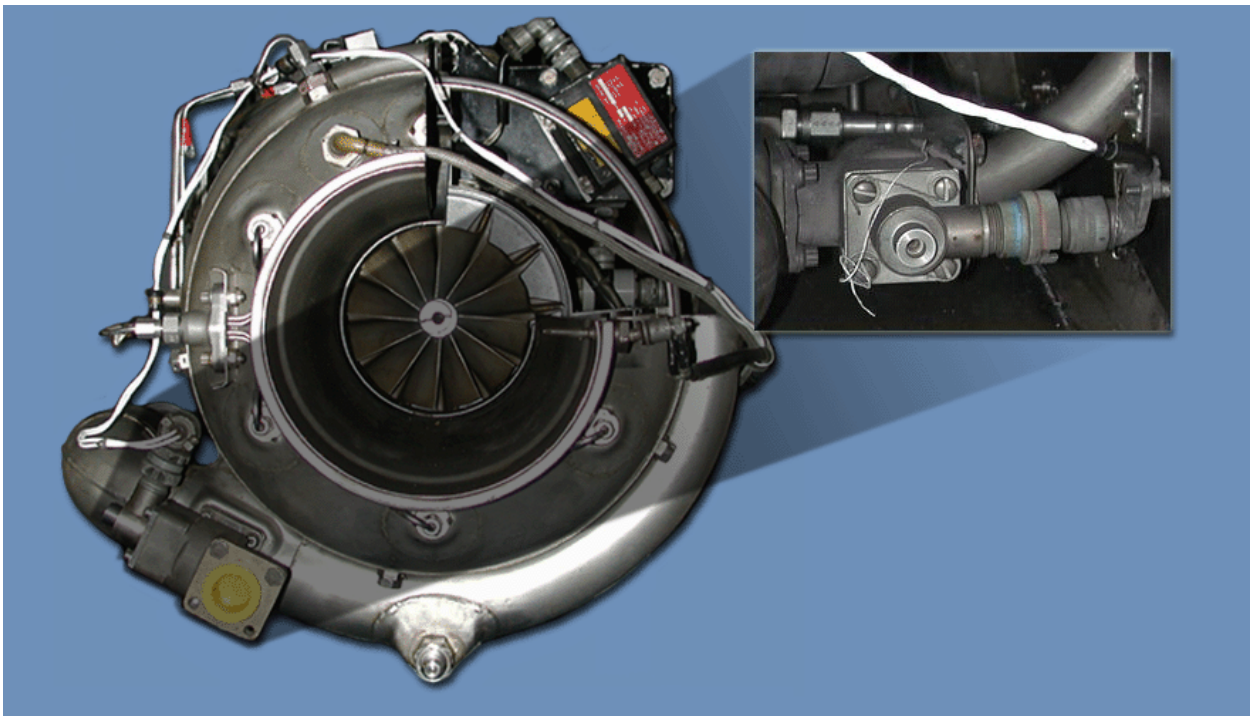
15) The output signal is used by the ESU for overtemperature protection and will shut down the APU if the EGT exceeds safe limits.

Frame #1235 (Meter Assembly)



16) The meter assembly provides accurate tracking of the APU operational hours, and number of starts (events) for the purposes of maintenance, inspection, and warranty coverage.

Frame #1240 (Start Bypass Valve)



17) The start bypass valve is electronically controlled by the ESU.

18) During normal operations, the start by pass valve is open. During engine start, the start by pass valve is closed.

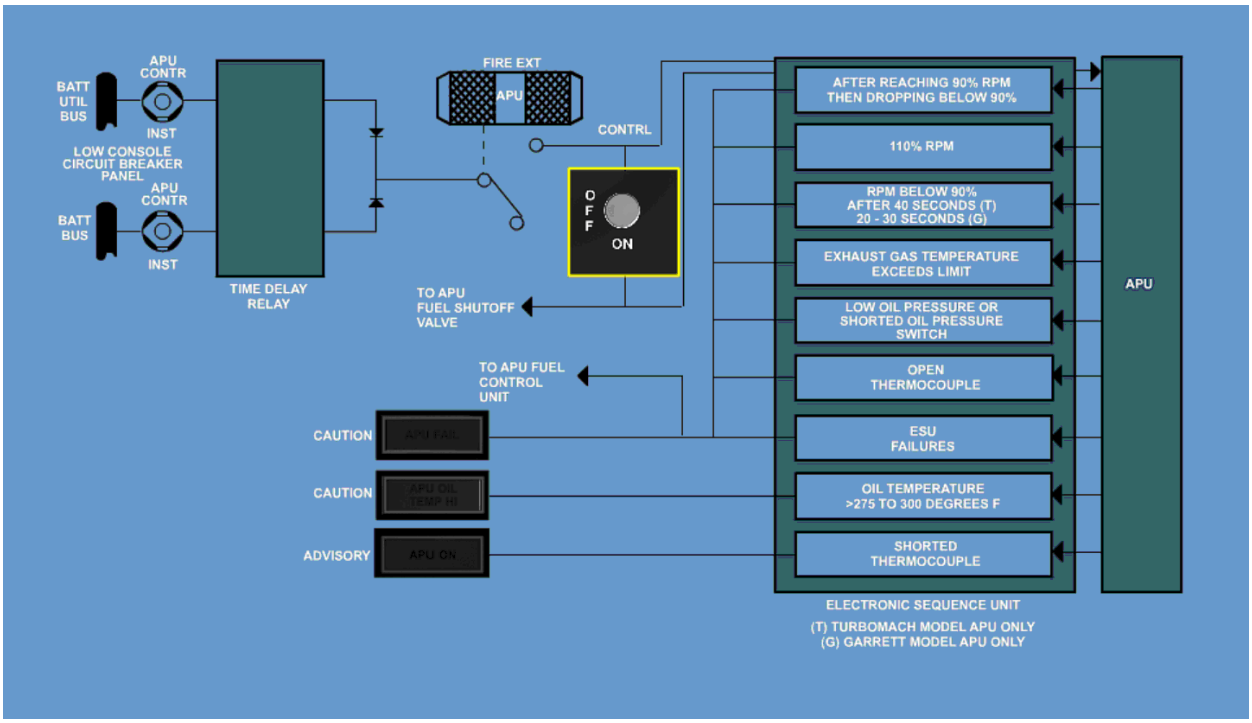
19) The start bypass valve helps to prevent compressor stalls, and under-speed/over-speed protection.

(c) Electronic Sequence Unit

Frame #1245 (Electronic Sequence Unit)

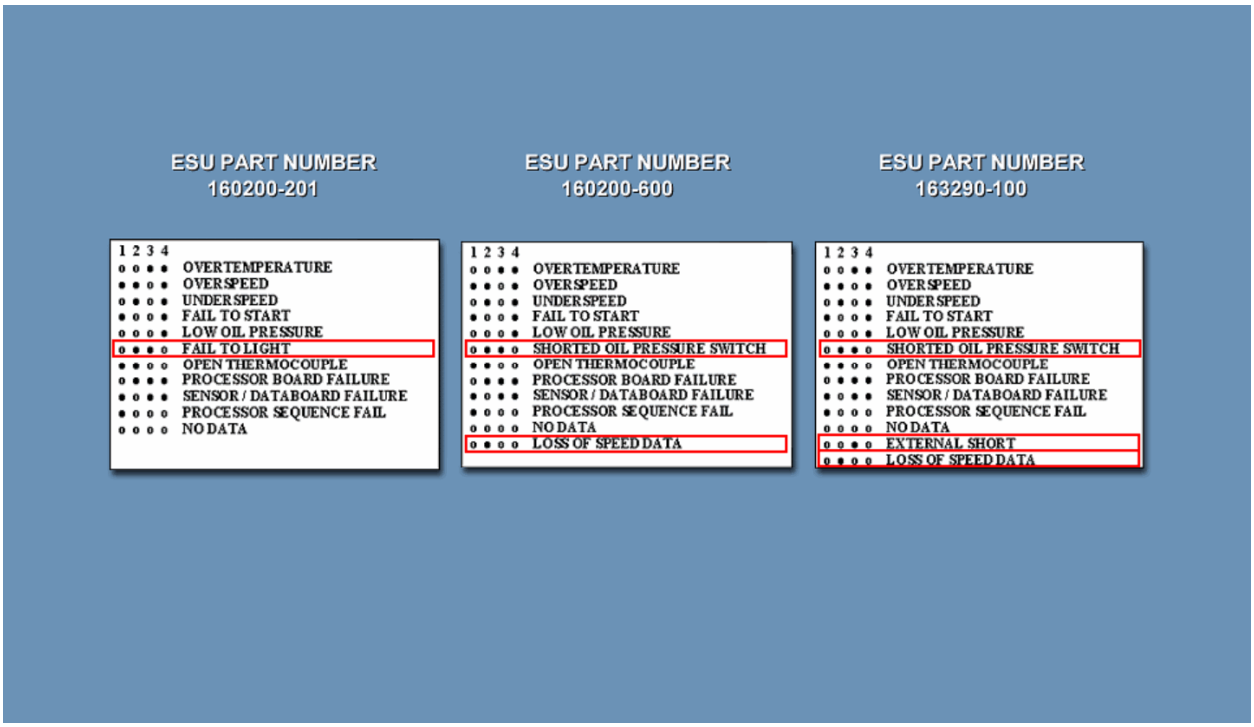
1) The ESU, located forward of the stabilator amplifiers in the aft cabin ceiling, provides automatic starting, and continuous operational monitoring.

Frame #1250 (Electronic Sequence Unit FLASH)



2) There are five primary situations monitored by the ESU during starting and continuous operations: over-temperature, over-speed, under-speed, low oil pressure, and high oil temperature.

Frame #1255 (Electronic Sequence Unit Types)



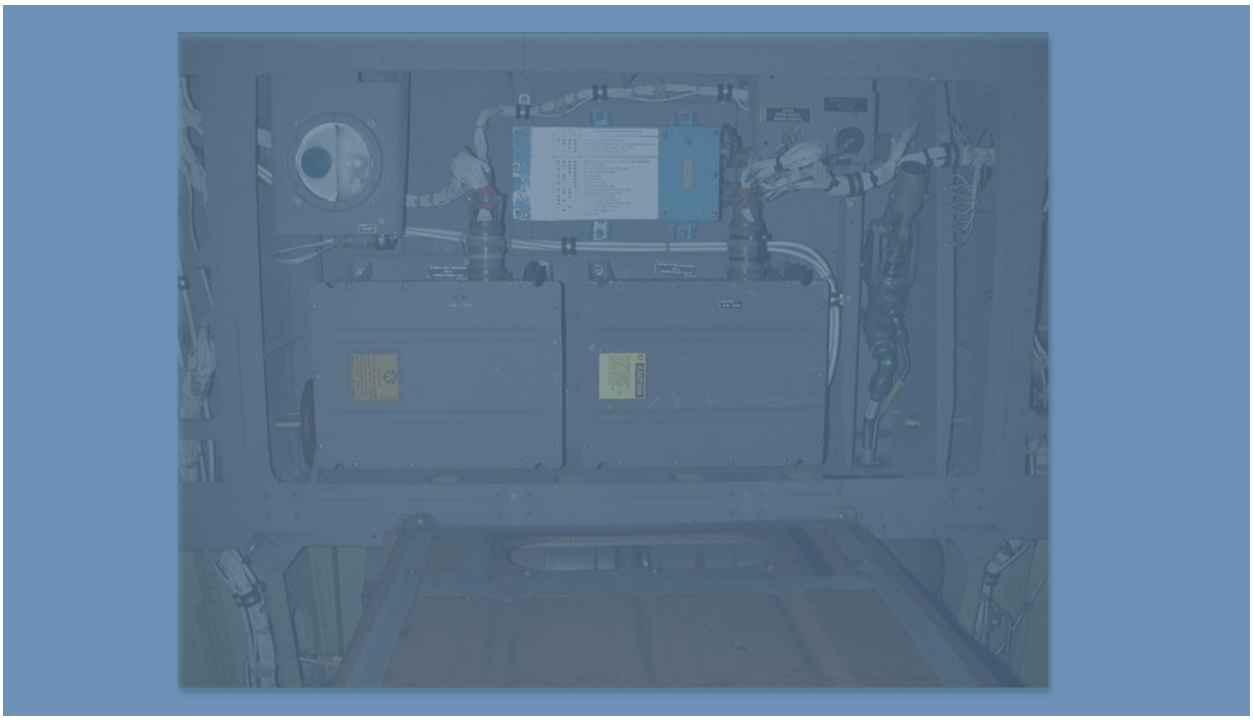
3) There are five styles of ESUs.

4) Three used on the APU part number 70550-02113-011 and two are used on the APU part number 70550-02113-012.

5) Each style ESU is interchangeable for the APU it is used on, but the ESUs have different BITE indications depending on the part number of the ESU.

6) The red highlighted blocks show examples of the different BITE indications you might experience.

Frame #1260 (ESU Function/Purpose)



NOTE: If the APU shuts down/fails to start, do not shutoff the battery. If the battery is shutoff, you will reset the bit indication.

If the APU fails to start, check the latch lights ONLY. If you get a fail to start, you can reset the battery to see if you get an open thermocouple of APU over-temperature.

7) The functions, and purpose of the ESU, are to receive, send, and record signals and data during the start sequence and operational modes.

8) The ESU serves as a central processor unit, which can be further divided into 2 data cards.

9) The first data card is an input card. The input card receives information from the APU control switch, T-handle, and the APU sensor switches.

10) The second data card is the output card. The output card sends signals to the APU, fuel solenoids, igniters, and the caution lights.

11) The ESU has a read only memory that compares inputs with previously stored data (if different from normal APU start and operational modes, and will not allow the APU to start).

12) The ESU has 2 modes, a start sequence, and operational mode.

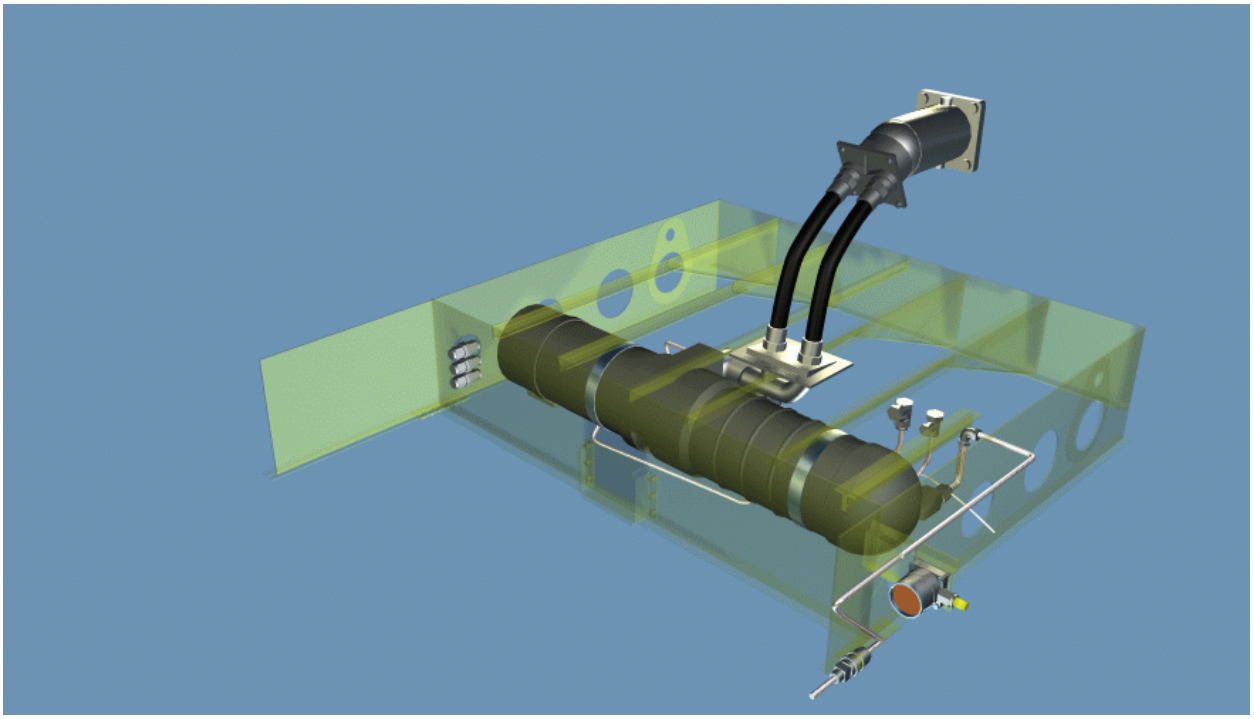
13) The start sequence activates the ignition, fuel fault detection, and BITE indicators.

14) The operational mode is initiated when the start sequence is completed.

15) The ESU will continuously monitor the APU operation as long as the APU is operating.

d. Hydraulic System

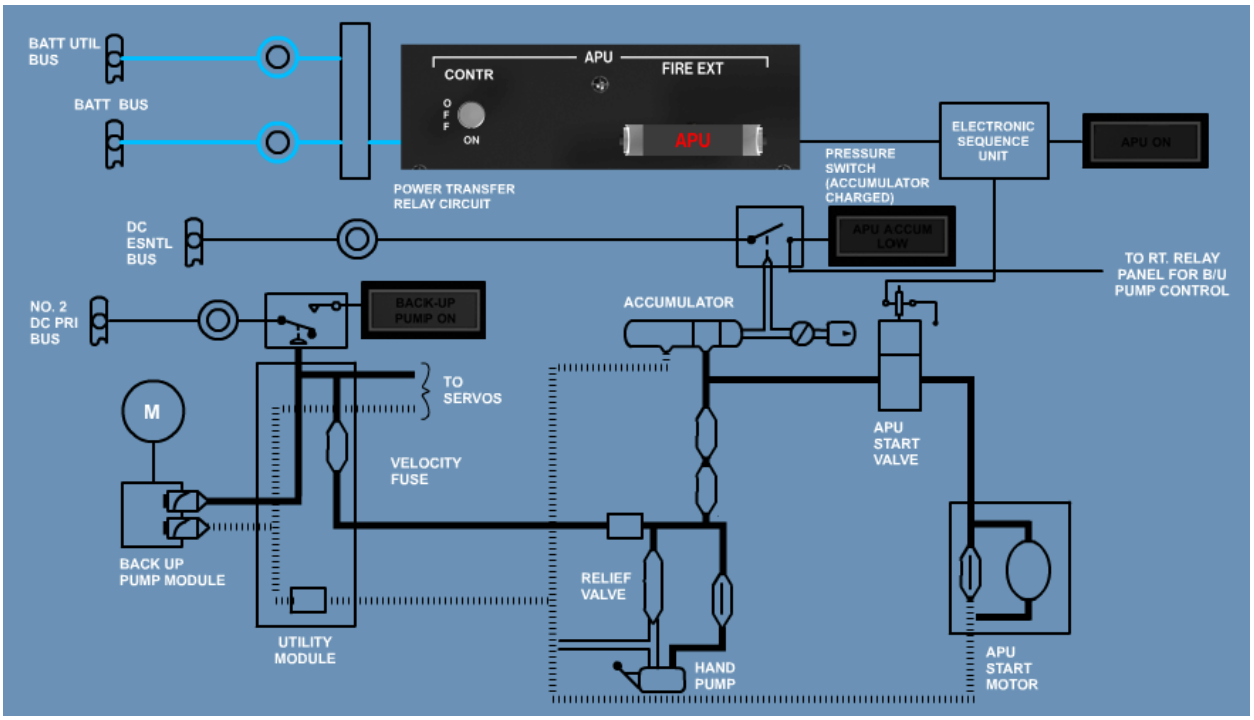
Frame #1300 (Hydraulic System)



(1) In the hydraulic system, the accumulator and start motor are used to start the APU.

(2) The accumulator is located above the fuel cells in the aft cabin ceiling, while the start motor is attached to the accessory drive assembly on the APU.

Frame #1305 (Hydraulic System FLASH)



(3) When the APU control switch is placed in the ON position, a signal is applied to the ESU.

(4) The ESU sends a signal that opens the APU start valve, releasing the hydraulic accumulator charge.

(5) The accumulator charge turns the APU start motor.

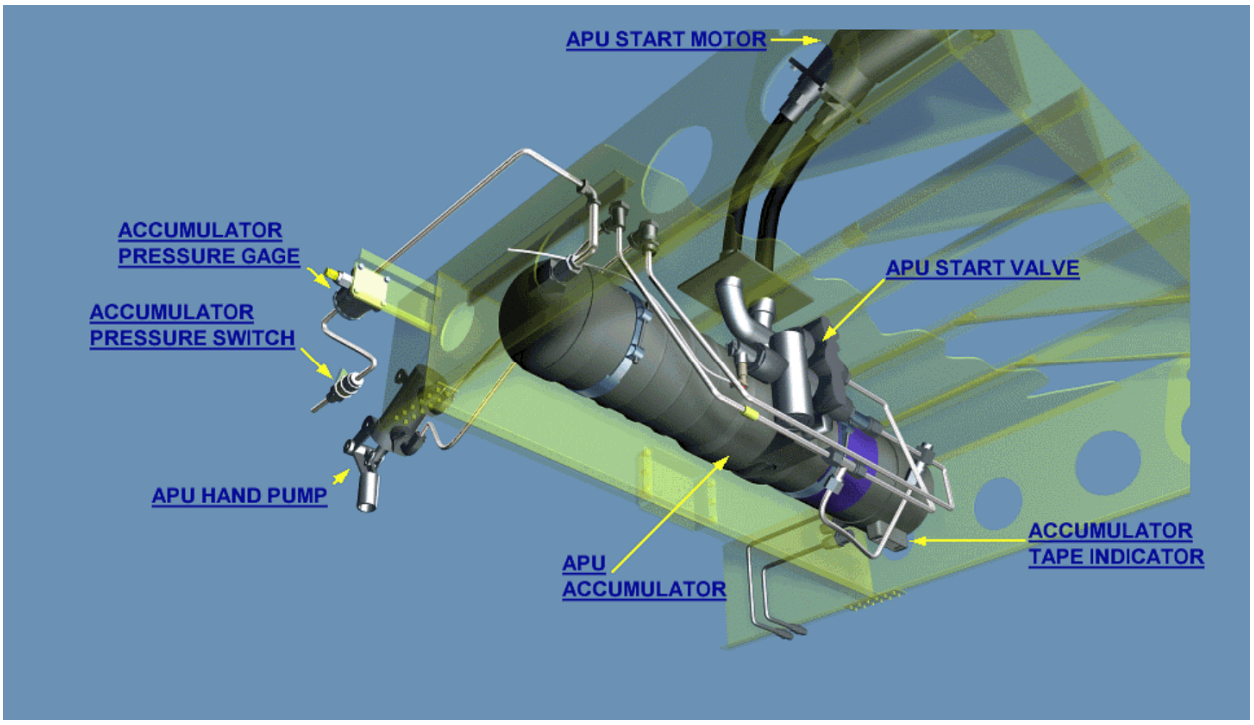
(6) The function of the APU start motor is to start the APU compressor and fuel pump rotating.

(7) At this time, the ESU sends a signal to the caution/advisory panel and the APU ON light illuminates.

(8) When the APU reaches (unloaded) 103% speed, the APU ACCUM LOW light will go on, and the backup pump will begin to recharge the accumulator.

(9) A pressure switch on the utility module will sense the backup pump is operating, and turns on the BACK-UP PUMP ON light at the caution/advisory panel.

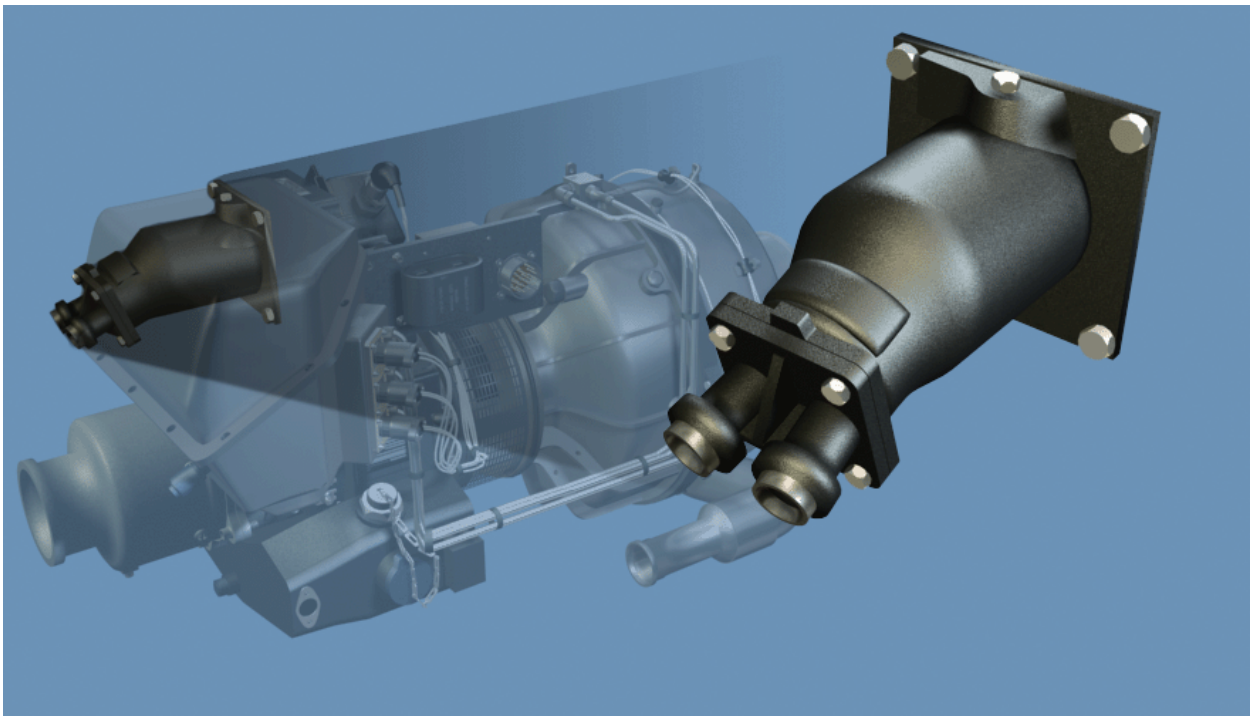
Frame #1307 (APU Accumulator Group)



(10) The hydraulic system can be broken down into seven major components: APU start motor, APU start valve, APU accumulator, accumulator tape indicator, APU hand pump, accumulator pressure switch, and the accumulator pressure gage.

(a) APU Start Motor

Frame #1327 (APU Start Motor)



1) The APU start motor, controlled by the ESU, is hydraulically driven to 20% - 30% speed, and drops out when the APU reaches 70% speed during the start sequence.

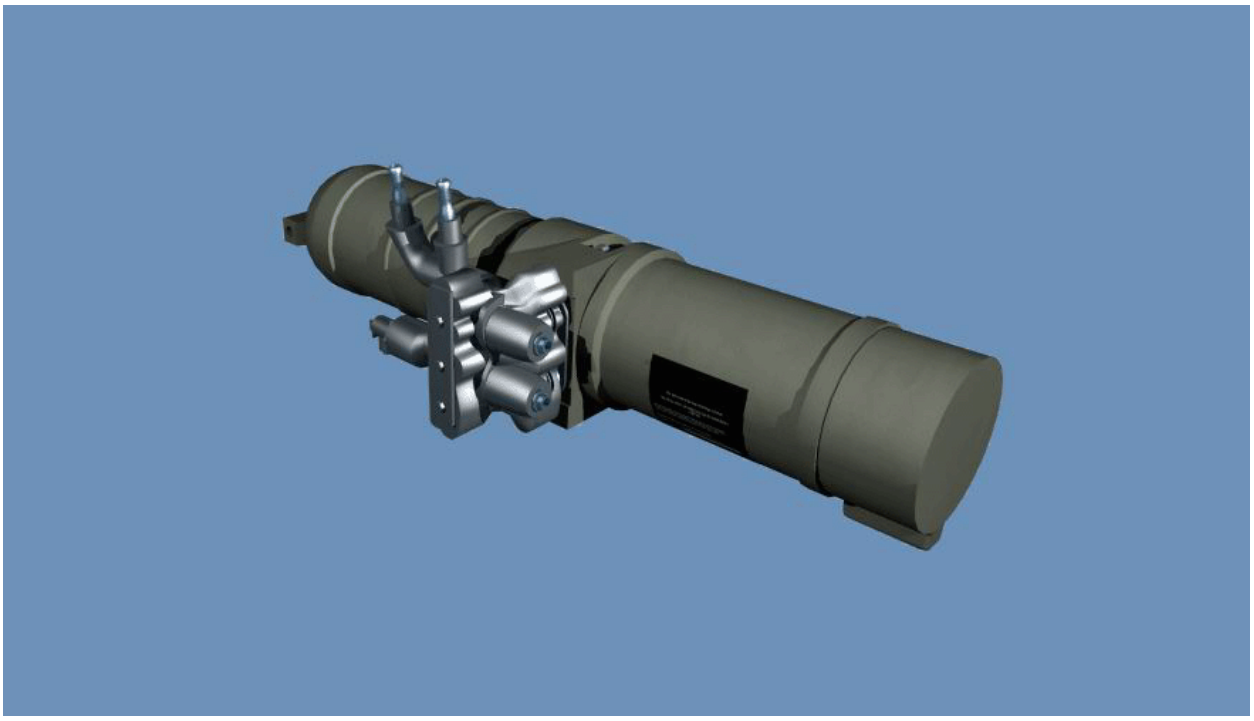
2) After the APU reaches 70% speed, the start motor becomes a free wheeling unit.

3) The hydraulic fluid used to drive the start motor enters from the accumulator through the pressure line, and returns to the accumulator through the return line.

4) The APU start motor is mounted to the accessory drive, and motors the compressor assembly during the start sequence.

(b) APU Start Valve

Frame #1325 (APU Start Valve)



1) The APU start valve, controlled by the ESU, releases the accumulator hydraulic charge to the APU start motor during the APU start sequence.

2) The manual release lever is located on the APU start valve.

3) During maintenance procedures, the manual release lever will release the hydraulic fluid charge from the accumulator, to the APU start motor, without the APU start sequence being initiated.

(c) Accumulator Tape Indicator

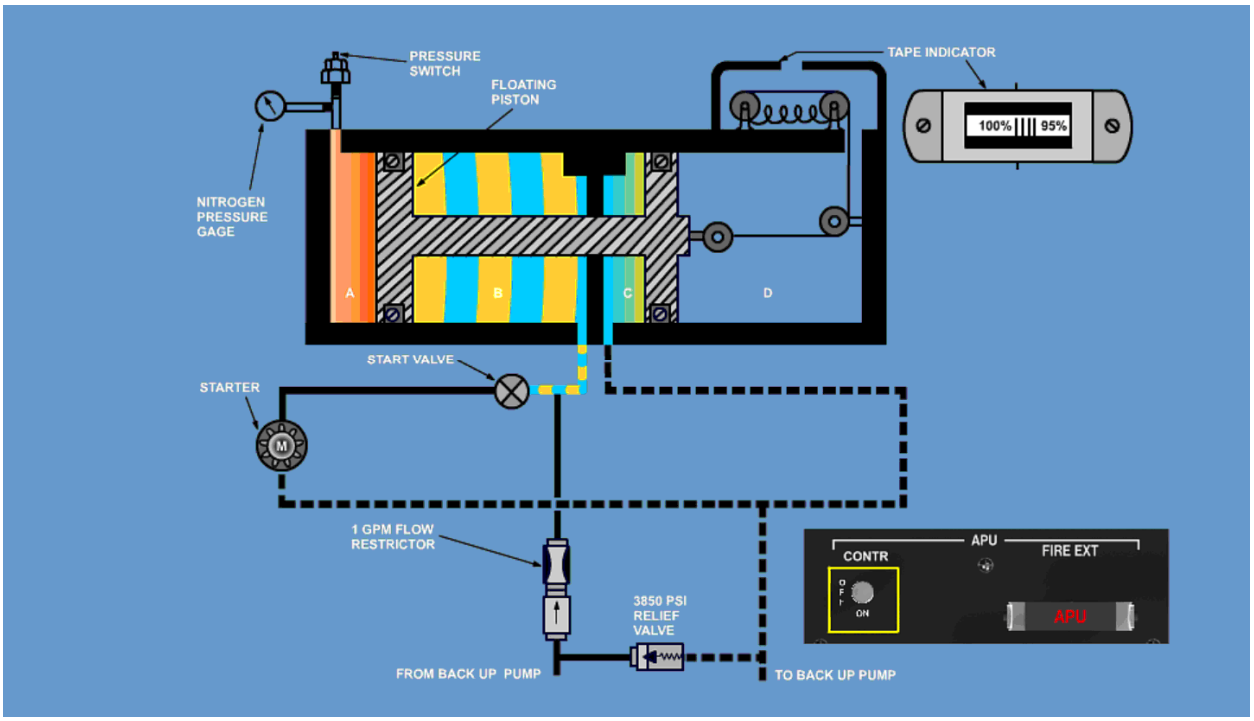
Frame #1315 (Accumulator Tape Indicator)

1) The accumulator tape indicator, on the APU accumulator, displays the percent of pressure charge in the accumulator.

2) The tape will indicate zero (0) when the hydraulic charge has been released.

(d) APU Accumulator

Frame #1310 (APU Accumulator FLASH)



1) Inside the APU accumulator, there are two chambers.

2) The first chamber contains a nitrogen pre-charge, hydraulic fluid, and is separated by a floating piston.

3) A service valve is connected to the nitrogen end of the chamber with a pressure gage (0 - 5000 PSI) attached.

4) Before operating, the nitrogen pressure gage should read 2700 - 3100 PSI.

5) The hydraulic end of the chamber supplies pressurized hydraulic fluid to the APU starter through a start valve.

6) Once the start valve closes, the backup pump supplies hydraulic fluid back to the chamber.

7) The second chamber contains hydraulic fluid, indicator tape, and is separated by a floating piston.

8) The hydraulic fluid end of the chamber receives hydraulic fluid from the APU start motor during the start sequence.

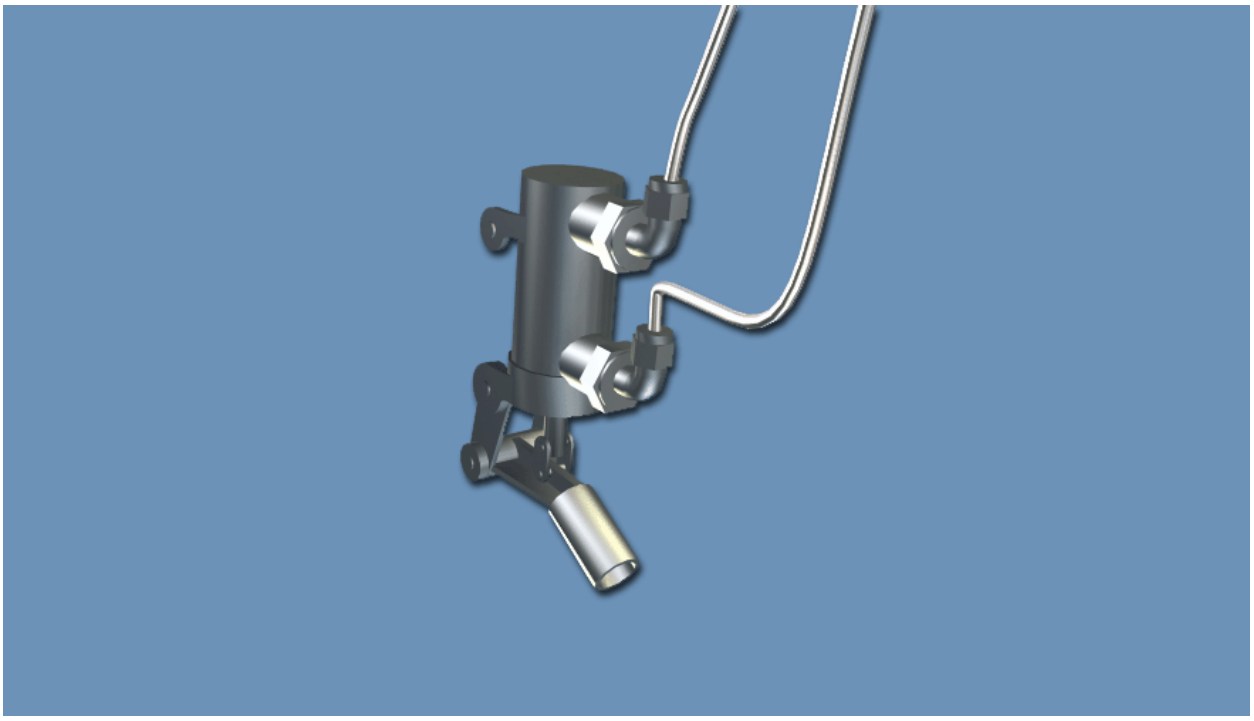
9) When the start valve closes, the hydraulic fluid is cycled to the backup pump.

10) As the floating piston moves throughout the accumulator, the indicator tape moves as well.

11) When the nitrogen pressure gage is indicating 1,450 psi, the indicator tape reading is 0% at 70 ºF (21 ºC).

(e) APU Hand Pump

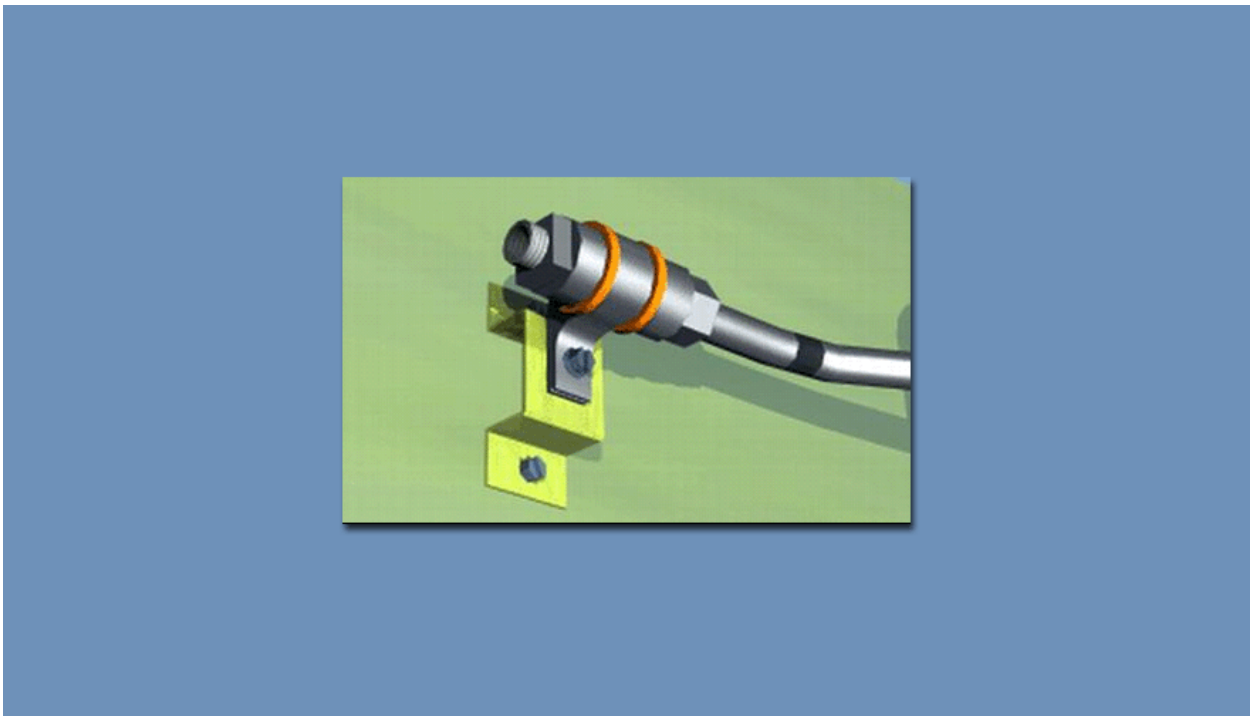
Frame #1330 (Hand Pump)



1) The APU hand pump is bi-directional, used for manually recharging the APU accumulator.

(f) Accumulator Pressure Switch

Frame #1322 (Accumulator Pressure Switch)



1) When the accumulator precharge pressure drops below 2000 PSI, the accumulator pressure switch sends a signal through the right hand relay panel, illuminating the APU ACCUM LOW caution advisory light.

2) As the accumulator precharge pressure increases to 2735 ± 50 psi, the APU ACCUM LOW advisory light will disappear.

(g) Accumulator Pressure Gage

Frame #1320 (Accumulator Pressure Gage)

2) The APU accumulator pressure gage indicates the nitrogen pressure inside the accumulator.

3) The nitrogen precharge in the accumulator at 70 ºC is 1450 PSI.

4) Hydraulic fluid inside the accumulator compresses the nitrogen precharge.

5) The pressure gage will indicate how much pressure the hydraulic charge has placed on the nitrogen precharge.

6) The acceptable minimum pressure before starting the APU is 2800 PSI.

7) When the hydraulic charge has been released during the APU start sequence, the pressure gage will indicate the nitrogen precharge.

8) When the hydraulic charge has been recharged, the nitrogen gage should return to the indication prior to the beginning of the start sequence.

9) The accumulator nitrogen precharge is serviced at the nitrogen-servicing valve on the pressure gage.

CHECK ON LEARNING

1. Which of the following oil is used to service the APU when the temperature is 0 ºC?

2. A high oil temperature indication, and a low oil pressure indication can be the result of which of the following?

3. The acceleration control assembly is comprised of three components: the governor housing, fuel control housing, and what other component?

4. To avoid shutdown, the K47 relay uses what to avoid a power interruption?

5. What is the primary function of the ESU?

6. Prior to beginning the APU start sequence, the minimum accumulator pressure should be at what psi?

SECTION V. -SUMMARY

1. REVIEW/SUMMARIZE:

You have completed the Subsystems topic of the APU.
The key points to remember are:

- There are two types of oil acceptable to use when servicing the APU: MIL-L 23699, and MIL-L 7808.
- When servicing the APU oil system, do not mix the two types of oils, unless it is in an emergency situation.
- Over servicing of the oil system can create oil foaming, leading to low oil pressure, and high oil temperature.
- The oil pump supplies oil to the system at 15 - 40 PSI.
- There is a 10 micron oil filter, equipped with a bypass valve, in the event the filter becomes clogged.
- An oil pressure switch sends a signal to the ESU, shutting the APU down should the oil pressure drop to 6 ± 1 PSI.
- An oil pressure relief valve assists in regulating the pressure throughout the system.
- The oil temperature switch monitors the oil temperature, sending a signal to the ESU when the temperature exceeds 149 ºC.
- An APU OIL TEMP HIGH caution light does not shut the APU down.
- The APU fuel control assembly is located on the reduction gear drive assembly.
- The fuel pump contains a 25 micron filter and an internal pressure regulating valve.
- The governor housing, fuel control housing, and bellows cover assembly, make up the three components of the acceleration control assembly.
- Three fuel solenoids supply fuel to the APU, and are sequenced by the ESU during the start sequence and operational mode.
- Preventing a build up of varnish to the start fuel nozzle is the function of the purge valve.
- The main fuel manifold connects the six fuel nozzles with a single fuel tube to six individual fuel tubes.
- The K47 relay, located in the left hand relay panel, provides a 0.5 second delay to the ESU in the event of interrupted power.
- Mounted to the reduction gear drive assembly, the APU generator provides an output frequency of 400 Hz.
- The magnetic pickup generates a magnetic field, which is broken as the gears of the accessory gear drive assembly turn, sending a speed signal to the ESU.
- The ESU provides automatic starting and continuous operational monitoring.
- The accumulator is a two part components, with hydraulic fluid to motor the APU start motor, and a nitrogen precharge to pressurize the hydraulic fluid.
- During the start sequence, the APU start motor drives the accessory and reduction gear drive assemblies to 20 - 30% speed before dropping out.

D. ENABLING LEARNING OBJECTIVE ELO No. 4

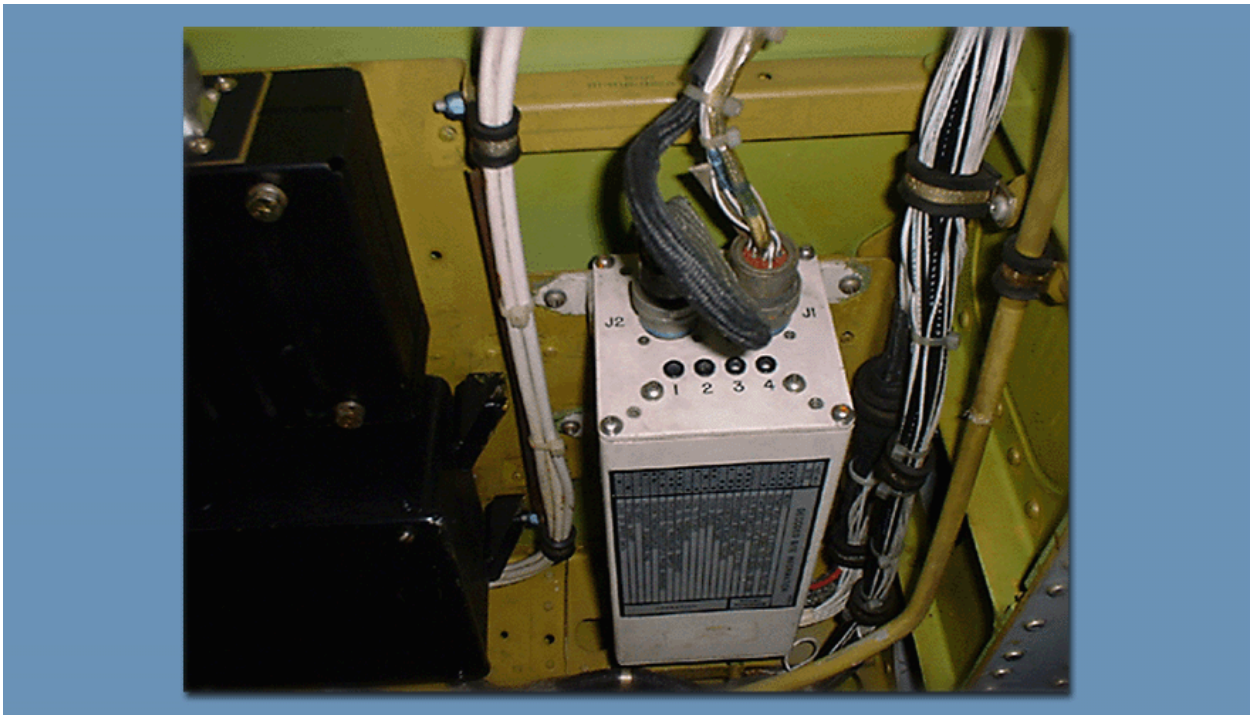
ACTION: Identify the APU system operational characteristics.

CONDITIONS: Using TM 55-2835-208-23 and TM 55-2835-209-23

STANDARD: IAW TM 55-2835-208-23 and TM 55-2835-209-23

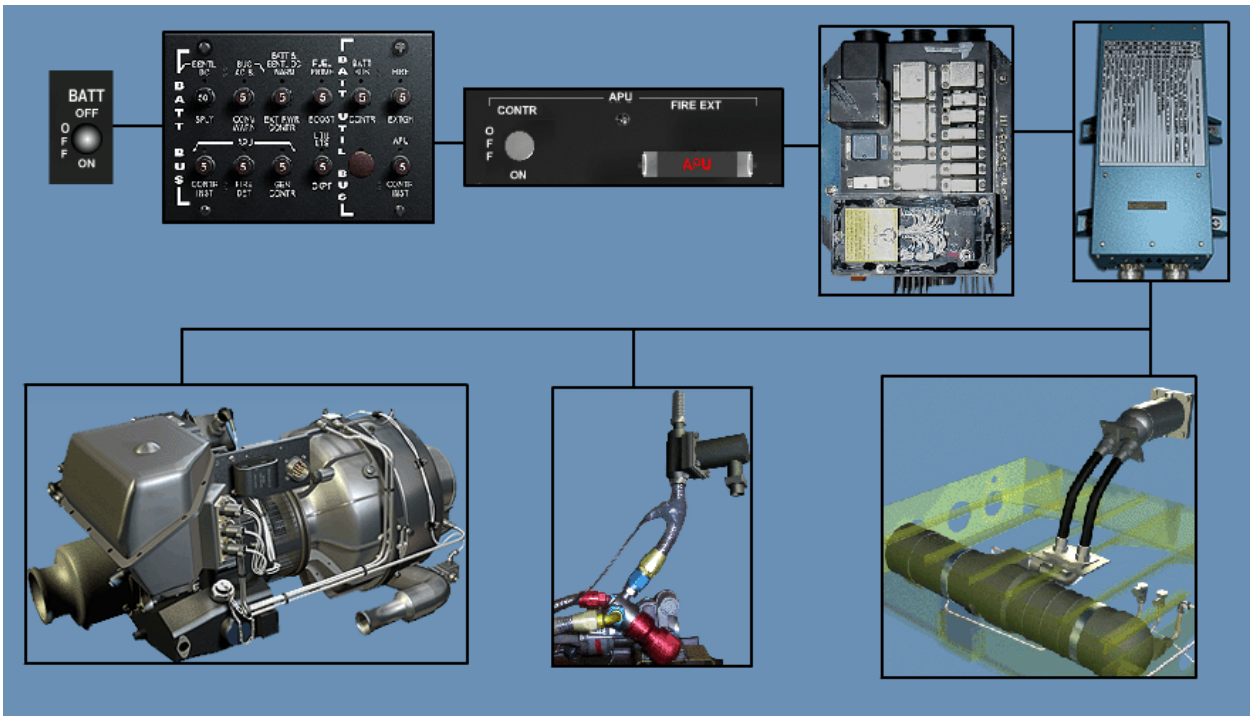
a. Electronic Sequence Unit

Frame #1505 (APU System Operational Characteristics)



(1) The APU system operation is completely automatic and controlled by the ESU.

Frame #1510 (APU System Operational Characteristics FLASH)



(2) APU has two modes of operation: start and operational.

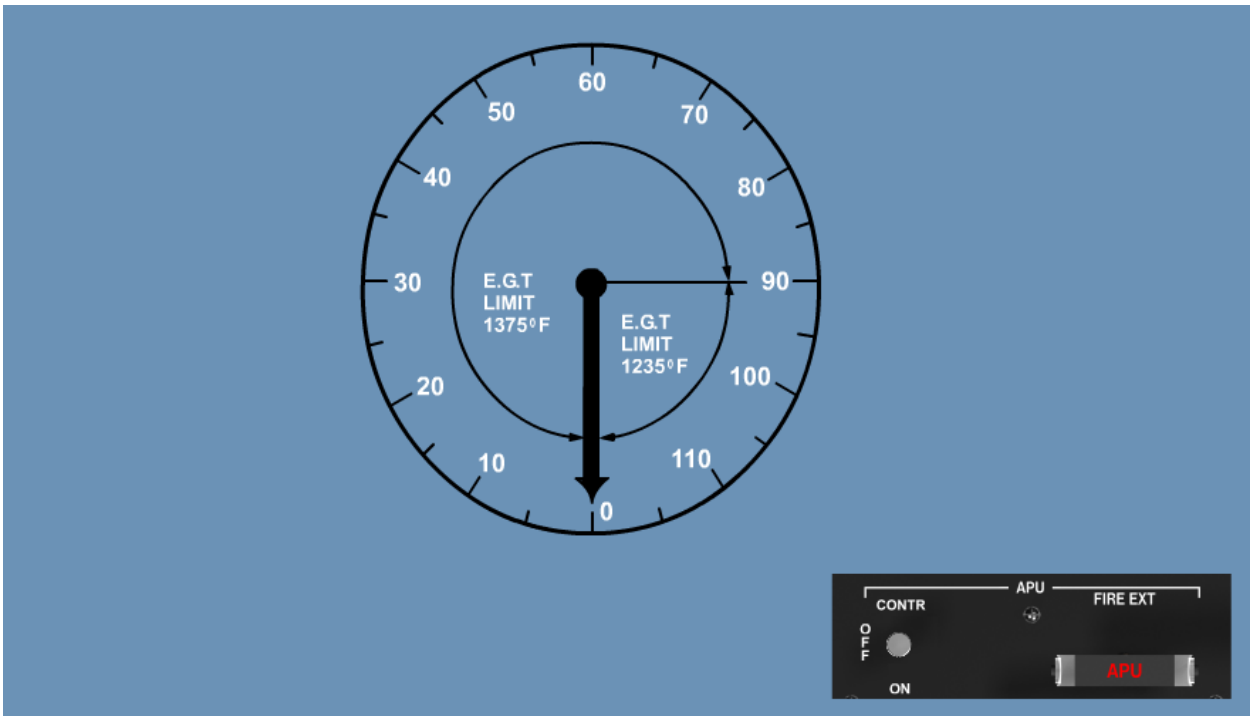
(a) The start operation begins when the battery switch is moved to the ON position, energizing the 28 vdc battery, battery utility buses, and the APU control switch.

(b) When the APU control switch is moved to the ON position, the battery and the battery utility busses supply power to the ESU through the transfer relay circuit (K47) in the left hand relay panel.

(c) The ESU opens the APU start valve at the accumulator, supplying hydraulic pressure to the APU start motor, powering the accessory drive, and associated components.

(d) The ESU also sends a signal to the prime/boost pump of the No. 1 fuel cell, providing a supply of fuel through the APU fuel shutoff valve to the APU fuel pump.

Frame #1515 (APU System E.G.T. FLASH)



(e) When the APU CONTR switch is placed in the ON position the APU builds speed up to 5%, the start fuel solenoid opens, and the ignition exciter comes on.

(f) At this time, the 40-second counter starts and the APU must be at 90% speed within 40 seconds.

(g) EGT over-temperature shutdown is enabled; fuel pressure increases to 350 to 450 PSI, while the thermocouple is checked for an open condition by the ESU.

(h) The ESU continues internal checks, the start fuel ignition begins, and the over-speed circuit is activated.

(i) At 14% speed, the main fuel solenoid opens, ignition continues, and the ESU self test will occur every 0.5 second during the 40 second start sequence, while the thermocouple is checked again.

(j) At 30% speed, the EGT is checked (must be above 50 ºF or the ESU will shut the sequence down).

(k) The ESU continues with a self-test.

(l) As the APU reaches 70% speed, the hydraulic start valve, and the fuel start valve close.

(m) The purge valve opens, and purges the fuel start nozzle; the ignition is off.

(n) The oil pressure circuit is on, the thermocouple is checked for an open condition while the ESU continues with a self-test.

(o) At 90% speed, the 40-second counter is disabled; the APU fail, and under-speed circuits are deactivated.

(p) The 1.5 second timer is activated while the thermocouple is checked for an open condition, and the ESU continues with a self-test.

(q) When the APU reaches the 90% +1.5 seconds, the maximum fuel valve opens with a corresponding APU ON capsule light at the caution advisory panel.

(r) The thermocouple is checked for a short condition, high oil temperature check is activated, and the EGT shutdown range is reduced to 1,240 – 1,280 (from 1,376).

(s) The ESU self-test continues during this process.

(t) The operational mode is initiated at 90% speed + 1.5 seconds.

(u) During the operational mode, the APU operates at 100% speed loaded.

(v) The APU operates at 103% speed unloaded.

(w) The ESU continuously monitors sensors, provides automatic shutdown if any predetermined values are exceeded, and BITE indications to isolate what value was exceeded during the operational mode.

CHECK ON LEARNING

1. The APU system operation is completely automatic and controlled by which component?

2. Power to the ESU is supplied from the battery bus and the battery utility bus through what component?

3. Fuel to the APU is supplied from the _____.

4. When the start fuel solenoid opens, the ignition exciter comes on and the 40 second counter begins at what % speed?

5. When the APU reaches the 90% + 1.5 seconds, which of the following events occur?

SECTION VI. -SUMMARY

1. REVIEW/SUMMARIZE:

You have completed the Operational Characteristics topic of the APU System. The key points to remember are:

- The APU system operation is completely automatic and controlled by the ESU.
- There are two modes of operation for the APU: start sequence and operational.
- The APU control switch is energized through the battery bus and the battery utility bus by the aircraft battery.
- Power to the ESU is supplied through the K47 relay in the left hand relay panel.
- The APU start valve, at the accumulator, supplies the hydraulic pressure to drive the APU start motor.
- Fuel requirements for the APU are met by the No. 1 fuel cell.
- At 5% speed, the start fuel solenoid opens, the ignition exciter comes on, and the 40 second counter starts, and start fuel ignition begins.
- At 14% speed, the main fuel solenoid opens and the ESU self-test begins.
- At 30% speed, the ESU checks the EGT for 50 ºF or above.
- At 70% speed, the hydraulic start valve, and the fuel start valve is closed, the purge valve opens, and the ignition is off.
- At 90% speed, the 40 second counter is disabled, the underspeed circuits are deactivated, the thermocouple is checked for an open condition, and the 1.5 second timer is activated.
- At 90% speed (± 1.5 seconds), the maximum fuel valve opens with a corresponding APU ON capsule light, the thermocouple is checked for a short condition, high oil temperature check is activated, and the EGT shutdown range is reduced to 1240 ºF - 1280 ºF.
- The APU operational mode begins when the APU reaches 90% speed + 1.5 seconds.

E. ENABLING LEARNING OBJECTIVE ELO No. 5

ACTION: Identify the characteristics of the APU temperature and speed simulator test set.

COND ITIONS: Using TM 55-2835-208-23 and TM 55-2835-209-23.

STANDARD: IAW TM 55-2835-208-23 and TM 55-2835-209-23

a. APU Test Set

Frame #2005 (APU Test Set)

(1) The APU temperature and speed simulator test set (H296B-1) is used for operational and troubleshooting procedures in the static (APU not running) or dynamic (APU running) modes.

(2) The test set is used on the Turbomach APU only.

(3) Testing of the APU is primarily done in the static mode.

(4) The H296B-1 test set has eight controlled functions (checks) that can be performed:

(a) Hydraulic start valve

(b) Speed sequence

(c) Overspeed

(d) Underspeed

(e) Low oil pressure

(f) Start bypass valve

(g) Over-temperature

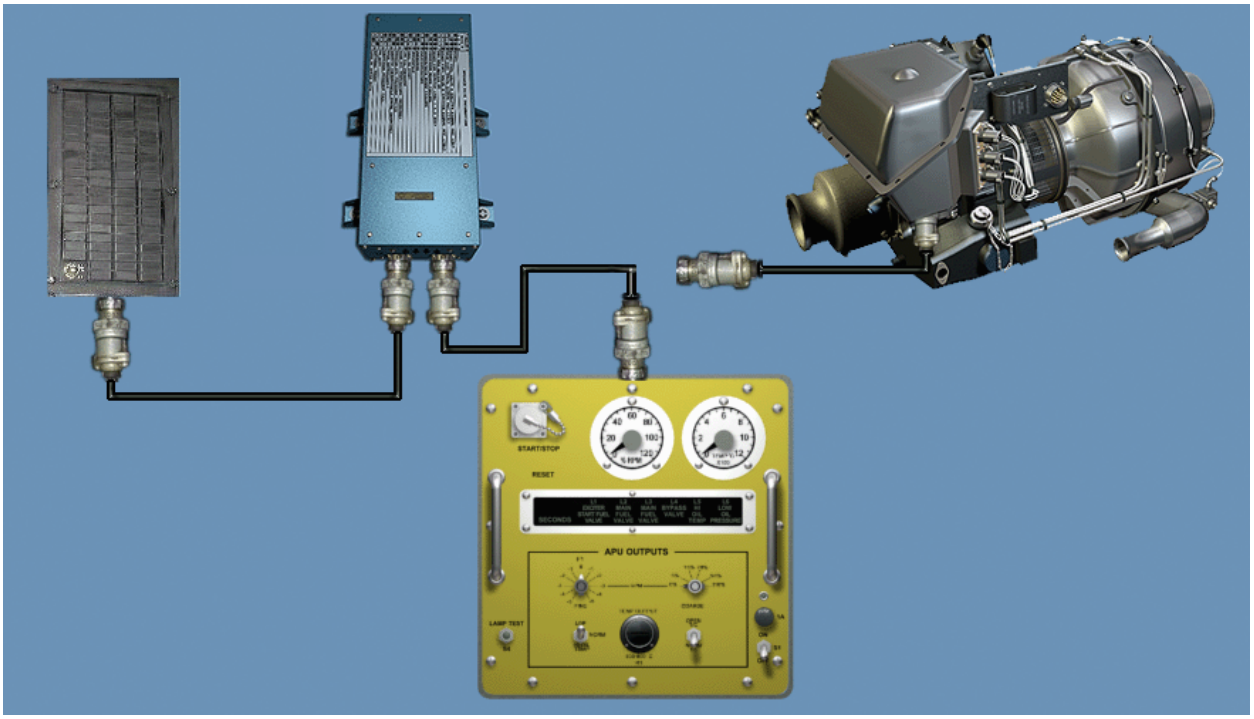
(h) Open thermocouple

(5) The test set has two test circuits available.

(6) The first test circuit is the high oil temperature; when the APU OIL TEMP HI caution advisory light illuminates.

(7) The second test circuit is the shortened thermocouple check, which is a BITE indication on the ESU.

Frame #2015 (APU Test Set Setup)



(8) When installing the test set in the static mode, the static test cable is connected to the ESU, in place of the P261 electrical connector.

CHECK ON LEARNING

1. The APU temperature and speed simulator test is primarily done in what mode?

2. When installing the APU test set in the static mode, the static test cable is connected to the ESU in place of which electrical connector?

3. High oil temperature is one of two test circuits available on the test set, what is the other?

SECTION VII. -SUMMARY

1. REVIEW/SUMMARIZE:

You have completed the Characteristics of the APU Temperature and Speed Simulator Test Set topic of the APU System.
The key points to remember are:

- The test set is primarily used in the static test mode.
- The test set is used for operational, and troubleshooting procedures on the APU.
- There are two test circuits available on the test set: high oil temperature and shortened thermocouple.
- Eight controlled functions are performed with the test set:
  - hydraulic start valve
  - speed sequence
  - overspeed
  - underspeed
  - low oil pressure
  - start bypass valve
  - overtemperature
  - open thermocouple
- When installing the test set in the static mode, the static test cable is connected to the ESU in place of the P261 electrical connector.

APPENDIX A

ILLUSTRATION LISTING

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0025	Location
0030	APU Mounts
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0040	Air Flow FLASH
0045	Secondary Purpose
0055	Principals of Operation FLASH
0060	Description and Operation
0063	Reduction Drive
0063	Reduction Drive Mounting
0066	Integral oil System
0061	Gas Turbine Power Section
0064	Pneumatic Air Flow
0065	Electrical Power Fuel Components
0067	ESU
0070	Description and Operation
0510	Reduction Gear Drive Assembly
0515	Accessory Gear Drive Assembly
0520	Turbine Assembly
0525	Turbine Assembly Exploded View
0530	Combustor Assembly
0535	Outer Housing
1010	Lubrication System
1011	Lubrication System Servicing
1012	APU Dipstick
1020	Lubrication System Components
1025	Oil Pump
1030	Oil Filter
1035	Oil Low Pressure Switch
1040	Oil Pressure Relief Valve
1045	Oil Temperature Switch
1050	Magnetic Chip Detector
1055	Lubrication System Function FLASH
1100	Fuel System
1105	APU Shutoff Valve
1110	Fuel Filter
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1121	Governor Housing
1122	Fuel Control Housing
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1125	Fuel Solenoid Valves
1126	Fuel Solenoid
1130	Fuel Lines
1135	Fuel Purge Valve Assembly
1140	Start Fuel Nozzle
1145	Main Fuel Manifold
1150	Combustor Drain Valve
1155	Fuel System Operation FLASH
1200	Electrical System

1205	Airframe Power Source
1210	Power Transfer System
1211	Battery Bus/Left Hand Relay/ESU
1215	APU Generator
1219	Generator Control Unit
1220	Ignition Exciter/Spark Plug
1225	Magnetic Pickup
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1240	Start Bypass Valve
1245	Electronic Sequence Unit
1250	Electronic Sequence Unit FLASH
1255	Electronic Sequence Unit Types
1260	ESU Function/Purpose
1300	Hydraulic System
1305	Hydraulic System FLASH
1307	APU Accumulator Group
1310	APU Accumulator FLASH
1315	Accumulator Tape Indicator
1320	Accumulator Pressure Gage
1322	Accumulator Pressure Switch
1325	APU Start Valve
1327	APU Start Motor
1330	Hand Pump
1505	APU System Operational Characteristics
1510	APU System Operational Characteristics FLASH
1515	APU System E.G.T. FLASH
2005	APU Test Set
2015	APU Test Set Setup

APPENDIX B

TEST AND TEST SOLUTIONS

1. This appendix is only used when the test and solutions are internal to the POI file.

2. When the test and solutions are internal to the POI file, then the POI file becomes a FOR OFFICIAL USE ONLY document.