MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE

National Aerospace University
“Kharkiv Aviation Institute”

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SYSTEMS OF A TURBOFAN POWER PLANT

Tutorial

Kharkiv “KhAI” 2020

UDC 629.7.036.34
B-44

Розглянуто загальні відомості щодо будови систем авіаційних силових установок з турбовентиляторними двигунами. Наведено основні дані, схеми паливної, змащувальної та інших систем. Описано принципи роботи цих систем.

Викладено основні відомості про деякі агрегати, що застосовуються у системах живлення паливом і мастилом, протипожежній, антикриговій системах, та їх розміщення на борту літака. Висвітлено функції, особливості конструктивного виконання, принципи роботи цих агрегатів.

Для англомовних студентів, які вивчають системи і агрегати авіаційних силових і енергетичних установок.

Reviewers: Candidate of Technical Science, Associate Professor A. Litvyak,
Candidate of Technical Science E. Pavlyuk

Bezuglyi, S.
B-44 Systems of a Turbofan Power Plant [Electronic resource] : Tutorial / S. Bezuglyi. – Kharkov : National Aerospace University «Kharkov Aviation Institute», 2020. – 78 p.

The tutorial deals with the general information about the design of aircraft power plants.

General information on the structure of systems of aircraft power plants with turbofan engines is considered. The basic data, schemes of fuel, lubrication, starting and other systems are given. The principles of operation of these systems are described.

The basic information about some of the units used in the fuel and oil supply systems, ice and fire protection system, their arrangement on board the aircraft is given. Functions, features of constructive execution, principles of operation of these units are specified.

This tutorial will be interesting for English-speaking students who study the systems and units of aircraft engines and power plants.

Figs 54. Bibliogr.: 2 names

UDC 629.7.036.34

CONTENT

ABBREVIATIONS

Abbreviation	Full name
UERF	Uncontained Engine Rotor Failure
FADEC	Full Authority Digital Engine Control
ECAM	Electronic Centralized Aircraft Monitor
CTR TK AUTO MODE XFR	Center Tank Auto Mode Transfer
NRV	Non-Return Valve
CTRTK FEEDG	Center Tank Feeding
IDG	Integrated Drive Generator
FRTT	Fuel Return To Tank
FLSCU	Fuel Level Sensing Control Unit
EIU	Engine Interface Unit
IFPC	Integrated Fuel Pump and Control
FF	Fuel Flow
LPSOV	Low Pressure Shut-Off Valve
FOHE	Fuel/Oil Heat Exchanger
RTT	Return To Tank
TM	Torque Motor
FMV	Fuel Metering Valve
LVDT	Linear Variable Differential Transducer
PRV	Pressure Regulating Valve
BDCV	Bypass Direction Control Valve
TCM	Thrust Control Malfunction
FDV	Flow Divider Valve
FFDP	Fuel Filter Differential Pressure
SD	System Display
EWD	Engine Warning Display
LSOP	Lubrication and Scavenge Oil Pump
OCM	Oil Control Module
FDGS	Fan Drive Gear System
AGB	Angle Gearbox

MGB	Main Gearbox
AOHE	Air/Oil Heat Exchanger
IDGOOHE	IDG Oil/Oil Heat Exchanger
FOHEBV	Fuel/Oil Heat Exchanger Bypass Valve
VORV	Variable Oil Reduction Valve
JOSV	Journal Oil Shuttle Valve
AODV	Active Oil Damper Valve
ODM	Oil Debris Monitor
OL	Oil Level
ODM	Oil Debris Monitoring
MOT	Main Oil Temperature
MOP	Main Oil Pressure
LOP	Low Oil Pressure
OFDP	Oil Filter Differential Pressure
AOP	Auxiliary Oil Pressure
PCS	Propulsion Control System
EEC	Electronic Engine Controller
PRSOV	Pressure Regulating and Shut-Off Valves
P/BSW	Push Button Switch
PTs	Pressure Transducers
SDAC/FWS	System Data Acquisition Concentrator/Flight Warning System
FDIMU	Flight Data Interface and Management Unit
CFDIU	Centralized Fault Display Interface Unit
FDU	Fire Detection Unit
AGB	Accessory Gear Box
FWC	Flight Warning Computer

1. AIRCRAFT FUEL SYSTEM

SYSTEM INTRODUCTION – Aircraft 1 (Fig. 1.1)
The wing tanks are divided into two parts.
Two fuel pumps are installed in each wing tank. One fuel pump is installed for the APU. Fuel is delivered to the engines from the wing tanks only. As the fuel level in the wing decreases, the center tank fuel is transferred to the wing tanks until the center tank is empty.
Transfer valves control fuel transfer from the center tank to the wing tanks. The fuel system also feeds the APU directly from the left hand side. The APU LP valve is installed to supply or cut off fuel to the APU. It closes when the APU is shut down or when the APU FIRE pushbutton is released out.

SYSTEM INTRODUCTION – Aircraft 2 (Fig. 1.2)
The **Aircraft 2** fuel tanks are installed into the center fuselage area and the wings. Like the **Aircraft 1**, the center tank is part of the center wing box but unlike the **Aircraft 1**, the wing tanks are not divided. The tanks are simply called left and right wing tanks.

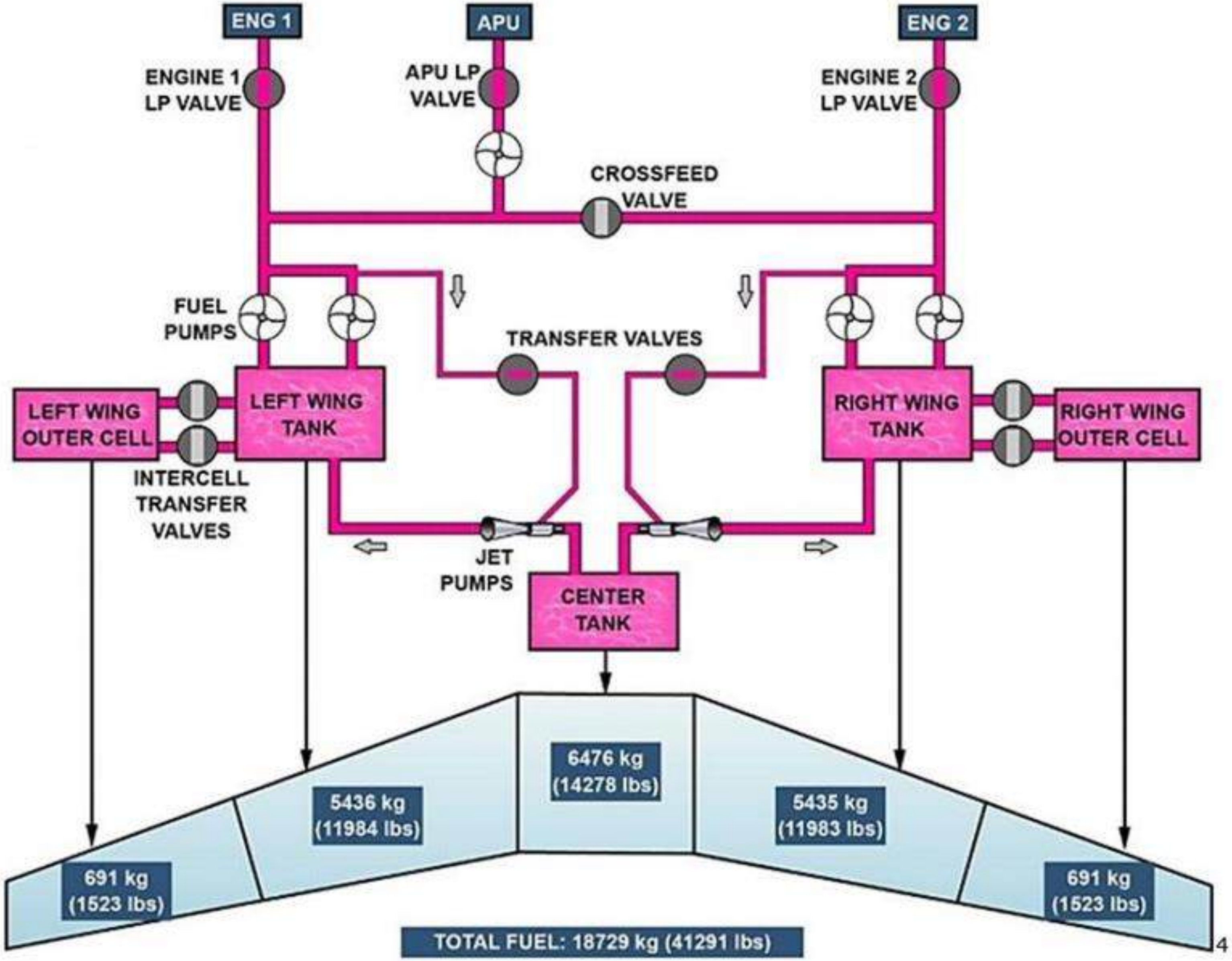

ENG 1
APU
ENG 2
ENGINE 1 LP VALVE
APU LP VALVE
ENGINE 2 LP VALVE
CROSSFEED VALVE
FUEL PUMPS
TRANSFER VALVES
LEFT WING OUTER CELL
LEFT WING TANK
RIGHT WING TANK
RIGHT WING OUTER CELL
INTERCELL TRANSFER VALVES
JET PUMPS
CENTER TANK
6476 kg (14278 lbs)
5436 kg (11984 lbs)
5435 kg (11983 lbs)
691 kg (1523 lbs)
691 kg (1523 lbs)
TOTAL FUEL: 18729 kg (41291 lbs)
4

Fig. 1.1

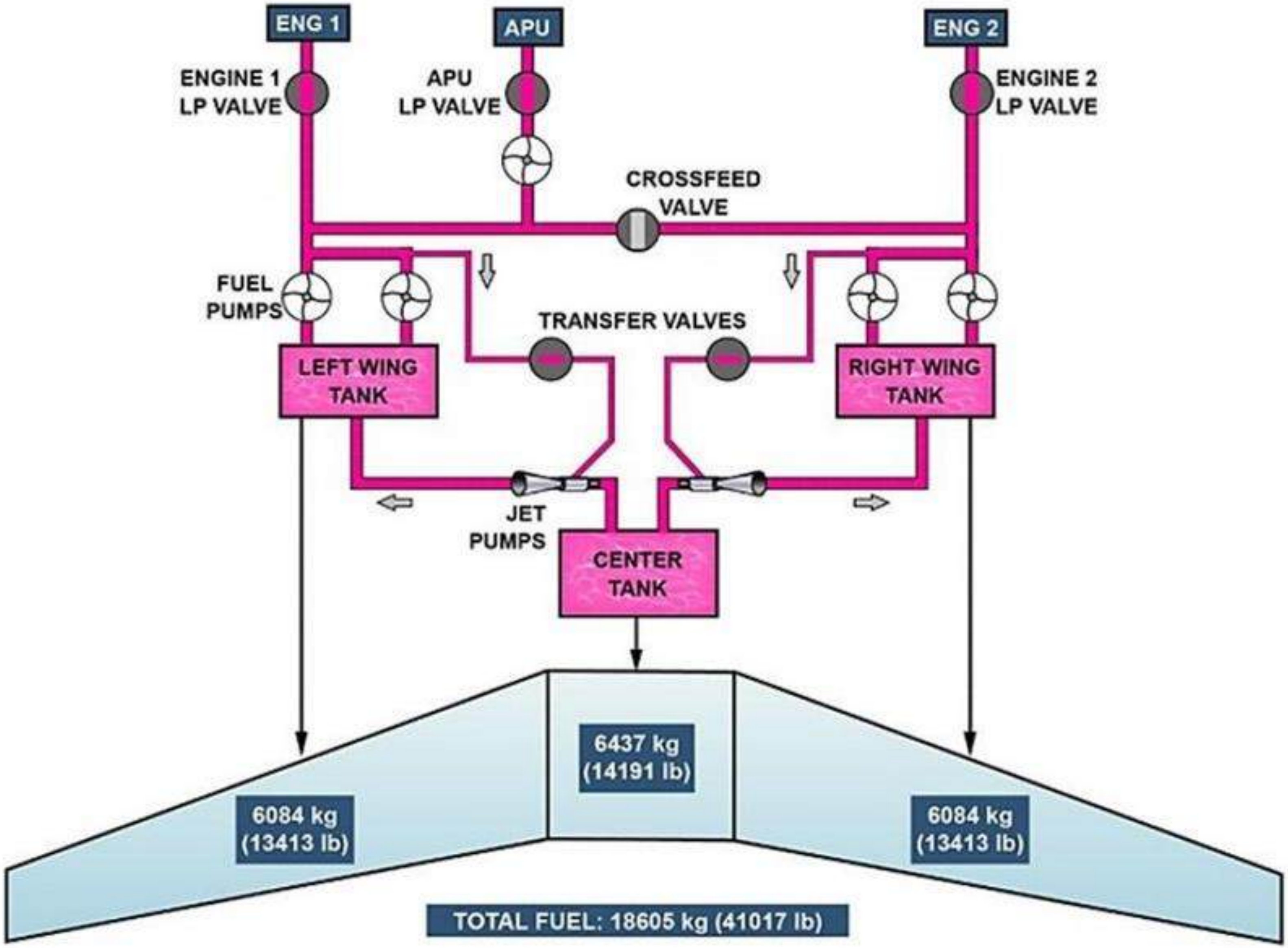

ENG 1
APU
ENG 2
ENGINE 1
LP VALVE
APU
LP VALVE
ENGINE 2
LP VALVE
CROSSFEED
VALVE
FUEL
PUMPS
TRANSFER VALVES
LEFT WING
TANK
RIGHT WING
TANK
JET
PUMPS
CENTER
TANK
6437 kg
(14191 lb)
6084 kg
(13413 lb)
6084 kg
(13413 lb)
TOTAL FUEL: 18605 kg (41017 lb)

Fig. 1.2

CENTER TANK AUTO MODE TRANSFER (Fig. 1.3)

Each center tank transfer valve is controlled independently by its adjacent wing tank level sensors, i. e. full and underfull.

When the fuel level in one wing has decreased by 200 kg, and has therefore reached the under full level, the center tank transfer valve is controlled to open, and is displayed green, in line on the ECAM. Fuel is transferred from the center tank to the wing tank. When the full level is reached, the transfer valve is controlled to close, and is displayed green, cross line on the ECAM.

NOTE: This sequence can be run on ground depending upon the fuel level.

The transfer sequence is terminated; the center tank transfer valves close when the center tank low level sensors are dry and 5 minutes time delay has elapsed.

GENERAL (Fig. 1.4)

The main fuel pump system supplies fuel from the wing fuel tanks to the engines. Each wing tank has two centrifugal booster pumps.

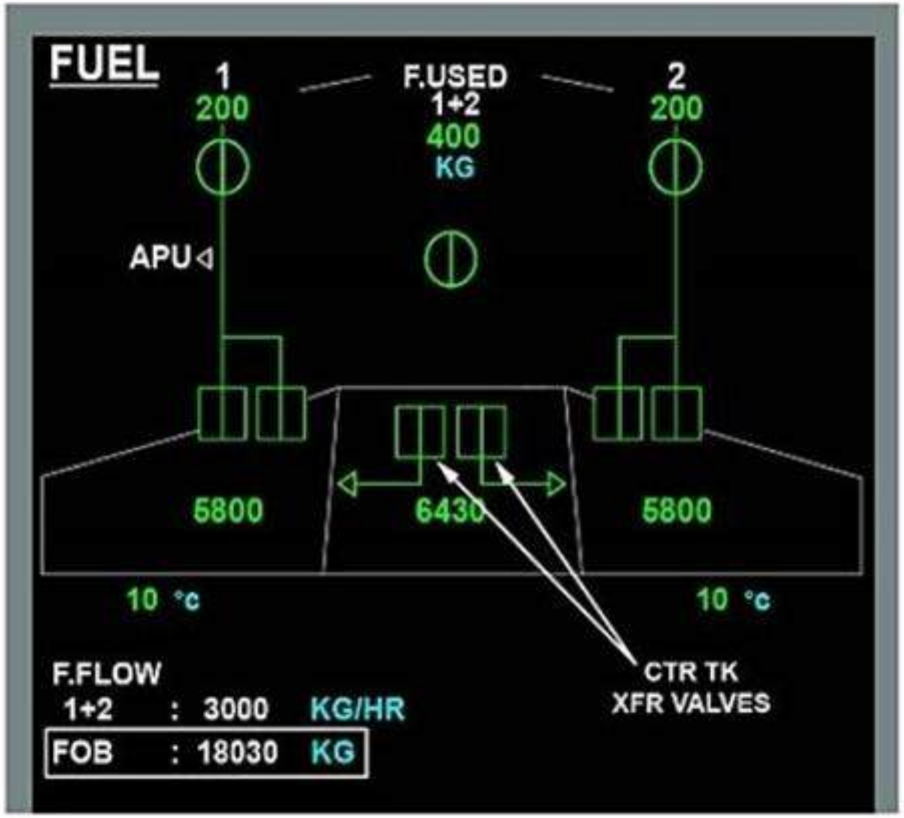
CROSSFEED VALVE

The crossfeed valve divides the engine fuel feed system into two independent systems. The valve is located in the center tank and is usually in the closed position. In this position, it divides the main fuel pump system into two parts, one part for each engine. When the crossfeed valve is open, either tank can supply fuel to either engine. The valve is electronically controlled and operated by two DC motors.

MAIN FUEL PUMPS

The main pumps are driven by a 3-phase 115V AC motor. The two pumps in each wing tank are supplied by different electrical power supply bus bars. When it is in operation, each main pump may supply fuel to:

- its related engine,
- Centre Tank (CT) transfer system,
- the fuel recirculation cooling system.



* CTR TK Transfer valve re-opens when the fuel level drop by fuel burn to the Underfull sensors (200 KG below FULL LVL)

Fig. 1.3

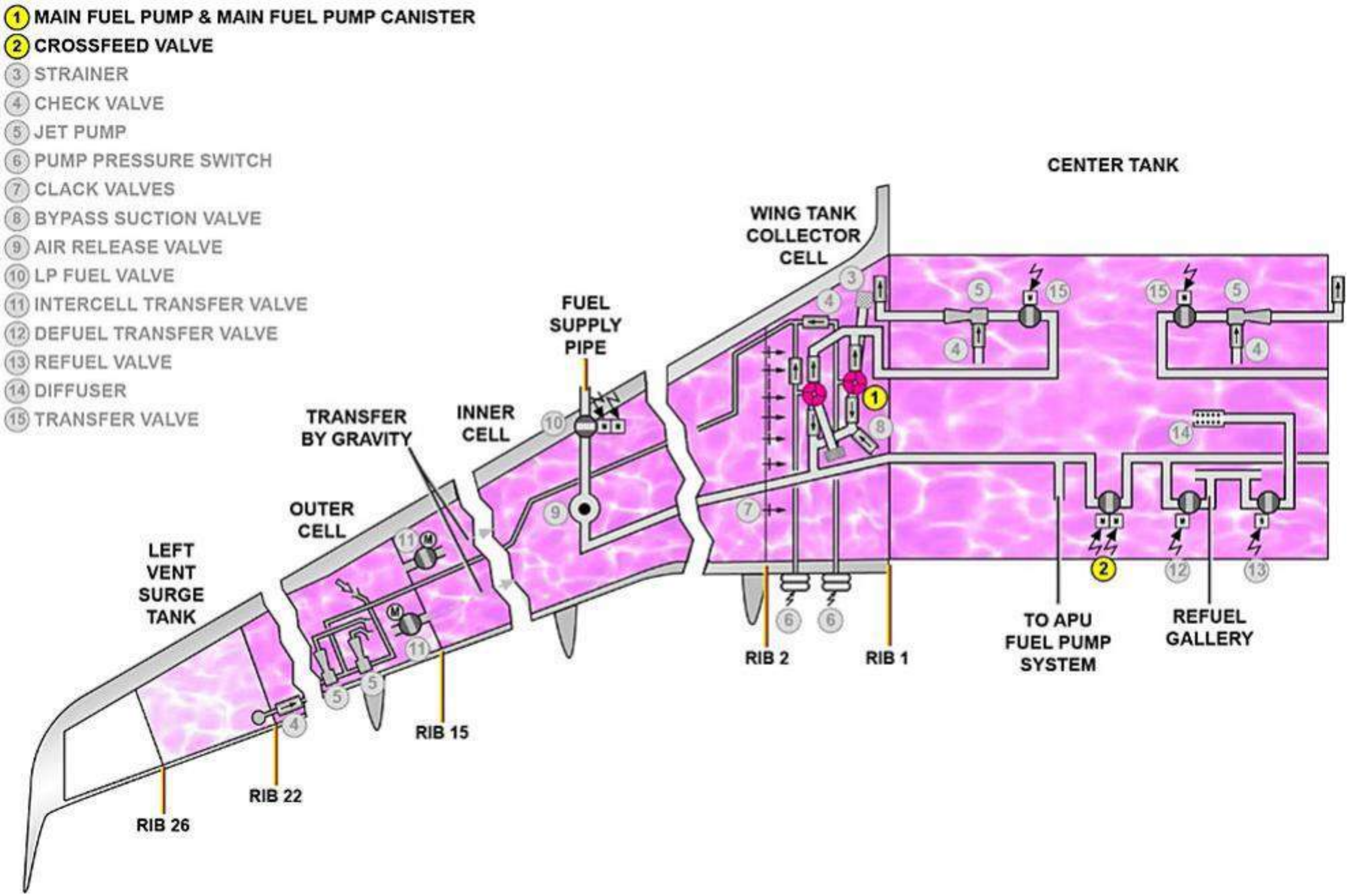

1 MAIN FUEL PUMP & MAIN FUEL PUMP CANISTER
2 CROSSFEED VALVE
3 STRAINER
4 CHECK VALVE
5 JET PUMP
6 PUMP PRESSURE SWITCH
7 CLACK VALVES
8 BYPASS SUCTION VALVE
9 AIR RELEASE VALVE
10 LP FUEL VALVE
11 INTERCELL TRANSFER VALVE
12 DEFUEL TRANSFER VALVE
13 REFUEL VALVE
14 DIFFUSER
15 TRANSFER VALVE
CENTER TANK
WING TANK COLLECTOR CELL
FUEL SUPPLY PIPE
INNER CELL
TRANSFER BY GRAVITY
OUTER CELL
LEFT VENT SURGE TANK
RIB 26
RIB 22
RIB 15
RIB 2
RIB 1
TO APU FUEL PUMP SYSTEM
REFUEL GALLERY

Fig. 1.4

FUEL PUMP CANISTER

The canister lets you replace the fuel pump without draining fuel. The fuel pump element is located in a canister attached to the bottom skin of the wing, with an inlet connected to a fuel strainer.

The canister has different outlets:

- one upper outlet is connected to the engine feed line and contains an internal flap check valve.

CENTER TANK JET PUMP OPERATION (Fig. 1.5)

Whenever the center tank jet pump is activated, as controlled by A/C logic, the center tank supplies fuel to its respective Wing Tank inner cell.

When a fuel jet pump is not in operation, the check valves prevent any reverse flow of fuel through the jet pump.

The center fuel jet pump element is located inside the center tank, with a lower inlet connected to a fuel strainer.

The CT transfer valve is located to the center tank bottom skin with a connection to the transfer valve actuator, located inside the blue or yellow hydraulic compartment.

JET PUMP OPERATION

The scavenge jet pump has:

- a jet pump body,
- a jet adaptor assembly.

The jet pump body fully contains the jet adaptor assembly. The jet pump body has a flange at one end for the installation to the tank structure. The jet pump body has also three threaded openings:

- Z is the outlet from the jet pump,
- a non-return valve (NRV),
- a jet nozzle.

The NRV has a spring and a valve assembly. If the related pump is set to off, the spring closes the NRV. Thus, fuel cannot enter the fuel pump that is set to off.

When the related fuel pump is on, fuel goes into the jet pump through the inlet X. The fuel flows through the NRV and the jet nozzle.

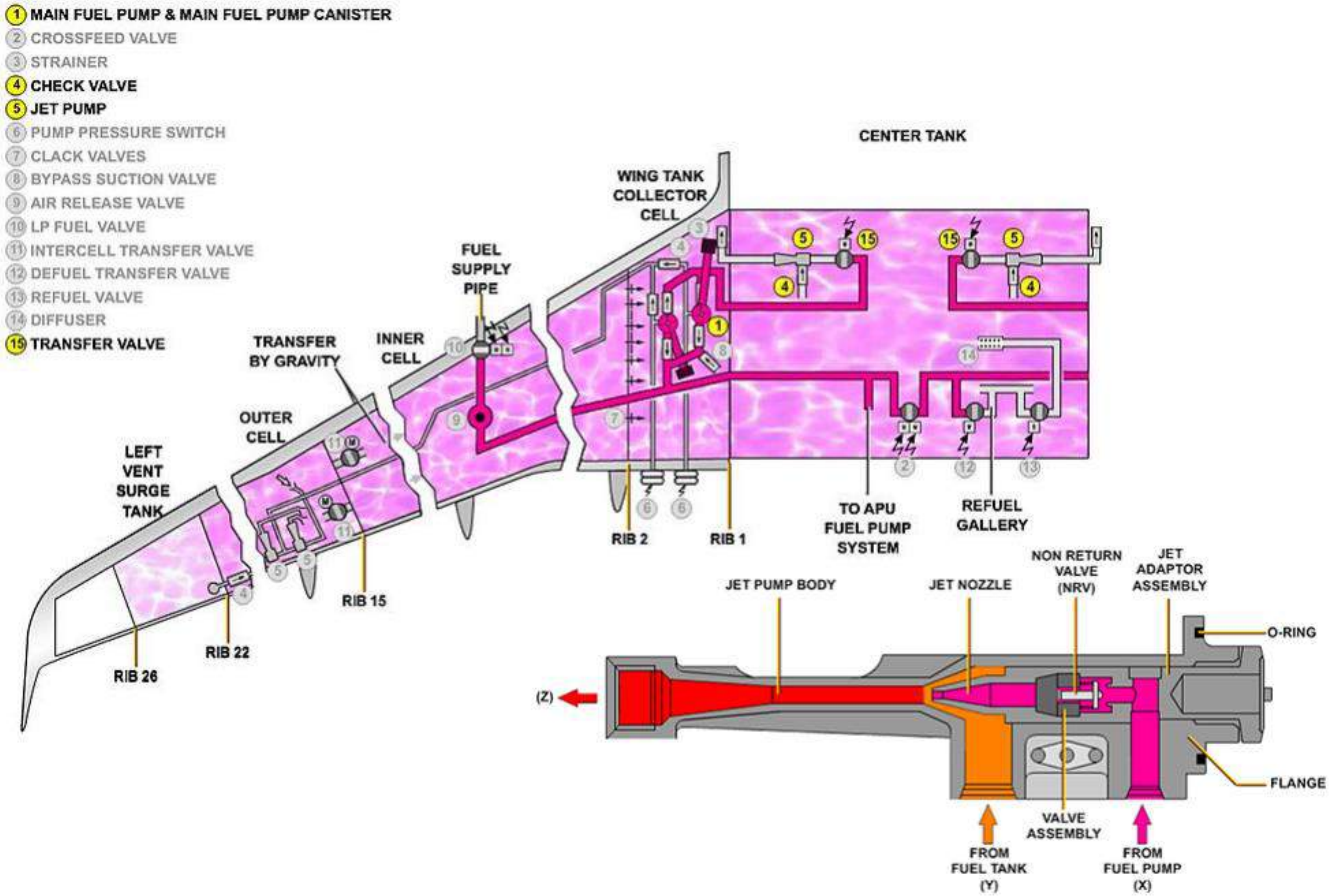

1 MAIN FUEL PUMP & MAIN FUEL PUMP CANISTER
2 CROSSFEED VALVE
3 STRAINER
4 CHECK VALVE
5 JET PUMP
6 PUMP PRESSURE SWITCH
7 CLACK VALVES
8 BYPASS SUCTION VALVE
9 AIR RELEASE VALVE
10 LP FUEL VALVE
11 INTERCELL TRANSFER VALVE
12 DEFUEL TRANSFER VALVE
13 REFUEL VALVE
14 DIFFUSER
15 TRANSFER VALVE
CENTER TANK
WING TANK COLLECTOR CELL
FUEL SUPPLY PIPE
TRANSFER BY GRAVITY
INNER CELL
OUTER CELL
LEFT VENT SURGE TANK
RIB 2
RIB 1
TO APU FUEL PUMP SYSTEM
REFUEL GALLERY
RIB 15
RIB 22
RIB 26
NON RETURN VALVE (NRV)
JET ADAPTOR ASSEMBLY
JET PUMP BODY
JET NOZZLE
O-RING
(Z)
FLANGE
VALVE ASSEMBLY
FROM FUEL TANK (Y)
FROM FUEL PUMP (X)

Fig. 1.5

AIR RELEASE VALVE (Fig. 1.6)
The air release valve releases air, trapped in the engine fuel feed line, into the wing tank. The air release valve is installed at the highest point between the pump and the LP fuel valve.

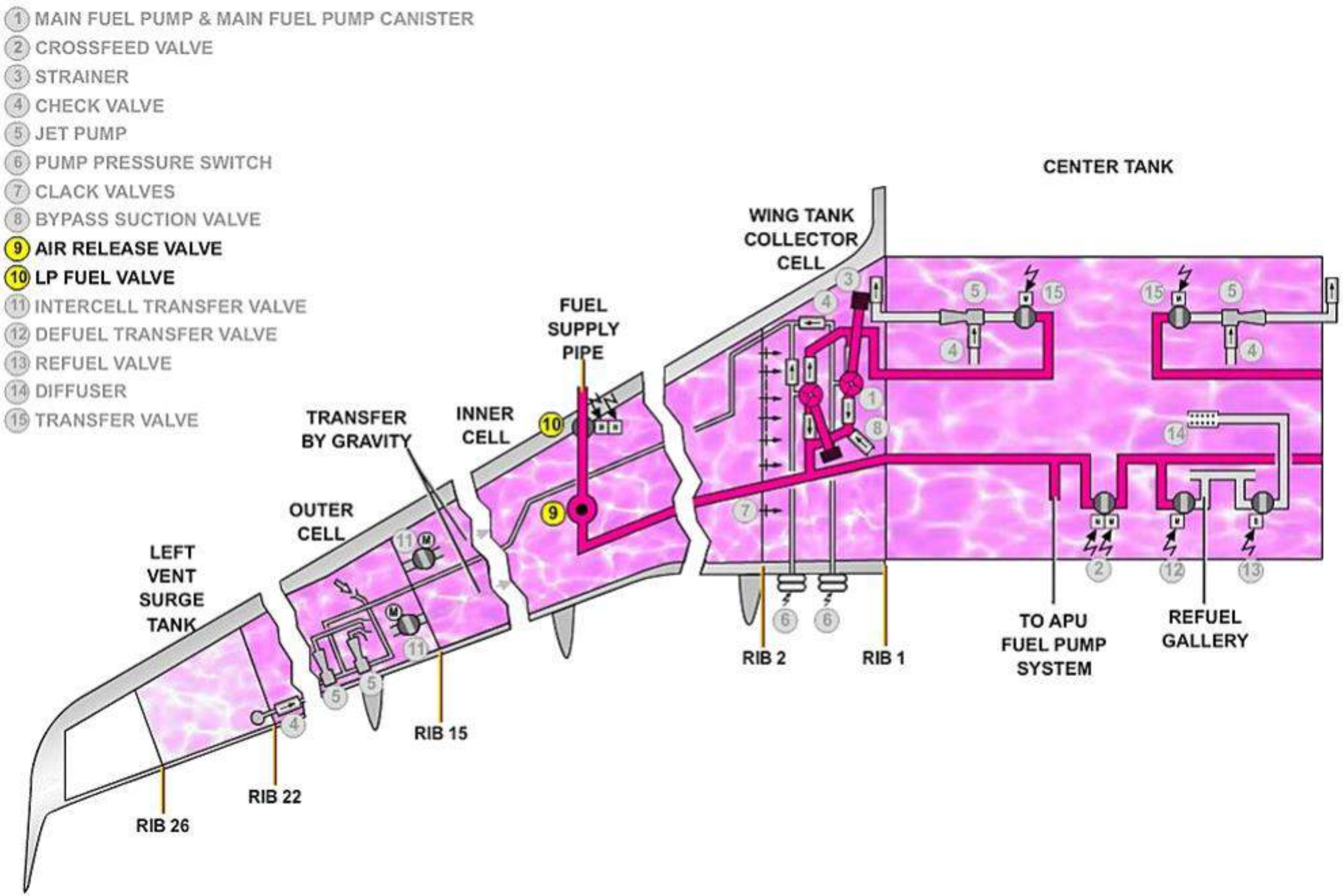
LOW PRESSURE (LP) FUEL VALVE
The LP fuel valve is installed on the wing tank front spar, in the feed line to the engine. Each LP fuel valve has an actuator with 2 electric motors. Each one of them is supplied by different 28 V DC power sources.

WING TANK PUMP OPERATION AND TRANSFER VALVE SUPPLY (Figs. 1.7, 1.8)
The center tank is emptied first by transferring fuel to the respective inner cell. The wing tank pumps are connected to the CT XFER VALVE in order to supply the CT Jet Pump with motive fuel pressure. As soon as the under full level sensor is dry, the transfer valve opens and fuel is transferred into the wing tank inner cell. When the Full Level sensor becomes wet, the transfer valve closes and the transfer stops. Left and right CT transfer is controlled independently. When the low-level sensor inside the CT becomes dry, the CT XFR VALVE will be closed after 5 min.

The pumps in each wing tank are located in the lowest area of the inner cell in a collector cell. Seven clack valves at the bottom of rib 2 allow the fuel to flow into the collector cell but prevent the fuel from flowing back during wing down maneuvers of the aircraft. Thereby the fuel pumps are sufficiently immersed in fuel even if the fuel level in the tank is low.

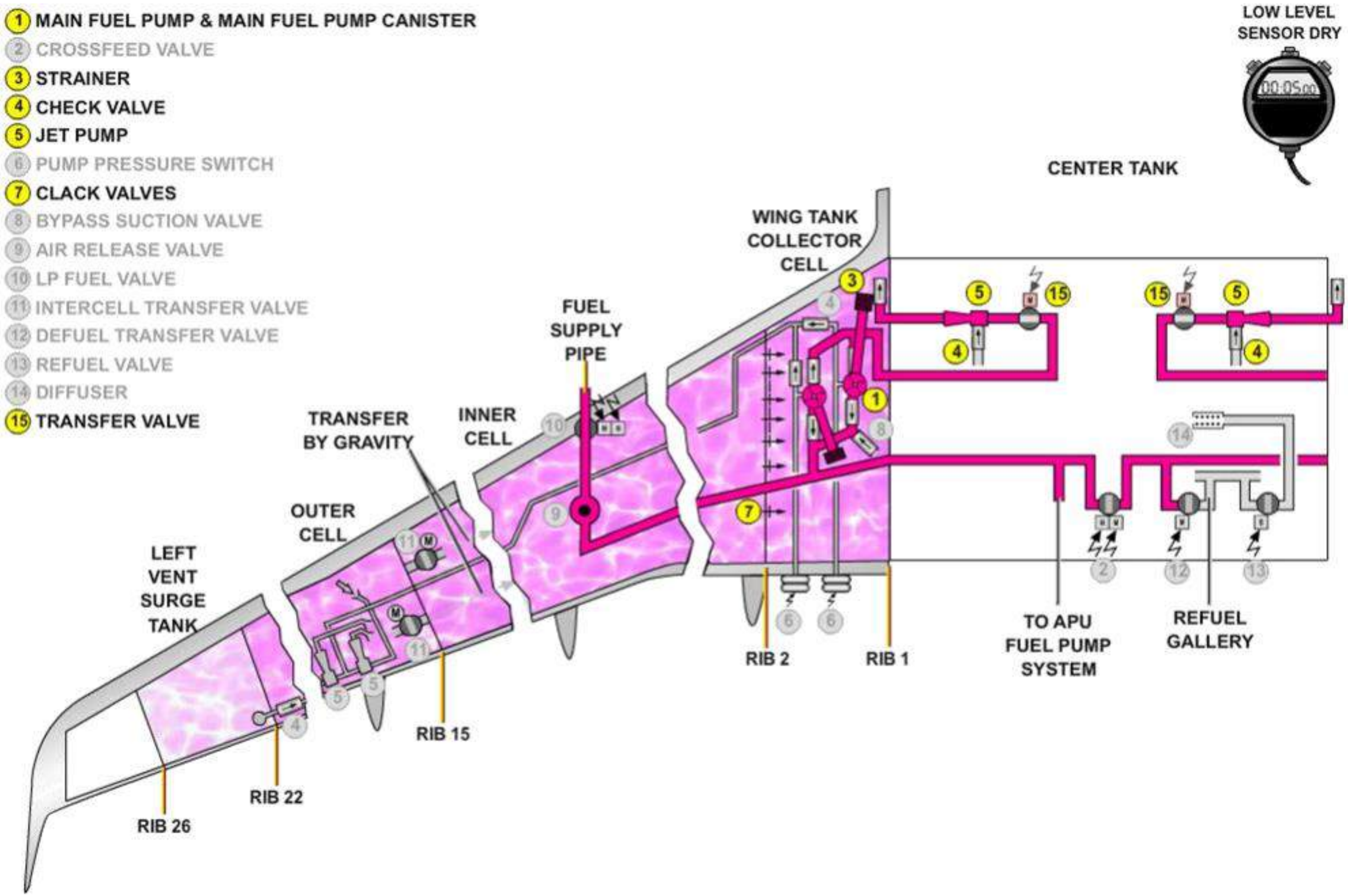
WING TANK PUMP PRESSURE SWITCHES/BYPASS SUCTION VALVE
The pressure switches monitor the output of the pumps through a pressure pipe. If the pressure from the main pump decreases to less than 6 psi (0.41 bars), the pressure switch sends a warning signal to the ECAM system.

A bypass suction valve is installed on the engine feed line, downstream of the main pumps. If both wing tank pumps fail with the crossfeed valve closed, the bypass suction valve lets fuel be sucked from the wing tank by the engine fuel pump system and thus engine supply is done by "gravity".



1 MAIN FUEL PUMP & MAIN FUEL PUMP CANISTER
2 CROSSFEED VALVE
3 STRAINER
4 CHECK VALVE
5 JET PUMP
6 PUMP PRESSURE SWITCH
7 CLACK VALVES
8 BYPASS SUCTION VALVE
9 AIR RELEASE VALVE
10 LP FUEL VALVE
11 INTERCELL TRANSFER VALVE
12 DEFUEL TRANSFER VALVE
13 REFUEL VALVE
14 DIFFUSER
15 TRANSFER VALVE
CENTER TANK
WING TANK COLLECTOR CELL
FUEL SUPPLY PIPE
INNER CELL
TRANSFER BY GRAVITY
OUTER CELL
LEFT VENT SURGE TANK
RIB 26
RIB 22
RIB 15
RIB 2
RIB 1
TO APU FUEL PUMP SYSTEM
REFUEL GALLERY

Fig. 1.6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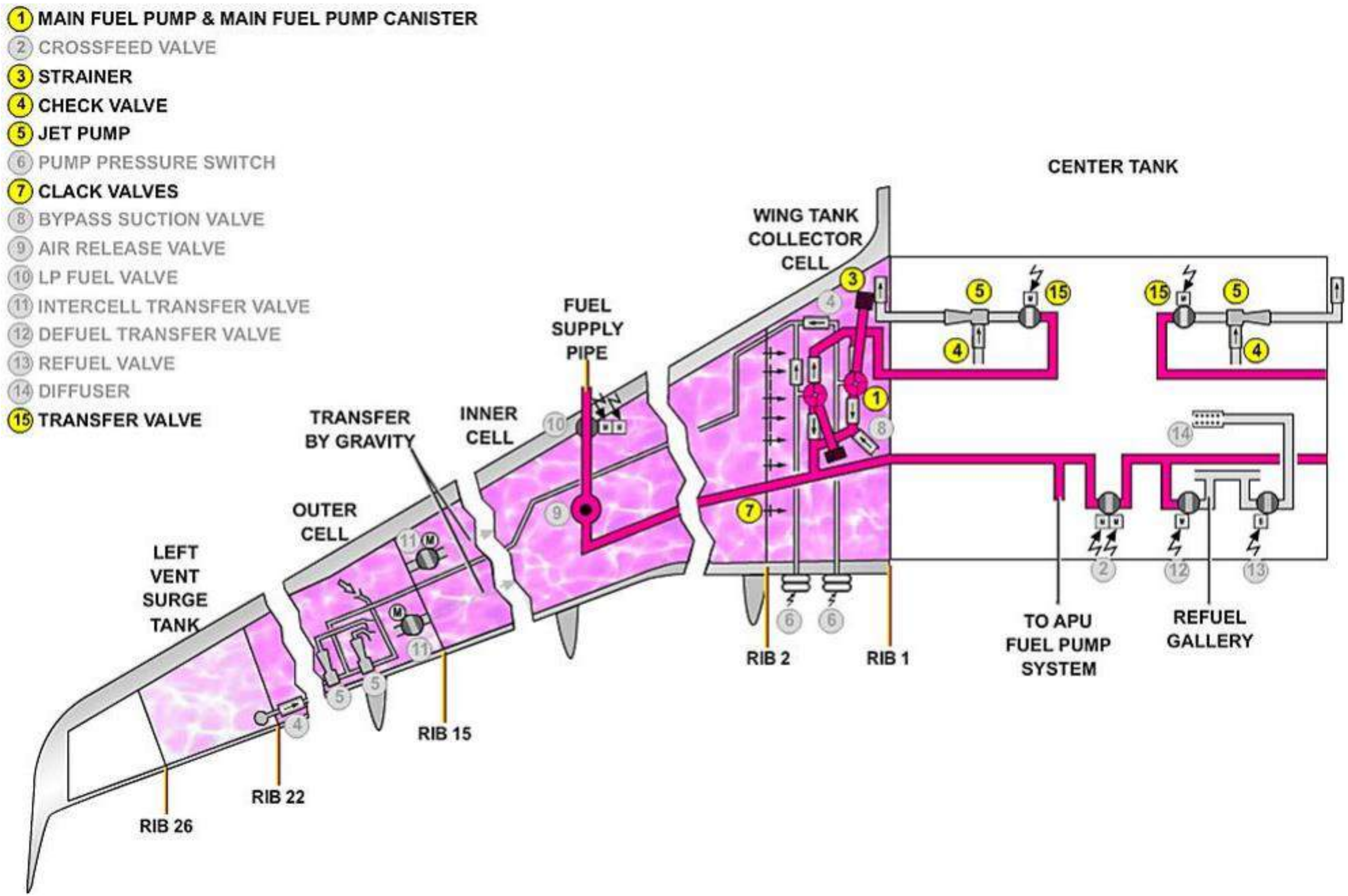
2 CROSSFEED VALVE
3 STRAINER
4 CHECK VALVE
5 JET PUMP
6 PUMP PRESSURE SWITCH
7 CLACK VALVES
8 BYPASS SUCTION VALVE
9 AIR RELEASE VALVE
10 LP FUEL VALVE
11 INTERCELL TRANSFER VALVE
12 DEFUEL TRANSFER VALVE
13 REFUEL VALVE
14 DIFFUSER
15 TRANSFER VALVE
LOW LEVEL SENSOR DRY
CENTER TANK
WING TANK COLLECTOR CELL
FUEL SUPPLY PIPE
INNER CELL
TRANSFER BY GRAVITY
OUTER CELL
LEFT VENT SURGE TANK
RIB 26
RIB 22
RIB 15
RIB 2
RIB 1
TO APU FUEL PUMP SYSTEM
REFUEL GALLERY

Fig. 1.7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2 CROSSFEED VALVE
3 STRAINER
4 CHECK VALVE
5 JET PUMP
6 PUMP PRESSURE SWITCH
7 CLACK VALVES
8 BYPASS SUCTION VALVE
9 AIR RELEASE VALVE
10 LP FUEL VALVE
11 INTERCELL TRANSFER VALVE
12 DEFUEL TRANSFER VALVE
13 REFUEL VALVE
14 DIFFUSER
15 TRANSFER VALVE
CENTER TANK
WING TANK COLLECTOR CELL
FUEL SUPPLY PIPE
TRANSFER BY GRAVITY
INNER CELL
OUTER CELL
LEFT VENT SURGE TANK
RIB 26
RIB 22
RIB 15
RIB 2
RIB 1
TO APU FUEL PUMP SYSTEM
REFUEL GALLERY

Fig. 1.8

WING SCAVENGE JET PUMPS (Figs. 1.9, 1.10)

One of the two scavenge jet pumps in the outer cells removes fuel out of the vent surge tank to the rear intercell transfer valve. A check valve, in the line between the vent surge tank and, combined with this jet pump, makes sure that fuel cannot enter the vent surge tank via the pump if the wing tank pumps are off.

The other scavenge jet pump mixes fuel and water within the outer cell.

Each scavenge jet pump receives its motive fuel pressure from the wing tank pumps, if running.

DEFUEL TRANSFER VALVE (Fig. 1.11)

The defuel transfer valve is electronically controlled and operated by one DC motor. The control is done through the Refuel / Defuel control panel in the belly fairing. The valve can only be controlled to open on ground.

When open, the valve interconnects the right hand engine supply line with the refuel gallery and allows fuel transfers and defueling operations.

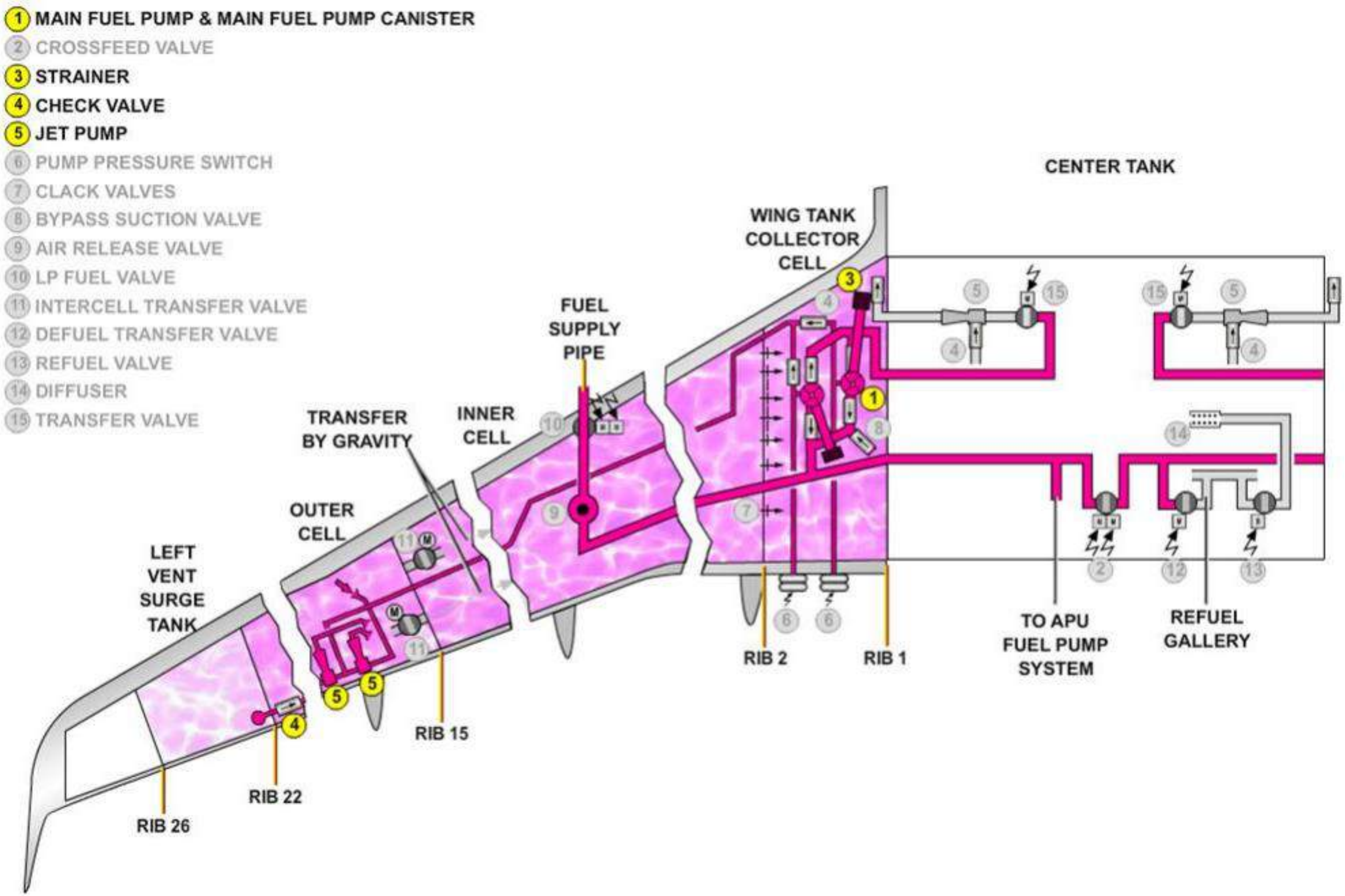
FUEL IDG COOLING SYSTEM PRINCIPLE (Fig. 1.12)

The temperature of the Integrated Drive Generator (IDG) oil is decreased by fuel through a recirculation system. Some of the fuel that supplies the engines is used to decrease the temperature of the IDG oil. A Fuel Return To Tank valve (FRTT) lets the hot fuel return to the outer cell. The FRTT opens the fuel flow back to the aircraft tank in special engine configurations (N 2, fuel flow...). The return valve mixes the hot fuel with cold fuel from the Low Pressure (LP) fuel pump to keep the temperature of the returned fuel less than 100 °C (212 °F). The Fuel Level Sensing Control Unit (FLSCU) 1 and the Engine Electronic Control (EEC) 1 control the recirculation system in the left wing. FLSCU 2 and EEC 2 control the right wing system.

FUEL RETURN

The recirculated fuel is sent to the outer cell through a check valve and a pressure- holding valve to not let the fuel get to boiling temperature. The pressure-holding valve keeps a pressure of 15.5 psi in the return line. If the pressure increases, fuel bleeds through the valve into the outer cell. The check valve prevents fuel flow from the wing tank to the engine when the recirculation system is not in operation.

Note: When the outer cell is full, the fuel overflows into the inner cell through a spill pipe.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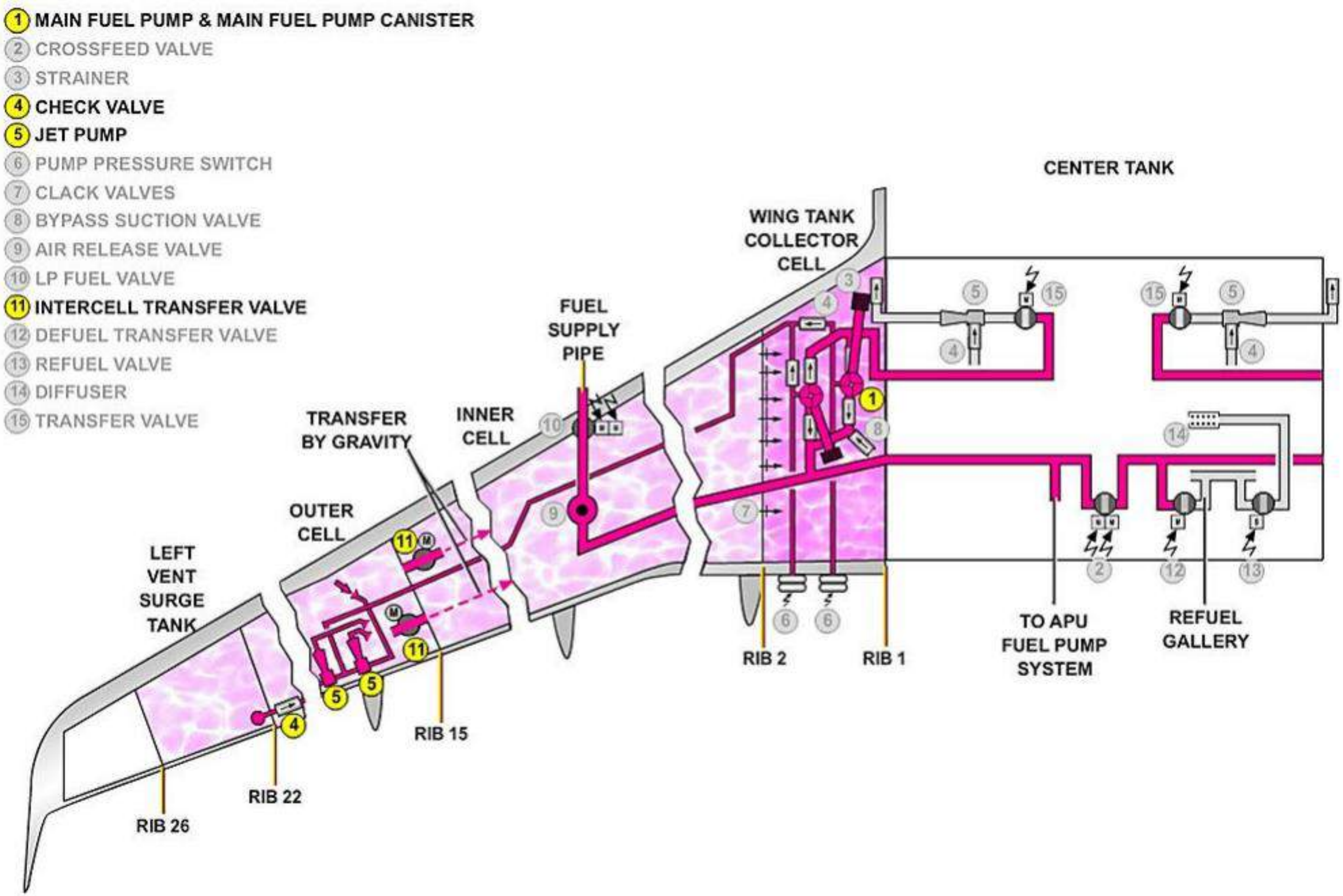
13 REFUEL VALVE
14 DIFFUSER
15 TRANSFER VALVE
CENTER TANK
WING TANK COLLECTOR CELL
FUEL SUPPLY PIPE
TRANSFER BY GRAVITY
INNER CELL
OUTER CELL
LEFT VENT SURGE TANK
RIB 26
RIB 22
RIB 15
RIB 2
RIB 1
TO APU FUEL PUMP SYSTEM
REFUEL GALLERY

Fig. 1.9



1 MAIN FUEL PUMP & MAIN FUEL PUMP CANISTER
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3 STRAINER
4 CHECK VALVE
5 JET PUMP
6 PUMP PRESSURE SWITCH
7 CLACK VALVES
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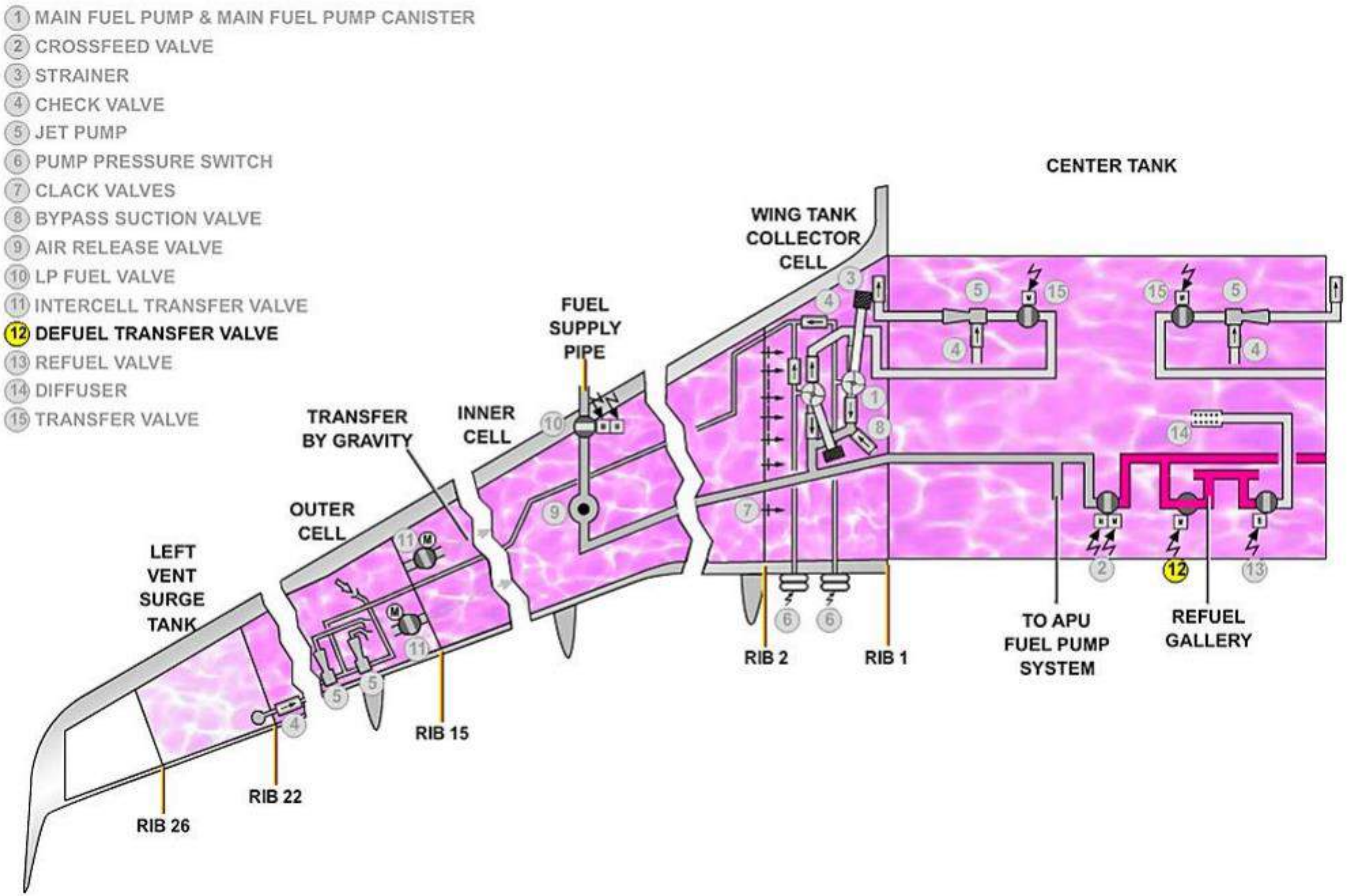
INNER CELL
OUTER CELL
LEFT VENT SURGE TANK
RIB 26
RIB 22
RIB 15
RIB 2
RIB 1
TO APU FUEL PUMP SYSTEM
REFUEL GALLERY

Fig. 1.10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3 STRAINER
4 CHECK VALVE
5 JET PUMP
6 PUMP PRESSURE SWITCH
7 CLACK VALVES
8 BYPASS SUCTION VALVE
9 AIR RELEASE VALVE
10 LP FUEL VALVE
11 INTERCELL TRANSFER VALVE
12 DEFUEL TRANSFER VALVE
13 REFUEL VALVE
14 DIFFUSER
15 TRANSFER VALVE
CENTER TANK
WING TANK COLLECTOR CELL
FUEL SUPPLY PIPE
TRANSFER BY GRAVITY
INNER CELL
OUTER CELL
LEFT VENT SURGE TANK
RIB 26
RIB 22
RIB 15
RIB 2
RIB 1
TO APU FUEL PUMP SYSTEM
REFUEL GALLERY

Fig. 1.11

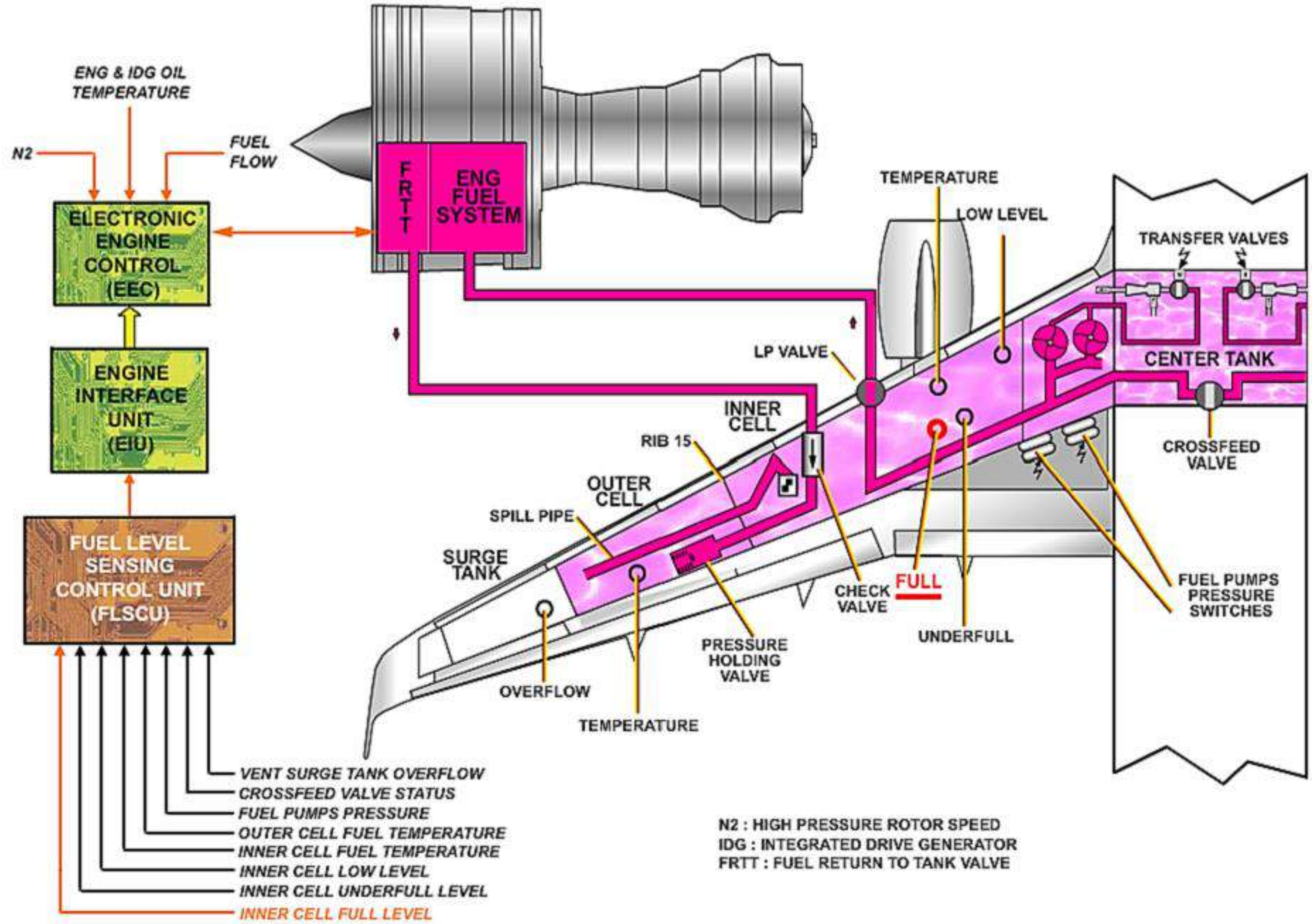

ENG & IDG OIL TEMPERATURE
N2
FUEL FLOW
ELECTRONIC ENGINE CONTROL (EEC)
ENGINE INTERFACE UNIT (EIU)
FUEL LEVEL SENSING CONTROL UNIT (FLSCU)
FRTT
ENG FUEL SYSTEM
TEMPERATURE
LOW LEVEL
TRANSFER VALVES
CENTER TANK
LP VALVE
INNER CELL
RIB 15
OUTER CELL
SPILL PIPE
SURGE TANK
CROSSFEED VALVE
CHECK VALVE
FULL
UNDERFULL
FUEL PUMPS PRESSURE SWITCHES
PRESSURE HOLDING VALVE
OVERFLOW
TEMPERATURE
VENT SURGE TANK OVERFLOW
CROSSFEED VALVE STATUS
FUEL PUMPS PRESSURE
OUTER CELL FUEL TEMPERATURE
INNER CELL FUEL TEMPERATURE
INNER CELL LOW LEVEL
INNER CELL UNDERFULL LEVEL
INNER CELL FULL LEVEL
N2 : HIGH PRESSURE ROTOR SPEED
IDG : INTEGRATED DRIVE GENERATOR
FRTT : FUEL RETURN TO TANK VALVE

Fig. 1.12

FUEL RETURN TO TANK VALVE CLOSURE OVERFLOW (Fig. 1.13)

The FRTT closes if the center tank transfer valves do not obey the logic signals of the full level sensors. This causes the wing tank to overflow through the tank ventilation system into the vent surge tank.

The overflow sensor sends an electrical signal to the FLSCU (Fuel Level Control System). The FLSCU sends a closure signal to the EEC through the Engine Interface Unit (EIU).

FUEL RETURN TO TANK VALVE CLOSURE

- OUTER CELL HIGH TEMPERATURE (Fig. 1.14)

The FRTT closes if the fuel temperature is too high in the outer cell, i. e. 52.5 °C (126.5 °F). Because the returned fuel from the engine is hot, the FLSCU prevents overheating in the wing tanks. The FLSCU sends a closure signal to the EEC through the EIU. The EEC closes the FRTT and stops the fuel supply back to the outer cell.

FUEL RETURN TO TANK VALVE CLOSURE

- INNER CELL HIGH TEMPERATURE (Fig. 1.15)

The FRTT closes if the fuel temperature in the inner cell is too high, i. e. 55 °C (131 °F). Thus, a large volume of high-temperature fuel will not go into the inner cell if the intercell valve opens. This also keeps the fuel temperature at an acceptable level if a tank rupture occurs.

FUEL RETURN TO TANK VALVE CLOSURE

- PUMP PRESSURE LOSS (Fig. 1.16)

The FRTT closes if a fuel pump Low Pressure (LP) is sensed by all pump pressure switches of one wing for the related engine when the crossfeed valve is closed, or if a fuel pump LP is sensed by all pump pressure switches of the two wings when the crossfeed valve is open.

FUEL RETURN TO TANK VALVE CLOSURE LOW LEVEL (Fig. 1.17)

The FRTT closes when the fuel level in the inner cell decreases to the inner low level sensor at 280 kg (620 lbs).

Note: When the FRTT closes, this decreases the quantity of fuel that cannot be used.

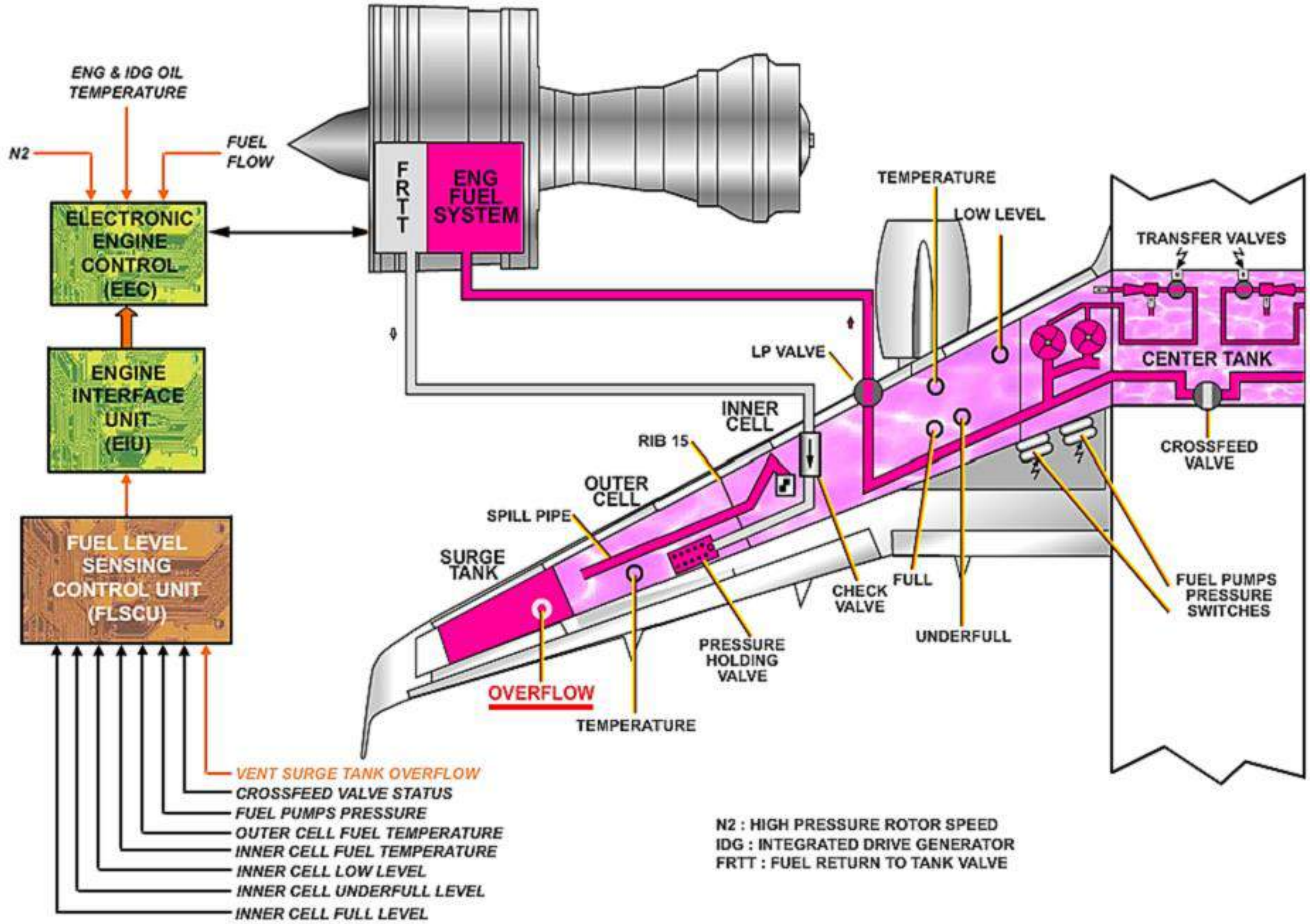
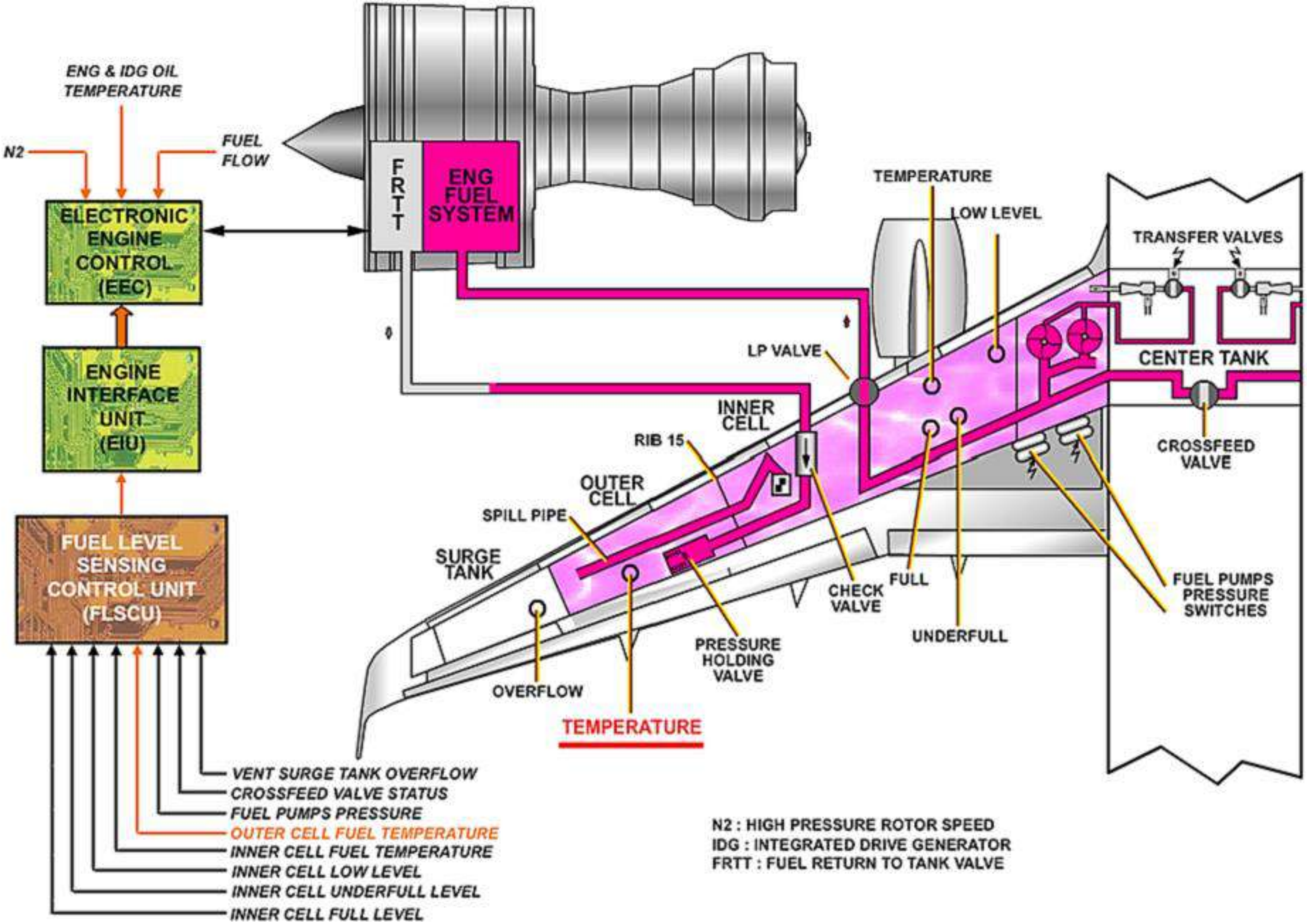

ENG & IDG OIL TEMPERATURE
N2
FUEL FLOW
ELECTRONIC ENGINE CONTROL (EEC)
ENGINE INTERFACE UNIT (EIU)
FUEL LEVEL SENSING CONTROL UNIT (FLSCU)
FRTT
ENG FUEL SYSTEM
TEMPERATURE
LOW LEVEL
TRANSFER VALVES
CENTER TANK
LP VALVE
INNER CELL
RIB 15
OUTER CELL
SPILL PIPE
SURGE TANK
CROSSFEED VALVE
CHECK VALVE
FULL
UNDERFULL
FUEL PUMPS PRESSURE SWITCHES
PRESSURE HOLDING VALVE
OVERFLOW
TEMPERATURE
VENT SURGE TANK OVERFLOW
CROSSFEED VALVE STATUS
FUEL PUMPS PRESSURE
OUTER CELL FUEL TEMPERATURE
INNER CELL FUEL TEMPERATURE
INNER CELL LOW LEVEL
INNER CELL UNDERFULL LEVEL
INNER CELL FULL LEVEL
N2 : HIGH PRESSURE ROTOR SPEED
IDG : INTEGRATED DRIVE GENERATOR
FRTT : FUEL RETURN TO TANK VALVE

Fig. 1.13


ENG & IDG OIL TEMPERATURE
N2
FUEL FLOW
ELECTRONIC ENGINE CONTROL (EEC)
ENGINE INTERFACE UNIT (EIU)
FUEL LEVEL SENSING CONTROL UNIT (FLSCU)
FRTT
ENG FUEL SYSTEM
TEMPERATURE
LOW LEVEL
TRANSFER VALVES
CENTER TANK
LP VALVE
INNER CELL
RIB 15
OUTER CELL
SPILL PIPE
SURGE TANK
CROSSFEED VALVE
FUEL PUMPS PRESSURE SWITCHES
CHECK VALVE
FULL
UNDERFULL
PRESSURE HOLDING VALVE
OVERFLOW
TEMPERATURE
VENT SURGE TANK OVERFLOW
CROSSFEED VALVE STATUS
FUEL PUMPS PRESSURE
OUTER CELL FUEL TEMPERATURE
INNER CELL FUEL TEMPERATURE
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INNER CELL FULL LEVEL
N2 : HIGH PRESSURE ROTOR SPEED
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Fig. 1.14

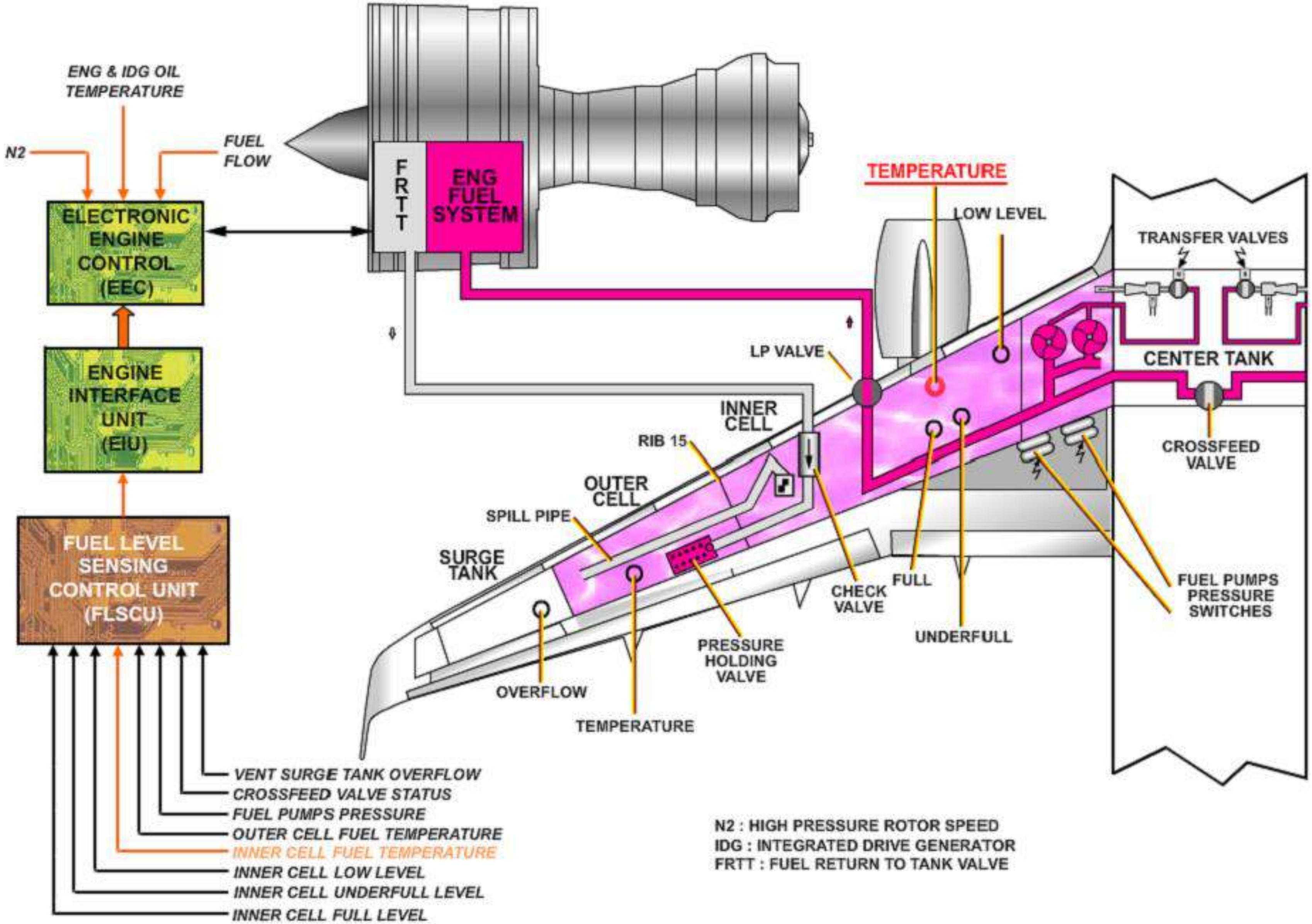

ENG & IDG OIL TEMPERATURE
N2
FUEL FLOW
ELECTRONIC ENGINE CONTROL (EEC)
ENGINE INTERFACE UNIT (EIU)
FUEL LEVEL SENSING CONTROL UNIT (FLSCU)
FRTT
ENG FUEL SYSTEM
TEMPERATURE
LOW LEVEL
TRANSFER VALVES
CENTER TANK
LP VALVE
INNER CELL
RIB 15
OUTER CELL
SPILL PIPE
SURGE TANK
CROSSFEED VALVE
CHECK VALVE
FULL
UNDERFULL
FUEL PUMPS PRESSURE SWITCHES
PRESSURE HOLDING VALVE
OVERFLOW
TEMPERATURE
VENT SURGE TANK OVERFLOW
CROSSFEED VALVE STATUS
FUEL PUMPS PRESSURE
OUTER CELL FUEL TEMPERATURE
INNER CELL FUEL TEMPERATURE
INNER CELL LOW LEVEL
INNER CELL UNDERFULL LEVEL
INNER CELL FULL LEVEL
N2 : HIGH PRESSURE ROTOR SPEED
IDG : INTEGRATED DRIVE GENERATOR
FRTT : FUEL RETURN TO TANK VALVE

Fig. 1.15

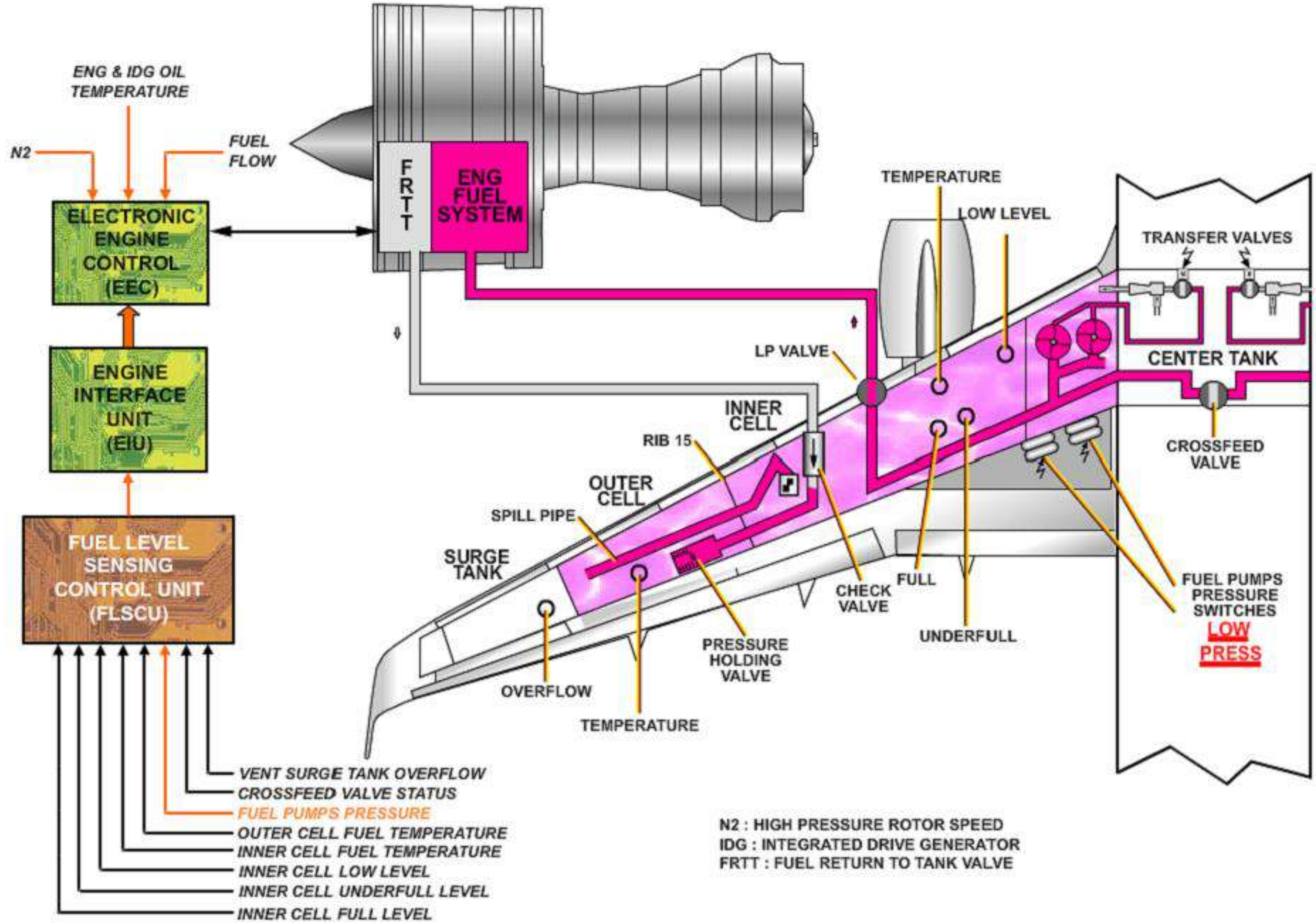

ENG & IDG OIL TEMPERATURE
N2
FUEL FLOW
ELECTRONIC ENGINE CONTROL (EEC)
ENGINE INTERFACE UNIT (EIU)
FUEL LEVEL SENSING CONTROL UNIT (FLSCU)
FRTT
ENG FUEL SYSTEM
TEMPERATURE
LOW LEVEL
TRANSFER VALVES
CENTER TANK
LP VALVE
INNER CELL
RIB 15
OUTER CELL
SPILL PIPE
SURGE TANK
CROSSFEED VALVE
CHECK VALVE
FULL
UNDERFULL
FUEL PUMPS PRESSURE SWITCHES
LOW PRESS
PRESSURE HOLDING VALVE
OVERFLOW
TEMPERATURE
VENT SURGE TANK OVERFLOW
CROSSFEED VALVE STATUS
FUEL PUMPS PRESSURE
OUTER CELL FUEL TEMPERATURE
INNER CELL FUEL TEMPERATURE
INNER CELL LOW LEVEL
INNER CELL UNDERFULL LEVEL
INNER CELL FULL LEVEL
N2 : HIGH PRESSURE ROTOR SPEED
IDG : INTEGRATED DRIVE GENERATOR
FRTT : FUEL RETURN TO TANK VALVE

Fig. 1.16

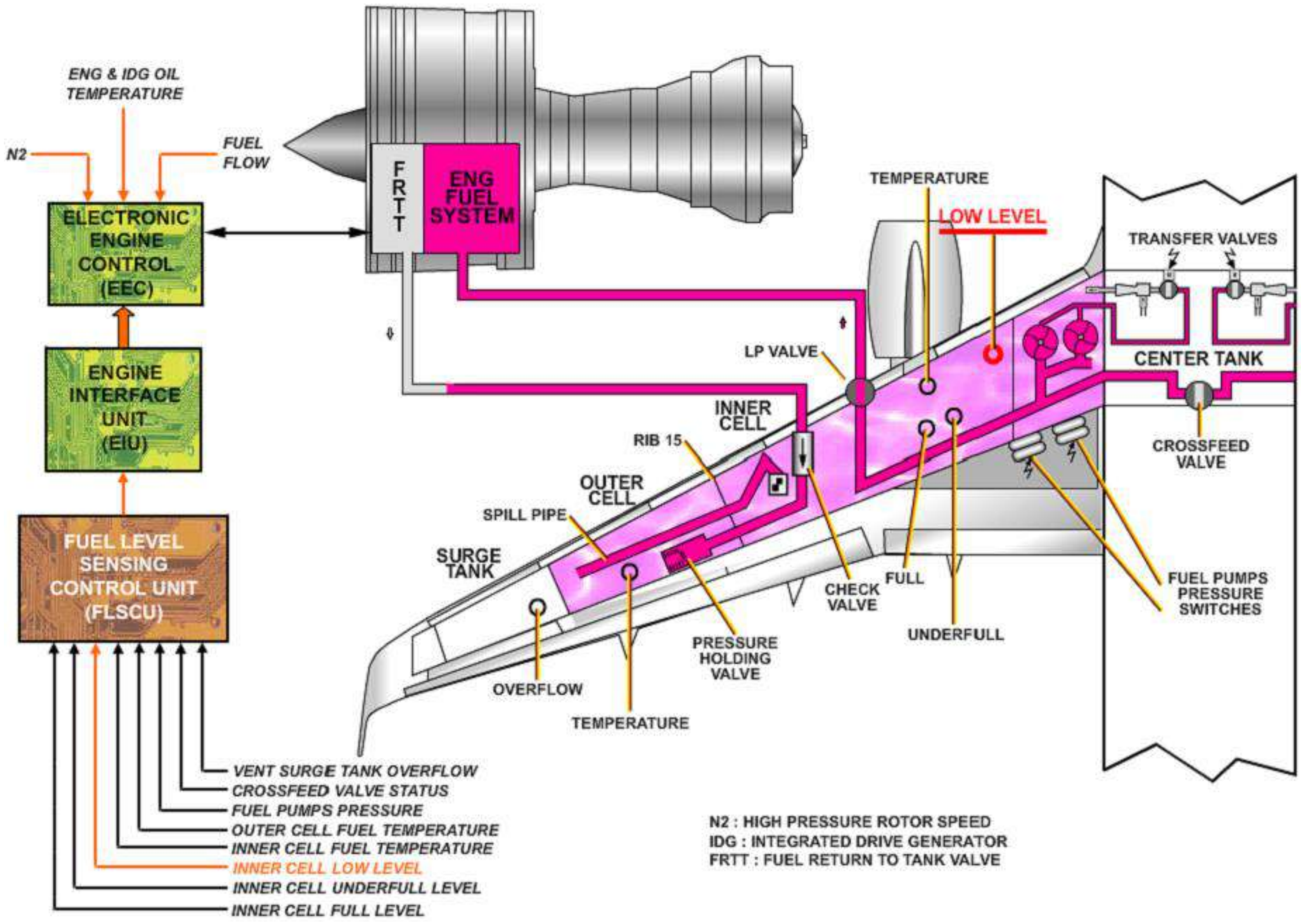

ENG & IDG OIL TEMPERATURE
N2
FUEL FLOW
ELECTRONIC ENGINE CONTROL (EEC)
ENGINE INTERFACE UNIT (EIU)
FUEL LEVEL SENSING CONTROL UNIT (FLSCU)
FRTT
ENG FUEL SYSTEM
TEMPERATURE
LOW LEVEL
TRANSFER VALVES
CENTER TANK
LP VALVE
INNER CELL
RIB 15
OUTER CELL
SPILL PIPE
SURGE TANK
CROSSFEED VALVE
FUEL PUMPS PRESSURE SWITCHES
CHECK VALVE
FULL
UNDERFULL
PRESSURE HOLDING VALVE
OVERFLOW
TEMPERATURE
VENT SURGE TANK OVERFLOW
CROSSFEED VALVE STATUS
FUEL PUMPS PRESSURE
OUTER CELL FUEL TEMPERATURE
INNER CELL FUEL TEMPERATURE
INNER CELL LOW LEVEL
INNER CELL UNDERFULL LEVEL
INNER CELL FULL LEVEL
N2 : HIGH PRESSURE ROTOR SPEED
IDG : INTEGRATED DRIVE GENERATOR
FRTT : FUEL RETURN TO TANK VALVE

Fig. 1.17

2. ENGINE FUEL SYSTEM

COMPONENT LOCATION – FUEL (Fig. 2.1)

The primary components of the fuel system are on the RH side of the engine core.

The Integrated Fuel Pump and Control (IFPC) is attached with bolts to the fuel manifold on the right side of the main gearbox at the 3 o'clock position.

FUEL DISTRIBUTION (Fig. 2.2)

The fuel distribution system supplies fuel from tanks to the engines. The fuel is metered, filtered and supplied at the pressure and flow rate necessary to enable stable engine operations during all the phases. The metered Fuel Flow (FF) is sent to the fuel nozzles for combustion, and pressurized fuel is supplied to the fuel-operated actuators of the engine (e. g. Air valves). The fuel is also heated to prevent ice formation and used to cool engine oil and Integrated Drive Generator (IDG) oil.

FUEL FEED FROM AIRCRAFT (Fig. 2.3)

When the Engine Master Lever is selected ON, the Low Pressure Shut-Off Valve (LPSOV) opens and fuel from the aircraft tanks flows through the main fuel supply line to the inlet port of the boost pump in the IFPC.

HEAT EXCHANGERS AND FUEL RETURN TO TANK (Fig. 2.4)

The boost pump sends LP fuel from the engine fuel supply line to the IDG Fuel/Oil Heat Exchanger (FOHE). Fuel flow is used to cool down the IDG oil through the IDG FOHE and the engine oil through the engine FOHE. In turn, fuel is heated and de-iced.

HEAT EXCHANGERS AND FUEL RETURN TO TANK (Fig. 2.5)

The Return-to-Tank (RTT) valve controls fuel to flow back to the aircraft tanks from downstream of the IDG FOHE and before it enters the engine FOHE as part of the fuel heat management system. The RTT valve is controlled by the Electronic Engine Controller (EEC) depending on the fuel temperature.

FUEL DISTRIBUTION SYSTEM (RIGHT SIDE)

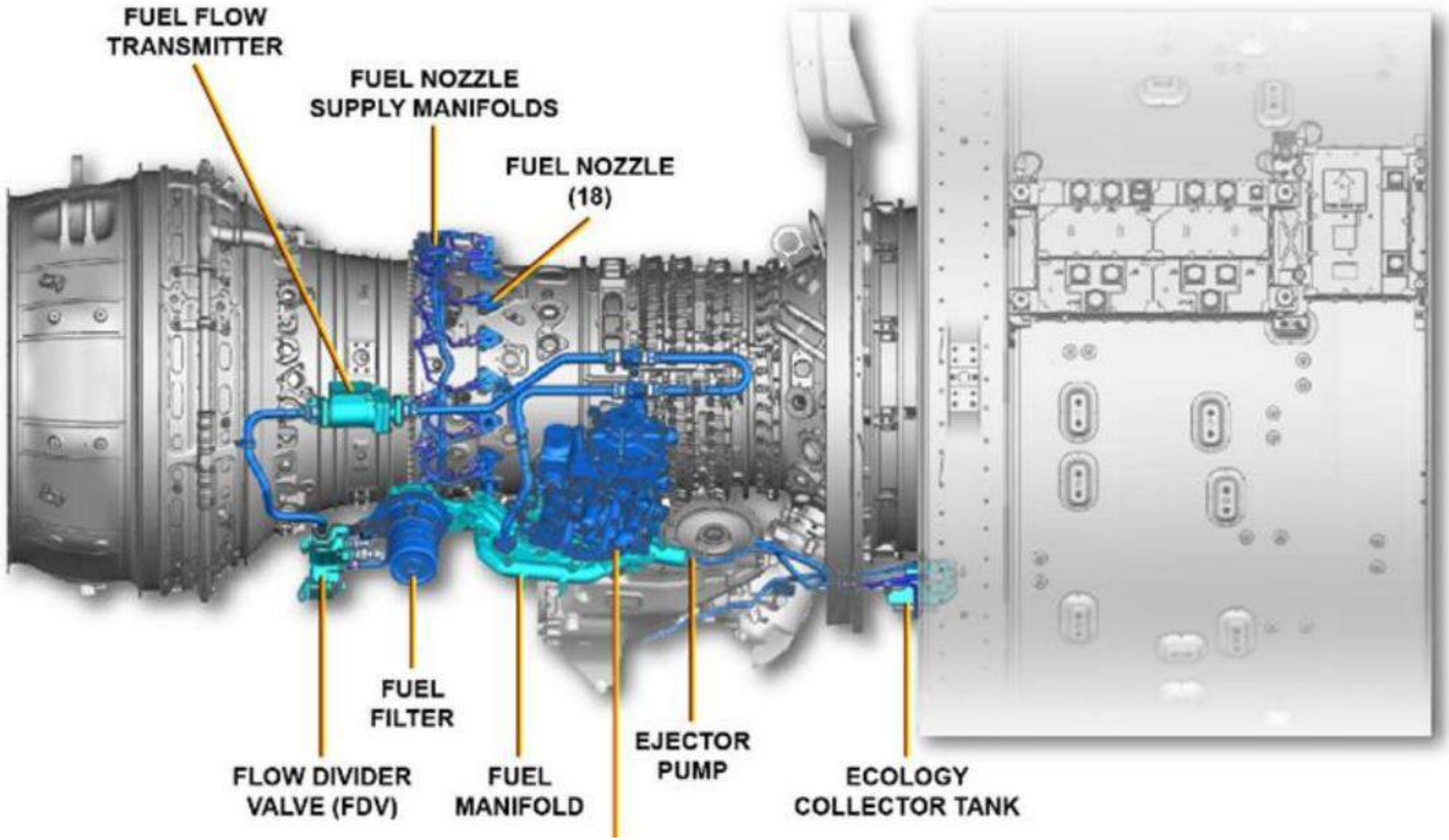
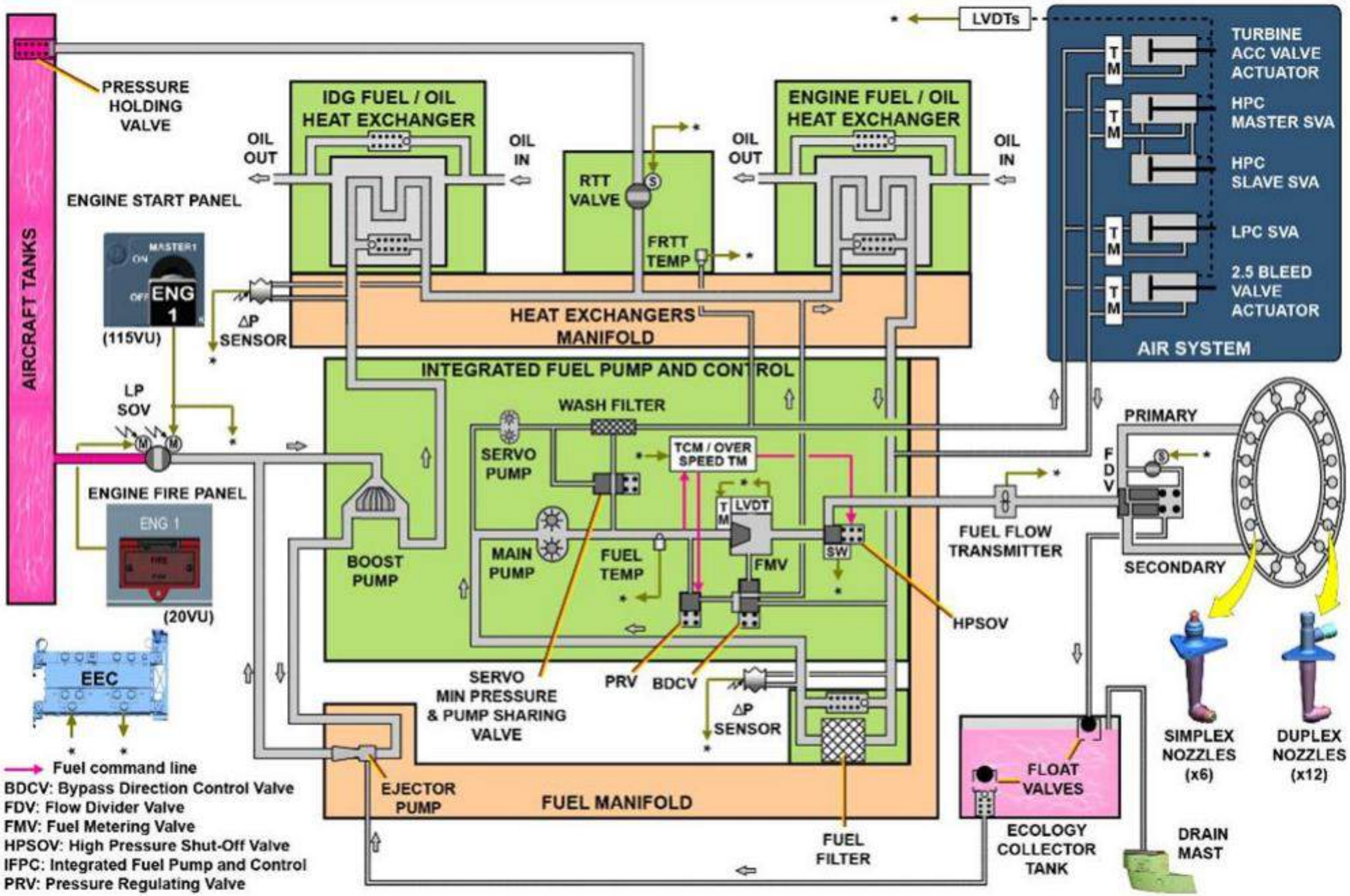
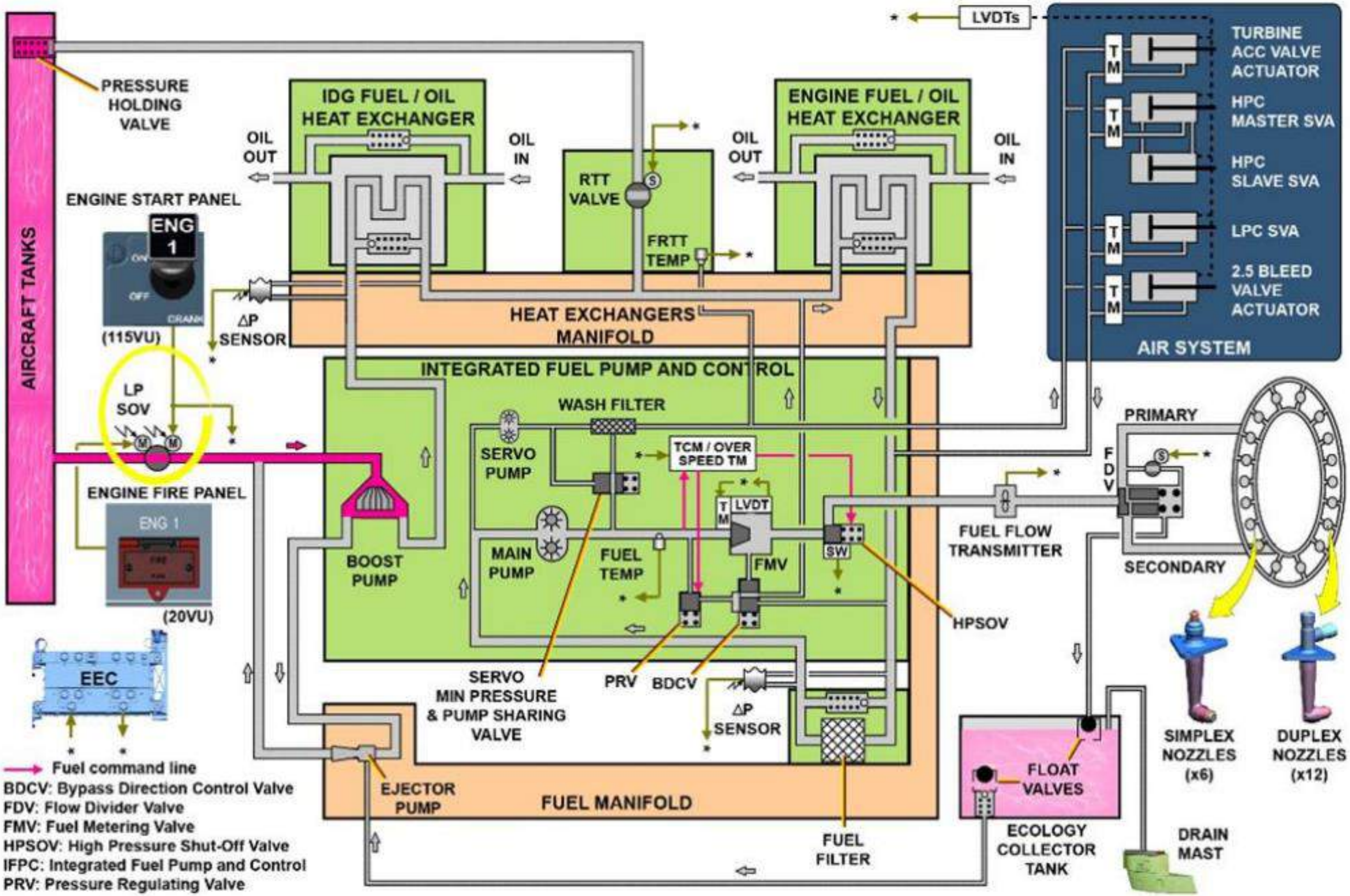


Fig. 2.1



LVDTs
TURBINE ACC VALVE ACTUATOR
HPC MASTER SVA
HPC SLAVE SVA
LPC SVA
2.5 BLEED VALVE ACTUATOR
AIR SYSTEM
PRESSURE HOLDING VALVE
IDG FUEL / OIL HEAT EXCHANGER
OIL OUT
OIL IN
RTT VALVE
FRTT TEMP
ENGINE FUEL / OIL HEAT EXCHANGER
OIL OUT
OIL IN
ENGINE START PANEL
AIRCRAFT TANKS
MASTER1
ON
OFF
ENG 1
(115VU)
ΔP SENSOR
HEAT EXCHANGERS MANIFOLD
INTEGRATED FUEL PUMP AND CONTROL
LP SOV
WASH FILTER
SERVO PUMP
TCM / OVER SPEED TM
LVDT
PRIMARY
FDV
ENGINE FIRE PANEL
ENG 1
(20VU)
MAIN PUMP
FUEL TEMP
FMV
SW
FUEL FLOW TRANSMITTER
SECONDARY
BOOST PUMP
HPSOV
EEC
SERVO MIN PRESSURE & PUMP SHARING VALVE
PRV
BDCV
ΔP SENSOR
SIMPLEX NOZZLES (x6)
DUPLEX NOZZLES (x12)
FLOAT VALVES
Fuel command line
BDCV: Bypass Direction Control Valve
FDV: Flow Divider Valve
FMV: Fuel Metering Valve
HPSOV: High Pressure Shut-Off Valve
IFPC: Integrated Fuel Pump and Control
PRV: Pressure Regulating Valve
EJECTOR PUMP
FUEL MANIFOLD
FUEL FILTER
ECOLOGY COLLECTOR TANK
DRAIN MAST

Fig. 2.2



PRESSURE HOLDING VALVE
AIRCRAFT TANKS
IDG FUEL / OIL HEAT EXCHANGER
OIL OUT
OIL IN
RTT VALVE
FRTT TEMP
ENGINE FUEL / OIL HEAT EXCHANGER
OIL OUT
OIL IN
LVDTs
TURBINE ACC VALVE ACTUATOR
HPC MASTER SVA
HPC SLAVE SVA
LPC SVA
2.5 BLEED VALVE ACTUATOR
AIR SYSTEM
ENGINE START PANEL
ENG 1
(115VU)
ΔP SENSOR
HEAT EXCHANGERS MANIFOLD
INTEGRATED FUEL PUMP AND CONTROL
LP SOV
WASH FILTER
SERVO PUMP
TCM / OVER SPEED TM
LVDT
PRIMARY
FDV
ENGINE FIRE PANEL
ENG 1
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MAIN PUMP
FUEL TEMP
FMV
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FUEL FLOW TRANSMITTER
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BOOST PUMP
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SIMPLEX NOZZLES (x6)
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IFPC: Integrated Fuel Pump and Control
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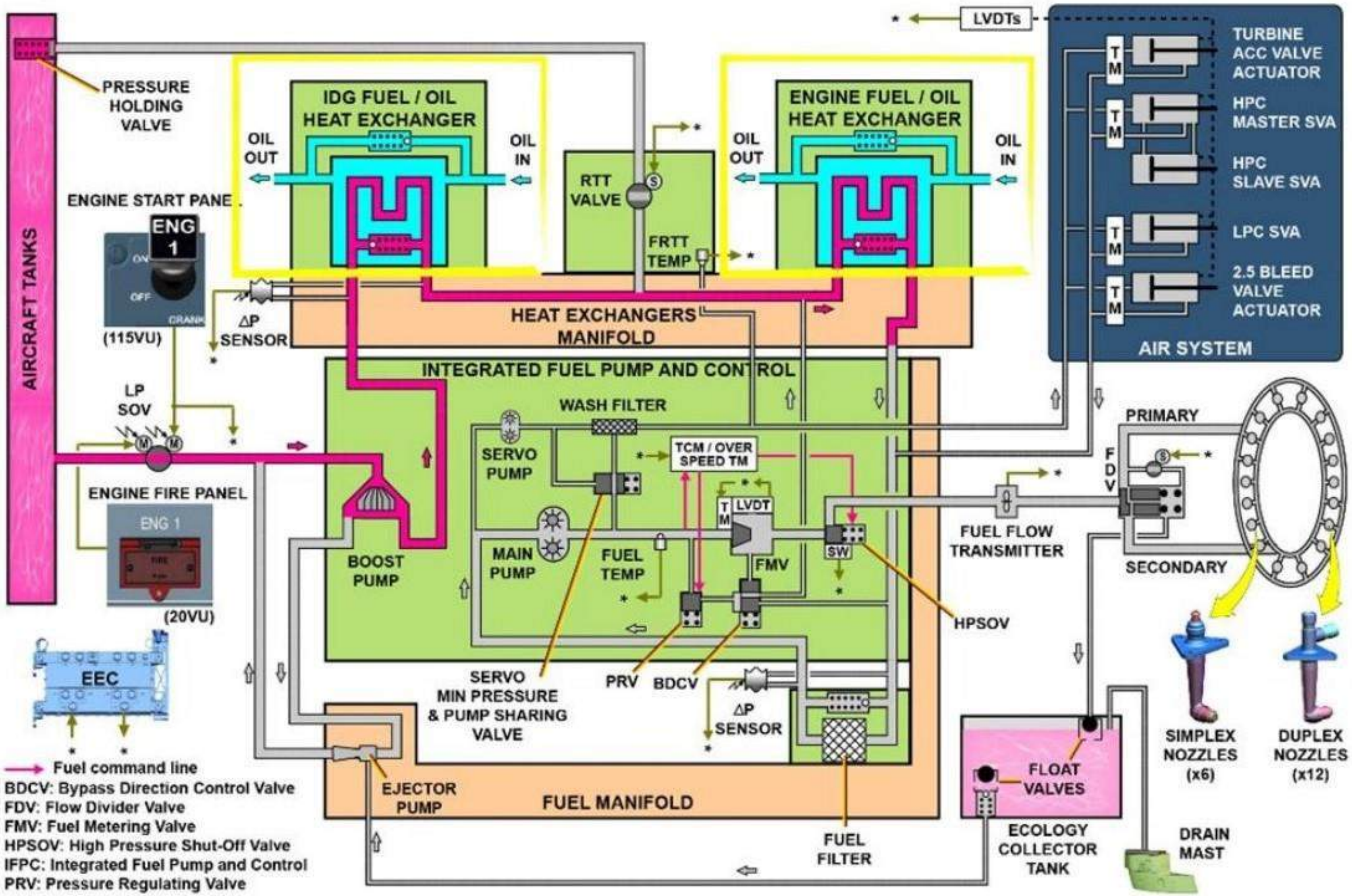
Fig. 2.3


AIRCRAFT TANKS
PRESSURE HOLDING VALVE
ENGINE START PANEL
ENG 1
ON
OFF
CRANK
(115VU)
ΔP SENSOR
LP SOV
ENGINE FIRE PANEL
ENG 1
(20VU)
EEC
IDG FUEL / OIL HEAT EXCHANGER
OIL OUT
OIL IN
RTT VALVE
FRTT TEMP
ENGINE FUEL / OIL HEAT EXCHANGER
HEAT EXCHANGERS MANIFOLD
INTEGRATED FUEL PUMP AND CONTROL
WASH FILTER
SERVO PUMP
TCM / OVER SPEED TM
LVDT
MAIN PUMP
FUEL TEMP
FMV
SW
BOOST PUMP
SERVO MIN PRESSURE & PUMP SHARING VALVE
PRV
BDCV
ΔP SENSOR
HPSOV
EJECTOR PUMP
FUEL MANIFOLD
FUEL FILTER
LVDTs
TURBINE ACC VALVE ACTUATOR
HPC MASTER SVA
HPC SLAVE SVA
LPC SVA
2.5 BLEED VALVE ACTUATOR
AIR SYSTEM
PRIMARY
FDV
FUEL FLOW TRANSMITTER
SECONDARY
SIMPLEX NOZZLES (x6)
DUPLEX NOZZLES (x12)
FLOAT VALVES
ECOLOGY COLLECTOR TANK
DRAIN MAST
Fuel command line
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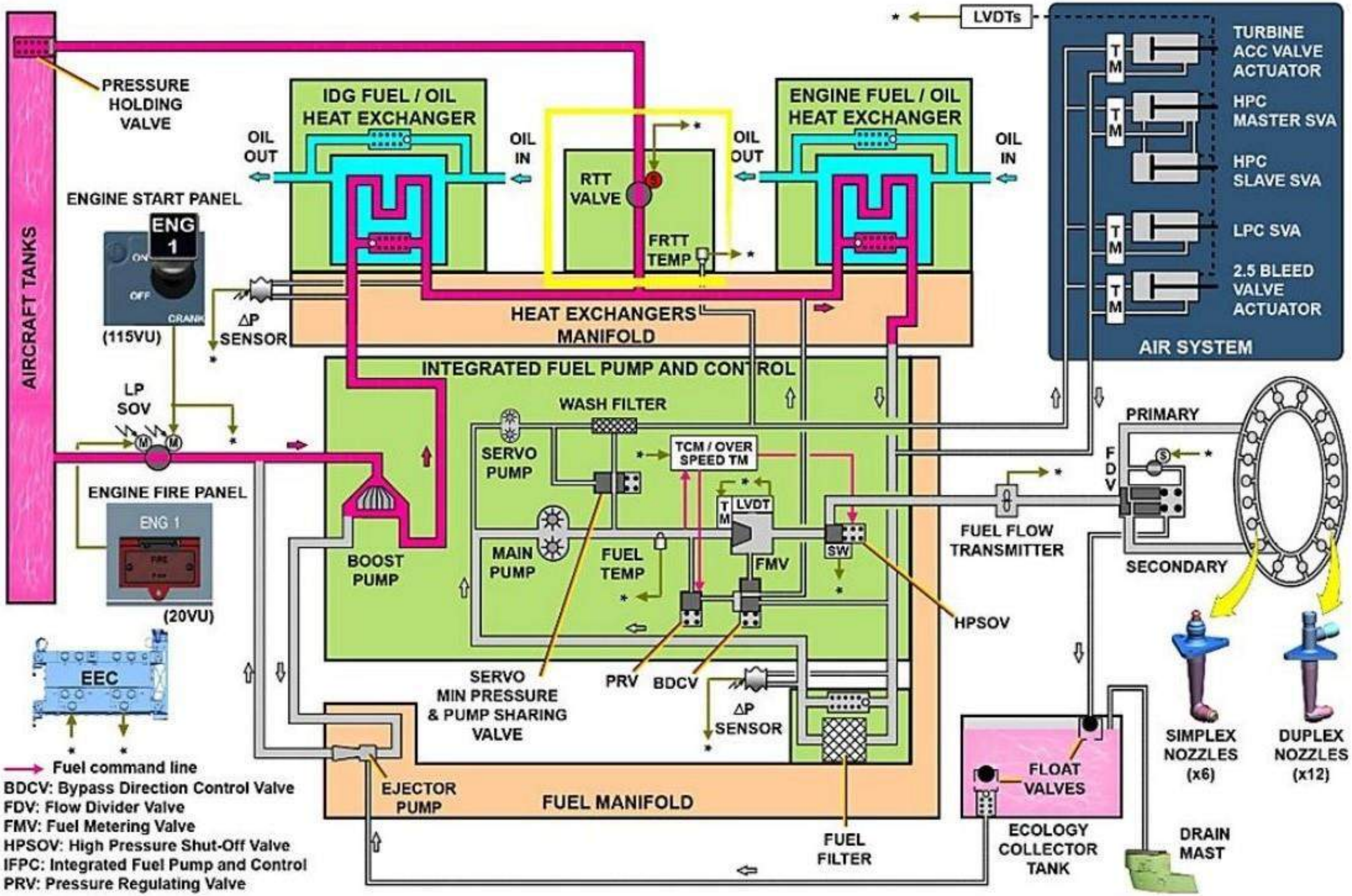
HPSOV: High Pressure Shut-Off Valve
IFPC: Integrated Fuel Pump and Control
PRV: Pressure Regulating Valve

Fig. 2.4


AIRCRAFT TANKS
PRESSURE HOLDING VALVE
IDG FUEL / OIL HEAT EXCHANGER
OIL OUT
OIL IN
RTT VALVE
FRTT TEMP
OIL OUT
ENGINE FUEL / OIL HEAT EXCHANGER
OIL IN
LVDTs
TURBINE ACC VALVE ACTUATOR
HPC MASTER SVA
HPC SLAVE SVA
LPC SVA
2.5 BLEED VALVE ACTUATOR
AIR SYSTEM
ENGINE START PANEL
ENG 1
(115VU)
ΔP SENSOR
HEAT EXCHANGERS MANIFOLD
INTEGRATED FUEL PUMP AND CONTROL
LP SOV
WASH FILTER
SERVO PUMP
TCM / OVER SPEED TM
LVDT
PRIMARY
FDV
ENGINE FIRE PANEL
ENG 1
(20VU)
MAIN PUMP
FUEL TEMP
FMV
SW
FUEL FLOW TRANSMITTER
SECONDARY
BOOST PUMP
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PRV: Pressure Regulating Valve
EJECTOR PUMP
FUEL MANIFOLD
FUEL FILTER
ECOLOGY COLLECTOR TANK
DRAIN MAST

Fig. 2.5

INTEGRATED FUEL PUMP AND CONTROL (Fig. 2.6)

The IFPC is an electronically controlled unit which integrates the fuel metering components and the fuel pumps in a single unit to limit the space and the number of external tubes required for the system. The IFPC uses dual coil torque motors and solenoids to control hydro-mechanical valves in relation to the fuel flow.

FUEL METERING VALVE AND HIGH PRESSURE SHUT-OFF VALVE (Fig. 2.7)

The EEC controls a dual Torque Motor (TM) which positions the Fuel Metering Valve (FMV) in the desired position. The close loop monitoring is ensured by the EEC using the valve LVDT feedback signals.

PRESSURE REGULATING VALVE AND BYPASS DIRECTIONAL CONTROL VALVE (Fig. 2.8)

Inside the IFPC, the fuel from the main pump is directed to the FMV and to the Pressure Regulating Valve (PRV). The purpose of the PRV is to maintain a constant fuel pressure drop across the FMV to ensure the correct fuel flow and acceleration for the engine.

PRESSURE REGULATING VALVE AND BYPASS DIRECTIONAL CONTROL VALVE (Fig. 2.9)

Pressurized fuel that passes through the PRV is directed to the Bypass Direction Control Valve (BDCV). The BDCV directs fuel by-passed by the PRV to the engine FOHE at low engine power or when the fuel temperature is low to help in maintaining the engine oil and fuel within operating limits.

EEC CONTROL (Fig. 2.10)

The EEC controls the dual TCM/Overspeed TM for HPSOV positioning.

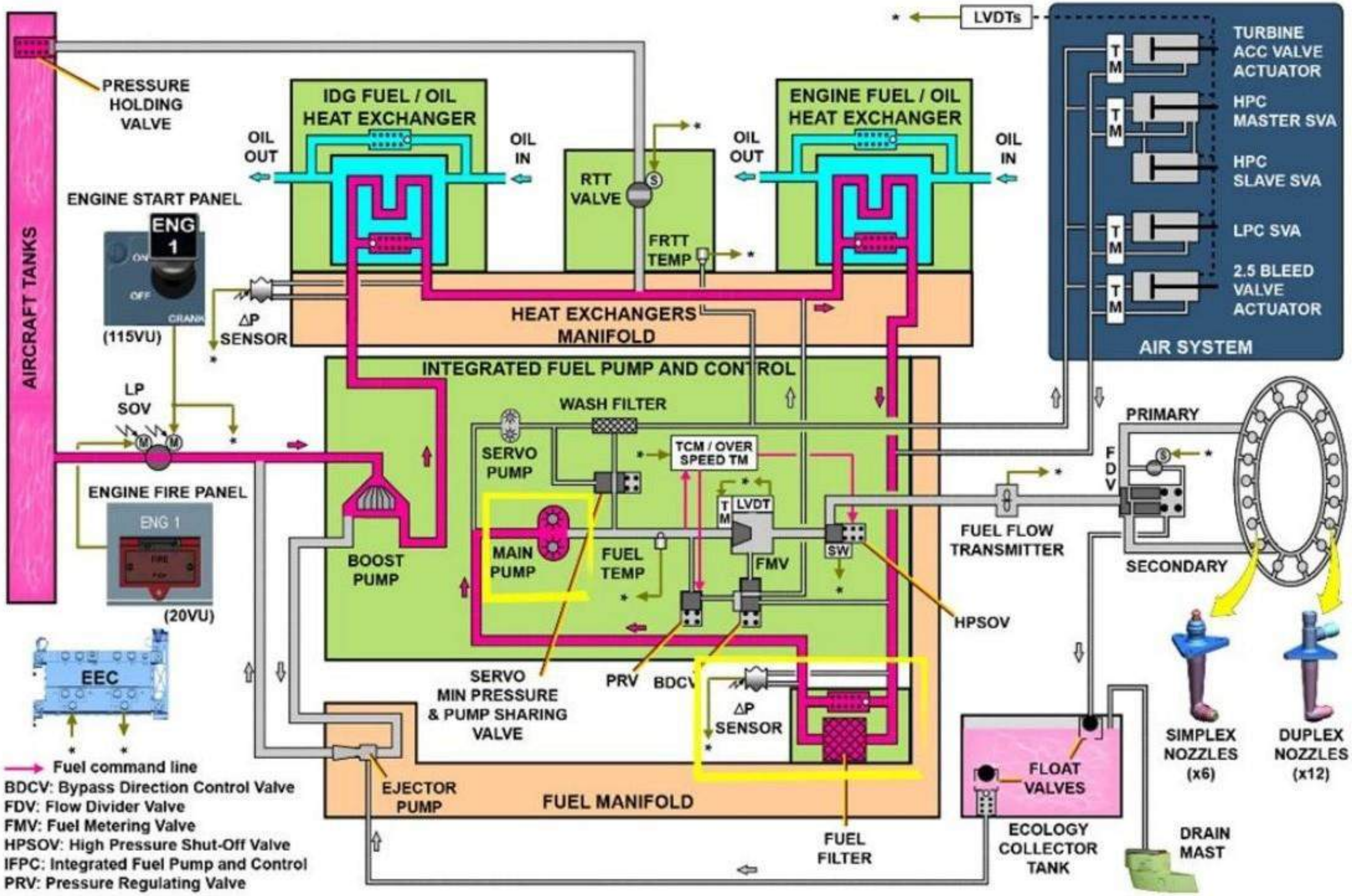
It monitors the fully closed valve position with the two proximity switches.

For the air system, the EEC controls the fuel-operated actuators with dual channel TMs and it monitors their position due to LVDT position feedbacks.

FUEL FLOW TRANSMITTER, FLOW DIVIDER VALVE AND FUEL NOZZLES (Fig. 2.11)

The metered fuel from the FMV crosses the HPSOV and flows to the fuel flow transmitter.

The fuel flow transmitter sends the fuel flow rate to the EEC channel A and directs fuel to the Flow Divider Valve (FDV).



LVDTs
TURBINE ACC VALVE ACTUATOR
HPC MASTER SVA
HPC SLAVE SVA
LPC SVA
2.5 BLEED VALVE ACTUATOR
AIR SYSTEM
PRESSURE HOLDING VALVE
IDG FUEL / OIL HEAT EXCHANGER
ENGINE FUEL / OIL HEAT EXCHANGER
OIL OUT
OIL IN
RTT VALVE
FRTT TEMP
ENGINE START PANEL
ENG 1
(115VU)
ΔP SENSOR
HEAT EXCHANGERS MANIFOLD
AIRCRAFT TANKS
LP SOV
INTEGRATED FUEL PUMP AND CONTROL
WASH FILTER
SERVO PUMP
TCM / OVER SPEED TM
LVDT
PRIMARY
FDV
ENGINE FIRE PANEL
ENG 1
(20VU)
BOOST PUMP
MAIN PUMP
FUEL TEMP
FMV
SW
FUEL FLOW TRANSMITTER
SECONDARY
HPSOV
EEC
SERVO MIN PRESSURE & PUMP SHARING VALVE
PRV
BDCV
ΔP SENSOR
SIMPLEX NOZZLES (x6)
DUPLEX NOZZLES (x12)
FLOAT VALVES
EJECTOR PUMP
FUEL MANIFOLD
FUEL FILTER
ECOLOGY COLLECTOR TANK
DRAIN MAST
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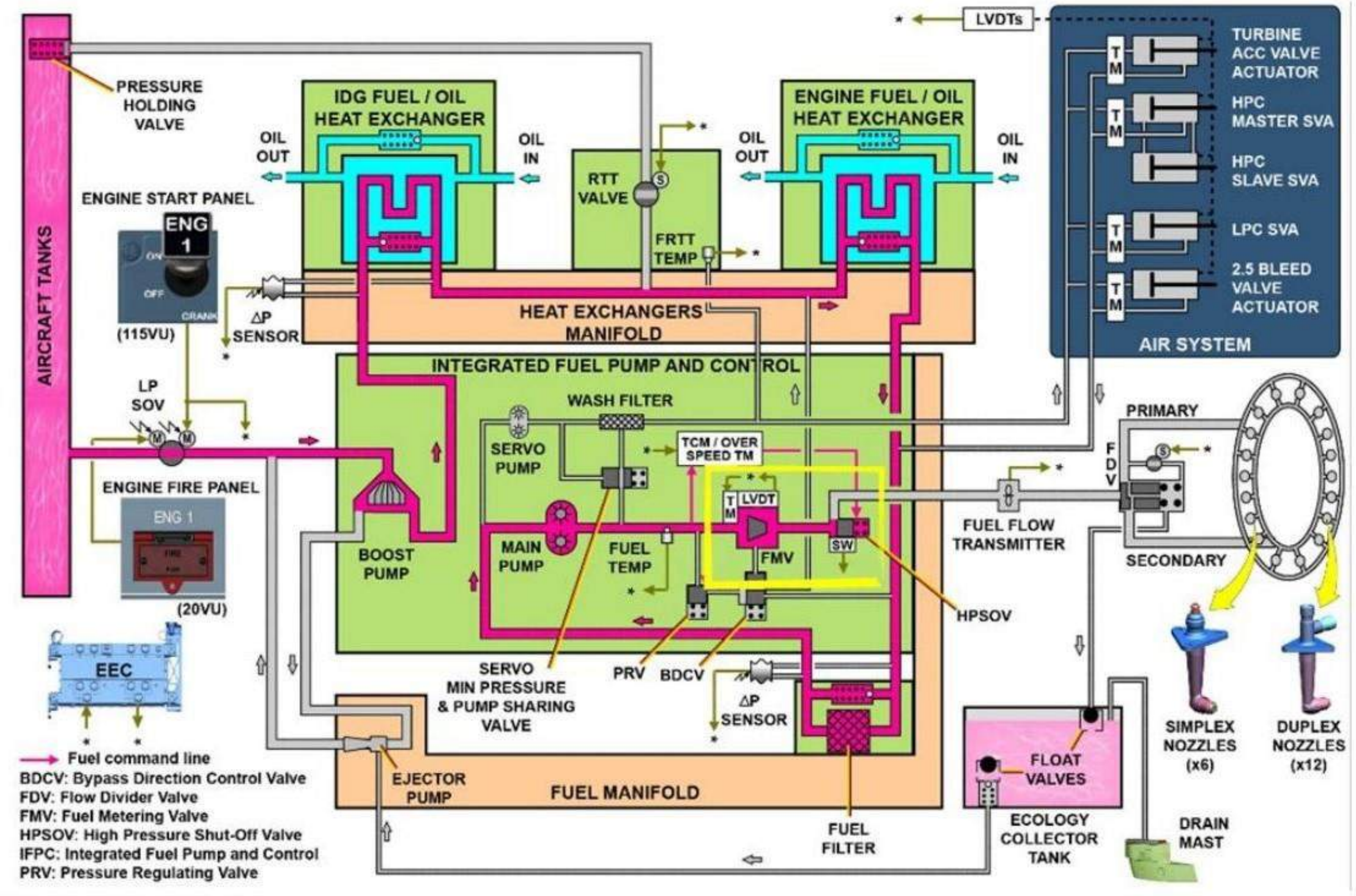
Fig. 2.6



PRESSURE HOLDING VALVE
AIRCRAFT TANKS
IDG FUEL / OIL HEAT EXCHANGER
OIL OUT
OIL IN
RTT VALVE
FRTT TEMP
ENGINE FUEL / OIL HEAT EXCHANGER
LVDTs
TURBINE ACC VALVE ACTUATOR
HPC MASTER SVA
HPC SLAVE SVA
LPC SVA
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AIR SYSTEM
ENGINE START PANEL
ENG 1
(115VU)
ΔP SENSOR
HEAT EXCHANGERS MANIFOLD
INTEGRATED FUEL PUMP AND CONTROL
LP SOV
WASH FILTER
SERVO PUMP
TCM / OVER SPEED TM
LVDT
FMV
SW
PRIMARY
FDV
FUEL FLOW TRANSMITTER
SECONDARY
ENGINE FIRE PANEL
(20VU)
BOOST PUMP
MAIN PUMP
FUEL TEMP
HPSOV
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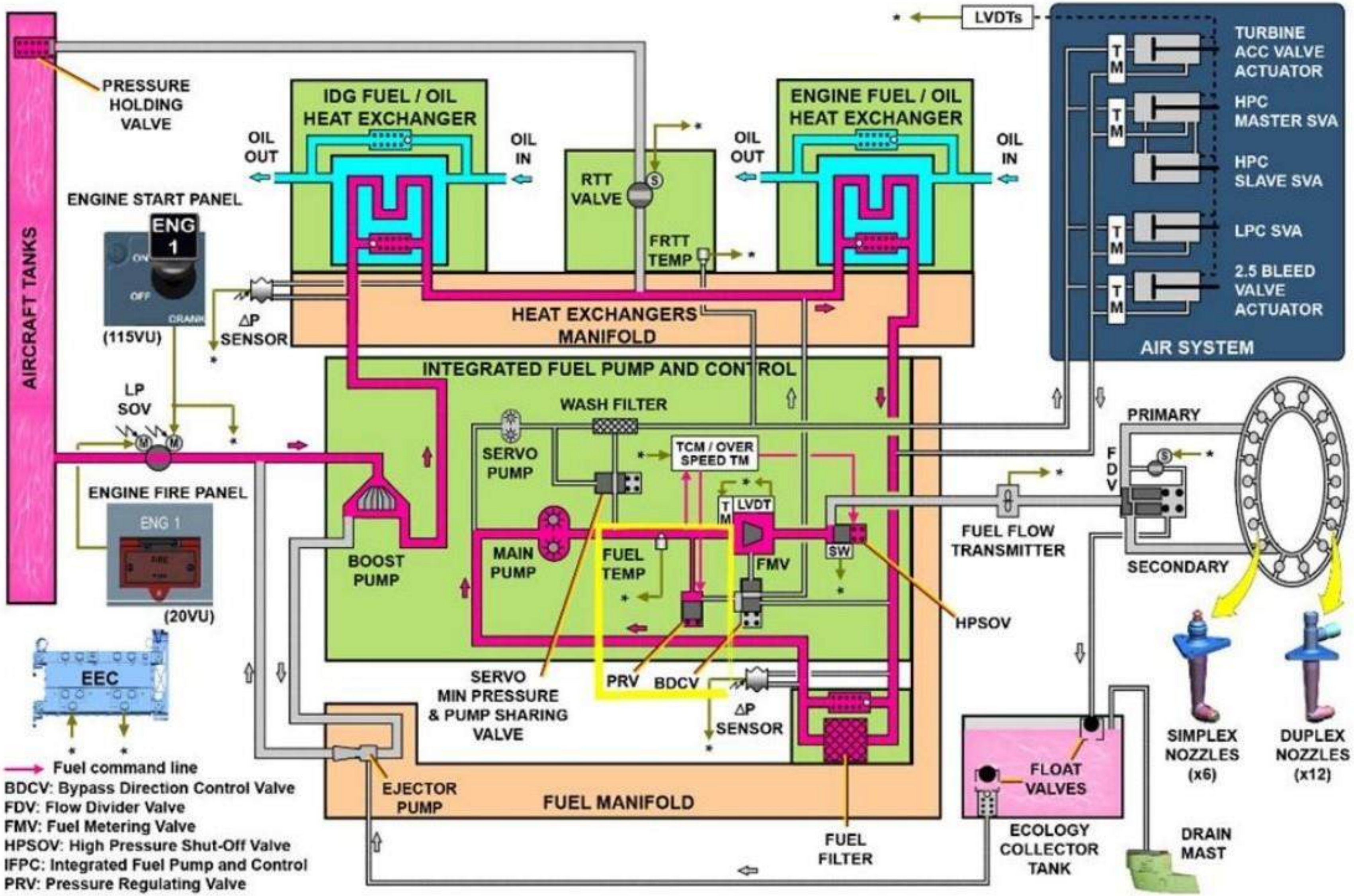
Fig. 2.7



PRESSURE HOLDING VALVE
AIRCRAFT TANKS
ENGINE START PANEL
ENG 1
(115VU)
ΔP SENSOR
LP SOV
ENGINE FIRE PANEL
(20VU)
EEC
IDG FUEL / OIL HEAT EXCHANGER
OIL OUT
OIL IN
RTT VALVE
FRTT TEMP
ENGINE FUEL / OIL HEAT EXCHANGER
OIL OUT
OIL IN
HEAT EXCHANGERS MANIFOLD
INTEGRATED FUEL PUMP AND CONTROL
WASH FILTER
SERVO PUMP
TCM / OVER SPEED TM
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FUEL TEMP
FMV
SW
HPSOV
SERVO MIN PRESSURE & PUMP SHARING VALVE
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BDCV
ΔP SENSOR
EJECTOR PUMP
FUEL MANIFOLD
FUEL FILTER
LVDTs
TURBINE ACC VALVE ACTUATOR
HPC MASTER SVA
HPC SLAVE SVA
LPC SVA
2.5 BLEED VALVE ACTUATOR
AIR SYSTEM
PRIMARY
FDV
FUEL FLOW TRANSMITTER
SECONDARY
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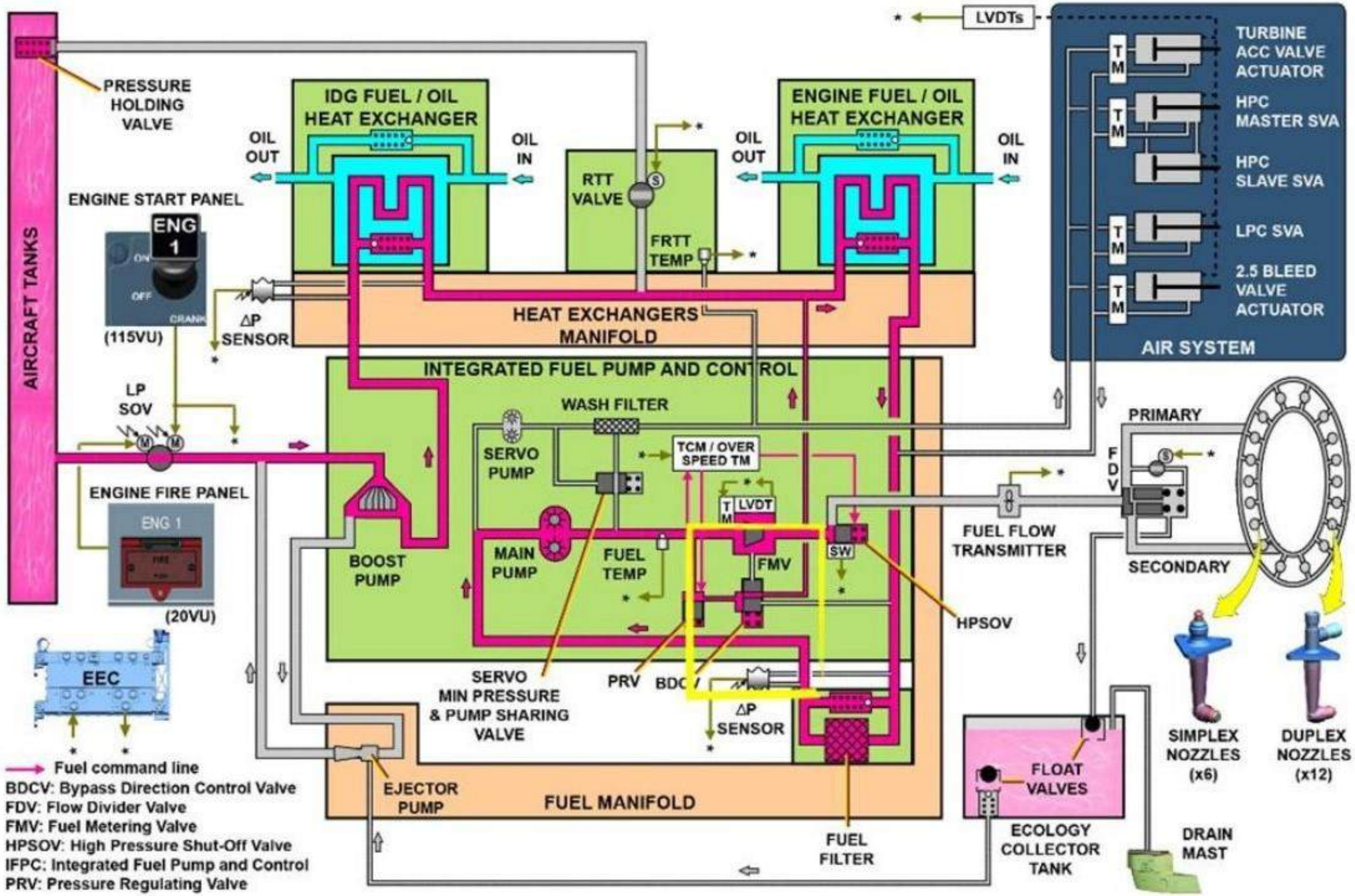
Fig. 2.8


PRESSURE HOLDING VALVE
AIRCRAFT TANKS
ENGINE START PANEL
ENG 1
(115VU)
IDG FUEL / OIL HEAT EXCHANGER
OIL OUT
OIL IN
RTT VALVE
FRTT TEMP
ENGINE FUEL / OIL HEAT EXCHANGER
OIL OUT
OIL IN
LVDTs
TURBINE ACC VALVE ACTUATOR
HPC MASTER SVA
HPC SLAVE SVA
LPC SVA
2.5 BLEED VALVE ACTUATOR
AIR SYSTEM
ΔP SENSOR
HEAT EXCHANGERS MANIFOLD
INTEGRATED FUEL PUMP AND CONTROL
LP SOV
WASH FILTER
SERVO PUMP
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ENGINE FIRE PANEL
ENG 1
(20VU)
BOOST PUMP
MAIN PUMP
FUEL TEMP
LVDT
FMV
SW
PRIMARY
FDV
FUEL FLOW TRANSMITTER
SECONDARY
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SERVO MIN PRESSURE & PUMP SHARING VALVE
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BDCV
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SIMPLEX NOZZLES (x6)
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FUEL MANIFOLD
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ECOLOGY COLLECTOR TANK
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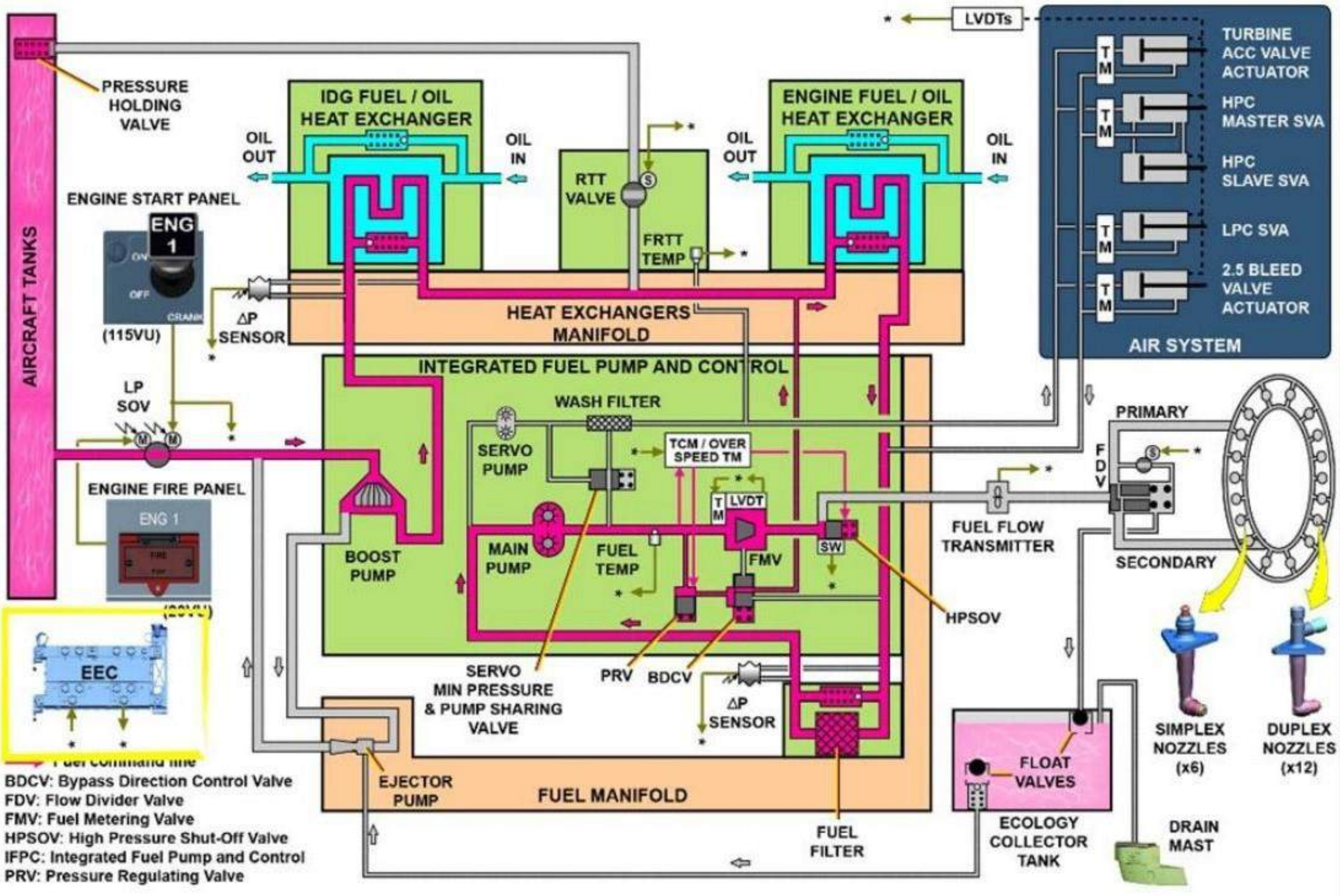
HPSOV: High Pressure Shut-Off Valve
IFPC: Integrated Fuel Pump and Control
PRV: Pressure Regulating Valve

Fig. 2.9


LVDTs
TURBINE ACC VALVE ACTUATOR
HPC MASTER SVA
HPC SLAVE SVA
LPC SVA
2.5 BLEED VALVE ACTUATOR
AIR SYSTEM
PRESSURE HOLDING VALVE
AIRCRAFT TANKS
IDG FUEL / OIL HEAT EXCHANGER
OIL OUT
OIL IN
RTT VALVE
FRTT TEMP
ENGINE FUEL / OIL HEAT EXCHANGER
OIL OUT
OIL IN
ENGINE START PANEL
ENG 1
(115VU)
ΔP SENSOR
HEAT EXCHANGERS MANIFOLD
INTEGRATED FUEL PUMP AND CONTROL
WASH FILTER
LP SOV
SERVO PUMP
TCM / OVER SPEED TM
LVDT
ENGINE FIRE PANEL
ENG 1
BOOST PUMP
MAIN PUMP
FUEL TEMP
FMV
SW
FUEL FLOW TRANSMITTER
PRIMARY
FDV
SECONDARY
HPSOV
EEC
SERVO MIN PRESSURE & PUMP SHARING VALVE
PRV
BDCV
ΔP SENSOR
EJECTOR PUMP
FUEL MANIFOLD
FUEL FILTER
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ECOLOGY COLLECTOR TANK
SIMPLEX NOZZLES (x6)
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DRAIN MAST
BDCV: Bypass Direction Control Valve
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FMV: Fuel Metering Valve
HPSOV: High Pressure Shut-Off Valve
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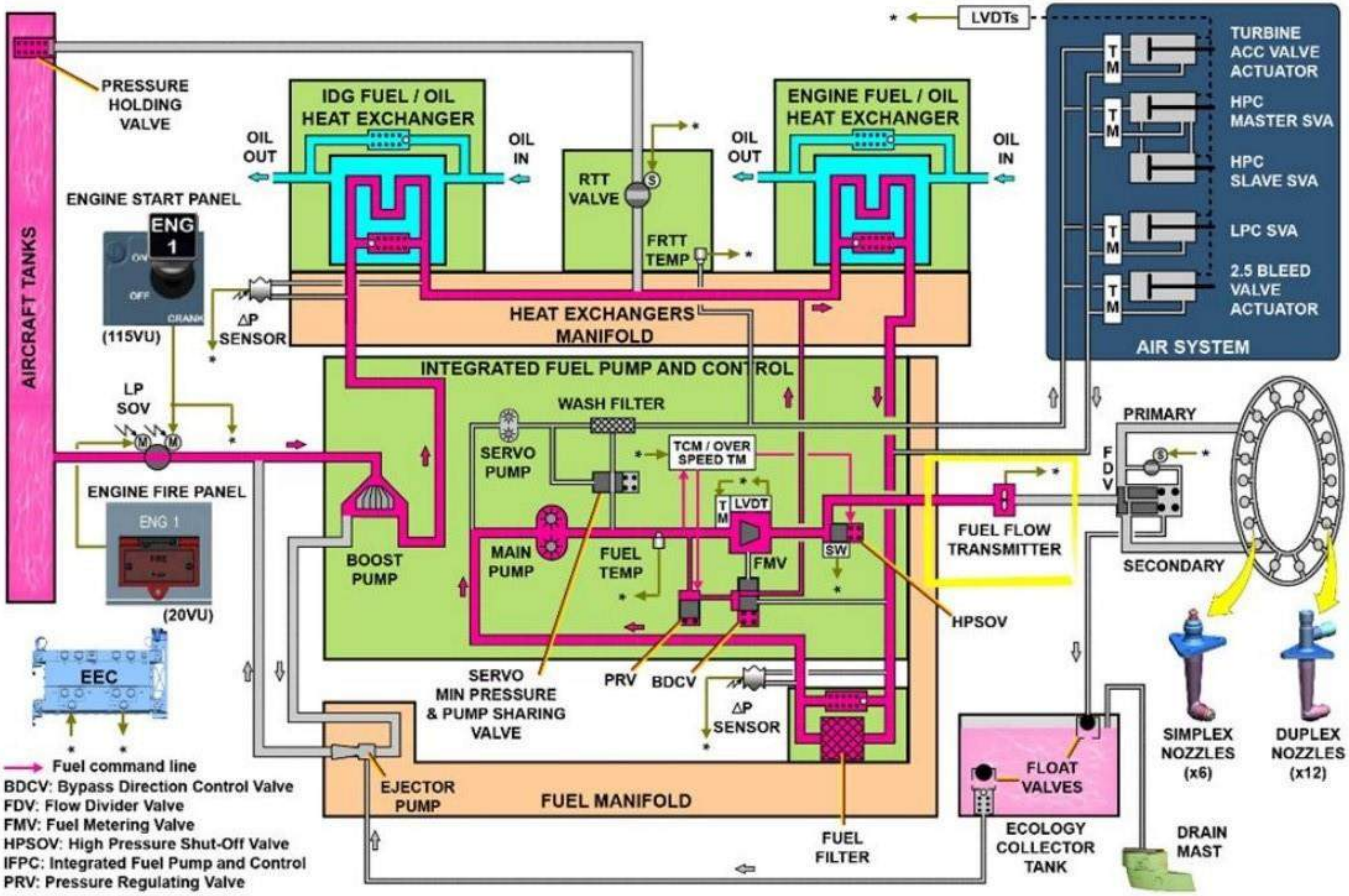
PRV: Pressure Regulating Valve

Fig. 2.10


LVDTs
TURBINE ACC VALVE ACTUATOR
HPC MASTER SVA
HPC SLAVE SVA
LPC SVA
2.5 BLEED VALVE ACTUATOR
AIR SYSTEM
PRESSURE HOLDING VALVE
IDG FUEL / OIL HEAT EXCHANGER
ENGINE FUEL / OIL HEAT EXCHANGER
OIL OUT
OIL IN
RTT VALVE
FRTT TEMP
ENGINE START PANEL
ENG 1
(115VU)
ΔP SENSOR
HEAT EXCHANGERS MANIFOLD
AIRCRAFT TANKS
INTEGRATED FUEL PUMP AND CONTROL
LP SOV
WASH FILTER
SERVO PUMP
TCM / OVER SPEED TM
PRIMARY
FDV
ENGINE FIRE PANEL
ENG 1
LVDT
FUEL FLOW TRANSMITTER
SECONDARY
BOOST PUMP
MAIN PUMP
FUEL TEMP
FMV
SW
(20VU)
HPSOV
EEC
SERVO MIN PRESSURE & PUMP SHARING VALVE
PRV
BDCV
ΔP SENSOR
SIMPLEX NOZZLES (x6)
DUPLEX NOZZLES (x12)
FLOAT VALVES
Fuel command line
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IFPC: Integrated Fuel Pump and Control
PRV: Pressure Regulating Valve
EJECTOR PUMP
FUEL MANIFOLD
FUEL FILTER
ECOLOGY COLLECTOR TANK
DRAIN MAST

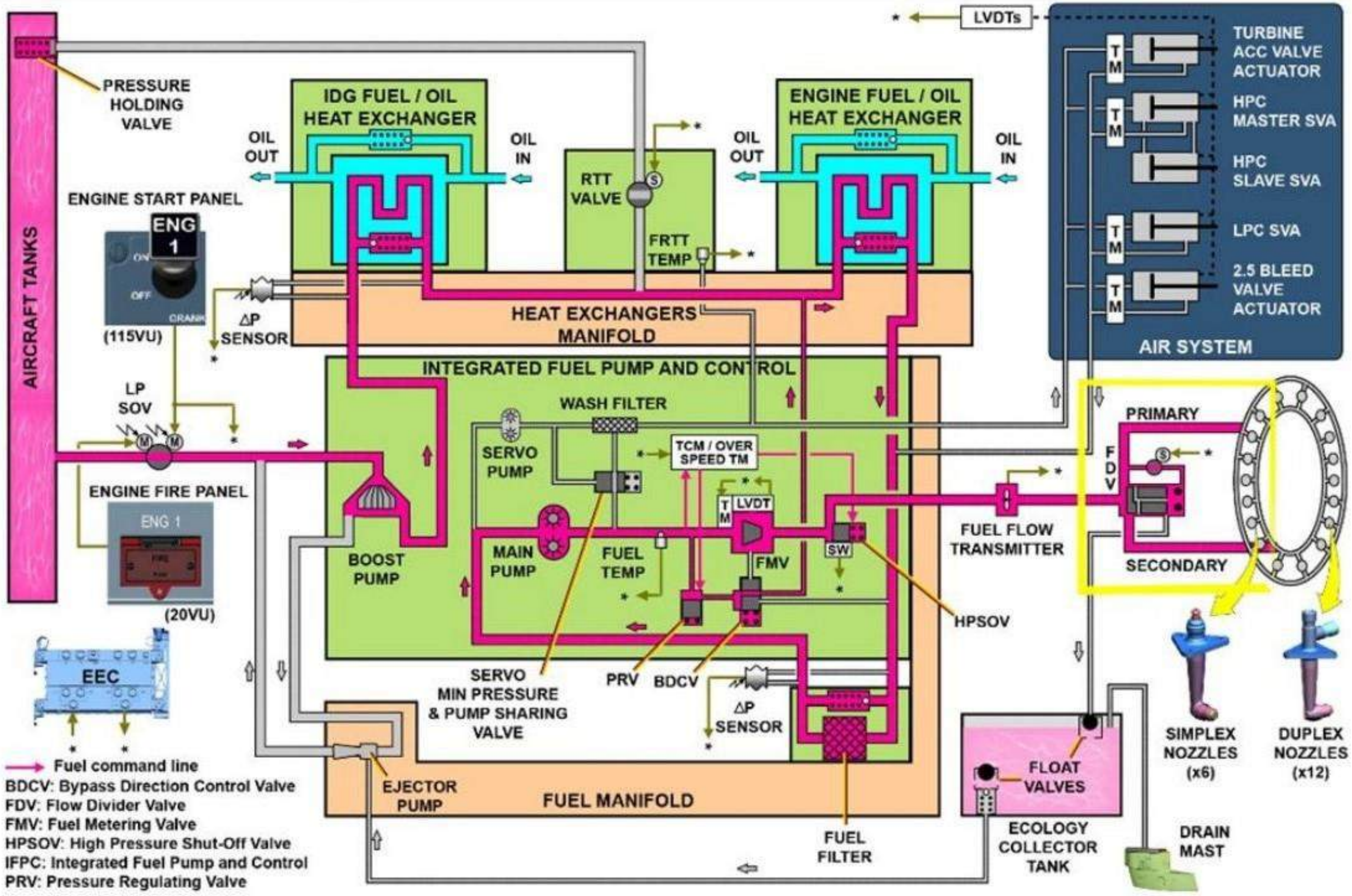
Fig. 2.11

FLOW DIVIDER VALVE (Fig. 2.12)
The EEC commands the FDV opening during starting to improve fuel atomization.
During engine start, the FDV sends most of fuel to the primary manifold.
Above idle, the FDV evenly divides metered fuel flow between the primary and secondary fuel manifolds.

FUEL NOZZLES (Fig. 2.13)
There are 18 fuel nozzles mounted to the outer diffuser case. All the nozzles atomize fuel inside the combustor. Twelve of them are duplex nozzles featuring both a primary and a secondary fuel flow paths while six others are simplex nozzles providing only a secondary fuel flow path.

SERVO FUEL PUMP (Fig. 2.14)
The servo pump housed in the IFPC is a gear-stage pump which sends pressurized fuel to a wash filter. Fine filtered, pressurized fuel from the wash filter is supplied to the engine air system actuators where it is used as servo and muscle pressure to position the actuator pistons.
These actuators are:
+ the Low Pressure Compressor (LPC) Stator Vane Actuator (SVA),
+ the LPC (2.5) Bleed Valve Actuator (BVA),
+ the turbine Active Case Cooling (ACC) valve,
+ and the High-Pressure Compressor (HPC) SVAs (primary and secondary).

SERVO MINIMUM PRESSURE AND PUMP SHARING VALVE (Fig. 2.15)
The Servo Minimum Pressure and Pump Sharing Valve is a spring-loaded valve that provides the five air system actuators with main pump fuel pressure when servo pump fuel pressure is not enough during start.



LVDTs
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WASH FILTER
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BOOST PUMP
MAIN PUMP
FUEL TEMP
FMV
SW
FUEL FLOW TRANSMITTER
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SIMPLEX NOZZLES (x6)
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FMV: Fuel Metering Valve
HPSOV: High Pressure Shut-Off Valve
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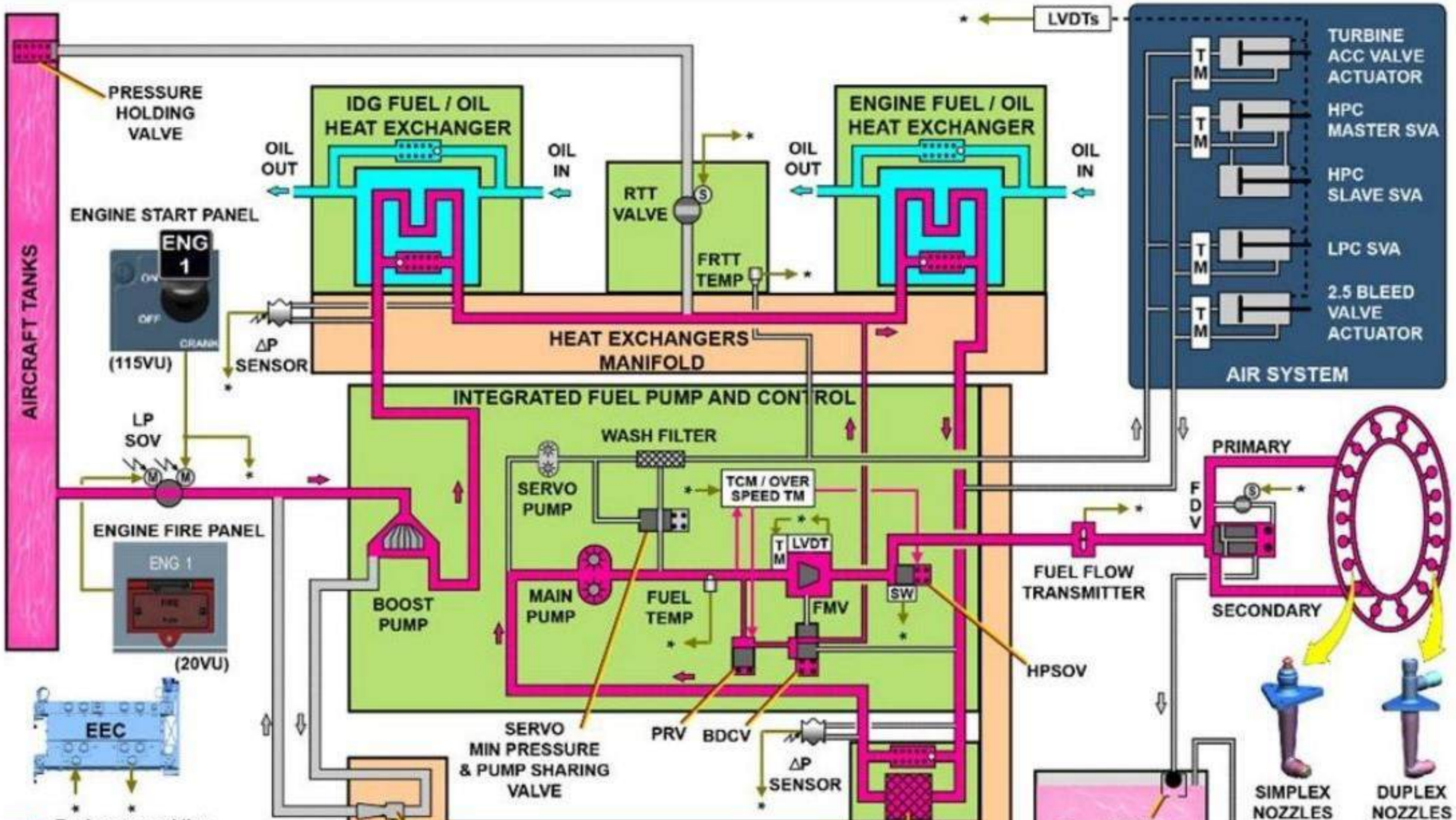
Fig. 2.12



Fuel command line
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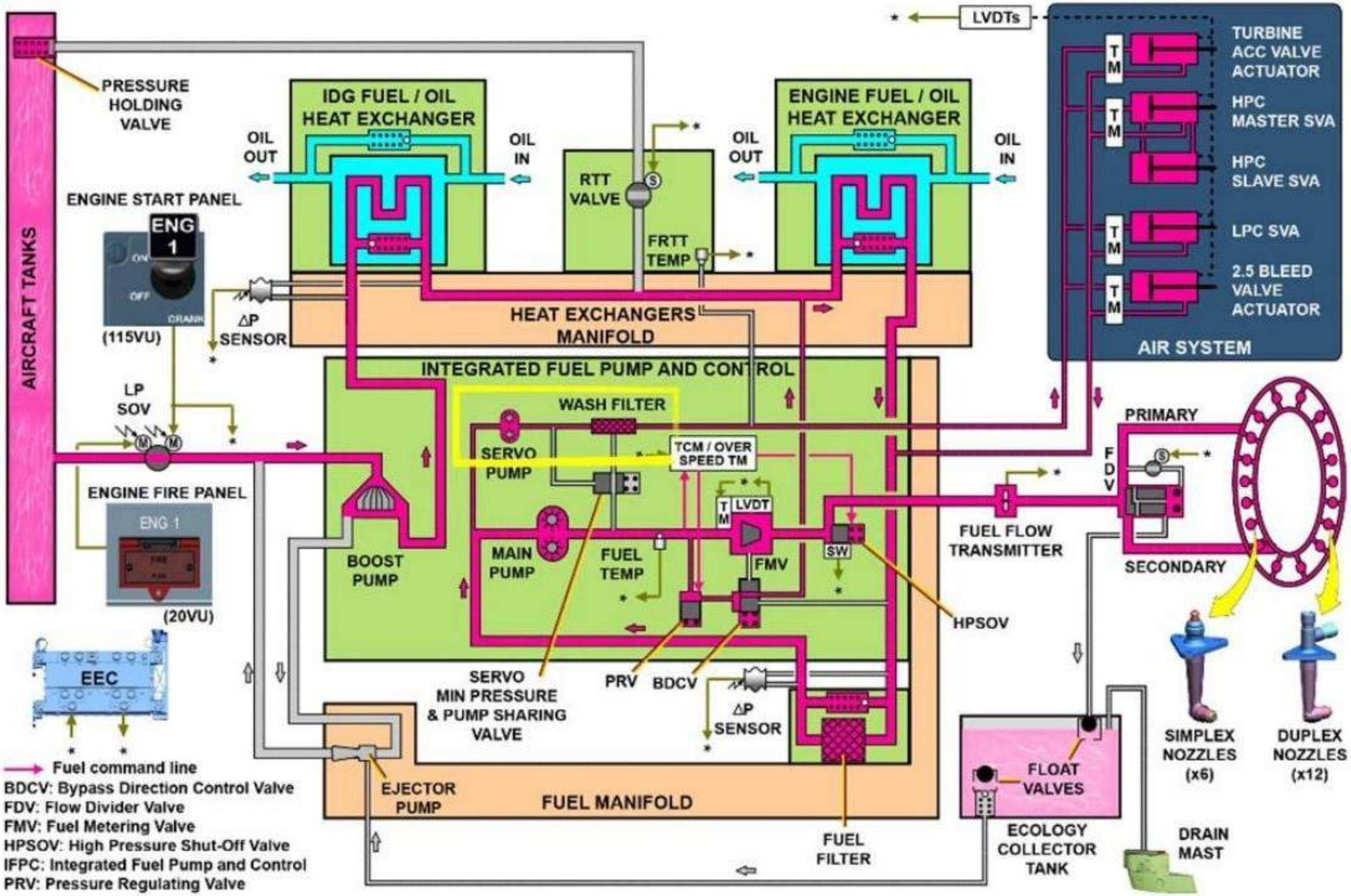
Fig. 2.13



LVDTs
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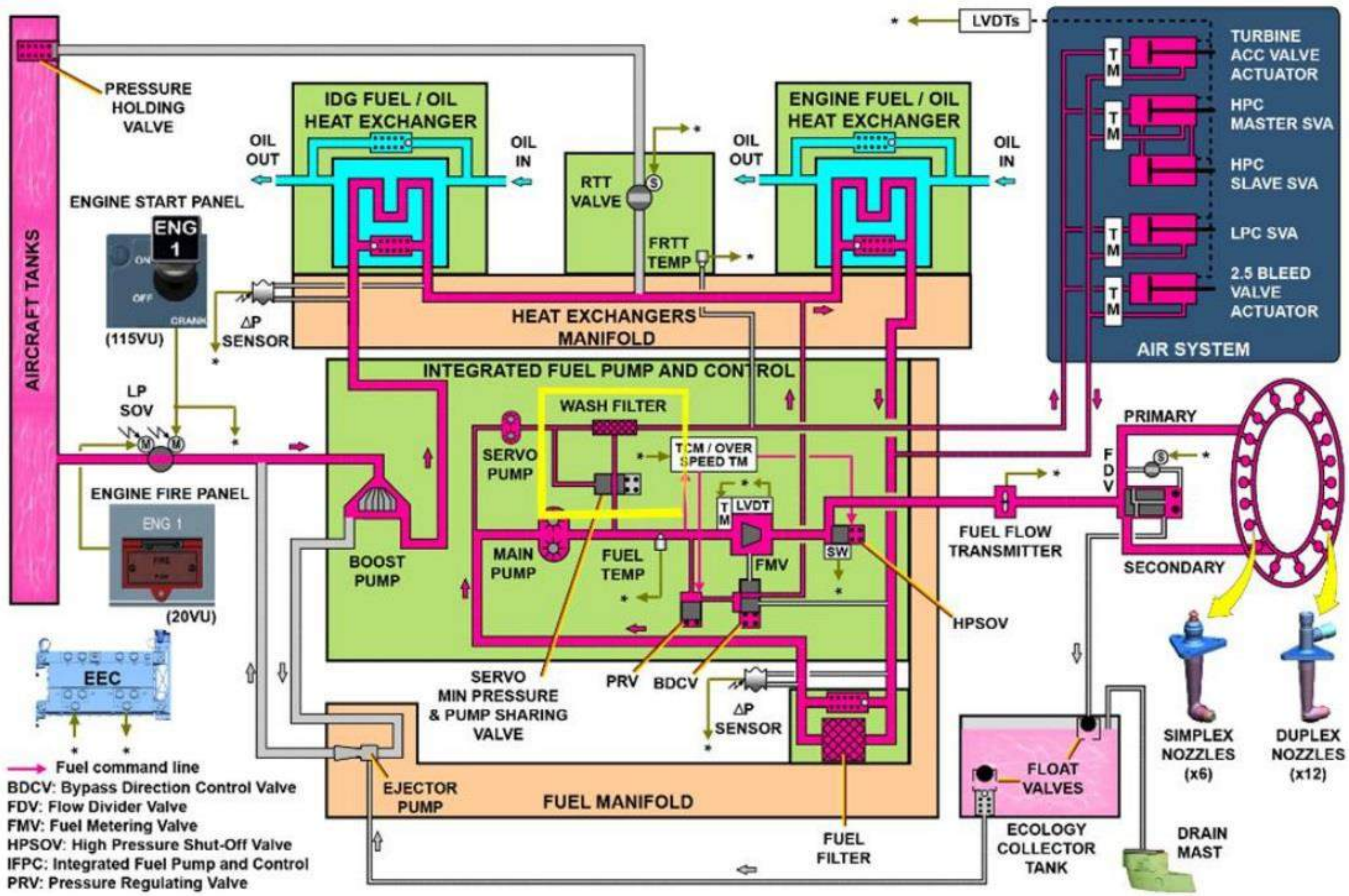
Fig. 2.14



PRESSURE HOLDING VALVE
AIRCRAFT TANKS
IDG FUEL / OIL HEAT EXCHANGER
OIL OUT
OIL IN
RTT VALVE
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ENGINE FUEL / OIL HEAT EXCHANGER
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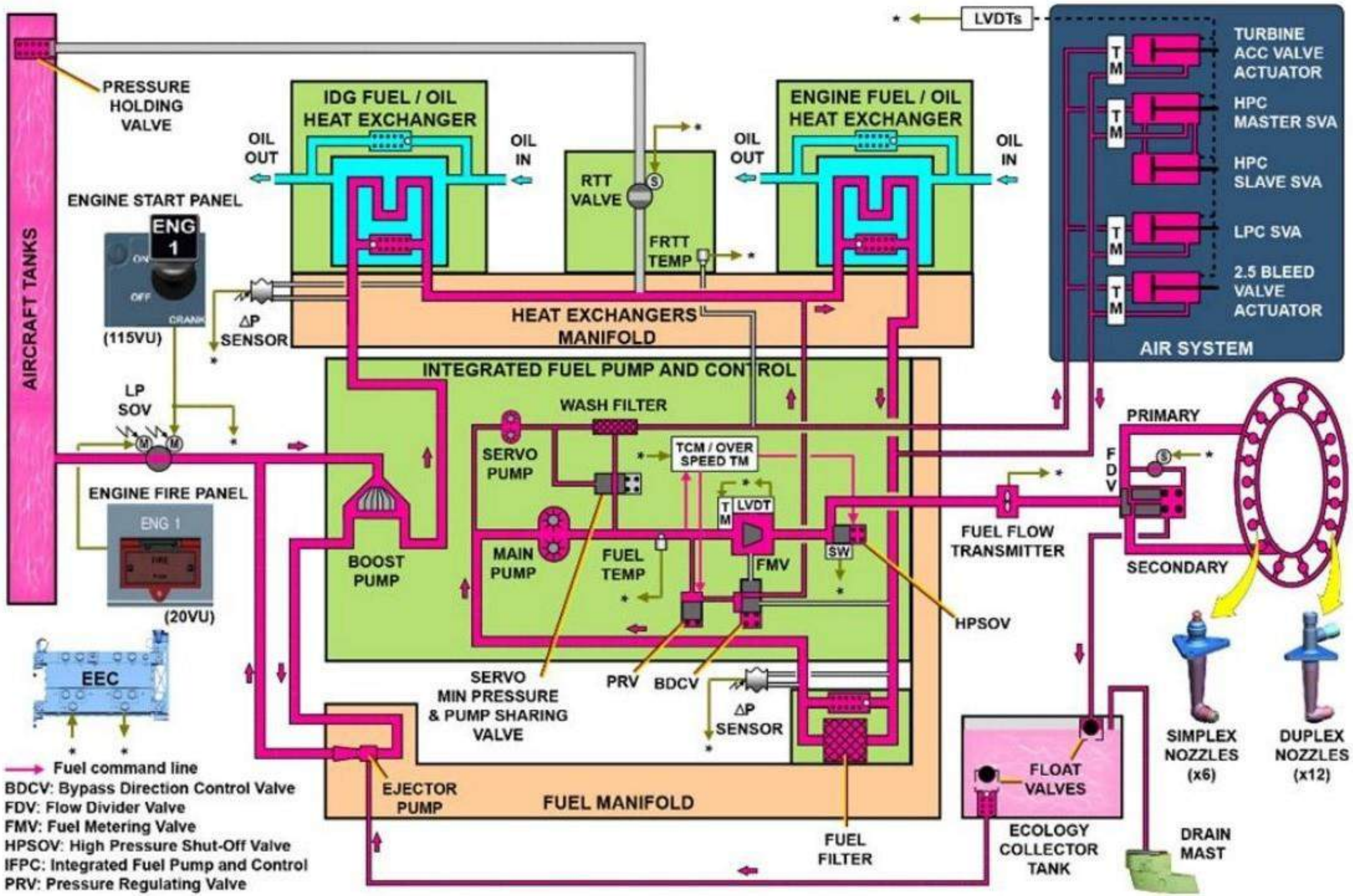
Fig. 2.15

ECOLOGY SYSTEM (Fig. 2.16)
At engine shutdown, residual fuel in the manifolds downstream of the FDV is drained back through the FDV to an ecology collector tank.
The collected fuel remains in the ecology collector tank until the next engine start when the fuel is drawn back into the fuel system.
During shutdown, the fuel pressure from the IFPC is reduced and the FDV closes to prevent fuel from entering the combustor and to drain any fuel remaining in both the primary and secondary fuel lines to the ecology collector tank.
At next engine start up, the ejector pump draws the fuel from the ecology collector tank back to the IFPC boost pump. The tank has an outlet float valve which closes when the tank has reached its minimum capacity and a check valve to avoid fuel transfer from the suction line.
STARTING – INITIATION (Fig. 2.17)
During starting, the servo pump fuel pressure is not enough to control the air system actuators and to close the Servo Minimum Pressure and Pump Sharing Valve.
In this position, the Servo Minimum Pressure and Pump Sharing Valve directs a portion of pressurized fuel from the main pump to the five actuators. The other portion of fuel from the main pump is sent to the PRV and to the FMV. The PRV opens partly and directs the excess of fuel flow to the BDCV which is spring loaded to send it to the engine FOHE.
STARTING – ACCELERATION (Fig. 2.18)
As the pumps rotation speed increases with the engine acceleration, the fuel pressure also increases. The FMV opens more and as a consequence the fuel pressure pushes the BDCV out of its rest position to direct the excess fuel flow to the fuel filter.
In parallel, the fuel pressure from the servo pump increases and pushes the Servo Minimum Pressure and Pump Sharing Valve, segregating the burn flow from the servo fuel.


AIRCRAFT TANKS
PRESSURE HOLDING VALVE
IDG FUEL / OIL HEAT EXCHANGER
OIL OUT
OIL IN
RTT VALVE
FRTT TEMP
ENGINE FUEL / OIL HEAT EXCHANGER
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AIR SYSTEM
ENGINE START PANEL
ENG 1
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FUEL TEMP
FMV
SW
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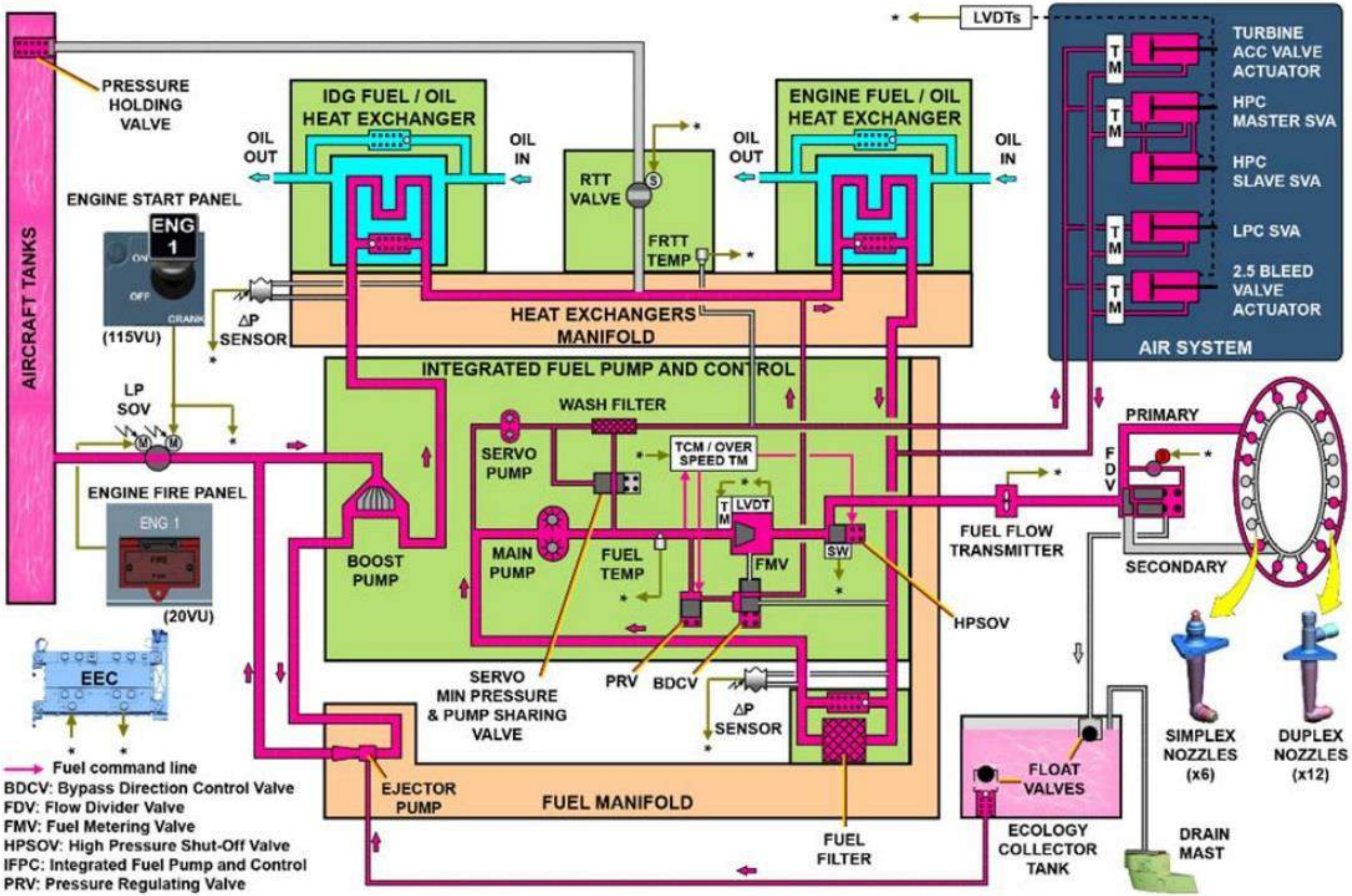
Fig. 2.16



LVDTs
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Fig. 2.17

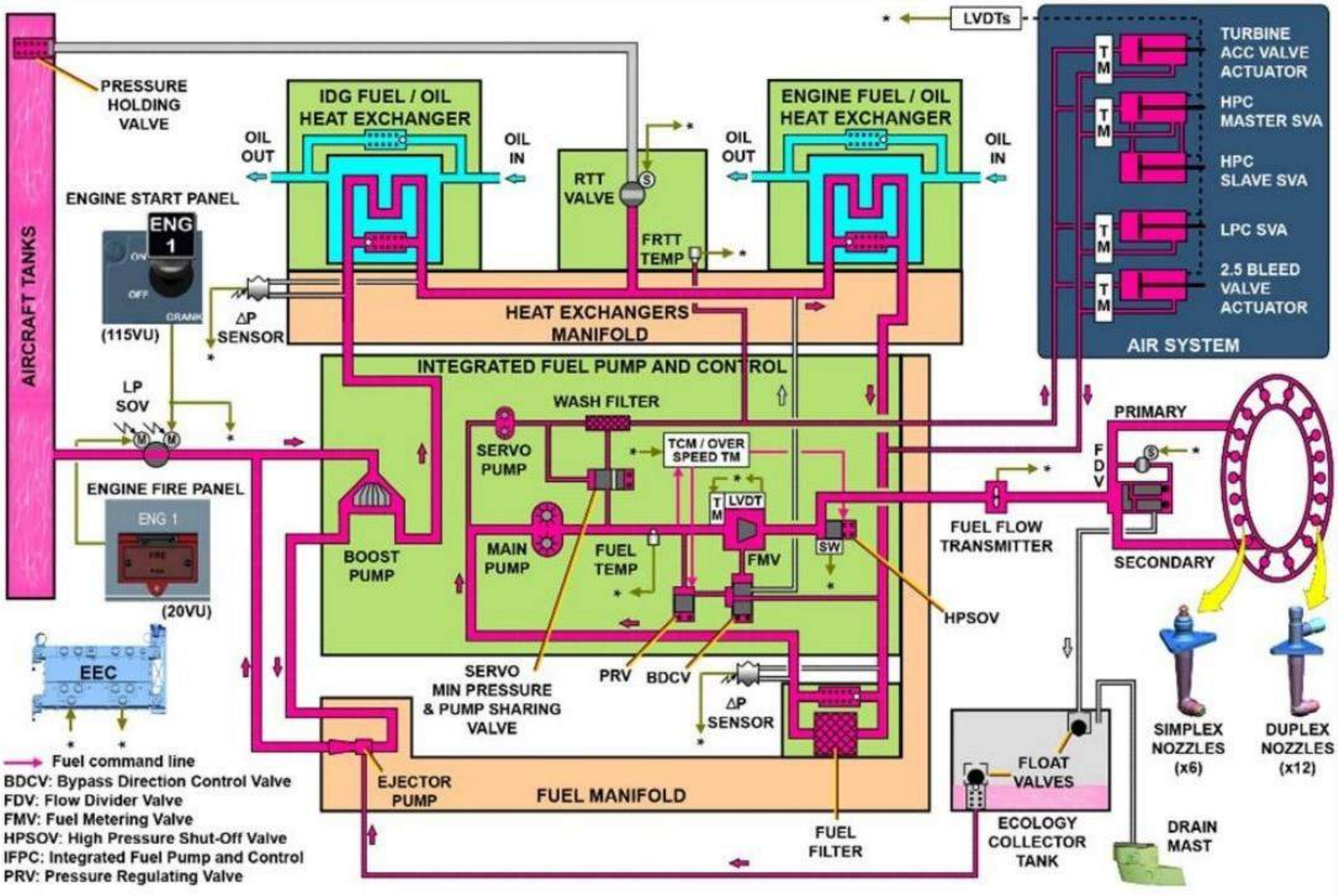
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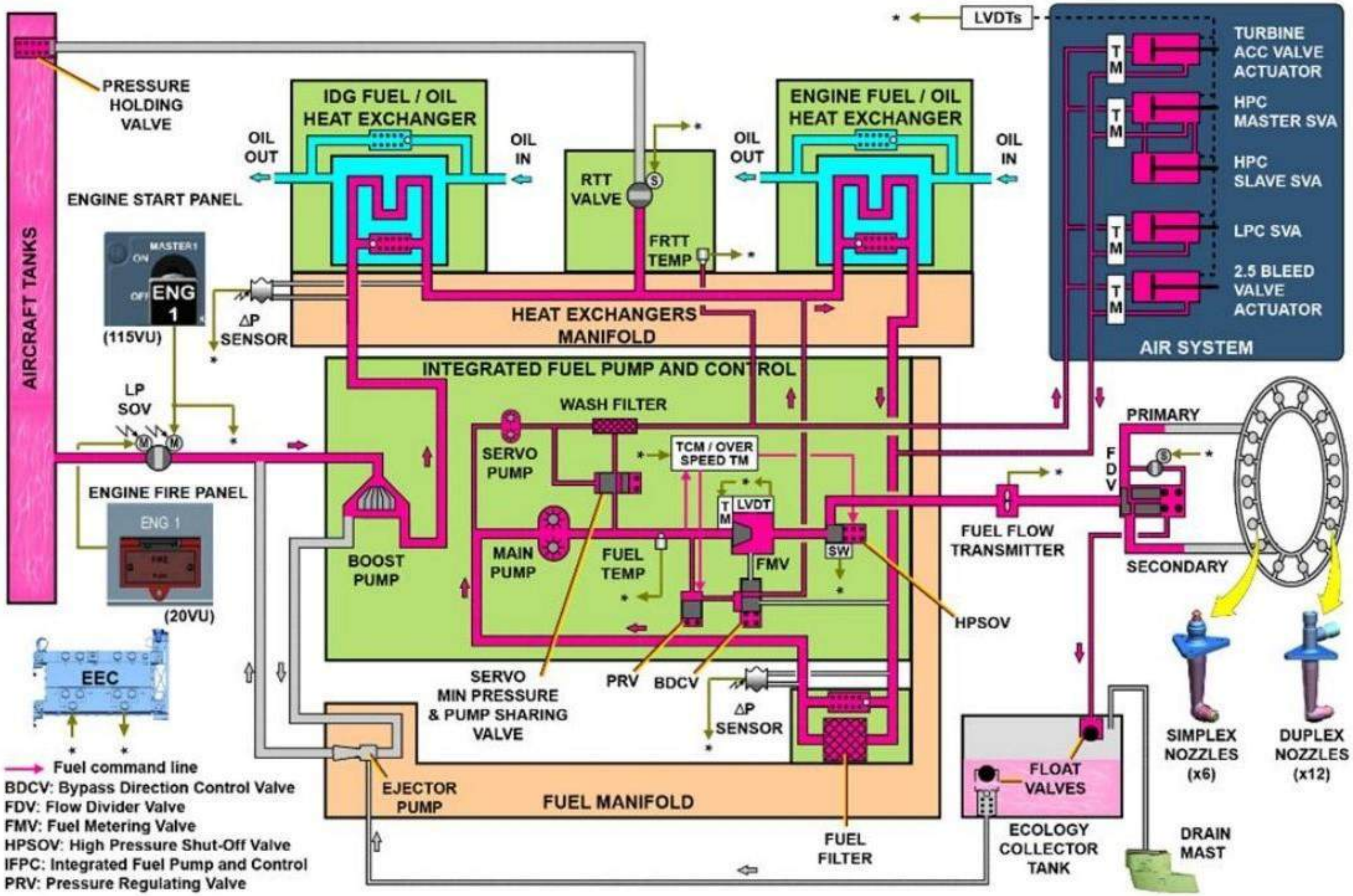
Fig. 2.18

SHUTDOWN - NORMAL SHUTDOWN (Fig. 2.19)
During a normal engine shutdown, the Master Lever controls the LPSOV to close and sends a shutdown signal to the EEC.
In turn when the related fuel pressure drops, the FDV closes to let the remaining fuel in the nozzle manifolds to drain in the ecology drain tank, and the Servo Minimum Pressure and Pump Sharing Valve reopens.
After the HPSOV is confirmed closed by the proximity switches, the EEC tests the FMV via its TM then closes it.
SHUTDOWN - ABNORMAL SHUTDOWN (Fig. 2.20)
The abnormal shutdown is initiated in case of an overspeed (N1 or N2), shaft shear (fan, LP or HP) or Thrust Control Malfunction (TCM) event detected on ground.
In such case, the TCM/overspeed TM directs fuel pressure to the back side of the HPSOV and of the PRV. This causes the PRV to open and stop fuel flow to the FMV, allowing rapid closure of the HPSOV and rapid engine shutdown.
FUEL INDICATING (Fig. 2.21)
The engine fuel indicating monitors the system condition and provides the system status to the cockpit displays.
The fuel flow transmitter sends signals to the EEC which enables the calculation of the fuel flow to the combustor.
The fuel flow is a primary engine parameter and is displayed on the EWD permanently. The EEC also sends this data for the fuel used computation and display on the System Display (SD).
The Fuel Filter Differential Pressure (FFDP) sensor measures the differential pressure across the fuel filter.
This helps to detect if the filter is partially or totally clogged.
According to the received value, the EEC will generate various warnings on the Engine Warning Display (EWD): ENG X FUEL FILTER DEGRAD or ENG X FUEL FILTER CLOG or ENG X FUEL SENSOR FAULT and on the SD: CLOG.
The IDG Fuel-Oil Heat Exchanger (FOHE) differential pressure sensor is used to sense the differential pressure on the fuel side of the FOHE and send a signal to the EEC in case of clogging detection. According to the status, the EEC will generate various warnings on the EWD: ENG X HEAT EXCHANGR CLOG or ENG X FUEL SENSOR FAULT.
For monitoring and Thermal Management System control by the EEC, the fuel temperature is sensed by two dual channel temperature sensors.



LVDTs
AIRCRAFT TANKS
PRESSURE HOLDING VALVE
IDG FUEL / OIL HEAT EXCHANGER
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RTT VALVE
FRTT TEMP
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OIL IN
TURBINE ACC VALVE ACTUATOR
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ENGINE START PANEL
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(115VU)
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HEAT EXCHANGERS MANIFOLD
INTEGRATED FUEL PUMP AND CONTROL
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BOOST PUMP
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FUEL TEMP
FMV
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FUEL MANIFOLD
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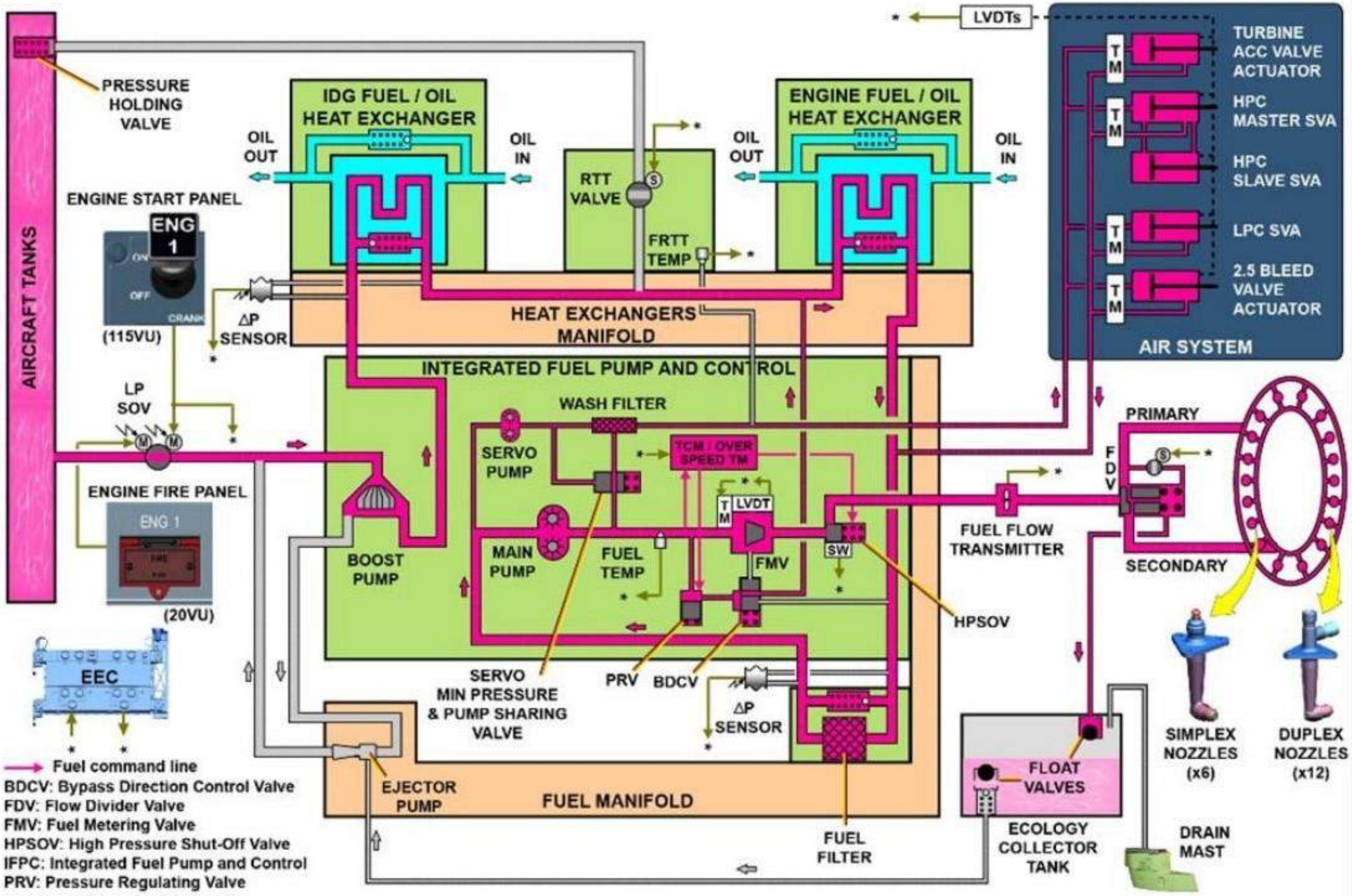
DRAIN MAST

Fig. 2.19



AIRCRAFT TANKS
PRESSURE HOLDING VALVE
ENGINE START PANEL
ENG 1
ON
OFF
CRANK
(115VU)
ΔP SENSOR
LP SOV
ENGINE FIRE PANEL
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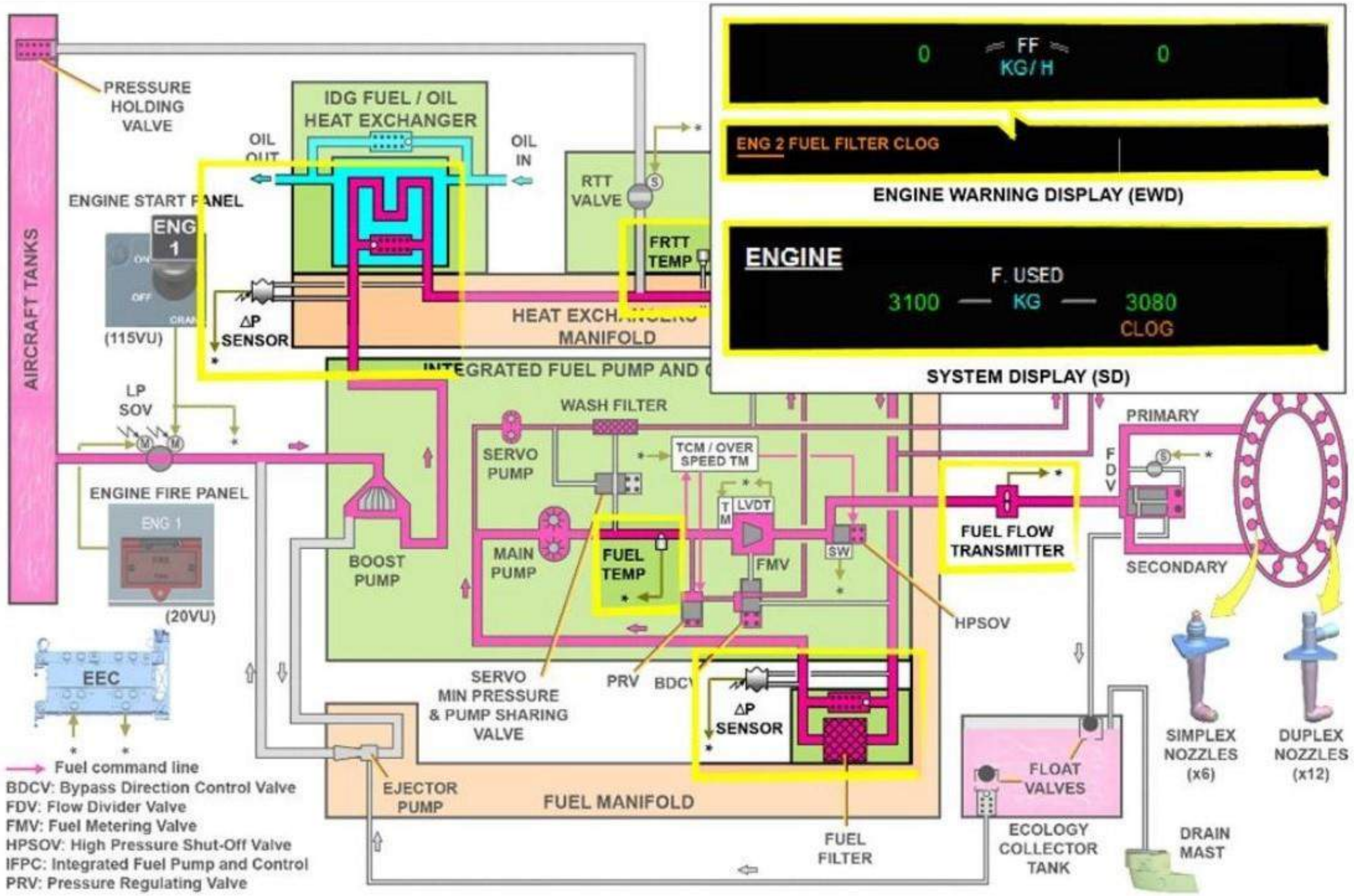
Fig. 2.20



PRESSURE HOLDING VALVE
IDG FUEL / OIL HEAT EXCHANGER
OIL OUT
OIL IN
RTT VALVE
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ENGINE START PANEL
ENG 1
(115VU)
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ENGINE FIRE PANEL
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FMV
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DUPLEX NOZZLES (x12)
FLOAT VALVES
EJECTOR PUMP
FUEL MANIFOLD
FUEL FILTER
ECOLOGY COLLECTOR TANK
DRAIN MAST
0
FF
KG/H
0
ENG 2 FUEL FILTER CLOG
ENGINE WARNING DISPLAY (EWD)
ENGINE
F. USED
3100
KG
3080
CLOG
SYSTEM DISPLAY (SD)
Fuel command line
BDCV: Bypass Direction Control Valve
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Fig. 2.21

3. OIL SYSTEM

The oil system comprises of an Oil tank, oil pumps located within the Lubrication and Scavenge Oil Pump unit (LSOP), Oil Control Module (OCM), filters and heat exchangers.

The oil is used to lubricate and cool the bearings, the Fan Drive Gear System (FDGS), gearboxes and accessories.

ENGINE BEARINGS (**Fig.** 3.1)

The engine bearings provide reduce rolling friction and support the rotor axially and radially within the structure.

It bears the different loads of the rotating shaft.

There are five bearing compartments containing a total of seven bearing.

No. 1 and 1.5 are tapered roller bearing and are used to support the fan rotor and FDGS. No. 2 and 3 are ball bearings and support the front part of LP and HP rotor respectively.

No. 4 is roller bearing and support the rear of N2.

No. 5 and 6 are roller bearing and support the rear of N1 rotor.

COMPONENT LOCATION – OIL (Fig. 3.2)

The engine oil tank is attached with frangible mounts to the fan case on the left hand side of the engine at the 9 o'clock position.

The Lubrication and Scavenge Oil Pump (LSOP) is attached to the rear of the main gearbox at the 6 o'clock position.

OIL SYSTEM LAYOUT (Fig. 3.3)

The oil system:

- Lubricates the engine bearings, Angle Gearbox (AGB), Main Gearbox (MGB) and Fan Drive Gear System (FDGS) with filtered, non-pressure regulated oil,
- Regulates the temperature of the engine oil with the Air/Oil Heat Exchanger (AOHE), engine fuel with the Fuel/Oil Heat Exchanger (FOHE), Integrated Drive Generator (IDG) oil with IDG Oil/Oil Heat Exchanger (IDGOOHE),
- Scavenges the hot lubrication oil back to the tank,
- Vents discharge the excess of sealing air from the bearing compartments overboard.

OIL SUPPLY (Fig. 3.4)

Oil flows from the pressurized oil tank to the lube pump in the Lubrication and Scavenge Oil Pump (LSOP).

The pressurized oil is directed to the main oil filter and to the Oil Control Module (OCM). The main part of the filtered oil flows to the Fuel/Oil Heat Exchanger Bypass Valve (FOHEBV) which modulates the oil flow between the AOHE and the FOHE. The oil flow that is directed to the AOHE also flows through the IDGOOHE.

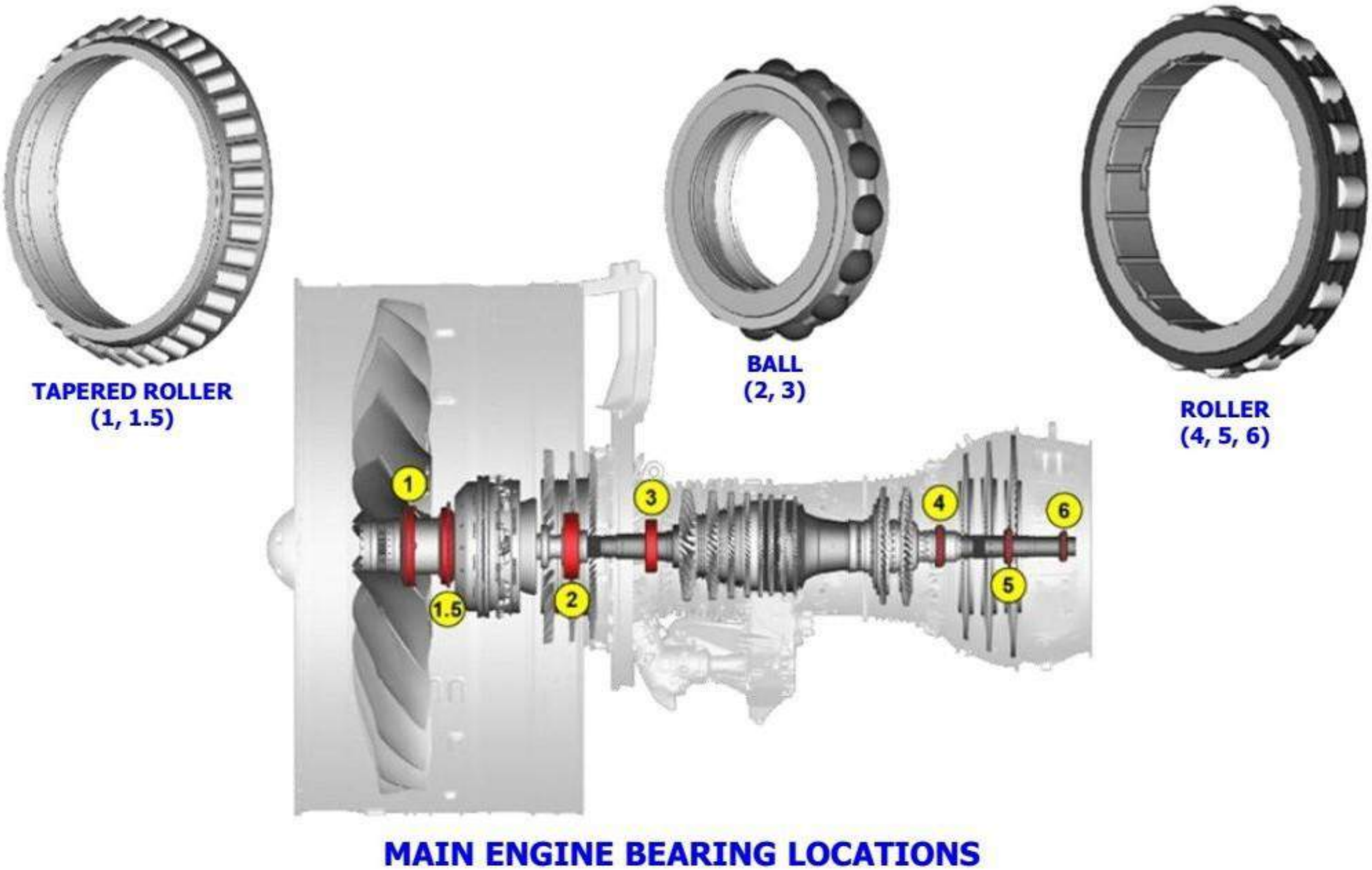

TAPERED ROLLER
(1, 1.5)
BALL
(2, 3)
ROLLER
(4, 5, 6)
1
1.5
2
3
4
5
6
MAIN ENGINE BEARING LOCATIONS

Fig. 3.1

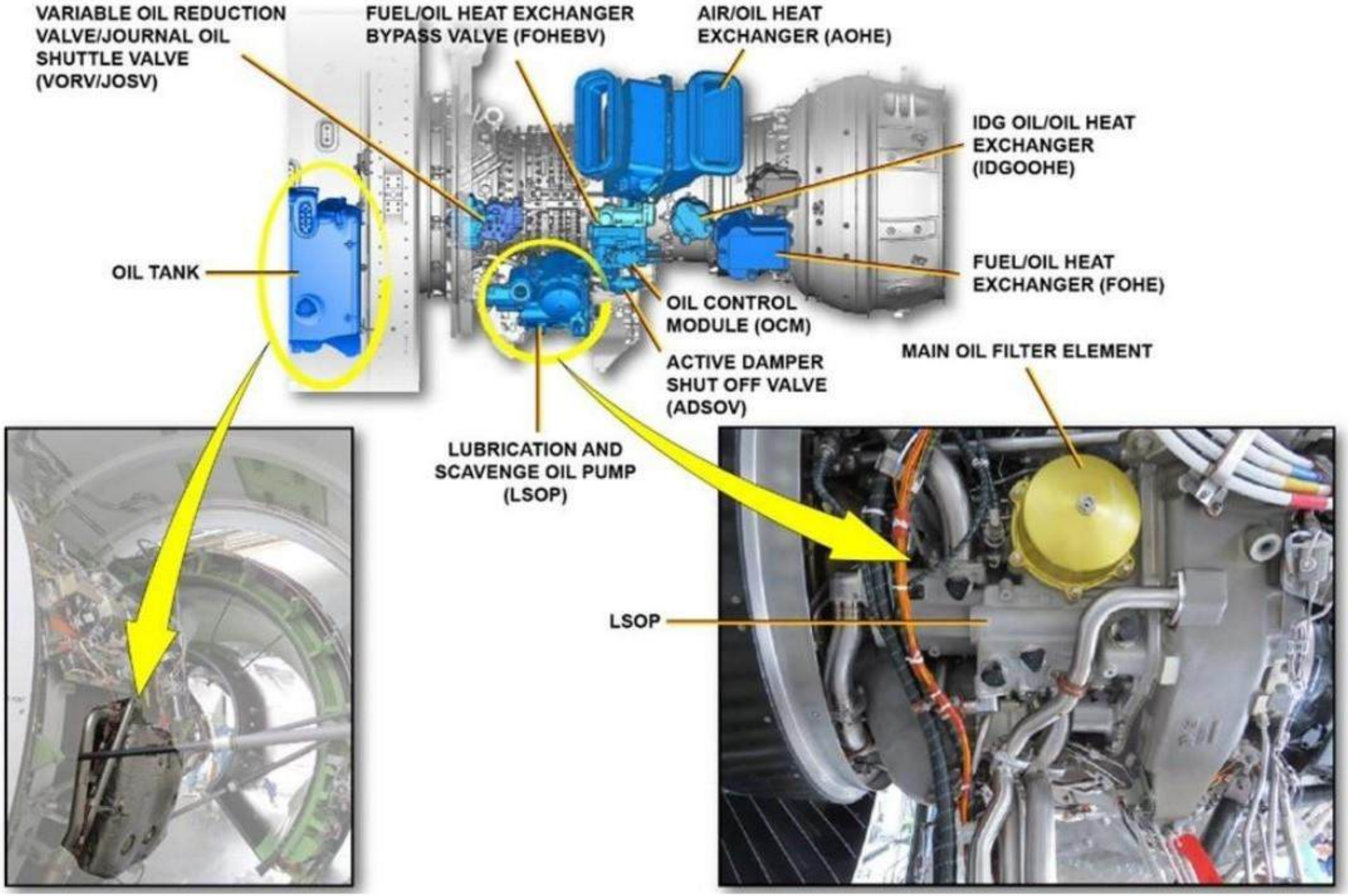

VARIABLE OIL REDUCTION VALVE/JOURNAL OIL SHUTTLE VALVE (VORV/JOSV)
FUEL/OIL HEAT EXCHANGER BYPASS VALVE (FOHEBV)
AIR/OIL HEAT EXCHANGER (AOHE)
IDG OIL/OIL HEAT EXCHANGER (IDGOOHE)
OIL TANK
FUEL/OIL HEAT EXCHANGER (FOHE)
OIL CONTROL MODULE (OCM)
ACTIVE DAMPER SHUT OFF VALVE (ADSOV)
MAIN OIL FILTER ELEMENT
LUBRICATION AND SCAVENGE OIL PUMP (LSOP)
LSOP

Fig. 3.2

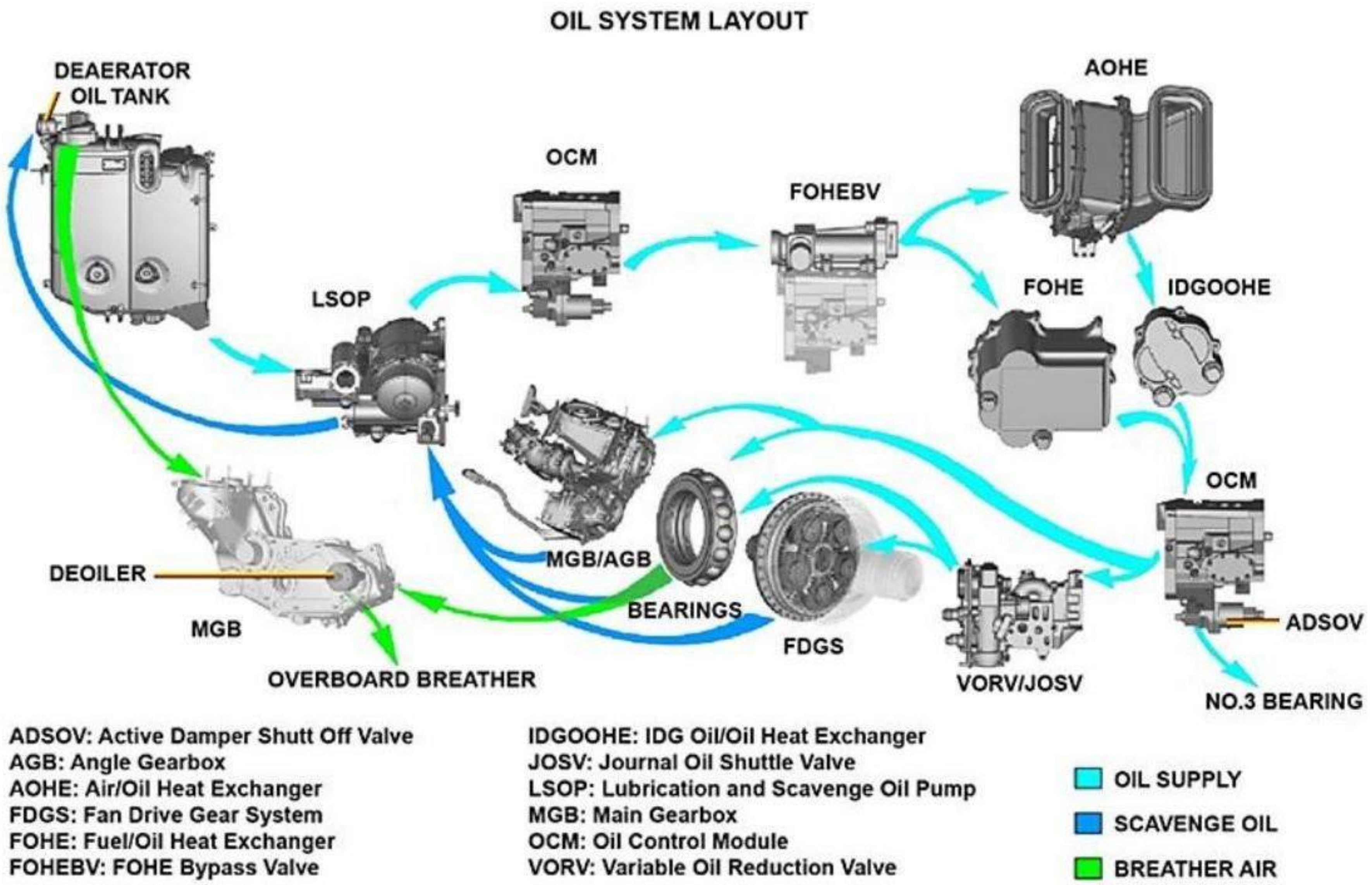

OIL SYSTEM LAYOUT
DEAERATOR
OIL TANK
OCM
FOHEBV
AOHE
LSOP
FOHE
IDGOOHE
MGB/AGB
OCM
DEOILER
BEARINGS
MGB
FDGS
ADSOV
OVERBOARD BREATHER
VORV/JOSV
NO.3 BEARING
ADSOV: Active Damper Shutt Off Valve
AGB: Angle Gearbox
AOHE: Air/Oil Heat Exchanger
FDGS: Fan Drive Gear System
FOHE: Fuel/Oil Heat Exchanger
FOHEBV: FOHE Bypass Valve
IDGOOHE: IDG Oil/Oil Heat Exchanger
JOSV: Journal Oil Shuttle Valve
LSOP: Lubrication and Scavenge Oil Pump
MGB: Main Gearbox
OCM: Oil Control Module
VORV: Variable Oil Reduction Valve
OIL SUPPLY
SCAVENGE OIL
BREATHER AIR

Fig. 3.3

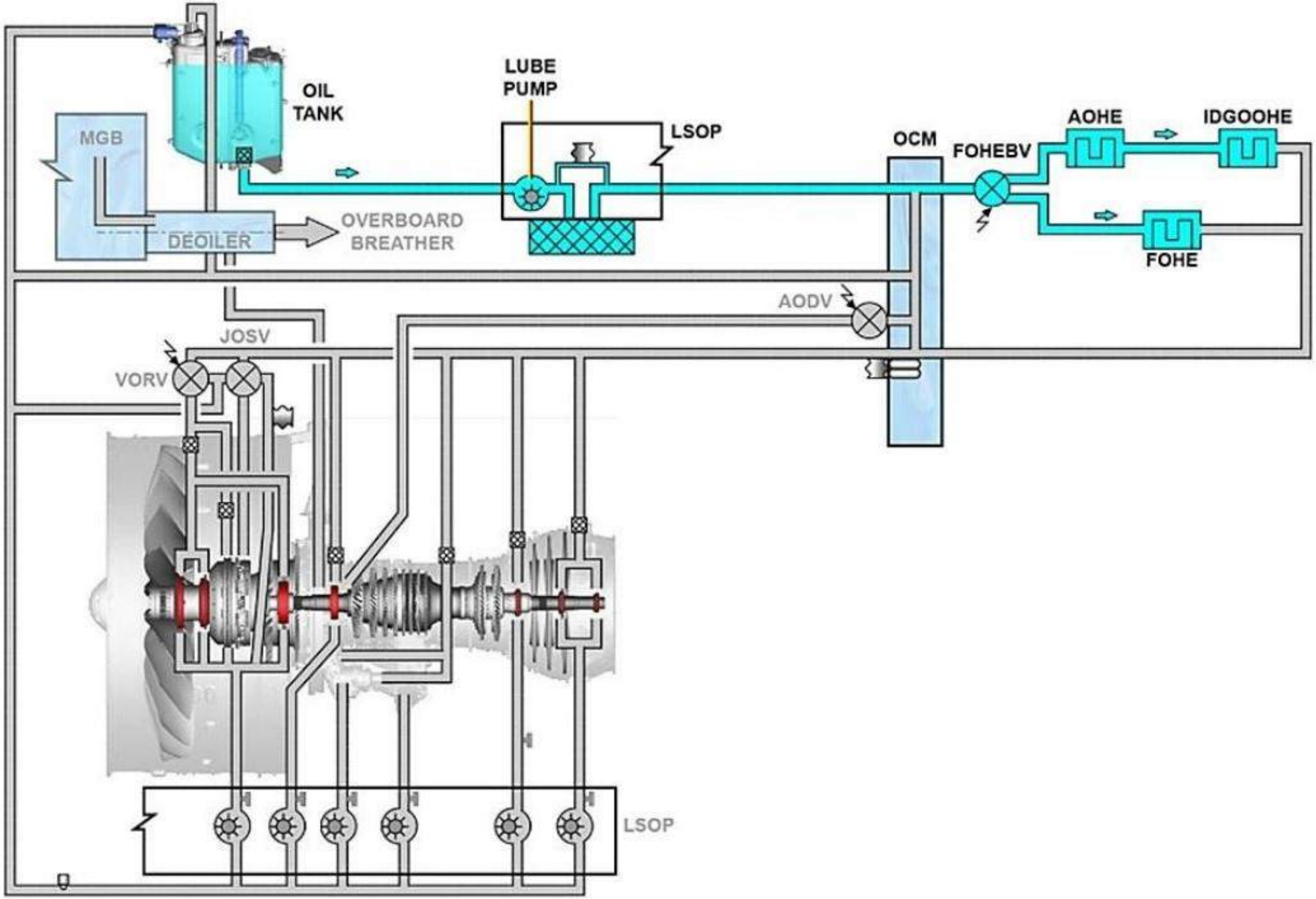

OIL
TANK
LUBE
PUMP
LSOP
OCM
FOHEBV
AOHE
IDGOOHE
FOHE
MGB
DEOILER
OVERBOARD
BREATHER
AODV
JOSV
VORV
LSOP

Fig. 3.4

OIL SUPPLY (Fig. 3.5)
Oil from the heat exchangers is sent through the OCM to the No. 3, 4, 5, 6 bearings and to the AGB and MGB. Oil is also sent to the Variable Oil Reduction Valve (VORV)/Journal Oil Shuttle Valve (JOSV), which modulates the flow of oil to the No. 1, 1.5, 2, and Fan Drive Gear System (FDGS) based on engine power settings.
The VORV is electronically controlled and monitored by the EEC to bypass part of the oil flow to the front bearings at low power setting.
The JOSV is a mechanical device that keeps a continuous supply of oil to the fan drive journal bearings from the main oil supply in normal condition or from the auxiliary oil supply in windmill or zero or negative gravity conditions.
OIL SUPPLY (Fig. 3.6)
The other part of the filtered oil is sent through the Active Oil Damper Valve (AODV) to the No. 3 bearing damper for N2 vibration control. The AODV is electronically controlled by the EEC to supply oil to the damper during starting and acceleration and shut it off at high power.
OIL SCAVENGE AND VENTING (Fig. 3.7)
The engine oil scavenge system is used to return the hot lubrication oil to the tank through the LSOP.
The LSOP has six scavenge pumps that are used to pull scavenge oil from the:
- No. 1, 1.5, 2 bearing and FDGS,
- No. 3 bearing compartment,
- No. 4 bearing compartment,
- No. 5 and 6 bearing compartment,
- MGB, - AGB.

Six magnetic chip collectors, installed upstream of the scavenge pumps, catch ferrous metal particles.
The scavenge pumps send the scavenge oil to the oil tank through the Oil Debris Monitor (ODM) and the deaerator.
OIL SCAVENGE AND VENTING (Fig. 3.8)
The engine oil breather system is used to remove sealing air from the bearing compartments, separate the air from the oil, and vent it overboard. In the tank, the deaerator is a static component that separates the air that is mixed with the scavenged oil. Part of the air is used to pressurize the tank and the excess is sent to the centrifugal de-oiler. The de-oiler is mechanically connected and driven by the MGB and receives the air/oil mist internally from the MGB, from the tank by the breather line and from the No. 3 bearing compartment by a dedicated breather vent tube.

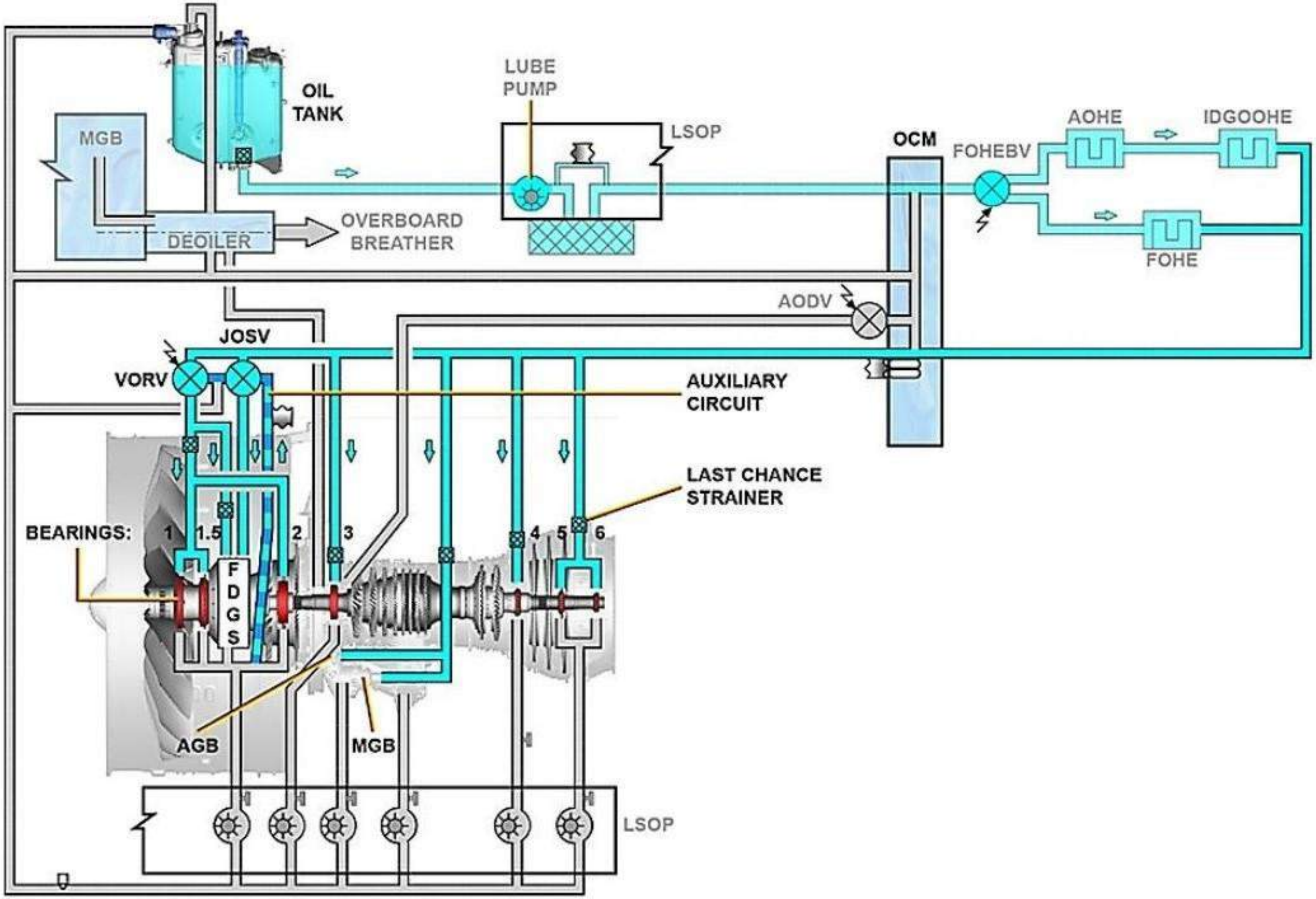

LUBE
PUMP
OIL
TANK
LSOP
OCM
FOHEBV
AOHE
IDGOOHE
MGB
DEOILER
OVERBOARD
BREATHER
FOHE
AODV
JOSV
VORV
AUXILIARY
CIRCUIT
LAST CHANCE
STRAINER
BEARINGS:
1
1.5
2
3
4
5
6
F
D
G
S
AGB
MGB
LSOP

Fig. 3.5

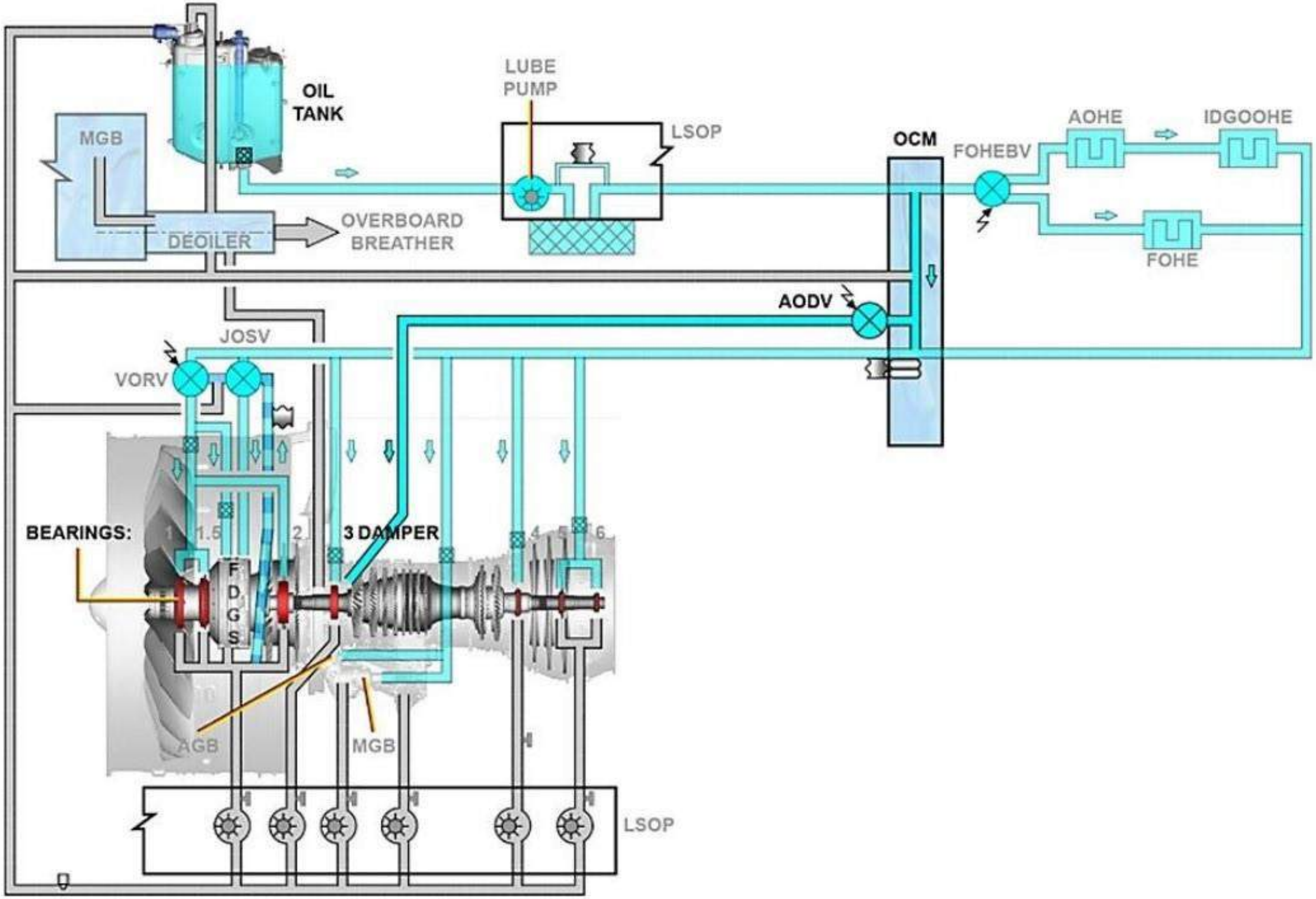
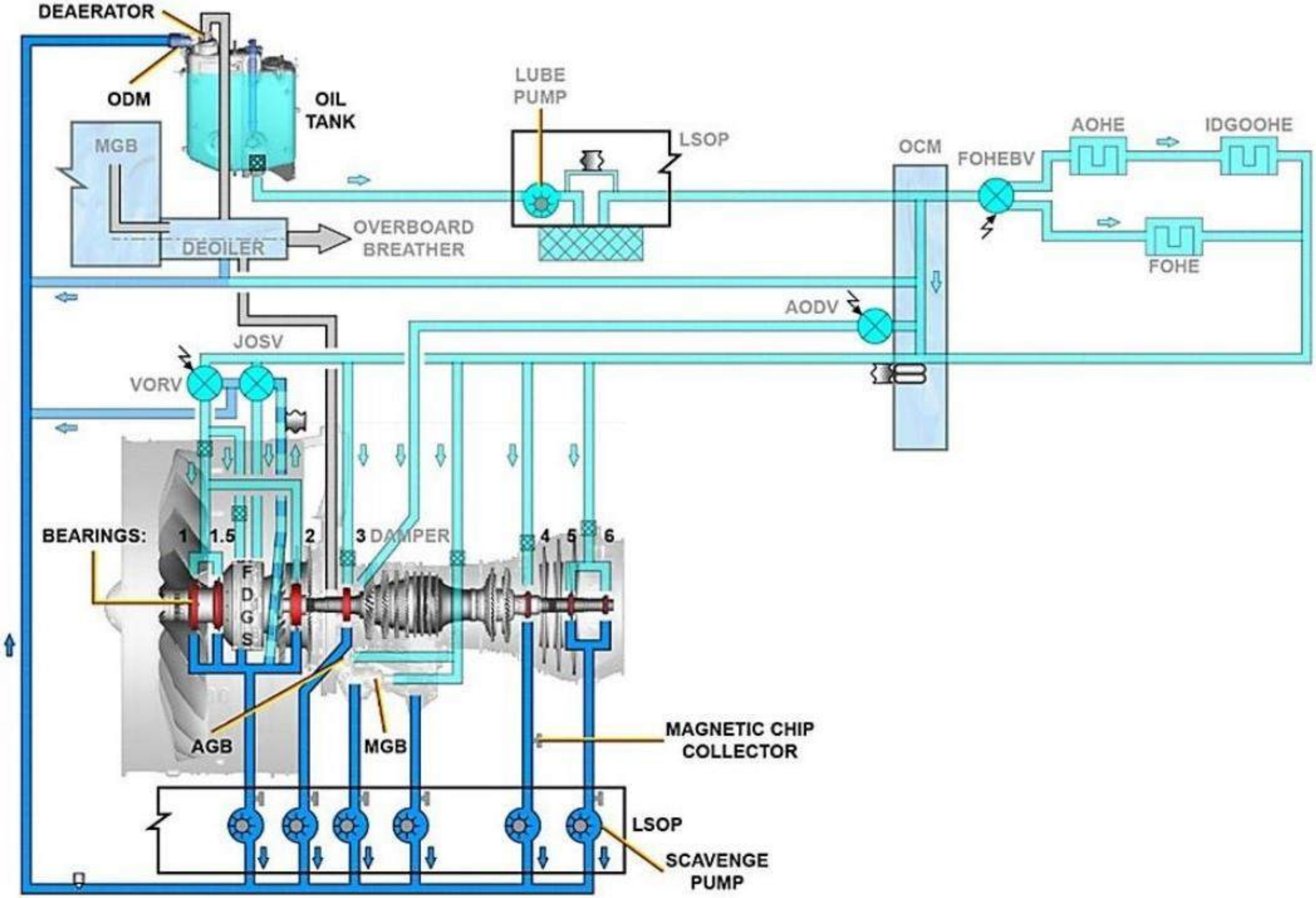
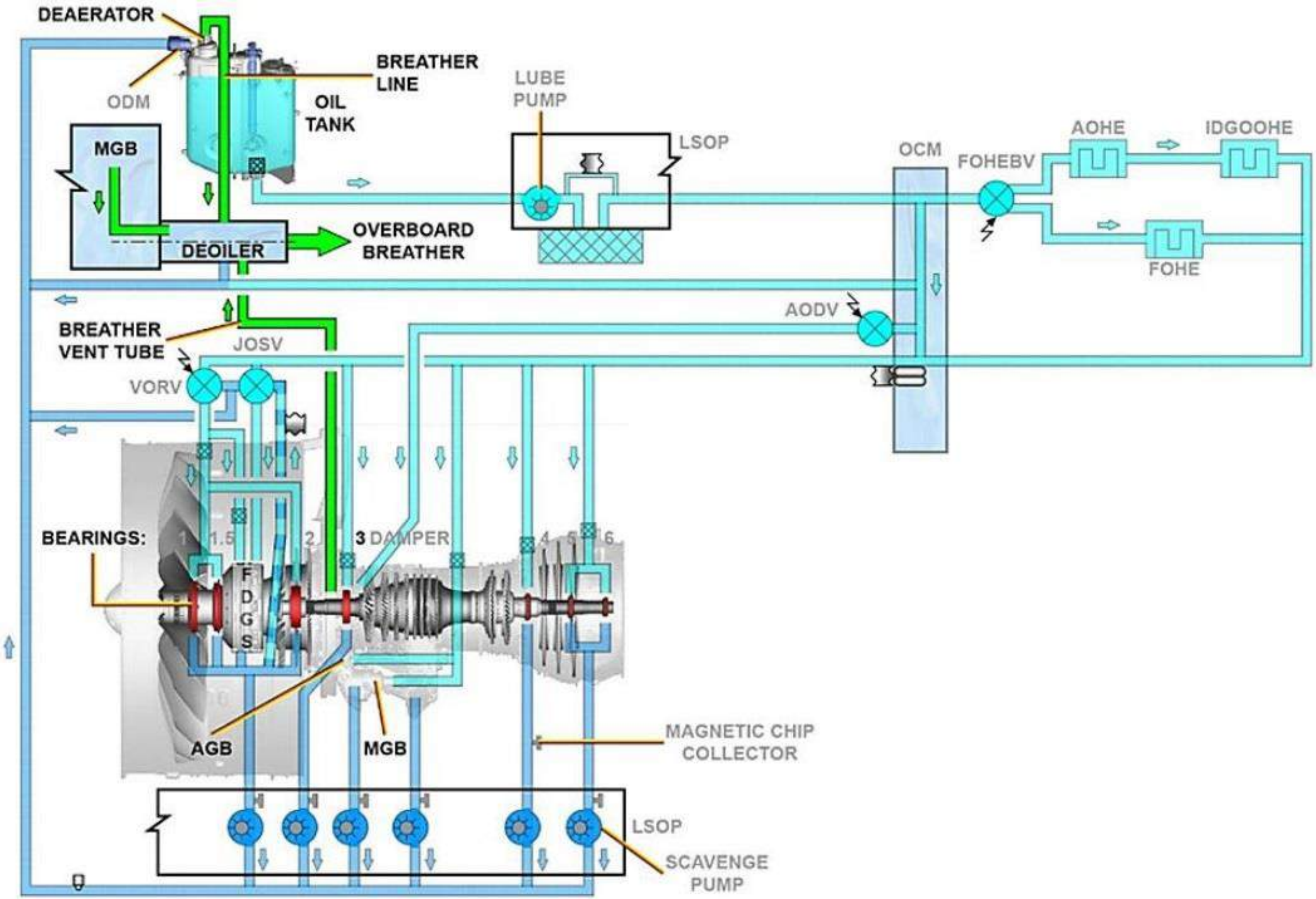

OIL
TANK
LUBE
PUMP
LSOP
MGB
DEOILER
OVERBOARD
BREATHER
OCM
FOHEBV
AOHE
IDGOOHE
FOHE
AODV
JOSV
VORV
BEARINGS:
1
1.5
F
D
G
S
2
3 DAMPER
4
5
6
AGB
MGB
LSOP

Fig. 3.6


DEAERATOR
ODM
OIL
TANK
MGB
DEOILER
OVERBOARD
BREATHER
LUBE
PUMP
LSOP
OCM
FOHEBV
AOHE
IDGOOHE
FOHE
AODV
JOSV
VORV
BEARINGS:
1
1.5
F
D
G
S
2
3
DAMPER
4
5
6
AGB
MGB
MAGNETIC CHIP
COLLECTOR
LSOP
SCAVENGE
PUMP
Fig. 3.7


DEAERATOR
ODM
BREATHER LINE
OIL TANK
LUBE PUMP
LSOP
OCM
FOHEBV
AOHE
IDGOOHE
FOHE
MGB
DEOILER
OVERBOARD BREATHER
AODV
BREATHER VENT TUBE
JOSV
VORV
BEARINGS:
1
1.5
2
3 DAMPER
4
5
6
F D G S
AGB
MGB
MAGNETIC CHIP COLLECTOR
LSOP
SCAVENGE PUMP
Fig. 3.8

OIL MONITORING AND INDICATING (Fig. 3.9)
The oil monitoring and indicating system comprises:
- Oil Level (OL) indicating,
- Oil Debris Monitoring (ODM),
- Main Oil Temperature (MOT) indicating,
- Main Oil Pressure (MOP) indicating,
- Low Oil Pressure (LOP) indicating,
- Oil Filter Differential Pressure (OFDP),
- Auxiliary Oil Pressure (AOP) indicating.

OIL LEVEL INDICATING
The oil level sensor is installed on the top of the oil tank. It is of the magnetic float and reed switch type. The signal relevant to the oil level is sent to the EEC channel B.

OIL DEBRIS MONITORING
The Oil Debris Monitoring (ODM) sensor is installed between the main oil scavenge line and the deaerator in the oil tank.
It detects any type of pollution that crossed its electromagnetic field.
The signal corresponding to the ferrous and non-ferrous debris is processed by the PHMU. The PHMU calculates the number of particles in a given time period and sends it to the EEC channel A.
The EEC compares the data to predefined values and generates a maintenance signal.

LOW OIL PRESSURE INDICATING
The low oil pressure switch is installed on OCM.
It detects low oil pressure condition on the oil supply line and sends the signals to the Engine Interface Unit (EIU).

OIL FILTER DIFFERENTIAL PRESSURE
The oil filter differential pressure sensor is installed on the OCM, adjacent to the oil filter.
The differential pressure signal is sent to both EEC channels.
When the differential pressure across the filter is more than the specified limit, a maintenance signal is generated.
When the differential pressure across the primary oil filter element is too much, the filter bypass valve will open. The pressurized oil then will go directly to the secondary filter and an oil filter bypass signal is also generated.

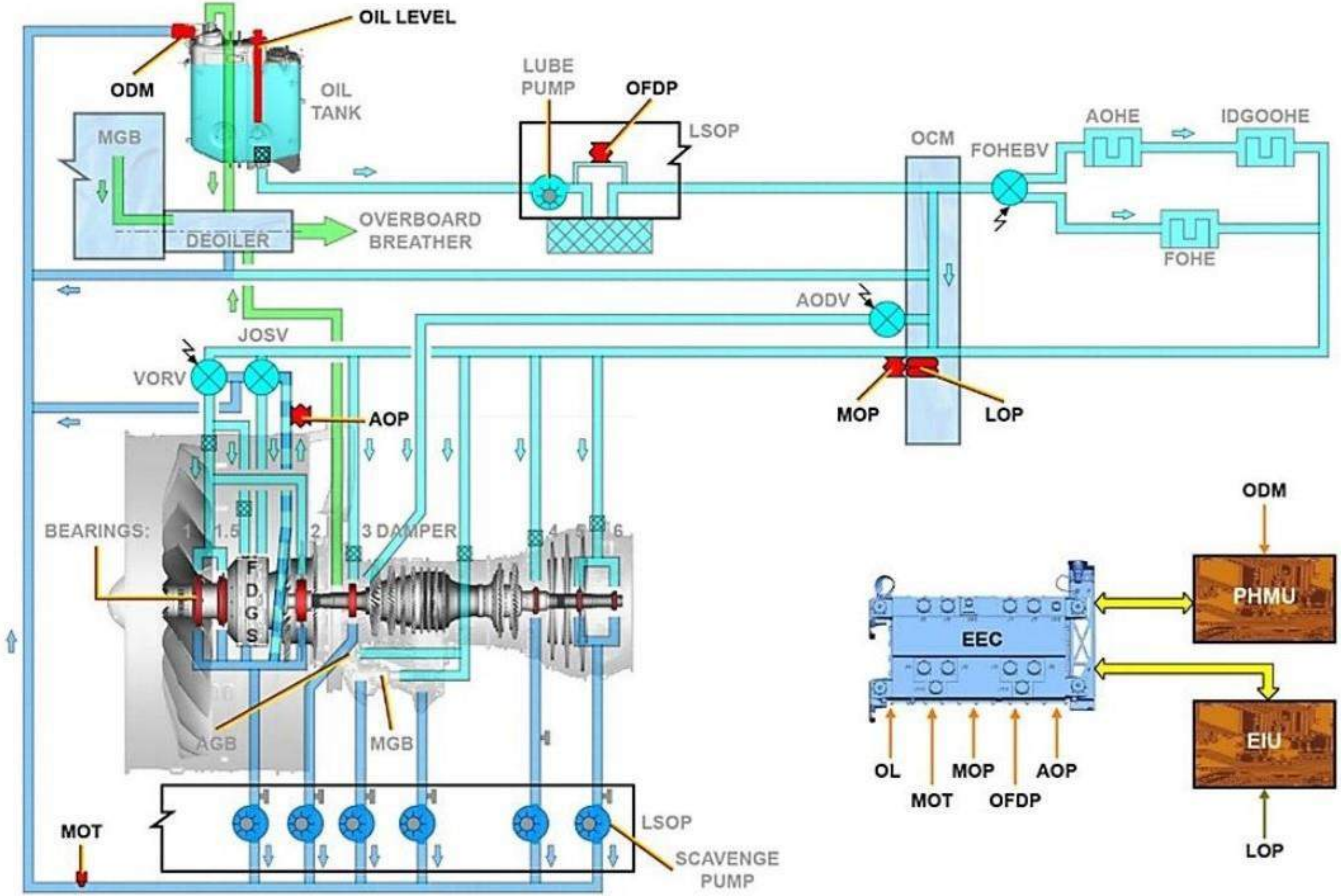

OIL LEVEL
ODM
OIL
TANK
LUBE
PUMP
OFDP
LSOP
MGB
OCM
FOHEBV
AOHE
IDGOOHE
DEOILER
OVERBOARD
BREATHER
FOHE
AODV
JOSV
VORV
AOP
MOP
LOP
BEARINGS:
1
1.5
2
3 DAMPER
4
5
6
F
D
G
S
AGB
MGB
ODM
PHMU
EEC
EIU
OL
MOT
MOP
OFDP
AOP
LOP
MOT
LSOP
SCAVENGE
PUMP

Fig. 3.9

4. ICE & RAIN PROTECTION SYSTEM

USERS (Fig. 4.1)

The Nacelle Anti-Ice (NAI) System is designed to prevent ice formation on the engine inlet, which could affect the engine operation. The engine air intake is heated during icing conditions using its related bleed air. The hot air is then discharged overboard.

SOURCE

Hot air for the Nacelle Anti-Ice System is supplied by a dedicated HP Compressor (HPC) bleed:

- on the PW1000G, 6th stage.

VALVE

The NAI System is controlled and monitored by the (Propulsion Control System (PCS) (Engine Electronic Controller (EEC) and Engine Interface Unit (EIU)). Each engine NAI System consists of two electronically controlled, pneumatically operated Pressure Regulating and Shut-Off Valves (PRSOV). The EEC energizes the solenoid to CLOSE the PRSOV. Therefore, in case of loss of electrical power supply, the valves will go fully open provided the engine bleed air supply pressure is high enough. In the absence of air pressure, the valve is spring-loaded to the closed position.

CONTROLS

When the ENG ANTI ICE P/BSW is selected ON, signals are sent to EEC for controlling the valves and to the EIU to calculate the bleed decrements.

NAI SYSTEM (Fig. 4.2)

Each engine air intake has its own independent Nacelle Anti-Ice (NAI) protection system.

NAI System uses the hot bleed air from a dedicated engine bleed port (6th stage High Pressure Compressor (HPC) for PW1100G). This bleed air is lead to engine air inlet through a feed duct, which passes along the RH side of the engine core, and fan case.

Each engine NAI system consists of one command P/B SW but two Pressure Regulating and Shut -Off Valves (PRSOVs) for good operability, two Pressure Transducers (PTs), temperature protection and supply ducts.

Both PRSOVs are located on the engine core, Right Hand (RH) side.

AIR INLET COWL

The air is released into the air intake lip (D- Duct) through a swirl system, which mixes the air and injects it in a specific pattern for effective heating.

The airflow exits the air intake lip by a single exhaust grid at the bottom of the nacelle outside the fan, which has 6 oval holes.

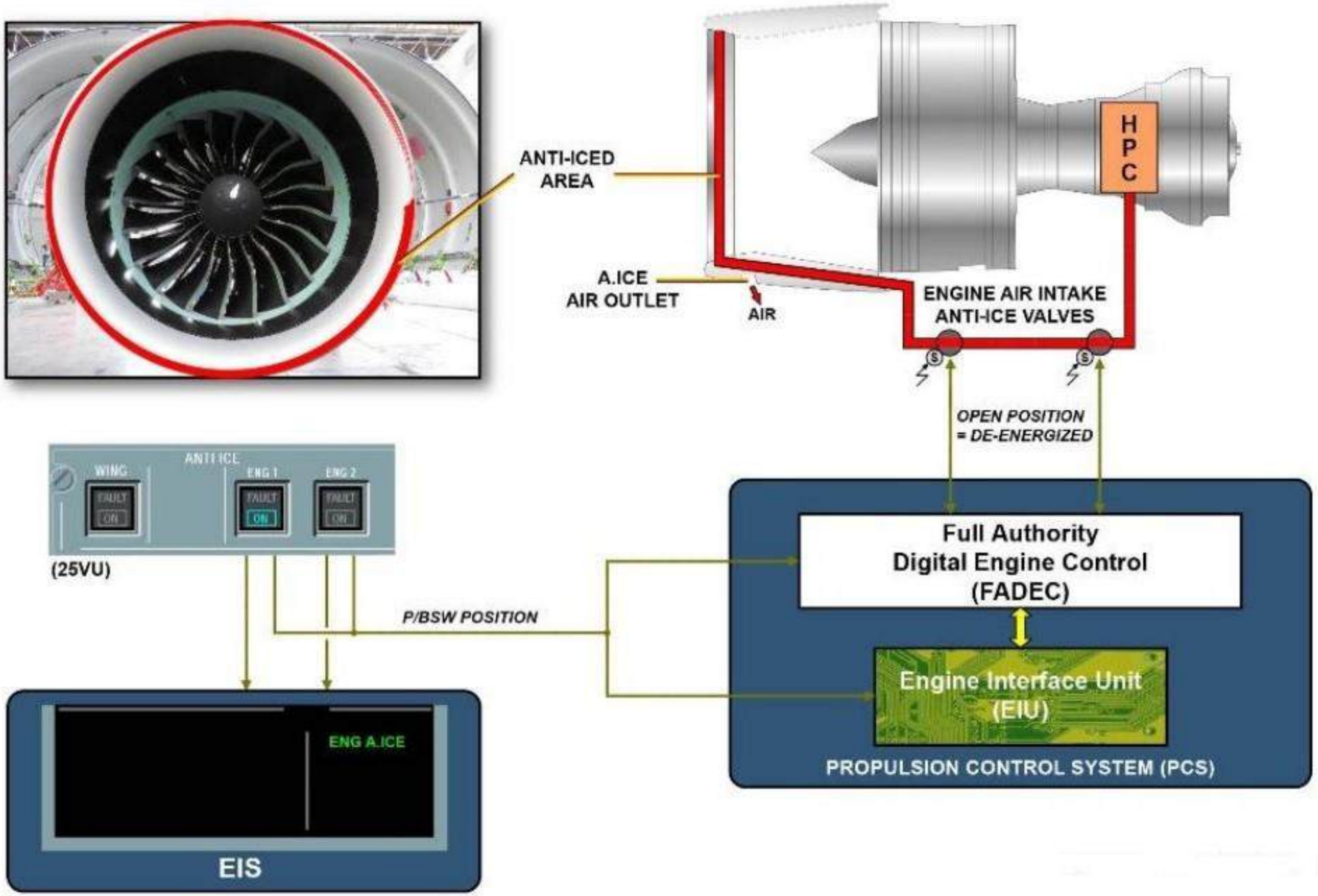

ANTI-ICED AREA
A.ICE AIR OUTLET
AIR
H P C
ENGINE AIR INTAKE ANTI-ICE VALVES
OPEN POSITION = DE-ENERGIZED
ANTI ICE
WING
ENG 1
ENG 2
FAULT
ON
(25VU)
P/BSW POSITION
Full Authority Digital Engine Control (FADEC)
Engine Interface Unit (EIU)
PROPULSION CONTROL SYSTEM (PCS)
ENG A.ICE
EIS

Fig. 4.1

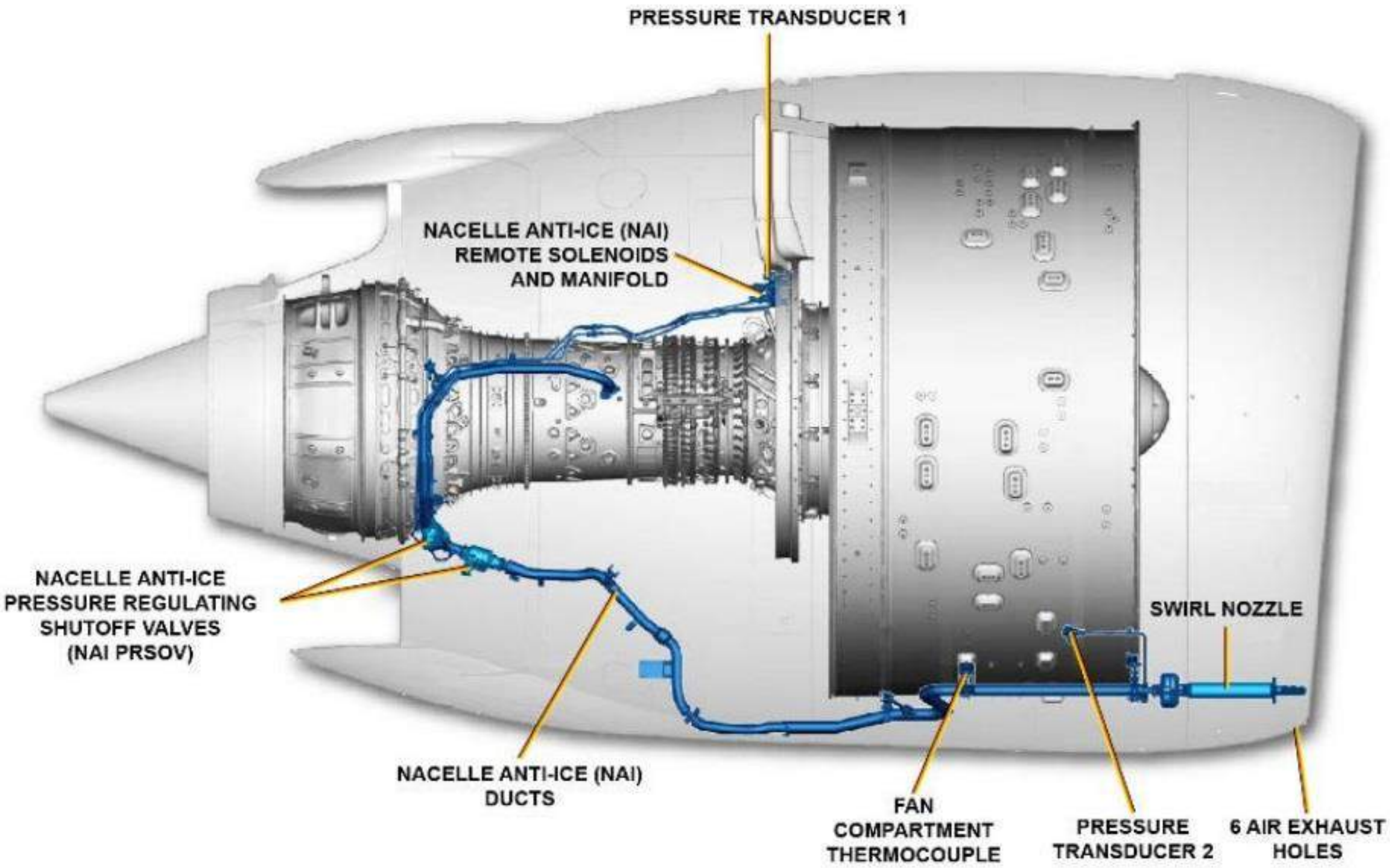

PRESSURE TRANSDUCER 1
NACELLE ANTI-ICE (NAI)
REMOTE SOLENOIDS
AND MANIFOLD
NACELLE ANTI-ICE
PRESSURE REGULATING
SHUTOFF VALVES
(NAI PRSOV)
SWIRL NOZZLE
NACELLE ANTI-ICE (NAI)
DUCTS
FAN
COMPARTMENT
THERMOCOUPLE
PRESSURE
TRANSDUCER 2
6 AIR EXHAUST
HOLES

Fig. 4.2

PRSOV CONTROL AND OPERATION (Fig. 4.3)

The NAI system is controlled and monitored by the Propulsion Control System (PCS) (Engine Electronic Controller (EEC) and Engine Interface Unit (EIU)).The EEC controls the PRSOV operation by energizing/de-energizing the solenoids. PRSOV 1 is controlled by EEC Channel A and PRSOV 2 is controlled by Channel B. Each PRSOV pneumatically regulates the downstream air pressure.

When the NAI PB S/W is selected to 'ON' position, the EEC de-energizes the solenoid valves of PRSOV to open the valves. Only when both valves are open, the bleed air is fed to the engine intake lip.

The PRSOV 1 regulates the upstream pressure then in cascade PRSOV 2 the downstream pressure at different threshold. When the engine is running and a "Hot Air Leakage” event is detected, the EEC energizes PRSOVs solenoids, which provide insulation function.

MONITORING

The EEC does a detailed monitoring of the PRSOVs with two PTs (PT1 & PT2) located downstream each PRSOV. PT1 is located in between the PRSOVs in the core engine area. It gives the feedback to EEC Channel A.

ENGINE ANTI ICE P/BSW (Fig. 4.4)

The P/B SW sends a discrete signal to the EEC to operate the PRSOVs.

The P/B SW position and the opposite engine P/B SW position are monitored by the EIU for computing the bleed decrements.

The "FAULT" light is triggered by the EIU based on the input from EEC. It appears when the engine is running and NAI is failed in OPEN or CLOSED. It also appears in case of monitoring fault.

PCS (EEC and EIU).

The EEC controls the PRSOV to open when the P/B SW is set to ON. The EEC monitors the position of the PRSOV by the two NAI transducers to trigger associated fault messages.

The System Data Acquisition Concentrator/Flight Warning System (SDAC/FWS), Flight Data Interface and Management Unit (FDIMU) and Centralized Fault Display Interface Unit (CFDIU) interfaces with the PCS.

FAILURE CONDITION

The fail safe position of the valves in case of EEC dual channel failure is OPEN.

In case of a single valve failure, the corresponding valve being failed open, the anti-ice function is still available.

The two pressure Transducers (PT1 for core zone and PT2 for fan zone) monitors leak or burst scenarios and a dual fan case thermocouple helps in identifying over temperature conditions due to leaks or burst. The EEC monitors the same and generates warning messages to the FWS.

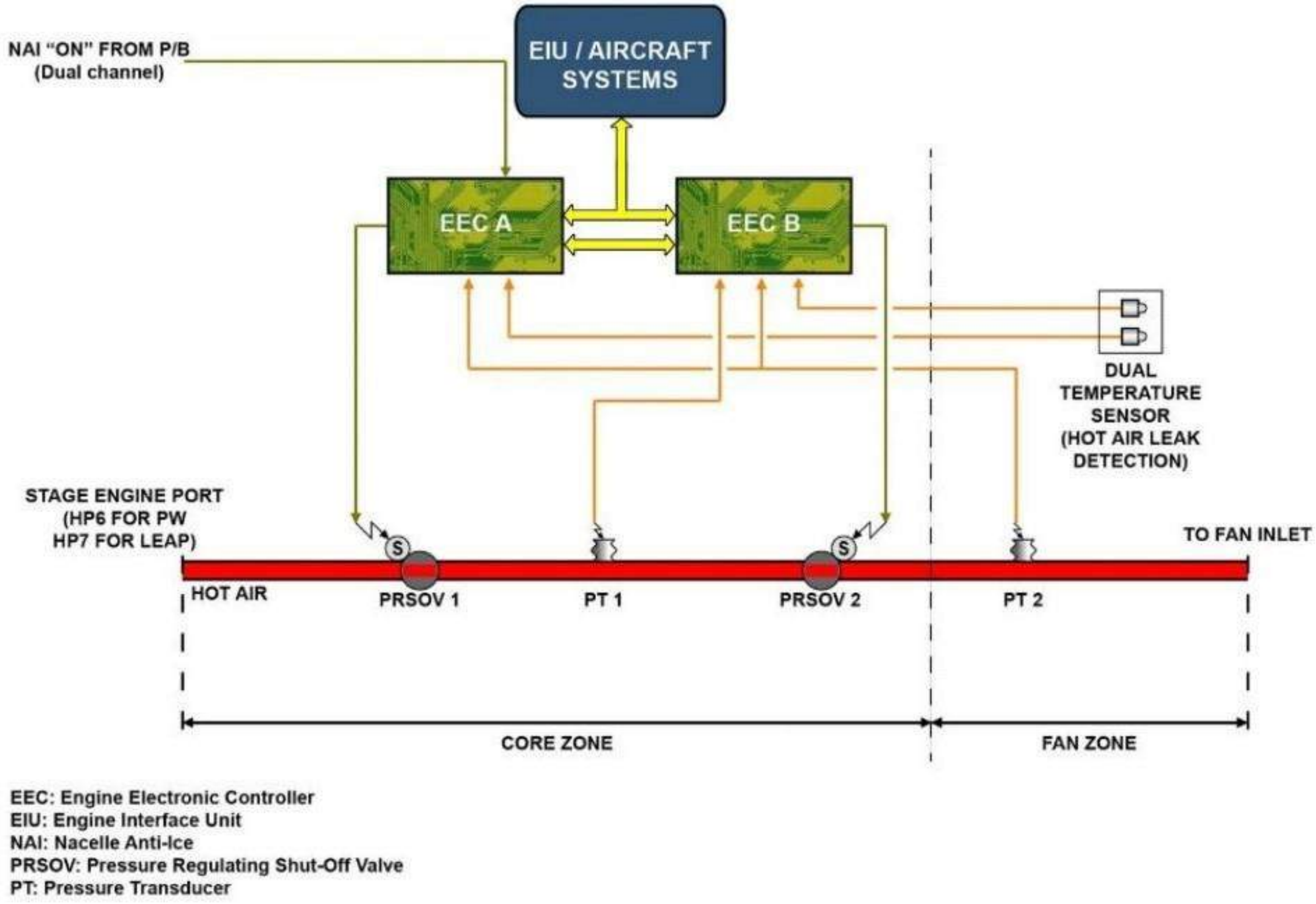
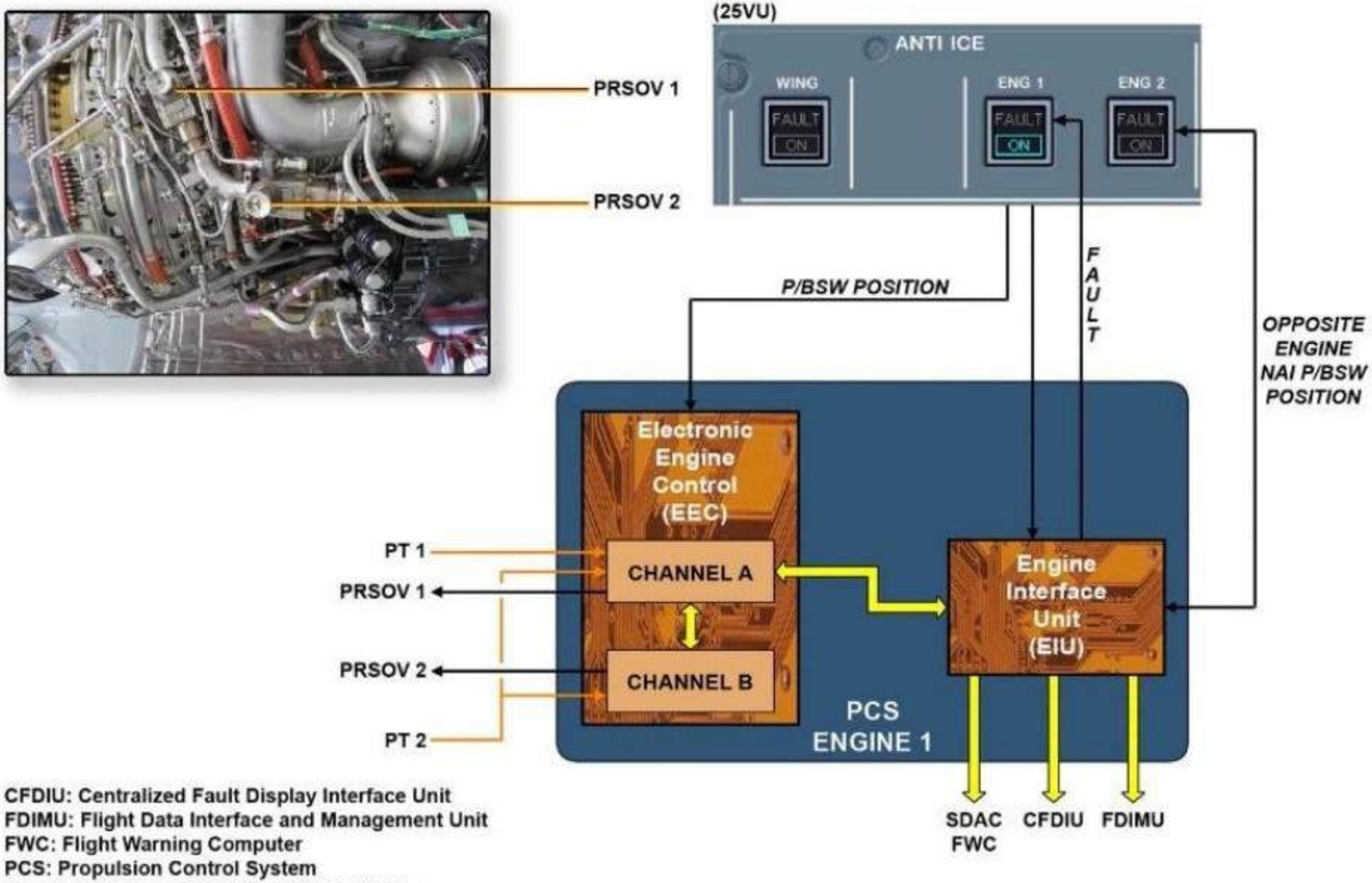

NAI "ON" FROM P/B
(Dual channel)
EIU / AIRCRAFT SYSTEMS
EEC A
EEC B
DUAL TEMPERATURE SENSOR (HOT AIR LEAK DETECTION)
STAGE ENGINE PORT (HP6 FOR PW HP7 FOR LEAP)
TO FAN INLET
HOT AIR
PRSOV 1
PT 1
PRSOV 2
PT 2
CORE ZONE
FAN ZONE
EEC: Engine Electronic Controller
EIU: Engine Interface Unit
NAI: Nacelle Anti-Ice
PRSOV: Pressure Regulating Shut-Off Valve
PT: Pressure Transducer

Fig. 4.3



CFDIU: Centralized Fault Display Interface Unit
FDIMU: Flight Data Interface and Management Unit
FWC: Flight Warning Computer
PCS: Propulsion Control System
PRSOV: Pressure Regulating Shut-Off Valve
PT: Pressure Transducer
SDAC: System Data Acquisition Concentrator

Fig. 4.4

5. FIRE PROTECTION SYSTEM

SYSTEM OVERVIEW (Fig. 5.1)

The engine and APU fire protection is done by two sub-systems: the fire detection system and the fire extinguishing system.

ENGINE AND APU FIRE PROTECTION

The engines and the APU have individual fire detection systems.

Each system has two identical detection loops (A and B) installed in parallel. Each loop includes 3 detector elements.

These detection elements are located around the Accessory Gear Box (AGB), core engine area and pylon area.

A Fire Detection Unit (FDU) monitors the two loops. FDU 1 monitors the loops on engine 1 and FDU 2 monitors the loops on engine 2.

The FDU sends FIRE and FAULT signals to the Flight Warning Computer (FWC) for display on ECAM.

The APU has two identical loops (A and B) installed in parallel on the APU compartment. FDU APU monitors these loops.

For the APU, there is only one fire extinguisher bottle, which is installed in the aft fuselage forward of the APU firewall. Its discharge is controlled by one AGENT P/BSW. On the ground, an APU FIRE will cause an automatic shutdown of the APU and an automatic discharge of the bottle.

The TEST buttons are used to do tests on the different fire detection and extinguishing systems and make sure they operate correctly.

ENGINE AND APU FIRE PROTECTION (Fig. 5.2)

For engine, the accessory gear box is located in the Core engine area.

The engine has 3 fire detectors (pylon, AGB and core).

COMPONENT LOCATION - ENGINE FIRE DETECTION (Fig. 5.3)

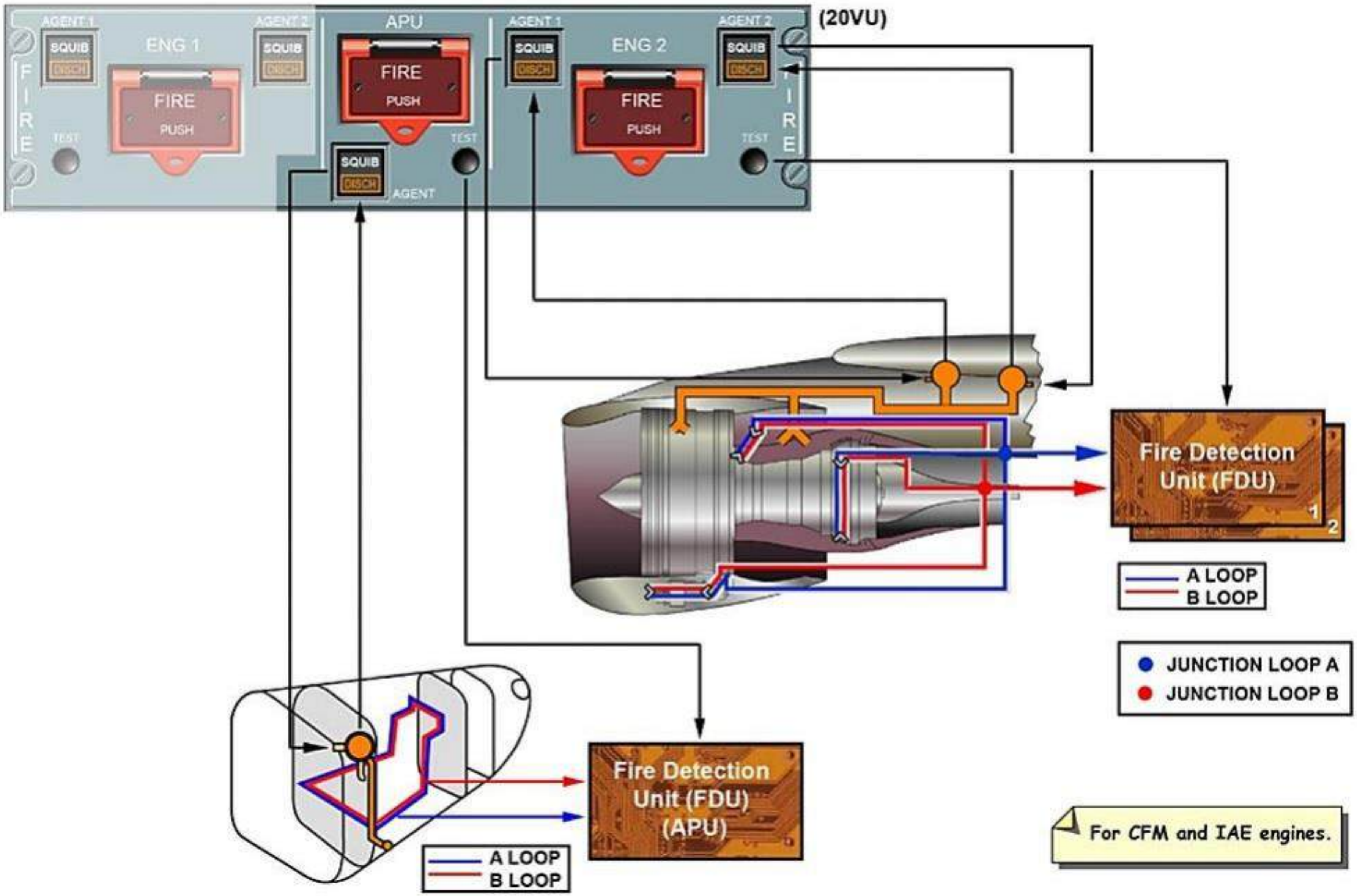
Each fire detection loop contains 3 detector elements connected in parallel.

The engine fire detectors are located:

- one around the AGB,
- one in the Core compartment (270 to 330 degrees) between the fuel nozzles and the aft circumferential ventilation outlet,
- one protecting the pylon above the combustion chamber.

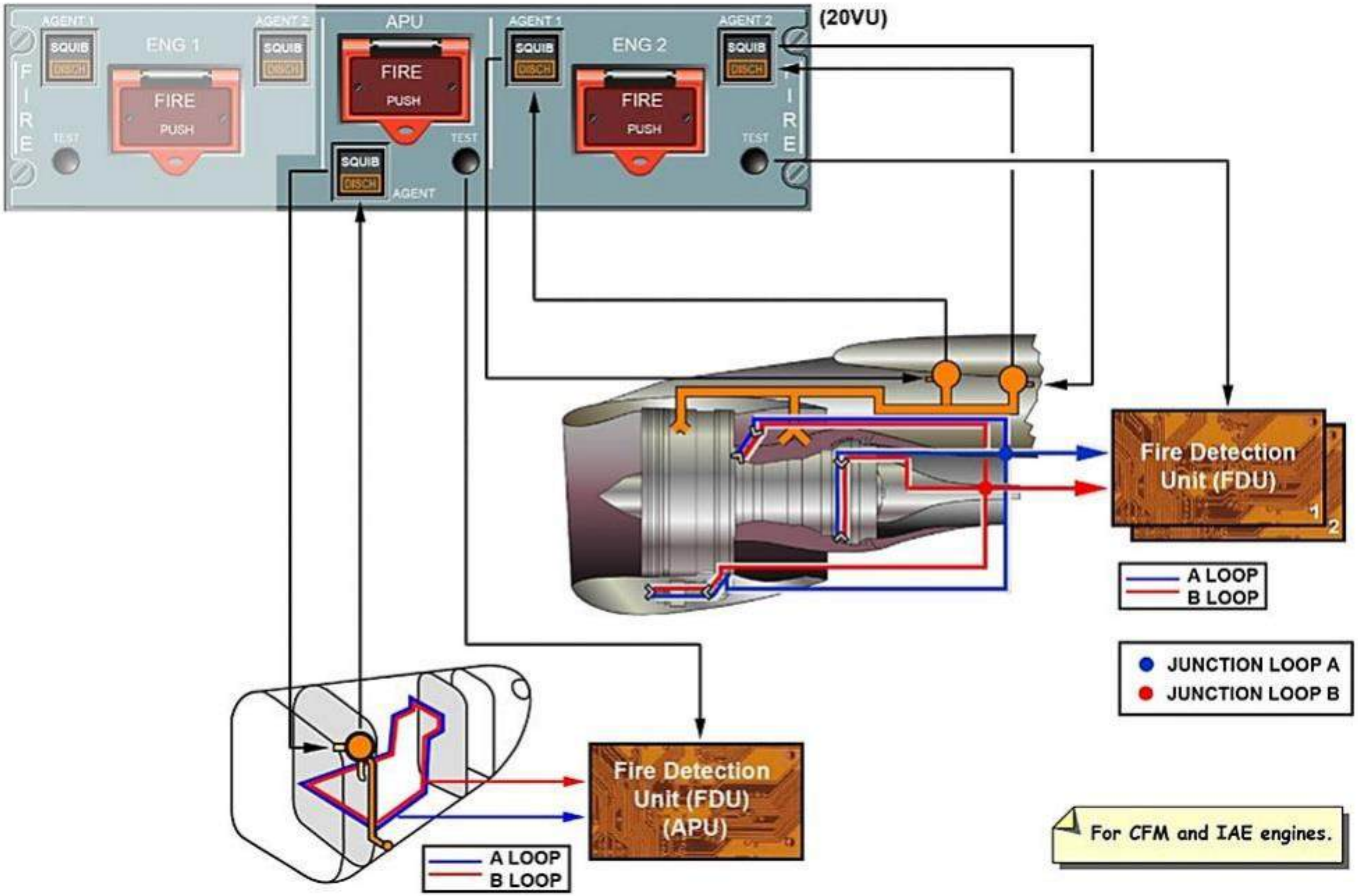
ENGINE FIRE EXTINGUISHING

The engine fire extinguishing bottles are in the pylon. There are access panels on the two sides of the pylon.



(20VU)
AGENT 1
SQUIB
DISCH
ENG 1
AGENT 2
FIRE
PUSH
TEST
APU
AGENT
ENG 2
Fire Detection Unit (FDU)
A LOOP
B LOOP
JUNCTION LOOP A
JUNCTION LOOP B
Fire Detection Unit (FDU) (APU)
For CFM and IAE engines.

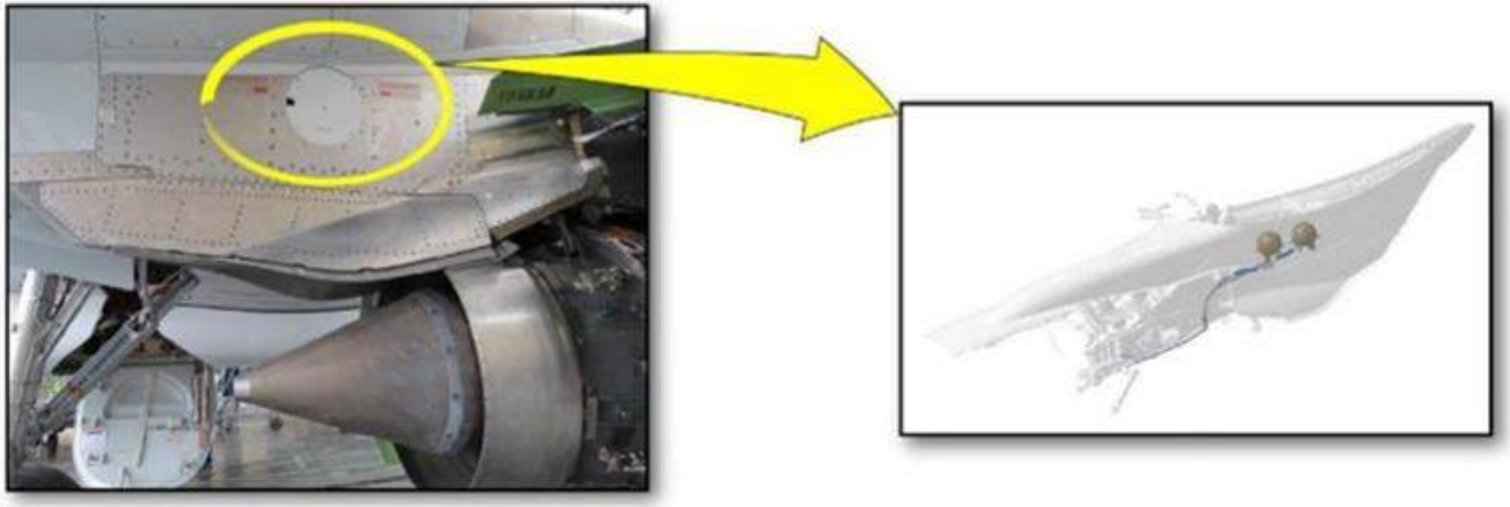
Fig. 5.1



(20VU)
AGENT 1
AGENT 2
ENG 1
SQUIB
DISCH
FIRE
PUSH
TEST
APU
AGENT
ENG 2
FIRE
Fire Detection Unit (FDU)
1
2
A LOOP
B LOOP
JUNCTION LOOP A
JUNCTION LOOP B
Fire Detection Unit (FDU) (APU)
For CFM and IAE engines.

Fig. 5.2

AGB FIRE DETECTORS



AIRCRAFT

Fig. 5.3

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Епифанов, С. В. Авиационные топливные системы [Текст] : учебник / С. В. Епифанов, А. И. Рыженко, Р. Ю. Цуканов. – Харьков : Нац. аэрокосм. ун-т им. Н. Е. Жуковского «Харьков. авиац. ин-т», 2018. – 558 с.

A318/A319/A320/A321. Flight Crew Operation Manual [Text] in 4 vol. – Airbus Industries, 2007. – V. 1 : Systems Description. – 1338 p.

Навчальне видання

Безуглий Сергій Володимирович

СИСТЕМИ СИЛОВОЇ УСТАНОВКИ З ТРДД

(Англійською мовою)

Редактор К. Р. Безпальченко

Технічний редактор В. І. Філатова

Зв. план, 2020
Підписано до видання 10.09.2020
Ум. друк. арк. 4,3. Обл.-вид. арк. 4,88. Електронний ресурс

Видавець і виготовлювач
Національний аерокосмічний університет ім. М. Є. Жуковського
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до Державного реєстру видавців, виготовлювачів і розповсюджувачів
видавничої продукції сер. ДК № 391 від 30.03.2001