GENERAL

A Honeywell 36–150(CL) constant-speed gas turbine auxiliary power unit (APU) is installed within a fire-resistant compartment in the aft equipment bay.

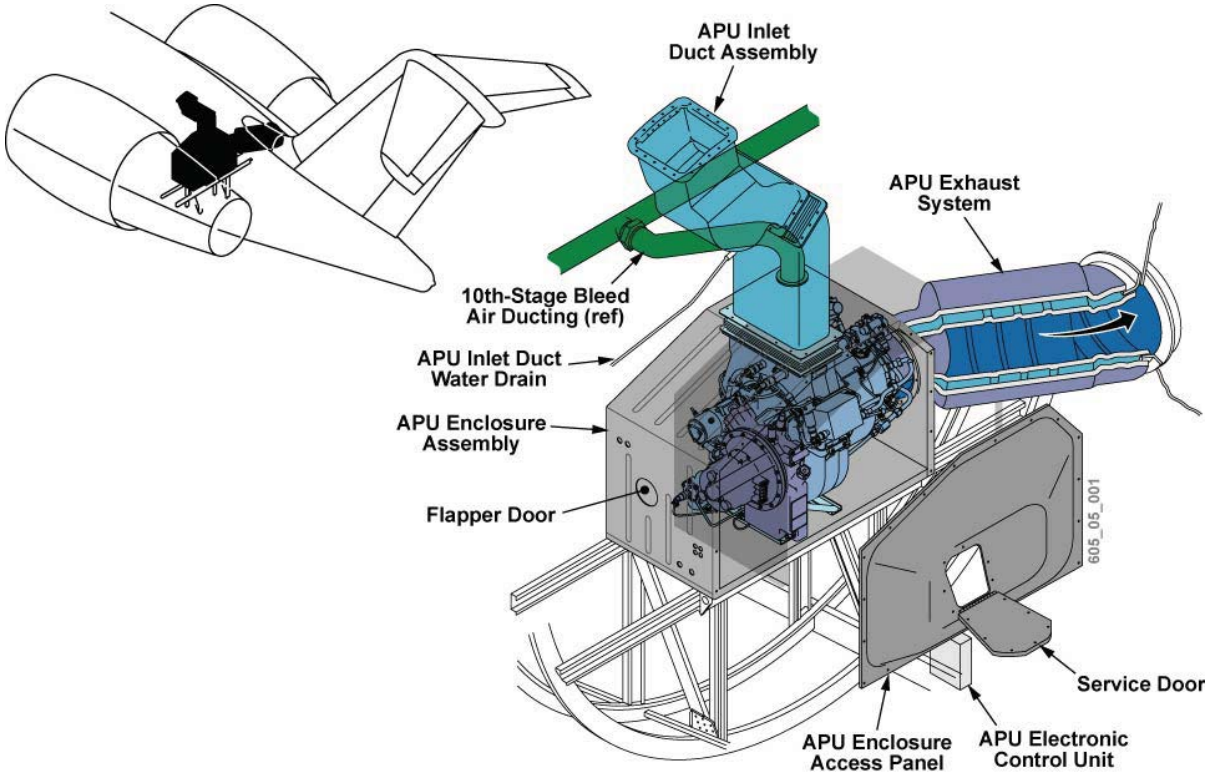
The APU drives a generator, providing AC electrical power, that serves as a backup AC power source up to an altitude of 20,000 feet. The APU also provides pressurized bleed air to the 10th-stage manifold for engine starting up to 15,000 feet. In-flight APU bleed air extraction for air conditioning is not permitted above 15,000 feet.

The maximum operating altitude of the APU is 20,000 feet MSL. In-flight APU starting is guaranteed up to 20,000 feet, from 141 to 290 KIAS.

APU Enclosure

The APU enclosure is a stainless-steel, fire-resistant box with dedicated fire detection and fire extinguishing capabilities. The enclosure is located in the forward section of the aft equipment bay, and is equipped with a service door for APU oil servicing. A spring-loaded closed flapper door is located on the left side of the enclosure, and opens to provide cooling airflow while the APU is operating.

Refer to Chapter 9, Fire Protection, for information on the APU fire detection/extinguishing systems.



Auxiliary Power Unit (APU)
Figure 05–10–1

POWER SECTION AND ACCESSORY GEARBOX

Description

The APU power section consists of a gas turbine engine with integrated oil, ignition, and start systems. The power section drives a gearbox that reduces the rotational speed of the APU to a speed appropriate for operation of gearbox-mounted accessories.

The APU powerplant consists of the following groups:

- Compressor
- Combustor
- Turbine
- Accessory gearbox
- Exhaust

Components and Operation

Power Section

Engine power is developed through compression of ambient air by a centrifugal compressor. The compressed air, when mixed with fuel and ignited in the annular reverse-flow combustor, drives a turbine. The rotating shaft of the turbine rotor drives the compressor and the drive shaft of the accessory gearbox.

Accessory Gearbox

The APU accessory gearbox assembly provides power transfer from the starter motor to the power section and accessories during APU starting, and to all gearbox-mounted accessories during on-speed rotation. The accessories include:

- Start motor
- Generator adapter
- Speed (rpm) sensor, oil temperature and oil pressure switches
- Lubrication module
- Fuel control unit

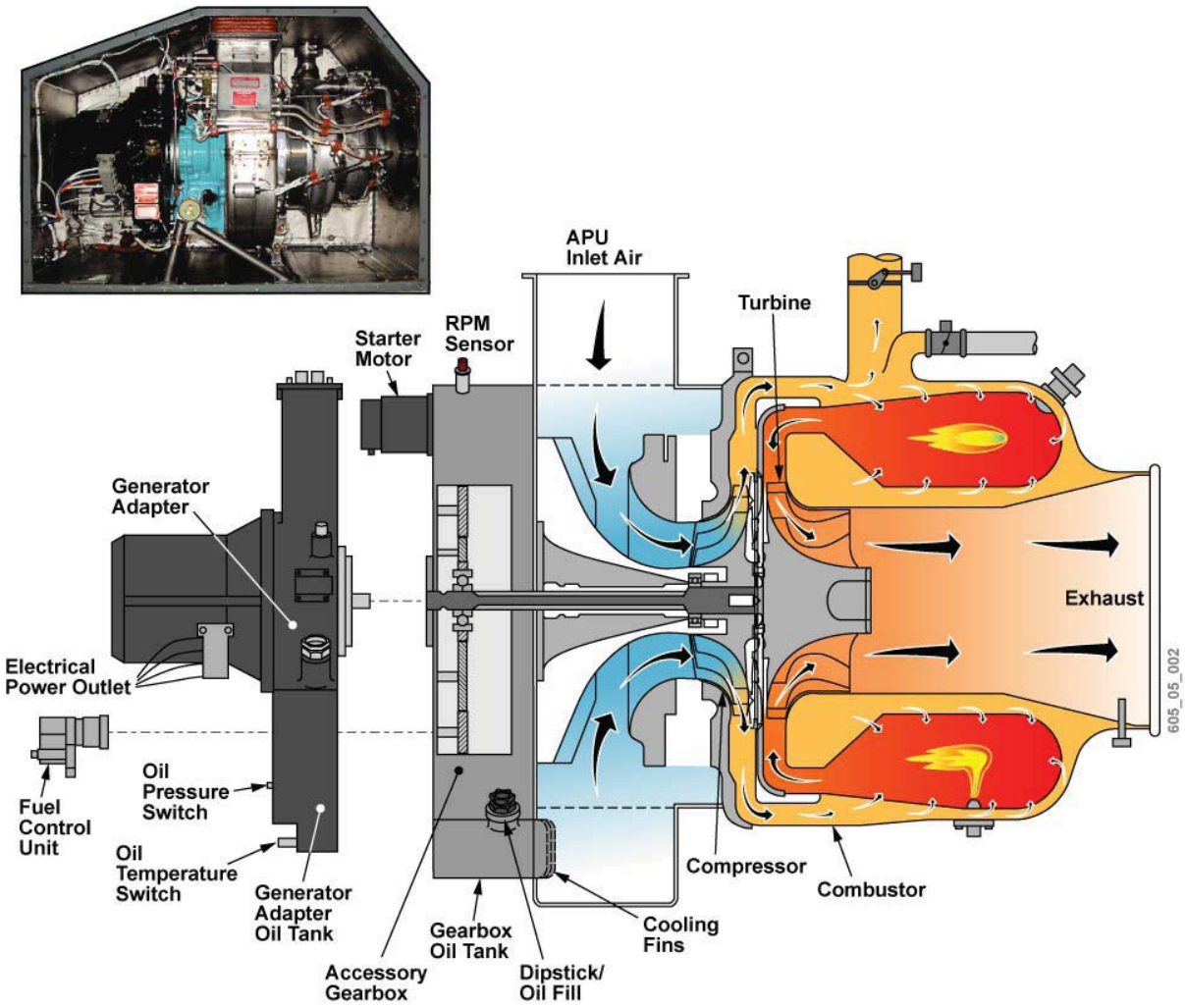
Gearbox Lubrication

The APU accessory gearbox also serves as an oil reservoir and wet-sump lubrication system. A filler cap with an integrated dipstick is incorporated for gearbox oil servicing. Gearbox oil cooling is achieved by directing airflow over the integral cooling fins, located in the lower casing of the accessory gearbox.

NOTE

Wait a minimum of 30 minutes after APU shutdown to allow the gearbox wet sump oil level to stabilize. Otherwise, quantity indications may be inaccurate, and the reservoir may be overfilled.

POWER SECTION AND ACCESSORY GEARBOX (CONT'D)



APU Power Section and Accessory Gearbox
Figure 05–10–2

GENERATOR ADAPTER

Description

The generator adapter transfers APU rotational power from the gearbox to the APU generator. The adapter has a dedicated pressurized lubrication system and pressure switches that monitor oil system parameters.

GENERATOR ADAPTER (CONT'D)

Components and Operation

APU Generator

The APU generator adapter drives a 30 kVA, 400 Hz, three-phase AC generator. The generator is identical to the engine-driven generators, providing a backup source of 115V/400 Hz electrical power for all aircraft systems, up to an altitude of 20,000 feet.

Refer to Chapter 7, Electrical, for additional information on electrical generation.

Generator Adapter Lubrication

Generator adapter lubrication is independent from the accessory gearbox lubrication, and has a separate filler cap with an integrated dipstick for servicing.

NOTE

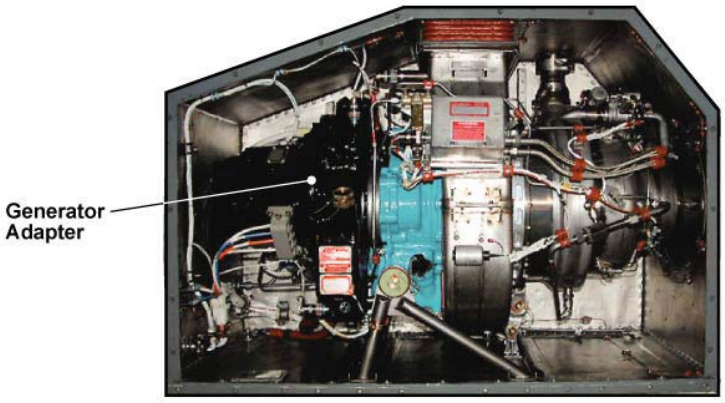
Wait a minimum of 30 minutes after APU shutdown to allow the generator adapter oil level to stabilize. Otherwise, quantity indications may be inaccurate, and the adapter may be overfilled.

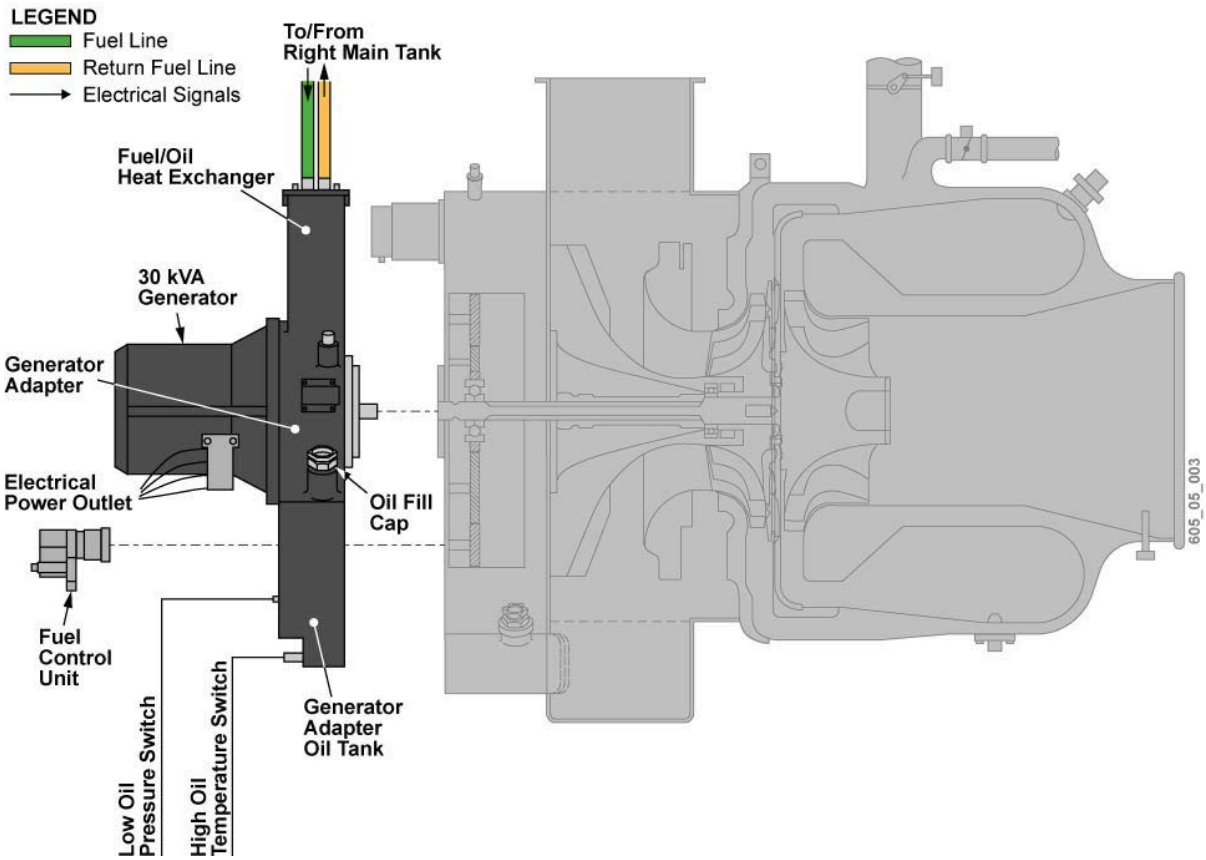
The oil within the generator adapter lubrication system is cooled by a fuel/oil heat exchanger. The cooling fuel supply to the heat exchanger comes from the normal APU fuel feed via the right main tank. If the normal fuel feed is not available, generator adapter oil cannot be cooled, and APU operating time is limited.

GENERATOR ADAPTER (CONT'D)

CAUTION

Generator adapter oil pressure is high immediately after APU shutdown. Prior to opening the APU generator/adapter oil filler cap, push and hold the pressure-relief valve cap for five seconds. This action releases pressure from the APU generator adapter housing.





AIR INTAKE AND EXHAUST

Description

The APU air intake is located on the upper left portion of the aft fuselage, near the base of the vertical stabilizer. The opening of the intake is flush with the fuselage.

APU exhaust gases are expelled through an exhaust, and exit on the right side of the aft fuselage.

Components and Operation

Air Intake

The air intake is an s-shaped duct, equipped with an inlet screen and a water trap (with associated drain line). The intake is attached to the top of the APU enclosure.

Intake Scoop

A permanent fixed intake scoop is located aft of the APU inlet opening. The purpose of the scoop is to increase inlet ram air recovery, providing for increased performance and decreased APU EGT.

Exhaust

The APU exhaust nozzle (tailpipe) directs exhaust gases from the APU into the exhaust duct, located below the right engine. The nozzle is smaller in diameter than the exhaust duct, and therefore acts as an ejector, drawing air inside the enclosure and mixing it with the exhaust gases. This method cools the exhaust gases, and also establishes a ventilation flow in the enclosure by drawing cooling air via the spring-loaded flapper door, installed on the opposite side of the APU enclosure.

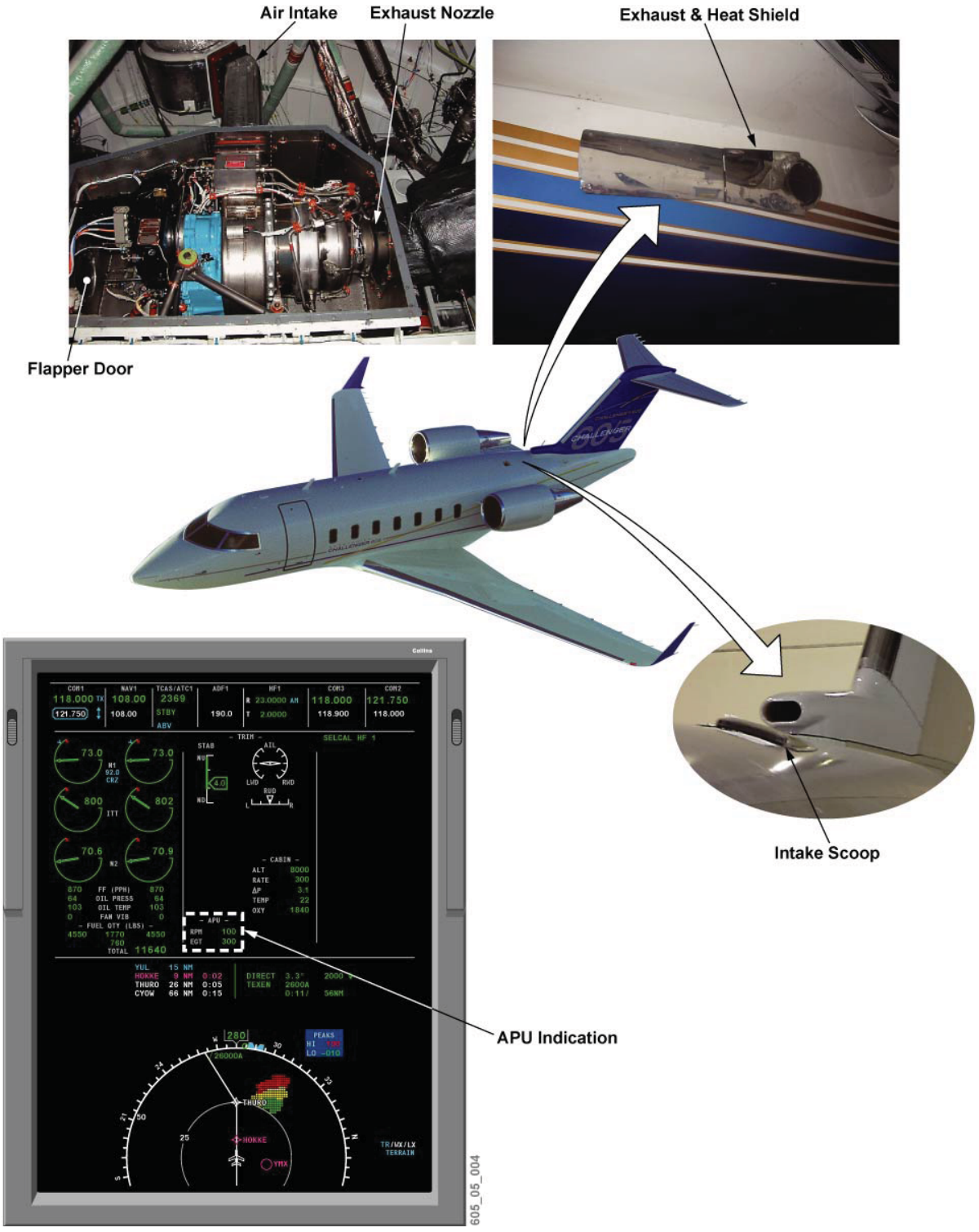
Heat Shield

The exhaust gas heat shield is installed on the aft side of the fuselage, below the right engine pylon. The heat shield is used to minimize the exhaust gas impact on the aircraft skin.

EGT Indications

APU exhaust gas temperature is represented on the EICAS page, using a grey legend (EGT) and a digital readout that is displayed in degrees Celsius. The APU's operating limits are represented by color change of the EGT readout by showing green, yellow and red when the APU temperature increases.

AIR INTAKE AND EXHAUST (CONT'D)



Air Intake, Exhaust and Indication
Figure 05–10–4

APU FUEL DISTRIBUTION

Description

The APU fuel system provides fuel for APU start, acceleration, and governed speed control. During start, the fuel system provides the correct amount of fuel to support combustion, and ensures smooth acceleration of the engine to full power. Once full power is reached, fuel flow is modulated, as necessary, to meet the demands of varying pneumatic and electrical loads, while maintaining a constant speed.

The normal fuel supply to the APU is from the right main tank. A backup fuel supply from the left engine motive flow system is provided in case negative-G conditions are encountered.

Components and Operation

APU Fuel Pump

The DC battery bus powers the APU fuel pump, which draws fuel from the right main tank. The pump provides fuel to the fuel control unit through the APU's feed line and the fuel shutoff valve. A portion of the fuel from the APU fuel pump is directed to the APU fuel control unit for combustion, while the remainder is routed through the fuel/oil heat exchanger to provide cooling of the APU generator adapter oil. Fuel that has passed through the fuel/oil heat exchanger is returned to the right main tank.

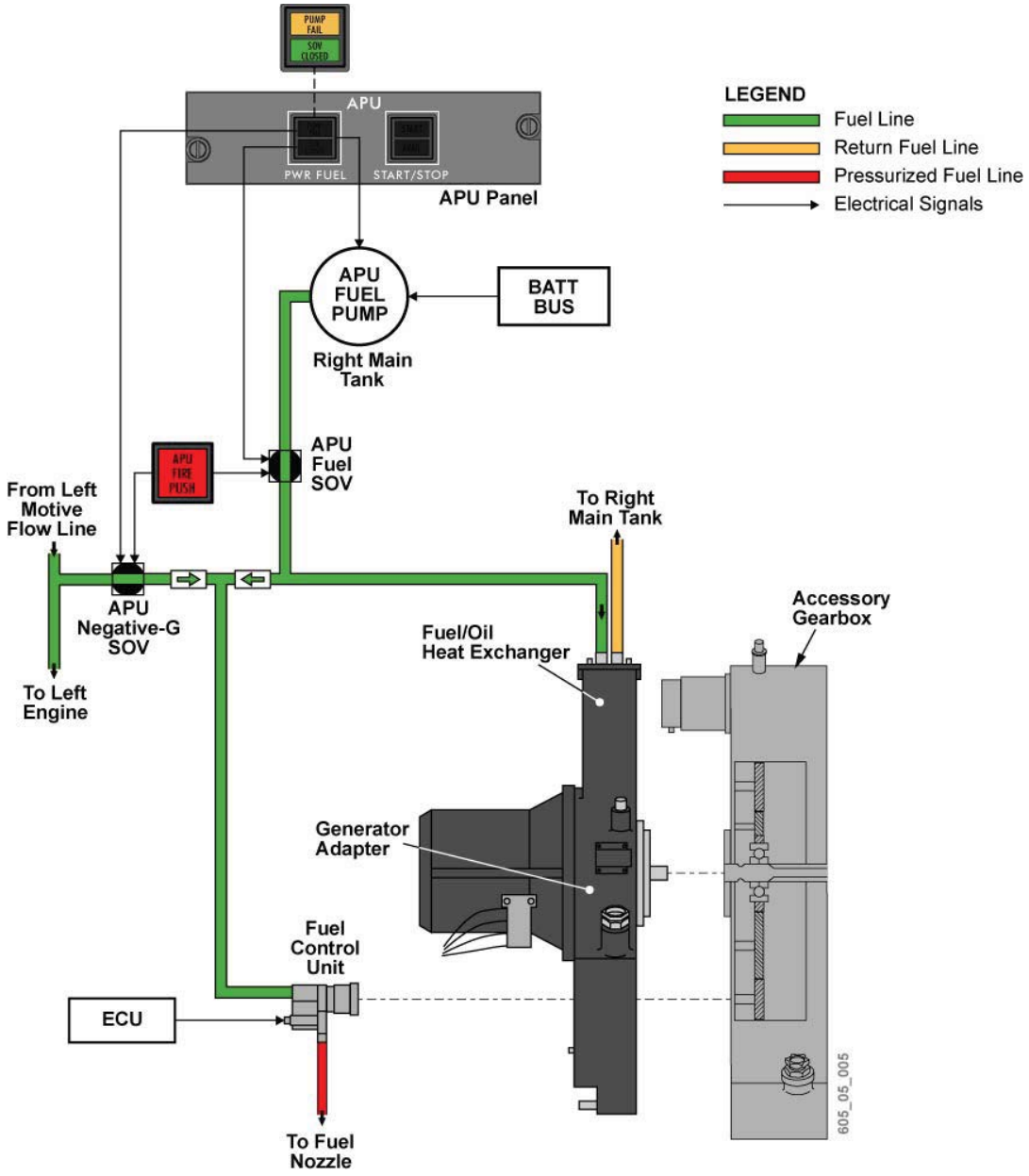
Selection of the APU PWR FUEL switch/light activates the APU fuel pump. This selection also opens the APU's fuel shutoff valve and negative-G shutoff valve. Insufficient APU fuel pump output pressure is indicated by an **APU PUMP** caution EICAS message, and illumination of the PUMP FAIL switch/light legend on the APU panel.

APU Fuel Shutoff Valve

The APU fuel shutoff valve (SOV) opens when the PWR FUEL switch/light is pressed in, and closes when it is pressed out. If the valve does not match the switch position within 5 seconds, an **APU SOV** caution EICAS message is displayed.

When the APU FIRE PUSH switch/light is pressed in, the APU fuel shutoff valve and the APU negative-G shutoff valve close. Successful closing of the valves is indicated by an **APU SOV CLSD** advisory message, and illumination of the green SOV CLOSED switch/light legend on the APU panel. If the APU SOV fails to close after APU FIRE PUSH switch/light selection, an **APU SOV** caution message is displayed.

APU FUEL DISTRIBUTION (CONT'D)



APU Fuel Pump and Shutoff Valve
Figure 05–10–5

APU Fuel Control Unit

The APU fuel control unit (FCU) is driven by the accessory gearbox, and meters fuel to the combustor under command of the electronic control unit (ECU). The APU fuel control unit is equipped with an internal solenoid-operated fuel shutoff valve that is commanded open and closed by the APU ECU, controlling fuel to the APU fuel control unit. In addition to controlling fuel shutoff, the ECU regulates fuel flow output from the fuel control unit, ensuring proper APU operating speed and temperature ranges.

APU FUEL DISTRIBUTION (CONT'D)

During normal or automatic APU shutdown, a simulated overspeed signal is generated within the ECU, commanding closure of the fuel control unit's solenoid shutoff valve. Closing this valve causes an isolation of fuel supply to the APU's fuel control unit, resulting in APU shutdown.

APU Negative-G Shutoff Valve

The APU negative-G shutoff valve opens and closes when the PWR FUEL switch/light is pressed. If the valve fails to close when the PWR FUEL switch/light is pressed out, the **APU NEG G SOV** caution message is displayed.

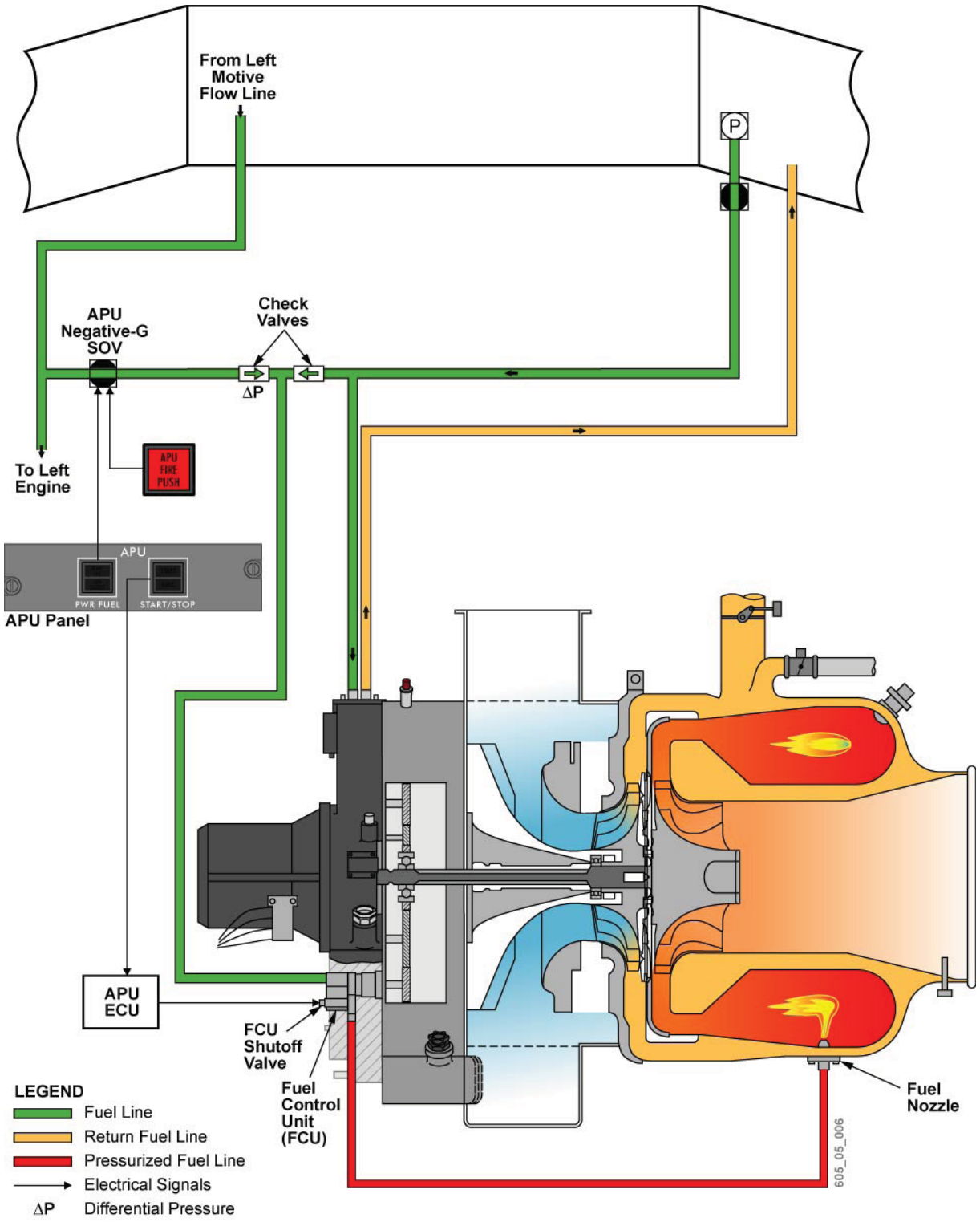
If a negative-G condition exists or the APU fuel pump fails, a one-way check valve, that operates based on positive differential pressure, allows fuel from the negative-G shutoff valve to feed the APU. An additional one-way check valve prevents this alternate fuel from entering the fuel-oil heat exchanger.

In the event of an actual APU fire, the negative-G shutoff valve is commanded closed when the APU FIRE PUSH switch/light is activated. If the valve fails to close, the left engine's motive flow continues to supply fuel to the APU fuel control unit, and the **APU NEG G SOV** caution EICAS message is displayed. Under this condition, it is necessary to shutdown the left engine in order to shut off the fuel supply to the APU.

NOTE

If the APU fuel pump is not operable, the APU has an operating time limit from start-up until shutdown, due to insufficient cooling of the generator adapter oil. Refer to FUEL ATA 28 of the Minimum Equipment List for the allowable operating time limit.

APU FUEL DISTRIBUTION (CONT'D)



Negative–G Shutoff Valve and FCU
Figure 05–10–6

START AND IGNITION

Description

APU start and ignition is automatically controlled by the APU electronic control unit.

Components and Operation

APU Battery

The 24-volt, 43-ampere-hour battery is located below the APU enclosure, and provides cranking power to turn the APU starter. A minimum of 22 volts is required for starter motor operation. In the event of APU battery rundown, external DC power may be used to supply the starter via the APU battery direct bus.

Electronic Control Unit

The electronic control unit (ECU) is powered from two 28V inputs: primary, via the battery bus, and secondary, via the main battery direct bus. The PWR FUEL switch/light controls the primary power, and secondary power is directly connected via circuit breaker. Secondary power is used by the ECU as a backup when the ECU's primary voltage drops below 22V. The ECU's internal logic disconnects the secondary 28V input (removing power from the ECU) after shutdown, and when all ECU shutdown tasks are completed.

The ECU monitors APU sensors and switches, and sets the appropriate fuel and temperature schedules. The ECU senses changes in shaft or bleed load, and adjusts the fuel supply to maintain a constant RPM at 100%. In addition, the ECU sends APU operating data to the data concentrator units for EGT and RPM display on the EICAS page. The ECU also provides operating data for fault identification on the APU FAULT panel, located on the left aft fuselage (next to the ground air adapter).

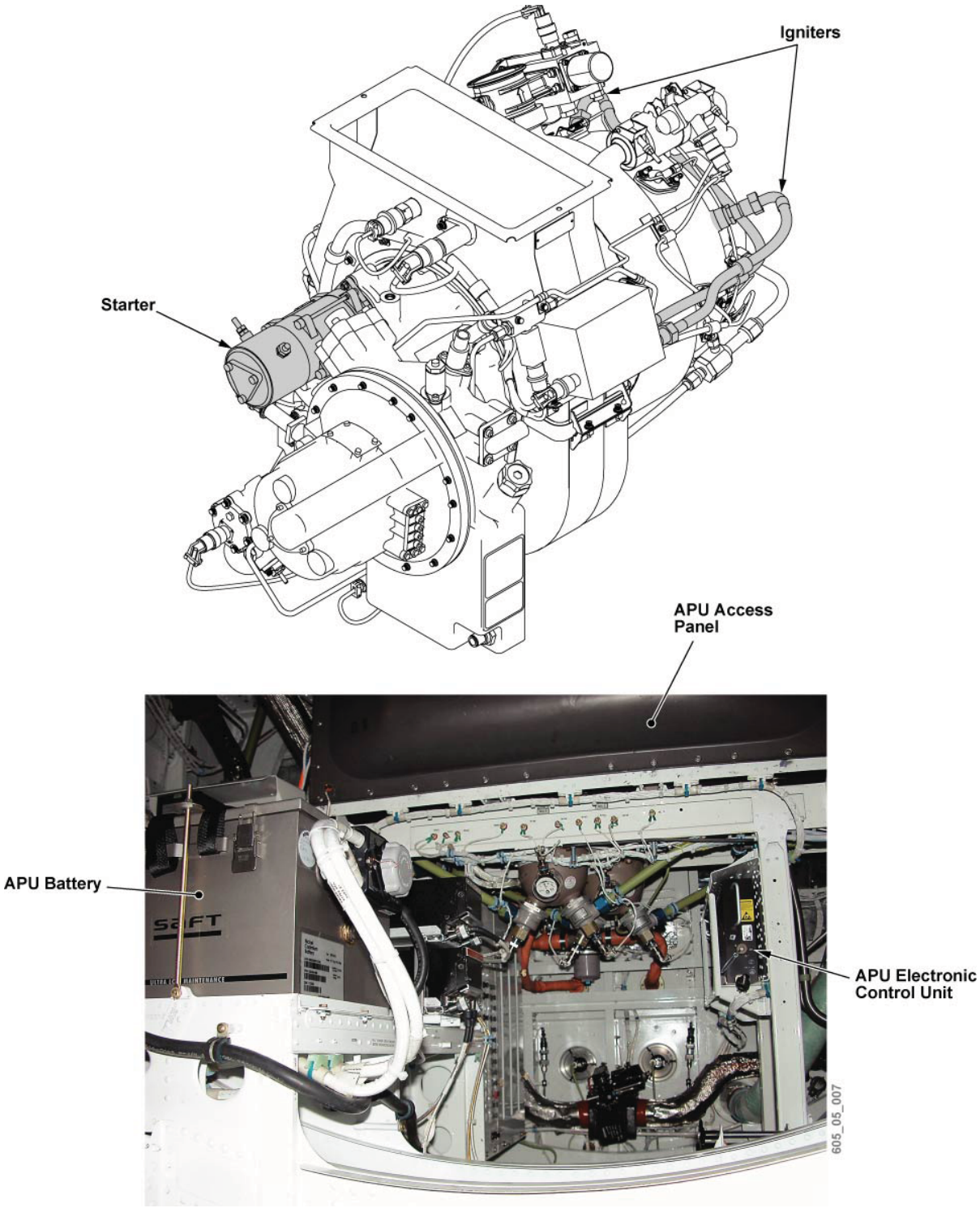
APU Starter

The APU starter motor is DC-powered by the APU battery direct bus, and transfers cranking power to the APU drive shaft through the accessory gearbox. The white START legend in the upper half of the START/STOP switch/light illuminates whenever the starter motor is engaged.

Ignition System

The ignition system ignites the fuel/air mixture during start. The system is energized after the START/STOP switch/light is pressed in and APU rpm reaches 5%. Ignition is de-energized when the rpm reaches 99%.

START AND IGNITION (CONT'D)



APU Start and Ignition
Figure 05–10–7

START AND IGNITION (CONT'D)

APU Start

With the battery master switch ON, pressing the PWR FUEL switch/light results in the following:

- APU ECU is powered, and after a 3-second BITE test, the APU EGT indication shows actual EGT (ambient temperature), and the rpm shows actual percentage;
- APU fuel shutoff and negative-G shutoff valves open; and
- APU fuel pump energizes.

Pressing the START/STOP switch/light signals the ECU to initiate the start sequence. The starter engages, the start legend is illuminated on the APU panel, and the following events occur:

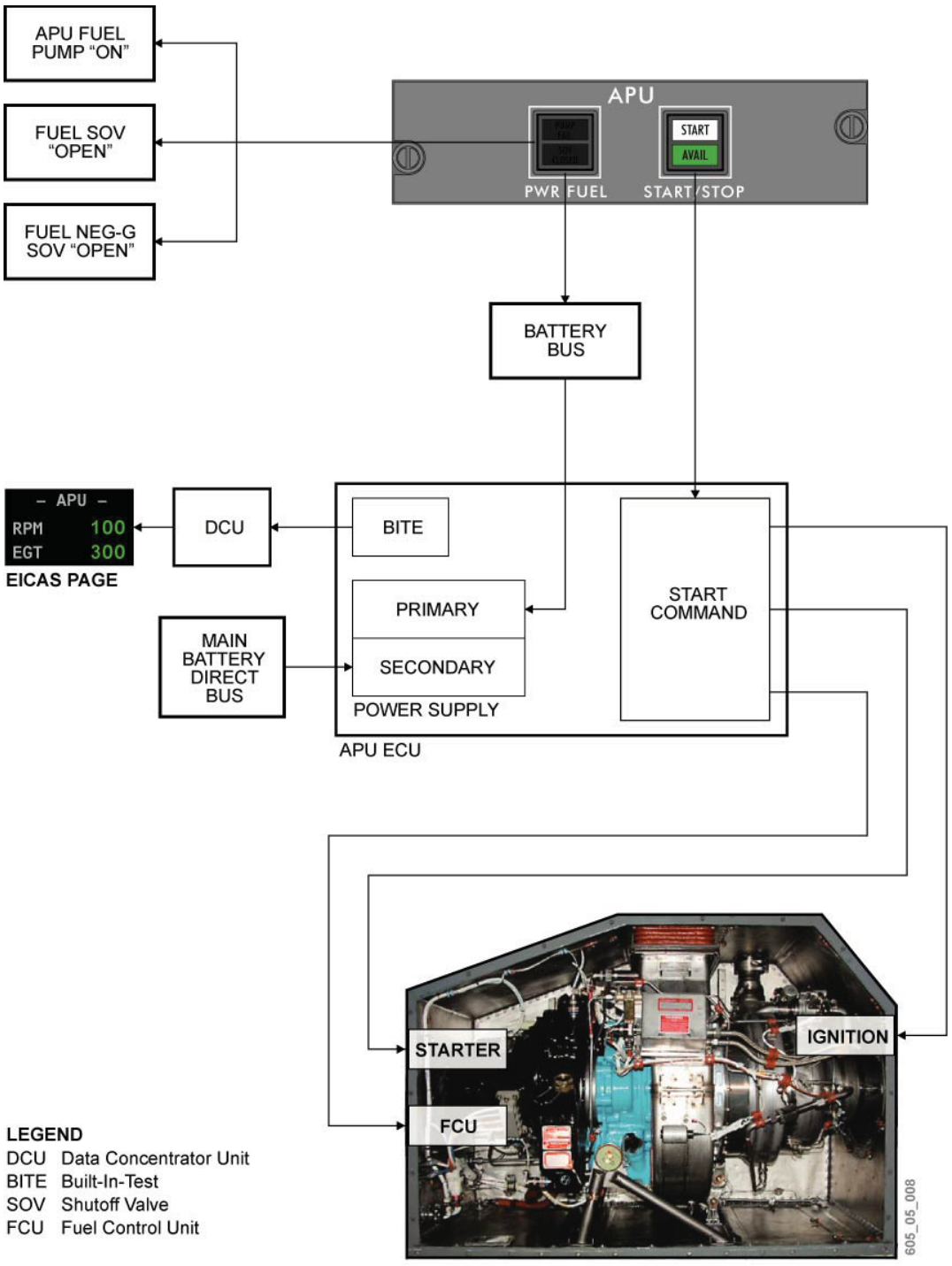
- 5% rpm – Fuel and ignition energized (a rapid increase in temperature, as shown on the EGT gauge, indicates light-off);
- 35–45% rpm – Starter cutout – START (white legend) out;
- 95% rpm + 4 seconds (approx) – APU AVAIL (green legend) on;
- 99% rpm – Ignition deactivated; and
- 100% rpm + 15 seconds (approx) – **APU GEN OFF** caution message on EICAS (indicating that the APU generator has not been selected on).

The green AVAIL legend on the START/STOP switch/light indicates that the APU is stabilized and ready for use.

NOTE

If time permits, allow APU rpm to stabilize at 100% for two minutes before applying electrical or bleed air loads.

START AND IGNITION (CONT'D)



APU Start
Figure 05–10–8

START AND IGNITION (CONT'D)

Normal Shutdown

The APU GEN switch is selected to the OFF/RESET position prior to shutting down the APU.

NOTE

A two minute wait is recommended prior to shutting down the APU, with the APU in a no-load condition.

Pressing out the START/STOP switch/light results in the following:

- AVAIL legend out;
- Internal FCU shutoff valve closes; and
- APU shuts down.

Pressing out the PWR FUEL switch/light results in the following:

- ECU primary power is removed;
- APU fuel shutoff and negative-G shutoff valves close;
- APU fuel pump turns off; and
- **APU GEN OFF**APU GEN OFF caution message out as the RPM and EGT decay.

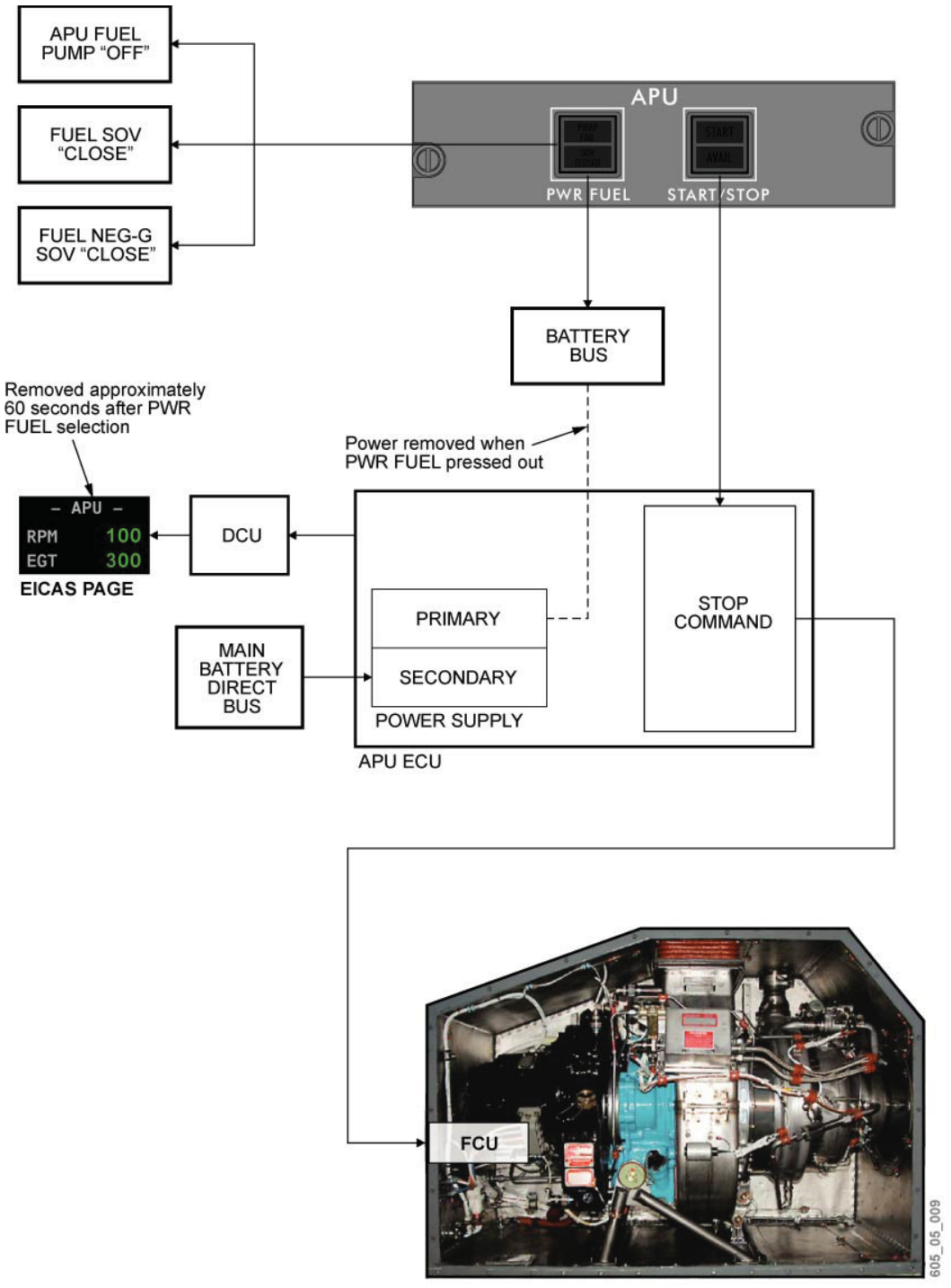
The RPM and EGT gauges remain in view for approximately 60 seconds while displaying the actual values, and are then removed.

NOTE

The battery master switch should not be selected off until the RPM and EGT indications are removed from the EICAS page. This interval allows the ECU time to complete its shutdown functions, and to power itself down.

ECU secondary power is removed when all ECU internal checks are completed, to avoid battery drain.

START AND IGNITION (CONT'D)



APU Normal Shutdown
Figure 05–10–9

START AND IGNITION (CONT'D)

Protective Shutdowns

The ECU automatically shuts down the APU when certain fault conditions are detected. Automatic protective shutdowns occur for the following pre-programmed conditions:

Protective Shutdowns Table

CONDITION	EICAS INDICATION
FIRE	Master warning, fire bell, APU fire light, **APU FIRE** warning message
OVERSPEED	Master warning, triple chime, **APU OVERSPEED** warning message
OVERTEMP	Master warning, triple chime, **APU OVERTEMP** warning message
LOW OIL PRESSURE	Master caution, single chime, **APU OIL PRESS** caution message
HIGH OIL TEMPERATURE	Master caution, single chime, **APU OIL TEMP** caution message
GENERATOR ADAPTER LOW OIL PRESSURE	Master caution, single chime, **APU OIL PRESS** caution message
GENERATOR ADAPTER HIGH OIL TEMPERATURE	Master caution, single chime, **APU OIL TEMP** caution message
LOSS OF EGT SENSOR	EGT digital readout dashed
UNDERSPEED	RPM readout/pointer (speed below 80% longer than 5 sec)
ECU FAIL	Loss of EICAS display for the APU

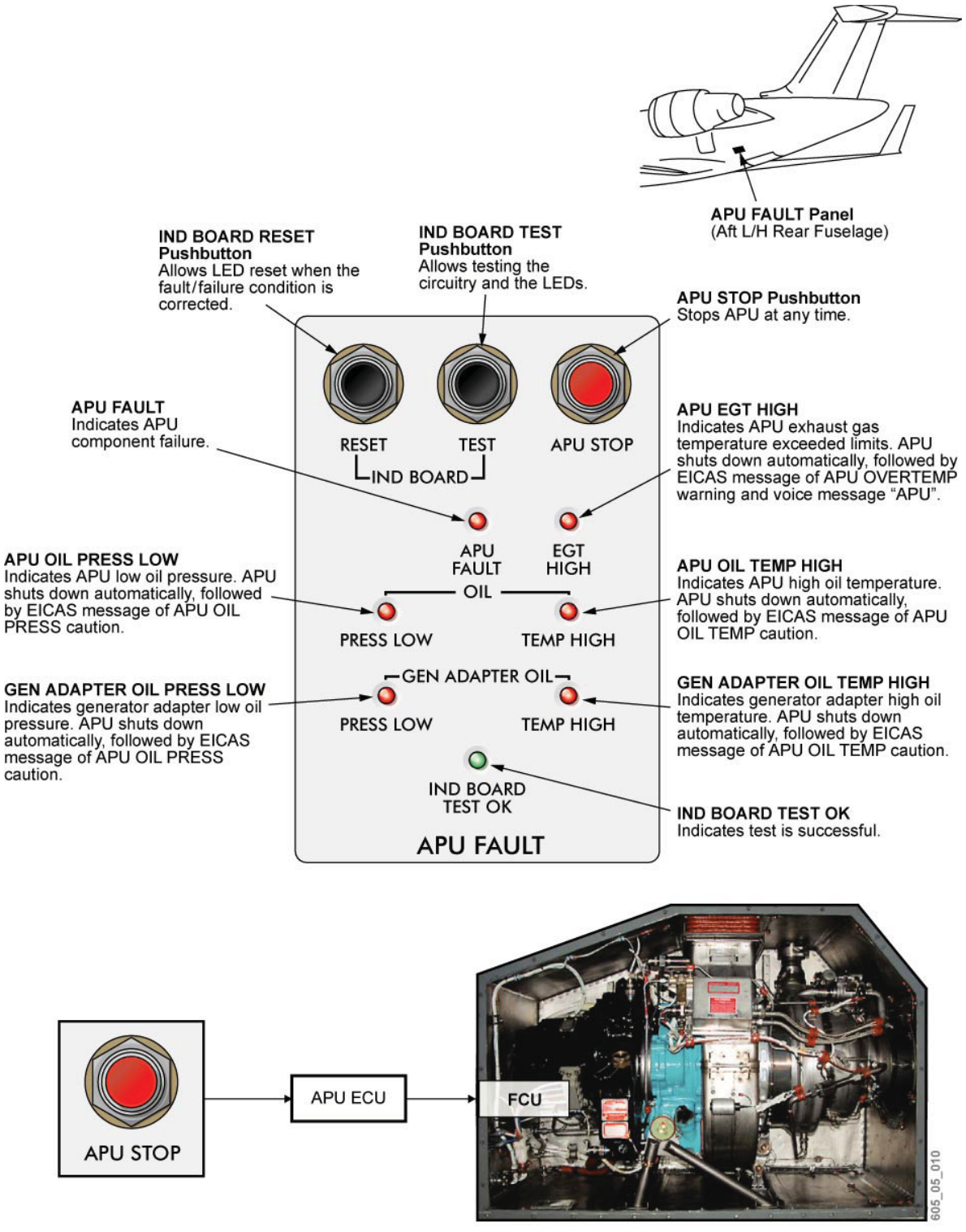
APU Fault Panel

Specific faults that cause APU shutdown are annunciated on the APU FAULT panel by solid state LEDs. This panel also includes an IND RESET button to clear all LEDs following rectification of the fault(s).

If necessary, an emergency shutdown of the APU may be accomplished by using the APU STOP button, located on the APU FAULT panel. When the APU STOP button is used, the APU FAULT indicator shows a faulted condition.

Following a protective shutdown or activation of the APU stop switch, the APU control panel switch/lights must be pressed out before the APU can be restarted.

START AND IGNITION (CONT'D)



APU Protective/Emergency Shutdowns and Faults
Figure 05–10–10

PNEUMATIC SUPPLY

Description

APU compressor bleed air is used to pressurize the left side of the 10th-stage bleed air manifold, providing pneumatics for engine starting and air conditioning. Reverse airflow protection from the main engines into the APU is provided by a one-way check valve and the 10th-stage bleed air switch/lights interlock control logic (Refer to Chapter 19, Pneumatic System, for additional information on the 10th-stage interlock circuit).

The APU pneumatic control system consists of two main components: the load control valve (LCV) and the surge control valve (SCV).

Components and Operation

Bleed Air Supply

The APU delivers a portion of its compressor discharge air to the 10th-stage manifold when the LCV is opened. This diversion takes pneumatic energy from the turbine, and some of the cooling air from the APU's combustion system. As with shaft loads, the rpm drops, and the APU recovers full governed speed by commanding an increase in fuel flow. The loss of pneumatic energy is replaced with thermal energy (fuel), and EGT increases.

Two variables influence EGT under bleed load conditions:

- Aircraft demand for bleed air (air conditioning packs or engine starting)
- Ambient air temperature and air density

If the EGT reaches its operating limit, the ECU reduces the bleed air load by commanding the LCV to cycle toward the closed position.

Load Control Valve

The APU LCV is located above and to the right of the APU turbine section. The valve is controlled by the APU ECU when the APU LCV switch/light on the BLEED AIR panel is selected to the open position. The LCV controls APU bleed air supply to the left side of the 10th-stage manifold. The ECU ensures that system priority is given to electrical loads over the bleed air demand, by cycling the LCV closed (reducing bleed load) when the exhaust gas temperature approaches operating limits.

Load control valve operation is indicated by illumination of the OPEN legend of the APU LCV switch/light. When the ECU cycles the LCV for EGT limit protection, the OPEN legend extinguishes. If the APU LCV has failed open with the 10th-stage switch/light interlock protection activated, the **APU LCV FAIL** caution message is displayed on EICAS.

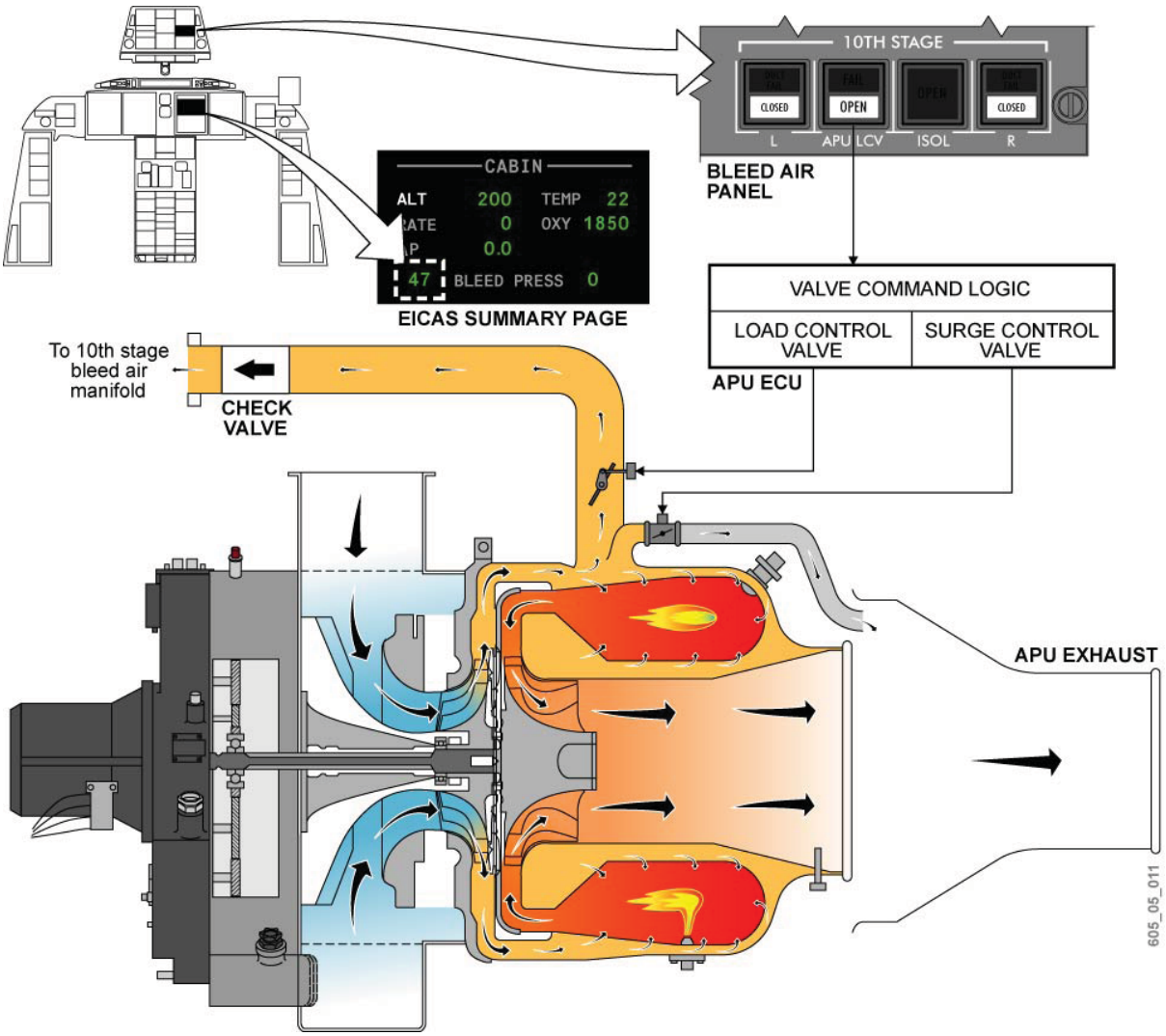
Surge Control Valve

To prevent compressor surge during high altitude shaft operation in flight, unused bleed air is vented through the SCV into the APU tailpipe. SCV operation is automatically controlled by internal logic within the ECU. The valve's open/closed schedule is based on pressure altitude and APU inlet temperature. The surge control valve is only required during in-flight APU operation, at altitudes above 15,000 feet.

PNEUMATIC SUPPLY (CONT'D)

Bleed Air Indication

APU bleed air indication is displayed on the EICAS page below the CABIN information section.



APU Pneumatic Supply
Figure 05–10–11

CONTROLS AND INDICATORS

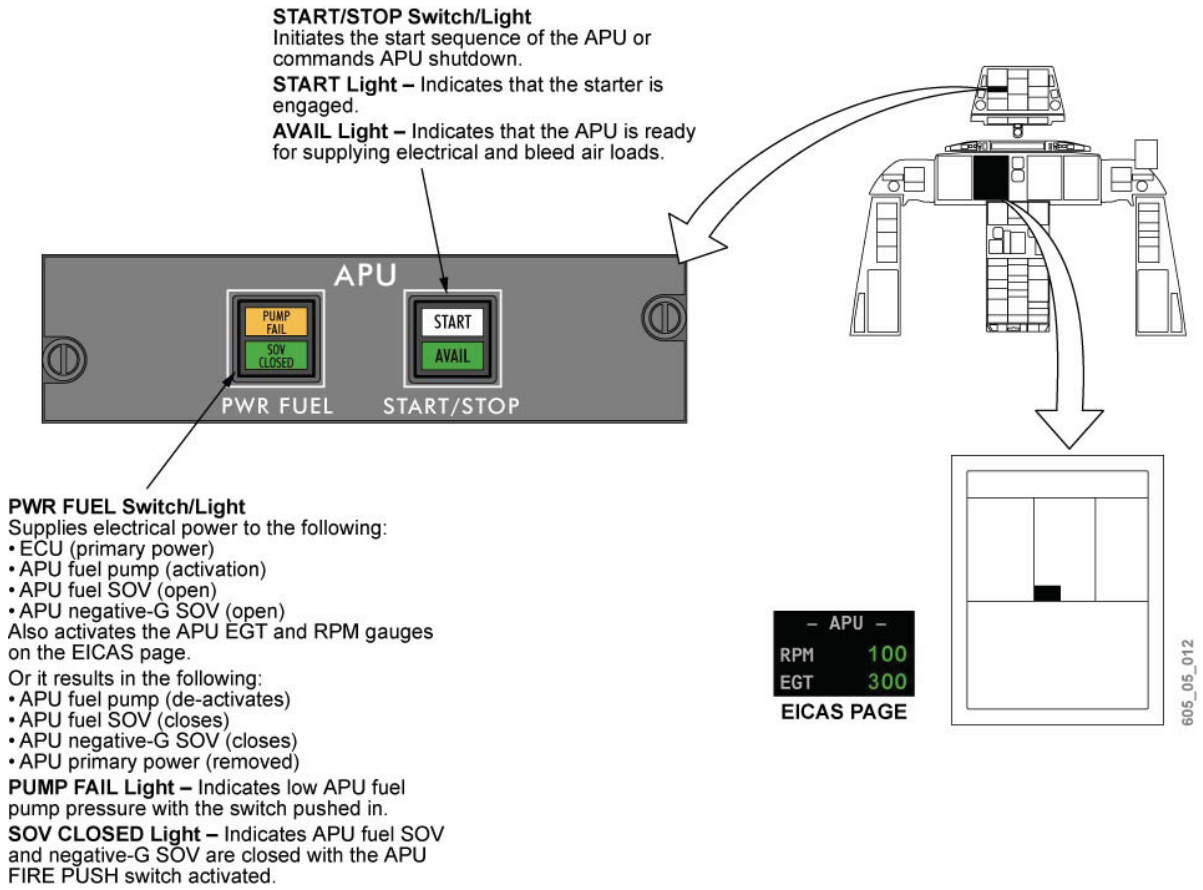
The APU panel provides the control for the APU operation, and the EICAS page provides a visual display of APU indications. The APU fault panel supplements the EICAS for specific APU faults.

The APU panel has two switch/lights:

- PWR FUEL; Activates the ECU, which commands fuel valves and pump operation.
- START/STOP; Commands APU start and shutdown modes of operation.

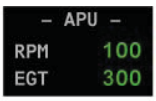
CONTROLS AND INDICATORS (CONT'D)

APU monitoring is provided by RPM and EGT digital readout on the EICAS page. The APU indications are activated when the PWR FUEL switch/light is pressed in, and are removed 60 seconds after selecting the PWR FUEL switch/light out.



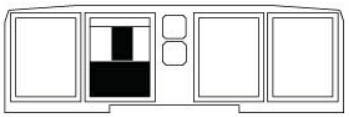
APU Panel and EICAS Indications
Figure 05–10–12

CONTROLS AND INDICATORS (CONT'D)



EICAS PAGE

AC ELECTRICAL SYNOPTIC PAGE



Description	Symbol	Condition
APU Generator Load Readout	7 KVA	Generator is loaded
	36 KVA	Generator is overloaded
	0 KVA	Generator is not on-line
	- - KVA	Invalid data
APU Generator Voltage Readout	113 V	Voltage between 100 and 125 VAC
	94 V	Voltage less than 100 VAC or more than 125 VAC
	- - - V	Invalid data
APU Generator Frequency Readout	401 HZ	Frequency between 375 and 425 Hz
	429 HZ	Frequency less than 375 Hz or more than 425 Hz
	- - - HZ	Invalid data
APU Generator Output Flow Lines (Upper)	▮	Generator line contactor at generator position
	| |	Generator line contactor at tie position
APU RPM Readout	– APU – RPM 100 EGT 300	Green: 0 to 104% Yellow: 105 to 106% Red: 107%
APU EGT Readout	– APU – RPM 0 EGT 18	Green: 0 to 680°C Yellow: 680 to 973°C Red: 974°C Running RPM from start to less than 60%
	– APU – RPM 100 EGT 300	Green: 0 to 680°C Yellow: 680 to 730°C Red: 731°C Running RPM more than 60%

605_05_013

EICAS and Synoptic Page Color Coding
Figure 05–10–13

EICAS MESSAGES

MESSAGE	MEANING	AURAL WARNING (IF ANY)
APU FIRE	Fire detected in the APU enclosure.	FIRE BELL
APU OVERSPEED	APU has shut down due to an overspeed condition.	“APU”
APU OVERTEMP	APU has shut down due to an overtemperature condition.	“APU”
APU LCV FAIL	APU load control valve has failed in the open position with APU LCV interlock activated.	
APU SOV	APU fuel shutoff valve is open with the APU FIRE PUSH switch activated, or the fuel shutoff valve position does not match the APU PWR FUEL switch position, within 5 seconds.	
APU NEG-G SOV	APU negative-G shutoff valve is open with the APU FIRE PUSH switch activated, or the negative-G shutoff valve position does not match the APU PWR FUEL switch position, within 5 seconds.	
APU OIL PRESS	APU oil pressure or APU adapter oil pressure is low and the APU will shut down.	
APU OIL TEMP	APU oil temperature or APU adapter oil temperature exceeds limits and the APU will shut down.	
APU PUMP	APU fuel pump has failed. PWR FUEL switch/light pressed in and the APU pump low pressure.	
APU SOV CLOSED	APU fuel shutoff and negative-G shutoff valves have closed after actuation of the APU FIRE PUSH switch/light.	

POWER SUPPLY AND CIRCUIT BREAKER SUMMARY

SYSTEM	SUB-SYSTEM	CB NAME	BUS BAR	CB PANEL	CB LOCATION	NOTES
Auxiliary Power Unit	APU Electronic Control Unit	APU ECU PRIM	DC BATT	5	A4	
		APU ECU SEC	APU Battery Direct Bus	5	B9	
	APU Fault Annunciation	APU FAULT ANN	DC BATT	1	L2	
	APU Start	APU START CONT	DC BATT	1	L3	
	Fuel	APU FUEL PUMP	DC BATT	2	P4	
	Control	APU CONTROL	DC BATT	1	L1	