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Airbus
A318/A319/A320/A321
(CFM56-5)

ATA 71−80
Power Plant

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ATA 71 POWER PLANT

71–00 GENERAL

CFM56 CONCEPT

The CFM56 turbofan engine family is a product of **C**ommercial **F**an **M**otor **I**nternational (CFMI).

CFMI is a company jointly owned by General Electric of the USA and **S**ociete **N**ationale d'**E**tude et de **C**onstruction de **M**oteurs d'**A**viation (SNECMA) of France.

snecma
- LP SYSTEM
- ACCESSORY DRIVE SYSTEM
- CONTROL & ACCESSORIES
- ENGINE INSTALLATION
- THRUST REVERSER

GE
- CORE ENGINE
- FUEL SYSTEM DESIGN
- ECU & HMU

cfm international
- MARKETING
- PROGRAM MANAGEMENT
- PRODUCT SUPPORT

Figure 1 CFM56 Concept

CFM 56-5A TURBOFAN ENGINE INTRODUCTION

GENERAL

The CFM56−5A is the powerplant which powered Airbus' entry into the single−aisle market −− the A320. Entering service in 1988, more than 1,100 engines are in service with more than 40 million flight hours. The −5A maintains dispatch reliability above 99.9% according to vendor data.

HISTORY OF THE CFM56−5A TURBOFAN ENGINE

Specifically designed to power the short− to medium−range Airbus A320, the 22,000 to 26,500 pound thrust CFM56−5A is a cost−effective, advanced derivative engine of the CFM56−2 and CFM56−3 families. Respectively rated at 22,000 and 23,500 pounds of thrust, the CFM56−5A is perfectly optimized for the shortened Airbus A319. Benefiting from the experience of the CFM56−3, which had accumulated over nine million flight hours at the CFM56−5A's entry into service, the CFM56−5A is characterized by enhanced efficiency of all components and an improved thermodynamic cycle.

Equipped with a 3−D aerodynamic fan design and a Full Authority Digital Electronic Control (FADEC) that efficiently unifies aircraft and engine systems, the CFM56−5A specific fuel consumption is 10−11 percent lower compared to its predecessors, resulting in a 15−17 percent fuel burn advantage for a typical A320 mission. In addition to its large noise and emissions margins versus FAA and Environmental Protection Agency (EPA) requirements, the CFM56−5A demonstrates an impressive dispatch reliability rate: less than one delay or cancellation per 1,600 aircraft departures due to engine causes for the A320/CFM56−5A association.

Figure 2 CFM56−5A Engine

Family Models	CFM 56-5A1	CFM 56-5A3	CFM 56-5A4	CFM 56-5A5	CFM 56-5B1	CFM 56-5B2	CFM 56-5B4	CFM 56-5B5	CFM 56-5B6
AIRCRAFT TYPE	A320	A320	A319	A319	A321	A321	A320	A319	A319
THRUST	25000 lb	26500 lb	22000 lb	23500 lb	30000 lb	31000 lb	27000 lb	22000 lb	23500 lb
FLAT RATED TEMPERA-TURE (DEG C / DEG F)	30°/86°	30°/86°	30°/86°	30°/86°	30°/86°	30°/86°	45°/113°	45°/113°	45°/113°
BYPASS RATIO	6 : 1	6 : 1	6.2 :1	6.2 : 1	5.5 : 1	5.5 : 1	5.7 : 1	6 : 1	5.9 : 1
MASS FLOW	852lb/sec	876lb/sec	816lb/sec	842lb/sec	943lb/sec	956lb/sec	897lb/sec	818lb/sec	844lb/sec
OVERALL PRESS. RATIO	31.3	31.3	31.3	31.3	35.5	35.5	32.6	32.6	32.6
EGT (DEG C)	890°/915°	915°	890°/915°	890°/915°	950°	950°	950°	950°	950°
N1 (RPM)	5100	5100	5100	5100	5200	5200	5200	5200	5200
N2 (RPM)	15183	15183	15183	15183	15183	15183	15183	15183	15183

ENGINE CHARACTERISTICS

Family Models	CFM 56-5A1	CFM 56-5A3	CFM 56-5A4	CFM 56-5A5	CFM 56-5B1	CFM 56-5B2	CFM 56-5B4	CFM 56-5B5	CFM 56-5B6
LENGTH (INCH)	95,4	95,4	95,4	95,4	102,4	102,4	102,4	102,4	102,4
FAN DIAMETER (INCH)	68,3	68,3	68,3	68,3	68,3	68,3	68,3	68,3	68,3
BASIC DRY WEIGHT (lb)	4995	4995	4995	4995	5250	5250	5250	5250	5250
FAN / LP / HP STAGE NUMBERS	1+3+9	1+3+9	1+3+9	1+3+9	1+4+9	1+4+9	1+4+9	1+4+9	1+4+9
HP / LP TURBINE STAGE NUMBERS	1+4	1+4	1+4	1+4	1+4	1+4	1+4	1+4	1+4

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CFM 56-5A1 ENGINE DATA (LUFTHANSA CONFIG)

Take OFF Thrust (Sea Level Static) Time Limit 5 min: Flat Rated Ambient Temperature Max Continous (Sea Level Static) Flat Rated Ambient Temperaturen	**25000 lbs = 11120 daN** **86° = 30°C** **23700 lbs = 10500 daN** **77°F = 25°C**
Airflow (Take off)	**852 lbs/sec = 426 kg/sec**
Bypass Ratio	**6 : 1**
Compressor Pressure Ratio (overall,Take Off, SLS)	**26,5 : 1**
Fan Pressure Ratio (Take Off, SLS)	**1,55 : 1**
Fan Thrust / Core Thrust (At Take Off)	**80%** / **20%**
Turbine Inlet Temperature (T41) (Take Off Hot Day)	**2311°F = 1265°C**
EGT (T49,5) RED LINE MAX CONTINOUS ENG. START	**890°C** **855°C** **725°C**
N1 & N2 Direction of Rotation	**Clockwise** (aft looking forward)
N1 Design Speed 100% N1 MAX. 102%	**5000 min -1** **5100 min -1**
N2 Design Speed 100% N2 MAX. 105%	**14460 min -1** **15183 min -1**
TSFC (**T**hrust **S**pecific **F**uel **C**onsumption): - Take Off -MAX. Contious - 75%	 **0,343 lbs/lbs x h** **0,339 lbs/lbs x h** **0,326 lbs/lbs x h**
TSFC (MACH 0,8) Altitude 35000 ft, Std. Day	**0,596 lbs/lbs x h**
Engine Weight	**4734 lbs = 2150 Kg**

DIFFERENCES CFM 56-5A1/5A5 (DLH VERSION ONLY)

CFM56-5A5 Dual Thrust Rating

The CFM56-5A5 engine is prepared for Dual Thrust Rating

- Basic rating is 23500 lbs with FLEX rating to maximum climb thrust
- Alternate rating is 22000 lbs, no FLEX rating

The selection of the thrust rating can be done via MCDU.

The letter "D" near to the N1 indication on the EWD indicates, that the alternate rating is selected (as soon as the ECU is powered).

Engine Commonality

After the embodiment of some CFMI service bulletins, a upgrading of the CFM56-5A1 (A320 standard) to the CFM56-5A5 (A319 standard) is possible. See also " ECU Intermix".

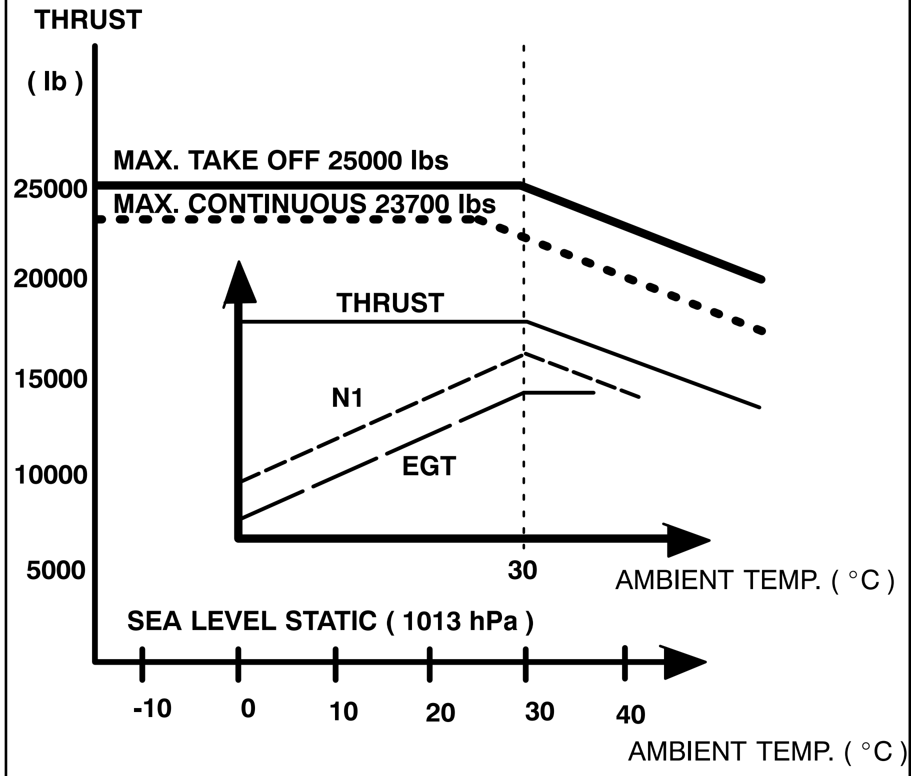


Figure 3 Flat Rated Thrust

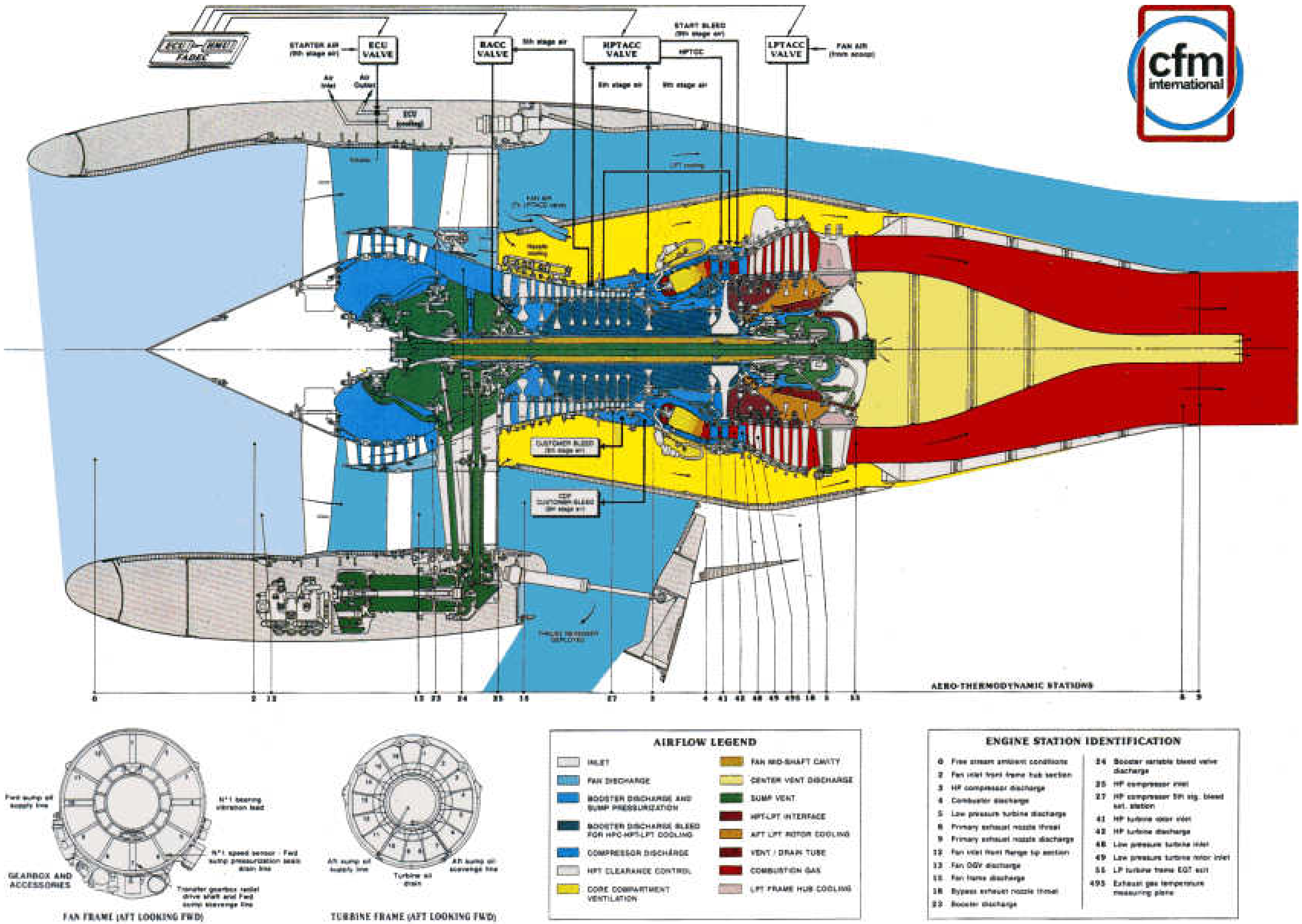


Figure 4 CFM56-5

CONTROLLING INTRODUCTION

General

The **F**ull **A**uthority **D**igital **E**ngine **C**ontrol system (FADEC) controls the engine and provides full range control to achieve steady state and transient performance when operated in combination with aircraft subsystems.

Thus the FADEC serves as an interface between the aircraft and the engine control and monitoring components.

The FADEC system of each engine consists of a dual channel **E**lectronic **C**ontrol **U**nit (ECU), with its associated peripherals. **I**t is located on the engine fan case at 4:00 o'clock position.

Full Authority Digital Engine Control

The FADEC system consists of a dual channel Engine Electronic Control Unit and the peripherals that follow:

- Hydromechanical Unit (HMU)
- Dedicated ECU Alternator (PMA)
- VSV and VBV, HPTACC, LPTACC, RACC systems
- Start System
- T/R System
- Oil/Fuel Temperature Control
- Engine Sensors
- Electrical Harness
- ECU Cooling

Engine/Aircraft Integration

Engine/Aircraft integration includes:

- Thrust reverser control
- Auto Thrust
- Automatic and manual starting
- Engine indication
- Engine maintenance data
- Condition monitoring data

Power Supply

The FADEC system is self-powered by a dedicated permanent magnet alternator when N2 is above 15%, and is powered by the aircraft for starting, as a backup and for testing with engine not running.

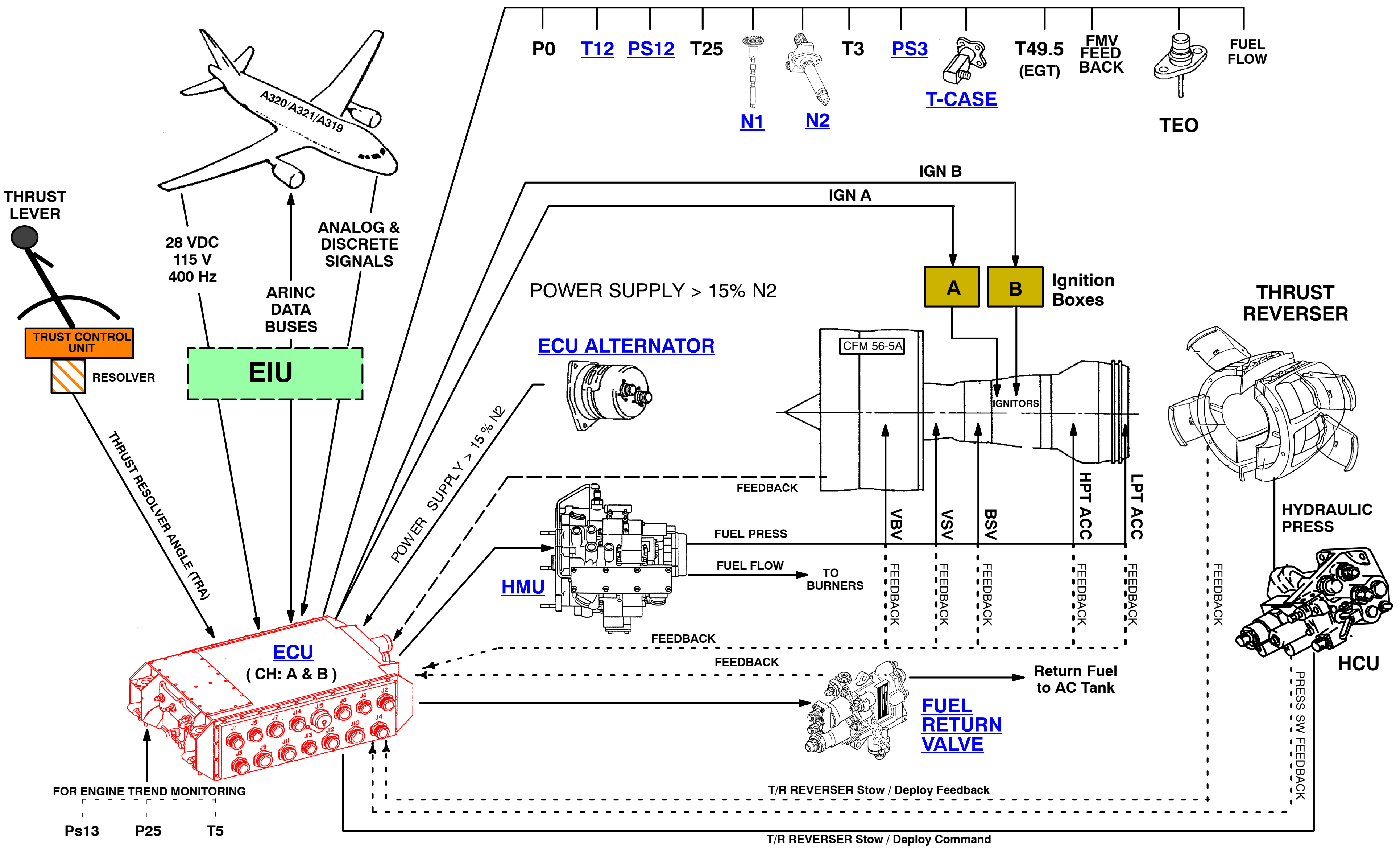


Figure 5 FADEC Presentation

ENGINE CONTROLS - GENERAL DESCRIPTION

General

The engines controls are located on the overhead panel and the pedestal.

Thrust Levers

There are two thrust levers, they are used as conventional throttles and as thrust rating limit selectors. Each thrust lever is fitted with a thrust reverser control lever. Two autothrust instinctive disconnect pushbuttons are provided on the throttle control levers

Engine Master Switches

Two Engine Master Switches with two positions, ON or OFF, are provided to open or close the High Pressure (HP) fuel valve and command and reset the FADEC functions. The red indicator light is activated in case of FIRE and the amber indicator light is activated in case of aborted start.

Engine Start

The rotary selector initiates either an IGN/START sequence or a CRANK sequence. After the start or crank sequence, the selector is set back to the NORM position.

Engine Manual Start

The Engine Manual Start Panel Pushbuttons are provided to open the start valves during an engine manual start or cranking sequence.

FADEC Ground Power

The FADEC is normally supplied with power by a dedicated generator driven by the gearbox. When the engine is not running, the FADEC can be powered from the aircraft network by using the FADEC Ground Power Pushbutton.

Engine Fire

When the Engine Fire Pushbutton is released out, the Low Pressure Fuel Shut Off Valve is closed, and the aircraft electrical power supply to the FADEC system is interrupted.

Engine Anti Ice

For each Engine, the hot bleed air is ducted via an ON/OFF valve which is controlled from the cockpit. The valve is pneumatically operated, electrically controlled and spring loaded open. In case of loss of electrical power supply, the valve will open. There is only a blue/amber light at the pushbutton and a message on the ECAM MEMO display.

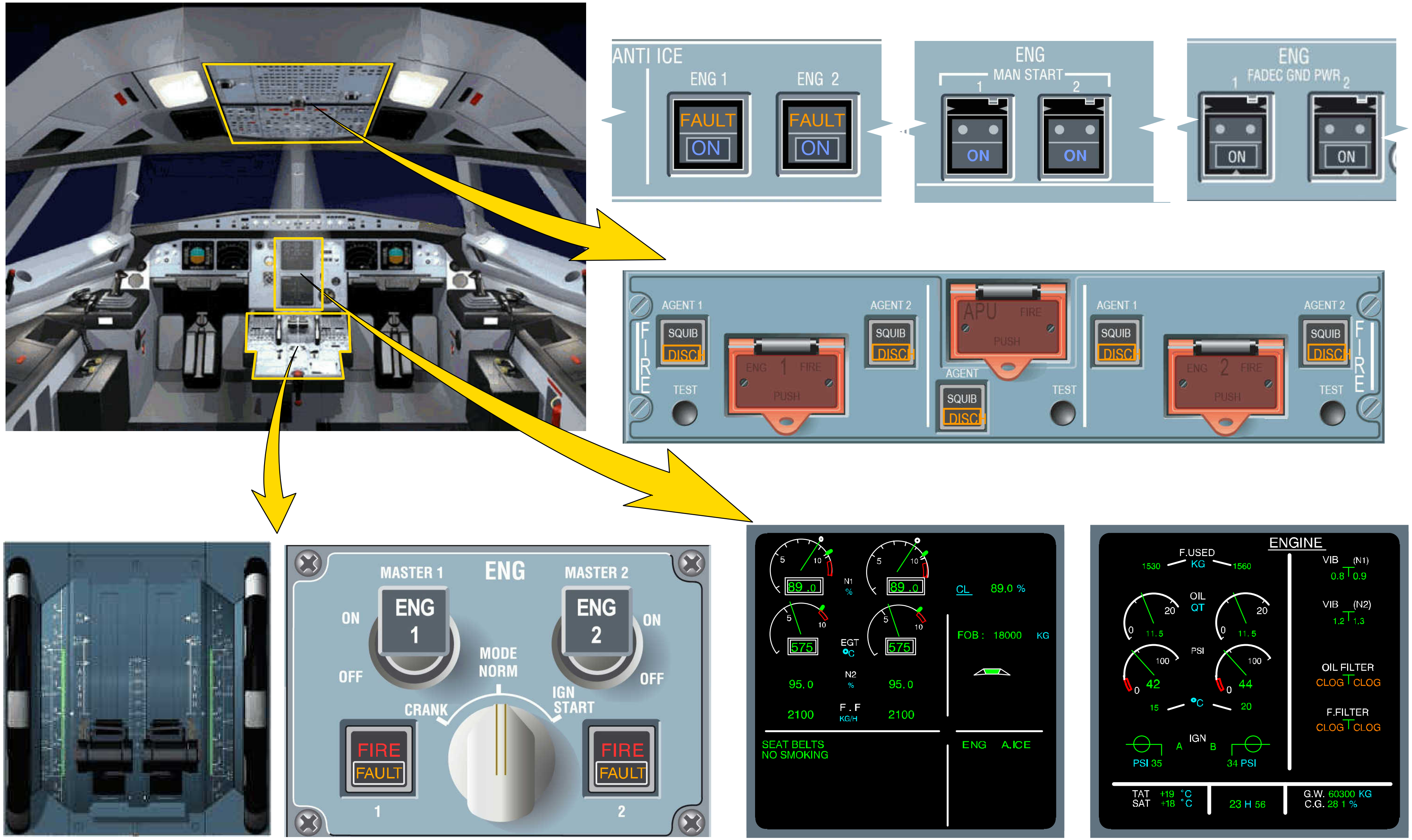


Figure 6 Engine Controls Overview

ENGINE INDICATING GENERAL DESCRIPTION

INTRODUCTION

The engine power management is effected by means of the:

- ECAM System (Upper and Lower Display Unit)
- Warning and Caution Systems

The engine is equipped with sensors for monitoring and indication purposes on the flight deck ECAM display units like:

- Temperature (e.g. oil & nacelle),
- Pressure (e.g. oil & starter air duct pressure),
- Speed,
- Vibration,
- Fuel Flow.

It also has switches that provide indication for

- Oil/Fuel Clogging,
- Starter Air Valve and T/R position.

Depending on the data transmitted, messages are generated on the following devices :

- Upper ECAM: Engine Warning Display (EWD),
- Lower ECAM: Systems Display (SD),
- Master Caution or Master Warning,
- Aural Warnings.

These messages are used to run the engine under normal conditions throughout the operating range, or to provide warning messages to the crew and maintenance personnel. The master caution and warning are located in front of the pilot on the glareshield.

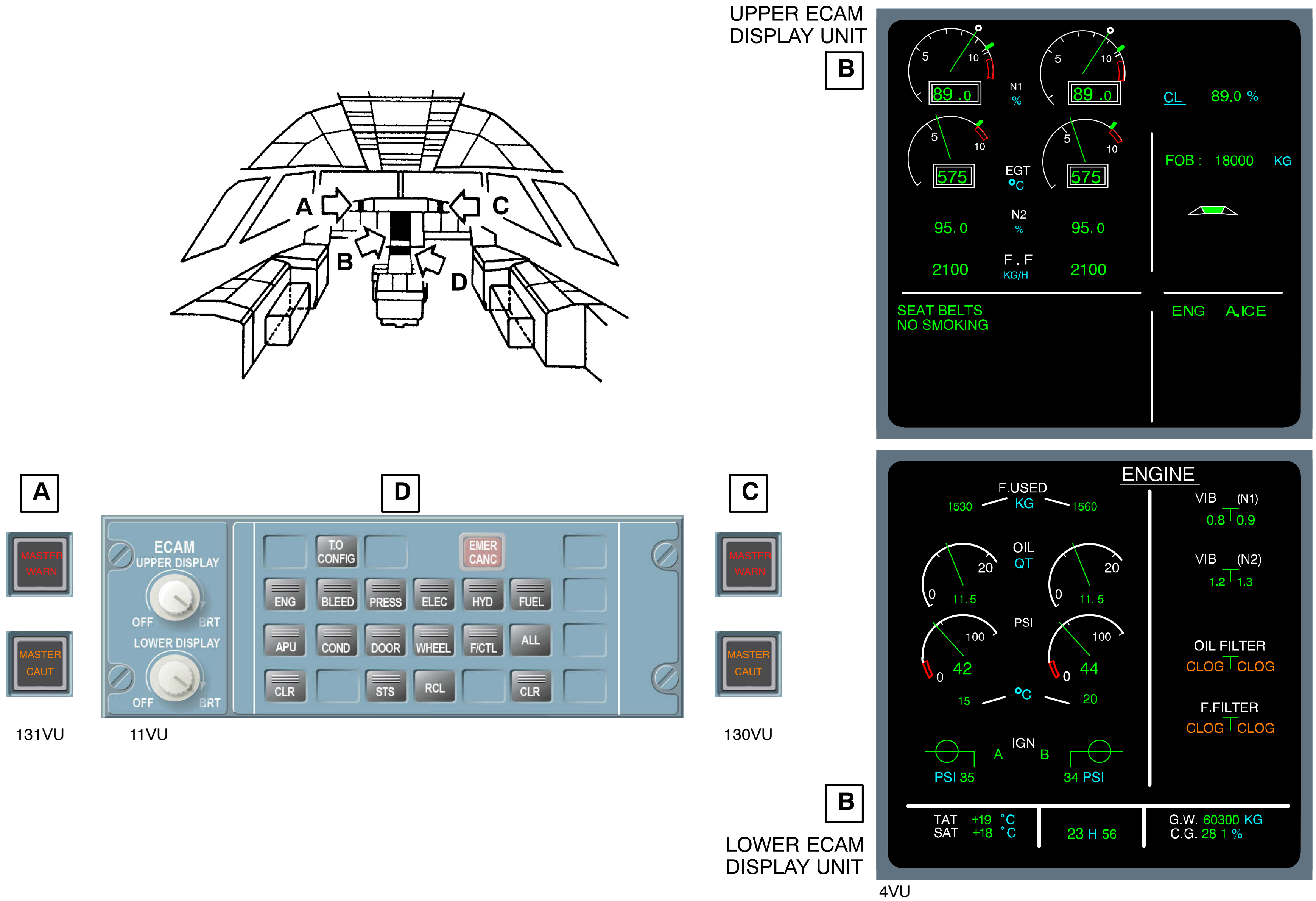


Figure 7 Engine Indication Presentation

SAFETY PRECAUTIONS

When you work on aircraft, make sure that you obey all the AMM (**A**ircraft **M**aintenance **M**anual) safety procedures.

This will prevent injury to persons and/or damage to the aircraft. Here is an overview of main safety precautions related to the engines.

Make sure that all engine dangerous areas are as clear as possible to prevent damage to the engine, the aircraft or persons in the area.

Make sure that you have fire fighting equipment available. Do not try to stop the fan from turning by hand.

After engine shutdown, let the oil tank pressure bleed off for a minimum of 5 minutes before you remove the tank filler cap. If you do not, pressurized oil can flow out of the tank and cause dangerous burns.

The engine ignition system is an electrical system with high energy.You must be careful to prevent electrical shock. Injury or death can occur to you. Do not do maintenance on the ignition system while operating the engine.

Make sure that the engine shutdown occurred for a minimum of 5 minutes before you proceed.

Make sure that the thrust reverser is deactivated during maintenance. If not, the thrust reverser can operate accidentally and cause injury to personnel and/or damage to the reverser.

When opening the engine cowls:

- respect the wind limitations and the opening/closing sequence,
- always secure cowls with the hold-open rods,
- make sure that the slats are retracted and install a warning notice to prevent slat operation.

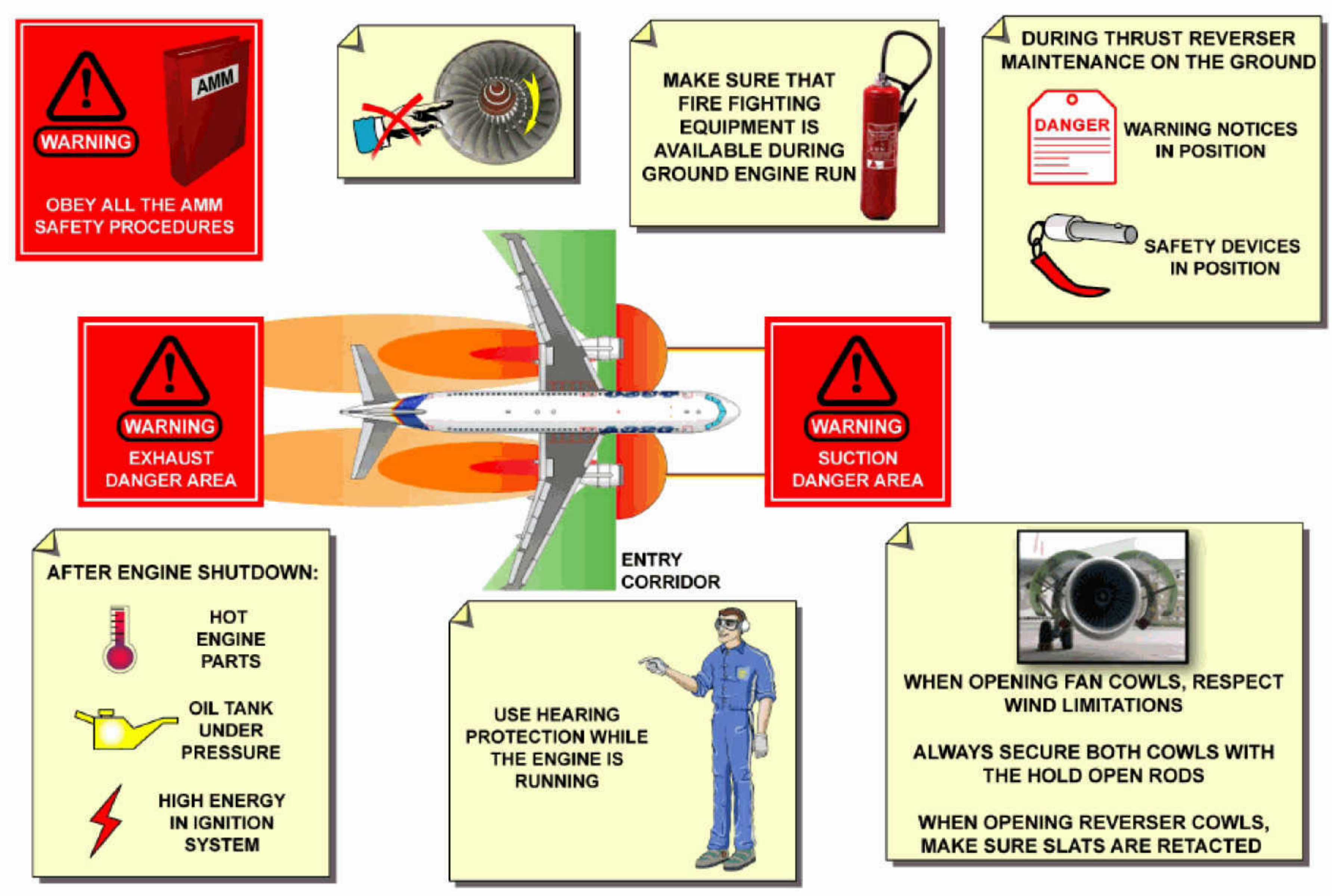


Figure 8 Safety Precautions

06|71-00|SFTY|5A|L1/B1/B2

ENGINE STORAGE

General

NOTE: The relative humidity must be sufficently low inside the engine during the preservation time for optional corrosion prevention (typical 40% or less).

Minimum storage requirements are specified in the AMM.

Make sure that all the steps for preservation of the engine are completed.

Install the dehydrating agent (Desiccant) (SPMC 214) as follows:

NOTE: Do not put the dehydrating agent (Desiccant) near the fan or turbine blades because the rotation of the blades can cause the desiccant bags to open.

NOTE: Engines that are stored in the desert or in an air−conditioned room, it is not necessary to install the desiccant).

Open the engine covers.

- The desiccant/humidity indicator must be installed evenly through the engine in the locations pointed out in the AMM.
- Put a calculated amount of dehydrating agent (refer to AMM) in the bottom of the engine bag or shipping container.

  NOTE: The quantity of desiccant is specifically calculated to give maximum protection from moisture during the specified storage times. It is not necessary to inspect the engine as long as the specified storage time is not exceeded.
- Put one half in the inlet area and the other half in the tailpipe area.
- Hang the dehydrating agent in all areas so that the agent does not touch the engine parts.
- Put relative humidity indicators inside the inlet and exhaust areas.

Seal the engine for storage

NOTE: If the power plant is stored in an air−conditioned hanger, it is not necessary to install the engine blanks. If the covers or blanks are removed during storage, it must be done on a dry day (low humidity) to prevent contamination of the desiccant by atmospheric moisture.

- Seal all the engine openings using the blanks as applicable.
- Install a tarp or PVC plastic sheet over the intake cowl, fan exhaust area and the engine exhaust area.
- The protective covers must have windows so that you can see the relative humidity indicators inside the engine.

Make a record of the engine preservation method and the date for each engine.

- Include the procedures used for the oil (oil drained) and the fuel systems (lubricating oil).

Example of a procedure to examine the engine during preservation.

- Every 15 days or less, examine the humidity indicators.
- If the relative humidity is less than 40 percent, change the dehydrating agent, if necessary, and permit the engine to continue in storage for 15 days more.
- If the relative humidity is more than 40 percent, but less than 60 percent, replace the dehydrating agent and continue in storage for 15 days more.
- If the relative humidity is more than 60 percent, replace the dehydrating agent and re−preserve the engine.

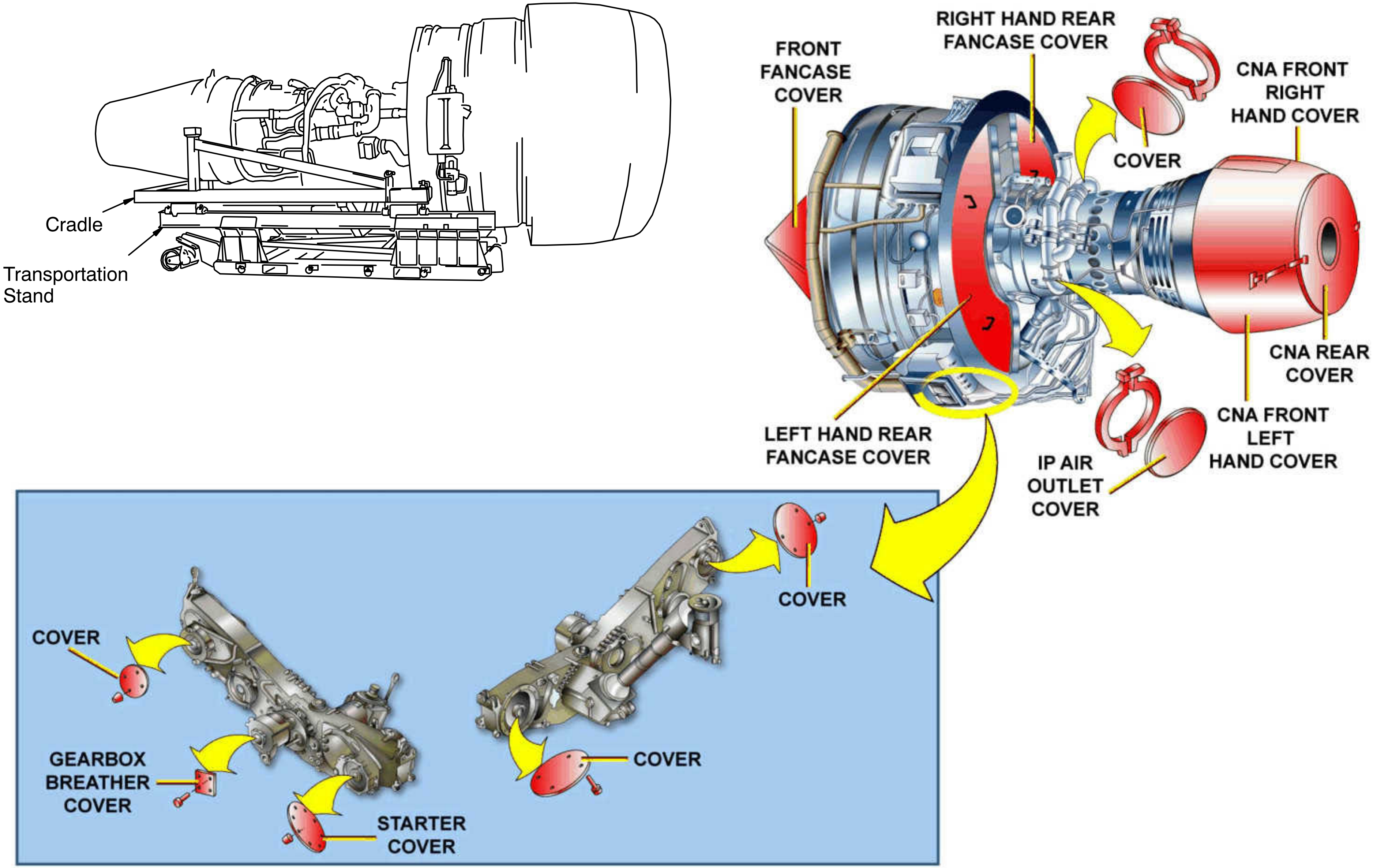


Figure 9 Engine Storage Equipment

ENGINE PRESERVATION MAINTENANCE PRACTICES

General

The preservation procedures protect the CFM56 engine against corrosion, liquid and debris entering the engine, and atmospheric conditions during periods of storage, and inactivity. This includes installed engines on inoperative aircraft or engines not to be operated for more than 30 days.

The procedure recommended for preservation of the engine will vary depending upon the duration of inactivity, the type of preservation used, and if the engine is operable or non–operable.

NOTE: Engines that can be started are considered operable. Engines that for any reason cannot be started are considered non–operable.

The preservation procedure is offered as a guideline for each operator to use as a baseline to determine what precautions should be exercised to provide adequate protection to the engine based on that operator's experience with local environmental influences and past preservation practices.

The engine preservation policy of any operator should be a flexible program, implemented to provide a maximum of protection to critical engine components (gears, bearings, accessory components, etc.) with consideration for seasonal changes in local conditions such as temperature and humidity.

Special care should be exercised in locations where exposure to severe temperature changes, severe humidity or salt water over extended periods of time could present a higher risk of damage to engine parts.

Ultimately, it is the responsibility of the engine operator to provide sufficient protection for engines out of service for extended periods of time.

Engines should not be preserved and placed into storage and forgotten. Engine preservation guidelines are provided to the operators for their use to establish and implement a viable engine preservation plan.

The preservation procedure to be used is based upon the following schedule: up to 30 days, up to 90 days, between 30 to 365 days, preservation renewal requirements, procedure for exceeded long term preservation and de–preservation.

See Aircraft Maintenance Manual (AMM) for specific storage requests. Before a preservation procedure some cautions must be observed.

CAUTION: IF ENGINE WAS FERRIED OR SUBJECTED TO AN IN-FLIGHT SHUTDOWN, ENGINE MUST BE DRIED OUT AND RE-LUBRICATED WITHIN 24 HOURS AS PER DRY OUT PROCEDURE OF THIS SECTION.

CAUTION: UNDER NO CIRCUMSTANCES SHALL PRESERVATIVE OIL OR EQUIVALENT BE SPRAYED INTO THE ENGINE INLET, CORE COMPRESSOR OR TURBINE, OR ENGINE EXHAUST. DIRT PARTICLES ON WET BLADES AND VANES MAY ADVERSELY AFFECT ENGINE PERFORMANCE DURING SUBSEQUENT OPERATION.

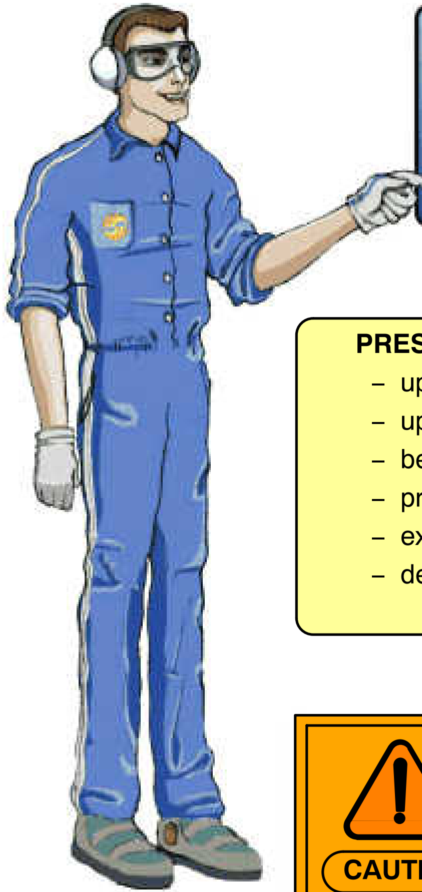
Preservation Renewal Requirements

You can refer to the AMM for preservation renewal requirements for operable and non operable engines. To exceed long–term preservation, refer to your CFM International (CFMI) representative.

Engine Depreservation

Remove all moisture barrier material, seals, caps, cover, etc., as applicable, from the engine. Connect fuel supply, reconnect oil supply and scavenge lines if applicable and drain the oil tank. Drain accessory drive assembly.
Fill the oil tank. Do a wet motoring of the engine. Do one or more dry motoring operations to remove the remaining fuel.

Period	Operable	Non Operable
up to 30 days	2 renewal	no renewal
up to 90 days	1 renewal	X
30 to 365 days	no restriction	no renewal



PRESERVATION PROCEDURE SCHEDULE

- up to 30 days
- up to 90 days
- between 30 to 365 days
- preservation renewal requirements
- exceed long term preservation
- depreservation

CAUTION

IF ENGINE WAS FERRIED OR SUBJECTED TO AN IN-FLIGHT SHUTDOWN, ENGINE MUST BE DRIED OUT AND RE-LUBRICATED WITHIN 24 HOURS AS PER DRY OUT PROCEDURE OF THIS SECTION

CAUTION

UNDER NO CIRCUMSTANCES SHALL PRESERVATIVE OIL OR EQUIVALENT BE SPRAYED INTO THE ENGINE INLET, CORE COMPRESSOR OR TURBINE, OR ENGINE EXHAUST. DIRT PARTICLES ON WET BLADES AND VANES MAY AFFECT ENGINE PERFORMANCE DURING SUBSEQUENT OPERATION.

Figure 10 Engine Preservation

ENGINE REMOVAL/INSTALLATION

Precautions

Make sure that you have the correct fire fighting equipment available before you start any task on the fuel system. Make sure that the landing gear safety-locks and the wheel chocks are in position. Put the safety devices and the warning notices in position before you start any task on or near:

- the flight controls
- the flight control surfaces
- the landing gear and the associated doors
- or any component that moves

Make sure that all the circuits in maintenance are isolated before you supply electrical power to the aircraft.

Make sure that the ENG MASTER control switch is OFF, slats are retracted and the appropriate circuit breakers are open.

NOTE: Before removing the engine, the electrical, fuel, hydraulic and pneumatic connections must be disconnected from the pylon interface panel and ducts.

WARNING

- correct fire fighting equipment
- landing gear safety-locks and wheel chocks in position
- safety devices and warning notices in position
- all circuits isolated
- engine master lever set to off, slats retracted and appropriate circuit breakers open

Figure 11 Precautions

Engine Interfaces

Engine interfaces on the engine LH side are:

- Fluid Disconnect Panel:
  - Fuel and Hydraulics
- Thrust Reverser Electrical Junction Box
  (on the L/H Thrust Reverser Cowl Door)
- Pneumatic System Coupling
  (in Engine FWD Mount Zone)

Engine interfaces on the engine RH side are:

- Core Electrical Junction Box
- Fan Electrical Connector Panel
  (including IDG Harness Connector
- T/R Hydraulic Control Unit (HCU) Harness Connectors
  (on the RH T/R Cowl Door
- Starter Duct Coupling.

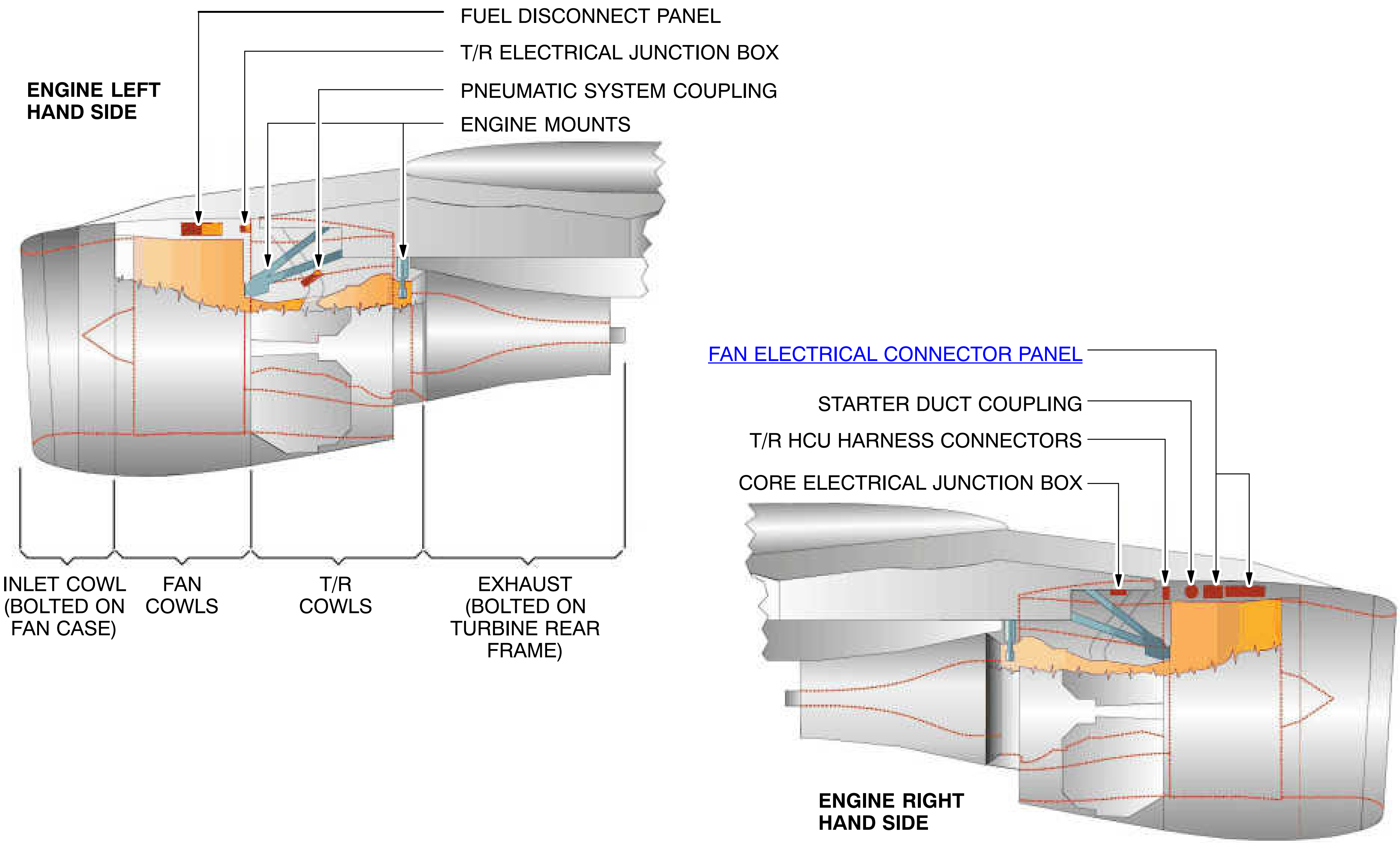


Figure 12 Engine Interfaces

Hold Open Cowl Brace Installation

To support the fan and thrust reverser cowls, during engine removal or installation, special braces are installed.

This enables the engine to be changed under the wing without removing the fan cowls and the thrust reverser cowl doors.

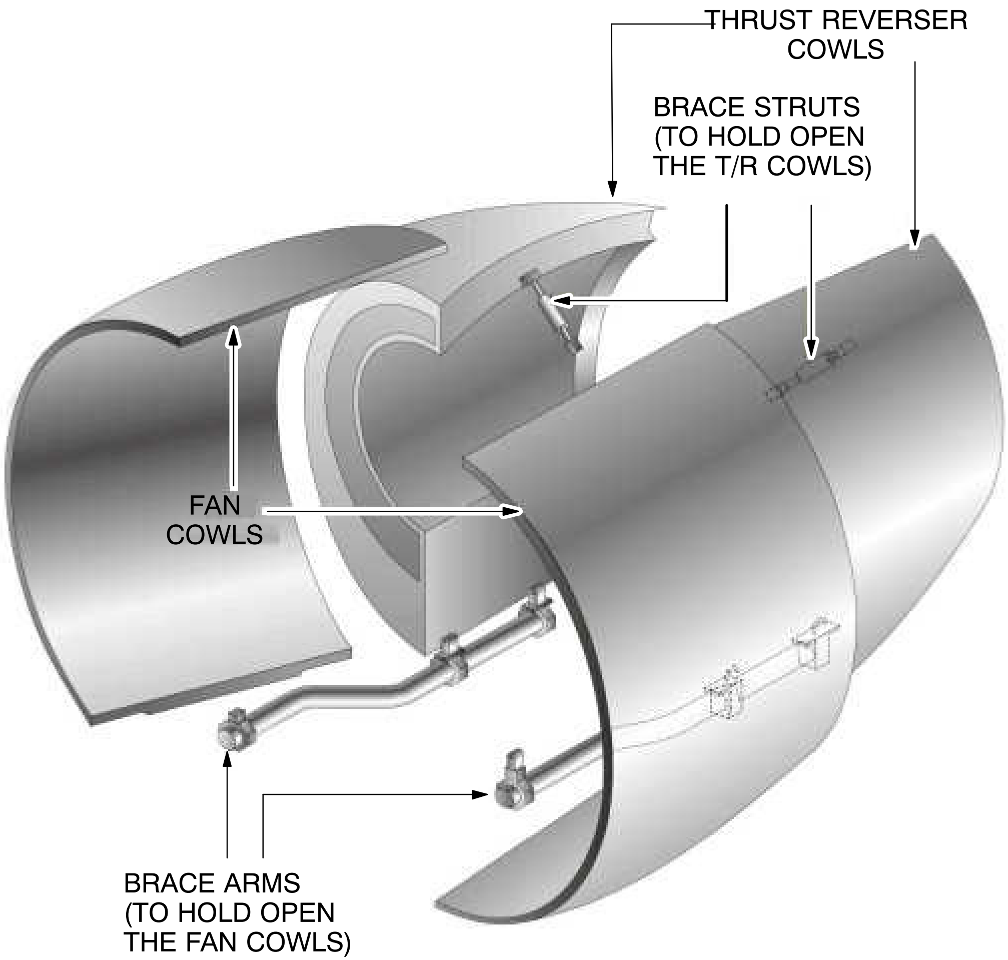


Figure 13 Hold Open Cowl Brace Installation

Engine Removal and Installation Systems

Equipment used for engine removal or installation is:

- Bootstraps installed on the Forward Mount and rear part of the pylon
- Four dynamometers and chain pulley blocks are installed at the end of the bootstraps to ensure the correct tension during engine removal or installation

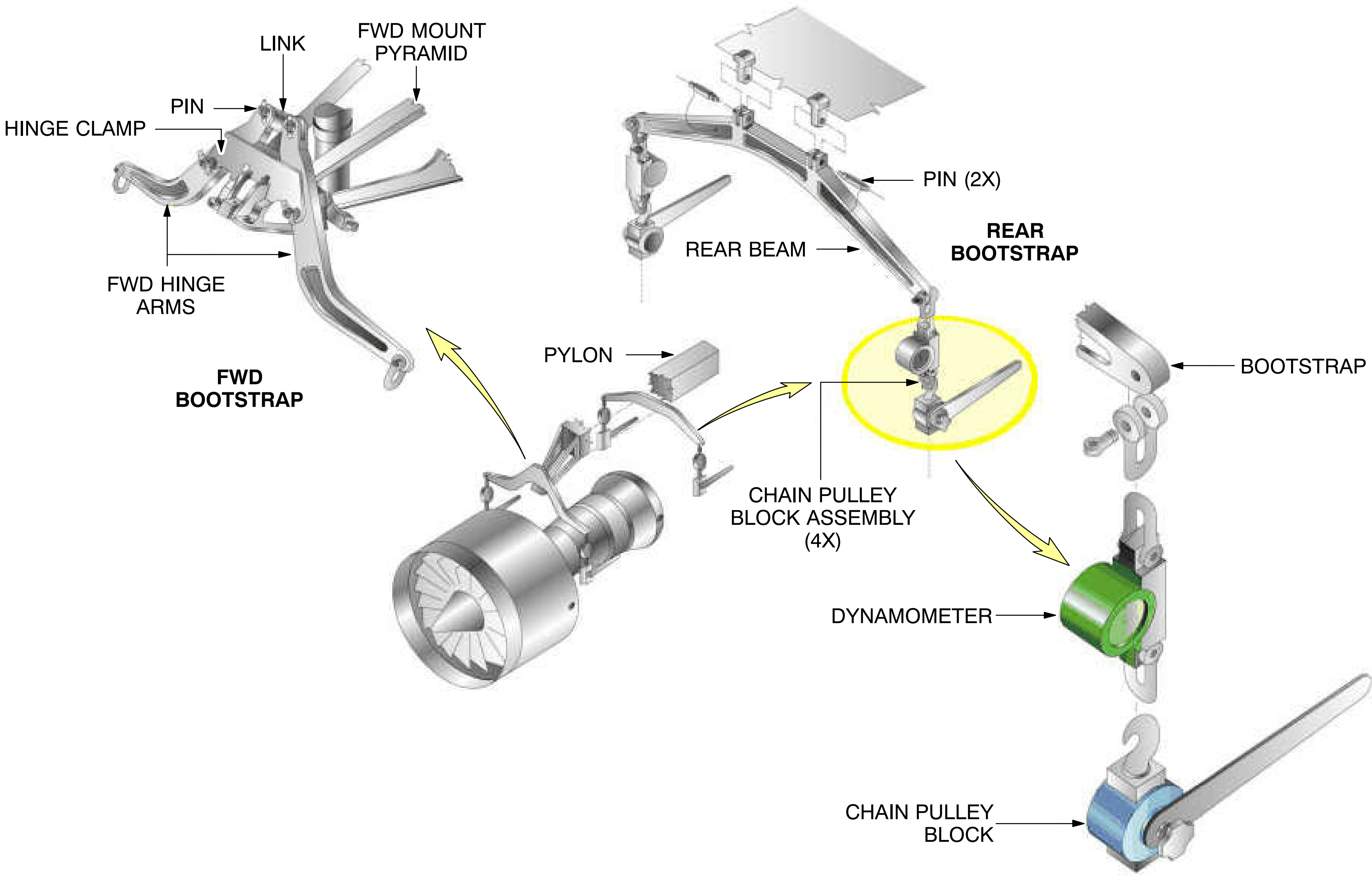


Figure 14 Engine Removal and Installation Systems

Engine Cradle and Trolley

The engine cradle and trolley are two associated tools, which let the engine to be removed and carried.

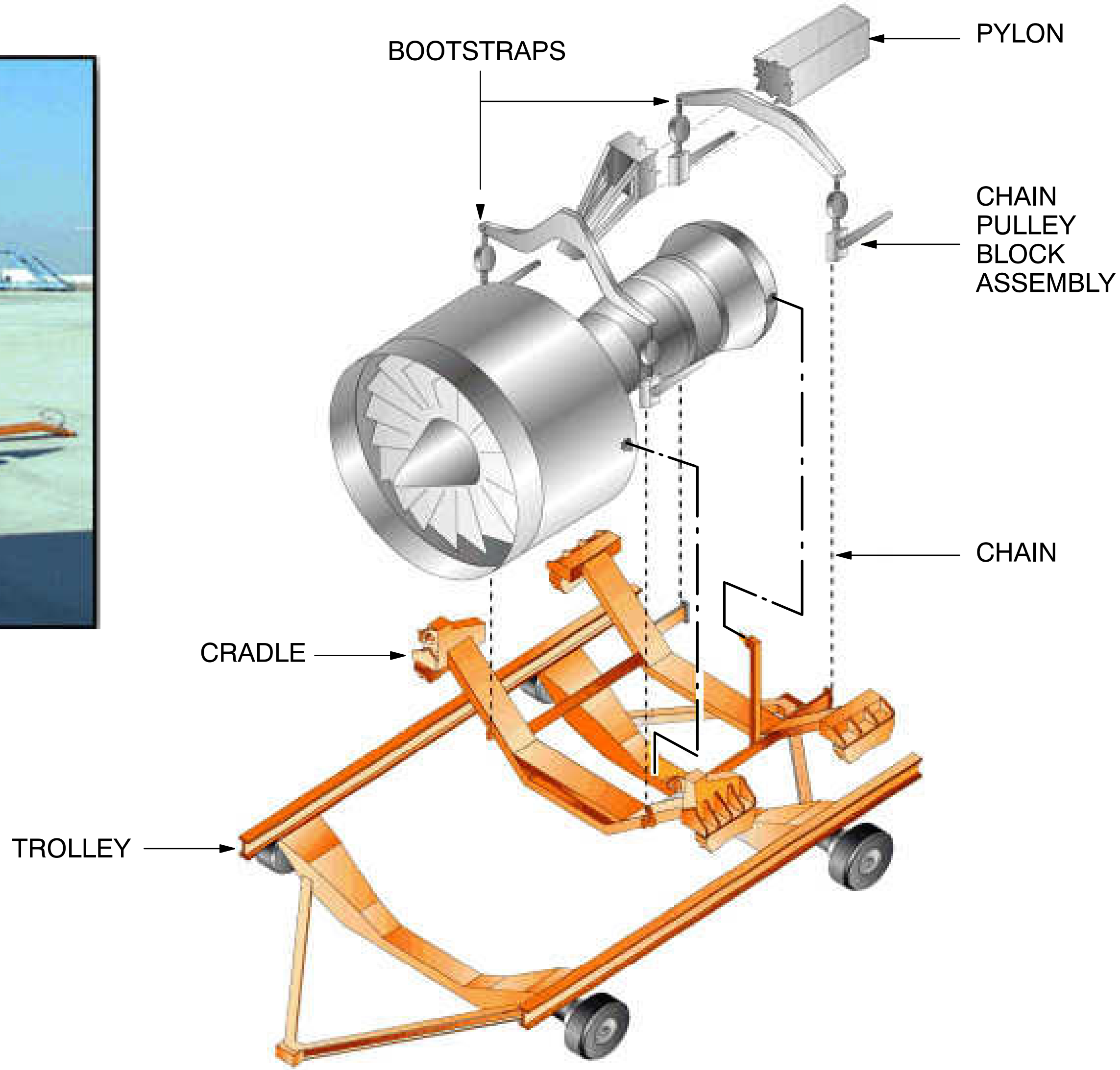


Figure 15 Engine Craddle and Trolley

Engine Hydraulic Positioner

The engine hydraulic positioner is a special hydraulic trolley, which supplies easy positioning and engine installation. For engine transportation, the same cradle can be transferred from the engine hydraulic positioner to a standard trolley.

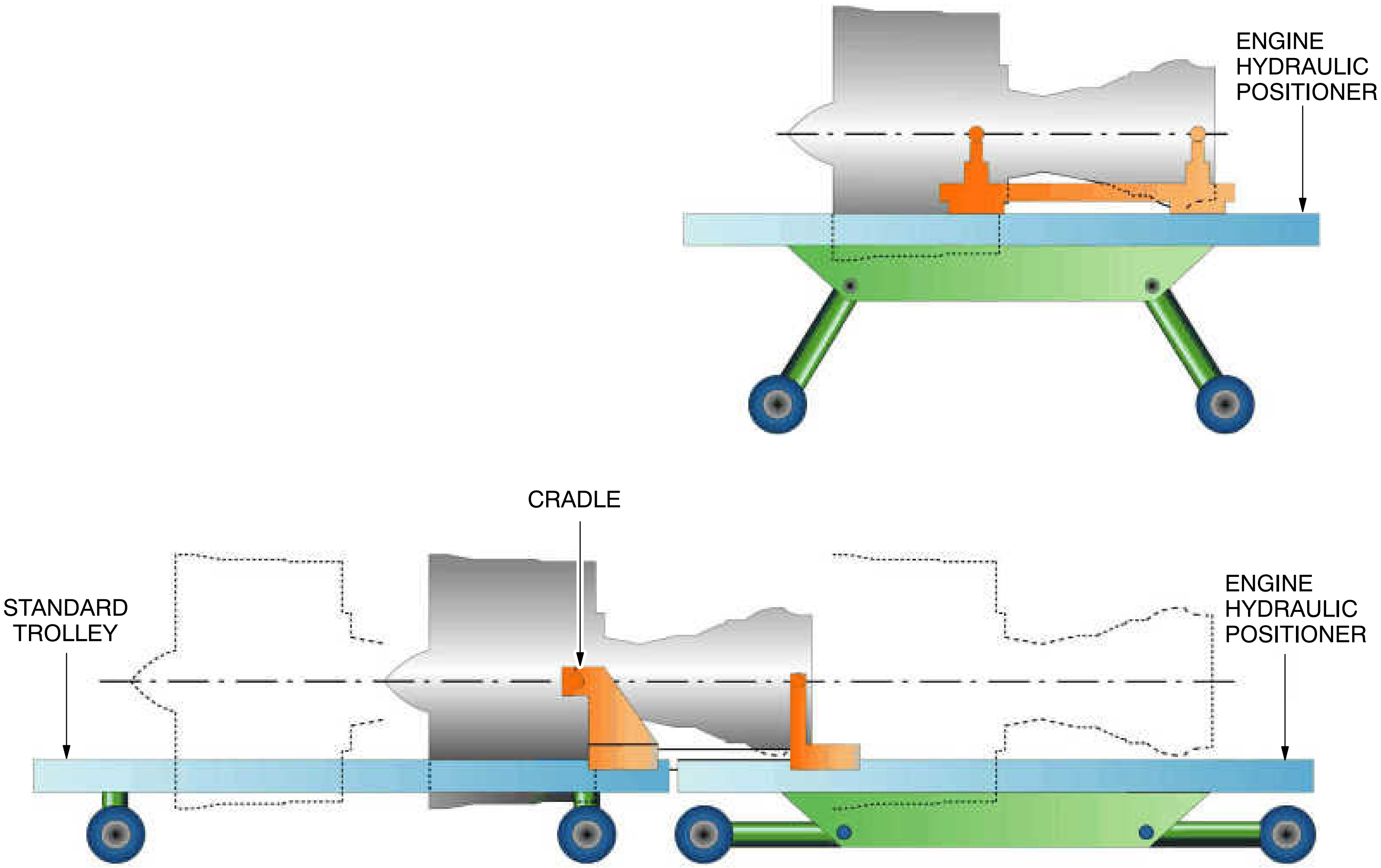


Figure 16 Engine Hydraulic Positioner

71-20 MOUNTS

ENGINE MOUNTS GENERAL DESCRIPTION

The engine mounts support the engine by transmitting loads from the engine case to the pylon structure.

They allow thermal expansion of the engine without inducing additional load into the mount system.

Each engine mount design provides dual load paths to ensure safe operation if one part fails.

The engine/pylon connection is achieved by means of a two-mount system:

- the FORWARD MOUNT,
- the AFT MOUNT,

Forward Engine Mount

The Forward Engine Mount is attached to the engine via the intermediate casing. It forces the X-loads (thrust), Y-loads (lateral) and Z-loads (vertical).

Aft Engine Mount

The Aft Engine Mount is attached to the engine via the exhaust casing. It forces the loads in a plane normal to the engine centerline i.e. Y-loads (lateral), Z-loads (vertical) and Mx (engine rotational inertia moment + Y-load transfer moment).

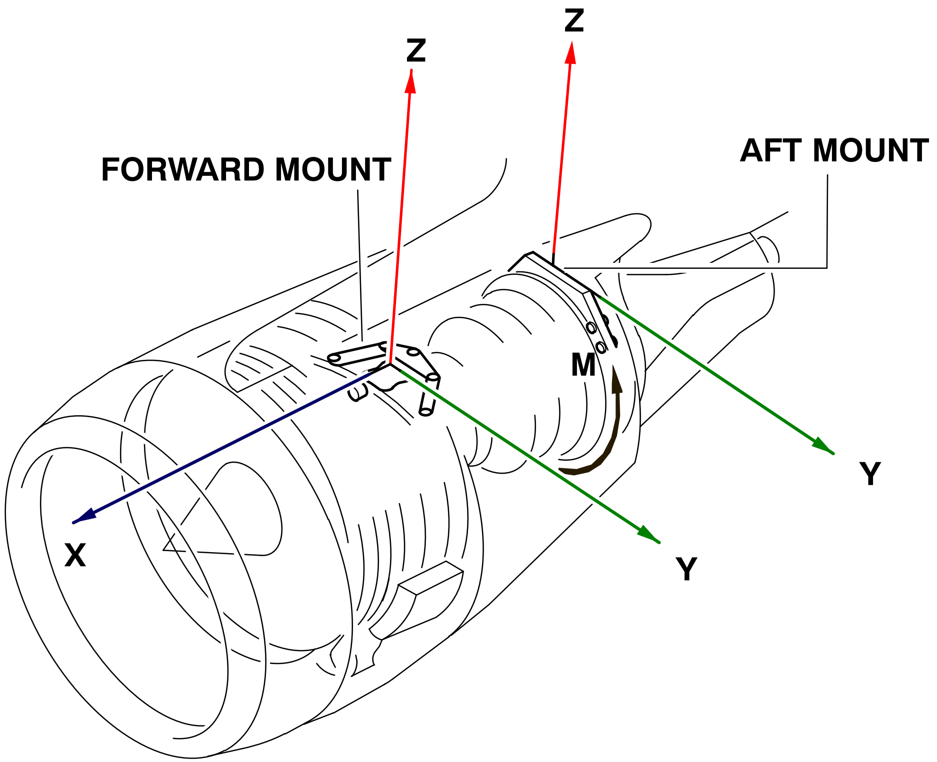


Figure 17 Engine Mount Loads

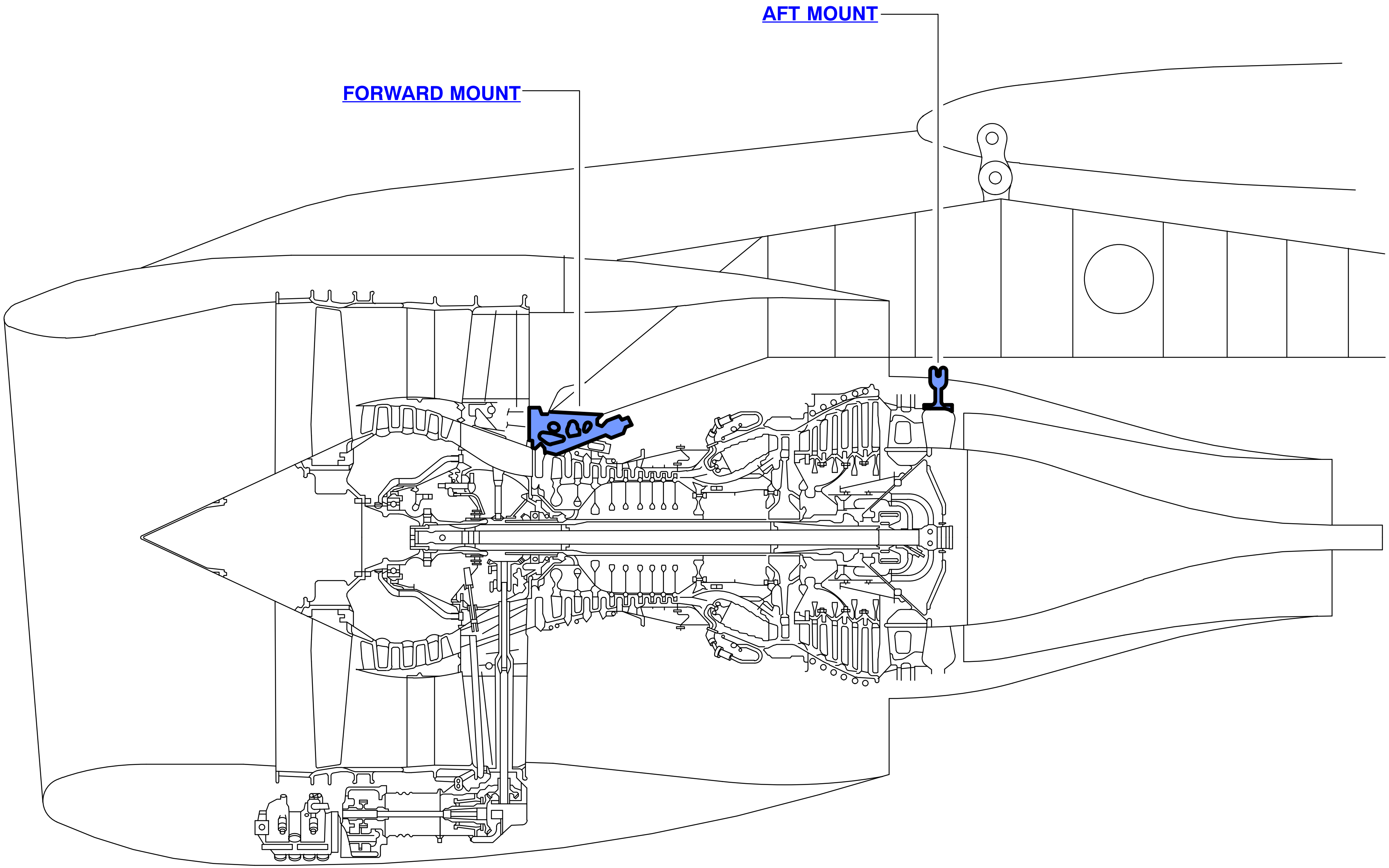


Figure 18 Engine Mounts

COMPONENT DESCRIPTION

Forward Mount

The forward mount connects the engine aft fan case with the engine pylon forward structure. The forward mount is of the damage tolerant design.

It is composed of a SUPPORT BEAM ASSEMBLY for pylon connection via four tension bolts and two alignment pins. This fail-safe designed fitting is an assembly of three components: two half-fittings and one plate.

Depending on engine modification status the fwd mount crossbeam may be manufctured from titanium or steel alloy.

Aft Mount

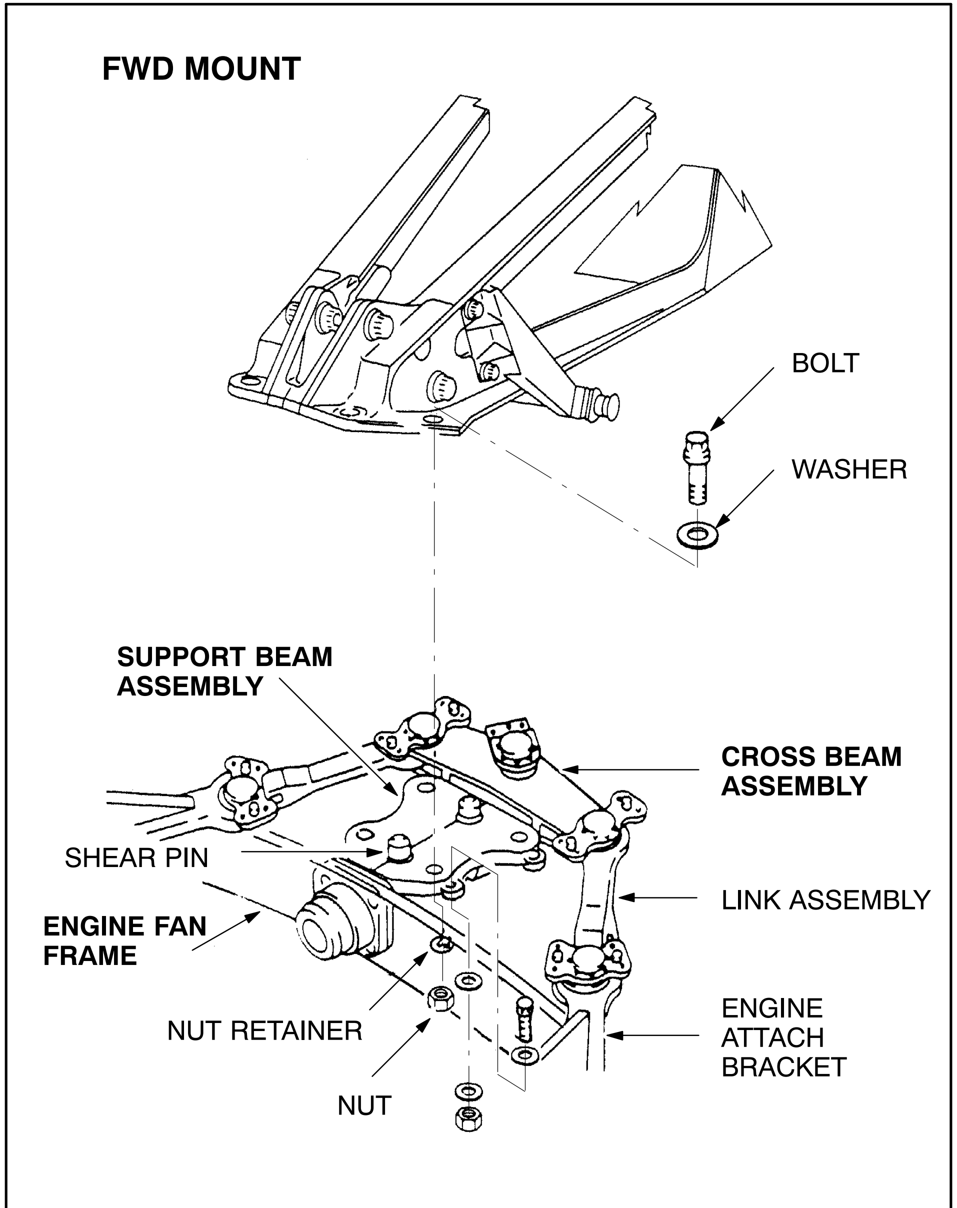
The aft mount connects the engine turbine rear frame with the engine pylon via a beam. The aft mount takes the loads in the plane normal to the engine centerline, i.e. y-, z-loads and Mx. The aft mount is of the damage tolerant design.

It consists of three links and a crossbeam assembly. There is a possibility of axial translation movement between the engine casing and the pylon since the three links are located in the same plane normal to the engine centerline and the link end bearings.

There is a possibility of axial translation movement between the engine casing and the pylon. This allows for casing expansions of about 6 mm in cruise and 7.5 mm at maximum thrust.

The aft mount consists of three fail-safe links. Each link is a triple element stacked assembly.

The cross beam has a mating face for connection with the engine pylon. This attachment is made through four tension bolts and two shear pins. One of the two shear pins is a back-up pin also used as an alignment pin. The cross beam fitting is of the fail-safe design, it consists of two lateral parts linked by shear pins.



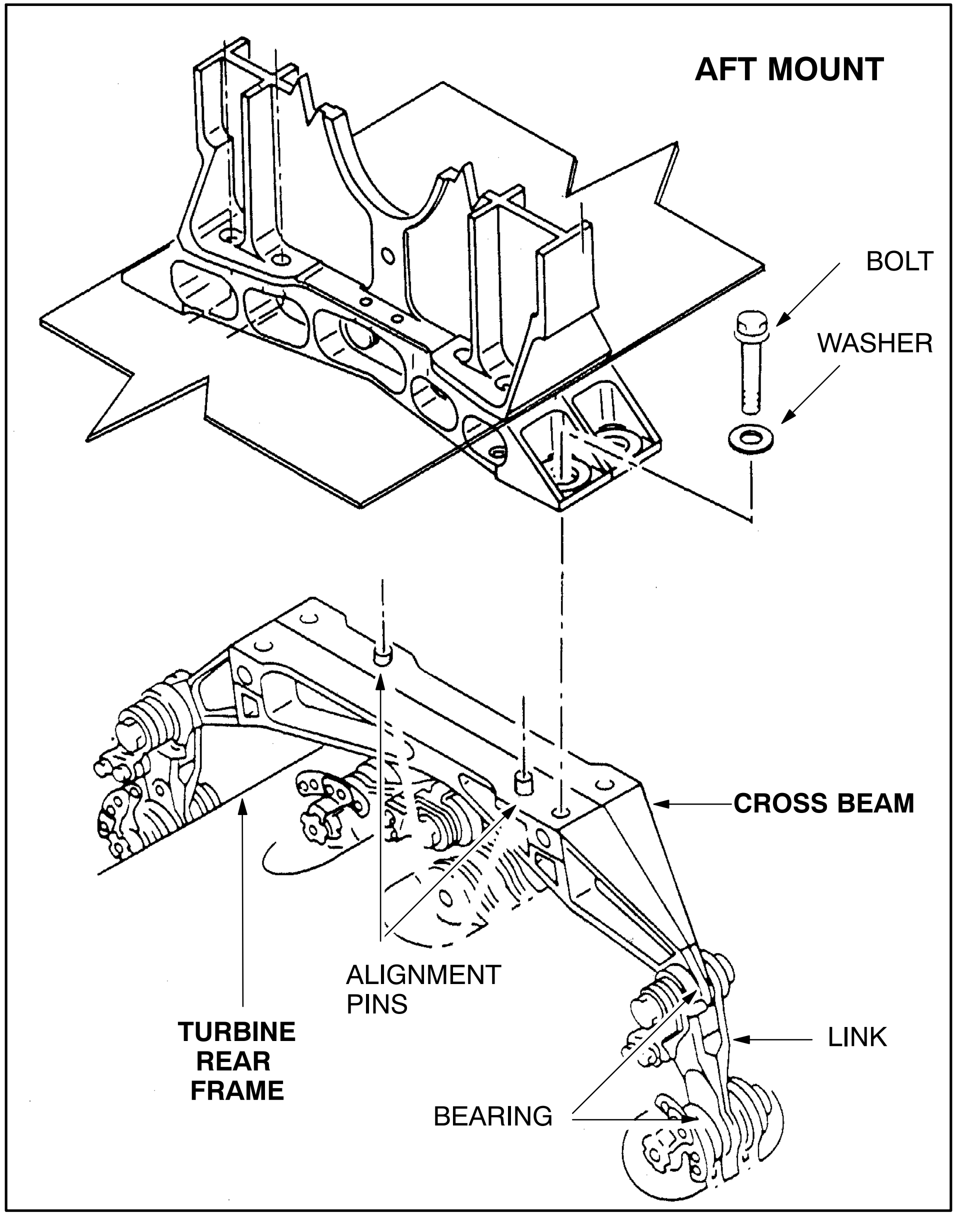


Figure 19 Engine Mount Components

71-10 COWLINGS

INTRODUCTION

Nacelle General

The cowls enclose the periphery of the engine so as to form the engine nacelle.

The nacelle provides:

- protection for the engine and the accessories,
- ensuring airflow around the engine during its operation,
- lightening protection,
- HIRF (**H**igh **I**ntensity **R**adio **F**requency) and EMI (**E**lectro**m**agnetic **I**nterference) attenuation.

Air Intake Cowl

The air intake cowl supplies the airflow to the engine.

Fan Cowls

The fan cowl doors enclose the engine fan case between the air intake cowl and fan thrust reverser. Three hinges at the pylon support each assembly. The door assemblies are latched along the bottom centerline with three adjustable tension hook latches.

To improve take-off performance, aerodynamic strakes have been installed on the inboard fan cowl of each nacelle on some aircraft configurations. The fan cowl doors are fire proof and fire resistant.

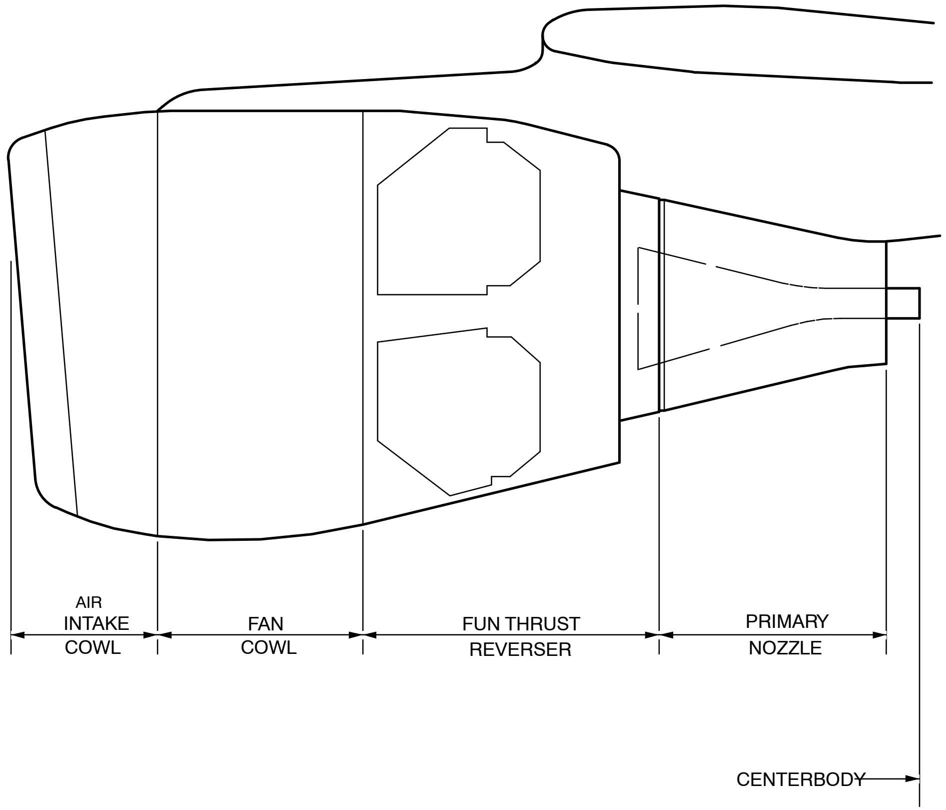


Figure 20 Engine Nacelle

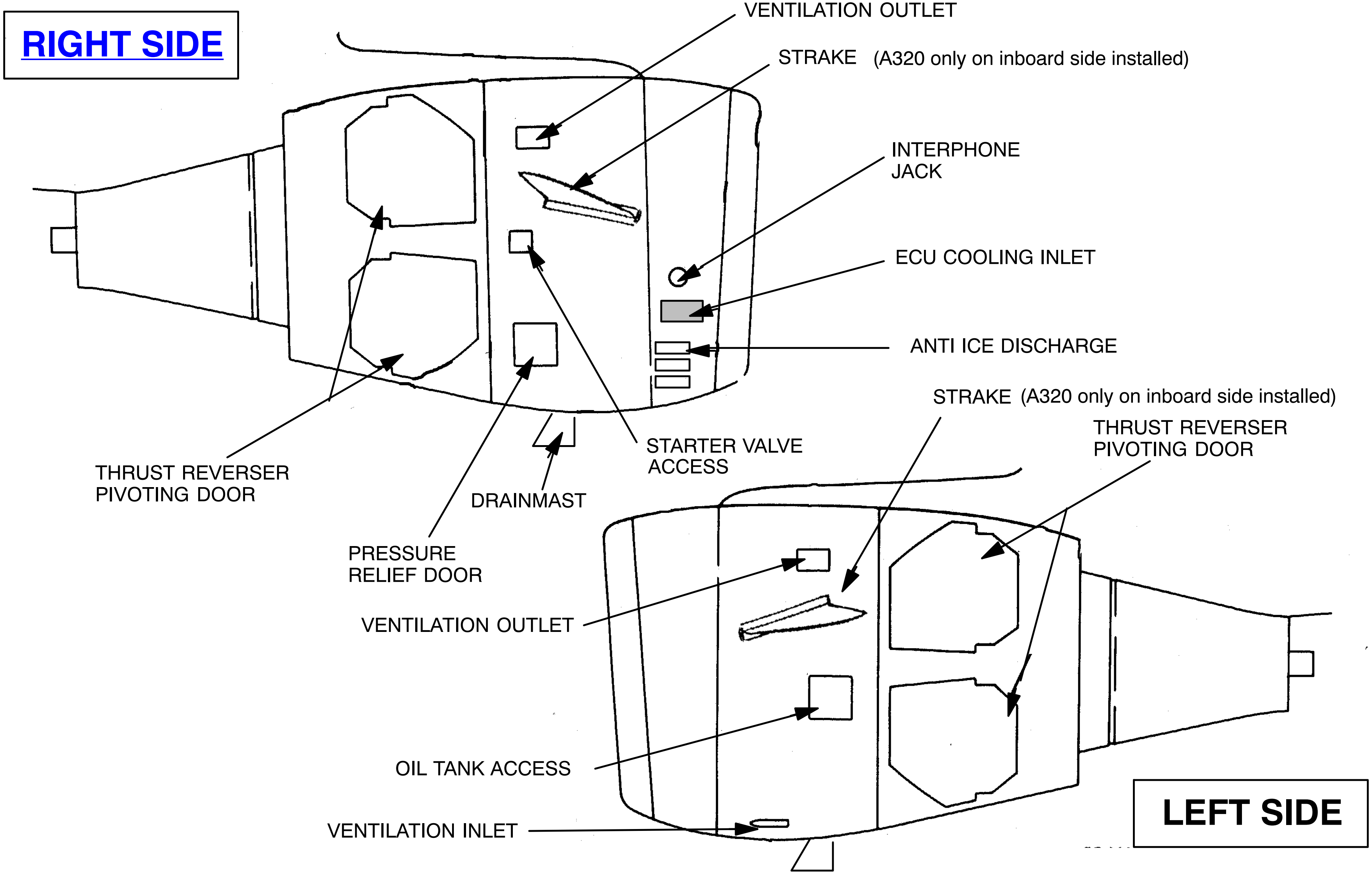


Figure 21 Nacelle and Access Doors

71−11 AIR INTAKE COWL

GENERAL DESCRIPTION

The engine air intake cowl structure is an interchangeable aerodynamically faired assembly. It is mounted to the forward face of the engine fan case A1 flange. The assembly is composed of:

- an inner and outer barrel
- a nose lip
- a forward and an aft bulkhead

The assembly also includes installation of:

- the anti−icing ducting
- the engine control unit cooling inlet and exhaust
- the interphone/ground jack
- the T12 sensor
- hoisting provisions
- pip pin receptacles for the intake cover

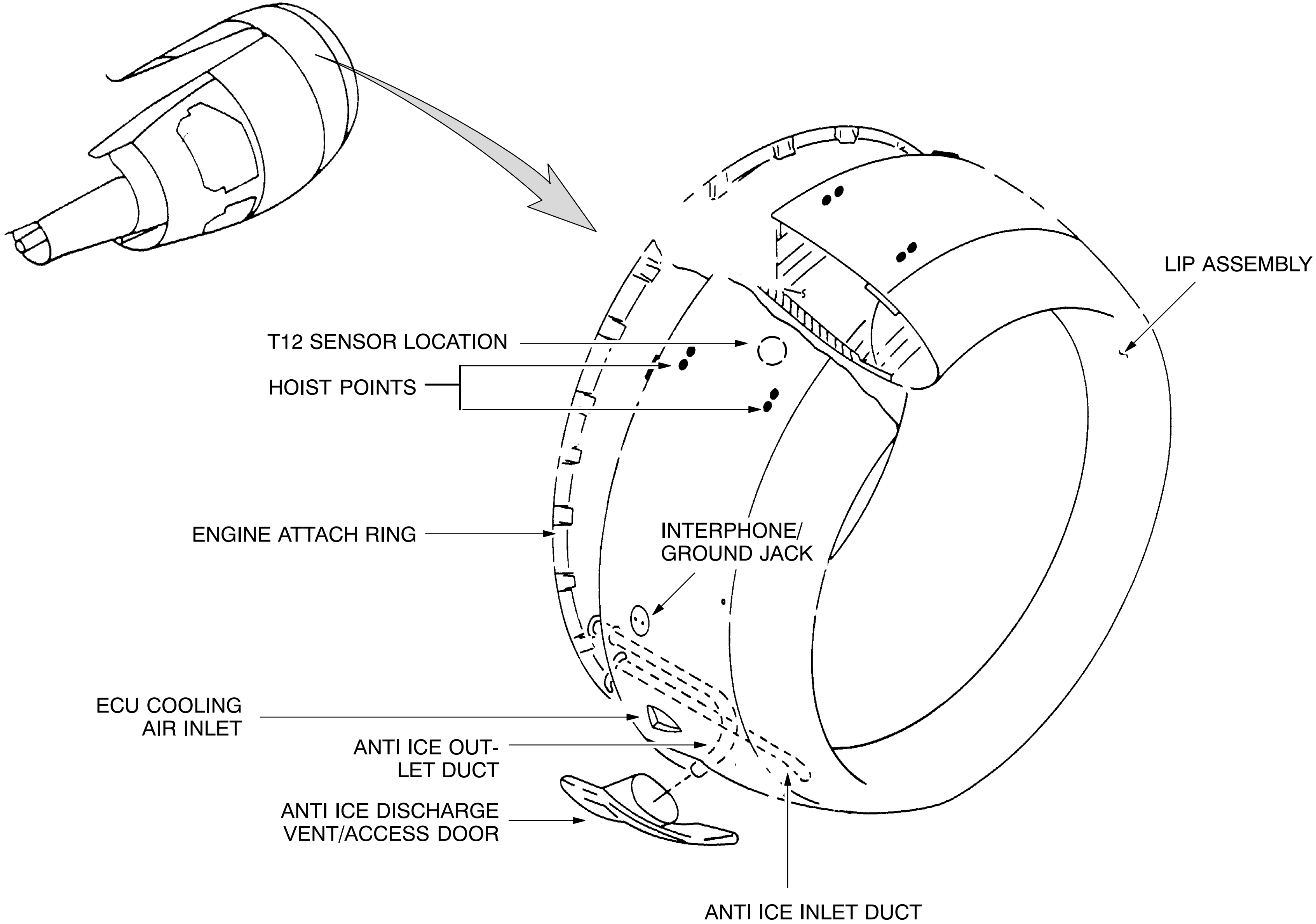


Figure 22 Air Intake Cowl

71-13 FAN COWL

GENERAL DESCRIPTION

General

The fan cowls enclose the engine fan case between the air intake cowl and the thrust reverser. Three hinges at the pylon support each fan cowl. The fan cowls are latched at the bottom with three adjustable tension hook latches.

Fan Cowl Opening and Closing

There are two telescopic hold open rods on each fan cowl door. When extended the hold open rods are positioned into brackets on the engine fan case. They support the fan cowl doors in the open position. A 40° position serves for routine maintenance and a 55° position serves for increased access.

NOTE: Engine Idle run with fan cowl doors open in the 40° position is allowed to perform maintenance tasks.

Access Doors

One access door in the right fan cowl door provides access to the starter valve manual override. An access door in the left fan cowl provides access for:

- engine oil service
- inspection of the hydraulic filter clogging

Pressure Relief Doors

A pressure relief door located in the right cowl door limits compartment pressure to a maximum of 4 psig.

Cooling Air

A compartment cooling air inlet is located in the lower quadrant of the left cowl door. The air inlet directs air toward the accessory gearbox. In the upper quadrants of the left and right cowls there are five air outlet vents.

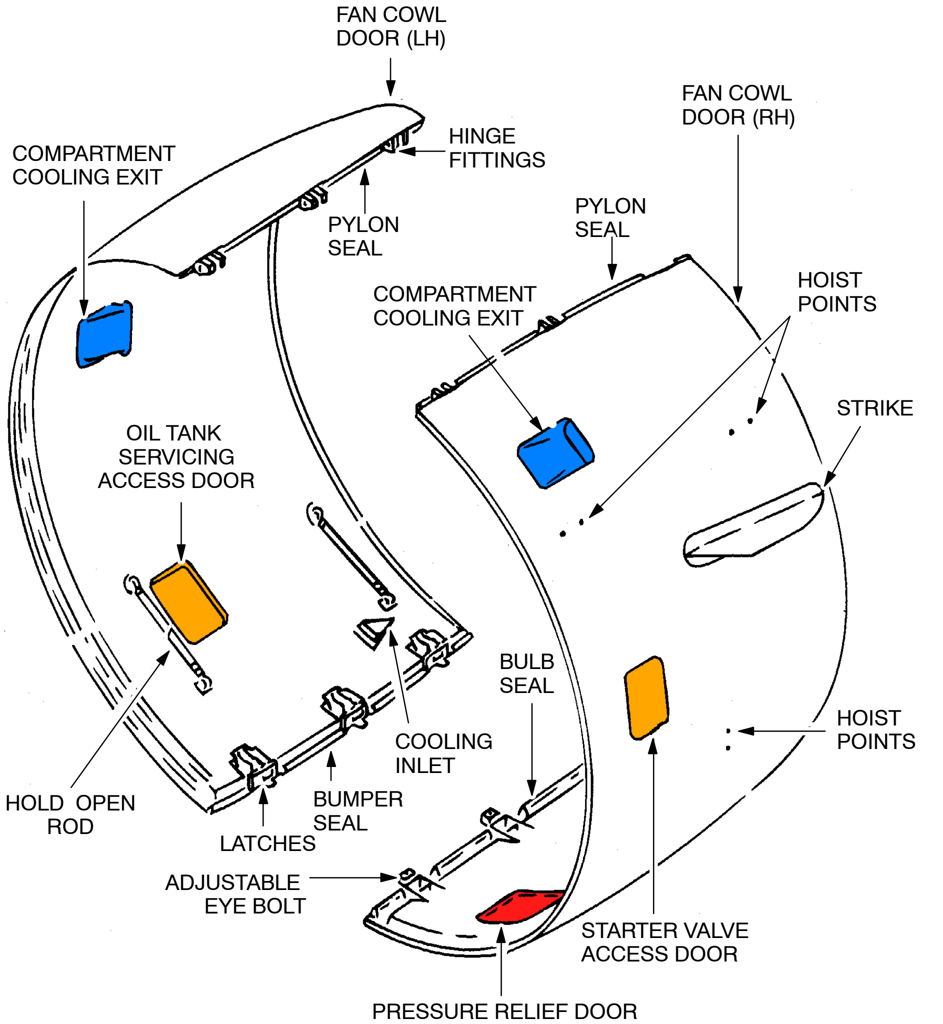
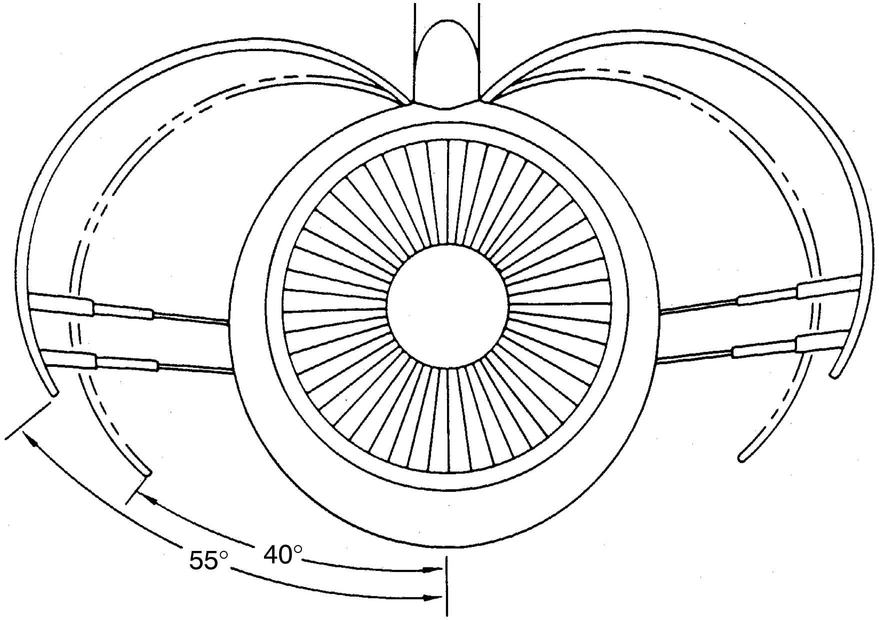
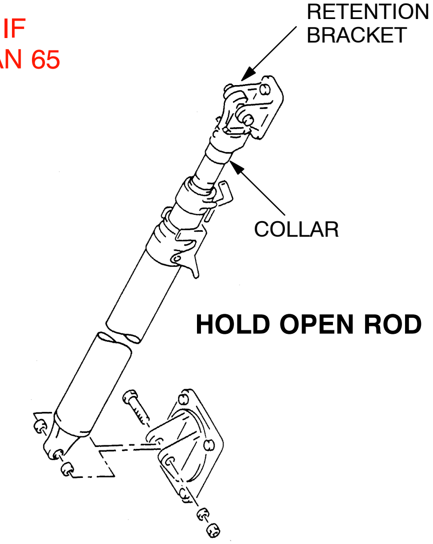
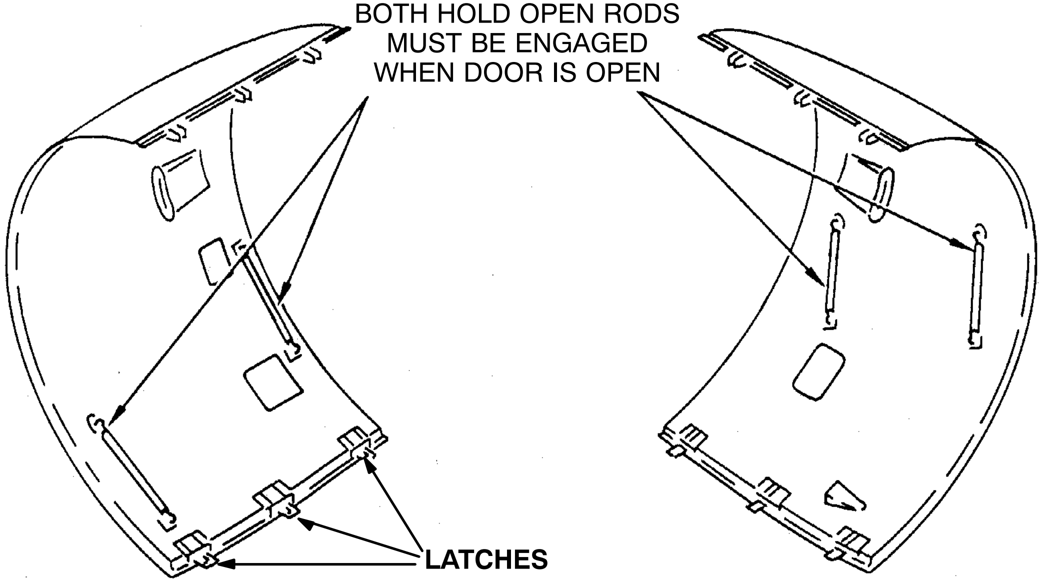


Figure 23 Fan Cowl Components



CAUTION: DO NOT OPEN COWLINGS IF WIND SPEED IS MORE THAN 65 KNOTS OR IF ENGINE IS RUNNING





OPENING:

- Unlock the three latches of the fan cowlings
- Release the Hold Open Rods from the stow brackets
- Extend the Hold Open Rods to the 40° or 55° position and attach them to the brackets on the engine

Figure 24 Fan Cowl Door Opening

Fan Cowl Latches and Latch Key Modification

The fan cowl door is latched by three adjustable tension latches.

Each latch assembly consists of a snap, a handle and a hook.

On new and modified engines a lockable latch is installed in the forward position (latch No. 1).

It must be opened and locked with the specific key and the ”remove before flight” flag assembly.

The key cannot be removed when the latch is open

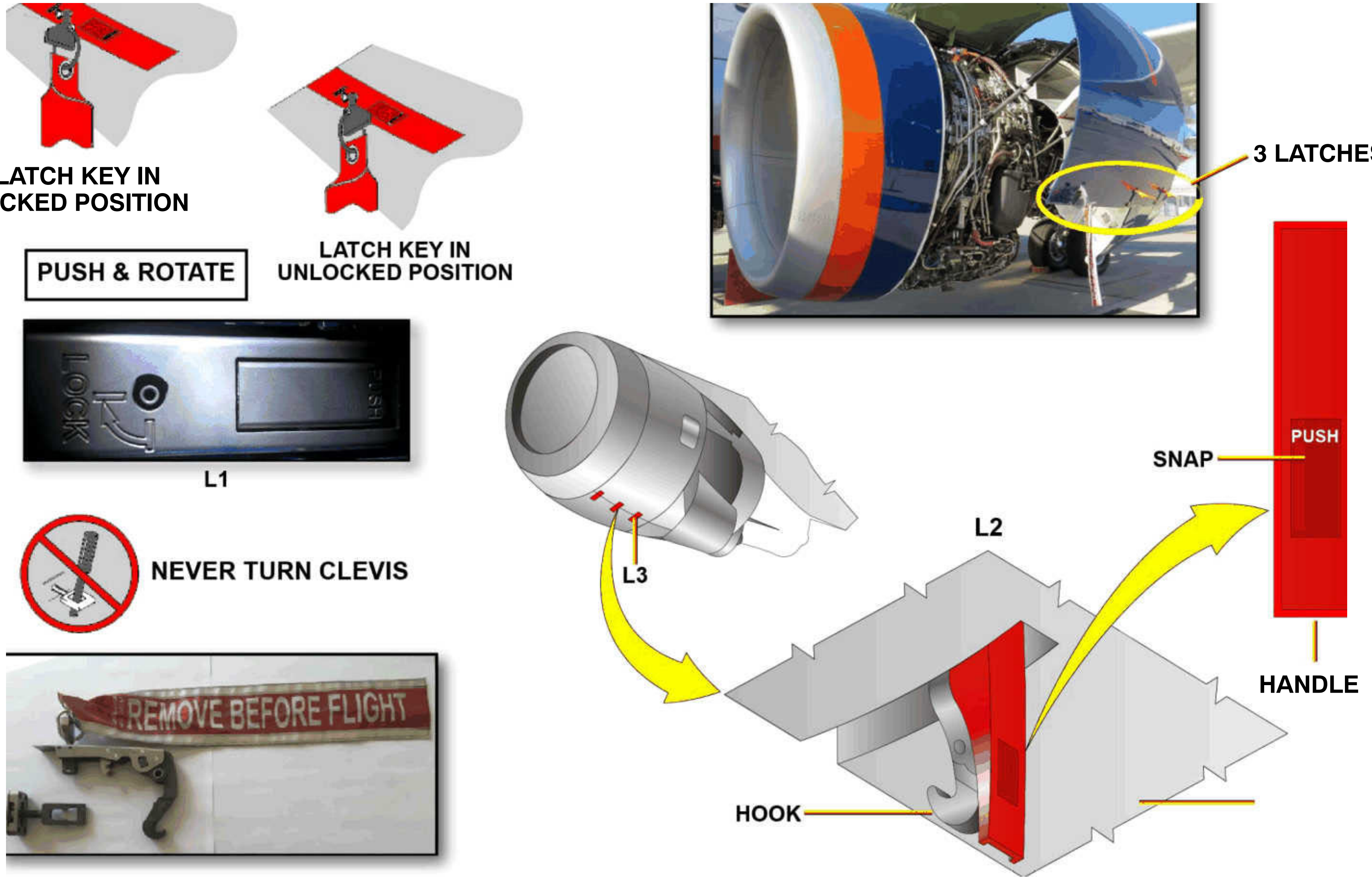


Figure 25 Fan Cowl Latches

78-36 T/R OPENING MECHANISM

GENERAL DESCRIPTION

CAUTION: DO NOT OPEN THE THRUST REVERSER COWLINGS IF THE WIND SPEED IS MORE THAN 40 KTS.

CAUTION: WING SLATS MUST BE RETRACTED IF THRUST REVERSER COWLINGS ARE OPENED MORE THAN 35° POSITION.

General

The two thrust-reverser half-cowl can be opened separately, using a hand pump. Opening of the thrust-reverser half-cowl provides access to the systems and components mounted in the engine core section.

Opening of the Thrust Reverser Cowlings

- Open the fan cowlings
- Move the HCU lever forward to make the thrust reverser unserviceable
- Install the LOCK-OUT PIN to hold the lever in the OFF position
- Unlock the four latches along the lower edge of the T/R-cowls
- Connect the hand pump
- Operate the hand pump to open the half cowling to the normal maintenance position. The doors can be opened to 33 degrees with the wing leading edge slats extended. However, beyond the 33 degree position they interfere with the wing leading edge slats when extended and thus can cause damage. Maximum opening angle is 45 degrees.

Closing of the Thrust Reverser Cowlings

- Operate the hand pump to pressurize the opening actuator to take the load of the hold-open rod
- Remove the hold open rod
- Open the hand pump relief valve to let the cowling close
- Close the four latches of the T/R-cowls
- Cowling pump must be connected for some time to allow a return flow of the oil from the opening actuator to the pump. (to prevent oil leakage of the opening actuators when the engine operates and the oil expands due to heat)

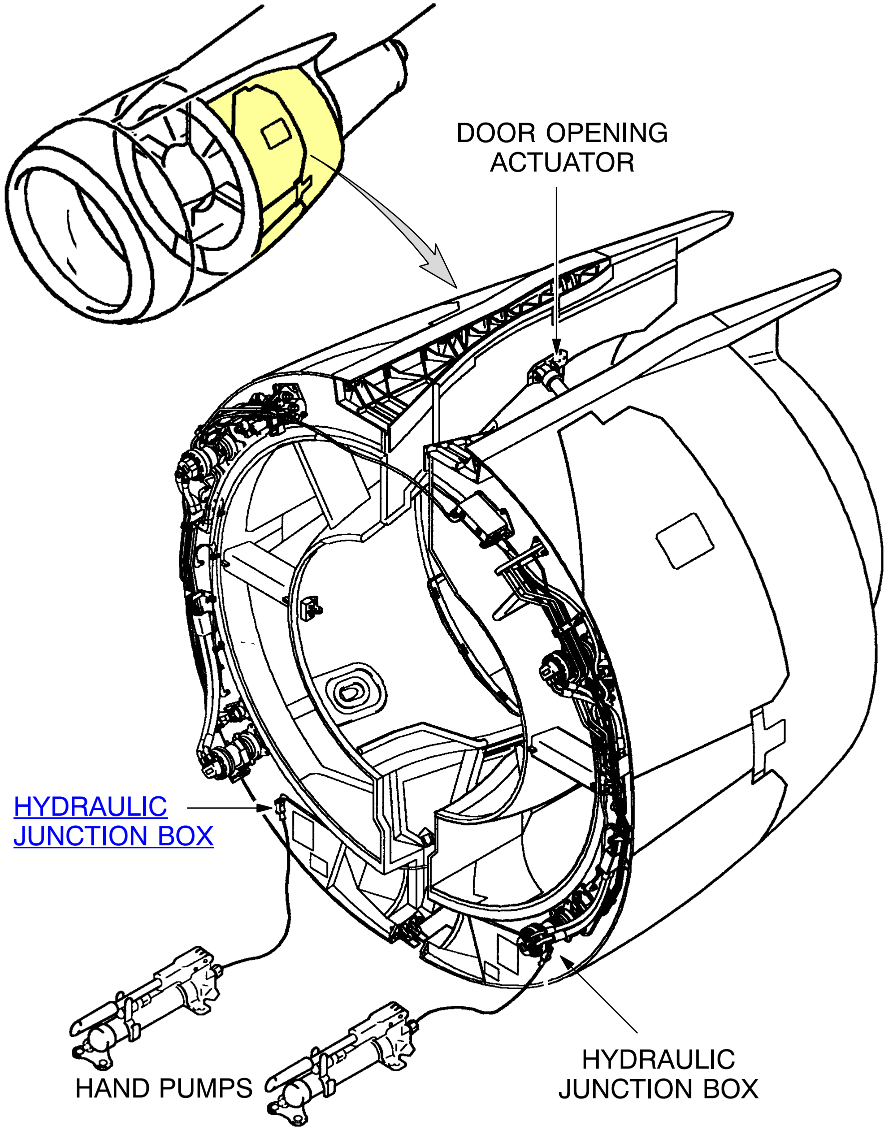


Figure 26 Thrust Reverser Cowls Opening Mechanism

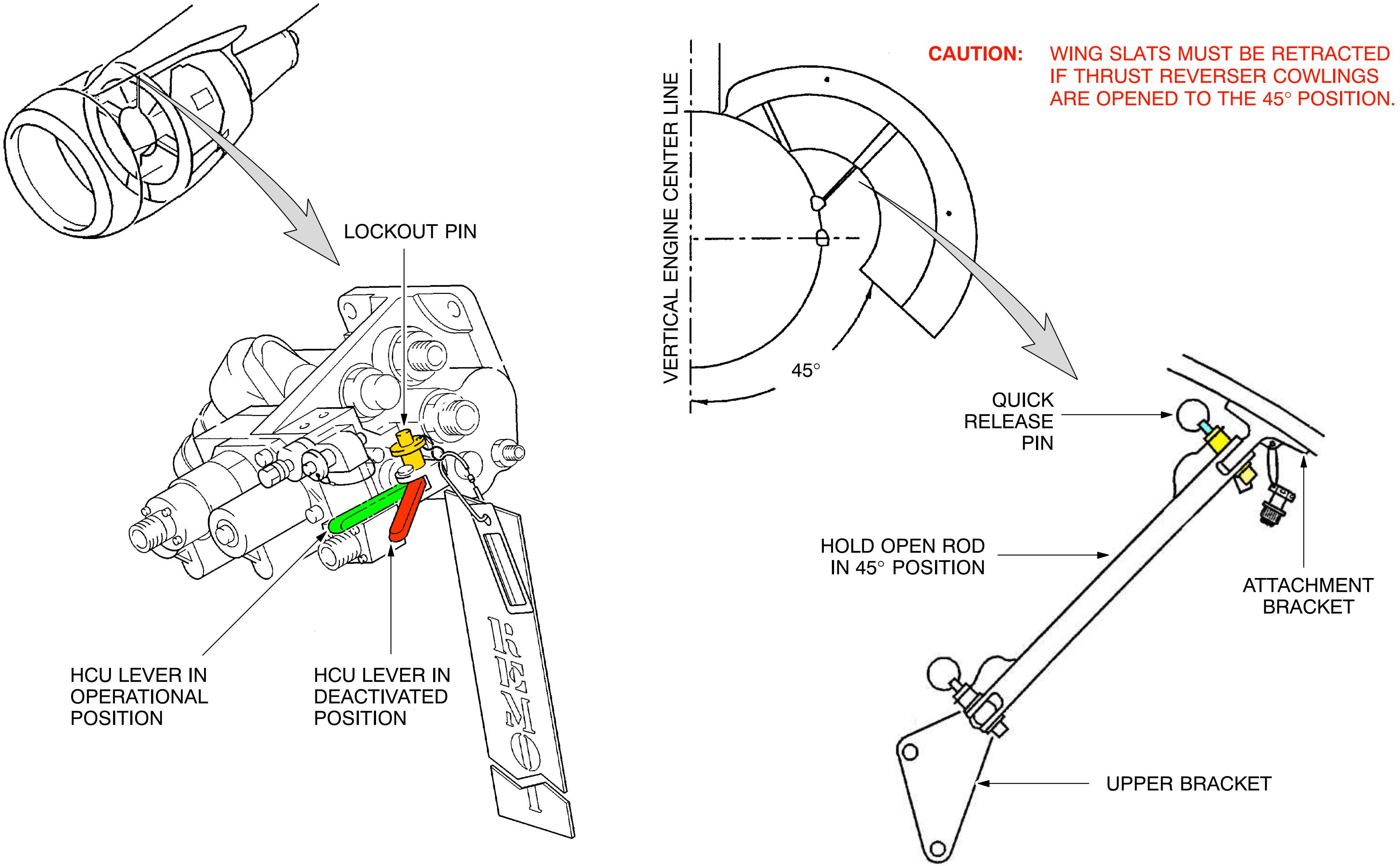


Figure 27 T/R Opening Components

71−70 DRAINS

ENGINE DRAINS DESCRIPTION

General

The drain and vent system consists of tubes. These tubes collect waste fluids and vapor from the nacelle, the engine and its accessories and carry them overboard. Drains are provided from any point where lines and accessories may leak and where fluids may accumulate in a cavity. Some drain lines serve as vents: they carry air and vapor from the engine and accessory cavity.

The drain and vent system is divided into three sections:

- The collector which collects and retains drained fluids
- the module assembly which discharges fluids
- the drain mast through which the fluids are discharged overboard

Collector

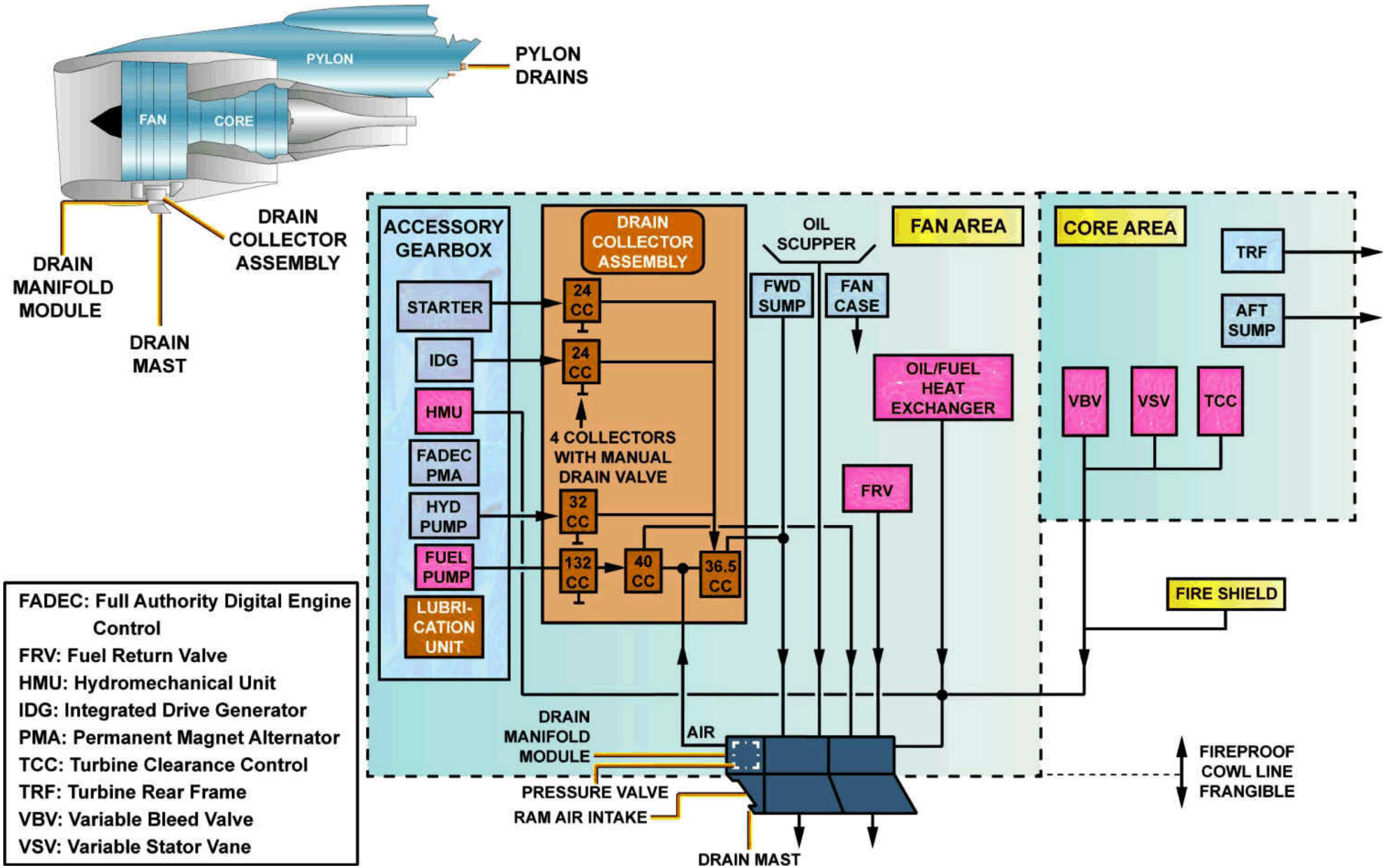
The collector assembly is composed of 4 drain valves and 2 holding tanks. The collector retains fluids until expelled during flight. The collector assembly is attached to the aft side of the engine gearbox.

Module Assembly

Various drain tubes are attached to the module assembly including a drain tube from the collector. The module assembly also supports the drain mast. The module is attached directly to the aft side of the engine gearbox.

Drain Mast

The drain mast is attached to the drain module assembly and protrudes through the fan cowl door into the airstream. The drain mast contains three cavities. The smaller forward cavity feeds ram air to the module assembly. The other two cavities are for drainage. The drain mast is located in the fan compartment (lower section).



FADEC: Full Authority Digital Engine Control
FRV: Fuel Return Valve
HMU: Hydromechanical Unit
IDG: Integrated Drive Generator
PMA: Permanent Magnet Alternator
TCC: Turbine Clearance Control
TRF: Turbine Rear Frame
VBV: Variable Bleed Valve
VSV: Variable Stator Vane

Figure 28 Engine Drains

System Operation

The collector retains drained fluids until expelled in flight. The module assembly discharges fluids directly overboard through the drain mast. The drain mast which protrudes through the fan cowl door into the airstream is the channel through which the fluids are discharged overboard except for the fuel shroud drain which discharges fluid directly overboard through an independent drain tube.

Each accessory seal (starter, IDG, hydraulic pump, fuel pump) has a separate drain to the collector in which leakage is contained. Manual drain valves in the bottom of each collector are used to drain each collector on the ground. Each collector is labeled with the accessory seal drain to which it is connected. These individual collectors overflow into the fuel/oil holding tank or a hydraulic fluid/oil holding tank.

Leakage is contained in the holding tank until the aircraft reaches an airspeed of 200 Knots. When the airspeed reaches 200 Knots a pressure valve in the module assembly admits ram air. The ram air pressurizes the holding tanks and any accumulated fluid is discharged overboard through the drain mast. Fluids from the following sources drain into the module assembly and are discharged directly overboard, except for the fuel shroud pipe which has its own drain tube:

- the Oil Tank Scupper
- the Forward Sump
- the Fan Case
- the Fuel/Oil Heat Exchanger
- the VBV
- the VSV
- the TCC
- the HMU
- the Aft Sump
- the Fuel Shroud Pipe (individual drain tube)

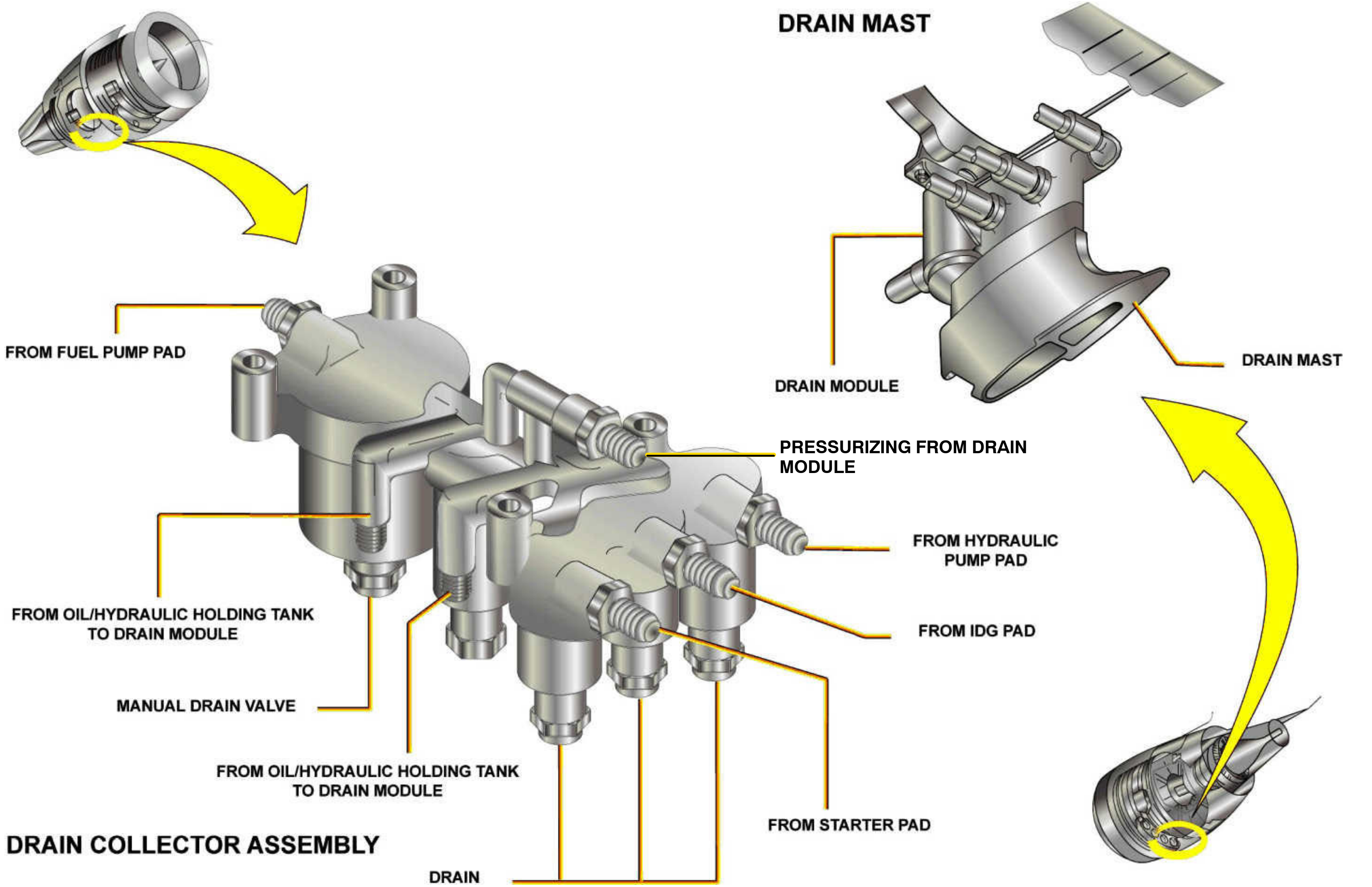


Figure 29 Collector Assembly

PYLON DRAINS DESCRIPTION

The engine pylon is divided into 7 compartments. Various systems are routed through these areas. Any leckage from fluid lines is drained overboard through seperate lines in the rear of the pylon.

DESIGNATION	ZONE	SYSTEMS
FORWARD FAIRING	A B1 B2	FLAMMABLE FLUIDS (FUEL/HYDRAULICS) BLEED AIR (HIGH AND LOW TEMP) ELECTRICS
PYLON BOX	C	HYDRAULICS WITHOUT COUPLINGS FIRE EXTINGUISHER BOTTLES
REARWARD SECONDARY STRUCTURE	D	HYDRAULICS LIMITED ELECTRICS
LOWER FAIRING	E	NONE
PYLON TO WING CENTER FILLETS	F	FUEL (ZERO LEAKAGE COUPLINGS) ELECTRICS BLEED AIR (LOW TEMP)

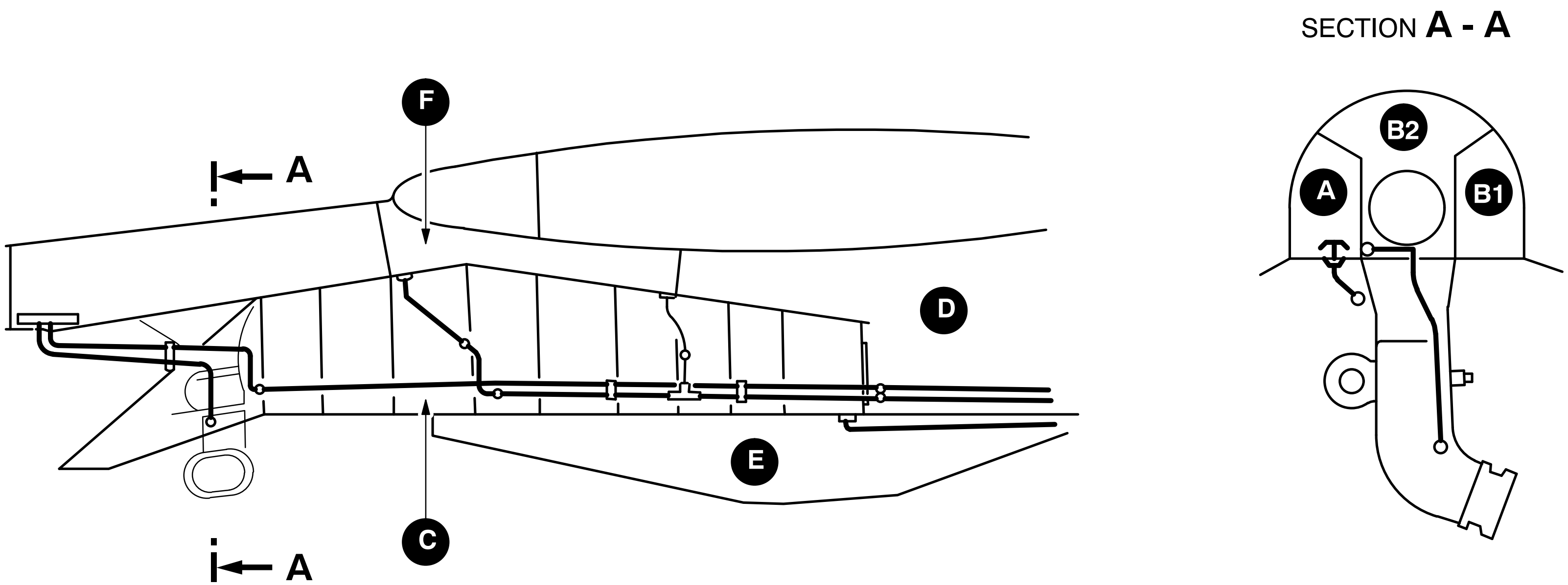


Figure 30 Pylon Drains

ATA 72 ENGINE

72−00 ENGINE - GENERAL

INTRODUCTION

ENGINE MODULES

Purpose

The engine is of modular design,thus enabling maintenance to be performed by maintenance work shops having limited repair capability. Modular maintenance is concerned primarily with replacement of modular assemblies and parts.

Major Modules

The engine has four major modules:

- Fan and Booster major module
- Core major module
- Low pressure turbine major module
- Accessory drive module

FRAMES

The load from the rotor systems and from the other cases are transferred to the frames. The frames transfer the load to the engine mounts.

ENGINE FLANGES

Flanges are located on the engine for attachment of brackets, claps, bolt, etc.

Physical Description

The external flanges of the engine have been assigned letter designations alphanumerical from A to U. The letters I, O and Q are not used. The letter designations are used for flange identification whenever it is necessary to be explicit about flange location.

Horizontal Flanges Identification

- Front stator case horizontal left flange
- Front stator case horizontal right flange

ENGINE MAIN BEARINGS

The rotors are supported by 5 bearings mounted in two engine sumps for lubrication system simplicity.

Bearings

The engine rotors are supported by bearings installed in the sump cavities provided by the two frames.

The forward sump is in the fan frame and is the location of bearings No.1, No. 2 (fan/booster shaft) and No. 3 (HP shaft forward part).

The aft sump is in the turbine rear frame where are bearings No. 4 (HP-shaft aft part) and No. 5 (LP-shaft aft part).

Oil Distribution

The bearings must be lubricated and oil is distributed to these components by nozzles. However, the oil must be retained within the engine, so seals of various types are provided to confine the oil and directs its recirculation.

Seals Arrangement

The arrangement of oil and air seals, the provisions for oil supply, oil scavenge, seal pressurization, sump vent subsystems produce a system known as a dry sump.

Engine sumps are vented to ambient pressure through the ”center−vent” tube which is contained in the LP shaft.

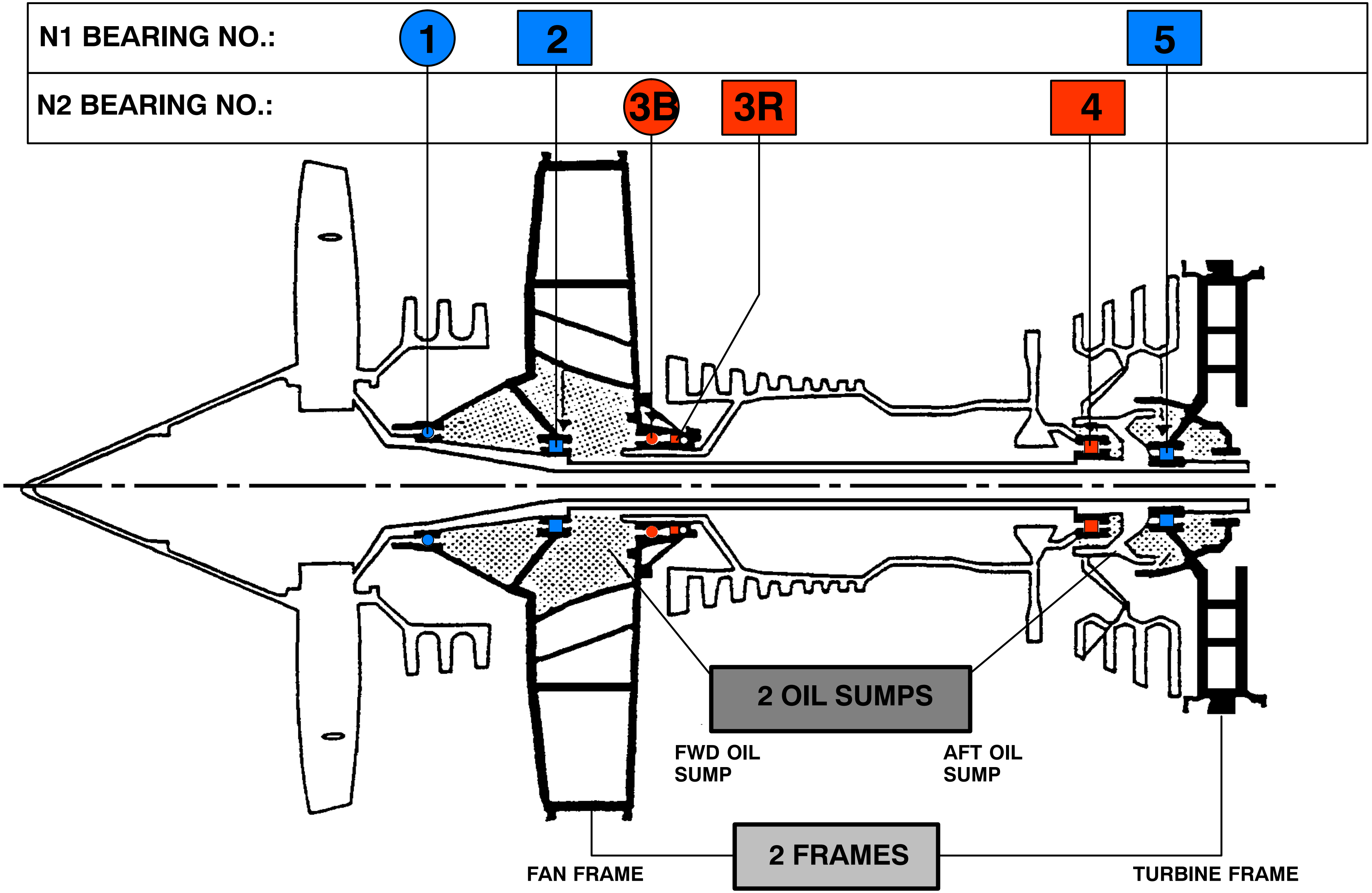


Figure 31 Engine Construction

STAGE NUMBERING CFM56-5A

STAGES :	COMPONENT :	STAGE NUMBER :	NOTES :
1	FAN	1	Fan air used for ACC
1 2 3	LOW PRESSURE COMPRESSOR (BOOSTER)	1 2 3	VBV
1 2 3 4 5 6 7 8 9	HIGH PRESSURE COMPRESSOR	1 2 3 4 5 6 7 8 9	IGV (VSV) VSV VSV VSV HPTACC, Eng A/I, Customer Bleed Customer Bleed, Muscle Press A/I, Start Bleed, HPTACC
	COMBUSTION CHAMBER		20 Fuel Nozzles, 2 Ignitor Plugs
1	HIGH PRESSURE TURBINE	1	ACC Cooling of HPT Shroud Support Structure
1 2 3 4	LOW PRESSURE TURBINE	1 2 3 4	ACC Cooling of LPT External Case (all stages)
	EXHAUST NOZZLE		

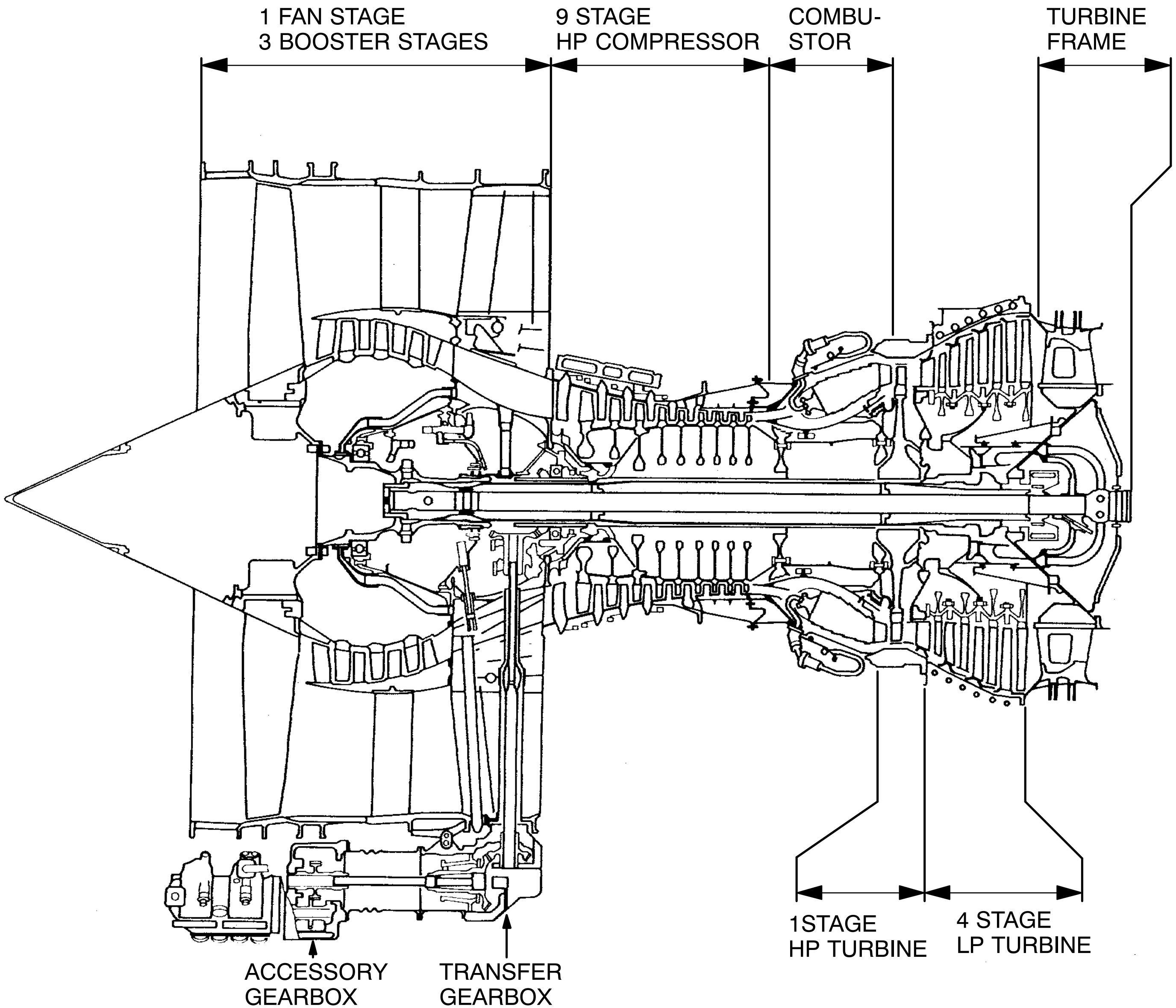


Figure 32 Engine Stages (CFM56-5A)

ENGINE STATIONS CFM 56-5A/B

AERODYNAMIC STATION :	STATION LOCATION :	STATION USED FOR:
0	**AMBIENT**	**P0** = Ambient Static Pressure used for FADEC.
10	**INTAKE / ENGINE INLET INTERFACE**	
12	**FAN INLET**	**T12** = Fan (Booster Inlet Temp.) used for FADEC. **PS12** = Fan (Booster) Inlet Press. (PT2) used for FADEC.
13	**FAN EXIT**	**PS13** = Static Pressure of Fan Bypass Air Flow used for Monitoring.
25	**L.P. COMPRESSOR (BOOSTER EXIT)**	**T25** = High Pressure Compressor Inlet Temp. (CIT) used for FADEC.**P25** = High Pressure Compressor Inlet Press.used for Monitoring
30	**H.P. COMPRESSOR (EXIT)**	**T3** = High Pressure Compressor Discharge Temp. (CDT) used for FADEC. **PS3** = Compressor Discharge Pressure (CDP) used for FADEC
40	**COMBUSTION SECTION EXIT**	
42	**H.P. TURBINE EXIT**	**T case** = HPT Shroud Support Temperature used for HPT Active Clearance Control
49	**L.P. TURBINE STAGE 2 INLET**	**T49.5** = Exhaust Gas Temp. (EGT) used for Cockpit Indication.
50	**EXHAUST**	**T5** = Total Temp. Turbine Rear Frame Plane used for Monitoring.

Flowpath aerodynamic stations have been established to facilitate engine performance assessment and monitoring. As the CFM56-5 is a high bypass engine, its airflow path features a primary and a secondary airflow. Therefore manufacturer differentiates between:

- **Primary Stations** and **Secondary Stations**

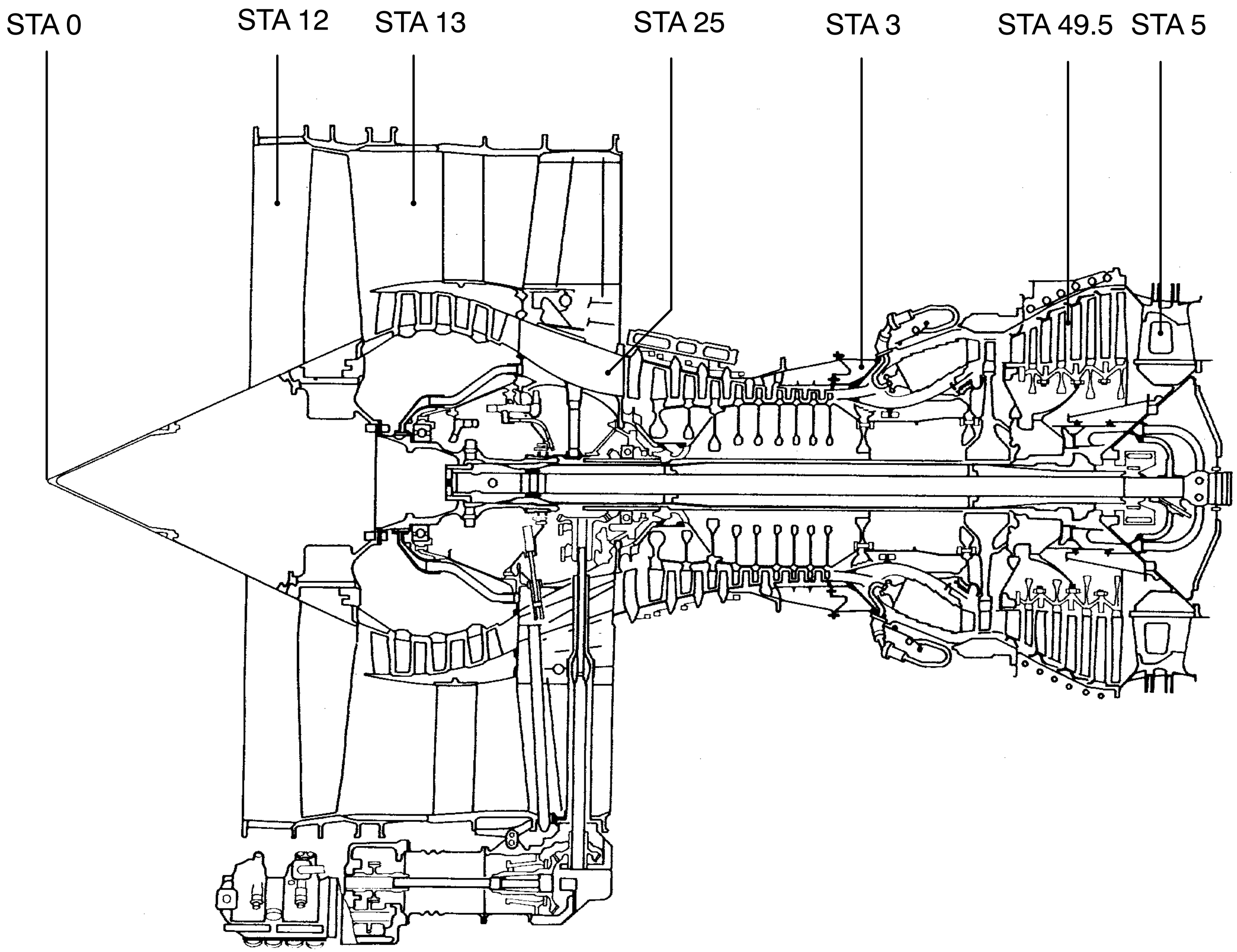


Figure 33 Aerodynamic Stations (CFM56–5A/B)

BORESCOPE INSPECTION PORTS LOCATION

General

There is a total of 21 borescope inspection ports along the engine length. Their location and identification is as follows:

Booster and Stator Assembly

The booster has one borescope inspection provision located at 03:30 position

- CFM 56−5A has one port S0 (CFM 56−5B has two ports S03 + S05)

HPC Front and Rear Stator Assembly

Has nine 9 borescope inspection provisions. Location between 4 and 5 o'clock. Starting from the compressor inlet plane (IGV) and progressing rearwards, their identification is as follows:

- S1, S2 ... S9

Combustion Case Assembly

Has eight 8 borescope inspection provisions located around the case an in three different planes. Starting from the front flange of the case and progressing rearwards, their identification is as follows:

- S10 and S11 (located in the same plane at approximately 4 and 8 o'clock). Their use as borescope ports necessitates the removal of the two igniters which are installed in these ports.
- S12, S13, S14, S15 (located in the same plane around the case)
- S16 and S17 (located in the same plane around the case)

LPT Case Assembly

Has four 3 borescope inspection provisions. Location at 5 o'clock approximately. Starting from the LPT case front flange and progressing rearwards, their identification is as follows:

- S18, S19, S20

NOTE: The borescope ports S16 and S17 (located on the combustion case) must be used for a more thorough borescope inspection of the leading edge and tip shroud of LPT rotor blades, stage 1.

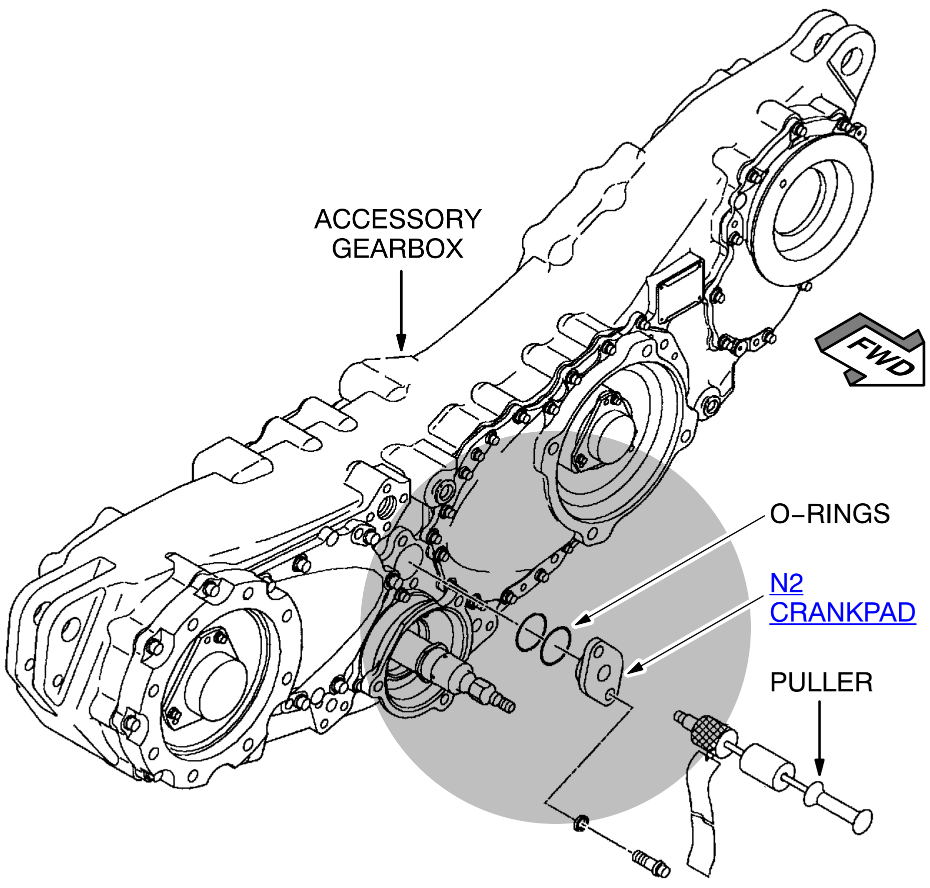
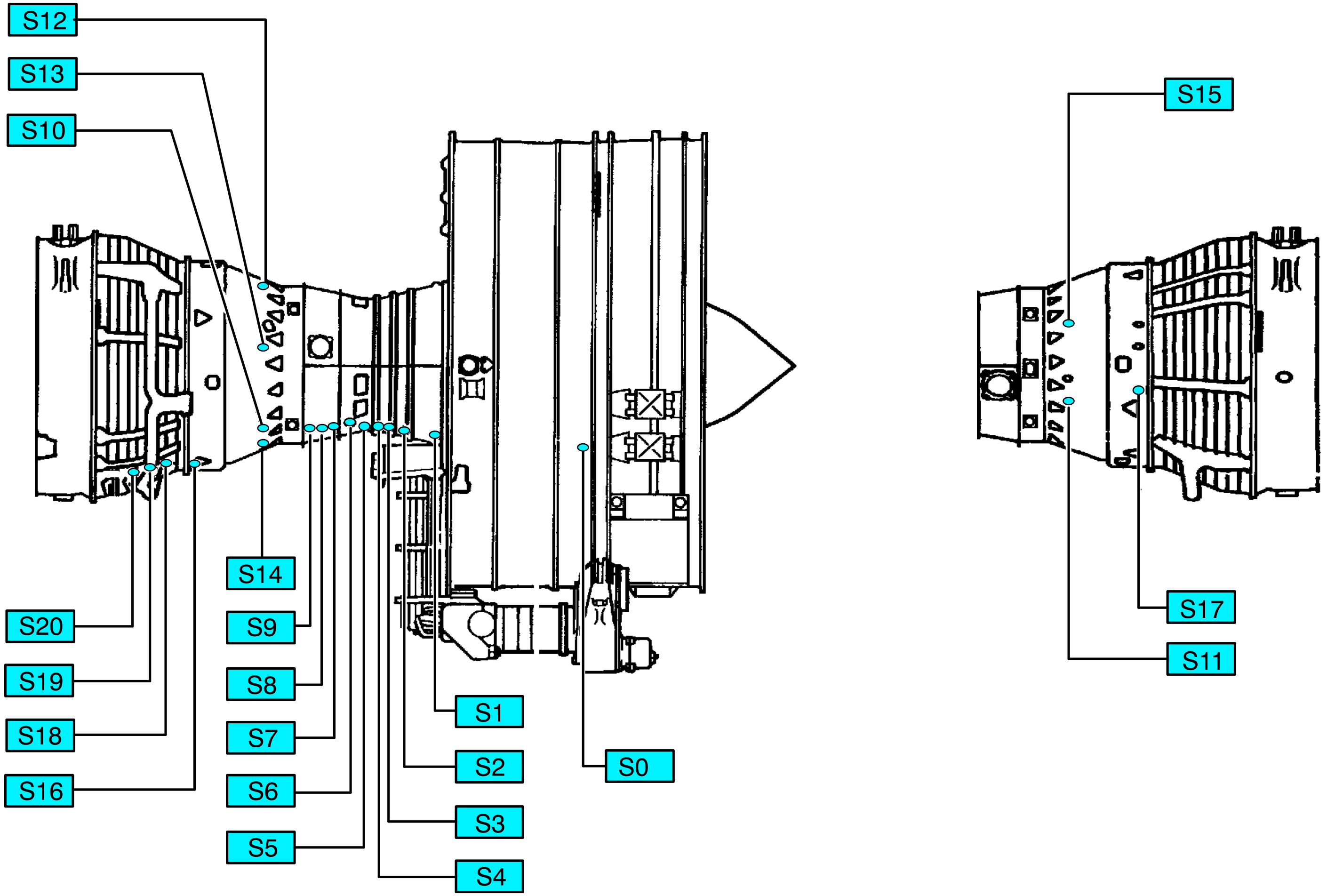


Figure 34 N2 Handcrank Location

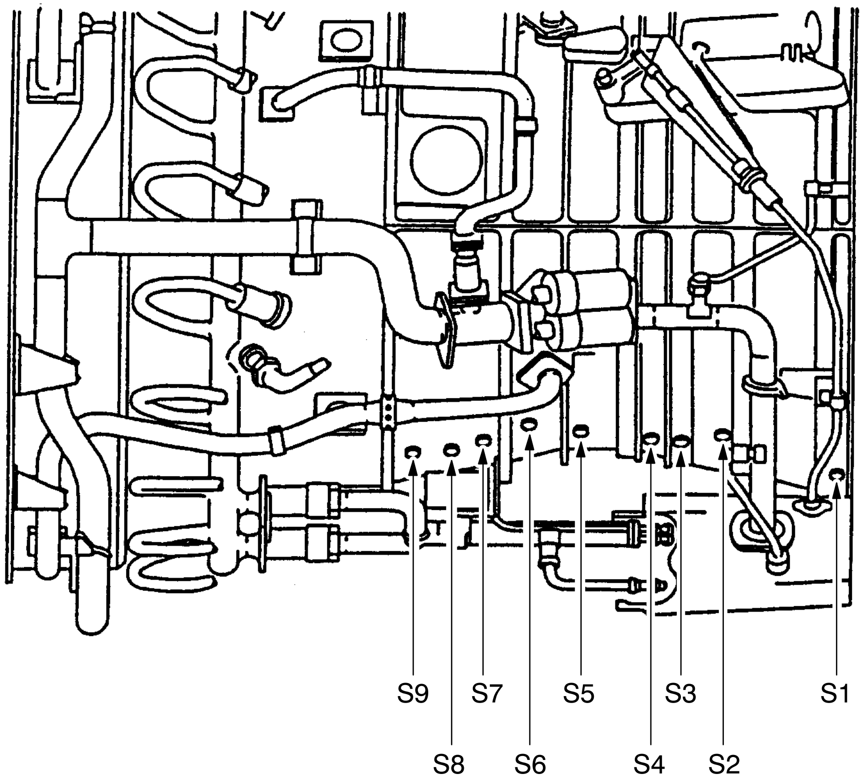


NOTE: Booster Borescope Ports S0 not shown at their true location in this view. Shown only for identification and location (3:30 o'clock) purposes.

Figure 35 Engine Borescope Access Ports

High Pressure Compressor

The borescope plugs S7, S8, and S9 are special double plugs. Install borescope plugs finger tight. Ensure contact between boss on inner liner and plug cap. Compress spring load on outer cap and apply recommended torque.



HPC - ROTOR BORESCOPE INSPECTION PORTS

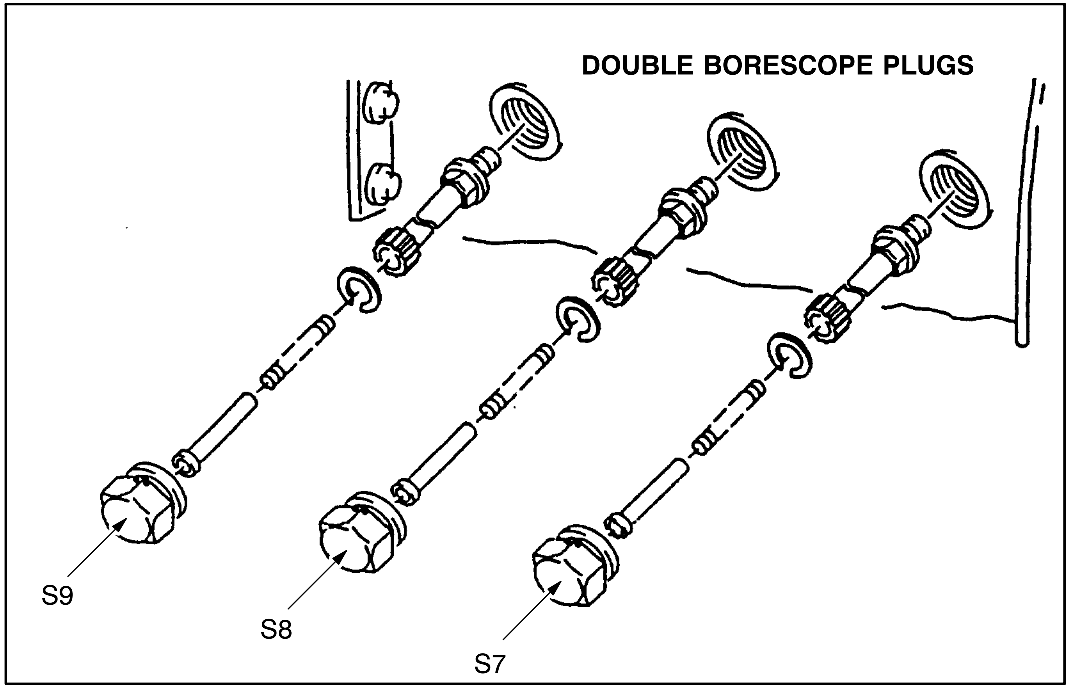


Figure 36 HPC Borescope Plugs

72−21 FAN AND BOOSTER ASSEMBLY

FAN AND BOOSTER MODULE

Purpose

The fan and booster (LPC) module is driven by the low pressure turbine and provides two separate air streams.

The primary (or inner) air stream flows through the fan and booster section where the air is compressed for introduction into the high pressure compressor. The secondary (or outer) air stream is mechanically compressed by the fan as it enters the engine and is ducted to the outside of the core engine,this secondary air stream adds to the propulsive force generated by the core engine.

Description

The fan and booster module consists of a single stage fan rotor and a 3-stage axial booster, cantilever-mounted at the rear of the fan disk.

The fan and booster module consists of the following major parts:

- Spinner rear and front cones.
- Fan disk.
- Fan blades.
- Booster rotor.
- Booster vane assemblies.

Spinner Front Cone

The spinner front cone is made of composite material. Its design precludes the need for an engine nose anti−icing system. The front cone is bolted to the rear cone.

Spinner Rear Cone

The spinner rear cone is made of aluminum alloy. Its rear flange is bolted to the fan disk and is part of the fan blades retention system. The outer rim of rear flange is provided with tapped holes for trim balance bolts. The front flange provides for attachment of the spinner front cone.

Fan Disk

The fan disk is a titanium alloy forging. Its inner rear flange provides attachment for the fan shaft and its outer rear flange is bolted to the booster rotor. The outer front flange provides attachment for the spinner rear cone.

The disk outer rim has 36 recesses designed for fan blade retention

Fan Blades

There are 36 titanium alloy, mid−span shrouded fan blades approximately 23 in. (590 mm) long. Each of the blades has a dovetail base that engages in disk rim recess. Blades are individually retained by a spacer that limits radial movement, a blade retainer that limits forward axial movement and by the booster spool front flange that limits axial movement rearward.

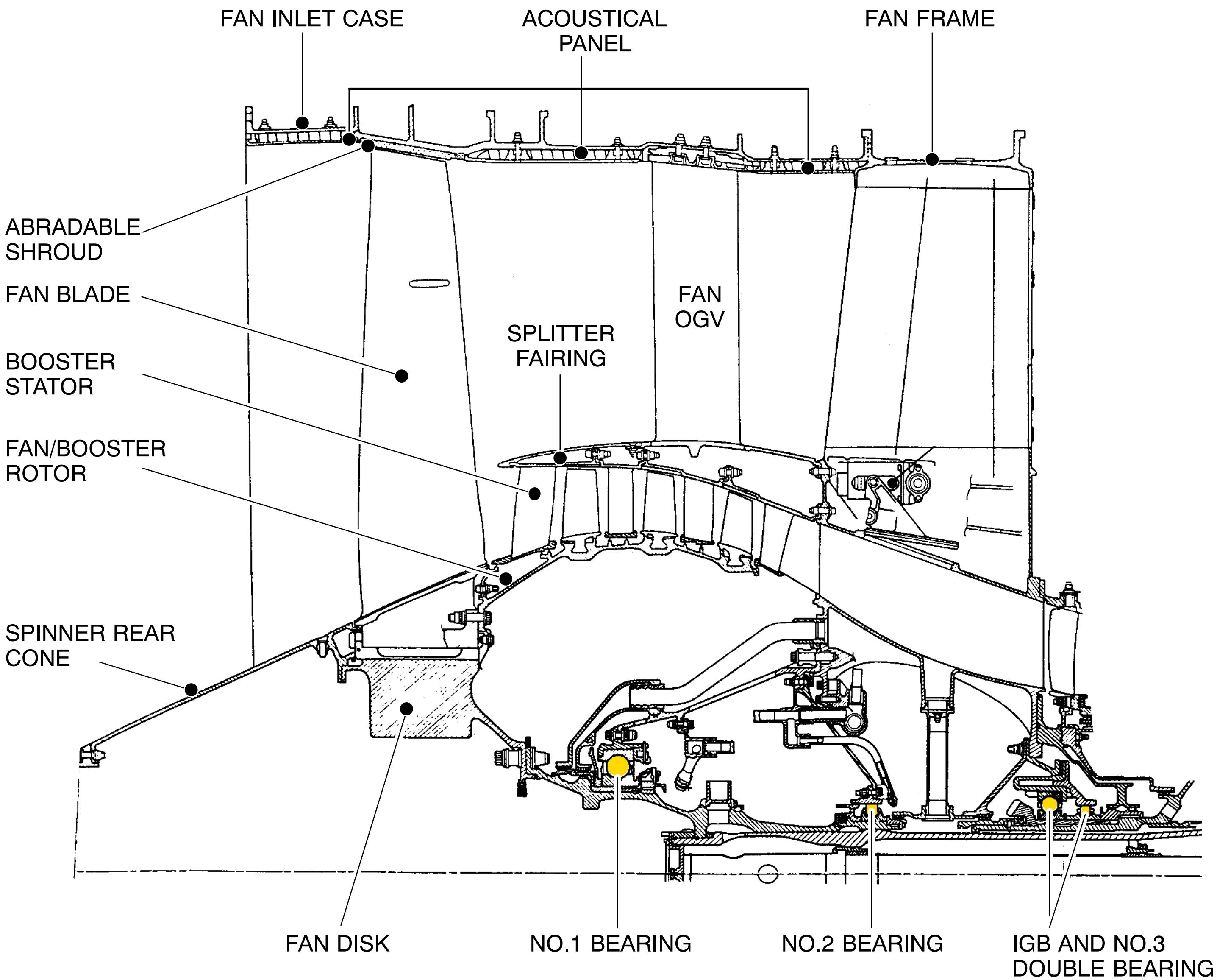


Figure 37 Fan and Booster Assembly

BEARING AND SEALS DESCRIPTION

ENGINE BEARINGS

The engine rotors are supported by bearings installed in the two sump cavities. The forward sump is in the fan frame and is the location of bearings No.1, No.2 (fan/booster shaft) and No. 3 (High Pressure (HP) shaft).

The aft sump is in the turbine rear frame where are bearings No.4 for the HP shaft aft and No.5 for the LP shaft.

Bearings provide reduced rolling friction, support the rotors axially and radially within the engine structure, and position the rotors relative to the stators. The bearing must control the forces of gravity weight, aerodynamic loads of pumping and turbine driving and gyroscopic loads due to aircraft maneuvers.

NO.1 and NO.2 Bearing

The No.1 ball bearing is a thrust bearing which carries the axial loads generated by the LP rotor system.

The No.2 roller bearing takes the radial loads from the fan and booster rotor.

NO.3 Bearing

The inlet gearbox assembly contains a core engine thrust bearing, and a core engine roller bearing.

NO.4 and NO.5 Bearing

The No.4 bearing, which takes the High Pressure Turbine (HPT) rotor radial loads, is a roller bearing installed between the HPT rear shaft and the Low Pressure Turbine (LPT) shaft.

The No.5 bearing supports the LPT rotor aft end inside the turbine frame and takes the radial loads.

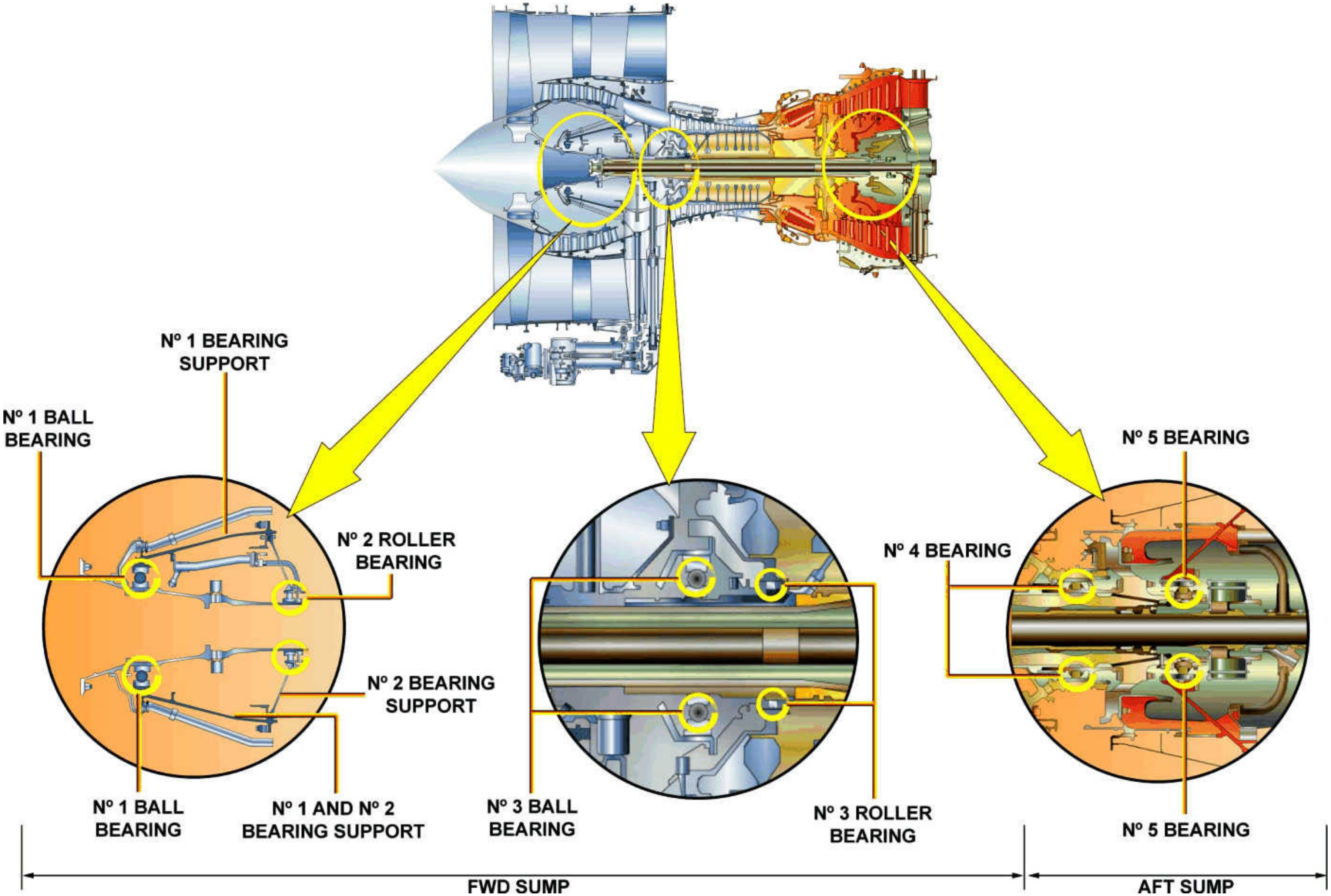


Figure 38 CFM56-5 Bearings

ENGINE SEALS

The oil is confined and recirculated in the bearing thanks to the air/oil seal.

Forward Stationary Air/Oil Seal

The stationary air/oil seal limits the engine forward sump at its front end, and is used to duct pressurization air to labyrinths provided on the No. 1 bearing sleeve. The space located between the seal inner and outer skin is divided into independent compartments for pressurization, drainage and oil scavenge.

Center Vent Tube

Engine sumps are vented to ambient pressure through the center−vent tube contained in the LP shaft.

Seal Pressurization Principle

The sumps are sealed with labyrinth type oil seals, which must be pressurized in order to make sure that the oil is retained within the oil circuit and, therefore, minimize oil consumption.

Pressurization air is extracted from the primary airflow (booster discharge) and injected between the two labyrinth seals. The air, looking for the path with the least resistance, flows across the oil seal, thus preventing oil from escaping.

Any oil that might cross the oil seal is collected in a cavity between the seals and routed to drain pipes.

Once inside the oil sump cavity, the pressurization air becomes vented air and is directed to an air/oil rotating separator and then, out of the engine through the center vent tube, the rear extension duct and the flame arrestor.

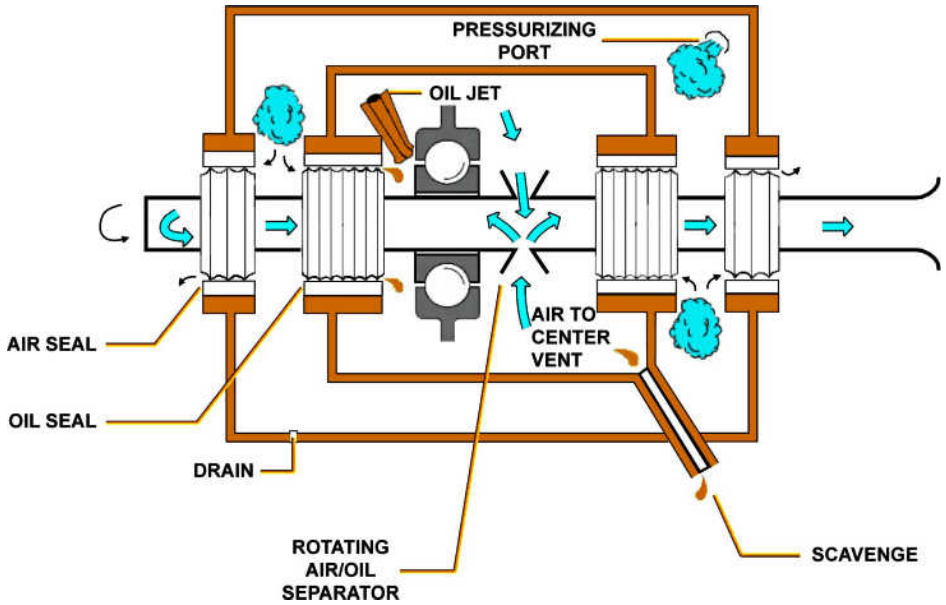


Figure 39 Seals Pressurizing Principle

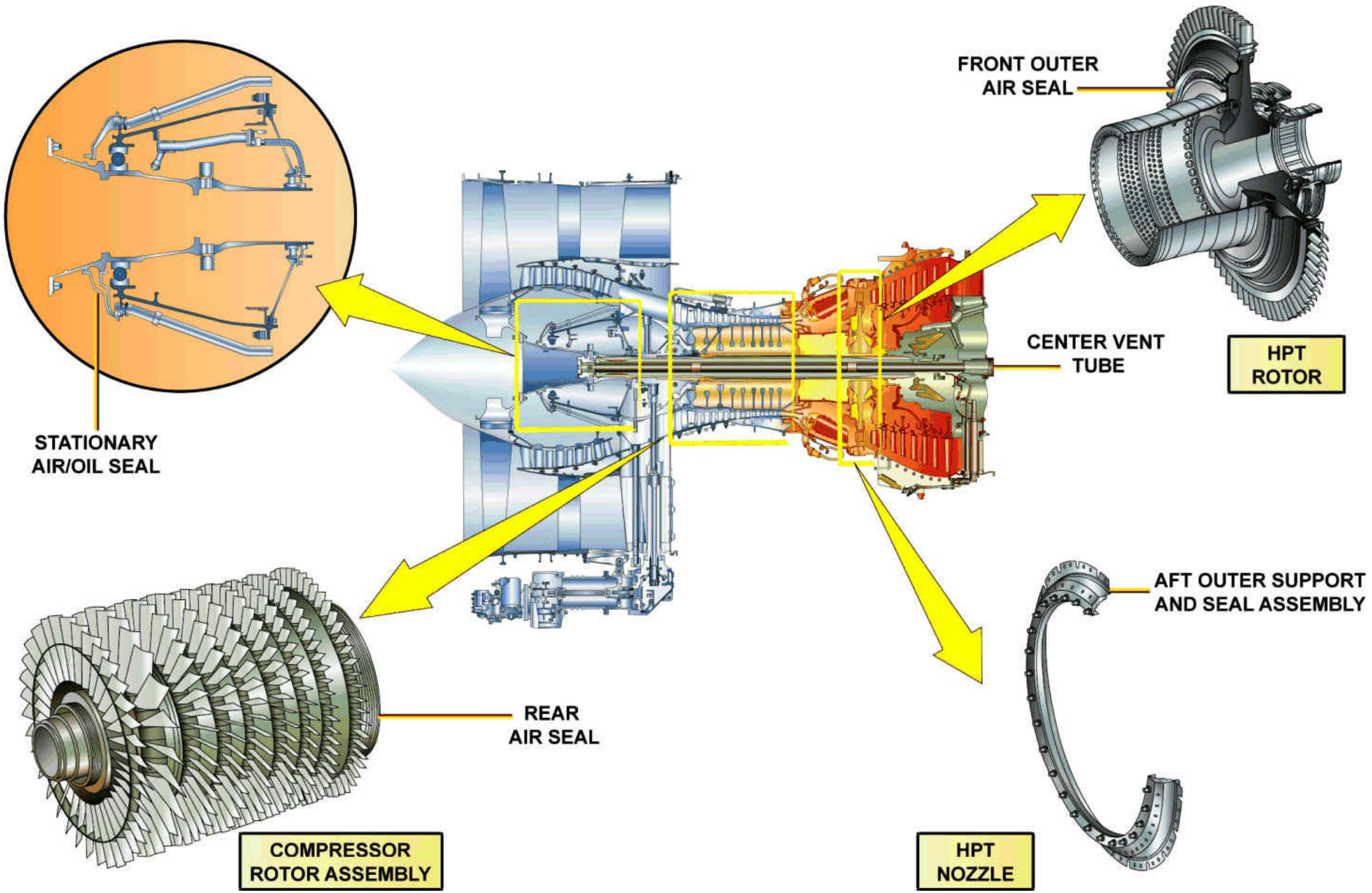


Figure 40 Engine Seals

72–23 FAN FRAME ASSEMBLY

FAN FRAME ASSEMBLY

PURPOSE

The fan frame module provides front handling mounts and is the main forward support for mounting the engine to the aircraft. Its purpose is to support the fan, booster and high pressure compressor (HPC) rotors, and to provide ducting for primary and secondary airflows.

The fan frame module consists of the following major assemblies:

- Fan Frame Assembly
- Fan **O**utlet **G**uide **V**ane (OGV) Assembly.

FUNCTIONAL DESCRIPTION

The Fan Frame and Fan Case perform the following primary functions:

Fan Frame

- An inlet airflow path to the core engine.
- A support for loads of the fan stator, fan rotor and fan reverser.
- Containment of accessory drive power take off gearing and shaft.
- A variable bypass valve system.
- Housing for service lines for lubrication of bearings, inlet gearbox and scavenge of the FWD oil sump.
- Support for the fan OGVs and fan inner flowpath acoustic panels.

Fan Case

- Provides for attachment of the engine inlet cowl and the support and transmission of attachment loads from this point to the fan frame.
- Provides fan blade containment.
- Provides attachment points for acoustical panels.
- Provides an abradable microballon shroud for fan blade tips.

CONSTRUCTION

The fan frame assembly is a fabricated structural weldment constructed of concentric rings connected by radial struts. It consists of the basic fan frame structure and the fan inlet case.

The basic fan frame structure is made of steel alloy. It consists of a hub, mid box structure and outer casing interconnected through 4 thick and 8 thin radial struts.

Structural strength for the fan frame is obtained from the 12 struts. The struts are hollow and provide passage for the following equipment :

- No. 1 Bearing Vibration Sensor Cable (strut#4)
- N1 Speed Sensor and FWD Sump Cavity Drain (strut#6)
- **T**ransfer **G**ear **B**ox Radial Drive Shaft and Scavenge Tube (strut#7)
- Forward Sump Oil Supply Tube (strut#10)

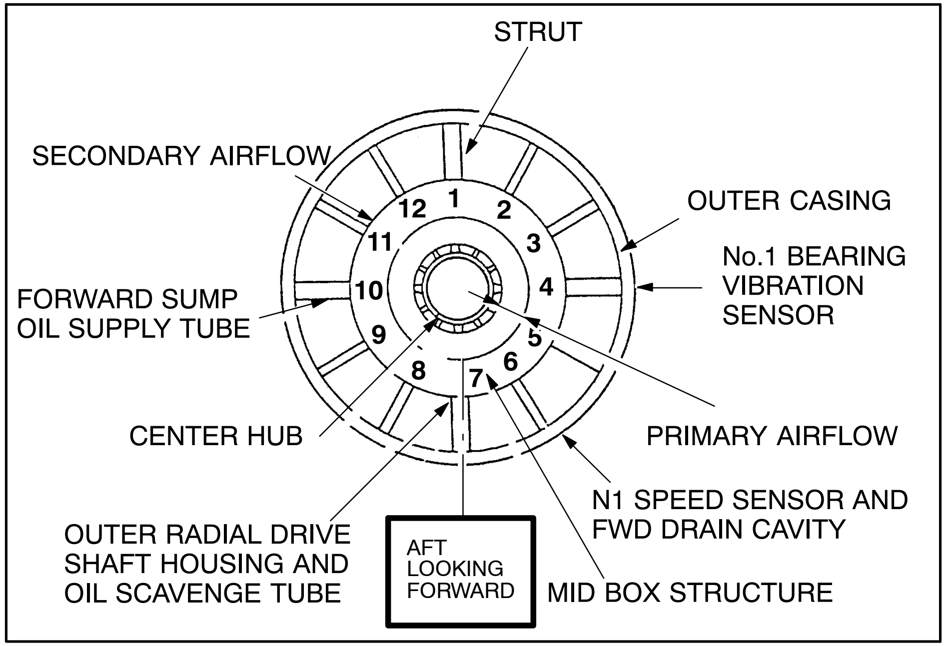
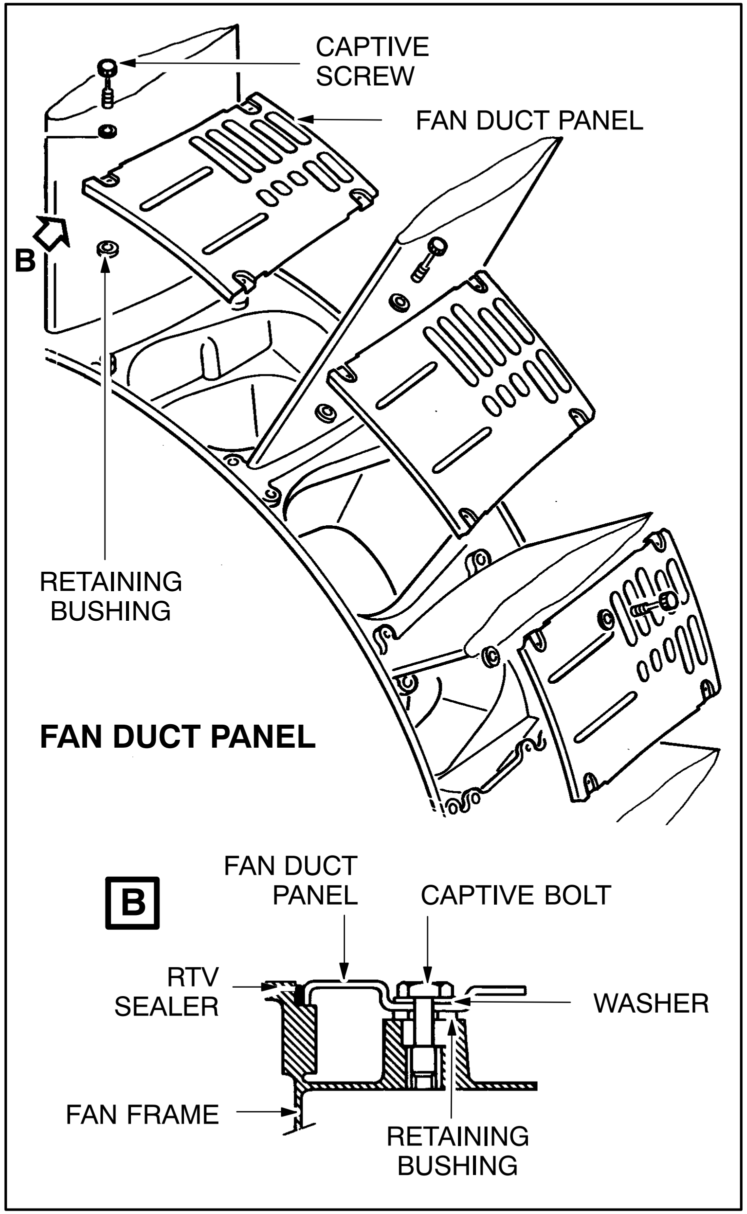
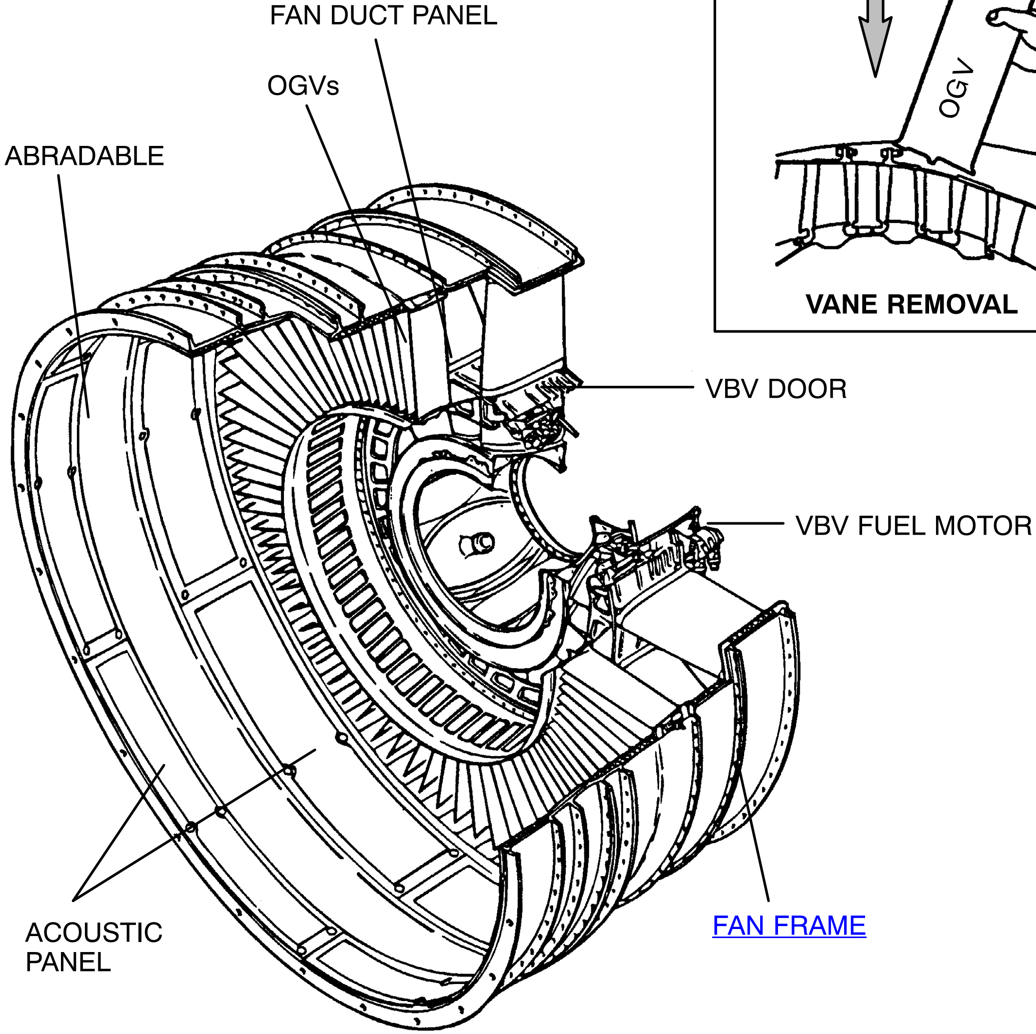


Figure 41 Radial Struts





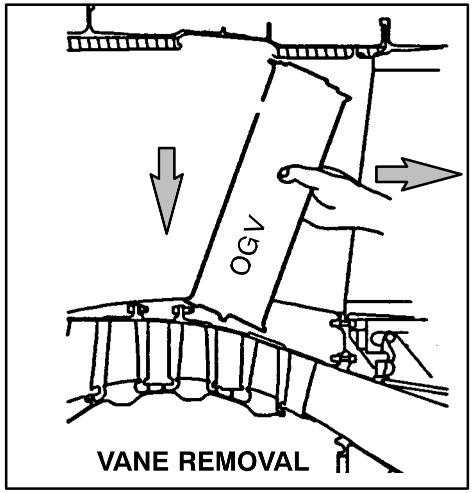


Figure 42 Fan Frame Assembly

72–21 FAN AND BOOSTER ASSEMBLY

SPINNER CONE MAINTENANCE PRACTICES

CAUTION: BE CAREFUL NOT TO LET THE SPINNER FRONT CONE FALL DOWN WHEN YOU DETACH IT FROM THE REAR CONE.

Removal of Spinner Front/Rear Cone

- Remove the bolts which attach the spinner front cone to the spinner rear cone
- Move the spinner front cone apart from the spinner rear cone with the 3 jackscrews from the *TOOL SET-JACK SCREW*
- Remove the bolts which attach the spinner rear cone to the fan disc
- Remove the spinner rear cone from the fan disk with the 6 jackscrews from the *TOOL SET JACK SCREW*

Installation of the Spinner Rear Cone

- Apply a thin layer of engine oil to the *3 PIN, GUIDE – SPINNER REAR CONE*
- Install the 3 guide pins, equally spaced, on the forward flange of the fan disk. Install one of the pins in the offset hole
- Apply a thin layer of graphite grease to the threads of the bolts
- Increase the temperature of the aft flange of the spinner rear cone to 60°C with a heat gun
- Install the spinner rear cone on the fan disk forward flange with the offset holes aligned

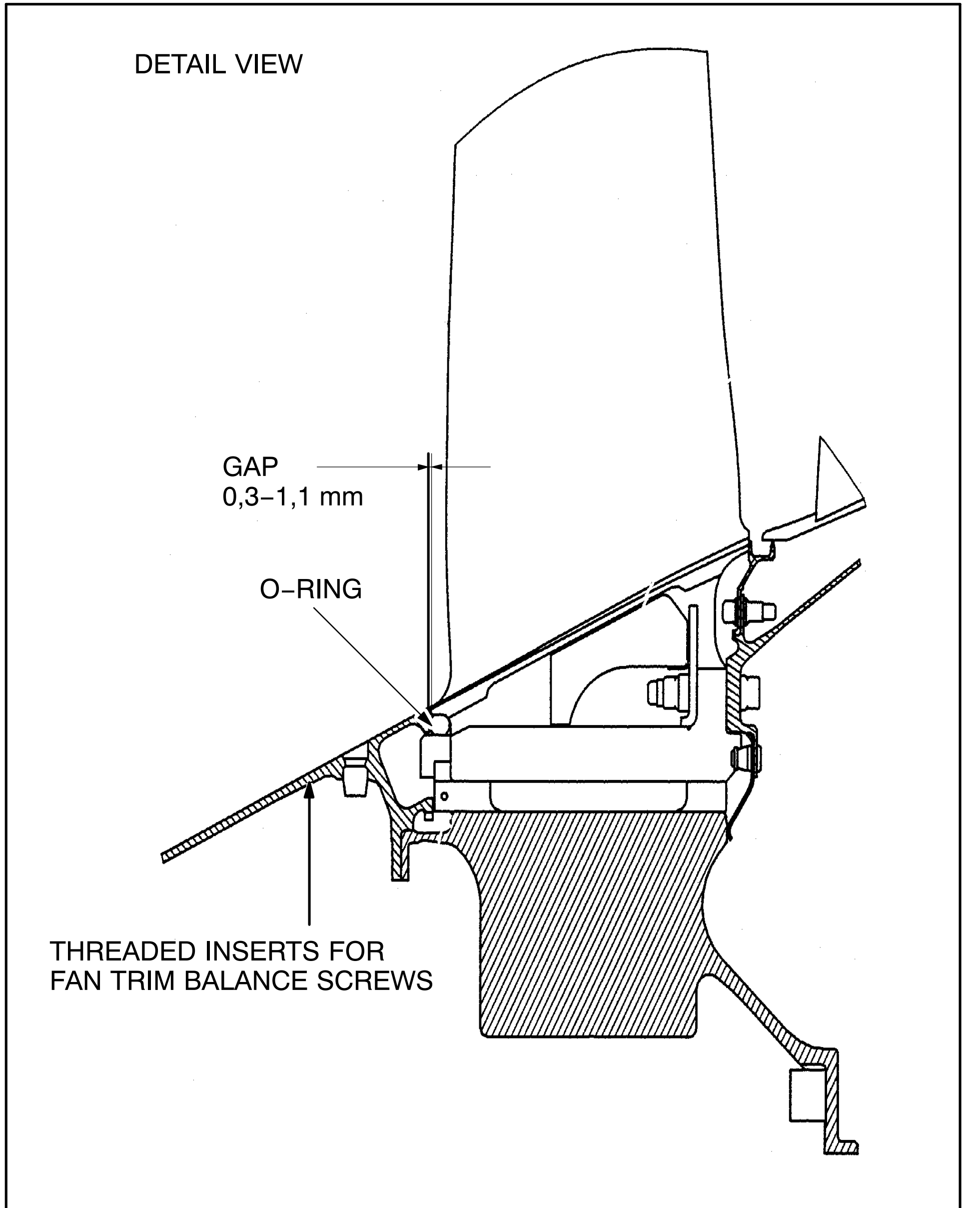
NOTE: The offset hole in the spinner rear cone is identified by a spherical indentation on its rear flange

- Attach the rear cone to the disk with 3 bolts and washers. Make sure it is correctly seated
- Let the assembly return to the ambient temperature. Then remove the guide pins. Replace the guide pins with the bolts and the washers.
- Torque the bolts acc. AMM

Do a check of the clearance (gap) between the rear edge of the spinner rear cone and the fan blades acc. AMM.

Installation of the Spinner Front Cone

- Apply a thin layer of engine oil the *3 PIN, GUIDE – SPINNER REAR CONE*
- Install the three guide pins equally–spaced on the front flange of the spinner rear cone. Install one of the pins in the offset hole of the flange.
- Increase the temperature of the front flange of the spinner rear cone to approximately 80°C with a heat gun
- Install the spinner front cone on the spinner rear cone. Carefully align the offset holes
- Apply a thin layer of engine oil to the threads of the 6 bolts, and attach the spinner front cone with the bolts. Tighten the bolts by hand, and let the mating parts return to the ambient temperature.
- Torque the bolts according AMM.



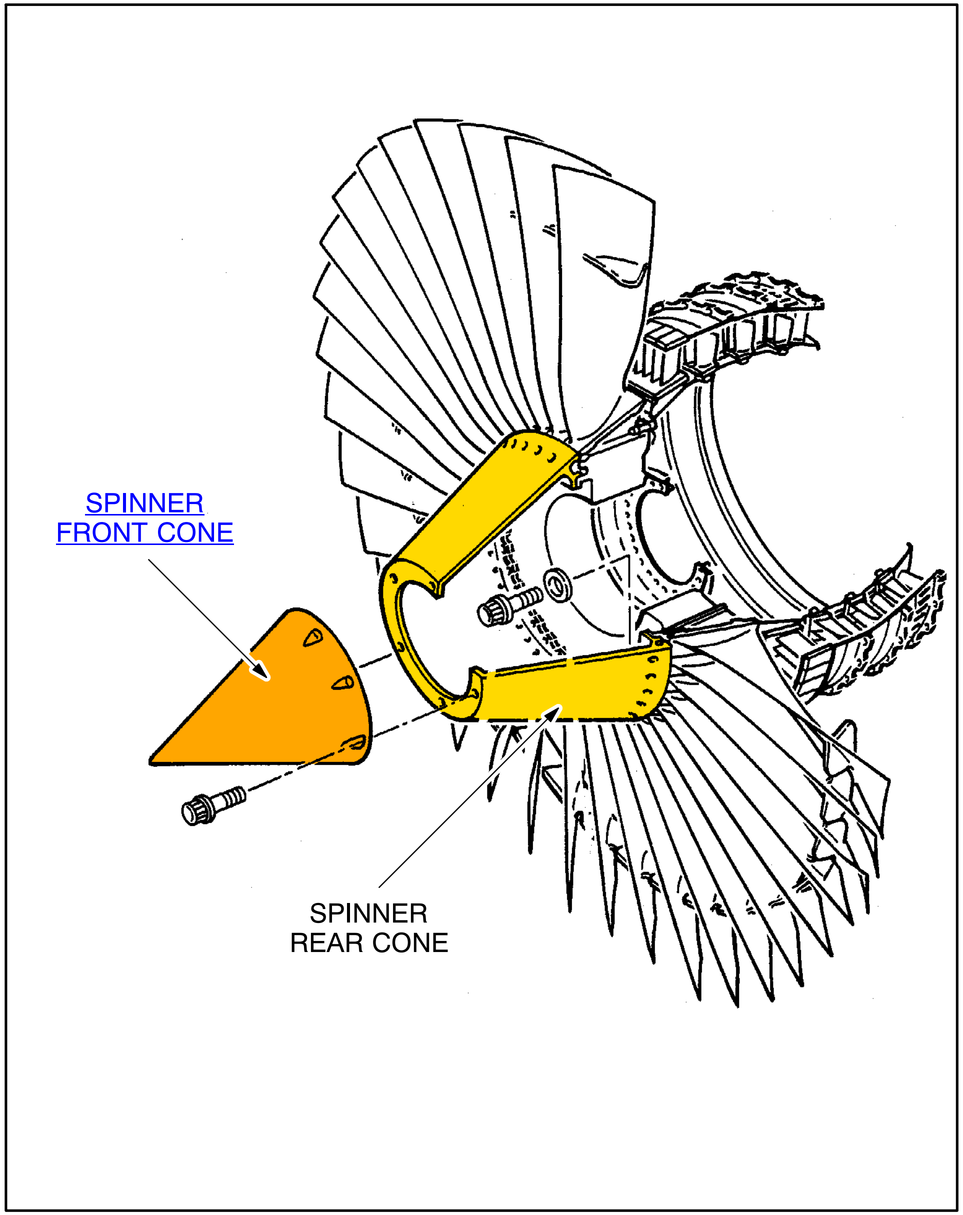


Figure 43 Spinner Cone Removal/Installation

FAN BLADES MAINTENANCE PRACTICES

Introduction

Sometimes it is necessary to change fan blades if they are damaged. Single or pairs of spare blades can then be installed.

The spare blades are grouped in pairs so that the difference between the moment weights is limited to 200 cm•g.

However, you must do the checks and corrections described below before and after blade installation to limit the engine vibration level and optimize its operation. Three possible cases may occur:

- If you must replace 3 pairs of fan blades or less and if the resultant static imbalance is less than 200 cm•g no correction is necessary
- If you must replace 3 pairs of fan blades or less and if the resultant static imbalance is between 200 cm•g and 400 cm•g, only a static correction of imbalance is necessary
- If you must replace more than 3 pairs of fan blades or if the resultant static imbalance is greater than 400 cm•g, a new fan blade distribution by hand method a computer method and a static correction of imbalance are necessary.

NOTE: In all replacement cases: 1,2,3....N pairs of fan blades and for individual fan blade replacement, a vibration survey can be performed (refer to AMM). Results from the vibration survey will determine if a trim balance is necessary. In this last case, do a trim balance operation acc. AMM if the aircraft is at the main base or as soon as the aircraft returns to the base.

Record location of each blade to be replaced and of each blade opposite.

CAUTION: FOR EACH PAIR OF FAN BLADES, INSTALL THE HEAVIER SPARE BLADE AT THE POSITION OF THE HEAVIER BLADE TO BE REMOVED.

NOTE: It is advisable to limit the number of balance screws on the spinner due the complexity and the risk of confusion when performing further corrections, and to install only one set of balance screws. This requires the construction of a vector diagram for determining the sum of the corrections. An example is given in the AMM.

Balance Screws

Balance screws are identified by a number corresponding to their moment weight (P01–P02–P03–P04–P05–P06–P07) engraved on screw head.

As it may be difficult to read the numbers due to erosion and pollution, the relationship between the screw reference and screw length is shown in inches.

Fan Blade Moment Weight and Classification Code

The moment weight (cm•g), is the weight of the fan blade multiplied by the distance centre of gravity to centre of rotation.

The moment weight is engraved on the lower side of the fan blade root. Weight and centre of gravity of fan blades is different due to manufacturing tolerances.

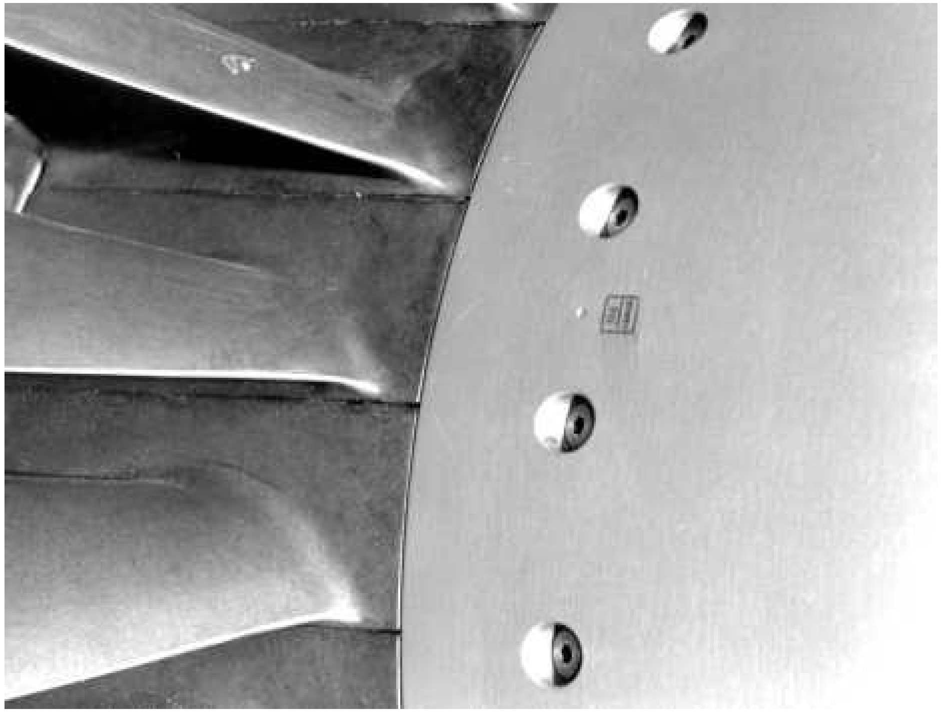
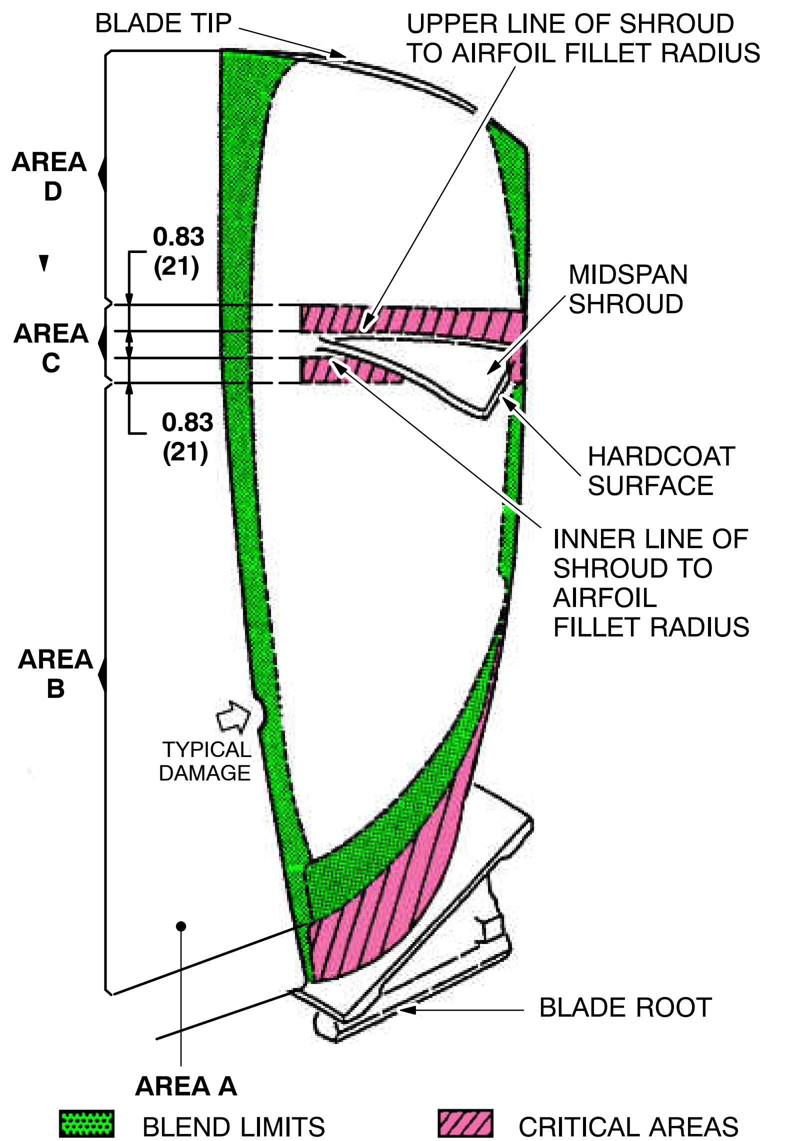
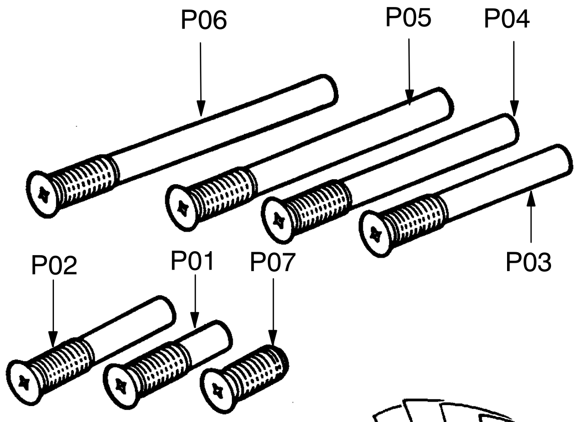


Figure 44 Balance Screws

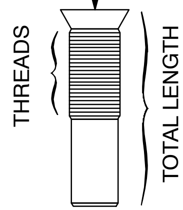
FAN BLADE DAMAGE LIMITS





P07 – INITIAL BALANCE SCREWS

BALANCE SCREWS



P0	TOTAL LENGTH mm	TOTAL LENGTH (in.)
P07	20.3	0.8
P01	33	1.3
P02	45.7	1.8
P03	58.4	2.3
P04	71.1	2.8
P05	83.8	3.3
P06	96.5	3.8

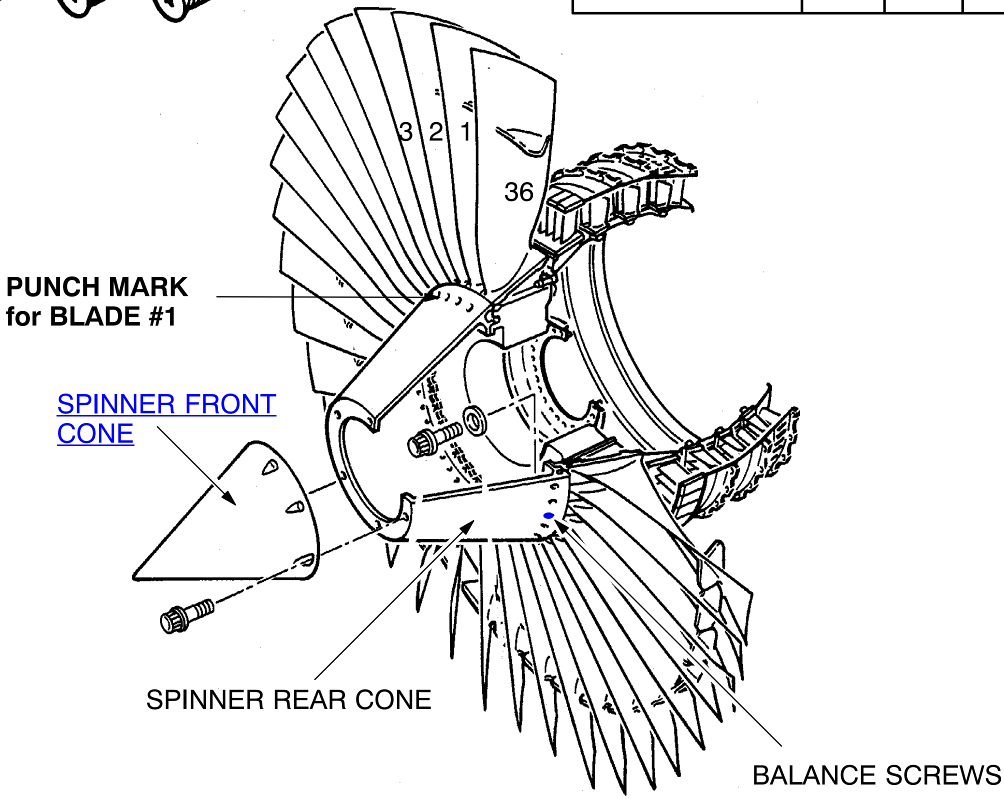


Figure 45 Fan Blade Replacement

FAN BLADE REMOVAL INSTALLATION

NOTE: All fan rotor blades shall be marked or numbered with approved marking material only

Removal of the Fan Rotor Blades

Remove spinner front and rear cone acc. AMM.

NOTE: Removal will be easier if fan blade to be removed is placed at the12 o'clock position

- Remove, partially or completely, the O-ring located between the fan blade platform and the fan disk
- Slide the spacer toward the front of the disk with the *ADAPTER PULLER – FAN BLADE SPACERS*, until the blade retainer is released
- Slide down the blade retainer located in the fan disk. Remove the blade retainer
- Move the blade radially inward to disengage the mid-span shroud. Then slide the blade forward until it comes out of the dovetail slot. Remove the blade damper
- Slide the adjacent blades forward, if necessary, as follows:
  - Pull the spacer under the adjacent blade forward with the *ADAPTER, PULLER – FAN BLADE SPACERS* and snap-on puller slide hammer CG240-9 and snap-on puller rod without end CG-240-8. Slide down and remove the retainer
  - Move the blade radially inward to disengage the midspan shroud. Then slide the blade forward until it comes out of the dovetail slot
  - Remove blade damper from the disk
  - Do the first three steps for the other adjacent blade

Installation of the Fan Rotor Blades

CAUTION: DO NOT DISSOCIATE FAN BLADE PAIRS MATCHED DURING ORIGINAL ASSEMBLY. BLADES FROM A SAME PAIR MUST ALWAYS BE LOCATED 180 DEGREES APART.

CAUTION: WHEN YOU INSTALL THE FAN BLADES, MAKE SURE THAT ALL DAMPERS ARE CORRECTLY INSTALLED UNDER EACH BLADE PLATFORM.

NOTE: Installation will be easier if the fan disk blade recess into which the blade is to be installed is placed at the 6 O'clock position.

- Apply a thin layer of molycote graphite to the mid-span shrouds, the roots, the platform mating surfaces under the platform, the anti wearshields of dampers and the disk slots
- Move the blade rearward into the disk slot. Then, move the blade radially outward to engage the mid-span shroud with the adjacent blades.

Blade Retainer Installation

- Slide the blade retainer into the related disk slot
- Slide the blade spacer into the disk recess until the spacer lug goes through the retainer slot
- Install the fan blade damper under the blade platform before you install the next blade in its disk slot

NOTE: Before installation of the last blade, you must make sure that all fan blade dampers are installed

- Install the other blades, retainers, spacers and fan blade dampers

NOTE: The midspan shroud section of the blades must engage and mate with the related midspan shroud sections of the adjacent blades

CAUTION: MAKE SURE THAT ALL THE 36 BLADES, RETAINERS, SPACERS AND DAMPERS ARE CORRECTLY INSTALLED

- If the O-ring is serviceable apply a thin layer of engine oil and install it by hand between the blade platform and the disk
- Install spinner rear cone and spinner front cone
- Perform a vibration check according AMM.

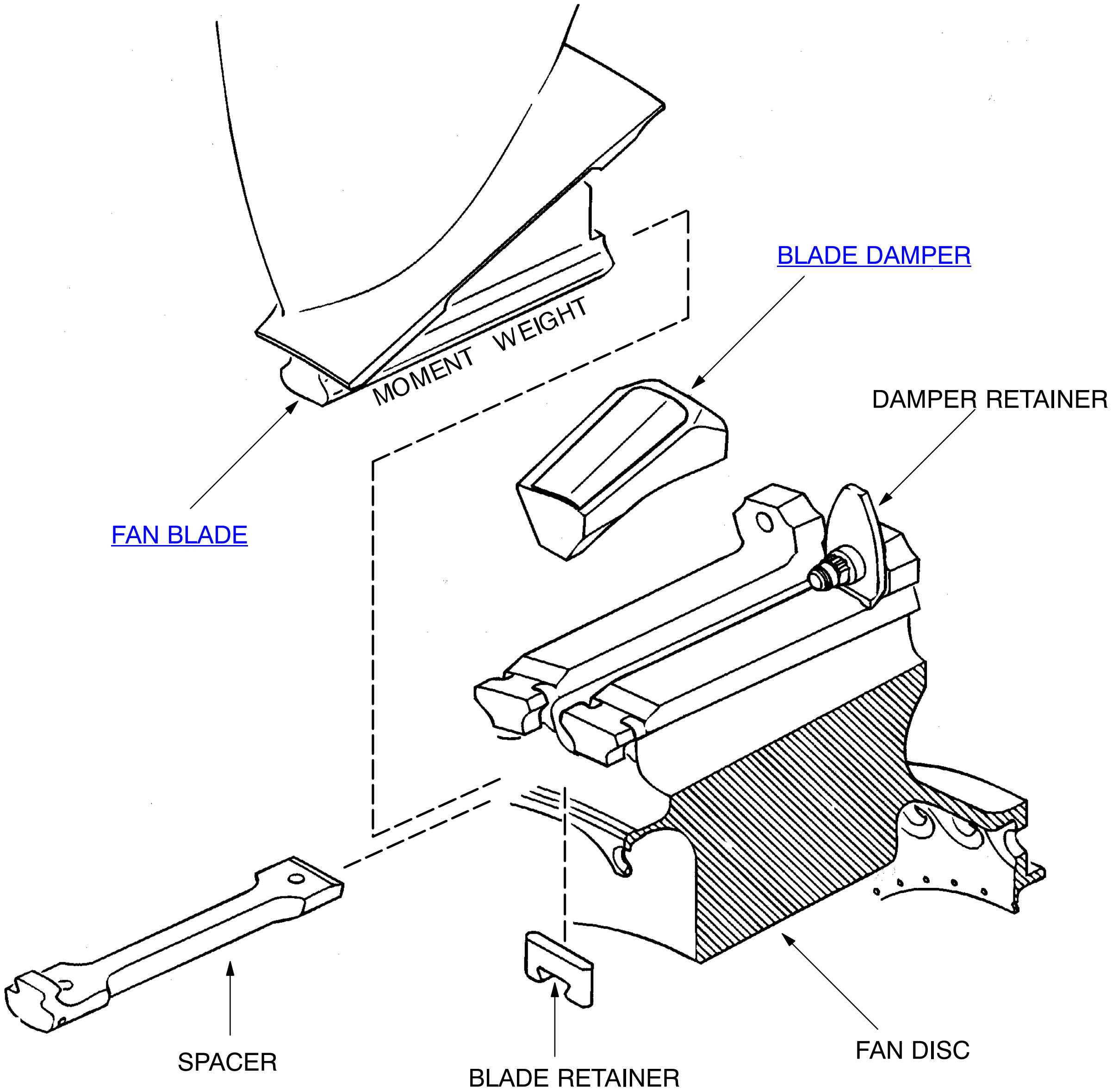


Figure 46 Fan Blade Removal/Installation

72–30 HP COMPRESSOR SECTION

OPERATION

The major Components of the compressor are: Compressor rotor and compressor stator. The front of the compressor stator is supported by the fan frame and the front of the compressor rotor is supported by the No 3 bearing in the fan frame.

The rear of the compressor stator is attached to the combustion case and the rear of the compressor rotor is attached to the HPT rotor to form the core rotor. The rear of the core rotor is supported by the No. 4 bearing.

A portion of the fan discharge airflow passes thru the booster to the compressor. Compression is progressive as the primary airflow moves from stage to stage through the axial compressor. Air passes through successive stages of compressor rotor blades and compressor stator vanes, being compressed as it passes from stage to stage.

After passing through 9 stages of blades, the air has been compressed. The inlet guide vanes and the first 3 stages of the stator are variable, and change their angular position as a function of compressor inlet temperature and engine speed. The purpose of this variability is to optimize efficiency and stall margin for engine speed, compressor inlet temperature and pressure conditions.

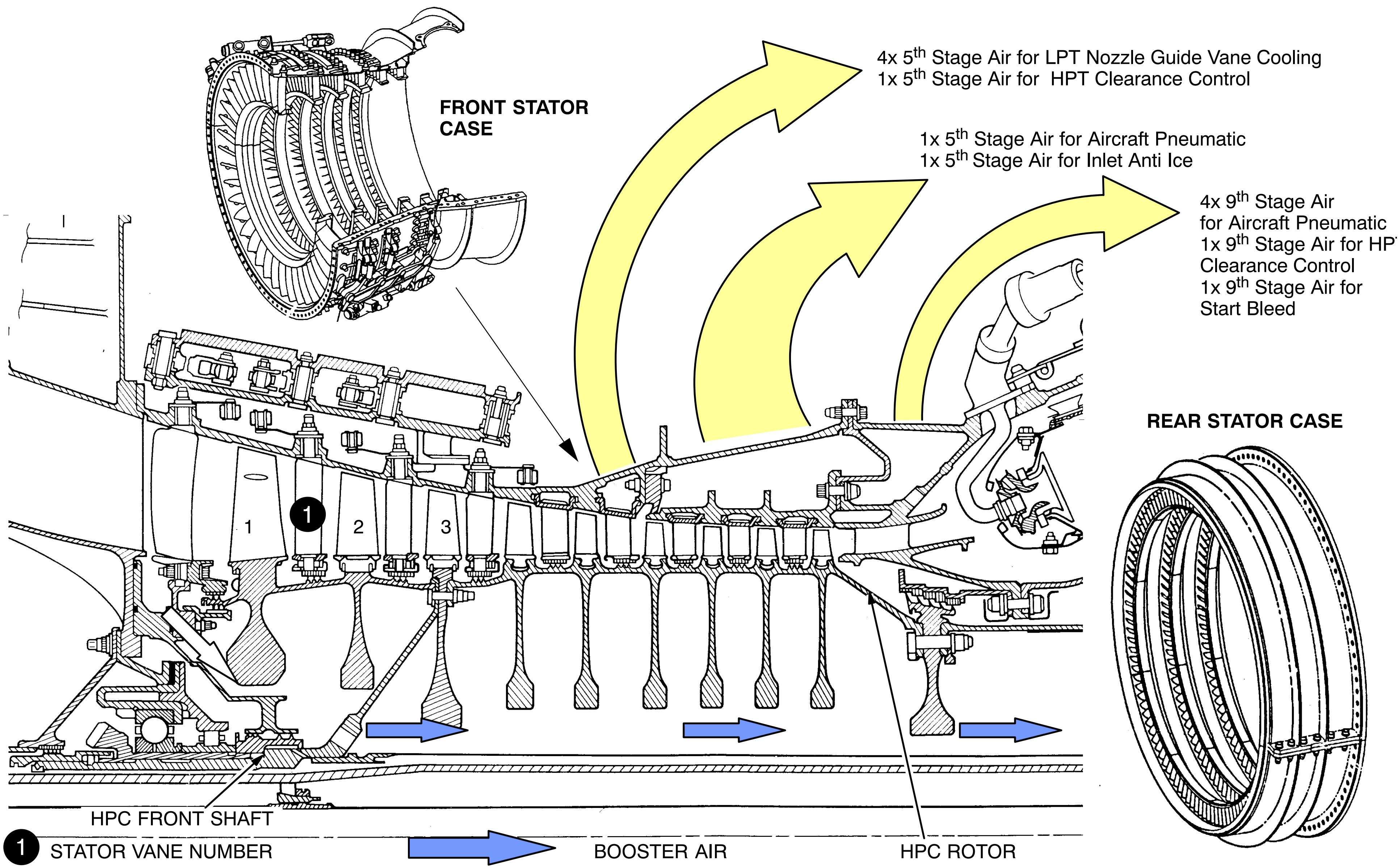


Figure 47 HP Compressor

72−40 COMBUSTION SECTION

COMPONENT DESCRIPTION

General

The combustion case is a fabricated structural weldment located between the high pressure compressor (HPC) and the low pressure turbine (LPT). It provides the structural interface, transmits the engine axial load, and provides gas flow path between the compressor and LPT. The case incorporates the compressor outlet guide vanes (OGV) and a diffuser for the reduction of combustion chamber sensitivity to the compressor air velocity profile.

Components

The combustion case encloses the combustion chamber and high pressure turbine (HPT) components. The combustion chamber, compressor rear stationary (CDP) seal, HPT nozzle assembly, and HPT shroud/stage 1 LPT nozzle assembly are mounted in and structurally supported by the combustion case. The case mounts and positions the 20 fuel nozzles, 2 igniters, and fuel manifold. The fuel manifold system is composed of a fuel supply manifold (Y tube), 2fuel manifolds halves, 3−piece drain manifold, and overboard drain tube.

Ports

There are 6 borescope ports ; 4 for inspection of the combustion chamber and HPT nozzles and 2 for inspection of the HPT blades and shrouds and the stage 1 LPT blades. The case has 4 ports for extraction of compressor discharge air for customer use, 4 ports for introduction of stage 5 compressor air for LPT nozzle guide vane cooling, 2 for introduction of air to the shrouds). There is also one port for the following : start bleed dump, P3 sensor, T3 sensor, and CDP air. There are 2 ports for the spark igniters and 2 ports for turbine clearance control thermocouples.

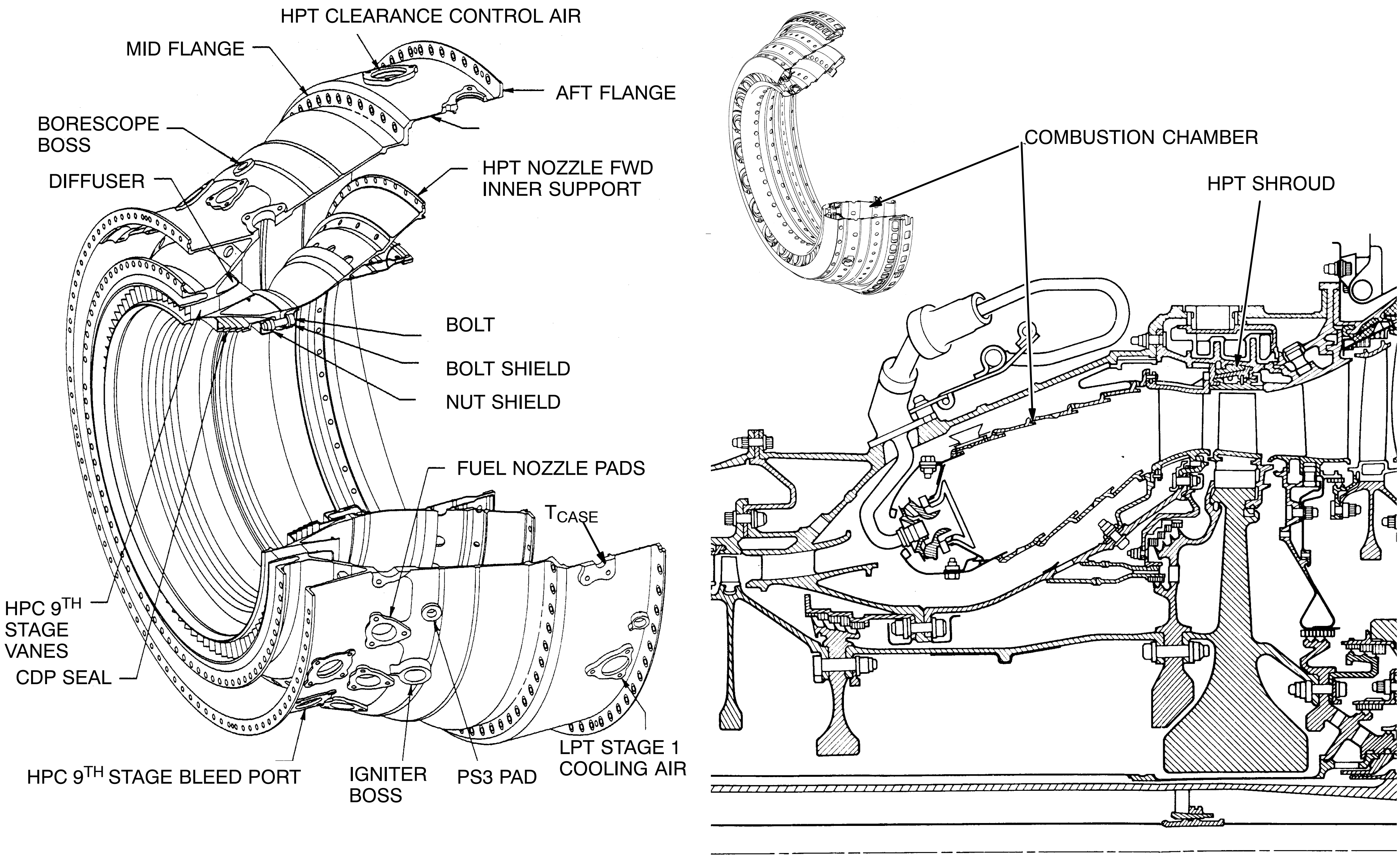


Figure 48 Combustion Section

72–50 TURBINE SECTION

HIGH PRESSURE TURBINE

General

The high pressure turbine (HPT) is a single–stage, air–cooled, high–efficiency turbine. Structurally the rotor consists of the:

- Front Shaft
- Front Rotating Air Seal
- Disk
- Rear Shaft

Front Shaft

The front shaft forms the structural connection between the compressor rotor and the HPT rotor, and supports the aft end of the compressor rotor.

Disk

The HPT disk is a forged and machined part that retains the turbine blades in dovetail slots. The inner part of the disk is cooled by booster discharge air. The outer part of the disk is cooled by compressor discharge air on the forward side and fourth stage purge air on the aft side.

Rear Shaft

The rear shaft is bolted to the aft side of the disk at a rabbeted flange and forms the aft support for the HPT rotor. The shaft is supported by the No. 4 roller bearing which rides on the low pressure shaft. Repairable abrasive coated seals are machined as an integral part of the rear shaft.

Front Rotating Air Seal

The front rotating air seal is bolted between the disk and the front shaft of the rotor. It forms a cavity between itself and the disk to direct compressor discharge air against the disk web and out through the turbine blades. The seal is a labyrinth inclined tooth form that reduces leakage past the seals. The seal teeth are abrasive coated and repairable.

Air Cavity

An air cavity between the shroud/nozzle support and the combustion case directs mixed 5^{th} and 9^{th} stage compressor bleed air onto the support .This cooling air maintains closer tip clearance between the shrouds and the rotor blades.

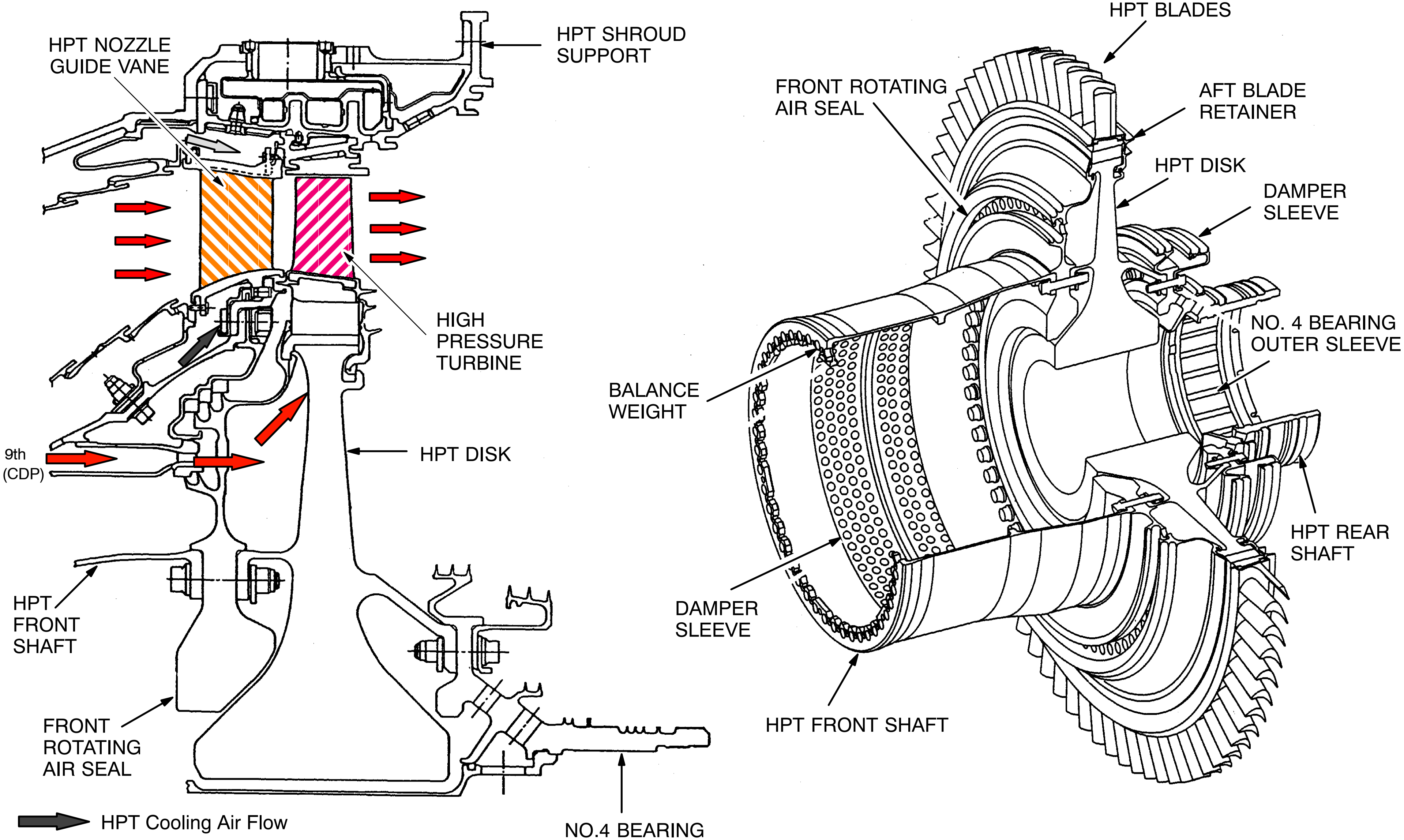


Figure 49 High Pressure Turbine

LOW PRESSURE TURBINE

General

The Low Pressure Turbine (LPT) module is a 4-stage axial-flow turbine. It is mounted between the high pressure turbine and the turbine frame. The module consists of the following major assemblies:

- LPT STATOR ASSEMBLY
- LPT ROTOR ASSEMBLY

Low Pressure Turbine Stator Assembly

The LPT stator assembly consists of the:

- LPT Case Assembly
- Stages 2-4 LPT nozzle assemblies
- Air Cooling Tubes and Manifolds Assembly
- A8 Flange Extension and the Partial Axial Flow Bulkhead Arrangement

LPT Case

Nine EGT (T49.5) thermocouples are installed on the LPT case and inserted into 9 vanes of the stage 2 LPT nozzle assembly.

Air Cooling Tubes and Manifolds Assembly (LPTCC)

The LPT cooling system includes 2 air cooling manifolds made of steel alloy and 2 tube halves made of steel alloy. Each manifold and tube half assembly is made up of 6 tubes provided with orifices which direct the air toward the LPT case.

Low Pressure Turbine Rotor Assembly

The LPT rotor assembly includes the:

- LPT Disks
- Stage 1 Blade Assembly
- Stage 2-4 Blade Assemblies
- Turbine Rotor Support

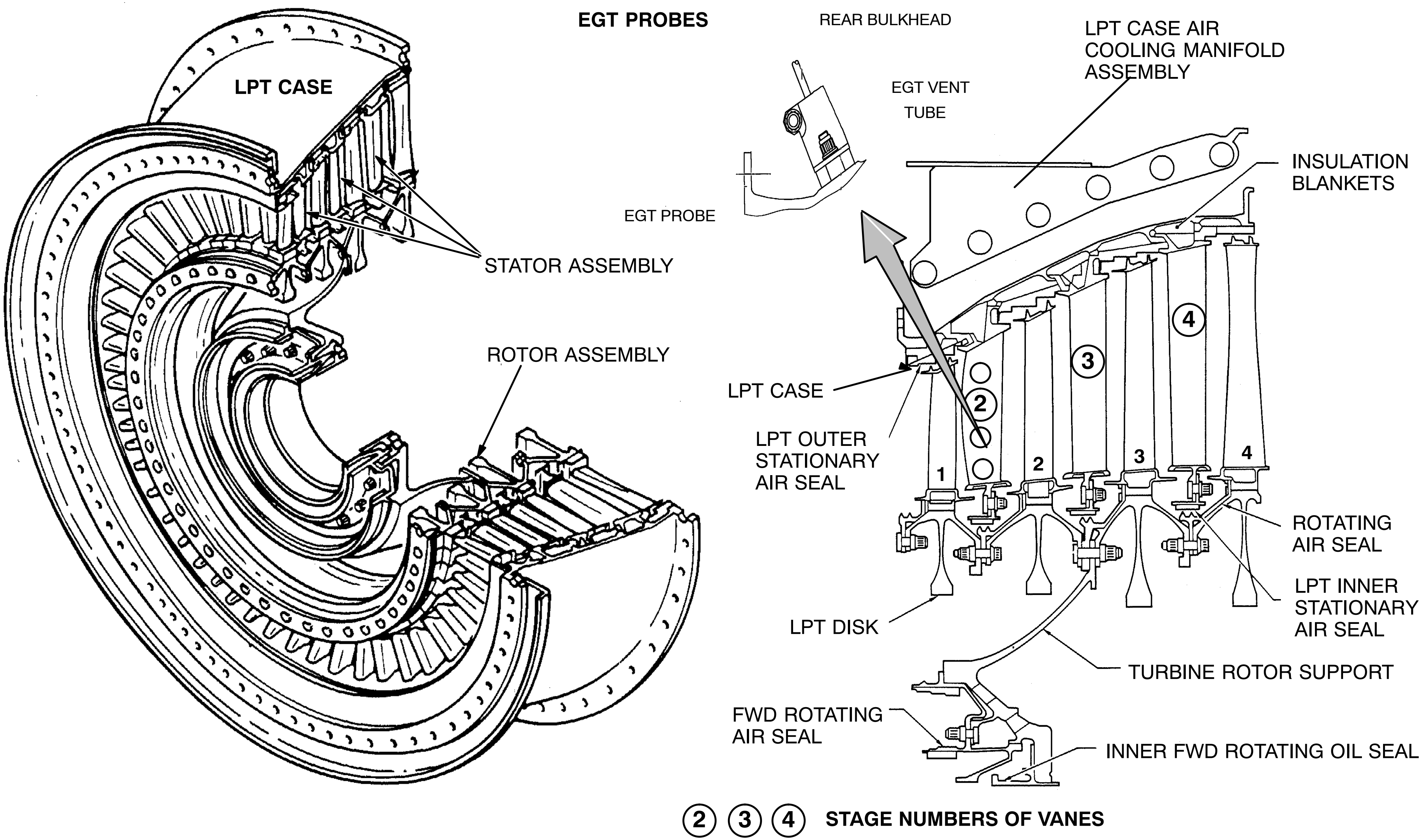


Figure 50 LPT Rotor & Stator Module

72–56 TURBINE FRAME ASSEMBLY

COMPONENT DESCRIPTION

The Turbine Frame consists of:

- Turbine Frame
- No. 5 Bearing Support with Oil Sump Assy
- Oil Inlet Cover
- Flange Assy
- Flame Arrestor
- 16 Radial Struts

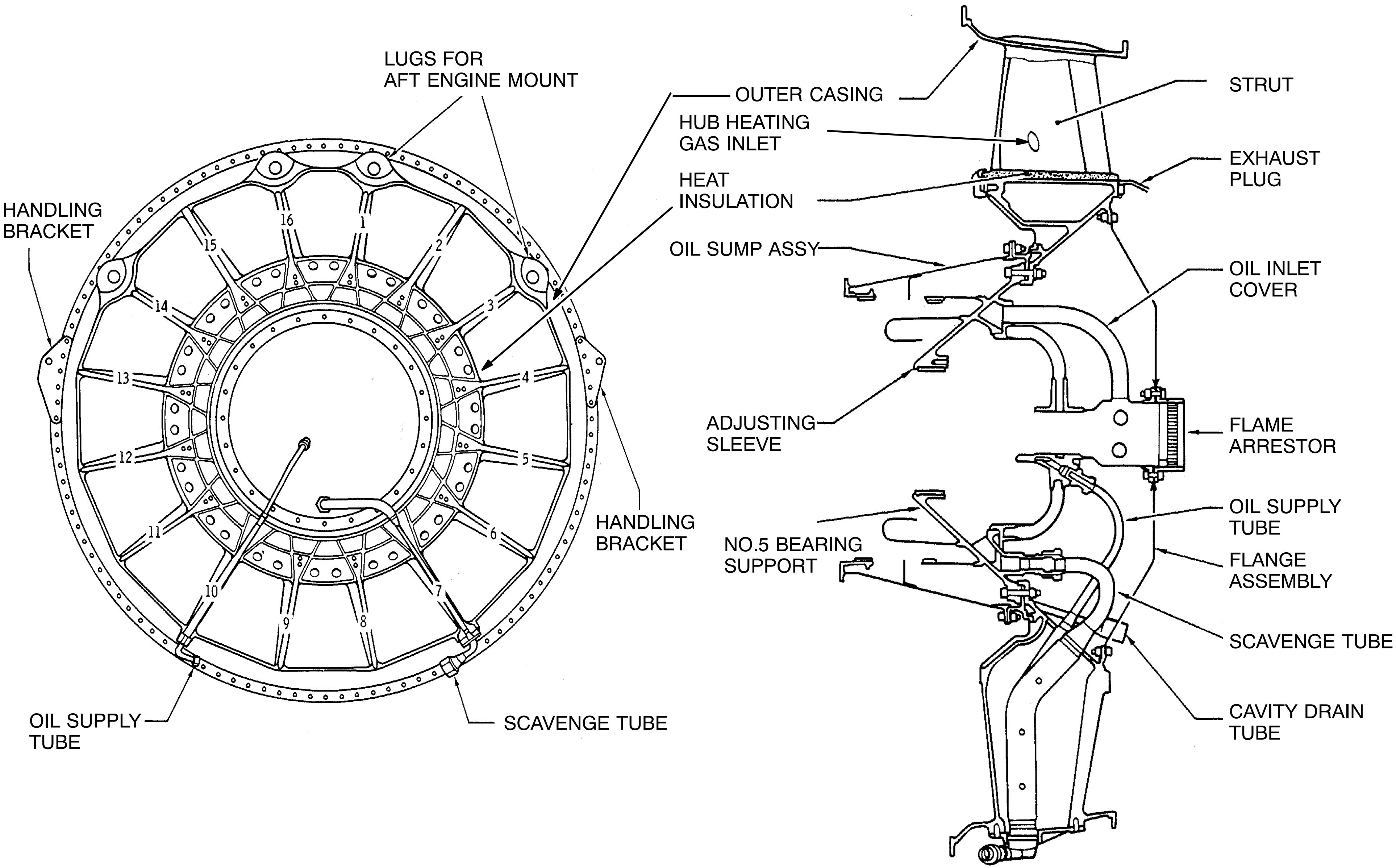


Figure 51 Turbine Frame Assembly

72−60 ACCESSORY DRIVE SECTION

ACCESSORY GEARBOX DESCRIPTION

Power for both engine and aircraft accessories is extracted thru a system of gearboxes and shafts. The accessory gearbox, which is supported by the compressor case, takes power from the core engine compressor stub shaft.

An inclined radial drive shaft transmits this power to the transfer gearbox, mounted below the compressor stator casing.

A horizontal drive shaft then transmits the power to the core mounted accessory drive gearbox.

The accessory gearbox drives the following equipment:

- IDG (electrical power generation)
- FADEC Control Alternator
- Hydraulic pump (hydraulic power generation)
- The Fuel Pump and HMU
- Lubrication Unit

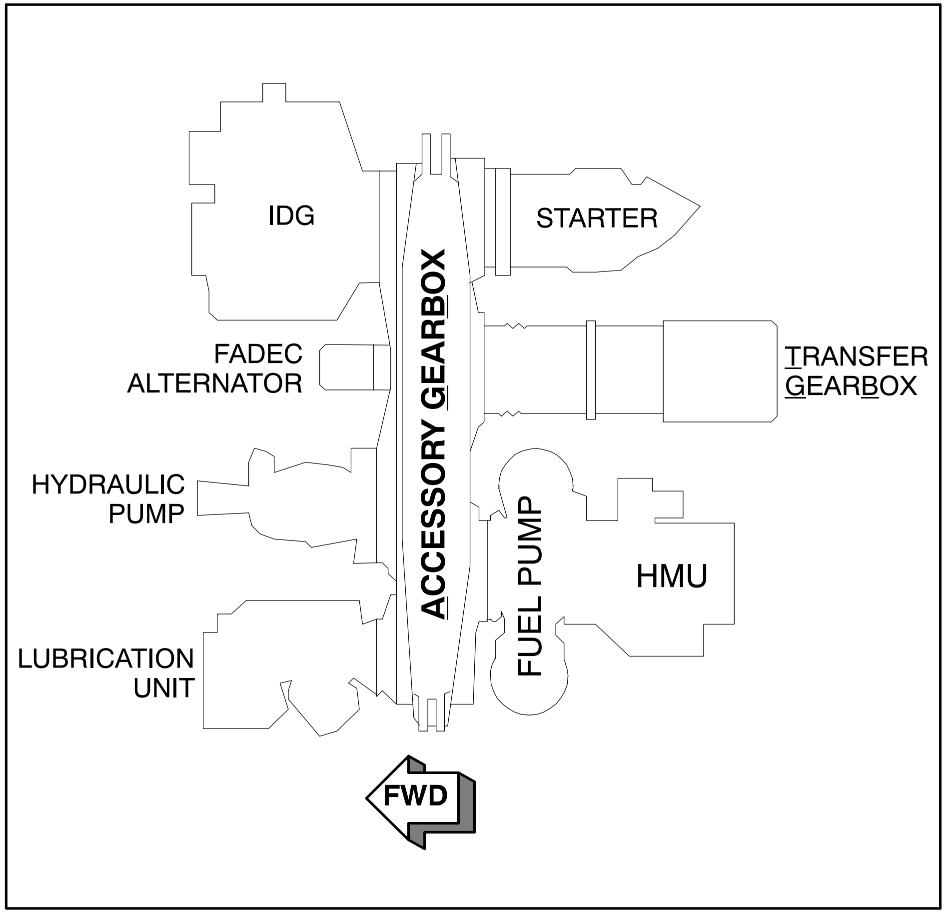


Figure 52 AGB Drive Section

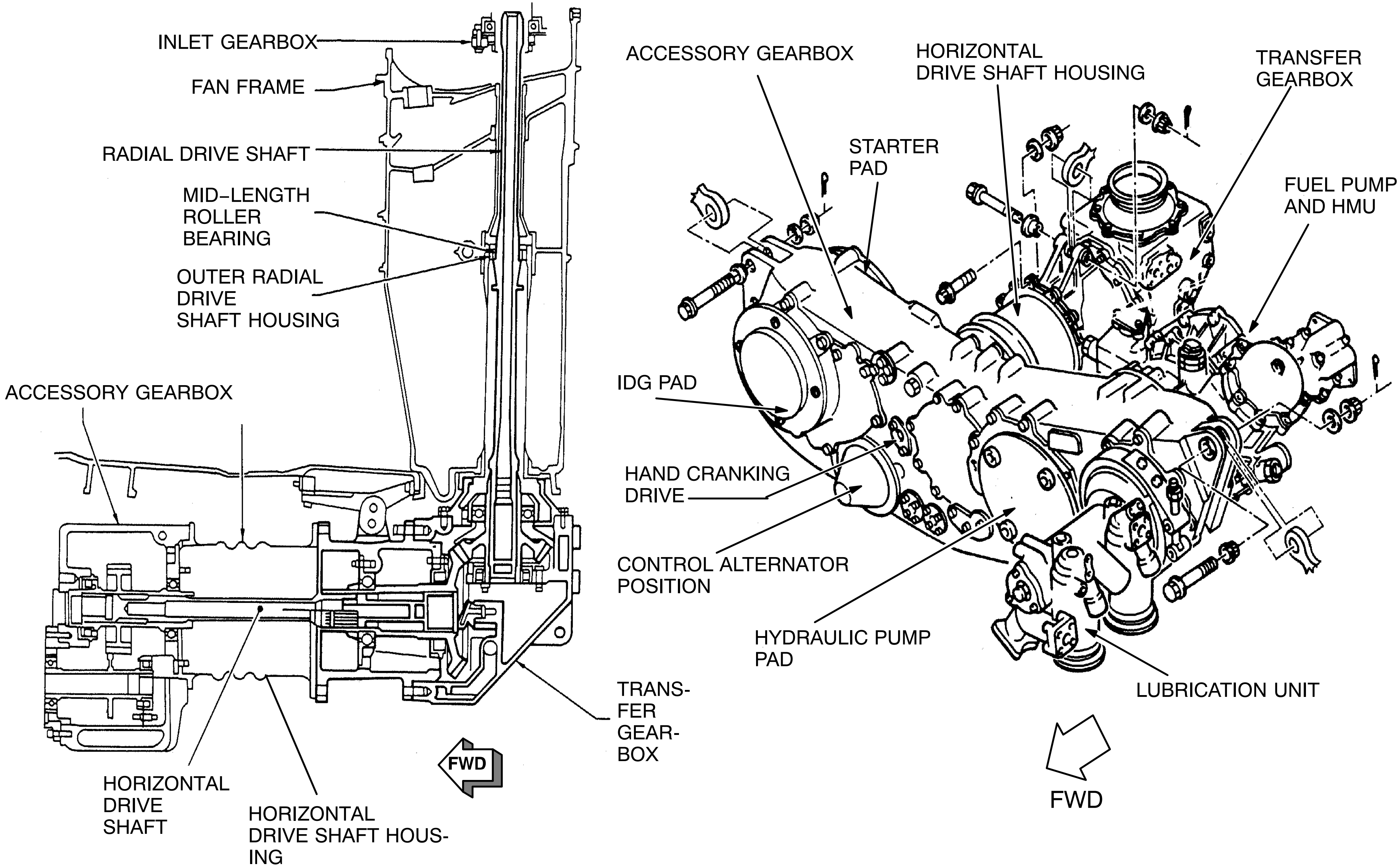


Figure 53 Accessory Gearbox

ATA 79 OIL

79–00 OIL - GENERAL

OIL SYSTEM INTRODUCTION

General

The lubrication system of one engine is completely self–contained and separated from the other engine or aircraft fluid systems.

Oil is distributed to components requiring lubrication and cooling by one lubrication pump element. Distribution is controlled by nozzles which direct the oil to the bearings of the forward and aft Sumps. It also lubricates bearings and gears in the transfer gearbox and accessory gearbox.

Four scavenge pump elements in the pump remove oil from the engine bearing sumps and gearboxes and return the oil to the tank.

Related oil system sensors deliver signals to the engine system display for monitoring purposes.

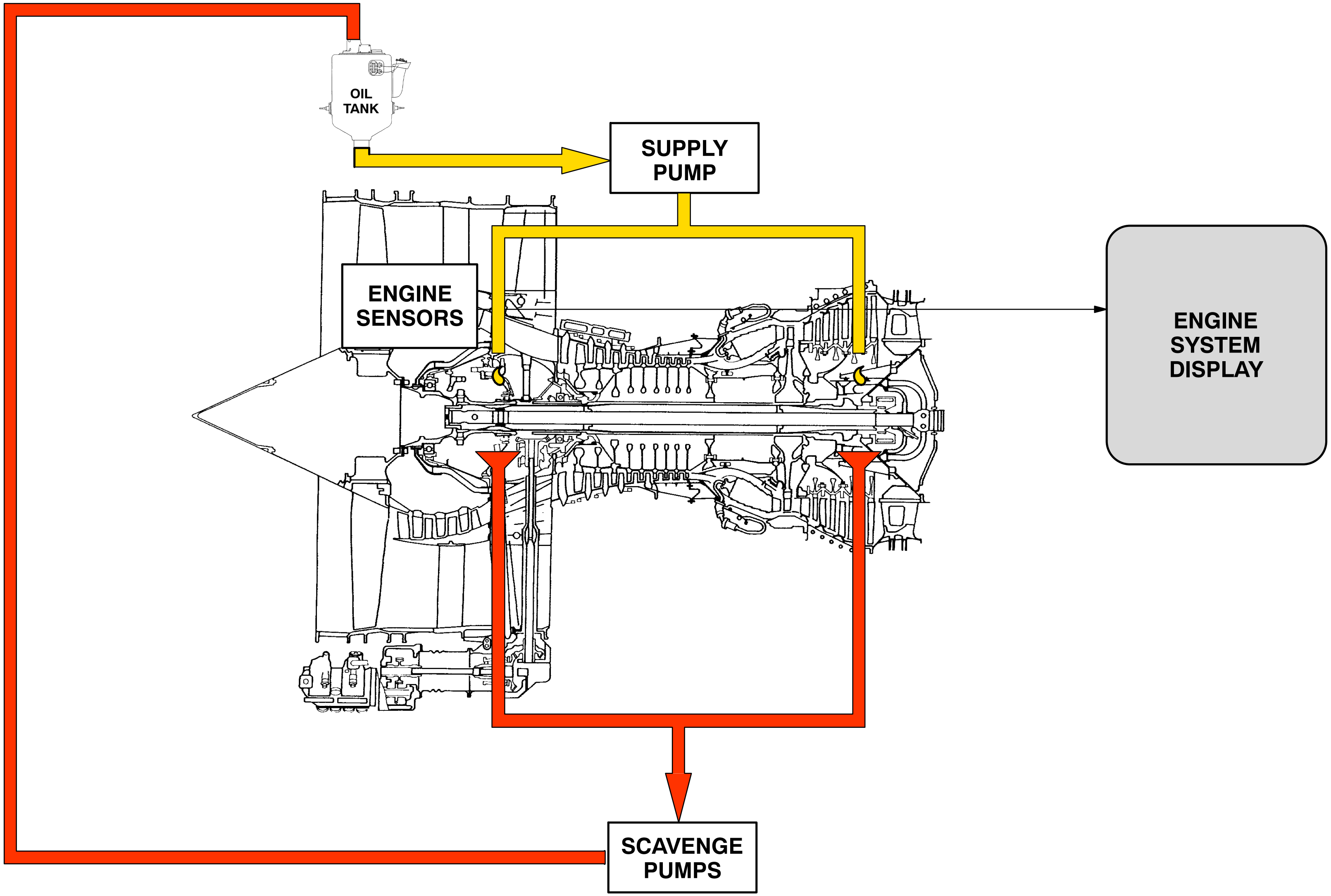


Figure 54 Oil System Presentation

CFM 56-5 OIL SYSTEM DESCRIPTION

General

The oil system includes a:

- Supply Circuit
- Scavenge Circuit
- Vent Circuit

The Major Components of the Oil System are:

- The Oil Tank
- The Lubrication Unit
- The Servo Fuel Heater
- The Main Fuel Oil Heat Exchangers.

Indicating and Monitoring is provided by the Detectors and Sensors shown on the Schematic.

Oil Supply Circuit

The Oil from the Tank passes through the Supply Pump and Supply Filter to lubricate the Forward and Aft Sump, and also the Accessories and Gearboxes.

The Oil Supply Line incorporates a Visual Filter Clogging Indicator, an Oil Temperature Sensor, an Oil Low Pressure Switch and an Oil Pressure Transmitter for Indication and Monitoring. An Oil Quantity Transmitter is provided on the Oil Tank.

Oil Scavenge Circuit

The Oil from Bearings, Transfer Gearbox and Accessory Gearbox returns to the Tank by means of four Scavenge Pumps protected upstream by Strainers and Chip Detectors.

To keep Oil Temperature within Limits, the Oil is cooled through the Servo Fuel Heater and the Fuel/Oil Heat Exchanger.

In Case of Scavenge Filter Clogging, an Oil Differential Pressure (Delta P) Switch signals it to the Cockpit and its Clogging Indicator shows it on the Engine system page with a message on E/WD accompanied by a single chime

Oil Vent Circuit

Some air within the scavenge oil is separated in the tank by a Deaerator and is vented to the Forward Sump through the Transfer Gearbox and Radial Drive Shaft.

The Sumps are vented Overboard through the Low Pressure Turbine Shaft to prevent Overpressure in the Sump.

Air entrapped in the Scavenge Oil Pressurizes the Tank and provides adequate Oil Pressure to the Supply Pump.

System Monitoring and Limitations

The operation of the engine oil system may be monitored by the following flight deck indications.

- engine oil pressure
- engine oil temperature
  - Minimum prior exceeding Idle: -10^{0}C
  - Maximum Continuous: 140^{0}C
  - Maximum Transient: 155^{0}C
- oil tank contents 24 US qt

In addition warnings may be given for the following abnormal conditions:

- LOW OIL PRESSURE
  - Red Line Limit: 13 PSI
- high oil pressure
  - Advisory: 90 PSI
- scavenge filter clogging

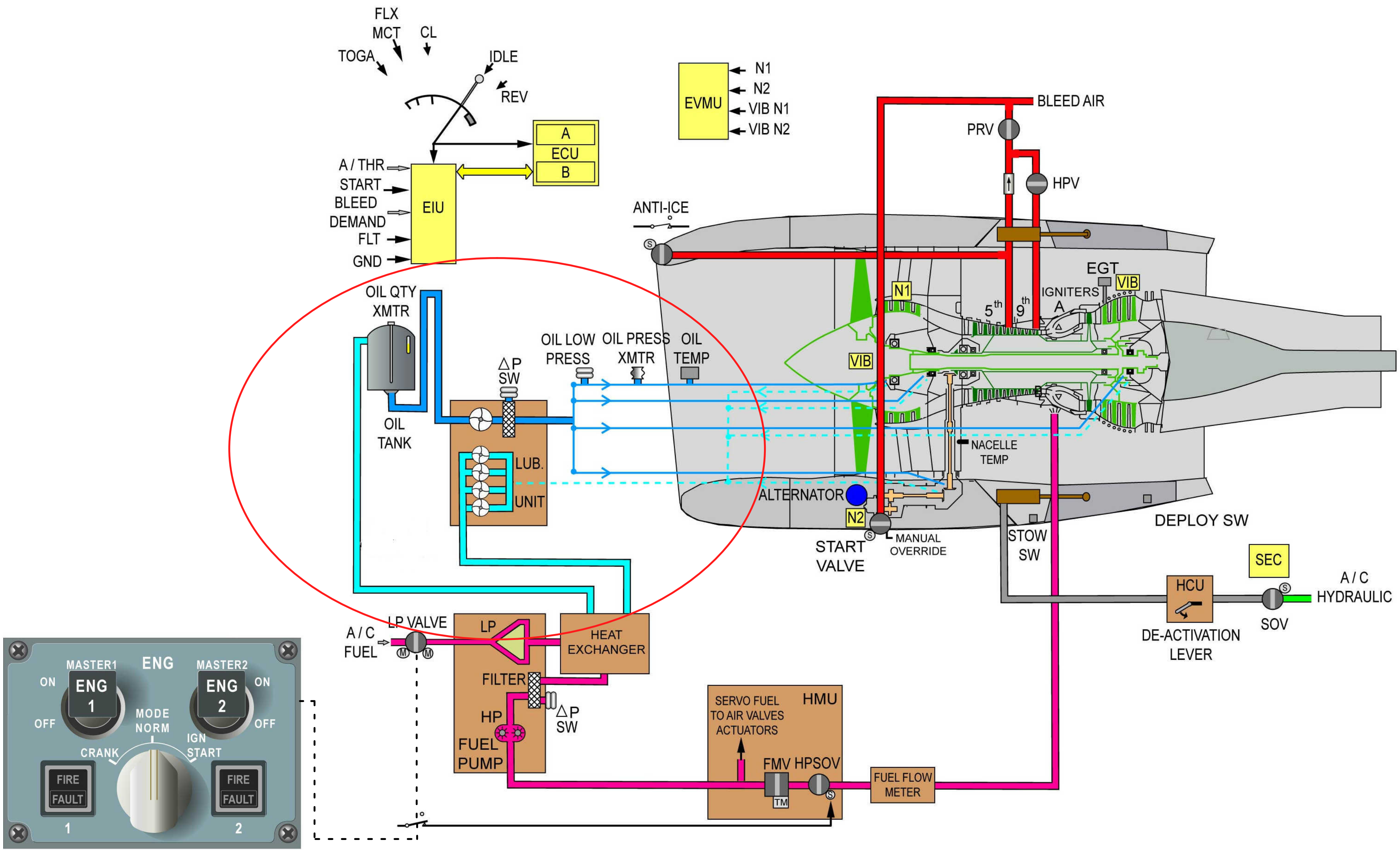


Figure 55 Oil System General

OIL SYSTEM OPERATION

General

The lubrication functions are provided by the lubrication unit.

The lubrication unit provides oil under the required pressure for lubrication of the 4 engine sumps, for scavenge of the oil after lubrication and circulation to the oil/fuel heat exchanger and oil tank. The lubrication unit its mounted on the AGB front face.

Description

The lubrication unit has a single housing containing the following items:

- Five positive displacement pumps (one oil supply and 4 scavenge pumps).
- Six filters (one oil supply filter, 4 chip detectors and scavenge pumps filters).
- One relief valve (on oil supply pump discharge side).
- Two clogging indicators (one for the oil supply filter and one for the main scavenge filter).
- Two bypass valves (one for the oil supply filter and one for the main scavenge filter).

Supply

Oil from the oil tank is routed to the lube pump which is protected upstream by a strainer and magnetic plug located at the bottom of the tank and downstream by a supply filter. The oil pressure is between 2.50 bars and 2.70 bars (36 PSID – 39 PSID).

The oil then is routed through a line.

Tappings are provided on this line to distribute the oil to the various items to be lubricated [forward sump (bearings 1, 2, 3), aft sump (bearings 4, 5), TGB, AGB].

Scavenge

The oil which has lubricated the engine bearings, accessory gearbox and TGB is scavenged by 4 pumps protected by a strainer equipped with a magnetic chip detector.

This oil is then collected in a single line comprising:

- a scavenge filter,
- an oil/fuel heat exchanger.

After having circulated through those elements, the oil is sent back into the tank. The oil passes through a deareator which separates the oil and the air. The air is then sent to the vent system.

The scavenge circuit main components are as follows:

- Four scavenge screens with chip detectors,
- Four scavenge pumps,
- One common scavenge filter,
- Oil/fuel heat exchanger.

Oil/fuel Heat Exchanger

The scavenged oil flows the lubrication unit through a pipe outside the unit to the servo fuel heater and the main oil/fuel heat exchanger, and then back to the oil tank.

The oil/fuel heat exchanger cools the oil by using fuel as a cooling medium.

The oil/fuel heat exchanger is installed on the fuel pump, between the AGB aft face and the servo fuel heater at the 9 o'clock position, aft looking forward.

The oil/fuel heat exchanger is of tubular type. It consists of a removable core, housing and cover.

The oil to fuel heat transfer is achieved through conduction and convection within the exchanger where both fluids are circulated.

Fuel from the fuel pump and from HMU enters the inlet. It flows in one direction through one half of the core tubes to the end cover. At the end cover, the fuel flows around the baffle and back through the other half of the core tubes to the fuel outlet. The fuel portion of the exchanger is equipped with a pressure relief valve which bypasses fuel around the exchanger if core clogging impedes fuel flow.

Oil from the scavenge system enters the oil inlet. The oil flows around the fuel tubes, as routed by interior baffles, and exits at the oil outlet. The oil portion of the exchanger is equipped with a pressure relief valve which bypasses oil through the exchanger if core clogging impedes oil flow.

Indicating

The filter clogging system indicates that the filter is clogged, when the scavenge filter pressure differential reaches 25.5 PSID.

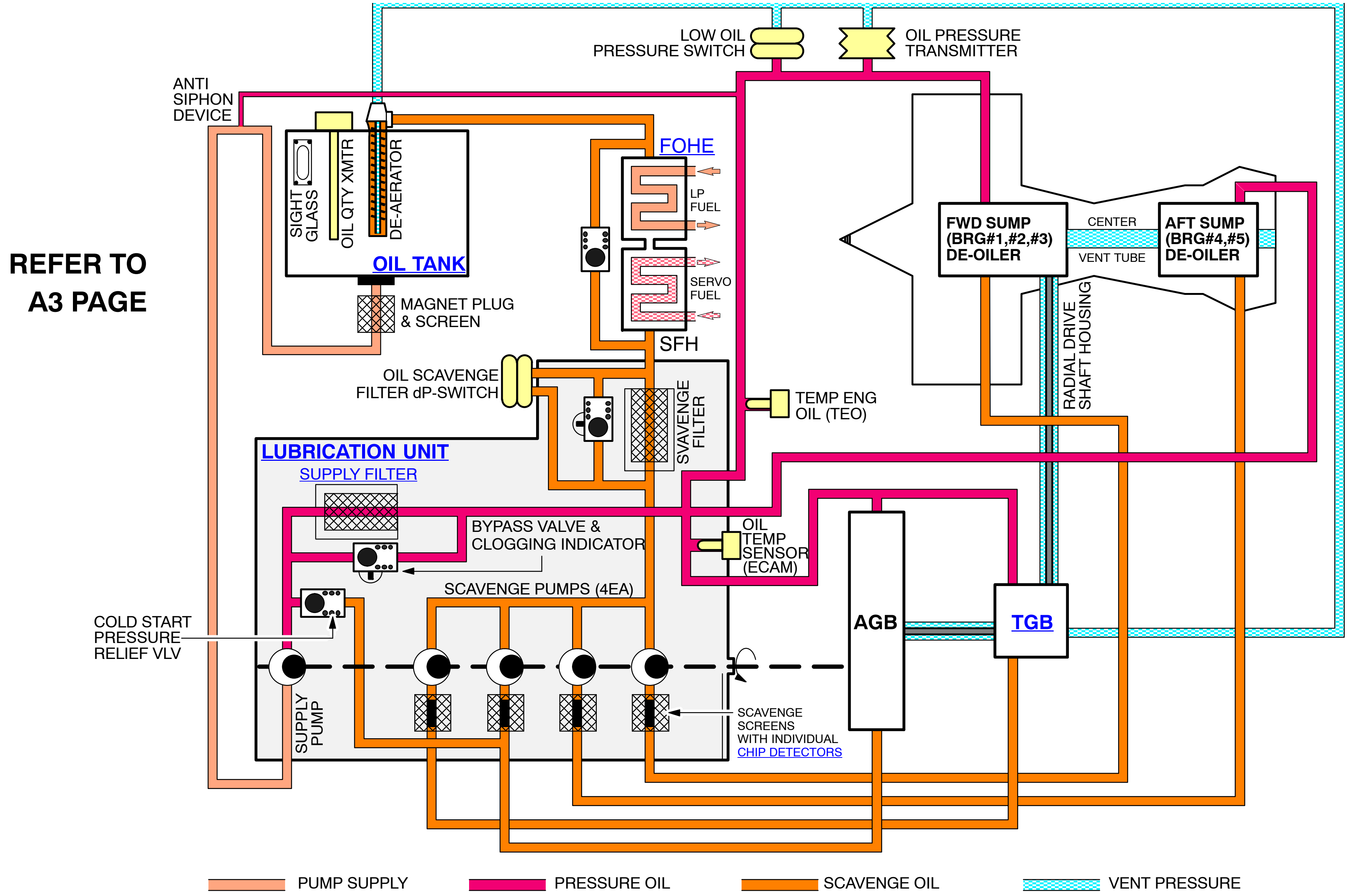


Figure 56 Oil System Schematic

79–11 STORAGE

SYSTEM PRESENTATION

Oil Tank

The Oil Tank Includes the following components:

- Oil Quantity Transmitter
- Pressure and Gravity Fill Ports
- Sight Glass for level indication
- Static Air and Oil Separator
- Magnetic Drain Plug
- Oil Scupper to drain oil spills during filling

Oil Tank Characteristics

	US Quarts	Liters
Max. unusable Quantity	2.5	2.35
Max. gulping effect	8	7.56
Min. useable oil volume	10	9.46
Max. oil total capacity	21.9	20.7
Total tank volume	24	22.7

ECAM Oil Quantity Indication on Ground

Before engine start:

- 11 quarts plus estimated consumption (0,3qts/h)

Engine at ground idle:

- 5 quarts plus estimated consumption (0,3qts/h)

Oil Tank Pressurization and Venting

In normal operation, the tank is pressurized by the air included in the scavenge oil. The pressurizing air in the tank is up to 0.8 bar above the external pressure.

The oil–in tube port discharges tangentially into a cavity connected with the tank vent and directing the air/oil mixture to a static air/oil separator.

During engine shut down, the pressurizing air is vented overboard, thus enabling the oil level to be checked five to thirteen minutes after engine shut down by opening the gravity filler cap or by looking at the cockpit indication.

The tank is vented to the forward sump through the transfer gearbox and radial drive shaft housing. Thus, oil tank pressure is adequate to provide pressurization of the supply pump inlet.

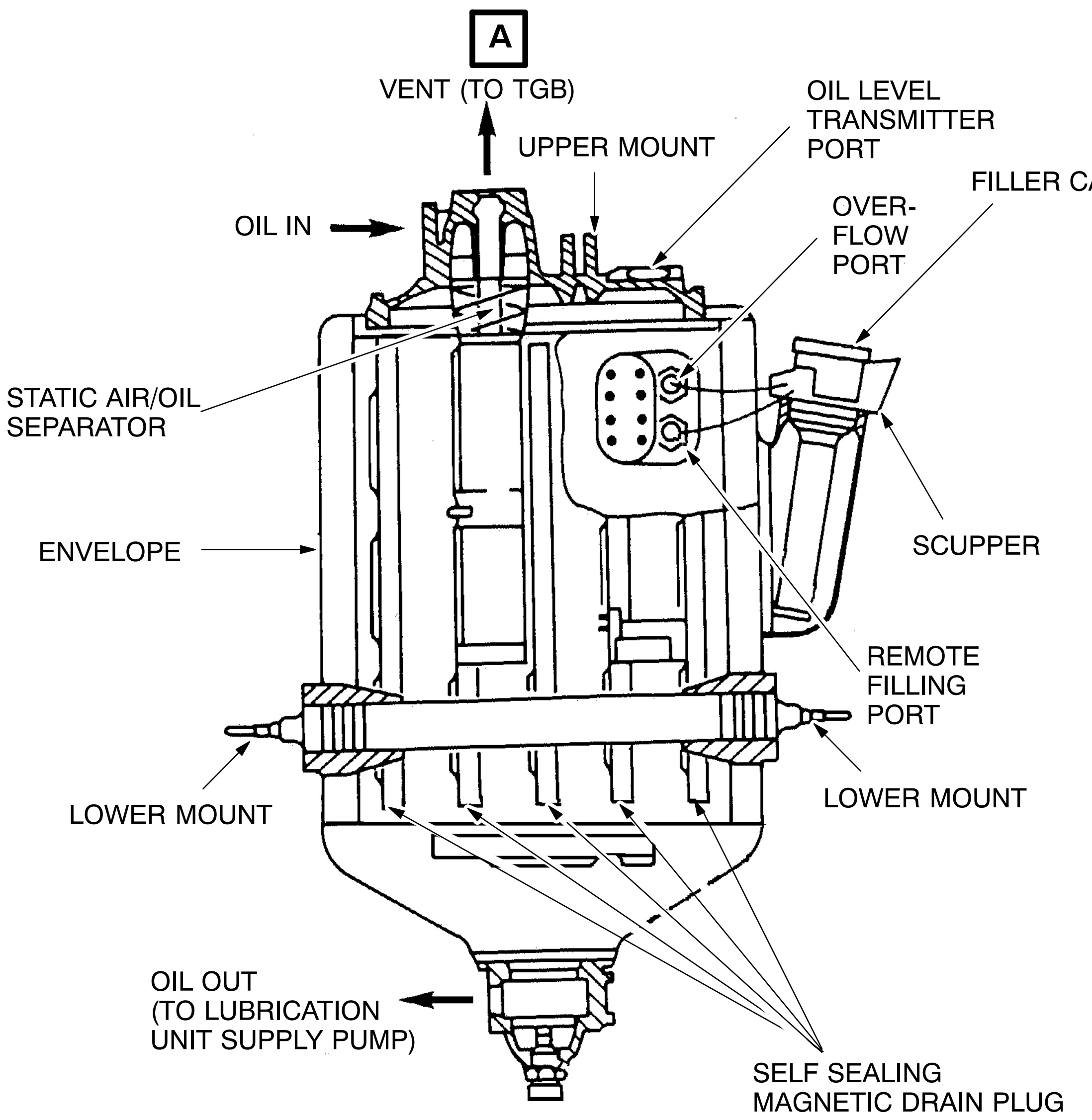
When engine N2 RPM increases from idle to take-off the quantity of oil in the tank may decrease to between 6 US Quarts (5.7 liters) and 8 US Quarts (7.6 liters) due to gulping effect.

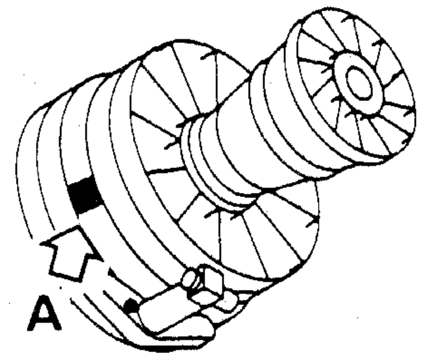
Engine Oil Servicing

Wait and let the pressure in the tank decrease for at least 5 minutes after engine shut down, before opening the filler cap.

In case of using the pressure fill port,open also the overflow port to make sure that the oil system will not be overfilled. The correct level can be checked on the sight glass.

NOTE: The oil system can be refilled any time but it is recommended to refill within 5 to 30 minutes to avoid oil spill after the next engine start because of thermal expansion.





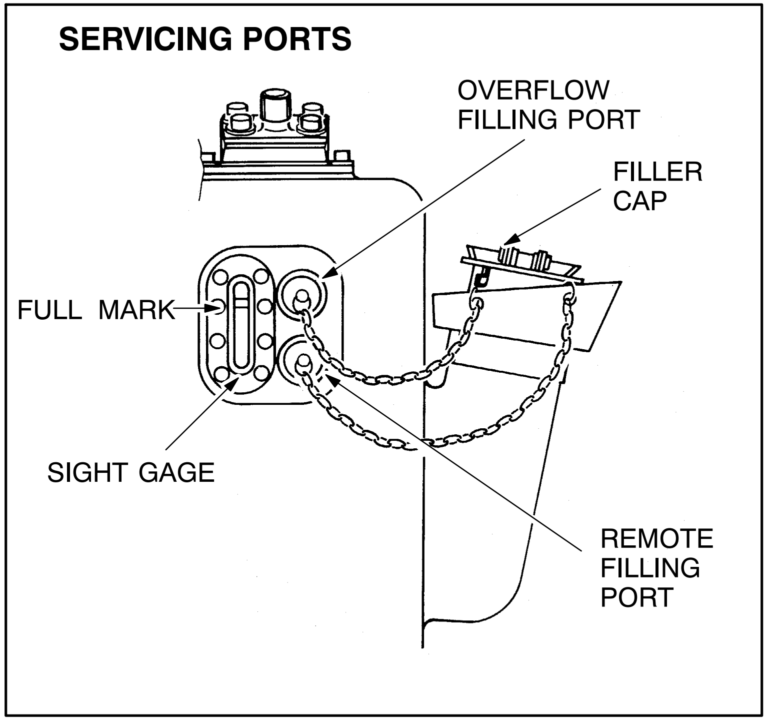


Figure 57 Oil Tank

79–21 DISTRIBUTION

COMPONENT DESCRIPTION

LUBRICATION UNIT

General

The lubrication unit provides oil under the required pressure for lubrication and for scavenge of the oil after lubrication and circulation to the oil/fuel heat exchanger and oil tank. The lubrication unit its mounted on the AGB front face.

Description

The lubrication unit has a single housing containing the following items:

- Five positive displacement gear type pumps (one oil supply and four scavenge pumps)
- Six filters (one oil supply filter, 4 chip detectors and scavenge pump filters).
- One relief valve (305 psi, on oil supply pump discharge side)
- Two clogging indicators (one for the oil supply filter and one for the main scavenge filter)
- Two bypass valves (one for the oil supply filter and one for the main scavenge filter)

Anti Syphon System

The supply lines from the oil tank to supply the pump has an antisiphon device to prevent the drainage of the lube tank into the gearboxes and sumps when the engine is shut down for extended periods.

Lube Pump Supply Filter

Downstream of the supply pump, the oil flows through the supply filter assembly. The filter has the following components:

- One filter (15 microns).
- One clogging indicator subjected to the upstream and downstream pressures of the supply filter. The indicator has a red warning indicator and is rearmed manually.
- One bypass valve which opens if the supply filter clogs (2.50 bars to 2.70 bars) (36 psid to 39 psid).
- Two capped provisions for a pressure gage upstream of the filter, and a temperature sensor.

Scavenge Filter

The flow from the 4 scavenge pumps are mixed together at the scavenge common filter inlet. This filter assembly consists of the following parts:

- One 25 micron filter.
- One clogging indicator, similar to the one on the supply filter (2 bars to 2.3 bars) (29 psid to 33 psid).
- An upstream and a downstream provision for measurement of filter pressure loss as a function of clogging. Filter clogging is indicated on the ECAM system.
- One bypass valve which opens if the filter clogs.(2.5 bars to 2.7 bars) (36 psid to 39 psid).

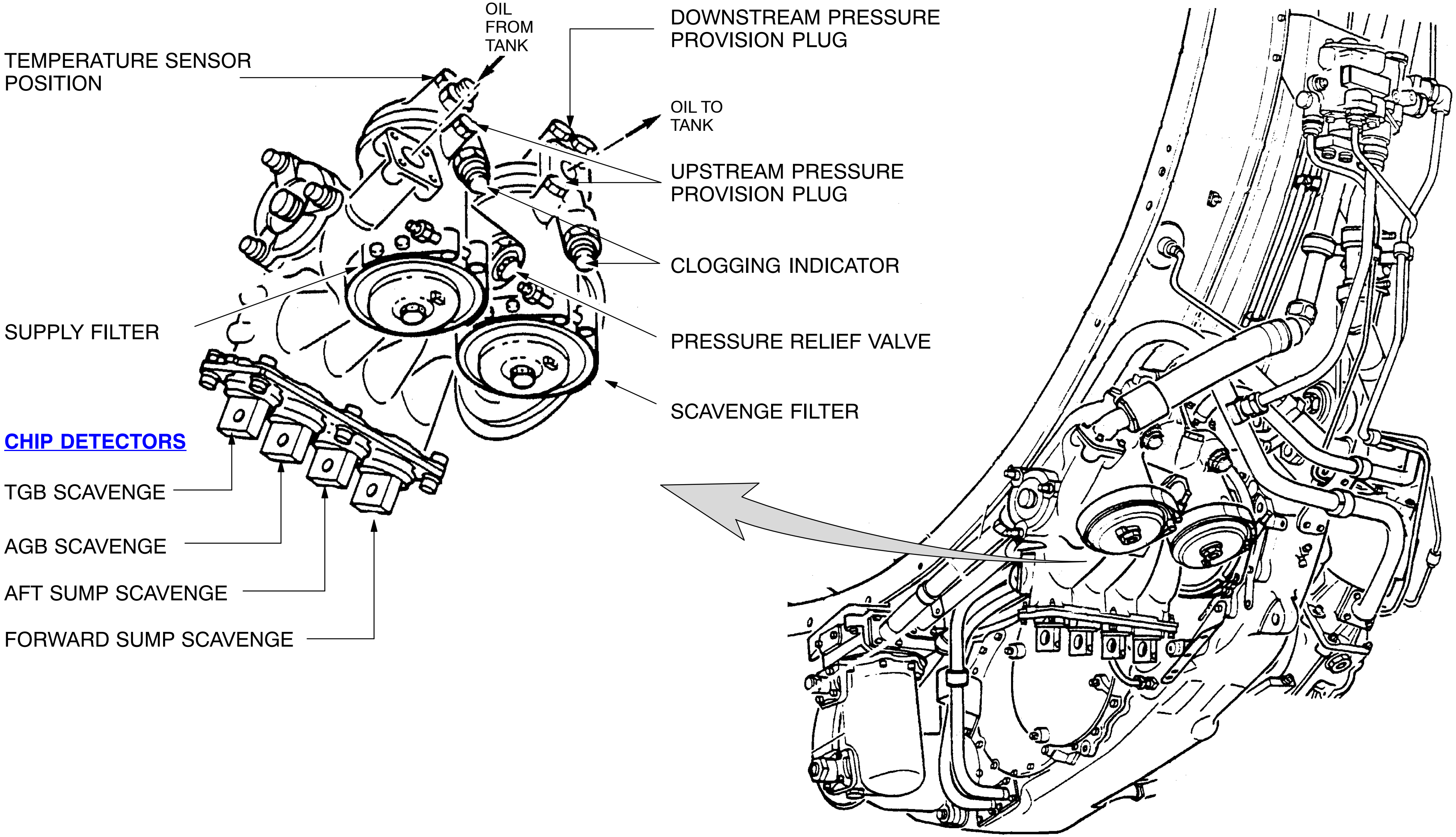


Figure 58 Lubrication Unit

MAGNETIC CHIP DETECTORS

The oil which has lubricated the engine bearings, accessory gearbox and TGB is scavenged by four pumps protected by a strainer equipped with a magnetic chip detector.

The air/oil mixtures are passed through the chip detectors and the scavenge filters, and then to the specific scavenge pump. Four Chip Detectors installed on the Lube unit:

- TGB Scavenge Chip Detector
- AGB Scavenge Chip Detector
- AFT Sump Scavenge Chip Detector
- FWD Sump Scavenge Chip Detector

Chip Detector Removal

Chip detector assembly can be removed by depressing it and rotating it one - quarter of a turn counter-clockwise (CCW).

Chip Detector Installation

Align plug keys of magnetic plug with sleeve keyways and rotate a quarter of a turn clockwise to complete engagement of keys in keyways. Ensure chip detector and magnetic plug assembly has snapped down into its lock position by pulling detector down, while lightly rotating from side to side. Flats of handle must be perpendicular to the center line of lube unit. Magnetic plugs are provided with a red point on plug handle. The red point must face the filters.

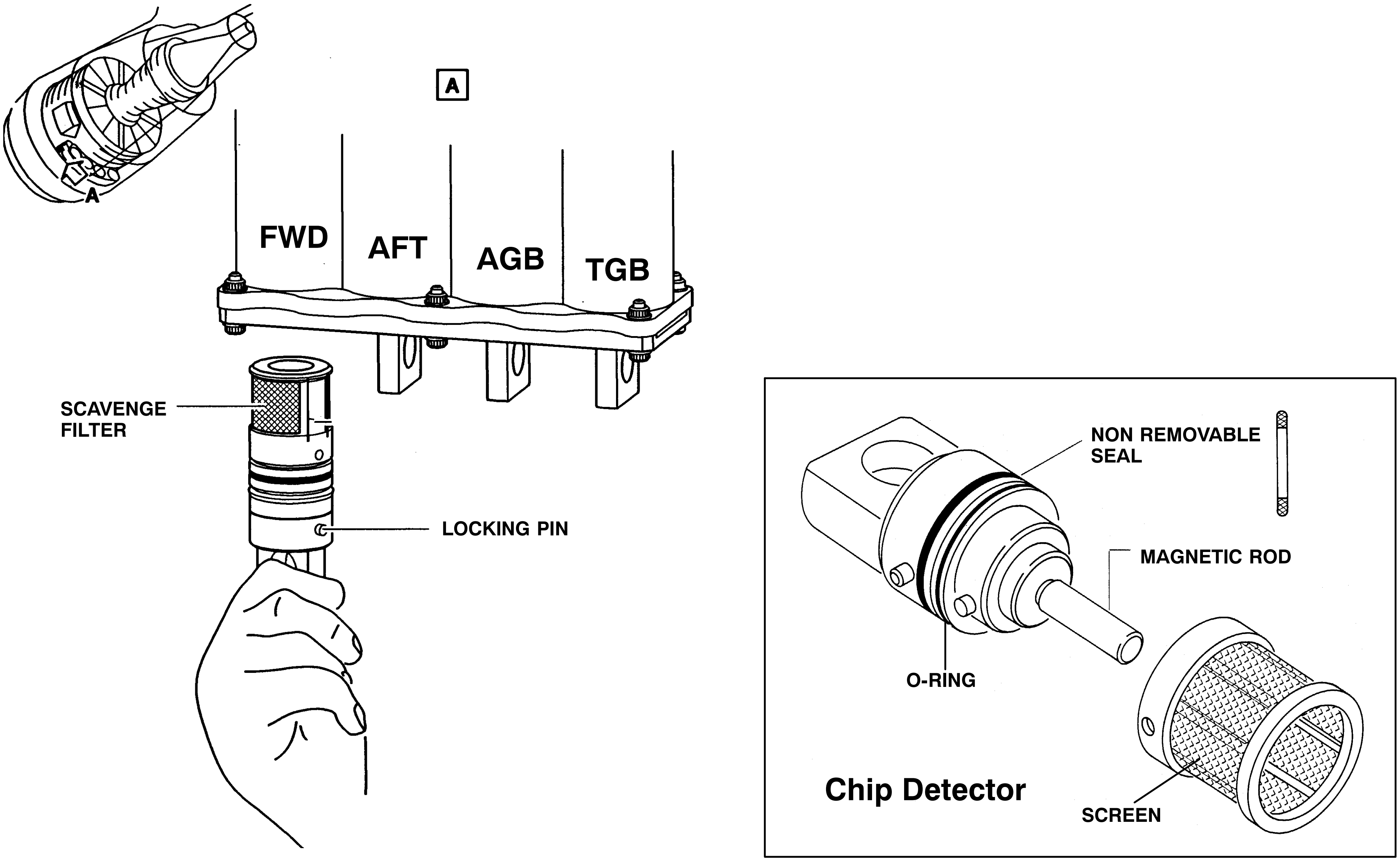


Figure 59 Magnetic Chip Detectors

MAIN FUEL OIL HEAT EXCHANGER

Purpose

The oil/fuel heat exchanger cools the oil by using fuel as a cooling medium. The oil to fuel heat transfer is achieved through conduction and convection within the exchanger where both fluids are circulated. Fuel from the fuel pump and from HMU enters the inlet. Oil from the scavenge system enters the oil inlet.

Location

The oil/fuel heat exchanger is installed on the fuel pump, between the AGB aft face and the servo fuel heater at the 9 o'clock position, aft looking forward.

Description

The oil/fuel heat exchanger is of tubular type. It consists of a removable core, a housing and a cover.

The housing contains the core of the oil/fuel heat exchanger. The following items are located on the outside of the oil/fuel heat exchanger housing:

- One oil pressure relief valve and one fuel pressure relief valve
- One drain port which collects possible fuel leaks from core and inner seal cavities and prevents fuel from leaking into the oil cavity and contaminating the oil system
- One attaching flange for the servo fuel heater
- One flange for attachment to the fuel pump
- One port on fuel−in for fuel returned from HMU after circulating through the IDG oil cooler

SERVO FUEL HEATER

Purpose

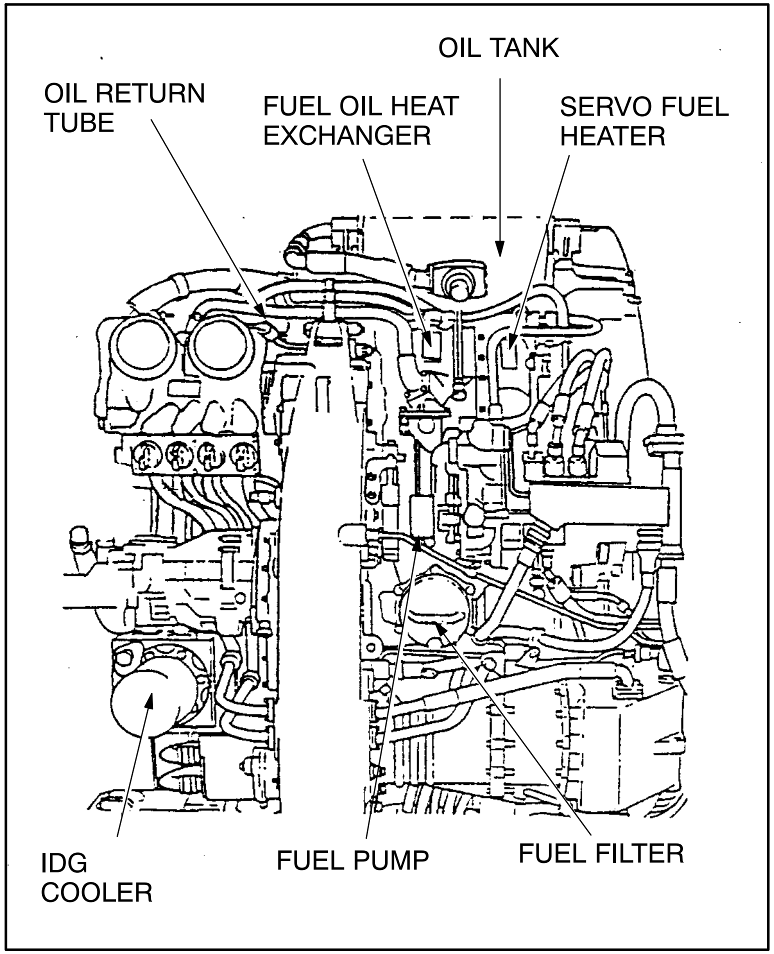
The servo fuel heater raises the temperature of the fuel. This prevents ice from entering the control servos inside the hydromechanical fuel unit (HMU).

Location

The servo fuel heater is mounted on the aft section of the main oil/fuel heat exchanger located on the accessory gearbox (AGB) aft face, between the oil tank and the fuel pump/HMU package.

Description

The servo fuel heater is a heat exchanger using oil as its heat source. Heat exchange between oil and fuel occurs by conduction and convection inside the unit. The two fluids circulate in the servo fuel heater through separate flowpaths.



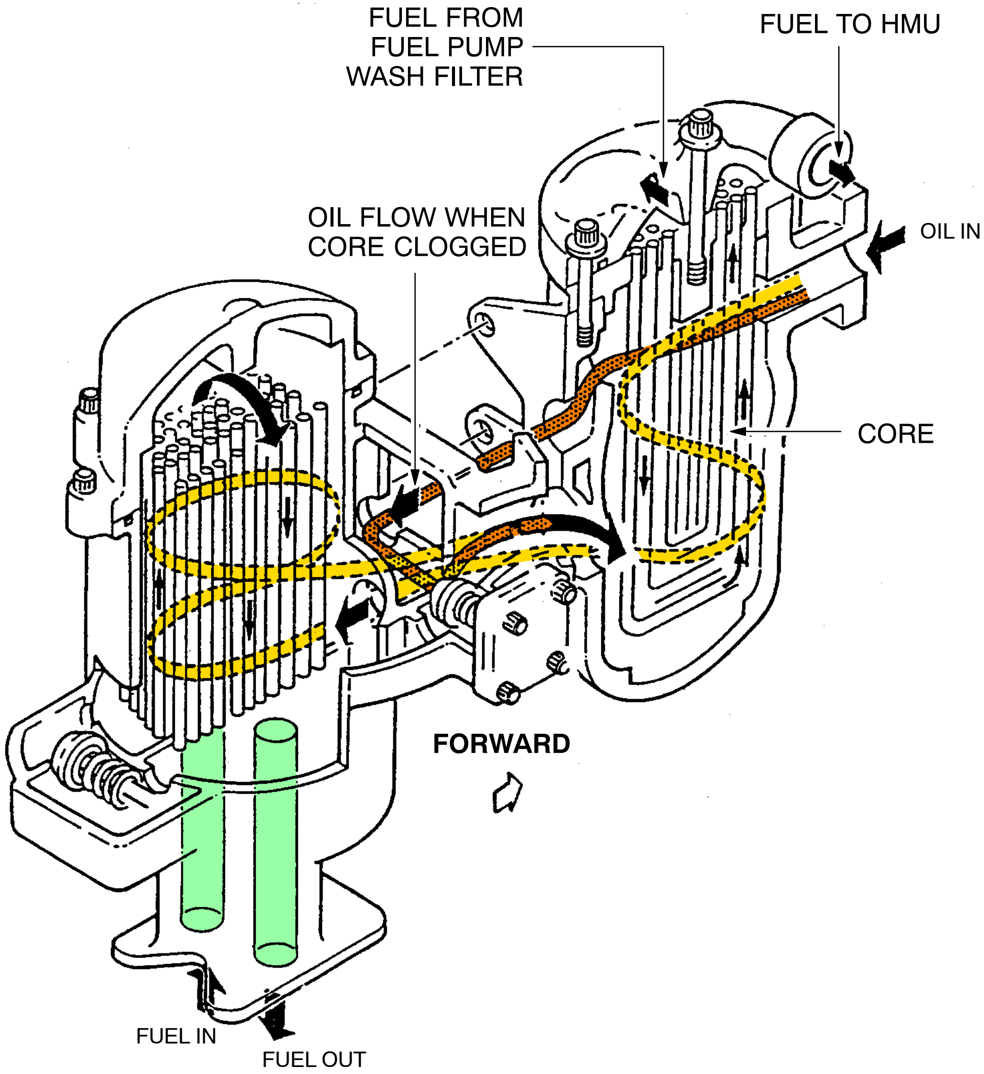


Figure 60 Main Fuel Oil Heat Exchanger

79–30 INDICATING

ECAM DESCRIPTION

1 Oil Temperature Indication

Flashes Green (Advisory) when Temp $\geq$ 140° C
Is amber when155°C or 15min >140°C.

2 Oil Pressure Indication

Color turns red (Warning) when Pressure <13 PSI.

3 Oil Quantity Indication

Flashes Green (Advisory) when QTY < 4 Quarts.

4 Oil Filter Clogging Indication

(White and Amber) Warning appears on the Screen when the Engine Scavenge Filter is Clogged.

ENG SYS PAGE (CFM)

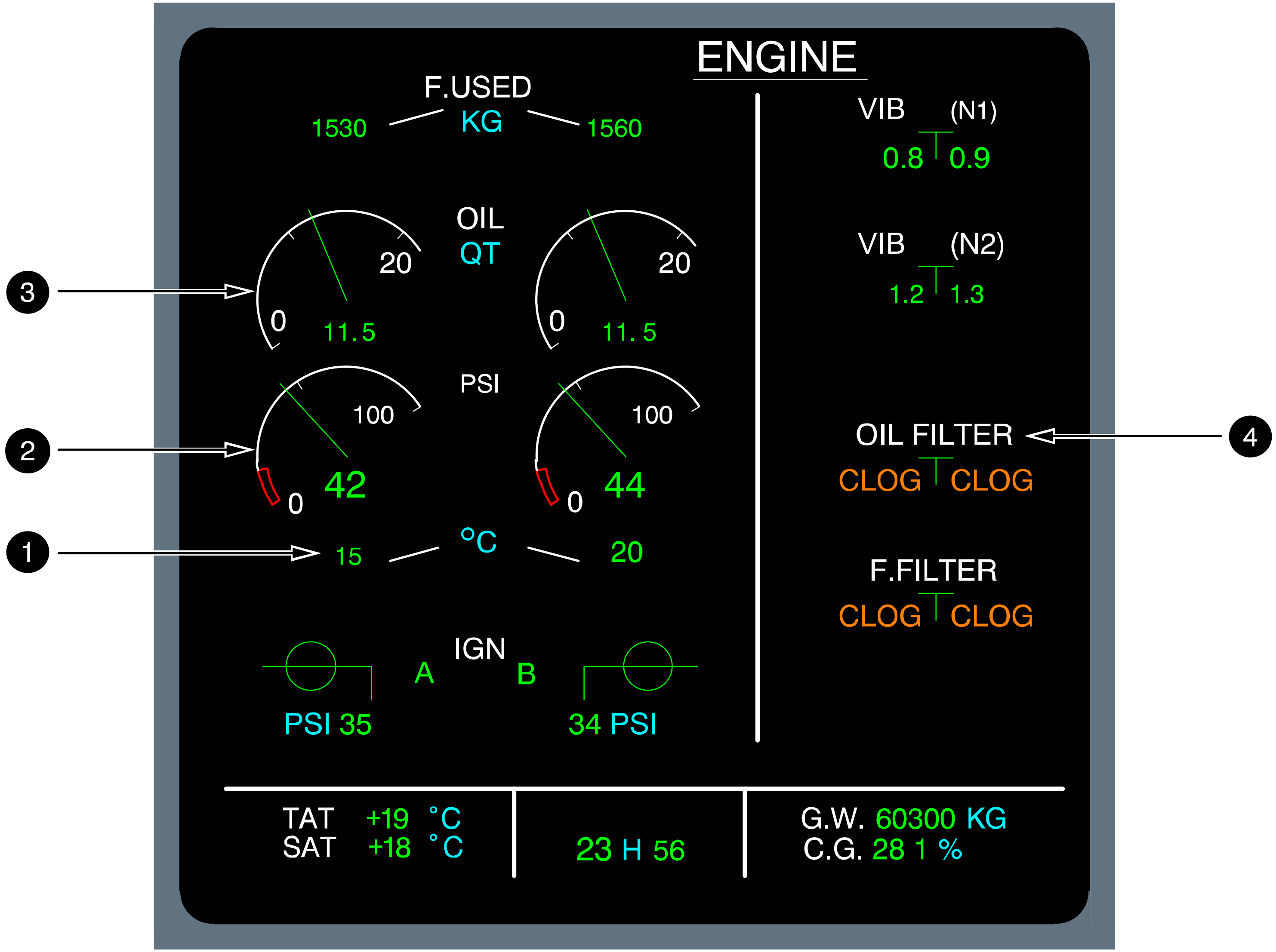


Figure 61 Engine System Page (Lower ECAM)

INDICATING COMPONENT LOCATION

Oil system monitoring is performed by means of:

- Oil Pressure
- Oil Temperature
- Oil Filter Clogging.
- Oil Quantity

The oil system is monitored by the following components

- Low Oil Pressure Switch
- Oil Pressure Transmitter
- Oil Temperature Sensor
- Oil Filter Differential Pressure Switch
- Oil Quantity Transmitter

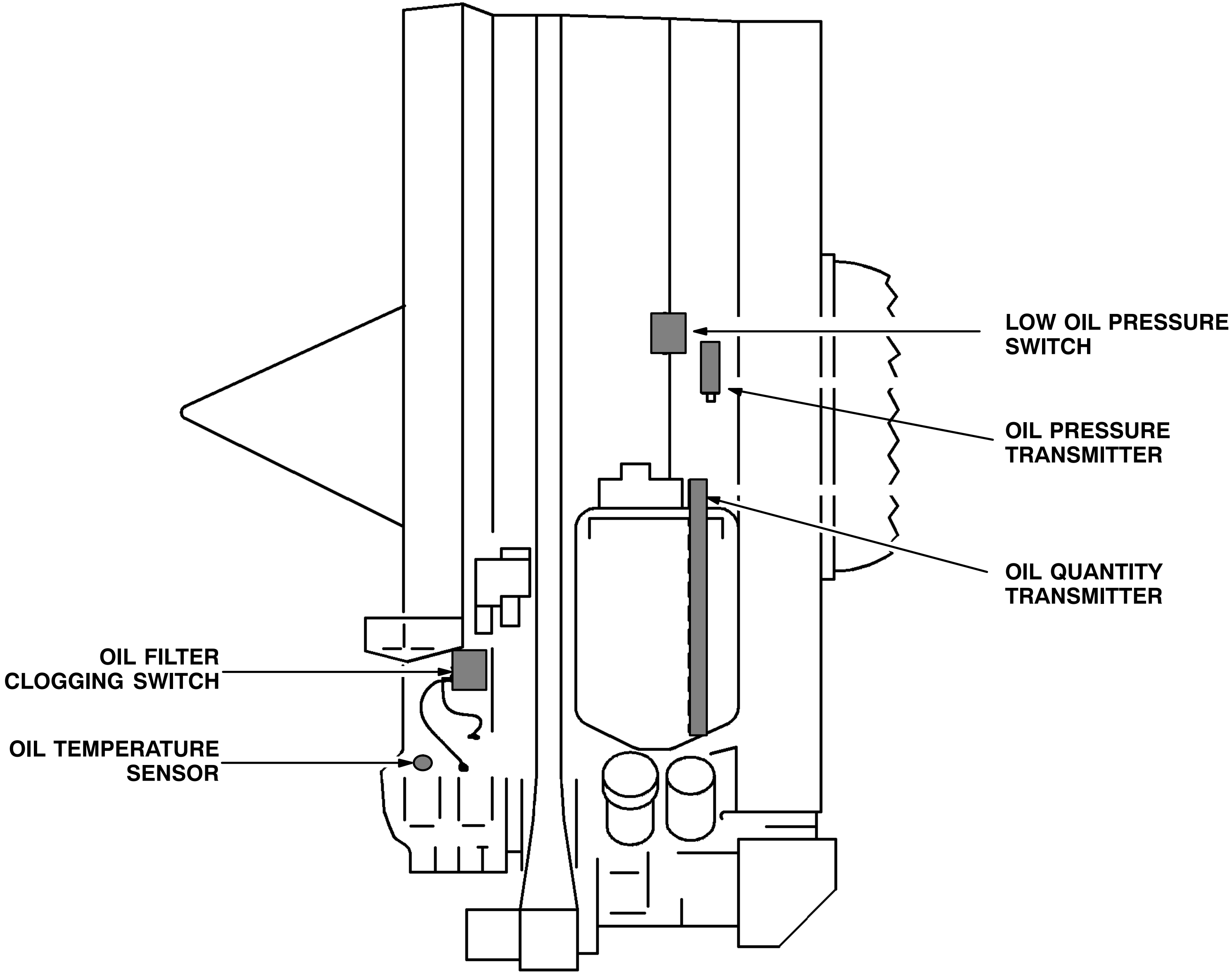


Figure 62 Oil Indication Components

OIL INDICATING COMPONENT DESCRIPTION

OIL PRESSURE INDICATION

The analog signal from the oil pressure transmitter is sent to the SDAC1 and 2 and the EIU which transforms the analog signal into a digital signal. The digital signal is then transmitted to the ECAM through the FWCs and the DMC.

LOW OIL PRESSURE SWITCHING

When the oil pressure drops below 13 ± 1 psid the pressure switch closes. This will lead to the following warnings and indications:

- the master warning (red) located on the glare shield comes on
- the audio warning is activated
- the ENG page appears on lower display unit of the ECAM system and the Oil Pressure Indication flashes red.

The following indications appear on the upper ECAM display:

- ENG1 (2) OIL LOW PRESS
- THROTTLE 1 (2) IDLE

The low oil pressure information is send to different aircraft systems. Two different switchings are possible:

Low Oil Pressure Switching (via Relay)

- To Steering
- Door Warning
- To FWC
- FAC
- TO FMGC
- To IDG SYSTEM CONTROL

Low Oil Pressure Switching via EIU

- To CIDS
- To DFDRS INTCON Monitoring
- To CVR power Supply
- To WHC
- To PHC
- To FCDC
- To Blue Main Hydraulic PWR
- To Green Main HYD PWR RSVR Indicating
- To Yellow Main HYD PWR RSVR Indicating
- To Blue Main HYD PWR RSVR Warning / Indicating

OIL FILTER DIFFERENTIAL PRESSURE SWITCH

When the differential pressure through the oil scavenge filter is higher than 25.5 ± 1 psid increasing pressure, the switch closes. The signal is send to the SDACs to the FWCs and the DMCs. In result:

- the MASTER CAUTION (amber) comes on
- the ENG page on the lower display unit of the ECAM appears with Oil Filter Clogging Indication (White and Amber)

OIL TEMPERATURE SENSOR

The oil temperature is sensed by a dual resistor unit. This element causes a linear change in the DC resistance when exposed to a temperature change. Temperature measurement range: – 70 °C to 300 °C. Both signals (channel A and B) are routed to the EIU which transforms this analog signal to a digital signal. The signal is send to the FWCs and DMCs and then displayed on ECAM.

OIL QUANTITY TRANSMITTER

The oil quantity transmitter probe (tube portion) is a capacitor. The signal from this capacitor is rectified and sent to the electronics assembly on top of the transmitter. The analog signal is sent to the SDACs and EIU which transforms it into a digital signal. The signal is sent to the FWCs. The system is power supplied with 28 VDC from busbar 101PP (202PP) through circuit breaker 2EN1 (2EN2).

TEMPERATURE ENGINE OIL (TEO)

This sensor is used for the IDG cooling system control (Fuel return).The oil temperature is sensed by a dual resistor unit. The unit consists of a sealed, wire–wound resistance element (Chromel/Alumel). This element causes a linear change in the DC resistance when exposed to a temperature change. Temperature measurement range: – 70 °C to 300 °C. Both signals (channel A and B) are routed to the ECU.

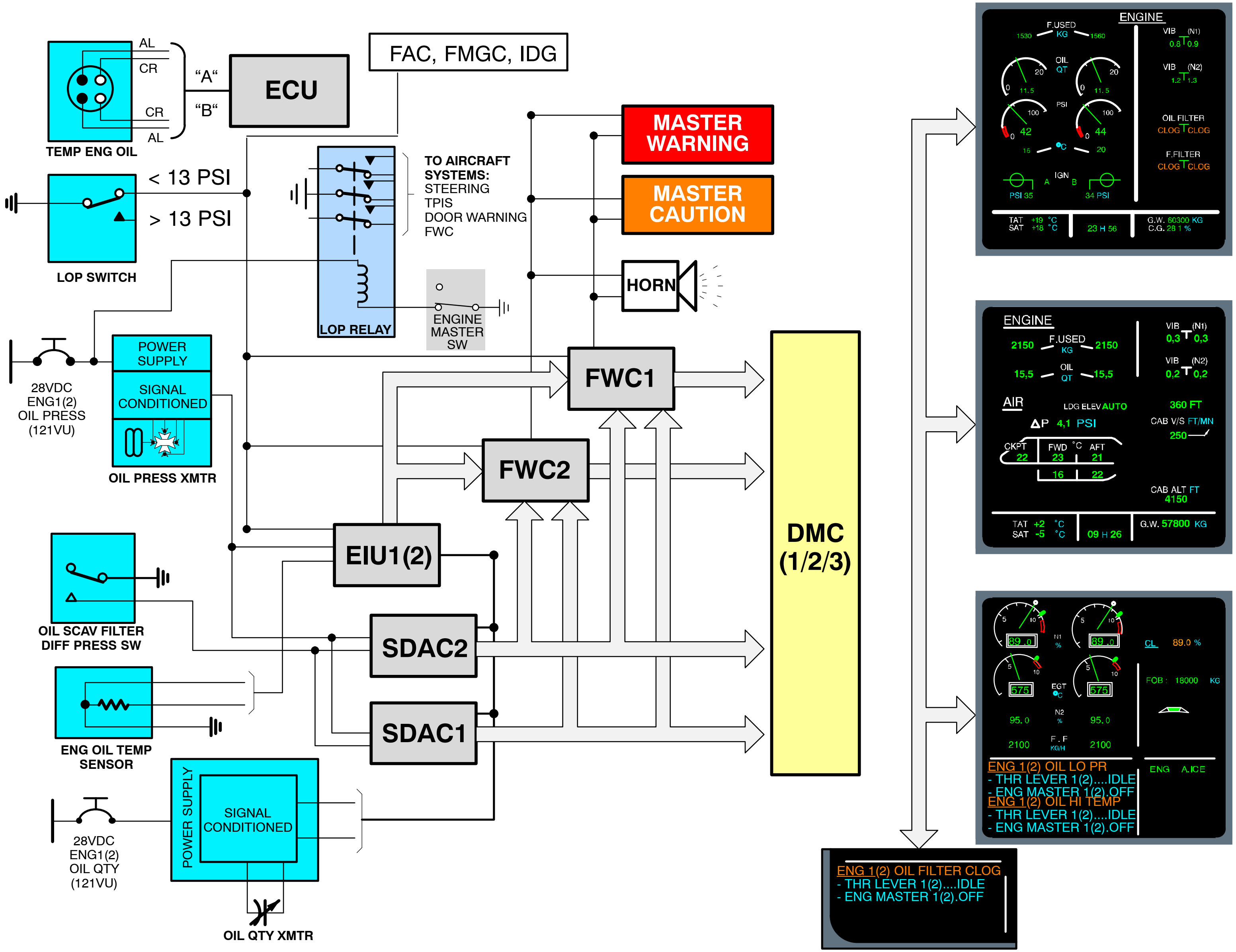
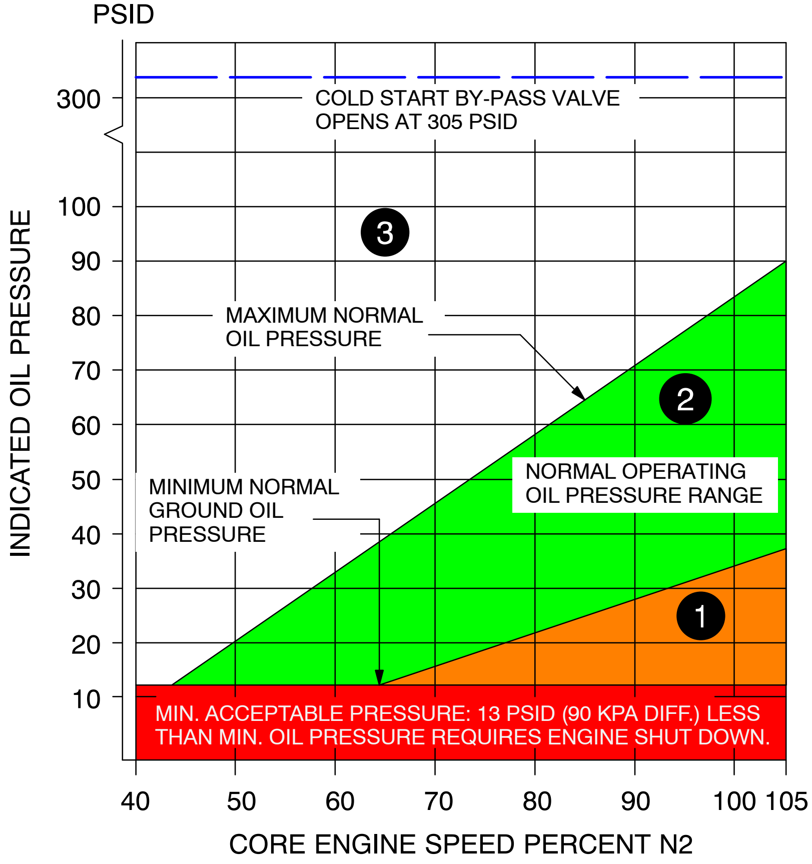


Figure 63 Indication Basic Schematic

CAUTION: MAINTENANCE ACTION IS REQUIRED PRIOR TO NEXT FLIGHT IF ENGINE OIL PRESSURE LEVELS ARE REPORTED TO BE IN AREA 1.
OPERATION IN AREAS 1 AND 3 REQUIRES CLOSE MONITORING OF OTHER OIL SYSTEM PARAMETERS.



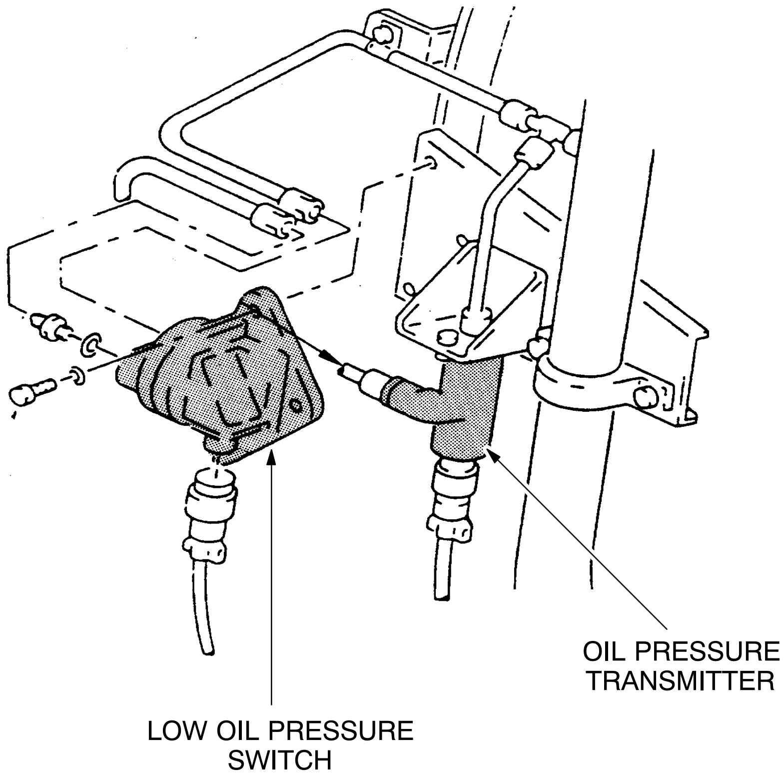
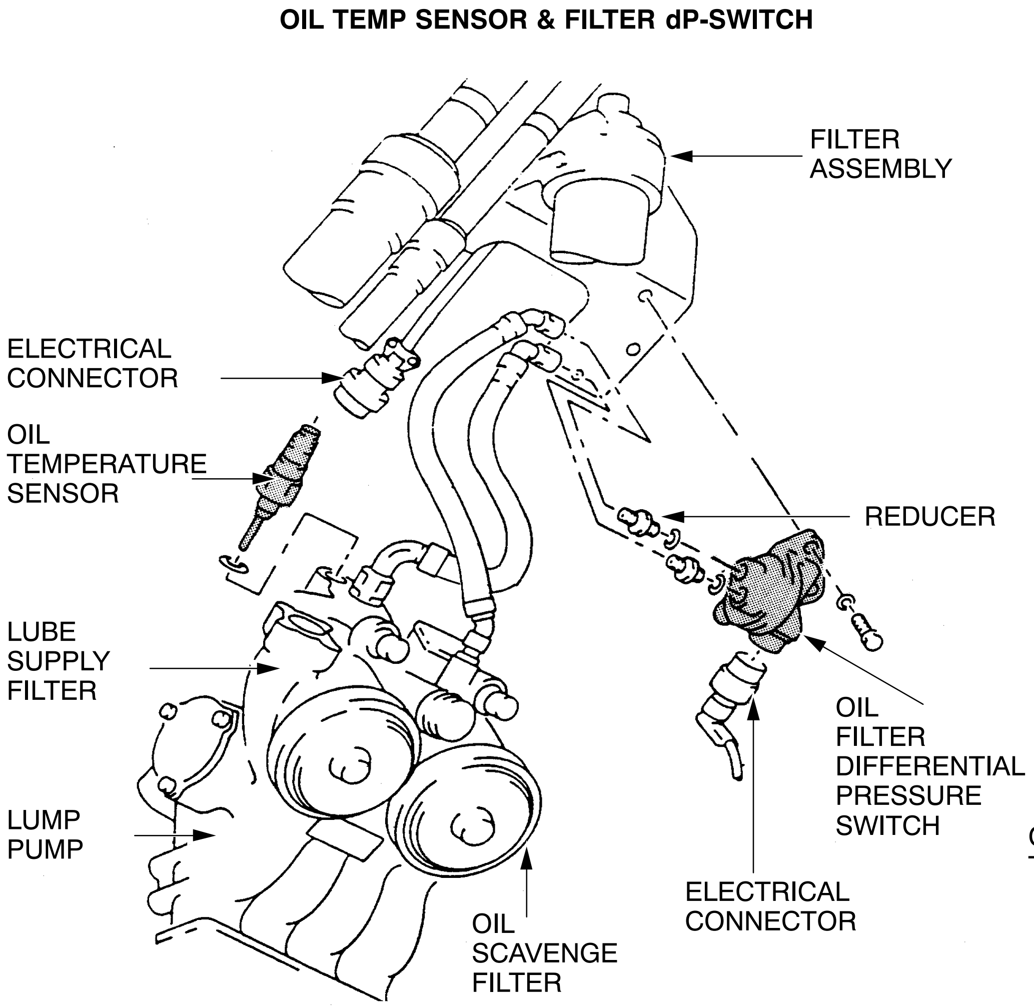
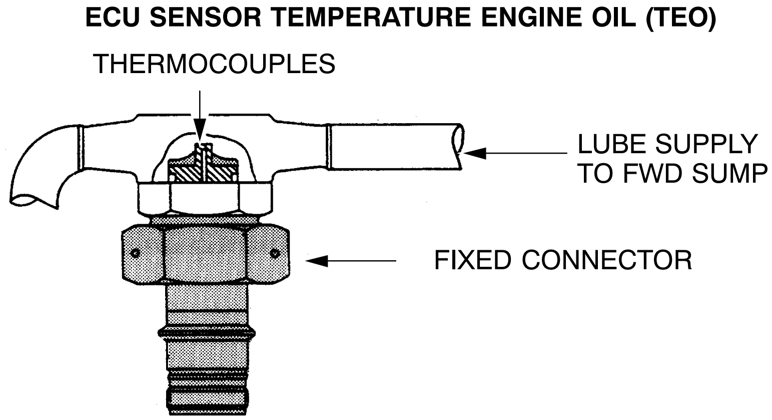


Figure 64 LOP-Switch and Oil Press X-Mtr





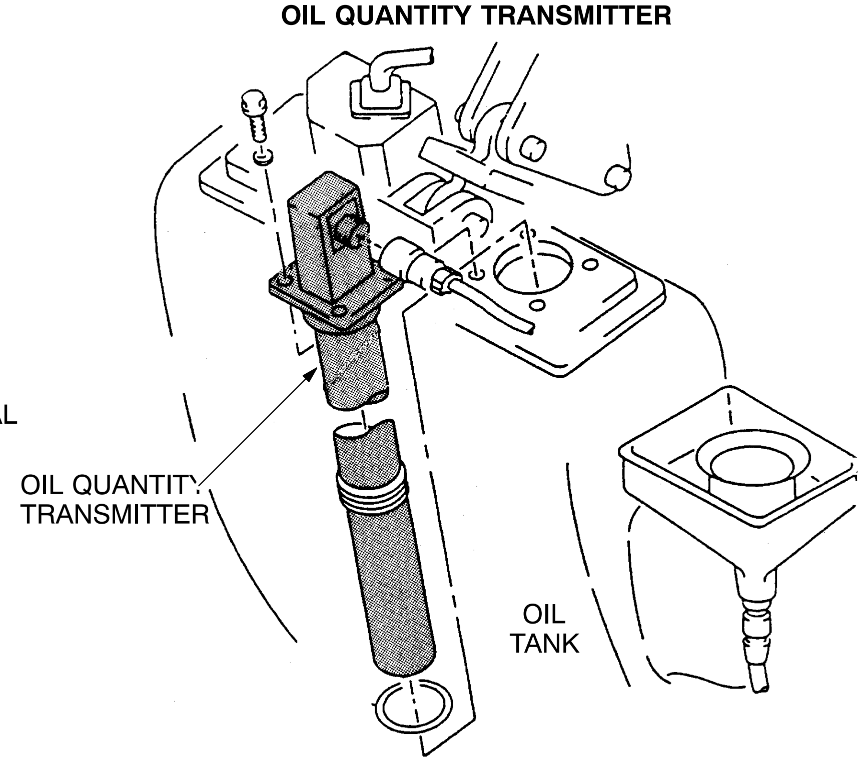


Figure 65 Oil Indicating Components

ATA 73 ENGINE FUEL AND CONTROL

73−00 ENGINE FUEL AND CONTROL − GENERAL

INTRODUCTION

The fuel system enables delivery of a fuel flow corresponding to the power required and compatible with engine limits.

The Fuel Pump pressurizes and circulates the fuel from the aircraft fuel tanks within the engine fuel system.

The Fuel/oil Heat Exchanger cools engine oil and warms up filtered fuel to prevent any icing conditions.

The Hydro Mechanical Unit (HMU) provides metered fuel for the combustion and servo fuel for engine sub systems.

System Control and Monitoring is performed by the Engine Electronic Control Unit (ECU). Important system data is indicated on the **E**lectronic **C**entralized **A**ircraft **M**onitoring (ECAM) displays.

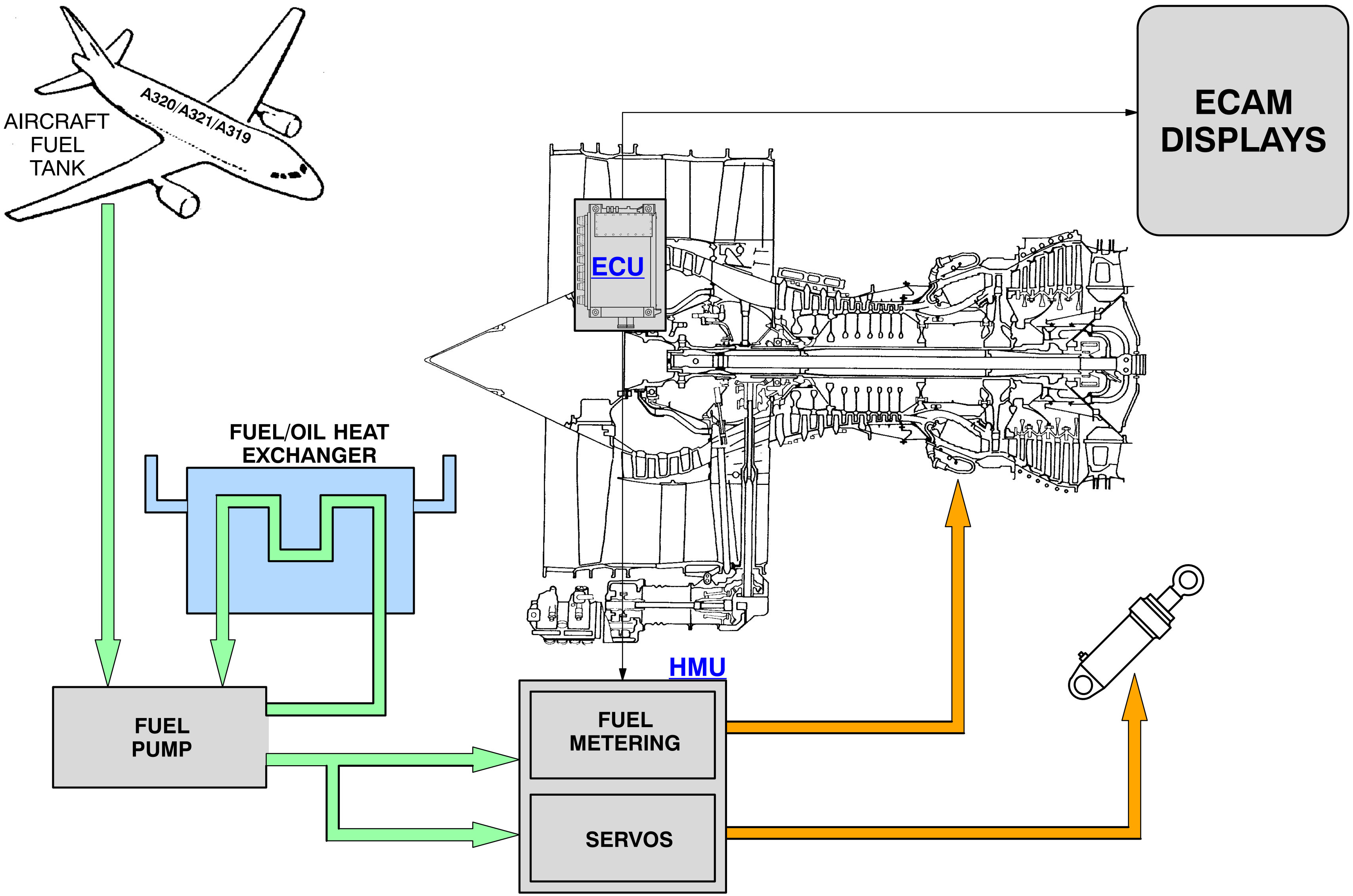


Figure 66 Fuel System Introduction

73–10 DISTRIBUTION

SYSTEM DESCRIPTION

General

The fuel system enables the delivery of a fuel flow corresponding to the power required and compatible with engine limits.

The fuel system is divided in three main functions:

- Distribution
- Controlling
- Indicating

Distribution

Fuel from the A/C tank enters the engine fuel pump, through a fuel supply line. After passing through the LP Fuel Pump, the pressurized fuel goes to the Main Fuel/Oil Heat Exchanger in order to cool down the engine scavenge oil.

Then it flows back to the Fuel Pump, where it is filtered, pressurized and split into two fuel flows. The main fuel flow goes through the HMU metering system, the fuel flow transmitter, the fuel nozzle filter and is then directed to the Burner Staging Valve and Fuel Nozzles. The other fuel flow goes to the Servo Fuel Heater, which warms up the fuel to prevent any ice particles entering sensitive servo systems.

The heated fuel flow enters the HMU servo–mechanism and is then directed to the various fuel–actuated components.

A line brings unused fuel, from the HMU, back to the inlet of the Main Fuel/Oil Heat Exchanger, through the IDG Oil Cooler.

A Fuel Return Valve (FRV), also installed on this line, may redirect some of this returning fuel back to the A/C tanks. Before returning to the A/C tank, the hot fuel is mixed with cold fuel from the outlet of the 1st stage of the fuel pump.

Controlling

A Full Authority Digital Engine Control (FADEC) controls the engine. The FADEC achieves steady state and transient engine performances when operated with subsystems. The FADEC is a dual channel ECU with cross talk and failure detection capabilities. In cases of failure detection, the FADEC switches from one channel to the other. A simplified hydromechanical unit includes a fuel metering valve and servo valves to control the airflow (VBV, VSV) and rotor tip clearances, (HP compressor and HP and LP turbine). The FADEC system performs the following functions:

- the control of the fuel flow and engine air flow and bleeds (to automatically maintain forward and reverse thrust setting and provide satisfactory transient response)
- the engine limits protection
- the automatic starting capability
- the engine clearance control
- extensive diagnostic and maintenance capabilities.

Indicating

The engine fuel system is monitored from:

- the Engine/Warning Display (EWD)
- the System Display (SD)
- the warning and caution lights.

The indications cover all the main engine parameters through the FADEC. The warnings and cautions reflect:

- the engine health and status through the FADEC
- the FADEC health and status
- the fuel filter condition through a dedicated hardwire.

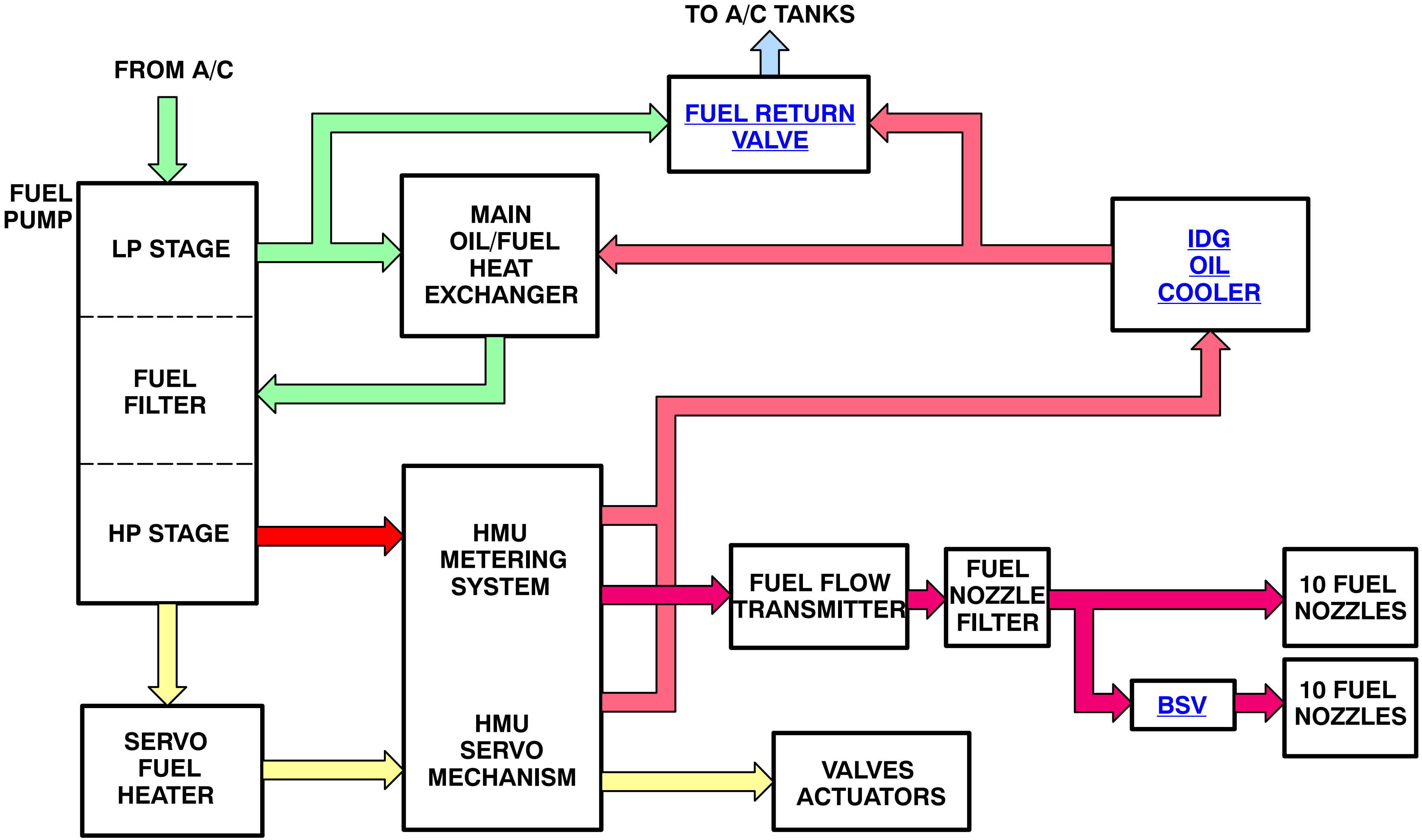


Figure 67 Fuel Distribution Schematic

DISTRIBUTION SYSTEM OPERATION

General

The engine fuel distribution system is designed to provide fuel flow into the combustion chamber and servo fuel for compressor and engine clearance system actuation.

Fuel Feed

The fuel coming from the A/C tanks through the LP valves is driven by the LP stage of the Main Fuel Pump. It is heated by the Main Fuel/Oil Heat Exchanger, filtered and then pressurized in the HP stage of the Main Fuel Pump before entering the **H**ydromechanical **M**etering **U**nit to elaborate the reference pressure to control:

- the Active Clearance Control
- the Compressor Control (VBV, VSV)

Metered Fuel

Fuel from the Fuel Pump passes through a **F**uel **M**etering **V**alve and a **PR**essurizing and **S**hut **O**ff **V**alve included in the HMU. Then routed to the Fuel Flowmeter and the **B**urner **S**taging **V**alve to the twenty nozzles. The BSV controlled by the ECU supplies either 10 or 20 fuel nozzles depending on power setting. The FMV is controlled by the **ECU** to obtain the desired N1, selected either by the thrust lever or the Auto Thrust System. When the Engine Master control is set to OFF, the LP and HP fuel shut-off valves are closed, and a hydraulic shut-off signal is sent from the HMU to the **F**uel **R**eturn **V**alve.

Servo Fuel

Filtered fuel is delivered, from a self cleaning wash filter, through a servo fuel heater to the servo valves of the HMU. Part of this fuel is also delivered to the FRV as muscle pressure. In the HMU, the servo valves are hydraulically driven by torque motors controlled by the ECU to provide the operation of:

- **V**ariable **S**tator **V**anes (VSV) and **V**ariable **B**leed **V**alves (VBV)
- **R**otor **A**ctive **C**learance **C**ontrol (RACC not installed on new engines)
- **H**igh **P**ressure **T**urbine **A**ctive **C**learance **C**ontrol (HPTACC)
- **L**ow **P**ressure **T**urbine **A**ctive **C**learance **C**ontrol (LPTACC)
- **F**uel **M**etering **V**alve (FMV)

IDG Oil Cooling

The fuel bypassed from the HMU is used to cool the IDG oil. The fuel then returns to the fuel pump interstage and recirculates through the system. If the recirculating fuel gets too hot, the ECU controls the Fuel Return Valve to allow some hot fuel to return to the aircraft tanks. A thermostat type valve inside the Fuel Return Valve mixes cold fuel from LP pump with the hot return fuel to reduce thermal stresses. The pressurizing valve ensures that there is always pressure in the Return line, to prevent fuel from vaporizing. The ECU uses the Engine Oil Temperature as its reference because the engine oil gets hot as the IDG oil gets hot, due to the recirculating fuel going successively through the engine and IDG oil/fuel heat exchangers.

Fuel Return Valve

The FRV is electrically controlled by the ECU, and hydraulically operated by the servo fuel. It receives a hydraulic shut-off signal at engine shut-down and is closed by a spring.

Fuel Return

A part of the fuel is recovered to provide IDG oil cooling before returning to the fuel circuit at the LP pump stage. When the thermal exchange is not sufficient, the fuel return valve will be opened by the ECU, according to a given temperature. The signal is inhibited at Take-Off, Climb and when the A/C tank temperatures are high or there is fuel in the vent tank. A hydraulic signal from the HP fuel SOV closes the valve at engine shutdown.

ECU Control

The ECU sends electrical signals to the torque motor servo valves of both the HMU and the fuel return valve. Thus, it provides the commanded position for the slave systems.

For each valve of VBV, VSV, RACC, HPTACC, LPTACC, and fuel systems the ECU has a control schedule. If a schedule is no longer operational, the corresponding valve goes to a fail safe position. For example: VBV open, VSV close, fuel metering valve closes (engine shutdown).

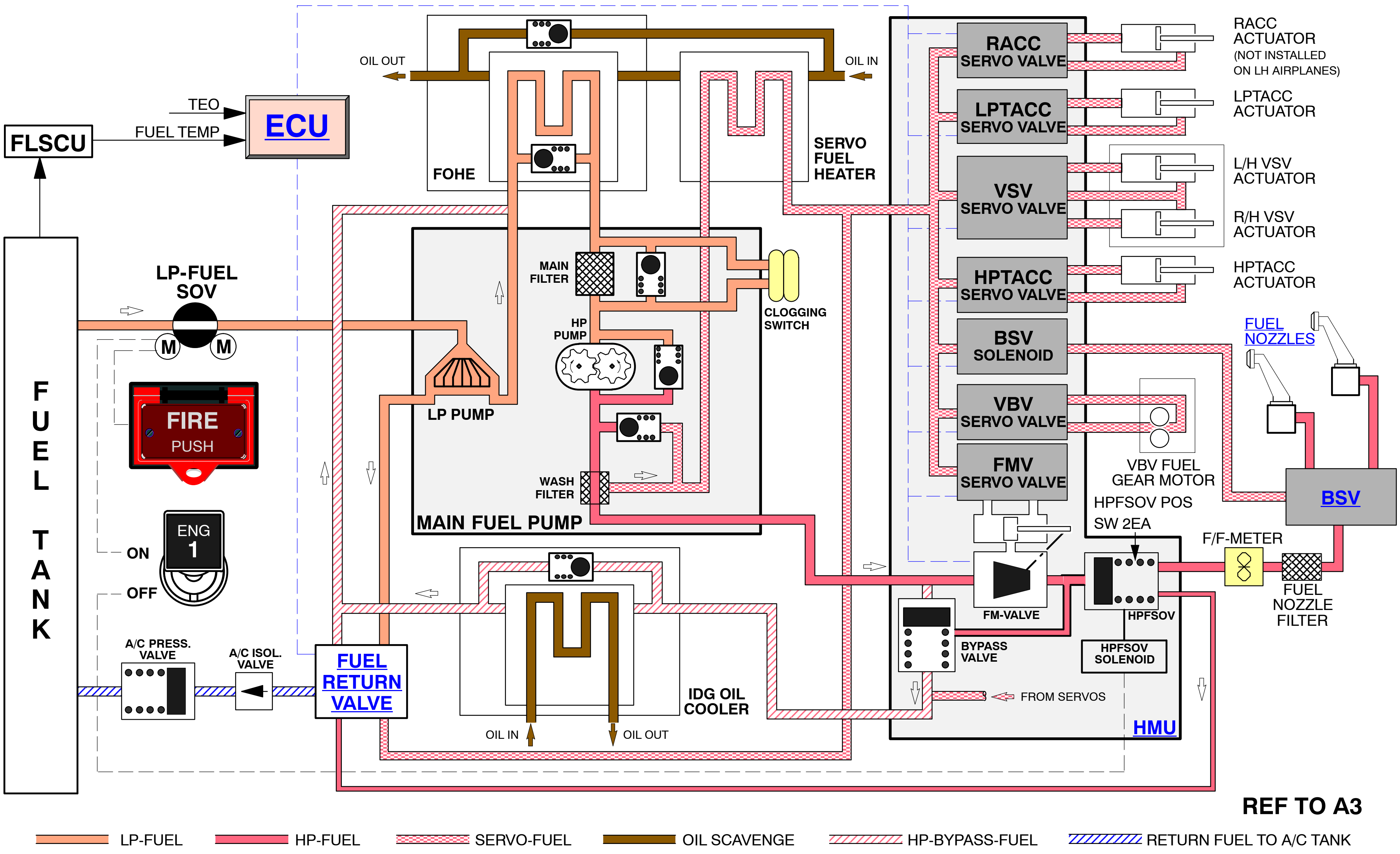


Figure 68 Fuel System Schematic

COMPONENT DESCRIPTION

FUEL PUMP

The Fuel Pump and the Hydro Mechanical Metering Unit are mounted as one unit. The fuel pump is located on the accessory gearbox (AGB) (aft face on the left side of the horizontal drive shaft housing, aft looking forward).

Fuel Pump Low Pressure Stage

The LP stage of the fuel pump is of the centrifugal type. It delivers a boost pressure to the HP stage to avoid pump cavitation. The LP stage general characteristics at takeoff power are as follows:

- Discharge pressure: 174 psi
- Speed rating: 6250 rpm

Fuel Pump High Pressure Stage

The HP stage hydraulic power is supplied by a positive displacement (gear−type) pump. For a given number of revolutions, the pump delivers a constant fuel flow regardless of the discharge pressure. A pressure relief valve connected in parallel with the HP pump protects the pump.
The HP stage general characteristics at takeoff power are as follows :

- Discharge pressure: 870 psi
- Speed rating: 6250 rpm
- Fuel flow: 57 US gal/min

FUEL FILTER ASSEMBLY

This fuel filter is located between the main oil/fuel heat exchanger and fuel pump HP stage. It protects the HMU from particles in suspension in the fuel. The filter disposable cartridge is designed to retain foreign material. The cartridge is periodically replaced. The removed cartridge is discarded.

The fuel filter consists of a filter cartridge and a pressure relief valve. The filter cartridge is installed in a cavity on the pump body.

The fuel circulates from the outside to the inside of the filter cartridge. In case of a clogged filter, a pressure relief valve bypasses the fuel to the HP stage.

Tappings on pump housing enable transmission of differential pressure across the fuel filter for clogging indication in the flight deck.

FUEL FILTER DIFFERENTIAL PRESSURE SWITCH

The fuel filter differential pressure switch is located on the fan case. The switch sends a signal to the SDAC when the differential pressure increases to a certain level when the fuel filter clogs. The fuel filter clog indication is provided on the lower ECAM display unit.

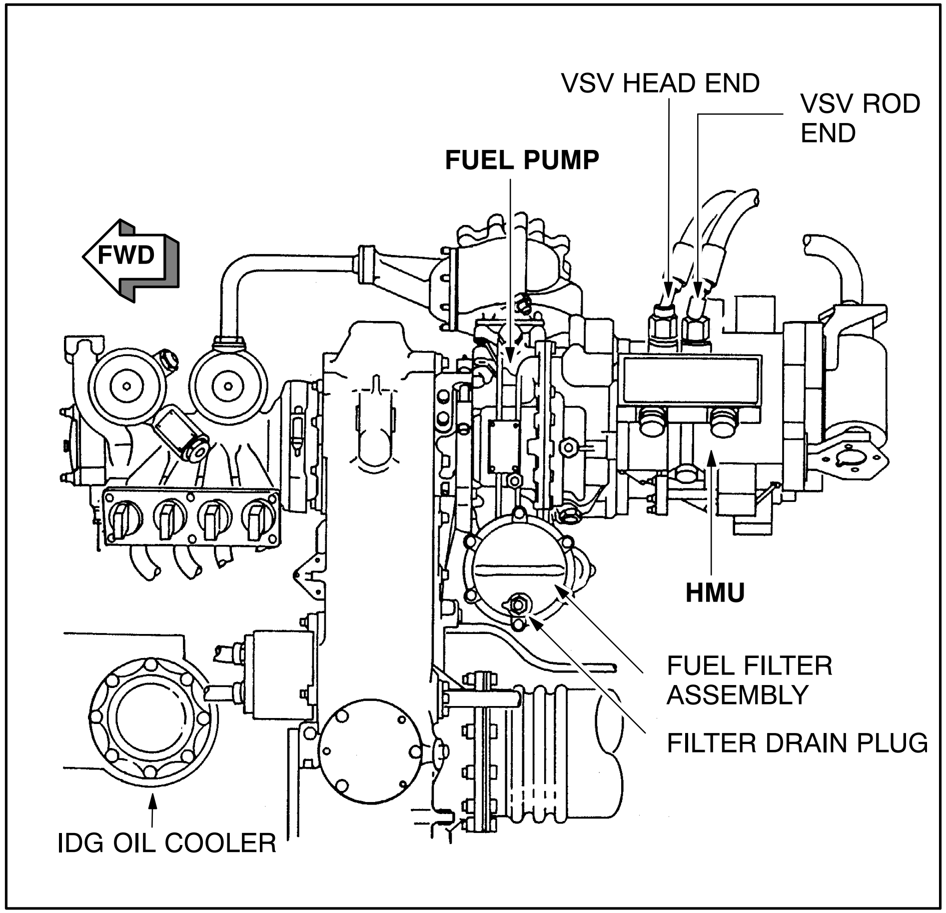


Figure 69 Fuel Pump and HMU Location

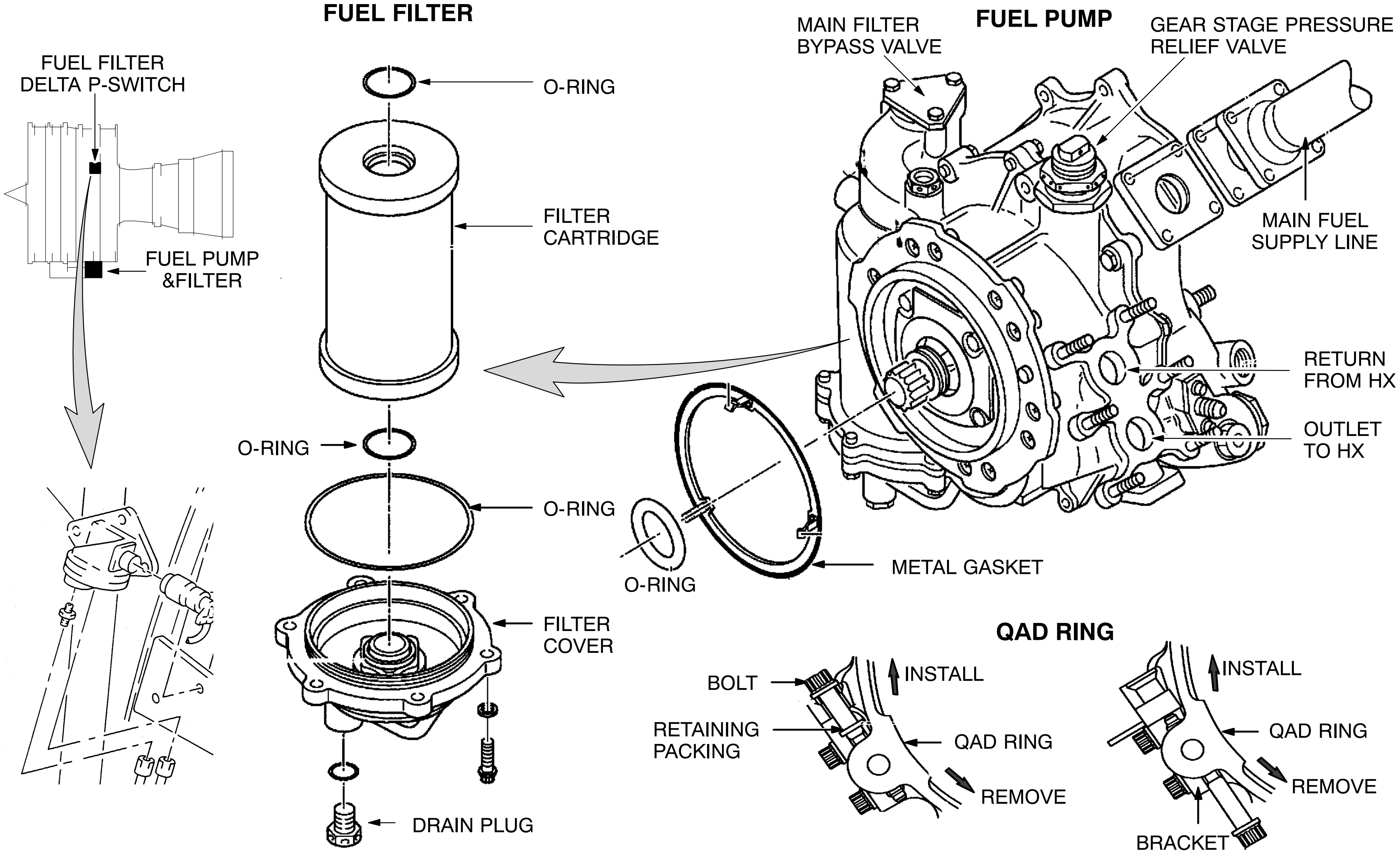


Figure 70 Fuel Pump and Filter Assembly

73–21 HYDRO–MECHANICAL UNIT (HMU)

HYDROMECHANICAL UNIT DESCRIPTION

General

The hydromechanical unit (HMU) is installed on the aft side of the accessory gearbox at the extreme left hand pad.

It receives electrical signals from the electronic control unit (ECU) and converts these electrical input signals through torque motors/servo valves into engine fuel flow and hydraulic signals to various external systems. Engine fuel is used as hydraulic medium.

NOTE: No maintenance adjustments (e.g. idle, part power etc.) can be performed at the HMU.

HMU Functions

- It provides internal calibration of fuel pressures
- It meters the fuel flow for combustion
- It provides the fuel shut–off and fuel manifold minimum pressurization levels
- It by–passes the return of unused fuel
- It provides mechanical N2 overspeed protection
- It delivers the correct hydraulic power source to various engine fuel equipment

The HMU has two electrical connectors to ECU channels A and B and an electrical connection between the shut–off solenoid and the A/C.

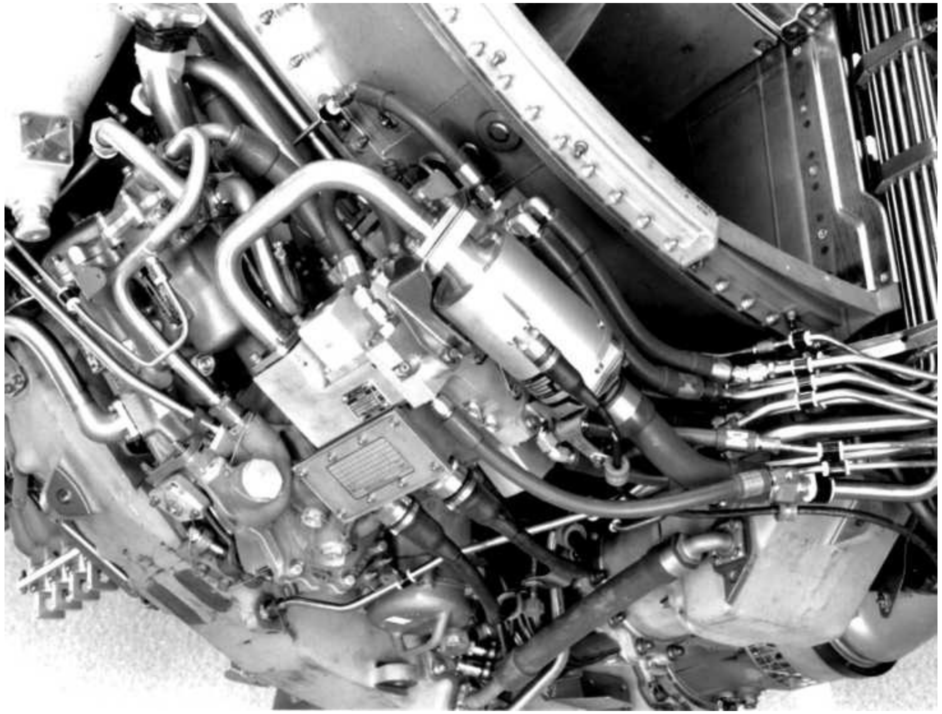


Figure 71 HMU Location

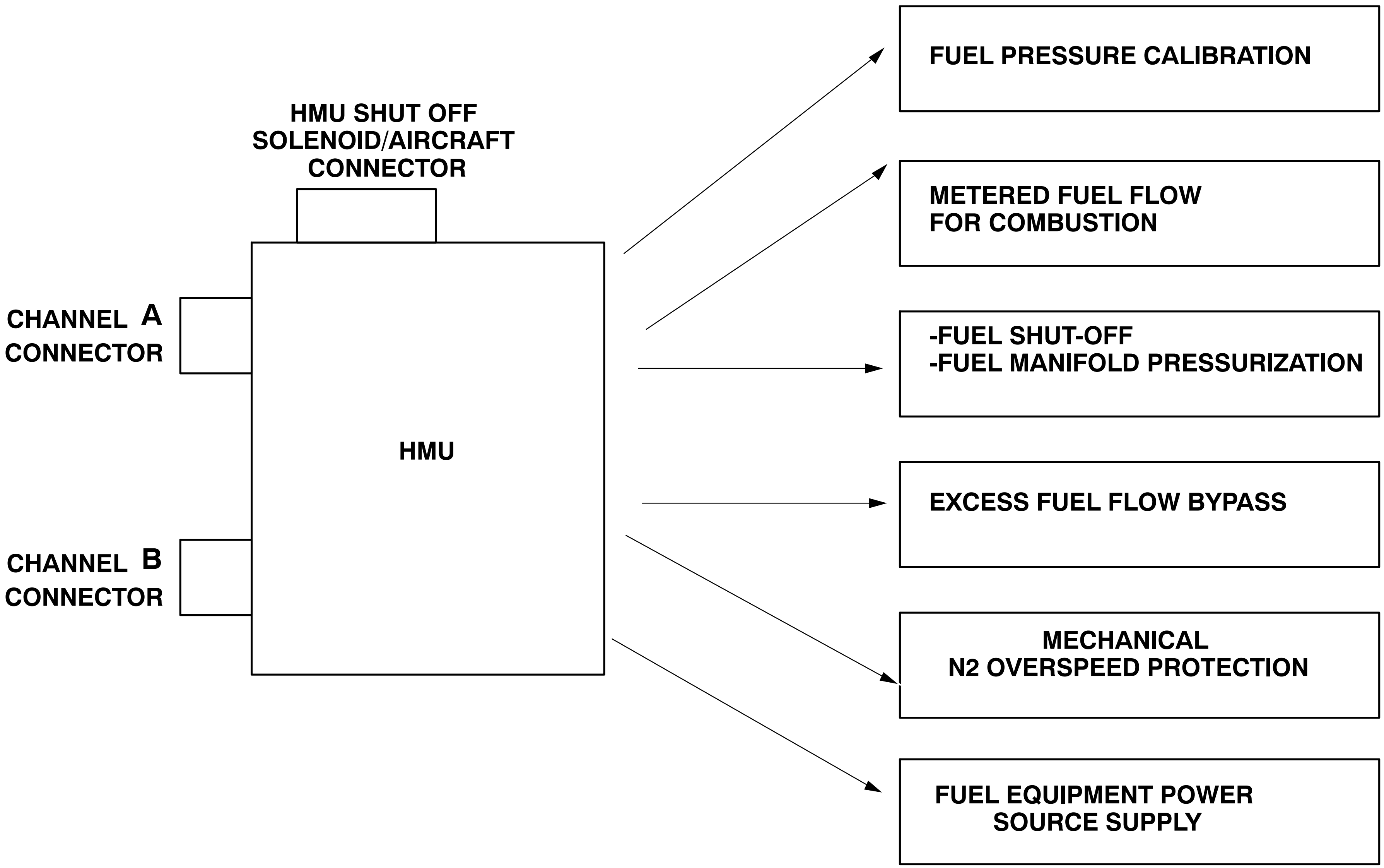


Figure 72 Hydromechanical Metering Unit Tasks

FUEL METERING OPERATION

General

The HMU is divided in the following systems:

- Servo Pressure Regulator System
- Fuel Metering System
- Overspeed Governor System
- Pressurizing Valve (HP Fuel SOV)
- Pump Unloading and Shutdown System
- Servo Flow Regulation System

Fuel Metering Valve

The fuel metering valve is hydraulically driven through a torque motor/ servo valve by the ECU. The torque motor contains two electrically isolated, independent coils, one dedicated to Channel A,the other to Channel B of the ECU.

Two fuel metering valve position resolvers, one dedicated to each channel in the ECU, produce an electrical feedback signal in proportion to fuel metering valve position. The ECU uses this signal to compute the current required at the fuel metering valve torque motor for achieving closed loop electrical control. At engine shutdown the Metering valve is completely closed.

Delta-P Valve

A differential pressure regulating valve maintains a constant pressure drop across the metering valve. As a result, fuel flow varies proportionally with metering valve position.

High Pressure Fuel shut−off valve

The valve is driven by a solenoid. The Valve closed / not closed position is indicated to the ECU by two electrical limit switches.

The fuel shut off valve shuts off fuel flow to the engine commanded by the master switch (solenoid energized by aircraft 28VDC from busbar 3PP).

The HP fuel shut−off valve opens when all three following conditions are met:

- command to open from the ENG/MASTER switch (solenoid de-energized)
- engine rotation speed above 15 percent N2
- fuel flow requested by ECU

NOTE: It has to be noted that the HP fuel shut off valve shut off signal by the Master Switch also closes the LP fuel valve.

Overspeed governor

The overspeed governor is of the fly ball type. It is designed to prevent the engine from exceeding a steady state speed in excess of 106.3% N2. A pressure switch sends a signal to the ECU if the overspeed governor fails when the engine is started (OVSPD PROTECTION FAIL).

Motive Flow Modulation

The HMU contains five additional torque motors/ servo pilot valves that modulate hydraulic signals to the following:

4. Low Pressure Turbine Clearance Control Valve
5. High Pressure Turbine Clearance Control Valve
6. Rotor Active Clearance Control System
   (not installed on new engines)
7. Variable Stator Vane Actuators
8. Variable Bleed Valve Actuators

Each torque motor contains two electrically isolated, independent coils. One is dedicated to channel A, the other to channel B, of the ECU. They provide flow and pressure at an HMU pressure port in response to electrical commands from the ECU.

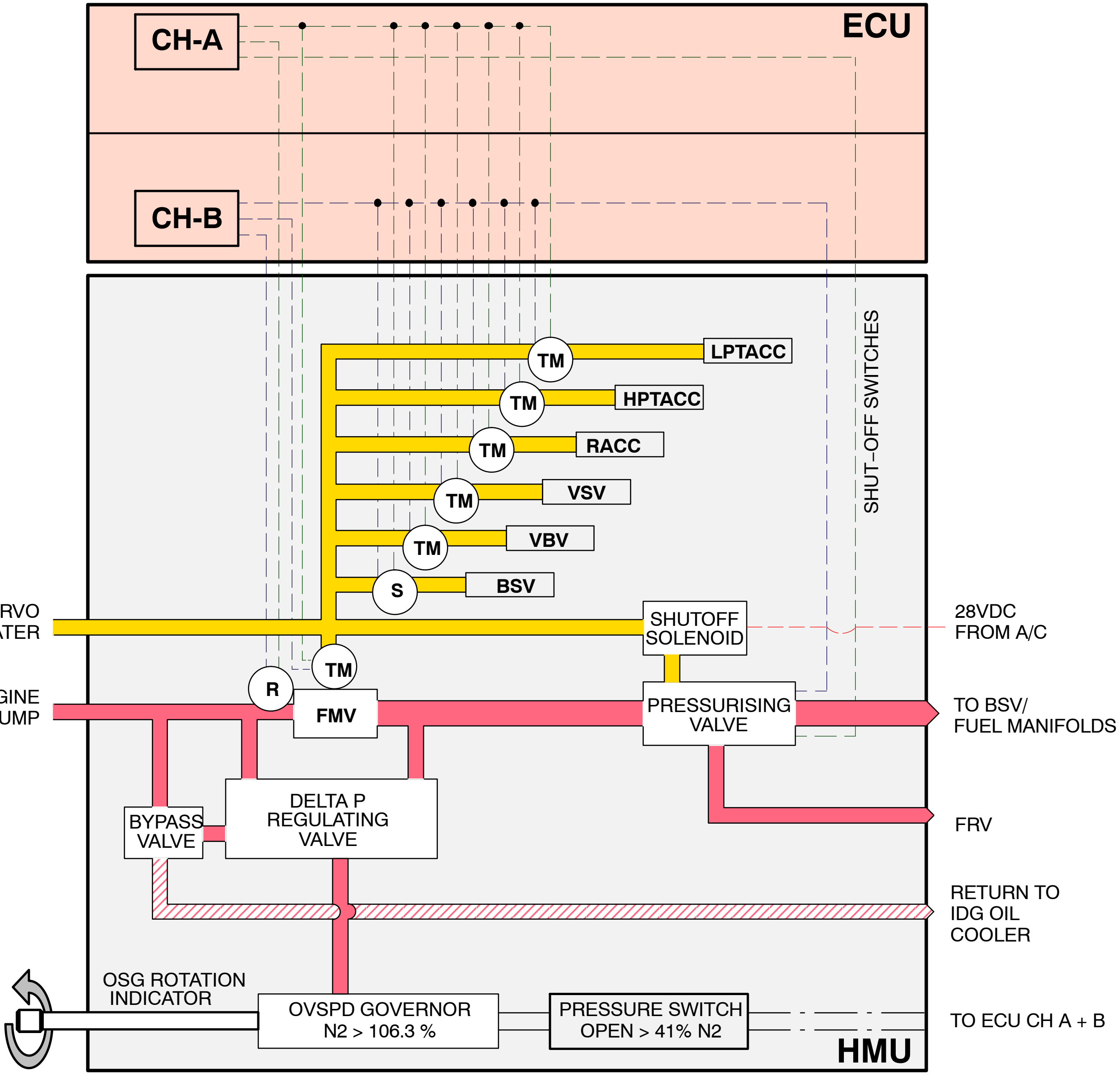


Figure 73 HMU System Schematic

HP AND LP FUEL SHUTOFF VALVE CONTROL

HIGH PRESSURE FUEL SHUTOFF VALVE CONTROL

Operation

The High Pressure Fuel Shutoff Valve is electrically controlled and fuel pressure operated.

It opens with fuel pressure coming from the Fuel Metering Valve provided the shut off solenoid is de-energized (Engine Master Control Switch ON). Thus a loss of electrical power supply does not lead to a High Pressure Fuel Shutoff Valve closure.

The High Pressure Fuel Shutoff Valve closes when the shutoff solenoid is energized (Engine Master Control Switch OFF) or when the Fuel Metering Valve is commanded to the closed position by the Electronic Control Unit (automatic start abort)

NOTE: Command from the ENG MASTER CONTROL switch takes priority over the command from the ECU.

LOW PRESSURE FUEL SHUTOFF VALVE CONTROL

The function of the LP fuel shut−off valve is to control the fuel supply at engine−to−pylon interface. The valve is located on the engine supply system in the wing leading edge.

Operation

The LP fuel shut off valve is controlled:

- From the flight compartment overhead panel by means of the Engine Fire Pushbutton Switch
- From the flight compartment center pedestal by means of the Engine Master Switch on the engine control panel

NOTE*:* The Low Pressure Fuel Shutoff Valve is commanded open via the relay 11QG when the C/B of the HP Fuel SOV is pulled.

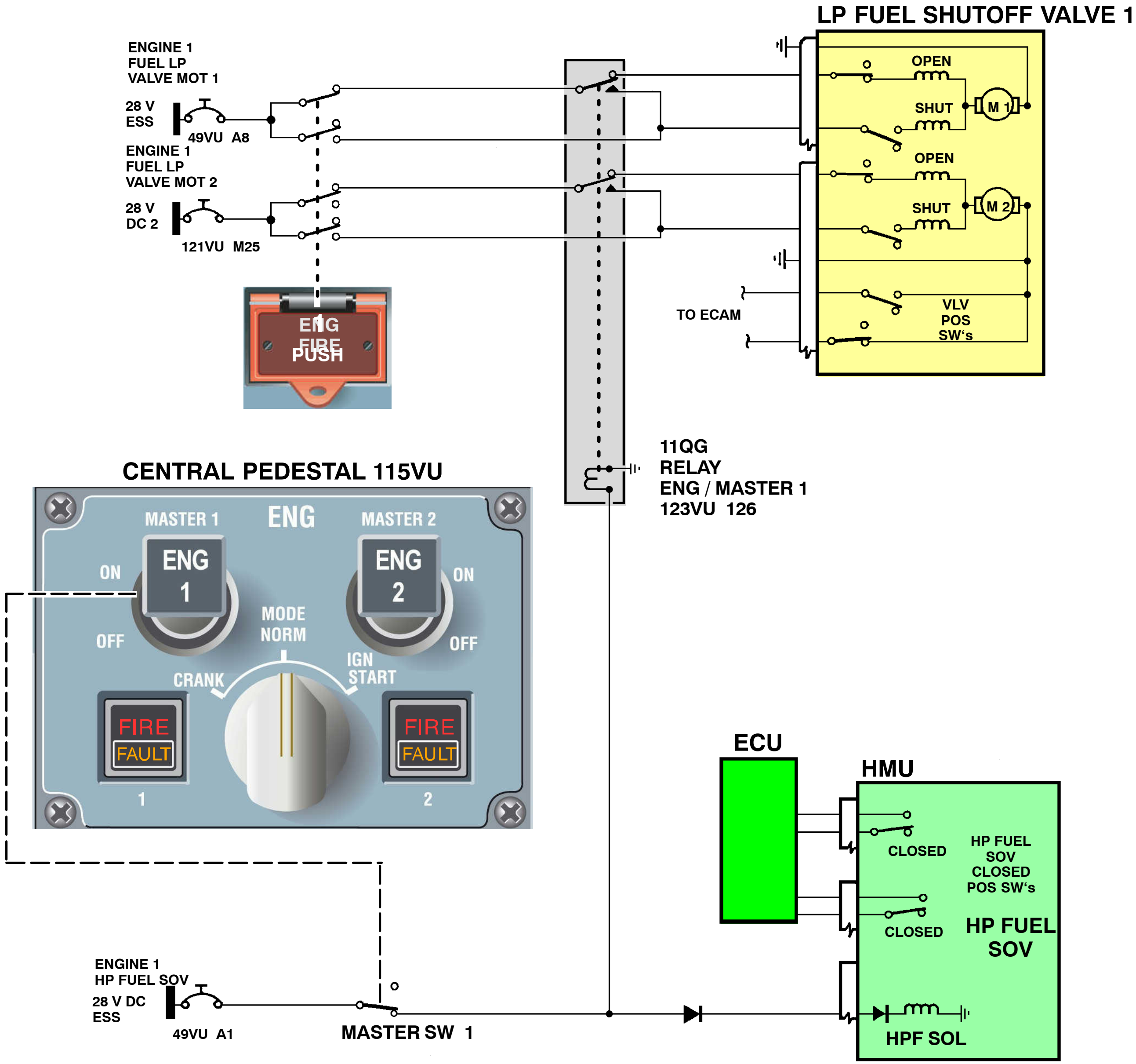


Figure 74 HP and LP Fuel SOV Control

73–10 DISTRIBUTION

FUEL RETURN SYSTEM OPERATION

Oil/Fuel Temperature Control

The IDG oil shall be cooled by engine fuel through an oil/fuel heat exchanger which is installed in the fuel bypass line.

For some aircraft operation, extra heat rejected in fuel shall be carried out of the engine fuel system through the valve fuel return valve (FRV) in order not to exceed defined temperature limits (either engine fuel/oil temperature or IDG oil temperature).

The FADEC performs this temperature control using the engine oil temperature and engine fuel measurement and performs two actions depending upon the temperature values and the aircraft flight conditions:

- command the FRV in order to permit a fuel return to the aircraft tank
- increase the engine speed when oil temp is 106 °C. (which leads to decrease the temperature of the cooling fuel flow). This function is inhibited when the aircraft is on ground.

Fuel Return Valve

The purpose of the fuel return valve is to return fuel flow to the tank.

The return fuel flow is controlled at the IDG oil cooler outlet by:

- the engine oil temperature (signal from TEO)
- the fuel temperature

The fuel return valve has a shutoff function when the engine is shutdown (solenoid de-energized) from the Engine Master Switch. The signal transits through the ARINC bus and ECU and overrides the engine "oil in" temperature command.

In case of high fuel flow conditions the electrical open signal is overridden by a hydraulic signal from the HMU and the shutoff valve is closed. A "close" command from the HMU interrupts both fuel flows to the aircraft.

The Fuel Level Sensing Control Unit (FLCSU) sends also FRV–Inhibition signal to the ECU of:

- High Fuel Temperature
- Fuel Tank low Level
- Fuel in Surge Tank

- Gravity Feed

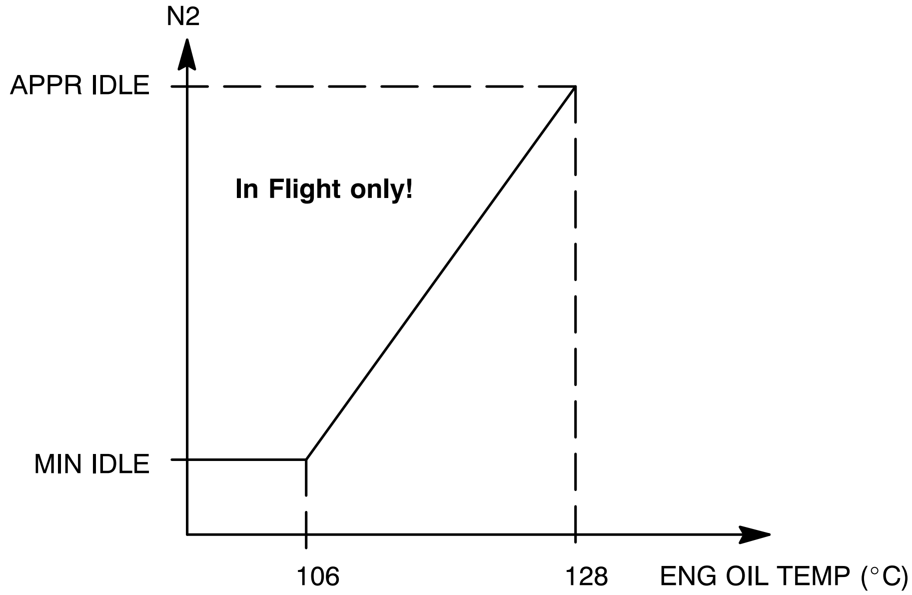


Figure 75 Fuel Return Control Parameter

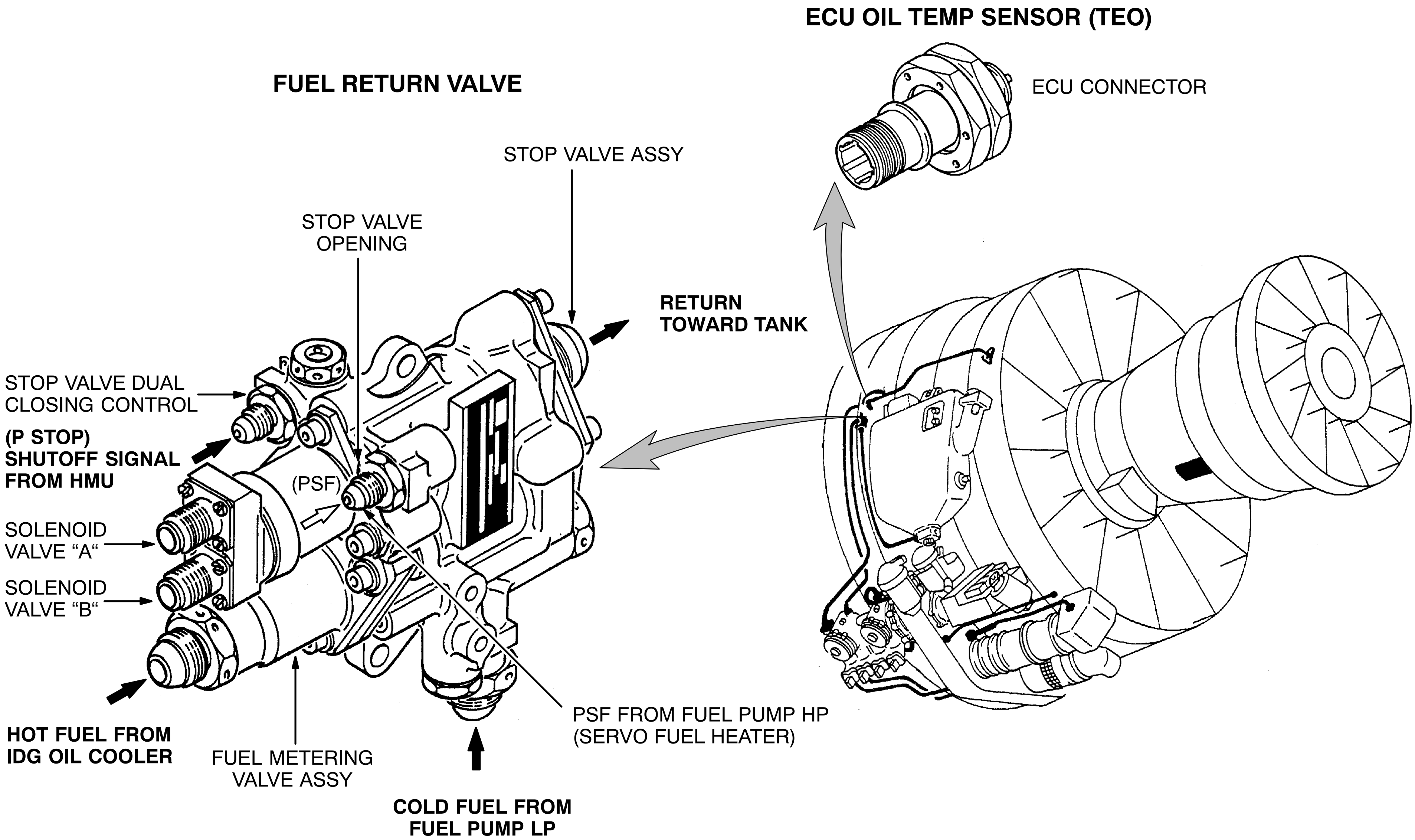


Figure 76 Fuel Return Valve

Operation

The fuel return valve controls two flow levels: the first level (300 kg/h) is controlled by the engine ”oil in” temperature when the temperature is higher than 93 °C. The V1 solenoid valve is energized by the electronic control unit (ECU).

The second level (which adds approximately 300 kg/h to the first flow level) is controlled by the IDG oil cooler ”fuel out” temperature when higher than130 °C The V2 thermostatic valve is controlled by the ”fuel out” temperature.

Return Fuel Temperature Limitation

The fuel return valve mixes a cold fuel flow (from the engine LP fuel pump) with the hot fuel flow (calibrated to maintain a temperature of 100 °C) in the return line. The mix is as follows:

- Fuel outlet temperature below 130 °C
  ⇒ 200 kg/h cold flow with 300 kg/h hot flow
- Fuel outlet temperature above 130 °C
  ⇒ 400 kg/h cold flow with 600 kg/h hot flow

A signal from the Engine Master Switch to FADEC permits to override the V1 opening signal if:

- Engine oil temperature is higher than 93 °C during take off or climb or specific operating conditions
- A hydraulic signal from the HP fuel shutoff valve closes the V1 valve at engine shutdown.

NOTE: A functional check of the fuel return valve can only be done with a engine idle run. A test set is used to simulate a temperature >93 °C. Also a flow gage must be fitted in the fuel return line. When the valve opens the gage indicates a positive reading (fuel returns to tank). For detailed information refer to AMM.

Oil Temp	IDG Cooler Fuel Temp	Hot Fuel Flow Return	Cold Fuel Flow Return	Total Fuel Return to Tank
T < 93°C	—	0 kg/h	0 kg/h	0 kg/h
T > 93°C	T < 130°C	300 kg/h	200 kg/h	500 kg/h
T > 93°C	T > 130°C	600 kg/h	400 kg/h	1000 kg/h

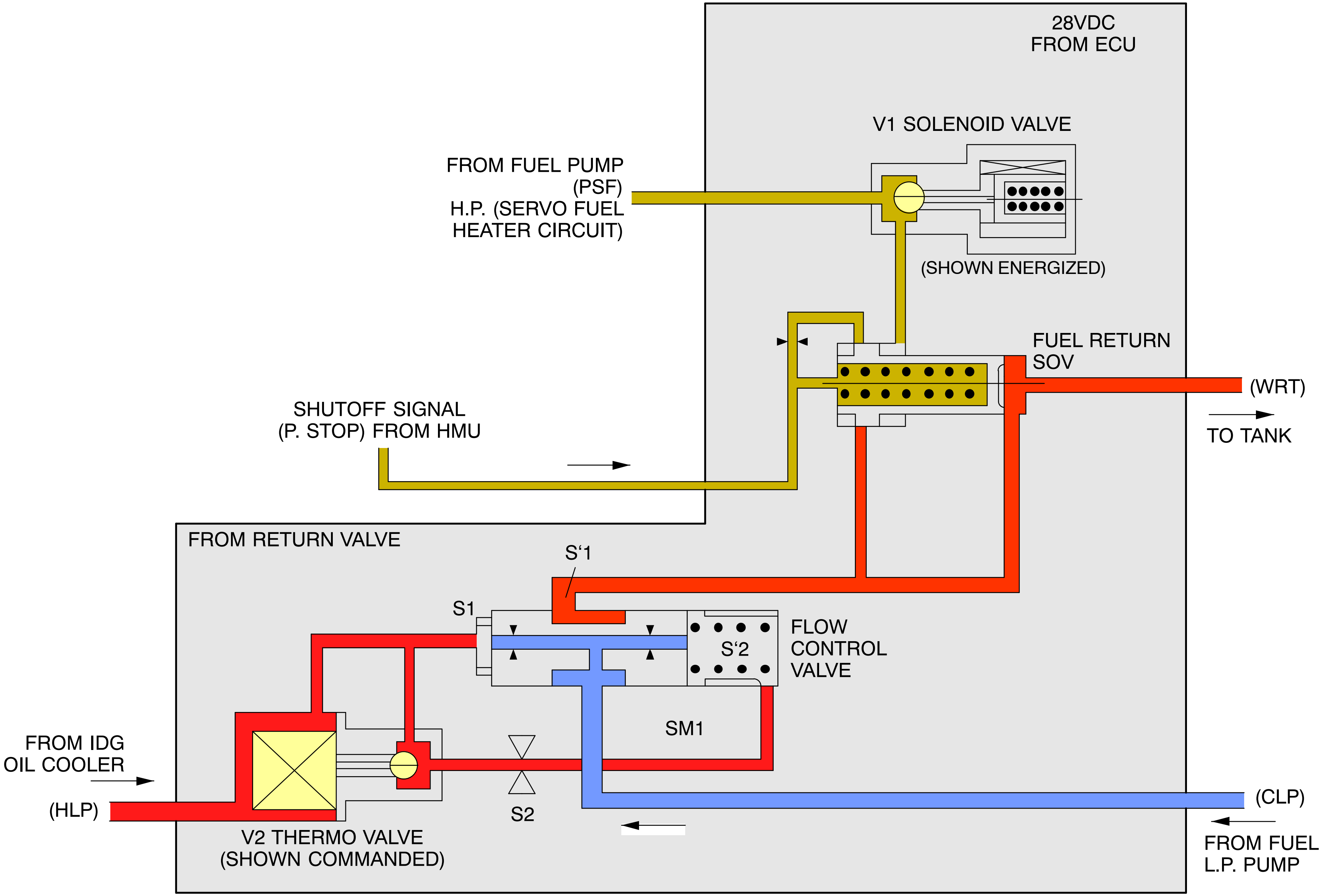


Figure 77 Fuel Return Valve Operation

IDG OIL COOLER COMPONENT DESCRIPTION

IDG FUEL COOLED OIL COOLER (FCOC)

Purpose

The purpose of the cooler assembly is to cool oil coming from the Integrated Drive Generator (IDG). The heat generated is transferred to the fuel coming from the HMU and returning to the oil/fuel heat exchanger.

Location

The IDG oil cooler is located on the front face of the AGB at 5:30 o'clock position, aft looking forward.

Description

The oil cooler is of tubular type. It consists of a removable core, housing and cover. A fuel pressure relief valve is connected in parallel with the fuel inlet and outlet ports.

The oil circulates through the stainless steel tube bundle brazed at both ends. This extracts the calories and transfers them to the engine fuel. The oil outlet temperature varies between (–54 °C and 160 °C).

The fuel circulates inside the tubes that evacuate the calories released by the oil. If the pressure drop inside the heat exchanger core increases the pressure relief valve opens and bypasses the heat exchanger core.

Operation

Fuel flows through the matrix (core) tubes in two passes. Should there be a build up of pressure in the system of more than 27 psi (186.2 kpa) on the fuel side, the pressure relief valve will allow the fuel to enter the ”fuel inlet” port connection then exit through the ”fuel outlet” port connection bypassing the cooler. Warm oil flows across the fuel filled matrix (core) tubes in eight passes to the oil outlet port.

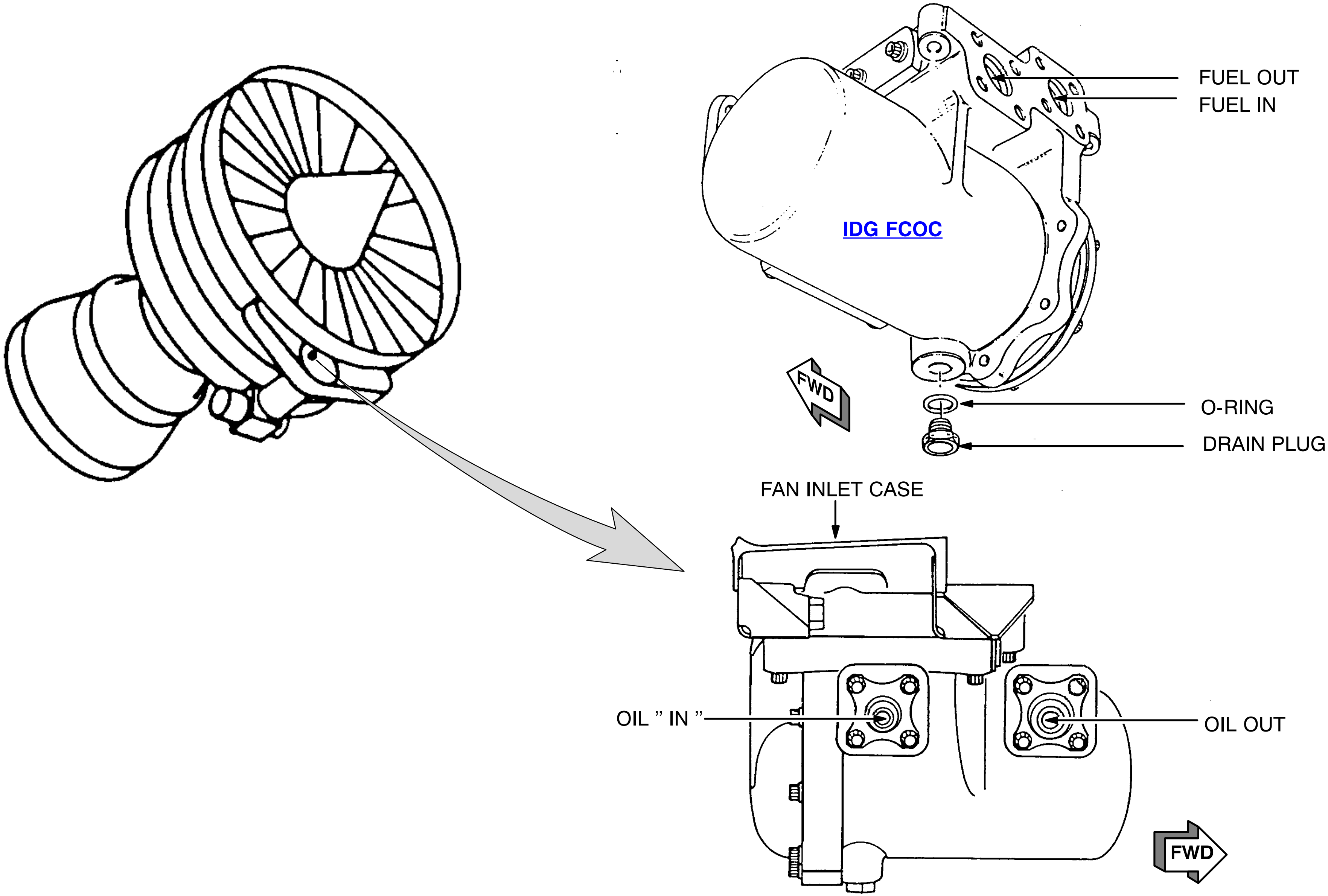


Figure 78 IDG Oil Cooler

BURNER STAGING VALVE COMPONENT DESCRIPTION

BURNER STAGING VALVE

Purpose

The purpose of the **B**urner **S**taging **V**alve (BSV) is to shutoff 10 of the 20 fuel nozzles as commanded by the ECU.

The BSV stages on 10 nozzles when a lower **F**uel **A**ir **R**atio (FAR) is required by the ECU. This ensures that there is adequate deceleration capability in the deceleration schedule. The 10 nozzles are also switched off to maintain a adequate flame out margin.

NOTE: 10 fuel nozzles are always supplied when the engine is in operation.

Operation

The BSV is a poppet type shutoff valve that is opened or closed by fuel pressure (PC or PCR) from the HMU based on ECU logic. The main poppet valve allows metered fuel delivery to the staged manifold and under most conditions is set to the open (unstaged) position to assure that all 20 fuel nozzles are used at the following power operations:

- N2K > 80%
- Approach Idle
- BSV Feedback Signal FAilure
- ECU or HMU Command Signal Failed
  (opened at 200 - 300 psi fuel pressure)

Control and Monitoring

Dual switches in the BSV monitor the position of the valve and transmit a feedback indication to the ECU. The switches are open when the valve is open (unstaged).

After the ECU logic has determined that a lower FAR is required, the BSV is staged to 10 nozzles through the HMU BSV solenoid. If the ECU receives a valid signal from the BSV feedback switches that the BSV did stage, the ECU then lowers the FAR in the deceleration schedule to ensure a constant rate of engine deceleration. In operating conditions where a low FAR is required, the design of the fuel nozzles provides the necessary spray pattern to ensure that the engine will decelerate properly and that adequate flame out margin is maintained.

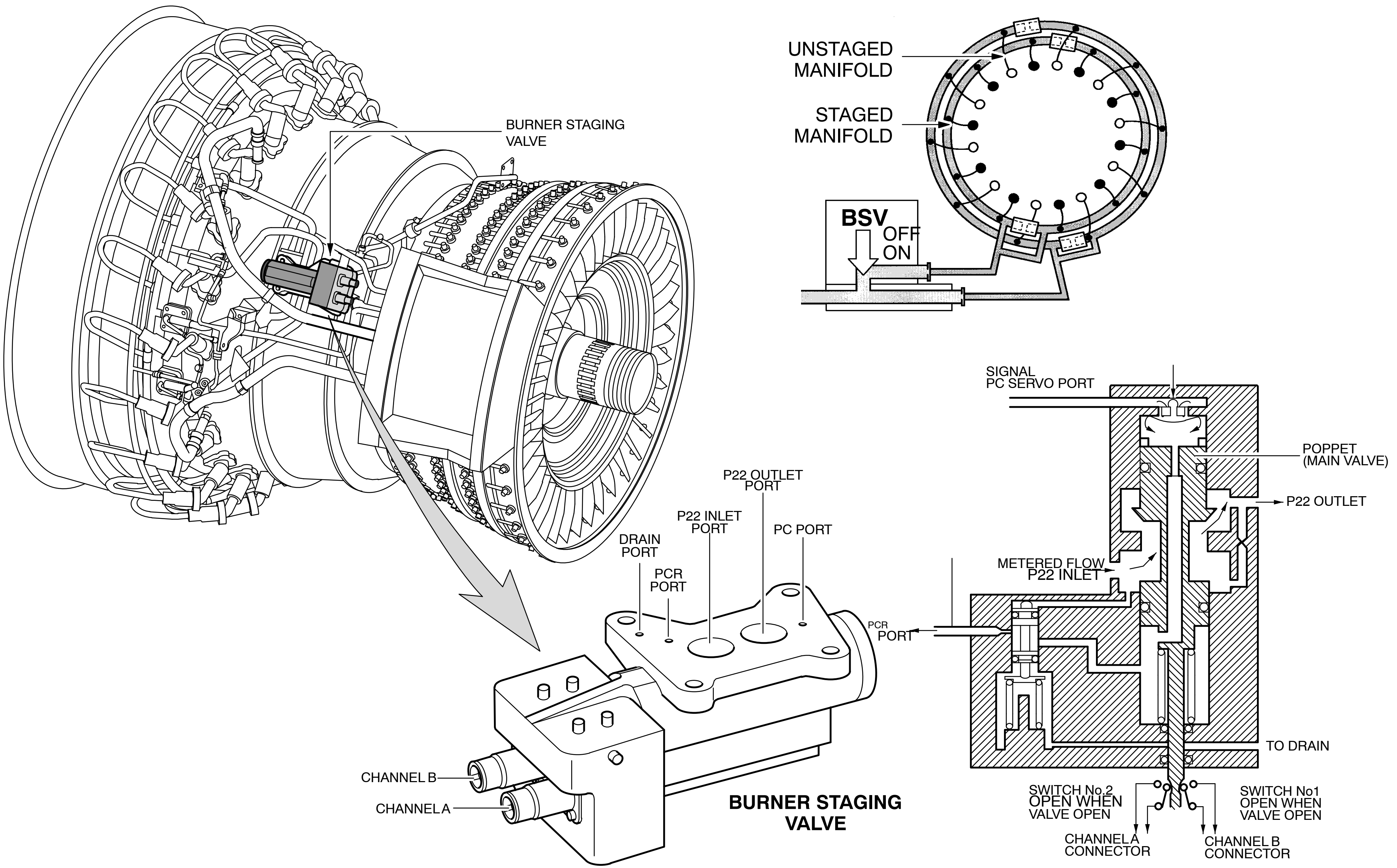


Figure 79 Burner Staging Valve

MAIN FUEL OIL HEAT EXCHANGER COMPONENT DESCRIPTION

MAIN FUEL OIL HEAT EXCHANGER

The Fuel/Oil Heat Exchanger is of the tubular design consisting of a removeable core, a housing and a cover. The core has two end plates, fuel tubes and two baffles. The fuel tubes are attached to the end plates and the baffles inside lengthen the oil circulation path around the fuel inlet tubes.

Sealing rings installed on the core provide insulation between the oil and fuel areas.

The Fuel/Oil Heat Exchanger housing encloses the core, and the following items which are located on its outer portion:

- an oil pressure relief valve, which by–passes the oil when the differential pressure across the oil portion of the exchanger is too high
- a fuel pressure relief valve, which by–passes the fuel when the differential pressure across the fuel portion of the exchanger is too high
- a drain port, for fuel leak collection from inter–seal cavities, that prevent oil cavity contamination
- an optional fuel–out temperature probe port
- two attachment flanges. One with the fuel pump which also provides fuel IN and OUT passages, and one with the servo fuel heater which also provides oil IN and OUT tubes
- one fuel IN port for fuel from the HMU, via the IDG oil cooler

NOTE: If there is contamination in the fuel, both the servo fuel heater and main oil/fuel exchanger must be replaced acc. AMM.

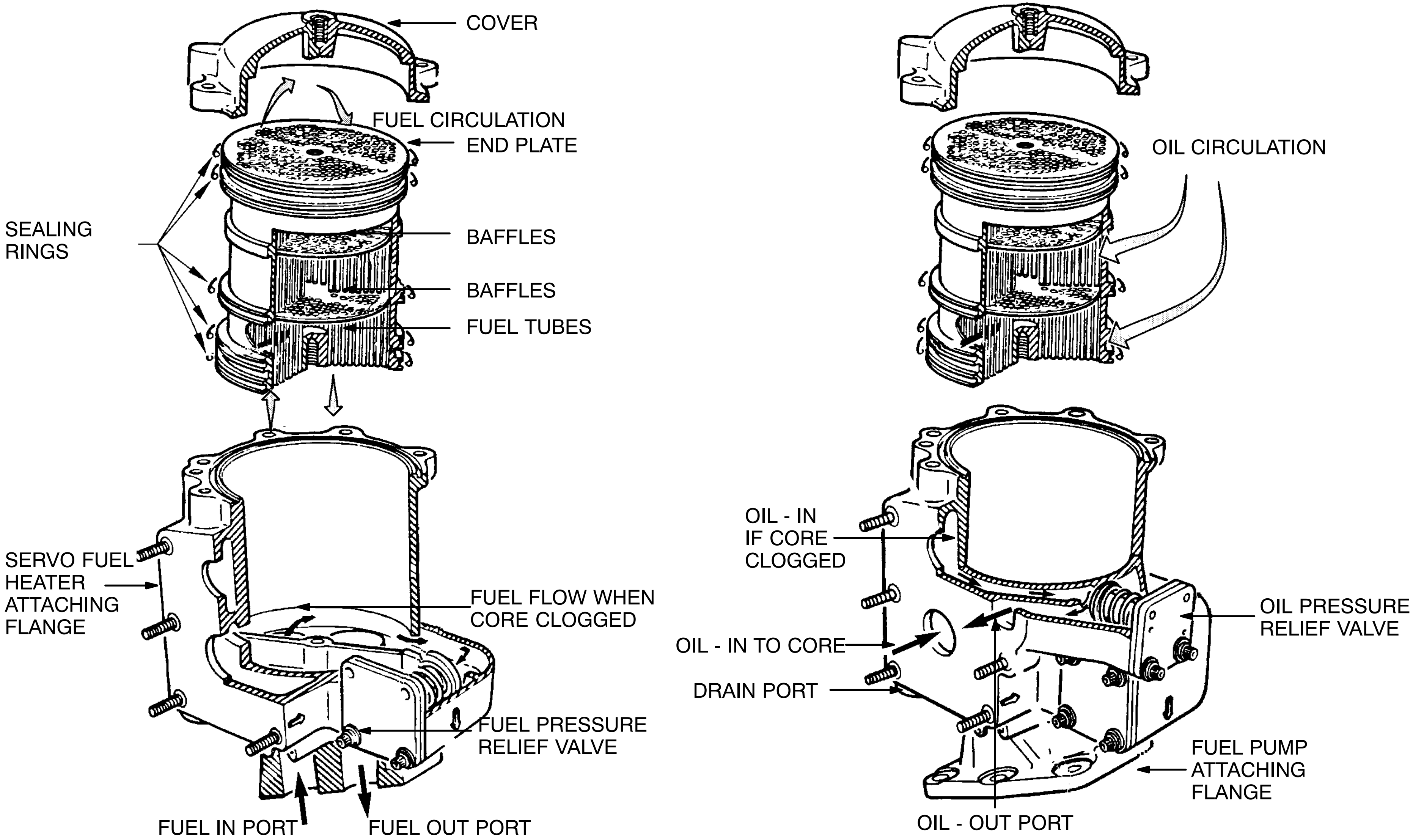


Figure 80 Main Fuel/Oil Heat Exchanger

SERVO FUEL HEATER COMPONENT DESCRPTION

SERVO FUEL HEATER

The servo fuel heater raises the temperature. This prevents ice from entering the control servos inside the Hydro Mechanical Unit (HMU).

The Servo−Fuel Heater consists of a cover and a housing with a heat exchanger core inside. The fuel enters and leaves through the cover. The oil enters the heater through one flange of the housing and circulates around the core tubes. Finally it leaves the housing through the opposite flange.

The oil−out flange has two orifices. One corresponding to the normal circuit the other is used if clogging of the main oil/fuel heat exchanger restricts oil circulation beyond acceptable limits.

The servo fuel heater is a heat exchanger using oil as a heat source. Heat exchange between oil and fuel occurs by conduction and convection inside the unit. The two fluids circulate in the servo fuel heater through separate flow paths.

The oil initially lubricates and cools the engine sumps. Then it enters the servo fuel heater, giving off heat to the fuel from the wash filter. The heated fuel then flows to the internal HMU servos.

NOTE*:* There is no fuel anti−clogging valve in the servo fuel heater system.

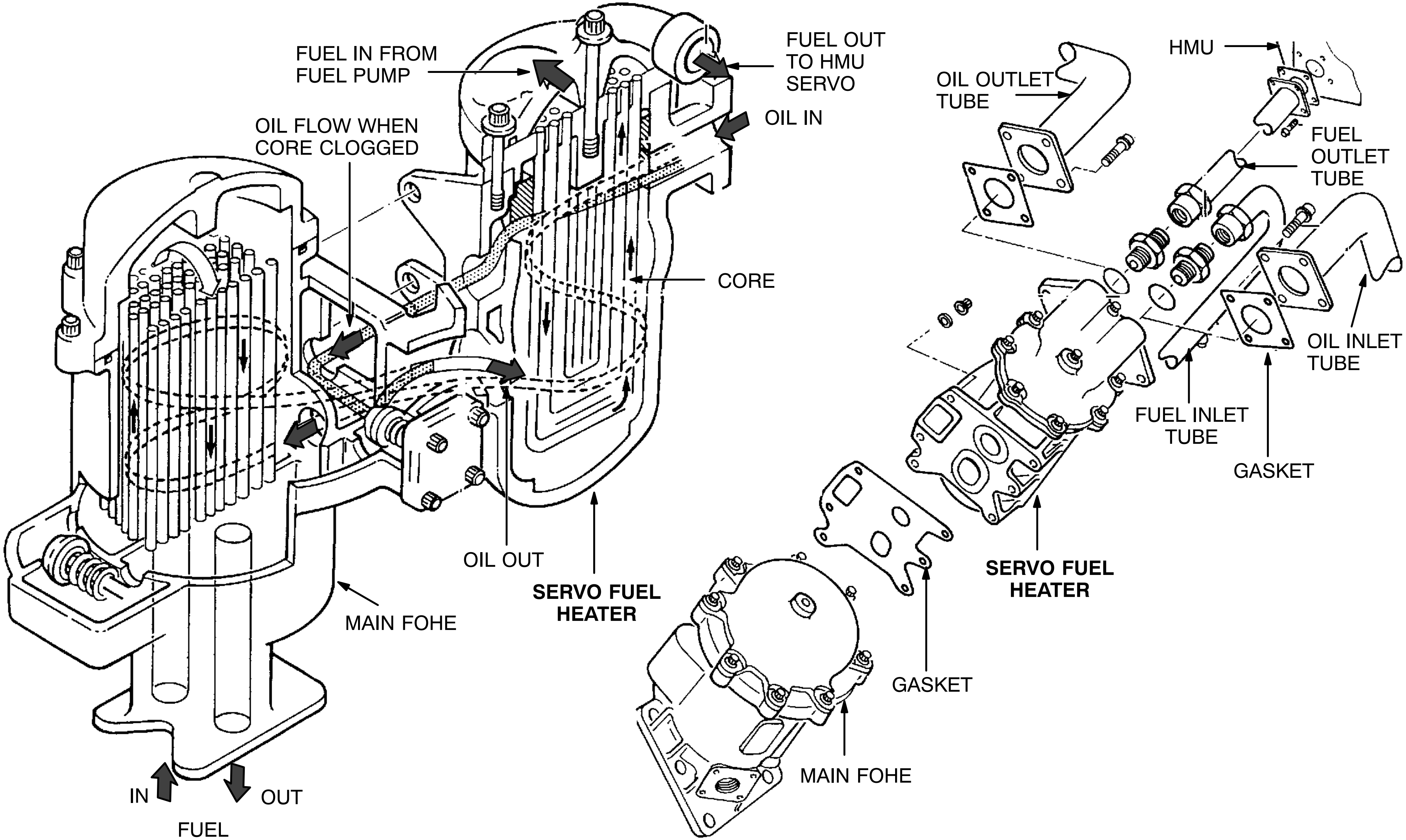


Figure 81 Servo Fuel Heater / Fuel Oil Heat Exchanger

FUEL NOZZLE COMPONENT DESCRIPTION

FUEL NOZZLES

Purpose

The fuel nozzles are installed into the combustion case assembly. They are connected to the fuel manifold assembly. The 20 fuel nozzles deliver fuel into the combustor in a spray pattern. This provides good light-off and efficient burning at high power.

Operation

The fuel nozzles contain both primary and secondary fuel flow passages. As the engine is started the fuel passes through the inlet, and accumulates in the portion of nozzle that houses the valves.

The low pressure primary flow is directed through the check valve, passes through the primary passage of the nozzle tube and tip, and enters the combustion chamber as an uniform density spray.

The high pressure secondary flow activates the flow divider valve. This fuel passes through the secondary passage of the nozzle tube and tip. Then it enters the combustion chamber as an uniform density, cone shaped spray. The cone of the secondary spray is wider than that of the primary, therefore, surrounding the primary spray pattern.

FUEL MANIFOLD

Purpose

The fuel manifold supplies metered fuel to the twenty fuel nozzles and drains any fuel that may leak from the fuel supply connection lines.

FUEL NOZZLE FILTER

The fuel nozzle filter is installed near the servo fuel heater at 8 o'clock and attached to the fuel flow transmitter.

The fuel nozzle filter collects any contaminants that may still be left in the fuel before it goes to the fuel nozzle supply manifold.

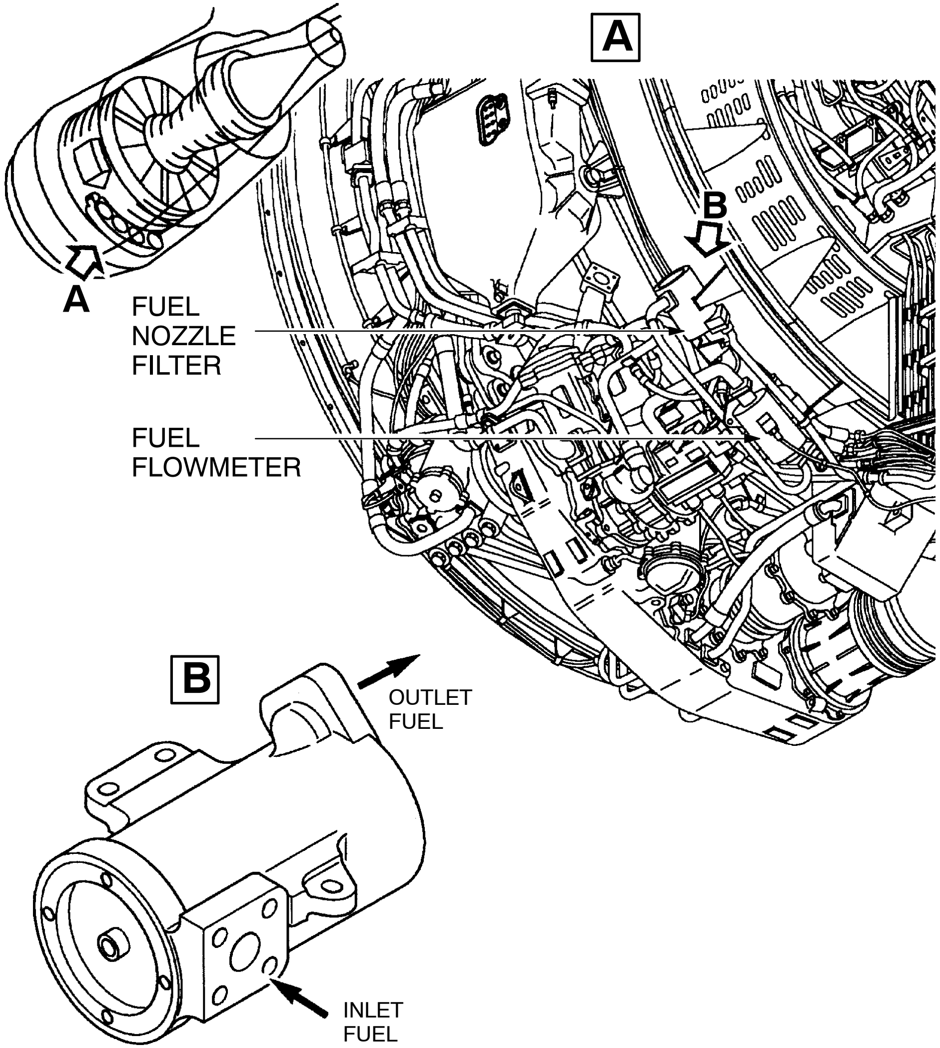
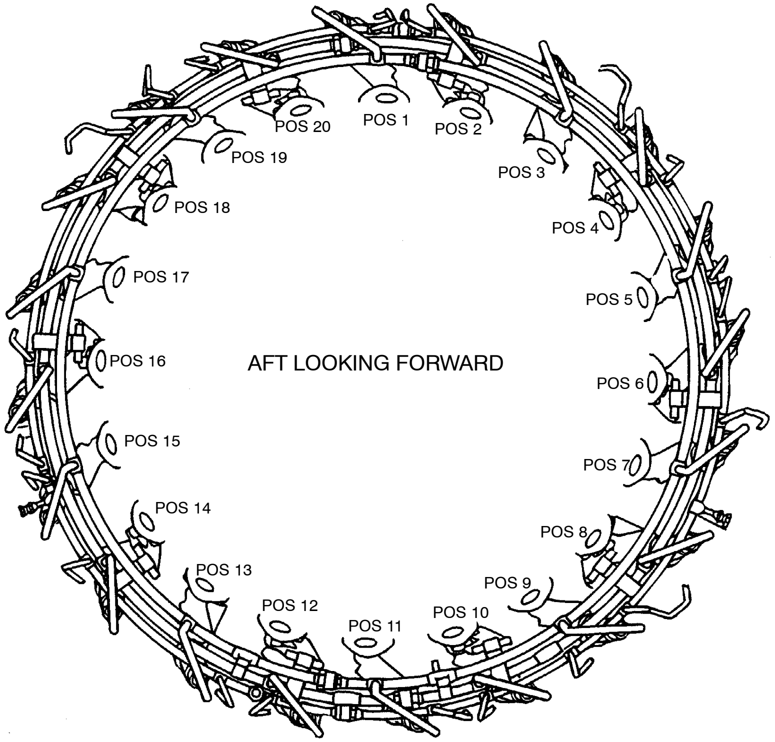


Figure 82 Fuel Nozzle Filter



Fuel Nozzle Arrangement

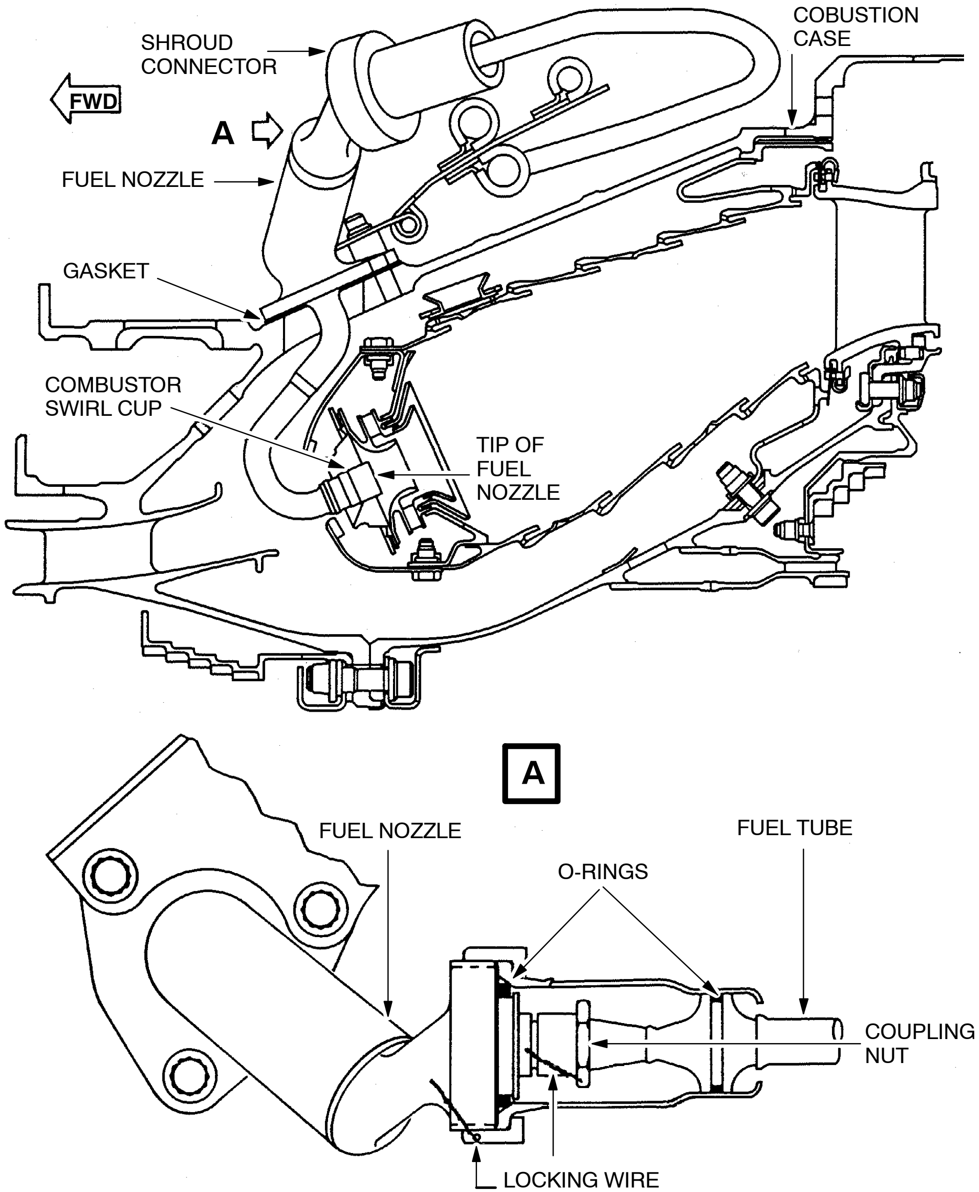


Figure 83 Fuel Nozzles and Manifolds

73–30 INDICATING

INDICATING DESCRIPTION

Fuel Flow Transmitter

The fuel flow transmitter is installed in the fuel line between the HMU and the burner staging valve. It is mounted on the lower left–hand side of the fan case, rearward of the LP/HP fuel pump.

The fuel flow transmitter is made of these primary assemblies:

- Transmitter Body
- Inlet Fitting and Clamps
- Turbine Assembly
- Measurement Assembly

Fuel Flow and Fuel Used Indication

The Fuel Flow Transmitter is installed at the HMU. The signals are routed to the ECU and via the DMCs to the ECAM. The Fuel Used-is calculated in the DMCs

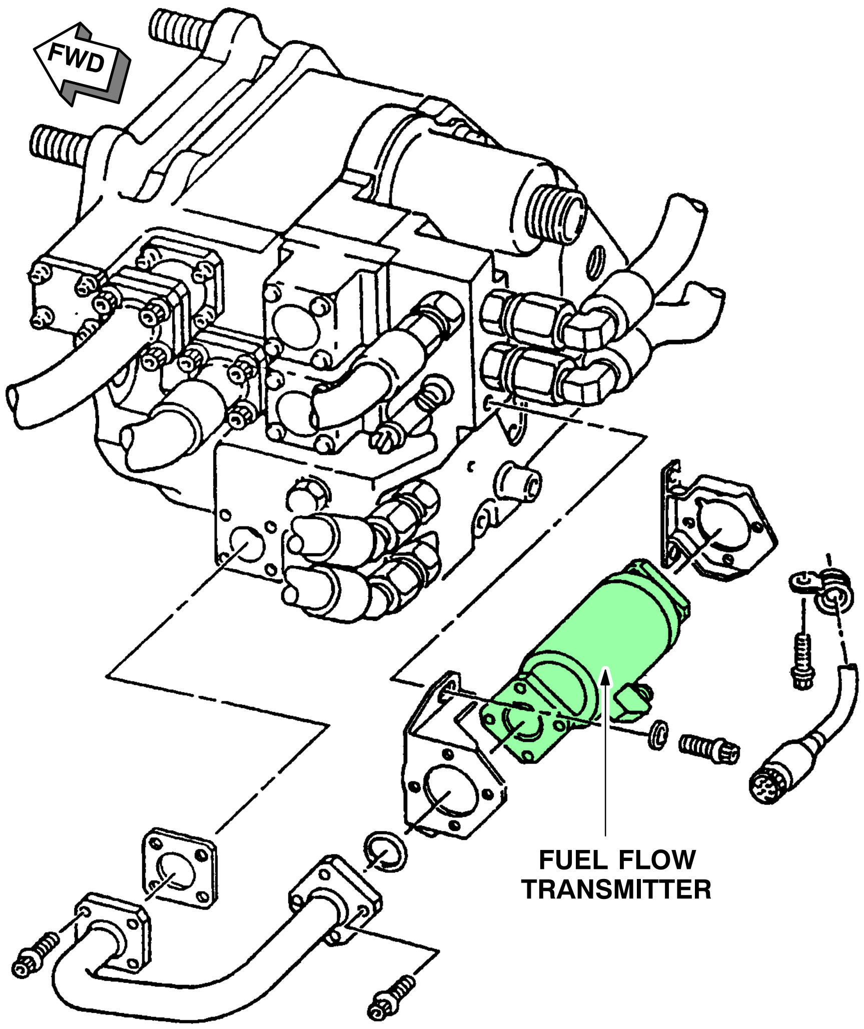


Figure 84 Fuel Flow Transmitter

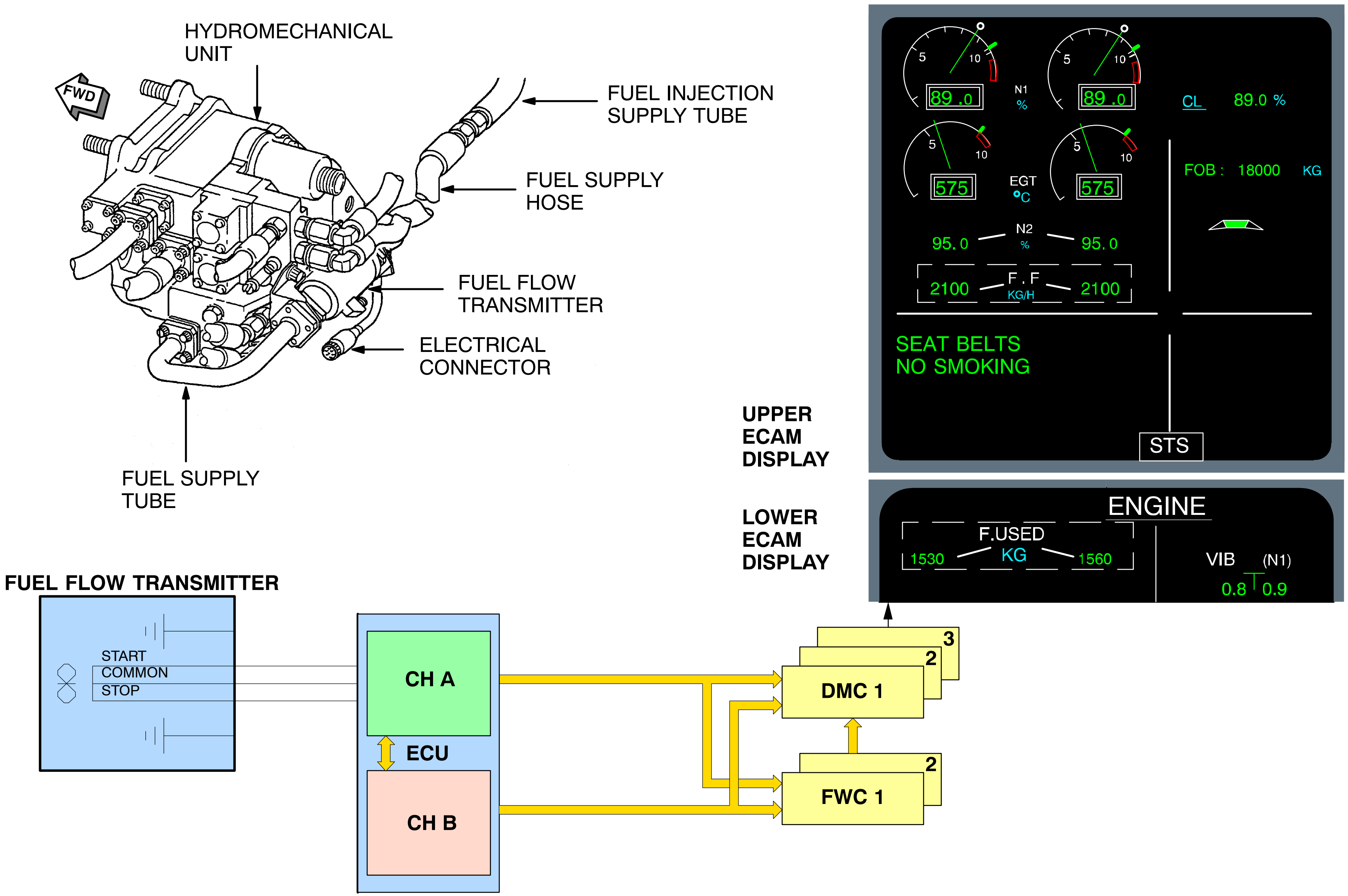


Figure 85 Fuel Flow / Fuel Used Indication

Fuel Filter Clogging Indication

The fuel filter clogging switch is installed at 10 o‘ clock position at the L/H fan frame.

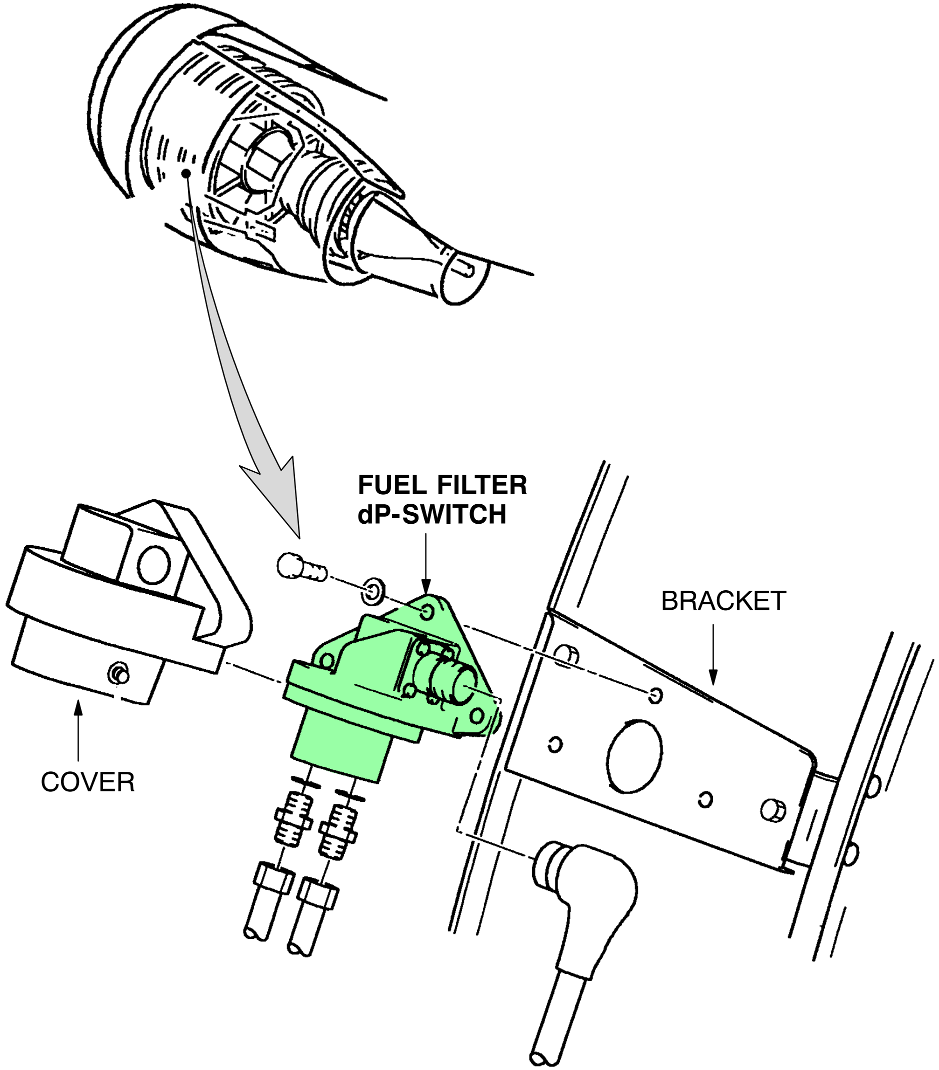


Figure 86 Fuel Filter dP-Switch

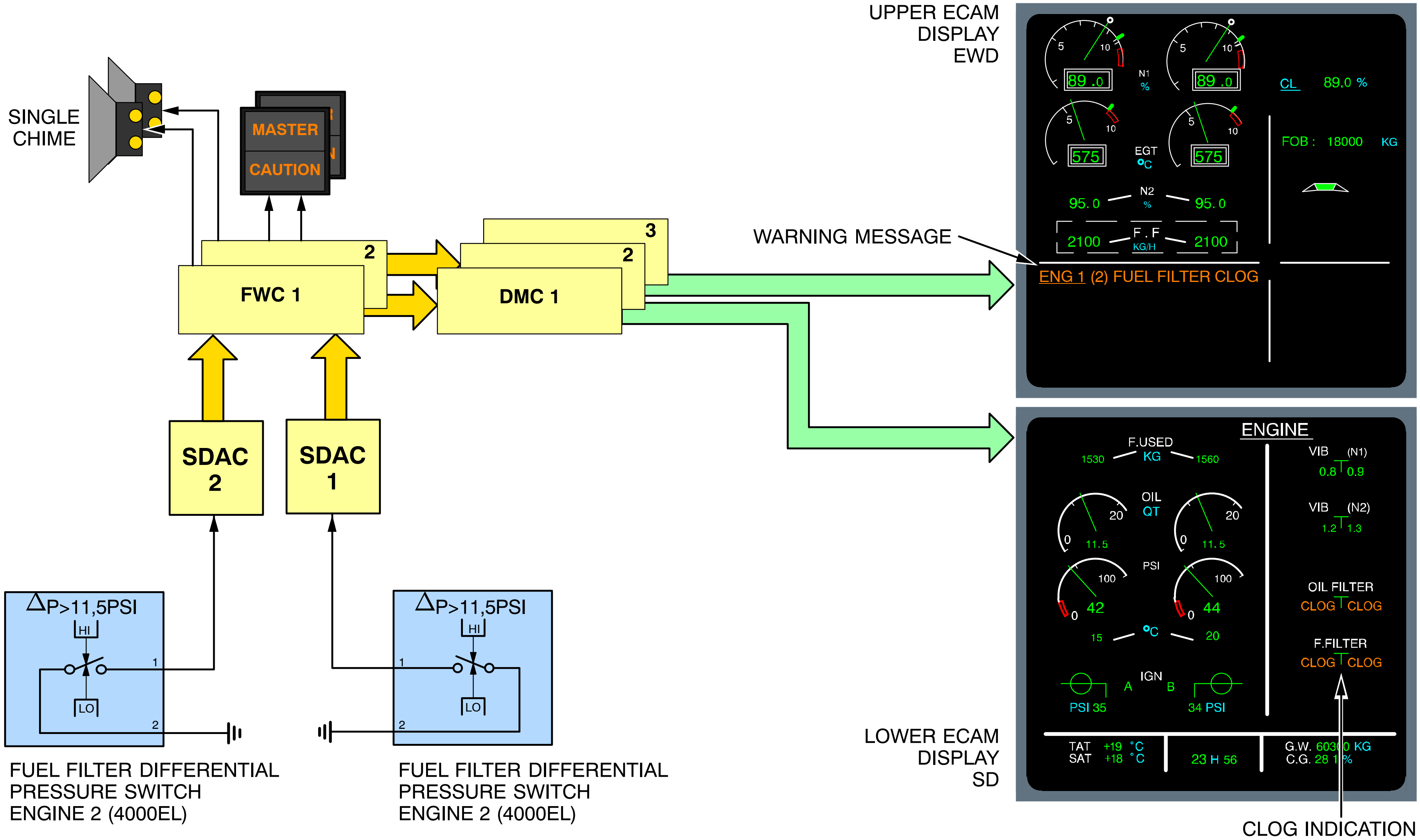


Figure 87 Fuel Filter Clogging Indication

FUEL FLOW TRANSMITTER COMPONENT DESCRIPTION

FUEL FLOW TRANSMITTER

The purpose of the fuel flow transmitter is to provide the ECU with information, for indicating purposes, on the weight of fuel used for combustion.

Located in the fuel flow path, between the HMU metered fuel discharge port and the fuel nozzle filter, it is installed on supporting brackets on the aft section of the HMU.

The interfaces are:

- a fuel supply hose, connected from the HMU.
- a fuel discharge tube, connected to the fuel nozzle filter.
- an electrical wiring harness, connected to the ECU.

The fuel flow transmitter consists of an aluminium body with a cylindrical bore containing a rotating measuring device, which generates electronic pulses proportional to the fuel flow.

An electrical connector is installed on the outside of a rectangular electronics compartment.

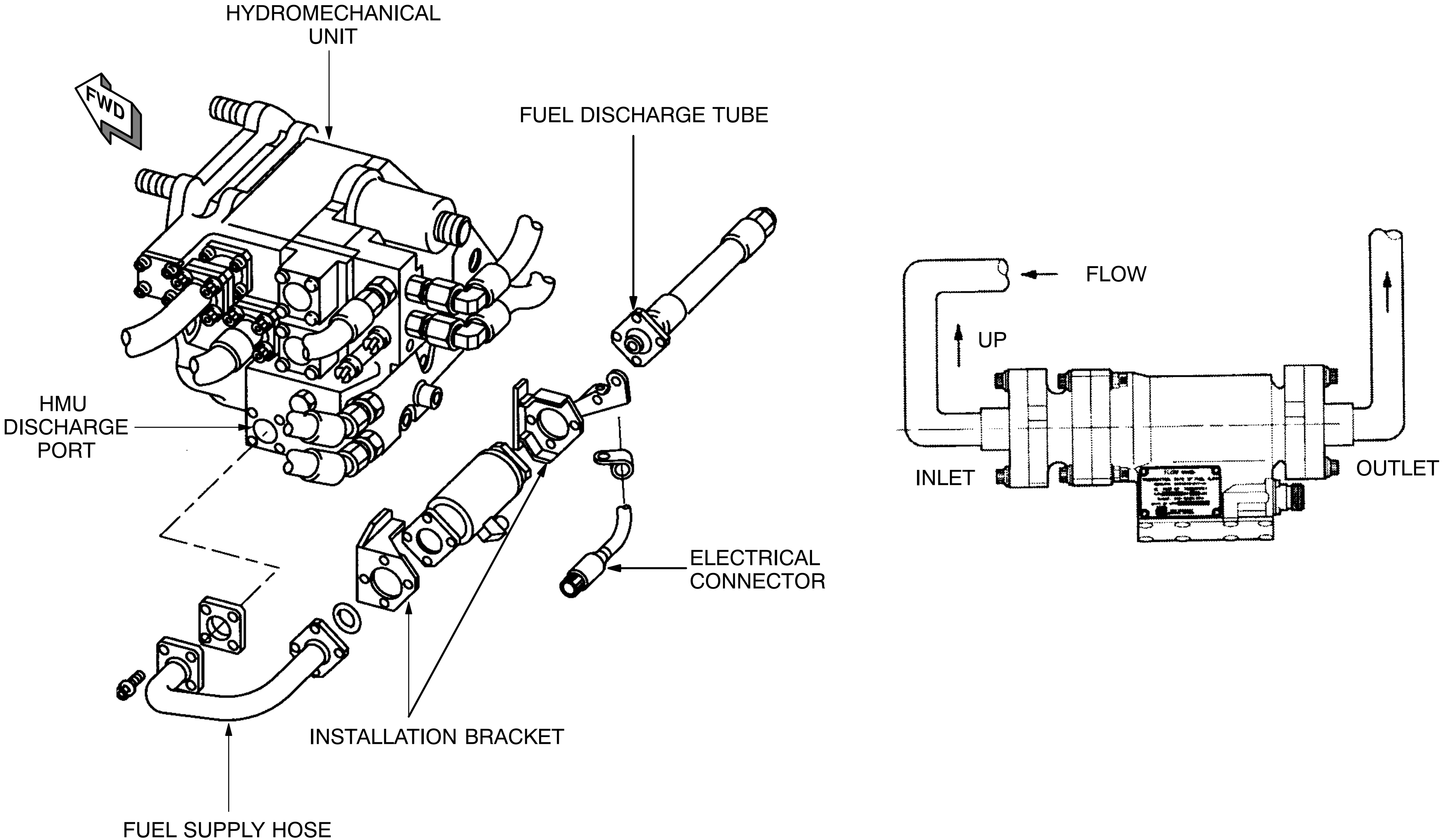


Figure 88 Fuel Flow Transmitter

ATA 76 ENGINE CONTROLS

76–00 ENGINE CONTROLS - GENERAL

General

The engines controls are located on the overhead panel and the pedestal.

Thrust Levers

There are two thrust levers, they are used as conventional throttles and as thrust rating limit selectors. Each thrust lever is fitted with a thrust reverser control lever. Two autothrust instinctive disconnect pushbuttons are provided on the throttle control levers

Engine Master Switches

Two Engine Master Switches with two positions, ON or OFF, are provided to open or close the High Pressure (HP) fuel valve and command and reset the FADEC functions. The red indicator light is activated in case of FIRE and the amber indicator light is activated in case of aborted start.

Engine Start

The rotary selector initiates either an IGN/START sequence or a CRANK sequence. After the start or crank sequence, the selector is set back to the NORM position.

Engine Manual Start

The Engine Manual Start Panel Pushbuttons are provided to open the start valves during an engine manual start or cranking sequence.

FADEC Ground Power

The FADEC is normally supplied with power by a dedicated generator driven by the gearbox. When the engine is not running, the FADEC can be powered from the aircraft network by using the FADEC Ground Power Pushbutton.

Engine Fire

When the Engine Fire Pushbutton is released out, the Low Pressure Fuel Shut Off Valve is closed, and the aircraft electrical power supply to the FADEC system is interrupted.

Engine Anti Ice

For each Engine, the hot bleed air is ducted via an ON/OFF valve which is controlled from the cockpit. The valve is pneumatically operated, electrically controlled and spring loaded open. In case of loss of electrical power supply, the valve will open. There is only a blue/amber light at the pushbutton and a message on the ECAM MEMO display.

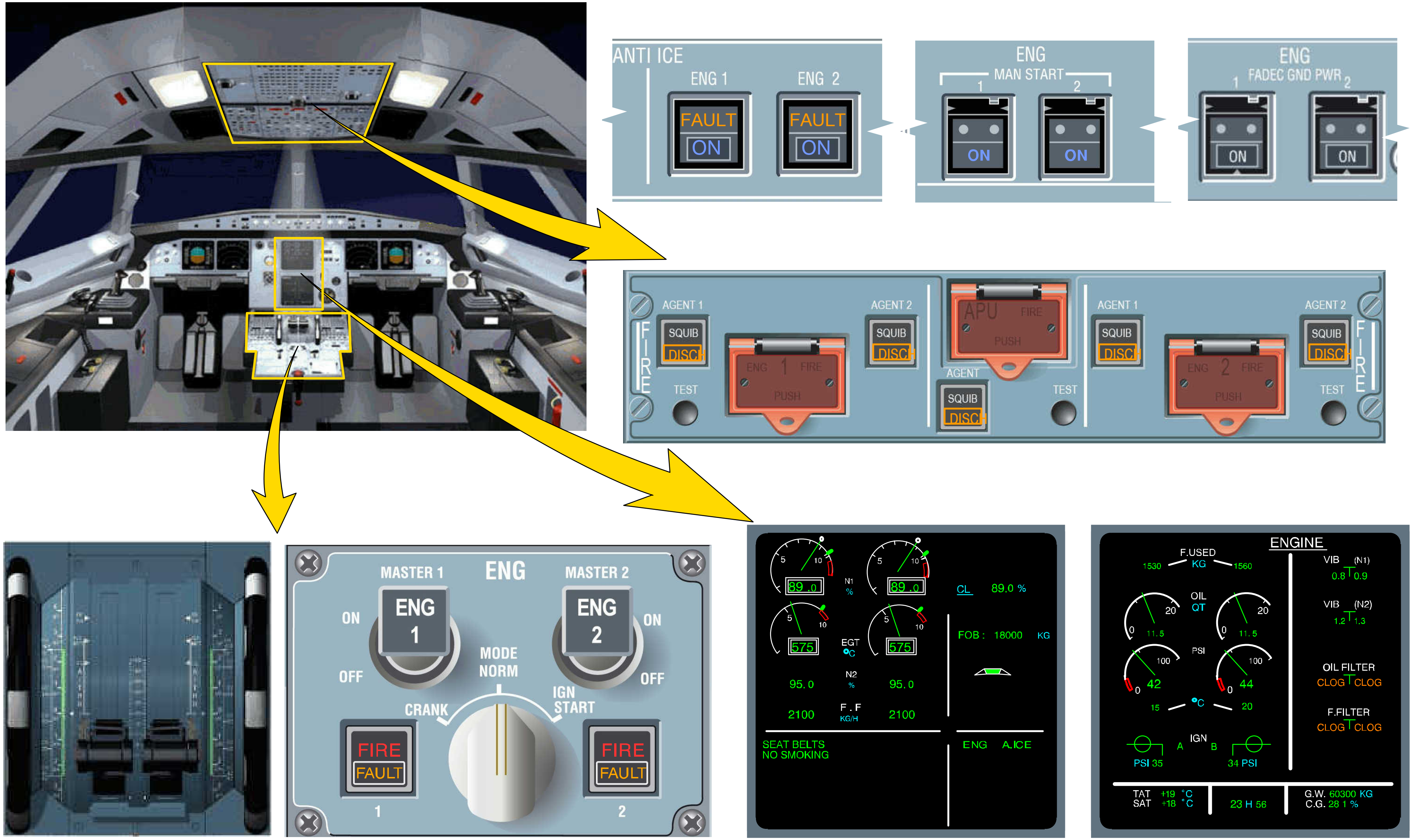


Figure 89 Engine Controls Overview

76-11 THROTTLE CONTROL

DESCRIPTION

General

The throttle control system consist of the:

- Throttle Control Lever
- Throttle Control Artificial Feel Unit (Mechanical Box)
- Thrust Control Unit
- Electrical Harness

The design of the throttle control is based upon a fixed throttle concept :

This means that the throttle control levers are not servo motorized.

Thrust Control Unit

The Thrust Control Unit contains two resolvers, each of which sends the thrust lever position to the Engine Control Unit. The extraction current for the resolvers is provided by the ECU.

Auto Thrust Disconnect Pushbutton

The Auto Thrust Instinctive Disconnect Pushbutton can be used to disengage the auto thrust function.

THROTTLE CONTROL LEVERS

General

The thrust levers comprises:

- a thrust lever which incorporates stop devices and autothrust instinctive disconnect pushbutton switch
- a graduated fixed sector
- a reverse latching lever

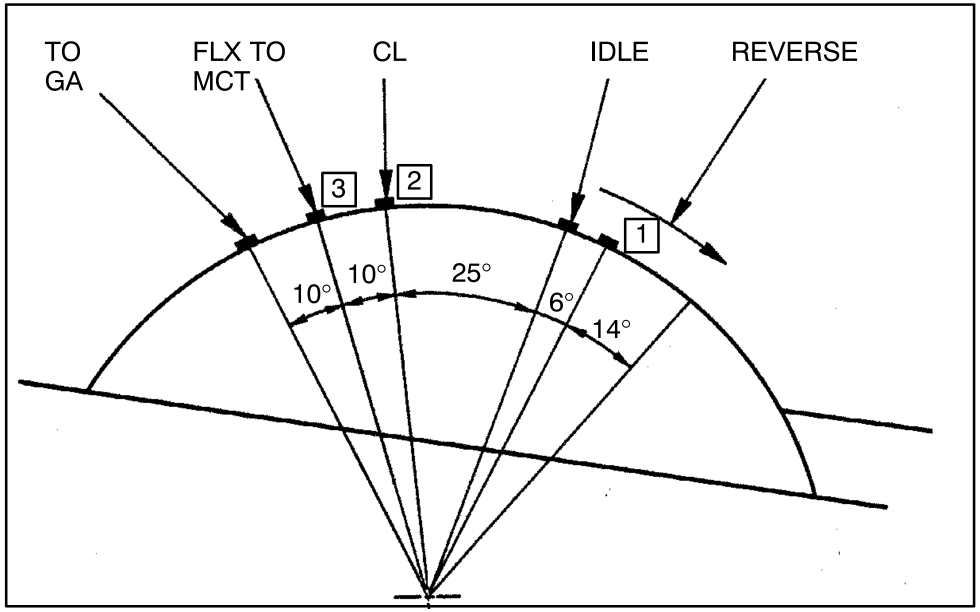
The thrust lever is linked to a mechanical rod. This rod drives the input lever of the throttle control artificial feel unit (Mechanical Box).

Reverse Thrust Latching Lever

To obtain reverse thrust settings, the Reverse Thrust Latching Lever must be lifted. A mechanical cam design is provided to allow reverse thrust selection when thrust lever is at forward idle position.

The thrust lever has three stops at the pedestal and three detents in the artificial feel unit:

- 0° STOP = FWD IDLE THRUST – IDLE
- -20° STOP = FULL REVERSE THRUST – MREV
- 45° STOP = MAX .TAKE OFF THRUST – TOGA
- DETENT 1 = (REVERSE) IDLE THRUST – REV
- DETENT 2 = MAX.CLIMB (ALSO CRUISE SELECTION) – CL
- DETENT 3 = MAX. CONT (FLEX TAKE OFF THRUST) – MCT/FLX T/O



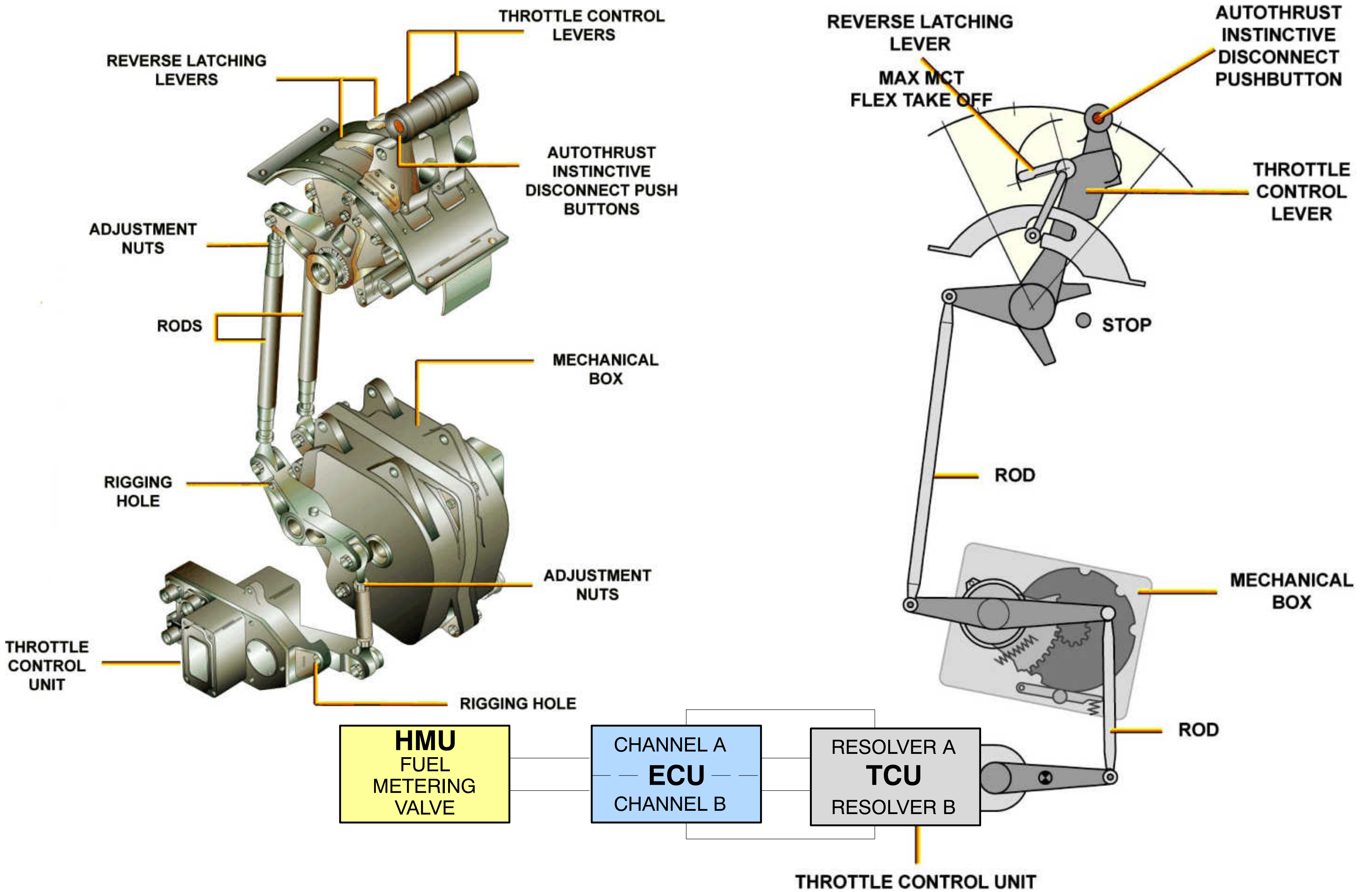


Figure 90 Engine Thrust Lever Control

THROTTLE CONTROL - COMPONENT DESCRIPTION

THROTTLE CONTROL ARTIFICIAL FEEL UNIT

The Throttle control artificial feel unit is located below the cockpit center pedestal. This artificial feel unit is connected to engine 1(2) throttle control lever and to the engine 1(2) throttle control unit by means of rods.

The artificial feel unit is a friction system which provides a load feedback to the throttle control lever.

This artificial feel unit comprises two symmetrical casings, one left and one right. Each casing contains an identical and independent mechanism.

Each mechanism is composed of:

- Friction Brake Assembly
- Gear Assembly
- Lever Assembly
- Bellcrank Assembly

Throttle lever travel is transmitted to the to the artificial feel unit and to the throttle control unit. The linear movement of the throttle levers is transformed into a rotary movement at the bell crank which turns about the friction brake assembly shaft. This movement rotates a toothed quadrant integral with the shaft.

This toothed quadrant causes inverse rotation of a gear equipped with a disk which has three detent notches. Each notch corresponds to a throttle lever setting and is felt as a friction point at the throttle levers.

MECHANICAL BOX(ES)

An adjustment screw is provided at the lower part of each mechanical box to adjust the artificial feel.

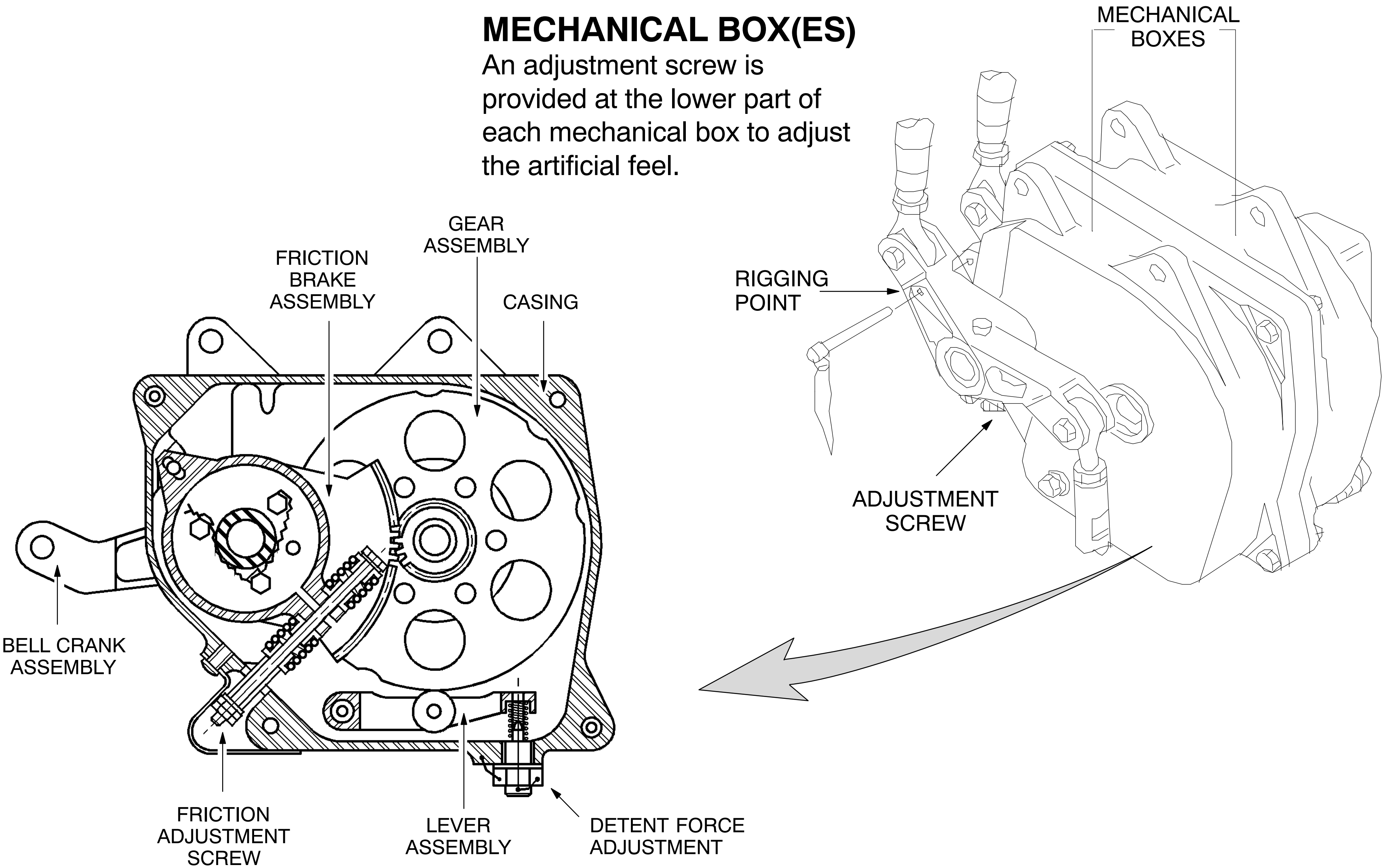


Figure 91 Mechanical Boxes

THROTTLE CONTROL UNIT

Components

- Input Lever
- Mechanical Stops which limit the angular range
- two Resolvers whose signals are dedicated to the ECU (one resolver per ECU channel)
- six Potentiometers fitted three by three. Their signals are used by the flight control system and the thrust reverser control system
- a device which drives the resolver and the potentiometer
- a pin device for rigging the resolvers and potentiometers
- a safety device which leads the resolvers outside the normal operating range in case of failure of the driving device
- two output electrical connectors

The input lever drives two gear sectors assembled face to face. Each sector drives itself a set of one resolver and three potentiometers.

TRA and TLA - Relation

The relationship between the throttle lever angle (TLA) and throttle resolver angle (TRA) is linear. AIDS Alpha Call Up is "TLA".

The accuracy of the throttle control unit (error between the input lever position and the resolver angle) is 0.5 deg. TRA.

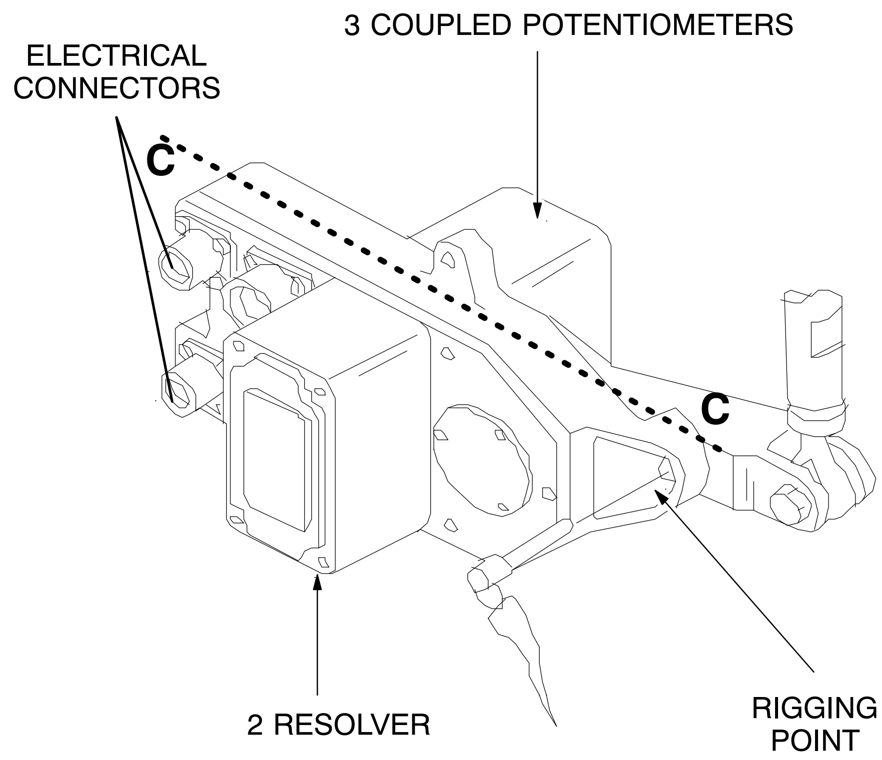
The maximum discrepancy between the signals generated by the two resolvers is 0.25 deg. TRA.

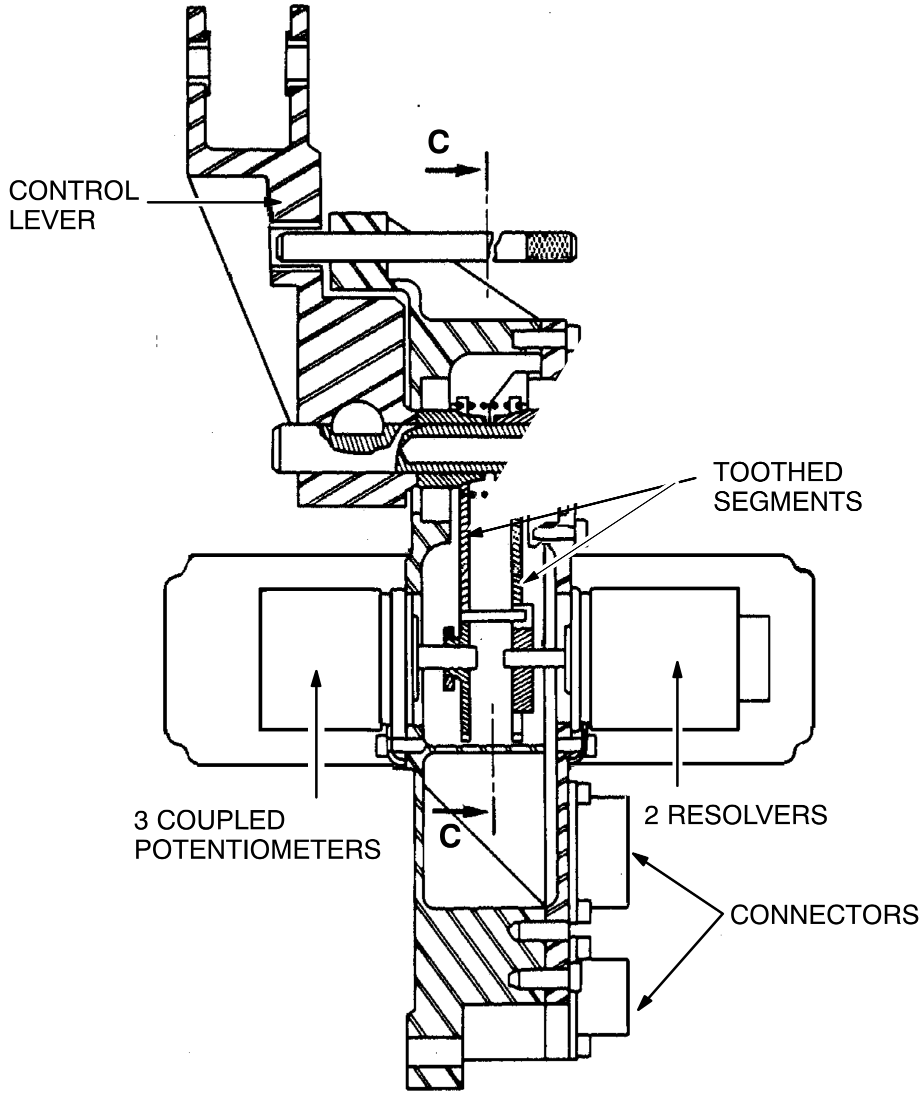
The TLA resolver operates in two quadrants. The first quadrant serves for positive angles and the fourth quadrant for negative angles. Each resolver is dedicated to one channel of the ECU and receives its electrical excitation from the ECU.

The ECU considers a throttle resolver angle value:

- less than −47.5 deg. TRA or
- greater than 98.8 deg. TRA as resolver position signal failure.

The ECU incorporates a resolver fault accommodation logic. This logic allows engine operation after a failure or a complete loss of the throttle resolver position signal.





THRUST CONTROL UNIT(S)

- 2 units

Each unit consists of:

- 2 resolvers
- 6 potentiometers

Figure 92 Throttle Control Units

BUMP RATING DESCRIPTION (OPTIONAL)

General

On some operators aircrafts the throttle control levers may be equipped with Bump Rating Pushbuttons - one per engine. This enables the ECU to be re-rated to provide additional thrust capability for use during specific aircraft operations.

Function

The takeoff bump ratings can be selected, regardless of the thrust lever angle when the airplane is on the ground. The bump ratings, if available, are selected by a push button located on the thrust lever.

Actuation of the switch will generate a digital signal to both ECUs via the EIU. The maximum take-off rating will then be increased by the pre−programmed delta N1 provided the airplane is on the ground.

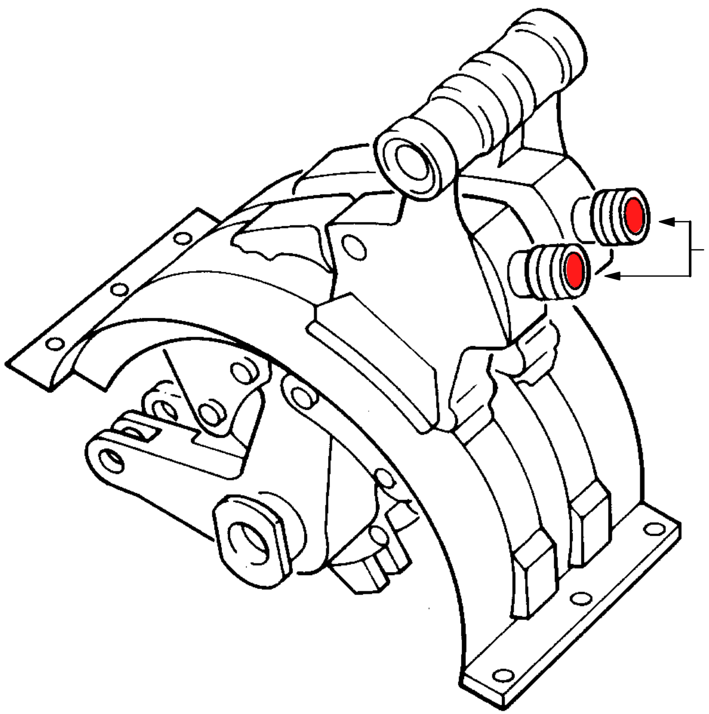
The bump ratings can be de−selected at anytime by actuating the bump rating push button as long as the airplane is on the ground and the thrust lever is not in the maximum takeoff (TO) detent.

In flight, the bump ratings are fully removed when the thrust lever is moved from the TO detent to, or below, the MCT detent.

The bump rating is available in flight under the following conditions.

- Bump rating initially selected on the ground.
- TO/GA thrust lever position set.
- Airplane is within the takeoff envelope.

The bump rating is a non−standard rating and is only available on certain designated operator missions. Use of the bump rating must be recorded. This information is for tracking by maintenance personnel.



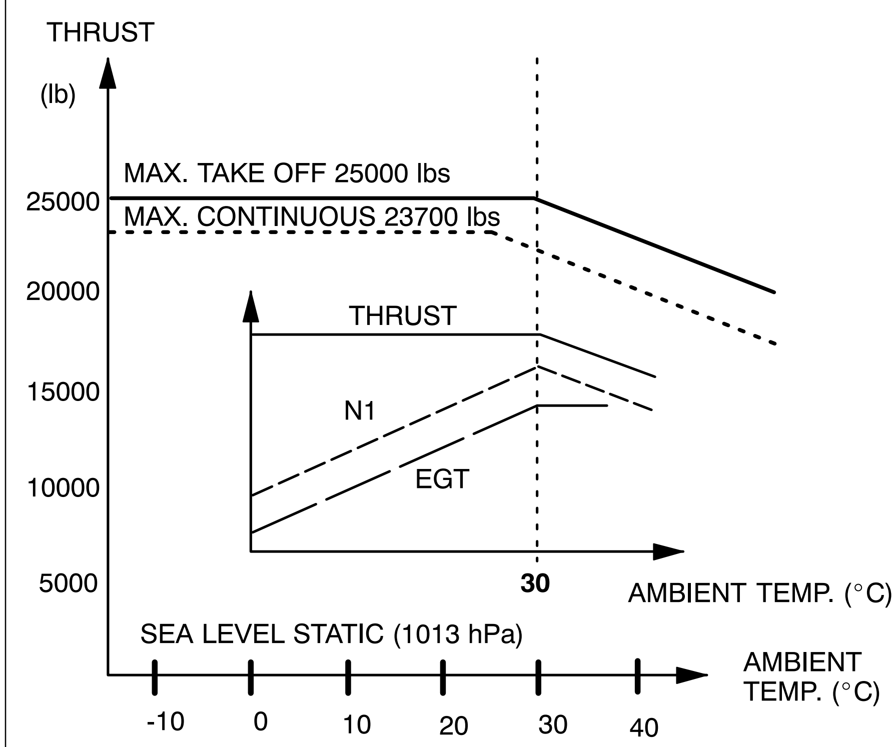


Figure 93 Bump Rating Pushbuttons

ATA 77 ENGINE INDICATING

77-00 ENGINE INDICATING GENERAL

INTRODUCTION

The engine power management is effected by means of the:

- ECAM System (Upper and Lower Display Unit)
- Warning and Caution Systems

The engine is equipped with sensors for monitoring and indication purposes on the flight deck ECAM display units like:

- Temperature
- Pressure
- Speed
- Vibration
- Fuel Flow

It also has switches that provide indication for

- Oil/Fuel Clogging.
- Thrust Reverser Hydraulic Pressure
- Starter Air Valve and T/R position

Depending on the data transmitted, messages are generated on the following devices :

- Upper ECAM: Engine Warning Display (EWD).
- Lower ECAM:Systems Display (SD).
- Master Caution, or Master Warning.
- Aural Warnings

These messages are used to run the engine under normal conditions throughout the operating range, or to provide warning messages to the crew and maintenance personnel. The master caution and warning are located in front of the pilot on the glance panel.

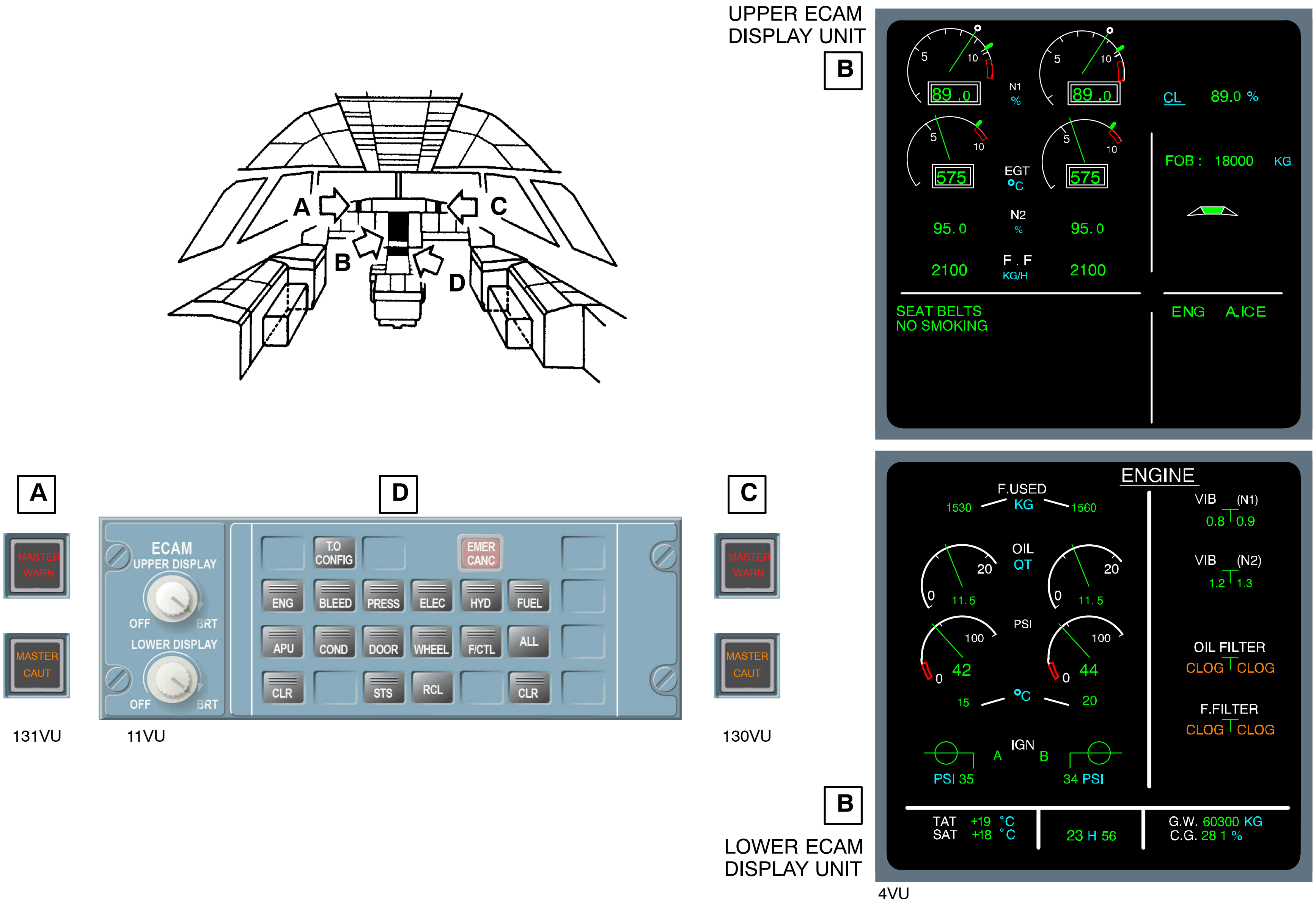


Figure 94 Engine Indication Presentation

INDICATION SYSTEM DESCRIPTION

Upper ECAM Display Unit

The engine primary parameters are permanently displayed on the upper ECAM Display Unit:

- N1 Shaft Speed
- Exhaust Gas Temperature
- N2 Shaft Speed
- Fuel Flow

The trust limit is shown in % on the left side for:

- TO/GA = Take Off / Go Around Power
- CL = Climb Power
- MCT = Max Continuous Power
- FLEX = Flex Take Off
  (The Temperature is shown behind the limit) Flex can be initiated via the MCDU REF page. A temperature above 30 °C will reduce the Power.
- MAX REV = Max Reverse Power

Lower ECAM Display Unit

The engine secondary parameters are displayed on the lower ECAM Display Unit (Engine System Display) when automatically or manually selected:

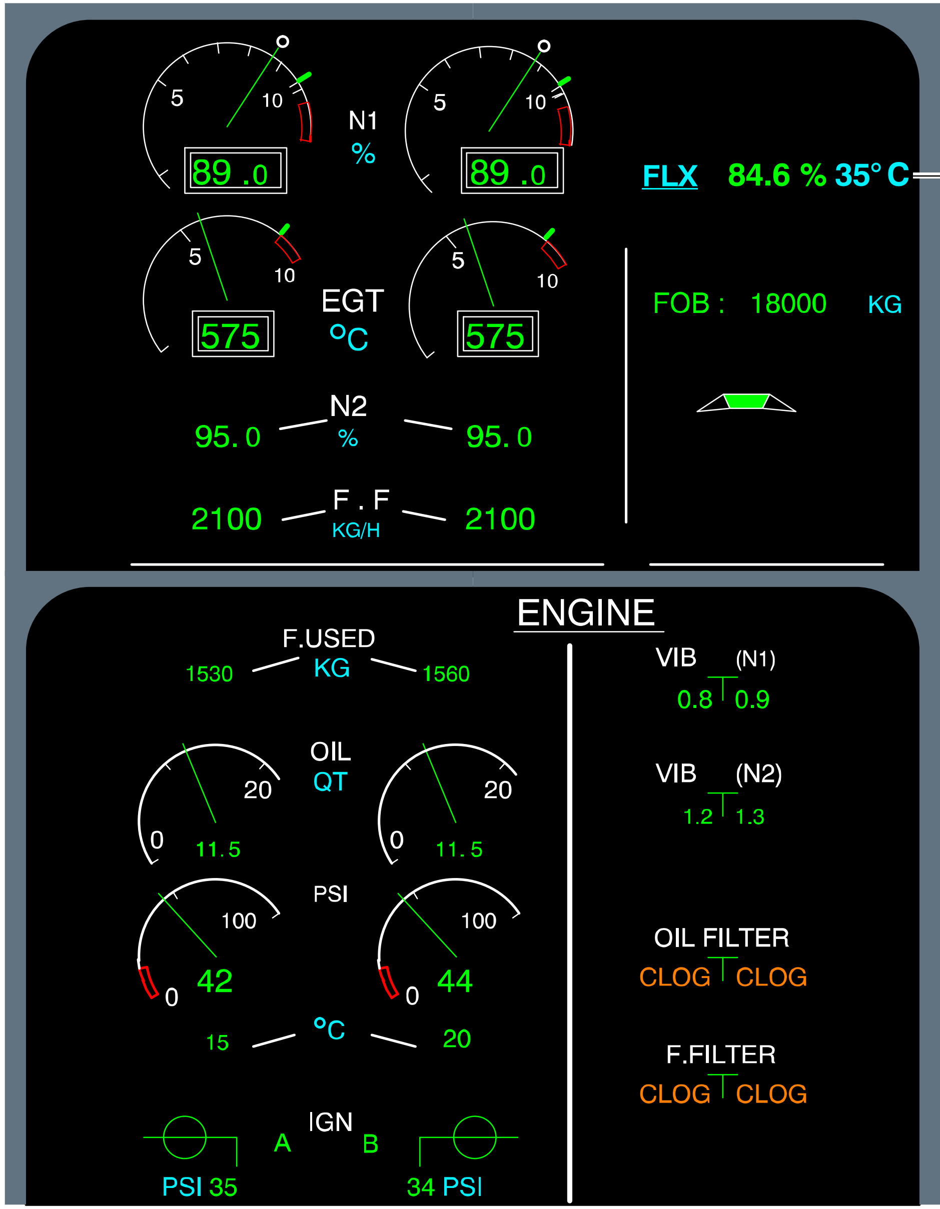
- Fuel Used
- Oil Quantity
- Oil Pressure
- Oil Temperature
- Ignition System
- Starter Air Valve Position and Starter Air Pressure

  NOTE: These indications are only shown during engine start sequence

- Nacelle Temperature
- Engine Shaft Vibration
- Oil Filter Clogging
- Fuel Filter Clogging

UPPER ENG. ECAM DISPLAY UNIT

LOWER ENG. ECAM DISPLAY UNIT



OR

CL	**88,1%**
MCT	**94,3%**
T/O	**95.4%**
M/REV	**70,0%**

NAC temp. indication:

NAC
240 c 90

Figure 95 ECAM Display Units

77-10 POWER

SPEED INDICATION OPERATION

N1 Speed Sensor

The N1 speed sensor is installed on the fan frame strut at the 5:00 o'clock position. It is secured to the fan frame with 2 bolts.

The N1 speed sensor detects the low pressure assembly rotational speed and transmits the corresponding signals to the Engine Vibration Monitoring Unit and the Electronic Control Unit, Channel A & Channel B.

The N1 Speed Sensor consists of the following:

- a three connector receptacle (Ch-A • A/C • Ch-B),
- an attachment flange,
- a sensor probe which includes the pole pieces.

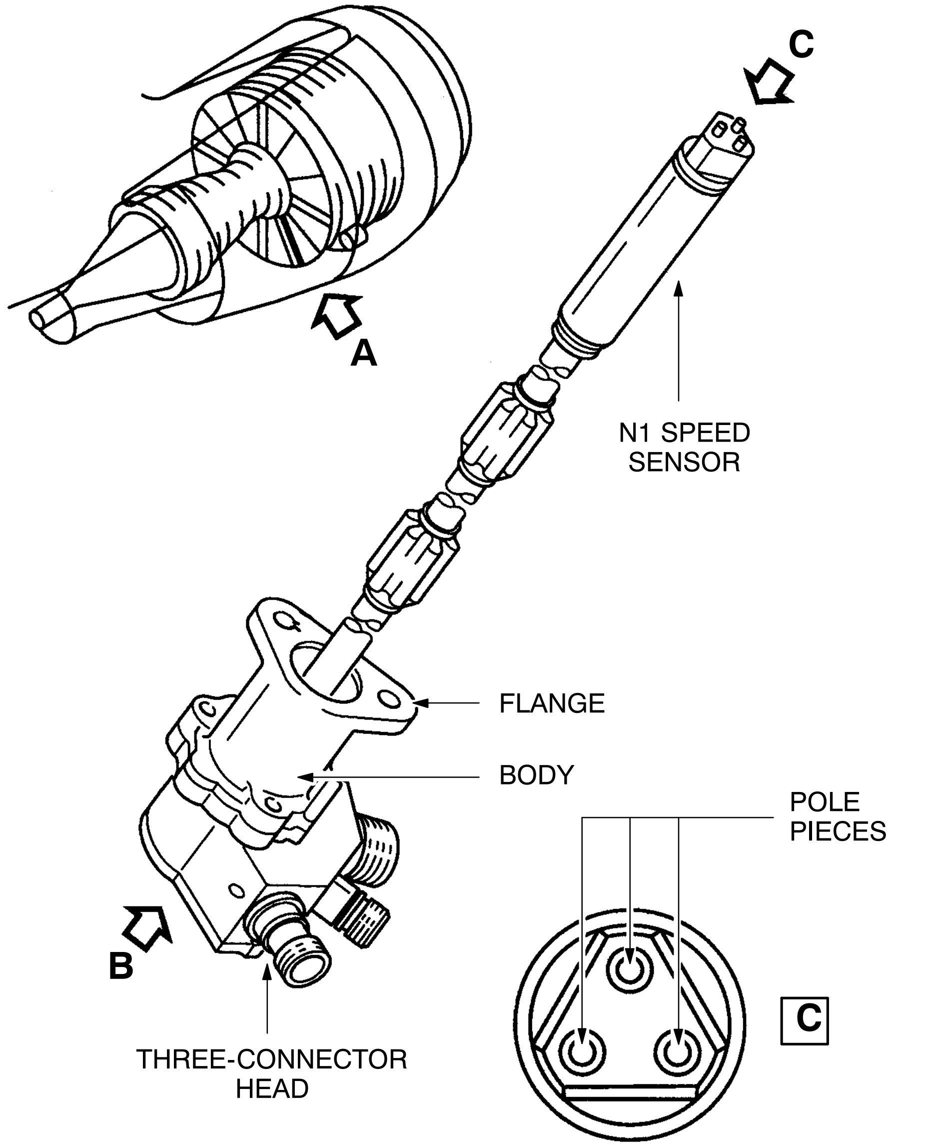


Figure 96 N1 Speed Sensor

Ⓐ **ACTUAL N1:** N1 NEEDLE AND N1 DIGITAL INDICATION ARE NORMALLY GREEN. THE NEEDLE PULSES AMBER WHEN THE ACTUAL N1 IS ABOVE THE N1 MAX. BOTH NEEDLE AND DIGITAL INDICATION PULSE RED WHEN THE ACTUAL N1 IS ABOVE THE N1 RED LINE(102%). WHEN N1 IS DEGRADED (BOTH N1 SENSORS FAILED),THE LAST DIGIT OF THE DIGITAL DISPLAY IS AMBER DASHED.

Ⓑ **N1 COMMAND:** N1 CORRESPONDING TO THE ATS DEMAND, LIMITED BY THE THRUST LEVER POSITION. NOT DISPLAYED IF A/THR OFF.

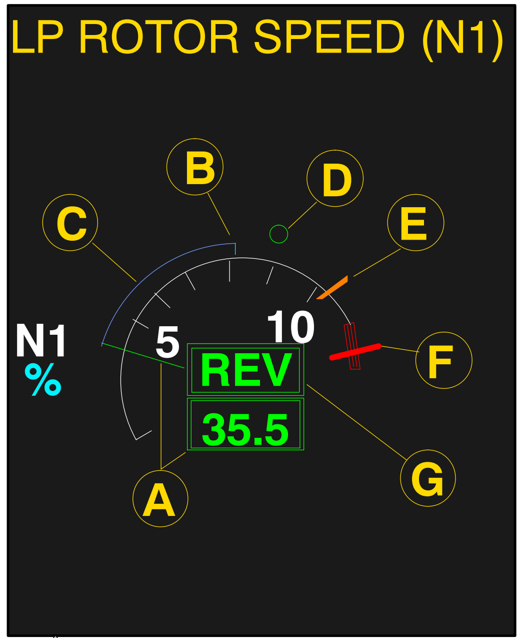
Ⓒ **TRANSIENT N1(BLUE ARC):** SYMBOLIZES THE DIFFERENCE BETWEEN THE N1 COMMAND AND THE ACTUAL N1. NOT DISPLAYED IF A/THR OFF.

Ⓓ **N1 TLA:** N1 CORRESPONDING TO THE THRUST LEVER POSITION (PREDICTED N1).

Ⓔ **MAX N1:** AMBER INDEX AT THE VALUE CORRESPONDING TO THE FULL FORWARD POSITION OF THE THRUST LEVER.

Ⓕ **N1 EXCEEDANCE:** IF 100.3% IS EXCEEDED, A RED MARK APPEARS AT THE MAX VALUE ACHIEVED. IT WILL DISAPPEAR AFTER A NEW START ON GROUND OR AFTER MAINTENANCE ACTION THROUGH THE MCDU.

Ⓖ **REVERSE:** APPEARS AMBER WHEN ONE REVERSER IS UNLOCKED. IT CHANGES TO GREEN WHEN THE DOORS ARE FULLY DEPLOYED. IF UNLOCKED IN FLIGHT,THE INDICATION FLASHES FOR 9 SECONDS AND THEN REMAINS STEADY.



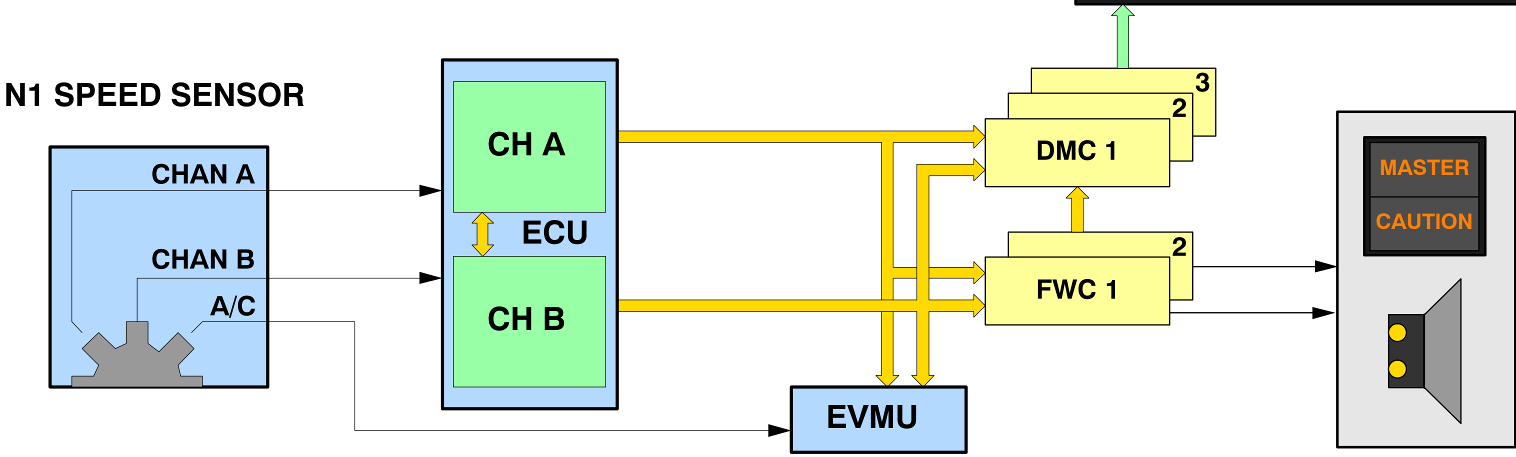


Figure 97 N1 Speed Indication

N2 Speed Sensor

The N2 Speed Sensor is installed at 6:30 o'clock on the accessory gearbox rear face.

The N2 speed sensor detects the rotational speed of the high pressure rotor assembly. It transmits the signal to the **E**ngine **V**ibration **M**onitoring **U**nit and **E**ngine **C**ontrol **U**nit channel A and channel B.

The N2 Speed Sensor consists of the following:

- a body with three fixed connectors
- a metal rigid tube which includes the three Pole Pieces

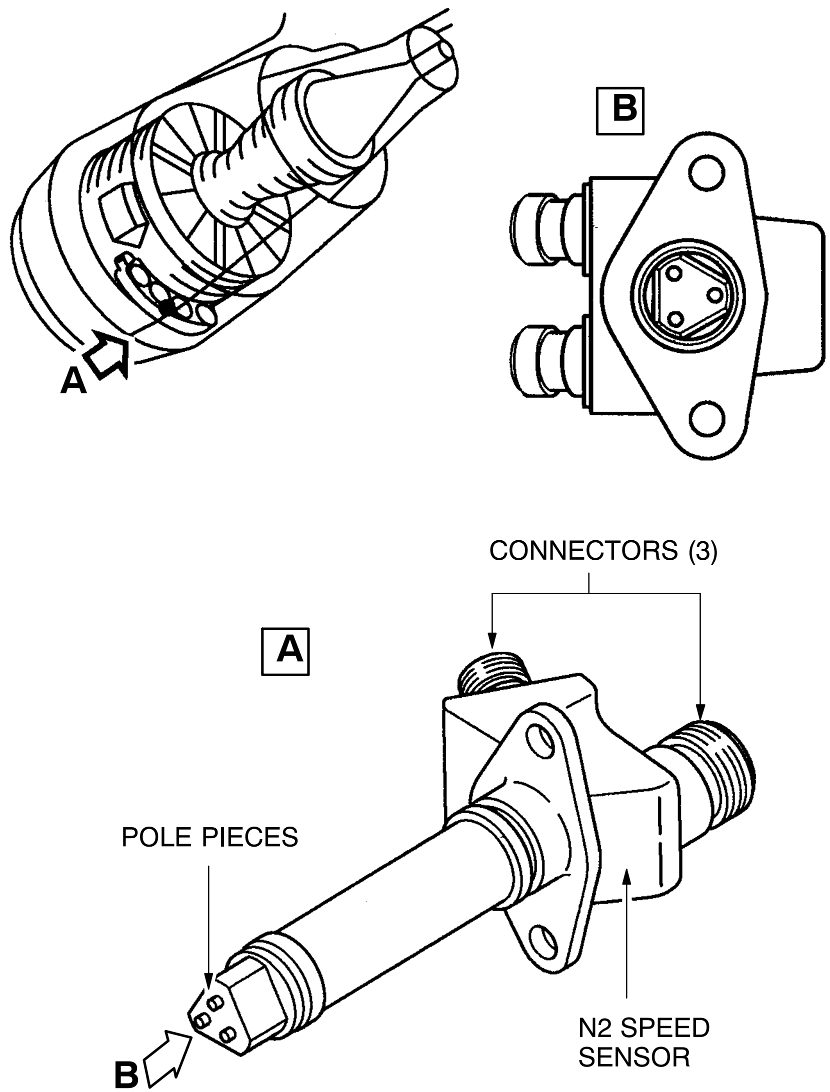


Figure 98 N2 Speed Sensor

THE HP ROTOR SPEED DIGITAL INDICATION IS NORMALLY GREEN. DURING THE START SEQUENCE THE INDICATION IS GREEN ON A GREY BACKGROUND.

WHEN N2 EXCEEDS 105.8 % A RED CROSS APPEARS NEXT TO THE DIGITAL INDICATION. IT WILL DISAPPEAR AFTER A NEW ENGINE START OR AFTER MAINTENANCE ACTION.

WHEN THE N2 VALUE IS DEGRADED (IN CASE OF BOTH N2 SENSORS FAILURE) THE LAST DIGIT IS AMBER DASHED.

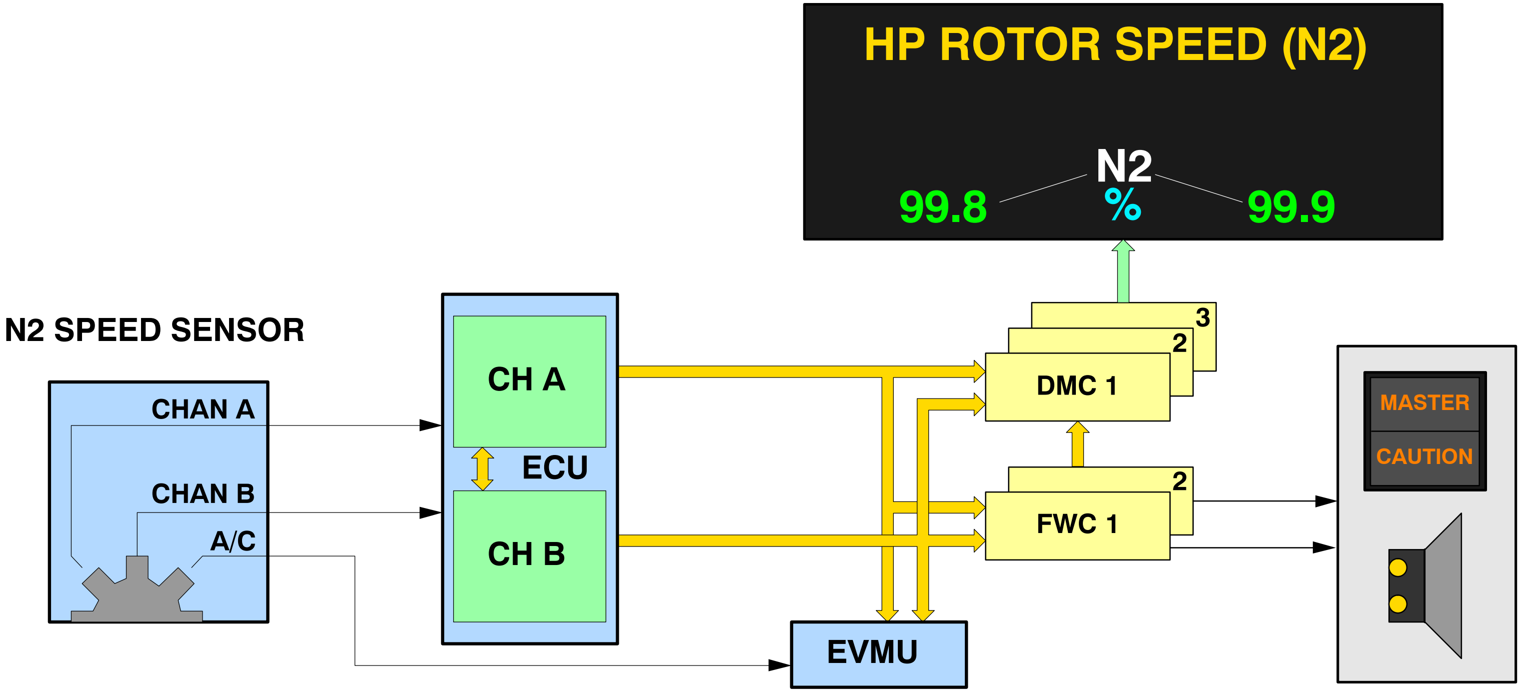


Figure 99 N2 Speed Indication

77-20 TEMPERATURE

EGT INDICATION OPERATION

The Exhaust Gas Temperature (EGT) is the temperature of the gas at the inlet to the Low Pressure Turbine (LPT). Nine thermocouple probes installed in the LPT stage 2 nozzle guide vanes generate an electrical voltage proportional to the temperature. The signal is transmitted to the cockpit to be displayed on the upper ECAM screen.

The T49.5 Thermocouple Wiring Harness consists of:

- three identical and interchangeable Thermocouple Lead Assemblies with two probes
- one Thermocouple Lead Assembly with three probes
- one Upper Extension Lead
- one Lower Extension Lead
- one Main Junction Box

The EGT indication appears on the upper display unit of the ECAM system. The ECAM provides the EGT indication in analog form through a pointer which deflects in front of a dial and in digital form, in the lower section of the dial.

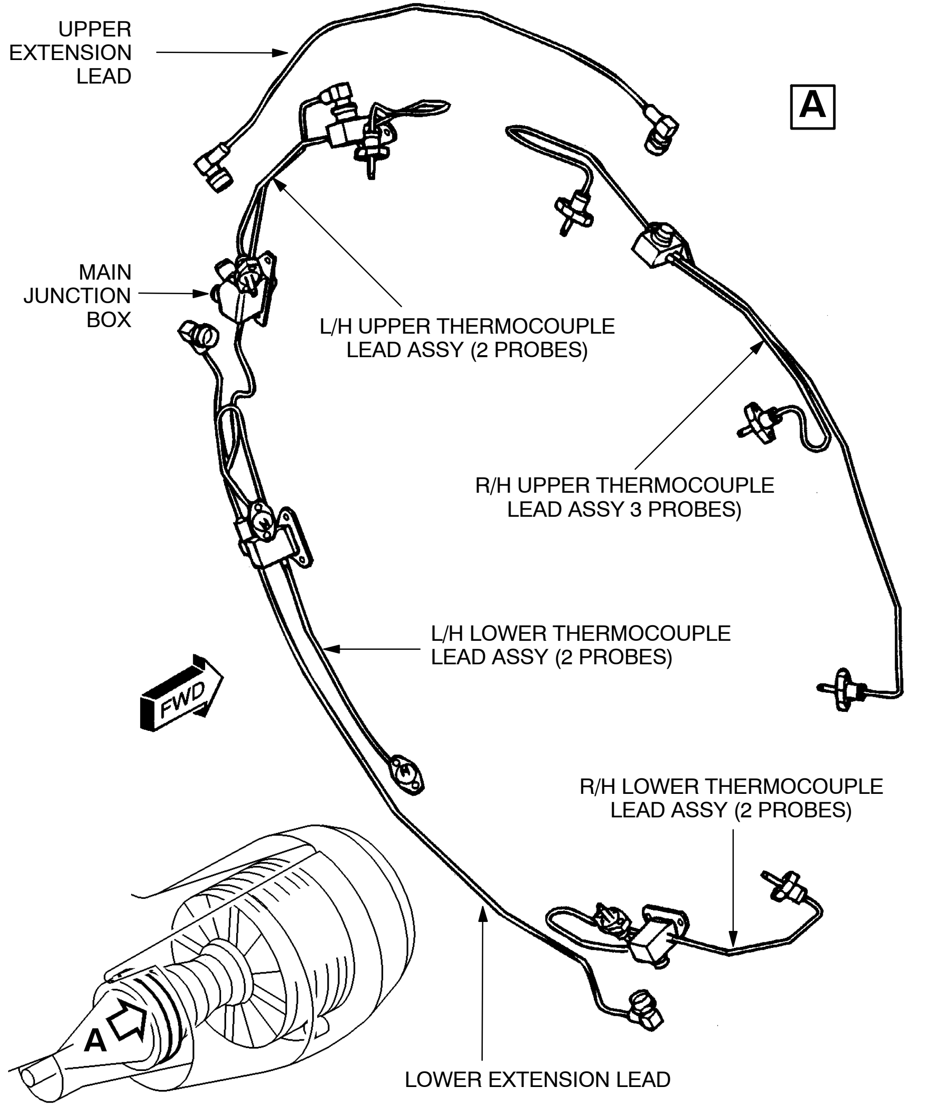


Figure 100 Thermocouple Wiring Harness

ACTUAL EGT: NORMALLY GREEN.

POINTER PULSES AMBER AND NUMERIC VALUE IS GREEN WHEN EGT IS HIGHER THAN 855.C, OR 725.C DURING THE ENGINE START SEQUENCE.
BOTH PULSE RED WHEN EGT EXCEEDS 915 C.

MAX EGT (AMBER INDEX): 725.C AT ENGINE START THEN 855°C (MCT).

EGT EXCEEDANCE (RED INDEX): IF 915 C IS EXCEEDED, A RED MARK APPEARS AT THE MAX VALUE ACHIEVED. IT WILL DISAPPEAR AFTER A NEW ENGINE START OR AFTER MAINTENANCE ACTION THROUGH THE MCDU.

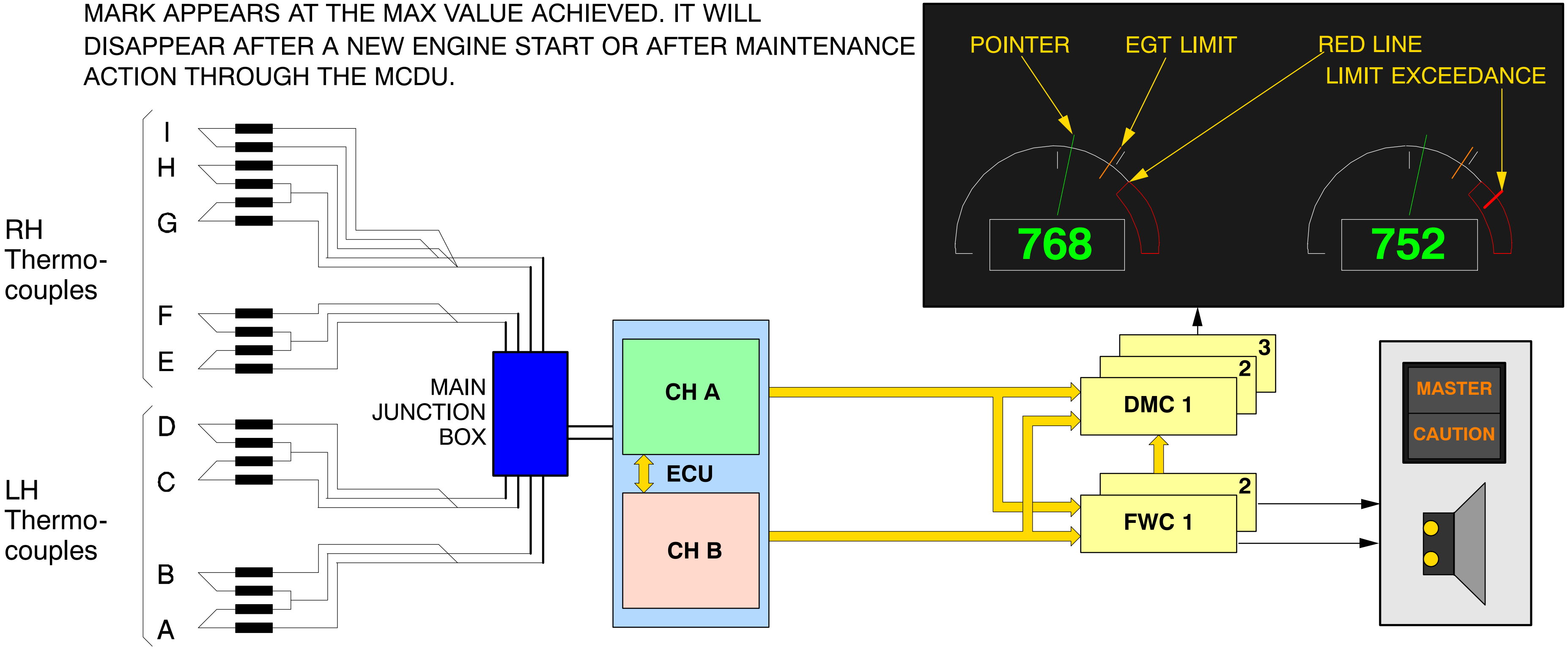


Figure 101 EGT Indication

MAX POINTER RESET OPERATION

Engine Parameters Monitoring

N1 , N2, EGT, and FF indications of both engines are monitored internally and externally. The DMC compares the N1 signal received from the ECU 1 with the feedback signal which reflects the displayed position of the N1 needle.

In order to grant dissimilarity with the engine 2 monitoring process the DMC compares the N1 signal from the ECU 2 with the feedback signal representing the N1 digital value.

The same applies to the EGT parameters indications, but with the displayed position of the engine 2 EGT needle and the engine 1 EGT digital feedback value.

As for the N2 and FF parameters, the DMC compares the direct signal from the ECU with the displayed digital value. In case of detected discrepancy, a CHECK amber message is displayed just below the relevant parameter indication.

In addition the FWCs perform an external monitoring between the feedback signals that correspond to the displayed values and the signals that are directly received by the FWCs from the ECUs

Should a discrepancy occur, for one or more parameters, a CHECK amber message is displayed under the relevant indication.

The FWCs generate a caution

- Single Chime (SC)
- Master Caution Light
- Upper ECAM Display Unit Message:
  ENG 1 (2) N1(N2/EGT/FF) DISCREPANCY

Max Pointer Reset (N1, N2 & EGT)

The Max pointers for N1, N2 and EGT can be reset using the CFDS menu INSTRUMENTS. The menu for the EIS 1,2,3, (DMC 1,2,3) must be selected. The memory cells which store the possible exceedance are reset either by pressing the GENERAL RESET line key or automatically at the subsequent engine start.

Engine Red Line Exceedance Read Out and Reset

The DMC connected to the upper ECAM DU monitors primary parameter indications of both engines.

Should an exceedance occur, the DMC memorizes in its BITE memory the maximum value reached during the Last Flight Leg.

The values of the N1, N2, EGT red lines and transitory over limit values are stored in 2 independent tables, one per engine.

Read out of this engine parameter exceedance can be performed via the DMC MCDU menu. With the function engines the parameters can be selected either for engine 1 or 2.

NOTE: Reset of the red line limits have to be performed on all three DMCs.

NOTE: Depending on FADEC software modifications the red line limit reset may be performed also via the FADEC menu (see 73-21)

N1 Red Line Exceedance

The N1 red line is represented by an arc shaped red ribbon situated at the end of the scale.

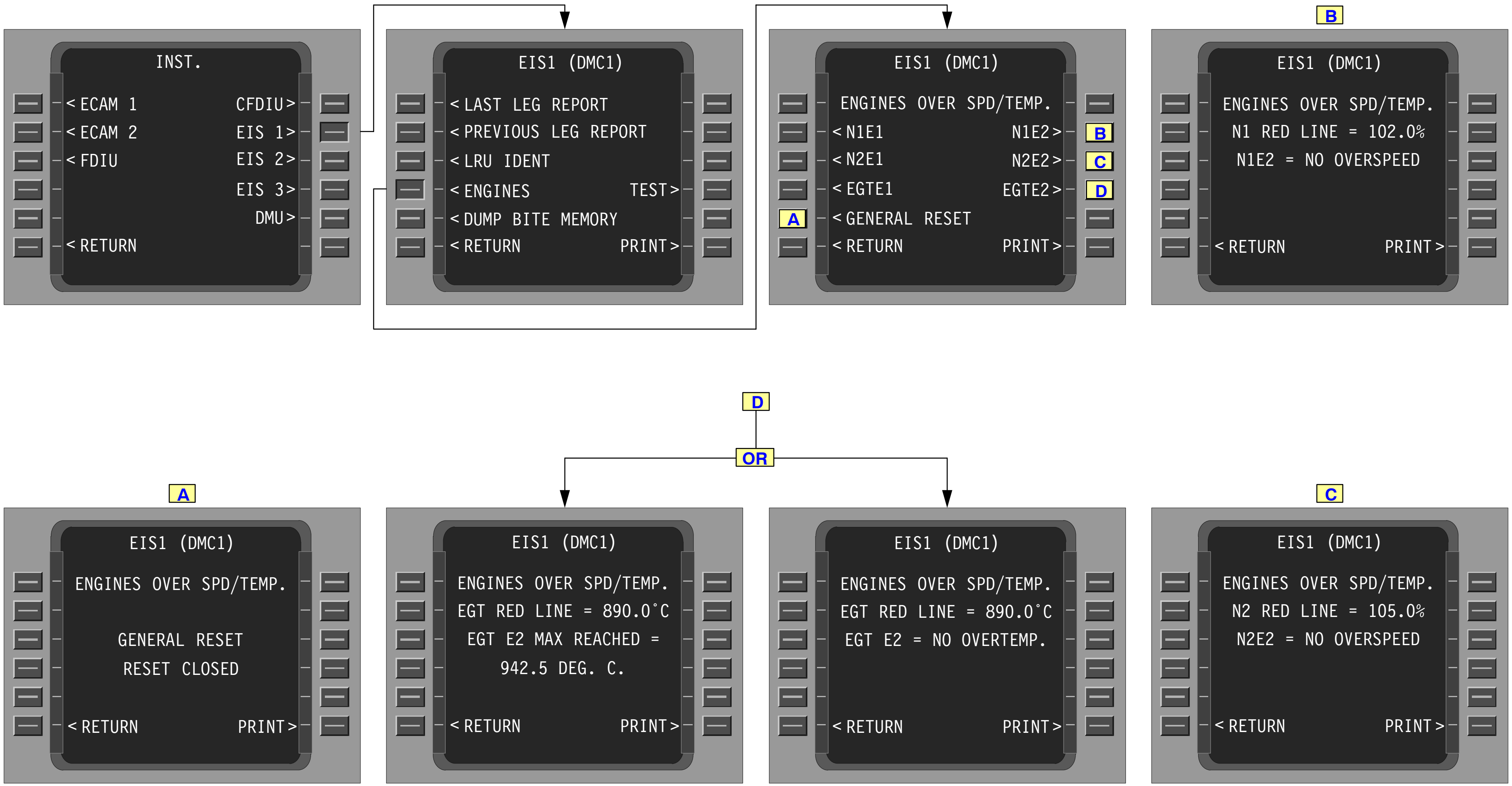
If the N1 actual value exceeds the N1 red line (even for a short period of time), a small red line appears across the N1 scale and then stays at the maximum value which has been reached. This indicates a N1 exceedance condition. Should this condition occur, the small red line disappears only after a new take-off or after a maintenance action through the MCDU DMC reset.

N2 Red Line Exceedance

The N2 indications are displayed in digital form only. 100% N2 correspond to 14460 RPM. Should N2 actual exceeds the N2 red line value, a red cross appears next to the digital indication. This red cross disappears only after a new take off or a DMC reset.

EGT Red Line Exceedance

The EGT indications are provided in the same form as for the N1 indications. The same applies to changes in color and EGT exceeding indications. However it has to be noticed that the amber line (EGT MAX) is variable: 725 °C at engine start and 855 °C afterwards. Red line limit is 890 °C.



NOTE: **According to the AMM the GENERAL RESET must be done with all three DMCs!**
(TASK 77–00–00–710–040)

Figure 102 Max Pointer Reset (Classic EIS)

77–30 ANALYZERS

ENGINE VIBRATION MONITORING DESCRIPTION

General

The purpose of the engine vibration monitoring system is to provide a cockpit indication of the state of balance of the engine main rotating assemblies during steady state running conditions. This information can alert operators to existing or impending engine problems and assist in planning engine removal, with minimum disruption to aircraft operation.

The Engine Vibration Monitoring System comprises:

- two Transducers (piezoelectric accelerometers)
- an Engine Vibration Monitoring Unit
- two vibration indications N1 and N2

The engine vibration system provides the following functions:

- vibration indication due to rotor unbalance via N1 and N2 slaved tracking filters
- excess vibration (above advisory levels)
- fan balancing (phase and displacement)
- shaft speed (N1 and N2)
- storage of balancing data
- initial values acquisition on request
- BITE and MCDU communication
- accelerometer selection
- frequency analysis when the printer is available (option).

Accelerometers

Two accelerometers installed on each engine permit N1 and N2 vibrations to be measured. The first is fitted on the number 1 bearing, the second on the turbine rear frame.

- Number 1 bearing accelerometer, normal pick-up, provides N1 and N2 vibration frequencies.
- The turbine rear frame (TRF) accelerometer is in standby and also used with the first to analyze results for engine balancing.

No. 1 Bearing Vibration Sensor

The No. 1 bearing vibration sensor (piezo-electric type) permanently monitors the vibrations from No. 1 bearing. It also senses vibrations from LPT and HPT shafts,though it is less sensitive to LPT and HPT shaft vibrations. It is also used for trim balance operations. The accelerometer part of the vibration sensor is located at the 9:00 o'clock position on No. 1 and No. 2 bearing support (near No. 1 bearing). The sensor cable is routed through the fan frame. It comes out at the 3:00 o'clock position on fan frame mid-box structure aft face.

NOTE: The No 1 bearing accelerometer is not a LRU. It can not be changed on line maintenance. It can only be changed when the fan module is removed in the shop.

Turbine Rear Frame Vibration Sensor

The Turbine Rear Frame (TRF) vibration sensor is used in conjunction with the No. 1 bearing vibration sensor to monitor and, if necessary, reduce the engine vibration level using the trim balance procedure. The vibration signal is used by the aircraft Engine Vibration Monitoring Unit (EVMU).

The TRF vibration sensor is installed at 12 o'clock (ALF) on the front flange of the turbine rear frame. It consists in a hermetically sealed housing that encloses the sensing element. A flange with two holes is used to attach the housing to the engine. One electrical connector at the end of semi-rigid cable provides the interface with an aircraft harness.

Engine Vibration Monitoring Unit (EVMU)

The Engine Vibration Monitoring Unit (EVMU) is located in the avionics compartment shelf 86VU. The EVMU has 2 channel modules. Each channel module processes the signals from the two engine accelerometers and from the two speed signals N1 and N2, this enables extraction from the overall vibration signal, of a component due to rotor unbalance. Only one accelerometer is used at a time. The second accelerometer is selected manually via MCDU Reconfiguration Menu or automatically at the next power up due to a failure of the N1 Vibration Sensor. The N1 and N2 signals are used to drive the tracking filters, and slave their center frequencies at the shaft rotational speed. The accelerometer signals pass through these tracking filters which extract the N1 and N2 related fundamental vibration. The acceleration signal is then integrated in order to express the vibration in velocity terms.

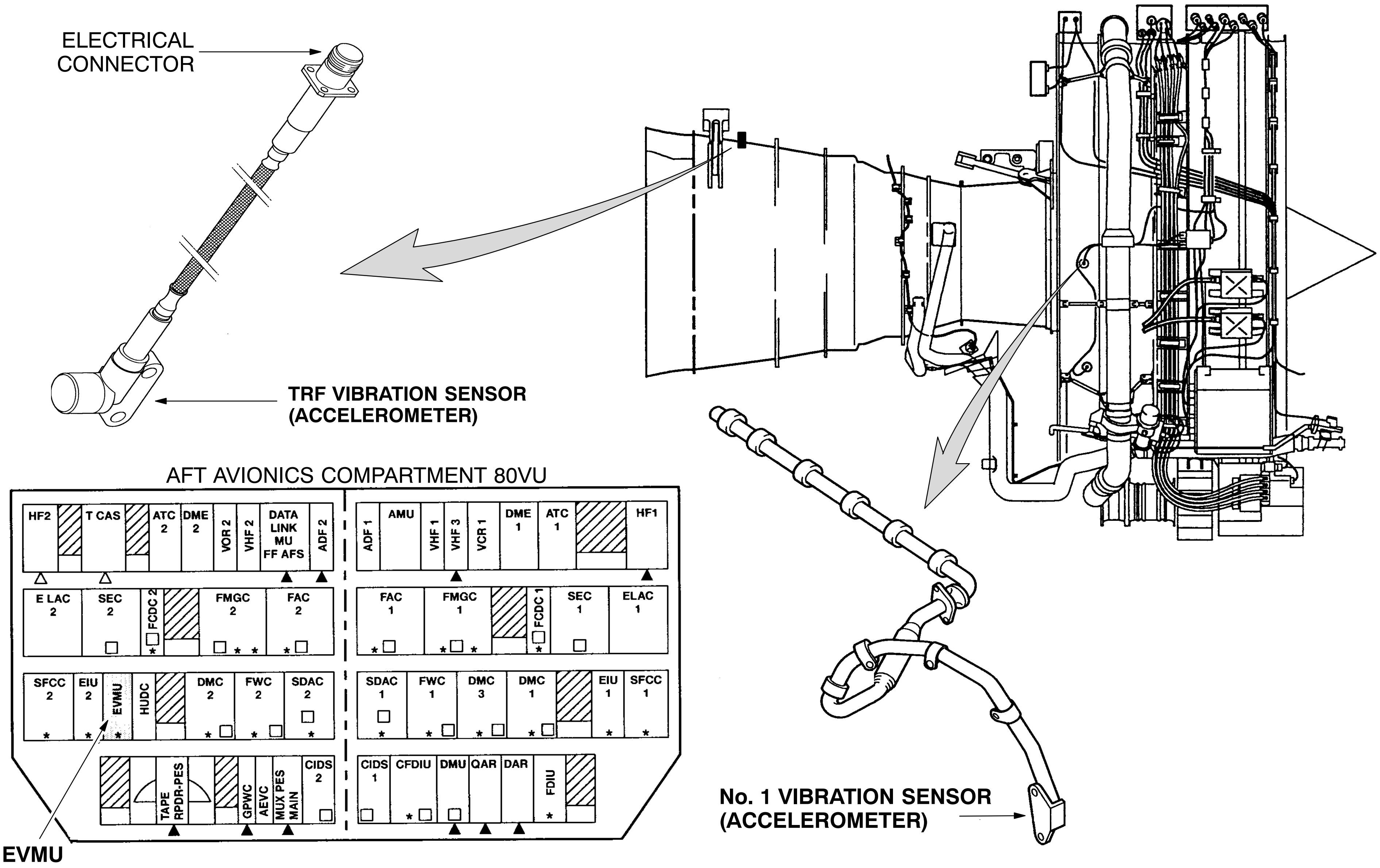


Figure 103 Vibration Sensors

77–32 ENGINE VIBRATION INDICATING SYSTEM

DESCRIPTION

Engine Vibration Monitoring Unit

An engine vibration monitoring unit monitors the N1 and N2 levels of both engines.

The EVMU receives analog signals from:

- the 4 engine accelerometers (2 per engine)
- the N1 and N2 speed sensors of each engine

It also receives digital input from CFDS through ARINC 429 data bus. The EVMU sends signals through the digital ARINC 429 data bus to:

- SDAC1 and 2 for cockpit indication
- the CFDIU
- the DMU
- and printer (if installed) for maintenance purposes

BITE System

The EVMU contains a BITE System (Built In Test Equipment) to detect internal and external failure during power up and internal cyclic sequence. Any detected failure is stored in the non–volatile memory with GMT,date and other reference parameters.

Interfaces

The EVMU interfaces with the ECAM and the CFDS (for maintenance fault messages).

VIBRATION INDICATION

The N1 and N2 vibrations of the left and right engines are displayed on the engine and cruise pages. Displayed values are up to 10 units range.

1 Unit = 0.3 inch/sec

1 MIL = 1/1000 inch

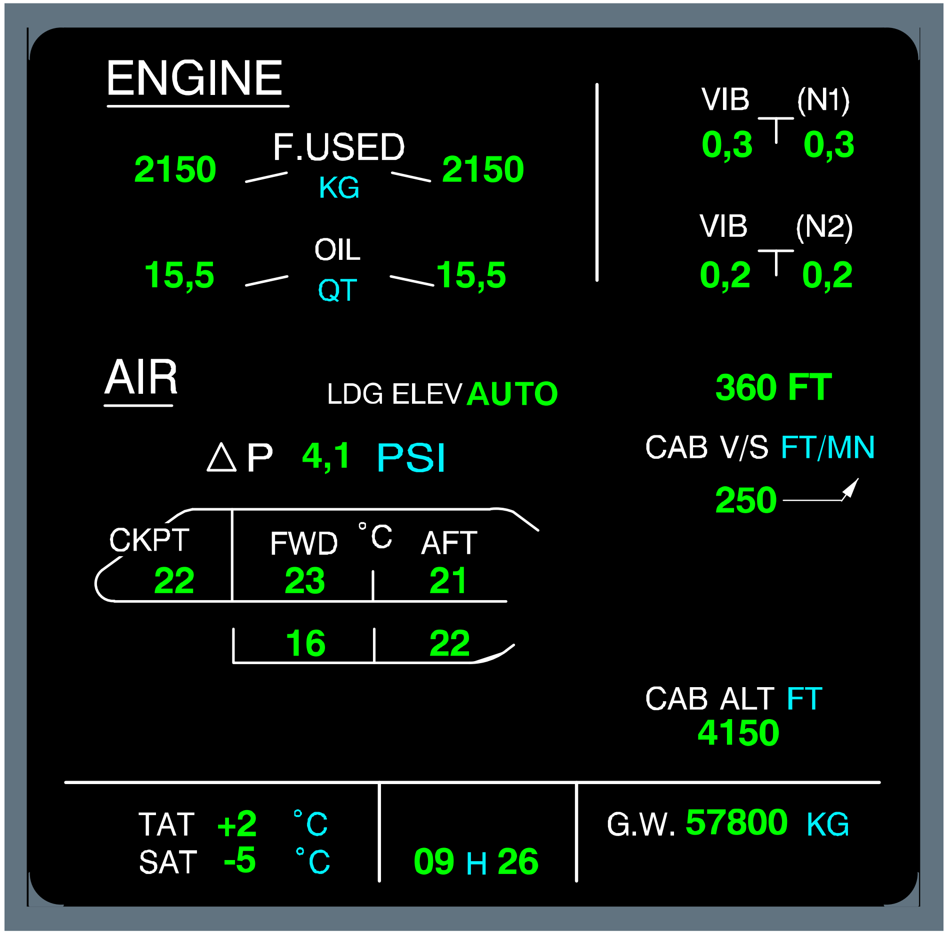


Figure 104 Cruise Page

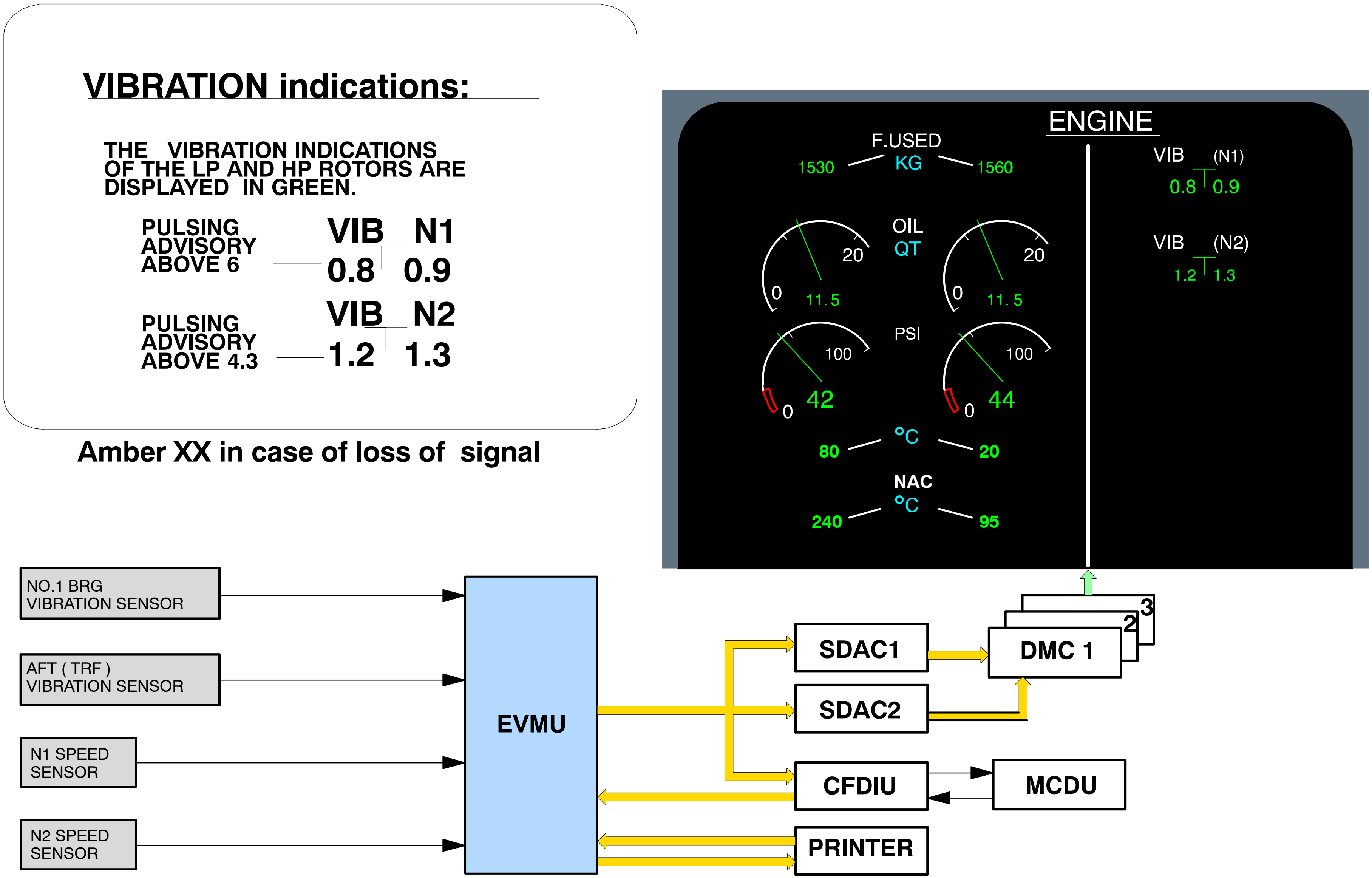


Figure 105 Vibration Indication

CFDS INTERFACE DESCRIPTION

The Centralized Fault Data System (CFDS) enables access to the systems. The CFDS gives, maintenance information and initiates tests through the system BITE.

When the maintenance personnel needs information on the condition of the EVMU, the CFDS operates in menu mode. The first menu sent to the MCDU is the main menu. The various functions are detailed here after.

Last Leg Report

The EVMU sends the list of the LRUs which have been detected faulty during the last leg. During the flight the following faults can be detected :

- EVMU
- N1 SPEED SENSOR, L
- N1 SPEED SENSOR, R
- N2 SPEED SENSOR, L
- N2 SPEED SENSOR, R

Previous Leg Report

The EVMU sends the list of the LRUs which have been detected faulty during the legs (maximum 62) previous to the last leg. The faults detected are the same as for the last leg report.

LRU Identification

The EVMU sends the part number.

Ground Failures

The EVMU sends the list of the LRUs which have been detected faulty during a ground test. Only the three last detected failures are displayed. The following LRUs are tested:

- EVMU
- N1 BEAR VIB SENSOR, L
- N1 BEAR VIB SENSOR, R
- TRF VIB SENSOR, L
- TRF VIB SENSOR, R

Test

The test item allows initiation of a complete check of the EVM system. If no failure has been detected, the message ”TEST OK” is displayed. If any failure has been detected the failed LRU is displayed. Checked LRUs are the ones listed in ”Ground failures” item.

Accelerometer Reconfiguration

This menu allows selection of the accelerometer (Fan No. 1 bearing or TRF) to be used for the next flights. The EVMU also indicates which accelerometer is in operation.

Engine Unbalance

This menu allows selection, per engine, of five different engine speeds (from 50 % to 100 % N1 RPM), at which unbalance data will be stored. It also permits reading of the unbalance data which were acquired during the previous command and to effectuate balancing for both engines with both accelerometers. The EVMU measures the position and the amplitude of the rotor unbalance of each engine. It provides these information to the output bus when available.

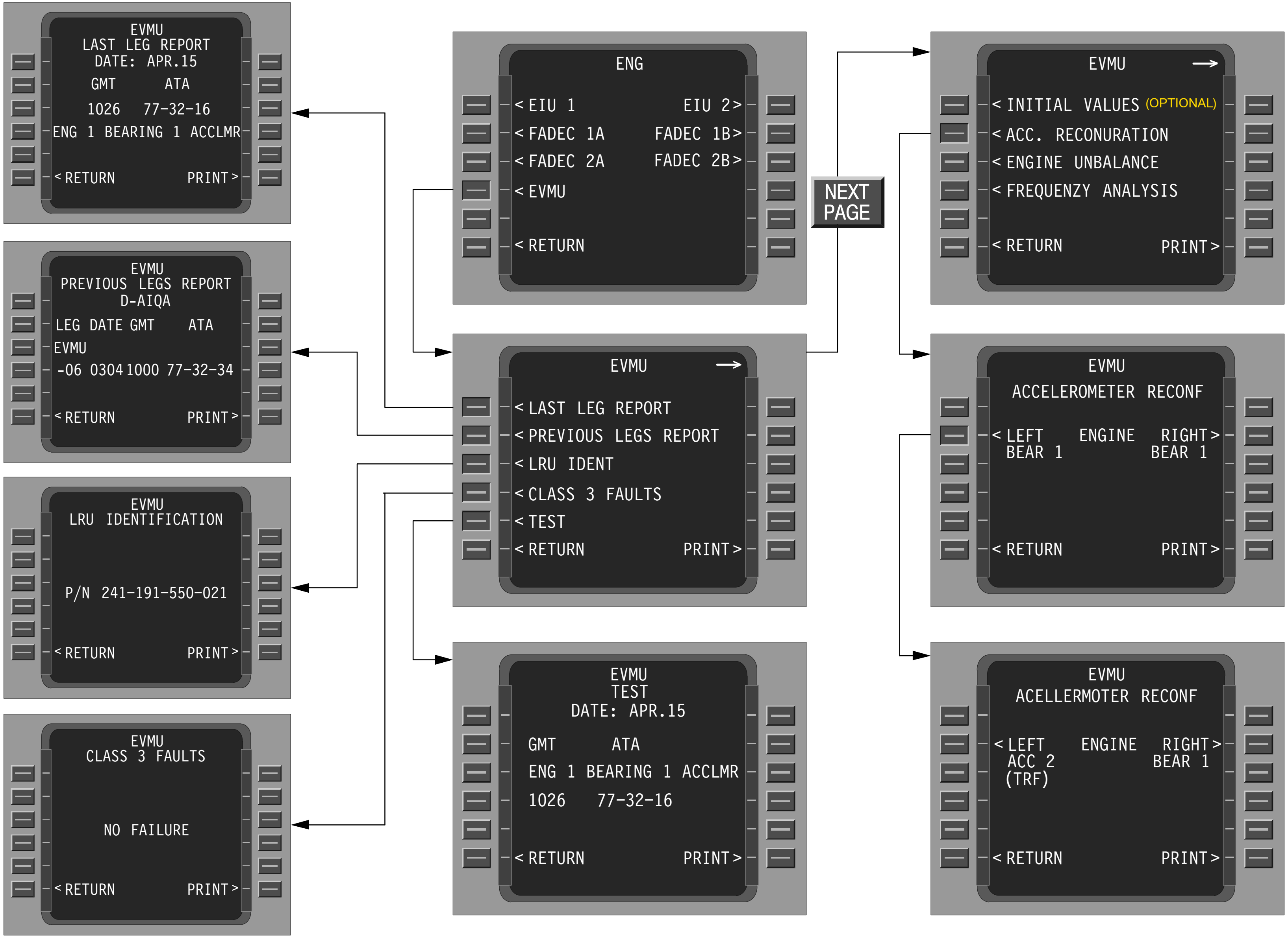


Figure 106 MCDU EVMU Menu

AIDS ENGINE RPORTS DESCRIPTION

AIDS Reports

A report is a comprehensive set of data related to a specific event (e.g. limit exceedance of engine parameters). The parameters contained in the reports are among the parameters provided with an alpha call−up (refer to Aircraft Maintenance Manual 31−37−00 for the detailed parameter list associated to each report).

The Data Management Unit (DMU) processes up to 23 different types of reports:

- 13 standard reports for basic aircraft, engine and APU monitoring.

  These reports have fixed trigger mechanism, fixed data collection and fixed output formatting. Nevertheless, certain constants and limits within fixed trigger logics are reprogrammable. Specific trigger conditions can be created for each report by means of the Ground Support Equipment (GSE).
- Up to 10 additional reports, numbered from 31 to 40, for airline specific investigation and trouble shooting.

  These reports are user programmable with the GSE for trigger conditions, data collection, report format and output destination.

In addition to the automatic trigger logics, all the reports can be manually generated:

- via MCDU,
- via Aircraft Integrated Data System (AIDS) PRINT P/B (according to flight phase associations, if programmed),
- via Air Traffic Service Unit (ATSU) (uplink request). Refer to AMM 31−37−00 for the detailed trigger logics associated to each report.

A non−volatile memory for storage of at least 10 reports per different type of report is provided within the DMU.

EVMU Data on AIDS Reports

Vibration data is provided to the Aircraft Integrated Data System (AIDS), which is used to monitor aircraft and engine parameters.

It allows maintenance staff to perform engine parameter trend monitoring and troubleshooting.

The vibration information is printed on various reports, which are:

- Engine Cruise Report <01>
- Cruise Performance Report <02>
- Engine Take−Off Report <04>
- Engine On−Request Report <05>
- Engine Mechanical Advisory Report <07>
- Engine Run−Up Report <11>

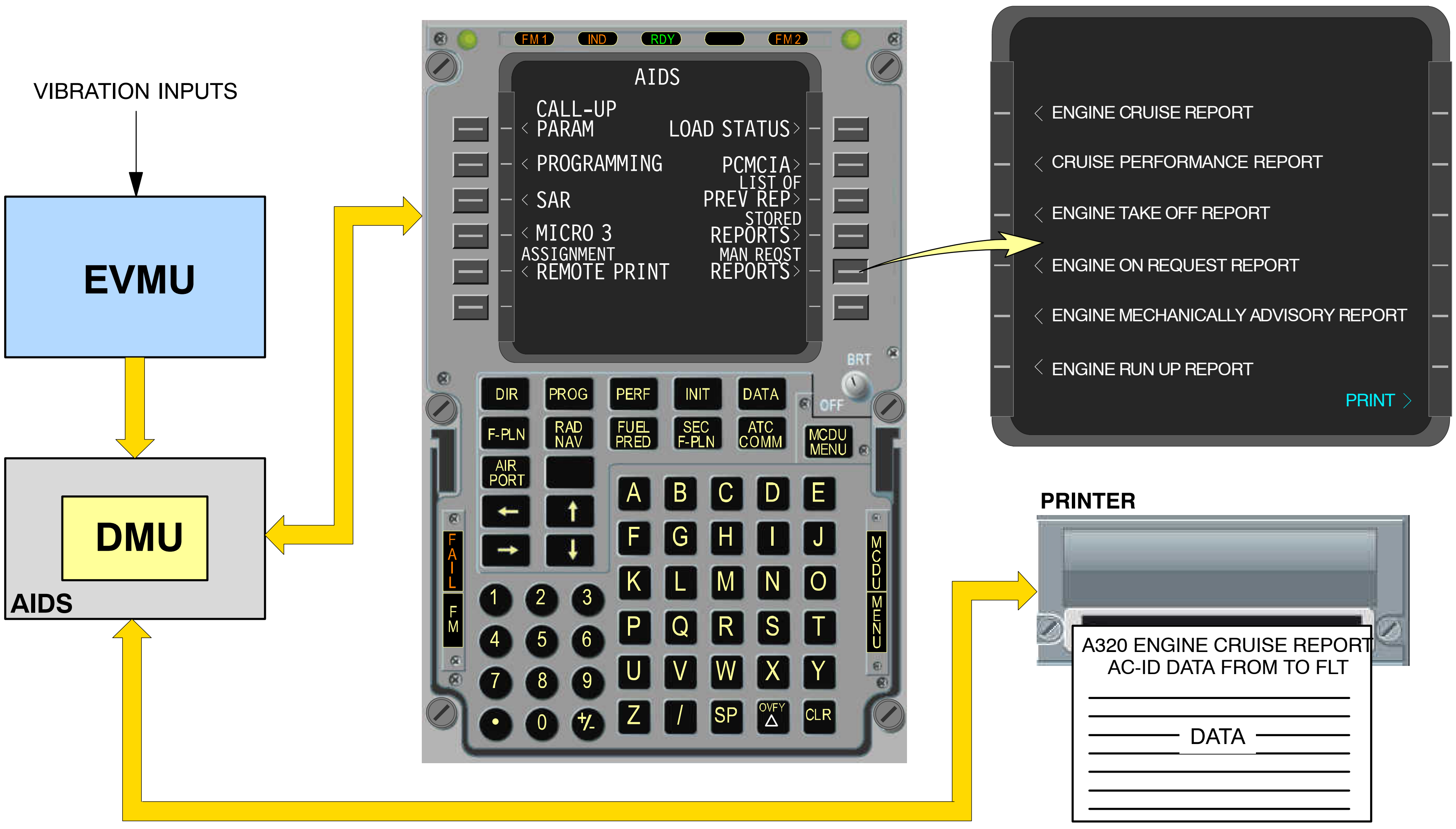


Figure 107 AIDS Reports

ATA 73 ENGINE FUEL AND CONTROL

73–20 CONTROLLING

CONTROLLING INTRODUCTION

General

The **F**ull **A**uthority **D**igital **E**ngine **C**ontrol system (FADEC) controls the engine and provides full range control to achieve steady state and transient performance when operated in combination with aircraft subsystems.

Thus the FADEC serves as an interface between the aircraft and the engine control and monitoring components.

The FADEC system of each engine consists of a dual channel **E**lectronic **C**ontrol **U**nit (ECU), with its associated peripherals. It is located on the engine fan case at 4:00 o'clock position.

Full Authority Digital Engine Control

The FADEC system consists of a dual channel Engine Electronic Control Unit and the peripherals that follow:

- Hydromechanical Unit (HMU)
- Dedicated ECU Alternator (PMA)
- VSV and VBV, HPTACC, LPTACC, RACC systems
- Start System
- T/R System
- Oil/Fuel Temperature Control
- Engine Sensors
- Electrical Harness
- ECU Cooling

Engine/Aircraft Integration

Engine/Aircraft integration includes:

- Thrust reverser control
- Auto Thrust
- Automatic and manual starting
- Engine indication
- Engine maintenance data
- Condition monitoring data

Power Supply

The FADEC system is self–powered by a dedicated permanent magnet alternator when N2 is above 15%, and is powered by the aircraft for starting, as a backup and for testing with engine not running.

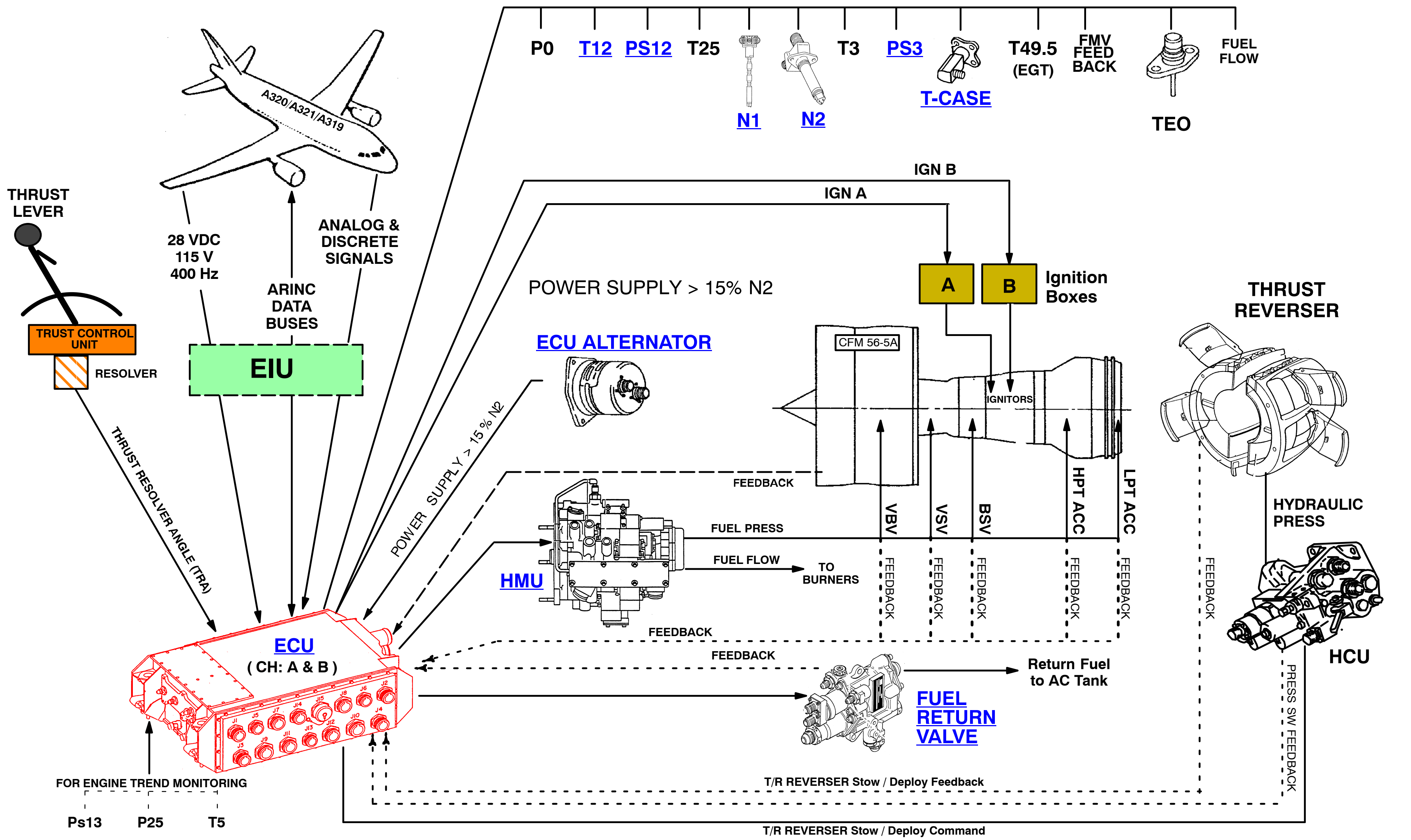


Figure 108 FADEC Presentation

FADEC ARCHITECTURE DESCRIPTION

Dual Channel Control

The Full Authority Digital Engine Control (FADEC) system is fully redundant and built around two independent Electronic Control Unit (ECU) control channels.

Dual inputs, dual outputs, and automatic switch over from one channel to the other, eliminates any dormant failure. The ECU consists of two channels (A and B). Each channel can control the different components of the engine systems. Channels A and B are permanently operational. The channel in control manages the systems.

Dual Inputs

All control inputs to the FADEC system are dual. Only some secondary parameters used for monitoring and indicating are single. To increase the fault tolerant design, the parameters are exchanged between the two control channels (inside the ECU) via the cross channel data link. Each channel can also operate independently, without cross channel data link.

Hardwired Inputs

Most of the communication between the A/C systems and the ECU is transmitted over digital data buses. In addition, some signals are hardwired directly from the A/C to the ECU.

Dual Outputs

All of the ECU control outputs are dual. The channel that is in control supplies the control signals to the various components such as torque motors and solenoids. The other channel calculation is used for cross-checking.

Built In Test Equipment (BITE) Capability

The ECU is equipped with a Built-in Test Equipment (BITE) system which provides maintenance information and test capabilities via the MCDU.

Fault Strategy

The ECU can detect and isolate failures using the BITE system. The BITE system allows the ECU to switch engine control functions from a faulty channel to the healthy one.

Fail Safe Control

If one channel is faulty, and the channel that is in control cannot ensure an engine component function, the component is moved to a fail-safe position. Example: if one channel is faulty and the other channel is unable to control the Variable Bleed Valve (VBV) position, the VBVs are set to the fail-safe open position.

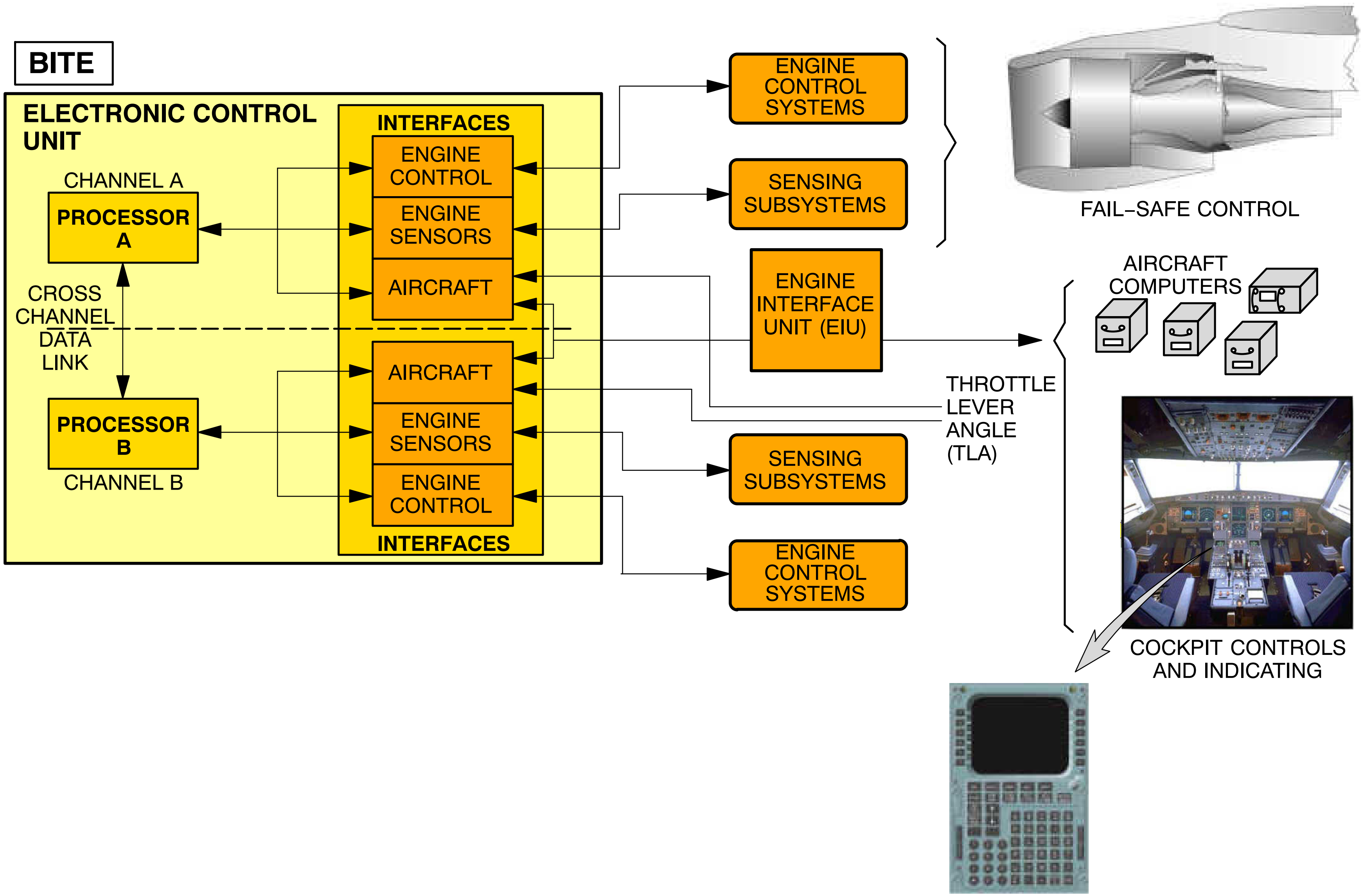


Figure 109 FADEC Architecture

FADEC PRINCIPLE DESCRIPTION

General

The Full Authority Digital Engine Control (FADEC) system manages the engine thrust and optimizes the performance.

FADEC

The FADEC consists of the Electronic Control Unit (ECU) and its peripheral components and sensors used for control and monitoring. The ECU interfaces with the other A/C systems through the Engine Interface Unit (EIU). The primary parameters (N1, N2, Exhaust Gas Temperature (EGT), Fuel Flow (FF), Fuel Temp) are sent directly by the ECU to the ECAM. The secondary parameters are sent to the ECAM through the EIU.

Engine Interface Unit

Each EIU, located in the avionics bay, is an interface concentrator between the airframe and the corresponding ECU located on the engine. There is one EIU for each engine. It interfaces with the corresponding ECU.

Power Management

The FADEC provides automatic engine thrust control and thrust parameter limit computation. The FADEC manages power according to two thrust modes:

- Manual mode depending on Throttle Lever Angle (TLA)
- Auto Thrust Mode depending on auto thrust function generated by the Auto Flight System (AFS).

The FADEC also provides two idle mode selections: minimum idle and approach idle, obtained when the slats are extended. The idle can also be modulated up to approach idle depending on: air conditioning demand, wing anti−ice demand, engine anti−ice demand and oil temperature (for Integrated Drive Generator (IDG) cooling).

Engine Limit Protection

The FADEC provides overspeed protection for N1 and N2, in order to prevent the engine from exceeding certified limits and also monitors the EGT.

Engine System Control

The FADEC provides optimal engine operation by controlling:

- Fuel Flow
- Turbine Clearance and Compressor Airflow

Starting and Ignition Control

The FADEC controls the engine start sequence. It monitors N1, N2, and EGT parameters and can abort or recycle an engine start. The FADEC controls the starting and ignition in automatic mode when initiated from the ENG start panel (115 VU) or manual mode when initiated from the ENG MAN START panel.

Thrust Reverser

The FADEC entirely supervises the thrust reverser operation. In case of malfunction, the thrust reverser is stowed.

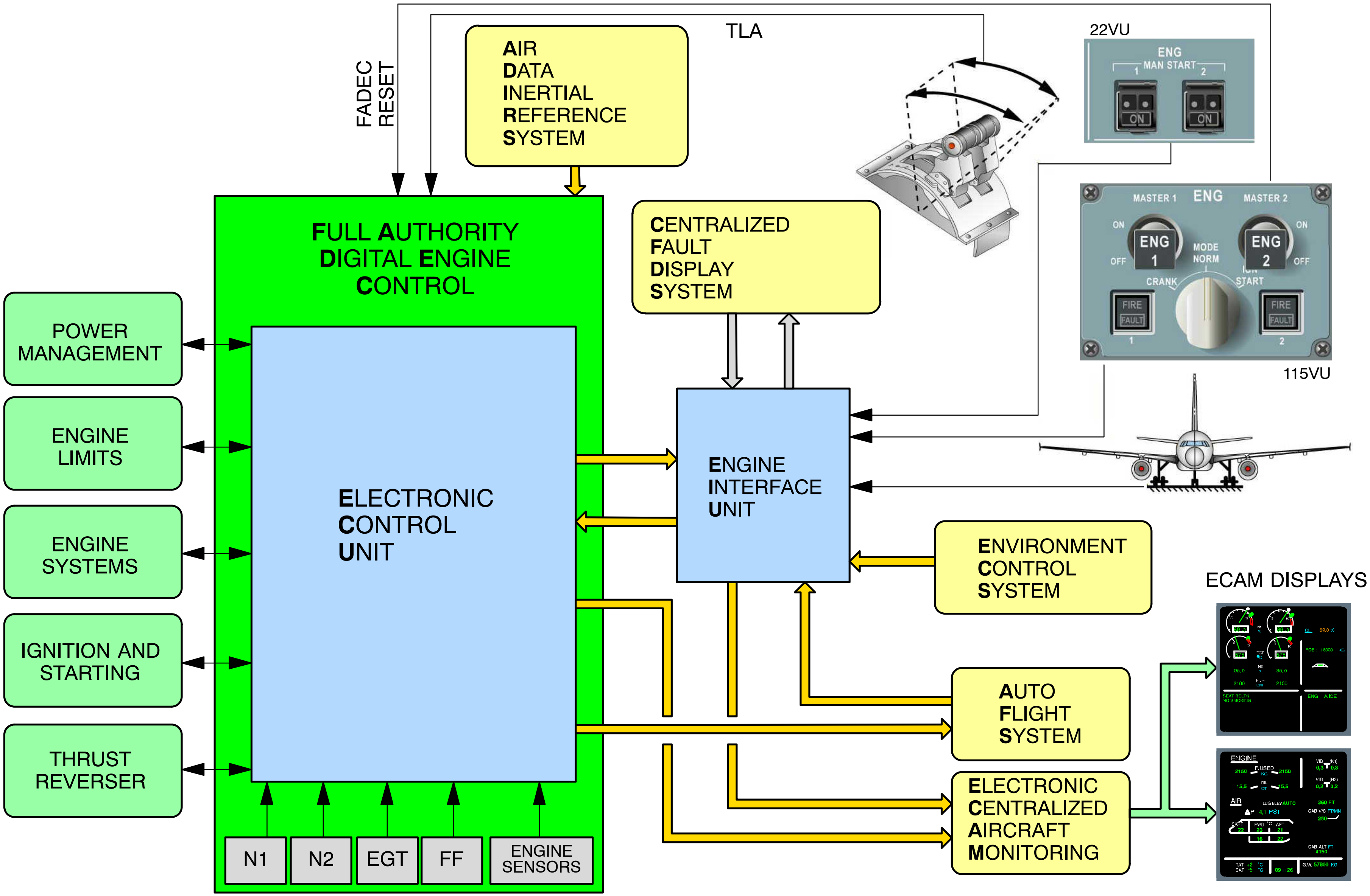


Figure 110 FADEC Principle

03|73–20|Princ|5A|L2/B1/B2

73–25 FUNCTIONAL INTERFACES

DESCRIPTION

General

The FADEC system which is composed of the **E**lectronic **C**ontrol **U**nit and its engine periphery interfaces with various aircraft functional interfaces. The main connective link between the aircraft and the FADEC system is the **E**ngine **I**nterface **U**nit.

The purpose of the EIU is to receive aircraft signals and system data to provide the FADEC system with necessary informations for safe engine operation. System data and aircraft commands are transmitted digital or as descrete and analog signals through the EIU or directly to the ECU.

The EIU also receives engine secondary parameter data from the ECU control and monitoring sensors for cockpit indication.

Engine primary parameters are provided from the ECU through the Electronic Centralized Aircraft Monitoring system to the E/WD and to the Digital Flight Data Recorder System.

Aircraft Commands

- Engine Master Switch
- Engine Mode Selector
- Engine Manual Start Pushbutton
- Wing/Engine Anti Ice Pushbutton Switch
- Throttle Control System (TLA/TRA)

System Data

- **L**anding **G**ear **C**ontrol and **I**nterface **U**nit
  - Air/Ground information and Engine Idle Control
- **S**poiler and **E**levator **C**omputer
  - Thrust Reverser Inhibition
- Slat/Flap Control Computer
  - Engine Idle Control
- **B**leed **M**onitoring **C**omputer
  - Engine Bleed Valve operation
- **E**nvironmental **C**ontrol **S**ystem
  - Bleed Status
- **C**entralized **F**ault **D**isplay **S**ystem
  - Engine data recording for maintenance purposes
- **A**ir **D**ata and **I**ntertial **R**eference **U**nit
  - Ambient conditions
- **A**uto **F**light **S**ystem
  - Auto Thrust Control

FADEC Processing

The Engine Electronic Control Unit uses aircraft commands signals and system data for:

- Power Management
- Engine Limit Protection
- Engine Control Systems
- Thrust Reverser Control
- Start/Ignition Control

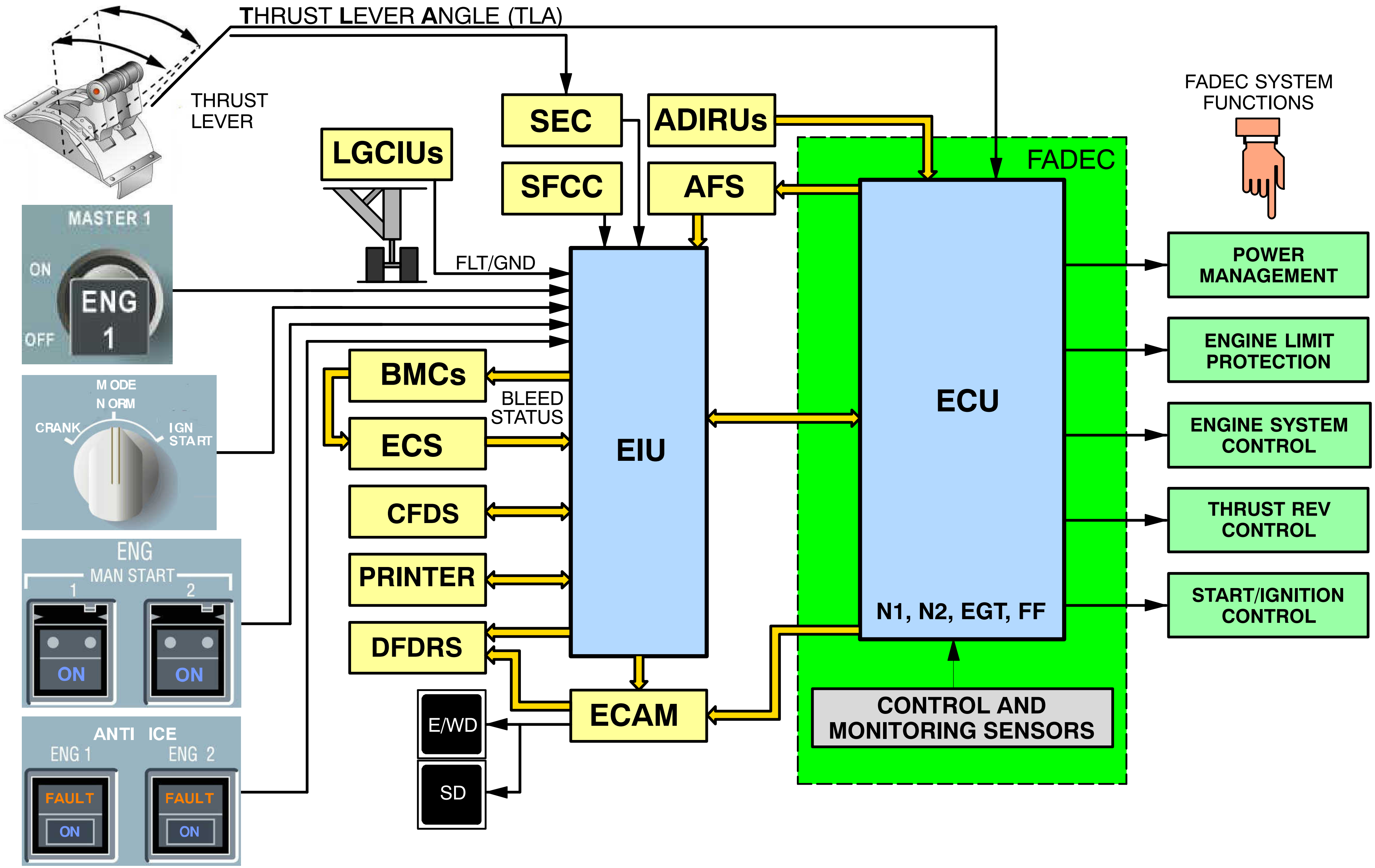


Figure 111 Engine/Aircraft Interface

ECU INTERFACES FUNCTIONAL OPERATION

General

The Electronic Control Unit (ECU) interfaces with various systems through channels A and B.

Power Supply

The ECU is designed to operate with the engine not running, the ECU is operational 2 to 3 seconds after it is electrically powered by 28VDC aircraft electrical network through the ENG/FADEC GND PWR pushbutton switch. The ECU is electrically powered by the aircraft electrical network through the EIU.

The 28VDC permits:

- automatic ground check of the FADEC before engine running,
- engine starting,
- powering the ECU while engine is running below 15 percent N2.

As son engine is running above 15 percent N2 the FADEC automatically switches from aircraft electrical network power to the engine alternator power supply.

After engine shut down the ECU is powered by the aircraft 28 VDC network for 5 minutes to allow the engine parameters monitoring.

Channel A and B 28VDC power inputs are independent. Faults propagation between 28VDC and FADEC alternator inputs within each channel is prevented by design.

NOTE: Depending on engine version the ECU is already supplied from the alternator when N2 is above 12%.

The 115 VAC power supply is dedicated to the ignition exciters.

ECU Channel A Inputs

Channel A receives via bus network:

- the anemometric parameters for thrust calculation from the Air Data Inertial Reference System (ADIRS)
- The A/C command signals from the Engine Interface Unit (EIU) for engine control.

Each ECU receives a single hardwired signal from the instinctive disconnect push buttons. The Throttle Control Unit sends the Throttle Resolver Angle (TRA). Each ECU also receives signals from engine sensors.

NOTE: The relationship between the Throttle Lever Angle (TLA) and TRA is linear.

ECU Channel B Inputs

Channel B has the same inputs as channel A from the ADIRS, EIU, Throttle Control Unit, Auto Thrust disconnect switches and engine sensors.

ECU Channel A Outputs

Channel A provides outputs via ARINC buses to the: EIU, Data Management Unit (DMU), Flight Warning Computers (FWCs), Display Management Computers (DMCs), Flight Management and Guidance Computers (FMGCs). Channel A also provides outputs to the engine controls (torque motors and solenoids).

ECU Cannel B Outputs

Channel B provides outputs via ARINC buses to the: EIU, FWCs, DMCs, and FMGC. It also provides outputs to the engine controls.

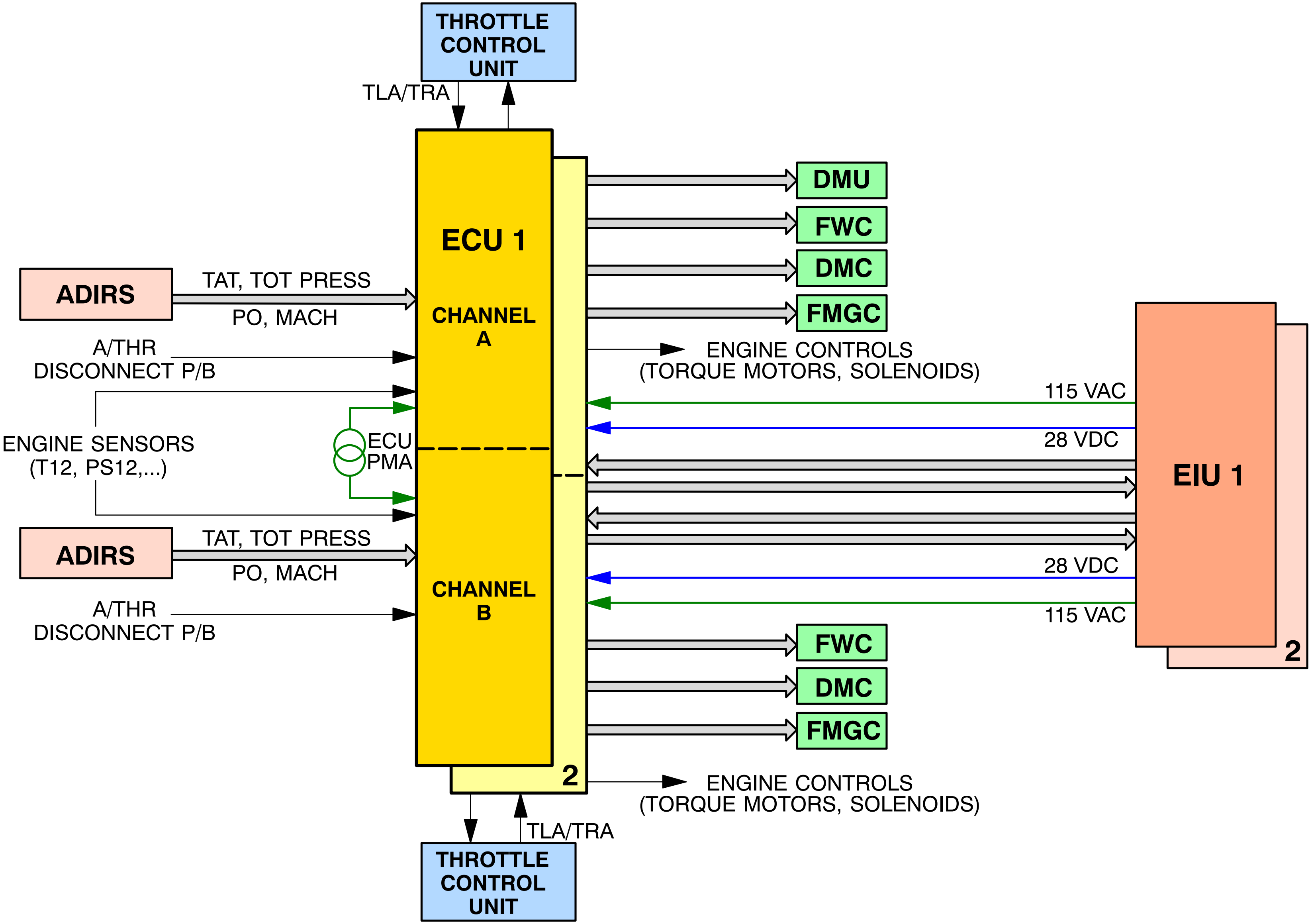


Figure 112 ECU Interfaces - Scheme 1

DISCRETE AND ANALOGUE INPUTS

Digital Inputs

The Engine Interface Unit (EIU) receives digital inputs from:

- the Centralized Fault Display Interface Unit (CFDIU) for engine troubleshooting and test
- the Zone Controller Controller for bleed air demands of the air conditioning system
- the Flight Control Unit (FCU) for the auto−thrust function

The EIU also receives data from each channel of the Electronic Control Unit (ECU).

Discrete Inputs

The EIU receives command signals from the following control panels:

- wing anti−ice
- engine anti−ice
- Full Authority Digital Engine Control (FADEC) ground power panel
- engine fire panel
- engine start panel
- Throttle Control Unit thrust reverser microswitch.

It also receives specific signals of A/C configuration from the following computers:

- Landing Gear Control Interface Unit (LGCIU)
- Slat and Flap Control Computer (SFCC)
- Fuel Level Sensing Control Unit (FLSCU)

Other discrete inputs are provided for the engine oil low pressure warning.

Analog Inputs

The EIU receives analog signals corresponding to values of secondary parameters from engine sensors, for display on the ECAM engine page.

DISCRETE AND ANALOG OUTPUTS

Digital Outputs

The EIU sends digital outputs to:

- the Bleed Monitoring Computer (BMC) for pneumatic valve operation
- the Flight Warning Computers (FWC) for alarms and indication
- the Centralized Fault Display Interface Unit, (CFDIU) for fault messages

Other digital outputs are sent to channel A and channel B of the ECU.

Discrete Outputs

The EIU provides the following discrete outputs to other A/C systems for some required commands and specific engine operations:

- start valve closure
- thrust reverser inhibition
- APU boost demand
- oil low pressure
- HP fuel Shut−off Valve (SOV) closed
- N2 at or above minimum idle
- Throttle Lever Angle (TLA) in takeoff position
- engine FAULT light on

Supply Module

The EIU contains a power supply module that is used to supply electrical power to the ECU and the ignition systems.

NOTE: If the EIU electrical power is lost, the EIU fails and engine restart is not possible.

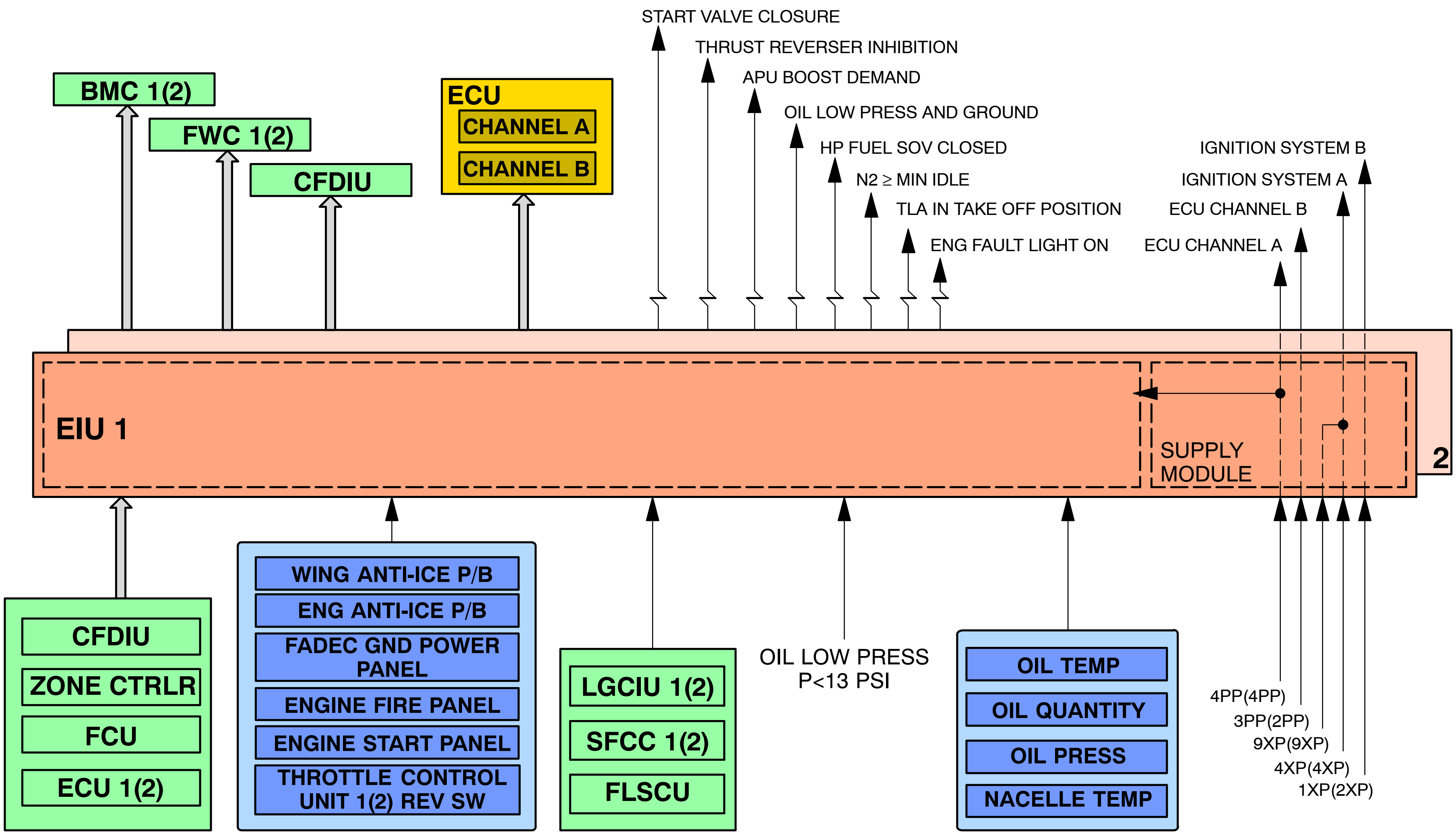


Figure 113 ECU Interfaces - Scheme 2

ECU INTERFACES OPERATION

General

The Engine Control Unit (ECU) is the computer of the FADEC system. The ECU consists of two channels (A and B) with a crosstalk. Each channel can control the different components of the engine systems.

The channels A and B are permanently operational. In case of failure on one channel, the system switches automatically to the other. During engine start the ECU is supplied with 28 VDC by the A/C network then by its own generator, mounted on the accessory gearbox, when N2 reaches 15%.

ECU Interfaces

The electronic control unit (ECU) is a dual channel digital electronic control with each channel utilizing a microprocessor for main control functions, a micro controller for pressure transducer interface functions and a micro controller for ARINC communication function.

The ECU receives engine inlet condition data from the aircraft Air Data Computers (ADCs) and operational commands from the Engine Interface Unit (EIU) in the aircraft on ARINC 429 data busses. It also receives operating condition data from the various dedicated engine sensors such as T12, PS12, P0, N1, N2, PS3, T25, T3 and TCase, and computes the necessary fuel flow, VSV, VBV, HPT clearance control, LPT clearance control valve positions.

The ECU provides the necessary current to the torque motors in the HMU to control the various modulating valves and actuators.

The ECU performs an On/Off control of the Ignition Relays, Starter Air Valve Solenoid, the Aircraft Thrust Reverser Directional Valve and the Thrust Reverser Pressurizing Valve.

The ECU provides digital data output in ARINC 429 format to the aircraft for engine parameter display, aircraft flight management system and the aircraft maintenance data system.

ECU hardware and software is designed so that the two channels operate normally with a set of internal inputs and outputs with access to cross channel data inputs. Each channel can also operate independently without cross channel data. Fault tolerance enables the engine to continue operation in the event any or all of the airframe digital data is lost.

The ECU is powered by a three-phase engine alternator. Aircraft power is required up to 15% N2 above which the alternator is able to self-power the unit. Two independent coils from the alternator provide the power to the two separate ECU channels.

The ECU is a vibration isolated single unit mounted on the fan case and is forced air cooled.

Engine Condition Parameters Transmission

Engine condition monitoring will be possible, by the ability of the FADEC to broadcast the engine parameters through the ARINC 429 bus output.

The basic engine parameters available are:

- PO, PS12, PS3
- T12, T25, T3, TCase, TOIL, T49.5
- N1, N2
- FF
- VSV, VBV
- HPTCC, LPTCC
- Status and Maintenance words
- Engine serial number and position

In order to perform a better analysis of engine condition some additional parameters are optionally available. These are:

- PS13
- P25
- T5

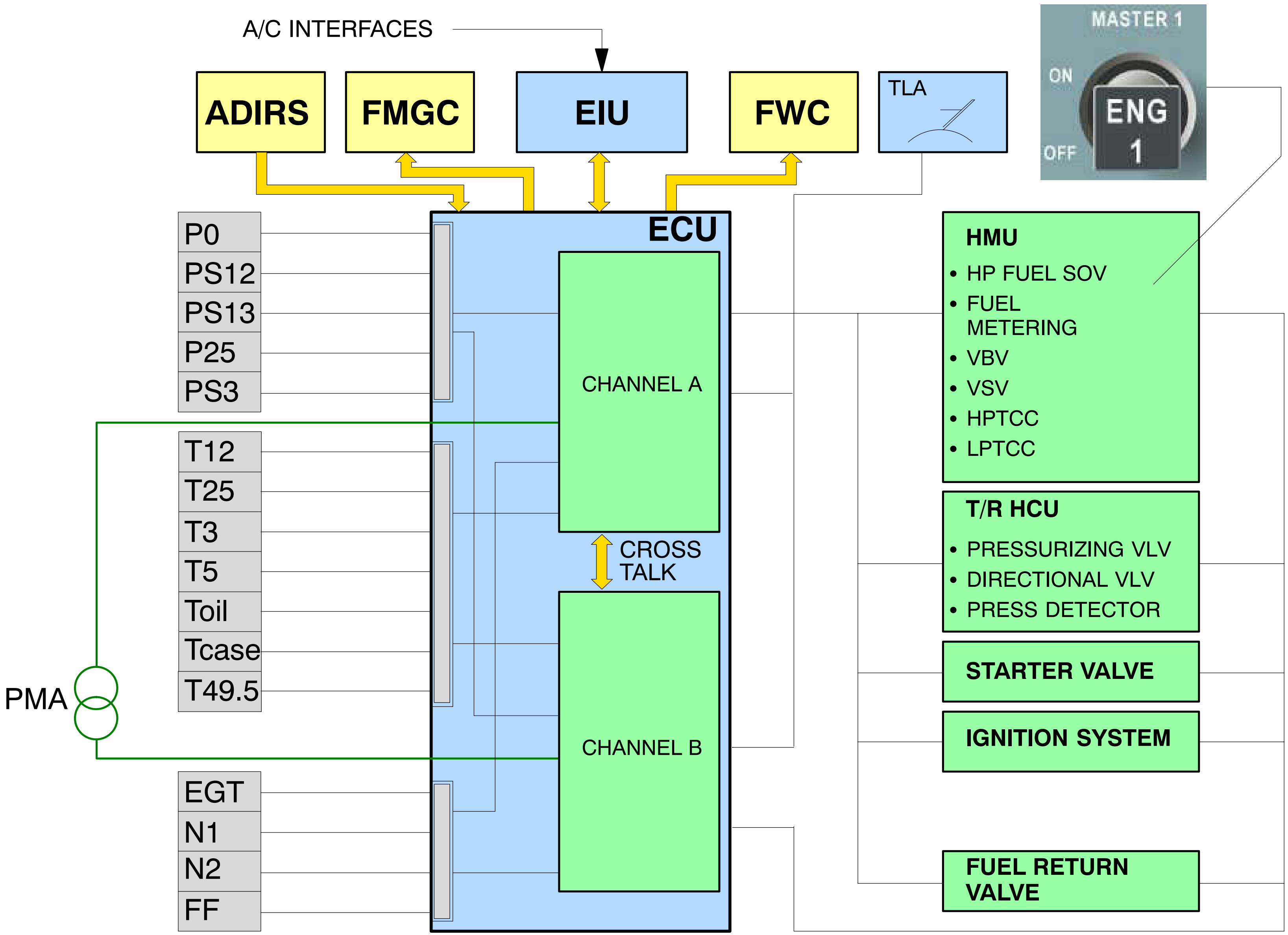


Figure 114 Electronic Control Unit Interfaces

FADEC POWER SUPPLY DESCRIPTION

Engine Interface Unit (EIU)

The EIU is powered from the aircraft electrical power, no switching has to be done.

Engine Control Unit (ECU)

The ECU is supplied from the aircraft electrical power when engine is shutdown, then from the ECU generator when the engine is running.

- Aircraft Electrical Power when N2 < 15%
- ECU Generator Power when N2 > 15%

POWER SUPPLY N2 < 15%

Each channel is independently supplied by the aircraft 28 volts through the Engine Interface Unit.

A/C 28 VDC permits :

- automatic ground check of FADEC before engine running
- engine starting
- powering the ECU while engine reaches 15% N2.

NOTE: The EIU takes power from the same bus bar as ECU.

POWER SUPPLY N2 > 15%

As soon as engine is running above 15% N2, the ECU generator supplies directly the ECU.

The ECU generator supplies each channel with three−phase AC. Two TRUs in the ECU provides 28VDC to each ECU channel.

Auto De-Energization

The FADEC is automatically de−energized on ground, through the EIU, after engine shutdown. The auto de−energization occurs on ground:

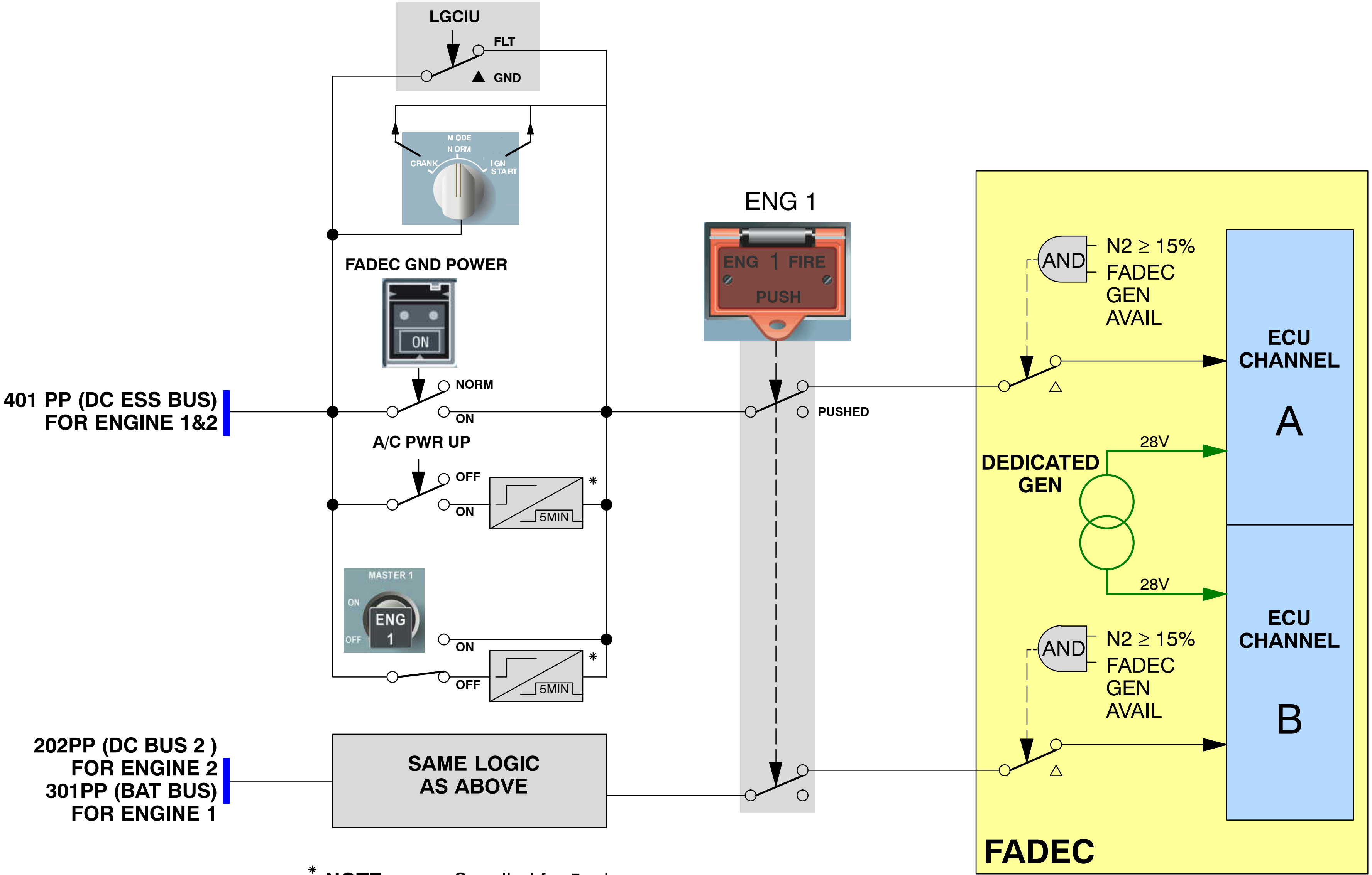
- 5 min after aircraft power up
- 5 min after engine shutdown
- 5 min after FADEC ground power supply
- at any time when the ENG FIRE pushbutton is released out

NOTE: Action on the Engine Fire Pushbutton provides ECU power cut off.

FADEC Ground Power Panel

For maintenance purposes and MCDU engine tests, the engine FADEC Ground Power Panel allows FADEC power supply to be restored on ground, with engine shut down. When the related FADEC Ground Power Pushbutton is pressed ON, the ECU recovers its power supply.

NOTE: The ECU is also energized as soon as the mode selector is set to IGN/START or CRANK position or when the master lever is set to ON.



* **NOTE:** Supplied for 5 min.

Figure 115 FADEC Power Supply

73–21 CONTROLLING

CONTROL ALTERNATOR

The control alternator is located on the left forward side of the accessory gearbox.

It is a high speed device without bearings that generates 3–phase electrical power for use by the engine control system. The output is sufficient for engine needs above 15% N2.

It consists of a separate interchangeable rotor and a separate interchangeable stator. The rotor contains permanent magnets and is piloted on the accessory shaft which has 3 equally spaced drive flats. The rotor is retained by a nut. The stator has dual 3–phase windings and is bolted to the accessory pad. Sealing is provided by an O–ring.

Control Alternator Characteristics

- Max. power output: 136 W
- Min. voltage: 14 VAC (15% N2)
- Max. voltage: 300 VAC (100 % N2)

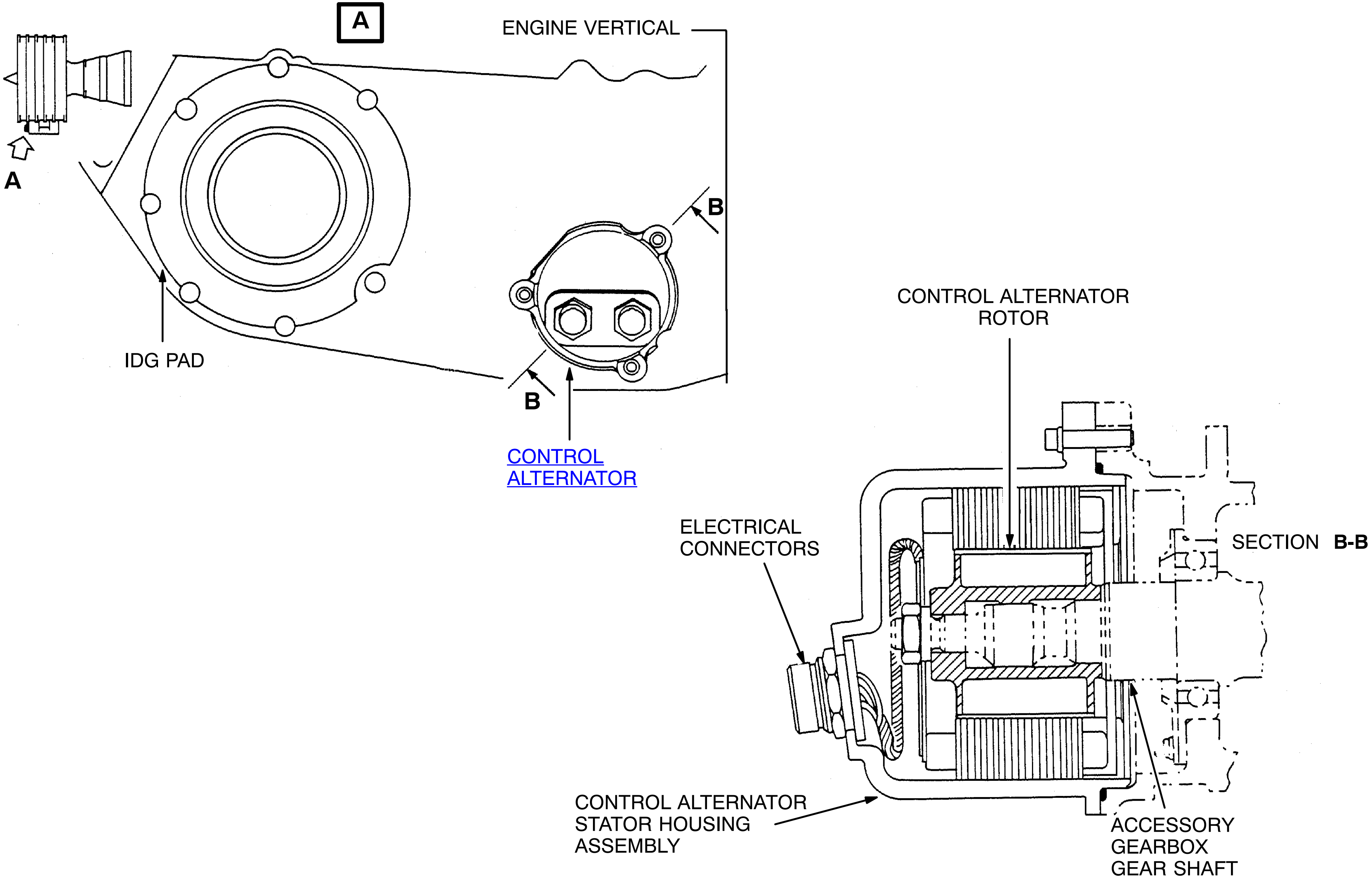


Figure 116 Control Alternator

FADEC SENSORS INTRODUCTION

SYNONYM	DESIGNATION	LOCATION
T12	FAN INLET TEMPERATIRE	FAN CASE 1:00 o'clock
T25	HPC INLET TEMPERATURE	FAN FRAME 5:30 o'clock
T3	HPC DISCHARGE TEMPERATURE	HPC CASE 11:00 o'clock
T49.5	EXHAUST GAS TEMPERATURE	LPT STAGE 2 NGV
T5	LPT EXHAUST TEMPERATURE	TURBINE REAR FRAME 3:00 o'clock
TCase	HPT CASE TEMPERATURE	HPT CASE 3:00 o'clock
PS12	FAN INLET PRESSURE	FAN INLET CASE 4:00/8:00/12.00 o'clock
PS13	FAN EXIT PRESSURE	FAN CASE 2:00 o'clock
P25	HPC INLET PRESSURE	FAN FRAME 6:00 o'clock
PS3	HPC DISCHARGE PRESSURE	HPC CASE 9:30 o'clock
N1	LPC ROTOR SPEED	FAN CASE 5:00 o'clock
N2	HPC ROTOR SPEED	REAR AGB 6:30 o'clock

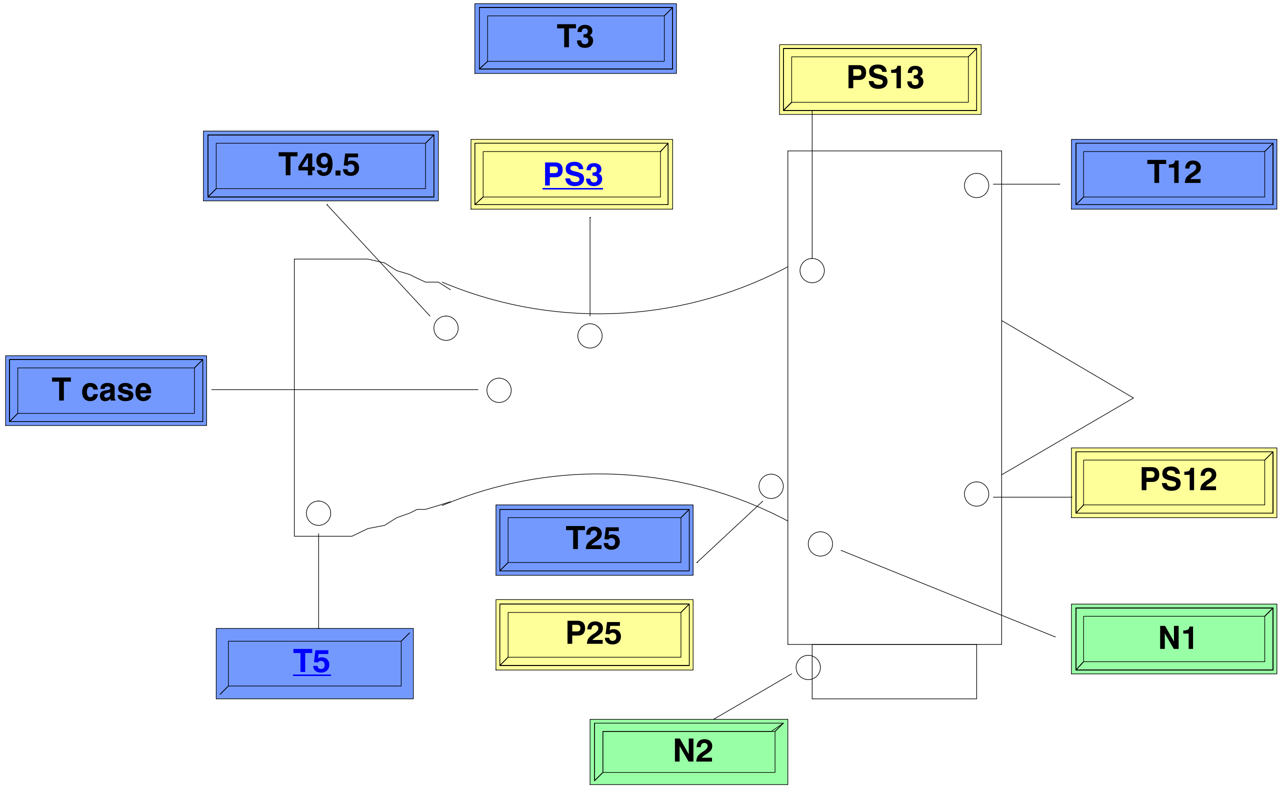


Figure 117 FADEC Sensors

FADEC SENSORS DESCRIPTION

T12 - Fan Inlet Temperature Sensor

The T12 sensor is made to measure the engine intake air temperature. It is installed on the air inlet cowl at the 1:00 o'clock position.

The T12 temperature sensor has 2 components: the sensing element and the housing.

PS12 - Fan Inlet Pressure Sensor

Three static pressure ports are mounted on the forward section of the fan inlet case, at the 4, 8 and 12 o'clock positions. A pneumatic line runs around the upper portion of the fan inlet case, collecting and averaging the pressures.

PS13 - Fan Exit Pressure Sensor

PS13 is part of the optional monitoring kit, available upon customer request. If the kit is not required, the PS13 port is blanked off on the ECU shear plate.

The PS13 pick−up is located at approximately 1:00 o'clock, downstream from the fan Outlet Guide Vanes (OGV). This signal is processed by channel A only.

PO - Ambient Pressure Port

The PO air pressure is measured through a vent plug, installed on the ECU shear plate. This value is used by the ECU, in case of lost signals from the Air Data Computer (ADC).

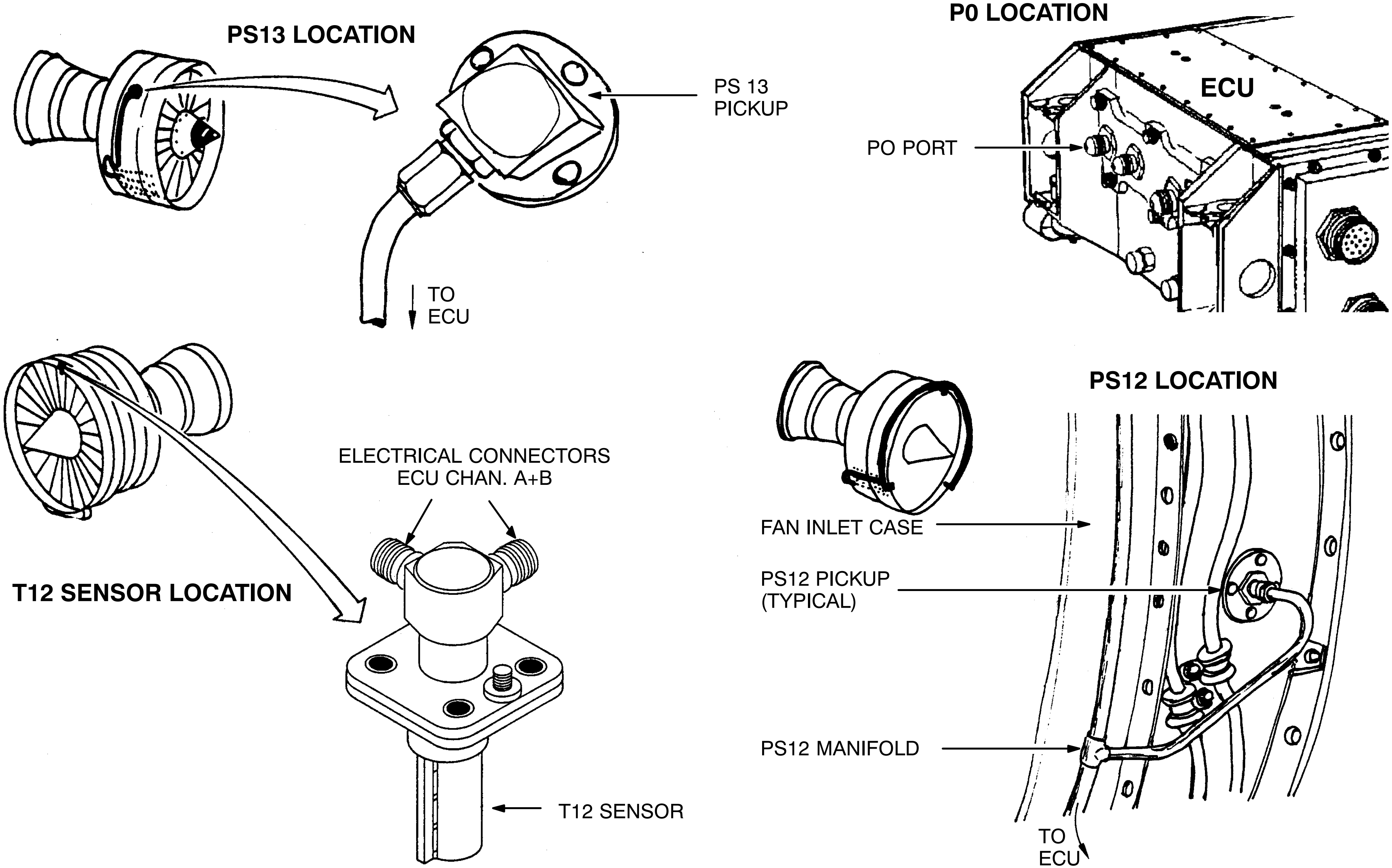


Figure 118 T12 Sensor, PS12, PS13 Location

T25 - HPC Inlet Temperature Sensor

The T25 sensor is located at 5:45 o'clock upstream of variable bleed (VBV) in fan frame. The sensor measures the air temperature downstream of the booster. This dual sensor is of the resistor probe type (platinum).

The operating principle of the sensor is based on the properties inherent to metals (in this case platinum), being that their resistance varies in relation to temperature.

A current generated by the ECU supplied to the probe resistor has its signal modified by the temperature surrounding the probe.

P25 - HPC Inlet Pressure Sensor

The P25 probe is installed in the fan frame mid−box structure at the 5 o'clock position.

P25 is part of the optional monitoring kit, available upon customer request. If the kit is not required, the P25 port is blanked off on the ECU shear plate. The pressure line exits the fan frame on its rear wall through a nipple. The signal is processed by channel B only.

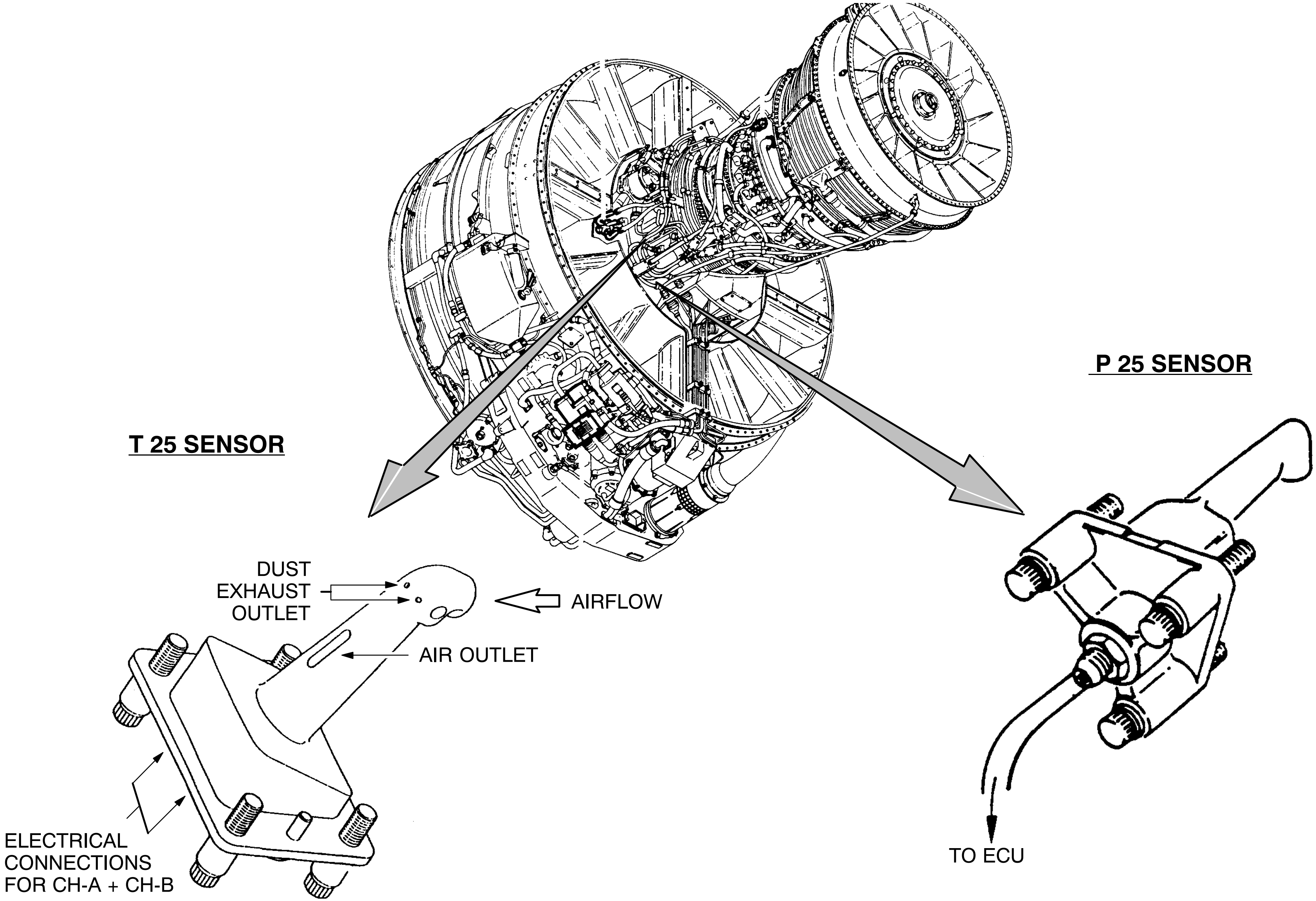


Figure 119 FADEC T25- P25-Sensor

T3 - Compressor Discharge Temperature Sensor

The T3 sensor is a thermocouple which is installed at the 12 o'clock position on the combustion case, just behind the fuel nozzles.

Two probes, enclosed in the same housing, sense the air temperature at the HPC outlet. The signals from both probes are directed through a rigid lead to a connector box, which accommodates two connectors, one per ECU channel.

The wiring in the sensor is encased in a tubing filled with magnesium oxide powder. The swaging process reduces the tubing size. This compresses the powder into a firm mass around the wires and provides equal spacing and insulation for the wires.

PS3 - HPC Compressor Discharge Pressure Sensor

The PS3 static pressure pick−up is located on the combustion case, at the 9 o'clock position between two fuel nozzles.

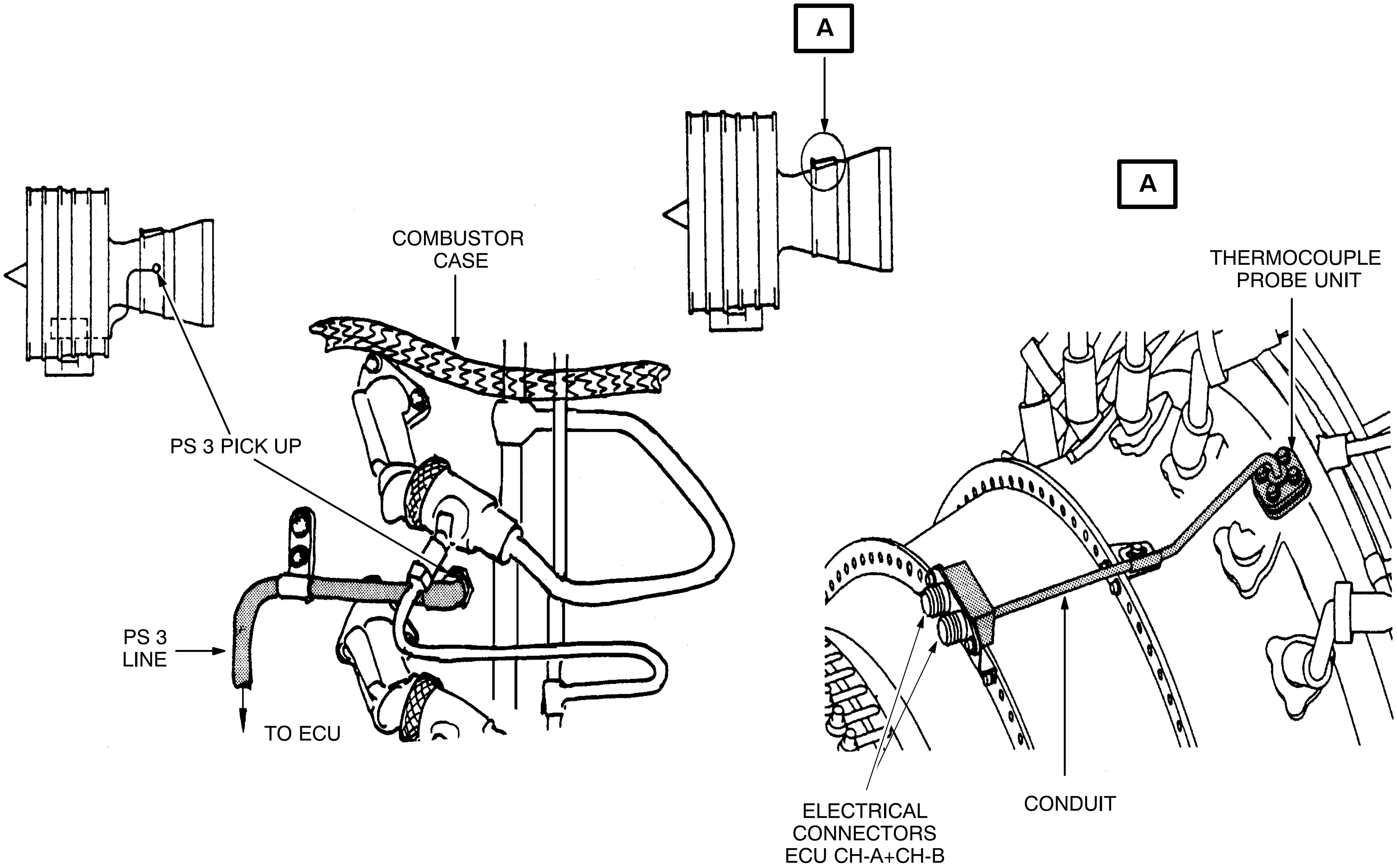


Figure 120 PS3 (CDP) and T3 Sensor

T5 - LPC Discharge Temperature Sensor

The T5 sensor is part of the optional monitoring kit, available upon customer request. When installed, it is located at the 4 o'clock position, on the turbine rear frame.

It consists of a metal body, which has two thermocouple probes and a flange for attachment to the engine. A rigid lead carries the signal from the probe to a main junction box with a connector that allows attachment to a harness.

The two thermocouples are parallel-wired in the box and a single signal is sent to the ECU channel A.

Tcase - HPT Case Temperature Sensor

The Tcase sensor is installed on the combustion case at the 3 o'clock position, and consists of:

- a housing, which provides a mounting flange and an electrical connector
- a sensing element, fitted inside the housing and in contact with the shroud support

It measures the High Pressure Turbine (HPT) shroud support temperature. The temperature value is used by the ECU in the HPT Clearance Control system logic.

NOTE: The probe is spring-loaded to ensure permanent contact with the shroud support.

Identification Connector J14

The engine identification plug acts as an "electronic nameplate" for the ECU. It is connected to the J14 ECU fixed connector. The mobile connector transmits the following electric coded signals to the Electronic Control Unit (ECU):

- Engine serial number
- Engine family
- Engine bump/overboost rating
- Engine nominal rating

It is coded in the factory during installation of new engine, and is inseparable from the engine.

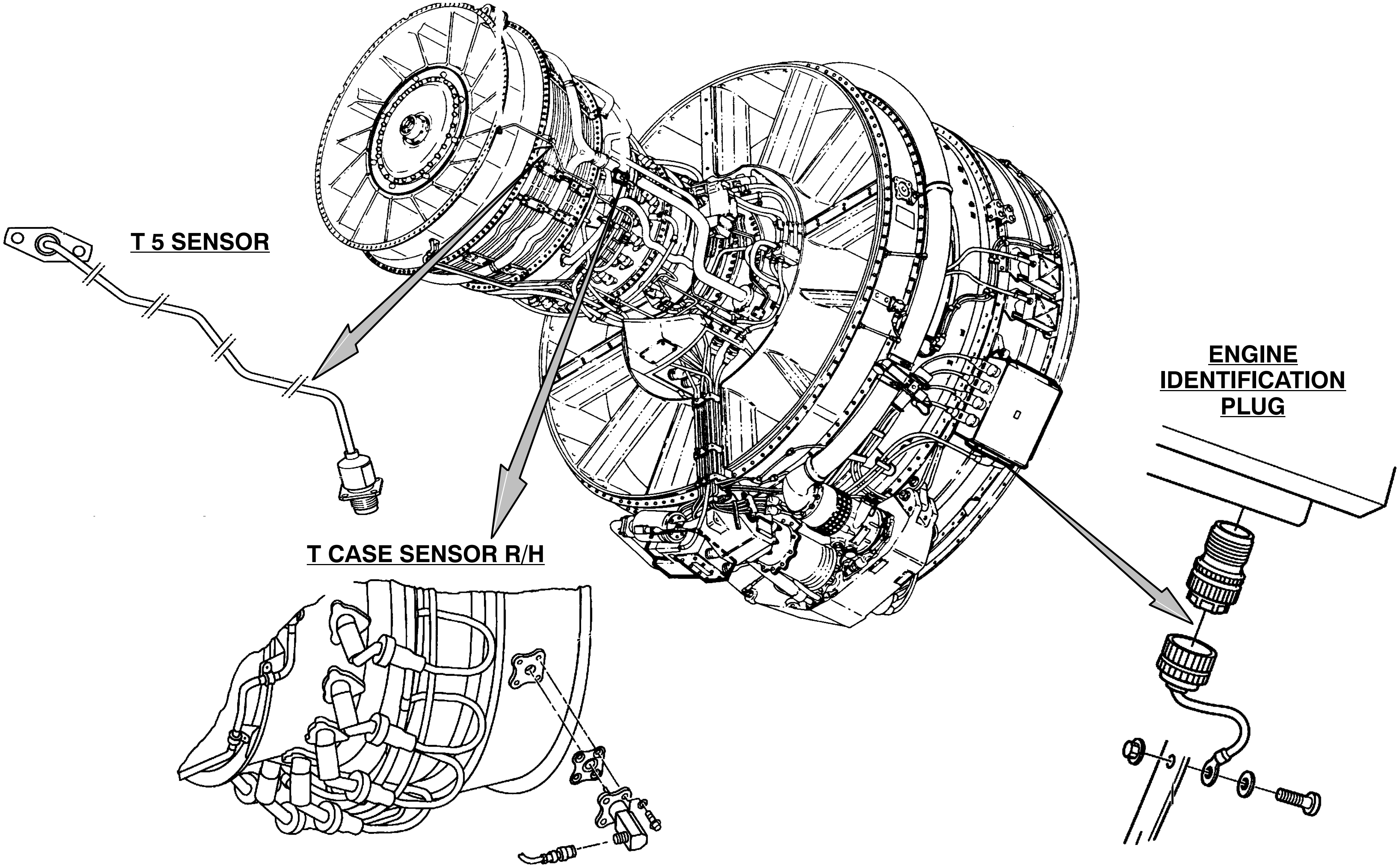


Figure 121 FADEC Components R/H Side

ECU COMPONENT DESCRIPTION

Software Main Functions

Ground test of electrical and electronic parts is possible from cockpit with engines not running through the CFDS.

The FADEC provides engine control system self–testing to detect problem at LRU level.

FADEC is such that no engine ground run for trim purposes is necessary after component replacement.

Pressure Inputs

Five pneumatic pressure signals are supplied to pressure sub-systems A and B of the ECU. These are converted into electric signals by pressure transducers inside the ECU.

The 3 pressures used for engine control (P0, Ps12, P3) are supplied to both channels.

The two optional monitoring pressures are supplied to a single channel (Ps13 to CH. A, P25 to CH–B)

The pressure sub-system shear plate serves as the interface between the pneumatic lines and the ECU. The shear plate is bolted onto the ECU chassis. A metal gasket with integral O-rings is installed between the plate and ECU. Correct orientation of the assembly is assured by an alignment pin on the chassis and corresponding holes in the gasket and the shear plate.

Electrical Connectors

Fifteen threaded electrical connectors are located on the lower panel of the ECU. Each has a unique key pattern which accepts only the correct corresponding cable.

Connector identification numbers from J1 to J15 are marked on the panel.

All engine inputs and command outputs are double and routed to and from channel A and B through separate cables and connectors.

Channel A Connectors	Channel B Connectors	Function
J 1	J2	Power Supply 28V, Ignition Power Supply 115VAC
J 3	J4	Input / Output to / from A/C, TLA Input
J 5	J6	Connection to Thrust Reverser
J 7	J8	HMU, N2 Sensor, FRV, ECU Cooling Valve
J 9	J10	Control Alternator, SAV, T12, N1 Sensor,
J11	J12	Feed Back Sensors, BSV Pos. Switches, T25
J14	J14	Engine Identification Plug
J13	J13	T3, Tcase, Toil, T5, EGT, Fuel Flow
J15	J15	Test Interface

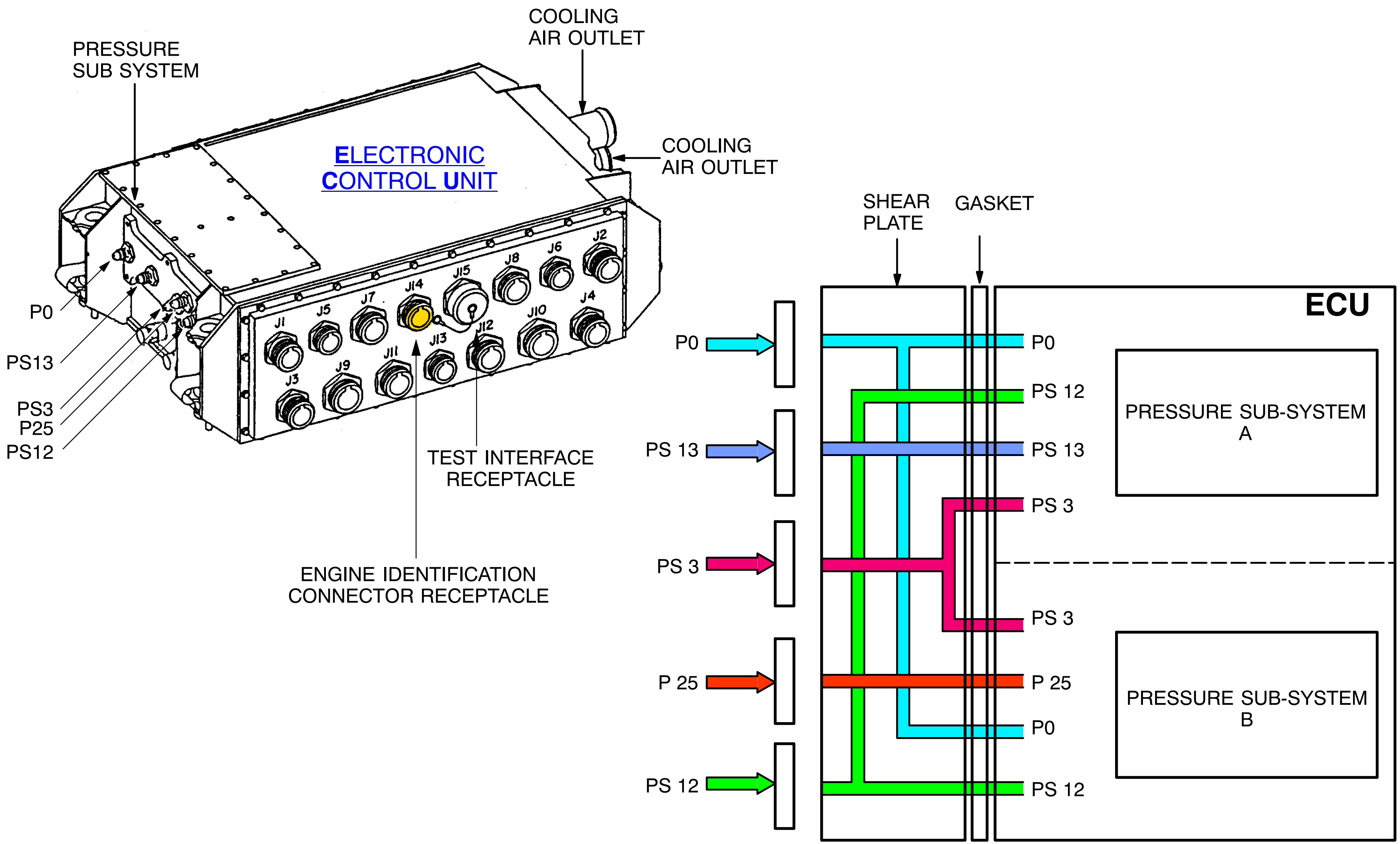


Figure 122 ECU Connections

THRUST MODES OPERATION

Thrust Limit Mode Selection

Throttle lever is used as a rating mode selection device. By receiving the throttle lever position signal, the FADEC computes permanently thrust limit ratings, shall select the corresponding limit value and send it to the cockpit. When the throttle lever is positioned between two unique positions, the FADEC will select the limit of the higher mode for display.

Two thrust setting modes are available, the manual mode and the auto thrust mode. The mode selection is depending on throttle lever position and upon the auto thrust activation/deactivation logic.

Manual Thrust Mode

In the Manual Thrust Mode (auto thrust function is not active) the throttle control lever on the center pedestal controls:

- the engine level of thrust
- the thrust limit mode

The ECU receives the throttle lever angle, computes the engine thrust limit parameter and adjusts the actual engine thrust parameter accordingly.

Auto Thrust Mode

During Automatic Thrust Mode (auto thrust function engaged and active) the throttle control lever controls:

- the thrust limitation (except in alpha floor condition)
- the thrust limit mode
- the FMGC computes the target thrust parameter and sends it to the ECU through the FCU and the EIU
- the ECU adjusts the actual engine thrust parameter according to this value. The target thrust parameter is limited by the actual position of the throttle control lever except when a alpha floor protection is activated (in that case the maximum available thrust is commanded)

In flight the auto thrust mode is available between greater than idle and CL (climb detent) for both engines in operation or greater than idle and MCT (maximum continuous thrust) when one engine is in operation only. The auto thrust function (A/THR) can be engaged-not active or engaged-active. The engagement logic is done in the FMGC and the activation logic is implemented into the ECU. The activation logic in the ECU unit is based upon two digital discretes A/THR engaged, A/THR active, from the FMGC, plus an analog discrete from the instinctive disconnect pushbutton on the throttle.

The A/THR function is engaged automatically in the FMGC by auto pilot mode demand and manually by action on the A/THR push button located on the Flight Control Unit (FCU).

After take−off the lever is pulled back to the maximum climb position. The auto thrust function will be active and will provide an N1 target for:

- Max climb thrust
- Optimum thrust
- An aircraft speed (Mach number)
- A minimum thrust

The A/THR de−activation and A/THR disengagement are achieved by action on the disconnect pushbutton located on the throttle levers or by depressing the A/THR pushbutton provided that the A/THR was engaged. Selecting the TLA in IDLE or in reverse range will also disengage the A/THR function.

Memo Mode

The thrust is frozen to the N1 actual (memo thrust setting) if:

1. A/THR was active in the FADEC unit and:
   - throttle is in MCT gate or CL gate
   - one of the deactivation conditions is present A/THR not engaged (from the ECU)
   - or N1 target not valid
   - or instinctive disconnect condition
2. Thrust was frozen and:
   - condition to switch to manual thrust setting not present
   - condition to switch to automatic thrust setting not present

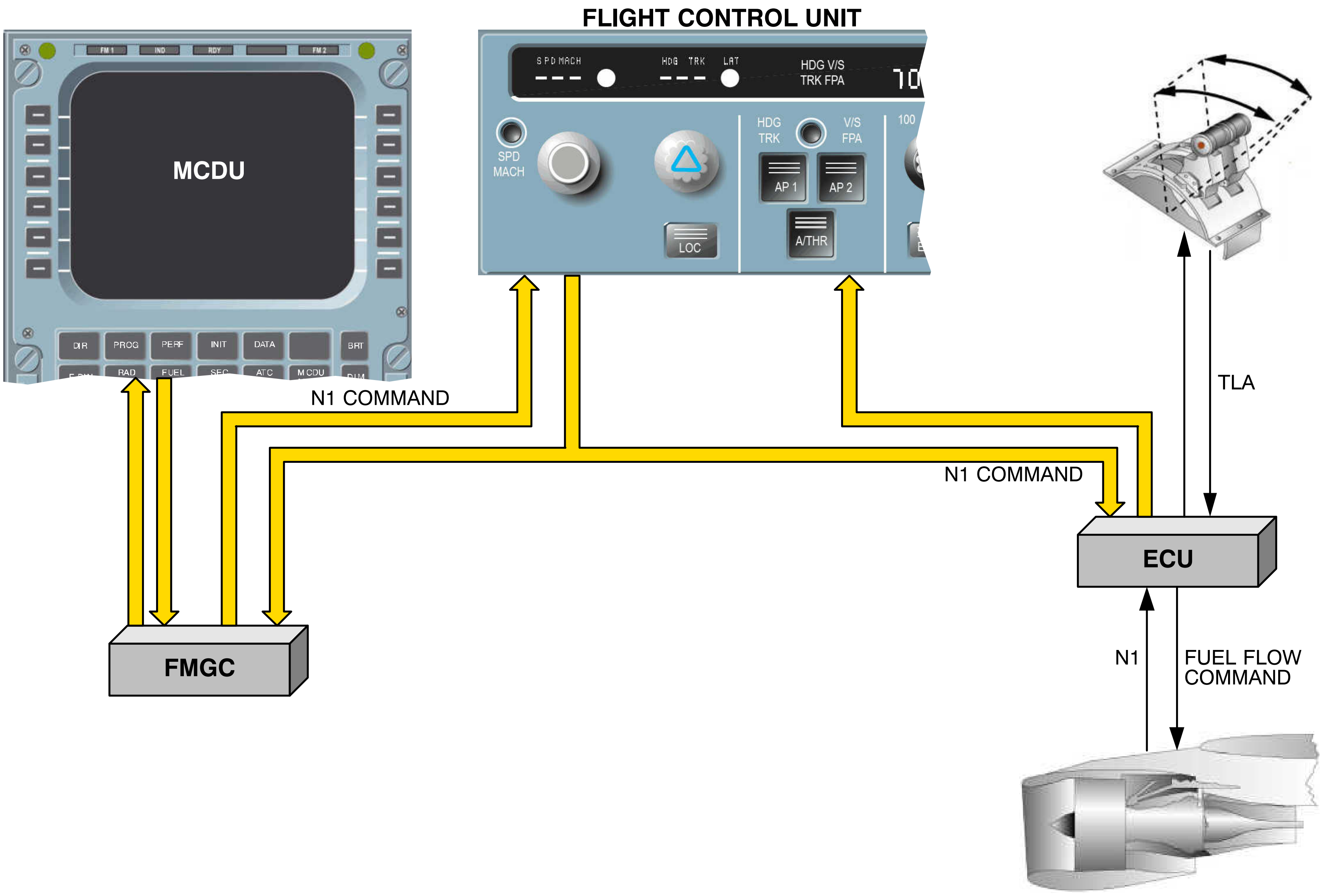


Figure 123 Thrust Control Architecture

ALPHA FLOOR OPERATION

If the Alpha Floor condition is not present, setting at least one throttle lever forward of the MCT gate leads to A/THR deactivation but maintains A/THR engaged ; the thrust is controlled by the throttle lever position and A/THR will be activated again as soon as both throttles are set at or below MCT gate. If the Alpha Floor condition is present, the A/THR function can be activated regardless of throttle position.

When A/THR is deactivated (pilot's action or failure), the thrust is frozen to the actual value at the time of the deactivation. The thrust will be tied to the throttle lever position as soon as the throttles have been set out of the MCT or MCL positions.

Manual Mode

The thrust is controlled manually (i.e., function of TLA position) if the throttles are not in the A/THR area.

This mode is also entered any time the conditions for auto thrust or memo modes are not present. In this mode, thrust lever sets an N1 value proportional to the thrust lever position up to maximum take−off thrust.

TLA versus rated thrust is consistent regardless of ambient conditions.

TAKE−OFF/GO−AROUND ratings are always achieved at full forward throttle lever position (except in Alpha−floor mode).

Other ratings (MAX CONTINUOUS, MAX CLIMB. IDLE, MAX REVERSE) are achieved at constant throttle lever positions. FLEXIBLE TAKE−OFF for a given derating is achieved at constant retarded throttle lever position.

Flexible take−off rating

FLEXIBLE TAKE−OFF rating is set by the assumed temperature method with the possibility to insert an assumed temperature value higher than the maximum one certified for engine operation to provide for the maximum derate allowed by the certifying Authorities.

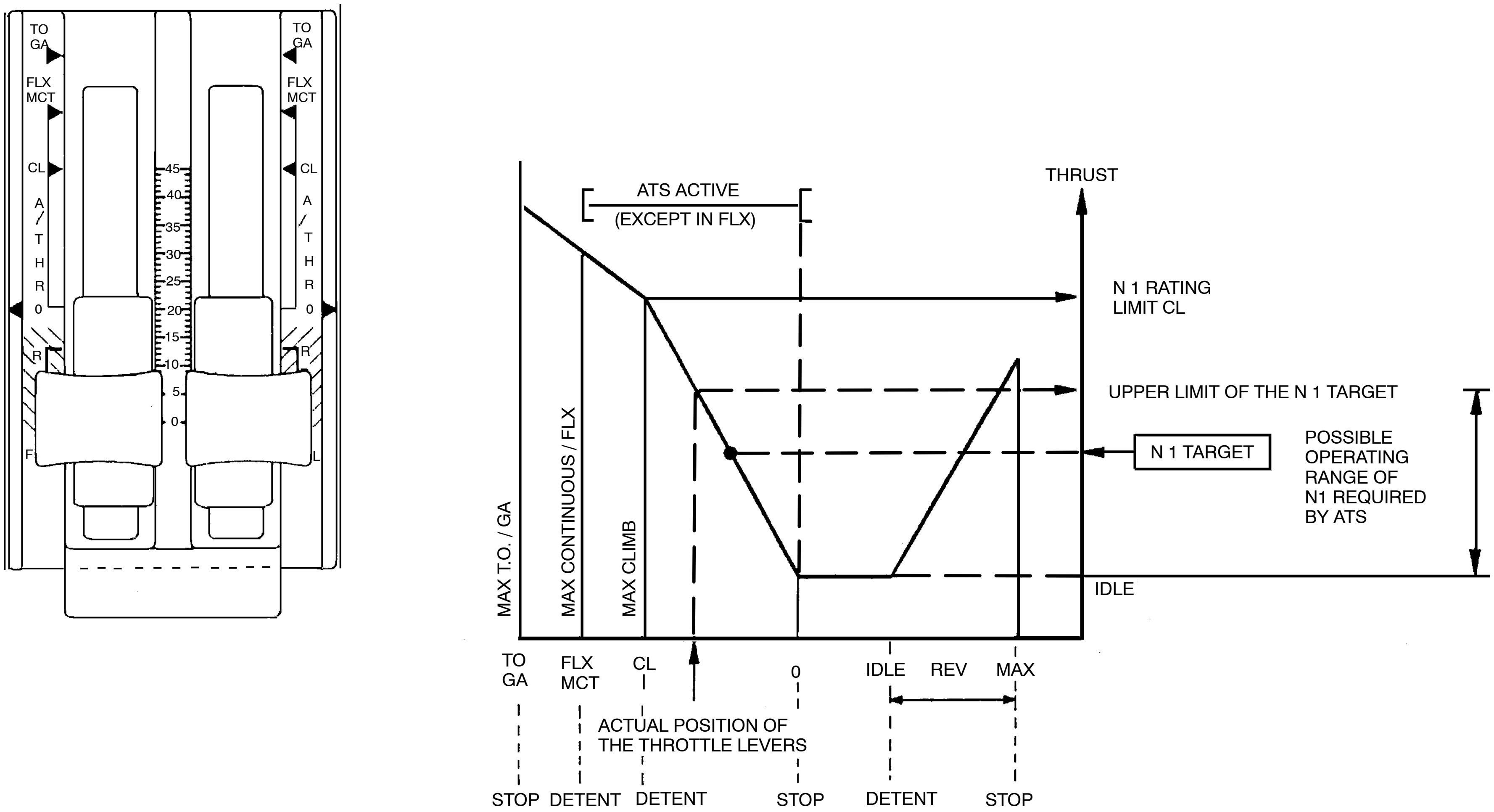


Figure 124 Thrust Lever Positions

IDLE CONTROL OPERATION

Minimum Idle (58,8% N2) Corrected for Ambient Temp >30°C

- Then the N2 will increase.

  The minimum idle should never be below 58,3% N2

Approach Idle (Approx. 70% N2)

- It varies as a function of Total Air Temperature (TAT) and altitude. This idle speed is selected to ensure sufficiently short acceleration time to go around thrust and is set when the aircraft is in an approach configuration.(Flap Lever Position -" NOT UP")

Bleed Idle = Bleed Demand

- Bleed Idle command will set the fuel flow requested for ensuring correct aircraft ECS system pressurization ,wing anti ice and engine anti ice pressurization (P/B-"ON" or valves not closed).

Reverse Idle (Approx. 70% N2)

- Approach Idle + 1000 RPM. FADEC sets the engine speed at reverse idle when the throttle is set in the reverse idle detent position.

IDG Idle Bias (Min Idle - Approach Idle)

- The min idle speed will increase to maintain the engine oil temperature within max limits (in flight only), when the engine oil temperature reaches more than 106 °C (signal from TEO sensor). The speed can increase up to approach idle.

Weather Idle Speed

- On the ECU software P28/P15 the new weather idle speed will be incorporated (SB 73-131). The purpose of this software eliminates the FCOM requirement that the pilot must manually select Nacelle Anti -Ice prior to penetrating moderate to heavy precipitation weather conditions in order to establish the minimum idle to 45% N1. This software reduces pilot work load.

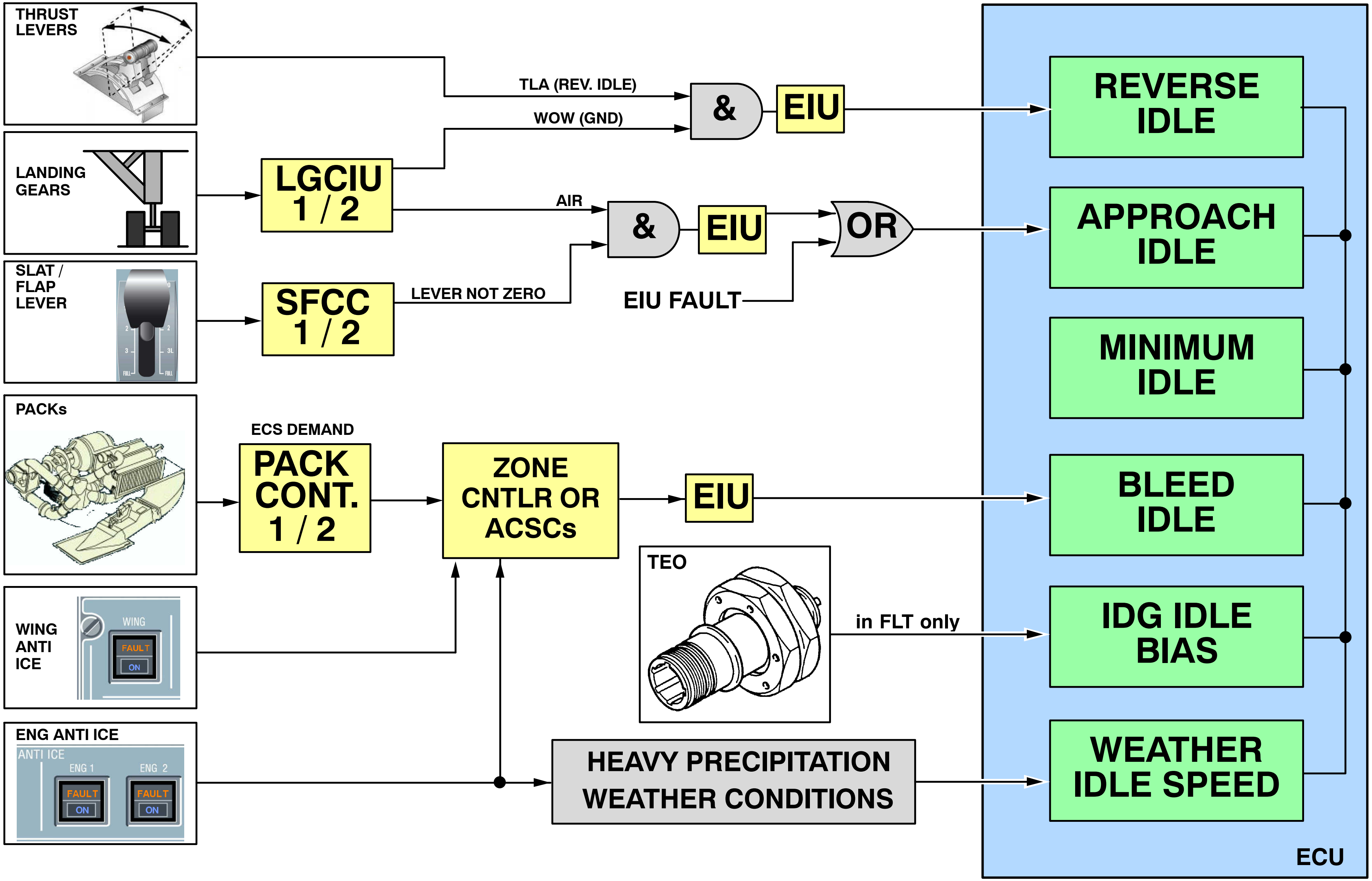


Figure 125 Idle Setting

CFDS MCDU PAGES

MCDU MENU

The system report/test menu for the FADEC has minimum options:

- LAST LEG REPORT
- PREVIOUS LEGS REPORT
- LRU IDENTIFICATION
- CLASS 3 FAULTS
- TROUBLE SHOOTING REPORT
- IGNITION TEST
- THRUST REVERSER TEST
- FADEC TEST
- SCHED MAINT REPORT

To get access to the FADEC CFDS menu the FADEC ground power switch on the maintenance panel must be "ON" ,otherwise "NO RESPONSE" is displayed on the MCDU.

Last Leg Report and Previous Leg Report

This report gives a list of the LRUs which have been detected faulty on the last flight leg and all the LRUs which have been detected faulty during the previous flight legs (max 62).

LRU Identification

This menu shows the ECU part number. The last digit of the number shows the software standard (e.g. P02)

Class 3 Faults

This menu shows the class 3 faults.

Specific Data/Max Values

Depending on FADEC software this menu can be used for trouble shooting in case of limit exceedance and for max. Values reset.

Water Wash

Depending on FADEC software this menu can be used during a water wash procedure.

Trouble Shooting Report

This report presents a snapshot at the time a fault occurred. It shows the time of occurrence and gives additional parameter infos.

- N1 Actual Selection (N1 ACTSEL)
- N2 Actual Selection (N2 ACTSEL)
- EGT Selection (T49.5SEL)
- Thrust Lever Angel Selection (TLASEL)
- CDP Selection (PS3SEL)
- Fuel Metering Valve Selection (FMVSEL)
- VSV Selection (VSVSEL)
- VBV Selection (VBVSEL)
- Ambient Static Pressure Sel.(P0SEL)
- TAT Selection (TATSEL)
- Mach Outside (MO)
- N1 Command (N1CMD)

Ignition Test

This test allows to perform a ignition test via the MCDU.

Reverser Test

This test allows to operate/test the reverser.

Scheduled Maintenance Report

The class 3 faults (without cockpit event) have been classified in the two following categories:

- the TIME LIMITED dispatch faults: which means that the fault may remain uncorrected within a maximum time frame specified by the Maintenance Planning Document.
- the UNLIMITED TIME dispatch faults: which means that the fault may remain uncorrected within an unlimited time frame.

All these faults are presented by the FADEC BITE in the 'Scheduled Maintenance Report' at the aircraft level and classified "S" in the Trouble Shooting Manual.

NOTE: FADEC power must be switched ON, otherwise NO RESPONSE is displayed.

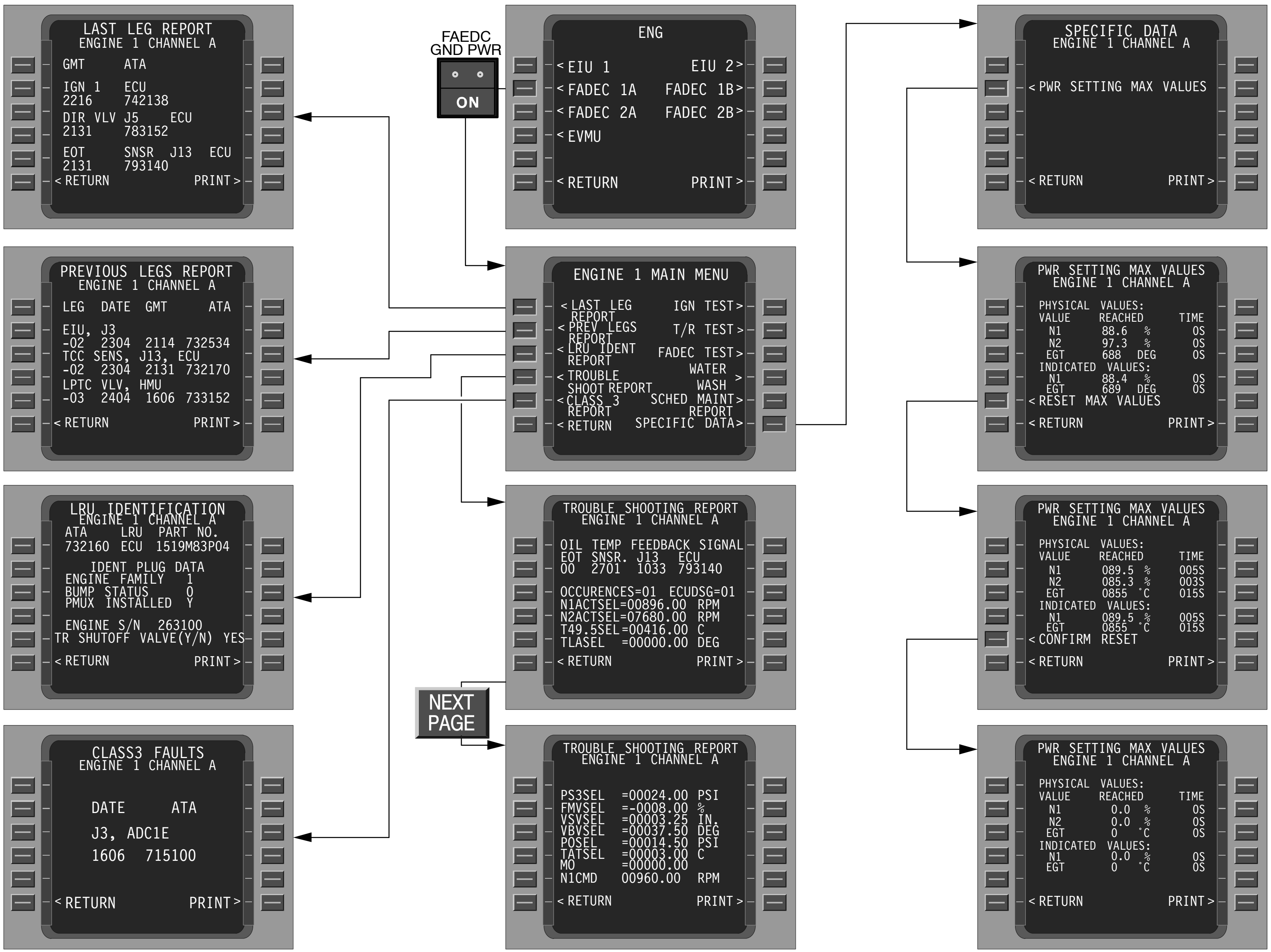


Figure 126 FADEC CFDS Menu

15|73–21|CFDS|5A|L2/B1/B2

FADEC TEST

Purpose

This test allows to test the FADEC system, by separate selection of channel A or channel B. A motoring or a non motoring test can be performed, depending if bleed air is supplied or not. When a motoring test is done the valves are driven with fuel press and all electrical circuits are checked. A non motoring test is only a static electrical test.

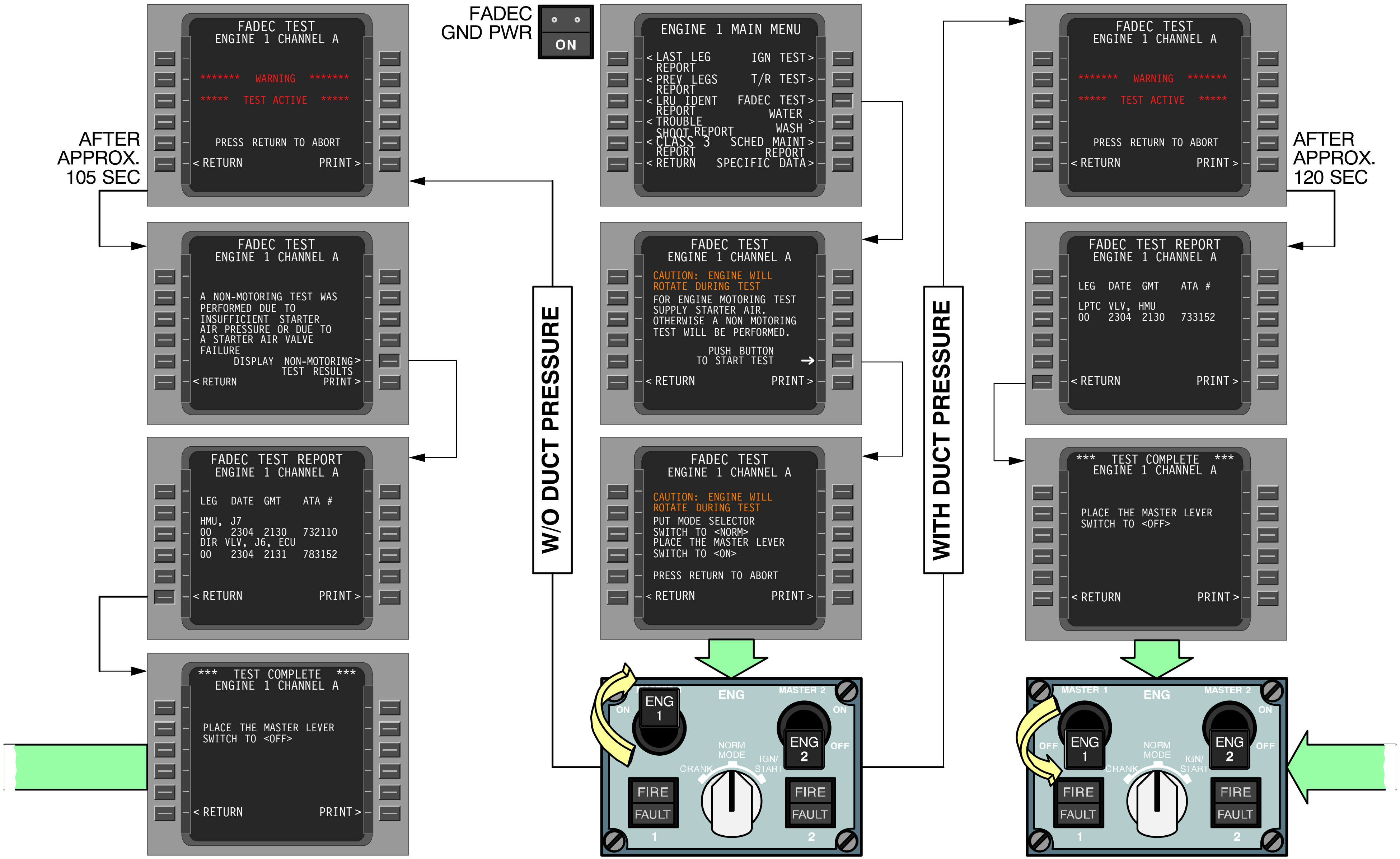


Figure 127 FADEC Test

15|73-21|CFDS|5A|L2/B1/B2

73–25 FUNCTIONAL INTERFACES

EIU DESCRIPTION

General

Two EIUs are fitted on each aircraft, one for engine 1, one for engine 2. Each EIU, located in the electronics bay 80VU, is an interface concentrator between the airframe and the corresponding FADEC located on the engine, thus reducing the number of wires. EIUs are active at least from engine starting to engine shutdown, they are essential to start the engine.

EIU Functions

The main functions of the EIU are:

- to concentrate data from cockpit panels and different electronic boxes to the associated FADEC on each engine
- to insure the segregation of the two engines
- to select the airframe electrical supplies for the FADEC
- to give to the airframe the necessary logic and information from engine to other systems (APU, ECS, Bleed Air, Maintenance).

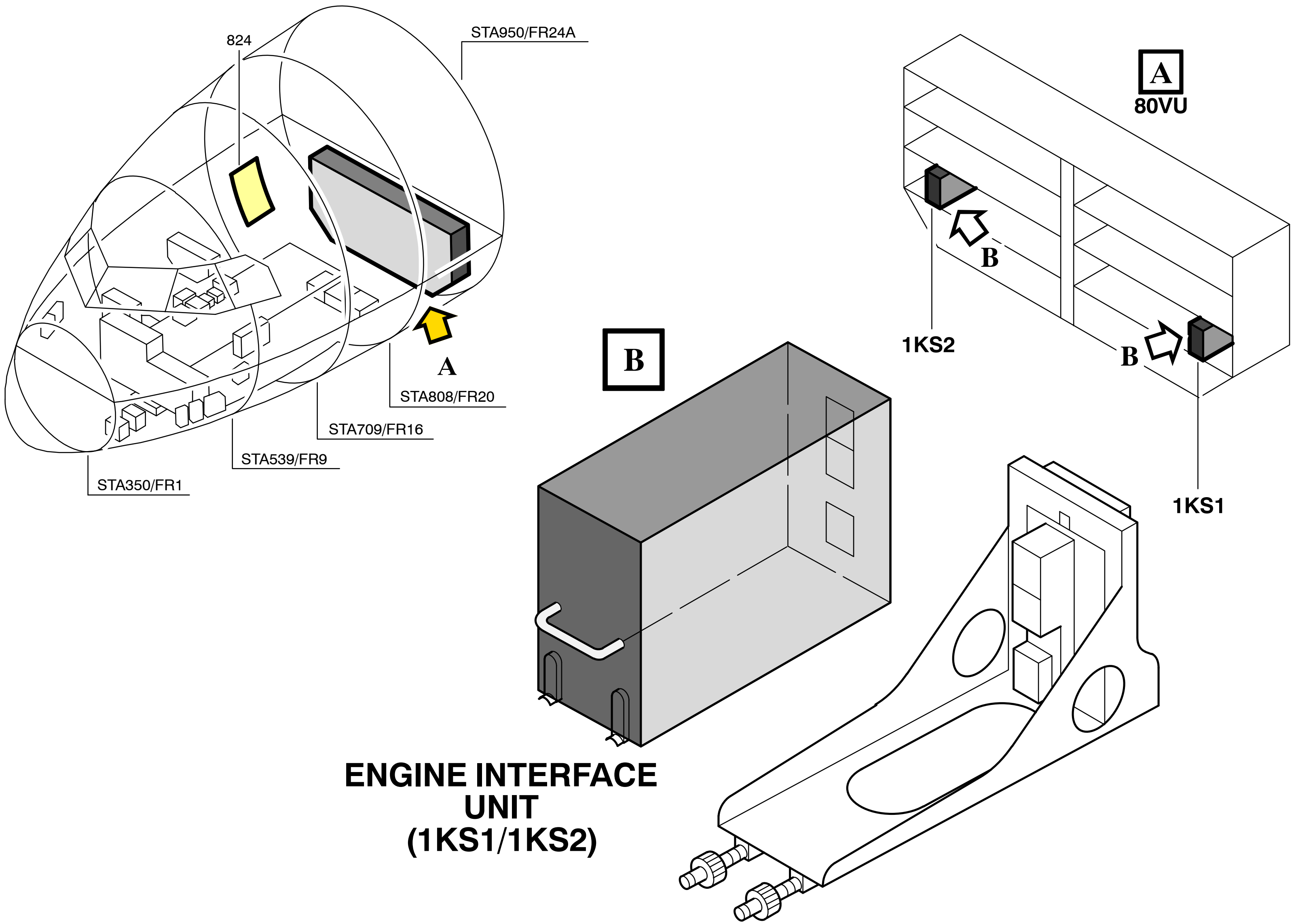


Figure 128 EIU Location

EIU INTERFACES

EIU Input from ECU

The EIU acquires two ARINC 429 output data buses from the associated ECU (one from each channel) and it reads data from the channel in control. When some data are not available on the channel in control, data from the other channel are used.

In the case where EIU is not able to identify the channel in control, it will assume Channel A as in control. The EIU looks at particular engine data on the ECU digital data flow to interface them with other aircraft computers and with engine cockpit panels.

EIU Output to ECU

Through its output ARINC 429 data bus, the EIU transmits data coming from all the A/C computers which have to communicate with the ECU, except from ADCs and throttle which communicate directly with the ECU. There is no data flow during EIU internal test or initialization.

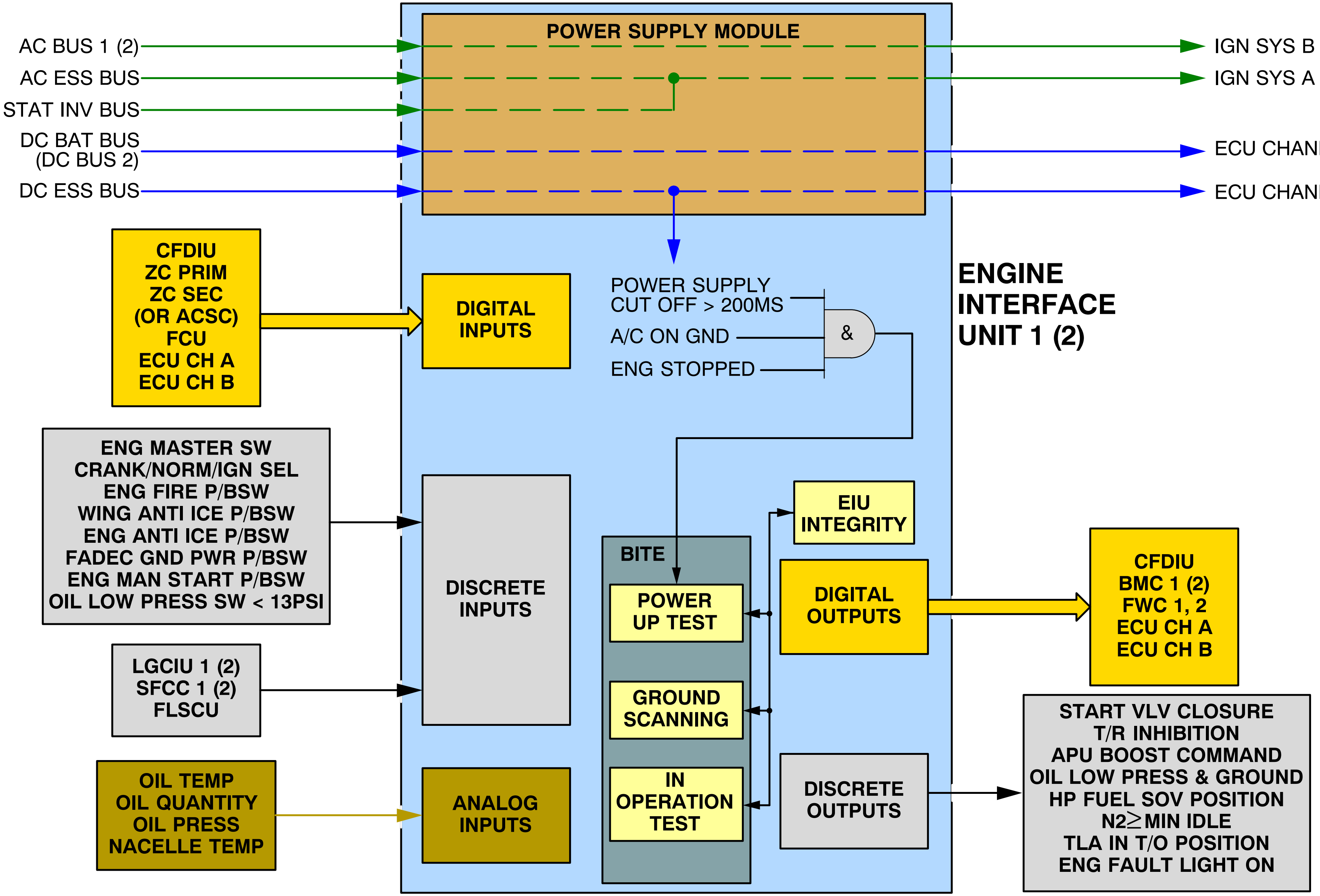


Figure 129 EIU Interfaces

CFDS SYSTEM REPORT/TEST EIU

Listed below is the menu of the Engine Interface Unit (EIU). The EIU is a Type 1 System. The EIU is available in CFDS back up Mode. The following menu options are available for the EIU 1 (2):

- LAST LEG REPORT
- PREVIOUS LEGS REPORT
- LRU IDENTIFICATION
- CLASS 3 FAULTS
- GROUND SCANNING

Last leg Report

Here are Displayed the Internal EIU Failures that Occurred during Last Flights.

Previous legs Report

The EIU sends a list of the LRU‘s which have been detected faulty during the previous 63 flight legs.

LRU Identification

Shows the EIU part number.

Class 3 Faults

This menu shows all class 3 faults present.

Ground Scanning

This Page gives the EIU Failures still present on Ground.

RTOK means Re-Test Ok, you can ignore this Fault.

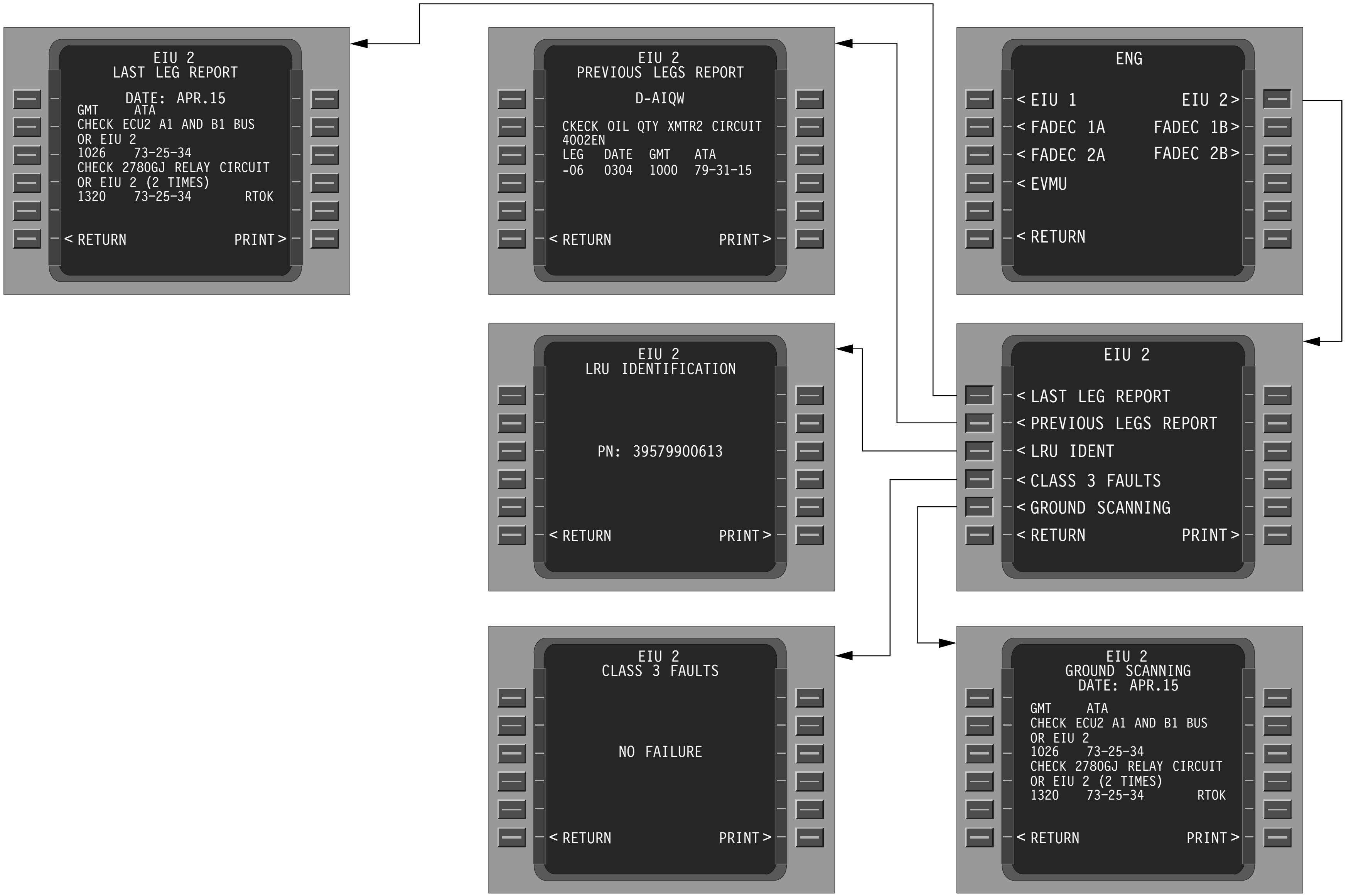


Figure 130 EIU CFDS Menu

18|73–25|BITE|5A|L2/B1/B2

ATA 75 AIR

75–00 AIR - GENERAL

INTRODUCTION

General

The engine air system covers the:

- Turbine Active Clearance Control System
- **R**otor **A**ctive **C**learance **C**ontrol System (RACC)
- Compressor Airflow Control System

Turbine Clearance Control System

There are two systems independently controlled by the ECU and actuated from the HMU which provide the engine clearance adjustment.

- **L**ow **P**ressure **T**urbine **A**ctive **C**learance **C**ontrol (LPTACC)
- **H**igh **P**ressure **T**urbine **A**ctive **C**learance **C**ontrol (HPTACC)

The clearance between the blade tips and the casings is actively controlled in order to optimize engine performance using cooling air to shrink the LP and HP turbine casings.

Rotor Active Clearance Clearance System

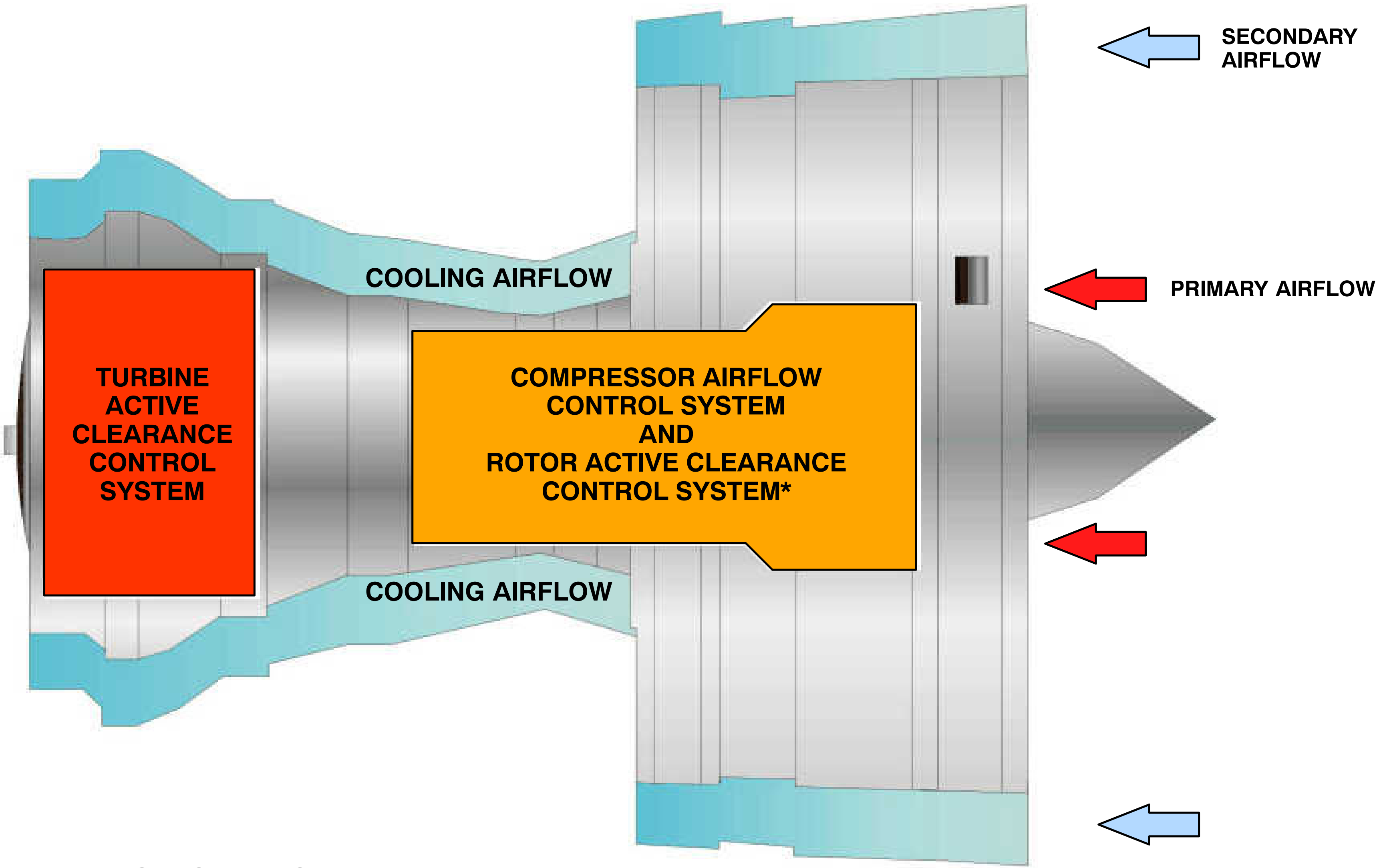
The RACC System improves compressor efficiency during cruise by means of controlling the **H**igh **P**ressure **C**ompressor (HPC) rotor clearances with 5th stage HPC airflow to the rotor bore.

Compressor Airflow Control System

To prevent compressor surge and to provide good acceleration, the engine is equipped with two compressor airflow control systems listed below:

- **V**ariable **B**leed **V**alve (VBV) System
- **V**ariable **S**tator **V**ane (VSV) System

Both systems are fuel operated by the **H**ydroMechanical **M**etering **U**nit (HMU) and controlled by the **E**lectronic **C**ontrol **U**nit (ECU).



*NOT INSTALLED ON
NEW CFM56 ENGINES

Figure 131 Air System Presentation

75–20 COOLING

ACTIVE CLEARANCE CONTROL SYSTEMS DESCRIPTION

HPT Active Clearance Control System

The HPTACC system uses HPC bleed air from stages 5 and 9 to obtain maximum steady–state HPT performance and to minimize EGT transient overshoot during throttle bursts. Air is supplied through the HPACC valve to a manifold surrounding the HPT shroud. The temperature of the air controls the HPT shrouds clearance relative to the HPT blade tips.

The HPTACC valve is fuel driven. Its position is determined by an ECU controlled servo valve inside the HMU. The ECU receives position feedback from the HPTACC valve for monitoring purposes.

LPT Active Clearance Control System

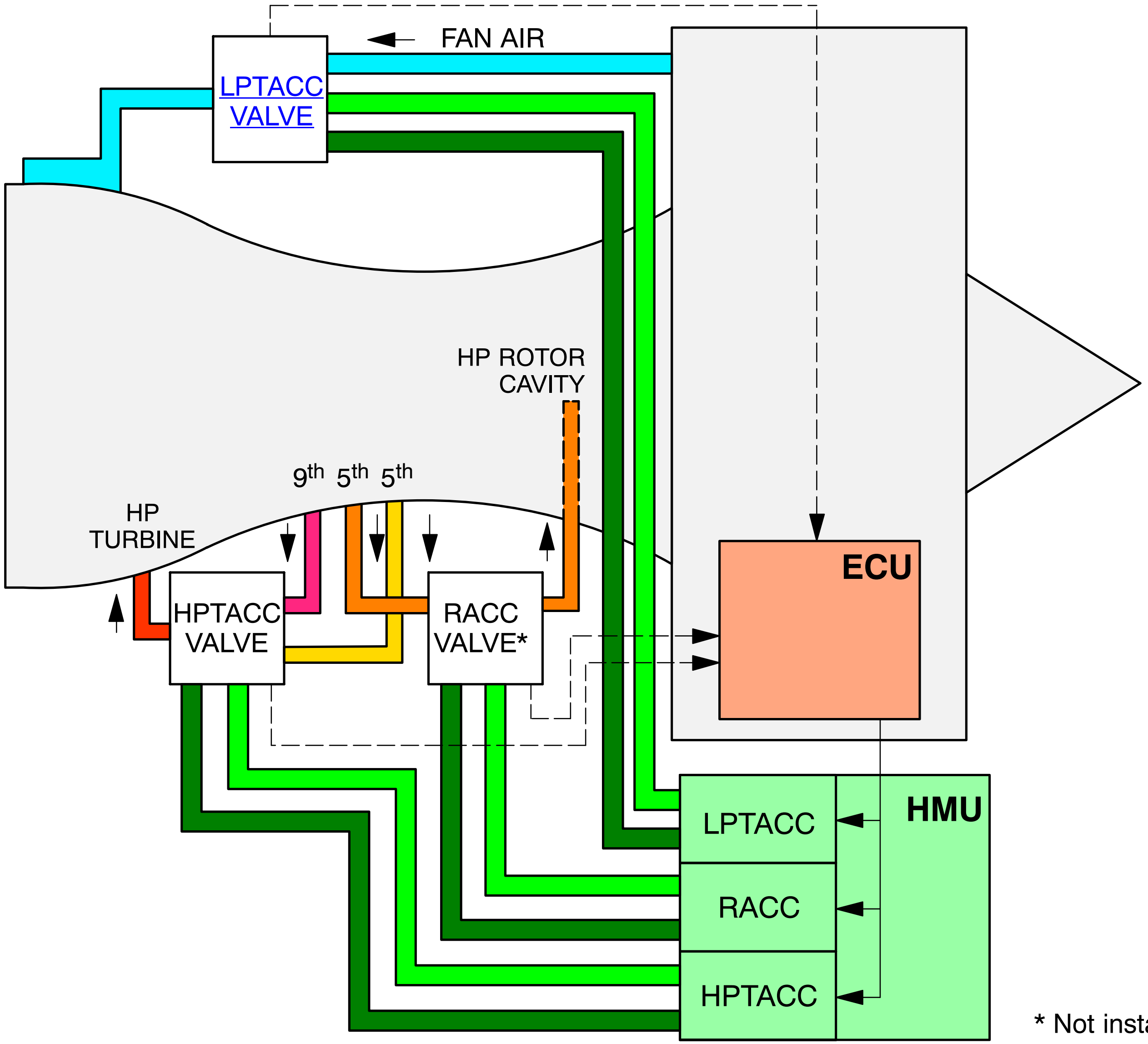
The LPTACC system uses fan air for external case cooling of the Low Pressure Turbine. Fan air is supplied through the LPTACC Valve and an array of piping and small air jet to the LPT casing. This maintains shroud clearances relative to LPT rotor blade tips.

The LPTACC valve is fuel driven by an ECU controlled servo valve within the HMU according to a specific schedule. The ECU receives Feedback signals from the LPTACC valve for monitoring purposes.

Rotor Active Clearance Control System (not installed on LH airplanes)

The RACC system modulates the fifth stage HPC bleed air into the compressor rotor bore to vary and control the clearances. The air flow to the rotor is mixed with the booster discharge air. By heating the compressor rotor with fifth stage bleed air, the compressor clearances are reduced and improve the efficiency of the compressor and improving the overall Specific Fuel Consumption (SFC) of the engine.

The RACC valve is fuel operated via an ECU controlled servo valve inside the HMU. The ECU gets feedback signals from the RACC valve for monitoring purposes.



* Not installed on DLH airplanes

Figure 132 Active Clearance Control Systems

75–21 HPT ACTIVE CLEARANCE CONTROL SYSTEM

SYSTEM OPERATION

General

The HPTACC is a closed loop system based on the HPT shroud temperature sensed by the Turbine Case Temperature Sensor (Tcase).

The Electronic Control Unit (ECU) first calculates the HPTACC valve position to control the temperature of the shroud to the desired level. Then, the ECU sends an electrical signal to the Hydromechanical Unit (HMU) to move the HPTACC valve.

The HPTACC valve is an hydraulic actuator linked with the 5th and the 9th stage butterfly valves which control air flow to the HPT shroud support structure. Two Linear Variable Differential Transformers (LVDT) are connected to the actuator to give valve position feedback to the two thermocouples which are embedded in the HPT shroud support structure and provide temperature feedback to the ECU.

Control

On engine start, the HPTACC valve moves to the 9th stage bleed position which unloads the compressor to improve engine acceleration. At and above ground idle, the HPTACC valve position is determined by the closed loop shroud temperature control. When the engine is shut down, the valve extends to a fail–safe no air position.

The HPT Clearance Control Systems uses the following control signals:

- N2
- T3
- Tcase

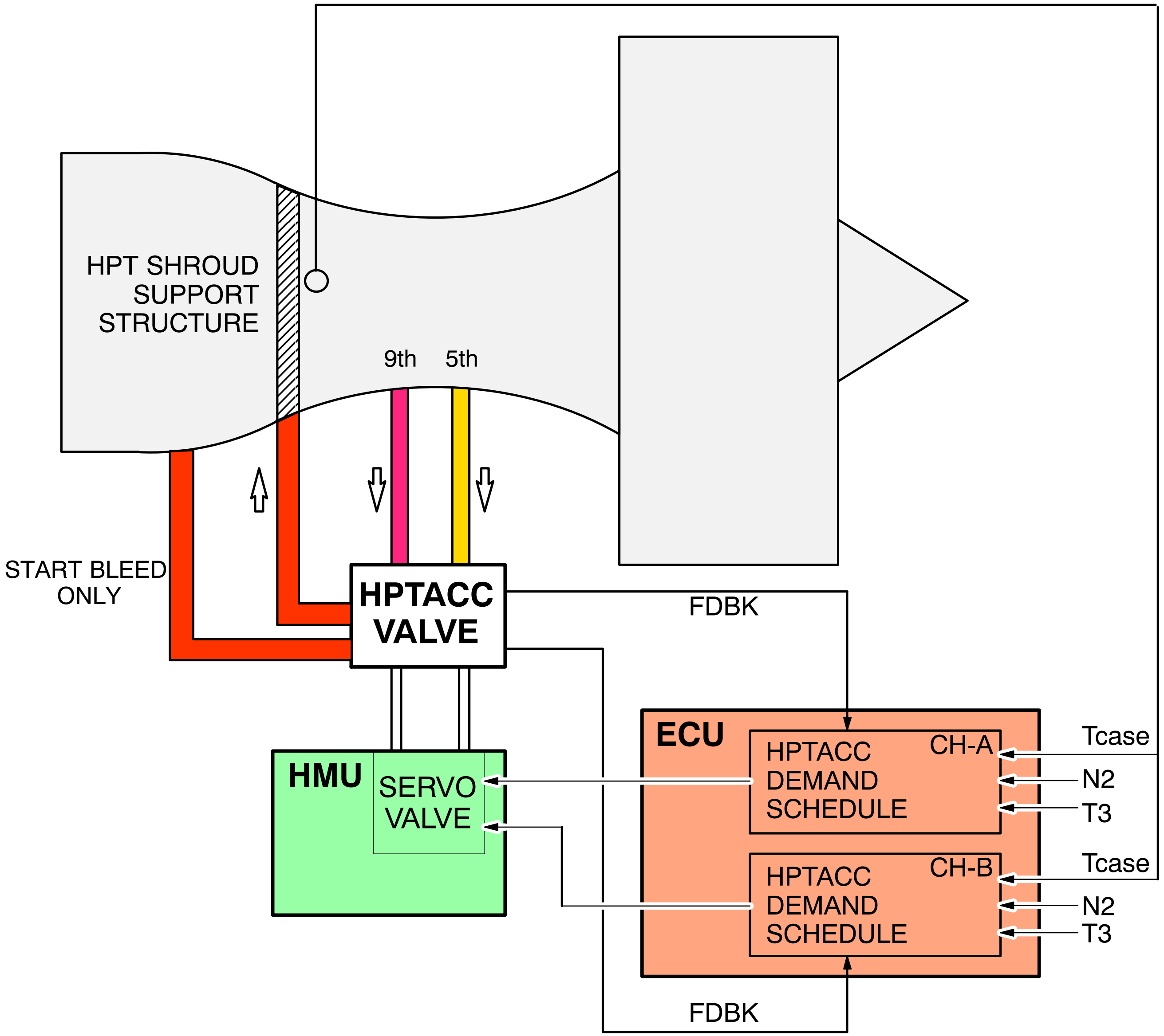


Figure 133 HPTACC System Schematic

COMPONENT DESCRIPTION

HPTACC Valve

The HPTACC valve has integrated dual butterfly valves driven by a single fuel powered actuator. Position feedback to the ECU is provided by a dual channel LVDT installed on the actuator. One butterfly valve controls the flow from 5th stage compressor bleed while the other butterfly valve controls the flow from the 9th stage compressor bleed. The 5th stage air is mixed with the 9th stage air downstream of the valve. The main valve modes are defined in the table that follows:

Schedule

ACTUATOR STROKE	MODE	5TH STAGE BUTTERFLY	9TH STAGE BUTTERFLY
0% FAIL–SAFE	NO AIR	CLOSED	CLOSED
22%	FULL 9TH	CLOSED	FULLY OPEN
42%	REGULAR 9TH	CLOSED	INTERMEDIATE
42–100%	MIXED	INTERMEDIATE	INTERMEDIATE
100%	FULL 5TH	FULLY OPEN	CLOSED

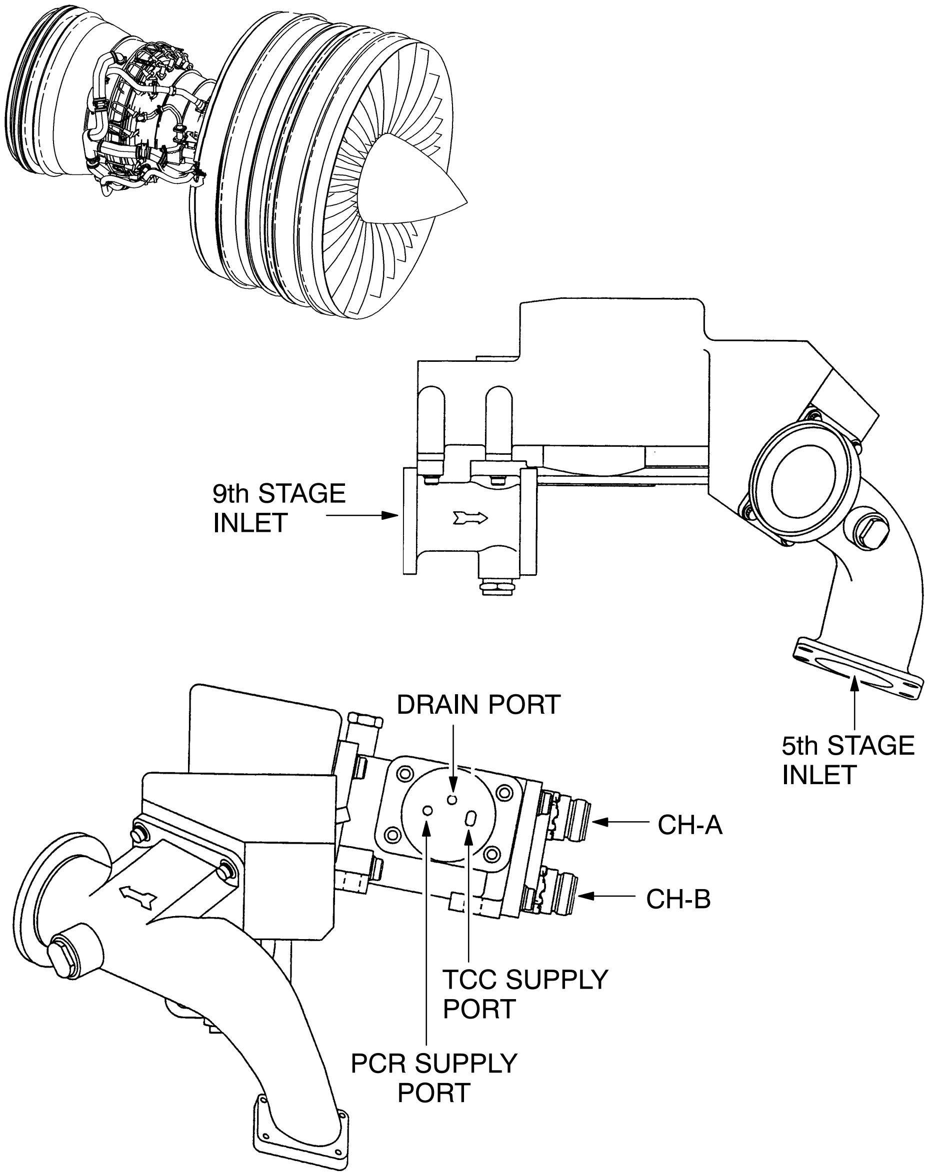


Figure 134 HPTACC Valve

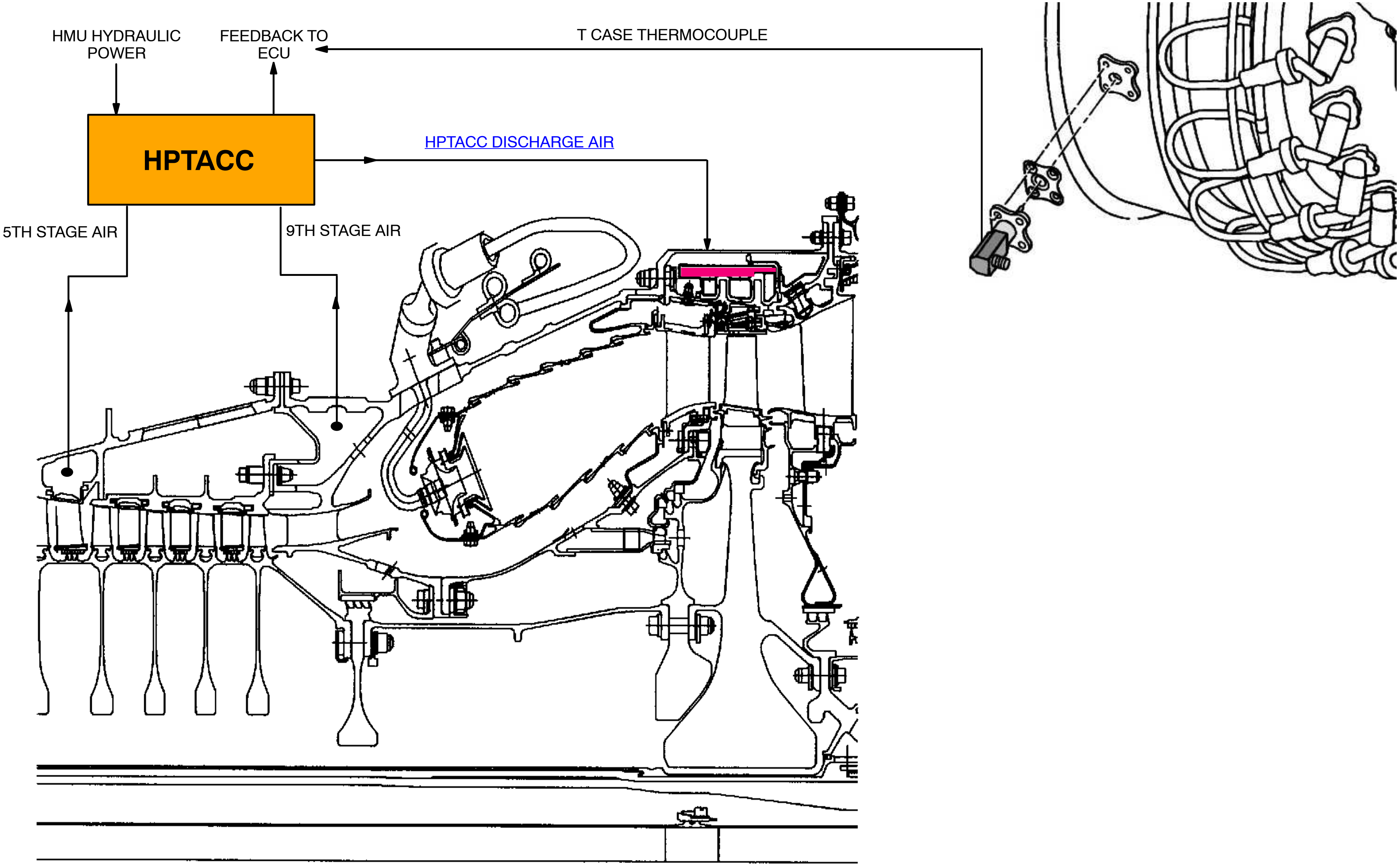


Figure 135 HPTACC Airflow Schematic

75–22 LPT ACTIVE CLEARANCE CONTROL SYSTEM

SYSTEM OPERATION

General

The LPTACC system supply fan bleed air from the inner barrel scoop of the thrust reverser to the LPT casing via circular pipings fitted around the shroud support structure. The fan bleed air flow is modulated by ECU according to engine operating conditions.

Operation

The ECU modulates the pressure of one of the piston chambers through the HMU. The HMU supplies a reference pressure to the second chamber. The ECU controls the travel of the piston and valve butterfly according to the engine parameters. The butterfly of the valve opens when the engine rating increases and closes when it decreases. When the engine is shut down, the valve butterfly is fully open.

LPT cooling air flow, controlled by the ECU depends on the following operating conditions and engine characteristics.

- N1
- P0
- TAT
- PT2
- T12

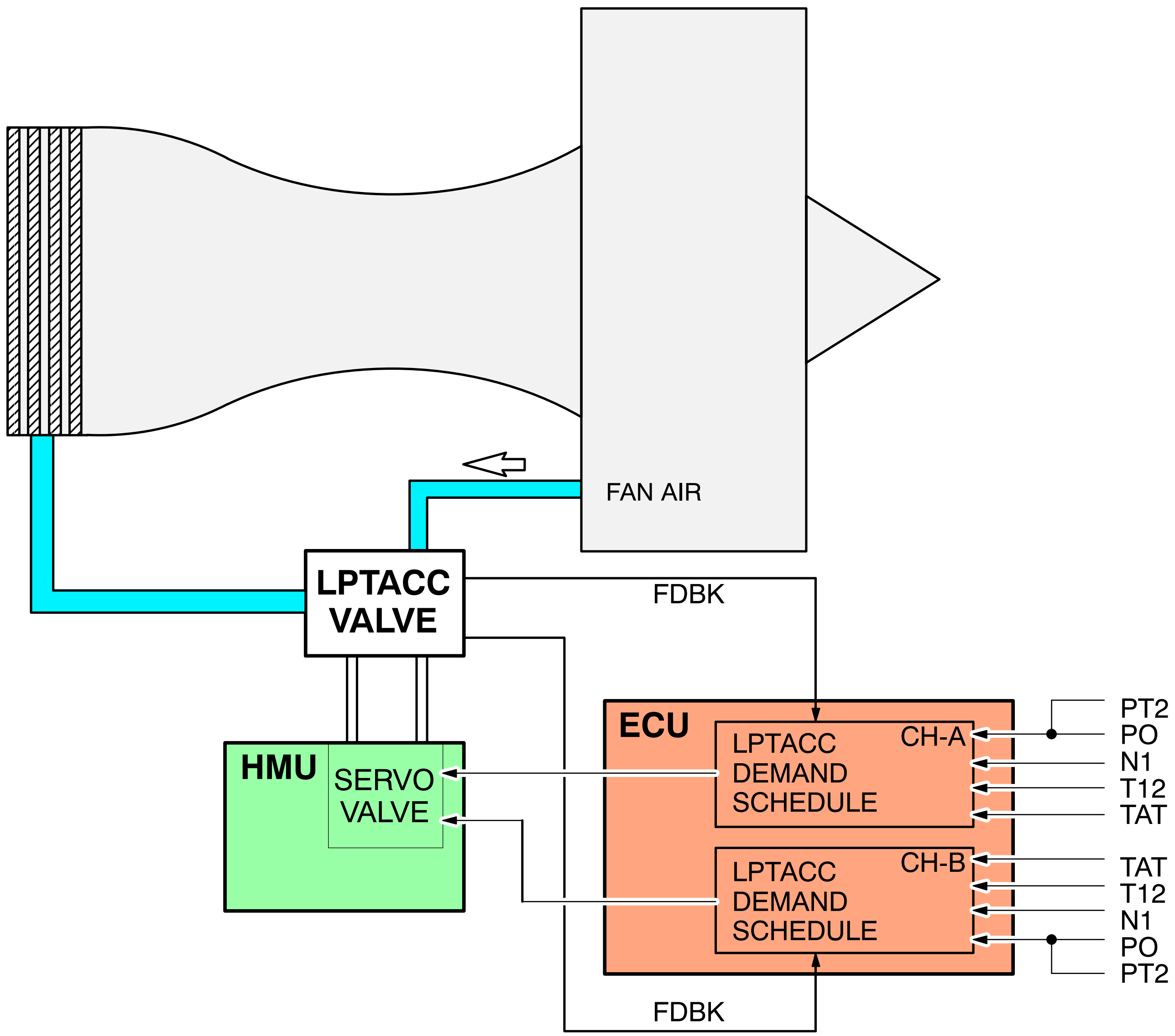


Figure 136 LPTACC System Schematic

COMPONENT DESCRIPTION

LPTACC Valve

LPT clearance control valve is a butterfly valve, the valve consists of an outer housing, a control plate, a linear actuator, 2 RVDT sensors for feedback signals and a butterfly valve actuation.

Under control of the PCR pressure applied at its head end and a PC/PB modulated pressure applied at its rod end, the linear actuator moves a rack controlling both the opening and closing of the butterfly valve which regulates the amount of air required for cooling the turbine as a function of the engine operating configuration (engine rating).

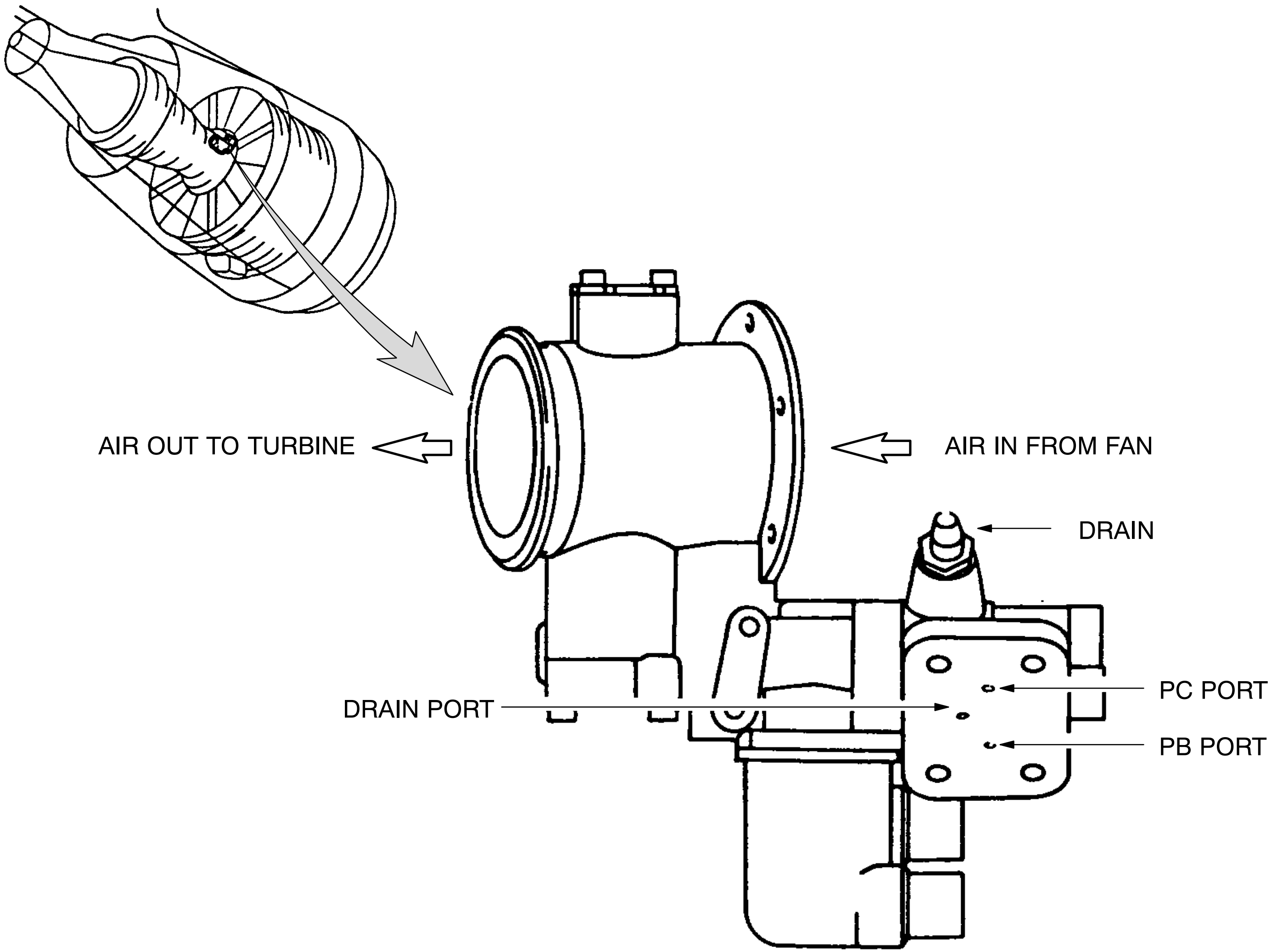


Figure 137 LPTACC Valve

75–30 COMPRESSOR CONTROL

DESCRIPTION

General

The variable geometry control system is designed to maintain satisfactory compressor performance over a wide range of operation conditions. To limit compressor surge and to provide good acceleration, the engine is equipped with a:

- **V**ariable **B**leed **V**alve (VBV) System
- **V**ariable **S**tator **V**ane (VSV) System

Both systems are fuel operated by Hydromechanical Metering Unit Servo Valves and controlled by the Electronic Control Unit via the Servo Valve Torque Motors (TMs).

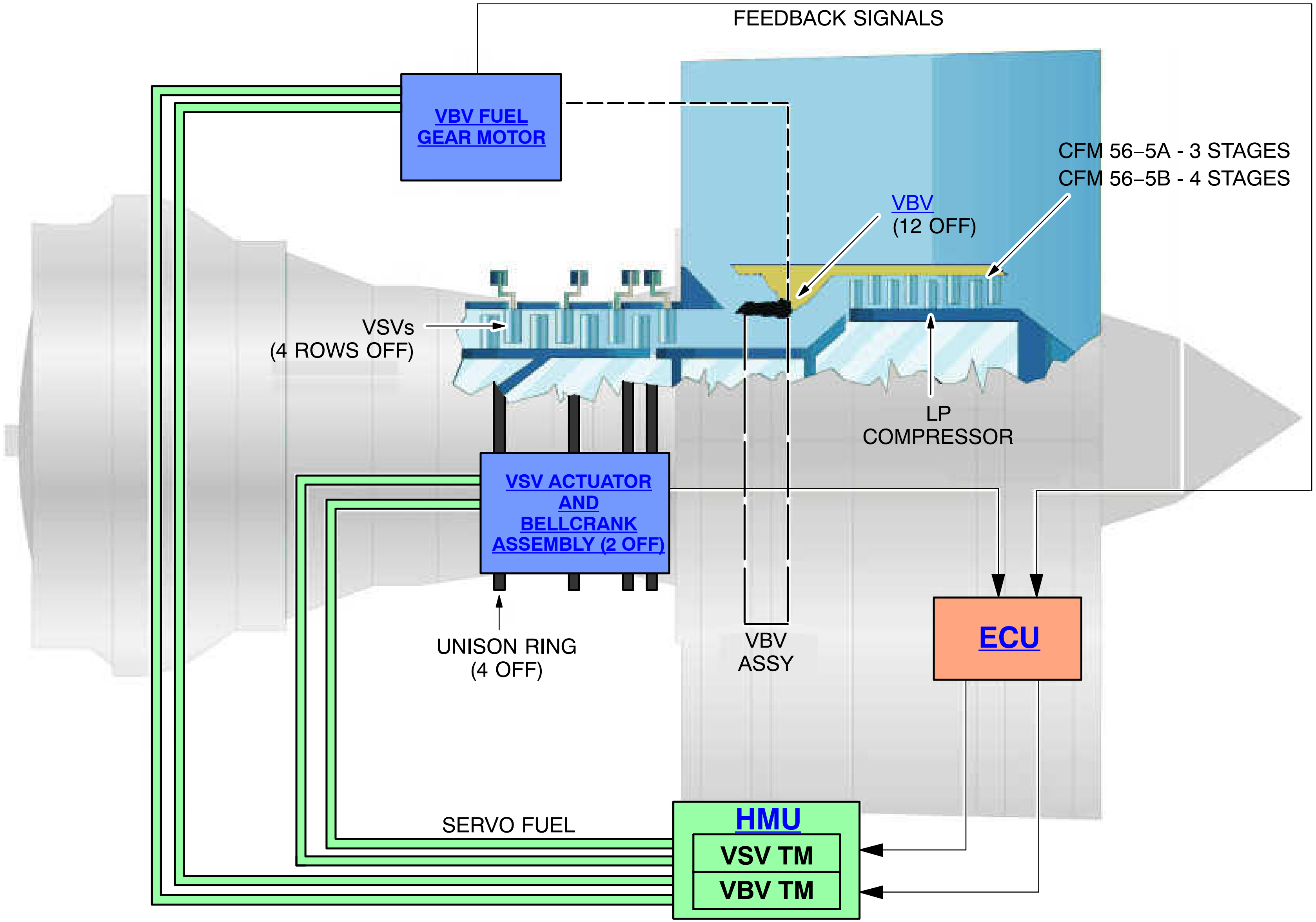


Figure 138 Compressor Control System

75−31 VARIABLE BLEED VALVE SYSTEM (VBV)

SYSTEM OPERATION

General

The Variable Bleed Valve system matches the Low Pressure compressor airflow to the High Pressure compressor requirement by bleeding off excess air to the fan discharge airstream. There are eleven Variable Bleed Valves installed circumferential of the LP compressor. The control system includes the following components:

- Servo Valve within the HMU
- Fuel Gear Motor
- **R**otary **V**ariable **D**ifferential **T**ransducer (RVDT)
- Master Ballscrew Actuator and Ballscrew Actuators
- Flexible Drive Shafts (11)
- Bleed Valves (11 + 1 Master)

Operation

The VBV position is related to the HPC operation. It is directly controlled by the angular setting of the variable compressor stator vanes at steady−state operation and during acceleration. The bleed valves open during low and transient operations to increase the booster mass flow and to improve booster and HPC matching. The bleed valves are fully open during fast decelerations.
The ECU uses the following signals for VBV positioning:

- N1
- N2
- VSV-Position Feedback

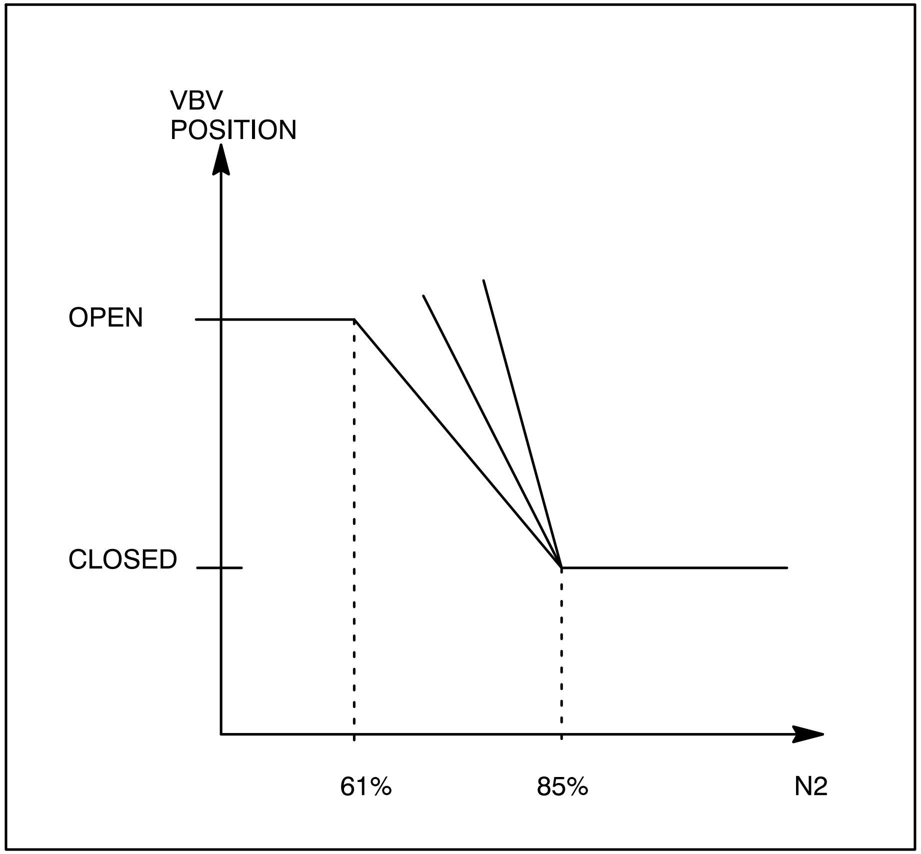


Figure 139 VBV Schedule

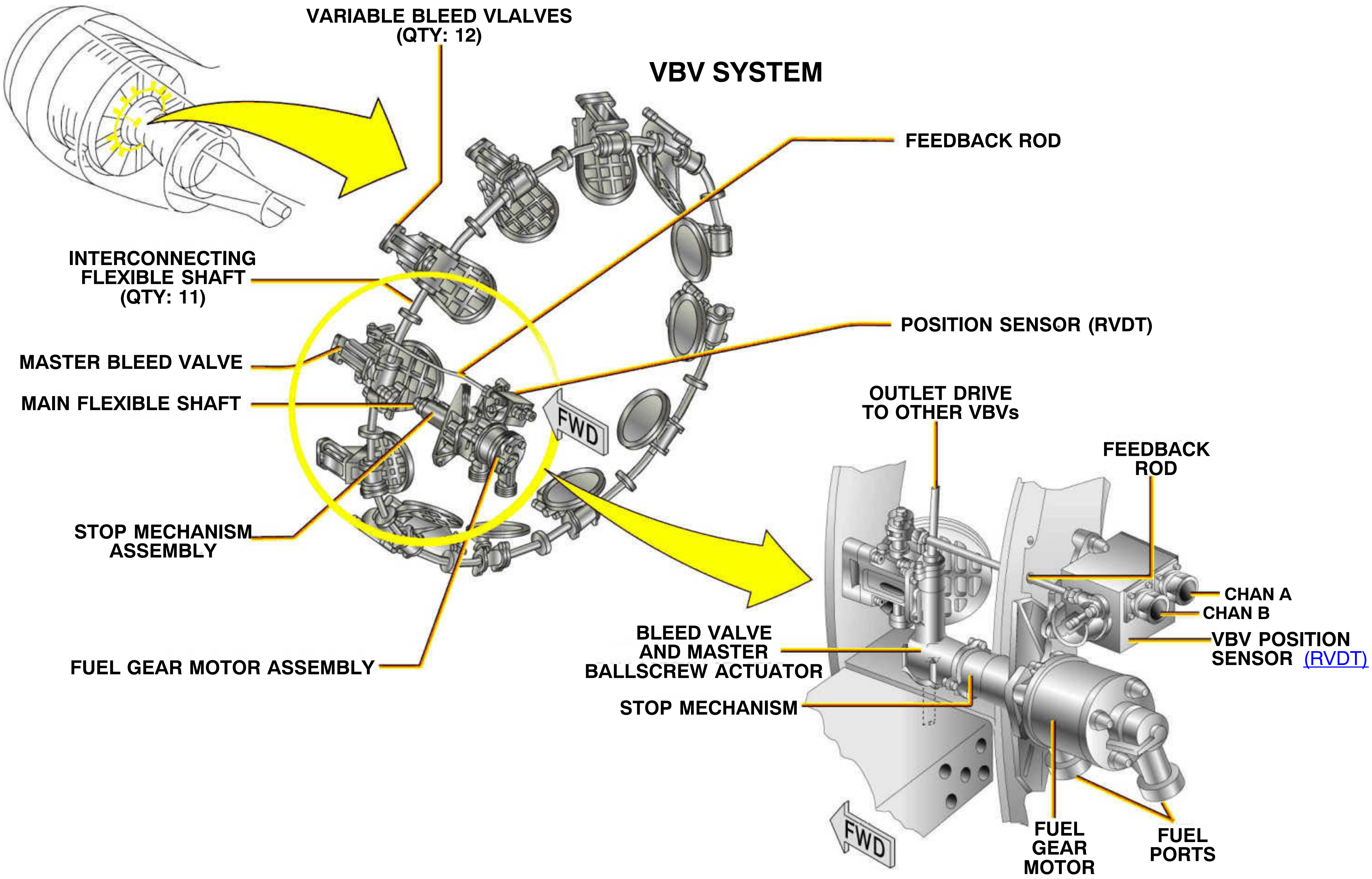


Figure 140 VBV System

VBV OPERATION

Fuel Gear Motor

The fuel gear motor transforms high pressure fuel flow into rotary driving power to position the master bleed valve, through a screw in the stop mechanism.

The fuel flow sent to the gear motor is constantly controlled by the ECU, via the torque motor and servo valve in the HMU.

Stop Mechanism

The Bleed Valve Stop Mechanism Assembly is a component of the Variable Bleed Valve Actuation System. It is located between the bleed valve Fuel Gear Motor and Master Ballscrew Actuator.

The function of the Bleed Valve Stop Mechanism Assembly is to limit the number of revolutions of the Bleed Valve Fuel Gear Motor to the exact number required for a complete cycle (opening−closing) of the VBV doors. This limiting function supplies the reference position for installing and adjusting the VBV actuators.

The bleed valve stop mechanism consists of a housing for a hollow screw which is driven by the bleed valve fuel gear motor. This hollow screw shaft holds the main VBV flexible shaft which connects the Bleed Valve Fuel Gear Motor to the Master Ballscrew Actuator. A follower nut runs along the screw and stops the rotation of the Bleed Valve Fuel Gear Motor when it reaches the ends of the screw threads.

A location is provided on the aft end of the Bleed Valve Stop Mechanism for installation of the RVDT. The RVDT is electrical supplied by the ECU and transmits the angular VBV position to ECU channel A and channel B by means of two electrical signals.

Master Bleed Valve and Feedback Sensor

The master bleed valve and ballscrew actuator assembly is a unit, which transmits the driving input from the gear motor to the 11 remaining variable bleed valves (VBV's).

A lever, integral with a hinged door, is connected to a feedback rod, which transmits the angular position of the door to an RVDT. This sensor gives the position feedback to the ECU.

It has two marks, which should be aligned when the system is adjusted to the fully closed position. The adjustment is done through the feedback rod in between the master bleed valve and the RVDT.

Variable Bleed Valves (VBVs)

The master bleed valve drives the 11 variable bleeds valves (VBVs) through a series of flexible shafts. The flexible shafts make sure that the VBVs remain fully synchronized throughout their complete operation.

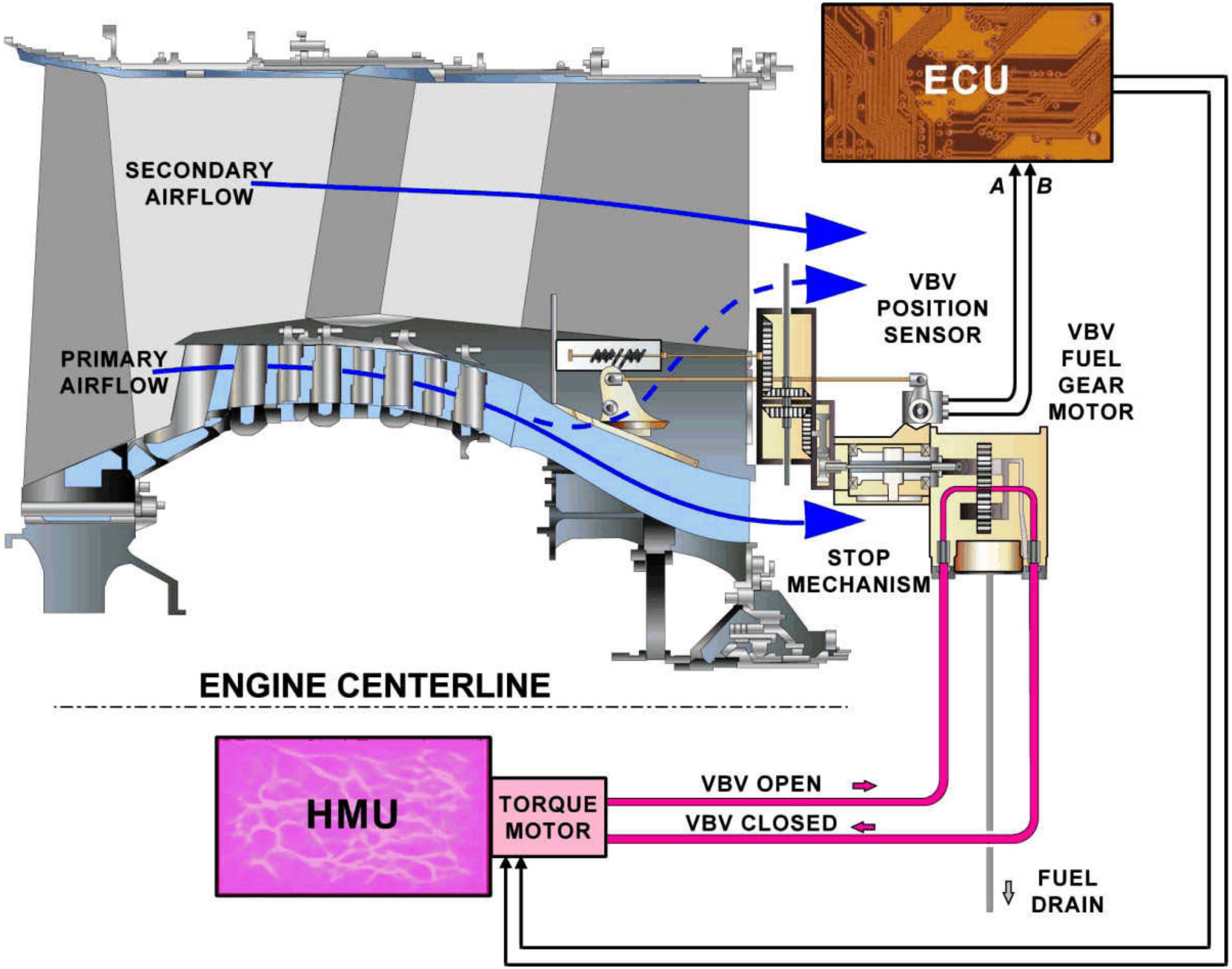


Figure 141 VBV Operation

System Actuation

The VBV actuation system provides an angular output through the Fuel Gear Motor Assembly to the Master Ballscrew Actuator. The Master Ballscrew Actuator transmits power from the main flexible shaft to the remaining ten Ballscrew Actuators.

The system is designed to open, close, or modulate the 12 VBV doors to an intermediate position in response to an input command signal. The VBVs remain fully synchronized throughout their complete stroke by the continuous mechanical flexible shaft arrangement. High pressure fuel hydraulically activates the VBV actuation system. The VBV position sensor provides VBV position bias to the ECU. The Master Ballscrew Actuator Assembly is connected by a push−pull feedback rod to the VBV position sensor (RVDT).

Control and Operation

The system performs four primary functions:

1. Positions the bleed valves in response to a differential fuel pressure through the motor of the fuel gear motor assembly
2. Mechanically synchronizes the 12 bleed valves throughout the stroke
3. Limits the bleed valve position at the end of each stroke
4. Provides the feedback of the VBV position sensor (RVDT) to the ECU

The Fuel Gear Motor, hydraulically actuated by the HMU Servo Valve drives the system to the commanded position. The Servo Valve Torque Motor current is based on the VBV demand schedule and depends on the ECU input parameters. The ECU determines direction and speed of the Fuel Gear Motor rotation.

Pressure across the Fuel Gear Motor is reduced as the system approaches the commanded position. The RVDT electrical position feedback to the ECU directs the HMU-Servo Control Valve to its null position. This reduces motor speed and allows the motor to engage the end of stroke stops to neutralize VBV loads.

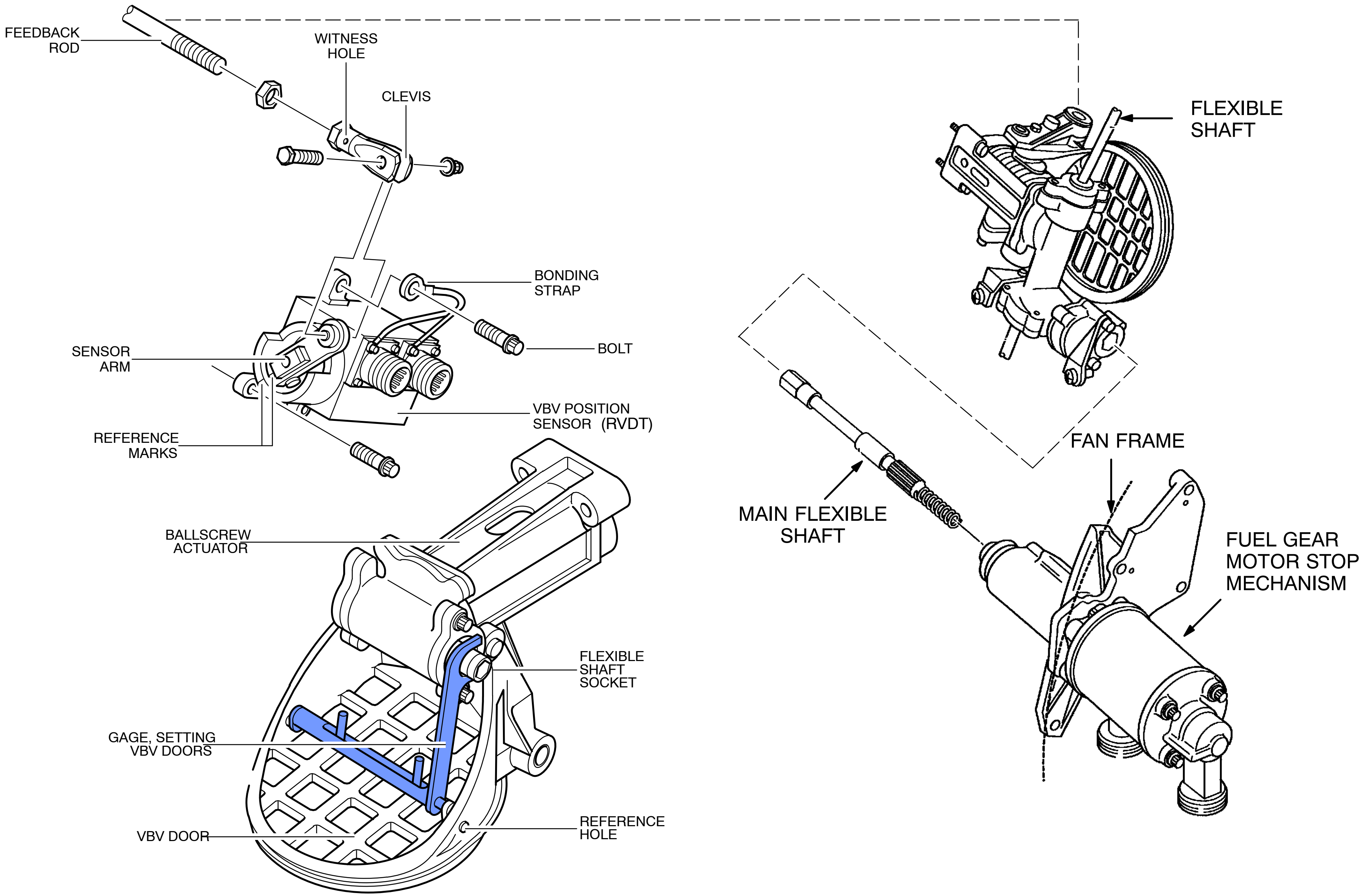


Figure 142 VBV Actuation System

75−32 VARIABLE STATOR VANE SYSTEM (VSV)

VSV SYSTEM OPERATION

General

The Variable Stator Vane (VSV) system provides optimum compressor efficiency at steady state and adequate stall margin for transient engine operation.

System Actuation

The system consists of 2 VSV hydraulic actuators with dual independent **L**inear **V**ariable **D**ifferential **T**ransformer (LVDT)) for position feedback, and 2 actuator mechanisms (bellcrank assembly) and linkages.

Operation

The Engine Control Unit (ECU) schedules the VSVs by controlling the VSV servo valve in the Hydraulic Mechanical Unit (HMU). The Hydraulic Mechanical Unit supplies high pressure fuel to the VSV actuators. Each actuator contains a LVDT for position feedback to the ECU, which provides the excitation current. The LH LVDT is dedicated to channel A and the RH one to channel B.

Each VSV actuator is connected through a clevis link and the stage 3 bellcrank to a master rod. Adjustable linkages connect the variable vane actuation ring to bellcranks which are connected to the master rod. The four actuation rings, which are connected at the horizontal split−line of the compressor casing rotate circumferential about the horizontal axis of the compressor. Movement of the rings is transmitted to the individual vanes through vane actuating levers.

Control

The ECU schedules the VSVs by controlling the VSV servo valve torque motor located in the Hydraulic Mechanical Unit. The actuators LVDT transmits a feedback signal of the actual vane position to the ECU in order to close the control loop. The vanes are closed at Low N2 and opened at High N2. VSV angle is a function of:

- Core Engine Speed (N2)
- Compressor Inlet Temperature (T25)
- Altitude (P0)

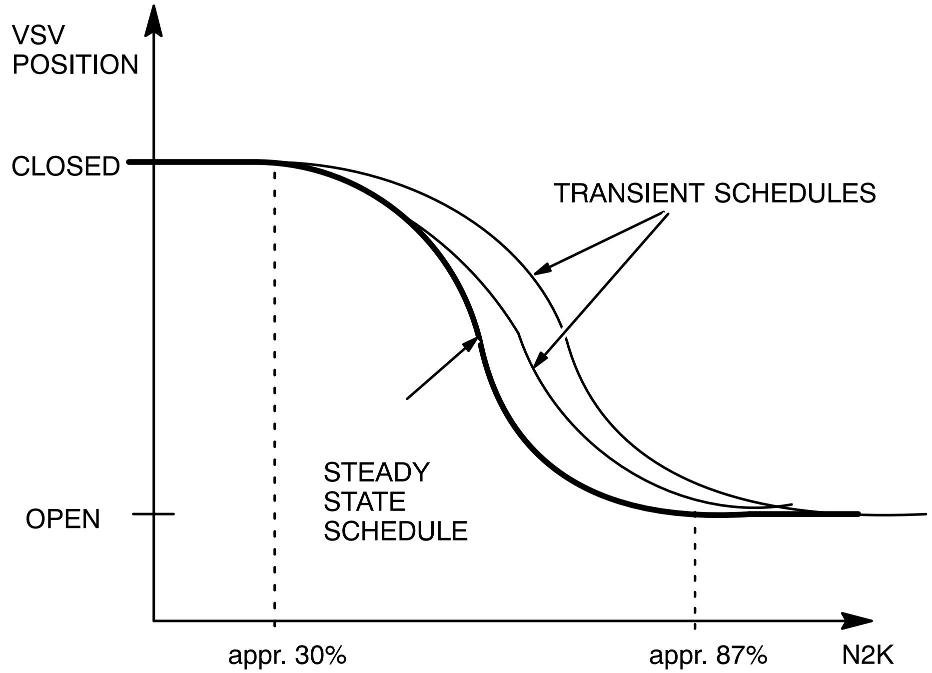


Figure 143 VSV Schedule

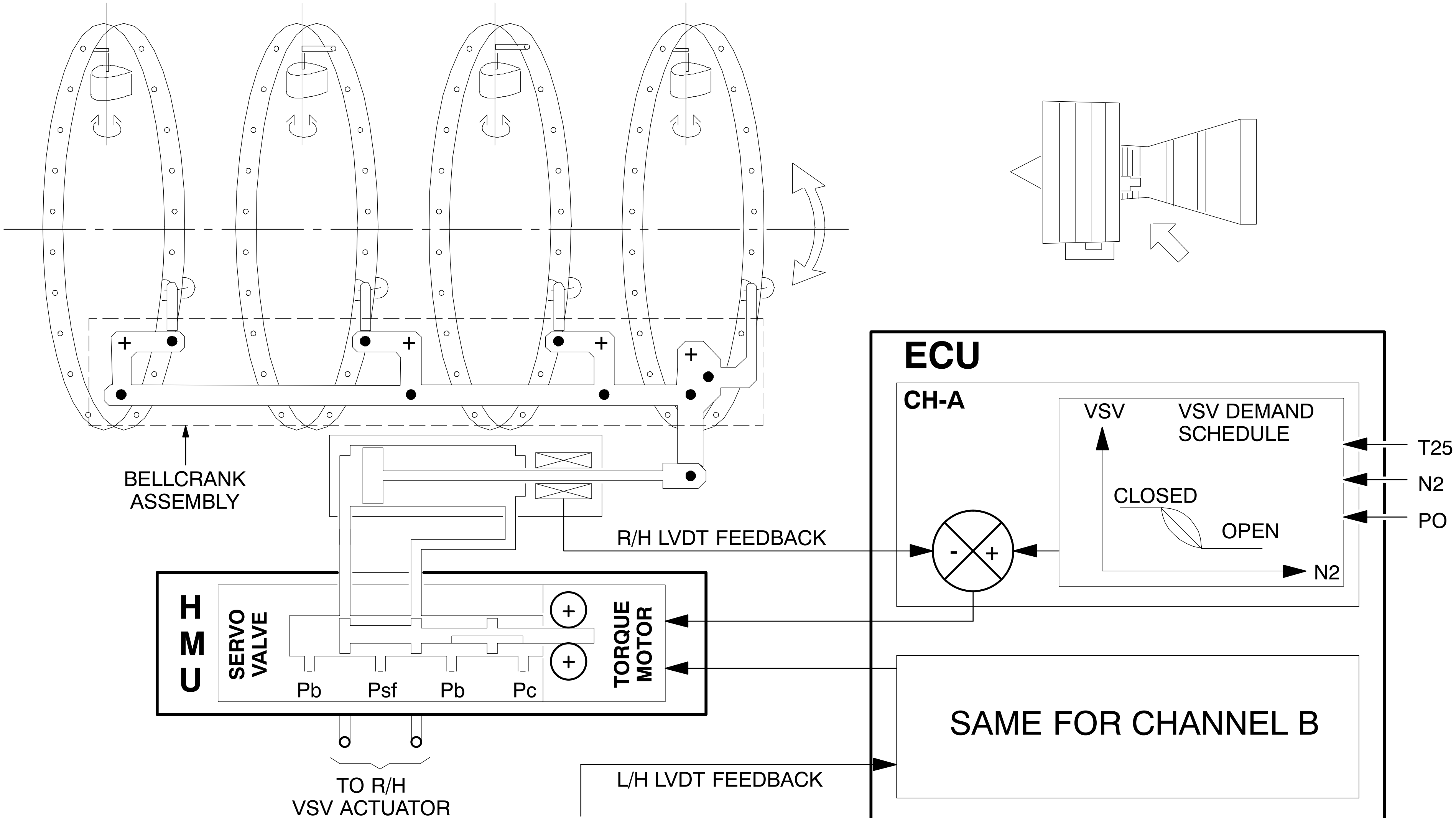


Figure 144 VSV Schematic

COMPONENT DESCRIPTION

VSV Actuator

The variable stator vane (VSV) actuator provides an output force and motion to the variable stator system in response to fuel pressures from the hydromechanical unit. The VSV actuators are mounted on the high pressure compressor stator case at the 2 and 8 o'clock positions.

Linear Variable Differential Transformer (LVDT)

Each actuator contains one independent LVDTs for position indication. Each LVDT consists of three windings: one excitation and two secondary. Excitation is provided by the electronic control unit.

The ECU compares the feedback signal to the scheduled value and modulates the control signal sent to HMU torque motor to maintain the VSV actuator position in agreement with the schedule.

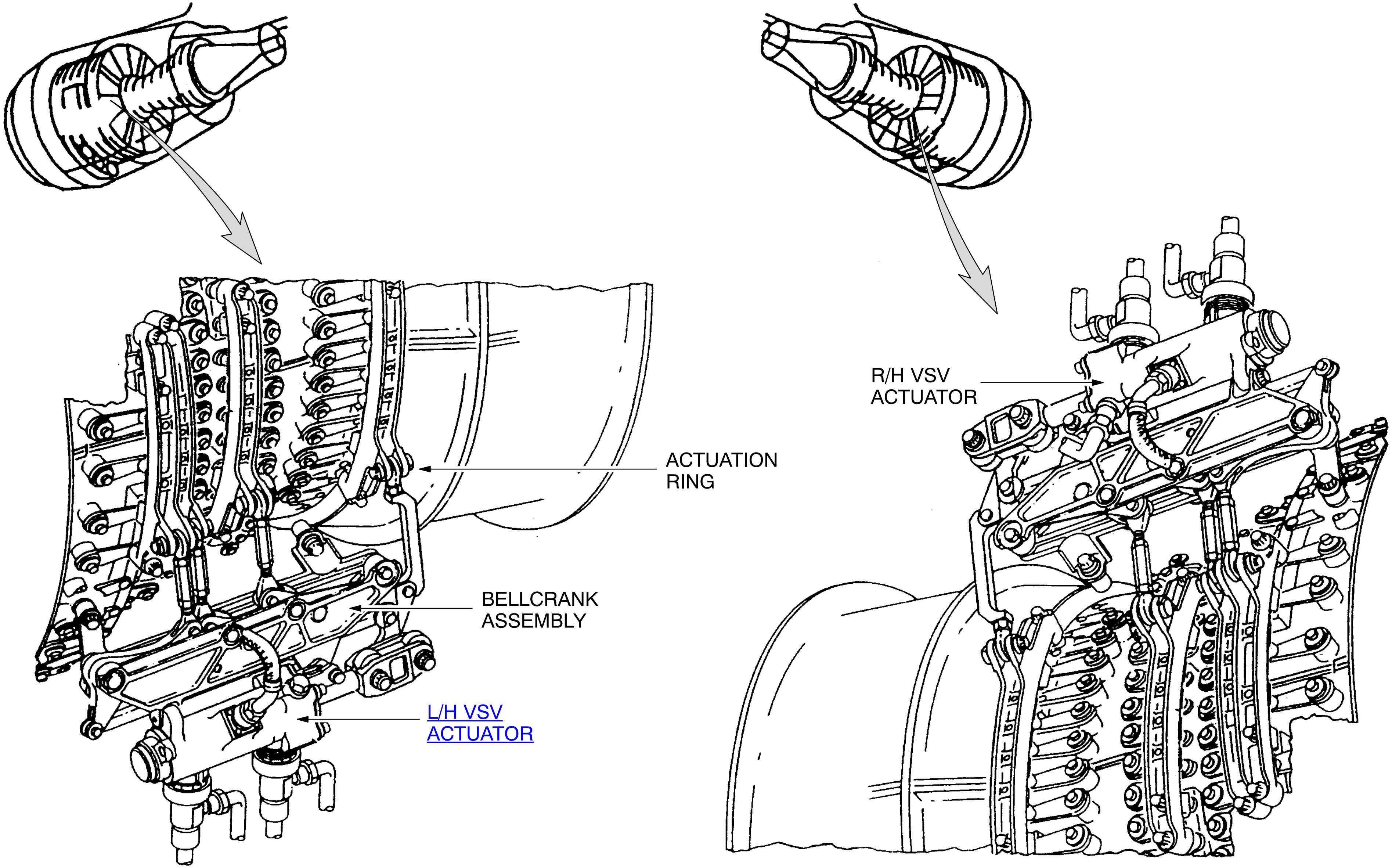


Figure 145 VSV Actuation System

75–25 NACELLE COMPARTMENT AND ACCESSORY COOLING

NACELLE COOLING DESCRIPTION

General

The nacelle installation is designed to provide cooling and ventilation air for engine accessories mounted along the fan and core casing. The nacelle is divided in three major areas:

- Engine Air Inlet
- Fan Compartment
- Core Compartment

Function

The function of the nacelle components are:

- Sufficient airflow to offset the effects of engine case heat rejection and engine flange air leakage, thereby maintaining an acceptable compartment temperature level
- Cooling of temperature critical components
- Cowling pressure load limiting in the event of pneumatic duct failures
- Ventilation of compartment during engine shutdown
- Ventilation of combustible fluid vapors to prelude fires

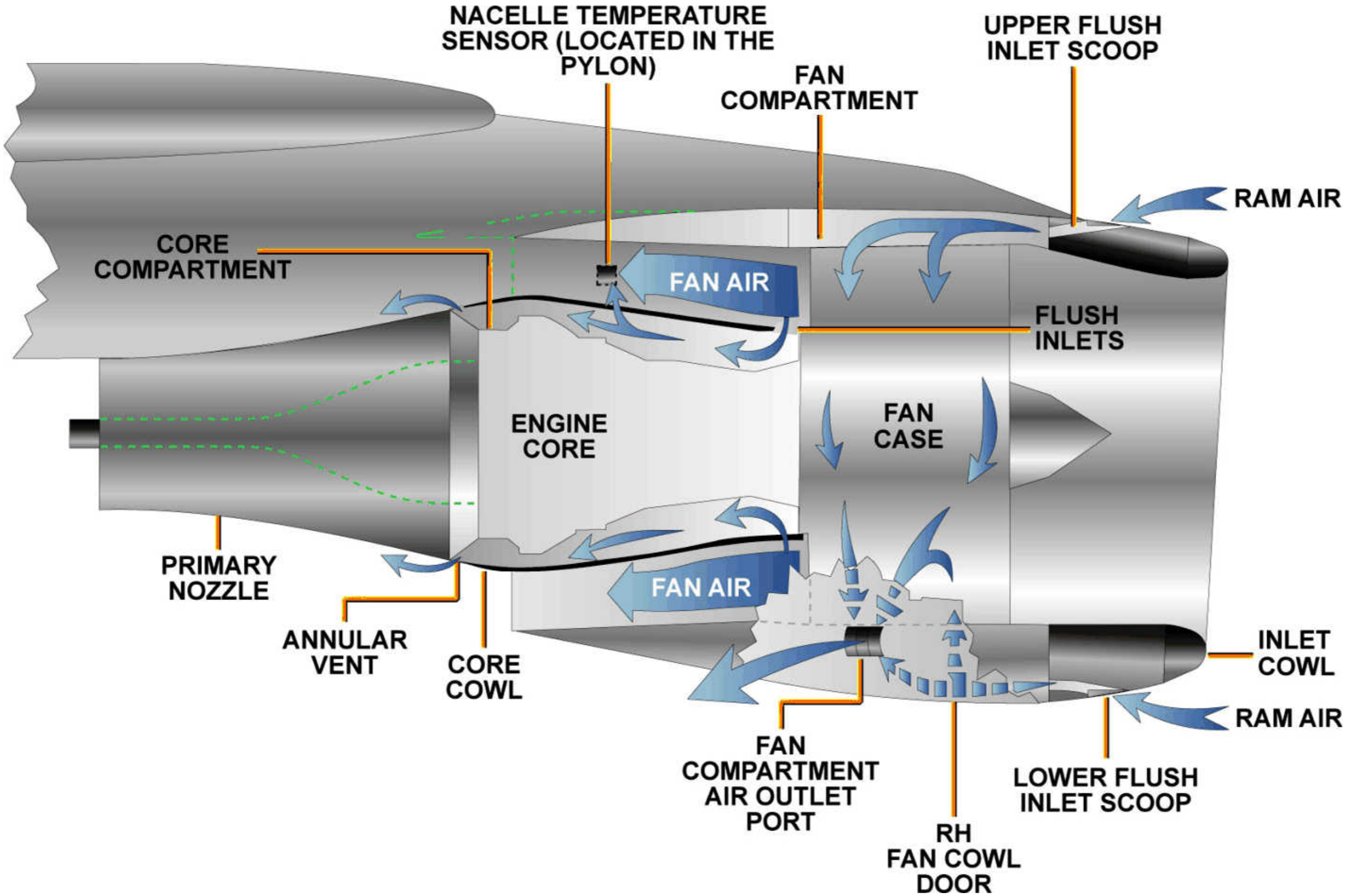


Figure 146 Nacelle Cooling

75−41 NACELLE TEMPERATURE INDICATING

DESCRIPTION

Purpose

A nacelle temperature probe measures core compartment temperature. It will indicate overtemperature resulting from loose or broken air ducts or from loose flanges, worn VSV bushings etc.

Indication

The nacelle temperature indicating system is composed of a probe and an indicator on the ECAM. The nacelle temperature probe has a measurement range of −55 °C to 300 °C.

The signal is fed to the EIU which transforms the analog information into digital form. Then the EIU transmit the data to the ECAM system.

The screen displays both nacelle temperatures if at least one of them is above 240°C. When the value reaches 240 °C the indication flashes (green advisory).

During engine starting, this parameter is replaced by the starter shutoff valve position, the bleed air pressure indication and the selected ignitor.

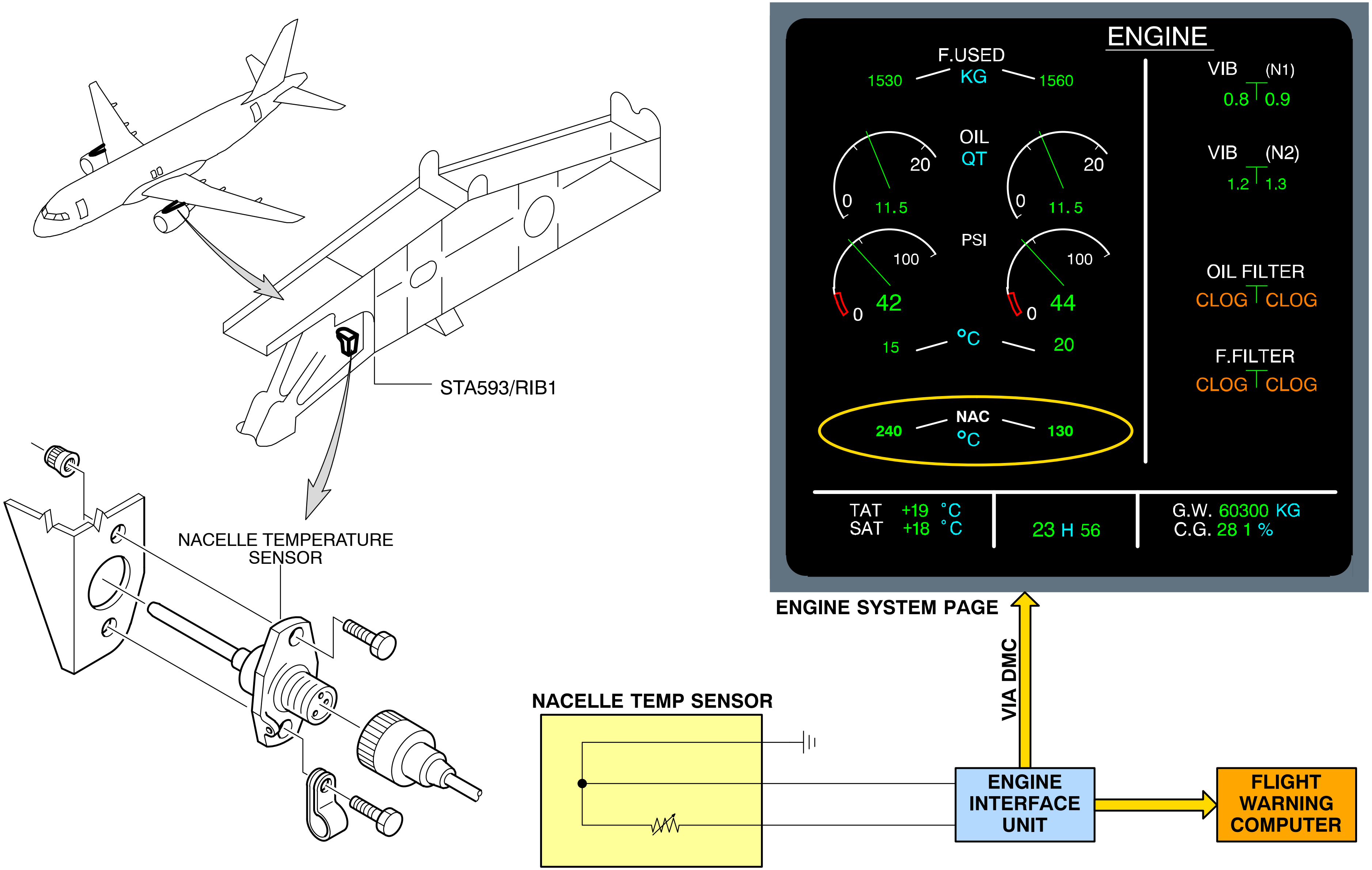


Figure 147 Nacelle Temperature Indicating

ATA 74 IGNITION

74−00 IGNITION - GENERAL

INTRODUCTION

Purpose

The ignition system is used to give an electrical spark. This spark is used to start ignition of the fuel/air mixture in the engine. This ignition is necessary to start the engine when the aircraft is on the ground or when the aircraft is airborne and to keep the engine started during some flight conditions and bad weather.

To achieve engine starting, the following sub−systems are combined:

- Starting
- Fuel
- Ignition

General

The ignition system has two independent circuits, systems A and B, consisting of:

- High Energy Ignition Exciters (2 EA)
- Ignition Lead Assemblies (2EA)
- Spark Igniters (2EA)

The ECU controls the engine starting sequences, engine cranking options and the ignition selection in response to aircraft command signals. The ECU is able to perform automatic and manual engine starts. Each channel of the ECU interfaces with the igniter systems, in order to control their operation during the starting phases.

WARNING: WORKING ON THE ENGINE IGNITION SYSTEM COULD BE SERIOUS DANGEROUS FOR YOUR LIFE IF YOU DO NOT OBEY THE SAFETY PRECAUTIONS GIVEN IN THE AMM.

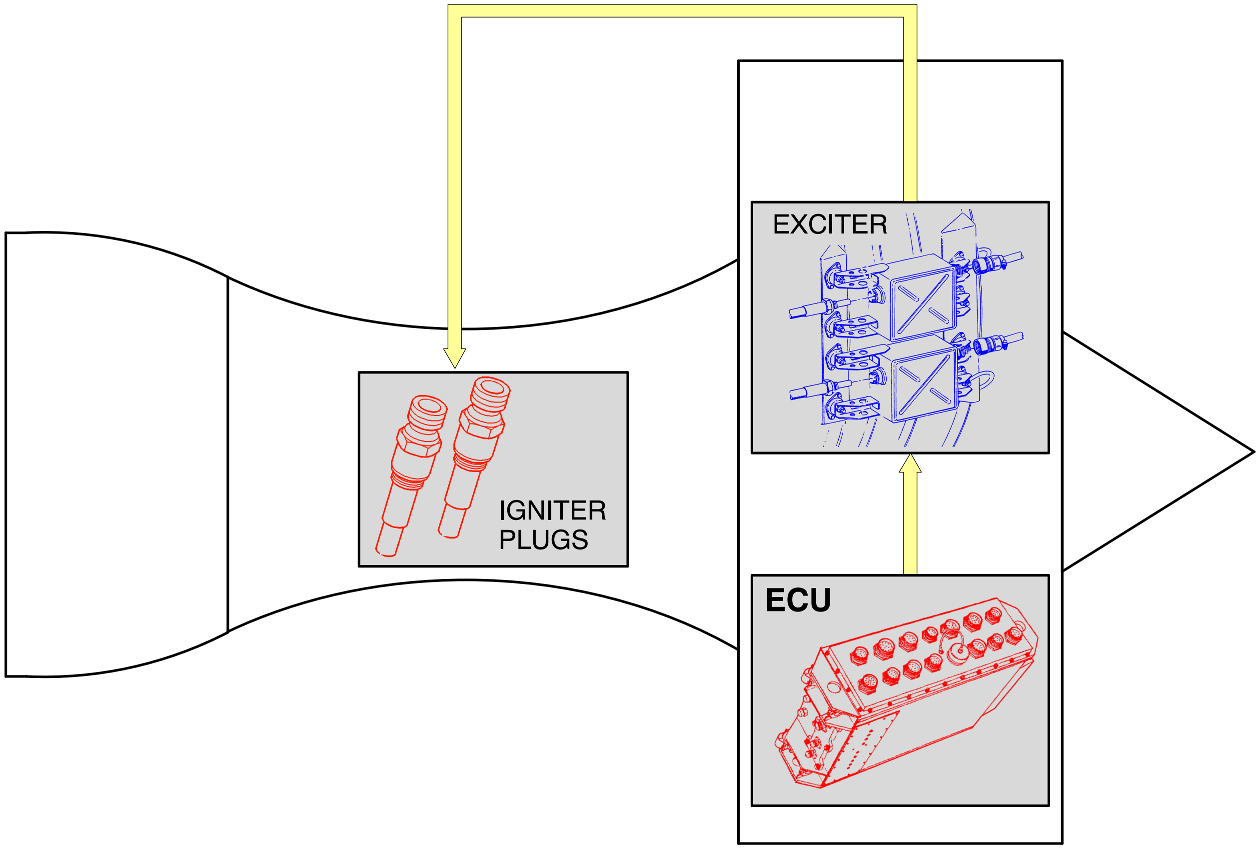


Figure 148 Ignition System Introduction

DESCRIPTION

Location

The engine is equipped with a dual ignition system, located on the right−hand side of the fan case and both sides of the core.

System A spark igniter, located on the right hand side, is connected to the upper ignition box #1.

System B spark igniter, located on the left hand side, is connected to the lower ignition box #2.

Control and Power Supply

The ignition system receives 115 VAC/400 Hz from the aircraft, through channels A and B of the ECU. A current is supplied to the ignition exciters and transformed into high voltage pulses. These pulses are sent, through ignition leads, to the tip of the ignitor plugs, producing sparks. The A/C power supply will be automatically disconnected by the Engine Interface Unit (EIU) if:

- the Master Lever is selected OFF
- in case of Fire Emergency Procedure.

The A/C ignition power supply is fail−safe to ON in case of a failed EIU.

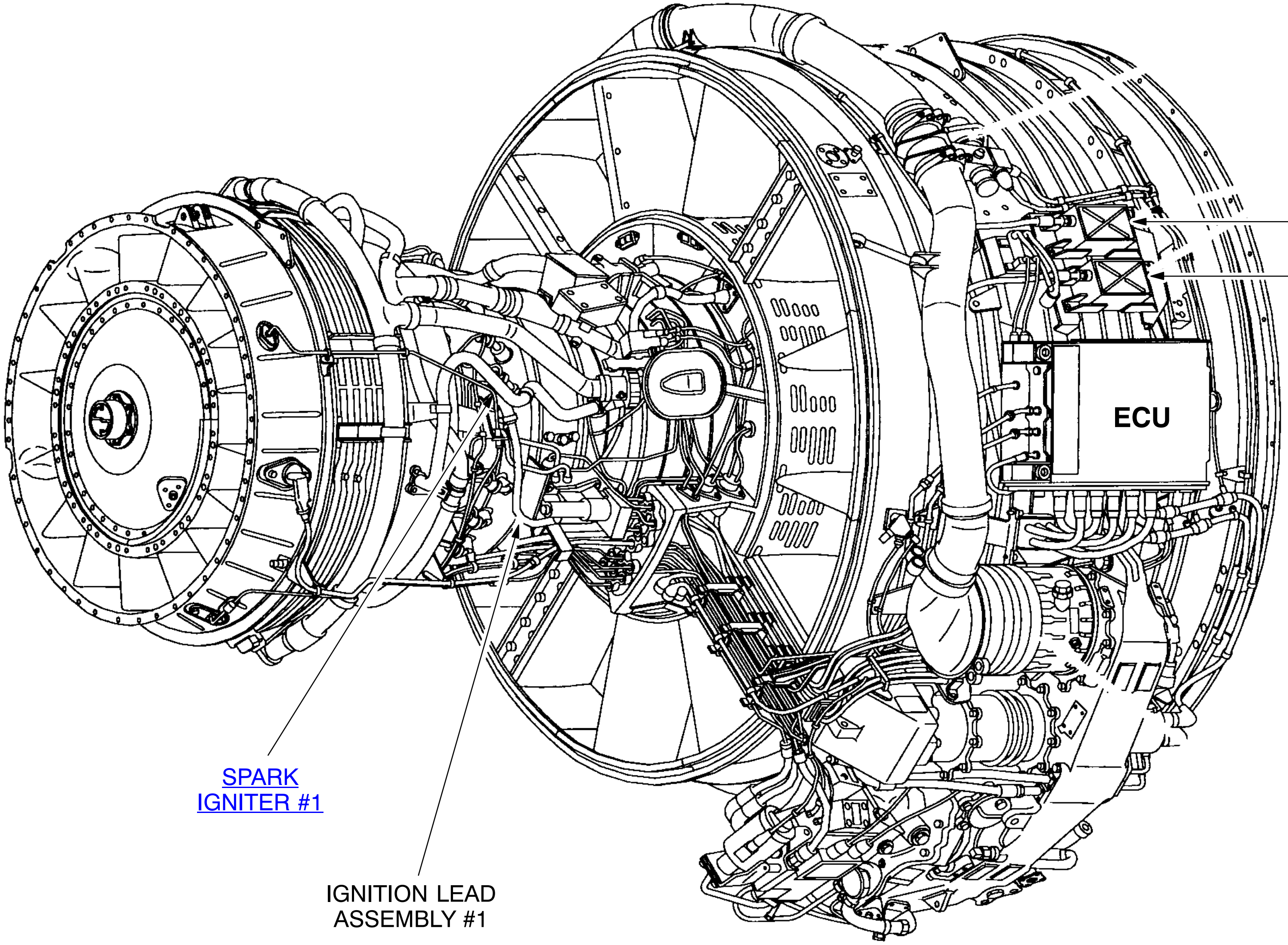


Figure 149 Ignition Components

74-30 SWITCHING

IGNITION CONTROLS DESCRIPTION

General

The Ignition System is controlled by:

- ECU
- EIU
- Engine Master Switch
- Engine Mode Selector
- Engine Manual Start Pushbutton

Engine Mode Selector

This is a common switch for both engines and can be placed in any of the following positions:

- CRANK
  - No ignition system is supplied but an engine dry motoring is possible
- NORM
  - This position is selected by the flight crew at the end of starting sequence. In this position the FADEC is able to select continuous ignition automatically under specific flight conditions (e.g. icing, EIU failure, flameout detected)
- IGN/START
  - This position is selected for
    - Normal Starting Procedure (Automatic)
    - Alternate Starting Procedure (Manual)
    - Continuous Ignition after Starting Sequence

NOTE: With engine running, continuous ignition can be selected via the ECU either manually using the rotary selector or automatically by the Full Authority Digital Engine Control.

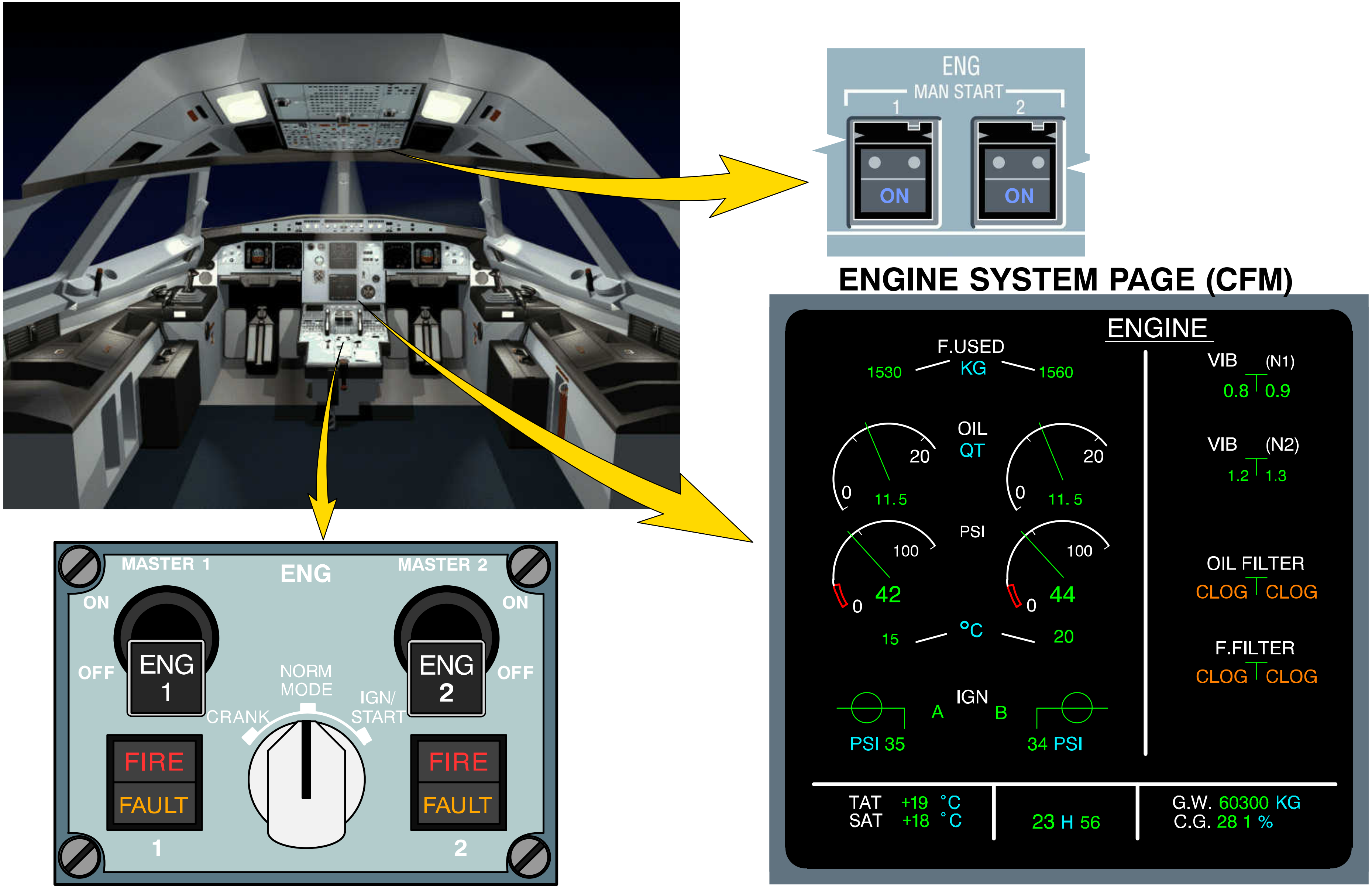


Figure 150 Ignition Controls

74−20 DISTRIBUTION

IGNITION COMPONENTS DESCRIPTION

Ignition Exciters

The two Ignition Exciters are mounted on shock dampened brackets on the outer surface of the fan case. Each Exciter has an input connector (Power Supply) and an output connector (Ignition Lead).

- Upper Box for system A.
- Lower box for system B.

The ignition boxes transform 115VAC−400Hz into high voltage (15 to 20 KV),to charge internal capacitors. The discharge rate is of one per second and energy delivered is 1,5 joules.

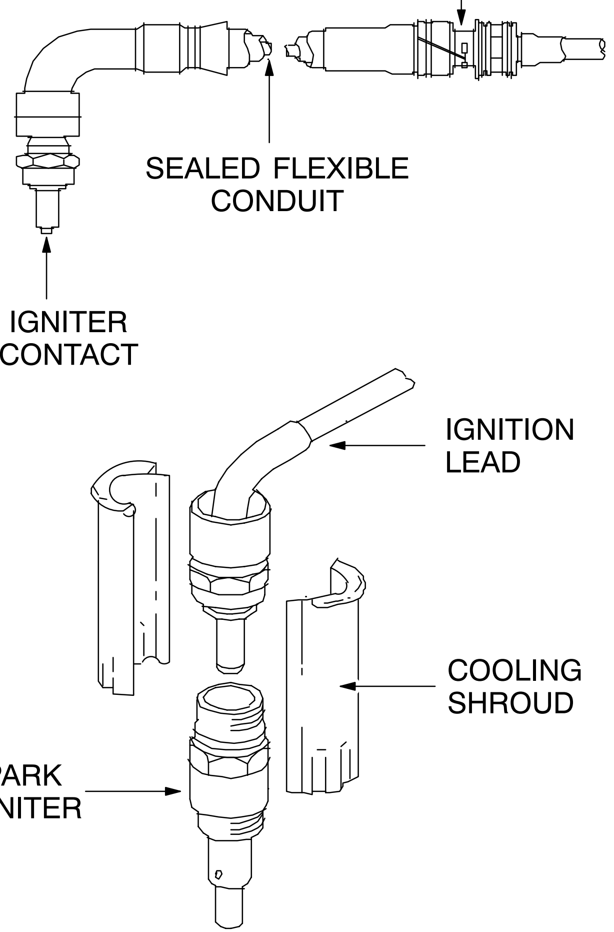
Ignitors

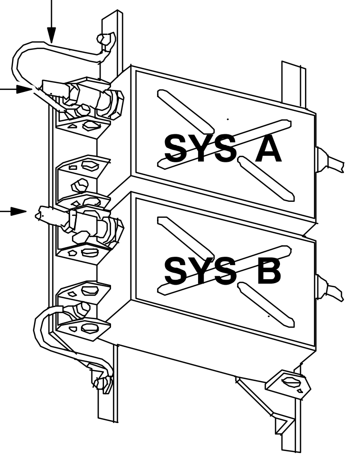
The two Spark Igniters are mounted into bosses at the 4:00 and 8:00 o'clock position on the outer surface of the combustion case. The inner tip extents through ferrules in the outer liner of the combustion chamber.

- Right igniter for system A.
- Left igniter for system B.
- Precautions have to be taken before removal / installation
- An ignition test is available through MCDU menus to verify the ignition circuit.

Ignition Leads

The Ignition Leads are constructed of insulated wire in a sealed flexible conduit having a copper inner braid and a nickel outer braid. The leads connect the Spark Igniters to the output connectors of the Ignition Exciters and transmit electrical energy. The aft ends of the leads are cooled by booster discharge air passing through the lead conduit.





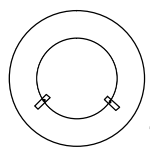


Figure 151 Ignition System Components

74-00 IGNITION GENERAL

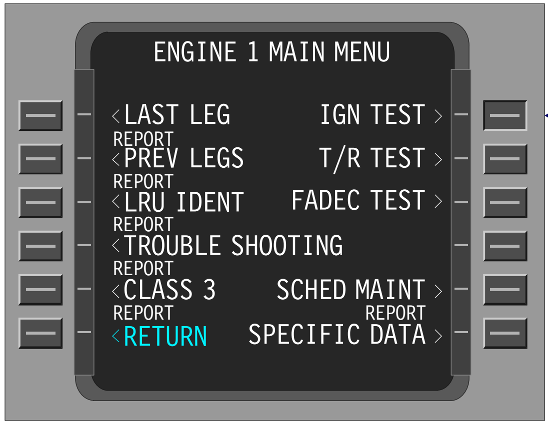
IGNITION TEST DESCRIPTION

Ignition Test with CFDS

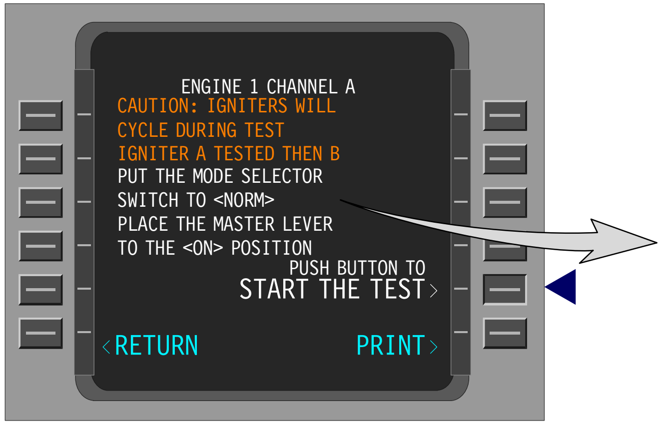
It is possible to perform an engine ignition test by means of the Centralized Fault Display System via the MCDU.

NOTE: For Detailed test procedure refer to AMM

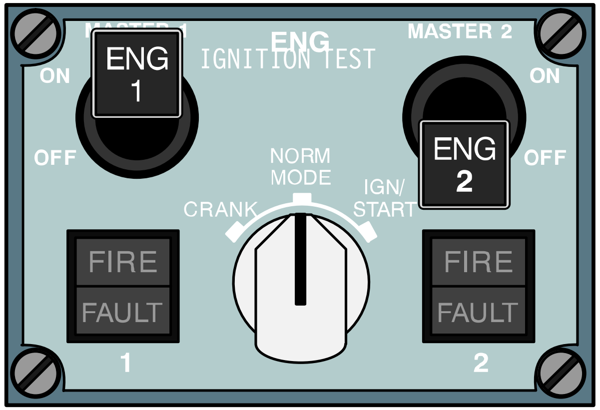
STEP 1



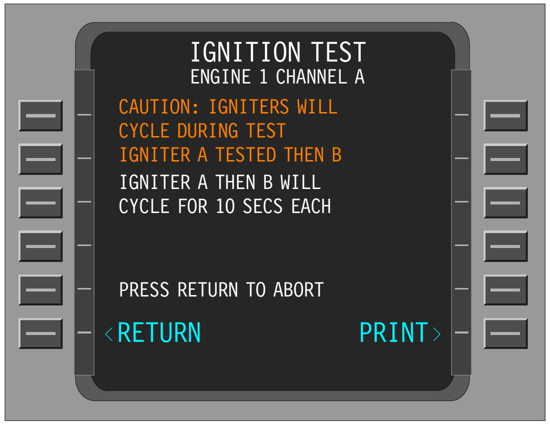
STEP 2



115VU



STEP 3



CAUTION: IN CASE OF IMMINENCE FOR HUMAN BEINGS IT IS POSSIBLE TO ABORT THE IGNITION TEST WITH THE RETURN PUSHBUTTON

STEP 4

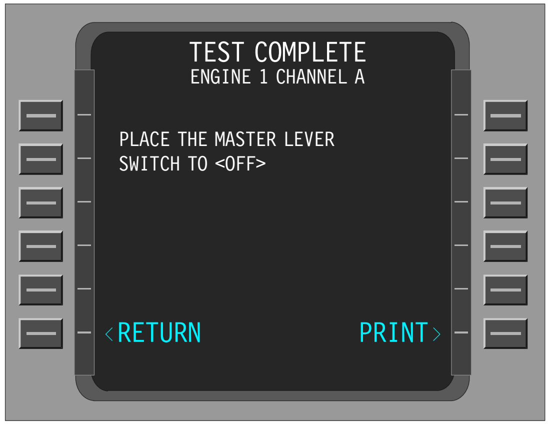


Figure 152 CFDS Ignition Test

MAINTENANCE PRACTICES

Ignition Test without CFDS

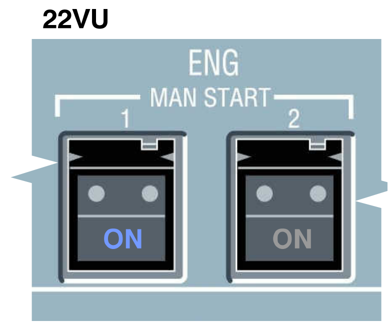
NOTE: For detailed test procedure refer to AMM.

During the test, an aural check of the ignitor plug operation has to be done.

WARNING: MAKE SURE THAT THERE IS ZERO PSI PRESSURE AT THE STARTER AIR VALVE INLET BEFORE YOU PUSH THE MANUAL START PUSHBUTTON TO ON. READ THE PRESSURE ON THE ECAM ENGINE SYSTEM DISPLAY.

1. **Starter Air Valve Position**
2. **Bleed Pressure**
3. **Selected Ignition System A and B during continuous ignition**

- Check Air Pressure at Starter Air Valve **0 PSI**
- Engine Mode Selector **IGN/START**
- Manual Start Pushbutton **ON**
- Master Lever **ON**
- Ignition A & B **CHECK ON**



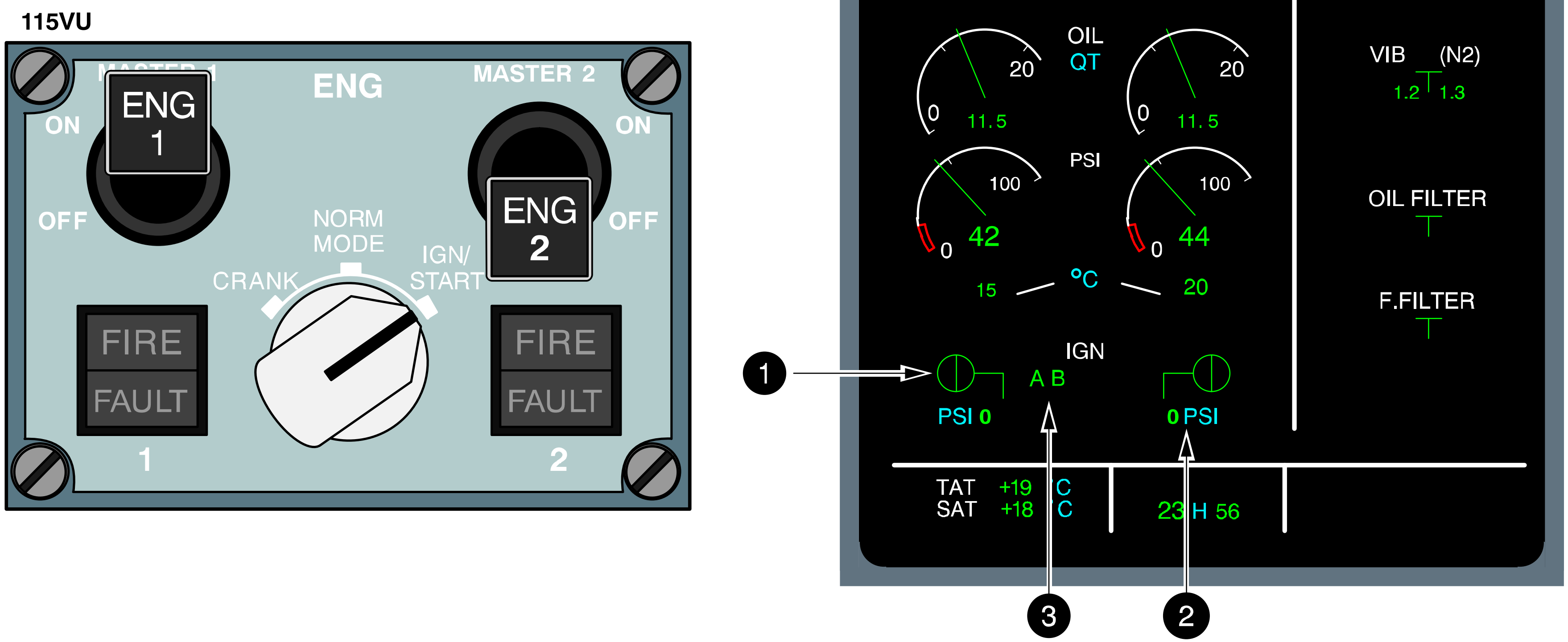


Figure 153 Ignition Test without CFDS

ATA 80 STARTING

80–00 GENERAL

INTRODUCTION

The Starting System operates in conjunction with the Ignition and Fuel System it mainly consists of the following components:

- Starter Air Valve
- Air Starter
- Ignition Exciters
- Spark Igniters

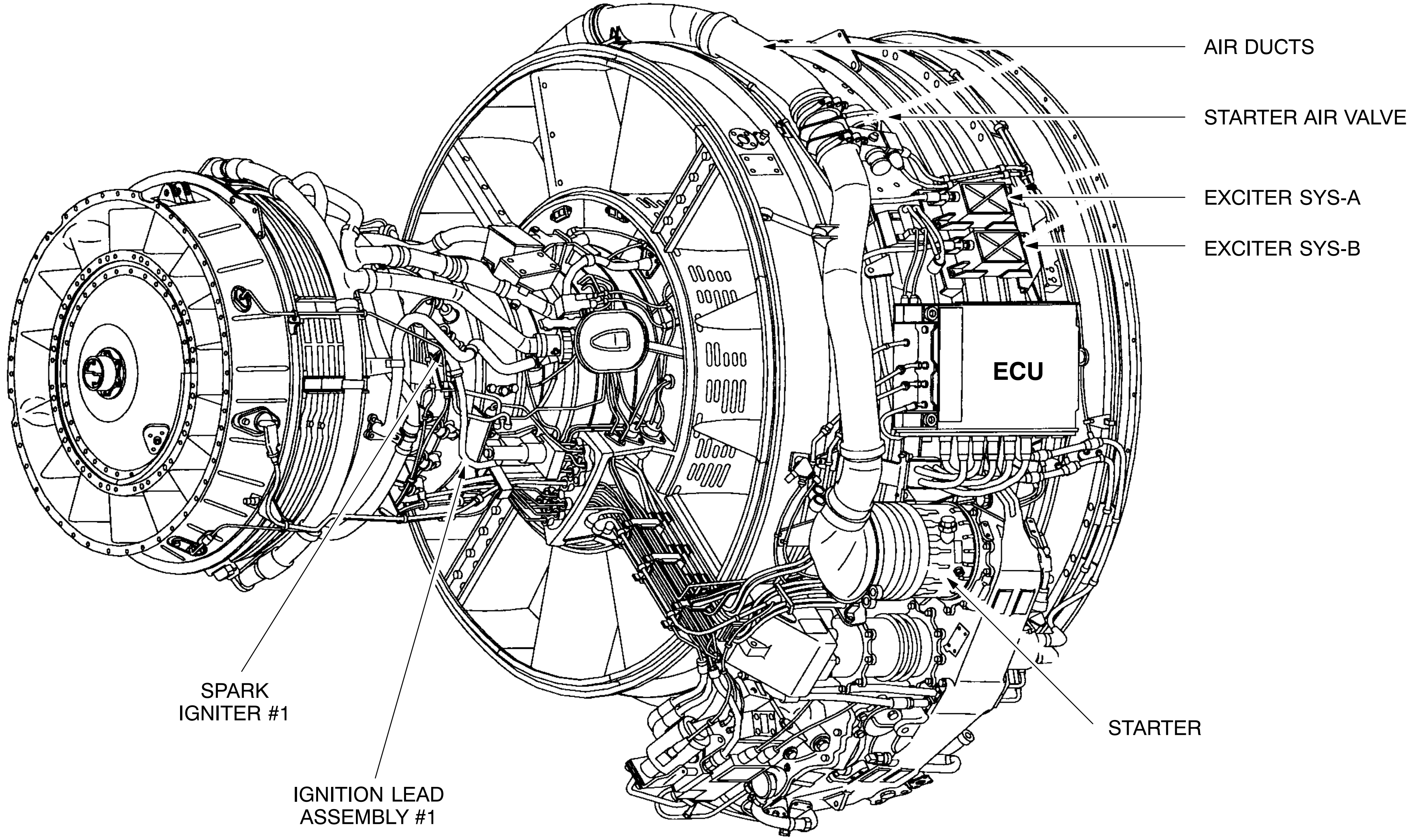


Figure 154 Starting Components

DESCRIPTION

Purpose

The FADEC is able to control engine starting, cranking and ignition, using aircraft control data. Starting can be performed either in Manual Mode, or Automatic Mode. For this purpose, the ECU is able to command:

- opening and closing of the Starter Air Valve (SAV)
- positioning of the Fuel Metering Valve (FMV)
- energizing of the ignitors

It also detects abnormal operation and delivers specific messages.

Flight Deck Controls

Starting is initiated from the following cockpit control panels:

- The engine control panel on the central pedestal, which has a single Rotary Mode Selector for both engines and two Master Levers, one for each engine
- The Engine Manual Start Pushbutton on the overhead panel, one for each engine. The Engine/Warning Display and Engine System Display on the upper and lower ECAM, where starting data and messages are displayed.

The Engine Control Unit (ECU) controls and monitors the start sequence either in automatic or manual mode. The ECU is able to abort the automatic start sequence in case of an incident:

- Start Valve Failure,
- Ignition Failure,
- HP Fuel Shut Off Valve Failure,
- High EGT,
- Engine Stall.

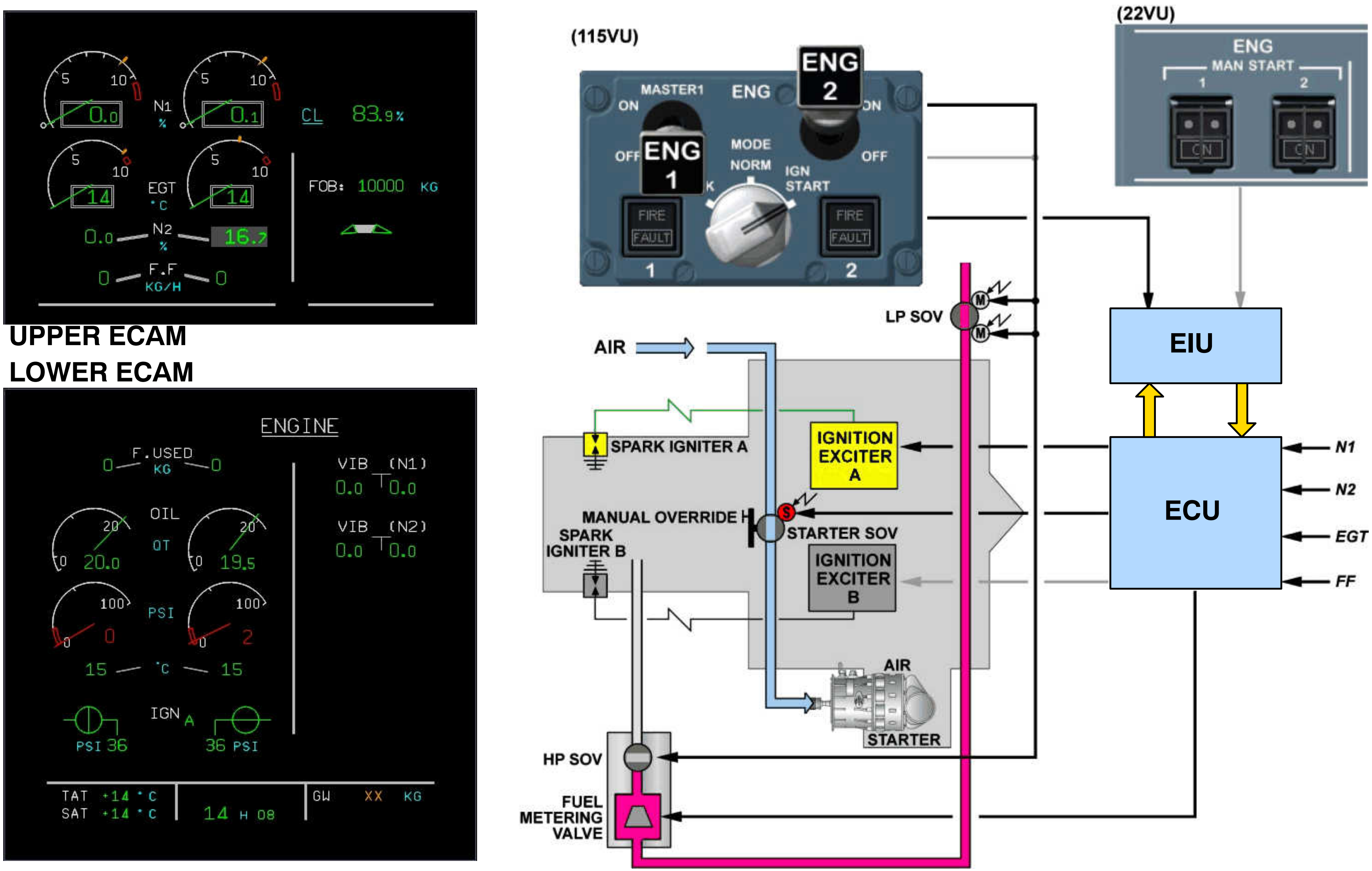


Figure 155 Ignition System Schematic

Operation

The starting system of the engine utilizes pressurized air to drive a turbine at high speed. This turbine drives the engine high pressure rotor through a reduction gear and the engine accessory drive system. The air which is necessary to drive the starter comes from:

- APU
- Opposite Engine
- Ground Power Unit

The starter supply is controlled by a starter shut-off valve (SOV) which is pneumatically operated and electrically controlled. In case of failure, the SOV can be operated by hand. The starter valve closes when the N2 speed reaches 50 %. The starter centrifugal clutch disengages when N2 speed is higher than 50%. Engine starting is controlled from the ENG start panel 115VU located on center pedestal and engine MAN START P/B on the overhead panel.

Indication

The position of the Starter Air Valve and the present starter duct pressure is displayed on the Engine System Display.

Starter Valve Manual Operation

CAUTION: DO NOT OPERATE THE MANUAL HANDLE OF THE PNEUMATIC STARTER VALVE, IF THE STARTER SYSTEM IS NOT PRESSURIZED. IF NOT DAMAGE TO THE PNEUMATIC STARTER VALVE CAN OCCUR.

WARNING: TAKE CARE WHEN OPERATING THE STARTER SHUTOFF VALVE WITH ENGINE RUNNING. OBEY TO SAFETY PRECAUTIONS.

Supply starter air and get access to the Starter Air Valve through access panel 438CR (448CR).

Operate the corresponding starter air valve by using the Manual Override Handle.

At approximately 50% N2 close the Starter Air Valve by using the Manual Override Handle.

Install a warning notice in flight compartment indicating that pneumatic starter valve system is inoperative and make an entry in the log book.

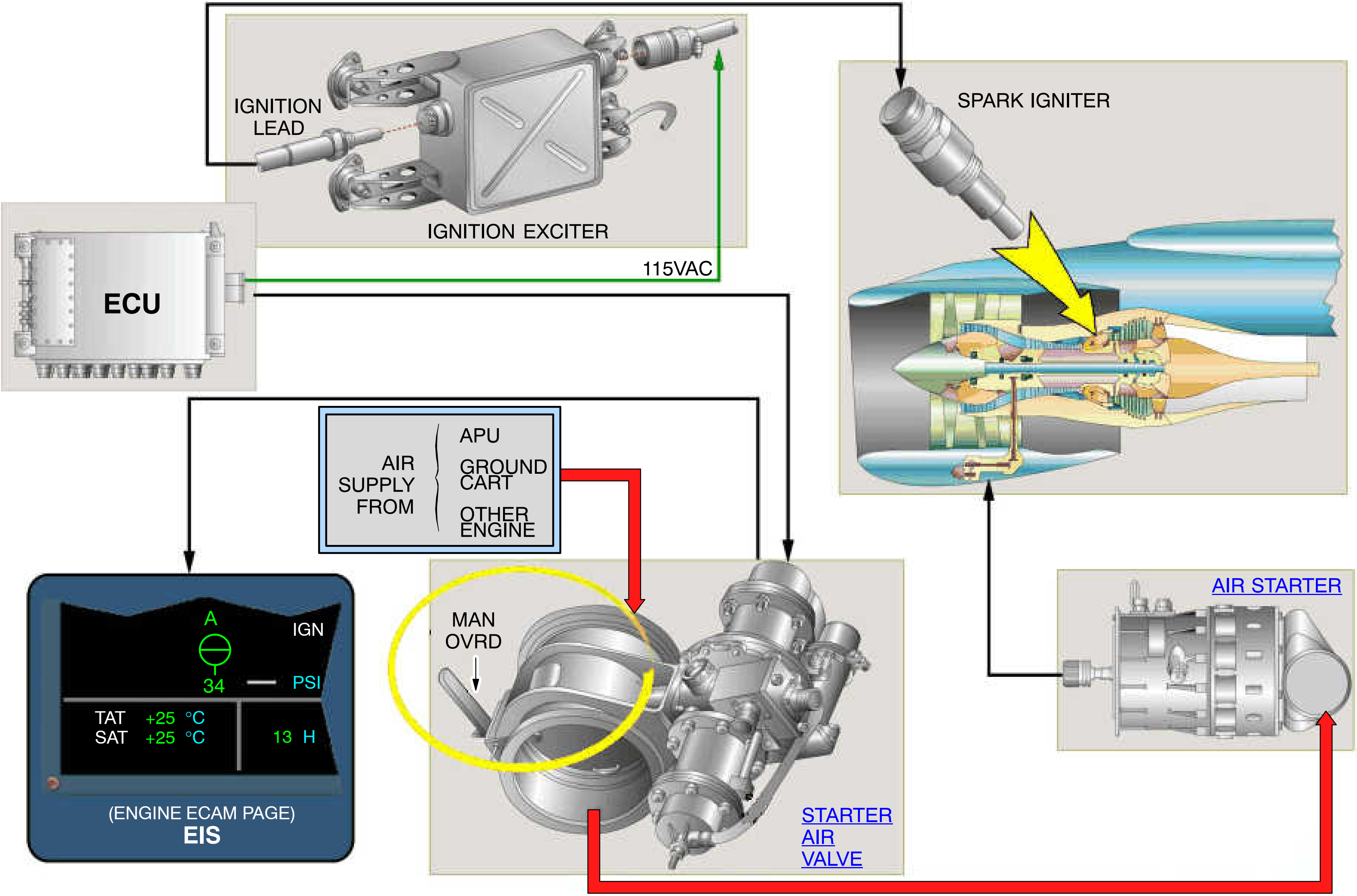


Figure 156 Starting System Operation

COMPONENT DESCRIPTION

AIR STARTER

The starter is installed on the aft side of the accessory gearbox, in the right-hand position (aft looking forward). The starter is filled with oil to lubricate the gears inside. It is equipped with a fill plug, an overflow port and a magnetic drain plug.

Starter Limits

Four times 2 minutes operation in between 20 seconds off
thereafter 15 minutes cooling
sequence may be repeated

STARTER AIR VALVE

The starter air valve is electrical controlled by a solenoid and pneumatic operated. It will open when the solenoid is energized (28VDC) and air pressure is available.

The valve is equipped with an manual override handle which aligns with markings on the valve to provide an external indication of butterfly position.

Position Switch Operation

The normally open redundant electrical position switches are actuated by the closing end of the actuator to provide remote indication when the butterfly is in any position except closed. Redundant solenoid

The solenoid has two independent coils, whether which one is energized, the valve will open.

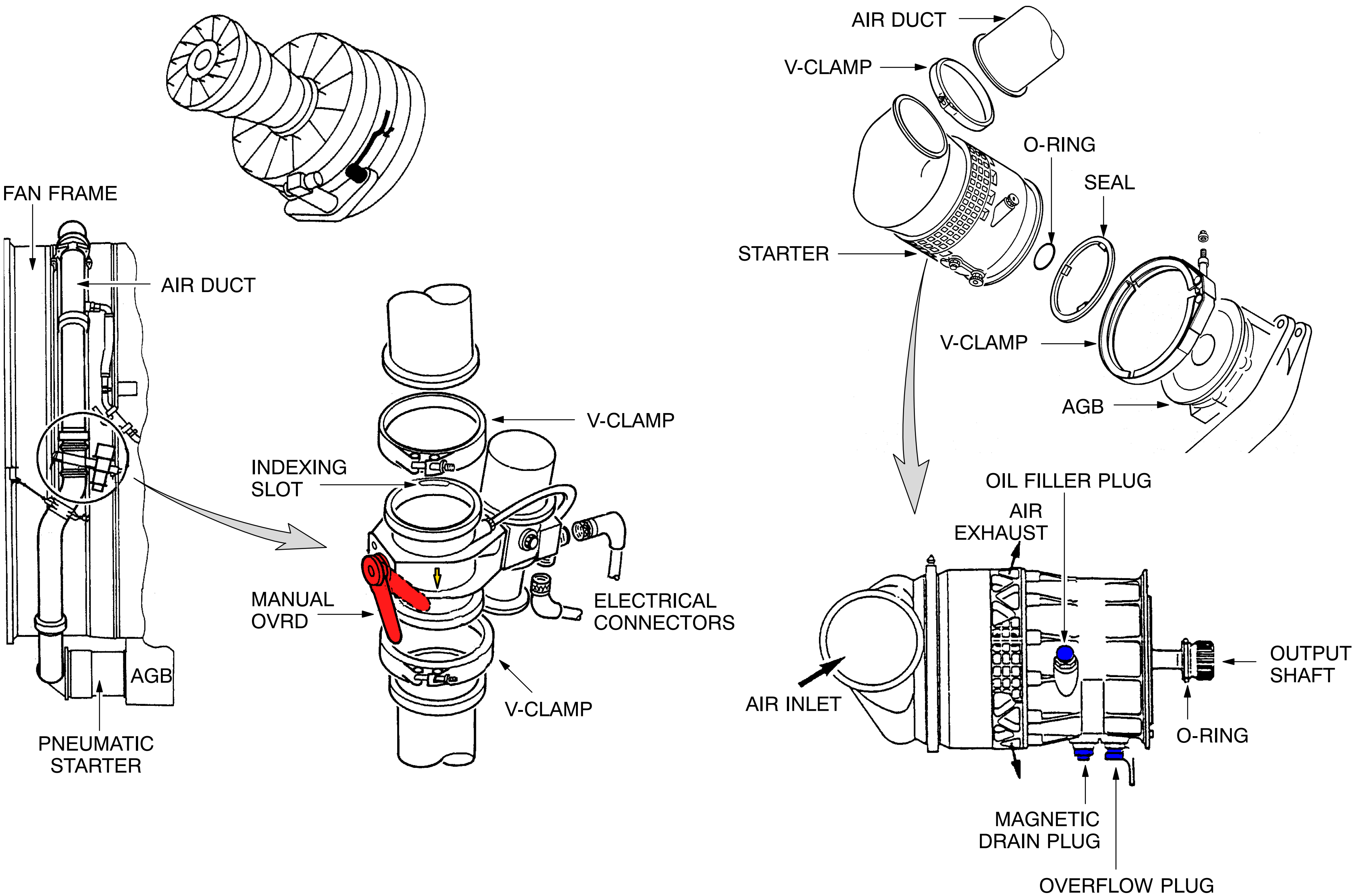


Figure 157 Starting System Components

80–10 CRANKING

DESCRIPTION

Dry Cranking

Requirement

A dry motoring of the engine will be needed when it is necessary to eliminate any fuel accumulated in the combustion chamber or a leak check of engine systems is needed.

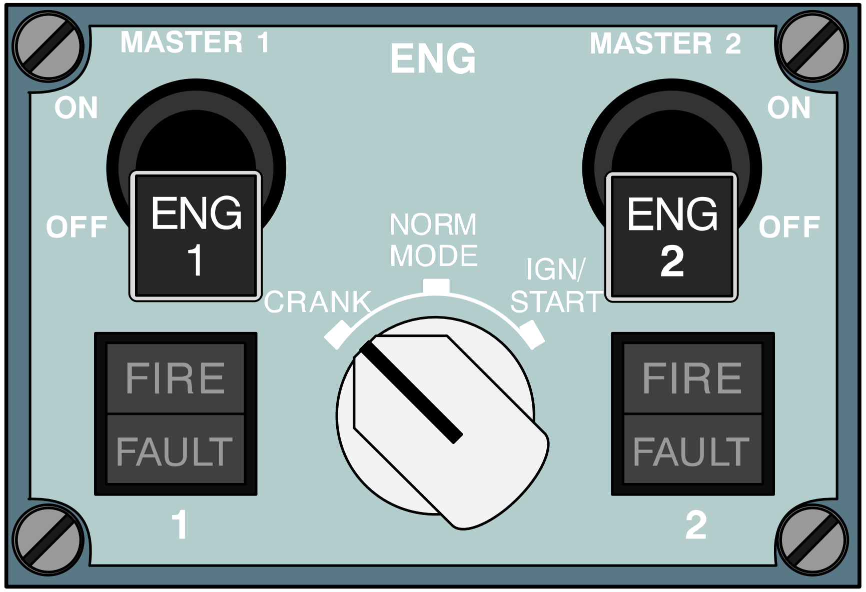
To perform this operation, the starter is engaged and the engine is motored but the HP fuel shut off valve remains closed and both ignition systems are OFF.

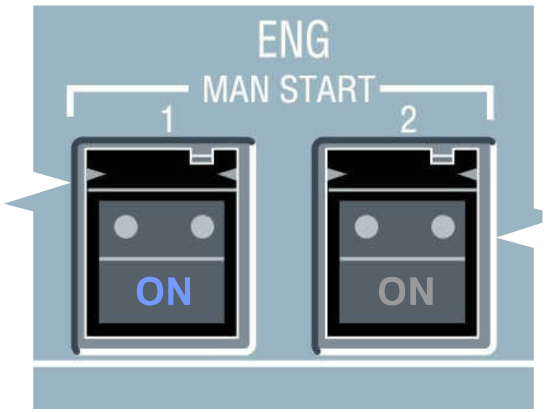
An engine dry motoring can be performed for a maximum of three consecutive cycles (4 of 2 minutes with a cooling period of 20 seconds between each cycle or one extended cycle of 15 minutes).

After three cycles or 4 minutes of continuous cranking, stop for a cooling period of 30 minutes.

Automatic Dry Cranking

An automatic selection of dry cranking is accomplished when the starting sequence is aborted by the FADEC. This can be interrupted at any time by placing the Engine Master Switch in OFF position.





PACKS	**OFF**
FUEL BOOST PUMP (Fuel pressure is delivered to engine)	**ON**
CB HP FUEL SOV (LP Fuel SOV opens, ECAM Warning)	**PULL**
ENGINE MODE SELECTOR ECAM Engine Start Page appears	**CRANK**
CHECK STARTER AIR PRESSURE	**MIN: 25 PSI**
MAN START P/B Starter Air Valve opens	**ON**
ECAM INDICATIONS N1, N2 and Oil Pressure increase	**CHECK**
AFTER MAX. 2 MIN. MAN START P/B SW Starter Air Valve closes, ECAM Ind. decrease	**RELEASE**
ENGINE MODE SELECTOR ECAM Engine Start Page disappears	**NORM**
CB HP FUEL SOV LP Fuel SOV closes	**CLOSED**
FUEL BOOST PUMP	**OFF**

Figure 158 Dry Cranking Procedure

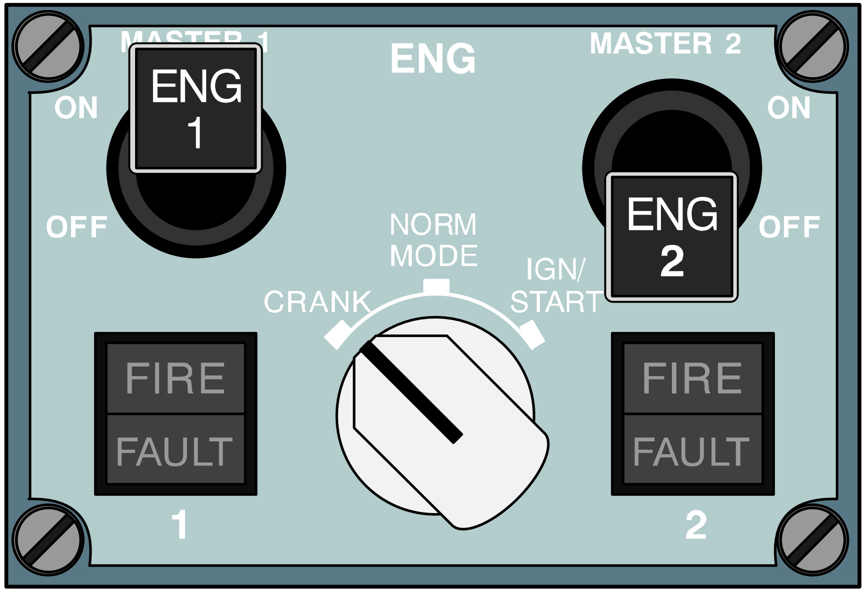
Wet Cranking

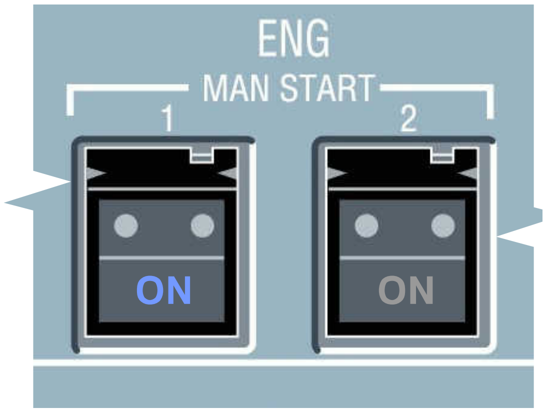
A wet motoring will be needed when the integrity of the fuel system has to be checked.

If such a test is performed, both ignition systems are off and the starter is engaged to raise N2 up to the required speed of 20%. The MASTER control switch is moved to ON and the exhaust nozzle of the engine carefully monitored to detect any trace of fuel.

The wet motoring can be performed for a maximum of 4 consecutive cycles (4 of 2 minutes with a cooling period of 20 seconds between each cycles).

In all cases, the MASTER control switch will be returned to OFF and the starter is reengaged automatically at 20% N2 and a engine motoring must be at least done for 60 seconds to eliminate entrapped fuel or vapor.





IGNITION SYSTEM CBs	**PULLED**
FUEL BOOST PUMPS	**ON**
Fuel Boost Pump starts to run	
ENGINE MODE SELECTOR	**CRANK**
ECAM Engine Start Page appears	
CHECK STARTER AIR PRESSURE	**MIN. 25 PSI**
MAN START P/B	**ON**
Starter Air Valve opens	
ECAM INDICATIONS	**CHECK**
N1, N2 and Oil Pressure increase	
N2 > 20% ENGINE MASTER SWITCH	**ON**
Fuel Flow Indication increases	
AFTER 10–20 SECS. ENG MSW	**OFF**
Fuel Flow Indication decreases	
Starter Air Valve closes	

At 20% N2 the ECU reengages the starter and performs an AUTO DRY MOTORING.

After 60 seconds:	
MANUAL START P/B	**OFF**
Starter Air Valve closes, Indications decrease	
ENGINE MODE SELECTOR	**NORM**
ECAM Engine Start Page disappears	
FUEL PUMPS	**OFF**
IGNITION CBs	**CLOSED**

Figure 159 Wet Cranking Procedure

AUTO AND MANUAL START FUNCTION

AUTOMATIC START

The ECU fully controls the automatic start procedure of an engine till reaching 50% N2. The ECU protects the engine up to 50% N2 in case a Hot start,Hung start, stall or ignition fault occurs. The oil pressure is not monitored by the ECU during engine start. This must be done by the operator who starts the engine.

NOTE: There must be a positive oil pressure indication before the engine reaches a stabilized ground idle.

Unsatisfactory Starts during Auto Start Sequence

The Auto Start system has equipment that collects input on problems. The equipment will automatically resequence the applicable control circuit to correct the unsatisfactory condition. Usually, the FADEC system is resequenced after a total of 4 cycles. If the problem is not corrected after resequencing, the applicable diagnostic indications will be shown on the flight deck screen.

Stall or Overtemperature

For either a stall or an overtemperature, the FADEC system will do the items that follow:

- Fuel is shut off for 7 seconds.
- Starter and ignition stay ON.
- At the end of the 7 seconds, the fuel is turned back on but, the fuel schedule is reduced 7 percent.
- If another stall or overtemperature occurs, the FADEC system repeats the sequence and reduces the fuel schedule by 7% more. The total amount that the fuel schedule has been reduced at this point is 14 percent.
- If a stall or overtemperature occurs a third time, the FADEC system will repeat the sequence and reduce the fuel schedule by 7 percent more. The total amount that the fuel schedule has been reduced at this point is 21%.
- If a stall or overtemperature occurs a fourth time, the start will automatically be aborted and the applicable message will be indicated on the flight deck screen.

Starter Air Pressure below 20 PSI

If the acceleration is below the threshold and a stall or overtemperature is indicated, the start will be automatically aborted if in auto start mode.

The fuel will not be turned on if the starter air pressure is too low to motor the core to 22 percent N2, the start will be automatically aborted if in auto start mode.

Hung Start during Auto Start

If engine acceleration ceases and there has been no reduction in the acceleration fuel schedule and there is no stall or overtemperature indication, the start will be automatically aborted if limits are exceeded.

If engine acceleration ceases and there has been a previous reduction in the acceleration fuel schedule and there is no stall or overtemperature indication, FADEC will automatically increase the acceleration fuel schedule to accomplish acceleration to idle.

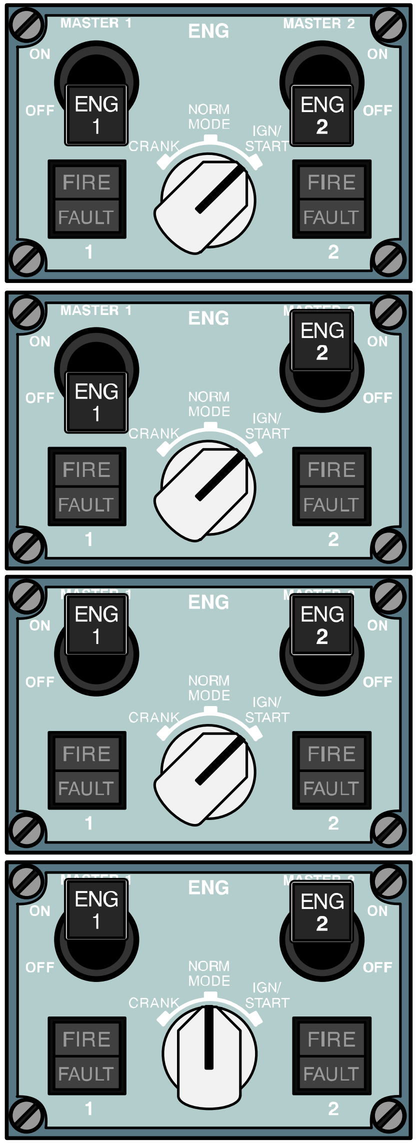
The FADEC system is resequenced after a total of 4 cycles. If the problem is not corrected after resequencing, the applicable diagnostic indications will be shown on the flight deck screen.

Ignition Fault

If the engine light off does not occur within 18 sec,the FADEC system automatically turns off the ignition,shuts the fuel flow and dry motors the engine for 30 sec.

Twenty five seconds into the dry motoring period,the FADEC system energizes both igniters and at 30 sec, turns fuel flowback on.

If on this second engine start attempt there is no light off within 13 sec,the FADEC system automatically turns off both igniters,shut off the fuel flow and turns the starter for 30 sec. to dry motor the engine. This will result in a start abort indication on the upper ECAM.



1 ENG Mode Selector IGN/START

2 ENG 2 Master Switch ON
- Starter Valve opens
- Ignition ON at 16% N2
- Fuel ON at 22% N2
- SAV closes at 50% N2
- Ignition OFF

3 ENG 1 Master Switch ON
- Starter Valve opens
- Ignition ON at 16% N2
- Fuel ON at 22% N2
- SAV closes at 50% N2
- Ignition OFF

4 ENG Mode Selector NORM when ENG stabilized at IDLE

Figure 160 Automatic Start

MANUAL START

The manual start mode limits the authority of the ECU so that the pilot can sequence the starter, ignition and fuel on/off manually. This includes the ability to dry crank or wet crank.

Pushing the manual start push button off during dry cranking closes the starter air valve and during wet cranking closes both the starter air and fuel shut off valves. The ECU continues to provide fault indications to the cockpit.

However, during manual operation, the ECU abort feature is disabled and conventional monitoring of the start parameters is required.

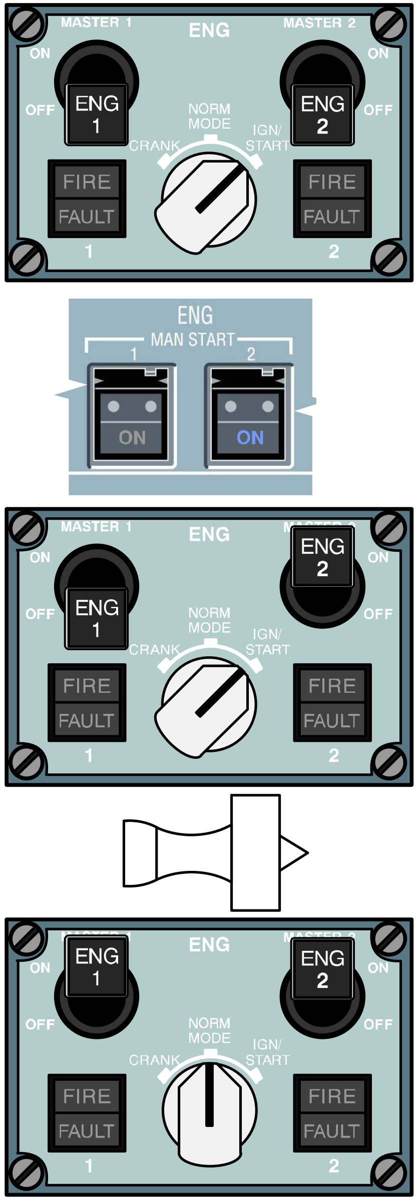
The manual start procedure commences when the mode selector is set to IGN/START. The manual start pushbutton switch is set to ON and the master switch is OFF. The starter air valve is then commanded open by the ECU. When the master switch is turned ON during a manual start, both ignitors are energized and fuel is turned on.

Intermittent mode selector position has no effect on the manual start sequence once the manual start procedure is initiated.

The starter air valve can be closed by selecting the manual start push button switch OFF at any time prior to turning the master switch ON.

Once the master switch is turned ON, the manual start push button switch has no effect on the start.

When the master switch is turned OFF, the control commands the HP fuel valve and LP-Fuel valve closed, the starter air valve closed and the ignitors off.



1 ENG Mode Selector IGN/START

2 ENG MAN Start P/B ON
Starter Air Valve opens

3 N2 > 20% Master Switch ON
- Ignition ON
- Fuel On
- at 50% N2 Starter Valve closes
- Ignition OFF

4 Start the 2nd Engine

5 ENG Mode Selector NORM
when ENG stabilized at IDLE

Figure 161 Manual Start

ATA 78 EXHAUST

78–00 EXHAUST – GENERAL

EXHAUST GENERAL DESCRIPTION

GENERAL

Part of the air absorbed by the fan is directly evacuated to the outside; the remaining part is directed to the engine combustion chamber and burnt gases are ejected through an exhaust nozzle.

The engine exhaust section directs fan discharge air for either normal or reverse thrust operation. In forward thrust mode, fan air flow and burnt gases are evacuated directly at the back.

Each engine is equipped with a reverser system which reverses cold fan air by means of blocker doors, integrated in the short nacelle body. The blocker doors turn the engine airflow forward and provide a braking effect for the aircraft on the ground.

NOTE: Thrust reverser can be operated only on the ground.

Description

The exhaust system consists of a primary nozzle for hot exhaust and a fan nozzle which incorporates the thrust reverser system.

FAN NOZZLE

The fan nozzle forms a part of the nacelle and provides an annulus for exit of the fan flow. It consists of fixed cowls, with pivoting doors which form:

- a continuation of the nacelle aerodynamic line,
- the outer wall of the exhaust nozzle.

This outer wall contains an inner cowl forming the inner wall of the exhaust nozzle. The fan nozzle/thrust reverser assembly is hinged to the pylon and clamped to the engine fan frame.

HOT EXHAUST

The hot exhaust consists of a center body and a conical primary nozzle. The nozzle directs the primary exhaust gas aft and regulates the gas stream flow.

Core Nozzle (or Primary Nozzle)

The primary nozzle is composed of:

- a forward flange for attachement to the engine outer primary exhaust frame (A6 flange) with 16 bolts,
- a conventional stiffened sheet metal inner and outer skin,
- and a forward bulkhead.

A spring seal is attached to the outer barrel which interfaces with the pylon. The outer barrels are of skin and frame construction. The primary nozzle structural assembly is a riveted conventional sheet metal structure.

Centerbody

The centerbody is composed of:

- a forward flange for attachment to the engine inner primary exhaust frame (A7 flange) with 16 bolts and,
- a stiffened sheet metal formed section with an open aft end for the engine center vent system

THRUST REVERSER SYSTEM

The thrust reverser system uses part of engine exhaust power to provide additional aerodynamic braking during aircraft landing.

The thrust reverser system is hydraulically actuated by the hydraulic pump mounted on the engine.

It is controlled through the FADEC (Full Authority Digital Engine Control) from the cockpit by a lever hinged to the corresponding throttle control lever.

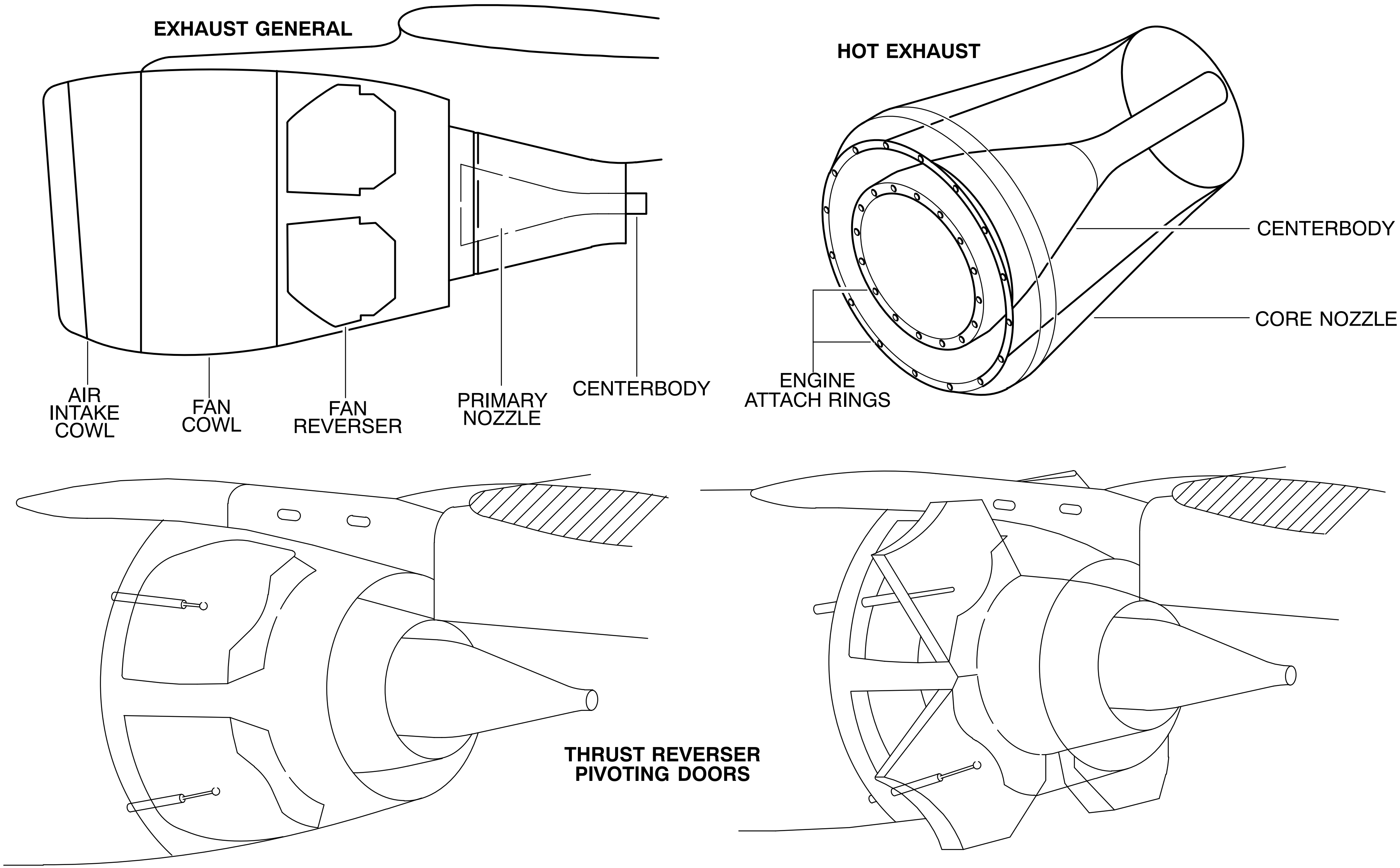


Figure 162 Exhaust Overview

78−30 THRUST REVERSER

INTRODUCTION

General

Thrust reverse is achieved by reversing the direction of the fan airflow using four pivoting blocker doors.

Each door is operated by a hydraulic actuator. The actuator receives fluid from a **H**ydraulic **C**ontrol **U**nit (HCU) which is controlled by the Electronic Control Unit.

A latch mechanism maintains each blocker door in the stowed position. The latches are hydraulically released at the beginning of the deploy sequence. Door positions are monitored by stow and deploy switches.

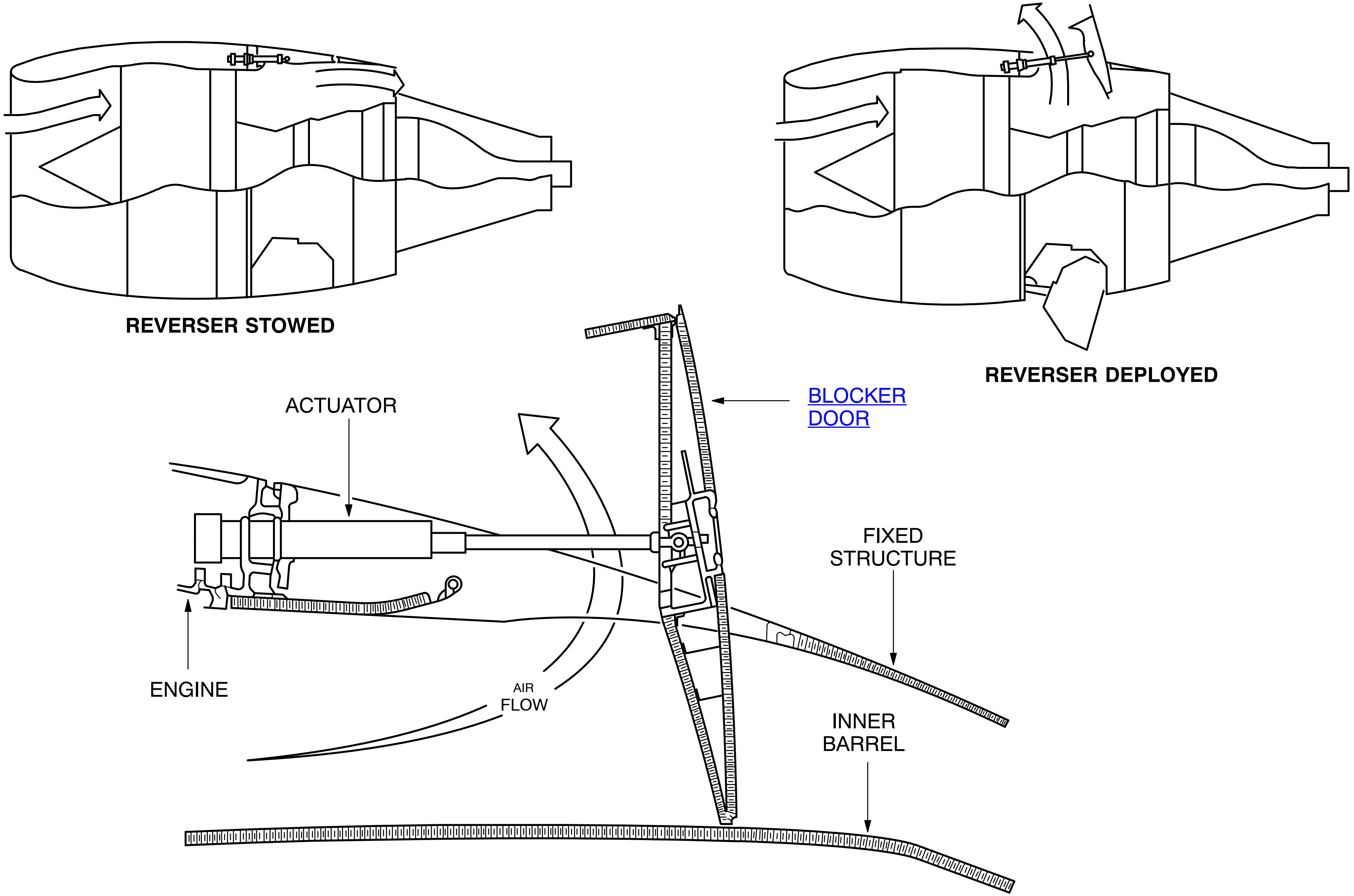


Figure 163 Thrust Reverser Principle

COMPONENTS LOCATION

T/R Components Summary

- Hydraulic Control Unit (HCU)
- Hydraulic Actuator (4)
- Hydraulic Latch /4)
- Pivoting Doors (4)
- Stow Switches (4)
- Dual Deploy Switches (2)
- Electrical Junction Box
- Reverser Cowl (2)
- Cowl Opening Actuator (2)
- Handpump Connection (2)

Hydraulic Actuators

There are four hydraulic actuators supplied by the HCU. The Actuators are mounted on the forward frame by a ball joint assembly support with a manual unlocking system for maintenance. They constitute a differential double−acting unit. Control and feedback signals are exchanged with the engine ECU.

These hydraulic actuators have four different functions:

- to deploy doors
- to stow doors
- to assure a secondary lock in stowed position by a system of claws
- to ensure that doors rotation speed slows down at the end of the deploy phase.

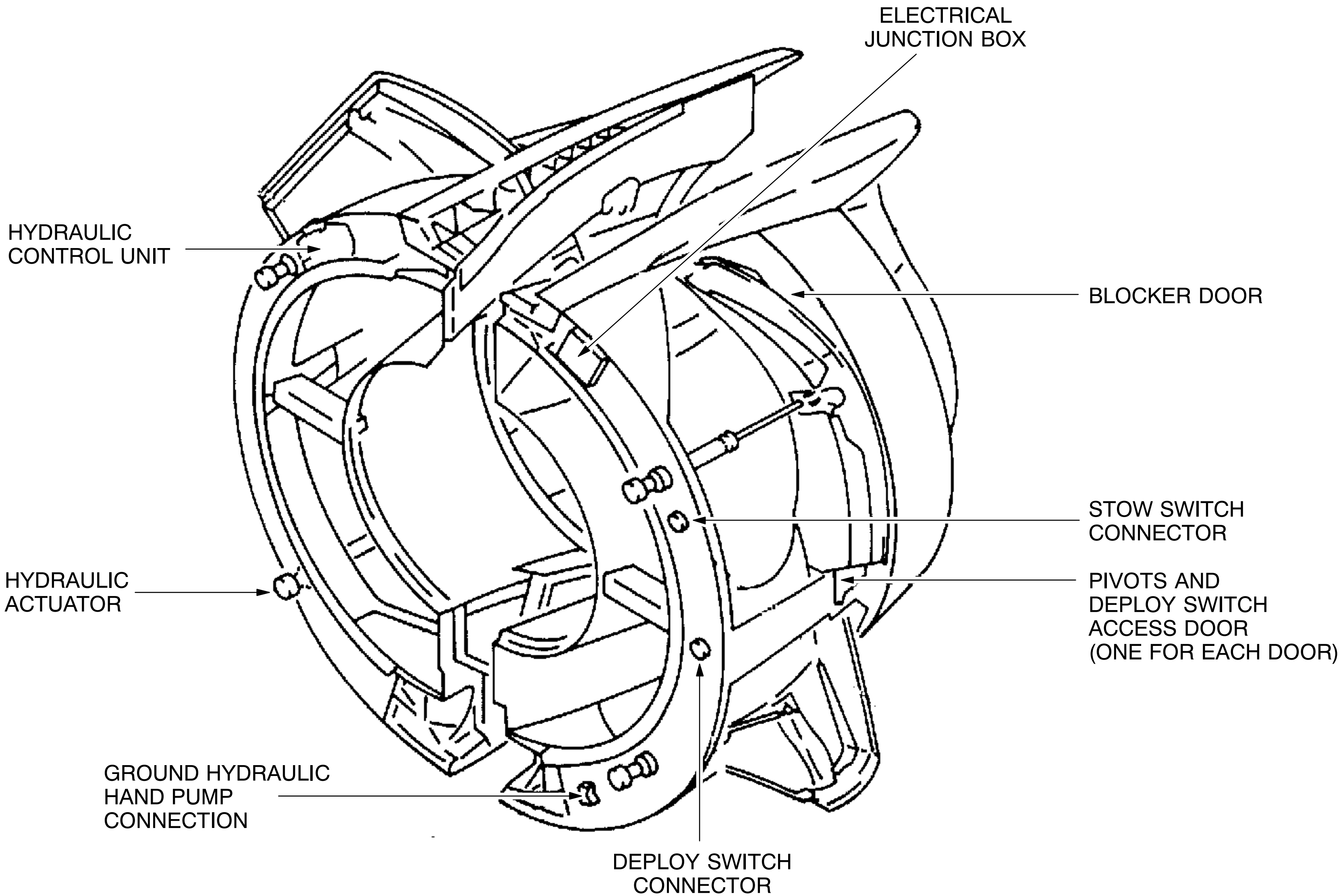


Figure 164 Engine Thrust Reverser LRU,s

SYSTEM DESCRIPTION

Thrust Reverser Design

The thrust reverser system is of the aerodynamic blockage type. It consists of 4 pivoting doors which stop and redirect fan discharge airflow. Two doors are installed on each ”C” duct. Thrust reverser operation is possible on ground only.

Hydraulic Supply

The thrust reverser system is hydraulically supplied by the corresponding hydraulic pump on the engine. The thrust reverser is isolated from the hydraulic supply by a Shut Off Valve.

Reverser Actuation

Each door is operated by a hydraulic actuator. The actuators receive fluid from the Hydraulic Control Unit (HCU) which is controlled by the Electronic Control Unit (ECU).

Two independent latch mechanisms maintain each pivoting door in the stowed position, one inside the actuator and the second with the door latch. The door latches are hydraulically released in series at the beginning of the deploy sequence.

Reverser Control

Basically the thrust reverser system is controlled through the ECU from the two reverser latching levers located on the throttle control levers. The HCU has a pressurizing valve and a directional valve to select deploy or stow mode.
The directional valve is operated to deploy only.

For third defence line purposes, the Spoiler Elevator Computers (SECs) have previously opened the Shut Off Valve and the hydraulic pressure is supplied to the HCU. Then, the Engine Interface Unit (EIU) permits reverser deployment by energization of the inhibition relay, so the directional valve can be opened by the ECU. To command the thrust reverser, the ECU needs an ”A/C on ground” signal supplied by the Landing Gear Control and Interface Units (LGCIUs).

Reverser Indicating

The actual state of the thrust reverser is shown on the ECAM warning display (REVerser indication in the middle of N1 dial). The signals come from the stow and deploy position switches. Reverse thrust is allowed when reversers are deployed.

Maintenance Practice

To help trouble shooting, a reverser test can be performed through the MCDU. For maintenance purposes or to increase A/C dispatch, the HCU is fitted with a deactivation lever to deactivate the thrust reverser system. For the lock−out procedure, four lock−out bolts should also be installed.

WARNING: THE THRUST REVERSER SYSTEM SHOULD BE DEACTIVATED USING THE HCU LEVER, BEFORE WORKING ON THE SYSTEM OR THE ENGINE.
IF NOT THE THRUST REVERSER CAN ACCIDENTALLY OPERATE AND CAUSE SERIOUS INJURIES TO PERSONNEL AND/OR DAMAGE TO THE REVERSER.

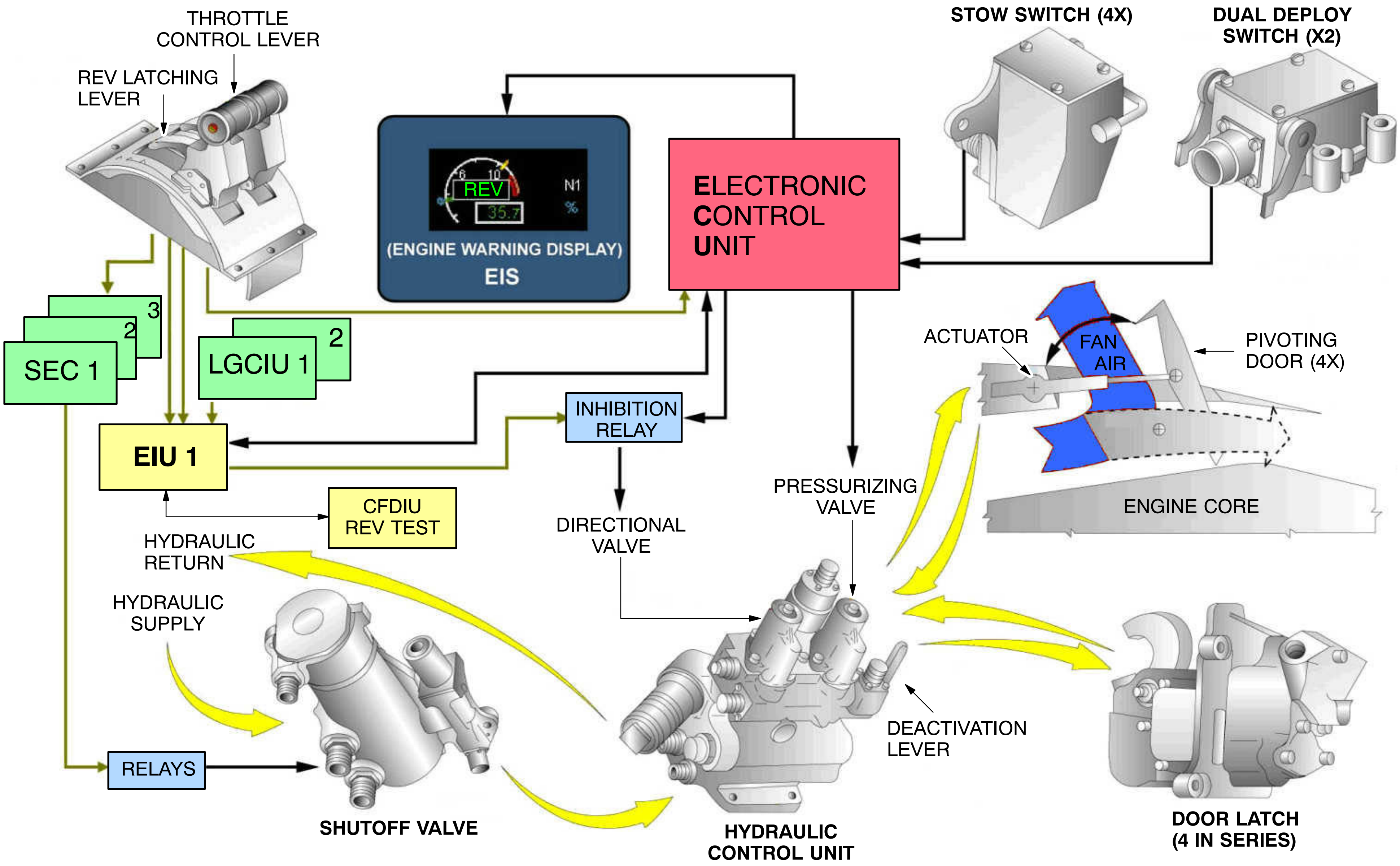


Figure 165 Thrust Reverser Schematic

COMPONENT DESCRIPTION

HYDRAULIC CONTROL UNIT

General

The purpose of the Thrust Reverser Hydraulic Control Unit is to performs the following functions:

- to supply pressure to hydraulic system (pressurizing valve)
- to regulate blocker doors stowing speed (flow limiter)
- to supply latches (directional valve solenoid)
- to supply actuators (directional valve).

The HCU incorporates the following items:

- Pressurizing Valve
- Directional Valve
- Flow Limiter
- Filter and Clogging Indicator
- Pressure Switch
- Bleed Valve

Electrical Connection

Each channel within the ECU shall interface with the thrust reverser valve solenoids. Each solenoid contains two electrically isolated, independent coils, one dedicated to channel A and the other to channel B.

Pressurizing Valve and Pressurizing Valve Solenoid

The pressurizing valve is a two position valve which is solenoid actuated to the open position. The valve is spring loaded to the closed position (solenoid de-energized).

The pressurizing valve can also be manually closed and pinned (inhibited) to prevent inadvertent actuation of the thrust reverser during maintenance work.

Energizing the valve solenoid opens a port. Then the hydraulic pressure is supplied to the stow side of the actuators and to the directional valve. In the pressurizing valve, there is a time delay system which limits the closing time of the piston valve at 2 seconds minimum.

Directional Valve and Directional Valve Solenoid

The directional valve is a three port, two position, valve. Energizing the valve solenoid opens a port allowing hydraulic pressure supply for the door latches (the HCU pressurizing valve must be opened).

When the last latch is supplied the hydraulic pressure return moves a piston valve to the deploy position. Then hydraulic pressure is ported to the deploy side of the actuator piston.

Flow Limiter

The flow limiter regulates the hydraulic fluid flow returning to the HCU from the actuator piston head in order to control/limit the blocker door stowing rate under varying conditions.

Bleed Valve

The bleed valve permits bleeding of the HCU.

Pressure Switch

The pressure switch indicates to the ECU that hydraulic circuit is pressurized or not. Pressure switch signal is available to the ECU and can be used for maintenance purpose.

Filter and Clogging Indicator

The hydraulic control unit filter is used to filter the fluid supply from the aircraft hydraulic system. The filter is a flow through cartridge type filter. The clogging indicator monitors pressure loss through the filter cartridge and features a pop-out indicator to signal when it is necessary to replace the filter element.

Manual Lockout Lever

With the manual lockout lever it is possible to shut the hydraulic supply to the reverser by closing the isolation valve in the HCU. The lever can be secured in the lockout position with a pin (this is also a part of deactivating the reverser).

CAUTION: THIS MUST BE ALWAYS PERFORMED BEFORE MAINTENANCE WORK ON THRUST REVERSER SYSTEM.

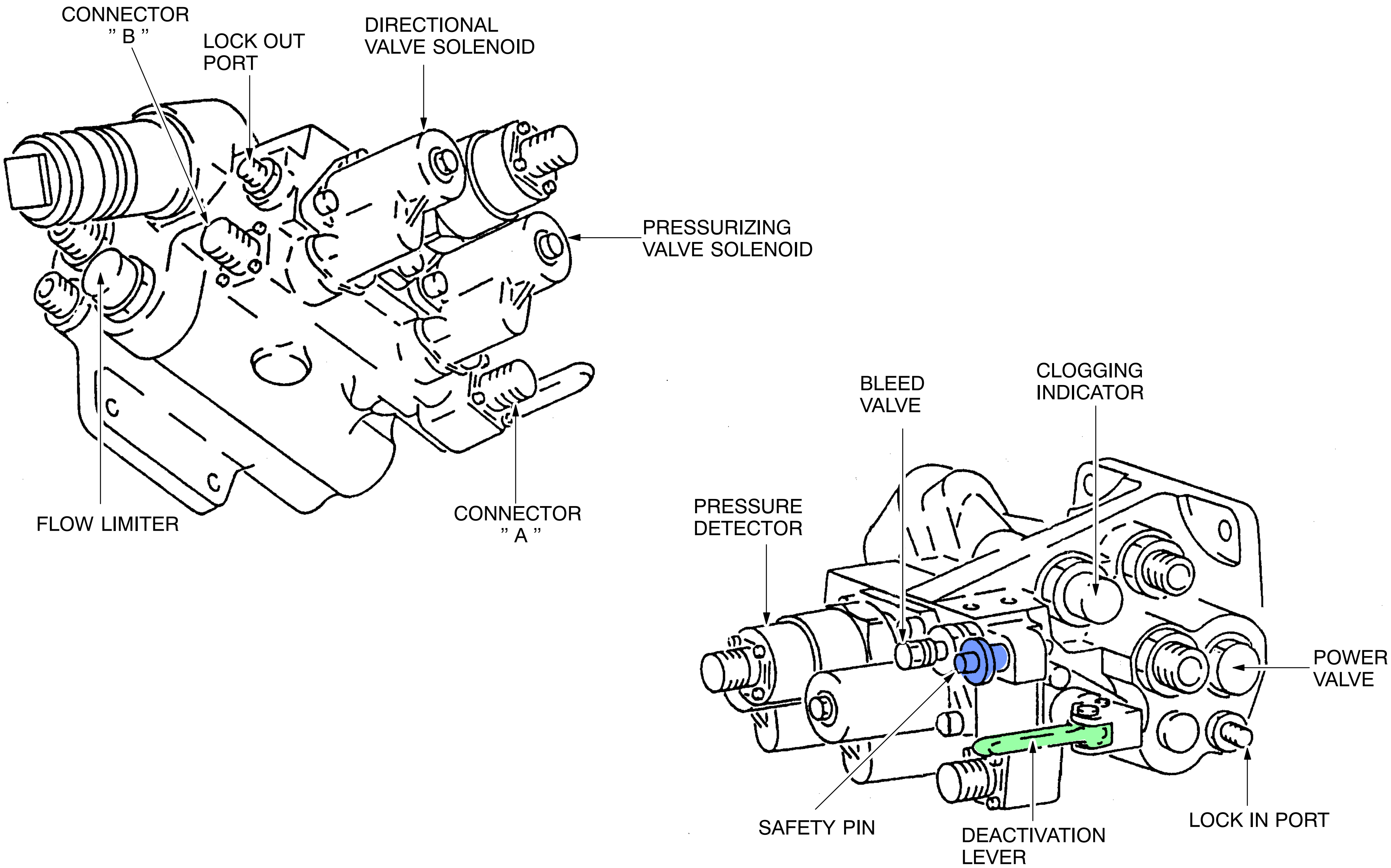


Figure 166 Hydraulic Control Unit

THRUST REVERSER LATCHES

There are four latches, one per blocker door. The latches hold the doors in the stowed position and are located beside the actuators on the thrust reverser forward frame. The latches are connected in series. In case a latch fails the hydraulic actuators which deploy or stow the pivoting doors have a secondary lock.

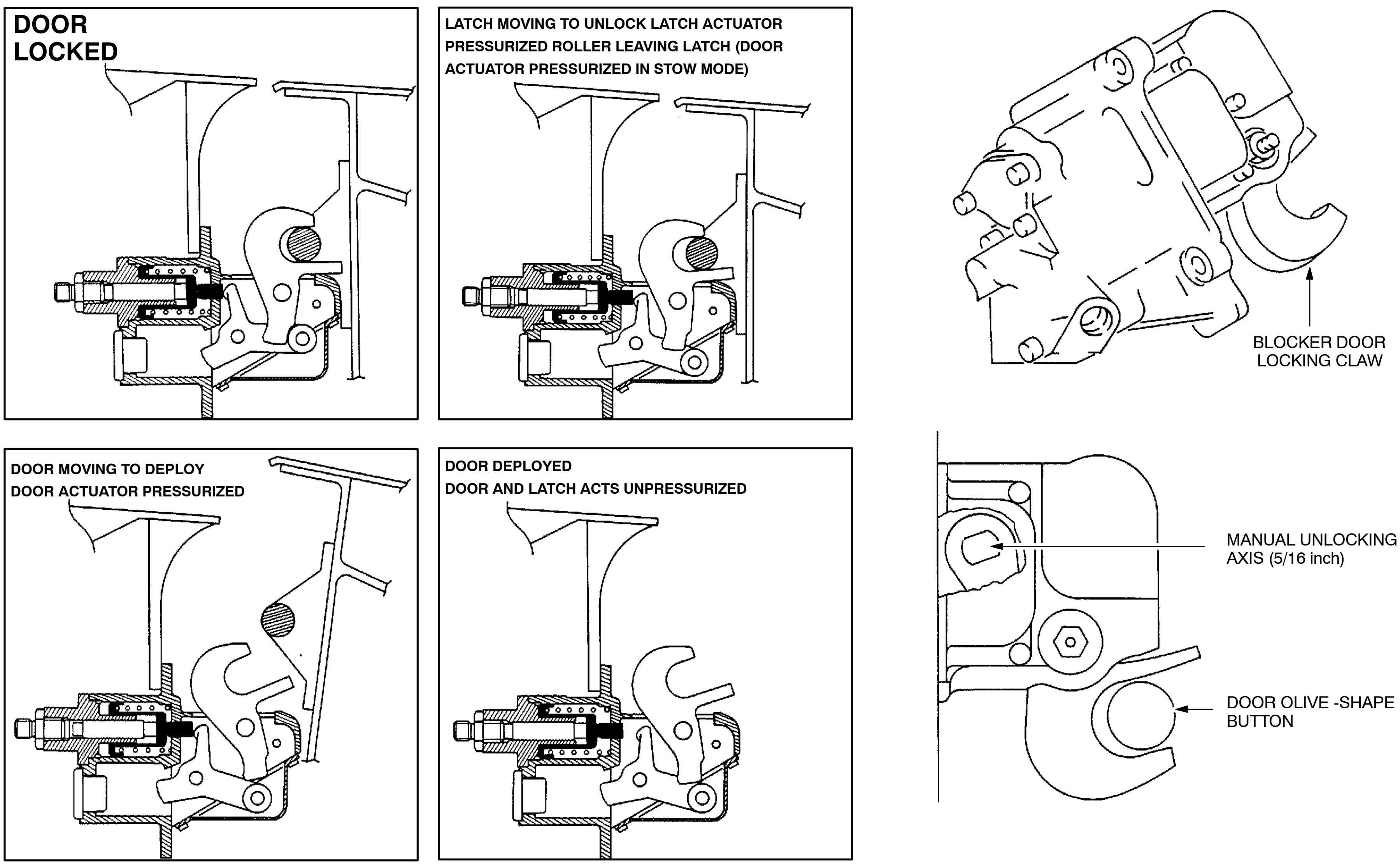


Figure 167 TR-Latches

HYDRAULIC ACTUATOR

There are four hydraulic actuators,mounted on the forward frame by a ball joint assembly support.

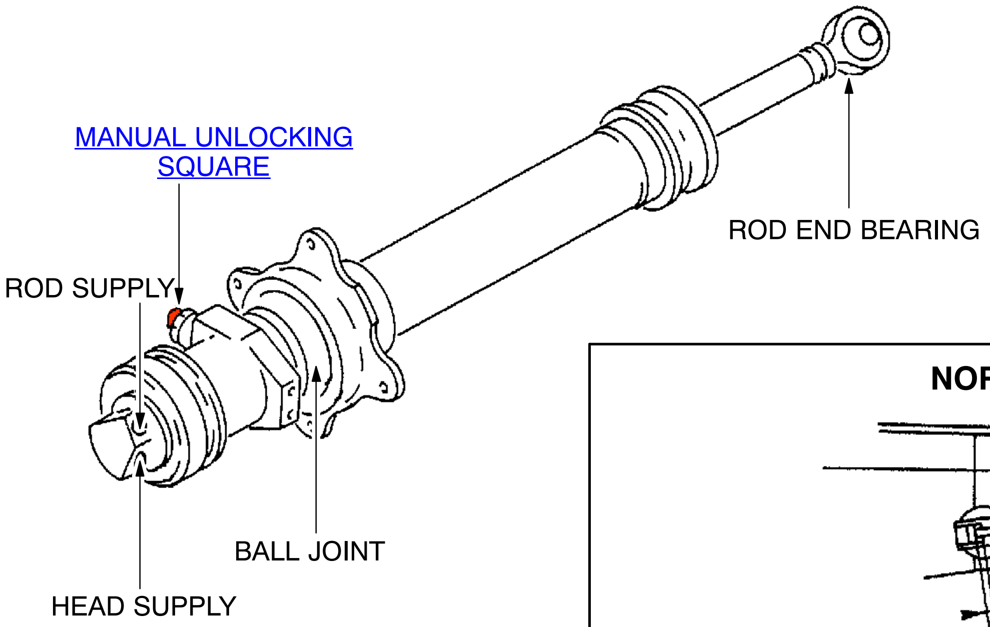
These hydraulic actuators have four different functions:

- to deploy the doors,
- to stow the doors,
- to ensure a secondary lock in stowed position,
- to ensure that the doors rotation speed slows down at the end of the deployment phase.

The actuators comprise a manual unlocking system for maintenance.

Door Latch Failure

If a door latch breaks, the actuator has a secondary lock. This prevents the door from moving more than 1/2 inch from the stowed position. This movement is sufficient to actuate the unstow switch to provide a warning in the cockpit.



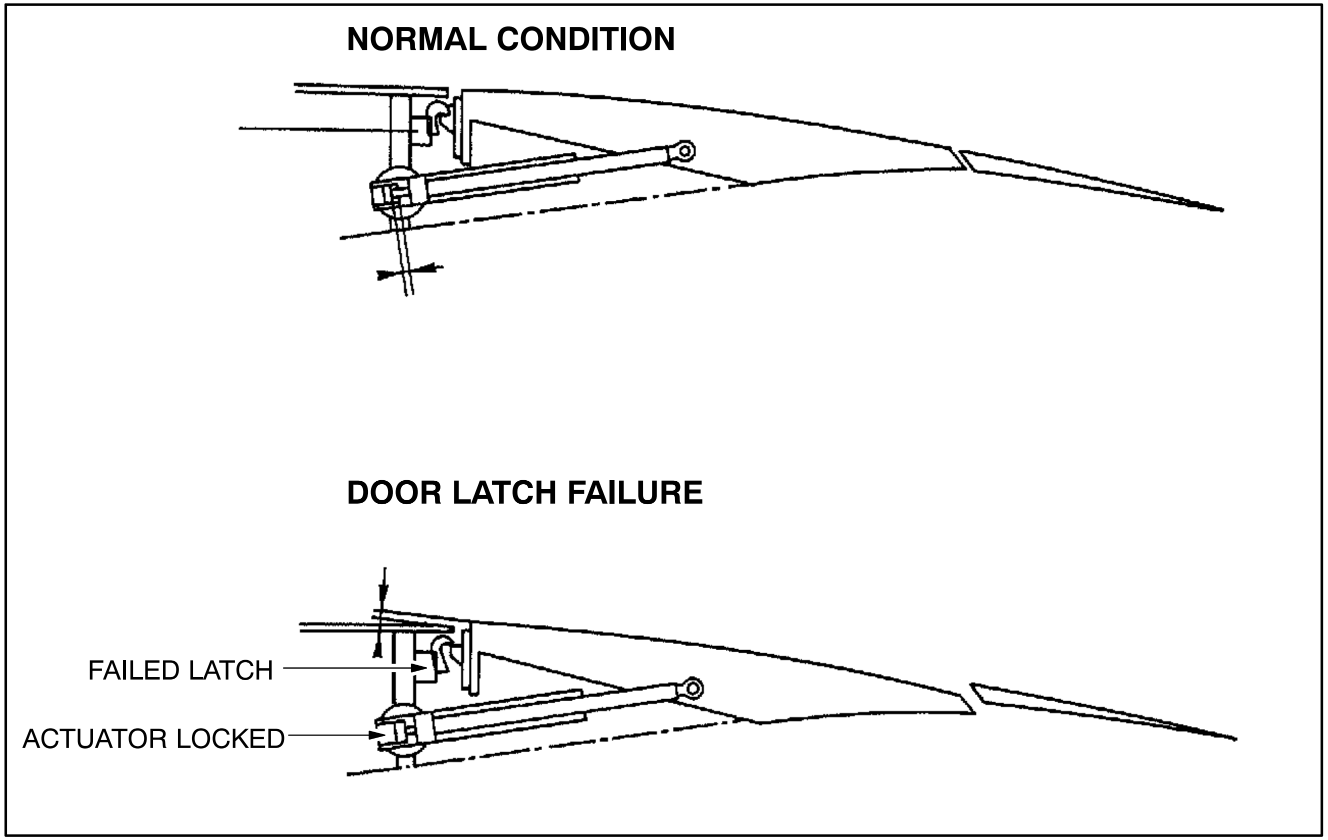


Figure 168 Hydraulic Actuators

STOW SWITCHES

For determining the stowed position of the doors, there are four thrust reverser single switches, one per door, located onto the forward frame rear side next to the latches. The switches are dual, i.e. they include 2 cells one dedicated to each channel of the ECU. The switches are connected to the ECU via the electrical junction box. All stow switches are connected in parallel. At 0.9% of pivoting doors flush position, the cells are closed.

Thrust Reverse Indication

The thrust reverser operating sequences are displayed in the cockpit on the ENGINE AND WARNING Display in the middle of the N1 dial with a REV Indication.

- REV Indication amber = transit
- REV Indication green = all REV doors in deploy position

In deployment, an amber REV indication will come in view at the middle of the N1 dial when at least one reverser door is unstowed or unlocked (stroke >1%). If this occurs in flight, REV will flash first for 9 sec, then it will remain steady. This indication will change to green color when all the fan reverser doors are fully deployed and than the reverse thrust can be applied.

In stowage, the indication changes to amber when one door at least is less than 95% deployed and disappears when all the 4 doors are stowed.

DEPLOY SWITCHES

The deployed position of the doors is sensed by two thrust reverser double switches, one for the two right side doors and one for the two left side doors.

They are located between the corresponding doors in 3 and 9 o'clock beams. One single switch includes 2 cells one for each ECU channel. Junction wires inside the switch are bedded in grease to avoid friction wear problems.

The switches are connected to the ECU via the electrical junction box. For each door, one cell is connected to ECU channel A, the other one to channel B. All doors are electrically connected in series. Each time a door reaches 95% of its travel, the circuit closes.

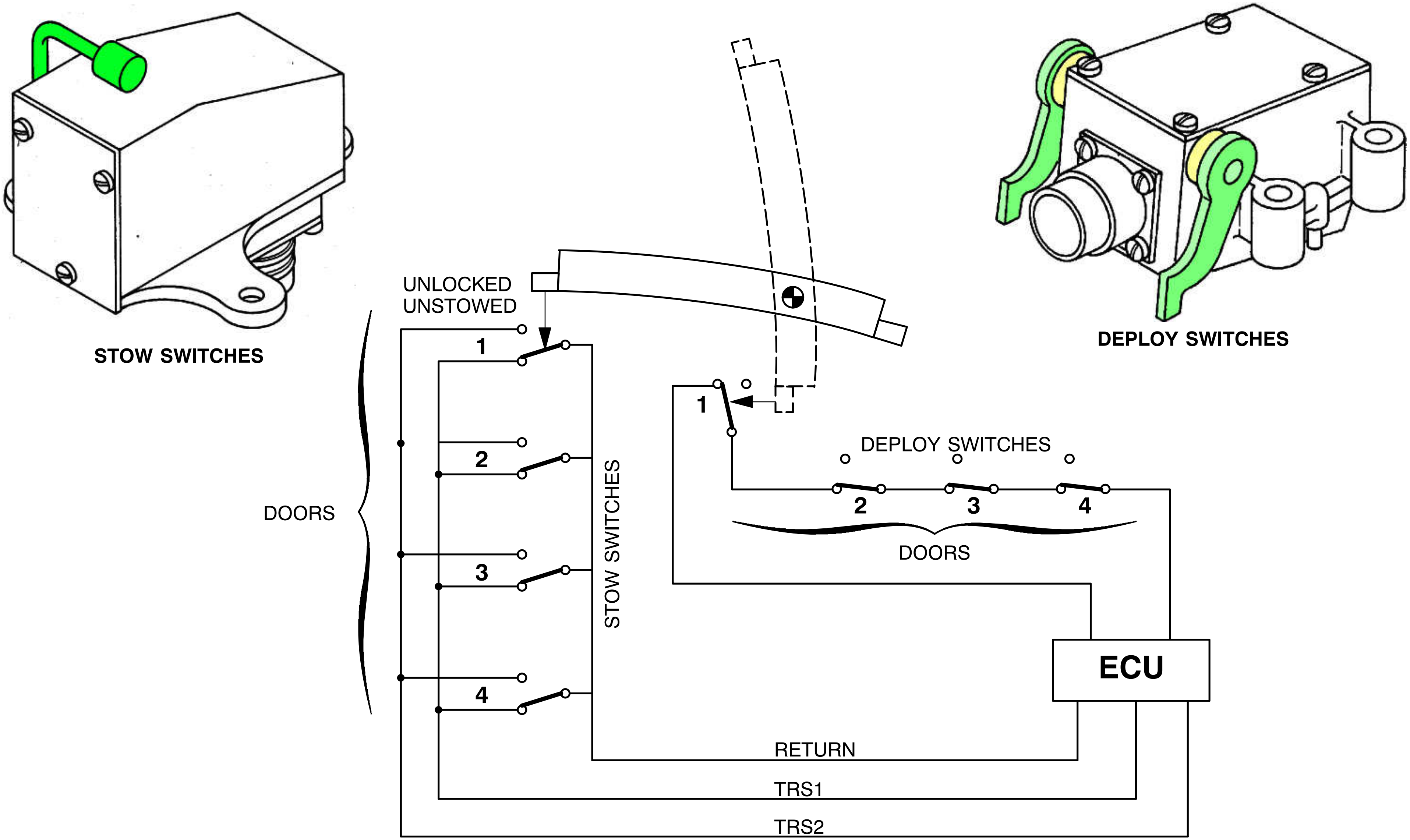
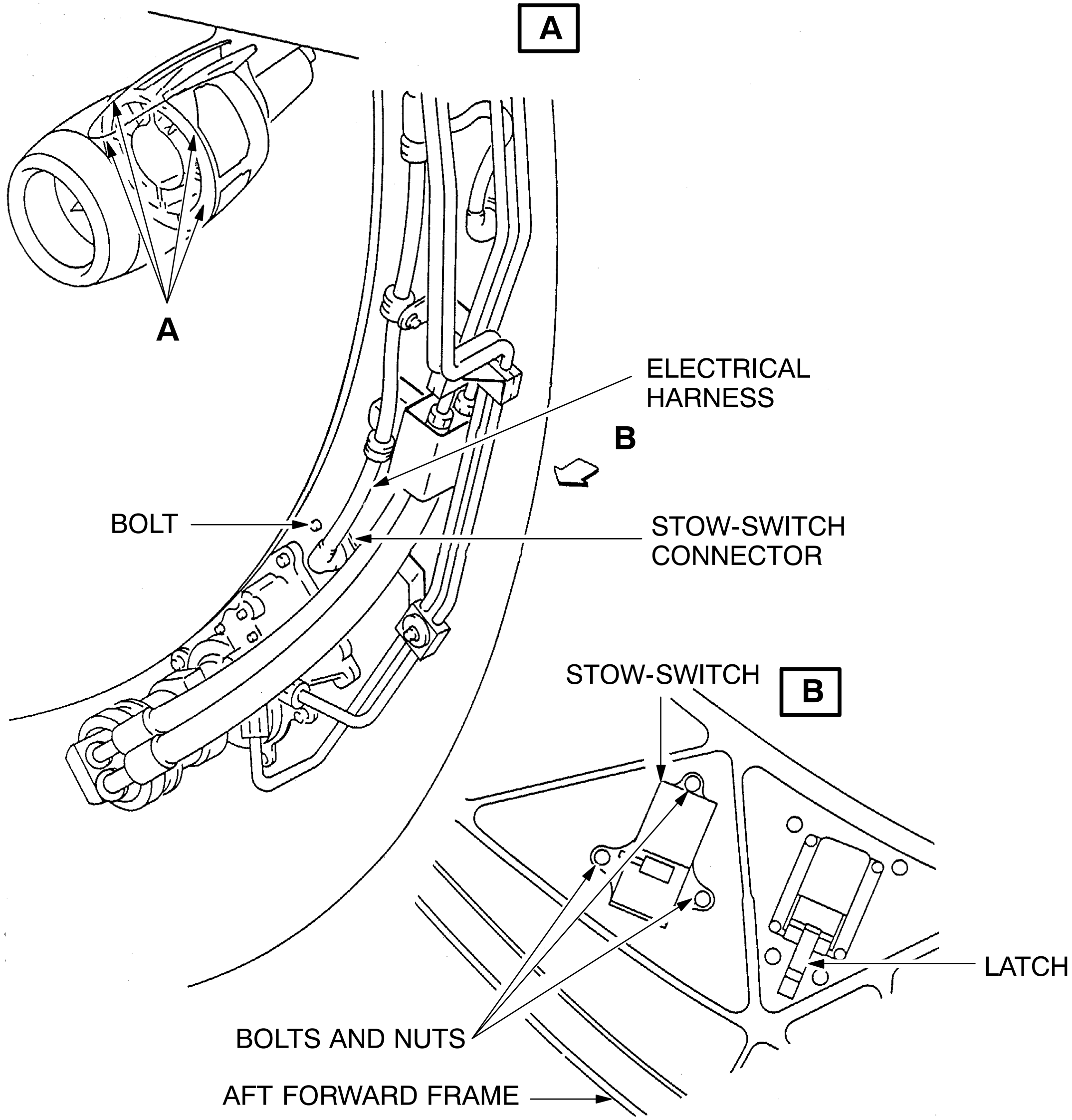


Figure 169 Thrust Reverser Stow / Deploy Switches



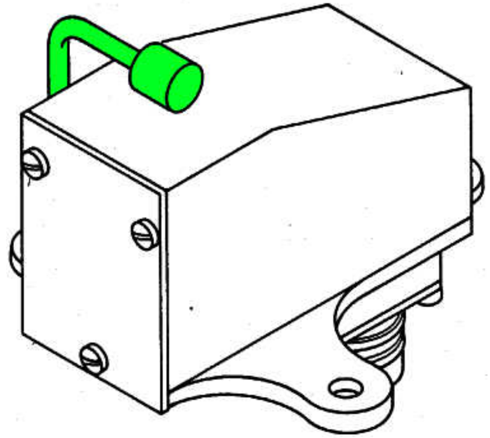
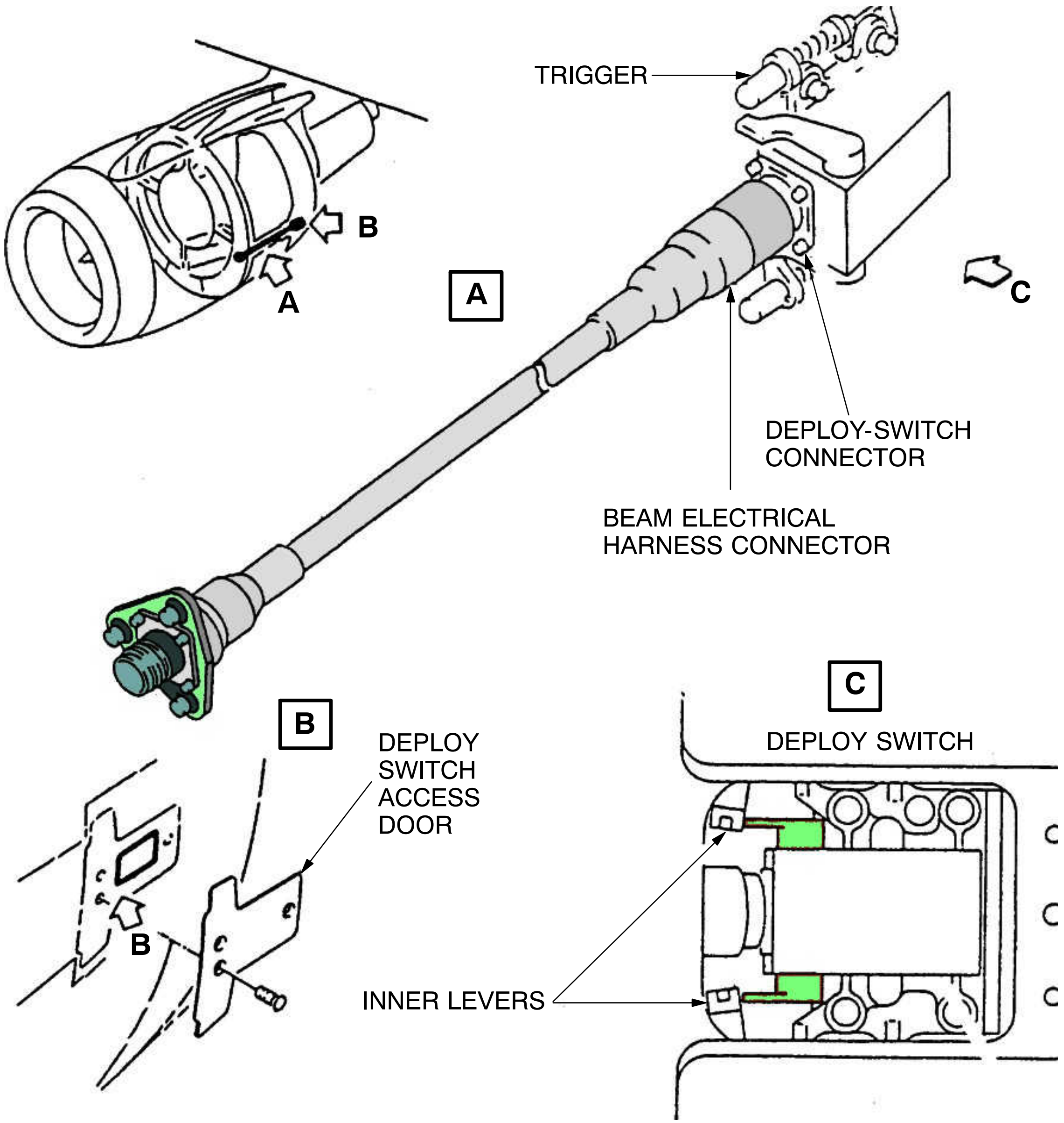


Figure 170 Stow Switch



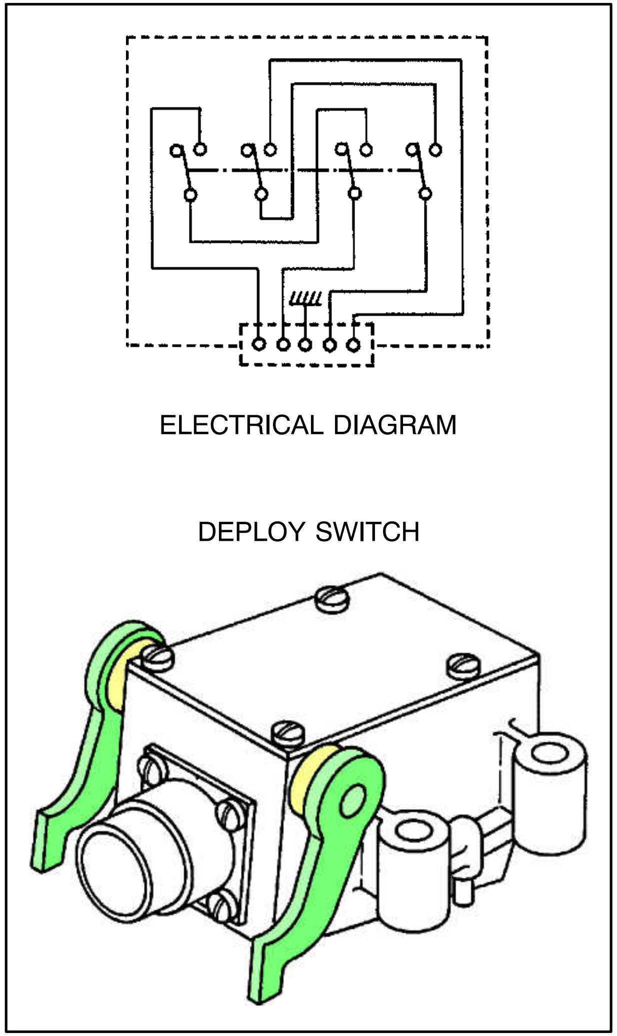


Figure 171 Deploy Switch

REVERSER FUNCTIONAL OPERATION

General

The thrust reverser system is controlled independently for each engine by the associated Full Authority Digital Engine Control (FADEC) system.

Thrust Reverser Actuation

The hydraulic power required for the actuators is supplied by the normal A/C hydraulic system:

- Green System ENG 1
- Yellow System ENG 2

A Shut Off Valve (SOV) located upstream of the Hydraulic Control Unit (HCU) provides an independently controlled locking system.

Each channel of the Electronic Control Unit (ECU) controls and monitors solenoid valves in the HCU. The HCU provides hydraulic pressure for unlocking, deploying, stowing and locking of the actuators and latches of the pivoting doors. The HCU includes a pressurizing valve, a pressure switch and a directional valve which is controlled through the inhibition relay.

Thrust Reverser Control

When the reverse thrust is selected in the cockpit, the following sequence occurs:

- When the potentiometers detect a Throttle Lever Angle (TLA) lower than −3°, the SOV opens if the altitude is less than 6 feet and if high forward thrust is not selected on the opposite engine. Then the HCU is supplied hydraulically. The SOV is controlled open by the Spoiler Elevator Computers (SECs) through the static and power relays
- When the switch of the throttle control unit detects a TLA < −3.8°, the Engine Interface Unit (EIU) energizes the inhibition relay
- When the A/C is on ground with engines running (N2 condition) and the resolvers detect a TLA < −4.3°, the ECU controls the thrust reverser operation through the HCU. The stow and deploy switches are used to monitor the pivoting door position and for ECU control.

Thrust Reverser Indication

The thrust reverser operating sequences are displayed in the cockpit on the EWD. An amber REV indication appears on the N1 indicator when the doors are in transit. It becomes green when the doors are deployed.

Centralized Fault Display System Interface

The Centralized Fault Display System (CFDS) interfaces with the EIU to provide thrust reverser fault diagnostics. For maintenance purposes, a thrust reverser test can be performed through the MCDU menus. During this test, the Centralized Fault Display and Interface Unit (CFDIU) simulates engine running (N2 condition) to permit the thrust reverser deployment.

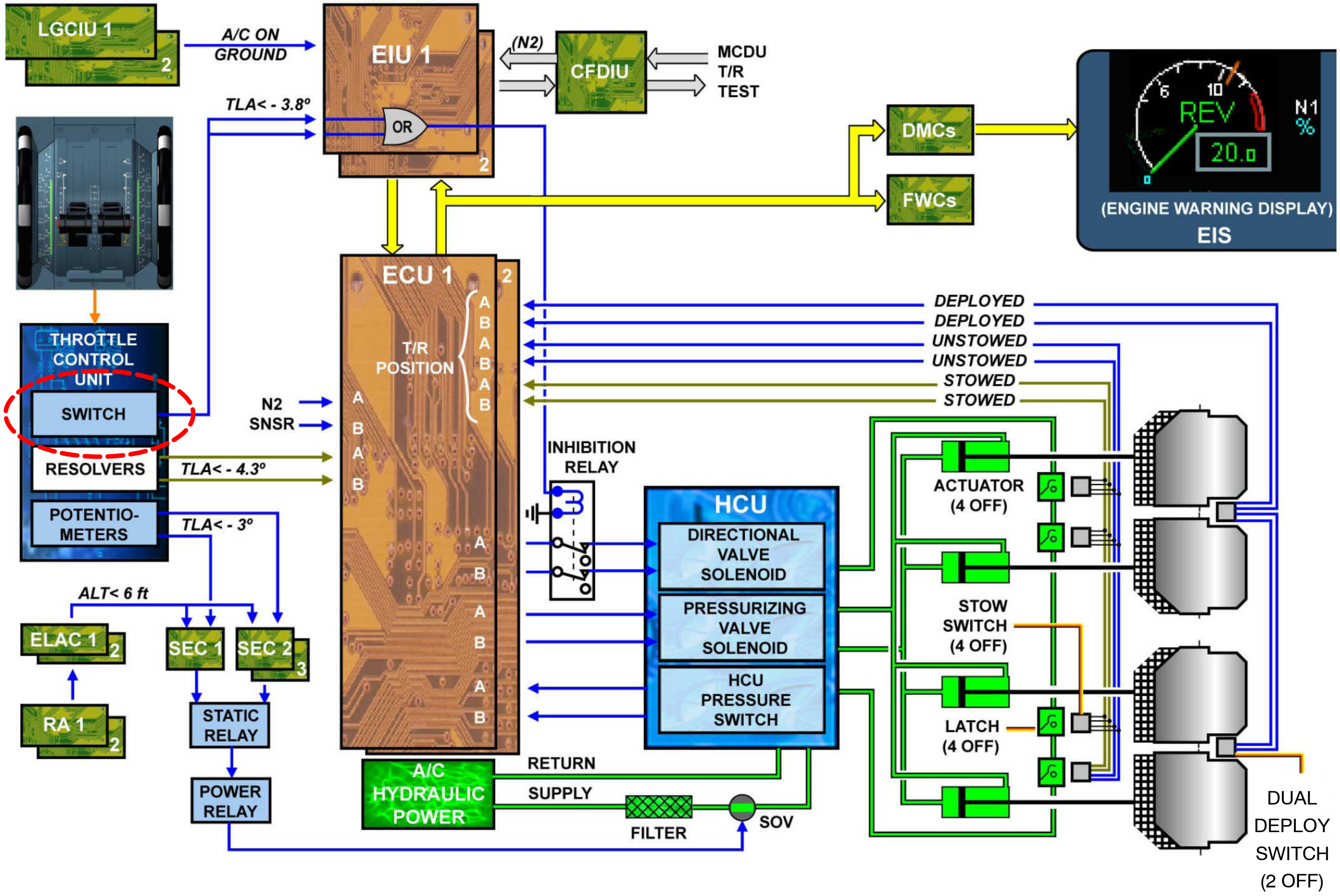


Figure 172 Thrust Reverser Schematic

DEPLOY AND STOW SEQUENCE OPERATION

DEPLOY SEQUENCE

Selection and System Pressurizing

When the reverse thrust is selected in the cockpit, the SOV is independently open following the third defense line logic then, the Electronic Control Unit (ECU) energizes the solenoid of the pressurizing valve.

The High Pressure (HP) is routed to the hydraulic actuator rods and the pressure detector indicates to the ECU that the system is pressurized.

Latches Unlocking and Actuators Supply

Then the ECU also energizes the solenoid of the directional valve. Therefore, the four latches, mounted in line, are hydraulically unlocked. When the last latch is open the pressure return drives the directional valve. Then the directional valve supplies the head chamber of the actuators. The pressures in the rod and head chambers are equal but the difference in surface between the head side and the rod side enables the movement of the actuators.

Reverser Indication

As soon as one pivoting door is at more than 1 % of its angular travel, its stow switch sends a signal to the ECU. The amber reverser indication is displayed on the ECAM during the transit.

When each pivoting door overshoots 95 % of its travel, the deploy switches are closed and the ECU receives the ”deployed doors” information. On the ECAM, the REV indication changes to green.

Doors Deployed

The ECU de−energizes the pressurizing valve solenoid. The pivoting doors are aerodynamically maintained at 100 % of their travel.

STOW SEQUENCE

Stow Selection

When stowing of pivoting doors is selected, the ECU ensures that stowing conditions are achieved. In this case the pressurizing valve solenoid is energized and the directional valve solenoid is de−energized.

Reverser Indication

When one door is at less than 95 % of its travel, the REV indication changes to amber.

When all pivoting doors are at less than one percent of their stowed position, they actuate stow switches which sends the stowed door information to the ECU. The REV indication disappears.

Electrical Power Supply

When the four pivoting doors are stowed, the ECU removes the pressurizing valve solenoid electrical supply, then the SOV is independently closed following the third defense line logic.

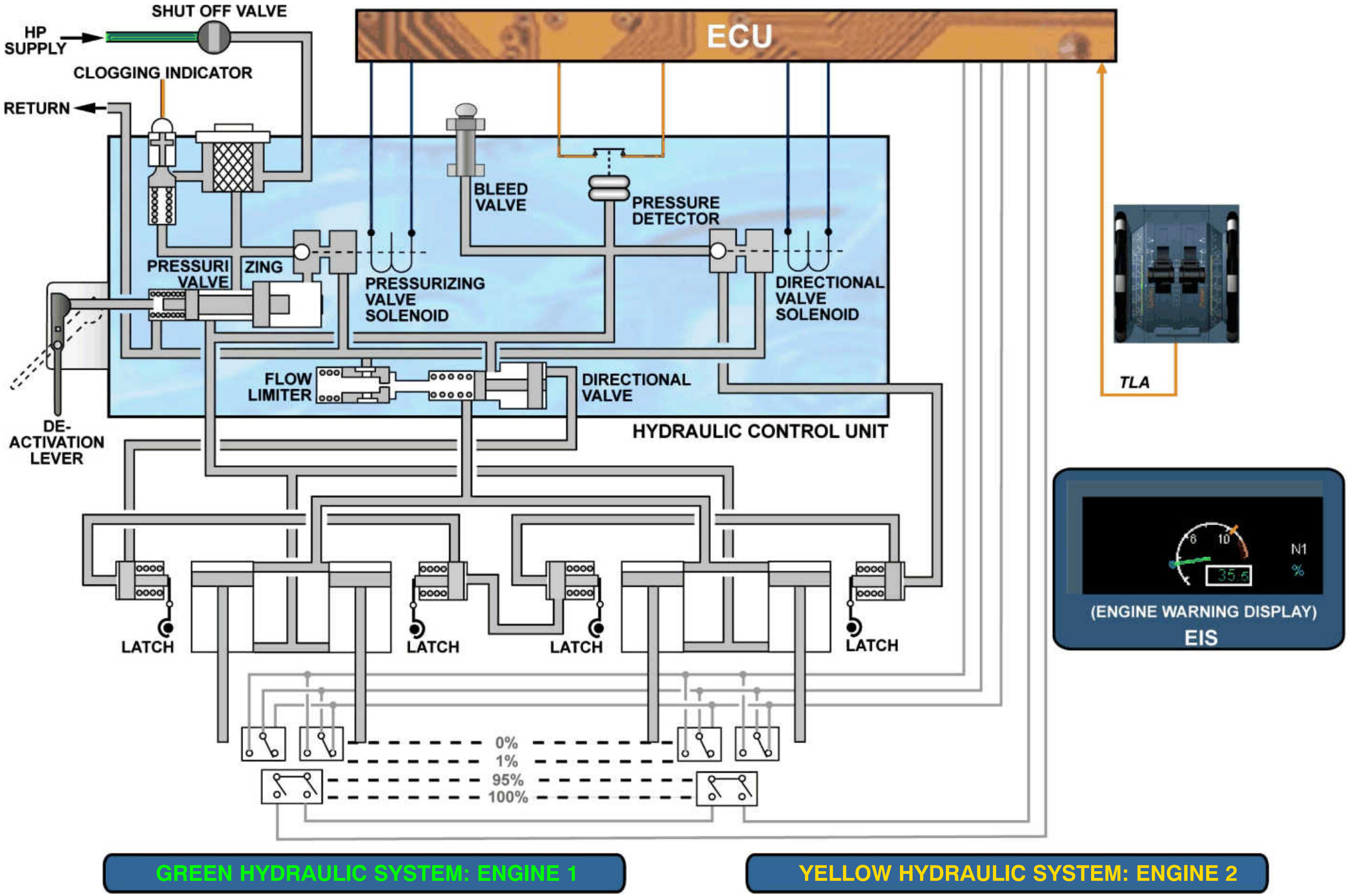


Figure 173 T/R Operation

78−37 THRUST REVERSER INDEPENDENT LOCKING SYSTEM

SYSTEM OPERATION

Third Line of Defense

To protect the thrust reverser system against inadvertent deployment, an additional and independent thrust reverser locking device (*third line of defence*) is installed on the aircraft.

For each engine, a shut−off valve is introduced between the Hydraulic Control Unit (HCU) and the associated Aircraft hydraulic unit. The shut−off valve (SOV) is installed under the engine pylon (on the FWD secondary structure in the fan compartment).

The opening/closure command of this SOV is provided through an aircraft logic, completely independent from the basic thrust reverser. FADEC command and monitoring logic/circuitry.

Each SOV opening/closure is obtained from the Throttle Control Unit (TLA signal −3.8°) and Spoiler Elevator Computers (SEC) which command a static relay to control 115 VAC power supply to the SOV solenoid.

The Engine Interface Unit (EIU) receives the TLA signal −3.8° from another position switch of the Throttle Control Unit, to energize the inhibition relay.

System Operation

Shut−Off Valve opening/closing operation. The hydraulic power for the thrust reverser operation is obtained from the engine driven pump of the hydraulic system (ref. 29−10−00), which supplies the HCU through the filter and the thrust reverser SOV. The thrust reverser SOV is designed to isolate the thrust reverser from the aircraft hydraulic system. The solenoid valve is de−energized closed. When the supply port is closed the thrust reverser is isolated from the aircraft hydraulic system. When the solenoid is energized the valve opens.

The thrust reverser SOV is commanded in the open position when the following conditions are satisfied:

- aircraft is on ground proximity (less than 6 ft)
- reverse thrust is selected
- high forward thrust not selected on opposite engine

The SOV valve solenoid is supplied with 115 VAC through a dedicated and physically segregated wiring. This power supply to the SOV is controlled by a power relay commanded by a static relay. The power relay coil is energized to open the SOV and de−energized to close the SOV. Its energization/de−energization is controlled through the 28VDC static relay which is piloted by the SEC (SEC 1 or 2 for engine 1 and SEC 1 or 3 for engine 2).

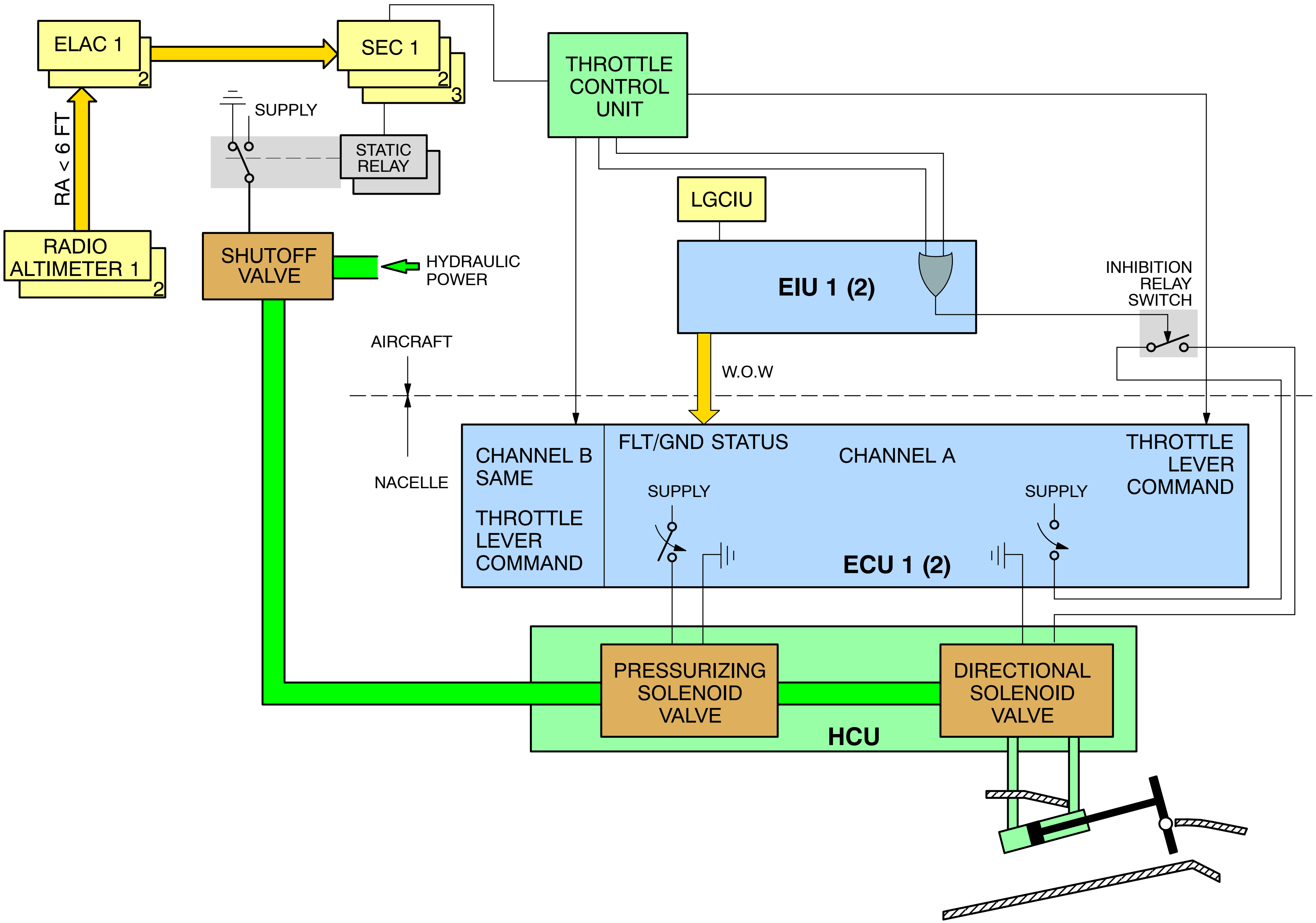


Figure 174 T/R Independent Locking System

COMPONENT DESCRIPTION

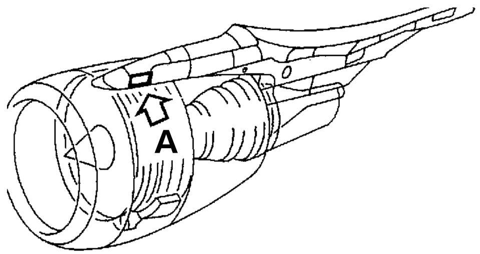
Shut-Off Valve

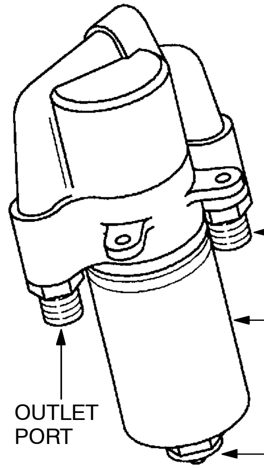
The thrust reverser Shut-Off Valve (SOV) is a 3 port, two position spool valve. It is controlled by a solenoid driven 3 port, two position normally open pilot valve. Electrical power is supplied to the SOV through the fan electrical feeder box.

Filter and Clogging Indicator

It is used to filter the fluid from the aircraft hydraulic system. The filter is a flow-through cartridge-type filter. The clogging indicator monitors the pressure loss through the filter cartridge and has a pop-out indicator to signal when it is necessary to replace the filter element.

The filter assembly contains a check valve to permit the removal of the canister and the change of the filter element with a minimum of spillage.





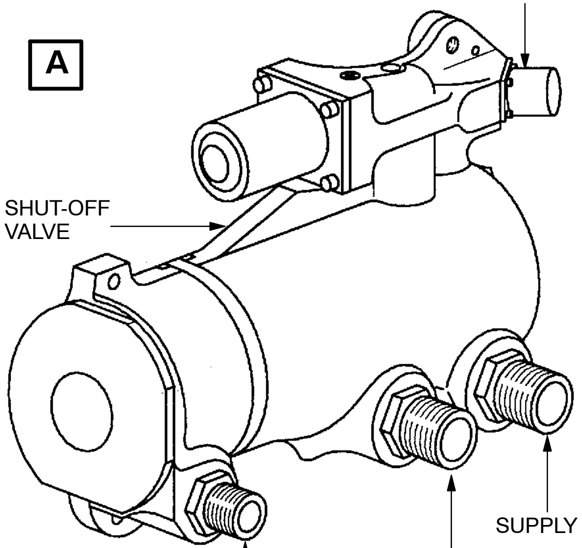


Figure 175 Independent Locking SYS Components

78–30 THRUST REVERSER

MAINTENANCE PRACTICES

Thrust Reverser Deactivation

- This is done when a reverser system fault occurred and the aircraft is dispatched according to MEL.
- The reverser is deactivated by turning the control lever on the HCU to ”OFF” and inserting the pin.
- And inserting the 4 lockout bolts in each blocker door to prevent it from opening.

HCU lockout is performed with the deactivation lever and must be performed for:

- operating the Blocker Doors manually (by hand) for Maintenance Actions
- preventing reverser system from unwanted operation
- deactivating the reverser

NOTE: Depending on FADEC and FWC software modification and additionially to the manual deactivation, the reverser has to be inhibited via the MCDU FADEC Menu ”INHIBITION STATUS”. In this case a ECAM message ”ENG # REV INHIBITED” is triggered. For correct procedure always use actual AMM.

MCDU Menu (depending on FADEC software)

Figure 176 Engine Menu Specific Data

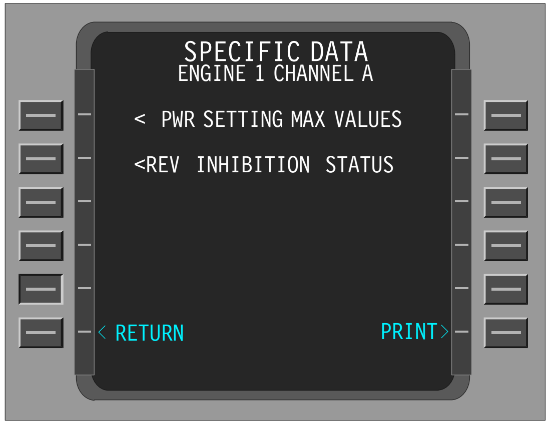
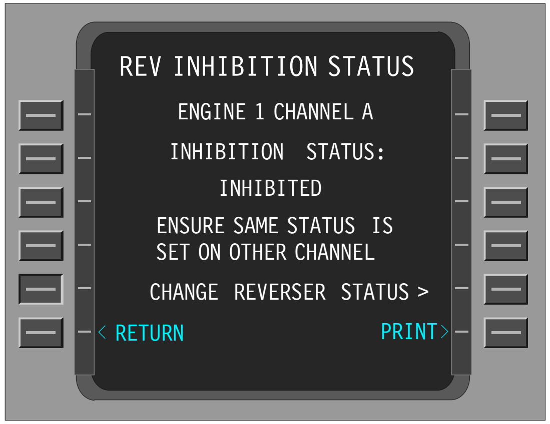


Figure 177 Inhibition Status



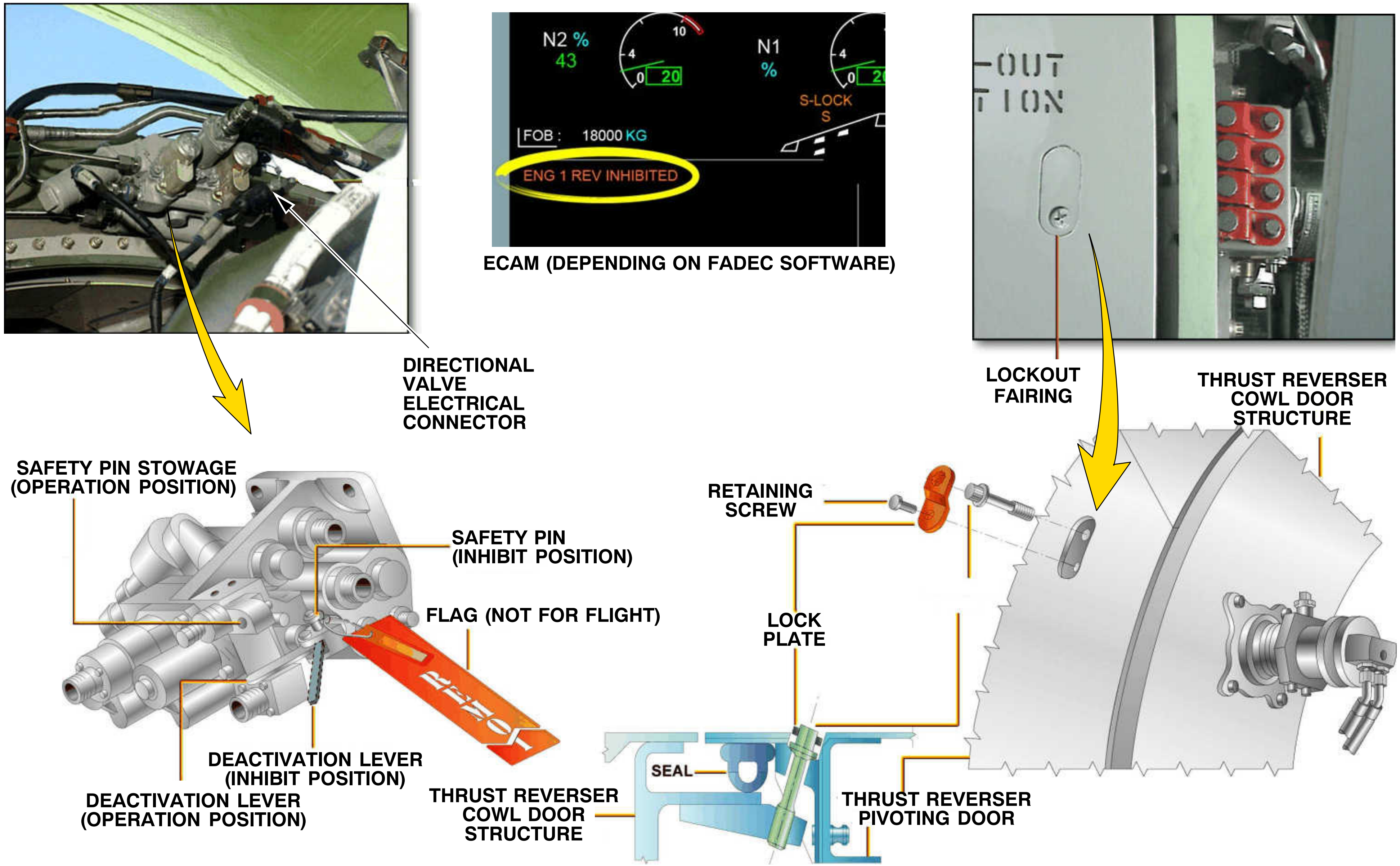


Figure 178 Thrust Reverser Deactivation

Manual Deployment of Pivoting Doors

- Make sure the appropriate engine has been shut down for at least 5 minutes
- Make the thrust reverser unserviceable
- turn the manual unlocking knob on the latch to the unlocked position and check the function of the secondary lock of the actuator

NOTE: The manual unlocking knob is located on slots aside of the latch.

- Using a 5/16 in. wrench turn the manual unlocking knob on the latch to the unlock position
- Turn the manual unlocking square on the actuator to the unlock position

NOTE: The pivoting door automatically disengage from its hook

CAUTION: DO NOT PUSH ON THE STOW SWITCH LEVER WHEN PIVOTING DOOR IS OPENED, DAMAGE CAN OCCUR.

- Open the pivoting door by manually pulling on its edge

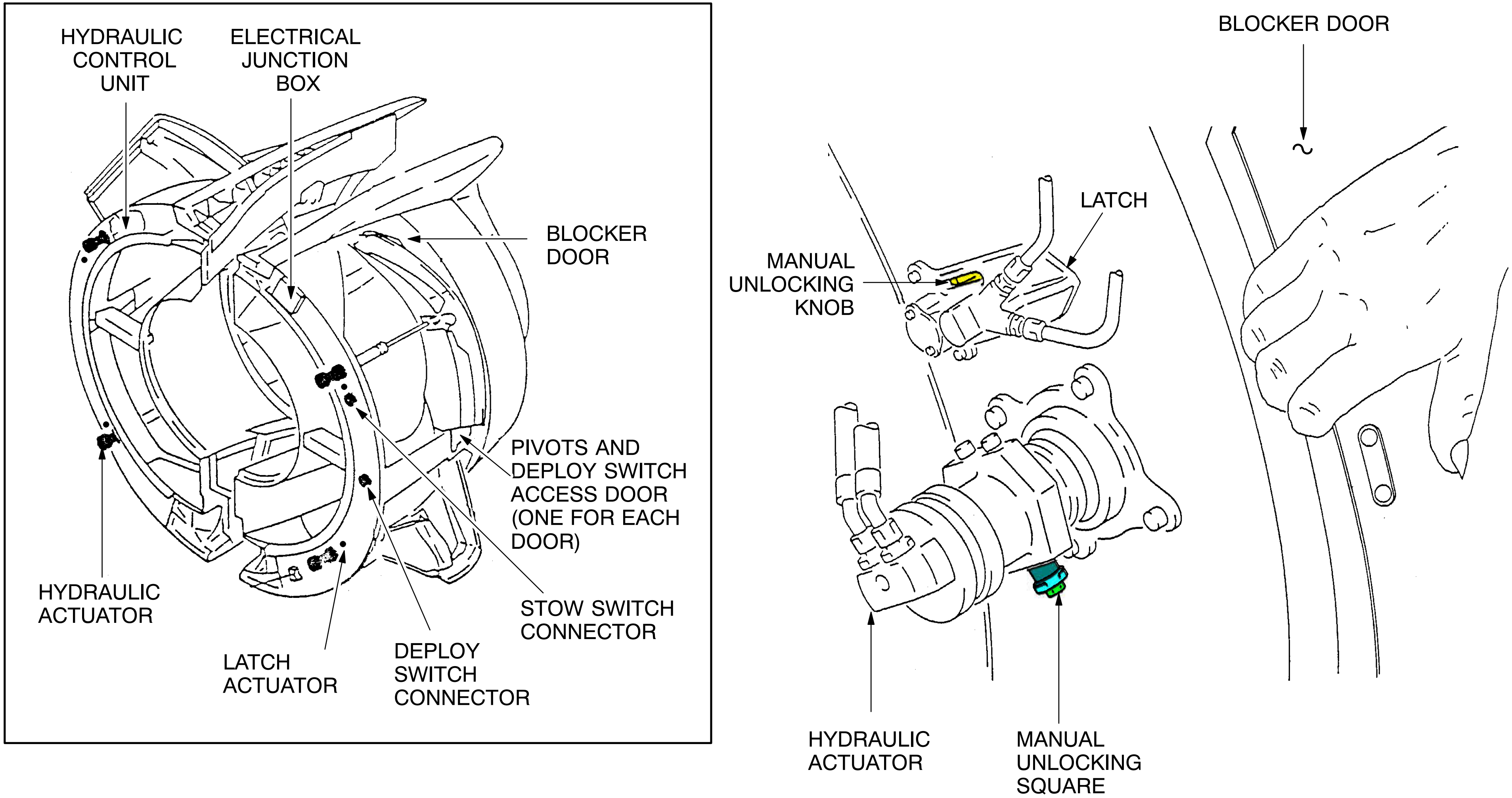


Figure 179 Pivoting Doors Manual Deployment

OPERATIONAL TEST OF THE T/R WITH CFDS

- for 1000EM1 pressurize the green hydraulic system with the yellow hydraulic system through the PTU
- for 1000EM2 pressurize the auxiliary yellow hydraulic system
- on the lower display unit of the ECAM system make sure that the HYD page shows that the pressure is 3000 psi (206 bar)
- on the maintenance panel 50VU
  - release the FADEC GND PWR 1 (2) pushbutton switch
    (on the pushbutton switch, the ON legend comes on)
  - release the HYD/LEAK MEASUREMENT VALVES/B/G/Y pushbutton switches
    (on the pushbutton switch the OFF legend comes on)
- on the FLT CTL panel 23VU
  - make sure that the SEC1 pushbutton switch is on
    (on the pushbutton switch the OFF legend is off)
- on the left or right MCDU get the SYSTEM REPORT/TEST ENG page.
  The following test can be done through the channel A or B of the FADEC 1.

Thrust Reverser Test

ACTION:	RESULT:
Push the line key adjacent to the T/R Test indication to get in the **T/R TEST** program.	The THRUST REVERSER TEST menu comes into view.
Push the line key adjacent to the **START TEST** indication.	The **CONFIRM START OF TEST** indication comes into view.
PUSH the line key adjacent to the **CONFIRM START OF TEST** indication.	**NOTE:** As soon this key is pushed, you must move the throttle control lever in the 35 subsequent seconds.
Put the thrust control lever in the **MAX REVERSE** position.	The thrust reversers of the engine 1(2) operate. On the upper display unit of the ECAM system: - The REV indication in the N1 indicator of the engine 1(2) must show in amber when the thrust reversers operate. – It must become green when the thrust reversers are deployed and locked.
NOTE : If you do not perform the subsequent step immediately install a warning notice on the throttle control lever of the engine 1(2) to prohibit any movement of the lever	
CONTINUED ON NEXT PAGE!	

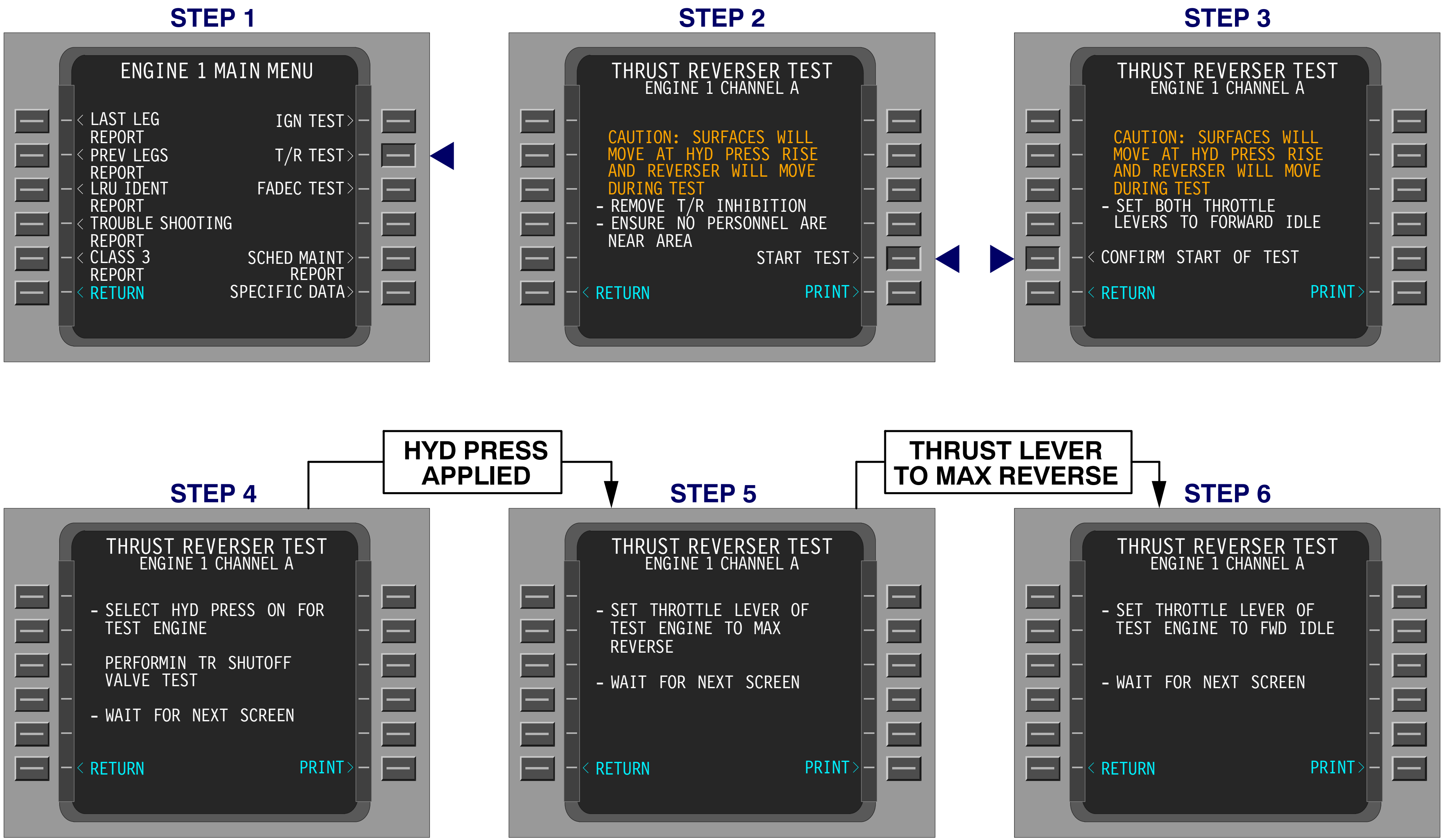


Figure 180 CFDS T/R Test (1)

When the **SET THROTTLE LEVER OF TEST ENGINE TO FWD IDLE** indication shows, put the thrust control lever in the IDLE position (zero on the scale).	The thrust reversers of the engine 1(2) operate. On the upper display unit of the ECAM system: – The REV indication in the N1 indicator of the engine 1(2) must show in amber when the thrust reversers operate. – It must become green when the thrust reversers are deployed and locked.
Push the line key adjacent to the **START RESTOW TEST** indication and do the test again. Push the line key adjacent to the **RETURN** indication.	-TR TEST REPORT comes into view.

WARNING :
YOU MUST USE THE LINE KEY ADJACENT TO THE ”RETURN” INDICATION TO COMPLETE THE TEST. IF YOU COMPLETE THE TEST WITH THE ”MCDU MENU” KEY, THE TEST WILL STAY IN OPERATION FOR ONE MINUTE WITH NO INDICATIONTO MAINTENANCE PERSONNEL. IF A PERSON MOVES THE THROTTLE CONTROL LEVER IN THIS ONE MINUTE, UNWANTED MOVEMENT OF THE THRUST REVERSER CAN OCCUR.

Push the line key adjacent to the **RETURN** indication	-The ENGINE 1(2) MAIN MENU- comes into view.
Do the procedure again for the channel B of the FADEC 1(2).	

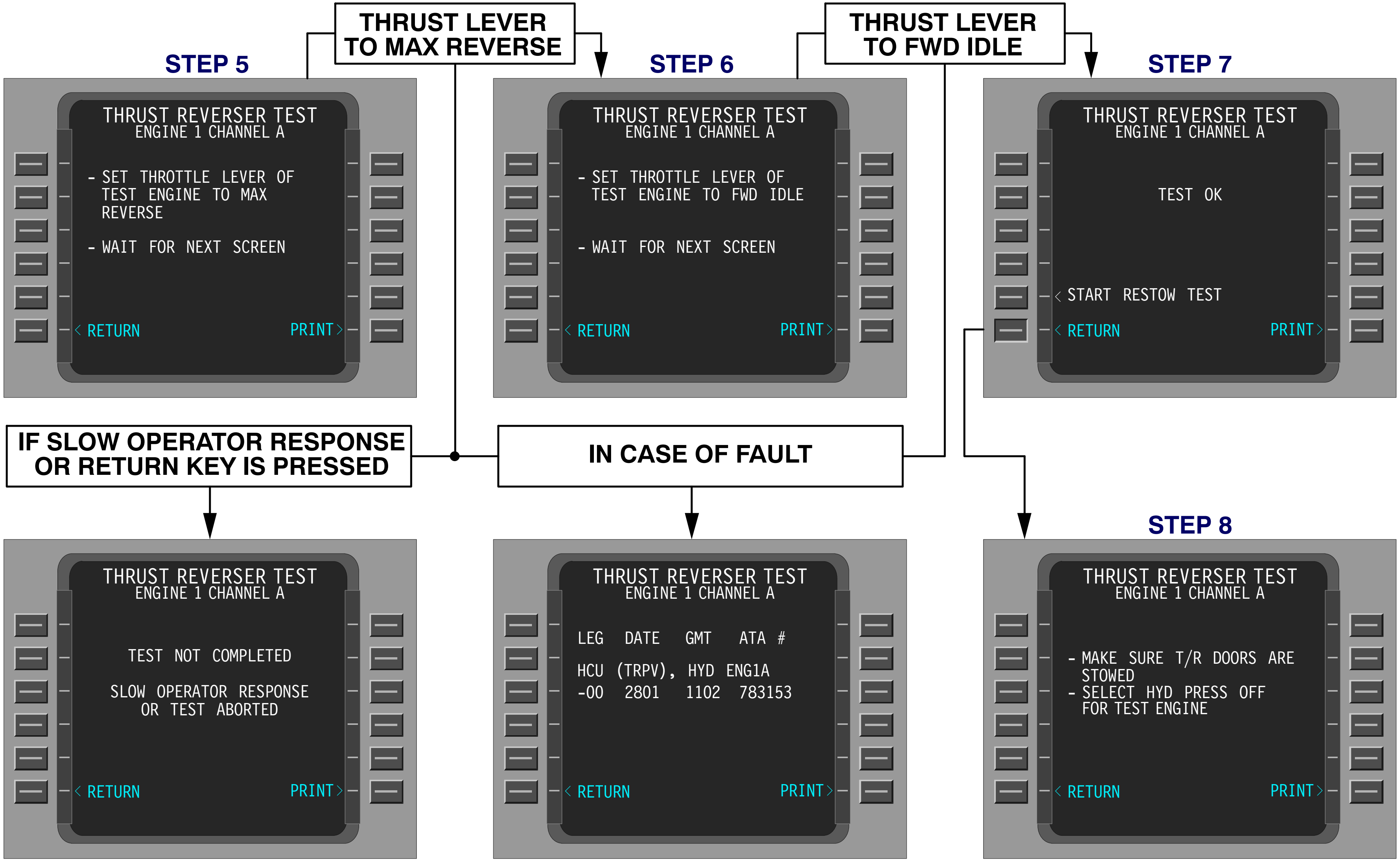


Figure 181 CFDS T/R Test (2)

08|78–30|Test|5A|L2/B1

71-00 CFM56–5B GENERAL

CFM56–5B CONFIGURATIONS INTRODUCTION

CFM56–5B:

EIS (**E**ntry **I**nto **S**ervice) configuration = the 14 first -5B engines have a specific LPT configuration - LPT Nozzle sealing strip conf.

Alitalia, Air France (ex Air Inter).

CFM56–5B/2:

DAC (**D**ual **A**nnular **C**ombustor) for Nox emissions.

CFM56–5B/P OR /2P

3D aero design of HPC/HPT/LPT Blades & Vanes for SFC improvement.

RACC (**R**otor **A**ctive **C**learance **C**ontrol) function deletion: RACSB (**R**otor **A**ctive **C**learance **S**tart **B**leed) replaced by TBV (**T**ransient **B**leed **V**alve).

CFM56–5B/2P NAC

LPT Frame external cooling system for NAC (**N**acelle **A**ir **C**ooling) at ground idle.

HISTORY OF THE CFM56–5B TURBOFAN ENGINE

The CFM56–5B, a high–performance, low–risk derivative engine of the CFM56 family, was originally developed to power the Airbus A321. Today, it is the only engine that can power every model of the A320 family with one bill of materials. This provides airlines with a distinct commonality advantage, in addition to the lowest cost of operation on this application.

Noise and emissions have become key factors in aircraft fleet planning and operations. This was a problem with the original single annular combustor **(SAC)** technology.

The CFM56–5B was the first engine to introduce advanced double annular combustor **(DAC)** technology in the mid–1990s. This technology reduced NOx (oxides of nitrogen) emissions by as much as 45 percent.

With the introduction of Tech Insertion and new combustor technology in 2007, CFM has been able to offer operators comparable improvement in a much simpler design (single annular combustor again). The optimized Tech Insertion combustor emits 25 percent less NOx to ensure that the engine meets the CAEP/6 regulations that went into effect in Jan. 2008.

In addition to lowering NOx emissions, the CFM56–5B Tech Insertion configuration provides operators with up to 1 percent improvement in fuel consumption over the life of the product compared to the base CFM56–5B engine, which also means fewer carbon emissions.

Figure 182 CFM56–5B Engine

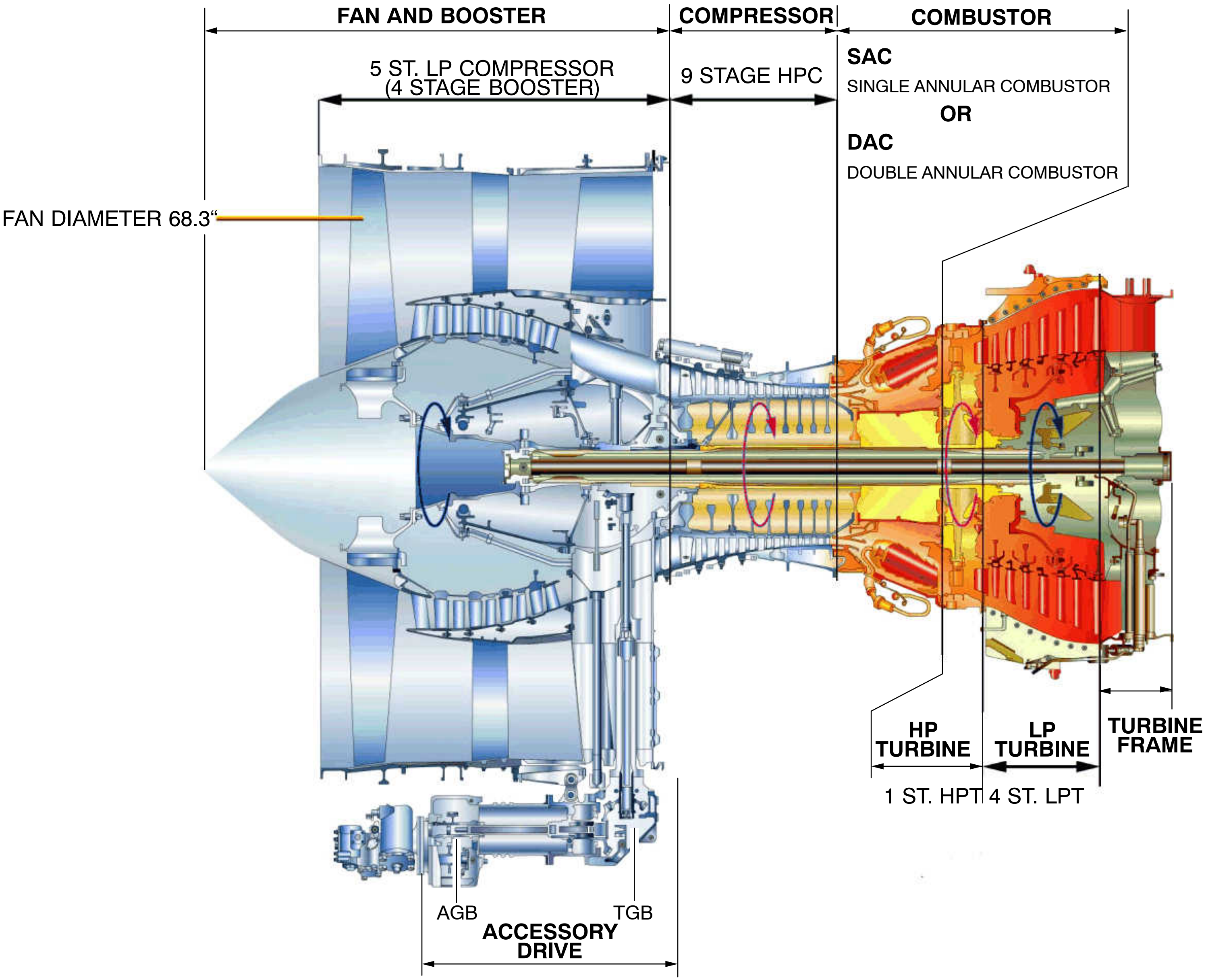


Figure 183 CFM56-5B Engine Overview

ENGINE GENERAL PARAMETERS

There is a different kind of thrust depending on the engine installed on the aircraft.

Until 33000 lb (14970 kg) can be achieved during take off with the CFM56−5B3 on A321, or 21600 lb (9800 kg) with CFM56−5B8 on A318, which is the lowest take−off thrust.

Notice the take−off thrust is the same between the CFM56−5B4 on A320 and CFM56−5B7 on A319 and A319 Corporate Jet, with a thrust value of 27000 lb (12250 kg).

TAKEOFF CONDITIONS (SEA LEVEL)		CFM56-5B1	-5B2	-5B3	-5B4	-5B5	-5B6	-5B7	-5B8	-5B9
- MAX. TAKEOFF	(lb)	30000	31000	33000	27000	22000	23500	27000	21600	23300
	(kg)	13610	14060	14970	12250	9980	10660	12250	9800	10570
- AIRFLOW	(lb/s)	943	956	968	897	818	844	897	811	841
	(kg/s)	428	420	439	407	371	383	407	368	381
- BYPASS RATIO		5.5	5.5	5.4	5.7	6.0	5.9	5.7	6.0	5.9
IN-FLIGHT PERFORMANCE (INSTALLED) (35000 ft - MACH=0.80 -ISA)		**-5B1**	**-5B2**	**-5B3**	**-5B4**	**-5B5**	**-5B6**	**-5B7**	**-5B8**	**-5B9**
- MAX. CLIMB THRUST	(lb)	6420	6420	6420	5630	5630	5630	6420	5630	5630
	(kg)	2912	2912	2912	2554	2554	2554	2912	2554	2554
- OVERALL PRESSURE RATIO AT MAX. CLIMB		35.4	35.4	35.5	32.6	32.6	32.6	35.5	32.6	32.6
- MAX. CRUISE THRUST	(lb)	5840	5840	5840	5020	5020	5020	5840	5020	5020
	(kg)	2649	2649	2649	2277	2277	2277	2649	2277	2277
ENGINE CHARACTERISTICS		**- 5B1**	**-5B2**	**-5B3**	**-5B4**	**-5B5**	**-5B6**	**-5B7**	**-5B8**	**-5B9**
- LENGTH (in)		102.4	102.4	102.4	102.4	102.4	102.4	102.4	102.4	102.4
- FAN DIAMETER (in)		68.3	68.3	68.3	68.3	68.3	68.3	68.3	68.3	68.3
- BASIC DRY WIGHT	(lb)	5250	5250	5250	5250	5250	5250	5250	5250	5250
	(kg)	2381	2381	2381	2381	2381	2381	2381	2381	2381
APPLICATIONS		A321	A321	A321	A320	A319	A319	A319 A319CJ	A318	A318

Figure 184 CFM56-5B Parameters

ATA ENGINE FUEL AND CONTROL

73–20 CONTROLLING

FADEC FUNCTIONAL OPERATION

Full Authority Digital Engine Control (FADEC)

The FADEC consists of the ECU (**E**ngine **C**ontrol **U**nit), HMU (**H**ydromechanical **U**nit) and its peripheral components and sensors used for control and monitoring.

FADEC Definition

Each engine is equipped with a duplicated FADEC system. The FADEC acts as a propulsion system data multiplexer making engine data available for condition monitoring.

FADEC Controls

The FADEC provides the engine sytem regulation and scheduling to control the thrust and optimize the engine opration.

The FADEC provides:

- Fuel control regulation
- power management
- gas generator control
- Turbine active clearance control
- engine limit protection
- feedback
- flight deck indication data
- Engine maintenance data
- Contitioning monitoring data
- thrust reverse control
- automatic engine starting
- Fuel return control for IDG cooling

Power Management

The FADEC provides automatic engine thrust control and thrust parameter limits computation. The FADEC manages power according to two thrust modes:

- manual mode depending on TLA (**T**hrust **L**ever **A**ngle)
- Autothrust mode depending on autothrust function generated by the AFS (**A**uto **F**light **S**ystem).

The FADEC also provides two idle mode selections:

- Approach Idle: It is obtained when slats are extended in FLT.
- Minimum Idle: It can be modulated up to approach idle depending on:
  - Air conditioning demand
  - Engine anti ice demand
  - Wing anti ice demand
  - TEO (**T**emperature **E**ngine **O**il for IDG cooling).

Engine Limit Protection

The FADEC provides overspeed protection for N1 and N2, in order to prevent engine exceeding certified limits, and also monitors the EGT.

Engine Systems Control

The FADEC provides optimal engine operation by controlling the:

- Fuel Flow
- Compressor air flow and
- Turbine clearence.

Thrust Reverse

The FADEC supervises entirely the thrust reverse operation.

In case of a malfunction, the thrust reverser is stowed.

Start and Ignition Control

The FADEC controls the engine start sequence. It monitors N1, N2 and EGT parameters and can recycle or abort an engine start.

Power Supply

The FADEC system is self–powered by a dedicated permanent magnet alternator when N2 is above 15%, and is powered by the aircraft electrical system for starting, as a backup and for testing with engine not running.

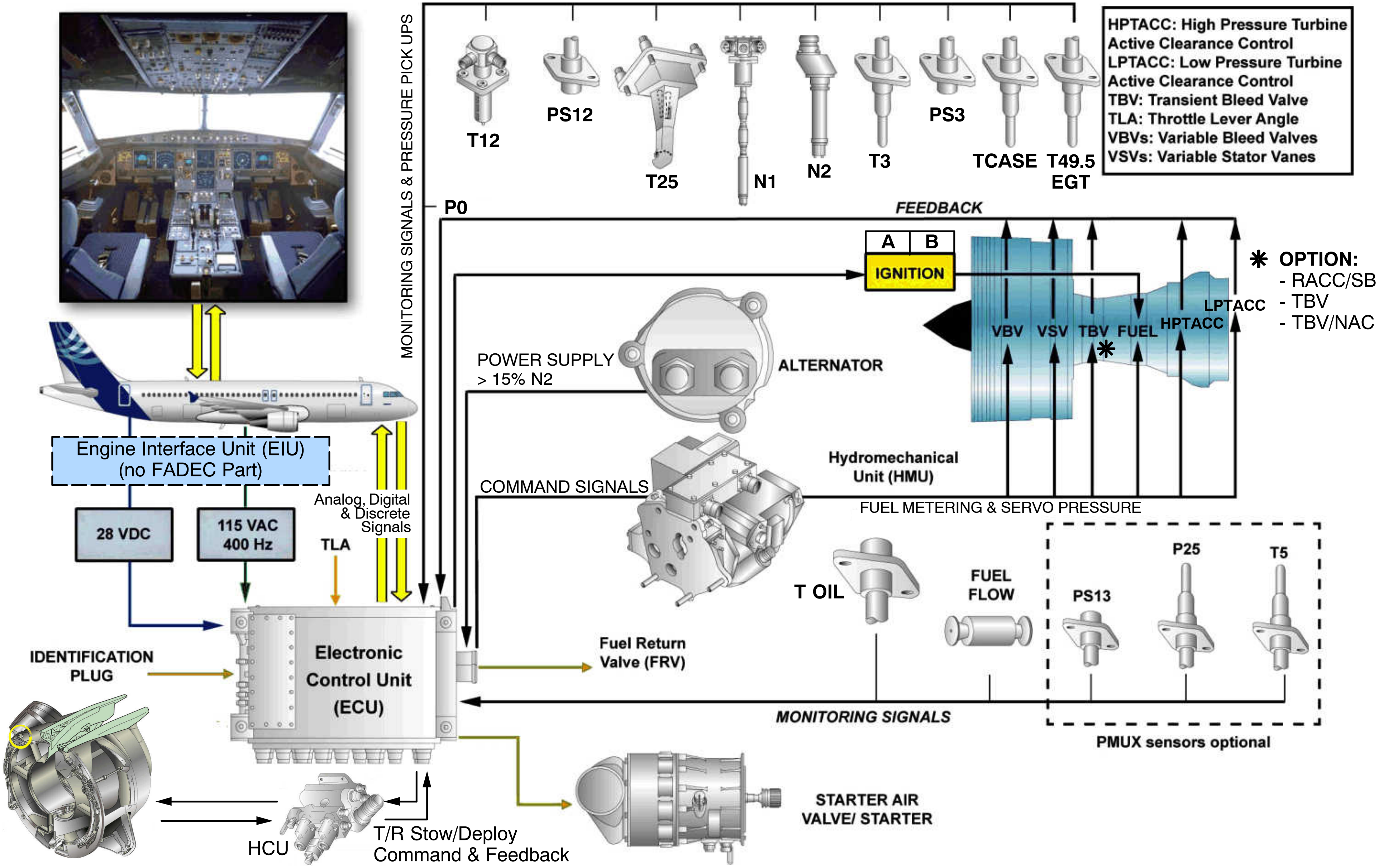


Figure 185 FADEC Presentation CFM 56-5B

ATA 72 ENGINE

72−00 GENERAL

ENGINE STATION AND STAGES PRESENTATION

Station numbers are assigned to identify specific positions along the aerodynamic flowpath of an engine.

A station is a position at the engine, where thermodynamically changes (Pressure, temperature or airspeed) starts or ends.

Engine stations are labeled continuously from 1 to 5 along the aerodynamic flowpath.

The station numbers are also used to identify instrumentation positions for pressure and temperature sensors. Temperature sensors are labeled with ”T”, pressure sensors are labeled with a ”P”, followed by a station number.

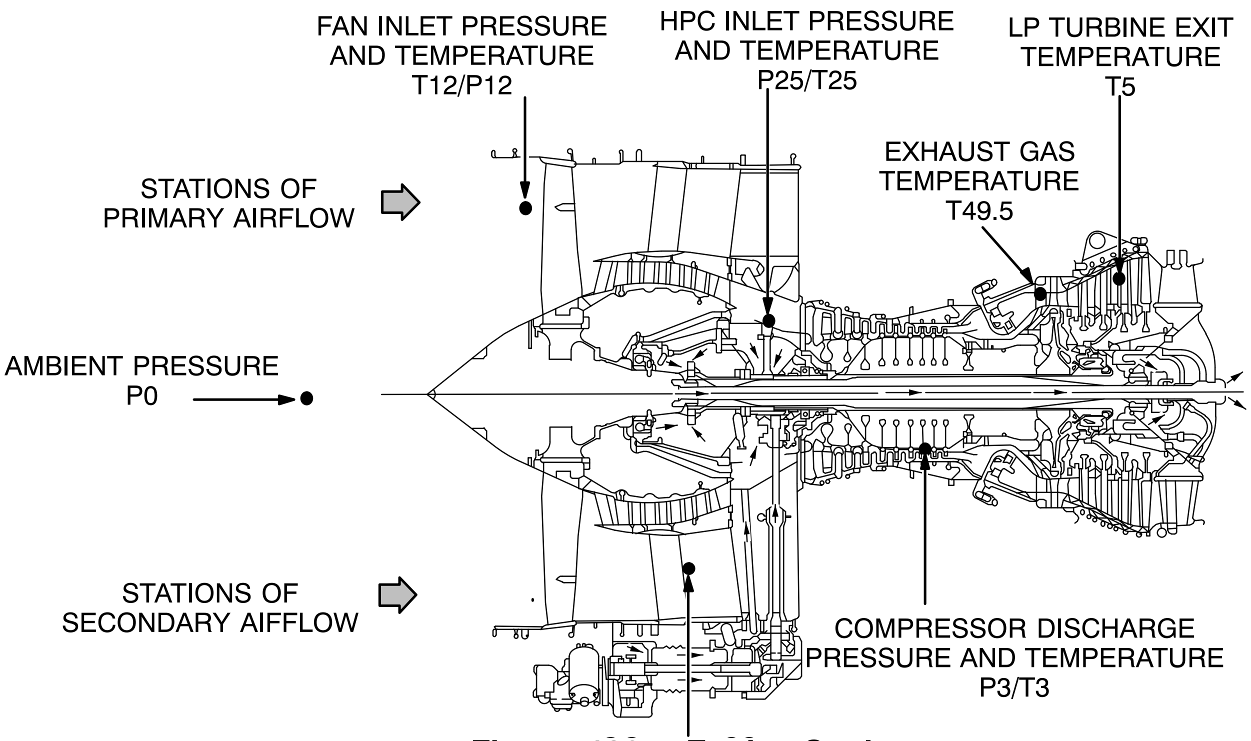


Figure 186 Engine Stations

USED FOR →		A	B	C	D	E	F	G	H	I
↑		FMV	VSV/VBV	HPTCC	LPTCC	RACC/SB/TBV	BSV	START / IGN	CON MON	ECAM
01	T 12	●		●	●					
02	T 25	●	●	●	●					
03	T 3.0			●		●	●			
04	T 49.5				●			●		●
05	T 5.0								●	
06	PS 13								●	
07	P 25								●	
08	PS 3.0	●		●			●			
09	PO	●	●	●	●	●	●			
10	PS12	●							●	
11	N1	●	●	●	●	●	●			●
12	N2	●	●	●	●	●	●	●		●
13	FF									●
14	TCASE			●						

LEGENDE (HORIZONTAL)

A FUEL METERING VALVE
B VARIABLE STATOR VANES / VARIABLE BLEED VALVES
C HIGH PRESSURE COMPRESSOR TURBINE CLEARANCE CONTROL
D LOW PRESSURE COMPRESSOR TURBINE CLEARANCE CONTROL
E ROTOR ACTVE CLEARANCE CONTROL /START BLEED OR TRANSIENT BLEED VALVE CONTROL
F BURNER STAGING VALVE
G AUTO START & IGNITION
H CONDITION MONITORING
I ELECTRONIC CENTRALIZED AIRCRAFT MONITORING

LEGENDE (VERTICAL)

01 ELECTRICAL FAN INLET TEMPERATURE SENSORS (2)
02 HIGH PRESSURE COMPRESSOR INLET TEMPERATURE SENSOR
03 HIGH PRESSURE COMPRESSOR DISCHARGE TEMPERATURE SENSOR
04 EXHAUST GAS TEMPERATURE SENSOR (EGT)
05 LOW PRESSURE TURBINE EXHAUST GAS TEMPERATURE SENSOR
06 FAN EXIT PRESSURE SENSOR
07 HIGH PRESSURE COMPRESSOR INLET PRESSURE SENSOR
08 HIGH PRESSURE COMPRESSOR DISCHARGE PRESSURE SENSOR
09 AMBIENT PRESSURE (PO)
10 ENGINE FAN INLET PRESSURE
11 LOW PRESSURE COMPRESSOR ROTOR SPEED SENSOR (N1)
12 HIGH PRESSURE COMPRESSOR ROTOR SPEED SENSOR (N2)
13 FUEL FLOW TRANSMITTER
14 T-CASE TEMPERATURE SENSOR

Figure 187 Aerodynamic Stations

STAGE NUMBERING CFM56-5B

STAGES :	COMPONENT :	STAGE NUMBER :	NOTES :
1	FAN	1	Fan air used for ACC
1 2 3 4	LOW PRESSURE COMPRESSOR (BOOSTER)	1 2 3 4	VBV
1 2 3 4 5 6 7 8 9	HIGH PRESSURE COMPRESSOR	1 2 3 4 5 6 7 8 9	(IGV)VSV VSV VSV HPT ACC CUST. BLEED, Eng. Anti Ice (A/I), CUST. BLEED, Muscle Press A/I Start Bleed, HPT ACC
	COMBUSTION CHAMBER		20 Fuel Nozzles,2 Ignitor Plugs
1	HIGH PRESSURE TURBINE	1	ACTIVE CLEARANCE CONTROL
1 2 3 4	LOW PRESSURE TURBINE	1 2 3 4	ACTIVE CLEARANCE CONTROL
	EXHAUST NOZZLE		

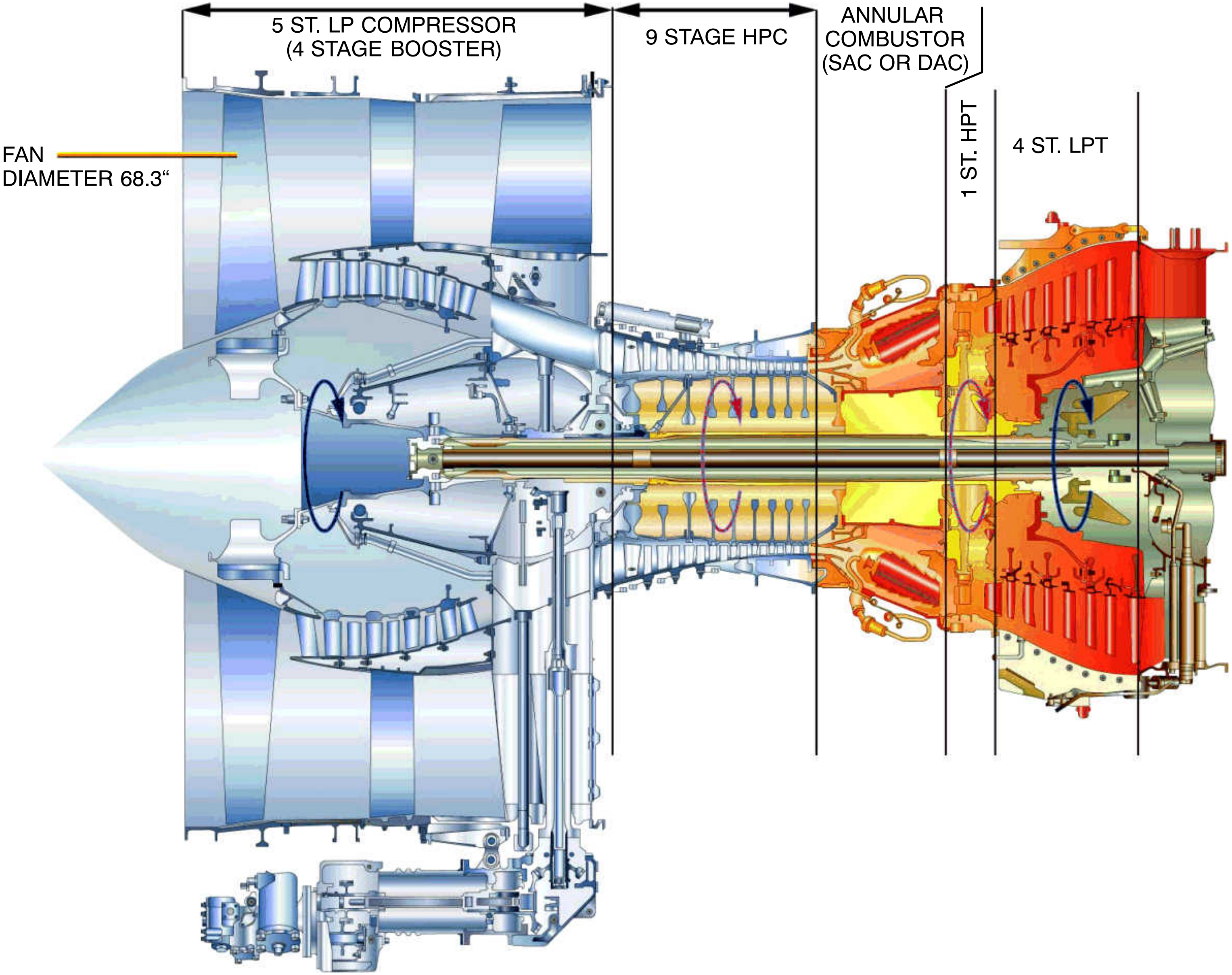


Figure 188 Engine Cross Section

72-20 FAN SECTION

SPINNER COMPONENT DESCRIPTION

Front Cone

Interference fit and single annular mounting positions are characteristics of the installation of the front and rear cone onto the fan disk.

The spinner front cone has an offset hole on its rear flange, identified by an indent mark, to ensure correct alignment for installation onto the rear cone front flange.The rear flange has 6 mounting screw locations and 3 threaded inserts, located every 120°, for installation of jackscrews used in removal procedures.

Spinner Rear Cone

The front flange of the spinner rear cone has 6 line replaceable, crimped, self-locking nuts.

The inner rear flange has 12 mounting screw holes, for installation onto the fan disk, and there are a further 6 threaded holes for the installation of jackscrews used in rear cone removal procedures.

Both front and rear flanges have an offset hole to ensure correct installation and they are identified by indent marks.

The rear cone also has an integrated air seal that is glued to its inner rear flange.

The rear cone prevents axial disengagement of spacers used in the fan blade retention system.

It also supports a series of balancing screws that are installed on its outer diameter. There are two sets of balancing screws available and the screws in each set are identified as either P01 to P07 or, P08 to P14. The numbers, which are engraved on the screw heads, are equivalent to various weights.

An indent mark is located in between two balancing screws for correct installation of the rear cone onto the fan disk and for identification of fan blade No.1.

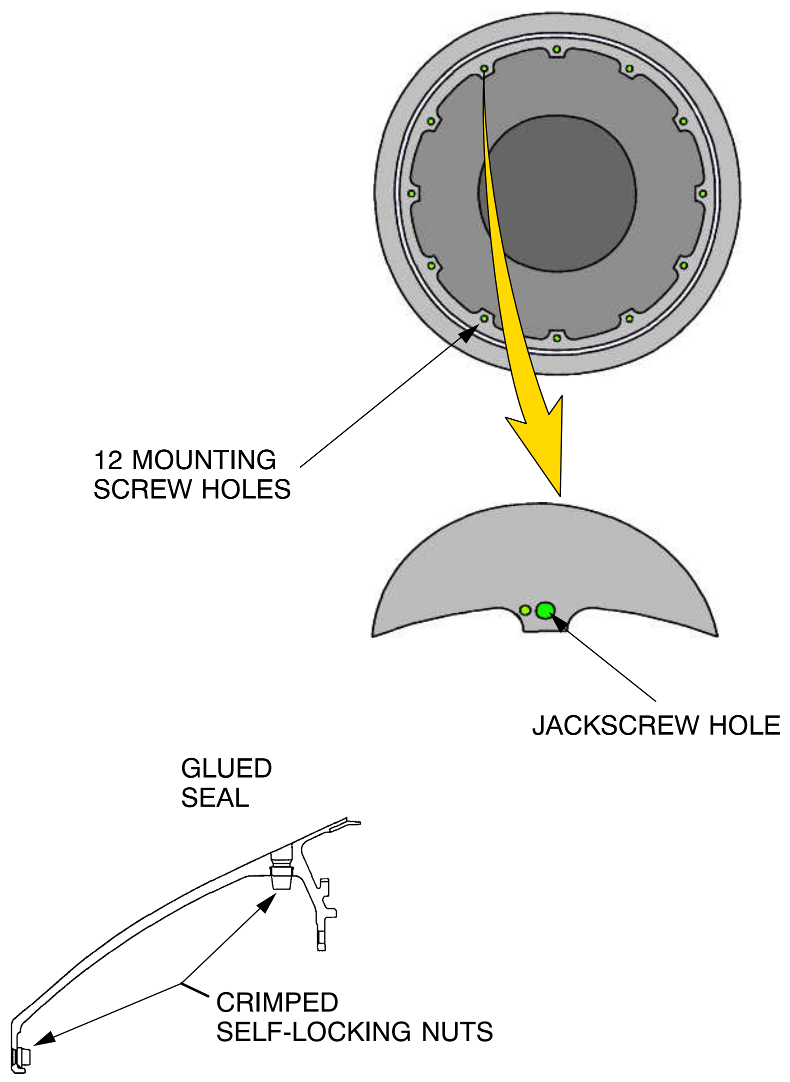


Figure 189 ***Spinner Rear Cone***

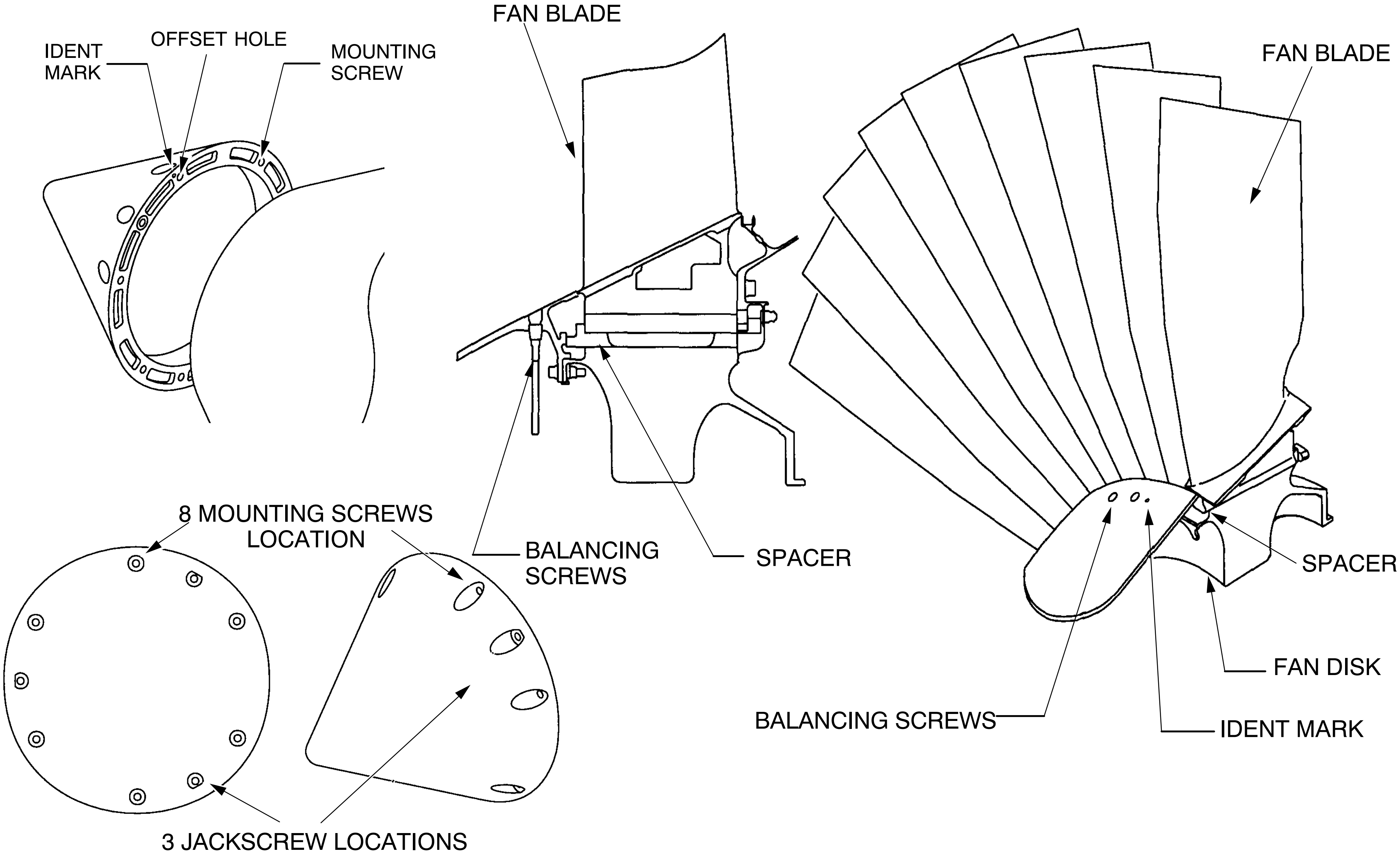


Figure 190 Spinner Cones

72-23 FAN FRAME ASSEMBLY

FAN MODULE COMPONENT DESCRIPTION

Fan Inlet Case

The inner surface of the upstream fan inlet case is lined with 6 forward acoustical panels, 6 mid acoustical panels and provides an abradabie shroud which faces the fan blade tips.

The inner surface of the downstream fan inlet case is lined with 12 aft acoustical panels.

The fan inlet case also houses the OGV (**O**utlet **G**uide **V**ane) assembly.

Fan Frame

The fan frame has 12 radial hollow struts that house various equipment and lines. Compartments formed between the adjacent struts house VBV (**V**ariable **B**leed **V**alve) actuators which, under certain conditions, redirect primary air into the secondary airflow.

The rear face of the fan frame mid section provides the front mounts for the engine and the front flange for the HPC (**H**igh **P**ressure **C**ompressor) section.

The OGV (Outlet Guide Vane) Assembly

The fan OGV assembly consists of the inner shroud and 35 twin vanes.

The inner shroud rear flange is bolted to the fan frame and has 35 apertures to allow passage of the vane inner platforms.

The vane inner platforms are axially retained by the inner face of the fan OGV inner shroud.

The vane outer platforms are bolted to the downstream fan inlet case.

A splitter fairing, which separates the primary and secondary airflows, is bolted onto the fan OGV inner shroud forward flange.

There are 2 unplugged holes on the inner shroud, between the 3 and 4 o'clock positions, to enable borescope inspection of the booster vane assemblies. One is located between the OGV's at the stage 3 vane assembly and the other at the stage 5 vane assembly.

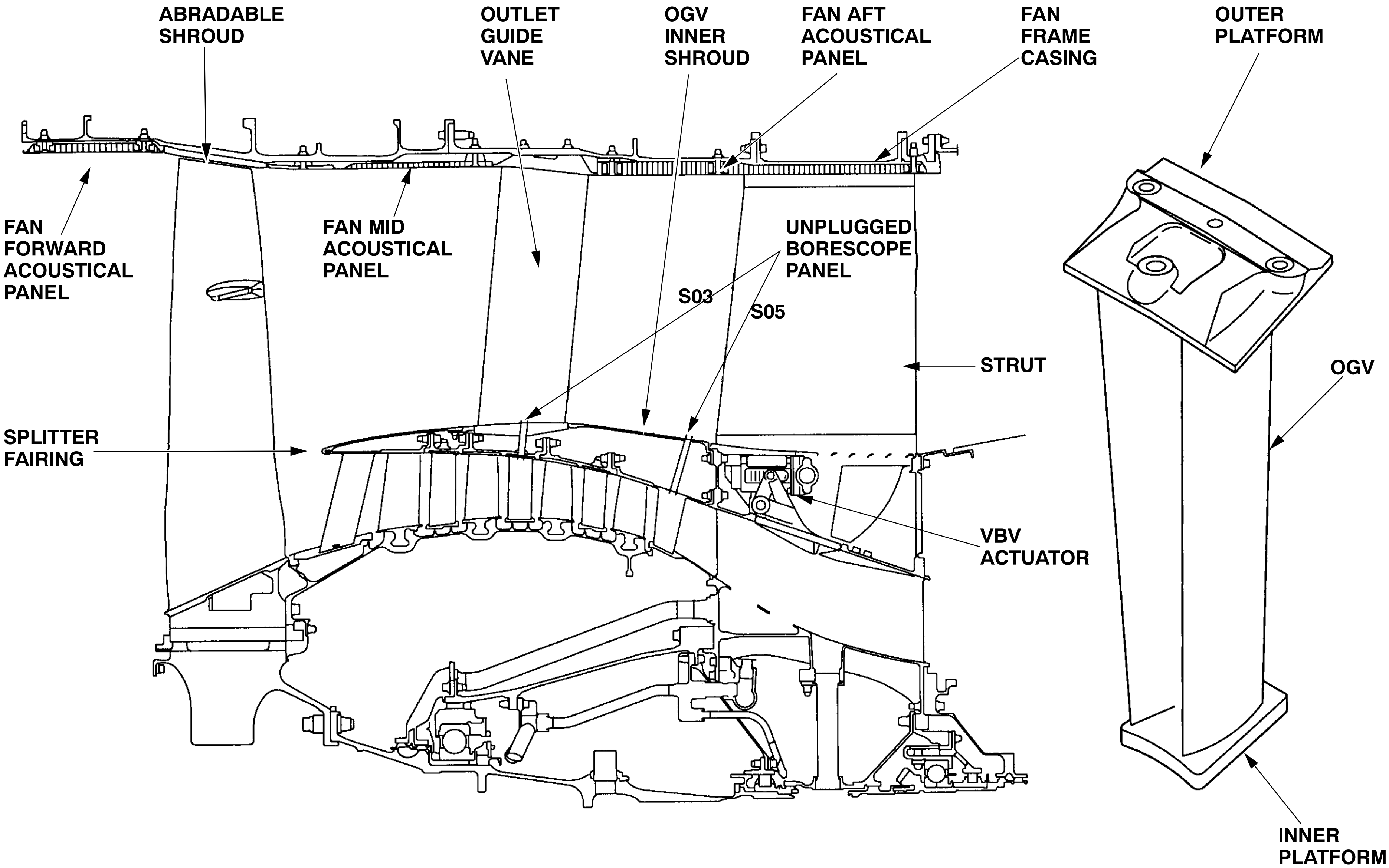


Figure 191 Fan Inlet Case/Fan OGV

72-20 FAN SECTION

FAN BLADE/FRONT AND REAR CONE

Fan Blades

There are 36 titanium alloy, mid-span shrouded, fan blades approximately 23 inches (584,2 mm) long. Each blade has a dovetail base that engages in a dovetail recess on the disk rim. A spacer limits the radial movement of each blade. A retainer lug, machined in the rear end of blade root, engages the forward flange of the booster spool and limits the forward and rearward axial movements.

Spinner Front Cone

The spinner front cone is made of composite material. Its design precludes the need for an engine nose anti-icing system. The front cone is bolted to the rear cone.

Spinner Rear Cone

The spinner rear cone is made of aluminum alloy. Its rear flange is bolted to the fan disk and is part of the fan blades axial retention system. The outer rim of rear flange is provided with tapped holes for trim balance screws. The front flange provides attachment of the spinner front cone.

Fan Disk

The fan disk is a titanium alloy forging. Its inner rear flange provides attachment for the fan shaft and its outer rear flange is bolted to the booster rotor. The outer front flange provides attachment for the spinner rear cone. The disk outer rim has 36 recesses designed for fan blade retention.

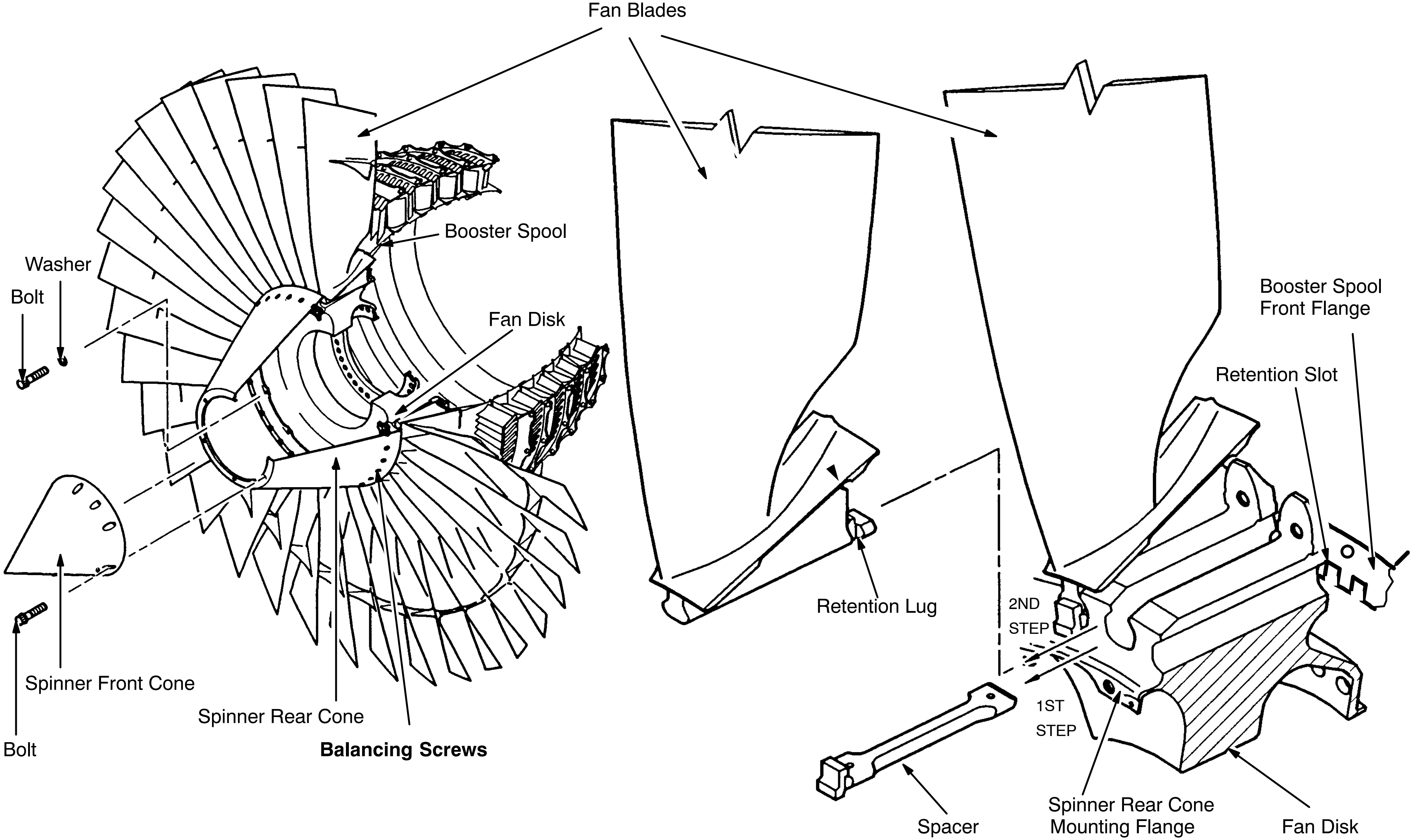


Figure 192 Fan Blade Retention

FAN COMPONENT AND BALANCING DESCRIPTION

FAN DISK

The fan disk outer rim has 36 dovetail recesses for the installation of the fan blades.

The inner front flange has an imprint to identify an offset hole for rear cone installation.

There are also two identification marks engraved on either side of blade recesses No.1 and 5.

FAN BLADES

There are 36 titanium alloy, mid−span shrouded fan blades.

Each blade has a dovetail base that slides into a recess on the fan disk outer rim.

A retainer lug, machined at the rear end of the blade root, engages the forward flange of the booster spool and limits axial movements.

A spacer, installed underneath each blade, limits the radial movement.

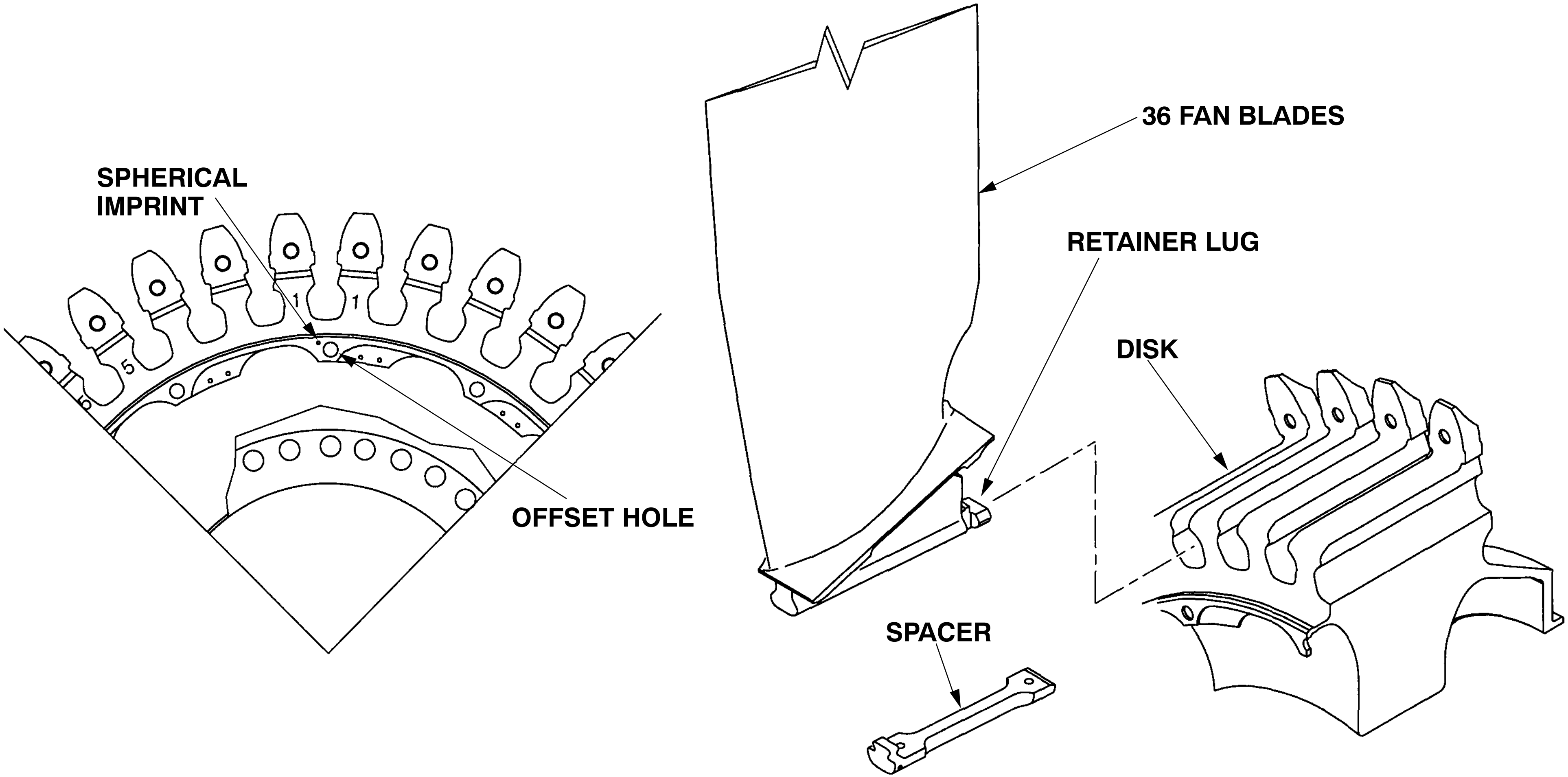


Figure 193 Fan Disk and Blades

FAN BLADES (CONT.)

Each blade has specific indications engraved on the bottom of the root:

- Part number
- Serial number
- Momentum weight
- Manufacturer code

The fan blade root pressure faces are sprayed with an anti-friction plasma coating, and dry molybdenum base film is applied to the blade roots.

The fan blade mid-span shroud contact surfaces are coated with tungsten-carbide.

COLD FAN BALANCING

Engine Fan Trim Balance

Trim balance is a procedure used to reduce the engine vibration level. This procedure must be applied every time the engine vibration level reaches 8.0 mils, which leads to rapid loss of the EGT margin, every time the engine vibration result in significant cabin noise, or after an engine check.

This procedure is known as Cold Trim Balance because it consists in correcting the imbalance on a cold engine without the need for successive ground runs to determine the imbalance to be corrected.

The imbalance is determined using the vibration parameters recorded in flight by the aircraft EVMU**.** This procedure allows the engine vibration level to be maintained continuously, at minimal cost. The same calculation can be performed with the aircraft on the ground, after replacement of fan blades when a static imbalance correction of 400 g.cm or more is necessary.

For imbalance correction calculation, the cold trim balance procedure uses the in-flight recording of the vibration delivered by the engine No.1 and TRF bearing vibration sensors.

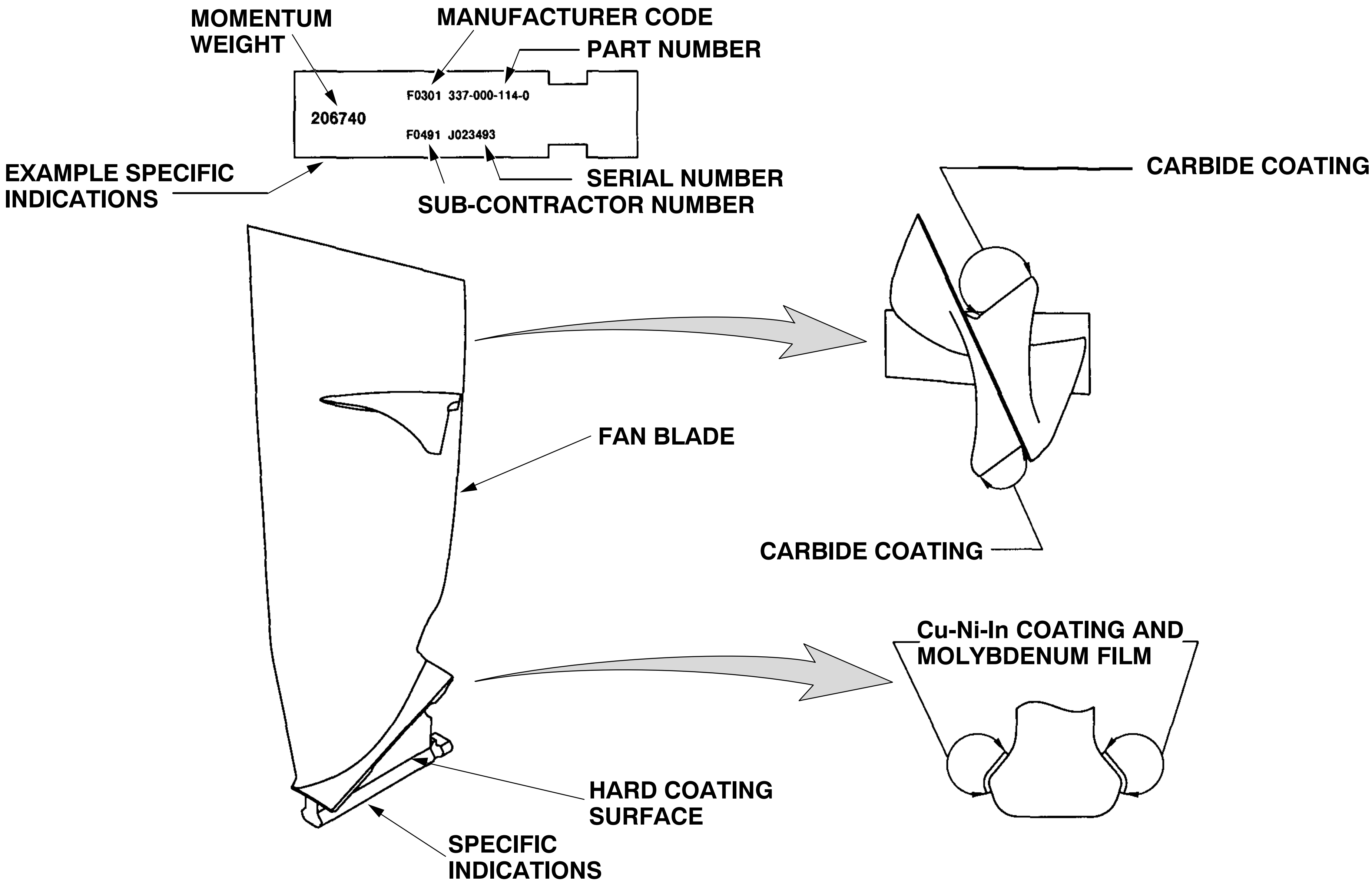


Figure 194 Fan Blade Root

72–30 HP COMPRESSOR SECTION

COMPONENT DESCRIPTION

The major components of the HPC (**H**igh **P**ressure **C**ompressor) are:

- one compressor rotor
- one compressor stator
- one compressor rear frame.

A portion of the fan discharge airflow passes through the booster and compressor. The front of the compressor stator is supported by the fan frame, and the compressor rotor is supported by the No. 3 bearing in the fan frame. The rear of the compressor stator is supported by the combustion case forward flange, and the rear of the compressor rotor is supported by the No. 4 bearing in the turbine rear frame.

Air, taken in through the fan and booster sections passes through successive stages of rotor blades and stator vanes, being compressed as it passes from stage to stage. After passing through the 9 HPC stages, the air is fully compressed.

The inlet guide vanes and the first 3 stages of the stator are variable, and change their angular position as a function of compressor inlet temperature and engine speed. The purpose of this variability is to optimize efficiency and provide improved stall margin.

The HPC (High Pressure Compressor) rotor.

The HPC (**H**igh **P**ressure **C**ompressor) rotor is a 9–stages, high–speed, spool–disk structure.

The HPC rotor consists of 5 major parts:

- front shaft
- stage 1–2 spool
- stage 3 disk
- stage 4–9 spool
- rear CDP (**C**ompressor **D**ischarge **P**ressure) rotating air seal.

Spools are assembled by inertia welding. The front shaft, disk, and spools are joined at a single bolted joint to form a rigid unit. Interfering rabbeted diameters are used for proper positioning of parts providing rotor balance stability.

Front Shaft

The front shaft which is bolted between the stage 1–2 spool and stage 3 disk, is the forward support for the rotor. The shaft is splined and secured to the IGB (**I**nlet **G**ear**b**ox) horizontal bevel gear by a coupling nut. The IGB contains the thrust anti–orbiting bearings for the core engine. This shaft is made of a titanium alloy.

Disk and Spools

The stage 1–2 spool and stage 3 disks are made of titanium alloy forgings and retain the blades in axial slots.The stage 4–9 spool is made of a nickel alloy and retains all blades in circumferential grooves.

The rotor internal temperature is maintained below pressure compressor (booster) discharge air which enters through holes in the front shaft and 5th stage air, provided by the RACSB (**R**otor **A**ctive **C**learance **S**tart **B**leed) valve through the fan frame. Labyrinth seals between the rotor blade stages improve compressor performance.

Blades

Blades in stages 1, 2 and 3 are made of titanium alloy. Blades in stages 4 through 9 are made of nickel alloy. The first 3 stages of blades are secured in the disk and spool axial slots by retaining rings; blades in the stages 4–9 spool are secured in the circumferential grooves by locking lugs. All blades are replaceable without disassembling the rotor.

Rear Seal

The HPC rotor rear rotating (CDP) air seal is a one–piece nickel alloy forged part with abrasive, protective–coated labyrinth seals. The seal is mounted to the aft flange of the stages 4–9 spool by a tight fitting rabbet diameter and is axially clamped by the bolts and nuts securing the forward flange of the high pressure turbine rotor to the compressor.

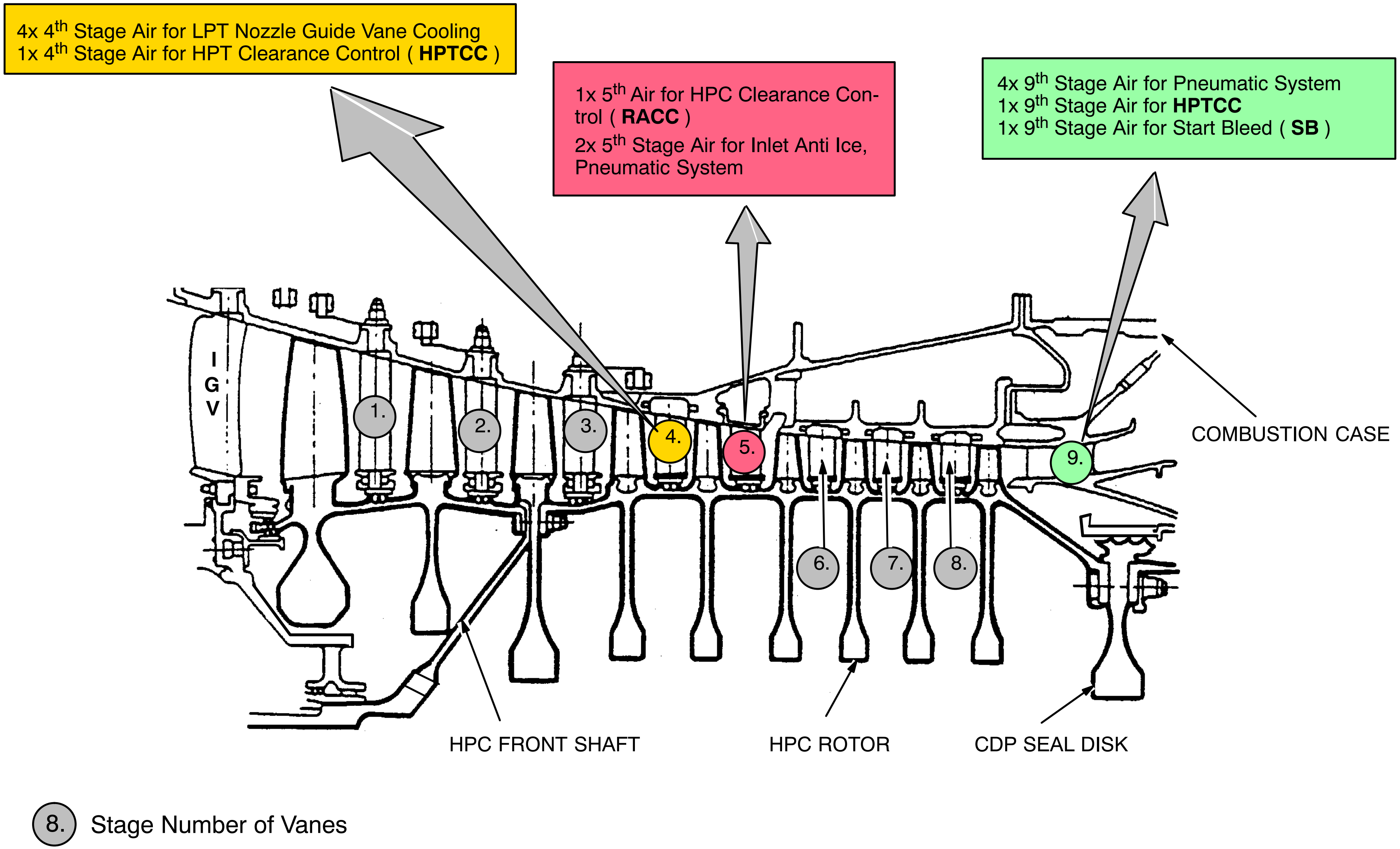


Figure 195 High Pressure Compressor

72−50 TURBINE SECTION

HIGH PRESSURE TURBINE

General

The turbine section provides the necessary power to drive the compressor rotors. It consists of the

- HPT (**H**igh **P**ressure **T**urbine)
- LPT (**L**ow **P**ressure **T**urbine)

HPT (High Pressure Turbine)

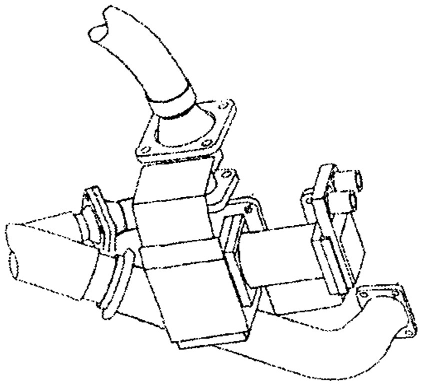
The HPT module is housed in the combustion case and consists of a single stage nozzle that directs the gas flow from the combustion chamber to the HPT rotor blades that drive the HPC rotor.

The LPT stage 1 nozzle is also housed in the combustion case.

Engine cooling

Air from the 4th stage of the HPC is ducted through 4 pipes, to cool down the 1st stage of the LPT and the front cavity.

Air from the 4th and 9th stage of the HPC goes through the HPTCC valve and is ducted through 2 pipes, to cool down the cavity that surrounds the HPT shroud.



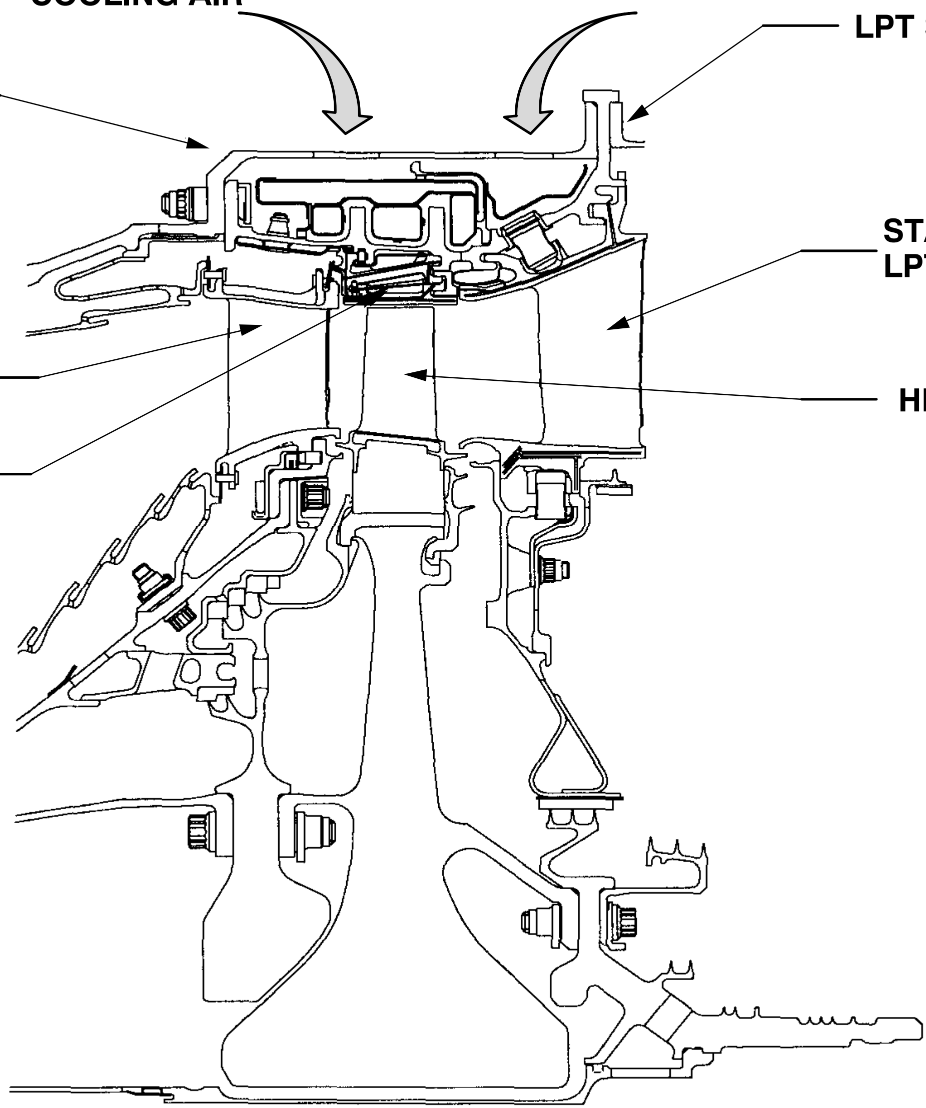


Figure 196 High Pressure Turbine

72−00 DAC GENERAL

ENGINE GENERAL CONCEPT PRESENTATION

The main hardware components are located in the core section of the engine.

CDP (**C**ompressor **D**ischarge **P**ressure) air is delivered to the combustion section which has a Double Annular Combustor (DAC).

Controlled release of the combustion energy is used to drive the turbine rotors. The residual energy is converted into thrust.

The combustion case is a welded structure that encloses the combustion chamber and the following HPT (**H**igh **P**ressure **T**urbine) components:

- CDP seal
- HPT (**H**igh **p**ressure **T**urbine) nozzles
- HPT shroud
- LPT (**L**ow **P**ressure **T**urbine) stage 1 nozzle assembly

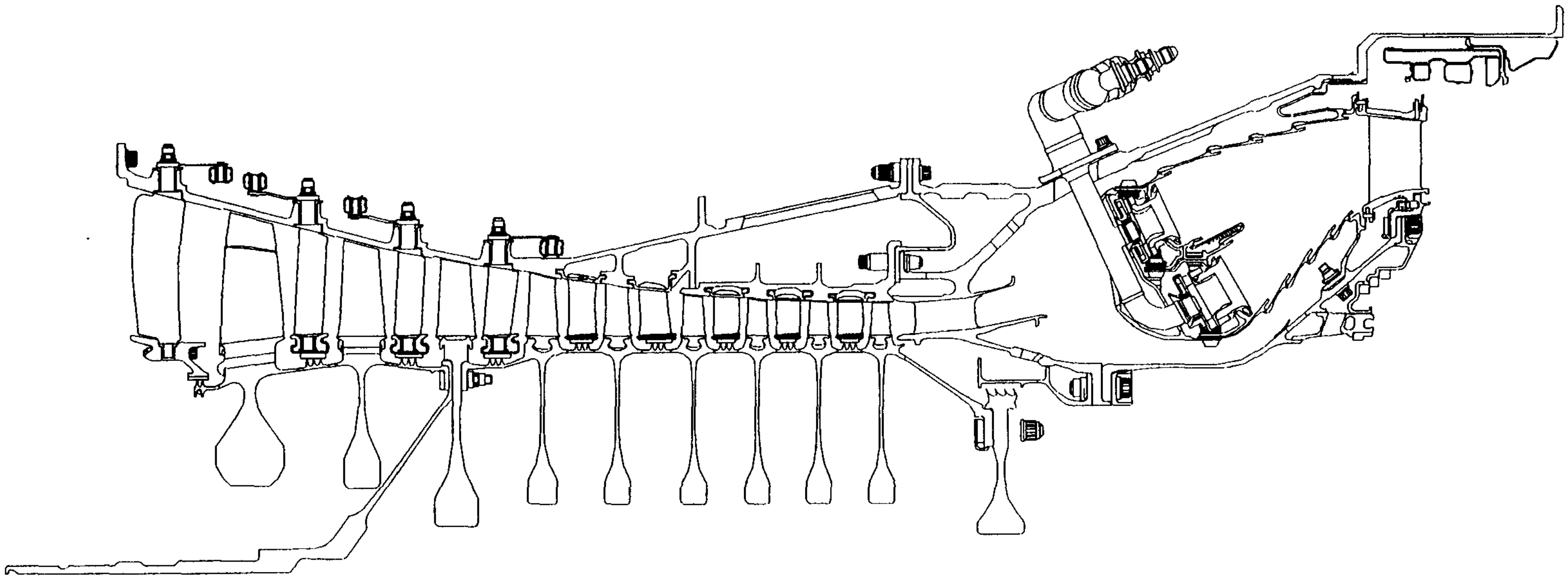


Figure 197 CFM56-5B DAC Core Engine

72−40 COMBUSTION SECTION (DAC)

The fuel/air mixture is ignited in the combustion section which consists of:

- the combustion case
- the combustion chamber

The combustion case provides the structural interface between the High Pressure Compressor section and the Low Pressure Turbine section.

The front face of the combustor is attached to the rear of the compressor module.

Its rear face is bolted onto the LPT module front flange. The rear section of the combustor houses the HPT module.

The −5B Double Annular Combustor contains an outer dome, known as pilot, and an inner dome, known as main.

The case has 20 double−tip fuel nozzle mounting pads and accommodates the following fuel supply manifolds:

- Pilot
- Main 1
- Main 2

Pilot Dome

The pilot dome is the low power region of the combustor and is designed to achieve high combustion efficiency. It minimizes the production of carbon monoxide and unburned hydrocarbons and acts as a pilot source of heat for the main dome.

Main Dome

The main dome is a high velocity/high air flow region and is designed to reduce the reaction temperature and residence time of combustion to minimize soot and nitric oxide formation.

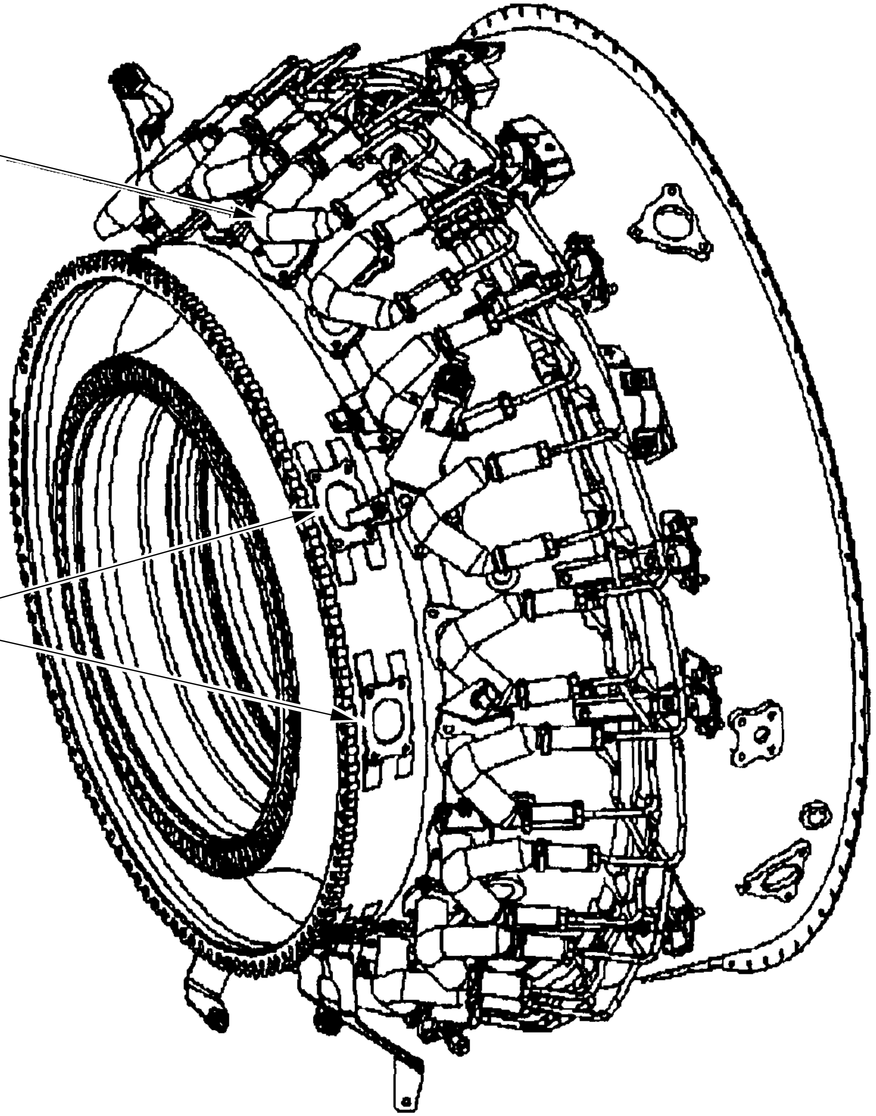


Figure 198 Combustion Case

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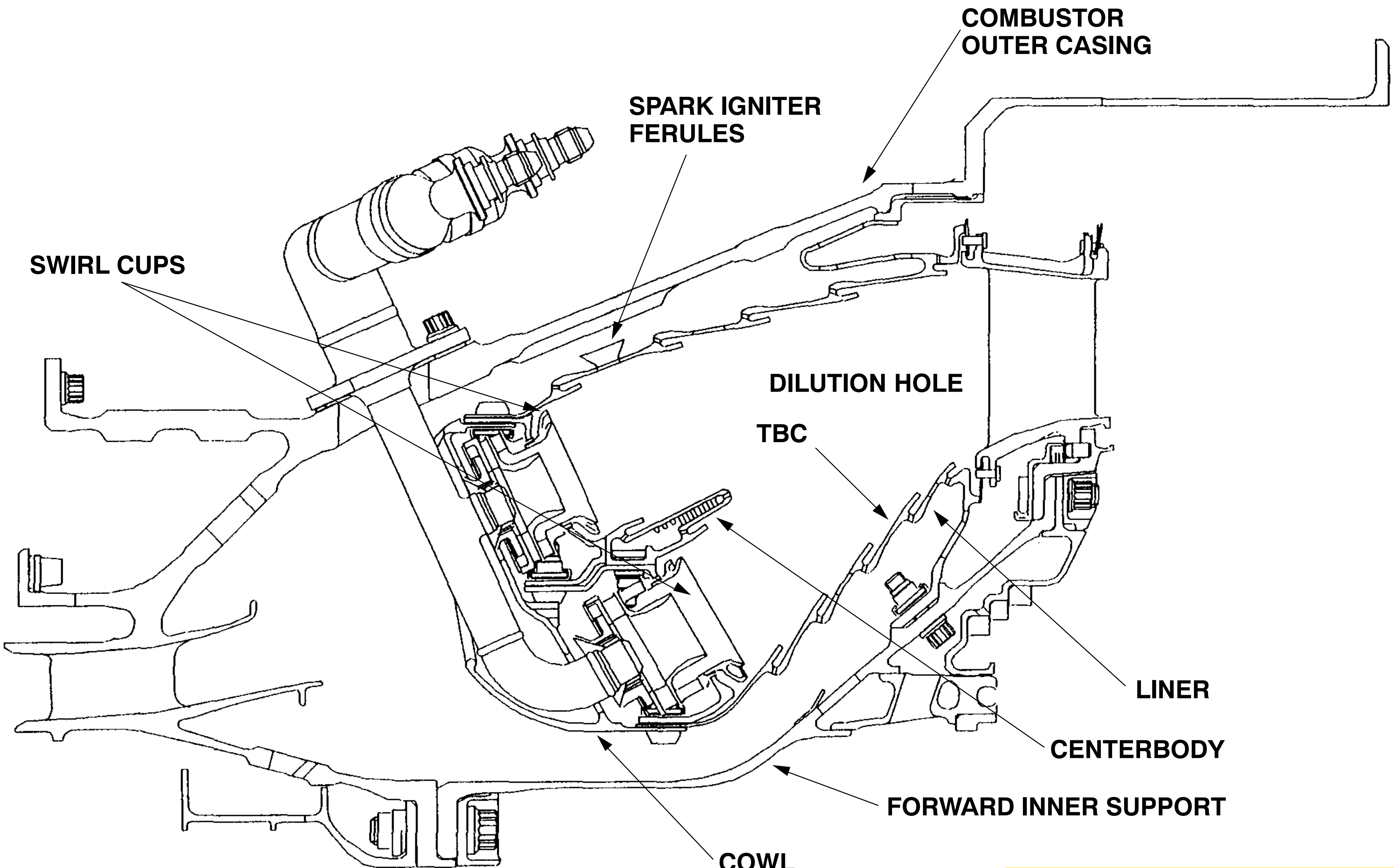


TBC: THERMAL BARRIER COATING

Figure 199 Combustion Chamber (DAC)

72–56 TURBINE FRAME ASSEMBLY

COMPONENT DESCRIPTION

GENERAL

The turbine frame module is the major structural assembly at the rear of the engine. It supports the LPT (**L**ow **P**ressure **T**urbine) rotor rear section and provides for engine rear mounting on the airframe. The turbine frame includes the following major parts:

- turbine frame
- No. 5 bearing support

Turbine Frame

The turbine frame assembly is a nickel–alloy weldment. It is made of a hub and a polygonal outer casing structurally connected by 16 airfoil–shaped struts, approximately tangent to the hub. The outer casing front outer flange bolts to the LPT case rear flange. The outer casing rear outer flange supports the e haust mixer.

At the periphery of the outer casing, there are 3 clevis for aft engine mounting to the aircraft pylon and 2 brackets for handling/lifting purposes. The hub forward side provides support and attachment for:

- the No.5 bearing support (hub inner front flange)
- the oil collector of the aft oil sump assembly (hub outer front flange)

On its aft side, the hub provides support and attachment for:

- the flange assembly
- supports for the flame arrestor
- the center body, or exhaust plug

From its front to aft sides, the hub provides passage for 8 tubular conduits. These conduits interconnect the rear rotating air/oil seals enclosure with the center body enclosure. They vent the oil vapors and drain the oil leakage (past the seals) into the center body enclosure from which they discharge outboard.

No. 5 Bearing Support

The No.5 bearing support is made of steel alloy. Its outer flange mounts to the turbine frame hub inner front flange. The front bore of the No.5 bearing support contains the No.5 bearing outer race and a concentricity–adjusting sleeve. The rear face of the support carries the oil inlet cover which supports the oil supply tube for the No.4 and 5 bearings, and provides for pressurization of the dual air/oil seal installed at the rear end of the center vent tube.

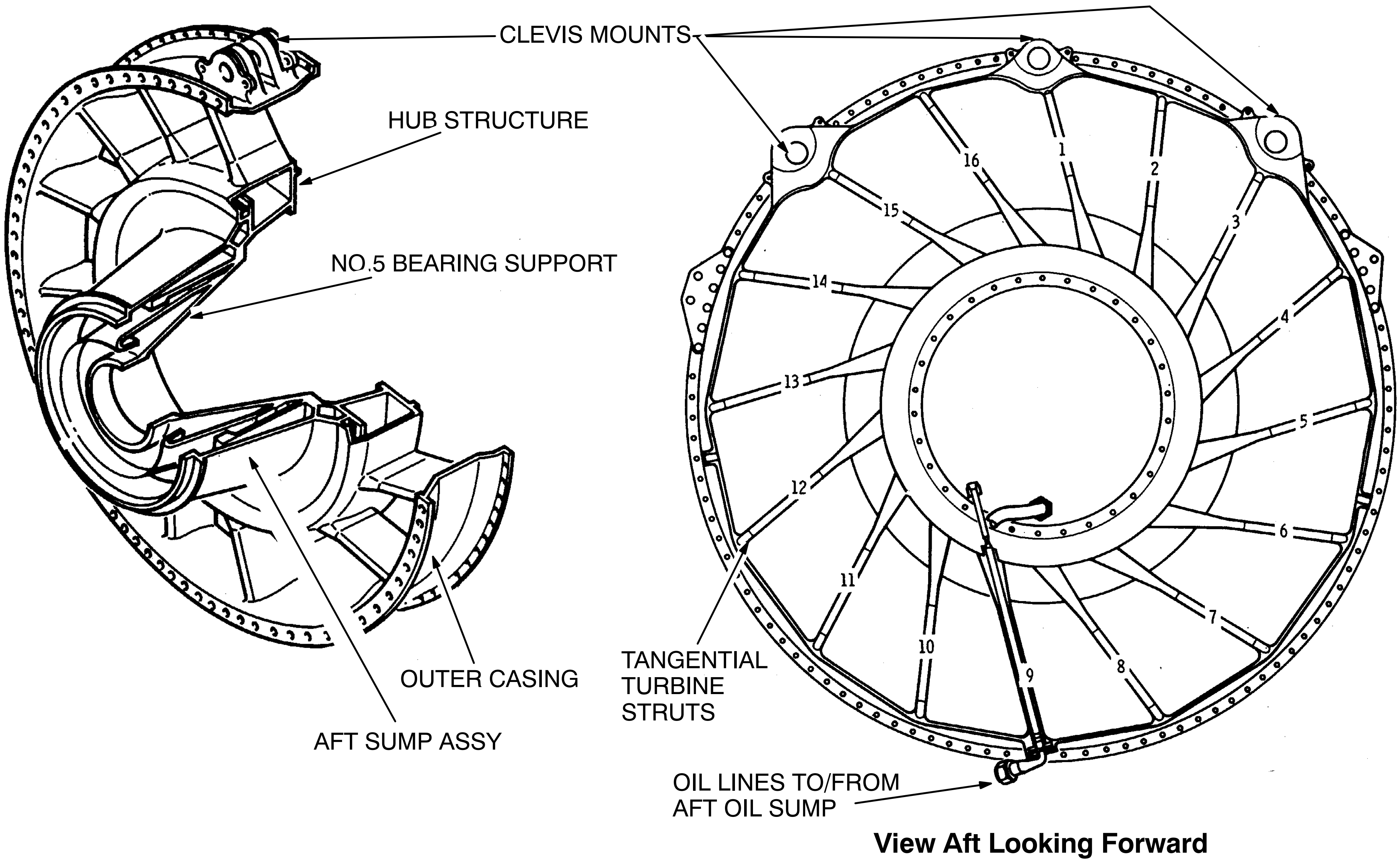


Figure 200 Turbine Frame Assembly

ATA 79 OIL

79-00 GENERAL

OIL SYSTEM PRESENTATION CFM 56-5A REVIEW

General Description

- a Supply Circuit
- a Scavenge Circuit
- a Vent Circuit

It Lubricates and cools the Bearings of the Forward and Aft Sumps.

It also lubricates Bearings and Gears in the Transfer and Accessory Gear Boxes.

The Major Components of the Oil System are:

- The Oil Tank
- The Lubrication Unit
- The Servo Fuel Heater
- The Main Fuel Oil Heat Exchangers.

Indicating and Monitoring is provided by the Detectors and Sensors shown on the Schematic.

Oil Supply Circuit

The Oil from the Tank passes through the Supply Pump and Supply Filter to lubricate the forward and aft Sumps, and also the Accessorys and Gearboxes.

On the Oil Supply Line a Visual Filter Clogging Indicator, an Oil Temperatur Sensor, an Oil Low Pressure Switch and an Oil Pressure Transmitter are provided for Indication and Monitoring.
Also an Oil Quantity Transmitter is provided on the Oil Tank.
Note the Installation of the ECU Oil Temperatur Sensor for the Fuel Return Valve.

Oil Scavenge Circuit

The Oil from Bearings, Transfer Gearbox and Accessory Gearbox returns to the Tank by means of four Scavenge Pumps protected upstream by Strainers and Chip Detectors.

To keep Oil Temperatur within Limits, the Oil is cooled through the Servo Fuel Heater and the Fuel/Oil Heat Exchanger.

In Case of Scavenge Filter Clogging, an Oil Differential Pressure (Delta P) Switch signals it to the Cockpit and its Clogging Indicator shows it on the Engine system page with a message on E/WD accompanied by a single chime

Oil Vent Circuit

Some Air entrained in the Scavenge Oil is separated in the Tank by a Dearator and is vented to the Forward Sump through the Transfer Gearbox and Radial Drive Shaft.

The Sumps are vented Overboard through the Low Pressure Turbine Shaft to prevet Overpressure in the Sump.

Air entrapped in the Scavenge Oil Pressurizes the Tank and provides adequate Oil Pressure to the Supply Pump.

System Monitoring and Limitations

The operation of the engine oil system may be monitored by the following flight deck indications.

- engine oil pressure
- engine oil temperature
  - MIN.PRIOR EXCEEDING IDLE: -10°C
  - MAX CONTINIOUS: 140°C
  - MAX TRANSIENT: 155°C
- oil tank contents 24 US quarts

In addition warnings may be given for the following non normal conditions:

- low oil pressure
  - RED LINE LIMIT: 13 PSI
- high oil pressure
  - ADVISORY: 90 PSI
- scavenge filter clogged.

CFM 56 -5A REVIEW

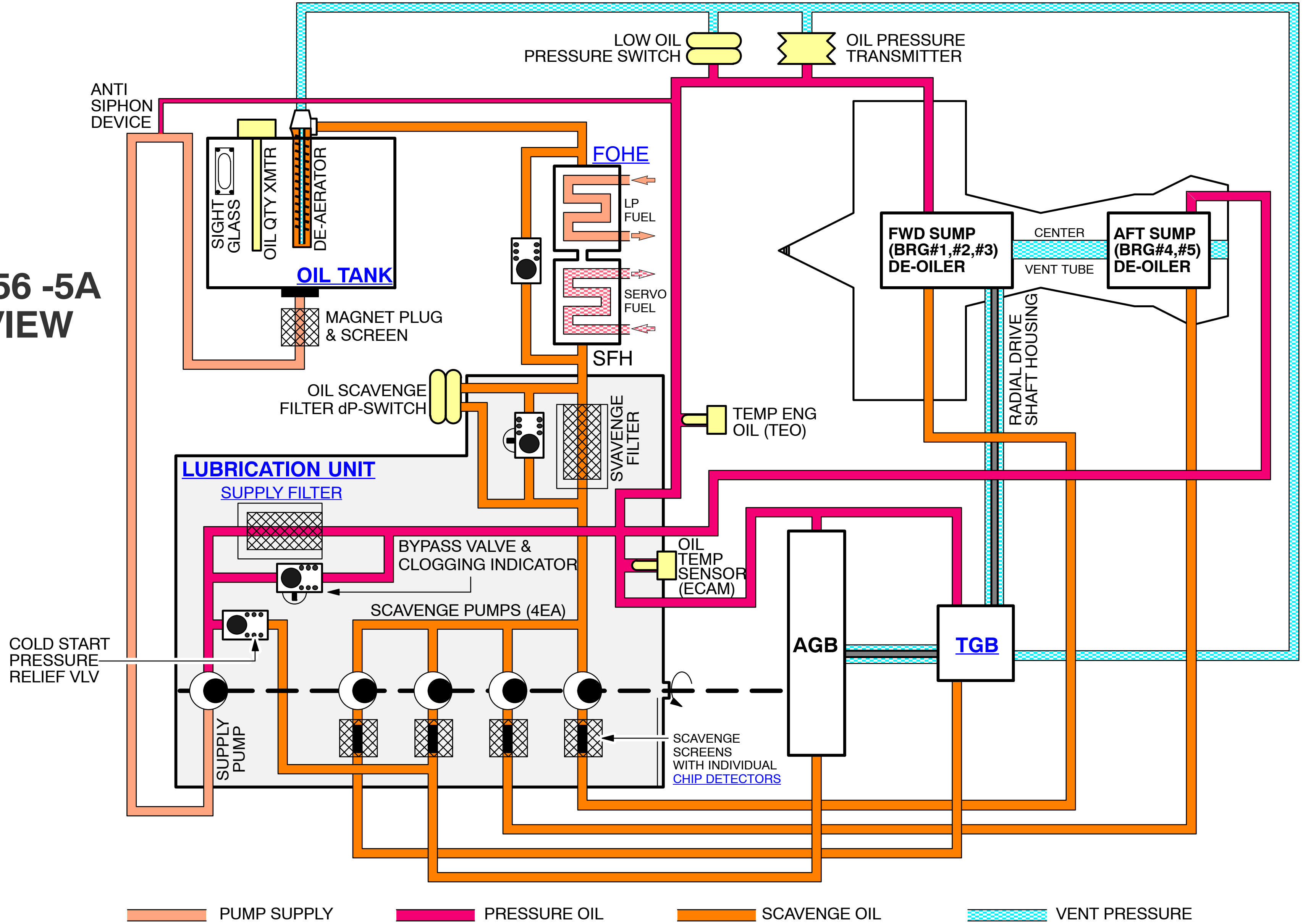


Figure 201 Oil System Schematic

LUBRICATION UNIT COMPONENT DESCRIPTION (REVIEW)

General

The lubrication unit provides oil under the required pressure for lubrication and for scavenge of the oil after lubrication and circulation to the oil/fuel heat exchanger and oil tank. The lubrication unit its mounted on the AGB front face.

Description

The lubrication unit has a single housing containing the following items:

- Five positive displacement pumps (Gear Type, one oil supply and 4 scavenge pumps).
- Six filters (one oil supply filter, 4 chip detectors and scavenge pump filters).
- One relief valve (305 psi, on oil supply pump discharge side).
- Two clogging indicators (one for the oil supply filter and one for the main scavenge filter).
- Two bypass valves (one for the oil supply filter and one for the main scavenge filter).

Anti Siphon System

The supply lines from the oil tank to supply the pump has an antisiphon device to prevent the drainage of the lube tank into the gearboxes and sumps when the engine is shut down for extended periods.

Lube Pump supply Filter

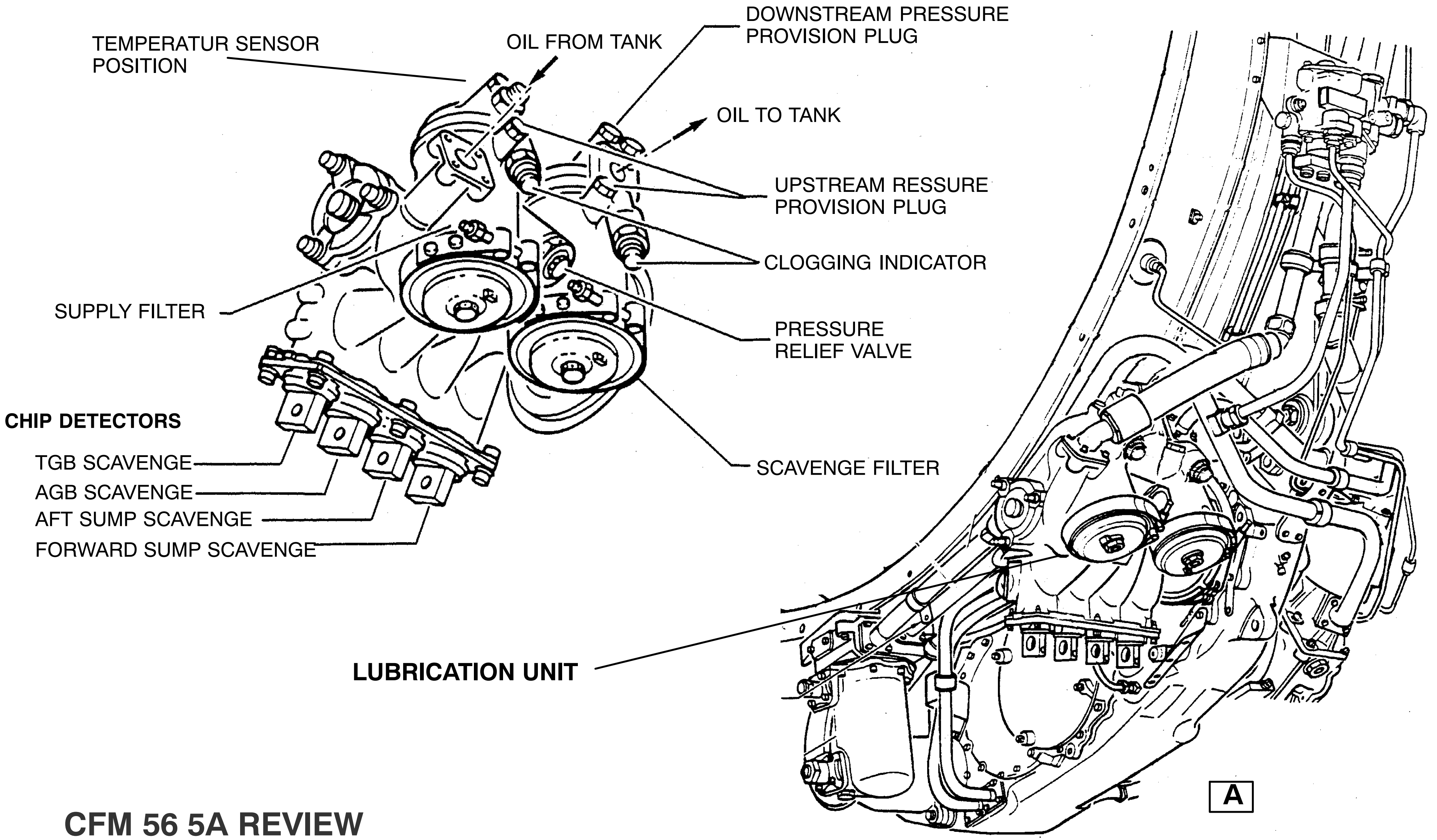
Downstream of the supply pump, the oil flows through the supply filter assembly. The filter has the following components.

- One filter (15 microns)
- One clogging indicator subjected to the upstream and downstream pressures of the supply filter.The indicator has a red warning indicator and is rearmed manually (2 bars to 2.3 bars) (29 PSID to 33 PSID).
- One bypass valve which opens if the supply filter clogs (2.50 bars to 2.70 bars) (36 PSID to 39 PSID).
- Two capped provisions for a pressure gage upstream of the filter,and a temperature sensor.

Scavenge Filter

The flows from the 4 scavenge pumps are mixed together at the scavenge common filter inlet. This filter assembly consists of the following:

- One 25 micron filter
- One clogging indicator, similar to the one on the supply filter (2 bars to 2.3 bars) (29 PSID to 33 PSID).
- An upstream and a downstream provision for measurement of filter pressure loss as a function of clogging.Filter clogging is indicated on the ECAM system.
- One bypass valve which opens if the filter clogs.(2.5 bars to 2.7 bars) (36 PSID to 39PSID)



CFM 56 5A REVIEW

Figure 202 Lubrication Unit

CFM56-5B OIL SYSTEM FUNCTIONAL DESCRIPTION

General Description

The engine oil system includes:

- a supply circuit,
- a scavenge circuit,
- a vent circuit.

It lubricates and cools the bearings of the forward and aft sumps.

It also lubricates bearings and gears in the transfer and accessory gear boxes.

The major components of the oil system are : the oil tank, the lubrication unit, the servo fuel heater and the fuel/oil heat exchangers.

Indicating and monitoring is provided by the detectors and sensors shown on the schematic.

REFER TO A3 PAGE

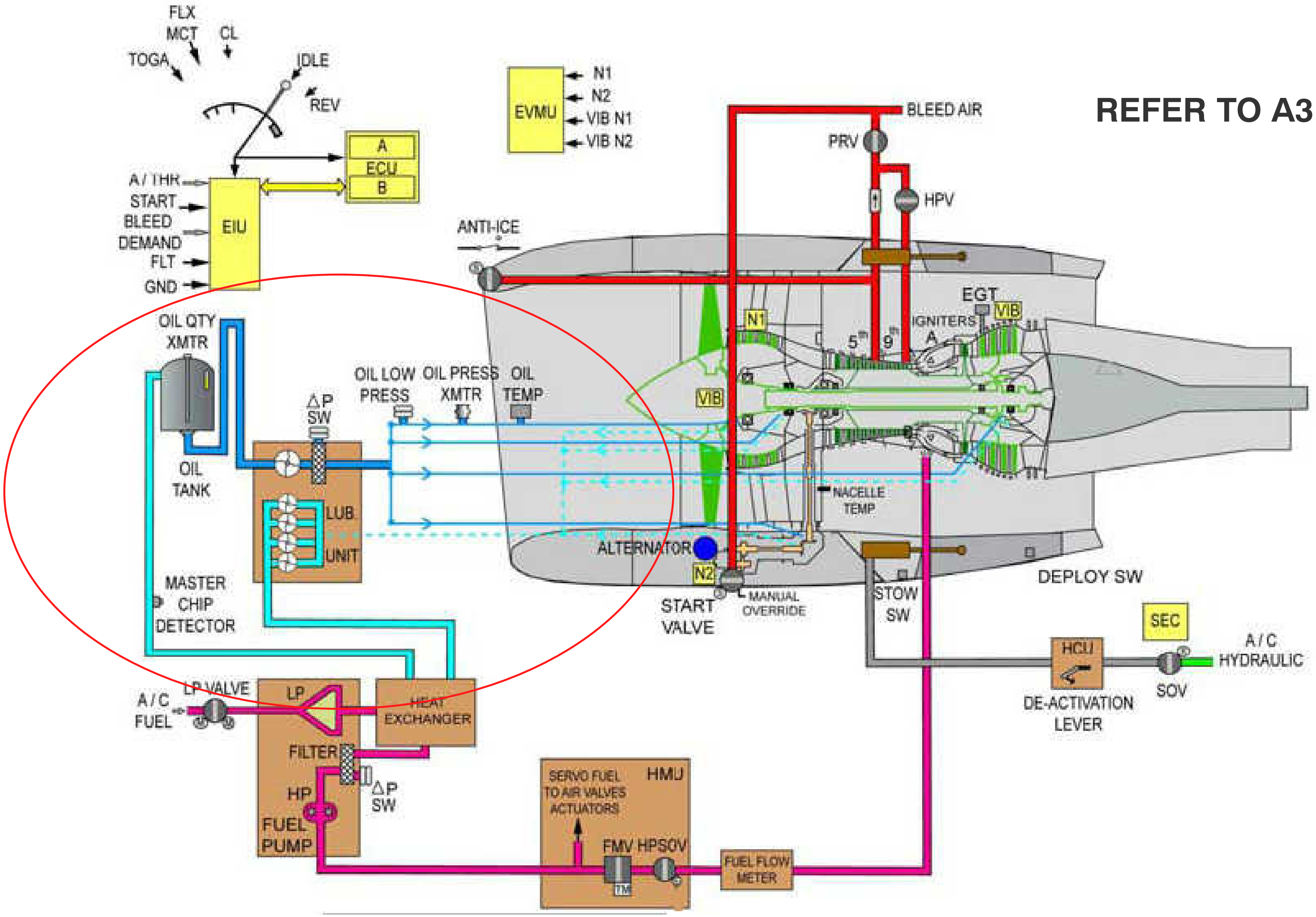


Figure 203 Oil System

CFM56-5B OIL SYSTEM OPERATION

Oil Supply

The oil from the tank flows through the supply pump and the main filter, or through the back up filter in case of main filter clogging.

It then flows to the forward and aft sumps, and to the accessory and transfer gearboxes.

The pump delivery pressure is not controlled, but the oil output flow is, by design, always in excess of the lubrication requirements.

A pressure relief valve bypasses part of the output flow to protect the supply pump against abnormal output pressure build-up.

If the main filter becomes clogged, a bypass valve opens and the oil flows through the backup filter.

A clogging switch sends a signal to the Engine Interface Unit (EIU) and a clogging indicator pops out on the filter housing.

The anti-siphon device prevents oil from draining by gravity from the tank through the pump into the gearbox after engine shutdown. It uses air from the forward sump.

Oil Scavange

The oil scavenge from the forward and aft sumps, and the transfer and accessory gearboxes is sucked by four scavenge pumps.

Each pump is protected by a strainer and a electrical **M**aster **M**agnetic **C**hip **D**etector.

The scavenge oil then flows through a master chip detector and a scavenge filter screen (inside the servo fuel heater), then it is cooled through the servo fuel heater and the fuel/oil heat exchanger before returning to the oil tank.

Oil Vent

The air mixed with the scavenge oil is separated in the tank by a deaerator and is vented to the forward sump through the transfer gearbox and radial drive shaft.

The sumps are connected together by the center vent tube, which vents them to the outside air by the engine exhaust plug, through a flame arrestor.

System Monitoring and Limitations

The operation of the engine oil system may be monitored by the following flight deck indications.

- engine oil pressure
- engine oil temperature
  - MIN.PRIOR EXCEEDING IDLE**:** -10°C
  - MAX CONTINIOUS: 140°C
  - MAX TRANSIENT: 155°C
- oil tank contents 24 US quarts

In addition warnings may be given for the following non normal conditions:

- low oil pressure
  - RED LINE LIMIT: 13 PSI
- high oil pressure
  - ADVISORY: 90 PSI
- filter clogged.

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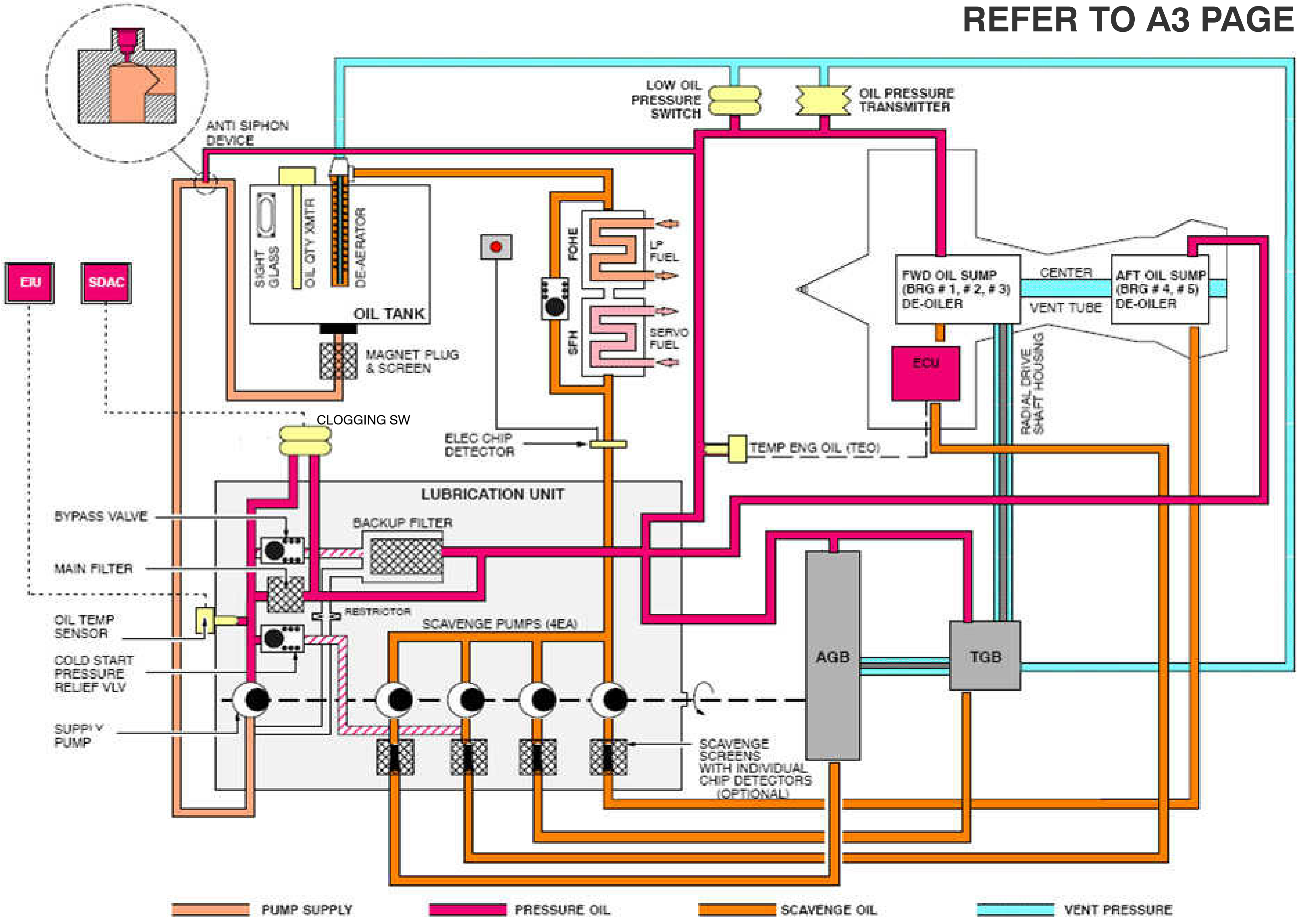


Figure 204 CFM 56-5B Oil System

LUBRICATION UNIT COMPONENT DESCRIPTION

The lubrication unit has two purposes

- it pressurizes and filters the supply oil for lubrication of the engine bearings and gears
- it pumps in scavenge oil to return it to the tank.

It is installed on the left hand side of the AGB front face.

Externally, the lubrication unit has:

- a suction port (from the oil tank),
- four scavenge ports (aft & fwd sumps, TGB, AGB),
- four scavenge screen plugs,
- an oil out port (to master chip detector),
- a main oil supply filter,
- a back-up filter,
- pads for the oil temperature sensor and the oil differential pressure switch.

Internally, it has 5 pumps driven by the AGB, through a single shaft. The lube unit is lubricated with supply pump outlet oil, which flows within the drive shaft.

The AGB mounting pad has no carbon seal and the lube unit has an 0-ring for sealing purposes.

NOTE: Individual Chip Detectors are used for Trouble Shooting!

MAIN SUPPLY AND BACKUP FILTER

Description and Operation

In the supply circuit, downstream from the pressure pump, oil flows through the supply system which includes, first, the main oil supply filter.

A sensor, installed in between the upstream and downstream pressures of the supply filter, senses any rise in differential pressure due to filter clogging.

If the filter clogs, an electrical signal is sent to the aircraft systems for cockpit indication.

A by-pass valve, installed in parallel with the filter, opens when the differential pressure across the valve is greater than the spring load.

The oil then flows through the back-up filter and goes to the pump outlet.

The back-up filter is a metallic, washable filter.

During normal operation, the oil flow, tapped at the main supply filter outlet, washes the back-up filter and goes back to the supply pump inlet, through a restrictor.

The main filter is discardable and secured on the lube unit cover by a drain plug.

To prevent the filter element from rotating when torquing the drain plug, a pin installed on the filter element engages between two ribs cast in the lube unit cover.

Description

Downstream of the supply pump, the oil flows through the supply filter assembly.

This filter assembly comprises:

- one filter
- one clogging indicator transmitter subjected to the upstream and down stream pressures of the supply filter
- one bypass valve which opens if the supply filter clogs
- one back up filter operating if the supply filter clogs
- two capped provisions for a pressure gage upstream of the filter, and a temperature sensor.

Downstream of supply filter, the oil flows through three outlets to the forward sump, aft sump and the AGB /TGB.

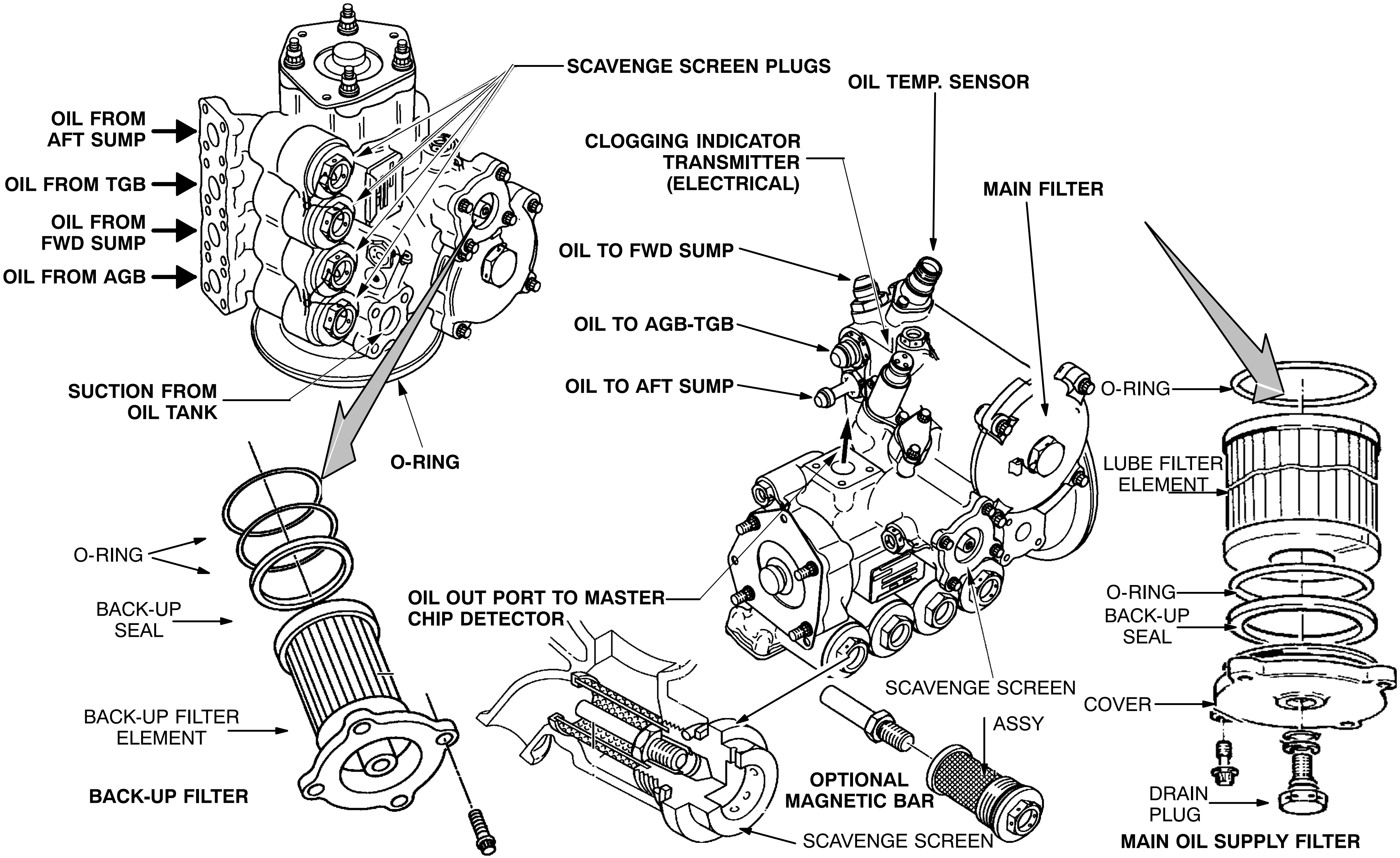


Figure 205 Lubrication Unit Interface

MASTER CHIP DETECTOR PRESENTATION

The MCD (**M**aster **C**hip **D**etector) collects magnetic particles suspended in the oil that flows from the common outlet of the four scavenge pumps, by means of two magnets on a probe immersed in the oil flow.

It is installed on the lubrication unit and is connected to an oil contamination pop−out indicator, through the DPM (**D**ebris **P**article **M**onitoring) wiring harness.

The probe is locked in position through a bayonet system.

When a sufficient amount of particles are caught, the gap between the 2 magnets is bridged and the resistance between them drops. This electrical signal is then sent to the contamination pop−out indicator.

The MCD assembly consists of :

- a housing which has two flanges for attachment.
- a check valve, built in the housing, that prevents oil spillage when the probe is removed and also provides a passage for the oil flow, in case of chip detector disengagement.
- a hand removable probe, which has a back−up seal, an 0−ring seal, and two magnets.
- a two−wire, shielded electrical cable and an interface connector.

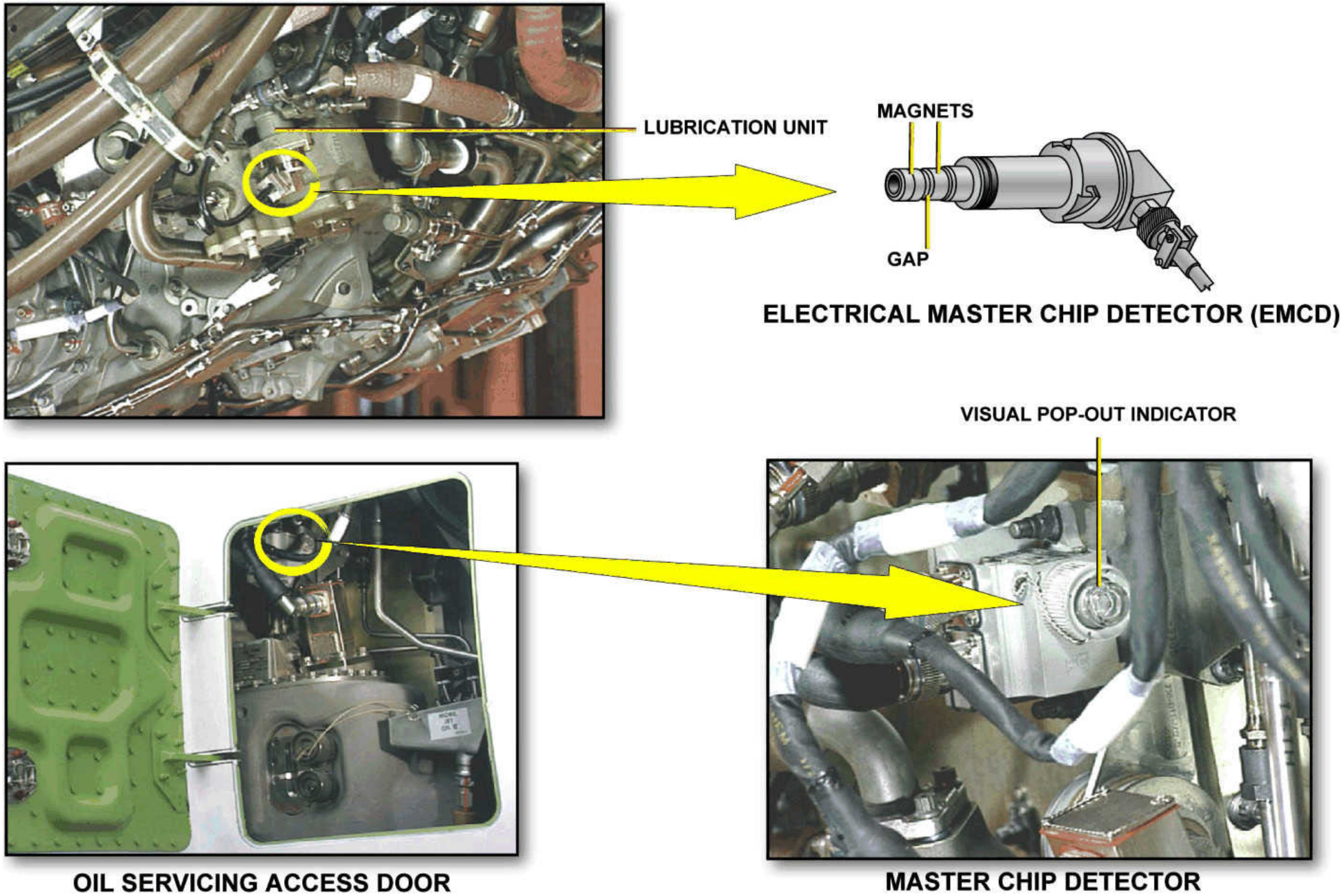


Figure 206 Master Chip Detector

MAGNETIC CONTAMINATION INDICATOR PRESENTATION

The magnetic contamination indicator works in conjunction with the MCD and its purpose is to provide maintenance personnel with a visual indication of oil circuit contamination.

The indicator is an electro−mechanical device, located on the right hand side of the downstream fan case, just above the oil tank.

When magnetic contamination in the oil occurs, an electronic circuit in the indicator detects a drop in resistance between the two magnets on the MCD probe.

The electronic circuit then energizes a solenoid which triggers a red pop−out button, thus providing a visual indication.

After maintenance action, the pop−out button must be manually reset.

It has 2 electrical connectors

- One for the wiring harness connected to the MCD
- One for the harness connecting the indicator to the EIU.

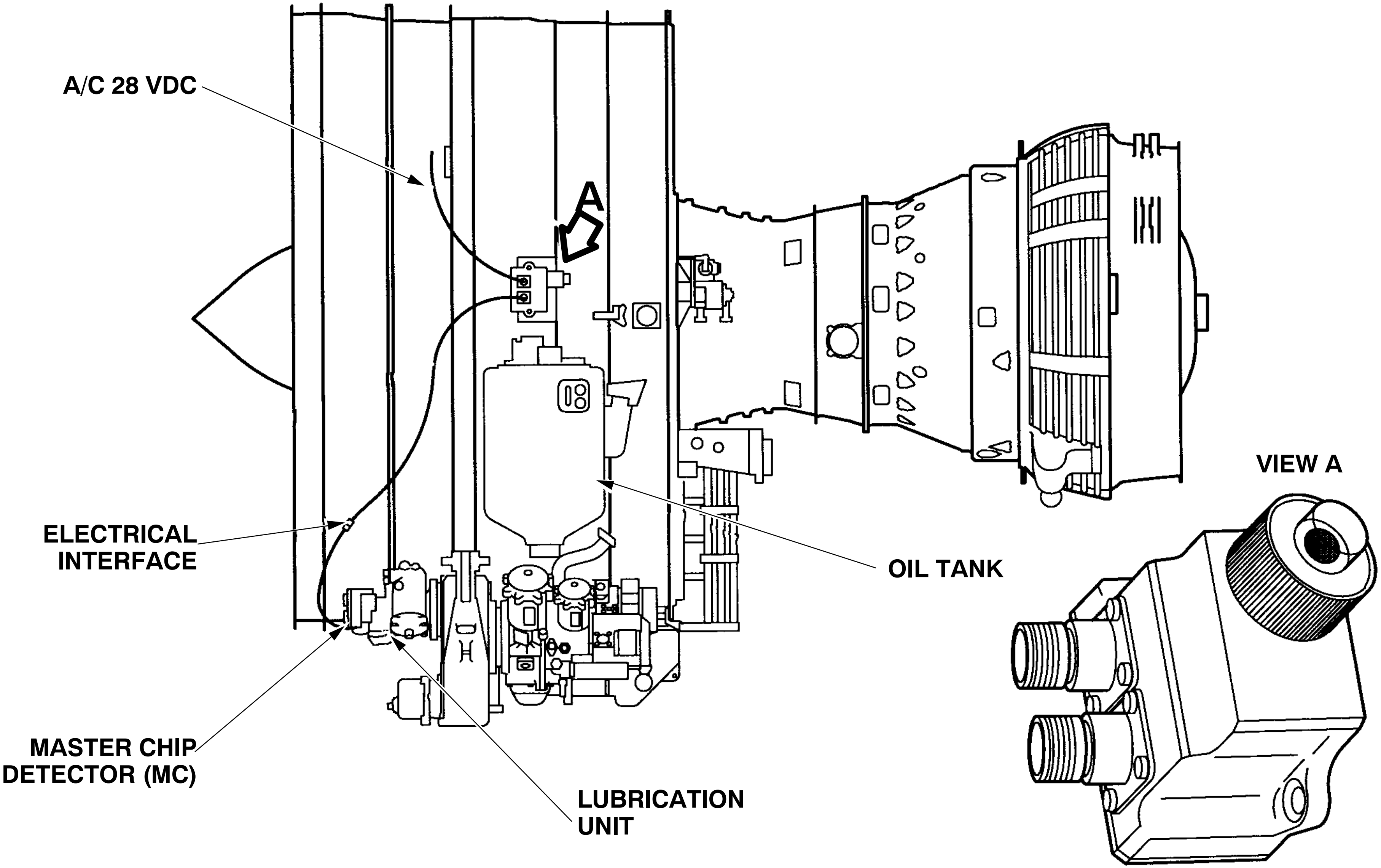


Figure 207 Oil Contamination Pop-Out Indicator

79–30 INDICATING

COMPONENTS DESCRIPTION

OIL TEMPERATURE SENSOR

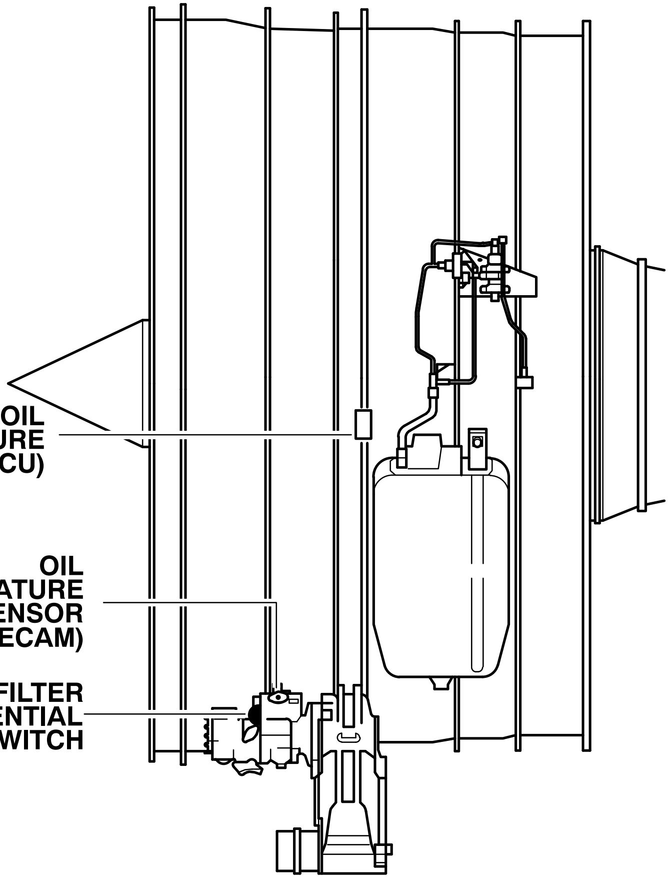
The oil temperature sensor is located on the oil pressure filter downstream of the pressure pump.The oil temperature is sensed by a dual resistor unit.

OIL FILTER DIFFERENTIAL PRESSURE SWITCH

The oil differential pressure switch is located on the engine close to the main filter.

Actuation of the differential pressure switch is at:

25.5 plus or minus 1 PSID increasing pressure 22 PSID decreasing pressure.



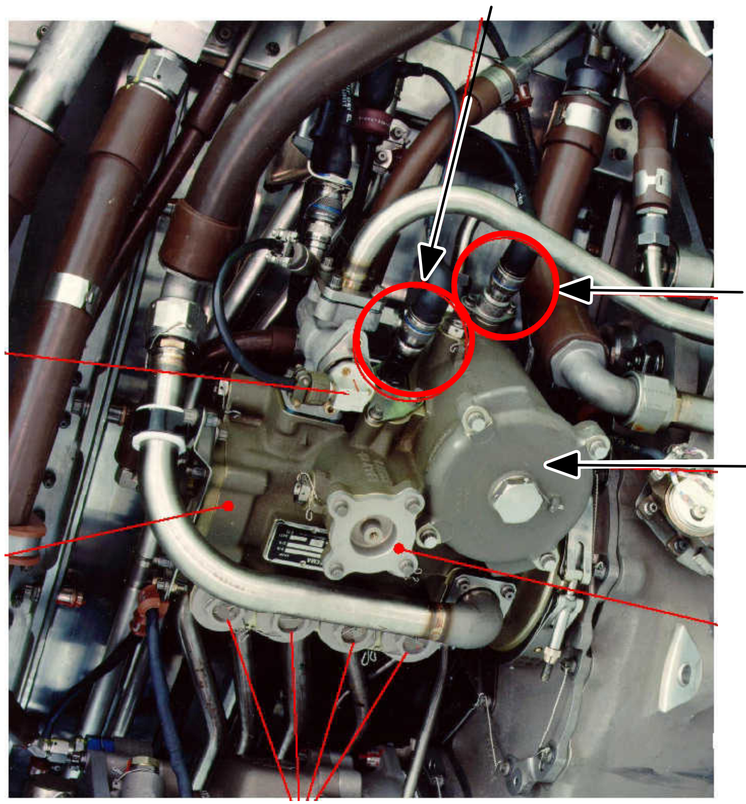


Figure 208 Oil Temp Sensor & dP-Switch Location

OIL FILTER CLOG
CLOG appears in amber if there is excessive pressure loss across the main oil filter.

OIL TEMPERATURE
These numbers are normally green.
They pulse above 140° C (increasing) or 135° C (decreasing).
They turn amber and a warning appears on ECAM if the temperature exceeds:
- 140° C for more than 15 minutes, or
- 155° C without delay.

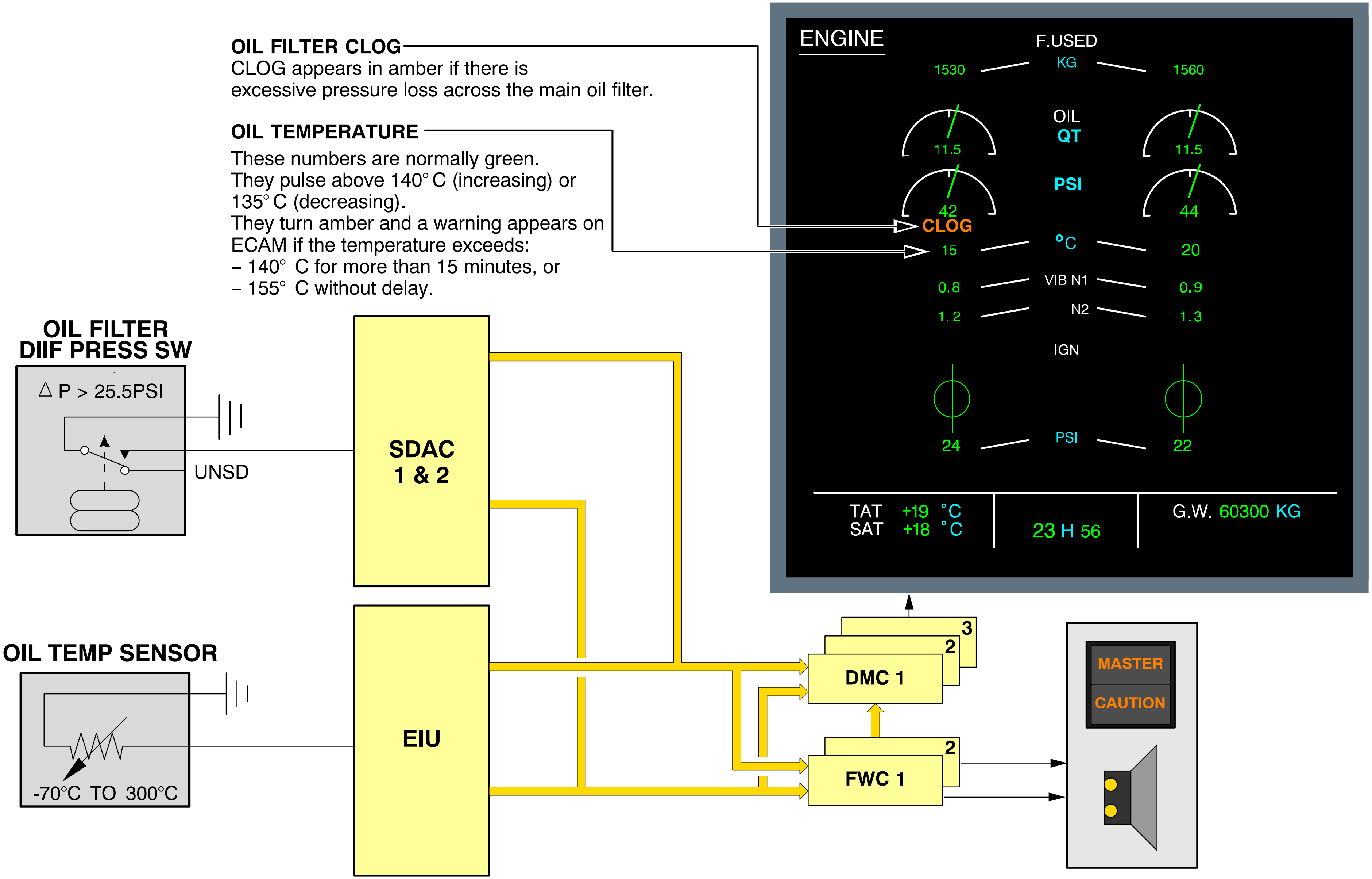


Figure 209 Oil Temp and -dP Indication

73−20 CONTROLLING

FADEC COMPONENTS DESCRIPTION

Front Panel Electrical Connectors

There are 15 threaded electrical connectors located on the front panel, identified through numbers 11 to J15 marked on the panel.

Each connector features a unique key pattern which only accepts the correct corresponding cable plug.

All engine input and command output signals are routed to and from channels A and B, through separate cables and connectors.

Engine Rating/Identification Plug

The engine rating/identification plug provides the ECU with engine configuration information for proper engine operation.

It is plugged into connector J 14 and attached to the fan case by a metal strap. It remains with the engine even after ECU replacement.

The plug includes a coding circuit, equipped with pushpull links which either ensure, or prohibit connections between different plug connector pins.

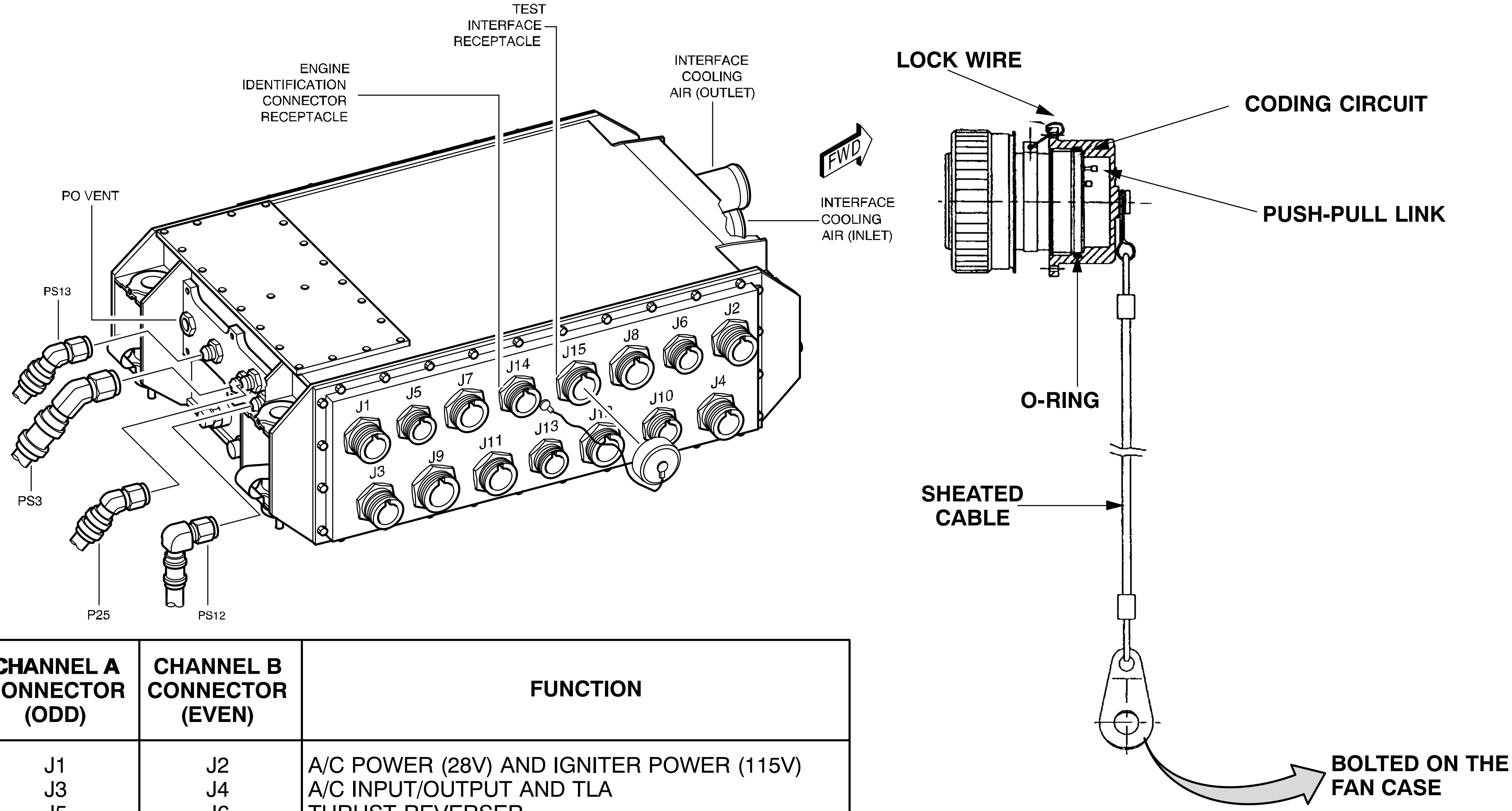
The push−pull links consist of switch mechanisms located between 2 contacts and can be manually opened, or closed, according to customer requests.

They include:

- 5B and 5B/P differentiation
- engine type (SAC or DAC)
- an optional PMUX engine condition monitoring kit
- optional full EGT monitoring
- tool, which enables the engine serial number to be loaded into the ECU's NVM (**N**on−**V**olatile **M**emory)
- N1 trim level, to correct thrust differences between engines operating at the same N1 speed

The ECU stores schedules in its NVM, for all available engine configurations. During initialization, it reads the plug and selects a specific schedule.

In the case of a missing, or invalid ID plug, the ECU uses the value stored in the NVM for the previous plug configuration.



CHANNEL A CONNECTOR (ODD)	CHANNEL B CONNECTOR (EVEN)	FUNCTION
J1	J2	A/C POWER (28V) AND IGNITER POWER (115V)
J3	J4	A/C INPUT/OUTPUT AND TLA
J5	J6	THRUST REVERSER
J7	J8	SOLENOIDS, TORQUE MOTORS, RESOVLERS, N2
J9	J10	ALTERNATOR, SAV, N1 AND T12
J11	J12	LVDT'S, RVDT'S, T25, B25 POSITION SWITCH
SHARED	J14	ENGINE IDENTIFICATION PLUG
J13	SHARED	WF METER, THERMOCOUPLES
J15	SHARED	TEST INTERFACE

Figure 210 FADEC Electrical Connectors

MAINTENANCE TASKS PRESENTATION

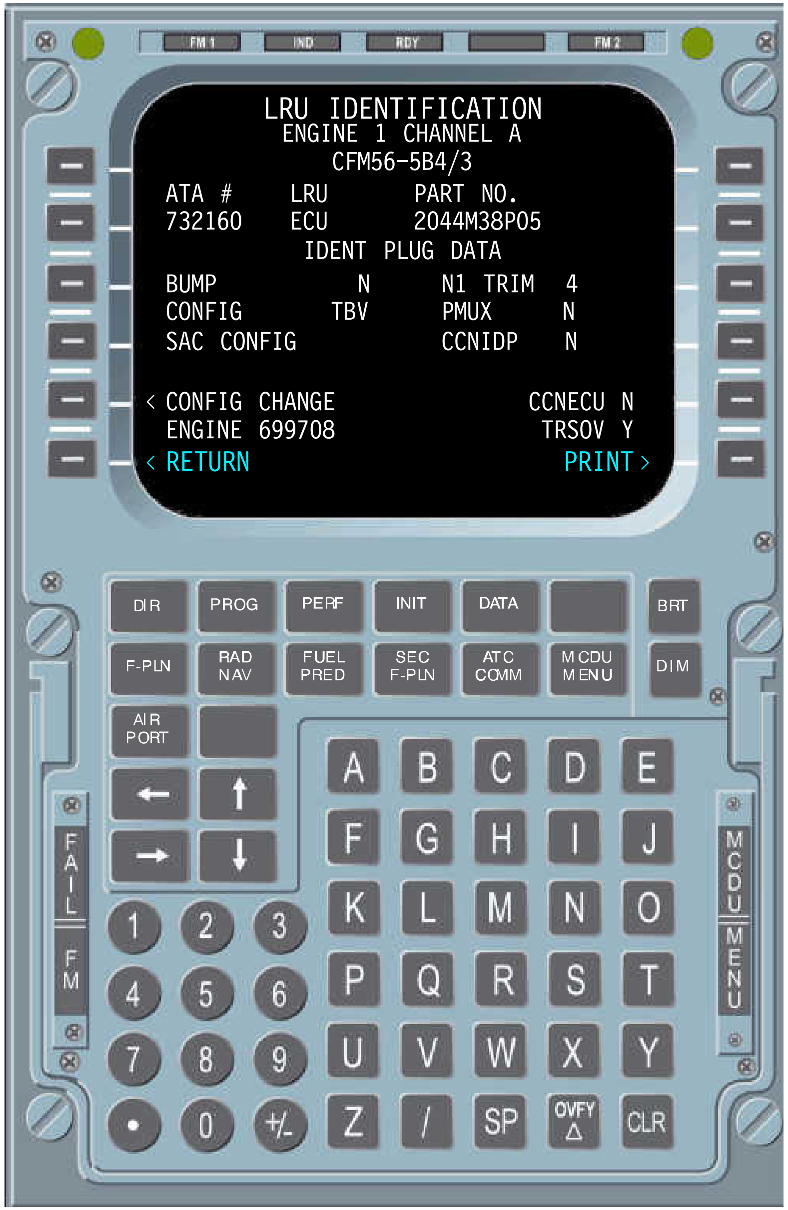
An LRU screen is available through the MCDU and is specific for DAC engines.

This screen enables the operator to know the engine type and also a lot of other useful information:

- Bump level
- N1 trim level
- Engine configuration
- PMUX option
- SAC/DAC configuration
- CCNIDP option
- CCNECU configuration
- SOV status*
- Engine serial number*

* The last two items can be accessed and modified through the keypad of the MCDU to be in accordance with the aircraft configuration.

The other parameters can only be read and are automatically updated when a new software version is programmed into the ECU, and/or, when the engine identification plug is installed an the ECU.



BUMP LEVEL: Y bump available
N bump not available

N1 TRIM: value from 0 to 7 indicates
trim level (modifier level)

CONFIG: RACSB, TBV, NACTB

PMUX option: Y indicates PMUX installed
N indicates PMUX not installed

SAC CONFIG: Single Anular Combustor installed
DAC CONFIG: 1 = DAC1 combustor with DAC1 fuel nozzle
2 = DAC1 combustor with DAC2 duel nozzles
3 = DAC2 combustor with DAC2 fuel nozzles

CCNIDP: Core Chevron Nozzle Status IDP (Y/N)
CCNECU: Core Chevron Nozzle Status ECU (Y/N)

TRSOV Y TRSOV installed
N TRSOV not installed

FADEC unit P/N is stored in **N**on−**V**olatile **M**emory, and in case of NVM fault, P/N will bei displaed as dashes

Figure 211 DAC LRU Ident & Serial Nr. Entry

FUEL RETURN VALVE DESCRIPTION

FUEL RETURN VALVE ASSEMBLY

The purpose of the fuel return valve is to return fuel back to the tank.

It mixes hot fuel flowing from the IDG fuel/oil heat exchanger and cold fuel from the LP fuel pump. It is controlled by the ECU based on engine oil temperature which is correlated with the IDG oil temperature.

It provides a stop function for the recirculated fuel, when no recirculation is commanded by the ECU.

The fuel return valve is located on the left-hand side of the fan inlet case, at the 10:00 o'clock position and between flanges E and F (above the IDG oil cooler).

Description

The rectangular-shaped FRV (starting from top and clockwise) has 6 fuel nipples for connection with the tubing which follows:

- Fuel return line to the fuel tank (WRT),
- PRE SB CFM 73-0096:
  - Shut-off signal line from the HMU (P Stop),
- POST SB CFM 73-0096:
  - Bypass line to the fuel pump LP stage (CLP),
    (END OF SB CFM 73-0096),
- Line from the fuel pump HP stage (PSF),
- Cold fuel line from the fuel pump LP stage (CLP),
- Hot fuel line from the IDG oil cooler (HLP),
- Fuel drain line.

The FRV has also 2 electrical receptacles for connection with the channels A and B of the ECU.

Operation

The fuel return valve controls 2 flow levels:

- The first level recirculates 500 kg/h (1100 lb/h) including 300 kg/h (726 lb/h) of hot fuel and 200 kg/h (440 lb/h) of cold fuel.
- The second level recirculates 1000 kg/h (2203 lb/h) including 600 kg/h (1320 lb/h) of hot fuel and 400 kg/h (881 lb/h) of cold fuel.

The mixing of the recirculated fuel is such that its temperature is maintained below 100 deg.C (212 deg.F) continuously and 110 deg.C (230 deg.F) transiently.

Both levels of the fuel return valve are controlled by the ECU based on the engine oil temperature value:

- On ground:
  - Only the first level is selected when engine oil temperature (TEO) is greater or equal to 90 deg.C (194 deg.F).
- In flight:
  - The first level is selected when TEO is greater or equal to 90 deg.C (194 deg.F).
  - The second level is selected when TEO is greater or equal to 95 deg.C (203 deg.F).

The shut off piston of the valve is equipped with a dual position switch to provide closed/not closed indication. These position switch indications are processed by the ECU.

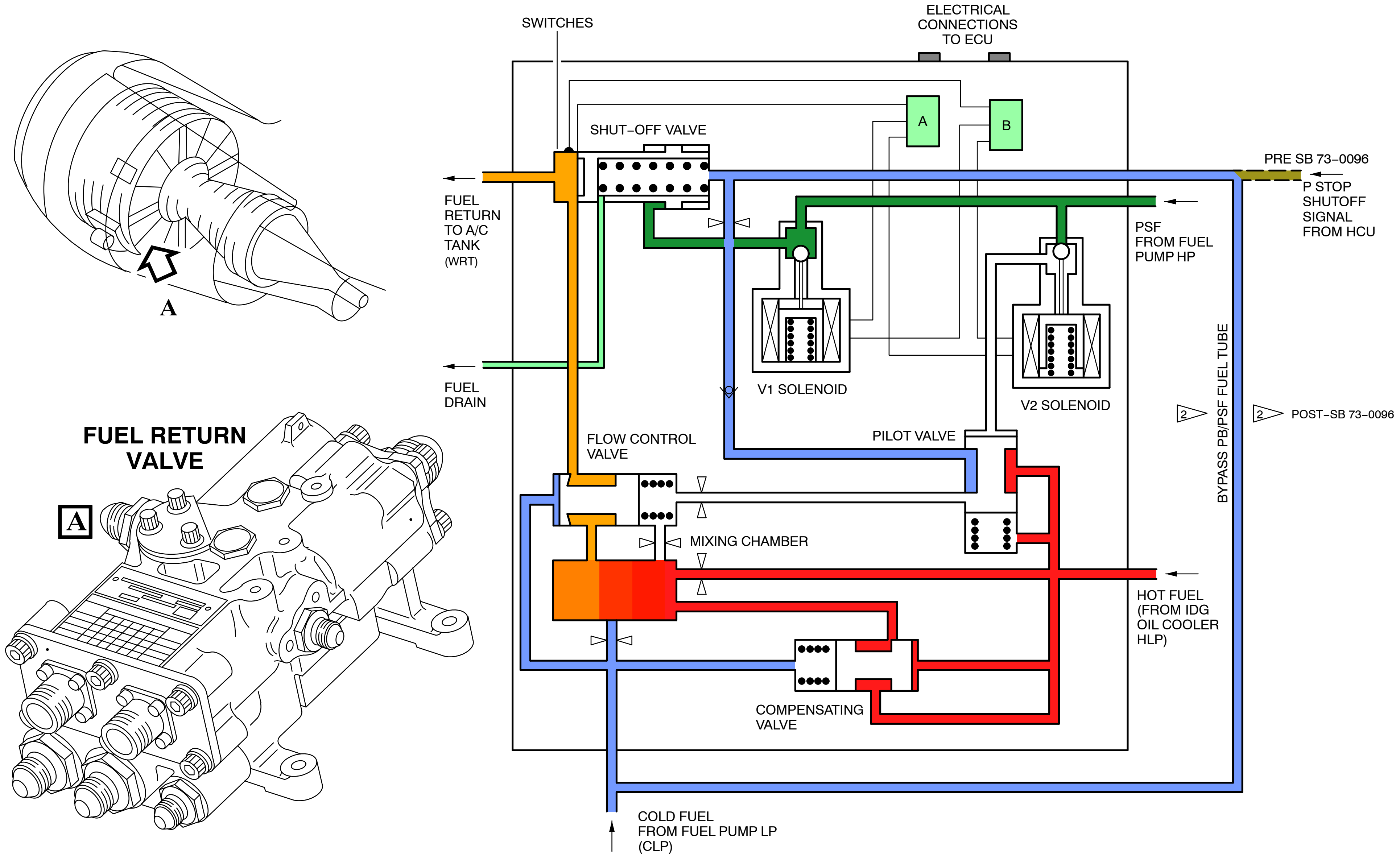


Figure 212 Fuel Return Valve Schematic

FUEL MANIFOLD MODIFICATION

SINGLE RING FUEL MANIFOLD

The Burner Staging Valve (BSV) system is deleted following a CFMI improvement program.

A single ring fuel manifold is fitted as the consequence of the BSV deletion.

Downstream of the Hydro Mechanical Unit (HMU), Nozzle Filter and Flow Transmitter the fuel directly flows to the twenty fuel nozzles which are connected to the single ring fuel manifold.

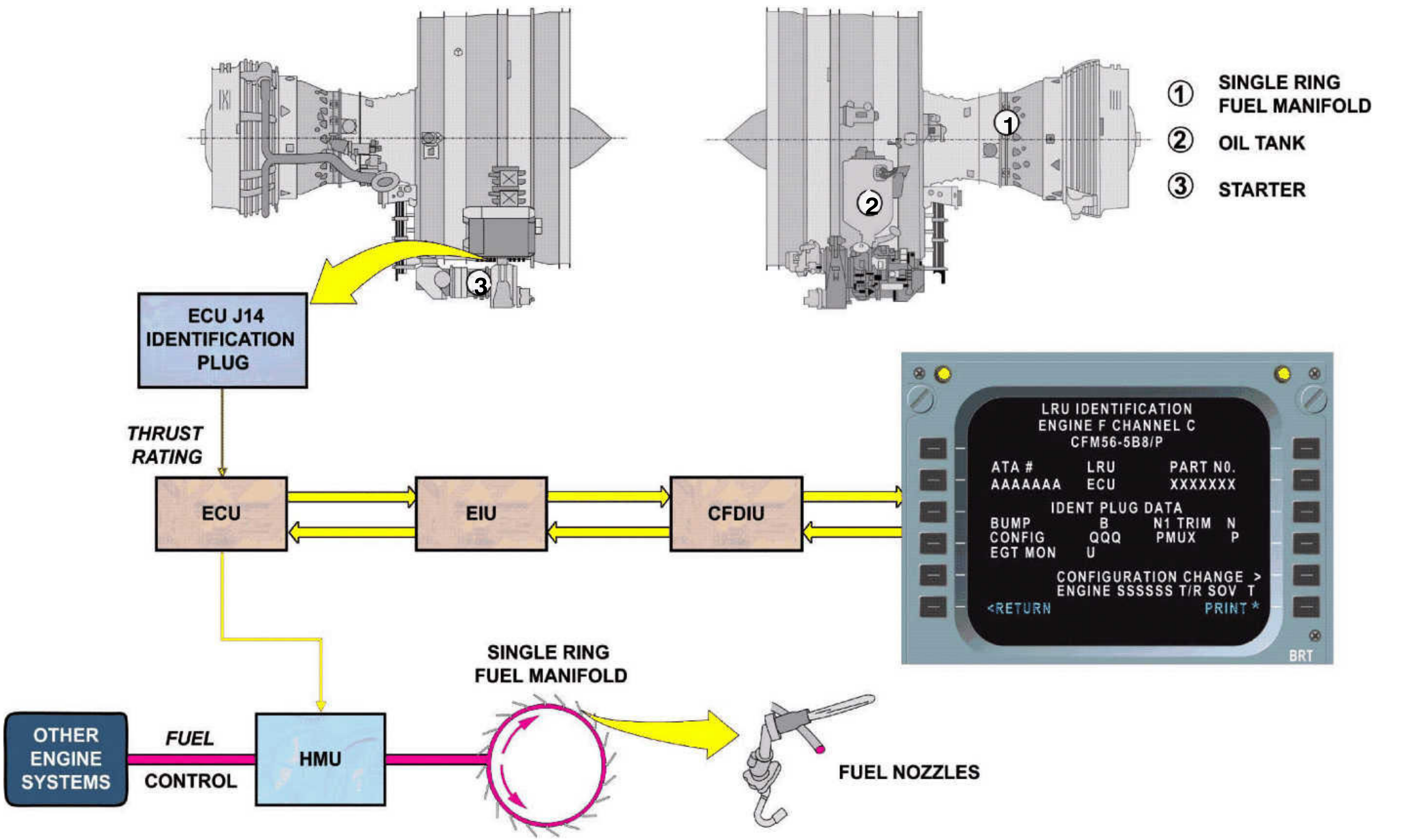


Figure 213 BSV Deletion

ATA 75 AIR

75-00 GENERAL

General

The engine air system is divided into three main functions:

- cooling
- compressor control
- indicating

The air system covers primary, secondary (bypass) and parasitic (cooling and pressurizing) airflows and the systems used to control airflow. It is composed of 2 major sections:

- engine
- and nacelle

Engine section

The airstream flowing through the CFM56 turbofan engine supplies 2 major systems:

- the internal
- the external air systems

The internal air system consists of the following sub-systems:

- propulsion airflow (secondary and primary flows)
- forward and aft bearing sump pressurizing air
- cooling air (HPTACC, RACSB)
- internal thrust balancing air

The external air system consists of the following sub-systems:

- fuel control system air (CDP)
- LPTACC (**L**ow **P**ressure **T**urbine **A**ctive **C**learance **C**ontrol)
- high-energy igniter harness cooling air
- engine customer bleed air
- ECU cooling

Nacelle section

The nacelle installation is designed to provide cooling and ventilation air for engine accessories installed on the fan and core casing. The distribution and circulation of the air in the compartments is such that the temperature limit for specific components is not exceeded. These limits ensure long life and provide good fire safety margins.

Compressor Control

The VSV (**V**ariable **S**tator **V**ane) and the VBV (**V**ariable **B**leed **V**alve) control the compressor through the ECU.

Indicating

The nacelle temperature only is indicated in the cockpit.

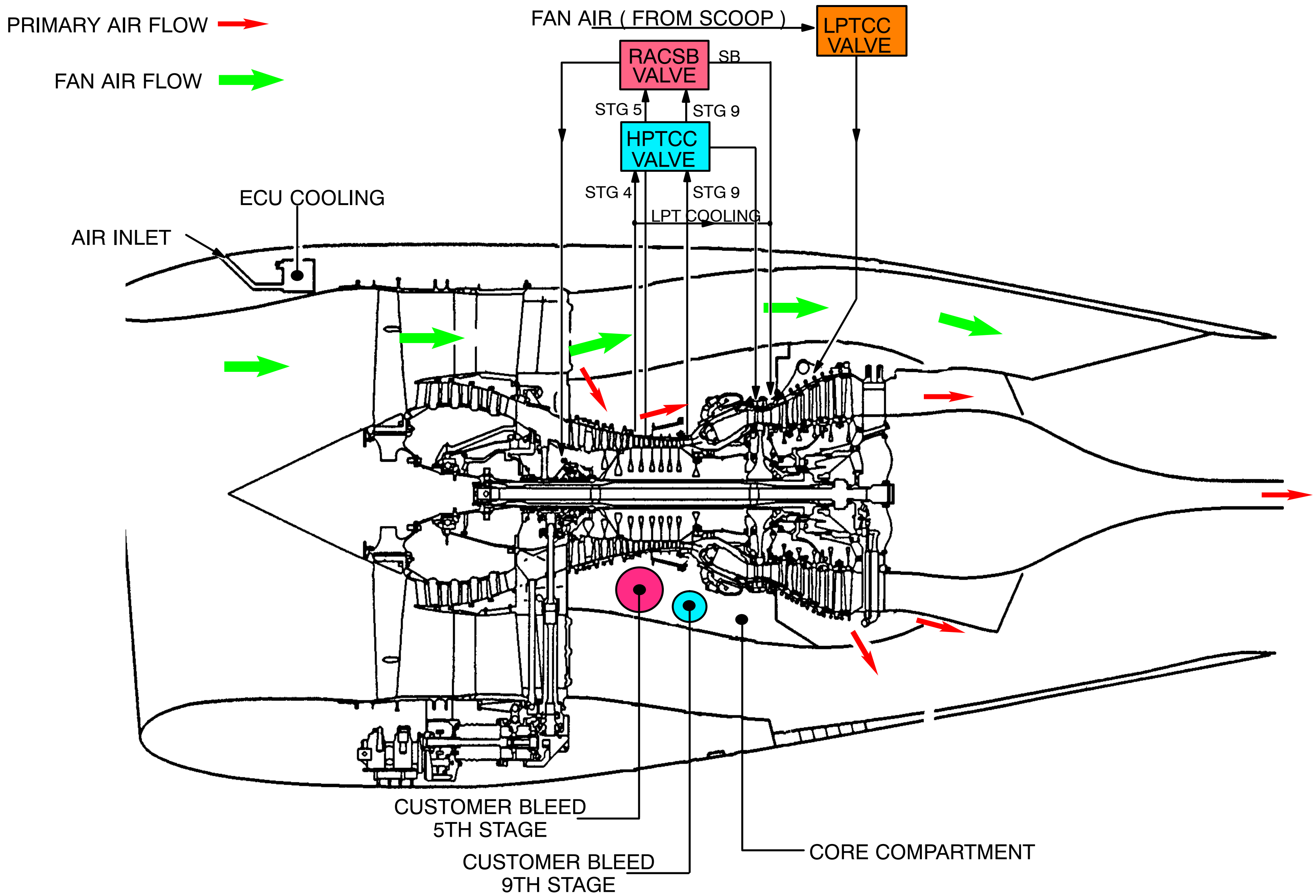


Figure 214 Engine Air System Schematic

75-20 COOLING

ACTIVE CLEARANCE CONTROL AND TRANSIENT BLEED DESCRIPTION

There are three systems independently controlled by the ECU and actuated from the HMU, which give to the engine clearance adjustment and transient bleed.

The clearance between the blade tips and the casings is actively controlled in order to optimize engine performance using cooling air to shrink the LP and HP turbine casings.

HIGH PRESSURE TURBINE ACTIVE CLEARANCE CONTROL

The High Pressure Turbine Active Clearance Control (HPTACC) system uses stage 4 and stage 9 HPC air to heat or cool the High Pressure Turbine (HPT) shroud support structure.

The ECU monitors the shroud support structure temperature using the T case sensor.

LOW PRESSURE ACTIVE CLEARANCE CONTROL SYSTEM

The Low Pressure Turbine Active Clearance Control (LPTACC) system uses fan air for external case cooling of the Low Pressure Turbine (LPT).

TRANSIENT BLEED VALVE SYSTEM

The Transient Bleed Valve (TBV) improves the compressor stall margin during transient and start conditions. The TBV unloads the HPC by discharging stage 9 HPC air in the LPT cavity.

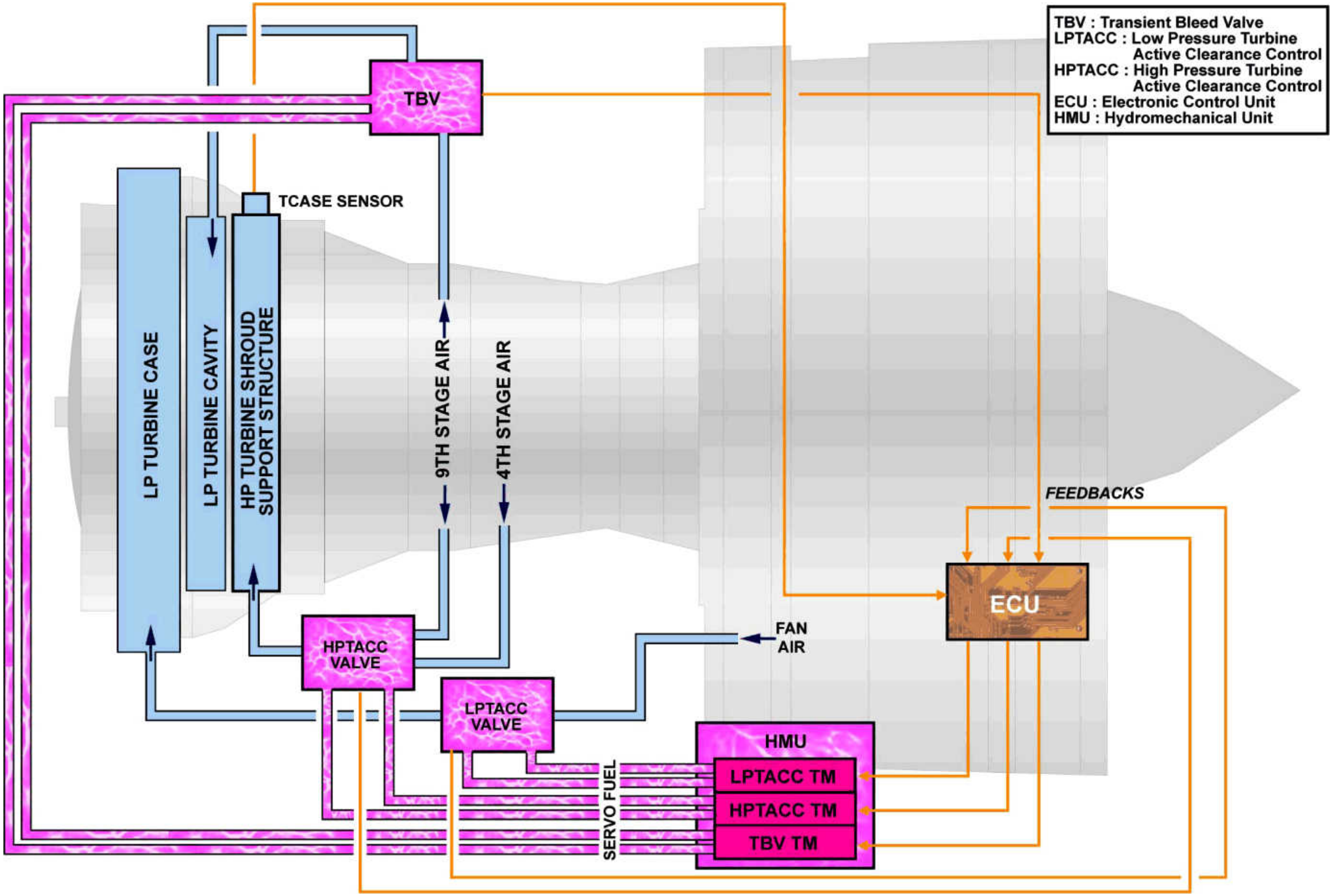


Figure 215 Active Clearance Control And Transient Bleed

HIGH PRESS. TURB. CLEARANCE CTRL PRESENTATION

High Pressure Turbine Clearance Control

The HPTCC system optimizes HPT efficiency through active clearance control between the turbine rotor and shroud and reduces compressor load during starting and transient engine conditions.

The HPTCC system uses bleed air from the 4th and 9th stages to cool down the HPT shroud support structure in order to:

- maximize turbine efficiency during cruise.
- minimize the peak EGT during throttle burst.

The HPTCC valve is located on the engine core section at the 3 o'clock position.

A thermocouple, located on the right hand side of the HPT shroud support structure, provides the ECU with temperature information.

The ECU uses various engine and aircraft sensor information to take into account the engine operating range and establish a schedule.

To control the temperature of the shroud at the desired level, the ECU calculates a valve position.

This valve position is then sent by the ECU to the HMU, which modulates the fuel pressure sent to command the HPTCC valve.

Two sensors (LVDT), connected to the actuator, provide the ECU with position feedback signals and the ECU changes the valve position until the feedback matches the schedule demand.

HPTCC Valve

The HPTCC valve has integrated dual butterfly valves, driven by a single actuator which receives the fuel pressure from the HMU servo valve.

Each butterfly valve controls its own dedicated compressor stage air pick-up.

One butterfly valve controls the flow from 4th stage compressor bleed while the other butterfly valve controls the flow from the 9th stage compressor bleed.

The 4th stage air is mixed with the 9th stage air downstream of the valve.

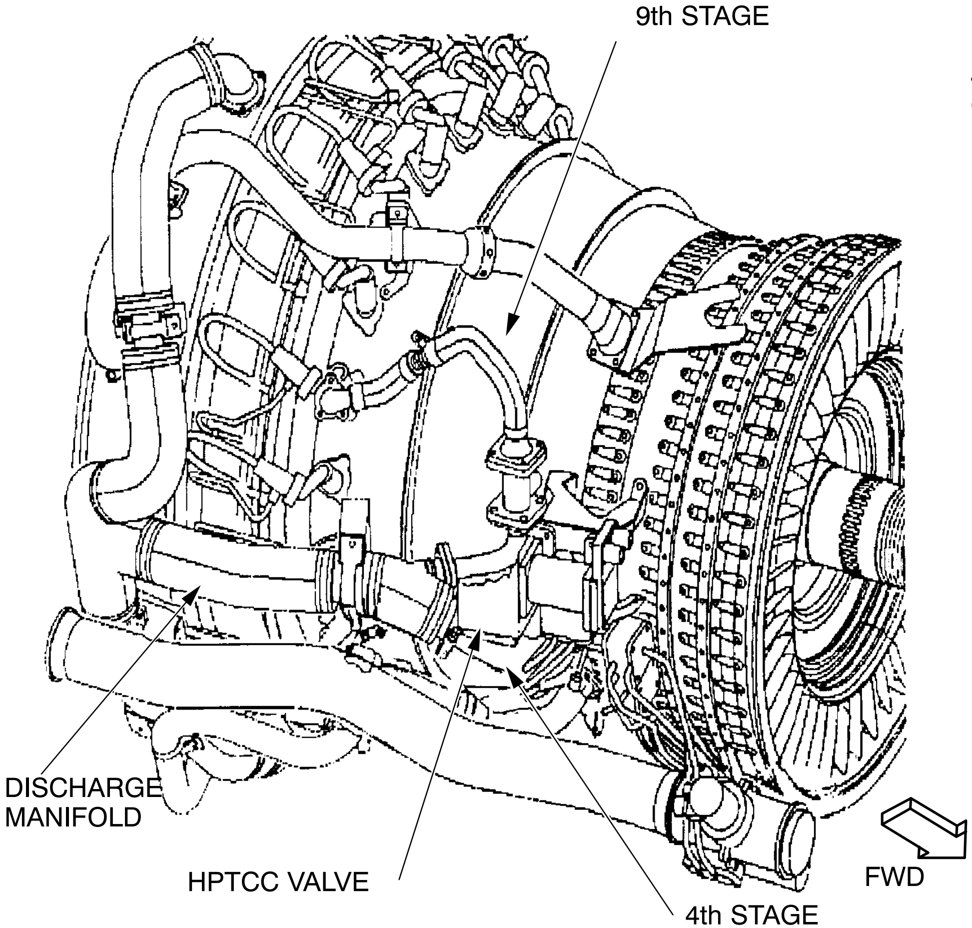
The two airflows are mixed downstream of the valve and sent through a thermally insulated manifold to the HPT shroud support, at the 6 and 12 o'clock positions.

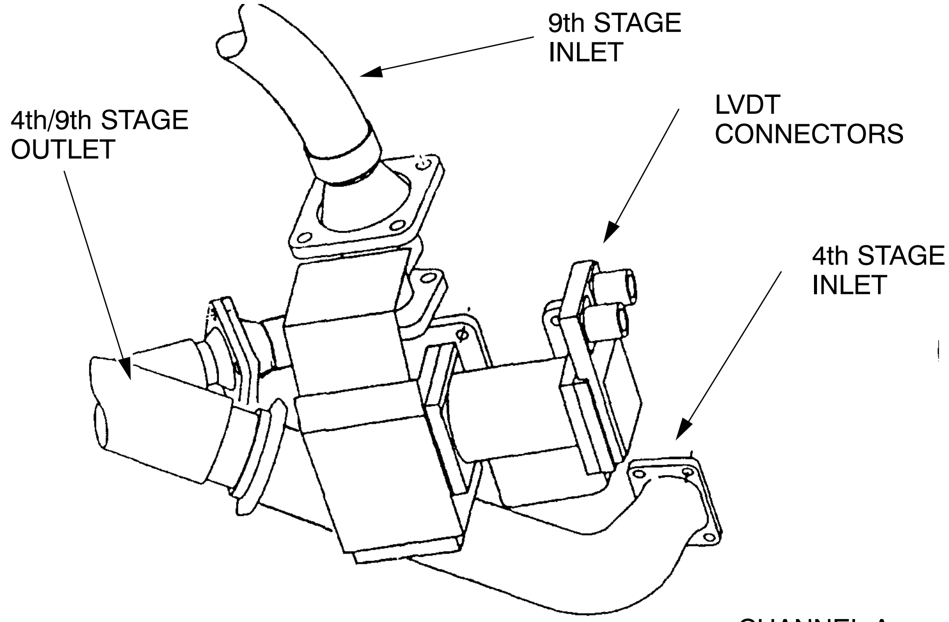
The actuator position is sensed by a dual LVDT and sent to both channels of the ECU.

A drain port on the valve directs any fuel leaks towards the draining system.

Component Description

The HPTACC valve has integrated dual butterfly valves driven by a single fuel powered actuator. Position feedback to the ECU is provided by a dual channel LVDT installed on the actuator. One butterfly valve controls the flow from 4th stage compressor bleed while the other butterfly valve controls the flow from the 9th stage compressor bleed. The 4th stage air is mixed with the 9th stage air downstream of the valve.





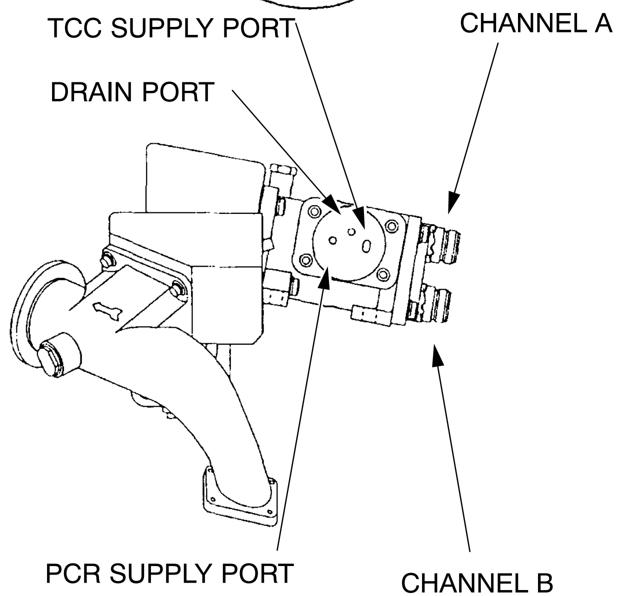


Figure 216 HPTCC System Location

HPT ACTIVE CLEARANCE CONTROL PRESENTATION

System Description

The HPTACC system regulates the HP turbine shroud support structure temperature by means of valves controlled by the HMU (**H**ydro**m**echanical **U**nit).

The HPTACC Valve has integrated dual butterfly valves driven by a single fuel powered actuator.

Fuel pressure is distributed in accordance with electrical signals sent by the ECU (**E**lectronic **C**ontrol **U**nit).

One butterfly valve controls the flow from the fourth stage compressor bleed while the other butterfly valve controls the ninth stage.

The fourth stage air is mixed with the ninth stage air downstream of the valve.

General

The HPTACC (**H**igh **P**ressure **T**urbine **A**ctive **C**learance **C**ontrol) system uses bleed air from the fourth and ninth stages to cool the high pressure turbine shroud support structure.

The purpose of the system is to :

- maximize turbine efficiency during cruise,
- minimize the peak EGT (**E**xhaust **G**as **T**emperature) during throttle burst.

The HPTACC valve also discharges ninth stage air to unload the HP (**H**igh **P**ressure) compressor on engine start.

Two Linear Variable Differential Transducers connected to the actuator and one thermocouple located on the right hand side of the HP turbine shroud support structure provide feedback signals to the ECU.

Control

In accordance with various parameters such as N2 and T3, the ECU sends electrical signals to the torque motor within the HMU to move the HPTACC valves.

When the engine is shut down the valves move to a failsafe closed position.

On engine start the HPTACC valve moves to the ninth stage bleed position which unloads the compressor to improve engine acceleration.

Above ground idle the position of the valves is determined by the closed loop shroud temperature control.

The HPTACC actuator drives the butterfly valves to different positions, as follows:

ACTUATOR STROKE	MODE	4TH STAGE BUTTERFLY	9TH STAGE BUTTERFLY
0% FAILSAFE	NO AIR	CLOSED	CLOSED
37%	FULL 9TH	CLOSED	FULLY OPEN
37 - 100%	MIXED	INTERMEDIATE	INTERMEDIATE
100%	FULL 4TH	FULLY OPEN	CLOSED

Figure 217 Butterfly Valves Positions

T-case

The T-case sensor measures the HPT (**H**igh **P**ressure **T**urbine) shroud support temperature.

The temperature value is used by the ECU in the HPT Clearance Control system logic.

It is installed on the combustion case at the 3 o'clock position, and consists of :

- a housing, which provides a mounting flange and an electrical connector.
- a sensing element, fitted inside the housing and in contact with the shroud support.

NOTE: The probe is spring–loaded to ensure permanent contact with the shroud support.

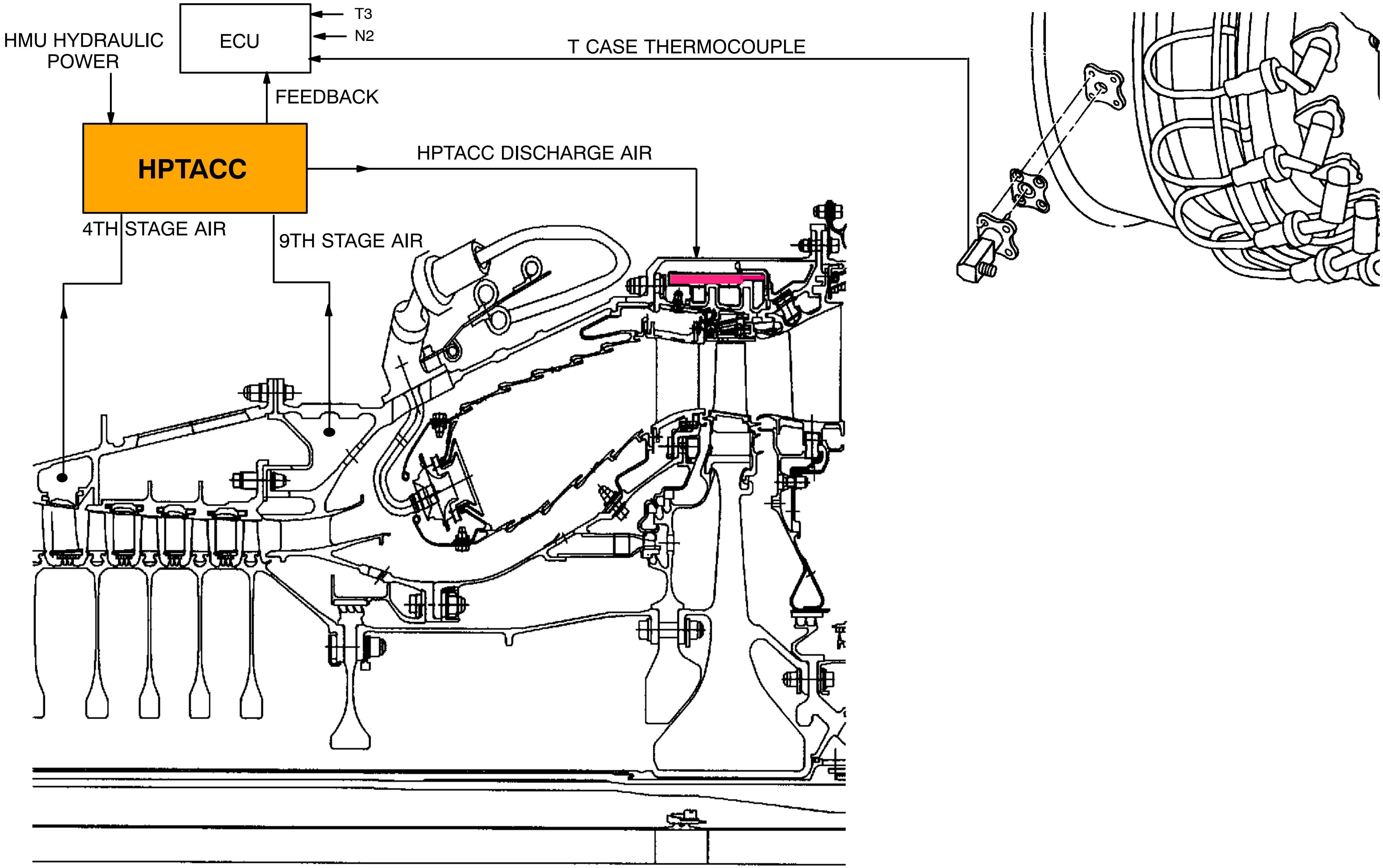


Figure 218 HPTACC Airflow Schematic

LOW PRESS. TURB. CLEARANCE CTRL SYST. OPERATION

To ensure the best performance of the LPT at all engine ratings, the LPTCC system uses fan discharge air to cool the LPT case during engine operation, in order to control the LPT rotor to stator clearances.

It also protects the turbine case from over-temperature by monitoring the EGT.

The LPTCC system is a closed loop system, which regulates the cooling airflow sent to the LPT case, through a valve and a manifold.

The LPTCC valve is located on the engine core section between the 4 and 5 o'clock positions.

The LPTCC system consists of:

- an air scoop
- the LPTCC valve.
- an air distribution manifold.
- six LPT case cooling tubes.

The purpose of the LPTACC (**LPT A**ctive **C**learance **C**ontrol **S**ystem) is to control the thermal expansion of the low pressure turbine case during engine operation in order to:

- optimize the LPT rotor-to-stator (blade tip) radial clearances
- and thus get the best performance from the LPT at all engine ratings

To achieve these requirements the system:

- scoops a controlled amount of fan discharge air,
- flows it through a dedicated system of ducting, control valve, manifolds and tubes arrangement.

Component Description

The LPTACC valve has the parts which follow:

- A housing with a drain boss to collect laminar leakage from the linear actuator.
- A control plate with 3 holes, which lets in the HMU fuel signals for active control of the LPT clearances.
- A linear actuator with a gear sector which rotates the butterfly valve shaft.
- A spring-return system fitted in the actuator.
- A RVDT redundant sensor fitted at one end of the butterfly valve shaft.
- A butterfly-type valve.

Operation

The actuator system of the butterfly valve uses fuel pressure signals from the HMU for its operation.

Within the HMU, the LPT active clearance control function operates under electrical signals/commands from the ECU.

Valve Feedback

A feedback of the different positions of the butterfly valve is supplied constantly to the ECU through the RVDT sensor electrical connectors. Under control of the PCR pressure applied at one end of the actuator and a PC/PB modulated pressure applied at the other end, the linear actuator rotates the shaft which controls the opening or closing of the butterfly valve. The butterfly valve regulates the amount of fan discharge air required to cool the turbine as a function of the engine power demand (engine rating). The PCR pressure is always between the PC and PB pressures. The only action that can displace the actuator piston is the PCR-PC or PCR-PB differential pressure.

During an acceleration of the engine:

- A PB signal is sent to the CCV (**C**learance **C**ontrol **V**alve) by the HMU.
- This pressure signal moves the actuator piston and rod toward the OPEN position of the butterfly valve.

During a deceleration of the engine:

- A PC signal is sent to CCV by the HMU.
- This pressure signal moves the actuator piston and rod toward the CLOSED position of the butterfly valve.
- When the engine is shut down, the butterfly valve is fully closed.

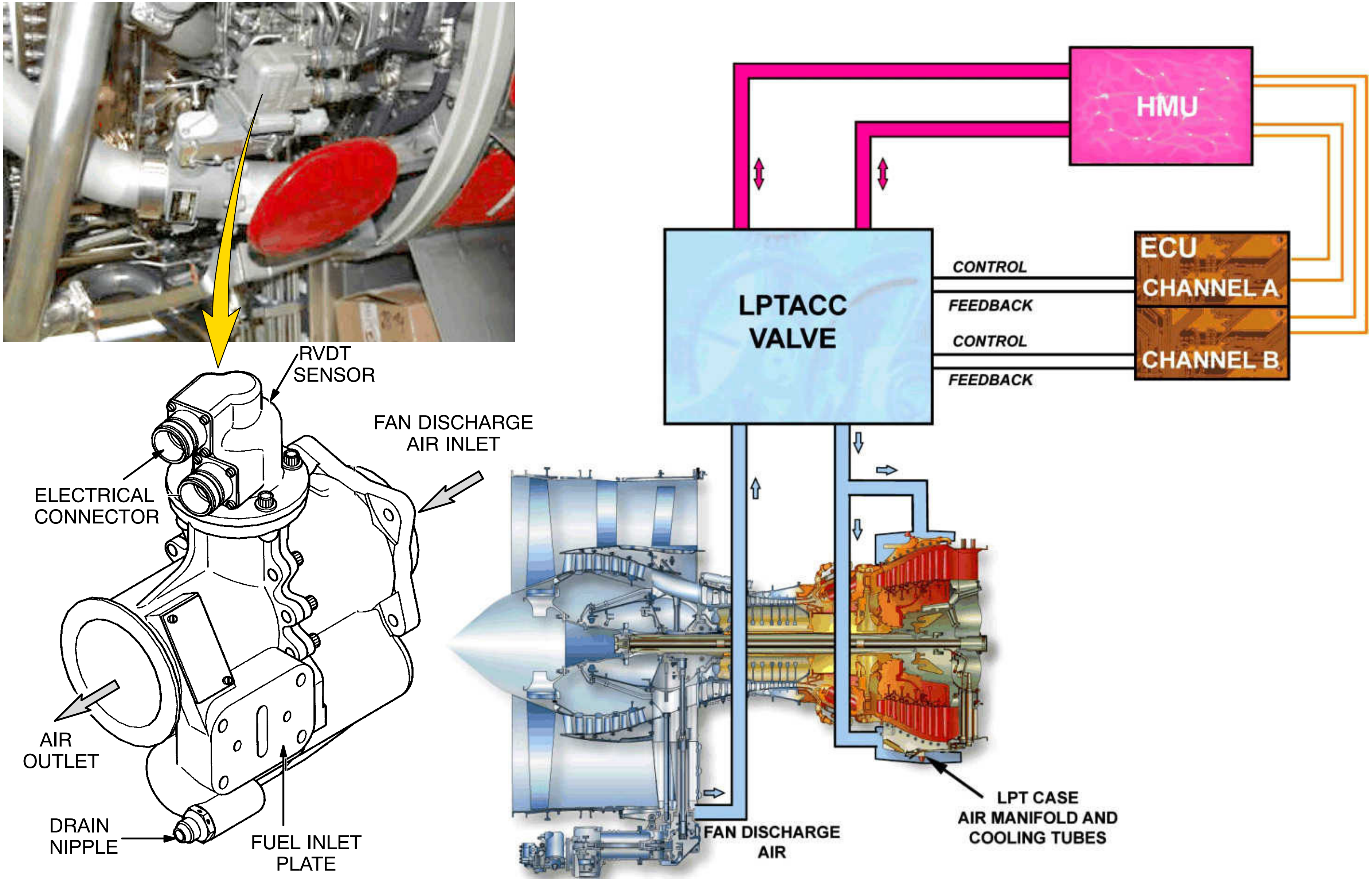


Figure 219 LPTACC Valve Schematic

TRANSIENT BLEED VALVE COMPONENT DESCRIPTION

The TBV (**t**ransient **b**leed **v**alve) system controls the quantity of the HPC (**h**igh **p**ressure **c**ompressor) 9th stage bleed air that goes into the stage 1 LPT (**l**ow **p**ressure **t**urbine) nozzles. The TBV system increases the HPC stall margin during engine start and during engine acceleration.

The TBV system has these parts:

- TBV valve
- TBV manifold.

TBV — COMPONENT LOCATION

These TBV (**t**ransient **b**leed **v**alve) system components are on the HPC (**h**igh **p**ressure **c**ompressor) case:

- Transient bleed valve (6:00 position)

  The TBV is a butterfly valve that operates with servo fuel pressure. It has two positions: open or closed. It has these parts:

  - Actuator body
  - 9th stage air butterfly valve body
  - Switch connector (2)
  - Thermal shield
  - Fuel manifold mount flange.
- TBV manifold (7:00 position).

You open the two fan duct cowls and thrust reverser cowls to get access to the TBV system components.

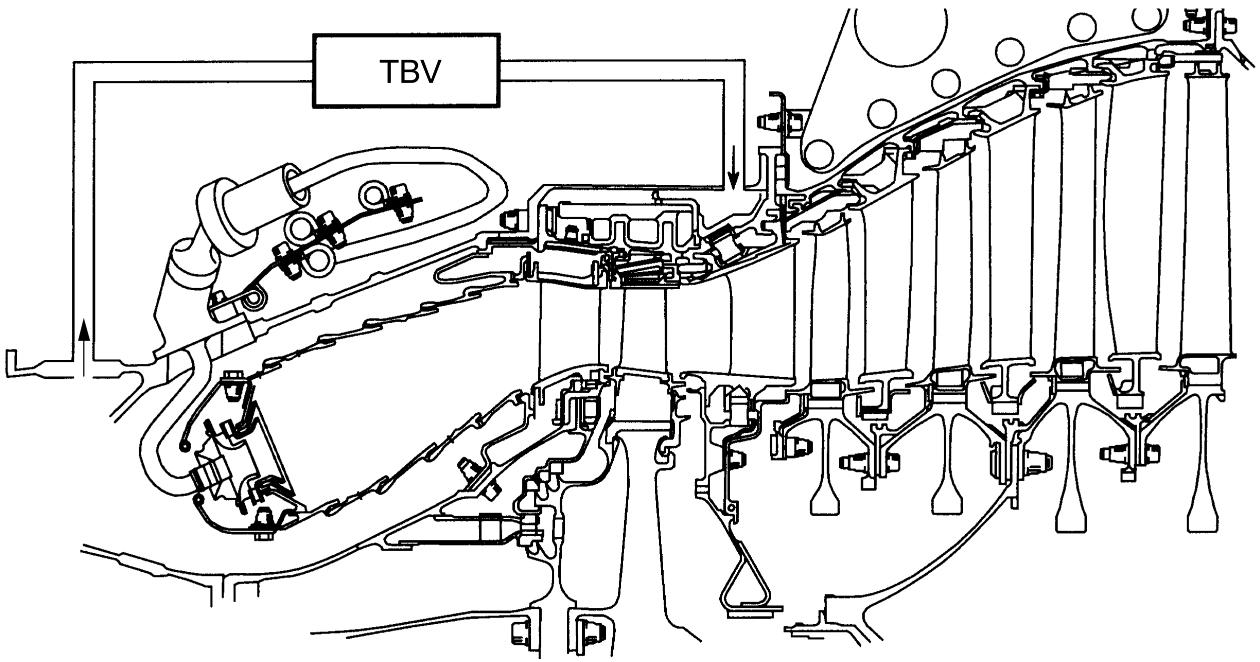


Figure 220 TBV-Schematic

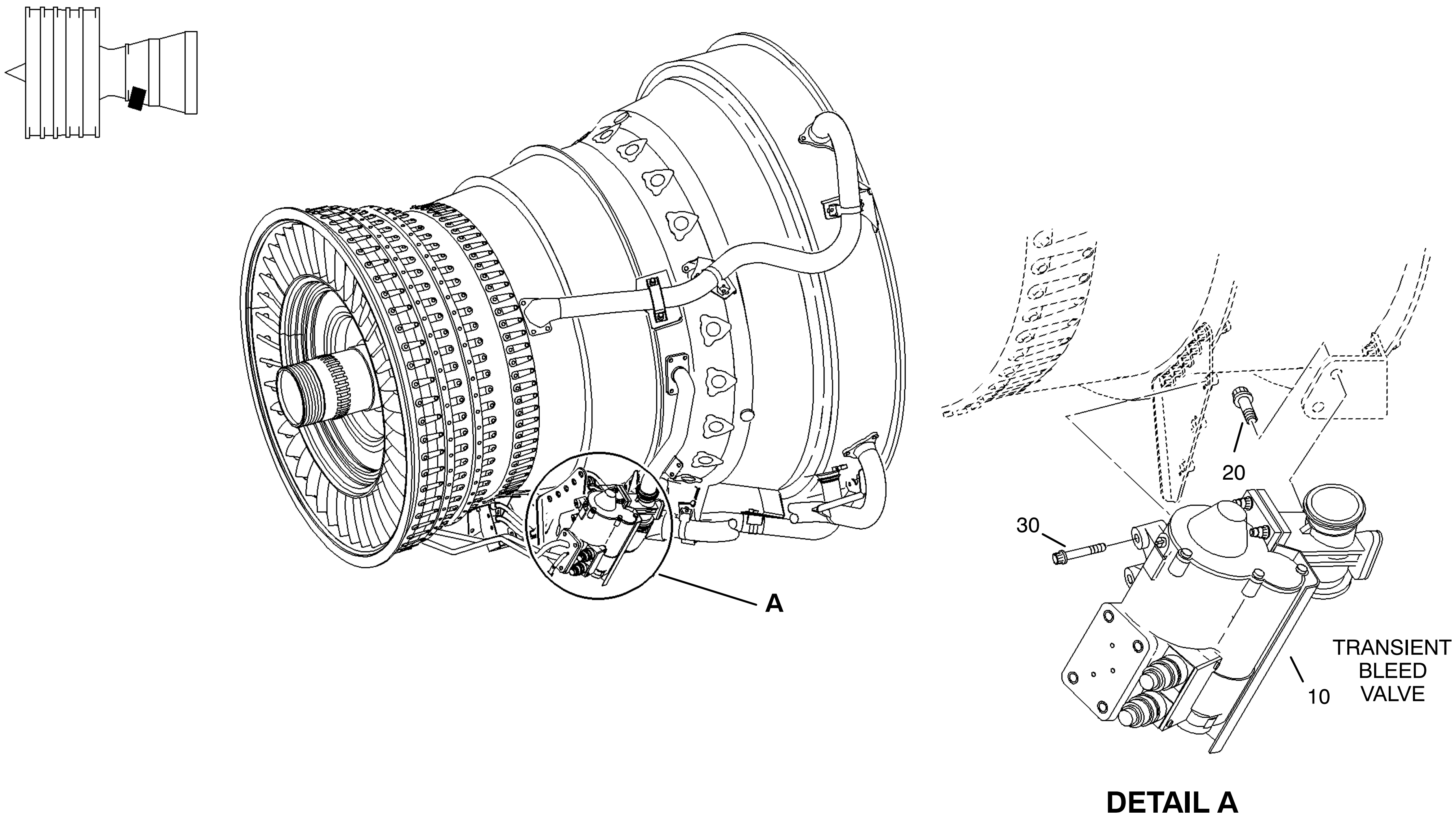


Figure 221 Transient Bleed Valve

ATA 77 ENGINE INDICATING

77-00 ENGINE INDICATING - GENERAL

ENGINE INDICATING DESCRIPTION

GENERAL

The engine primary parameters are permanently displayed on the upper ECAM E/WD. The secondary parameters are displayed on the lower ECAM DU when selected automatically or manually. The ECU receives engine inlet condition data from the Air Data/Inertial Reference System (ADIRS), operational commands from the Engine Interface Unit (EIU), and monitoring parameters from the various dedicated engine sensors.

The AIDS system (ATA 31-36) receives the engine monitoring parameters through the FADEC.

PRIMARY PARAMETERS

1. **LP Rotor Speed N1**

   The N1 needle and N1 digital indication are normally green. The needle pulses amber when the actual N1 is above the N1 MAX. The needle pulses red when the actual N1 is above the red line N1. When N1 is degraded (in case both N1 sensors fail), the last digit of the digital display is amber dashed.

   - **REV Indication**

     It is displayed in amber, when at least one reverser cowl is unstowed or unlocked. It becomes green, when the reverser cowls are fully deployed. (If unlocked in flight, the indication first flashes for 9 seconds, then remains steady).

   - **AVAIL Indication**

     Displayed in green to indicate a successful engine start on ground. It pulses in green to indicate a successful engine relight in flight. It is triggered when the engine is at, or above, idle.

2. **Thrust Limit Mode**

   The legend that appears in blue here, TOGA, FLX, CL, MCT, or MREV, is the limit mode selected by the position of whichever thrust lever is farther forward. If FLX mode is selected, the flexible takeoff temperature selected through the MCDUs is displayed in blue.

3. **N1 Rating Limit**

   This number, computed by the FADEC for the present thrust lever angle, is displayed in green.

NOTE: When the aircraft is on the ground with the engines running, the N1 rating limit displayed here corresponds to the TOGA thrust limit regardless of the position of the thrust lever. When the aircraft is on the ground with the engines running and FLEX mode selected, this number is the FLEX N1, regardless of the position of the thrust lever between idle and FLX/MCT.

4. **FLEX Temperature**

   If FLX mode is selected, the flexible takeoff temperature selected through the MCDUs is displayed in blue.

5. **EGT Indicator**

   Actual EGT is normally indicated in green. Needle pulses amber above 915° C except for high power operation (FLEX TO or thrust lever above MCT or at MAX REV, or activation of alpha floor). Needle pulses amber above 725° C during start sequence.

6. **HP Rotor Speed N2**

   Numbers are normally green. (During start sequence, they are green on a grey background). When N2 is above 105 % the indication turns red and a red cross appears next to it. When the N2 value is degraded (if both N2 sensors fail), the last digit is amber and is dashed.

7. **Fuel Flow**

   These numbers are green.

NOTE: If the system detects a discrepancy between the N1, N2, EGT and fuel flow values on the FADEC-DMC bus and the corresponding displayed values, an amber CHECK appears underneath the affected parameter.

8. **IDLE Indication**

   This legend appears in green when both engines are at idle. It flashes for 10 seconds, then is steady.

ENGINE/WARNING DISPLAY ENHANCED

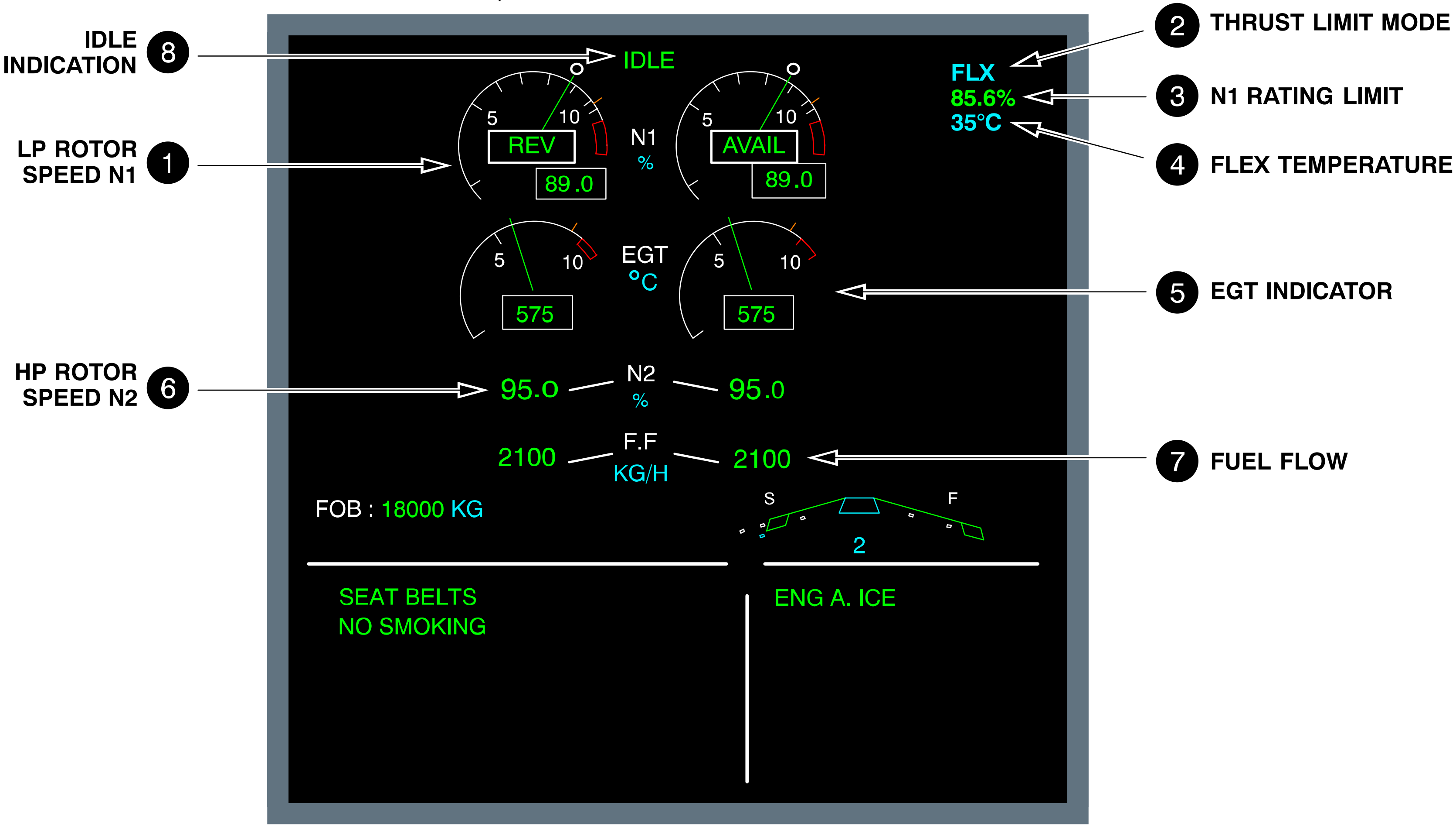


Figure 222 Engine Indications on Upper ECAM

SECONDARY PARAMETERS

1. **Fuel Used**

   The green number is the fuel used as computed by the FADEC. It resets when the engine starts (MASTER switch ON) on the ground.

   It is frozen at its last value (until the next engine start) when the engine shuts down. (The ECAM CRUISE page also displays it).

   The two last digits are dashed if the fuel-used indication is inaccurate due to the loss of fuel flow data for more than one minute.

2. **Oil Quantity**

   The needle and the numbers are normally green. The indication pulses when oil quantity goes below three quarts (decreasing) or above five quarts (increasing).

3. **Oil Pressure**

   The needle and the numbers are normally green.

   The digital indication pulses if:

   - oil pressure exceeds 90 psi (increasing) or 85 psi (decreasing),
   - oil pressure drops below 16 psi (decreasing) or 20 psi (increasing).

   The indication turns red and a warning appears on ECAM if the oil pressure drops below 13 psi.

4. **Oil Temperature**

   These numbers are normally green. They pulse above 140° C (increasing) or 135° C (decreasing). They turn amber and a warning appears on ECAM if the temperature exceeds:

   - 140° C for more than 15 minutes, or
   - 155° C without delay.

5. **VIB Indication**

   The legend is green. VIB N1 pulses above 6. VIB N2 pulses above 4.3.

   These numbers also appear on the ECAM CRUISE page.

NOTE: An MCDU procedure may reduce the advisory threshold to the level of vibration reached during the last flight. If this function has been activated, the N1 and N2 VIB indications pulse below 6 and 4.3, respectively.

6. **Oil Filter Clog**

   CLOG appears in amber if there is excessive pressure loss across the main oil scavenge filter.

7. **Fuel Filter Clog**

   CLOG appears in amber if there is excessive pressure loss across the fuel filter.

8. **Ignition**

   IGN appears in white during the start sequence. The letters A, B or AB appear in green when the respective igniters are firing.

9. **Start Valve Position**

   Is shown in green in the fully open or closed position.

10. **Engine Bleed Pressure**

    The green numbers show the bleed pressure upstream of the precooler.

    They become amber when the pressure drops below 21 psi with N2 = 10 % or if there is an overpressure.

11. **Nacelle Temperature**

    It is displayed, except during the start sequence, and is normally in green.

    A nacelle temperature above 240° C pulses in green.

    The advisory threshold is indicated by a white check mark.

ENGINE SYSTEM PAGE ENHANCED

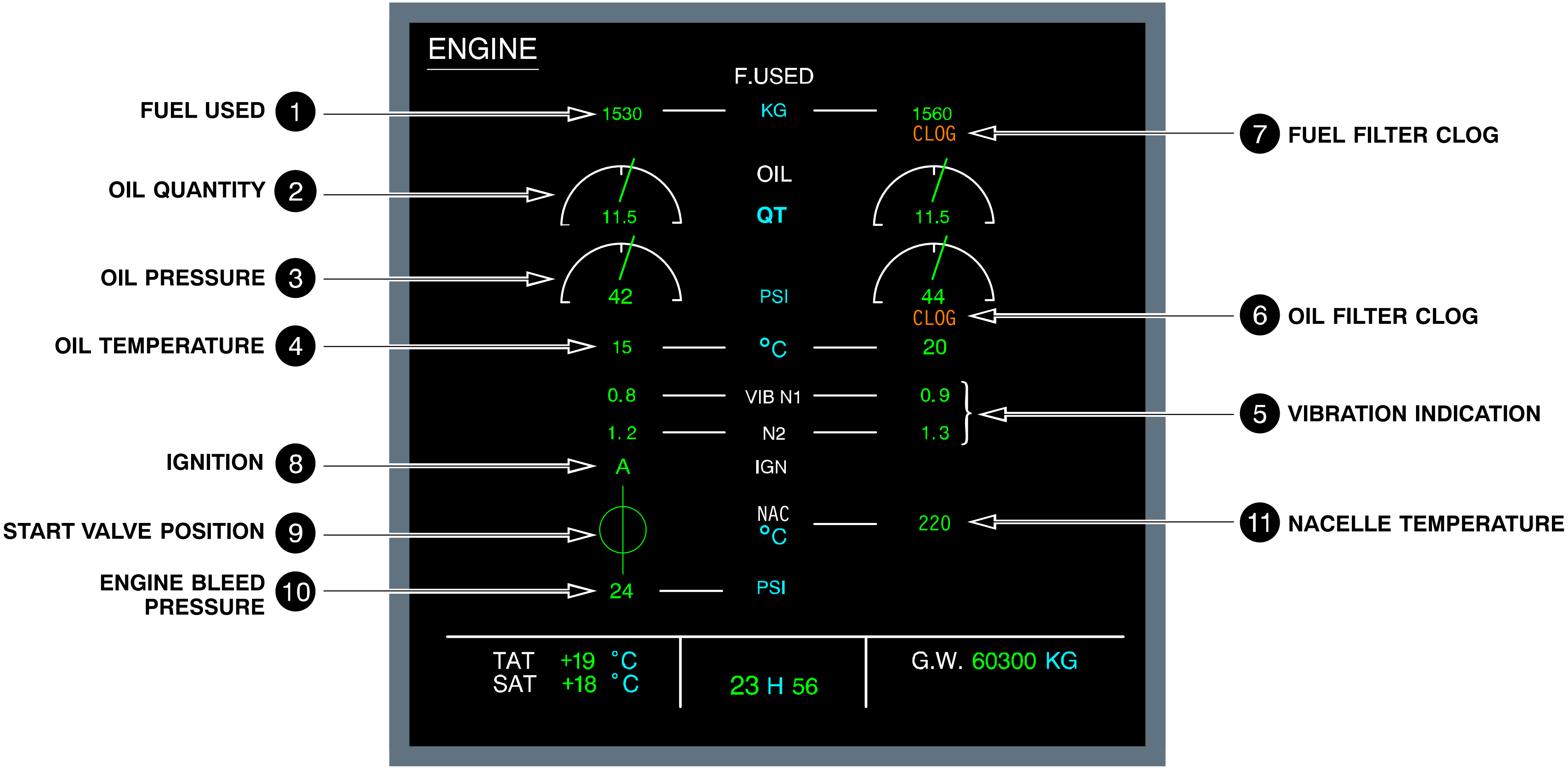


Figure 223 Engine Indications on Lower ECAM

POWER PLANT INDICATING DESCRIPTION

Rotational Speed Parameters Description

The N1 speed sensor is installed in the fan frame strut No.6 at the 5:00 o'clock position. It senses the LP rotor assembly rotational speed and transmits the corresponding signals to the Engine Vibration Monitoring Unit (EVMU) and the ECU. The N1 rotational speed indication is shown in the ECAM EWD by a needle and a N1 digital indication display.

The N2 speed sensor is installed at 6:30 o'clock on the Accessory Gearbox (AGB) rear face. The N2 speed sensor detects the rotational speed of the HP rotor assembly and transmits the signal to the EVMU and the ECU. The N2 rotational speed is indicated in the ECAM EWD.

LPT Section Parameters Description

The engine EGT is sensed and averaged by 9 thermocouple probes located in the T49.5 plane of Low Pressure Turbine (LPT) stage−2 nozzle assembly. The actual engine EGT is displayed in the ECAM EWD by a needle and an EGT digital indication.

Fuel Flow Parameter Description

The FF transmitter (XMTR) is mounted at 7 o'clock on the engine next to the AGB and does not require an electrical power input. The maximum flow across this XMTR is 6360 kg/hr (14000 lb/hr). The FF is shown in the ECAM EWD by a FF digital indication.

Oil Parameters Description

The oil quantity XMTR is located in the oil tank. It is displayed on ECAM SD. The oil pressure XMTR is located on the lubrication unit outlet line. It is displayed on ECAM SD. An oil temperature sensor for the Engine Condition Monitoring (signal to EIU) is located on the main oil pressure filter housing of the lubrication unit, downstream of the pressure pump oil system. It is displayed on the ECAM SD. An oil differential pressure switch (also named oil clogging switch) is installed on the lubrication unit. The pressure switch signal is used by the ECAM system to generate the main oil filter clog indication when the oil differential pressure across this filter is comprised between 29 psig (2 bar) and 33 psig (2.28 bar). An engine oil temperature sensor for the Integrated Drive Generator (IDG) cooling system control (signal to ECU) is located above the oil tank.

Vibration Parameters Description

The No. 1 bearing sensor is formed by an accelerometer located at 9:00 o'clock position on No. 1 and No .2 bearing support and a sensor cable that is routed through the fan frame. The No. 1 bearing vibration sensor permanently monitors the vibrations from No. 1 bearing and the vibrations from LPT and High Pressure Turbine (HPT) shafts. It's also used to the fan trim balance procedure. The Turbine Rear Frame (TRF) vibration sensor is installed at 12 o'clock on the front flange of the TRF. The TRF vibration sensor is used as back−up of N1 bearing accelerometer to monitor and, if necessary, reduce the engine vibration level using the trim balance procedure. The aircraft EVMU uses the vibration and the rotational speed signals to extract all the vibration signals and compute the position and the amplitude of the unbalanced signals. As normal vibration is depending on rotor speed, for each speed, the EVMU processes the ratio actual value/maxi value. This ratio is multiplied by 10 and is available on the EVMU output for display on the ECAM SD.

Fuel Parameters Description

The fuel used value computed by the FADEC is displayed in green on the ECAM SD. A CLOG message appears in amber, associated with an ECAM message only when the differential pressure across the fuel filter is excessive.

Nacelle temperature Indication

The nacelle temperature is monitored by a temperature probe installed in the ventilated core compartment. The nacelle temperature sensor can provide indication to the ECAM SD.

Compressor, Combustion & LPT Parameters

The T12 sensor is made to measure the engine intake air temperature. It is installed on the engine fan inlet case at the 1:00 o'clock position. The PS12 sensor measures the static pressure from the fan inlet. The T25 sensor is located at 4:30 o'clock upstream of Variable Bleed Valve (VBV) in the fan frame. The sensor measures the air temperature downstream of the booster or the HPC inlet.Tcase sensor is located between the combustion chambers and the HPT. The T3 sensor measures the compressor discharge temperature. The PS3 sensor meters the compressor discharge pressure.

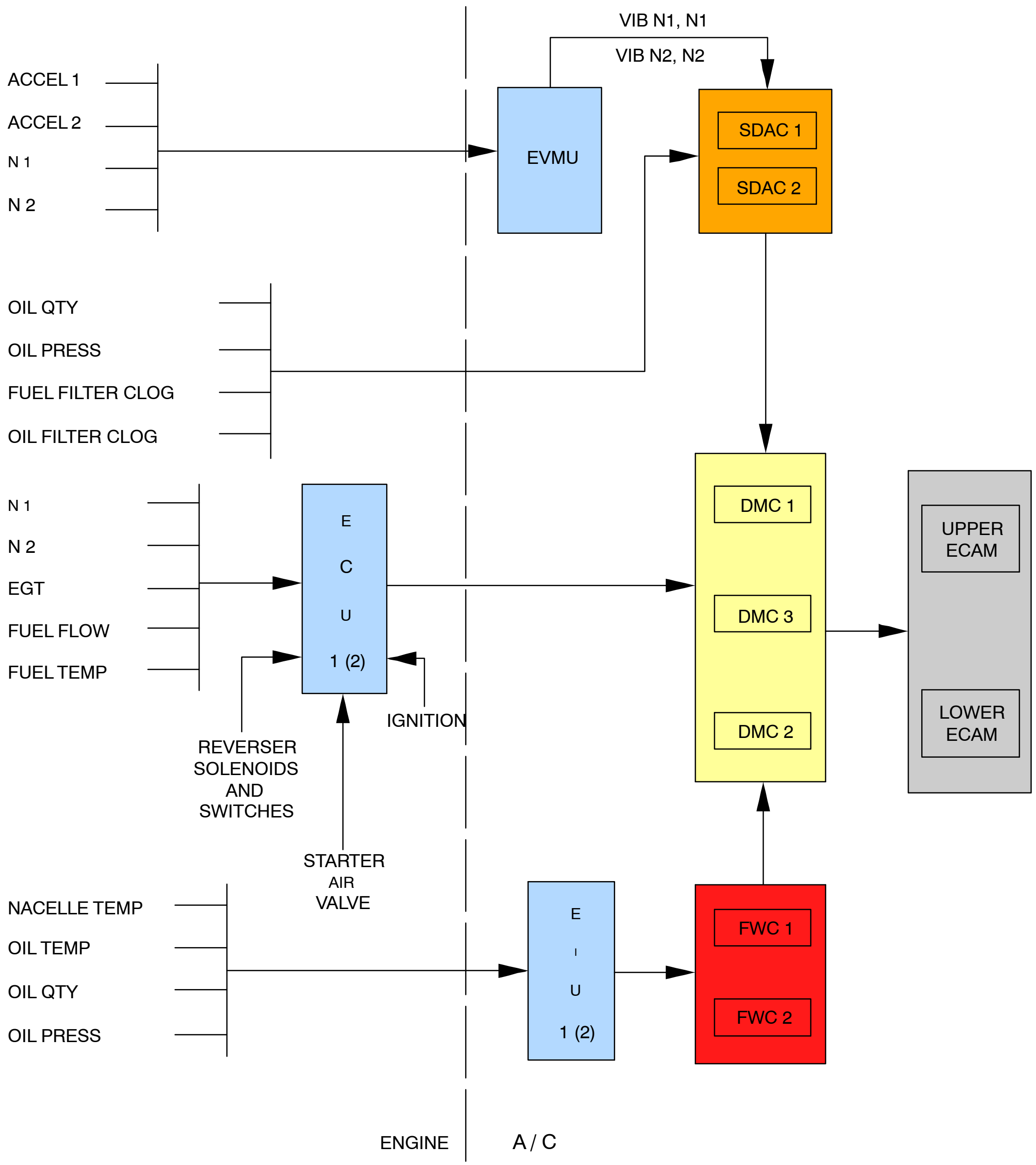


Figure 224 Engine Indication Schematic

ATA 30 ICE AND RAIN PROTECTION

30−21 ENGINE AIR INTAKE ICE PROTECTION

GENERAL INTRODUCTION

General

The ice protection system of the engine air intakes is normally selected only in icing conditions.

Ice protection heats the intake cowls with air bled from the engine compressor. The function of the ice protection of the engine air intakes is to supply bleed air to heat the inlet lip during icing encounters. This maintains the inlet duct of the engine free of harmful accumulation of ice.

The air bled from the fifth stage of the high compressor is the heat source. The anti ice shutoff valve provides the on−off control. The swirl nozzle distributes the air within the leading edge of the intake cowl. The spent air exhausts via a flush duct in the aft cavity of the intake cowl.

Source

Air is bled from high pressure compressor 5th stage of each engine.

Function

For each engine, hot bleed air is controlled by an OPEN/CLOSED valve. In the absence of air pressure, the valve is spring−loaded to the closed position. With air pressure available and solenoid energized, the valve closes. In case of loss of electrical power supply, the valve is fully open provided engine bleed air pressure is high enough.

For each engine, the OPEN/CLOSED valve is controlled by a P/BSW located on the ANTI ICE section of the overhead panel. When the engine anti−ice valve is open, the cabin Zone Controller (classic A/C) or Air Conditioning System Controller (enhanced A/C) determines the bleed demand for the Full Authority Digital Engine Control (FADEC) system.

This decreases the N1 limit relative to the ambient conditions, the engine operating conditions and the load of the anti ice bleed.

Indication

If at least one of the two engine air intake anti−ice protection systems is selected ON, a message appears in green on the upper ECAM MEMO display.

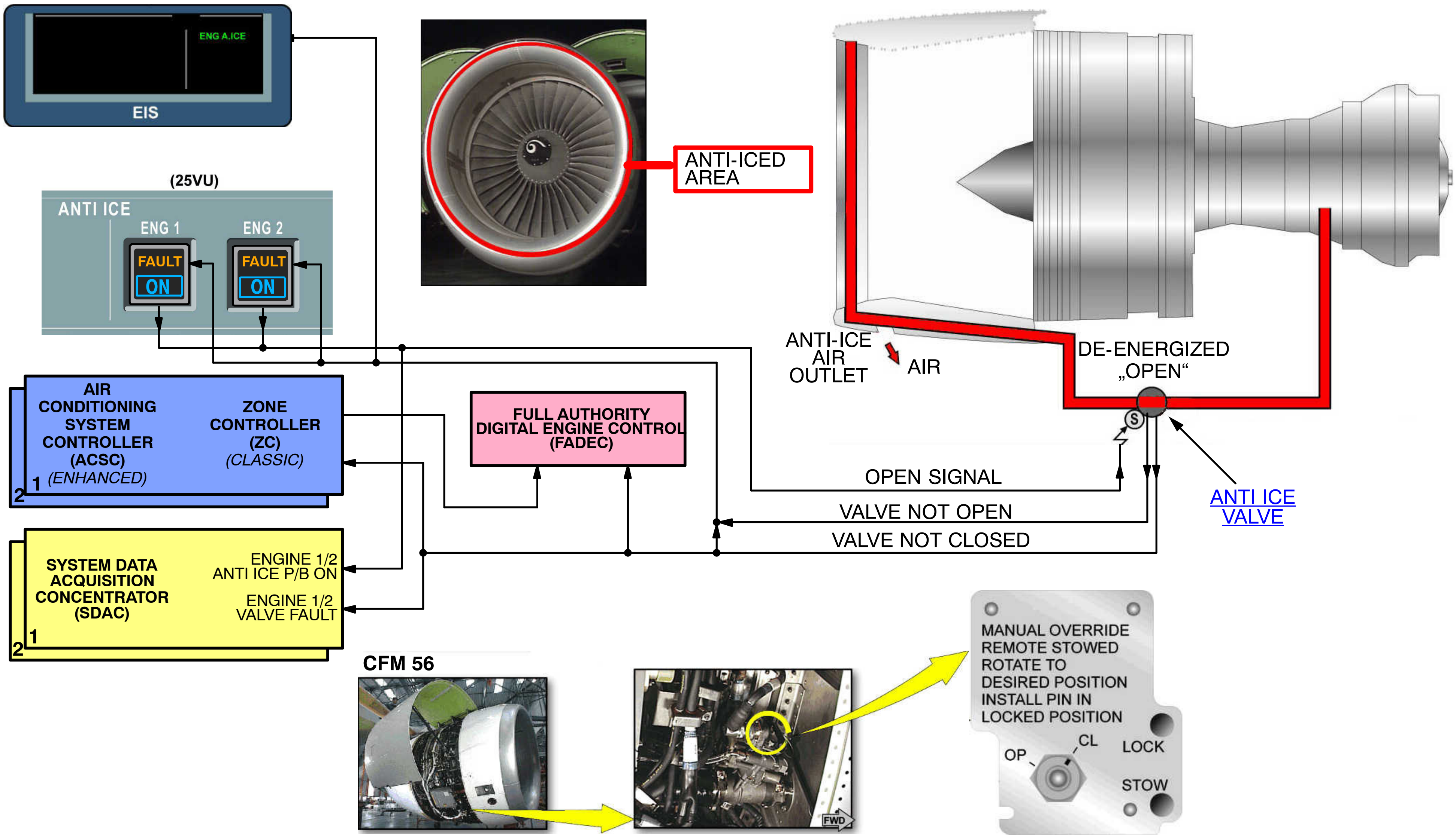


Figure 225 Engine Air Intake Ice Protection System

OPERATION/CONTROL AND INDICATING DESCRIPTION

GENERAL

The air bled from the fifth stage of the compressor passes through four duct sections and a line-mounted valve of the on-off type. At the forward bulkhead of the intake cowl, the anti ice system interfaces with the swirl nozzle in the intake lip. The spent air then enters the cavity of the intake cowl aft of the forward bulkhead: the air passes through holes in the inner cap of the bulkhead between the skin inner barrel and the bulkhead.

Finally, the air exhausts overboard through the flush duct in the outer barrel. The airflow pressure is controlled by an anti ice valve which is of the butterfly type and electrically operated. The safety position of the valve is full open.
Q = airflow (kg/s).

When the anti ice valve is open, the information is fed to the zone controller. The latter determines the configuration of the engine bleed air to control the FADEC: this decreases the N1 limit relative to the ambient conditions, the engine operating conditions and the load of the anti ice bleed.

CONTROL AND INDICATING

The control and indicating components are located on the overhead panel, on the ANTI ICE section of panel 25VU. Two pushbutton switches designated ENG 1 and ENG 2 are available, each associated with one engine.

Each pushbutton switch includes two luminous legends:

- ON (blue),
- FAULT (amber).

When you release the pushbutton switch, the ON legend is off and the system is not selected on. When you push the pushbutton switch, the ON legend is on and the system is selected on. Illumination of the FAULT legend indicates:

- With the ON legend off, the following failure:
  - the anti ice valve is not fully closed.

    It is necessary to push the ENG 1(2) pushbutton switch to extinguish the FAULT legend (the ON legend comes on).
- If the ON legend is on, the following failure:
  - the anti ice valve is not fully open.

    It is necessary to release the ENG 1(2) pushbutton switch to extinguish the FAULT legend (the ON legend goes off).

    If failure of the anti ice valve is detected on the ground, it is possible to lock the valve butterfly in either the open or closed position for the next flight.

The ENG ANTI ICE ON indication is displayed in green on the MEMO page on the lower part of the upper ECAM display unit if at least one of the two ice protection systems of the engine air intakes is selected on.

Central Warnings

Illumination of the FAULT legend of the ENG 1(2) pushbutton switch is accompanied by activation of the ECAM system:

- activation of the single chime,
- flashing of the amber MASTER CAUT light,
- warning display on the lower part of the upper ECAM display unit.

ANTI-ICE VALVE OVERPRESSURE INDICATOR (OPTION)

The anti-ice valve mechanical overpressure indicator has a release pressure that is set by the pressure reducer piston. When the pressure is between 120 psi (8.27 bar) and 180 psi (12.41 bar) the indicator will move to the extended position (pop out).

When the overpressure indicator on the anti-ice valve is in the extended position there is a problem with the regulator in the valve or there is a problem with the overpressure indicator.

The regulator in the valve is used to reduce the pressure inside the valve. When the pressure is reduced it extends the life of the seals of the actuator piston.

Failure of the regulator to reduce the actuator pressure will shorten the life of the piston seals. If the seals are not good and the piston does not operate correctly it can possibly cause the valve to move to the closed position. If the valve moves to the closed position the air will not flow through the valve or the anti-ice system.

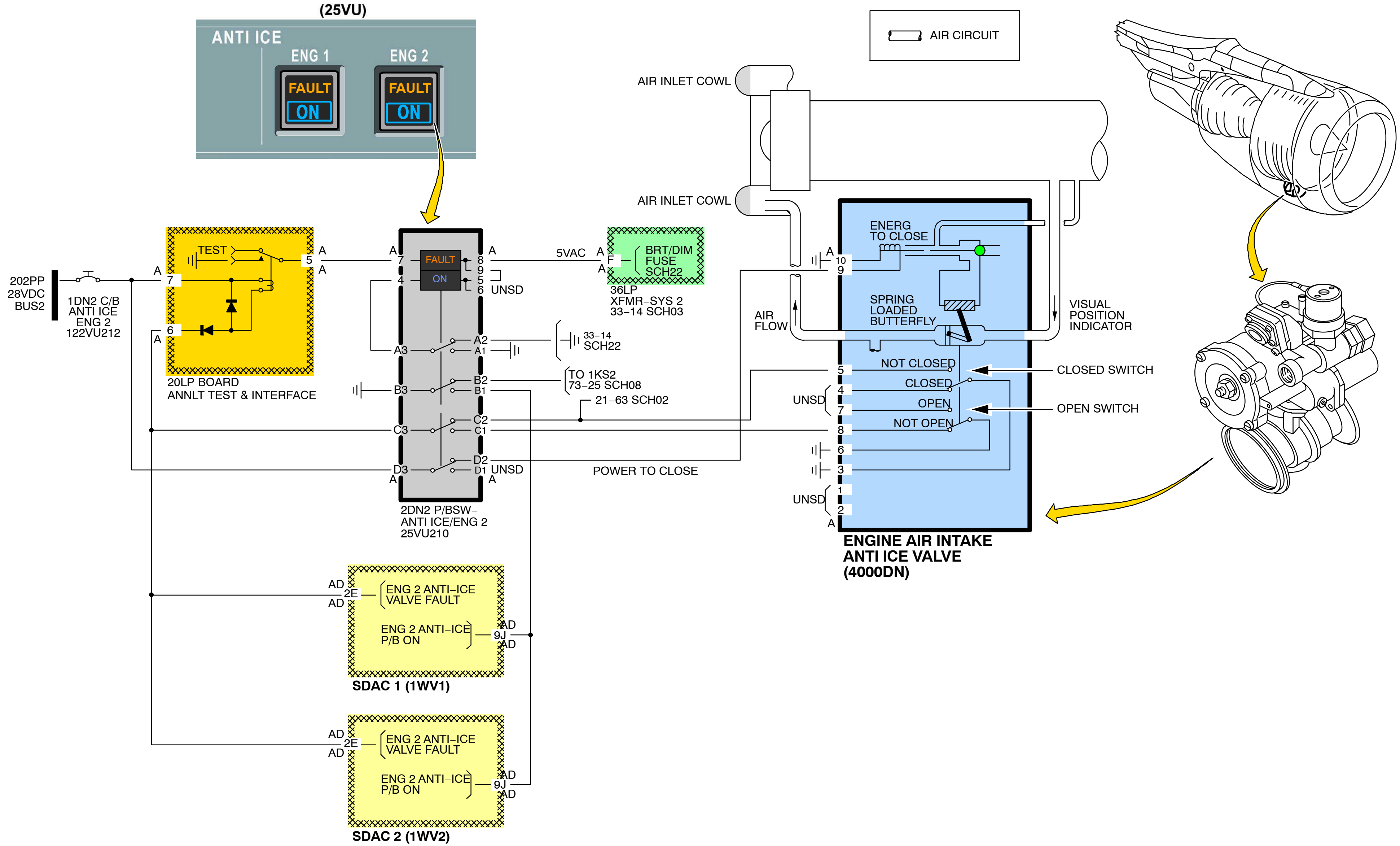


Figure 226 Control Schematic

MAINTENANCE PRACTICES

Engine Air Intake Anti Ice Valve Deactivation

WARNING: BE CAREFUL WHEN YOU WORK ON THE ENGINE COMPONENTS IMMEDIATELY AFTER THE ENGINE IS SHUTDOWN. THE ENGINE COMPONENTS CAN STAY HOT FOR UP TO ONE HOUR.

- Lock the intake anti-ice valve in the open or the closed position
- Remove the lock-pin from the transportation hole in the valve
- Use an applicable wrench on the nut and move the valve to the necessary position (open or closed)
- Hold the valve in the necessary position and install the lock-pin in to the valve locking hole

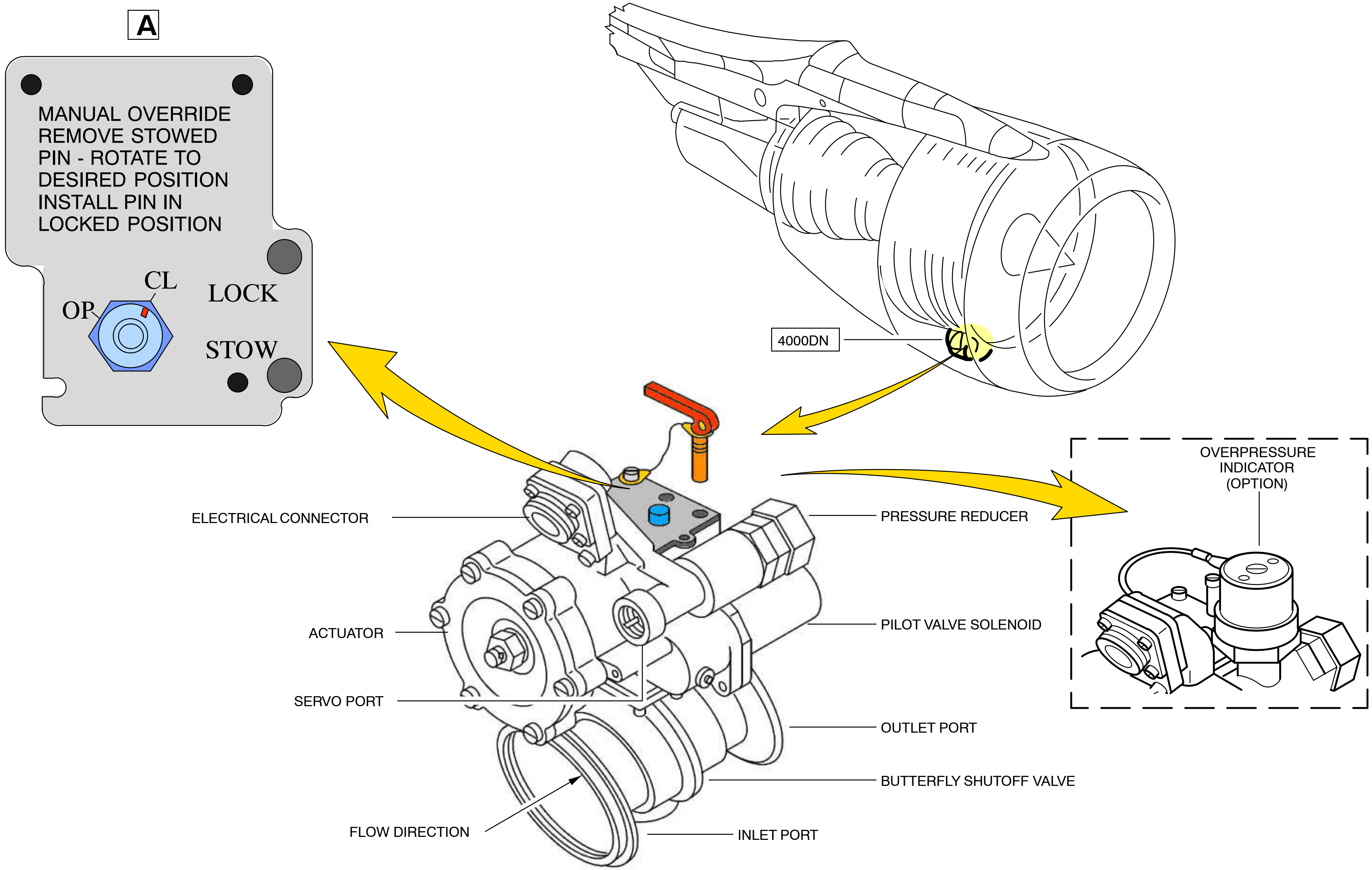


Figure 227 Engine Nacelle Anti ice Valve

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