INTRODUCTION
Thank you for preferring FPT and we congratulate you on your choice of engine. Before performing any operation that involves the engine or its equipment, please carefully read the instructions contained in this manual; following these instructions is the best way to guarantee that the engine will run perfectly for a long period of time.

The content of this manual refers only to the standard engine configuration and the illustrations are purely indicative. Some instructions are given by describing the sequence of operations that make it possible to obtain the expected behaviour from the engine and/or its equipment. In some cases they depend on the configuration of the controls and versions of the equipment in which the engine is installed; for anything that differs from the content of this manual, refer to the indications of the equipment manufacturer or its specific manual.

The following information is current as of the date of publication. The Manufacturer reserves the right to make changes without notice at any moment for technical or commercial reasons as well as due to adaptations of the engine to the laws of various countries. No liability is accepted for errors or omissions.

Remember that the skills and professionalism of the FPT Technical Service Network will be at your side wherever you are.
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GENERAL INFORMATION

WARRANTY
To ensure the best engine performance and rely on the FPT warranty, the instructions provided in this publication must be followed carefully; failure to observe them or following them incorrectly could invalidate the warranty.

SPARE PARTS
It is required to exclusively use Original FPT Spare Parts to maintain the engine in its original condition. The use of non-original spare parts shall invalidate the warranty and exonerate FPT from all liability for the entire life of the engine.

RESPONSIBILITY
The Manufacturer's responsibility is subordinate to the performance of the check and maintenance operations specified and described in this manual; their performance must be demonstrated for this purpose. Any necessary extraordinary maintenance operations must be carried out by qualified FPT Network Workshop personnel, using the specifically provided instruments and equipment.

SAFETY
The purpose of the following information is to focus attention on engine use to prevent damage to people and property deriving from improper or incorrect behaviours.

- The engines must only be used for the purposes declared by the Manufacturer.
- Tampering, modifications and the use of non-original spare parts could adversely affect the proper operation of the engine and its safety during use; changes must not be made to the wiring and the units that equip the engine as well as its connections to external electrical networks.
- Pay attention to the engine's moving parts, those at a high temperature and the circuits with pressurised fluids; its electrical equipment is a source of electrical voltage and currents.
- The exhaust gas emitted by the engine is harmful to health.
- The engine must only be handled with suitable lifting devices and using the specific eyebolts provided on the engine.
- The engine must not be started and used before satisfying the safety requirements for the equipment in which it is installed and before ensuring compliance of the latter with the standards and local laws.
- The operations required for guaranteeing the best state of use and preservation of the engine must be carried out by personnel with proven experience using instruments considered appropriate by FPT.

Additional safety recommendations can be found in the CHECKS AND MAINTENANCE chapter.
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.

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

**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.

**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 specified on the nameplate positioned on different parts of the engine, depending on the model: flywheel case, tappet cover, coolant tank.

**C13 ENT L W**

<table>
<thead>
<tr>
<th>Code</th>
<th>C13 ENT L W</th>
</tr>
</thead>
</table>
| Engine family               | F3HFE613B*B011  
                            | F3HFE613D*B011  |
| Cycle                       | Diesel 4-stroke |
| Number and arrangement of cylinders | 6, in line |
| Bore x stroke               | 135 x 150 mm |
| Total displacement          | 12882 cm³ |
| Compression ratio           | 16.5:1 |
| Air supply                  | Supercharged with intercooler |
| Injection method            | Electronically controlled common rail |
| Max. injection pressure     | 1800 bar |
| Engine rotation direction   | Anti-clockwise (flywheel side view) |
| Dry weight                  | 1320 kg (1) |
| Cooling                     | Water |
| Control system              | Electronic |

**Electric system** 24 V

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Battery capacity</td>
<td>180 Ah or greater</td>
</tr>
<tr>
<td>Maximum input</td>
<td>7.5 kW</td>
</tr>
</tbody>
</table>

**Performance** (2)

<table>
<thead>
<tr>
<th>Code</th>
<th>C13 ENT L W</th>
</tr>
</thead>
</table>
| F3HFE613B*B011 (Stage IV)   | 407 kW (553 CV) @ 2100 rpm  
                            | 2407 Nm @ 1400 rpm |
| F3HFE613D*B011 (Stage IV)   | 384 kW (522 CV) @ 2100 rpm  
                            | 2258 Nm @ 1400 rpm |

(1) Approximate dry weight of the basic engine without A/C compressor, clutch, oil and coolant

(2) Power at the flywheel in accordance with directive 97/68 EC (without fan), after 50 hours’ operation, tolerance ±3%, fuel EN590; Test in compliance with specification ISO 3046/1, turbocharger inlet air temperature 25°C, atmospheric pressure 100 kPa, humidity 30% - Also in compliance with specification DIN 6271, BS 5514, SAE J1349.

All the data are based on engine operation with fuel system, water pump, lubricant oil pump and intake and exhaust restriction within or below, the limits indicated in the "data sheet".

Additional loads estimated at 20 Nm from idle speed to nominal speed.

The fan duty cycle must be less than 20%

**WARNING**

It is strictly forbidden to alter the aforesaid characteristics and, in particular, to modify the stored data in the injection system’s electronic units or the characteristics of the engine and its components. Failure to comply with the above shall result in the loss of warranty, in addition to FPT declining all responsibility.
### C13 ENT Z W

<table>
<thead>
<tr>
<th>Code</th>
<th>C13 ENT Z W</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Engine family</strong></td>
<td>F3HFE613B*B010</td>
</tr>
<tr>
<td></td>
<td>F3HFE613D*B010</td>
</tr>
<tr>
<td><strong>Cycle</strong></td>
<td>Diesel 4-stroke</td>
</tr>
<tr>
<td><strong>Number and arrangement of cylinders</strong></td>
<td>6, in line</td>
</tr>
<tr>
<td><strong>Bore x stroke</strong></td>
<td>135 x 150 mm</td>
</tr>
<tr>
<td><strong>Total displacement</strong></td>
<td>12882 cm³</td>
</tr>
<tr>
<td><strong>Compression ratio</strong></td>
<td>16.5:1</td>
</tr>
<tr>
<td><strong>Air supply</strong></td>
<td>Supercharged with intercooler</td>
</tr>
<tr>
<td><strong>Injection method</strong></td>
<td>Electronically controlled common rail</td>
</tr>
<tr>
<td><strong>Max. injection pressure</strong></td>
<td>1800 bar</td>
</tr>
<tr>
<td><strong>Engine rotation direction</strong></td>
<td>Anti-clockwise (flywheel side view)</td>
</tr>
<tr>
<td><strong>Dry weight</strong></td>
<td>1320 kg (1)</td>
</tr>
<tr>
<td><strong>Cooling</strong></td>
<td>Water</td>
</tr>
<tr>
<td><strong>Control system</strong></td>
<td>Electronic</td>
</tr>
</tbody>
</table>

#### Electric system

<table>
<thead>
<tr>
<th><strong>24 V</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Battery capacity</strong></td>
</tr>
<tr>
<td><strong>Maximum input</strong></td>
</tr>
</tbody>
</table>

#### Performance (2)

<table>
<thead>
<tr>
<th>C13 ENT Z W</th>
<th>F3HFE613B*B010 (Tier 4B)</th>
<th>407 kW (553 CV) @ 2100 rpm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2407 Nm @ 1400 rpm</td>
</tr>
<tr>
<td>C13 ENT Z W</td>
<td>F3HFE613D*B010 (Tier 4B)</td>
<td>384 kW (522 CV) @ 2100 rpm</td>
</tr>
<tr>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

(1) Approximate dry weight of the basic engine without A/C compressor, clutch, oil and coolant

(2) Power at the flywheel in accordance with directive 97/68 EC (without fan), after 50 hours’ operation, tolerance ±3%, fuel EN590; Test in compliance with specification ISO 3046/1, turbocharger inlet air temperature 25°C, atmospheric pressure 100 kPa, humidity 30% - Also in compliance with specification DIN 6271, BS 5514, SAE J1349.

All the data are based on engine operation with fuel system, water pump, lubricant oil pump and intake and exhaust restriction within or below, the limits indicated in the “data sheet”.

Additional loads estimated at 20 Nm from idle speed to nominal speed.

The fan duty cycle must be less than 20%

---

**WARNING**

It is strictly forbidden to alter the aforesaid characteristics and, in particular, to modify the stored data in the injection system’s electronic units or the characteristics of the engine and its components. Failure to comply with the above shall result in the loss of warranty, in addition to FPT declining all responsibility.
**C13 ENT L W - C13 ENT Z W**


**C13 ENT L W - C13 ENT Z W**

C13 ENT L W - C13 ENT Z W


C13 ENT L W - C13 ENT Z W

LABELS
Some warning labels (below the description) are affixed to the engine.  
NOTE: labels containing an exclamation mark highlight a potential danger.

Hoisting point (engine only).

Fuel filling cap  
(on the tank, if present).

Lubricant oil filling cap.

Lubricant oil level dipstick.

Risk of burns:  
Expulsion of pressurized hot water.

Risk of burns:  
Presence of parts at high temperature.

Risk of fire:  
Presence of fuel.

Risk of injury 
from moving parts:  
Presence of fans, pulleys, belts or other.
USE

PRELIMINARY CHECKS
Every time before starting the engine:
- Check and top up the level of the technical fluids, if necessary (fuel, engine oil and coolant).
- Make sure that the air intake filter is not obstructed or clogged.
- Make sure that the batteries are efficient and that the terminals are correctly connected.

STARTING AND STOPPING THE ENGINE
The methods for starting and stopping will vary if the equipment manufacturer has created a customised dashboard; these methods vary based on the different choices of the Manufacturer. In these cases, refer to what is indicated in the specific documentation for information regarding the start and stop sequences and the interpretation of the indicator instruments.

Starting the engine
1. Insert the key in the starter switch and turn it clockwise to the "Run" position. After the test phase of the light signals and the acoustic alarm has stopped, check that the instruments provide indications that are plausible with the values of the physical temperature, battery voltage and oil pressure parameters.
2. Turn the key to the “Start” position, releasing it when the engine has started, without accelerating.
3. Check that the “Alternator recharge” and “Low oil pressure” indicators are off and the instruments provide indications that are plausible with the new values of the relative physical parameters.
4. If it does not start, it is possible to return to the start condition after releasing the key only after turning the switch to the rest position.

ATTENTION!
Make sure that the environment where the engine will operate is free of combustible vapours or gases. Make sure that there is sufficient ventilation and a suitable exhaust gas extraction system for closed environments.
**Stop engine**

Before stopping the engine, it is recommended to keep it idling for a few minutes without a load; this will permit a uniform reduction in temperature and prevent harmful thermal shocks.

The stop methods depend on the type of equipment.

**With the stop circuit “de-excited”**
- Turn the key switch to the REST position

**With the stop circuit “excited”**
- Turn the key switch to the STOP position

Follow the instructions provided by the equipment manufacturer.

**To restart the engine:**
1. Return the key switch to the rest position, which resets all the functions performed by the instrument panel (required for electronic control engines).
2. Turn the key to the “Start” position, releasing it when the engine has started, without accelerating.
3. Proceed as indicated previously.

**SPECIAL WARNINGS**

**High coolant temperature**

In the event of an excessive temperature being signalled by the instrument or the alarm, reduce the engine speed and stop it in order to check the condition of the cooling circuit; also check and have the following checked:

- the tension of the water pump and alternator control belts;
- the operation of the thermostatic valve;
- the cleanliness of the heat exchangers.

**ATTENTION**

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.

**Low lubricant oil pressure**

Should the pressure indicated by the instrument be considered insufficient or if the “low oil pressure” warning light comes on, stop the engine and check the oil level. Top up the oil if necessary (see CHECKS AND MAINTENANCE section).

If the fault persists, return to low speed, and contact a Service centre.
**Presence of water in the fuel prefilter**

It is advisable to drain the water from the filters before the relevant warning light comes on.
Do not use the engine if the tank only contains the quantity of fuel kept as reserve; this condition promotes the formation of condensate and the intake of sludge or air, causing the engine to stop.

**ATTENTION**

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.

**Clogged air filter and exhaust circuit inefficiencies**

Regularly inspect the cleanliness of the air intake inlets and the exhaust ducts. The maintenance intervals contained in this manual only take into account the performances of the engine parts and not of those parts manufactured at the Yard or any other external intervention.

**ATTENTION**

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

**Battery or alternator charging fault**

Periodically check the cleanliness, condition and correct tensioning of the drive belt.

**ATTENTION**

The drive belt members are located under protective grilles. Their removal must be carried out only when the engine is not turning.

**Electrical system irregularities**

Periodically check the cleanliness and efficiency of the batteries, particularly during winter, by performing the checks and top-ups as described in the CHECKS AND MAINTENANCE chapter; close attention must be paid to the caution notices. In the event of battery replacement, please observe the characteristics contained in the ENGINE TECHNICAL DATA section.

**ATS system**

This system is used to limit the nitrogen oxide (NOx) emissions in the exhaust within the limits required by standards, transforming the nitrogen oxide into inert compounds: free nitrogen (N₂) and water vapour (H₂O).

Periodically test the system using PT-Box and clean the filters at the intervals indicated in the CHECKS AND MAINTENANCE chapter.
RUN-IN

Thanks to modern engine construction technologies a particular run-in procedure is not required. However, it is recommended to avoid using the engine at high power for long periods during the first 50 hours.

To guarantee high performance during the engine life of the engine, the following is required during the first 50 hours of use:

- keep the engine at average speeds during the first minutes after engine start without using the power take-off in order to reach optimal operating temperature conditions.
- do not run the engine at maximum power for a continuous period of 2 hours
- do not exceed 2100 rpm.
- let the engine rest every 30 minutes.
- do not idle the engine for long periods.
CHECKS AND MAINTENANCE

MAINTENANCE PERSONNEL

The engine check and maintenance operations specified in this chapter require preparation, skill and compliance with safety standards; therefore, they must be carried out by responsible personnel, as indicated below.

- **Checks to be made during periods of use:** by workshop personnel or if necessary by the machine use.
- **Periodic maintenance:** by qualified personnel equipped with proper work tools and suitable protections.
- **Extraordinary maintenance:** by qualified Service Centre personnel in possession of precise technical information and specific equipment.

The most qualified Service Centres are those included in the FPT Technical Support Network.

ACCIDENT PREVENTION

- Always wear safety footwear, gloves and suits.
- Do not wear loose clothing, rings, bracelets and/or necklaces near the engines or moving parts.
- Wear protective gloves and goggles while:
  - filling the batteries with acid solution
  - filling up inhibitors or antifreeze
  - changing or filling the lubricant oil (hot engine oil can cause burns. It is recommended to perform these operations only when their temperature is lower than 50 °C).
- When working in the engine compartment, pay maximum attention to all movements to avoid coming into contact with rotating or hot components.
- Wear goggles while using compressed air (the maximum air pressure used for cleaning is 200 kPa (2 bar, 30 psi, 2 kg/cm²)).
- Wear a protective helmet if working in an area with suspended loads or overhead systems.
- Use protective creams for hands.
- Immediately replace wet gloves.
- Always keep the engine clean, removing spots of oil, diesel and coolant.
- Return oily rags to fire-proof containers.
- Do not leave foreign objects on the engine.
- Use adequate and safe containers for the used oil.
- At the end of a repair, implement suitable measures to stop air intake by the engine if, after starting, the engine runs at uncontrolled speeds.

Do not perform maintenance in the case of live electrical voltage: check the condition of the equipment’s ground connection. During the diagnostics and maintenance operations, make sure your hands and maintenance operators, make sure your hands and feet are dry and use insulating footboards if possible.
REFILLING

<table>
<thead>
<tr>
<th>Parts to be refilled</th>
<th>C13 ENT L W</th>
<th>C13 ENT Z W</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>litres (kg)</td>
<td></td>
</tr>
<tr>
<td>Cooling circuit (1)</td>
<td>19.5</td>
<td></td>
</tr>
<tr>
<td>Lubrication circuit(2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>total capacity(3)</td>
<td>32 (28.8)</td>
<td></td>
</tr>
<tr>
<td>Periodic replacement:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sump at minimum level</td>
<td>20 (18)</td>
<td></td>
</tr>
<tr>
<td>Sump at maximum level</td>
<td>28 (25)</td>
<td></td>
</tr>
<tr>
<td>Fuel tank (4)</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Urea tank (5)</td>
<td>61/75/156</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 in accordance with ISO 22241 specification.

WARNING

Filling from drums or tanks can cause contamination of the diesel, with the consequent risk of damaging the injection system; if necessary, perform suitable filtration or sedimentation of the impurities before refuelling.

Diesel oil for low temperatures

Standard EN590 defines different diesel classes, identifying the characteristics of those most suitable for use at low ambient temperatures. It is entirely the responsibility of the oil companies to comply with the regulations regarding the distribution of fuels suitable for the climatic and geographical conditions of the various countries.
FREQUENCIES

The frequencies indicated below take into account factors of use of different engine uses; the most suitable duration of the maintenance intervals for the different applications will be indicated by the maintenance personnel based on the use and operating conditions of the engine.

<table>
<thead>
<tr>
<th>Checks to be made during periods of use</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check the engine lubricant oil level</td>
<td>every start-up</td>
</tr>
<tr>
<td>Check engine coolant level</td>
<td>every start-up</td>
</tr>
<tr>
<td>Visual inspection of the engine</td>
<td>50 hours</td>
</tr>
<tr>
<td>Drain the water from the fuel prefilter</td>
<td>150 hours (1)</td>
</tr>
<tr>
<td>Check tension and condition of auxiliary belt</td>
<td>300 hours</td>
</tr>
<tr>
<td>Inspection of the exhaust duct/s</td>
<td>Six-months</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Periodic maintenance</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine lubricant oil change (*)</td>
<td>600 hours (2) (3)</td>
</tr>
<tr>
<td>Replacing the engine oil filter (*)</td>
<td>600 hours (2) (3)</td>
</tr>
<tr>
<td>Fuel prefilter change</td>
<td>600 hours (1) (5)</td>
</tr>
<tr>
<td>Fuel filter change</td>
<td>600 hours (1) (2)</td>
</tr>
</tbody>
</table>

Extraordinary maintenance:

<table>
<thead>
<tr>
<th>Extraordinary maintenance:</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check tappets clearance and adjust if necessary</td>
<td>2400 hours</td>
</tr>
<tr>
<td>Change the engine coolant</td>
<td>3000 hours (5)</td>
</tr>
</tbody>
</table>

* Frequency for construction equipment application:

- 100 hours versus standard application.

1) Maximum period relating to the use of high quality fuel, (specification ASTM D975 or EN 590); which is reduced in the event of fuel contamination and alarm signals caused by filter clogging and/or the presence of water in the prefilter. The filter clogging signal indicates that the filter must be replaced. If the warning light of water present in the prefilter does not go off after drainage, then the prefilter must be replaced.

2) To be performed every year even if the specified operating hours interval has not been reached.
3) Frequencies are valid for lubricant oils which comply with the international specifications as indicated in the table REFILLING.

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.

---

In the event in which fuel is used with a sulphur percentage greater than 0.5%, or oils are used which do not comply with the specifications in the REFILLING section, then the replacement frequencies of the oil, engine oil filter and oil vapour filter must be halved, or suitably adjusted, in accordance with the use and operating conditions of the engine; please consult the personnel in charge of maintenance operations for appropriate advice.

---

The operations described above require the use of specific tools which guarantee safe and effective results. It is recommended that such operations are carried out by qualified personnel of the FPT Technical Service Network.

---

### Scheduled maintenance of ATS system

<table>
<thead>
<tr>
<th>Action</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tank prefilter (300 μm or 100* μm (1))</td>
<td>No maintenance planned (clean if necessary)</td>
</tr>
<tr>
<td>Prefilter supply module (100 μm or 70 μm (1))</td>
<td>Cleaning with water @ every oil change interval (2)</td>
</tr>
<tr>
<td>AdBlue inlet filter to supply module (100 μm)</td>
<td>No maintenance planned (clean if necessary)</td>
</tr>
<tr>
<td>Filter supply module</td>
<td>Replace every 3600 hours (3)</td>
</tr>
<tr>
<td>AdBlue return filter from supply module to tank (100 μm)</td>
<td>No maintenance planned (clean if necessary)</td>
</tr>
<tr>
<td>Dosing module filter (36 μm)</td>
<td>Not serviceable</td>
</tr>
</tbody>
</table>

1) For applications operating in dusty environments.

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

3) To be performed every two years even if the specified operating hours interval has not been reached.
**ATS System filter location**


---

**REQUIREMENTS**

- Do not disconnect the battery supply while the engine is running.
- Do not perform arc welding near the engine without first removing its electrical wiring.
- After all maintenance operations that require disconnection of the batteries, make sure the clamps have been securely reconnected on the poles.
- Do not use a battery charger to start the engine.
- Electrically disconnect the battery/ies from the network during charging.
- Do not paint the devices, components and electrical connectors of the engine equipment.
- Electrically disconnect the battery/batteries before performing any electrical work.
- Contact the Manufacturer before installing any electronic equipment.

---

\[ \text{Do not perform any operation that would change the calibration of the injection pump.} \]
\[ \text{It was adjusted during the engine test phase and based on its destination.} \]
CHECKS TO BE MADE DURING PERIODS OF USE – HOW TO PROCEED

Check the engine lubricant oil level

Only proceed when the engine is not turning and is at low temperature in order not to run the risk of burns; make sure the engine is level or in its normal operating position in order to obtain an accurate oil level reading.

- Use the oil level dipstick (2) to check that the lubricant oil level is between the "Min" and "Max" limits.
- If the level is insufficient, it is necessary to top up the oil by removing the cap and pouring lubricant oil through the hole (1).

For the top-up only use lubricant oil that complies with the international standards as indicated in the REFILLING section

Clean the oil cap before performing the operation so as to minimize the risk of contaminating the system.

- Use the oil level dipstick (2) to check that the lubricant oil level does not exceed the "Max" limit on the dipstick.

Make sure that the dipstick is fully inserted and that the filler plug is tightened fully in the clockwise direction.
Engine coolant level check (demonstrative)

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

- 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 fluids, as indicated in the REFILLING section.
- Top up the expansion tank until the “MAX” limit is reached; if there is no level indicator on the expansion tank, make sure that the coolant in the expansion tank is a few centimetres below the filling hole in order to allow an increase in the coolant volume following a rise in temperature.

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.

Clean the pressurization cap of the expansion tank before performing the operation so as to minimize the risk of contaminating the system.

Visual inspection of the engine

Perform a thorough check before start-up in order to obtain maximum engine duration.

Check for any leaks (oil, coolant and fuel), broken or weakened pipes, loose clips and bolts, worn belt, wiring (loose connections, worn or frayed cables) and a build-up of dirt; in the event of any problems, perform the operations necessary to restore the engine.

Any spilt fluid must be removed for all types of leak (coolant, oil or fuel).

If a leak is discovered then find its source and carry out the necessary repair.

A build-up of oil or grease on the engine represents a fire risk.
Draining the water from the fuel prefilter

In the case of a high risk of refuelling with fuel polluted with foreign agents and water, the following check should be performed at every refuelling.
Proceed when the engine is not turning.

- Place a container for collecting liquids under the prefilter (2).
- Unscrew the valve plug (1) located at the bottom of the filter; in some versions, the plug includes the water in diesel sensor.
- Drain the liquid until only “diesel” is released.
- Fully retighten the plug manually.
- Dispose of the drained liquids according to the applicable regulations in force.

**Clean the cock tap (1) before performing the operation so as to minimize the risk of contaminating the system.**
Check tension and condition of auxiliary 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.

Inspection of the exhaust duct/s

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.

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.
PERIODIC MAINTENANCE - HOW TO PROCEED

Engine lubricant oil change

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

- Place a suitable container for collecting the spent oil under the oil sump next to the lubricant oil drain plug (3).
- Unscrew the lubricant oil drain plug (3); afterwards extract the oil level dipstick (2) and remove the lubricant oil cap (1) to assist the flow of the engine lubricant oil.
- Wait until the oil sump has completely emptied, then retighten the lubricant oil drain plug (3) to the torque indicated in the table.
- Proceed with the refilling operation through the hole (1) situated on the tappet cover, using lubricant oil that complies with the international standards as indicated in the REFILLING section.
- Use the oil level dipstick (2) to check that the quantity of lubricant oil does not exceed the "Max" limit.
- Retighten the lubricant oil cap (1).
- Together with the replacement of the engine lubricant oil it is necessary to replace the oil filter (see ENGINE OIL FILTER CHANGE paragraph).

<table>
<thead>
<tr>
<th>Ref.</th>
<th>No.</th>
<th>Description</th>
<th>Torque</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>1</td>
<td>Oil drain plug</td>
<td>95 ± 10 Nm</td>
</tr>
</tbody>
</table>

- Clean the plugs before performing the operations so as to minimize the risk of contaminating the system.
- After changing the engine lubricant oil make sure that the level does not exceed the "Max" limit on the oil level dipstick.
- Make sure that the dipstick is fully inserted and that the filler plug is tightened fully in the clockwise direction.
- Dispose of consumable materials and parts in contact with them (e.g. filters) in accordance with the law.
Engine oil filter change

Only use filters with the following specifications:

- degree of filtering < 12 μm
- filtering efficiency $\beta > 200$ (99.5%)

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

- Proceed with draining the spent lubricant oil (see ENGINE LUBRICANT OIL CHANGE paragraph).
- Place a suitable container for collecting the spent oil under the oil filter next to the drain plug (3).
- Remove the filter (4) by unscrewing it.

- Replace the filter element (2) and the O-ring seal (1) contained inside the filter (4).
- Carefully clean the surfaces
- Moisten the O-ring seal (1) of the new filter with oil.
- Tighten the drain plug (3) and the filter body (4) to the torque indicated in the table.
- Proceed with the refilling operation of the lubricant oil (see ENGINE LUBRICANT OIL CHANGE paragraph).

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.

<table>
<thead>
<tr>
<th>Ref.</th>
<th>No.</th>
<th>Description</th>
<th>Torque</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>Engine oil filters</td>
<td>60 ± 5 Nm</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>Drain plug on engine oil filter</td>
<td>6.5 ± 1.5 Nm</td>
</tr>
</tbody>
</table>

After changing the engine lubricant oil make sure that the level does not exceed the "Max" limit on the oil level dipstick.

Make sure that the dipstick is fully inserted and that the filler plug is tightened fully in the clockwise direction.
Replacement of fuel prefilter (demonstrative)

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

- Close the tank cock.
- Place a suitable container for collecting the fuel under the fuel prefilter next to the bleeder plug or, if present, the water presence sensor (2)
- Remove the filter cartridge (1)
- Moisten the O-ring seal (3) of the new filter with oil.
- Screw the cartridge by hand until it comes into contact with the support and then tighten it to the torque indicated in the table.
- Reconnect the lower electric connection of the water presence sensor, if present.

<table>
<thead>
<tr>
<th>Ref.</th>
<th>No.</th>
<th>Description</th>
<th>Torque</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>Fuel prefilter cartridge</td>
<td>19.5 ±1 Nm</td>
</tr>
</tbody>
</table>

Dispose of consumable materials and parts in contact with them (e.g. filters) in accordance with the law.

Do not fill the new prefilter until it has been positioned on the support: this prevents allowing impurities to enter and damage the circuit and injection system.
Loosen the following bleeder connections and connect them with appropriate pipes to allow any residue to drain into suitable containers so as to prevent soiling:

- Screw (1) situated on the prefilter support.
- Bleeder connection (3) situated on the filter support.

Operate the pump (2) situated on the fuel prefilter (provided by the vehicle/equipment manufacturer) until fuel flows out without air from the bleeder screw (1); upon completion of the operation tighten the screw.

Continue to operate the pump until fuel flows out without air from the bleeder connection (3) situated on the fuel filter; upon completion of the operation tighten the screw.

Tighten the bleeder screws to the prescribed torque.

<table>
<thead>
<tr>
<th>Ref.</th>
<th>No.</th>
<th>Description</th>
<th>Torque</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>Prefilter bleeder screw</td>
<td>18 ±2 Nm</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>Bleeder connection</td>
<td>18 ±2 Nm</td>
</tr>
</tbody>
</table>

Start the engine and allow it to idle for a few minutes to expel any residual air from the circuit.

Dispose of consumable materials and parts in contact with them (e.g. filters) in accordance with the law.

Take utmost care to prevent any fuel from soiling the control belt.

For the engine to function correctly the fuel circuit must be free from air.
Fuel filter change

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

- Close the tank cock.
- Place a suitable container for collecting the fuel under the fuel filter next to the drain plug (4).
- Open the drain plug (4) and the bleeder connection (5) and drain any residual fuel.
- Remove the filter element (2) by unscrewing the relative bell-shaped support (3).
- Replace the filter element (2) and the O-ring seal (1) contained inside the bell-shaped support (3).

- Moisten the O-ring seal (1) of the filter with oil.
- Insert the filter element (2) and tighten the relative bell-shaped support (3) to the torque indicated in the table.
- Tighten the drain plug (4) to the torque indicated in the table.

---

Do not fill the new filter until it has been positioned on the support: this prevents allowing impurities to enter and damage the circuit and injection system.

<table>
<thead>
<tr>
<th>Ref.</th>
<th>No.</th>
<th>Description</th>
<th>Torque</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>1</td>
<td>Fuel filter</td>
<td>32.5 ±2.5 Nm</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>Threaded plug</td>
<td>1.5 ±0.5 Nm</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>Bleeder connection</td>
<td>18 ±2 Nm</td>
</tr>
</tbody>
</table>
Loosen the following bleeder connections and connect them with appropriate pipes to allow any residue to drain into suitable containers so as to prevent soiling:

- Screw (1) situated on the prefilter support.
- Bleeder connection (3) situated on the filter support.
- Operate the pump (2) situated on the fuel prefilter (provided by the vehicle/equipment manufacturer) until fuel flows out without air from the bleeder screw (1); upon completion of the operation tighten the screw.
- Continue to operate the pump until fuel flows out without air from the bleeder connection (3) situated on the fuel filter; upon completion of the operation tighten the screw.

Tighten the bleeder screws to the prescribed torque.

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<td>1</td>
<td>Bleeder connection</td>
<td>18 ±2 Nm</td>
</tr>
</tbody>
</table>

Start the engine and allow it to idle for a few minutes to expel any residual air from the circuit.

For the engine to function correctly the fuel circuit must be free from air.

Dispose of consumable materials and parts in contact with them (e.g. filters) in accordance with the law.
**Change the auxiliary device belt**

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

- Using a 1/2 inch square wrench, operate on the belt tensioner (1) and pull off the control belt of the crankshaft / electromagnetic coupling / water pump / alternator (A) pulley.
- Replace the worn belt with a new one and fit it on the pulleys and guide rollers.
- Using the aforesaid tools, operate on the automatic belt tensioner in order to force fit the new belts in their operating position.

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

*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.*
Check turbocharger connection pipes and wastegate linkage

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

**Turbocharger lubricant pipe tightness check**

- Check the tightening torque of the connections (1,2) and perform a visual inspection to check for any oil leaks.
- In the event of an oil leak replace the gaskets (3,4) of the connectors (1,2).

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The exhaust pipes must not have sharp bends and angles of less than 30°

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The flange replacement gaskets and fixtures must be fitted without sealant: this may contaminate the oil.
**Turbocharger gasket seal check**
- Check that there are no soot deposits between the intake manifold and the turbocharger. Replace the gasket, if necessary.
- Check the turbocharger gasket for any signs of breaks or distortions and replace it, if necessary.

**Turbocharger blade check**
- Check for the presence of cracks on the turbocharger.
- Check that there are no bent or damaged blades in the compressor impeller.

**Wastegate linkage check**
- Check that the wastegate control linkage is fully tightened, lubricated and not deformed.

**Replacing blow-by filter element**
- Unscrew the screws (3) and remove the cover (4)
- Unscrew the screws (2) and remove the blow-by filter element (1)

> Carefully clean the filter seat and the cover.

- Position the new blow-by filter element (1) in its seat.
- Apply some Loctite 243 on the screws (3) and tighten them to the torque indicated in the table.
- Position the cover (4) and tighten the screws (3) to the torque indicated in the table.

<table>
<thead>
<tr>
<th>Ref.</th>
<th>No.</th>
<th>Description</th>
<th>Torque</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2</td>
<td>Fastening screws for blow-by filter element</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Pre-tightening</td>
<td>5 Nm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tightening</td>
<td>15 Nm</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>Fastening screws for blow-by cover</td>
<td>7 ± 1 Nm</td>
</tr>
</tbody>
</table>
Check tappets clearance and adjust if necessary

Adjustment of the clearance between the rocker arms and the intake and exhaust valve control rods must be performed with high attention. Put the cylinder requiring clearance adjustment into combustion phase; the valves of this cylinder will be closed while those of the symmetrical cylinder are balanced. The symmetrical cylinders are 1-6, 4-3 and 2-5.

In order to correctly perform these operations proceed as described in the relative Repair Manual.

Changing the engine coolant (by way of example)

- 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 fastening elements and remove the coupling 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, restore the integrity of the cooling circuit, by ensuring the perfect seal of the sleeves.
- Refill the engine and the heat exchanger until the cooling circuit is completely full with fluids, as indicated in the REFILLING section. Do not fill the expansion tank to the brim.
With the coolant filler plug 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 then top up with 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.

If there is an external level indicator on the heat exchangers, proceed with the top-up making sure that the coolant does not completely fill the exchanger in order to allow an increase in the coolant volume following a rise in temperature.

**ENGINE HANDLING**

The engine must only be disconnected and reconnected by Service Centre personnel.

To lift only the engine use the eyelets specified in this manual in the ENGINE TECHNICAL DATA section and marked on the engine with specific plates.

It must be hoisted using a rocker arm that keeps the metal ropes that support the engine parallel, using all the provided eyelets at the same time; it is not permitted to use only one eyelet.

The capacity and dimensions of the engine hoisting system must be suitable for the engine weight and dimensions; make sure there is no interference between the hoisting system and the engine components. Do not hoist the engine before removing the transmission components coupled to it.

**DISPOSAL OF WASTE**

The engine consists of parts and elements that can cause ecological damage if disposed of in the environment.

The materials listed below must be delivered to authorised collection Centres; The laws in force in the different countries foresee severe penalties for violators:

- Starter batteries.
- Spent lubricant oils.
- Water and antifreeze mixtures.
- Filters.
- Auxiliary cleaning material (e.g. rags soaked in or moistened with fuel).

**Failure to observe the procedure described above does not guarantee the presence of the correct quantity of coolant in the engine.**

**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.**
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 assemble 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 PERIOD OF ENGINE INACTIVITY**

**PREPARING THE ENGINE FOR A LONG PERIOD OF INACTIVITY**

In the case of a planned period of inactivity that lasts longer than two months, to prevent the interior parts of the engine and some components of the injection system from oxidising, prepare the engine as follows:

1. Drain the lubricant oil from the sump after heating the engine.
2. Pour protective oil type 30/M into the engine up to the "minimum" level indicated on the oil level dipstick. Start the engine and run it for approx. 5 minutes.
3. Drain the fuel from the injection circuit, from the filter and from the injection pump channels.
4. Connect the fuel circuit to a tank containing CFB protective liquid (ISO 4113) and introduce the liquid by pressurising the circuit and driving the engine for approx. 2 minutes, after excluding the operation of the injection system. The required operation may be completed by directly polarising terminal 50 of the electric starter motor with positive voltage equal to that of the nominal system voltage, using the specifically provided conductor.
5. Nebulize the protective oil 30/M in a quantity of approx. 130 g (10 g per litre of displacement) in the turbocharger intake inlet, during the engine turning operation described in the previous paragraph.
6. Close all of the engine’s intake, discharge, ventilation and bleeder holes with plugs or seal them with adhesive tape.
7. Drain the residual 30/M protective oil from the sump, which can be used for an additional 2 preparations.
8. Place warning notices of ENGINE WITHOUT OIL on the engine and dashboard.
9. Drain the coolant if it was not mixed if necessary with antifreeze and corrosion inhibitors, positioning signs that this operation was performed.

In the case of prolonged inactivity, repeat these operations every 6 months, according to the following procedure:

- A) drain the 30/M protective oil from the sump;
- B) repeat the operations from point 2 to point 7.

To protect the external parts of the engine, spray the OVER 19 AR protective liquid on the unpainted metal parts such as the flywheel, pulleys, etc., and do not spray it on belts, connector cables and electrical equipment.
ENGINE START-UP AFTER A LONG PERIOD OF INACTIVITY

1. Drain the residual 30/M protective oil from the sump.
2. Add the type and quantity of lubricant oil to the engine as specified in the REFILLING table.
3. Drain the protective fluid CFB from the fuel circuit bringing to a close the operations as indicated in point 3 of the PREPARATION OF THE ENGINE FOR A LONG PERIOD OF INACTIVITY.
4. Remove the plugs and/or seals from the engine's intake, discharge, ventilation and bleeder holes, restoring normal conditions of use. Connect the turbocharger intake inlet to the air filter.
5. Join the fuel circuits to the machine's tank bringing to a close the operations as indicated in point 4 of the PREPARATION OF THE ENGINE FOR A LONG PERIOD OF INACTIVITY. During the filling operations, connect the tank fuel return pipe to a collection container to prevent the residual CFB protective liquid from flowing into the car's tank.
6. Check and fill the engine with coolant as required, degassing if necessary.
7. Start the engine and let it idle until completely stabilised.
8. Check that the indications on the dashboard are plausible and that there are no alarm signals.
9. Stop the engine.
10. Remove the warning notices of ENGINE WITHOUT OIL from the engine and dashboard.
ENGINE FAULTS

The Electronic Unit that manages and controls all engine operations is able to detect the occurrence of faults and adopt strategies to proceed in a safe manner.

The event, signalled by the switching on of the EDC Fault indicator on the dashboard involves the programmed limitation of power within the thresholds determined based on the severity of the situation.

In the case of brief anomalies, the performance will be reduced until the engine stops.

BEHAVIOUR IN CASE OF FAILURE

Fault in the accelerator’s electronic circuit

If anomalies are detected in the accelerator’s electric circuit, the engine’s electronic control unit will adopt strategies defined as "minimum accelerated speeds".

The possible operating modes are:

A. The accelerator lever does not “respond”: the rotation speed stabilizes at 850 ± 100 revs/min. to allow slow manoeuvring by only engaging and disengaging the inverter, without accelerating.

B. The accelerator lever “responds partially”: the idle rotation speed is 850 ± 100 revs/min. Positioning the accelerator lever approximately halfway gradually increases the speed up to 2350 ± 50 revs/min.; returning the lever to minimum the speed rapidly drops to 850 ± 100 revs/min.

Recharging system fault

The electronic engine control units are programmed to increase the speed if the electrical system voltage reaches the values considered at the limit of efficiency. In that case, check the state of the battery or batteries and if necessary, have diagnostics performed for the system components.

---

**ATTENTION!**

The engine’s electronic control unit may adopt the safety strategies while using the equipment at any moment conditions are verified that could place the engine’s integrity at risk.

If these conditions occur, proceed only if necessary and in a cautious and attentive manner.

---

**ATTENTION!**

Never abandon the equipment with the engine operating without previously engaging the brake or parking lock.
<table>
<thead>
<tr>
<th>SIGNALLED ANOMALY</th>
<th>POSSIBLE CAUSE</th>
<th>RECOMMENDED TESTS OR OPERATIONS</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low performance upon load request. Possible smoke.</td>
<td>Low fuel level in the tank.</td>
<td>Check the fuel level.</td>
<td>The possible smoke derives from the fact that if not enough fuel arrives, the control unit tries to compensate by extending the excitation time of the injectors.</td>
</tr>
<tr>
<td>Fuel suction in the tank partially blocked by impurities or deformation caused by over-heating.</td>
<td>Check whether the priming pump on the prefilter is working correctly. If the pump knob remains sucked downwards by the vacuum, remove and check the tank suction unit. If the suction unit is functional, replace the prefilter.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air filter or air intake ducts clogged.</td>
<td>Check the filters and intake ducts.</td>
<td>Remove the cause of the filter clogging and clean the air intake ducts.</td>
<td></td>
</tr>
<tr>
<td>Fuel leaks from couplings or low pressure pipes downstream of the feed pump.</td>
<td>Check the O-Rings and the correct connection of the hose couplings down stream of the feed pump (the stops must be out and the couplings properly connected). Visually check the integrity of the low pressure pipes.</td>
<td>As long as the leak is not excessive, there will not be any performance problems. To check the condition of the O-Rings, remove the fuel return pipe from the tank, hermetically plug the end and operate the priming pump, pressurising the low pressure circuit.</td>
<td></td>
</tr>
<tr>
<td><strong>SIGNALLEDSIGNALLED ANOMALY</strong></td>
<td><strong>POSSIBLE CAUSE</strong></td>
<td><strong>RECOMMENDED TESTS OR OPERATIONS</strong></td>
<td><strong>NOTES</strong></td>
</tr>
<tr>
<td>----------------------------------</td>
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<td>----------</td>
</tr>
<tr>
<td>Low performance upon load request.</td>
<td>Excessive fuel blow-by from the rail over-pressure valve.</td>
<td>Disconnect the pipe and visually check if there are evident blow-bys from the over-pressure valve: in that case replace the valve.</td>
<td></td>
</tr>
<tr>
<td>Possible smoke.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The engine stops suddenly (without previous hesitations) and does not restart.</td>
<td>Fuel filter clogged.</td>
<td>Replace the fuel filter.</td>
<td>Remove the cause of filter clogging (empty and clean the tank and the part of the hydraulic circuit up-line of the filter; fill-up with clean fuel).</td>
</tr>
<tr>
<td>Difficult starting and low performance in all conditions.</td>
<td>Inefficient high-pressure pump.</td>
<td>After excluding all other causes, replace the high pressure pump.</td>
<td></td>
</tr>
<tr>
<td>Difficult starting, low performance and the engine runs with one less cylinder.</td>
<td>Injector with shutter or core of the solenoid (mechanical part) locked open.</td>
<td>The non-operative injector can be easily identified by feeling the lack of pulsations in the relative high pressure pipe.</td>
<td>In the case of slight blow-bys, which prevent the mechanical operation of the injector but does not activate the flow limiter, errors are not stored in the control unit. If the flow limiter is activated, also the error is signalled.</td>
</tr>
<tr>
<td>SIGNALLED ANOMALY</td>
<td>POSSIBLE CAUSE</td>
<td>RECOMMENDED TESTS OR OPERATIONS</td>
<td>NOTES</td>
</tr>
<tr>
<td>---------------------------------------------------------------------------------</td>
<td>-----------------------------------------------------</td>
<td>-----------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Starting requires many seconds, considerable development of white smoke at the exhaust, fuel odour.</td>
<td>Injector locked open (irreversibly).</td>
<td>The non-operative injector can be identified by feeling the lack of pulsations in the relative high pressure pipe.</td>
<td>In the presence of such symptoms, it is instinctive to stop trying to start the engine. However, by insisting, the engine may start. By insisting, if the pressure is able to close the flow limiter in the rail, the engine starts with one less cylinder and the smoke gradually reduces and disappears.</td>
</tr>
<tr>
<td>Breakage of the high pressure pipe from the pump to the rail.</td>
<td>Anomalous vibrations caused by the pipe brackets coming loose.</td>
<td>Replace the piping, properly tightening the screws of the anti-vibration brackets.</td>
<td>In addition to correct tightening, it is important to keep the brackets in their original position.</td>
</tr>
<tr>
<td>The engine operates with one less cylinder, without storing the faults in the control unit.</td>
<td>Injector locked open.</td>
<td>Identify the injector that is no longer functioning and replace the injector and the relative high pressure union.</td>
<td>The non-operative injector can be easily identified by feeling the lack of pulsations in the relative high pressure pipe.</td>
</tr>
</tbody>
</table>
BEHAVIOURS IN CASE OF EMERGENCY

The user of the equipment, implemented according to safety regulations, following the instructions provided in this manual and with the support of the instructions located on the engine label, operates in safe conditions.

If incorrect behaviours cause accidents, request the immediate help of specialised emergency personnel.

In the case of an emergency and while waiting for emergency personnel to arrive, the following instructions are provided.

Engine faults
If proceeding with the engine in a faulty state, pay maximum attention to the manoeuvres and check that any people on-board are secured to secure grips.

Fire
Put out the fire using the foreseen devices and according to the methods indicated by the competent authorities (the fire-fighting equipment for some cars and equipment has been made mandatory by current safety regulations).

Burns
- Put out the flames on the clothing of the burn victim by means of:
  - flooding with water;
  - use of powder extinguishers, without directing the jet towards the face;
  - covers or rolling the victim on the ground.
- Do not remove the shreds of clothing that adhere to the skin;
- If the burns are caused by liquids, quickly but carefully remove the clothing saturated with the hot liquid;
- Cover the burn with an anti-burn pack or with a sterile bandage.

Carbon monoxide (CO) poisoning
The carbon monoxide contained in the engine's exhaust gas is dangerous both because it causes poisoning as well as because it forms an explosive mixture with the air.

In closed areas, carbon monoxide is very dangerous because it can reach a critical concentration in a short period of time.

If aiding a poison victim in a closed room:
- Immediately ventilate the room to reduce the concentration of gas.
- When accessing the room, the rescuer must hold his/her breath, not light flames, turn on lights or activate electric bells or telephones in order to prevent explosions.
- Bring the poison victim to safety in a ventilated room, or in the open air, placing the victim on his/her side if unconscious.
**Electrocution**

The engine's 24 V electrical system does not involve any electrocution risks. However, in the event of a short circuit caused, for example, by a metal tool, there shall be the risk of burns caused by the object overheating due to conduction of the electric current. In that case:

- Remove the object that caused the short circuit by using means that provide sufficient thermal insulation.
- If present, use the main switch to cut off the power supply.

**Injuries and fractures**

The magnitude of the cases and the specific nature of the interventions makes it necessary to contact medical structures.

- If the victim is bleeding, compress the injury externally until the rescuers arrive.
- If there is a possibility of fractures, do not move the affected part and transfer the injured person very carefully and only if absolutely necessary.

**Corrosion**

Skin corrosion is caused by contact with substances with a high degree of acidity or basicity. For personnel performing maintenance on electrical devices, this is typically caused by acid escaping from the batteries; in this circumstance proceed as follows:

- Remove any clothing saturated with the caustic substance.
- Wash thoroughly with running water, without spraying uninvolved parts.

If battery acid, lubrication oil or diesel has entered the eyes: wash the affected eye with water for at least 20 minutes, keeping the eyelids open so the water flows onto the eyeball (facilitate washing of the eye by moving it in all directions).