CHAPTER 71 - POWER PLANT

TABLE OF CONTENTS

GENERAL ... **71-1**
ENGINE ASSEMBLY ... **71-2**
ENGINE FUEL SYSTEM ... **71-6**
OIL LUBRICATION SYSTEM ... **71-10**
ENGINE STARTING AND IGNITION SYSTEMS ... **71-14**
PROPELLERS ... **71-19**
CONTROL SYSTEM ... 71-19
AUTOFEATHER SYSTEM ... 71-31
PROPELLER SYNCHRONIZATION SYSTEM ... 71-34
PROPELLER BRAKE SYSTEM (left engine only) ... 71-35
POWER PLANT CONTROL ... **71-38**
POWER PLANT INDICATING SYSTEM ... **71-48**

LIST OF FIGURES

71-1 Engine 71-3
71-2 Engine Cooling Intakes 71-4
71-3 Engine Operation 71-5
71-4 Engine Fuel System 71-8
71-5 Engine Fuel System - Indicators 71-9
71-6 Power Module Lubrication....71-11
71-7 Propeller Reduction Gear Box (RGB) Lubrication 71-12
71-8 Lubrication System - Controls and Indicators....71-13
71-9 Engine Starting and Ignition Systems....71-17
71-10 Engine Starting and Ignition Systems - Controls and Indicators 71-18
71-11 Propeller Control System 71-20
71-12 Automatic Propeller Operating Modes....71-22
71-13 Blade Angles vs PVM-measured PL Position....71-23
71-14 Beta Lockout System (BLS) 71-24
71-15 Secondary Low Pitch Stop System (SLPS) 71-25
71-16 Overspeed Governor (OSG) 71-26
71-17 Feathering 71-27
71-18 Manual Propeller Operation (EPC Failure) 71-28
71-19 Propeller Control System - Controls and Indicators....71-30
71-20 Autofeather System....71-32
71-21 Autofeather System - Controls and Indicators 71-33
71-22 Propeller Synchronization System 71-34
71-23 Propeller Brake System (left engine) 71-36
71-24 Propeller Brake System - Controls and Indicators....71-37
71-25 Automatic Engine Control 71-40
71-26 Automatic Engine Control Failure 71-41
71-27 Engine Control Quadrant - Controls and Indicators....71-45
71-28 Power Plant Control System - Controls and Indicators 71-47
71-29 Normal Power Plant Readings....71-53
71-30 Backup Power Plant Readings....71-54
71-31 IEDS Screens Display Formats....71-55
71-32 IEDS Maintenance Screens 71-56
71-33 Power Plant Indicating System - Controls and Indicators....71-58

GENERAL

The aircraft has two turboprop engines housed in identical wing-mounted nacelles located symmetrically to the aircraft longitudinal axis.

Each power plant is attached to the wing structure by means of bars and flexible dampers which are intended to reduce vibration transmission to the rest of the aircraft. Each attachment has also an anti-torsion bar located beneath the propeller reduction gearbox. This reduces engine Casing rotation relative to the nacelle during operation.

Outside air is supplied to each engine through an s-shaped intake, which incorporates an inertial separator for ice or foreign particles ingestion avoidance. An inflatable boot system driven by engine bleed air prevents from intake ice accretion.

One special feature of this power plant is that air-cooled oil cooler (ACOC) LH engine discharge has an engine bleed air powered ejector intended to force cold air through the oil radiator when the engine is in APU mode (propeller brake operated), when there is no propeller blow.

Each power plant has a Pratt & Whitney Canada PW127G engine driving a six-blade, variable-pitch Hamilton Sundstrand 568F-5 propeller.

Each engine is able to deliver 2645 SHP for normal take-off (NTO) at sea level with outside temperatures of up to 35º. If an engine fails during take-off, the Automatic Power Reserve (APR) system can automatically increase the other engine power up to 2920 SHP.

Engine exhaust gases are discharged outside through an eductor. This has an exhaust nozzle (primary) which discharges exhaust gases into an external concentric exhaust duct (secondary). This acts as a Venturi pump to draw air from engine compartment, engine anti-surge valve (HBV, Handling Bleed Valve) and pneumatic system precooler.

ENGINE ASSEMBLY

Engine purpose is to transform fuel energy-content into mechanical power at the propeller shaft.

DESCRIPTION

The PW127G is a free-turbine turboprop with a two-stage gas generator (high and low pressures HP and LP, respectively) and a power turbine. There are three mechanically-separate shafts turning at different speeds and in opposite turning directions.

– High-pressure spool, which turns at NH, consists of a single-stage axial turbine which drives a centrifugal compressor and the accessory gearbox (AGB).

– Low-pressure spool turns at NL, consists of a single-stage axial turbine which drives a centrifugal compressor by means of a shaft which runs inside the high pressure spool shaft centre.

– Power spool, including a two-stage free axial turbine. The free axial turbine shaft runs inside the low-pressure spool centre and drives the propeller reduction gearbox (RGB).

This configuration allows the engine starting torque to be relatively low, easing start-up by only requiring to drive the NH shaft during start-up.

Basically, the engine assembly has a propeller reduction gearbox (RGB) and a power module.

Propeller Reduction Gear Box (RGB)

The propeller reduction gearbox (RGB) is intended to transmit turbine rotating power and reduce it to an appropriate propeller speed (it is reduced from a turbine speed of 20000 rpm to approximately 1200 rpm at the propeller).

As well as reduction gears, RGB comprises:

– Auxiliary Feathering Pump

– Main Oil Pump for propeller pitch control

– Hydraulic/Mechanical Propeller Control by means of Propeller Valve Module (PVM)

– Propeller Overspeed Control, by means of Overspeed Governor (OSG)

– Alternator

LH engine RGB has a hydraulic brake which, when on-ground operated (APU mode) allows the engine to be used as both aircraft electrical power and air-conditioning sources.

Power Module

The power module has a gas generator and a free turbine, which shaft runs inside gas generator shafts to drive the reduction gearbox (RGB). The power module is intended to convert fuel energy content into mechanical power at RGB. To that purpose it forces outside cold air through two separate centrifugal compressors (LP and HP) once compressed, the air is fed into a reverse flow annular combustion chamber where air is mixed with fuel from 14 injectors; and the mixture is ignited by two igniters. Combustion gases expand through two gas turbine generators (LP and HP, which drive their relevant centrifugal compressors) and the two-stage power turbine, which drives the propeller through the RGB.

At each compressor outlet there are bleed air outlets connected to the pneumatic system. These discharge to the atmosphere through a handling bleed (anti-surge) valve on the compressor (HBV) to avoid any surge when power is changed abruptly. The pneumatic system powers a number of aircraft systems, such as air-conditioning, ice protection, pressurization, rudder booster, and LH engine oil cooler ejector.

Both EEC (Electronic Engine Control) and AFU (Autofeather Unit) are located at the front-top of each power module. At the rear, both fuel heater and exciters are located. Also located at the top of the module and meshed with the high pressure spool, is the accessory gear box (AGB), which drives:

– Oil Pump
– Engine Fuel Pump
– Generator/Starter
– Mechanical Fuel Control Unit (MFCU)

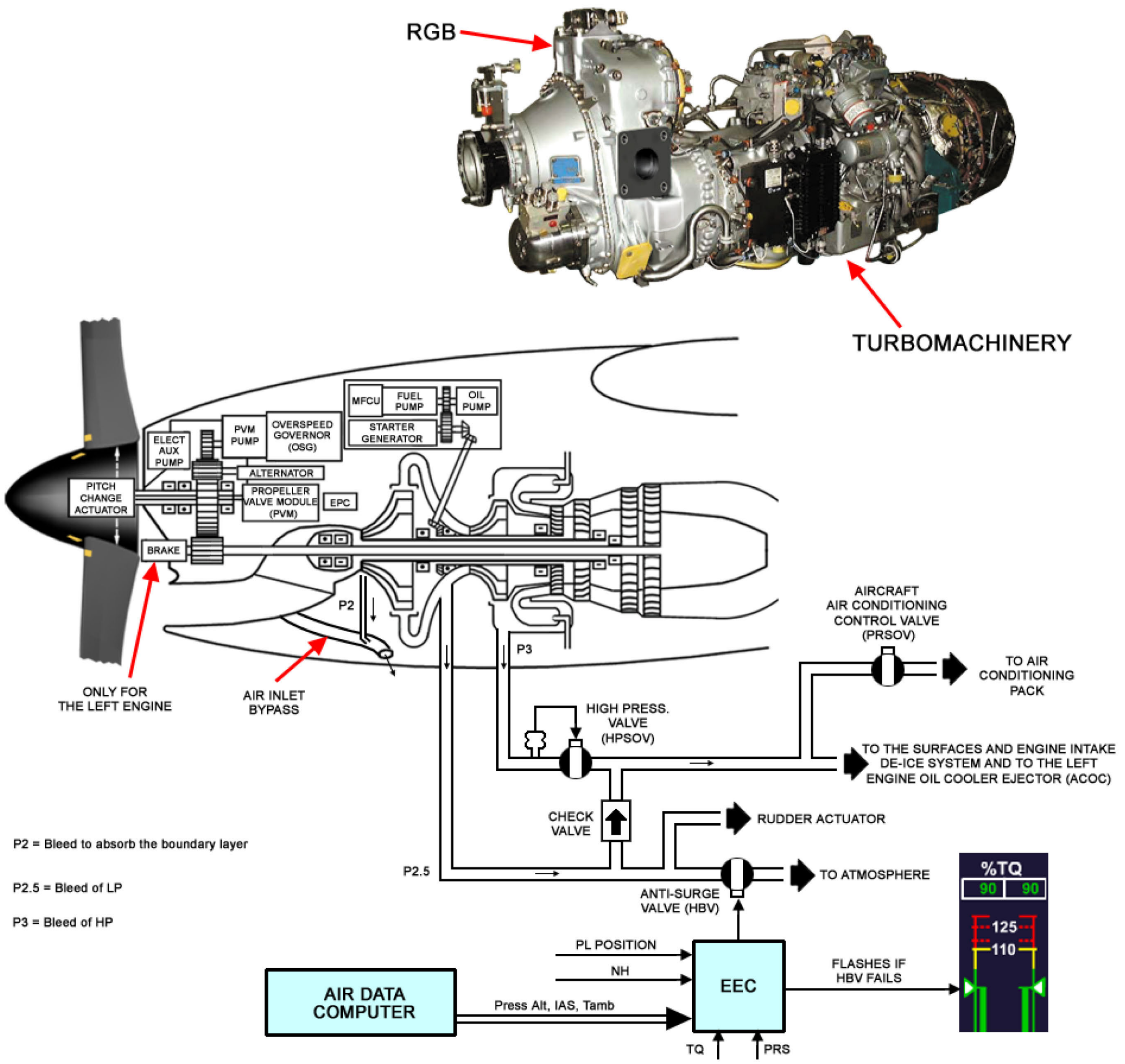


Figure 71-1 Engine

Engine-Cooling System

The engine-cooling system is intended to prevent engine, engine compartment, and/or other power plant components, such as air-cooled oil cooler (ACOC) alternator, and engine generator/starter from overheating.

– ***Engine Compartment Cooling:*** engine compartment is cooled by a pair of scoop intakes, one at each side of the spinner, allowing cold air to be drawn-in to cool the engine zone. Air entering the engine compartment is pumped to the exhaust through an eductor. This eductor also expels the air discharged by the pneumatic system precooler and the compressor anti-surge valve (HBV).

– ***Oil Cooling:*** oil system takes in cold air from a NACA inlet located beneath the fairing and subsequently returns it to the atmosphere. LH engine discharge duct also includes an air ejector (from HP engine bleed) to force cold air through the oil cooler in APU mode (propeller braked) and when the oil reaches high temperatures (over 100ºC).

– ***Alternator Cooling:*** alternator is cooled by air from a NACA inlet located at the left-front fairing. The air is discharged into the engine compartment.

– ***Generator/Starter -Cooling:*** the generator/starter is cooled by air from a NACA inlet located at the right-front fairing. The air is discharged to the atmosphere through an outlet.

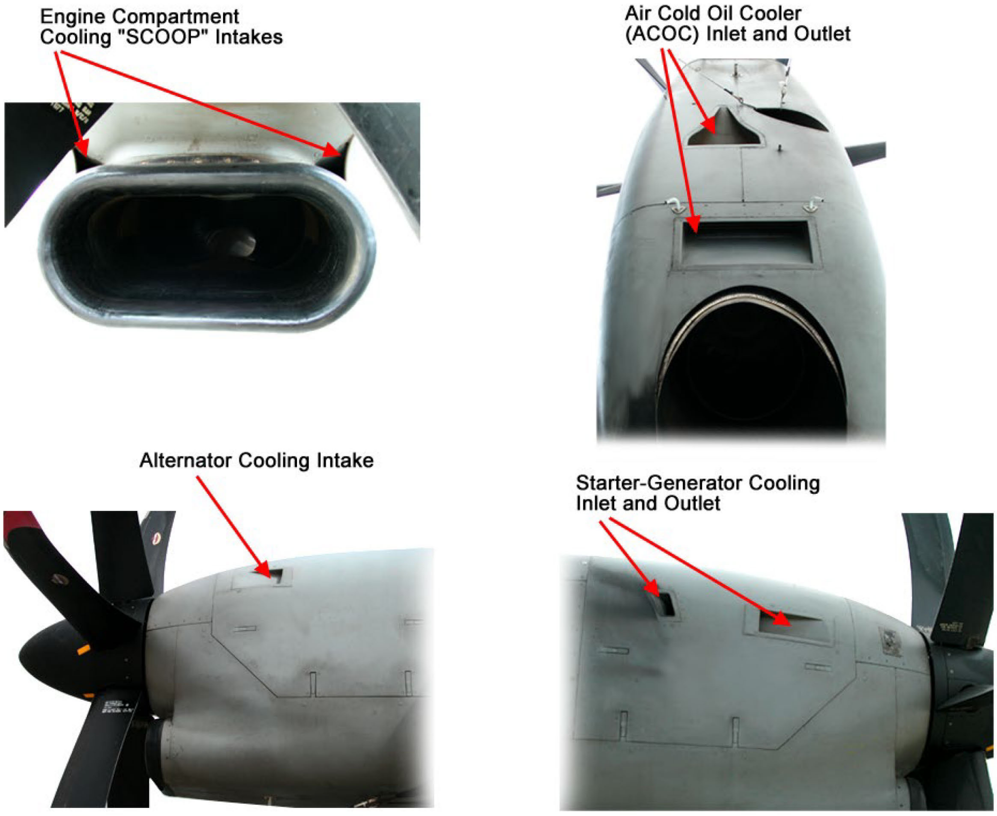


Figure 71-2 Engine Cooling Intakes

OPERATION

Engine starting sequence initiates when the generator/starter (working in starter mode) turns the high-pressure compressor. The air is forced into the combustion chamber and mixed with fed-fuel by the injectors when a given HP compressor speed is reached (NH). Fuel-air mixture is then ignited by the two igniters. This continuous combustion accelerates the engine until idle speed is reached. At this point, ignition is disconnected and the generator/starter starts working in generator mode. Through the process the power turbine and therefore the propeller, also accelerate until stable speeds below normal operating speeds are reached (as the engine is started-up with propeller feathered).

Once the engine has started-up, power plant control systems adjust both fuel flow and propeller pitch as well to appropriate values according to operating conditions.

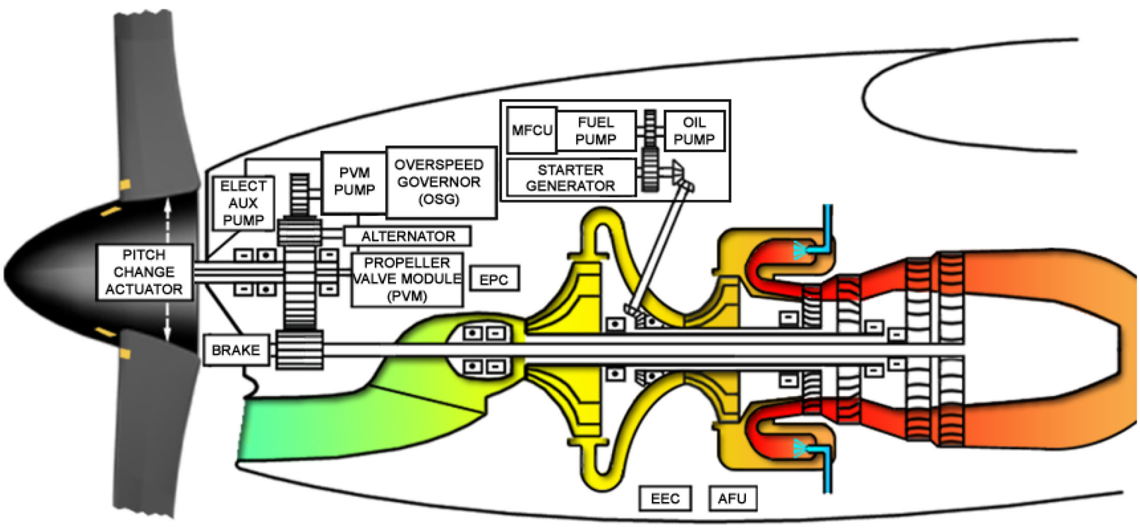


Figure 71-3 Engine Operation

ENGINE FUEL SYSTEM

Engine fuel system is intended to supply with required fuel, combustion chamber in appropriate cleanliness, temperature and pressure conditions. Controlling the fuel supply (and the propeller control as well) enables to control traction as power plant delivered.

DESCRIPTION AND OPERATION

Main system components are:

– ***Fuel Heater:*** filters and heats fuel from tanks.

– ***Engine Fuel Pump:*** accessory gearbox (AGB) driven.

– ***Mechanical Fuel Control Unit (MFCU):*** regulates engine-entering fuel flow, and thus power.

– ***Fuel-Cooled Oil Cooler (FCOC):*** an oil-fuel heat exchanger located at RGB inlet.

– ***Flow and Discharge Divider:*** distributes fuel to the injectors and drains collectors while the engine is stopped.

– ***Collectors and Injectors:*** drives fuel and atomize it at combustion chamber.

– ***Drain Tank:*** collects fuel as drained-off from flow divider and discharge.

– ***Motion Flow Divider:*** supplies high-pressure fuel to the jet pump located at the main wing tank.

– ***Electronic Engine Control (EEC):*** controls (jointly with MFCU) engine power by regulating fuel flow supplied to combustion chamber.

The system takes fuel from aircraft tanks, filters it and warms it by means of fuel heater lubricating oil. Fuel is then pressurized at accessory gearbox (AGB) driven fuel pump. Part of the fuel flow is sent to the main wing tank jet pump. The rest of the fuel is dosed by the MFCU and passes through the engine fuel-cooled oil cooler and a flow meter which sends a fuel flow reading to the cockpit where it is IEDS-displayed. The fuel then flows to the flow divider, and from here to combustion chamber 14 injectors.

Once the engine is stopped, fuel at injectors is drained through the flow divider and discharge, to avoid carbon deposits. Drained fuel is piped to the drain tank, which returns it to the system next time the engine is started-up.

Both fuel heater and engine fuel pump have a filter (to prevent fuel heater and injectors, from contamination), a bypass valve (to ensure fuel can flow even if filter blocking is excessive) and a differential pressure sensor, which generates an IEDS maintenance (NEW EXCEEDANCE) signal if the filter is partially blocked. Filter blocked signal is enough in-advance, to ensure bypass does not need to open, so as to prevent fuel heater, pump or injectors from contamination.

If fuel exits the fuel heater below 4ºC (approx.) IEDS will display 1, 2 FUEL C caution. If pressure drops below 9 PSI (approx.) IEDS will display 1, 2 FUEL P caution.

IEDS fuel flow (FUEL FLOW) legend can be displayed in either lb/h or kg/h, depending on the selection made on the maintenance menu.

IEDS fuel consumption reading can be displayed in either lb or kg, depending on the selection made on the maintenance menu (where reading can also be set to zero).

Fuel flow is controlled by both power lever (PL), and fuel and feather lever (FFL), as well as by mechanical fuel control unit (MFCU) and electronic engine control (EEC). EEC operates according to the position selected on the power range selector (PRS).

EEC operates MFCU to control fuel flow in response to the signals it receives from aircraft and engines to ensure PRS and PL powers are engine-delivered under all flight conditions. It also controls engine anti-surge valve (HBV), autoignition, auxiliary power reserve (APR), minimum propeller speed (NP) regulation and rudder booster actuation. It is also responsible for detecting, managing and memory-saving any failures that might take place.

Fuel is diversely-dosed by the MFCU depending on the mode of operation (AUTOMATIC or MANUAL). In both cases, MFCU receives a PL mechanical signal and converts it into an electrical one which is sent to the EEC. The system limits the maximum speed (NH) depending on its current mode of operation:

– In AUTOMATIC MODE EEC controls MFCU for fuel control purposes depending on outside conditions, PL position and PRS.

– If EEC (or processed signals) fails, relevant 1, 2 EEC caution will be IEDS-displayed. In this case, EEC-regulated power is fixed (fail fix) and does not respond to any PL position change, unless PL is retarded below a given position (between MAX AUTO and FI), thus going into MANUAL MODE control. If EEC is operative it is possible to change from automatic mode to manual mode by pressing-in the relevant L, R ENGINE pushbutton (MAN light on) on the ELECTRONIC CONTROL/STATUS control panel. In manual mode, fuel flow is separately EEC-regulated by setting an NH value for each PL position.

Engine is started-up with PL in ground idle (GI) or flight idle (FI) position-as proceeds, and forwarding FFL from OFF to START positions, once reached a given NH value.

In order to stop the engine, FFL is retarded to the OFF position.

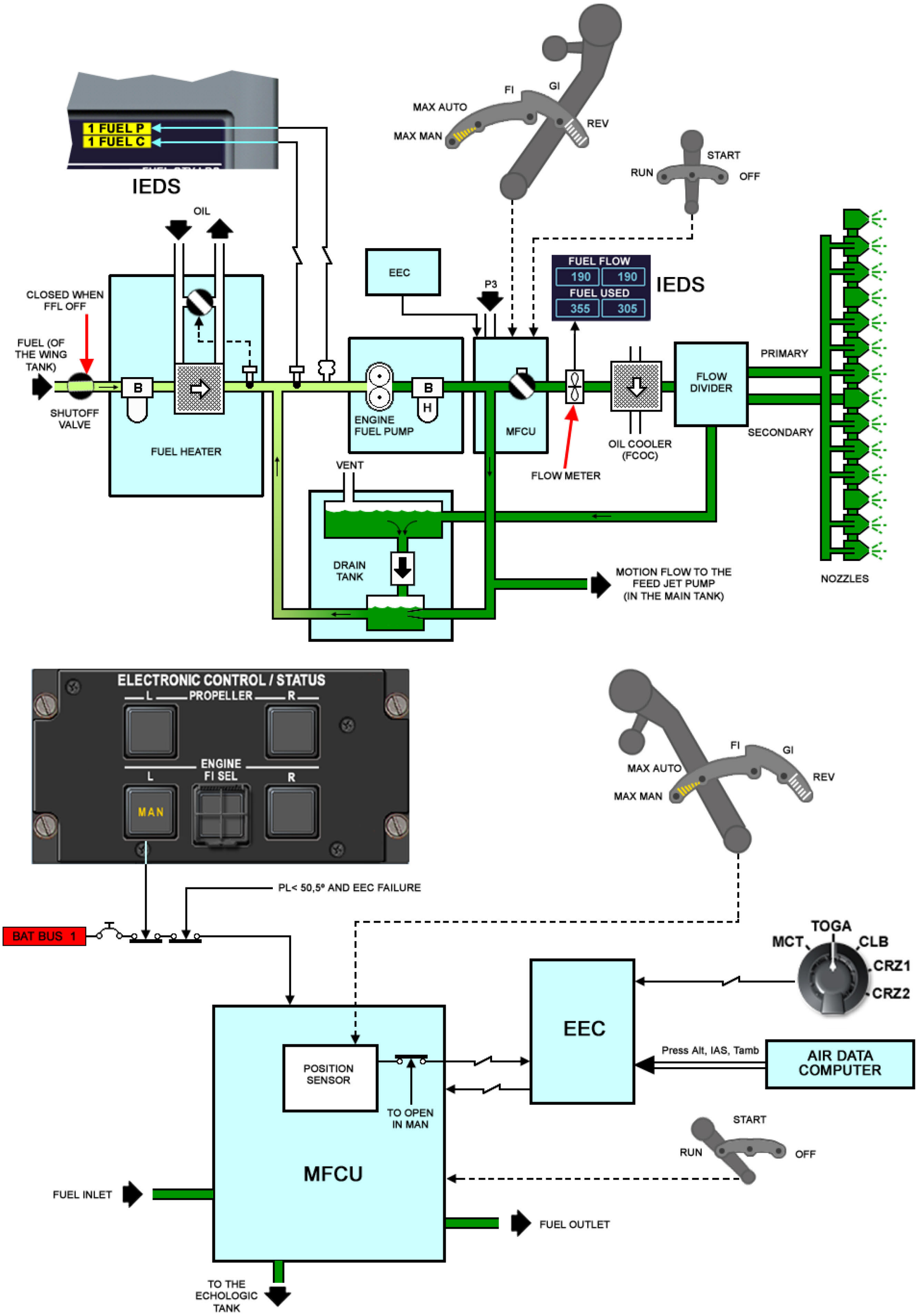


Figure 71-4 Engine Fuel System

CONTROLS AND INDICATORS

(1) 1, 2 FUEL C Caution (IEDS):

Fuel temperature at heater outlet below 4ºC.

(2) 1, 2 FUEL P Caution (IEDS):

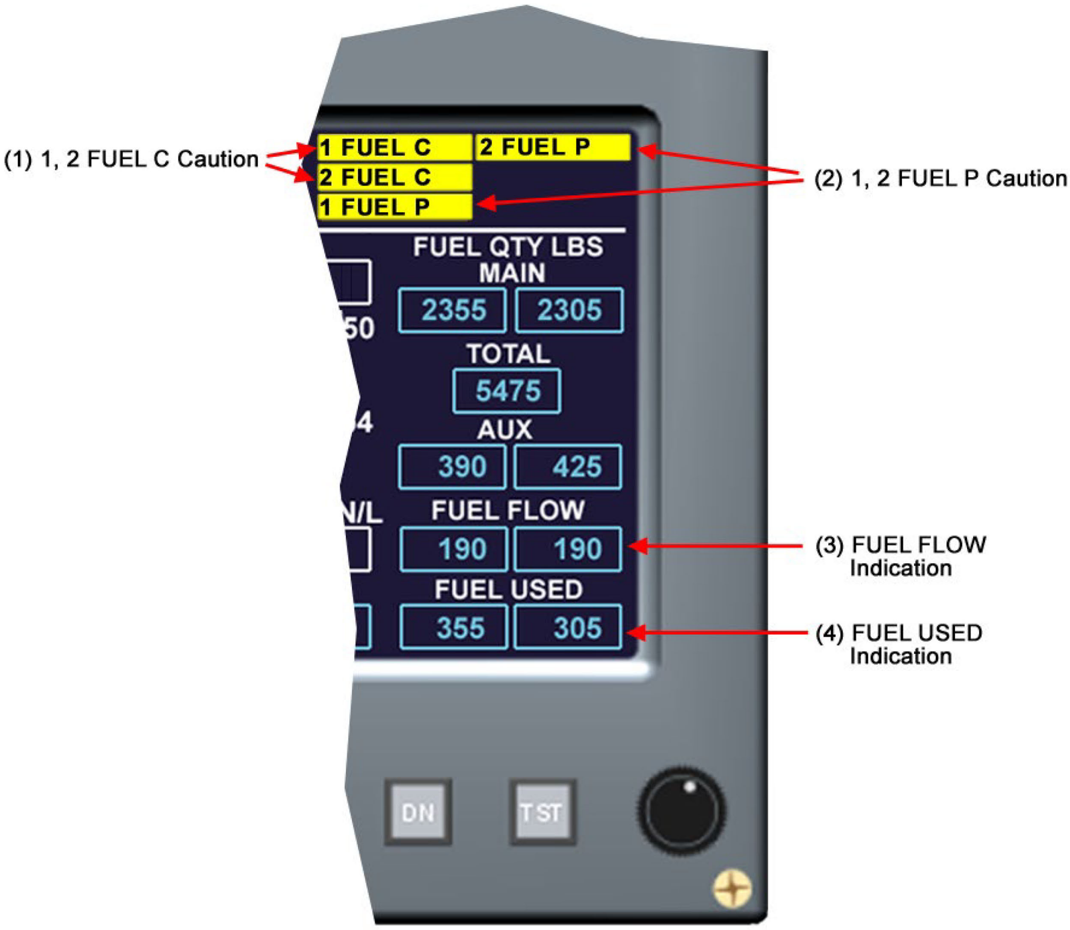
Fuel pressure at engine fuel pump inlet, below 9 PSI.

(3) FUEL FLOW Indication (IEDS):

Fuel flow entering the engine in either lb/h or kg/h (units can be IEDS-selected at the maintenance menu).

(4) FUEL USED Indication (IEDS):

Engine-used fuel in either lb or kg since the reading was IEDS set to zero from maintenance menu.



IEDS

Figure 71-5 Engine Fuel System - Indicators

OIL LUBRICATION SYSTEM

DESCRIPTION

There are two different zones in the power plant that use oil for lubrication: engine and propeller rotating parts, and the rest of the power plant components.

First of these, uses oil stored at the sealed spinner, with no required control, indications or other components.

The second is fully independent from the first and is described below. Each engine has its own lubrication system, which is shared by both its power module and RGB. Intended to lubricate, clean and cool the below mentioned components, keeping the oil at adequate conditions in terms of temperature, pressure and cleanliness:

– Power module rotating components.

– Accessory gearbox (AGB)

– RGB rotating components

– Propeller pitch control components

In addition, the system provides anti-icing protection to engine intake, heats fuel entering the engine, and supplies oil as required by the propeller pitch control system.

Main components are:

– ***Main Oil Tank:*** built-in to the engine air intake, is fitted with quick release cap filler neck, a sight glass showing the quantity of oil in the tank, chip detector (to detect metal particles) and drain plug.

– ***Oil Pump (Pressure Pump):*** fitted with two scavenge pumps. A safety valve prevents from pressure increase during cold starting by returning oil excess to the main oil tank.

– ***Air-Cooled Oil Cooler (ACOC):*** located at the base of the nacelle, cools the oil with outside air. Includes a by-pass valve for temperature oil flow ACOC regulation.

– ***ACOC Ejector Valve (LH engine only):*** forces cold air through the radiator while LH engine operates in APU mode (with propeller braked).

– ***Pressure Regulating Valve***

– ***Oil Filters (two):*** includes a by-pass valve ensuring oil flows even in case of blocked filter, and a differential pressure sensor generating an IEDS maintenance signal (NEW EXCEEDANCE) enough in advance to ensure by-pass valve does not open, thus preventing from contaminated oil flowing through the valve and reaching other components.

– ***Check Valve:*** delays engine bearings oil supply until air pressure increases enough to seal the cavities in which they are housed. This prevents the seals from oil leakage while engine starts and stops.

– ***Oil Temperature Sensor:*** measures oil temperature and sends the information to the IEDS.

– ***Oil Pressure Sensor:*** measures oil pressure and sends the information to the IEDS.

– ***RGB Auxiliary Tank:*** stores oil to be used by the RGB lubrication system.

– ***RGB Chip Detector:*** sends IEDS recordable signals from the RGB lubrication system for subsequent maintenance procedures.

POWER MODULE LUBRICATION

Pressure pump sucks oil from the main tank and forces it through the air-cooled oil cooler (ACOC). From the ACOC the oil is fed to the pressure regulator valve as well as to the filter. This oil is partially fed to the power module and the rest to the RGB.

At the power module the oil heats the engine intake (INLET HOLLOW STRUTS) to avoid ice accretion and lubricates both engine bearings and accessory gearbox (AGB) prior to return to the main tank by gravity and by means of the scavenge pump.

Both chip detector (if any chip is detected) and the filters (partial blockage is detected) send IEDS-recordable signals for subsequent maintenance-download purposes.

A temperature sensor and a pressure sensor send IEDS signals, thus cockpit displaying oil temperature and pressure readings (in ºC and PSI, respectively). If oil pressure is below 40 PSI (approx.) 1 or 2 E/OIL P warning is IEDS-displayed.

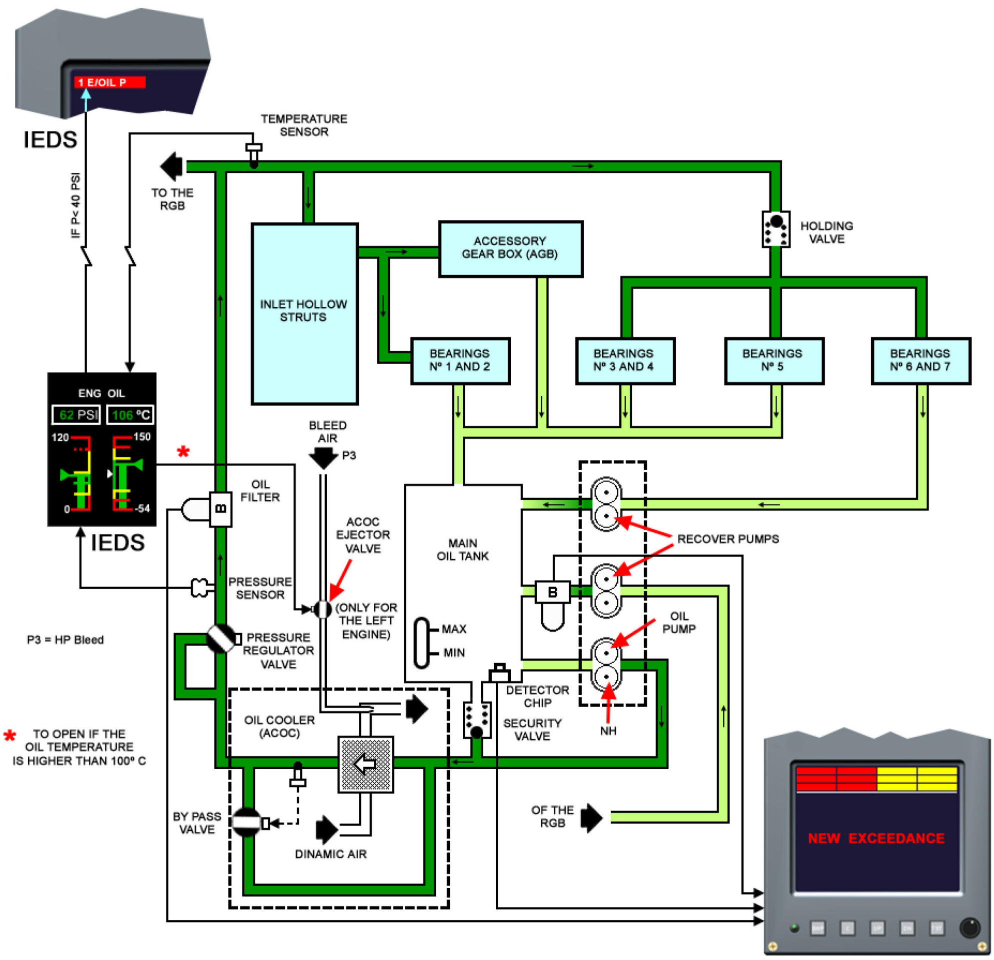


Figure 71-6 Power Module Lubrication

PROPELLER REDUCTION GEARBOX (RGB) LUBRICATION

Pressure pump forces oil to the RGB, which flows through two heat exchangers where it is fuel-cooled at the fuel heater and the fuel cooled oil cooler (FCOC). Prior to be fed to the auxiliary propeller oil tank, located at the RGB. This tank ensures both propeller valve module (PVM) and overspeed governor (OSG) to be oil supplied, even if the power module system fails. Propeller pitch control oil is therefore circulated by the main oil pump, which is driven by the RGB or the auxiliary feathering pump, if main pump fails. Oil also lubricates both gears and bearings at the RGB where another chip detector is located, prior to return to the main tank. Chip detector sends IEDS-recordable signals for subsequent maintenance downloading purposes.

Oil from the RGB flows through engine inlet (INLET HOLLOW LIP), heating it to prevent from ice accretion. Finally, oil is returned to the main tank by a scavenge pump.

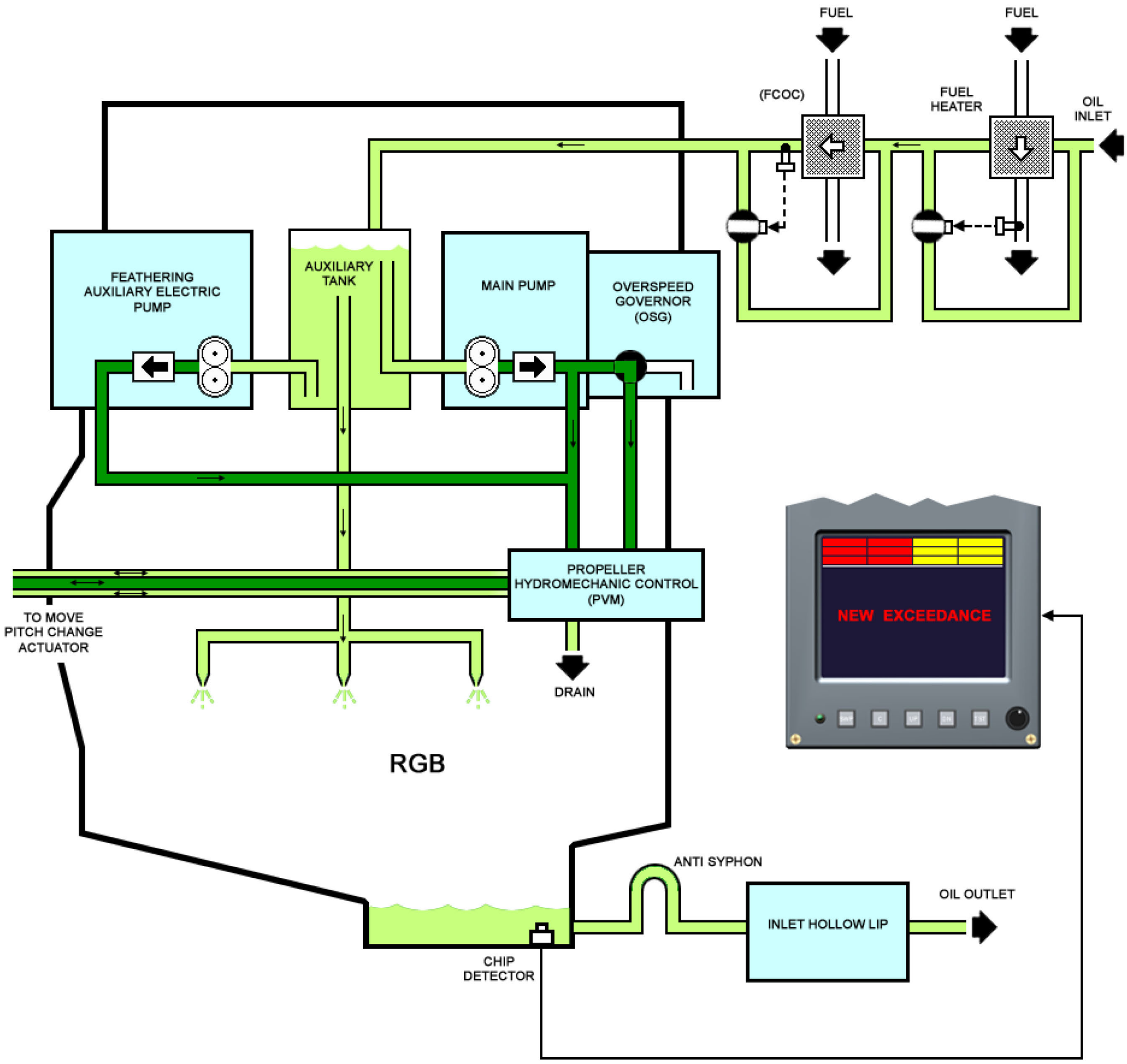


Figure 71-7 Propeller Reduction Gear Box (RGB) Lubrication

CONTROLS AND INDICATORS

(1) (IEDS) 1, 2 E/OIL P Warning:

Oil pressure at power module lubrication distributor is below 40 PSI.

(2) (IEDS) Engine Oil Temperature Indication:

Indicates lubricating oil temperature in centigrade degrees on both scale and numerical readings.

(3) (IEDS) Engine Oil Pressure Indication:

Indicates lubricating oil pressure in PSI on both scale and numerical readings.

(IEDS) Chip Detectors and Filters NEW EXCEEDANCES:

IEDS-displayed, to indicate particles in tanks that might block filters so that crew do properly notify maintenance personnel. Indications are displayed with grounded aircraft and engines being stopped.

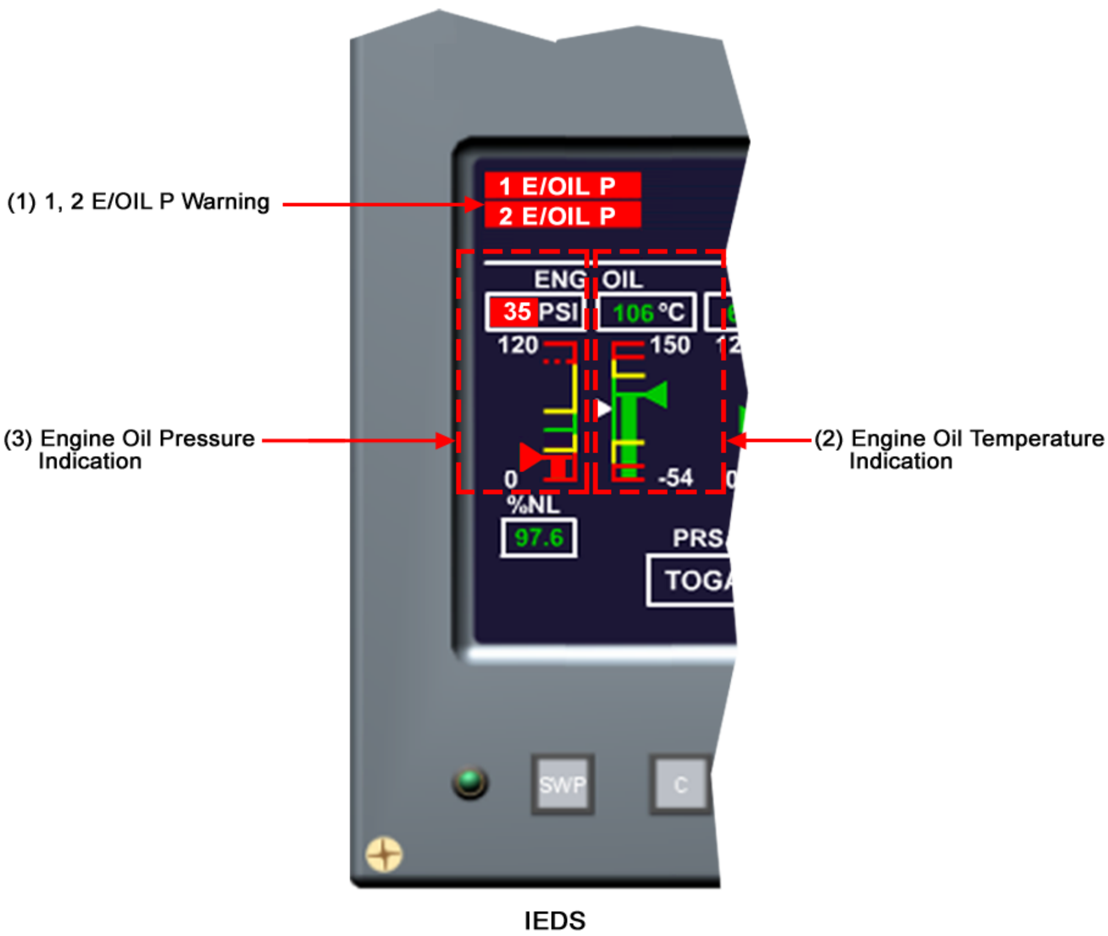


Figure 71-8 Lubrication System - Controls and Indicators

ENGINE STARTING AND IGNITION SYSTEMS

DESCRIPTION

Engine starting system is intended to turn the engine during starting, provide ventilation (engine turning without combustion) and other maintenance actions.

Ignition system is intended to generate air-fuel mixture combustion at the engine combustion chamber when engine start-up procedure initiates.

The engine is turned by a starter/generator operating in starter mode, which meshes with the high-pressure compressor through the accessory gearbox (AGB). The starter/generator changes mode always controlled by the generator control unit (GCU). Starter mode is inhibited when reaching 50% of NH. Generator mode starts when reaching 62% of NH.

Ignition is generated by two igniters located at the combustion chamber, each of them powered by an exciter.

Main engine starting and ignition system components are:

– ***Starter-Generator (one per engine):*** primary acting as starter motor to turn the high-pressure compressor until self-sustained speed is reached. Then it acts as a generator. The unit is fitted with overheat protection and a fan.

– ***Exciter (two per engine):*** a sealed unit containing an electrical circuit which transforms input DC voltage into high-voltage output for the igniters by charging/discharging a condenser.

– ***Igniters (two per engine):*** these produce sparks as required to ignite air-fuel mixture using the exciter-supplied power.

– ***ENGINE START Control Panel:*** located at the cockpit overhead panel, allows controlling and monitoring the system.

OPERATION

The starting and ignition circuit allows three ways of engine starting:

– *By means of a Ground Power Unit (GPU):* DC GPU is connected (ON and GPU lights on the POWER GENERATION control panel DC EXT pushbutton are on) and supplies enough power to turn the starter-generator. MODE SEL selector is in GPU/X START position for this operation.

NOTE

Engine cannot be started by means of AC GPU.

– *By means of aircraft own batteries:* GPU is not connected and both aircraft-batteries (connected in parallel) power is used to turn the starter-generator. MODE SEL selector is in BAT position for this operation.

NOTE

With a single battery, it is not possible to start the engine.

NOTE

With one engine operative and the MODE SEL in BAT, the operative generator is isolated from the rest of the electrical system.

– *By starting the second engine with the help of the first one (cross start):* Cross start allows the engine to be started-up using electrical power from two batteries connected in parallel, aided by the running engine. MODE SEL selector is in GPU/X START position for this operation.

NOTE

MODE SEL switch has a sole GPU/X START position. When this position is selected GPU starting mode will be used only if GPU is connected.

Once this starting mode has been selected, ENGINE SEL switch allows the pilot to select the engine to be started-up. When ENGINE SEL switch is positioned in either L or R positions, ARM light on the engine-associated START pushbutton comes on, indicating the starter-generator is ready to function as a starter.

When IGN pushbutton is pressed-in ARM light comes on to indicate ignition is ready. At this point exciters are energized and start sparks-generation at the combustion chamber. Exciters remain energized until IGN pushbutton is pressed out.

In addition, the starting system has an automatic circuit (AUTOIGNITION) which connects it (even with IGN pushbutton out) if EEC detects any NH rapid deceleration below 64.4% with propeller unfeathered. This feature enables even engine-recovery in case of flameout. If re-light is unsuccessful and NH continues decreasing, EEC disconnects ignition at 30% NH.

Starter-generator starts turning the high-pressure compressor when START pushbutton is pressed-in. Starter stops turning the compressor at 50% NH, but ARM light on START pushbutton does not go-off until ENGINE SEL switch is set to OFF position.

In order to supply fuel for ignition at the combustion chamber, FFL is moved forward to START (at 10% NH if ITT < 250ºC, or at 15% NH if ITT ≥ 250 °C).

At 50% NH, starter-generator automatically disconnects now the engine is self-sustained.

At 62% NH starter-generator switches to generator mode.

Finally, at 66% NH (approx.) the engine stabilizes at ground idle (GI).

Described operations sequence is valid for GPU start-up. In BAT mode operations sequence is similar, but power is supplied by onboard batteries. These are connected in parallel throughout the starting process. In cross start (X START), which can obviously be used only if one engine is already running, both batteries remain connected in parallel throughout the sequence. However, they are aided by the running engine generator, which is automatically connected in parallel with the batteries between 12% and 50% NH.

The starting sequence is automatically controlled by NH signals generated by a sensor in the starter-generator. If the sensor does not send NH signals when engine starting initiates, FAIL light on engine START pushbutton will come on. As well as if starter-generator does not automatically disconnect at 50% NH.

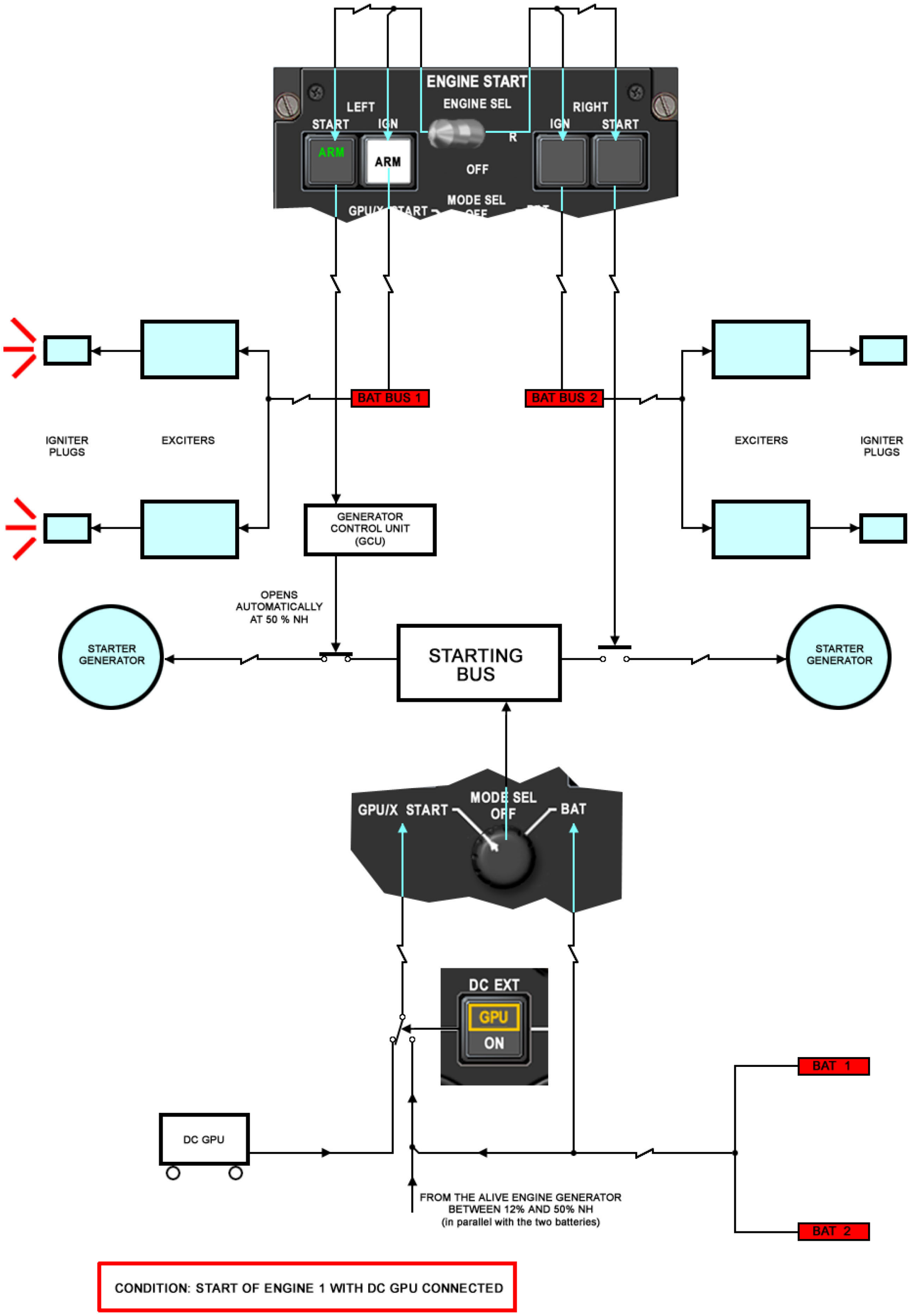


Figure 71-9 Engine Starting and Ignition Systems

CONTROLS AND INDICATORS

(1) MODE SEL Selector:

- *GPU/X START:* circuit can be DC GPU (if connected) powered or from both batteries (connected in parallel throughout the starting sequence), aided by the other engine generator, which is connected in parallel with the batteries between 12% and 50% NH.

- *BAT:* circuit is powered from both batteries, which are connected in parallel throughout the starting sequence, until 50% NH is reached.

(2) ENGINE SEL Selector:

- *L:* engine selected for starting is No. 1 engine (ARM light on the LH START pushbutton comes-on).

- *R:* engine selected for starting is No. 2 engine (ARM light on the RH START pushbutton comes-on).

(3) START Pushbutton:

- *ARM light on:* corresponding engine has been selected for starting on the ENGINE SEL selector. The starter-generator circuit receives available power when START pushbutton is momentarily pushed-in. The circuit will disconnect at 50% NH, but ARM light will not go-off until the engine selection for starting is set to OFF.

- *FAIL light on:* failure of the starter-generator speed signal when initiating an engine start, or disconnection of the starter-generator (50% NH).

(4) IGN Pushbutton:

- *Pressed-in (ARM light on):* ignition circuit is active and sparks are being generated by the igniters.

- *Pressed-out (ARM light off):* ignition circuit disconnected.

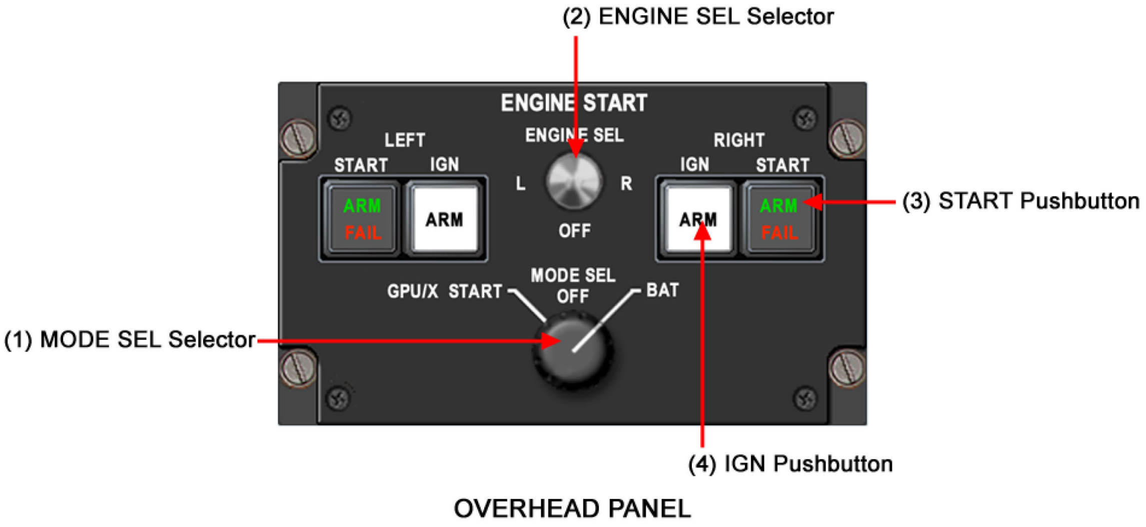


Figure 71-10 Engine Starting and Ignition Systems - Controls and Indicators

PROPELLERS

Propellers are intended to transform mechanical power, as supplied by the engine, into traction.

DESCRIPTION

Each power plant has a Hamilton Sundstrand HS568F-5 propeller which is engine-driven. Each propeller has six blades and rotates clockwise (looking towards flight direction). Blades are variable-pitch type, and are fitted with feather and reverse capabilities. Both propeller pitch and feather are controlled by means of the engine oil. The system has two pumps with hydraulic/mechanical controls (PVM and OSG) and an electronic control (EPC). Each propeller has also a de-icing system (refer to CHAPTER 30 - ICE AND RAIN PROTECTION), and both synchronization and automatic feather functions as well. Left engine has also a hydraulic propeller brake which allows to stop the propeller while the aircraft is grounded and the left engine is being used to supply both electrical and pneumatic power.

Main system components are:

– ***Propeller:*** includes both rotating parts and pitch-change actuator. It is RGB power turbine driven.

– ***Hydraulic/Mechanical Propeller control (PVM: Propeller Valve Module):*** RGB-driven, it is a hydraulic/mechanical unit delivering oil pressure through a transfer pipe towards the pitch control actuator. During normal operation (automatic) it follows electronic propeller control (EPC), power lever (PL) and overspeed governor (OSG) commands. It has two potentiometers: one converts PLs mechanical movements into electrical signals, and the other gauges propeller pitch by measuring pitch change actuator displacements. Both signals are sent to the relevant EPC.

– ***Main Pump:*** RGB-driven, supplies pressure oil to hydraulic/mechanical controls (PVM and OSG).

– ***Auxiliary Feathering Pump:*** electrically powered, allows the propeller to be feathered if either PVM or engine fails. To that purpose, it supplies pressurized oil to the hydraulic/mechanical controls (PVM and OSG).

– ***Overspeed Governor (OSG):*** RGB-driven, OSG is a hydraulic/mechanical unit that prevents the propeller from exceeding a given speed (105% NP, approximately).

– ***Autofeather Unit (AFU):*** when autofeather unit is armed if the engine fails, it forces the propeller to feather automatically and sends a signal to the operative engine electronic engine control (EEC) to activate the APR system (Automatic Power Reserve).

– ***Electronic Propeller Control (EPC):*** EPC is located at the engine nacelle and has two redundant channels. During normal operation it controls both propeller pitch and speed by PVM operation. It uses both PL and pitch angle signals as PVM-transmitted.

– ***Propeller Brake:*** hydraulically actuated, allows to stop the left propeller while the aircraft is grounded.

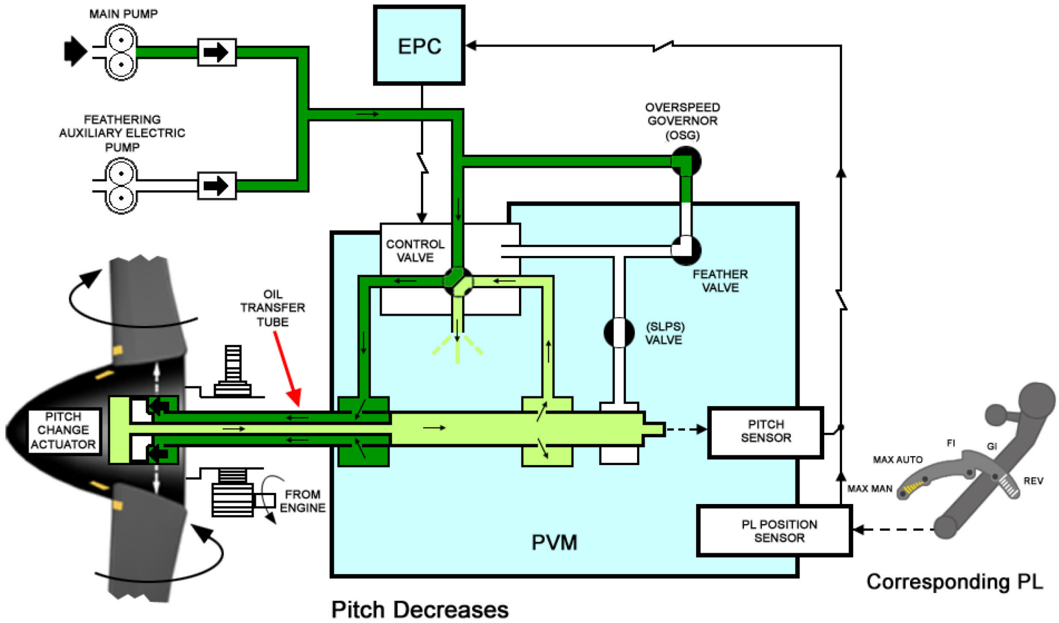
CONTROL SYSTEM

The system operates as follows:

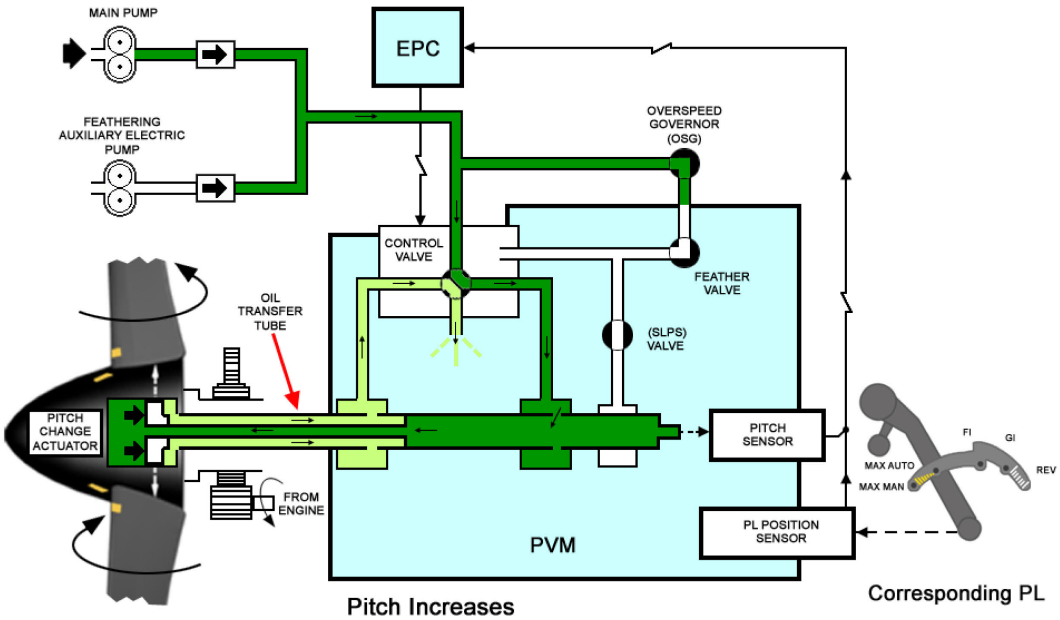
The propeller is engine-driven through the RGB. Both propeller and PVM are connected by an oil transfer pipe.

The main pump and in some cases the auxiliary feathering pump, supply oil to both overspeed governor (OSG) and PVM. This one sends oil pressure to the actuator chambers by means of two concentric ducts at the transfer pipe. Thus, when PVM increases pressure in the front chamber and drains the rear one, the piston moves backwards and increases propeller pitch.

Propeller pitch decreases when PVM operates in the opposite way. PVM acts by pitch increasing/decreasing depending on the signals received from the electronic propeller control unit (EPC).



Pitch Decreases



Pitch Increases

Figure 71-11 Propeller Control System

AUTOMATIC PROPELLER OPERATING MODES

There are two basic modes of automatic operation (managed by the EPC): speed regulation or governing mode, and pitch regulation or beta mode. Refer to Figure Automatic Propeller Operating Modes and Figure Blade Angles vs PVM-measured PL Position.

– Propeller operates in **GOVERNING MODE** when with PL at or above FI, engine-delivered power is enough to keep the propeller speed (NP) constant at the speed set by the PRS:

  1. In MCT and TOGA position: 100% NP
  2. In CLB position: 95% NP
  3. In CRZ1 position: 90% NP
  4. In CRZ2 position: 80% NP

  In this mode, EPC adjusts pitch angle to keep NP constant by acting on PVM. However, it never reduces the pitch below the relevant to FI value. If at any moment engine-delivered power is no longer enough to keep NPs constant by pitch decreasing, the system automatically switches to beta mode.

  Governing mode is used throughout practically every aircraft flight envelope, except at very low speeds and for PL positions close next to FI. On ground, high PL positions are required to operate in this mode.

– Propeller operates in **BETA MODE** when PL is below FI or if even above FI, engine-delivered power is not enough to keep NPs at PRS-selected value.

  In this mode EPC adjusts to constant pitch equal (if PL > FI) or less (if PL < FI) than FI pitch for each PL position. Two pairs of BETA MODE lights (one pair for each engine) located at the top of each pilot instrument panel indicate the relevant propeller is operating in this mode when coming-on while pitch angle is below FI.

  Beta mode is mainly used while on ground, except at extremely forwarded PL positions. On ground it only applies at low speeds and with positions close next to FI.

In both cases normal control (automatic) is achieved by means of EPCs. These operate the relevant PVM to provide adequate propeller speed control (governing mode) or pitch control (beta mode) depending on outside conditions, power-plant PRS-selected range power lever (PL) position, and fuel and feather lever (FFL) as well.

In case of EPC failure or disconnection, the system switches to manual control as explained later in the manual (refer to MANUAL PROPELLER OPERATION MODE (EPC FAILURE)).

There is an electronic adjustment procedure (trimming) for the normal control (EPC) which equalizes both EPCs response for the same PL position by means of the INT (in EPC position) and TRIM switches (L or R position) this minimizes the asymmetries between the propellers in automatic operation mode.

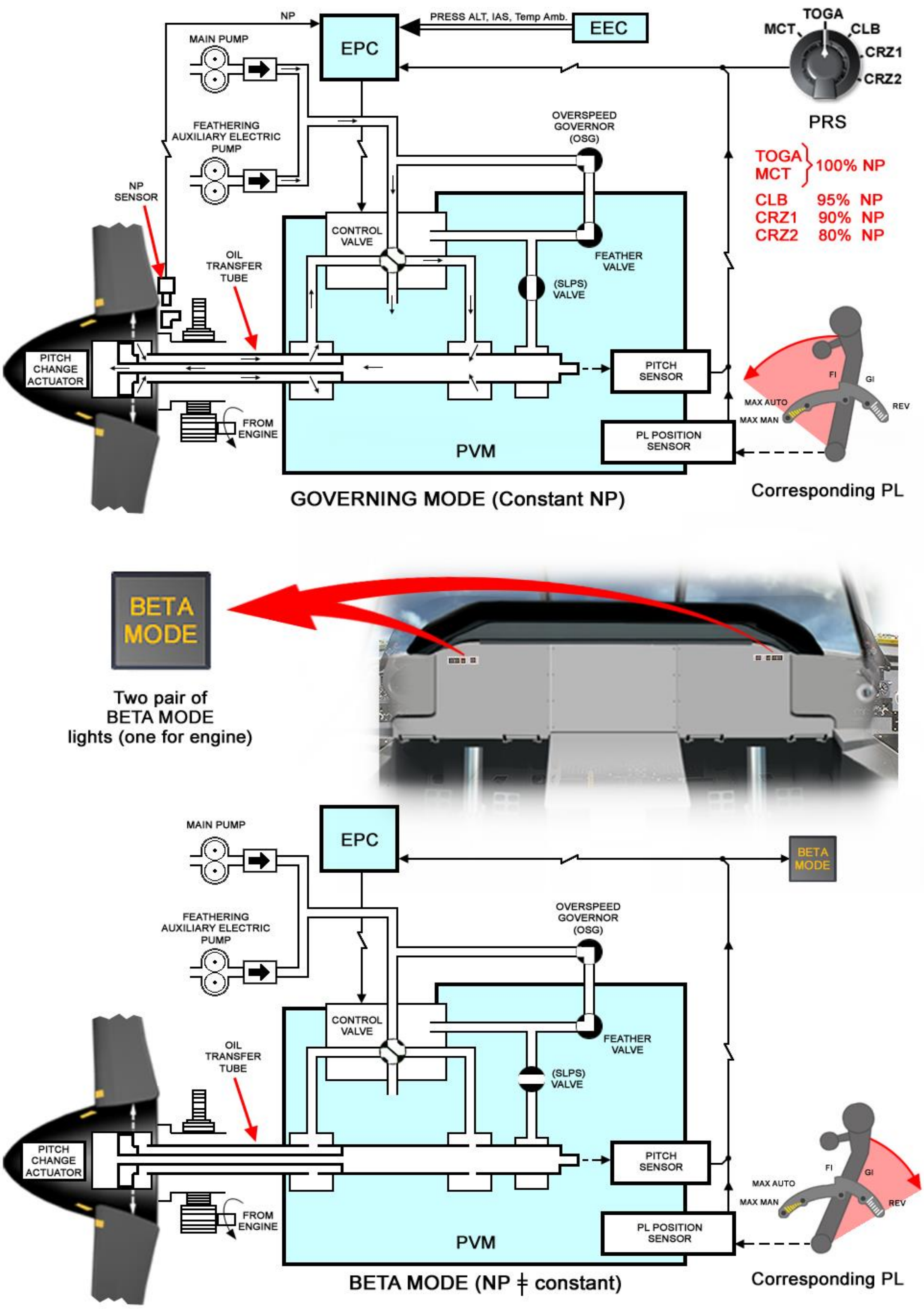


Figure 71-12 Automatic Propeller Operating Modes

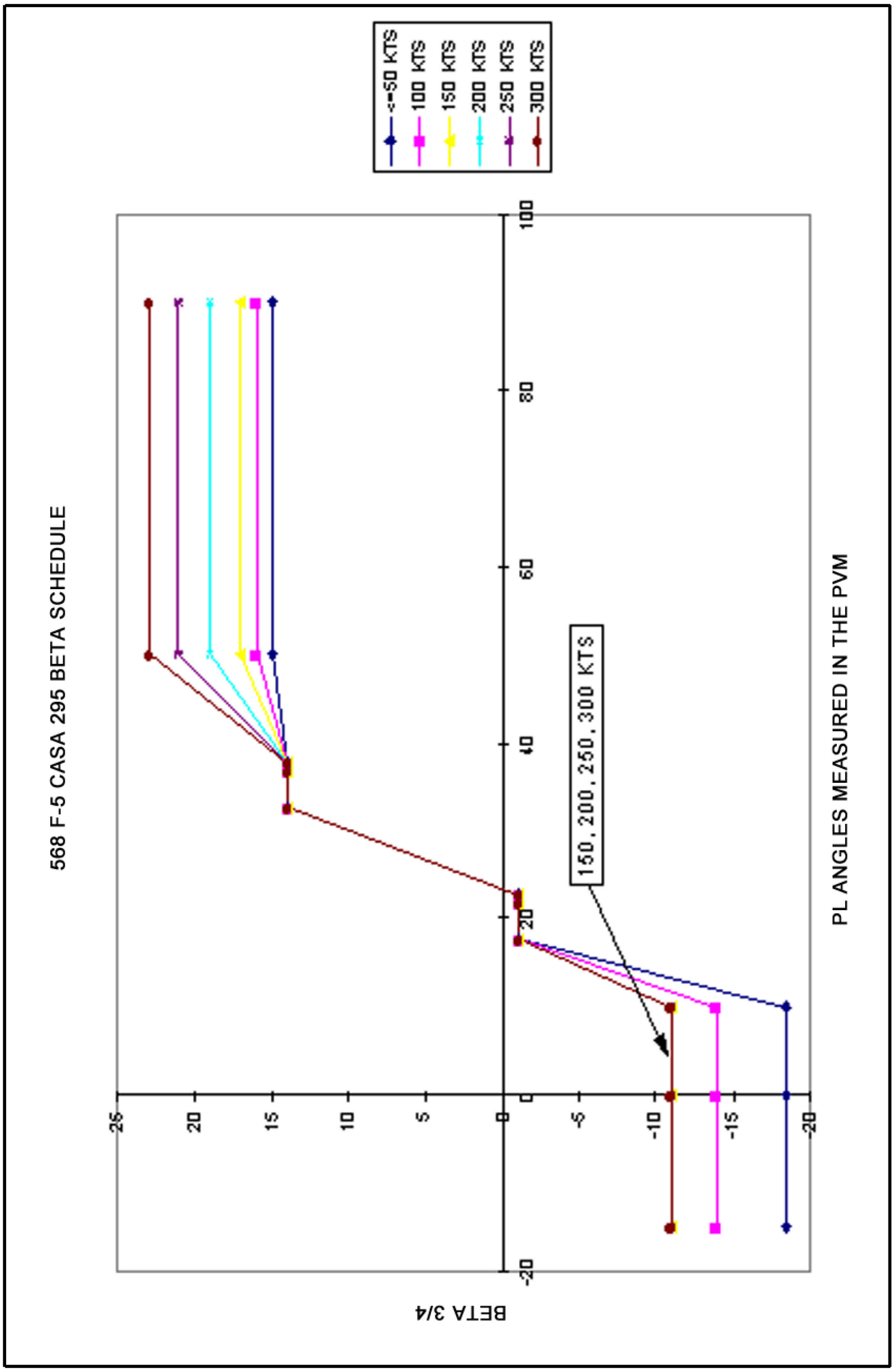


Figure 71-13 Blade Angles vs PVM-measured PL Position

BETA LOCKOUT SYSTEM (BLS)

This system prevents PLs from being retarded below FI while airborne. The system detects when the aircraft takes-off, and activates a locking rod on the engine control quadrant which physically prevents PLs from being moved below FI. The system has also two BETA UNLKD located at each pilot instrument panel (between BETA MODE lights). These come-on when protection is disconnected. Protection is disconnected automatically on ground, either if weight-on-wheels microswitch closes or reverse control unit detects main landing gear wheels are speed-rotating. If protection is not disconnected on landing, a BETA LOCKOUT pushbutton (under guard) located at the engine control quadrant allows the pilot to do so (OVRD light on). This action is IEDS-recorded as 'NEW EXCEEDANCE'. This pushbutton should only be used if automatic system fails, when the aircraft is grounded, and is verified that PLs cannot be retarded.

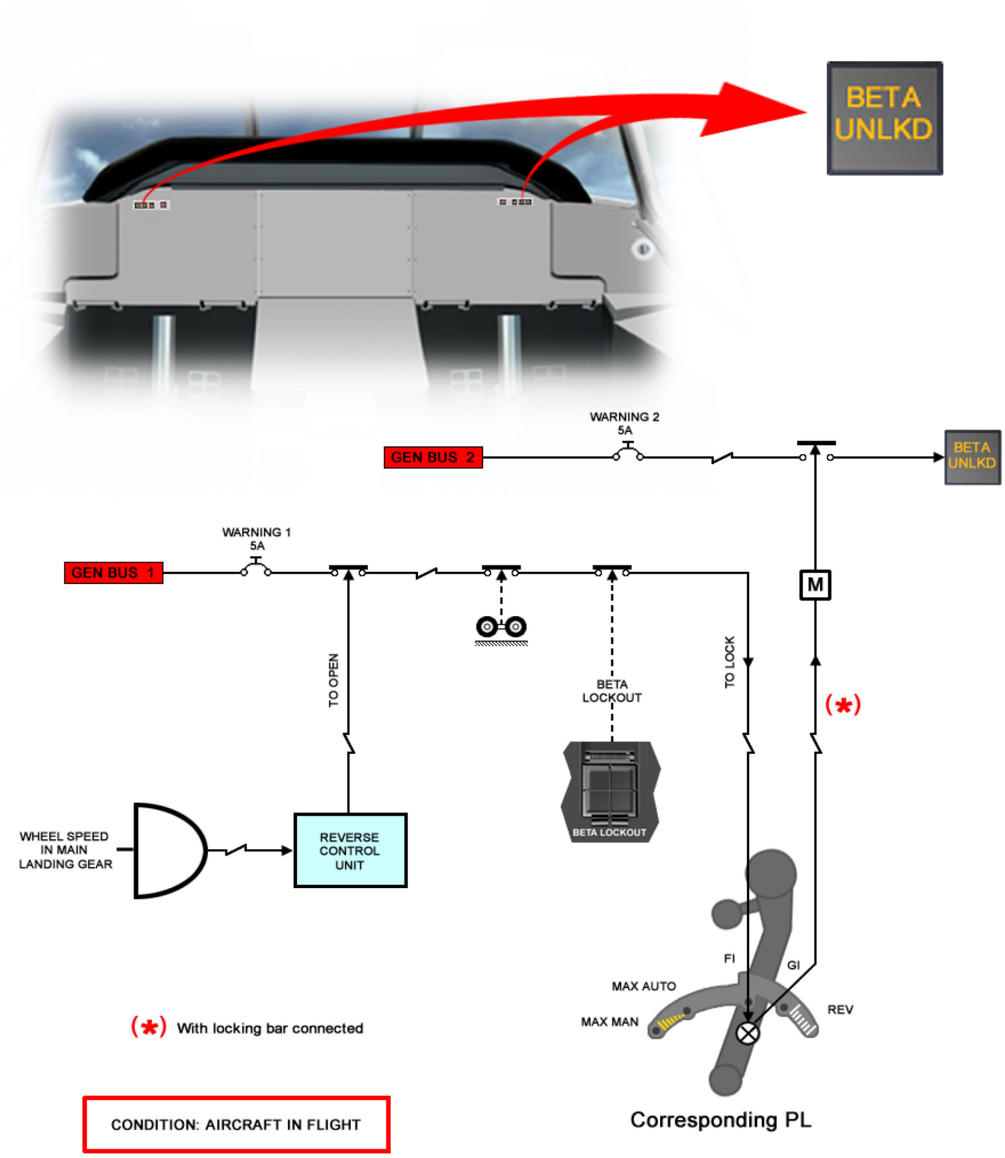


Figure 71-14 Beta Lockout System (BLS)

SECONDARY LOW PITCH STOP SYSTEM (SLPS)

SLPS prevents the propeller pitch angle from decreasing below FI pitch while airborne, thus avoiding uncommanded overspeed or propeller pitch reversal in-flight. Three devices prevent from low pitch:

– EPC normal (primary) control

– Secondary low pitch stop system (SLPS)

– Blade counterweights

EPC is the primary protection device, avoiding blade pitch below flight idle pitch, while PL is forwarded beyond FI position. If fails, SLPS (secondary protection device) automatically comes into operation. This works as follows: while not energized, SLPS valve is open (refer to figure). This means that when pitch decreases below FI pitch, a drain opens at the transfer pipe. As a result, control valve opens to increase pitch until it reaches FI value.

While on ground, SLPS is cancelled, allowing to select lower pitch values, and also reverse pitch. Once the engine is started-up SLPS is tested automatically when FFL is moved forward to RUN in order to unfeather the propeller. If EPC is disconnected, SLPS is not cancelled, even if PL is below FI (SLPS valve will remain open). It will therefore not be possible to achieve propeller pitch values below FI, and therefore it will not be possible to use reverse (refer to MANUAL PROPELLER OPERATION MODE (EPC FAILURE)).

Finally, oil loss will result losing the above mentioned devices. If this happens, blade counterweights force a larger propeller pitch angle, thus providing protection as required.

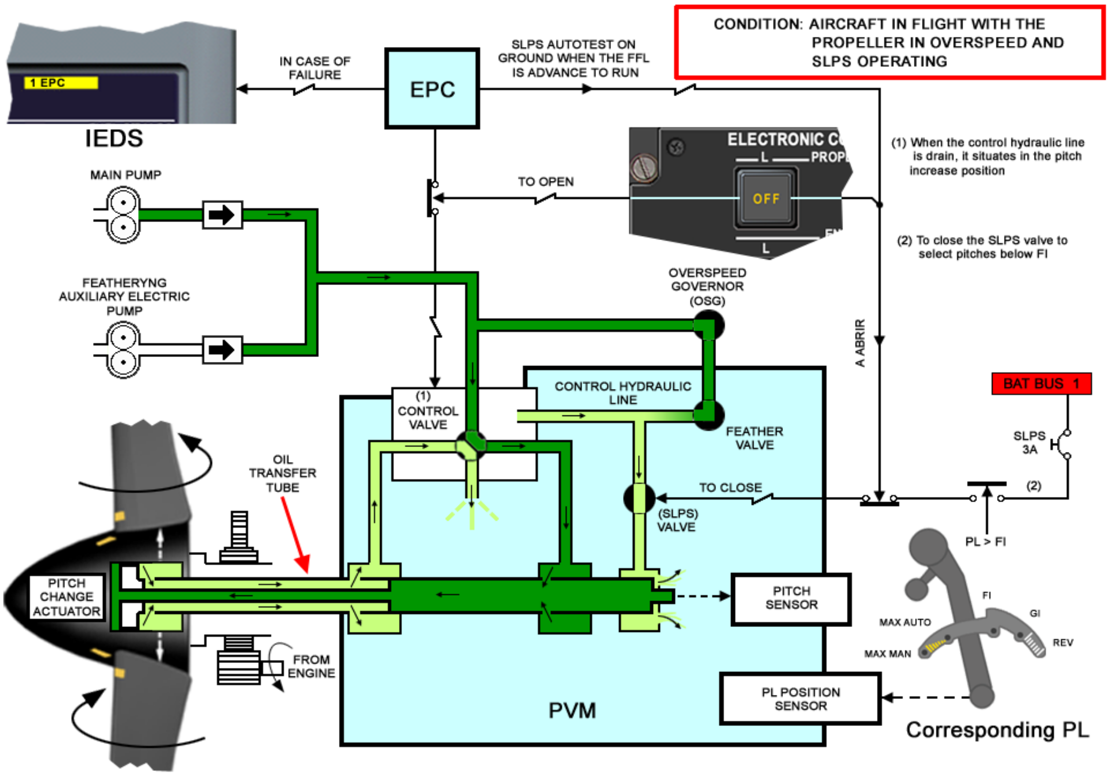


Figure 71-15 Secondary Low Pitch Stop System (SLPS)

OVERSPEED GOVERNOR (OSG)

Overspeed governor (OSG) is a hydraulic/mechanical unit which acts when PLs are above FI and normal control (EPC) fails. In this case, when propeller speed exceeds 103.5% NP, propeller pitch is increased to reduce NPs by draining the hydraulic control line through a counterweight-operated valve. If NPs exceed 106%, OSG acts on the MFCU (refer to ENGINE FUEL SYSTEM, in this chapter) to reduce fuel flow and therefore engine power. For PL positions below FI OSG operation limits increase to avoid undesirable performance during rapid transitions to reverse pitch. Thus, from 103.5% it raises to 118% NP, and from 106% to 122% NP.

OSG is tested by means of OVSP TEST switch at cockpit POWERPLANT MAINTENANCE panel.

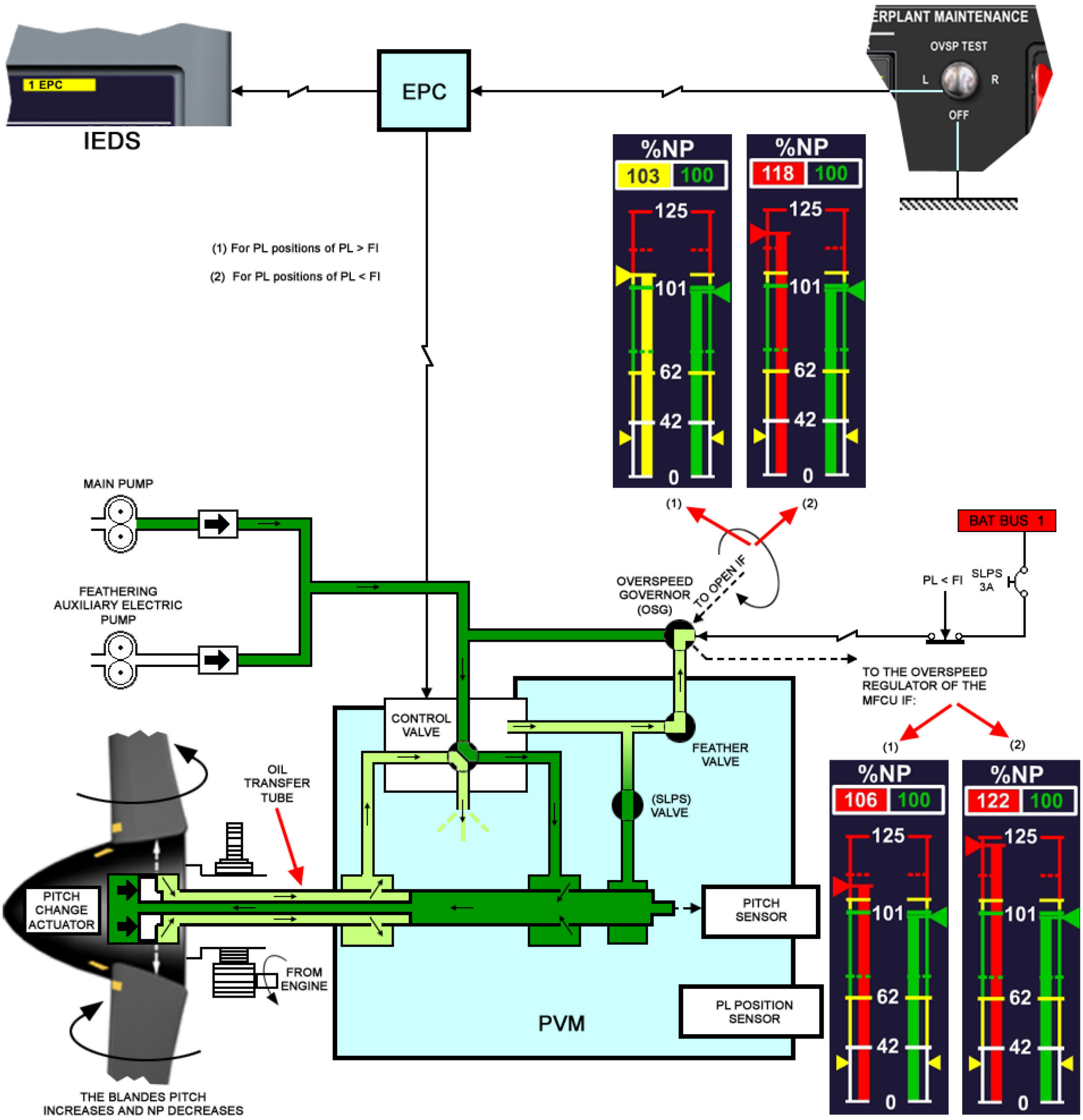


Figure 71-16 Overspeed Governor (OSG)

FEATHERING

Normal propeller feathering (on ground) is achieved by retarding FFL from RUN to START position. This closes a switch in the engine control quadrant, which sends an electrical signal to open the PVM feather valve. Also, EPC acts in parallel on the PVM, sending a control valve signal (setting the valve to the correct position to increase the pitch) to ensure feathering.

When propeller is in-flight feathered (FFL directly to OFF), as well as opening the feather valve, a signal turns-on the auxiliary feathering for thirty seconds for safety purposes. If the feather valve is inoperative, EPC operates the control valve for propeller feathering.

If excessive propeller speed is observed (overspeed), once FFL has been retarded to OFF, MAN switch on the FEATHER/APR panel allows the propeller to be fully feathered, both in-flight and on ground, by opening the feather valve and connecting the auxiliary feathering pump. EPC also receives this signal and acts (redundantly) on the control valve to ensure feathering. The same effect can be achieved by pulling the fire handle.

The propeller is fully feathered when yellow marks on the blades and on spinner are aligned.

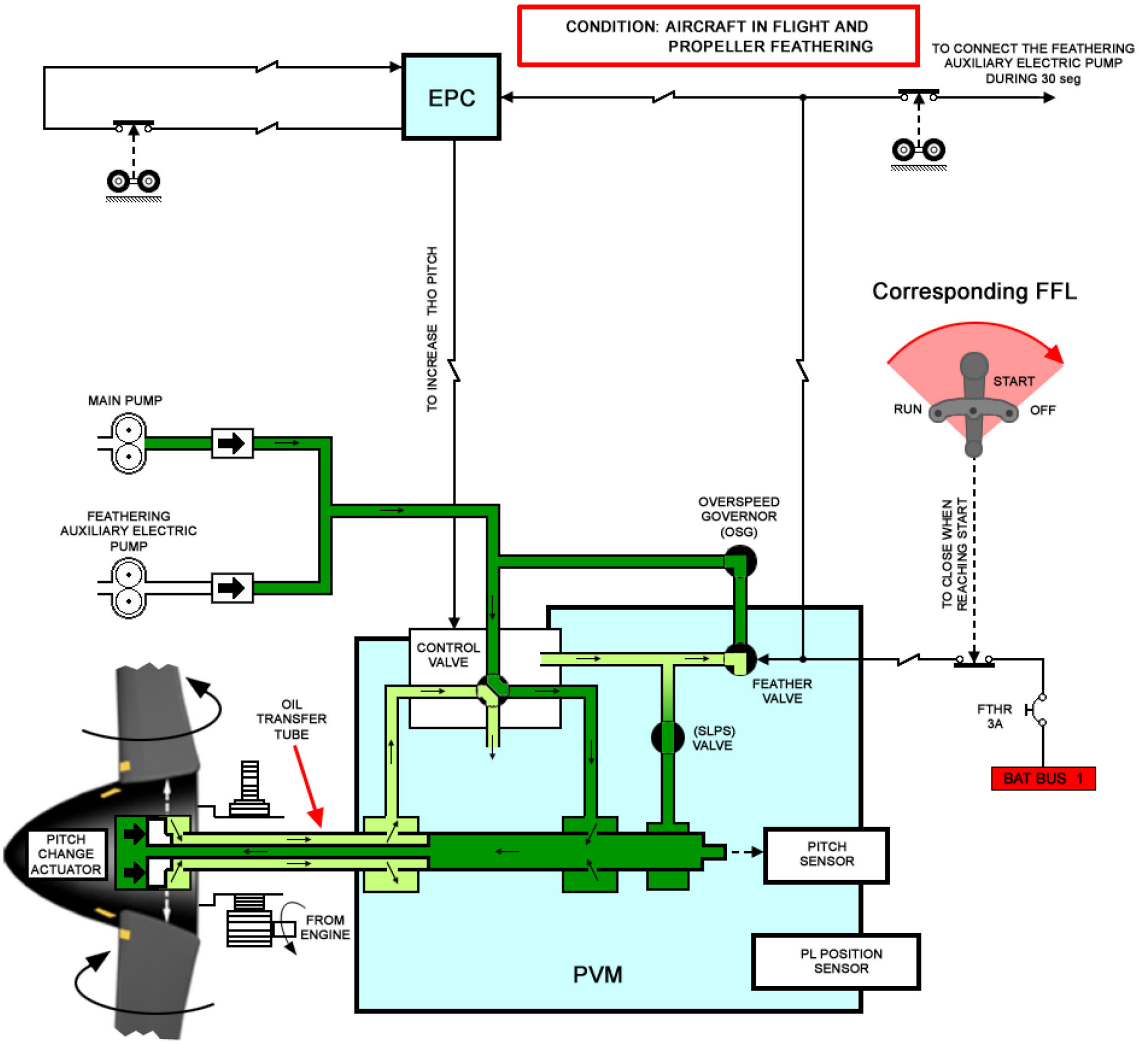


Figure 71-17 Feathering

MANUAL PROPELLER OPERATING MODE (EPC FAILURE)

EPC has two channels. If the first channel fails, FAIL light on the PROP section of the POWERPLANT MAINTENANCE panel will come-on and propeller control will automatically be transferred to the backup channel without requiring any action or precautions to be taken by the crew. If backup channel also fails, the propeller is directly controlled by both overspeed governor (OSG), secondary low pitch stop system (SLPS) and propeller counterweights as well. 1, 2 EPC caution will also be IEDS-displayed. In order to switch to manual mode or attempt to reset EPC after a failure has been declared detected, the appropriate L or R PROPELLER pushbutton on the ELECTRONIC CONTROL/STATUS panel should be pressed-in (OFF light will come on). This will cancel IEDS caution.

If EPC is disconnected (or if its signal is lost), the control valve automatically goes to the pitch reduction position in order to avoid excess torque at forwarded PL positions. This means that if EPC is disconnected in-flight it is normal for NPs to increase to up to 102.5±1%NP (refer to 'ENGINE PROPELLER CONTROL (EPC) FAILURE' at the Flight Manual).

In manual operating mode (with EPC disconnected), the propeller responds to any PL movement such that pitch is never below FI value (due to the SLPS) and never exceeds NP limits as imposed by OSG. Thus, when engine-delivered power is enough to reach OSG NPs (103.5% NP) propeller pitch will increase so that this limit is not exceeded. If power is not enough, pitch will decrease (FI pitch maximum). This mode is therefore the same as the automatic one, but with different limit values: in this case NPs (maximum) are not given by PRS position but by OSG. Moreover, due to SLPS it is not possible to achieve reverse pitch angles.

EPC memory-saves every failures that have occurred during operation. Memory-saved failure data are indicated by MAINT light on the PROP section of the POWERPLANT MAINTENANCE panel. Maintenance personnel can download failure data from the IEDS by setting INT selector to EPC position, once the guard is raised and the required side of the aircraft is selected by means of the LRU selector.

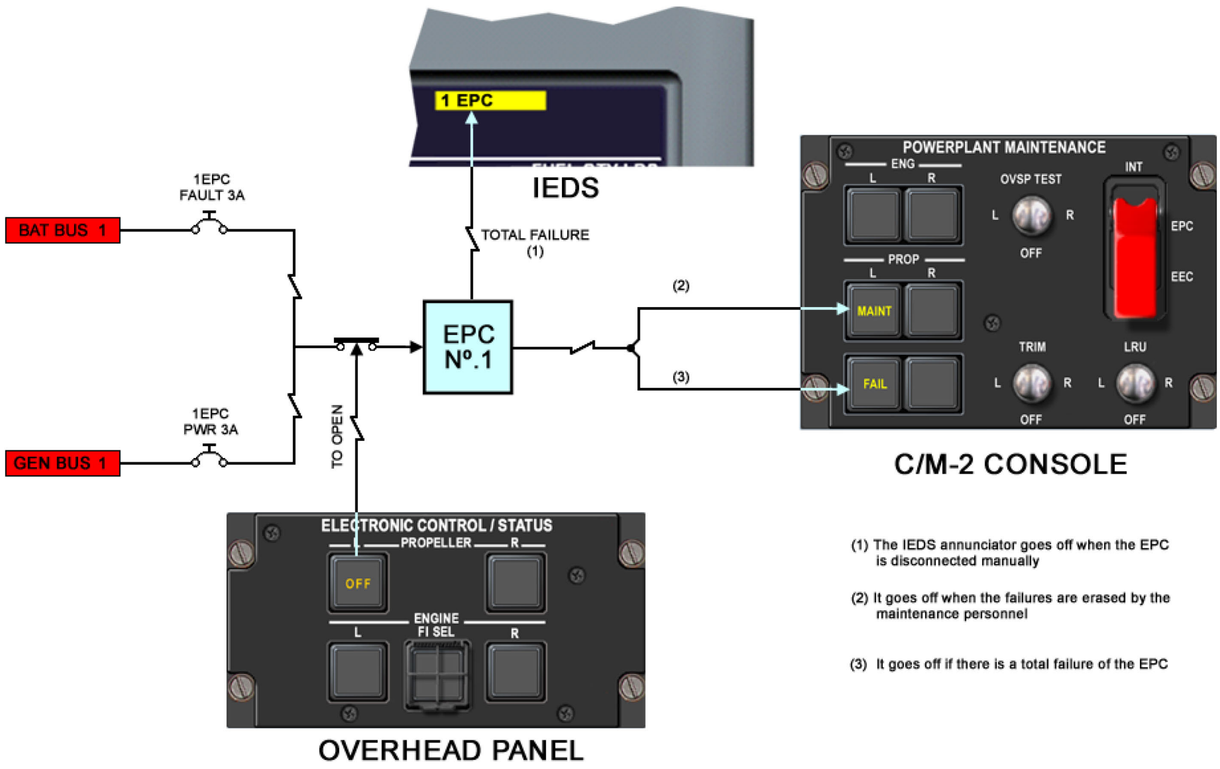


Figure 71-18 Manual Propeller Operation (EPC Failure)

PROPELLER CONTROL SYSTEM CONTROLS AND INDICATORS

(1) BETA LOCKOUT Pushbutton:

- *Pressed-in (OVRD light on):* disconnects the locking rod which prevents PLs from being retarded to below FI. This action is IEDS-recorded as "NEW EXCEEDANCE".

(2) BETA UNLKD Indicators (two):

indicate when the locking rod is disconnected.

(3) BETA MODE Indicators (two pairs):

- *On:* indicate the relevant propeller pitch angle is below FI pitch angle.

(4) OVSP TEST Selector:

- *L or R:* simulates an overspeed condition, forcing EPC to reduce propeller pitch.

(5) INT Selector (under guard):

- *EPC:* selects IEDS-access to EPC memory-saved data (for maintenance personnel purposes). It also enables electronic adjustment to equalize both EPCs response for the same PL position in automatic propeller operating mode (for maintenance personnel purposes).

(6) LRU Selector:

- *L or R:* with INT switch in EPC position, EPC memory-saved failures are IEDS-displayed.

(7) TRIM Selector:

- *L or R:* with INT switch in EPC position, the switch allows PLs electronic trimming to equalize both EPCs response for the same PL position in automatic propeller operation mode (for maintenance personnel purposes).

(8) L, R PROP FAIL Indicators:

- *On:* primary EPC channel failure. No action by the crew is required.

(9) L, R PROP MAINT Indicators:

- *On:* EPC memory saves every failure during operation. Maintenance personnel can IEDS-download failure data.

(10) L, R PROPELLER Pushbuttons:

- *Pressed-in (OFF light on):* relevant EPC is disconnected and IEDS 1, 2 EPC caution goes-off.

(11) MAN Feathering Selector:

- *L or R:* sends a signal to the relevant feather valve, EPC and electric auxiliary pump to feather the propeller.

(12) (IEDS) 1, 2 EPC Caution Message:

Failure on both EPC channels.

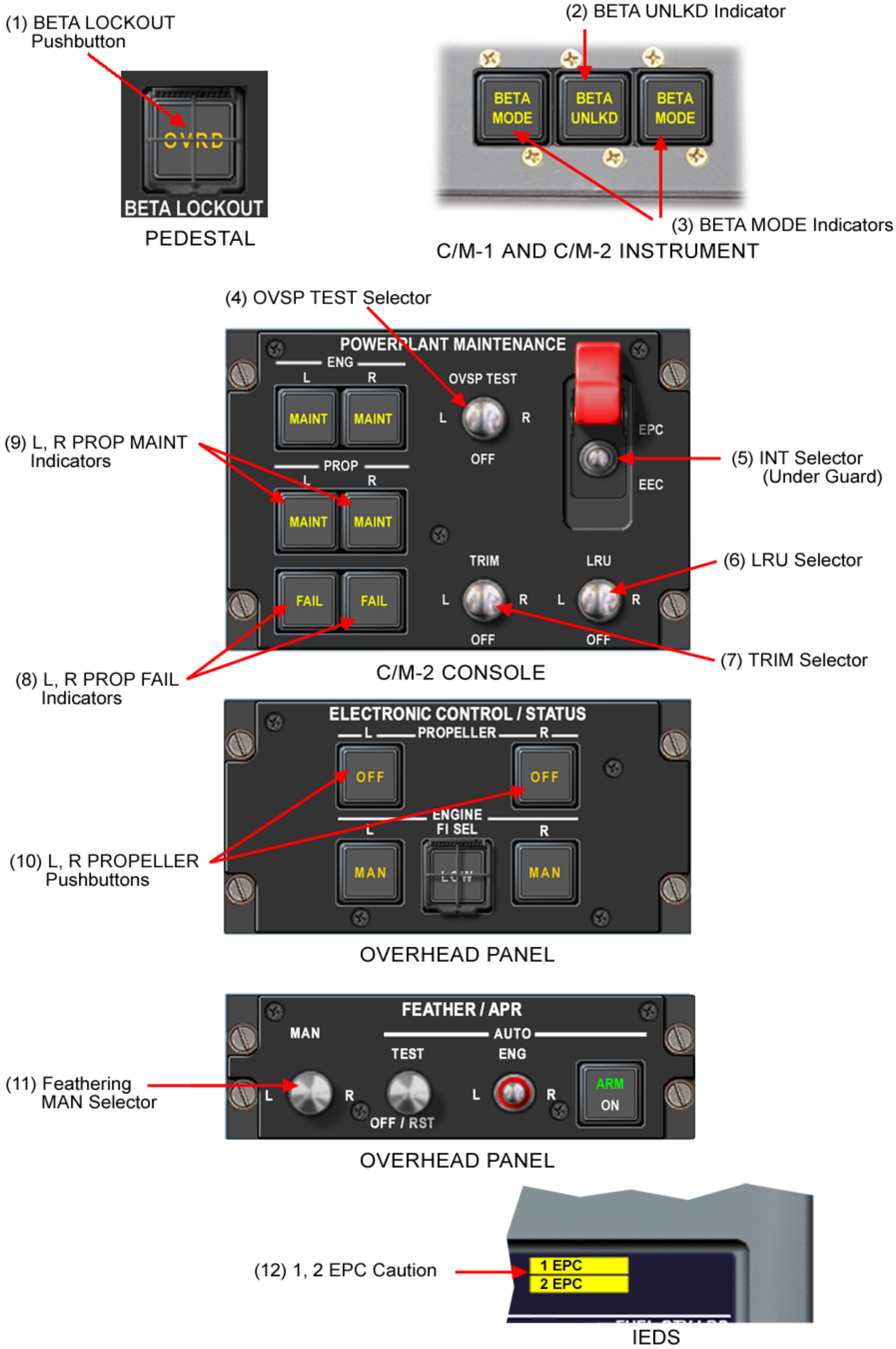


Figure 71-19 Propeller Control System - Controls and Indicators

AUTOFEATHER SYSTEM

Autofeather system automatically increases propeller pitch to the feathered position after an engine stops, when the system is connected and armed.

Each engine is fitted with an Autofeather Unit (AFU) which processes engine torque (TQ), PLs Positions and PRS selection, to determine if the engine has stopped unintentionally, and if so, it sends the following signals:

– Feathering signal to PVM, EPC and electric auxiliary feathering pump of the relevant engine.

– Power increase signal (APR) to the other engine EEC.

– Autofeather inhibition signal to the other engine.

Autofeather system is controlled and monitored from the FEATHER/APR panel on the cockpit overhead panel. This panel also includes the manual feathering switch (MAN) described in the "Feathering" section.

Autofeather system is armed (ARM light on the ARM/ON pushbutton is on), indicating is ready to operate if required, when the following conditions are met:

– ARM/ON pushbutton pressed-in. ON light comes-on (system connected).

– PRS at TOGA.

– Both PLs close to MAX AUTO.

– Both engine torques above 48% TQ.

The autofeather system will therefore be:

– CONNECTED (ON light on ARM/ON pushbutton is on): during take-off, approach and landing.

– ARMED (ARM and ON lights on ARM/ON pushbutton are on): during take-off (and go-around as well).

Once the system is armed, it starts automatically if an engine torque falls below 19% TQ while the other torque remains above 48% TQ. In this case, failed-engine AFU feathers the propeller and orders the operative engine EEC to increase power from take-off power to Automatic Power Reserve (APR). Finally, ARM light goes-off indicating that once one of the propellers is feathered the other cannot be autofeathered.

AUTFR warning is IEDS-displayed if while the system is connected and meeting the required conditions to be armed, one of the AFUs does not send the armed signal.

Additionally, AUTO section on the FEATHER/APR panel includes both a TEST switch and an engine switch (ENG) allowing to both select and test each engine while the aircraft is grounded.

If during take off, with weight on wheels signal present and moved-forward PL position (close to MAX AUTO), autofeather system is not connected (ON light in the ARM/ON pushbutton is off),), Unsafe Take-Off Configuration warning will be displayed, i.e. UNSAFE TO warning will be IEDS-displayed and the associated acoustic LYRE warning will ring (refer to CHAPTER 31 - INDICATING AND RECORDING SYSTEM).

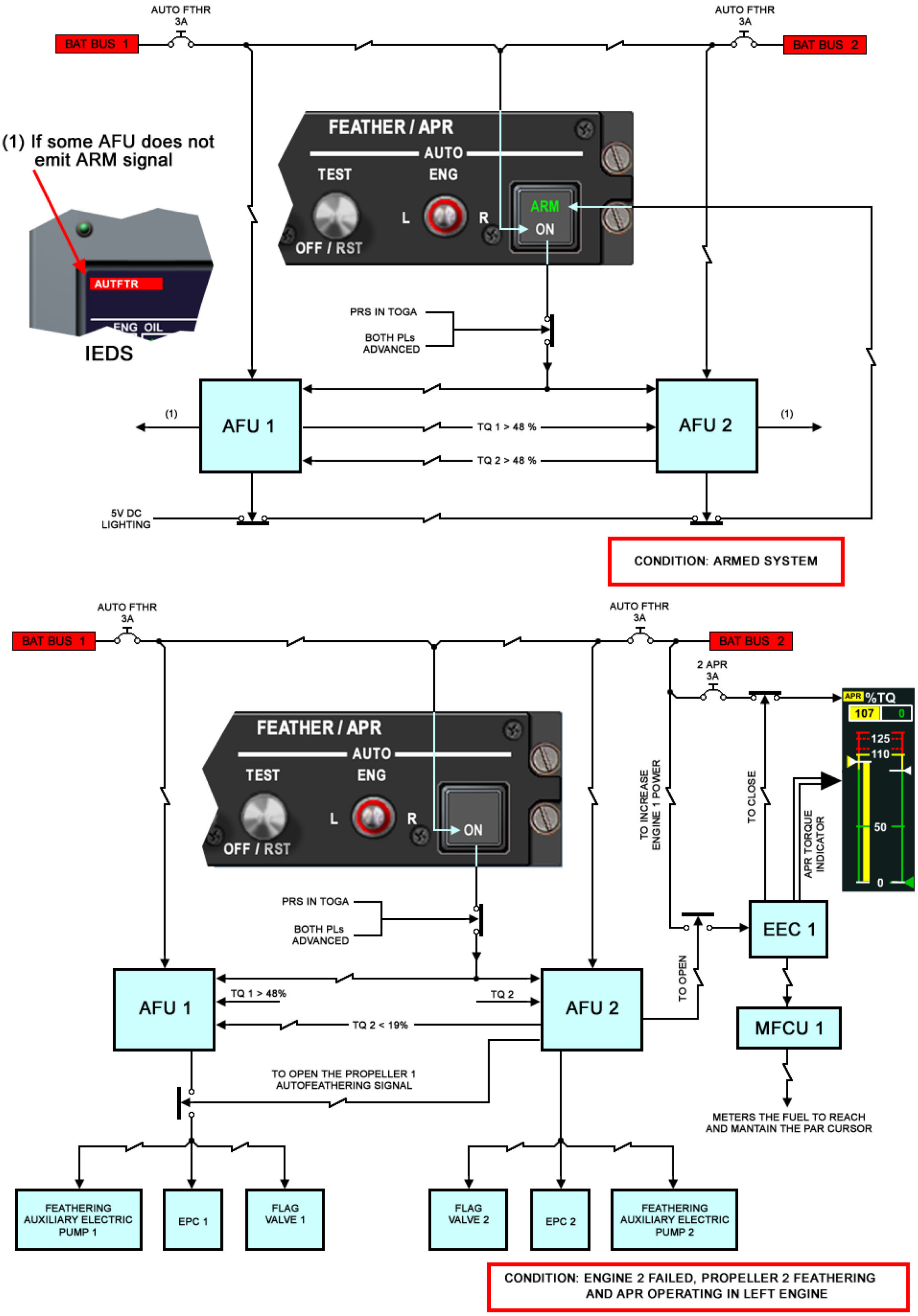


Figure 71-20 Autofeather System

AUTOFEATHER SYSTEM CONTROLS AND INDICATORS

(1) Autofeather Unit (AFU) Test Selector:

- *TEST:* performs the self-test of both AFUs, ARM lights on each ARM/ON pushbuttons come-on and propellers indicate 78±3%TQ.
- *OFF/RST:* once one propeller has been tested (L or R), ARM light goes-off and torque reading goes back to previous value. This is the final position once the test has been performed on both sides.

(2) ENG Selector:

- *L or R (momentarily):* with test selector in TEST position, it checks the relevant propeller feathering system (L or R) while the aircraft is grounded. IEDS will indicate the other engine will increase its TQ (and APR message will display at the top of the scale) and tested-engine NPs will decrease.

(3) ARM/ON Pushbutton:

- *Pressed-in (ON light on):* autofeather system is connected.
- *ARM light on:* autofeather system is armed to feather the propeller in case of engine failure during take-off or go-around. It also comes-on during system test.

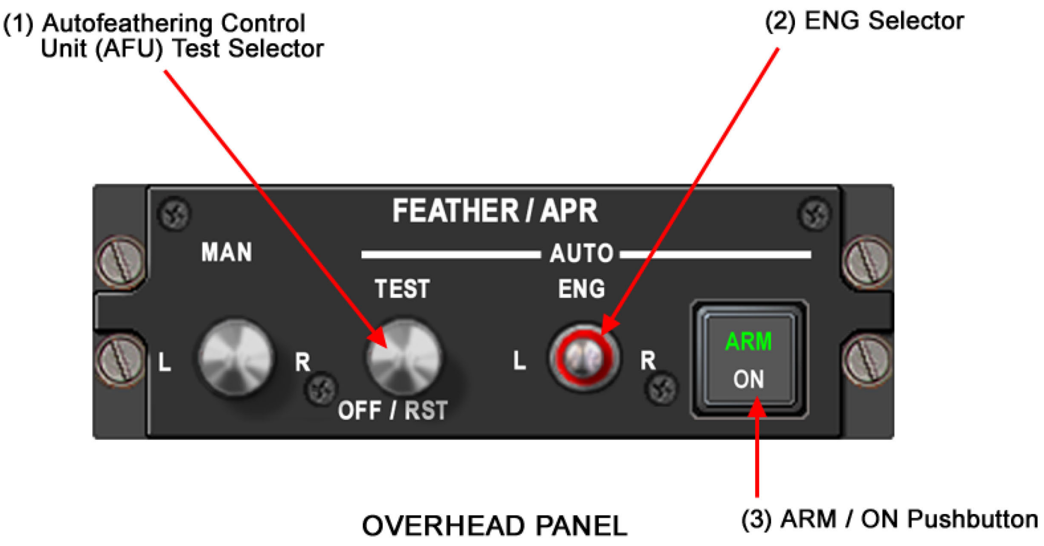


Figure 71-21 Autofeather System - Controls and Indicators

PROPELLER SYNCHRONIZATION SYSTEM

This system reduces propeller-generated noise and vibration by equalizing their speeds (NP) and adjusting between-propellers blade phase angles to preset values.

The system is fully automatic and is controlled by EPC No. 2, which receives NP signals from both propellers. EPC No. 2 compares both signals and adjust slightly propeller No. 2 NP to synchronize both NPs and the phase between them as well. EPC No. 2 starts synchronization process when:

– The right propeller is operating in governing mode (refer to AUTOMATIC PROPELLER OPERATING MODES) and

– The difference between both propellers NPs does not exceed 0.5%.

Synchronization is disconnected when difference between the NPs is equal to or above, 0.8% NP.

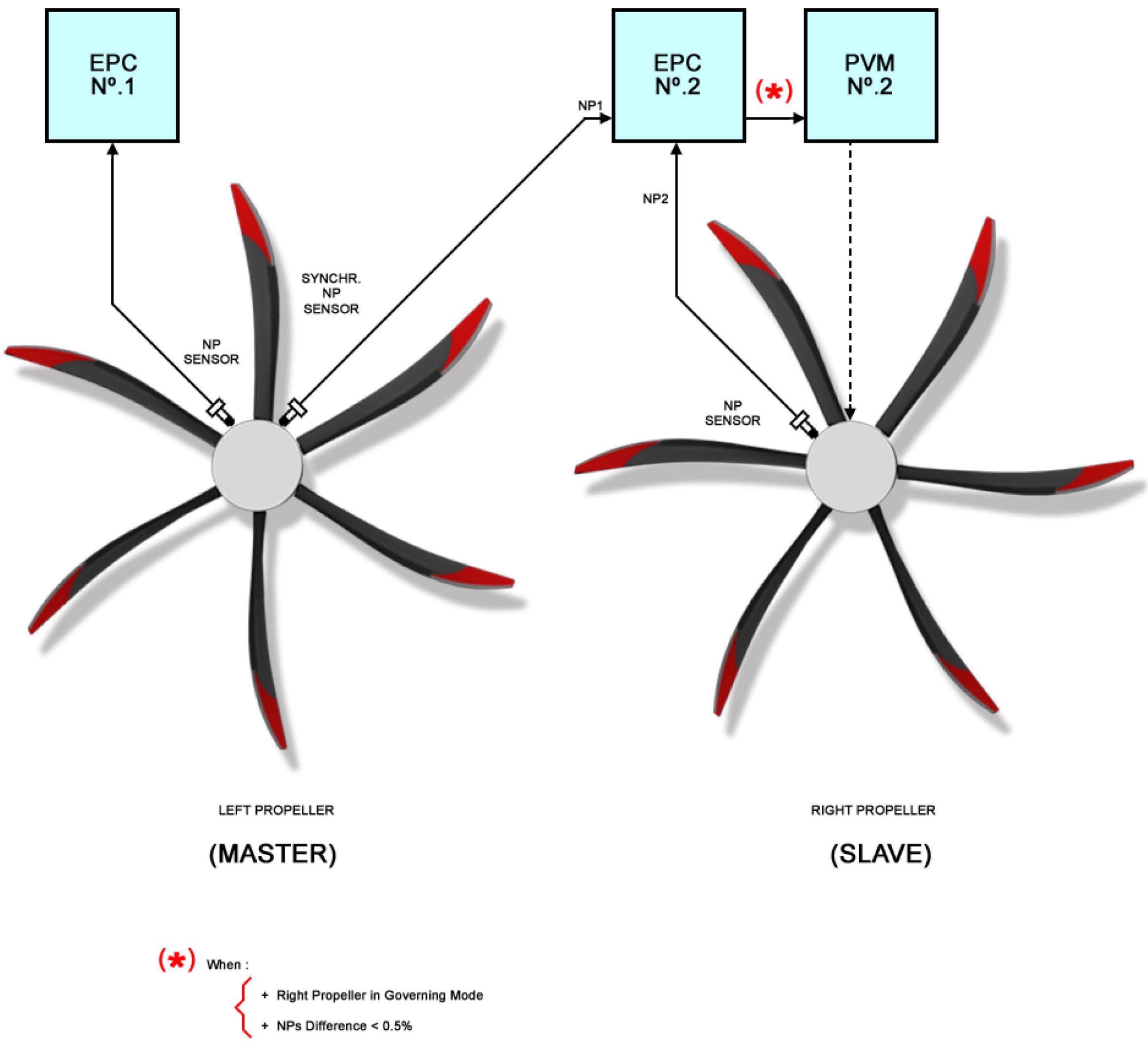


Figure 71-22 Propeller Synchronization System

PROPELLER BRAKE SYSTEM (left engine only)

The propeller brake system is intended to allow LH engine to be used on ground with propeller stopped. This mode of operation known as APU mode or HOTEL mode, allows to supply air-conditioning and electrical power when the aircraft is grounded. It also improves the conditions under which the RH engine is started-up when no GPU is available (cross-start).

NOTE

It is recommended to minimize as much as possible the operation on ground (HOTEL mode or GPU) at temperatures above ISA.

Brake is hydraulically operated and has a piston which compresses a set of fixed disks against a set of rotating disks that are meshed with the reduction gearbox (RGB) to prevent the propeller from turning.

The propeller brake is operated from PL at GI. For brake operation, every following condition shall be met:

- Aircraft grounded.
- FFL at START (propeller feathered and Fuel Shut-Off Valve open)
- Fire handle not pulled (normal position)
- Gust Lock Lever vertical (lock operated) and
- At least one hydraulic pump connected thus delivering approximately 3000 PSI pressure.

Under these conditions, propeller brake pushbutton RDY light will come-on.

Once these conditions have been met, propeller brake can be operated by pressing-in the Propeller Brake pushbutton (under guard). Both ON and UNLKD lights will come on. Once brake has been operated and propeller has stopped, BRK light will come-on and UNLKD light will go-off. The system has a locking cone which keeps the whole unit compressed, and two "start and end-of-run" microswitches. Once the brake has been operated it will continue to be operated if one or more of the above mentioned conditions are lost.

In normal operation mode (automatic), EEC controls engine power, setting it to the appropriate NH value (depending on outside conditions) in order to limit brake-operated torque. EEC also changes IEDS ITT scale to the appropriate one for APU mode.

During manual operation (EEC disconnected) the pilot has to actuate on PL to control power in order to avoid NH limit-exceedance as established for manual operation (refer to Flight Manual).

The system has a PROP BRK warning which is IEDS-displayed if while activation/deactivation system UNLKD light remains on for more than 15 seconds or an unsafe condition occurs while brake is on. PROP BRK warning also comes on when UNLKD light comes-on while at APU operating mode.

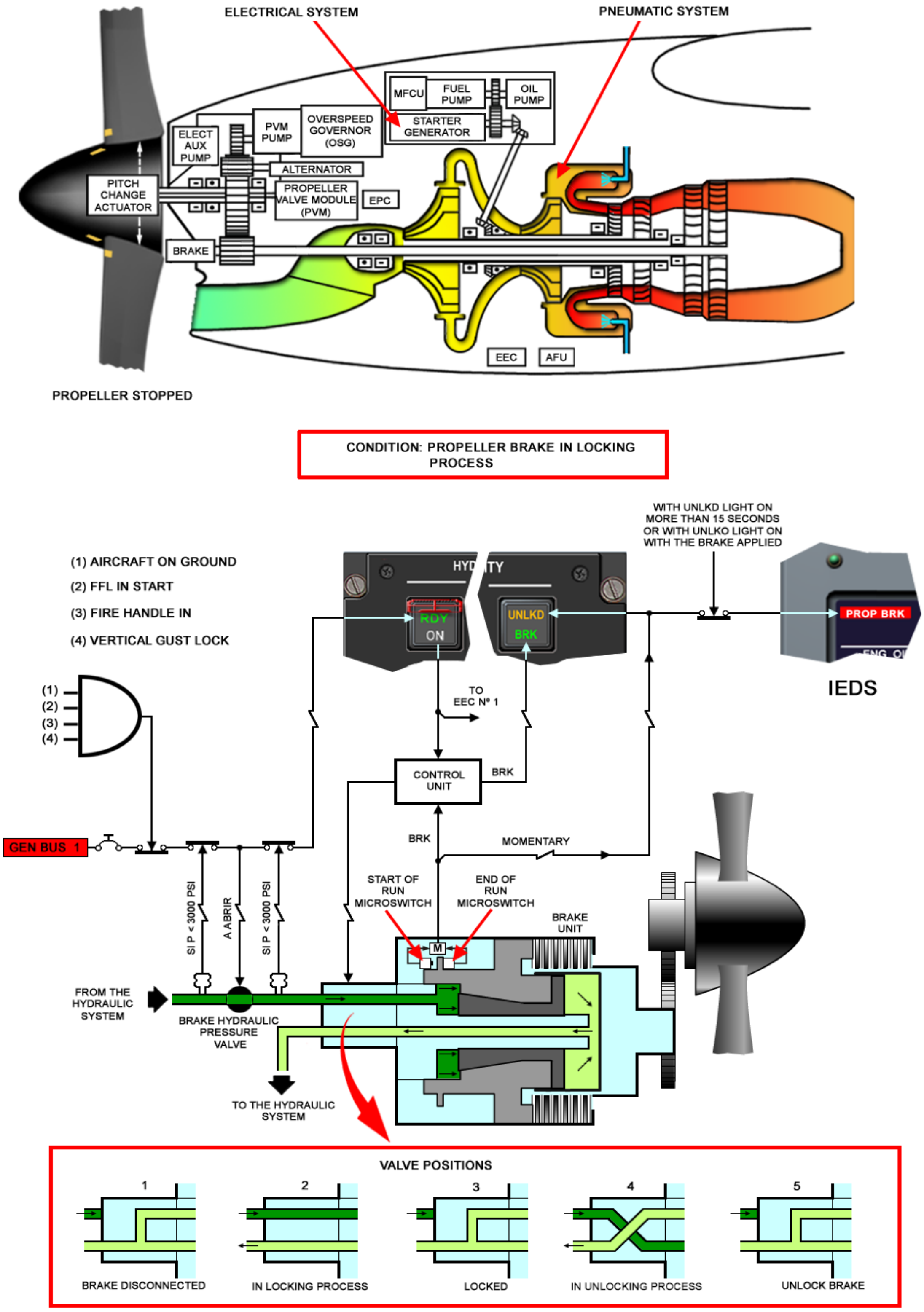


Figure 71-23 Propeller Brake System (left engine)

PROPELLER BRAKE SYSTEM CONTROLS AND INDICATORS

(1) Propeller Brake Pushbutton:

- *RDY light on:* circuit is ready to stop the propeller (all the above mentioned conditions have been met).

- *Pressed-in (ON light on):* system acts on both control unit and EEC (if connected) in order to operate propeller brake.

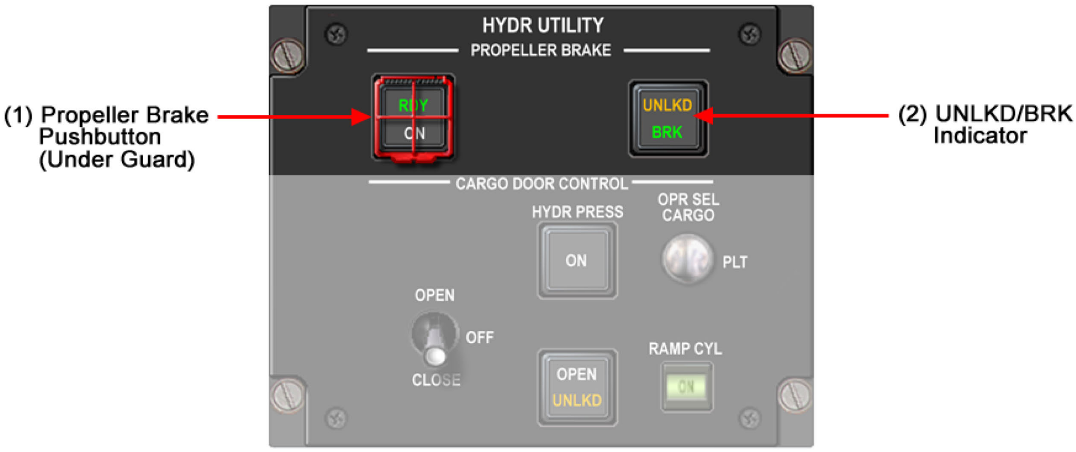
(2) UNLKD/BRK Indicator:

- *UNLKD light on:* propeller brake pushbutton is pressed-in and propeller is either engaging or releasing.

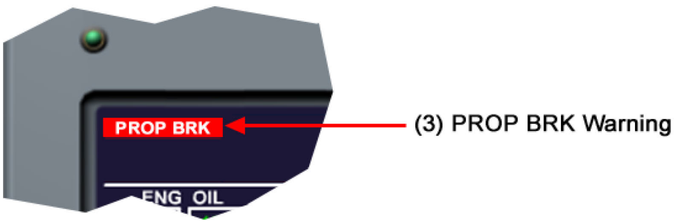
- *BRK light on:* propeller brake is operated and secure.

(3) (IEDS) PROP BRK Warning:

An unsafe condition has taken place with brake operated or non-stopped propeller once brake is operated or released.



OVERHEAD PANEL



IEDS

Figure 71-24 Propeller Brake System - Controls and Indicators

POWER PLANT CONTROL

DESCRIPTION

Each power plant is manually-controlled from both power lever (PL), and fuel and feather lever (FFL) and a power range selector (PRS) as well, which is common to both.

Automatic control is performed by the electronic engine control (EEC).

In addition, each power plant is also controlled by both automatic and backup systems described in previous sections. These are:

– Electronic Propeller Control (EPC)
– Beta Lockout System (BLS)
– Secondary Low Pitch Stop System (SLPS)
– Overspeed Governor (OSG)
– Autofeather System
– Propeller Synchronization System

Main engine control components are:

– ***Power Levers (PL):*** mechanically transmit requirements regarding:
  1. Power (to the mechanical fuel control unit, MFCU) and
  2. Propeller pitch (to the propeller valve module, PVM)
– ***Fuel and Feather Levers (FFL):*** enable the relevant propeller and by means of a levers/cables system, send requirements for:
  1. Fuel shut-off (mechanically at engine (MFCU) and electrically at fuel shut-off valve) and
  2. Propeller feathering (electrically)
– ***Power Range Selector (PRS):*** in normal operation (automatic mode), enables different power and propeller speed ranges selection by sending signals to the electronic control units (EEC and EPC, respectively).

OPERATION

NOTE

For power plant control system better understanding, please refer to PL, FFL and PRS positions as described at "Engine Control Quadrant - Controls and Indicators".

System two modes of control are:

– Automatic Mode
– Manual Mode

AUTOMATIC ENGINE CONTROL

This is the normal mode of operation. In this mode EEC sets the maximum PRS selected-range engine torque (TQ), according to outside conditions, and IEDS displays as a TQ bug. This is the torque value that would be obtained by moving forward the PL to the MAX AUTO position.

Therefore, engine torque values vary with altitude according to outside conditions. Maximum values for standard atmosphere at sea level are given below (not limited by outside conditions) for each PRS position:

– TOGA= 100% TQ (100% NP)

NOTE

With failure of opposite engine (APR), the value of TQ at TOGA is 110% TQ (100% NP).

– MCT= 110% TQ (100% NP)

– CLB= 89% TQ (95% NP)

– CRZ1= 90% TQ (90% NP)

– CRZ2= 101% TQ (80% NP)

With PL in MAX AUTO, EEC adjusts TQ to the value of TQ bug. Torque varies almost linearly between FI torque and the previous torque as PL is moved from FI to MAX AUTO.

With PRS in any position, if PL is moved forward to MAX MAN, EEC will switch to the MCT program. To do so, detent has to be overcome by pushing hard on the lever. PL positions beyond MAX AUTO are only for emergency situations and are IEDS recorded as "NEW EXCEEDANCE".

EEC increases/decreases NH until detects that the engine has reached the required power. In other words, EEC controls NH and thus indirectly, NP as well. However, NH regulation is replaced by NP regulation when propeller speed tends to decrease below the minimum (yellow band), and EEC-included underspeed governor prevents NP from decreasing below 71%. This is normal at low power (between GI and FI). In addition, when PL is retarded towards reverse thrust, NP minimum value gradually increases according to aircraft speed, up to a maximum of 100% NP if maximum reverse thrust is selected with aircraft stopped or moving very slowly.

There is an electronic adjustment procedure (trimming) for normal control. This uses the INT (on the EEC) and TRIM switches (L or P) on POWER PLANT MAINTENANCE panel, this equalizes both EECs responses when PLs are in the same position, thus minimizing asymmetries between them in automatic operation mode.

Outside condition data, as used by EEC to correct theoretical engine torque values for each PRS position, are altitude pressure, temperature and aircraft speed supplied by aircraft air data system. If this one fails, EEC uses data from its own sensors. Both NP signal and air conditioning system connection are also considered by the EEC as corrective factors (refer to Figure Automatic Engine Control).

When the FI SEL pushbutton is pressed to select LOW power, the EEC controls the thrust provided by the engine that is 0 SHP when the PL is in FI, instead of the 185 SHP provided without LOW. The yellow annunciator LOW is displayed, in the IEDS, below TQ indicators (refer to Figure Automatic Engine Control).

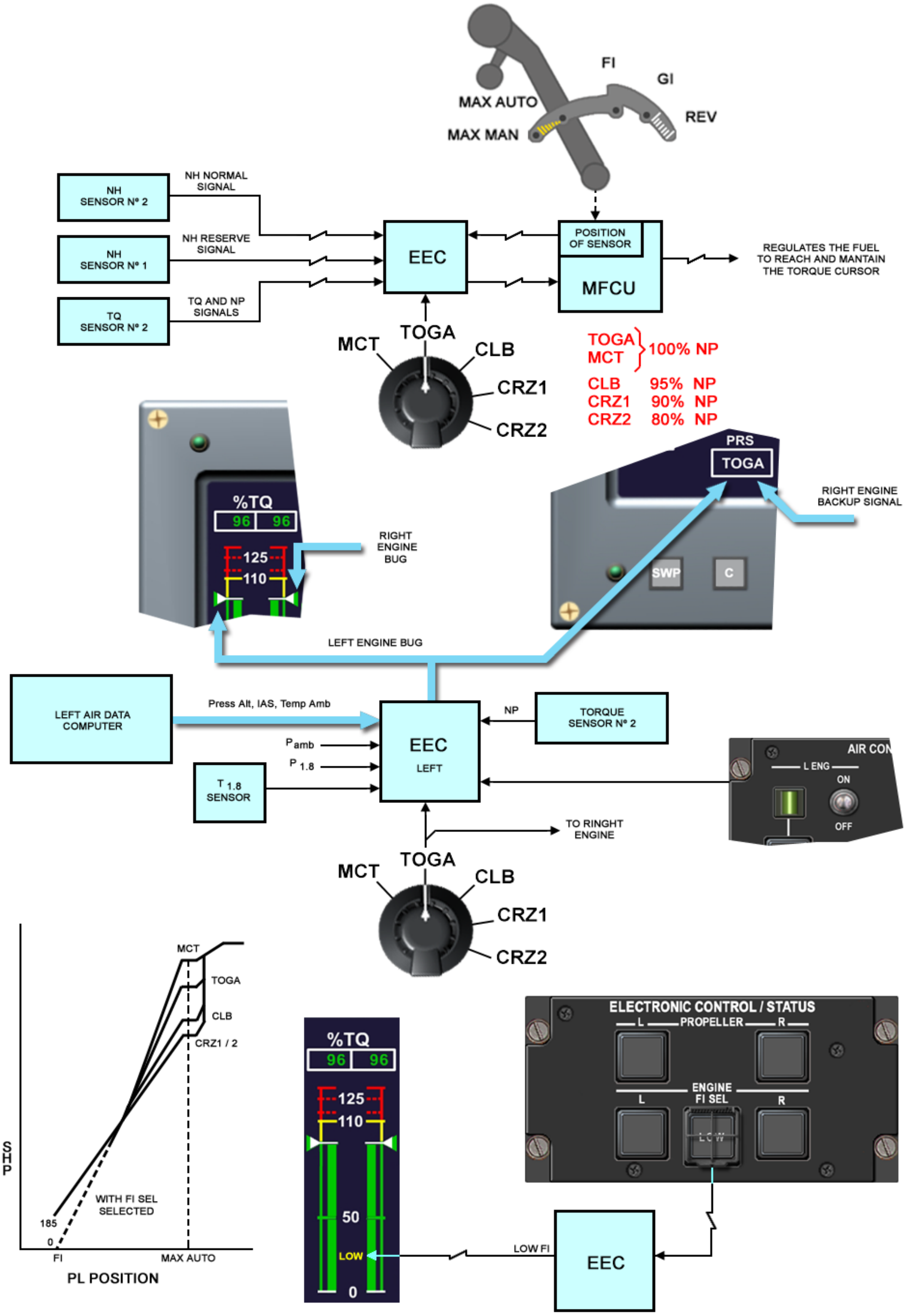


Figure 71-25 Automatic Engine Control

In case of EEC or processed-signals failures, the following messages may appear:

- ENG (MAINT) light on the POWERPLANT MAINTENANCE panel: indicates EEC has detected an EEC or received signals, minor failure. This sort of failures does not affect pilots actuation and therefore does not require changing to manual mode. This sort of failures is saved as EEC-failure code subsequent IEDS-download, for later maintenance analysis purposes.

- 1, 2 EEC (amber) caution on IEDS: if failure is severe enough to affect engine control. In this case, power is latched at the last position EEC-considered (fail fix). It does not respond to PL movements until manual mode is selected. In order to change to manual mode or EEC reset attempt after a failure has been IEDS-displayed, relevant L or R ENGINE pushbutton on the ELECTRONIC CONTROL/STATUS panel is used (MAN light will come on). This will cancel IEDS caution. It will also change to manual mode when PL is retarded below a given position between MAX AUTO and FI, but does not cancel IEDS caution or turn-on MAN light on L or R ENGINE pushbutton.

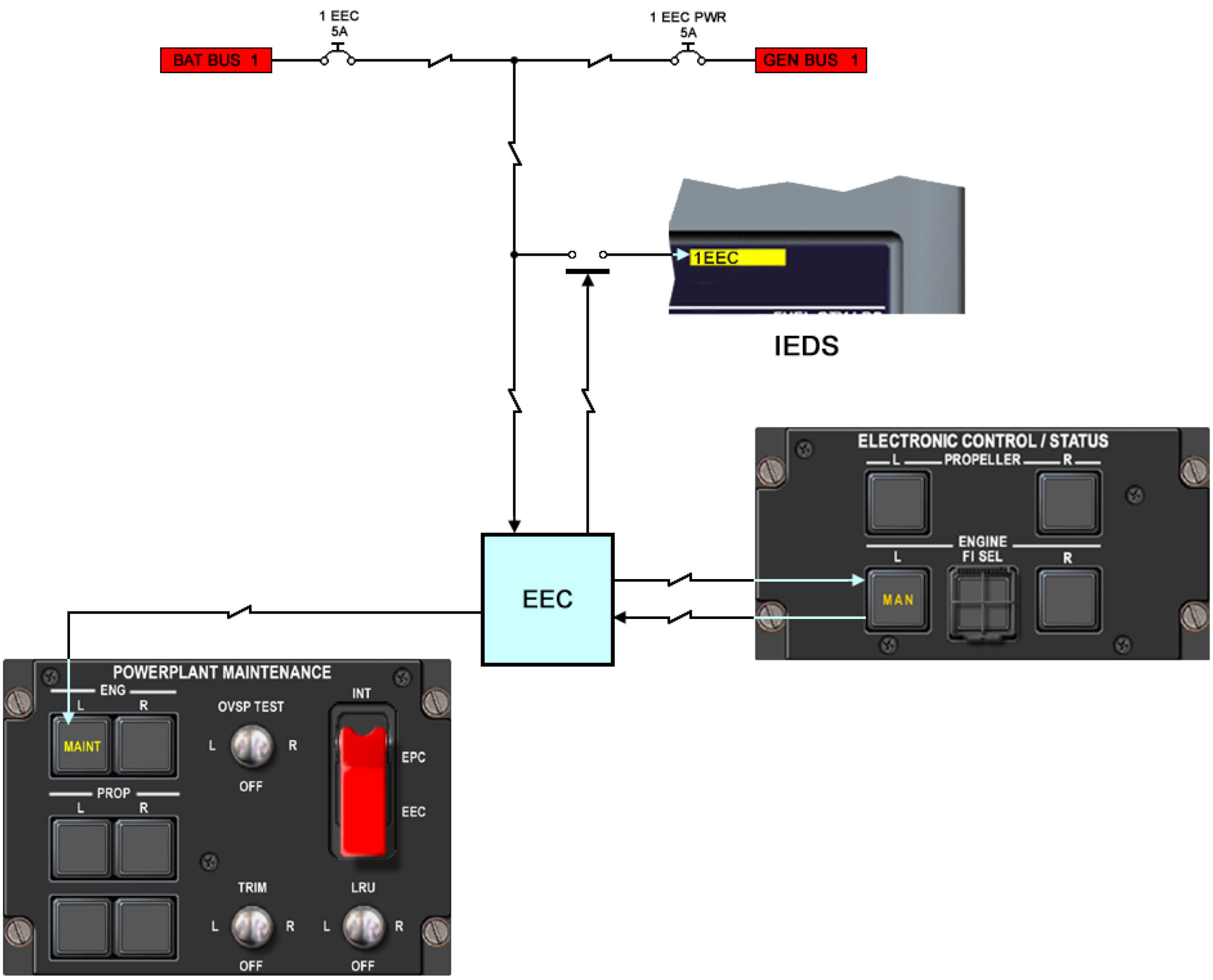


Figure 71-26 Automatic Engine Control Failure

MANUAL ENGINE CONTROL (EEC DISCONNECTED)

This can be selected voluntarily by the pilot, as previously stated, once a failure is detected in the automatic control mode, or for any other reason.

In this mode, PL acts directly on the mechanical fuel control unit (MFCU) for NH regulating (refer to ENGINE FUEL SYSTEM). EEC preset restrictions are lost and engine response is faster.

Also, during ground operation there is no minimum NP regulation (underspeed governor is not operative as EEC is disconnected). Therefore, NPs can fall below normal values, thus reducing reverse capability (not completely lost).

Due to EEC protection mechanisms loss, this mode of operation requires the pilot to carefully operate PLs while paying extra attention to their indicators in order to avoid applicable restrictions exceeding.

In this mode of operation, PRS range selection has no effect on engine power.

In this mode of operation, as well as in either automatic or normal operation, if engine limits are exceeded, information is IEDS recorded as NEW EXCEEDANCE, where it can subsequently be downloaded for maintenance purposes.

AUTOMATIC POWER RESERVE SYSTEM (APR)

(refer to PROPELLER AUTOFEATHERING SYSTEM, in this chapter).

This system is only operative when the engine is EEC-controlled (automatic control).

If an engine fails during take-off or go-around, APR system increases power from the other engine. System operation is linked to propeller autofeather and both arming and activation conditions are the same.

Therefore as power drops when an engine fails, autofeather unit (AFU) feathers its propeller and sends a signal to the other engine EEC to increase power. At IEDS display operative engine TQ bug moves from normal take-off power to APR power. APR legend also comes-on to indicate the system is working correctly.

APR increase from normal power to maximum take-off power is always 10%

ENGINE CONTROL QUADRANT CONTROLS AND INDICATORS

(1) Gust Lock Lever:

this prevents PLs from being moved forward to positions that can affect the propeller brake correct operation.

(2) Power Lever Trigger:

allows the power lever to be moved below FI

(3) Power Lever (PL) (two): performs:

1. Engine power control from GI to MAX MAN.
2. Propeller pitch control directly from FI to maximum reverse (REV).
3. While airborne is not possible to moved back levers beyond FI position (due to the mechanical beta lockout rod (BLS)).
4. While grounded it can be moved back by lifting the triggers at FI.

The following positions are marked:

– *REV range:* to generate propeller negative traction.

– *GI (ground idle):* provides zero traction with the aircraft stopped while engine-starting on ground.

– *FI (flight idle):* minimum airborne position, limited by the beta lockout system (BLS) mechanical stop. Once grounded, PL can be moved back towards GI and REV by lifting the triggers, while airborne engine-starting.

– *MAX AUTO:* maximum position during normal operation. Supplies maximum power for PRS selected range.

– *MAX MAN range:* exclusively for emergency operation, reached once detent has been overcome. If this zone is entered while operating in normal mode (automatic), EEC changes to the MCT program independently from PRS selection, and as PL is moved forward, supplied power is greater than the maximum continuous (MCT) (refer to SHP vs PL position graph in Figure Automatic Engine Control). In this zone it is easy to exceed power plant limits. Thus if used, PL must be carefully operated while associated engine parameters watched closely.

(4) Fuel and Feather Lever (FFL) (two): the lever should be moved to one of the following positions:

- *OFF:* shuts-off fuel supply (mechanically and electrically) and feathers the propeller.
- *START:* opens fuel supply (mechanically and electrically), while engine-starting. In this position the propeller remains feathered.
- *RUN:* the propeller is unfeathered, while at power plant normal operation.

(5) Power Rate Selector (PRS):

in normal operation (automatic mode), selects between different power and propeller speed ranges by sending signals to electronic control units (EEC and EPC, respectively). PRS range selection has no effect on engine power while operating in manual mode (EEC disconnected). If EPC is disconnected, PRS selector will have no effect on propeller speed (NP). It has five positions:

– MCT (maximum continuous): for continuous operation after an engine failure or when necessary for safety reasons. Provides 100% NP and with PL at MAX AUTO, maximum continuous thrust (very similar to APR power).

– TOGA (Take-off and Go Around): for normal take-off and a go-around, provides 100% NP and relevant power, with PL at MAX AUTO. If one engine fails, APR system automatically increases operative engine power by 10% (APR power) without the need for the pilot to operate PLs or PRS.

– CLB (Climb): for a two-engine climb, provides 95% NP and with PL at MAX AUTO, maximum relevant power.

– CRZ1 (Cruise 1): for two-engine and high NPs cruising. Provides 90% NP and with the PL at MAX AUTO, maximum relevant power.

– CRZ2 (Cruise 2): for two-engines and low NPs (less noise and vibration) cruising provides 80% NP and with the PL at MAX AUTO, maximum relevant power. Both CRZ1 and CRZ2 powers are identical, but as NP differs, engine torques (TQs) are also different (greater in the case of CRZ2 than CRZ1).

(6) FIRE Warning Indicator (two):

- *On:* overheating or fire in the relevant engine (refer to CHAPTER 26 - FIRE PROTECTION).

(7) PLs Friction Adjustment:

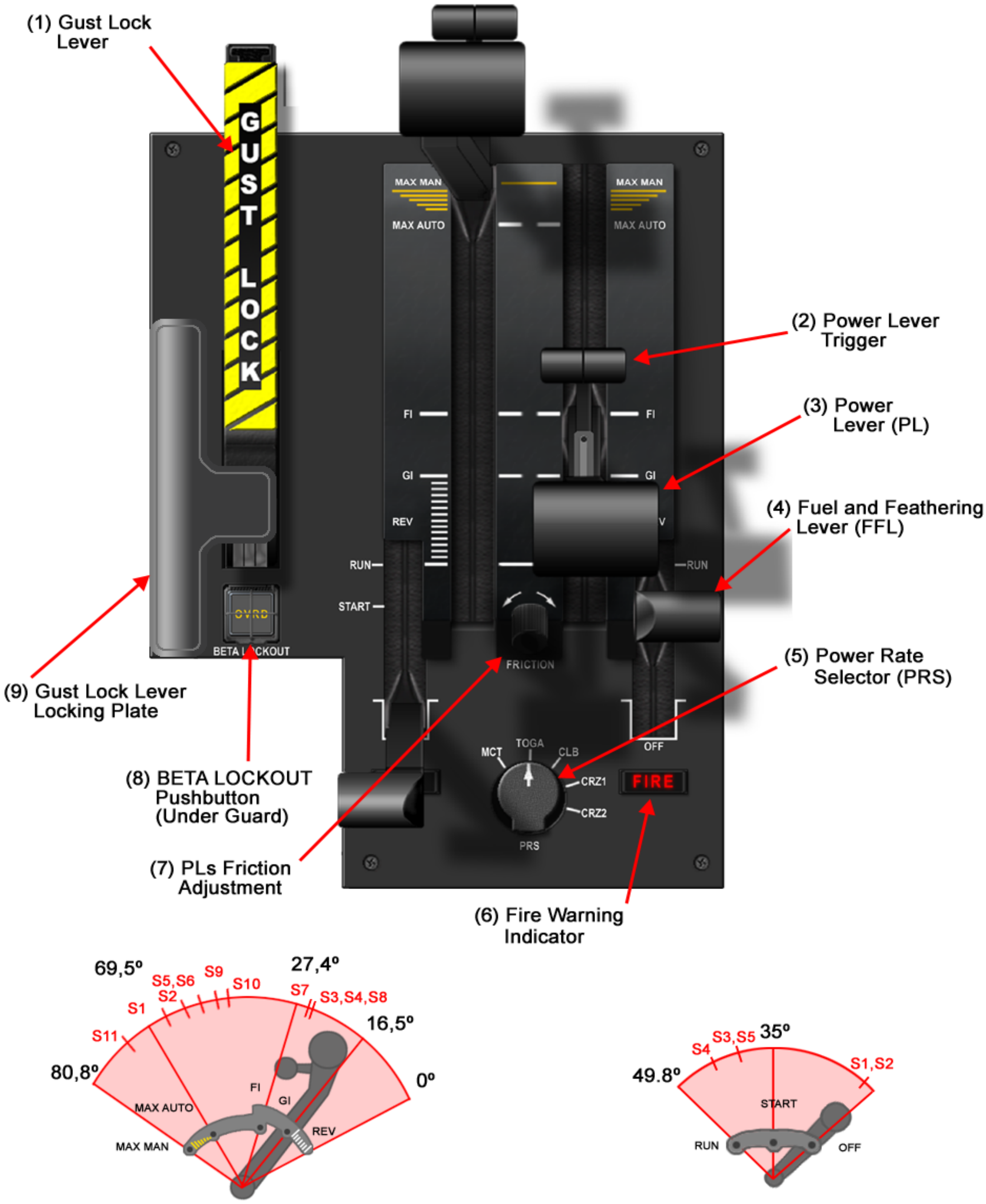
adjusts PLs movement friction (not operative).

(8) BETA LOCKOUT Pushbutton:

- *Pressed-in (OVRD light on):* disconnects lockout rod thus preventing PLs from being retarded below FI, if it has not already been disconnected automatically during landing. This action is IEDS-recorded as "NEW EXCEEDANCE" (refer to section on "BETA LOCKOUT SYSTEM (BLS)).

(9) Gust Lock Lever Locking Plate:

prevents gust-lock lever from moving other than horizontal position.



PLs MICROSWITCHES

S1. TO CLOSE OVER (UNSAFE TAKE OFF)
S2. TO CLOSE OVER (DISCONNECTION IN CASE OF FAILURE: GO TO MANUAL MODE)
S3. TO CLOSE BELOW (SIGNAL TO FDR)
S4. TO CLOSE BELOW (NP OVERRIDE)
S5. TO CLOSE OVER (ALLOWS THE AUTOFEATHER)
S6. TO CLOSE OVER (ALLOWS THE AUTOFEATHER)
S7. TO CLOSE OVER (ALLOWS THE SLPS)
S8. TO CLOSE BELOW (RBS INHIBIT)
S9. TO CLOSE OVER (ALLOWS THE LIMITS EXPANSION OF THE RUDDER)
S10. TO CLOSE BELOW (ALLOWS ANTI-ICE)
S11. TO CLOSE OVER (FEATHER)

FFLs MICROSWITCHES

S1. TO CLOSE BELOW (SHUT OFF-VALVE)
S2. TO CLOSE BELOW (SHUT OFF-VALVE)
S3. TO CLOSE BELOW (ALLOWS THE PROPELLER BRAKE)
S4. TO CLOSE BELOW (AUTOFEATHERS)
S5. TO CLOSE BELOW (ALLOWS THE PROPELLER BRAKE)

Figure 71-27 Engine Control Quadrant - Controls and Indicators

CONTROLS AND INDICATORS

(1) ENGINE L, R Pushbuttons:

- *Pressed-in (MAN light on):* relevant EEC is disconnected and IEDS 1, 2 EEC caution goes off.

(2) FI SEL Pushbutton (under guard):

- *Pressed-in (LOW light on):* reduces engine power (TQ) to allow greater vertical descending speeds.

(3) L, R ENG MAINT Indicators:

- *On:* EEC memory saves every failure as occurred during operation. Maintenance personnel can download failure data through IEDS.

(4) INT Selector (under guard):

- *EEC:* selects IEDS access to EEC memory-saved data (for maintenance download purposes). It also enables electronic adjustment to equalize both EECs responses for the same automatic control mode PL position (for maintenance personnel purposes).

(5) LRU Selector:

- *L or R:* with INT switch in EEC position, IEDS displays relevant EEC memory-saved failures.

(6) TRIM Selector:

- *L or R:* with INT switch is in EEC position, allows power levers electronic trimming to each EEC response to an identical automatic control mode (for maintenance personnel) PL position.

(7) (IEDS) 1, 2 EEC Caution:

relevant EEC failure.

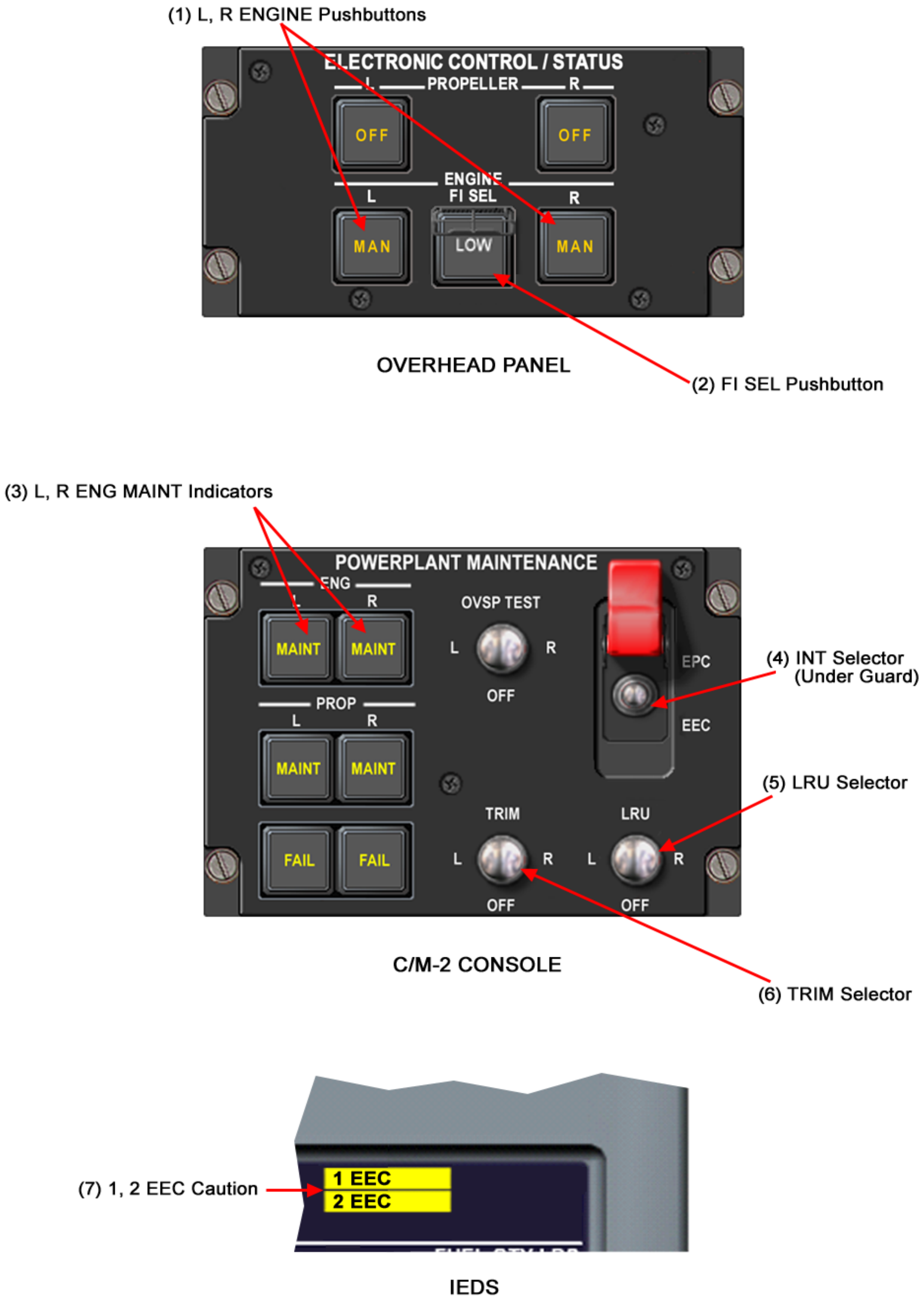


Figure 71-28 Power Plant Control System - Controls and Indicators

POWER PLANT INDICATING SYSTEM

DESCRIPTION

The integrated engine display system (IEDS) is a unit that processes and displays both aircraft and engine data as well as caution and warning messages. Additionally, the system monitors engine parameters and calculates when they have exceeded operational limits. It also registers failures and stores them in non-volatile memory for maintenance purposes. IEDS is located at the central instrument panel and also has a remote control panel on the pedestal.

Power plant parameters are IEDS digitally displayed by means of a vertical scale (except NL, which does not have any scale). Displayed parameters are:

– **TQ (%):** engine torque, displayed for values ranging from 0 to 130%, with a digital display resolution of 1%. 100% TQ is the torque at maximum normal take-off power (2645 SHP) with 100% NP. The torque is measured by an engine sensor that detects power shaft torsion. It is AFU-processed before being sent to the IEDS. Reading scale does not depend on the type of operation. Vertical scale, cursor and digital reading colours are:

  1. RED at > 112%
  2. YELLOW from 101.6 to ≤ 112.0%
  3. GREEN from 0 to ≤ 101.5%

  Scale marks are:

  1. Discontinuous Red Marks at 112.1% and 124.8%
  2. White Mark at 110.4%

– **ITT (ºC):** engine temperature (Inter Turbine Temperature). Displayed in ºC, with vertical scale values ranging from 200 to 1000ºC, and digital reading from 0 to 999ºC, with a digital display resolution of 1ºC. When temperature is over 999ºC display flashes while indicating 99ºC. Temperature is measured by means of turbine-located thermocouples. Reading scale depends on the type of operation: engine start mode (IGN pushbutton pressed-in), normal mode (IGN pushbutton pressed-out), or APU mode (propeller brake operated). Vertical scale, cursor and the digital reading colours are:

  1. RED at > 800 ºC
  2. YELLOW from 766 to ≤ 800ºC (from 716 to ≤ 800 ºC in APU mode)
  3. GREEN from 301 to ≤ 765 ºC (from 301 to ≤ 715 ºC in APU mode)
  4. WHITE from 200 to ≤ 300 ºC
  5. WHITE from 0 to ≤ 200 ºC (digital reading only)

  Scale marks are:

  1. Red discontinuous mark at 840ºC (at 950ºC in engine start mode)
  2. Yellow triangle at 715ºC in APU mode

- **NP (%):** both propeller and power turbine speed. Torque is displayed for values ranging from 0 to 125%, with a digital display resolution of 1%. A 100% reading is equivalent to a propeller speed of 1200 rpm. Signal is given by an RGB sensor. Reading scale does not depend on the type of operation. Vertical scale, cursor and digital reading colours are:

  1. RED at > 103.5%
  2. YELLOW from 101.1 to ≤ 103.5%
  3. GREEN from 62.5 to ≤ 101%
  4. YELLOW from 42.2 to < 62.5%
  5. WHITE from 0 to ≤ 42.1%

  Scale marks are:

  1. Discontinuous red mark at 109.6%
  2. Discontinuous green mark at 70.8%
  3. Yellow triangle at 40%

- **NH (%):** high-pressure spool speed. Torque is displayed for values ranging from 0 to 130%, with a digital display resolution of 0.1%. When reading is over 99.9%, digital display goes to 00.0%. Signal is given by an accessory gearbox (AGB) sensor. Reading scale does not depend on the type of operation. Vertical scale, cursor and digital reading colours are:

  1. RED at > 103.7%
  2. YELLOW from 102.4 to ≤ 103.7%
  3. GREEN from 64.0 to ≤ 102.3%
  4. WHITE from 0 to < 64.0%

  Scale marks are:

  1. Discontinuous red mark at 104.3%

- **NL (%):** low-pressure spool speed. Speed is only displayed as a digital reading over a 0 to 125% range, with a digital display resolution of 0.1%. Signal is given by a spool sensor. In case of overspeed (NL>106.5%), a 1, 2 NL OVSP warning will be IEDS-displayed. Digital reading colours do not depend on the type of operation and are as follows:

  1. RED at > 104.6%
  2. YELLOW from 102.9 to ≤ 104.6%
  3. GREEN from 45.0 to ≤ 102.8%
  4. WHITE from 0 to < 45.0%

– **ENG OIL Temperature (ºC):** the temperature of the engine oil, displayed in ºC over a range from -54 to +150 ºC, with a digital display resolution of 1 ºC. Signal is given by an engine sensor (refer to LUBRICATION SYSTEM, in this chapter). Reading scale does not depend on the type of operation. Vertical scale cursor and digital reading colours are:

  1. RED from -54 to < -40 ºC
  2. YELLOW from -40 to < 0 ºC
  3. GREEN from 0 to ≤ 125 ºC
  4. YELLOW from 126 to ≤ 140 ºC
  5. RED from 141 to < 150 ºC

  Scale marks are:

  1. A white triangle at 45ºC (shows the temperature below which the aircraft should not take off under icing conditions).

– **ENG OIL Pressure (PSI):** pressure of the engine oil displayed in PSI for values ranging from 0 to120 PSI, with a digital display resolution of 1 PSI. Signal comes from an engine sensor (refer to LUBRICATION SYSTEM, in this chapter). Reading scale does not depend on type of operation. Vertical scale, cursor and digital readings colours are as follows:

  1. RED from 0 to < 40 PSI
  2. YELLOW from 40 to < 55 PSI
  3. GREEN from 55 to ≤ 65 PSI
  4. YELLOW from 66 to ≤ 100 PSI
  5. RED from 101 to < 120 PSI

  Scale marks are:

  1. Discontinuous red mark at 100 PSI

– **Power Rate Selection (PRS selection):** window-displayed (secondary display) in white with "PRS" legend. When the aircraft is landing-configured and power rate selector (PRS) is in other mode than MCT or TOGA, screen flashes to display one of the following:

  1. MCT
  2. TOGA
  3. CLB
  4. CRZ1
  5. CRZ2

– **FUEL FLOW:** to indicate injectors-delivered fuel flow, display just as a digital reading in blue. Units are lb/h (PPH) or kg/h (KPH), depending on IEDS selection made at maintenance menu. Values range from 0 to 1600 PPH in steps of 5 PPH. Signal comes from a flowmeter (refer to ENGINE FUEL SYSTEM, in this chapter).

– **FUEL USED:** to indicate consumed fuel, displays just as a digital reading in blue. Units are pounds (LBS) or kilograms (KGS) depending on IEDS selection made at maintenance menu. Values range from 0 to 9999 LBS in steps of 10 LBS and from 0 to 5000 KGS in steps of 5 KGS. Signal comes from a flowmeter (refer to ENGINE FUEL SYSTEM, in this chapter).

IEDS receives both discrete and analogue signals from the engine as well as from other aircraft systems (refer to CHAPTER 31 - INDICATION AND RECORDING SYSTEM). Once signals are processed, the system displays them digitally and/or on a scale (refer to Figure Normal Power Plant Readings).

IEDS uses both TQ and NP backup signals (from backup TQ sensor) and NH backup signal (from the backup NH sensor) as well, when normal sensors signals fail (refer to Figure Backup Power Plant Readings). In this case the relevant digital reading window (box) flashes in order to take appropriate maintenance action.

During normal operation one screen displays a primary display format (by default, the one displayed at the top of the screen) and the other displays a secondary display format. If one of the screens fails a composite display format can be selected on the operative screen by pushing-in the "C" pushbutton. The following are three-possible parameters display formats (refer to Figure IEDS Screens Display Formats):

1. **Primary Display:** displayed readings include:

   – Each engine torque (TQ)

   – Each engine temperature (ITT)

   – Each engine propeller speed and turbine power (NP)

   – Each engine high-pressure spool speed (NH)

2. **Secondary Display:** displayed readings include:

   – Fuel Quantity (refer to CHAPTER 28 - FUEL): in both main tanks (MAIN), in both auxiliary tanks (AUX) total quantity in tanks (TOTAL).

   – Fuel flow for both engines (FUEL FLOW)

   – Fuel consumption for both engines (FUEL USED)

   – Fuel temperature (F TEMP)

   – Each engine low-pressure spool speed (NL)

   – Power rate selection

   – Each engine oil pressure

   – Each engine oil temperature

   – Caution and Warning Messages (refer to CHAPTER 31 - INDICATING AND RECORDING SYSTEM)

3. **Composite Display:** displayed readings include:
   - Each engine oil pressure at each engine
   - Each engine oil temperature at each engine
   - Fuel quantity (refer to CHAPTER 28 - FUEL): in both main tanks (MAIN), in both auxiliary tanks (AUX) and total quantily in tanks (TOTAL).
   - Fuel Flow for both engines (FUEL FLOW)
   - Fuel Consumption for both engines (FUEL USED)
   - Each engine high-pressure spool speed (NH)
   - Each engine torque (TQ)
   - Each engine temperature (ITT)
   - Each engine propeller speed and turbine power (NP)
   - Caution and Warning Messages (refer to CHAPTER 31 - INDICATING AND RECORDING SYSTEM)

While the aircraft is grounded it is possible to access specific pages for maintenance, allowing to analyze recorded anomalies (refer to Figure IEDS Maintenance Screens). These pages are displayed by simultaneously pressing "SWP" and "DN" buttons for 4 seconds. Maintenance displays enable the following functions:

- Fuel quantity used deletion
- Parameters update
- Engine anomalies review
- IEDS failures review
- Engine history monitoring
- EEC failures history
- EPC failures history
- Maintenance

IEDS performs a power-on self-test (BITE) as well as continuous status monitoring to ensure data integrity and process completion. It also has a user-initiated test that can be performed at any time using the TST pushbutton.

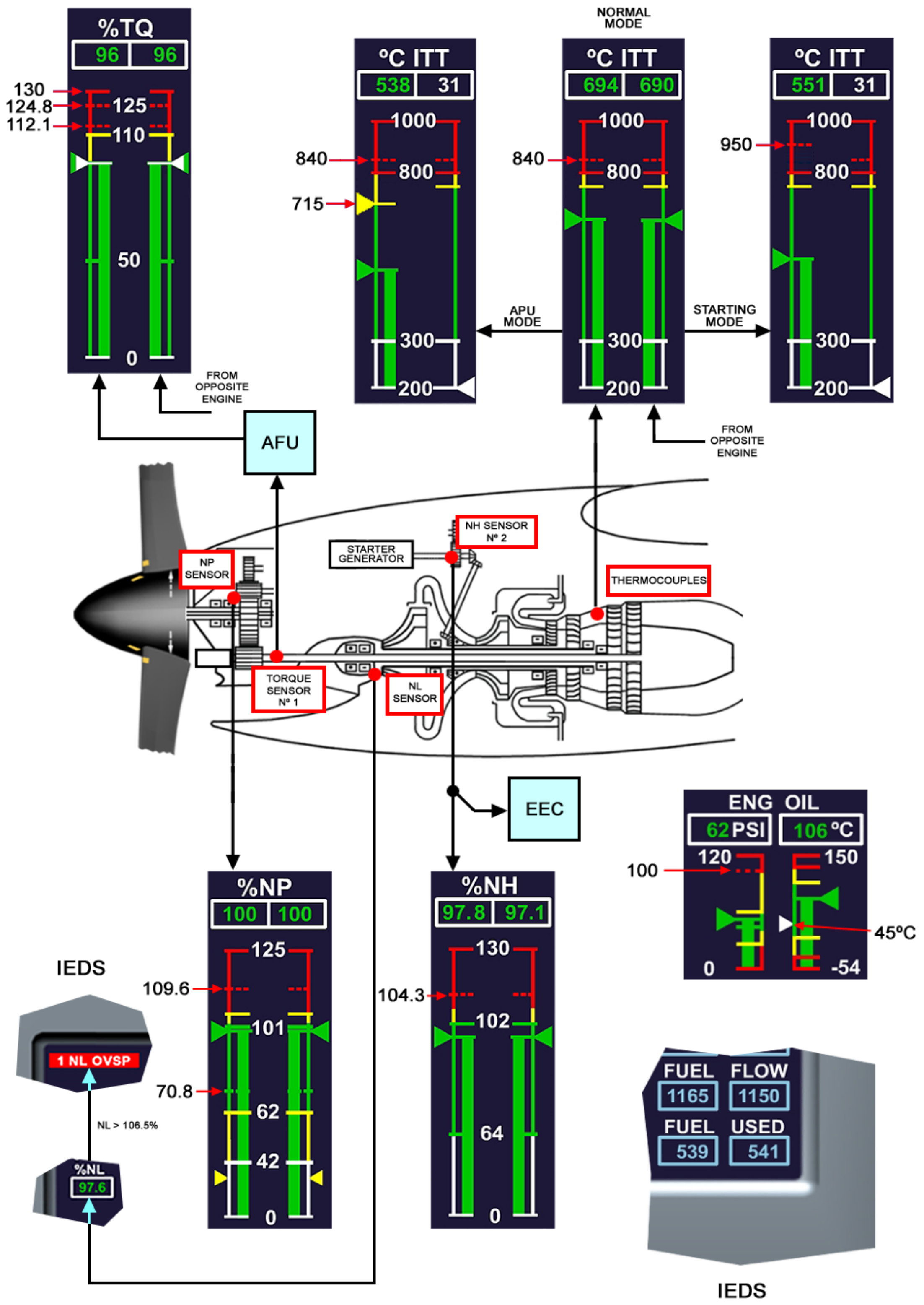


Figure 71-29 Normal Power Plant Readings

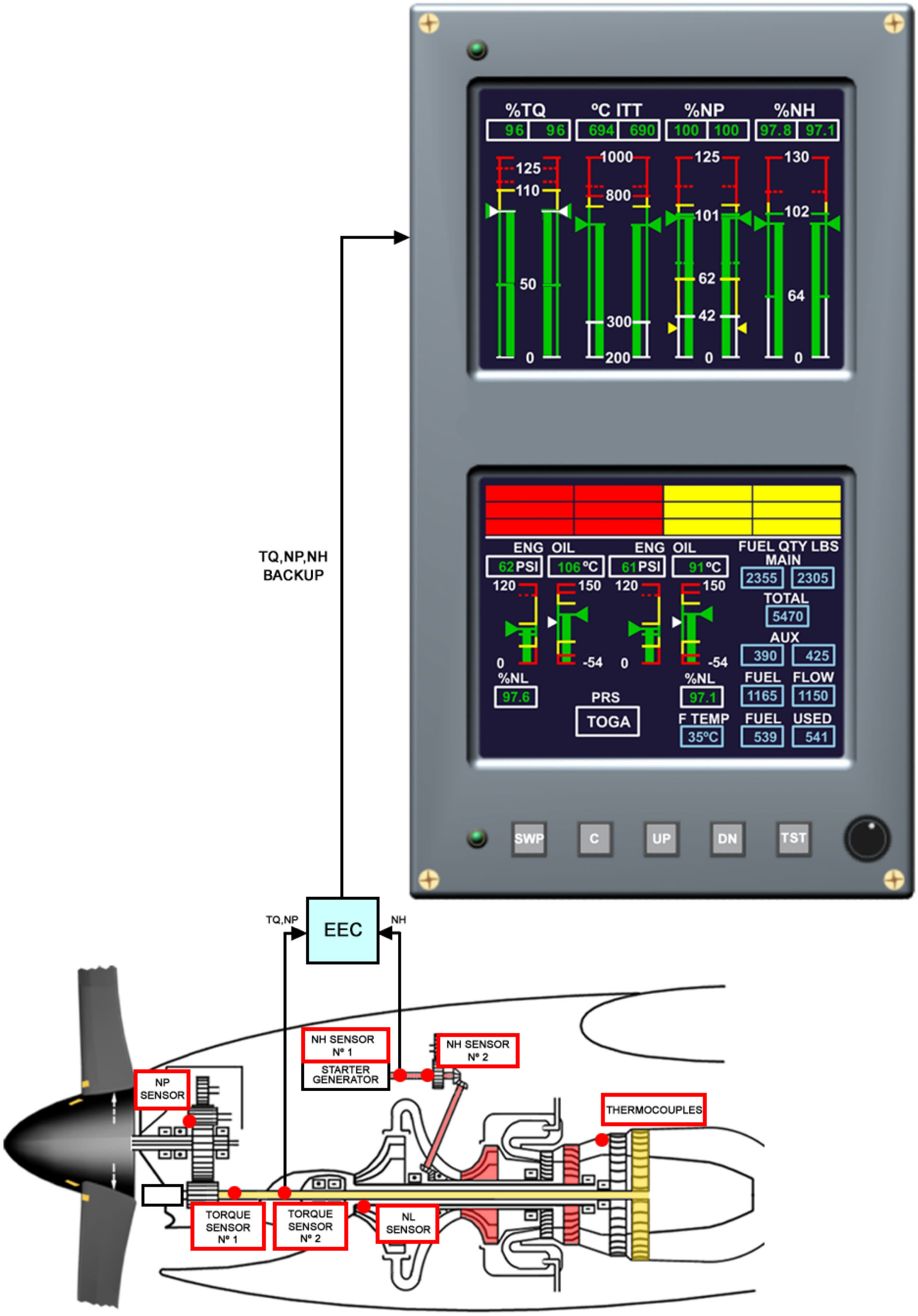


Figure 71-30 Backup Power Plant Readings

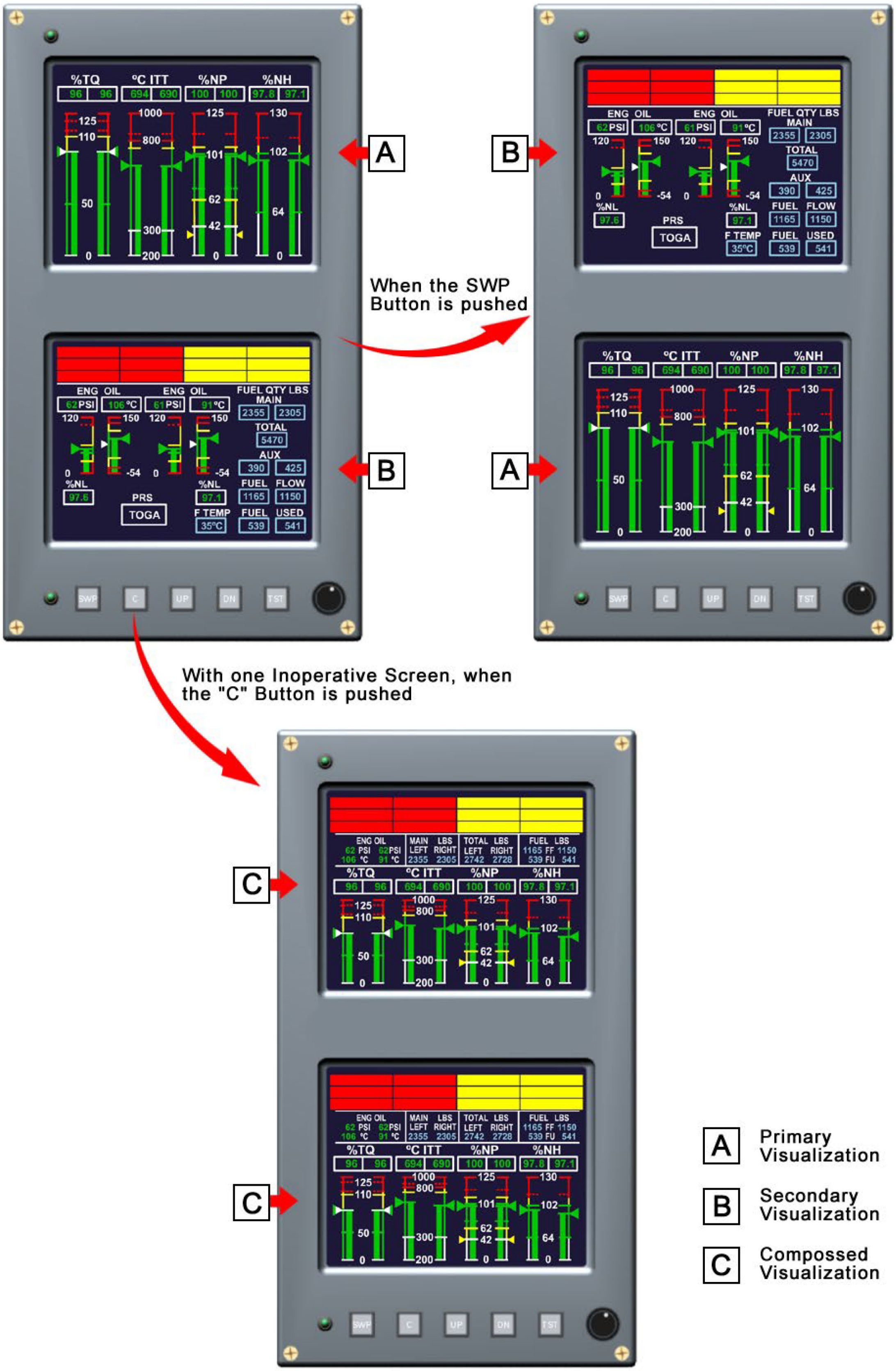


Figure 71-31 IEDS Screens Display Formats

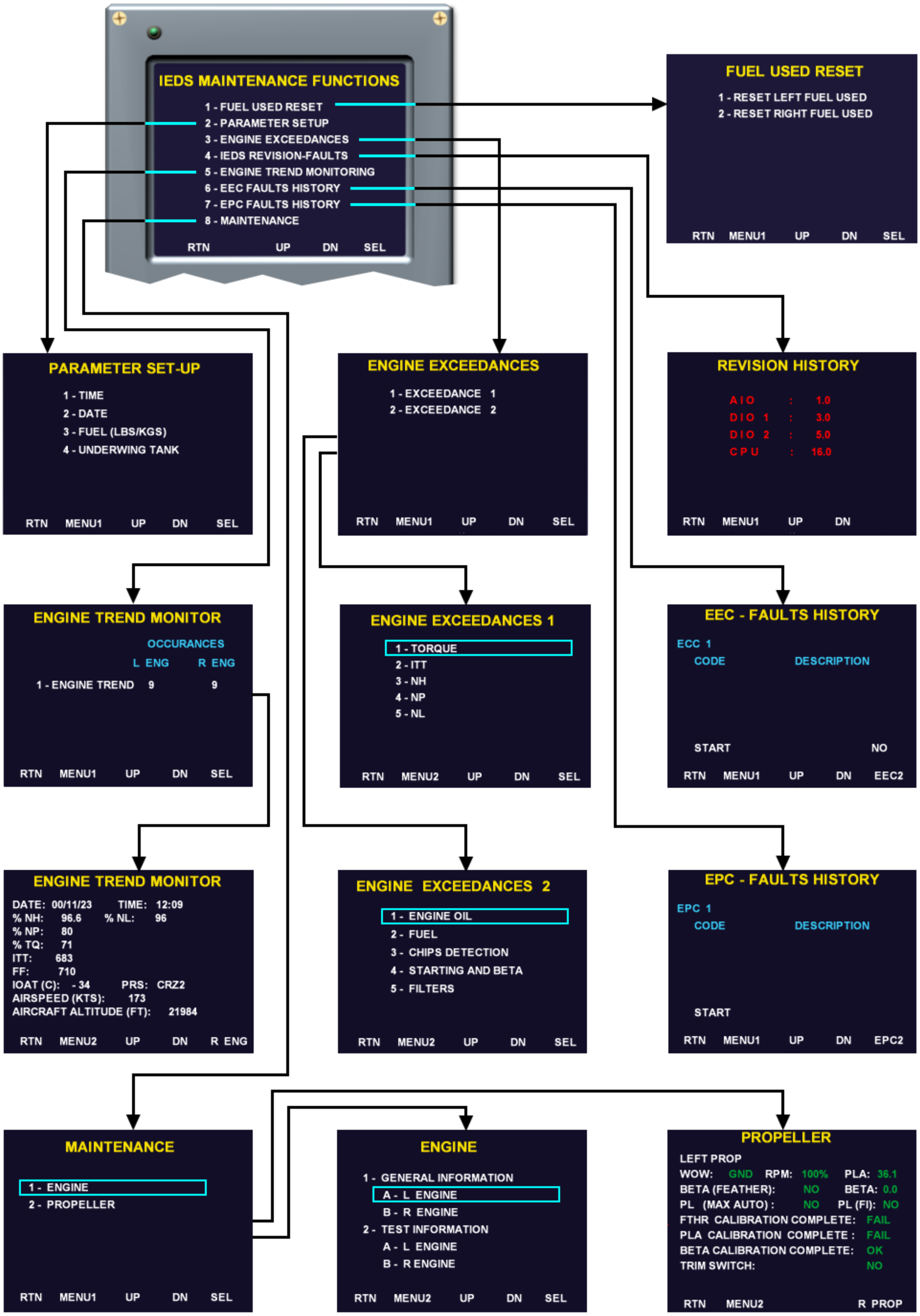


Figure 71-32 IEDS Maintenance Screens

CONTROLS AND INDICATORS

(1) (IEDS) Brightness Control:

adjusts display backlight brightness. In addition, a light-sensitive sensor adjusts brightness according to surrounding conditions.

(2) (IEDS) TEST Button:

- *Pressed-in and held:* the system performs the self-test (BITE). Test page is displayed on both screens simultaneously and the aural MASTER, LYRE BIRD (unsafe take-off), CRICKET (overspeed), HORN (landing gear up), and FIRE BELL (fire) warnings ring sequentially prior to a new, aural MASTER warning ring. Both MASTER CAUTION and MASTER WARNING lights come on. In addition, test pages state whether the tests have run successfully.

(3) (IEDS) DN Button:

- *Pressed shortly:* allows the list of caution messages to be scrolled-down when there are more messages than those which can be window-displayed. It is also used to scroll through maintenance menus.

(4) (IEDS) UP Button:

- *Pressed shortly:* allows the list of caution messages to be scrolled-up when there are more messages than those which can window-displayed. It is also used to scroll through maintenance menus.

(5) (IEDS) C Button:

- *Pressed shortly:* selects composite display mode at both screens.

(6) (IEDS) SWP Button:

- *Pressed shortly:* swaps screen displays. Pressing-in twice, it restores original configuration.

(7) (Pedestal IEDS Panel) SWP Button:

- *Pressed shortly:* performs the same as IEDS SWP pushbutton.

(8) (Pedestal IEDS Panel) C Pushbutton:

- *Pressed shortly:* performs the same as IEDS C pushbutton.

(9) (Pedestal IEDS Panel) W/C Selector:

- *UP:* set to this position, performs the same as IEDS UP pushbutton.

- *DN:* set to this position, performs the same IEDS DN pushbutton.

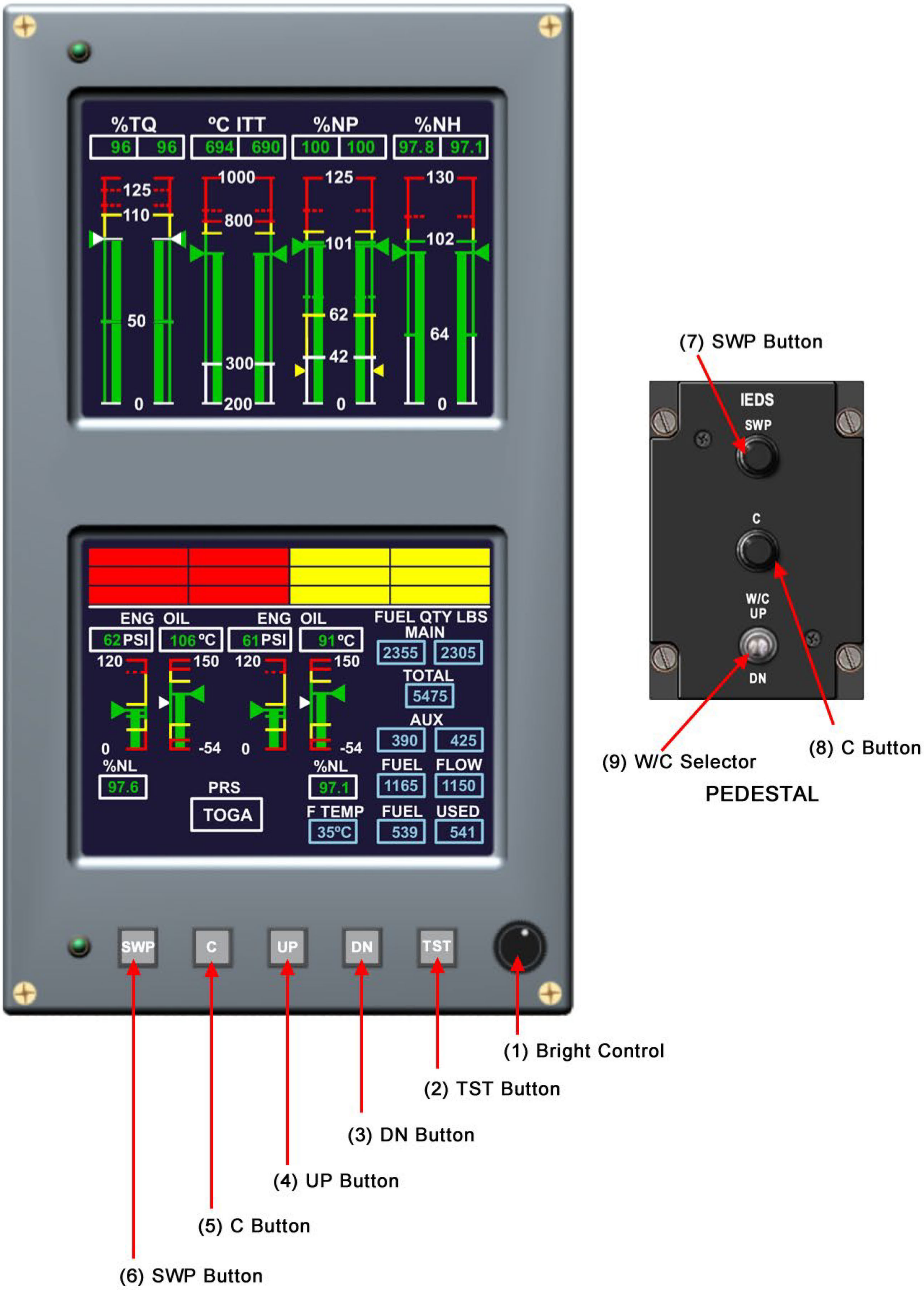


Figure 71-33 Power Plant Indicating System - Controls and Indicators