POWER PLANT SYSTEMS

DESCRIPTION

The PW306A Engine is a two-spool turbofan engine, featuring a full-length annular bypass duct. A concentric shaft system supports the high and low pressure rotors. The inner shaft supports the low pressure (LP) compressor (fan) and is driven by a three-stage turbine at the rear. The outer shaft is mechanically independent of the LP shaft and supports the four axial stages and one centrifugal stage of the high pressure (HP) compressor, and is driven by a two-stage turbine supported at the rear.

Air enters the engine through the fan case, is accelerated rearwards by the fan and is split into bypass and core flow streams through concentric dividing ducts. The bypass air passes through a single stage of stators and a faired bypass duct before exiting with the core flow through a common mixing nozzle.

The core airflow passes through variable inlet guide vanes and first-stage variable stator vanes, which allow optimum airflow into the HP compressor. Both sets of vanes are hydraulically actuated by fuel pressure from the hydro-mechanical unit, as commanded by the electronic engine control. From the HP compressor, core airflow is passed through 24 diffuser tubes, which convert velocity to static pressure. The diffused air then passes to the annulus surrounding the combustion chamber liner.

The combustion chamber liner consists of an annular straight-through assembly, with multi-holed patterns for air mixing and dilution with the combustion gases.

The air enters the combustion chamber liner and mixes with fuel is injected into the combustion chamber by 24 air blast nozzles supplied by a single-tube manifold.

Two of the nozzles are hybrid-type, having an additional fuel supply line of lower pressure, to provide a separate primary fuel flow, for ease of starting. During starting, the mixture is ignited by two spark igniters which protrude into the combustion chamber liner.

The resultant gases expand from the combustion chamber liner and pass through the first-stage HP turbine stator to the first stage HIP

turbine. The first-stage HP vanes and rotor blades are cooled by air flowing through second-stage HP vanes and turbine, then to the three-stage LP turbine and associated stator vanes, then to atmosphere through the exhaust duct, subsequently mixing with the bypass flow.
All engine driven accessories, with the exception of the N_1 LP rotor speed sensor, are mounted on the accessory gearbox secured to the bottom of the intermediate case. The accessories are driven by a tower drive shaft geared to the HP rotor shaft (N_2), passing downward through the intermediate casing to mesh with a bevel gear in the accessory gearbox. The N_2 speed sensors are of an electromagnetic pulse type. A spur gear on the alternator gear shaft passes over the probes, creating an impulse which is transmitted to the FADEC. The N_1 speed sensors are mounted in the aft end of the engine, in the exhaust case. The operation of the N_1 probes is the same as the N_2 probes, and transmits signals to the FADEC.
The engine oil tank is integral with the intermediate case and is located between the core and bypass flow passages.

Maximum continuous and maximum climb ratings (or thrust settings) are meant for different purposes. Maximum continuous rating is authorized without time limitations for aircraft certification to meet FAA approved performance for single engine operations or in emergency conditions, but it is not authorized for normal cruise operations. Use of this rating under normal operating conditions may void engine warranty and cause excessive cost of maintenance. Climb setting is limited same as the maximum continuous thrust setting, and can only be used for climb segment and acceleration to cruise speed. For engine Operating Limitations, see LIMITATIONS, SECTION I.

Anti-icing system for nacelle and engine is also provided. (Sea ANTI-ICING AND RAIN PROTECTION SYSTEMS, this section.)

Engine vibration is monitored by a system consisting of an accelerometer mounted on the engine flange and signal conditioner. Its output is fed to the EICAS

When the EICAS indicator points at the yellow band, thrust should be reduced to bring the pointer to the green band. If the pointer stays in the yellow band with engine idle, shutdown the engine.

If changing thrust does not change pointer position, continue operation and monitor engine indications.

Thrust Management

The fuel system regulates fuel flow and operates engine variable guide vane system as a function of various schedules to meet the required thrust setting.

The fuel system components control the following features:

• Proper fuel flow at minimum fuel introduction speed (5.2% N_2)
• Sequencing fuel distribution to the proper nozzles during start
• Controlling ground and flight idle speed
• Providing strong surge free acceleration
• Providing rapid deceleration without extinguishing the combustion
• Providing fuel shut off and fuel dump after shut down
• Providing protection against ITT overtemperature
• Providing protection against compressor and fan overspeed

PW306A engine thrust is controlled by a dual channel full authority digital electronic control (FADEC) which regulates high pressure rotor speed (N_2) and low rotor (fan) speed N_1 in response to a pilot-operated Thrust Lever (TL), ambient conditions, pilot selection and aircraft discrete inputs. The main control system components are the Thrust Lever, Electronic Engine Control (EEC) and the Hydromechanical Fuel Metering Unit (HMU).
The hydromechanical fuel metering unit (HMU) responds to EEC electrical command.

During engine start, left and right FADEC's are powered by 28 VDC supplied by Emergency bus, through L and R FADEC-A & B circuit breakers, on overhead panel. After start, power is supplied by engine-mounted power management accessory.

During start-up and at idle, the FADEC supervises and controls high pressure compressor speed (N_2). Above idle, the FADEC controls and supervises N_1 speed. This is done in accordance with the data supplied by aircraft and engine sensors, engine trim and airframe discrete inputs from the flight deck.

Determining the proper N_1 to get the required thrust is accomplished by the FADEC. It features two independent channels, either of which can fully control the engine. The required N_1 is a function of thrust lever position and the ambient conditions. The channel in control adjusts the fuel metering valve position within the HMU, to achieve the appropriate fan speed to produce thrust.

Calculated N_1 speed is a function of:

- thrust lever position
- Ambient conditions: total temperature, total and ambient pressure
- APR status
- Aircraft status as indicated via discrete inputs for such conditions as cabin bleed(s) open, inlet anti-ice on, synchronization selection and reverse thrust operation
- Specific engine trim (T4.5 and N_1)
- Mechanical red line speeds
- Engine thermal protection

In addition to dual channel FADEC, following components redundancy is available:

- Dual overspeed protection system independent of the EEC control logic
- Redundant low and high pressure rotor speed sensors
- Dual channel permanent magnet alternator supply power to EEC software logic and overspeed protection circuitry with aircraft 28 VDC bus for start and back up.
- Redundant means of effecting shut-off

The EEC is configured such that, while either channel may fully control the engine, if one channel degrades, (such as sensor failure), values are taken from the other channel or control is transferred automatically to the more fit of the two channels. Control of the engine is still achieved if both channels become degrades, with reduced capacity.

The EEC roles are:

- Starting and shut-down control and supervision
- Power management
- Rating display
- Compressor bleed valve control and VGV control
- T4.5, N_1 & N_2 display
- Speed synchronization
- Automatic power reserve control
- N_1 and N_2 overspeed protection overtemperature protection (T4.5)
- Fault management
- Motive fuel flow control
- EICAS and diagnostic display

Thrust Levers

Each engine is controlled by a thrust lever, prominently located in center of pedestal. An RVDT connected to the FADEC senses thrust lever position to control engine speed for either forward or reverse thrust setting.
Go-Around (GA) switches on the outboard side of each thrust lever allow the pilot to disconnect the autopilot (leaving the yaw damper engaged) and position the flight director command bar to 9°.

Engine Synchronization

Engine synchronization maintains the slave engine speed within ± 0.1% of the master engine speed. Either N_1 or N_2 engine synchronization can be selected. The engine with the higher fan speed is chosen as the master engine. Synchronization is available when the following conditions are met:

- The ENGINE SYNC switch is either in the N_1 or N_2 position.
- The thrust lever is at or above idle detent and at or below maximum climb detent
- APR is not armed
- The thrust reversers are stowed
- The N_1 or N_2 speed differential between engines is within the capture band of ± 5%
- N_1 and N_2 signals are available
- The slave engine is at steady state

EICAS ENGINE DATA DISPLAY

General

Each engine is factory-trimmed to provide accurate thrust management and display. The trim is achieved by a trim plug installed on the engine, providing 0% to -3.3% N_1 reduction.
When engine synchronizer is off, the EICAS displays trimmed RPM, corresponding to the required thrust.
When synchronizer is on, untrimmed (actual) RPM is displayed.
The left engine is normally the master engine. It is factory set to be the engine with the higher trim value. If the master engine has a lower trim value, difference of up to 1% is allowed between the engine trim settings. When the master engine thrust rating is more than 1% less than the slave engine, strapping changes must be made between the master and slave engines
Engine synchronizer disconnects when: a difference of more than 5% N_1 between the engines, APR is armed, slave engine thrust setting is beyond MAX CLIMB or master engine thrust setting is more than 1% N_1 beyond MAX CLIMB.

Thrust Setting and Bug Setting

N_1 bug setting and digital readout are always similar. On ground when not in reverse thrust, the bug is always set to TAKE OFF or APR, if activated.
Take-off thrust N_1 should always be 0% to +2% above bug setting. If APR is activated N_1 thrust setting rises; the failed engine **APR** display disappears and the operating engine **APR** display turns green.
When reverse thrust is selected, the bug is set to MAX REVERSE.
Reverse thrust setting is modulated according to airspeed: from 85% N_1 above 100 KIAS to 50% N_1 at 40 KIAS or below.

In flight, the bug settings always correspond to the next higher thrust lever ‘detent’ settings, with the exception of maximum cruise (MCR) as follows:
Up to 35,000 ft, bug setting and N_1 readout are at normal maximum

cruise, corresponding to the scheduled thrust setting. Above 35,000 ft, bug setting stays at normal maximum cruise but N_1 readout and thrust setting are at high maximum cruise (**HIGH CRUISE POWER** message on) and rise incrementally (by up to 7% thrust at 39,000 ft). This is allowed for up to 30 minutes per flight, after which thrust needs to be reduced to bug setting.

If N_1, N_2 or ITT is exceeded, EICAS page 1 is automatically displayed and the above-limit display flashes red for 4 seconds. When APR is armed, ITT limit is reduced, to accommodate a corresponding rise when APR is activated.

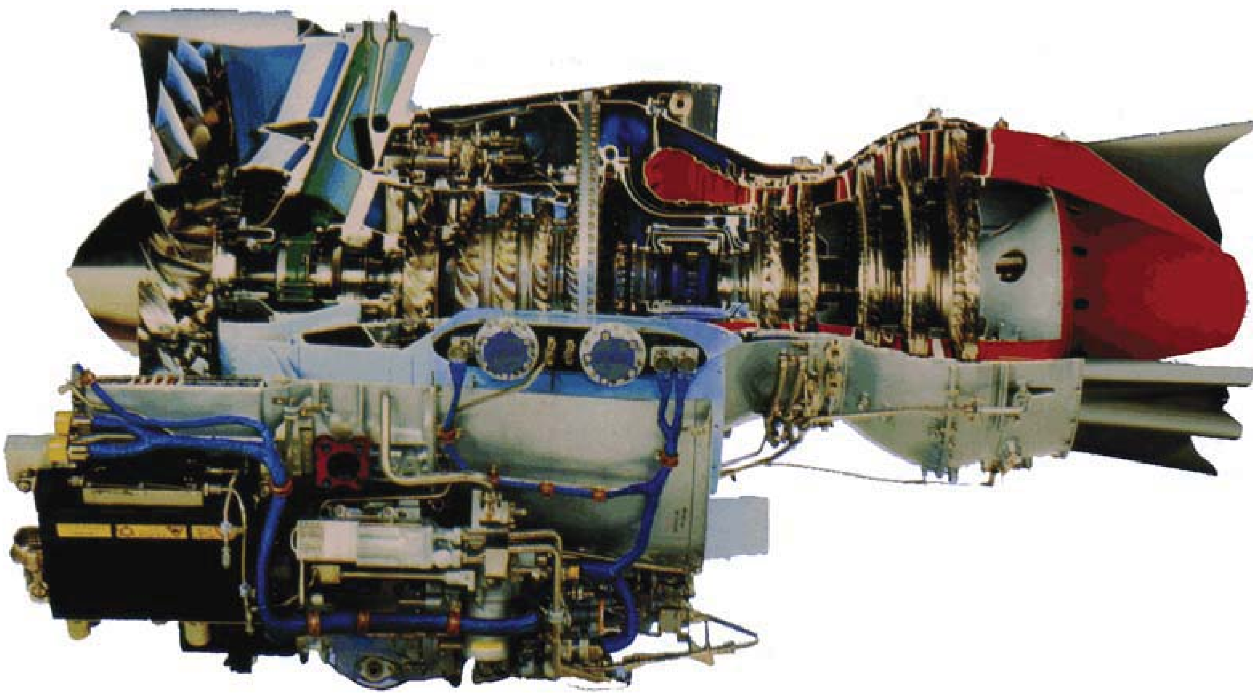

Figure 5-40. Engine Cutaway View

ENGINE CONTROL SYSTEM - CONTROLS AND INDICATORS

STARTER switch - Located on overhead panel; it has three positions:
- START - Momentary position to engage starter
- OFF - Starter is off
- STOP - Stops starter operation

STBY FUEL PUMP switch - Located on overhead panel; it has three positions:
- AUTO - Standby pump comes on automatically, when required
- OFF - Standby pump is off
- ON - Standby pump is on continuously

IGNITION switch - Located on overhead panel; it has two positions:
- ON - Ignition is continuous
- AUTO - Ignition comes on when required during engine start or by FADEC command

APR ARM pushbutton, on pilot panel - Arms the APR system

ENG. SYNC toggle switch, on pedestal - Engages engine synchronizer by N_1 or N_2

L / R ENGINE FUEL CUT OFF pushbuttons - Located on pedestal. Controls fuel supply to the respective engine. Pushbutton is lit when fuel supply is cut off.

ENG DATA REC L/R buttons - located on right pedestal sidewall. Spring-loaded to off. Toggle switch if it is necessary to record engine data for later maintenance. Four minutes prior to button press and one minute afterwards are recorded

Engine vibration indicator - dual indicator for monitoring engine vibrations. The green band is for normal condition and the yellow band indicates excessive vibrations.

Warning Messages

ENG FIRE (L/R) - Engine fire (zone 1)
ENG OVER HEAT (L/R) - Engine overheat (zone 2)
ENG OIL PRESS LOW (L/R) - Engine oil pressure is low
ENG OIL PRESS HI (L/R) - Engine oil pressure above limit
ENG OIL TEMP LOW (L/R) - Engine oil temperature below limit
ENG OIL TEMP HI (L/R) - Engine oil temperature above limit

Caution Messages

FADEC MAJOR (L/R) - Full Authority Digital Engine Control computer malfunction.
FADEC FAULTY (L/R) - Full Authority Digital Engine Control computer failure
ENG OIL LEVEL LOW (L/R) - Engine oil quantity too low (comes on on ground only, & engine not running)
ENG OIL TEMP HI (L/R) - Engine oil temperature approaching limit

Advisory Messages

IGNITION ON (L/R) - Engine ignition is on
HIGH CRUISE POWER - Engine providing high thrust (above 35,000 ft)

Status Messages

ENG CHIP DETECT (L/R) - Metal particles found in engine oil
ENG OIL FILTR (L/R) - Engine oil filter is clogged
FADEC MINOR (L/R) - FADEC (Full authority digital engine control) minor malfunction. Appears on ground only with engine off and up to 1 minute after engine start.
L ENG FIRE BTLE - Aircraft in flight and left engine fire extinguisher bottle pressure below 400 psi
R ENG/APU FIRE BTLE - Aircraft in flight and right engine/APU fire extinguisher bottle pressure below 400 psi

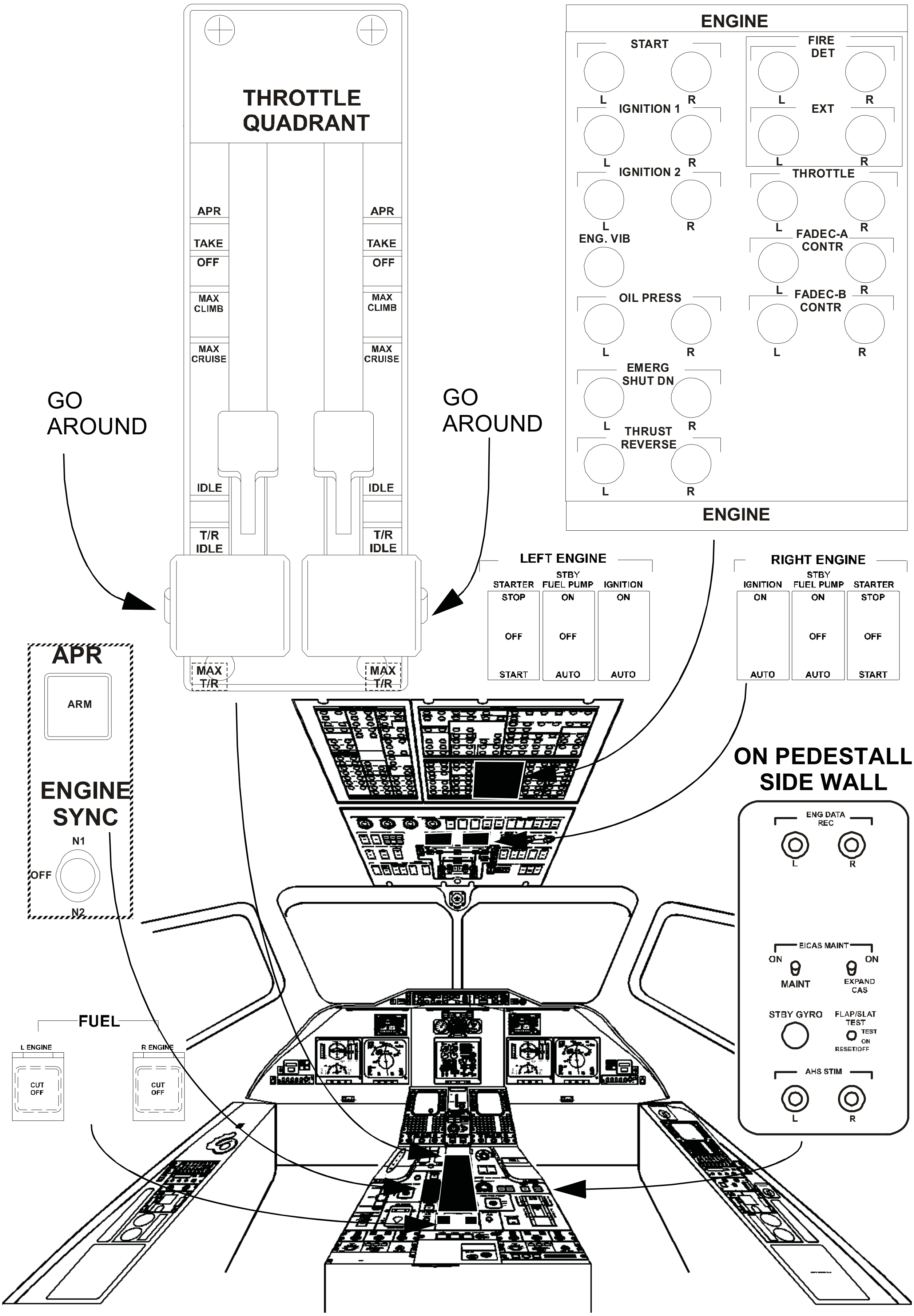

Figure 5-41. Engine Controls

APPROVED OIL

Approved oils conforming to Pratt & Whitney Canada specification, PWA521:

- Aeroshell/Royco 560
- Esso/Exxon 2380 Turbo Oil
- Castrol 5000
- Mobil Jet Oil II
- Mobil Jet 254