TABLE OF CONTENTS

ATA 49 AIRBORNE AUXILIARY POWER 1

49–00 AIRBORNE AUXILIARY POWER GENERAL 2
APS 3200 INTRODUCTION 2
APU SYSTEMS INTRODUCTION 6
CONTROL AND INDICATING 8
SAFETY PRECAUTIONS 12
OPERATING LIMITATIONS 14

49–11 POWER PLANT 16
POWER PLANT INTRODUCTION 16
APU ACCESS DOOR DESCRIPTION 18
APU COMPONENT LOCATION (APU LEFT SIDE) 22
COMPONENT LOCATION (APU RIGHT SIDE) 24

49–12 APU MOUNTS 26
DESCRIPTION 26

49–16 AIR INTAKE SYSTEM 28
AIR INTAKE SYSTEM DESCRIPTION 28
AIR INTAKE FLAP ACTUATOR OPERATION 30
AIR INTAKE COMPONENT DESCRIPTION 32

49–17 APU DRAIN SYSTEM 34
APU DRAIN SYSTEM DESCRIPTION 34

49–20 ENGINE 36
INTRODUCTION 36
APU BORESCOPE INSPECTION 38

49–90 OIL 40
OIL SYSTEM DESCRIPTION 40
OIL SERVICING 44
OIL SYSTEM COMPONENT DESCRIPTION 46

49–30 ENGINE FUEL AND CONTROL 66
APU FUEL FEED SYSTEM DESCRIPTION 66
APU FUEL FEED SYSTEM COMPONENT DESCRIPTION 68

49–32 APU FUEL CONTROL 72
SYSTEM DESCRIPTION 72
FUEL CONTROL UNIT COMPONENT DESCRIPTION 74
FCU OPERATION 76
START FUEL FLOW CONTROL OPERATION 78
FLOW DIVIDER OPERATION 80
FUEL MANIFOLDS AND INJECTORS COMPONENT DESCRIPTION 82

49–50 AIR SYSTEM 84
AIR SYSTEM DESCRIPTION 84
INLET GUIDE VANE SYSTEM OPERATION 86
AIR BLEED SYSTEM OPERATION 88
AIR SYSTEM SENSORS DESCRIPTION 90
ACCESSORY COOLING OPERATION 92

49–40 IGNITION AND STARTING 94
INTRODUCTION 94
IGNITION AND STARTING SYSTEM DESCRIPTION . 96
COMPONENT LOCATION 98
COMPONENT DESCRIPTION 100

49–60 ENGINE CONTROLS 104
GENERAL 104
ECB BITE 106
BITE TEST AND FAULT INDICATION 108
ELECTRONIC CONTROL BOX COMPONENT DESCRIPTION .. 114

49–61 CONTROL AND MONITORING 118
APU START EVENTS FUNCTIONAL OPERATION 118
APU SHUTDOWN EVENTS 119
PROTECTIVE AUTO SHUTDOWN OPERATION 120
EMERGENCY SHUTDOWN OPERATION 120

49–73 ANALYZERS 122
FAULT TABLES PRESENTATION 122

49–70 INDICATING 126
SYSTEM DESCRIPTION 126

TABLE OF CONTENTS

APU ECAM SYSTEM PAGE DESCRIPTION 132
ENG WARNING AND STATUS PAGE PRESENTATION 134

Airbus
A318/A319/A320/A321

ATA 49
Auxiliary Power Unit

APS 3200

EASA Part-66
B1/B2

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Training Manual

Lufthansa Technical Training

Lufthansa Technical Training

Dept HAM US
Lufthansa Base Hamburg
Weg beim Jäger 193
22335 Hamburg
Germany

Tel: +49 (0)40 5070 2520
Fax: +49 (0)40 5070 4746
E-Mail: Customer-Service@LTT.DLH.DE

www.Lufthansa-Technical-Training.com

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ATA 49 AIRBORNE AUXILIARY POWER

49–00 AIRBORNE AUXILIARY POWER GENERAL

APS 3200 INTRODUCTION

LEADING PARTICULARS

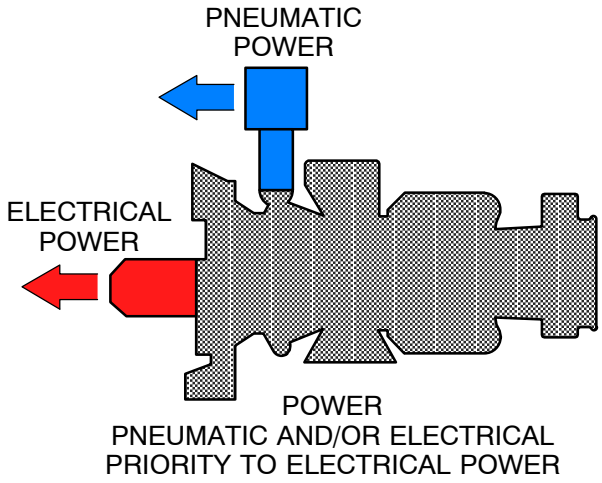
Main Features

- Total Equivalent Power: 400 kW (536 hp)
- Approximately Weight: 136 kg
- Specific Fuel Consumption: 0.372 kg/kWh

Operating Conditions

Supply of pneumatic and electrical power is possible simultaneously or independently. The rated load is the gas generator power (load compressor and gearbox power) without exceeding the gas temperature. The electrical power always has priority in order to protect the APU against overload.

- Flight Operating Envelope
  - Pressure altitude: –1.000 ft to 39.000 ft
  - Ambient temperature: –70°C to +55°C
- Pneumatic and Electric Power
  - Pneumatic Power can be supplied from –1000 ft to 20000 ft
  - Electrical Power can be supplied from –1000 ft to 39.000ft
- Ground Operation
  - Ground Start Up Altitude up to 8000 ft
  - Ground Operation Limit up to 15000 ft
- APU Starting
  - No Limitations within Normal Flight Operating Envelope



APU MAIN FEATURES
TOTAL EQUIVALENT POWER 400 kW
SPECIFIC FUEL CONSUMPTION 0.372 kg/kWh
WEIGHT 136 kg (299 lb)
NOISE LEVEL < 83 dB – AIRCRAFT DOORS < 80 dB – 20 m (65.6 ft) PERIMETER

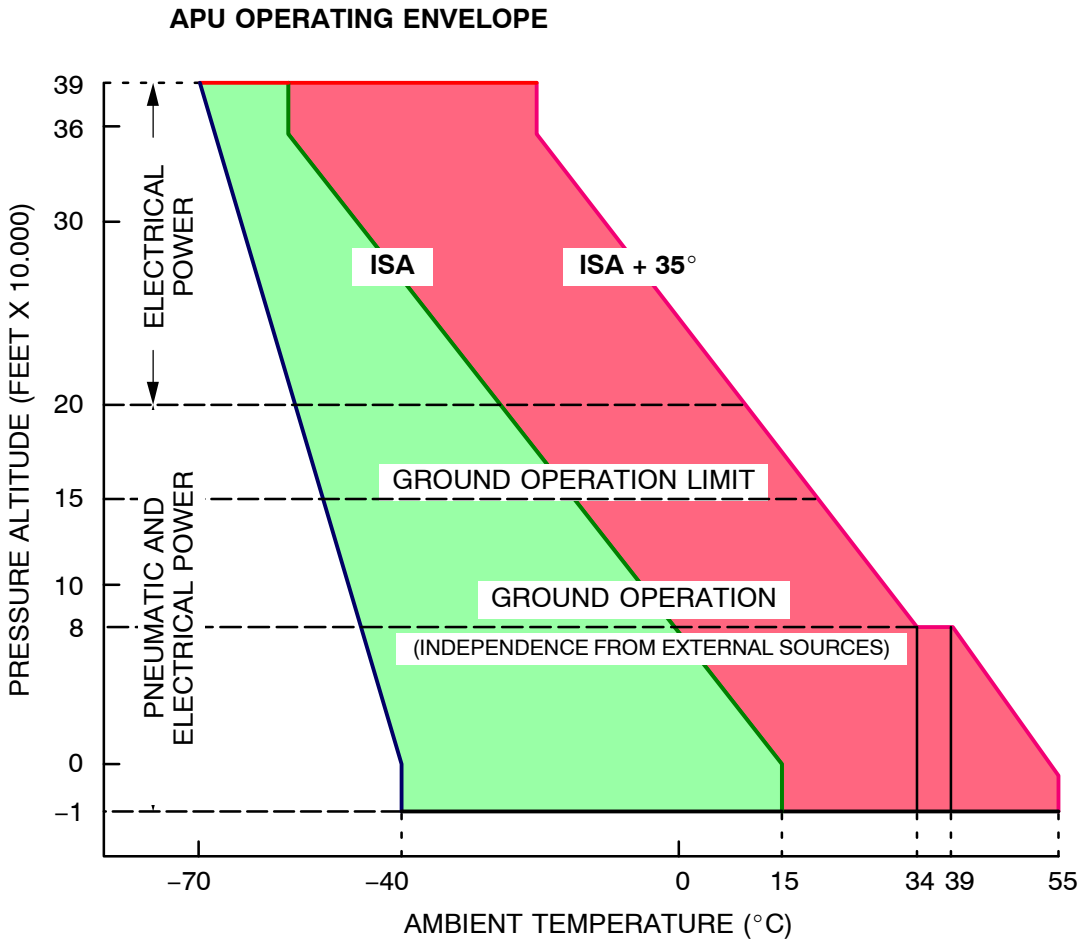


Figure 1 APU Operating Envelope

General

The APU is a small turbine engine especially designed to provide electrical power and air when the main engines are not running. It incorporates a sophisticated control system which, when it receives a start signal from the cockpit starts itself, maintains a constant speed under varying loads and monitors its own operation continually, ready to stop if a malfunction occurs.

Under normal conditions the APU is considered as nonessential equipment. However, there are certain conditions when the APU is considered essential equipment on the MEL (**M**inimum **E**quipment **L**ist) as defined by the aircraft specifications.

Purpose

The APS 3200 is designed to provide compressed air and electrical power to the aircraft on the ground and during flight

- Electrical power supply to aircraft systems
- Compressed air supply to aircraft systems
  - ECS (**E**nvironmental **C**ontrol **S**ystem)
  - MES (**M**ain **E**ngine **S**tart)
  - Wing Anti—icing

The APU can perform non—routine duties

- MMEL (**M**aster **M**inimum **E**quipment **L**ist)
- ETOPS (**E**xtended **T**win **E**ngine **O**perations)

The APU is then used as ”essential equipment” to provide electrical power when one main engine is inoperative.

Main Components

The main components are:

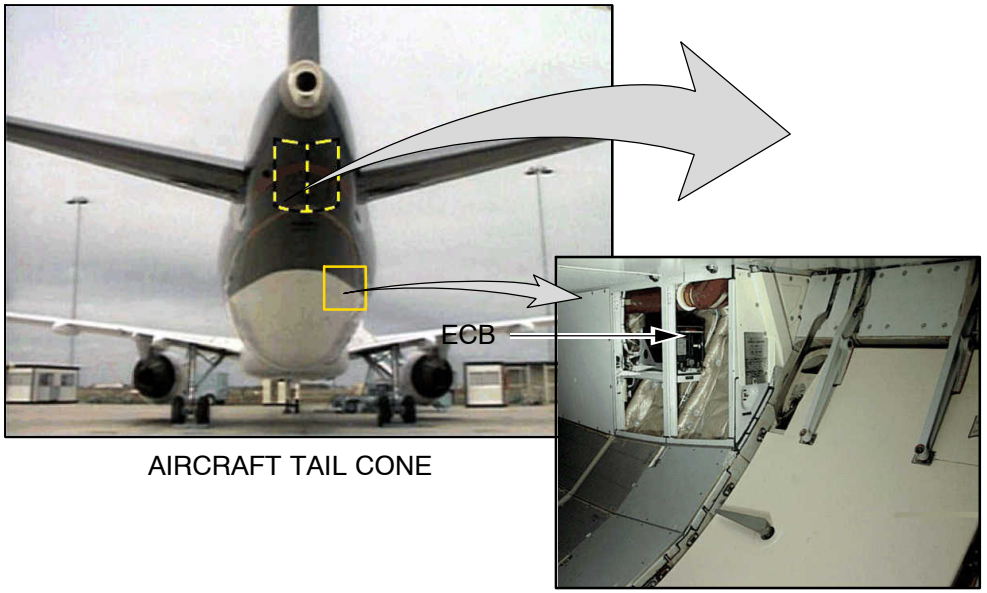
- The APU (**A**uxiliary **P**ower **U**nit)
- The ECB (**E**lectronic **C**ontrol **B**ox)
- The aircraft systems (Pneumatic system, Electrical system, Control panels)

The APU is a single spool gas turbine engine which drives a load compressor and an AC generator.

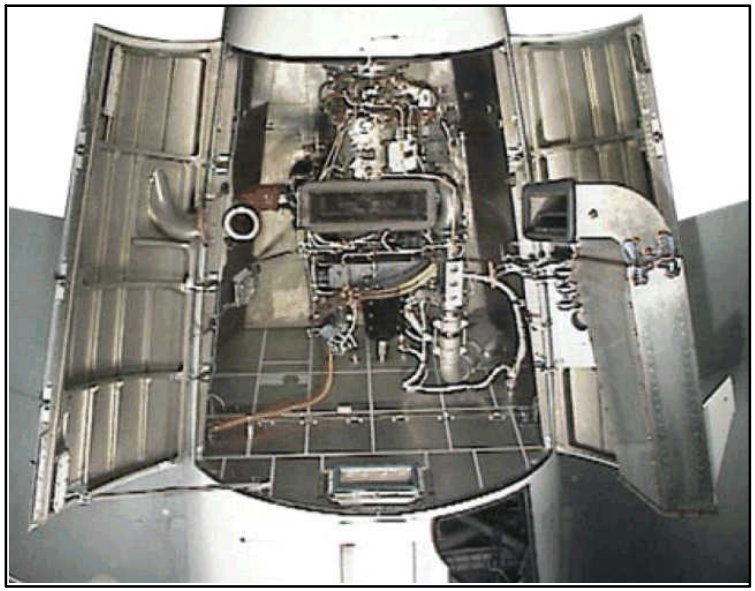
The ECB is an electronic controller of FADEC (**F**ull **A**uthority **D**igital **E**lectronic **C**ontrol) type.

Component Location

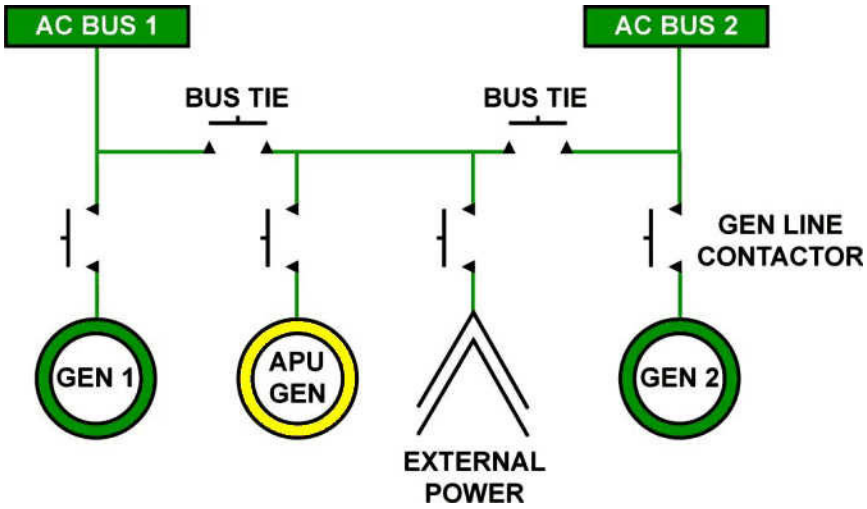
- The APU is installed in the tail section of the aircraft
- The ECB is installed in the Aft cargo compartment in the fuselage.



AIRCRAFT TAIL CONE



AUXILIARY POWER UNIT (APU)



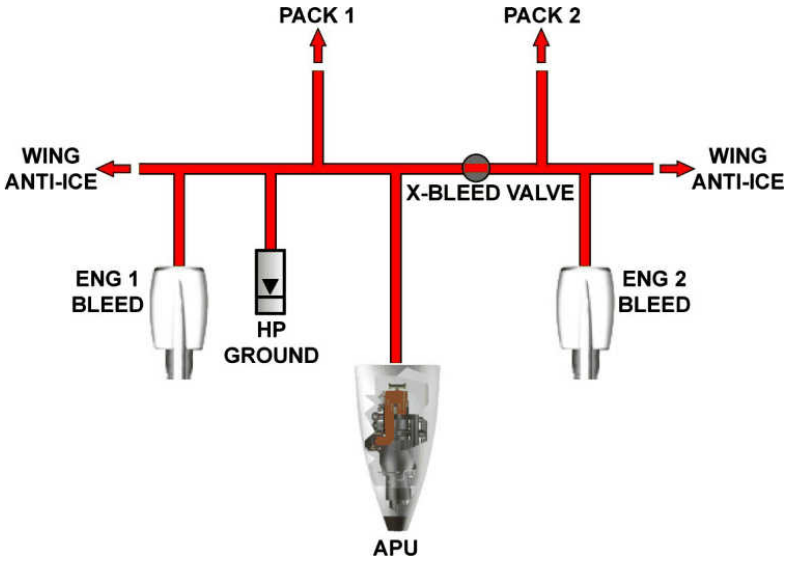


Figure 2 APU Presentation

APU SYSTEMS INTRODUCTION

Power Plant (Ref. 49–10–00)

The power plant is installed in the rear fuselage aft of the passenger compartment. It occupies the tailcone, the rearmost portion of the fuselage. The tailcone has been fitted with a fireproof compartment to house the APU. Peripheral systems are installed both in the APU compartment as well as to the front and rear of it. Doors permit access to all components of the power plant.

Engine (Ref. 49–20–00)

The engine supplies:

- pneumatic power,
- electrical power, and
- cooling air.

To fulfill these requirements, the engine consists essentially of a power section to generate shaft power. A load compressor is flanged to this shaft to generate pneumatic power. Subject shaft also drives a gearbox. A generator is attached to this gearbox to generate electrical power. A fan to provide cooling air is also attached to the gearbox.

Engine Fuel and Control (Ref. 49–30–00)

The APU system receives fuel from the A/C APU fuel supply system (Ref. 28–22–00). Incoming fuel is metered by the FCU (**F**uel **C**ontrol **U**nit) and delivered to the FDDVA (**F**low **D**ivider and **D**rain **V**alve **A**ssembly). From there it is routed via 2 fuel manifolds to the fuel nozzles, located in the combustion chamber.

Ignition and Starting (Ref. 49–40–00)

The APU is fitted with a DC starter motor (8KA), which draws its power from the electrical system battery bus. It turns the engine to such speed that self–sustained engine operation becomes possible. The fuel–air mixture in the combustion chamber is ignited by the ignition system, also fitted to the APU. Electrical power to the ignition system is supplied through the ECB.

Air (Ref. 49–50–00)

The engine is equipped to provide 2 separate air sources:

- pneumatic power (bleed air) for MES (**M**ain **E**ngine **S**tart) and the ECS (**E**nvironmental **C**ontrol **S**ystem),
- cooling air for ventilation of the APU compartment and cooling of the APU lubrication system.

Engine Controls (Ref. 49–60–00)

In order to start, control its performance and to shut off the auxiliary power system, manual and automatic controls are provided.

Manual control of the APU is possible through the crew interfaces in the cockpit. Automatic control is accomplished through the ECB.

Indicating (Ref. 49–70–00)

The ECB monitors the operation of the auxiliary power system. It transmits operation information to the A/C indicating and recording systems ECAM, CFDS and AIDS. It also records system faults in its internal memory. Display of subject data is in the cockpit on the CFDS monitor.

Exhaust (Ref. 49–80–00)

The APU exhaust system serves to duct the engine exhaust overboard. Its secondary purpose is to reduce the exhaust noise level. In order to minimize aerodynamic losses during APU operation, the duct is designed sufficiently large in diameter. Also, exhaust discharge takes place at the very aft end of the A/C, where a low pressure area exists during flight. Thus it is also assured that exhaust gas does not re–enter the APU air intake system

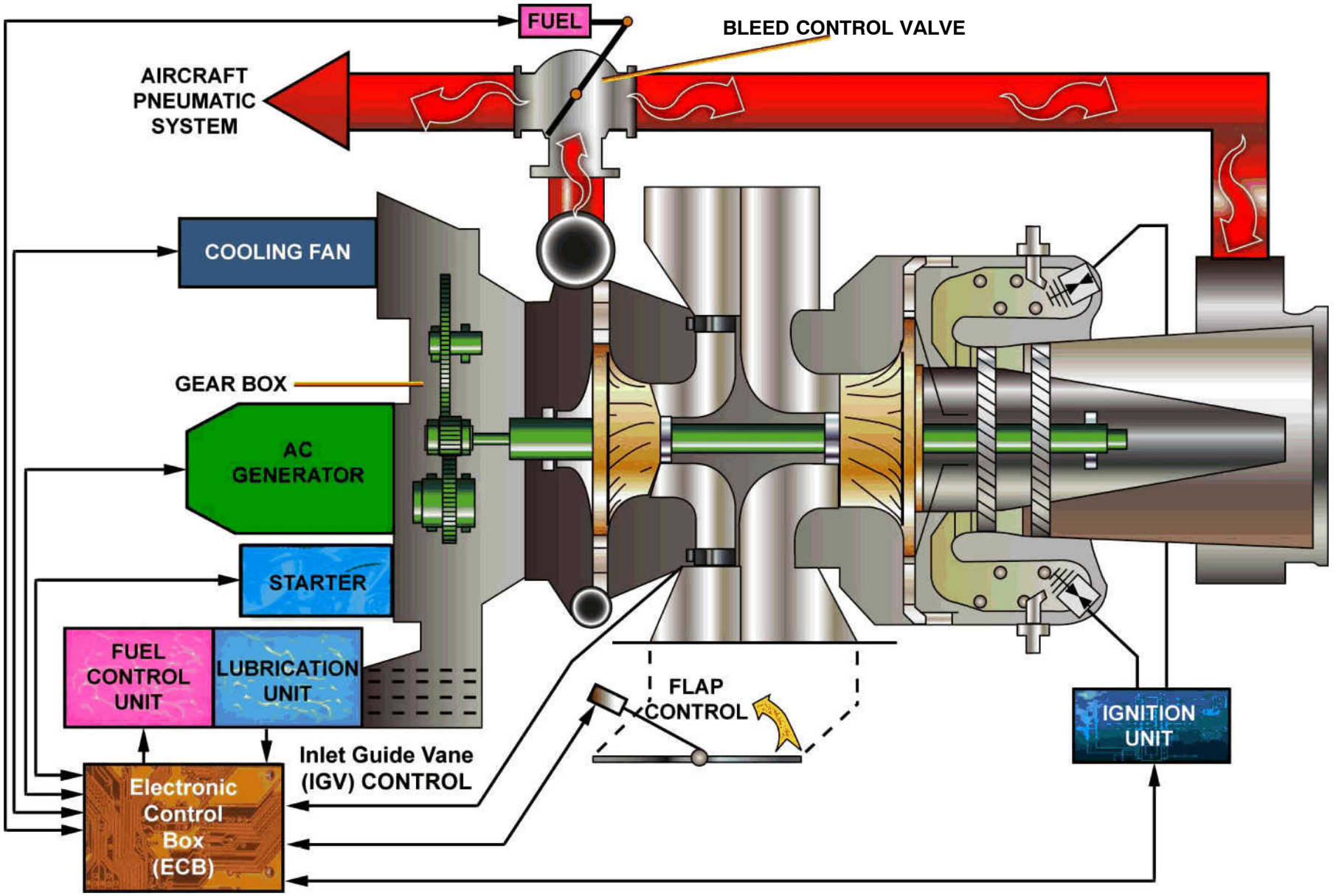


Figure 3 APU Systems Overview

CONTROL AND INDICATING

1 Master Switch

The MASTER SWITCH controls the power supply for the APU operation and protection.

Master SW ”ON” (P/B pressed in)

The ON light illuminates blue when:

- If ground power or main generator power is used, the APU page appears on the ECAM system display.
- The APU system is powered, the ECB carries out the Power Up Test, the air intake flap opens.
- The APU fuel isolation and fuel low pressure valve opens. If required, the APU fuel pump starts running.

Master SW ”Off” (P/B released out)

A normal shutdown sequence is initiated when the MASTER SWITCH is released out.

- The ON light in the MASTER SWITCH goes off.
- If bleed air was used, the APU keeps running for a cooling period of 120 seconds maximum.

At $\leq$ 7 % speed (N)

- The APU fuel isolation and fuel low pressure valve closes.
- The APU fuel pump stops.
- The air intake flap closes.

Master SW Fault Light

The FAULT light comes on amber and the corresponding warnings are activated when an automatic shutdown occurs.

2 Start Pushbutton

The START push button initiates the APU start sequence.

Start P/B ”ON”

The blue ON light stays on as long as the start sequence is in progress (up to APU 95 % RPM) and illuminates when:

- The Back Up Start Contactor closes when the intake flap is open
- The Start Contactor closes
- The Starter Motor is energized
- at 55% RPM Starter Motor ”OFF”
- at 95% RPM the ON Light goes ”OFF”

The AVAIL light comes on green 2 sec. after APU speed has reached 95 % RPM.

3 APU Generator P/BSW (see ATA 24)

4 APU Bleed P/BSW (see ATA 36)

5 APU Fire Handle

The APU FIRE push button, when released out, causes an immediate shut down arms the fire extinguishing system and isolates the APU fuel system.

6 APU AUTO EXTINGuishing TEST SWITCH

The test will only be done during greater maintenance checks:

The test PB sw must be held during test. MASTER sw must be selected ON. APU FIRE warning auto extinguishing and shutdown circuits are tested. Sequence duration is 10 sec. The OK light comes on to indicate a successful test.

NOTE: If APU is in operation, the APU shuts down.

7 RESET SWITCH

When pressed, the test circuit is resetted.

It has to be done after every AUTO EXTINGuishing TEST.

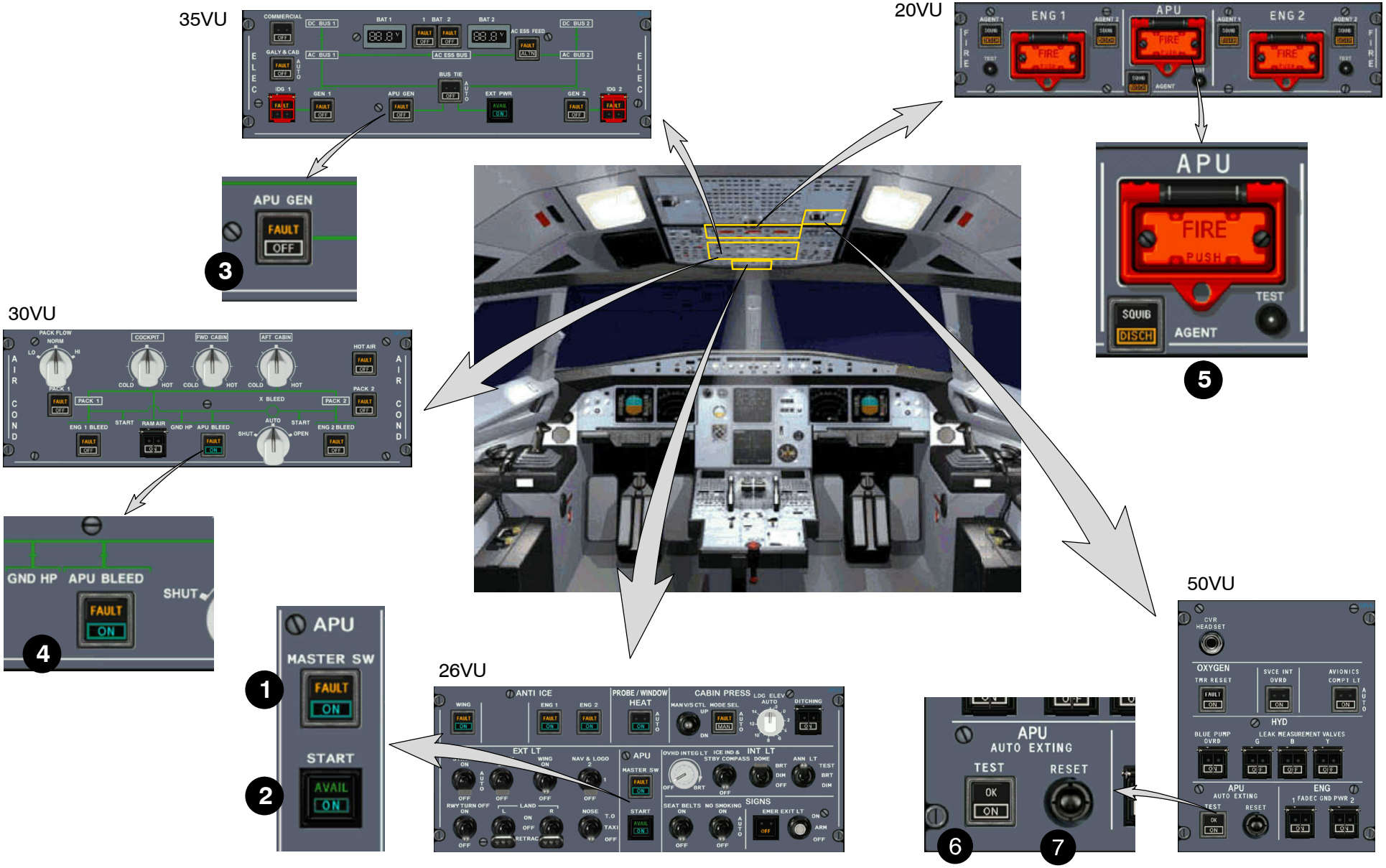


Figure 4 APU Control Panels

ECAM APU Page

APU parameters are displayed on the ECAM APU page. The APU generator parameters are duplicated on the ECAM ELEC page and the APU pneumatic parameters are duplicated on the ECAM BLEED page.

External Controls

In case of an APU FIRE warning on the ground, a loud horn will sound in the nose wheel well to tell ground personnel. Associated with the horn, a red APU FIRE light will come on, on the external power control panel on the lower fuselage. It is possible to do an EMERGENCY shut down of the APU from this panel by lifting the guard and pushing the APU SHUT OFF P/BSW.

8 APU SHUT OFF PUSH BUTTON

An APU emergency shutdown can be performed using the APU SHUTOFF push button located on the external power control panel, next to the nose landing gear, within the EXTERNAL POWER CONNECTOR access panel.

9 APU FIRE LIGHT

The APU FIRE red light comes on when a fire is detected on ground. Red light illumination is accompanied by the ground horn.

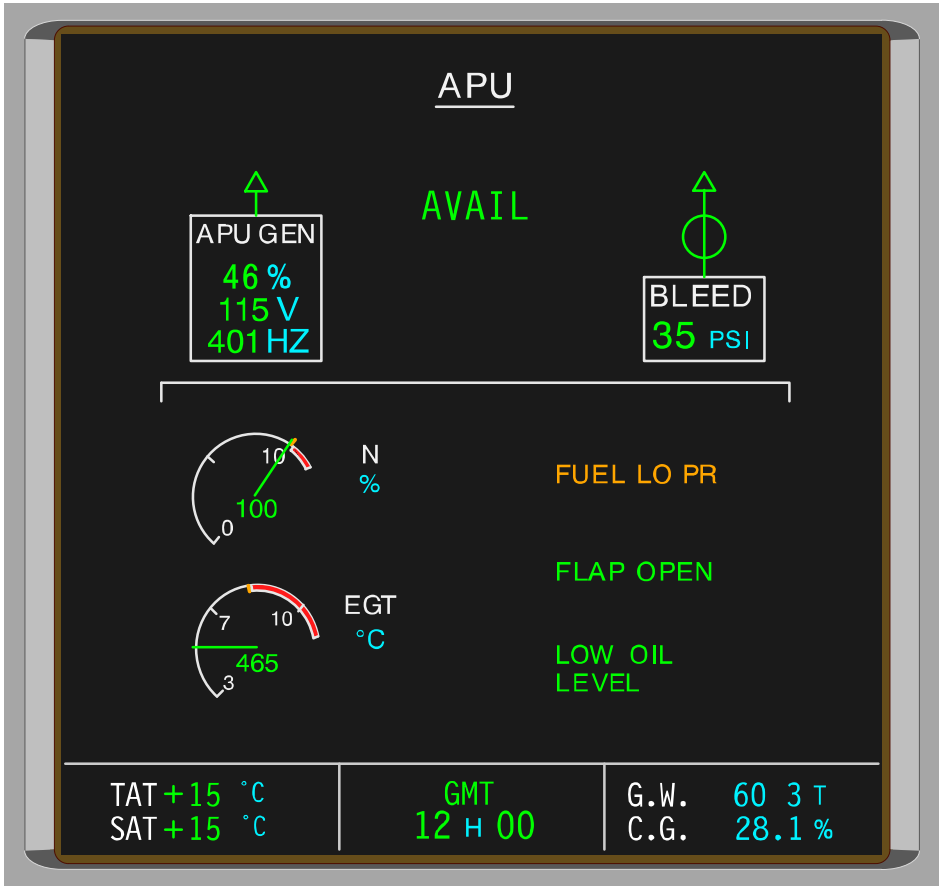
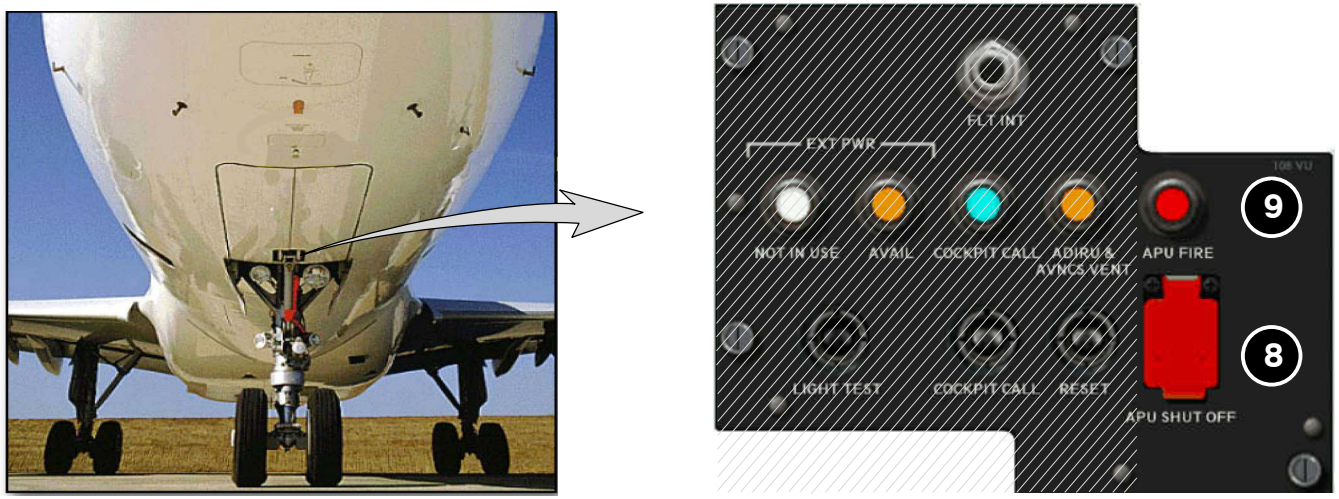


Figure 5 APU ECAM SYSTEM DISPLAY



EXTERNAL POWER CONTROL PANEL (108VU)

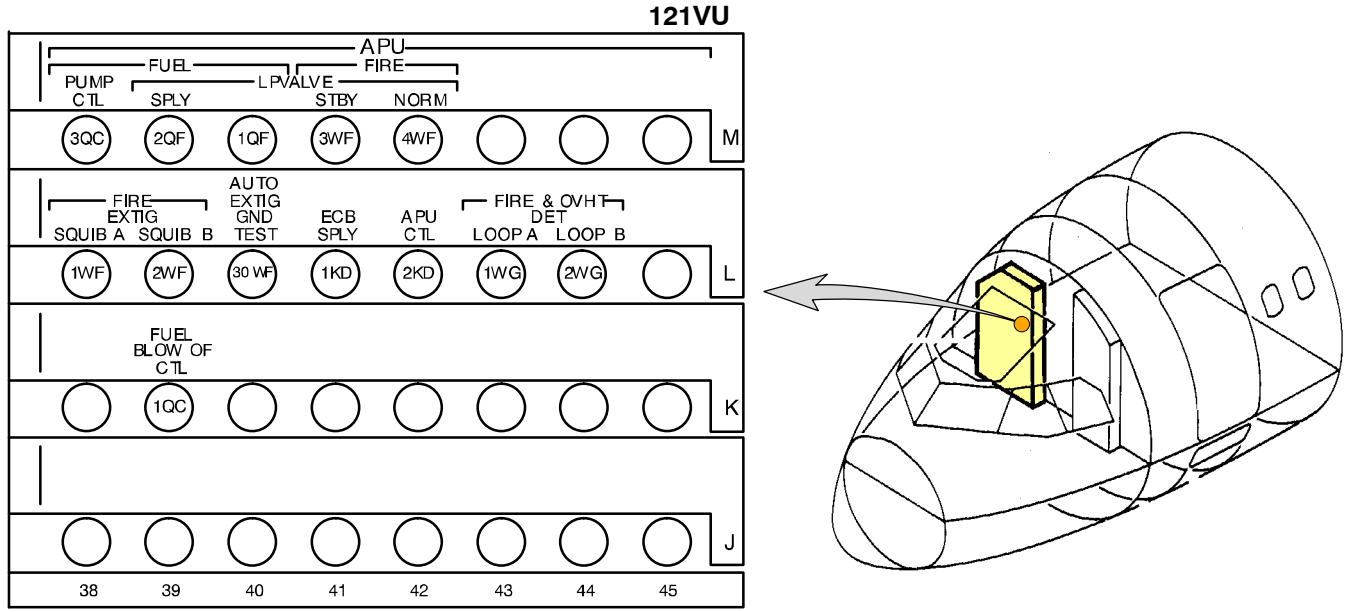


Figure 6 APU External Controls & Indicating

SAFETY PRECAUTIONS

General

When you work on A/C, make sure that you obey all the Aircraft Maintenance Manual (AMM) safety procedures. This will prevent injury to persons and/or damage to the A/C.

- Make sure that you use the correct personal protection when you work on the APU, as fuel and oil are poisonous.
- Do not touch the APU until it is sufficiently cool.
- If you operate the APU with the APU access doors open or removed, make sure that you have the correct fire fighting equipment available.
- The onboard APU fire extinguishing system is not sufficient when these doors are not closed.

Figure 7 Safety Precautions

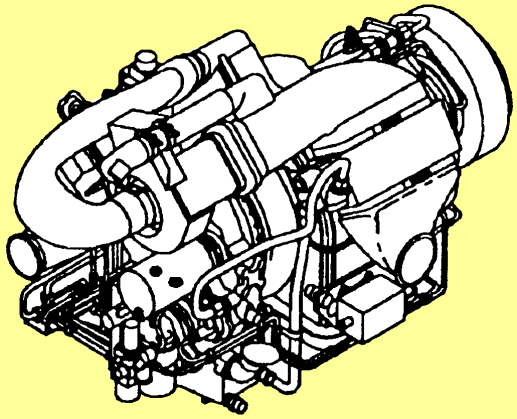
OPERATING LIMITATIONS

INLET AIR TEMPERATURE
MAX ALLOWABLE: 55°C (131°F)

OPERATING ENVELOPE
PRESSURE ALTITUDE:
-300 m + 11900 m (-1000 ft + 39000 ft)
AMBIENT TEMPERATURE:
-70°C + 55°C (-94°F + 131°F)

STARTING TIME
FROM 0 TO GOVERNED SPEED:
LESS THAN 90 SECONDS

APU ROTATION SPEED
NORMAL OPERATION (100%): 49300 RPM
UNDERSPEED SHUTDOWN: < 95 %
OVERSPEED SHUTDOWN: > 105 %
OVERSPEED SHUTDOWN BACK-UP: > 107 %



ELECTRICAL LIMITATION
NOMINAL OUTPUT POWER:
90kVA

OIL LEVEL
MAX OIL LEVEL:
3.8 LITERS (1 US G)
MIN OIL LEVEL:
2.6 LITERS (0.68 US G)

EXHAUST GAS TEMPERATURE
MAX CONTINUOUS:
557°C
OVERTEMPERATURE SHUTDOWN:
670° TO 760°C
(DEPENDING ON OUTSIDE CONDITIONS)

OIL PRESSURE
NORMAL OPERATION:
345 – 414 kPa (50 – 60 PSIG)
LOW OIL PRESSURE SHUTDOWN:
241 kPa (35 PSIG)

AIR BLEED
MIN FLOW: 1.16 kg/s (2.55 lb/s)
MIN. PRESSURE: 289.6 kPa (42 PS/G)

OIL CONSUMPTION
MAX OIL CONSUMPTION:
4 cc/h (0.009 PPH)

OIL TEMPERATURE
MAX OIL TEMPERATURE:135°C
(HIGH OIL TEMP SHUTDOWN)
AC GENERATOR MAX OIL TEMPERATURE: 185°C
(GEN HIGH OIL TEMP SHUTDOWN)

NOTE: PROTECTIVE SHUTDOWN CONDITIONS MAY DEPEND ON ETOPS STATUS

Figure 8 Operating Limitations

49–11 POWER PLANT

POWER PLANT INTRODUCTION

Power Plant Installation

The APU power plant is installed in a fireproof compartment of the fuselage tailcone, between FR80 and FR84. A pair of access doors on the bottom of the tailcone opens outwards to permit the APU to be lifted and lowered.

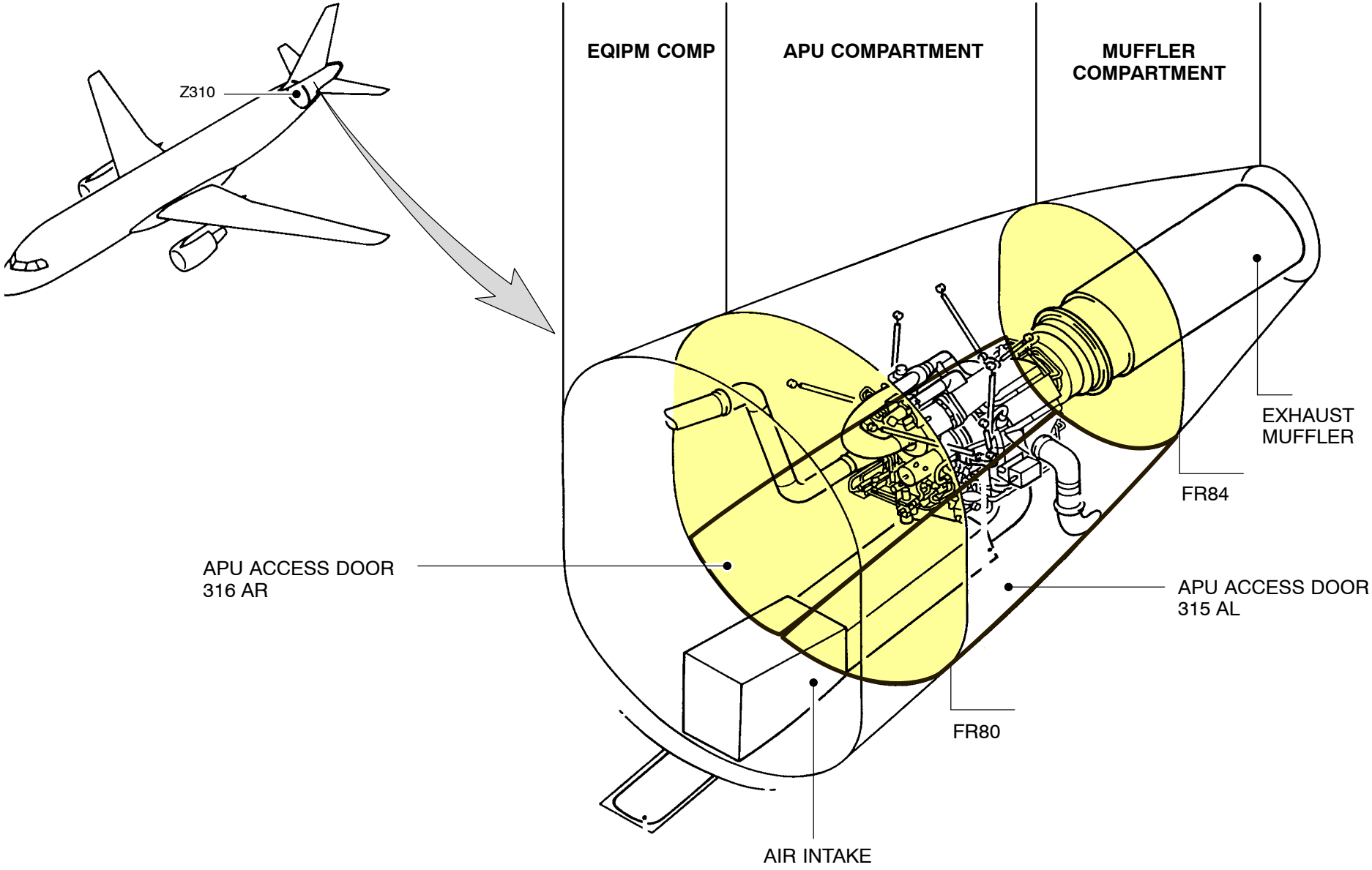


Figure 9 APU Installation

APU ACCESS DOOR DESCRIPTION

WARNING: DO NOT TOUCH THE AUXILIARY POWER UNIT UNTIL IT IS SUFFICIENTLY COOL TO PREVENT BURNS WHEN YOU DO THE MAINTENANCE TASK. MAKE SURE THAT THE THREE QUICK RELEASE FASTENERS ON THE APU LEFT ACCESS DOOR ARE CORRECTLY STOWED. THIS PREVENTS DAMAGE TO THE SEAL ON THE APU LEFT ACCESS DOOR.

CAUTION: IN THE EVENT OF DOOR REMOVAL YOU MUST SECURE THE RIGHT ACCESS DOOR HOLD OPEN SPRING MECHANISM BY INSERTING THE RED COLORED PIP-PIN IN THE LOCKING HOLE. THE PIN IS STOWED NEXT TO THIS LOCKING HOLE.

DOOR OPENING

1. In the cockpit, open the APU circuit breakers
2. Position a work stand suitable to reach the aircraft under the APU compartment.

NOTE: The APU doors are secured by a total of seven latches, five latches secure the left door and two latches secure the right door. The left hand door must be opened first to gain access to the latches for the right hand door.

3. Start by releasing the rear latch. Next, the three latches connecting the doors together are undone. As each latch is undone, secure the latch hook on the latch lever. Continue to release the forward and aft remaining latches.
4. When all latches have been released, pull the door open and secure with the door support strut. The strut is stowed at the forward end of the left door. Release the strut pip–pin from the door, extend the telescopic strut and secure it to the aircraft using the pip–pin.
5. Push the door open until the strut locks in the fully extended position. This completes the opening of the left hand door.

   With the left hand door open, the two latches securing the right hand door are now visible. The forward latch is released. Followed by the rear latch and the door is ready to be opened.
6. Use the assist handle mounted on the air inlet duct and swing the door fully open. The door hold open mechanism incorporates a counterbalance spring that takes most of the door weight. The door will lock automatically in the door open position.
7. No locking pins are necessary to secure the right hand door in the open position. The mechanism in overcentered position holds the door open. This completes the APU door opening procedure.

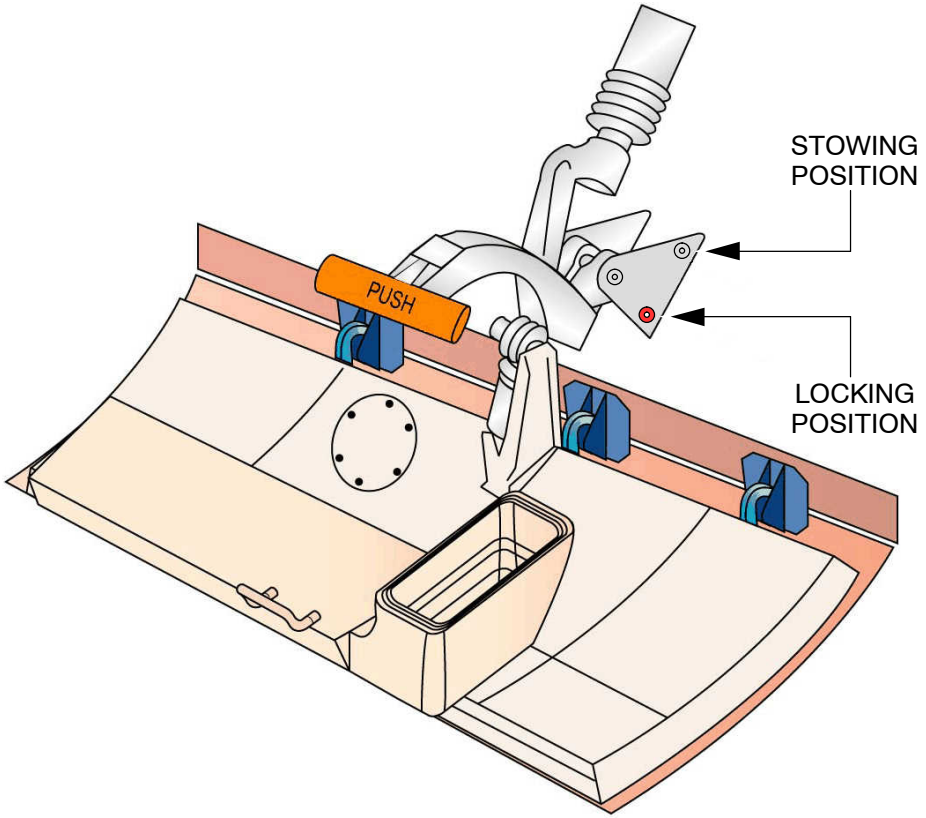


Figure 10 Locking for Door Removal

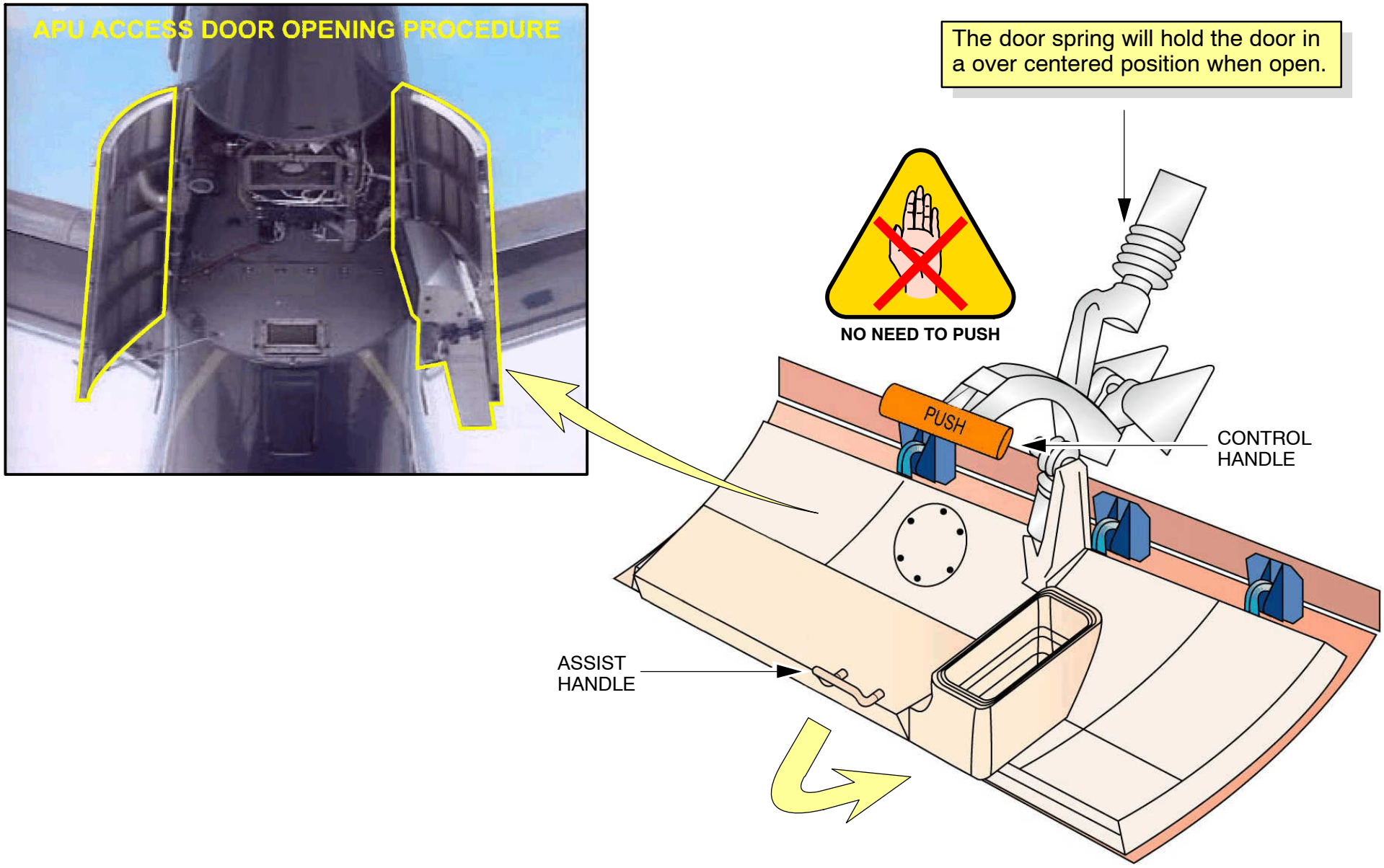


Figure 11 APU Access Door Opening

DOOR CLOSURE

1. To close the right hand door, apply a lifting force to the door with one hand, and at the same time, tap the orange colored release handle marked “PUSH” in a downward, outward direction to release the overcentered geometric lock on the door hold open mechanism. Lift the door to the closed position, using the assist handle on the air inlet duct.
2. Secure the forward and rear latches on the right hand door.
3. The left door support strut must be stowed before closing the left door.

   To release the lock on the left hand door support strut, pull down on the knurled collar. While holding the collar down, partially close the door.
4. Hold the door with the left hand and with the right hand, release the door support strut pip–pin from the aircraft.
5. Stow the support strut on the door.
6. Lose the left door.
7. Secure the forward latch.
8. Ensure that the latch release lever is flush with the latch.
9. Secure the rear latch.
10. Secure the three latches holding the left and right doors together. Repeat the closing procedure for the remaining latches.
11. Carry out a final visual inspection to ensure that all latches are secure.

    This completes the APU access door closing procedure.
12. Finally, reset the APU circuit breakers in the cockpit.

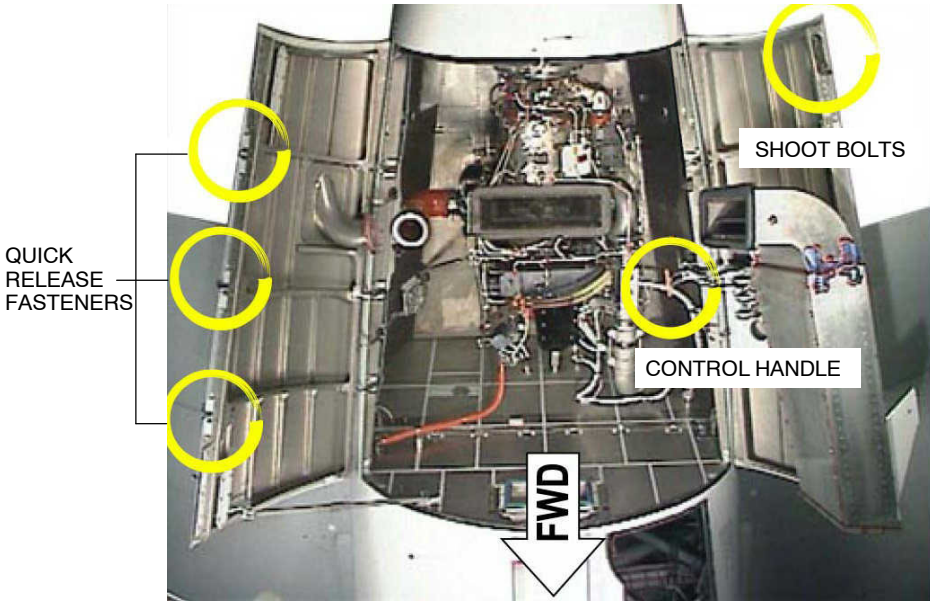


Figure 12 Access Door Latches

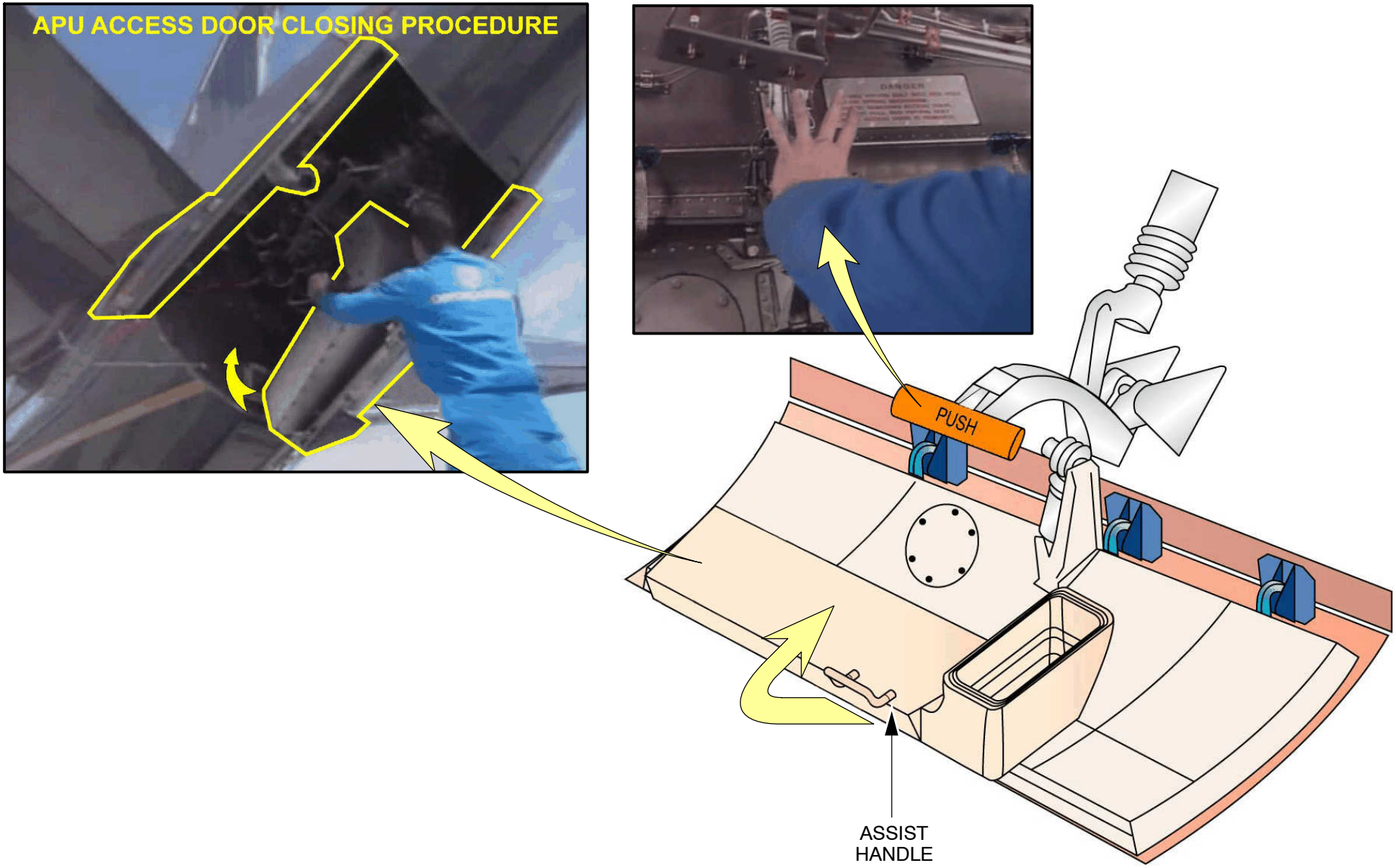


Figure 13 APU Access Door Closing

APU COMPONENT LOCATION (APU LEFT SIDE)

The following components are mentioned in the following figure:

1. The APU air intake which is connected to the aircraft air intake system.
   The APU air intake has a screen to protect the APU internal components against foreign object damage.
2. The compartment cooling valve which is installed on the cooling fan assembly.
3. The cooling fan assembly located at the top of the gearbox front face.
4. The starter motor which drives the APU rotating assembly during starting. The starter motor is located on the front face of the gear box, at the left of the AC generator.
5. The fuel control unit which supplies and meters fuel to the APU. It mainly includes fuel pumps, a fuel filter, a servovalve and a 3 way solenoid valve. The fuel control unit is located on the gearbox front face below the starter motor.
6. The load compressor casing which houses the loadcompressor, the scroll and the inlet guide vanes.
7. The air inlet plenum which ensures the supply of air to the compressors.
   The air inlet plenum is located between the loadcompressor and the power section.
8. The ignition exciter which supplies high energy to the igniter plugs.
   The ignition exciter is mounted on the lower part of the air inlet plenum.
9. The oil cooler which transfers the heat of the lubricating oil to the cooling air supplied by the cooling fan assembly.
10. The APU exhaust system which guide the burnt gas to the aircraft exhaust pipe. The exhaust diffuser is located at the rear of the powersection.
11. APU fuel flow divide
12. De-oiling valve
13. Serial number encoder

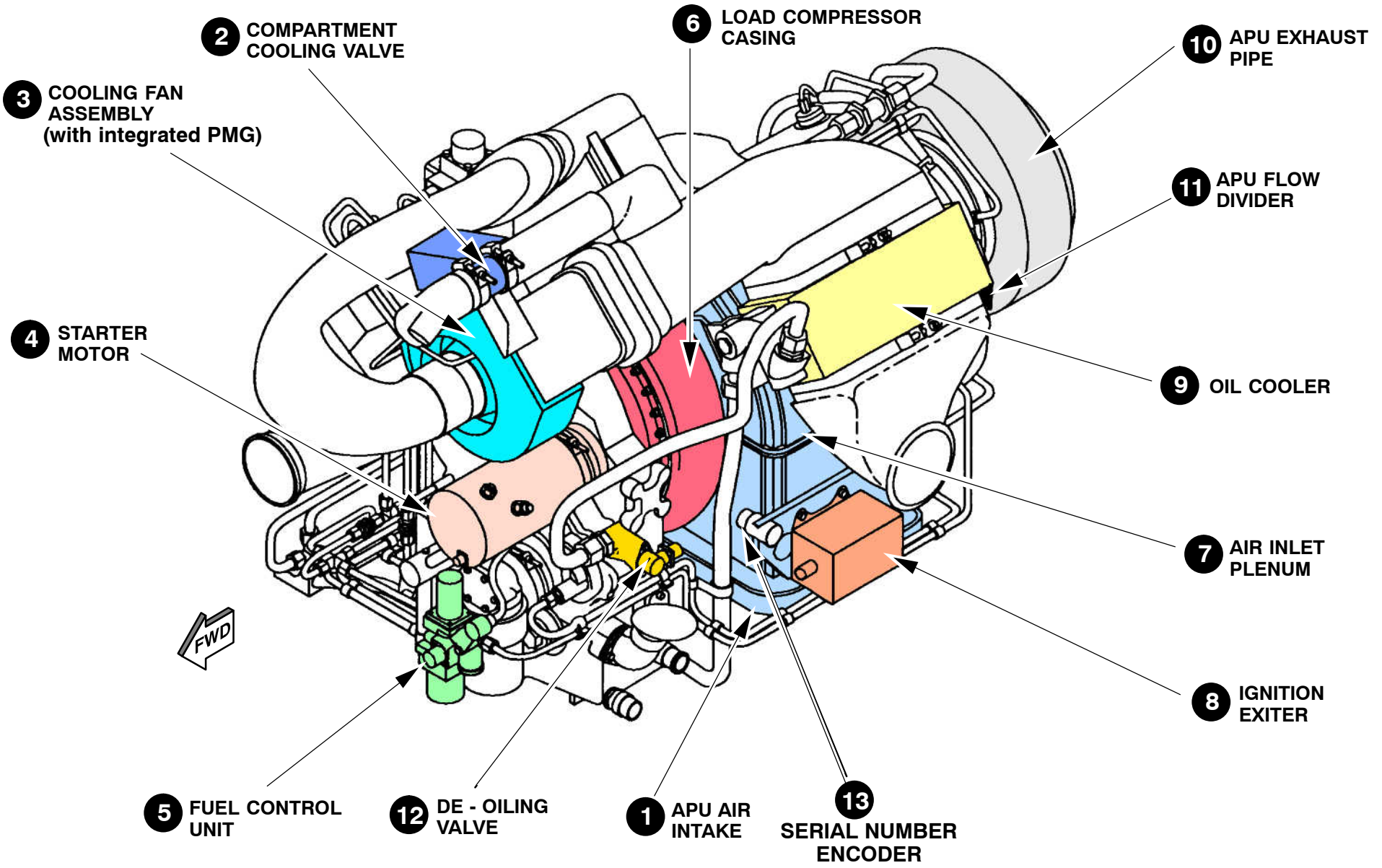


Figure 14 APU Components (Left Side)

COMPONENT LOCATION (APU RIGHT SIDE)

The following components can be identified:

1. The gearbox which provides the drive for the AC generator and the accessories required for APU operation. The gearbox also forms the oil sump of the oil system
2. The AC generator which transforms the mechanical power into electrical power used by the aircraft systems
3. The cooling fan assembly which provides air circulation for the oil cooler and for the ventilation of the engine compartment. The cooling fan assembly is located at the top of the gearbox front face
4. The APU drain collector which collects the various drainage and leaks. The collector is installed on the right side of the gearbox by means of 2 struts
5. The air bleed system which includes a servo valve, an actuator and a bleed control valve
6. The inlet guide vane system which includes a servo valve, an actuator, the inlet guide vanes and their control mechanism
7. The combustor casing which houses the combustion chamber and the turbine wheels
8. Main and pilot fuel injection system installed at the rear of the combustor casing
9. Inlet air pressure and temperature sensor
10. Load compressor discharge temperature sensor
11. Load compressor discharge pressure sensors
12. Oil level sensor
13. Generator scavenge filter ΔP switch
14. RPM speed sensor (2)
15. Low oil pressure switch
16. Oil Temperature sensor

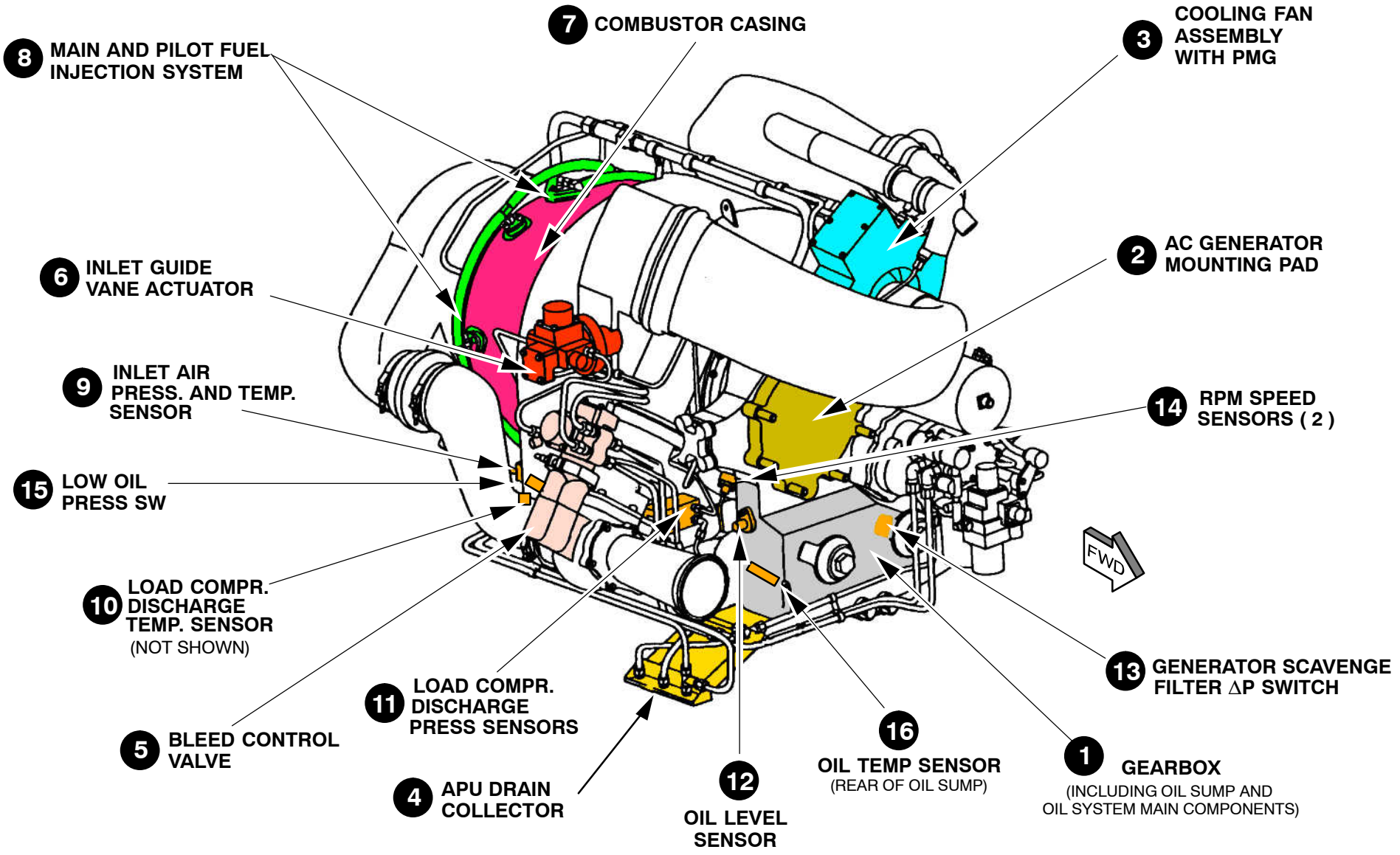


Figure 15 APU Components (Right Side)

49–12 APU MOUNTS

DESCRIPTION

General

The suspension system is designed 'fail–safe' with respect to the failure of any one of the 7 suspension rods or their respective structure attachment bracket or vibration isolator housing lug or clevis.

Forward Mounts

The left forward vibration isolator is supported by three suspension rods and is thus fixed in space. The right forward vibration isolator is supported by two rods such, that movement in the y–direction is possible.

Aft Mount

The aft mount is designed similarly, but allowing movement in the x–direction. This design approach permits production and installation tolerances in the APU as well as the suspension system to be washed out.

Vibration Isolators

The function of the vibration isolators is to mechanically isolate the APU from the A/C–structure in order to minimize the two–way transmission of vibration and shocks.

In case of fire in the APU compartment, the design of the vibration isolator core member and housing does not allow separation of these parts if the elastomer component is damaged or destroyed. Although the function of the vibration isolators will then be lost, the APU will settle only slightly.

Maintenance

The entire suspension system is classified "ON CONDITION".
Therefore, no regular maintenance tasks need to be carried out.

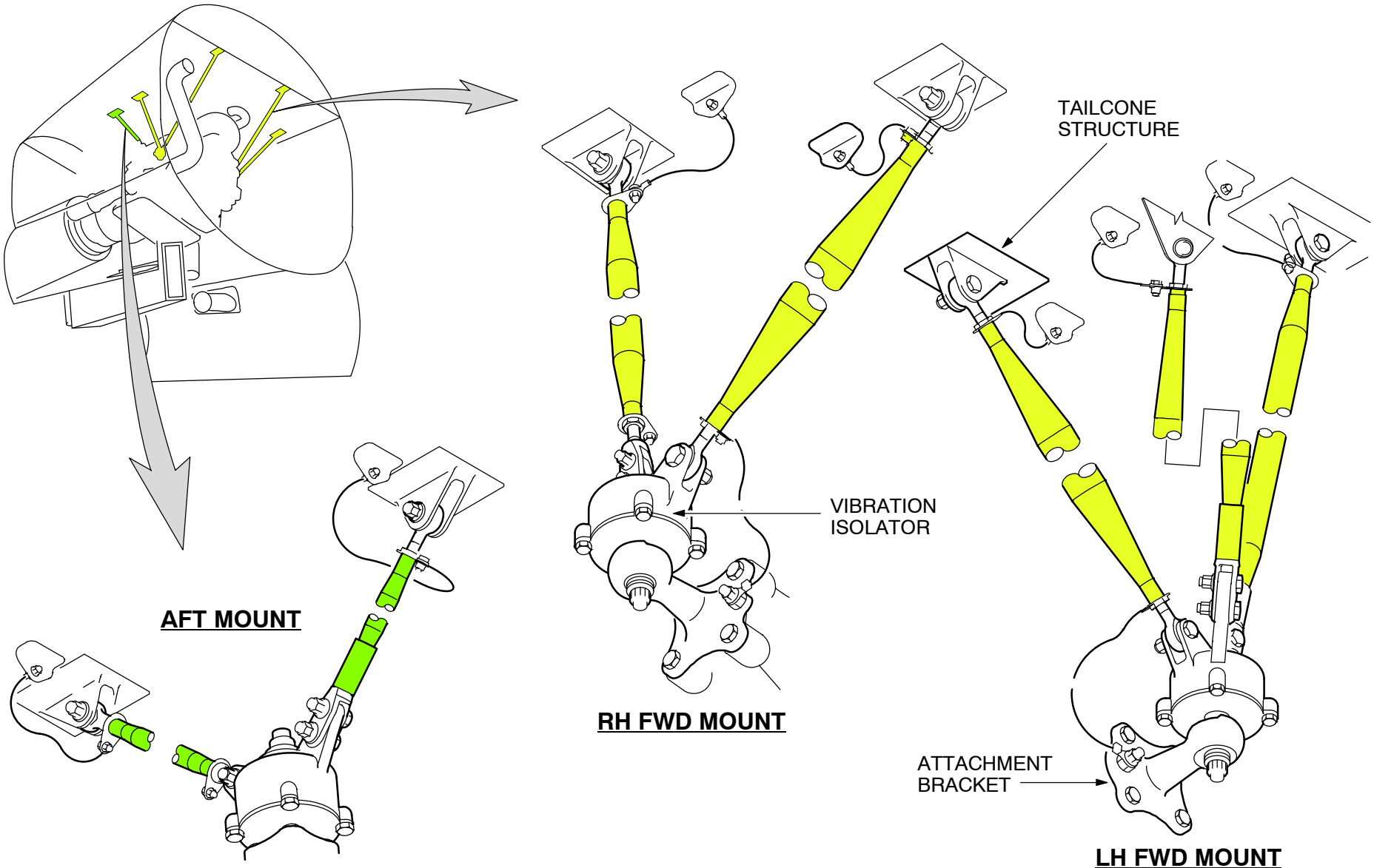


Figure 16 APU Mounts

49–16 AIR INTAKE SYSTEM

AIR INTAKE SYSTEM DESCRIPTION

General

The air intake system supplies ambient air to the APU (**A**uxiliary **P**ower **U**nit) plenum chamber. The system includes:

- a fixed diverter unit,
- an air intake housing with an inlet flap and an actuator,
- an air intake duct with a diffuser and an elbow.

All the components in the system are made to give:

- a quiet operation,
- a low weight,
- a minimum flow resistance,
- a minimum air inlet distortion.

This permits the air intake to supply sufficient air to the APU during the certified ground or flight operation conditions. It also permits the APU to operate without any bad effects or dangerous loss of power (surge conditions).

Air Intake General

The air intake is installed to make sure that the exhaust (from the APU or main engine) or unwanted material does not go into the system. A diverter unit is installed in front of the air intake. Fluid gutters behind and parallel to the air intake are also installed.

This arrangement prevents fluids, such as hydraulic fluid, glycol, fuel, oil and water, which could possibly flow along the fuselage and enter the system. There are no screens in the air intake, and the material does not soak up sufficient quantities of flammable fluids to become dangerous.

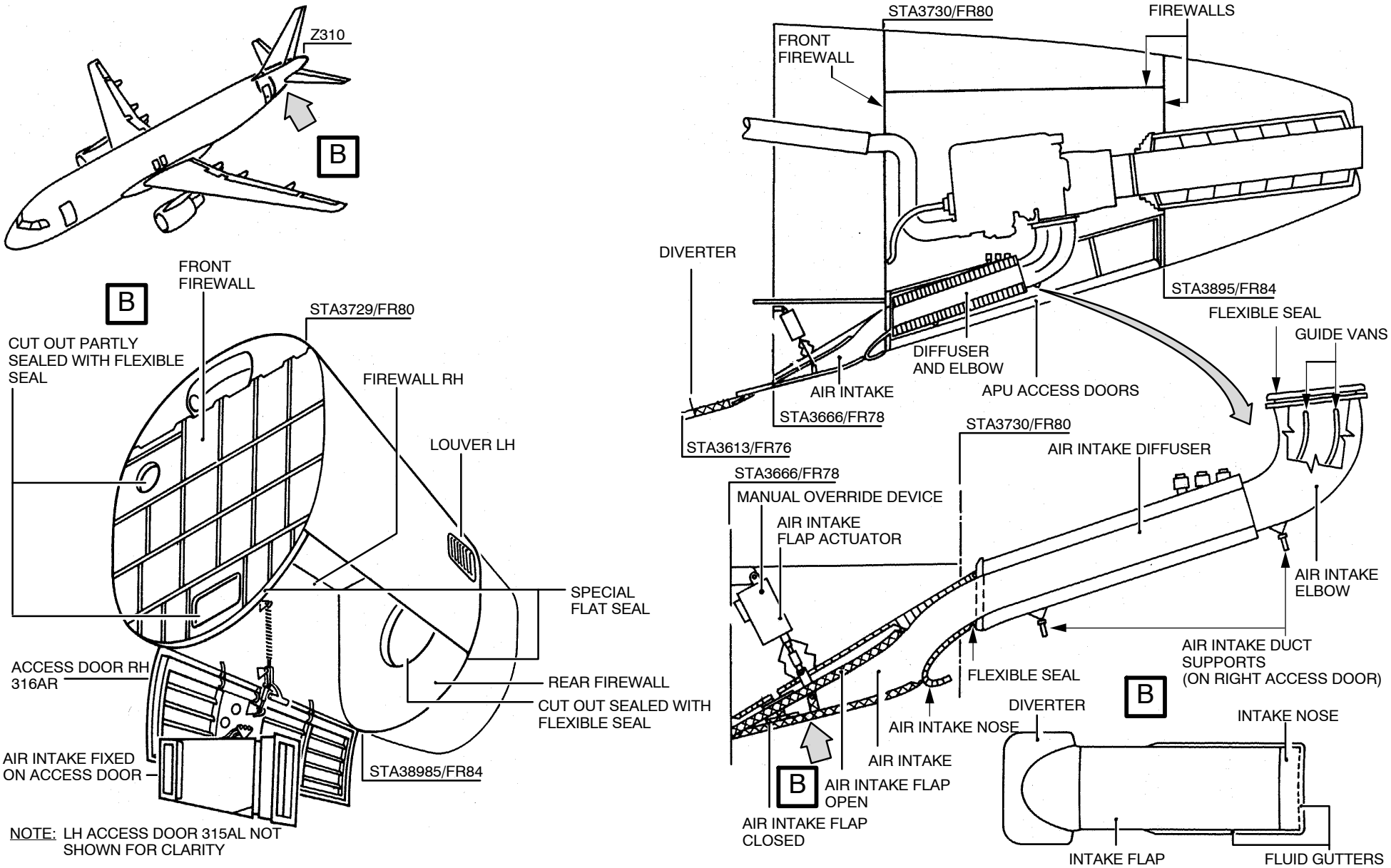


Figure 17 Air Intake Installation

AIR INTAKE FLAP ACTUATOR OPERATION

Air Intake Flap Open

To open the air intake flap the 28 V DC busbar 301PP must be energized. The circuit breakers ECB SPLY 1KD and APU CTL 2KD must be closed.

The MASTER SW must be set to the ON position.

When the above operations are complete, the subsequent sequence occurs:

- the blue annunciator ON light in the MASTER SW comes on,
- the APU MAIN relay 4KD is energized,
- the busbar 301PP supplies 28 V DC to the ECB 59KD, through the APU MAIN relay 4 KD,
- the ECB 59KD transmits a " flap open " command signal to the air intake flap actuator,
- the air intake flap actuator operates to open the air intake flap. When the air intake flap actuator reaches its fully open position, a "flap open" signal is transmitted to the ECB 59KD.

The air intake flap is fully open in approximately 20 s.

Air Intake Flap Close

1. Normal APU S/D (**S**hut**d**own)

   When the MASTER SW 14KD is set MANUALLY to OFF position, these steps occur:

   – the APU continues to run for up to 120 s in a cool–down cycle if the APU BLEED SW was in ON position. This cool–down period is set in the workshop.

   When the APU speed has decreased below 7 %, this sequence occurs:

   – the ECB 59KD supplies a "flap close" command signal to the air intake flap actuator,
   – the air intake flap actuator operates to close the air intake flap. After the air inlet flap actuator has closed:
   – the (close) position switch of the air intake flap actuator transmits a "flap closed" signal to the ECB 59KD (Ref. 49–61–00),
   – the APU MAIN relay 4KD is de–energized,
   – the ECB 59KD 28 V DC supply is disconnected through the APU MAIN RELAY 4KD. The air intake flap closes fully in approximately 20s.

APU EMERGENCY STOP Ground Signal

2. When the ECB 59KD receives an APU EMERGENCY STOP ground signal for 50ms:
   – the ECB 59KD shuts down the APU immediately. When the APU speed has decreased to 7 %, this sequence occurs:
   – the ECB 59KD transmits a "flap close" command signal to the air intake flap actuator,
   – the air intake flap actuator operates to close the air intake flap. After the air intake flap has closed:
   – the (close) position switch of the air intake flap actuator transmits a "flap closed" signal to the ECB 59KD (Ref. 49–61–00).

   After the MASTER SW 14KD is set to OFF:

   – the APU MAIN relay 4KD is de–energized,
   – the ECB 59 KD 28 V DC supply is disconnected through the APU MAIN RELAY 4KD.

Air Intake Flap Not Fully Open (Class 1 Fault)

3. When the ECB 59KD BITE (**B**uild–**I**n **T**est **E**quipment) completes the PUT (**P**ower **U**p **T**est) but does not receive an inlet door open signal within 30seconds:
   – the ECB 59KD inhibits the APU start,
   – the ECB 59KD transmits a 'flap close' command signal to the air intake flap actuator,
   – the air intake flap actuator operates to close the air intake flap. When the air intake flap actuator reaches its fully closed position:
   – the (close) position switch of the air intake flap actuator transmits a "flap closed" signal to the ECB (Ref. 49–61–00).

   After the MASTER SW 14KD is set to OFF:

   – the APU MAIN relay 4KD is de–energized,
   – the ECB 59 KD 28 V DC supply is disconnected through the APU MAIN relay 4KD.

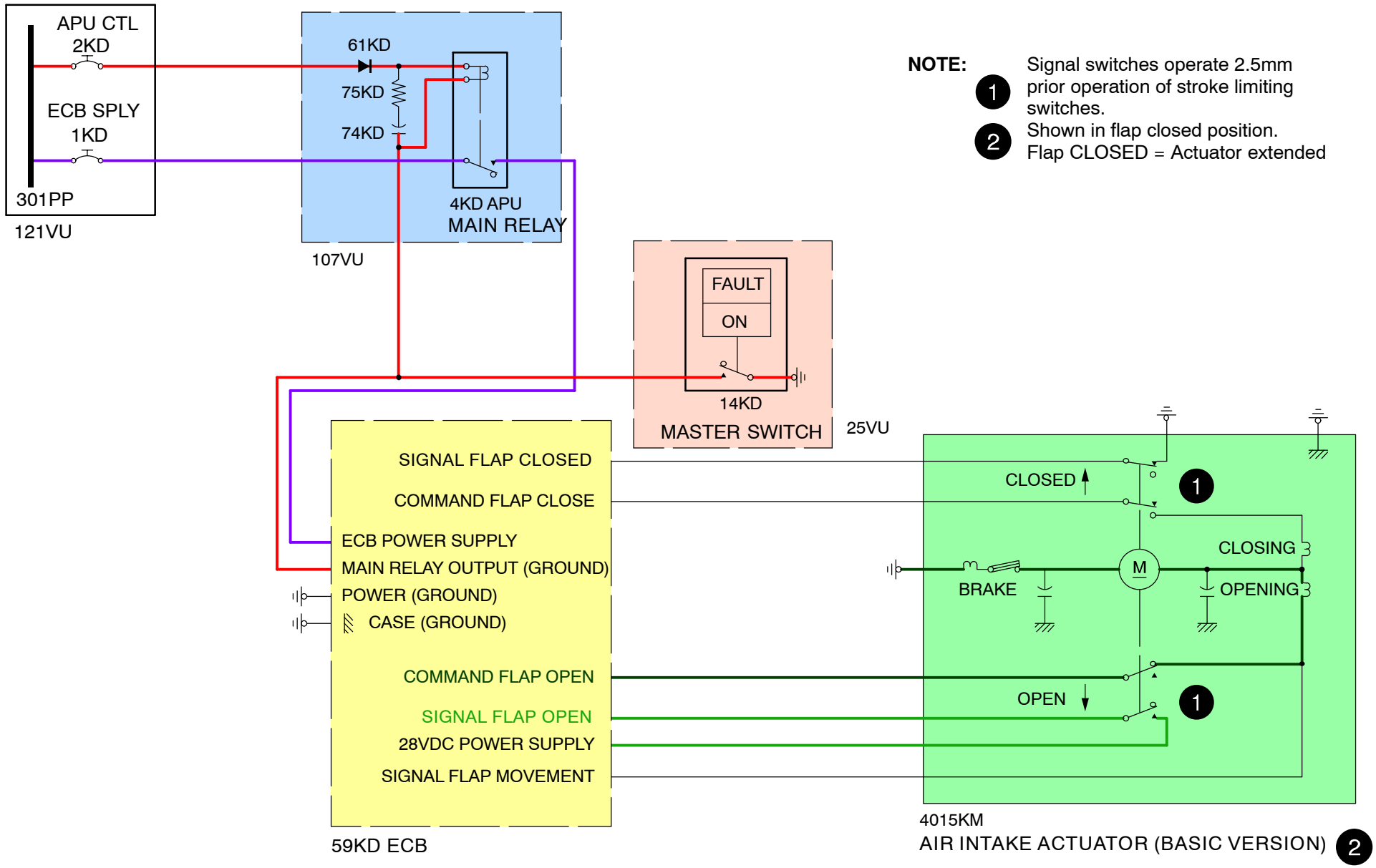


Figure 18 Air Intake Flap Electrical Schematic

AIR INTAKE COMPONENT DESCRIPTION

Air Intake Diverter

The fixed diverter increases the ram–air recovery as it reduces the low–energy part of the boundary layer (during APU operation in flight). It also makes sure that any fluids which could flow along the fuselage, do not go into the air intake. The diverter is installed between FR76 and FR78.

1 Air–Intake Flap Actuator

An electrical linear actuator operates the air intake flap.

The air Intake flap actuator includes:

- a DC Motor with Brake Control
- two Travel Limit Switches
- two Position Switches (one for open and one for close position)
- a Thermal Overload Protection Device
- an Electrical Connector
- a Manual Override Device

The DC motor drives a screw jack assembly through a system of gears and cluster gears. This extends or retracts the air intake flap.

Two travel limit switches control the length of extension and retraction of the actuator which has a linear travel of 75 mm.

Two flap position switches are installed 3mm from the maximum extend and retract positions of the actuator.

They send “flap open“ and “’flap closed“ signals to the ECB 59KD, which are then displayed on the ECAM when the APU systems page is selected.

A Manual Override Device, installed on the actuator, permits the air intake flap to be opened or closed manually on the ground with a normal tool.

This operation is done through the access door 314AR.

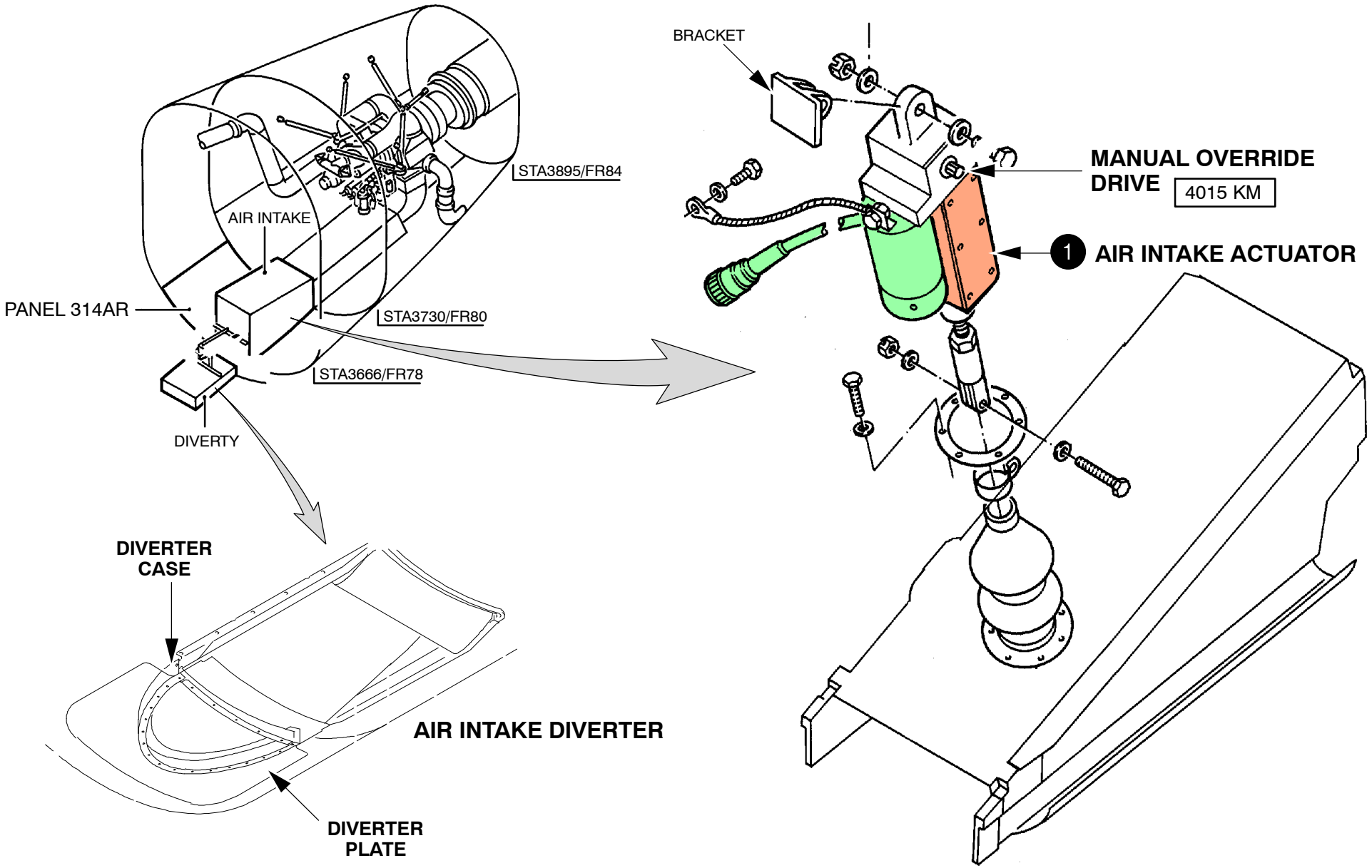


Figure 19 Air Intake Components

49–17 APU DRAIN SYSTEM

APU DRAIN SYSTEM DESCRIPTION

General

The system (Ecological system) collects the drainage and leaks in a small drain tank which is discharged overboard via a drain mast when the aircraft speed reaches about 200 kt.

The heatshield drain and the exhaust coupling drain are mounted together and drained directly overboard through the same drain mast.

Fuel/Oil Pump Drain

The fuel and oil pump seal drain line is routed via a collector line to the drain tank

This line drains fuel or oil leaks

BCV (Bleed Control Valve) Actuator Drain

Drain of possible leakage through the actuator shaft seal

Inlet Guide Vane Actuator Drain

The IGV (**I**nlet **G**uide **V**ane) actuator drain line is routed via a collector line to the drain tank.

This line drains only fuel leaks.

Front Bearing Seal Drain

Oil leak flows overboard and indicates a front bearing seal failure.

Combustor Drain

Combustion chamber drain. The lower part of the combustor casing has a drain valve which drains unburnt fuel. The valve which is actuated by air pressure, closes when the compressor delivery pressure becomes sufficient at about 10% Rpm.

Air Bypass Plenum

The air bypass plenum which is installed on the lower exhaust casing section, is provided with a drain line direct to the drain mast.

Exhaust Coupling Drain

The exhaust coupling and heatshield drain are mounted together and drain directly to the drain mast.

Fuel Flow Divider

As the pressure decreases in the fuel system (during APU shutdown), the two valves of the flow divider close. Then, the fuel which remains in the pilot injector and manifold is purged to the exhaust.

Oil Vent

The gearbox is vented to the exhaust through an external pipe.

Drain Tank

The various drain lines are connected to a drain tank (collector) which retains the liquid until the aircraft is flying.

The bottom of the tank is connected to a suction line which is positioned so that the tank is drained only when the pressure makes it possible. This usually happens when the aircraft speed reaches approximately 200 kt.

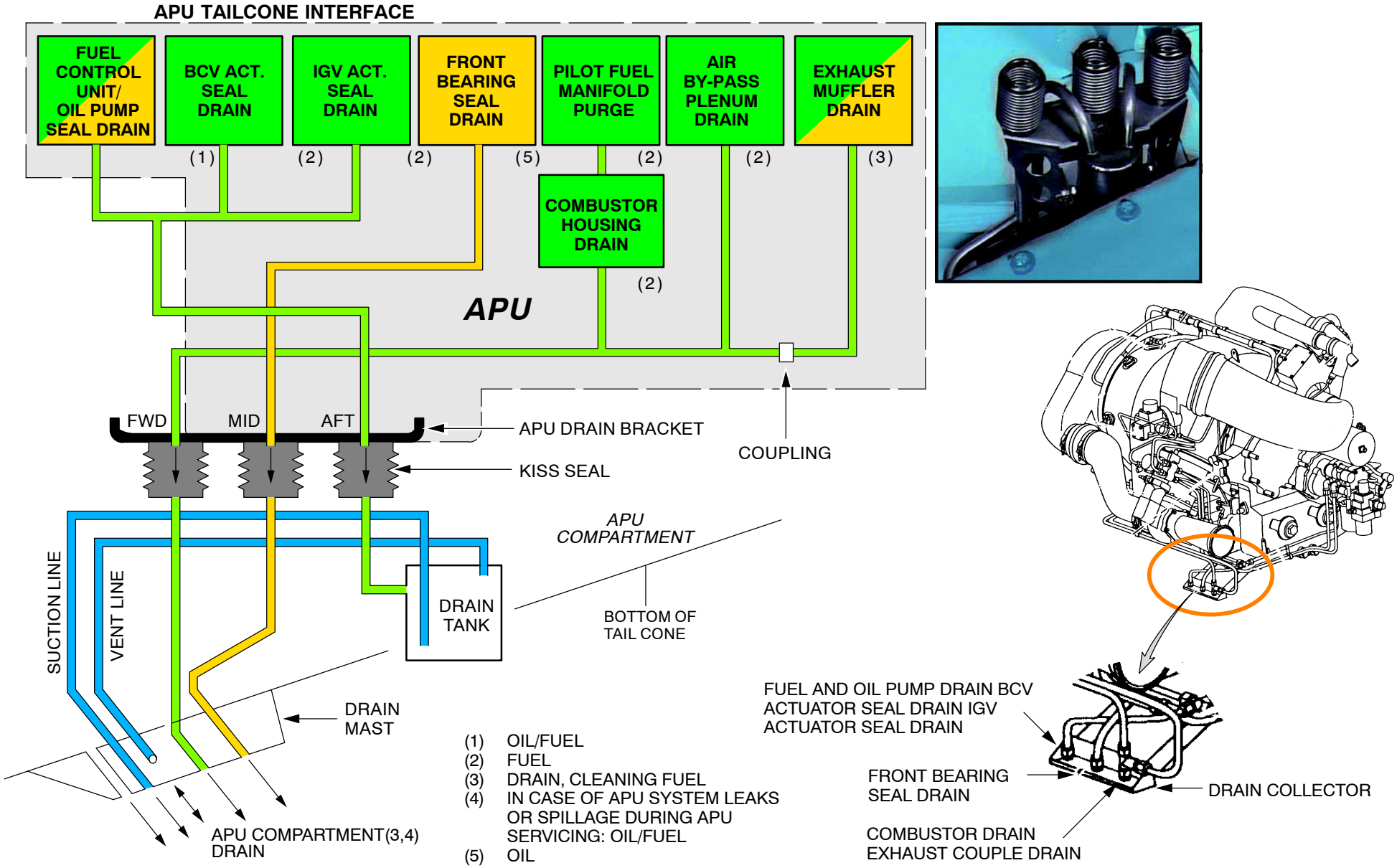


Figure 20 APU Drain System

49–20 ENGINE

INTRODUCTION

Purpose

The APU provides compressed air and electrical power to the aircraft.

Location

The APU is installed in the aircraft tail section.

Type

The Auxiliary Power Unit is of the SSLC (**S**ingle **S**haft **L**oad **C**ompressor) Type Gas Turbine Engine driving a load compressor and an AC generator through a gearbox.

Main Components

- Gearbox (with AC generator and APU accessory drive)
- Load compressor (centrifugal type provided with inlet guide vanes)
- Air inlet plenum (air intake and air distribution)
- Power section including:
  - a centrifugal compressor
  - a reverse flow combustion chamber (or combustor)
  - a two stage axial flow turbine.

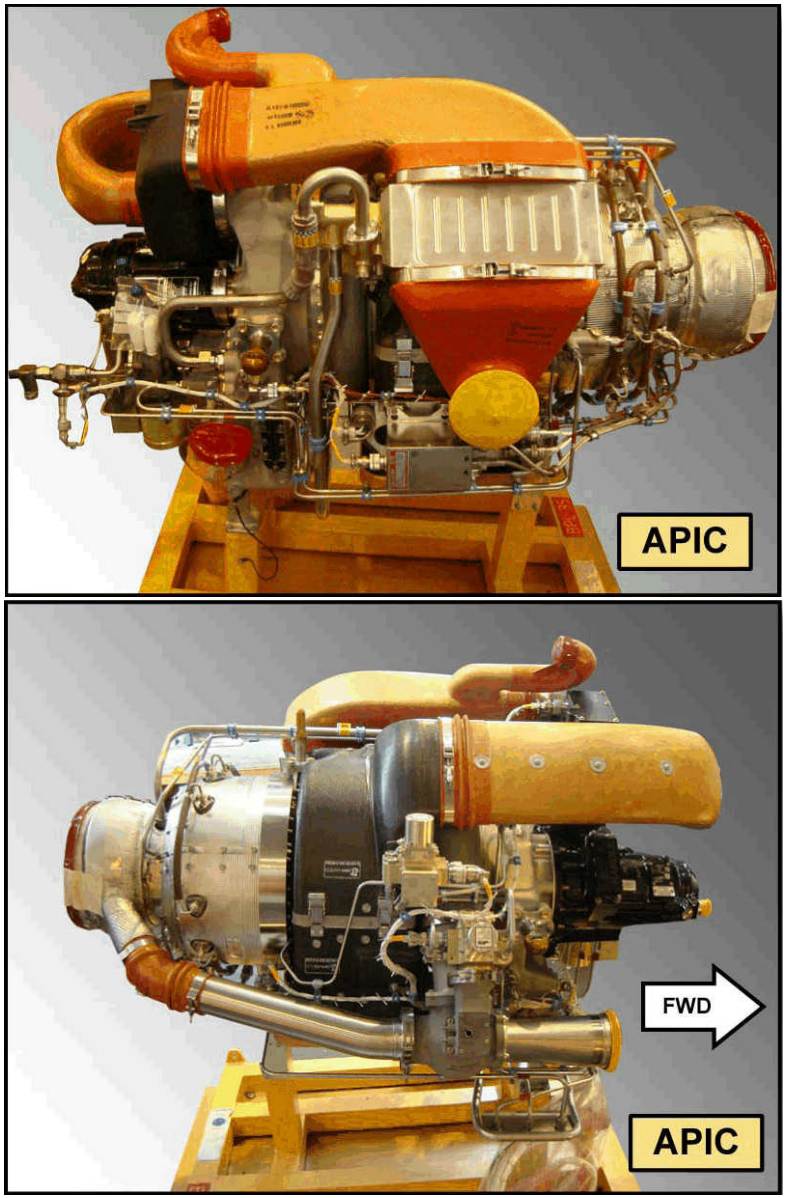


Figure 21 APU Total Views

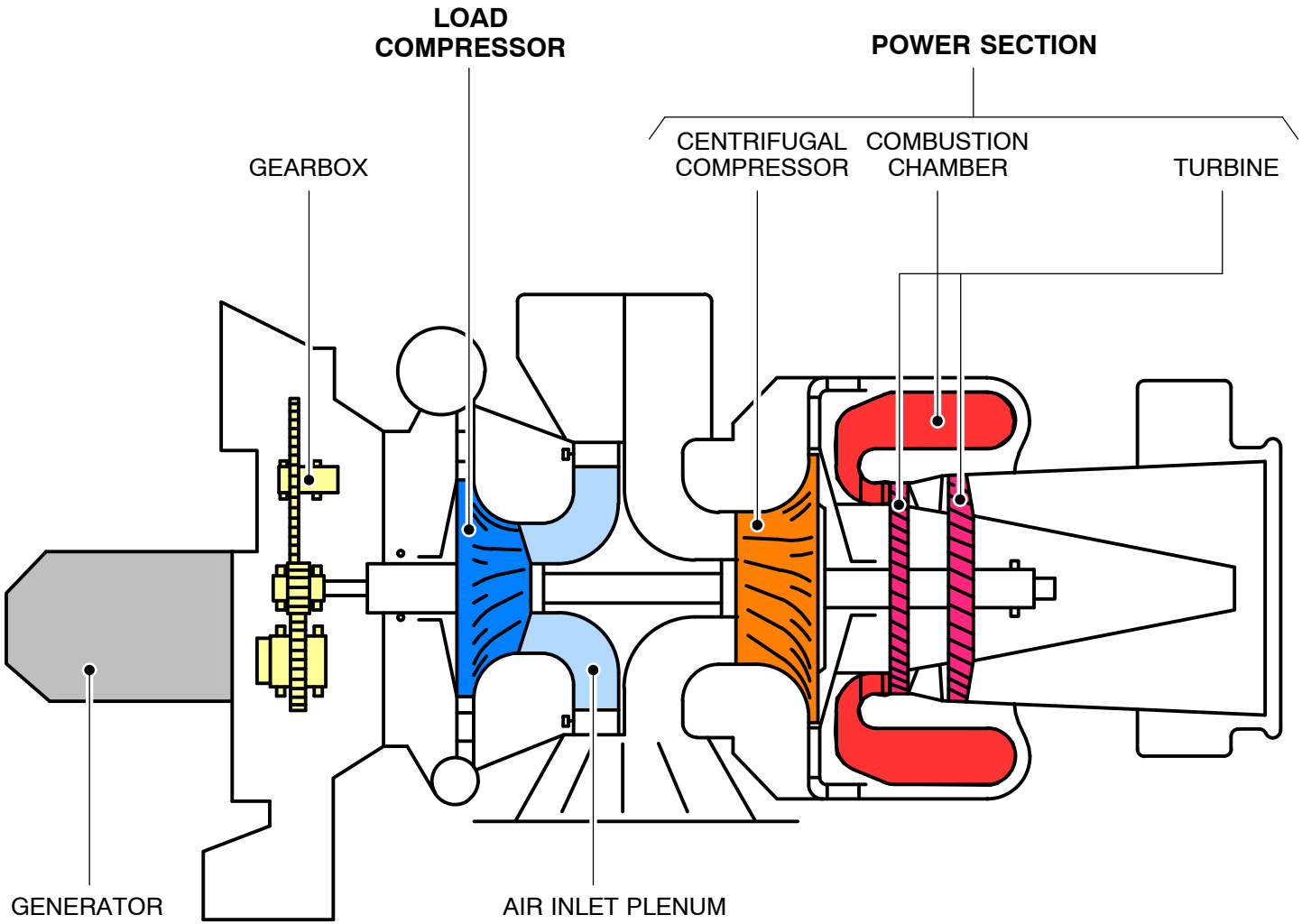


Figure 22 APU Sections

APU BORESCOPE INSPECTION

Visual Inspections

APU general visual inspection

Visually inspect components for tightness, worn areas, cracks and corrosion:

- Electrical connectors and harness
- Air, oil, fuel pipes
- Units
- Engine external casings.

Borescope Inspection

The APU internal components can be inspected using a fiberscope (5 mm diameter) Borescoope and the handcrank provision is by turning the cooling fan at the top of the gearbox.

The components which can be inspected are:

- The load compressor impeller (all blade leading edges) inspection through the air inlet plenum, the load compressor air intake and the drilled inlet guide vanes
- The power section compressor impeller (all blade leading edges): inspection through the air inlet plenum and the power section air intake
- The combustor (2 places – 3 borescope orientations) inspection through the left and right igniter plug boss
- The first stage turbine wheel (all blade leading edges) inspection through the left igniter plug boss, the combustor and the first stage nozzle guide vane
- The second stage turbine wheel (all blade trailing edges) inspection through the thermo couple boss.

One CAUTION concerning the heat which can damage the fiberscope.

Refer to Aircraft Maintenance Manual for procedure, examination and damage criteria.

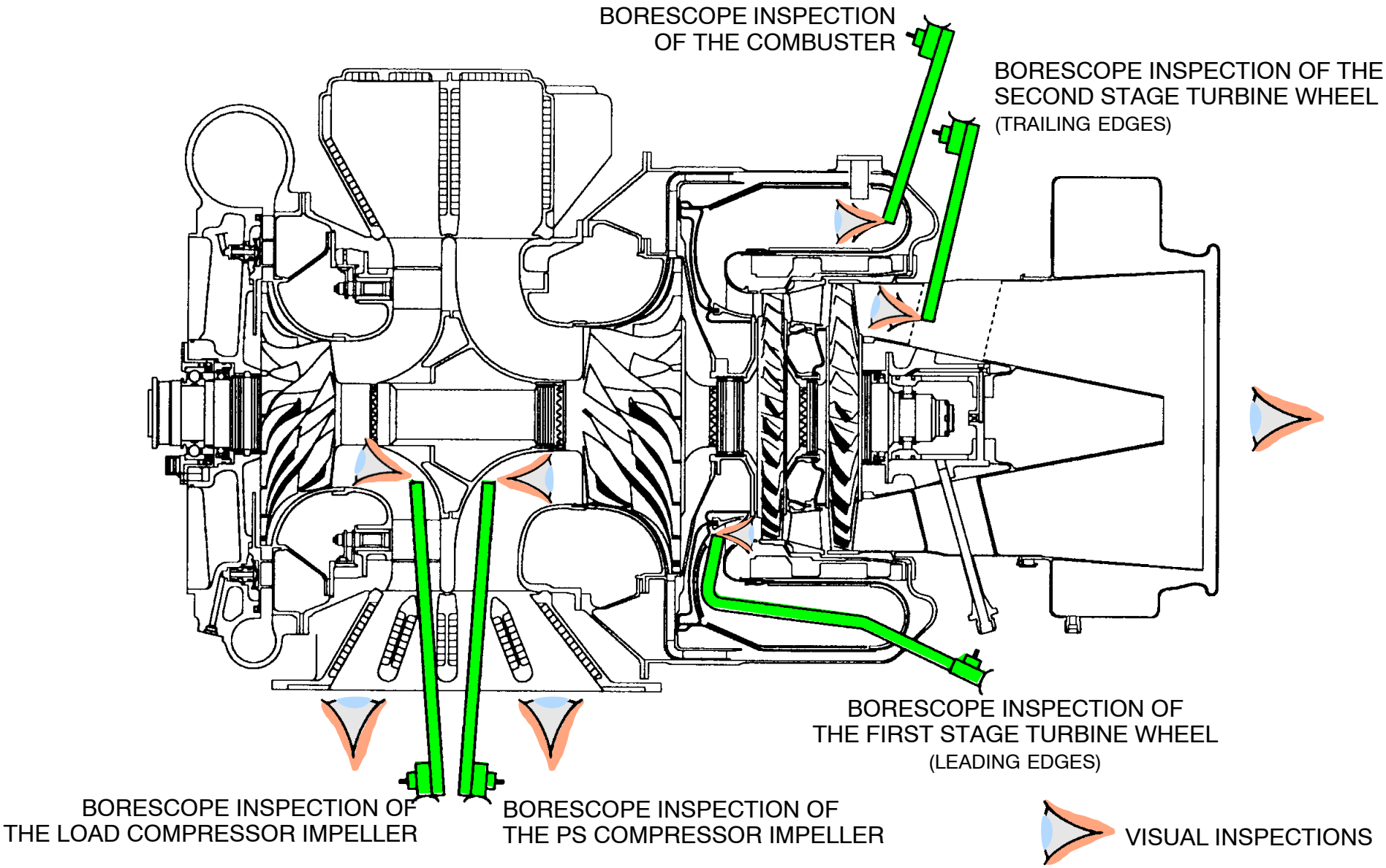


Figure 23 APU Borescope Inspection

49–90 OIL

OIL SYSTEM DESCRIPTION

Function

The system is used to lubricate and cool the APU and the AC generator.

Location

The system components are all located on the gearbox except the oil cooler which is located on the APU left side.

Main Features

Self–contained, full flow system. The system operates with the same oil types as approved for the main engines.

- Max oil temperature: 135° C (275° F)
- Max oil consumption: 4 cc/h (0.009 PPH)
- Normal oil pressure: 345 – 414 kPa (50 – 60 PSIG)
- Low oil pressure: 241 kPa (35 PSIG)
- Oil volume: 3.8 liters (1 US G) at FULL mark.

Lubrication and Cooling Requirements

The requirements are for:

- the APU rear bearing
- the APU front bearing
- the gearbox gears and bearings
- the AC generator

No oil is permitted to leak into the load compressor or the air bleed system

Satisfactory operation is ensured in the event of prolonged windmilling in the normal and reverse direction.

Oil System Operation

The main functions of the oil system are: pressure supply, scavenge return, venting and indicating.

Pressure Supply

The pressure pump draws the oil from the sump and delivers it under pressure. During starting, the de–oiling valve opens and air is drawn into the pump in order to reduce the load. The oil passes to the oil cooler, then to the filter which retains any particles in the oil.

If the filter becomes blocked, the Delta P indicator operates, and then the by–pass valve. If the pump pressure exceeds a given value, the relief valve opens and returns excess oil to the inlet side of the pump.

The oil pressure is sensed by a pressure switch which detects low pressure. The oil then flows to lubricate and cool:

- the AC generator
- the AC generator splines
- the APU splines
- the cooling fan splines
- the gearbox
- the front bearing
- the rear bearing.

Scavenge Return

After lubrication, the oil falls to the bottom of the sumps and is immediately scavenged by two pumps:

- One for the power section rear bearing which returns the oil directly to the sump
- One for the AC generator which returns the oil to the sump through a filter.

NOTE: The front bearing and the gearbox are scavenged by gravity.

Venting

Oil mist in the gearbox passes through a centrifugal air–oil separator. The gearbox is vented to the exhaust through an external pipe.

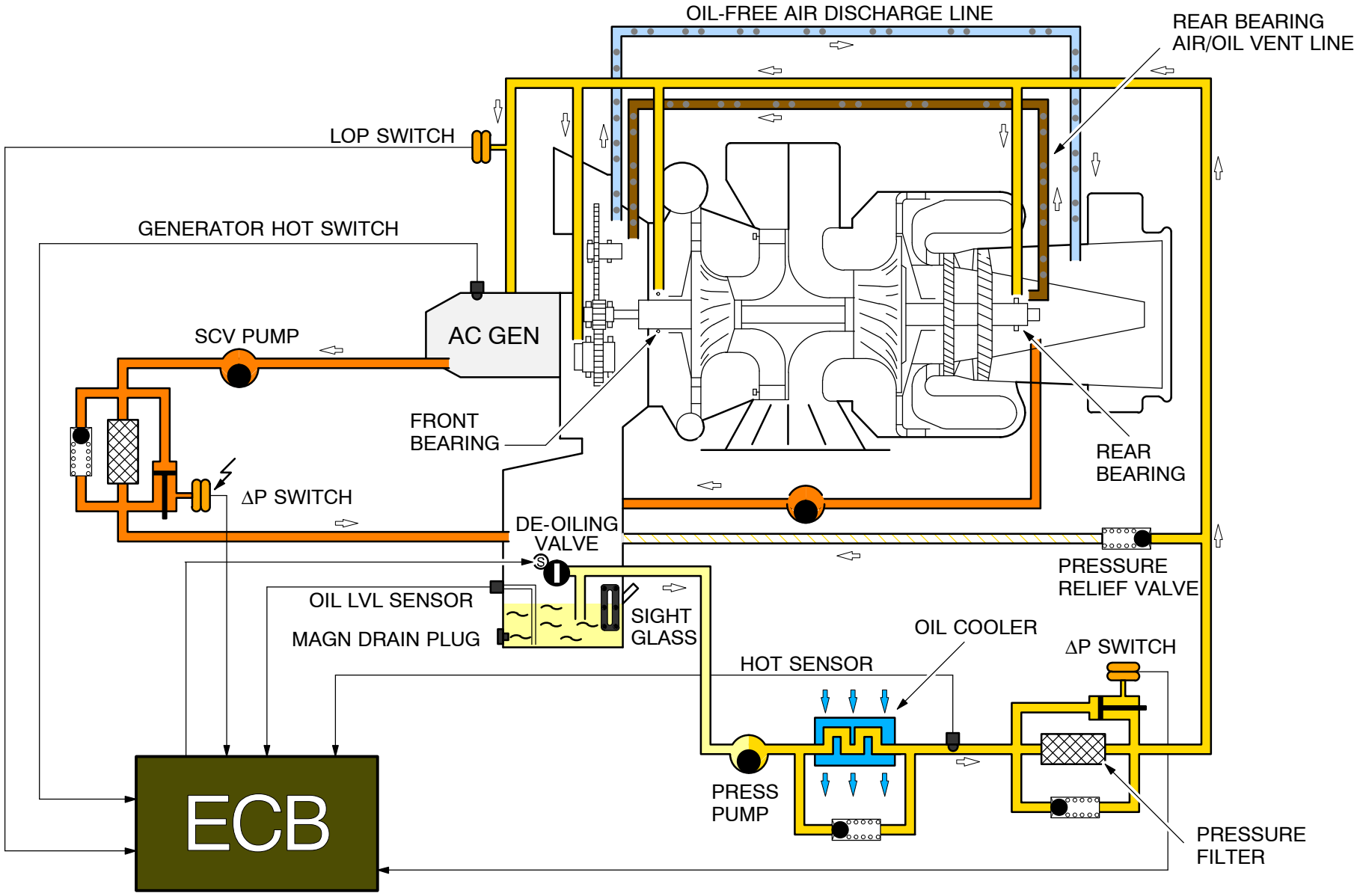


Figure 24 Oil System Schematic

Oil Sump

The oil sump is formed by the lower part of the gearbox.

The gearbox has a fill tube for gravity filling, an overflow drain, a pressure fill connector and a sight glass.

An air/oil separator is formed by one of the gears in the gearbox, and is connected to the gearbox vent.

Oil Pump

One pressure pump and two scavenge pumps are mechanically driven and are mounted on a drive pad of the gearbox.

The pressure system is provided with a pressure relief valve located on the gearbox.

Oil Filters

There is one filter on the pressure line and one on the AC generator scavenge line.

Both filters are similar. They comprise the filter element, a by–pass valve and an impending filter blockage indicator. They are mounted on the lower front face of the gearbox. The scavenge filter has an impending filter blockage switch.

Oil Cooler

The oil cooler (with an APU driven fan) cools the oil after the pressure pump. The cooler has a by–pass valve.

De–Oiling Valve

The de–oiling valve is a solenoid valve located at the inlet of the pressure pump. When open, the valve prevents oil flow thus reducing the load on the pump.

Monitoring Devices

- low oil pressure switch
- high oil temperature sensor
- AC generator high oil temperature sensor
- oil level sensor
- oil level sight glass
- Supply and generator scavenge oil filter impending blockage indicators
- Generator scavenge oil filter impending blockage switch
- Magnetic chip detector.

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OIL SERVICING

OIL SUMP

The sump contains the oil required for the APU lubrication. It is located in the bottom of the gearbox. The capacity of the oil sump must be able to ensure 300 operating hours without refilling at the max oil consumption rate.

An oil level sight glass is located on the lower left side of the gearbox housing, close to the oil fill tube.

It provides a visual indication of the oil level in the sump.

When the level is at the “ADD” mark, the APU must be able to continue running for at least 60 hours.

- Capacity at the “FULL” mark: 3.8 liters (1 USG)
- Capacity at the “ADD” mark: 2.6 liters (0.68 USG)
- Max oil consumption: 4 cc/h (0.009 PPH).

Main Components

The main components which are part of the oil sump are the following

- Fill tube
- Oil overflow boss
- Oil pressure fill port
- Air–oil separator
- Draining point and magnetic plug
- Pressure relief valve
- Oil level sensor
- Oil level sight glass.

Magnetic Chip Detector

A magnetic drain plug is located on the lower front side of the gearbox housing. Removing the plug allows the oil drainage from the sump. The drain plug embodies a magnetic chip detector that attracts ferrous metal particles in the oil. The detector can be removed, inspected and installed without draining the oil sump.

A self sealing device located inside the drain plug prevents the oil drainage when the detector is removed.

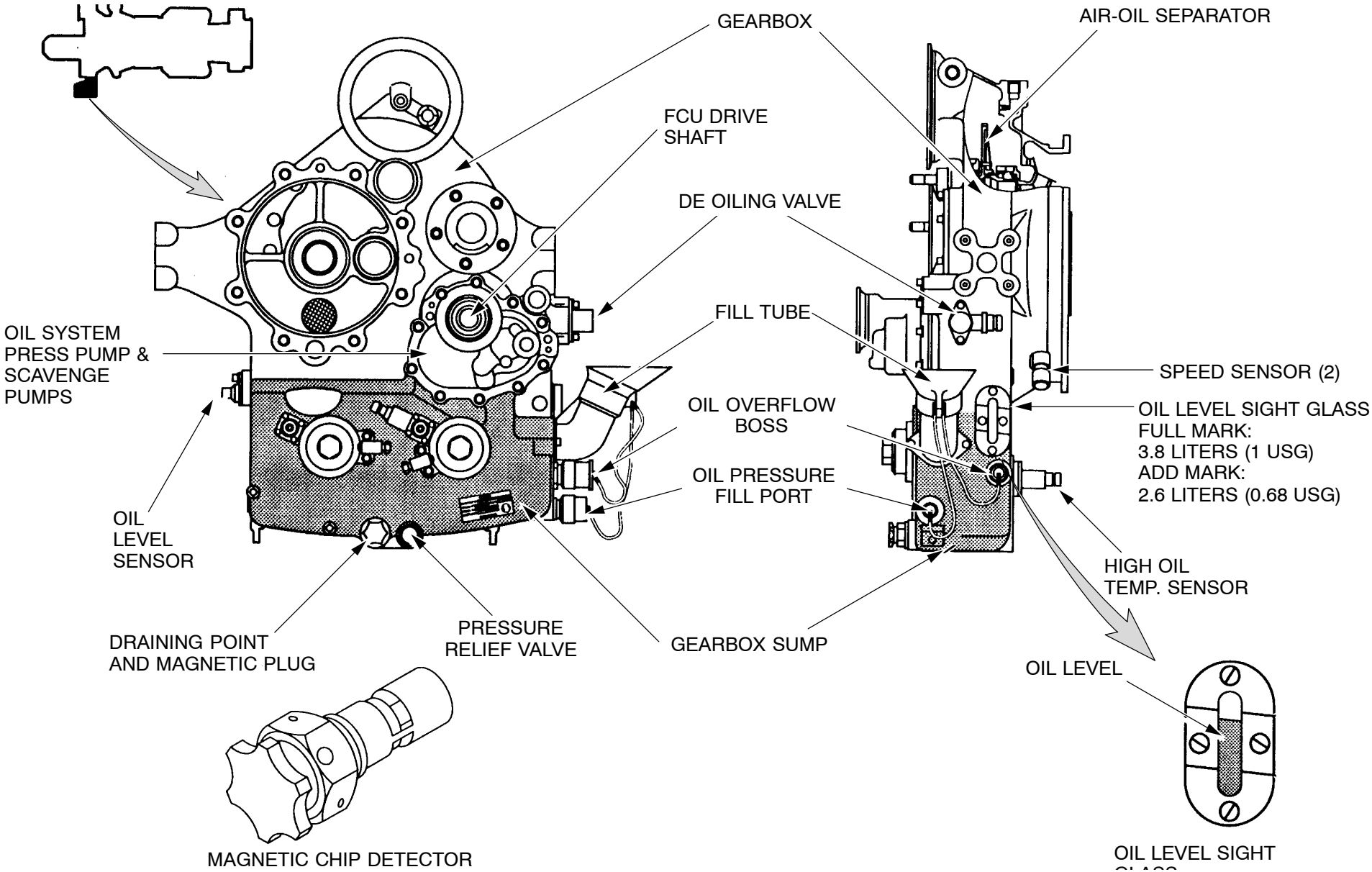


Figure 25 Oil Servicing

OIL SYSTEM COMPONENT DESCRIPTION

OIL PUMP MODULE

One pump module contains a pressure pump for the pressure supply and two scavenge pumps for oil return. The oil pump module is mounted on a pad on the gearbox front face.

Pressure Pump (Vane Type)

- Pressure: 380 – 450 kPa (55–65 PSID)
- Flow: 2160 l/h (570 GPH)

Pressure relief valve setting: 450–52OkPa (65–75 PSID)

AC Generator Scavenge Pump (Vane Type)

- Flow 2160 l/h (570 GPH)

Rear Bearing Scavenge Pump (Gerotor Type)

- Flow: 160 l/h (42 GPH)

Gerotor Type Function

The gerotor is a positive displacement pumping unit consisting of an inner and outer rotor. The inner rotor has one less tooth than the outer, and has its centerline positioned at a fixed eccentricity from the centerline of the outer element. The inner element is driven by one pinion of the gearbox.

Vane Type Function

The vane type pump is a pumping unit consisting of a slotted inner rotor equipped with vanes and a precision ground cam profile plus housing body.

Pressure Relief Valve Operation

The oil pressure relief valve is a non adjustable, spring loaded relief valve.

It opens when the pump pressure exceeds 450–520 kPa (65–75 PSIG), thus allowing the return of the oil to the sump.

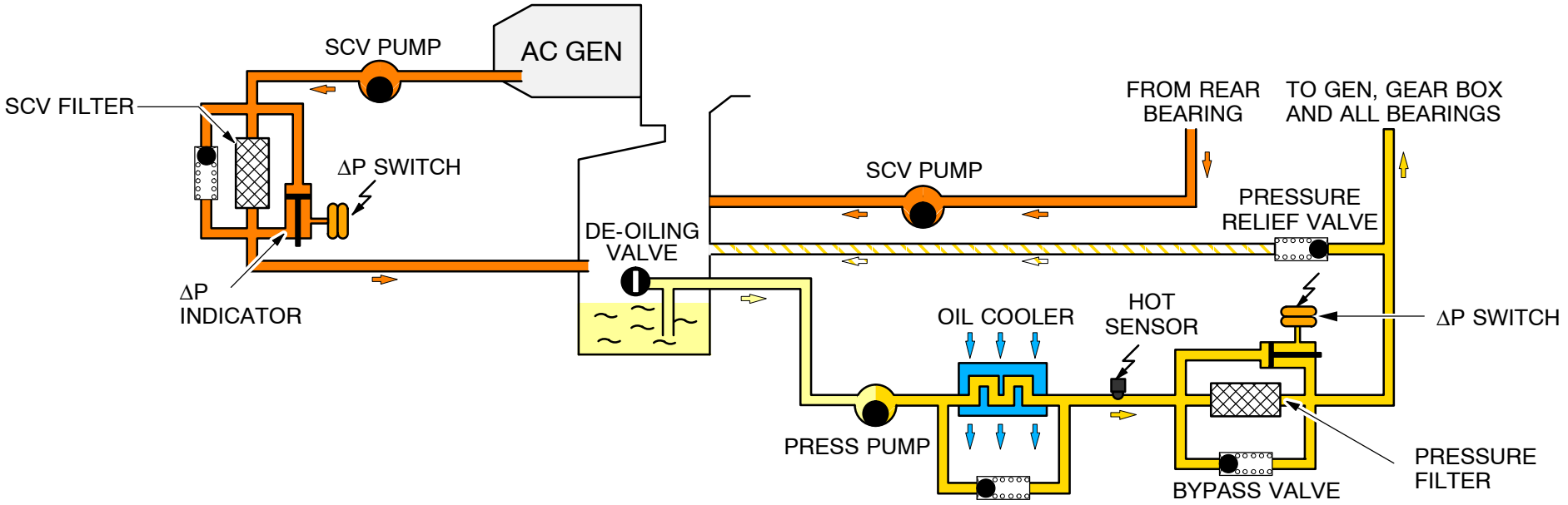


Figure 26 Lubrication

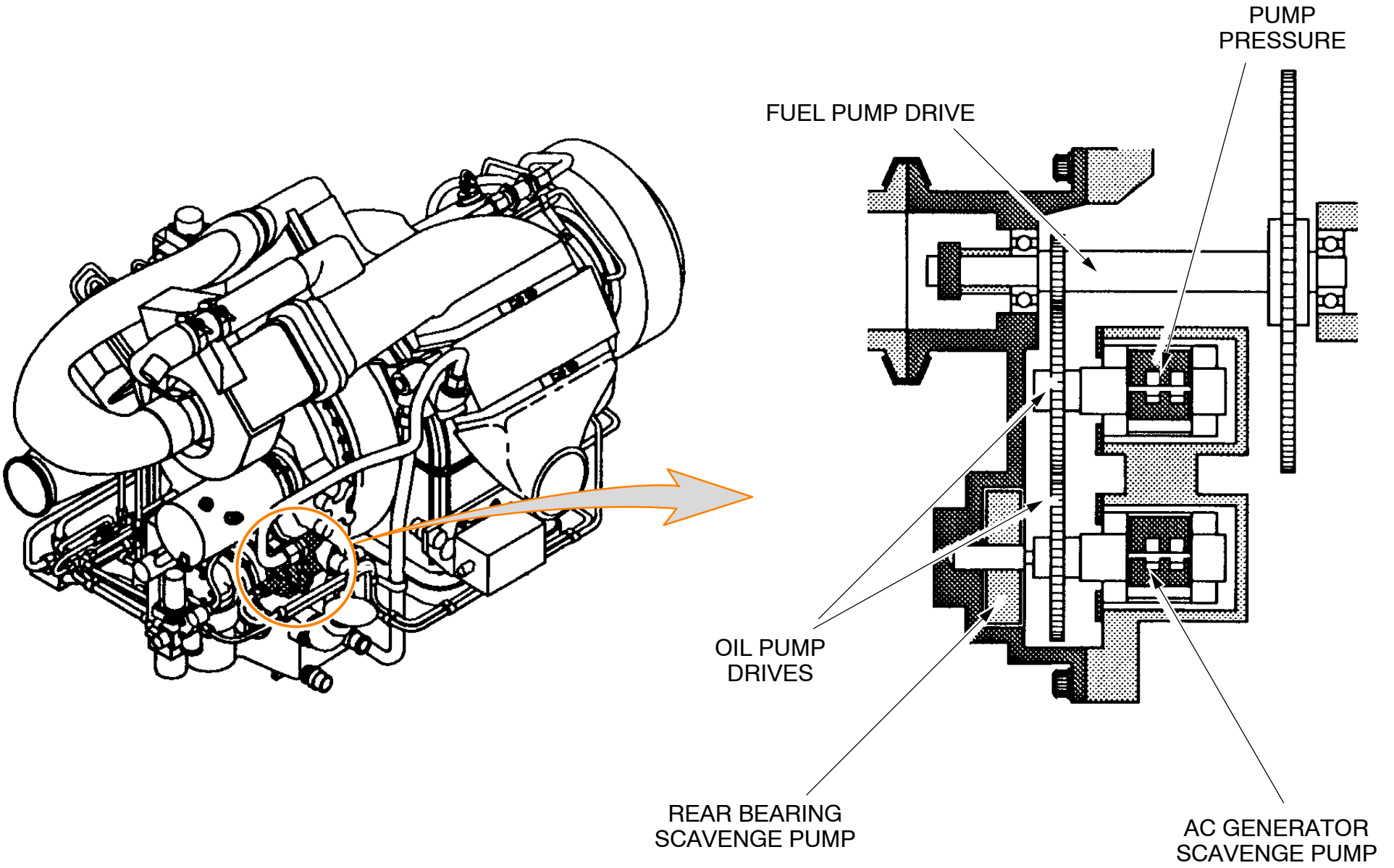


Figure 27 Oil Pump Description

OIL COOLER

Purpose

The oil cooler transfers the heat of the lubricating oil to the air cooling system.

Location

The oil cooler is installed on the left side of the APU.

In the oil system, the cooler is located between the pressure pump and the filter.

Main features

- Oil cooling ability: 2160 l/h (540 GPH)
- Heat rejection capacity
- Oil cooler by–pass valve setting
  - Opening threshold: 207 kPa (30 PSID)
  - Fully open: 345 kPa (50 PSID).

Oil Cooler Design

The oil cooler is a rectangular unit which includes:

- An oil cooler housing which consists of an integrally brazed aluminium heat–exchanger with aluminium face flanges and stainless steel back–up flanges located on the air side
- A check valve and a by–pass valve to regulate the internal pressure and the oil flow through the oil cooler
- A drain plug to drain the oil cooler.

OIL COOLER OPERATION

Normal Operation

The oil delivered by the pressure pump flows through the aluminium cooling tubes which are subjected externally to a “cold” air flow accelerated by a fan. The cooled oil is then delivered to the various APU lubrication points through the lubrication filter.

By–pass operation

When the pressure exceeds 207 kPa (30 PSID), the by–pass valve opens.

The oil circulation by–passes the cooler. The oil is then delivered to the lubrication system.

Check valve operation

The check valve is an oil pressure operated valve. When the pressure in the oil system is very low (at the beginning of the APU starting and at the end of the APU shutdown sequences), the check valve closes and thus prevents possible oil leaks through the rotor bearings.

Air flow

The air, which is taken from the plenum chamber and accelerated by the fan, flows through the oil cooler and is then vented overboard. Refer to cooling fan for more details.

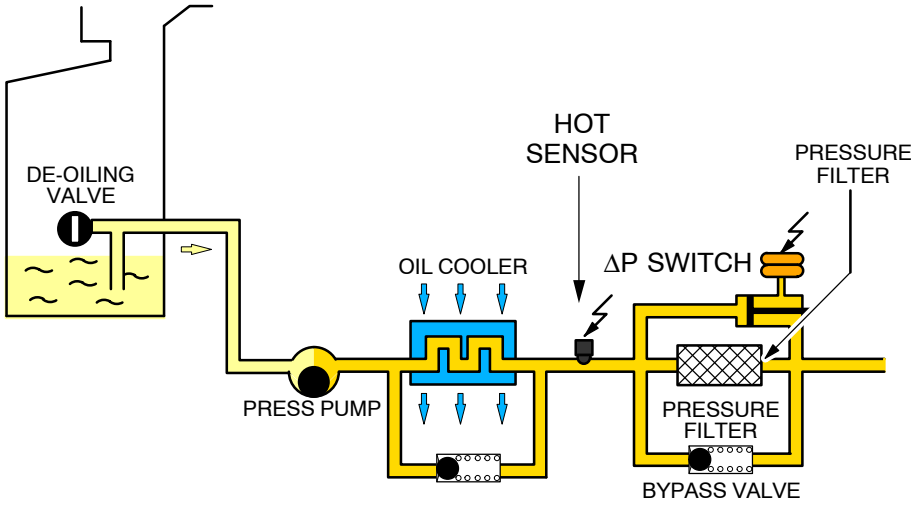


Figure 28 Oil Cooler Bypass Valve Schematic

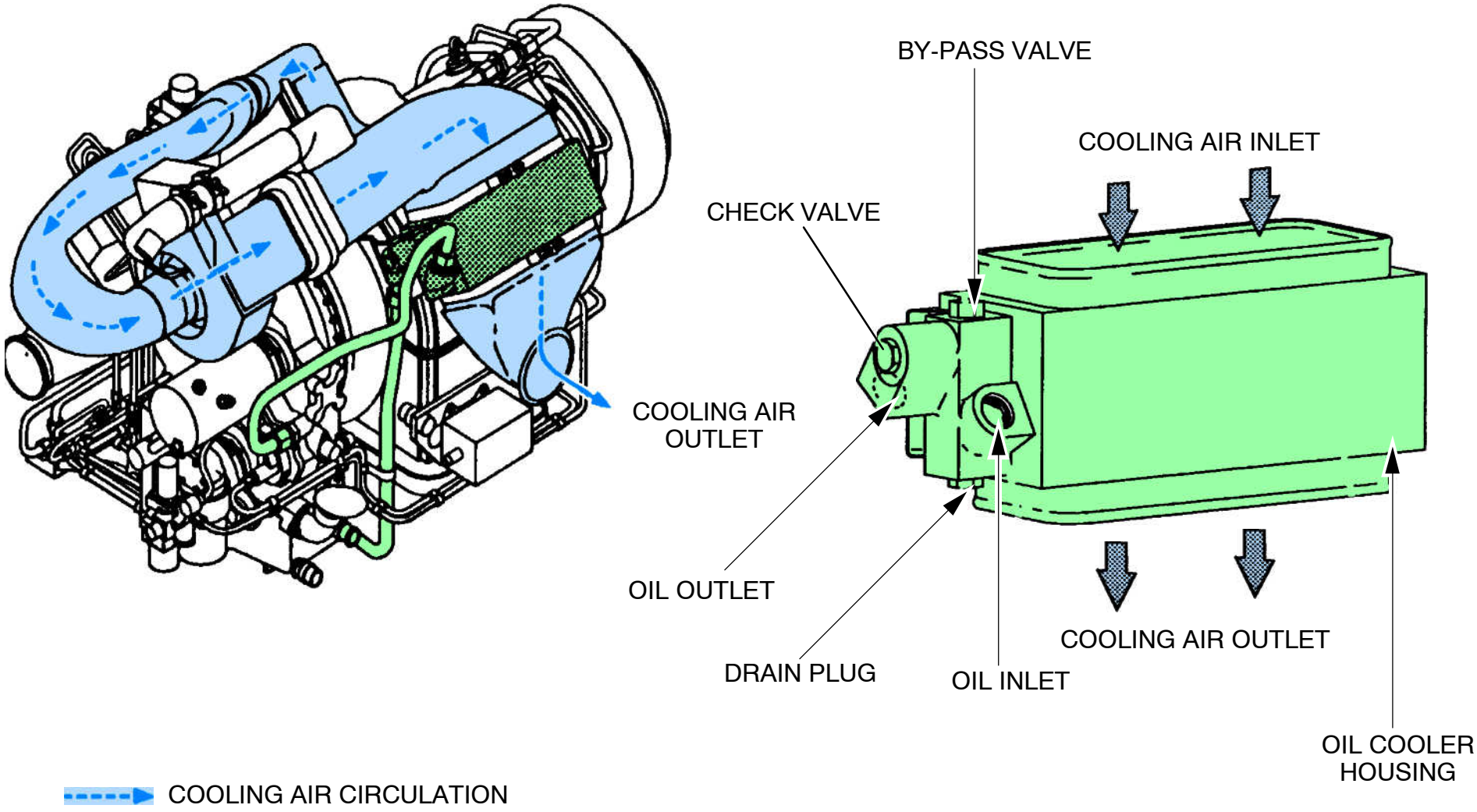


Figure 29 Oil Cooler and Bypass Valve Description

OIL FILTER

Function

The function of the oil filters is to remove debris from the lubricating oil. The filters retain small pieces of matter held in the oil. There are two filters, one on the pressure line, and one on the AC generator scavenge line. They are of similar construction.

Each filter consists of:

- A 20 micron disposable cartridge
- An oil filter impending blockage indicator
- A by–pass valve.

NOTE: The AC generator scavenge filter is also provided with a Delta P switch connected to the ECB (**E**lectronic **C**ontrol **B**ox).

(Refer to oil filter operation for more details).

Location

The lubrication filter is located on the pressure line after the oil cooler.

The scavenge filter is located after the AC generator scavenge pump.

On the engine, both filters are installed at the bottom front face of the gearbox.

Main features:

- Filter element: 20 microns
- By–pass valve setting: 345–414 kPa (50–60 PSID)
- Impending blockage indicator: 207–241 kPa (30–35PSID)
- Delta P switch setting: 207–241 kPa (30–35 PSID)

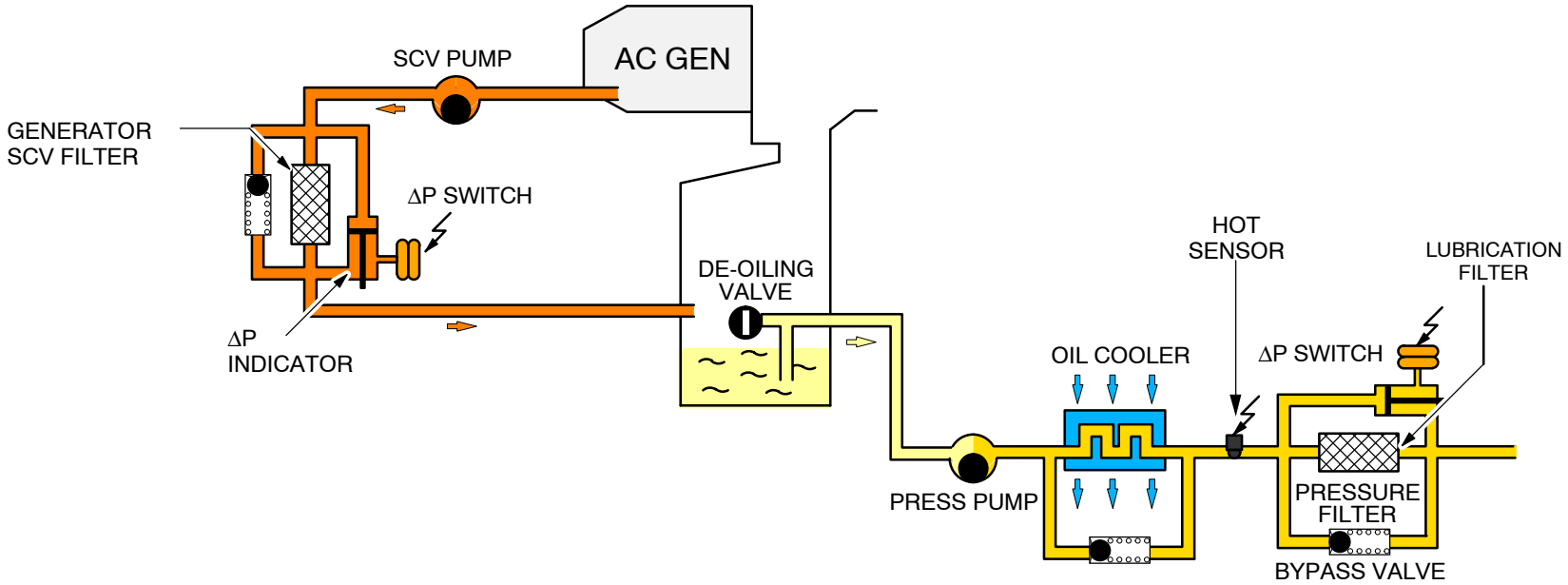


Figure 30 Oil Filter Schematic

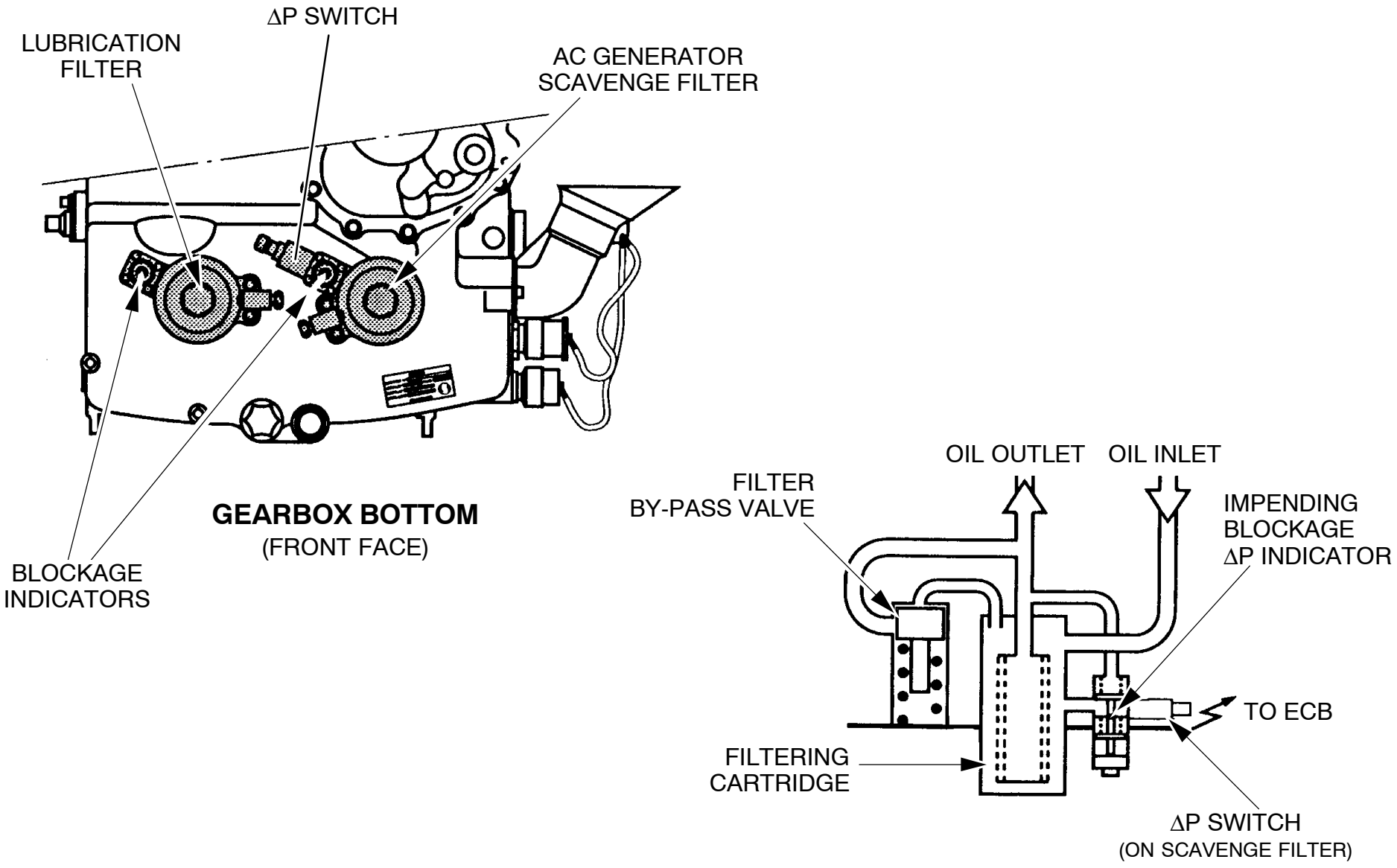


Figure 31 Oil Filter Description

DE–OILING VALVE

Purpose

The de–oiling valve reduces the pressure pump load during starting, especially during cold start conditions when the oil becomes very thick.

Location

On the APU the valve is located on the left side of the gearbox.

In the oil system: the valve is located at the inlet of the pressure pump.

Main features:

- Solenoid valve operated by the ECB (as a function of a given rotation speed)
- Solenoid valve energized open.

Description

The de–oiling valve is a solenoid operated valve directly controlled by the ECB.

The valve includes :

- an air inlet port
- an oil inlet port
- an outlet port.

Operation

During engine starting, the de–oiling valve is energized open by the ECB. This prevents oil flow through the pressure pump and reduces the load on this pump.

Above 55 % of the APU rotation speed, the ECB deenergizes the de–oiling valve which closes. Then, the oil pump produces pressure for the circuit.

During engine shut–down, the de–oiling valve is energized open by the ECB when APU stop is selected and speed decreases below 95 %. The valve then supplies air to the oil pressure pump. This is to prevent coking of the oil remaining in the bearing chambers.

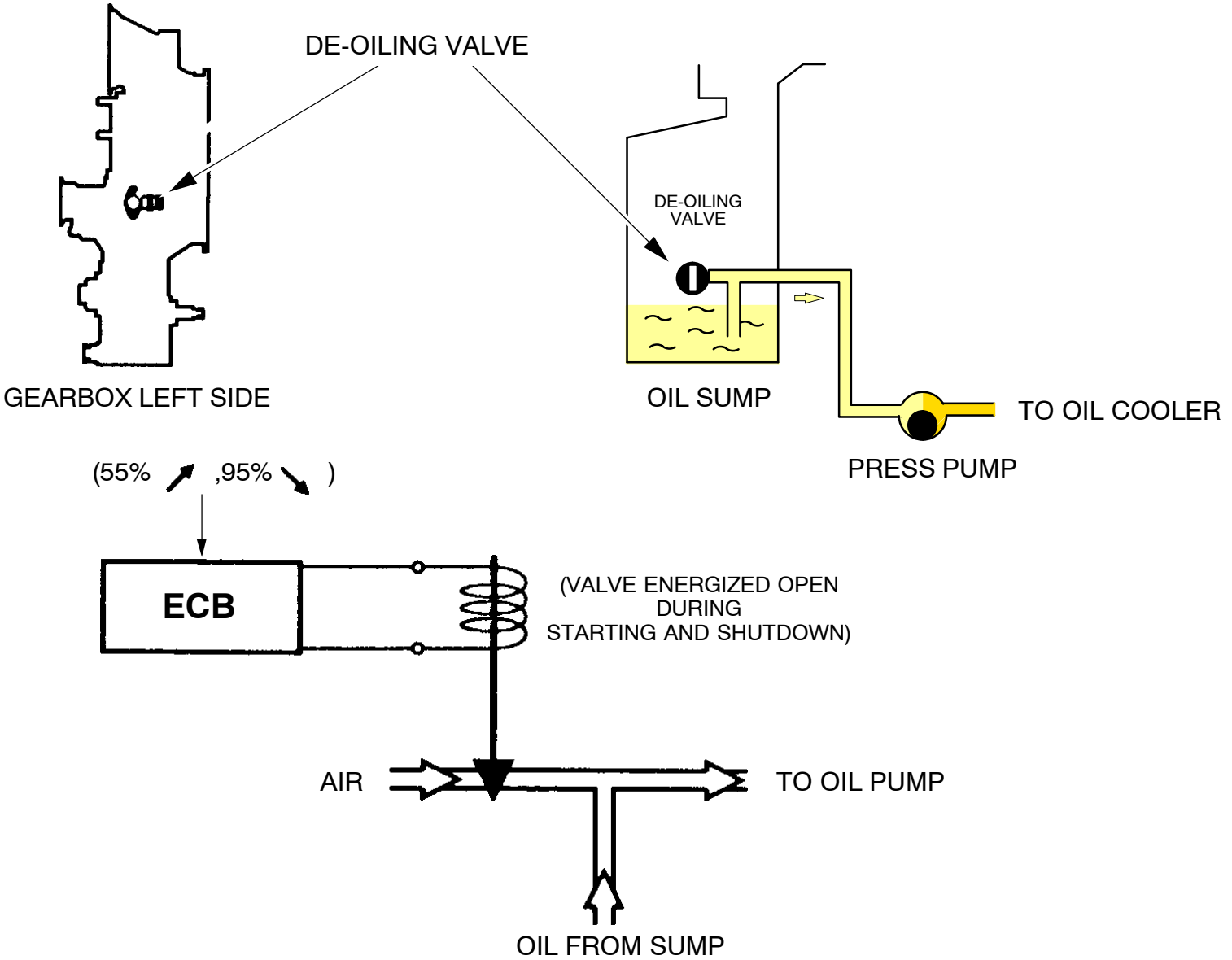


Figure 32 De–Oiling Valve

LOW OIL PRESSURE SWITCH

Purpose

The LOP (**L**ow **O**il **P**ressure) switch senses the pressure downstream of the filter. The LOP switch initiates automatic APU shutdown when the oil pressure is too low.

Location

The LOP switch is located in the AC generator pressure line of the oil system and is mounted on the air intake plenum.

Main Features

- LOP switch setting: 241 kPa (35 PSID)
- Output signal to ECB: ground signal.

Interfaces

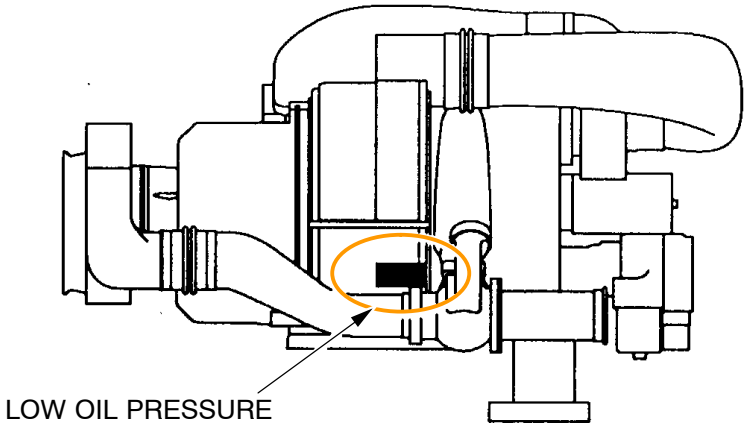
- The ECB
- The APU oil system.

Operation

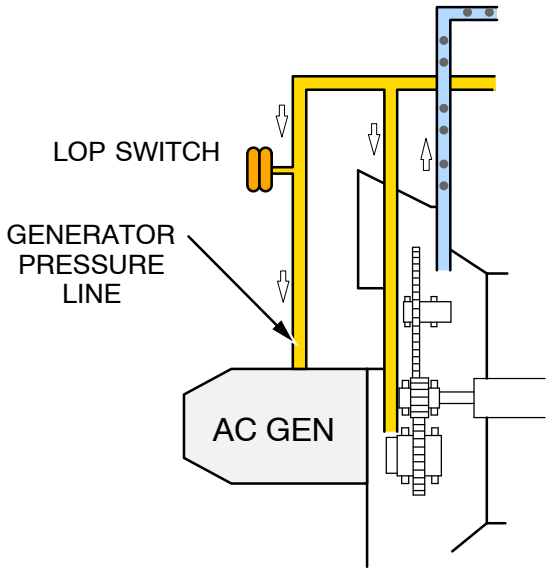
The LOP switch mainly consists of a switch contact which is normally open.

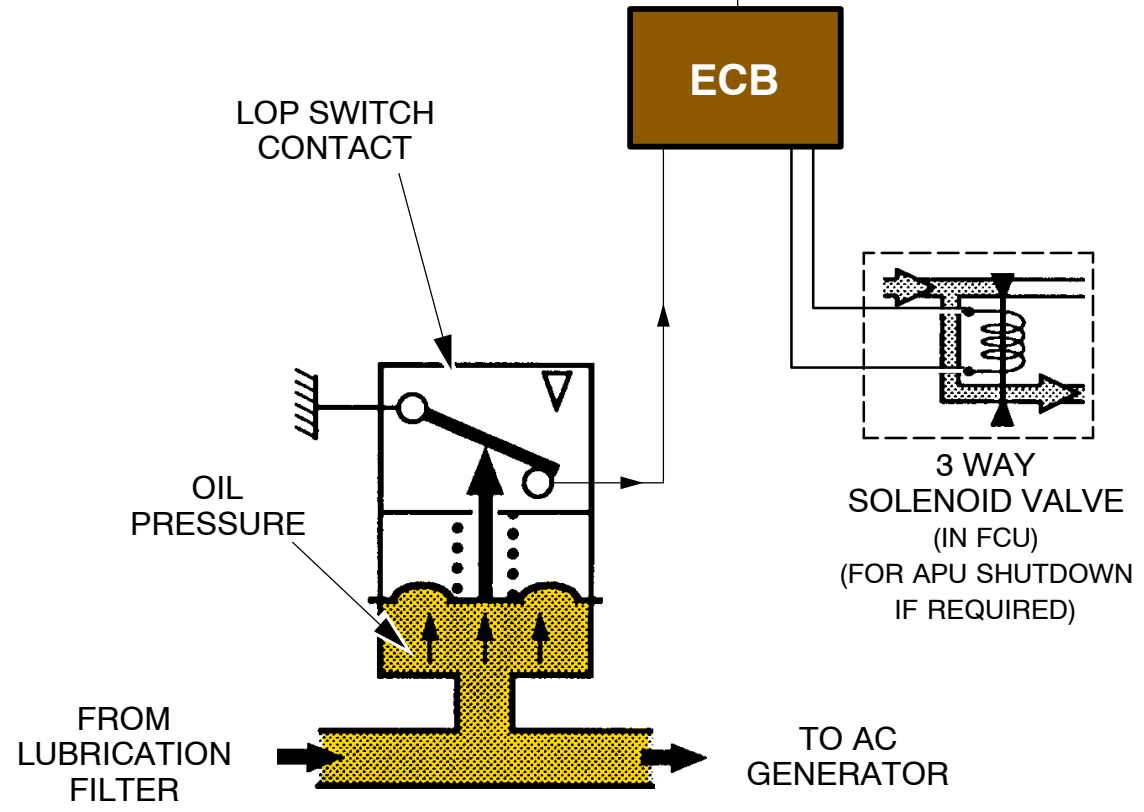
A decreasing oil pressure below 241 kPa (35 PSID) downstream of the filter causes the contact to close.

The LOP switch then puts out a ground signal to the ECB which can initiate the automatic APU shut down.



APU RIGHT SIDE





LOP SWITCH OPERATION

Figure 33 Low Oil Press. Switch Description

HIGH OIL TEMPERATURE SENSOR

Purpose

The HOT (**H**igh **O**il **T**emperature) sensor measures the temperature of the oil at the outlet of the oil cooler. When the oil temperature is too high, the HOT sensor initiates automatic APU shut down.

Location

On the APU, the HOT sensor is installed on the lower rear face of the gearbox.

In the oil system, the HOT sensor is located on the pressure line downstream of the oil cooler.

Main Features

- HOT sensor setting: 135°C (275°F)
- Sensor input signal (from ECB): 1 mA
- Sensor output signal (to ECB): variable output voltage.

Interfaces

- The ECB
- The APU oil system.

Operation

The HOT sensor is a RTD (**R**esistance **T**emperature **D**etector) supplied by the ECB with a constant current of 1 mA. The resistance varies with the oil temperature and modifies the sensor output voltage.

When the oil temperature reaches a limit value of approximately 135°C (275°F), the ECB can initiate the automatic APU shutdown.

NOTE: The AC generator has also a high oil temperature sensor which causes the APU to shutdown when an excessive temperature is detected.

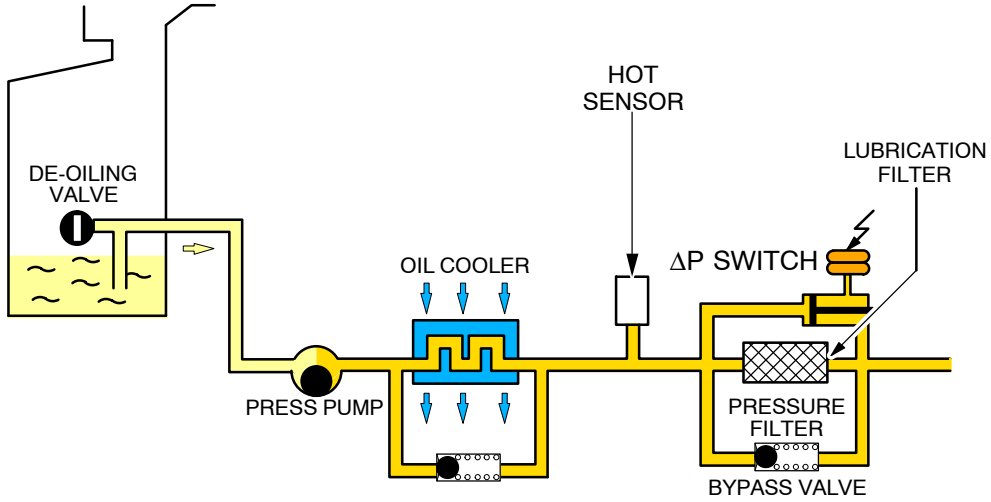
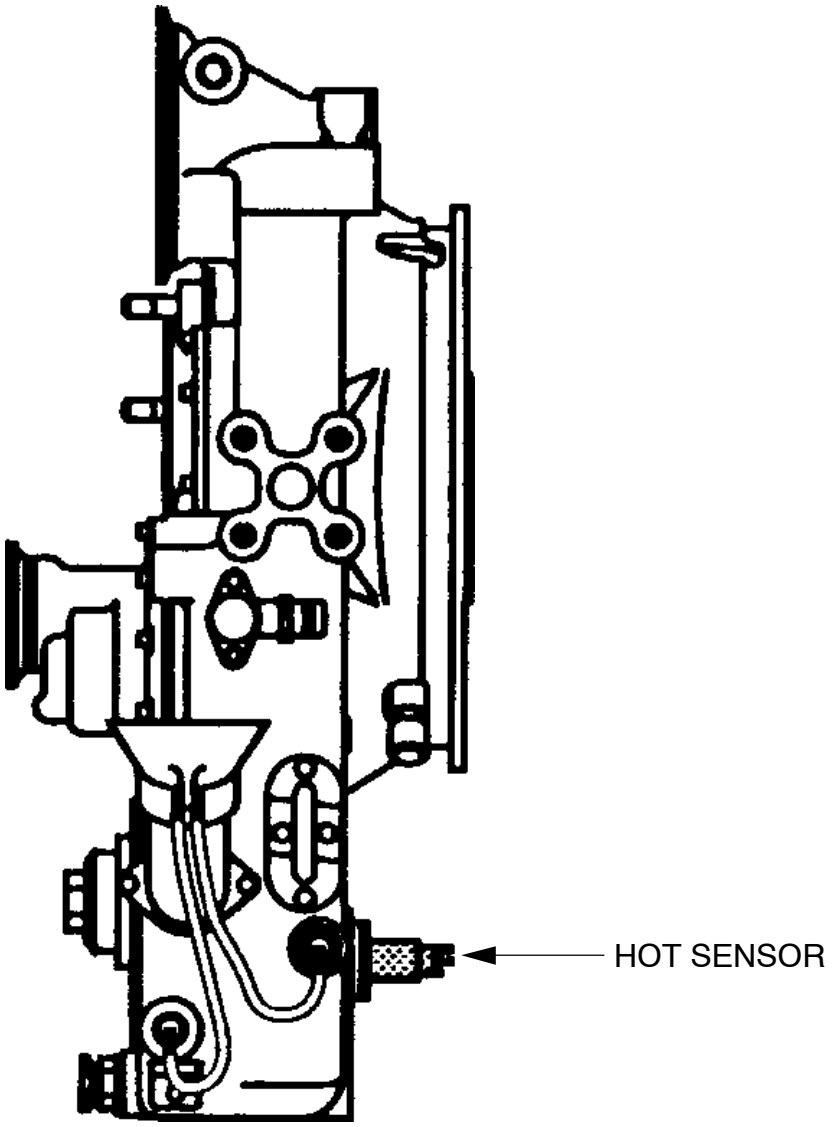
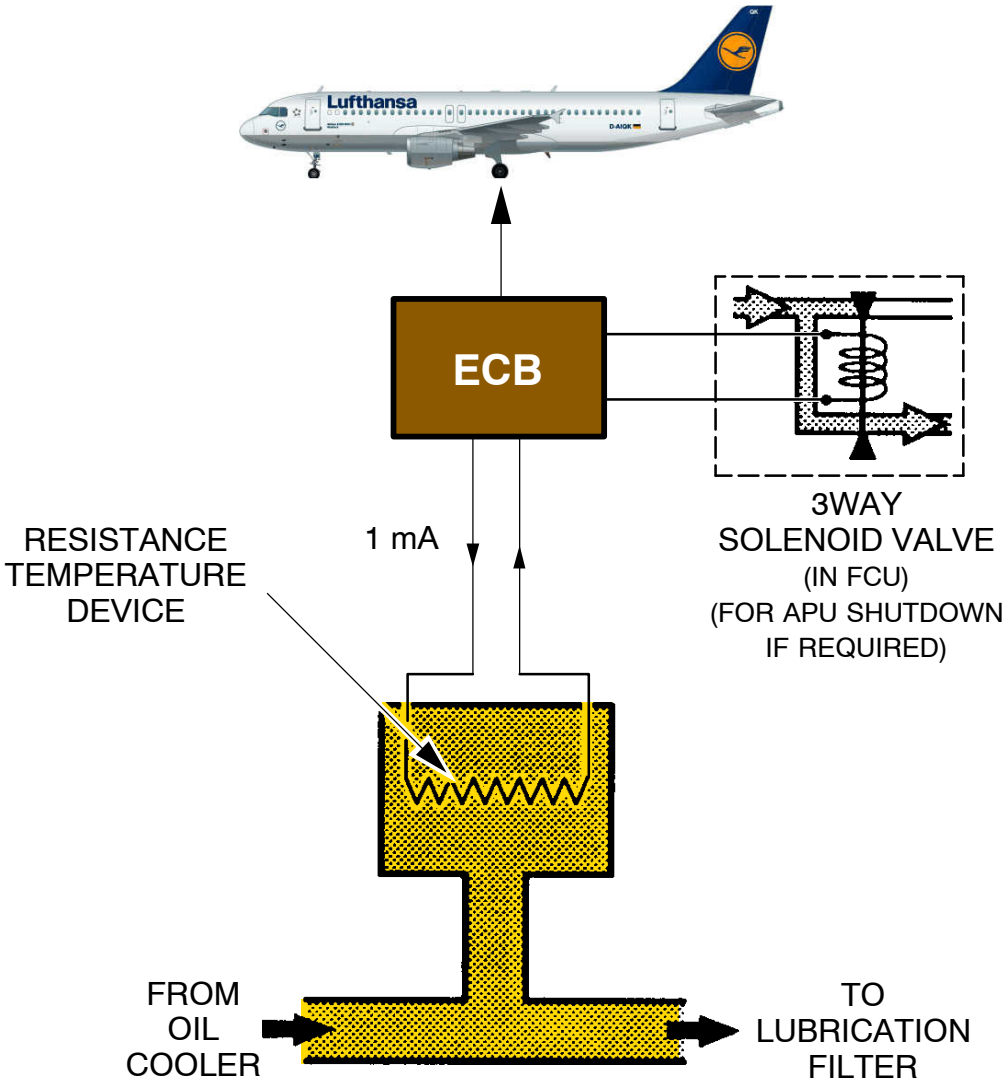


Figure 34 Figure Text



GEARBOX LEFT SIDE



HOT SENSOR OPERATION

Figure 35 High Oil Temp. Sensor

AC GENERATOR SCAVENGE FILTER DELTA-P SWITCH

Purpose

The oil filter impending blockage indicators and the differential pressure switch (Delta P switch) indicates the pre–blockage situation of the filter.

Location

The oil filter impending blockage indicators and the Delta P switch are located on the gearbox lower front face close to the oil filters.

Main Features

- Delta P switch: 207–241 kPa (30–35 PSID).

Interfaces

- The APU oil system
- The ECB (for the Delta P switch).

Operation

Differential pressure switch (Delta P switch)

When the cartridge of the scavenge filter becomes dirty, the difference of pressure across the cartridge increases. For a Delta P higher than 207–241 kPa (30–35 PSID), the Delta P switch sends an electrical ground signal to the ECB.

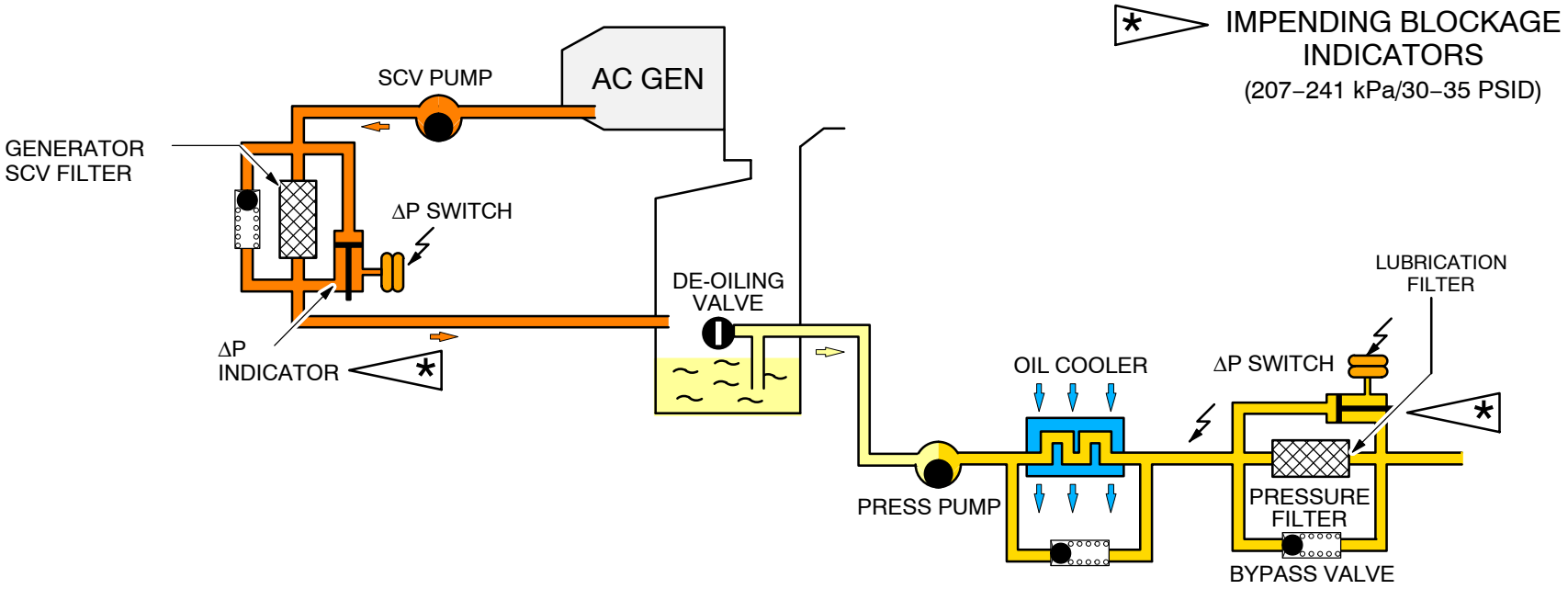


Figure 36 Figure Text

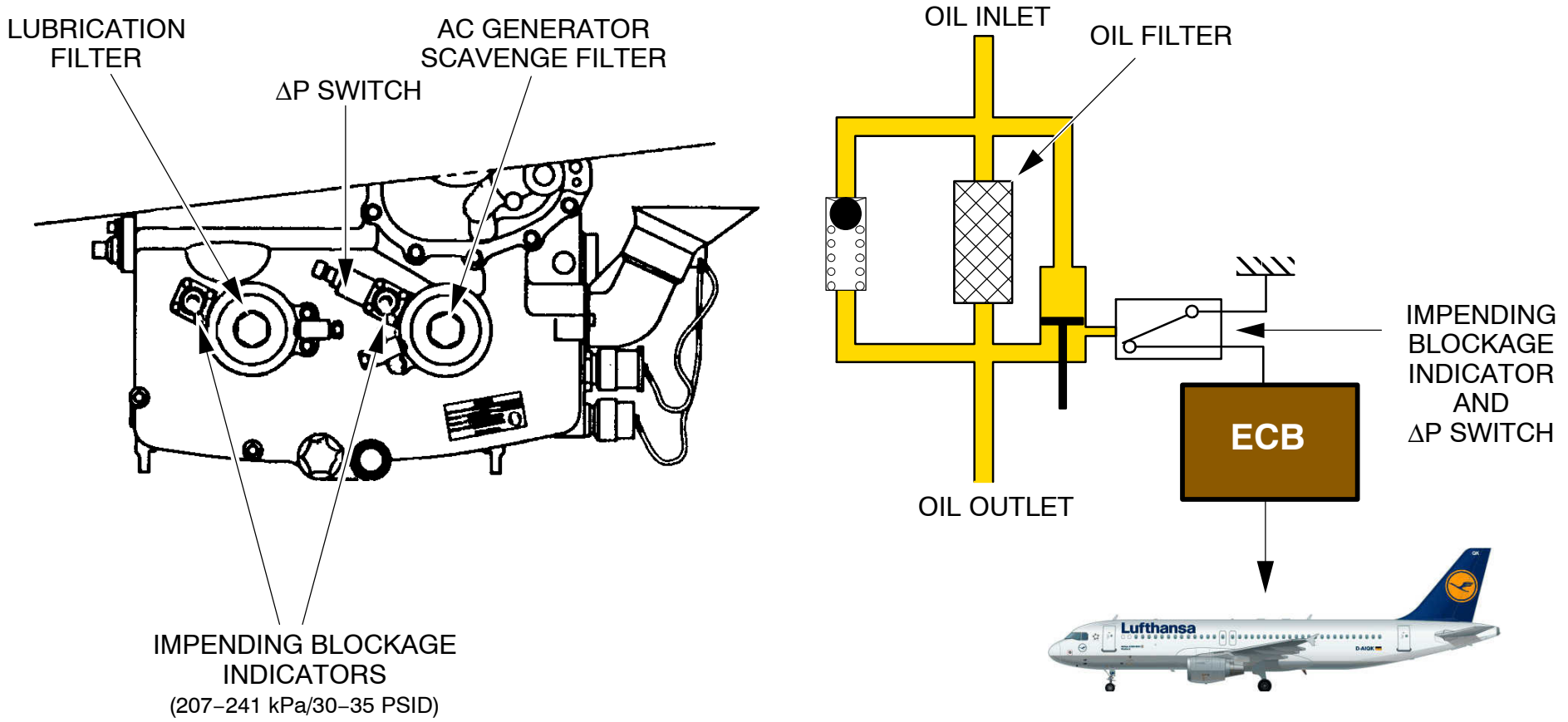
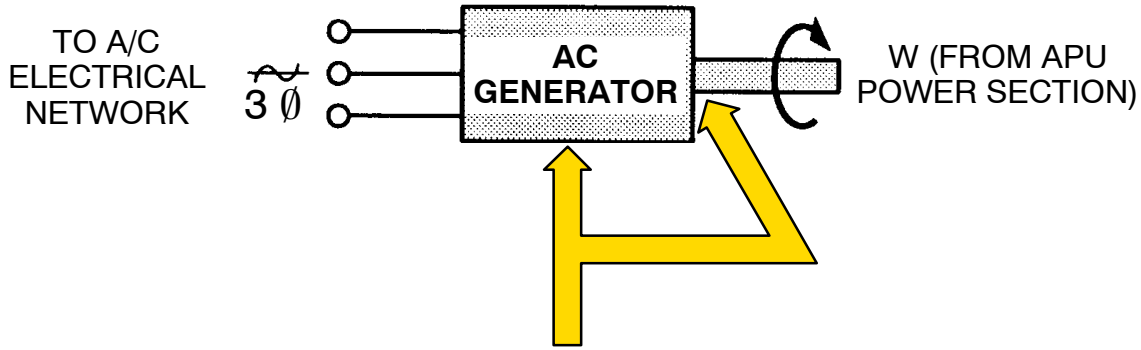


Figure 37 Generator Scavenge Filter Delta P Switch

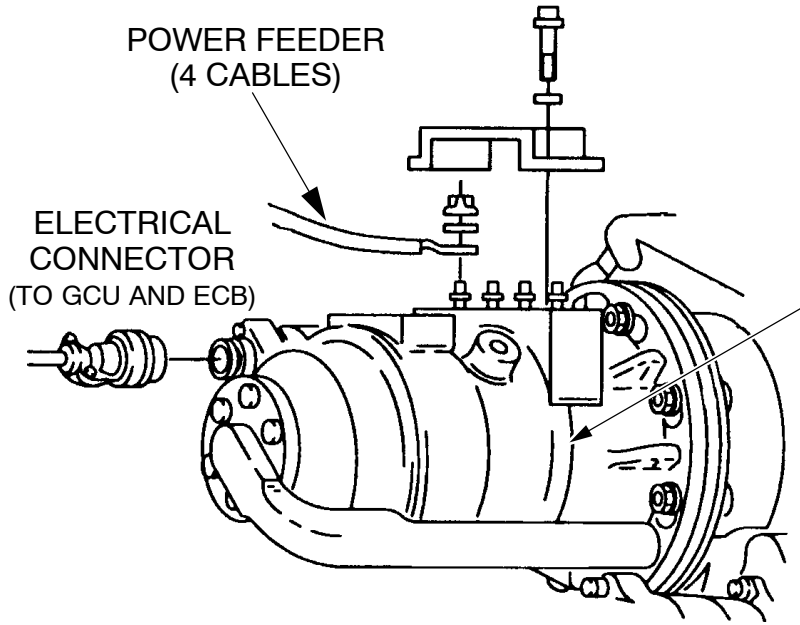
GENERATOR HIGH OIL TEMPERATURE SENSOR

The Generator High Oil Temperature Sensor senses the oil temperature in the generator.

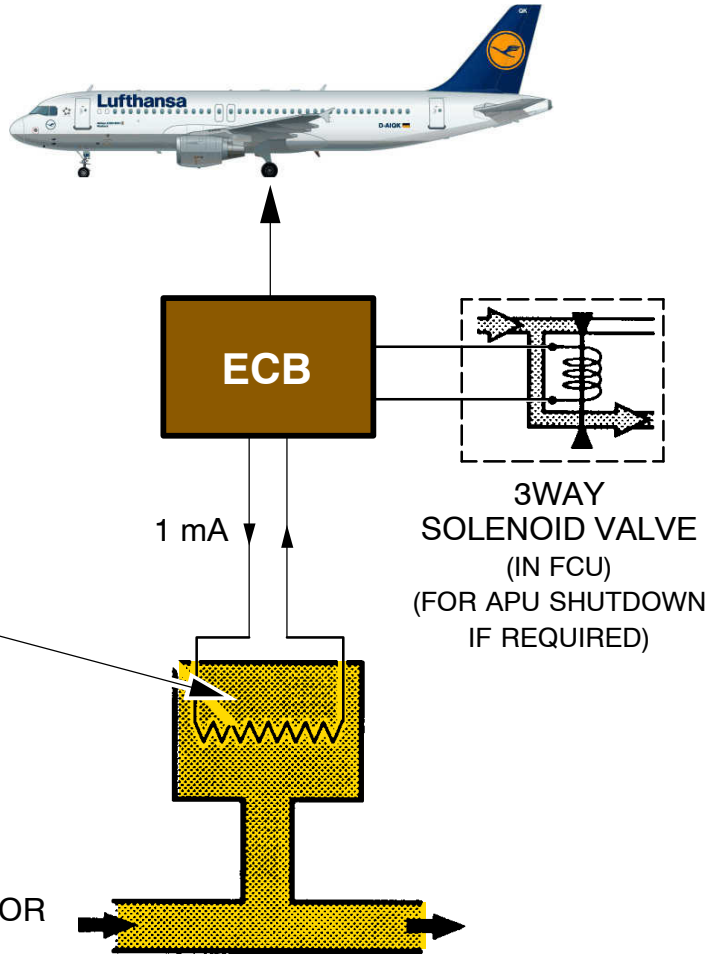
- A signal will be send to the APU ECB when the temp. exceeds 185°C. This leads to an APU Auto shutdown.
- The Sensor is located inside of the generator



LUBRICATION AND COOLING OIL
(FROM APU OIL SYSTEM)



AC GENERATOR



HOT SENSOR OPERATION

Figure 38 Generator High Oil Temp. Sensor

OIL LEVEL SENSOR

The oil level sensor measures the quantity of oil in the gearbox sump.

When the oil level is too low, the sensor provides a flight deck warning of low oil quantity.

The oil level sensor is located on the right side of the gearbox.

Main features

- Sensor input signal (from ECB): 75 mA
- Sensor output signal (to ECB): variable output voltage.

Interfaces

- The ECB
- The APU oil system

Operation

The oil level sensor is a RTD (**R**esistance **T**emperature **D**etector) supplied by the ECB with a constant current of 75 mA.

The resistance varies with the oil level and modifies the sensor output voltage checked by the ECB.

At power up, the oil level is checked over a period of 8 seconds and is determined OK or LOW by the ECB.

If the oil level is too low (less than 2,6 liter), the ECB sends a warning signal to the aircraft control panel (ECAM lower display unit). and CFDS.

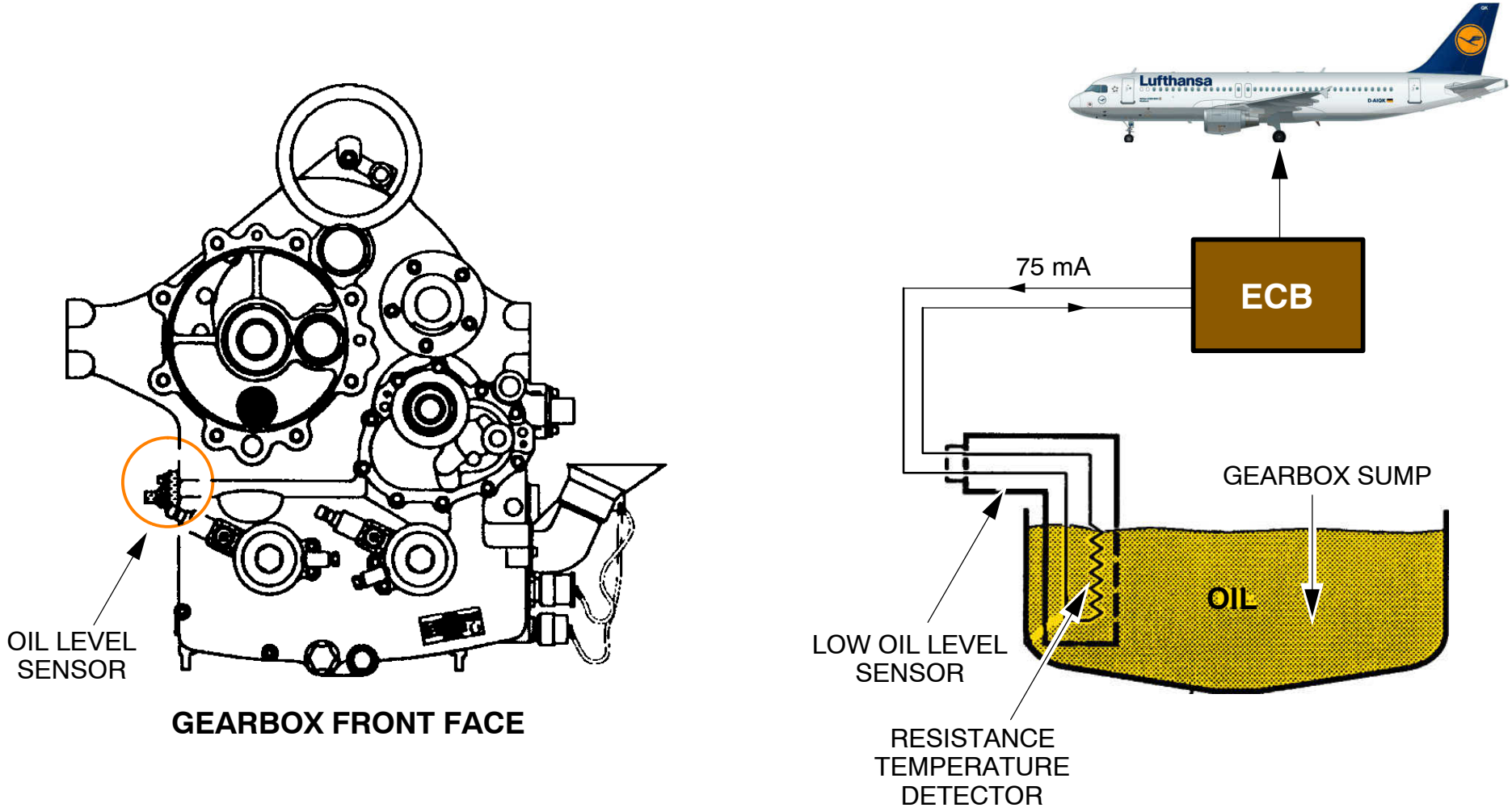


Figure 39 Oil Level Sensor

AIR–OIL SEPARATOR

Purpose

The air–oil separator separates the oil from the air.

Location

The air–oil separator is located in the upper part of the gearbox.

The separator is installed on the intermediate idler gear driving the oil cooling fan.

Description

The air–oil separator consists of several vanes mounted on the intermediate gear driving the cooling fan.

The pinion is integral with a hollow shaft with radial drillings. This shaft is supported by two roller bearings, the sealing of the rear one being made by a lip seal. The rear end of the hollow shaft vents into a passage in the gearbox casing in order to expel to the exhaust the de–oiled air

Operation

During engine running, the air oil mist created by the lubrication of the gears and bearings is separated by the rotating action of the air oil separator located inside the gearbox.

The de–oiled air is then vented to the exhaust through an external pipe.

The oil returns to the sump by gravity.

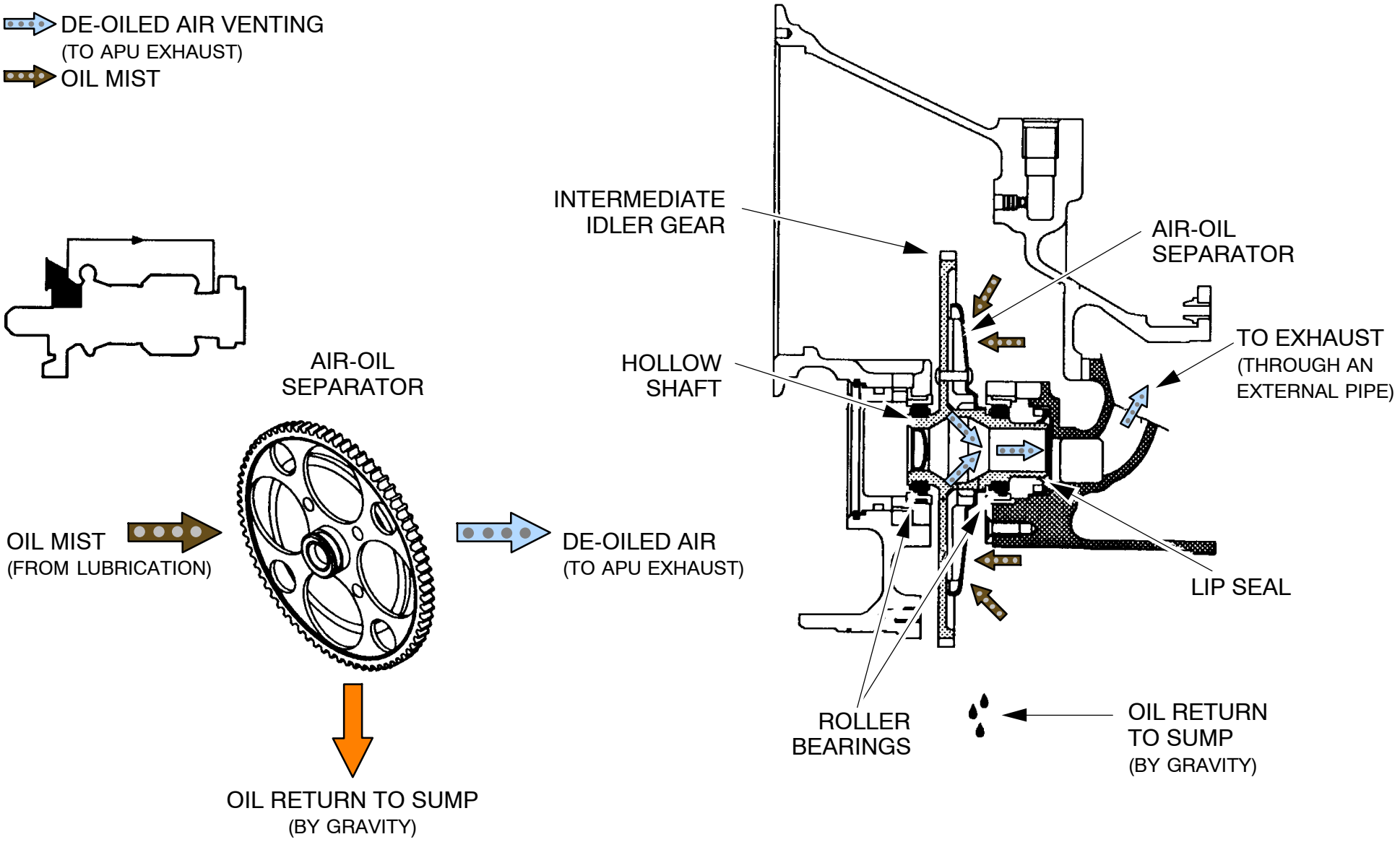


Figure 40 Air–Oil Separator

49-30 ENGINE FUEL AND CONTROL

APU FUEL FEED SYSTEM DESCRIPTION

System Layout

The Auxiliary Power Unit fuel feed system is connected to the aircraft main-engine fuel feed system and supplies fuel to the APU fuel system.

The APU fuel feed system includes:

1. an APU fuel feed pump 4QC and canister 9QM,
2. an APU fuel pressure switch 7QC,
3. an actuator fuel LP valve 3QF and APU fuel low pressure isolation valve 14QM,
4. a vent APU fuel line switch 8QC,
5. an APU inlet fuel low pressure switch 5030QM,
6. a fuel drain and vent valve 5040QM,

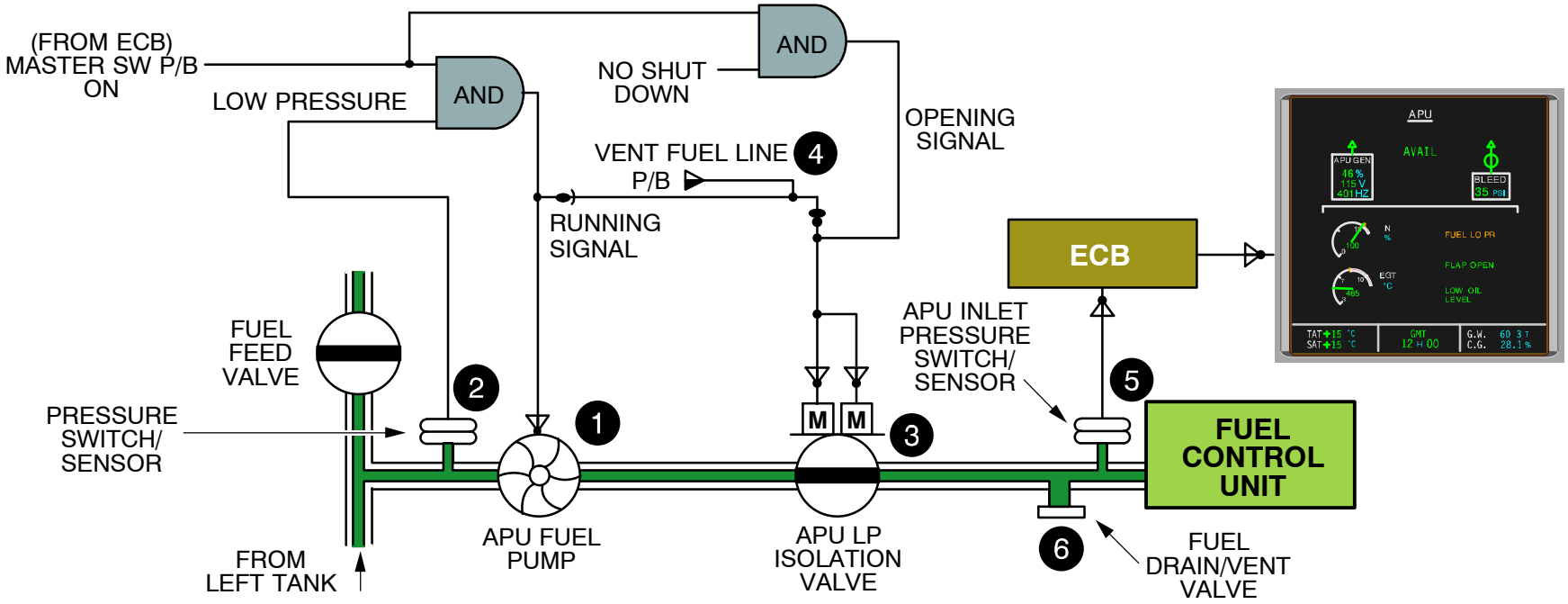


Figure 41 Fuel Control Logic

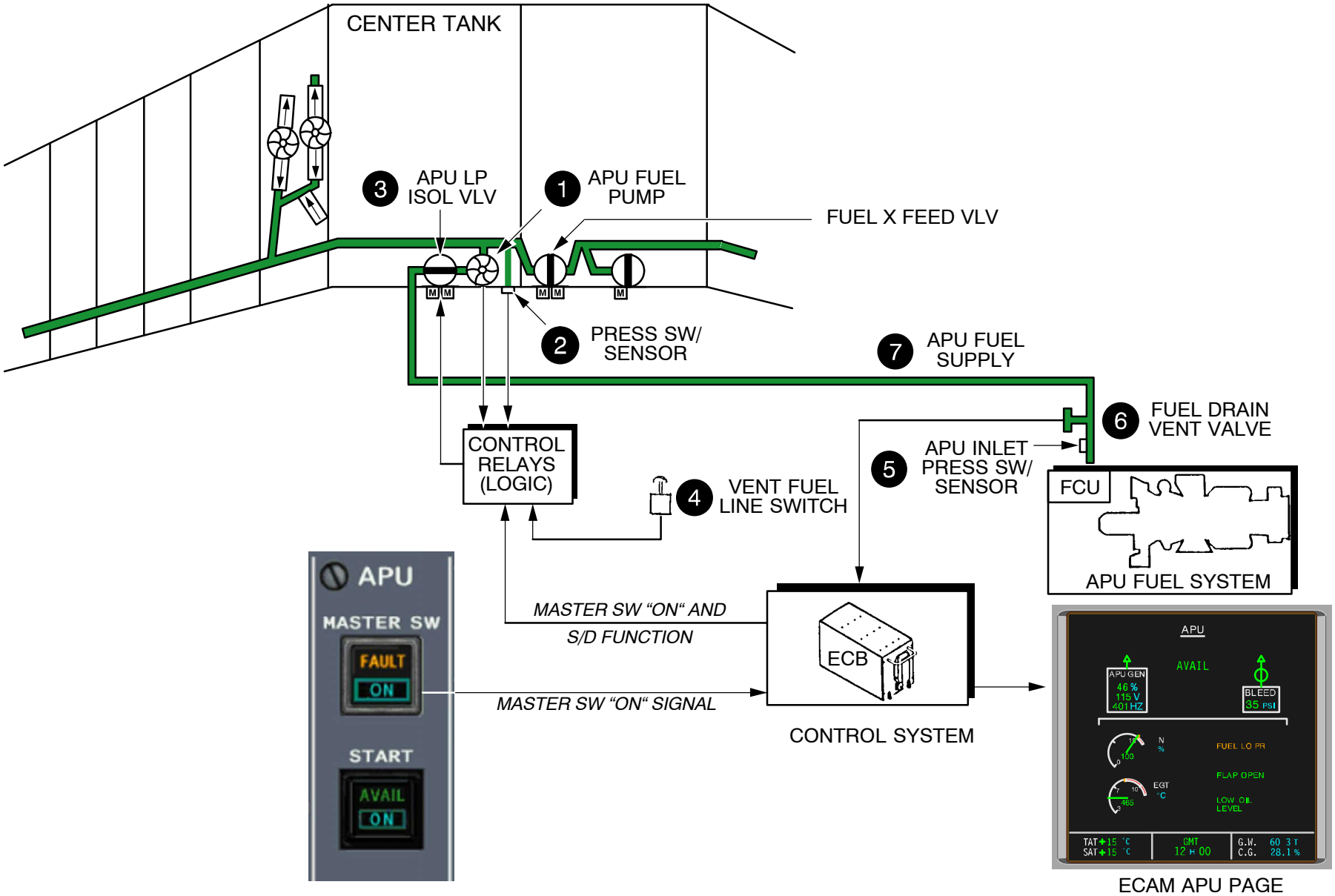


Figure 42 APU Fuel Feed System

APU FUEL FEED SYSTEM COMPONENT DESCRIPTION

1 APU Fuel Feed Pump 4QC and Canister 9QM

It is a centrifugal pump driven by a single– phase 115V AC motor. It is installed at the rear spar of the wing center–box, in the APU fuel feed line (which connects with the left main–engine fuel–feed line).

For normal operation, the NORMAL AC 1 busbar 103 XP (115V AC) supplies the pump motor. When the NORMAL AC 1 busbar is not energized, the static inverter busbar 901 XP (115V AC) supplies the pump motor.

The APU fuel pressure switch 7QC (installed adjacent to the pump) monitors crossfeed line pressure (close to the APU pump inlet) and automatically controls the pump operation.

2 APU Fuel Pressure Switch 7QC

The switch operates on fuel absolute pressure in the crossfeed line. When the pressure in the crossfeed line decreases to 22PSI, it closes to operate the APU fuel–feed pump 4QC. When the pressure in the crossfeed line increases to 23 PSI, it opens to stop the APU fuel–feed pump operation.

3 APU Fuel Low Press. Valve 3QF

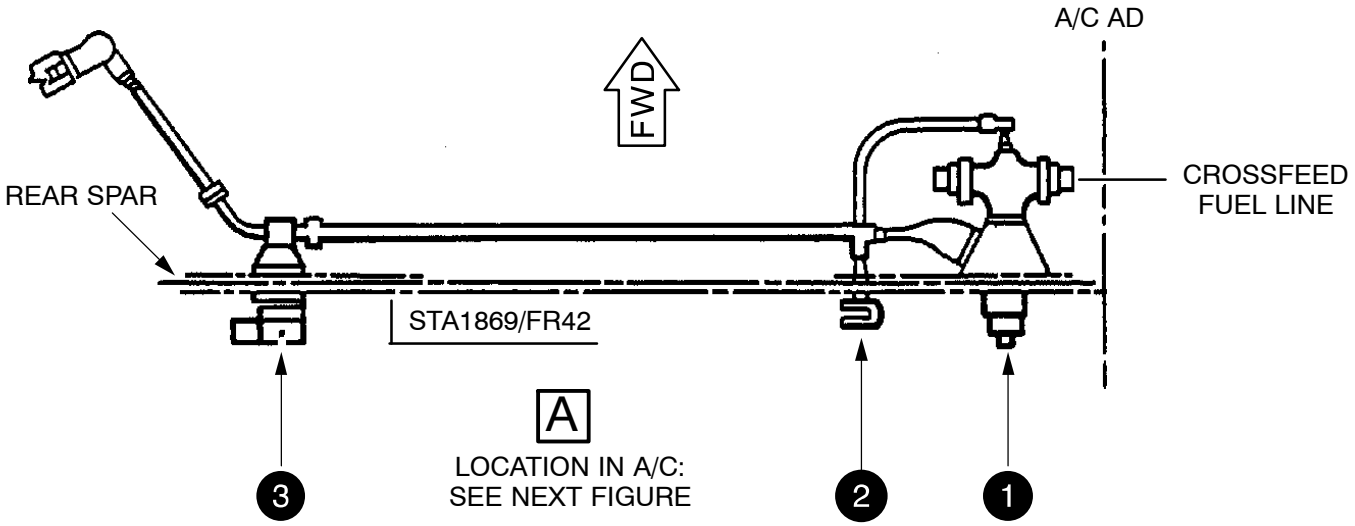
has two 28V DC motors. It will operate with no time delay if failure of one of the motors occurs. It is installed on the rear–spar of the wing center–box, downstream of the APU fuel–feed pump 4QC.

The valve closes automatically to shutoff the APU fuel–feed valve when:

- the APU SHUTOFF switch 1KL (guarded red) on the external power panel 108VU forward of the nose landing gear bay, is operated,
- the APU FIRE switch (guarded red) on module 1WD (panel 20VU) on the overhead panel is operated,
- an APU shutdown occurs on the ground after a fire detection,
- any other protective shutdown occurs.

4 APU Fuel Vent PB Switch 8QC

is installed on the front firewall in the APU compartment. When operated, it opens the fuel low press. valve and permits the APU fuel–feed pump 4QC to operate on the ground (to purge the fuel–feed line during maintenance of the system).



1 APU FUEL FEED PUMP 4QC
WITCH CANISTER 9QM

2 APU FUEL PRESSURE
SWITCH 7QC

3 ACTUATOR FUEL LP VALVE 3QF
VALVE APU FUEL LP 14QM

Figure 43 APU Fuel Feed Components (1)

NOTE:

1. VENTED SHROUD FITTED AROUND THE HOSE (ALUMINIUM ALLOY TUBE 1.5 in DIA.)
2. DOUBLE WALLED FLEXIBLE HOSE, 0.5/1.75 in DIA.
3. FLEXIBLE HOSE, 0.5 in DIA. (TEFLON WITH SILICON FIBERGLASS FIRE SLEEVE)

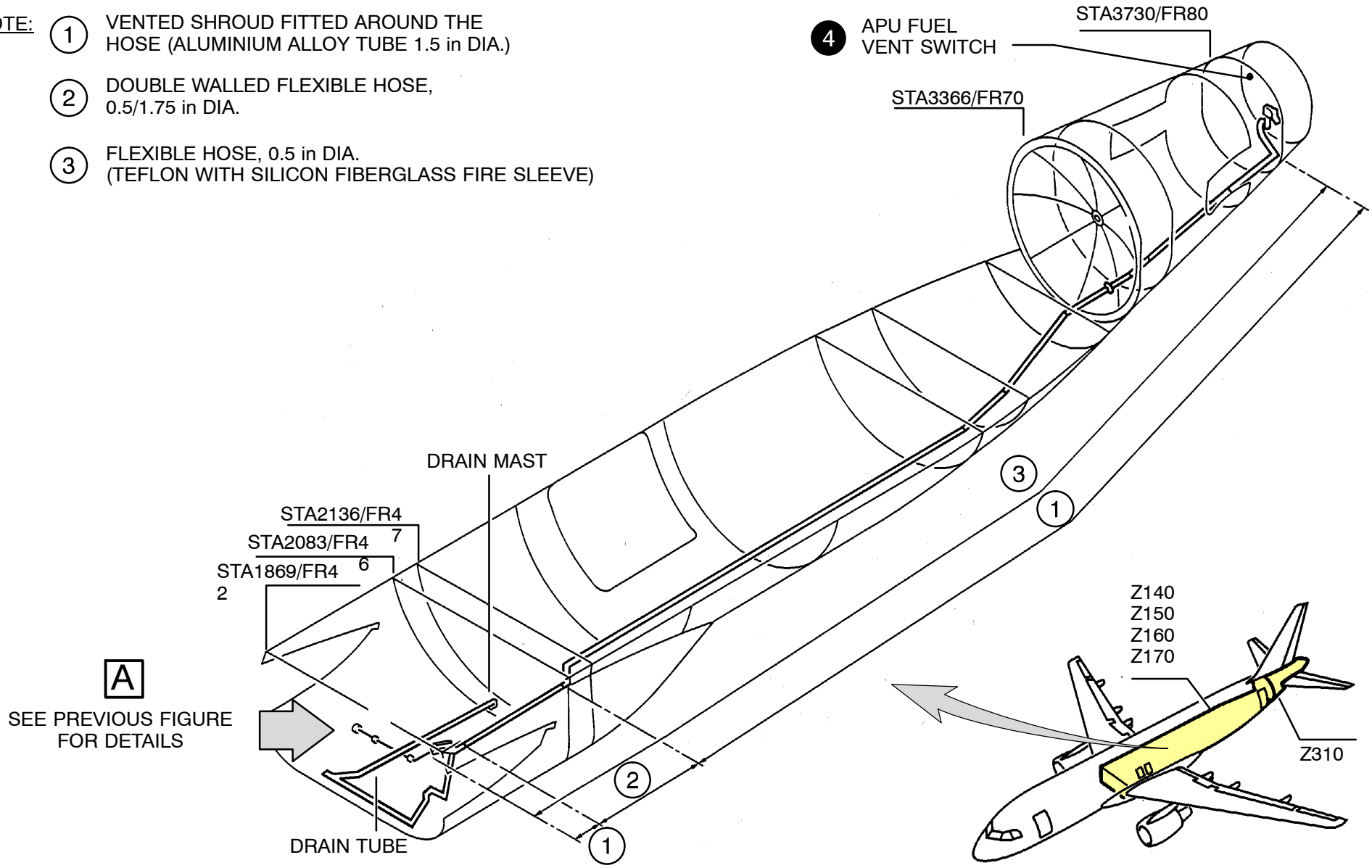


Figure 44 APU Fuel Feed Components (2)

5 APU Inlet Low Press. Switch 5030QM

The switch is installed in the APU compartment at the fuel inlet connection to the FCU. It operates on fuel absolute pressure in the APU fuel–feed line at the inlet to the FCU.

When it operates, it transmits a signal to the ECB (**E**lectronic **C**ontrol **B**ox) 59KD and an ECAM Message ”LOW FUEL PRESSURE” on the APU Page appears.

The switch closes when the inlet pressure decreases to 16 psi. The switch opens when the inlet pressure increases to 17psi.

6 Drain and Vent Valve 5040QM

The Valve is installed in the APU compartment at the fuel inlet connection to the FCU. It permits the APU fuel–feed line to be drained of fuel and bled of air during maintenance of the system.

For this the APU Fuel Vent PB Switch has to by pressed.

7 Fuel feed line

The fuel feed line connects the main–engine fuel–feed system and crossfeed line, at the wing center–box rear spar. It supplies fuel to the APU fuel inlet connection at the APU compartment.

The APU fuel–feed line installation includes:

- a 12.7mm (0.5 in.) diameter aluminium–alloy tube, installed from the cross feed line to the top of the wing center tank (immediately forward of FR42),
- a double–walled vented hose, installed from FR42 to FR80,
- 12.7mm (0.5 in.) diameter high–pressure Teflon flexible hose which incorporates spacing rings to support and locate the hose in its tube.
- a fire sleeve from FR80 to the APU fuel inlet connection.
- a 9.525mm (0.375 in.) outside diameter drain tube, which connects to the vented shroud, at its lowest point (top of the wing center–box, immediately forward of FR42).
- a drain mast at FR47, which connects to the drain tube. It permits the fuel to drain overboard if a fuel leak occurs in the hose.

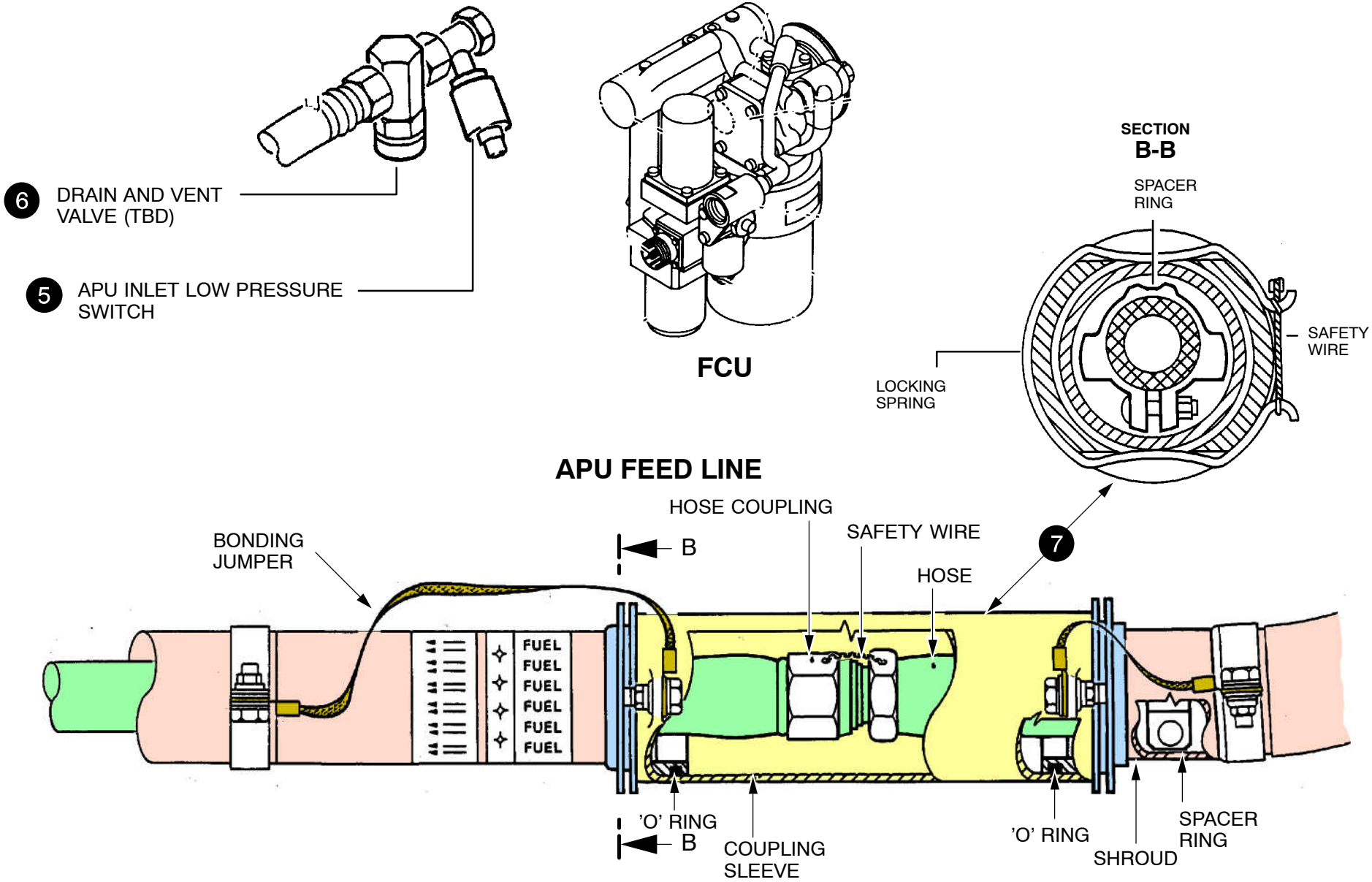


Figure 45 APU Fuel Feed Components (3)

49–32 APU FUEL CONTROL

SYSTEM DESCRIPTION

General

The APU fuel system operates fully automatically and has no external controls. The APU fuel system includes:

- a FCU (**F**uel **C**ontrol **U**nit) 4005KM2,
- a FDDVA (**F**low **D**ivider and **D**rain **V**alve **A**ssembly) 4005KM1,
- a Low Pressure (Inlet) Filter

Fuel Control Unit

The FCU together with the FDDVA, schedule the fuel flow to the APU.

The FCU also supplies high–pressure fuel to the bleed control valve and to the IGV (**I**nlet **G**uide **V**ane) Actuator to give the necessary power to position the load compressor IGVs and the bleed control valve.

The fuel which is supplied to the FCU passes through the centrifugal low pressure pump to the inlet fuel filter and into the high–pressure fuel pump.

The output from the high–pressure fuel pump is supplied to the:

- Actuator Pressure Regulator
- Servo Valve

Metered fuel flows through the Constant ΔP Valve, 3-Way Fuel Solenoid Valve and comes out of the discharge port. The differential pressure indicator gives a signal to the ECB for CFDS when the filter is clogged. The filter bypass valve permits continued operation with a clogged filter.

Flow Divider and Drain Valve Assembly

The FDDVA (**F**low **D**ivider and **D**rain **V**alve **A**ssembly) together with the FCU, schedule the fuel flow to the APU. The FDDVA controls the fuel flow to the main– and the pilot manifolds and drains them at APU shutdown. Fuel from the FCU is supplied to the inlet port of the fuel flow divider during APU starting and normal operation. Fuel is supplied from the pilot fuel port to the pilot fuel manifold during engine starting and operation. Fuel supply begins from the main fuel port to the main fuel manifold when the engine reaches approxi. 20% speed during starting. Fuel continues to be supplied from this port during APU operation. During engine shutdown, fuel is purged from the pilot fuel nozzles and flows from the purge port of the fuel flow divider to the exhaust.

Operation

1. Set the MASTER SW 14KD to ON. When you push the APU START switch 2KA, the engine starts to turn. After approx. 1.5 sec. the ECB 59KD energizes the fuel solenoid valve to the open position. Fuel from the servo valve of the FCU flows through the pilot injector and purge valve of FDDVA. From the FDDVA it is sent to the pilot fuel nozzles. After another 1.5 sec. the ECB 59KD energizes the ignition system, combustion occurs and the engine continues to accelerate.
2. At 55% engine speed, the ECB 59KD de–energizes the exciter and the starter motor 8 KA. The engine continues to accelerate under its own power to governed speed. The speed control function in the ECB 59KD transmit a signal to the FCU. The FCU then increases or decreases the fuel flow as necessary for the changes in load. This keeps the speed of the APU constant.
3. As the engine accelerates, the ECB 59KD transmits a signal to the servo valve in the FCU to control the metered fuel flow. The fuel acceleration control in the ECB 59KD keeps the necessary fuel flow until the engine gets to governed speed.

   At low speed all pump flow goes to the pilot injectors. The engine accelerates, the fuel flow increases to a set level and the main injector valve of the FDDVA opens. This permits more fuel to flow. The ECB 59KD, which controls the fuel pressure, also keeps the IGV actuator in the closed position.

APU Shutdown

When APU shutdown is initiated (automatically or manually controlled shut–down), the ECB de–energizes the 3 way solenoid valve which closes the fuel supply to the pilot and main injectors. The APU decelerates.

The ECB also de–energizes the fuel servo valve which ” closes“ the fuel supply to the 3 way solenoid valve. The excess fuel then returns to the HP pump inlet through the constant Delta P valve and the fuel filter.

The fuel remaining in the pilot fuel manifold and injectors is purged to the exhaust.

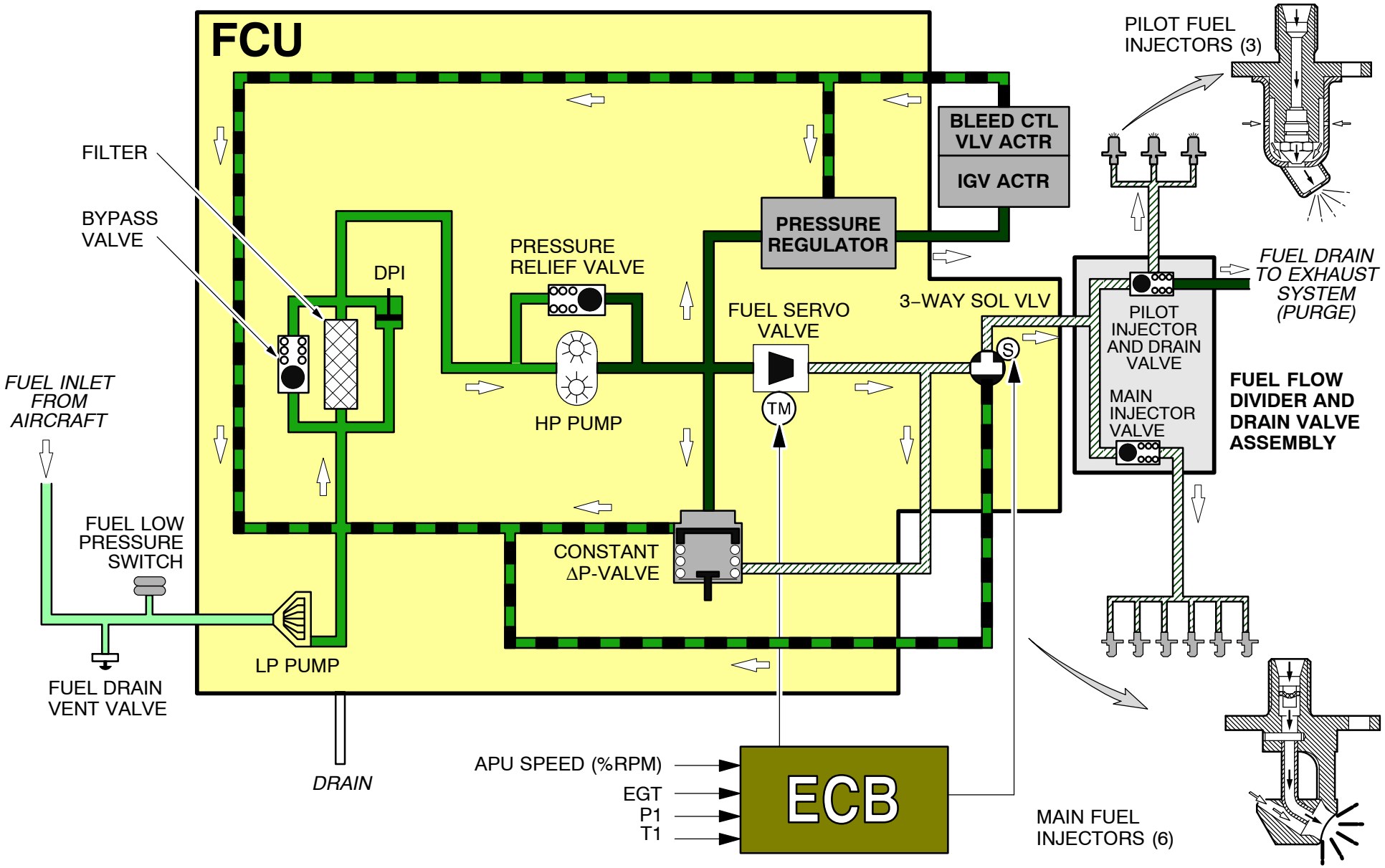


Figure 46 Fuel System Schematic

FUEL CONTROL UNIT COMPONENT DESCRIPTION

1 Low Pressure Fuel Pump

The low pressure fuel pump ensures a pressure increase in order to obtain a positive pressure supply at the inlet of the high pressure pump to avoid cavitation.

The pump is mechanically driven at the same speed as the high pressure pump by a splined shaft (driven by one pinion of the gearbox).

The drive shaft is provided with a seal and a drain connected to the drain system.

2 High Pressure Fuel Pump

The high pressure fuel pump supplies a fuel flow always higher than the APU requirements. The excess fuel is returned to the pump inlet by the constant Delta P valve. The pump is provided with a pressure relief valve.

3 Fuel Filter

The filter is located at the outlet of the low pressure pump.

The filter includes the following components :

- A Filter element to remove foreign material from Fuel.
- An impending blockage Delta P indicator to indicate the pre-blockage situation of the filter element. (at 7PSID)
- A by-pass valve to ensure the fuel supply in the event of filter blockage.

4 Servo-Valve

The servo-valve meters the, fuel during starting and normal running conditions.

The valve consists of a servo coil which actuates a fuel metering valve (clevis type).

The servo is electrically supplied by the ECB. The current operates the clevis valve which determines the fuel flow.

During starting, the ECB and servo-valve meter an increasing fuel flow to obtain the acceleration.

In normal running conditions, the fuel flow is metered to obtain a constant speed of the APU.

The main features of the servo valve are

- Type: Torque motor
- Current: 0 – I 00 mA
- Metered flow: 0 – 180 kg/h (O – 395 PPH).

5 3 Way Solenoid Valve

The valve opens and closes the fuel supply for starting and shutdown.

The solenoid valve is energized open (control from ECB).

When the valve closes, the fuel returns to the inlet side of the high pressure fuel pump.

6 Constant Delta-P Valve

This valve keeps a constant pressure difference across the servo valve so as to obtain a flow only depending upon the metering valve position.

The valve is subjected to upstream pressure on one side and downstream pressure plus the force of a spring on the other side. The valve position determines the amount of fuel which is returned to the inlet of the pump. In so doing, the valve keeps the Delta P constant and reduces the load on the pump

The Delta P setting of the constant Delta P valve is of 689 kPa (100 PSID).

7 Pressure Regulator

The pressure regulator provides the hydraulic fuel supply to the inlet guide vane actuator and to the bleed control valve actuator.

The regulator controls a constant delivery pressure.

The delivery pressure of the pressure regulator is of 1724 kPa (250 PSI).

From 0 to 60 %, the pressure regulator is shut-off. It opens above 60 %

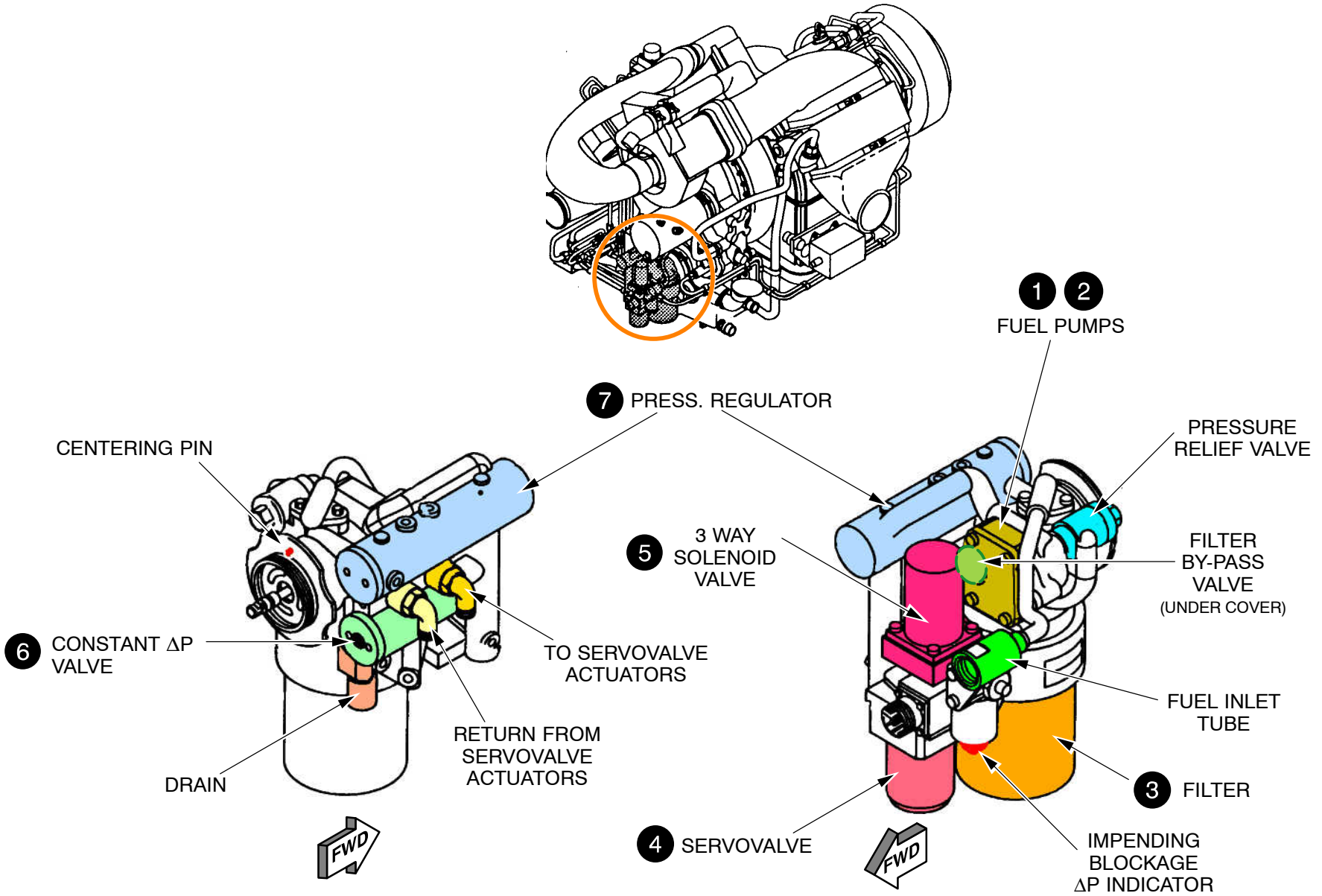


Figure 47 Fuel Control Unit Components

FCU OPERATION

General

The operation is considered in the following operating phases: starting, running condition (stabilized and transient), shutdown.

Starting

When APU starting is selected:

- The starter motor operates and cranks the APU rotating assembly
- The ignition exciter operates and supplies high voltage to produce sparks at the tip of the two igniter plugs
- The 3 way solenoid valve is energized to open the fuel flow N > 3%
- The servo valve is electrically supplied to control the fuel flow.

The fuel from the aircraft fuel system is supplied by the low pressure and high pressure pumps through the servo valve and the 3 way solenoid valve.

When the fuel pressure reaches approximately 138 kPa (20 PSI), the flow divider allows fuel supply to the pilot injectors. The fuel sprayed is ignited by the sparks of the igniter plugs.

During starting,

The fuel flow is controlled by the ECB and the servo valve.

At self-sustaining speed, the starter and the ignition system are de-activated and the APU continues to accelerate.

At nominal speed, the “ECB-servo valve” assembly governs a constant speed by metering the fuel flow.

The high pressure fuel pump also supplies the pressure regulator for the fuel operated actuators of the pneumatic control system (Inlet guide vane control) and (Bleed valve control).

Running condition

- Stabilized condition

  The pumps supply a flow higher than the APU requirements. The fuel flow is metered by the servo valve according to the ECB programme. The excess fuel is returned to the inlet side of the HP pump through the constant Delta P valve and the fuel filter.

- Transient condition

  When the load applied to the power section changes, the rotation speed changes. The ECB senses the change and implements a signal sent to the servo valve. The fuel flow is thus metered to keep the rotation speed constant.

- Shutdown

  When APU shutdown is initiated (automatically or manually controlled shut-down), the ECB de-energizes the 3 way solenoid valve which closes the fuel supply to the pilot and main injectors. The APU decelerates.

  The ECB also de-energizes the fuel servo valve which ”closes“ the fuel supply to the 3 way solenoid valve. The excess fuel then returns to the HP pump inlet through the constant Delta P valve and the fuel filter.

  The fuel remaining in the pilot fuel manifold and injectors is purged to the exhaust.

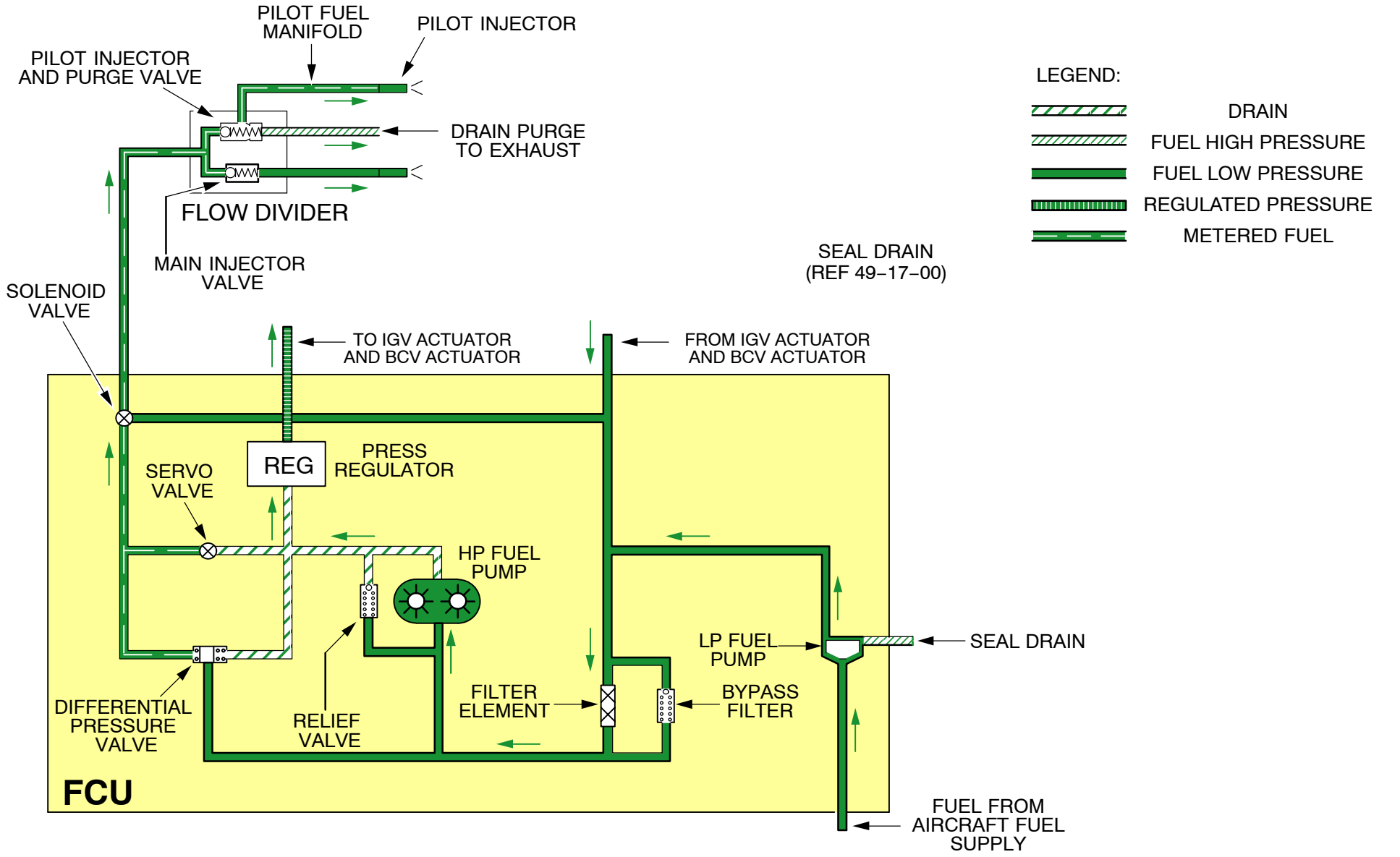


Figure 48 APU Fuel Schematic (FCU)

START FUEL FLOW CONTROL OPERATION

General

This function meters the fuel flow during APU starting.

Components

- Speed sensors, the EGT thermocouples, the air inlet pressure and temperature probes
- ECB (**E**lectronic **C**ontrol **B**ox)
- Fuel servo valve.

System Operation

The fuel flow programme has two phases

- A first phase: Until a rise of EGT (Delta EGT) higher than 50'F is detected
- A second phase: From Delta EGT detection to 95 % speed + 2 seconds.

During the first phase, the fuel supply is mainly used to fill the manifold. The fuel flow is metered as a function of the rotation speed only.

During the second phase, the fuel is scheduled as a function of two selectable programmes (automatically selected):

- One programme controls the fuel flow rate after comparison of the actual acceleration with an acceleration rate datum
- The other programme controls the fuel flow rate after comparison of the actual EGT with an EGT datum variable with the rotation speed.

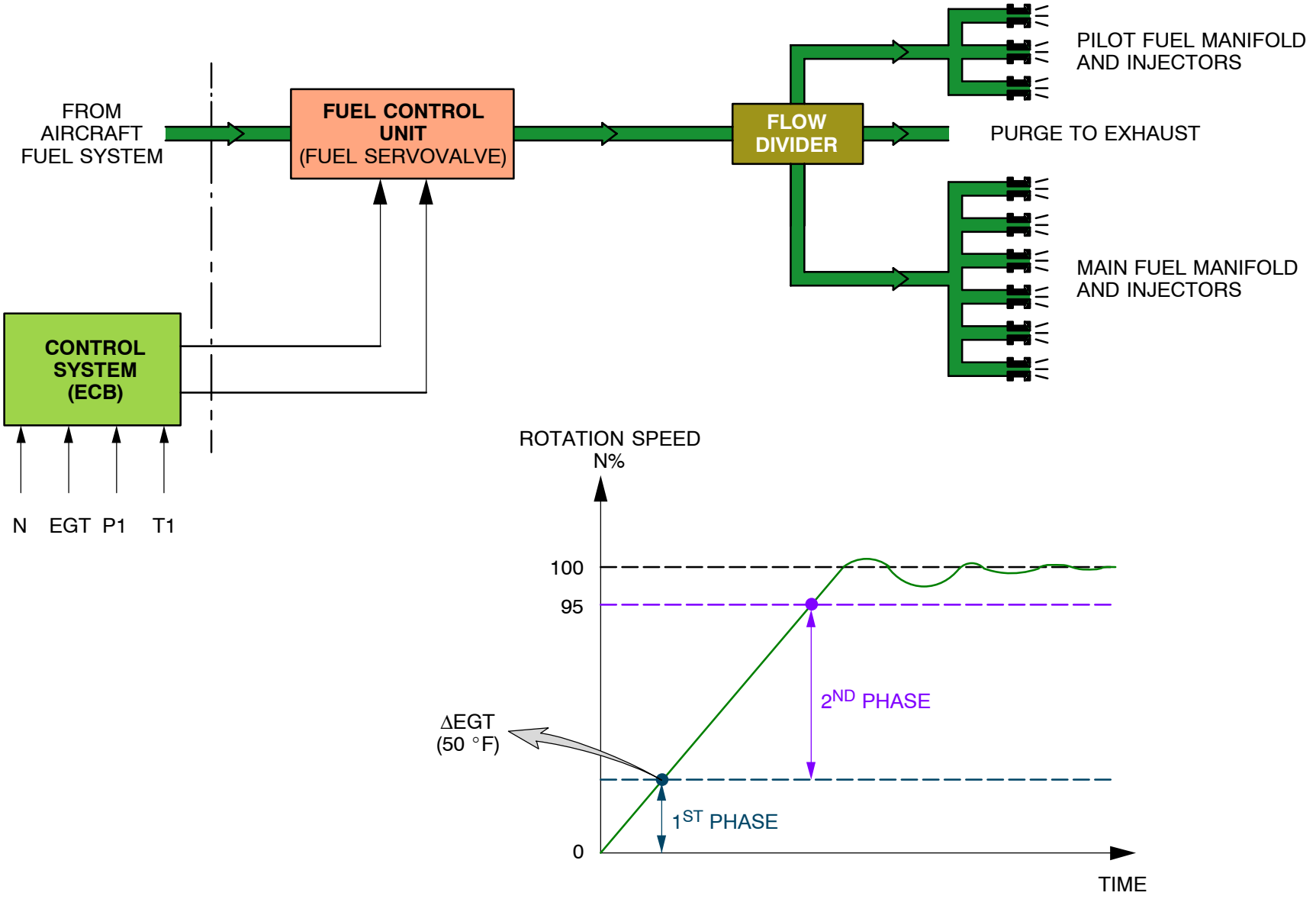


Figure 49 APU Start FF Control Schematic

FLOW DIVIDER OPERATION

Purpose

The flow divider distributes the fuel from the fuel control unit to the pilot and main injectors. It also ensures the purge of the pilot injectors during “APU shut–down.

Location

The flow divider is installed on the left side of the combustor housing.

In the fuel system, the flow divider is located downstream of the 3 way solenoid valve.

System Layout

The flow divider mainly consists of:

- A pilot injector and purge valve set at approx. 20 PSID
- A main injector valve set at approx. 200 PSID
- A filter screen (located at the fuel inlet of the flow divider)

SYSTEM OPERATION

Starting

When APU start is selected, the supply pressure increases and, at 20 PSID, the pilot injector valve opens, allowing fuel supply to the pilot injectors. All pump flow goes to the pilot injectors.

When the pressure reaches 200 PSID, the main injector valve opens allowing fuel supply to the main injectors without fuel pressure drop in the system.

Normal running condition

The two valves are in the open position and the fuel is allowed to flow to the pilot injectors and to the main injectors. The continuous fuel flow through the pilot injectors prevents coking.

Shutdown

As the Fuel pressure decreases, the two valves close. The Fuel remaining in the pilot injectors is purged to the exhaust by compressed air flowing through the purge valve.

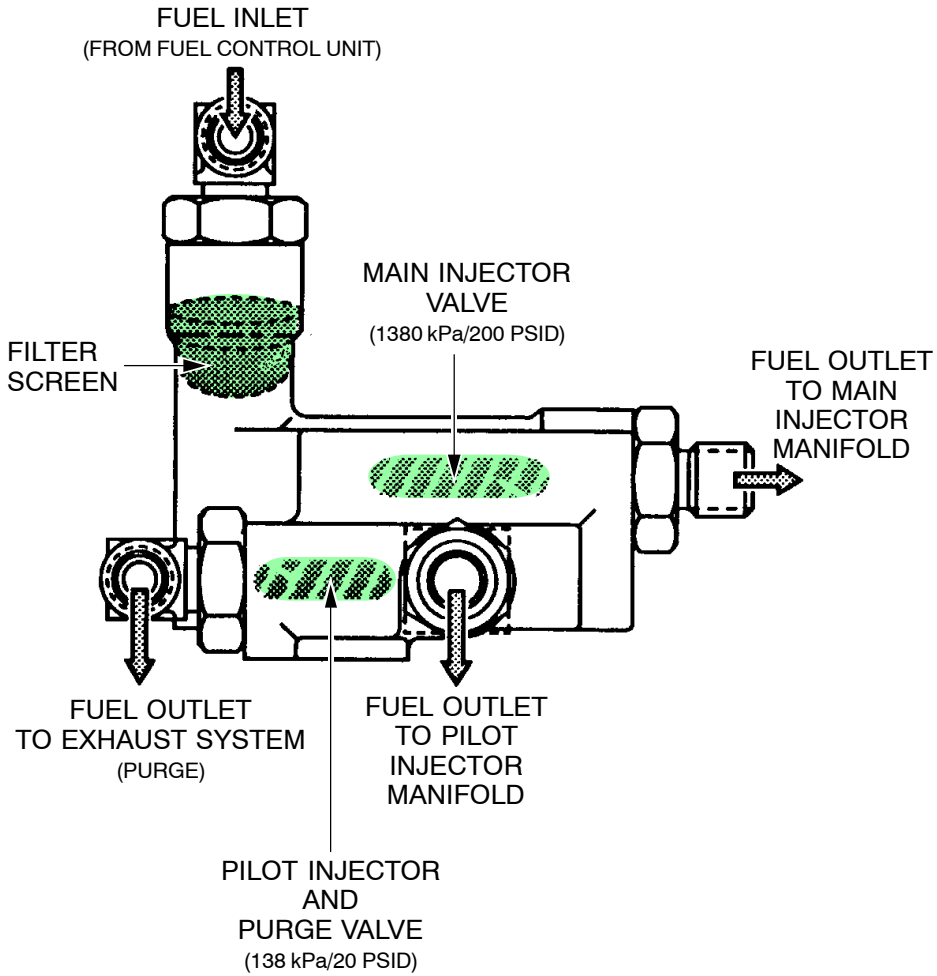


Figure 50 Flow Divider

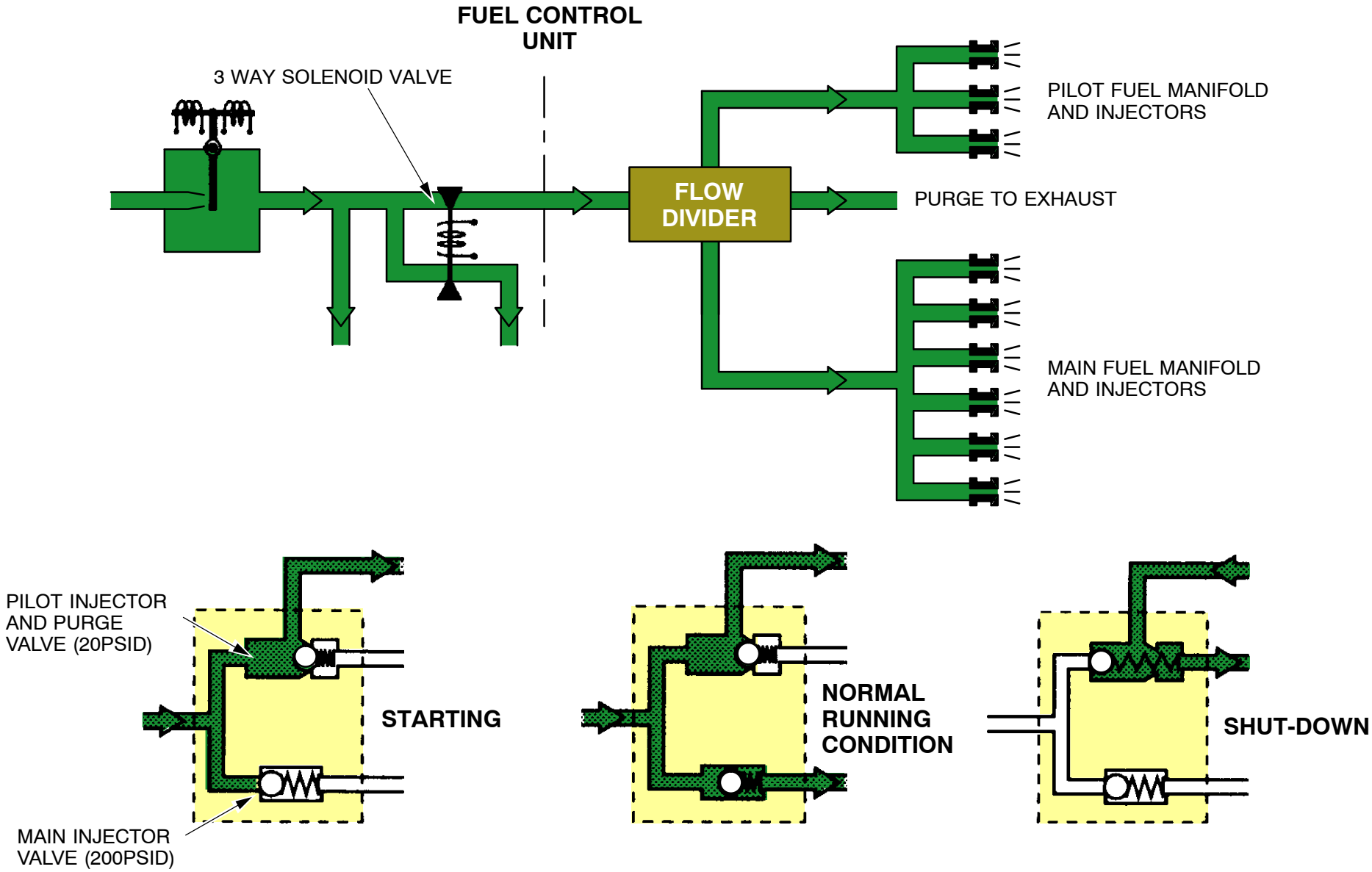


Figure 51 Flow Divider Operation

FUEL MANIFOLDS AND INJECTORS COMPONENT DESCRIPTION

Pilot Fuel Manifold

The pilot fuel manifold delivers the Fuel from the flow divider to the 3 pilot injectors which spray the fuel into the combustion chamber to permit starting.

The pilot fuel manifold also supplies pilot fuel injectors with fuel during normal running condition.

The pilot fuel manifold is mounted around the combustor rear face close to the main fuel manifold.

Main Fuel Manifold

The main fuel manifold provides the fuel supply from the flow divider to the 6 main injectors which spray the fuel into the combustion chamber.

The main fuel manifold is mounted around the combustor rear face close to the pilot fuel manifold.

Pilot Fuel Injectors

The 3 pilot injectors spray the fuel into the combustion chamber to permit starting. They also remain in operation during normal running conditions.

Main Fuel Injectors

The 6 main injectors spray the fuel into the combustion chamber to provide efficient burning. The fuel that enters the injector is mixed with compressed air. The flow of fluid is “broken” by shearing effects and thus, the fuel is finely sprayed into the combustion chamber. The 6 airblast injectors penetrate radially into the combustor and the spraying provides a stable and efficient combustion.

Drain (Purge)

At APU shutdown, as the fuel pressure deceases, the two valves (main and pilot injector valve) close. The fuel remaining in the pilot injectors is purged to the APU exhaust by compressed air flowing through the purge valve.

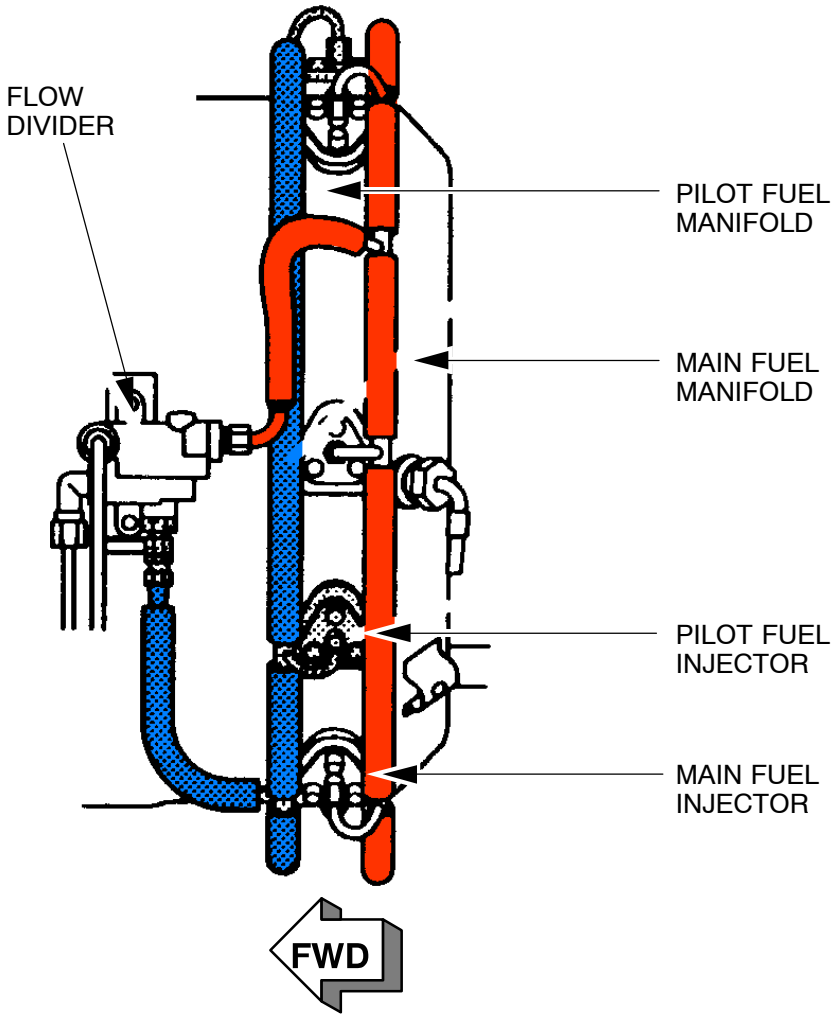


Figure 52 Combustor Housing (LH-Side)

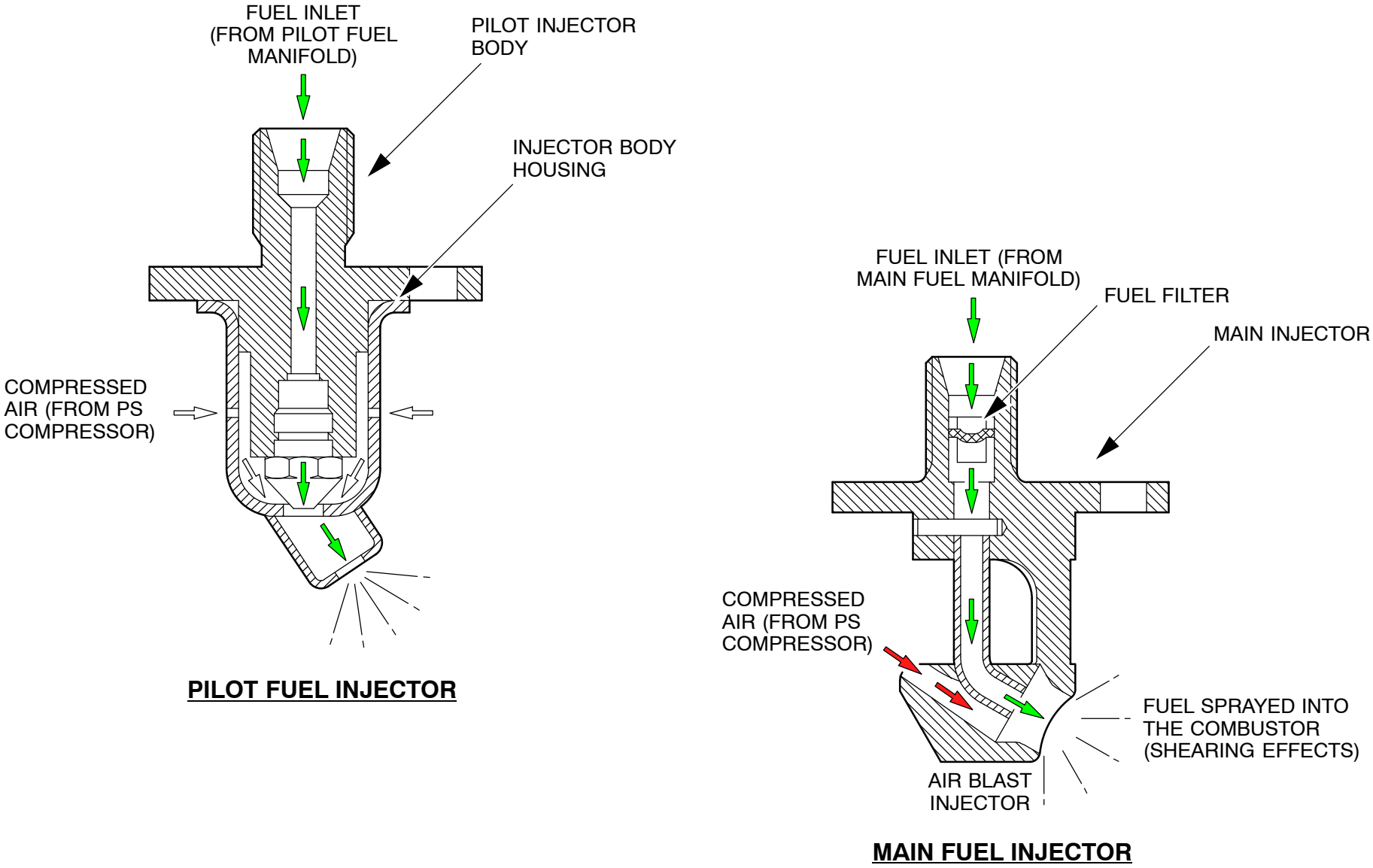


Figure 53 Fuel Manifolds and Injectors

49–50 AIR SYSTEM

AIR SYSTEM DESCRIPTION

Purpose

The air system provides compressed air to the aircraft on the ground and in flight.

Main Features

- Flow: 1.2 kg/s (2.6 PPS)
- Pressure: 400 kPa (59.4 PSI)
- Temperature: 232 °C (450 °F).

Main Components

Two systems are considered:

- The inlet guide vane system which operates so as to avoid overtemperature of the power section.

  It mainly includes:

  – a servo valve
  – an actuator
  – an inlet guide vane control mechanism and the inlet guide vanes.
- The air bleed system which operates to deliver air while avoiding compressor surge.

  It mainly includes:

  – a servo valve
  – an actuator
  – a bleed control valve.

These two systems also include sensors (for temperature and pressure) and uses fuel as the hydraulic fluid.

They are both controlled by the ECB.

Component Location

The inlet guide vane system components are located on the right upper part of the APU on the load compressor casing. The inlet guide vanes are located in the load compressor air inlet.

The air bleed system components are located on the right lower part of the APU at the scroll outlet.

All the sensors are located on the APU.

Interfaces

- The ECB
- The aircraft pneumatic system
- The APU fuel system.

NOTE: The air system also includes the Accessory Cooling with Ducts, Cooling Fan and Compartment Cooling Valve.

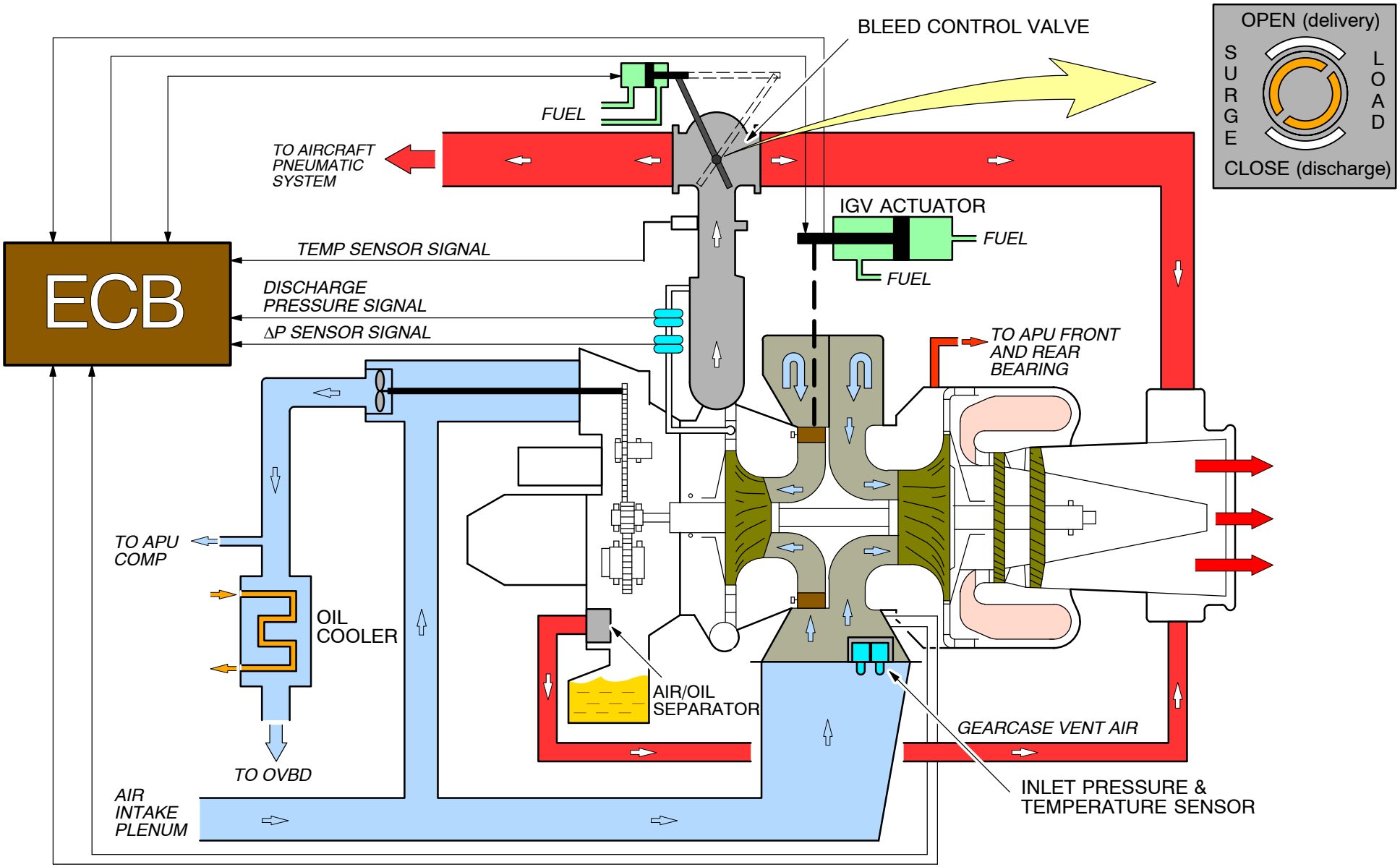


Figure 54 Air System Schematic

INLET GUIDE VANE SYSTEM OPERATION

Operation Principle

The inlet guide vane system controls the air flow into the load compressor in order to avoid overtemperature of the power section.

The ECB implements a current signal in relation to the rotation speed, the EGT (**E**xhaust **G**as **T**emperature) and to other parameters such as the operation mode MES (**M**ain **E**ngine **S**tart) or ECS (**E**nvironmental **C**ontrol **S**ystem) and pressure and temperature parameters (OAT, OAP). This current signal is sent to the servo valve and causes the angular displacement of the spill valve which controls the leak of the potentiometric jet. In stabilized condition, there is an average current (of approx. 50 mA) corresponding to a stabilized position of the actuator.

The servo valve then delivers to the actuator a modulated fuel pressure in relation to the signal.

The actuator spool valve is subjected on one side to the modulated fuel pressure and on the other side to the fuel pressure.

When the modulated fuel pressure varies, it creates a difference of pressure between the two sides of the spool valve which moves and drives the actuator piston. The linear voltage differential transducer sends the spool valve position signal to the ECB to control the operation of the actuator.

The piston displacement causes the displacement of the arm of the rack and pinion system which rotates. The rack and pinion system rotation then causes the rotation of the inlet guide vanes through their sector gears.

The load compressor can then supply compressed air either to the exhaust system or to the aircraft pneumatic system according to the pilot selection and operating conditions.

Servo Valve

The servo valve consists of a flap valve which is opposed to a potentiometric jet. The servo valve has a fuel pressure inlet, a modulated fuel pressure outlet and a fuel return outlet. The fuel pressure depends on the position of the servo valve which is controlled by two solenoids. The solenoid control current (0–100 mA) is sent by the ECB in relation to reference signals.

Actuator

The actuator consists of a spool valve moving in a sleeve. The spool valve is subjected on one side to the fuel pressure and on the other side to the modulated fuel pressure supplied by the servo valve.

The actuator housing also includes a linear bearing which has double dynamic seals with a chamber drain in between.

The spool valve is integral with the actuator piston which is connected to the control mechanism.

The position of the actuator is fed back to the ECB by a LVDT (**L**inear **V**oltage **D**ifferential **T**ransformer) located inside the spool valve.

IGV Control Mechanism and IGVs

The inlet guide vanes are mounted in a support assembly. Each vane has a sector gear engaged in a common ring gear which is driven in rotation on the support assembly by the inlet guide vane actuator. Thus, all vanes rotate simultaneously.

When the inlet guide vanes are fully open, the maximum air flow is delivered to the load compressor.

APU Starting

During start, the inlet guide vanes are in the closed position to reduce the resisting torque of the load compressor.

In Flight Operation

During flight operation, the opening or closing of the inlet guide vanes depends on the aircraft pneumatic system requirements.

In case of EGT exceeding the limit, the inlet guide vanes also automatically move to the closed position to reduce the resisting torque of the load compressor.

In case of inlet guide vane control failure, the vanes automatically move to the closed position.

Note: For IGV position data in relation to bleed status refer to section 49–73/00 Analyzers.

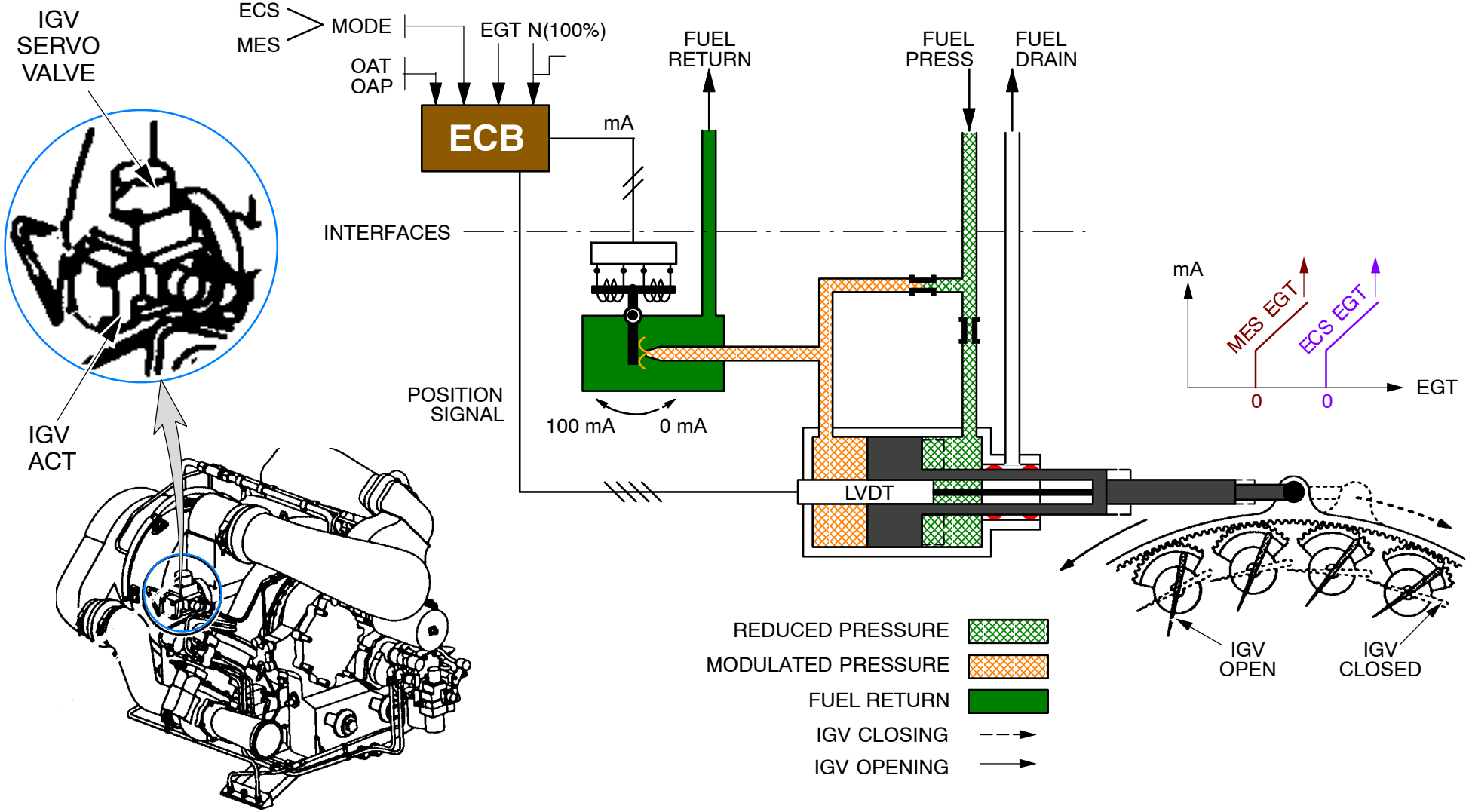


Figure 55 IGV Operation Schematic

AIR BLEED SYSTEM OPERATION

Bleed Valve

The valve is of butterfly type. It has a compressed air inlet, exhaust and aircraft outlets. It mainly consists of a flap which directs the compressed air to the exhaust system when closed or to the aircraft pneumatic system when open.

The diverter valve also includes a visual position indicator.

The flap is driven in rotation by a rotary actuator.

Servo Valve

The servo valve consists of a spill valve which is opposed to a potentiometric jet. The servo valve has a pressure inlet, a modulated fuel pressure outlet and a fuel return outlet. The fuel pressure depends on the position of the spill valve which is controlled by two solenoids.

The solenoid control current (O–100 mA) is sent by the ECB according to reference signals.

Actuator

The actuator consists of a spool valve moving in a sleeve. The spool valve is subjected on one side to the fuel pressure and on the other side to the modulated fuel pressure delivered by the servo valve.

The actuator housing includes a linear bearing which has double dynamic seals with a chamber drain in between.

The position of the actuator is fed back to the ECB by a LVDT (**L**inear **V**oltage **D**ifferential **T**ransformer) located inside the spool valve.

The spool valve is integral with the actuator piston which is mechanically connected to the rotary actuator of the valve.

Discharge to Exhaust

The compressed air is discharged to the exhaust system to reduce the resisting torque of the load compressor. According to inlet signals (pressure and rotation speed signals) the ECB implements a current signal. This current signal is sent to the servo valve and causes the angular displacement of the spill valve which closes the leak of the potentiometric jet. The modulated fuel pressure then increases. This increased modulated fuel pressure causes a difference of pressure between the two sides of the spool valve. The spool valve then moves and causes the actuator piston displacement. The LVDT sends the spool valve position signal to the ECB to control the operation of the actuator. The linear motion of the actuator piston is transformed into angular motion by the rotary actuator in order to set the flap in the discharge position.

The compressed air is then discharged to the exhaust system. The system also discharges the compressed air into the exhaust to prevent surge during APU shutdown.

Compressed Air Delivery to Aircraft

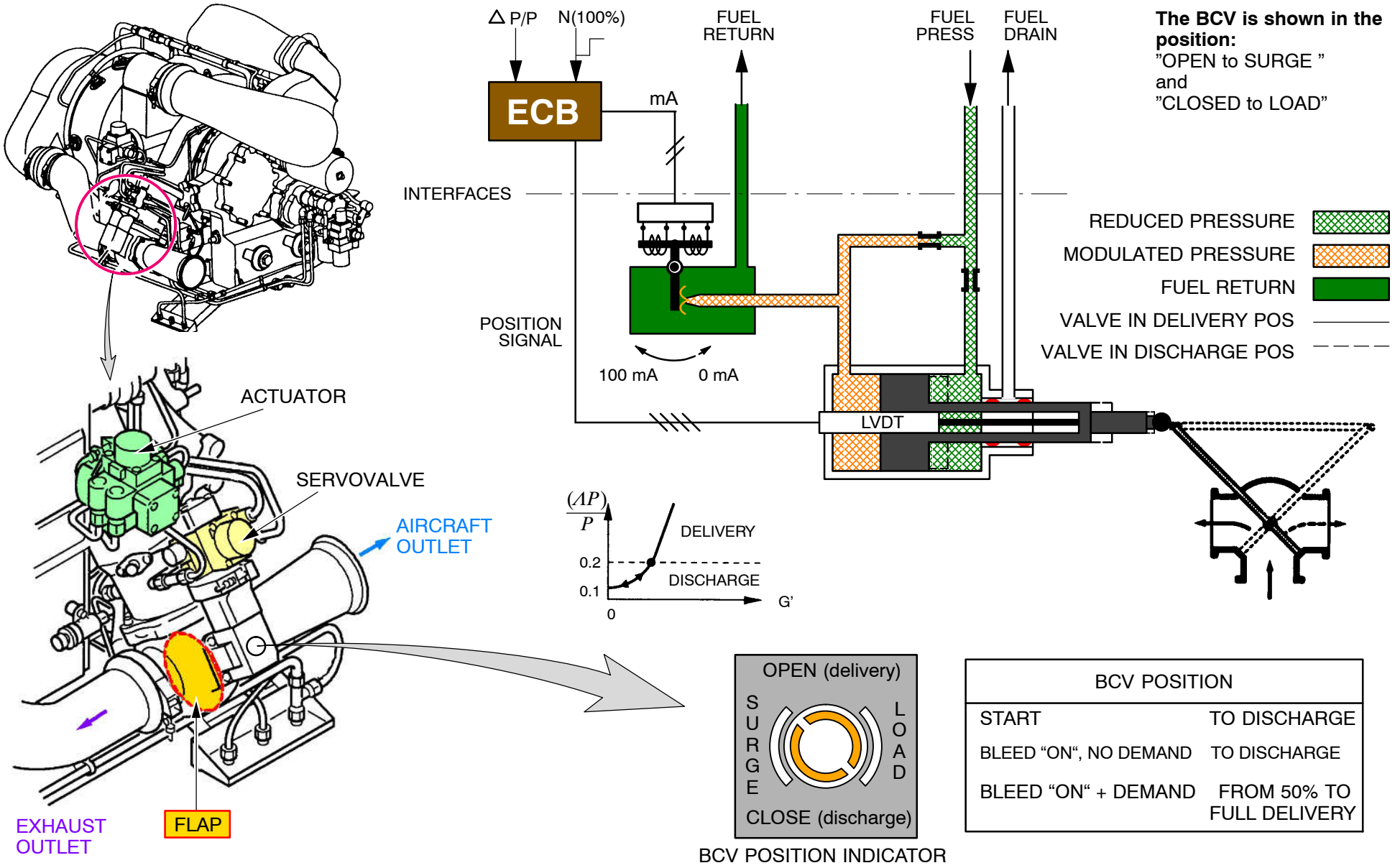
According to inlet signals (pressure and rotation speed signals) the ECB implements a current signal. This current signal is sent to the servo valve and causes the angular displacement of the spill valve which opens the leak of the potentiometric jet. The modulated fuel pressure then decreases.

This decreased modulated fuel pressure causes a difference of pressure between the two sides of the spool valve. The spool valve then moves and causes the actuator piston displacement. The LVDT sends the spool valve position signal to the ECB to control the operation of the actuator. The linear motion of the actuator piston is transformed into angular motion by the rotary actuator in order to move the flap to the delivery position.

The system then delivers the compressed air to the aircraft pneumatic system.

In case of a control system failure, the valve automatically moves to the discharge position.

NOTE: In stabilized condition, there is an average current (of approx. 50 mA) corresponding to a stabilized position of the actuator.



BCV POSITION	
START	TO DISCHARGE
BLEED "ON", NO DEMAND	TO DISCHARGE
BLEED "ON" + DEMAND	FROM 50% TO FULL DELIVERY

Figure 56 Air Bleed System Operation Schematic

AIR SYSTEM SENSORS DESCRIPTION

General

The Signals of the sensors are used by the ECB for fuel metering, EGT limitation and air flow calculation.

Inlet Air Pressure/Temperature Sensor

Inlet Air Pressure and temperature sensor are housed in one sensor assembly which is located on the air intake plenum.

The inlet air temperature and the inlet air pressure is used by the ECB for control purposes (fuel metering, EGT limitation, air flow calculation).

In case of failure the condition monitoring parameters are not taken and a back up value is used. A failure does not directly cause the APU to shutdown, however it affects several functions (fuel, IGV, etc.).

Load Compressor Discharge Temperature Sensor

The temperature sensor is located on the air discharge duct. The temperature is measured in order to calculate the bleed air flow condition. The purpose of measuring the bleed air flow is to control the Bleed Control valve (and then to avoid load compressor surge).

In case of failure, the ECB commands the Bleed Control Valve to close the aircraft bleed and to bypass the compressed air to the discharge.

Load Compressor Discharge Pressure Sensors

The pressure Sensors (Delta P and Total P) are assembled together in one unit and are located on the air intake plenum.

The load compressor discharge pressure sensors give 2 signals, the Delta P and the total Press. in order to calculate the bleed air flow condition, to control the Bleed Control Valve (and thus to avoid load compressor surge).

The sensor is also responsible for the revers flow shutdown protection

In case of failure, the ECB commands the Bleed Control Valve to close the aircraft bleed and to bypass the compressed air to the discharge.

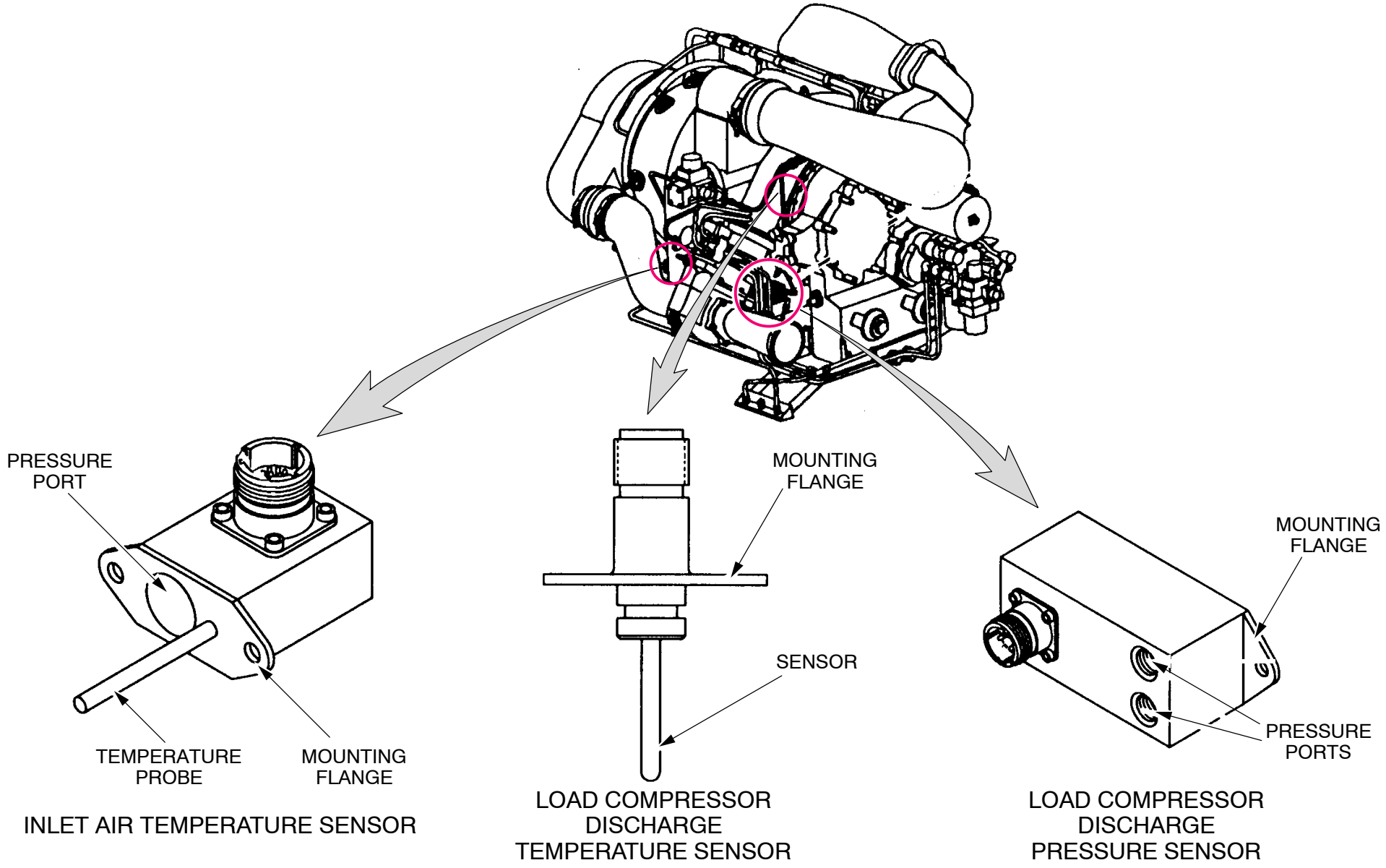


Figure 57 Air System Sensors

ACCESSORY COOLING OPERATION

Cooling Fan

The cooling fan (driven by one of the gears of the gearbox) provides air circulation for the oil cooler and for the ventilation of the engine compartment.

A cooling fan integral generator serves as a PMG (**P**ermanent **M**agnetic **G**enerator) also provides an emergency direct current supply to the electronic control box, should the Main supply fail.

- Cooling fan rotation speed is 51965 RPM
- Permanent Magnet Generator output is 40V DC (100 % of N).

  It is used as an emergency supply to the ECB in the event of a faulty main supply
- Speed signal for backup of the overspeed protection system: 107 %
- Compartment cooling valve is operated by air pressure to provide compartment ventilation when the APU is operating.

Location

The cooling fan is located at the top of the gearbox front face and is secured by a V–band clamp.

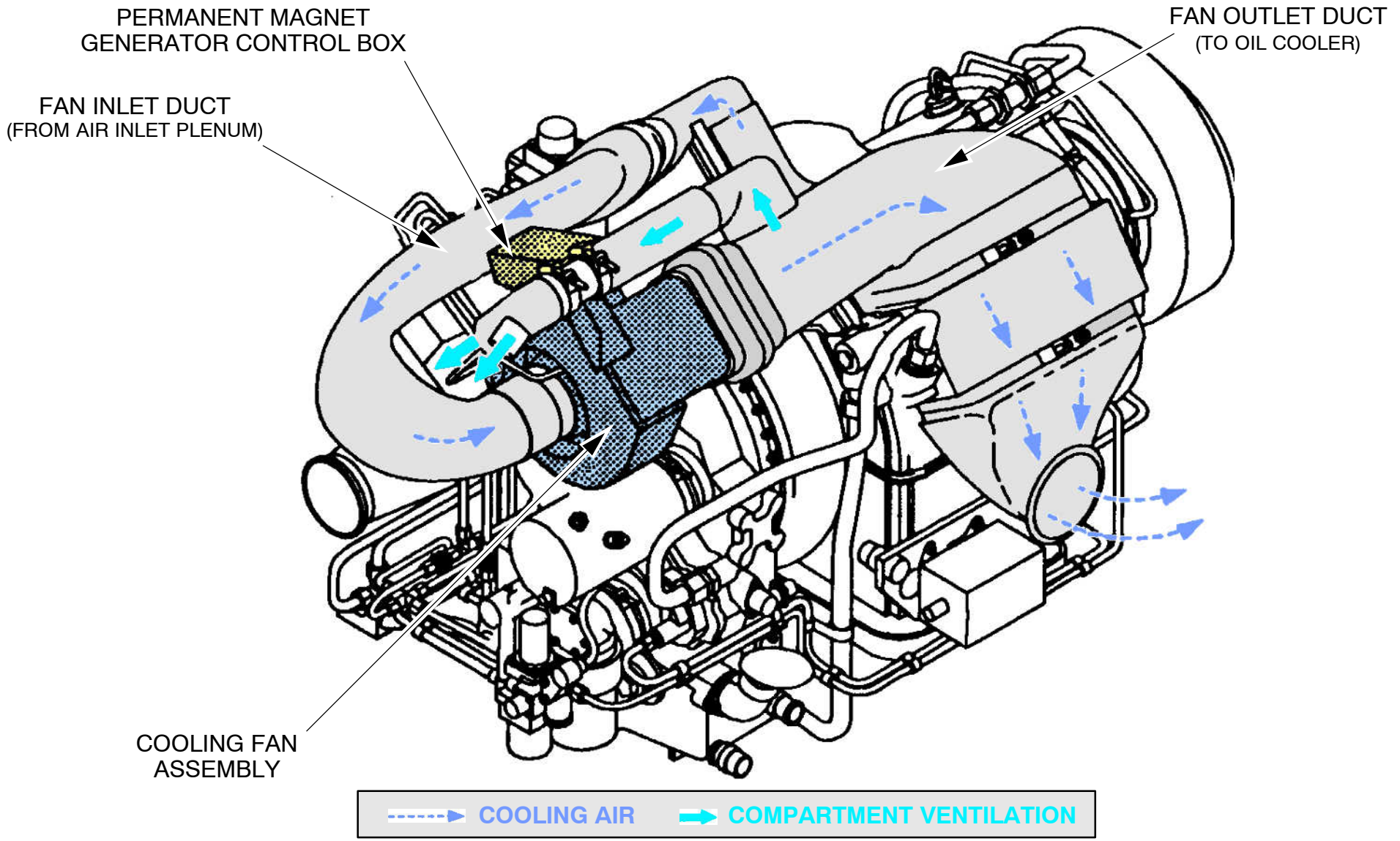


Figure 58 Accessory Cooling Components

49–40 IGNITION AND STARTING

INTRODUCTION

Starter Control

The starting system drives the APU (**A**uxiliary **P**ower **U**nit) rotor through a clutch and gearbox. When the APU speed is 55% rpm, the start logic of the ECB (**E**lectronic **C**ontrol **B**ox) cuts off the supply to the start contactors, which switch off the starter motor. The timed acceleration loop of the ECB causes the APU to accelerate to reach the governed speed.

Ignition Control

The ignition system is used to ignite and maintain combustion during the start phase. It operates from initial crank up to 55% rpm.

The ignition system includes the subsequent components:

- One Ignition Unit
- Two Ignition Leads
- Two Igniter Plugs

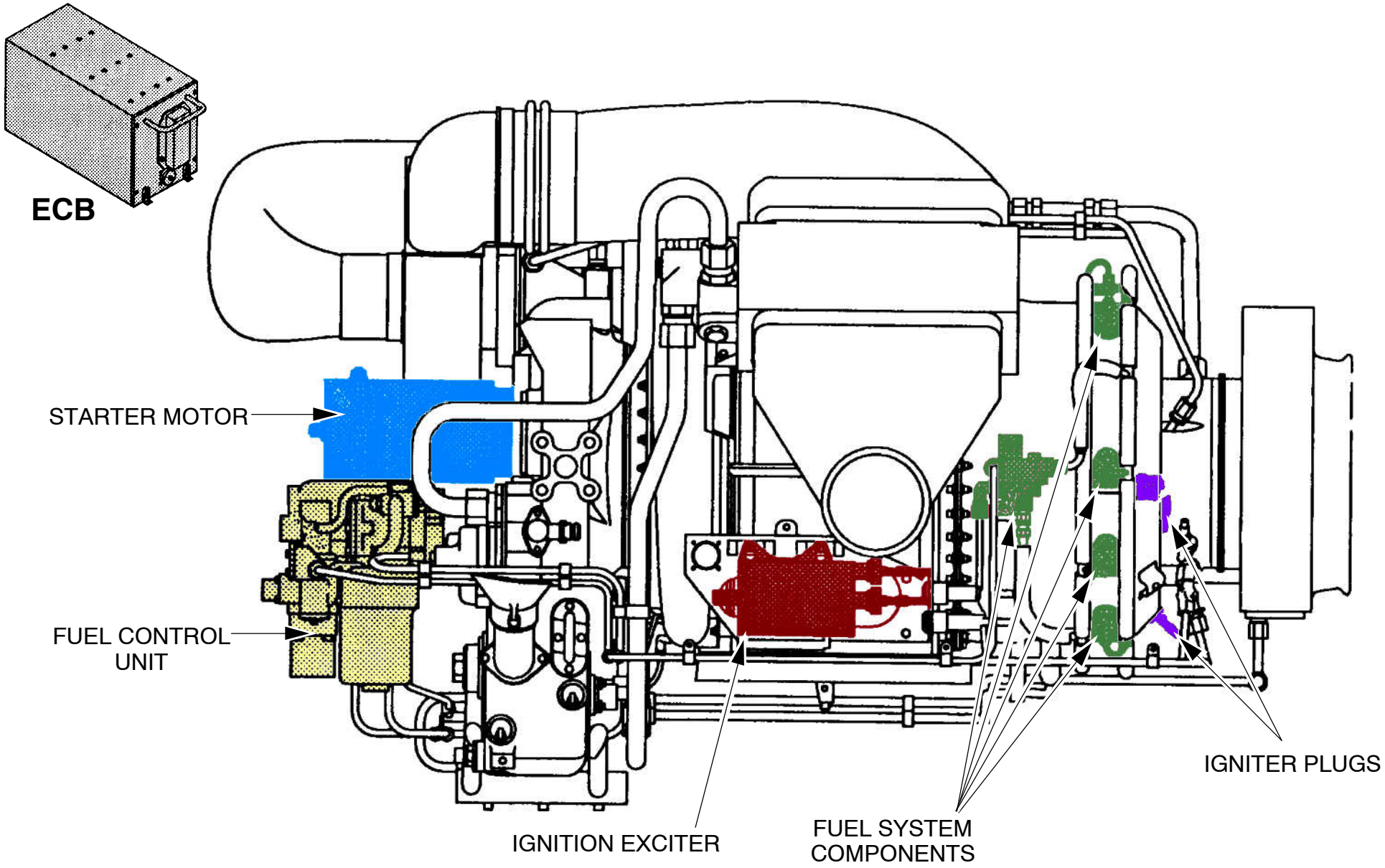


Figure 59 Ignition and Starting System Layout

IGNITION AND STARTING SYSTEM DESCRIPTION

General

The starting system rotates and accelerates the rotor of the APU to 55 % of the APU speed. The system also prevents excessive battery power consumption if the APU does not start. Three starts, one after the other (with a one minute interval) are allowed. After a third unsuccessful try the starter motor must cool down for at least 60 minutes.

NOTE: During RAT (**R**am **A**ir **T**urbine) extension, APU starting is inhibited by the BCL1 and BCL2 (**B**attery **C**harge **L**imiter), which prevents operation of the main start contactor.

Starting Sequence Initiation

The APU MASTER SW and the START switch are installed on the overhead panel 25VU in the cockpit. The start sequence begins when the MASTER SW and then the START switch have been pressed to the ON position. The main relay is energized when the MASTER SW is pressed.

Starting Operation

After the start push button is pressed the following sequence occurs:

- The Air Intake Flap is checked to be open
- 100ms later the backup start contactor is energized,
- 1.5 sec later the gearbox de–oiling valve solenoid, the exciter and the main start contactor are energized
- At N > 3% the 3 way fuel solenoid valve is energized
- At N > 15% acceleration control to 100% is initiated,
- At N > 55% the exciter is turned off and the gearbox de– oiling valve solenoid and the main start contactor are de–energized
- 5 sec. later the backup start contactor is de–energized
- At N > 95% the surge control is initiated
- 2 sec later the APU available signal is activated and the start in progress signal is de–activated
- steady state speed control is initiated and APU operates in the run state.

  The EGT increases as the APU accelerates, with starter motor assistance.

  Both, speed and EGT can be seen on the ECAM APU system display page, when selected.

  The ECB monitors and controls the APU. It will shutdown the APU if the acceleration rate is not as shown:

  – 0.1 % per sec when gearbox oil temp is below or equal to –40 °C
  – 0.5 % per sec when gearbox oil temp is greater than 21 °C
- acceleration rate is linear interpolated when –40 °C and gearbox oil temperature is below or equal to 21 °C

  You can start the APU again if it is shutdown. To do this, the MASTER SW must be switched off (until the inlet flap has closed) and then ON again, before each start attempt.

Engagement of the starter motor is prevented when the APU speed is above 7 %, to prevent damage to the APU.

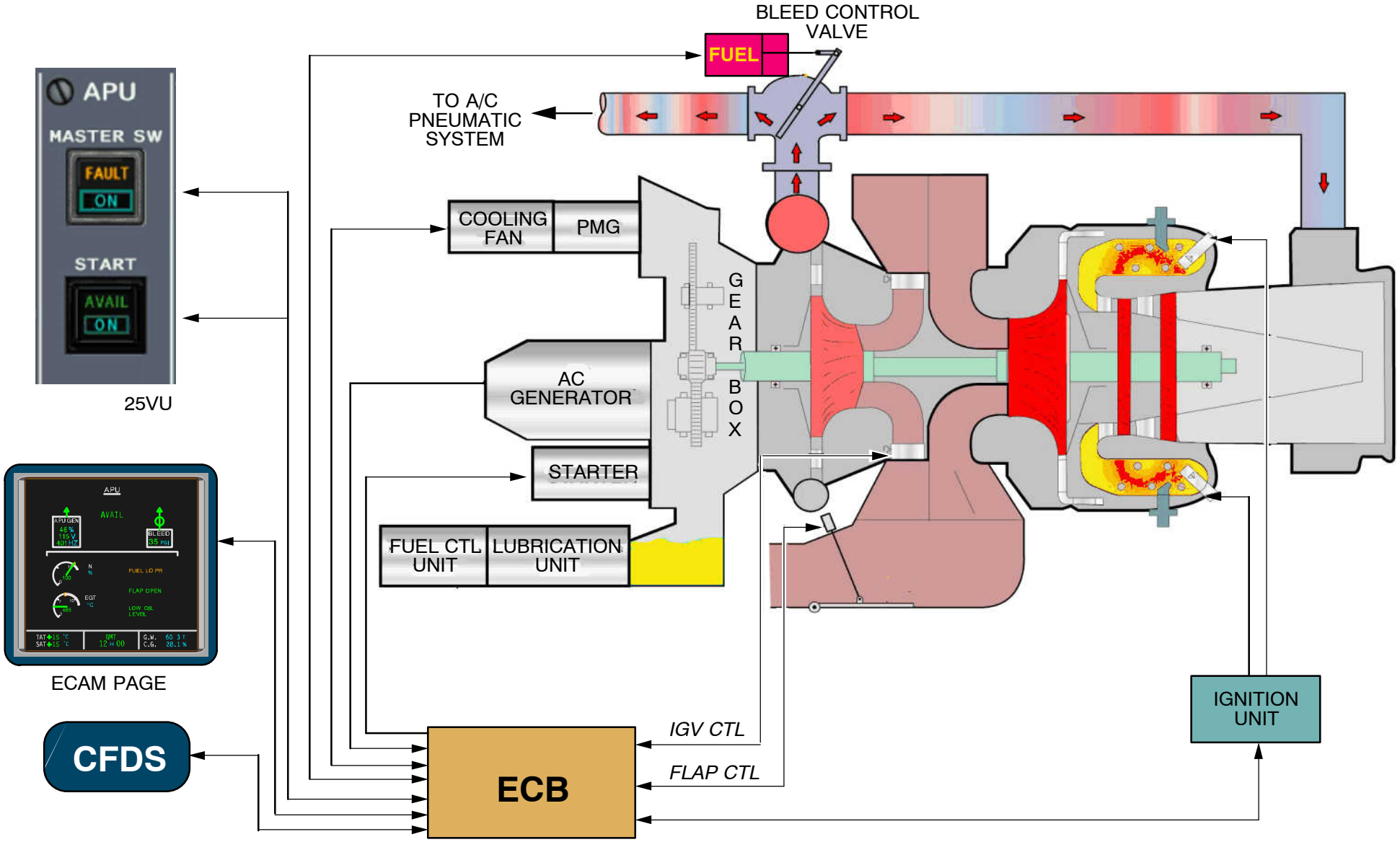


Figure 60 Ignition & Starting System Schematic

COMPONENT LOCATION

Main and Backup Start Contactor

The main start contactor 5KA and the back–up start contactor 10KA are installed in the 120VU which is located in the rear of the cockpit. In this location there is also the 400 ampere APU starter fuse installed.

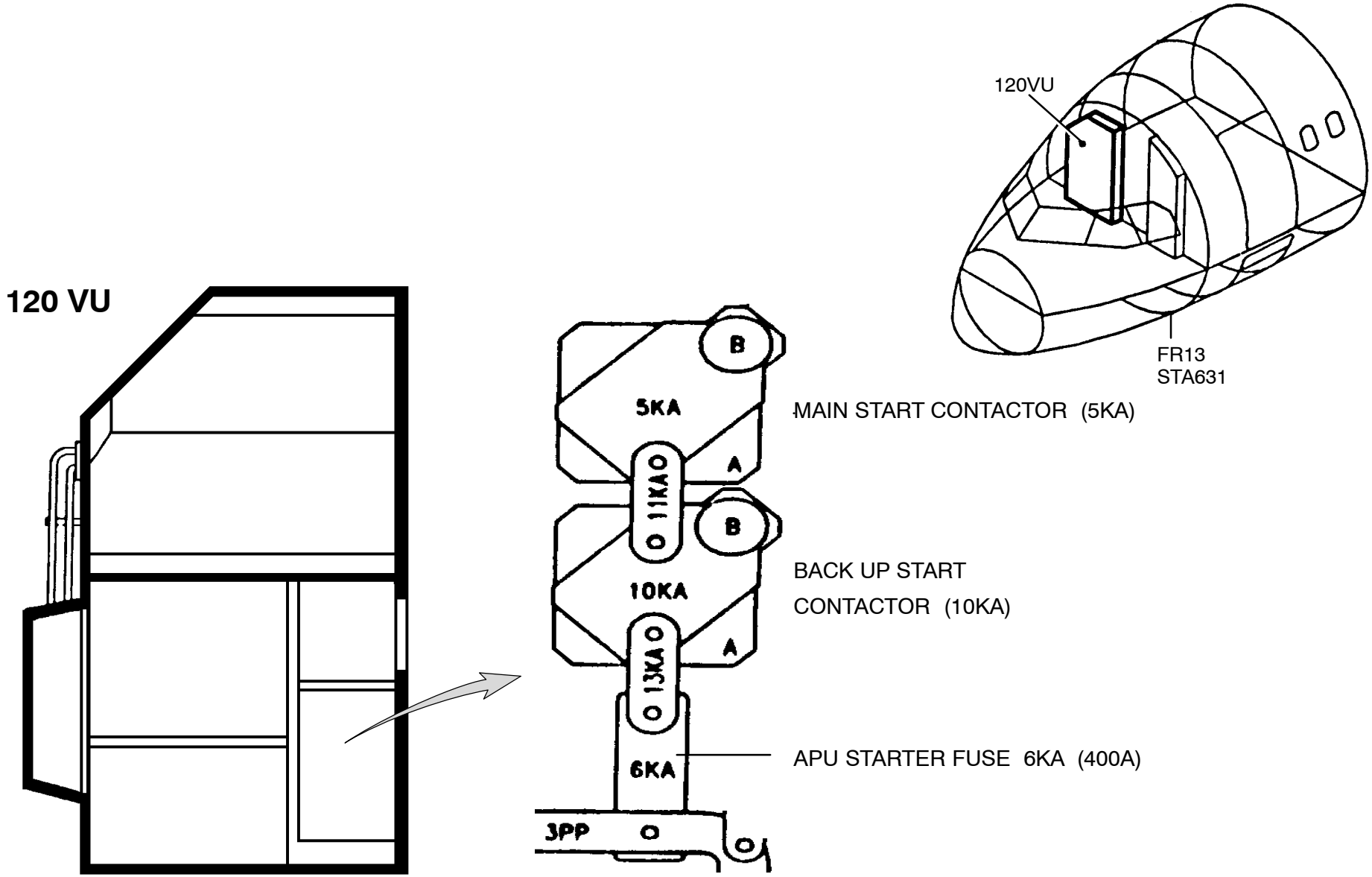


Figure 61 Starting System Components (CFDS Monitored)

COMPONENT DESCRIPTION

Starter Motor

The starter motor 8KA is a series wound DC electric motor with four poles and four brushes, and has a maximum speed of 17600 rpm. Both the positive and negative terminals are insulated.

It is equipped with a visual and an electrical brush wear indicator. The visual indicator pin protrudes up into a clear plastic cover. As the brush with the indicator pin wears, the pin goes into the cover until it becomes flush inside the cover. When the pin is visible, it is time to remove the starter motor and replace the brushes.

A voltage sense connector is internally wired to the positive terminal cable (this voltage signal is used by the ECB).

The starter motor weighs approx. 10 pounds and is attached to the gearbox with a V–clamp.

The starter motor operates on 28V DC with a normal starter voltage being approx. 18V DC. It drives the APU rotor to 55% of the APU speed through a clutch assembly between the motor and the gearbox. At 55 % APU speed the electrical power is removed from the starter motor.

Starter Sprag Clutch

Two operating phases are considered: starter motor engaged and starter motor disengaged.

- Starter motor engaged

  During start, the starter motor applies torque to the inner race; the sprag pawls pivot and lock the two races which accelerate together.

- Starter motor disengaged

  At self–sustaining speed, the electrical supply to the starter motor is de–energized while the APU continues to accelerate. The sprag pawls disengage and the centrifugal force keeps them outward to prevent friction against the inner race.

Start Contactor and Backup Start Contactor

The start contactor 5KA and the backup start contactor 10KA are installed on rack 120VU, rear of the cockpit. These are heavy duty contactors that switch electrical current to the starter motor 8KA.

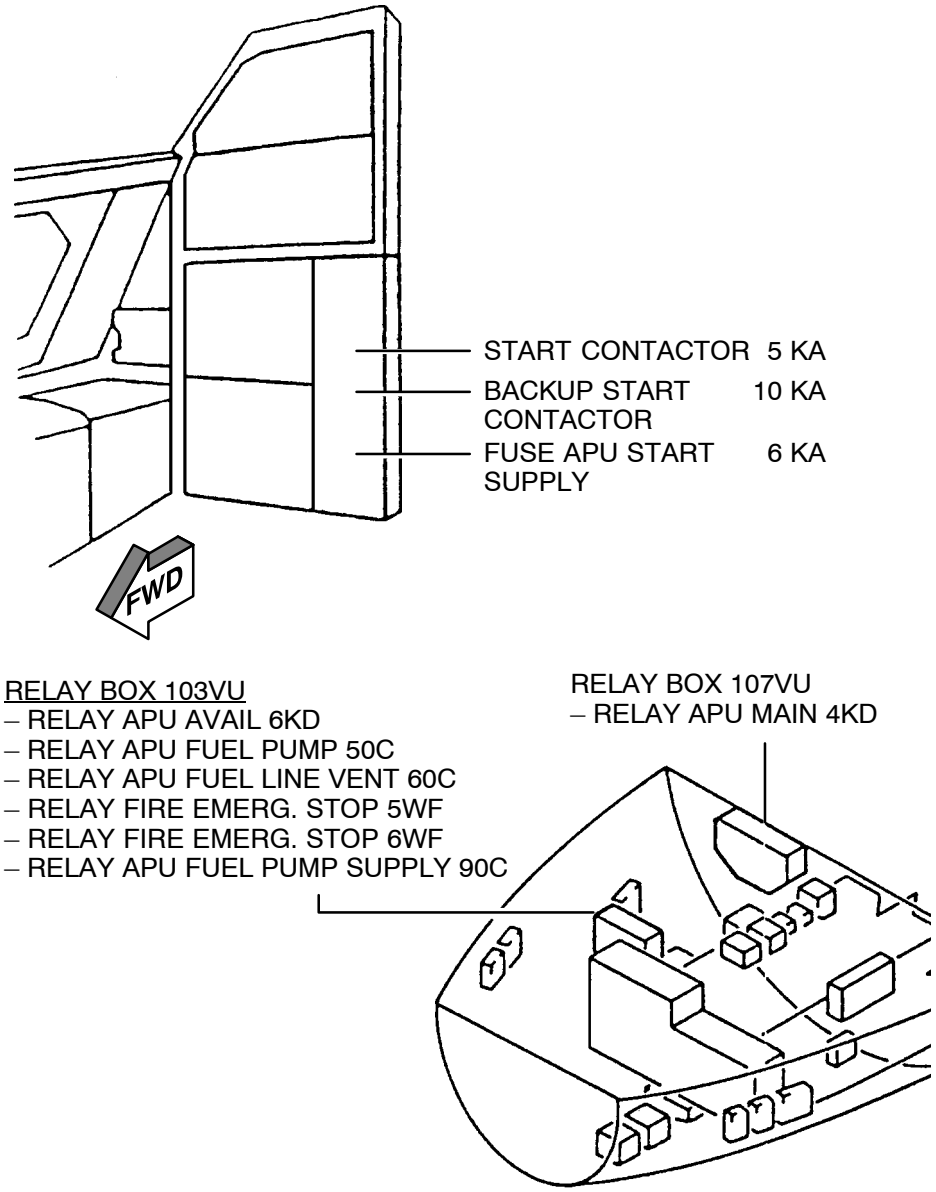
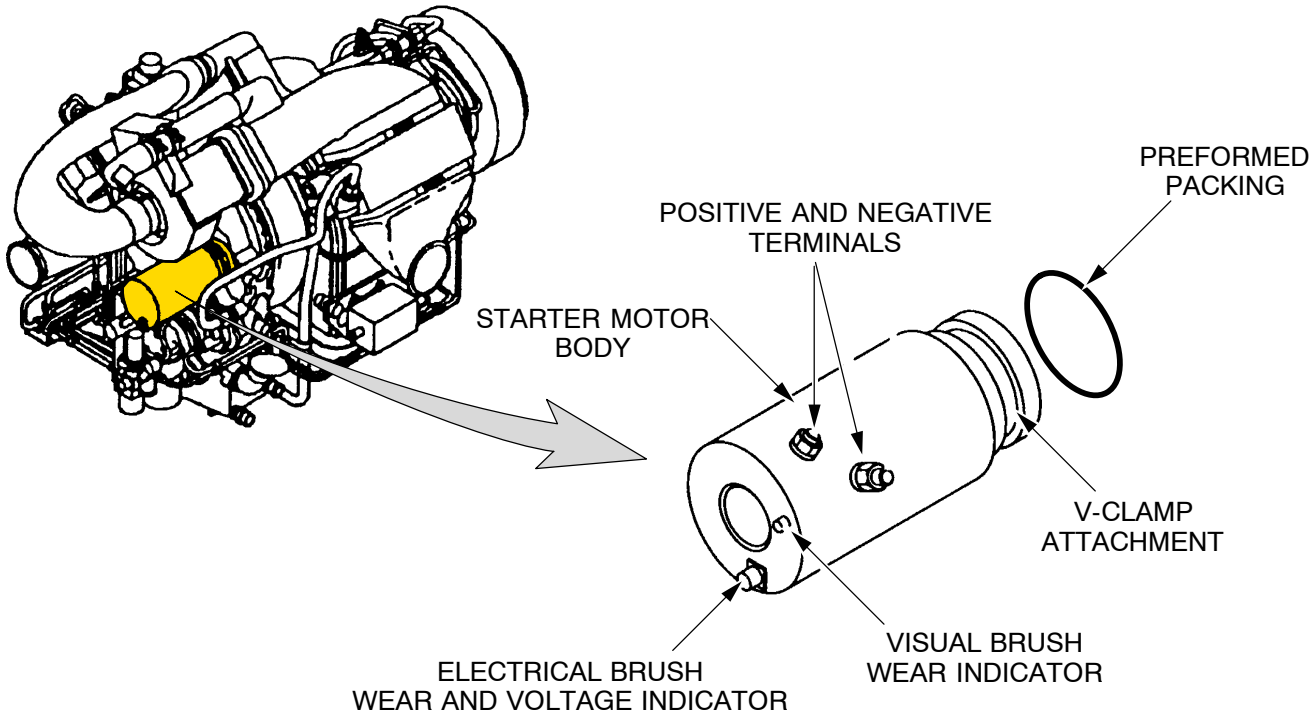
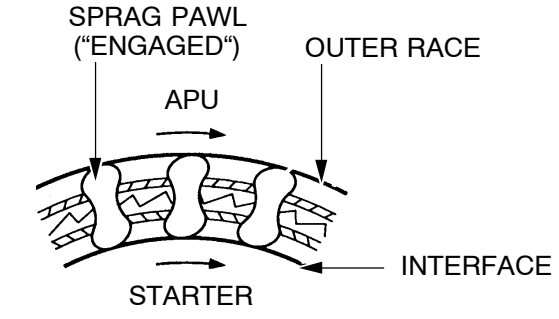
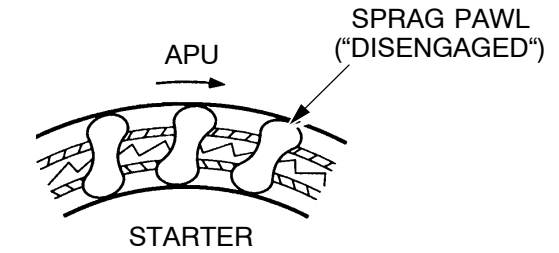


Figure 62 Component Location

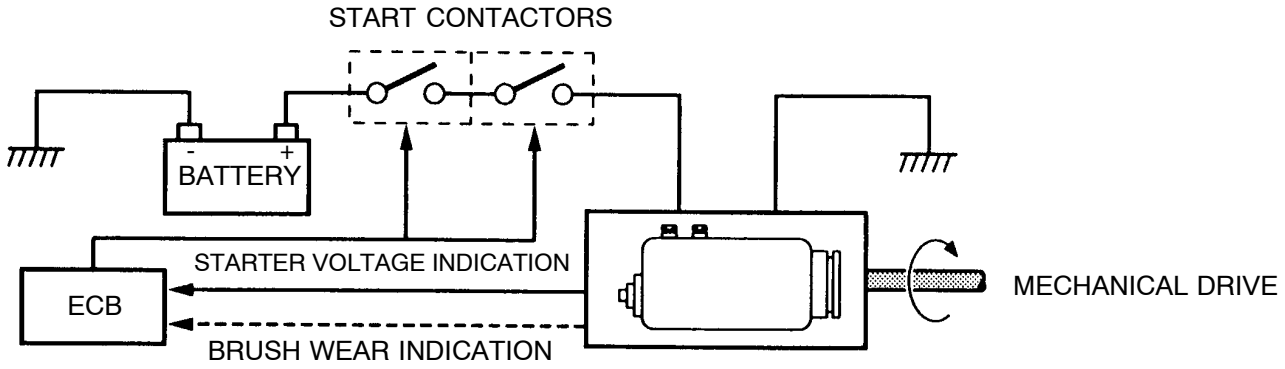




STARTER MOTOR ENGAGED



STARTER MOTOR DISENGAGED



STARTER SPRAG CLUTCH OPERATION

Figure 63 Starter Motor and Sprag Clutch

Ignition Exciter

The ignition exciter is a sealed metal box assembly with a mounting bracket on one side.

Power is supplied to the ignition exciter through a multi–pin electrical connector installed on one end of the box. The two igniter leads connect the two connectors, located on the opposite end of the box, to the igniters. The unit is shop–repairable only.

The ignition exciter transforms the low DC voltage into a high energy supply for the igniters.

Ignitor Plug

Two igniter plugs produce the sparks required to ignite the fuel during the initial phase of starting. Two igniter cables carry high voltage current from the ignition exciter to the igniter plugs.

The two igniter plugs are located at the rear of the combustor housing close to the two pilot fuel injectors:

- One at 5 o’clock
- One at 9 o’clock

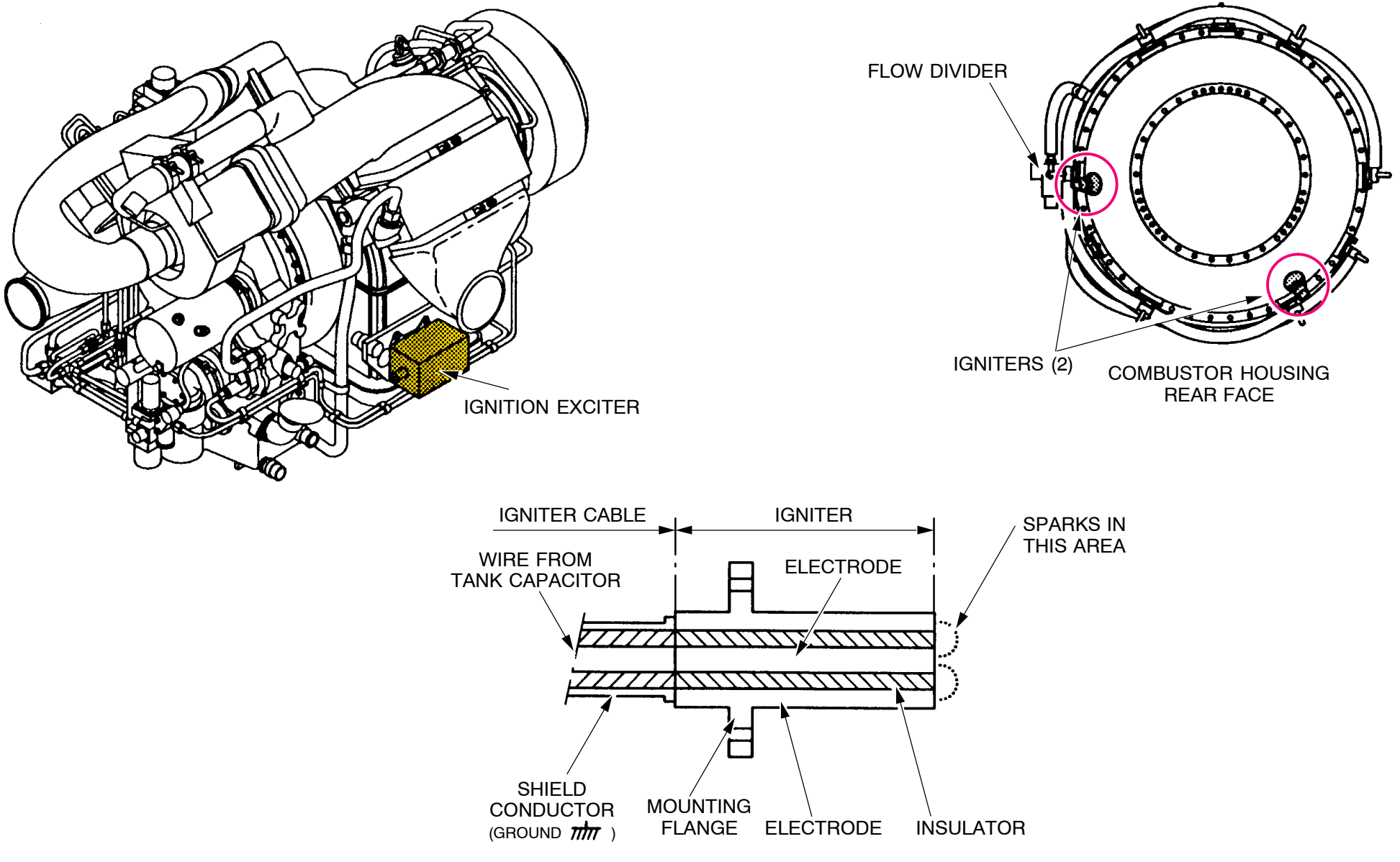


Figure 64 Ignition Components

49–60 ENGINE CONTROLS

GENERAL

Functions

The functions of the APU Control System FADEC (**F**ull **A**uthority **D**igital **E**lectronic **C**ontroller) are:

- To keep the power unit rotation speed constant so as to obtain a constant AC generator frequency output,
- to protect the power unit from overtemperature,
- to avoid load compressor surge,
- to ensure a quick and safe start of the power unit,
- to provide the sequences of the operating states,
- to protect the APU in case of a component defective operation and
- to ease the APU maintenance by supplying information for trouble shooting, engine condition and life (historical data retention).

Main Features

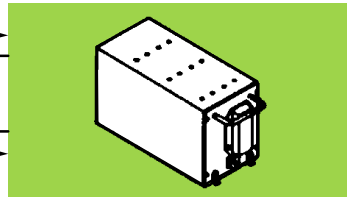
- FADEC
- Single computer
- Electrical supply from the aircraft DC system and the APU Generator

APU CONTROL
- CONSTANT ROTATION SPEED N 100 %
- EGT LIMITATION
- LOAD COMPRESSOR SURGE PROTECTION
- QUICK AND SAFE START
- OPERATION SEQUENCES

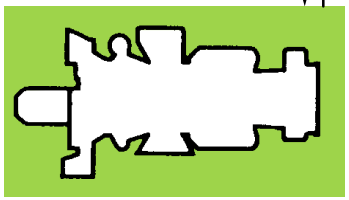
APU MAINTENANCE
- TROUBLE SHOOTING
- CONDITION MONITORING DATA
- HISTORICAL DATA RETENTIONS

APU PROTECTION
- SHUTDOWN
- INDICATION

AIRCRAFT
CONTROL PANELS



ELECTRONIC CONTROL BOX



APU ACCESSORIES

Figure 65 APU Control System

ECB BITE

General

The ECB is a fully digital electronic controller. It does self tests, protective shutdowns and continuous monitoring of APU function.

APU continuously monitored functions are:

- Start sequence and Shutdown sequence incl. automatic shutdown
- Speed (N)
- EGT (**E**xhaust **G**as **T**emperature)
- Bleed air supply

Power Supply

The ECB is electrically supplied with 28V DC when the APU MASTER SW push button is set to ON.

An internal TRU (**T**ransformer **R**ectifier **U**nit) supplies the ECB circuit with 24V DC power. The ECB continuously monitors its internal voltages and shuts down the APU in case of DC power loss. When the APU is running, its APU PMG supplies the internal TRU maintaining the APU control in case of short interruption of normal DC power.

BITE

The BITE (**B**uilt **I**n **T**est **E**quipment) of the ECB makes an analysis of the performance of the APU. The readout of this analysis is shown on the MCDU, through the functions of the CFDS.

The BITE of the ECB operates in three main modes:

- Power Up Test mode
- In Operation Test mode
- Self Test mode.

The test mode depends on the step of APU operation and which of the LRUs are examined.

The BITE memory of the ECB keeps the analysis data which are:

- the APU life data (containing the serial number of the APU, operating hours and APU cycles).
- the APU fault data (when an LRU fails the ECB shuts down the APU and the failed LRU information is kept in the BITE fault memory which is non–volatile).

Power up test (POST)

As soon as the MASTER SW Push Button is set to ON, the BITE of the ECB starts the Power Up Test. It sends test signals to the different control system components and sensors and does the analysis of the replies.

The ECB makes a decision according to the collected data and permits or not the APU start attempt. If any non–critical LRU has failed, it permits the APU start to continue and uses alternate values and schedules. The failed LRUs are memorized in the BITE fault memory.

NOTE: The POST takes approximately 3 seconds. the APU will start only if it is completed.

In Operation Test

During APU start, operation and shutdown, the BITE of the ECB continuously monitors the APU operation limits. It makes sure that the APU operates in a pre–programmed envelope.

During an APU start, the BITE of the ECB monitors the APU performance and stops it if it leaves the limits. The cause is memorized in the BITE fault memory. According to the type of failed LRU, it permits or not the operation of APU using alternate values and schedules. When the APU operates outside of its limits according to the APU configuration and flight phase, the ECB stops the APU. The fault is memorized in the BITE fault memory.

Self Test

The Self Test is initiated from the MCDU APU menus when the APU is not running. It examines all the internal ECB and external APU circuits. A record of LRU failures is transmitted to the CFDS.

The Self Test is also used to make sure that the system works correctly after a maintenance action.

NOTE: Do the self test only if APU is not running. It takes also approximately 3 seconds.

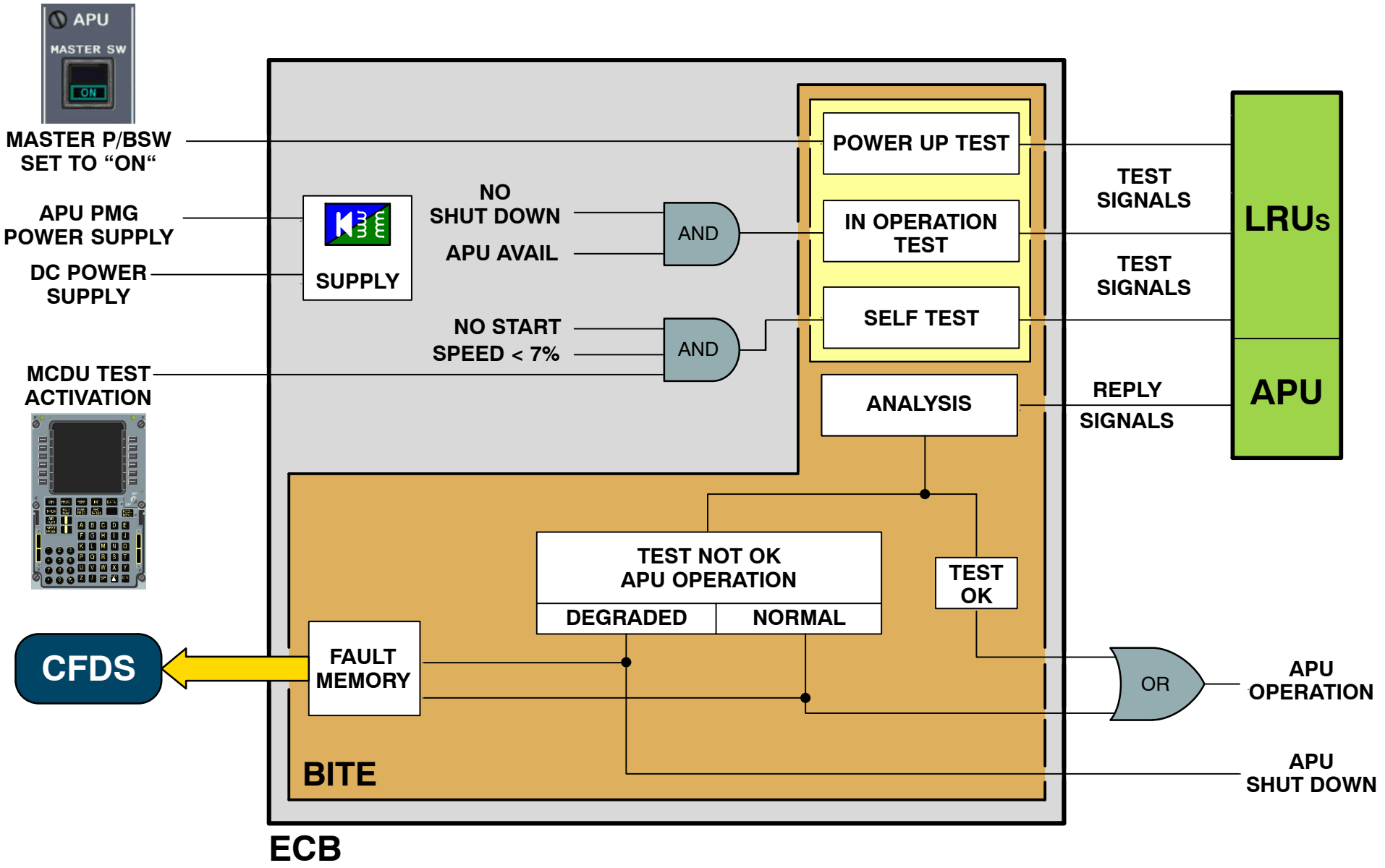


Figure 66 ECB Bite Schematic

BITE TEST AND FAULT INDICATION

General

By the use of both MCDUs (**M**ulti Function **C**ontrol and **Display U**nits) in the cockpit and the CFDS (**C**entralized **F**ault **D**isplay **S**ystem) it is possible to do a Fault analysis and an APU System Test.

The MCDU shows the APU information in normal mode and menu mode through the CFDS.

Normal Mode

During a normal mode the ECB continuously transmits all class 1 and 2 faults and messages to the CFDS. The MCDU display shows the faults and messages when the ”LAST LEG REPORT” is set. The CFDIU creates the display on the MCDU in a normal mode.

Menu Mode

The menu mode is available on the MCDU display when the ”SYSTEM REPORT TEST” is set and an “APU“ selection is made. The MCDU display shows the related APU system data and the faults when a selection of the APU menu is made. The ECB makes the display on the MCDU in a menu mode.

The APU menu includes the:

- LAST LEG REPORT,
- PREVIOUS LEG REPORT,
- LRU IDENTIFICATION,
- SYSTEM SELF TEST,
- APU DATA / OIL,
- SHUT DOWNS,
- CLASS 3 FAULTS.

1. < LAST LEG REPORT >

This gives the LRU failures (class 1 and 2) during the last flight leg, related to the system selection.

2. < PREVIOUS LEG REPORT >

This gives all the LRU failures (class 1 and 2) for the previous flight legs, a maximum of 30 failures.

3. < LRU IDENTIFICATION >

This gives the part and serial number of the ECB only.

4. < SYSTEM SELF TEST >

This will start a self test and will show any LRU failures (not related to class of fault).

5. < APU DATA / OIL >

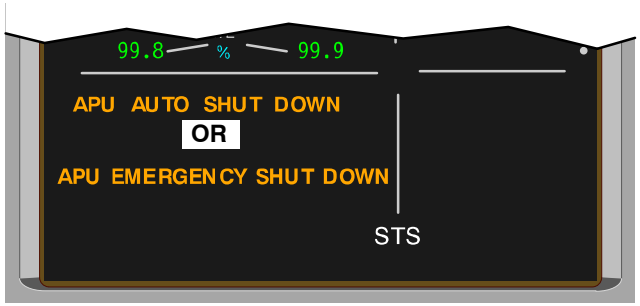
This gives the APU serial number, operation hours, cycles, ECB configuration (TSO or JAR) and the oil level.

6. <SHUT DOWNS>

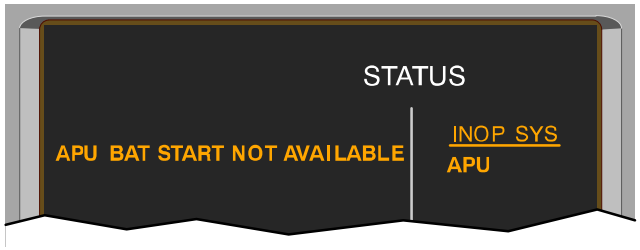
This gives the cause of the shutdown and the related class 1 LRUs. A list of the shutdown faults and texts of the possible causes is shown in tables 2, 3 and 5.

7. < CLASS 3 FAULTS >

This gives every class 3 fault that has occurred, see table 6. The MCDU display format changes. The change is related to the mode selection that is made. The text of the LRU failures is related to which LRU has failed. A sample of the LRU failures is given in tables 2, 3, 4 and 6. A flight ”LEG” is specified as from initial power up, through flight, to power off after the aircraft has landed.

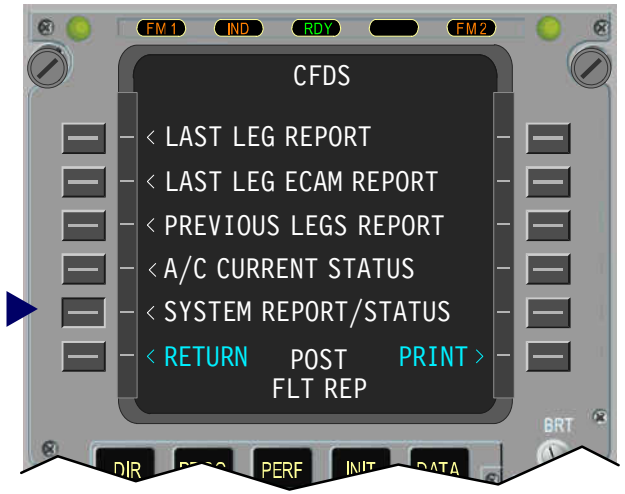


ENGINE WARNING DISPLAY



STATUS PAGE

STEP 1



MCDU

STEP 2

STEP 3

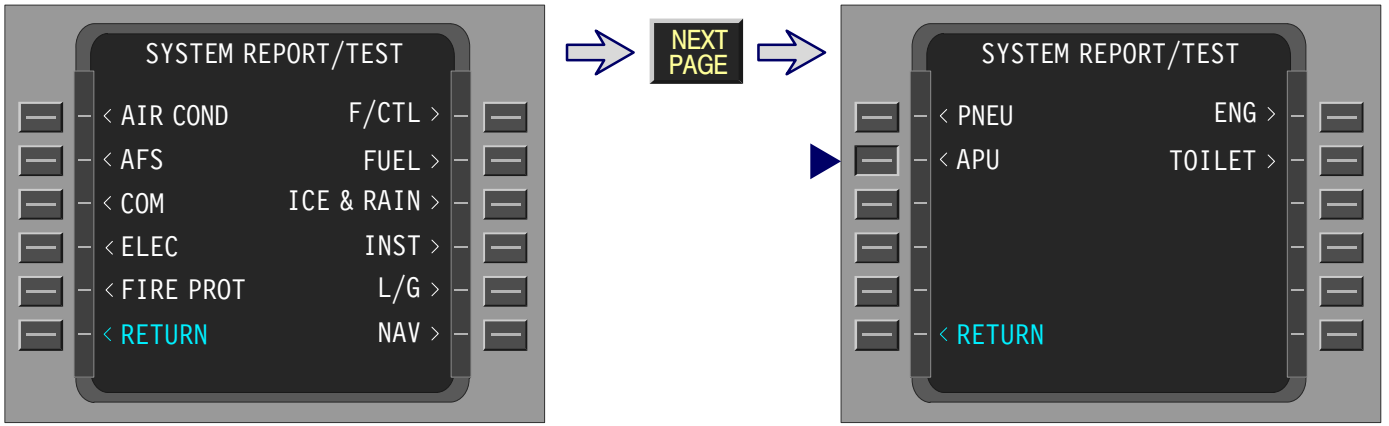


Figure 67 ECAM Messages and MCDU MENU

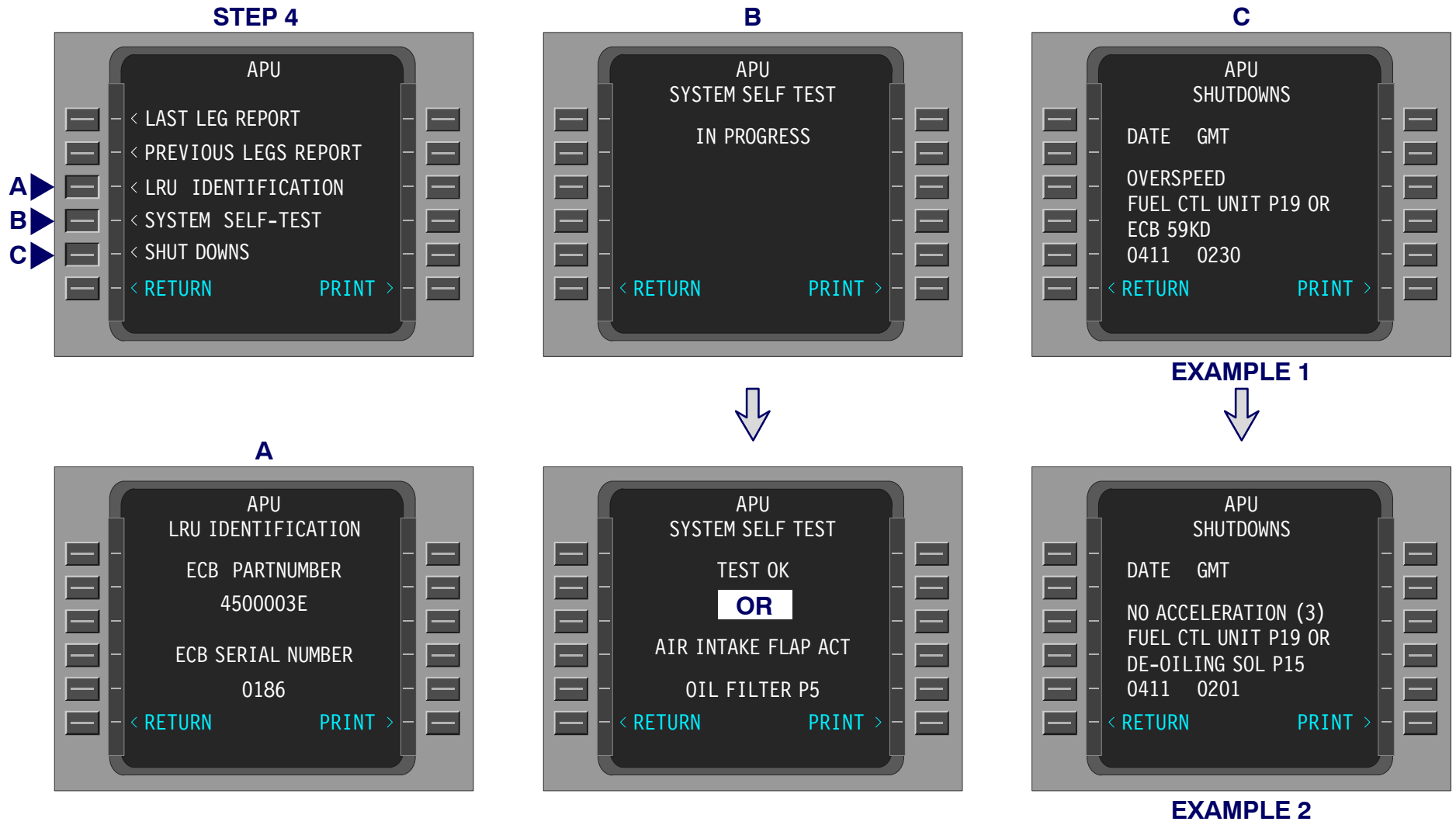
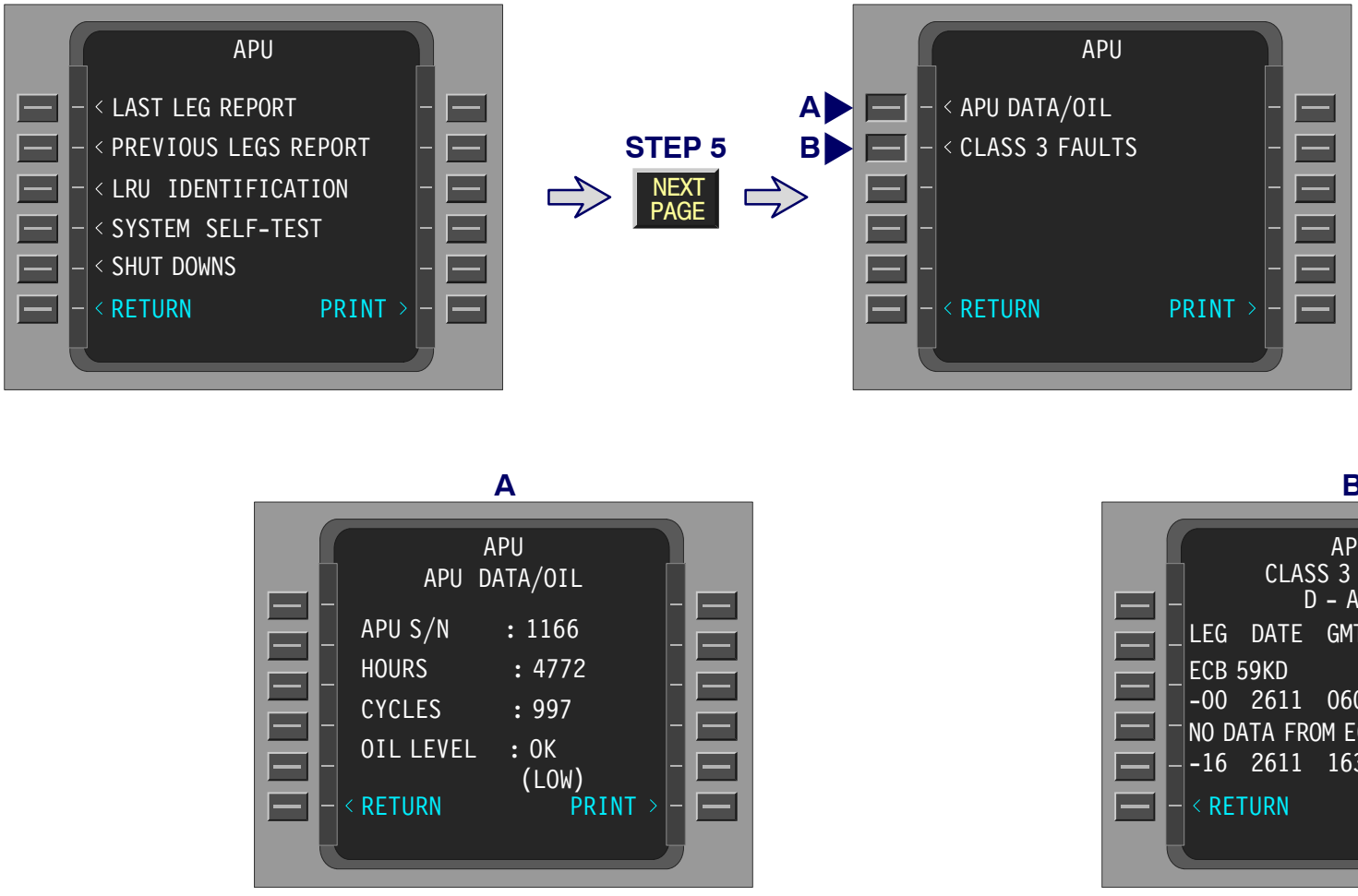


Figure 68 LRU IDENT, Self Test and S/D Reports



RESULT: NOT OK **RESULT: OK**

Figure 69 APU Data/Oil and Class 3 Reports

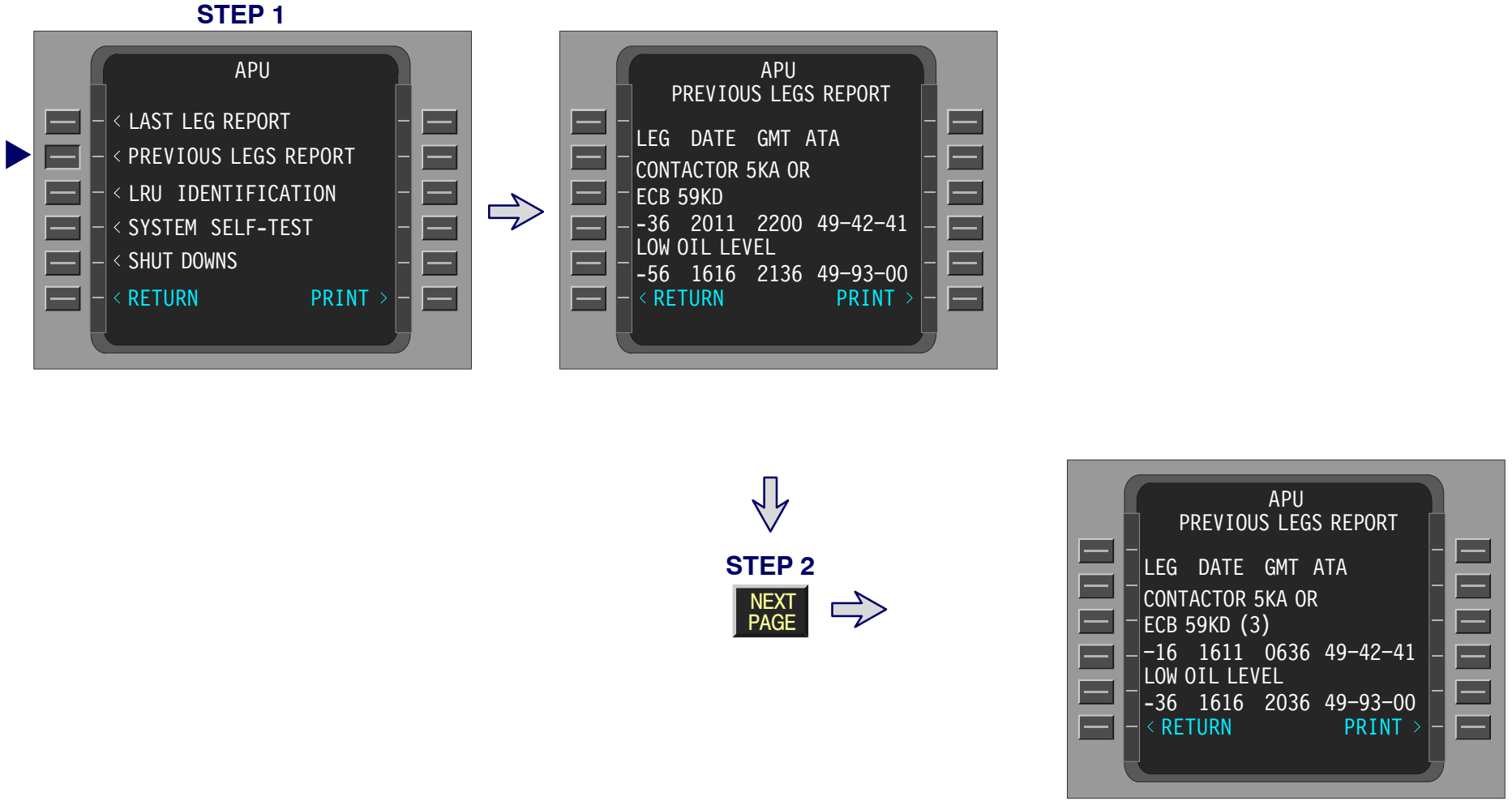


Figure 70 APU Previous Legs Report

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ELECTRONIC CONTROL BOX COMPONENT DESCRIPTION

FUNCTION OF ECB

The Electronic Control Box controls and monitors the Auxiliary Power System. This part lists all the inputs and outputs of the electronic control box.

ECB INPUTS

Analog Inputs

- Generator oil temperature sensor
- Inlet air pressure and temperature sensors
- EGT sensors
- Rotation speed sensors
- Oil level sensor
- Two oil temperature sensors (ENG oil and GEN oil temperature)
- Load compressor discharge air pressure sensors
- Load compressor discharge air temperature sensor
- Engine ID module (data entry plug)
- Inlet Guide Vane and Bleed Control Valve LVDTs
- Starter motor voltage sensor
- PMG

Discrete Inputs

- APU stop, emergency stop
- MES mode
- Air/Ground position
- TSO/JAR and A320/A321 configurations
- Load compressor valve activation
- Start contactor monitor, start command
- Air intake flap open and closed position
- Air intake flap movement
- Low fuel and low oil pressures
- Oil filter bypass

ECB OUTPUTS

APU Discrete and Analog Outputs

- Oil system de–oiling valve
- Oil level RTD
- GEN scavenge oil filter differential pressure switch
- LOP switch
- Pressure transducers excitation
- Inlet Guide Vane LVDT
- Bleed Control Valve LVDT
- Inlet Guide Vane, Bleed Control Valve and fuel servovalve
- Exciter
- 3 way solenoid valve.

Aircraft Discrete and Digital Outputs

- Back–up start contactor
- Main start contactor
- Aircraft relay
- Bleed control valve open
- APU available
- Start in progress
- Fault
- Flap open and flap closed command
- Aircraft serial communications (ARINC 429, RS 232 C).

APU ECB Location

The ECB is installed in the aft Cargo compartment

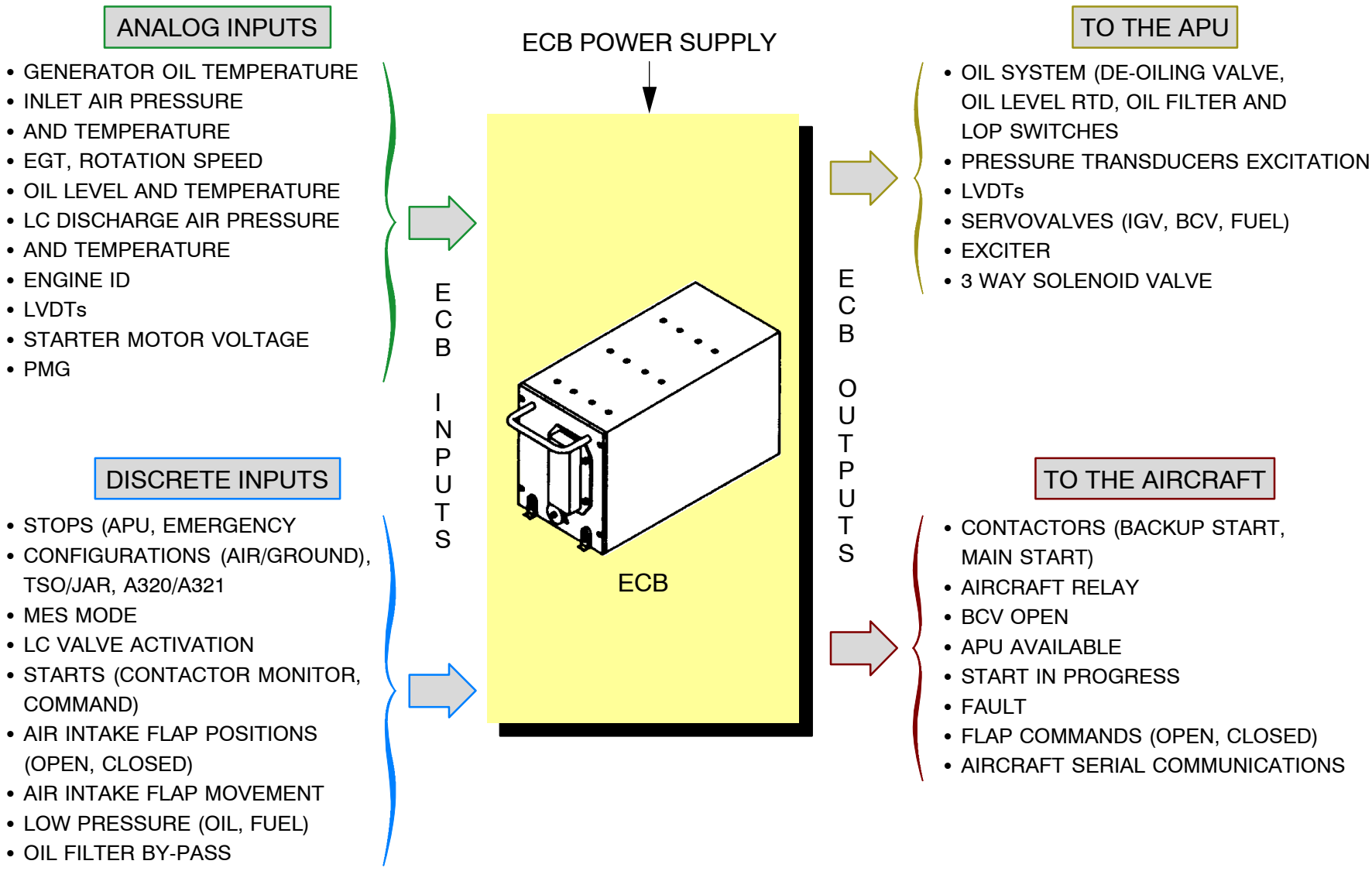

Figure 71 APU ECB Description

ECB POWER SUPPLY

Main Power Supply

With the APU Master Switch to ON the Main Relay 4KD will be powered from the aircraft electrical system via 301PP Battery Bus.

Emergency Backup Supply

When The APU is running a PMG (**P**ermanent **M**agnet **G**enerator) will backup the ECB power.

The PMG is part of the APU cooling fan.

The PMG sends also a speed signal to the ECB for a backup overspeed protection (shutdown).

Power Cutoff

The ECB power is cutoff, when the APU is shutdown and the air intake door is closed, or when the air inlet door fails to close (Door closing process exeeds 30 sec).

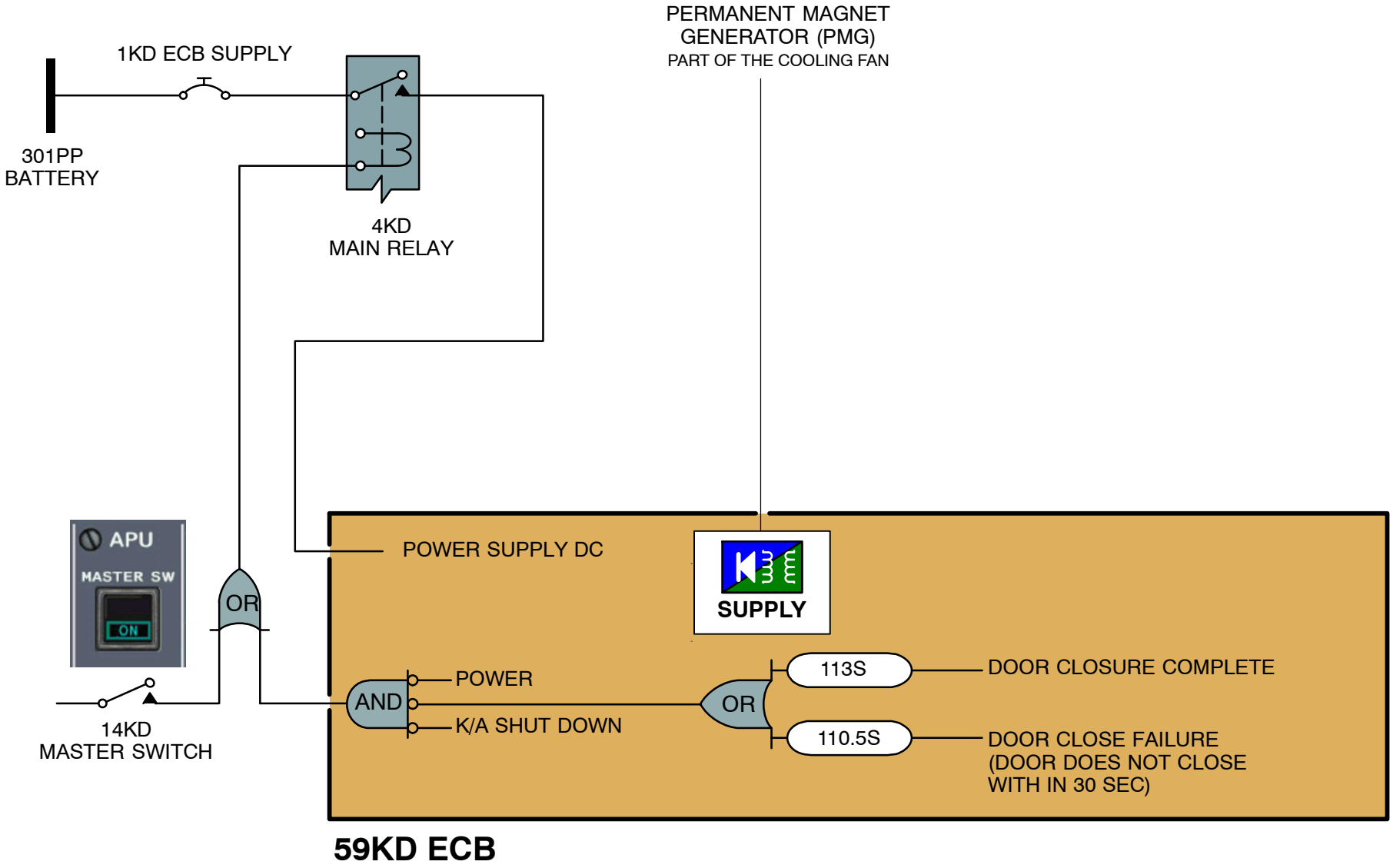

Figure 72 ECB Power Supply

49–61 CONTROL AND MONITORING

APU START EVENTS FUNCTIONAL OPERATION

APU Master switch- ”ON”

- APU main relay energizes (4KD)
- Inlet door opens
- APU fuel feed pump ”ON” (if pressure < 22PSI)
- APU fuel low pressure shutoff valve opens
- ECB performs power up test
- Inlet guide vanes are closed

Start switch actuated

- Backup start contactor 10KA closes
- 1,5 sec later main Start contactor 5KA closes
- Starter cranks APU
- ”ON” light in start P/BSW ”ON”
- Inlet guide vanes are closed
- De–oiling valve solenoid energizes (open)
- Exciter energizes (Ignition ”ON”)

ACCELERATION PROCESS

3 % RPM

- 3 way solenoid valve energized
- Servo valve pulses

5 % RPM

- ECB controls the ”basic” fuel flow to obtain correct ignition in combustion chamber.
- Delta EGT > 50 °F initiating acceleration control to 100 % RPM (fuel rate depending on EGT and acceleration).

55 % RPM

- Exciter deenergized (Ignition ”OFF”)
- De–oiling solenoid deenergized (closed)
- Main start contactor 5KA ”opens”
- Starter motor stops
- 55 % RPM + 5 sec later: Backup start contactor ”opens”

95 % RPM plus 2 sec

- ON light in start P/BSW ”OFF”
- AVAIL light in start P/BSW ”ON”
- Surge control activated
- Steady state speed control loop activation

100% RPM

- Steady state speed control active to keep constant speed
- Inlet guide vanes are closed until BLEED is switched ”ON”
- EGT control active (achieved by controlling IGV position)

APU SHUTDOWN EVENTS

COMMANDED SHUTDOWN

- Bleed switched ”OFF”
  If bleed was not switched ”OFF” a cool down timer is activated. (120 sec)
- IGV closed

SHUTDOWN

- Fuel Valve (3 Way Solenoid Valve) closes
- 1 sec later Fuel Servo Valve ”Closes”
- EGT and RPM drops

95 % RPM

- AVAIL light in start P/BSW ”OFF”

90 % RPM

- De–oiling solenoid energized (open)

7 % RPM

- De–oiling valve de–energizes (closed)
- Inlet flap closes
- APU main relay de–energizes
- APU fuel low pressure shut off valve closes and APU fuel feed pump stops.

PROTECTIVE AUTO SHUTDOWN OPERATION

Description

When the ECB is electrically supplied, it controls the APU starting and running phases. If an abnormal parameter is detected, it initiates an immediate shutdown without time delay, even if APU bleed air system is used.

- Main start contactor if failed open
- Back up start contactor if failed open
- LOP switch and OIL level RTD failed
- LOP switch and low oil level
- Overspeed/Back up overspeed
- Overtemperature
- Low oil pressure
- High oil temperature
- Failure EGT sensor No1 and No2
- Air intake flap not fully open
- IGV shut–down
- IGNITION unit
- No flame
- Reverse flow
- No acceleration/low acceleration
- DC power lost
- ECB failure
- Generator high oil temperature
- Loss of speed sensing No I and No 2
- Underspeed
- Generator and gearbox OIL RTDs lost
- Speed sensor No1 and opposite N–converter
- Speed sensor No2 and opposite N–converter
- 3 way fuel solenoid valve (FCU)
- Fuel servo valve (FCU)
- EGT sensor No1 and opposite EGT converter
- EGT sensor No2 and opposite EGT converter

EMERGENCY SHUTDOWN OPERATION

The ECB initiates an Emergency shutdown when either the APU FIRE pushbutton located in the cockpit is released out, or when the APU SHUT OFF pushbutton located on the external power receptacle panel is pressed.

The ECB initiates an automatic emergency shutdown when an APU FIRE is detected on ground.

The APU shuts down immediately without time delay, even if the APU bleed air system is used.

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49–73 ANALYZERS

FAULT TABLES PRESENTATION

NOTE: An (n) at the end of text messages, indicates the number of occurrences (when more than one). Occurrences of four or more are indicated with the number 4. In normal mode the ATA chapter will be transmitted without hyphens.

Class 1 faults

1st Table: These faults cause the APU to shutdown (or not available)

BITE Detection	ATA Chapter	Text for CFDS Indication
Main Start Contactor (if failed open)	49–42–41	CONTACTOR 5KA (n)
Back–up Start Contactor (if failed open)	49–42–42	CURRENT LIMITER 6KA OR CONTACTOR 10KA (n)
Main Start Contactor (if output open or shorted)	49–42–41	CONTACTOR 5KA or ECB 59KD (n)
B/U Start Contactor (if output open or shorted)	49–42–42	CONTACTOR 10KA or ECB 59KD (n)
Low Oil Pressure Switch /oil level RTD failed	49–94–14	OIL PRESS SW P14 and OIL LEVEL SNSR P8 (n)
Low Oil Pressure Switch and Low Oil Level	49–94–14	OIL PRESS SW P14 and LOW OIL LEVEL (n)
Air Intake Actuator (if inlet door failed in not fully open position)	49–16–51	AIR INTAKE FLAP ACTR (n)
Fuel Solenoid	49–32–11	FUEL CTL UNIT P19 (n)
Fuel Servo	49–32–11	FUEL CTL UNIT P19 (n)
Ignition Unit	49–41–38	IGNITION UNIT P10 (n)
ECB	49–61–34	ECB 59KD (n)
Speed Sensor No.1 and Speed Sensor No2	49–71–13	SPEED SNSRS P26, P27 (n)
Speed Sensor No.1 and opposite N–Converter	49–71–13	SPEED SNSR P26 AND ECB 59KD (n)
Speed Sensor No.2 and opposite N–Converter	49–71–13	SPEED SNSR P27 AND ECB 59KD (n)
EGT Sensor No.1 and EGT Sensor No.2	49–72–15	EGT TC1 P30 AND EGT TC2 P31 (n)
EGT Sensor No.1 and opposite EGT–converter	49–72–15	EGT TC1 P30 AND ECB 59KD (n)
EGT Sensor No.2 and opposite EGT–converter	49–72–15	EGT TC2 P31 AND ECB 59KD (n)
Generator and Gearbox Oil RTDs	49–91–51	OIL TEMP SNSR P25 AND GENERATOR 8XS (n)

2nd Table: These faults are likely to cause the APU to shutdown

BITE Detection	ATA Chapter	Text for CFDS Indication
Overspeed S/D, Primary	49–32–11	FUEL CTL UNIT P19 OR ECB 59KD (n)
Overspeed S/D, Backup	49–61–34	ECB 59KD (n)
Overtemperature S/D	49–23–51	IGV ACTR P21 OR FUEL CTL UNIT P19 (n)
Low Oil Pressure S/D	49–91–00	CHECK OIL LEAKAGE OR OIL PRESS SW P14 (n)
High Oil Temp S/D	49–52–51	COOLING FAN/PMG ASSY OR OIL COOLER ASSY (n)
No Flame S/D	49–41–38	IGNITION UNIT P10 OR FUEL CTL UNIT P19 (n)
No Acceleration S/D (Low Acceleration)	49–32–11	FUEL CTL UNIT P19 OR DE–OILING SOL P15 (n)
Reverse Flow S/D	49–51–19	BLEED FLOW XDCR P24 OR BLEED CONTROL VALVE P33 (n)
Generator High Oil Temperature S/D	49–91–00	CHECK OIL SYSTEM OR GENERATOR 8XS (n)
Loss of DC Power	–	–
Emergency Stop	–	–
Underspeed S/D	49–32–11	FUEL CTL UNIT P19 (n)
No Acceleration S/D (Fail to Crank)	49–42–51	STARTER MOTOR 8KA OR STARTER CLUTCH ASSY (n)
No Acceleration S/D (Deceleration)	49–32–11	FUEL CTL UNIT P19 OR FUEL FLOW DIVIDER (n)
No APU Connected	–	–
Overspeed S/D, Backup (Fan/PMG Assembly)	49–52–51	FAN/PMG ASSY OR ECB 59KD (n)

3rd Table: These faults lead to reduced air bleed performance

BITE Detection	ATA Chapter	Text for CFDS Indication
Delta P Transducer	49–51–19	BLEED FLOW XDCR P24 (n)
Bleed Flow Transducer	49–51–19	BLEED FLOW XDCR P24 (n)
Bleed Control Valve	49–51–53	BLEED CTL VLV P33 (n)
IGV Actuator	49–23–53	INLET GUIDE VANE ACTR P21 (n)
Failed 10V Pressure Excitation	49–61–34	ECB 59KD OR APU HARNESS (n)
T LCD Temp. RTD	49–23–16	LCDT SENSOR P29 (n)
T Inlet Sensor	49–23–17	INLET TEMP/PRESS SNSR P22 (n)
P Inlet Sensor	49–23–17	INLET TEMP/PRESS SNSR P22 (n)
LC reverse flow detected	49–51–19	BLEED FLOW XDCR P24 (n)

Class 2 faults

These faults may have consequences if a second fault occurs

BITE Detection	ATA Chapter	Text for CFDS Indication
Fuel Low Pressure	49–34–00	FUEL LOW PRESSURE OR LOW FUEL PRESS SW P17 (n)
Air Intake Actuator Failed in Not Fully Closed Position	49–16–51	AIR INTAKE FLAP ACTR (n)
ECB	49–61–34	ECB 59KD (n)
Oil Filter (scavenge generator)	49–91–41	OIL FILTER P5 (n)
Fuel Valve Stuck Open	49–32–11	FUEL CTL UNIT P19 (n)
Low Oil Pressure Switch	49–94–14	OIL PRESS SW P14 (n)
Low Oil Level Sensor	49–93–17	OIL LEVEL SNSR P8 (n)
Low Oil Level	49–93–00	LOW OIL LEVEL (n)
Illogical Flap Actuator Switch Inputs	49–16–51	AIR INTAKE FLAP ACTR (n)

Class 3 faults

No shutdowns

BITE Detection	ATA Chapter	Text for CFDS Indication
APU Serial Number Encoder	49–73–51	SERIAL NUMBER ENCDR P20
ECS Demand Signal	21–63–34	NO DATA FROM ECS
Incorrect ID Pin Coding	49–61–00	WRG ACFT TYPE PIN PROG OR ECB 59KD
EGT Sensor No.1	49–72–15	EGT TC1 P30
EGT Sensor No.2	49–72–15	EGT TC2 P31
Speed Sensor No.1	49–71–13	SPEED SNSR P26
Speed Sensor No.2	49–71–13	SPEED SNSR P27
Gearbox Oil Temp RTD	49–91–51	OIL TEMP SNSR P25
Generator Oil Temp RTD	24–23–51	GENERATOR 8XS
Gearbox Deprime Valve	49–91–49	DE–OILING SOL P15
Cold Junction RTD	49–61–34	ECB 59KD
Low PMG Voltage	49–52–53	COOLING FAN/PMG ASSY
APU Low Fuel Pressure Valve Output	26–22–00	FIRE EMERG STOP RLY 6WF
Main Start Contactor Failed Closed	49–42–41	CONTACTOR 5KA
Backup Start Contactor Failed Closed	49–42–42	CONTACTOR 10KA

APU BLEED PARAMETERS (A318/A319/A320)

	IDLE			BLEED SEL			1 PACK			2 PACKS			MES		
	LOW	MID	HIGH	LOW	MID	HIGH	LOW	MID	HIGH	LOW	MID	HIGH	LOW	MID	HIGH
EGT (deg.C)	400	400	460	450	480	520	470	480	530	520	540	585	550	570	615
IGV POSITION (deg)	82	82	82	48	48	48	48	48	48	48–30	48–30	48–30	–5	–5	–5
PT (psi)	16.3	16.3	16.3	42.4	42.4	42.4	42.4–49.7	42.4–49.7	39.5–45.3	49.7	49.7	42.4–46.8	54	54	42.4–49.7
LCIT (deg.C) (STANDARD SEA LEVEL)	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
P2A (mbar) (STANDARD SEA LEVEL)	980	980	980	980	980	980	980	980	980	980	980	980	980	980	980
WB (kg/sec)	0	0	0	0.32	0.32	0.32	0.32	0.35	0.38	0.32	0.35	0.38	0.39	0.41	0.45

APU BLEED PARAMETERS (A321)

	IDLE			BLEED SEL			1 PACK			2 PACKS			MES		
	LOW	MID	HIGH	LOW	MID	HIGH	LOW	MID	HIGH	LOW	MID	HIGH	LOW	MID	HIGH
EGT (deg.C)	400	400	460	450	480	520	480	490	540	530	550	590	550	570	615
IGV POSITION (deg)	82	82	82	48	48	48	48	48	48	48–10	48–10	48–10	–5	–5	–5
PT (psi)	16.3	16.3	16.3	42.4	42.4	42.4	42.4–51.1	42.4–51.1	39.5–45.3	51.1	51.1	42.4–48.2	54	54	42.4–49.7
LCIT (deg.C) (STANDARD SEA LEVEL)	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
P2A (mbar)	980	980	980	980	980	980	980	980	980	980	980	980	980	980	980
WB (kg/sec)	0	0	0	0.32	0.32	0.32	0.32	0.35	0.38	0.32	0.35	0.38	0.39	0.41	0.45

N_TS_490000_2_LCM0_01_00

NOTE: LOW, MID AND HIGH RELATE TO THE TIME OF THE APU SINCE INSTALLED.

Figure 73 APU Bleed Parameters

49–70 INDICATING

SYSTEM DESCRIPTION

SPEED SENSORS (2)

General

It is necessary for the APU control system to have a correct speed signal.

Two identical, but separate speed sensors are used. They are located on the gearbox casing.

A phonic wheel with 24 teeth is attached to the rotor shaft. The gap between the phonic wheel and the speed sensor is 5 mm and is non–adjustable.

Electronic Components in the ECB

The two sensors are connected to the ECB which calculates the average value of the sensors signals.

When the signal difference is greater than 5%, the sensor with the highest value is selected. This voltage (signal) is sent to an ARINC driver which, through the ARINC 429 bus, supplies the speed information to the system page of the ECAM.

Indication

The system page of the ECAM shows the APU speed information.

The ECB 59KD transmits the speed information to the ECAM through the ARINC 429 Bus as a binary word with Label 176.

The display format has:

- an analog scale from 0 % to 120 % with an amber box at 102 % and with a RED sector for speeds more than 105 %,
- a digital readout in %

NOTE: A speed signal is also delivered by the PMG (part of the cooling fan). This speed signal is used by the back–up overspeed protection 107 %.

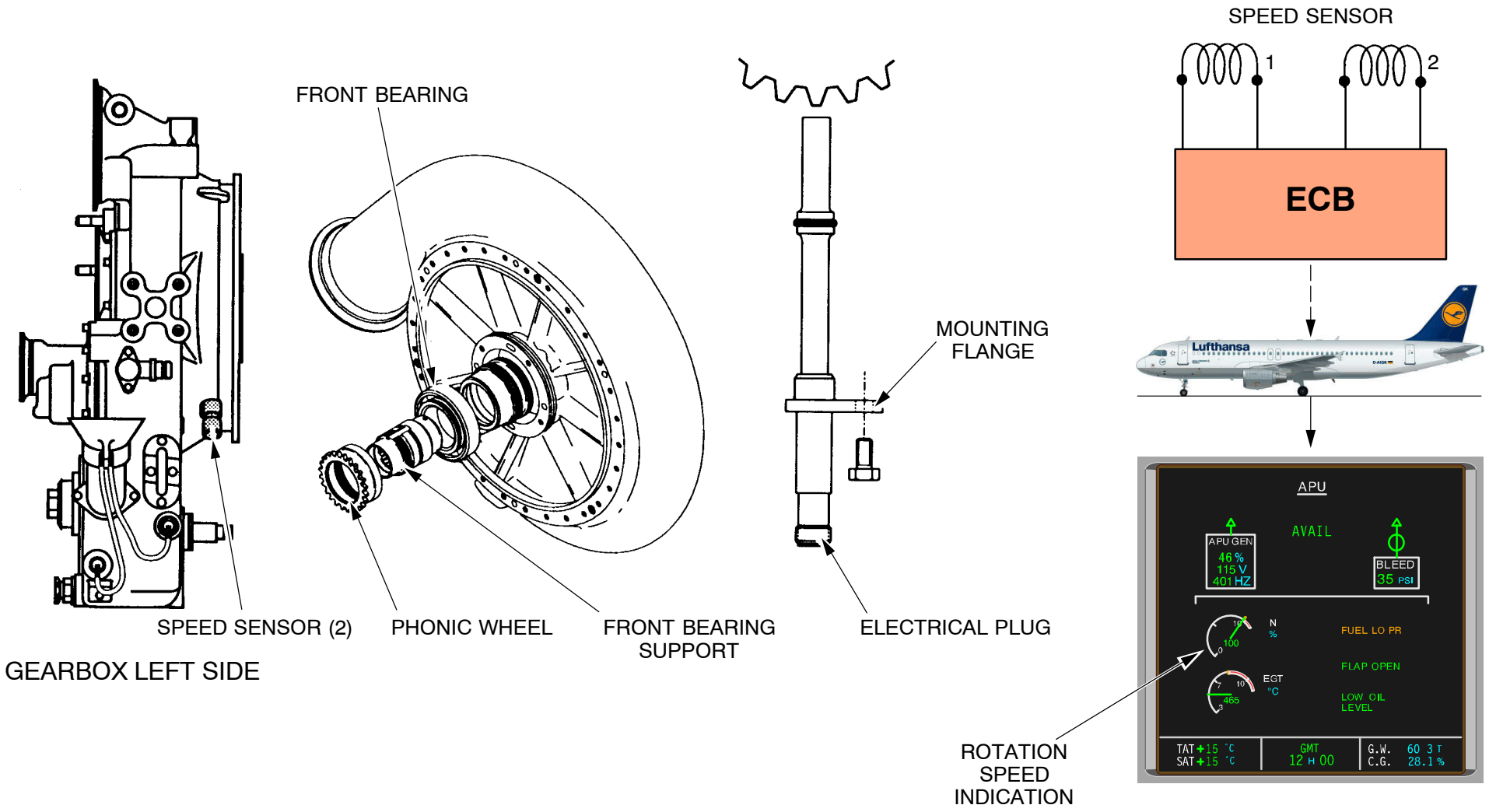


Figure 74 RPM Speed Sensor Description

THERMOCOUPLES

General

The chromel and alumel type thermocouples provide an electromotive force in function of the temperature difference between the hot junction in the exhaust gas stream and the cold junction connected to the measuring device.

The voltage value is approx. one millivolt per 24 °C (75 °F).

Electronic Components in ECB. The ECB compares the two effects, adjusts automatically for the cold junction effect and calculates the average EGT value.

An EGT system failure is declared if:

- EGT is lower than 120 °C (250 °F), on an running APU
- EGT is higher than 1200 °C (2200 °F),

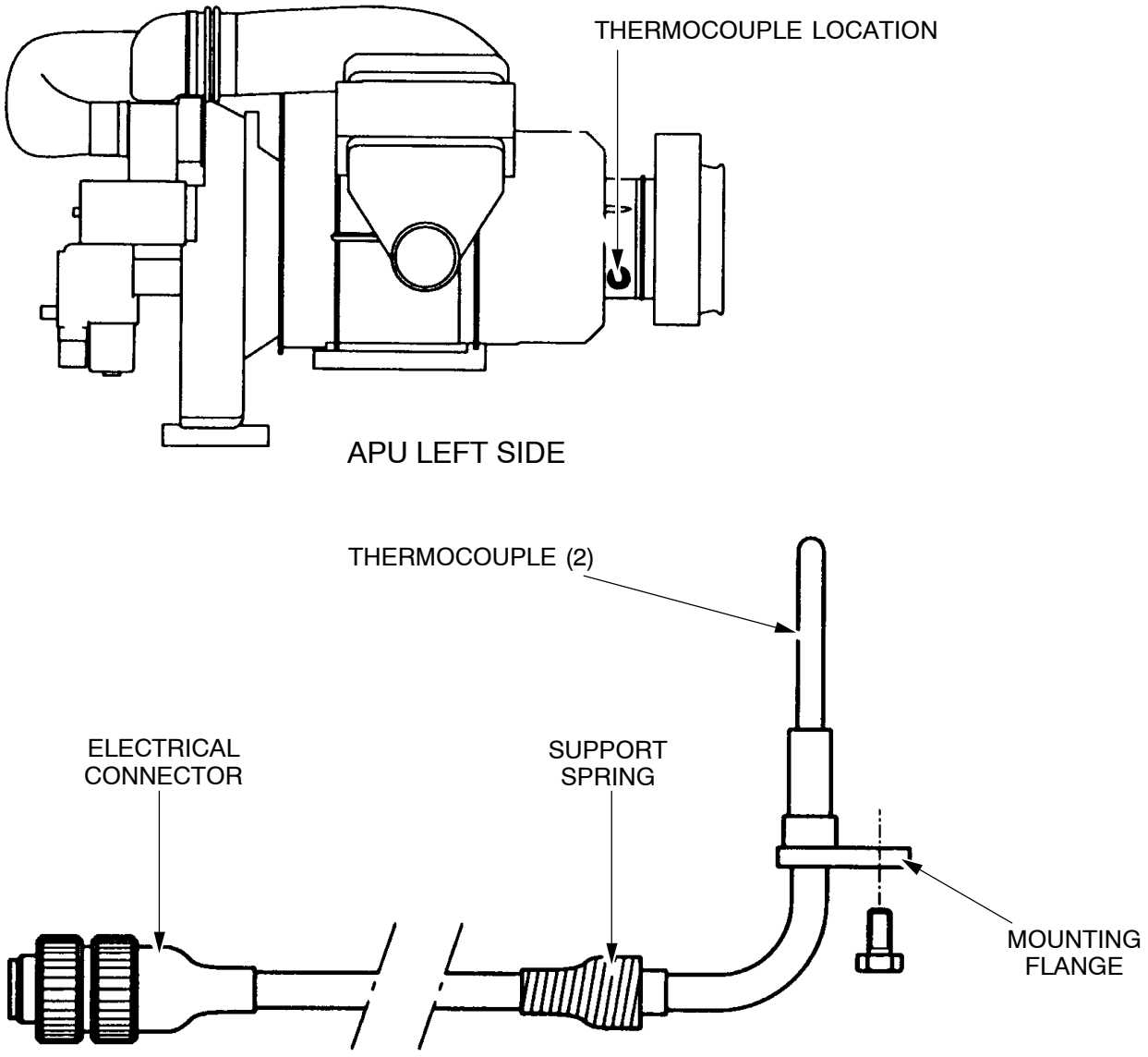
If the difference between the thermocouples is higher than 41 °C (105 °F), the thermocouple with the highest EGT value is selected. As there are two separate thermocouples, should one fail, the ECB will continue to use the output of the other.

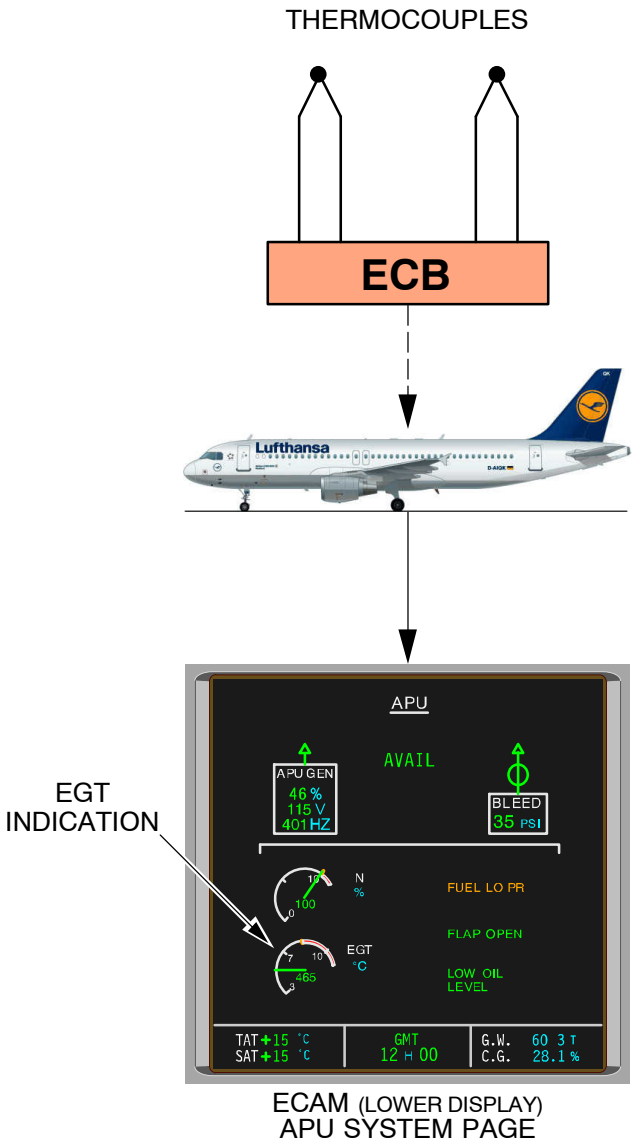
Indication

The System page of the ECAM shows the APU EGT information. The ECB 59KD transmits the EGT information to the ECAM through the ARINC 429 Bus as a binary word with label 175.

The display format has:

- a green analog scale which has an amber (advisory) sector and a red (warning) sector,
- a digital readout in °C.





ECAM (LOWER DISPLAY)
APU SYSTEM PAGE

Figure 75 EGT Thermocouple Description.

SERIAL NUMBER ENCODER

General

To associate the engine serial number to all information supplied by the ECB.

The ID (**ID**entification) module –SERIAL NUMBER ENCODER– consists of a printed circuit board which has resistors.

The ECB provides the ID number to the CFDS MCDU display system.

Functional Description

The ID module is made of resistors located on printed circuit board.

The board is housed in an electrical plug and is connected to the ECB by means of 4 electrical wires.

There are 3 voltage lines VI, V2, V3 and a return line.

The engine ID number is read, validated and stored during the power up phase of the ECB.

In case of ID module failure, the APU system history data is associated with the last valid ID number.

If a new valid ID number is available, it is used without erasing the previously recorded historical data.

Location

The module is installed on the ignition exciter support (APU left side).

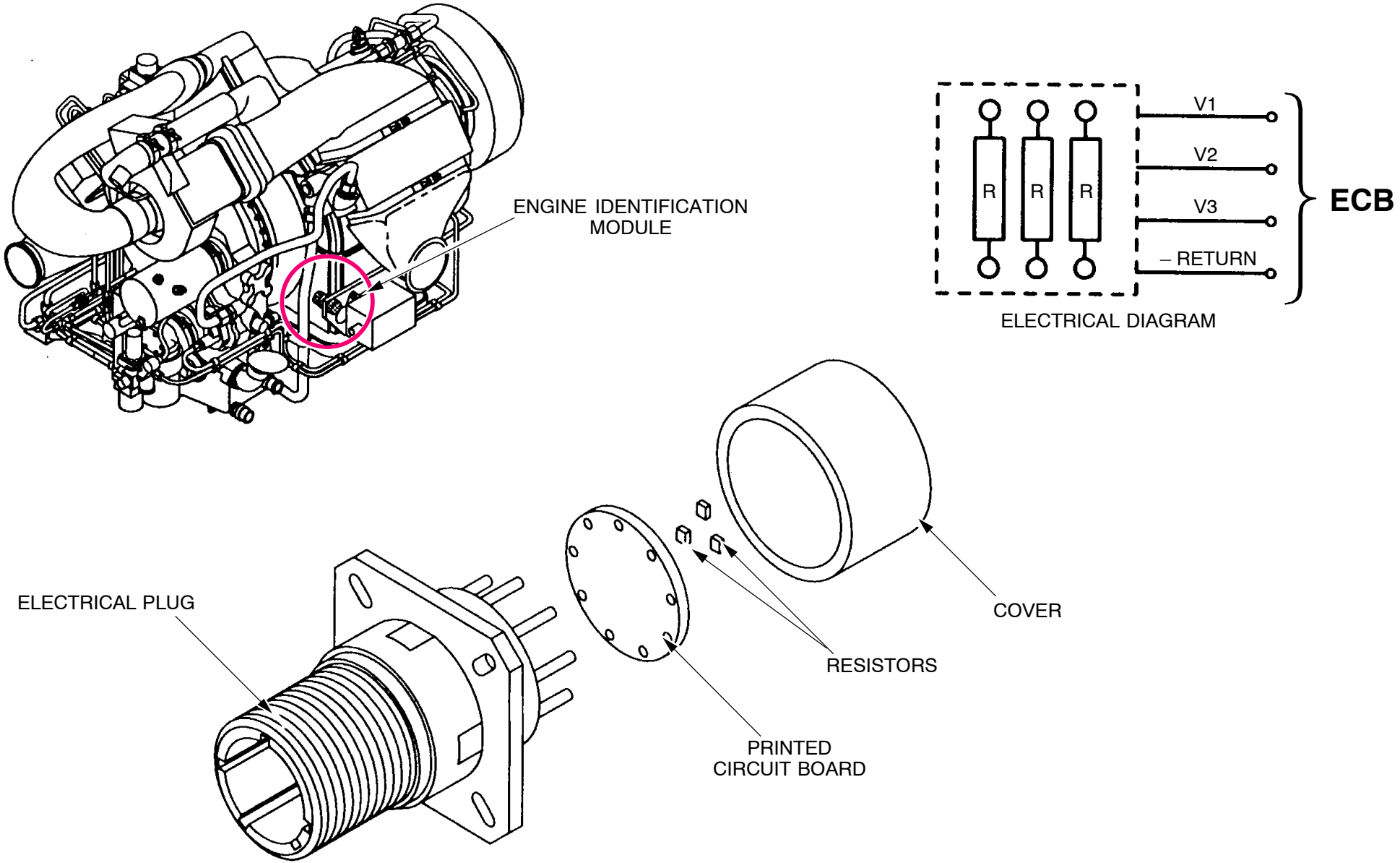


Figure 76 Serial Number Encoder Description

APU ECAM SYSTEM PAGE DESCRIPTION

1 AVAIL Indication

Displayed green when APU N is above 95%

2 APU BLEED VALVE POSITION

- In line
  Valve not closed, green.
- cross line
  Valve fully closed, green.

3 APU BLEED AIR PRESSURE

The relative air pressure is displayed in green.

Amber ”XX” replaces the indication when the ADIRS #2 is not available or selected OFF.

4 APU GENERATOR LINE CONTACTOR Indication

Displayed green when the APU GEN line contactor is closed.

5 APU GEN Parameters

Identical with APU GEN parameter on ELEC page.

6 FUEL LO PR Indication

Displayed amber in case of APU fuel low pressure detection (Fuel press in APU fuel feed line is below 16 PSI).

7 FLAP OPEN Indication

- Displayed green when APU air intake flap is fully open (Master Switch at ON).
- Advisory if not fully closed 3 mn after Master Switch has been set to OFF.

8 APU N Indication

- APU speed is displayed in green.
- Becomes amber when N > 102 %.
- Becomes red when N > 105 %.

9 APU EGT Indication

- APU EGT is displayed in green.
- Advisory pulses green at 675°C (inhibited during APU start).
- Becomes amber execssive EGT (above 758° C with APU running)
  and (above 1038° C during APU start).
- Becomes red * over temperature (above 798° C with APU running).
  * EGT max is calculated in the ECB and transmitted to ECAM it is a function of N during start and a function of ambient temperature when APU is running.

10 LOW OIL LEVEL

This message is displayed pulsing on the ECAM APU page when the APU MASTER SW is ON and the oil quantity is below the set operation level.

* LOW OIL LEVEL (green) if the quantity becomes lower than 2.6 liter the indication than pulses on the APU page.

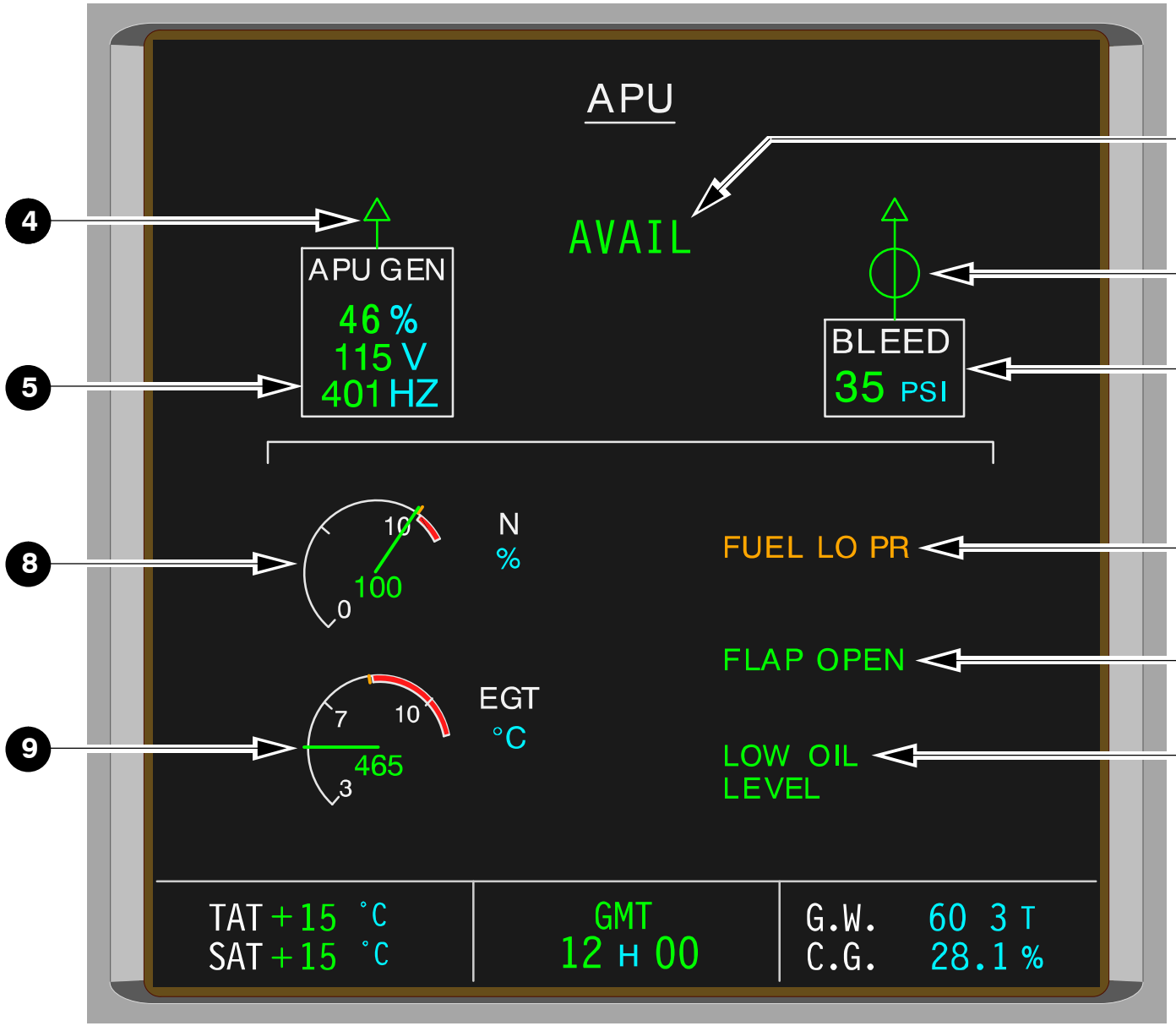


Figure 77 APU ECAM System Display

ENG WARNING AND STATUS PAGE PRESENTATION

1 APU AVAIL.

If APU is running the green ”APU AVAIL” Message will be displayed on the MEMO page. If APU Bleed is ”ON” the Message will be ”APU BLEED”.

2 APU Emerg. STOP or APU Auto Shut Down

”APU EMERG STOP” is displayed in case of fire.

”APU AUTO SHUT DOWN” is displayed in case of a FAULT other than a fire.

3 STS

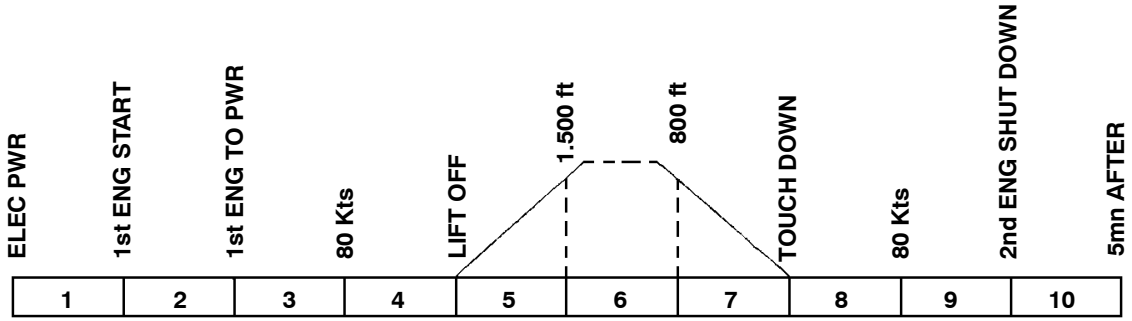
4 APU

If APU is shown on the STS-page a Class 2 Fault is present. Using the CFDS the fault which is stored in the ECB can be identified.

Warnings and Cautions

When the Auxiliary Power Unit operates outside its set limits, the ECB (**E**lectronic **C**ontrol **B**ox) shuts down the APU automatically.

If an Automatic Shutdown occurs, the following cockpit warnings are set.

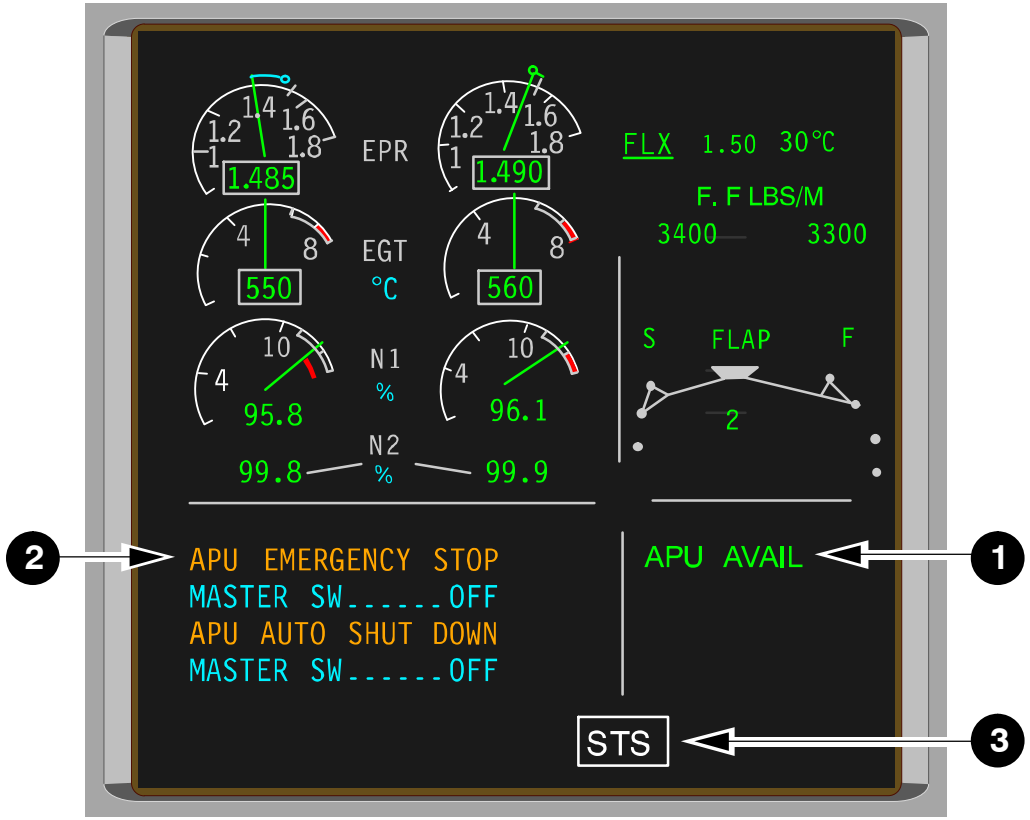


E / WD : FAILURE TITTLE condition	AURAL WARNING	MASTER LIGHT	SD PAGE CALLED	AURAL WARNING	FLT PHASE INHIB
AUTO SHUT DOWN automatic shut down of APU for a reason other than fire	SINGL E CHIME	MASTER CAUT	APU	APU MASTER SW FAULT LT	3 4 5 7 8
EMER SHUT DOWN fire detection on ground or use of APU shut off P/B on interphone panel or APU FIRE P/B pushed	REPETITIVE CHIME	MASTER WARN			

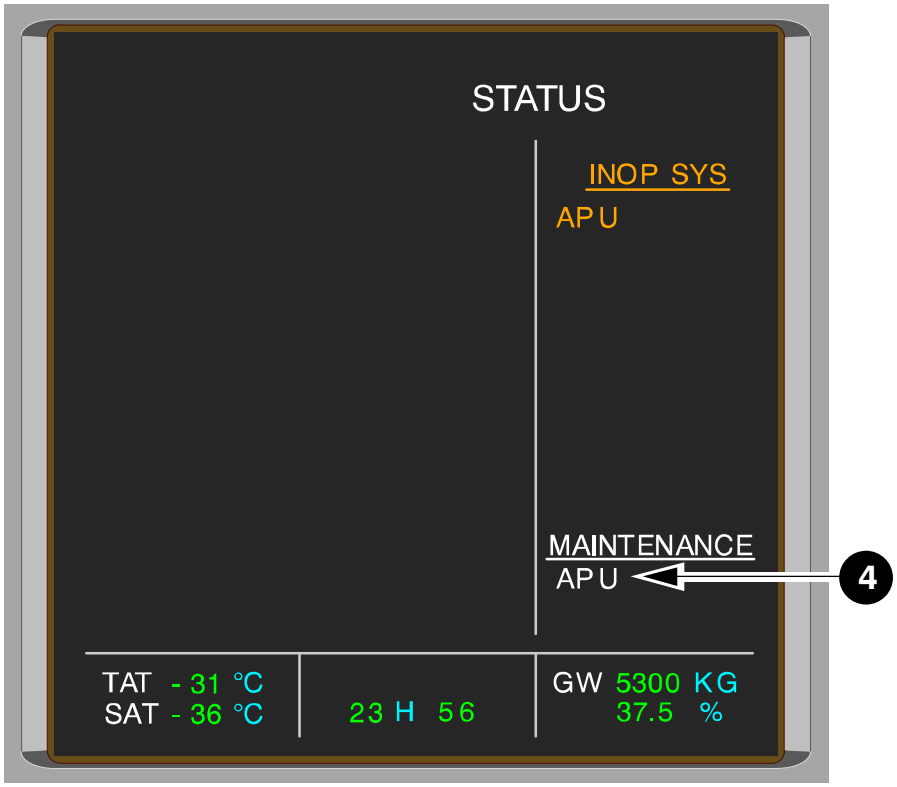
MEMO DISPLAY

APU AVAIL message is displayed in green when the APU N is above 95 %.

Figure 78 ECAM Flight Phases



ENGINE WARNING DISPLAY (E/WD)



STATUS PAGE (SD)

Figure 79 ECAM Warning and Cautions

TABLE OF CONTENTS

ATA 49 AIRBORNE AUXILIARY POWER 1

49–00 AIRBORNE AUXILIARY POWER GENERAL 2
APS 3200 INTRODUCTION 2
APU SYSTEMS INTRODUCTION 6
CONTROL AND INDICATING 8
SAFETY PRECAUTIONS 12
OPERATING LIMITATIONS 14

49–11 POWER PLANT 16
POWER PLANT INTRODUCTION 16
APU ACCESS DOOR DESCRIPTION 18
APU COMPONENT LOCATION (APU LEFT SIDE) 22
COMPONENT LOCATION (APU RIGHT SIDE) 24

49–12 APU MOUNTS 26
DESCRIPTION 26

49–16 AIR INTAKE SYSTEM 28
AIR INTAKE SYSTEM DESCRIPTION 28
AIR INTAKE FLAP ACTUATOR OPERATION 30
AIR INTAKE COMPONENT DESCRIPTION 32

49–17 APU DRAIN SYSTEM 34
APU DRAIN SYSTEM DESCRIPTION 34

49–20 ENGINE 36
INTRODUCTION 36
APU BORESCOPE INSPECTION 38

49–90 OIL 40
OIL SYSTEM DESCRIPTION 40
OIL SERVICING 44
OIL SYSTEM COMPONENT DESCRIPTION 46

49–30 ENGINE FUEL AND CONTROL 66
APU FUEL FEED SYSTEM DESCRIPTION 66
APU FUEL FEED SYSTEM COMPONENT DESCRIPTION 68

49–32 APU FUEL CONTROL 72
SYSTEM DESCRIPTION 72
FUEL CONTROL UNIT COMPONENT DESCRIPTION 74
FCU OPERATION 76
START FUEL FLOW CONTROL OPERATION 78
FLOW DIVIDER OPERATION 80
FUEL MANIFOLDS AND INJECTORS COMPONENT DESCRIPTION 82

49–50 AIR SYSTEM 84
AIR SYSTEM DESCRIPTION 84
INLET GUIDE VANE SYSTEM OPERATION 86
AIR BLEED SYSTEM OPERATION 88
AIR SYSTEM SENSORS DESCRIPTION 90
ACCESSORY COOLING OPERATION 92

49–40 IGNITION AND STARTING 94
INTRODUCTION 94
IGNITION AND STARTING SYSTEM DESCRIPTION . 96
COMPONENT LOCATION 98
COMPONENT DESCRIPTION 100

49–60 ENGINE CONTROLS 104
GENERAL 104
ECB BITE 106
BITE TEST AND FAULT INDICATION 108
ELECTRONIC CONTROL BOX COMPONENT DESCRIPTION .. 114

49–61 CONTROL AND MONITORING 118
APU START EVENTS FUNCTIONAL OPERATION 118
APU SHUTDOWN EVENTS 119
PROTECTIVE AUTO SHUTDOWN OPERATION 120
EMERGENCY SHUTDOWN OPERATION 120

49–73 ANALYZERS 122
FAULT TABLES PRESENTATION 122

49–70 INDICATING 126
SYSTEM DESCRIPTION 126

TABLE OF CONTENTS

APU ECAM SYSTEM PAGE DESCRIPTION 132
ENG WARNING AND STATUS PAGE PRESENTATION 134

TABLE OF FIGURES

Figure 1 APU Operating Envelope . . . 3
Figure 2 APU Presentation . . . 5
Figure 3 APU Systems Overview . . . 7
Figure 4 APU Control Panels . . . 9
Figure 5 APU ECAM System Display . . . 10
Figure 6 APU External Controls & Indicating . . . 11
Figure 7 Safety Precautions . . . 13
Figure 8 Operating Limitations . . . 15
Figure 9 APU Installation . . . 17
Figure 10 Locking for Door Removal . . . 18
Figure 11 APU Access Door Opening . . . 19
Figure 12 Access Door Latches . . . 20
Figure 13 APU Access Door Closing . . . 21
Figure 14 APU Components (Left Side) . . . 23
Figure 15 APU Components (Right Side) . . . 25
Figure 16 APU Mounts . . . 27
Figure 17 Air Intake Installation . . . 29
Figure 18 Air Intake Flap Electrical Schematic . . . 31
Figure 19 Air Intake Components . . . 33
Figure 20 APU Drain System . . . 35
Figure 21 APU Total Views . . . 36
Figure 22 APU Sections . . . 37
Figure 23 APU Borescope Inspection . . . 39
Figure 24 Oil System Schematic . . . 41
Figure 25 Oil Servicing . . . 45
Figure 26 Lubrication . . . 46
Figure 27 Oil Pump Description . . . 47
Figure 28 Oil Cooler Bypass Valve Schematic . . . 48
Figure 29 Oil Cooler and Bypass Valve Description . . . 49
Figure 30 Oil Filter Schematic . . . 50
Figure 31 Oil Filter Description . . . 51
Figure 32 De–Oiling Valve . . . 53
Figure 33 Low Oil Press. Switch Description . . . 55
Figure 34 Figure Text . . . 56
Figure 35 High Oil Temp. Sensor . . . 57
Figure 36 Figure Text . . . 58
Figure 37 Generator Scavenge Filter Delta P Switch . . . 59
Figure 38 Generator High Oil Temp. Sensor . . . 61
Figure 39 Oil Level Sensor . . . 63
Figure 40 Air–Oil Separator . . . 65
Figure 41 Fuel Control Logic . . . 66
Figure 42 APU Fuel Feed System . . . 67
Figure 43 APU Fuel Feed Components (1) . . . 68
Figure 44 APU Fuel Feed Components (2) . . . 69
Figure 45 APU Fuel Feed Components (3) . . . 71
Figure 46 Fuel System Schematic . . . 73
Figure 47 Fuel Control Unit Components . . . 75
Figure 48 APU Fuel Schematic (FCU) . . . 77
Figure 49 APU Start FF Control Schematic . . . 79
Figure 50 Flow Divider . . . 80
Figure 51 Flow Divider Operation . . . 81
Figure 52 Combustor Housing (LH-Side) . . . 82
Figure 53 Fuel Manifolds and Injectors . . . 83
Figure 54 Air System Schematic . . . 85
Figure 55 IGV Operation Schematic . . . 87
Figure 56 Air Bleed System Operation Schematic . . . 89
Figure 57 Air System Sensors . . . 91
Figure 58 Accessory Cooling Components . . . 93
Figure 59 Ignition and Starting System Layout . . . 95
Figure 60 Ignition & Starting System Schematic . . . 97
Figure 61 Starting System Components (CFDS Monitored) . . . 99
Figure 62 Component Location . . . 100
Figure 63 Starter Motor and Sprag Clutch . . . 101
Figure 64 Ignition Components . . . 103
Figure 65 APU Control System . . . 105
Figure 66 ECB Bite Schematic . . . 107
Figure 67 ECAM Messages and MCDU MENU . . . 109
Figure 68 LRU IDENT, Self Test and S/D Reports . . . 110
Figure 69 APU Data/Oil and Class 3 Reports . . . 111
Figure 70 APU Previous Legs Report . . . 112

TABLE OF FIGURES

Figure 71 APU ECB Description 115
Figure 72 ECB Power Supply 117
Figure 73 RPM Speed Sensor Description 127
Figure 74 EGT Thermocouple Description. 129
Figure 75 Serial Number Encoder Description 131
Figure 76 APU ECAM System Display 133
Figure 77 ECAM Flight Phases 134
Figure 78 ECAM Warning and Cautions 135