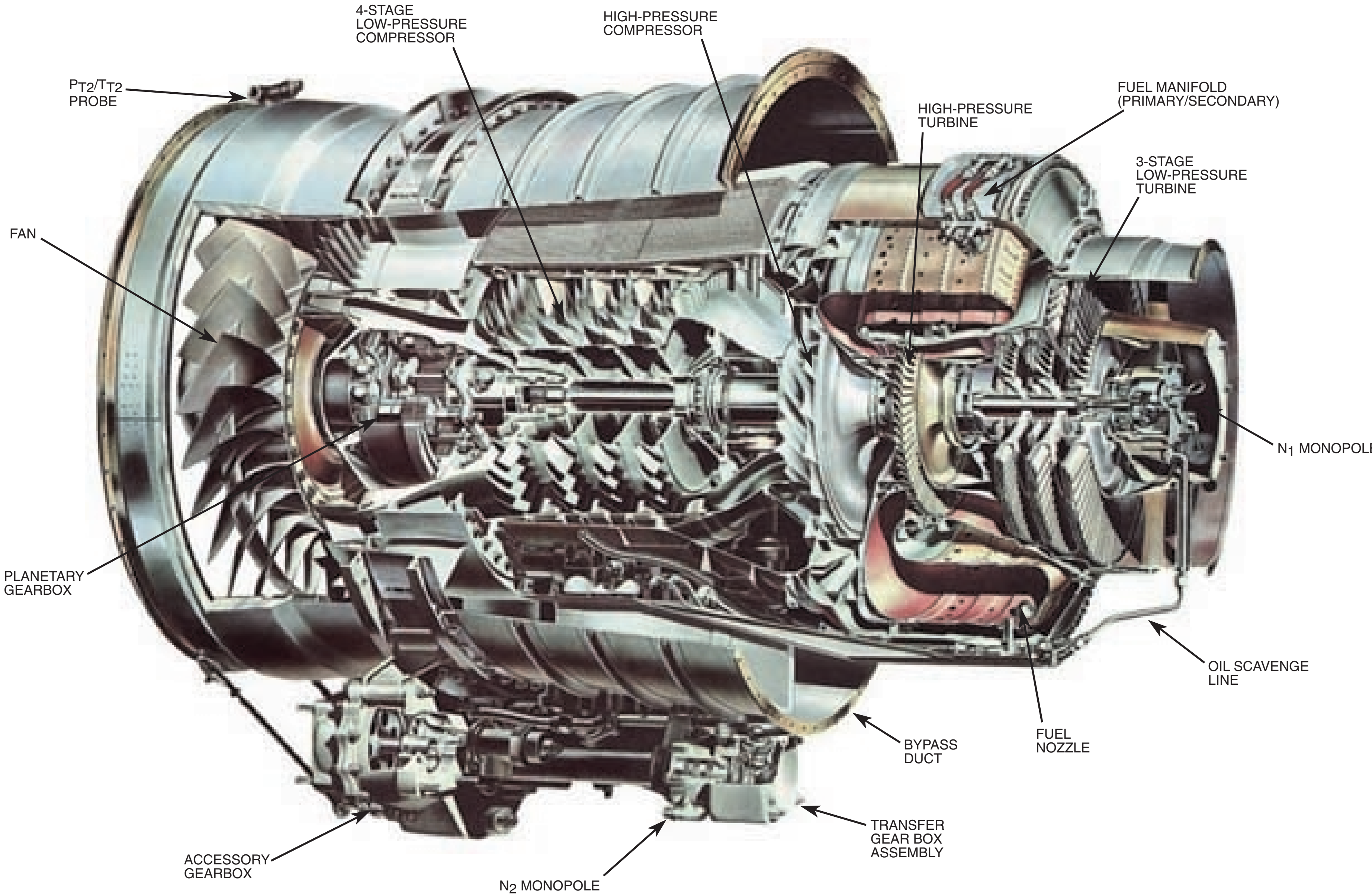
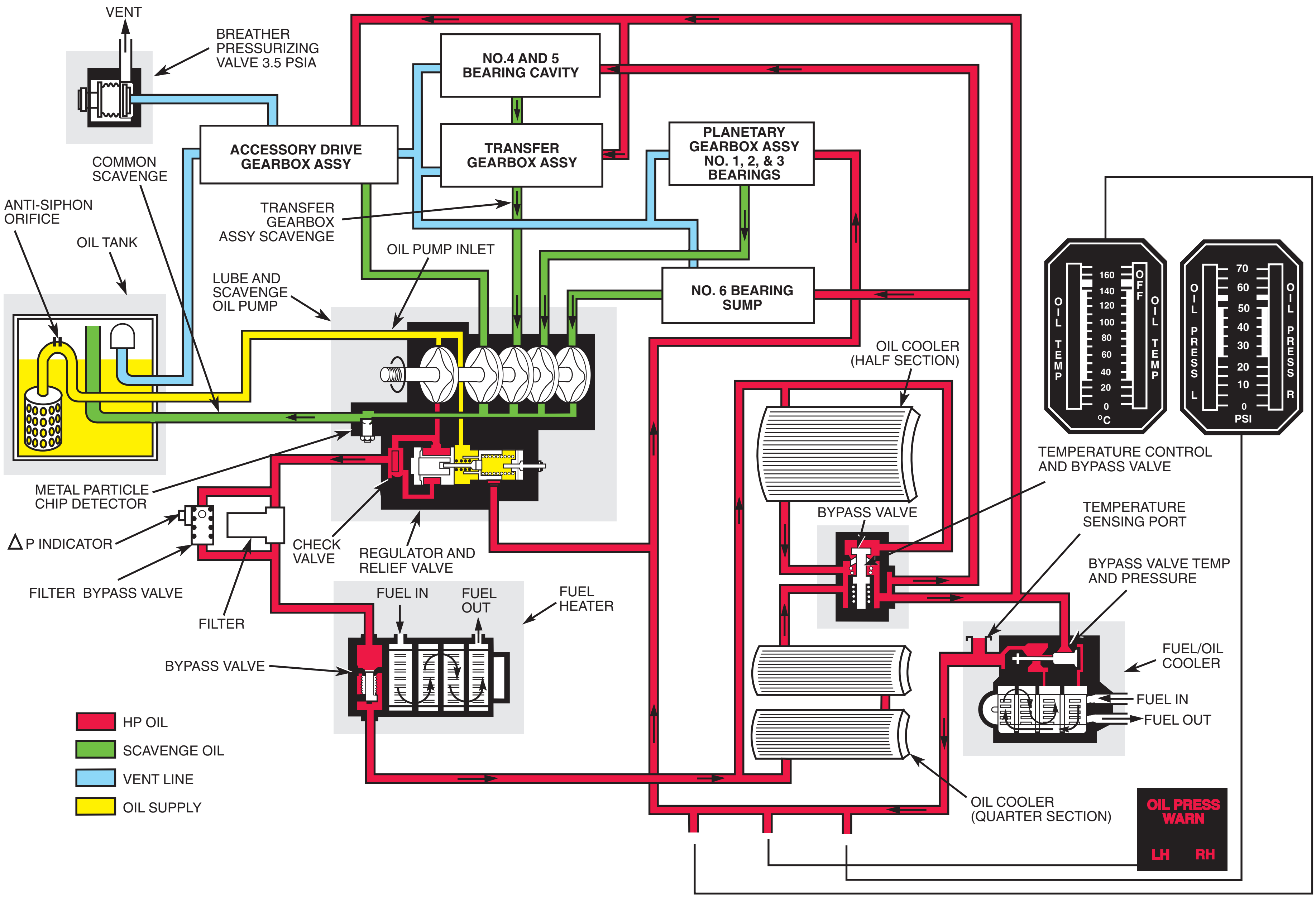
Garrett TFE731-3B-100S Engine



Engine Oil System



Powerplant

This chapter provides a brief overview of the Garrett AiResearch TFE731-3B-100S/-3C-100S engine and its systems. This includes:

- engine indicating
- lubrication
- engine fuel and fuel control
- ignition
- engine controls
- engine synchronization
- optional automatic performance reserve (APR) system.

Also included is a brief description of the various optional auxiliary power units (APUs).

TFE731

Two TFE731-3B-100S/-3C-100S engines power the Citation III/VI aircraft. Service bulletins allow the use of a mixed engine pair or replacement of the original -3B engines with a -3C engines.

Each engine produces 3,650 lbs of static thrust at sea level. The TFE731-3BR-100S/-3CR-100S engines are part of an optional automatic performance reserve (APR) system that produces an additional 200 lbs of thrust during emergencies.

The engine is a two-spool turbofan that consists of:

- geared single-stage fan (N_1)
- four-stage axial low pressure compressor (N_1)
- single-stage centrifugal high pressure compressor (N_2)
- annular (ring-shaped) combustion chamber
- single-stage axial high pressure turbine (N_2)
- three-stage axial low pressure turbine (N_1).

In the TFE731 engine, thrust begins with the acceleration of air by the front fan. The air then splits into two streams. One stream passes around the engine core through the bypass duct to the exhaust. The second stream enters the four-stage low pressure (LP) axial compressor, flows through the single-stage high pressure (HP) compressor, and finally enters the combustion chamber.

Entering the combustion chamber, the air is forced forward through a 180° turn. Fuel introduced in the combustion chamber mixes with the air where two igniters provide an electrical spark to ignite the fuel/air mixture. After engine start, the combustion process is self-sustaining. The fuel/air mixture burns and expands to produce a high-temperature, high-velocity gas stream. The gas stream leaves the combustion chamber and makes another 180° turn before it reaches the HP turbine. The high-velocity gas stream rotates the HP turbine that, in turn, drives the HP compressor through an outer concentric shaft and drives the accessory gearbox through a vertical tower shaft and transfer gearbox. The accessory gearbox, in turn, drives the fuel pump, fuel control unit (FCU), oil pump, starter/generator, alternator, and hydraulic pump.

The gas stream travels aft where it turns the three-stage LP turbine; the LP turbine then drives the LP compressor through an inner concentric shaft and the front fan through a planetary gearbox. Finally, the high velocity gas stream mixes with low velocity bypass air aft of the exhaust tail pipe to produce forward thrust. The combined streams then exit through the exhaust nozzle.

Engine Indicating

A transducer on the engine's low pressure turbine shaft provides an engine speed signal to the FAN indicator tape and digital readout and its electronic engine computer (EEC). The indicator powered by the Emergency Crossover bus shows N_1 RPM as a percentage with 100% equalling 20,690 RPM.

A transducer driven by the transfer gearbox provides an electrical signal to the digital readout TURB indicator and its EEC. The indicator shows N_2 RPM as a percentage with 100% equalling 29,692 RPM. The Left Feed bus powers the left engine's TURB indicator and the Right Feed bus powers the right engine's TURB indicator.

Ten parallel-wired alumel-chromel thermocouples extend into the gas path between the high and low pressure turbines. Together, they provide an average reading of inter-turbine temperature (ITT) as electrical signals to the ITT indicator tape and digital readout and EEC. The ITT indicator receives power from the Emergency Crossover bus.

Lubrication

The oil pump's pressure elements draw oil from the oil tank and provide it under constant pressure through a filter to the fuel heater. If the filter begins to clog, its bypass valve opens to route oil around the filter. A red indicator pin "pops out" as a visual indication of filter clogging.

Oil flows from the filter to the fuel heater where the hot oil flows through a heat exchanger to warm the fuel before the fuel reaches the engine fuel control. At low oil temperatures where oil may resist flowing, a bypass valve opens to route oil around the fuel heater. After warming fuel, the oil flows to the three section air/oil cooler in the bypass duct.

A temperature-controlled bypass valve regulates oil temperature by controlling the amount of oil flowing through the air/oil cooler. At an oil temperature below approximately 149°F (65°C), the bypass valve opens to route oil around the cooler. Above 149°F (65°C), the valve closes and most of the oil flows through the air/oil cooler. If the air/oil cooler blocks, a pressure-operated bypass valve opens to bypass oil around the cooler.

After leaving the air/oil cooler, the oil flow splits. One flow continues to the fuel/oil cooler, and the other flows to the accessory and transfer gearboxes and the engine bearings. In the fuel/oil cooler, transfer of oil's heat to the fuel maintains oil at a maximum temperature of 260°F (127°C). Below approximately 210°F (99°C), the bypass valve routes oil past the fuel/oil cooler. If the cooler clogs, the bypass valve also opens to route oil past the cooler. After flowing through the fuel/oil cooler, oil flows to the engine's No. 1, 2, and 3 bearings and the fan planetary gear case.

After the oil lubricates, cools, and cleans the engine, the oil pump's scavenge elements draw oil from the bearing sumps, cavities, and casings and return it to the oil tank.

The lubrication system has a pressurization and venting system that ensures efficient oil pump operation and prevents oil foaming at high altitudes.

A pressure transmitter and a temperature transmitter downstream of the fuel/oil cooler drive the vertical tape OIL PRESS and OIL TEMP indicators respectively. The left oil pressure and temperature indicating system receives power from the Left Feed bus. The right oil pressure and temperature indicating system receives power from the Crossover Right Feed bus.

If oil pressure drops to 25 PSI, a pressure switch downstream of the fuel/oil cooler illuminates the LH/RH OIL PRESS WARN annunciator. The annunciator extinguishes with an oil pressure above 38 PSI.

If sufficient ferrous metal particles accumulate on a chip detector downstream of the oil pump's scavenge elements, the associated OIL CHIP DETECTOR LH/RH annunciator illuminates.

Fuel System

The fuel control system provides fuel under pressure from the fuel pump, filters contaminants, meters fuel with an electronic engine computer (EEC) and hydro-mechanical fuel control unit (FCU), and then delivers the fuel from the fuel flow divider to the twelve duplex nozzles. The EEC provides efficient fuel scheduling and overspeed, surge, and overtemperature protection based on engine inlet pressure (P_{t2}), inlet temperature (T_{t2}), ITT, N_1 RPM, N_2 RPM, and power lever angle (PLA).

With these operating parameters, the EEC commands the FCU's torque motor to provide the correct fuel flow during all operating conditions. The EEC provides overtemperature and overspeed protection by limiting fuel flow through the FCU. The EEC also controls the engine's surge bleed valve to prevent engine surging and stalling during acceleration and deceleration.

Fuel flows from the engine-driven pump through the fuel heater to the fuel control unit and then to the fuel flow divider. During engine start, the fuel flow divider supplies fuel to only the primary fuel nozzles. As engine speed and fuel pressure increases, the flow divider begins supplying fuel to the secondary nozzles.

Controlled by the LH/RH FUEL COMP switches, the left and right EECs operate on 28V DC supplied by the Left Main DC and Right Main DC buses respectively.

Twelve duplex (primary and secondary) fuel nozzles, fed by the fuel manifolds, extend into the engine's combustion chamber. When supplied with fuel, each duplex nozzle supplies a cone-shaped spray of finely atomized fuel into the combustion chamber.

Ignition

Each engine has a high-voltage ignition system that operates on 28V supplied by the Battery bus or the Left and Right Main DC buses.

During engine start with an IGNITION switch in NORM and the START button pressed, moving the throttle lever from the cutoff position supplies power through the de-energized ignition relay and energized boost pump relay to the ignition unit. The ignition unit operates until the generator control unit (GCU) de-energizes the start control relay that, in turn, de-energizes the boost pump relay.

Placing the switch in ON supplies power directly from the Left Feed bus or Crossover Right Feed bus (depending on system selected) to the ignition unit for continuous operation. Placing an IGNITION switch in SEC or an ENG ANTI-ICE switch in ON also provides continuous ignition operation by supplying power from the tailcone junction box.

Whenever the ignition unit receives power, a green IGN light in the ITT indicator illuminates. Illumination of the IGN light only indicates power to the ignition unit and not unit operation.

Engine Controls

Each throttle lever indirectly operates the fuel control unit (FCU) through the EEC or directly with torque tubes, pushrods, and controlex cables. In response to throttle lever movement, the EEC senses power lever angle (PLA) and combines this with the engine operating parameters to operate the FCU's torque motor. The FCU, in turn, either increases or decreases fuel flow to the engine to obtain the desired thrust setting.

With the EEC failed or with its FUEL COMP switch in MAN, movement of the throttle lever directly controls the FCU.

During intentional and unintentional thrust reverser operation, a feedback cable between the thrust reverser actuating mechanism, FCU, and throttle lever ensures that the FCU is in the idle thrust position during thrust reverser deployment and stowing. This mechanism also drives the associated throttle lever to the idle position.

Engine Synchronizer

When operating, the engine synchronizer compares and automatically adjusts right engine (slave) speed to match left engine (master) speed.

With both FUEL COMP switches in NORM, placing the three-position (FAN/OFF/TURB) switch in FAN compares right engine N_1 speed to left engine N_1 speed. The synchronizer unit then supplies a trim up or trim down signal to the right engine's EEC until its speed matches the left engine. Placing the switch in TURB performs the same function but compares and matches right engine N_2 speed to the left engine's N_2 speed. When engine synchronization is operating, the SYNC ON light next to the R ENG indicator illuminates. Placing the switch in OFF disables engine synchronization.

Engine synchronization has a limited authority range and only operates when left and right engine speed is within 2.5% N_2 at throttle midrange. Above and below midrange, authority range decreases.

Automatic Performance Reserve

On **aircraft with TFE731-3BR or -3CR engines or SB650-76-01**, an automatic performance reserve (APR) system provides an additional 200 lbs of thrust to the operating engine if the opposite engine loses power during takeoff. With the system armed (ARM light illuminated), the APR controller through the EECs monitors left and right engine N_2 speed. If a 5% N_2 speed difference occurs between the engines during takeoff, the APR controller removes the trim signals from the EEC that, in turn, raise engine operating limits by 1% N_2 and 25°C (77°F) ITT. During APR operation the APR ON switchlight illuminates.

The system can be also be manually activated by pressing the APR ON switchlight. With the system automatically or manually activated, pressing the DISARM/ARM switchlight disarms the system.

Ground Idle System

A ground idle system automatically reduces engine idle speed to reduce landing roll, taxi speeds, and brake wear. With the GND IDLE switch in NORM, the system senses touchdown through the main landing gear squat switch. After an eight-second delay, the engine synchronizer sends a trim down signal to the EECs that, in turn, reduce engine idle speed. With the system operating, the GROUND IDLE annunciator illuminates.

Placing the GND IDLE switch in HIGH overrides the system and prevents automatic thrust reduction at touchdown during touch-and-go landings and system malfunction.

Auxiliary Power Unit

Optional auxiliary power units (APUs) on the Citation III/VI include the Turbomach T62T-40 installed by Cessna or PATS, Inc. and the Garrett GTCP36-100 APUs installed by Duncan Aviation or PATS, Inc. Please refer to **Table 4-A** for a listing of the various APUs and their operating and DC power capabilities. For additional information, refer to the Aircraft Flight Manual (AFM), AFM Supplements, and the applicable manufacturer's manuals.

Depending on the installation, the APU's generator supplies DC power for operation of aircraft systems and engine starting and bleed air for air conditioning and heating. If the APU has a hydraulic pump, it can also power the main hydraulic system. On flight-rated APUs, the APU can also power the aircraft's DC electrical and main hydraulic system.

The APU powerplant is a continuous cycle, gas turbine engine that has a single stage, radial inflow turbine. A starter-generator provides torque for APU starting and, after the APU reaches operating speed, DC power. The APU has aircraft-independent lubrication, fuel and fuel control, ignition, fire protection, and electrical systems. The APU draws fuel from a tapping in the right engine low pressure fuel feed line downstream of the fuel shutoff valve.

APU	Max Altitude	Max Amps Ground[1]	Max Amps Air
Cessna T62T-40 (ground only)	N/A	350 ≤ISA -5°C 200 ≤ISA +37°C	N/A
Cessna T62T-40 (ground/flight)	25,000	350 ≤ISA -5°C 200 ≤ISA +37°C	200
PATS T62T-40 (STC SA298NE)	20,000[2] 30,000[3]	150	150
Duncan GTCP36-150 (STC SA2110CE)	20,000[2] 30,000[3]	150 to 300[4]	150 to 300[4]
PATS GTCP36-150 (STC SA755NE)	20,000[2] 30,000[3]	150	150

Table 4-A; Auxiliary Power Unit

[1] Transient current greater than shown permitted for APU generator engine starts

[2] Maximum starting altitude

[3] Maximum operating altitude

[4] Varies with pressure altitude and static air temperature