ARRIEL 2B-2B1

TURBOSHAFT ENGINE

Training manual

March 2003

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Turbomeca
snecma group

FOREWORD

This document provides, in a teaching form, all the information required for the operation and the maintenance of the ARRIEL 2B - 2B1 Turboshaft engine for training purposes only.

It will not be updated, and if required, modifications will be included in a new issue.

TURBOMECA Training Centre

SUMMARY

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This training manual is established to meet training requirements and takes into consideration, to a certain extent, ATA 104 specifications.

This document has 446 pages. It was produced using a desktop publishing system.

LIST OF ABBREVIATIONS

The abbreviations / symbols shown below may be used during training:

A/C	Aircraft
AC	Alternating Current
ACMS	Automatic Control Monitoring System
ACW	Anti-clockwise
AEO	All Engines Operating
ATA	Air Transport Association
BITE	Built In Test Equipment
C or Tq	Torque
cc/h	Cubic centimetres per hour
CH	Fuel consumption
CNR	Calculateur Numérique de Régulation (=DECU=EECU)
cSt	Centistoke
CW	Clockwise
CWP	Control Warning Panel
daN	DecaNewton
dB	Decibel
DC	Direct Current
DDR	DECU Digital Read-out
DECU	Digital Engine Control Unit (=CNR)
DGAC	Direction Générale de l'Aviation Civile
EBCAU	Engine Back-up Control Auxiliary Unit
Ec	Kinetic energy
EECU	Engine Electronic Control Unit (=CNR)
EGT	Exhaust Gas Temperature
FAA	Federal Aviation Agency
FADEC	Full Authority Digital Engine Control
FCU	Fuel Control Unit
FLI	First Limit Indicator
FMU	Fuel Metering Unit
FOD	Foreign Object Damage
ft	Feet
FWD	Forward
G	Mass air flow
g	Gram
HE	High Energy
HP	Horse Power
HP	High Pressure
HUMS	Health and Usage Monitoring System
Hz	Hertz
ICP	Intermediate Contingency Power
ID	Identification
IFDS	Integrated Flight Display System
ILS	Integrated Logistic Support

LIST OF ABBREVIATIONS

(CONTINUED)

ISA	International Standard Atmosphere
ISV	Servo-valve intensity
kHz	Kilohertz
kPa	Kilopascal
kW	Kilowatt
lb	Pound
lb/HP.hr	Pounds per Horse Power per hour
lb/hr	Pounds per hour
lb/sec.	Pounds per second
LRU	Line Replaceable Unit
LTT	Learning Through Teaching
LVDT	Linear Voltage Differential Transducer
m	Metre
mA	Milliampere
MAX	Maximum
MCP	Max Continuous Power
MCQ	Multi Choice Questionnaire
MGB	Main gearbox
MHz	Mega Hertz
MIN	Minimum
mm	Millimetre
mP	Micro-processor
MTBF	Mean Time Between Failure
MTBUR	Mean Time Between Unscheduled Removal
MTCP	Maintenance Test Control Panel
MTOP	Max. Take-Off Power
mV	Millivolt
N	Rotation speed
N1	Gas generator rotation speed
N2	Power turbine rotation speed
NFT	Free turbine speed
NMD	Navigation and Mission Display
NOVRAM	Non Volatile Read Only Memory
NR	Rotor rotation speed
O/S	Overspeed
OEI	One Engine Inoperative
P	Pressure
P3	Compressor outlet pressure
PH	Oil pressure
POS	Position
PPM	Parts per million
PSI	Pounds per Square Inch
PSIA	Pounds per Square Inch Absolute
PSID	Pounds per Square Inch Differential

LIST OF ABBREVIATIONS

(CONTINUED)

PSIG	Pounds per Square Inch Gauge
PT	Power Turbine
Q	Fuel flow
RAM	Random Access Memory
ROM	Read Only Memory
RPM	Revolutions Per Minute
RTD	Resistive Temperature Device
SFC	Specific Fuel Consumption
Shp	Shaft horse power
SI	International System
t	Time
T/O	Take-Off
TBO	Time Between Overhauls
TET	Turbine Entry Temperature
TM	Turbomeca
Tq or C	Torque
t°	Temperature
t°4	Gas temperature
t°H	Oil temperature
US G	US Gallon
VAC	Volt, Alternating Current
VEMD	Vehicle Engine Multifunction Display
VDC	Volt, Direct Current
W	Power
XTL	N2 trim signal
XCP	Collective Pitch Signal
XMV	Metering needle position
Z	Altitude
Zp	Pressure altitude
°C	Degrees Celsius
°F	Degrees Fahrenheit
°K	Degrees Kelvin
±	Positive and negative for electrical circuits
Ω	Ohm
Δ	Difference
ΔP	Pressure difference
%	Percent
<	Is lower than
>	Is higher than

CONVERSION TABLE

UNIT	International System	British or American Systems
Length	1 mm 1 m	= 0.039 inch = 3.28 ft = 1.09 yard
Volume	1 dm^3 = 1 litre	= 0.26 US gallon
Mass	1 kg	= 2.2 lbs
Power	1 kW	= 1.34 HP
Temperature	° C ° K	= (°F-32). 5/9 = [(°F-32)5/9] + 273
Pressure	1 kPa = 0.01 bar	= 0.145 PSI
Flow (air, oil, fuel)	1 kg/s	= 2.2 lbs/sec.
Specific Fuel Consumption	1 g/kW.h	= 0.00164 lb/HP.hr

1 - INTRODUCTION

GENERAL INFORMATION

«The power of knowledge»

Adequate training is essential for obvious safety reasons, but also to reduce additional maintenance costs incurred by unjustified removals and excessive downtime.

"Greater knowledge leads to greater efficiency".

Objectives of training

The main objective is the acquisition of the knowledge required for the tasks to be achieved (know and know how).

Further information is also communicated to widen the skill and the experience of the trainee.

Training approach

- **Performance based training according to task analysis,** with classroom sessions, student involvement, practical work and troubleshooting techniques

- **Advanced training aids:** training manual, Computer Aided Presentation (or overhead projection), multimedia courseware and demonstration mock-ups

- **Experienced and formally** trained instructors

- **Courses are taught in English and French and, in special circumstances, in German and Spanish.**

Training Centre

The Training Centre is located in one of the buildings of TURBOMECA's TARNOS factory.

TARNOS .. 5 kms north of the BAYONNE - ANGLET - BIARRITZ district - Access by train (BAYONNE station), by plane (BIARRITZ-PARME airport), by road (A63 highway, exit 7: ONDRES-TARNOS).

Address .... TURBOMECA - 40220 TARNOS FRANCE

Telephone (33) 5 59 74 40 07 or 05 59 74 40 07

Fax .... (33) 5 59 74 45 16 or 05 59 74 45 16

E-mail .... training.centre@turbomeca.fr

Web site ... www.turbomeca-support.com "T.O.O.L.S" (TURBOMECA OPERATOR ON-LINE SUPPORT).

The training centre is organized in order to answer to training demands (administration, training aids, instructors).

Training sites

Training courses are also conducted in subsidiaries, in approved training centres and on site:

- by a TURBOMECA qualified instructor, in certain subsidiaries and approved training centres
- or by an instructor detached from TURBOMECA France, in our subsidiaries and in the clients' premises.

TRAINING

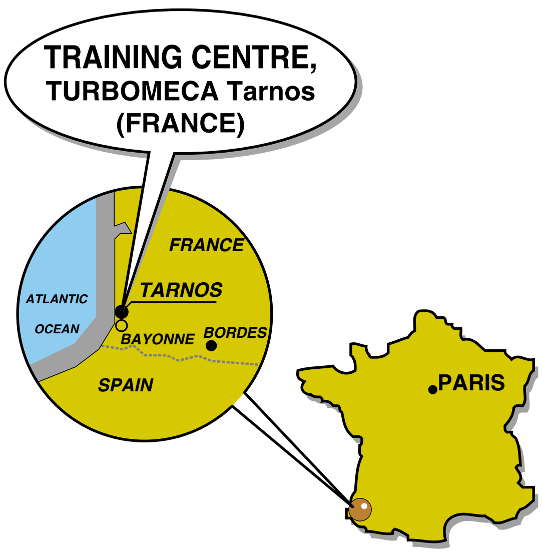
«The power of knowledge»

Adequate training is essential for obvious safety reasons, but also to reduce additional maintenance costs incurred by unjustified removals and excessive downtime.

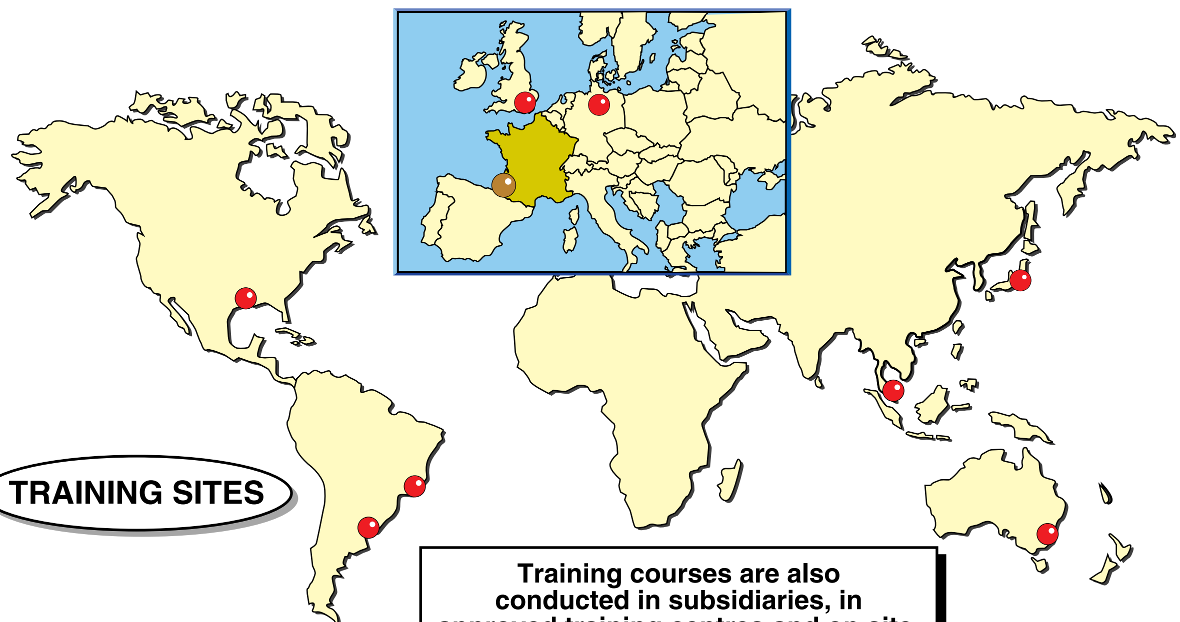
"Greater knowledge leads to greater efficiency".

→ **OBJECTIVES OF TRAINING**

→ **TRAINING APPROACH**



TRAINING SITES



Training courses are also conducted in subsidiaries, in approved training centres and on site.

GENERAL INFORMATION

TRAINING METHOD

Knowledge transmission process

The required knowledge is transmitted in such a manner that the student may use it efficiently in various circumstances.

The training is conducted in accordance with a process which considers:

- A phase of **explanation** for understanding

- A phase of **assimilation** leading to the complete acquisition and long-term retention of the knowledge.

Continuous checking of knowledge helps to ensure the information is assimilated. It is more a method of work than a testing in the traditional sense (refer to chapter 16).

Training method

The training method is a carefully balanced combination of:

- Lecture

- Exercises

- Discussions

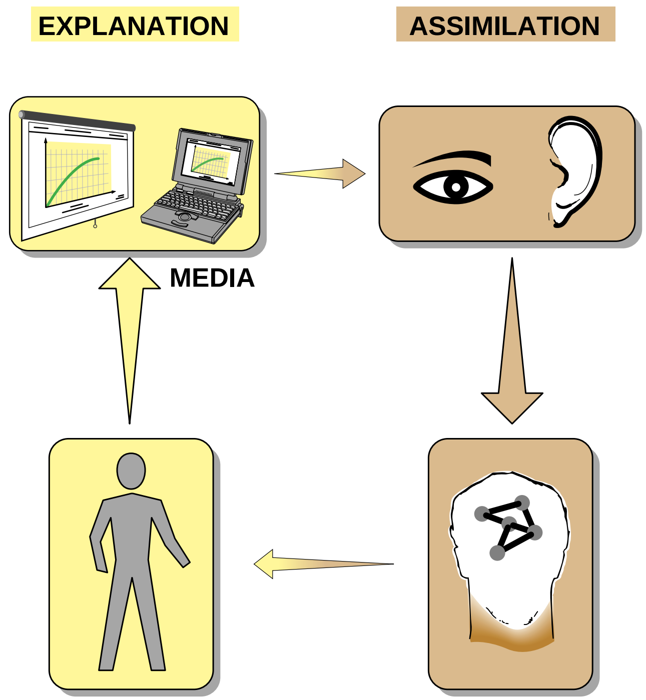
- Practical work.

KNOWLEDGE TRANSMISSION, PHASES:

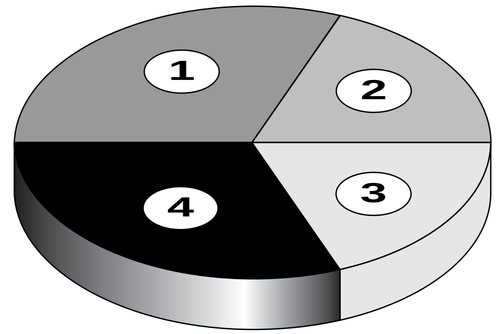
- Explanation
- Assimilation

CHECKING OF KNOWLEDGE:

- Continuous checking, treated in chapter 16



KNOWLEDGE
TRANSMISSION PROCESS



1 - LECTURE
2 - EXERCISES
3 - DISCUSSIONS
4 - PRACTICAL WORK

TRAINING METHOD

TRAINING METHOD

TRAINING AIDS

Training manual

The training manual is the basic source of information.

It contains, in a teaching form, all required information and explanations, following a layout derived from the ATA 104 standard. Thus each subject is treated following a plan which allows the material to be adapted to different levels of training.

Typical plan:

- General (function, position, main characteristics, main components)
- Description (general and detailed)
- Operation (phases, synthesis).

Other technical publications are also used during a course.

Computer Aided Presentation

Computer Aided Presentation consists of a file which permits the display of all the training manual illustrations by a computer for projection.

The Computer Aided Presentation replaces the transparencies which were used before to display these same illustrations.

Multimedia courseware

The multimedia courseware is a Computer Based Training software following the training manual layout. It gives information in a teaching and interactive manner.

This multimedia system uses text, photos, illustrations, sounds, animation and video. Questionnaires are also used for check-up of knowledge.

It forms the essential support of training courses and ensures their uniformity.

This system with quick and easy access can be very efficient for maintaining knowledge levels in the workplace.

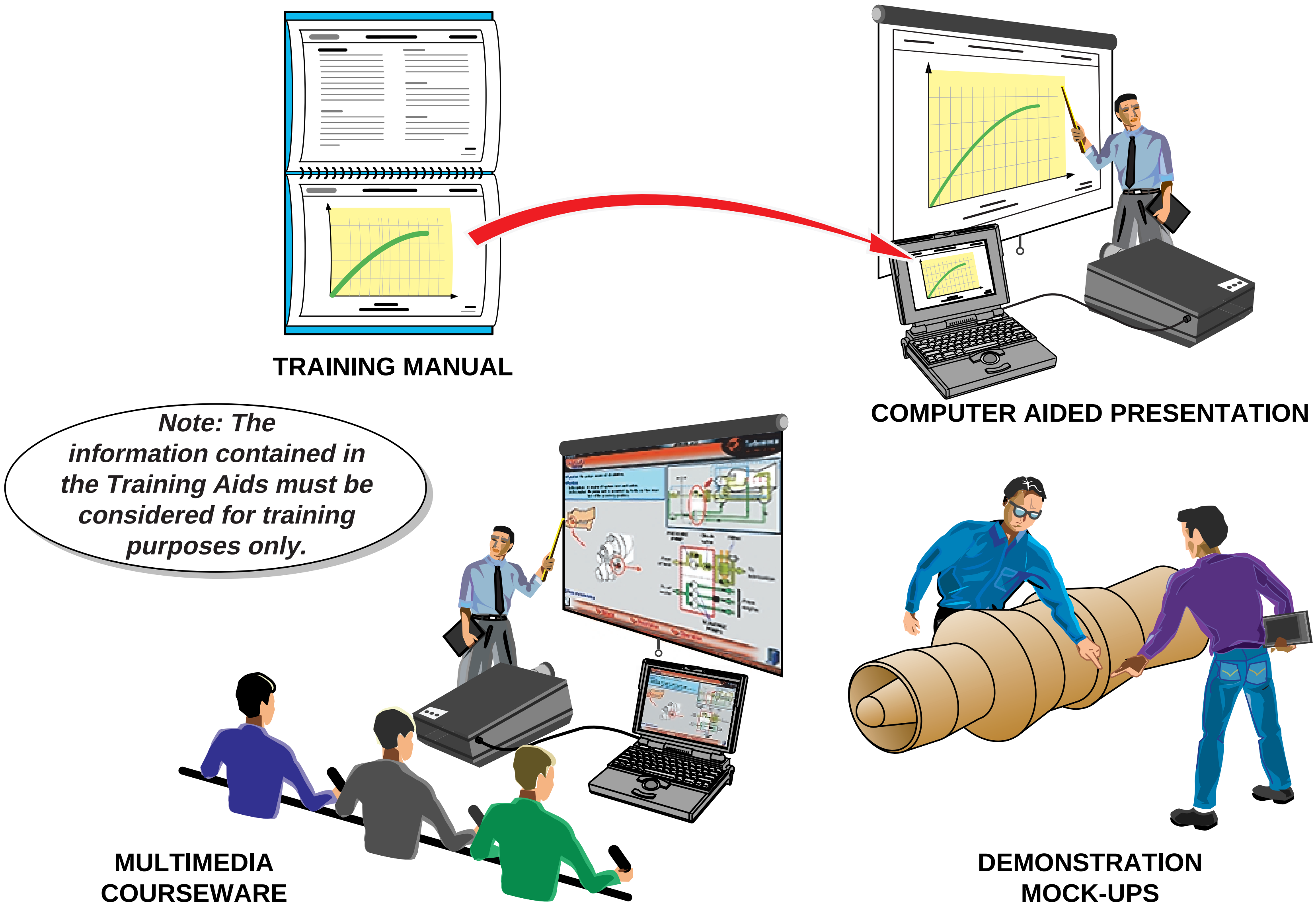
However, only a course delivered by a TURBOMECA instructor or TURBOMECA qualified instructor would lead to the issue of an engine maintenance authorisation card.

Note: *The multimedia courseware and the Computer Aided Presentation are available on CD-ROM (contact the training centre for sale conditions and availability).*

Demonstration mock-ups

Demonstration mock-ups are also used for component identification and maintenance procedures.

Note: *The information contained in the Training Aids is considered for training purposes only.*



TRAINING AIDS

TRAINING PROGRAMME

The **course programme** follows the manual. However, it should be noted that the "classroom sessions" alternate with periods devoted to demonstrations and practical work.

According to the contents, each session is mainly devoted to description and operation.

The engine maintenance aspect is mainly covered by the last part of the manual, which also deals with various elements related to maintenance (standard practices, technical publications, logistics and mainly trouble shooting).

Examples of programme:

The following pages provide examples of training programme:

- Familiarization course
- 1st line maintenance (O level): preventive and corrective maintenance
- 2nd line maintenance (I level): modules, SRU
- 3rd line maintenance (H level): deep maintenance
- Refresher
- Trouble shooting
- Fuel and control system
- Engine documentation.

FAMILIARIZATION COURSE

Objective: At the end of this course, the student will be able to describe the engine, to explain its principle of operation and to identify the main components of the engine and systems.

Programme:

FIRST DAY	- **Introduction** - **General presentation of the engine** - **Engine description** - **Engine systems**
SECOND DAY	- **Engine systems (continued)** - **Main aspects of maintenance** - **Revision - Checking of knowledge**

1st LINE MAINTENANCE COURSE (O LEVEL): PREVENTIVE AND CORRECTIVE MAINTENANCE

Objective: At the end of this course, the student will be able to identify the engine components, to describe and to explain the operation of the engine and its systems, to carry out maintenance procedures (engine installed in the airframe) and to diagnose operating failures.

Programme:

FIRST DAY	**- Introduction - General** **- Engine presentation - Engine description - Oil system - Air system**
SECOND DAY	**- Fuel system - Control system - Indication - Starting** **- Electrical system**
THIRD DAY	**- Engine installation - Operating limitations and procedures** **- Various aspects of maintenance - Pratical work**
FOURTH DAY	**- Pratical work** **- Trouble shooting**
FIFTH DAY	**- Visits - Revision** **- Examination - Course conclusion**

2nd LINE MAINTENANCE COURSE (I LEVEL): MODULES, SRU

Objective: At the end of this course, the student will be able to identify the engine components, to carry out all the maintenance procedures (engine removed from the airframe), mainly the removal/installation of modules and shop replaceable units.

Programme: The programme mainly includes practical work. This programme can be carried out after the 1st line maintenance programme.

FIRST DAY	**- Introduction** **- Revision (if this course is not conducted directly after the 1st line course)** **- Removal of modules**
SECOND DAY	**- Removal of modules** **- Inspection and check of modules**
THIRD DAY	**- Installation of modules** **- Inspection and checks after installation**

3rd LINE MAINTENANCE COURSE (H LEVEL): DEEP MAINTENANCE

Objective: At the end of the course, the trainee will be able to carry out the intramodular maintenance procedures (deep maintenance).

Programme:

FROM 3 DAYS TO 3 WEEKS	- **Introduction** - **Definition of procedures** - **Practical work**

REFRESHER

Objective: At the end of this course, the trainee will have a greater understanding of the engine and its systems.

Programme:

FIRST DAY	**- Introduction** **- Revision of the 1st line maintenance course**
SECOND DAY	**- Revision (continued)** **- Fleet situation - Engine upgrade - Course conclusion**

Note: *This course is recommended for technicians who have attended the first line maintenance course, after about one year of experience on an engine type.*

TROUBLE SHOOTING

Objective: At the end of this course, the trainee will be able to better identify and correct operating problems.

Programme:

FIRST DAY	**- Introduction** **- Revision of all engine systems**
SECOND DAY	**- Fault finding and restification** **- Fleet situation - Engine upgrade - Course conclusion**

Note: *This course is recommended for technicians who have attended the first line maintenance course, after about one year of experience on an engine type.*

FUEL AND CONTROL SYSTEM

Objective: At the end of this course, the trainee will have an in-depth understanding of the engine fuel and control systems.

Programme:

FIRST DAY	**- Introduction** **- Fuel and control systems**
SECOND DAY	**- Measurement and indicating systems** **- Engine upgrade - Course conclusion**

Note: *This course is recommended for technicians who have attended the first line maintenance course, after about one year of experience on an engine type.*

ENGINE DOCUMENTATION

Objective: At the end of this course, the trainee will be able to understand and use the engine documentation.

Programme:

FIRST DAY	**- Introduction** **- Presentation of the engine documentation**
SECOND DAY	**- Exercises** **- Course conclusion**

Note: *A general knowledge of engines is recommended.*

2 - POWER PLANT

POWER PLANT - GENERAL

Function

The power plant provides power by transforming the energy contained in the air and fuel into shaft power.

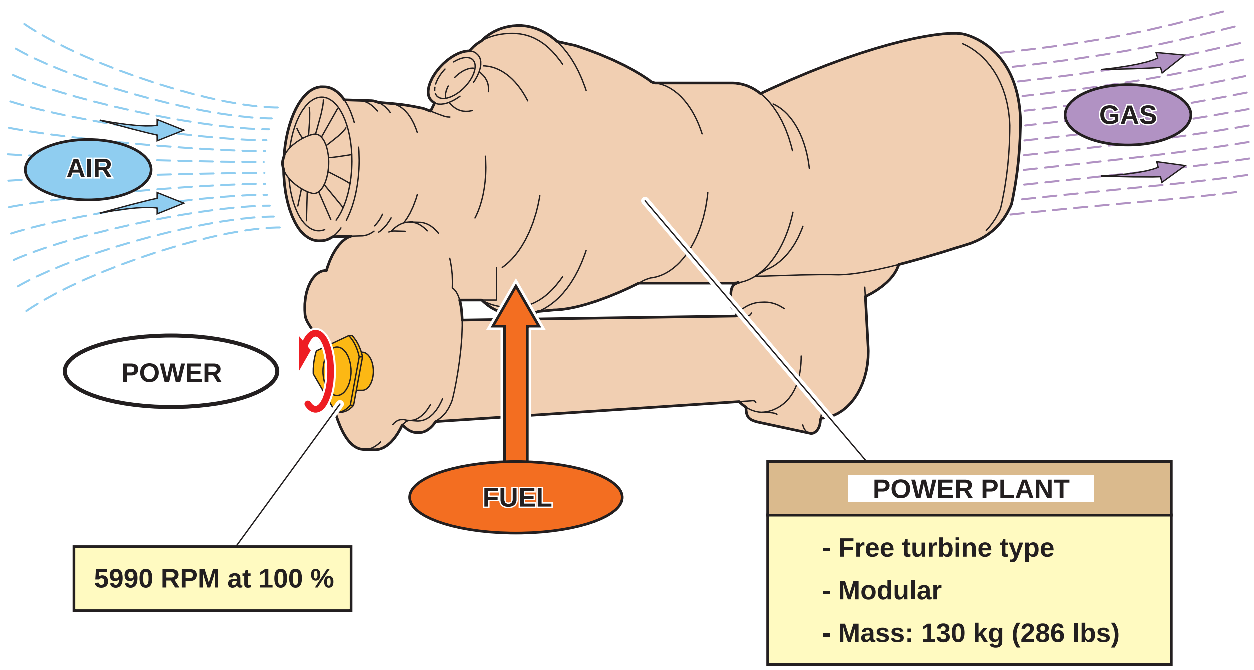
Main characteristics

- Type: Free turbine turboshaft engine, with forward power drive, external power transmission shaft
- Concept: Modular
- Max take-off power (engine installed):
  - *2B: 547 kW (733 Shp)*
  - *2B1: 557 kW (746 Shp)*
- Specific fuel consumption: 376g/kW.h at 400 kW
- Output shaft speed: 5990 RPM (at 100 %)
- Mass: 130 kg (286 lbs) dry with "specific equipment".

"Specific equipment": without starter and exhaust pipe extension, with Engine Electronic Control Unit and corresponding electrical harness.

Main components

- Turboshaft engine with its equipment
- Engine Electronic Control Unit (EECU).



Max take-off power:
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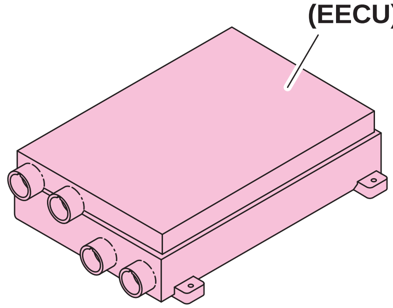


POWER PLANT - GENERAL

POWER PLANT - DESCRIPTION

This description considers the main functional components of the engine.

Gas generator

- Single stage axial compressor
- Centrifugal compressor
- Annular combustion chamber with centrifugal fuel injection
- Single-stage axial turbine.

Power turbine

- Single-stage axial turbine.

Exhaust pipe

- Elliptical, axial exhaust pipe.

Reduction gearbox

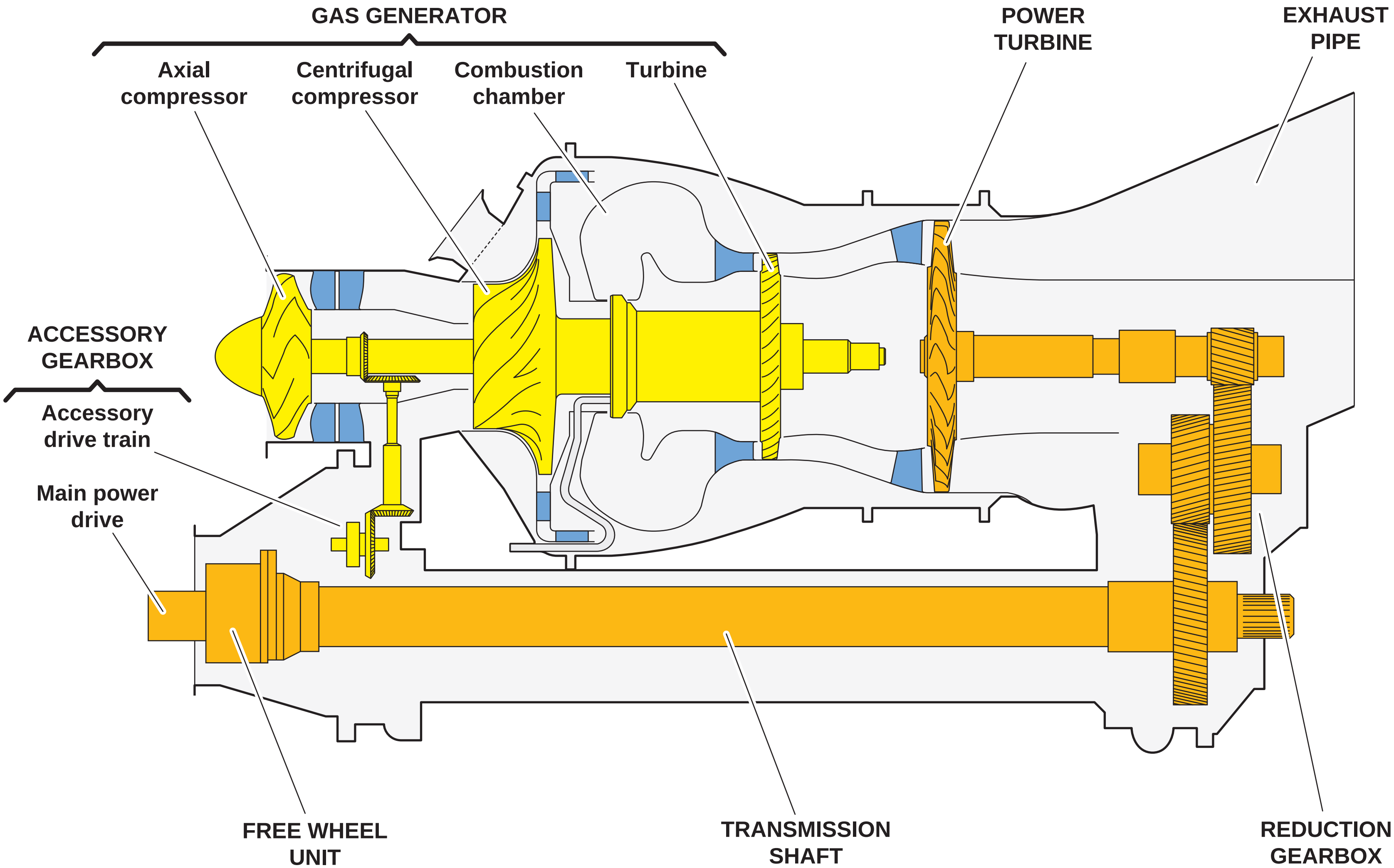
- Reduction gearbox comprising three helical gears.

Transmission shaft

- External shaft located in a protection tube which connects the reduction gearbox to the accessory gearbox
- An output shaft with front and rear drives is fitted co-axially in the transmission shaft which drives it through a free wheel unit.

Accessory gearbox

- Gearbox containing the accessory drive train (accessories driven by the gas generator) and the main power drive.



POWER PLANT - DESCRIPTION

POWER PLANT - OPERATION

This part deals with the basic operation of the engine.

Gas generator

- Admission of air through the aircraft air intake
- Compression of the air in the axial and centrifugal compressors
- Combustion of the fuel/air mixture in the annular combustion chamber
- Gas expansion in the single stage turbine which drives the compressors and engine accessories.

Power turbine

- Expansion of the gas in the single stage turbine which drives the output shaft through the reduction gearbox.

Exhaust

- End of expansion and discharge overboard of the gas.

Reduction gearbox

- Reduces the power turbine rotation speed and transmits the power forwards
- The reduction gearbox provides a power drive to drive the tail rotor gearbox.

Transmission shaft

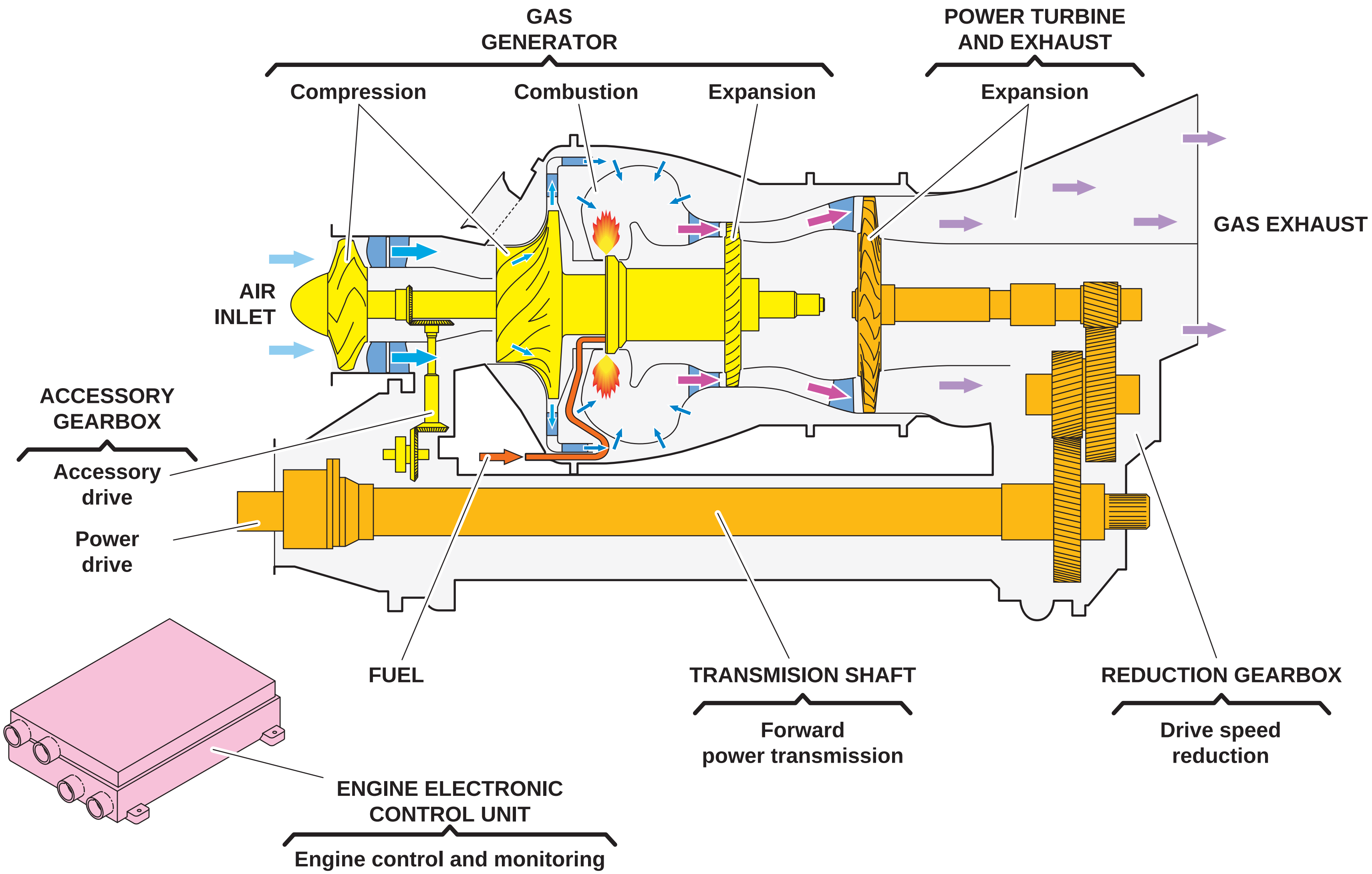
- Transmission of the power from the reduction gearbox to the output shaft.

Accessory gearbox

- Power take-off to drive the helicopter main gearbox
- Drive of the accessories by the gas generator through a bevel gear, a vertical drive shaft and a gear train.

Engine Electronic Control Unit

- Control and monitoring of the engine operation.



POWER PLANT - OPERATION

POWER PLANT - OPERATION - ADAPTATION

This part deals with the parameters and the adaptation of the gas generator and power turbine.

Component adaptation

For the engine operation, two functional assemblies can be considered:

- The gas generator which provides kinetic energy
- The power turbine which transforms the gas energy into mechanical power on a shaft.

The two assemblies have different rotation speeds.

Gas generator

The gas generator operation is defined by:

- The air mass flow G (air flow which enters the engine)
- The air pressure P3 and air temperature t3 at the centrifugal compressor outlet
- The fuel flow Q injected into the combustion chamber
- The gas temperature TET at the turbine entry
- The rotation speed N1 of the gas generator
- The kinetic energy Ec supplied to the power turbine.

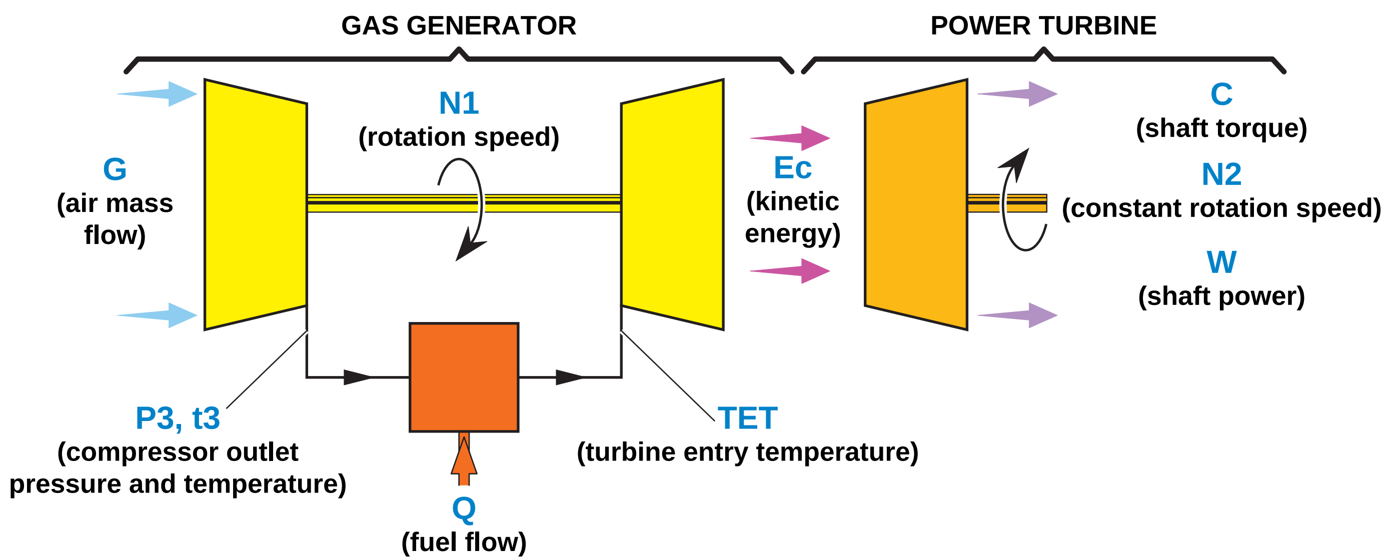
Power turbine

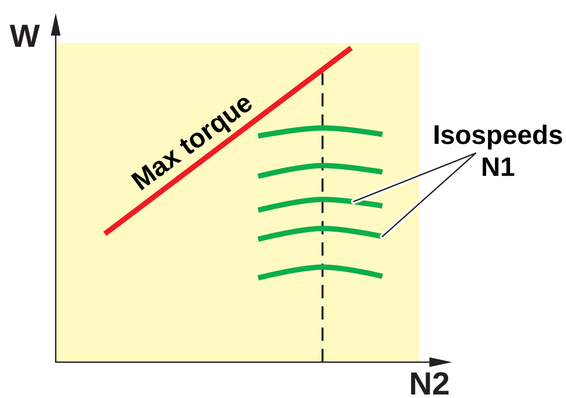
The power turbine operation is defined by the balance between the power received from the gas generator and the torque applied on the shaft, that is the torque C and the rotation speed N2.

Operation

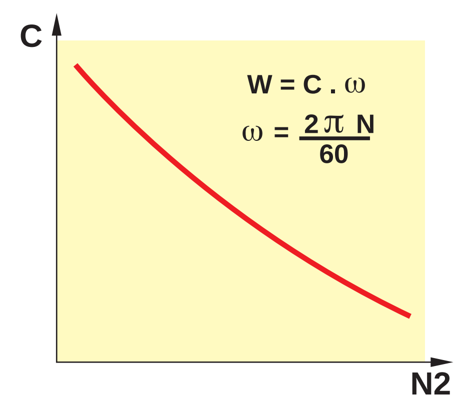
The operation is represented by the diagram which shows the power W, the rotation speeds N1 and N2 and the max torque limit C imposed by the mechanical transmission:

- The torque C is a function of the N2 rotation speed
- The power W is equal to the torque C multiplied by the angular velocity ω
- At constant N2 speed, the power is only a function of the torque
- The engine parameters can be represented as a function of a reference parameter; N1 for example.

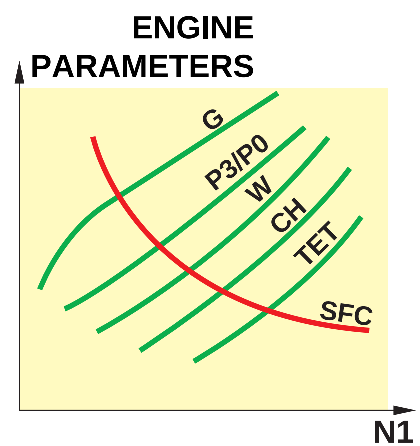




Power W and speeds N1, N2



Torque as a function of N2



P3/P0 : Compression ratio
CH : Hourly fuel consumption
SFC : Specific fuel consumption

POWER PLANT - OPERATION - ADAPTATION

PRINCIPLE OF ADAPTATION TO THE HELICOPTER

Power transmission in a single engine configuration

The mechanical power supplied by the engine, is used to drive the helicopter rotors through a mechanical transmission.

This power drives:

- The main rotor (approximately 82 %)
- The tail rotor (approximately 10 %)
- The main gearbox (approximately 8 %).

In a single engine configuration, the engine is installed at the rear of the main gearbox.

The power turbine of the engine is mechanically connected to the main gearbox which drives the main rotor.

A drive from the rear of the engine drives the tail rotor drive shaft.

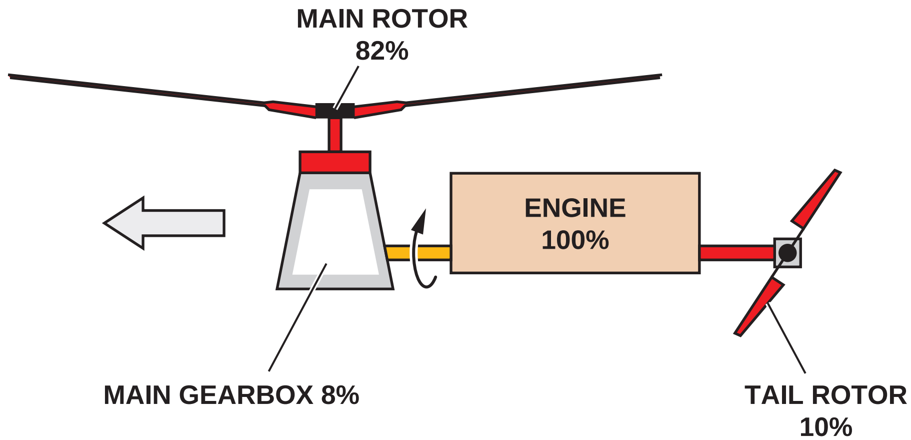
Installation requirements

The main functional requirements of the installation are:

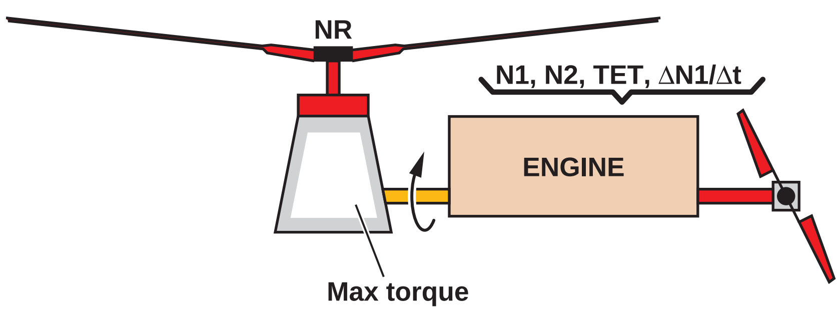
- Constant rotor rotation speed NR in all operating conditions
- Max torque limit C (usually imposed by the aircraft transmission)
- Complete engine protection (N1 and N2 speeds, TET, acceleration control $\Delta N1/\Delta t$…).

Adaptation to requirements

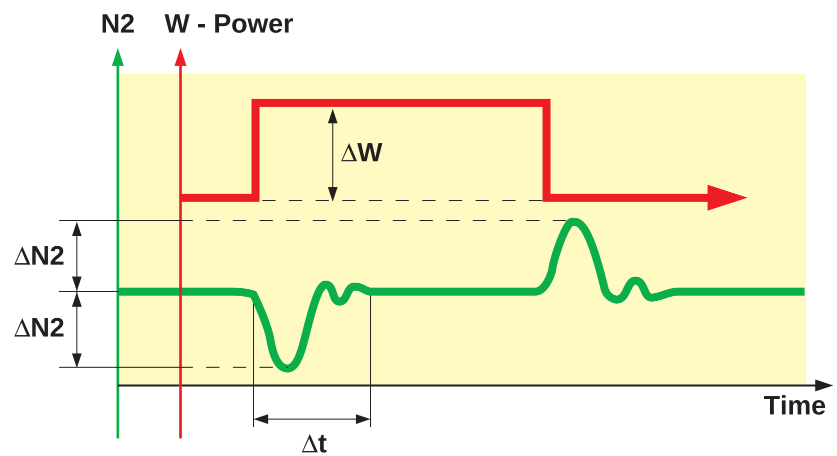
To have a constant rotation speed of the power turbine N2, the power supplied by the engine is automatically adapted to the demand. This adaptation is ensured by the control system which meters the fuel flow injected into the combustion chamber so as to deliver the required power (variation of the gas generator N1 rotation speed) while keeping the engine within its operational limits.



POWER TRANSMISSION
IN SINGLE ENGINE CONFIGURATION



INSTALLATION REQUIREMENTS



ADAPTATION TO REQUIREMENTS

PRINCIPLE OF ADAPTATION TO THE HELICOPTER

MAIN CHARACTERISTICS (1)

Engine ratings

The engine ratings correspond to given conditions of helicopter operation. The ratings are generally defined under determined speed and temperature conditions.

The following ratings are considered:

- Max take-off power: max rating which can be used during take-off. This rating has a limited duration (5 minutes continuous)
- Max continuous power: rating which can be used without time limitation (this does not imply that it is used permanently).

Engine performance

The performance values specified correspond to minimum values defined under the following conditions:

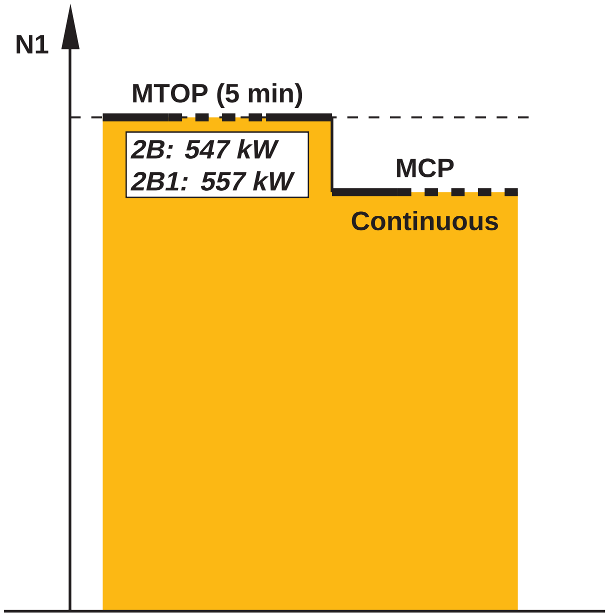
- ISA conditions at sea level on test bed
- Engine equipped with a test bed air intake and a primary exhaust pipe
- No air bleed
- No extra power taken (other than those of the engine accessories)
- Under determined conditions of speed
- With a given calorific power of fuel
- Without torque limitations.

The power is the power available on the output shaft. It is expressed in kilowatt (kW) or shaft horse power (Shp).

The fuel consumption (CH or WF) is the quantity of fuel consumed in a unit of time. It is expressed in kilogrammes per hour (kg/hr).

The specific fuel consumption (SFC) is the quantity of fuel required to produce one unit of power in one unit of time (SFC = CH/W). It is expressed in grammes of fuel per kilowatt per hour (g/kW.hr).

Note: *1 kW = 1.34 Shp.*



ENGINE RATINGS

Ratings	Power kW	Power Shp	Specific fuel consumption SFC
2B: MTOP (5 min) *2B1: MTOP (5 min)*	*547* *557*	*733* *746*	376 g/kW.h at 400 kW (0.827 lb/HP.hr)
MCP	522	700	
Cruise	400	536	

ENGINE PERFORMANCE

Note: The power indicated corresponds to the following configuration: engine installed, max. torque in the corresponding rating, ISA conditions at sea level.

ENGINE RATINGS AND PERFORMANCE
MAIN CHARACTERISTICS (1)

MAIN CHARACTERISTICS (2)

Engine operating envelope

The engine is designed to operate within a given climatic envelope.

The envelope is defined by:

- The atmospheric temperature t0
- The pressure altitude Zp
- And lines of standard atmosphere.

Flight envelope

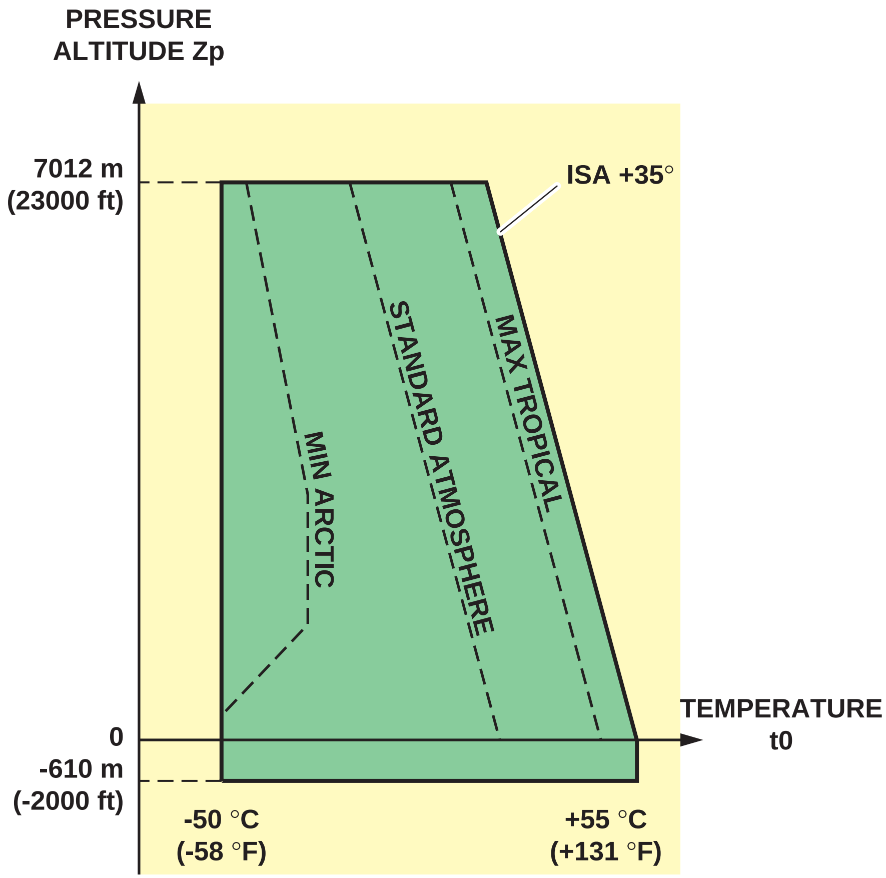
The flight envelope is illustrated by the t0/Zp diagram and the lines of standard atmosphere, with the max tropical zone and the min arctic zone.

Starting and relight envelope

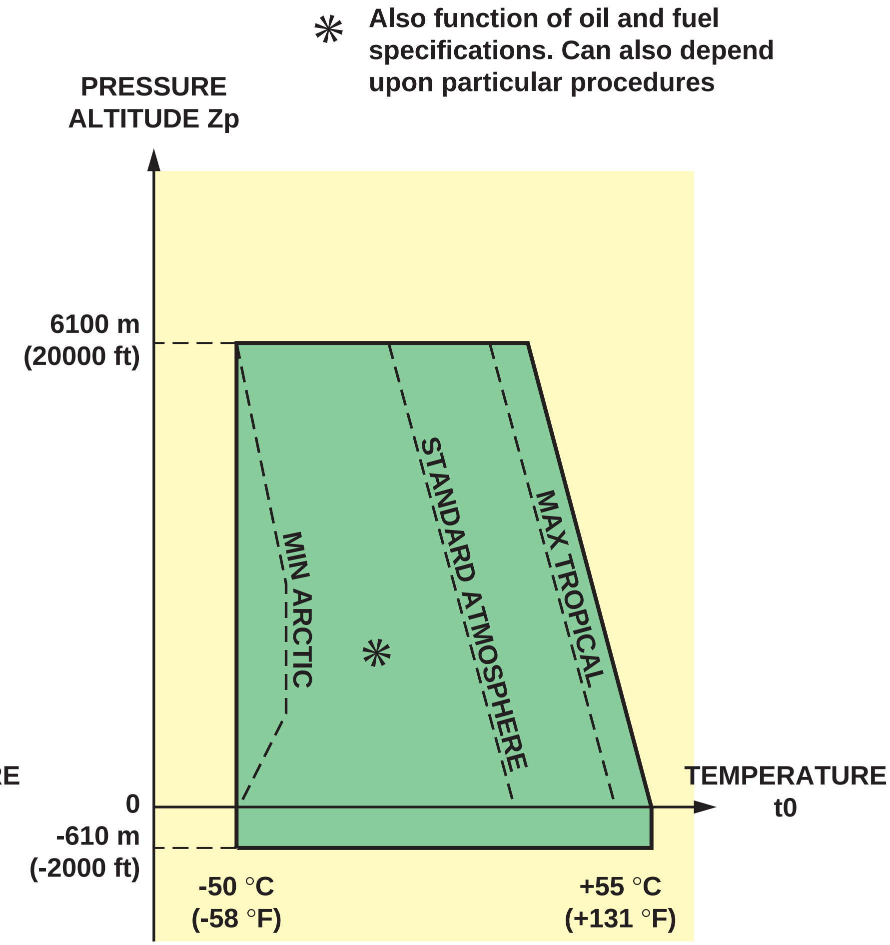
The starting and relight envelope is defined in the same way, but it is also affected by the specifications of oil and fuel used, and sometimes by particular procedures.

Note: *The engine operates within various limitations: rotation speeds, temperatures, pressures…*

Refer to corresponding chapters and official publications.



FLIGHT ENVELOPE



STARTING AND RELIGHT ENVELOPE

ENGINE OPERATING ENVELOPE
MAIN CHARACTERISTICS (2)

DESIGN AND DEVELOPMENT

Principles of design

The engine is designed to meet the aircraft propulsion requirements and particularly for the new generation of helicopters.

The engine design is based on:

- An optimised thermodynamic cycle which gives high performance
- Simple and reliable components giving a good supportability, and a good maintainability to reduce the costs.

Development steps

- Launch ARRIEL 2: 1992
- ARRIEL 2B certification: Nov. 97 (JAA)
- Introduction into service:
  - December 1997 - ARRIEL 2B
  - March 2001 - ARRIEL 2B1.

Applications

The ARRIEL 2B and 2B1 are actually provided to power the single engine helicopters:

- Squirrel AS 350 B3 - ARRIEL 2B
- Squirrel EC 130 B4 - ARRIEL 2B1

but other applications can be expected.

Maintenance concept

The ARRIEL 2 is designed to provide a high availability rate with reduced maintenance costs.

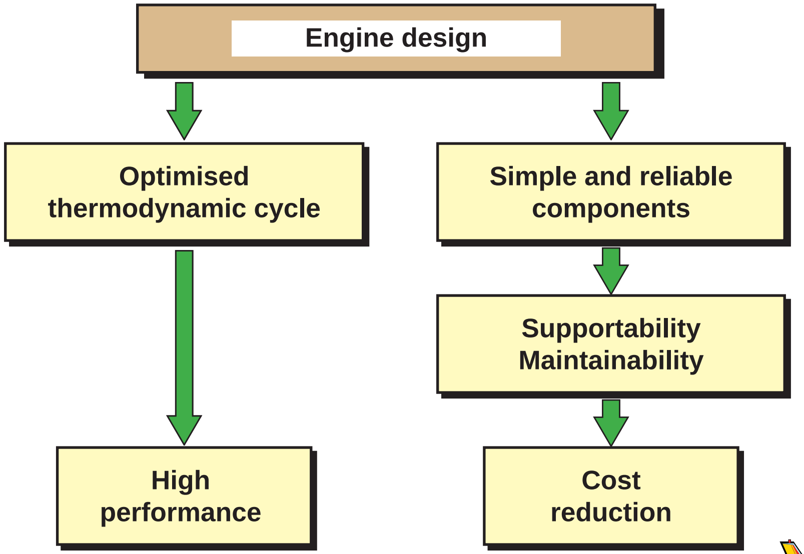
The main aspects of the maintenance concept are the following:

- Full modularity
- Good accessibility
- Reduced removal and installation times
- "On condition" monitoring
- High initial TBO
- Low cost of ownership:
  - Low production costs
  - Durability (TBO, defined and proven life limits)
  - High reliability
  - Low fuel consumption.

Engine designation

ARRIEL - According to TURBOMECA tradition: name of a Pyrenean lake for the turboshaft engines.

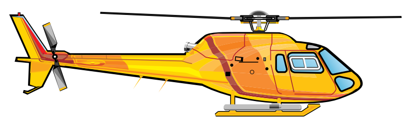
- 2: Type
- B: Variant
- 1: Version.



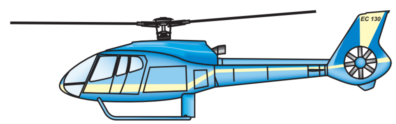
PRINCIPLES OF DESIGN

MAINTENANCE CONCEPT

- Full modularity
- Good accessibility
- Reduced removal and installation times
- "On condition" monitoring
- High initial TBO
- Low cost of ownership:
  - Low production costs
  - Durability (TBO, defined and proven life limits)
  - High reliability
  - Low fuel consumption.

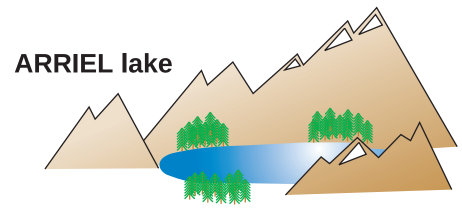


SQUIRREL AS 350 B3
ARRIEL 2B (x 1)



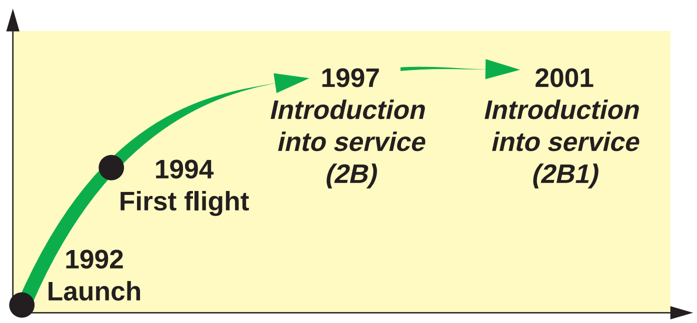
SQUIRREL EC 130 B4
ARRIEL 2B1 (x 1)

APPLICATIONS



Example: ARRIEL 2B1
ARRIEL: Name of a Pyrenean lake for the turboshaft engines
2: Type
B: Variant
1: Version

ENGINE DESIGNATION



DEVELOPMENT STEPS

DESIGN AND DEVELOPMENT

3 - ENGINE

(XX-XX-XX): Page references which deal with the subject in the maintenance documentation.

ENGINE - GENERAL

Function

The engine transforms the energy contained in the fuel and in the air into mechanical power on a shaft.

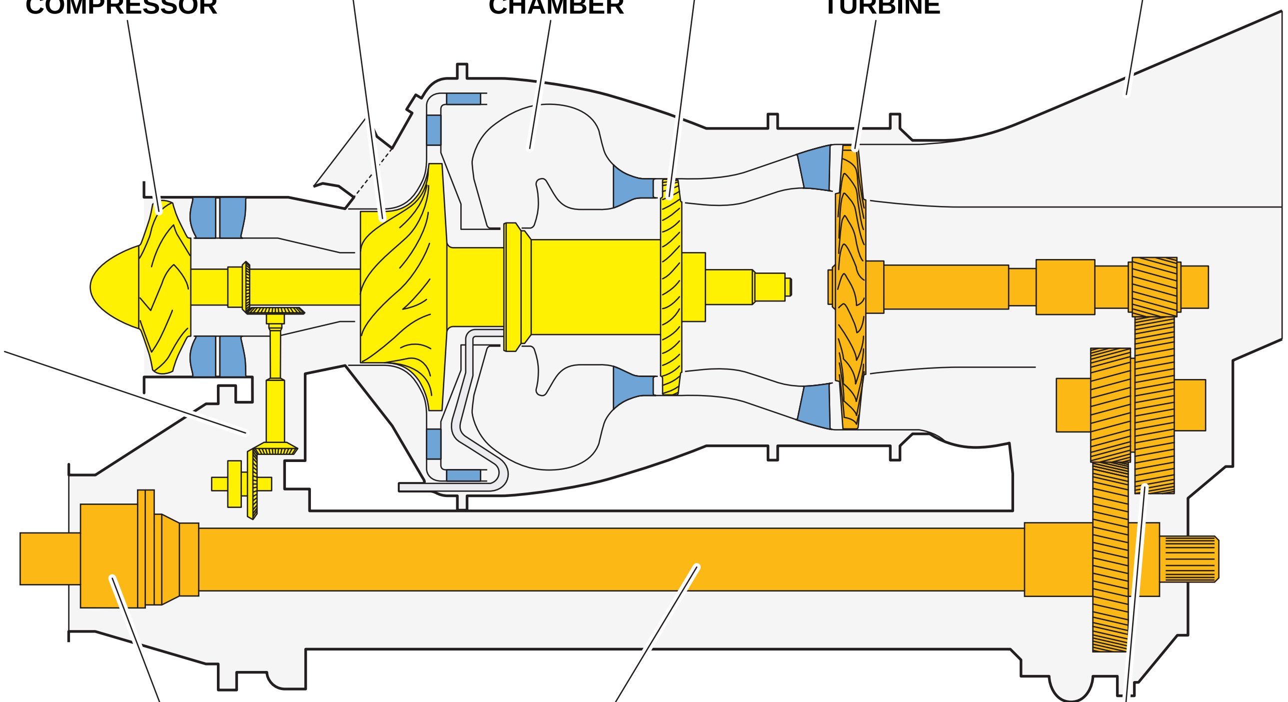
Main characteristics

- Type: Free turbine with forward drive via an external shaft
- Gas generator speed (N1): 52110 RPM (100 %)
  - Direction of rotation: anti-clockwise
- Power turbine speed (N2): 39095 RPM (100 %)
  - Direction of rotation: clockwise
- Output shaft speed: 5990 RPM (100 %)
  - Direction of rotation: clockwise

***Note**: Direction of rotation given viewed from the rear.*

Main components

- Gas generator
  - Axial compressor
  - HP section
    - Centrifugal compressor
    - Annular combustion chamber
    - Single stage turbine
- Single stage power turbine
- Exhaust pipe
- Reduction gearbox
- Transmission shaft
- Free wheel
- Accessory gearbox.



Type:
Free turbine

Gas generator (N1):
52110 RPM (100 %), ACW

Power turbine (N2):
39095 RPM (100 %), CW

Output shaft:
5990 RPM (100 %), CW

ENGINE - GENERAL

ENGINE - DESCRIPTION

Modular layout

The engine comprises 5 modules:

- Module M01: Transmission shaft and accessory gearbox
- Module M02: Axial compressor
- Module M03: Gas generator HP section
- Module M04: Power turbine
- Module M05: Reduction gearbox.

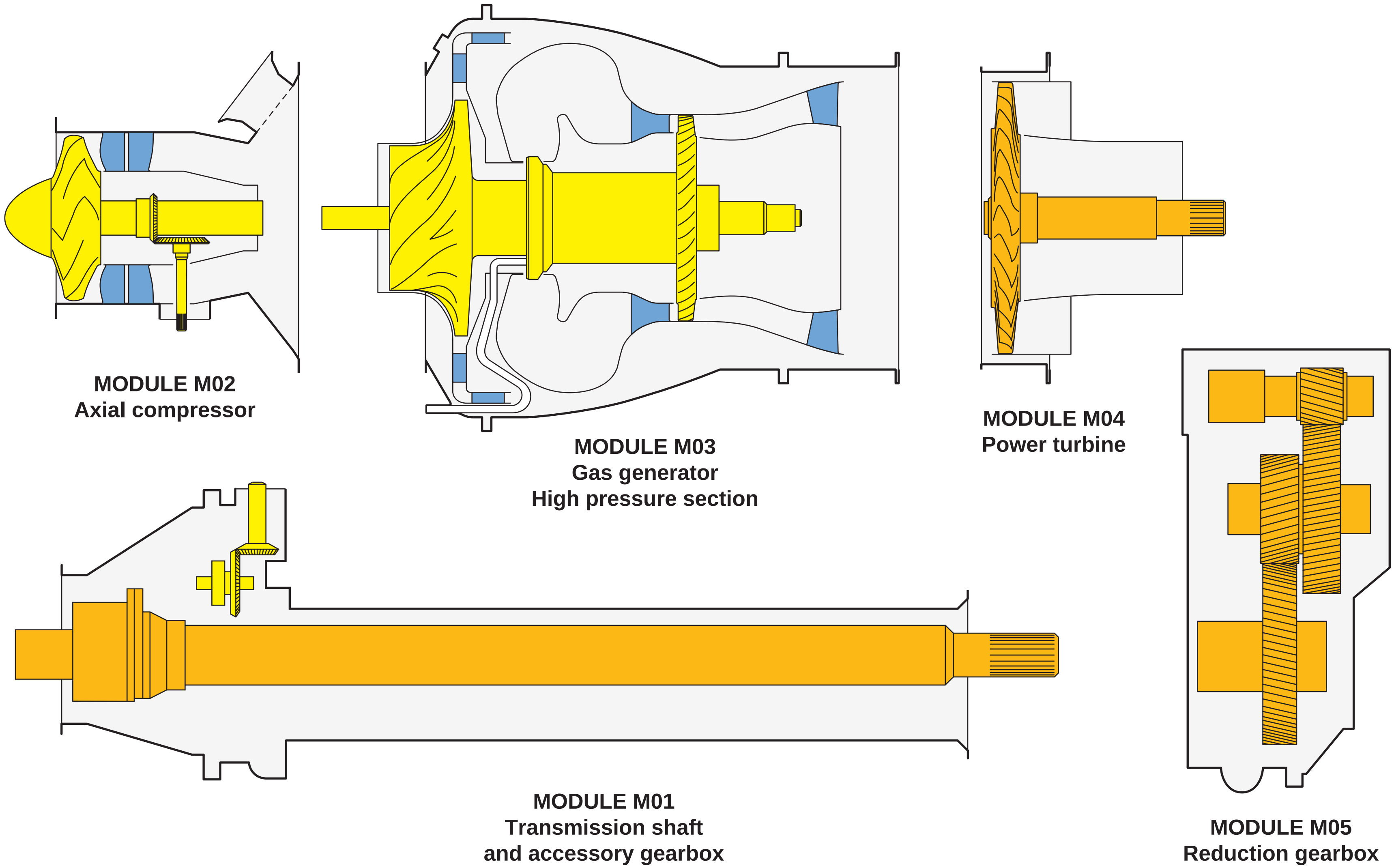
Note 1: *A module is a sub-assembly which can be replaced on-site (2nd line maintenance) without complex tooling or adaptation work.*

Each module has an identification plate. The engine identification plate is fitted on the left hand side of the M01 protection tube.

Note 2: *Some accessories are provided with each module.*

In this manual, those components are dealt with in the chapters corresponding to the main systems.

Note 3: *The exhaust pipe is not a module.*



ENGINE - DESCRIPTION

ENGINE - OPERATION

The engine provides power by transforming the energy in the air and fuel into mechanical energy on a shaft.

The process comprises compression, combustion, expansion and the transmission of the power.

Compression

The ambient air is compressed by an axial supercharging compressor and a centrifugal compressor.

This phase is essentially characterised by the air flow (approx. 2.5 kg/s; 5.5 lbs/sec.) the temperature increase and the compression ratio (approx. 8.2).

Combustion

The compressed air is admitted into the combustion chamber, mixed with the fuel and burnt in a continuous process.

The air is divided into two flows:

- A primary flow for combustion
- A secondary flow for cooling the gas.

This phase is essentially characterised by the temperature rise, flame temperature approx. 2500 °C and turbine entry temperature of approx. 1100 °C, and a pressure drop of about 4 %.

Expansion

- The gas expands in the gas generator turbine which extracts the energy required to drive the compressor and accessories
- There is a further expansion in the power turbine which extracts most of the remaining energy to drive the output shaft

During this phase the pressure and temperature of the gas drop, whilst the velocity increases.

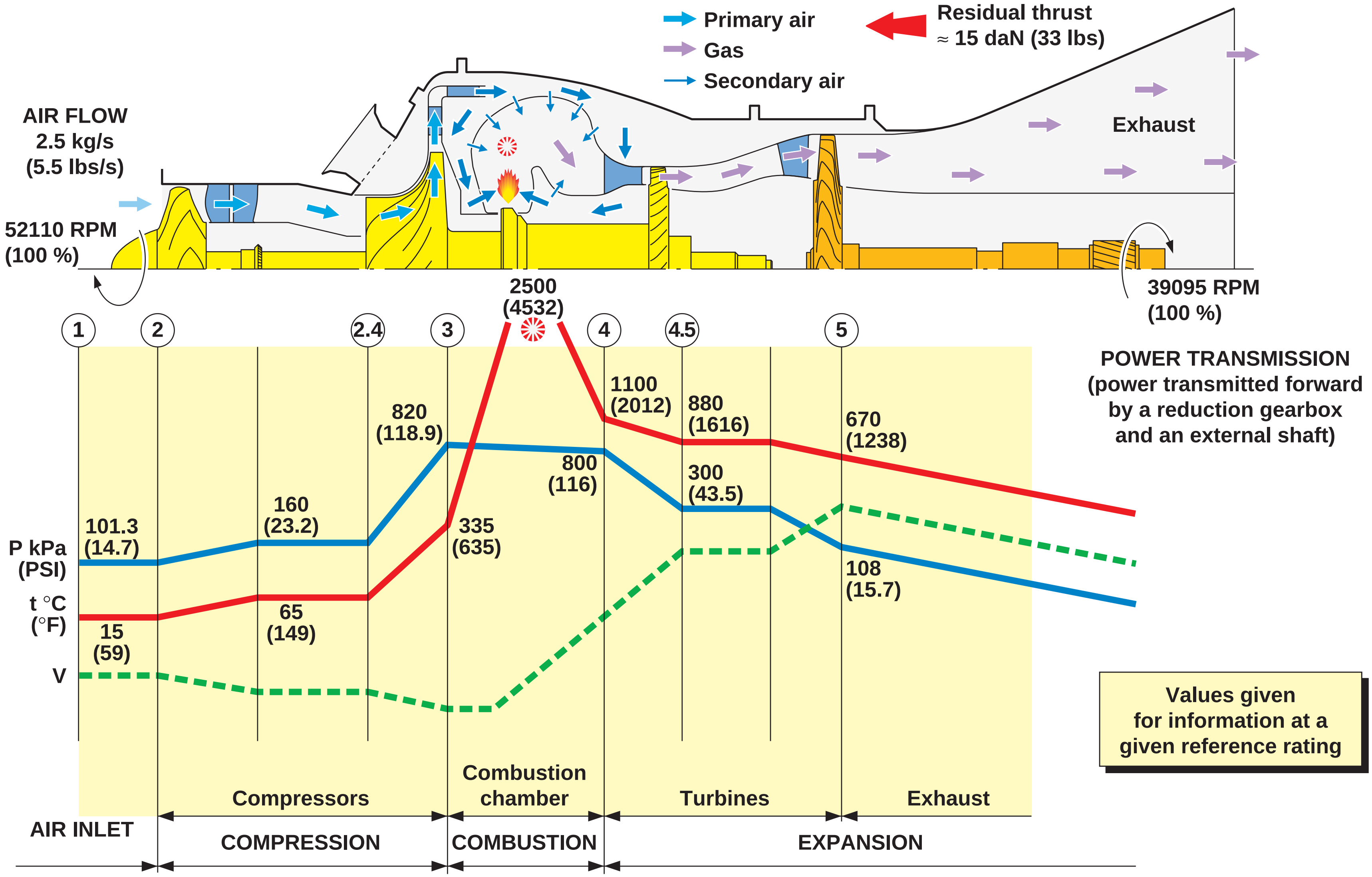
After the power turbine the gas is discharged overboard via the exhaust pipe, giving a slight residual thrust.

Power transmission

The power is transmitted forward by a reduction gearbox and an external transmission shaft.

Note: *The engine reference stations are:*

0 - Ambient air
1 - Air intake
2 - Axial compressor inlet
2.4 - Centrifugal compressor inlet
3 - Centrifugal compressor outlet
4 - Turbine inlet
4.5 - Gas generator turbine outlet
5 - Power turbine outlet.



ENGINE - OPERATION

AXIAL COMPRESSOR - GENERAL

Function

The axial compressor ensures a first stage of compression to supercharge the centrifugal compressor.

Position

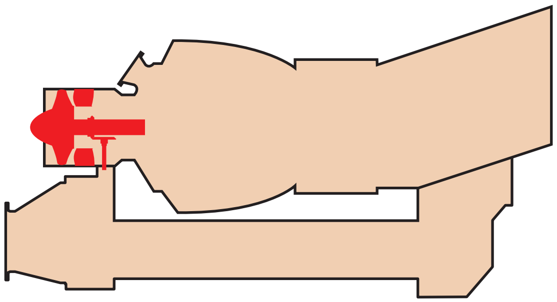
- At the front of the engine (the axial compressor assembly forms the module M02).

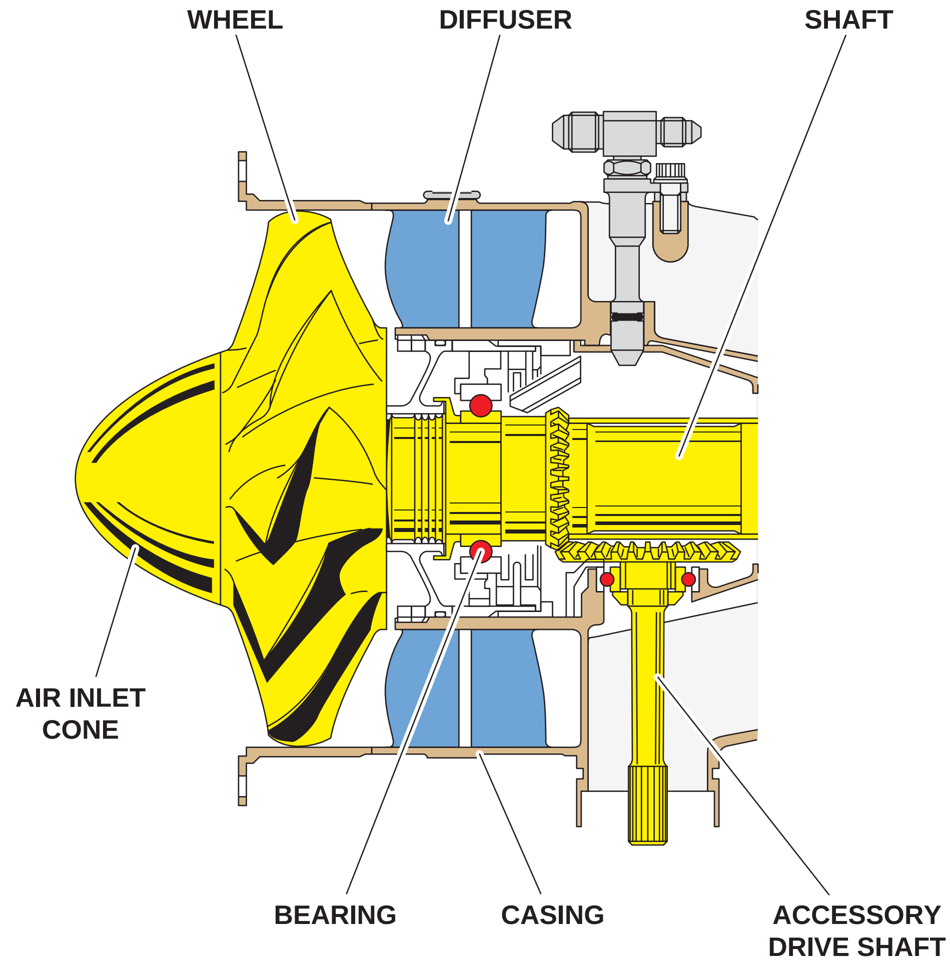
Main characteristics

- Type: single stage axial compressor
- Air flow: 2.5 kg/sec (5.5 lbs/sec.)
- Rotation speed: N1; ACW.

Main components

- Rotating components
  - Air inlet cone
  - Axial wheel, shaft, bearing and accessory drive shaft
- Stationary components
  - Diffuser
  - Casing.





Type:
single stage axial compressor

Air flow:
2.5 kg/s (5.5 lbs/sec.)

Rotation speed:
N1; ACW

AXIAL COMPRESSOR - GENERAL

AXIAL COMPRESSOR - DESCRIPTION

The axial compressor module (module M02) includes rotating and stationary components.

Rotating components

The rotating assembly comprises the inlet cone, the axial wheel and the accessory drive gear.

The inlet cone, made of light alloy, is screwed into the front of the shaft.

The compressor wheel is fitted to the shaft. It is a disc made of titanium alloy with blades cut from the solid.

The shaft connects the centrifugal compressor to the axial compressor. The shaft is secured by a nut onto the tie-bolt.

This assembly is supported by two bearings: a ball bearing at the rear of the axial compressor and a ball bearing in a flexible cage at the front of the centrifugal compressor.

The accessory drive consists of a bevel gear on the shaft which drives a vertical drive shaft.

Stationary components

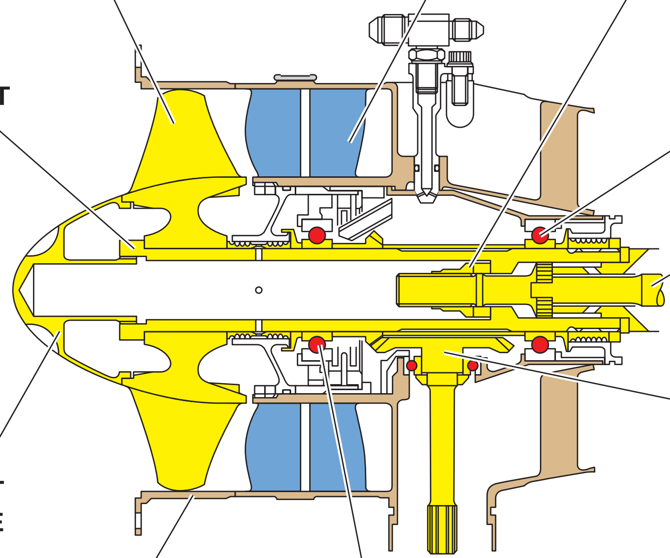
The stationary assembly includes the diffuser and the casing.

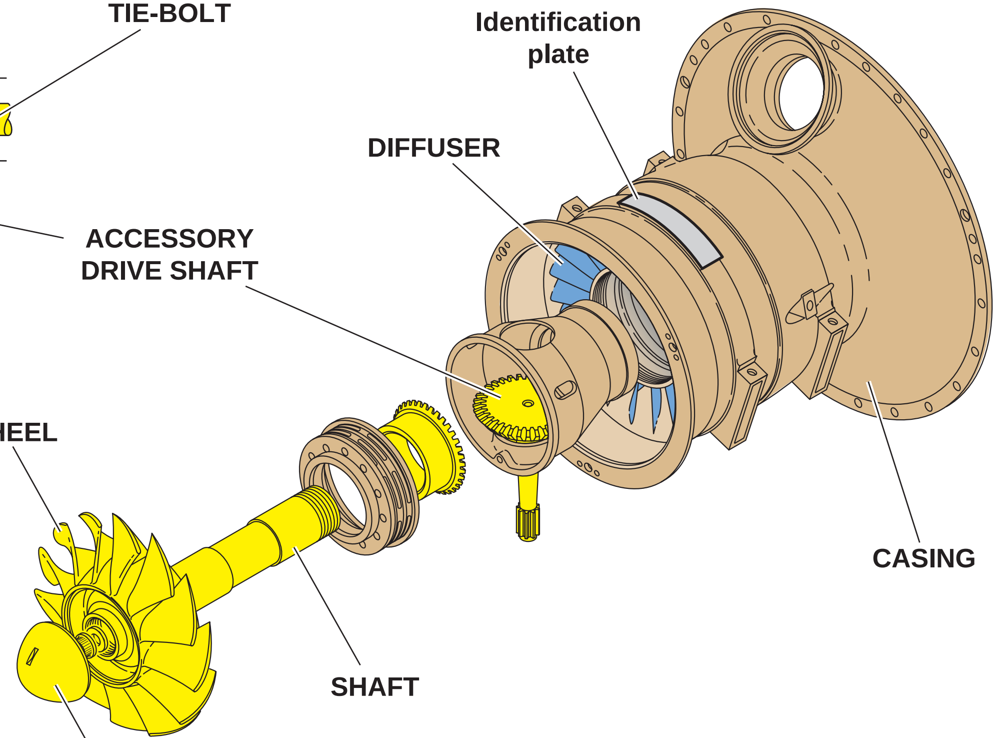
The diffuser (diffuser-straightener) welded inside the casing has two rows of steel stator vanes which form a divergent passage for the air.

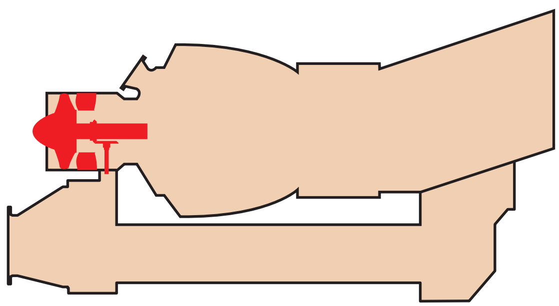
The casing, made of steel, houses all the compressor components. It has a front flange for the mounting of the air inlet duct and a rear flange for the attachment to the module M03. The inner hub of the casing provides the location for the bearings.

The casing has a boss for the mounting of the compressor bleed valve.

The module identification plate is located at the top of the casing.







AXIAL COMPRESSOR - DESCRIPTION

AXIAL COMPRESSOR - OPERATION

The axial compressor ensures a first stage of compression in order to supercharge the centrifugal compressor.

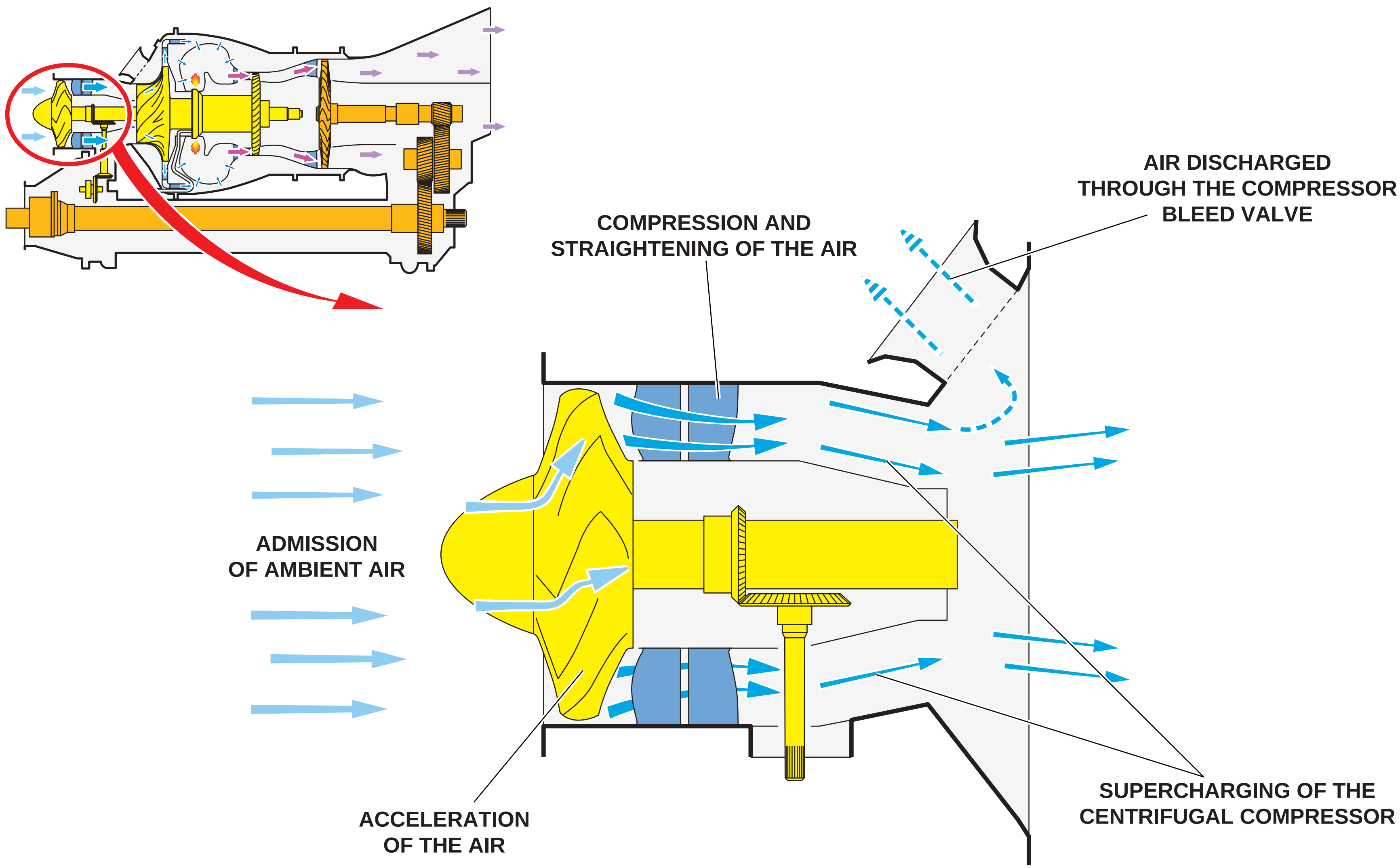
Compressor air flow

The ambient air, admitted through the air intake duct and guided by the inlet cone, flows between the blades of the axial compressor. The air is discharged rearwards with an increased axial velocity.

The air then flows through the vanes of the diffuser. Due to the divergent passage, the air velocity is transformed into pressure.

The flow is straightened by the stator vanes before being admitted, through an annular duct, to the centrifugal compressor.

Note: *In order to avoid compressor surge, a valve discharges overboard a certain amount of air in certain operating conditions (refer to "AIR SYSTEM" chapter for further details on the compressor bleed valve).*



AXIAL COMPRESSOR - OPERATION

CENTRIFUGAL COMPRESSOR - GENERAL

Function

The compressor supplies the compressed air required for combustion.

Supercharged by the axial compressor, it ensures the second stage of compression.

Position

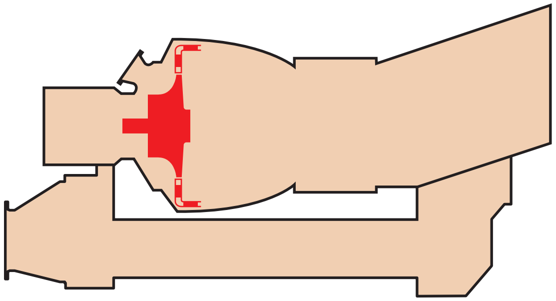
- At the front of the module M03.

Main characteristics

- Type: centrifugal
- Air flow: 2.5 kg/s (5.5 lbs/sec.)
- Rotation speed: N1; ACW.

Main components

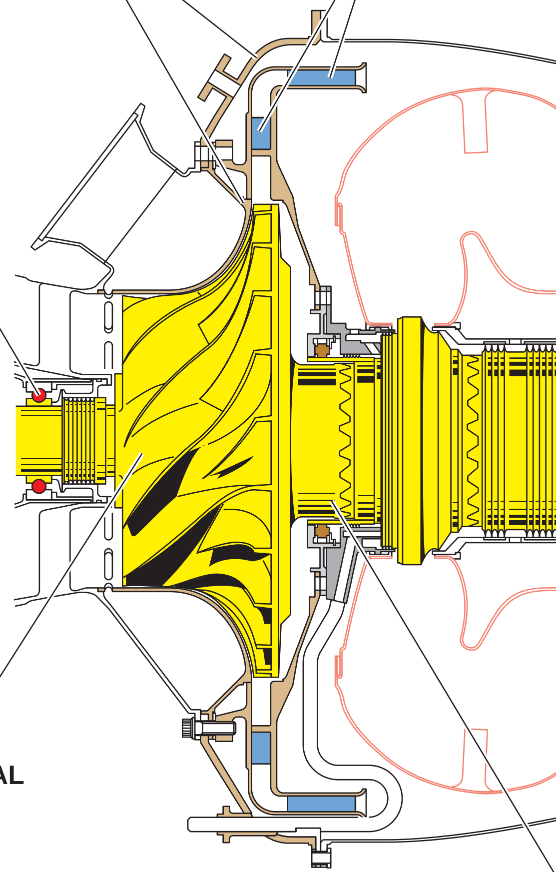
- Rotating components (wheel, shaft, bearing)
- Stationary components (diffusers, casings).



Type:
Centrifugal

Air flow:
2.5 kg/s (5.5 lbs/sec.)

Rotation speed:
N1; ACW



CENTRIFUGAL COMPRESSOR - GENERAL

CENTRIFUGAL COMPRESSOR - DESCRIPTION

The centrifugal compressor assembly (part of module M03) includes rotating and stationary components.

Rotating components

The centrifugal wheel is the main rotating component. The wheel has blades which are cut from the solid in a disc of titanium alloy.

The front part of the wheel connects to the axial compressor shaft. This shaft is supported by a ball bearing.

The rear part has a curvic-coupling for the mounting of the centrifugal fuel injection wheel. The rotating components are secured by a central tie-bolt.

Stationary components

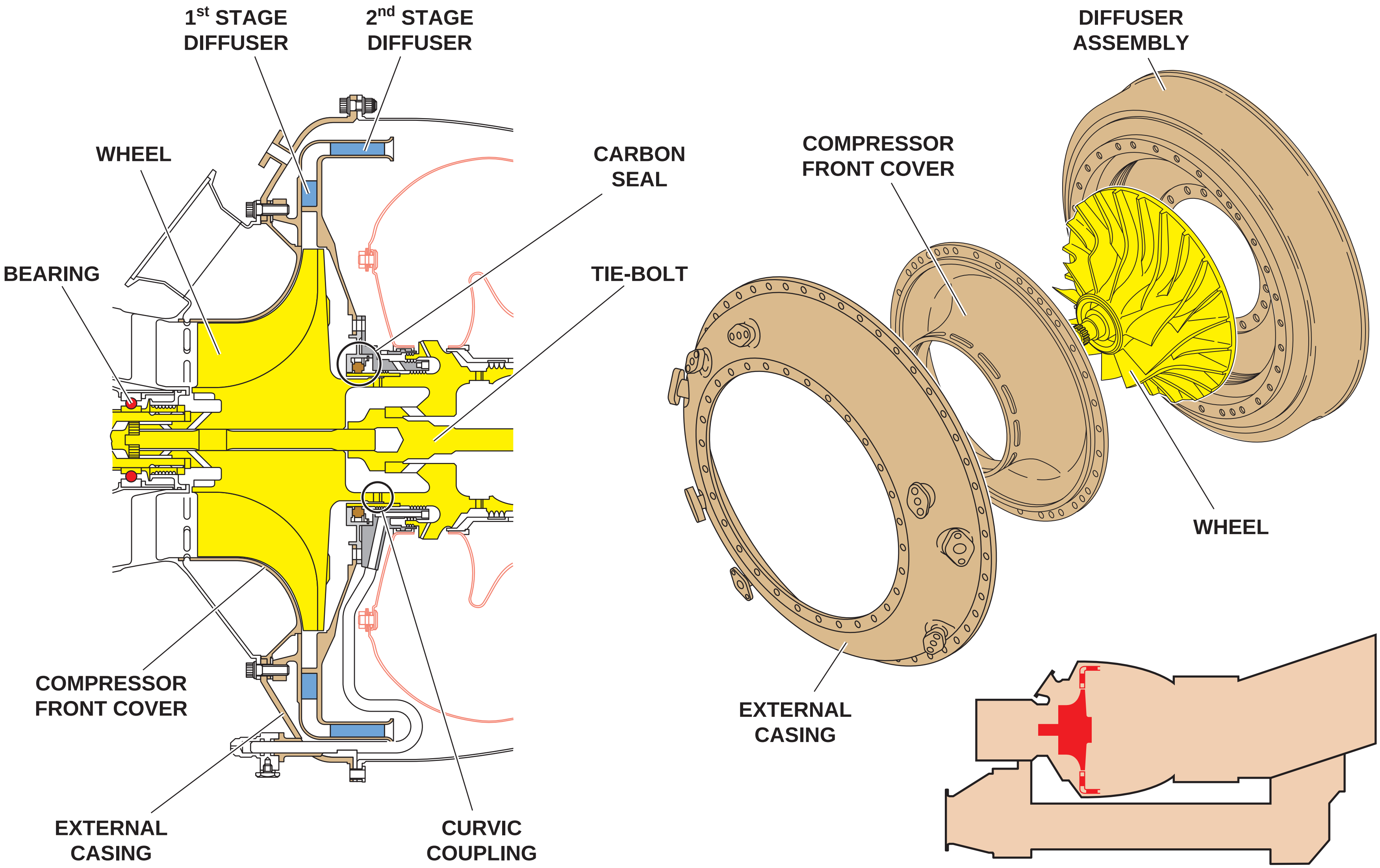
The stationary assembly includes the diffusers and the casings.

The compressor front cover is mounted inside the external casing by means of a ring of bolts which also secure the axial compressor casing, the front cover and the diffuser assembly.

The external casing of the centrifugal compressor is bolted to the turbine casing. It is provided with several bosses for air bleeds.

The diffuser assembly comprises the first stage diffuser (radial stator vanes) and the second stage diffuser (axial stator vanes). The diffuser holder plate forms a partition between the compressor and the combustion chamber. Its inner hub supports a carbon seal and the fuel distributor.

The carbon seal is a floating ring seal fitted in a tungsten steel holder and it runs on the forward extension of the injection wheel.



CENTRIFUGAL COMPRESSOR - DESCRIPTION

CENTRIFUGAL COMPRESSOR - OPERATION

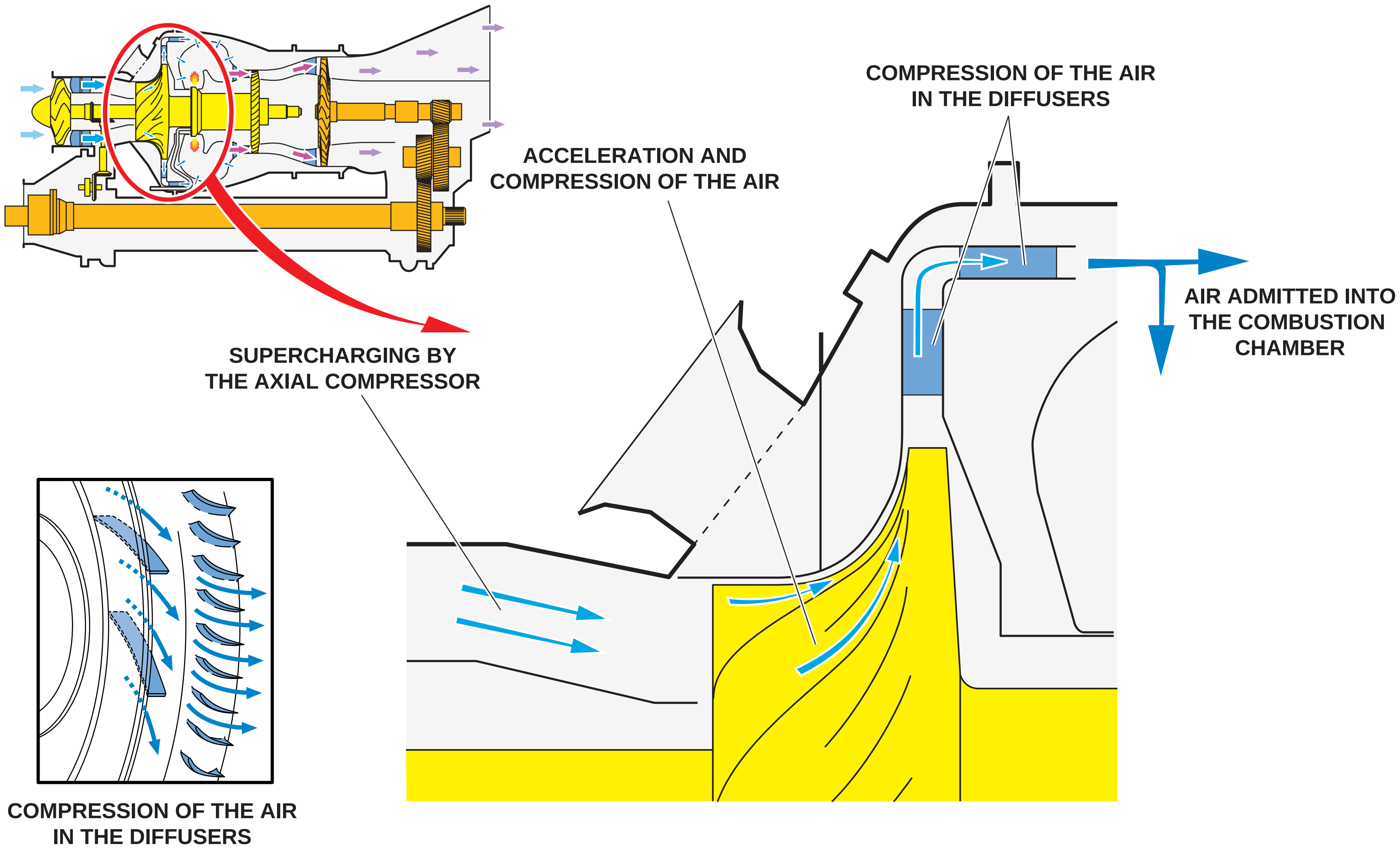
The centrifugal compressor ensures the main stage of compression.

Compressor air flow

The air supplied by the axial compressor flows between the blades of the centrifugal compressor. The air pressure increases due to the divergent passage between the blades and the air velocity increases due to the centrifugal flow.

The air leaves the tips of the blades at very high velocity and then flows through the first stage diffuser vanes where the velocity is transformed into pressure.

The air then passes through an elbow and the flow becomes axial. In the second stage diffuser, the velocity is again transformed into pressure. The air is then admitted into the combustion chamber.



CENTRIFUGAL COMPRESSOR - OPERATION

COMBUSTION CHAMBER - GENERAL

Function

The combustion chamber forms an enclosure in which the air/fuel mixture is burnt.

Position

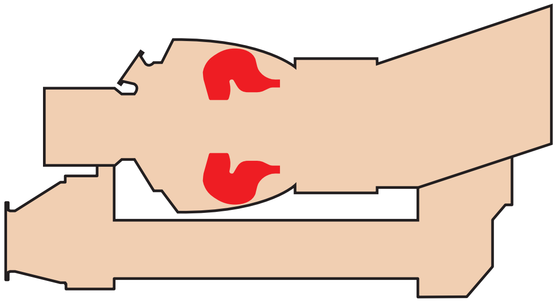
- Central section of the gas generator.

Main characteristics

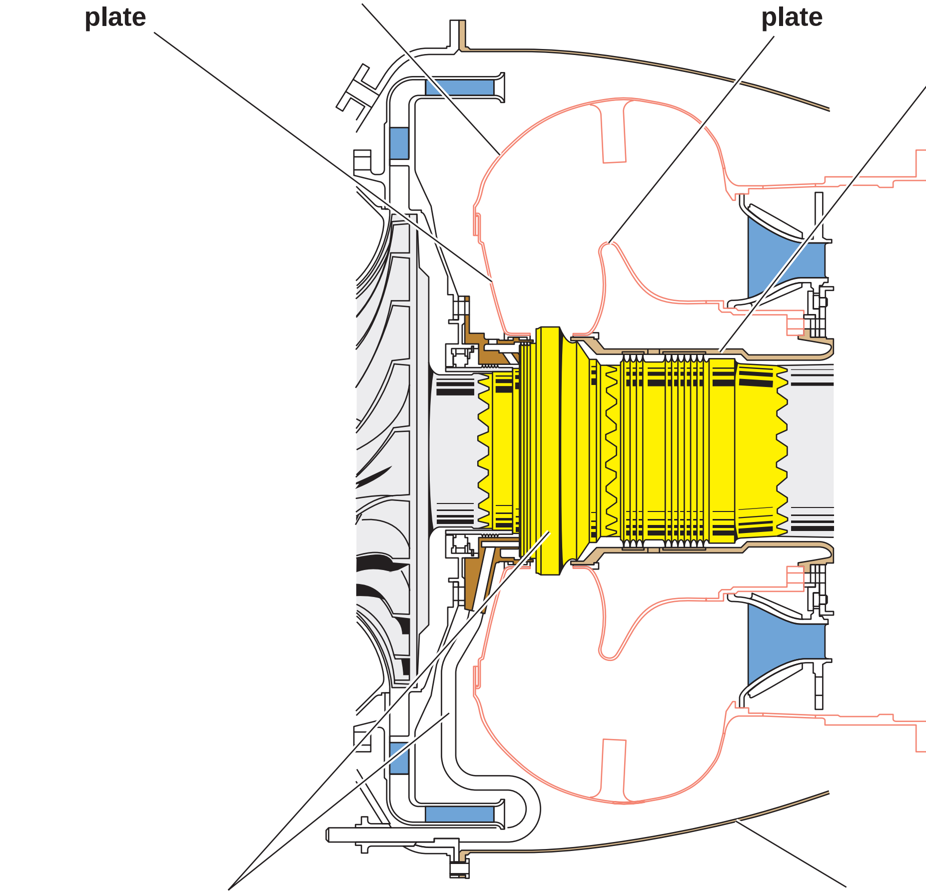
- Type: annular with centrifugal fuel injection.

Main components

- Outer part (front swirl plate and mixer unit)
- Inner part (rear swirl plate and shroud)
- Fuel injection system
- Casing.



Type:
Annular with centrifugal fuel injection



COMBUSTION CHAMBER - GENERAL

COMBUSTION CHAMBER - DESCRIPTION

The combustion chamber assembly (part of module M03) includes the outer part, the inner part, the turbine casing and the fuel injection system.

Outer part

The outer part includes the front swirl plate and the mixer unit. **The front swirl plate** is provided with calibrated orifices for the passage of primary air; it is secured to the mixer unit with special rivets.

The mixer unit is provided with calibrated orifices for the passage of dilution air; it is bolted to the rear flange of the turbine casing.

Inner part

The inner part includes the rear swirl plate and the shroud.

The rear swirl plate is provided with calibrated orifices for the passage of primary air.

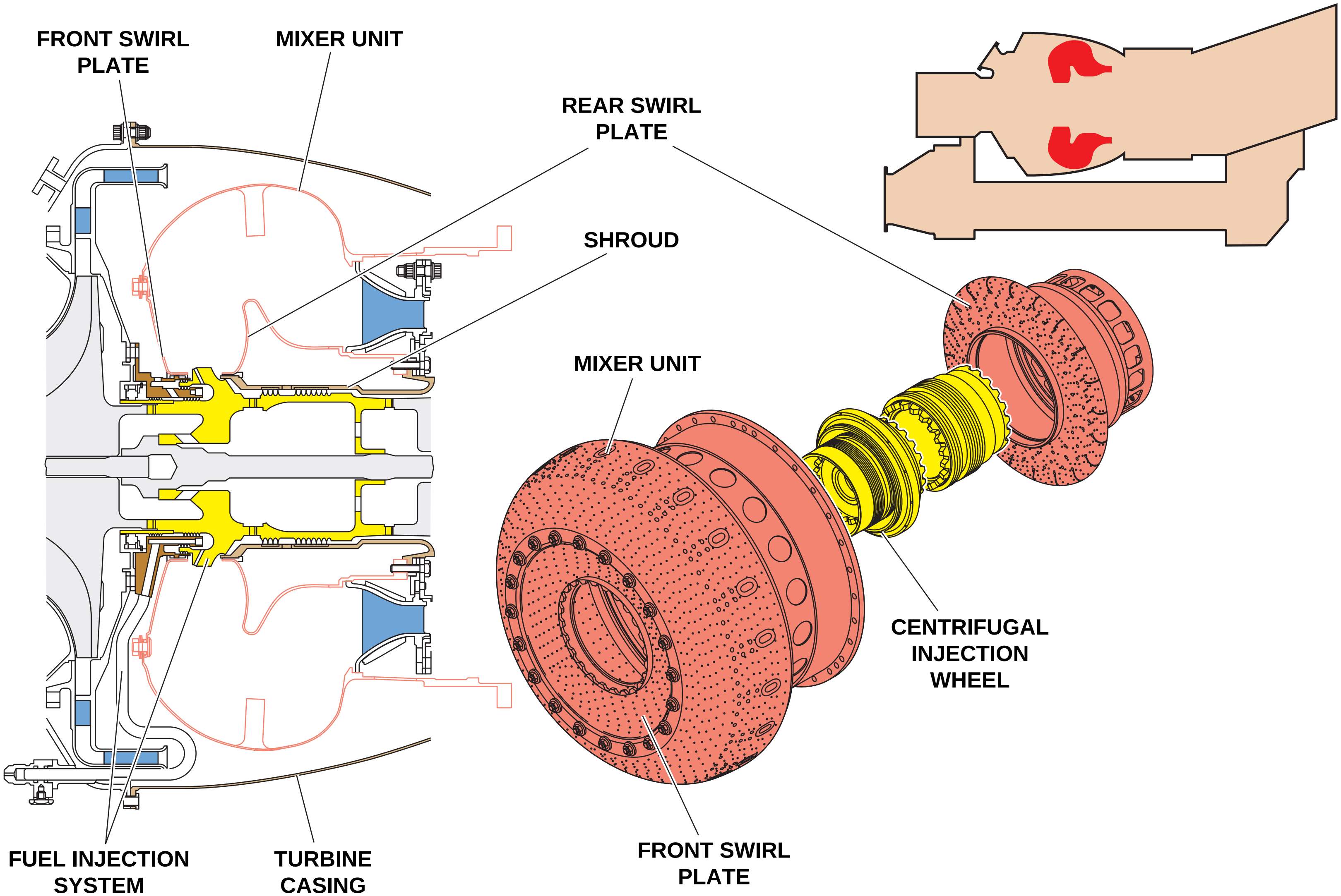
The shroud, integral with the rear swirl plate surrounds the shaft; it is bolted to the turbine nozzle guide vane.

***Note**: The two parts are made of special alloy. The calibrated orifices are drilled using the electron beam process.*

Fuel injection system

The main fuel injection system includes: the fuel inlet union, the radial fuel tube, the fuel distributor and the centrifugal injection wheel.

The injection wheel is mounted by means of curvic couplings between the compressor and the turbine shaft (refer to "FUEL SYSTEM" chapter for further details on the fuel injection system).



COMBUSTION CHAMBER - DESCRIPTION

COMBUSTION CHAMBER - OPERATION

The combustion chamber forms an enclosure in which the fuel/air mixture is burnt.

Combustion chamber flow

In the combustion chamber, the compressed air is divided into two flows: a primary air flow mixed with the fuel for combustion and a secondary air flow (or dilution air flow) for cooling of the burnt gases.

Primary air

One part flows through the orifices of the front swirl plate.

A second part flows through the hollow vanes of the turbine nozzle guide vane (cooling of the vanes) and through the orifices of the rear swirl plate.

The primary air is mixed with the fuel sprayed by the injection wheel. The combustion occurs between the two swirl plates. The flame temperature reaches approximately 2500 °C (4532 °F).

Secondary air

The secondary air (or dilution air) flows through the orifices of the mixer unit. It is calibrated to obtain flame stability, cooling of the burnt gases, and distribution of temperature on the turbine.

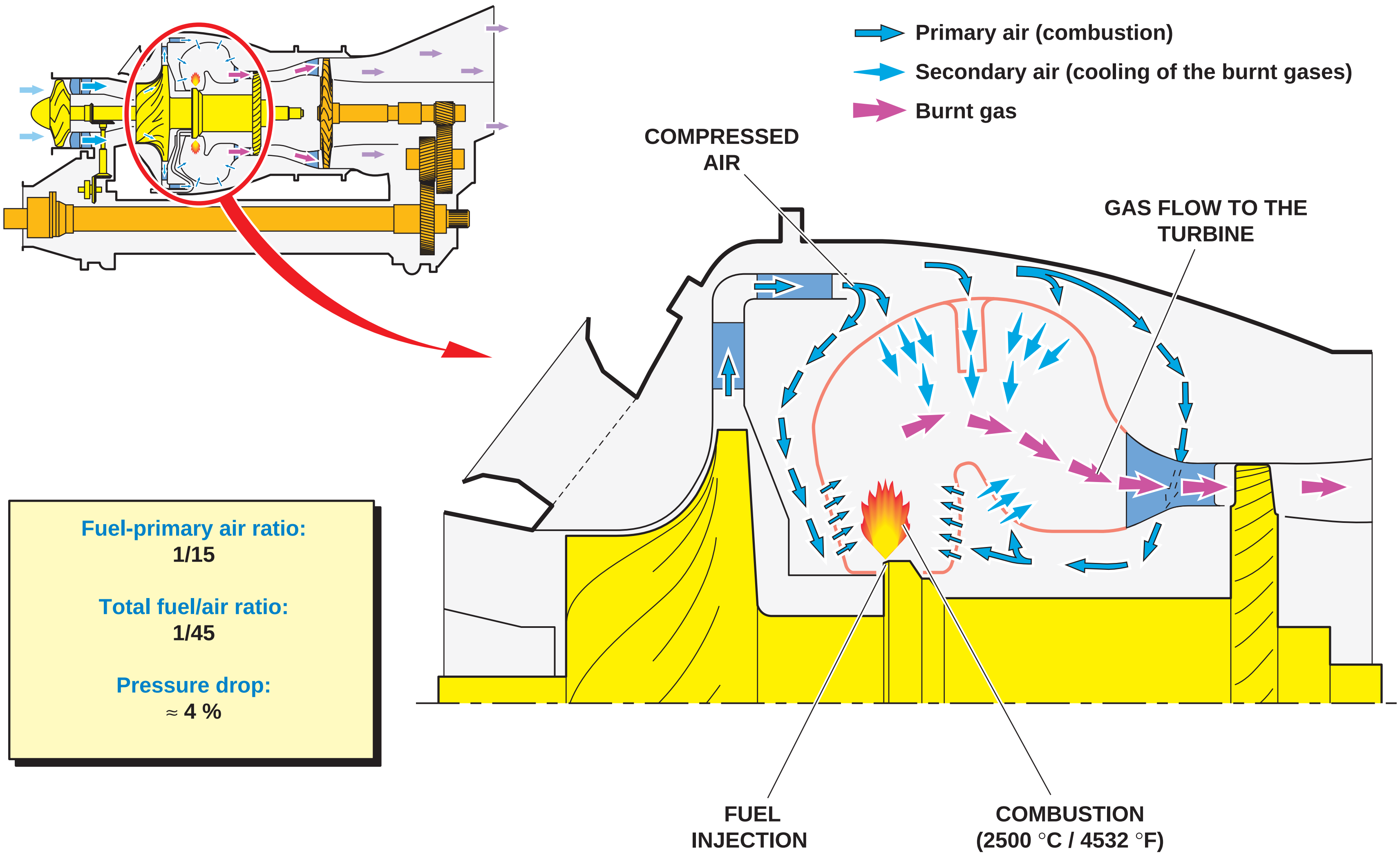
Gas

The gas produced by the combustion is directed into the turbine nozzle guide vane.

Operating parameters

The fuel/air ratio for combustion (primary air) is approximately 1/15; the total ratio is approximately 1/45.

The pressure drop in the combustion chamber is approximately 4 %.



Fuel-primary air ratio:
1/15

Total fuel/air ratio:
1/45

Pressure drop:
≈ 4 %

COMBUSTION CHAMBER - OPERATION

GAS GENERATOR TURBINE - GENERAL

Function

The turbine extracts sufficient energy from the gas flow to drive the compressor and the accessories.

Position

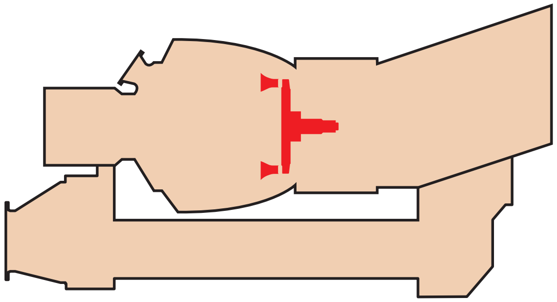
- At the rear of the gas generator.

Main characteristics

- Type: axial, single stage
- Turbine inlet temperature: 1100 °C (2012 °F)
- Rotation speed: N1; ACW.

Main components

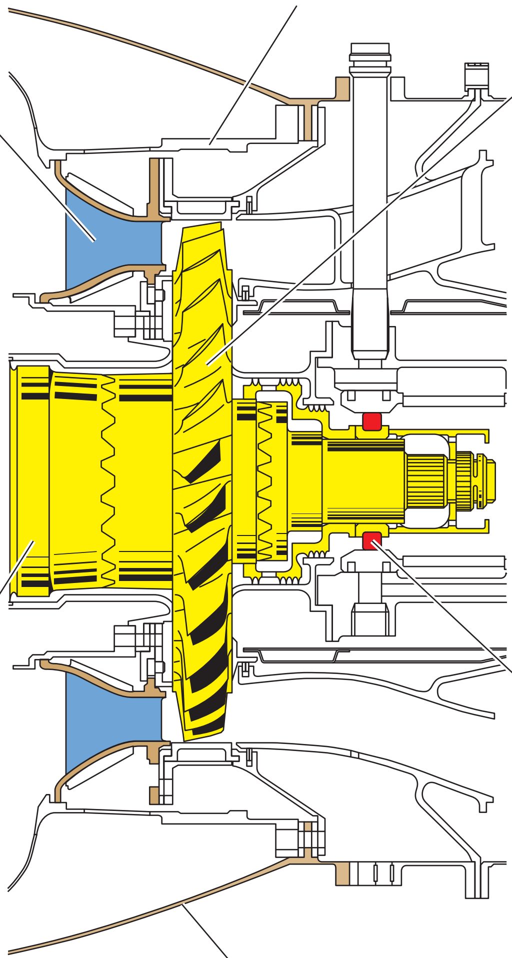
- Rotating components (wheel, shafts, bearing)
- Stationary components (nozzle guide vane, containment shield, casing).



Type:
Axial, single stage

Turbine inlet temperature:
1100 °C (2012 °F)

Rotation speed:
N1; ACW



GAS GENERATOR TURBINE - GENERAL

GAS GENERATOR TURBINE - DESCRIPTION

The gas generator turbine assembly (part of module M03) includes rotating components and stationary components.

Rotating components

The main rotating component is the turbine wheel.

The turbine wheel consists of a disc and fir-tree mounted, single crystal blades.

At the front, the wheel is coupled by a curvic-coupling to the turbine shaft . At the rear, the wheel is coupled to a stub shaft.

The rear part is supported by a roller bearing. Rotating labyrinths provide sealing.

A tie-bolt secures the rotating assembly.

Stationary components

The main stationary components are the nozzle guide vane, the turbine shroud and the exhaust diffuser.

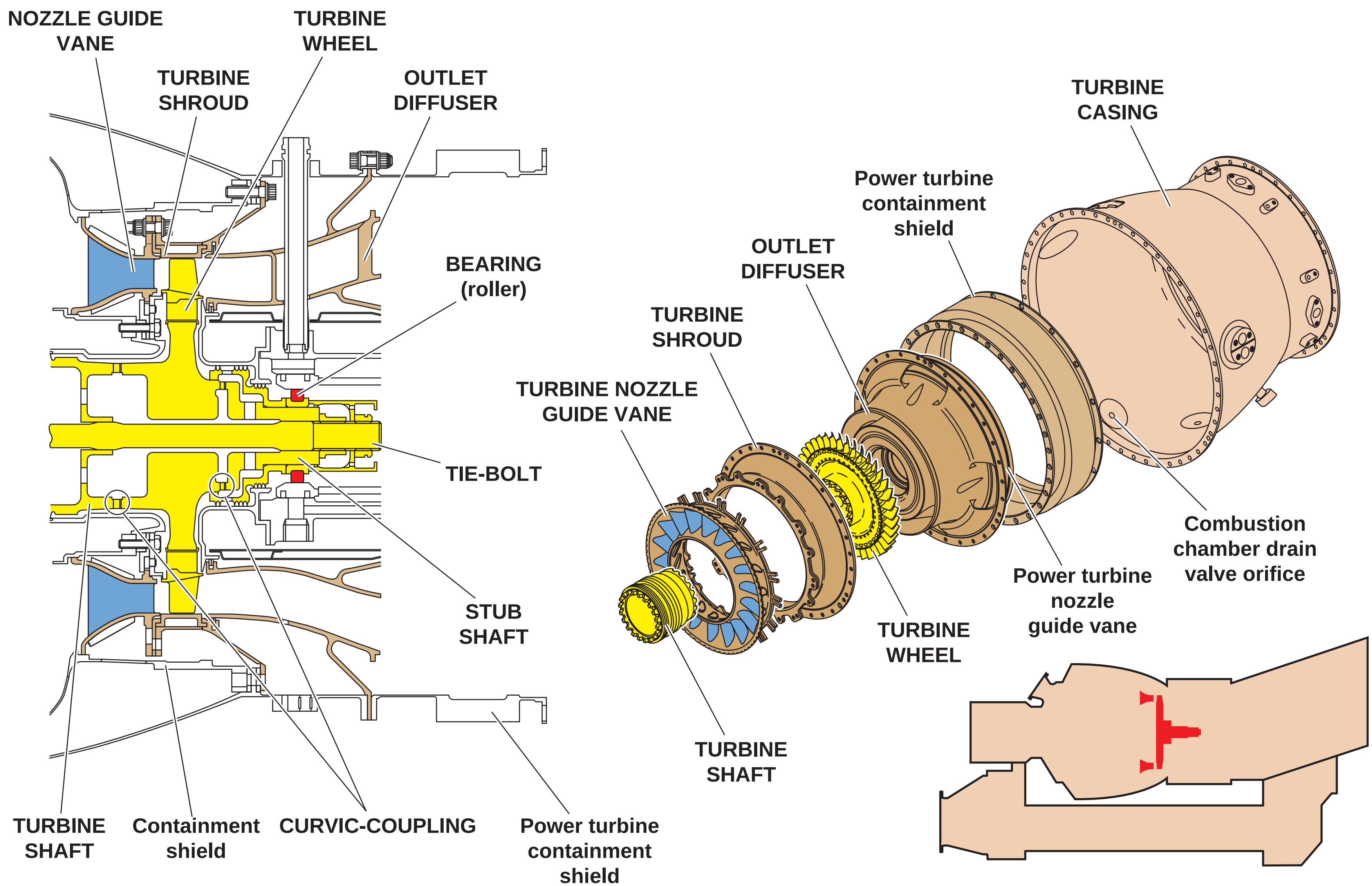
The nozzle guide vane includes a row of hollow vanes. It is bolted to the combustion chamber inner part and to the containment shield.

The turbine shroud accommodates the turbine components and the containment shield. It is bolted to the nozzle guide vane and to the inner flange of the turbine casing.

The outlet diffuser ensures the gas flow between the gas generator and the power turbine. Its inner hub provides the location for the rear bearing. It also incorporates the power turbine nozzle guide vane.

The power turbine containment shield secured to the outlet diffuser is part of the module M03.

The turbine casing houses the combustion chamber and the turbine. It has various bosses and, particularly the boss for the combustion chamber drain valve at the bottom of the casing.



GAS GENERATOR TURBINE - DESCRIPTION

GAS GENERATOR TURBINE - OPERATION

The gas generator turbine transforms the gas energy into mechanical power to drive the compressors and various accessories.

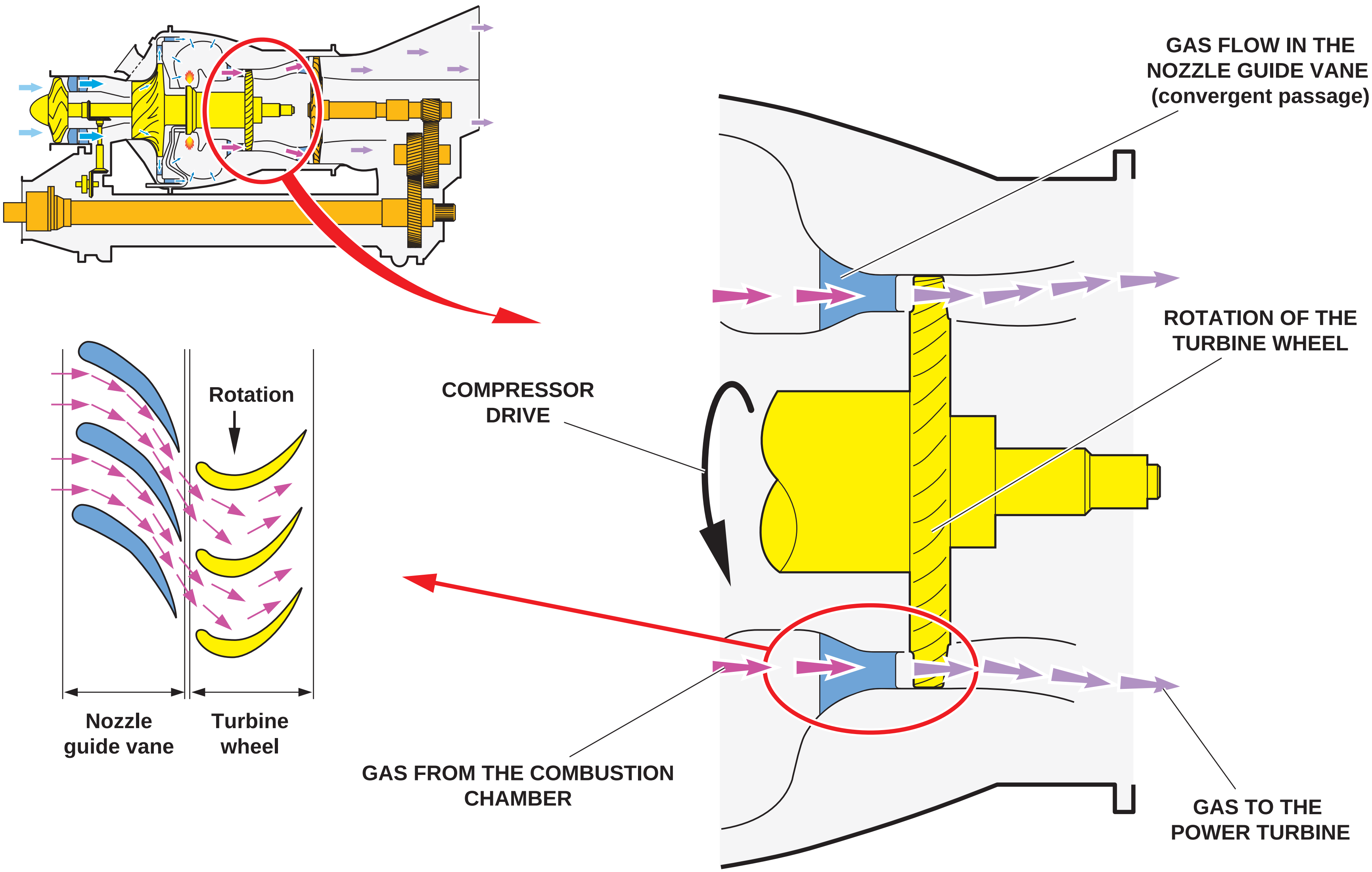
The operation is characterized by the first phase of expansion.

Turbine gas flow

The burnt gas first flows through the nozzle guide vanes. The gas velocity increases due to the convergent passage.

The flow on the blades results in aerodynamic forces whose resultant causes the rotation of the wheel.

The gas, still containing energy, is directed to the power turbine.



GAS GENERATOR TURBINE - OPERATION

POWER TURBINE - GENERAL

Function

The turbine extracts the energy from the gas to drive the power shaft through the reduction gearbox.

Position

- Between the gas generator and the reduction gearbox.

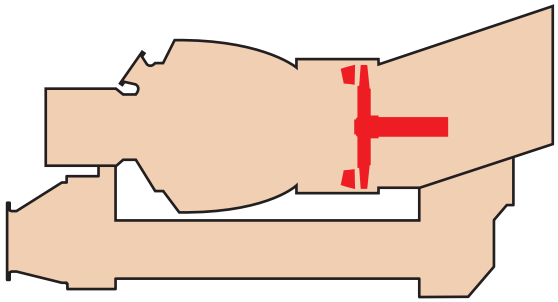
It forms the module M04.

Main characteristics

- Type: axial, single-stage
- Rotation speed: N2; CW.

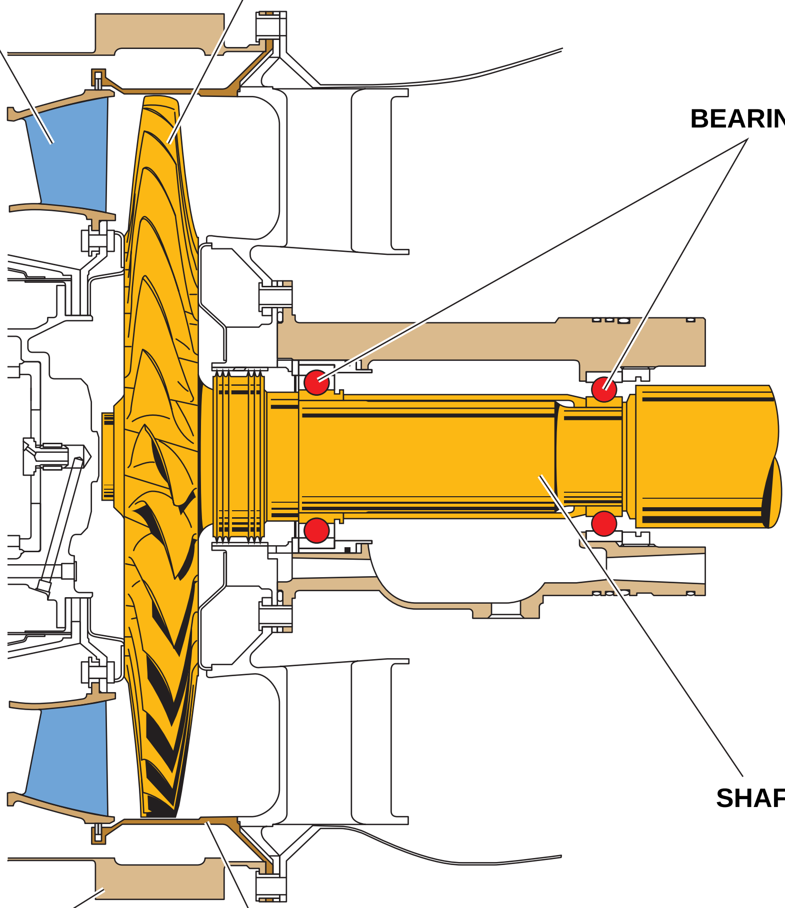
Main components

- Rotating components (wheel, shaft, bearings)
- Stationary components (nozzle guide vane, containment shield, casing).



Type:
Axial, single stage

Rotation speed:
N2; CW



POWER TURBINE - GENERAL

POWER TURBINE - DESCRIPTION

The power turbine assembly forms the module M04. It includes rotating components and stationary components.

Rotating components

The main rotating component is the power turbine wheel with its shaft.

The power turbine wheel includes a disc (integral with the shaft) and fir-tree mounted directionally solidified blades.

The shaft is supported by two bearings: a front ball bearing and a rear ball bearing.

The front bearing sealing is ensured by a pressurised labyrinth seal (pressurisation with compressor air directed to the power turbine through an external pipe and inner ducts).

The power is transmitted to the reduction gear by a muff coupling.

Stationary components

The main stationary components are the turbine nozzle guide vane, the power turbine casing and the bearing housing.

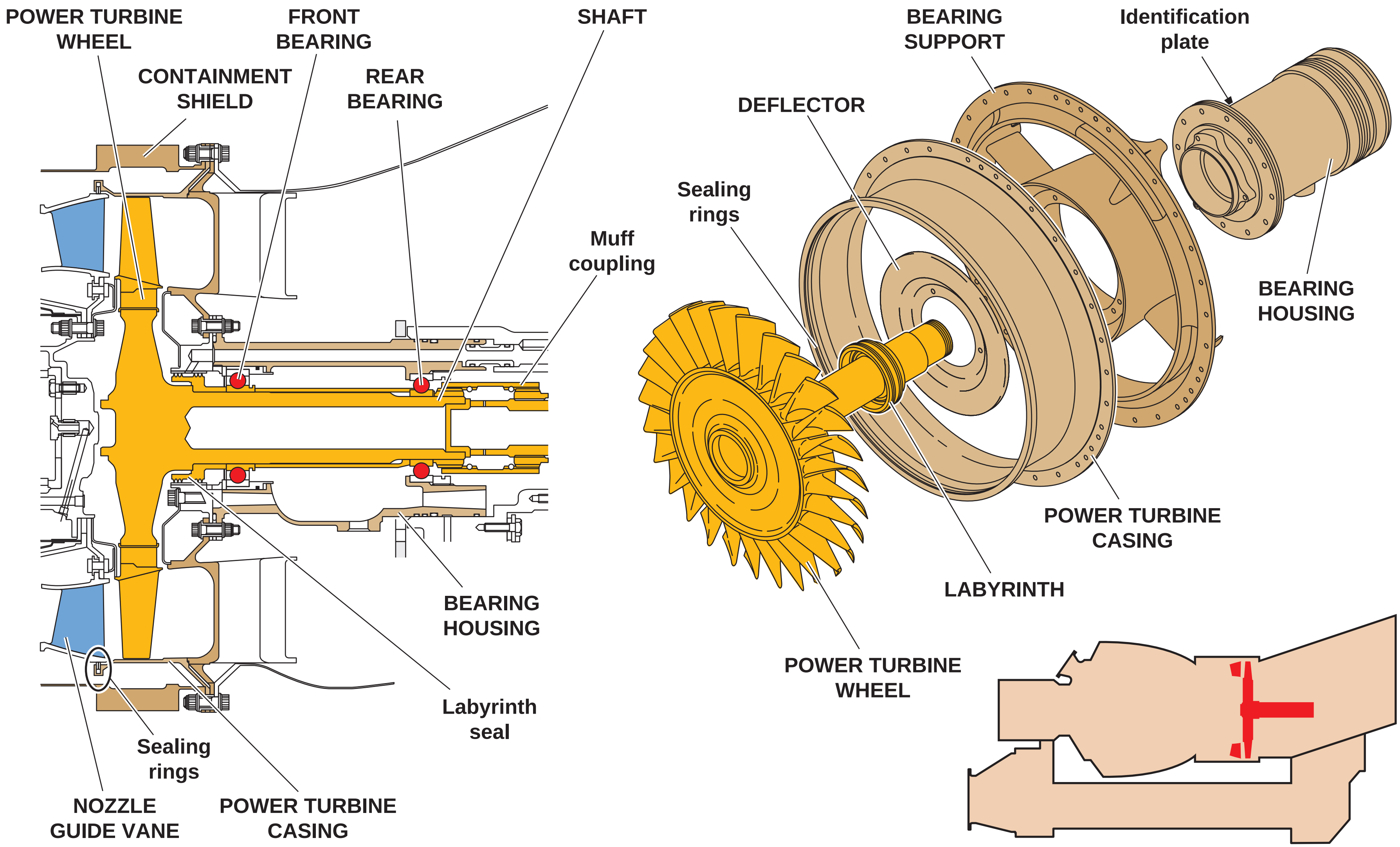
The nozzle guide vane includes a row of vanes. It is part of the module M03.

The power turbine casing engages in the exhaust diffuser and is retained by 3 screws. It is bolted to the containment shield together with the exhaust pipe. It comprises an outer casing and an inner hub supported on four struts.

Two sealing rings are used for sealing between the power turbine casing and the power turbine nozzle guide vane.

The bearing housing is installed in the inner hub of the casing. Its rear part is engaged in the reduction gearbox. A fork shaped steel plate prevents rearward movement of the power turbine in case of overspeed; it is secured to the reduction gearbox front cover.

The identification plate is located on the bearing housing.



POWER TURBINE - DESCRIPTION

POWER TURBINE - OPERATION

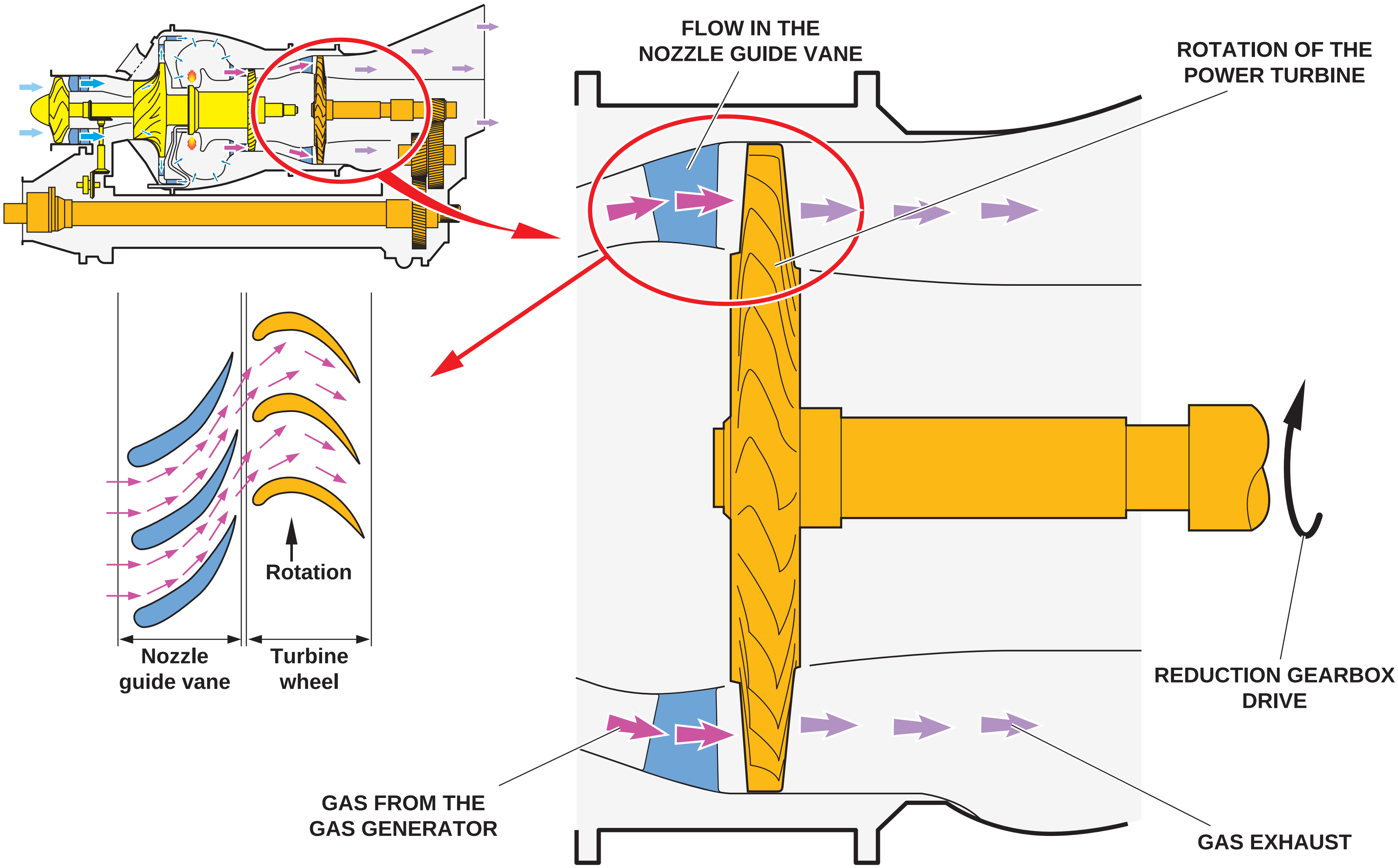
The power turbine transforms the gas energy into mechanical power to drive the reduction gearbox.

The operation is characterised by the second phase of expansion.

Turbine flow

The gas supplied by the gas generator flows first through the nozzle guide vane. In the nozzle guide vane, the gas velocity increases due to the convergent passage.

The gases are directed onto the turbine wheel and the resultant of the aerodynamic forces on the blades causes the wheel to rotate. The gases are then expelled overboard through the exhaust pipe.



POWER TURBINE - OPERATION

EXHAUST SYSTEM

Function

The exhaust pipe continues the expansion phase and expels the gas overboard.

Position

- Behind the power turbine, around the reduction gear.

Main characteristics

- Type: elliptical
- Non-modular part
- Gas temperature: 670 °C (1238 °F).

Main components

- Exhaust pipe
- Heat shield.

***Note**: The exhaust pipe is considered to be an SRU (Shop Replaceable Unit).*

Description

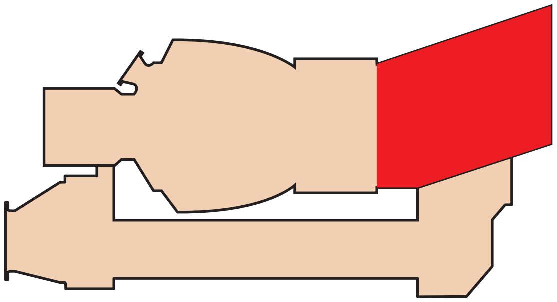
The exhaust pipe, which has an elliptical outlet, is made from stainless steel. It is bolted to the rear flange of the power turbine casing with the containment shield.

A heat shield is fitted between the exhaust pipe and the reduction gearbox to protect the gearbox from the exhaust heat.

The exhaust pipe has a drain at the bottom.

Operation

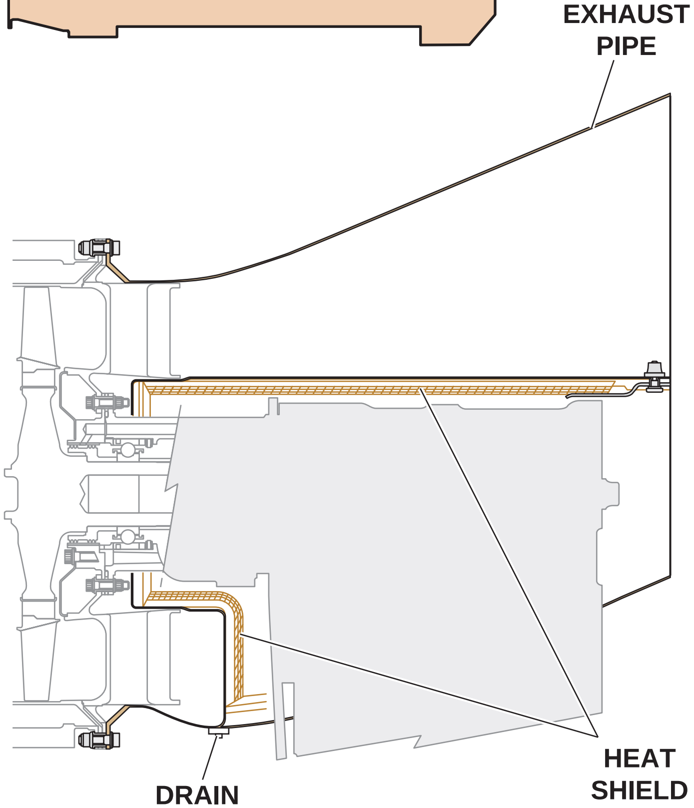
Functionally it should be noted that the exhaust gas still contains a certain amount of energy which produces a small residual thrust.



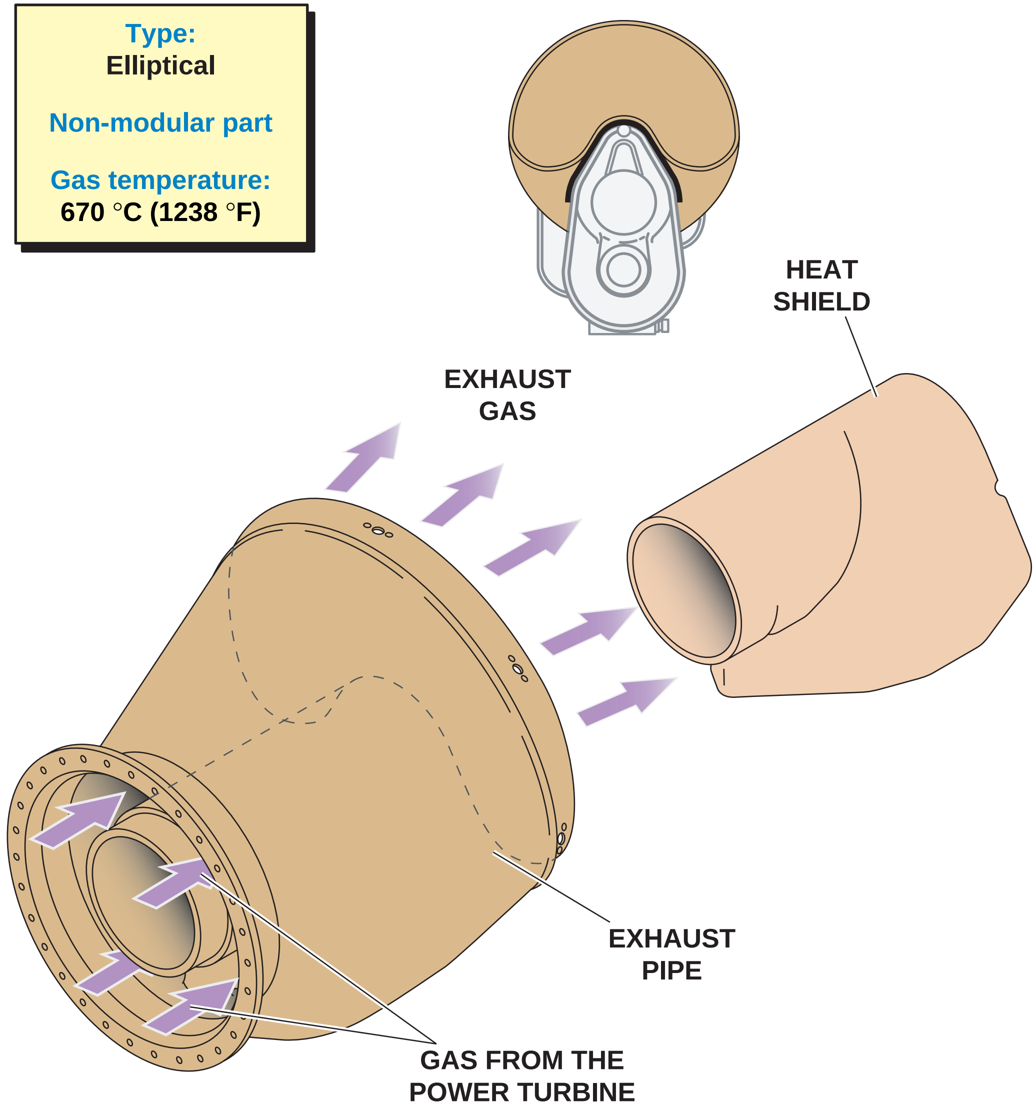
Type:
Elliptical

Non-modular part

Gas temperature:
670 °C (1238 °F)



DESCRIPTION



EXHAUST SYSTEM

REDUCTION GEARBOX - GENERAL

Function

The reduction gearbox provides a reduced speed output and transmits the drive forwards.

Position

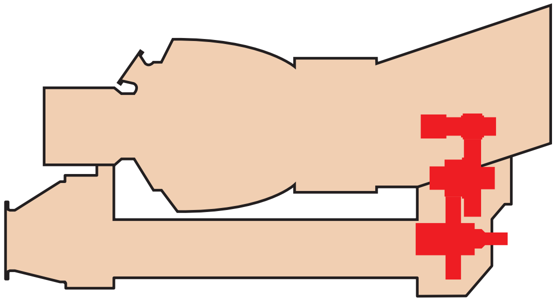
- At the rear of the engine
- It forms the module M05.

Main characteristics

- Type: 3 stage, helical gears
- Drive gear speed: N2
- Output gear speed: 5990 RPM.

Main components

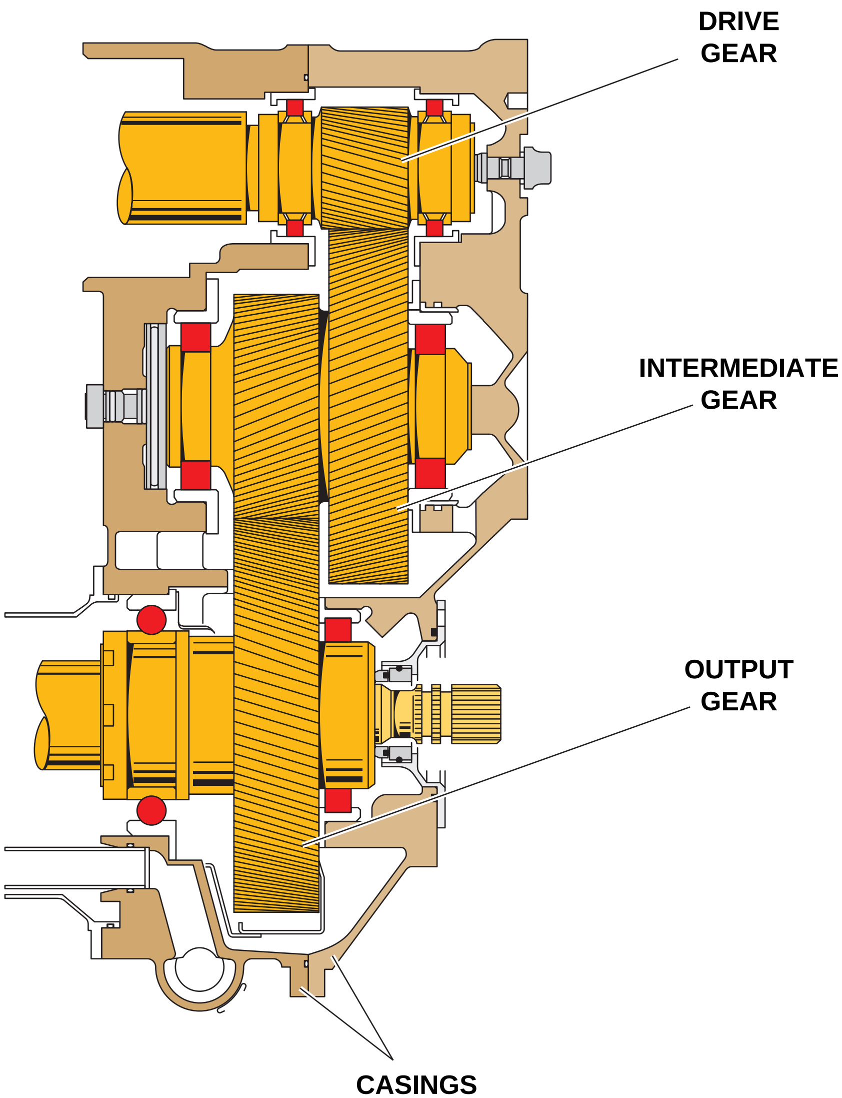
- Drive gear
- Intermediate gear
- Output gear
- Casings.



Type:
3 stage, helical gears

Drive gear speed:
N2

Output gear speed:
5990 RPM



REDUCTION GEARBOX - GENERAL

REDUCTION GEARBOX - DESCRIPTION - OPERATION

The reduction gearbox module mainly includes three gears contained in two half casings.

Drive gear

The drive gear is driven by the power turbine through a muff coupling. It is supported by two roller bearings.

Intermediate gear

The intermediate gear is a double helical type gear: one gear meshes with the drive gear, the other one with the output gear. The intermediate gear is supported by two roller bearings. A piston is fitted to the intermediate gear with its head located in the gearbox front casing. It is supplied with oil pressure to balance the load on the gear.

Output gear

The output gear is a simple gear supported by a ball bearing at the front and a roller bearing at the rear.

The hub is internally splined to receive the transmission shaft. It rotates at 5990 RPM.

Note: *The output gear is also used as a phonic wheel for detection of power turbine rotation speed. Refer to "MEASUREMENT AND INDICATING SYSTEMS" chapter for further details.*

Reduction gearbox casing

The gears are housed in a light alloy casing (front and rear casings). A fork shaped steel plate is mounted on the front face of the casing to prevent rearward movement of the power turbine in the event of overspeed.

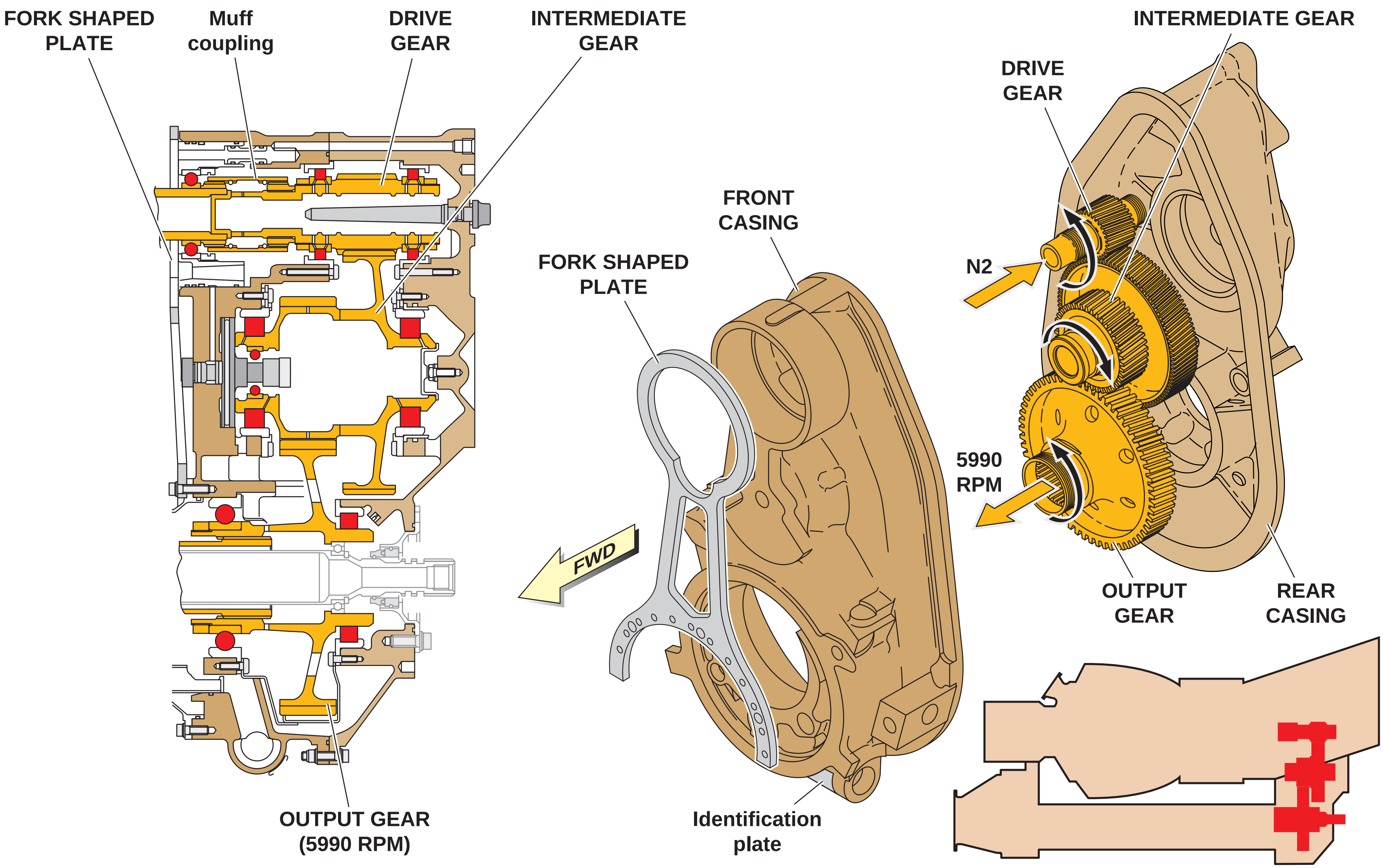
The module identification plate is located at the bottom of the casing.

Operation of the reduction gear

The reduction gear provides a forward output drive at a reduced speed.

The drive gear is directly driven by the power turbine shaft (muff coupling drive). It transmits the movement to the intermediate gear.

The intermediate gear drives the output gear which provides the power drive at a speed of approximately 5990 RPM, clockwise.



REDUCTION GEARBOX - DESCRIPTION - OPERATION

TRANSMISSION SHAFT AND ACCESSORY GEARBOX - GENERAL

Function

The shaft transmits the power to the front of the engine.

The accessory gearbox provides the drive for the engine accessories.

Position

- Shaft beneath the engine
- Accessory gearbox at the front of the engine
- This assembly forms the module M01.

Main characteristics

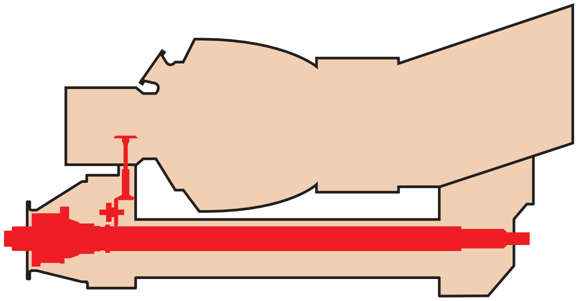
- Type of gears: bevel and spur gears.

Main components

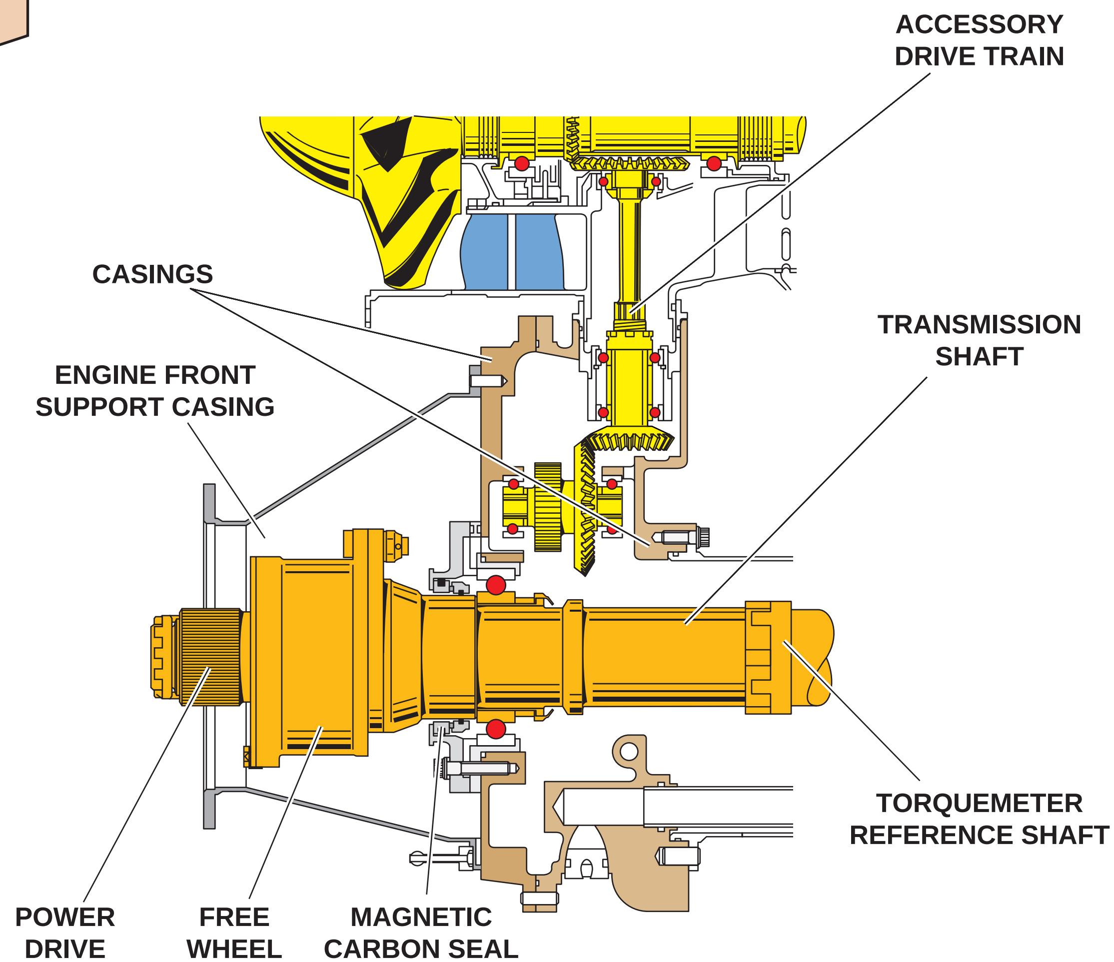
- Transmission shaft
- Torquemeter reference shaft
- Free wheel
- Power drive
- Accessory drive train
- Casings
- Engine front support casing.

Note 1: *The alternator drive gear also includes a phonic wheel for detection of the gas generator rotation speed. Refer to "MEASUREMENT AND INDICATING SYSTEMS" chapter for further details.*

Note 2: *The transmission shaft also includes a torquemeter. Refer to "MEASUREMENT AND INDICATING SYSTEMS" chapter for further details.*



Type of gears:
Bevel and spur gears



TRANSMISSION SHAFT AND ACCESSORY GEARBOX - GENERAL

TRANSMISSION SHAFT AND ACCESSORY GEARBOX - DESCRIPTION (1)

The module M01 comprises mainly the output shaft protection tube, the accessory gearbox and the engine front support. It is this module which provides the rigidity of the engine.

At the rear of the protection tube is the flange for attachment to module M05.

The accessory gearbox is provided with mounting flanges for various accessories.

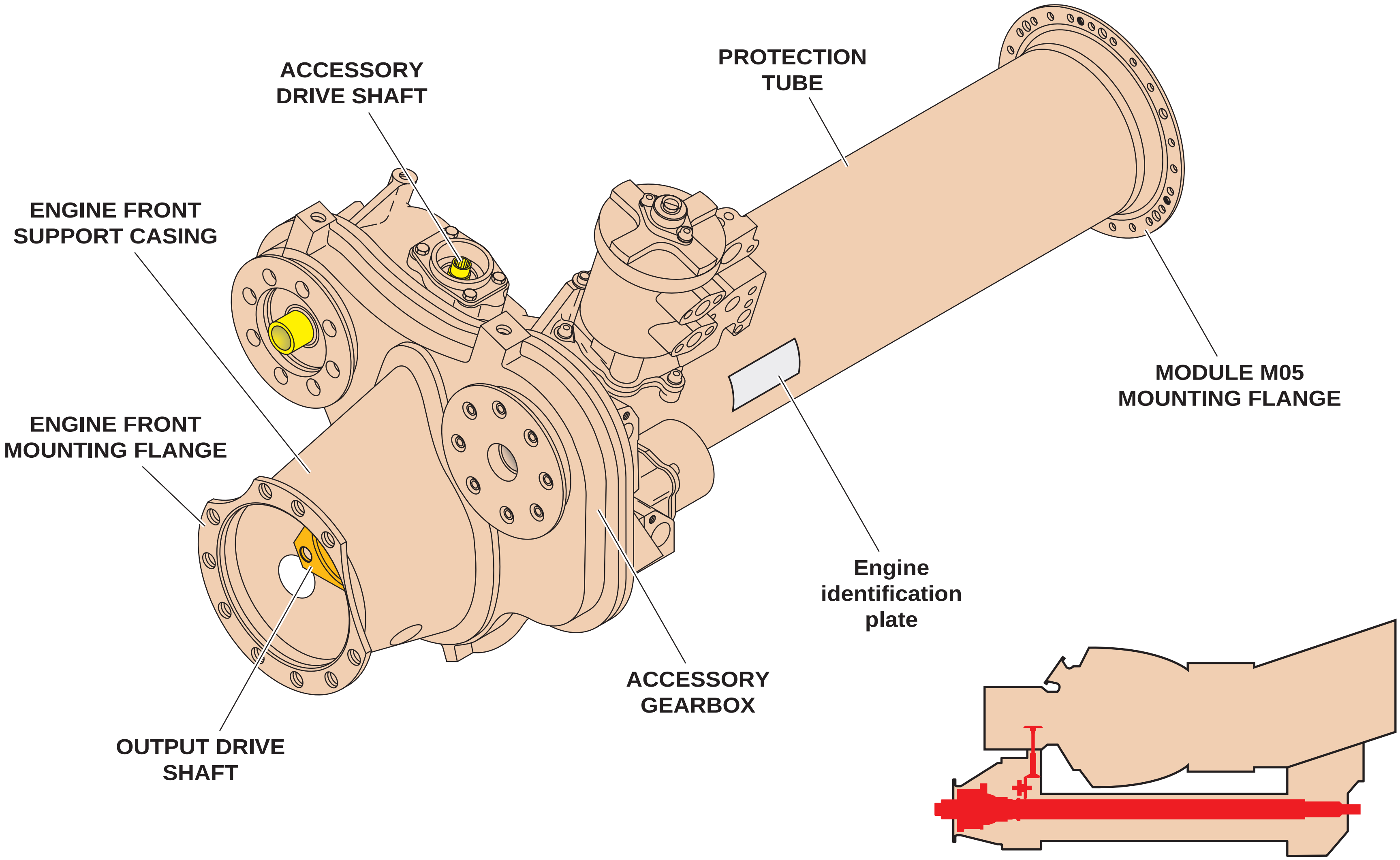
The engine front support casing is bolted to the accessory gearbox front face.

The output drive shaft is located in the engine front support casing.

The engine front support casing is installed on the front face of the gearbox.

The module identification plate is located on the protection tube right hand side.

The engine identification plate is located on the protection tube left hand side.



TRANSMISSION SHAFT AND ACCESSORY GEARBOX - DESCRIPTION (1)

TRANSMISSION SHAFT AND ACCESSORY GEARBOX - DESCRIPTION (2)

Transmission shaft

The shaft assembly takes the drive from the reduction gear to the accessory gearbox. The shaft itself is located in a protection tube bolted to the reduction gearbox at the rear and to the accessory gearbox at the front. The front of the shaft is supported by a ball bearing. The power drive flange is mounted on the shaft splines. Sealing of the oil which lubricates the bearing is ensured by a carbon seal.

Three oil tubes are located in the protection tube.

Accessory gearbox

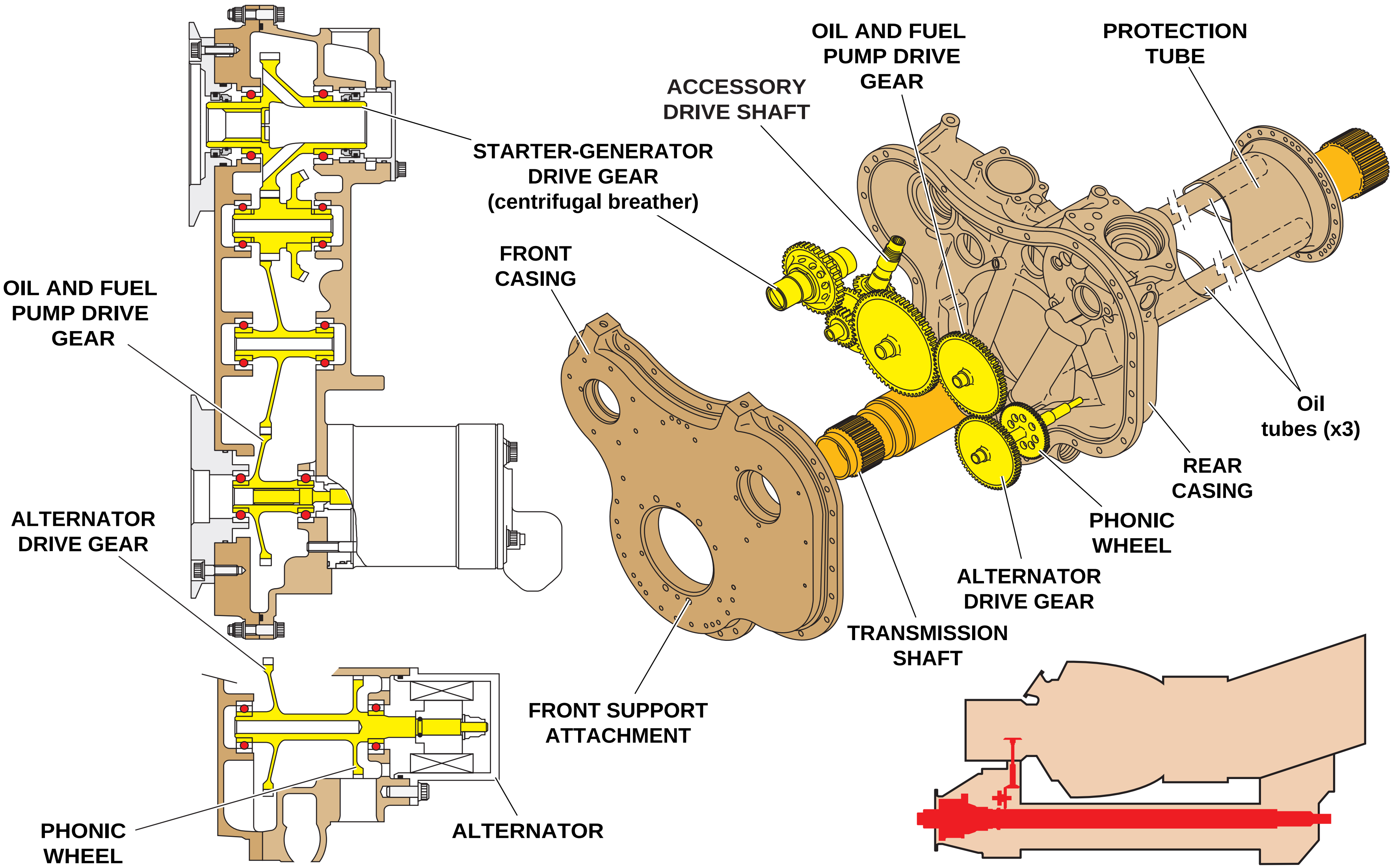
The gearbox assembly includes a train of gears housed in a light alloy casing. The gearbox is installed under the axial compressor by means of four bolts.

The front face of the gearbox accommodates the following drives:

- Starter-generator
- Fuel pumps
- Main output drive.

The rear face of the gearbox accommodates the following drives:

- Oil pumps
- Alternator.



TRANSMISSION SHAFT AND ACCESSORY GEARBOX - DESCRIPTION (2)

TRANSMISSION SHAFT AND ACCESSORY GEARBOX - DESCRIPTION (3)

Function

The shaft transmits the power from the reduction gearbox to the helicopter.

Position

Lower part of the engine.

Main characteristics

- Hollow steel shaft with co-axial output shaft
- Drive through freewheel unit.

Main components

- Transmission shaft
- Protection tube
- Output shaft
- Freewheel unit.

Description

The front of the transmission shaft is supported by a ball bearing in the accessory gearbox and the rear by the reduction gearbox output gear. Sealing is ensured by carbon magnetic seal at the front and the rear.

A triangular flange is fitted on the shaft front splines. A freewheel unit is mounted on the flange to drive the co-axial output shaft which in turn drives the helicopter main gearbox and tail rotor.

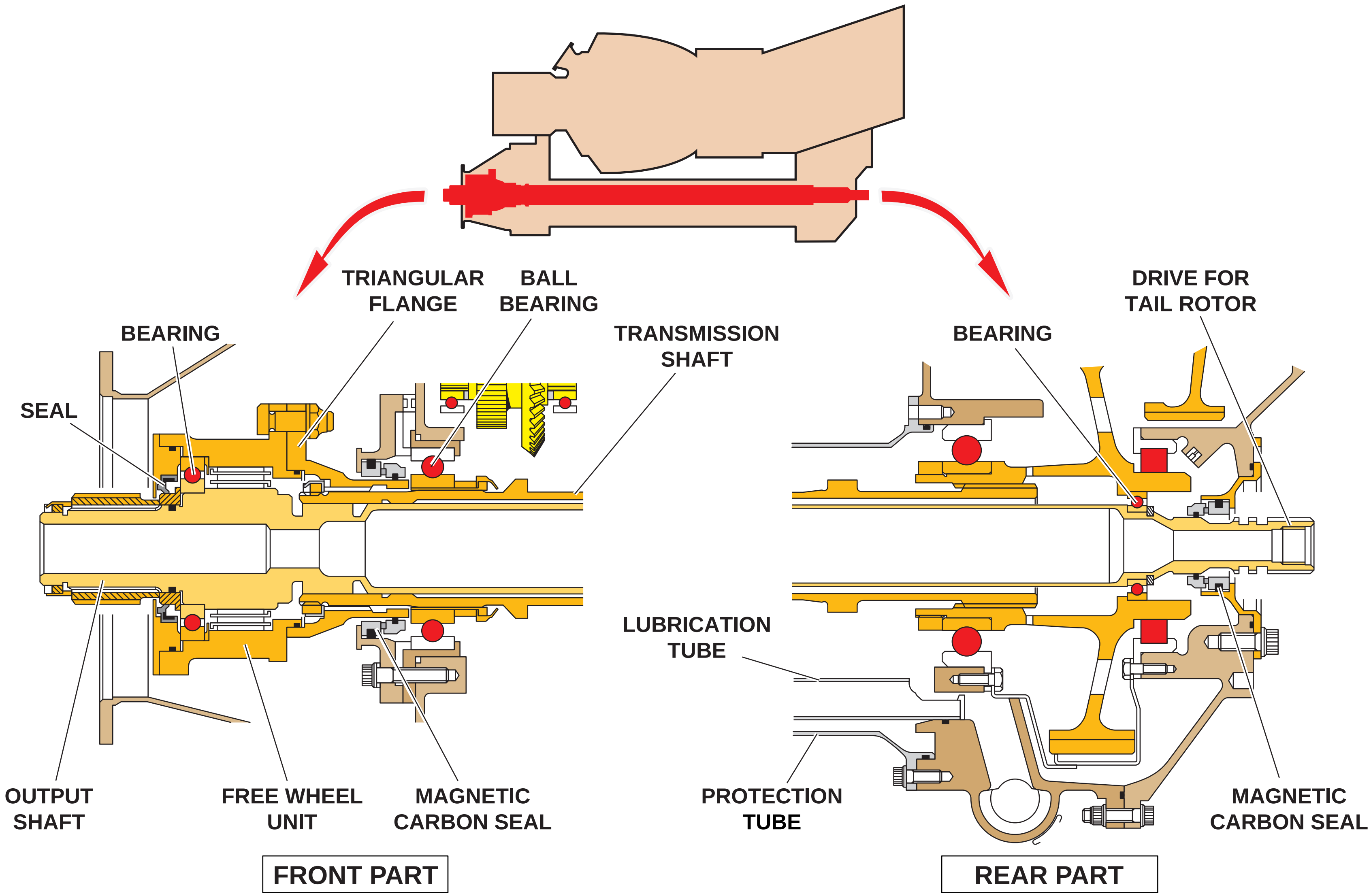
The output shaft is supported at the front by the triangular flange and at the rear by a bearing in the hub of the reduction gearbox output gear.

Three oil tubes are fitted inside the protection tube to transmit oil between the reduction and accessory gearboxes.

Operation

The transmission shaft drives the output shaft through the freewheel unit to drive the MGB and tail rotor. In the event of autorotation the free wheel disengages.

Note: *The freewheel unit and shaft assembly is supplied by the aircraft manufacturer.*



TRANSMISSION SHAFT AND ACCESSORY GEARBOX - DESCRIPTION (3)

TRANSMISSION SHAFT AND ACCESSORY GEARBOX - DESCRIPTION (4)

Sealing of drives

Sealing of the various drives is ensured by seals fitted either in the support casing or in the accessory.

Main power drive

This is ensured by a magnetic carbon seal fitted in the accessory gearbox front casing.

Tail rotor drive

This is ensured by a magnetic carbon seal fitted in the reduction gearbox rear casing.

Starter-generator drive

A magnetic carbon seal is fitted in a support on the gearbox front casing.

Centrifugal breather gear (rear half of the starter-generator gear)

Sealed by a magnetic carbon seal mounted in a support on the rear face of the gearbox.

Note 1: ***Fuel pump drive***

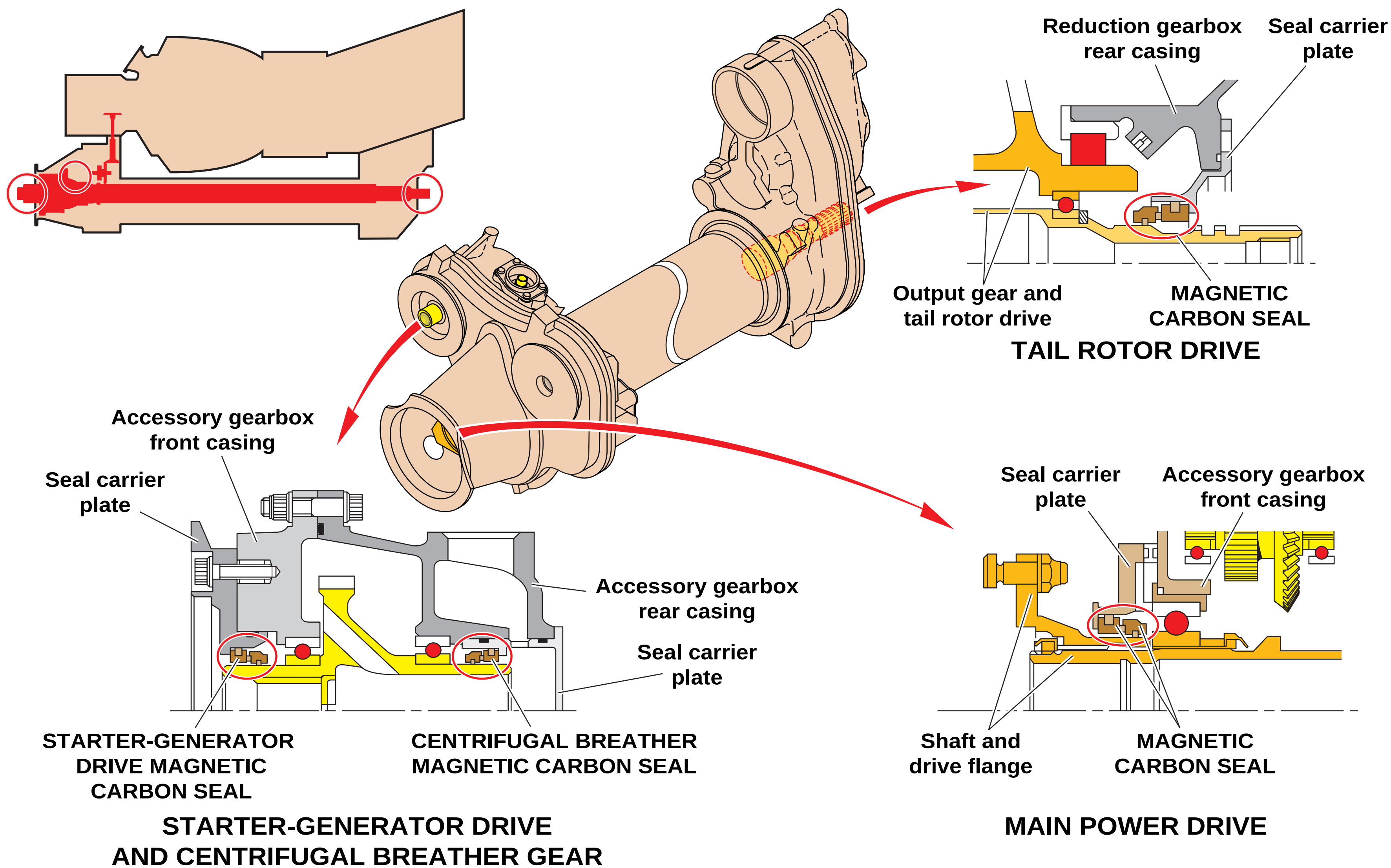
Seals fitted in the fuel pump casing (see "FUEL SYSTEM")

Note 2: ***Alternator drive***

No seal on the drive shaft. The alternator cover is sealed by an O'ring on the mounting flange (see "ELECTRICAL SYSTEM).

Note 3: ***Oil pump drive***

No seal on the drive shaft. An O'ring is fitted on the mounting flange (see "OIL SYSTEM").



SEALING OF DRIVES

TRANSMISSION SHAFT AND ACCESSORY GEARBOX - DESCRIPTION (4)

TRANSMISSION SHAFT AND ACCESSORY GEARBOX - OPERATION

The operation is considered during engine starting and in normal running.

Operation during engine starting

During starting, the starter motor drives the accessory gearbox and thus the gas generator rotating assembly.

The compressor supplies air to the combustion chamber and the starting sequence continues.

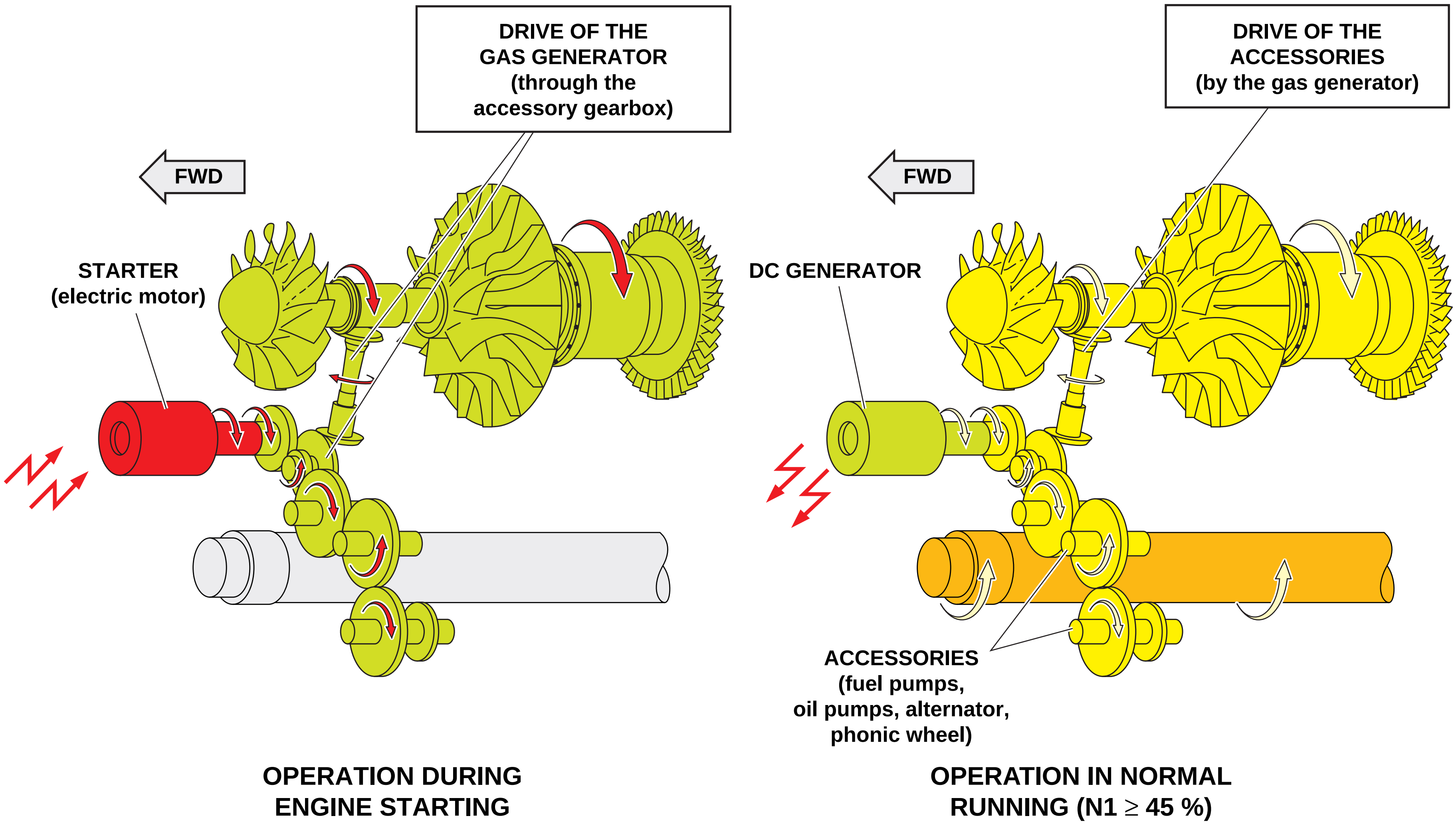
Operation in normal running

At self-sustaining speed (approximately 45 % N1) the electrical supply to the starter motor is automatically cut. The starter motor is then mechanically driven by the engine and operates as a generator to provide DC current to the aircraft electrical system.

The gas generator drives the accessory gear train through the bevel gear located between the axial compressor and the centrifugal compressor.

The following accessories are driven:

- Starter-generator
- Fuel pumps
- Oil pumps
- Alternator / phonic wheel.



TRANSMISSION SHAFT AND ACCESSORY GEARBOX - OPERATION

4 - OIL SYSTEM

(XX-XX-XX): Page references which deal with the subject in the maintenance documentation.

OIL SYSTEM - GENERAL

Function

The oil system ensures lubrication and cooling of the engine.

Position

All the components are fitted on the engine except the tank and cooler.

Main characteristics

- System type: variable pressure, full flow, dry sump, synthetic oil
- Max oil temperature: 115 °C (239 °F)
- Min oil pressure switch setting: 130 kPa (18.85 PSIG)
- Low oil pressure: 980 kPa (142.1 PSIG)
- Max oil consumption: 0.2 l/h.

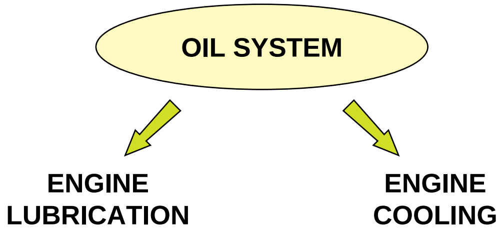
Lubrication requirements

Lubrication is required for the following components:

- Gas generator front bearings
  - Axial compressor bearing
  - Centrifugal compressor bearing
  - Accessory drive bearings
- Gas generator rear bearing
- Power turbine bearings
- Reduction gearbox
- Accessory gearbox.

Sealing

Gas generator and power turbine bearings are sealed by pressurized labyrinths, which are provided with abradable deposits.



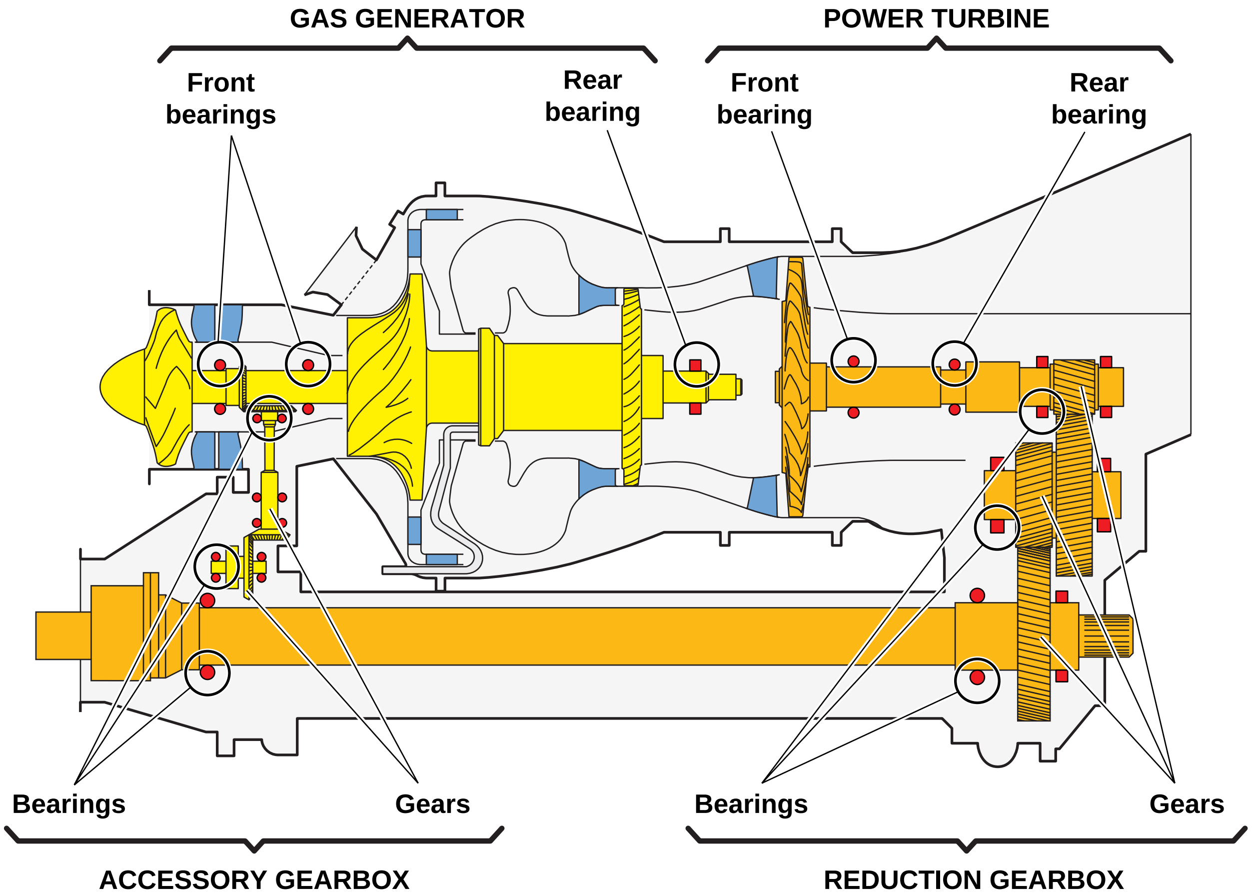
Type:
Variable pressure, full flow, dry sump, synthetic oil

Max oil temperature:
115 °C (239 °F)

Low oil pressure switch setting:
130 kPa (18.85 PSIG)

Max oil pressure:
980 kPa (142.1 PSIG)

Max oil consumption:
0.2 l/h



Sealing:
Gas generator and power turbine bearings are sealed by pressurized labyrinths, which are provided with abradable deposits.

OIL SYSTEM - GENERAL

OIL SYSTEM - DESCRIPTION

The system contains all the components necessary for engine lubrication: tank, pumps, filter, cooler, breather and indicating devices.

Oil tank

The oil tank contains the volume of oil required to lubricate the engine. It is supplied by the aircraft manufacturer.

Oil pumps

The oil pump pack contains one pressure pump and three scavenge pumps. The gerotor type pumps are driven by the accessory gearbox. The pressure pump is equipped with a pressure relief valve.

Oil valve assembly

The oil valve assembly houses a check valve, an electrical magnetic plug and the strainer for the gas generator rear bearing.

Oil filter

The oil filter retains any particles which may be present in the oil. It is provided with a by-pass valve and a pre-blockage indicator. It also forms a heat exchanger with the fuel system.

Scavenge strainers

The scavenge strainers protect the scavenge pumps from debris in the system.

Magnetic plugs

Mechanical magnetic plugs are fitted upstream of the scavenge pumps. An electrical magnetic plug is fitted at the scavenge outlet.

Oil cooler

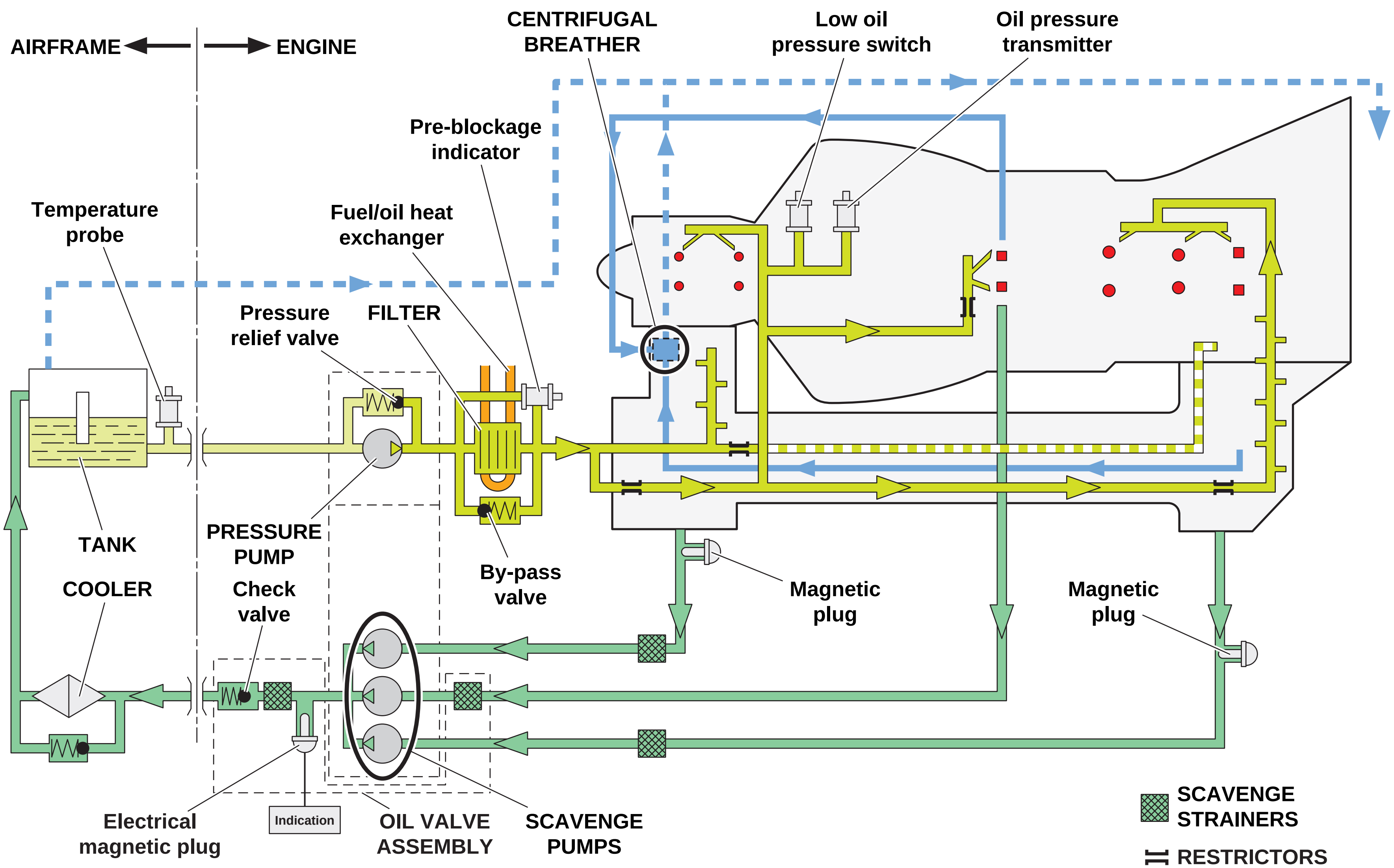
The air cooled oil cooler cools the oil. It is supplied by the aircraft manufacturer.

Centrifugal breather

The centrifugal breather separates the oil from the air/oil mist and vents the system.

Indicating devices

- Oil temperature probe
- Low oil pressure switch
- Oil pressure transmitter
- Electrical magnetic plug.



OIL SYSTEM - DESCRIPTION

OIL SYSTEM - OPERATION

The main functions of the oil system are: supply, scavenge, breathing and indicating.

Supply

The pressure pump draws the oil from the tank and supplies the system. A pressure relief valve limits maximum pressure by returning oil to the pump inlet.

The oil is then delivered to the oil filter and restrictors to the engine sections which require lubrication:

- Gas generator front bearings
- Gas generator rear bearing
- Power turbine bearings
- Reduction gearbox and intermediate gear balance piston
- Accessory gearbox (supply upstream of the calibrated orifice).

The oil is sprayed by jets onto the parts to be lubricated. It also supplies a squeeze film for the gas generator rear bearing and the power turbine front bearing.

Scavenge

After lubrication, the oil falls by gravity to the bottom of the sumps. The oil is then immediately drawn away by the scavenge pumps and returned to the tank through a check valve and the oil cooler (dry sump system).

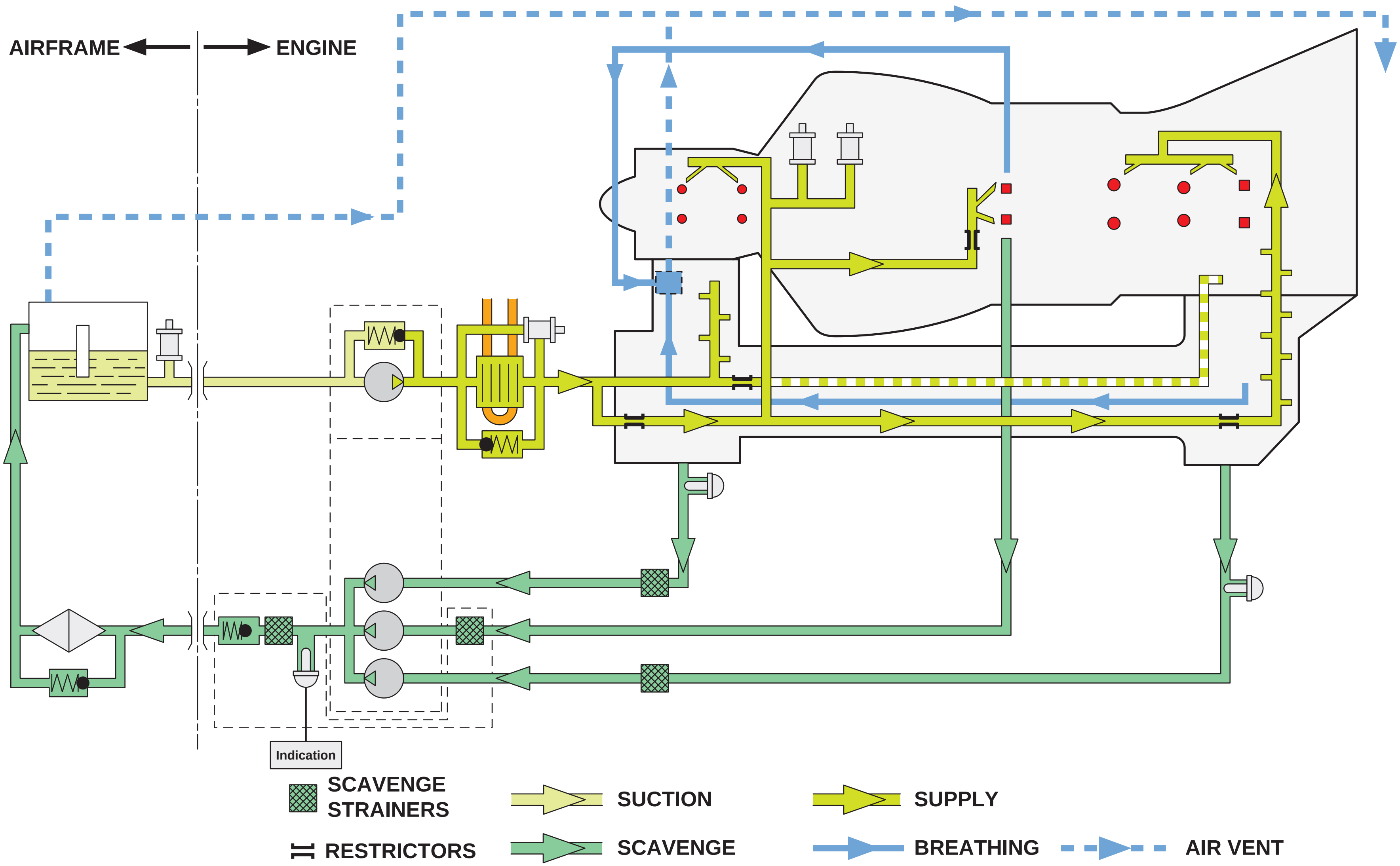
The scavenge strainers protect the scavenge pumps against any particles which may be held in the oil. The magnetic plugs retain magnetic particles which may be in the oil.

Breathing

The oil mist which results from lubrication is returned to the accessory gearbox, where the oil is separated from the air by a centrifugal breather which vents overboard.

Indicating

The system ensures the following indications: pressure, temperature, low pressure, electrical magnetic plug and filter pre-blockage.



OIL SYSTEM - OPERATION

OIL TANK

Function

The tank contains the oil required for engine lubrication.

Position

- In the system: between the oil cooler and the pressure pump
- On the aircraft: it is installed on the decking beside the MGB.

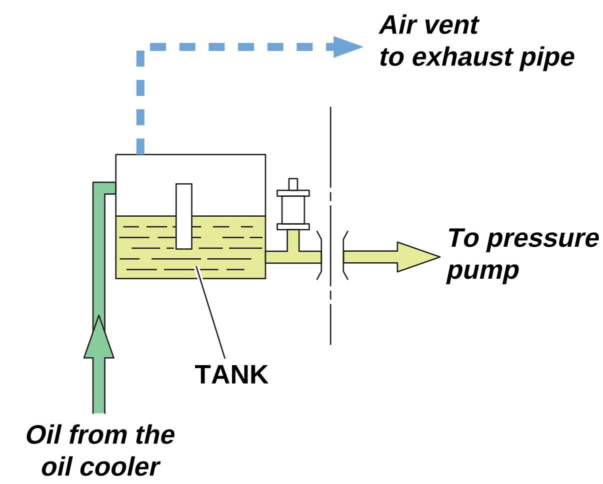
Main characteristics

- Aircraft manufacturer's supply.

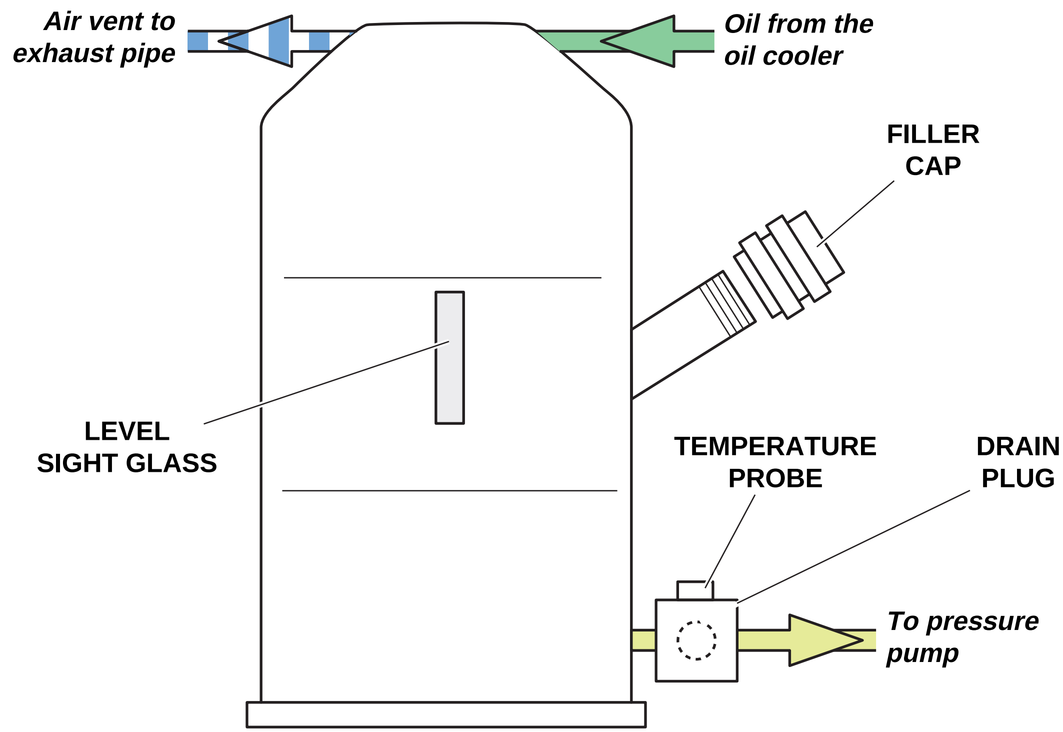
Main components

- Filler cap
- Level sight glass
- Drain plug
- Temperature probe
- Unions (supply, return and vent)
- Fan thermostatic switch.

Note: *Refer to the aircraft manual for the description and operation.*



AIRCRAFT MANUFACTURER'S SUPPLY:
Installed on the decking beside the MGB



OIL TANK

OIL PUMPS - GENERAL - DESCRIPTION

Function

The pumps ensure oil circulation.

Position

- In the system: on engine oil system inlet and outlet
- On the engine: the pump unit is mounted by bolts on the rear face of the accessory gearbox.

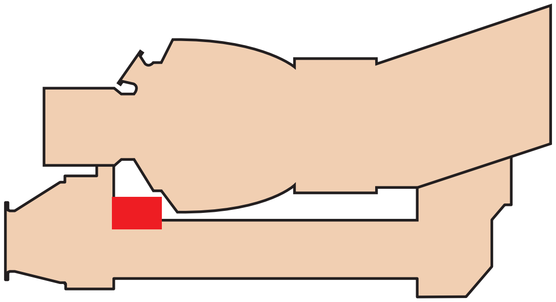
Main characteristics

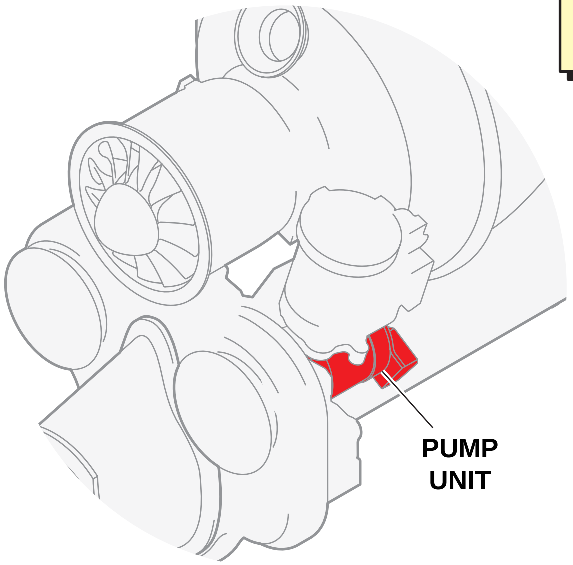
- Type: gerotor
- Quantity: 4
- Pressure relief valve setting: 1500 kPa (217.5 PSI).

Description

The pump unit comprises a body containing four pumps (one pressure pump and three scavenge pumps), and a pressure relief valve.

The four pumps are driven by means of a common shaft connected to the accessory drive (N1 drive).

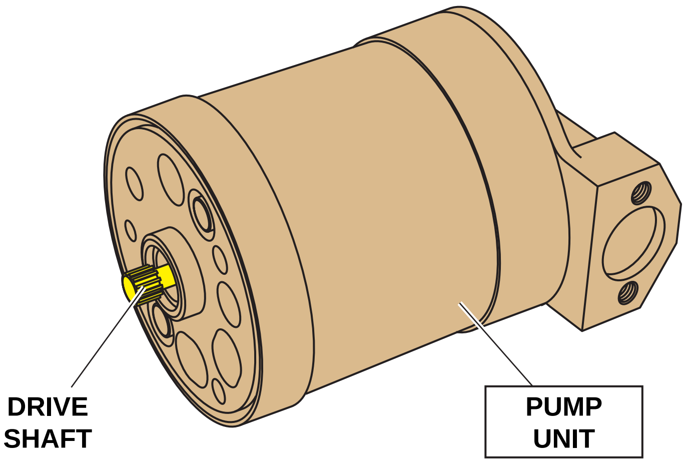


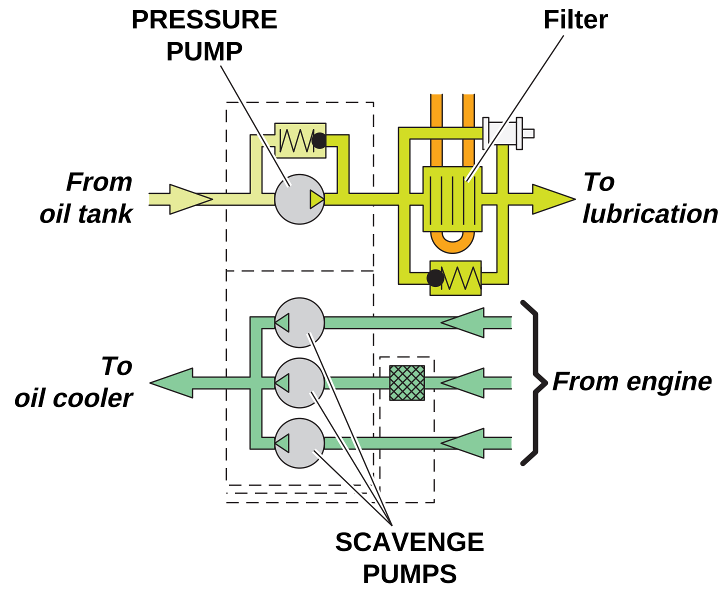


Type:
Gerotor

Quantity:
4

Pressure relief
valve setting:
1500 kPa (217.5 PSI)





OIL PUMPS - GENERAL - DESCRIPTION

OIL PUMPS - OPERATION

Operating principle of a gerotor pump

A gerotor pump is a pump which comprises an inner rotor driving an outer rotor.

The inner rotor is eccentric to the outer rotor and has one less lobe than the outer rotor has spaces.

Because of the eccentricity, the size of the chambers formed between the two rotors varies with rotation.

Thus the oil is drawn in as the low pressure chamber size is increasing and is forced out under pressure as the high pressure chamber size decreases.

The process is continuous for each chamber, ensuring a smooth, positive flow.

Operation of the pressure pump

The pressure pump draws the oil from the tank and forces it out under pressure in the supply system.

The whole pump flow is used (full flow; pressure is function of the rotation speed, oil viscosity and oil temperature).

Pressure relief valve operation

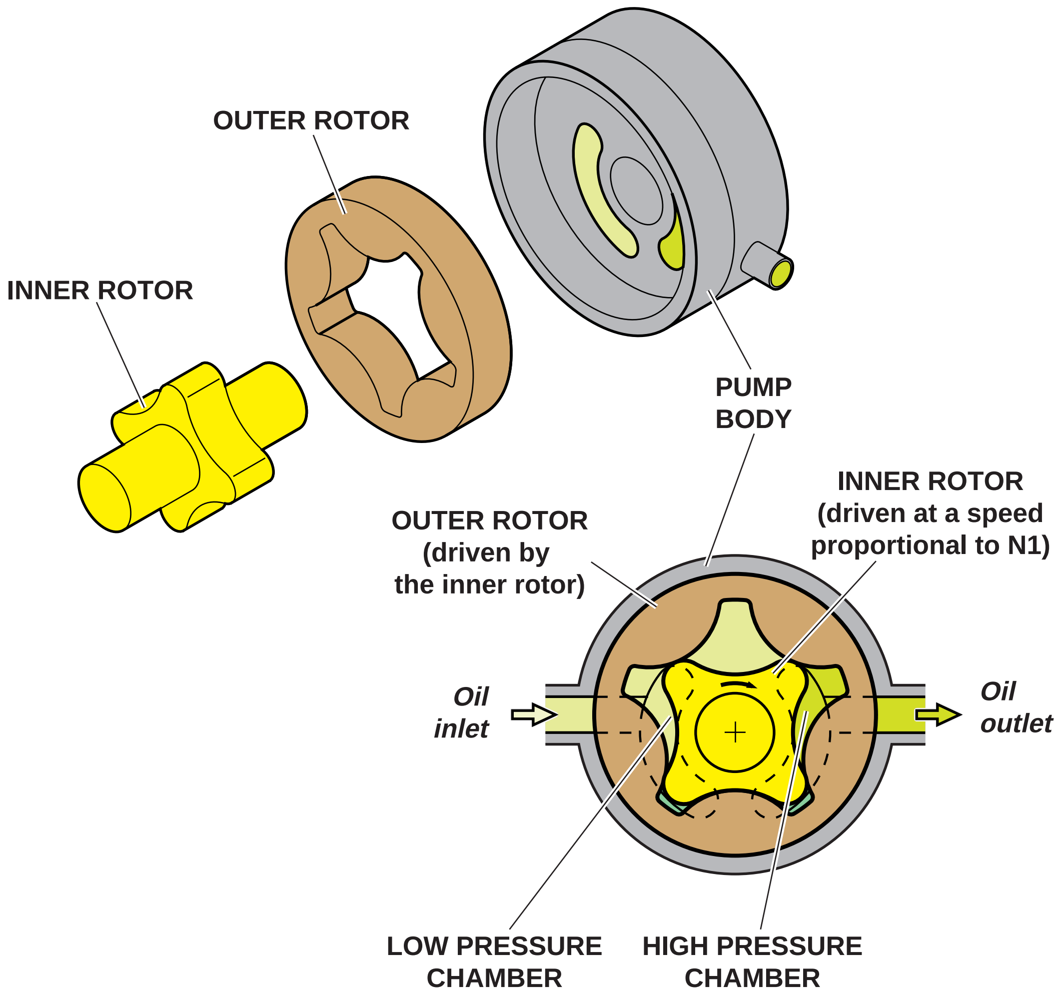
If the oil pressure exceeds the valve setting the valve opens and allows the oil to return to the pump inlet.

In normal operation the valve is closed and only opens in exceptional circumstances, e.g. starting with very low temperature.

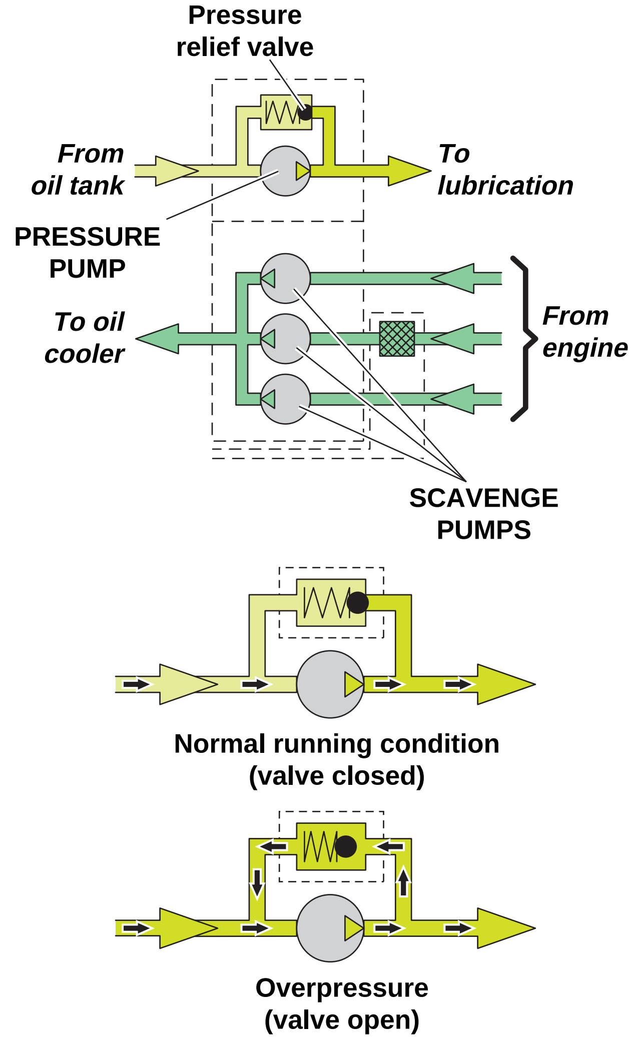
Operation of the scavenge pumps

Three scavenge pumps, one for the reduction gearbox, one for the gas generator bearing, one for the compressor bearings and the accessory gear train, return the oil to the oil cooler and the tank.

The pump flow is higher than that of the pressure pump (dry sump type system).



PRINCIPLE OF OPERATION OF A GEROTOR PUMP



OPERATION OF THE PRESSURE RELIEF VALVE

OIL PUMPS - OPERATION

OIL VALVE ASSEMBLY

Function

The assembly houses a check valve and an electrical magnetic plug and the strainer for the gas generator rear bearing.

The check valve prevents oil flow from the cooler to the engine when the pressure is very low (engine stopped).

The electrical magnetic plug collects ferrous particles which may be in the oil.

Position

- In the system: downstream of the scavenge pumps
- On the engine: on the rear face of the accessory gearbox.

Main characteristics

- Check valve setting: 15 kPa (2.17 PSI).

Main components

- Check valve
- Electrical magnetic plug and strainer
- Scavenge strainer for the gas generator rear bearing.

Check valve description

The check valve comprises:

- A piston
- A spring
- A cover.

Check valve operation

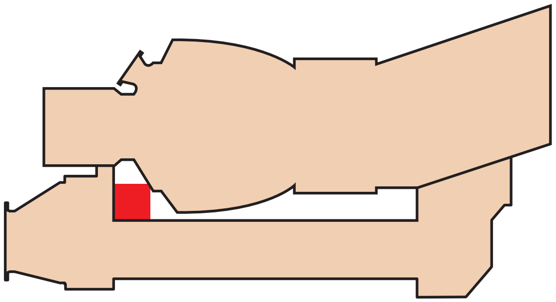
Engine running

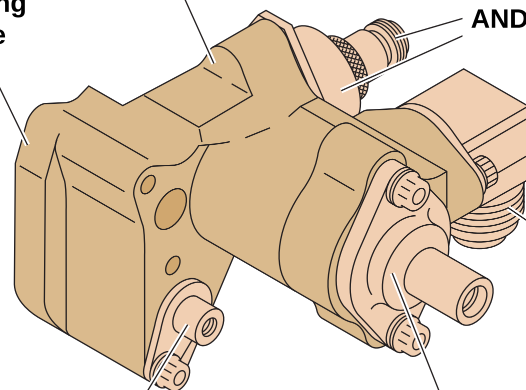
The outlet pressure of the scavenge pumps pushes the piston, compressing the spring thus allowing flow to the cooler.

Engine stopped

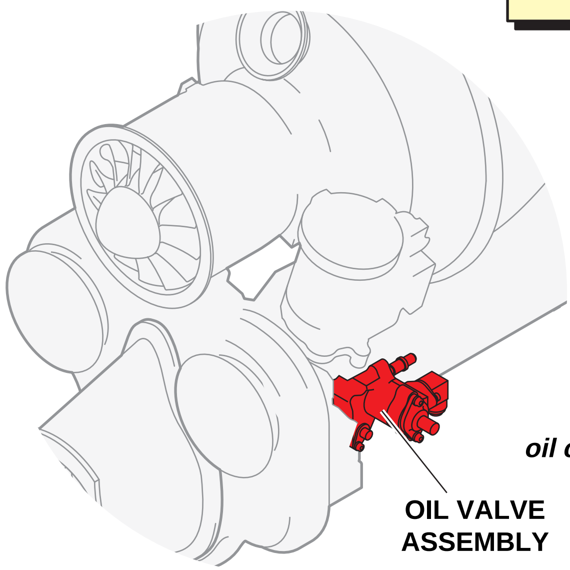
The scavenge pump outlet pressure is very low or zero.

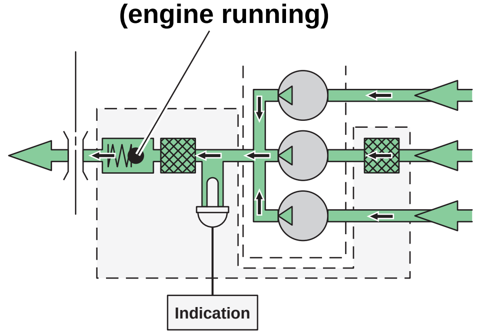
Spring pressure closes the valve and prevents any flow from the cooler into the engine.

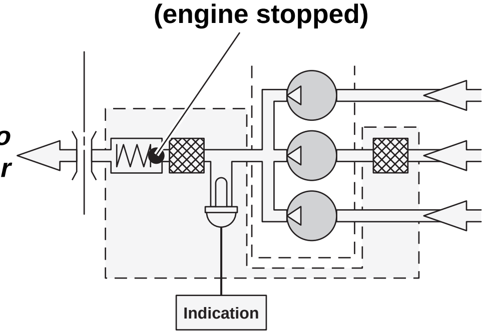




Check valve setting:
15 kPa (2.17 PSI)







OIL VALVE ASSEMBLY

OIL FILTER AND HEAT EXCHANGER - GENERAL

Function

The filter retains particles that may be in the oil. The filter housing forms a fuel/oil heat exchanger.

Position

- In the system: downstream of the pressure pump
- On the engine: on the left rear face of the accessory gearbox.

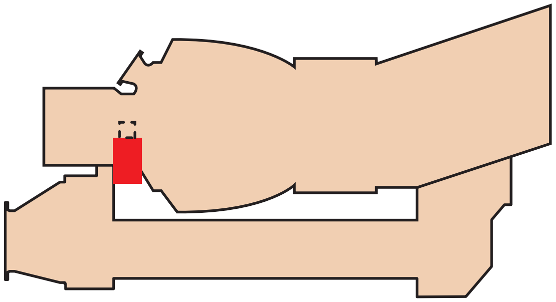
Main characteristics

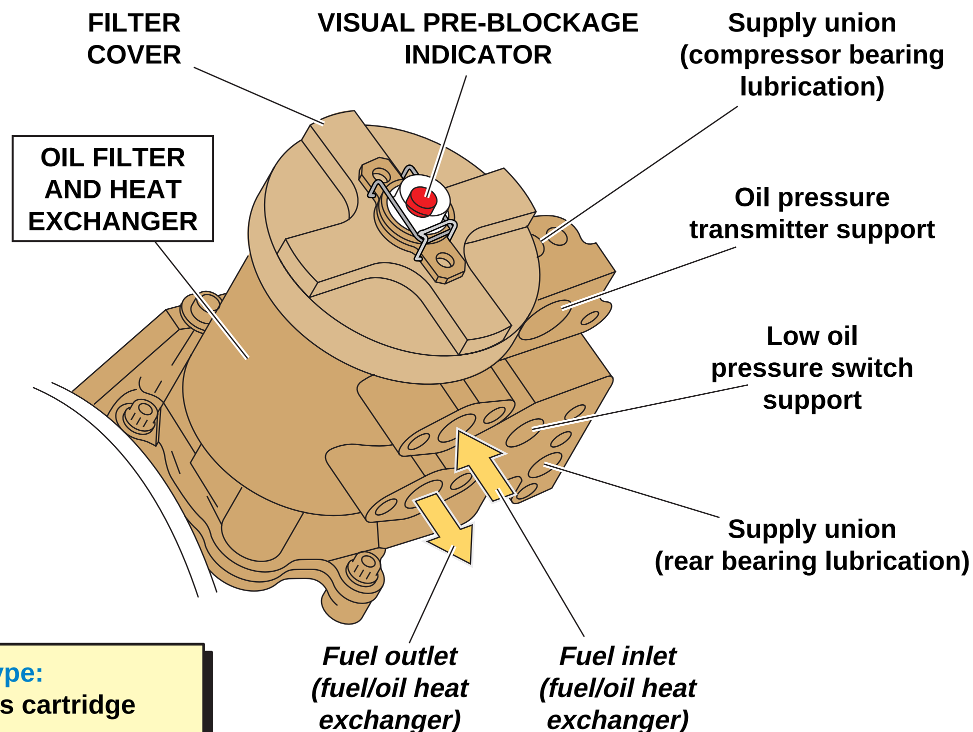
- Type: fibreglass cartridge
- Filtering ability: 20 microns
- Mechanical pre-blockage indicator setting: ΔP 120 kPa (17.4 PSID)
- By-pass valve setting: ΔP 420 kPa (60.9 PSID).

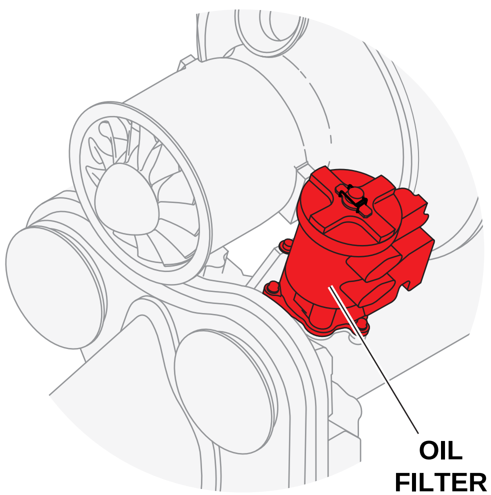
Main components

The filter contains the interchangeable filtering element, accessible by a cover, and the fuel/oil heat exchanger.

It also provides the support for accessories (pre-blockage indicator, low oil pressure switch, oil pressure transmitter, outlet unions).





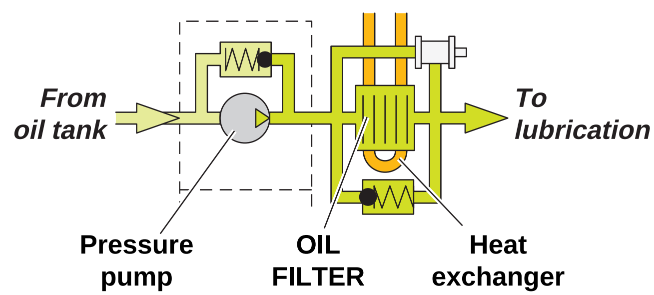


Type:
Fibreglass cartridge

Filtering ability:
20 microns

Mechanical pre-blockage indicator setting:
ΔP 120 kPa (17.4 PSID)

By-pass valve setting:
ΔP 420 kPa (60.9 PSID)



OIL FILTER AND HEAT EXCHANGER - GENERAL

OIL FILTER AND HEAT EXCHANGER - DESCRIPTION - OPERATION

Description

The main components of the filtering unit are the following:

- Filter base
- Filter cover (screwed onto the filter base)
- Fuel/oil heat exchanger fitted with walls which permit fuel flow around the oil filter casing
- Fibreglass cartridge (filtering element)
- By-pass valve (fitted inside the filter housing)
- Pre-blockage indicator
- Spring.

The filter base incorporates:

- Mounting points for the following:
  - Low oil pressure switch
  - Oil pressure transmitter
  - Oil outlet unions (compressor bearing lubrication and rear bearing lubrication)
  - Fuel inlet and outlet unions.

O'ring seals ensure the oil filter sealing.

Operation

Filtering (normal condition)

The oil supplied by the pressure pump passes through the filter from outside to inside. The filtered oil then passes to the engine for lubrication.

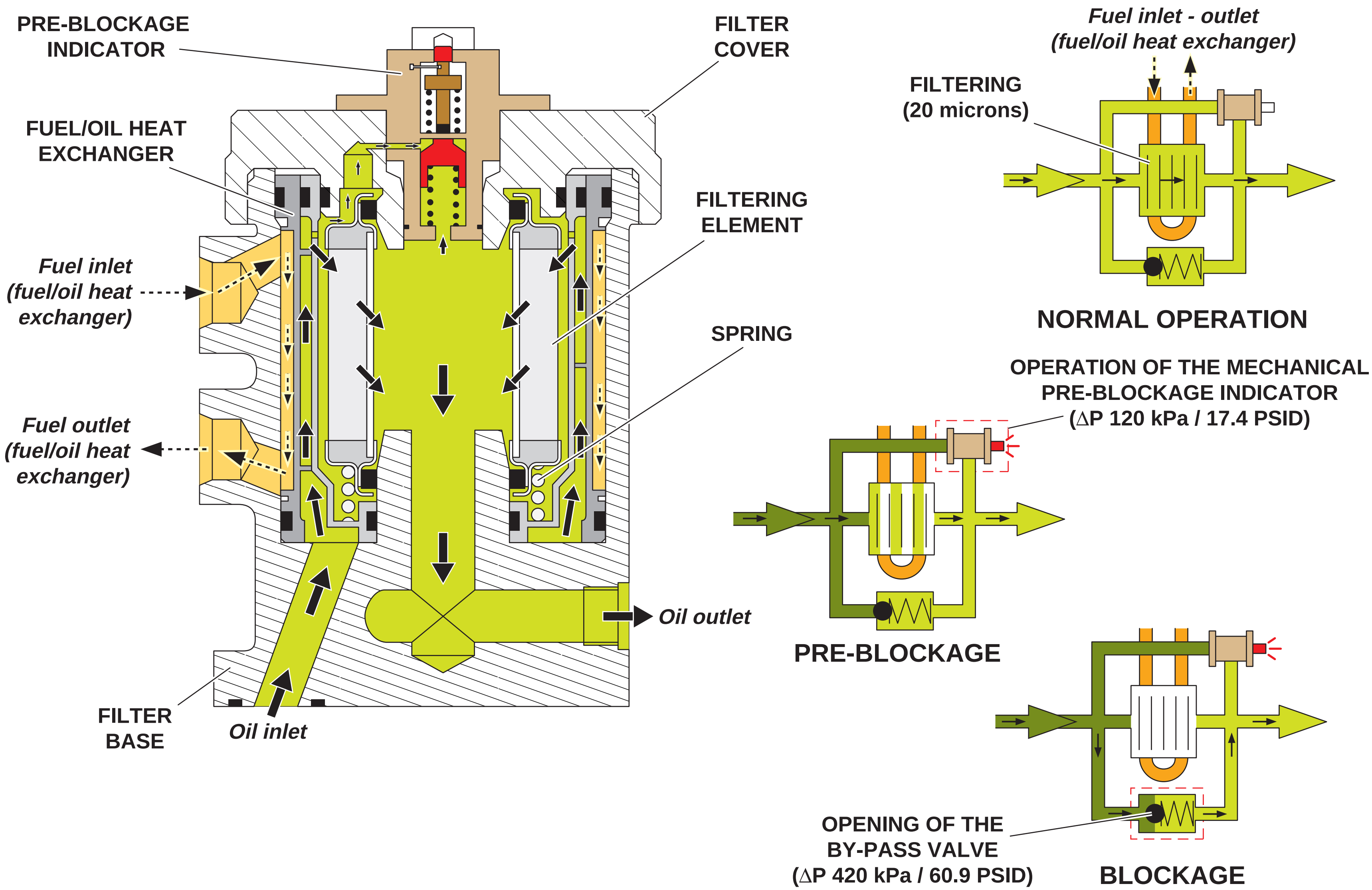
The oil is also used to heat the fuel through the heat exchanger as the fuel flows around the oil filter.

Pre-blockage

If the filter begins to become blocked the pressure difference across the filter increases. At a given difference (120 kPa / 17.4 PSID) a red mechanical indicator pops out. The oil continues to flow through the filter.

Blockage

If the pressure difference exceeds 420 kPa (60.9 PSID), the by-pass valve opens and unfiltered oil passes to the system.



OIL FILTER AND HEAT EXCHANGER - DESCRIPTION - OPERATION

OIL FILTER PRE-BLOCKAGE INDICATOR

Function

The indicator detects the onset of filter blockage.

Position

- In the system: between inlet and outlet of the oil filter

- On the engine: on the filter housing cover.

Main characteristics

- Type: differential
- Setting: ΔP 120kPa (17.4 PSID).

Description

The pre-blockage indicator comprises the following parts:

- Indicator body including:
  - Mounting flange
  - Filter upstream pressure inlet
  - Filter downstream pressure inlet
- Red indicator piston
- ΔP piston
- Transparent cover
- Thermal lock
- O'ring seals.

Operation

Normal condition

Filter downstream pressure plus spring pressure is greater than upstream pressure. The two pistons are held together by magnetic force. The indicator is not visible.

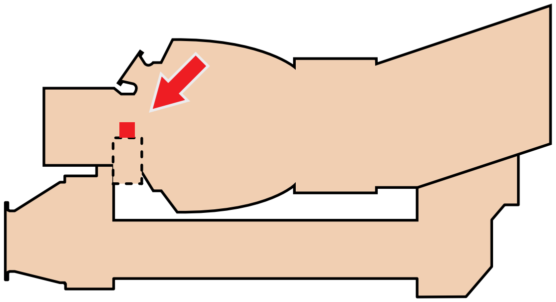
Pre-blockage condition

Filter upstream pressure exceeds downstream plus spring pressure and the ΔP piston displaces.

This breaks the magnetic hold and the indicator piston is pushed out by its spring. The indicator is visible.

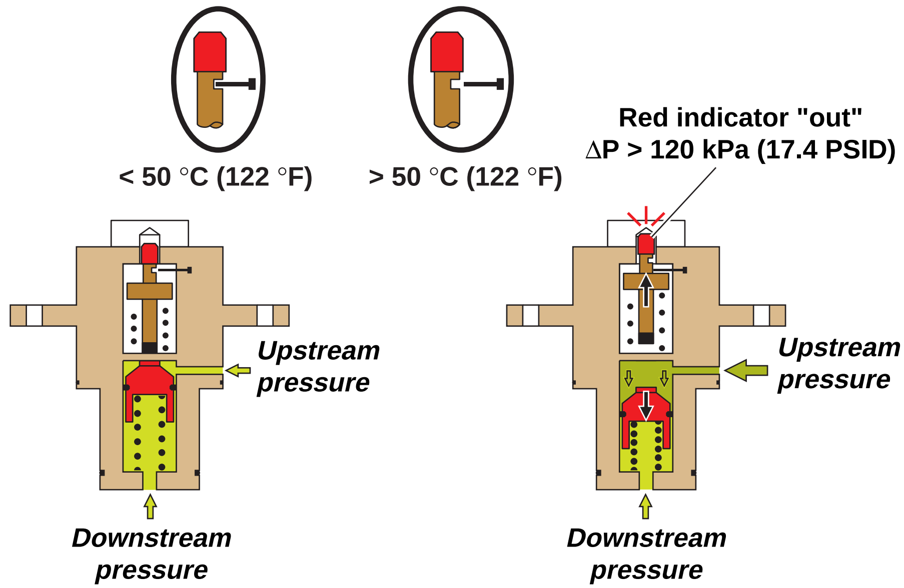
The bi-metallic thermal lock ensures that the indicator doesn't operate when a large ΔP is caused by low temperature (locked below 50 °C (122 °F)).

The indicator is re-armed by pushing in the indicator.



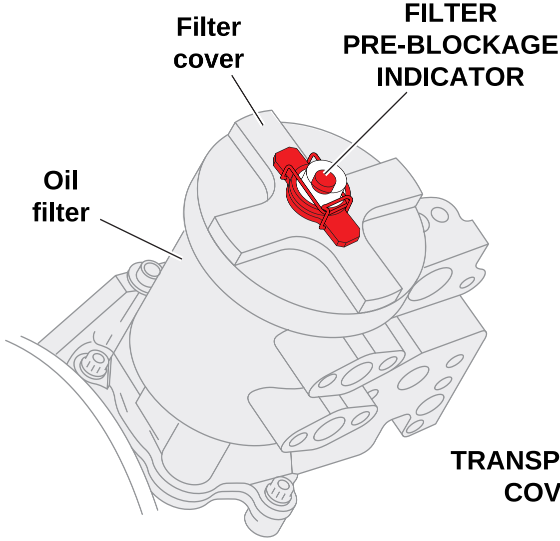
Type:
differential

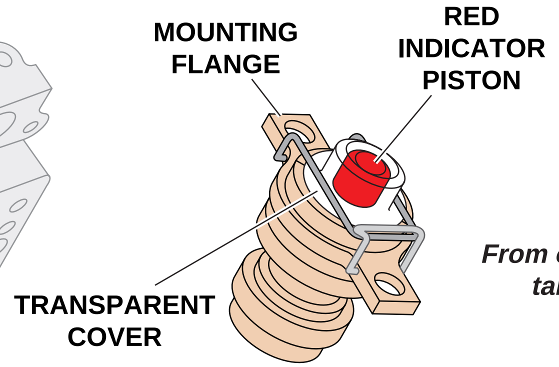
Setting:
ΔP 120 kPa (17.4 PSID)

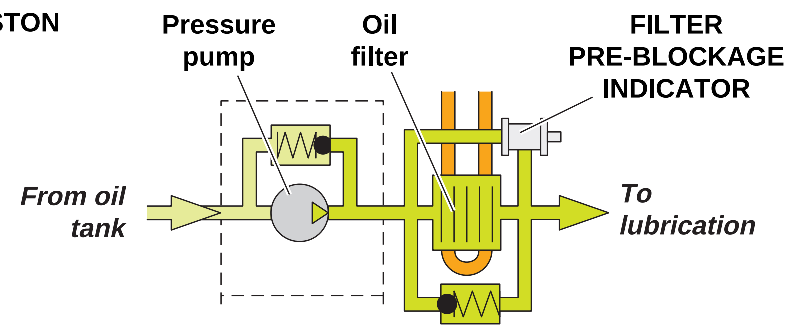


NORMAL CONDITION

PRE-BLOCKAGE CONDITION







OIL FILTER PRE-BLOCKAGE INDICATOR

OIL COOLER

Function

The oil cooler cools the oil after it has passed through the engine.

Position

- In the system: between the scavenge pumps and the tank
- On the aircraft: it is installed in front of the main gearbox.

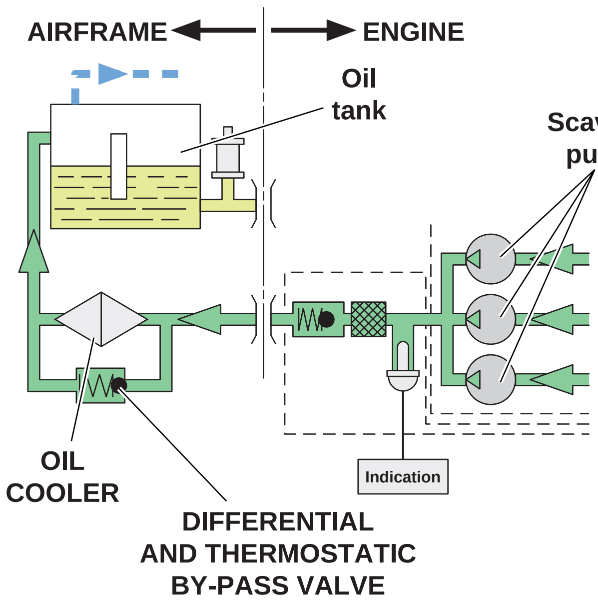
Main characteristics

- Supplied by the aircraft manufacturer
- Type: air/oil cooler
- Differential and thermostatic by-pass valve.

Main components

- Oil cooler
- Differential and thermostatic by-pass valve
- Unions (oil inlet and outlet)
- Cooling fan.

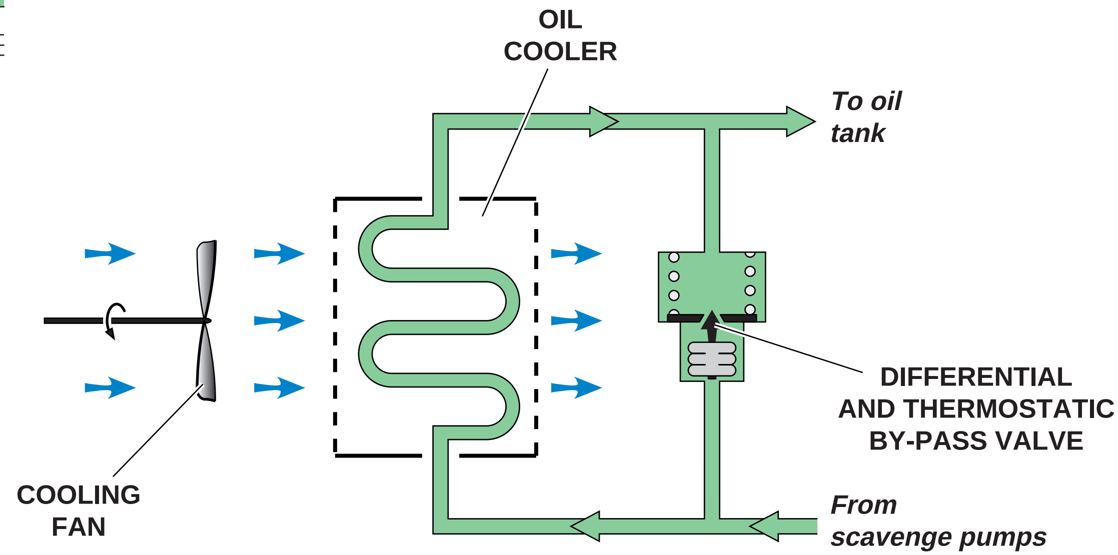
Note: *For further details, refert to the aircraft documentation.*



AIRCRAFT MANUFACTURER'S SUPPLY:
Installed in front of the main gearbox

Type:
Air/oil cooler

Differential and thermostatic
by-pass valve



OIL COOLER

CENTRIFUGAL BREATHER

Function

The centrifugal breather separates the oil from the air/oil mist created by the oil system.

Position

- In the system: before the general vent line of the system
- On the engine: it is formed by the starter/generator drive gear in the accessory gearbox.

Main characteristics

- Type: centrifugal
- Air vent: through the rear part of the gear hollow shaft, connected to the exhaust.

Description

The centrifugal breather is formed by the starter-generator drive gear. This gear is formed in one piece with a hollow shaft and has holes which provide a passage between the gearbox and the air vent.

The gear is supported by two ball bearings and has a magnetic carbon seal at each end.

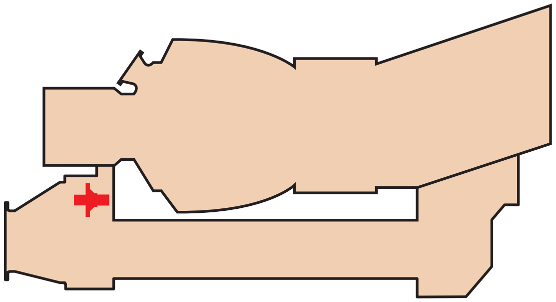
The breather air outlet is at the rear end of the shaft, where the air passes into the gearbox outlet.

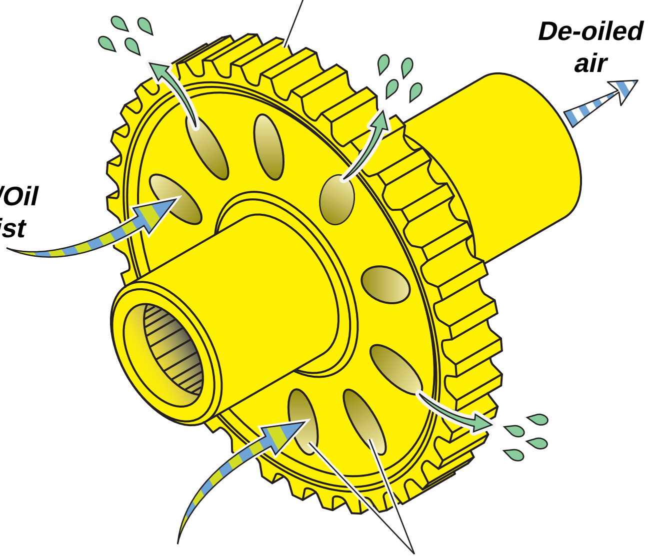
Operation

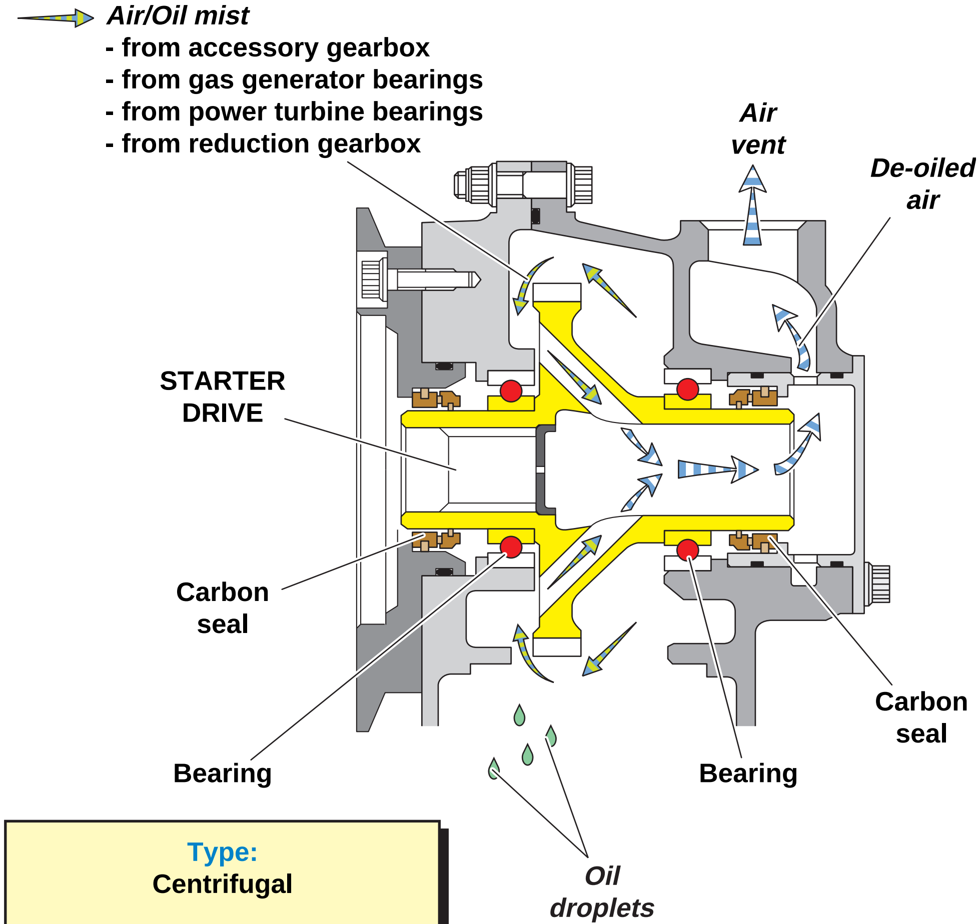
The centrifugal breather is driven by the intermediate gear of the accessory drive.

When the engine is running the air/oil mist passes through the breather:

- Centrifugal force throws the oil droplets out into the gearbox where they fall to the bottom of the casing
- The de-oiled air passes out through the shaft, via a gearbox passage, into an external pipe which discharges into the exhaust.







Type:
Centrifugal

Air vent:
Through the rear part
of the gear hollow shaft,
connected to the exhaust

CENTRIFUGAL BREATHER

ELECTRICAL MAGNETIC PLUG

Function

The electrical magnetic plug attracts magnetic particles in the oil system and provides a cockpit indication.

Position

- In the system: downstream of the scavenge pumps
- On the engine: mounted on the oil valve assembly.

Main characteristics

- Type:
  - Magnetic with electrical indication
  - Self-sealing housing with strainer
  - Optional chip pulse system
- Indication: light on the aircraft instrument panel.

Description

The electrical magnetic plug comprises a magnetic probe which has two parts which are electrically insulated from one another and have a small gap between them.

The plug is connected, via the engine electrical harness, to the aircraft instrument panel.

The plug is fitted into a housing which is provided with a self-sealing valve and a mounting flange.

A bayonet type locking pin system ensures the locking of the electrical magnetic plug.

The housing is bolted onto the oil valve assembly where the scavenge oil can flow across the magnetic probe.

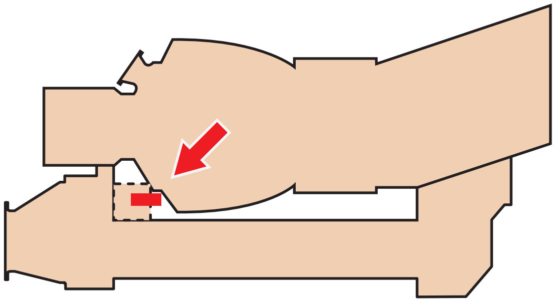
Operation

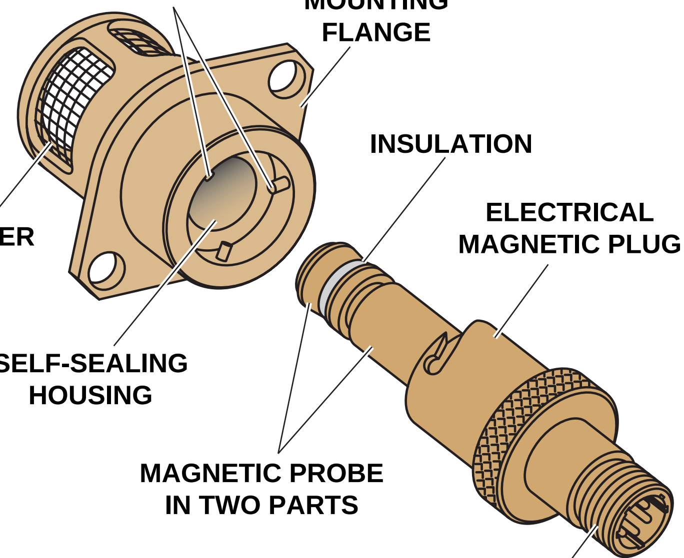
The magnetic probe attracts magnetic particles present in the oil.

If it attracts sufficient particles to form a bridge across the gap, this will complete the electrical circuit between the two magnetic parts and thus provide indication on the aircraft instrument panel.

***Note 1**: The oil system also has two mechanical magnetic plugs, one located on the lower part of the accessory gearbox and one on the lower part of the reduction gearbox.*

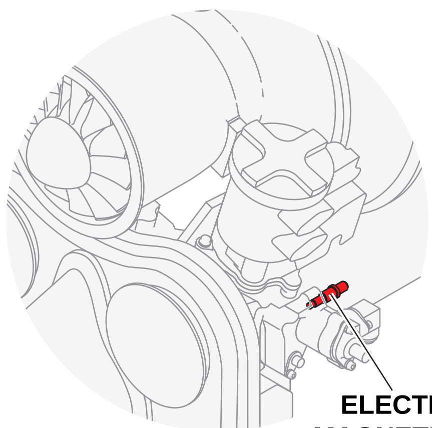
***Note 2**: An optional chip pulse system may be installed by the aircraft manufacturer. This allows plug debris to be burnt off.*

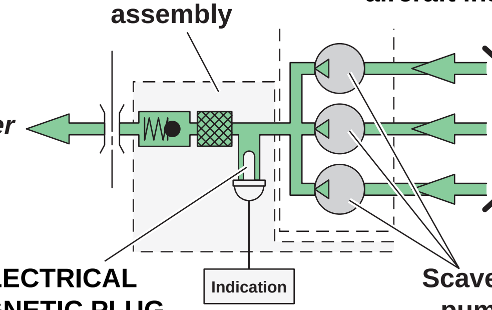




Type:
- Magnetic with electrical indication
- Self-sealing housing with strainer
- Optional chip pulse system

Indication:
On the aircraft instrument panel





ELECTRICAL MAGNETIC PLUG

MECHANICAL MAGNETIC PLUGS

Function

The magnetic plugs retain magnetic particles which may be in the oil.

Position

- In the system:
  - One on the reduction gear scavenge return
  - One on the accessory gearbox scavenge return.
- On the engine:
  - One at the bottom of the reduction gearbox
  - One at the bottom of the accessory gearbox.

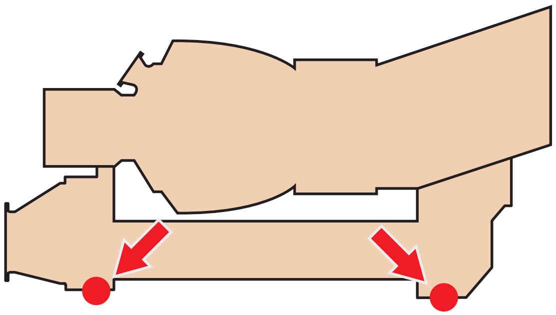
Main characteristics

- Type: single magnetic probe. Self-sealing housing
- Quantity: 2

Description

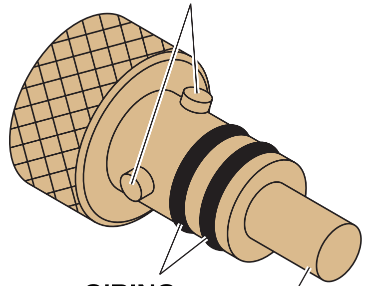
The magnetic plug includes: a magnet, O'ring seals and locating pins.

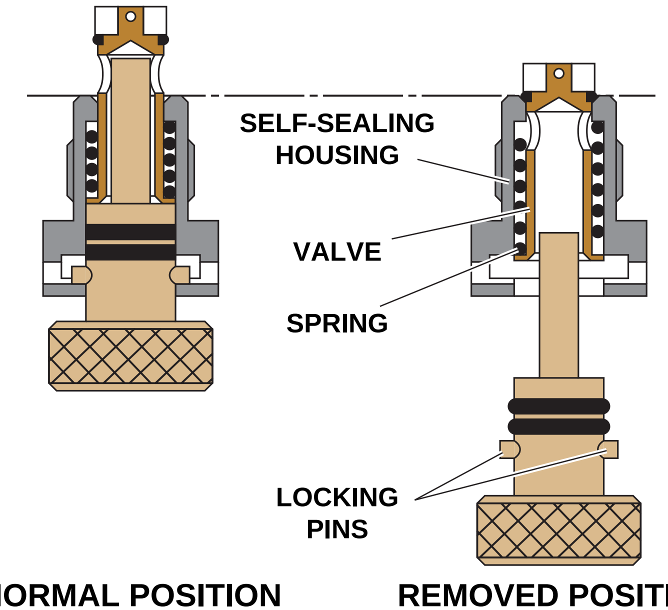
The magnetic plug is installed in a self-sealing housing (valve, spring).

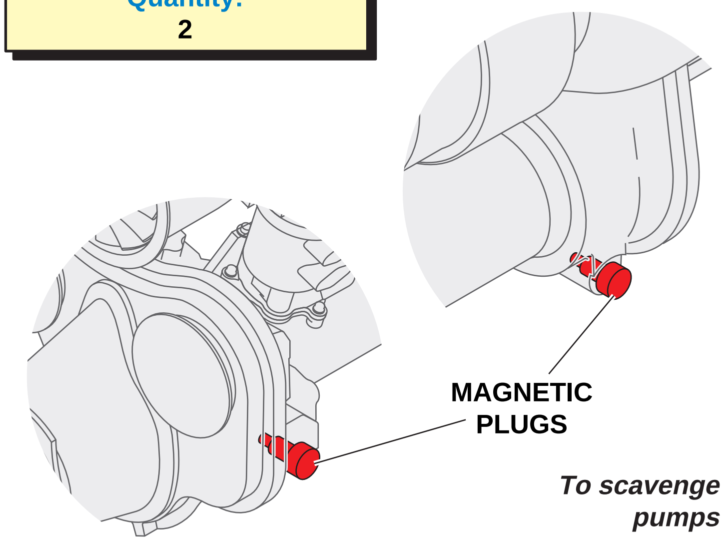


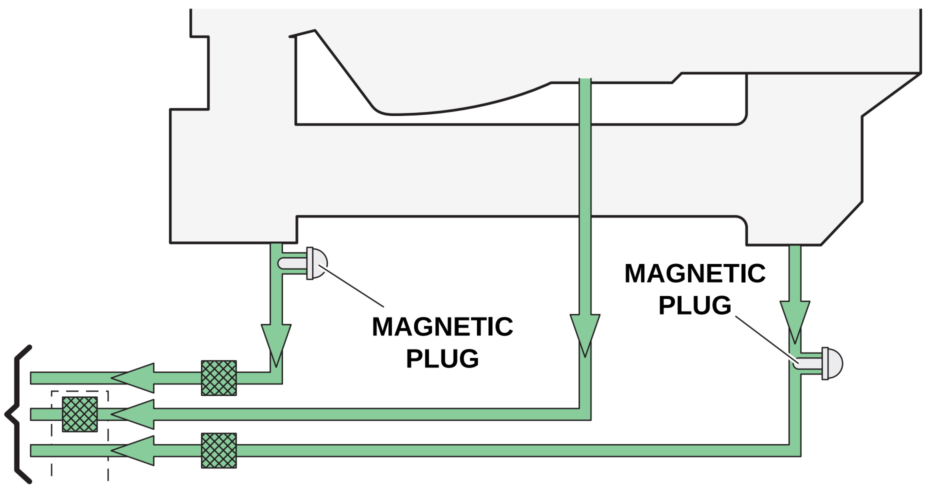
Type:
Single magnetic probe
Self-sealing housing

Quantity:
2









MECHANICAL MAGNETIC PLUGS

SCAVENGE STRAINERS

Function

The strainers protect the scavenge pumps against large particles which might be in the oil.

Position

- In the system:
  - One strainer is fitted in each scavenge line upstream of the scavenge pump
  - One strainer is located downstream of the scavenge pumps.

- On the engine:
  - Two different strainers are located on the accessory gearbox casing:
    - one to the reduction gearbox
    - one to the accessory gearbox scavenge
  - One strainer is located on the oil valve assembly (gas generator rear bearing scavenge).

Main characteristics

- Type: wide mesh filter
- Quantity: 3

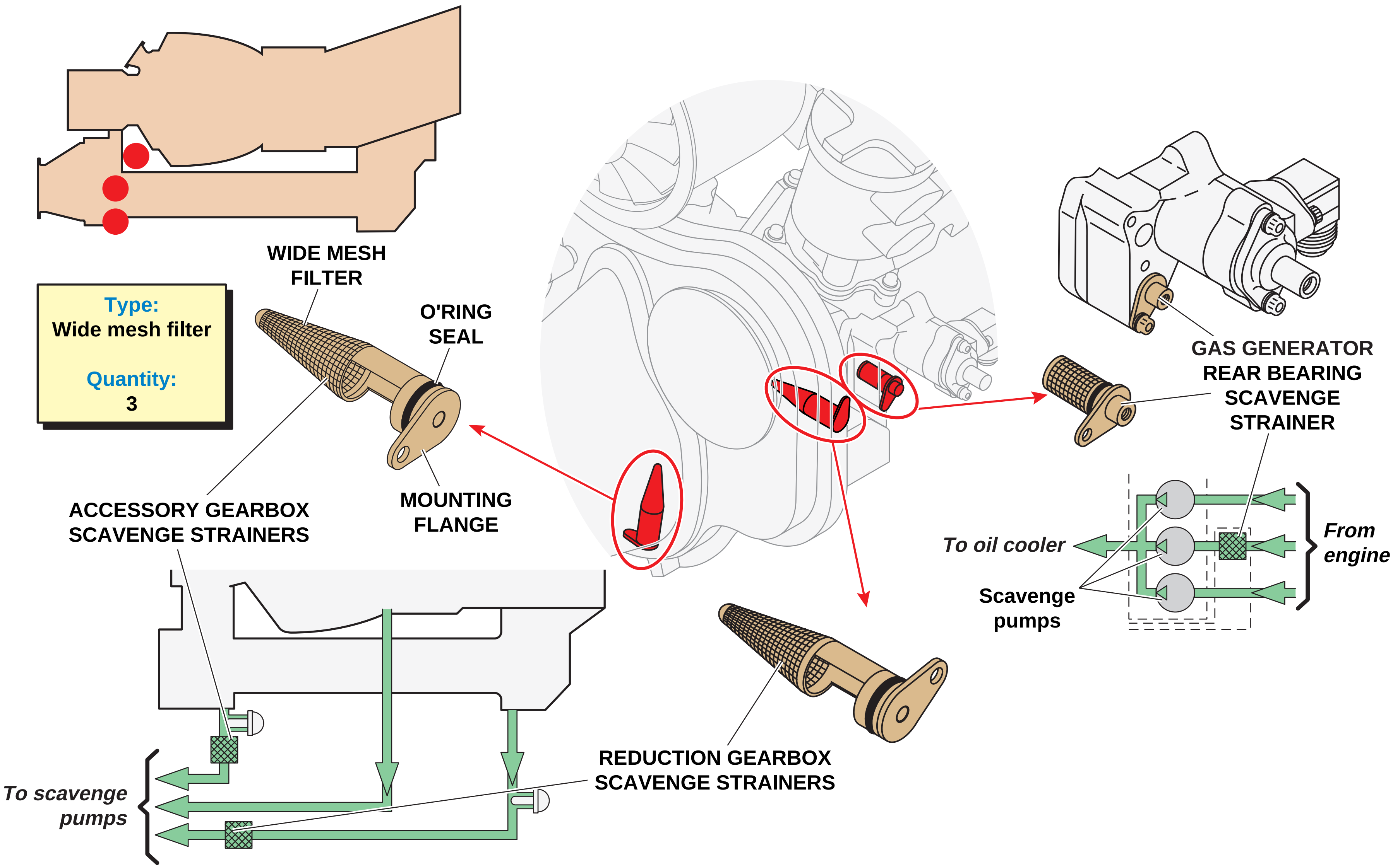
Description

Each strainer includes the following components: a wide mesh filter, a mounting flange and an O'ring seal.

Operation

A strainer is a wide mesh filter which retains any large particles which may be present in the oil in order to protect the scavenge pumps.

Note: *The electrical magnetic plug, mounted on the oil valve assembly, is fitted with its own strainer.*



SCAVENGE STRAINERS

LOW OIL PRESSURE SWITCH

Function

The low oil pressure switch provides cockpit indication of low oil pressure.

Position

- In the system: downstream of the filter
- On the engine: mounted on the filter base.

Main characteristics

- Type: diaphragm pressure switch
- Setting: 130 kPa (18.9 PSI)
- Indication: light on instrument panel.

Description

The pressure switch comprises the following components: a mounting flange and an electrical connector (connection with the instrument panel).

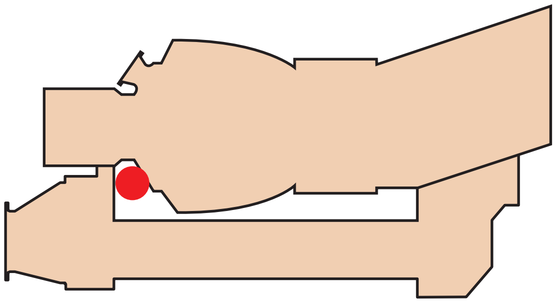
The pressure switch is secured by means of two screws onto the filter base.

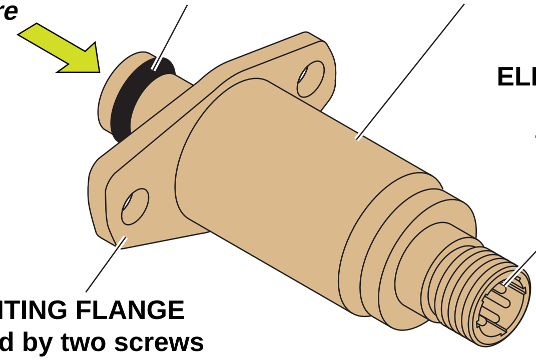
One O'ring seal ensures the sealing between the pressure switch and the filter base.

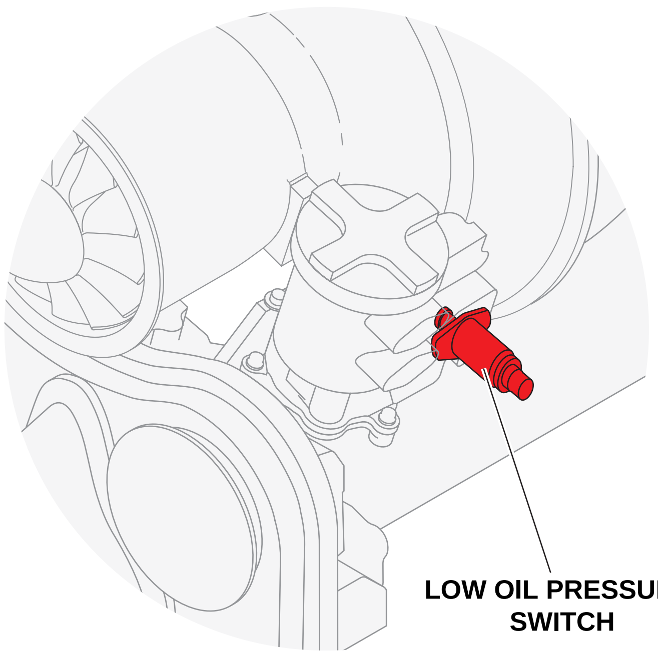
Operation

The pressure switch microswitch is open during normal engine operation.

If the oil pressure reduces to less than 130 kPa (18.9 PSI), the diaphragm moves down. This causes the electrical contact to close, completing the circuit of the low oil pressure warning light.



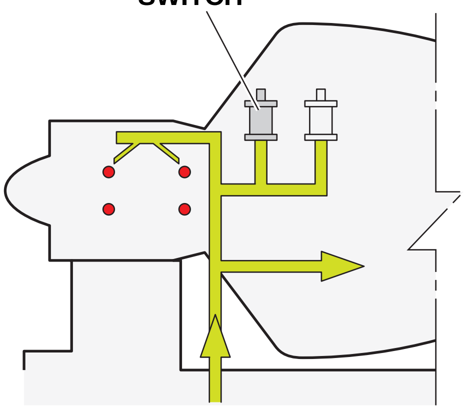




Type:
Diaphragm pressure swich

Setting:
130 kPa / (18.9 PSI)

Indication:
Light on instrument panel



LOW OIL PRESSURE SWITCH

OIL PRESSURE TRANSMITTER

Function

The transmitter provides a signal of oil pressure.

Position

- In the system: in the supply system, downstream of the filter after the restrictor.

- On the engine: mounted on the filter base.

Main characteristics

- Supplied by the aircraft manufacturer

- Type: resistive

- Output signal: voltage proportional to the oil pressure

- Indication: on instrument panel.

Description

The transmitter includes:

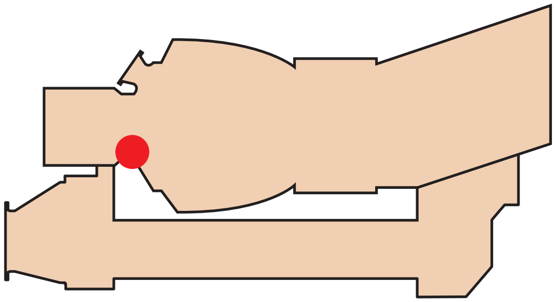
- A mounting flange (mounting on the filter base)

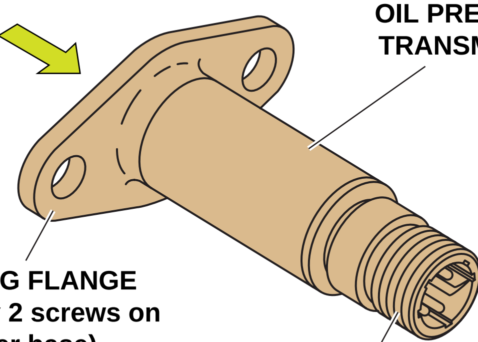
- An electrical connector (connection with the instrument panel).

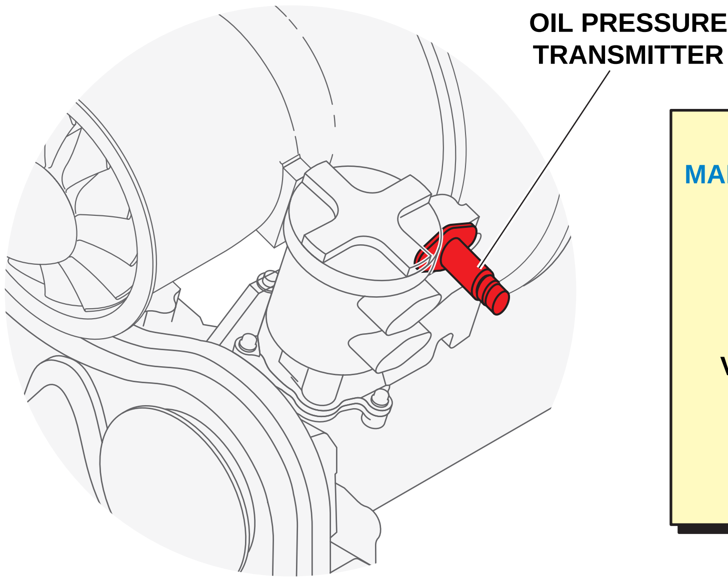
Operation

The oil pressure transmitter incorporates a bridge of resistors printed on a flexible support.

The deformation of the support produces an output voltage proportional to the oil pressure for a constant input voltage.





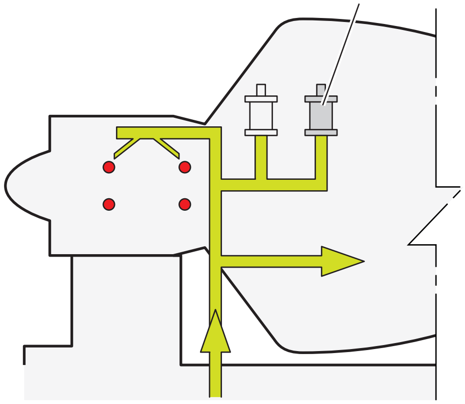


AIRCRAFT MANUFACTURER'S SUPPLY

Type:
Resistive

Output signal:
Voltage proportional to the oil pressure

Indication:
On instrument panel



OIL PRESSURE TRANSMITTER

EXTERNAL OIL PIPES

This description deals with the external pipes of the oil system.

Function

The oil pipes ensure the oil circulation between the oil system components and the lubricated parts of the engine (bearings).

Main characteristics

- Type of pipelines: rigid (one flexible)
- Type of union: flanged union.

Description

Lubrication

- Oil inlet (from oil tank to pressure pump; aircraft manufacturer's supply)
- From pressure pump to filter base
- Supply of the gas generator front bearings
- Supply of the gas generator rear bearing.

Scavenge

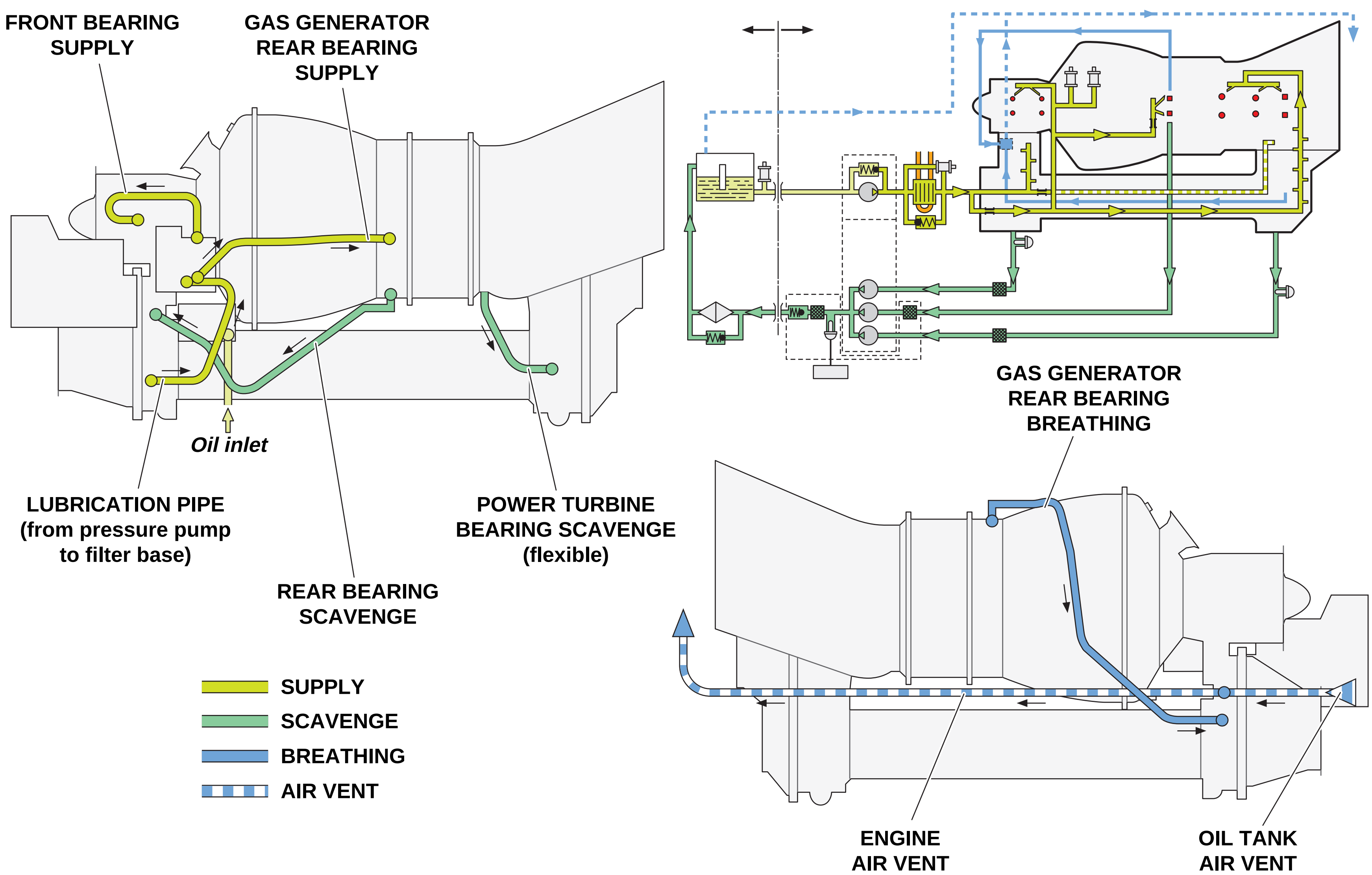
- Scavenge of the gas generator rear bearing
- Scavenge of the power turbine bearings (from power turbine to reduction gearbox; flexible pipe).

Breathing

- Gas generator rear bearing (external pipe).

Air vent

- External pipe from centrifugal breather to the exhaust pipe.



EXTERNAL OIL PIPES

5 - AIR SYSTEM

(XX-XX-XX): Page references which deal with the subject in the maintenance documentation.

AIR SYSTEM

Function

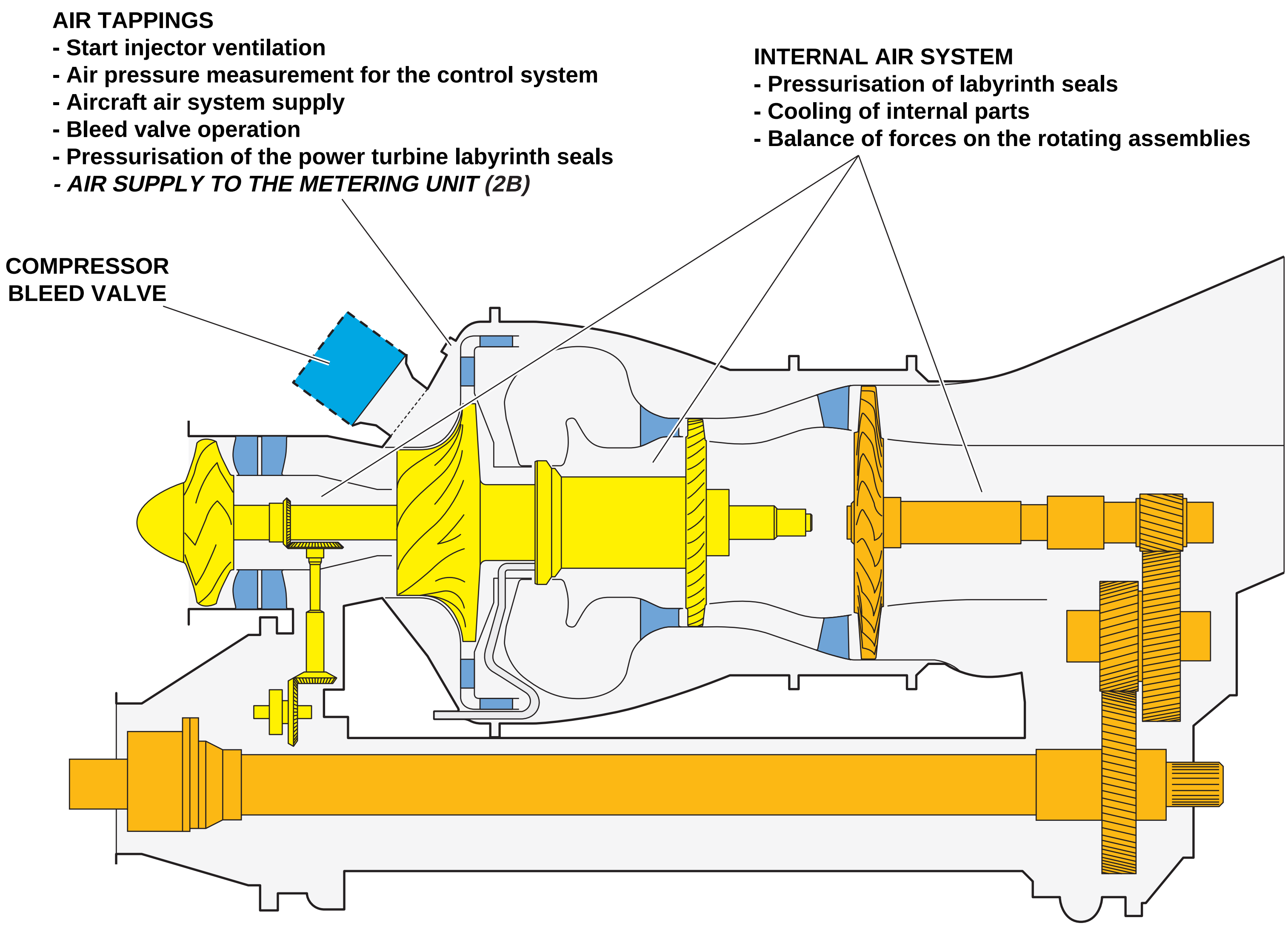
The engine air system includes:

- **An internal air system** which ensures:
  - The pressurisation of the labyrinth seals
  - The cooling of the engine internal parts
  - The balance of forces on the rotating assemblies

- **Air tappings** which ensure:
  - The air pressure measurement for the control system
  - The start injector ventilation
  - The aircraft air system supply
  - *2B : The air supply to the pump and metering unit assembly (metering unit)*
  - The air for the bleed valve operation
  - The air for the pressurisation of the power turbine labyrinth seals.

- **The compressor bleed valve.**

Note: *Refer to the various systems for the location, the characteristics, the description and operation.*


AIR TAPPINGS
- Start injector ventilation
- Air pressure measurement for the control system
- Aircraft air system supply
- Bleed valve operation
- Pressurisation of the power turbine labyrinth seals
- AIR SUPPLY TO THE METERING UNIT (2B)
INTERNAL AIR SYSTEM
- Pressurisation of labyrinth seals
- Cooling of internal parts
- Balance of forces on the rotating assemblies
COMPRESSOR
BLEED VALVE

AIR SYSTEM

INTERNAL AIR SYSTEM

Function

The internal air system pressurises the labyrinth seals, cools certain parts and provides a balancing of forces.

Position

All the parts of the system are internal except the pressurisation of the power turbine labyrinth which is supplied by an external pipe.

Main characteristics

- Type: air tapping with a calibrated flow
- Air pressures used:
  - P2.4: centrifugal compressor inlet pressure
  - P2.6: centrifugal compressor wheel outlet pressure
  - P3: centrifugal compressor outlet pressure.

***Note**: The internal air system is also referred to as the secondary air system.*

Functional description

The internal air system can be considered in three parts: the front section, the gas generator HP section and the power turbine section.

Front section

Air tapped from the centrifugal compressor inlet is used to pressurise the front bearing labyrinths. There is a very small flow of air into the bearing chamber. Air tapped from the same point is discharged through the compressor bleed valve, mounted on the compressor casing (see compressor bleed valve).

Gas generator HP section

Air tapped from the centrifugal compressor wheel outlet passes down the rear face of the compressor wheel, through the curvic-couplings, the hollow shaft and internal passages. It is used to:

- Cool the rear face of the gas generator turbine (discharging into the gas flow)
- Pressurise the labyrinth seal of the gas generator rear bearing (small flow into the bearing housing)
- Cool the front face of the power turbine (discharge into the gas flow).

The air from the centrifugal compressor outlet flows through the hollow nozzle guide vanes and through holes in the shroud. It is used to cool the nozzle guide vane and the front face of the gas generator turbine. A small amount of air is also used to cool the turbine shroud.

The centrifugal compressor casing is fitted with air tapping points. This air is called clean air as it is out of the main air flow stream.

Power turbine section

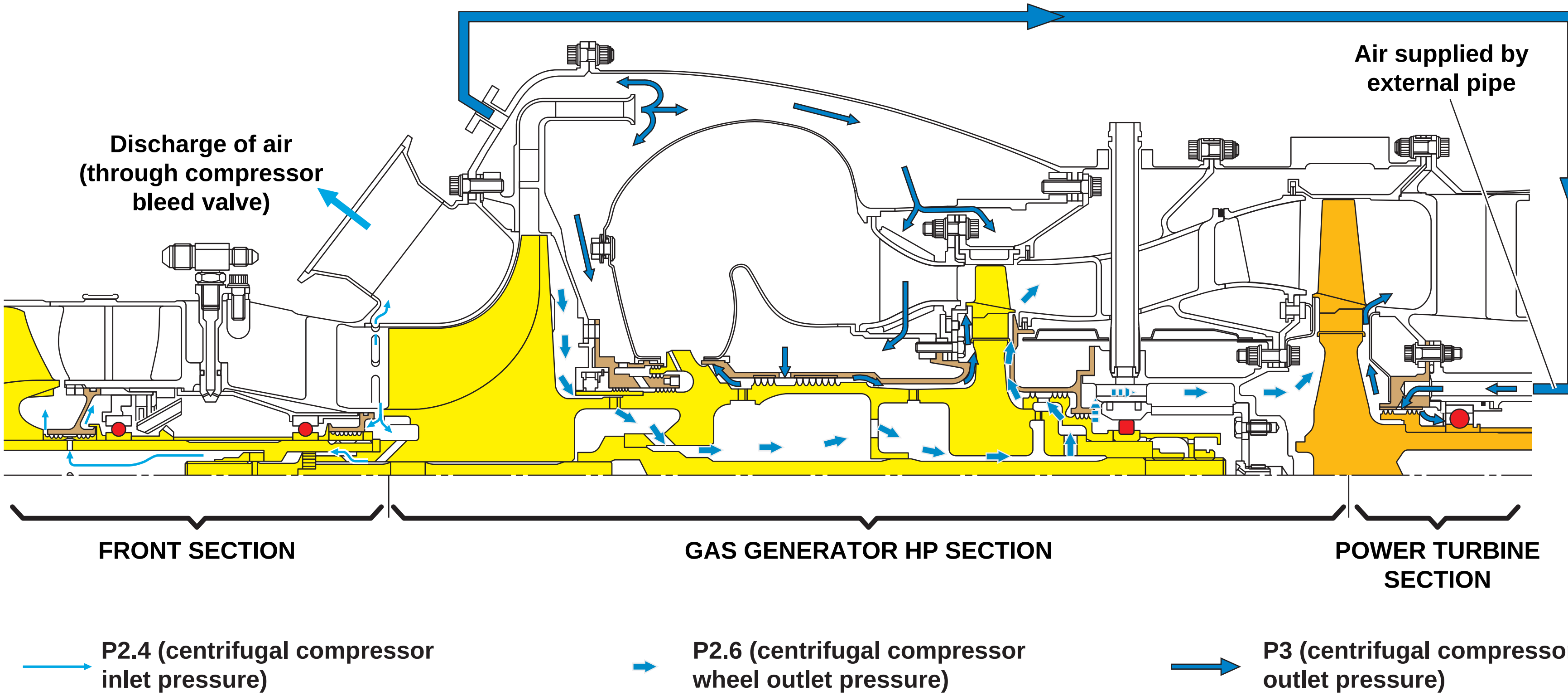
The air is tapped from the front face of the centrifugal compressor casing (clean air) and is taken by an external pipe to the reduction gearbox casing. It then passes through internal passages to pressurise the labyrinth seal on the power turbine shaft and to cool the rear face of the power turbine.

Type:
Air pressure tapping with a calibrated flow

Air pressures used:
- Centrifugal compressor inlet pressure
- Centrifugal compressor wheel outlet pressure
- Centrifugal compressor outlet pressure

INTERNAL AIR SYSTEM

- Internal passages



INTERNAL AIR SYSTEM

AIR TAPPINGS

Function

Air tappings are used for:

- Fuel control
- *2B: The pump and metering unit assembly (metering unit)*
- Start injector ventilation
- Aircraft services
- Bleed valve operation
- Pressurisation of the power turbine labyrinth seals.

Main characteristics

- P3 air: 820 kPa (118.9 PSI) / 335 °C (635 °F)
- Air tapping limited by restrictors.

Functional description

Fuel control

A P3 pressure transmitter measures the centrifugal compressor outlet air pressure.

The signal of pressure is transmitted to the EECU.

2B: Air tapping for the pump and metering unit assembly.

The air tapped from the outlet of the centrifugal compressor supplies the metering unit through an external pipe (anti-surge function for manual control).

Start injector ventilation

Compressor delivery air is used to ventilate the start injectors to avoid blockage by the carbonisation of unburnt fuel.

The system comprises a tapping union and a pipe connected to the start electro-valve.

Aircraft services

Compressor delivery air is tapped off for use in various aircraft systems.

The engine has two air tapping unions (used for the aircraft services) located on the centrifugal compressor casing.

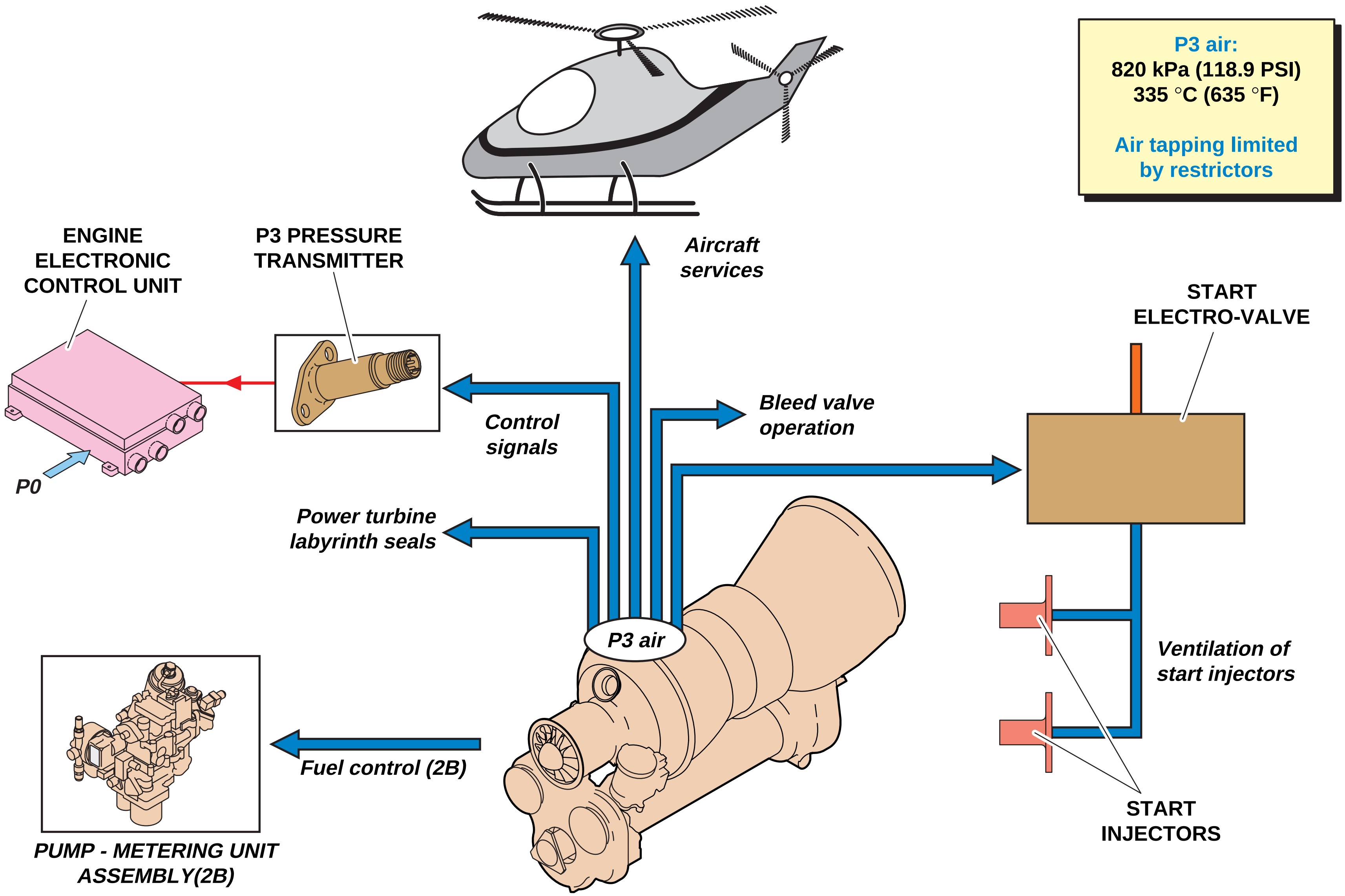
***Note**: The use of this bleed is restricted during take-off and in single engine mode.*

Bleed valve operation

Compressor delivery air is tapped to operate the compressor bleed valve.

Pressurisation of the power turbine labyrinth seals

Refer to page 5.4



AIR TAPPINGS

COMPRESSOR BLEED VALVE - GENERAL

Function

The valve prevents compressor surge by bleeding off a certain quantity of air tapped from the axial compressor outlet. When the valve is open, the discharge of air causes the air flow through the axial compressor to increase thus moving the operating line away from the surge line. The operation of this valve depends on the P3/P0 pressure ratio.

Position

- In the system: between the axial and centrifugal compressors
- On the engine: at the top of the counter casing.

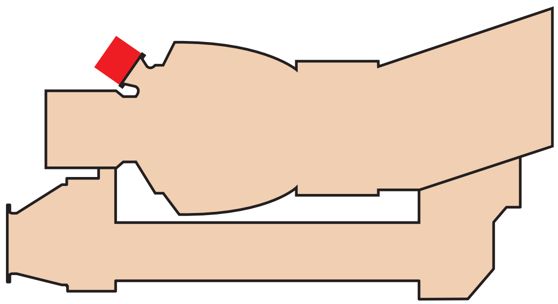
Main characteristics

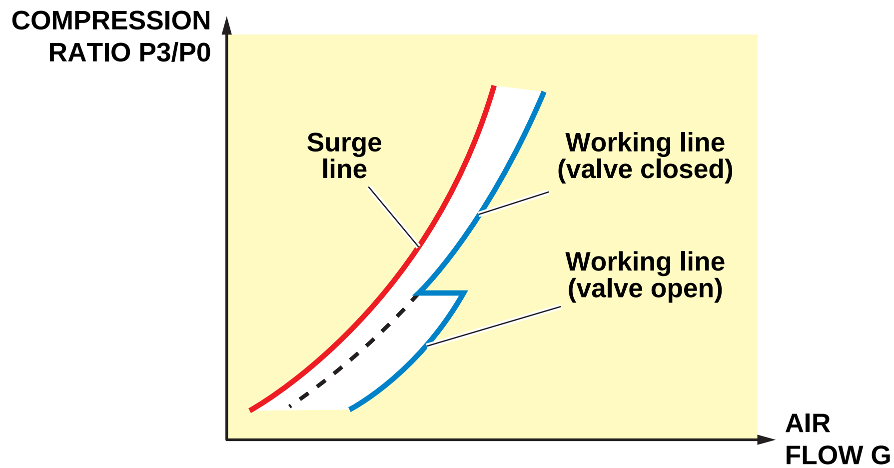
- Type: pneumatic, butterfly valve
- Control: by P3/P0 pressure ratio.

Main components

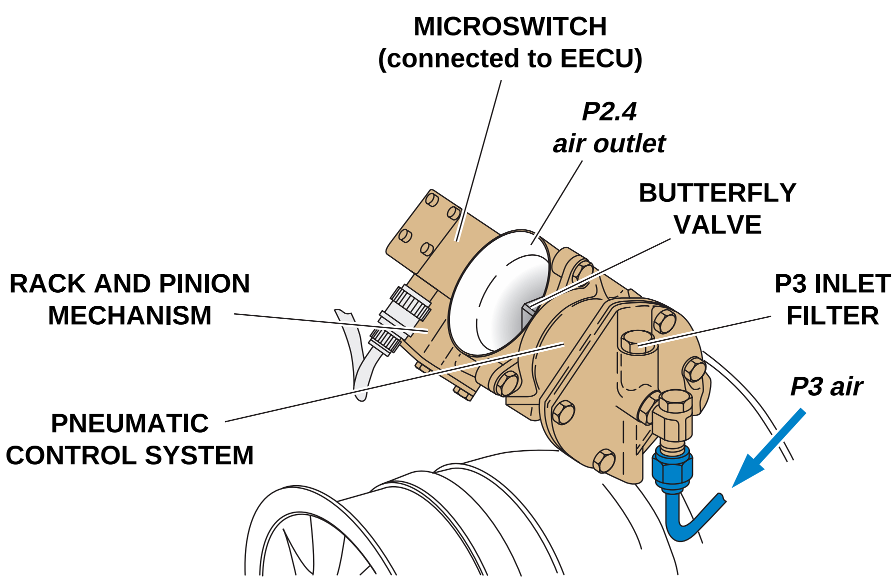
- Pneumatic control system
- Butterfly valve
- Rack and pinion mechanism
- Microswitch (connected to the EECU)
- P2.4 air outlet
- P3 inlet filter.

***Note**: The air can be discharged under the cowling in order to improve cooling of the engine compartment.*





COMPRESSOR FIELD DIAGRAM



Type:
Pneumatic, butterfly valve

Control:
By P3/P0 pressure ratio

COMPRESSOR BLEED VALVE - GENERAL

COMPRESSOR BLEED VALVE - DESCRIPTION - OPERATION

Description

The compressor bleed valve includes 3 main parts: the detection capsule, the intermediate stage and the bleed valve.

Detection capsule

It is subjected to P3/P0 pressure ratio and controls the air discharge downstream of the calibrated orifice B.

It is fitted with a filter at the inlet.

Intermediate stage

It includes a diaphragm which is subjected to the pressure downstream of B. The diaphragm controls the discharge which determines the pressure downstream of the calibrated orifice A.

Bleed valve

It includes a spring loaded piston subjected to the pressure downstream of restrictor A. The piston actuates the butterfly valve by means of a rack and pinion mechanism.

It also includes a microswitch, operated by the piston, which sends a position signal to the EECU.

The EECU outputs a position signal to the cockpit.

Operation

Open position

The P3/P0 pressure ratio is not sufficient to activate the capsules and there is an air discharge downstream of the calibrated orifices. The piston is not actuated and the butterfly valve is open.

A certain amount of air, tapped from the centrifugal compressor inlet, is discharged overboard.

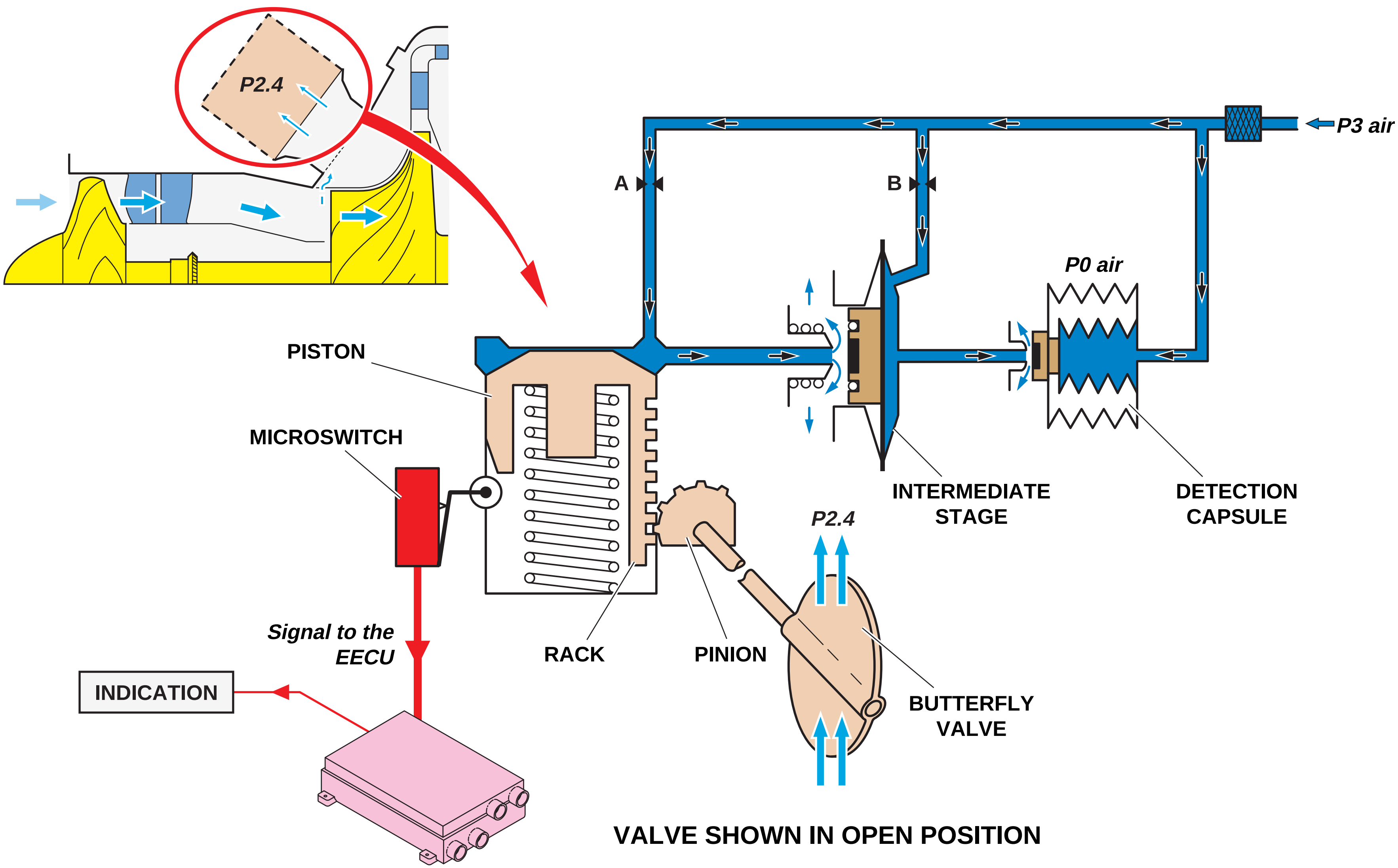
The microswitch contact is closed and sends an open signal to the EECU.

Closed position

When the gas generator rotation speed N1 increases, the compression ratio P3/P0 increases and beyond a certain value:

- The pressure becomes sufficient to deform the detection capsule which closes the discharge
- The pressure downstream of the calibrated orifice B increases
- The diaphragm of the intermediate stage closes the discharge
- The pressure downstream of the calibrated orifice A increases
- The piston moves down under P3 pressure and rotates the butterfly valve through the rack and pinion mechanism. The valve closes and stops the air bleed.

The microswitch contact, actuated by the piston, opens. This provides a closed signal to the EECU.



COMPRESSOR BLEED VALVE - DESCRIPTION - OPERATION

P3 PRESSURE TRANSMITTER

Function

The P3 pressure transmitter senses the compressor outlet air pressure and supplies a signal to the EECU.

Position

- In the system: connected to the EECU

- On the engine: on the ignition unit support.

Main characteristics

- Type: resistive

- Output signal: voltage proportional to the air pressure

- Supply voltage: 10 VDC.

Description

The P3 pressure transmitter system comprises the P3 tapping, an air pipe and the pressure transmitter.

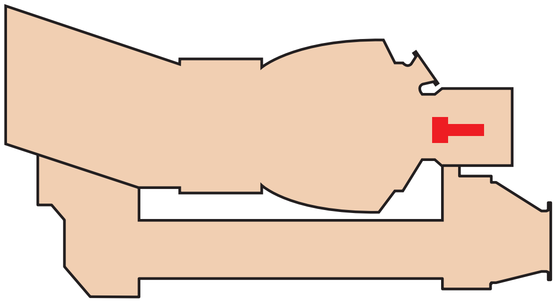
The transmitter is secured on the ignition unit support by 2 screws.

The electrical connector provides the connection with the EECU.

Operation

The transmitter produces an electrical voltage proportional to the P3 air pressure.

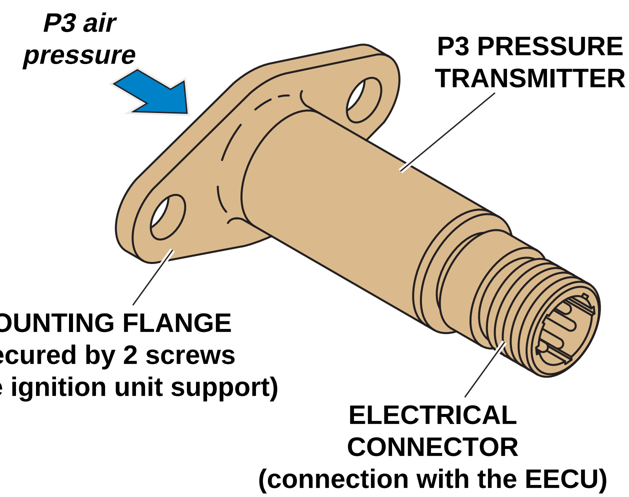
The pressure signal is used by the EECU for engine control (fuel flow limit, surge control).

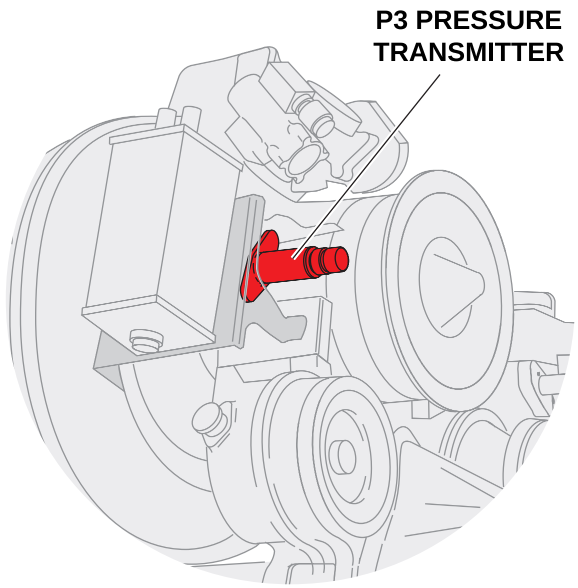


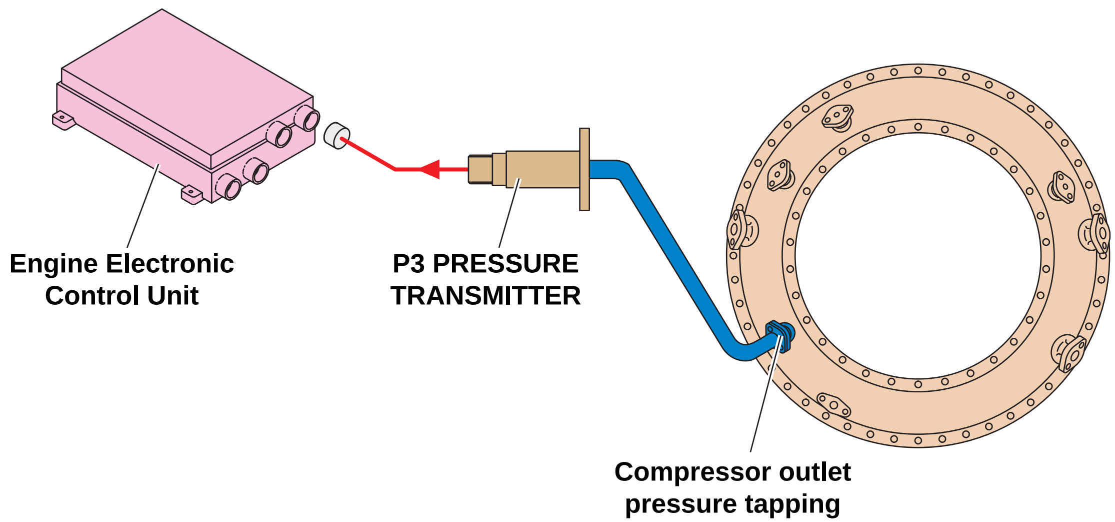
Type:
Resistive

Output signal:
Voltage proportional to the air pressure

Supply voltage:
10 VDC







P3 PRESSURE TRANSMITTER

AIR TAPPING UNIONS

Function

The air tapping unions allow air to be tapped from the centrifugal compressor outlet.

Position

They are located on the centrifugal compressor casing front face. The air in this zone is considered clean air as it is out of the main air stream and thus contains very little debris.

Main characteristics

At 100 % N1, in standard conditions:
- Air pressure: 820 kPa (118.9 PSI)
- Air temperature: 335 °C (635 °F).

Functional description

Start injector ventilation

Standard union.
Air flow: very low.

Power turbine labyrinth pressurisation

Standard union.
Air flow: very low.

P3 pressure transmitter

Standard union.

Air flow: nil.

Aircraft services

Standard union.

Max air flow: 100 g/s (0.22 lb/sec.).

Compressor bleed valve

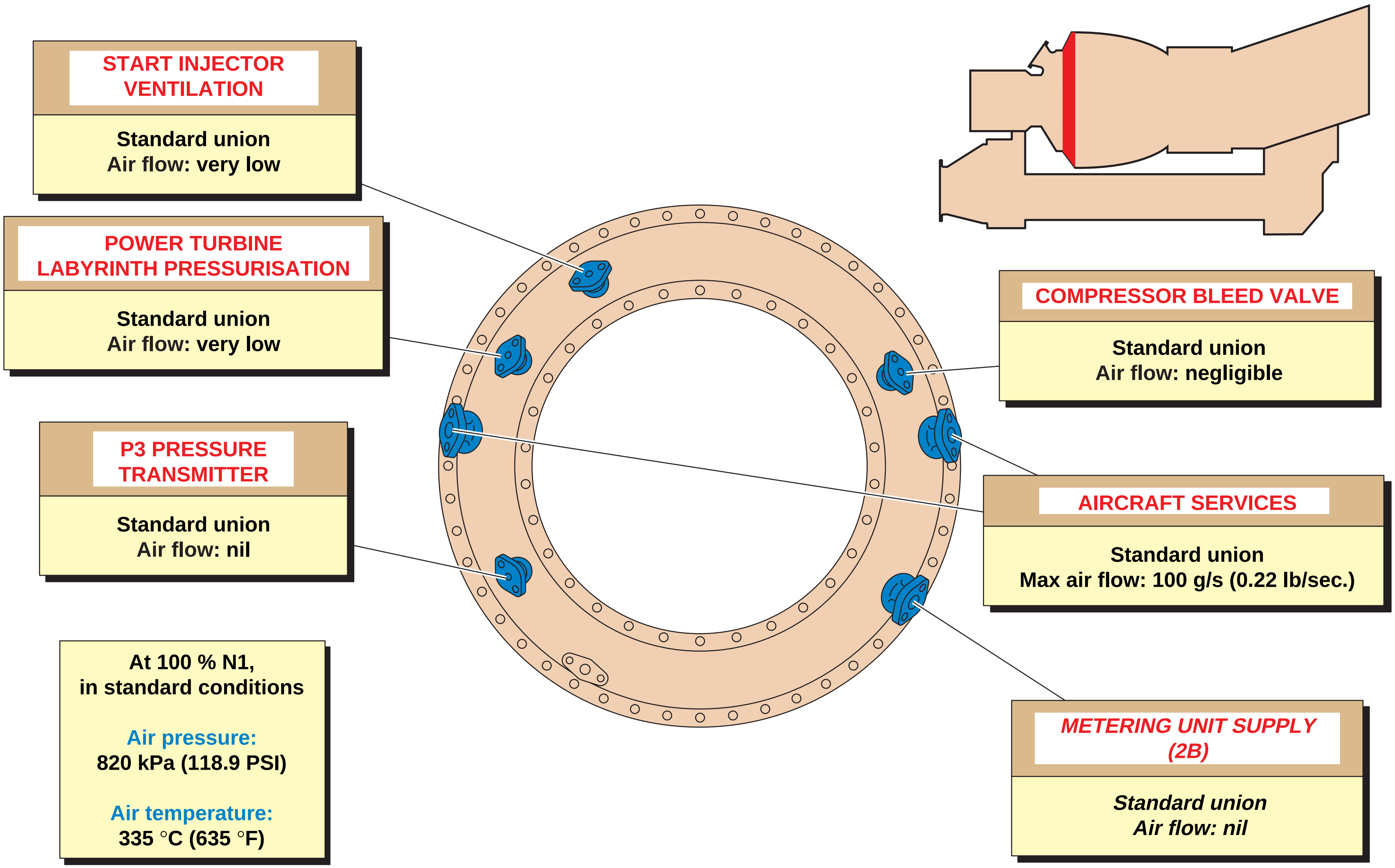
Standard union.

Air flow: negligible.

2B: Metering unit supply

Standard union.

Air flow: nil.



AIR TAPPING UNIONS

EXTERNAL AIR PIPES

This part considers the external air pipes of the air system.

Function

The air pipes ensure the air supply from/to the various system components.

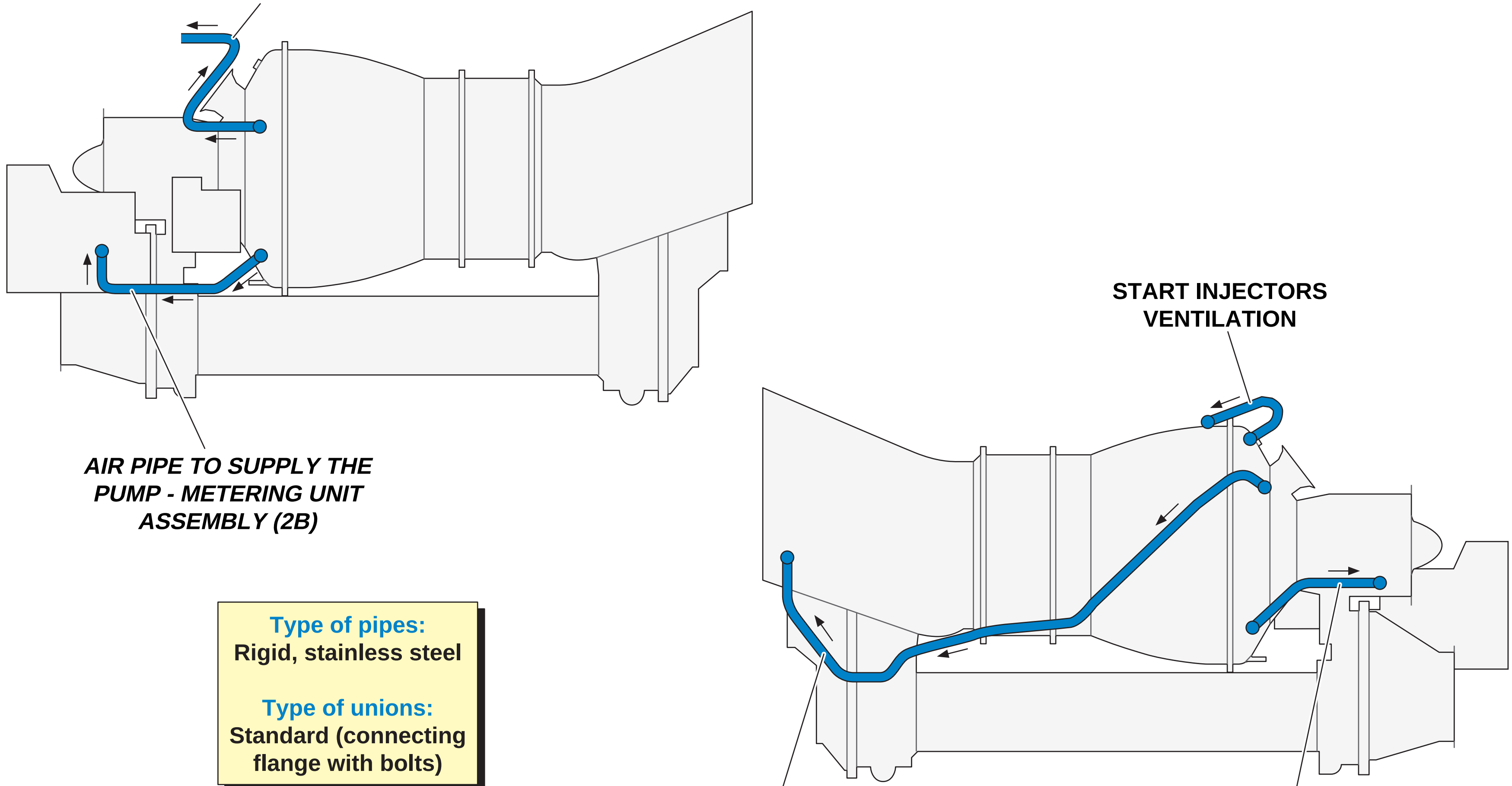
Main characteristics

- Type: rigid, stainless steel
- Unions: standard (connecting flange with bolts).

Description of the pipes

The air system uses the following external pipes:

- P3 air pipe for the control of the compressor bleed valve
- Air pipe for the ventilation of the start injectors
- Air pipe to supply the P3 pressure transmitter
- Air pipe for the pressurisation of the power turbine labyrinth
- *2B: Air pipe to supply the pump and metering unit assembly (acceleration controller).*



Type of pipes:
Rigid, stainless steel

Type of unions:
Standard (connecting flange with bolts)

EXTERNAL AIR PIPES

6 - FUEL SYSTEM

(XX-XX-XX): Page references which deal with the subject in the maintenance documentation.

FUEL SYSTEM - GENERAL

Function

The fuel system ensures fuel supply, distribution, control, metering and injection.

Position

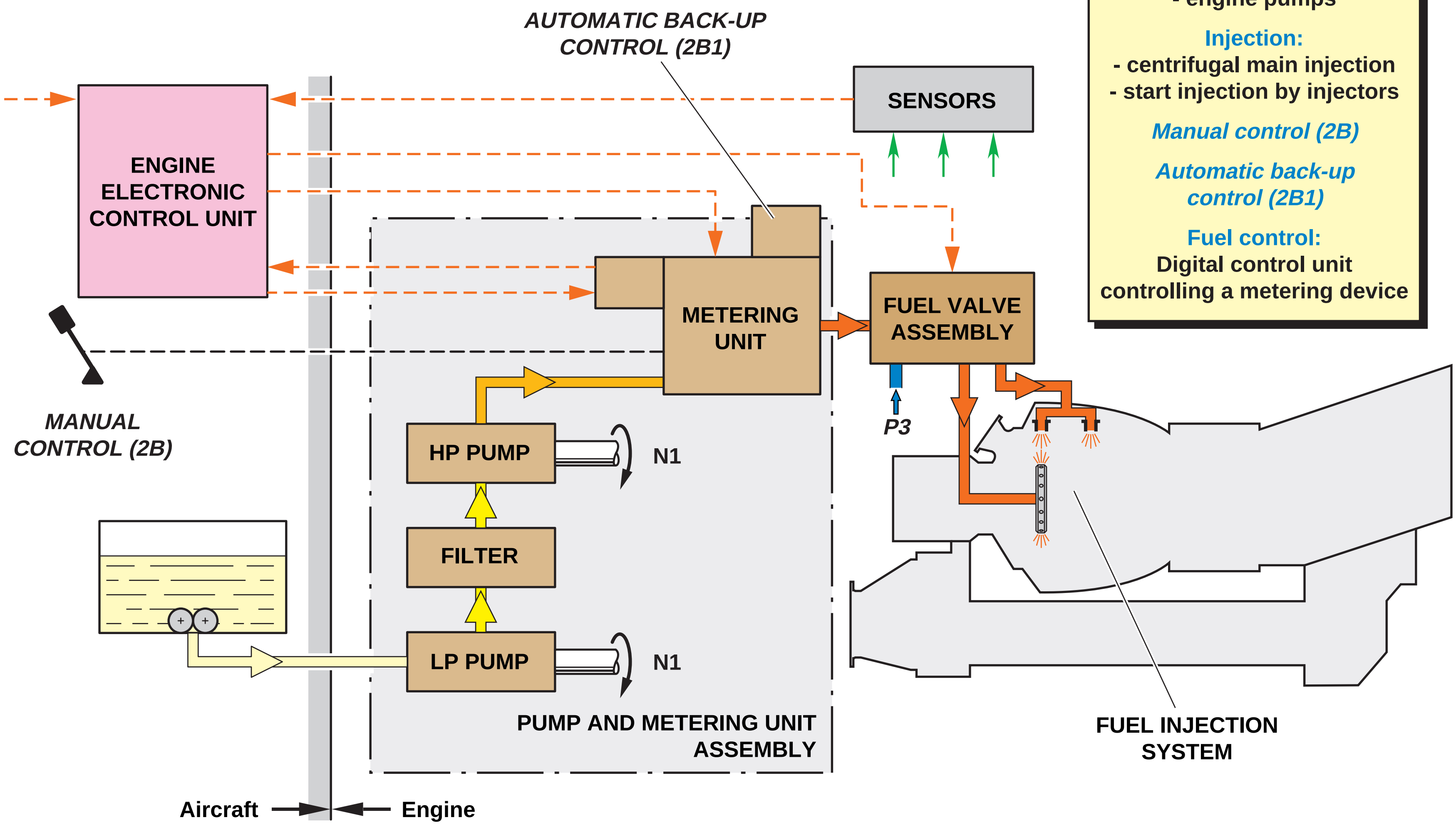
All the system components are mounted on the engine except the EECU.

Main characteristics

- Supply by the aircraft system and the engine pumps
- Centrifugal main injection and start injection by injectors
- *2B: Manual control*
- *2B1: Automatic back-up control*
- Fuel control: digital control unit controlling a metering device.

Main components

- Pump and metering unit assembly:
  - LP pump
  - Filter
  - HP pump
  - Metering unit
- Fuel valve assembly
- Injection system.



Supply:
- aircraft system
- engine pumps

Injection:
- centrifugal main injection
- start injection by injectors

Manual control (2B)

Automatic back-up control (2B1)

Fuel control:
Digital control unit controlling a metering device

FUEL SYSTEM - GENERAL

FUEL SYSTEM - DESCRIPTION

This part shows the main components of the fuel system.

Low pressure pump (LP)

Centrifugal type pump which gives an initial pressure rise.

Oil/Fuel heat exchanger (oil filter)

Filter

Fitted between the LP and HP pumps, this filter has a blockage indicator and a by-pass valve.

Start purge valve

To eliminate air from the system before start.

Fuel filter pre-blockage pressure switch

Provides a cockpit indication of the onset of the filter blockage.

Low fuel pressure switch

Sensing the filter outlet pressure, it gives a cockpit indication of system low pressure.

High pressure pump (HP)

Spur gear type pump which provides the high pressure supply. It is fitted with a pressure relief valve.

Metering unit

- Automatic control (stepper motor, resolver, metering needle, constant ΔP valve)
- *2B: Manual control: twist grip on collective lever*
- *2B1: Automatic back-up control: by-pass valve and actuator (the actuator is supplied by the aircraft manufacturer).*

Additional check valve

The valve permits the correct operation of the constant ΔP valve in low fuel flow conditions (particularly during starting).

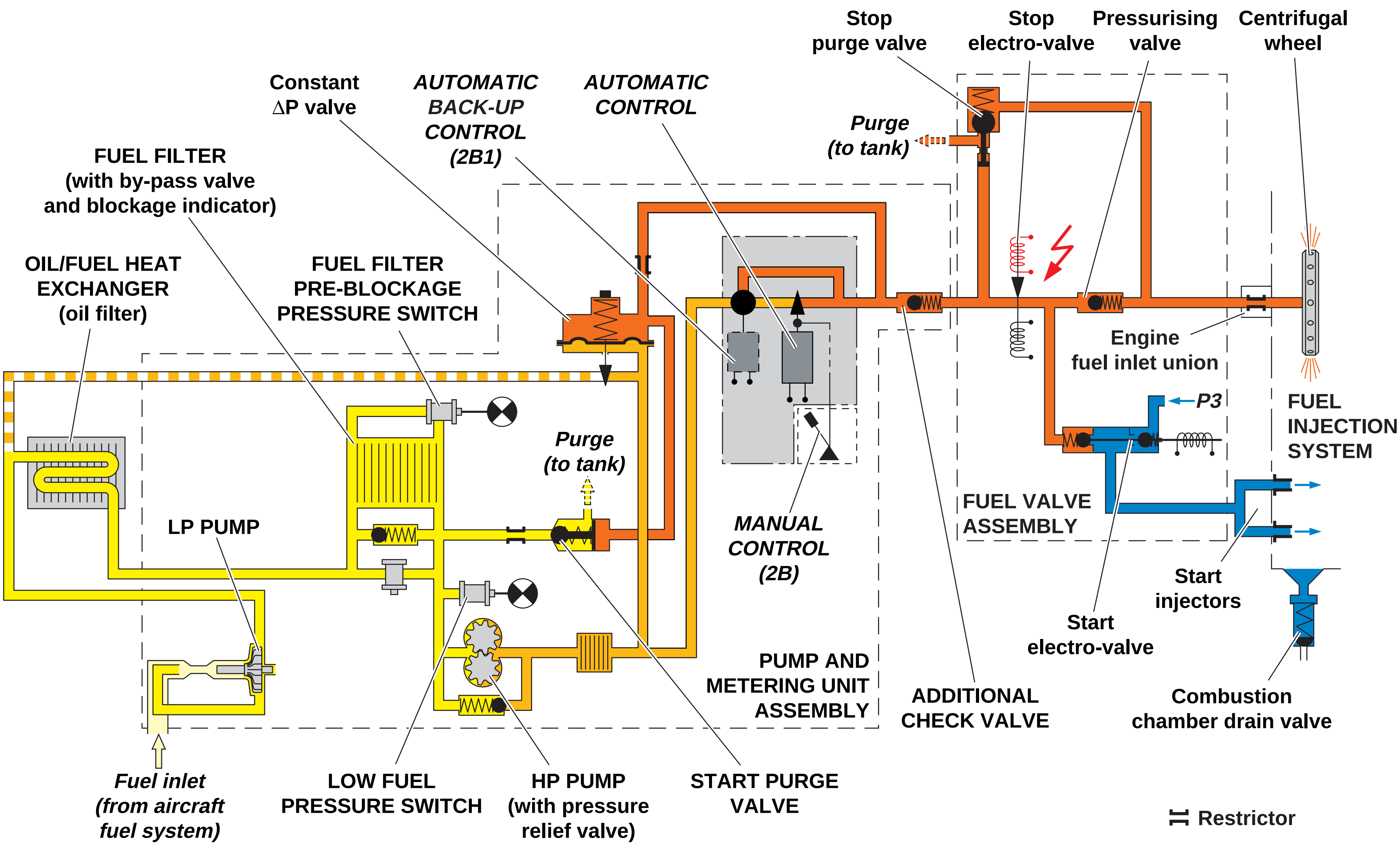
Fuel valve assembly

- Start electro-valve
- Stop electro-valve
- Pressurising valve
- Stop purge valve.

Fuel injection system

- Start injectors (2)
- Main injection (centrifugal wheel)
- Engine fuel inlet union
- Combustion chamber drain valve.

***Note**: A fuel flowmeter, supplied by the aircraft manufacturer, can be fitted between the metering unit and the fuel valve assembly.*



FUEL SYSTEM - DESCRIPTION

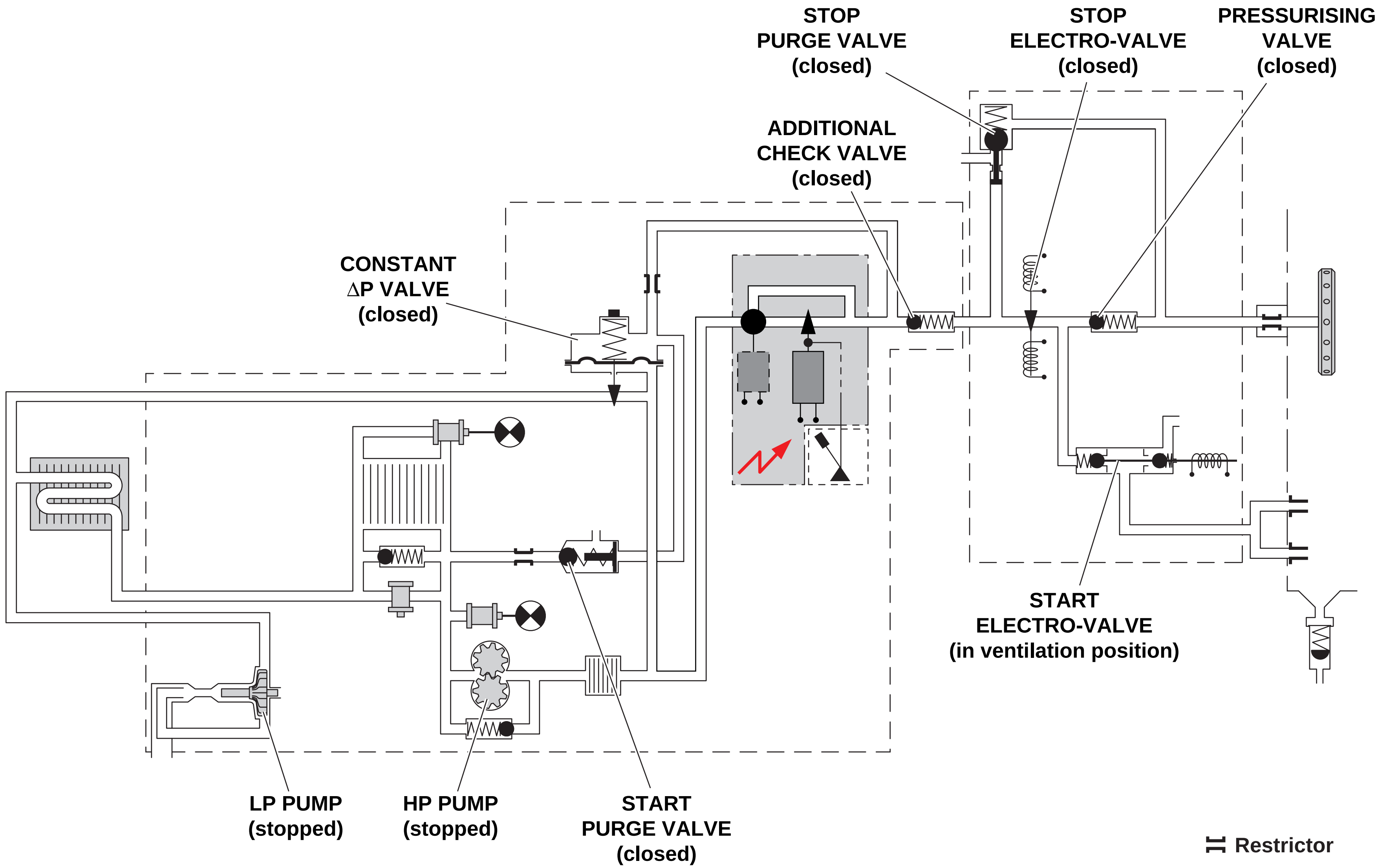
FUEL SYSTEM - OPERATION (1)

This part deals with the following operating phases: pre-start, purge, starting, normal running, back-up control and shut-down.

Pre-start

- The LP and HP pumps do not operate and there is no pressure in the system
- The constant ΔP valve is closed
- The stop electro-valve is closed
- The pressurising valve is closed
- The additional check valve is closed
- The start purge valve is closed
- The stop purge valve is closed
- The start electro-valve is in the ventilation position (no electrical supply).

2B: At power-up the metering valve is positioned to permit the engagement of the manual control should this be necessary.



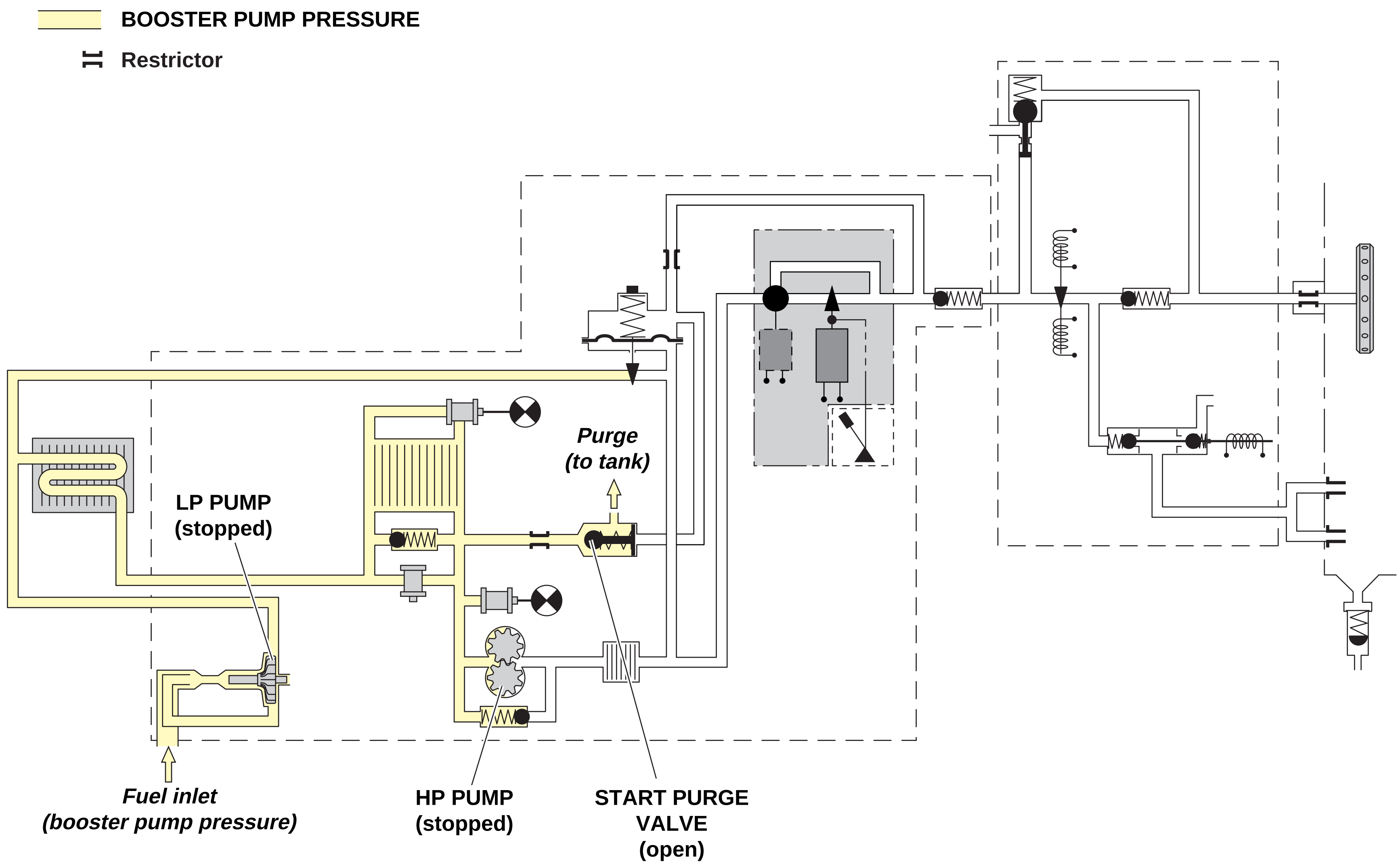
PRE-START
FUEL SYSTEM - OPERATION (1)

FUEL SYSTEM - OPERATION (2)

Fuel system purge

Before starting, the booster pump is switched on. The low pressure fuel flows through the LP pump and filter, and is returned to the tank through the start purge valve.

This purge must be carried out before each start, for 15 to 20 secs.



FUEL SYSTEM PURGE

FUEL SYSTEM - OPERATION (2)

FUEL SYSTEM - OPERATION (3)

Starting

When start is selected, the start accessories are electrically supplied.

The pumps are driven at a speed proportional to N1. First they supply the start injectors and then the centrifugal injection wheel.

The start purge valve closes.

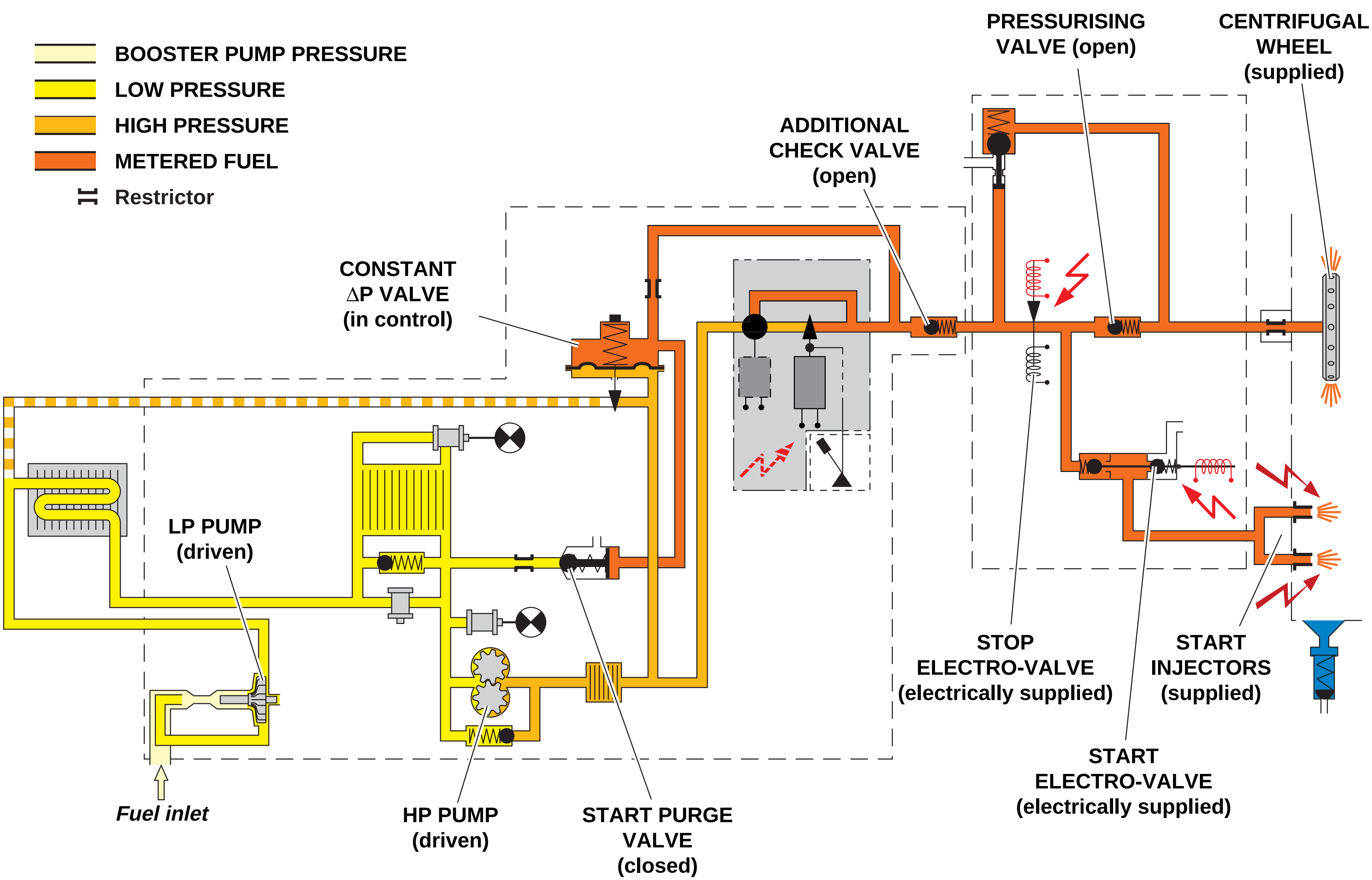
The constant ΔP valve operates and returns the excess fuel to the LP pump outlet.

The additional check valve ensures the operation of the constant ΔP valve when the HP pump pressure is very low. It increases the HP fuel pressure during starting, particularly at altitude.

The fuel flow is metered by the metering unit according to control laws determined by the Engine Electronic Control Unit.

At the end of starting, the start accessories are de-energised and the start injectors are ventilated by P3 air pressure.

The gas generator rotation speed is stabilised at a controlled value.



STARTING

FUEL SYSTEM - OPERATION (3)

FUEL SYSTEM - OPERATION (4)

Normal running

The required fuel flow is metered by the metering needle. The metering needle position is determined by the Engine Electronic Control Unit (refer to "CONTROL SYSTEM" chapter).

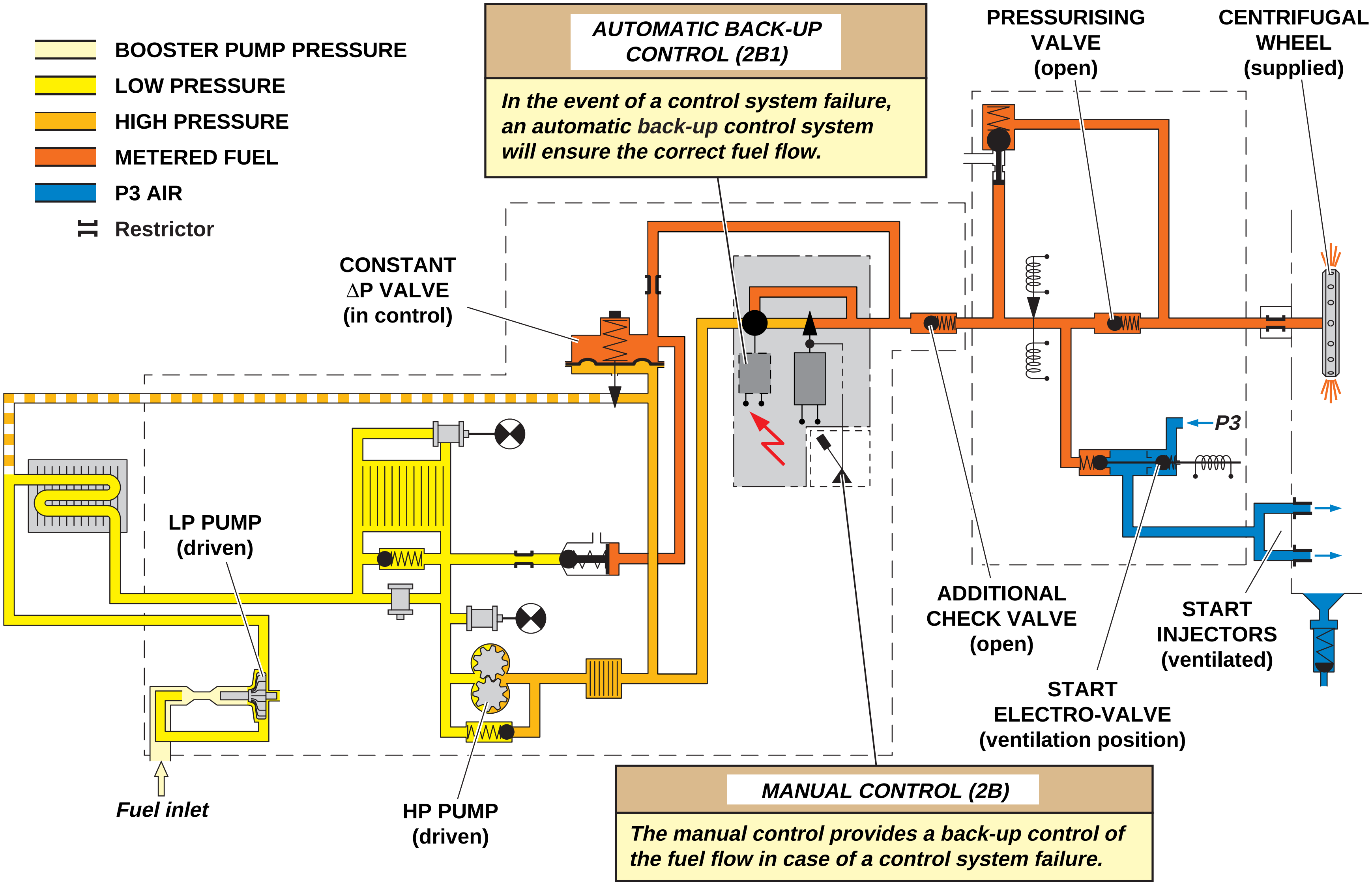
The HP pump always supplies more fuel than the engine requires. The excess fuel returns to the LP pump outlet through the constant ΔP valve.

The start injectors are continuously ventilated by P3 air circulation.

Back-up control

2B: *The manual control provides a back-up control of the fuel flow in case of a control system failure.*

2B1: *In the event of a control system failure, an automatic back-up control system will ensure the correct fuel flow.*



NORMAL RUNNING - BACK-UP CONTROL

FUEL SYSTEM - OPERATION (4)

FUEL SYSTEM - OPERATION (5)

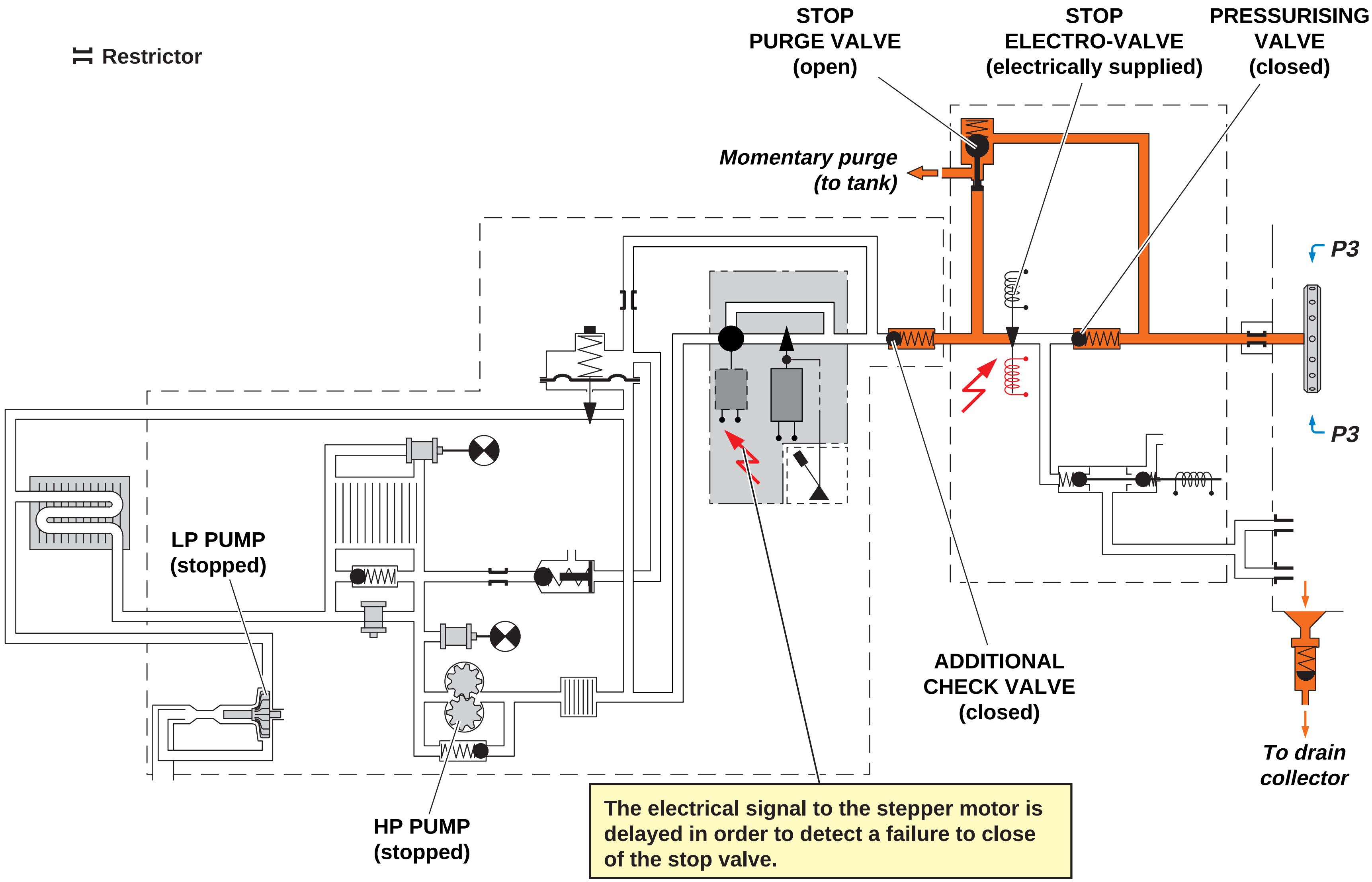
Shut-down

The engine stop command electrically supplies the stop electro-valve and the stepper motor to close the metering valve.

The fuel supply to the injection wheel is cut and the engine stops.

The stop purge valve opens briefly to drain the fuel from the injection line to the tank.

***Note**: The electrical signal to the stepper motor is delayed in order to detect a failure to close of the stop valve.*



SHUT-DOWN

FUEL SYSTEM - OPERATION (5)

PUMP AND METERING UNIT ASSEMBLY - GENERAL

Function

The pump and metering unit assembly ensures fuel supply and fuel flow metering.

Position

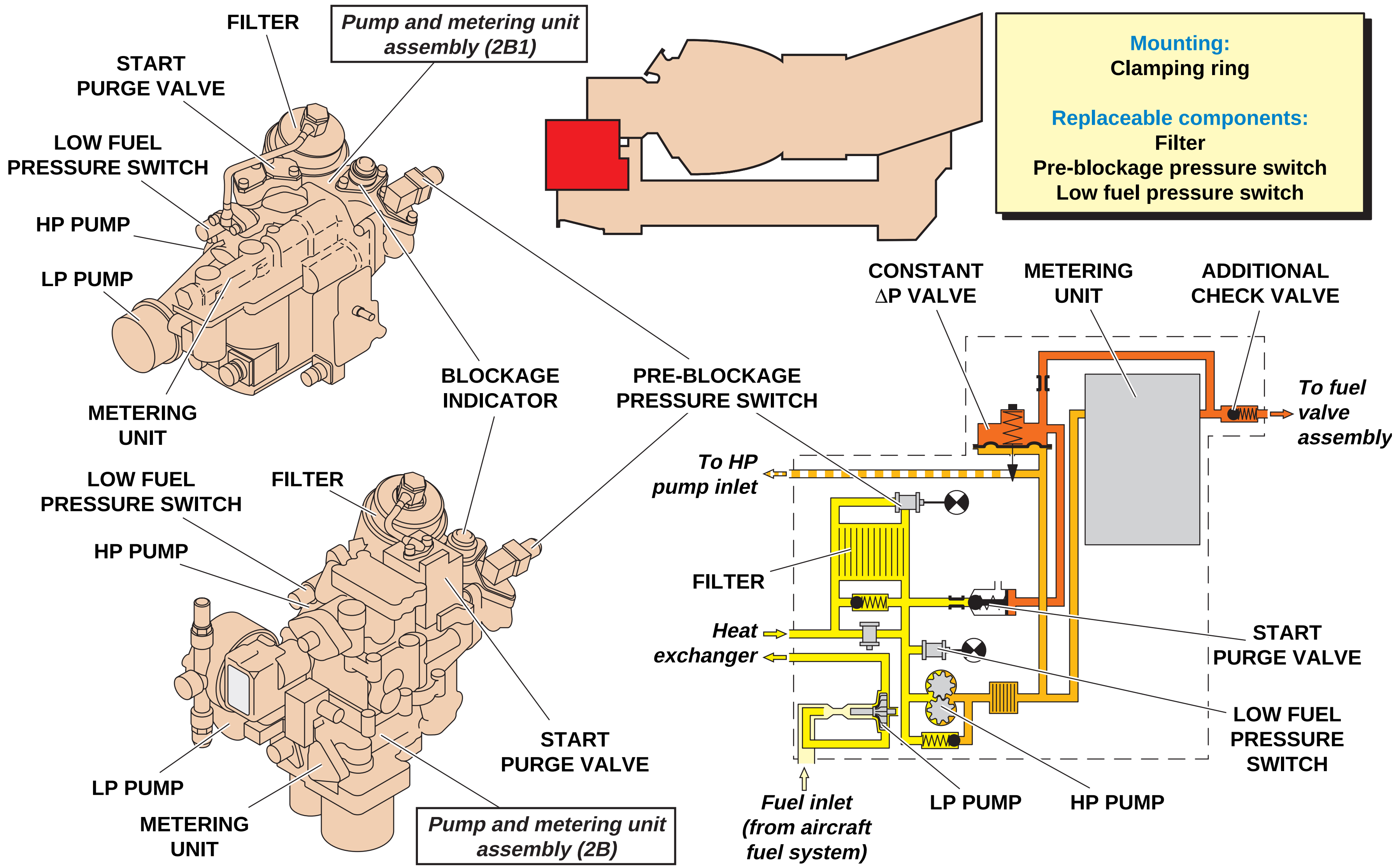
- In the system: before the fuel valve assembly
- On the engine: on the left front face of the accessory gearbox.

Main characteristics

- Mounting: clamping ring
- Replaceable components (LRUs):
  - Filter
  - Pre-blockage pressure switch
  - Low fuel pressure switch
  - Fuel filter blockage indicator.

Main components

- LP pump
- Filter
- Pre-blockage pressure switch
- Blockage indicator
- Low fuel pressure switch
- Start purge valve
- HP pump
- Constant ΔP valve
- Metering unit
- Additional check valve.



PUMP AND METERING UNIT ASSEMBLY - GENERAL

PUMP AND METERING UNIT ASSEMBLY - FUEL PUMPS - GENERAL - DESCRIPTION

Function

The pump assembly supplies fuel under determined conditions of pressure and flow.

Position

- In the system: before the metering unit
- On the engine: on the right side of the pump and metering unit assembly.

Main characteristics

- Type:
  - LP pump: centrifugal type
  - HP pump: spur gear type.

Description

The pump assembly includes an LP pump and an HP pump fitted with a pressure relief valve.

Low pressure pump (LP)

The low pressure pump is a centrifugal pump. It includes an impeller driven at a speed proportional to N1. The impeller is mounted on a shaft supported by bearings. This shaft also drives the high pressure pump.

The pump has an ejector supplied by fuel from the pump outlet in order to improve the pump suction efficiency.

The pump is capable of operating with contaminated fuel so there is no filter at the inlet.

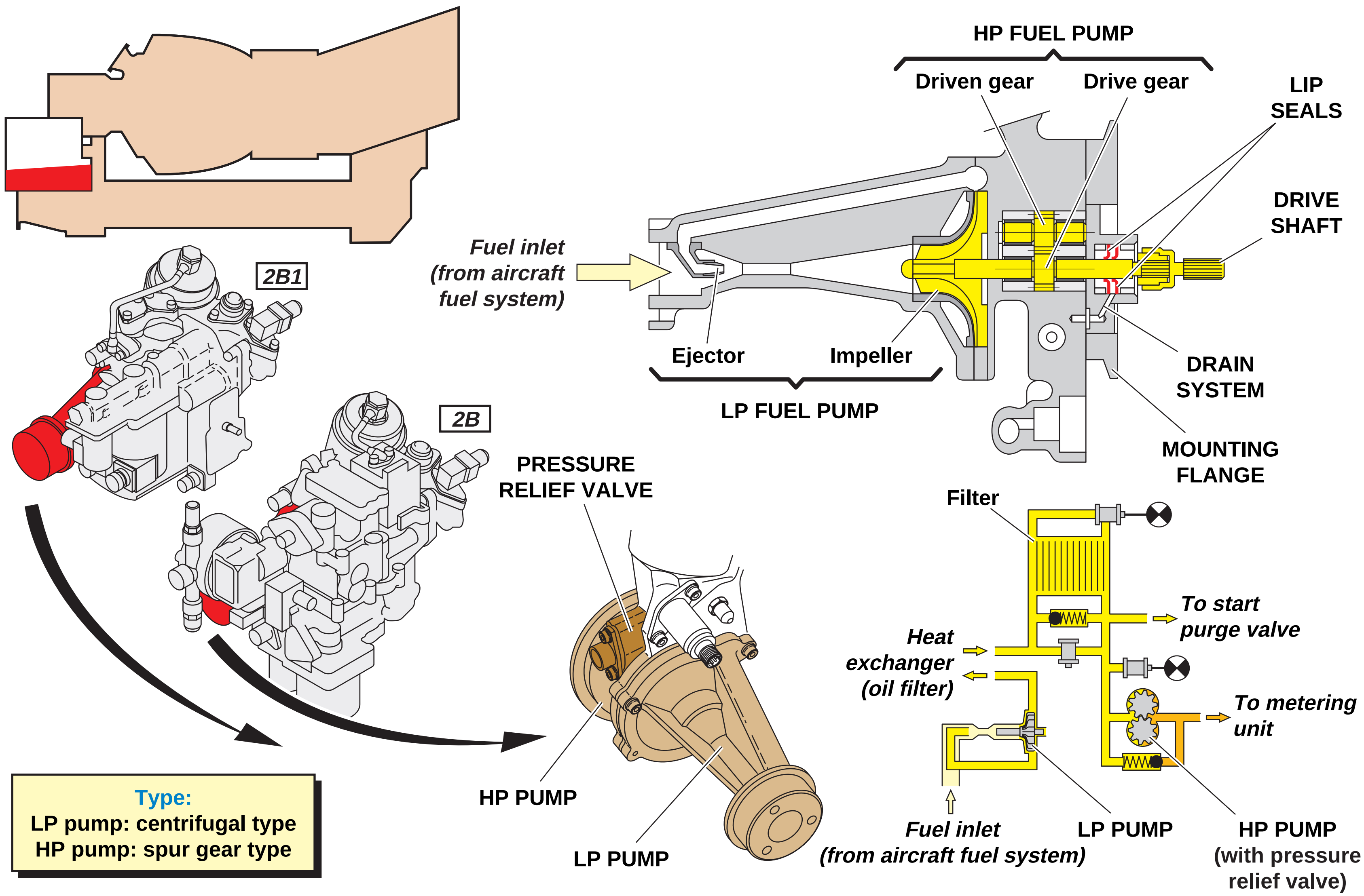
The shaft of the LP and HP pumps is a shear shaft.

High pressure pump (HP)

The high pressure pump is a gear type pump. It has a driven gear and a drive gear driven at a speed proportional to N1.

The drive shaft is fitted with two lip seals with a drain chamber between them. Any fuel leakage will thus be drained overboard and no fuel can enter the accessory gearbox.

The high pressure pump also includes a pressure relief valve which returns the excess fuel to the HP pump inlet.



PUMP AND METERING UNIT ASSEMBLY - FUEL PUMPS - GENERAL - DESCRIPTION

PUMP AND METERING UNIT ASSEMBLY - FUEL PUMPS - OPERATION

Fuel from the aircraft system enters the LP pump which provides an initial pressure increase to supply the HP pump. The HP pump gives a second pressure rise and supplies the metering unit.

The LP pump is capable of drawing fuel from the aircraft tank and therefore booster pumps are not necessary after starting.

LP pump operation

The centrifugal impeller draws the fuel in and forces it out towards the heat exchanger.

The pump efficiency is improved by an ejector pump at its inlet, supplied from the centrifugal impeller outlet.

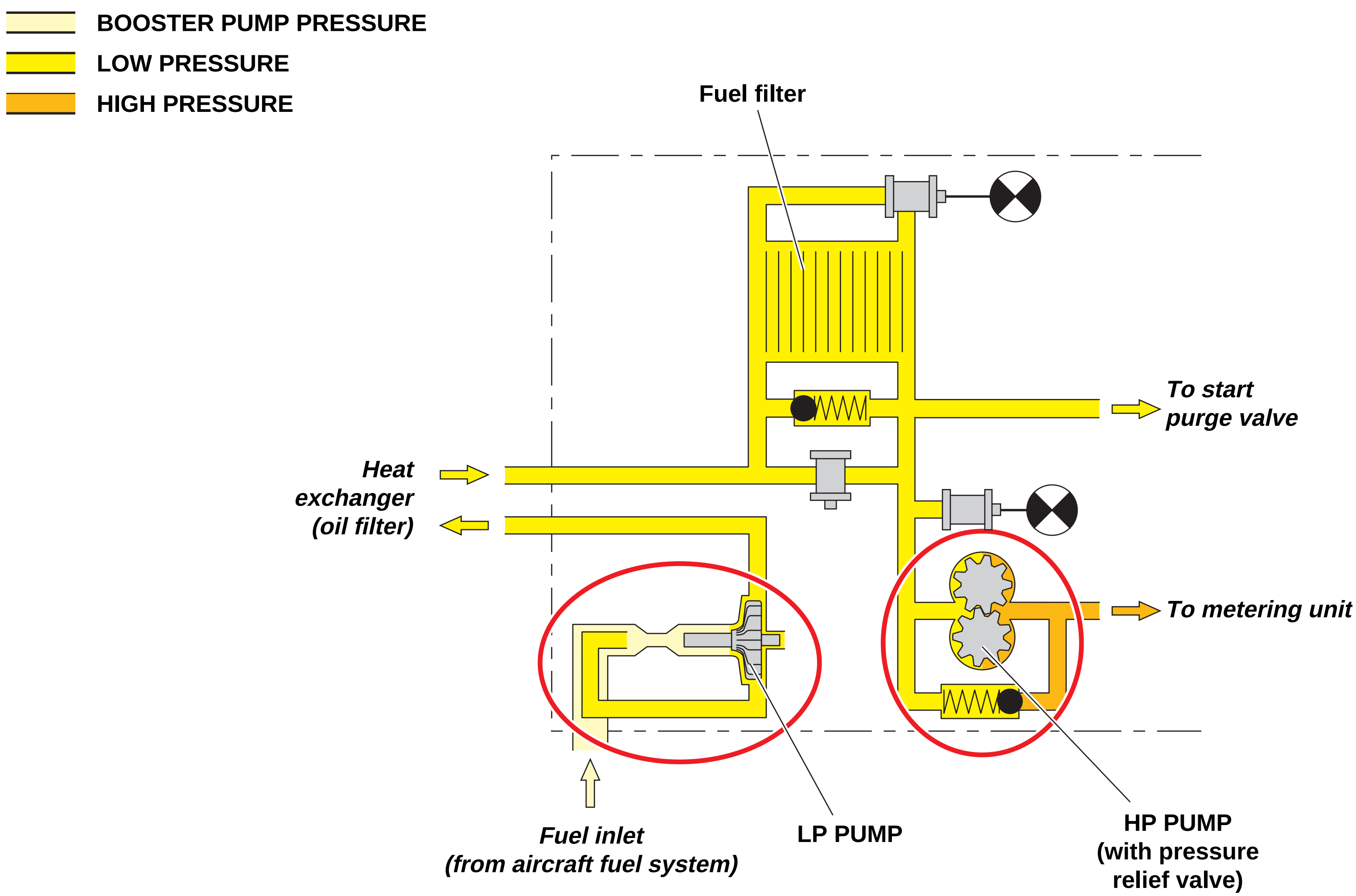
The LP pump is said to be "transparent" as fuel can flow through it when it is not turning.

HP pump operation

The fuel arriving from the LP pump, via the filter, is forced out under pressure by the HP pump to the metering unit.

The amount of fuel supplied by the pump is always greater than that required by the engine.

The HP pump is provided with a pressure relief valve. In the event of overpressure the valve opens and returns some of the flow to the pump inlet. This valve is closed during normal engine running.



PUMP AND METERING UNIT ASSEMBLY - FUEL PUMPS - OPERATION

PUMP AND METERING UNIT ASSEMBLY - START PURGE VALVE

Function

The start purge valve permits a purge of air from the fuel system before engine start.

Position

- In the system: between the filter and the return line to the fuel tank
- On the engine: on the upper part of the pump and metering unit assembly.

Main characteristics

- Type: ball valve controlled by a piston and a spring.

Description

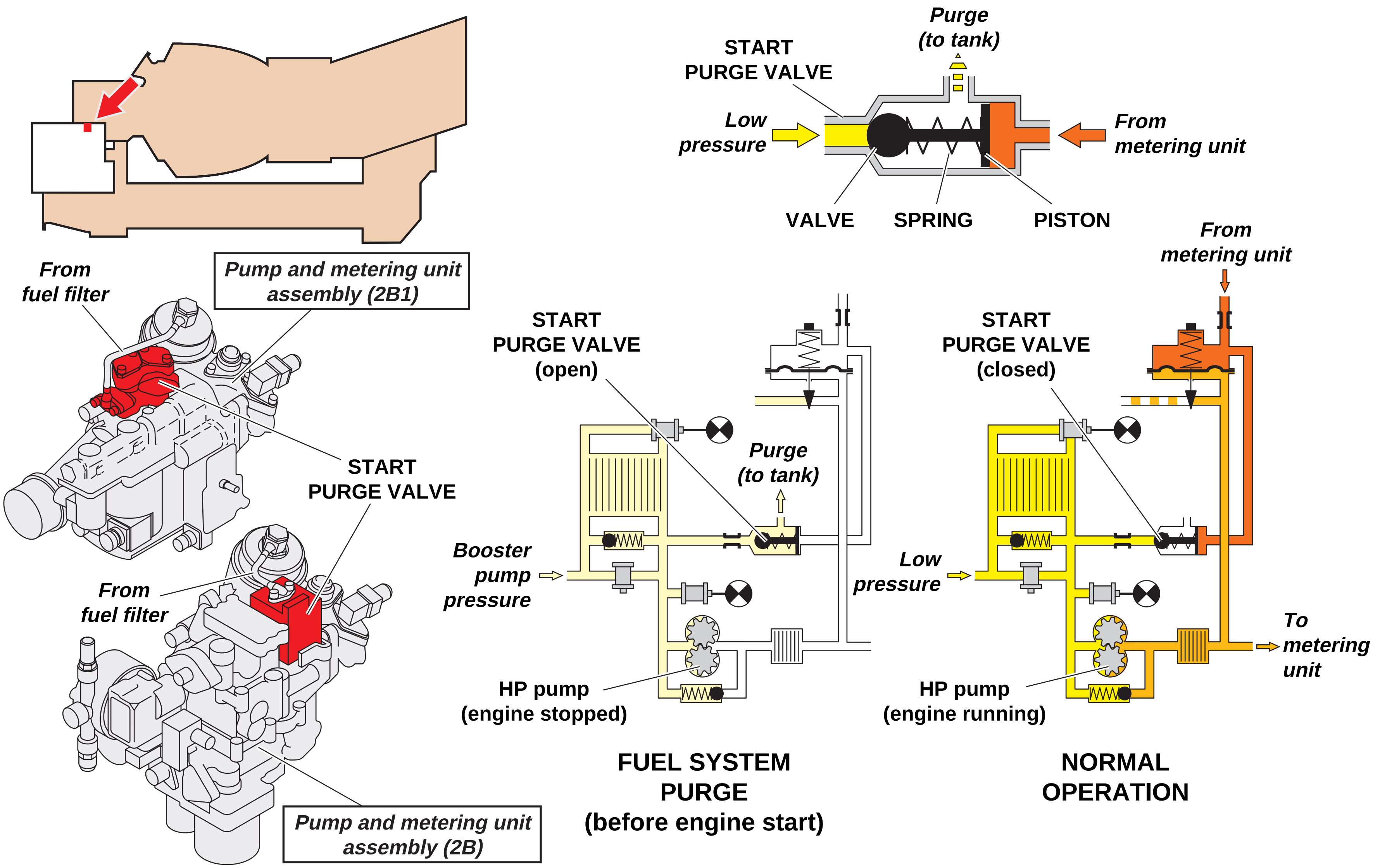
- A valve
- A piston
- A spring.

Operation

When the aircraft booster pump is swiched on, fuel is supplied to the engine.

As soon as engine start is selected, HP pump pressure acts on the piston to close the start purge valve.

The start purge valve is open. The fuel passes through the LP pump, the filter and return to the tank.



PUMP AND METERING UNIT ASSEMBLY - START PURGE VALVE

PUMP AND METERING UNIT ASSEMBLY - METERING UNIT (2B) - GENERAL - DESCRIPTION

Function

The metering unit controls the fuel flow in automatic mode in response to signals from the EECU.

In the event of control system failure, it permits fuel flow control in manual mode.

Position

- *In the system: downstream of the HP pump*
- *On the engine: at the front part of the pump and metering unit assembly.*

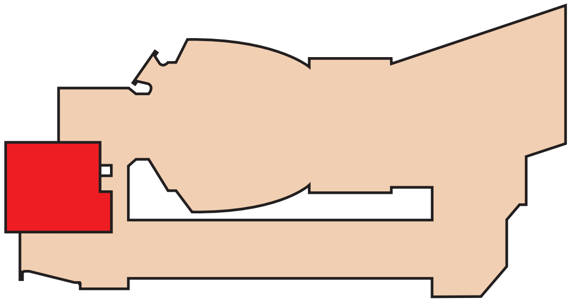
Main characteristics

- *Automatic control by an electrical actuator (stepper motor) driving a metering needle*
- *Manual control by a mechanical unit.*

Description

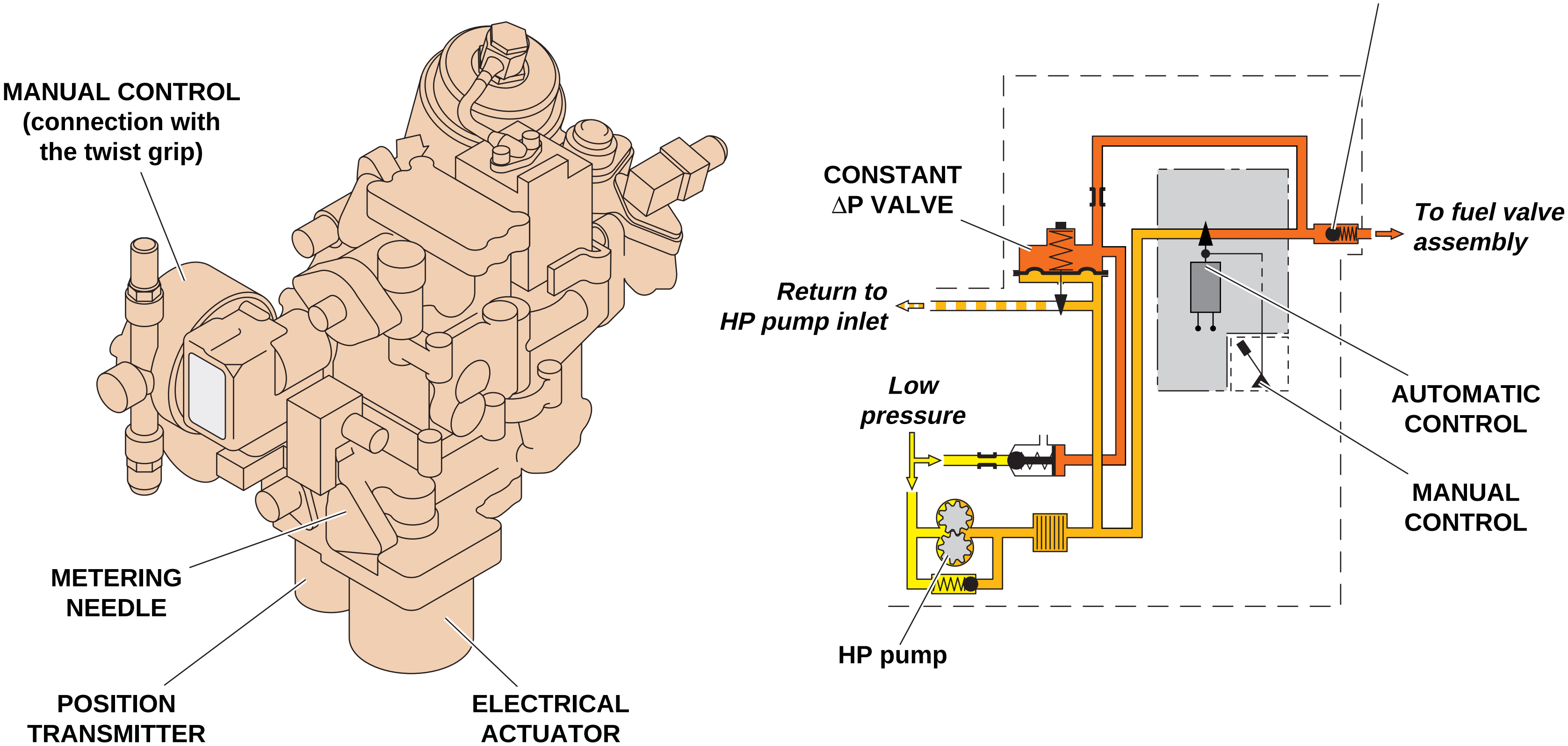
- *Constant ΔP valve (common)*
- *Additional check valve (common)*
- *Automatic control system*
- *Manual control system.*

***Note**: The position transmitter can also be called the resolver.*



Automatic control by an electrical actuator (stepper motor) driving a metering needle

Manual control by a mechanical unit



PUMP AND METERING UNIT ASSEMBLY - METERING UNIT (2B) - GENERAL - DESCRIPTION

PUMP AND METERING UNIT ASSEMBLY - METERING UNIT (2B) - OPERATION (1)

This unit incorporates the automatic and manual control systems in one unit.

The manual control is connected to a twist grip control on the collective pitch lever

Automatic control system (normal operation)

The twist grip and manual system are in the "neutral" notch.

The manual control mechanism is "clutched" and, consequently, the upper end of the metering needle control lever is fixed. On the other hand, the acceleration control lever is kept away from the stops; thus it does not offer any resistance to the displacement of the metering needle.

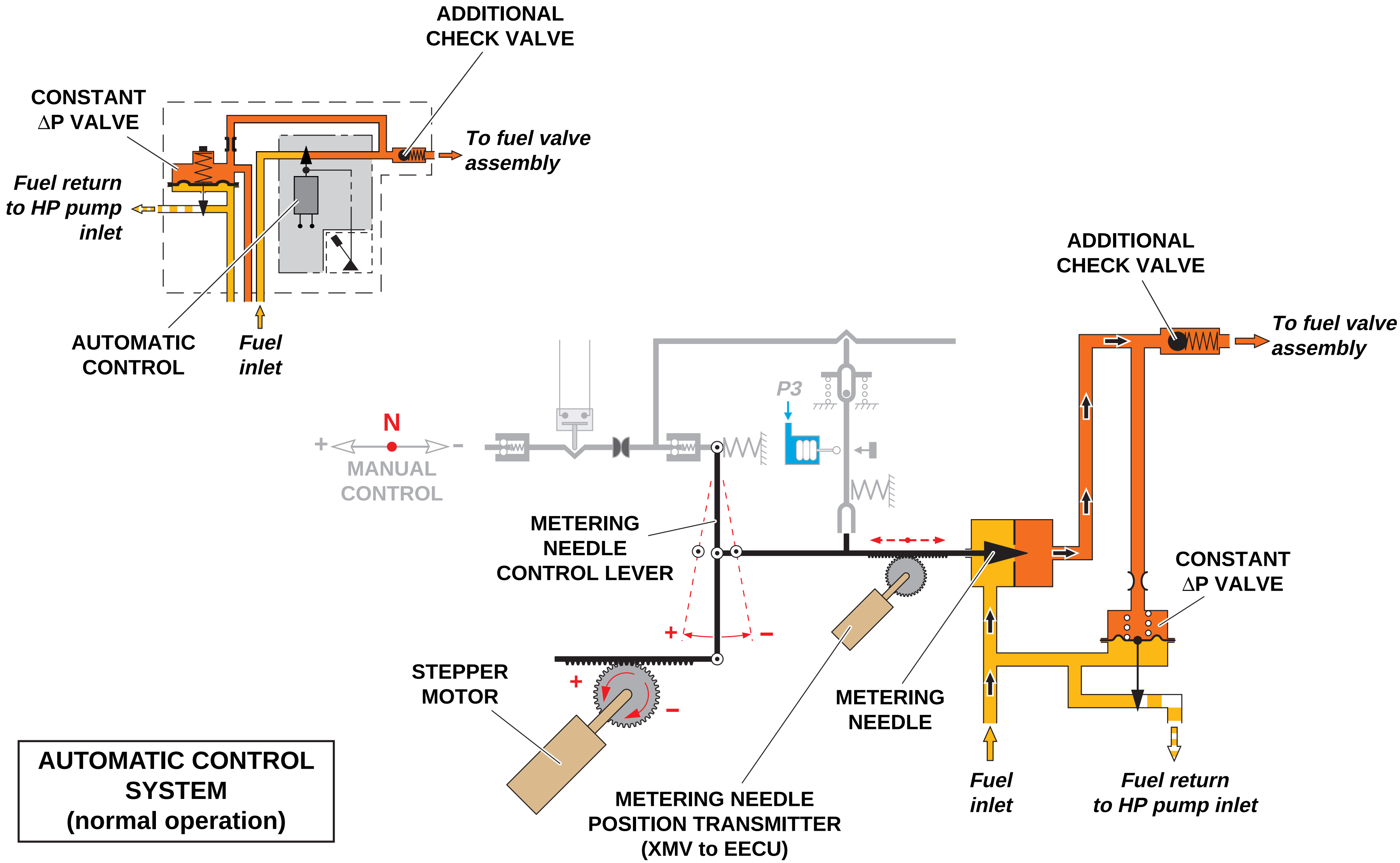
The metering needle position is controlled by the stepper motor.

When the EECU commands a fuel flow increase the stepper motor rotates and through the rack and pinion mechanism, drives the metering needle open. The upper end of the vertical lever acts as a pivot point. The horizontal metering needle rod has a rack and pinion mechanism which drives the position resolver which provides a metering needle position signal to the EECU (XMV). For a fuel flow decrease, the system operates in the opposite sense.

The constant ΔP valve returns the excess fuel to the HP pump inlet and maintains a constant ΔP across the metering needle. Thus fuel flow is only a function of metering needle position, unaffected by change of ΔP.

During shut-down the metering needle is moved to the closed position by the EECU.

During power-up, the metering needle is positioned to permit engagement of the manual control.



AUTOMATIC CONTROL SYSTEM
(normal operation)

PUMP AND METERING UNIT ASSEMBLY - METERING UNIT (2B) - OPERATION (1)

PUMP AND METERING UNIT ASSEMBLY - METERING UNIT (2B) - OPERATION (2)

Manual control system

Fuel flow increase demand (+ range)

The stepper motor is "frozen". The lower end of the transmission system is then fixed and acts as a pivot.

When the manual control is moved, the acceleration controller lever is engaged onto the metering needle control lever.

Thus the metering needle moves according to the manual control until it reaches the P3 capsule stop.

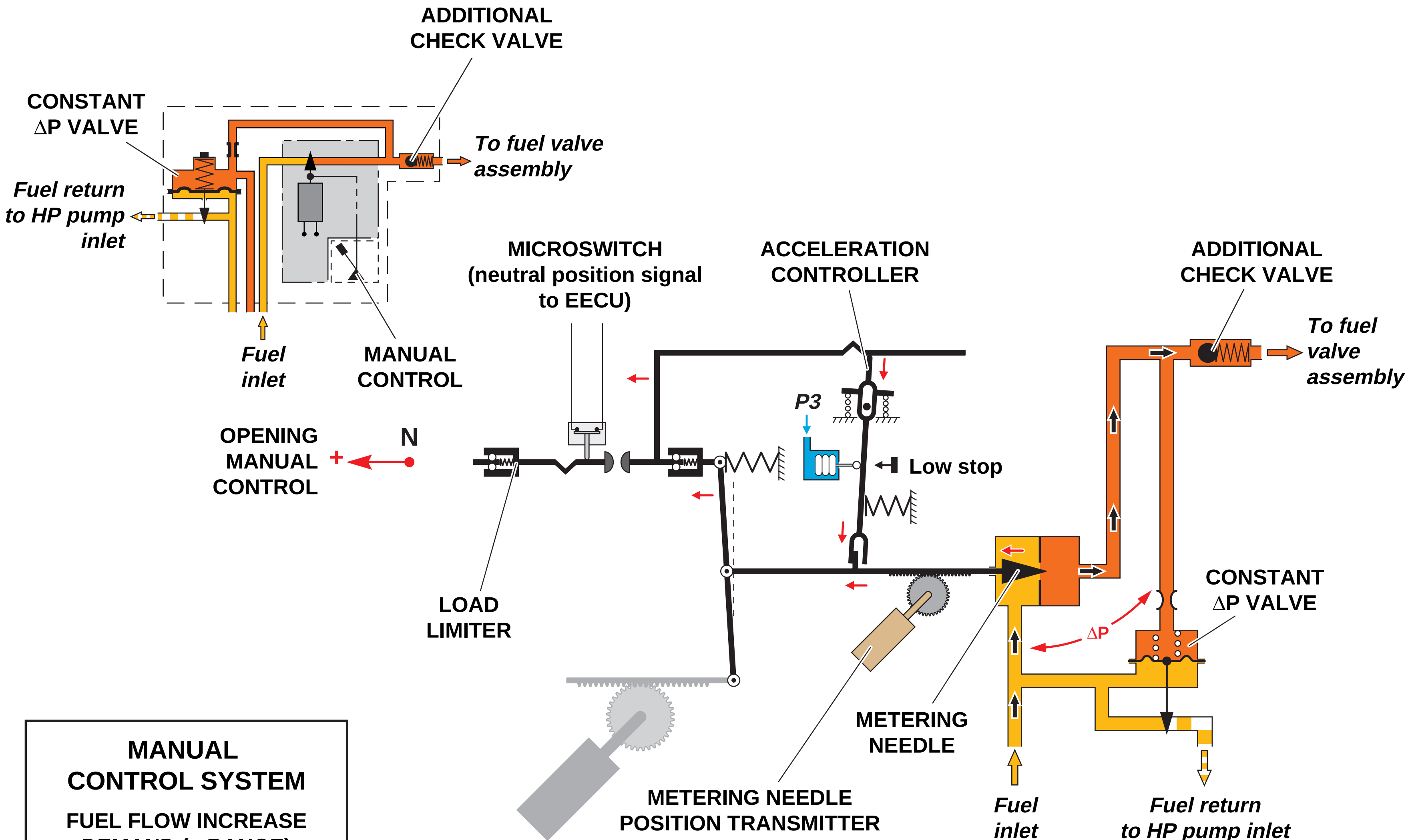
This provides an instant step of fuel flow increase caused by the opening of the metering needle.

Should the manual control continue to move, the transmission system would temporarily declutch.

The metering needle opening is afterwards controlled by the capsule compression caused by the progressive increase of the P3 air pressure.

Thus, the fuel flow required is obtained without surge or exceeding the limits.

The acceleration ends when the metering needle control lever reaches the flow stop or the twist grip cable position.



MANUAL
CONTROL SYSTEM

FUEL FLOW INCREASE
DEMAND (+ RANGE)

PUMP AND METERING UNIT ASSEMBLY - METERING UNIT (2B) - OPERATION (2)

PUMP AND METERING UNIT ASSEMBLY - METERING UNIT (2B) - OPERATION (3)

Manual control system (continued)

Fuel flow decrease demand (- range)

The stepper motor is "frozen". The lower end of the transmission system is then fixed and acts as a pivot.

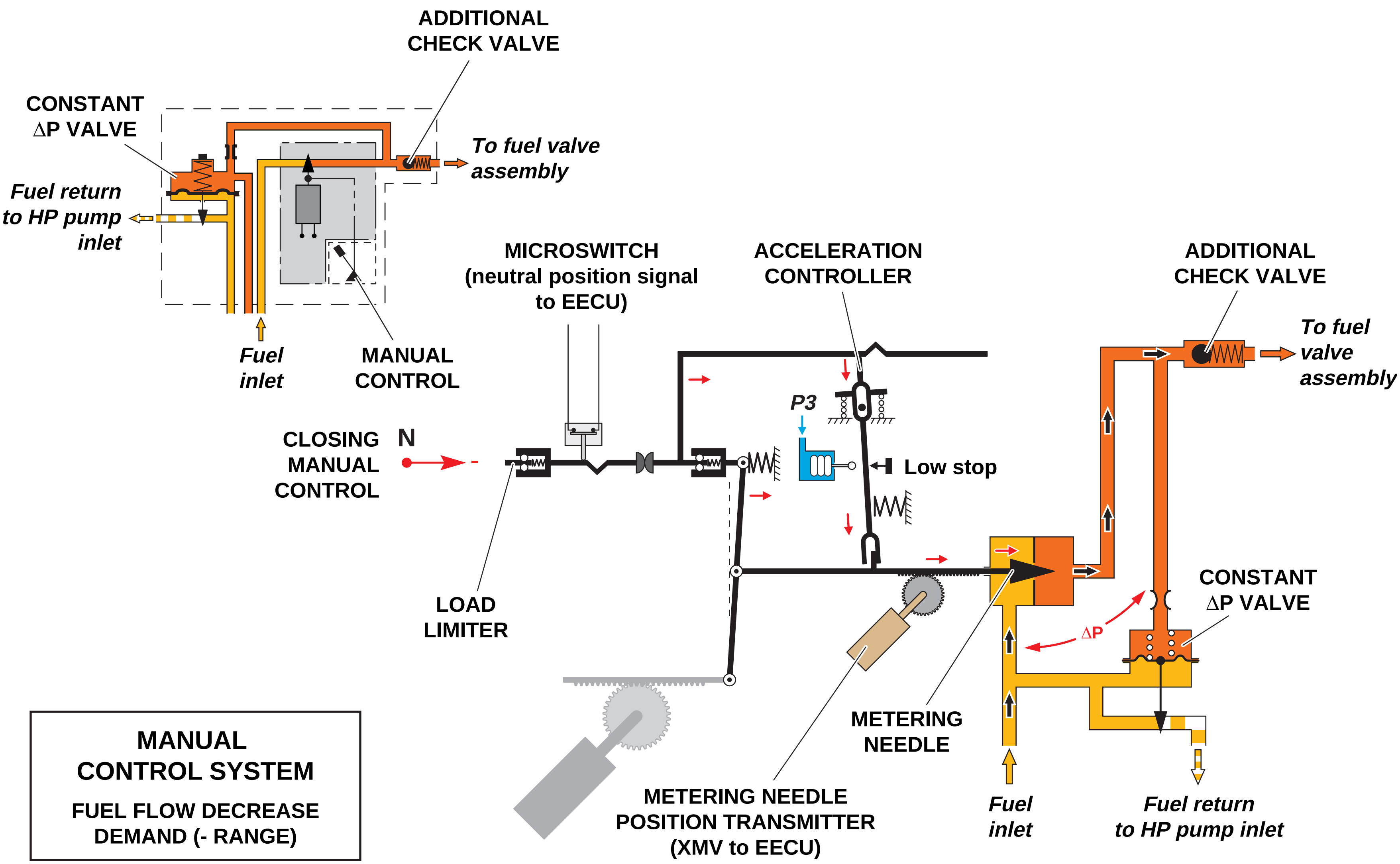
The clutch transmission system is pushed by the twist grip.

The acceleration controller lever is engaged onto the metering needle control lever.

Thus the metering needle moves with to the manual control until it reaches the fixed low stop.

If the metering needle reaches the low stop, the transmission system is declutched in order to limit the stresses on the mechanical lever.

In the case of sudden control movement, the load limiter reduces the load on the pump and metering unit assembly internal mechanism.



PUMP AND METERING UNIT ASSEMBLY - METERING UNIT (2B) - OPERATION (3)

PUMP AND METERING UNIT ASSEMBLY - METERING UNIT (2B) - OPERATION (4)

Manual control system (continued)

"Mixed" mode

During normal operation (automatic mode), if the twist grip is moved out of the neutral notch:

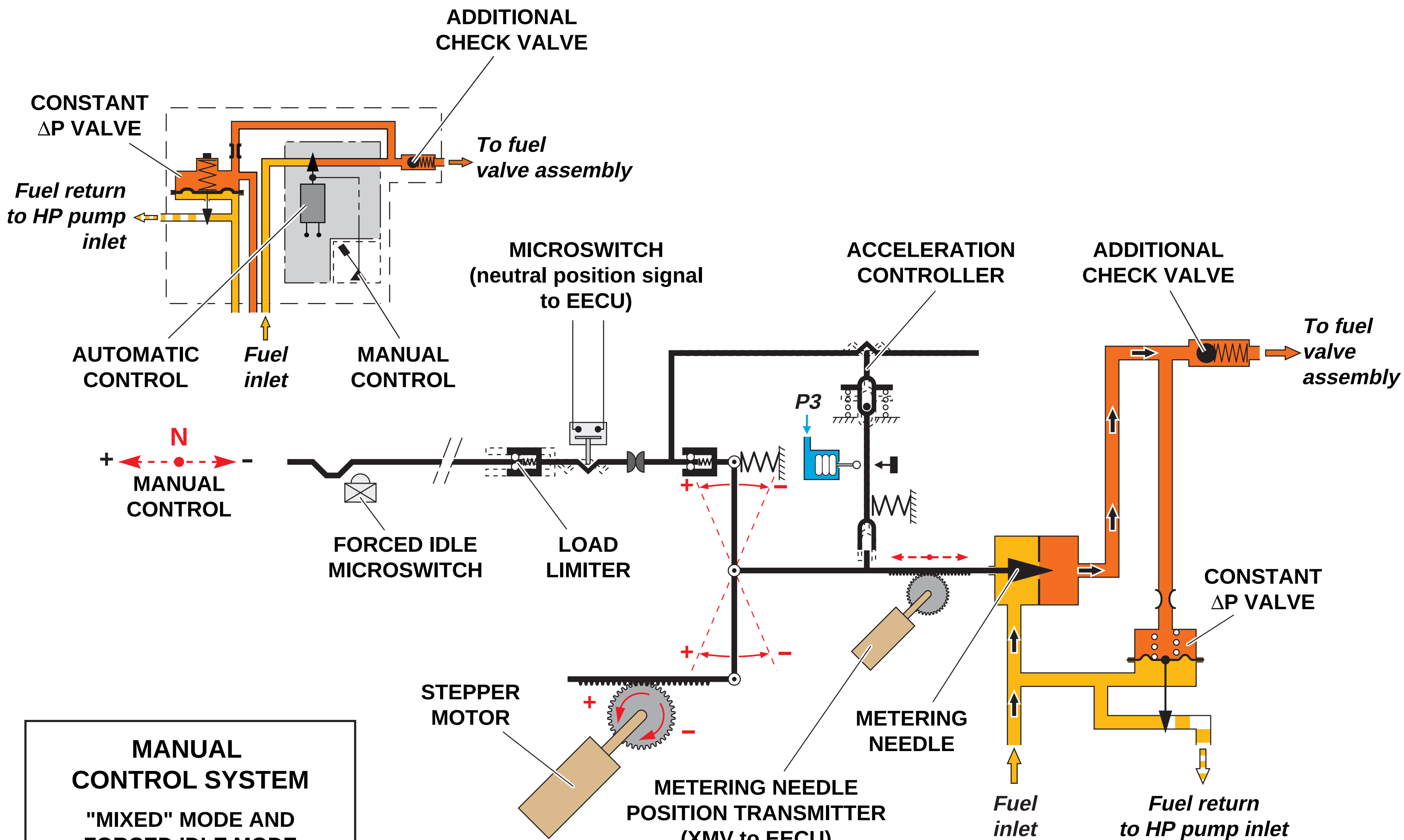
- *The neutral position switch sends a signal to the EECU*
- *The stepper motor continues to operate*
- *The EECU outputs a signal to the cockpit.*

Any variation of fuel flow commanded by the twist grip will be automatically compensated by the EECU.

Consequently the N1 and the power delivered by the engine will still be controlled by the EECU.

Forced idle mode

To permit autorotation training, a microswitch (forced idle) is operated at the end of movement of the twist grip in the flow decrease direction. When this switch is made its output to the EECU causes the software to decelerate the engine to idle (67 % N1). The engine no longer supplies power to the aircraft transmission and autorotation is possible. Return to normal flight power is made as soon as the twist grip is moved off the minimum stop and the microswitch opens.



MANUAL
CONTROL SYSTEM

"MIXED" MODE AND
FORCED IDLE MODE

PUMP AND METERING UNIT ASSEMBLY - METERING UNIT (2B) - OPERATION (4)

PUMP AND METERING UNIT ASSEMBLY - METERING UNIT (2B1) - GENERAL - DESCRIPTION

Function

The metering unit controls the fuel flow in automatic mode in response to signals from the EECU.

In the event of control system failure, it permits fuel flow control in automatic back-up mode.

Position

- *In the system: downstream of the HP pump*
- *On the engine: at the front part of the pump and metering unit assembly.*

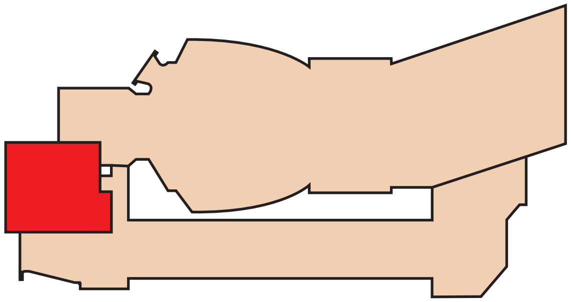
Main characteristics

- *Automatic control by an electrical actuator (stepper motor) driving a metering needle*
- *Back-up control by an automatic unit which operates a back-up by-pass valve.*

Description

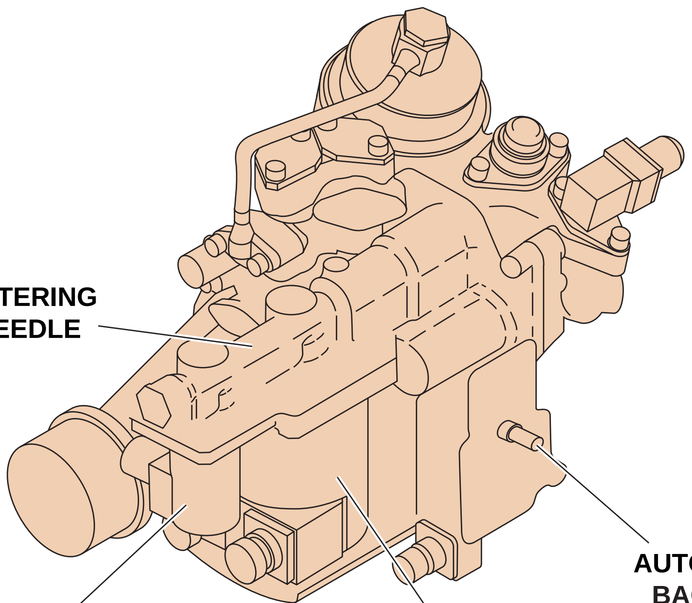
- *Constant ΔP valve (common)*
- *Automatic back-up control system*
- *Additional check valve (common)*
- *Automatic control system.*

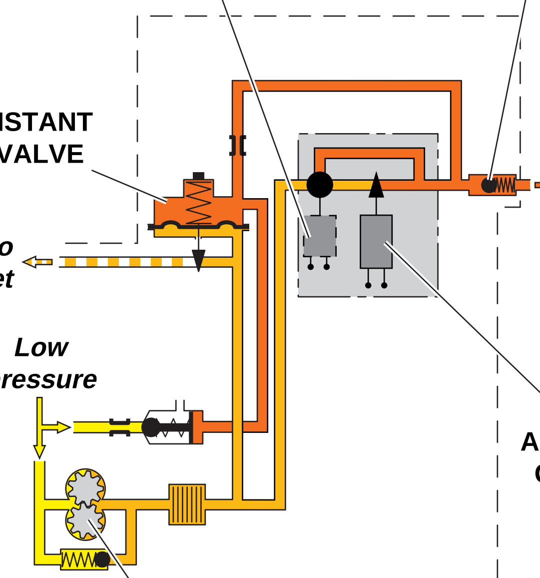
***Note**: The position transmitter can also be called the resolver.*



Automatic control by an electrical actuator (stepper motor) driving a metering needle

Back-up control by an automatic unit





PUMP AND METERING UNIT ASSEMBLY - METERING UNIT (2B1) - GENERAL - DESCRIPTION

PUMP AND METERING UNIT ASSEMBLY - METERING UNIT (2B1) - OPERATION (1)

This unit incorporates the automatic control system and the mechanical part of the back-up control system in one unit.

Automatic control system

Normal operation

In normal operation, the by-pass valve is closed to by-pass and fully open to metering needle supply. This is the neutral position.

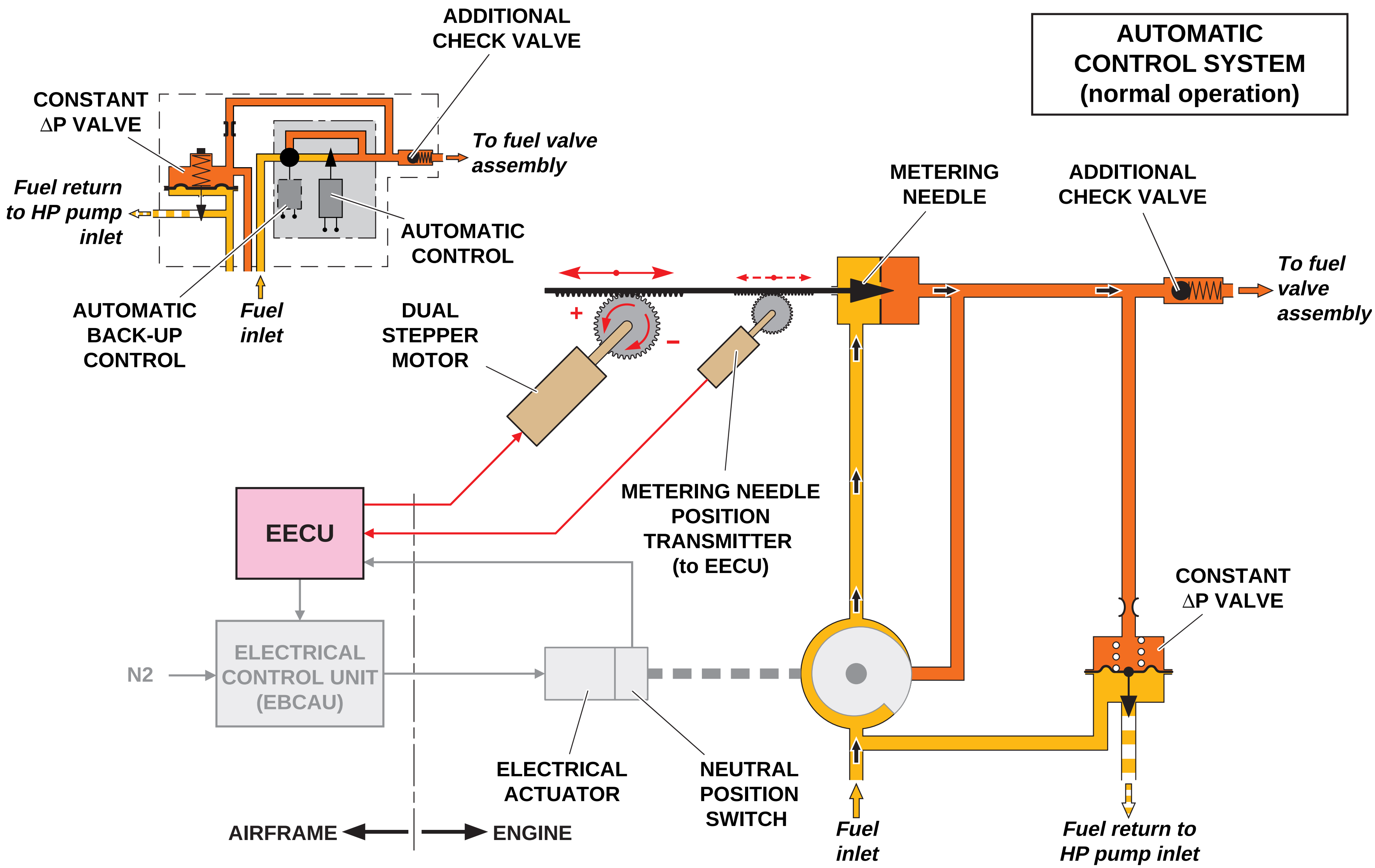
The metering needle position is controlled by the stepper motor.

When the EECU commands a fuel flow increase, the stepper motor rotates and through the rack and pinion mechanism, drives the metering needle open. The metering needle rod movement drives the resolver through a rack and pinion which provides a metering needle position signal to the EECU. For a fuel flow decrease, the system operates in the opposite sense.

The constant ΔP valve returns the excess fuel to the HP pump inlet and maintains a constant pressure drop across the metering needle. Thus fuel flow is only a function of metering needle position, unaffected by changes of ΔP.

During shut-down the metering needle is moved to the closed position by the EECU.

Note: *NPS: Neutral position switch*



PUMP AND METERING UNIT ASSEMBLY - METERING UNIT (2B1) - OPERATION (1)

PUMP AND METERING UNIT ASSEMBLY - METERING UNIT (2B1) - OPERATION (2)

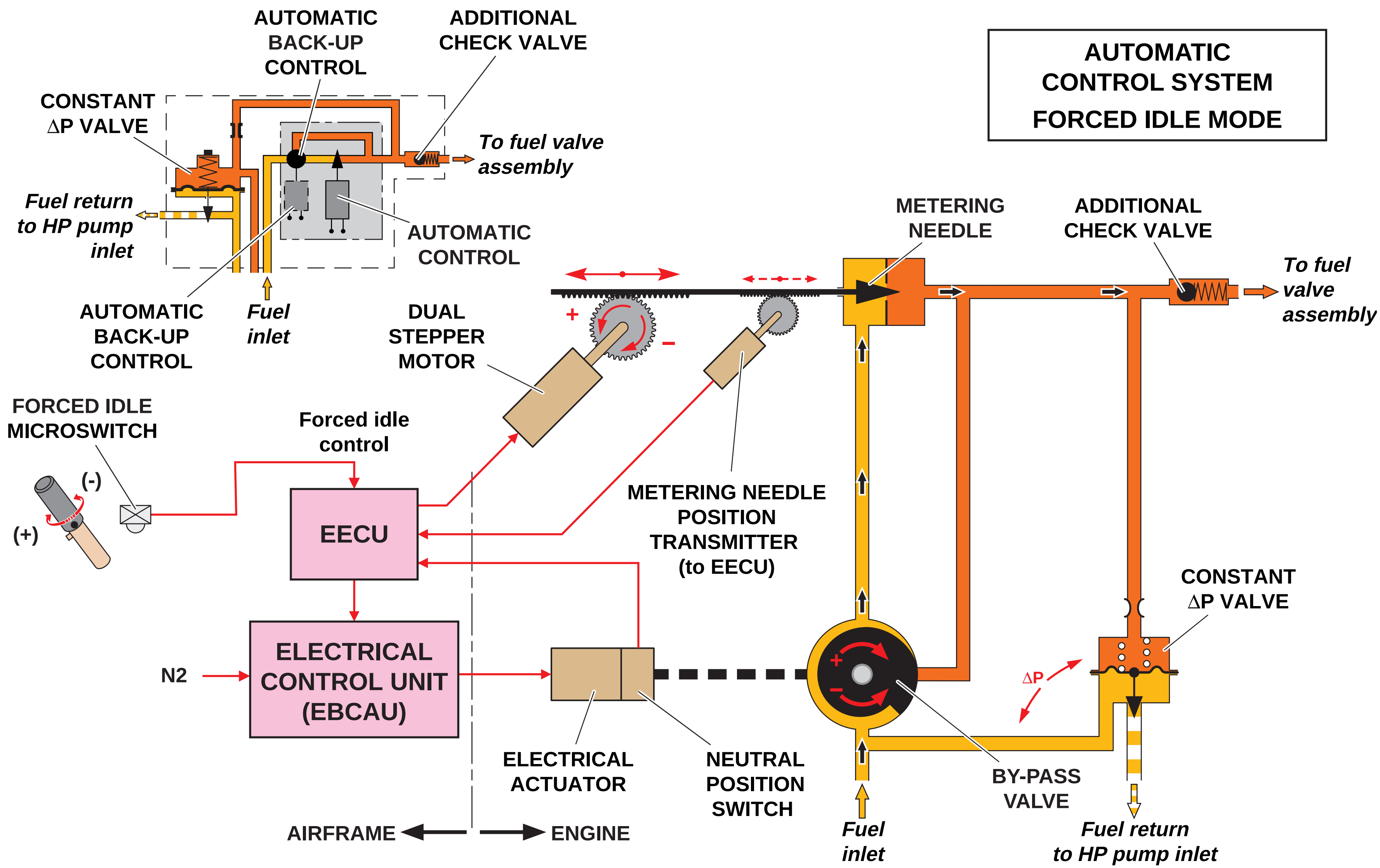
Automatic control system (continued)

Forced idle mode

To permit autorotation training, a microswitch (forced idle) is operated at the end of movement of the twist grip in the flow decrease direction. When this switch is closed its output to the EECU causes the software to decelerate the engine to idle (67 % N1).

The engine no longer supplies power to the aircraft transmission and autorotation is possible.

Return to normal flight power is made as soon as the twist grip is moved off the microswitch.



PUMP AND METERING UNIT ASSEMBLY - METERING UNIT (2B1) - OPERATION (2)

PUMP AND METERING UNIT ASSEMBLY - METERING UNIT (2B1) - OPERATION (3)

Automatic back-up control system

The automatic back-up system includes an electrical control unit (EBCAU) in the aircraft and an electrical actuator fitted on the pump and metering unit assembly linked to a metering needle by-pass valve.

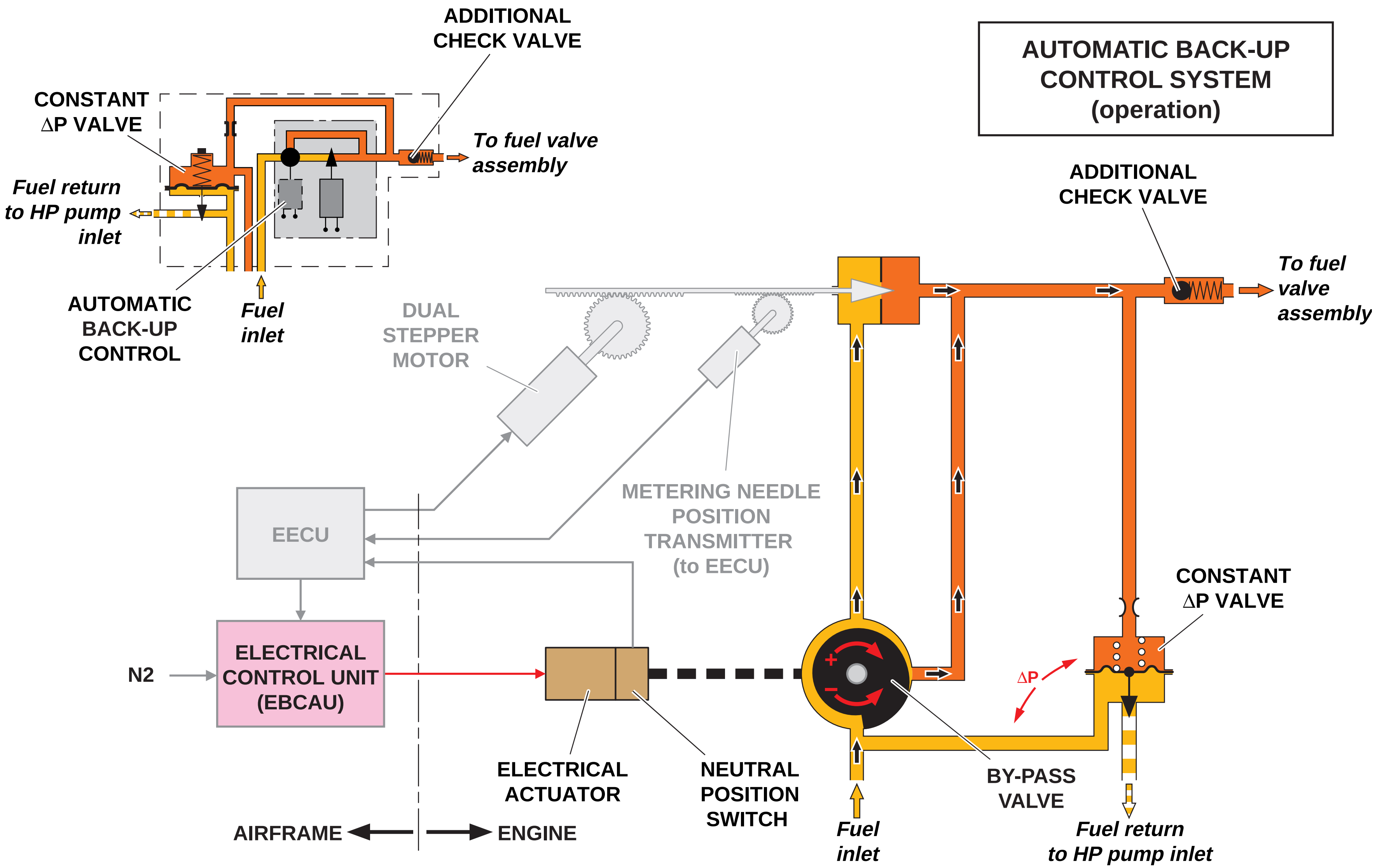
In the unlikely event of a total EECU failure, the stepper motor will be frozen and the back-up system will maintain N2 at 100 %. The electrical control unit receives a signal of N2 from the engine.

If the N2 decreases, it will command the actuator to open the by-pass thus permitting an increased fuel flow in by-pass of the metering needle.

If the N2 increases, the control unit will command the actuator to rotate the by-pass valve in the opposite direction. This will reduce the flow to the main metering needle without opening the by-pass.

The rate of engine acceleration and deceleration is a function of the speed of movement of the actuator which is designed to avoid the possibility of surge or flame-out.

Note: *The electrical control unit (EBCAU: Engine Back-up Control Auxiliary Unit) and the electrical actuator are supplied by the aircraft manufacturer.*



PUMP AND METERING UNIT ASSEMBLY - METERING UNIT (2B1) - OPERATION (3)

FUEL FILTER - GENERAL

Function

The filter retains any particles that may be in the fuel in order to protect the metering unit components.

Position

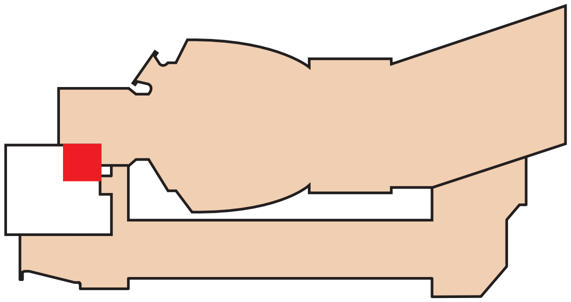
- In the system: between the LP and HP pumps
- On the engine: on top of the pump and metering unit assembly.

Main characteristics

- Type: fibreglass cartridge
- Filtering ability: 20 microns
- By-pass valve setting: ΔP 120 kPa (17.4 PSID)
- Pre-blockage pressure switch setting: ΔP 70 kPa (10.2 PSID).

Main components

- Filter
- Blockage indicator
- By-pass valve
- Pre-blockage pressure switch
- Cover with union (supply to start purge valve).

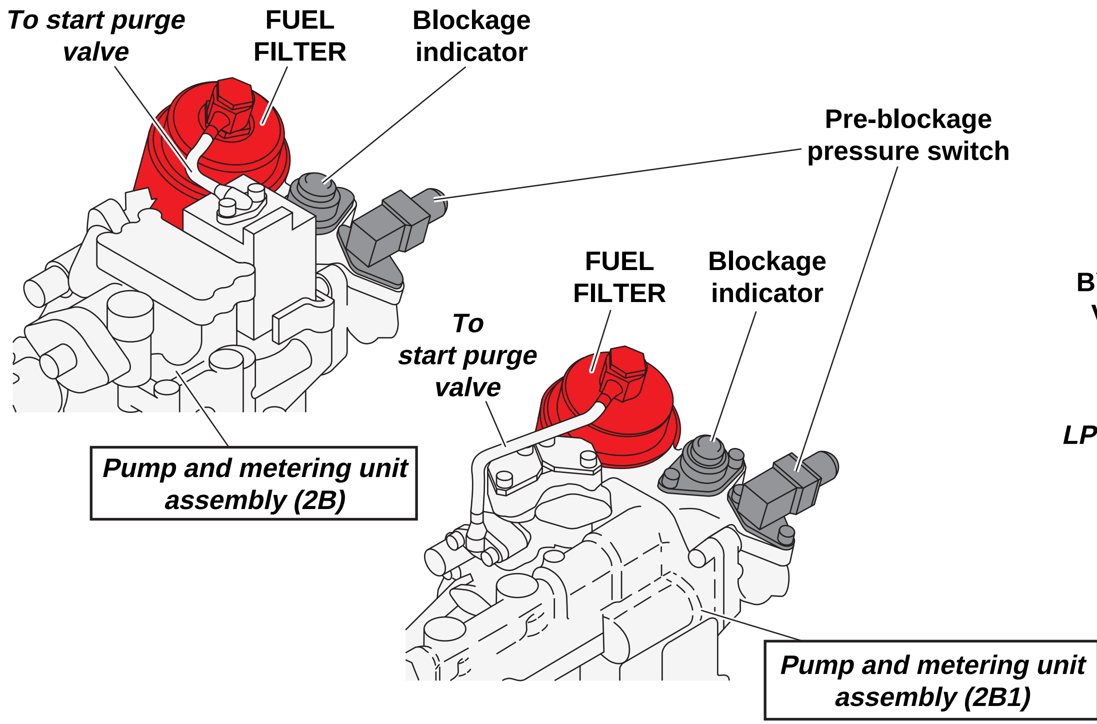


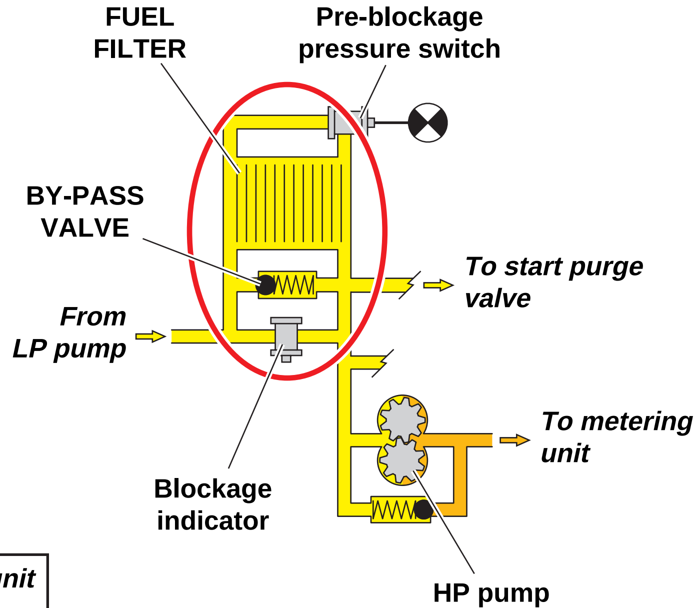
Type:
Fibre glass cartridge

Filtering ability:
20 microns

By-pass valve setting:
ΔP 120 kPa (17.4 PSID)

Pre-blockage setting:
ΔP 70 kPa (10.2 PSID)





FUEL FILTER - GENERAL

FUEL FILTER - DESCRIPTION

The assembly comprises the housing, the filtering element, the by-pass valve, the pre-blockage pressure switch and the blockage indicator.

Filtering element

It is a fibreglass cartridge with a filtering ability of 20 microns.

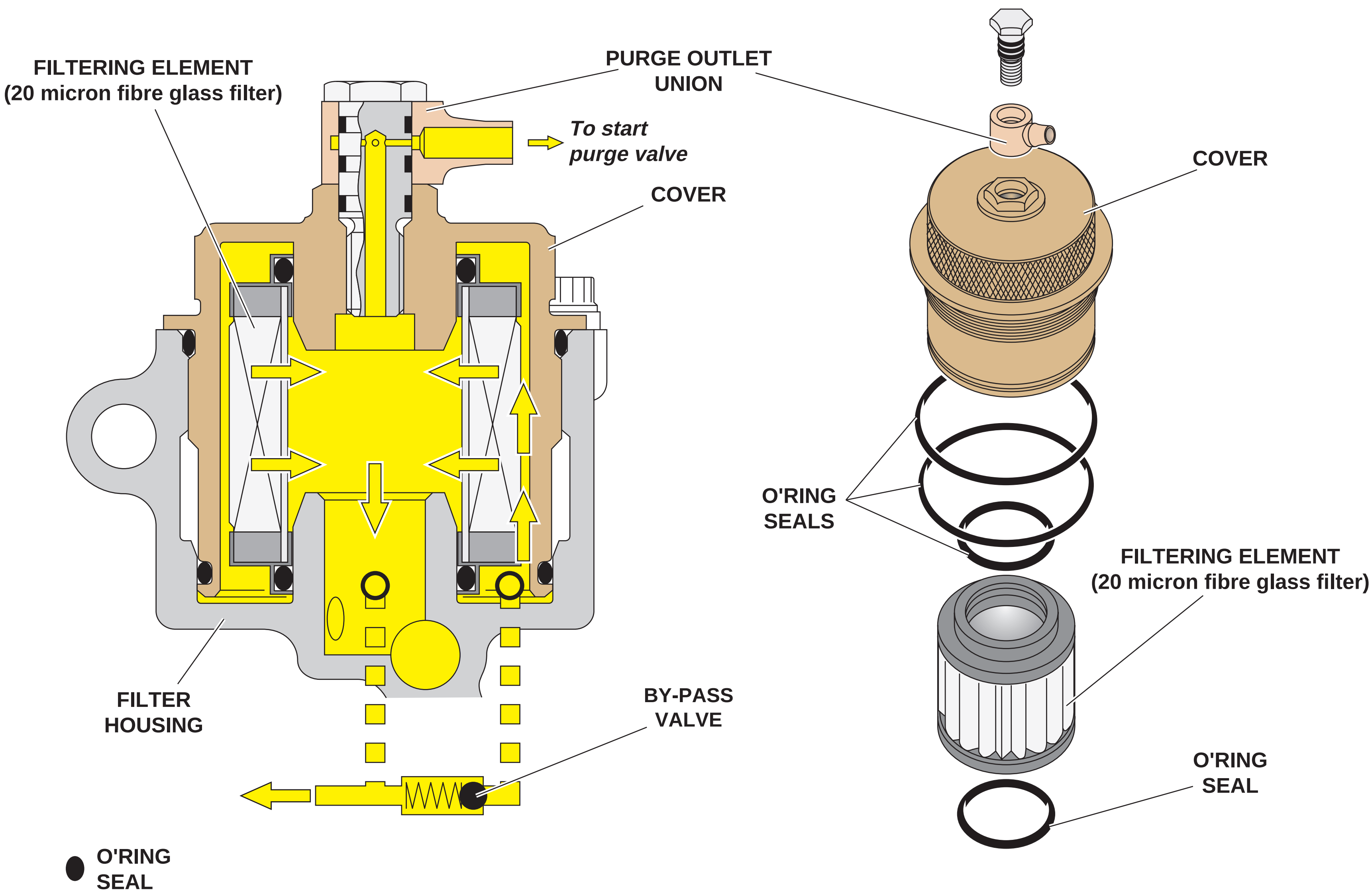
O'ring seals ensure the sealing between the cartridge and the filter housing.

The filter cover is fitted with a purge outlet union.

By-pass valve

This valve ensures a fuel flow to the metering unit in the event of filter blockage. It is subjected on one side to filter upstream pressure and on the other side to downstream pressure plus the force of a spring.

Note: *The by-pass valve is fitted inside the pump and metering unit assembly body.*



FUEL FILTER - DESCRIPTION

FUEL FILTER - OPERATION

The operation is considered in normal operation, pre-blockage and blockage.

Normal operation

The fuel provided by the LP fuel pump enters the fuel filter and flows through the filtering element (from outside to inside).

The filtering element retains particles larger than 20 microns. The fuel then flows to the HP pump.

Note: *Before entering the fuel filter, the fuel passes through the heat exchanger formed by the oil filter housing.*

Pre-blockage

When the filter becomes dirty, the pressure difference across the filtering element increases.

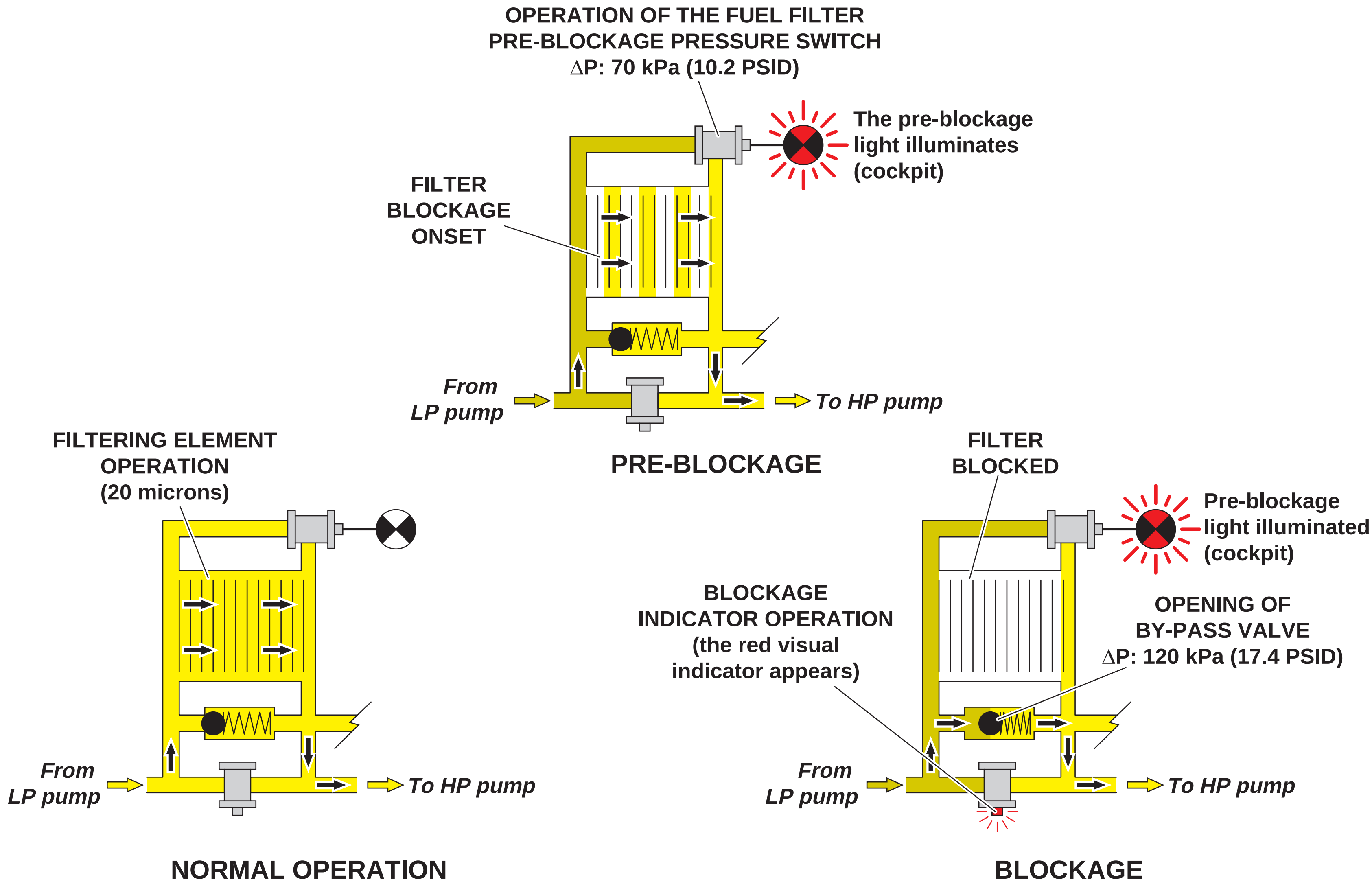
If the pressure difference becomes higher than 70 kPa (10.2 PSID), the electrical contact of the pressure switch closes and supplies the "fuel filter pre-blockage" indication in the cockpit.

Blockage

When the pressure difference across the filtering element exceeds 120 kPa (17.4 PSID), the by-pass valve opens and causes:

- The red indicator to pop out
- The fuel flow to by-pass the filter.

Note: *Refer to the following pages for the pre-blockage pressure switch operation.*



FUEL FILTER - OPERATION

FUEL FILTER PRE-BLOCKAGE PRESSURE SWITCH

Function

The pre-blockage pressure switch provides an indication of the onset of filter blockage.

Position

- In the system: between the fuel inlet and outlet of the filter
- On the engine: on the pump and metering unit assembly beside the fuel filter.

Main characteristics

- Type: differential pressure switch
- Setting: ΔP 70 kPa (10.2 PSID)
- Indication: light in the cockpit.

Description

The pre-blockage pressure switch includes the following components:

- The pressure switch body which houses the electrical contact
- The mounting flange: the pre-blockage pressure switch is secured by two screws on the pump and metering unit assembly
- Electrical connector (connected to an indicating light in the cockpit).

Two O'ring seals ensure the sealing between the pre-blockage pressure switch and the pump and metering unit assembly body.

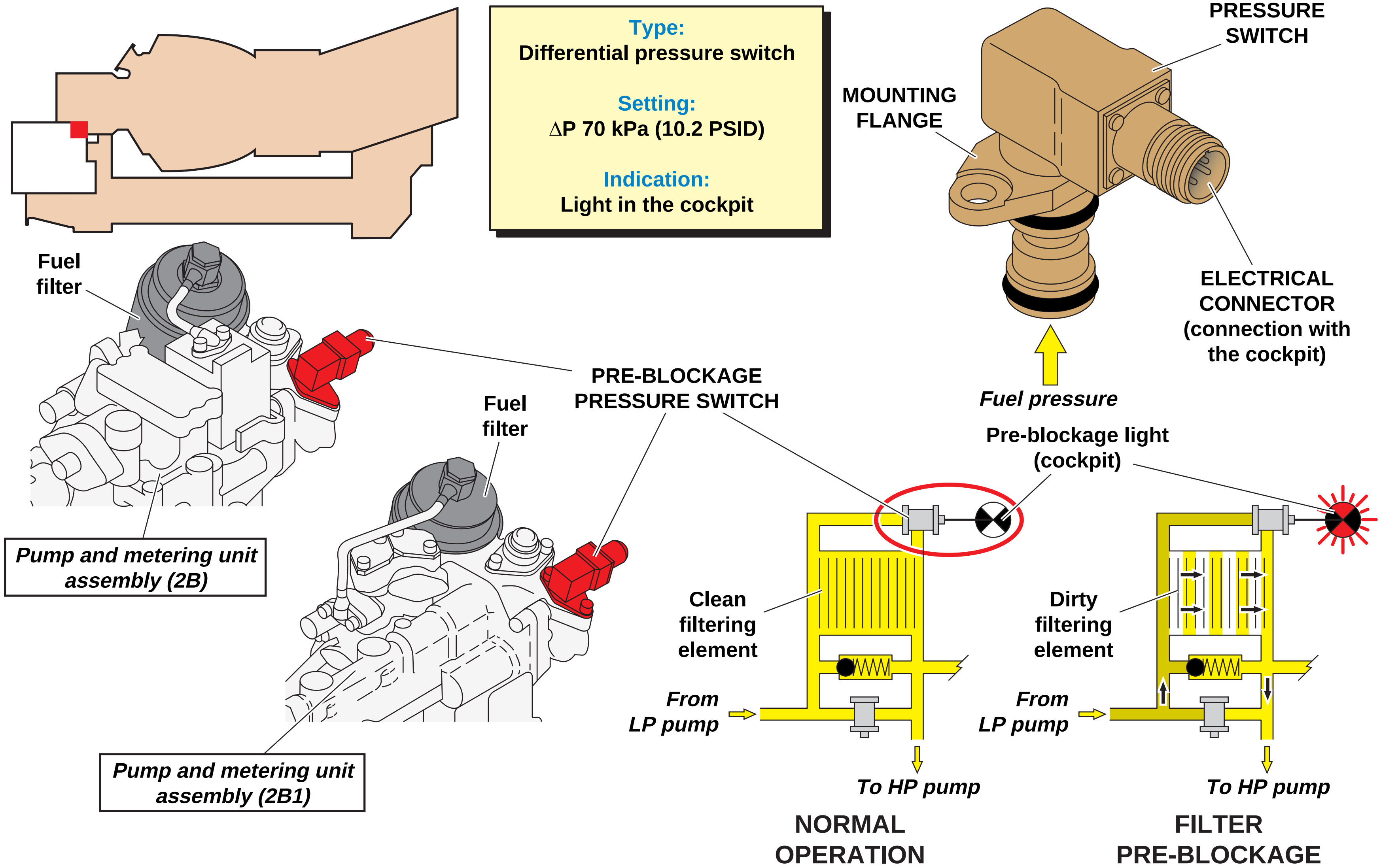
Operation

Normal operation

The filtering element is clean. The pressure difference on each side of the filtering unit is lower than the pre-blockage pressure switch setting: the electrical contact is open and there is no indication.

Filter pre-blockage

When the filtering unit becomes dirty, the pressure difference across the filter increases. When the pressure difference exceeds the pressure switch setting (70 kPa/ 10.2 PSID) the electrical switch closes and lights the fuel filter pre-blockage light in the cockpit.



FUEL FILTER PRE-BLOCKAGE PRESSURE SWITCH

FUEL FILTER BLOCKAGE INDICATOR

Function

The blockage indicator provides a visual indication of filter blockage.

Position

- In the system: between the fuel inlet and outlet of the filter
- On the engine: on the pump and metering unit assembly beside the fuel filter.

Main characteristics

- Type: differential pressure, magnetic arming device
- Setting: ΔP 120 kPa (17.4 PSID)
- Indication: red indicator.

Decription

The indicator comprises:

- A body with a mounting flange
- A red indicator
- A removable transparent cover (manual reset)
- O'rings.

Operation

Normal operation

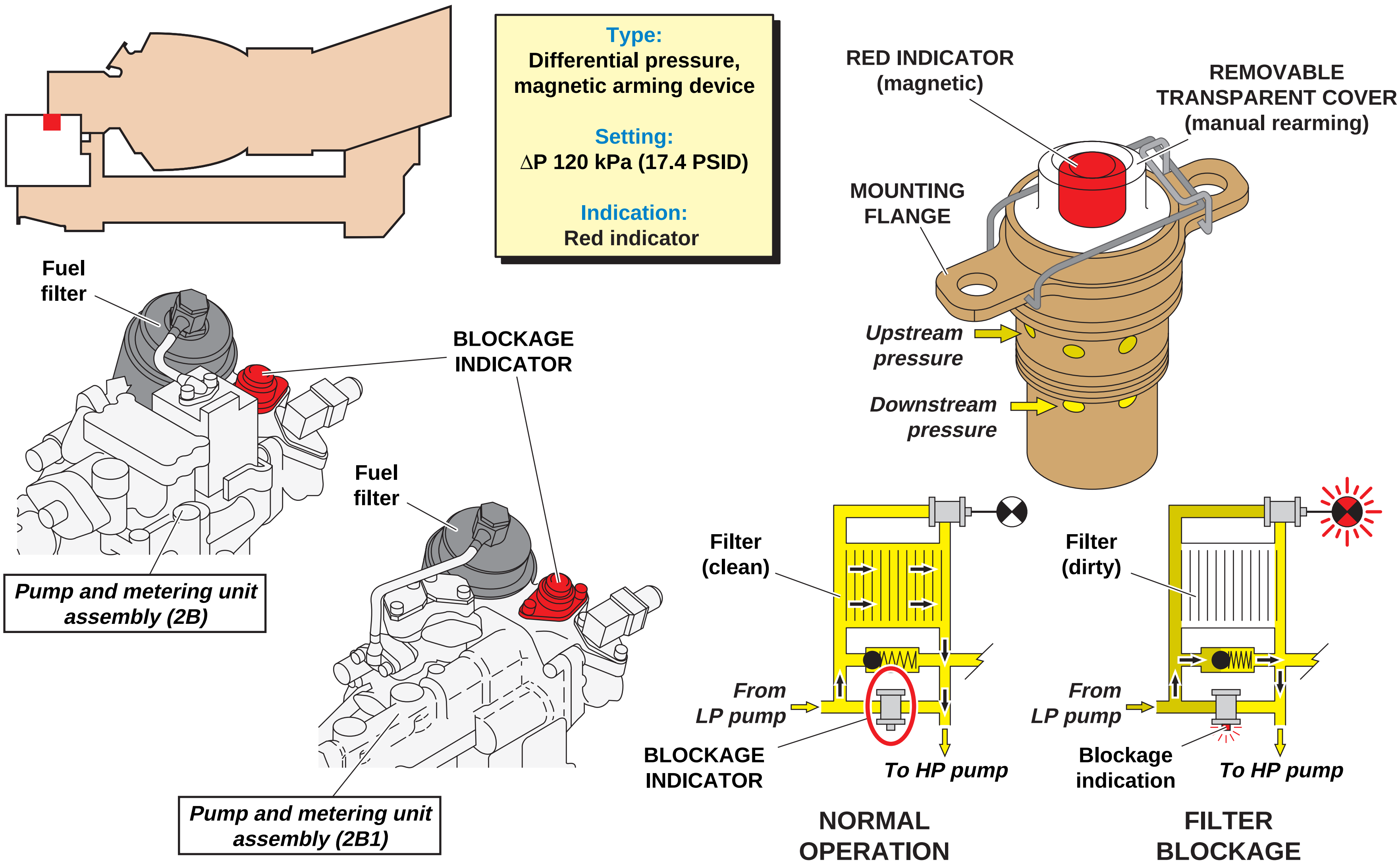
The filtering element is clean. The pressure difference on each side of the filter is lower than the blockage indicator setting: the indicator doesn't protrude (armed)

Filter blockage

When the filter becomes dirty, the pressure difference increases.

When the pressure difference exceeds the setting (120 kPa / 17.4 PSID) it causes the by-pass valve to open and the indicator to pop out.

Note: *The indicator is reset, after the removal of the cover by pushing it back into its housing.*



FUEL FILTER BLOCKAGE INDICATOR

LOW FUEL PRESSURE SWITCH

Function

The low fuel pressure switch detects low pressure at the LP pump outlet.

Position

- In the system: upstream of the HP pump
- On the engine: on the pump and metering unit assembly front face above the LP pump.

Main characteristics

- Type: diaphragm
- Setting: 60 kPa (8.7 PSI)
- Indication: light on the instrument panel.

Description

The pressure switch includes:

- A fuel inlet orifice
- A diaphragm and a microswitch
- An electrical connector (connection with the instrument panel).

The low fuel pressure switch is secured by 2 screws on the pump and metering unit assembly front face.

Operation

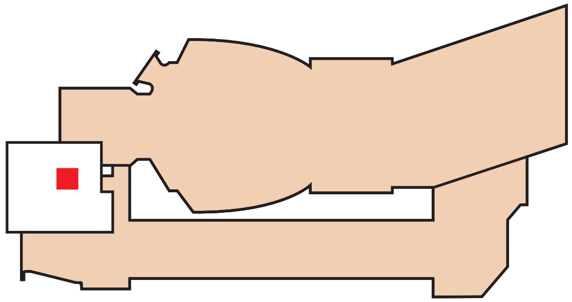
Normal engine running

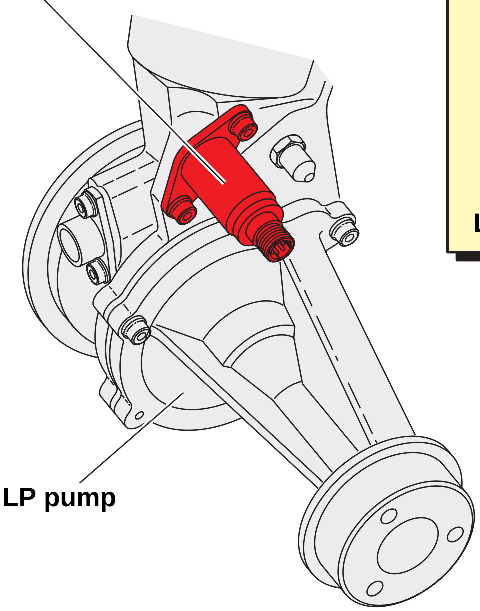
In normal operation the fuel pressure is sufficient to hold the electrical contact open.

The warning light on the instrument panel is extinguished.

Low pressure operation

If the fuel filter downstream pressure drops below 60 kPa (8.7 PSI), the electrical contact closes and completes the circuit to the low fuel pressure warning light.

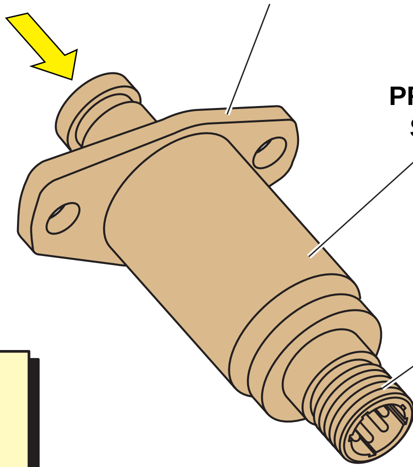


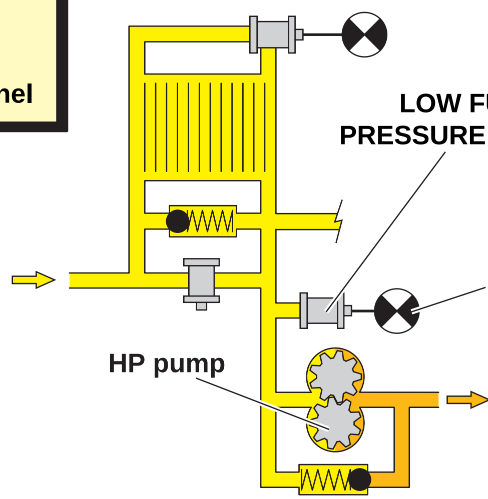


Type:
Diaphragm

Setting:
60 kPa (8.7 PSI)

Indication:
Light on the instrument panel





LOW FUEL PRESSURE SWITCH

FUEL VALVE ASSEMBLY - GENERAL - DESCRIPTION

Function

The fuel valve assembly distributes the fuel to the injection system.

Position

- In the system: between the metering unit and the injection system
- On the engine: on a support at the upper part of the centrifugal compressor casing.

Main characteristics

- Assembly which comprises electro-valves and hydromechanical valves
- Setting of the pressurising valve: 300 kPa (43.5 PSI)
- Setting of the stop purge valve: 1300 kPa (188.5 PSI).

Description

This assembly includes the start electro-valve, the stop electro-valve, the pressurising valve and the stop purge valve (injection wheel purge).

Start electro-valve

This valve allows either fuel or air to flow to the start injectors. It is a 3-way, mono-stable valve. It consists of a solenoid which controls a double valve. The three ways are: the fuel inlet, the air inlet and the outlet to the injectors.

Stop electro-valve

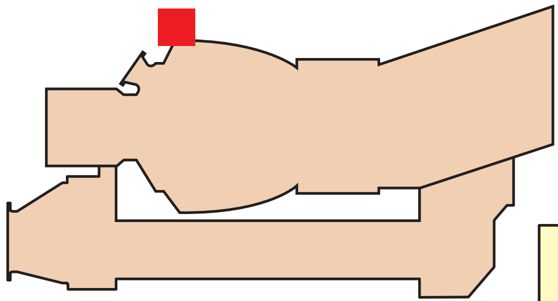
This valve controls the fuel flow to the injection system. It is a bi-stable type valve and consists of a solenoid with two coils (open and close) and a two position valve.

Pressurising valve

During starting it ensures priority of flow to the start injectors. It is a ball valve which is spring-loaded closed.

Stop purge valve

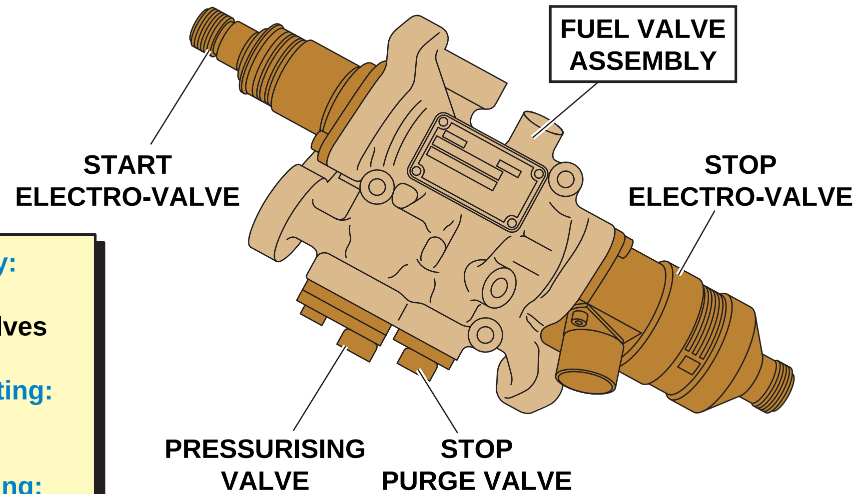
It is a ball valve which is spring loaded closed. It purges the centrifugal injection wheel during engine shut-down to prevent carbonisation of residual fuel.

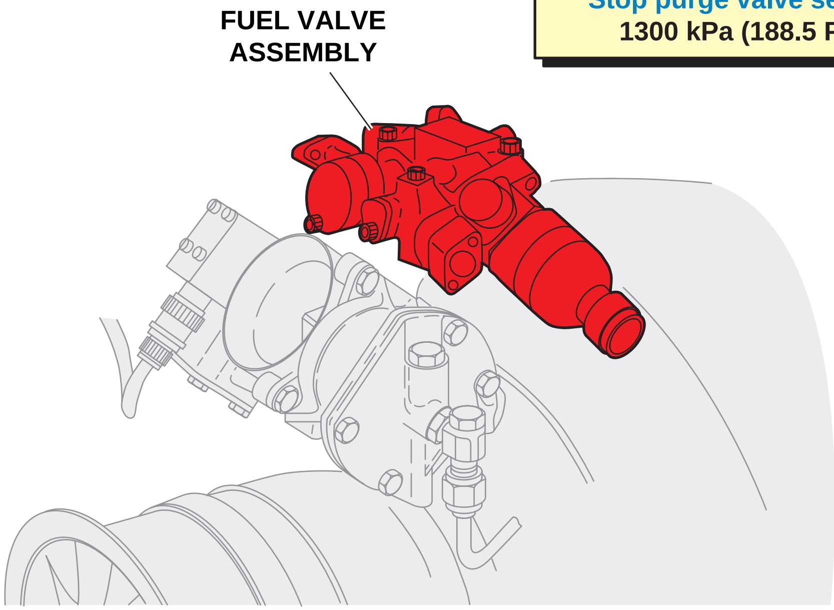


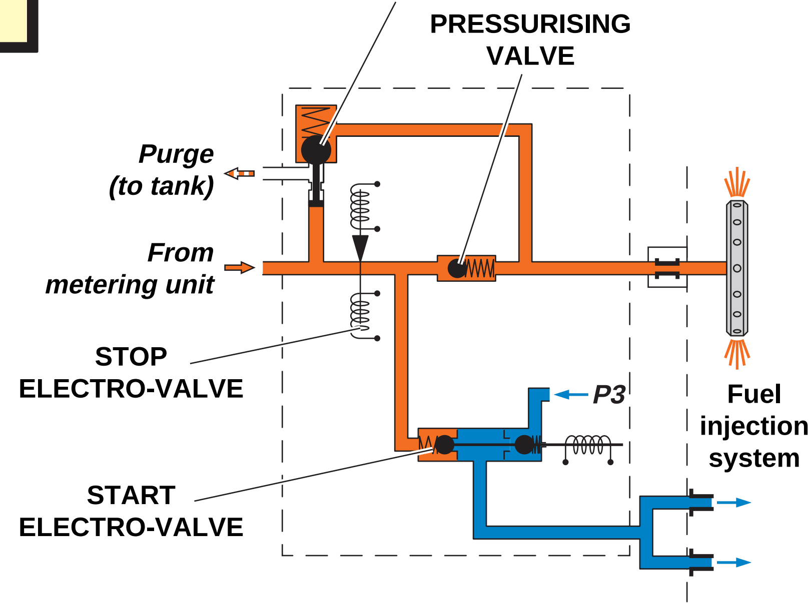
Fuel valve assembly:
- Electro-valves
- Hydromechanical valves

Pressurising valve setting:
300 kPa (43.5 PSI)

Stop purge valve setting:
1300 kPa (188.5 PSI)







FUEL VALVE ASSEMBLY - GENERAL - DESCRIPTION

FUEL VALVE ASSEMBLY - OPERATION

The following phases are considered: starting, normal running and shut-down.

Starting

When start is selected, the start electro-valve is electrically supplied. The double valve opens the fuel supply to the start injectors. At the same time the stop electro-valve is energised to the open position to admit the fuel flow from the metering valve.

When there is sufficient fuel pressure (300 kPa / 43.5 PSI), the pressurising valve opens and fuel flows to the centrifugal injection wheel.

When the engine reaches self-sustaining speed (approx. 45 % N1) the electrical supply to the start electro-valve is cut. The valve moves across under spring pressure, closing the fuel supply and opening the P3 air supply to ventilate the injectors.

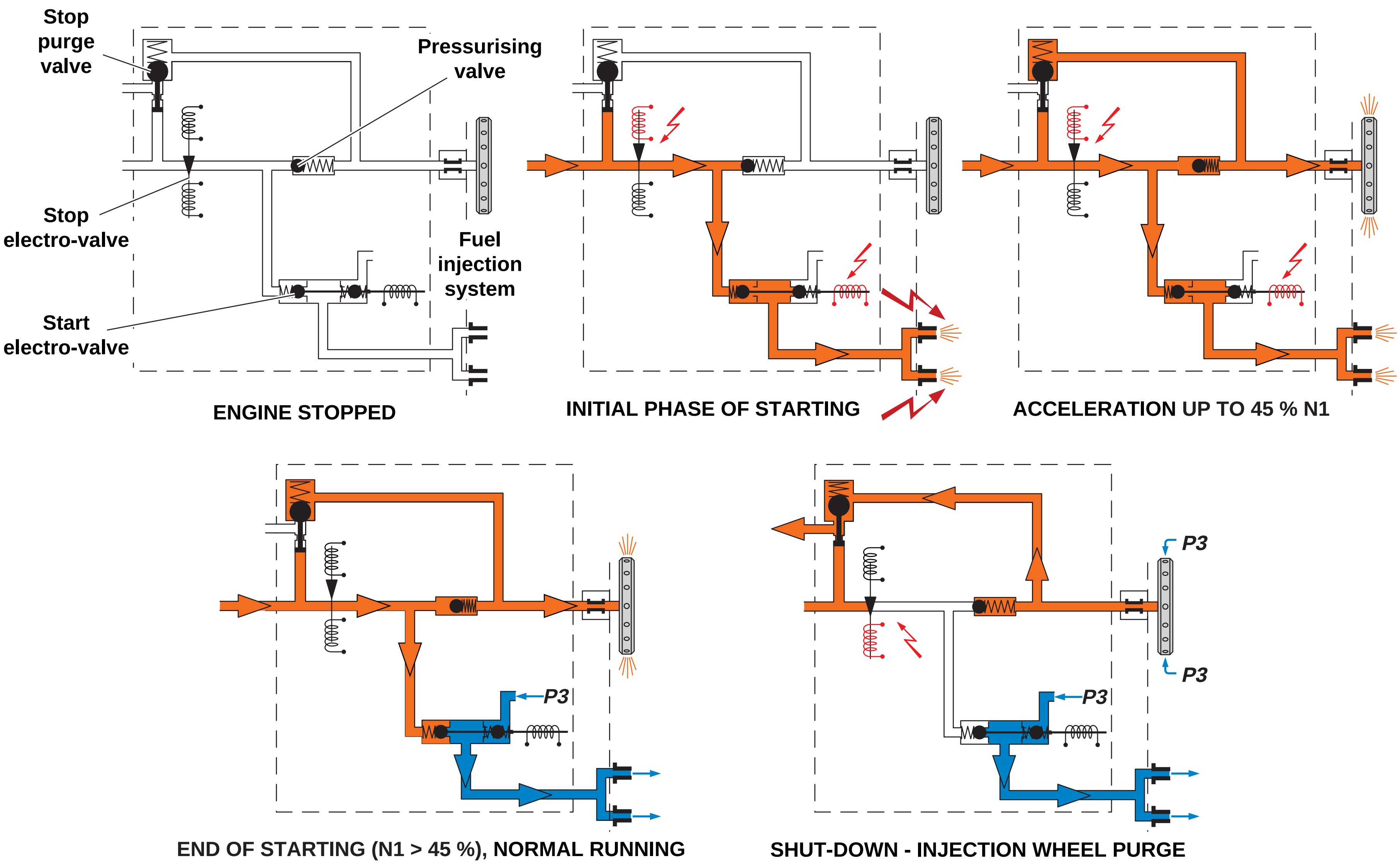
Normal running

In this condition the fuel is supplied to the centrifugal injection wheel and the start injectors are still ventilated with P3 air.

Shut-down - Injection wheel purge

When shut-down is selected the closing coil of the stop electro-valve is supplied. The valve closes and there is no further supply to the injection system. The pressurising valve closes and the engine begins to run down. The sudden but brief pressure rise, upstream of the stop electro-valve, causes the purge valve to open against its spring. This allows combustion chamber air pressure to purge the residual fuel from the centrifugal injection wheel supply line. This prevents carbonisation of the residual fuel which might cause the blockage of the injection system. The fuel is returned to the fuel tank.

As the fuel pressure decreases, the purge valve closes under the action of its spring.



FUEL VALVE ASSEMBLY - OPERATION

MAIN INJECTION SYSTEM

Function

The injection system sprays fuel into the combustion chamber to give stable and efficient combustion.

Position

- In the system: downstream of the fuel valve assembly
- On the engine: inside the combustion chamber. The injection wheel is mounted between the centrifugal compressor and the turbine shaft.

Main characteristics

- Type: centrifugal injection
- Radial fuel supply.

Description

The main injection system comprises the fuel inlet union, the internal supply pipe and the centrifugal injection assembly.

Engine fuel inlet union

Fitted at the lower right front face of the compressor casing, it has a restrictor and a leak test plug.

Internal supply pipe

This pipe connects the inlet union to the fuel distributor.

Centrifugal injection assembly

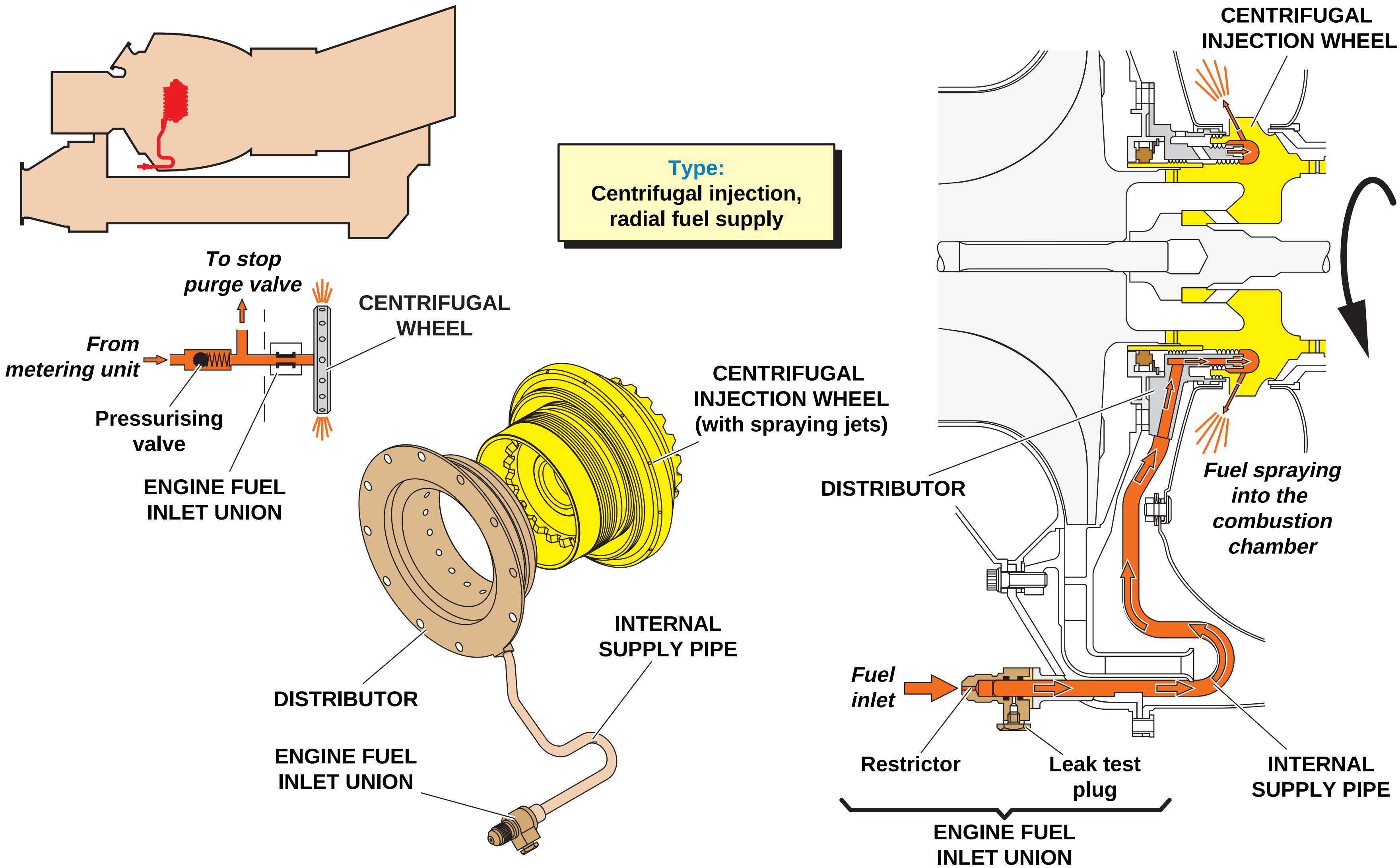
This assembly consists of a stationary distributor and an injection wheel. The distributor is drilled with holes which deliver the fuel to the wheel. The injection wheel, mounted between the compressor and the turbine shaft, is drilled with holes which form the fuel spraying jets. Sealing between the distributor and the wheel is achieved by pressurised labyrinth seals.

Operation

As the injection wheel is rotating at high speed (N1) the fuel is centrifuged out through the radial holes and is sprayed between the two swirl plates.

It should be noted that the injection pressure is supplied by the centrifugal force and therefore the fuel system does not require very high pressures.

The injection wheel fuel chamber is sealed by pressurised labyrinth seals. There is a small air flow into the fuel chamber. During shut-down the fuel remaining in the system is purged via the fuel valve assembly.



MAIN INJECTION SYSTEM

ENGINE FUEL INLET UNION

Function

The union ensures transfer of the fuel from the external pipe to the internal supply pipe.

Position

- In the system: downstream of the pressurising valve
- On the engine: it is fitted at the lower right front face of the compressor casing.

Description

The device comprises:

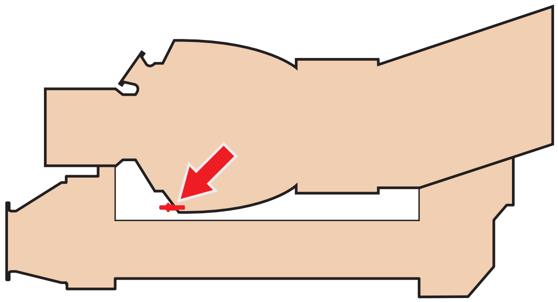
- A body with a mounting flange and an internal restrictor
- A leak test plug
- Seals (O'rings and copper seal).

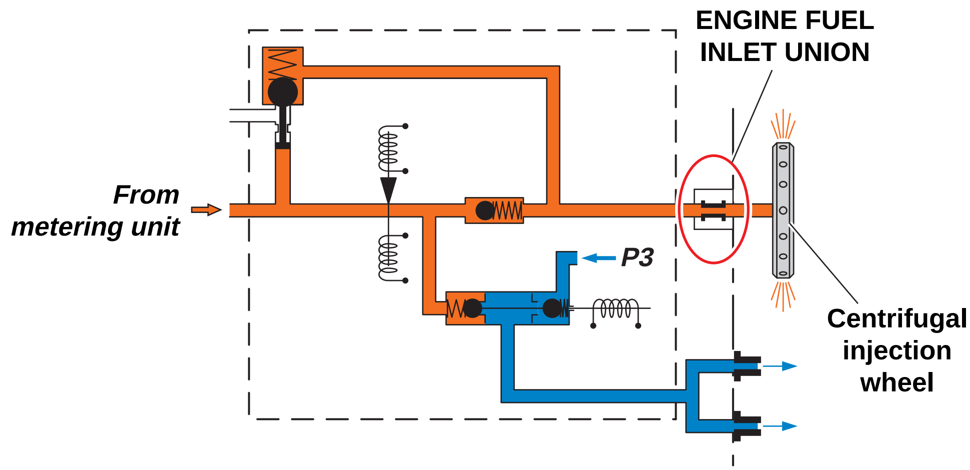
Operation

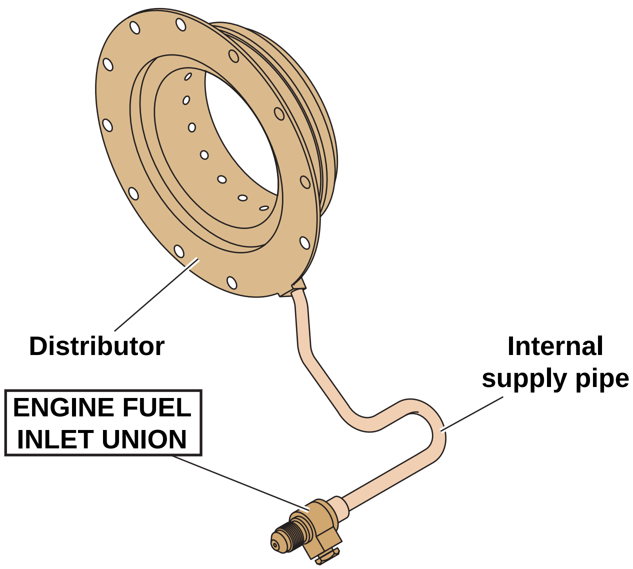
The union ensures the fuel transfer between the external and internal fuel ducts of the main injection system.

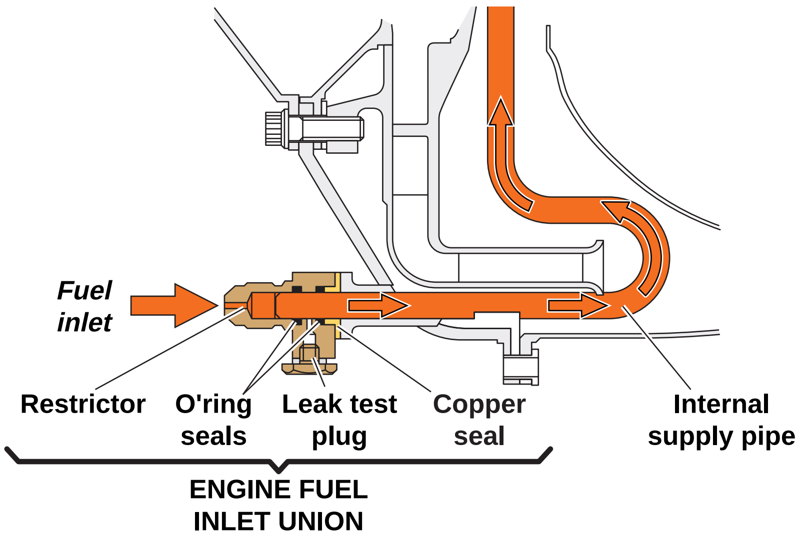
The restrictor is used to increase the union upstream pressure thus to improve the pump and metering unit assembly ΔP valve operation.

The leak test plug helps to check the internal sealing of the union (there should not be any leak).









ENGINE FUEL INLET UNION

START INJECTORS - GENERAL

Function

The two start injectors spray fuel into the combustion chamber during engine starting.

Position

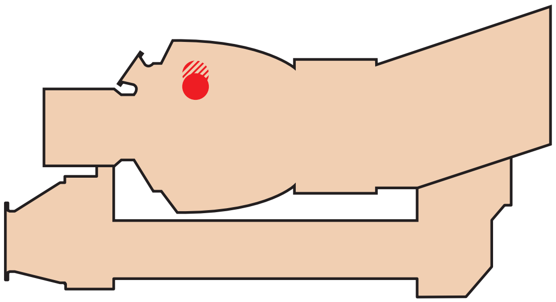
- In the system: downstream of the start electro-valve
- On the engine: on the upper half of the turbine casing at 2 o'clock and 10 o'clock
- They penetrate into the mixer unit.

Main characteristics

- Type: simple injector
- Quantity: 2
- Ventilation: by air flow.

Main components

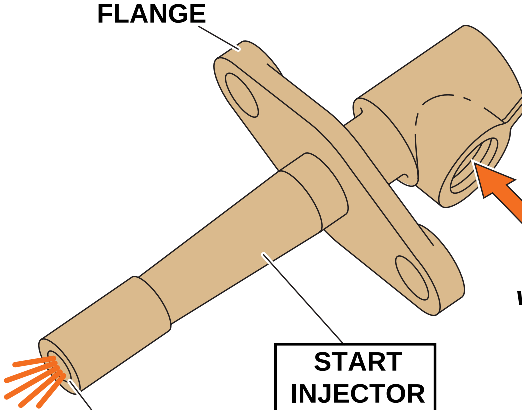
- Mounting flange
- Fuel inlet union
- Injector body
- Spraying jet.

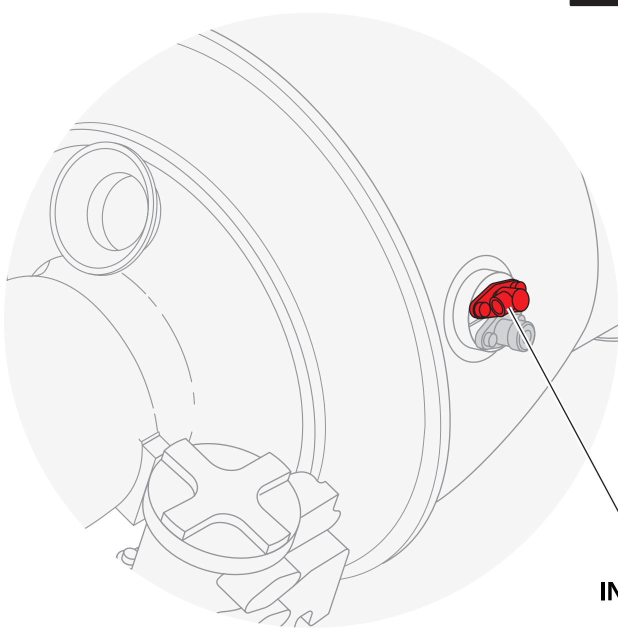


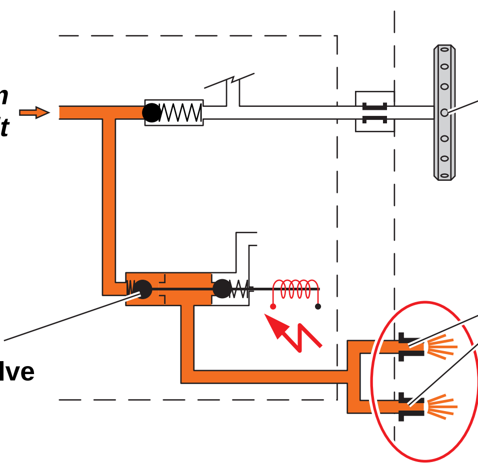
Type:
Simple injector

Quantity:
2

Ventilation:
By air flow







START INJECTORS - GENERAL

START INJECTORS - DESCRIPTION - OPERATION

Description

The injectors are mounted on the upper part of the turbine casing. They penetrate into the combustion chamber through holes in the mixer unit.

They are secured by two bolts onto bosses with seals and spacers to prevent leaks and adjust the depth of penetration into the combustion chamber.

Injector components

- Injector body
- Fuel inlet (threaded to receive a union)
- Spacers and seals (depth adjustment)
- Mounting flange (secured by 2 bolts)
- Filter
- Nut
- Jet
- Shroud.

Operation

Starting

During starting the injectors are supplied with fuel.

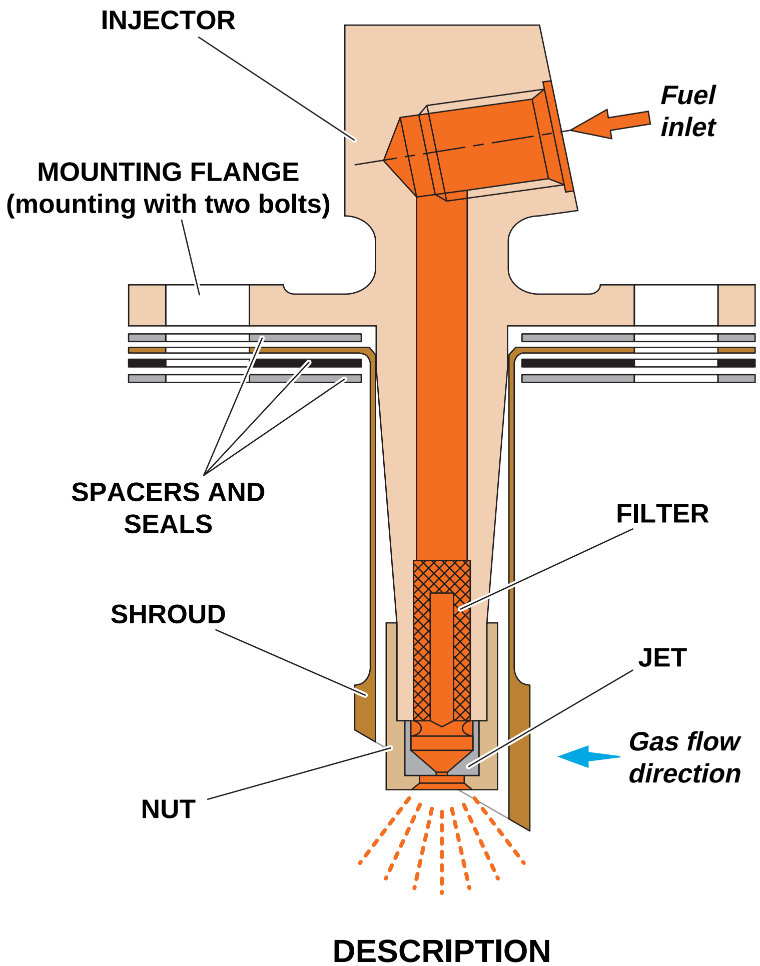
The fuel is atomised and is ignited by the sparks from the igniter plugs. The flame thus produced, ignites the fuel sprayed by the centrifugal injection wheel.

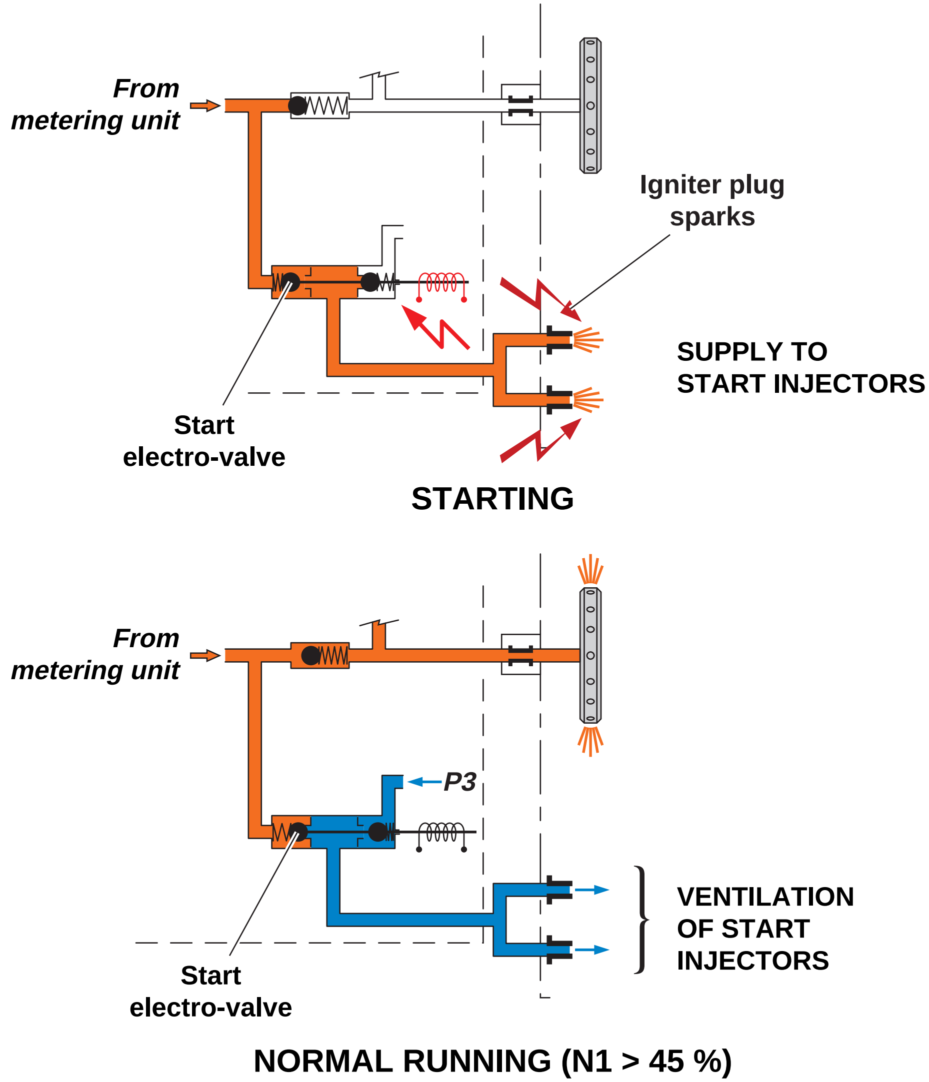
Normal running

When the engine reaches self-sustaining speed (approx. 45 %) the fuel supply to the injectors is shut off.

P3 air is then blown through the injectors to avoid carbonisation of the residual fuel.

It should be noted that ventilation is continuous during engine running.





START INJECTORS - DESCRIPTION - OPERATION

COMBUSTION CHAMBER DRAIN VALVE

Function

The valve drains overboard any unburnt fuel remaining in the combustion chamber.

Position

- On the engine: at the bottom of the turbine casing.

Main characteristics

- Type: piston valve
- Setting: closing threshold as a function of N1 and P0.

Description

The drain valve includes the following components:

- A mounting flange (secured by two bolts on a mounting pad located at the bottom of the turbine casing)
- A piston valve held open by a spring
- An outlet union which connects to the drain system.

Operation

The valve has two positions: open and closed.

Open position

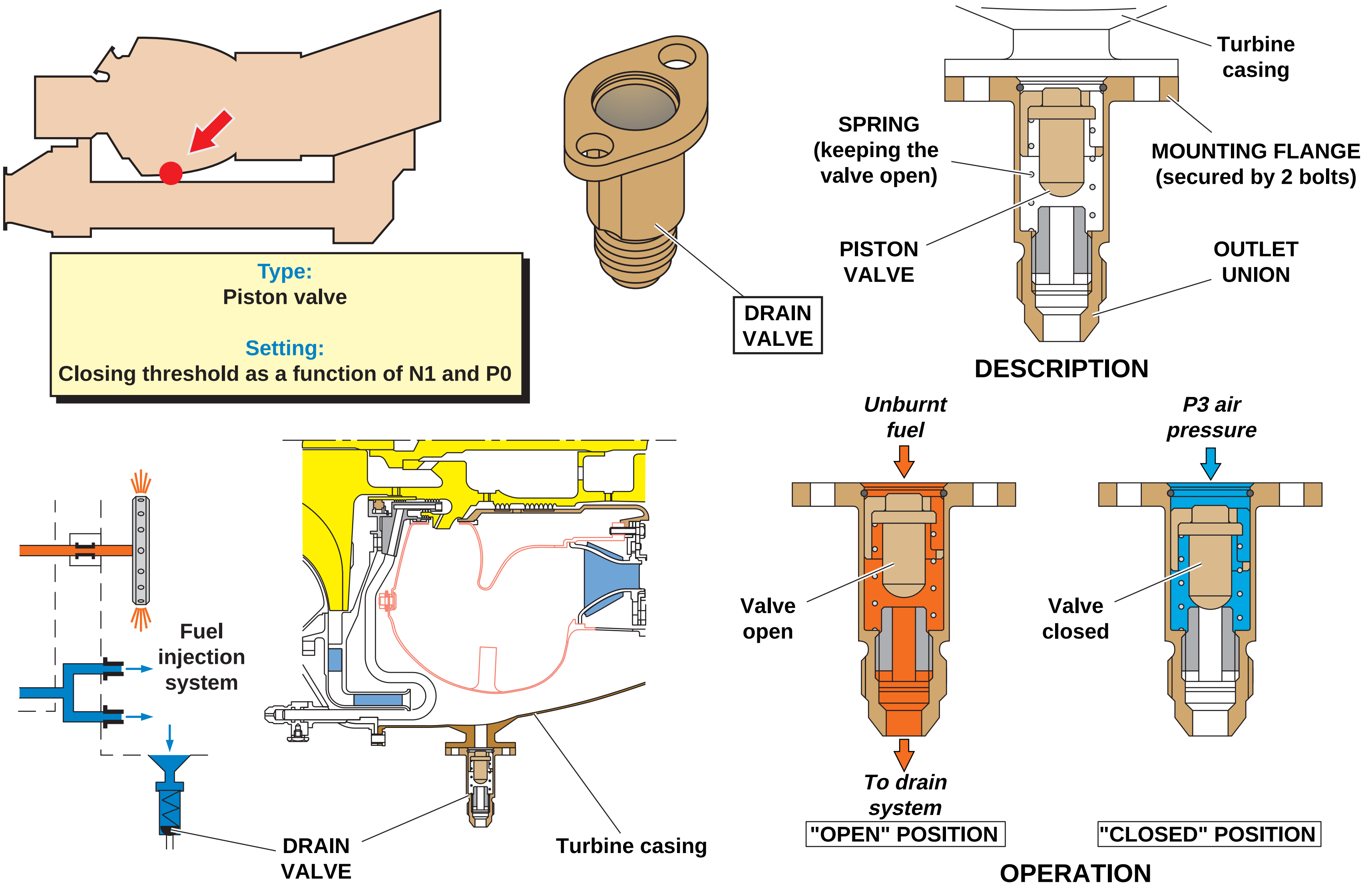
When the engine is not running and at the beginning of start, the valve is held open by the action of the spring.

Any unburnt fuel in the combustion chamber will drain through the valve overboard to the drain system. This ensures that no fuel accumulates in the combustion chamber which could cause starting problems (e.g.: overtemperature).

Closed position

As the engine starts the combustion chamber pressure increases. This pressure is felt on the upper surface of the valve which moves down to close the drain.

The valve closes during starting when the pressure reaches a given threshold as a function of N1 and P0.



COMBUSTION CHAMBER DRAIN VALVE

EXTERNAL FUEL PIPES

Function

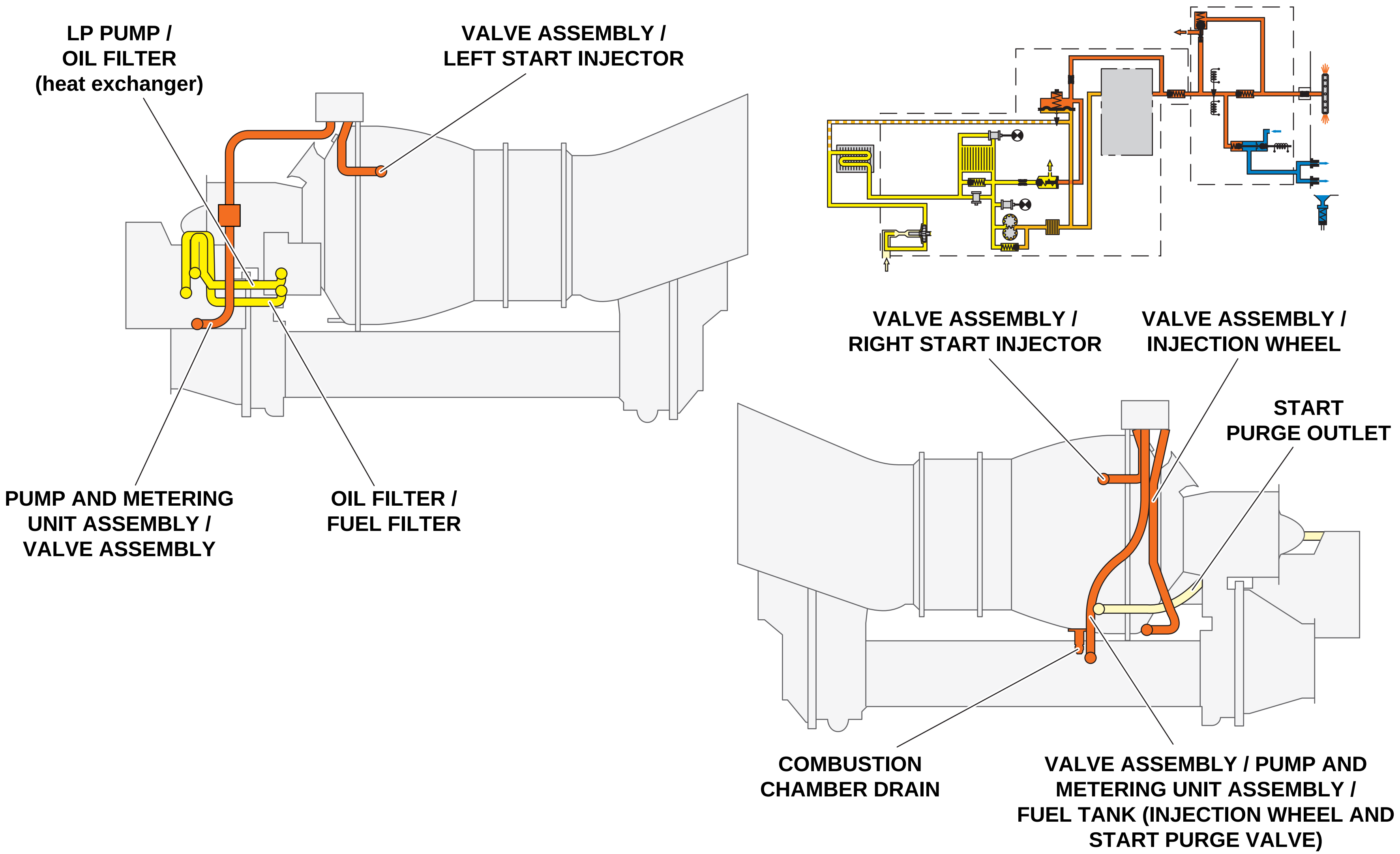
The fuel pipes ensure the circulation of fuel between the components of the system.

Main characteristics

- Type: rigid, stainless steel.

Main pipes

- From LP pump to oil filter (heat exchanger)
- From oil filter to fuel filter
- From pump and metering unit assembly to valve assembly
- From valve assembly to start injectors (x2)
- From valve assembly and pump and metering unit assembly to tank (injection wheel and start purge valve)
- From valve assembly to injection wheel.



EXTERNAL FUEL PIPES

7 - CONTROL SYSTEM

(XX-XX-XX): Page references which deal with the subject in the maintenance documentation.

CONTROL SYSTEM - GENERAL

Functions

The system is designed to adapt the engine to the aircraft power requirements whilst remaining within defined limits.

The main functions are:

- Starting
- Speed control
- Various limits
- *2B: Manual control*
- *2B1: Automatic back-up control*
- System monitoring and fault management.

Main characteristics

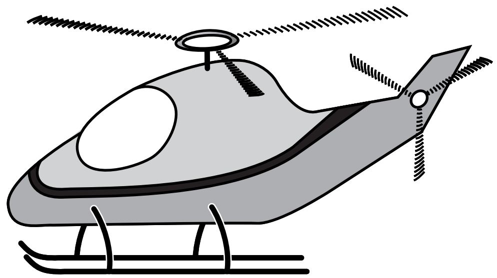
2B: - *Single channel digital electronic control system*
- *Manual control*

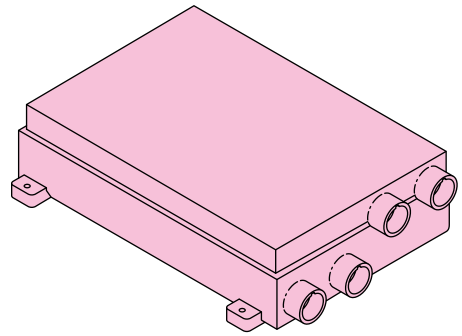
2B1: - *Dual channel digital electronic control system*
- *Automatic back-up control*

- Redundant electrical supply (from the aircraft and from the engine alternator).

Main components

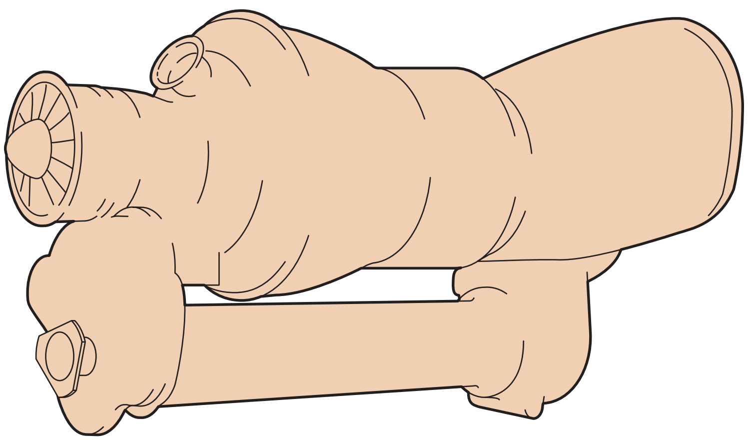
- Engine Electronic Control Unit
- Engine and systems
- Aircraft: various systems (control, indication, supply).





MAIN FUNCTIONS

- Starting
- Speed control
- Various limits
- *2B: Manual control*
- *2B1: Automatic back-up control*
- System monitoring and fault management



CONTROL SYSTEM - GENERAL

CONTROL SYSTEM (2B) - DESCRIPTION

The complete system includes aircraft components, engine components and the EECU.

Aircraft components

- *Switches, buttons, etc. (logic and analog signals)*
- *Indicators, warning lights, etc.*
- *EECU power supply*
- *Start and stop selection logic.*

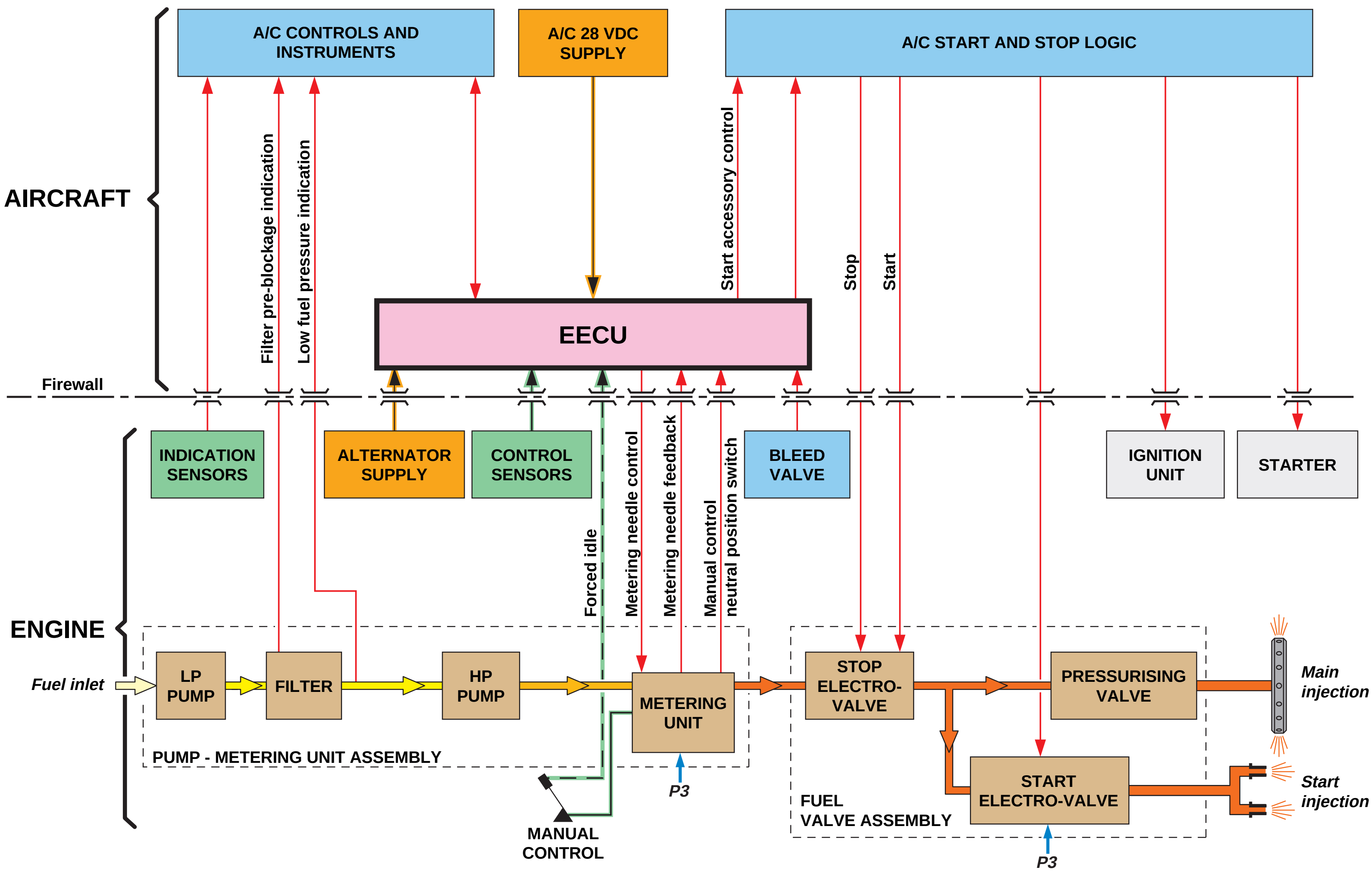
Engine components

- *Hydromechanical components:*
  - *LP pump*
  - *Filter*
  - *HP pump*
  - *Metering unit (with manual control)*
  - *Check valve*
  - *Start injection*
  - *Main injection system*
- *Electrical components:*
  - *Control system sensors*
  - *Indication system sensors*
  - *Dedicated alternator*
  - *Position transmitter*
  - *Stepper motor*
  - *Bleed valve position microswitch*
  - *Forced idle microswitch*
  - *Stop electro-valve*
  - *Start electro-valve*
  - *Neutral position switch.*

Engine Electronic Control Unit (EECU)

Computer which controls and monitors the engine.

- *Digital*
- *Mounted in the aircraft*
- *Serial data link with the aircraft.*



CONTROL SYSTEM (2B) - DESCRIPTION

CONTROL SYSTEM (2B1) - DESCRIPTION (1)

The complete system includes aircraft components, engine components and the EECU.

Aircraft components

- *Switches, buttons, etc. (logic and analog signals)*
- *Indicators, warning lights, etc.*
- *EECU power supply*
- *Start and stop selection logic.*

Engine components

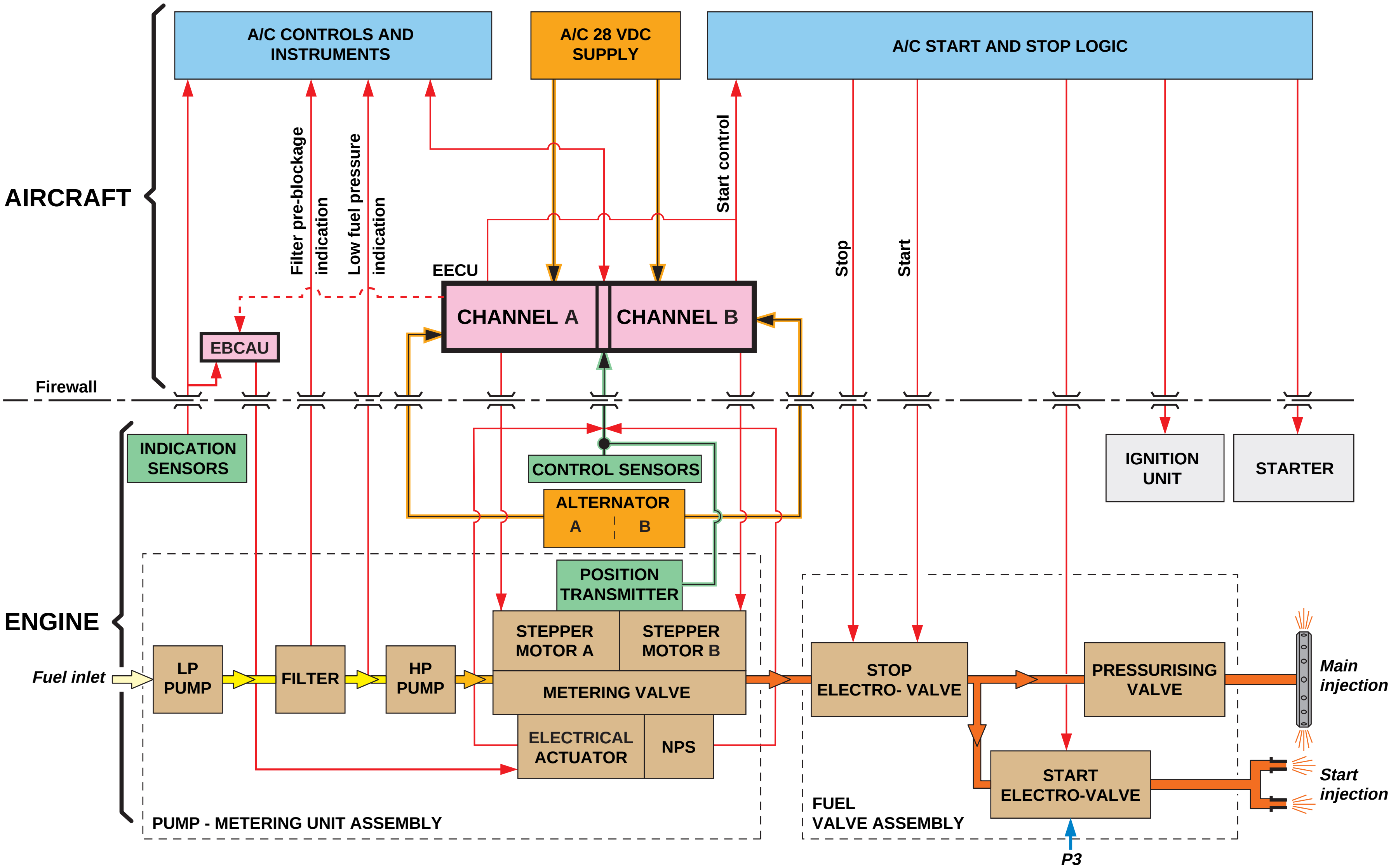
- *Hydromechanical components:*
  - *LP pump*
  - *Filter*
  - *HP pump*
  - *Metering unit (with automatic back-up)*
  - *Check valve*
  - *Start injection*
  - *Main injection system*
- *Electrical components:*
  - *Control sensors*
  - *Indication sensors*
  - *Dedicated alternator*
  - *Position transmitter*
  - *Stepper motor*
  - *Stop electro-valve*
  - *Start electro-valve*
  - *Neutral position switch (NPS)*
  - *EBCAU back-up control unit (fitted in the aircraft)*
  - Electrical actuator.

Note: *EBCAU = Engine Back up Control Auxiliary Unit.*

Engine Electronic Control Unit (EECU)

Computer which controls and monitors the engine.

- *Digital, dual channel*
- *Mounted in the aircraft*
- *Serial data link with the aircraft.*



CONTROL SYSTEM (2B1) - DESCRIPTION (1)

CONTROL SYSTEM (2B1) - DESCRIPTION (2)

The EECU has two independent channels A and B. Both channels have the same software.

Analog inputs

The two channels receive the following analog inputs: P3, t4.5, resolver position,Tq, N2 trim, P0, t0, collective pitch and conformation resistances Tq and t4.5.

The inputs are shared between the two channels. The N1 and N2 inputs are independent for each channel.

There is a data link between the two channels.

This configuration ensures that if all the acquisitions on one channel fail the acquisitions of the other channel are sufficient to control the engine safely.

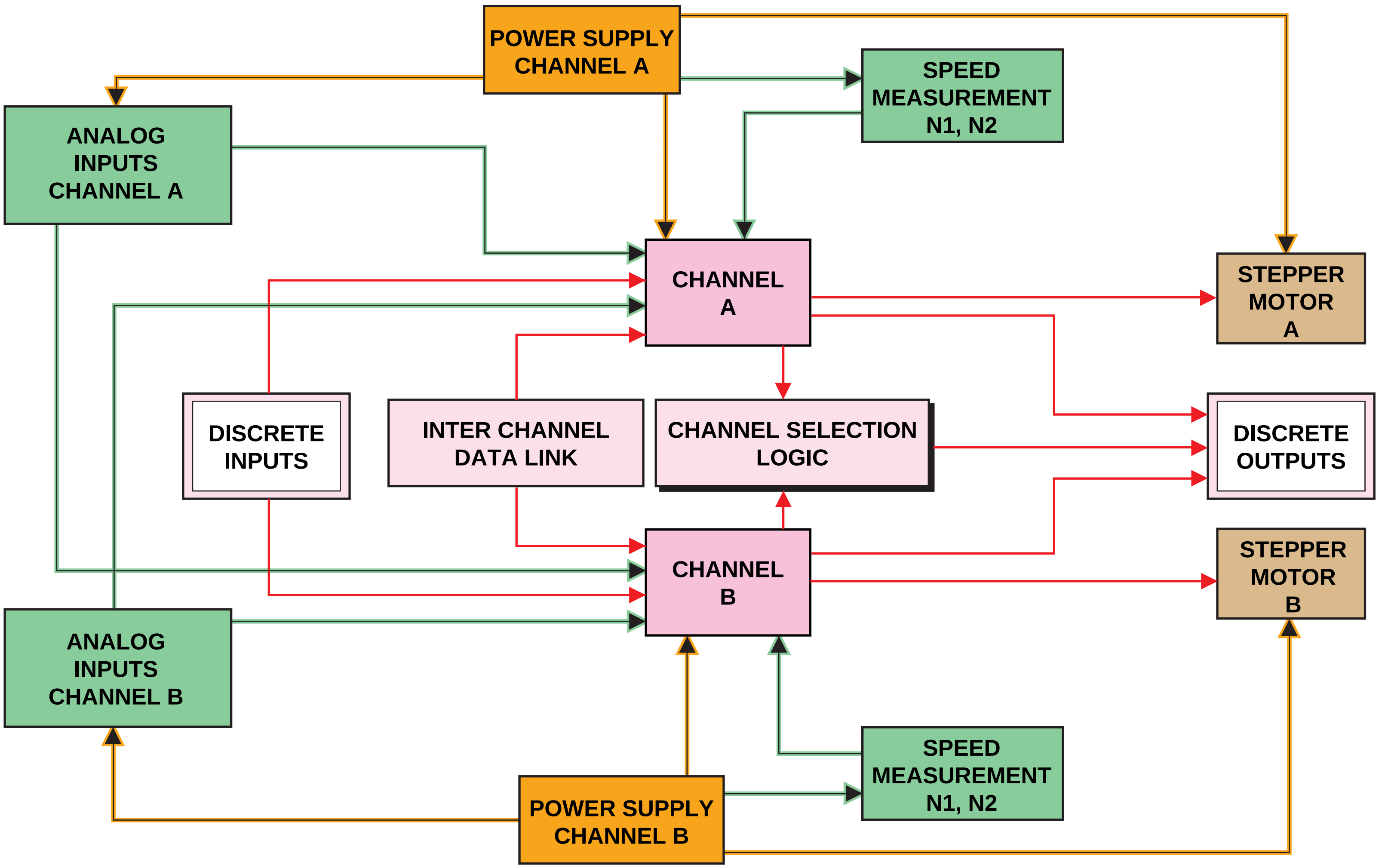
Discrete inputs and outputs

The discrete inputs are received and shared by the two channels and the discrete outputs are controlled by the selected channel. The resources of each channel receive their power supply from the corresponding channel. The shared resources receive their power supply from both channels.

Channel selection

A channel selector in the EECU will select which channel will control the engine depending on the signals it receives from the two channels. The normal channel is A. If it fails, the system changes automatically to channel B.

If both channels are unable to control the engine, the dual stepper motor is frozen.



CONTROL SYSTEM (2B1) - DESCRIPTION (2)

CONTROL SYSTEM - OPERATION (1)

Main functions of the control system

The control system ensures the following functions: starting, speed control, *manual control (2B)* and monitoring.

Starting

This function guarantees a quick and safe start under all operating conditions:

- Sequential control
- Control of the fuel flow required to start.

Speed control

This function maintains the aircraft rotor rotation speed constant (almost constant) in all operating conditions.

It also protects the engine with various limitations: rotation speeds, acceleration, deceleration, fuel flow…

2B: Manual control

This function permits manual engine control in the event of failure of the automatic control system.

2B1: Automatic back-up control

This function permits automatic fuel control as a function of N2, by-passing the main metering needle, in the event of a major failure.

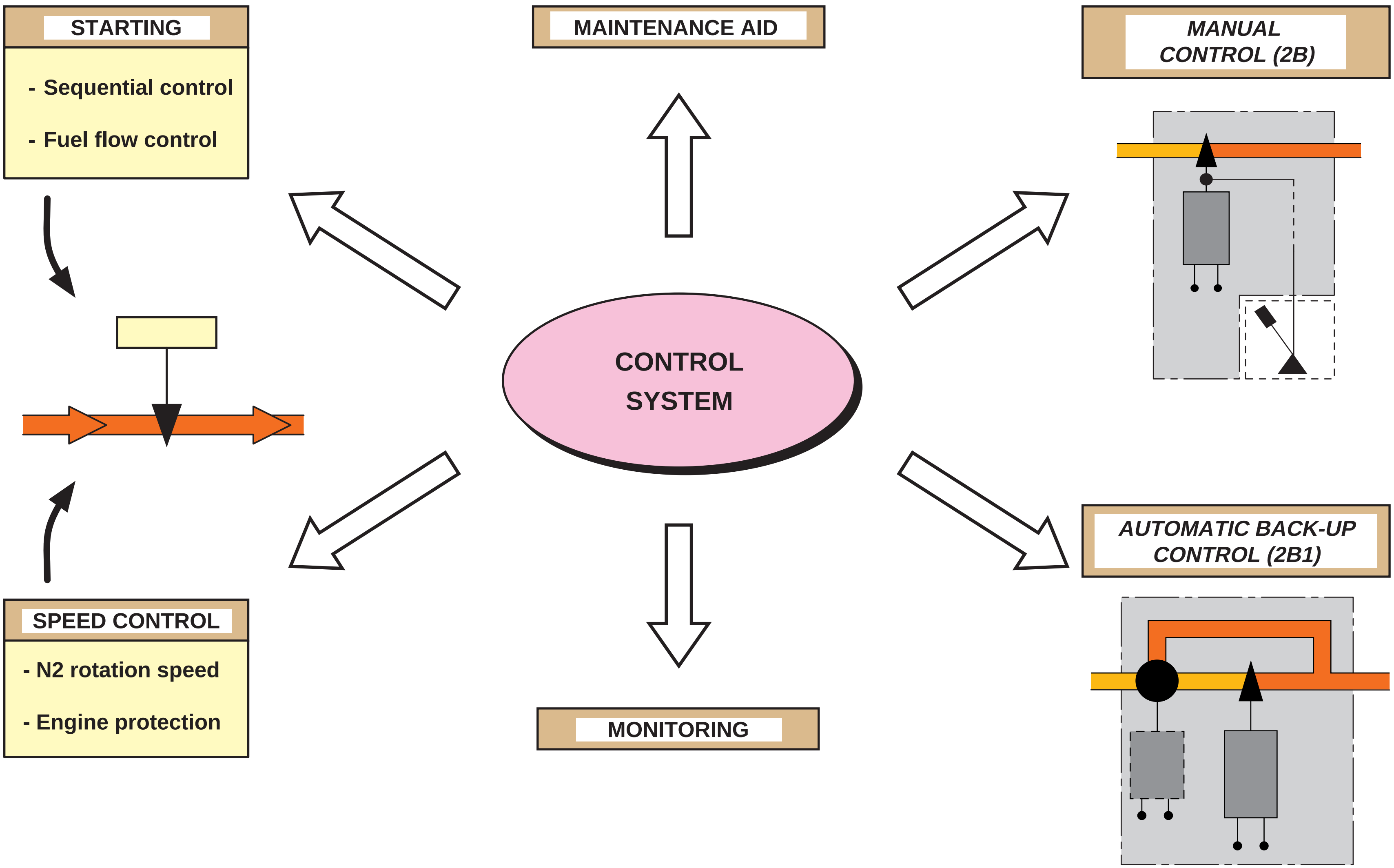
Monitoring

This function ensures engine monitoring, fault management and maintenance aid.

Maintenance aid

The EECU permanently records and memorises the parameters and engine events.
They can be transmitted to the displays and indicators in the cockpit, for maintenance aid purposes.

Note: *The operation described in the following pages considers the following modes:*
- *Starting*
- *Idle and Transition from idle to flight*
- *Fuel control - Generalities*
- *Speed control*
- *N1 limits*
- *Fuel flow limits*
- *Selection and indication of ratings*
- *2B:Manual mode training*
- *Indication and monitoring*
- *2B:Manual control.*



MAIN FUNCTIONS
CONTROL SYSTEM - OPERATION (1)

CONTROL SYSTEM - OPERATION (2)

Functions ensured by the electronic control system

This part mentions in a general way the main functional electronic blocks.

Note: *In the ARRIEL 2B1, both channels can perform all of these operations.*

Control mode determination

Starting

N2 datum selection

N2 speed control

Anticipation

N1 datum selection

Limitations (N1, torque…)

N1 speed control

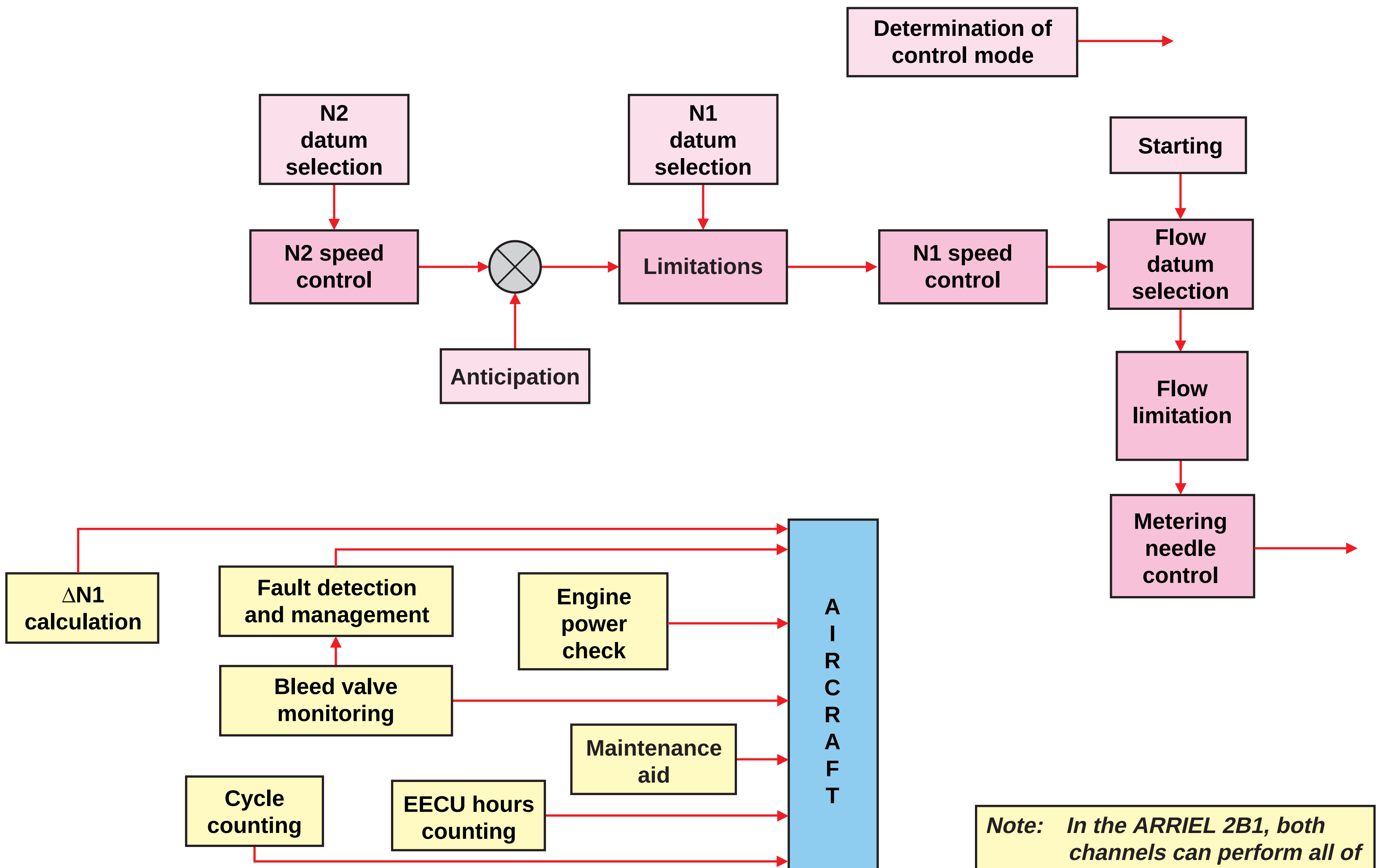
Flow datum selection

Flow limitation

Metering needle control.

Monitoring

- Engine power check
- ΔN1 indication calculation
- Cycle counting
- EECU hours counting
- Definition of serial messages
- Fault detection and management
- Data bus interfaces with the aircraft
- Bleed valve monitoring
- Maintenance aid.



Note: In the ARRIEL 2B1, both channels can perform all of these operations.

FUNCTIONS ENSURED BY THE ELECTRONIC CONTROL SYSTEM

CONTROL SYSTEM - OPERATION (2)

CONTROL SYSTEM - OPERATION (3)

Starting

This function includes the starting sequence, the starting fuel flow control, idling, the transition from idle to flight and relight in flight.

Starting sequence

The system ensures the cranking (starter), ignition (ignition unit) and the fuel supply.

Start is selected using the Stop / Idle / Flight selector:

- Stop (selection of engine shut-down)
- Idle (start control up to idle)
- Flight (normal control).

Note: *Refer to "FUEL SYSTEM" and "STARTING" chapters for more details on engine starting.*

In-flight relight

The sequence is identical to a ground start, but only permitted below 17 % N1.

Starting fuel flow control

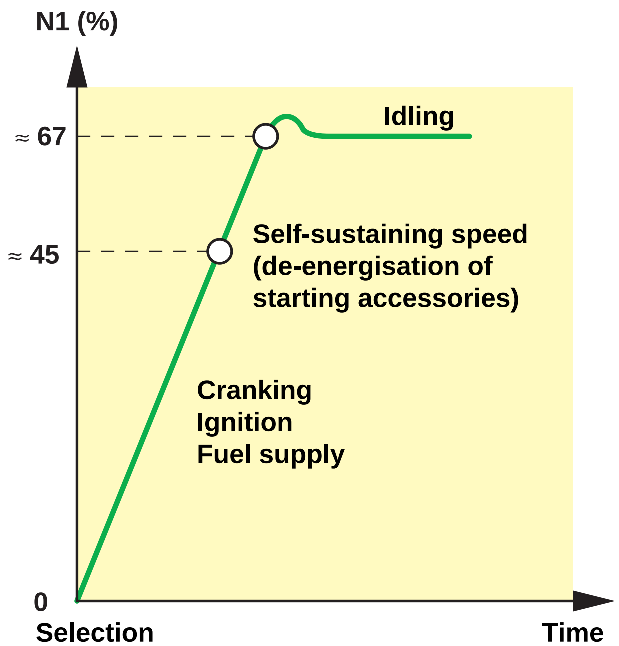
During starting, the fuel flow CH is metered so as to provide a rapid start without overtemperature.

To this end, the fuel flow is controlled according to different laws:

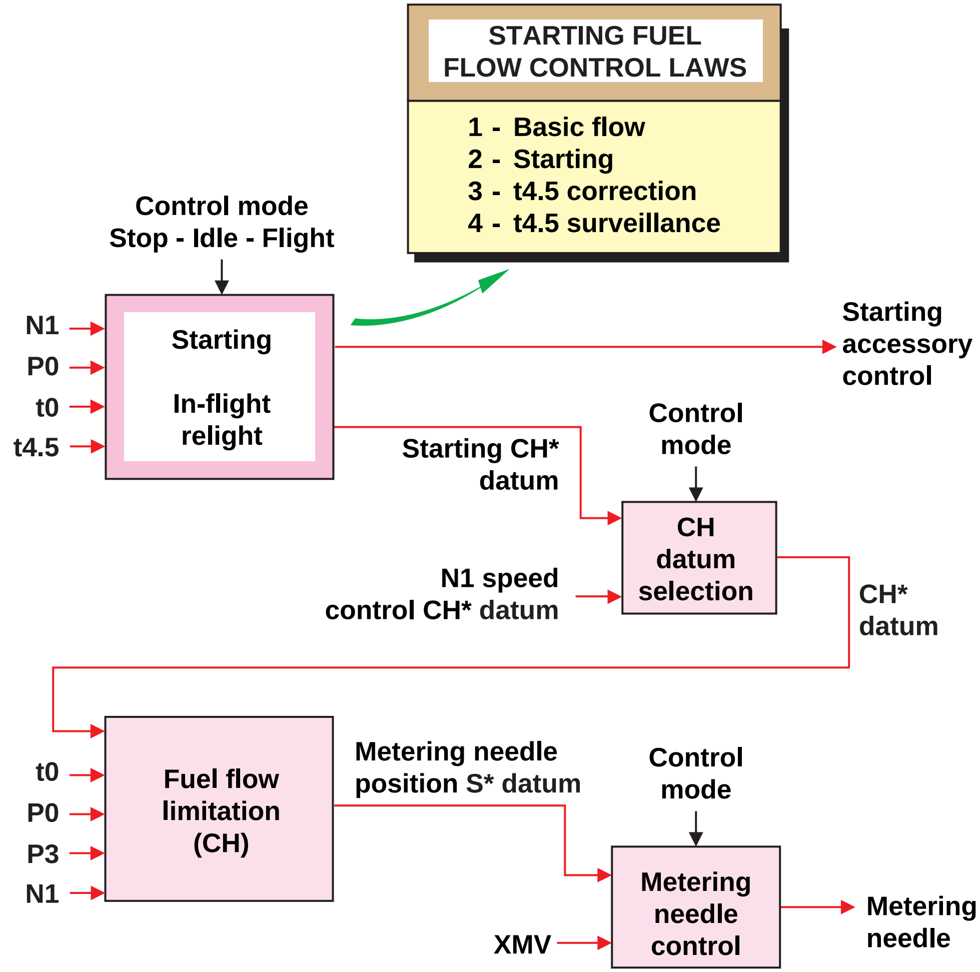
- Basic flow law as a function of t0 and residual t4.5 gas temperature
- Starting flow law as a function of N1 acceleration (ΔN1/Δt)
- Flow correction law as a function of t4.5 indexed proportional to N1
- t4.5 surveillance law: automatic engine shutdown if t4.5 does not exceed 100°C before 27 % N1.

The elaborated fuel flow datum CH* is used to control the metering needle via:

- Choice of datum
- Flow limitation stage
- Metering needle control, depending on the datum and the actual position signal XMV.



STARTING CONTROL SEQUENTIAL



STARTING FUEL FLOW CONTROL

STARTING
CONTROL SYSTEM - OPERATION (3)

CONTROL SYSTEM - OPERATION (4)

Starting (continued)

Idle

When starting is completed, the rotation speed stabilises at idle which is 67 - 68 % (function of t0).

Transition from idle to flight

This is effected by moving the selector from idle to flight.

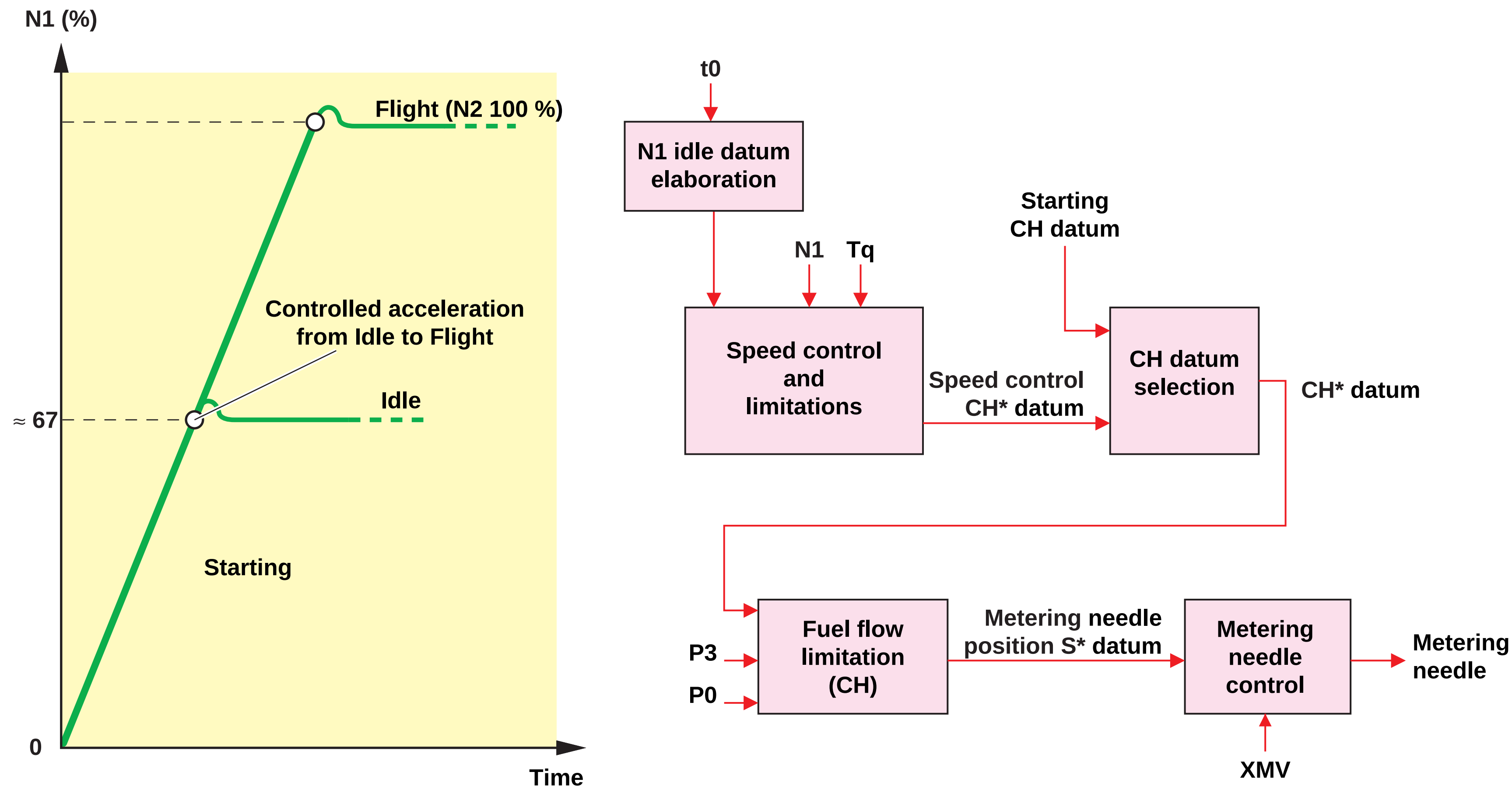
This transition is prohibited until a given increase of N2 has been registered.

During the transition, the torque and N2 acceleration are limited.

The transition is completed when the system enters into nominal speed control. The control loop comprises the N2 control which elaborates an N1 datum, and the N1 control which elaborates a fuel flow datum CH*.

Control functions

- Elaboration of the N1 idle datum as a function of t0
- Transition control
- Speed control (N2, N1, limitations, etc)
- Selection of fuel flow datum CH*
- Flow control
- Metering needle control.



IDLE AND TRANSITION FROM IDLE TO FLIGHT
CONTROL SYSTEM - OPERATION (4)

CONTROL SYSTEM - OPERATION (5)

Control - General

Installation configuration

The gas generator supplies power to the power turbine which is connected to the helicopter main rotor.

Installation requirements

- Aircraft rotor speed (NR) almost constant in all operating conditions (because of the rotor efficiency) whatever the load applied
- Max torque limitation (imposed by the mechanical transmission and the helicopter main gearbox)
- Power turbine rotation speed (N2) within given limits (in fact almost constant, as it is connected to the rotor)
- Limitation of the gas generator rotation speed N1:
  - Max N1
  - Min N1 (to avoid engine flame-out and critical speeds)
- Protection against surge, flame-out, overtemperature ...

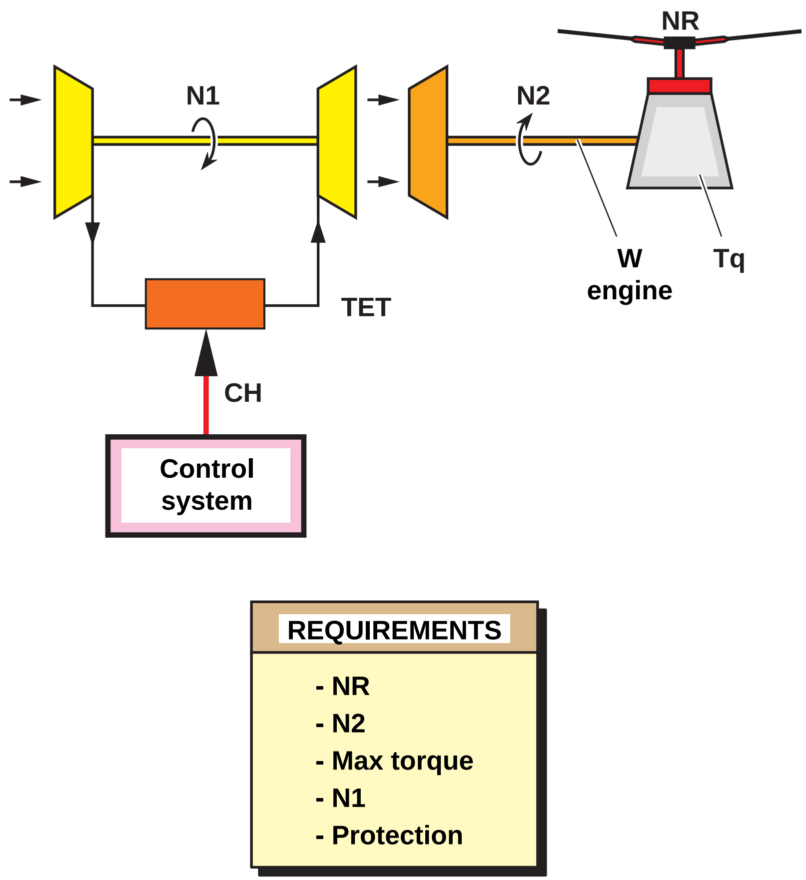
Adaptation to requirements

The control system ensures the engine adaptation to the requirements by metering the fuel flow CH sprayed into the combustion chamber.

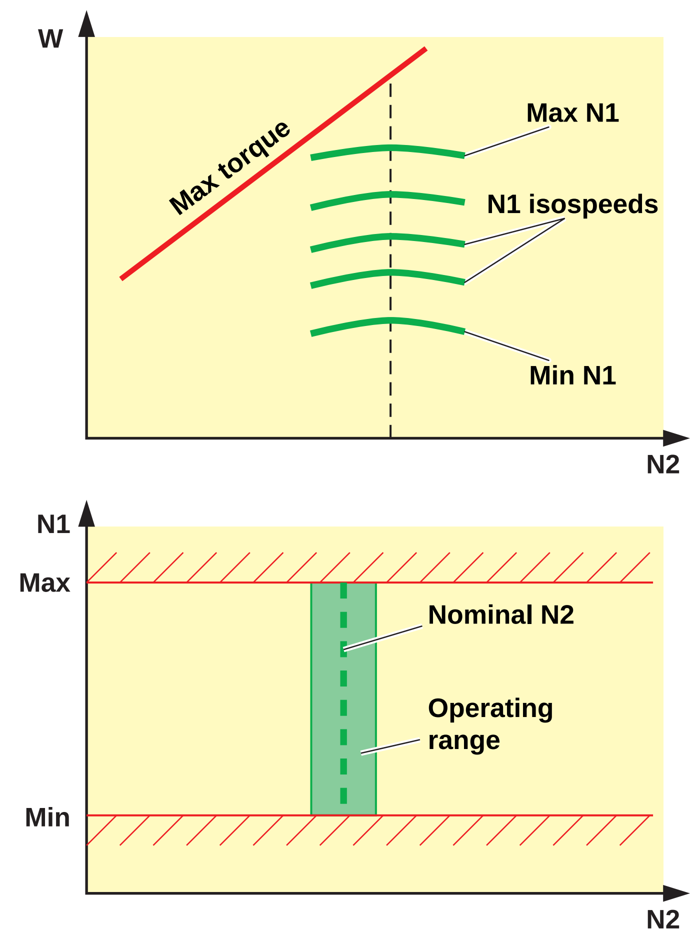
Thus, the gas generator adapts automatically to the requirements (N1 demand) to maintain the power turbine rotation speed N2 constant whilst keeping all the other parameters within determined limits.

This adaptation is illustrated by:

- The diagram W/N1, N2 which illustrates the power W, the max torque C and the rotation speeds N1 and N2
- The diagram N1/N2 which illustrates the N1/N2 relation curve.



INSTALLATION CONFIGURATION AND REQUIREMENTS



ADAPTATION TO REQUIREMENTS

CONTROL - GENERAL

CONTROL SYSTEM - OPERATION (5)

CONTROL SYSTEM - OPERATION (6)

Speed control - General

Control loop

The control loop comprises essentially:

- An anticipator linked to the helicopter collective pitch lever
- A power turbine speed (N2) controller
- An N1 datum limiter for max and min N1, acceleration…
- An N1 controller
- A fuel flow limiter (CH) for max and min flow, anti flame-out, anti-surge
- A fuel flow controller to control the fuel metering needle.

Operating principle

In this type of control system the position of the helicopter collective pitch lever, which represents the power required, determines the basic N1 datum. This function, which is called the anticipator, permits an initial adaptation of the gas generator speed to balance the power supplied with the power required and thus maintain the N2 constant. Furthermore the anticipator supplies an instant signal of a load variation, which reduces the detection time and provides a rapid reaction of the control system. However, this first reaction is not sufficient, as the power required depends on other factors.

The basic datum is modified by the N2 controller, which is a proportional controller, after comparing the difference between a datum (the nominal NR) and the measured N2. Thus the N2, and therefore the NR, are maintained constant without static droop.

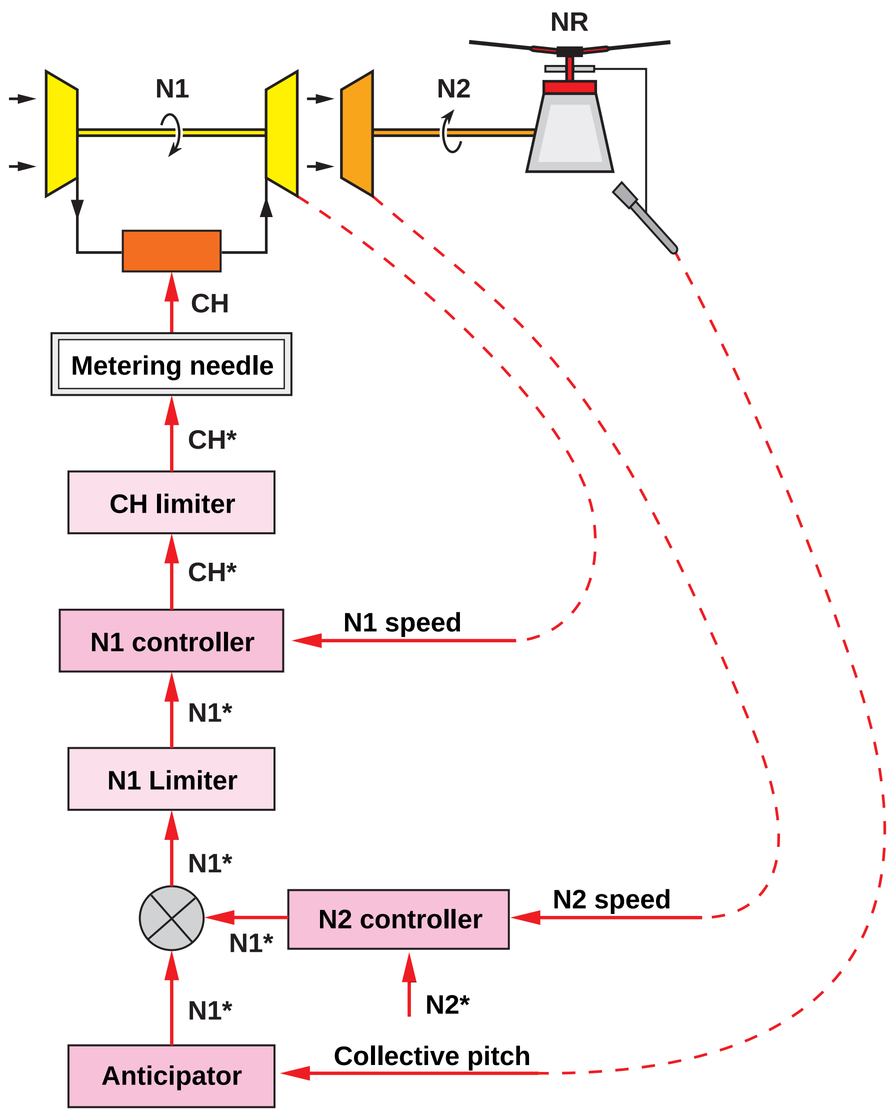
The N1 datum is thus elaborated as a function of the anticipator and the N2 controller.

The N1 datum is then limited in order to assure certain functions such as rating stops, acceleration and deceleration control.

The N1 controller is proportional/integral and treats the difference between the N1 datum and the actual N1. It translates the difference into a fuel flow datum CH, in order to maintain the N1 constant with the datum without static droop.

The fuel flow limiter then modifies this datum in order to assure certain protection functions such as anti-surge, anti flame-out, torque limitation, etc.

Finally the fuel flow datum is treated to give a signal to the metering unit which determines the actual fuel flow injected into the combustion chamber, which determines the operation of the gas generator, particularly the rotation speed N1.



SPEED CONTROL - GENERAL

CONTROL SYSTEM - OPERATION (6)

CONTROL SYSTEM - OPERATION (7)

Speed control

The control loop comprises N2 control, anticipation, N2 datum selection, limitations and N1 control.

N2 control

2B: *The N2 controller is a proportional controller which treats the difference between the actual N2 and a datum N2*. This datum is elaborated as a function of a signal XTL. This signal comes from a potentiometer in the cockpit which permits servicing adjustment of N2.*

2B1: *The N2 controller is a proportional type controller which treats the difference between the actual N2 and a datum N2*. This datum is elaborated as a function of a signal XTL (rudder position), P0 and NFT. The NFT signal comes from an adjuster in the cockpit which permits servicing adjustment of N2, during certain maintenance tasks.*

P0 varies NR with altitude for noise reduction in proximity to the ground.

***Note**: If the XCP signal is lost the N2 controller becomes proportional/integral.*

Anticipation

Load variations are anticipated by a signal from a potentiometer linked to the collective pitch lever.

This signal, XCP, acts on the N1 datum.

N1 datum selection

This stage chooses the N1* datum as a function of the control mode, that is: N1 idle or N1* datum.

N1 limiter

The N1 datum is limited to assure various limitations (details on the following pages).

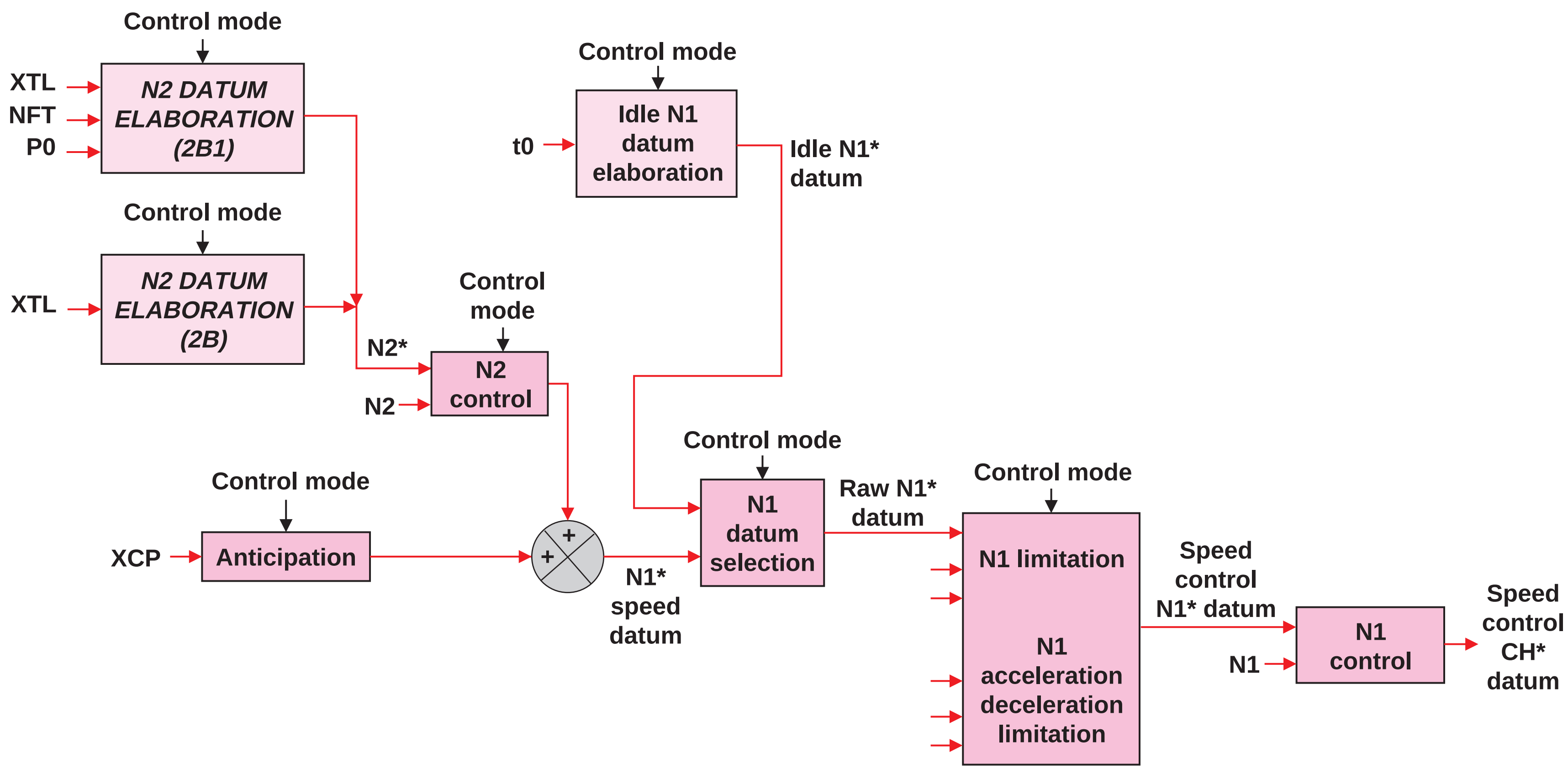
N1 control

The N1 controller is a proportional/integral controller, that is without static droop. This controller treats the difference between the datum and the actual N1 and elaborates the necessary fuel flow datum CH*.

Acceleration and deceleration control

During acceleration, the rate of change of the N1 datum is limited in order to avoid surge caused by overfuelling. The rate of change ($\Delta N/\Delta t$) is modified as a function of P0 and t0. The system includes a more limiting recovery law which it uses in the event of the P3 signal becoming defective.

During deceleration, the rate of change of the N1 datum is limited to prevent flame-out during rapid deceleration.



SPEED CONTROL
CONTROL SYSTEM - OPERATION (7)

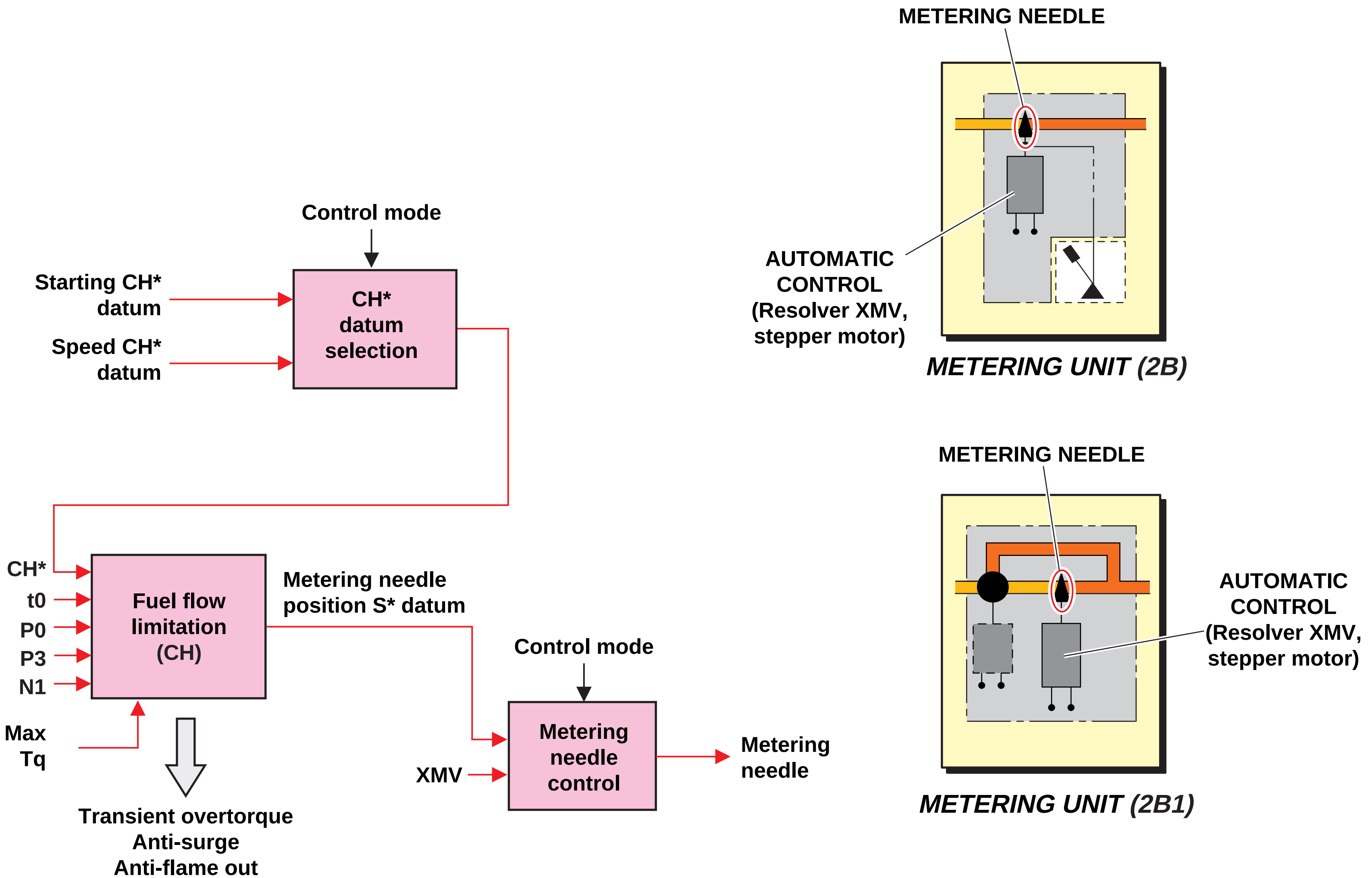
CONTROL SYSTEM - OPERATION (8)

Fuel flow limitation

The system has several fuel flow limitations to control:

- Transient overtorque of the power turbine shaft: max flow limitation signal as a function of a constant
- Surge: max flow limitation as a function of N1, t0, P3 and P0 with back-up law in the event of loss of t0 or P0 signals
- Flame out: min flow limitation as a function of N1, t0, and P0, with back-up laws in the event of loss of t0 or P0 signals.

The fuel flow datum CH* coming from the speed control loop passes first through a datum selection stage which makes the choice between starting CH* and speed control CH*. The choice depends on the control mode, that is the present state of control. The output from the selector is passed to a flow limiter which treats the flow datum as a function of t0, P0 and P3 to assure the limits. It elaborates a metering needle position datum which is transmitted to the metering needle control stage. This control stage receives a signal of metering needle position XMV and elaborates a control signal for the stepper motor which positions the metering needle.



FUEL FLOW LIMITATION

CONTROL SYSTEM - OPERATION (8)

CONTROL SYSTEM - OPERATION (9)

Principle of limitations

The principle of limitations is based on one limit parameter: the gas generator rotation speed (N1 or Ng).

This speed is therefore the essential piloting parameter.

The other parameters (TET, N2, torque) are kept within given limits by the control system.

Max N1 limitation

The maximum N1 is limited automatically, in the following manner:

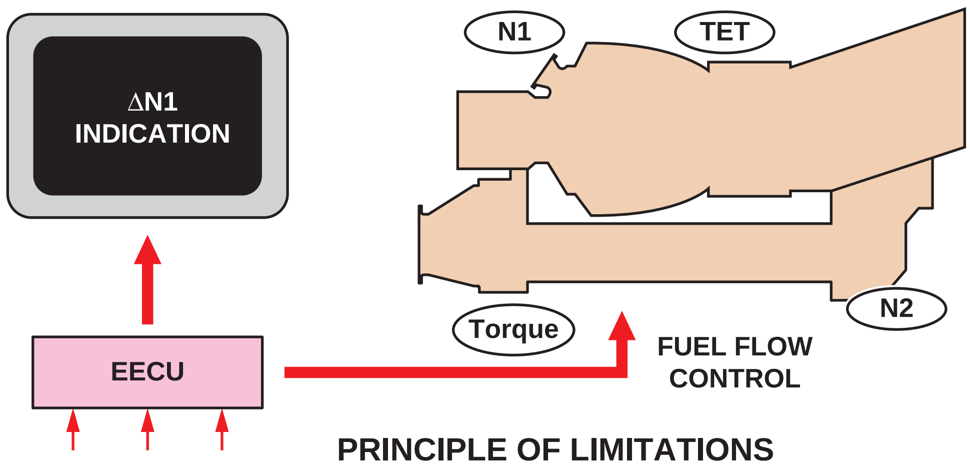
There is no automatic limitation of the take-off rating which is controlled by the pilot. However a stop prevents any exceedance of the max N1.

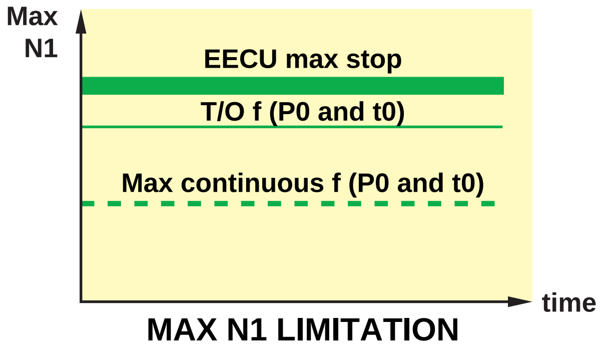
If the sand filter is active, the EECU derates the N1 limits; the EECU also takes into account the sand filter active signal for the power check calculation.

Max continuous power is also controlled by the pilot.

Torque limitation

The pilot also controls the max torque applied to the main gearbox, however as a safety measure the EECU elaborates a max fuel flow (CH) limit as a function of torque to prevent overtorque of the MGB and free wheel unit.





CONTROL SYSTEM - OPERATION (9)

CONTROL SYSTEM (2B) - OPERATION (10)

Manual mode

This mode permits manual control of the engine in the event of complete failure of the control system.

Manual reversion

If the electronic control fails the system is automatically in manual control. In this mode the fuel flow will only alter if the manual control is moved.

Manual control

The twist grip in the cockpit is connected by a mechanical linkage to the pump and metering unit assembly.

It has a neutral position, automatic flow control; a flow increase range (the plus range), and a flow reduction range (the minus range).

For more details refer to "FUEL SYSTEM".

Note: *The aircraft electrical power should be switched on before moving the twist grip.*

Fuel metering in manual mode

The manual control has a range between min flow and max flow.

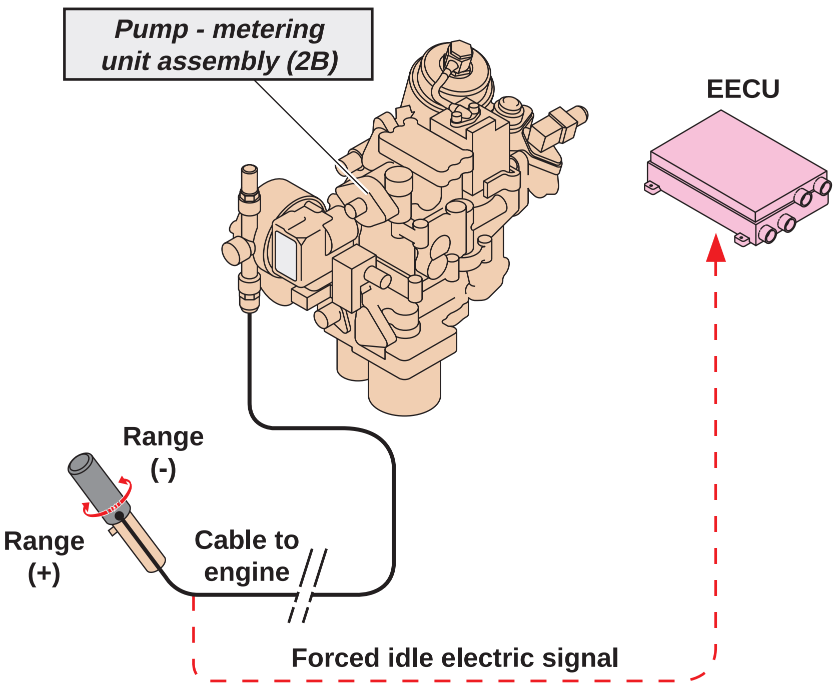
It allows:

- *Engine acceleration without surge (e.g. from minimum power to 95 % of T/O power in less than 5 seconds) and engine deceleration without flame-out*
- *The engine to be reduced to idle by means of a stop on the twist grip.*

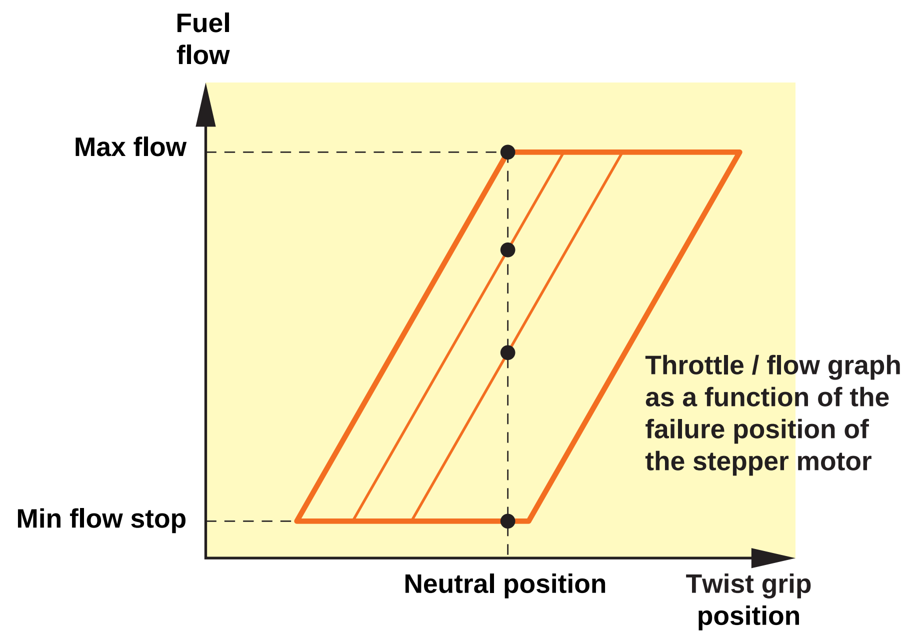
Note 1: *It is possible to return to automatic mode at anytime, however it is recommended to do so from a stable condition.*

Note 2: *The 2B1 version system is also equipped with a twist grip. The sole purpose of this is to permit autorotation training via the forced idle switch.*

TRANSITION TO MANUAL MODE



MANUAL CONTROL



FUEL METERING IN MANUAL MODE

MANUAL MODE

CONTROL SYSTEM (2B) - OPERATION (10)

CONTROL SYSTEM (2B) - OPERATION (11)

Manual mode training

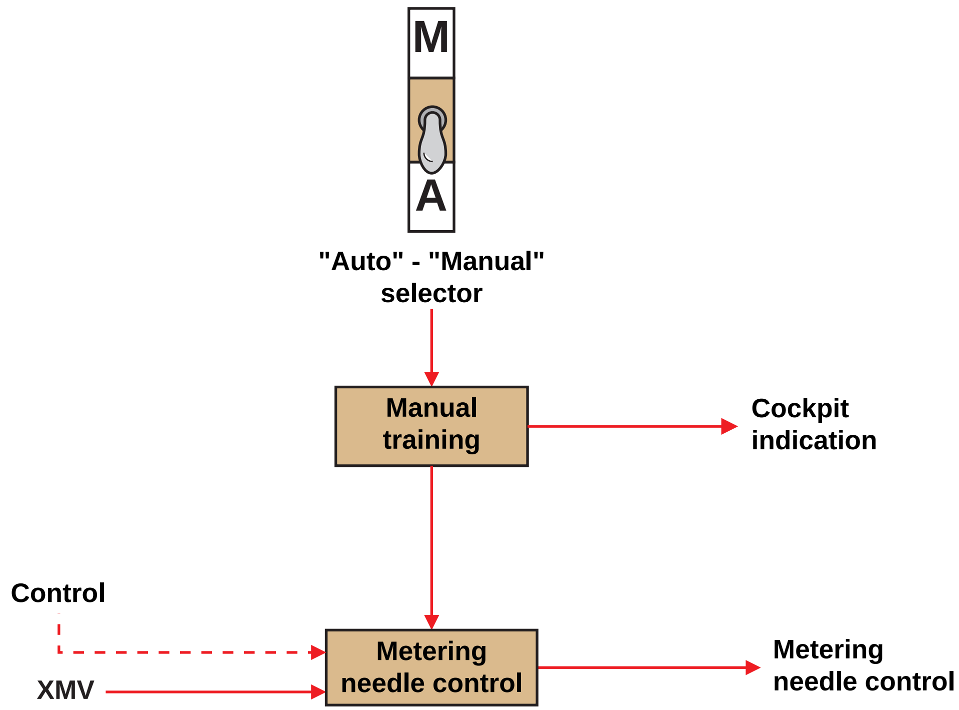
The system is designed to allow training in manual mode by simulating a complete failure of the electronic control system by freezing the stepper motor.

The mode is selected using a manual/automatic selector and an indicator gives the status of the system.

The system can be returned to automatic at any time.

***Note 1**: Manual control is carried out by displacing the twist grip out of the neutral position (flight position). Refer to the "manual control function" p. 7.28 and to the chapter "FUEL SYSTEM" for details.*

***Note 2**: The above procedure does not apply to the 2B1 version. The "Auto" / "Manual" selector is only used for periodic maintenance testing of the automatic back-up control system.*



MANUAL MODE TRAINING
CONTROL SYSTEM (2B) - OPERATION (11)

CONTROL SYSTEM - OPERATION (12)

Operating principle

In this type of control system the position of the helicopter collective pitch lever, which represents the power required, determines the basic N1 datum. This function, which is called the anticipator, permits an initial adaptation of the gas genetator speed to balance the power supplied with the power required and thus maintain the N2 constant. Furthermore the anticipator supplies an instant signal to a load variation, which reduces the detection time and provides a rapid reaction. However the first reaction is not sufficient, as the power required depends on other factors.

The basic datum is modified by the N2 controller, which is a proportional controller, after comparing the difference between a datum (the nominal NR) and the measured N2. Thus the N2, and therefore the NR, are maintained constant without static droop.

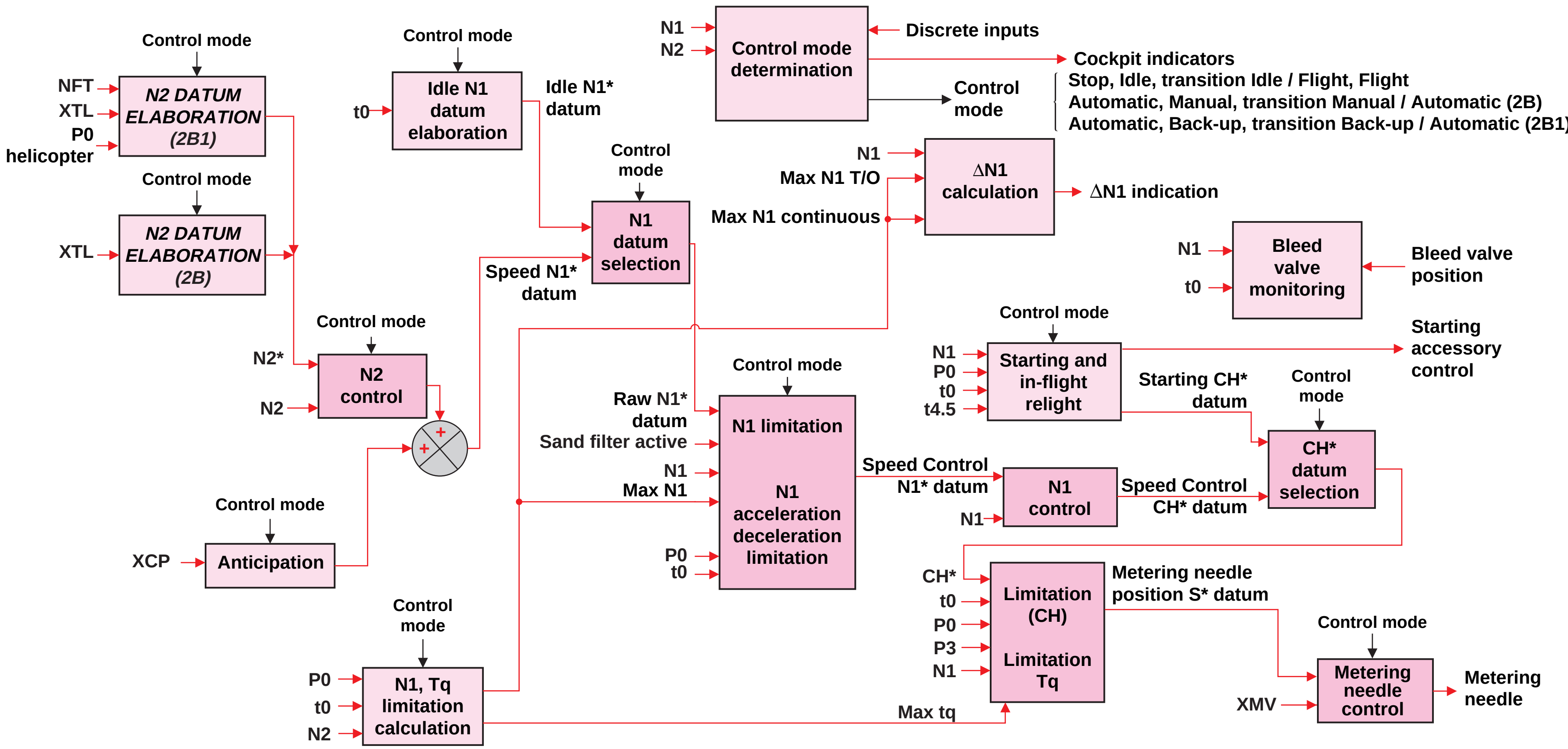
The N1 is thus elaborated as a function of the anticipator and the N2 controller.

The N1 datum is then limited in order to assure certain functions such as rating stops, acceleration and deceleration control.

The N1 controller is proportional/integral and treats the difference between the N1 datum and the actual N1. It translates the difference into a fuel flow datum CH, in order to maintain the N1 constant with the datum without static droop.

The fuel flow limiter then modifies this datum in order to assure certain protection functions such as anti-surge, anti flame-out, torque limiting, etc.

Finally the fuel flow datum is treated to give a signal to the metering unit which determines the actual fuel flow injected into the combustion chamber, which determines the operation of the gas generator, particularly the rotation speed N1.



CONTROL SYSTEM - OPERATION (12)

CONTROL SYSTEM - INDICATION AND MONITORING (1)

The system ensures the indication of engine parameters, performance indication, cycle counting, rating exceedance time counting, fault indication and maintenance aid.

Engine parameter indication

Indication of N1, N2, t4.5, to allow engine monitoring in the event of total electronic failure and to check that the EECU is maintaining the engine within limits.

These indications are independent of the electronic control. Refer to the "MEASUREMENT AND INDICATING SYSTEMS" chapter for further details.

Torque indication

The system provides an indication as a function of the actual measured torque and "conformed" torque (refer to "torque" indicating system for further detail).

FLI indication

It indicates the difference between the actual N1 and the take-off N1. This shows the pilot the power reserve.

Engine power check

It is possible to carry out an engine power check.

In stabilised conditions a power check is selected while the necessary parameters are being transmitted to the EECU (P0, t0, configuration).

The EECU verifies the stability of the parameters and calculates the minimum guaranteed performance. It records the result and transmits it to the aircraft: date, hours run, configuration, N1, N2, P0, t0, calculated minimum guaranteed torque, max guaranteed calculated t4.5, difference in torque and t4.5, validity of test.

Cycle counting

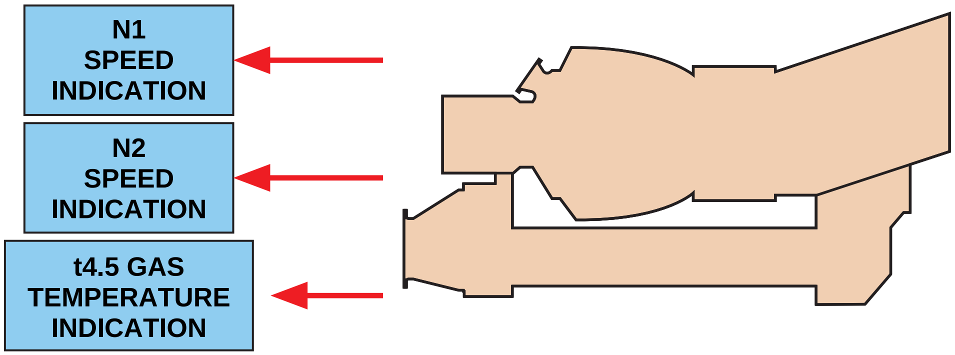
The EECU counts and records:

- Power turbine cycles
- Gas generator cycles.

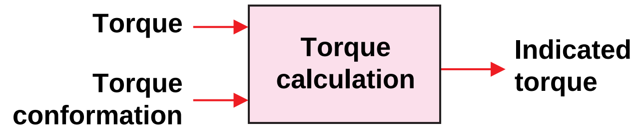
The counting capacity is 16000 cycles with reset to zero when achieved.

EECU hours counting

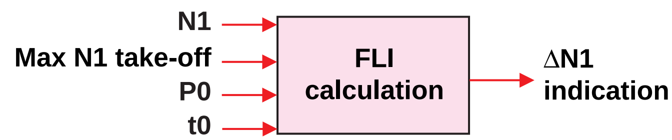
The EECU counts and records the EECU running hours.



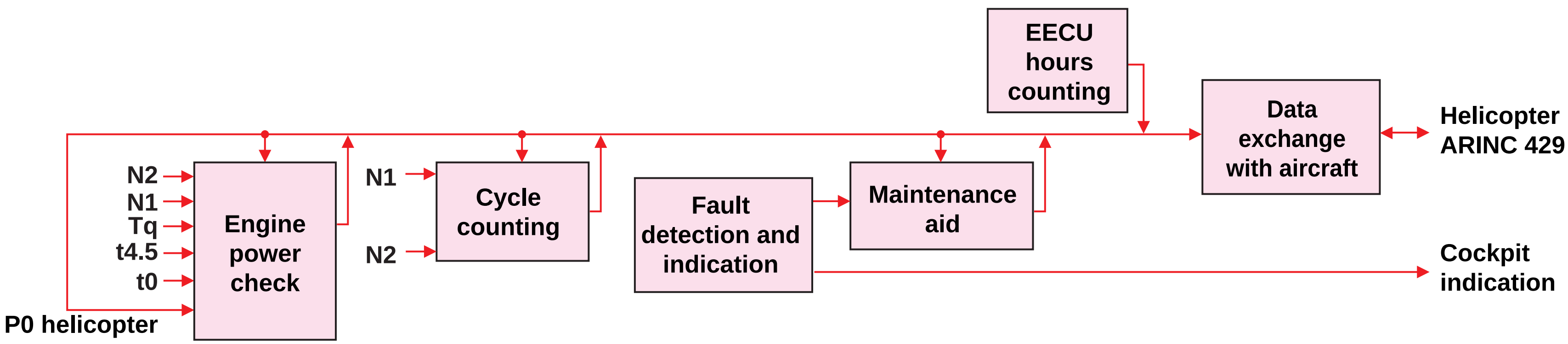
ENGINE PARAMETER INDICATION
(independent from the control system)



TORQUE INDICATION



FLI INDICATION



CONTROL SYSTEM - INDICATION AND MONITORING (1)

CONTROL SYSTEM (2B) - INDICATION AND MONITORING (2)

Fault tolerance, Indication and Management

Fault tolerance

If a fault affects a nominal law the system uses a back-up law. The essential functions (N1 and N2 control, acceleration and deceleration control) remain ensured.

In the event of a fault affecting a main law and the back-up law the system declares itself unable to control the engine and the engine must be controlled manually.

Fault indication

There are three levels of indication:

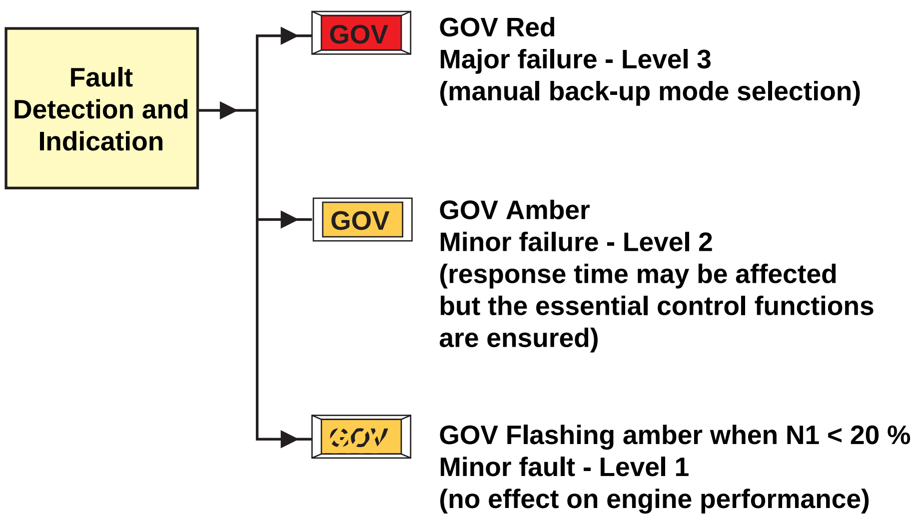
- Level 3 - *Major failure: manual mode reversion*
- Level 2 - *Minor failure:* response time may be affected but the essential control functions are ensured
- Level 1 - *Minor fault: loss of redundancy with no effect on engine performance.*

Two lights provide the fault indication: GOV (Red) and GOV (Amber)

- *A GOV (Red) indicates a total failure of the control system*
- *A GOV (Amber) indicates degraded operation of the control system. This light also indicates a minor fault by flashing during engine starting, idle rating or during shut-down (N1 < 20 %).*

Control system failure	Consequences
Faults affecting a main control law & the back-up law: major failure - level 3	Manual control (GOV red)
Faults affecting a main control law: minor failure - level 2	Use of a back-up law (GOV amber)
Faults not affecting a main control law: minor fault - level 1	The system remains on the main control law (GOV flashing amber)

FAULT TOLERANCE



FAULT INDICATION

CONTROL SYSTEM (2B) - INDICATION AND MONITORING (2)

CONTROL SYSTEM (2B) - INDICATION AND MONITORING (3)

Fault management

For each input signal, the EECU has a set of criteria with which it can decide if the signal is valid. The tables on the following pages show the logic used by the EECU in the event of an invalid signal. They also show the associated fault level, the CWP indication and the VEMD indication where applicable.

Note 1: *CWP: Central Warning Panel*

VEMD: Vehicle and Engine Multifunction Display (indication and message screen).

Note 2: *In the following pages, the CWP indications correspond to:*

R = GOV Red

A = GOV Amber

FA = GOV Amber flashing when N1 < 20 %

Note 3: ***The codes listed in the following pages are given for instruction purposes only. In all cases, refer to the maintenance manual for the reasons of fault alarm, for the meaning of fault codes and for the corrective action.***

CONTROL SYSTEM (2B) - INDICATION AND MONITORING (3) FAULT TOLERANCE TABLES (EXAMPLE)

Refer to trouble shooting manual

Input	Effect on EECU operation	Level	CWP	VEMD Message	Comments
N1B (sensor)	Use of N1 alternator	1	FA	FAIL 2 - 0020	In normal operation EECU uses N1B
N1 (alternator)	Use of N1B sensor	1	FA	FAIL 2 - 0080 or FAIL 2 - 0480	
N1B & N1 Alt	Stepper motor freeze	3	R	FAIL 2 - 00A0 or FAIL 2 - 04A0	Manual control
N2B	Use of N2C	1	FA	FAIL 2 - 0010	In normal operation EECU uses N2B
N2C	Use of N2B	1	FA	FAIL 2 - 0040	
N2B & N2C	Stepper motor freeze	3	R	FAIL 2 - 0050	Manual control
P3	Max fuel flow reduced; Acceleration law adapted	2	A	FAIL 1 - 0080 or FAIL 1 - 4000	Degraded operation

CONTROL SYSTEM (2B1) - INDICATION AND MONITORING (4)

Fault tolerance, Indication and Management

Fault tolerance

In the event of a fault the system automatically reconfigures itself, without losing the essential functions, i. e. N1 and N2 control, acceleration and deceleration control. For these functions the software has recovery laws which it will use if a main control input becomes invalid.

In normal operation, channel A is the prefered channel. The system will only change to channel B if channel A has a major failure:

- *If a minor fault affects channel A,the system remains on channel A*
- *If a fault affects a main control law on channel A, it will use a recovery law.*
- *If a fault or faults affect a main control law and its recovery law, the system changes automatically to channel B*
- *If a fault or faults affect a main control law and the recovery law of both channels, the system freezes the stepper motor automatically and enables the back-up system.*

Fault indication

There are three levels of indication:

- *Level 3 - Major failure: stepper motor frozen*
- *Level 2 - Minor failure: response time may be affected but the essential control functions are ensured*
- *Level 1 - Minor fault: no effect on engine operation.*

There are two lights in the cockpit to indicate these faults, a GOV red and GOV amber:

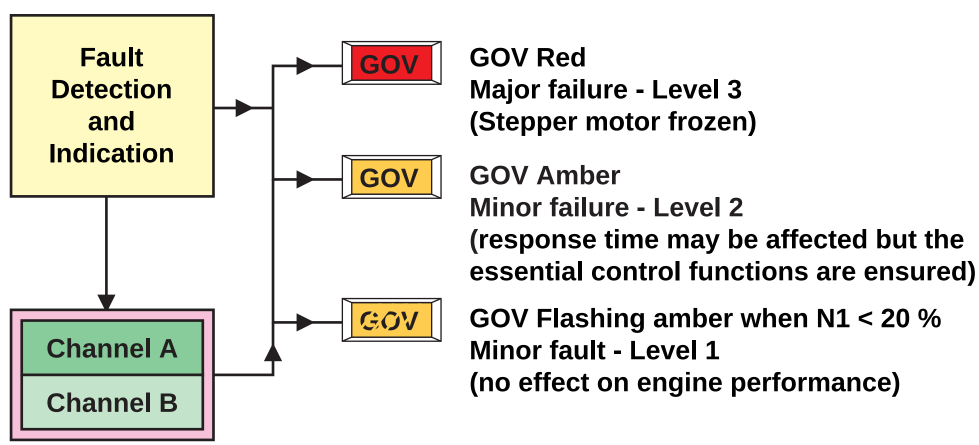
- *The GOV red indicates a major failure*
- *The GOV amber indicates a minor failure. This light also indicates a minor fault by flashing when N1 < 20 %.*

Note: *The control system will always be on channel A, which can receive information from channel B, unless an internal malfunction of channel A causes a major failure.*

FAULT TOLERANCE

Channel B \ Channel A	A: No failure	A: Failure level 1	A: Failure level 2	A: Failure level 3
B: No failure	Ch. in control: A EECU: No failure GOV: No	Ch. in control: A EECU: Redun. failure GOV: Flashing amber	Ch. in control: A EECU: Minor failure GOV: Amber	Ch. in control: B EECU: Redun. failure GOV: Flashing amber
B: Failure level 1	Ch. in control: A EECU: Redun. failure GOV: Flashing amber	Ch. in control: A EECU: Redun. failure GOV: Flashing amber	Ch. in control: A EECU: Minor failure GOV: Amber	Ch. in control: B EECU: Redun. failure GOV: Flashing amber
B: Failure level 2	Ch. in control: A EECU: Redun. failure GOV: Flashing amber	Ch. in control: A EECU: Redun. failure GOV: Flashing amber	Ch. in control: A EECU: Minor failure GOV: Amber	Ch. in control: B EECU: Minor failure GOV: Amber
B: Failure level 3	Ch. in control: A EECU: Redun. failure GOV: Flashing amber	Ch. in control: A EECU: Redun. failure GOV: Flashing amber	Ch. in control: A EECU: Minor failure GOV: Amber	Ch. in control: None EECU: Total failure GOV: Red

FAULT INDICATION



Note: The control system will always be on channel A, which can receive information from channel B, unless an internal malfunction of channel A causes a major failure.

CONTROL SYSTEM (2B1) - INDICATION AND MONITORING (4)

CONTROL SYSTEM (2B1) - INDICATION AND MONITORING (5)

Fault management

For each input signal, the EECU has a set of criteria with which it can decide if the signal is valid. The tables on the following pages show the logic used by the EECU in the event of an invalid signal. They also show the associated fault level, the CWP indication and the VEMD indication where applicable.

Note 1: *CWP: Central Warning Panel*
VEMD: Vehicle and Engine Multifunction Display (indication and message screen).

Note 2: *In the following pages, the CWP indications correspond to:*

R = GOV Red

A = GOV Amber

FA = GOV Amber flashing when N1 < 20 %

CONTROL SYSTEM (2B1) - INDICATION AND MONITORING (6)
FAULT TOLERANCE TABLES (EXAMPLE)

Level 1 - Minor fault: GOV amber flashing if N1 < 20%.

The EECU redundancy failure is output if one of the following signals is declared invalid:

- *Engine t4.5*
- *Helicopter t4.5*
- *Start switch failure after start (flight mode automatically selected)*
- *Engine P0 with helicopter P0 valid*
- *Single N1 signal*
- *Single N2 signal*
- *Single stepper motor*
- *Tq conformation after power-up*
- *t4.5 conformation after power-up*
- *Helicopter P0 with engine P0 valid*
- *Engine t0 failure*
- *Helicopter t0*
- *Helicopter ARINC, reversible after engine shutdown.*

CONTROL SYSTEM (2B1) - INDICATION AND MONITORING (7)
FAULT TOLERANCE TABLES (EXAMPLE)

Level 2 - Minor failure: GOV amber.

The EECU minor failure is output if one of the following events occurs:

FAULT	INDICATION	COMMENTS
Loss of XTL signal (rudder pedal position)		Recovery law - No effect on N2
Loss of P0 engine and P0 helicopter		Recovery law permitting N1 max, degraded transients but maintaining surge and flame-out protection
Loss of XCP signal (collective pitch)		Recovery value - N2 in integral control
Loss of P3 signal		Degraded transients, engine still protected against surge and flame-out
Loss of t0 engine and t0 helicopter		Recovery value permitting N1 max, degraded transients but maintains surge and flame-out protection
Loss of torque signal		No max torque limit
Loss of Tq conformation at power-up		Recovery value - Max Tq remains available
Loss of t4.5 at power-up or stop		Recovery value - Degraded starting
Stop electro-valve failure		Engine shut-down by stepper motor
Loss of alternator power supply		Supply from helicopter 28 V bus
Loss of 28 VDC supply from helicopter		Use of alternator supply - No start
Back-up fuel valve out of neutral		
Resolver failure		

CONTROL SYSTEM (2B1) - INDICATION AND MONITORING (8)
FAULT TOLERANCE TABLES (EXAMPLE)

Level 3 - Major failure: GOV red.

The EECU major failure is output if one of the following events occurs:

- *Dual stepper motor failure*
- *P0 failure, P0 helicopter failure and P3 failure*
- *t0 failure, t0 helicopter failure and P3 failure*
- *"Stop" / "flight" selector failure in stop mode*
- *Hardware / watchdog failure*
- *Double N1 failure*
- *Double N2 failure.*

CONTROL SYSTEM - INDICATION AND MONITORING (9)

Maintenance aid

The system ensures the following functions:

- Fault detection
- Fault isolation and identification of the component affected
- Writing of a fault report containing information such as fault type, location
- Transmission of the fault report to the memory or to the helicopter system
- Recording in the memory of the last 32 fault reports.

Data exchange with the aircraft

The EECU exchanges data with the aircraft by means of a serial data link ARINC 429.

It can receive:

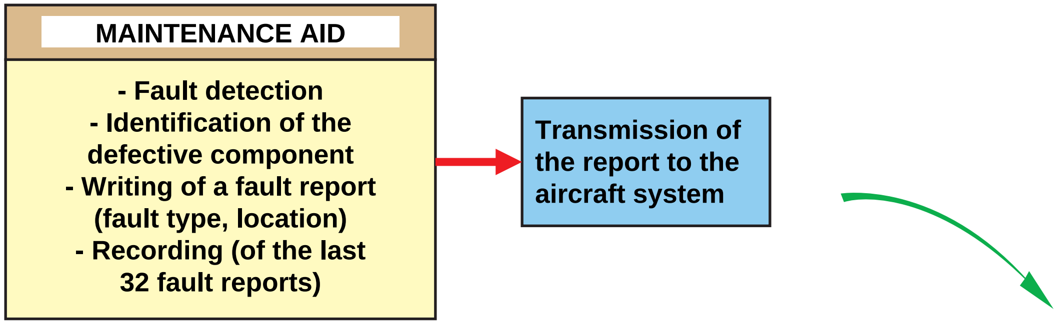
- P0 and t0
- The request for a performance check and read-out of results
- The request to read the cycle and hours counters
- The request for a fault report.

It can transmit:

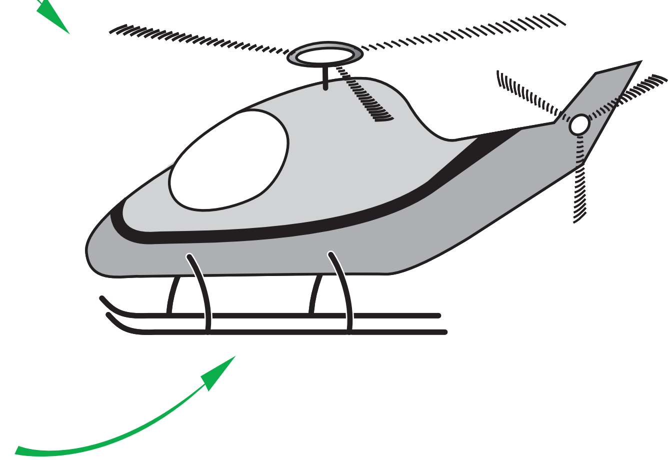
- The indications of torque, FLI, bleed valve position
- The value of EECU inputs and outputs
- The counters contents
- The reports.

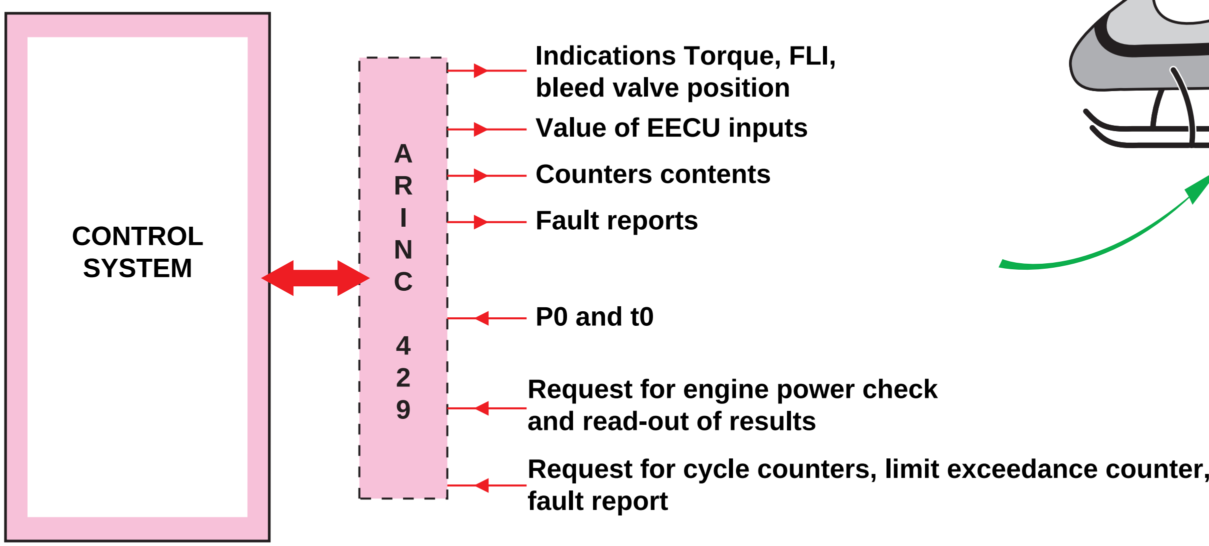
Two types of messages can be considered:

- Standard messages which are continuously transmitted
- Maintenance messages which are supplied on demand.



MAINTENANCE AID





DATA EXCHANGE WITH THE AIRCRAFT

CONTROL SYSTEM - INDICATION AND MONITORING (9)

ENGINE ELECTRONIC CONTROL UNIT - GENERAL

Function

The EECU controls and monitors the engine operation.

Position

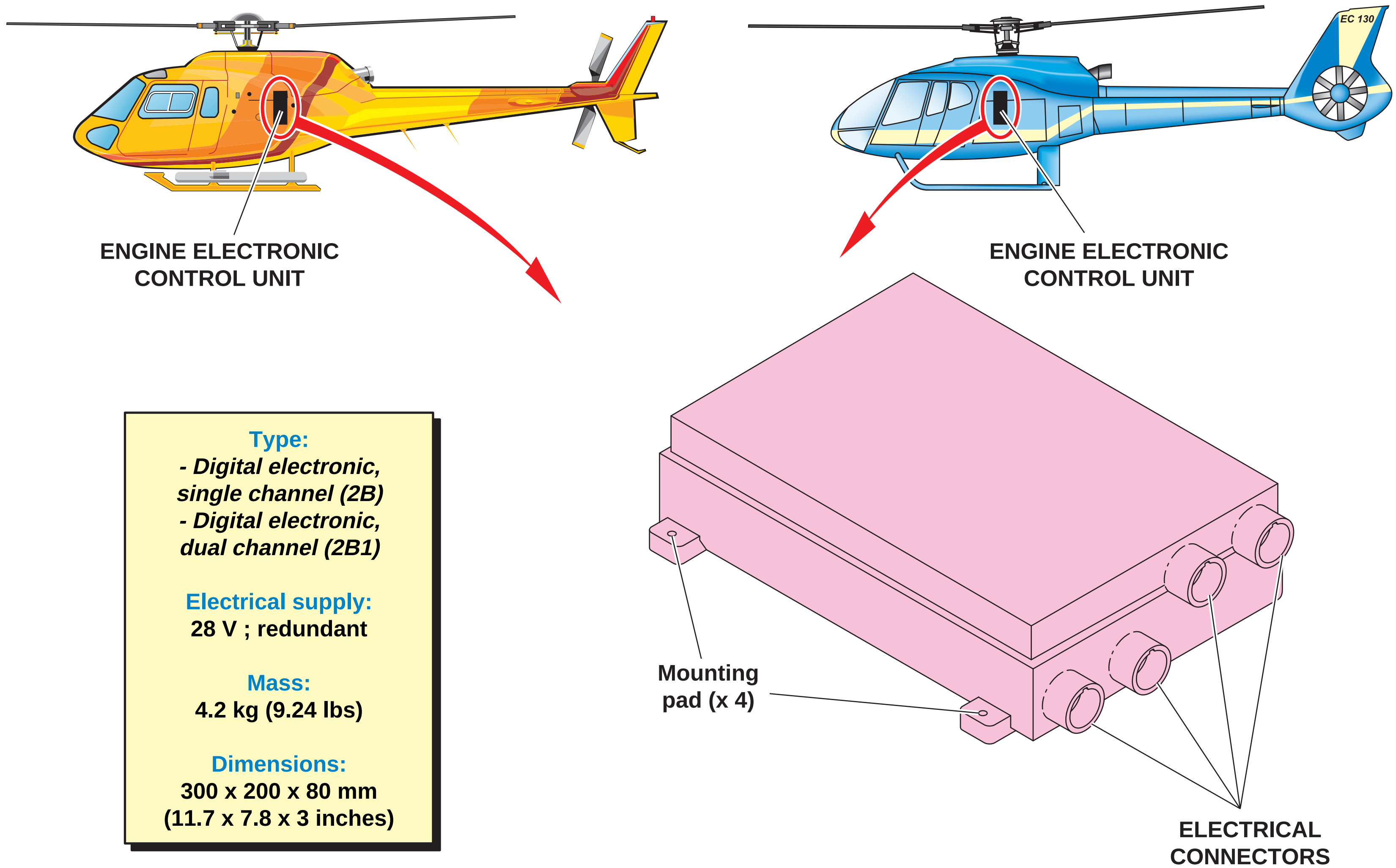
- The EECU is installed in a helicopter compartment.

Main characteristics

- *2B: Single channel digital electronic*
- *2B1: Dual channel digital electronic*
- Redundant electrical supply: 28 V
- Mass: 4.2 kg (9.24 lbs)
- Dimensions: 300 x 200 x 80 mm (11.7 x 8 x 3 inches).

Main components

- Electrical connectors
- Mounting pads.



Type:
- Digital electronic, single channel (2B)
- Digital electronic, dual channel (2B1)

Electrical supply:
28 V ; redundant

Mass:
4.2 kg (9.24 lbs)

Dimensions:
300 x 200 x 80 mm
(11.7 x 7.8 x 3 inches)

ENGINE ELECTRONIC CONTROL UNIT - GENERAL

EECU - FUNCTIONAL DESCRIPTION (1)

EECU inputs

From the aircraft

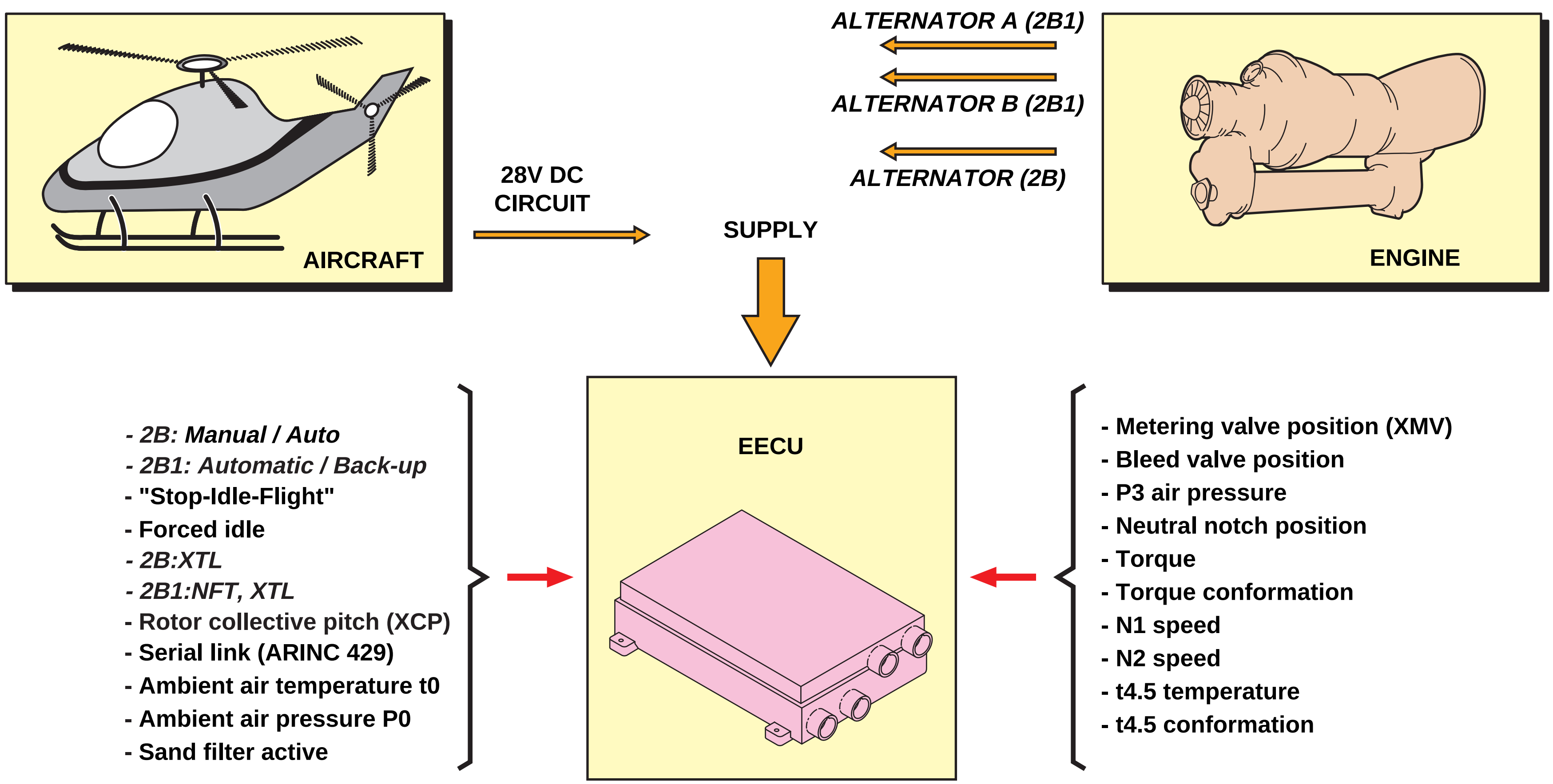
- *2B: Manual/Auto*
- *2B1: Automatic/Back-up*
- "Stop-Idle-Flight"
- Forced idle
- *2B: Trim N2 (XTL)*
- *2B1: NFT, XTL*
- Collective pitch (XCP)
- Ambient air temp t0
- Ambient air pressure P0
- Serial links
- Sand filter active.

From the engine

- Metering needle position
- Bleed valve position
- P3 air pressure
- Neutral notch position
- Torque
- Torque conformation
- N1 speed
- N2 speed
- t4.5 temperature
- t4.5 conformation.

Power supply

- Aircraft 28 VDC supply bus bar
- Engine alternator.



EECU INPUTS

EECU - FUNCTIONAL DESCRIPTION (1)

EECU - FUNCTIONAL DESCRIPTION (2)

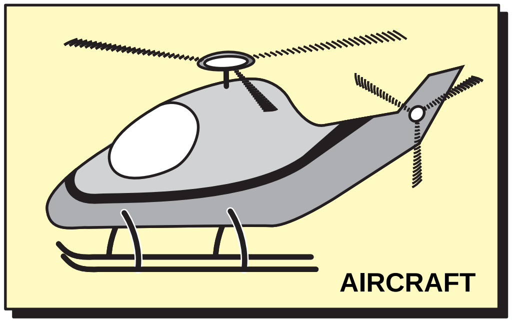
EECU outputs

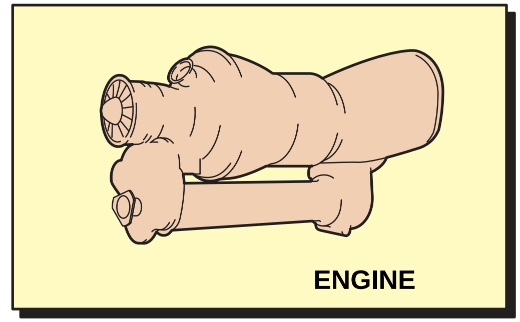
To the aircraft

- Start accessory relay
- ΔN1 indication (FLI)
- Torque indication
- Fault lights
  - Major failure
  - Minor failure
  - Minor fault
- *2B: Twist grip out of neutral position*
- Serial links
- Bleed valve position
- *2B1: Neutral Position return*
- *2B1: EBCAU enable.*

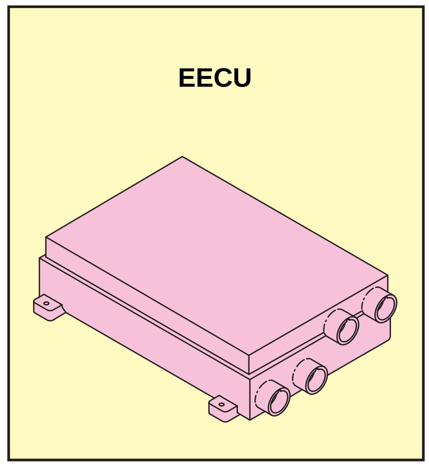
To the engine

- Fuel metering needle
- P3 pressure transmitter
- XMV resolver.





- **Start accessory relay**
- **ΔN1 indication (FLI)**
- **Torque indication**
- **Failure lights (Major, Minor, Minor fault)**
- ***2B: Twist grip out of neutral position***
- **Serial links**
- **Bleed valve indication**
- ***2B1: Neutral Position return***
- ***2B1: EBCAU enable***



- **XMV resolver**
- **Fuel metering needle**
- **P3 pressure transmitter (power supply)**

EECU OUTPUTS

EECU - FUNCTIONAL DESCRIPTION (2)

8 - MEASUREMENT AND INDICATING SYSTEMS

(XX-XX-XX): Page references which deal with the subject in the maintenance documentation.

MEASUREMENT AND INDICATING SYSTEMS

Functions

The measurement and indicating system provides the following functions:

- It allows the pilot to check that the engine is operating within determined limits
- It signals faults or abnormal changes of parameters
- It permits the checking of certain operating phases.

Note: *In fact, there are operating parameters (e.g.: N1 and torque) and monitoring parameters (e.g. N2, t4.5, oil temperature and pressure).*

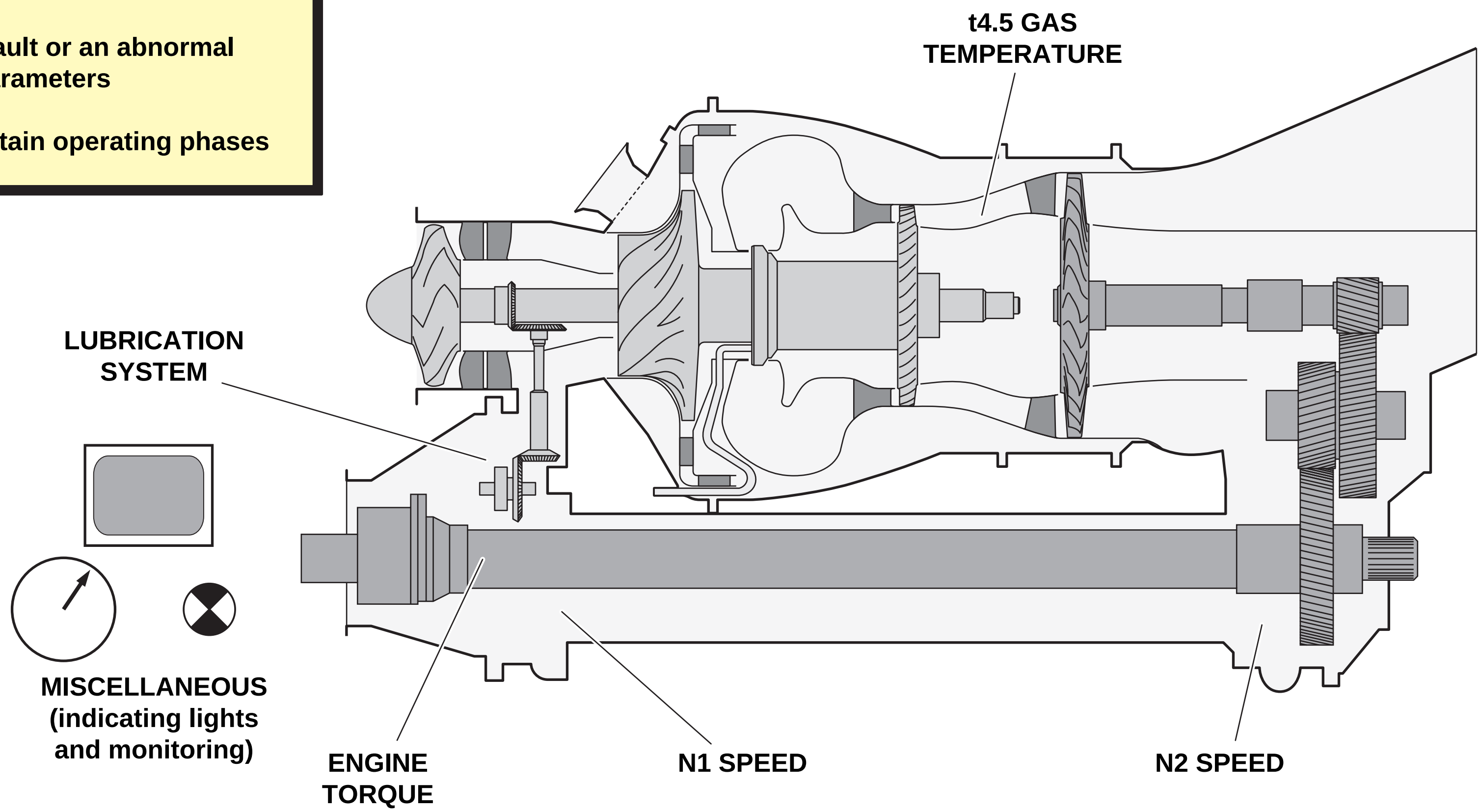
Miscellaneous measurement and indicating systems

- N1 gas generator rotation speed
- N2 power turbine rotation speed
- t4.5 gas temperature
- Engine torque
- Lubrication system (refer to chapter "OIL SYSTEM")
- Miscellaneous (indicating lights and monitoring).

Note*:* *Refer to the various systems for the description and operation.*

FUNCTIONS

- To ensure that the engine operates within determined limits
- To signal a fault or an abnormal change of parameters
- To check certain operating phases



MEASUREMENT AND INDICATING SYSTEMS

SPEED MEASUREMENT AND INDICATING SYSTEM (2B)

Function

This system measures the rotation speeds of the gas generator (N1) and the power turbine (N2).

Main characteristics

- *Type: phonic wheels and electro-magnetic sensors*
- *Sensor signals: frequency proportional to the rotation speed.*

Main components

- *N1 speed sensors*
- *N2 speed sensors*
- *Connection to the EECU*
- *Connection to the indicators.*

Description

Refer to following pages and the aircraft documentation.

Operation

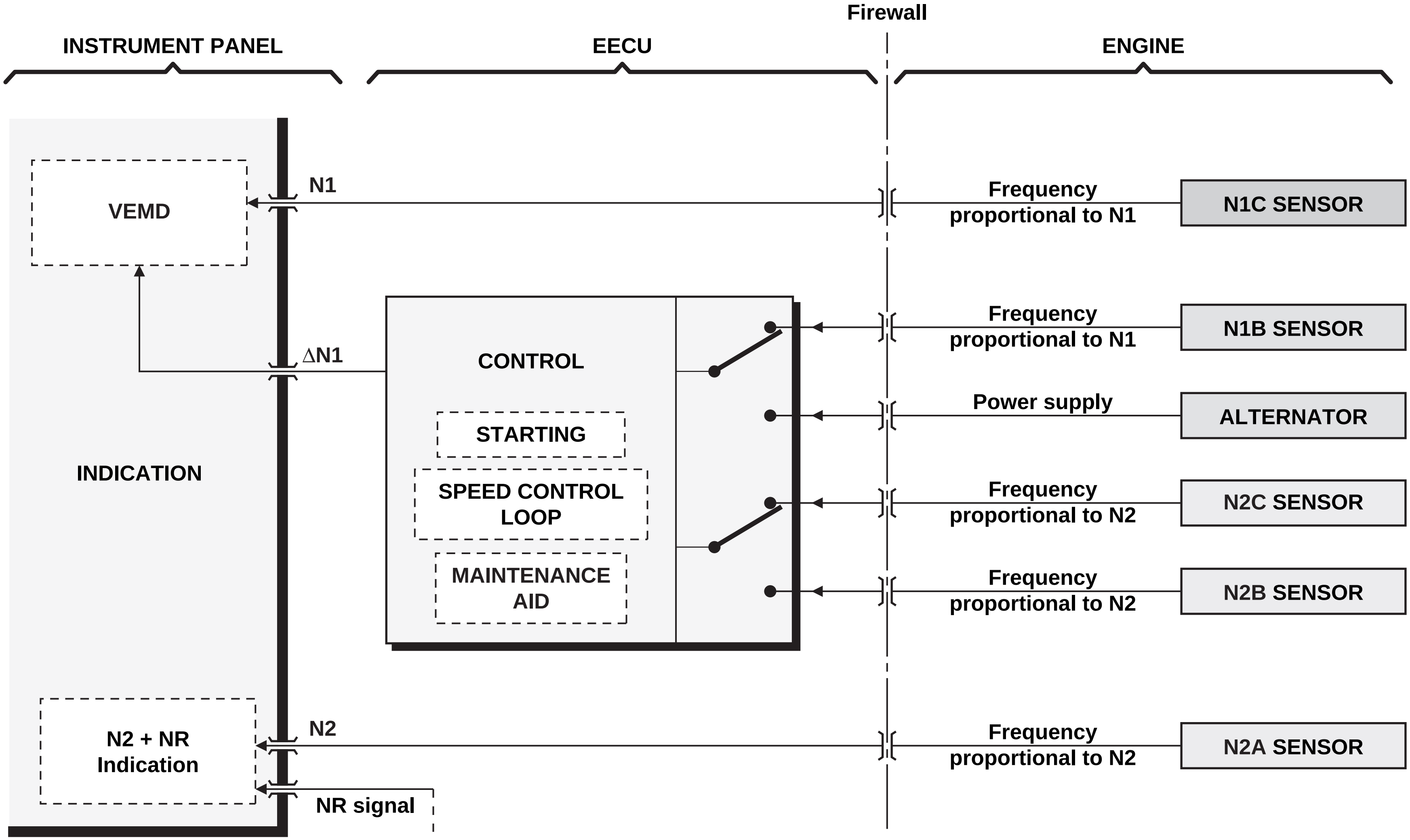
The N1 signals are used for:

- *Engine control (starting, speed control loop)*
- *Indication (N1 actual and delta)*
- *Cycle and hours counting*
- *Maintenance aid.*

N1 is an operating parameter as it reflects the engine power and serves to determine the limit ratings.

The N2 signal is used for:

- *Engine control (speed control loop) and cycle counting*
- *Indication (associated with the NR indication).*



SPEED MEASUREMENT AND INDICATING SYSTEM (2B)

SPEED MEASUREMENT AND INDICATING SYSTEM (2B1)

Function

This system measures the rotation speeds of the gas generator (N1) and the power turbine (N2).

Main characteristics

- Type: phonic wheels and electro-magnetic sensors
- Sensor and alternator signals: frequencies proportional to the rotation speed.

Main components

- One N1 speed sensor
- Double alternator (generation of N1 signals)
- Three N2 speed sensors
- Electrical harnesses for connection to the EECU and the indicators.

Description

Refer to following pages and the aircraft documentation.

Operation

The N1 signal from the sensor goes direct to the cockpit indicator and is thus independent from the EECU.

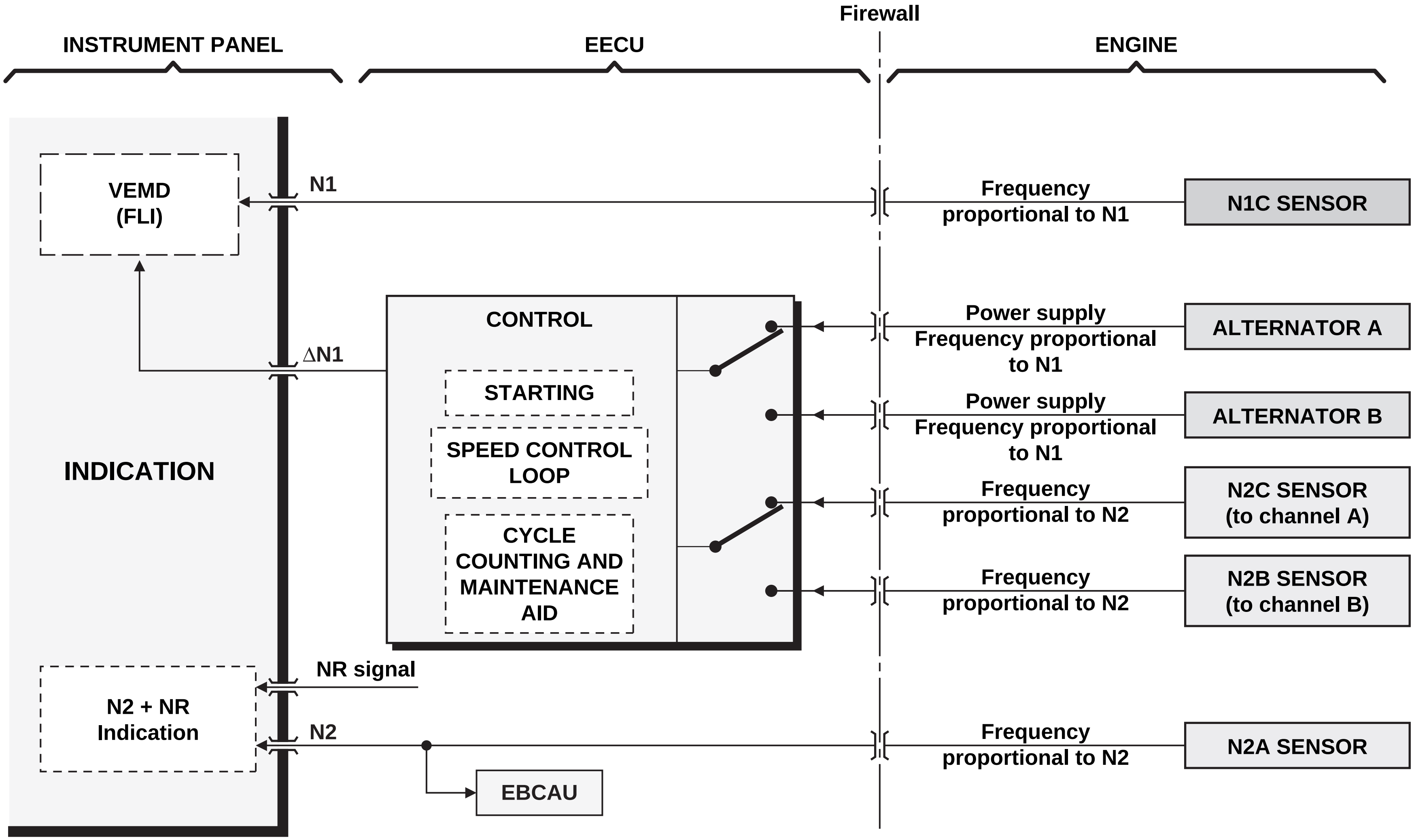
The ΔN1 indication is supplied to the cockpit by the EECU which derives its N1 signals from the two alternator frequencies.

N1 is an operating parameter as it reflects the engine power.

It is also used for engine control, cycle counting and maintenance aid.

Two N2 signals are used for engine control (speed control loop, cycle counting and maintenance aid).

One N2 signal goes direct to the cockpit for the speed indication associated with the NR indication.



SPEED MEASUREMENT AND INDICATING SYSTEM (2B1)

N1 SPEED SENSORS (2B)

Function

The N1 speed sensors measure the gas generator rotation speed. The signals are used by the N1 indicator (digital indication) and by the EECU.

Position

- *In the system: connected to the indicator and the EECU*
- *On the engine: left side of the accessory gearbox.*

Main characteristics

- *Quantity: 2 identical sensors (interchangeable)*
- *Type: electro-magnetic*
- *Phonic wheel:*
  - *Quantity: 1*
  - *On the alternator drive shaft.*

Main components

- *Phonic wheel (in module 01)*
- *Sensor body*
- *Mounting flange*
- *Electrical connector.*

Description

The N1 speed measurement and indicating system includes:

- *A phonic wheel mounted on the alternator drive shaft*
- *Two electro-magnetic sensors each of which has:*
  - *A permanent magnet*
  - *A coil.*

Each sensor is secured by one screw on a mounting pad on the alternator drive casing.

An O'ring seal ensures the sealing between the sensor body and the casing.

Operation

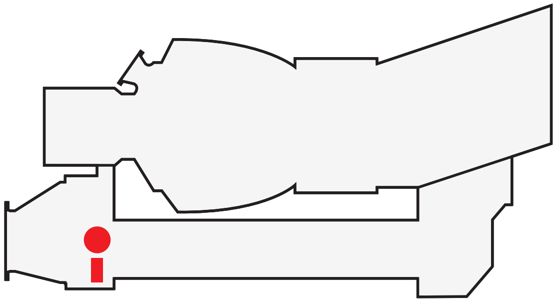
The rotation of the phonic wheel causes the sensor to produce an electrical signal.

The frequency of the signal is proportional to the rotation speed and the number of teeth on the phonic wheel.

The output signal from the N1C sensor is transmitted directly to the VEMD.

The output signal from the N1B sensor is transmitted to the EECU; it is used for start fuel flow control, speed control and speed indication:

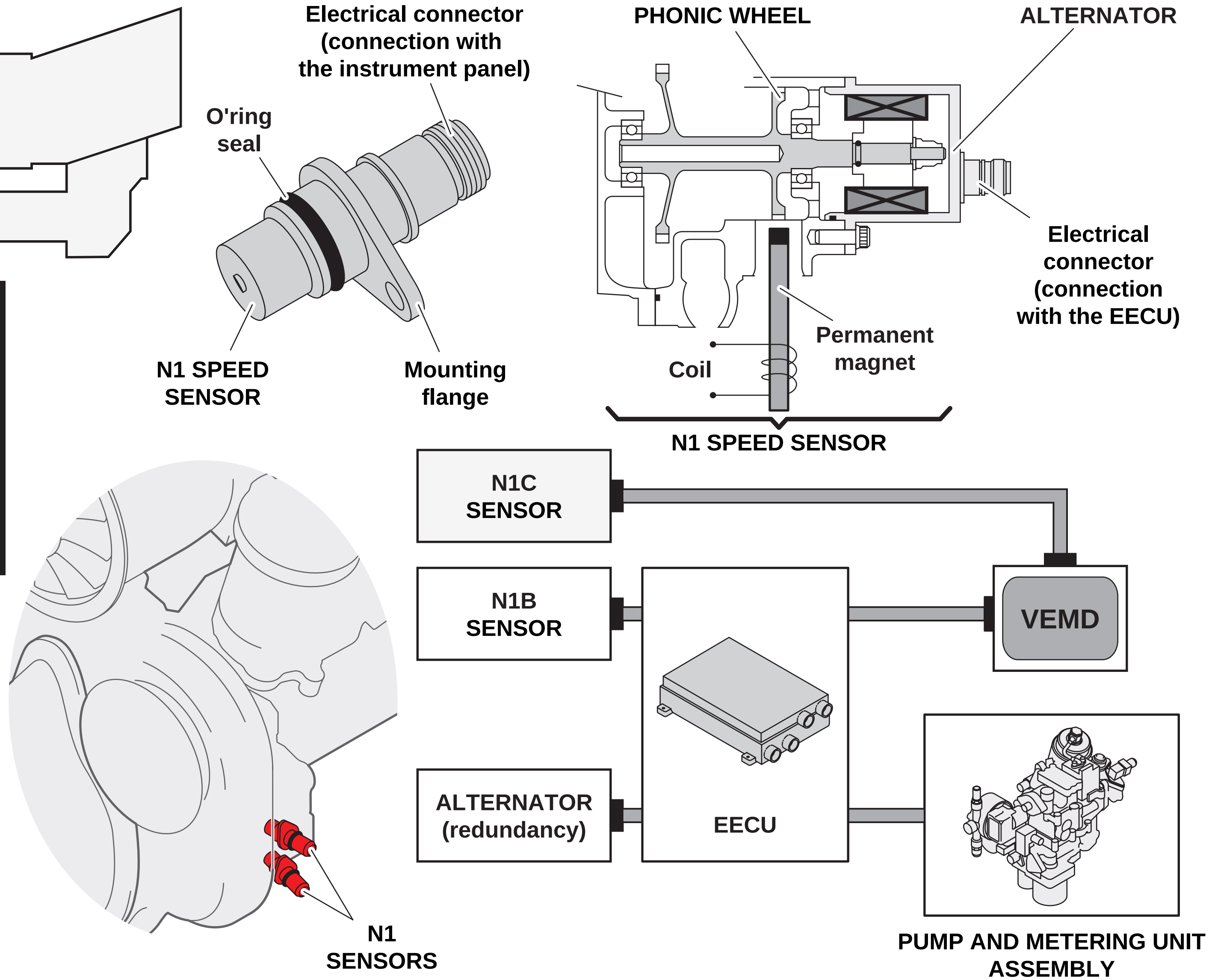
- *Priority signal from N1B*
- *Redundancy signal from the engine alternator.*



Quantity:
2

Type:
Electro-magnetic

Phonic wheel:
- Quantity: 1
- On the alternator drive shaft



N1 SPEED SENSORS (2B)

N1 SPEED SENSOR (2B1)

Function

The N1 speed sensor measures the gas generator rotation speed. The signal is used by the N1 indicator (digital indication).

Position

- *In the system: connected to the VEMD*
- *On the engine: left side of the accessory gearbox.*

Main characteristics

- *Quantity: 1*
- *Type: electro-magnetic*
- *Phonic wheel:*
  - *Quantity: 1*
  - *On the alternator drive shaft.*

Main components

- *Phonic wheel (in module M01)*
- *Sensor.*

Description

The N1 speed measurement and indicating system includes:

- *A phonic wheel mounted on the alternator drive shaft*
- *One electro-magnetic sensor which has:*
  - *A permanent magnet*
  - *A coil.*

The sensor is secured by one screw on a mounting pad located on the alternator drive casing.

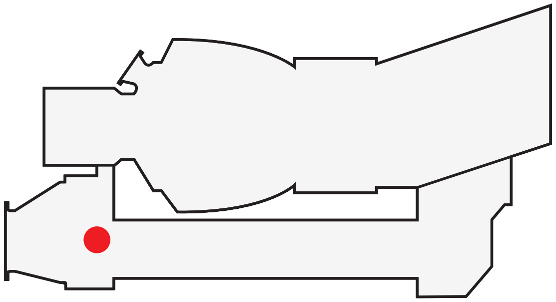
An O'ring seal ensures the sealing between the sensor body and the casing.

Operation

The rotation of the phonic wheel causes the sensor to produce an electrical signal.

The frequency of the signal is proportional to the rotation speed and the number of teeth on the phonic wheel.

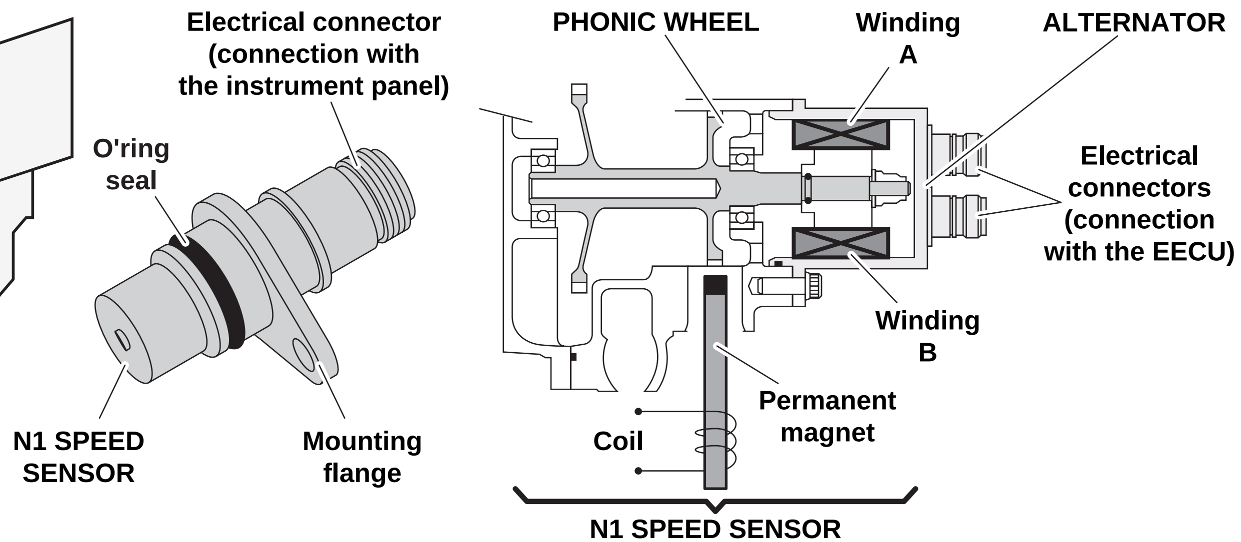
Note: *The N1 signals for the EECU are derived from the alternator frequencies (A and B).*

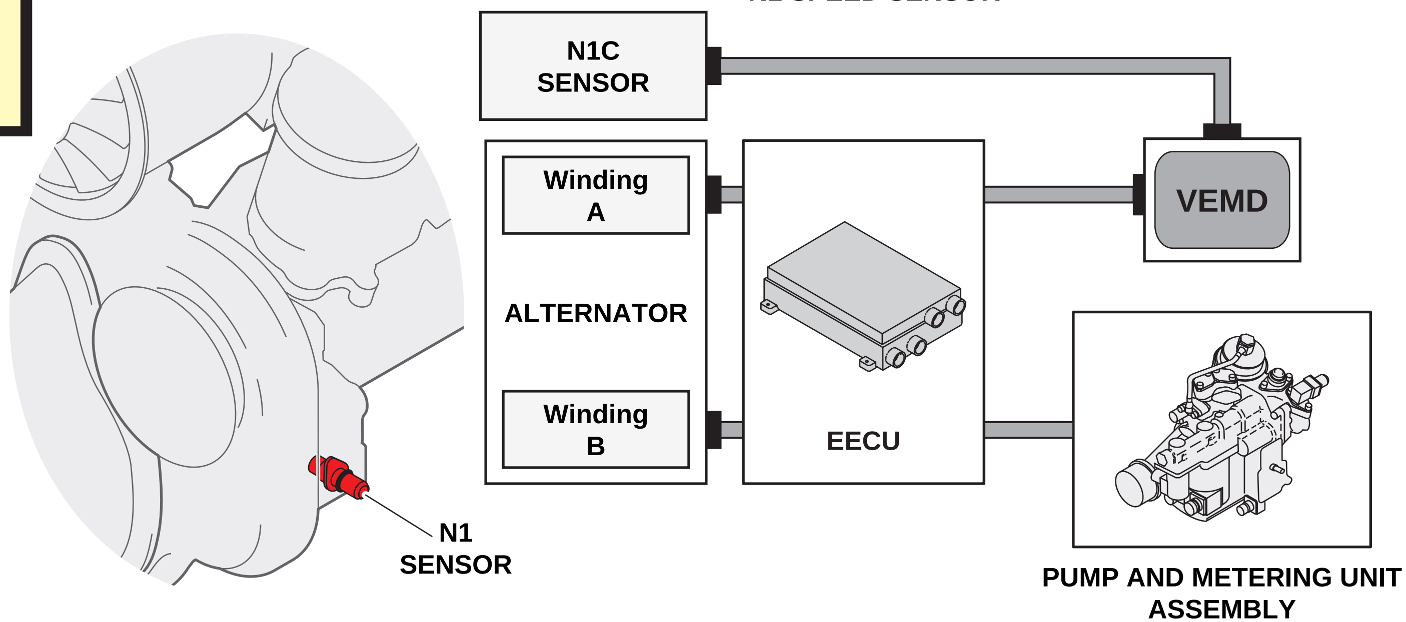


Quantity:
1

Type:
Electro-magnetic

Phonic wheel:
- Quantity: 1
- On the alternator drive shaft





N1 SPEED SENSOR (2B1)

N2 SPEED SENSORS

Function

The N2 speed sensors measure the power turbine rotation speed.

Position

- In the system: connected to the indicator or to the EECU
- On the engine: on either side of the reduction gearbox
  • N2A and N2B on the right
  • N2C on the left.

Main characteristics

- Quantity: 3 identical sensors (interchangeable)
- Type: electro-magnetic
- Phonic wheel:
  • Quantity: 1
  • Reduction gearbox output gear.

Main components

- Phonic wheel (reduction gearbox output gear)
- Sensors.

Description

The N2 speed measurement and indicating system includes:

- A phonic wheel which is the reduction gearbox output gear
- Three electro-magnetic sensors each of which has:
  • A permanent magnet
  • A coil.

Each sensor is secured by one screw on a mounting pad located on the reduction gearbox casing and is sealed by an O'ring.

Operation

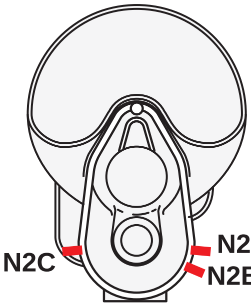
The rotation of the phonic wheel causes the sensor to produce an electrical signal.

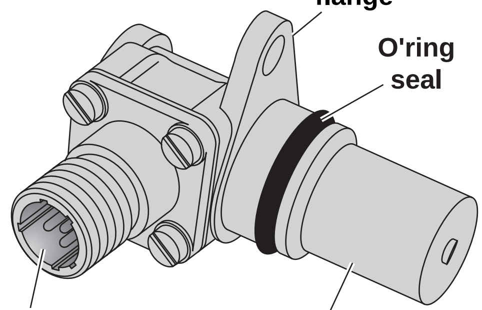
The frequency of the signal is proportional to the rotation speed and the number of teeth on the phonic wheel.

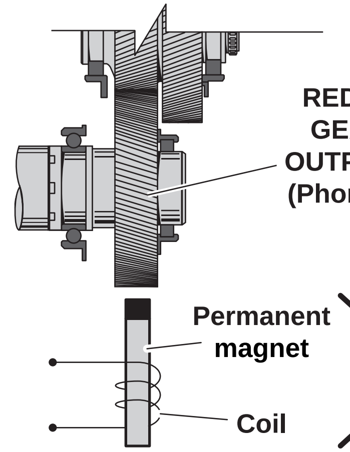
The output signal from the N2A sensor is transmitted directly to the speed indicator in the cockpit.

The output signals from the N2B and N2C sensors are transmitted to the EECU; they are used for speed control and N2 cycle counting.

2B1: N2B goes to channel B
N2C goes to channel A.



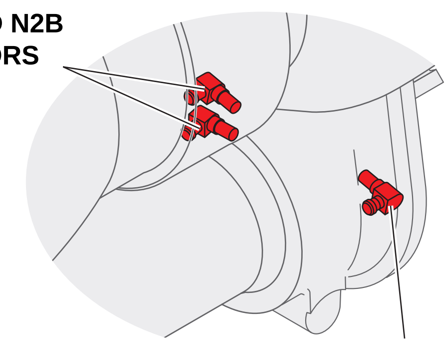


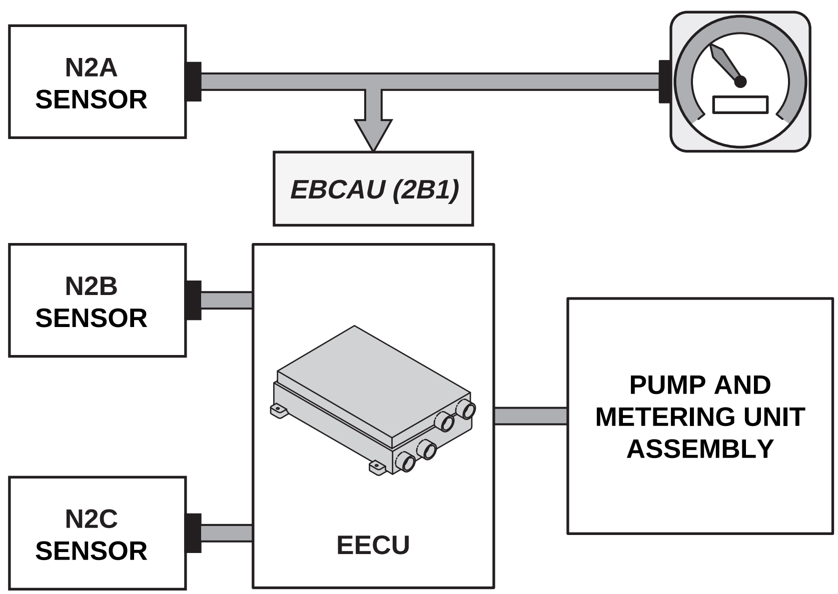


Quantity:
3 identical sensors
(interchangeable)

Type:
Electro-magnetic

Phonic wheel:
- Quantity: 1
- Reduction gearbox output gear





N2 SPEED SENSORS

t4.5 GAS TEMPERATURE MEASUREMENT AND INDICATING SYSTEM

Function

This system provides a measurement and indication of the gas temperature (t4.5) at the gas generator turbine outlet.

Position

- All the system components are located on the engine except the EECU and the t4.5 indicator.

Main characteristics

- Type: Alumel / Chromel thermocouple probes
- Indication: degrees Celsius
- Quantity: 8 probes (with 2 thermocouples each) connected in parallel through a conformation box.

Main components

- Thermocouple harness (x2)
- t4.5 conformation box
- Engine Electronic Control Unit
- Indicator.

Description

Refer to following pages and aircraft documentation.

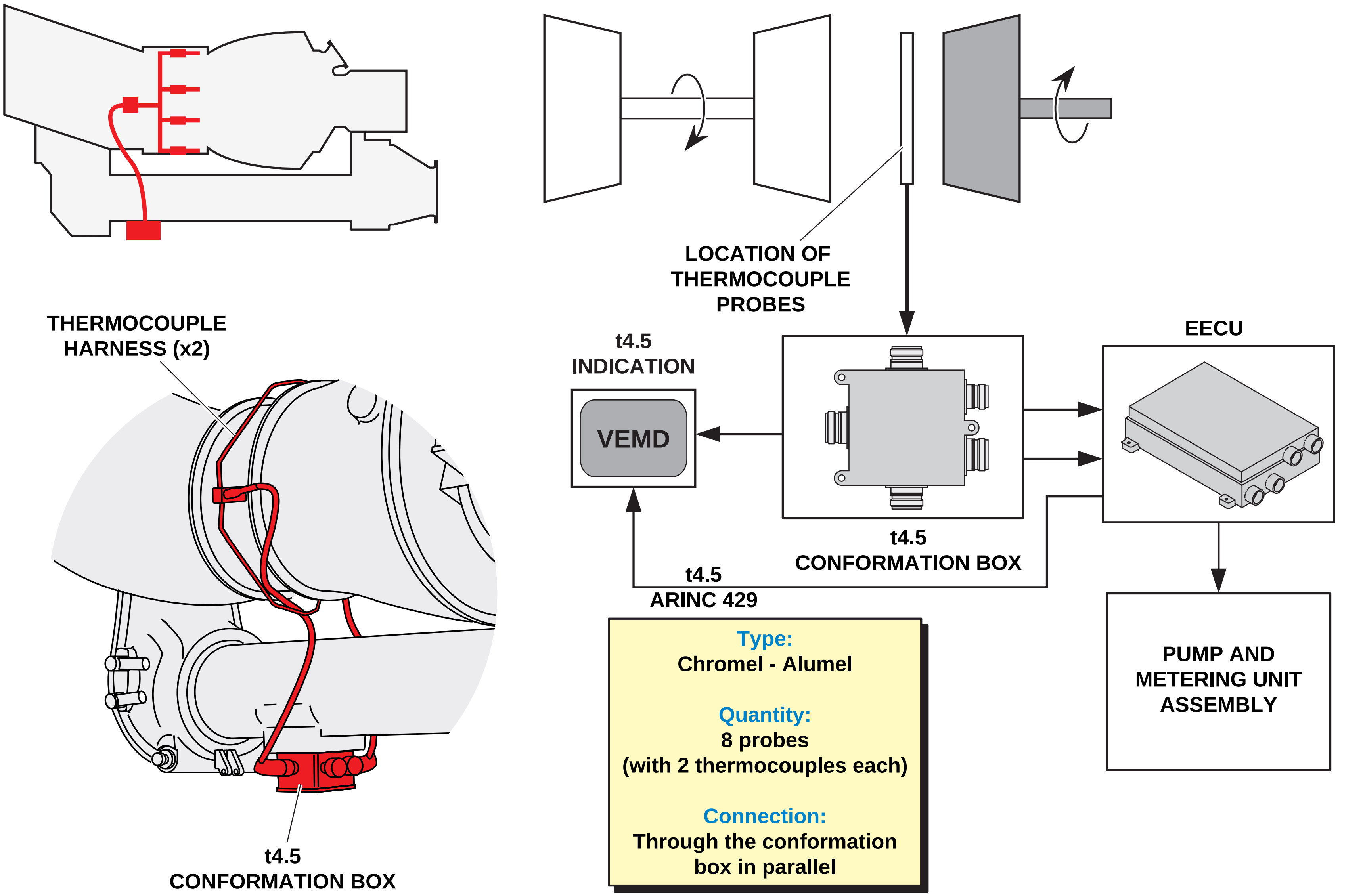
General operation

The gas temperature (t4.5) is an operating parameter, particularly during engine starting.

The signal from the thermocouples is used for:

- Engine control (starting fuel flow)
- Indication.

The conformation box provides the connection point between the thermocouples, the indicator and the EECU.



Type:
Chromel - Alumel

Quantity:
8 probes
(with 2 thermocouples each)

Connection:
Through the conformation box in parallel

t4.5 GAS TEMPERATURE MEASUREMENT AND INDICATING SYSTEM

t4.5 THERMOCOUPLE PROBES

Function

The thermocouples supply a signal for:

- t4.5 indication
- Fuel flow control at start (limitation of t4.5 by means of the EECU).

Position

- In the system: connected to the indicator and the EECU
- On the engine: the probes (x8) are located around the rear part of the turbine casing and each probe is secured by a bolt.

Main characteristics

- Type: Chromel - Alumel
- Quantity: 8 probes (16 thermocouples) in 2 harnesses.

Description

The 2 groups of 4 thermocouple probes are identical. They are positioned to give a homogeneous measurement.

Each probe contains two hot junctions (Chromel and Alumel wires soldered together).

Thus the t4.5 gas temperature measurement system includes two distinct measuring channels, each comprising:

- 8 thermocouples, connected in parallel, used by the t4.5 indicating system
- 8 thermocouples, also connected in parallel, used by the Engine Electronic Control Unit.

In fact, the system consists of 2 assemblies of 4 probes. Each assembly is an LRU.

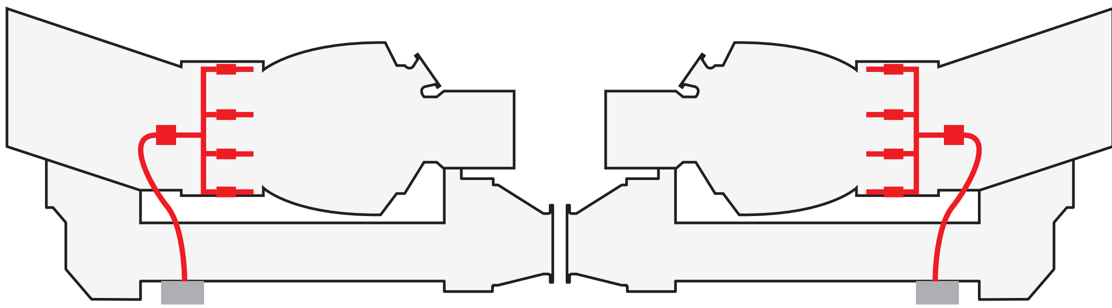
Principle of operation

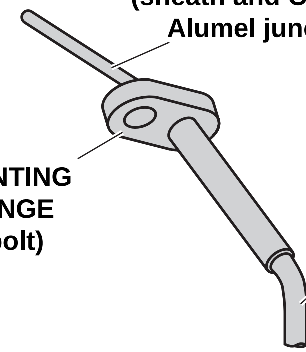
A thermocouple produces an electromotive force which is proportional to the temperature difference between the hot and the cold junction.

This voltage is supplied, via the conformation box to:

- The EECU (for start fuel flow control)
- The t4.5 indicator (millivoltmeter graduated in degrees Celsius).

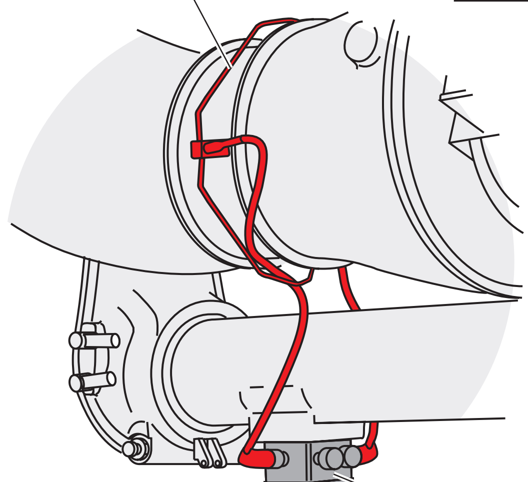
The probes are wired in parallel, thus the reading obtained is an average temperature.

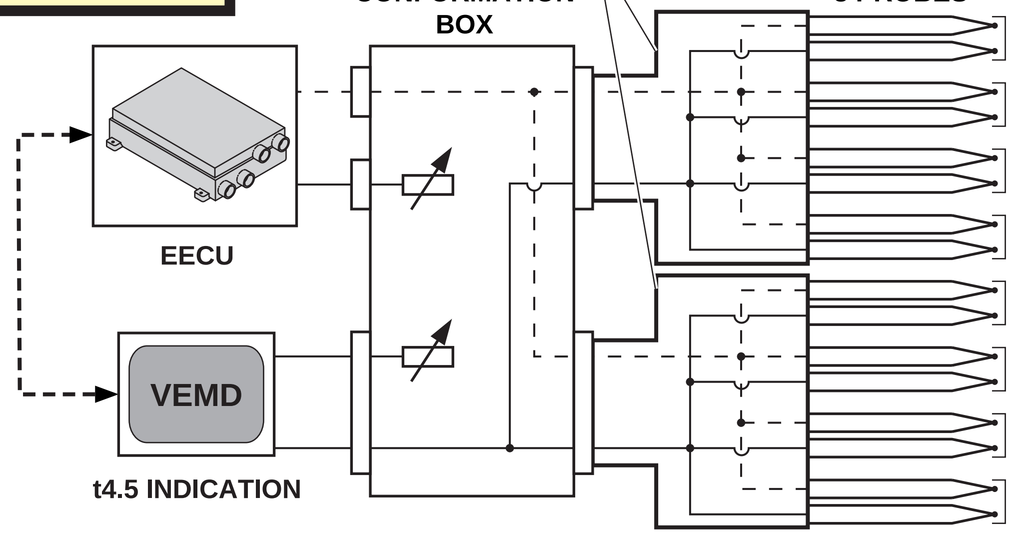




Type:
Chromel - Alumel

Quantity:
8 probes (16 thermocouples)
in 2 harnesses





SCHEMATIC DIAGRAM

t4.5 THERMOCOUPLE PROBES

t4.5 CONFORMATION BOX

Function

The conformation box forms the interface between the thermocouples, the indicator and the EECU.

It also allows a corrected temperature indication for a given turbine inlet temperature.

Being given discrepancies of measurement, the conformation ensures a reading which reflects a reference temperature identical for all engines.

The conformation box is matched to the gas generator module.

Position

- In the system: connected to the indicator and the EECU
- On the engine: on a support mounted underneath the output shaft protection tube.

Main characteristics

- Type: box with conformation resistors installed on a printed circuit board
- Setting: adapted to the gas generator (M03 module).

Description

The t4.5 conformation box is mounted on a support on the output shaft protection tube.

The box is provided with:

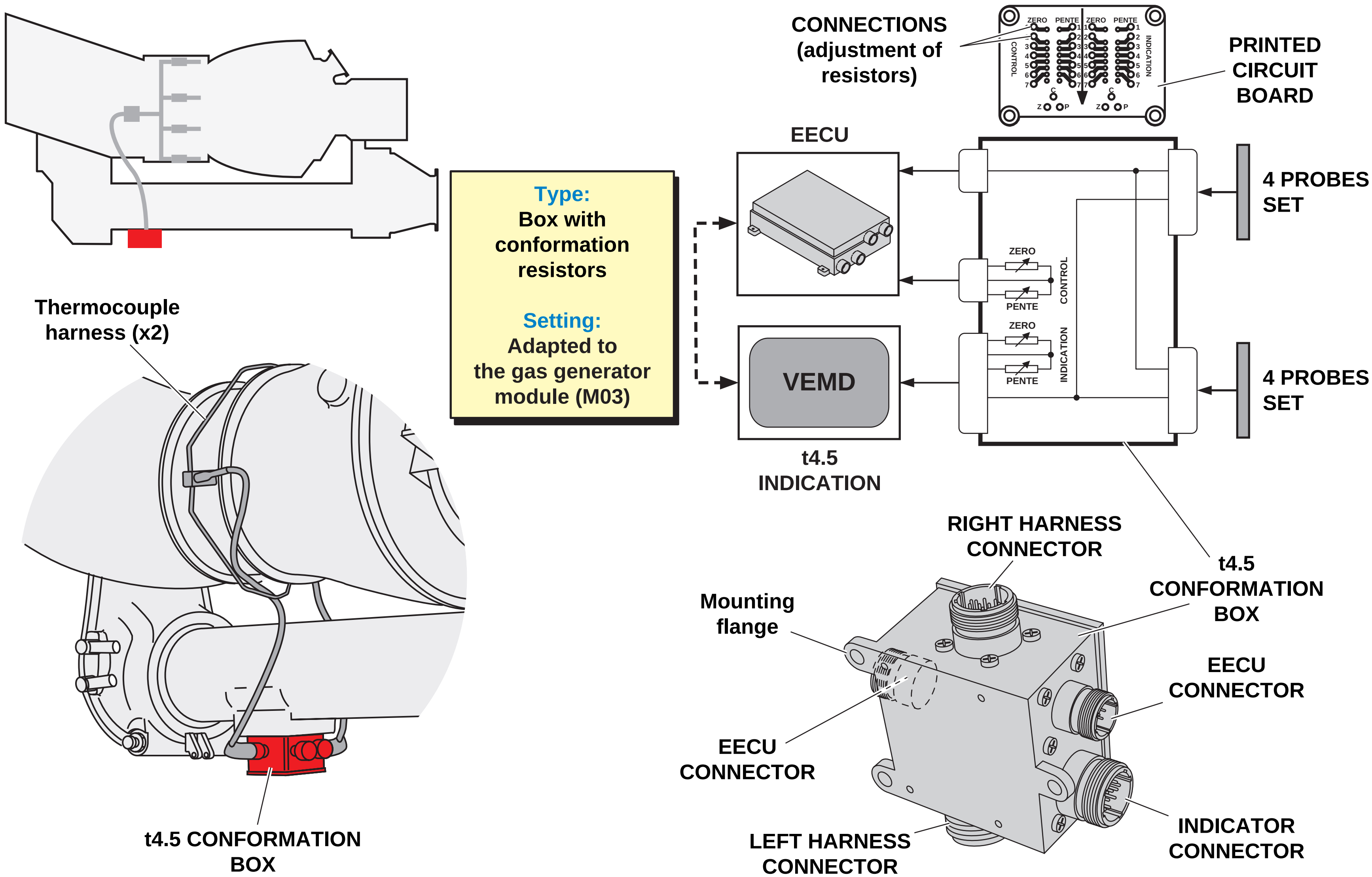
- 5 electrical connectors:
  - 2 harness connectors
  - 2 EECU connectors
  - 1 indicator connector.
- Printed circuit board equipped with:
  - 2 equal ZERO resistors
  - 2 equal PENTE (slope) resistors.

Operation

The t4.5 conformation box provides the connection point between the thermocouples, the EECU and the indicator. It contains resistors which enable a uniform t4.5 indication for a given turbine inlet temperature.

The resistor values are matched with the gas generator and are recorded on the module M03 log card.

Note: *The resistors can be adjusted by opening connectors printed on the board.*



t4.5 CONFORMATION BOX

TORQUE MEASUREMENT AND INDICATING SYSTEM - GENERAL

Function

The system provides measurement of the engine torque, measured on the power transmission shaft.

Position

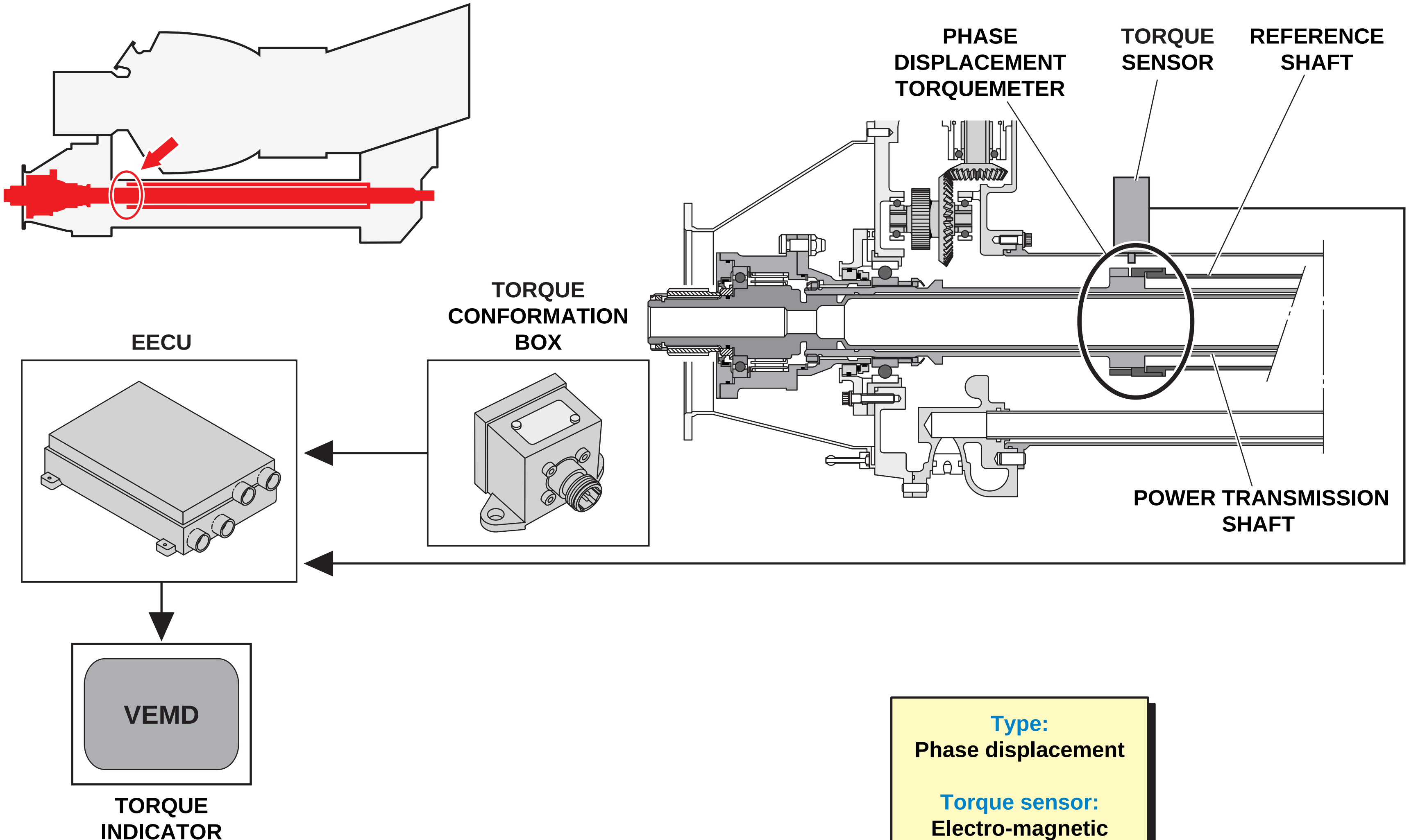
All the system components are located on the engine except the EECU and the torque indicator.

Main characteristics

- Type: phase displacement
- Torque sensor: electro-magnetic

Main components

- Power transmission and reference shafts
- Torque sensor
- Torque conformation box
- Engine Electronic Control Unit
- Torque indicator.



Type:
Phase displacement

Torque sensor:
Electro-magnetic

TORQUE MEASUREMENT AND INDICATING SYSTEM - GENERAL

TORQUE MEASUREMENT AND INDICATING SYSTEM - DESCRIPTION - OPERATION

Description

The torquemeter mainly includes:

- The transmission shaft fitted with 4 equidistant teeth
- A reference shaft (not submitted to torsion) also fitted with 4 equidistant teeth.

  These 8 teeth form the phonic wheel of the torque measuring system
- An electro-magnetic sensor is located in front of this phonic wheel.

Note: *The system includes resistors (located in the conformation box) to obtain a corrected torque value.*

Operation

The rotation of the phonic wheel causes the sensor to output an electrical signal to the EECU.

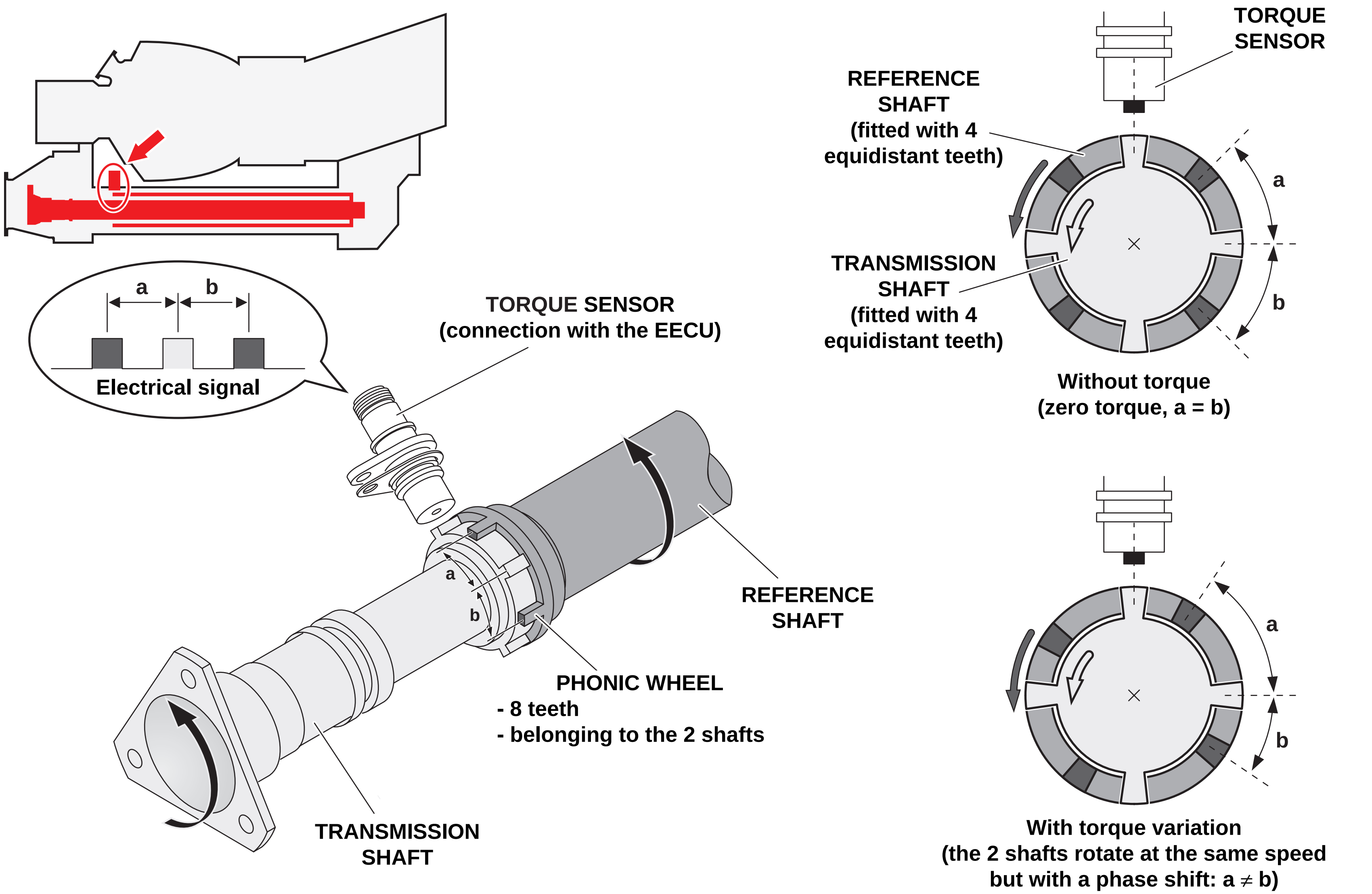
The EECU measures the phase displacement of the signals.

When there is no torque (zero), the distances between teeth are equal (a = b).

When the torque changes, the distances between teeth change (a ≠ b). The EECU measures this change and determines the engine torque value.

Example:

- When torque increases: the main shaft twist in relation to the reference shaft causes a variation of the distances (a increases, b decreases).



TORQUE MEASUREMENT AND INDICATING SYSTEM - DESCRIPTION - OPERATION

TORQUE SENSOR

Function

The torque sensor provides an electrical signal to the EECU for torque indication and fuel control purposes.

Position

- In the system: connected to the EECU
- On the engine: on the forward right hand side of the output shaft protection tube.

Main characteristics

- Type: electro-magnetic sensor
- Phonic wheel: 1 phonic wheel formed by 4 teeth on the transmission shaft and 4 teeth on the reference shaft
- Output signal: signal with phase displacement.

Description

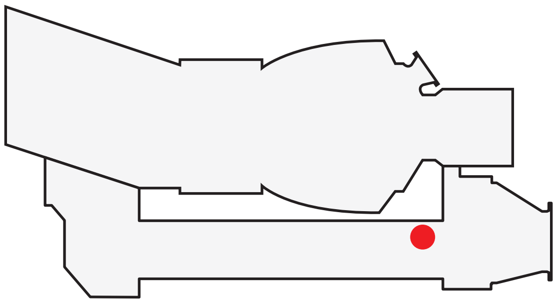
The sensor is attached by one screw on a mounting pad located on the forward right side of the protection tube. Its depth of penetration is adjusted by a laminated shim.

The sensor includes an electrical connector connected to the EECU.

Operation

The rotation of the phonic wheel (8 teeth) causes the sensor to produce an electrical signal.

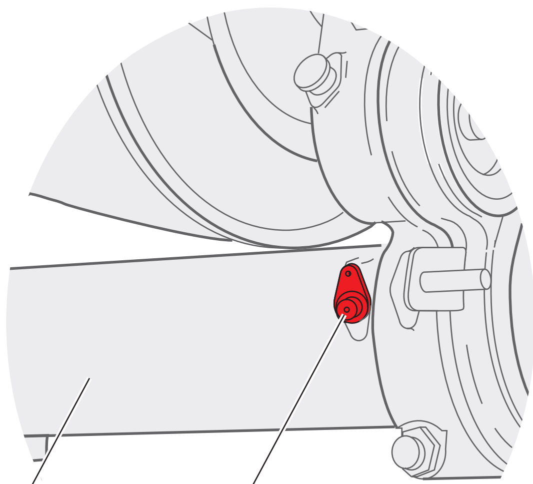
The phase of the signal varies as function of the torque.

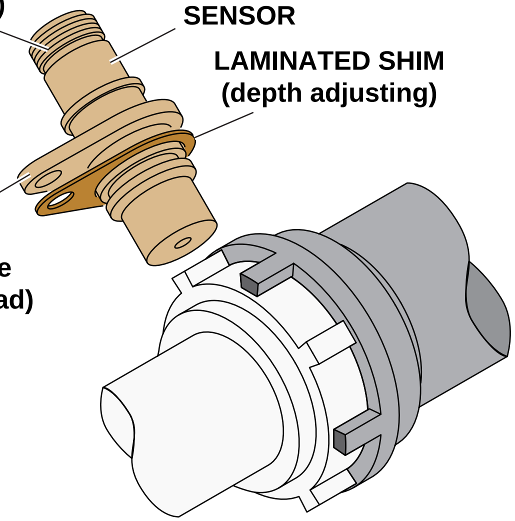


Type:
Electro-magnetic sensor

Phonic wheel:
1 phonic wheel formed by 4 teeth on the transmission shaft and 4 teeth on the reference shaft

Output signal:
Signal with phase displacement





TORQUE SENSOR

TORQUE CONFORMATION BOX

Function

The torque conformation box adapts the torque sensor signal to the output shaft characteristics, being given the variations due to the manufacturing tolerances.

The conformation ensures that the torque reading reflects the real torque. It is matched to the module M01.

Position

- In the system: connected to the EECU
- On the engine: on a support secured by means of a clamp on the protection tube.

Main characteristics

- Type: box housing conformation resistors
- Setting: adapted to the output shaft (M01 module).

Description

The torque conformation box includes:

- A box which houses two conformation resistors mounted on a printed circuit board (ZERO and PENTE)
- A mounting flange: box screwed onto a securing clamp on the left side of the protection tube
- An electrical connector to connect the torque conformation box to the EECU.

***Note**: The resistances can be adjusted by opening connections printed on the circuit board.*

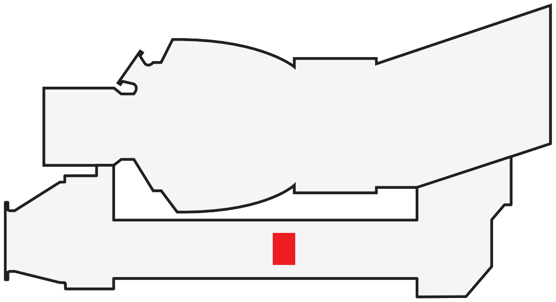
Refer to maintenance manual.

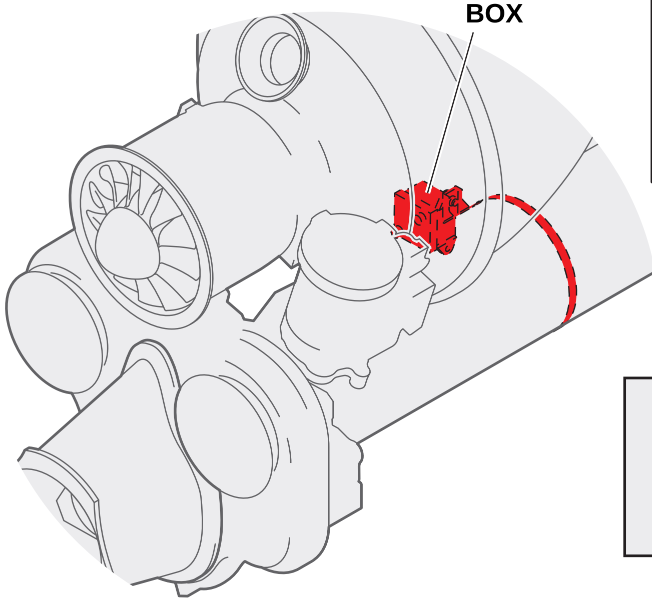
Operation

The zero (ZERO) and slope (PENTE) resistor values, take into account the difference of the torque sensor output according to the reference measurement achieved with the engine on the test bench.

These values are therefore "matched" to the power transmission shaft which houses the torquemeter.

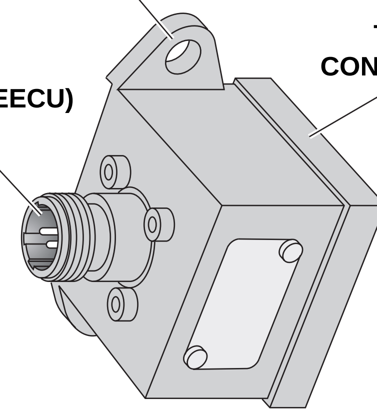
The resistor values are recorded on the module M01 log card.

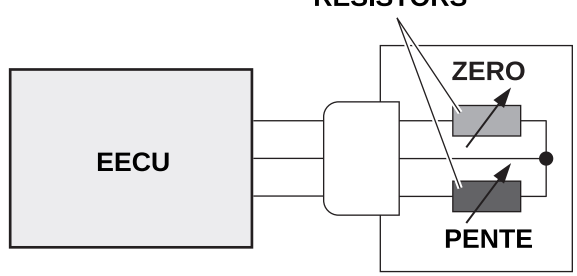


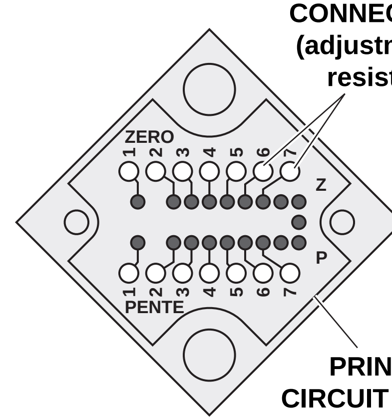


Type:
Box housing
conformation resistors

Setting:
Adapted to the
output shaft
(matched to the module M01)







TORQUE CONFORMATION BOX

INDICATORS

There are several indicators which give information about the engine operation. These pages summarize the various lights which have already been dealt with in other chapters.

Position

- On the instrument panel.

Main characteristics

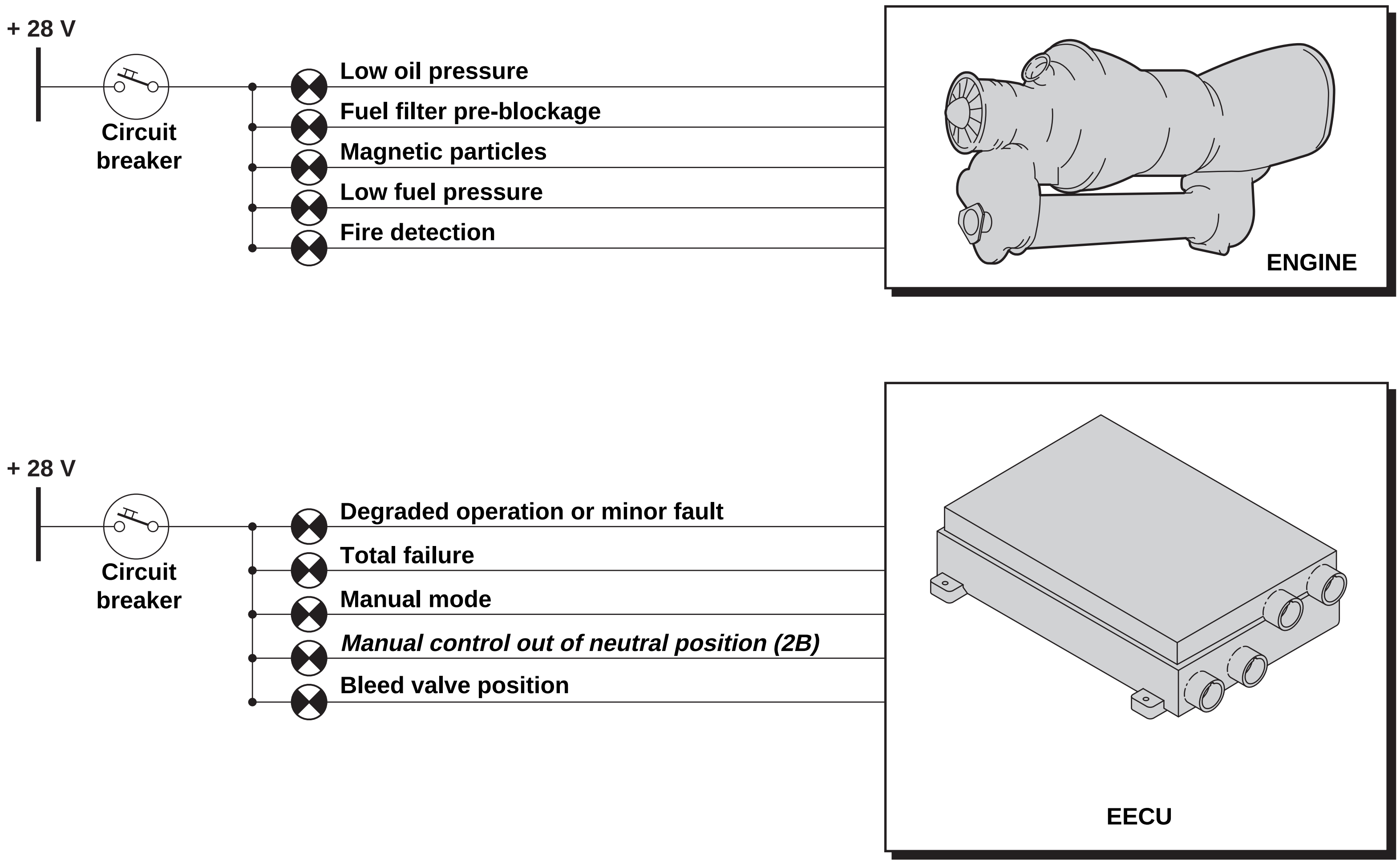
- Indicators directly connected to the engine sensors
- Indicators whose signal is provided by the EECU.

Engine sensors connected direct to the cockpit

- Low oil pressure
- Fuel filter pre-blockage
- Magnetic particles
- Low fuel pressure
- Fire detection.

Indications supplied through the EECU

- Total failure
- Degraded operation or minor fault
- Manual mode
- *Manual control out of neutral position (2B)*
- Bleed valve position.


+ 28 V
Circuit breaker
Low oil pressure
Fuel filter pre-blockage
Magnetic particles
Low fuel pressure
Fire detection
ENGINE
+ 28 V
Circuit breaker
Degraded operation or minor fault
Total failure
Manual mode
Manual control out of neutral position (2B)
Bleed valve position
EECU

INDICATORS

MISCELLANEOUS INDICATIONS

Function

To provide information in the cockpit about the operation of the aircraft and engine systems.

Position

- On the instrument panel.

Main characteristics

- Central Warning Panel
- Display unit with two screens
- Liquid crystal displays.

Main components

- Engine sensors
- EECU
- VEMD
- CWP.

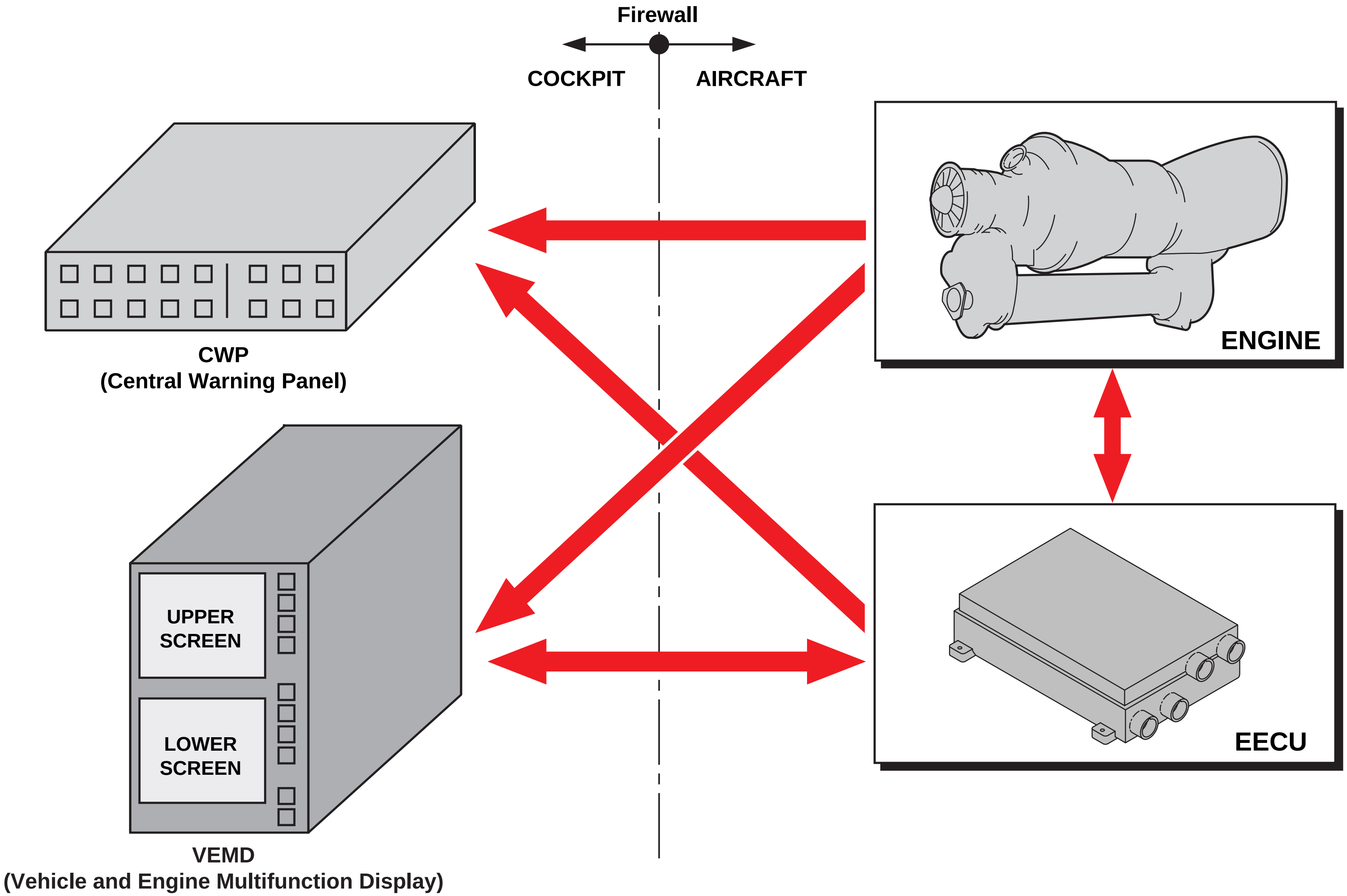
Description

There are two main indicating devices in the cockpit:

- The VEMD - Vehicle and Engine Multifunction Display
- The CWP - Central Warning Panel.

The VEMD displays all the necessary vehicle and engine parameters. It can also display maintenance information when the aircraft is on the ground. It comprises an upper and lower screen and ten selector buttons for selecting the various functions.

The CWP has a set of warning lights to alert the pilot to any malfunction in any helicopter vital system.



MISCELLANEOUS INDICATIONS

MISCELLANEOUS INDICATIONS - VEMD - GENERAL - DESCRIPTION

Function

To provide information in the cockpit about the operation of the aircraft and engine systems.

Position

- On the instrument panel.

Main characteristics

- 1 upper screen
- 1 lower screen
- Control buttons.

Description

The upper screen has two display modes:

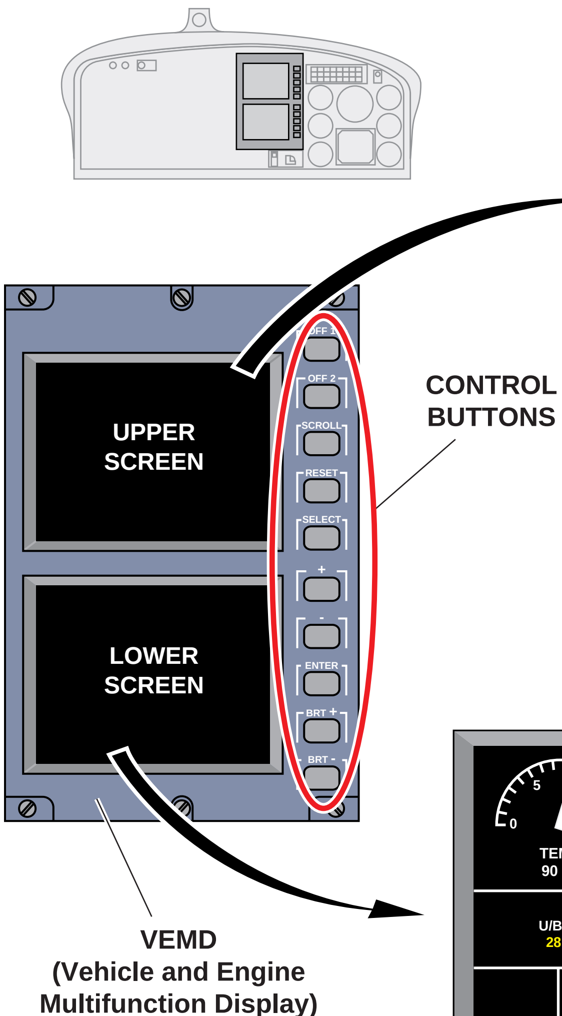
- Engine parameter screen in starting
- Engine parameter screen in operation (N1>...).

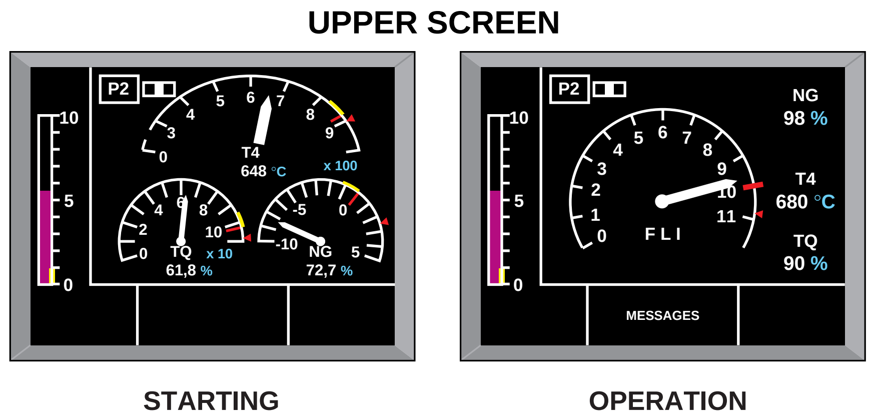
The lower screen has three display modes:

- Operation screen in flight
- Engine parameter screen in operation (upper screen failure)
- Maintenance screen (engine stopped).

Note 1: *VEMD - Vehicle and Engine Multifunction Display.*

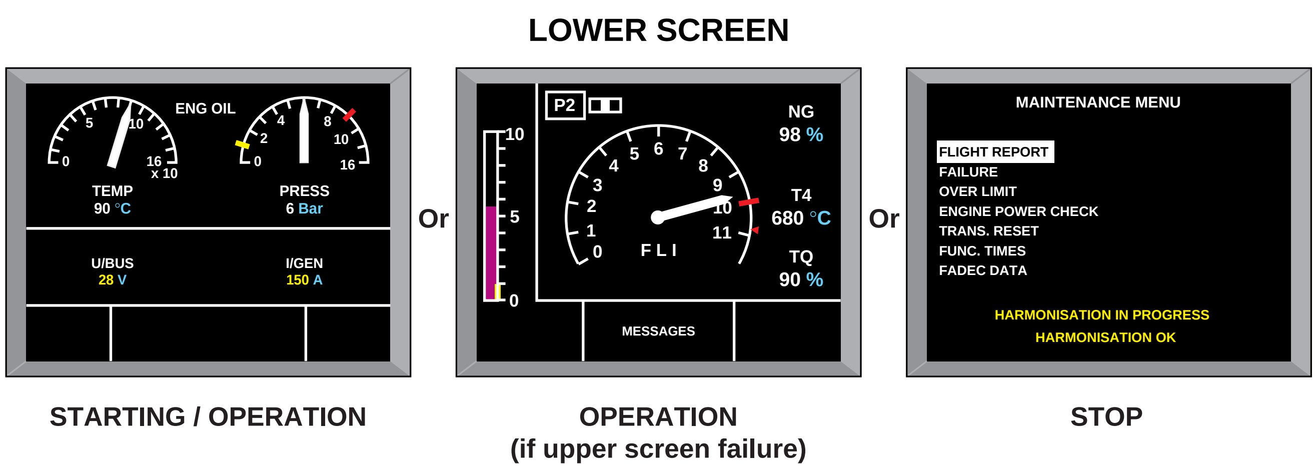
Note 2: *For more information, refer to the aircraft manufacturer's documentation.*





Note 1: VEMD - Vehicle and Engine Multifunction Display.

Note 2: For more information, refer to the aircraft manufacturer's documentation.



MISCELLANEOUS INDICATIONS - VEMD - GENERAL - DESCRIPTION

MISCELLANEOUS INDICATIONS - VEMD OPERATION (1)

There are two operating modes: operational and maintenance.

Operational mode

In this mode, in normal operation, there are two displays possible - starting display and flight display.

Starting Display

- Upper Screen: "3 info display"
  - t4.5 analog and digital
  - Delta N1 analog
  - N1 digital
  - Tq analog and digital
  - Bleed valve flag
  - P2 (sand filter)
  - OAT digital
  - Fuel quantity analog and digital

- Lower Screen
  - Eng oil pressure analog and digital
  - Eng oil temp. analog and digital
  - Starter current digital
  - Main Bus volts digital
  - Fuel quantity digital
  - Flight time remaining digital.

The display changes automatically to the flight display at 60% N1 and to the starting display during rundown at 40% N1.

Flight Display

- Upper Screen: FLI

FLI means First Limit Indicator. This is an analog indicator graduated from 0 to 11. The needle of this indicator is positioned as a function of the parameter which is nearest its limit. The parameters used are N1, t4.5, Tq. When the needle reaches 10 one of the parameters is at its take-off limit. There is a digital indication of each parameter to the right of the FLI indicator. When a parameter approaches its limit a yellow line will flash under the digital display; when it reaches the limit the line becomes red and an aural warning sounds.

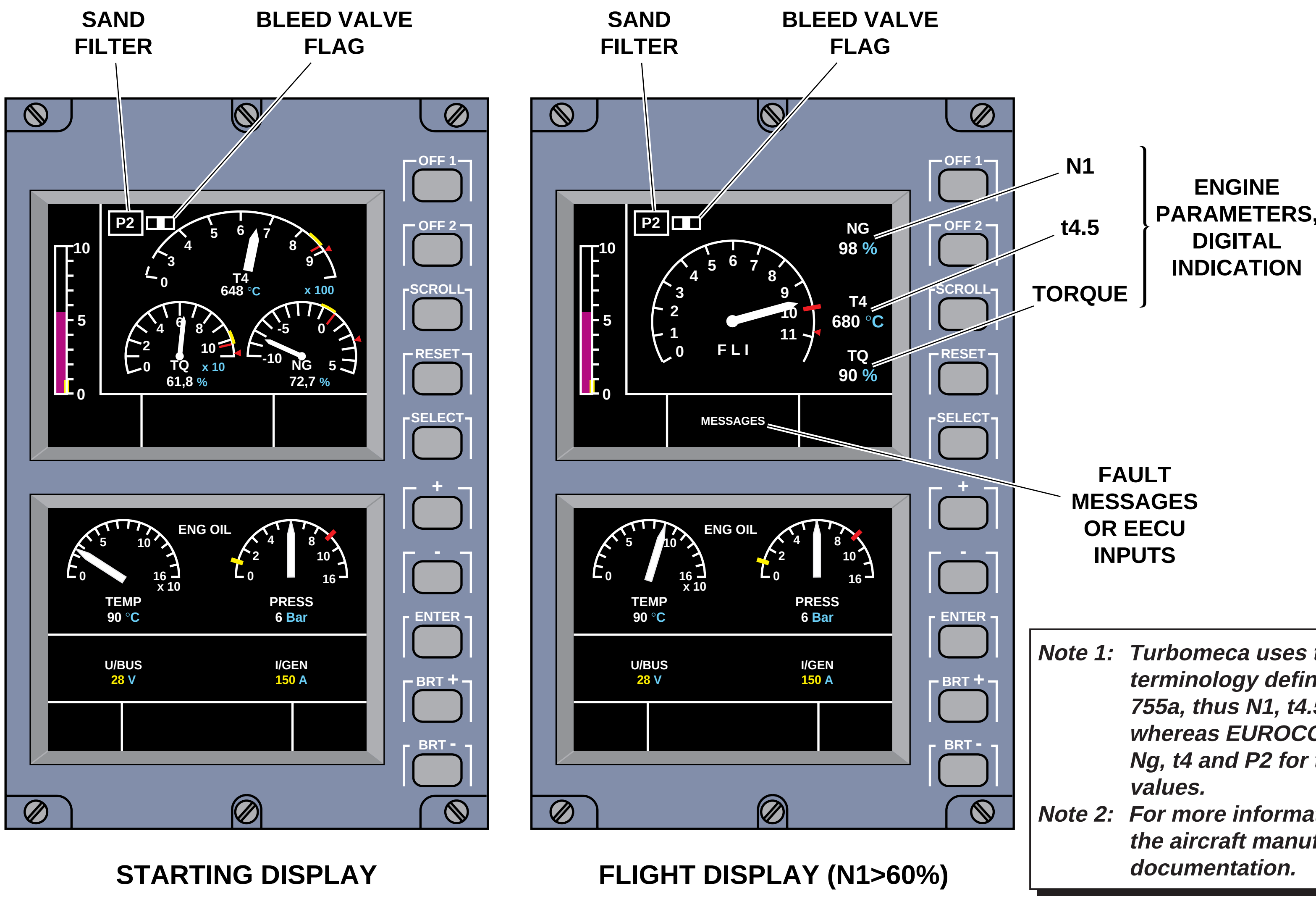
- Lower Screen.

Same indication as in start display except that starter current is replaced by generator current.

At the bottom of the screen is an area for fault messages. The EECU inputs to the VEMD may also be displayed in this area by pressing "SELECT".

Note 1: *TURBOMECA uses the terminology defined in ARP 755a, thus N1, t4.5, P3, whereas EUROCOPTER uses Ng, t4 and P2 for the same values.*

Note 2: *For more information, refer to the aircraft manufacturer's documentation.*



Note 1: Turbomeca uses the terminology defined in ARP 755a, thus N1, t4.5, P3, whereas EUROCOPTER uses Ng, t4 and P2 for the same values.

Note 2: For more information, refer to the aircraft manufacturer's documentation.

MISCELLANEOUS INDICATIONS - VEMD - OPERATION (1)

MISCELLANEOUS INDICATIONS - VEMD - OPERATION (2)

Maintenance mode

In maintenance mode the following functions are available:

- FLIGHT REPORT
- FAILURE
- OVERLIMIT
- ENGINE POWER CHEK
- TRANS. RESET
- FUNC. TIMES
- FADEC DATA.

Flight Report

At the end of a flight the Flight Report is automatically displayed on the lower screen when N1 ≤ 10% and NR ≤ 70 RPM.

It provides the following information:

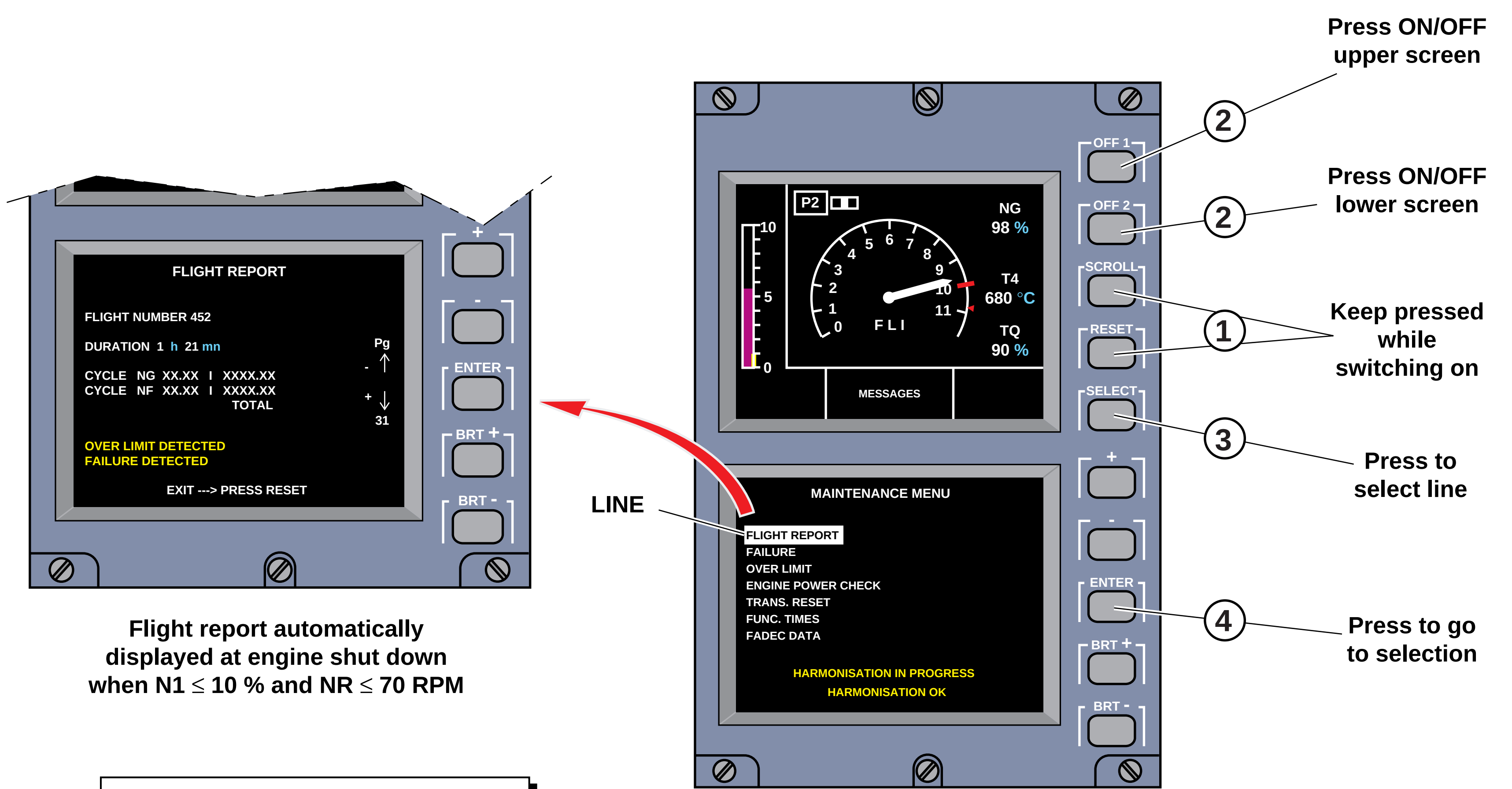
- Flight number
- Flight duration
- N1 and N2 cycles, this flight and totals
- Overlimit flag in event of exceedance
- Failure flag in event of a failure.

The other maintenance pages are accessible (when the engine is stopped) by switching on the VEMD whilst pressing simultaneously the "SCROLL" and "RESET" buttons and keeping both buttons depressed, energize the VEMD with the buttons OFF1 and OFF2 until the message "release keys" appears on the screens. This function is only available when N1 < 10% and NR < 70 RPM.

On the "MAINTENANCE MENU" page use the "SELECT" button to select the required item and the "ENTER" button to go to this page.

Refer to chapter 15 of this manual for further information on trouble shooting.

Note: *For more information, refer to the aircraft manufacturer's documentation.*



Flight report automatically displayed at engine shut down when N1 ≤ 10 % and NR ≤ 70 RPM

Note: For more information, refer to the aircraft manufacturer's documentation.

① TO ④ : SELECTION ORDER

MISCELLANEOUS INDICATIONS - VEMD - OPERATION (2)

MISCELLANEOUS INDICATIONS - VEMD - OPERATION (3)

Maintenance mode

Flight Report

This page displays the last 32 flight reports in the memory.

Failure

Failures are displayed on three pages, the +/- buttons are used to change from one page to another. 256 failures can be recorded.

Over Limit

This page displays any limit exceedances recorded in memory for the last 32 flights.

Engine Power Check

The last 8 power check results can be accessed.

Trans. Reset.

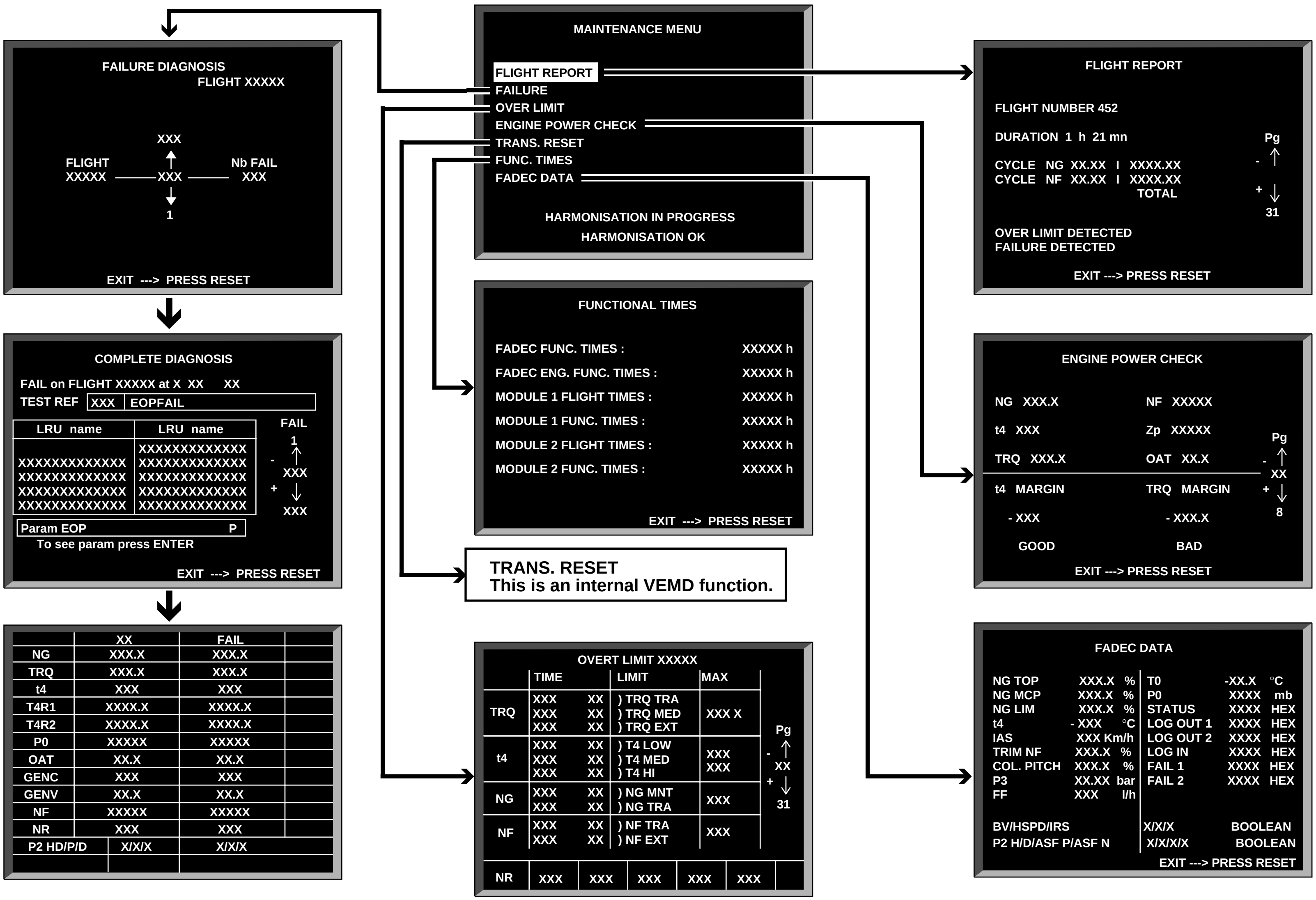
This is for transferring information between the 2 VEMD modules after a module change.

Func. Times

This page displays the total operating hours of the VEMD and the EECU (FADEC).

Fadec Data

This page displays the values of the inputs to the VEMD from the EECU.



MISCELLANEOUS INDICATIONS - VEMD - OPERATION (3)

9 - STARTING

(XX-XX-XX): Page references which deal with the subject in the maintenance documentation.

STARTING SYSTEM - GENERAL - DESCRIPTION

Function

The starting system ensures starting (on the ground and in flight) and dry crank of the engine. It includes the following functions: cranking, fuel supply, ignition and sequential control.

Position

All the starting accessories are installed on the engine except the EECU which is installed in the aircraft. Indicating and control components are aircraft components.

Main characteristics

- Starting envelope: refer to flight manual
- Start duration: between 25 and 30 sec
- Max dry crank time: < 20 sec
- Stabilisation time before shut-down: 60 sec at idle
- Run-down time: > 30 sec from 67 to 0 % N1
- Max t4.5 during start: refer to flight manual.

Main components

- In the cockpit:
  - *Stop/Idle/Flight selector (2B)*
  - *On/Off (2B1)*
  - Auto/Manual selector
  - Dry crank push button
  - Circuit breakers
- In the aircraft:
  - Starter contactor
  - Accessory relay
  - EECU
- On the engine:
  - Starter generator
  - Ignition system
  - Start electro-valve
  - Stop electro-valve.

Starting envelope:
Refer to Flight Manual

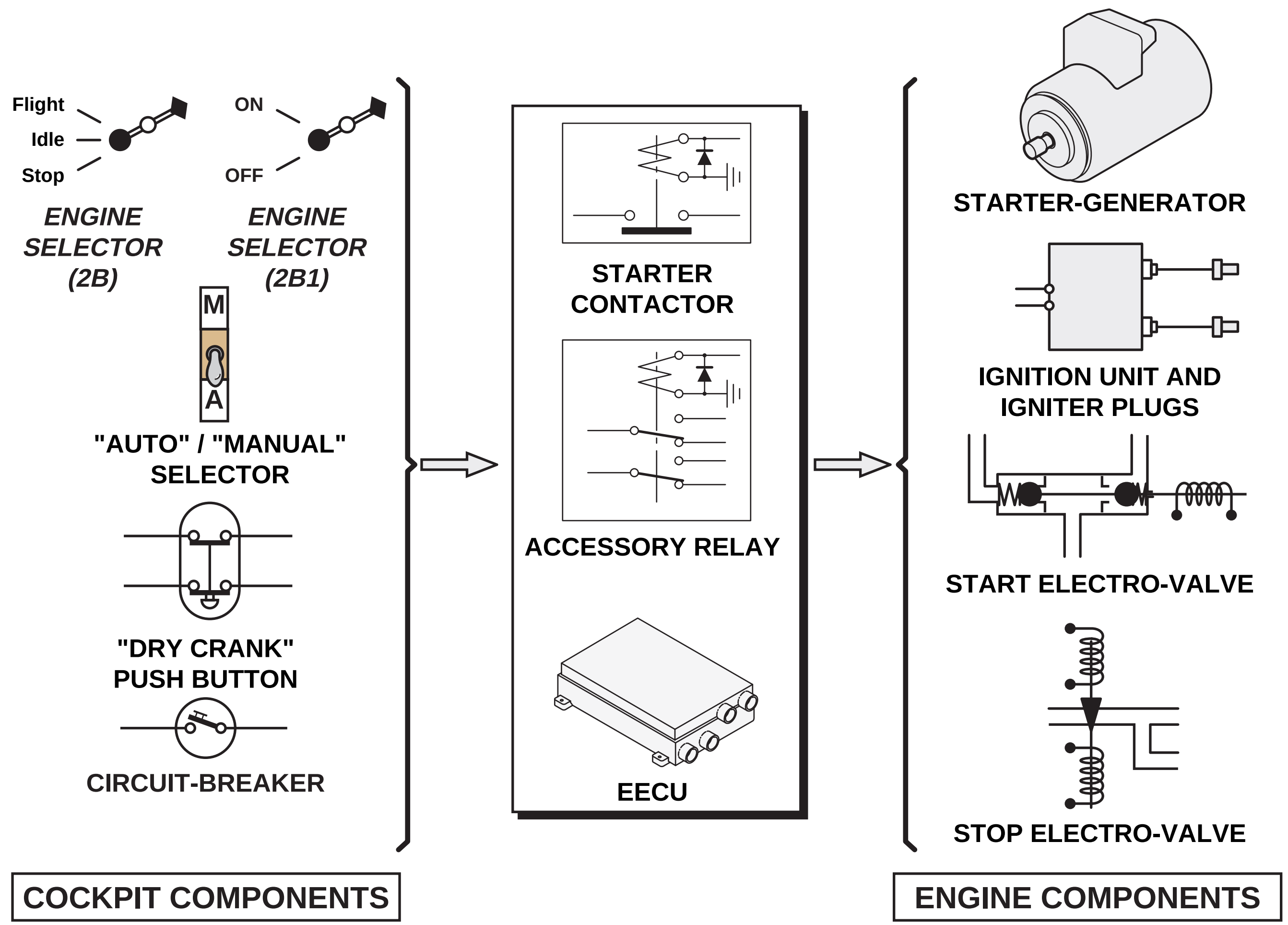
Start duration:
Between 25 and 30 sec

Max dry crank time:
< 20 sec

Stabilisation time before shut-down:
60 sec at idle

Run-down time:
> 30 sec from 67 to 0 % N1

Max t4.5 during start:
Refer to Flight Manual



STARTING SYSTEM - GENERAL - DESCRIPTION

STARTING SYSTEM - OPERATION

This section deals with operating sequences associated with the starting system: start, shut-down and dry crank.

Starting cycle

The starting cycle is characterised by the evolution of the engine parameters, especially the rotation speed and the gas temperature.

The main points of the starting cycle are:

- Start selection
- Self-sustaining speed (de-energisation of the starter and ignition unit)
- End of start (stabilisation at idle speed).

Shut-down cycle

This cycle comprises the following points:

- Stabilisation at idle speed
- Stop selection
- Run-down and stop.

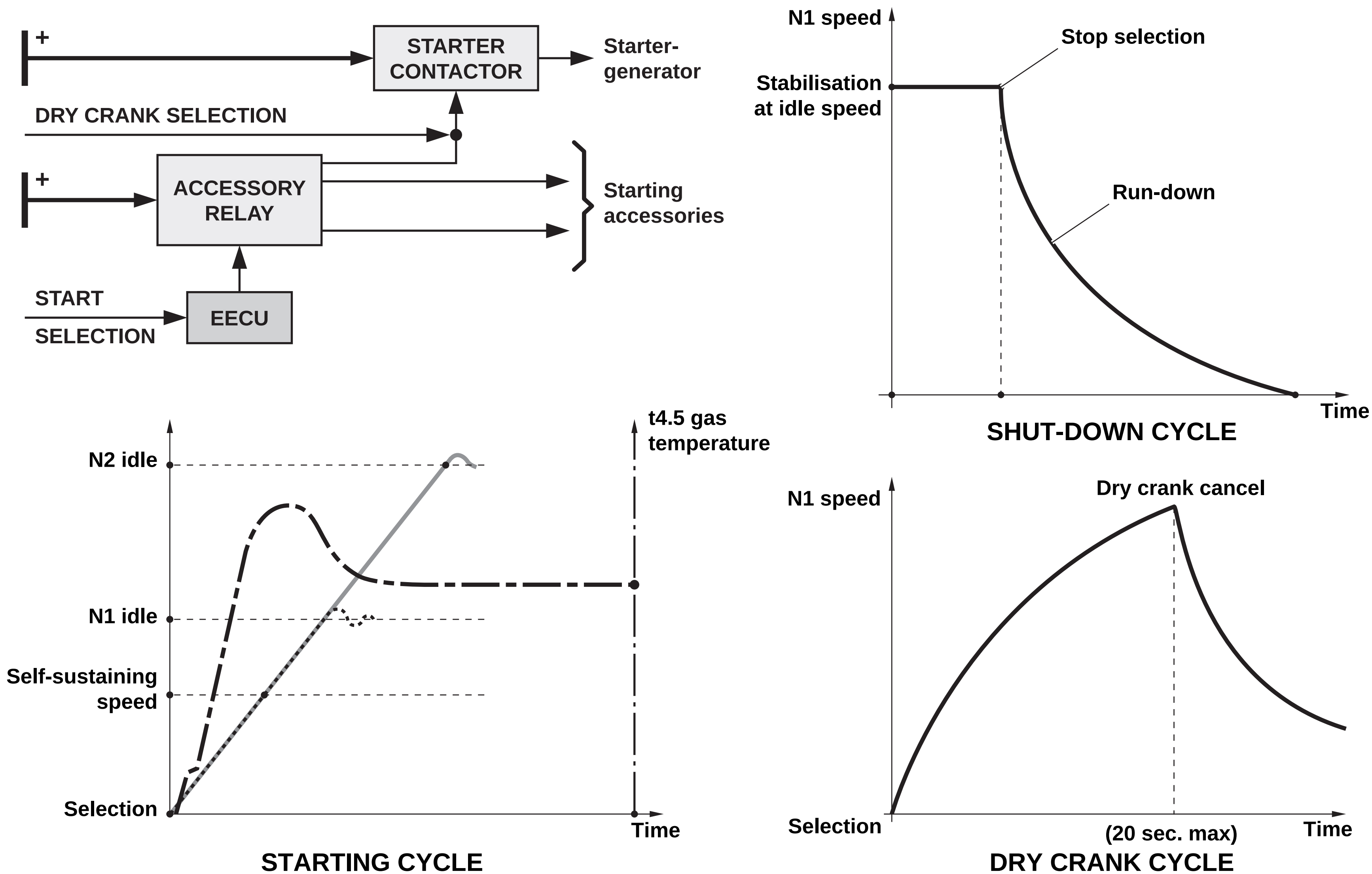
Dry crank cycle

A dry crank consists of cranking the rotating assembly without supplying fuel or ignition (dry crank). It is used for cooling the engine or for maintenance procedures.

The dry crank cycle comprises the following phases:

- Dry crank selection
- Cranking of the rotating assembly
- End of dry crank and run-down.

Note*:* *Dry crank time is limited to 20 sec. to avoid overheating of the starter motor.*



STARTING SYSTEM - OPERATION

STARTER-GENERATOR

Function

The starter motor cranks the gas generator rotating assembly during starting and dry crank.

At the end of starting and when the rotation speed is sufficient, the starter operates as a Direct Current generator.

Position

- On the engine: on the front face of the accessory gearbox.

Main characteristics

- Supplied by aircraft manufacturer
- Type: starter-generator
- Supply: 28 VDC.

Description

The starter main components are:

- The starter (starter-generator)
- The mounting flange
- The supply terminals.

Operation

Engine cranking (starter)

When "START" is selected the starter contactor closes and connects the aircraft DC bus bar to the starter.

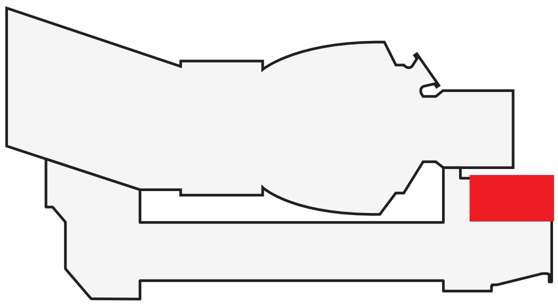
The starter then cranks the rotating assembly through the accessory drive train.

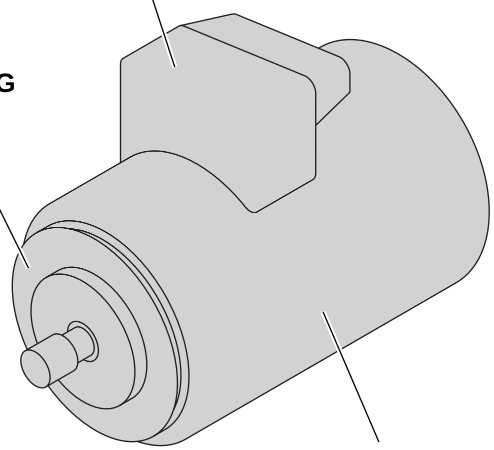
The torque on the starter shaft is inversely proportional to the gas generator speed and will be higher when the atmospheric temperature is low.

The N1 increases up to self-sustaining speed (45 %) at which point the torque becomes negative. The supply to the starter is cut by the opening of the starter contactor.

Generator operation

When self-sustaining speed is reached, the starter then operates as an electrical DC generator and supplies the aircraft electrical system.

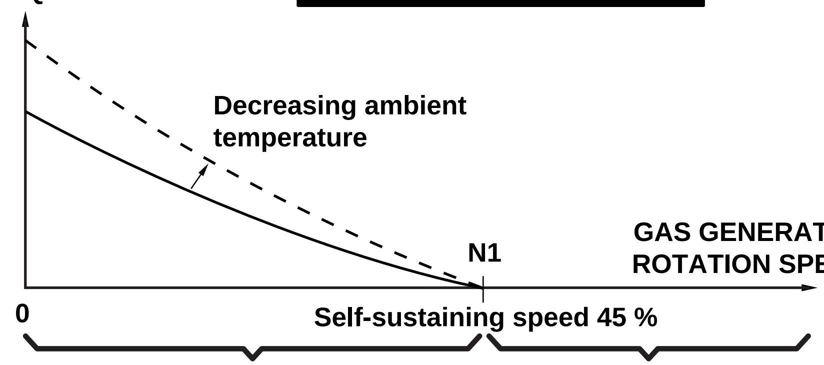


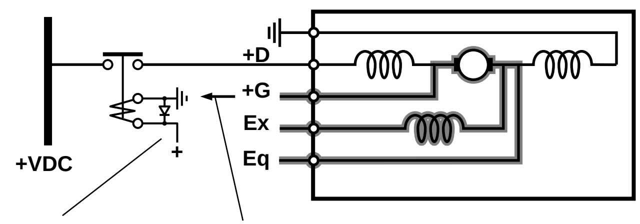


SUPPLIED BY AIRCRAFT MANUFACTURER

Type:
Starter - generator

Supply:
28 VDC





STARTER-GENERATOR

IGNITION SYSTEM

Function

This system ensures the ignition of the fuel sprayed by the start injectors into the combustion chamber.

Position

All the ignition system components are installed on the engine, except the electrical supply circuit.

Main characteristics

- Type: High Energy (HE)
- Supply voltage: 28 VDC.

Description

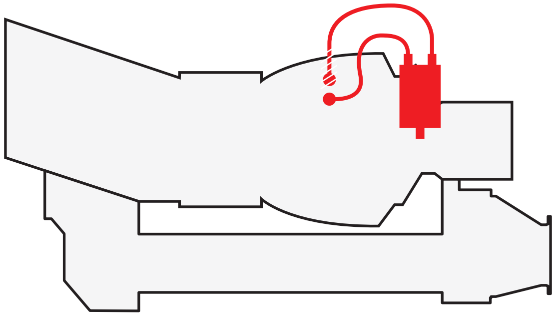
The ignition system includes the following components:

- 1 double ignition unit
- 2 ignition cables
- 2 igniter plugs.

Operation

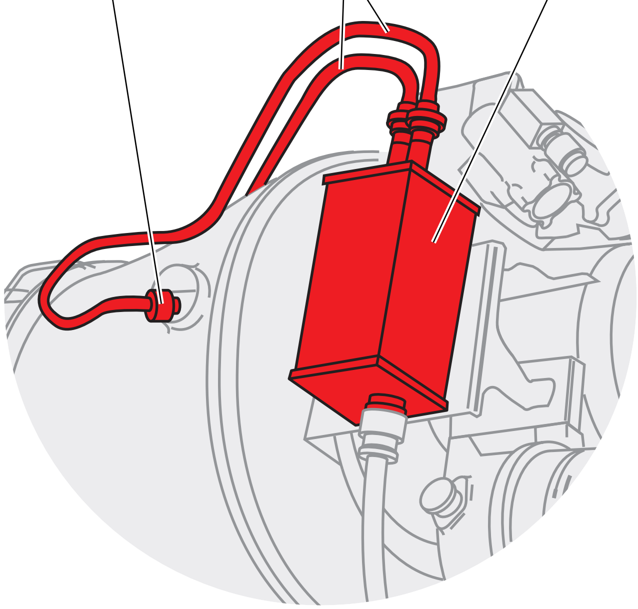
The system is electrically energised from the start selection until self-sustaining speed is reached (45% N1).

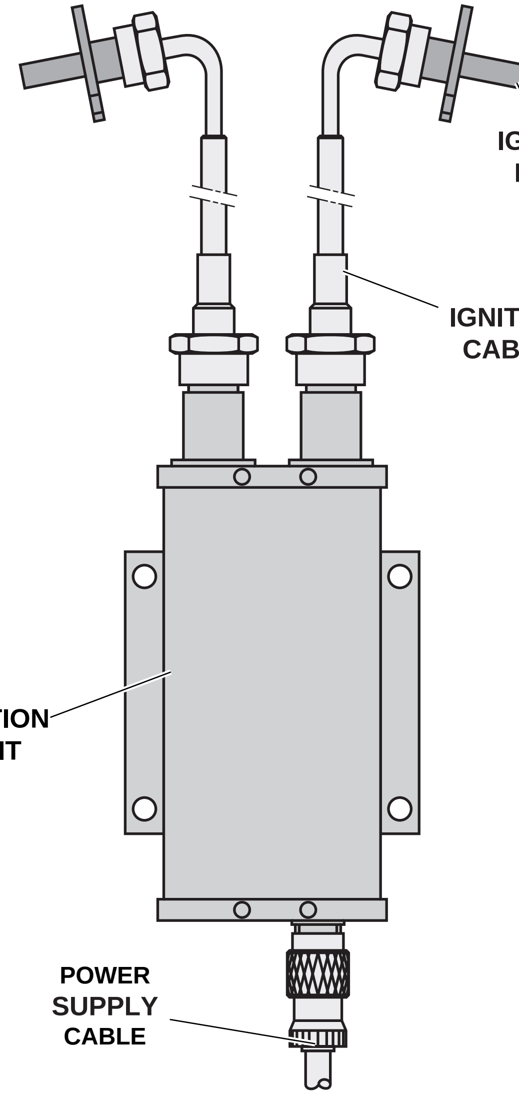
During this period sparks are provided between the electrodes of the igniter plugs.



Type:
High Energy

Supply voltage:
28 VDC





IGNITION SYSTEM

IGNITION UNIT

Function

The ignition unit transforms the input voltage into a high energy output.

Position

- In the system: connected to aircraft accessory relay
- On the engine: mounted on a support at the front right part of the engine.

Main characteristics

- Type: High Energy (HE).

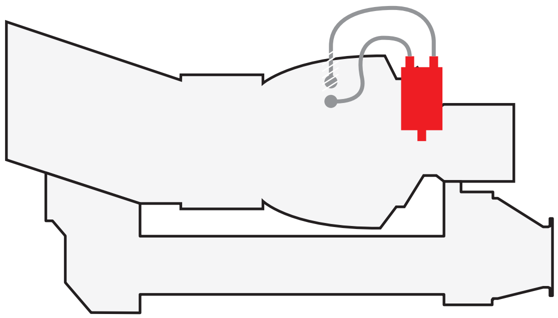
Description

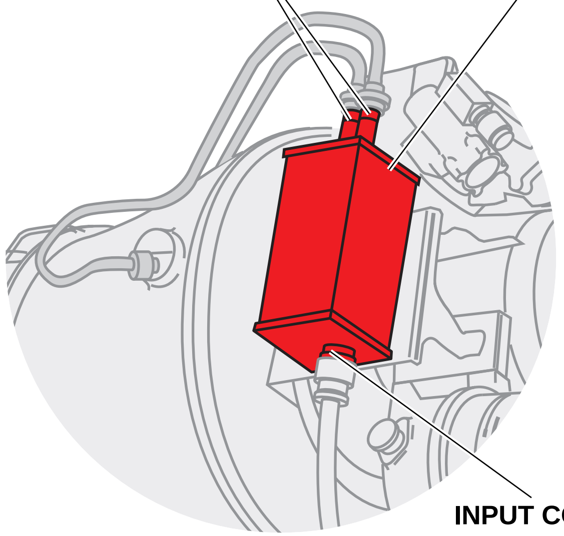
The ignition unit includes the following components in a sealed box:

- An input connector (28 VDC)
- Two connectors (HE) for the 2 plugs
- 2 mounting brackets.

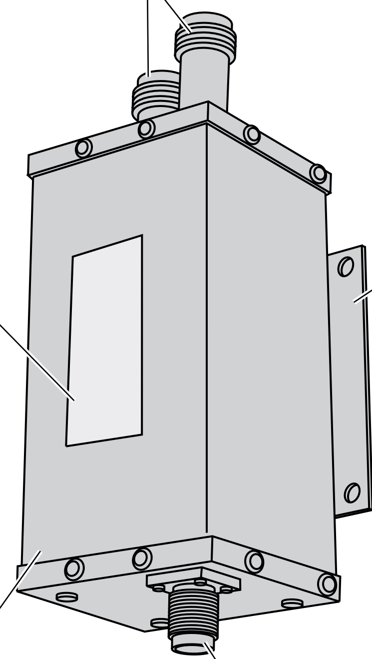
Operation

The ignition unit is supplied with 28 VDC, it changes this to a high energy voltage which is delivered to the igniter plugs through the ignition cables.





Type:
High Energy (HE)



IGNITION UNIT

IGNITION CABLES

Function

The ignition cables supply the high energy current (produced by the ignition unit) to the igniter plugs.

Position

- In the system: between the ignition unit and the plugs
- On the engine: on the front upper part of the engine.

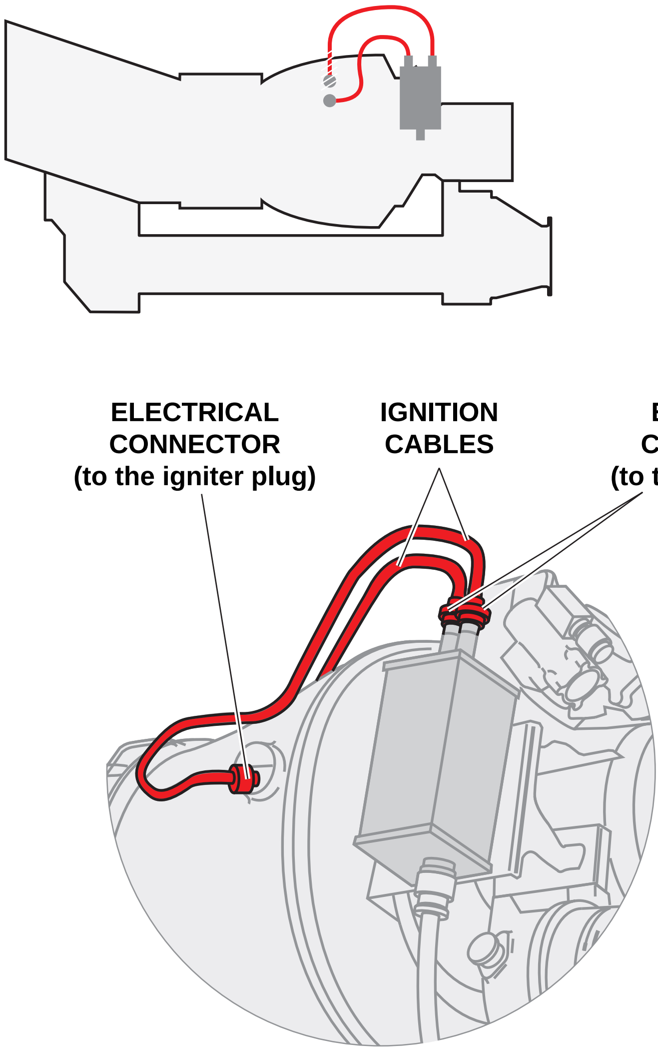
Main characteristics

- Type: multi-core nickel-plated copper wire
- Quantity: 2 identical independent cables
- Shielding: triple braided.

Description

An ignition cable includes:

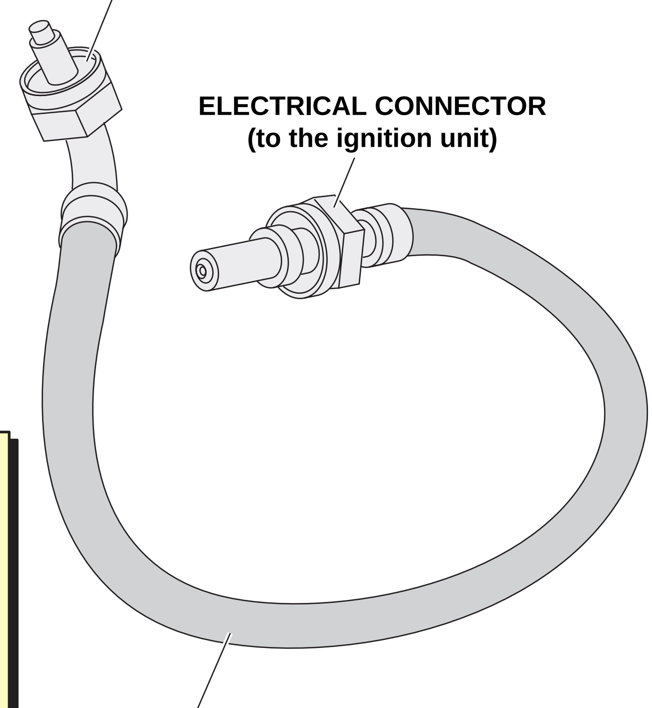
- An internal conductor
- An outer shielding (stainless steel braid)
- Two stainless steel rigid end fittings
- Two electrical connectors
  - One igniter plug connector (ceramic insulator, spring and nut)
  - One ignition unit connector (teflon insulator, silicone joint, spring and nut).



Type:
Multicore nickel-plated copper wire

Quantity:
2 identical independent cables

Shielding:
Triple braided



IGNITION CABLES

IGNITER PLUGS

Function

The igniter plugs produce sparks to ignite the fuel sprayed by the start injectors.

Position

- In the system: at the end of each igniter cable
- On the engine: mounted beside the start injectors on either side of the combustion chamber casing.

Main characteristics

- Type: High Energy (HE), surface discharge
- Quantity: 2.

Description

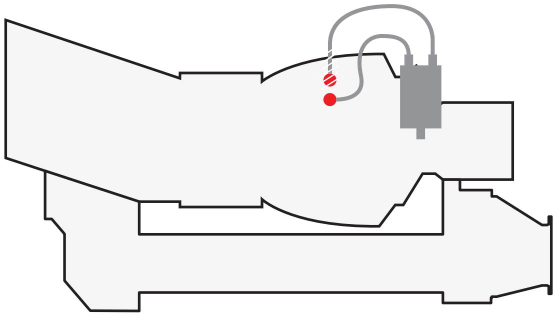
An igniter plug comprises:

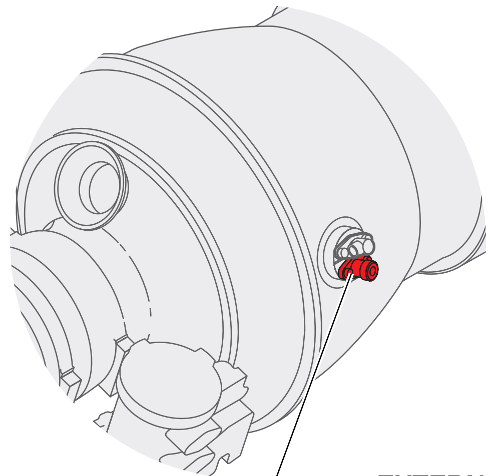
- An external body connected to the negative terminal
- A semi-conductor fitted in the tip of the plug
- An insulator
- A central electrode connected to the positive terminal
- An electrical connector for connection to the ignition unit
- Mounting flange (2 bolts on the power turbine boss)
- Seals and spacers (depth adjustment).

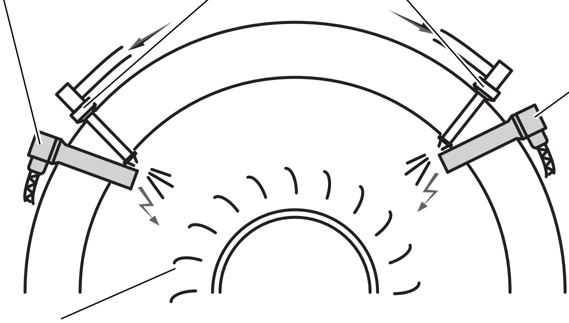
Operation

The high energy current produced by the ignition unit is supplied to the central electrode of the igniter plug. It discharges, across the semi-conductor to the plug body causing a powerful spark.

This spark ignites the air fuel mixture sprayed into the combustion chamber by the two start injectors.



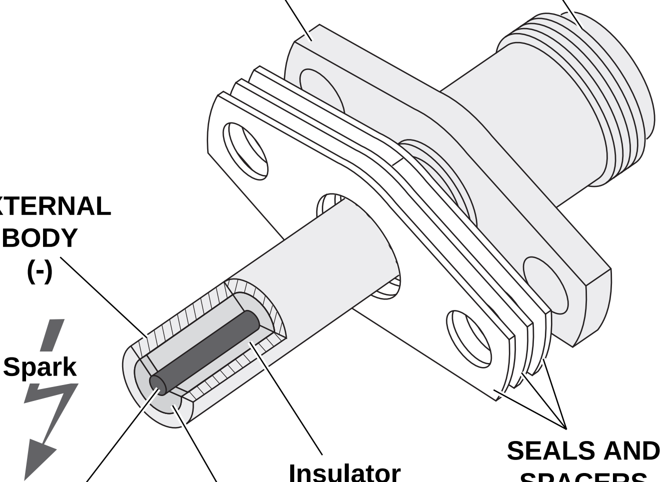




DESCRIPTION

Type:
High Energy (HE), surface discharge

Quantity:
2



OPERATION

IGNITER PLUGS

10 - ELECTRICAL SYSTEM

(XX-XX-XX): Page references which deal with the subject in the maintenance documentation.

ELECTRICAL SYSTEM

Function

The system contributes to the various indicating and control functions of the engine:

- Control
- Control system
- Safety system
- Maintenance aid.

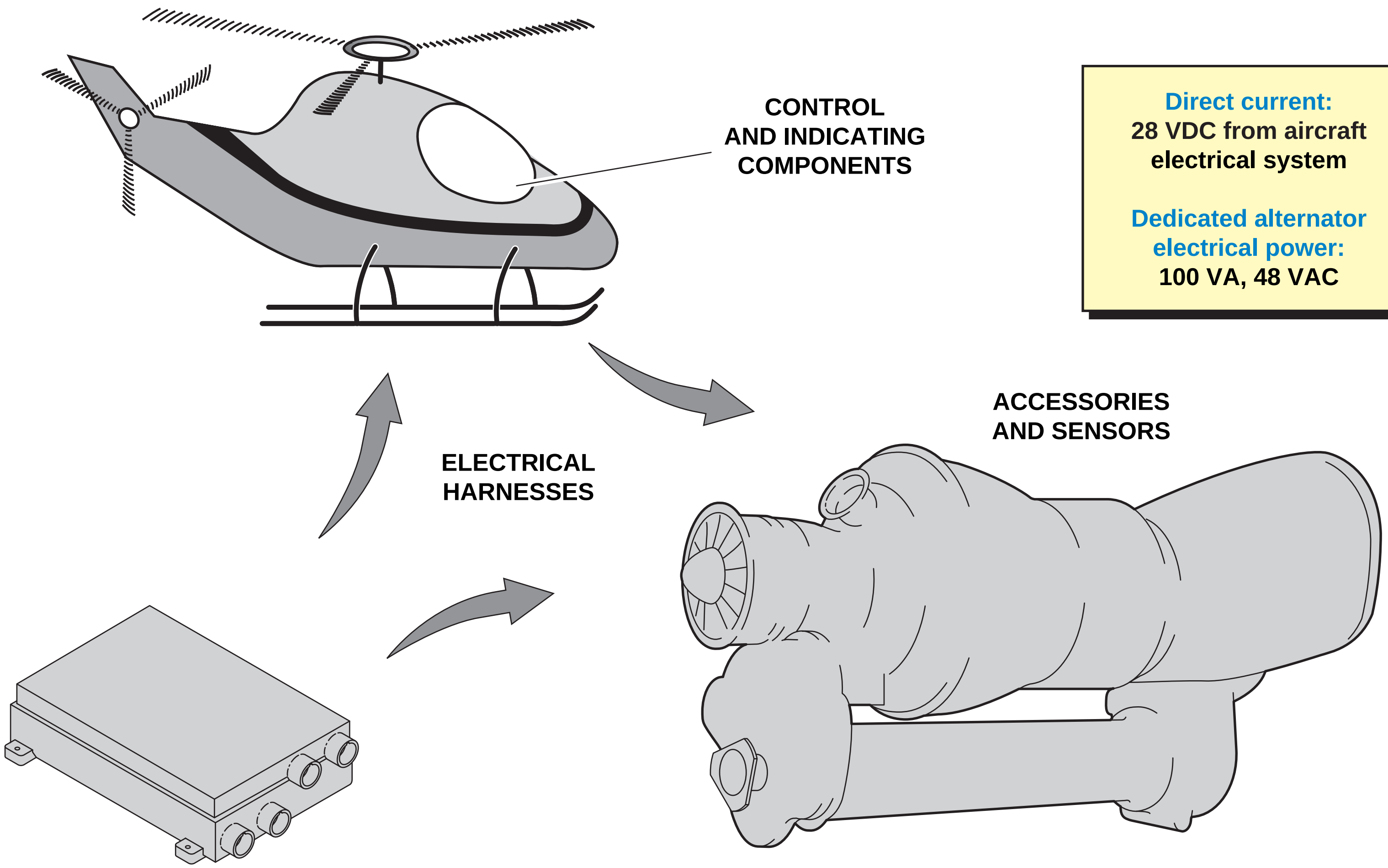
Main characteristics

- Direct current: 28 VDC from aircraft electrical system
- Dedicated alternator electrical power: 100 VA, 48 VAC.

Main components

- Engine electrical components (accessories and sensors)
- Control and indicating components (aircraft)
- Engine Electronic Control Unit (installed in the airframe)
- Electrical harnesses.

Note: *The accessories are dealt with in the corresponding chapters except the alternator.*



Direct current:
28 VDC from aircraft electrical system

Dedicated alternator electrical power:
100 VA, 48 VAC

ELECTRICAL SYSTEM

ALTERNATOR - GENERAL

Function

The alternator provides electrical power and N1 signals to the EECU.

Position

- On the engine: on the rear face of the accessory gearbox.

Main characteristics

- Type:

2B: three phase alternator, permanent magnet rotor

2B1: three phase double alternator, permanent magnet rotor

- Power: 100 VA
- Output voltage: < 48 VAC.

Main components

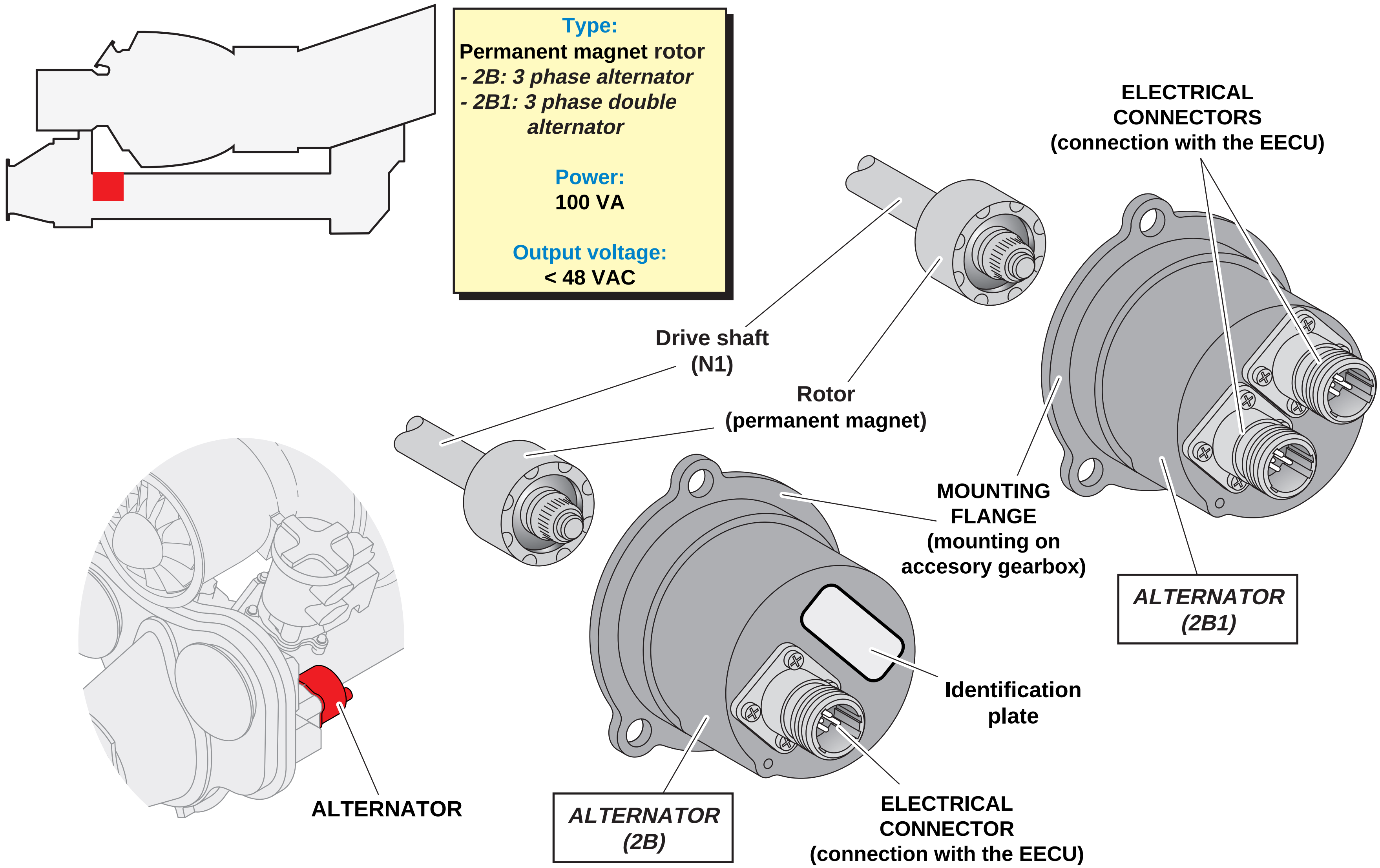
- Drive shaft
- Mounting flange
- Alternator body
- Rotor
- *2B: one electrical connector (connection with the EECU)*
- *2B1: two electrical connectors (connection with the EECU).*

Note: *The rotor is mounted on the drive shaft.*

Type:
Permanent magnet rotor
- 2B: 3 phase alternator
- 2B1: 3 phase double alternator

Power:
100 VA

Output voltage:
< 48 VAC



ALTERNATOR - GENERAL

ALTERNATOR (2B) - DESCRIPTION - OPERATION

Description

The alternator is secured by 3 screws on the rear face of the accessory gearbox. The flange has threaded holes for extraction.

It includes the following components:

- *A rotor mounted on the drive shaft. It is provided with permanent magnets (8 poles)*
- *A stator formed by a three phase winding located around the rotor*
- *An electrical connector for the connection with the EECU (electrical supply to the EECU).*

Operation

The alternator transforms the mechanical power available on the drive shaft into electrical power.

This electrical power supplies the EECU.

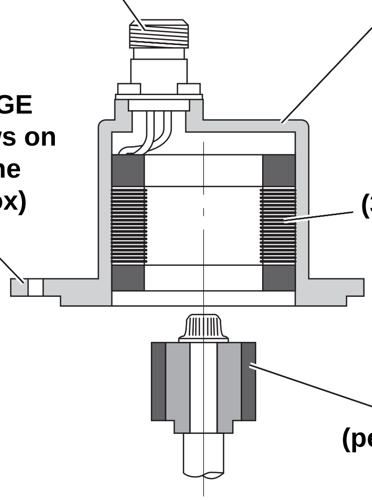
The three phase voltage is rectified through a Graetz bridge housed in the EECU.

The output frequency is used by the EECU as an N1 back-up signal.

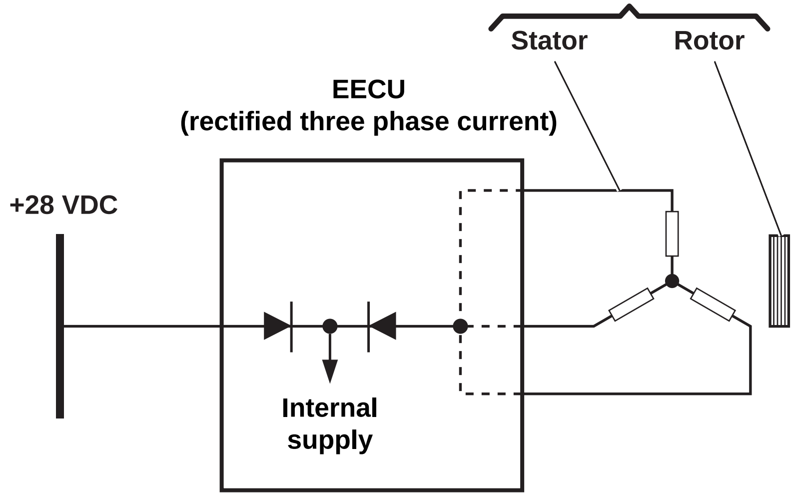
EECU electrical supply

The Engine Electronic Control Unit is electrically supplied either from the aircraft + 28 VDC bus bar or from the engine alternator as follows:

- *The aircraft + 28 VDC bus bar is used alone during starting and in the event of an alternator failure during flight*
- *The engine alternator is used above approx. 60 % N1 (normal operation)*
- *The EECU switches automatically from the aircraft supply to the alternator supply without any affect on its operation.*



DESCRIPTION



OPERATION

PRINCIPLE OF EECU ELECTRICAL SUPPLY	N1 0 % ≈ 60 %	100 %
Normal operation	28 V bus bar	Alternator
28 VDC bus bar failure		Alternator
Alternator failure	28 V bus bar	28 V bus bar

ALTERNATOR (2B) - DESCRIPTION - OPERATION

ALTERNATOR (2B1) - DESCRIPTION - OPERATION

Description

The alternator is secured by 3 screws on the rear face of the accessory gearbox. The flange has threaded holes for extraction.

It includes the following components:

- *A rotor driven by the accessory drive train (N1). It is provided with permanent magnets (8 poles)*
- *Two stators formed by two windings (A and B) with stator winding located at each side of the rotor. One for channel A and one for channel B*
- *Two electrical connectors for connection with the EECU, one connector for each channel.*

- The windings, all wiring and the connectors for each channel are separate and insulated from one another.

Operation (for one winding, A or B)

The alternator transforms the mechanical power available on the drive shaft into electrical power.

This electrical power is supplied to a channel of the EECU.

The three phase voltage is rectified through a Graetz bridge housed in the EECU.

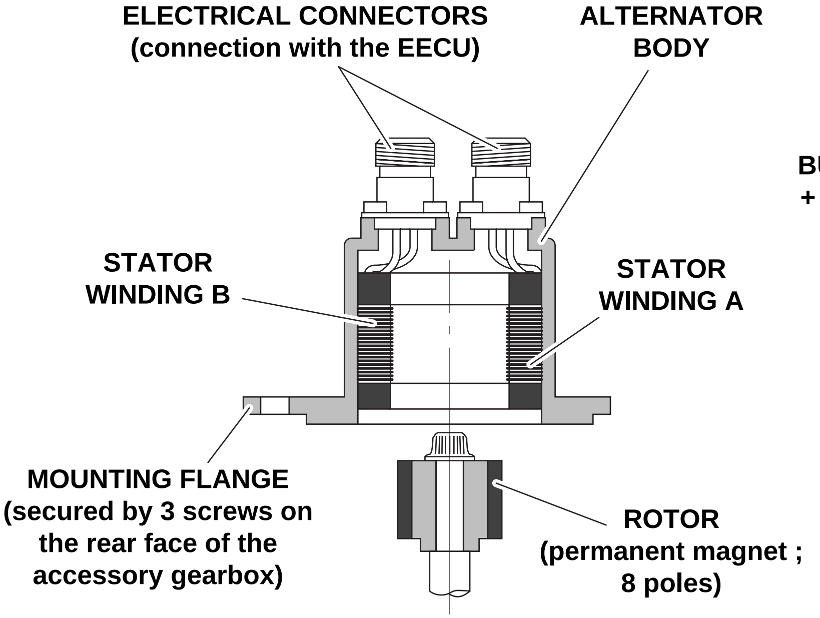
The output frequency is used by the channel as an N1 signal for fuel flow control etc.

EECU electrical supply

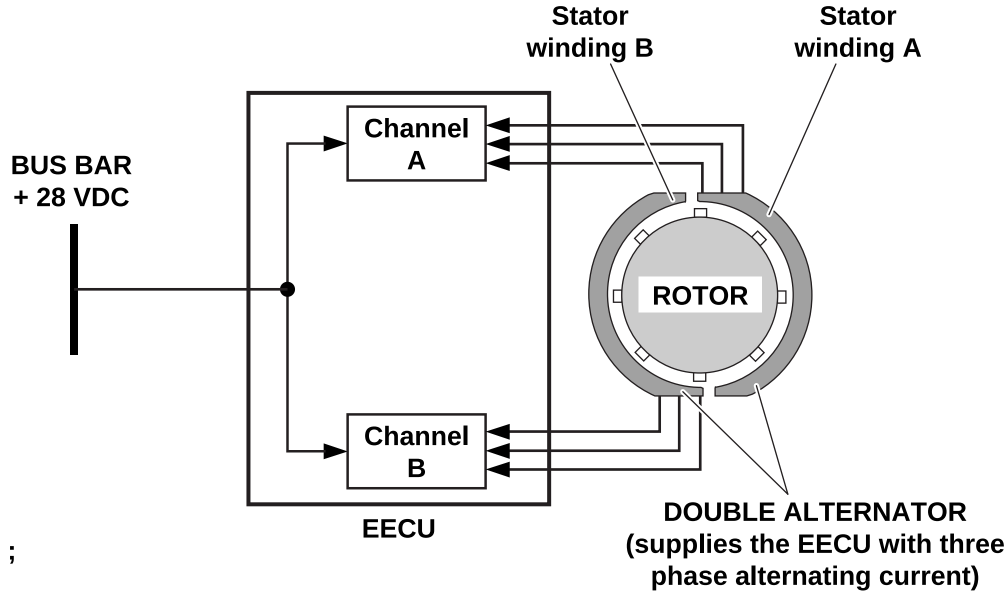
The Engine Electronic Control Unit is electrically supplied either from the aircraft 28 VDC bus bar or from the engine alternator as follows:

- *By the aircraft 28 VDC bus bar alone during starting and in the event of an alternator failure*
- *By the engine alternator above approx. 60 % N1.*

The EECU switches automatically from the aircraft supply to the alternator supply without any effect on its operation.



DESCRIPTION



OPERATION

PRINCIPLE OF EECU ELECTRICAL SUPPLY	N1 0 % ≈ 60 % 100 %	
Normal operation	28 V bus bar	Alternator
28 VDC bus bar failure		Alternator
Alternator failure	28 V bus bar	28 V bus bar

ALTERNATOR (2B1) - DESCRIPTION - OPERATION

ELECTRICAL HARNESSES

Function

The harnesses connect the engine electrical components to the EECU and the aircraft circuit.

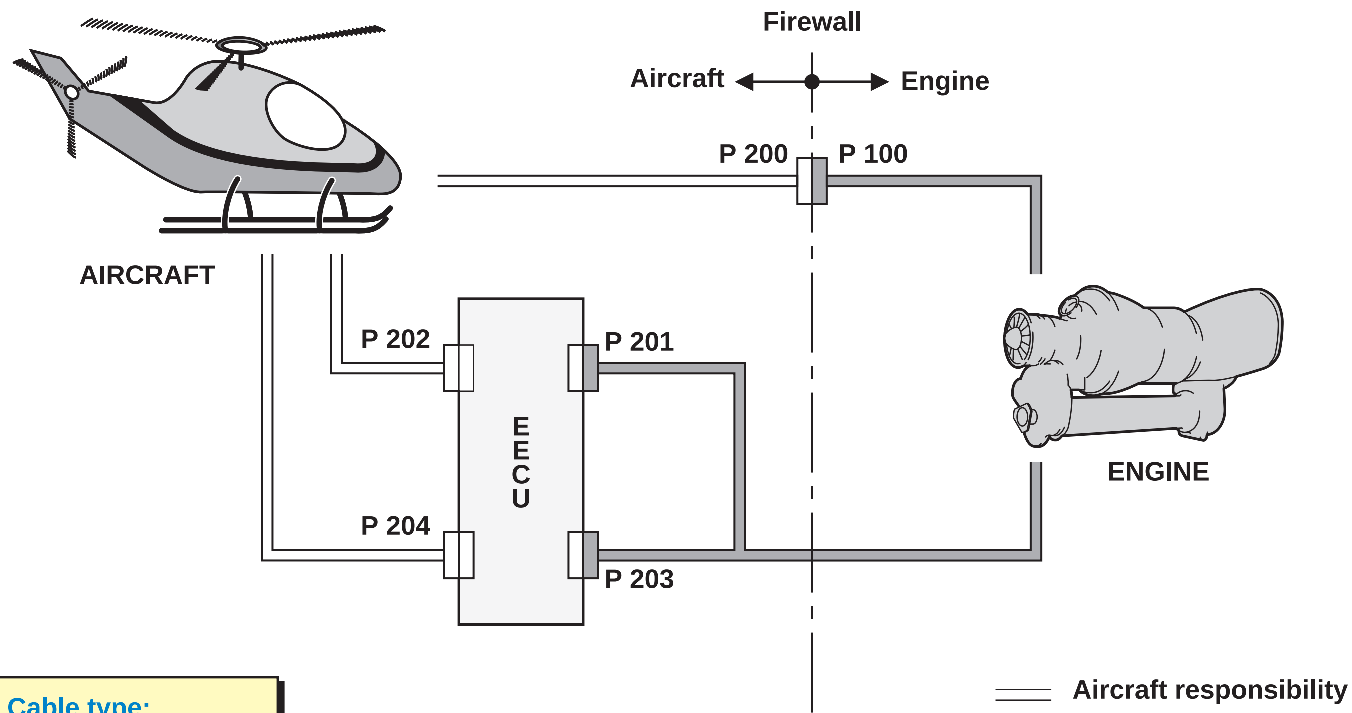
Main characteristics

- Cable type: shielded or double-shielded
- Type of connectors: threaded, self-locking.

Main components

Two engine harnesses:

- 1 engine to EECU harness (P201 and P203 connectors)
- 1 engine to Aircraft harness (P100 connector)



Cable type:
shielded or double-shielded

Type of connectors:
threaded, self locking

ELECTRICAL HARNESSES

11 - ENGINE INSTALLATION

(XX-XX-XX): Page references which deal with the subject in the maintenance documentation.

ENGINE COMPARTMENT

Function

The engine compartment houses the engine.

Position

- At the rear of the helicopter main gearbox.

Main characteristics

- Insulated compartment
- Compartment ventilation by air circulation.

Main components

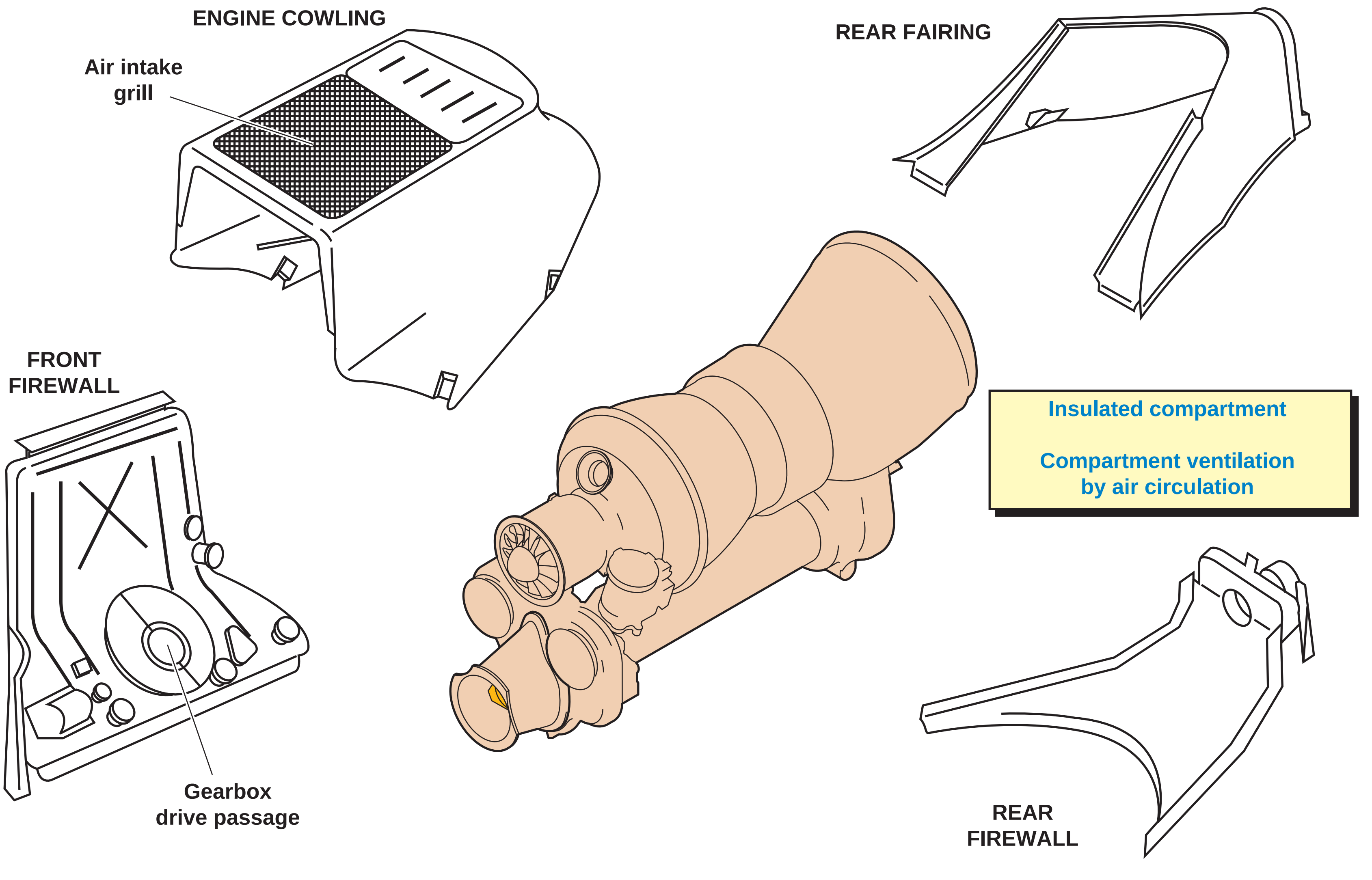
- Firewalls
- Cowlings
- Support platform.

Description

The engine compartment includes the following components:

- The firewalls:
  - Front firewall
  - Rear firewall
- Rear fairing
- Engine cowling which includes the air intake grill.

The compartment ventilation is ensured by air circulation in order to maintain an acceptable temperature in the various areas.



ENGINE COMPARTMENT

ENGINE MOUNTING AND HANDLING

Function

The engine mountings attach the engine to the aircraft. The lifting brackets permit engine lifting.

Position

Engine mounting

- Front mounting: on the support casing front flange
- Rear mounting: two clamps on the protection tube.

Engine lifting

- Two lifting brackets at the junction of the compressor and combustion chamber casings
- One lifting bracket on the mounting flange of the exhaust pipe.

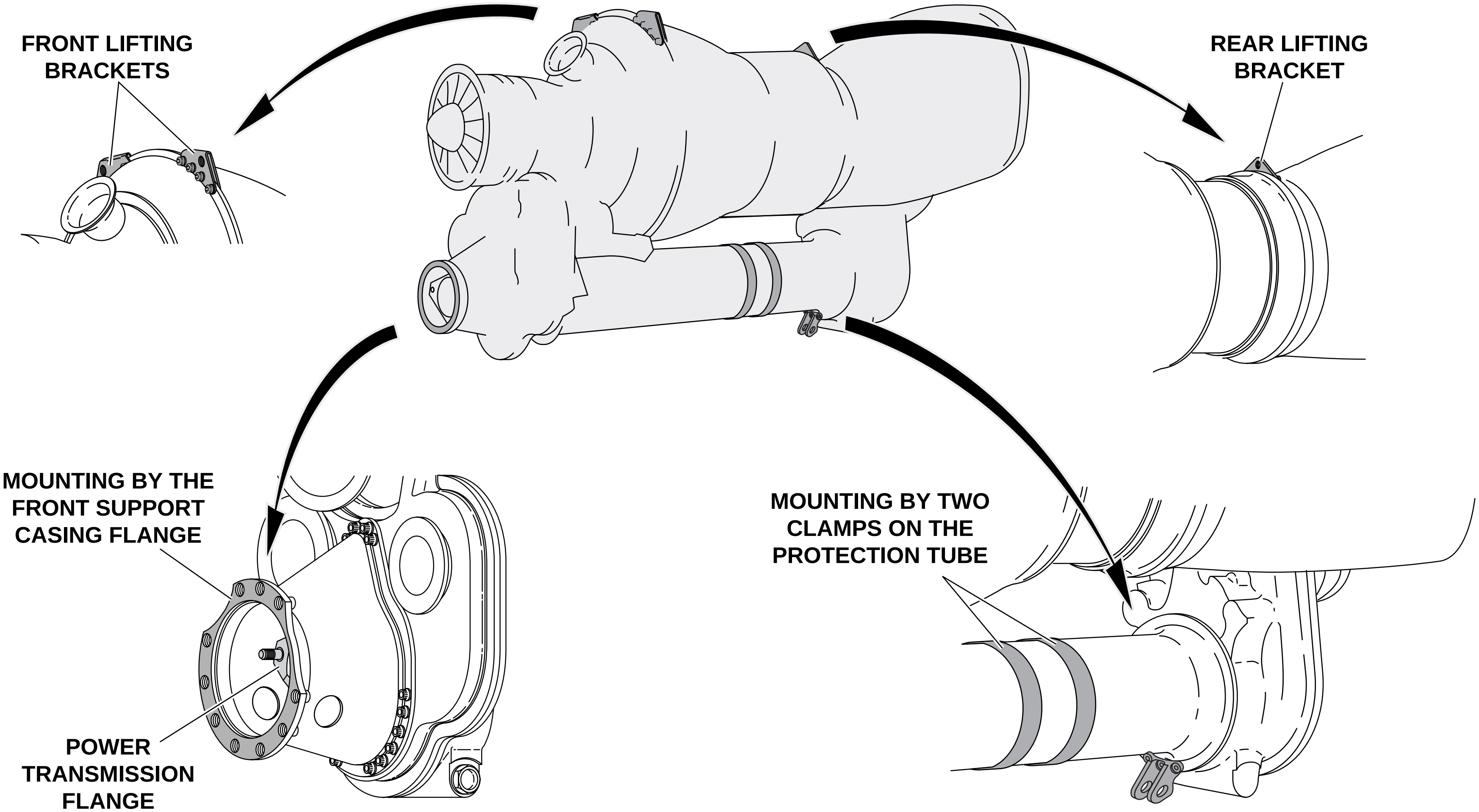
Functional description

The front support is ensured by a ring of bolts through the front flange of the front support casing into the main gearbox input casing.

The rear support is ensured by means of a cradle and two clamps on the protection tube.

The lifting brackets permit the installation of a lifting sling.

Note: *The power transmission triangular flange is located in the front support casing.*



FRONT MOUNTING

REAR MOUNTING
(aircraft manufacturer's supply)

ENGINE MOUNTING AND HANDLING

AIR INTAKE AND EXHAUST SYSTEM

Air intake

Function

The air intake system directs the ambient air into the engine.

Position

- In front of the engine.

Main characteristics

- Type: dynamic, annular
- Air flow: 2.5 kg/s (5.5 lbs/sec.).

Main components

- Helicopter air intake
- Air duct.

Functional description

A circular flange on the compressor casing permits connection of the aircraft air duct.

The admission of air can be made through a static or a dynamic intake which can be provided with protection devices (filters, anti-icing...).

A pressurized seal can also be fitted to improve the connection sealing. Some versions are provided with a connection for compressor washing.

Exhaust system

Function

The exhaust system discharges the exhaust gas overboard.

Position

- At the rear of the engine.

Main characteristics

- Type: annular.

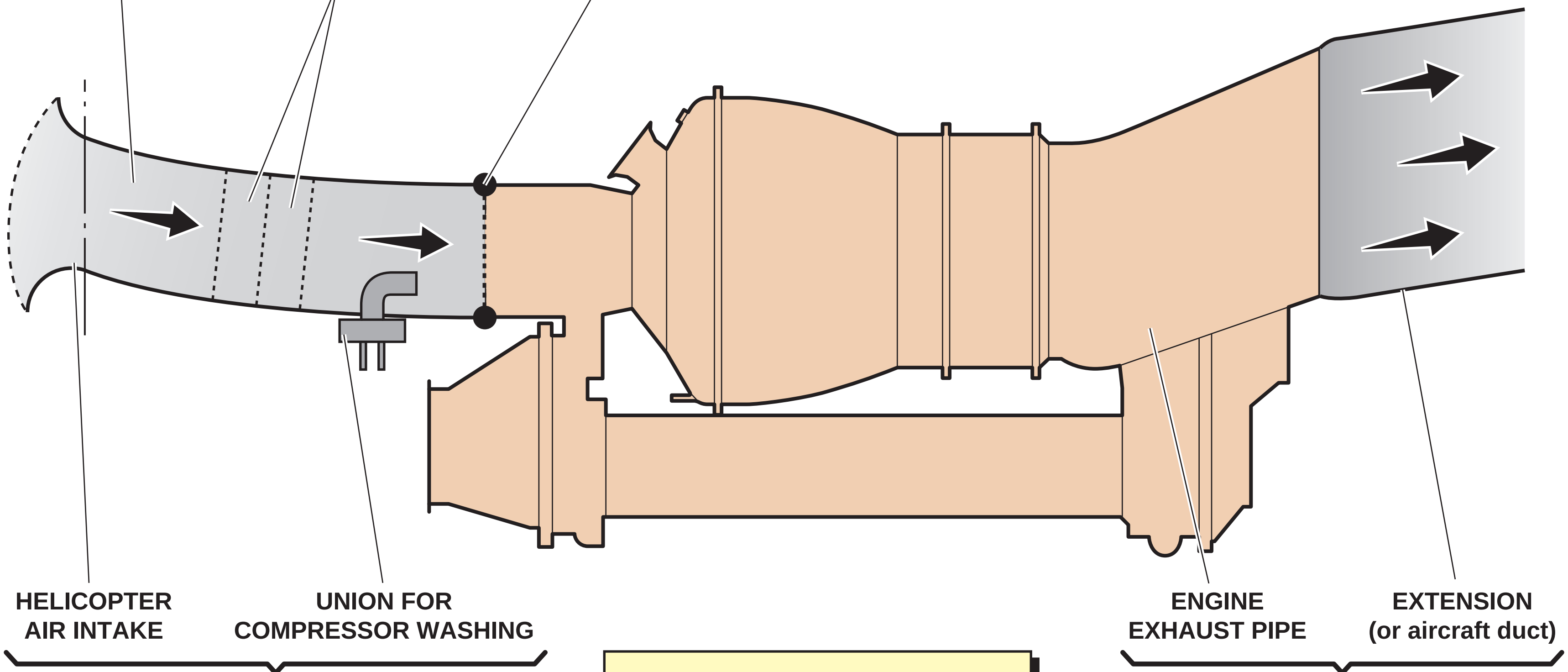
Main components

- Engine exhaust pipe
- Exhaust extension (air frame).

Functional description

The exhaust expels the gases directly but it can be adapted to the aircraft by means of an extension.

The extension is supplied by the aircraft manufacturer. It is secured by a ring of bolts at the rear of the engine exhaust pipe.



Air intake
- Type: dynamic, annular
- Air flow: 2.5 kg/s (5.5 lbs/sec.)

Exhaust system
- Type: annular

AIR INTAKE AND EXHAUST SYSTEM

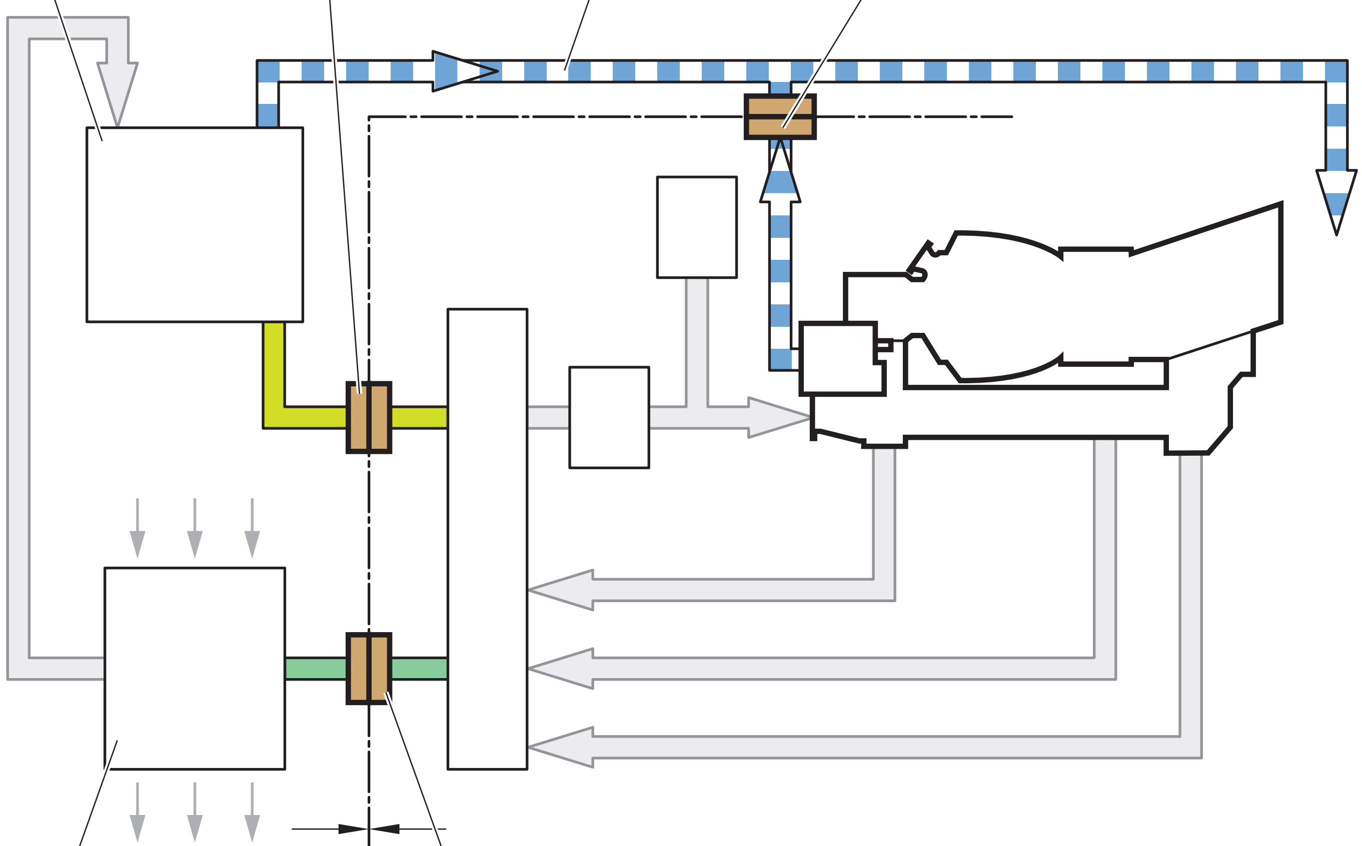
ENGINE SYSTEM INTERFACES (1)

Oil system

The oil system has three interfaces which are installed on the front firewall, inside the engine compartment.

The oil system interfaces are:

- Oil outlet line to the oil cooler
- Oil supply line to the oil pump pack. The oil supply line is fitted with a drain plug on the interface
- Engine breathing and oil tank vent line.



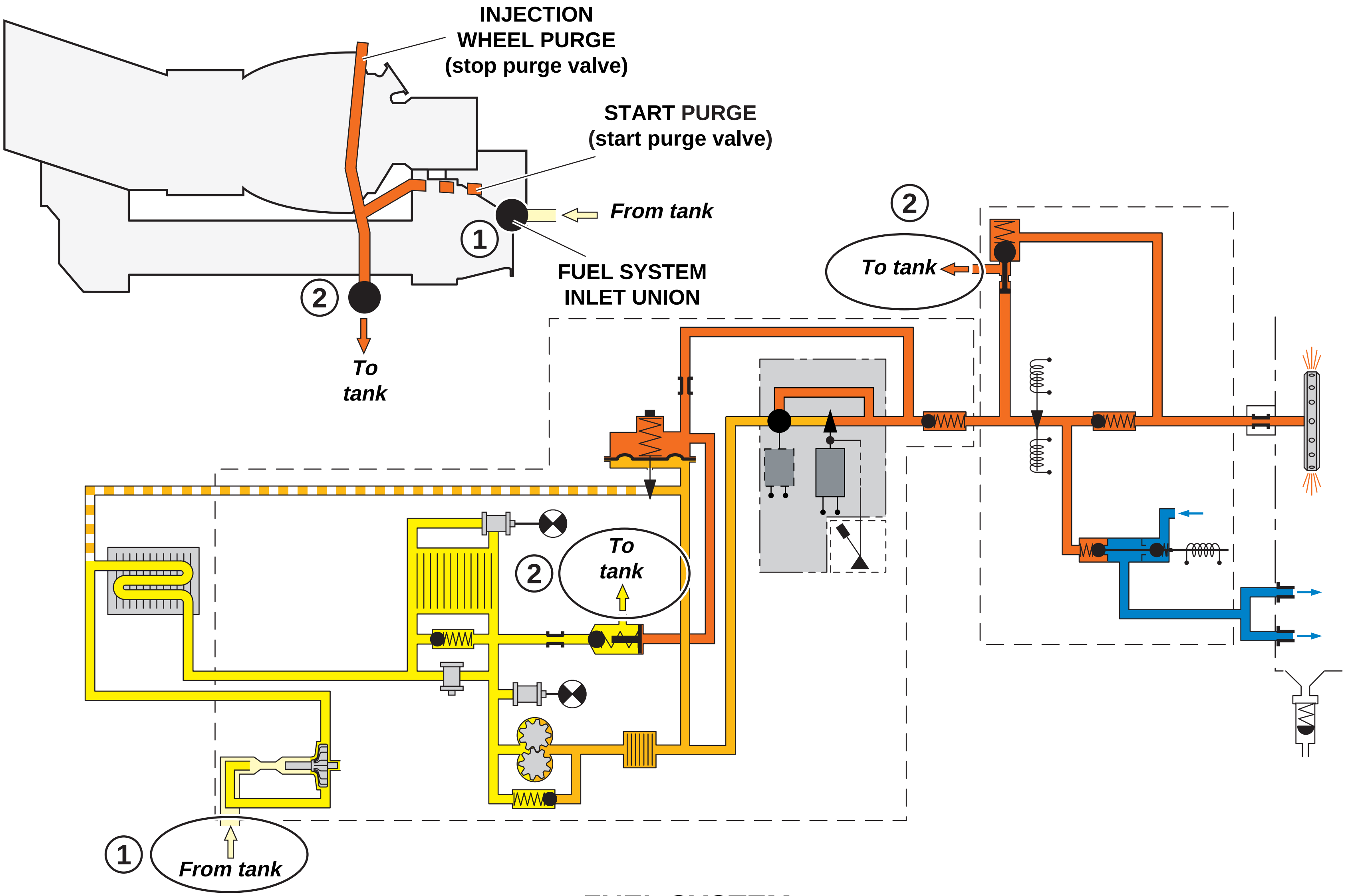
OIL SYSTEM
ENGINE SYSTEM INTERFACES (1)

ENGINE SYSTEM INTERFACES (2)

Fuel system

The engine is provided with:

- A fuel system inlet union
- A fuel return line (start purge and injection wheel purge) back to the tank.



FUEL SYSTEM
ENGINE SYSTEM INTERFACES (2)

ENGINE SYSTEM INTERFACES (3)

Drain system - Purge - Air vent

Function

To drain fluids from certain engine components.

Position

- Various pipelines on the engine connected to the aircraft drain system.

Main characteristics

- Stainless steel tubes.

Main components

- Combustion chamber drain valve
- Engine breather union
- Fuel pump drive drain
- Injection wheel purge
- Start purge valve outlet
- Exhaust pipe drain
- Output shaft seal drain.

Description

A drain collector is fitted on a bracket at the bottom of the accessory gearbox casing and is connected by a flexible pipe to an aircraft drain.

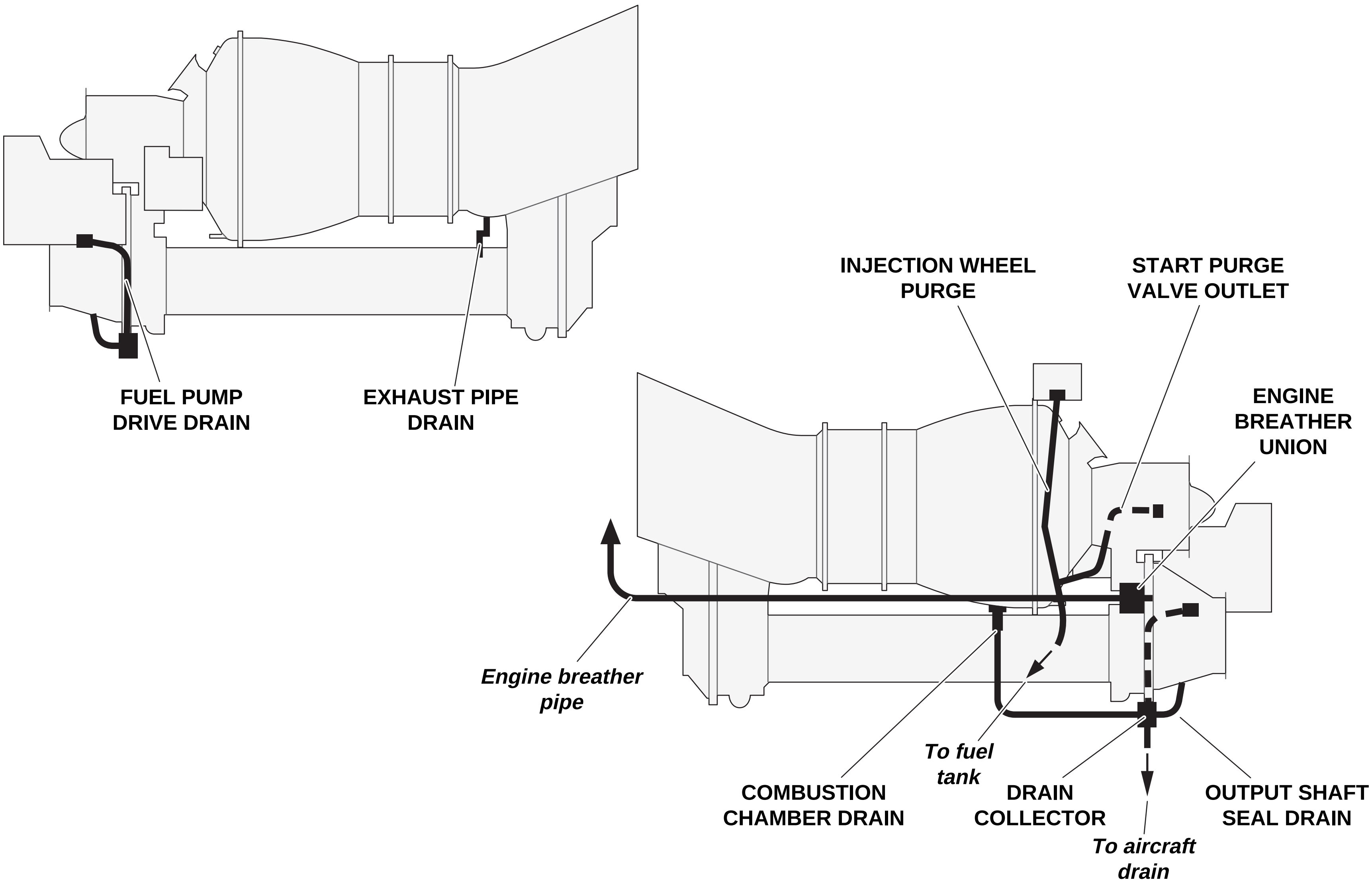
Three drain tubes are connected to the drain collector:

- The output shaft seal drain
- The fuel pump drive drain
- The combustion chamber drain.

The engine breather comprises a T union on the upper right side of the accessory gearbox. Connected to the front of this union is the oil tank breather and to the rear, the pipe which discharges into the exhaust.

The injection wheel purge drain and start purge valve drain connect to the aircraft to be returned to the tank.

The double exhaust pipe drain connects into one pipe which is connected to an aircraft overboard drain.



DRAIN SYSTEM - PURGE - AIR VENT

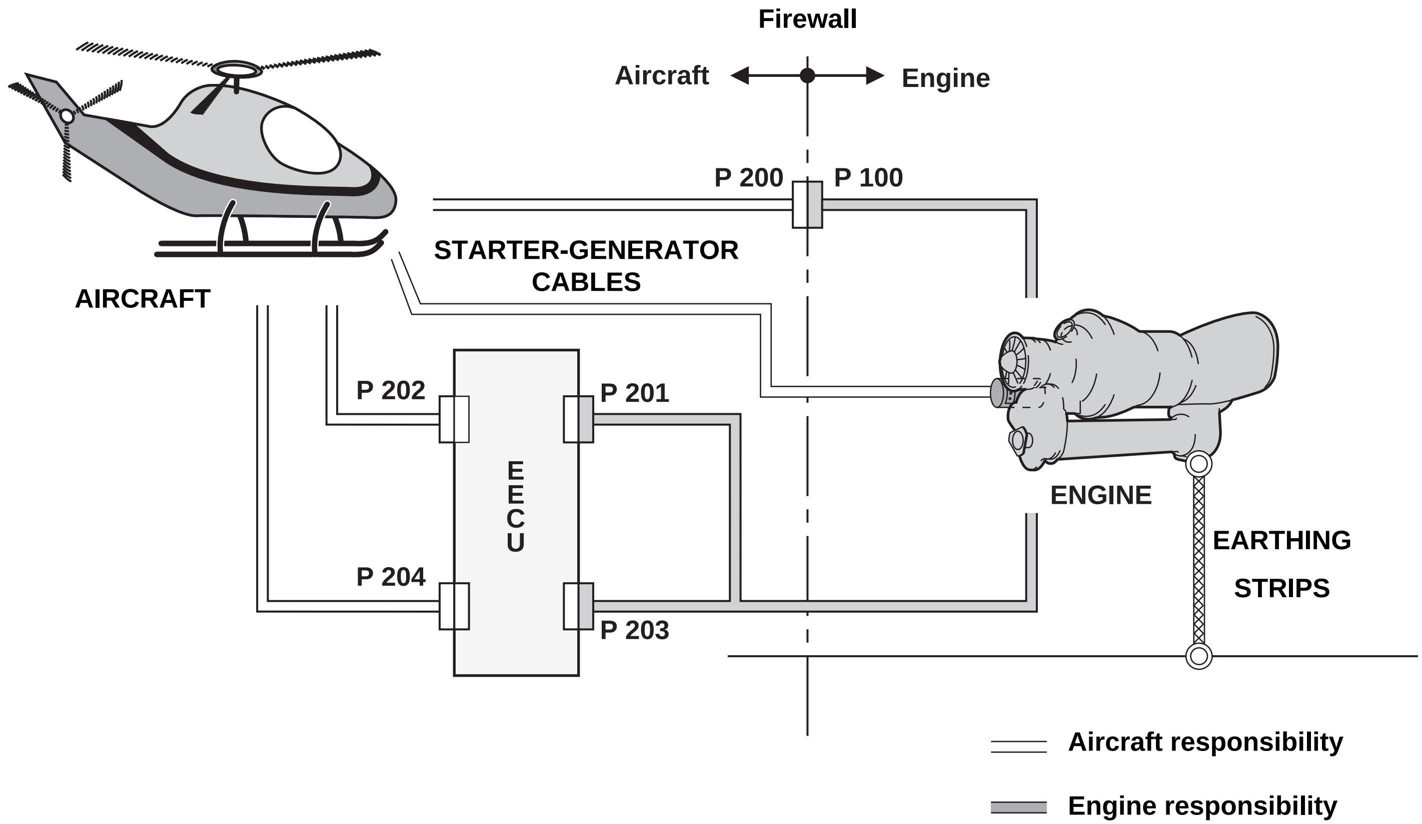
ENGINE SYSTEM INTERFACES (3)

ENGINE SYSTEM INTERFACES (4)

Electrical system

The engine electrical harness is connected to the EECU installed in the airframe and to the aircraft electrical system by means of three connectors (P100, P201, P203).

There are also earthing strips and starter-generator cables.



ELECTRICAL HARNESSES

ELECTRICAL SYSTEM
ENGINE SYSTEM INTERFACES (4)

FIRE DETECTION

Function

The fire detection system detects overtemperature in the engine compartment and gives a cockpit indication.

Position

- One detector on the right of the accessory gearbox
- One detector on top of the pump and metering unit assembly
- One detector on the rear flange of the combustion chamber casing left side.

Main characteristics

- Sealed bi-metallic strip detectors.

Main components

- Three detectors
- Electrical harness
- Detection logic system and indication in airframe.

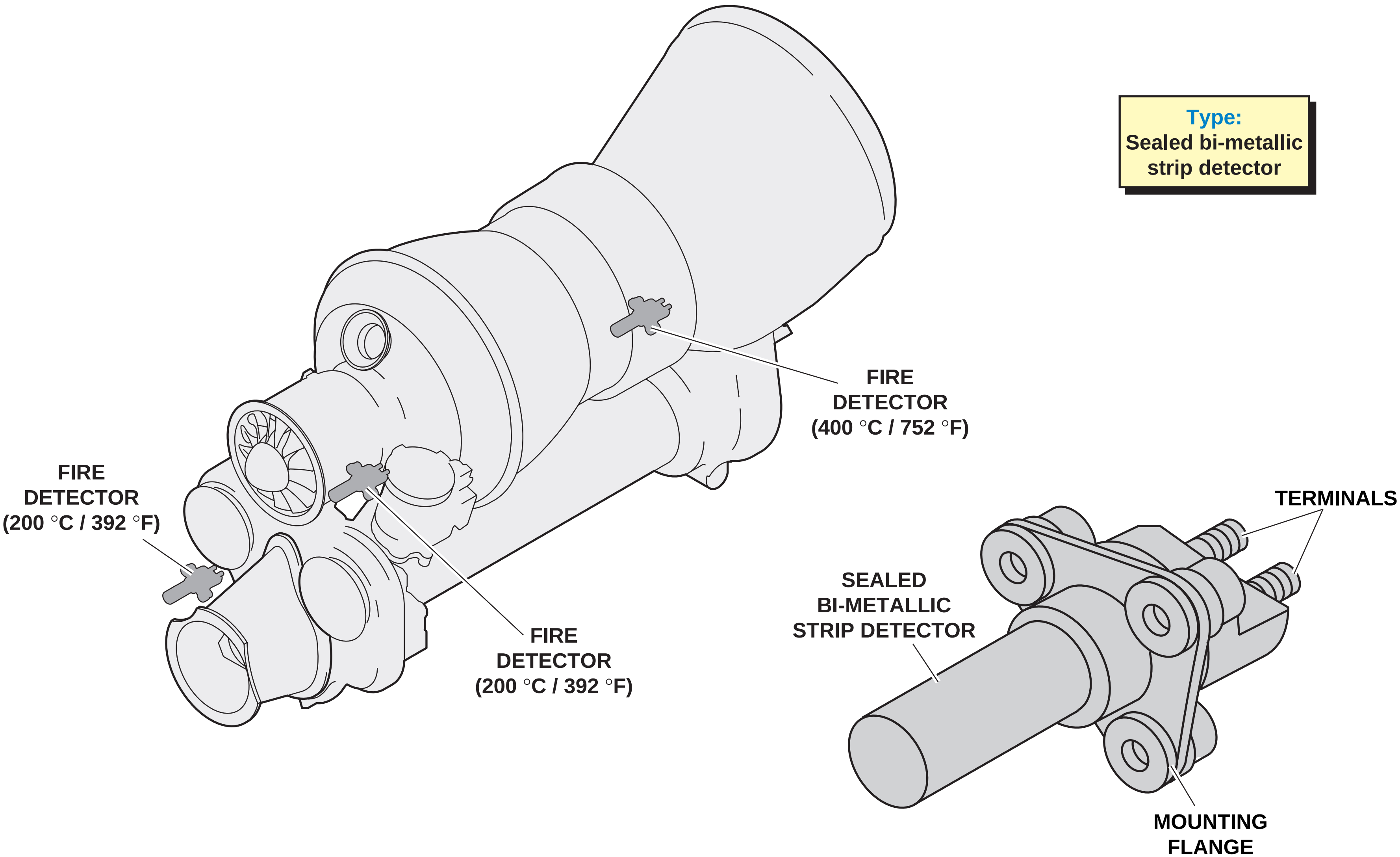
Functional description

Each fire detector comprises a bimetallic detector sealed in a steel tube.

Each detector is fitted by three bolts.

The two detectors on the accessory gearbox are set at: 200 °C (392 °F).

The one on the gas generator is set at: 400 °C (752 °F) .



FIRE DETECTION

12 - OPERATING LIMITATIONS AND PROCEDURES

OPERATING LIMITATIONS

All operating limitations are defined in the official documents:

- Flight manual

- Maintenance manual(s).

The main engine limitations are:

- Flight envelope

- Gas generator rotation speed N1

- Power turbine rotation speed N2

- t4.5 gas temperature

- Torque

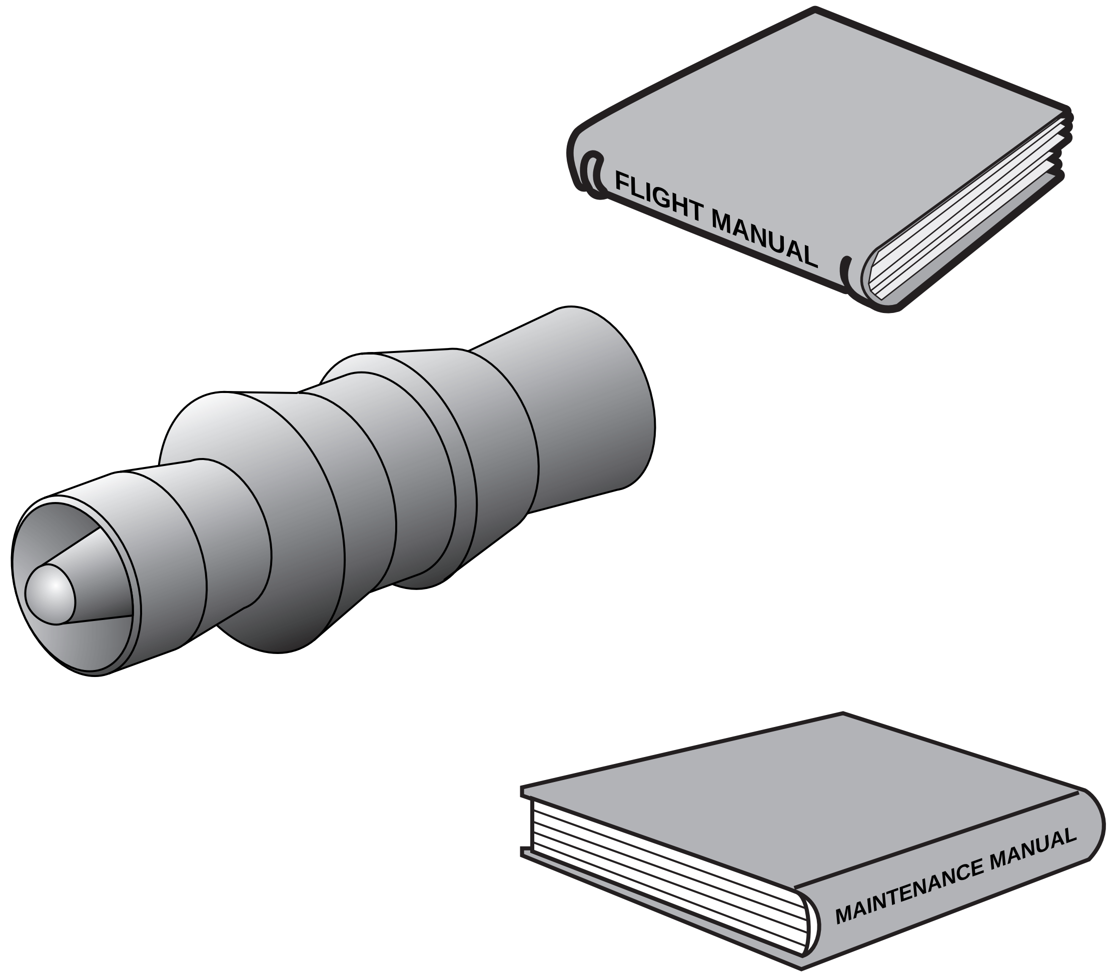
- Miscellaneous (load factors, vibration...).

The systems general limitations are:

- Pressure, flow, volume, voltage...

ENGINE AND SYSTEM LIMITATIONS

- **Flight envelope**
- **N1 rotation speed**
- **N2 rotation speed**
- **t4.5 gas temperature**
- **Torque**
- **Miscellaneous (load factors, vibration...)**
- **Pressure, flow, volume, voltage...**



OPERATING LIMITATIONS

OPERATING PROCEDURES (1)

The operating procedures are considered for training purposes only. Refer to the aircraft manual.

Pre-start checks

- Inspections, checks…

2B: Starting

- *Power "On"*
- *Move selector to "Idle"*
- *The engine starts and accelerates to idle speed (≈ 67 % N1). During start, check: N1, N2, t4.5, oil Pr and t°*
- *Selector moved to "Flight".*

The engine accelerates up to nominal rotor speed.

Note: *Starting can be selected by placing the control lever directly to the "flight" position.*

2B1: Starting

- *Power "On"*
- *Move twist grip to "Idle"*
- *Selector to "On"*
- *The engine starts and accelerates to idle speed (≈ 68 % N1)*
- *Twist grip moved to "Flight".*

The engine accelerates up to nominal N2 speed.

Shut-down

- After stabilisation: at idle
- Selector to "Stop". The engine shuts down: check the rundown time.

Dry crank

Ensure that N1 < 10 %

- Selector to "Stop"
- Press dry crank button (and maintained). The engine accelerates without ignition and fuel: dry crank should not exceed 20 seconds
- Release dry crank push button.

Relight in flight

- Move selector to "Stop" and return to "Flight".

Note*:* *Wait until N1 has decelerated. The start will commence automatically when the N1 is less than 17 %.*

PRE-START CHECKS

- Inspections, checks...

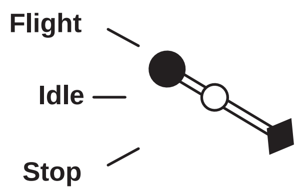
The operating procedures are considered for training purposes only. Refer to the aircraft manual.

STARTING (2B)

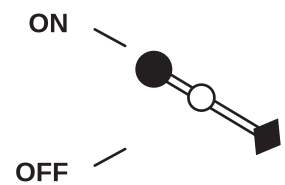
- *Power "On"*
- *Move selector "Stop - Idle - Flight" to "Idle"*
- *Selector moved to "Flight"*

STARTING (2B1)

- *Power "On"*
- *Move twist grip to "Idle"*
- *Selector to "On"*
- *Twist grip moved to "Flight"*



2B VERSION



2B1 VERSION

SHUT DOWN

- After stabilisation: at idle
- Selector to "Stop"
- Check the rundown time

DRY CRANK

- Selector to "Stop"
- Press Dry crank push button (and maintained)
- Ventilation should not exceed 20 seconds
- Release dry crank push button

RELIGHT IN FLIGHT

- Move selector to "Stop" and return to "Flight"

OPERATING PROCEDURES (1)

OPERATING PROCEDURES (2)

Flight

- Selector in "Flight" position
- Automatic control: monitor engine parameters and especially the N1 indication.

2B: Control system total failure

The fault is indicated and the manual control procedure can be applied ("plus" and "minus" range): close monitoring of parameters.

2B1: Control system total failure

If both EECU channels can not control fuel flow, the N2 speed will be automatically maintained at 100 % by the automatic back-up control system.

2B: Training to control system failure

- *"Manual" selection of the "Manual " / "Auto" selector*
- *Manual control procedure.*

Note 1: *Return to normal mode possible at any time but preferably from a stable condition.*

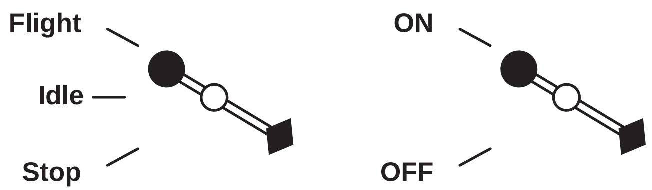
Note 2: *If the manual control procedure is applied without selecting "Manual", the operating mode is the "mixed mode".*

2B1: Automatic backup test procedure

On the EC 130, a periodic test of the automatic back-up control system must be carried out.

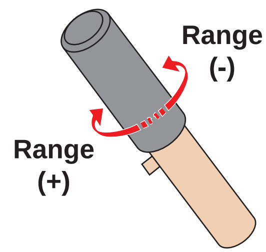
This procedure is described in the flight manual and requires selection of manual mode to test the system.

FLIGHT



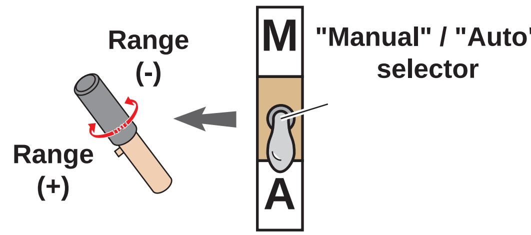
2B VERSION *2B1 VERSION*

CONTROL SYSTEM TOTAL FAILURE (2B)

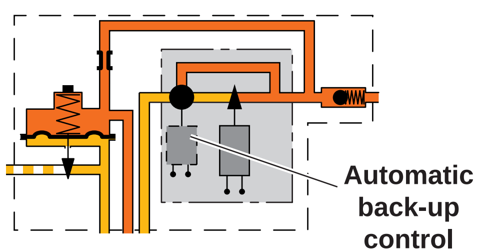


TRAINING TO CONTROL SYSTEM FAILURE (2B)

(Training to manual mode)



CONTROL SYSTEM TOTAL FAILURE (2B1)



AUTOMATIC BACKUP TEST PROCEDURE (2B1)

OPERATING PROCEDURES (2)

13 - VARIOUS ASPECTS OF MAINTENANCE

MAINTENANCE CONCEPT

Introduction

The engine is designed to have a high availability rate with reduced maintenance.

The main aspects of the maintenance concept are the following:

- Effective modularity
- Good accessibility
- Reduced removal and installation times
- On-condition facility
- Quick repair.

Maintenance levels

Four maintenance levels can be considered:

First line maintenance: engine installed on the aircraft (O level).

- Scheduled and preventive maintenance
  - Checks and inspections
  - Life limit or completed TBO removal
- Corrective maintenance
  - Fault detection
  - Component replacement (LRU)
  - Check.

Second line maintenance: engine maintenance in shop (I level).

- Corrective maintenance: SRU and module removal and installation.

Third line maintenance: deep maintenance which involves module repairs (H level).

- Corrective maintenance: component replacement.

Fourth line maintenance: overhaul and repair in specific shop (D level).

- Maintenance scheduled when the TBO is completed or when the life limit of a component is reached
- Corrective maintenance.

Other aspects of maintenance

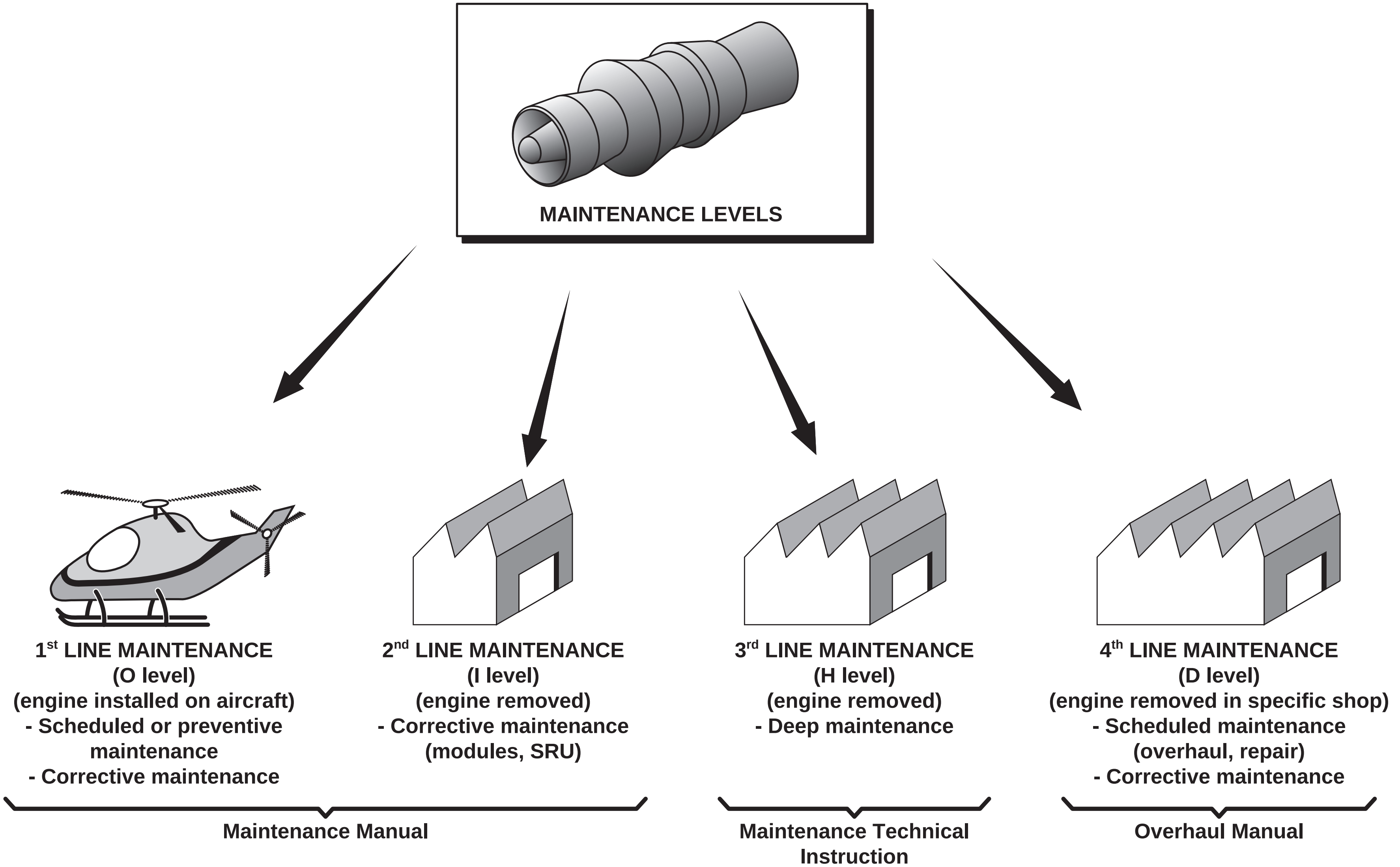
Refer to the following pages.

Note 1: *LRU - Line Replaceable Unit*

SRU - Shop Replaceable Unit.

Note 2: *The maintenance steps are determined by the operator taking into account the difficulties, the personnel and logistic considerations.*

As far as the engine manufacturer is concerned, the current maintenance procedures (1st, 2nd line) are defined and described in the maintenance manual. Deep maintenance (3rd line) and general overhaul (4th line) are described in other documents and are subject to particular license agreements.



MAINTENANCE CONCEPT

TBOs AND LIFE LIMITS

Engine, module and accessory TBOs

TBOs (operating Time Between Overhauls) are defined for the engine, the modules and some accessories. These TBOs, determined by tests and experience, are subject to an extension programme.

The TBO is expressed in operating hours.

Component life limits

Certain components (mainly rotating parts such as compressor, turbines, injection wheel…) have a life limit which requires the part to be scrapped when the limit is reached.

The life limit is expressed in operating cycles.

Calendar limits

The calendar limit is the time (expressed in years) after which the complete engine, module or part subjected to calendar limit has to be returned to the factory or an approved repair center.

The count starts at the engine first intallation in the aircraft (since new, overhaul or repair).

Counting of hours and cycles

A cycle is a clearly defined operating sequence. Cycle counting is effected either manually or automatically. The method of counting cycles and the various limits are described in Chapter 5 of the maintenance manual.

A counting check (comparison between automatic counting and manual counting) is a procedure planned in the periodic maintenance.

A simple check can be carried out by comparing the two engine readings for a given period of operation.

TBO components (flight hours)

The TBO is expressed in operating hours:

- Engine
- Modules
- Some accessories.

Life limited components (N1 or N2 cycles)

Life limits are expressed in operating cycles:

- Axial and centrifugal compressors (N1 cycles)
- Injection wheel (N1 cycles)
- Turbines (N1 or N2 cycles).

Consumable and repairable components (examples)

- Oil pumps (repairable)
- EECU (repairable)
- Igniter plug, start injector (consumable).

On-condition components (examples)

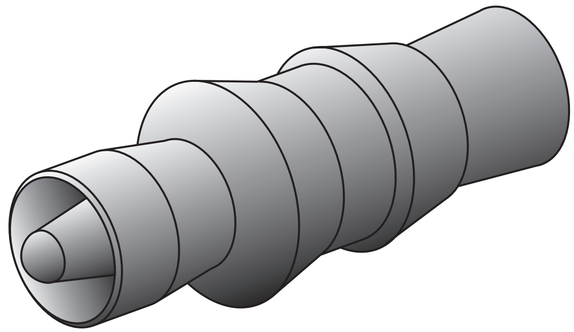
- Engine, engine components, ...

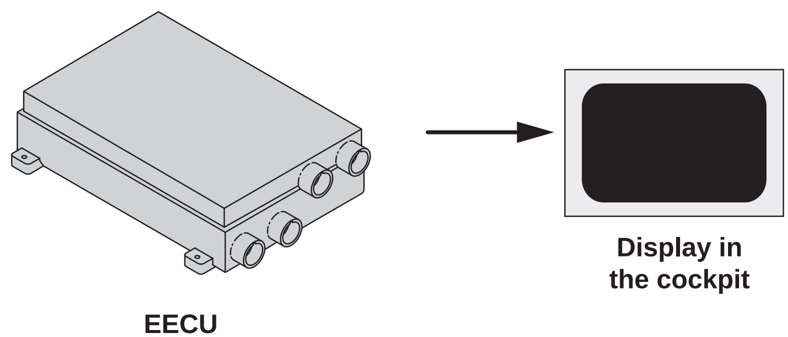
TBO
- Engine
- Modules
- Accessories

LIFE LIMITS
Cycles for:
- Compressors
- Turbines
- Injection wheel

CALENDAR LIMITS
Time limits:
- Engine
- Modules
- Accessoires
(since new, overhaul or repair)

COUNTING
- Manual counting
- Automatic counting
- Counting check





AUTOMATIC COUNTING

TBOs AND LIFE LIMITS

PREVENTIVE MAINTENANCE

Preventive maintenance includes the procedures which must be systematically carried out and the procedures which are recommended.

Refer to maintenance manual (chapter 05-20-00).

Servicing inspections

- Inspection before the first flight of the day
- Inspection after the last flight of the day.

Periodic inspections

- These procedures can be "blocked" (at fixed intervals for all the procedures) or staggered (each procedure is distributed over a period of time to reduce the turnaround time while still respecting the intervals)
- Visits are scheduled as a function of flight hours (ex: every 500 hours) or calendar (ex: 2 years)
- Special inspections:
  - Particular inspections
  - Inspections according to airworthiness.

The procedures are also qualified as follows:

- **Mandatory** maintenance inspections.

  The actions to be carried out to meet the Airworthiness objectives are listed in the table of the mandatory maintenance tasks.

- **Required** maintenance inspections.

  The engine manufacturer considers that the tasks of the required maintenance inspections, listed in the table, although not affecting directly the flight security, must be performed.

- **Recommended** maintenance inspections.

  The tasks of the recommended maintenance inspections, listed in the table, are advised by the engine manufacturer in order to improve the reliability, the availability and reduce the operating cost of the engine.

Main inspection points of preventive maintenance

- Visual inspections
- Run-down check
- Magnetic plug and filter inspection
- Oil sampling for analysis
- Oil level checks
- Compressor cleaning (according to operating conditions)
- Operating checks and ground run test
- EECU data operation:
  - Hour counting check
  - Cycle counting check
  - Mode check.

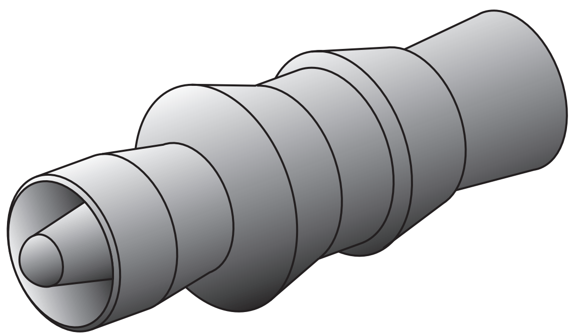
SERVICING INSPECTIONS

- Inspection "before the first flight of the day"
- Inspection "after the last flight of the day"

REFER TO MAINTENANCE MANUAL

PERIODIC INSPECTIONS

- Procedure "blocked" or "staggered" (flight hours or calendar schedule)
- Special inspections



- Mandatory
- Required
- Recommended

MAIN INSPECTION POINTS

- Visual checks
- Run-down check
- Inspection of filters
- Inspection of magnetic plugs
- Oil sampling (for analysis)
- Oil level (and replenishment if required)
- Compressor cleaning (depending on operating conditions)
- Ground run test
- EECU data operation

PREVENTIVE MAINTENANCE

ON-CONDITION MONITORING

When applying on-condition maintenance, the maintenance procedures are carried out according to the condition of engine components. It requires a monitoring which includes appropriate procedures studied during the engine design.

Objectives of on-condition monitoring

The objective is to increase safety and to reduce maintenance costs.

This is obtained as the monitoring ensures an early diagnosis of anomalies which could have serious consequences; on the other hand, monitoring avoids unnecessary maintenance tasks.

On-condition monitoring resources

On-condition monitoring implies an appropriate design of the engine which allows the use of monitoring tools.

The following procedures are available:

- **Borescopic inspection**: this permits inspection of internal parts which are not accessible without disassembly: compressor, combustion chamber and turbine. A special tool is used to allow direct visual inspection of the parts.

- **Lubrication oil check**: various methods are used to check for the contamination of the oil (magnetic plugs, strainers sampling). Samples of oil are taken at regular intervals and the samples are analysed to measure the contamination and anticipate incipient failures (analysis by magnetoscopy, ferrography, spectrometric oil analysis)

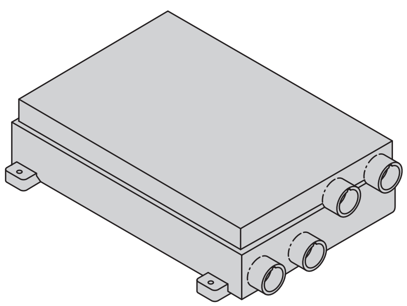
- **Vibration level check**: the vibration level of the rotating assemblies gives an indication of the engine condition. Sensors installed at given points are used to measure the vibration level. This type of check is carried out during periodic inspections or according to engine condition

- **Health monitoring**: the monitoring is ensured by means of the Engine Electronic Control Unit (refer to "CONTROL SYSTEM" chapter and Flight Manual)

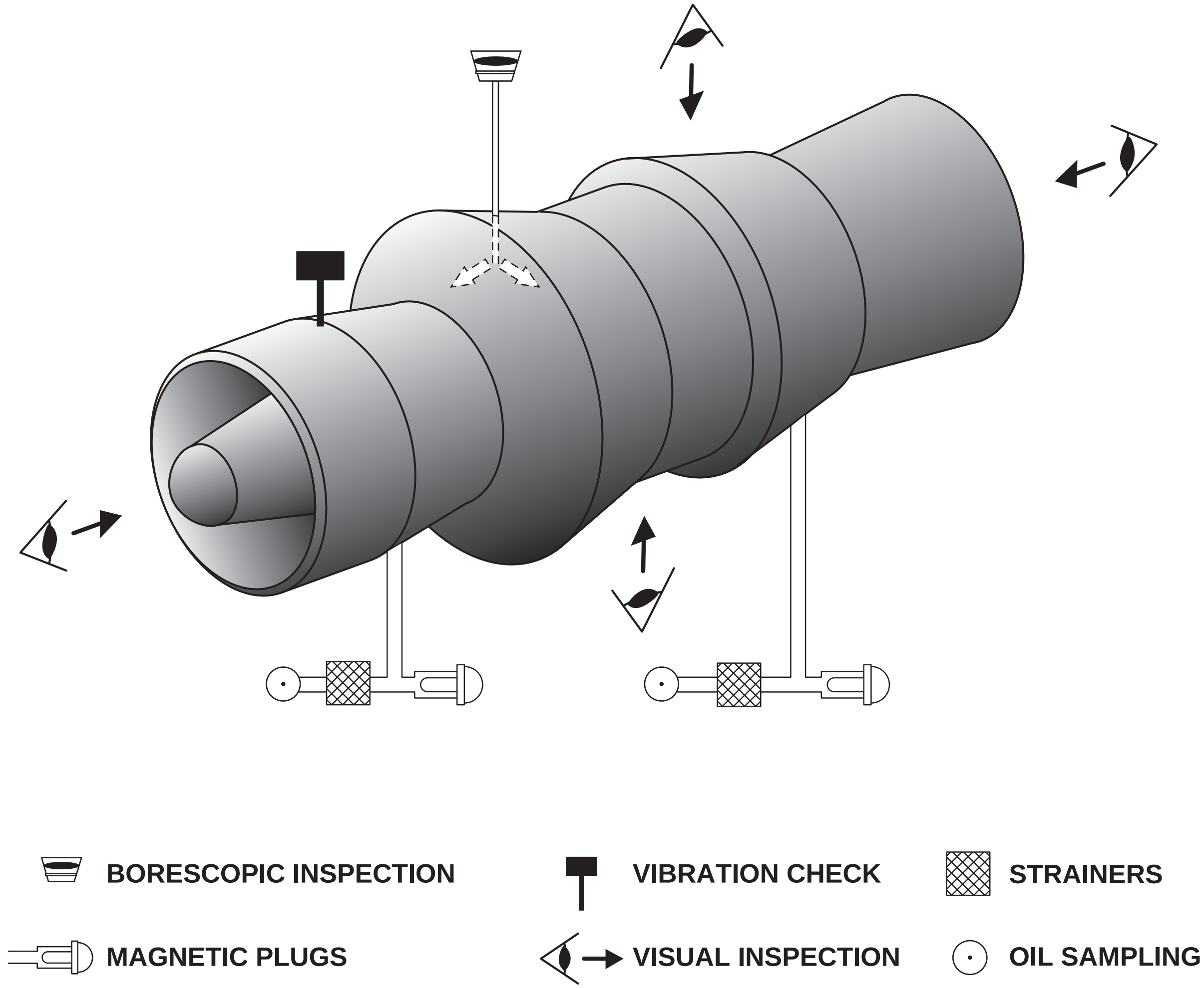
- **Visual inspection**: conventional visual inspections are also considered for on-condition monitoring (air intake inspection , exhaust pipe inspection, exhaust and engine external inspections…).

OBJECTIVES OF ON-CONDITION MONITORING

- To increase safety
- To reduce maintenance costs



HEALTH MONITORING



ON-CONDITION MONITORING

CORRECTIVE MAINTENANCE

Objective of corrective maintenance

The objective is to put the engine back into normal service as soon as possible. Corrective maintenance includes all procedures which must be carried out when required (failure, fault…). It implies general and particular activities.

Corrective maintenance main tasks

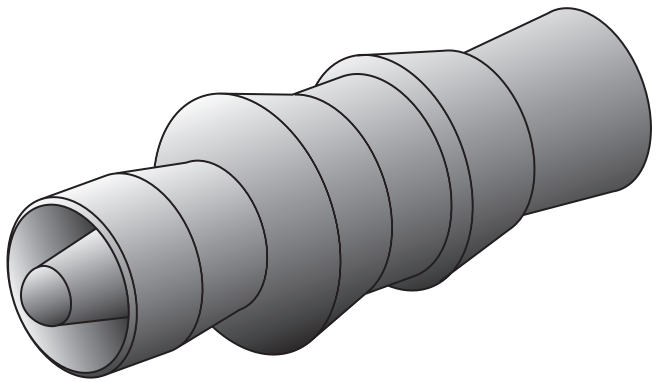
- **Fault finding** (refer to Maintenance Manual or Trouble Shooting Manual: Chapter 71.00.06)
- **Functional checks**
- **Condition checks**
- **Removal and installation:** removal and installation of the complete power plant, of the accessories and of the modules and of some engine components as required.

***Note**: Assembly and disassembly of the engine is dealt with in general overhaul and repair.*

- **Adjustments**
- **Miscellaneous procedures:** cleaning, storage…
- **Repair or replacement**
- **Particular instructions:** for example, procedures in the event of oil contamination, surge, heavy landing, handling accident, lightning...

OBJECTIVES OF CORRECTIVE MAINTENANCE

- To put the engine back into normal service as soon as possible



CORRECTIVE MAINTENANCE MAIN TASKS

- Fault finding
- Functional and condition checks
- Removal and installation
- Adjustments
- Miscellaneous procedures (cleaning, storage ...)
- Repair (or replacement)
- Particular instructions

CORRECTIVE MAINTENANCE

TECHNICAL PUBLICATIONS - GENERAL

This part deals with the engine technical documentation.

Operation documents

The operation documents are:

- The control documents (e.g.: flight manual)
- The management documents:
  - Engine log book (records and provides information on the engine status).

Maintenance documents

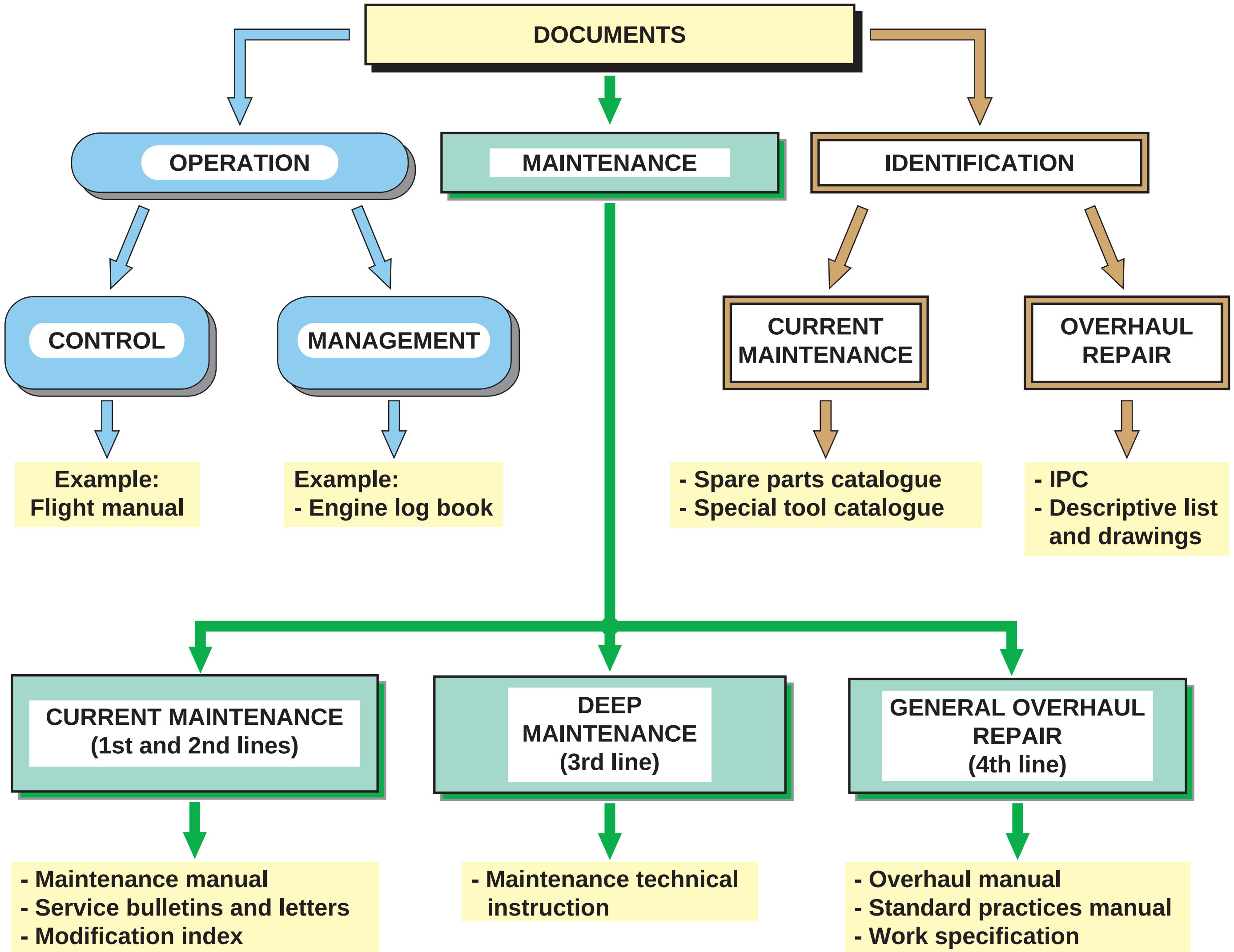
- The current maintenance documents are the following (1st and 2nd lines):
  - Maintenance manual (describes the engine and its systems and all the maintenance procedures)
  - Service bulletins (approved by the authorities, and issued to inform the operators of a modification or an instruction which affects the operational aspects)
  - Service letters (letter sent to inform the operator of certain instructions related to the operation of the engine)
  - Modification index
- The general overhaul and repair documents (4th line):
  - Overhaul manual
  - Standard practices manual
  - Work specification
- The deep maintenance instructions (3rd line):
  - Maintenance technical instruction.

Identification documents

The identification documents are:

- The current maintenance documents:
  - Spare parts catalogue (list and reference of all the spare parts)
  - Special tool catalogue (tool designations and references)
- Overhaul and repair documents:
  - Illustrated parts catalogue (illustrates in detail all the engine and accessory parts; only used for general overhaul)
  - Descriptive list and drawings.

***Note**: Before all maintenance procedures:*
- Refer to official documentation
- Use the documentation "in a rational way"
- Make sure that documentation is up-to-date.



TECHNICAL PUBLICATIONS - GENERAL

TECHNICAL PUBLICATIONS - ADVISORY NOTICES

Three types of advisory notice are used in the technical publications:

- WARNING
- CAUTION
- NOTE.

Interpretation

WARNING: warns the reader of the possibility of physical harm (e.g.: wounding, intoxication, electrocution).

CAUTION: warns the reader of the possibility of damaging the engine or tooling.

NOTE: gives the reader advice on how best to carry out a task.

Examples

WARNING: do not breath the oil fumes. Do not leave oil in contact with the skin.

CAUTION: if the flush is being carried out because of metal particles in the oil system, change the filter and thoroughly clean the tank.

NOTE: take the oil sample before carrying out any replenishment.

WARNING
(physical harm)

Examples:

- **Toxicity of engine oil and vapours**
- **Toxicity of cleaning products**
- **Toxicity of extinguishing products**
- **Eye protection**
- **Fire risk**
- **Electrical discharge from ignition units:**
    - **electrocution**
    - **risks with use in an inflammable atmosphere**
- **……**

CAUTION
(possibility of damage)

Examples:

- **Titanum part cleaning**
- **Scrapping of O'ring seals**
- **Use of the correct cleaning products**
- **Engine cooling**
- **Engine cleaning after use of extinguishing product**
- **Orifice protection during removal**
- **Borescope fragility**
- **Tightening torque**
- **……**

NOTE
(advice)

Examples:

- **Oil analysis**
- **Cycle counting**
- **Installation of O'ring seals**
- **Engine storage**
- **Insulation measurements**
- **Procedural change with modification**
- **……**

TECHNICAL PUBLICATIONS - ADVISORY NOTICES

14 - MAINTENANCE PROCEDURES

1ST LINE MAINTENANCE PROCEDURES (O LEVEL)

The 1st line maintenance procedures are described in the Maintenance Manual and can be carried out on the engine installed, in the airframe.

They include:

- Preventive maintenance procedures
- Corrective or unscheduled maintenance procedures (engine installed).

These 1st line procedures are listed in the following pages in two groups:

- Check and servicing procedures
- LRU removal and installation procedures.

Note 1: *LRU - Line Replaceable Unit*

Note 2: *Refer to maintenance manual before carrying out any maintenance procedure.*

Refer to maintenance manual before carrying out any maintenance procedure.

1st line	CHECK AND SERVICING PROCEDURES

ENGINE

- Rundown time check	(71-02-09)
- Cycle counting manual	(73-21-00)
- Engine storage procedure	(71-05-01)
- Borescopic inspection of the combustion chamber	(72-00-43)
- Borescopic inspection of the gas generator turbine	(72-00-43)
- Inspection of the axial compressor blades (impacts, erosion measurement,...)	(72-00-32)
- Compressor cleaning and washing	(71-01-00)

OIL SYSTEM

- Oil change	(79-00-00)
- Oil pressure check	(79-00-00)
- Oil sampling for analysis	(71-02-08)
- Oil dilution check	(70-02-00)
- Oil filter replacement	(72-61-00)
- Fuel - oil heat exchanger	(72-61-00)
- Oil filter pre-blockage indicator reset	(72-61-00)
- Mechanical magnetic plug : magnetism check	(72-61-00)
- Electrical magnetic plug : magnetism check and electrical test	(79-38-00)
- Low oil pressure switch test	(79-31-00)

1/3

(XX-XX-XX): Page references which deal with the subject in the maintenance documentation

1ST LINE MAINTENANCE PROCEDURES (O LEVEL)

Refer to maintenance manual before carrying out any maintenance procedure.

1st line	CHECK AND SERVICING PROCEDURES

AIR SYSTEM
- **P3 pressure transmitter test ---------- (75-41-00)**
- **Check of the bleed valve operation ---------- (75-31-00)**

FUEL SYSTEM
- **Fuel filter replacement ---------- (73-23-11)**
- **Test of the fuel filter pre-blockage pressure switch ---------- (73-23-32)**
- **Fuel filter blockage indicator reset ---------- (__-__-__)**
- **Low fuel pressure switch test ---------- (73-23-33)**
- **Fuel valve assembly check ---------- (73-14-00)**
- **Fuel inlet union leak check ---------- (72-43-00)**
- **Permeability injection manifold check ---------- (72-00-43)**
- **Calibration of start injector penetration ---------- (72-43-00)**

CONTROL SYSTEM
- **Cycle counting check by the EECU ---------- (73-21-00)**

2/3

(XX-XX-XX): Page references which deal with the subject in the maintenance documentation

1ST LINE MAINTENANCE PROCEDURES (O LEVEL)

Refer to maintenance manual before carrying out any maintenance procedure.

1st line — **CHECK AND SERVICING PROCEDURES**

INDICATING SYSTEM

- N1 speed sensor test ---------- (77-11-00)
- N2 speed sensor test ---------- (77-12-00)
- Pyrometric harness test ---------- (77-21-00)
- Pyrometric harness inspection ---------- (77-21-00)
- Calibration of t4.5 conformation resistors ---------- (72-43-00)
- Calibration of torque sensor penetration ---------- (72-61-00)
- Calibration of torque conformation resistors ---------- (72-61-00)
- Vibration check ---------- (71-02-10)

STARTING SYSTEM

- Check of the high energy ignition unit operation ---------- (74-11-10)
- Calibration of igniter plugs penetration ---------- (72-43-00)

ELECTRICAL SYSTEM

- Electrical harness check and test ---------- (71-51-00)

3/3

(XX-XX-XX): Page references which deal with the subject in the maintenance documentation

1ST LINE MAINTENANCE PROCEDURES (O LEVEL)

Refer to maintenance manual before carrying out any maintenance procedure.

1st line — **LRU REMOVAL AND INSTALLATION PROCEDURES**

ENGINE
- Seal of the centrifugal breather cover (72-61-00)
- Seal of the starter-generator adaptor (72-61-00)
- Fire detectors (26-11-00)
- Drain collector (71-71-00)

OIL SYSTEM
- Oil valve assembly (79-25-00)
- Oil pump (79-24-00)
- Oil filter (72-61-00)
- Pre-blockage visual indicator (72-61-00)
- Strainers (72-61-00)
- Mechanical magnetic plugs (72-15-00)
- Electrical magnetic plug (79-38-00)
- Low oil pressure switch (79-31-00)
- Fuel-oil heat exchanger (72-61-00)
- Pressure transmitter (aircraft supply)

AIR SYSTEM
- P3 pressure transmitter (75-41-00)
- Compressor bleed valve (75-31-00)

FUEL SYSTEM
- Pump and metering unit assembly (73-23-00)
- Fuel filter (73-23-11)
- Blockage visual indicator (73-23-31)
- Pre-blockage pressure switch (73-23-32)
- Low fuel pressure switch (73-23-33)
- Fuel valve assembly (73-14-00)
- Engine fuel inlet union (72-43-00)
- Start injectors (72-43-00)
- Combustion chamber drain valve (71-71-00)

1/2

(XX-XX-XX): Page references which deal with the subject in the maintenance documentation

1ST LINE MAINTENANCE PROCEDURES (O LEVEL)

Refer to maintenance manual before carrying out any maintenance procedure.

1st line — **LRU REMOVAL AND INSTALLATION PROCEDURES**

CONTROL SYSTEM
- Engine Electronic Control Unit .... (73-21-00)

INDICATING SYSTEM
- N1 speed sensors .... (77-11-00)
- N2 speed sensors .... (77-12-00)
- Torque sensor .... (72-61-00)
- Torque conformation box .... (72-61-00)
- t4.5 conformation box .... (72-43-00)
- t4.5 thermocouple harness (x2) .... (77-21-00)

STARTING SYSTEM
- Starter-generator (aircraft supply)
- Ignition unit .... (74-11-10)
- Igniter plugs .... (72-43-00)
- Ignition cables .... (74-24-10)

ELECTRICAL SYSTEM
- Electrical harnesses .... (71-51-00)
- Alternator .... (72-61-00)

2/2

(XX-XX-XX): Page references which deal with the subject in the maintenance documentation

1ST LINE MAINTENANCE PROCEDURES (O LEVEL)

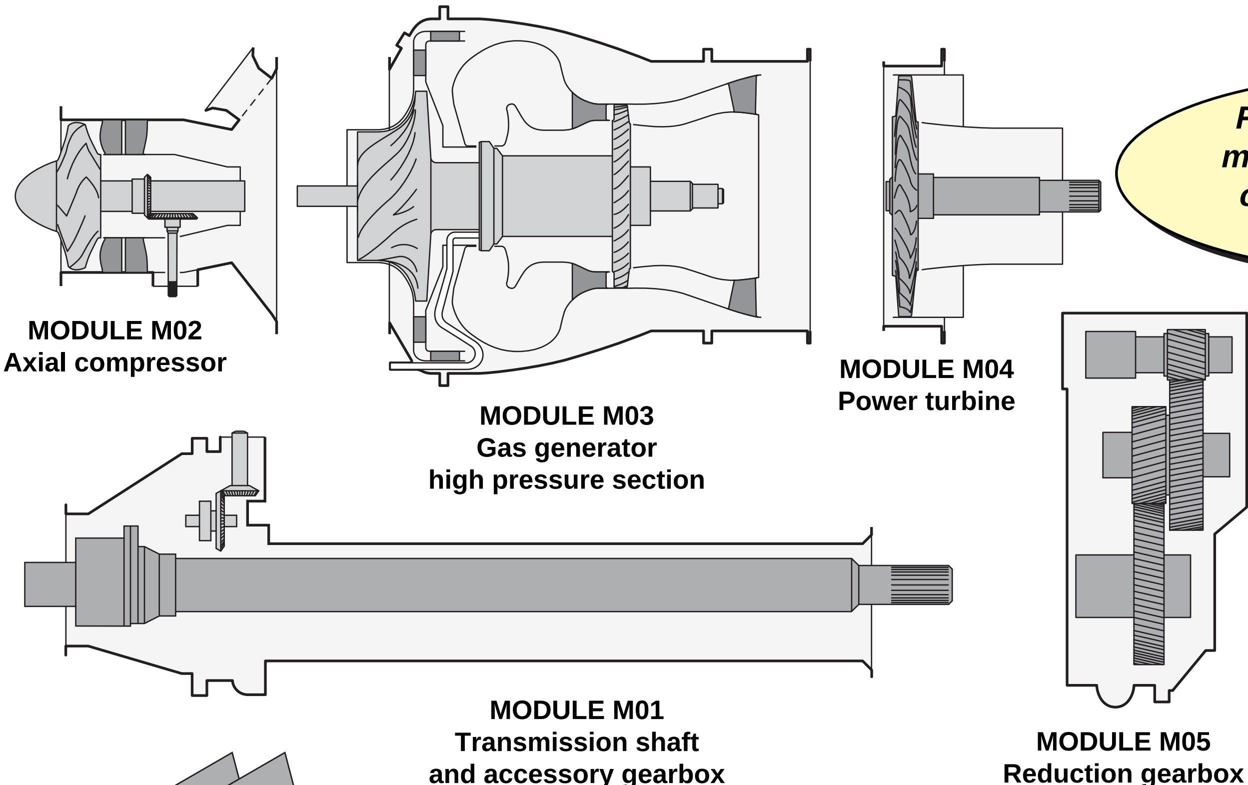
2ND LINE MAINTENANCE PROCEDURES (I LEVEL)

The 2nd line maintenance procedures are described in the Maintenance Manual and must be carried out on the engine removed from the airframe.

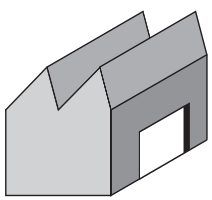
They consist of scheduled and unscheduled maintenance procedures, engine removed:

- Module removal and installation
- SRU removal and installation (e.g. output shaft seal, exhaust system...)

Note: *SRU: Shop Replaceable Unit.*



Refer to maintenance manual before carrying out any maintenance procedure.



2nd LINE MAINTENANCE (I Level)
- Engine removed
- Modules and SRU

SRU

- Output shaft seal
- Exhaust pipe
- ...

2ND LINE MAINTENANCE PROCEDURES (I LEVEL)

3RD LINE MAINTENANCE PROCEDURES (H LEVEL)

Definition

The 3rd line (or deep) maintenance procedures are carried out on removed major parts (e.g. modules) in a workshop.

They consist of replacement or reconditioning of subassemblies without repair or adjustment (e.g. injection wheel replacement).

Procedure

3rd Line Maintenance may be carried out on site by operators, provided that the operator has been formally trained, is in possession of the official updated documentation (technical instruction) and has received the corresponding TURBOMECA approval (periodically renewable).

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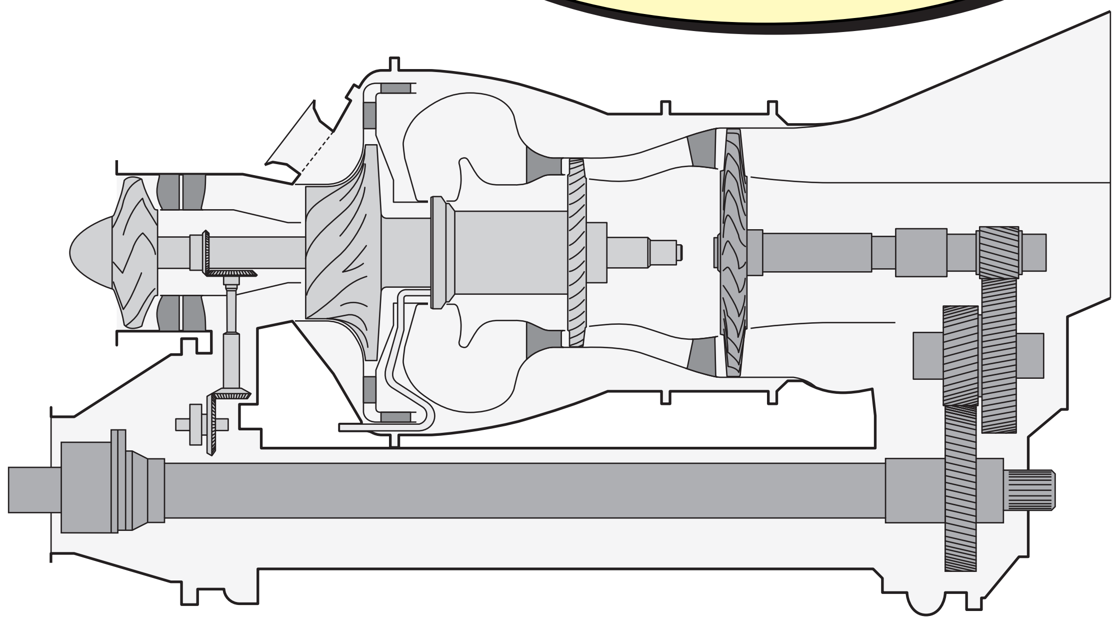
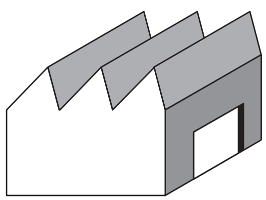




3rd LINE MAINTENANCE (H Level)
(engine removed)
- Deep maintenance

3RD LINE MAINTENANCE PROCEDURES (H LEVEL)

4TH LINE MAINTENANCE PROCEDURES (D LEVEL)

Repair and overhaul

Overhaul

Overhaul is a maintenance operation which is carried out when the engine (or module) has reached the end of its TBO, either in operating hours or cycles.

The overhauled engine (or module) is then put back into service with zero hours for a new TBO.

Repair

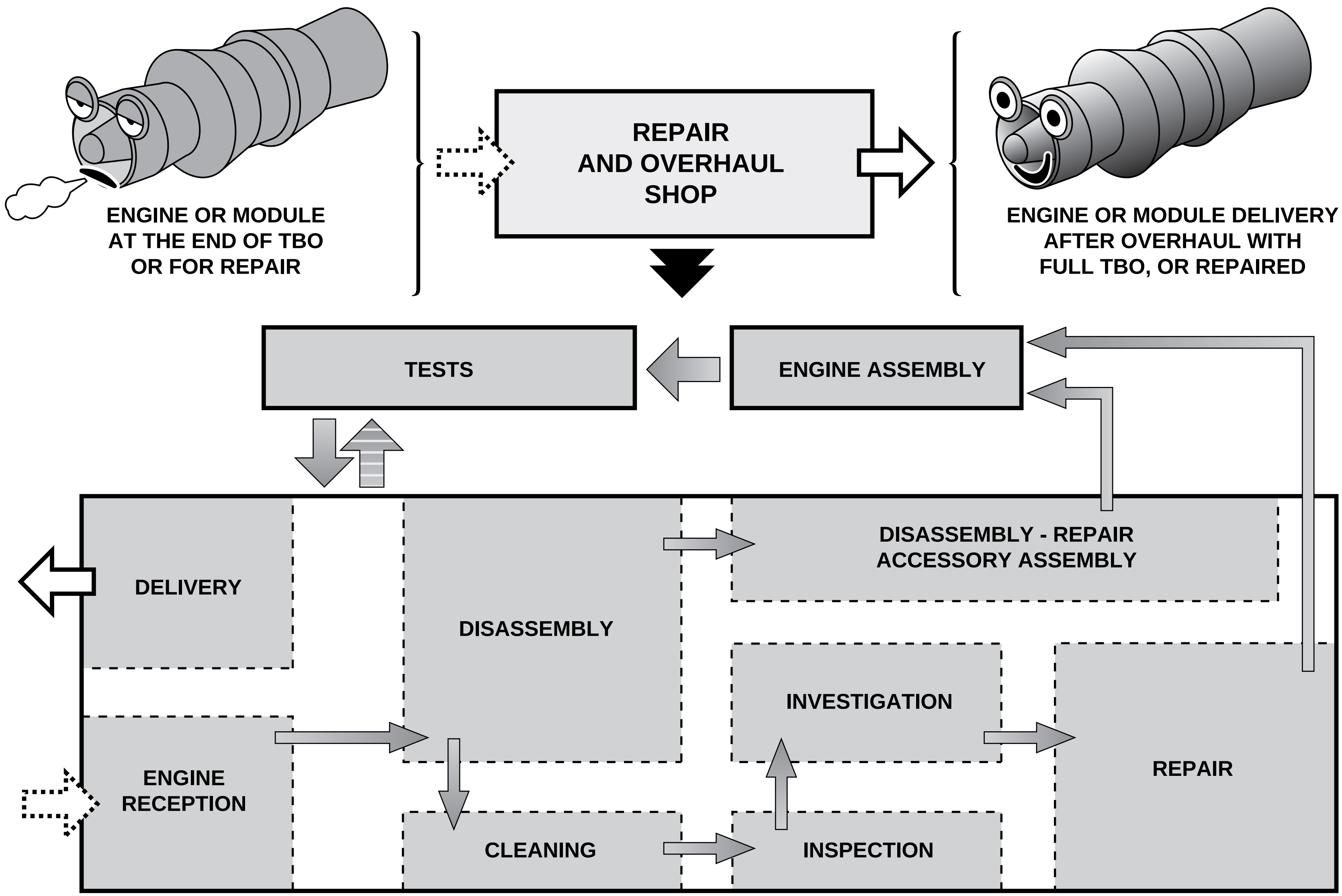
Repair is a maintenance operation which must be carried out when the engine (or module) is unserviceable.

After a repair, the engine (or module) is returned to service with a TBO according to the work carried out and the engine standard.

Note: *TBO: Time Between Overhaul.*

Main procedure steps

- Engine reception
- Disassembly
- Cleaning
- Inspection
- Investigation
- Repair
- Installation (of engine and accessories)
- Tests
- Delivery.



REPAIR AND OVERHAUL

4TH LINE MAINTENANCE PROCEDURES (D LEVEL)

15 - TROUBLE SHOOTING

GENERAL

Introduction

Trouble shooting is a very important aspect of maintenance.

Efficient diagnosis reduces the extra maintenance costs due to unjustified removals and additional diagnosis time.

In fact, even with a very high reliability product, failure is inevitable and required actions should be taken efficiently.

After the fault analysis which consists of finding the effect of a given failure, this section considers the case in reverse ; i.e.: finding the probable cause of a fault.

Repair procedure

The repair procedure should be guided by two main considerations:

- Minimum downtime

- Justified removal of components.

The procedure to be applied depends on the case but in general, a good knowledge of the product and a methodical research would permit a safe diagnosis and a quick corrective action.

Generally, the procedure includes failure identification, its analysis, the isolation of the faulty component, and the repair choice.

Inevitable

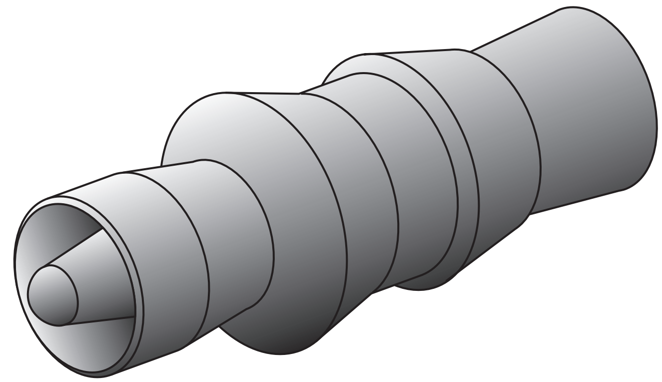
Random

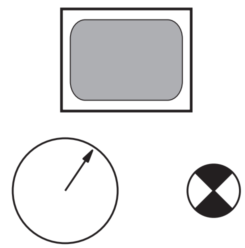
Fault
(single, double,
dormant)

Trouble shooting
- Diagnosis
- Remedy
- Repair
- Check

- Adequate means and procedures
- Training of personnel

MTTR
(Mean Time To Repair)
Total time required
for repairing





Or other perception

Symptoms (and other additional indications…)
All factors should be taken into consideration as well as the interactions.

Analysis of the fault

Identification of the faulty component

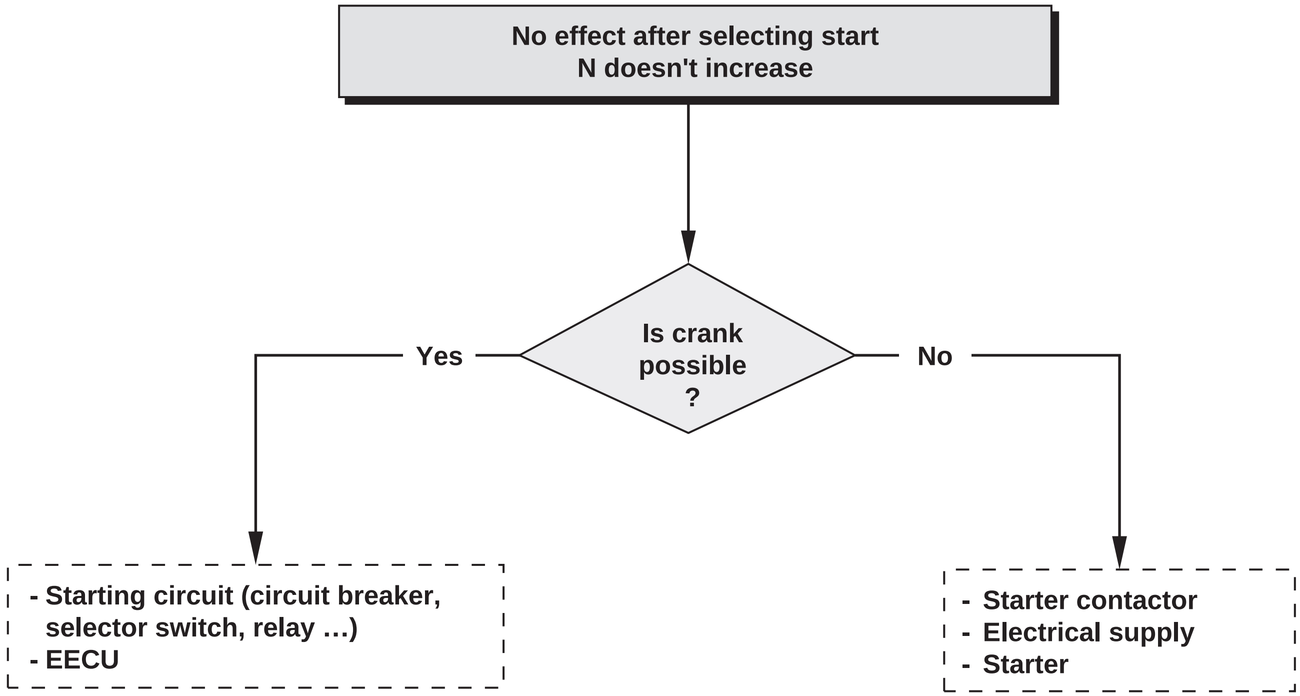
Additional checks

Deduction

Substitution

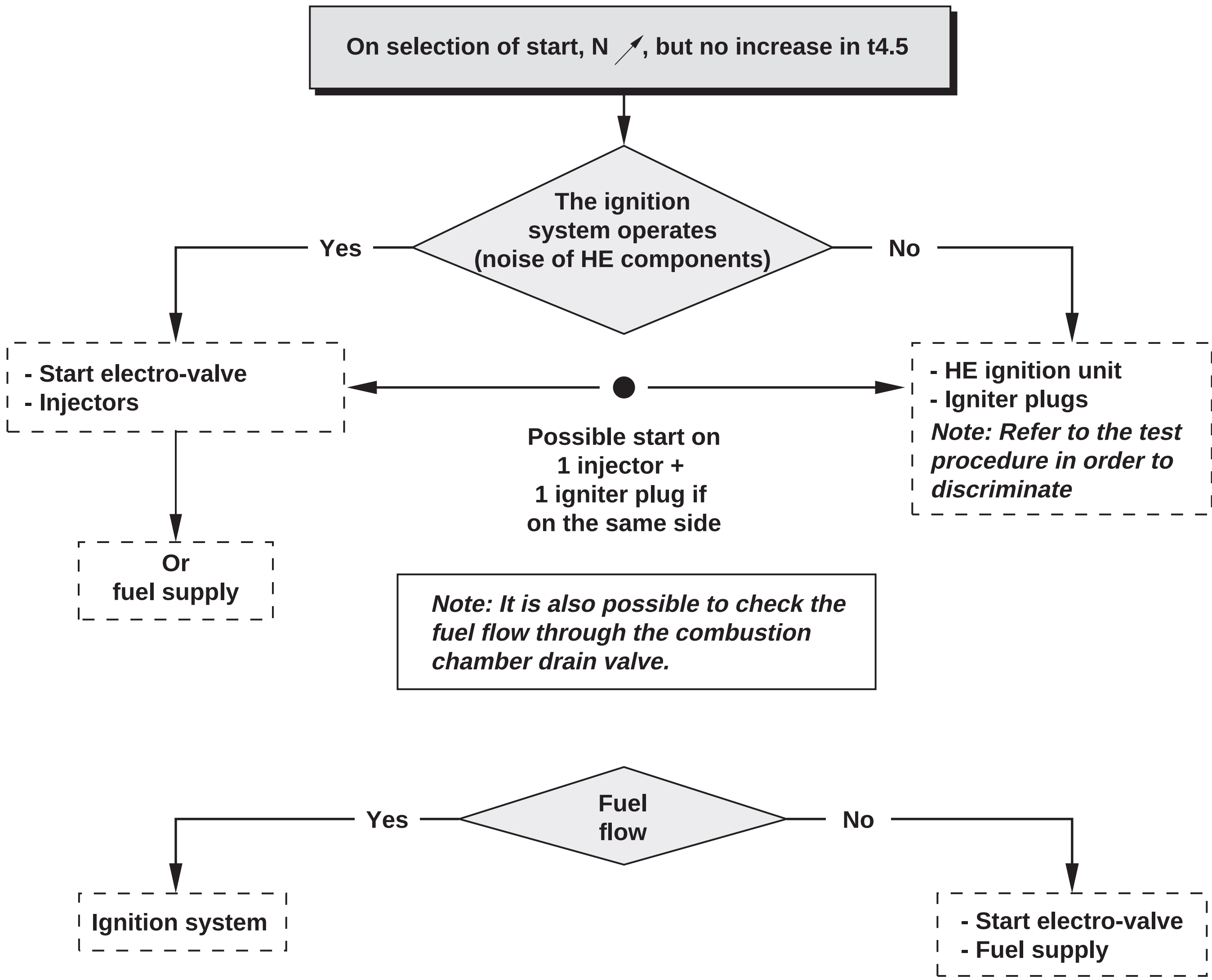
Remedy
(adjustment, replacement, cleaning, repair...)

GENERAL

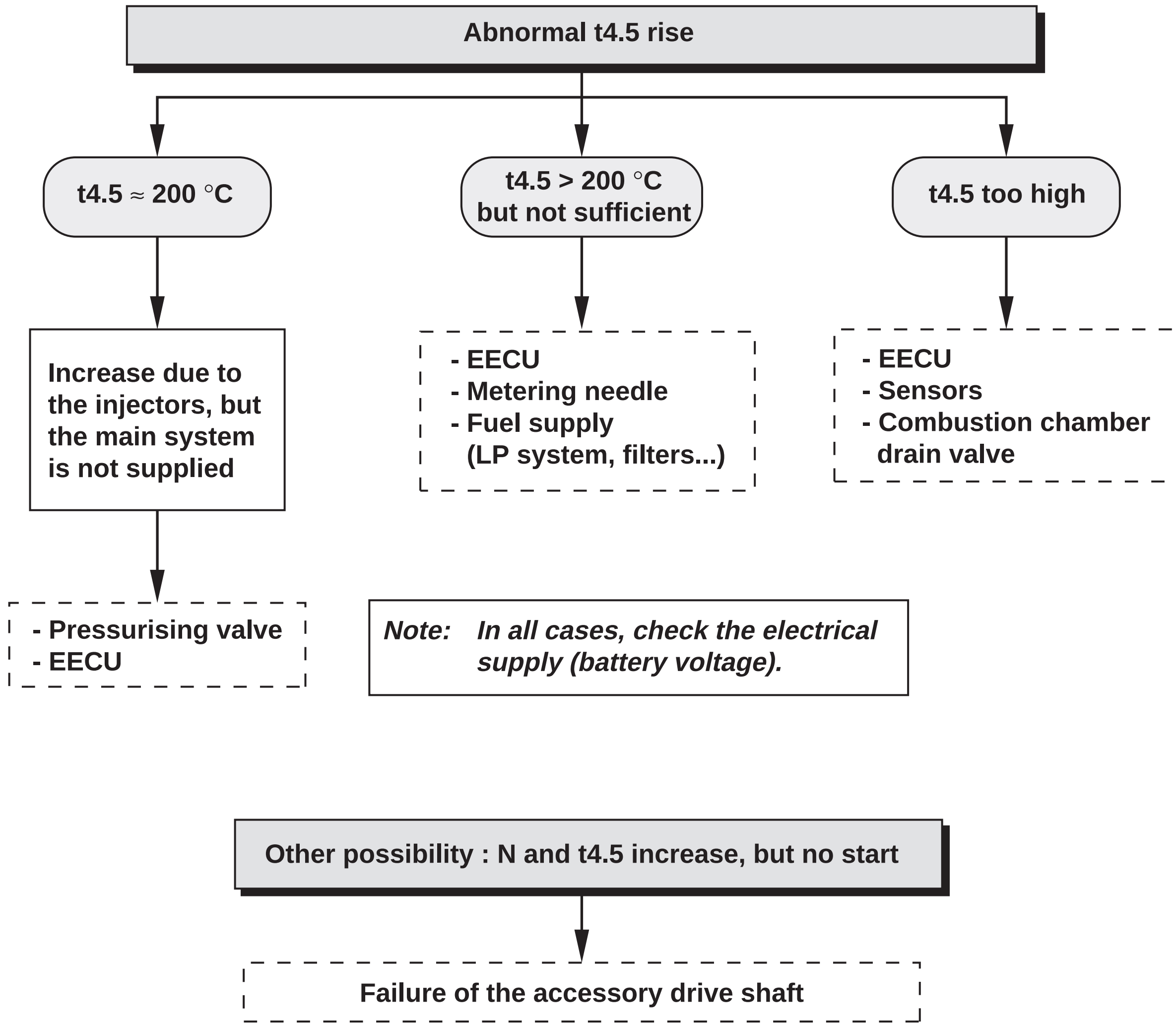


Note: Further tests (failure code, engaging noise of the contactor…) help locate the failure.

TROUBLE SHOOTING - STARTING FAULTS (1)



TROUBLE SHOOTING - STARTING FAULTS (2)



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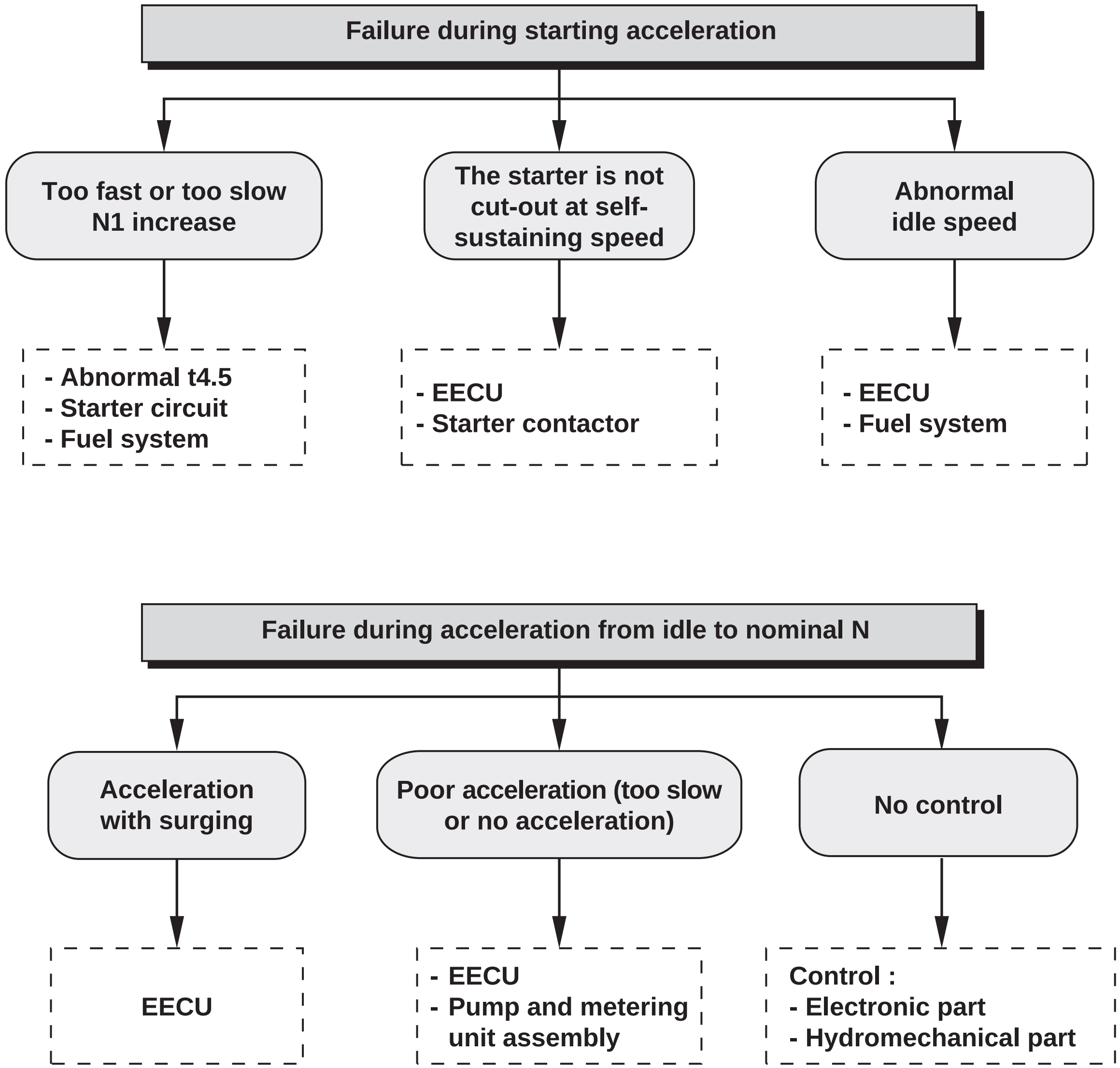
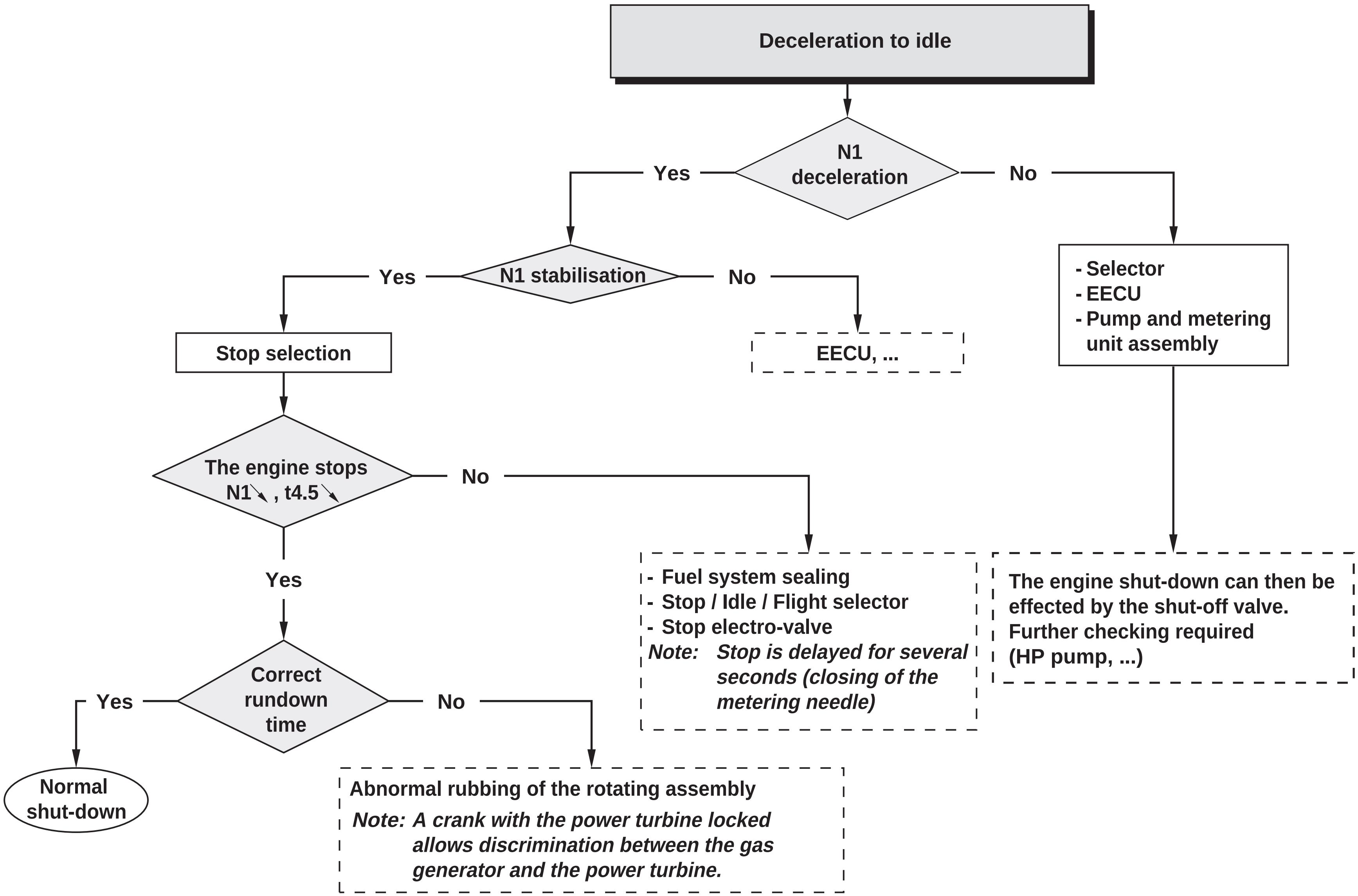
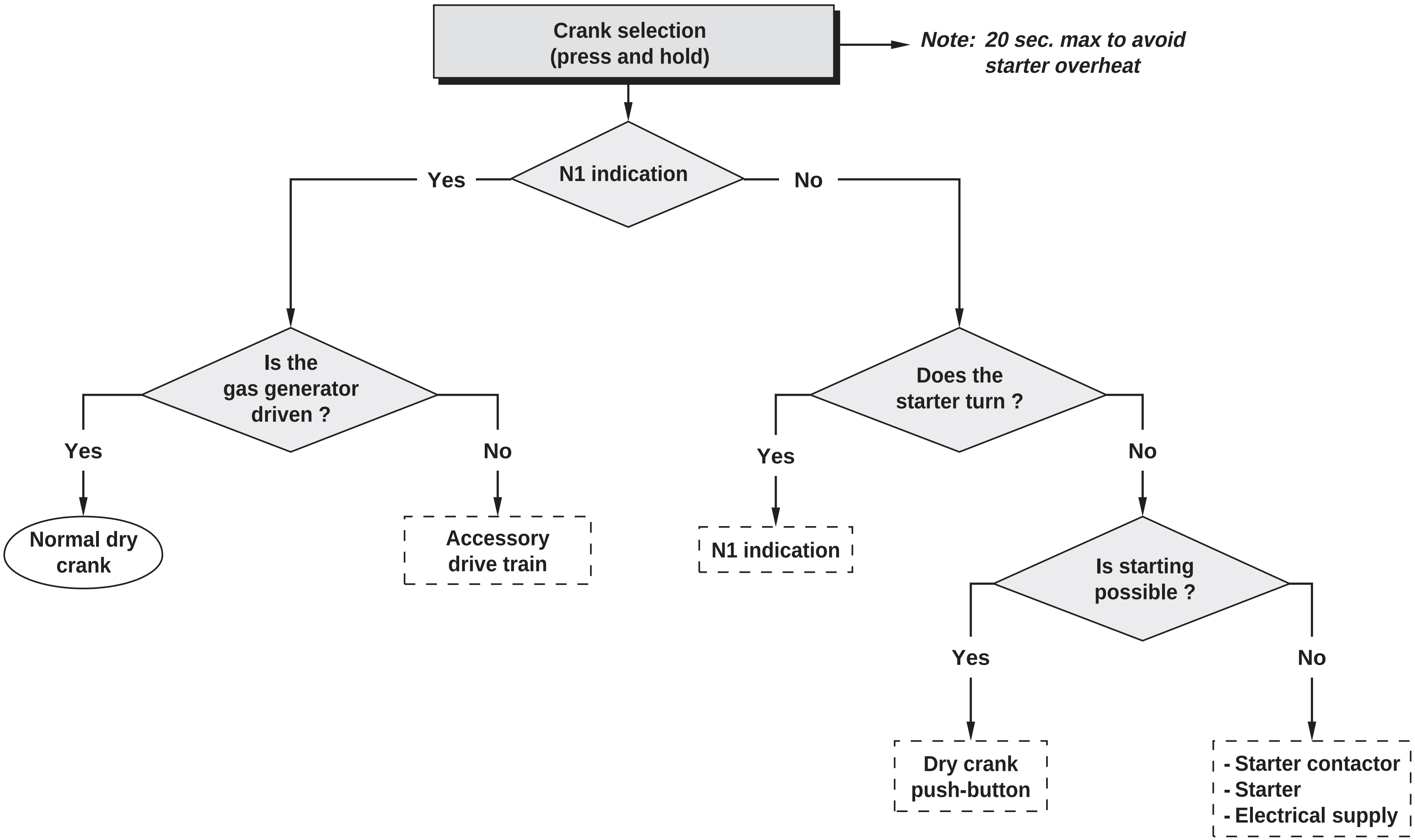


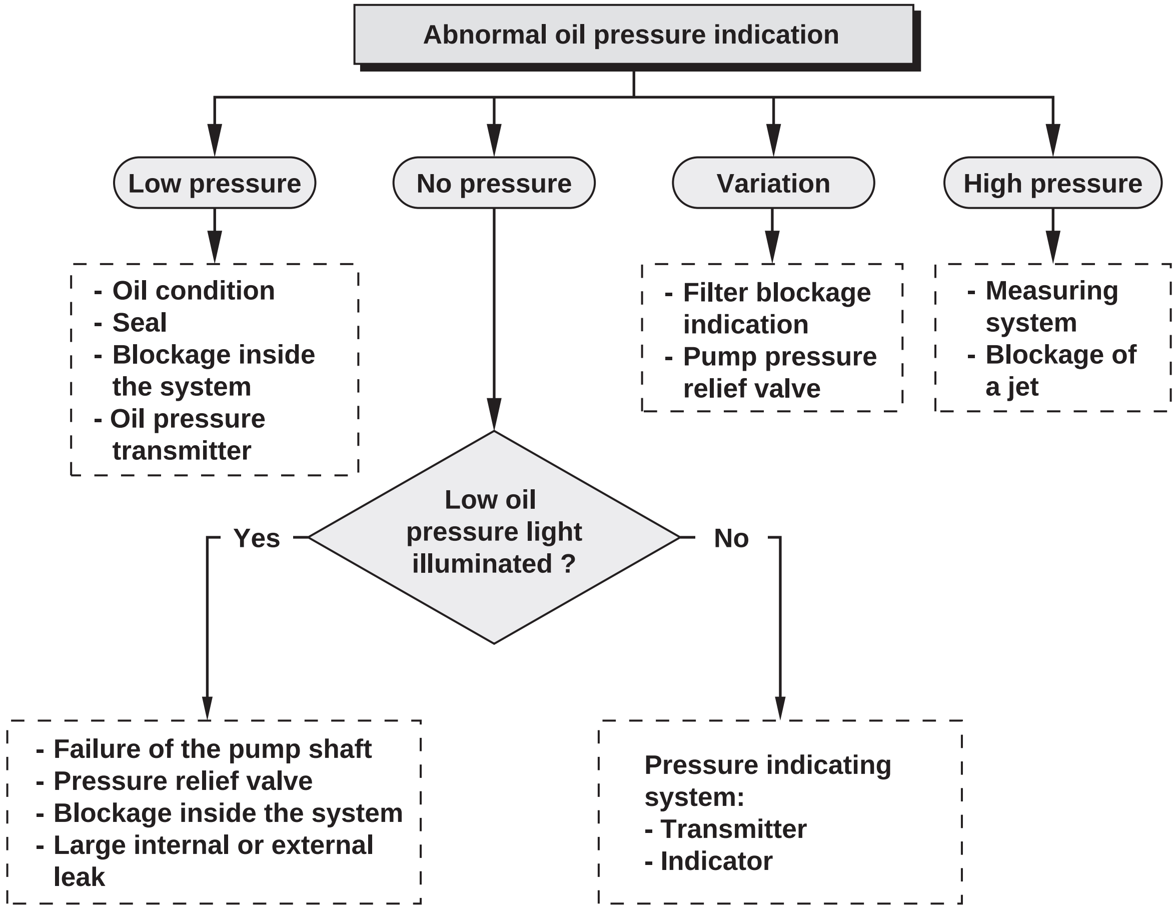
TROUBLE SHOOTING - STARTING FAULTS (4)



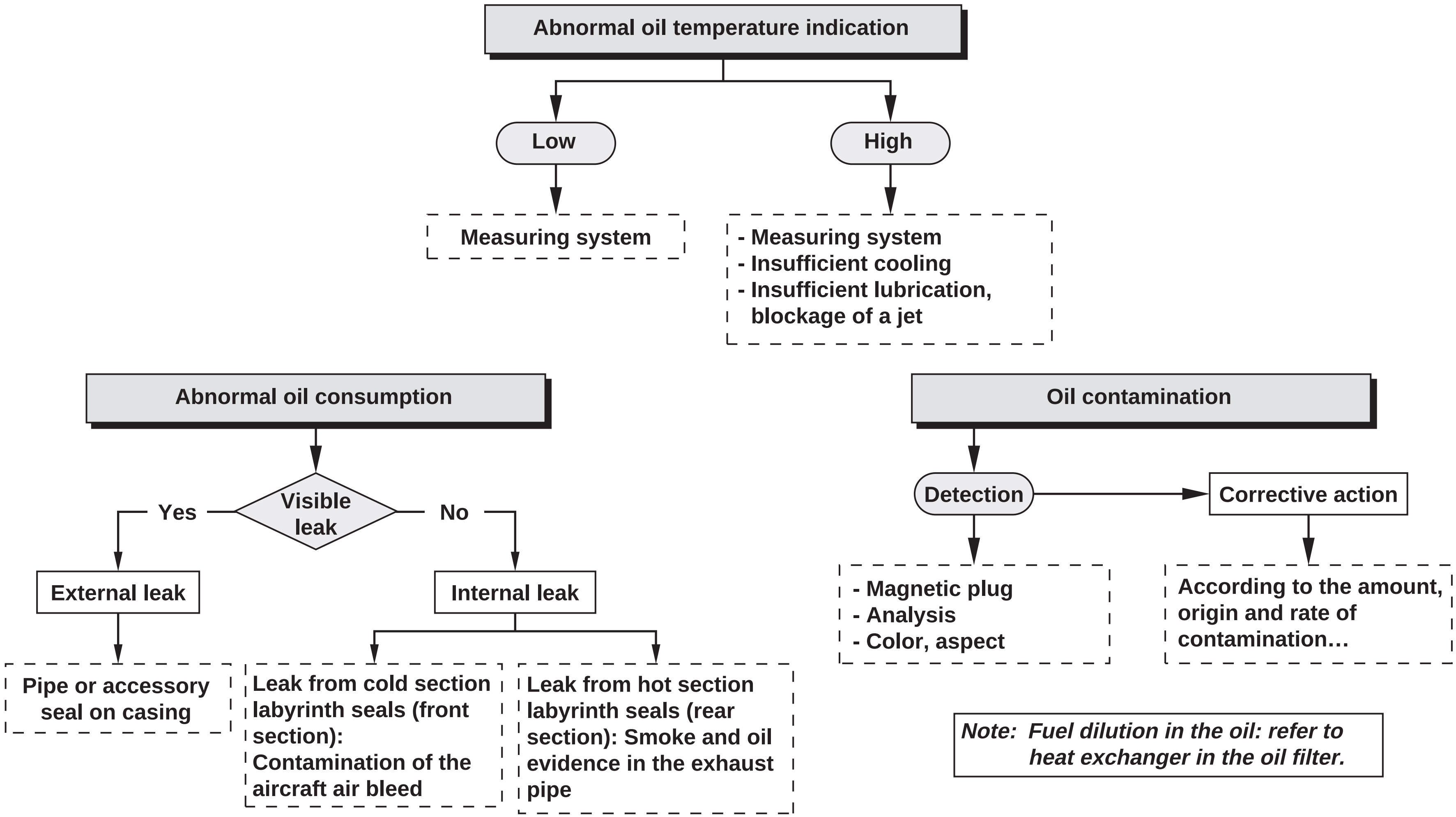
TROUBLE SHOOTING - FAULTS DURING SHUT-DOWN



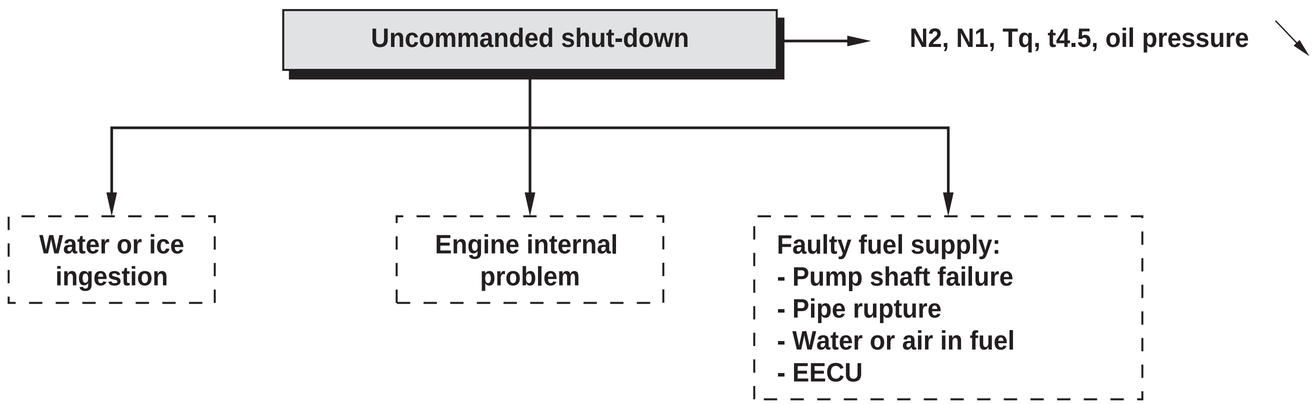
TROUBLE SHOOTING - FAULTS DURING DRY CRANK



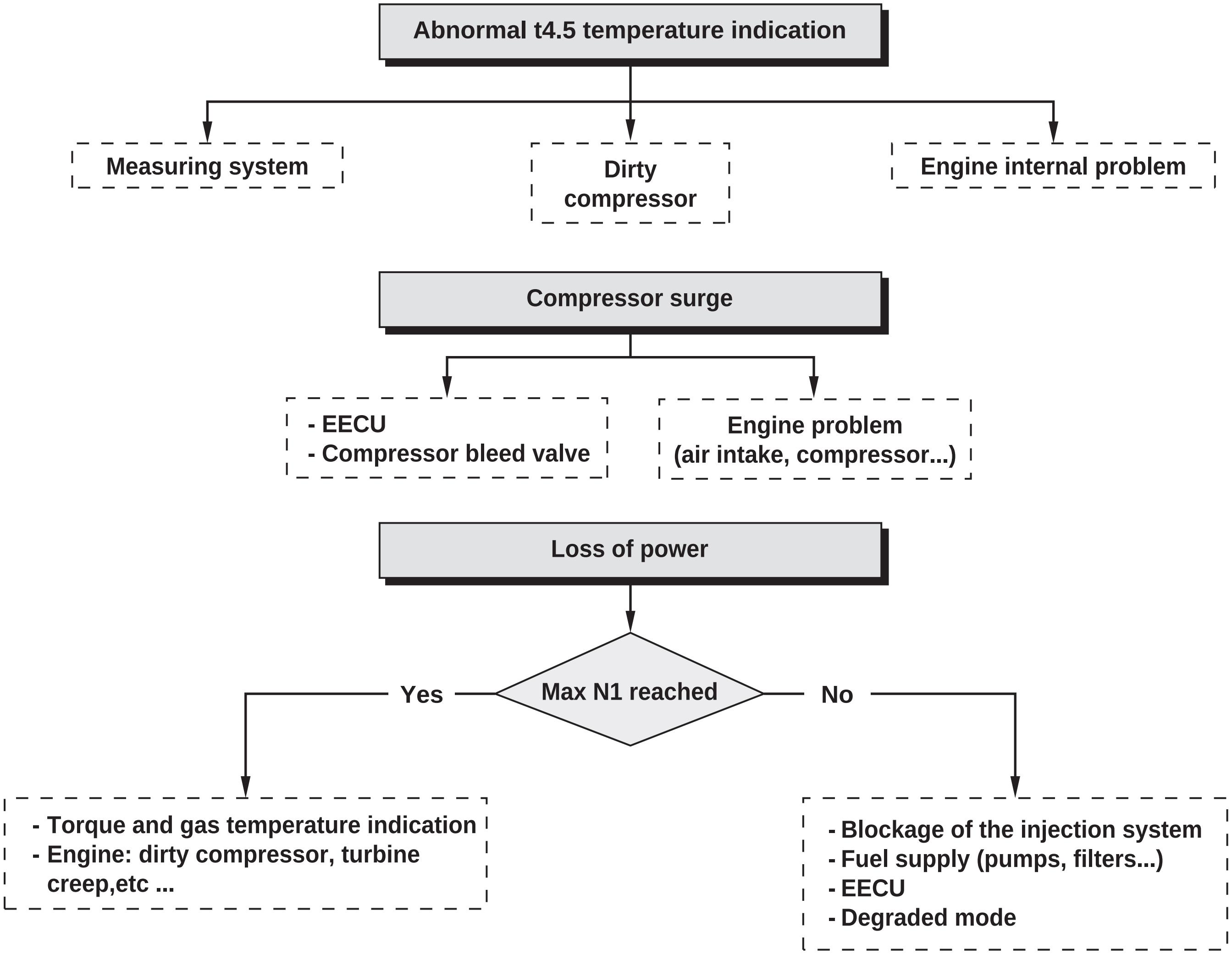
TROUBLE SHOOTING - LUBRICATION FAULTS (1)



TROUBLE SHOOTING - LUBRICATION FAULTS (2)

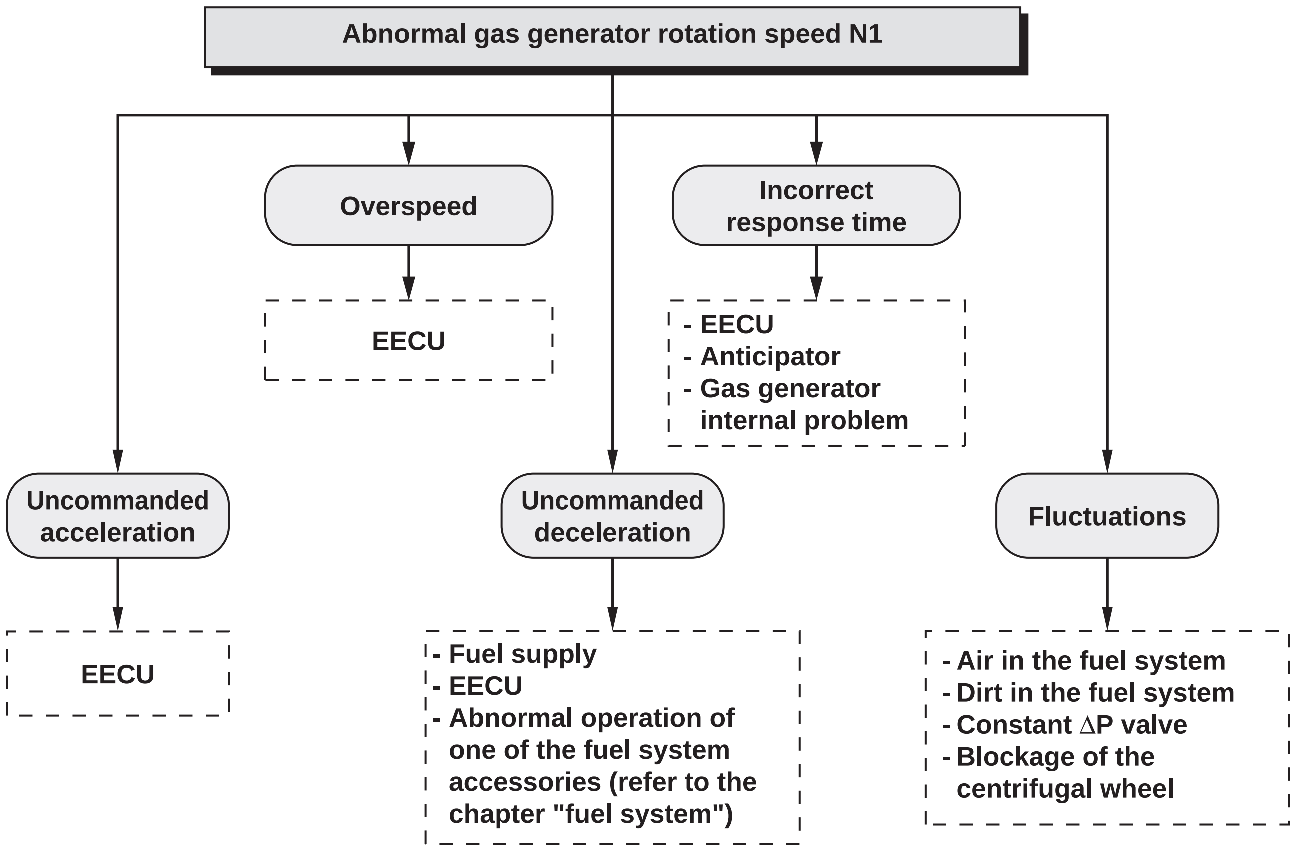


TROUBLE SHOOTING - FAULTS LEADING TO ENGINE SHUT-DOWN IN FLIGHT



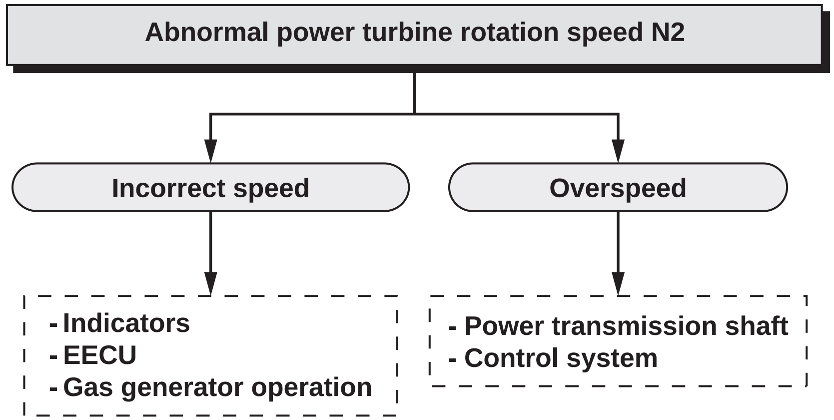
Note: Particular attention: check of the max N1.

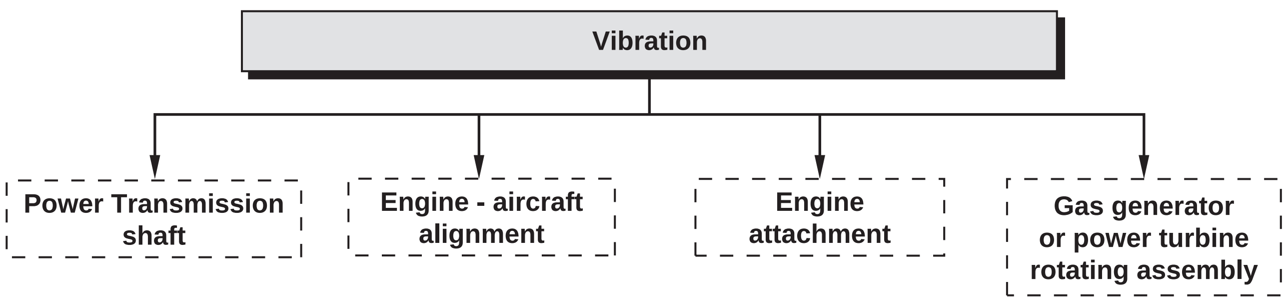
TROUBLE SHOOTING - MISCELLANEOUS CASES (1)



TROUBLE SHOOTING - MISCELLANEOUS CASES (2)

Edition: March 2003





TROUBLE SHOOTING - MISCELLANEOUS CASES (3)

TROUBLE SHOOTING - VEMD (1)

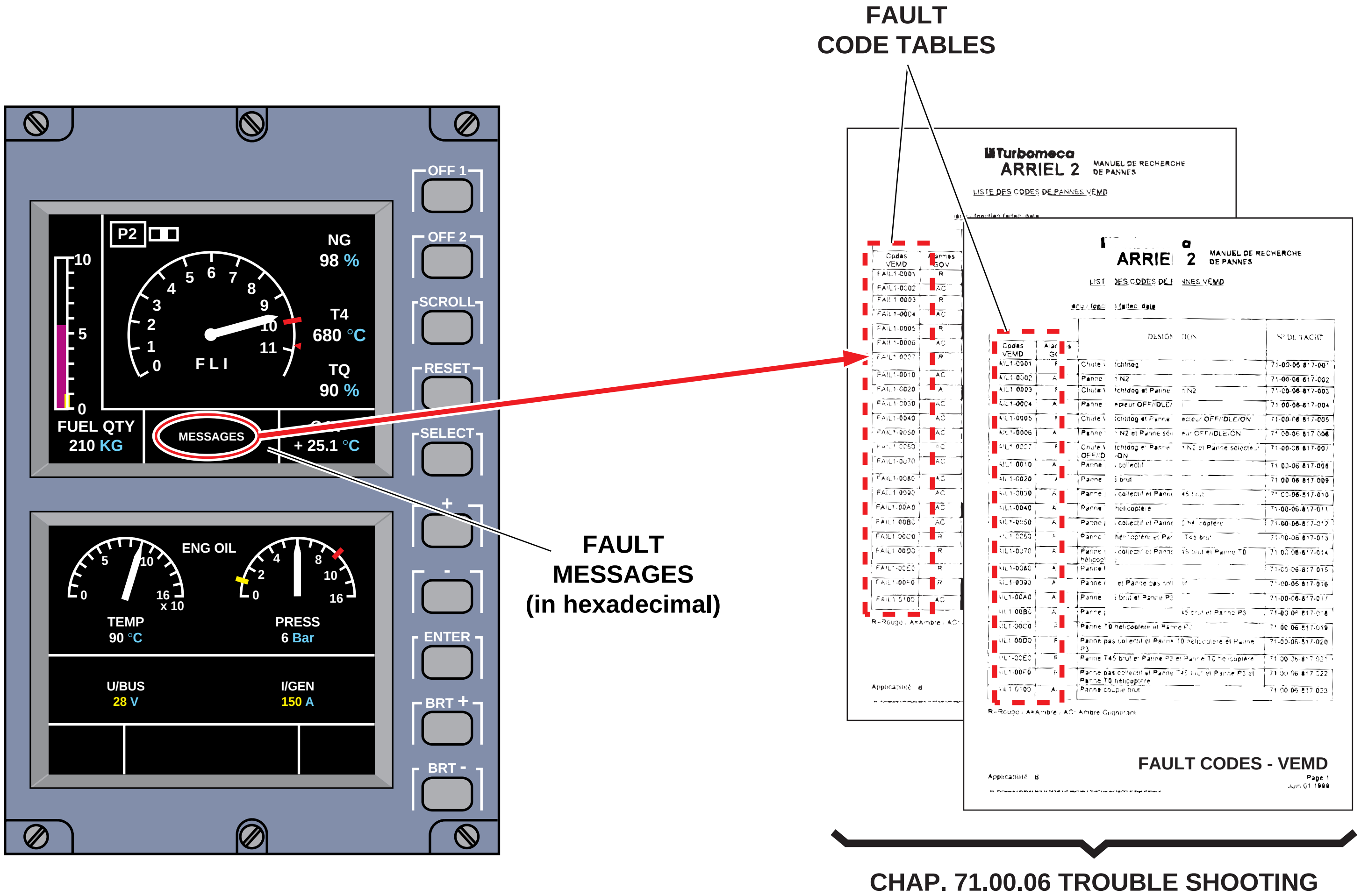
The VEMD includes a maintenance aid facility to help with trouble shooting.

Faults

Faults detected by the EECU are transmitted to the VEMD which displays them on the lower part of the upper screen. This display is in the form:

FAIL 1 XXXX or FAIL 2 XXXX

Fail 1 and Fail 2 refer to the fault code tables in Chapter 71.00.06 trouble shooting (Maintenance manual). These tables identify the fault related to each code.



TROUBLE SHOOTING - VEMD (1)

TROUBLE SHOOTING - VEMD (2)

Flight Report

The "FLIGHT REPORT" is automatically displayed during shut-down. It can also be accessed from the Maintenance menu at any time. Up to 32 records can be stored in memory. In the event of problem being detected, the Flight Report will include one or both of the following messages:

OVERLIMIT DETECTED
FAILURE DETECTED

To see the details of an overlimit or failure proceed as follows:

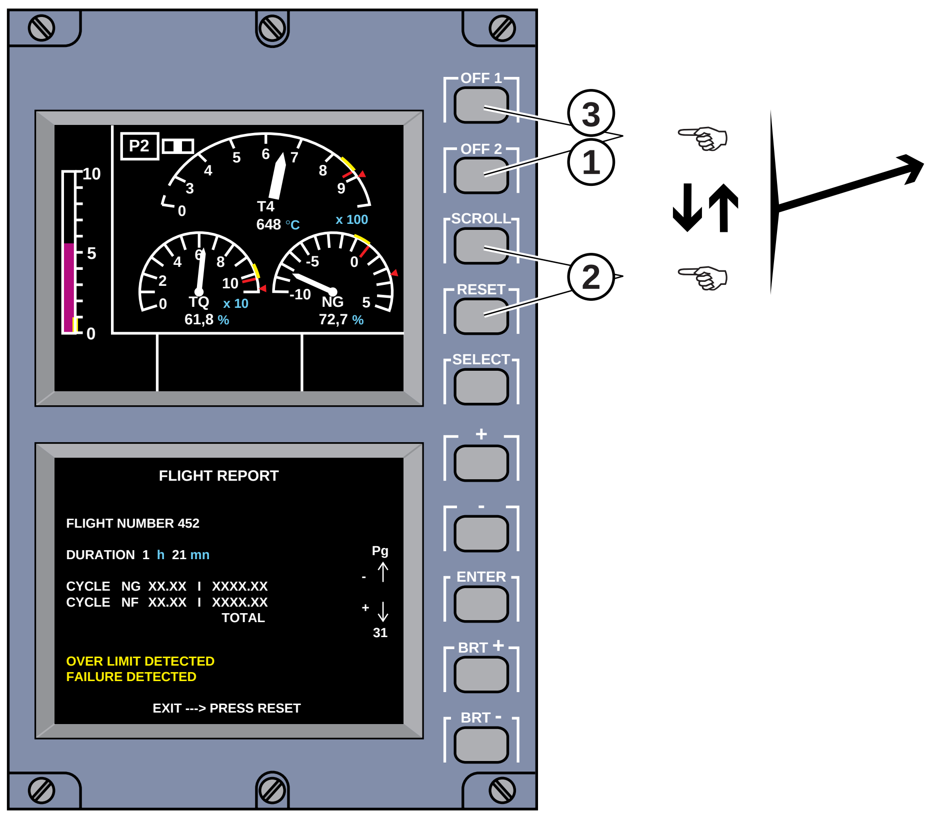
- (1) Switch off the VEMD screens by pressing "OFF 1" and "OFF 2
- (2) Depress and keep depressed the "SCROLL" and "RESET" buttons
- (3) Depress the buttons OFF 1 and OFF 2.

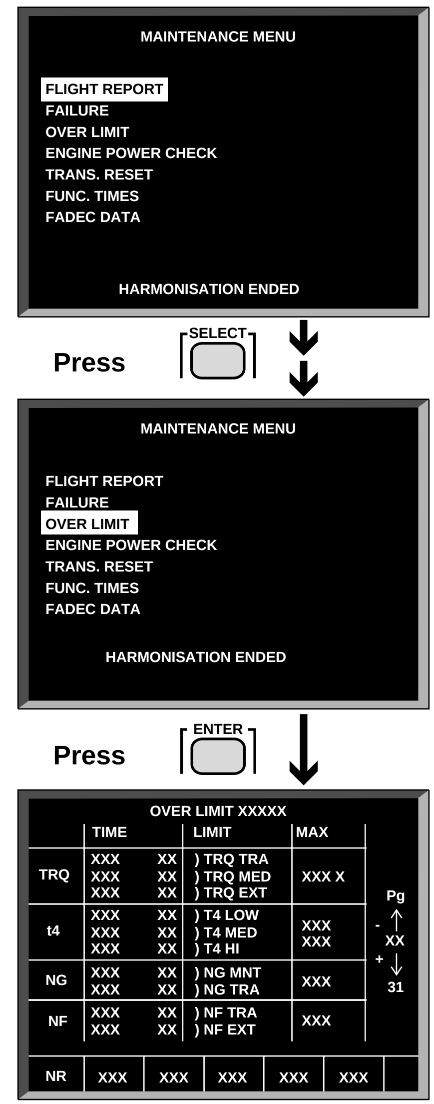
The screens display the message "TEST IN PROGRESS" followed by "RELEASE KEYS" followed by the Maintenance Menu on the lower screen.

Use the "SELECT" button to highlight a subject and the "ENTER" button to display its page.

Over Limit

The Over Limit page records any overlimits of Tq, t4.5, N1, N2 and NR. It displays the duration and value of the excess.





The "flight report" is automatically displayed during shutdown (it can also be accessed from the Maintenance menu at any time).

(1) To (3) : SELECTION ORDER

TROUBLE SHOOTING - VEMD (2)

TROUBLE SHOOTING - VEMD (3)

Failure Diagnosis

The failure diagnosis is given on 5 pages.

"FAILURE DIAGNOSIS" page:

Displays all the faults in the memory for the last 32 flights. It includes:

- The total number of flights with failures detected
- The flight number with number of failures detected
- The number in the list of flights with failures.

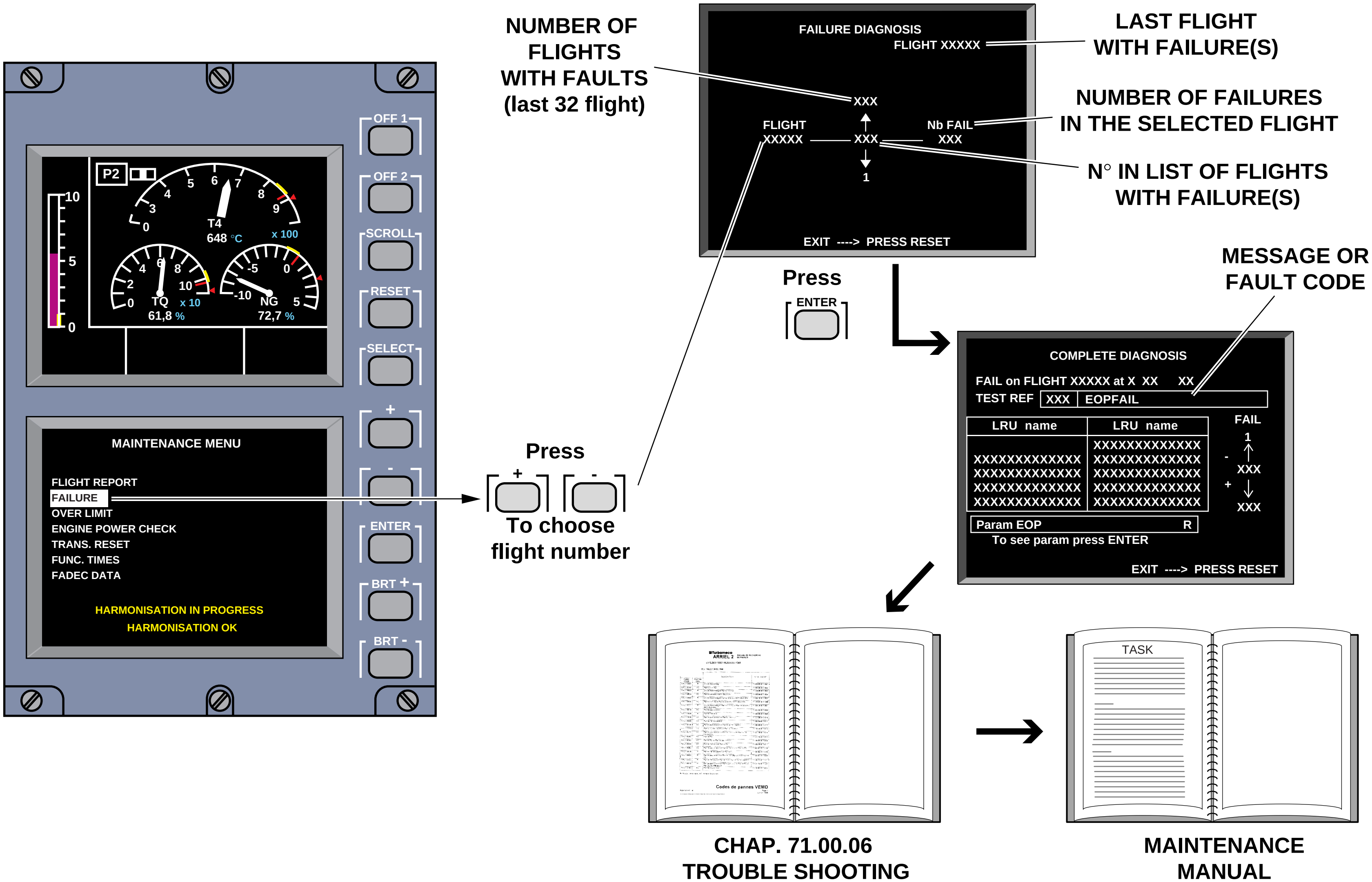
Use the "+" and "-" buttons to scroll through the flights, then the "ENTER" button to see the details of the flight selected.

"COMPLETE DIAGNOSIS" page:

Displays the flight details and the accessory identification, plus a fault code which can be decoded in chap. 71.00.06 Trouble shooting. To each fault code corresponds a task number. To the task number corresponds a "fault finding tree".

Note: *The fault code FAIL 1 or FAIL 2 can also be read on the FLI page or on the FADEC DATA page.*

At last the "fault finding tree" indicates the necessary tasks; maintenance tasks described in the maintenance manual.



TROUBLE SHOOTING - VEMD (3)

TROUBLE SHOOTING - VEMD (4)

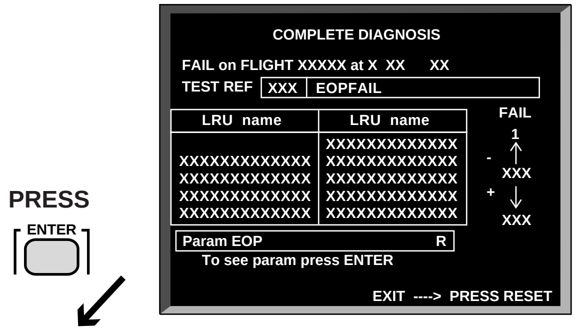
Failure Diagnosis (cont.)

"PARAMETERS" pages:

The Parameters pages of the fault diagnosis display the engine parameters. They can be accessed by pressing the "Enter" button when on the complete diagnosis page.

The parameters are on 3 pages which will be displayed automatically (one or several) according to the faults detected.

The values of each parameter are given in 2 columns. The first column (left) shows the values 12 seconds before the failure and the second column (right) shows the values when the fault was detected.



PARAMETERS

	XX	FAIL	
NG	XXX.X	XXX.X	%
TRQ	XXX.X	XXX.X	%
t4	XXX	XXX	°C
T4R1	XXXXX.X	XXXX.X	Ω
T4R2	XXXXX.X	XXXX.X	Ω
P0	XXXXX	XXXXX	mb
OAT	-XX.X	-XX.X	°C
I. GENC	XXX	-XXX	A
U. BUS	XX.X	XX.X	V
NF	XXXXX	XXXXX	RPM
NR	XXX	XXX	RPM
VZ	-XXXX	-XXXX	Ft / mn
P2 HD/P/DFAIL	X/X/X	X/X/X	BOOLEAN

PARAMETERS (continued)

	XX	FAIL	
EOP	XXX.X	XXX.X	bar
EOT	XXX.X	XXX.X	°C
FQ	XXX	XXX	Kg
FT	XXXX.X	XXXX.X	°C
FF	XXXX.X	XXXX.X	Kg / h
SUNG	XXXXX	XXXXX	Kg
OAT	XX.X	XX.X	°C

PARAMETERS (continued)

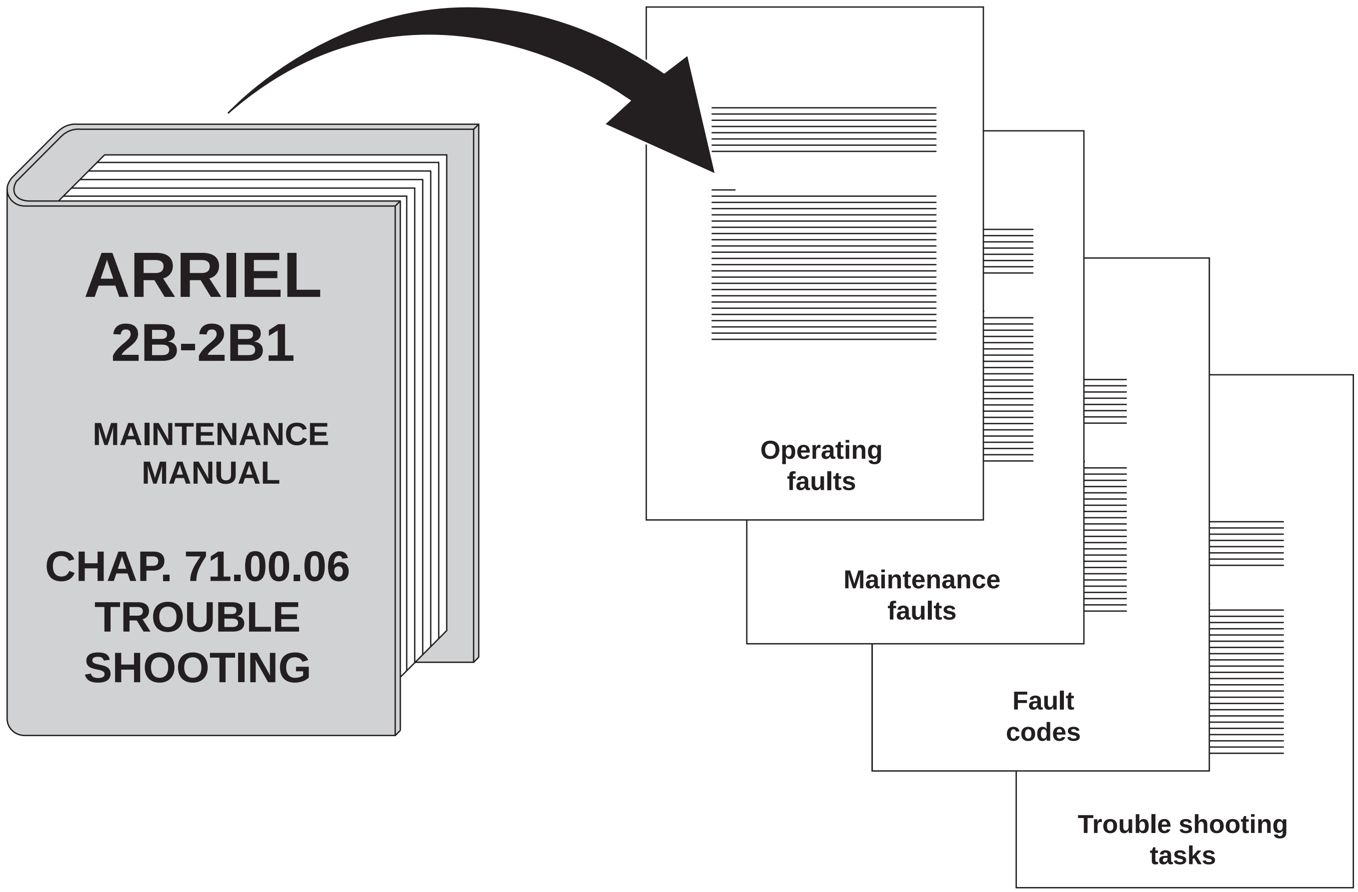
	XX	FAIL	
NG	XXX.X	XXX.X	%
NG F.	XXX.X	XXX.X	%
TRQ F.	XXX.X	XXX.X	%
t4	XXX	XXX	°C
T4 F.	XXX	XXX	°C
NF	XXXXX	XXXXX	RPM
NF F.	XXXXX	XXXXX	RPM
FAIL 1	XXXX	XXXX	HEX
FAIL 2	XXXX	XXXX	HEX
OUT 1	XXXX	XXXX	HEX
OUT 2	XXXX	XXXX	HEX
IN	XXXX	XXXX	HEX

TROUBLE SHOOTING - VEMD (4)

TROUBLE SHOOTING - MISCELLANEOUS

Chapter 71.00.06 of the Maintenance Manual, which is dedicated to trouble shooting includes:

- A list of faults observed in operation
- A list of faults observed during maitenance
- A list of fault codes and their interpretation
- A list of trouble shooting tasks.



TROUBLE SHOOTING - MISCELLANEOUS

TROUBLE SHOOTING - CONCLUSION

Despite the high reliability of the product, failures remain inevitable and happen at random. But their rate and effects can be reduced if the "enemies" of the engine are taken into consideration.

When the failure occurs, you have to be in a position to correct it.

"Enemies" of the engine

The traditional adverse conditions for this type of engine are:

- Supply (oil, air, fuel, electricity)
  - Oil - Not in conformity with spec., contamination
  - Air - Sand, salt, pollution
  - Fuel - Not in conformity with spec., contamination
  - Electricity - Low voltage, connectors
- Operation ("non respect" of instructions and procedures)
- Maintenance ("non respect" of inspection frequencies, and of the strict application of the procedures).

FUEL

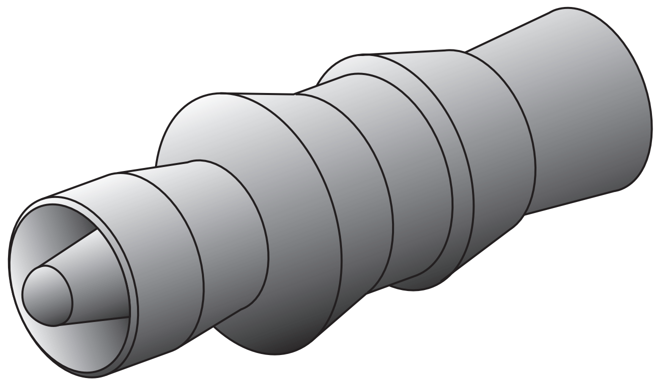
- Not in conformity with specifications
- Water in fuel
- Sulphur + salt in the air = sulfidation

ELECTRICITY

- Too low voltage during starting
- Interference

AIR

- Sand
- Salt
- Pollution



OPERATION

- "Non respect" of instructions and procedures
- Severe operating conditions

OIL

- Not in conformity with specifications
- Contamination

MAINTENANCE

- "Non respect" of inspection frequencies
- Various mistakes
- Wrong logistic

"ENEMIES" OF THE ENGINE

TROUBLE SHOOTING - CONCLUSION

16 - CHECKING OF KNOWLEDGE

INTRODUCTION

Method

Continuous checking helps to ensure the information is assimilated. It is more a method of work than a testing in the traditional sense.

Objectives of the questionnaires

The questionnaires permit a progressive assimilation and a long term retention. The questionnaires are a subject for discussion (effects of group dynamics). They also permit students to consider important subjects several times under different aspects.

Integration into the training programme

- First hour every day for revision of the subjects previously studied
- After each chapter (or module) of the course
- At the end of the training course.

Types of questionnaires

Several types of questionnaire can be employed during a course:

- Traditional written questionnaire
- "Short answer" questionnaire
- Multi Choice Questionnaire (MCQ)
- Oral questionnaire
- Learning Through Teaching (LTT; the student has to explain a given subject).

Examination

The final examination at the end of the course consists of three tests: written, oral and practical. A certificate and an approval card are given to the student if the results are satisfactory.

QUESTIONNAIRE 1

This traditional questionnaire is established according to the same plan as the training manual in which the answers can be found.

Power plant

1 - List the main functional components of the power plant.

2 - Explain the thermodynamic operation of the engine.

3 - State the following features (at take-off, in standard atmosphere):

- Power on the shaft
- Output shaft rotation speed
- Mass of the engine with specific equipment
- Main overall dimensions of the power plant.

4 - Explain the principle of engine adaptation to helicopter power requirements.

5 - Give a definition of the operating ratings.

Engine

1 - List the main components of the gas generator.

2 - State the following characteristics:

- Compression ratio
- Turbine entry temperature
- N2 speed at 100 %
- N1 speed at 100 %

3 - Describe the power turbine assembly.

4 - Describe the fuel injection system.

5 - List the engine driven accessories.

6 - List the bearings which support the gas generator.

7 - Describe the system used for bearing sealing.

8 - Describe the modular construction of the engine.

9 - Describe the engine air intake.

10 - List the manufacturing materials of the engine main components.

QUESTIONNAIRE 1 (continued)

Oil system

1 - Explain the general operation of the oil system.
2 - Describe the oil filter assembly.
3 - State the location of strainers and magnetic plugs.
4 - What is the purpose of the check valve?
5 - How many magnetic plugs are there on the engine?

Air system

1 - List the functions ensured by the internal air system (secondary system).
2 - List the function of the various air tappings.
3 - Why are the start injectors ventilated?
4 - Explain the purpose and the operation of the compressor bleed valve.

Fuel system

1 - What type of fuel system is it.
2 - Describe the HP fuel pump.
3 - Describe the fuel metering unit.
4 - What is the purpose of the constant ΔP valve.
5 - Explain the principle of fuel injection (main and starting injection).
6 - Explain the operation of the fuel valve assembly.

Control system

1 - List the main functions of the control system.
2 - Explain the basic principle of the control system.
3 - Explain the operating principle of the speed control.
4 - List the components of the Engine Electronic Control Unit.
5 - List the logic input signals of the EECU.
6 - List the analog input signals of the EECU.
7 - Describe and explain the operation of the auto/manual selector.
8 - Describe the Engine Electronic Control Unit.

Measurement and indicating systems

1 - List the various measurement and indicating systems.
2 - Describe the power turbine speed measurement and indicating system.
3 - Explain the operating principle of the torquemeter system.
4 - Describe the gas temperature measurement and indicating system.
5 - What is the purpose of the torque conformation box?
6 - To which module is the t4.5 conformation box matched?

QUESTIONNAIRE 1 (continued)

Starting

1 - Describe the cranking function of the engine.

2 - Describe the ignition system (ignition unit and igniter plugs).

3 - List the main phases of the starting cycle.

Electrical system

1 - Describe the electrical harnesses and connectors.

2 - Describe the alternator.

Engine installation

1 - Describe the attachment of the engine to the aircraft.

2 - Describe the engine power drive and the power transmission.

3 - List the various engine / aircraft interfaces.

4 - Describe the fire protection system of the engine.

Limitations and engine handling

1 - List the main operating limitations of N1.

2 - Describe the engine dry crank procedure.

Various aspects of maintenance

1 - List the main practices of a periodic inspection.

2 - List the methods used for "on condition monitoring".

3 - List the technical publications used for engine maintenance.

Maintenance procedures

1 - Describe the compressor cleaning procedure.

2 - Name the LRUs of the air system.

3 - Explain the attachment of each of the modules.

Trouble shooting

1 - Carry out the trouble shooting exercises.

QUESTIONNAIRE 2

The following questions require short and accurate answers.

The student can answer orally or in the space provided for the answers.

Questions	Answers
1 - ARRIEL 2 power class?	
2 - Power turbine rotation speed at 100 %?	
3 - Type of main fuel injection?	
4 - Number of engine modules?	
5 - Number of power turbine stages?	
6 - Name the two engine ratings?	
7 - Mass of the equipped engine?	
8 - Power evolution when N1 increases?	
9 - Specific fuel consumption at 400 kW?	

Questions	Answers
10 - Flight envelope - Max altitude?	
11 - Flight envelope - Max temperature?	
12 - Start envelope - Max altitude?	
13 - Engine air flow at 100 % N1?	
14 - Overall compression ratio?	
15 - Max turbine entry temperature?	
16 - Gas generator rotation speed at 100 % N1?	
17 - Direction of rotation of the gas generator?	
18 - Direction of rotation of the power turbine?	
19 - Manufacturing material for the axial compressor?	
20 - What type of bearing is the axial compressor bearing?	

QUESTIONNAIRE 2 (continued)

Questions	Answers
21 - How is the axial compressor mounted on the gas generator module?	
22 - Axial compressor compression ratio?	
23 - Manufacturing material for the centrifugal compressor wheel?	
24 - Number of stages of the centrifugal compressor diffuser?	
25 - Type of combustion chamber?	
26 - Manufacturing material for the combustion chamber?	
27 - How is the injection wheel mounted on the shaft?	
28 - Pressure drop in the combustion chamber?	
29 - Number of stages of the gas generator turbine?	

Questions	Answers
30 - Type of power turbine front bearing?	
31 - Type of gas generator rear bearing?	
32 - To which module does the power turbine nozzle guide vane belong?	
33 - Type of power turbine?	
34 - Does the exhaust pipe belong to one module (yes or no)?	
35 - Type of exhaust pipe attachment?	
36 - Number of gears in the reduction gearbox?	
37 - What type of gears are used in the reduction gearbox?	
38 - Number of driven accessories on the accessory gearbox?	
39 - Manufacturing material for the accessory gearbox casing?	

QUESTIONNAIRE 2 (continued)

Questions	Answers
40 - Is the oil pressure adjustable?	
41 - Number of pumps in the oil pump pack?	
42 - Type of oil pumps?	
43 - What is the setting of the oil filter pre-blockage indicator?	
44 - Filtering ability of the oil filter?	
45 - Setting of the oil filter by-pass valve?	
46 - Which bearings are squeeze film type?	
47 - Type of seal for the gas generator rear bearing sealing?	
48 - Max oil consumption?	
49 - Type of oil pressure transmitter?	

Questions	Answers
50 - Setting of the low oil pressure switch?	
51 - Max oil temperature?	
52 - Location of the centrifugal breather?	
53 - Air tapping for the pressurisation of the power turbine front bearing?	
54 - Air pressure at the centrifugal compressor outlet?	
55 - Air temperature at the centrifugal compressor outlet?	
56 - When does the start injector ventilation begin?	
57 - Max air tapping flow?	
58 - Type of compressor bleed valve?	
59 - Position of the bleed valve during starting?	

QUESTIONNAIRE 2 (continued)

Questions	Answers
60 - What is the bleed valve control signal?	
61 - Where is the P3 transmitter fitted?	
62 - Type of LP fuel pump?	
63 - Filtering ability of the fuel filter?	
64 - Setting of the fuel filter by-pass valve?	
65 - Type of HP fuel pump?	
66 - Position of the pump pressure relief valve in normal engine running?	
67 - Type of fuel metering unit?	
68 - Position of the constant ΔP valve when the engine is stopped?	
69 - Type of manual fuel flow control?	
70 - Type of metering needle control actuator?	

Questions	Answers
71 - What type of valve is the stop electro-valve?	
72 - Setting of the fuel pressurising valve?	
73 - Fuel flow through the start injectors?	
74 - Number of start injectors?	
75 - Position of the combustion chamber drain valve when the engine is stopped?	
76 - Type of fuel control system?	
77 - Signals for the start fuel flow control?	
78 - Is the max torque limit calculated by the EECU?	
79 - N2 speed at idle N1?	
80 - Is the metering needle frozen in "mixed" control mode?	

QUESTIONNAIRE 2 (continued)

Questions	Answers
81 - Origin of XTL signal?	
82 - Type of N2 controller?	
83 - What are the two functions of the t4.5 signal in the EECU?	
84 - Location of the EECU?	
85 - How many modules does the EECU include?	
86 - Position of the manual control in normal engine running?	
87 - Type of speed sensors?	
88 - Number of N1 speed sensors?	
89 - Number of N2 speed sensors?	
90 - Number of thermocouple probes?	

Questions	Answers
91 - Location of the t4.5 conformation box?	
92 - How are the thermocouples connected (parallel or series)?	
93 - Location of the torquemeter?	
94 - Type of torque sensor?	
95 - Type of signal output by the torque sensor?	
96 - Is the torque sensor associated with a particular module?	
97 - Is the bleed valve position known by the EECU?	
98 - Type of ignition system?	
99 - Gas generator rotation speed at starter cut-off?	

QUESTIONNAIRE 2 (continued)

Questions	Answers
100 - Number of igniter plugs?	
101 - Max duration of a dry crank?	
102 - Is the ignition cable integral with the igniter plug?	
103 - Number of electrical connectors?	
104 - Location of the alternator?	
105 - Type of seal on the power shaft?	
106 - Type of connection engine/MGB?	
107 - Number of engine drains?	
108 - How many fire detectors are there?	
109 - Power turbine max overspeed?	
110 - Max gas temperature during starting?	

Questions	Answers
111 - Minimum rundown time?	
112 - How many engine lifting points?	
113 - Min electrical supply voltage before starting?	
114 - Meaning of IPC?	
115 - Meaning of TBO?	
116 - Is borescopic inspection of the combustion chamber possible?	
117 - Procedure in case of indication of fuel filter blockage?	
118 - Is there an adjustment of the torquemeter sensor?	
119 - Is the removal of the free wheel permitted in field maintenance?	

QUESTIONNAIRE 3

This multi-choice questionnaire is used to review, in a relatively short time, certain important points and to test the acquired knowledge.

Answers to the questions can be found at the end of the questionnaire.

1 - The ARRIEL 2 engine is:

a) a free turbine turboshaft engine
b) a turbo-jet engine
c) a fixed turbine turboshaft engine.

2 - Section of passage of the compressor diffusers:

a) regular
b) divergent
c) convergent.

3 - Type of combustion chamber:

a) annular with centrifugal injection
b) annular, reverse flow
c) annular, indirect flow.

4 - The power turbine nozzle guide vane belongs to:

a) module M04
b) module M03
c) module M02.

5 - Type of exhaust pipe attachment:

a) bolts
b) mounting pads
c) clamp.

6 - How many bearings support the gas generator:

a) 4
b) 2
c) 3.

7 - The engine includes:

a) a hot section and a cold section
b) 5 modules
c) 4 modules.

8 - Type of oil system:

a) dry sump
b) constant pressure
c) lubrication by splashing.

9 - Setting of the oil filter pre-blockage indicator:

a) lower than the by-pass valve
b) higher than the by-pass valve
c) the same as the pump valve.

10 - The oil scavenge strainers are located:

a) at the outlet of the pumps
b) on the inlet of the scavenge pumps
c) at the inlet of the lubricated components.

11 - Is there a max oil temperature:

a) yes, 60 °C
b) no
c) yes, 115 °C maxi.

QUESTIONNAIRE 3 (continued)

12 - The air tapped at the centrifugal wheel outlet pressurises:
a) some labyrinth seals
b) the tank
c) the pumps.

13 - Position of the bleed valve during flight:
a) open
b) closed
c) depends on conditions.

14 - Ventilation of start injectors:
a) does not exist
b) is made with air from the compressor
c) is made with atmospheric pressure air.

15 - The injection centrifugal wheel is drained:
a) permanently
b) to enable the ventilation cycle
c) during engine shut-down.

16 - The max speed of the gas generator is:
a) limited by the EECU
b) limited by a mechanical stop
c) not limited by the Fuel Control Unit.

17 - The signal from the P3 pressure transmitter is used to:
a) to indicate pressure
b) to avoid overpressure
c) to control the fuel flow.

18 - The LP fuel pump is:
a) vane type
b) gear type
c) centrifugal.

19 - The fuel system pressurising valve:
a) is electrically controlled
b) operates when overpressure occurs
c) gives priority to the start injectors.

20 - Type of EECU:
a) hydraulic
b) analog
c) digital.

21 - The thermocouples are wired:
a) in series
b) in parallel
c) on the turbine casing.

QUESTIONNAIRE 3 (continued)

22 - The torque indicating system:
- a) is hydraulic
- b) is not used
- c) is of phase displacement type.

23 - Number of thermocouple probes:
- a) 8 x 2
- b) 4 x 2
- c) 3 x 2

24 - Number of N2 signals:
- a) 2
- b) 6
- c) 3

25 - Number of N1 signals:
- a) 3
- b) 2
- c) 6

26 - The starter cut-off is made:
- a) automatically
- b) manually
- c) with air pressure.

27 - Starting is possible with one igniter:
- a) yes
- b) no
- c) yes, in emergency.

28 - HE ignition means:
- a) Hot Electrode
- b) High Energy
- c) High Emission.

29 - Borescopic inspection is used to check:
- a) the external parts condition
- b) the condition of internal parts which are not accessible without removal
- c) the reduction gearbox condition.

30 - The reliability of the engine is:
- a) good
- b) fairly good
- c) extremely good.

Answers

1 - a	2 - b	3 - a	4 - b	5 - a
6 - c	7 - b	8 - a	9 - a	10 - b
11 - c	12 - a	13 - c	14 - b	15 - c
16 - a	17 - c	18 - c	19 - c	20 - c
21 - b	22 - c	23 - a	24 - c	25 - b
26 - a	27 - a	28 - b	29 - b	30 - abc ?

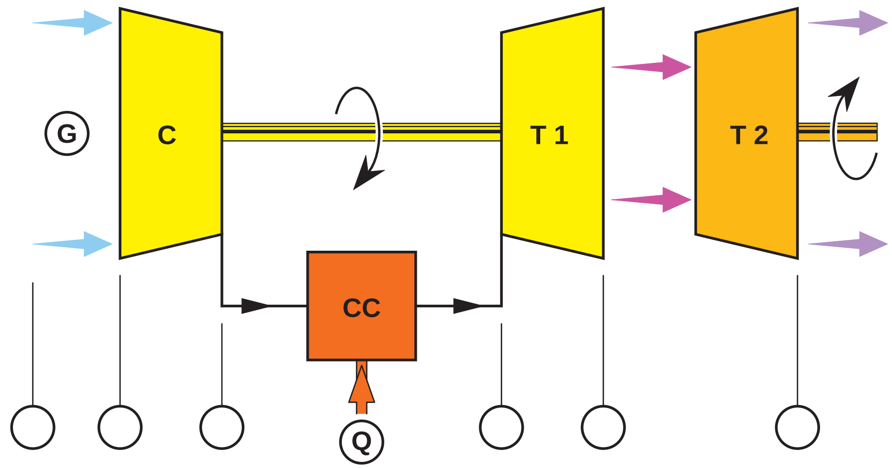
QUESTIONNAIRE 4

This questionnaire is a sort of drill which is also used to test and perfect the knowledge acquired.

1 - Complete this table (with values):

Max take-off power	....
Compression ratio	....
Engine air flow	....
N2 speed at 100 %	....
N1 speed at 100 %	....

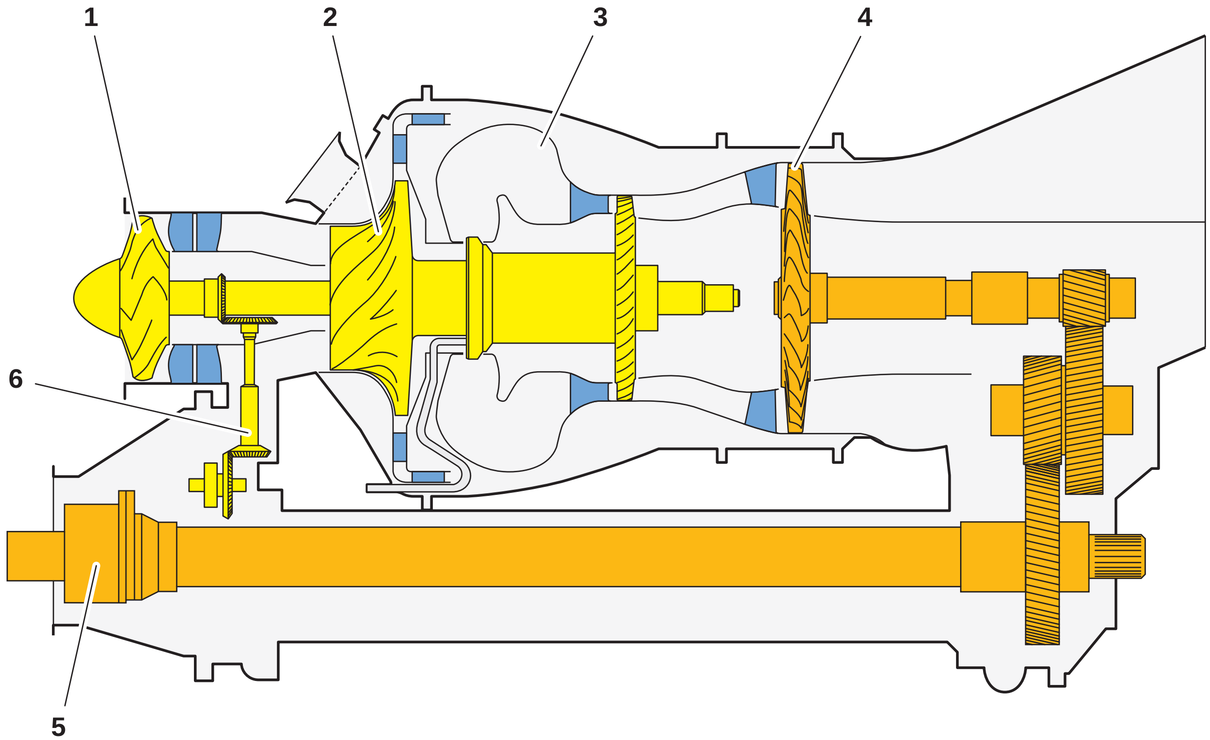
2 - Name the reference stations and locate the number in the right box:



3 - .... **4,5** - ....

QUESTIONNAIRE 4 (continued)

3 - Engine description - Complete the legend of the diagram:

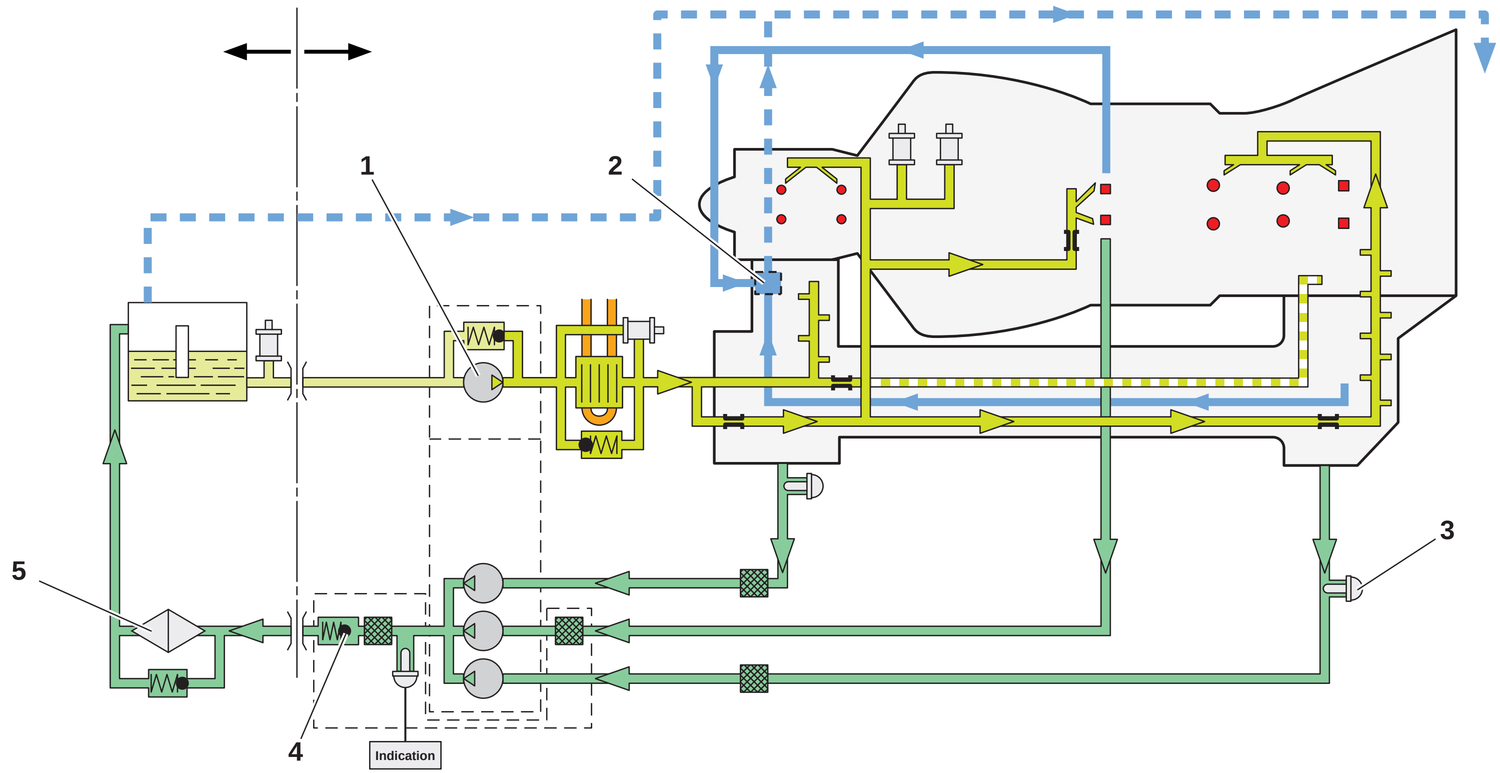


1 - .... 2 - .... 3 - ....

4 - .... 5 - .... 6 - ....

QUESTIONNAIRE 4 (continued)

4 - Oil system - Complete the legend of the diagram:



1 - ....   **2 -** ....   **3 -** ....   **4 -** ....   **5 -** ....

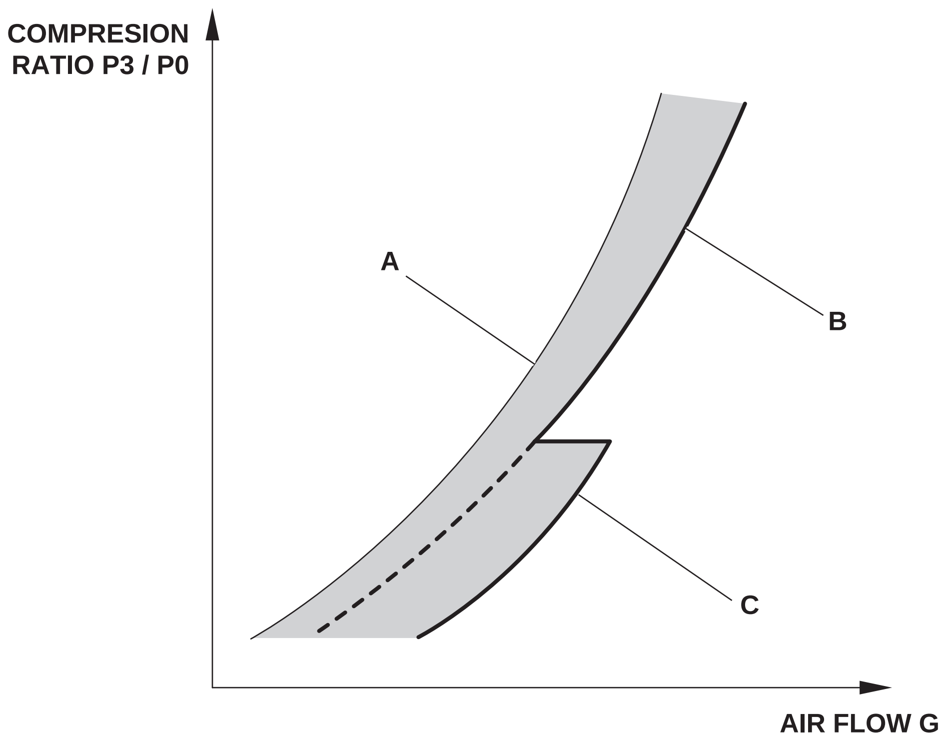
QUESTIONNAIRE 4 (continued)

5 - Complete the following table:

	P0	P2.6	P3
Injector ventilation			
Aircraft services			
Bleed valve control pressure			
Injection wheel pressurisation			
Axial compressor bearing pressurisation			
Gas generator NGV cooling			
Power turbine front bearing pressurisation			
Gas generator front turbine disc cooling			

QUESTIONNAIRE 4 (continued)

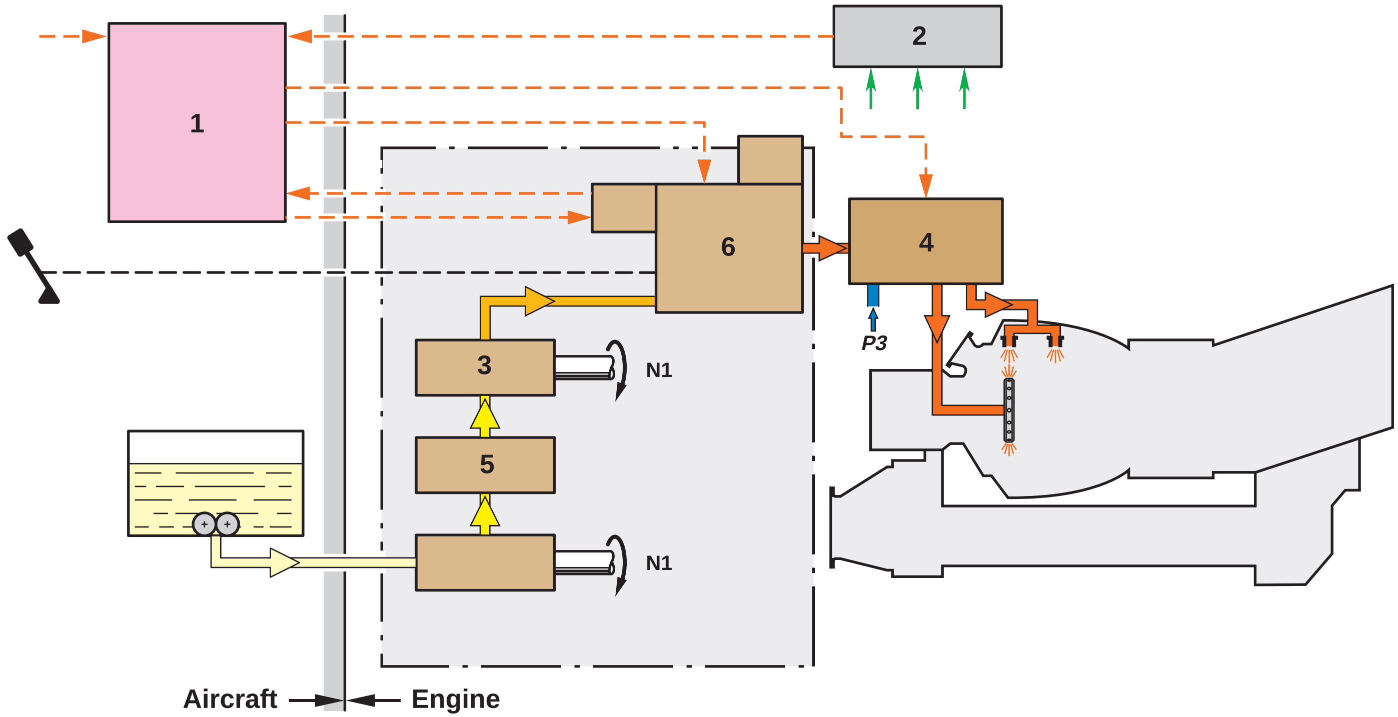
6 - Complete the legend of the compressor field diagram:



A - .... **B -** .... **C -** ....

QUESTIONNAIRE 4 (continued)

7 - Fuel system - List the components:

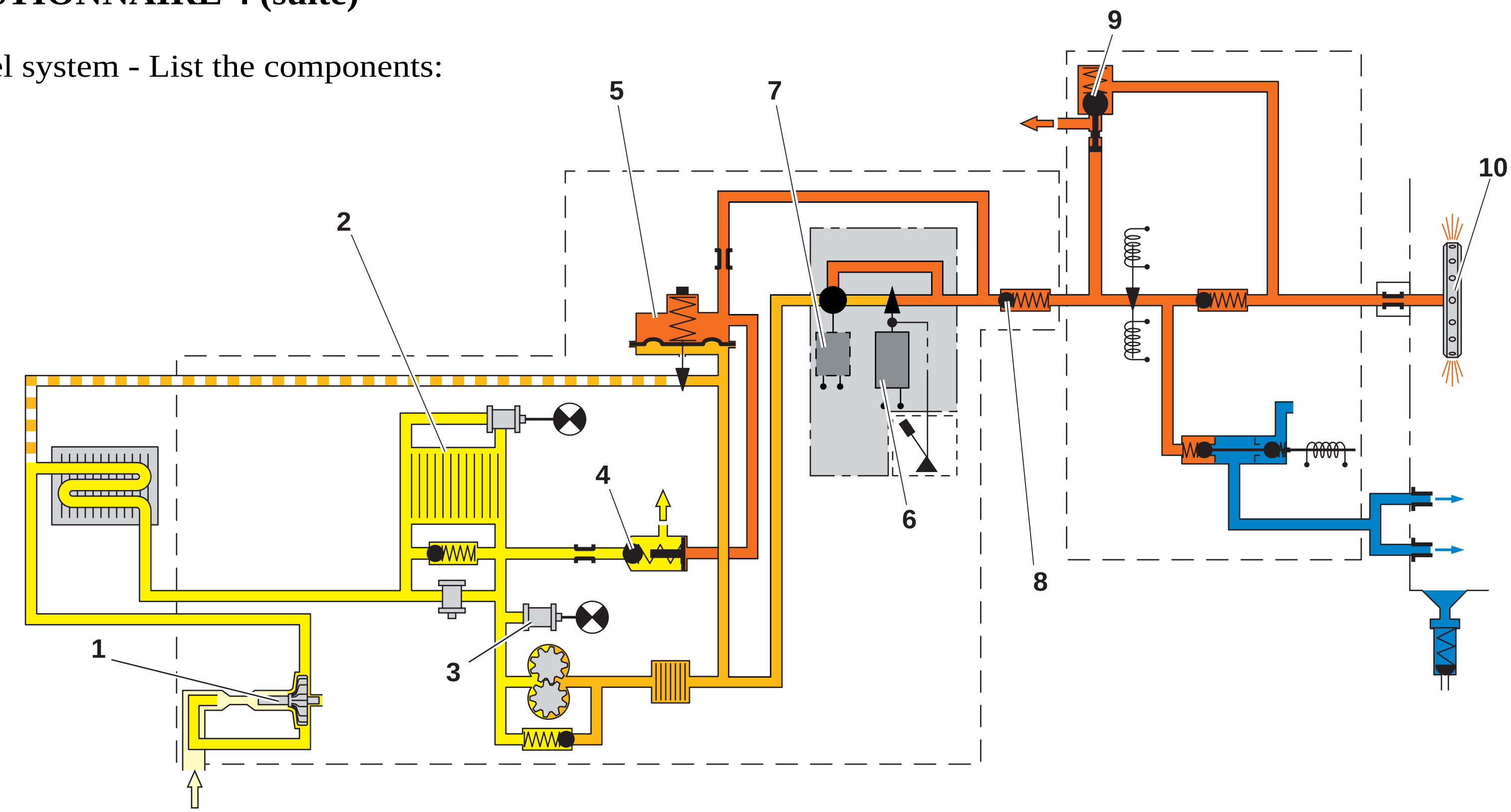


1 - .... **2 -** .... **3 -** ....

4 - .... **5 -** .... **6 -** ....

QUESTIONNAIRE 4 (suite)

8 - Fuel system - List the components:



1 -	**2** -	**3** -	**4** - ....
5 -	**6** -	**7** -	**8** - ....
9 -	**10** -		

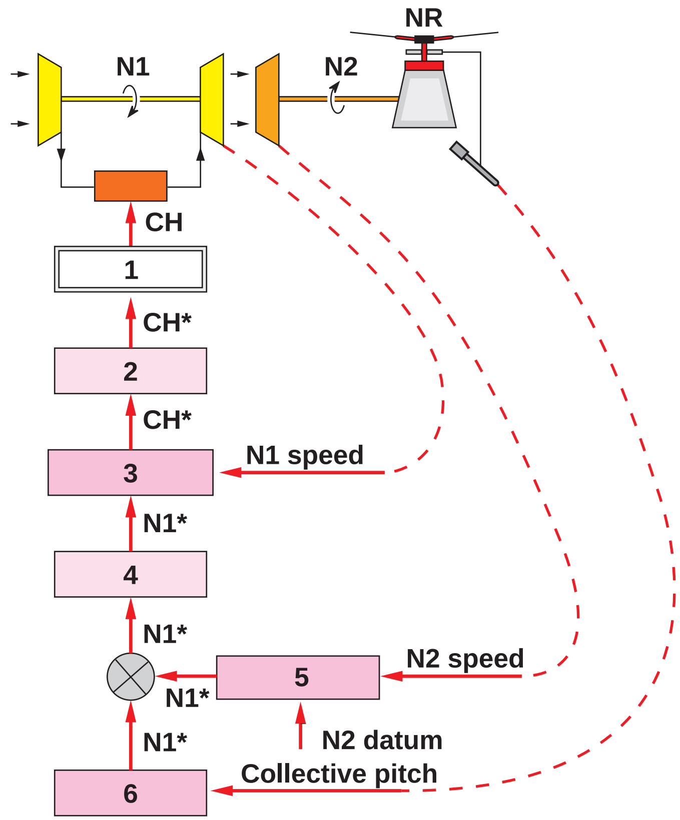
QUESTIONNAIRE 4 (continued)

8 - Complete the following table:

	Engine stopped	Engine in stabilised flight
Fuel pumps		
Pump pressure relief valve		
Constant ΔP valve		
Metering needle		
Stop electro-valve		
Start electro-valve		
Pressurising valve		
Injection wheel purge valve		
Combustion chamber drain valve		

QUESTIONNAIRE 4 (continued)

10 - Control system - List the components:

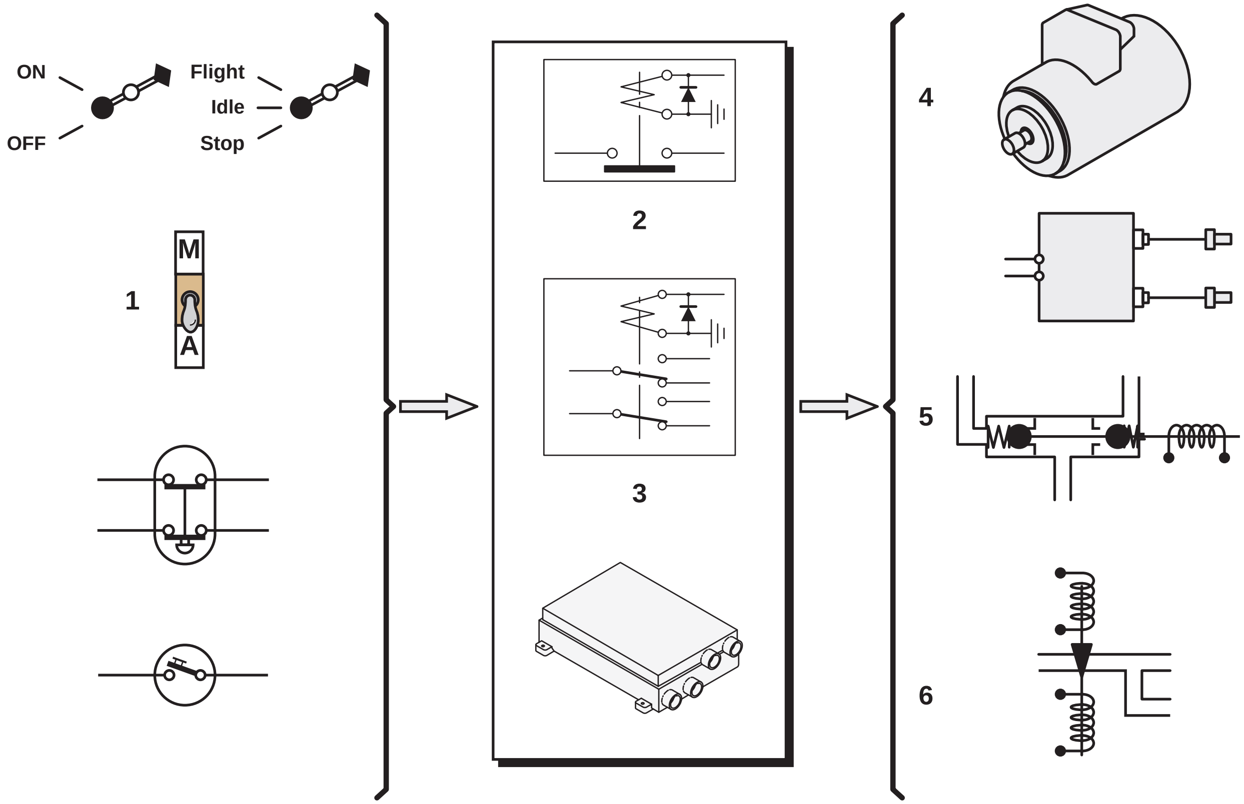


1 - .... 2 - .... 3 - ....

4 - .... 5 - .... 6 - ....

QUESTIONNAIRE 4 (continued)

11 - Starting system - List the components:



1 -	....	**2** -	....	**3** -	....
4 -	....	**5** -	....	**6** -	....

QUESTIONNAIRE 4 (continued)

12 - Complete the following table:

Number of lifting points?	
Type of fire detectors?	
Number of drain points?	
How many oil system engine/aircraft interfaces?	
Max air tapping flow for aircraft use?	
Loss of power due to aircraft tapping?	

13 - List the main resources for on condition monitoring:

1 - ....

2 - ....

3 - ....

4 - ....

5 - ....

6 - ....

7 - ....

8 - ....

QUESTIONNAIRE 4 (continued)

14 - Definition of the following documents:

Maintenance manual	
Spare parts catalogue	
Tool catalogue	
Service bulletin	
Service letter	
Engine log book	
Flight manual	

QUESTIONNAIRE 4 (continued)

15 - Maintenance procedures

1 - List 2 advisory notices of "warning" category.	
2 - Time of non operation requiring long duration storage.	
3 - Compressor washing - Product and procedure.	
4 - Procedure to rotate the power turbine for borescopic inspection.	
5 - Location of the vibration sensor - Installation.	
6 - Type of attachment of the compressor bleed valve.	
7 - Type of attachment of the fuel control unit.	

QUESTIONNAIRE 4 (continued)

16 - Trouble shooting. Indicate the cause(s) in the case of the following faults.

1 - On start selection, N increases but not the gas temperature (t4.5).	
2 - On start selection, N and t4.5 increase but not sufficiently to obtain start.	
3 - Surge of the compressor.	
4 - Max power not obtained.	
5 - On stop selection, the engine does not completely shut-down.	
6 - Incorrect speed of the helicopter rotor.	
7 - Power turbine overspeed.	
8 - Drop of oil pressure.	
9 - Abnormal t4 temperature.	
10 - N1 overspeed.	

END

of this manual and (maybe also) of the course

but not the END of your training
which must be continued,
harmonizing knowledge and experience.

THANK YOU for your kind attention.

Au revoir
Good bye
Adiós
Auf Wiedersehen
Adeus
Arrivederci
Farvel
Tot ziens
Adjö
Näkemiin
Antio
Ma salaam
Selamat jalan

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