INTRODUCTION

We would like to thank you for buying an FPT product, and compliment you on your choice of engine.

Before you carry out any operation involving the engine or its fittings, please read the contents of this manual carefully; compliance with the instructions provided in the manual is the best way to guarantee trouble-free, long term operation of the engine.

The contents of this manual refer to the standard configuration of the engine, and the illustrations are purely indicative.

Some instructions are provided by giving the sequence of operations to be carried out in order to allow the engine and/or its fittings to perform in a certain way.

In some cases they will be dependent on the configuration of the commands and the set-up of the machine on which the engine is installed; for any points that differ from the contents of this manual, please consult the instructions provided by the machine Manufacturer or a specific manual.

The information provided below was current at the date of publication.

The Manufacturer reserves the right to make modifications at any time without prior notice, for technical or commercial reasons or to update the engines to comply with legal requirements in the various Countries.

The Manufacturer declines all liability for any errors or omissions.

Please remember that the FPT Technical Service Network is available to offer you its experience and professional skills, wherever you may be.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GENERAL INFORMATION</strong></td>
<td>3</td>
</tr>
<tr>
<td>Guarantee</td>
<td>3</td>
</tr>
<tr>
<td>Spare parts</td>
<td>3</td>
</tr>
<tr>
<td>Liability</td>
<td>3</td>
</tr>
<tr>
<td>Safety</td>
<td>3</td>
</tr>
<tr>
<td>Safety warning symbols</td>
<td>4</td>
</tr>
<tr>
<td>Engine technical data</td>
<td>5</td>
</tr>
<tr>
<td>Exhaust gas after-treatment system (ATS)</td>
<td>8</td>
</tr>
<tr>
<td>Signs</td>
<td>9</td>
</tr>
<tr>
<td><strong>USE</strong></td>
<td>10</td>
</tr>
<tr>
<td>Preliminary checks</td>
<td>10</td>
</tr>
<tr>
<td>For proper use of the engine</td>
<td>10</td>
</tr>
<tr>
<td>Special warnings</td>
<td>11</td>
</tr>
<tr>
<td>Run-in</td>
<td>12</td>
</tr>
<tr>
<td><strong>CONTROLS AND MAINTENANCE</strong></td>
<td>13</td>
</tr>
<tr>
<td>Maintenance personnel</td>
<td>13</td>
</tr>
<tr>
<td>Accident prevention</td>
<td>13</td>
</tr>
<tr>
<td>Refilling</td>
<td>14</td>
</tr>
<tr>
<td>Frequency</td>
<td>16</td>
</tr>
<tr>
<td>Requirements</td>
<td>18</td>
</tr>
<tr>
<td>Checks to be made during the period of use -</td>
<td>19</td>
</tr>
<tr>
<td>how to proceed</td>
<td>19</td>
</tr>
<tr>
<td>Planned maintenance - how to proceed</td>
<td>24</td>
</tr>
<tr>
<td>Extraordinary maintenance - how to proceed</td>
<td>32</td>
</tr>
<tr>
<td>Moving the engine</td>
<td>32</td>
</tr>
<tr>
<td>Disposal of waste</td>
<td>33</td>
</tr>
<tr>
<td><strong>LONG PERIODS OF INACTIVITY</strong></td>
<td>37</td>
</tr>
<tr>
<td>Preparing the engine for a long period of inactivity</td>
<td>37</td>
</tr>
<tr>
<td>Restarting the engine after a long period of inactivity</td>
<td>38</td>
</tr>
<tr>
<td><strong>ENGINE MALFUNCTIONS</strong></td>
<td>39</td>
</tr>
<tr>
<td>Behaviour in case of failure</td>
<td>39</td>
</tr>
<tr>
<td><strong>BEHAVIOUR IN EMERGENCY</strong></td>
<td>43</td>
</tr>
</tbody>
</table>
GENERAL INFORMATION

GUARANTEE
In order to ensure that your engine gives the best possible performance and to take advantage of the FPT guarantee, you must follow the indications provided in this publication with great care; failure to do so may result in invalidation of the guarantee.

SPARE PARTS
Always use Original FPT Spare parts. This is essential to keep the engine in original running order. The use of non-original spare parts will not only invalidate the guarantee, but will mean that FPT will not be considered liable in any way during the whole working life of the engine.

LIABILITY
The Manufacturer will only be considered liable subject to performance of the control and maintenance operations indicated and described in this manual; to this effect, proof that these operations have been performed must be provided. Any extraordinary maintenance operations that may be necessary must be carried out by qualified technicians from Workshops in the FPT Network, using the instruments and equipment provided for the purpose.

SAFETY
The following information is intended to encourage caution when using the engine, so as to avoid damage to persons or property as a result of improper or incorrect behaviour.

- The engines must only be used for the purposes indicated by the Manufacturer.
- Any tampering, modification and use of non-original spare parts may compromise proper operation and safe use of the engine; **never, under any circumstances** make modifications to the wiring and to the units equipping the engine, or connect them to other power systems.
- Pay particular attention to moving parts of the engine, to high temperature components and to circuits containing pressurised fluids; its electrical equipment houses electrical currents and voltage.
- The exhaust fumes produced by the engine are bad for your health.
- The engine must be handled using suitable lifting tackle, making use of the U-bolts provided on the engine for that purpose.
- The engine must not be started up and used until the machine in which it installed has satisfied all necessary safety requirements, or until the machine has been guaranteed to comply with local laws and regulations.
- The operations required to guarantee the best possible use and preservation of the engine must only be carried out by persons of proven experience, equipment with tools considered suitable by FPT.
For the purpose of safety, further recommendations are given in the CONTROLS AND MAINTENANCE section.
SAFETY WARNING SYMBOLS
You will find these symbols on the following pages; follow the instructions to which they refer, for your own safety and that of your engine.

Risk of injury: failure to comply with these instructions can result in the risk of serious injury.

Risk of serious damage to the engine: the partial or total non-observance of these instructions could cause serious damage to the engine and may nullify the warranty.

General risk: combines the risks of both the signs described above.

Safeguarding the environment: indicates the correct behaviour so that vehicle use is as environmentally friendly as possible.
**ENGINE TECHNICAL DATA**

The technical code and serial number are indicated on a plate, which is located on different parts of the engine, according to the model: flywheel casing, tappet cover, other.

<table>
<thead>
<tr>
<th>Code</th>
<th>C87 ENT Z W</th>
<th>C87 ENT L W</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine family</td>
<td>F2C</td>
<td></td>
</tr>
<tr>
<td>Cycle</td>
<td>4-stroke diesel</td>
<td></td>
</tr>
<tr>
<td>Number and arrangement of cylinders</td>
<td>6, in line</td>
<td></td>
</tr>
<tr>
<td>Bore x stroke</td>
<td>117 x 135 mm</td>
<td></td>
</tr>
<tr>
<td>Total displacement</td>
<td>8,709 cm³</td>
<td></td>
</tr>
<tr>
<td>Air system</td>
<td>Turbocharged - with intercooler</td>
<td></td>
</tr>
<tr>
<td>Injection type</td>
<td>Direct - high pressure pump supply and common rail system</td>
<td></td>
</tr>
<tr>
<td>Compression ratio</td>
<td>15.9 : 1</td>
<td></td>
</tr>
<tr>
<td>Cooling</td>
<td>Liquid</td>
<td></td>
</tr>
<tr>
<td>Engine direction of rotation</td>
<td>Anticlockwise (seen from flywheel side)</td>
<td></td>
</tr>
<tr>
<td>Dry weight</td>
<td>~ 870 kg</td>
<td></td>
</tr>
</tbody>
</table>

**Electrical system**

<table>
<thead>
<tr>
<th>24 V</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Accumulator/s</strong></td>
</tr>
<tr>
<td>- capacity</td>
</tr>
<tr>
<td>- discharge current (EN 50342)</td>
</tr>
</tbody>
</table>

**Performance (*)**

<table>
<thead>
<tr>
<th>F2CFE613</th>
<th>245 kW (333 hp) @ 2,100 rpm</th>
<th>1,510 Nm (153.92 kgm) @ 1,500 rpm</th>
</tr>
</thead>
<tbody>
<tr>
<td>E*B012</td>
<td>245 kW (333 hp) @ 2,100 rpm</td>
<td>1,510 Nm (153.92 kgm) @ 1,500 rpm</td>
</tr>
<tr>
<td>A*B012</td>
<td>305 kW (415 hp) @ 2,100 rpm</td>
<td>1,800 Nm (183.49 kgm) @ 1,500 rpm</td>
</tr>
<tr>
<td>E*B013</td>
<td>245 kW (333 hp) @ 2,100 rpm</td>
<td>1,510 Nm (153.92 kgm) @ 1,500 rpm</td>
</tr>
<tr>
<td>A*B013</td>
<td>305 kW (415 hp) @ 2,100 rpm</td>
<td>1,800 Nm (183.49 kgm) @ 1,500 rpm</td>
</tr>
</tbody>
</table>

(*) Net power to the flywheel in compliance with ISO 3046-1. Test conditions: temperature 25 ºC; atmospheric pressure 100 kPa; relative humidity 30%.

Any alteration of the above mentioned characteristics, in particular modification of the data stored in the injection system electronic units or the characteristics of the engine and its fittings, is strictly prohibited, penalty invalidation of the guarantee and absence of all liability on the part of FPT.
C87 ENT Z W - C87 ENT L W (245-305 kW)


C87 ENT Z W - C87 ENT L W (245-305 kW)

C87 ENT Z W - C87 ENT L W (245-305 kW)

C87 ENT Z W - C87 ENT L W (245-305 kW)
SIGN

Certain warning signs are affixed to the engine by the Manufacturer, and their meanings are indicated below.

N.B. The signs with an exclamation mark on them underline a potential danger.

- **Lifting point (engine only).**
- **Fuel Cap**  
  *(on the fuel tank, if there is one).*
- **Oil Cap.**
- **Oil dipstick.**
- **Danger of burning:**  
  Expulsion of hot water under pressure.
- **Danger of burning:**  
  Presence of high temperature parts.
- **Danger of fire:**  
  Fuel present.
- **Danger of impact or catching on moving parts:**  
  Presence of fans, pulleys, belts or the like.
USE

PRELIMINARY CHECKS
Before starting the engine every time:
- Check the level of technical fluids (fuel, engine oil and coolant), and top-up if necessary.
- Make sure that the air aspiration filter is not blocked or obstructed.
- Make sure that the start batteries are efficient and relative clamps are correctly connected.

FOR PROPER USE OF THE ENGINE
- It is not efficient to leave the engine running at minimum speed while waiting for it to reach the proper working temperature; it is preferable that, after approximately one minute from start-up, the engine load should be increased gradually.
- Do not leave the engine running at minimum speed for long, as this increases the production of harmful emissions and does not guarantee the best performance.
- The engine speed must be increased and decreased gradually, to allow regular combustion and proper operation of all engine components.
- The running speed and power values must comply with the specifications on the technical and commercial documentation.

During use, periodically check that:
- The engine coolant temperature does not reach the alarm threshold.
- The oil pressure remains within normal values.

CAUTION!
Make sure that no fuel vapours or gases are present in the area in which the engine should be operated. Ensure that closed areas are adequately ventilated and fitted with a suitable exhaust extraction system.
SPECIAL WARNINGS

Coolant circuit

When the engine is running, regularly check that the engine coolant temperature does not reach the alarm threshold. In case the temperature detected is excessive, disconnect the load and stop the engine to check the cooling circuit status.

CAUTION!

When the engine is hot, pressure builds up in the cooling circuits which may eject hot liquid violently, resulting in a risk of burns. Open the filler cap of the coolant tank only when the engine is cold.

If the temperature is considered too high, reduce speed and stop to check the state of the cooling system circuits. Check the following:

- a) the tension of the auxiliary member drive belt;
- b) the thermostatic valve’s efficiency;
- c) the conditions of the heat exchanger (to be cleaned if necessary).

Fuel circuit

Avoid using the engine with small reserve of fuel in the fuel tank. Thus the vapour condensation is encouraged and makes the engine more likely to suck up dirt or air, resulting in engine stoppage.

CAUTION!

While refuelling, always pay attention to ensure that no solid or liquid pollutants enter the fuel tank; remember that smoking and live flames are prohibited during refuelling.

CAUTION!

Never lose the high pressure fuel circuit connectors in any way.

Lubrication circuit

Regularly check that the oil pressure keeps within normal values. If the value detected is too low, check the oil level and refill if necessary following the instructions reported in the CONTROLS AND MAINTENANCE section. If the condition persists, contact the Service Centre.

Air intake and exhaust gas circuits

Inspect the cleanliness of the air intake circuit on a regular basis. The maintenance intervals indicated in this manual vary according to the conditions in which the engine is operated. In particular dusty environments it is necessary to carry out maintenance within more frequent intervals than indicated in the CONTROLS AND MAINTENANCE section.
ATS system
This system is used to maintain the nitrogen oxide (NOx) emissions in the exhaust within the limits required by standards, transforming the nitrogen oxide into inert compounds: nitrogen (N₂) and water vapour (H₂O). Periodically clean the filters at the intervals indicated in the CONTROLS AND MAINTENANCE section.

Electric starter system
Check periodically the cleanliness and efficiency of the batteries, particularly during winter, as indicated in the CONTROLS AND MAINTENANCE section. Top up if necessary.
In the event of battery replacement, observe the characteristics contained in the ENGINE TECHNICAL DATA section.

RUN-IN
Thanks to modern engine design technology, no particular run-in procedure is required.
However, for the first 50 hours, it is not recommended to operate the engine at high power for long periods.
To guarantee high performance during the engine life cycle, during the first 50 hours of use it has been prescribed to:
- keep the engine at average speed during the first minutes after engine start without using the power take-off components in order to reach optimal operating condition.
- do not run the engine at maximum power for a continuous period of 2 hours.
- do not exceed 1,900 rpm.
- let the engine rest every 30 minutes.
- do not idle the engine for long periods.

CAUTION!
Visually check that the exhaust circuit is not obstructed or damaged to prevent the formation of noxious and harmful fumes inside the ducts.

The batteries contain an acid solution that will burn the skin and corrode clothing; when checking them, always wear protective clothing, gloves and goggles, do not smoke or use live flames in the vicinity, and make sure that the room they are housed in is adequately ventilated.

Contact a specialised workshop and check battery and recharging system efficiency if the voltmeter indicates a voltage below 11 V (for 12 V rated systems), or 22 V (for 24 V rated systems).
**CONTROLS AND MAINTENANCE**

**MAINTENANCE PERSONNEL**

The engine control and maintenance operations described in the following chapter require training, experience and compliance with current safety regulations. For this reason, the following operations must be carried out by special technicians.

- **Checks to be made during periods of use:** by workshop personnel or if necessary by the machine user.
- **Periodic maintenance:** by qualified personnel using suitable equipment and adequate means of protection.
- **Extraordinary maintenance:** by qualified personnel from Authorised Service Centres who have detailed technical information and specific equipment.

The most qualified Assistance Centres are those which make up the FPT Technical Assistance Network.

**ACCIDENT PREVENTION**

- Always wear heavy-duty footwear, gloves and suits.
- Never wear loose, flapping garments, rings, bracelets and/or necklaces close to engines or moving parts.
- Always wear protective gloves and goggles when:
  - filling up batteries with acid solution
  - check cleanliness of battery clamps and terminals
  - refilling with inhibitors or antifreeze
- replacing or topping up lubricant (hot engine oil may cause burns and scalds. Only carry out these operations when the oil has dropped to a temperature of below 50°C).
- While working in the engine compartment, pay particular attention on movements, to avoid contact with moving parts and high temperature components.
- Wear safety goggles while using compressed air jets. Maximum air pressure used to clean is 200 kPa (2 bar, 30 psi, 2 kg/cm²).
- Wear a protective helmet when working in an area were there are suspended loads or systems installed at/above head-height.
- Use protective hand creams.
- Replace wet gloves immediately.
- Always keep the engine clean removing oil, fuel and coolant stains.
- Store cloths in flame-proof containers.
- Do not leave external objects on the engine.
- Use suitable, safe containers for used oil.
- Once the repair activities are completed, take the necessary steps to stop engine air suction in case of uncontrolled increase in engine speed after start-up.

**WARNING**

Do not carry out maintenance operations when the electric power supply is turned on: always check to ensure that the appliances are properly earthed. During diagnosis and maintenance operations, make sure that your hands and feet are dry, and whenever possible use insulating stands.
## REFILLING

<table>
<thead>
<tr>
<th>Parts to be supplied</th>
<th>C87 ENT Z W</th>
<th>C87 ENT L W</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>litres (kg)</td>
<td></td>
</tr>
<tr>
<td>Cooling circuit</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Lubrication circuit</td>
<td>26 (23.4)</td>
<td></td>
</tr>
<tr>
<td>total capacity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Periodic changing:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>oil sump at minimum level</td>
<td>20 (18)</td>
<td></td>
</tr>
<tr>
<td>oil sump at maximum level</td>
<td>23 (20.7)</td>
<td></td>
</tr>
<tr>
<td>Fuel tank</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Urea tank</td>
<td>43 / 80 / 135</td>
<td></td>
</tr>
</tbody>
</table>

(1) The quantities indicated only relate to the engine in its standard configuration. Use a 50% mixture of water and Actifull OT CONCENTRATE (or Actifull OT PREMIX without adding water) even during the summer months. As an alternative to Actifull OT, use another product that complies with FPT norm FPI9.COOL002 and / or ASTM D-6210 standard.

(2) Only use lubricants which meet the international standards API CJ-4 / ACEA E9. Recommended oil is SAE 10W-40 that complies with FPT norm FPI9.LUBR001. FPT suggest to use original AkcelA or AmbrA lubricants compliant with SAE 10W40 standard. The oil consumption is considered to be acceptable until a quantity equaling 0.5% of fuel consumption is reached.

(3) The quantities indicated relate to the first refill only and are relative to the engine, oil sump and filter filling.

(4) Use STANDARD fuel compliant to the ASTM D975 or EN 590. Instructions connected to the fuel tank capacity are the responsibility of the vehicle/equipment manufacturer since these are subject to changes depending on the various vehicle/equipment configurations.

(5) Only use AdBlue®/DEF (32.5% solution in water) in accordance with ISO 22241 specification.
Coolant refilling

For the initial engine start-up and in the cases in which the refilling of the cooling circuit is required with a considerable quantity of coolant, proceed as follows:

- Refill the engine and the exchanger until the exchanger is completely filled.
- With the coolant filler plug open, start the engine and let it idle for approx. 1 minute. This helps to completely bleed the air contained in the cooling circuit.
- Stop the engine and then top up with coolant if necessary.

The failure to observe the aforesaid procedure does not guarantee the presence of the correct quantity of coolant in the engine.

Refuelling

Use only diesel oil in accordance with ASTM D975 or EN 590 standard normally commercially available. Fuel additives are not recommended. Use of additives can limit the guarantee performance offered for the vehicle.

CAUTION!

Pay maximum attention when refuelling, making sure that solid or liquid pollutants do not enter the tank; please remember that smoking is prohibited while refuelling. The couplings of the fuel circuit under high pressure must not be loosened under any circumstances.

Low temperature diesel

At low temperatures the degree of fluidity of the diesel can become low due to the separation of the paraffin resulting in the filters becoming clogged.

ASTM D975 or EN590 specifications distinguish different classes of diesel fuel, identifying the characteristics of those best suited to low temperatures.

It is entirely up to the Oil companies to comply with these regulations, which foresee that fuels suited to the climactic and geographic conditions of the various Countries be distributed.
The maintenance intervals indicated below take into account the typical working factors for various types of engine use; the most suitable interval for maintenance operations for the various applications will be indicated by the maintenance staff, according to the way and working conditions in which the engine is used.

### Checks (during the period of use)

<table>
<thead>
<tr>
<th>Checks</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine lubricant oil level check</td>
<td>Daily</td>
</tr>
<tr>
<td>Engine coolant level check</td>
<td>Daily</td>
</tr>
<tr>
<td>Engine visual inspection</td>
<td>50 hours</td>
</tr>
<tr>
<td>Air filter and housing cleanliness check</td>
<td>1 month</td>
</tr>
<tr>
<td>Tension and condition check of auxiliary</td>
<td>300 hours</td>
</tr>
<tr>
<td>members' belt</td>
<td></td>
</tr>
<tr>
<td>Exhaust duct(s) condition check</td>
<td>6 months</td>
</tr>
</tbody>
</table>

### Planned maintenance

<table>
<thead>
<tr>
<th>Planned maintenance</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water drainage from the fuel pre-filter</td>
<td>150 hours</td>
</tr>
<tr>
<td>(if present)</td>
<td></td>
</tr>
<tr>
<td>Condensed water drainage from fuel tank</td>
<td>150 hours</td>
</tr>
<tr>
<td>Engine lubricant oil replacement</td>
<td>600 hours</td>
</tr>
<tr>
<td>(*)</td>
<td></td>
</tr>
<tr>
<td>Lubricant oil filter replacement</td>
<td>600 hours</td>
</tr>
<tr>
<td>(*)</td>
<td></td>
</tr>
<tr>
<td>Fuel pre-filter replacement (if present)</td>
<td>600 hours</td>
</tr>
<tr>
<td>Fuel filter replacement</td>
<td>600 hours</td>
</tr>
<tr>
<td>Air filter replacement (***)</td>
<td>1,200 hours</td>
</tr>
<tr>
<td>Auxiliary members' belt replacement</td>
<td>1,200 hours</td>
</tr>
<tr>
<td>Heat exchanger (radiator) cleaning (**)</td>
<td>1,200 hours</td>
</tr>
<tr>
<td>Blow-by filter replacement</td>
<td>1,800 hours</td>
</tr>
</tbody>
</table>

### Extraordinary maintenance

<table>
<thead>
<tr>
<th>Extraordinary maintenance</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turbocharger visual inspection</td>
<td>1,200 hours</td>
</tr>
<tr>
<td>Valves/rocker arms clearance adjustment</td>
<td>2,400 hours</td>
</tr>
<tr>
<td>Engine coolant replacement</td>
<td>3,000 hours</td>
</tr>
</tbody>
</table>
(*) Frequency for construction equipment application:
- 100 hours versus standard application.

(**) Indicated frequencies are valid only if the component (s) supplied by FPT.

1) Maximum period relative to the use of high quality fuel, (specification ASTM D975 or EN 590); this is reduced based on fuel contamination and the alarm signals due to filter clogging and/or the presence of water in the pre-filter. The filter clogging signal indicates that the filter must be replaced. If the signal of water present in the pre-filter does not turn off after drainage, the filter must be replaced.

2) To be performed every year even if the specified operating hours interval has not been reached.

3) The frequencies are applicable for lubricants which meet the international standards API CJ-4 / ACEA E9 as specified in the REFILLING section.

4) Only use filters with the following specifications:
   - degree of filtering < 12 μm
   - filtering efficiency 99.5% (β > 200).

5) To be performed every two years even if the specified operating hours interval has not been reached.

6) To be performed every three years even if the specified operating hours interval has not been reached.

7) To be performed every 15 days even if the specified operating hours interval has not been reached.

8) To be performed every six months even if the specified operating hours interval has not been reached.

The extraordinary maintenance operations described hereunder fall within the exclusive competence of manufacturer’s personnel or specialised personnel having proper working tools and adequate protection devices. The procedure and modality for carrying out these operations are illustrated in the FPT Technical and Repair Manual.

<table>
<thead>
<tr>
<th>Scheduled maintenance for the ATS system</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tank Neck Filter (300 or 100* μm)</td>
<td>No regular service planned (Cleaning, if required)</td>
</tr>
<tr>
<td>SM Pre-Filter (100 or 70* μm)</td>
<td>Cleaning with water @ every oil change interval</td>
</tr>
<tr>
<td>SM Inlet-Filter (100 μm)</td>
<td>No regular service planned (Replacement, if required)</td>
</tr>
<tr>
<td>SM Main-Filter</td>
<td>Change every 3,600 hours or 2 years (whichever occurs first)</td>
</tr>
<tr>
<td>SM Backflow-Filter (100 μm)</td>
<td>No regular service planned (Replacement, if required)</td>
</tr>
<tr>
<td>Dosing Valve Filter (36 μm)</td>
<td>Cannot be serviced</td>
</tr>
</tbody>
</table>

* for application working in dusty environment only.
ATS System filter location


REQUIREMENTS

- Do not disconnect the batteries with the engine running.
- Do not carry out arc welding operations in the vicinity of the engine without first removing electrical cables.
- After each maintenance operation involving disconnection of the battery/batteries, make sure that the terminals have been properly locked onto the poles.
- Do not use battery chargers to start the engine.
- Disconnect the on-board network battery/batteries when recharging.
- Do not paint the appliances, components and electrical connectors equipping the engine.
- Disconnect the battery/batteries before any electrical operations.
- Contact the Manufacturer before installing electronic equipment on board.

Do not execute any operation which may change the high pressure fuel pump's calibration.
The high pressure fuel pump's calibration has been carried out in phase of engine system test based on its final use or destination.
CHECKS TO BE MADE DURING THE PERIOD OF USE - HOW TO PROCEED

**Engine visual inspection**

It is a good habit to execute, before engine start, a series of simple checks that might represent a valid warranty to avoid inconveniences, even serious, during engine running. Such checks are usually up to the operators and to the vehicle's drivers.

- Level controls and checks of any eventual leakage from the fuel, cooling and lubricating circuits.
- Notify the maintenance if any inconvenience is detected or if any filling is necessary.

After engine start and while engine is running, proceed with the following checks and controls:

- Check presence of any eventual leakage from the fuel, cooling and lubricating circuits.
- Verify absence of noise or unusual rattle during engine working.
- Verify, using the vehicle devices, the prescribed pressure temperature and other parameters.
- Visual check of fumes (colour of exhaust emissions)
- Visual check of cooling liquid level, in the expansion tank.

**Engine lubricant oil level check**

The check must be executed when the engine is disconnected and possibly cool.

Only proceed with the engine stopped and at low temperature, in order to avoid the risk of burning.

- Make sure the machine is on a flat surface.
- Use the oil dipstick (not supplied by FPT) to check that the lubricant oil level is between the "Min" and "Max" limits.
- Whether it should be difficult to make the evaluation, proceed cleaning the oil dipstick using a clean cloth with no rag grinding and put it back in its slot. Draw it off again and check the level.
- If the level is insufficient, it is necessary to top up with lubricant oil which meets the international specifications API CJ-4 / ACEA E9, as indicated in the REFILLING section: remove the lubricant oil cap (1) and pour engine lubricant oil through the hole.
- Use the oil dipstick to check that the lubricant oil level does not exceed the "Max" limit.
Engine coolant level check

Only proceed with the engine stopped and at low temperature, in order to avoid the risk of burning.

- Remove the pressurization cap from the expansion tank.
- Check that the coolant in the expansion tank is above the minimum level.
- If necessary, top up the expansion tank with a mixture of 50% water and Actifull OT CONCENTRATE, as contained in the REFILLING section. Do not fill the expansion tank to the brim.
- When the engine is cold, make sure that the coolant level is a few centimetres below the filling hole.

In the event of an externally located level indicator as regards the heat exchangers, proceed with the top up operation by making sure that the coolant does not overfill the internal volume of the exchanger in order to allow the expansion of coolant volume during increases in temperature.

- Make sure that the oil dipstick is fully inserted and that the oil filler cap is fully tightened in a clockwise direction.

If the refill operations occur frequently a diagnosis of the cooling circuit is necessary.
Water drainage from the fuel pre-filter (if present)
The high risk of refuelling with fuel that is polluted by foreign bodies and water makes it advisable to carry out this control every time you refuel.
Proceed with the engine stopped.
- Place a container under the pre-filter to collect the fluid.
- Unscrew the tap plug (3) in the bottom part of the filter; in some lay-outs the plug includes a sensor to detect the presence of water in the diesel.
- Drain off liquid until only “diesel” can be seen.
- Close the plug again, tightening it completely by hand.
- Dispose of the drained fluids according to current requirements.

CAUTION!
When the engine is hot, pressure builds up in the cooling circuits which may eject hot liquid violently, resulting in a risk of burns.
Open the filler cap of the coolant tank only if necessary and only when the engine is cold.

The components of the common rail system will be rapidly damaged if the fuel contains water or impurities.
Immediately perform the operation on the pre-filter to drain the water present in the fuel supply circuit.
Air filter and housing cleanliness check
(Supplied on demand)

Only proceed with the engine stopped.

- Remove the filter cover (1) after first unscrewing the locking handle.
- Remove the external cartridge (2), after unfastening the second locking handle; during this operation, take care to ensure that no dust get into the sleeve.
- Check that there is no dirt. If there is, clean the filter element as indicated below.
- Blow dry compressed air through the filter element, from the inside outward (maximum pressure 200 kPa). Do not use detergents; do not use diesel.
- Never use tools to beat the filter element, and check its condition before replacing it.
- Replace the filter if any breakages or tears are found.
- Check that the gasket at its base is in good condition. Some filter systems are fitted with a second filter element (3) which does not require cleaning; this must be replaced at least once every 3 changes in the main element.
- Reassemble by repeating the above operations in reverse order.
- Set up the mechanical blockage indicator for operation by pressing the button located on the top part of the indicator. This operation is not necessary if there is an electrical sensor.

CAUTION!

Take care to ensure that the parts are reassembled correctly. Improper assembly might result in unfiltered air being sucked into the engine, causing serious damage.
Tension and condition check of auxiliary members' belt

Only proceed when the engine is not turning and is at low temperature so as not to run the risk of burns.

- Check that the belt is not worn, soiled with oil or fuel, or showing signs of tears. Otherwise replace the belt if necessary.
- Use a ½ inch square wrench to check the efficiency of the automatic belt tensioner.

**CAUTION!**

*When the engine is off, but still hot, the belt may start to move without warning. Wait for the engine temperature to decrease to prevent serious danger of an accident.*

Exhaust duct(s) condition check

Visually check that the exhaust gas system is not blocked, corroded or damaged.
In the event of any problems, perform the operations necessary to restore the exhaust duct.
PLANNED MAINTENANCE - HOW TO PROCEED

Engine lubricant oil replacement

Only proceed when the engine is not rotating. It is recommended to drain the engine oil when hot. To avoid working on the engine with an excessive oil temperature, wait 3 hours after turning off the machine.

- Place a suitable container for collecting the spent oil under the oil sump (2) next to the lubricant oil drain plug (3).
- Unscrew the lubricant oil drain plug (3); afterwards extract the oil level dipstick (not supplied by FPT) and remove the lubricant oil cap (1) to assist the flow of the engine lubricant oil.
- Wait until the oil sump (2) has completely emptied, then retighten the lubricant oil drain plug (3).
- Proceed with the refilling operation through the hole situated on the tappet cover, using lubricant oil that meets the international standards API CJ-4 / ACEA E9, as indicated in the REFILLING section.
- Use the oil dipstick to check that the lubricant oil level does not exceed the "Max" limit.
- Whether it should be difficult to make the evaluation, proceed cleaning the oil dipstick using a clean cloth with no rag grinding and put it back in its slot. Draw it off again and check the level.
- Retighten the lubricant oil cap (1).
- Together with the replacement of the engine lubricant oil it is necessary to replace the oil filter (see LUBRICANT OIL FILTER REPLACEMENT paragraph).
**Lubricant oil filter replacement**

The filter must also be replaced when the lubricant oil is changed. Only use filters with a filtering degree that is the same as the previous one (see the FREQUENCY section). Only proceed with the engine stopped and at low temperature, in order to avoid the risk of burning.

- Place a container for collecting the spent oil under the filter support (1).
- Unscrew and remove the filter (4) from its relative support (1) by suitable tool.
- Replace the filter element (3) and the sealing gasket (2) contained inside the filter (4).
- Carefully clean the surfaces of the support (1) in contact with the sealing gasket (2).
- Moisten the sealing gasket (2) of the new filter (4) with a thin layer of oil.
- Manually tighten the new filter (4) on the support (1) until it comes into contact with the gasket (2). Additionally tighten it using a specific tool to a torque of 60 ± 5 Nm.
- Operate the engine for a few minutes and then check the level using the dipstick. If necessary, top up to compensate for the quantity of oil used to fill up the filtering cartridge.

Eliminate the consumables and any materials in contact with them (for example, filters) in accordance with current regulations. The FPT Technical Service Network workshops are equipped for this purpose.

Make sure that the oil dipstick is fully inserted and that the oil filler cap is fully tightened in a clockwise direction.
Given the high operating temperature of the engine, suitable protective gloves should be worn.

The engine oil reaches very high temperatures: always wear protective gloves.

The engine oil is highly pollutant and noxious. In case of contact with skin, wash thoroughly with water and detergent. Suitably protect skin and eyes; proceed in accordance with accident prevention standards.

Only use recommended oils or oils with the properties required for proper engine operation. If topping up, do not mix oils with different properties. Failure to observe these standards will invalidate the servicing warranties.

Eliminate the consumables and any materials in contact with them (for example, filters) in accordance with current regulations. The FPT Technical Service Network workshops are equipped for this purpose.
Fuel pre-filter replacement (if present)

Only proceed with the engine stopped.

- Should the filter be fitted with a sensor to detect the presence of water (3), remove the whole sensor from its seat.
- Remove the pre-filter by unscrewing it.
- Check that the new filter has performance levels that satisfy the needs of the engine (e.g. by comparing them with the old one).
- Damp the new filter seal with diesel or engine oil.
- Hand screw the new filter into place until the seal gasket touches the support, then lock by a further 3/4 of a turn.
- Place the water presence sensor in its seat, taking care to couple the threads correctly.
- Loosen the bleeder screw (1) on the pre-filter support and activate the hand pump (2) until the supply circuit is full. Ensure that any fuel coming out is not dispersed into the environment.
- Lock the bleeder screw tightly.
- Start the engine and run it at idle for a few minutes to eliminate any residual air.

Fuel filter replacement

Only proceed with the engine stopped and at low temperature, in order to avoid the risk of burning.

- Place a container for collecting the diesel under the filter support (2).
- Drain the fuel from the fuel filter (5) by loosening the drain screw (6).
- Remove the filter (5) by unscrewing it from its relative support (2).
- Replace the filter element (4) and the O-ring seal (3) contained inside the filter (5).
- Carefully clean the surfaces of the support (2) in contact with the O-ring seal (3).
- Smear the O-ring seal (3) of the new filter with oil.
- Manually tighten the new filter (5) onto the support (2) until it comes into contact with the gasket (3). Additionally tighten it using a specific tool to a torque of 32.5 ± 2.5 Nm.

After the fuel filter (5) has been replaced it is possible that air bubbles get trapped inside the fuel supply circuit.

If it is necessary to speed up the residual air bleeding phase, use the hand pump also while starting.
- Bleed residual air from the fuel filter (5) by loosening the vent plug (1) connecting it to a suitable container by a transparent flexible hose.
- With the hand pump of the fuel pre-filter pump until fuel completely free of air bubbles flows from the vent plug (1).
- Tighten the vent plug (1) to prescribed torque.
- Start the engine and allow it to run at minimum for a few minutes to expel any remaining air.

⚠️ Do not smoke or use open flames during this operation. Do not inhale the vapours that exit the filter.

⚠️ Pay attention to the electric fuel pre-heater (if installed) and the relative electrical connection.

⚠️ Do not fill the new fuel filter before placing it on the support in order to prevent harmful impurities from entering the fuel circuit and the injection system.

⚠️ Eliminate the consumables and any materials in contact with them (for example, filters) in accordance with current regulations. The FPT Technical Service Network workshops are equipped for this purpose.
Blow-by filter replacement

Only proceed with the engine stopped and at low temperature, in order to avoid the risk of burning.
- Unscrew the fastening screws (4) and remove the timing cover (3).
- Unscrew the fastening screws (2) and remove the blow-by filter (1).
- Replace and install the centrifugal filter element (1) on the timing gear (5) and tighten the fastening screws (2).
- Fit the timing cover (3) and tighten the fastening screws (4).

CAUTION!

Ensure that any fuel coming out of the vent plug or drain screw does not dirty the auxiliary members’ drive belt and is not dispersed into the environment. Never loose connectors of the high-pressure fuel pipes and of the common rail in any way.

If it is necessary to speed up the residual air bleeding phase, use the hand pump also while starting.
Auxiliary members' belt replacement

- Pull the automatic belt tensioner (8) by using appropriate tool (7) and remove the auxiliary members' belt (4) from alternator (1), water pump (3), fan control pulley (2), crankshaft pulley with damper (6) and fixed guide roller (5).
- Replace the worn belt (4) with new one.
- Fit the auxiliary members' belt (4) on the pulleys and guide roller.
- Use the appropriate tool (7) on the automatic belt tensioner (8) in order to fit the new belt (4) in the operating position.
- Additional adjustments are not required. The belt tension is adjusted automatically by the calibrated spring in the automatic belt tensioner (8).
- Operate the engine for a few hours and check that the auxiliary members' belt (4) is properly fitted.

CAUTION!

When the engine is off, but still hot, the belt may start to move without warning. Wait for the engine temperature to decrease to prevent serious danger of an accident.
Air filter replacement
(Supplied on demand)
Refer to the instructions provided for air filter cleaning.

Heat exchanger (radiator) cleaning
(Supplied on demand)
Check that the air intake surfaces of the radiators are free of impurities (dust, mud, straw etc.).
Clean them if necessary using compressed air or steam.

Replace the belt if it shows signs of abrasion, cracks or tears or if it is soiled with oil or fuel.

When using compressed air, it is required to use suitable personal protections for hands, face and eyes. The requirements can be found in the ACCIDENT PREVENTION paragraph.
EXTRAORDINARY MAINTENANCE - HOW TO PROCEED

Turbocharger visual inspection
Only proceed when the engine is not turning over. Visually check that the turbine and compressor impellers and the relative inlet and outlet ducts are not obstructed or damaged, otherwise replace them.

Adjustment of valve/rocker arm clearance
- Clearance between rockers (1) and intake/exhaust valve control bridges (3) must be strictly adjusted with maximum care using special spanner (5), polygonal spanner (2) and feeler gauge (4).
- Bring the cylinder under examination to the firing stage: the valves of this cylinder should remain closed and the clearance could be adjusted while the symmetric cylinder valves are balanced.
- The cylinder pairs are 1-6, 4-3 and 2-5.
- In order to carry out these operations correctly, follow the indications provided in the relevant Technical and Repair manual.

Engine coolant replacement
Only proceed when the engine is not turning, and is at low temperature, so as not to run the risk of burns.
- Place a container for collecting coolant under the heat exchanger (radiator).
- Remove the pressurization cap from the expansion tank.
- Loosen the retaining elements and remove the sleeves connecting the engine cooling circuit to the heat exchanger.
- Drain the coolant from the heat exchanger (radiator) and wait until it is completely empty.
- Once emptied, refit the cooling circuit making sure the sleeves are perfectly sealed.
Refill the engine and the heat exchanger until the cooling circuit has been completely refilled using a mixture of 50% water and Actifull OT CONCENTRATE, as contained in the REFILLING section. Do not fill the expansion tank to the brim.

With the coolant cap open, start the engine and let it idle for approx. one minute. This helps to completely bleed the air contained in the cooling circuit.

Stop the engine and top up with more coolant, if necessary.

When the engine is cold, make sure that the coolant in the expansion tank is a few centimetres below the filling hole.

In the event of an externally located level indicator as regards the heat exchangers, proceed with the top up operation by making sure that the coolant does not overfill the internal volume of the exchanger in order to allow the expansion of coolant volume during increases in temperature.

The failure to observe the aforesaid procedure does not guarantee the presence of the correct quantity of coolant in the engine.

CAUTION!

When the engine is hot, pressure builds up in the cooling circuits which may eject hot liquid violently, resulting in a risk of burns. Open the filler cap of the coolant tank only if necessary and only when the engine is cold.

MOVING THE ENGINE

The operations necessary to disconnect and subsequently reconnect the engine must only be carried out by technicians from Service Centres.

When lifting the engine only, use the U-bolts indicated in this manual in the ENGINE TECHNICAL DATA section and marked on the engine with special stickers.

Lifting must be carried out using a rocker arm that keeps the metal cables supporting the engine parallel, using all the U-bolts provided simultaneously; the use of a lower number of lifting eyelets is not permitted.

The engine lifting system must have a capacity and size suited to the weight and dimensions of the engine; check that there is no interference between the lifting system and the engine components. Do not lift the engine before removing the transmission members that are coupled to it.

DISPOSAL OF WASTE

The engine is made up of parts and elements that, if discarded, may cause damage to the environment.

The materials listed below must be handed over to specialised Collection Centres:

- Starter batteries.
- Used lubricants.
- Mixtures of water and antifreeze.
- Filters.
- Additional cleaning materials (e.g. greasy or fuel-soaked cloths).

The laws in force in the various countries provide for severe penalties for lawbreakers.
SCHEDULED MAINTENANCE FOR THE ATS SYSTEM - HOW TO PROCEED

Change Supply Module main-filter

To prevent damage to the pump and dosing module, the supply module contains a filter which removes any impurities from the AdBlue.

Please refer to the following procedure for replacement of the filter.


Filter disassembly

- Unscrew and remove the filter cover (1).
- Remove the equalizing element (2).

During installation of the supply module on the vehicle, take into account the minimum aperture for filter replacement.

The minimum value is approx. 155 mm.
- Insert the appropriate tool (1) in the correct direction in the filter, based on the colour of the filter supplied.
- Insert the appropriate tool (1) until a click is felt which indicates the complete engagement of the filter (2).
- Remove the filter (2).

Filter assembly
- Carefully clean with water the contact surface (1).
- Oil gasket (3) and assembly the new filter (2).
- Assembly a new equalizing element (2).
- Carefully clean the filter cover (1).
- Tighten the filter cover (1) to a torque of 20 ± 5 Nm.

Check that the filter cover and the contact surface of the supply module are not cracked or damaged. If necessary, replace any damaged components.
LONG PERIODS OF INACTIVITY

PREPARING THE ENGINE FOR A LONG PERIOD OF INACTIVITY

In order to prevent oxidation of the internal parts of the engine and of certain components in the injection system, when the engine is expected to be inoperative for periods of more than two months, the following operations must be carried out in preparation for this:

1. Drain the lubricant from the sump, after first warming up the engine.

2. Fill the engine with protective oil type 30/M, up to the "minimum" level indicated on the dipstick. Start the engine and keep it running for approximately 5 minutes.

3. Drain the fuel from the injection circuit, from the filter and from the injection pump pipes.

4. Connect the fuel circuit to a tank containing CFB (ISO 4113) protective fluid, and feed in the fluid by putting the circuit under pressure and running the engine for approximately 2 minutes, after first disabling the injection system. This operation can be performed by polarising terminal 50 of the starter motor with a positive voltage equivalent to the rated voltage of the system, using a conductor provided for that purpose.

5. Nebulise approximately 87 g of 30/M protective oil (10 g per litre displacement) into the turbocharger suction inlet, during the pressurised filling operation described in the previous point.

6. Close all the suction, delivery, ventilation and bleeder openings in the engine with suitable plugs, or seal them with adhesive tape.

7. Drain the residual 30/M protective oil from the sump. This oil can be used again for a further 2 preparation operations.

8. Fit signs reading "ENGINE WITHOUT OIL" to the engine and to the on-board control panel.

9. Drain the coolant, if it has not been mixed with suitable antifreeze and corrosion inhibitors, and affix a sign to indicate the fact.

In the event of prolonged inactivity, the operations described must be repeated every 6 months, following the procedure given below:

A) drain the 30/M protective oil from the sump;

B) repeat the operations described from point 2 to point 7.

Should you intend to protect external parts of the engine, proceed by spraying OVER 19 AR protective liquid on unpainted metal parts, such as the flywheel, pulleys and the like, avoiding belts, connector cables and electrical equipment.
RESTARTING THE ENGINE AFTER A LONG PERIOD OF INACTIVITY

1. Drain the residual 30/M protective oil from the sump.
2. Fill the engine, as prescribed, with lubricant of the type and amount indicated in the REFILLING section.
3. Drain the CFB protective fluid from the fuel circuit, carrying out this operation as indicated under point 3 of PREPARING THE ENGINE FOR A LONG PERIOD OF INACTIVITY.
4. Remove the plugs and/or seals from the suction, delivery, ventilation and bleeder openings in the engine, restoring it to a normal state of use. Connect the turbocharger suction inlet to the air filter.
5. Connect the fuel circuits to the machine’s fuel tank, completing the operations as indicated in point 4 of PREPARING THE ENGINE FOR A LONG PERIOD OF INACTIVITY. During filling operations, connect the fuel return pipe to a collection tank, so as to prevent any residual CFB protective fluid from flowing into the machine’s fuel tank.
6. Check the engine and fill it up with coolant as prescribed, bleeding it if necessary.
7. Start the engine and keep it running until the idling speed rate has stabilised completely.
8. Check that the instruments on the on-board control panel/s are showing plausible values, and that no alarms are shown.
9. Stop the engine.
10. Remove the ENGINE WITHOUT OIL signs from the engine and from the on-board control panel.
ENGINE MALFUNCTIONS

The electronic unit overseeing management and control of all operation of the engine is capable of recognising any malfunctions that may occur, and of adopting strategies that will allow you to proceed in full safety. The event, signalled by light-up of the EDC MALFUNCTION indicator on the on-board control panels, results in programmed limitation of power within certain thresholds, set according to the severity of the case.
In the case of temporary malfunctions the reduction in performance will remain in force until the engine is stopped.

BEHAVIOUR IN CASE OF FAILURE

Accelerator electronic circuit malfunction
When certain problems in the accelerator electric circuit are recognised, the Electronic Unit controlling the engine adopts a strategy known as “accelerated minimum speed running”, that will enable running/work to continue in emergency mode. The possible operating modes are as follows:
A. The accelerator lever does not “respond”: the engine speed stabilises at 600 ± 100 rpm to allow manoeuvring at crawling speed by simply engaging and disengaging the clutch without accelerating.
B. The accelerator lever “responds partially”: the minimum running speed is set to 600 ± 100 rpm. When the accelerator lever is moved to approximately half way, the speed gradually increases up to 2110 ± 50 rpm; when the lever is returned to minimum the speed rapidly decreases to 600 ± 100 rpm.

Malfunction in the recharging system
The Electronic engine control units are programmed to increase the minimum running speed if the voltage in the electrical system reaches values considered to be at the limits of efficiency. In this case, check the efficiency of the battery/ies and if necessary perform a check-up on the system components.

CAUTION!
The engine electronic control unit can adopt safety strategies at any time during use of the machine or vehicle, should conditions arise that are considered to put the engine at risk.
When conditions of this kind occur, proceed only if necessary and with the greatest possible care and attention.

CAUTION!
Do not leave vehicles or machines with the engine running without first putting the parking lock or brake on.
<table>
<thead>
<tr>
<th>ANOMALY</th>
<th>POSSIBLE CAUSE</th>
<th>RECOMMENDED TESTS OR INTERVENTION</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low performance at load request.</td>
<td>Insufficient fuel level in the tank.</td>
<td>Check fuel level.</td>
<td>The excessive smoke is due to the fact that, in case of insufficient fuel feeding, the engine control module tries to compensate prolonging the injectors working time.</td>
</tr>
<tr>
<td></td>
<td>Fuel tank device partially obstructed by impurities or deformed because of overheating.</td>
<td>Check if the priming pump of the pre-filter is working correctly. If the pump plunger is permanently depressed disassemble and check the tank pick-up tube. If this is in order, replace the pre-filter.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Obstructed air filter.</td>
<td>Replace the air filter.</td>
<td>Solve the cause of the filter’s obstruction.</td>
</tr>
<tr>
<td></td>
<td>Excessive fuel blow-by from rail boost valve.</td>
<td>Check the O Rings and the correct connection of the pipe fittings under the feeding pump (the lockers must stay outside and the fittings must be well locked). Visually check the low pressure pipeline integrity.</td>
<td>Unless the leakage is significant, no performance failures will be detected. To verify O-rings integrity, extract from the tank the fuel recycling pipeline, seal the end and activate the priming pump driving the low pressure circuit.</td>
</tr>
<tr>
<td></td>
<td>Excessive fuel blow-by from rail boost valve.</td>
<td>Disconnect the pipe and visually check if there are any significant blow-by from the boost gauge valve; in such case replace the valve.</td>
<td></td>
</tr>
<tr>
<td>ANOMALY</td>
<td>POSSIBLE CAUSE</td>
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<tr>
<td>The engine suddenly stops (with no previous problems) and does not start again.</td>
<td>Obstructed fuel filter.</td>
<td>Replace the fuel filter.</td>
<td>Solve the cause of the filter’s obstruction (empty and clean the tank and the part of the circuit over the filter, refill with clean fuel).</td>
</tr>
<tr>
<td>Difficult start and low performance in all conditions.</td>
<td>Inefficient high pressure pump.</td>
<td>After having excluded any other possible cause, replace the high pressure pump.</td>
<td></td>
</tr>
<tr>
<td>Difficult start, low performance and engine running with one cylinder less.</td>
<td>Injector with obstructor or solenoid (mechanical part) blocked open.</td>
<td>The non-working injector is easily recognisable detecting by feeling the absence of pulsing within the relevant high pressure pipe.</td>
<td>In case of low entity blow-by, inficiating the mechanical working of the injector but not involving flow limiter activation, there is no error memorisation in the engine control module. If the flow limiter is activated. Check error code memory.</td>
</tr>
</tbody>
</table>
Starting requires in excess of ten seconds, followed by huge white exhaust fumes, and a fuel smell.

Injector blocked in open position (with no return).

The non-working injector is easily recognisable detecting by feeling the absence of pulsing within the relevant high pressure pipe.

Usually, whether such symptoms appear, it is instinctive to give up engine start. However, by insisting, it is possible to start the engine. As a matter of facts, by insisting, if within the rail the pressure makes the flow limiter close up, the engine starts with one cylinder less and gradually the grade of fumes reduces and disappears.

Breaking of high pressure pipeline from pump to rail.

Strange vibrations provoked by slack of pipe bracket.

Replace the pipeline ensuring the correct tightening of the anti-vibration bracket screws.

It is very important, in addition to correct blocking, to keep the brackets in the original position.

The engine works with one cylinder less, without memorising failure codes in the engine control module.

Injector blocked in closed position.

Identify the injector that is not working any more and the relating high pressure filler.

The non-working injector is easily recognisable detecting by feeling the absence of pulsing within the relevant high pressure pipe.
BEHAVIOUR IN EMERGENCY

The user of a machine that has been constructed according to safety regulations, when following the instructions provided in this manual and the indications given on the engine labels, will be working in safe conditions.

Should improper conduct result in accidents, always request the intervention of trained first aid specialists immediately.

In an emergency and while awaiting the arrival of first aid specialists, follow the instructions given below.

In case of fire

Extinguish the fire using the fire-fighting equipment foreseen, and in the manner indicated by Fire prevention authorities (fire-fighting equipment for certain machines and equipment is compulsory under current safety legislation).

Burns and scalds

- Extinguish any flames on the burned person's clothing, by:
  - throwing water over them;
  - using a powder fire-extinguisher, without directing the jet at the person’s face;
  - covering with blankets or rolling the victim on the ground.
- Do not attempt to remove pieces of clothing that may have stuck to the skin;
- In the case of scalding, immediately but carefully remove any clothing that may be soaked in the hot liquid;
- Cover the burn with a special burn dressing or sterile bandage.

Carbon monoxide intoxication (CO)

Carbon monoxide from the engine exhaust is without smell, and is dangerous both because it causes intoxication, and because when combined with air it forms an explosive mixture.

In closed rooms, carbon monoxide is extremely dangerous, as it can reach critical concentrations within a very short time.

When assisting an intoxicated person in a closed room:

- Ventilate the room immediately, to reduce the concentration of gas.
- When entering the room, hold your breath, do not light flames, lights or ring electric doorbells or phones, to avoid the risk of explosion.
- Carry the intoxicated person out into the fresh air or into a well ventilated room, resting him on one side if he is unconscious.
Electrocution
The engine’s electrical 12 V or 24 V electrical system does not involve the risk of electrocution, however, in the event of a short-circuit caused, for example, by a metal tool, there is a risk of burning due to overheating of the object through which the electrical current runs. In these circumstances:
- Remove the object that caused the short-circuit, using means that provide sufficient heat insulation.
- Switch off the power at the main switch, if there is one.

Injuries and fractures
The vast number of possible circumstances and the specific nature of operations required means that the intervention of a medical team is necessary.
- In the event of bleeding, keep the edges of the wound pressed together until help arrives.
- If there is any suspicion of a fracture, do not move the injured part and only move the patient if absolutely necessary.

Caustic burns
Caustic skin burns are caused by contact with extremely acid or alkaline substances.
For electric maintenance technicians these are typically caused by acid from batteries; in these circumstances, proceed as follows:
- Remove any clothing soaked in the caustic substance.
- Wash the area with lots of running water, avoiding parts that have not been burned.
If either battery acid, lubricants or diesel come into contact with the eyes: wash the eyes with water for at least 20 minutes, keeping the eyelids open so that the water flows over the eyeball (move the eye in all directions to wash more thoroughly).