



CHAPTER 5

AUXILIARY POWER UNIT

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CHAPTER 5

AUXILIARY POWER UNIT

GENERAL

This APU is a gas turbine equipped with a gearbox driving an oil-cooled 30-kva AC generator. Running at 100% rpm, the APU drives the AC electrical generator at a constant speed of 12,000 rpm. This maintains generator frequency output at 400 Hz. The APU's bleed port supplies pneumatic power to drive the main engine air turbine starters or the air cycle machines within the air conditioning packs.

The APU is in the rear fuselage behind the rear pressure bulkhead (Figure 5-1) and can operate on the ground or in flight. Drains in the APU enclosure prevent a dangerous buildup of combustible liquids. An electronic control unit (ECU) controls starting and ignition. Pressurized oil is supplied to the APU gearbox, bearings, and electrical generator.

SYSTEM DESCRIPTION

A full-authority, digital, electronic-control unit (ECU) controls and monitors APU operation. A PWR FUEL switchlight and a START/STOP switchlight are located on the APU control panel on the cockpit overhead panel. These switchlights control APU starting and manual stopping.

POWERPLANT

The self-contained APU requires only a source of fuel and DC electrical power to operate. Start and stop controls are located on the APU control panel on the cockpit overhead panel. APU indications, cautions, and warnings display on the EICAS primary and secondary displays. The powerplant mounts in a fire containing enclosure equipped with inlet and exhaust ports

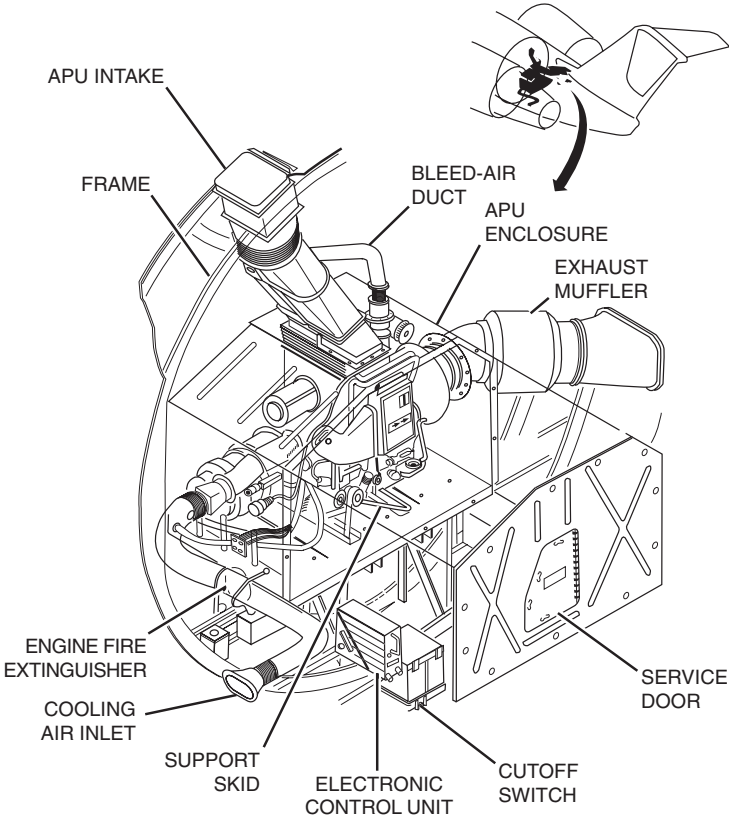


Figure 5-1 APU Installation



Enclosure

An APU enclosure creates a fire zone, isolates the APU from the aft equipment compartment, and prevents damage to the aircraft should a fire occur. The bottom of the enclosure is connected to a drain system to prevent the buildup of fluids in the container.

Air Inlet and Exhaust Port

The APU air inlet is located on the upper left side of the rear fuselage and connected to the APU by an inlet-duct assembly. A variable-position inlet door, controlled by the ECU, is installed in the inlet. The APU electronic unit controls the operation of the air intake door according to an airplane pressure altitude and true airspeed schedule (Figure 5-2).

The potentiometer provides inlet door position information to the ECU. The EICAS secondary display then presents inlet door position messages on the status page based on ECU-supplied information. Ducts vent APU exhaust through a port below the right engine.

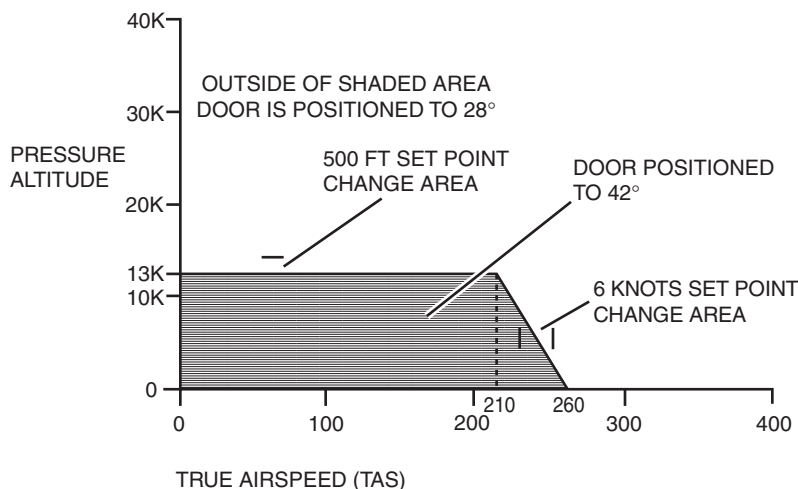


Figure 5-2 Pressure Altitude and True Airspeed Schedule



ELECTRONIC CONTROL UNIT

A full-authority digital ECU controls the APU engine. The system has manual and automatic controls to start, stop, and maintain the APU within safe operating limits. The ECU automatically stops the APU for specific failure conditions.

Manual APU control is needed for fuel supply selection, START/STOP switchlight operation, and load selection.

FUEL CONTROL

Under normal conditions, both the left and right aircraft fuel tanks supply the APU with fuel. A 28-VDC electric fuel pump supplies pressurized fuel. The APU electric fuel pump is also the power crossflow pump and can perform both operations simultaneously.

The APU fuel supply is interrupted by the following:

- START/STOP switch on the overhead panel in the cockpit
- APU FIRE PUSH switchlight on the glareshield in the cockpit
- ECU automatic close signal



PNEUMATIC SUPPLY

Modulation of the APU load control valve (APU LCV), and the position of the compressor's variable diffusers, control APU pneumatic 10th-stage bleed air output (Figure 5-3). During bleed loading, LCV opening modulates to limit turbine temperatures. The system gives priority to AC generator load in the event of a combined generator/pneumatic power overload condition.

The APU compressor is protected against surge, by altering the position of the compressor's variable diffusers, which is controlled by the valve signals to the APU ECU. In flight, during minimum bleed conditions with a full AC generator load, the diffuser is positioned closed. During ground operation and maximum bleed conditions, the diffuser is positioned fully open.

The APU compressor is also protected from a stall or surge, by interlocking the APU LCV switch with the other bleed-air switches. If the left hand 10th stage bleed-air switch is open, the APU LCV will close, or remain closed. If the 10th stage isolation valve switch and the right hand engine bleed air switch are open, the APU LCV will close, or remain closed.

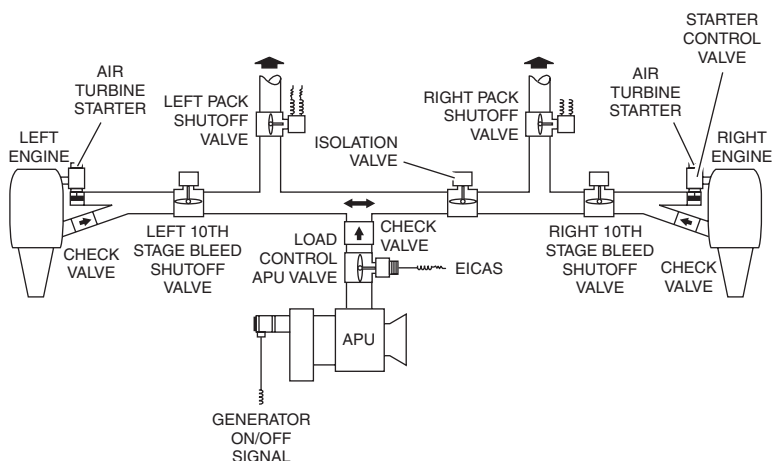


Figure 5-3 Pneumatic Supply Schematic



LCV position (open/closed) and status indications display on the BLEED AIR panel and on the EICAS. The environmental control systems (ECS) page presents bleed supply pressure indications.

FIRE PROTECTION SYSTEM

The APU enclosure has a fire warning and extinguishing system. If a fire occurs in the enclosure, the following occur:

- APU FIRE indications display on the engine indication and crew alerting system (EICAS)
- The APU FIRE PUSH light illuminates
- An audible fire bell sounds (W.O.W. only)

Fire Detection

The fire detection system detects fire conditions and warns the flight crew. The fire detection system consists of the following components (Figure 5-4):

- Two loop sensing elements
- Loop selection APU switch on the FIRE DETECTION/FIREX MONITOR panel
- One card in the fire/overheat detection control unit
- TEST WARN/FAIL switch on the FIRE DETECTION/FIREX MONITOR panel

An APU stop switch in the AC EXTERNAL SERVICE panel permits ground personnel to shut down the APU from outside the aircraft in an emergency.

Fire Extinguishing

The APU fire extinguishing system discharges a container of fire extinguishing agent into the APU compartment should a fire occur.



If the aircraft is on the ground, the extinguishing agent automatically discharges. If the aircraft is in flight, the crew must use the APU FIRE PUSH switchlight and the BOTTLE ARMED PUSH TO DISCH switchlight to discharge the extinguishing agent.

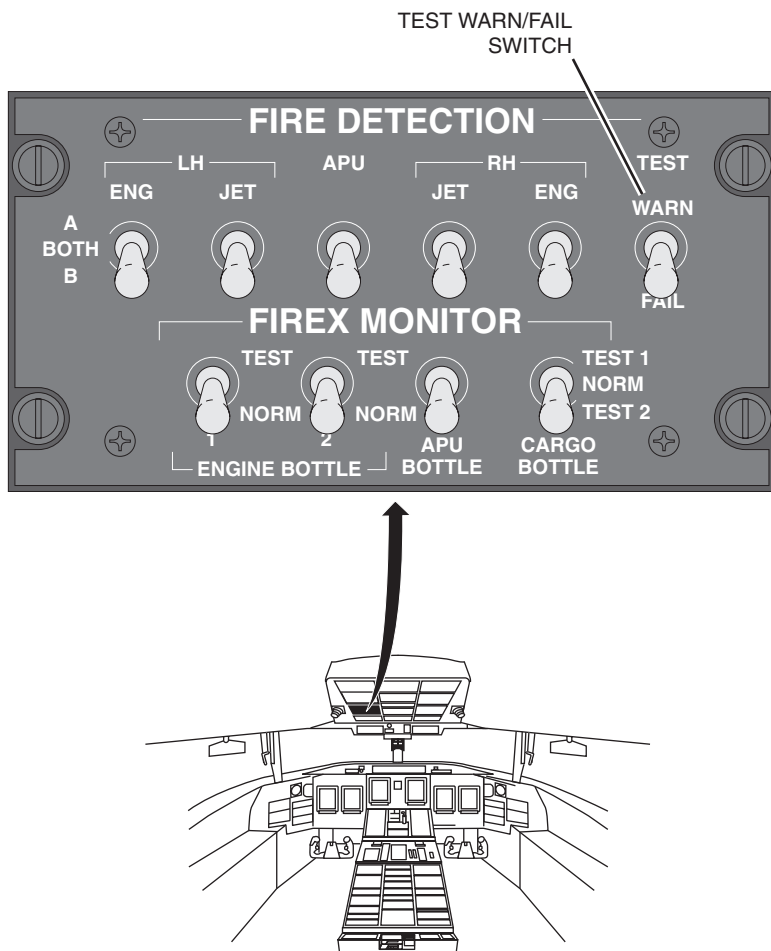


Figure 5-4 FIRE DETECTION/FIREX MONITOR Panel



For more detailed information regarding the fire protection system, see Chapter 8, Fire Protection.

OIL SYSTEM

Pressurized oil is supplied to the APU gearbox, APU bearings, and electrical generator by an integral G-rotor pump. Low oil pressure (LOP) and high oil temperature (HOT) switches provide system condition monitoring. Activation of either switch results in APU shutdown on the ground.

Low-Oil Pressure Switch

A low-oil pressure switch is located in the fuel module housing. The switch is spring-loaded closed and opens when the pressure increases to 40 psi. It closes when the pressure decreases to 32 psi. If the switch is closed for more than ten seconds after APU rpm reaches 99%, a signal is sent to the ECU and autosutdown occurs.

High-Oil Temperature Sensor

A high-oil temperature sensor is in the oil reservoir. If the oil temperature is more than 163°C (325°F), the ECU produces an autosutdown after a 10-second delay.

IGNITION AND STARTING SYSTEMS

The ignition and starting systems operate together to start the APU. The battery bus supplies 28 VDC to the starter, through the ignition-control circuits, which turns the APU rotor. The ignition system ignites the fuel-air mixture.

A START/STOP switchlight, on the APU control panel in the cockpit, operates the starter motor control circuit. APU starting and ignition is controlled by the APU ECU. The ECU automatically controls the starter motor operation and the ignition sequence for the high-energy igniter plugs during APU start.



Start Sequence

At APU start (BATTERY MASTER at ON, PWR FUEL switchlight operated), the control system does the following:

- Performs a selftest (APU IN BITE)
- Opens the fuel shutoff valve (APU SOV OPEN)
- Energizes the APU gauges
- Opens the APU inlet door
- Energizes the starter relay

Operating the START/STOP switchlight energizes the start motor through the starter relay (APU START), accelerating the engine to light-off speed. At 10% APU speed, the control system does the following:

- Energizes the ignition system
- Opens the FCU shutoff valve (FCU SOV), providing current to the FCU torque motor for APU starting operation

During APU acceleration, the control system compares the actual engine speed against a speed reference which ramps upward from 3 to 6% per second. Fuel flow is controlled until the engine speed tracks the reference speed. At 50% APU speed, the start motor is deenergized and the APU START message disappears.

At 95% APU speed, the ignition system is de-energized, and the system transitions from timed acceleration to proportional governor control. The ready-to-load relay is then operated and the APU can be loaded, the AVAIL light comes on, and the APU SOV OPEN message disappears. APU bleed air is modulated by the load control valve to maintain turbine temperatures within limits.



NORMAL STOP SEQUENCE

Normal shutdown occurs when the START/STOP switch is operated to STOP. An overspeed test signal is generated, the control system then deenergizes the fuel control torque motor and FCU shutoff valve solenoid, resulting in shutdown.

EMERGENCY STOP SEQUENCE

To perform an emergency stop of the APU from the cockpit, push the APU FIRE PUSH switchlight on the glareshield.

To perform an emergency stop of the APU using the AC EXTERNAL POWER panel located on the right forward fuselage, push the APU SHUT-OFF switch.

The ECU executes autosutdown if certain conditions occur. Any one of three sources command emergency APU shutdown of the APU:

- The APU fire pushbutton located on the cockpit glareshield
- Two remote cutoff switches
- The automatic fire extinguishing system (only when the aircraft is on the ground)

CONTROLS AND INDICATIONS

The APU control and indication system consists of the APU control panel, glareshield switchlights, bleed-air control panel, and the EICAS display messages (Figure 5-5).

APU CONTROL PANEL

The APU control panel, on the cockpit overhead panel, has two pushbutton switchlights which control the fuel shutoff valve and the start and stop operations of the APU. These switchlights are the PWR FUEL switchlight and the START/STOP switchlight.

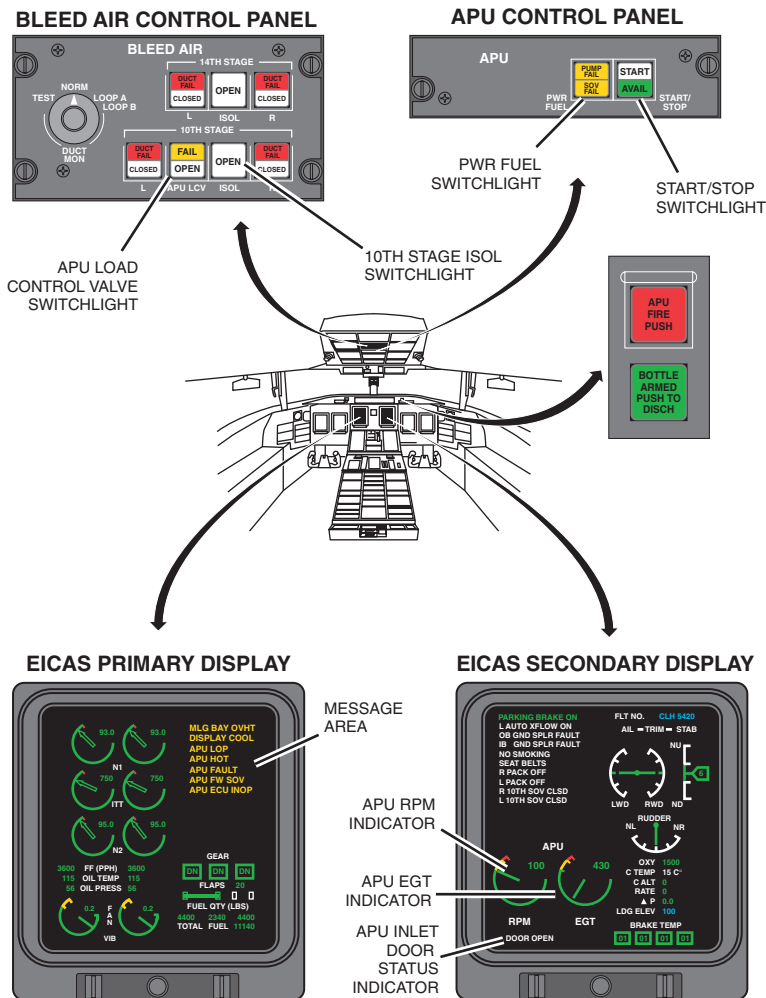


Figure 5-5 APU Cockpit Controls and Indications



PWR FUEL Switchlight

When pressed in, the following actions take place:

- Crossflow/APU pump is energized.
- APU IN BITE illuminates on the EICAS secondary display.
- APU gages are energized.
- Door is scheduled to open.
- APU fuel shutoff valve opens.

The PUMP FAIL light on this switchlight illuminates to indicate the crossflow/APU pump has failed. The SOV FAIL light on this switchlight illuminates to indicate the APU fuel feed SOV has failed.

START/STOP Switchlight

When the START/STOP switchlight is pressed in, the following actions take place:

- Starter motor energized.
- White START light illuminates.
- At 50% rpm, the START light extinguishes.
- Four seconds after reaching 95% rpm, the green AVAIL light illuminates.

When the START/STOP switchlight is pressed out, the following actions take place:

- FCU shutoff valve closes.
- APU shuts down.
- AVAIL light extinguishes.



GLARESHIELD SWITCHLIGHTS

The glareshield has two switchlights, APU FIRE PUSH and BOTTLE ARMED PUSH TO DISCH. These are used in the event of an APU fire.

APU FIRE PUSH Switchlight

The APU FIRE PUSH switchlight illuminates when an APU fire is detected. An audible fire bell accompanies this indication. Pressing this pushbutton shuts down the APU.

BLEED AIR CONTROL PANEL

The APU LCV switchlight connects or disconnects APU supply to 10th-stage bleed-air manifold by opening or closing the LCV. It indicates LCV fault by illuminating FAIL on this switchlight. It indicates the load control valve is open by illumination of OPEN on this switchlight. The ISOL switchlight isolates or interconnects the left and right pneumatic systems.

APU LCV Switchlight

The APU LCV switchlight connects or disconnects APU supply to the 10th-stage bleed-air manifold by opening or closing the load control valve (LCV). A load control valve fault is indicated by illumination of FAIL on this switchlight. Opening of the load control valve open is indicated by illumination of OPEN on this switchlight.

ISOL Switchlight

The ISOL switchlight isolates or connects the left and right pneumatic systems.



ENGINE INDICATING AND CREW ALERTING SYSTEM DISPLAYS

The EICAS displays consist of primary and secondary CRT displays in the center of the cockpit main panel. APU power and temperature indications display on the EICAS secondary display status page. APU warning and caution messages display on the EICAS primary display.

EICAS Primary Display

The EICAS primary display presents warning and caution messages as they apply to APU operation.

Warning Messages

The following EICAS warning messages display in red:

APU OVERSPEED—Indicates the APU is running in excess of 107% rpm—This message is accompanied by an audible voice message. The APU automatically shuts down.

APU OVERTEMP—Indicates the EGT is greater than 743°C with APU rpm greater than 87%, or the EGT is greater than 974°C at any time—This message is accompanied by an audible voice message. The APU automatically shuts down (on ground only).

NOTE

If overspeed or overtemperature occur during flight, do not restart the APU.

Caution Messages

The following EICAS caution messages display in amber:

APU OIL PRESS—Indicates APU has low oil pressure—This message is accompanied by an audible voice message. APU shuts down automatically (on ground only).



APU OIL TEMP—Indicates APU has high oil temperature (325°C)—This message is accompanied by an audible voice message. APU shuts down automatically (on ground only).

APU FAULT—Indicates loss of APU control circuits (microprocessor, thermocouple, or speed signal)—The APU shuts down automatically.

APU SOV FAIL—Indicates the APU fuel feed shutoff valve is not in a confirmed position (either open or closed)

APU SOV OPEN—Indicates the APU fuel feed shutoff valve is open 10 seconds after an APU fire condition

APU LCV FAIL—Indicates the load control valve has failed (either open or closed)

APU BLEED ON—Indicates the load control valve is open and barometric altitude is greater than 15,000 feet

XFLOW/APU PUMP—Indicates the APU's transfer pump has failed (low pressure)—It is accompanied by the illumination of the XFER/APU PUMP switchlight.

EICAS Secondary Display

APU EGT Indicator and Digital Readout

The APU EGT indicator, with digital readout, displays exhaust gas temperature in degrees Centigrade.

APU RPM Indicator and Digital Readout

The APU RPM indicator, with digital readout, displays percent rpm.

NOTE

The gauges will remain in view for approximately 60 seconds, after PWR FUEL switch/light pressed out.



Status Messages

The following EICAS status messages display in white:

APU IN BITE—Indicates the ECU is running diagnostics (prior to start), for approximately five seconds

APU START—Indicates the APU start is in progress

APU ECU FAIL—Indicates the ECU has failed—APU fuel feed SOV is confirmed open.

APU SOV OPEN—Indicates the APU fuel feed shutoff valve is open with the APU not ready and no APU fire is detected

APU LCV OPEN—Indicates the APU load control valve is open

The following represent the various APU inlet door status indicator displays:

- **DOOR CLSD (0°)**
- **DOOR MID (28°)**
- **DOOR OPEN (42°)**

The following indicate door position inhibited by maintenance personnel:

- **DOOR INHIB/CLSD (0°)**
- **DOOR INHIB/MID (28°)**
- **DOOR INHIB/OPEN (42°)**

If the door's position is unknown, the following displays:

- **DOOR (with an amber dash)**



Advisory Messages

The APU SOV CLSD advisory message displays in green and indicates the APU fuel feed shutoff valve is closed during an APU fire condition.

Fuel Page

The EICAS secondary display presents the fuel page (Figure 5-6).

APU pump fuel feed LH, RH—The indication displays green to indicate at least 10 pounds in the respective tank.

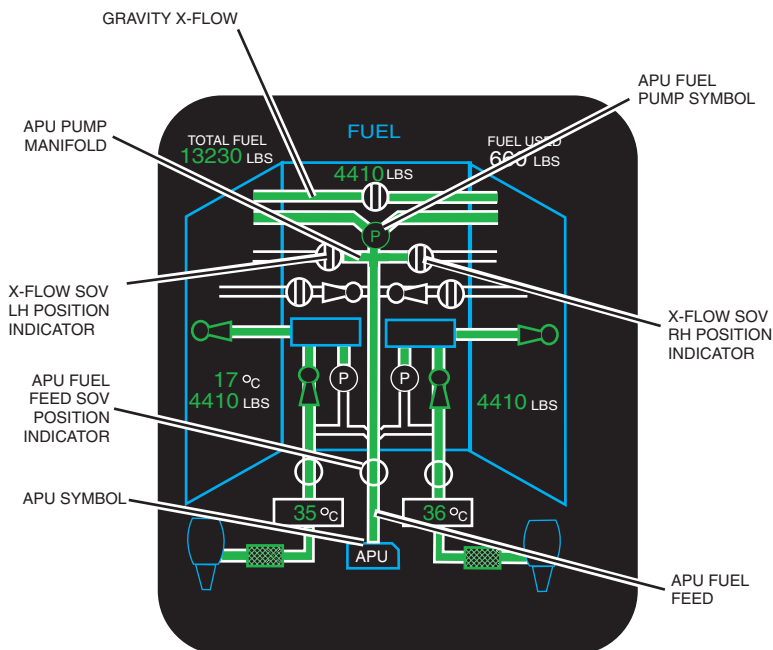


Figure 5-6 EICAS Secondary Display—Fuel Page



APU pump manifold—Manifold fuel lines display in the following color schemes:

- Green—Indicates APU pump on
- Amber—Indicates APU pump failure

Refer to Table 5-1 for APU fuel feed and crossflow SOV position indications.

Table 5-1 APU SHUTOFF VALVE INDICATIONS

CONDITION	SOV POSITION	SOV FLOW LINE	SOV OUTLINE
Open		Green	White
Closed		White	White
Failed		White (Closed)	Amber
Input Data Invalid		White	Half Intensity Magenta
Input Data Invalid		White	Half Intensity Magenta

APU symbol—This indication displays in the following color scheme:

- White—Indicates the APU is not running
- Half-intensity cyan—Indicates the APU is ready to load
- Half-intensity magenta—Indicates invalid data



APU fuel feed—This indication displays in the following color scheme:

- Green—Indicates normal fuel flow
- Amber—Indicates restricted flow (shutoff valve, pump, or fuel filter)
- Red—Indicates fire in the APU with the shutoff valve failed open or at midposition

APU fuel pump symbol—This indication displays in the following color scheme:

- White—Indicates the pump is off
- Green—Indicates the pump is on
- Amber—Indicates the pump failed
- Half-intensity magenta—Indicates invalid data



ECS Page

The EICAS secondary display presents the ECS page (Figure 5-7).

Pneumatic supply pressure LH, RH—Indicates the pneumatic supply pressure available for operation of the air conditioning system or main engine starts.

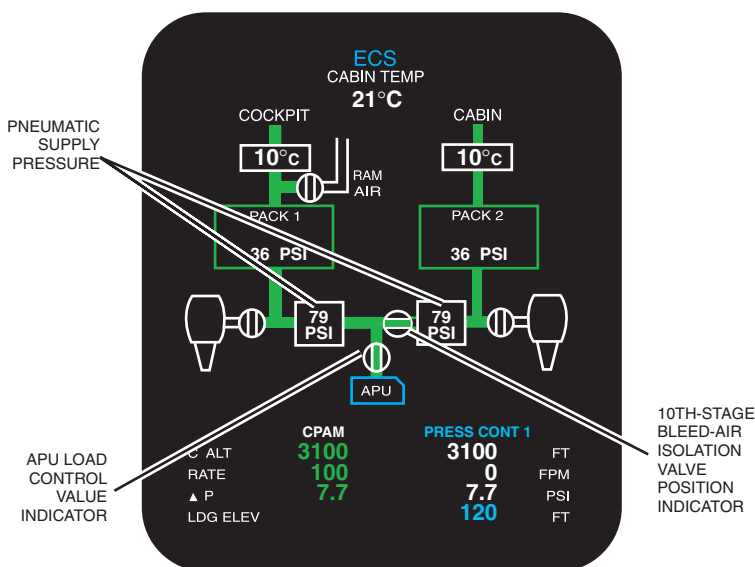


Figure 5-7 EICAS Secondary Display—ECS Page



Refer to Table 5-2 for 10th-stage bleed-air isolation, and APU load control valve position indications.

Table 5-2 BLEED-AIR AND LOAD CONTROL VALVE POSITION INDICATORS

CONDITION	VALVE POSITION
Open	
Closed	

CIRCUIT BREAKERS

Table 5-3 presents power supply and circuit-breaker information.

Table 5-3 POWER SUPPLY AND CIRCUIT BREAKERS

SYSTEM	SUB-SYSTEM	CB NOMENCLATURE	BUS BAR	CB PANEL NUMBER	CB LOCATION	NOTES
Auxiliary Power Unit	APU Controls	APU BAT CONT	APU BAT DIR	5	B2	
		APU ACT	MAIN BAT DIR		A3	
	APU Electronic Control Unit	APU ECU	DC BAT	1	N12	
	Battery Charging	APU CHARGER	AC UTIL 2	2	E5	
	Fire Extinguishing	APU FIRE EXT	DC EMERGENCY	1	R5-6	



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