# User and maintenance manual for generating sets


## R350C2

33501782801NE_3_1

EN

# 1. Preface

## 1.1. General recommendations

Thank you for choosing an electrical generating set from our company.

This manual has been designed to help you operate and maintain your electrical generating set correctly.
The information contained in this manual is taken from technical data available at the time of print. In line with our policy of continually improving the quality of our products, this information may be amended without warning.

Read the safety instructions attentively in order to prevent any accidents, faults or damage. These instructions must always be followed.

You are likely to encounter several warning symbols in this manual.

| | |
|---|---|
|  Danger | This symbol indicates an immediate danger to human health and life in case of exposure. Failure to follow the corresponding advice entails serious consequences for human health and life in case of exposure. |

| | |
|---|---|
|  Warning | This symbol draws attention to the potential risks to human health and life in case of exposure. Failure to follow the corresponding advice entails serious consequences for human health and life in case of exposure. |

| | |
|---|---|
|  Important | This symbol indicates a dangerous situation if the warning is not heeded.<br>Failure to follow the corresponding advice risks resulting in minor injury of personnel or damage to any other object in case of exposure. |

In order to obtain optimum efficiency and the longest possible life for the electrical generating sets, maintenance operations must be carried out according to the periods indicated in the attached preventative maintenance tables. If the electrical generating set is used under dusty or unfavourable conditions, some of these periods will be shorter.

Ensure that all repairs and adjustments are carried out by personnel who have received appropriate training. Dealers have this qualification, and can answer all of your questions. They can also supply you with spare parts and other services.

The left and right sides can be seen from the back of the electrical generating set (the radiator is at the front).

Our electrical generating sets have been designed so that damaged or worn parts can be replaced by new or reconditioned parts thereby reducing the out of action period to a minimum.
For any replacement of parts, contact your nearest dealer for our company who will have the necessary equipment and can offer properly trained and informed staff to carry out maintenance, parts replacement and even total reconditioning of generating sets.

Contact your local dealer for the available repair manuals and to make the necessary arrangements for training personnel in implementation and maintenance.

| | |
|---|---|
|  Important | Some user and maintenance manuals for the engines fitted to generating sets cover control units and include the start-up and shutdown procedures for the engines.<br>As the generating sets are fitted with control units that are specific to the generating sets, only the information that appears in the documentation for the generating sets' control units should be taken into consideration.<br>In addition, according to the manufacturing criteria of the generating sets, some engines may be fitted with specific electrical wiring different to that described in the engine documentation. |

## 1.2. Pictograms and their meanings

Safety notices are clearly mounted on the equipment to draw the operator's or maintenance technician's attention to the potential dangers and explain the action to be taken in the interest of safety. These notices are reproduced in this publication for ease of identification by the operator.
Replace any notice that is missing or illegible.

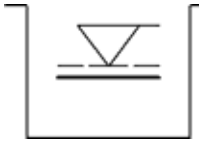
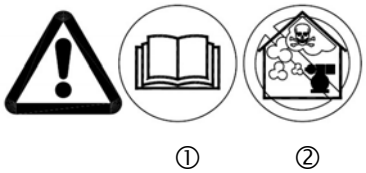
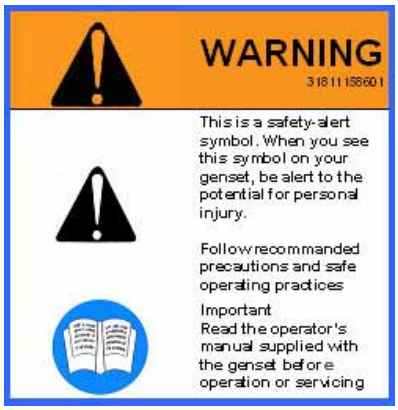
| | | |
|---|---|---|
|  Caution: danger |  Publications delivered with the generating set must be referred to |  Caution: risk of explosion |
|  Caution: risk of electric shock |  Protective clothing must be worn |  Naked flames and unprotected lights prohibited.<br>No smoking |
|  Caution: toxic materials |  Eyes and ears must be protected |  Entry prohibited to non-authorised persons |
|  Caution: pressurised fluids |   Periodic maintenance must be carried out |  Jet washing prohibited |
|  Caution: high temperature, risk of burns |  Battery level must be checked |  Earth |
|  Caution: rotating or moving parts (risk of getting caught in the machinery) |  Lifting point must be used |  Caution: corrosive product |
|  Fork pockets for lifting |  Retention tank level high | |
|    | ① Important: refer to the documentation accompanying the generating set.<br>② Important: emission of toxic exhaust gases. Do not use in a confined or badly ventilated area. | |

**Figure 1.1**: Pictograms and their meanings




WARNING: DANGER

This symbol warns of a safety hazard. The presence of this symbol indicates a risk of injury.
Observe the safety instructions and precautions for use.

Important:
Carefully read the instructions supplied with the generating set before using or servicing the equipment.


WARNING: DANGER

Risk of electrocution
- Do not touch the cables or connections when the generating set is in operation.
- Switch off the generating set for maintenance operations.


DANGER

Use diesel fuel only.
- The fuel is highly flammable, handle with care. Do not smoke near the generating set or expose it to a naked flame or sparks.
- Shut down the generating set engine before filling the fuel tank. Fill with fuel outside.
- To prevent fire risks, clean the generating set regularly. Wipe away any dirt and traces of grease or fuel.


WARNING: DANGER

- The exhaust gases from the engine are toxic and can affect health or even cause death.
- Use the generating set outdoors only, in well ventilated areas, or fit an exhaust extension to discharge the exhaust gases outside.

**Figure 1.2**: Pictograms and their meanings


WARNING: DANGER

- Hot coolant can cause serious burns.
- Switch off the engine. Do not remove the filler cap until it is completely cold.
- Do not open the radiator when it is hot.


DANGER

- Rotating parts can cause serious injury.
- Do not operate the generating set with the doors open.
- Do not remove the enclosures.
- Shut down the generating set before any maintenance or servicing operation.


DANGER

- Avoid any contact with the exhaust pipes, turbochargers and silencers. Keep flammable materials away from hot parts.
- Wait for the machine to cool down completely before touching it.

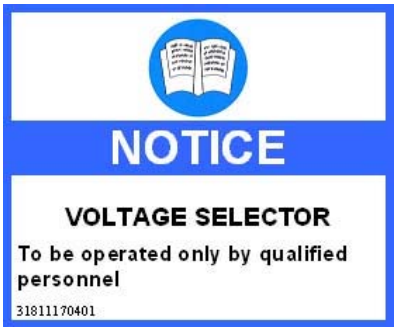

WARNING: DANGER

- The gas from the battery electrolyte is explosive. Keep the batteries away from any flames.
- The battery electrolyte (sulphuric acid) is toxic. Risk of poisoning.

**Figure 1.2 (continued)**: Pictograms and their meanings

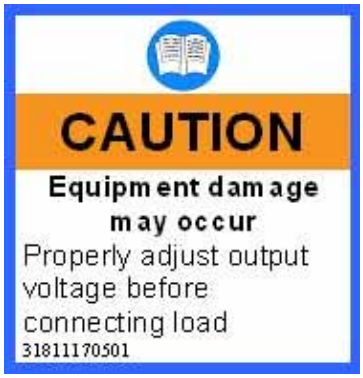

WARNING: DANGER

- A poor earth connection can lead to serious injuries or death.
- Always connect the earth terminal of the generating set to an external earth terminal.




WARNING

Voltage selector
This function should be used by qualified persons only.




WARNING

Adjust the output voltage correctly before connecting a load.


WARNING

The voltage selector must not be used when the generating set is operating.

**Figure 1.2 (continued)**: Pictograms and their meanings

## 1.3. Instructions and safety regulations

**THESE SAFETY GUIDELINES ARE IMPORTANT**

If you do not understand or have any questions about any point in this manual, contact your dealer who will explain it to you or give you a demonstration. A list of risks and precautionary measures to take follows. You should also refer to any local and national regulations that apply in accordance with your own jurisdiction.

**KEEP THIS MANUAL**

This manual contains important instructions which must be followed when installing or carrying out maintenance on a generating set or batteries.

### 1.3.1 General advice

Use

- ✓ The operating and safety instructions must be made known to operating personnel. They will be regularly updated.
- ✓ Read and understand the manuals provided with the generating set, pump unit or lighting column properly. The manufacturer's instructions must remain at the disposal of technicians, if possible in situ.
- ✓ The facility must be operated under the direct or indirect supervision of a person appointed by the operator, who is familiar with the operation of the facility, and the dangers and drawbacks of the products used or stored in the facility.
- ✓ Do not wear loose clothing, or get close to machines in operation. Note that the fans are not clearly visible when the engine is running.
- ✓ Warn personnel present to keep their distance during operation.
- ✓ Do not run the generating set, pump unit or lighting column without refitting the protective covers and closing all the access doors.
- ✓ Never let a child touch the generating set, pump unit or lighting column, even when shut down.
- ✓ Avoid operating the generating set, pump unit or lighting tower in the presence of animals (disturbance, scares, etc.).
- ✓ Engage the parking brake when the generating set or lighting tower on its trailer is installed on the operating site. When chocking the trailer on a slope; ensure that there is nobody in the path of the trailer.
- ✓ Never start the engine without an air filter or exhaust.
- ✓ Engine with turbocharger: never start the engine without fitting the air filter. The compressor wheel rotating inside the turbocharger may cause serious bodily injury. Foreign objects in the inlet pipe may cause mechanical damage.
- ✓ Engine with air preheating (starting components): never use a starting spray or any other similar starter assistance product. Upon contact with the starting component, an explosion may occur in the inlet tube, causing bodily injury.
- ✓ Do not touch the lighting column lights when they are switched on.

Maintenance

- ✓ Follow the maintenance table and its instructions.
- ✓ Always use tools in good condition which are suited to the work to be done. Ensure you have understood the instructions before beginning any operation.
- ✓ Goggles should be worn when carrying out maintenance operations and watches, bracelets etc. should be removed.
- ✓ Fit only original parts.
- ✓ Disconnect the battery and the pneumatic starter (if fitted) before undertaking any repairs, to prevent the engine from starting accidentally. Fit a panel over the controls to prevent any attempt to start.
- ✓ Only use the correct crankshaft turning techniques for turning the crankshaft manually. Do not try to turn the crankshaft by pulling it or levering the fan. This method may cause serious bodily or material damage, or damage the vanes of the fan, reducing the service life of the fan.
- ✓ Clean off any trace of oil, fuel or coolant using a clean cloth.
- ✓ Do not use a soapy solution containing either chlorine or ammonia, as these two chemicals prevent bubble formation.
- ✓ Never use petrol or other inflammable substances to clean the parts. Use only approved cleaning solvents.
- ✓ Do not use a high pressure cleaner for cleaning the engine and equipment. The radiator, hoses, electrical components, etc. may be damaged.
- ✓ Avoid accidental contact with parts at high temperatures (exhaust manifold, exhaust).
- ✓ Before any maintenance operation on a lighting column light, cut the electrical power supply and wait for the bulbs to cool down.

Consumables

- ✓ Observe regulations in force concerning use of fuel before using your generating set, pump unit or lighting tower.
- ✓ Under no circumstances use seawater or any other corrosive or electrolytic product in the cooling circuit.

Environment

- ✓ The operator must take the necessary measures to comply with the aesthetics of the site of use. The whole site must be maintained in a good state of cleanliness.
- ✓ The premises must be kept clean, and be regularly cleaned so as to avoid accumulation of dangerous materials or pollutants and dust, which could ignite or cause an explosion. The cleaning equipment must be suited to the risks posed by the products and dust.
- ✓ The presence of dangerous or combustible materials inside premises housing combustion devices shall be limited to the operating requirements.

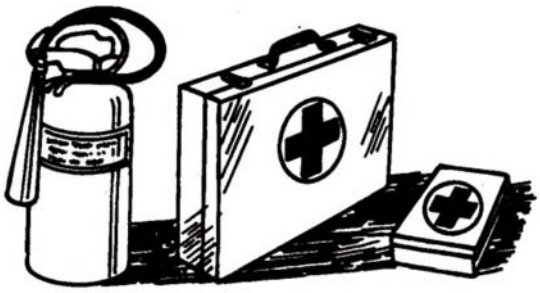
- ✓ Facilities must be operated under the constant supervision of a qualified person, who must regularly check that the safety devices are operating correctly and ensure that the combustion devices have the correct fuel supply.
- ✓ Apart from the combustion devices, it is prohibited to use fire in any form. This restriction must be clearly displayed.
- ✓ Spreading of waste water, sludge and waste is prohibited.
- ✓ The fuels to be used must correspond to those featured in the declaration file and the specifications recommended by the combustion device manufacturer.
- ✓ The fuel is considered to remain in the same physical state as when it is introduced into the combustion chamber.
- ✓ Burning of waste in the open air is prohibited.
- ✓ Always protect your hands when checking for leaks. Pressurised liquids may penetrate body tissue and cause serious damage. Risk of blood contamination.
- ✓ Drain and dispose of engine oil in a specially provided container (fuel distributors can collect your used oil).
- ✓ Except by special agreement, once closed, the gas supply main unit must only be re-opened by the gas distributor. However, the user may access it under certain conditions. Check these for each site.

### 1.3.2 Risks related to exhaust gases and fuels

| | |
|---|---|
|  | The carbon monoxide present in exhaust gases may cause death if the concentration levels in the air breathed are too high.<br>Always use generating sets, pump units or lighting towers in a well-ventilated place where gases cannot accumulate.<br>In case of indoor use:<br>✓ Be sure to evacuate exhaust gases outdoors.<br>✓ Provide appropriate ventilation so that personnel present are not affected. |
| Danger | |

- ✓ Observe the local regulations in force for generating sets, pump units or lighting towers, as well as local regulations for use of fuel (petrol, diesel fuel and gas) before using your generating set, pump unit or lighting tower.
- ✓ Fuel filling should be carried out when the engine is off (except for generating sets with an automatic filling system).
- ✓ Engine exhaust gases are toxic: do not run the generating set, pump unit or lighting column in unventilated premises. If installed in a ventilated room, additional requirements for fire and explosion protection must be observed.
- ✓ A leaking burnt gas exhaust may increase the sound level of the generating set, pump unit or lighting column. To check on its efficiency, regularly examine the burnt gas exhaust.
- ✓ Pipes must be replaced as soon as their condition demands it.

### 1.3.3 Risks related to toxic products

| | | |
|---|---|---|
|  | The corrosion inhibitor contains alkali.<br>Do not swallow it.<br>This substance should not come into contact with the eyes. In the event of contact with the eyes, rinse immediately with plenty of water for at least 15 minutes.<br>Avoid prolonged or repeated contact with the skin. In the event of contact with the skin, wash thoroughly with water and soap. CONSULT A DOCTOR IMMEDIATELY. KEEP THE PRODUCT OUT OF THE REACH OF CHILDREN**.**<br><br>The anti-rust product is toxic and dangerous if absorbed. Avoid all contact with the skin and eyes. Read the instructions on the packaging. | Glycol is a toxic product and dangerous if absorbed. Avoid all contact with the skin and eyes. Read the instructions on the packaging.<br>  |
| Warning | | |

- ✓ Caution: fuels and oils are dangerous to inhale. Ensure proper ventilation, and use a protective mask.
- ✓ Never expose the equipment to liquid splashes or rainfall, and do not place it on wet ground.

- ✓ The battery electrolyte is harmful to skin and especially eyes. If splashes get into eyes, rinse immediately with running water and/or a 10% diluted boric acid solution**.**
- ✓ Wear protective eyewear and strong base resistant gloves for handling the electrolyte.

### 1.3.4 Risk of fire, burns and explosion

| | |
|---|---|
|  Danger | The engine should not be operated in environments containing explosive products. As not all of the electrical and mechanical components are shielded, there is a risk of sparks forming. |




- ✓ Make sure not to create sparks or flames, and not to smoke near the batteries, as the electrolyte gases are highly flammable (especially if the battery is charging). Their acid also poses a risk to the skin, and in particular to the eyes.
- ✓ Never cover the generating set, pump unit or lighting tower with any material during operation or just after shutdown (wait for the engine to cool).
- ✓ Do not touch hot parts such as the exhaust pipe, or put combustible materials on it.
- ✓ Keep all flammable or explosive materials (e.g. petrol, oil, cloth, etc.) out of the way when the set is running.
- ✓ Proper ventilation is required for your generating set, pump unit or lighting column to work properly. Without this ventilation, the engine would very quickly rise to an excessively high temperature, causing accidents or damage to the equipment and to surrounding property.
- ✓ Do not remove the radiator cap if the engine is hot and the coolant is pressurised, due to risks of burns.
- ✓ Depressurise the air, oil and cooling circuits before removing or disconnecting all the fittings, pipes or connected components. Watch out for the possible presence of pressure when disconnecting a device from a pressurised system. Do not try to find pressure leaks by hand. Oil at high pressure can cause bodily damage.
- ✓ Some preservative oils are flammable. Also, some are dangerous to inhale. Ensure proper ventilation. Use a protective mask.
- ✓ Hot oil causes burns. Avoid contact with hot oil. Check that the system is no longer pressurised before carrying out any procedures. Never start or run the engine with the oil filler cap off (oil may splash out).
- ✓ Never coat the generating set, pump unit or lighting column with a thin layer of oil to protect it from rust.
- ✓ Never top up the oil or coolant if the generating set, pump unit or lighting column is running, or if the engine is hot.
- ✓ A generating set can only operate when stationary, and cannot be installed on a vehicle or other mobile equipment, without a prior study taking into account the various specific features of using the generating set.

### 1.3.5 Risks related to electrical networks

- ✓ The electrical equipment supplied with the generating set complies with standard NF C15.100 (France), or with the standards of the countries in question.
- ✓ The earth connection must be installed in accordance with the standards in force in each country in question, and with the neutral system sold.
- ✓ Read the manufacturer's identification plate carefully. The values for voltage, power, current and frequency are shown. Check that these values match the supply use.
- ✓ Never accidentally touch stripped cables or loose connections.
- ✓ Never handle a generating set with wet hands or feet.
- ✓ Maintain electrical wires and connections in good condition. Using equipment in poor condition can lead to electrocution and damage to equipment.

- ✓ Always disconnect the power to the equipment or facility (generating set voltage, battery voltage and network voltage) before any operation.
- ✓ The electrical connections must be made in accordance with current standards and regulations in the country of use.
- ✓ Do not use faulty, poorly insulated or provisionally connected wires.
- ✓ Never reverse the positive and negative terminals on batteries when connecting them. This could cause severe damage to the electrical equipment. Follow the wiring diagram supplied by the manufacturer.
- ✓ The generating set should not be connected to any other power sources, such as the mains supply network. In specific cases where there is to be a connection to existing electrical networks, this must only be installed by a qualified electrician, who should take the operating differences of the equipment into account, according to whether the mains supply network or generating set is being used.

- ✓ Protection against electric shocks is ensured by an assembly of specific equipment. If this needs to be replaced, it should be by components with identical nominal values and specifications.
- ✓ If the protective plates (blanking covers) need to be removed to route cables, the protector (blanking cover) must be refitted when the operations are finished.
- ✓ Due to high mechanical stresses, use only strong flexible wiring with rubber sheathing, compliant with IEC 245-4, or equivalent wiring.

### 1.3.6 Dangers presented by electric currents (first aid)

First aid

In the event of an electric shock, shut off the power immediately and activate the emergency stop on the generating set or lighting column. If the voltage has not yet been cut off, move the victim out of contact with the live conductor as quickly as possible. Avoid direct contact both with the live conductor and the victim's body. Use a dry plank of wood, dry clothes or other non-conductive materials to move the victim away. The live wire may be cut with an axe. Take great care to avoid the electric arc that will be generated by this.

Begin emergency procedures

Resuscitation

If breathing has stopped, begin artificial respiration at once in the same place the accident took place unless the victim or operator's life could be endangered by this.

In the event of cardiac arrest, carry out cardiac massage.

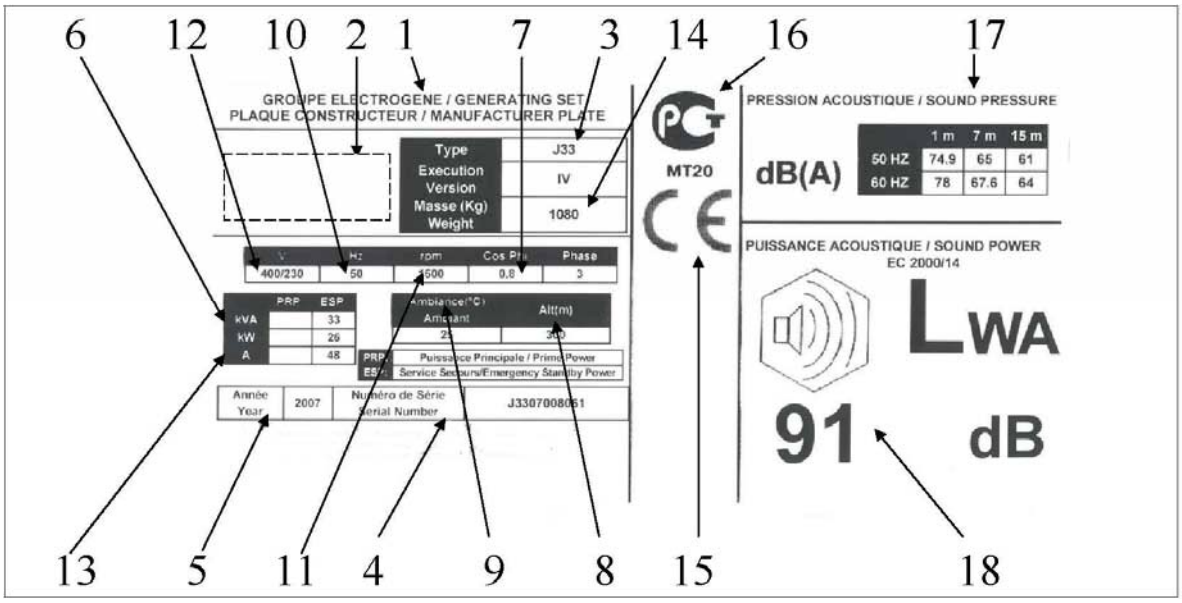
### 1.3.7 Risks related to moving the set

To unload the generating sets, pump units or lighting columns from their transport support brackets under optimum safety and efficiency conditions, you must ensure that the following points are observed:

- ✓ The lifting machinery or equipment is suited to the work required, in good condition and with sufficient lifting capacity.
- ✓ The slings are positioned in the rings provided for this operation, the forklift arms are resting fully underneath all of the base frame cross-beams, or the lifting bars are inserted in the apertures provided for this purpose in the base to lift the entire generating set (according to models).
- ✓ For completely safe working conditions and to prevent damage to the components fitted on the upper edge of the set, pump unit or lighting column, the generating set, pump unit or lighting column must be lifted up with an adjustable boom. All the chains and cables must be parallel with each other, and as perpendicular as possible with the upper edge of the generating set, pump unit or lighting column.
- ✓ If other equipment fitted on the generating set, pump unit or lighting column alters its centre of gravity, special lifting devices may be necessary to maintain correct balance and completely safe working conditions.
- ✓ The ground must be able to withstand the load of the generating set, pump unit or lighting column and its lifting machinery without stress (otherwise, put down beams of sufficient strength in a stable configuration).
- ✓ Position the generating set, pump unit or lighting column as close as possible to its place of use or transport, in a clear space with free access.
- ✓ Never perform work on a generating set, pump unit or lighting tower just hanging from a lifting device.

## 1.4. Identifying sets

Generating sets and their components are identified by means of identification plates.
The precise rules for identifying each major component (engine, alternator etc.) are set out in each manufacturer's documentation contained in the appendices of this manual.




| | |
|---|---|
| 1 - Generating set | 9 - Maximum ambient temperature for the rated power (°C) |
| 2 - Manufacturer name | 10 - Rated frequency (Hz) |
| 3 - Model | 11 - Generating set rotation speed (RPM) |
| 4 - Serial number | 12- Rated voltage (V) |
| 5 - Year of manufacture | 13 - Rated current (A) |
| 6 - Rated output (kVA and kW) according to the ISO 8528-1 standard<br>PRP: main power<br>ESP: emergency power | 14 - Weight (kg) |
| | 15 - CE marking |
| | 16 - Non CE standard marking (e.g.: GOSSTANDART) |
| 7 - Rated power factor | 17 - Sound pressure |
| 8 - Maximum altitude of the site above sea level (m) for the rated power | 18 - Sound power |

**Figure 1.3**: Example of generating set identification plate

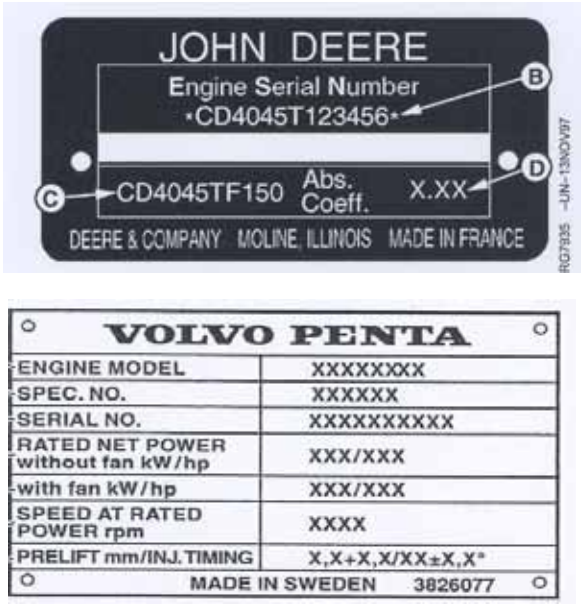




**Figure 1.4**: Examples of engine identification plates



**Figure 1.5**: Examples of alternator identification plates

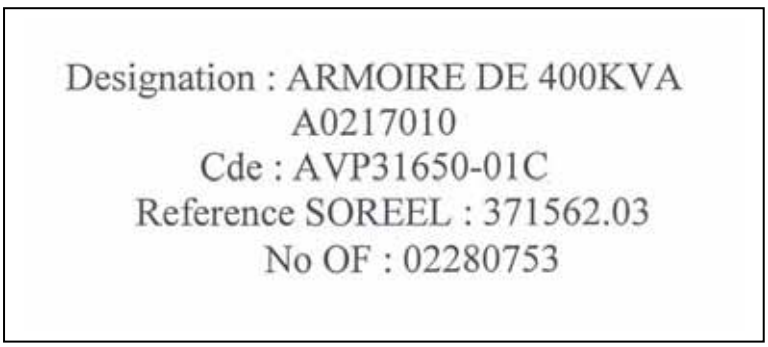
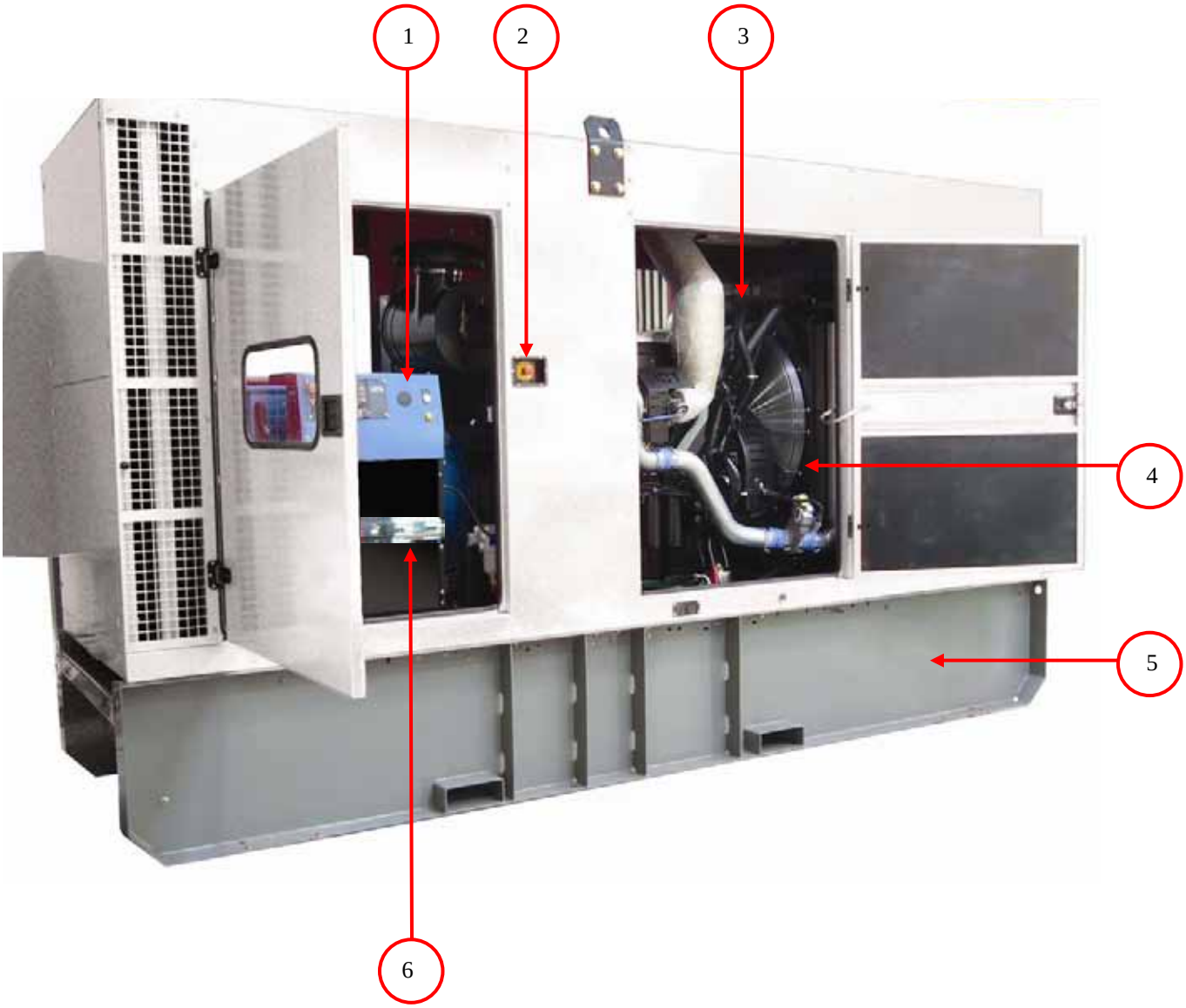



**Figure 1.6**: Example of control box identification plate

# 2. General description

## 2.1. Description

***Overview***

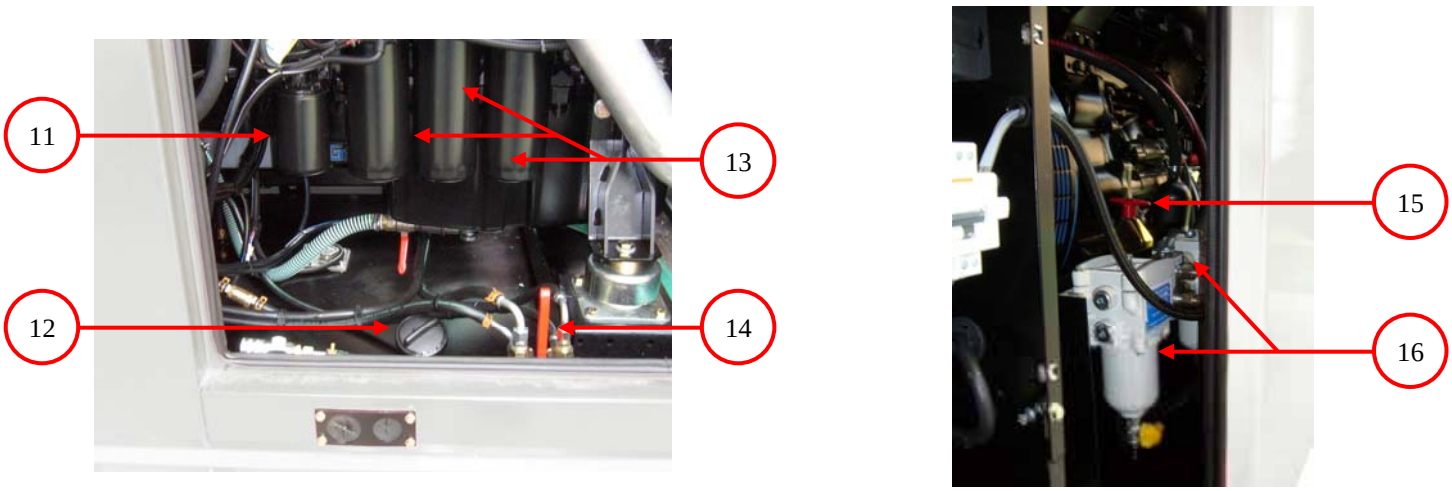



| | | | |
|---|---|---|---|
| 1 | Control unit | 4 | Protective grilles |
| 2 | External emergency stop | 5 | Chassis |
| 3 | Expansion bottle | 6 | Circuit breakers |

**Figure 2.1:** General description of the generating set


| | | | |
|---|---|---|---|
| 7 | Battery charge alternator | 9 | Main circuit breaker |
| 8 | Starter batteries | 10 | Connection termination box |

**Figure 2.1 (continued):** General description of the generating set



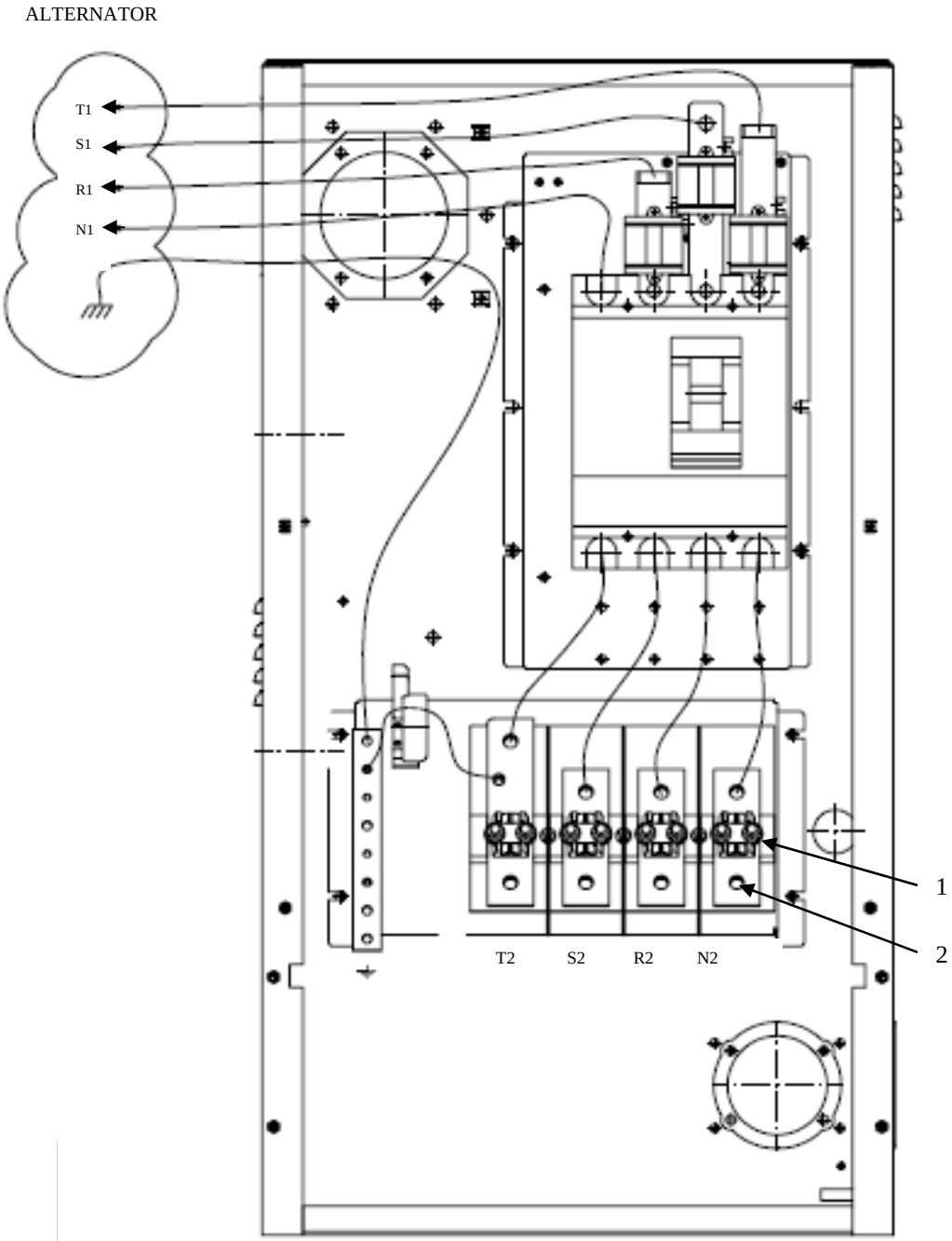

| | | | |
|---|---|---|---|
| 11 | Coolant filter | 14 | External fuel supply combined tap (optional) |
| 12 | Filling with fuel | 15 | Circuit breaker |
| 13 | Oil filters | 16 | Interchangeable fuel pre-filters |

**Figure 2.1 (continued):** General description of the generating set

***Fittings***

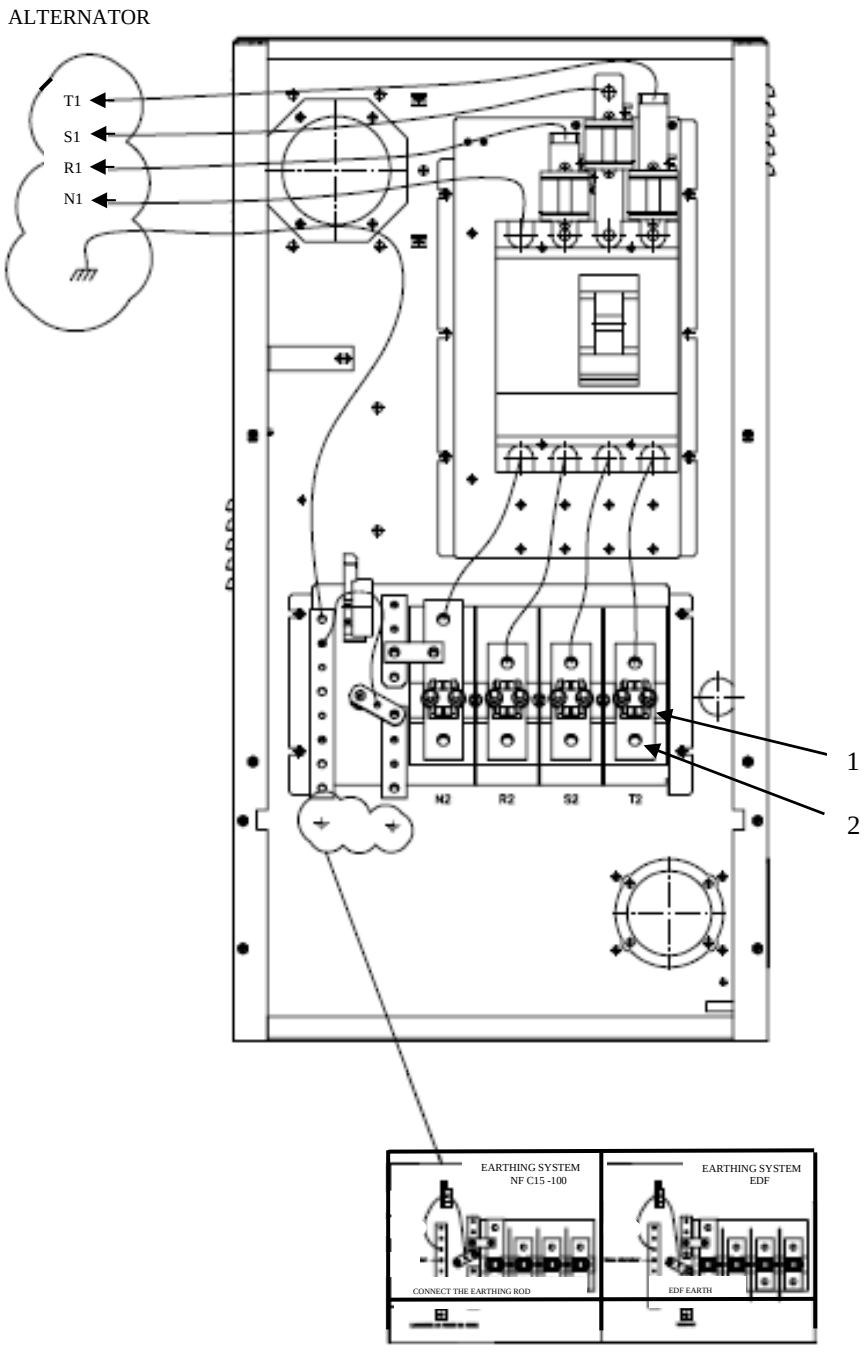
Socket control panels and terminals by cover type:

**AIPR 1 LOC 400/630A**




| | |
|---|---|
| 1 | MAX CONNECTION CABLE CROSS-SECTION 185MM² |
| 2 | Ø M10 BOLT; Ø M10 NUT |

**AIPR 1 LOC 400/630A TT EDF**



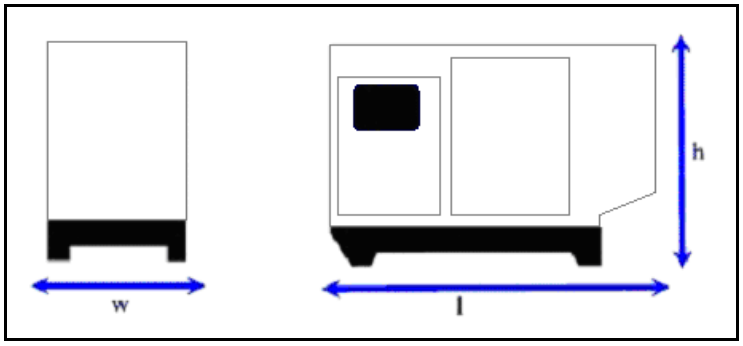

| | |
|---|---|
| 1 | MAX CONNECTION CABLE CROSS-SECTION 185MM² |
| 2 | Ø M10 BOLT; Ø M10 NUT |

## 2.2. Technical specifications

| ***Range / Generating set type*** | RENTAL POWER / R350C2 |
|---|---|

**Weights and Dimensions**

**Dimensions with standard tank**



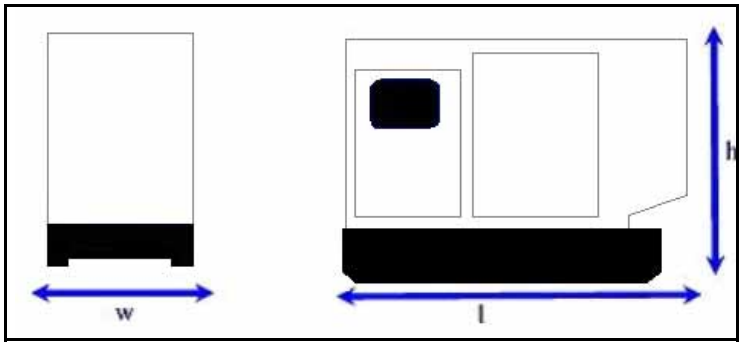

Dimensions l x w x h:
4475mm x 1410mm x 2690mm

Weight:
3830kg dry weight 4300kg in operating configuration

Hood:
M228C

Noise level:
67 dB @ 7 m
97 Lwa

**Dimensions with high autonomy tank**




Dimensions l x w x h:
4527mm x 1410mm x 2780mm

Weight:
4520kg dry weight 5888kg in operating configuration

Hood:
M228C-DW

Noise level:
67 dB @ 7 m
97 Lwa

***Output***

| Voltage | Hz | Phase | Load factor | Max current (A) Emergency/Prime | Emergency power [1] kW / kVA | Prime power [2] kW / kVA |
|---|---|---|---|---|---|---|
| 400/230 | 50 | 3 | 0.8 | 505 / 455 | 280 / 350 | 252 / 315 |

*(1) ESP: Stand-by output available for emergency use under variable charge up to 200hrs per year as per ISO 8528-1, no overload available under these service conditions.*

*(2) PRP: Main output available continuously under variable load for an unlimited time period per year as per ISO 8528-1, an overload of 10% one hour every 12 hours is available, as per ISO3046-1.*

| ***Engine data*** | |
|---|---|
| Manufacturer / model | VOLVO TAD941GE |
| Type | 4-cycle, Turbo, Air/Air |
| Cylinder configuration | 6 L |
| Cubic capacity | 9.36 L |
| Rotation speed | 1500 Rpm |
| Max emergency/prime power at nominal speed | 320 / 290 kW |
| Adjustment type | Electronical |

| ***Fuel consumption*** | |
|---|---|
| 110 % (emergency power) | 75.9 L/h |
| 100 % main power | 68.1 L/h |
| 75 % main power | 50.6 L/h |
| 50 % main power | 35.1 L/h |

| ***Fuel*** | |
|---|---|
| Fuel type | Diesel |
| Standard fuel tank | 470 L |
| High autonomy fuel tank | 1368 L |

| ***Lubrication*** | |
|---|---|
| Oil capacity with filter | 33 L |
| Min. Oil pressure | 0.7 bar |
| Nominal oil pressure | 6 bar |
| Oil consumption (100 % load) | 0,06 L/h |
| Oil sump capacity | 28 L |
| Type of lubricant | Genlub |

| ***Cooling*** | |
|---|---|
| Engine capacity with radiator | 41 L |
| Max coolant temperature | 103 °C |
| Fan power | 15 kW |
| Ventilator air flow | 5.9 m3/s |
| Refrigerant type | Gencool |
| Thermostat | 82-92°C |

| ***Emissions*** | |
|---|---|
| HC | 30 mg/Nm3 |
| CO | 340 mg/Nm3 |
| NoX | 2200 mg/Nm3 |
| PM | 30 mg/Nm3 |

| ***Alternator data*** | |
|---|---|
| ● Compliant with NEMA MG21 standards, UTE NF C51.111, VDE 0530, BS 4999, IEC 34.1, CSA | ● The alternator is protected against short circuits<br>● Vacuum impregnation, epoxy winding, IP23 protection rating |
| Type | LEROY SOMER LSA462VL12 |
| Number of phases | 3 |
| Power factor (cos Phi) | 0.8 |
| Number of poles | 4 |
| Excitation type | AREP |
| Voltage regulator | R448 |
| Short-circuit current | 3 IN |
| Number of bearings | 1 |
| Coupling | Direct |

| **Control unit(s)** | |
|---|---|
| TELYS<br>  | Standard specifications:<br>Voltmeter, Ammeter, Frequency meter<br>Alarms and faults:<br>Oil pressure, Water temperature, Start failure, Overspeed, Alternator min/max, Battery voltage min/max, Emergency stop<br>Engine parameters:<br>Timer, Oil pressure, Water temperature, Fuel level, Engine speed, Battery voltage |
| KERYS<br>  | Coupling: pre-programmed coupling mode selector.<br>Electrical measurements:<br>Voltmeter, Ammeter, Frequency meter<br>Alarms and faults:<br>Oil pressure, Water temperature, Start failure, Overspeed, Alternator min/max, Battery voltage min/max, Emergency stop<br>Engine parameters:<br>Timer, Oil pressure, Water temperature, Fuel level, Engine speed, Battery voltage<br>Additional specifications :Coupling Website, Troubleshooting, Assistance and maintenance, plotting and logging, load impact, 8 configurations available, Compliance with international standards… |

## 2.3. Fuel and consumables

All specifications (product features) are given in the motor and alternator maintenance manuals attached to this manual.
In addition, we recommend the consumables to be used in the "specifications" section.

### 2.3.1 Specifications

#### 2.3.1.1. Oil grades

| Engine | | Oil | |
|---|---|---|---|
| Make | Type | Make | Type |
| John Deere | All | John Deere | John Deere PLUS-50 |
| | | GenPARTS | GENLUB TDX 15W40 |
| MITSUBISHI | All | GenPARTS | GENLUB TDX 15W40 |
| Volvo | All | GenPARTS | GENLUB TDX 15W40 |

**GENLUB TDX 15W-40**
Top-of-the-range lubricant recommended for diesel engines: for generating sets used under severe conditions.

**USES:**

- ✓ Particularly suited to more modern engines with or without turbochargers, *intercoolers*, or sophisticated injection systems (e.g. ***HEUI*****,** injector-pumps).
- ✓ **All types of use**: can cope with the most demanding applications.
- ✓ **Depolluted engines:** complies with EURO 2 and EURO 3 technology and can be used with all types of diesel fuel, especially ecological diesel with low sulphur content.

**PERFORMANCE:**

**ACEA E3**
**API CH-4**

- ✓ Meets level E3 of the specifications defined by European manufacturers in the ACEA standards 98 edition.

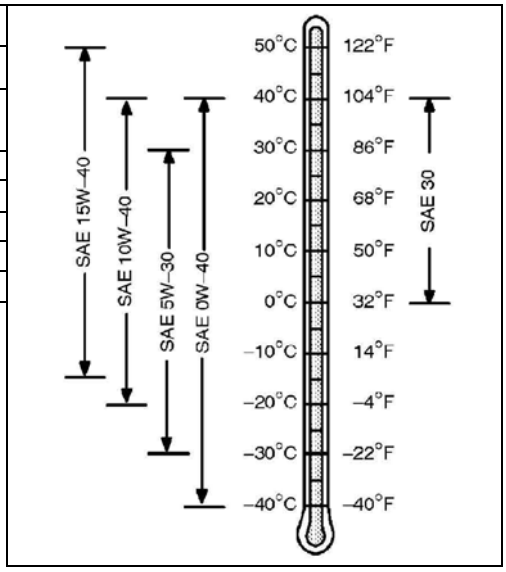
**ADVANTAGES:**

- ✓ **Less frequent oil services**: this product has been put to the test during thousands of hours of use on worksites under varying conditions, demonstrating its high quality.
- ✓ **Conformity with new environmental legislation**: adherence to new anti-pollution standards required for new EURO 2 and EURO 3 engines.

**SPECIFICATIONS:**

| **SAE Grade** | **15W-40** | |
|---|---|---|
| Density at 15°C | 0.883 | |
| Cinematic viscosity at 40 °C<br>Cinematic viscosity at 100 °C | 105<br>14.1 | mm2/s (cSt)<br>mm2/s (cSt) |
| Viscosity index | 140 | |
| Dynamic viscosity at -15 °C | 3000 | mPa.s(cP) |
| Pour point | - 30 | °C |
| Flash point | 220 | °C |
| Sulphated ash content | 1.4 | % weight |

(Values given as examples only)



### 2.3.1.2. Specifications of coolants

| Engine | | Coolants | |
|---|---|---|---|
| Make | Type | Make | Type |
| John Deere | All | GenPARTS | GENCOOL PC -26°C |
| MITSUBISHI | All | Mitsubishi | LLC |
| | | GenPARTS | GENCOOL PC -26°C |
| Volvo | All | GenPARTS | GENCOOL PC -26°C |

**GenCOOL PC -26**
High-protection coolant, approved by manufacturers.
**GenCOOL PC -26** is a ready-to-use, highly protective coolant which is produced from an antifreeze recommended by the majority of European manufacturers.

- It is made from antifreeze and G 48 inhibitors.
- It protects up to -26°C.
- It is free from nitrates, amines and phosphates.
- It is a clear, fluorescent orange liquid.

**REFERENCES/APPROVALS (for the antifreeze):**

| HEAVY GOODS VEHICLE | LIGHTER VEHICLES |
|---|---|
| Approved by MTU, MERCEDES BENZ, MAN, KHD, GENERAL MOTORS<br><br>Conforms with VOLVO, IVECO, VAN HOOL and STAYR TRUCK specifications | Approved by BMW, VOLKSWAGEN, MERCEDES, PORSCHE<br><br>Conforms with VOLVO, OPEL, SEAT and SKODA specifications |

**Conforms with the NF R 15.601 standard**

**REINFORCED ANTI-CORROSION FEATURES:**

- Protects **against high-temperature corrosion** by oxidisation of ethylene (cylinder head protection).
- Protects **against high-temperature cavitation** (top of cylinder and coolant pump protection).
- Non-corrosive for seals and hoses.
- Improves the **efficiency and longevity of the cooling system.**
- **GenCOOL PC -26** is especially recommended for engines fitted with aluminium or light alloy radiators.

**HIGH TEMPERATURE SUITABILITY:**

- Provides good conditions for thermal exchange.
- Perfect stability at high temperatures.
- **GenCOOL PC -26** is specially adapted for engines with high power densities.

**LONG LASTING PROTECTION:**

- High alkaline reserve/stability and longevity of corrosion inhibitors.
    - Maintains its technical properties during prolonged use at high temperatures (neutralisation of acids).
- Ensures maximum heat transfer without the build up of deposits in the cooling system.
- **GenCOOL PC -26** ensures optimum protection against overheating and corrosion in extreme conditions of vehicle use.

EN

## PACKAGING/STORAGE:

- **GenCOOL PC -26** is supplied in 210 l metallic barrels with smooth interior linings.
- It can be stored for 2 years in its original container and packaging.
- Avoid zinc coated containers.

## RECOMMENDATIONS FOR USE:

- Compatible with the original fluid.
- It is recommended that the cooling system is completely drained when replacing the fluid.

| SPECIFICATIONS | UNITS | SPECIFIED VALUES | TRIAL METHODS |
|---|---|---|---|
| **Density at 20°C** | $kg/m^3$ | **1,059 +/- 3** | R 15-602-1 |
| **pH** | pH | **7.5 to 8.5** | NF T 78-103 |
| **Alkalinity reserve** | ml | **>=10** | NF T 78-101 |
| **Boiling point** | °C | **105 +/- 2** | R 15-602-4 |
| **Freezing point:** | °C | **-26 +/- 2** | NF T 78-102 |
| **Glassware corrosion** : (test with antifreeze) | mg/test piece | | R 15-602-7 |
| - Copper | | **+/- 2.6** | |
| - Weld | | **+/- 0.5** | |
| - Brass | | **+/- 2.3** | |
| - Steel | | **+/- 1.6** | |
| - Cast iron | | **+/- 0.8** | |
| - Cast aluminium | | **+/- 1.0** | |
| **Corrosion on warm plate** (test with antifreeze) | $mg/(cm^2 week)$ | **+/- 0.17** | R 15-602-8 |

# 3. Installation

## 3.1. Unloading

### 3.1.1 Safety during unloading

- To unload electrical generating sets from their transport supports under optimum safety and efficiency conditions, you need to ensure that the following points are observed:
- Lifting machinery or equipment appropriate to the work required.
- Slings positioned in the eyes provided for this operation or lifting arms resting fully underneath the chassis cross members.
- Ground able to take the load of the set and the lifting machinery without stress (otherwise lay down beams of sufficient strength and stability).
- Set put down as close as possible to its point of use or transportation, in a clear area with free access.

Example of equipment to be used:

- ✓ crane, slings, cross bar, safety catch, shackles.
- ✓ Fork lift truck.

### 3.1.2 Instructions for unloading

#### 3.1.2.1. Slings

❶ Attach the lifting vehicle slings to the rings on the generating set designed for this procedure. Hang the slings carefully.

❷ Check that the slings are correctly attached and the equipment is solid.

❸ Lift the generating set carefully.

❹ Direct and stabilise the set towards the chosen position.

❺ Carefully set down the equipment while continuing to position it.

❻ Release the slings, then detach and remove the lifting rings.

#### 3.1.2.2. Fork lift truck

❶ Position the forklift arms under the base frame (except with generating sets fitted with "forklift pockets", in which case position the forklift arms in these pockets), making sure that only its cross-members are resting on the arms.

❷ Lift the equipment, handling it gently.

❸ Set down the generating set in its unloading position.

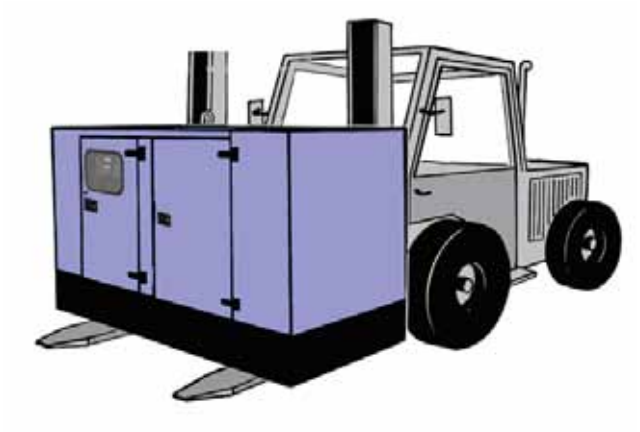


**Figure 3.1**: Transporting a generating set using a forklift truck

## 3.2. Fluid retention

Any outflow of the fluids contained in the generating sets (fuel, oil and coolant, or rainwater or condensation) will be collected in a retention container if the generating set is fitted with this option.
The containers have a capacity which allows 110% of the fluids contained in the generating set fitted with this option to be collected.
Three different fittings are available.

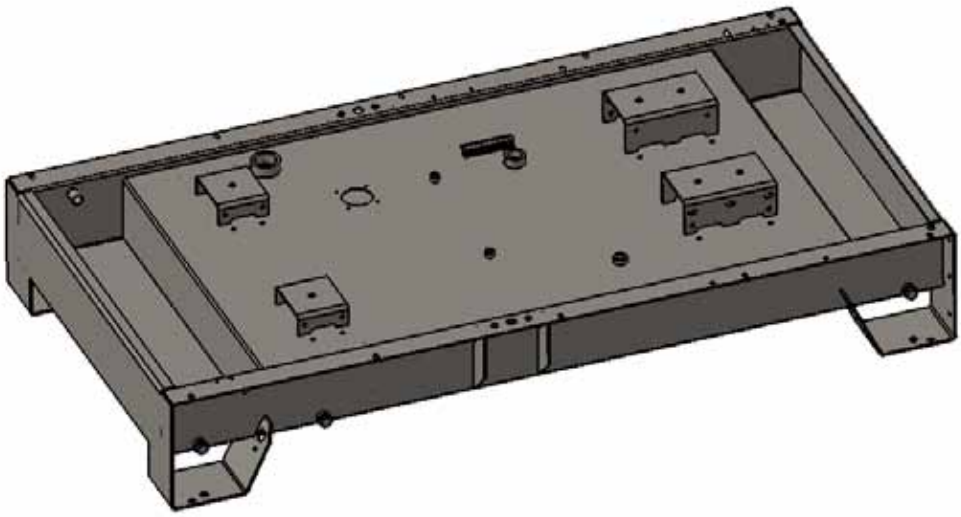


**Diagram 3.2**: Fluid retention container integrated into the tank chassis.

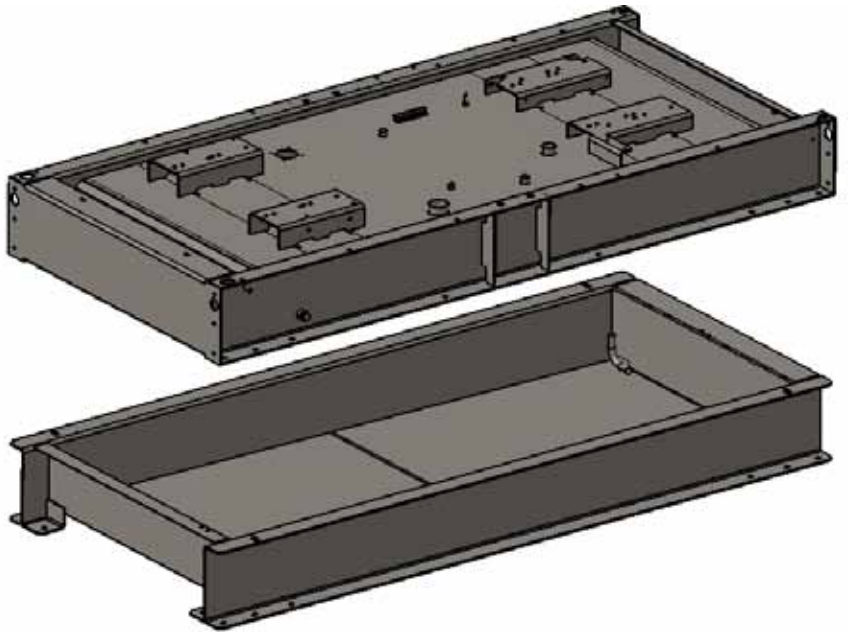


**Diagram 3.3**: Offset fluid retention container underneath the generating set chassis.

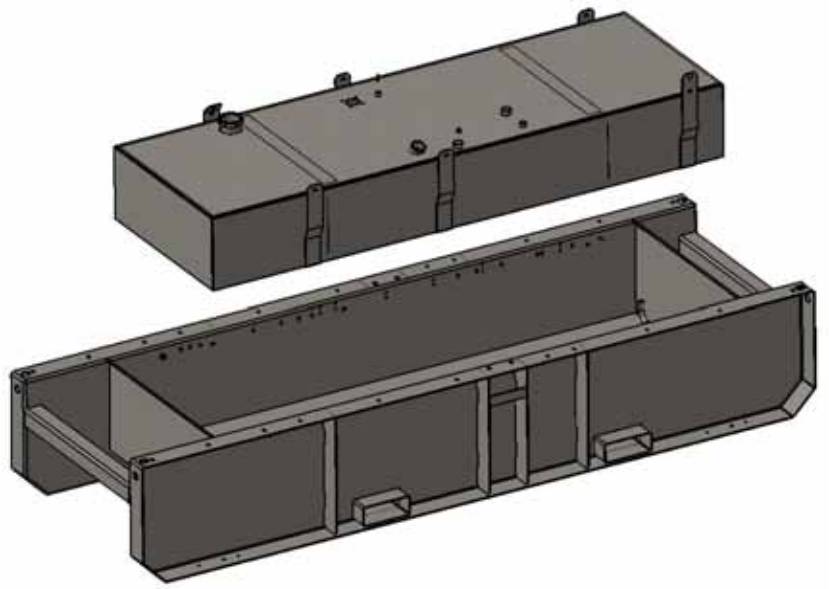


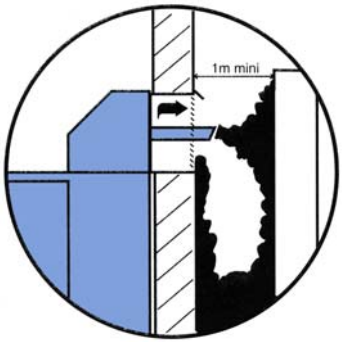
**Diagram 3.4**: Offset fluid retention container integrated into the chassis and tank.

Generating sets fitted with the offset tank option (DW) above also have a high level indicator in the retention container.
In all cases, the retention containers must be regularly checked to ensure they contain no fluid (fuel, oil and coolant, or rainwater or condensation). If necessary, drain the containers either via the drain port or by using the drain pump (for containers fitted with this pump).

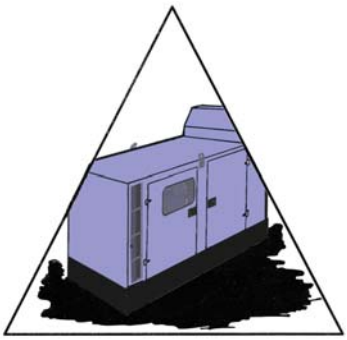
- ✓ **Note**: Never allow these fluids to drain onto the ground; ensure they are collected in a designated container.

## 3.3. Choice of location

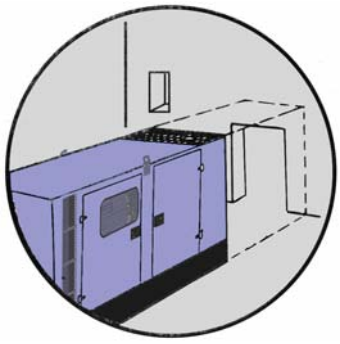
It should be determined on the basis of use. There are no specific rules governing the choice of location, other than proximity to the electric distribution panel and disturbances caused by the noise. However, fuel supply, burnt gas evacuation, and the direction of these gases and the noises emitted should be taken into account.
The choice of its position will be based on carefully considered compromise!
Examples of problems that may be encountered:



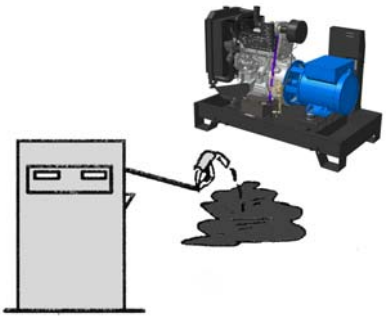

Incorrect exhaust and ventilation



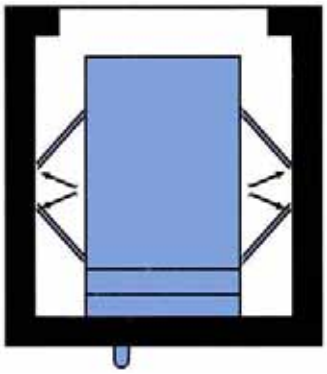
Ground too uneven or soft.
Set incorrectly positioned



Reduced access



Fuel filling impossible



Opening cover doors impossible

**Diagram 3.5**: Examples of problems that may be encountered

## 3.4. Electricity

a) Connections - general information

As with low voltage electrical installations, use and maintenance is governed by standard NFC 15.100 (France) or by the standards in the relevant country, based on international standard IEC 60364-6-61.

They must also adhere to the regulations in the NFC 15.401 application guide (France) or to the regulations and standards in the relevant country.

b) Power cables

These can be unipolar or multipolar according to the power of the generating set.

Power cables should preferably be installed in ducts or on a cable tray for this purpose.

The cable cross-section and number of cables should be determined according to the cable type and the current standards to be observed in the country of installation. The choice of conductors must comply with international standard IEC 30364-5-52.

**Three phase - Calculation hypothesis**
Fitting method = wiring in cable runs or non perforated trays.
Permissible voltage drop = 5%
Multiconductors or single conductor joined when precision 4X…(1)
Cable type PVC 70°C (e.g. H07RNF).
Ambient temperature = 30°C.

| Circuit breaker calibre (A) | Cable sizes | | |
|---|---|---|---|
| | 0 - 50m | 51 - 100m | 101 - 150m |
| | mm²/AWG | mm²/AWG | mm²/AWG |
| 10 | 1.5 / 14 | 2.5 / 12 | 4 / 10 |
| 16 | 2.5 / 12 | 4 / 10 | 6 / 9 |
| 20 | 2.5 / 12 | 4 / 10 | 6 / 9 |
| 25 | 4 / 10 | 6 / 9 | 10 / 7 |
| 32 | 6 / 9 | 6 / 9 | 10 / 7 |
| 40 | 10 / 7 | 10 / 7 | 16 / 5 |
| 50 | 10 / 7 | 10 / 7 | 16 / 5 |
| 63 | 16 / 5 | 16 / 5 | 25 / 3 |
| 80 | 25 / 3 | 25 / 3 | 35 / 2 |
| 100 | 35 / 2 | 35 / 2 | 4X(1X50) / 0 |
| 125 | (1) 4X(1X50) / 0 | 4X(1X50) / 0 | 4X(1X70) / 2/0 |
| 160 | (1) 4X(1X70) / 2/0 | 4X(1X70) / 2/0 | 4X(1X95) / 4/0 |
| 250 | (1) 4X(1X95) / 4/0 | 4X(1X150) / 2350MCM | 4X(1X150) / 2350MCM |
| 400 | (1) 4X(1X185) / 0400MCM | 4X(1X185) / 0400MCM | 4X(1X185) / 0400MCM |
| 630 | (1) 4X(2X1X150) / 2x 2350MCM | 4X(2X1X150) / 2x 2350MCM | 4X(2X1X150) / 2x 2350MCM |

**Single phase - Calculation hypothesis**
Fitting method = wiring in cable runs or non perforated trays.
Permissible voltage drop = 5%
Multiconductors.
Cable type PVC 70°C (e.g. H07RNF).
Ambient temperature = 30°C.

| Circuit breaker rating (A) | Cable sizes | | |
|---|---|---|---|
| | 0 - 50m | 51 - 100m | 101 - 150m |
| | mm²/AWG | mm²/AWG | mm²/AWG |
| 10 | 4 / 10 | 10 / 7 | 10 / 7 |
| 16 | 6 / 9 | 10 / 7 | 16 / 5 |
| 20 | 10 / 7 | 16 / 5 | 25 / 3 |
| 25 | 10 / 7 | 16 / 5 | 25 / 3 |
| 32 | 10 / 7 | 25 / 3 | 35 / 2 |
| 40 | 16 / 5 | 35 / 2 | 50 / 0 |
| 50 | 16 / 5 | 35 / 2 | 50 / 0 |
| 63 | 25 / 3 | 50 / 0 | 70 / 2/0 |
| 80 | 35 / 2 | 50 / 0 | 95 / 4/0 |
| 100 | 35 / 2 | 70 / 2/0 | 95 / 4/0 |
| 125 | 50 / 0 | 95 / 4/0 | 120 / 2250MCM |

c) Battery cables
Install the battery or batteries in the immediate vicinity of the electric starter motor. The cables will be connected directly from the battery terminals to the starter motor terminals.
The primary instruction to follow is to ensure that the polarities between the battery and starter motor match. Never reverse the positive and negative battery terminals when connecting them. This could cause severe damage to the electrical equipment.
The minimum cross-section of the cables will be 70 $mm^2$. It varies according to the power of the starter motor but also the distance between the batteries and the set (voltage drops on the line).

d) Safety guidelines
References: NFC 15-100:2002 (France) - IEC: 60364-5-54

In order to protect personnel against electric shocks, this generating set is equipped with a differential residual current protector "factory" set to trigger instantly, with a sensitivity of 30 mA.

| | |
|---|---|
|  Important | Any modification to this setting could endanger personnel. Any modification would render the user liable, and must only be performed by qualified and authorised personnel.<br>When the generating set is disconnected from a facility after use, the master differential protector must be returned to its "factory" settings, and this must be checked by trained personnel. |

For effective protection against electric shocks, the generating set needs to be earthed. To do this, use a copper wire, with a minimum cross-section of 25 $mm^2$ for a stripped cable and 16 $mm^2$ for an insulated cable, connected to the generating set earth socket and a galvanised steel earthing rod embedded vertically into the ground.

The earthing rod resistance value should comply with the values shown in the table below.
Note: use the highest differential setting from the installation as a guideline.

The resistance value is calculated in the following way: $R = \frac{Ul}{I\,\Delta n}$

Maximum resistance value of the earth socket R (Ω) according to the differential unit operational current (operation time should not be longer than 1 second).

| I Δn differential | Earth R (Ω) Ul: 50 V | Earth R (Ω) Ul: 25 V |
|---|---|---|
| ≤ 30 mA | 500 | > 500 |
| 100 mA | 500 | 250 |
| 300 mA | 167 | 83 |
| 500 mA | 100 | 50 |
| 1A | 50 | 25 |
| 3A | 17 | 8 |
| 5A | 10 | 5 |
| 10A | 5 | 2.5 |

The Ul value: 25 V is required for work site installations, and livestock buildings, etc.

For a default voltage of 25 V and a default current of 30 mA, this rod must be of a minimum length of: see table below

| Nature of ground | Length of rod in metres | |
|---|---|---|
| Thick arable land,<br>moist compact ballast | 1 | |
| Lean arable land,<br>Gravel, coarse ballast | 1 | |
| Bare stony soils, dry sand,<br>impermeable rock | 3.6 | To obtain an equivalent length, you can use several earthing rods connected in parallel and set apart by at least their length.<br>Example: 4 interconnected 1 metre rods separated by 1 metre. |

Note: For the United States (National Electrical Code reference NFPA-70).
The generating set must be earthed. To do this, use a copper wire with a minimum cross-section of 13.3 mm² (or AWG 6, at most) connected to the generating set earth socket and a galvanised steel earthing rod fully embedded into the ground vertically.
This earthing rod embedded fully in the ground must have a minimum length of 2.5 m.

## 3.5. Special arrangements

Generating sets are not fitted with protection against power surges caused by drops in atmospheric pressure or manoeuvring.
The company does not accept any responsibility regarding damage caused by these occurrences.
However, lightning conductors can be installed, on the understanding that this does not give total protection.

# 4. Trailer

## 4.1. Trailer linkage

Before attaching the trailer, check the trailer hook on the tow vehicle; it should fit the trailer ring perfectly.

| | |
|---|---|
| **Danger** | **Trying to tow a trailer with a non-matching device (bar, wires, cords, etc.) could lead to serious accidents.**<br>**Also check:**<br>**- no incipient fractures or excessive wear on the hitching system.**<br>**- locking system is operating properly.** |

To hitch the trailer, proceed as follows:

❶ Lock the wheels to stop the trailer from moving.
❷ Lift up the rear trailer supports and lock them.
❸ Release the parking brake.
❹ Release the locking levers for the draw bar arms and adjust the ring to the same height as the vehicle hook.
❺ Hitch the trailer, remove the locks on each side of the wheels then lift up the front wheel fully using its handle.
❻ Connect the electrical circuit of the trailer to that of the tow vehicle.
❼ Hook the handbrake safety wire onto the hook on the tow vehicle.

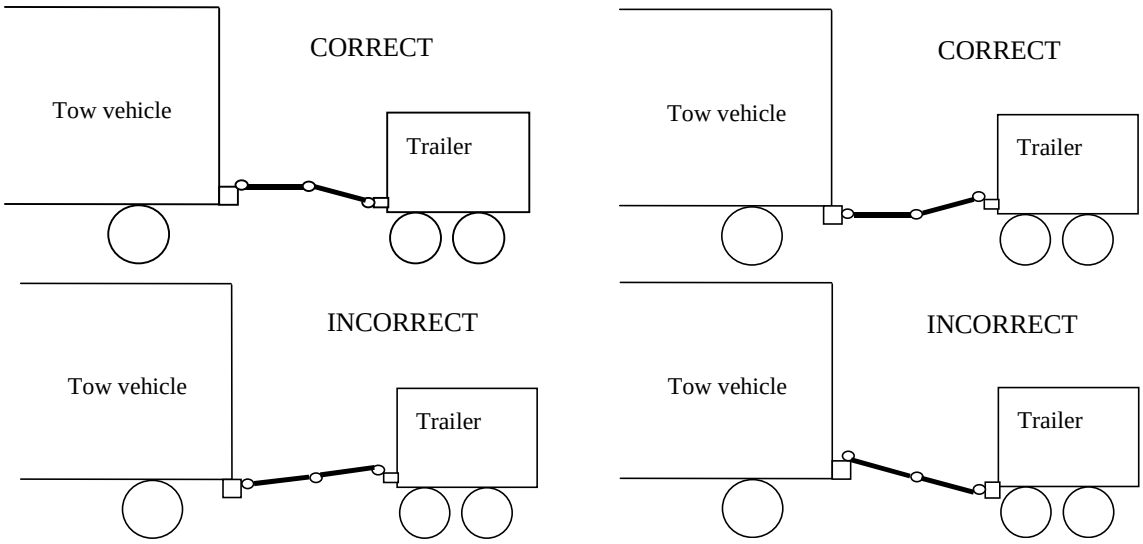



**Diagram 4.1** : Coupling a trailer

## 4.2. Check before towing

Before towing, check the following:

- ✓ Tightness of the generating set enclosure bolts.
- ✓ Wheel tightness.
- ✓ Hitching hook locked.
- ✓ Tyre pressure.
- ✓ Signalling lights working, for "on-road" trailers.
- ✓ Enclosure doors closed.
- ✓ Parking brake released, for "on-road" trailers.
- ✓ Guide wheels (jockey wheels) and stands lifted (if fitted).
- ✓ Towbar arm locking levers tightened and pinned (if fitted with an adjustable towbar).
- ✓ Brake test, for "on-road" trailers.
- ✓ Safety cable fitted, for "on-road" trailers.

## 4.3. Operation

"On-site" trailer

These trailers are not fitted with a main brake, and so cannot be braked in motion; the tyres allow for a maximum speed of 27 km/h. So it is absolutely prohibited to exceed this speed.

Nor are these trailers fitted with signalling lights. On-road use is prohibited.

"On-road" trailer

The driving speed must be suited to the condition of the road and the handling of the trailer.

Driving at high speed causes heating of the tyres; so it is important to stop from time to time, and check them. Excessive heating may cause a puncture, and therefore a serious accident. For reversing manoeuvres, remember to lock the inertia brake.

| | |
|---|---|
| Warning | Particular attention must be paid to the tightness of the wheels on new vehicles. In the first few miles' driving, heating of the brake hubs and drums will actually reduce the wheel tightness. It is therefore essential to check the tightness every 6 miles (10 kilometres) until no further loosening is noted. Nonetheless the tightness must be checked whenever you are about to tow the trailer. |

Lights/signalling (only for "on-road" trailers)

Warning lights are obligatory for on-road driving. Signalling must comply with regulations in force in the country of use.

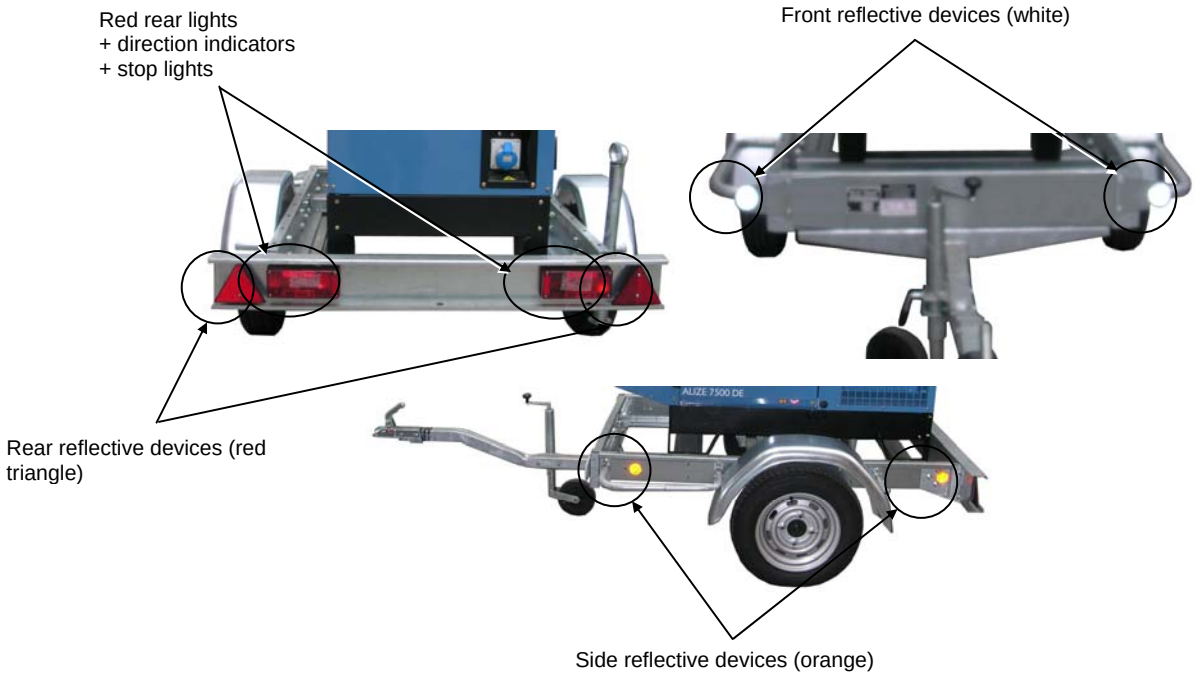



**Figure 4.2**: Example of French signalling

## 4.4. Unhitching the trailer

This operation should be carried out on horizontal, flat, stable ground.

1. Lock the wheels.
2. Lower the front wheel.
3. Disconnect the road signals wire.
4. Refit the hitch using the wheel to release the hook ring from the tow vehicle.
5. Engage the handbrake.
6. Release the tow vehicle.

## 4.5. Implementation for installation

Operations to be carried out:

- ✓ Ensure that the ground is strong enough for the assembly not to sink into it.
- ✓ Unhitch the trailer as per paragraph 5.2.1 "Hitching and unhitching the trailer".
- ✓ Immobilise the trailer by placing chocks under the wheels.
- ✓ Fully engage the parking brake (if fitted).
- ✓ Using the front wheel, position the generating set as close to horizontal as possible.
- ✓ Lower the stands (if fitted), and lock them.

## 4.6. Break transmission adjustment

| | |
|---|---|
| ⚠ Important | - The handbrake is used only as a parking brake.<br>- Setting is carried out starting with the brakes moving to the brake control. |

❶ After fitting the wheels on the axle, turn the wheels in the FORWARD direction (on all RA 2 type brakes, check that the adjustment screw 8 reaches the “FORWARD” stop on the brake backing plate).

❷ Adjust the brake setting using screw 8, with the cables not connected to the cross bar(s). The shoes should rub the drum slightly.

❸ Connect the brake cables to the cross bars(s) and tighten the nuts and lock nuts, leaving the end of the threaded end protruding by around 10 mm (Fig. 4.4).

**IMPORTANT**: Wherever possible, cables must cross over to achieve the highest possible gain curve (Fig. 4.5).

❹ Check that the parking lever 1 is in the ‘REST” position and that the compensating spring 4 is completely free on its rod (unscrew the nuts 5 fully).

❺ Check that the hook slide 2 is not compressed and the yoke 3 is in the pulled out position.

❻ Fit the transmission and adjust the assembly using the tensioner 6 until a gap (J1) of 1 mm max is obtained between the linkage 9 and slide 2.

❼ Adjust the compensating spring 4 at one end pressing it against the anchorage plate, and at the other end leaving a 2 mm gap (J2) max between the spring and nuts 5.

❽ Tighten all the lock nuts.

**Checking the setting (trailer on axle stands):**

❶ Pull the parking lever 2 notches - the wheels cannot turn in a FORWARD direction.
The wheels can turn in REVERSE (adjustment screw 8 switches to the REAR position).

❷ Pull the parking lever fully.
The wheels will not turn either in FORWARD or REVERSE and the cross bar(s) must remain parallel with the axle body.

- ➢ Check the transmission setting after 180 miles (300 km) (running in period) and if necessary adjust the gap (J1) using the tensioner.

**Parking**

- ➢ The lever must be fully pulled up, so that the compensating spring is fully compressed.
- ➢ Every 900 miles (1500 km), check the braking settings and distribution on all the wheels.

**Important**

- ➢ The brake controls are designed to draw trailers behind flexible suspension touring vehicles. If used behind an HGV, be sure to provide the fitted ball joint with a shock absorber to prevent premature wear.
- ➢ During any manoeuvres with the trailer coupled, do not turn more than 90° or force reverse.

- ➢ The specifications of our brake controls are indicated on a manufacturer's plate, and the items on this should be supplied to us when requesting replacement parts, in particular for the shock absorber, of a special type, approved by the Service des Mines to correspond to European standards (it is advisable to have a spare shock absorber to enable instant repairs).

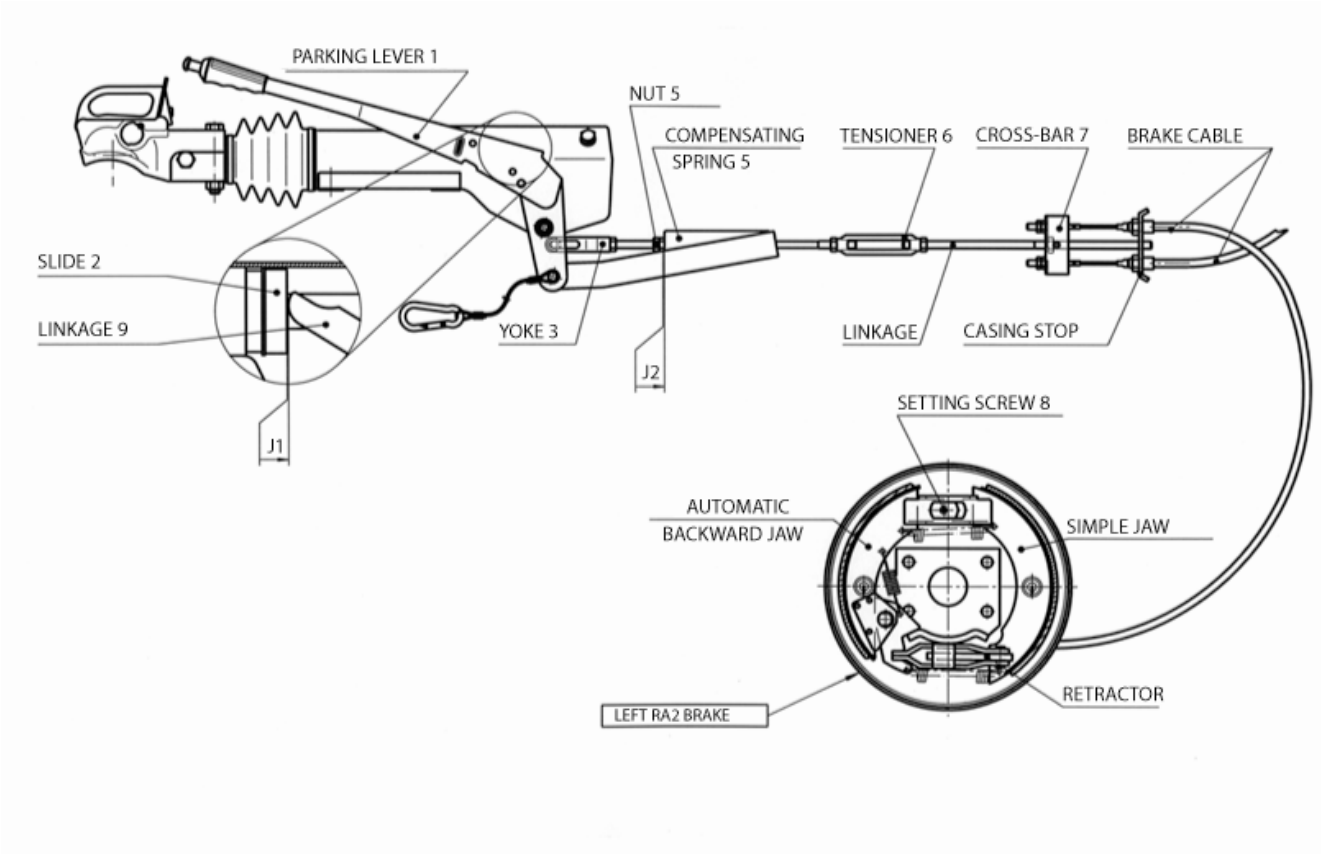



**Figure 4.3**: Braking transmission

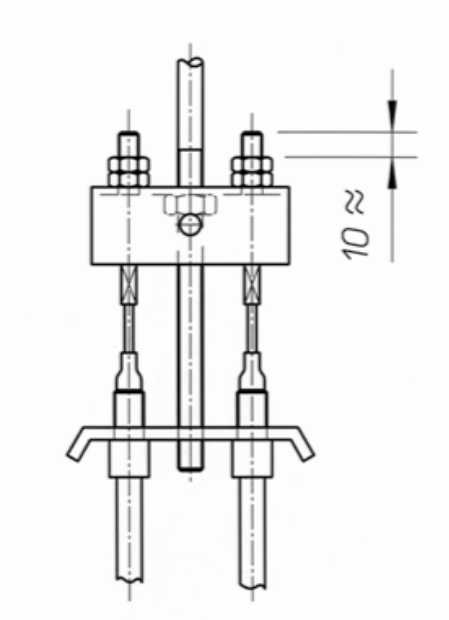



**Figure 4.4**: Cross bar fitting

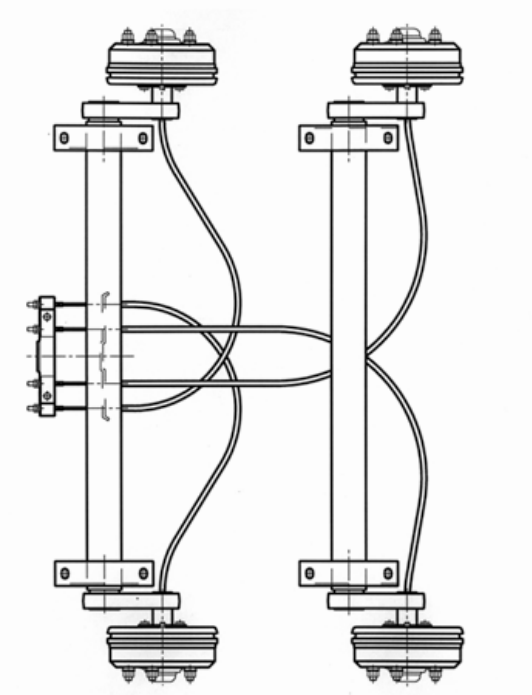


**Figure 4.5**: Tandem bearing fitting

## 4.7. Faults and repairs

| Fault observed | Origin | Solutions |
|---|---|---|
| Erratic braking of trailer | - Faulty shock absorber | Replace the shock absorber |
| Braking too weak | - Jaws worn | Replace the jaws |
| | - Jaws not run in | Fault will disappear only after running in |
| | - Incorrect linkage setting | Adjust the setting |
| | - Significant friction on the slide | Grease the sliding parts |
| | - Slide corrosion | Remove the corrosion and grease |
| | - Coupling height does not match that of the towing vehicle | Adjust the height so that the two parts are in the same horizontal plane |
| Drum temperature abnormally high | - Incorrect linkage setting | Adjust the settings |
| | - Incorrect brake setting | Adjust the settings |
| | - High levels of dust in the drums | Remove the dust |
| | - Jaws, springs, drums damaged | Replace the damaged parts |
| | - Brake cables or link rod damaged | Replace the damaged parts |
| Jerky braking | - Incorrect linkage setting | Adjust the settings |
| | - Interfering parts on the slide | Remove, clean and grease |
| | - Corroded slide | Remove the corrosion and grease |
| | - Damage to slide guide rings | Replace the rings (and possibly the slide) and grease |
| | - Faulty shock absorber | Replace the shock absorber |
| Trailer tending to swerve upon braking | - Cross-bar(s) not balanced | Adjust the cross-bar(s) |
| | - Different brake setting on the two sides | Adjust the brake settings |
| | - Cables damaged or incorrectly fitted | Replace the damaged parts<br>Refit the cables |
| | - Poor load distribution | Check the load distribution |
| When starting the trailer holds back the towing vehicle | - Damage to slide or to guide rings | Replace the faulty parts and grease |
| | - Slide corrosion | Remove the corrosion and grease |
| | - Tie rod damaged | Replace the tie rod and adjust the settings |
| | - Linkage damaged or incorrectly set | Replace the damaged parts and adjust the settings |
| | - Brake on | Loosen the brake |
| Play in the coupling head | - Head worn (see wear indicator) | Replace the head |
| | - Ball joint worn | Replace the ball joint |
| Parking braking too weak | - Compensating spring incorrectly set | Adjust the setting |
| | - Braking system incorrectly set | Adjust the setting |
| | - Notched sector damaged | Replace the sector and adjust the setting |
| | - Lever ratchet worn | Replace the lever and adjust the setting |
| | - Cable ruptured | Replace the cable and adjust the setting |

## 4.8. Electrical connection diagram

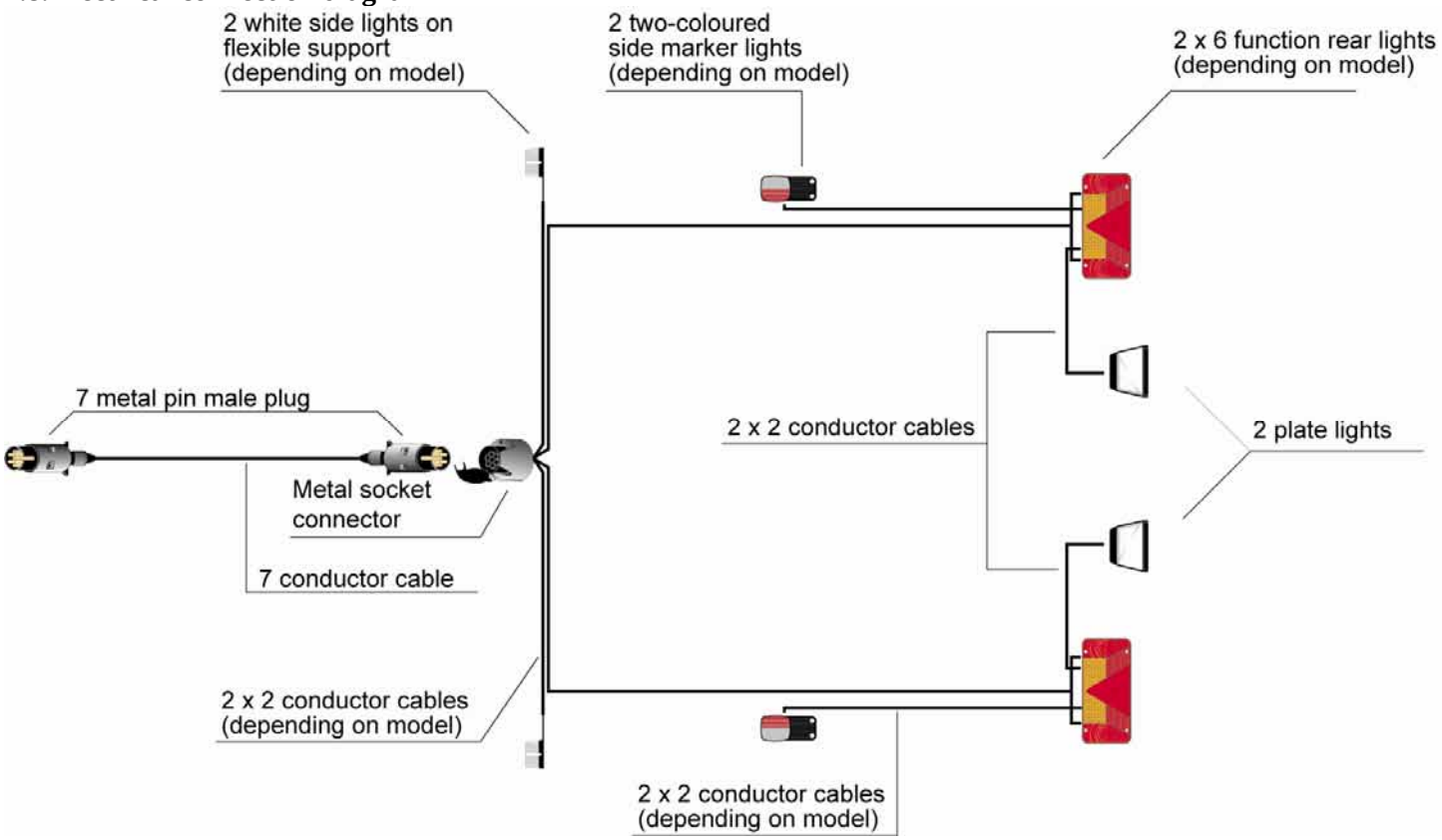



**Figure 4.6** : Electrical connection diagram

## 4.9. Complete wheels technical information

| **TYRES** | | | | | **COMPLETE WHEELS** | |
|---|---|---|---|---|---|---|
| Dimensions | Indices | Diameter (mm) | Cross section (mm) | Radius under load (mm) | Load (Kg) | Pressure (bar) |
| 135 R 13 | | 550 | 134 | 265 | 335 | 2.4 |
| 145 R 13 | 75 T | 566 | 145 | 272 | 387 | 2.4 |
| 155 R 13 | 79 T | 578 | 150 | 277 | 437 | 2.4 |
| 145/70 R 13 | 71 T | 534 | 150 | 259 | 345 | 2.5 |
| 155/70 R 13 | 75 T | 548 | 147 | 263 | 387 | 2.5 |
| 185/70 R 13 | 86 T | 594 | 185 | 285 | 530 | 2.5 |
| 165 R 14 C | 98 N | 622 | 172 | 284 | 650 | 3.8 |
| 155/70 R12 | 100 N | 525 | 155 | 244 | 650<br>800 | 6.25 |
| 185 R 14 C | 102 P | 650 | 188 | 316 | 675<br>850 | 4.5 |
| 195 R 14 C | 106 P | 666 | 198 | 32 | 950 | 4.5 |
| 195/50 x 10 | 98 N | 450 | 190 | - | 750 | 6.0 |

## 5. Preparation before operating the set

| | |
|---|---|
| Danger | The inspections referred to in this section enable the electrical generator set to operate.<br>Specific skills are required to carry out these operations.<br>They must only be entrusted to personnel with the necessary skills.<br>Failure to follow these instructions in any way could result in malfunction or very serious accidents. |

### 5.1. Installation checks

- ✓ check that the general recommendations given in the installation section (ventilation, exhaust, fluids, etc.) are observed.
- ✓ carry out the level checks (oil, water, diesel fuel, battery).
- ✓ check the generating set earth connection is earthed.
- ✓ check that the electrical connections are in order.

### 5.2. Checks after starting the generating set

- ✓ carry out the mechanical checks (oil pressure, water temperature, absence of noise etc.)
- ✓ carry out the electrical checks (voltage and frequency)
- ✓ carry out the safety checks (emergency stop, oil pressure, water temperature etc.)

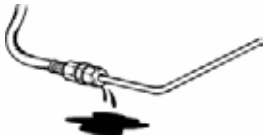
## 6. Using the generating set

### 6.1. Pre-Start Inspection

- **Engine and engine compartment, general check**

Visually check the engine and engine compartment before starting the engine and after stopping the engine.
Check:

- ➢ there are no oil, fuel or coolant leaks,
- ➢ the screws are tightened,
- ➢ the condition of the belts (wear, tension).

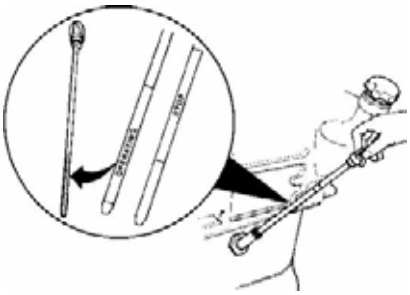


| | |
|---|---|
| Warning | Fuel, oil and grease deposits on the engine or in the engine compartment are always a fire hazard and must be removed as soon as they are noticed. |

| | |
|---|---|
| Important | If there are any oil, fuel or coolant leaks, locate the origin of the fault and repair it immediately before starting the engine. |

| | |
|---|---|
| Important | Never use a high pressure cleaner for cleaning the engine and equipment. |

- **Oil level, check and top up**



- Check the oil level every day before the first start-up.
- Check that it is between the MAX and MIN marks on the oil dipstick.
- If necessary, top up the oil through the filler opening, on the left-hand side of the engine.
  Before checking the level again, wait a few minutes for the oil to drain into the sump.

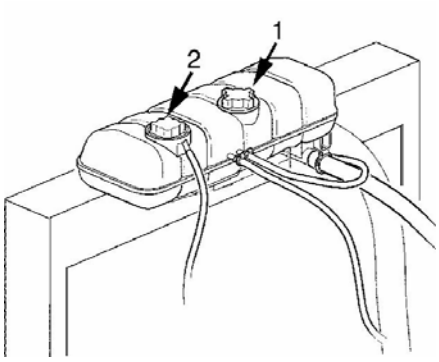
| | |
|---|---|
| Important | Never fill oil past the maximum level.<br>Only use oil of the recommended grade. |

- **Coolant level, check**

| | |
|---|---|
| Warning | Do not open the filler cap when the engine is hot, except in an emergency. Boiling liquid or vapour may be ejected. |

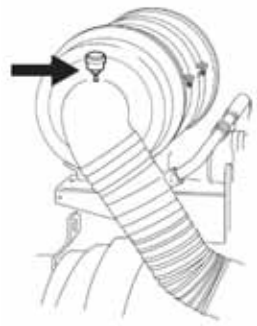
| | |
|---|---|
| Important | The system must be filled up with liquid which has identical proportions to that already contained in the cooling system.<br>Only open the filler cap (1). |

- The coolant level must be between the MIN and MAX marks. Top up the oil if necessary.




- **Checking the air filter clogging indicator**

| | |
|---|---|
| Important | Special air filters must be used for extremely dusty conditions. |



- Replace the filter when the indicator remains in the red zone after the engine has been stopped.
- Reset the indicator after the filter has been replaced by pressing the button.

## 6.2. Generator set with TELYS control panel

### 6.2.1 Control panel presentation

#### 6.2.1.1. View of the front panel

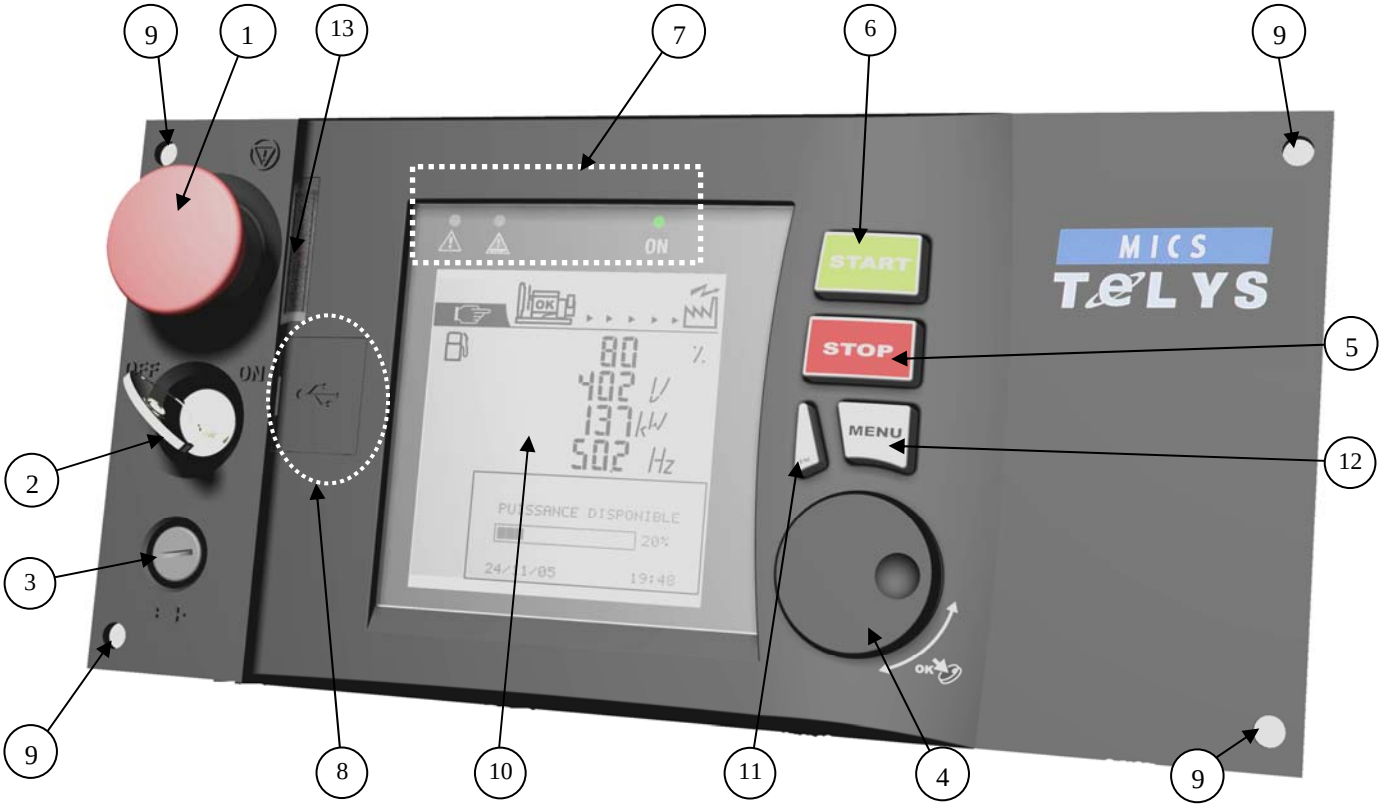



Fig. 6.1 - View of the front panel

**1** Emergency stop button (AU) for switching off the generating set in the event of a fault which could endanger personnel or damage equipment.
**2** Key switch for switching the module on/off.
**3** Electronic board protection fuse.
**4** Scrolling and selection wheel for scrolling through the menus and screens and selecting items simply by pressing the wheel.
**5** STOP button, press to switch off the generating set.
**6** START button, press to switch on the generating set.
**7** Power ON LEDs and alarm/fault warning LEDs.
**8** Location of USB ports.
**9** Mounting bolt.
**10** LCD for displaying alarms and faults, operating statuses, electrical and mechanical quantities.
**11** ESC button: for returning to the previous selection and for default RESET function.
**12** MENU button for accessing the menus.
**13** Lighting for the emergency stop button.


Fig. 6.2 – Description of the LEDs

A lit LED indicates:

**1** Alarm activated (flashing yellow).
**2** Fault found (flashing red).
**3** Module on (green, on continuously).

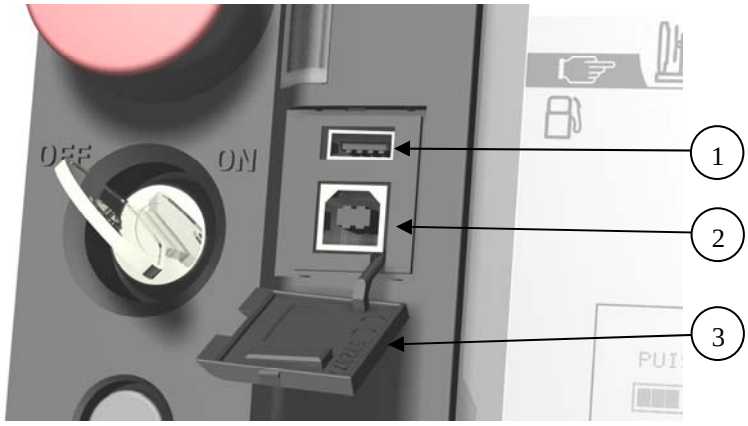



Fig. 6.3 – Close-up of USB ports

**1** USB key connection (HOST): file transfer between USB key and TELYS and vice versa.
**2** Connection for microcomputer (DEVICE):
- file transfer between PC and TELYS and vice versa,
- main module power supply.

**3** Protective cover.

### 6.2.1.2. Description of the screen

The screen is backlit and requires no contrast adjustments. This screen is divided into 4 zones.

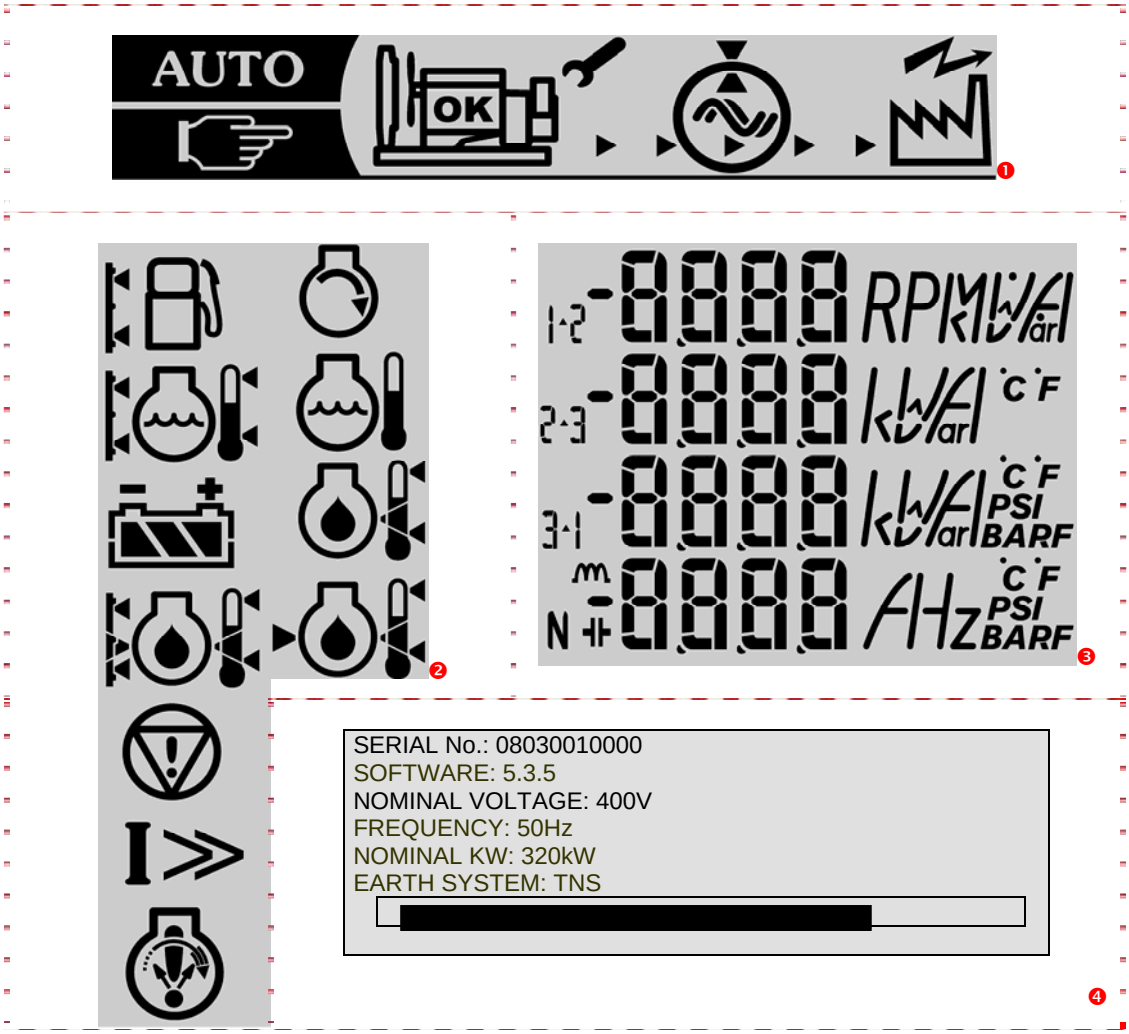



Fig. 6.4 – description of the screen (example)

❶ Zone 1: in this zone, the status of the generating set is displayed

❷ Zone 2: in this zone, pictograms relating to dimensions measured are displayed, as well as Alarm and Fault pictograms

❸ Zone 3: in this zone, the measured values corresponding to the measured dimensions are displayed with the corresponding units of measurement

❹ Zone 4: in this zone, messages relating to the control of the generating set and the menus are displayed.

Note: the information displayed on measurements, alarms and faults as well as messages and menus relating to control of the generating set will depend on the equipment level of each generating set. Certain screens may therefore not be present.

### 6.2.1.3. Description of the pictograms in zone 1

Pictograms in zone 1

| Pictograms | Display | Activation conditions |
|---|---|---|
|  "MANU" Mode | Fixed | TELYS in manual mode (MANU) |
| | Flashing | For 5 seconds when switching from AUTO mode to MANU mode |
|  "AUTO" Mode | Fixed | TELYS in automatic mode (AUTO) |
| | Flashing | For 5 seconds when switching from MANU mode to AUTO mode |
|  | Flashing | Generating set in start-up phase |
| | Fixed | Generating set started |
|  | Fixed | Generating set stabilised (voltage and frequency) |
|  | Flashing (appearance of constant movement from left to right) | The generating set is powering the installation |
|  | Fixed | The installation is supplied |
|  | Not used | |
|  | Not used | |

### 6.2.1.4. Description of the pictograms in zone 2

Alarm and fault pictograms in zone 2

All the pictograms in this zone are activated when TELYS is initialised.

| Data displayed | | | |
|---|---|---|---|
| Fuel level indicator | | | |
| Alarm / Fault low fuel level  | | Alarm / Fault high fuel level  | |
| Coolant level / temperature indicator | | | |
| Alarm Low level fault  | High level fault alarm  | Alarm High temperature fault  | No preheating fault alarm  |
| Battery | | | |
| Min battery voltage (flashing)  | Max battery voltage (flashing)  |  | Battery charge indicator (flashing bars) |
| Oil pressure / temperature indicator | | | |
| Oil pressure Alarm / Fault  | High or low oil level Alarm / Fault  | High or low oil temperature Alarm / Fault  | |
| Emergency stop | | | |
| Emergency stop fault  | | | |
| Overload or short circuit | | | |
| Tripping of circuit breaker following an overload or short circuit  | | | |
| Engine speed | | | |
| Underspeed fault  | Overspeed fault  | Non-starting fault  | |

### 6.2.1.5. Description of the pictograms in zone 3

Pictograms in zone 3

All the pictograms in these zones are activated when TELYS is initialised. The pictograms below are given as examples.

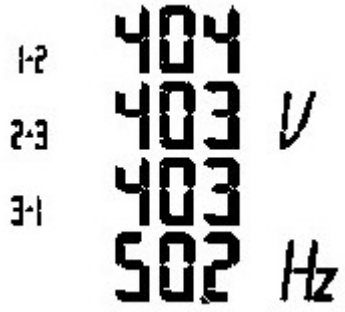
***Generating set stopped***

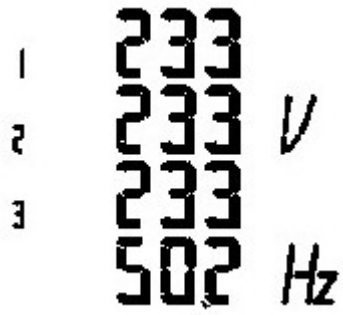
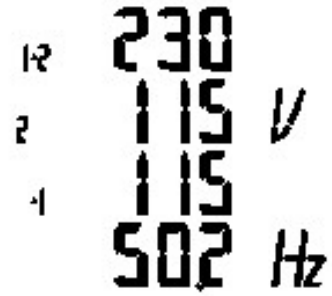
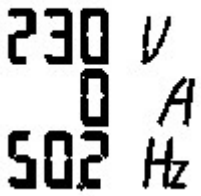
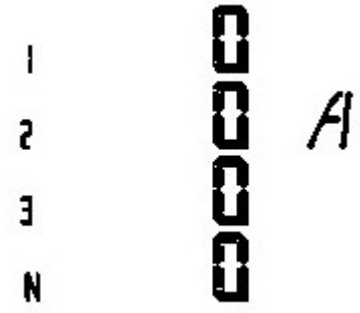
| Screen no. | Pictograms | Data displayed |
|---|---|---|
| P1 |  | Fuel Level Indicator<br><br>Indication of Temperature of High Temperature coolant (HT) (units according to settings menu)<br><br>Indication of Battery Voltage<br><br>Indication of Oil Temperature (units according to settings menu) |

***Generating set start-up or generating set started or generating set switching off in progress***

| Screen no. | Pictograms | Data displayed |
|---|---|---|
| P2 |  | Engine Speed Indication<br><br>Indication of Temperature of High Temperature coolant (units according to settings menu)<br><br>Indication of Oil Pressure (units according to settings)<br><br>Indication of Oil Temperature (units according to settings menu) |

***Generating set started***

| Screen no. | Pictograms | Data displayed |
|---|---|---|
| P3 Default screen in operation |  | Fuel Level Indicator<br><br>Alternator composite Voltage Indicator<br><br>Total Active Power Indicator<br><br>Alternator Frequency Indicator |
| P4 |  | U12 Alternator composite Voltage Indicator<br><br>U23 Alternator composite Voltage Indicator<br><br>U31 Alternator composite Voltage Indicator<br><br>Alternator Frequency Indicator |

| Screen no. | Pictograms | Data displayed |
|---|---|---|
| P5 |  | V1 Alternator single Voltage Indicator<br>V2 Alternator single Voltage Indicator<br>V3 Alternator single Voltage Indicator<br>Alternator Frequency Indicator |
| P6 |  | U12 Alternator composite Voltage Indicator<br>V2 Alternator single Voltage Indicator<br>V1 Alternator single Voltage Indicator<br>Alternator Frequency Indicator |
| P7 |  | V1 Alternator single Voltage Indicator<br>Single phase Alternator current indicator<br>Alternator Frequency Indicator |
| P8 |  | Single phase Alternator current indicator<br>Two phase Alternator current indicator<br>Three phase Alternator current indicator<br>Neutral Alternator current indicator |
| P9 |  | Total Active Power Indicator<br>Total Reactive Power Indicator<br>Total Effective Power Indicator<br>Total Power Factor Indicator (lagging or leading) |

| Screen no. | Pictograms | Data displayed |
|---|---|---|
| P10 |  | Fuel Level Indicator<br>Indication of Battery Voltage<br>Indication of Battery Amps |

Screen order of appearance according to network type with the generating set on.

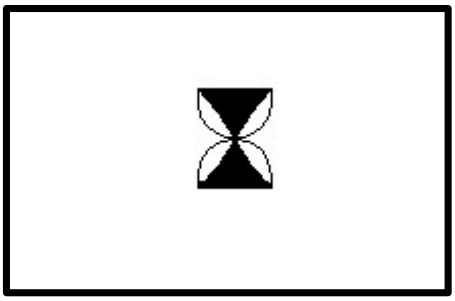
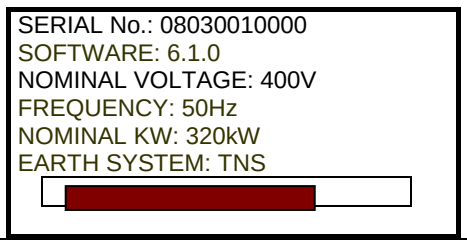
| | Type of network | | | |
|---|---|---|---|---|
| **Order of appearance** | **3P+N** | **3P** | **2P+N** | **1P+N** |
| 1 | P3 | P3 | P3 | P3 |
| 2 | P4 | P4 | P6 | P7 |
| 3 | P5 | P8 | P8 | P9 |
| 4 | P8 | P9 | P9 | P2 |
| 5 | P9 | P2 | P2 | P10 |
| 6 | P2 | P10 | P10 | |
| 7 | P10 | | | |

Change screens by using the scrolling and selection wheel.
When the wheel is rotated clockwise, the screens scroll upwards and vice-versa.
The screens scroll in a loop.
E.g.: On three-phase + neutral network, then screen 7, then screen 1 and vice-versa.

### 6.2.1.6. Display of messages in zone 4

The display (zone 4), among other things, displays messages relating to the operation of the generating set. The messages are as follows:

Initialisation of TELYS

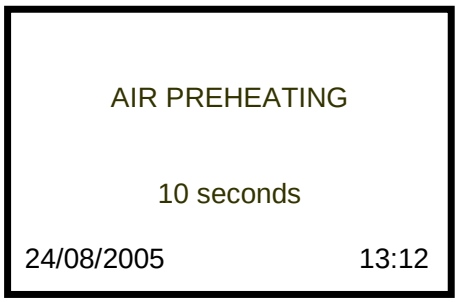
| Screen no. | Screen | Data displayed |
|---|---|---|
| G 1 |  | Initialisation of TELYS when the power is switched on and/or when loading a configuration |
| G 2 |  | Generating set serial no.<br>Software version of TELYS<br>Alternator Nominal Voltage<br>Alternator Nominal Frequency<br>Nominal Active Output<br>Neutral Point<br>Bar graph indicating the display delay of the screen |

Generating set stopped

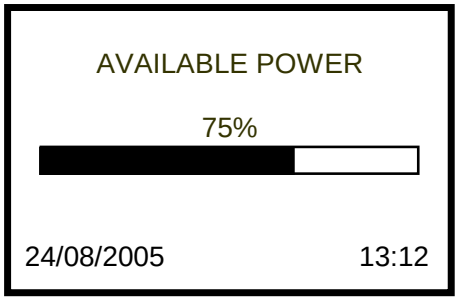
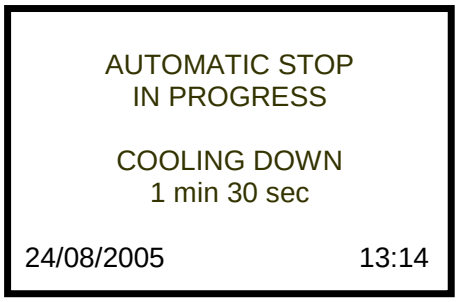
| Screen no. | Screen | Data displayed |
|---|---|---|
| G 3 | OPERATION<br>MANUAL<br><br>Press START<br>to start<br><br>24/08/2005 13:12 | Operating mode - generating set in Manual Mode ready to start<br>Date and time (depending on settings) |
| G 4 | OPERATION<br>AUTO<br><br>WARNING<br>START-UP POSSIBLE<br>IMMEDIATELY<br><br>24/08/2005 13:12 | Operating mode - generating set in Auto Mode ready to start<br>Date and time (depending on settings) |
| G 5 | WARNING<br><br>AUTOMATIC Start<br>19 min 30 sec<br><br>24/08/2005 13:12 | Operating mode - generating set in Auto Mode with programmed start<br>Countdown to micro disconnection delay or EJP notice delay (for France only)<br>Date and time (depending on settings) |

Generating set start-up

| Screen no. | Screen | Data displayed |
|---|---|---|
| G 6 | START-UP<br>IN PROGRESS<br><br>24/08/2005 13:12 | Operating phase - generating set in starting phase<br>Date and time (depending on settings) |

| Screen no. | Screen | Data displayed |
|---|---|---|
| G 7 |  | Operating phase - air preheating prior to starting generating set<br>Countdown for air preheating delay<br>Date and time (depending on settings) |

Generating set started

| Screen no. | Screen | Data displayed |
|---|---|---|
| G 8<br>Default screen |  | Operating phase – generating set in operation – stable voltage and frequency<br>Available power<br>Date and time (depending on settings) |
| G 9 |  | Operating mode - operation in Auto Mode<br>Opening of power supply device (motorised circuit breaker or source changeover switch controlled by TELYS)<br>Countdown for the mains return delay OR the load test delay<br>Date and time (depending on settings) |
| G 10 |  | Operating mode - operation in Auto Mode<br>Generation set cooling in progress<br>Countdown for Engine Stop delay (cooling) OR Gradual Stop delay (Coolant temperature) OR Overload Gradual Stop delay OR OFF load test delay<br>Date and time (depending on settings) |

Generating setstop

| Screen no. | Screen | Data displayed |
|---|---|---|
| G 11 | OFF<br>IN PROGRESS<br><br>24/08/2005 13:16 | Generating set stop in progress<br>Date and time (depending on settings) |

Operating mode changeover (switching from Manual Mode to Auto Mode following auto start demand)

| Screen no. | Screen | Data displayed |
|---|---|---|
| G 12 | Start Demand<br>AUTO<br>Do you wish to change<br>to Auto Mode?<br>WARNING<br>Immediate start<br><br>OK Esc | Operating mode - operation in Manual Mode<br>AUTOMATIC start demand |

Generating set stop request due to fault or by pressing STOP in Auto Mode

| Screen no. | Screen | Data displayed |
|---|---|---|
| G 13 | Manual Mode<br>activated<br><br>Do you wish to change<br>to AUTO mode?<br><br>OK Esc | Operating mode - operation in Auto Mode<br>(generating set in operation)<br>Warning message for switching to Manual Mode<br>after the STOP button has been pressed or a fault<br>has appeared |

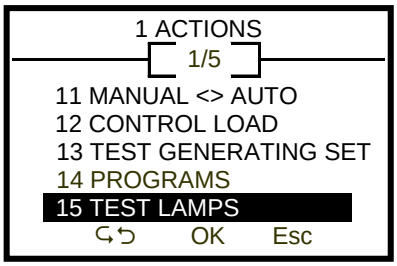
### 6.2.2 Starting

| | |
|---|---|
| Danger | Check that the generating set circuit breaker has triggered. |

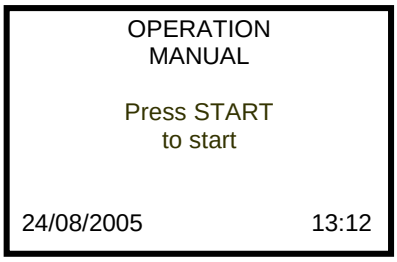
❶ Connect the generating set battery

❷ Turn the key switch to the ON position (without forcing it to the ON position), the ON lamp will light up (if the lamp does not light up, check and replace the fuse if necessary)

❸ Test the Alarm and Fault LEDs (menu 15 – TEST LAMPS)

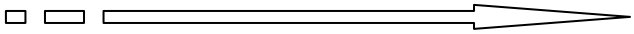


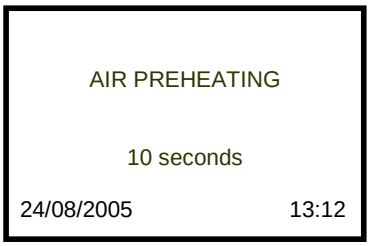

❹ Press "Esc" several times to return to the following home menu



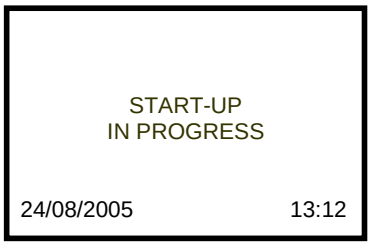

❺ Check the battery voltage 

❻ Press START:



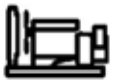


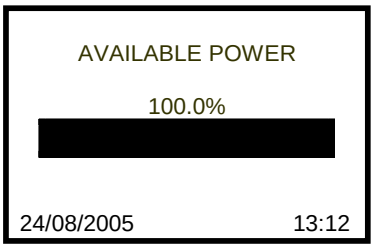

- If the engine is equipped with an air preheating system, there is a delay (adjustable) before the engine starts (preheating activation period).
- If the motor is not fitted with an air preheating system or once the preheating delay has elapsed, the engine starts up (start of a cycle comprising 3 attempts to start up the engine).




Warning: the number of successive and automatic starting attempts is limited to 3.

The following pictogram will flash






The following pictogram is displayed


The following information is displayed

| | | |
|---|---|---|
| | Speed of rotation | |
| | Coolant temperature | Options |
| | Oil pressure | |
| | Oil Temperature | |

### 6.2.3 Switching off

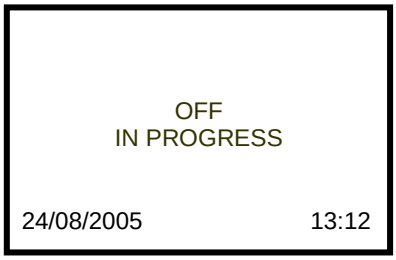
❶ Open the circuit breaker

- manually OR
- by selecting menu 12 "CONTROL LOAD"

The following display will disappear (supply stopped) 

❷ Press the STOP button

❸ The following screen is displayed and the generating set will stop




❹ Switch TELYS off by turning the key to "OFF" (without forcing it to the "OFF" position).

### 6.2.4 Alarms and faults

#### 6.2.4.1. Viewing alarms and faults

Alarms and faults are displayed as follows:

① Alarms

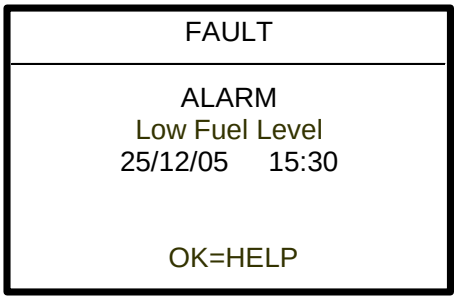
All alarms will cause:

- the yellow LED to flash "General alarm". 

In conjunction with this LED:

- a flashing pictogram appears on the LCD screen representing the circuit affected by the alarm and the associated indicator, if present (example)

- message on graphic display (example)



② Faults

All faults will cause:

- **the generating set to stop: immediate or gradual stop (coolant temperature and overload or short circuit)**
- the red LED to flash "General fault".


In conjunction with this LED:

- a flashing pictogram appears on the LCD screen representing the circuit affected by the fault and the associated indicator, if present (example)

- message on graphic display (example)

| FAULT |
|---|
| FAULT<br>Oil Pressure<br>25/12/05 15:30<br><br>OK=HELP |

Faults have priority over alarms. Faults are displayed in the descending order of their appearance (from the most recent to the oldest).

### 6.2.4.2. Activation of an alarm or fault

The appearance of an alarm **or** a fault causes the corresponding screen to be displayed (examples below)

| FAULT |
|---|
| ALARM<br>Low coolant Level<br>06/10/06 10:30<br><br>OK=HELP |

| FAULT |
|---|
| FAULT<br>Emergency Stop<br>06/10/06 15:30<br><br>Esc=RESET OK=HELP |

Press OK (on the scrolling and selection wheel) to access the help message if it is available (example below)

| HELP |
|---|
| Check the level<br>fuel<br><br>Esc=EXIT |

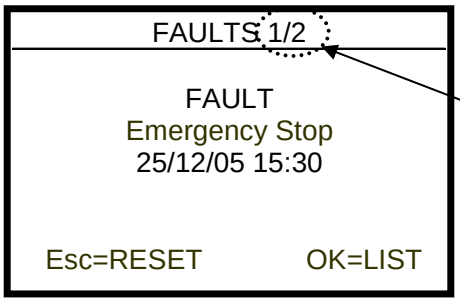
If the alarm is no longer active, it is reset automatically (cause disappears).
Press Esc to reset a fault:

- reset acknowledged if the cause of the fault has been removed
- reset not performed if the cause of the fault is still present.

### 6.2.4.3. Activation of an alarm and a fault

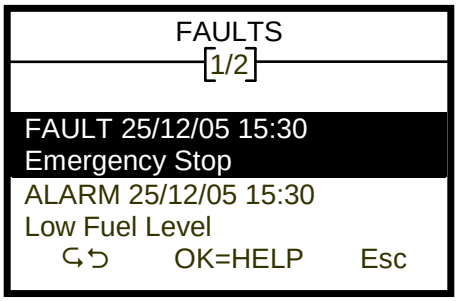
The appearance of an alarm **and** a fault causes:

- The yellow and red LEDs to flash
- the related screen to be displayed (example below)

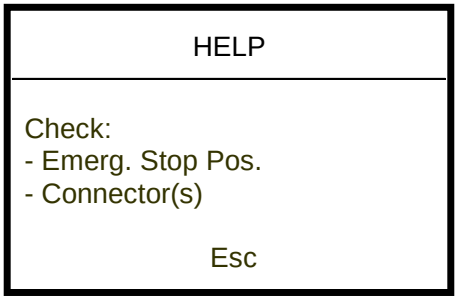



If several faults are present, the number of faults is displayed at the top of the screen.

The faults list can be accessed by pressing OK (of the scrolling and selection wheel) (examples below)




Press Esc to return to the previous screen.
Press OK to go to the HELP screen (help on the highlighted fault)
Use the scrolling and selection wheel to scroll through the list of faults.




If the alarm is no longer active, it is reset automatically (cause disappears).
Press Esc to reset a fault:

- reset acknowledged if the cause of the fault has been removed
- reset not performed if the cause of the fault is still present.

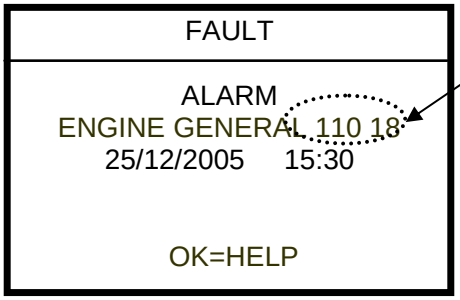
### 6.2.4.4. Engine fault codes display

Certain alarms and engine faults generate specific fault codes. These codes are standardised according to the J1939 and/or J1587 standards, except for MTU engines that have a specific transmission protocol (see appendix, if applicable).

| | |
|---|---|
| **Terminology used by the SAE CAN J1939 standard** | |
| SPN: Suspect Parameter Number | This represents the system or component at fault, for example: SPN 100, indicates an oil pressure problem or a problem with the oil pressure sensor. |
| FMI: Failure Mode identifier | This represents the type of fault that has occurred. This may be an electrical, mechanical or equipment fault. |
| **Terminology used by VOLVO** | |
| SID: System Identifier | This term, used in the J1587 standard, has an equivalent in the J1939 standard (SPN).<br>However, this term corresponds, more particularly, to an assembly of components, for example, the injection system. |
| PID: Parameter Identifier | This term, used in the J1587 standard, has an equivalent in the J1939 standard (SPN).<br>However, this term corresponds, more particularly, to a specific component, for example, a sensor. |
| PPID: Parameter Identifier | This term, used in the J1587 standard, has an equivalent in the J1939 standard (SPN).<br>PPID corresponds to PID, but is only used by VOLVO. |
| FMI: Failure Mode identifier | This represents the type of fault that has occurred. This may be an electrical, mechanical or equipment fault. VOLVO uses a SID-FMI or PID-FMI or PPID-FMI combination. |
| **Terminology used by PERKINS** | |
| CID: Component parameter | This term used by PERKINS has an equivalent in the J1939 standard (SPN). |
| FMI: Failure Mode identifier | This represents the type of fault that has occurred. This may be an electrical, mechanical or equipment fault. |
| **Terminology used by JOHN DEERE** | |
| SPN: Suspect Parameter Number | This represents the system or component at fault, for example: SPN 100, indicates an oil pressure problem or a problem with the oil pressure sensor. |
| FMI: Failure Mode identifier | This represents the type of fault that has occurred. This may be an electrical, mechanical or equipment fault. |

| Terminology used by MTU | |
|---|---|
| Displaying faults | The ADEC and MDEC general system faults are indicated on the equipment in the following way: fault code numbers (generated by the ECU - Engine control unit). |

In the event of a fault, the screen will display the following message:




Engine fault code.
Pressing OK will display fault finding information.
In addition, appendix A and B indicate the meaning of the code. The checking and maintenance operations to carry out in order to solve the fault are included in the user and maintenance manuals of the engines supplied with the generating set documentation.

For JOHN DEERE (JD), PERKINS (PE) and VOLVO (VO) engines, the codes displayed are SPN and FMI codes.

### 6.2.4.5. Horn reset

Depending on the settings made (menu 363 - HORN), the activation of an alarm and/or a fault leads to the horn sounding and the following screen appearing:


This screen will display first any messages relating to the alarms and faults that appear as soon as OK is pressed.

## 6.3. Generator set with KERYS control panel

### 6.3.1 Presentation of the KERYS

The MICS Kerys system consists of a set of electronic modules in which each module performs a specific function..
These modules are interconnected according to a very precise architecture and exchange data to allow the following: the command, control, regulation and protection of one or more generating sets according to multiple configurations.
The configurations range from the so-called “solo” generating set, with or without source inverter, to generating sets coupled to each other, enabling electrical power plants to be created that can be coupled to one or more distribution grids in low voltage (LV) and medium voltage (MV).

The MICS Kerys system consists of the following modules:

- man/machine interface module, also called MMI module,
- base module (heart of the system),
- regulation module,
- protection module,
- logic input/output module,
- analogue input/output module,
- temperature input module.

For the operation of a generating set in the smallest possible architecture, at least the following elements will be found:

- a man/machine interface module,
- a base module,
- a regulation module.

#### 6.3.1.1. Operating conditions

| | |
|---|---|
| ✓ Operating temperatures: | - 20 °C ⇔ + 70 °C |
| ✓ Storage temperatures: | - 20 °C ⇔ + 70 °C |
| ✓ Relative humidity during operation: | 10 % to 95 % without condensation<br>according to IEC 1131-2 and equivalent UL/CSA |
| ✓ Relative humidity during storage: | 5 % to 95% without condensation<br>according to IEC 1131-2 and equivalent UL/CSA |
| ✓ Height: | 2,000 m during operation (Transfer 3,000 m) |
| ✓ Degree of protection: | - Outside cabinet: IP54 (front of MMI modules).<br>- Inside cabinet: IP20 (BASE, ESTOR, ESANA, ETEMP, back of the MMI). |
| ✓ Mechanical strength: | Free falls (with packing), 5 random falls of:<br>1 m if p< 10 kg<br>0.5 m from 10 to 40 kg<br>0.25 m >40 kg |

### 6.3.1.2. Conformity to legal and regulatory requirements

The various components of the system comply with the following standards:

- ✓ Requirements specific to programmable controllers:
  (Functional characteristics, immunity, robustness, safety, etc.)
  ⇨ EN 61131-1/2/3 (IEC 1131-2, IEC 664), EN61326,
  ⇨ CSA 22-2,
  ⇨ UL508.

- ✓ Compliance with European directives (low voltage, electromagnetic compatibility, machinery). **CE marking** in application of the safety requirements of standard EN 61131-2 – Programmable controllers, Part 2 – Equipment requirements and tests. To obtain the specific information prescribed by EN 61131-2, refer to the appropriate sections of that publication.

- ✓ Electrical and self-extinguishability properties of insulating materials:
  ⇨ UL 746C,
  ⇨ UL 94.

- ✓ Pollution degree: 2

- ✓ Mechanical strength (details):
  Vibration resistance: EN 61131-2 1994 (§2.1.3.2),
  Frequency range: 10 - 57 Hz,
  Continuous vibrations: 0.0375mm amplitude,
  Occasional vibrations: 0.075mm amplitude.

  Frequency range: 57Hz - 150Hz,
  Continuous: 0.5 g constant acceleration,
  Occasional: 1 g constant acceleration.
  Complies with standard IEC 68-2-6, test Fc

  Shock resistance
  Occasional shocks: 15g, 11ms, semi-sinus.
  Complies with standard IEC 68-2-27, test Fa

- ✓ Emissions: Complies with standard EN55022 class A

- ✓ Variation in supply voltage: EN61131-2 §6.3.7.3

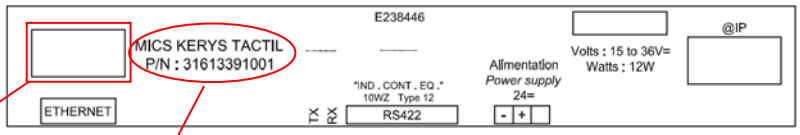
- ✓ Immunity:

| | |
|---|---|
| Complies with standard IEC 61000-4-2: | Electrostatic discharge: 4 kV for contact discharge, 8 kV for air discharge. |
| Complies with standard IEC 61000-4-3 | Radiated field at 10V/m from 80MHz to 1GHz with sinusoidal modulation AM 1kHz. |
| Complies with standard IEC 61000-4-4: | Rapid transients in waves of 2 kV on power cables, 1 Kv on signal cables. |
| Complies with standard IEC 61000-4-5: | Shock waves of 2 kV between wires and ground, 11 kV between wires for the supplies and 1kV relative to ground for long signal circuits (lines from a building or from a distance of over 30 m). |
| Complies with standard IEC 61000-4-6: | Immunity to current injected at 3V from 150 kHz to 80 MHz (could be increased to 10V). |
| Complies with standard IEC 61000-4-8: | Immunity to the magnetic field at the grid frequency at 30 A/m. |

## 6.3.2 Description of the KERYS

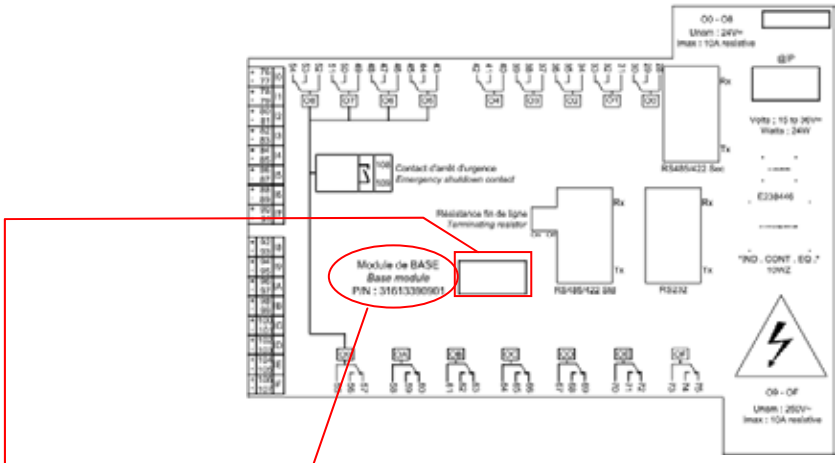
### 6.3.2.1. Identification of the hardware components

**KERYS Tactil MMI module**




| MMI Module | |
|---|---|
| **P/N: 31613391001** | Module item reference |
| **D346000/B1** | **D346000**: manufacturer product reference<br>**B1**: module hardware upgrade index |
| **S/N: 1800** | **1800**: serial number “not related” with a batch number<br>(1800 = the 1800$^{th}$ module manufactured since the start) |
| **BATCH No.: 08/06** | **08**: year of manufacture (year 2008)<br>**06**: week of manufacture (week 6) |

**Base module**

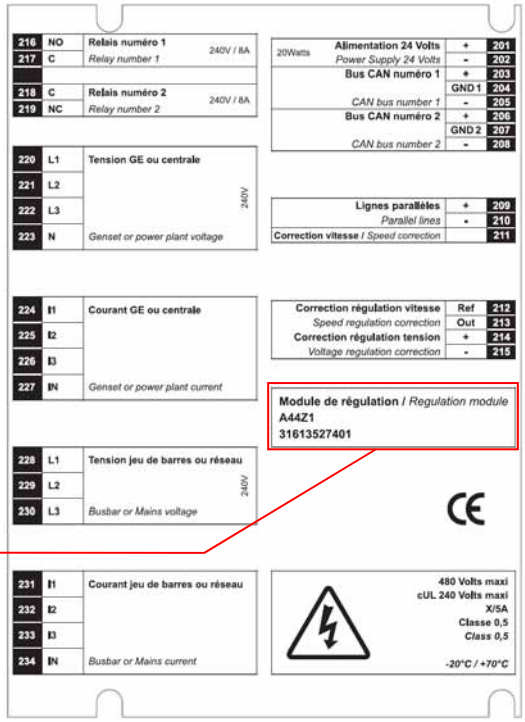



| Base module | |
|---|---|
| **P/N: 31613390901** | Module item reference |
| **D338000/B8** | **D338000**: manufacturer product reference<br>**B8**: Module hardware upgrade index |
| **S/N: 3491** | **3491**: serial number “not related” with a batch number<br>(3491 = the 3491$^{st}$ module manufactured since the start) |
| **BATCH No.: 07/45** | **07**: year of manufacture (year 2007)<br>**45**: week of manufacture (week 45) |

## Regulation module

| Regulation module | |
|---|---|
| **31613391501** | Module item reference |
| **A44Z1-G** | **A44Z1**: manufacturer product reference<br>**G**: “main” module hardware upgrade index |
| **0408A519** | **04**: week of manufacture (week 4)<br>**08**: year of manufacture (year 2008)<br>**A**: “secondary” module hardware upgrade index<br>**519**: serial number “related” with a batch number (*)<br>(519 = the 519th module manufactured in week 04 of the year 2008) |

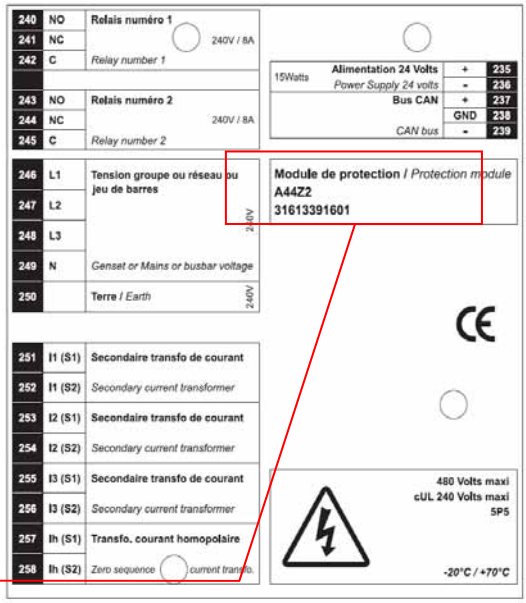
(*) i.e. a maximum of 999 modules that can be related with a batch number.




## Protection module

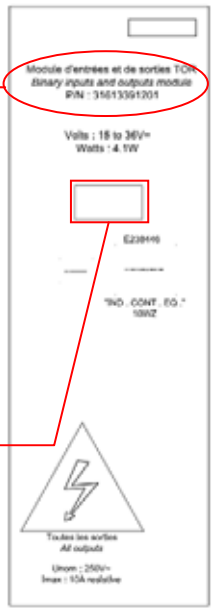
| Protection module | |
|---|---|
| **31613391601** | Module item reference |
| **A44Z2-E** | **A44Z2**: manufacturer product reference<br>**E** : “main” module hardware upgrade index |
| **4307A035** | **43**: week of manufacture (week 43)<br>**07**: year of manufacture (year 2007)<br>**A**: “secondary” module hardware upgrade index<br>**035**: serial number “related” with a batch number (*)<br>(035 = the 35th module manufactured in week 04 of the year 2008) |

(*) i.e. a maximum of 999 modules that can be related with a batch number.



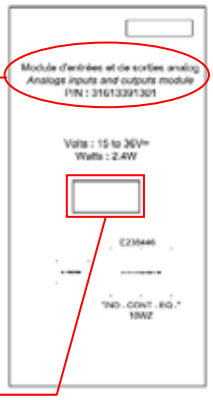
## Logical inputs and outputs module

| Logical inputs and outputs module (ESTOR – Binary inputs and outputs) | |
|---|---|
| **P/N : 31613391201** | Module item reference |
| **D341000/B1** | **D341000**: manufacturer product reference<br>**B1**: module hardware upgrade index |
| **S/N: 0250** | **0250**: serial number “not related” with a batch number<br>(0250 = le 250th module manufactured since the start) |
| **Batch No.: 06/49** | **06**: year of manufacture (year 2006)<br>**49**: week of manufacture (week 49) |



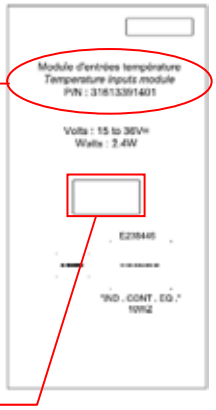
## Analogue inputs and outputs module

| Analogue inputs and outputs module (ESANA) | |
|---|---|
| **P/N: 31613391301** | Module item reference |
| **D343000/B1** | **D343000**: Manufacturer product reference<br>**B1**: module hardware upgrade index |
| **S/N: 0200** | **0200**: serial number “not related” with a batch number<br>(0200 = the 200th module manufactured since the start) |
| **BATCH No.: 06/49** | **06**: year of manufacture (year 2006)<br>**49**: week of manufacture (week 49) |



## Temperature inputs module

| Temperature inputs module (ETEMP) | |
|---|---|
| **P/N: 31613391401** | Module item reference |
| **D344000/B1** | **D344000**: manufacturer product reference<br>**B1**: module hardware upgrade index |
| **S/N: 0150** | **0150**: serial number “not related” with a batch number<br>(0150 = the 150th module manufactured since the start) |
| **BATCH No.: 06/49** | **06**: year of manufacture (year 2006)<br>**49**: week of manufacture (week 49) |



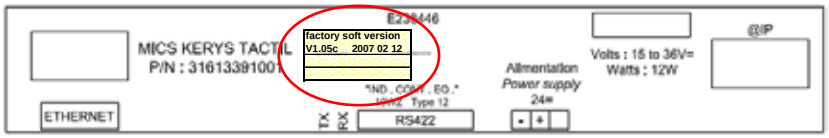
### 6.3.2.2. Identification of the software components

Only the components base module, MMI module, regulation module and protection module have embedded software.
”Software version” is referred to in order to identify a program implemented in one of the components.

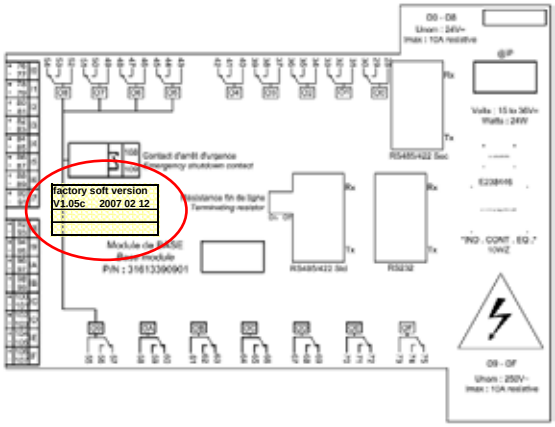
| | |
|---|---|
| **V1.05c1** | **V**: as software version<br>**1.05** : is the revision, which is a combination of 3 digits<br>**c** : main revision index<br>**1** : secondary revision index used for specific projects |
| **2007_02_12** | Date of software version in English (year, month, day). |

| | |
|---|---|
| For a modification of a software version during the life of one of the products (developments, corrections, etc.), the new software version implemented will be entered by hand in a space reserved for this. The old software version will then be deleted. | **factory soft version**<br>**V1.05c 2007 02 12** |

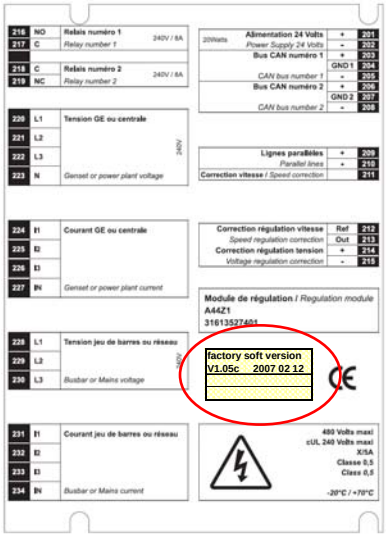
**Location of the version labels**



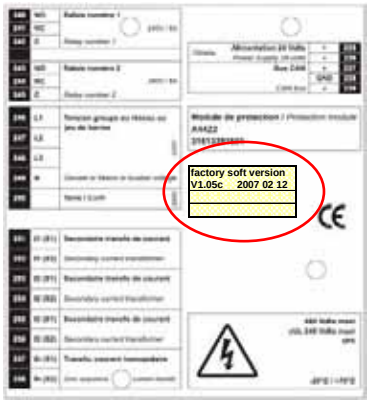

MMI




Base module



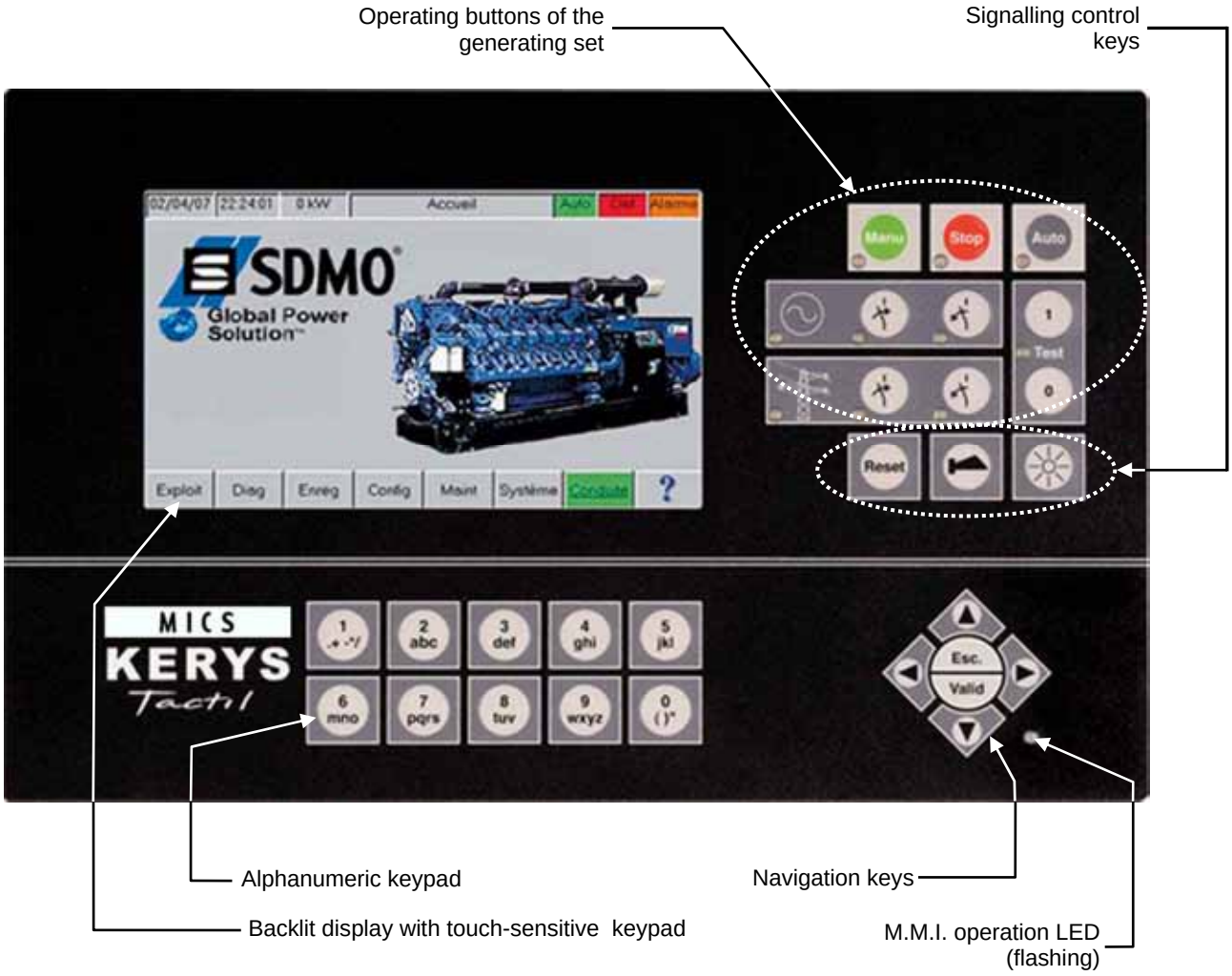

Regulation module




Protection module

### 6.3.3 Description of the Man Machine Interface (IHM/MMI)

#### 6.3.3.1. The Man Machine Interface

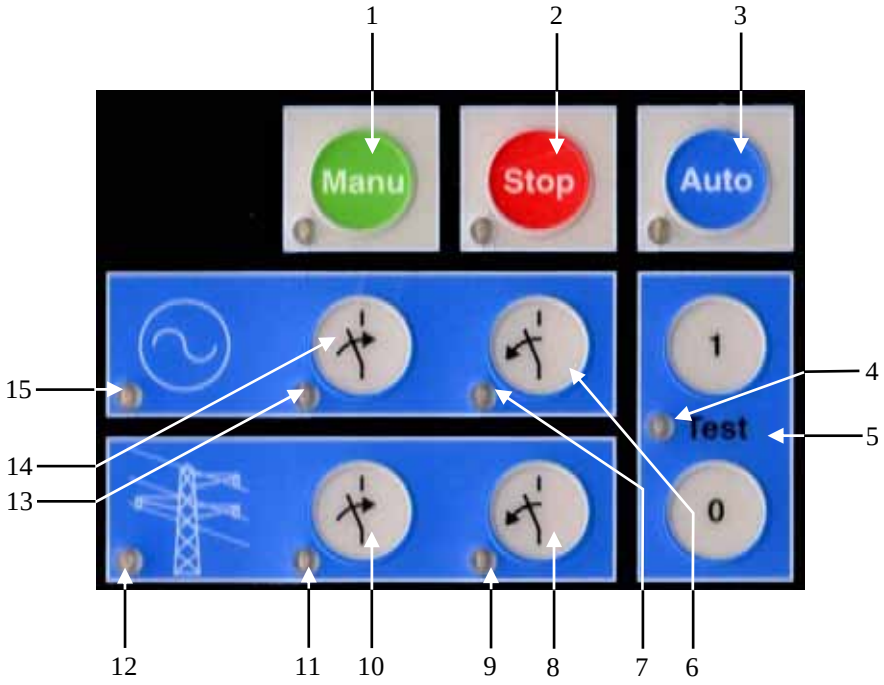



**Display**

The display has the following specifications:

- 7-inch colour TFT display, 16/9, 65536 colours
- dimensions: 154 mm x 86 mm
- neon backlighting
- 480 x 234 resolution
- touch panel (8 columns x 8 rows).

## The generating set operational keys




1 Manual mode selection. The illuminated led indicates that the mode is active
2 Selecting stop mode. The illuminated led indicates that the mode is active
3 Automatic mode selection. The illuminated led indicates that the mode is active
4 Test in progress LED.
5 In auto mode: test sequence control (off load test / load test) (*)
In manual mode: engine start-up and stop
6 Generating set circuit breaker opening control
7 Led indicating that generating set circuit breaker is open
8 Grid circuit breaker opening control
9 Led indicating that grid circuit breaker is open
10 Grid circuit breaker closing control
11 Led indicating that grid circuit breaker is closed
12 Led indicating the presence of grid voltage
13 Led indicating that grid circuit breaker is closed
14 Closing control for generating set circuit breaker
15 Led indicating the presence of generating set voltage

(*) The test request brings up a screen which offers a choice between “load test” and “off load test”.

## The signalling control keys

The 

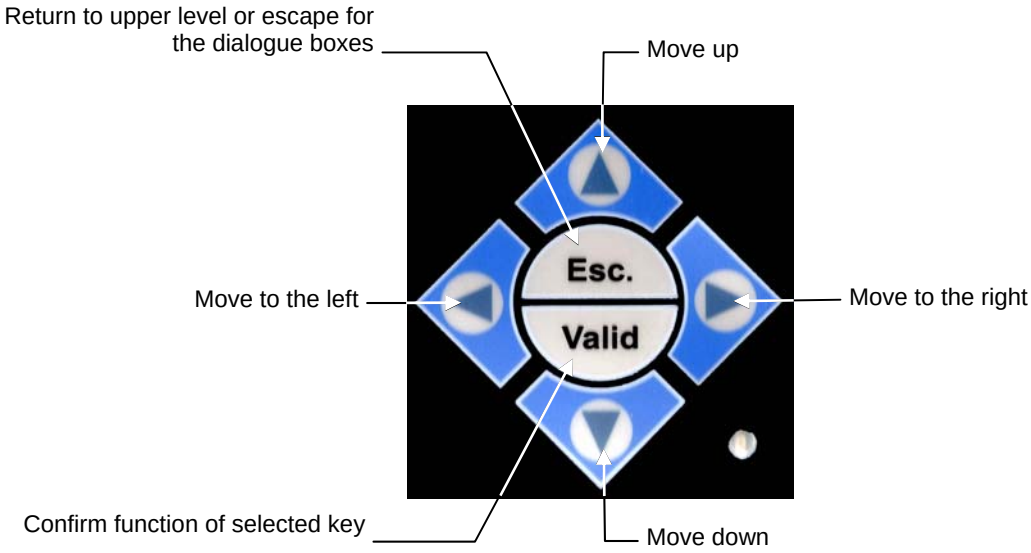
key clears the faults.

The  key stops the buzzer.

The  key commands testing of the LED’s on the front of the MMI.

**The navigation keys**

It is also possible to navigate through the menus using the keypad.




It is possible to gain direct access to a menu by pressing the numerical key corresponding to its name.

**The alphanumeric keys**

They allow alphanumeric input by successive pressing of the keys. The characters entered appear in the order they were typed on the keypad.

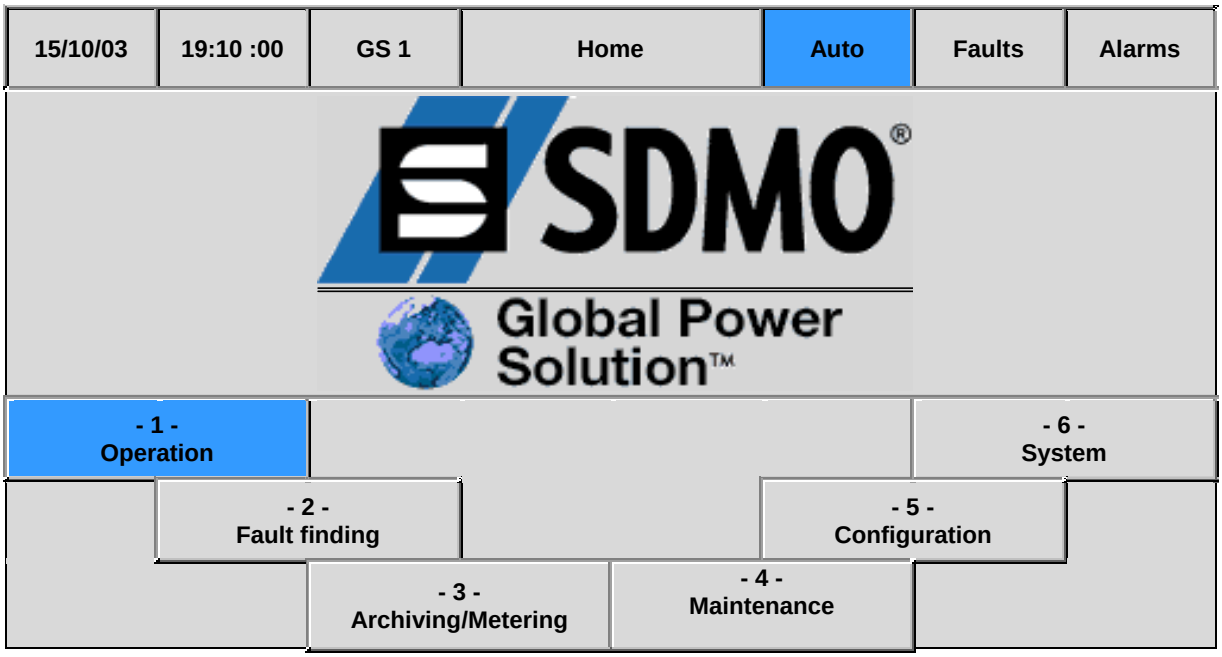
### 6.3.3.2. Navigation in the screens

There are three types:

- the home screen,
- the navigation screens,
- the operation and configuration screens.

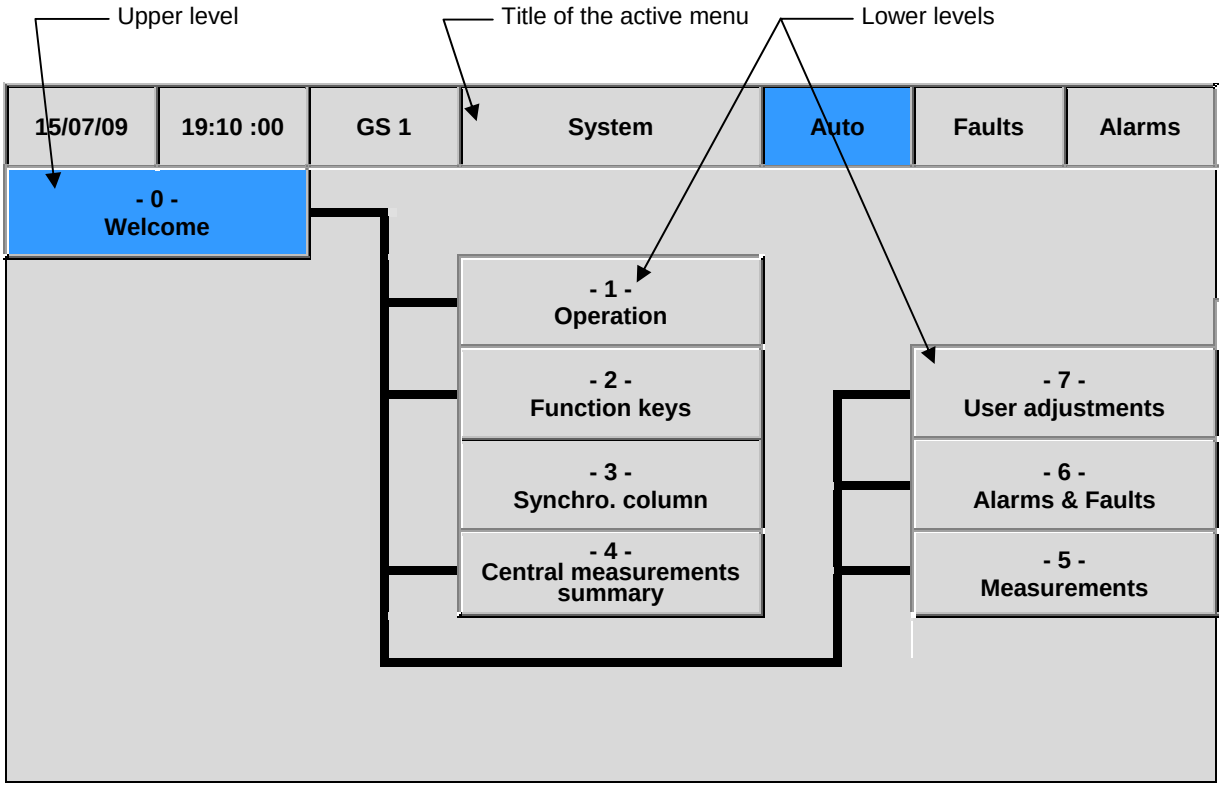
**Home screen**

This screen is the entry point to the system. It enables the main functions of the navigation to be accessed.




**Navigation screens**

These screens enable the various sub-menus to be accessed.

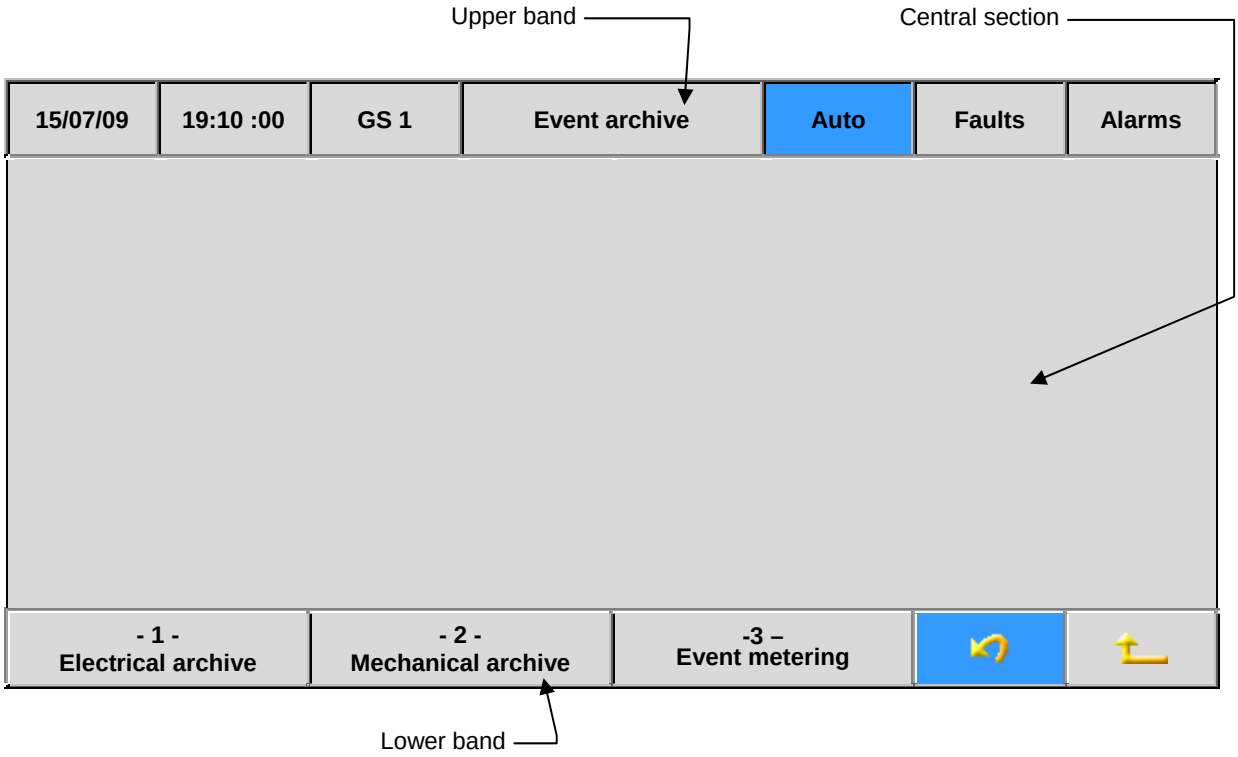


When a key is selected the lower level sub-menu appears if available or the allocated operation screen.
A sub-menu can also be accessed by pressing the corresponding key.
E.g.: by pressing key “1” on the alphanumeric keypad, you can directly access the "Operation” screen.

**The operating and configuration screens**

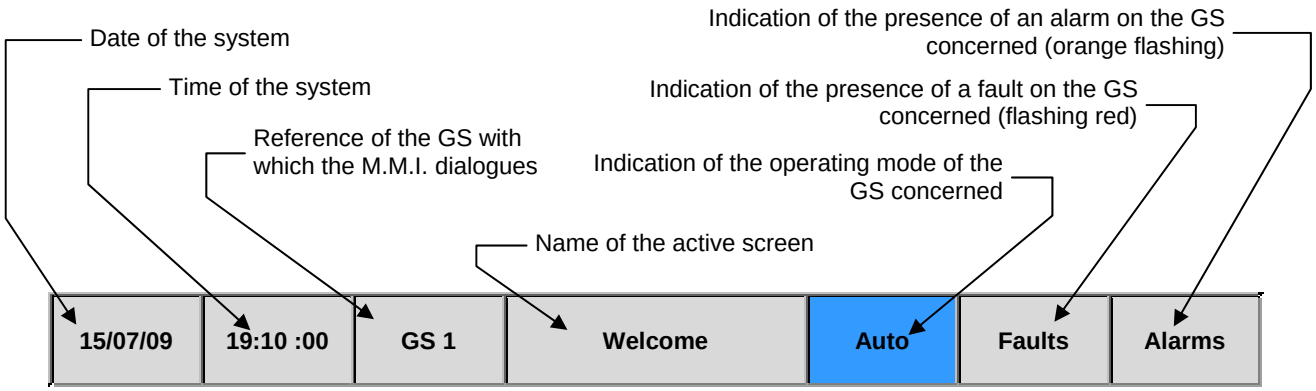
These screens bring up the information and commands relating to the active menu.
They are divided into three zones:

- an upper band common to all types of screens.
- the central section in which the specific information on the selected menu appears.
- a lower band.

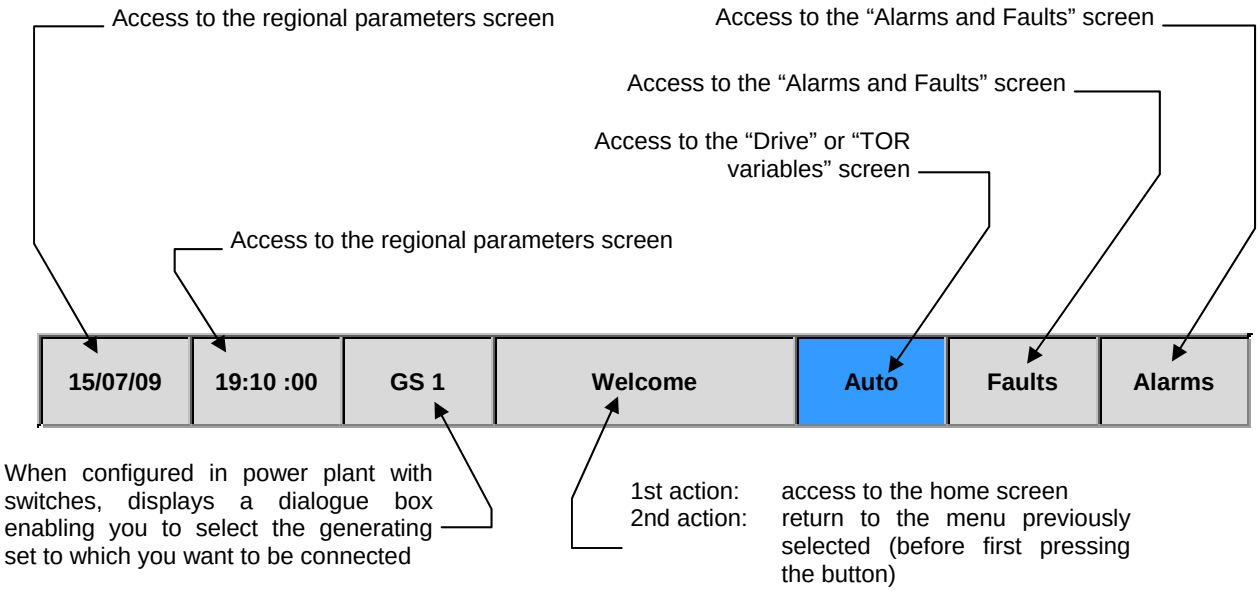



**Upper band**

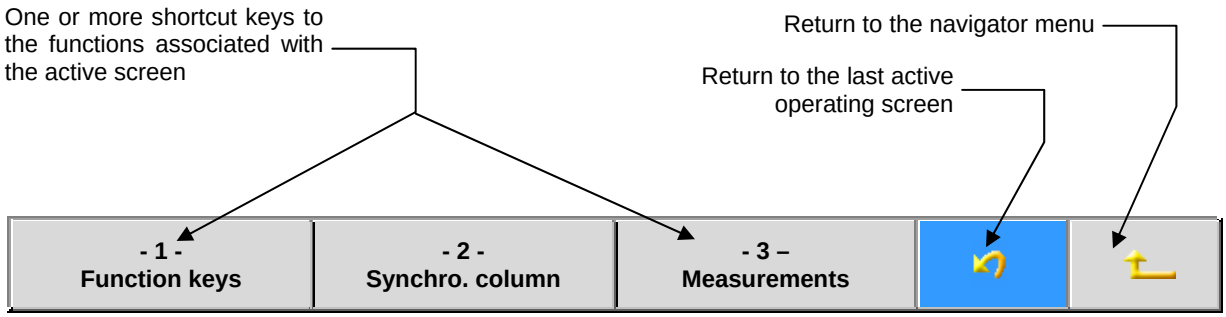
## Indications



## Controls




### Lower band



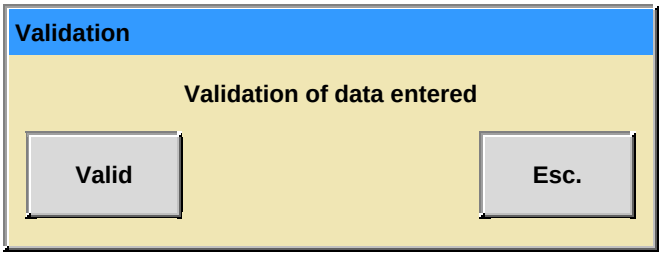

**The registration dialogue box**

### The registration dialogue boxes

To facilitate the entry of the information (parameters, texts), there are special screens, called "dialogue boxes", which appear when the need arises.

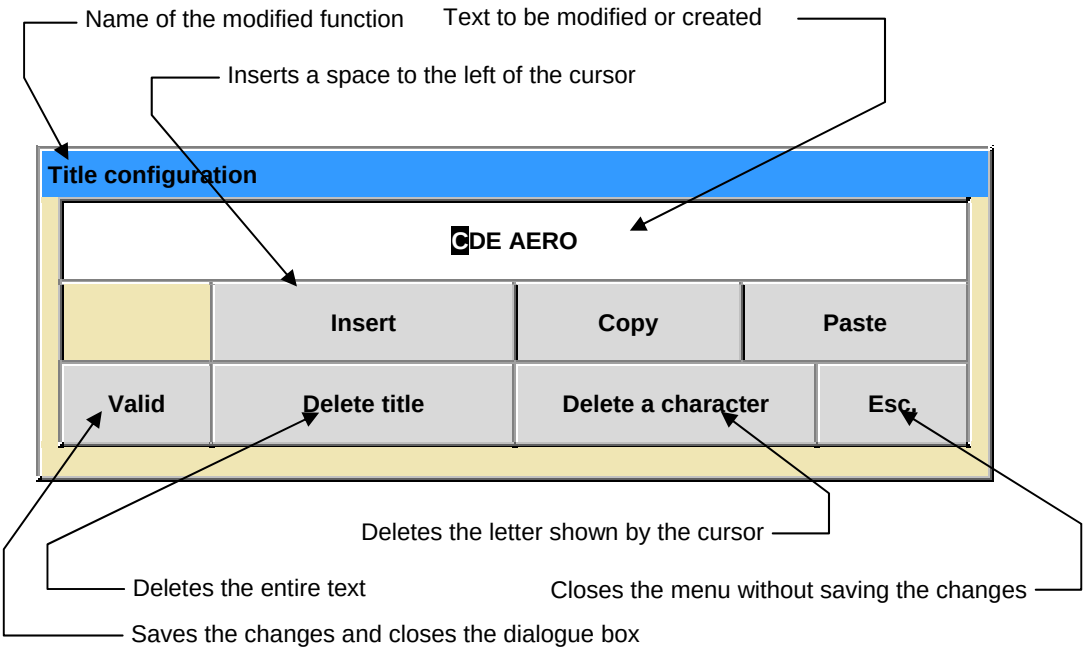
### Confirmation of an entry in a menu

After the modification of a value in a menu the following dialogue box appears:




The confirmation key **"Valid"** saves the modification, the escape key **"Esc."** cancels the modification.

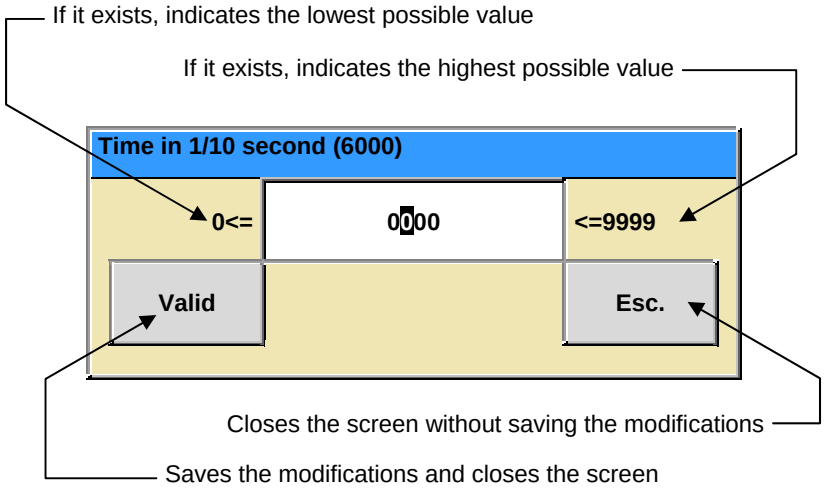
## Entry of a text




You move within the text using the “right” or “left” arrows on the keypad.
The characters are entered by means of the alphanumeric keys on the keypad.

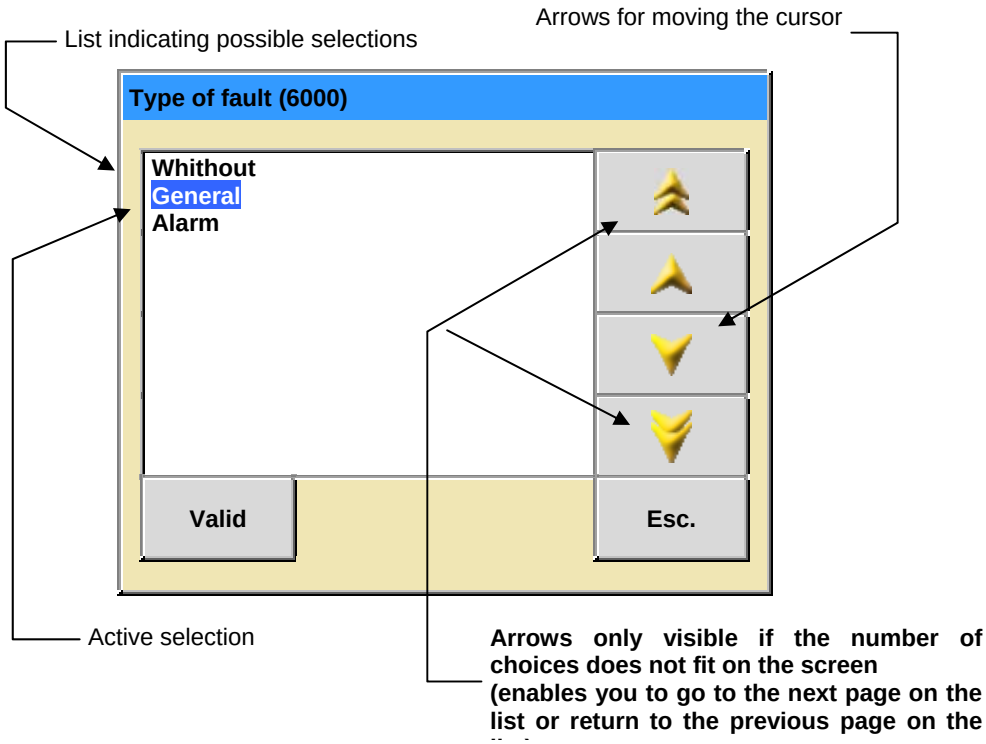
## Entering numerical values

The heading of the box provides information on the type of value entered, its unit and the variable concerned.
These indications are linked to the type of modified parameter.



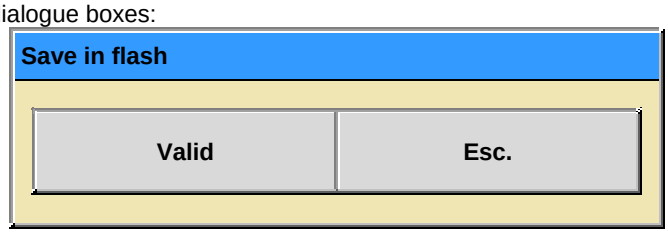
## Selecting from a list

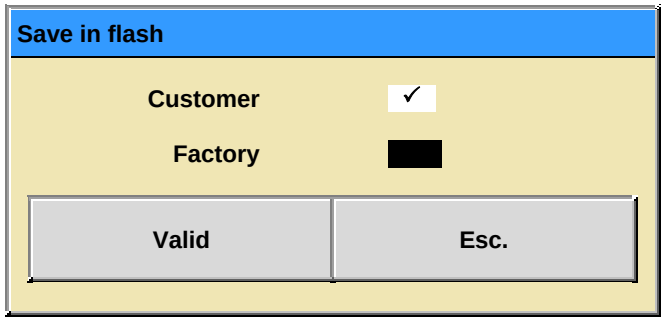
The box heading indicates the parameter which will be assigned from your selection.




## Saving changes

After changing a parameter, the new data is stored in volatile memory, which means that in the event of a power failure, any changes will be lost. It is also necessary to transfer these values to permanent memory. This is the “Save in flash” operation.
Following a modification a red “Sauvegarde à faire” (Save) indicator light flashes at the top left of the screen. Pressing this indicator light brings up one of the following dialogue boxes:

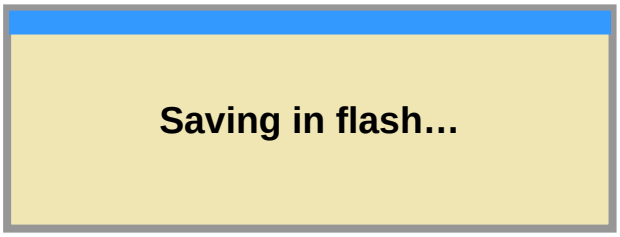



**Always select “Client”**

Pressing “Valid” confirms the operation, pressing “Esc.” cancels it.

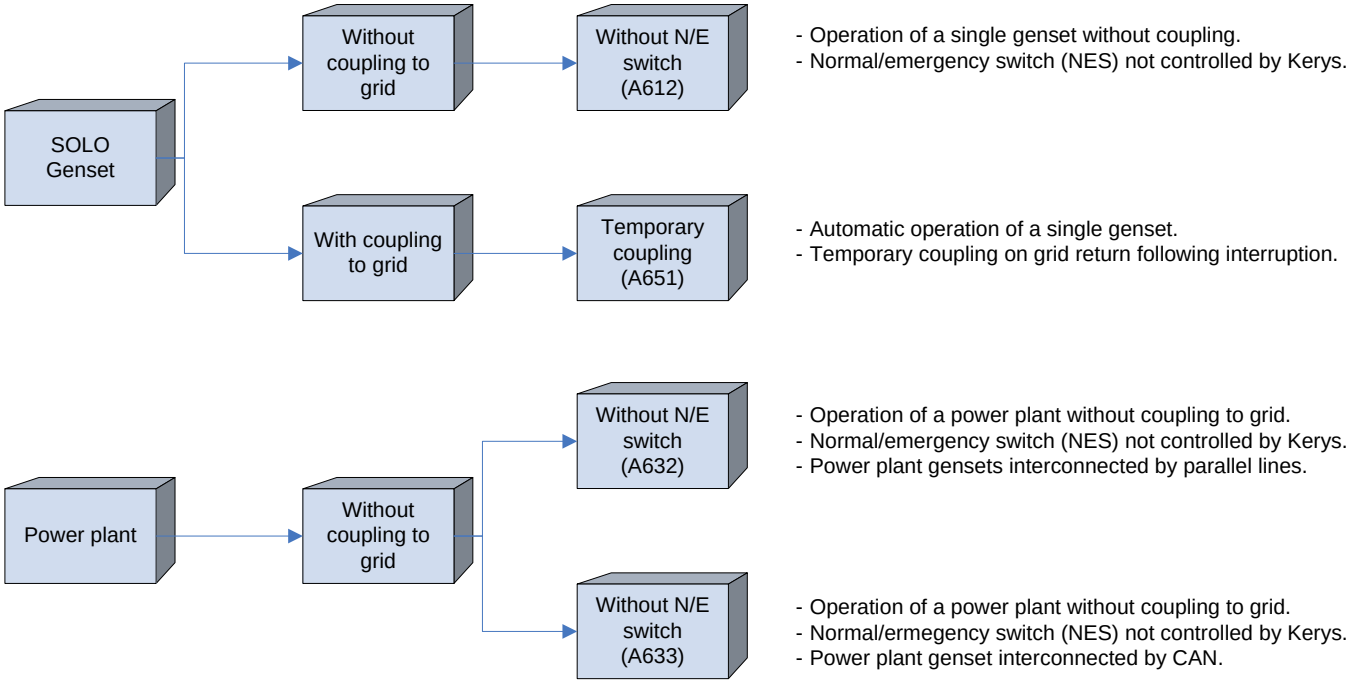
During saving, the following screen indicates that the operation in is progress:




### 6.3.4 Configurations

#### 6.3.4.1. Operating principle

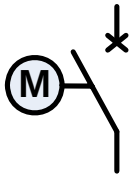
The operational modes are as follows:




Note:

Without coupling: the switch is equipped with electrical and mechanical interlocking.
With coupling: the switch is not equipped with an electrical and mechanical interlock.

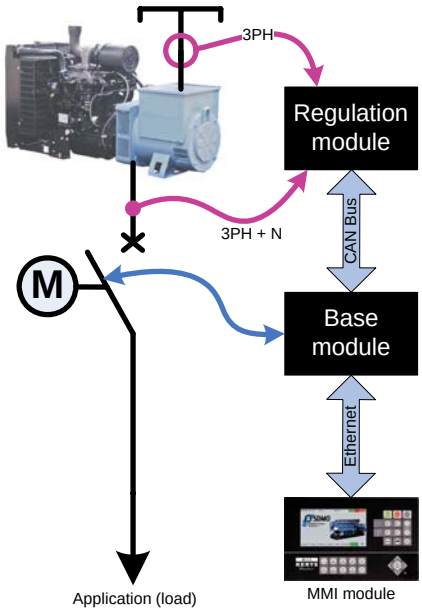
### 6.3.4.2. Legends

| | |
|---|---|
|  | Electrically controlled circuit breaker |
|  | Exchange of information from A to B and from B to A |
|  | Transmission of information from A to B only |
| 3 PH | ”Current” information, 3 PH = 3 phases |
| 3 PH + N | ”Voltage” information, 3 PH + N = 3 Phases + Neutral |

### 6.3.4.3. Configuration in solo generating set

**Without Normal/Emergency inverter (A612)**
This configuration is designed to provide:

- ✓ The generation of electricity for an installation from an external starting command (dry contact).
- ✓ The generation of electricity for an installation in forced operation.




**Automatic operation (Kerys in “AUTO” mode)**

**Loss of grid voltage**

- Generating set start request (dry contact, switch, clock, etc.).
- The speed and voltage of the generating set increase.
- Generating set power unit switched off after voltage and frequency stabilisation.

**Return of grid voltage**

- Dry contact, switch, clock, etc. switched on.
- Cooling delay.
- Generating set stopped and set to standby.

**FORCED OPERATION (Kerys in “AUTO” mode)**

**Start of FORCED OPERATION**

- Generating set start request (dry contact, switch, clock, etc.).
- The speed and voltage of the generating set increase.
- Generating set power unit switched off after voltage and frequency stabilisation.

**The installation is supplied by the generating set**

**End of FORCED OPERATION**

- Dry contact, switch, clock, etc. switched on.
- Generating set power unit switched on.
- Cooling delay.
- Generating set stopped and set to standby.

**The Kerys remains in ”AUTO” mode**

**Manual operation of generating set**

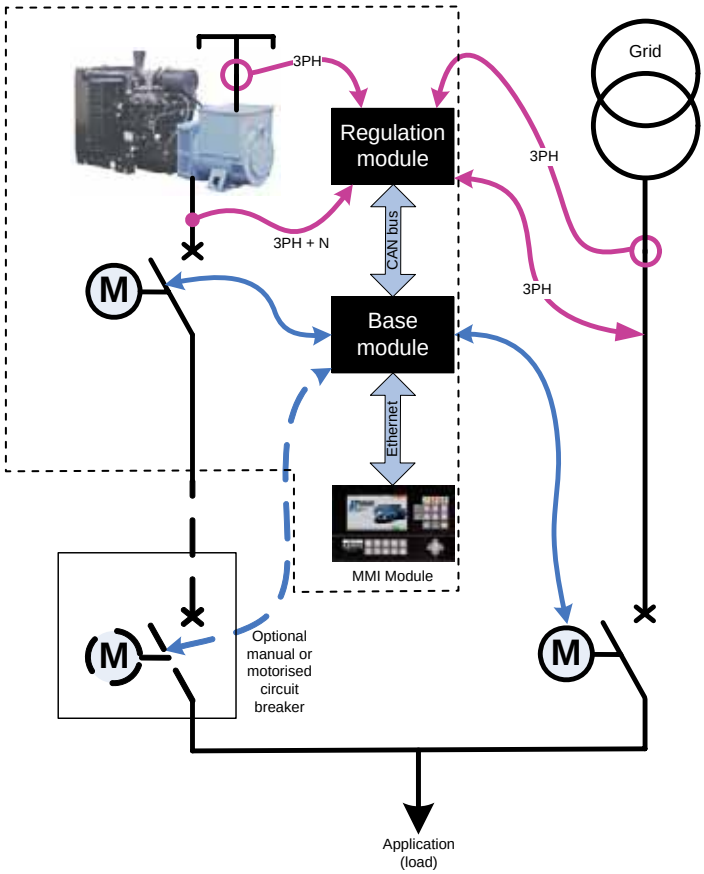
This mode of operation is selected with the “MANU” key (on the front of the MMI module). The operator is able to start and stop the generating set by using the MMI keypad. The generating set power unit is switched off by means of the MMI keys. The safety devices of the generating set remain active in this mode of operation.

***This mode of operation is the responsibility of the operator.***

**Temporary coupling to the grid (A651)**

This configuration is designed to provide:

- ✓ Emergency electricity supply to an installation following a grid loss. Return to the grid is achieved by a temporary coupling with transfer of the generating set load to the grid.
- ✓ FORCED OPERATION with a generating set.
- ✓ Temporary coupling for “Effacement Jour de Pointe” (EJP)* mode or other rates (Information transmitted by dry contacts).




* the “EJP” (Peak Day Load Shedding) system is specific to the French power grid.

**Automatic operation (Kerys in "AUTO" mode)** (temporary "grid return" coupling)

**Loss of grid voltage**

- Adjustable grid loss acquisition delay (controlled by the Kerys or by a mains detection module).
- Generating set start request.
- The speed and voltage of the generating set increase.
- Power unit switched on, grid side.
- Generating set power unit switched off after voltage and frequency stabilisation.

**Return of grid voltage**

- Adjustable grid return acquisition delay (controlled by the Kerys or by a mains detection module).
- Synchronisation of the generating set to the grid.
- After synchronisation, the grid power unit is switched off.
- Transfer of the active and reactive power of the generating set to the grid according to a predetermined ramp. The ramp does not exceed 10 seconds for transfer of the generating set's rated output. The generating set power unit is disconnected when the power on the generating set reaches the lower limit.
- Generating set power unit switched on.
- Cooling delay.
- Generating set stopped and set to standby.

***The Kerys remains in "AUTO" mode***

**FORCED OPERATION (Kerys in "AUTO" mode)** (temporary outward and return coupling)

**Start of FORCED OPERATION**

- Generating set start request.
- The generating set voltage and speed increase.
- When the generating set is stabilised in speed and voltage, synchronisation of the generating set to the grid is requested.
- After synchronisation, the generating set power unit is switched off.
- Transfer of the active and reactive power from the grid to the generating set according to a predetermined ramp. The ramp does not exceed 10 seconds for transfer of the generating set's rated output. The generating set power unit is disconnected when the power on the generating set reaches the lower limit.
- Power unit switched on, grid side.

***The installation is supplied by the generating set***

**End of FORCED OPERATION**

- Opening of the forced operation order.
- Synchronisation of the generating set to the grid.
- Grid power unit switched off.
- Transfer of the generating set's active and reactive power to the grid.
- Generating set power unit switched on.
- Cooling delay.
- Generating set stopped and set to standby.

***The Kerys remains in "AUTO" mode***
***The installation is supplied by the grid***

**Manual generating set operation**

This mode of operation is selected with the "MANU" key. The operator is able to start and stop the generating set via the MMI keypad. The power unit is switched off manually with the manual synchronisation of the generating set to the grid using the keys "+ F", "- F", "+V", "-V", the load transfer remains automatic. The safety devices of the generating set remain active in this mode of operation.

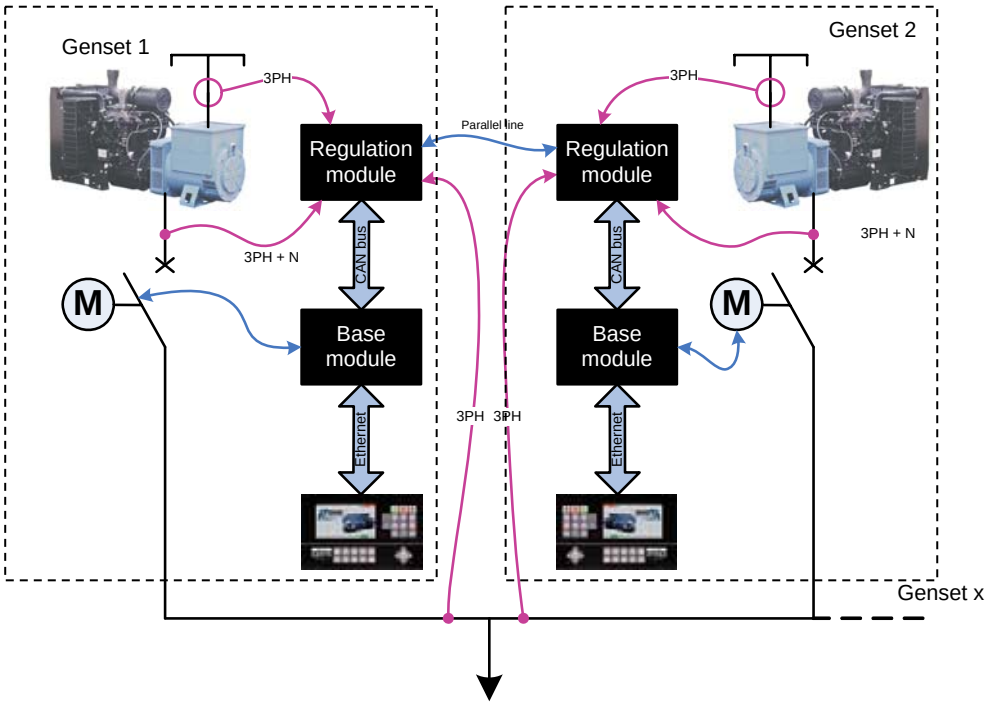
***This mode of operation is the responsibility of the operator***

### 6.3.4.4. Power plant configuration (Several generating sets in parallel)

**Without common part and without Normal/Emergency inverter (A632)**

This configuration is designed to provide:

- ✓ Emergency electricity supply to an installation following a grid loss (The grid loss is not controlled by Kerys). Return to the grid will be achieved by Normal / Emergency switchover by means of a self-driven inverter (not controlled by Kerys).
- ✓ FORCED OPERATION with a generating set.
- ✓ Operation in “Effacement Jour de Pointe” (EJP)* mode or other rates.(Information transmitted by dry contacts).
- ✓ An active power regulation (speed of the generating sets) by parallel lines connected between all the regulation modules.




(*) the “EJP” (Peak Day Load Shedding) system is specific to the French power grid.

Note 1: In this operating mode there is no reactive power regulation (generating set voltage); the generating sets are static.

Note 2: In an installation of the power station type (several generating sets in parallel) two modes of coupling between generating sets are possible

- Coupling when stopped.
- Coupling in normal operation.

**Principle of coupling when stopped**

- all the generating set power units are switched off,
- starting of all the generating sets,
- when the speed reaches 1450 rpm, activated excitation command on all the generating sets,
- the voltage generated by each generating set increases gradually and the voltage is therefore the same in all generating sets,
- the generating sets therefore reach 1500 rpm at 400 V 50 Hz.

At the end of global operation, if the power consumed by the installation does not require the operation of all the generating sets within the power plant, one or more generating sets will be stopped according to the wattmetric control.
Restarting of the generating set (these generating sets) depends on the load and wattmetric control of the load.
However, if a generating set is reconnected to a busbar already subjected to a load, the “recoupling” is carried out in normal operation and not when the generating set is stopped.

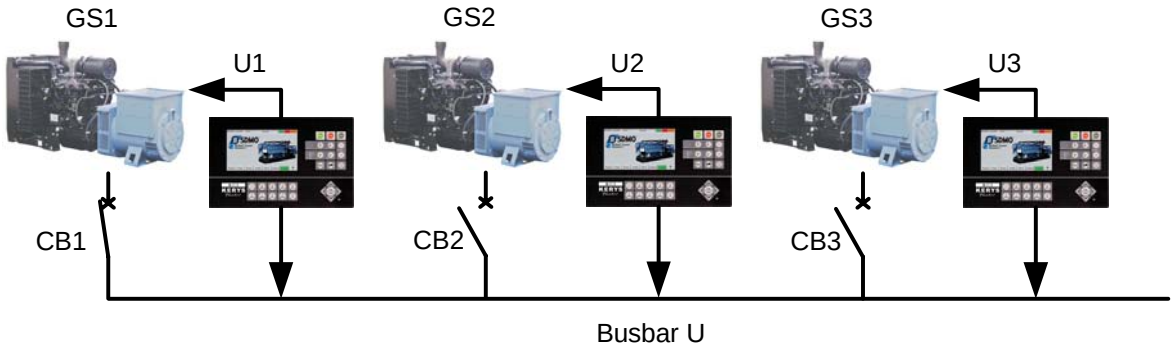
**Principle of coupling in normal operation**

Coupling in normal operation enables all the generating sets to be coupled (in voltage and frequency) to a busbar supplied by a generating set designed as master at the output.
A number (1 to 15) is assigned to each Kerys. This number serves solely to establish the IP address of each Kerys for communication by Ethernet and loading the programs.
A second number (from 1 to 15) is also assigned to each Kerys and defines the priority.

Example: let us assume a plant of 8 generating sets

| Gen set | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Priority | 08 | 07 | 06 | 05 | 04 | 03 | 02 | 01 |

The numbers on the first line enable the IP address of each Kerys to be allocated. The numbers on the second line define the priority.
Therefore Kerys no. 8 with priority 01 is considered to be the master generating set and closes its flow first. The other generating sets then synchronise one by one to the central busbar, transmitting the information on voltage, frequency and phase difference to this busbar (see sketch).




Example for 3 GSs:
- DJ1 (Circuit breaker 1) is closed, the voltage is present on the busbar.
- Kerys 2 analyses the differences between U2 and U of the busbar before coupling.
- Kerys 3 analyses the differences between U3 and U of the busbar before coupling.

Each Kerys, independently of its neighbour, will close its discharge on the central busbar.

**Wattmetric control**

The wattmetric control is used when two generating sets are coupled. It provides optimum management of the number of generating sets operating by constantly analysing the power required by the user.

Let us take the example of a power plant of 4 x 600 kW generating sets.
The threshold setting screen (1-7-3-3) supplies the following data:

| | | | | | |
|---|---|---|---|---|---|
| Threshold 1 GS => 2 GS | 75% | 450 kW | Threshold 2 GS => 1 GS | 30 % | 360 kW |
| Threshold 2 GS => 3 GS | 75% | 900 kW | Threshold 3 GS => 2 GS | 30 % | 540 kW |
| Threshold 3 GS => 4 GS | 75% | 1350 kW | Threshold 4 GS => 3 GS | 30 % | 720 kW |

The maximum available power is 600 x 4 = 2400 kW. Assuming that a single generating set is operating, we will have the following sequence in the case of linear progression of the load.

When the power required by the application reaches 75% of the power of the generating set in operation (GS at priority 01), i.e. 450 kW, the second GS (at priority 02) is started and is synchronised with GS 1. Its flow is then closed.

The second GS thus coupled initiates its power on ramp (adjustable delay) and the distribution of power among the two generating sets takes place. Each generating set will then take 50% of the required power, i.e. 225 kW.

When the power required for the application reaches 75% of the power of the two generating sets in operation (GSs at priority 01 and 02), i.e. 900 kW, the third GS (at priority 03) is then started and is synchronised with GS1 and GS2. Its flow is then closed. The third GS thus coupled initiates its power on ramp (adjustable delay), and the distribution of power among the three generating sets takes place.
Each generating set will then take 33.33% of the required power, i.e. 300 kW, corresponding to 50% of its rated output (600 kW).

When the power required for the application reaches 75% of the power of the three GSs in operation (GSs at priority 01, 02 and 03), i.e. 1350 kW, the fourth GS (at priority 04) is then started and synchronised with GS1, GS2 and GS3. Its flow is then closed. The fourth GS thus coupled initiates its power on ramp (adjustable delay) and the distribution of power among the four generating sets takes place. Each generating set will then take 25% of the power required, i.e. 337.5 kW, corresponding to 56.25% of its rated output (600 kW).

The power required for the application may continue to increase up to the upper plant limit (95%) of 2400 kW, i.e. 2280 kW (the setting can be changed). This corresponds of course to the upper generating set limit, i.e. 570 kW (95% of 600 kW).

**Automatic operation (All Kerys PLCs in "AUTO" mode)** (coupling when stopped)

**Loss of grid voltage**

- Grid loss acquisition delay (controlled by the mains detection module).
- Generating set power units switched off.
- Generating set start request.
- The generating sets' speed increases.
- Speed stabilisation delay.
- Order of excitation for each generating set at nominal speed; the voltage is then quickly established on the busbar.
- Start of distribution of active power.
- Resumption of use at the rated power and frequency.

**Wattmetric control**
This wattmetric control will be activated after a global operation delay. This global operation enables the application to be resumed after power is restored to the different outputs, and ensures stability of the load before the wattmetric control is started.
Depending on the power for the application, the number of generating sets in production may vary in order to optimise the production for consumption.

The procedure is as follows:

- End of the global operation delay.
- Start of analysis of the active power consumed.

✓ Example: A generating set must be stopped according to the set thresholds.

- Power cut at the non-priority generating set, transfer of the power to the generating set(s) remaining in production.
- Uncoupling of the non-priority generating set, at zero power, by switching on the generating set power unit.
- Cooling delay.
- Generating set stopped and set to standby.

✓ Example of increase in power:

- Generating set start request.
- The speed of the generating set increases.
- Alternator excitation, the generating set establishes its voltage.
- Request for synchronisation of the generating set to the busbar (i.e. the other coupled generating sets).
- Generating set power unit switched off.

**Return of grid voltage**

- Grid return acquisition delay (controlled by the mains detection module).
- Generating set power units switched on.
- Cooling delay.
- Generating sets stopped and set to standby.

***The Kerys PLCs remain in "AUTO" mode***

## FORCED OPERATION

**Start of FORCED OPERATION**

- Generating set power units switched off.
- Generating set start request.
- The generating sets increase in speed.
- Speed stabilisation delay.
- Order of excitation for each generating set at nominal speed; the voltage is then quickly established on the busbar.
- Start of active power distribution.
- Resumption of application at rated voltage and frequency.

***The Kerys PLCs remain in "AUTO" mode***
***The installation is supplied by the generating sets***

**End of FORCED OPERATION**

- Generating set power units switched on.
- Cooling delay.
- Generating sets stopped and set to standby.

***The Kerys PLCs remain in "AUTO" mode***
**The installation is supplied by the grid**

**Manual power plant operation**

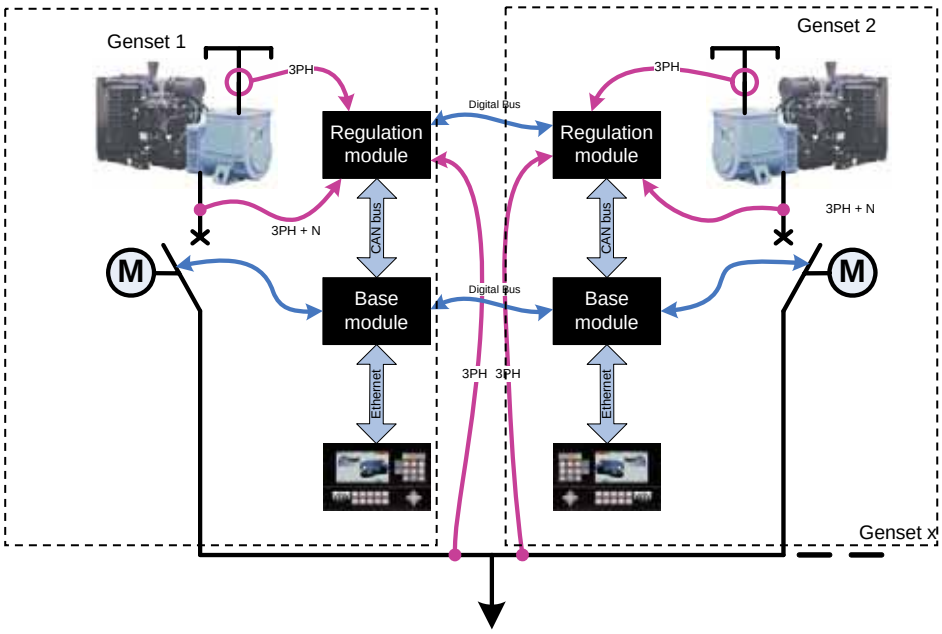
This mode of operation is selected with the "MANU" key. This enables the operator to start and stop the generating sets one by one via the MMI keypad. The generating set power unit is switched off manually with synchronisation of each generating set to the busbar using the MMI keys "+F", "-F", "+V" and "-V". The distribution of power among the generating sets remains automatic. The safety devices of the generating sets remain active in this mode of operation.

**This mode of operation is the responsibility of the operator.**

**Without common part and without Normal/Emergency inverter (A633)**

This configuration is designed to provide:

- ✓ Emergency electricity supply to an installation following a grid loss (The grid loss is not controlled by the Kerys). Return to the grid can be achieved via Normal / Emergency switchover with a self-driven inverter (not controlled by the Kerys).
- ✓ FORCED OPERATION with a generating set.
- ✓ Operation in "Effacement Jour de Pointe" (EJP)* mode or other rates. (Information transmitted by dry contacts).
- ✓ Active power regulation (speed of the generating sets) by digital buses connected between all the regulation modules.




(*) the "EJP" system is specific to the French power grid.

Note 1: In this operating mode active and reactive power is distributed by a digital bus between the regulation modules (voltage of the generating sets).

Note 2: In an installation of the power plant type (several generating sets connected by digital bus), two modes of coupling between generating sets are possible

- Coupling when stopped.
- Coupling in normal operation.

**Principle of coupling when stopped**

- all the generating set power units are switched off,
- starting of all the generating sets,
- when the speed reaches 1450 rpm, activated excitation command on all the generating sets,
- the voltage generated by each generating set increases gradually and the voltage is therefore the same in all generating sets,
- the generating sets therefore reach 1500 rpm at 400 V 50 Hz.

At the end of global operation, if the power consumed by the installation does not require the operation of all the generating sets within the power plant, one or more generating sets will be stopped according to the wattmetric control.
Restarting of the generating set (these generating sets) depends on the load and wattmetric control of the load.
However, if a generating set is reconnected to a busbar already subjected to a load, the “recoupling” is carried out in normal operation and not when the generating set is stopped.

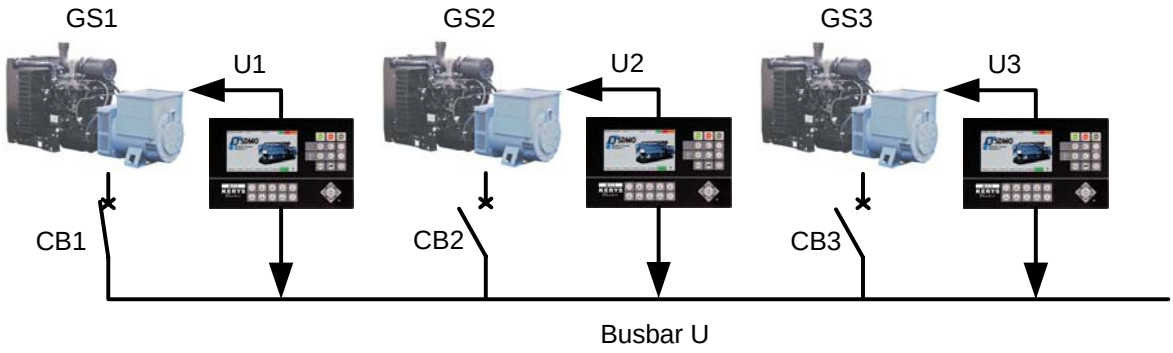
**Principle of coupling in normal operation**

Coupling in normal operation enables all the generating sets to be coupled (in voltage and frequency) to a busbar supplied by a generating set designed as master at the output.
A number (1 to 15) is assigned to each Kerys. This number serves solely to establish the IP address of each Kerys for communication by Ethernet and loading the programs.
A second number (from 1 to 15) is also assigned to each Kerys and defines the priority.

Example: let us assume a plant of 8 generating sets

| Gen set | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Priority | 08 | 07 | 06 | 05 | 04 | 03 | 02 | 01 |

The numbers on the first line enable the IP address of each Kerys to be allocated. The numbers on the second line define the priority.Therefore Kerys no. 8 with priority 01 is considered to be the master generating set and closes its flow first. The other generating sets then synchronise one by one to the central busbar, transmitting the information on voltage, frequency and phase difference to this busbar (see sketch).




Example for 3 GSs:

- DJ1 (Circuit breaker 1) is closed, the voltage is present on the busbar.
- Kerys 2 analyses the differences between U2 and U of the busbar before coupling.
- Kerys 3 analyses the differences between U3 and U of the busbar before coupling.

Each Kerys, independently of its neighbour, will close its discharge on the central busbar.

**Wattmetric control**

The wattmetric control is used when two generating sets are coupled. It provides optimum management of the number of generating sets operating by constantly analysing the power required by the user.

Let us take the example of a power plant of 4 x 600 kW generating sets.
The threshold setting screen (1-7-3-3) supplies the following data:

| | | | | | |
|---|---|---|---|---|---|
| Threshold 1 GS => 2 GS | 75% | 450 kW | Threshold 2 GS => 1 GS | 30 % | 360 kW |
| Threshold 2 GS => 3 GS | 75% | 900 kW | Threshold 3 GS => 2 GS | 30 % | 540 kW |
| Threshold 3 GS => 4 GS | 75% | 1350 kW | Threshold 4 GS => 3 GS | 30 % | 720 kW |

The maximum available power is 600 x 4 = 2400 kW. Assuming that a single generating set is operating, we will have the following sequence in the case of linear progression of the load.

When the power required by the application reaches 75% of the power of the generating set in operation (GS at priority 01), i.e. 450 kW, the second GS (at priority 02) is started and is synchronised with GS 1. Its flow is then closed.
The second GS thus coupled initiates its power on ramp (adjustable delay) and the distribution of power among the two generating sets takes place. Each generating set will then take 50% of the required power, i.e. 225 kW.

When the power required for the application reaches 75% of the power of the two generating sets in operation (GSs at priority 01 and 02), i.e. 900 kW, the third GS (at priority 03) is then started and is synchronised with GS1 and GS2. Its flow is then closed. The third GS thus coupled initiates its power on ramp (adjustable delay), and the distribution of power among the three generating sets takes place.Each generating set will then take 33.33% of the required power, i.e. 300 kW, corresponding to 50% of its rated output (600 kW).

When the power required for the application reaches 75% of the power of the three GSs in operation (GSs at priority 01, 02 and 03), i.e. 1350 kW, the fourth GS (at priority 04) is then started and synchronised with GS1, GS2 and GS3. Its flow is then closed. The fourth GS thus coupled initiates its power on ramp (adjustable delay) and the distribution of power among the four generating sets takes place. Each generating set will then take 25% of the power required, i.e. 337.5 kW, corresponding to 56.25% of its rated output (600 kW).

The power required for the application may continue to increase up to the upper plant limit (95%) of 2400 kW, i.e. 2280 kW (the setting can be changed).This corresponds of course to the upper generating set limit, i.e. 570 kW (95% of 600 kW).

**Automatic operation (All Kerys PLCs in "AUTO" mode)** (coupling when stopped)

**Loss of grid voltage**

- Grid loss acquisition delay (controlled by the mains detection module).
- Generating set power units switched off.
- Generating set start request.
- The generating sets increase in speed.
- Speed stabilisation delay.
- Order of excitation for each generating set at nominal speed; the voltage is then quickly established on the busbar.
- Start of active power distribution.
- Resumption of application at rated voltage and frequency.

**Wattmetric control**
This wattmetric control will be activated after a global operation delay. This global operation enables the application to be resumed after power is restored to the different outputs, and ensures stability of the load before the wattmetric control is started.
Depending on the power for the application, the number of generating sets in production may vary in order to optimise the production to consumption.

The procedure is as follows:
- End of the global operation delay.
- Start of analysis of the active power consumed.

✓ Example: A generating set must be stopped according to the set thresholds.
- Power cut at the non-priority generating set, transfer of the power to the generating set(s) remaining in production.
- Uncoupling of the non-priority generating set, at zero power, by switching on the generating set power unit.
- Cooling delay.
- Generating set stopped and set to standby.

✓ Example of increase in power:
- Generating set start request.
- The generating set increases in speed.
- Alternator excitation, the generating set establishes its voltage.
- Request for synchronisation of the generating set to the bus bar (i.e. the other coupled generating sets).
- Generating set power unit switched off.

✓ **Return of grid voltage**
- Grid return acquisition delay (controlled by the mains detection module).
- Generating set power units switched on.
- Cooling delay.
- Generating sets stopped and set to standby.

***The Kerys PLCs remain in "AUTO" mode***

**FORCED OPERATION**

**Start of FORCED OPERATION**
- Generating set power units switched off.
- Generating set start request.
- The generating sets increase in speed.
- Speed stabilisation delay.
- Order of excitation for each generating set at nominal speed; the voltage is then quickly established on the busbar.
- Start of active power distribution.
- Resumption of application at rated voltage and frequency.

***The Kerys PLCs remain in "AUTO" mode***
***The installation is supplied by the generating sets***

**End of FORCED OPERATION**
- Generating set power units switched on.
- Cooling delay.
- Generating sets stopped and set to standby.

***The Kerys PLCs remain in "AUTO" mode***
**The installation is supplied by the grid**

**Manual power plant operation**
This mode of operation is selected with the "MANU" key. This enables the operator to start and stop the generating sets one by one via the MMI keypad. The generating set power unit is switched off manually with synchronisation of each generating set to the busbar using the MMI keys "+F", "-F", "+V" and "-V". The distribution of power among the generating sets remains automatic. The safety devices of the generating sets remain active in this mode of operation.

**This mode of operation is the responsibility of the operator.**

### 6.3.5 Connections of the generating sets

#### 6.3.5.1. Recommendations before the connections

| | |
|---|---|
|  Warning | **Disconnect the battery cables before carrying out any work on the generating set.** To disconnect the battery disconnect the negative cable (-) first. |

#### 6.3.5.2. Connections according to the configurations

| | Solo generating set without inverter (A612) | Solo generating set, CRF coupling (A651) | Power plant without common part without inverter (A632) | Power plant without common part and without inverter (A633) |
|---|---|---|---|---|
| Ground connection | X | X | | |
| Ground connection box | | | X | X |
| Facility power outlet | O | O | O | O |
| Connecting cables between the generating sets (CAN BUS) | | | | X |
| Connecting cables between the generating sets (Parallel line) | | | X | |
| Power cables | X | X | X | X |
| Customer terminal: | | | | |
| Remote operation | ● | ● | ● | ● |
| External emergency stop | ● | ● | ● | ● |
| EJP | ● | ● | ● | ● |
| Switch grid detection [(1)] | ● | | ● | ● |
| Grid detection by regulation card [(1)] | ● | X | ● | ● |
| Emergency N/E switch control | | ● | | |
| Emergency cutout | | ● | | |
| Normal N/E switch control | | ● | | |
| Summary of faults and alarms | ● | ● | ● | ● |
| Generating set operation | ● | ● | ● | ● |
| Generating set available in Auto | ● | ● | ● | ● |

X: to be connected O: if available ●: if necessary

[(1)] Only one of the two grid detections needs to be cabled.

### 6.3.5.3. Earthing system (Standard only)

- The ground of the generating set must be connected to earth. To do so, use a copper cable (Green / Yellow), 25 mm² minimum for a bare cable and 16 mm² for an insulated cable, connected to the earth of the generating set, and to a ground rod of galvanised steel pushed vertically into the ground.

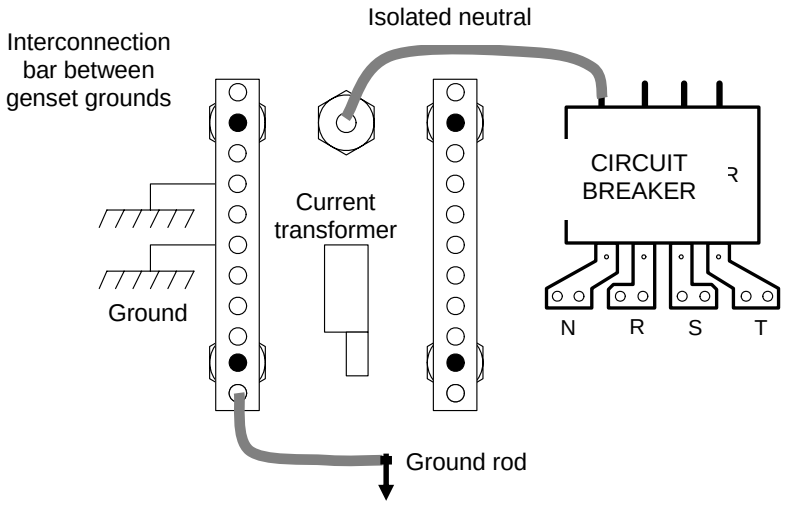
For a fault voltage of 25 V and a fault current of 30 mA.

| Nature of the ground | Rod length (in metres) | |
|---|---|---|
| Rich arable land, moist compact hard core | 1 | |
| Poor arable land | 1 | |
| Poor arable land, gravel, coarse hard core | 1 | |
| Stony bare soils, dry sand, impermeable rocks | 3.6 | To obtain an equivalent length several ground rods can be used connected in parallel and separated by at least their length. Example: Four 1 metre rods interconnected and separated by 1 metre respectively. |

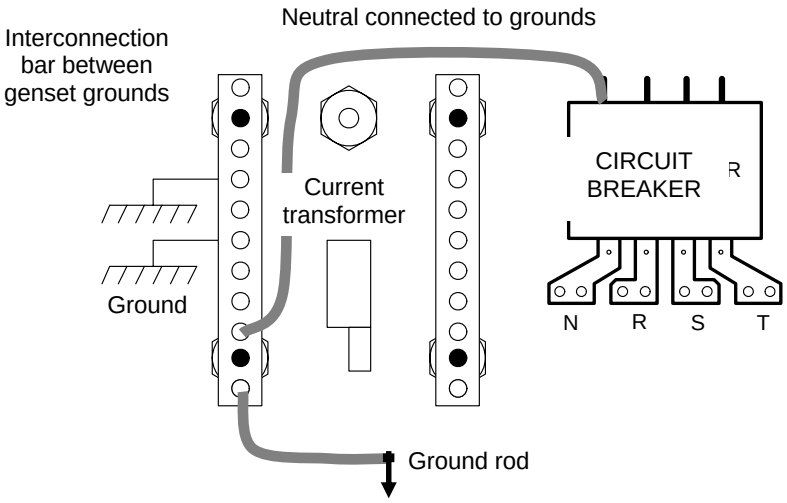
- Check the earthing connection before switching on the generating set.
- Check that the safety earthing system is working.

**Single genset**
**Earthing system: IT**

Active isolation controller

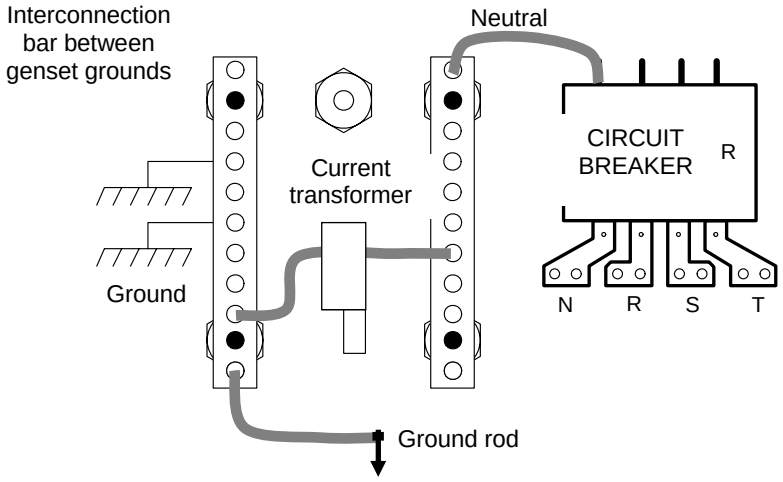


**Earthing system: TNS**



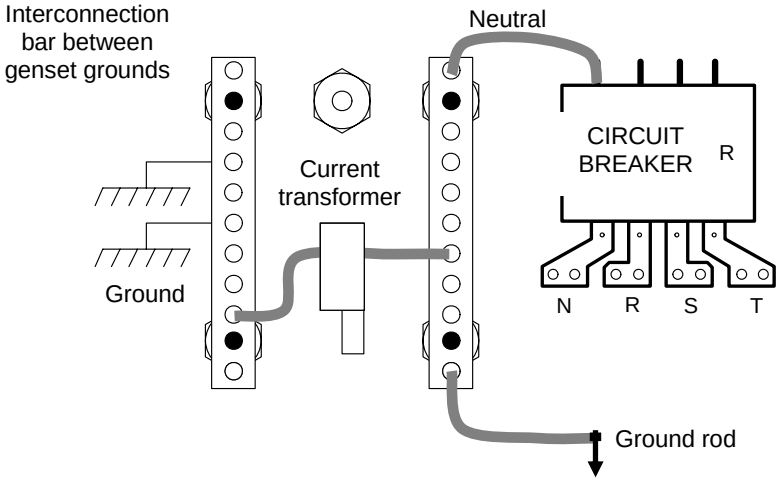

**Earthing system: TT**

Active differential circuit breaker

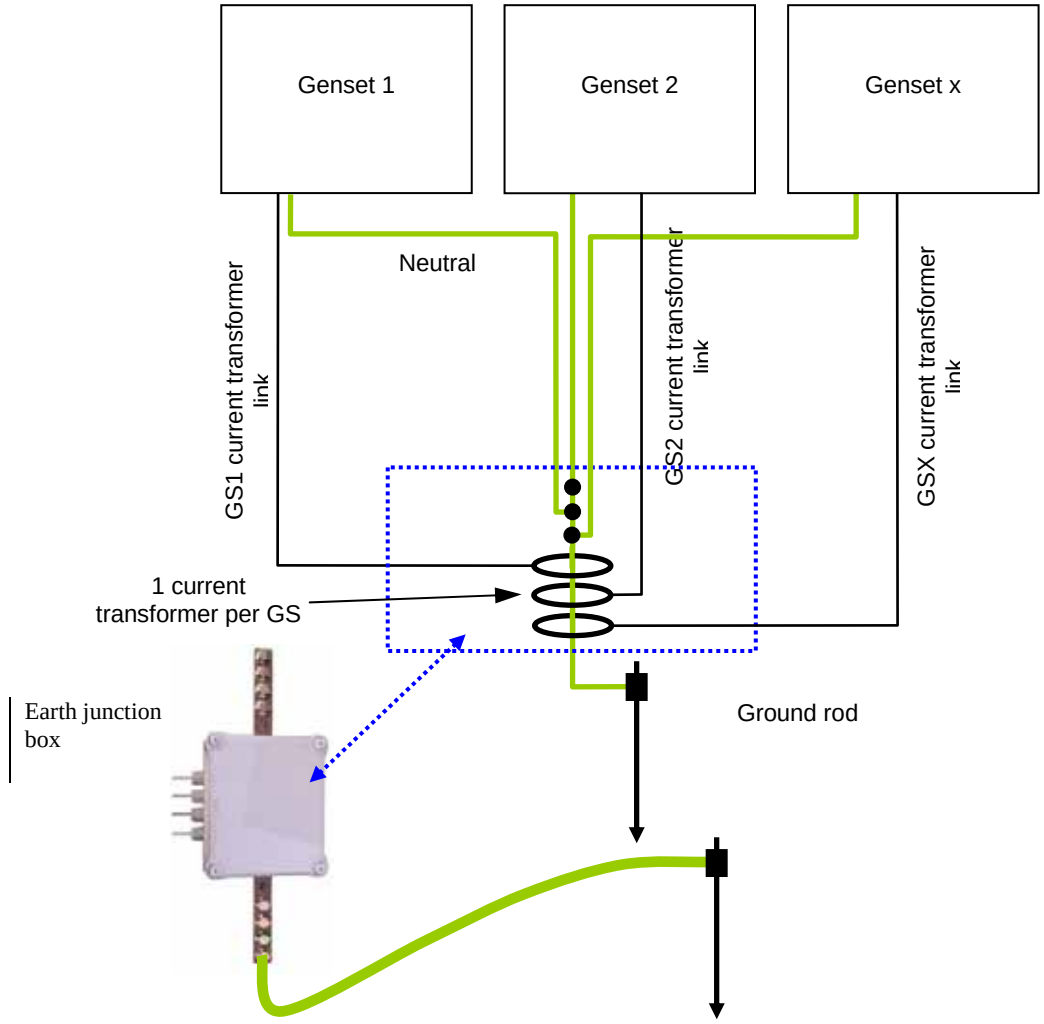


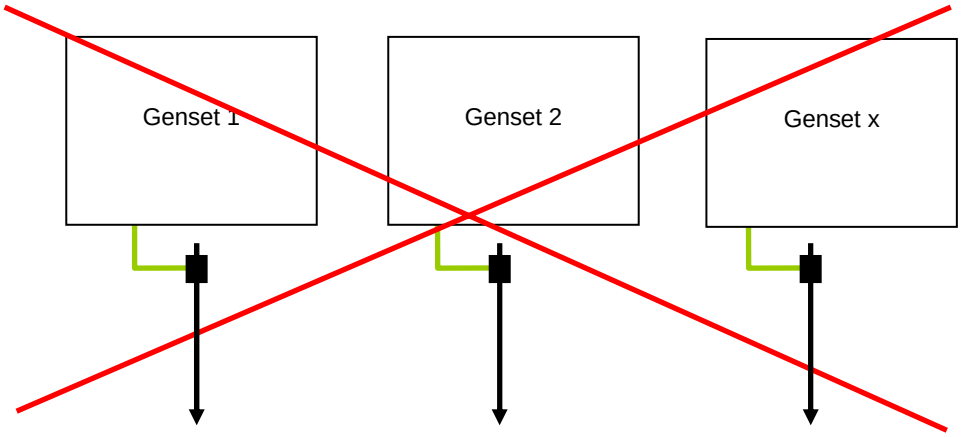

**Type of earthing system: EDF application** *(On rental generating set only)*

Active differential circuit breaker



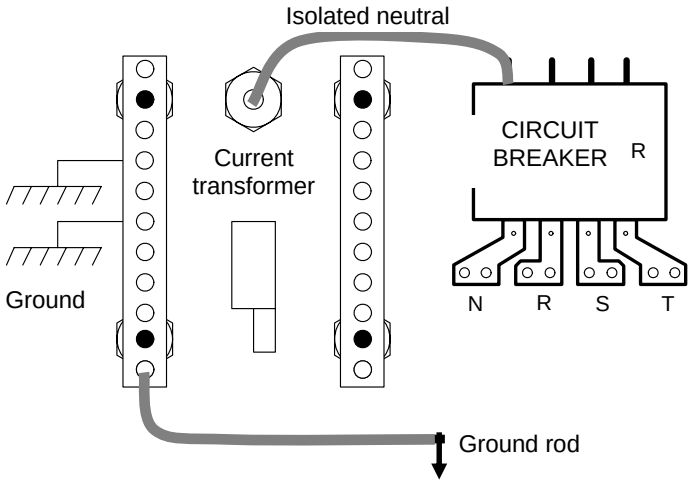
**Power plant**
**Connection of the generating sets to the box**



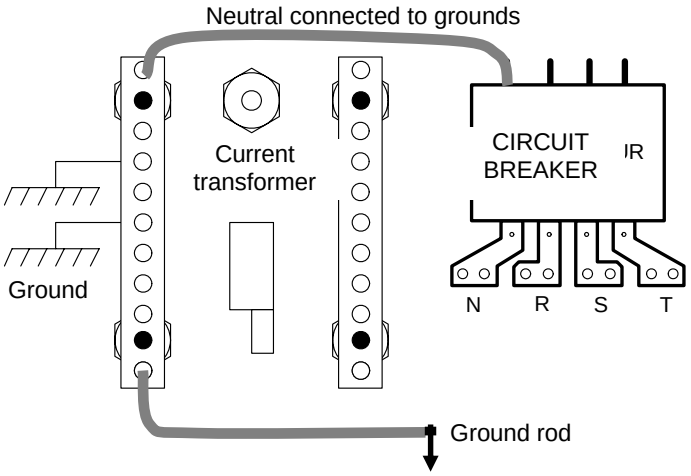




| | |
|---|---|
| Important | One ground rod for one generating set power plant |

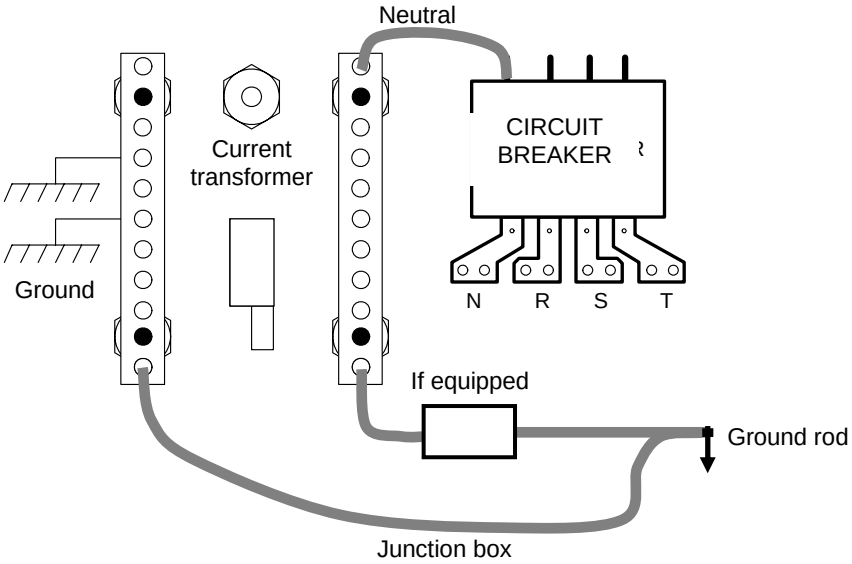
**Earthing system: IT**



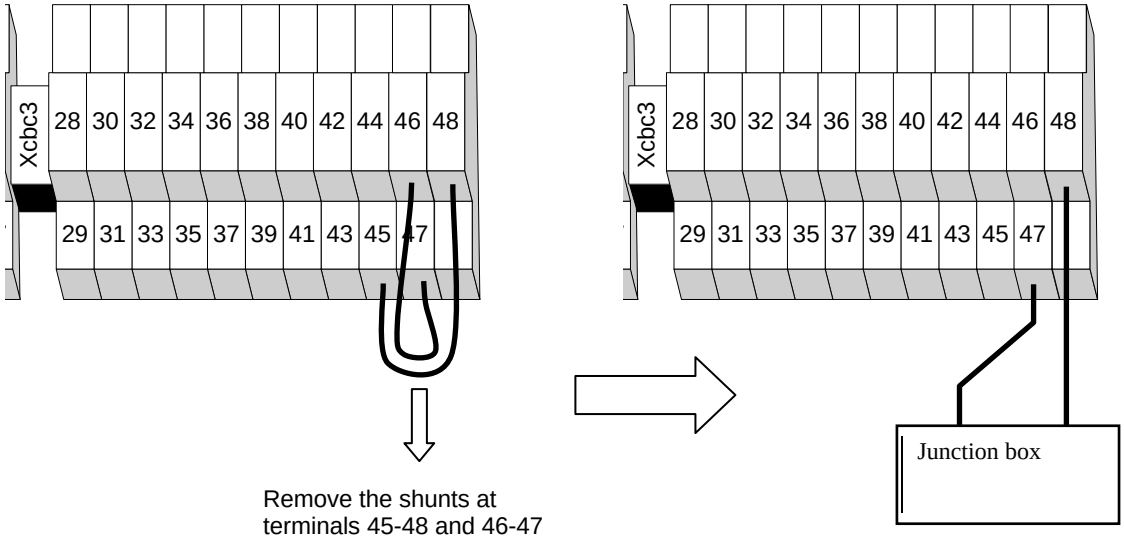

**Earthing system: TNS**




**Earthing system: TT**



**Connection of generating sets to client terminal boards**

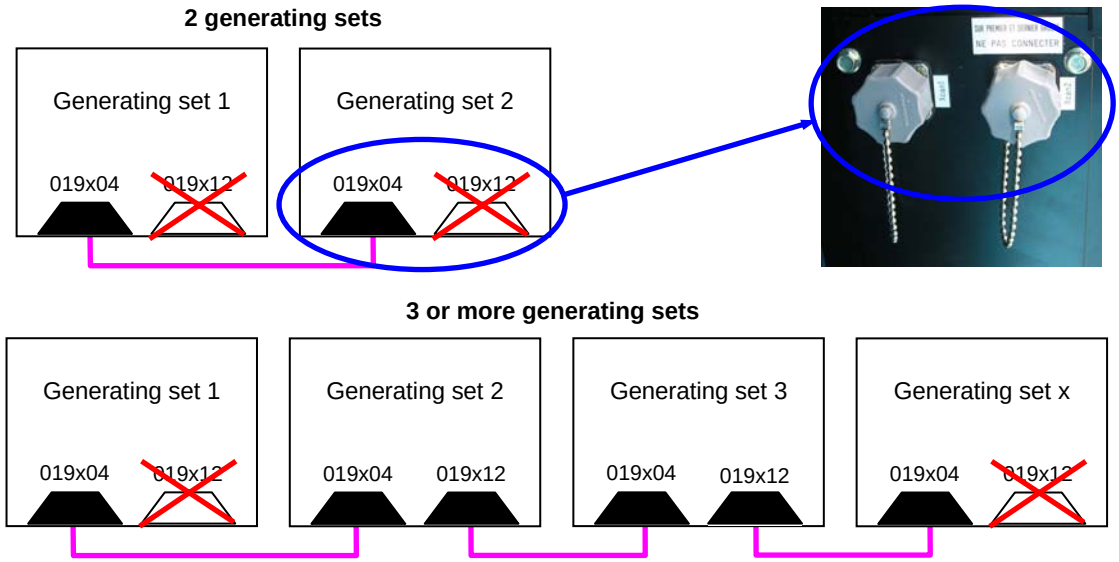



| | |
|---|---|
| Important | Reinsert the shunts of terminals 45 and 46 after having disconnected the current transformer from the junction box. |

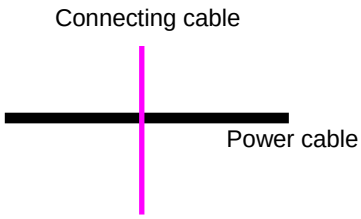
### 6.3.5.4. Facility power outlet

The facility power outlet (if fitted) provides the emergency supply to the generating set from an external electrical source. It enables the different units (preheating, desk, etc.) to be powered without using their batteries.

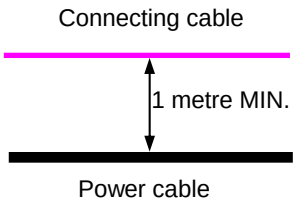
### 6.3.5.5. Connecting cable between the generating sets (power plant)




| | |
|---|---|
| Important | The power cables and the generating set connecting cable may intersect |



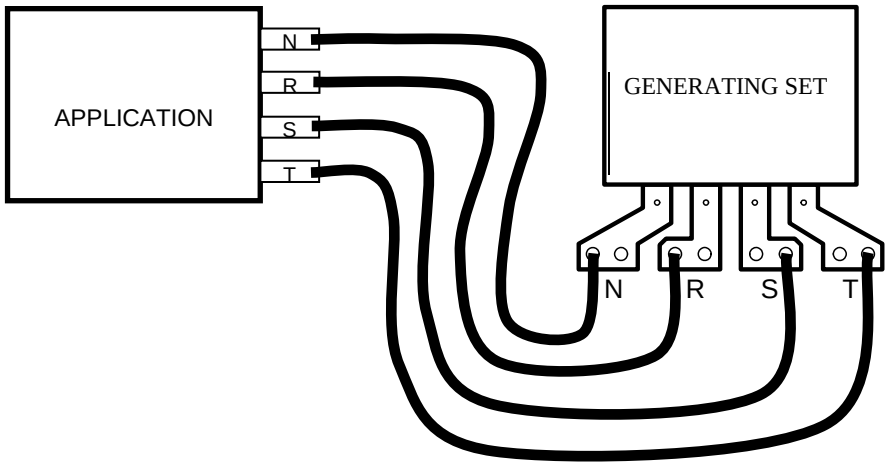

| | |
|---|---|
| Important | **Rental application**<br>The generating set power cables and connecting cable cannot be placed in parallel less than 1 metre apart. |




| | |
|---|---|
| Important | The generating set power cables, the generating set connecting cable and the connections must be in perfect condition. Replace them if necessary. |

### 6.3.5.6. Power

1. Pass the power cables through the access hatch to the power box of the generating set (AIPR or console, depending on the generating set).
2. Connect the power cables to the busbars.
3. Connect the power cables to the application.




| | |
|---|---|
| Important | Check that the direction of rotation of the phases between the generating set and the application is the same. |

Type of cables: Use H074NF type cables according to the standards in force in the country of use of the generating set (In France refer to the standard C15.100).

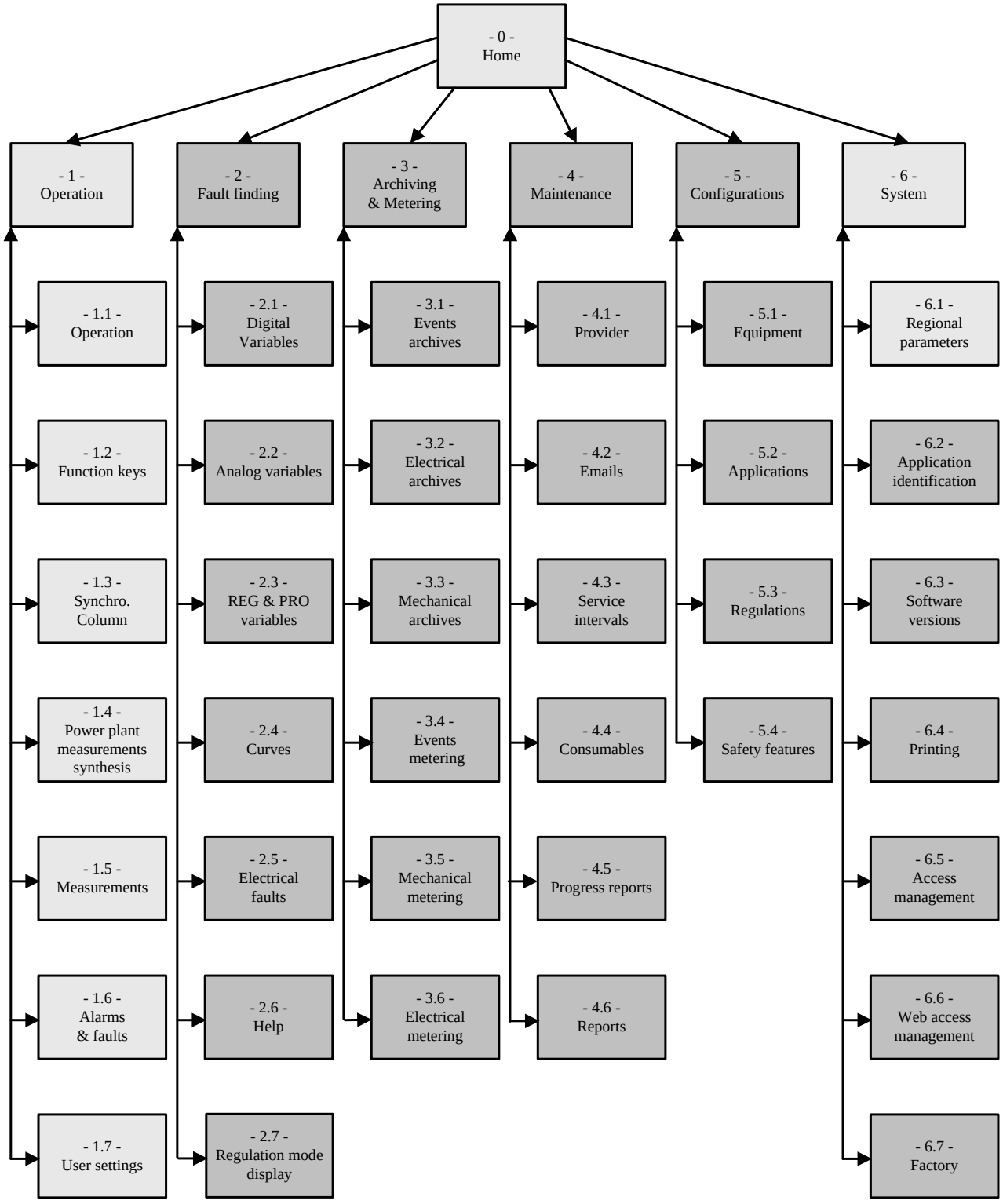
### 6.3.5.7. Client terminal block

Refer to the wiring diagrams according to the configuration selected and the requirements.

### 6.3.6 Operation and setting menus

#### 6.3.6.1. Layout of the menus

The diagram below shows the layout of the main menus.



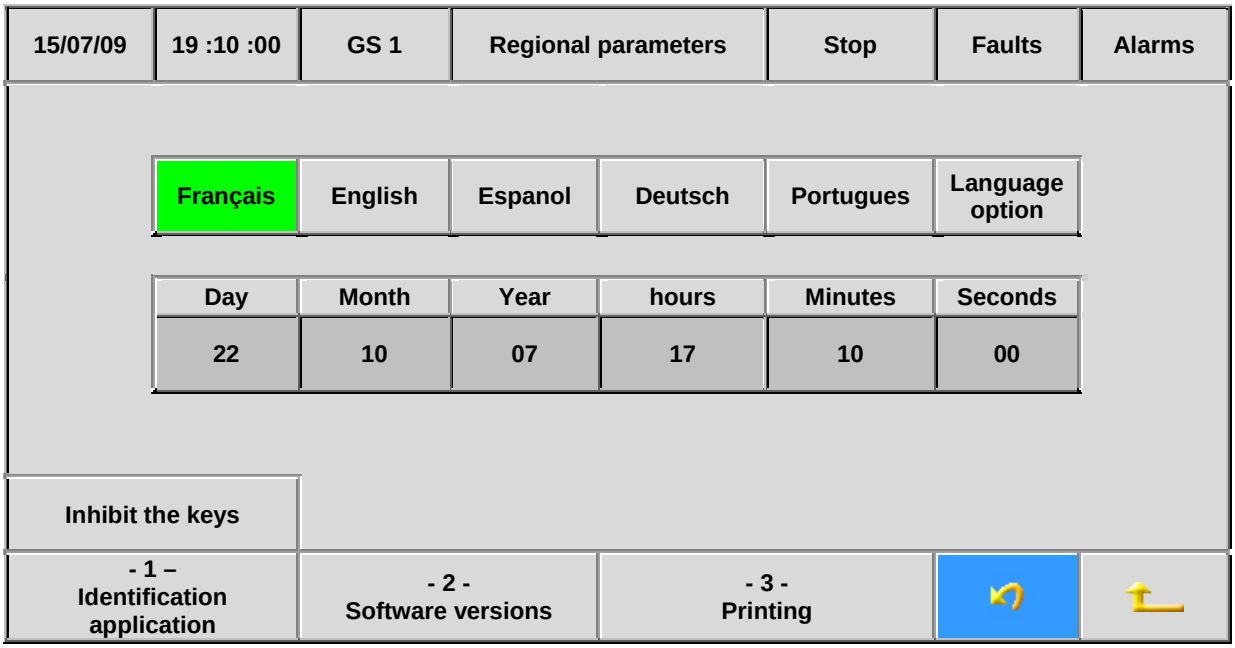

| | |
|---|---|
| Important | Only the menu functions on a white background are described in this manual. |

### 6.3.6.2. Setting of regional parameters

Without an input access code this screen allows:

- input of the display language
- setting of date and time

**Navigation reference: 6.1**

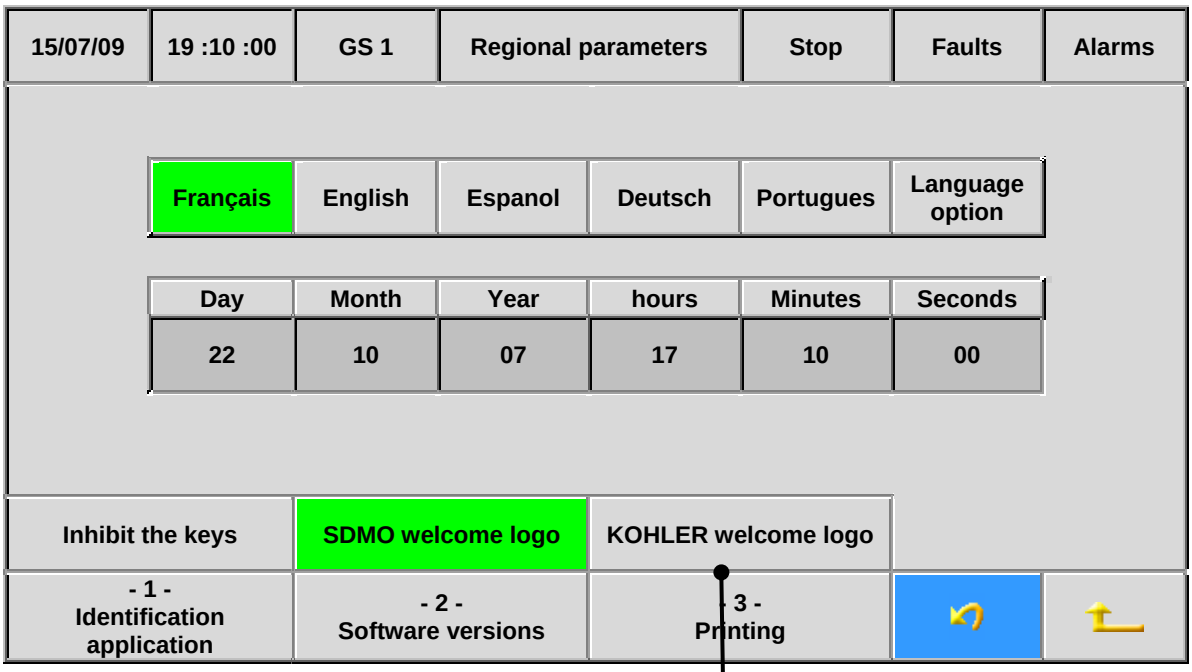



To clean the touch screen (dust, hydrocarbons, etc.) the key inhibition function prevents keys on the screen from being pressed for some twenty seconds. A special screen shows the time elapsing.

When an access code of a sufficient level is validated this screen also allows:

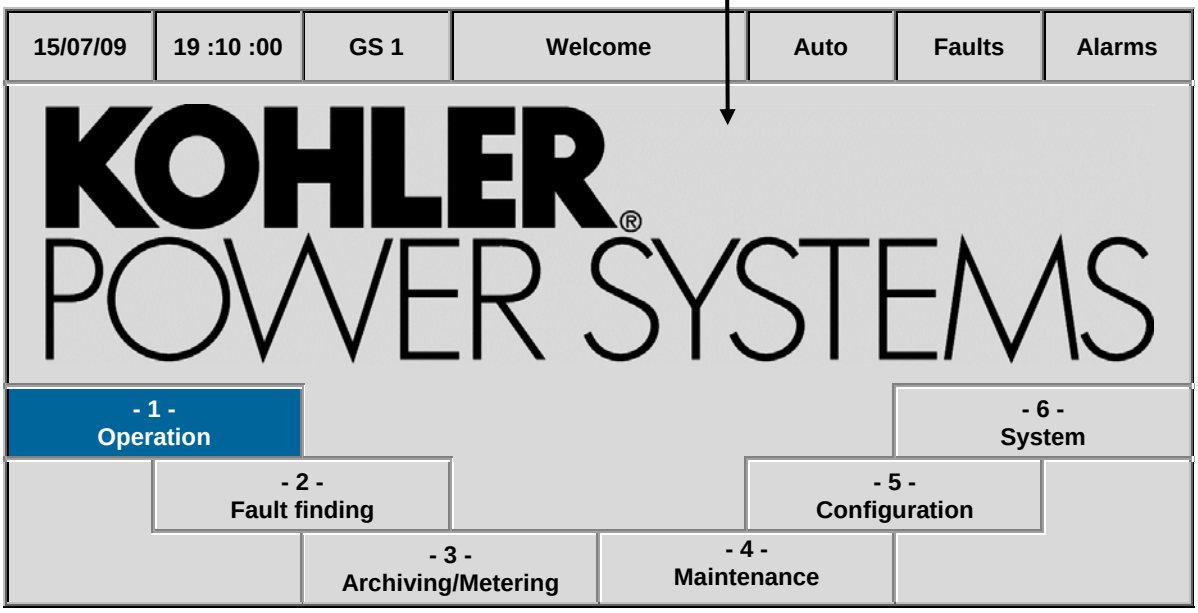
- Setting of the module synchronisation time
- Selection of the logo displayed on the Kerys home screen.

When the time setting by the SNTP protocol is not active the screen looks like this.

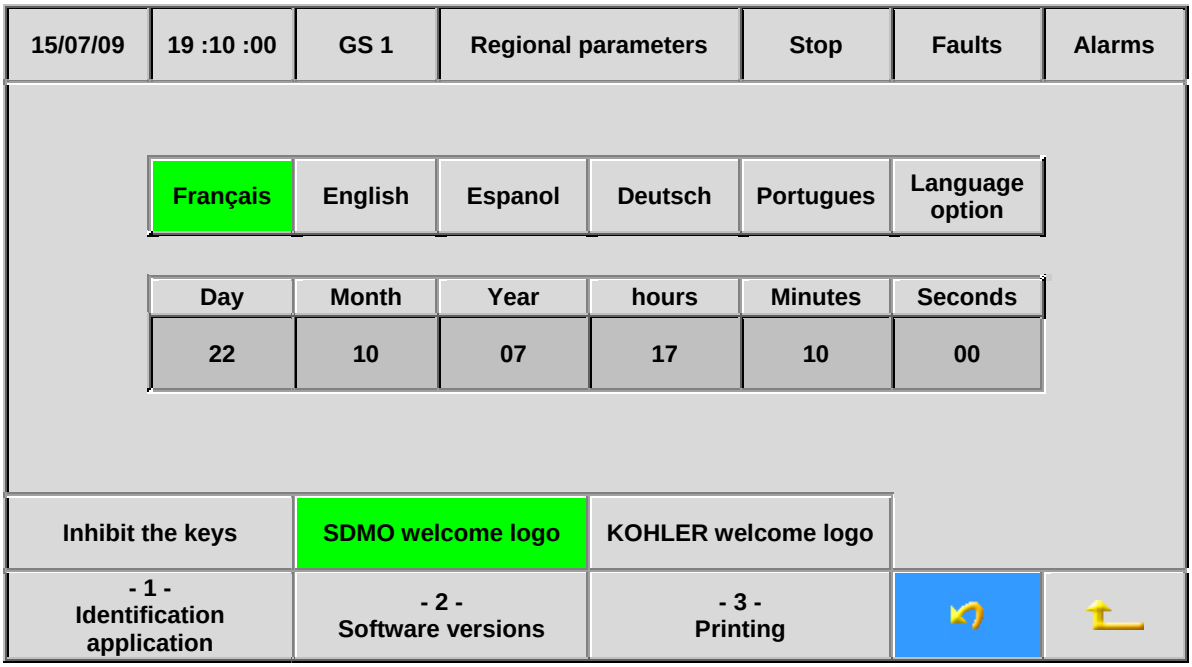



In this case the transmission of a signal to the bus, enabling the different real time clocks to be reset, is defined by the synchronisation time.

Pressing the “KOHLER home logo” key alters the appearance of the home screen by replacing the KOHLER logo with the SDMO logo as default. The home screen then looks like this:



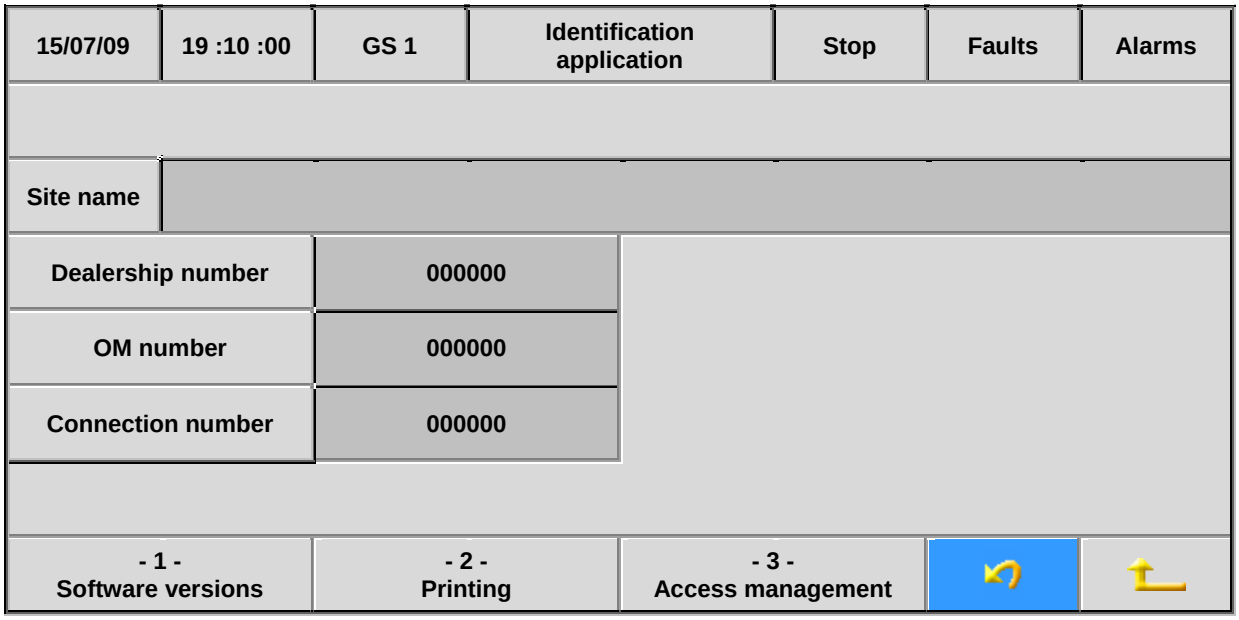
In the second case the screen has this appearance.




### 6.3.6.3. Information on the KERYS

**Indication of the application**
**Navigation reference: 6.2**

This screen enables SDMO to identify the project.
This information is required for queries sent to SDMO's customer service, so that the associated file can be consulted.




Project number: reference of the production file for the control equipment.

OM number: reference of the production file for the generating set.

Connection number: reference used to identify the site at the time of the telephone connection.

## Software version

**Navigation reference: 6.3**

The information relating to the software versions installed in the different modules is accessible from this menu. Only the lines corresponding to the installed equipment appear

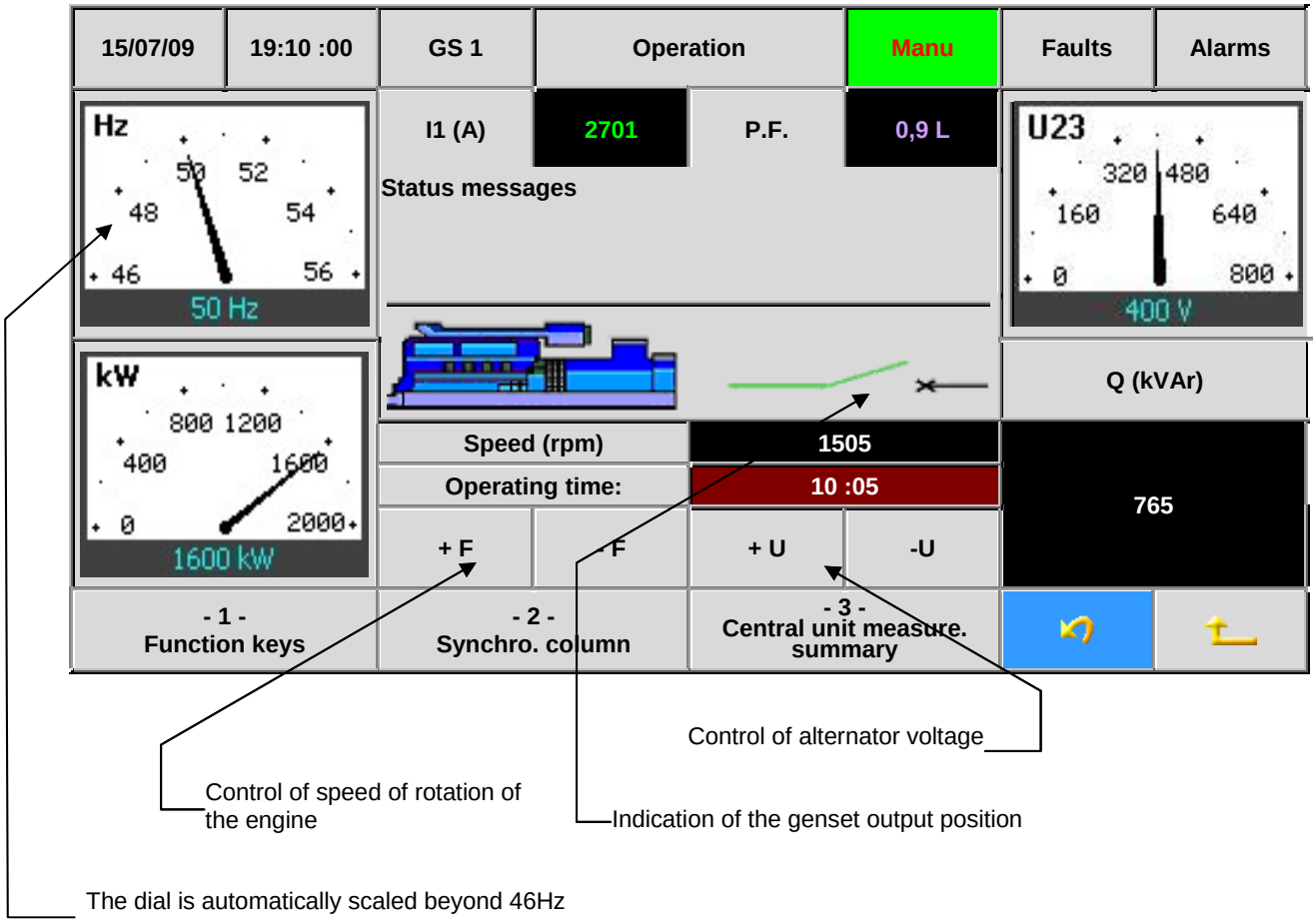
| 15/07/09 | 19 :10 :00 | GS 1 | Software versions | Stop | Faults | Alarms |
|---|---|---|---|---|---|---|
| | Module | | Software versions | Software version dates | | |
| | IHM | | 0.00 | 00/00/00 | | |
| | Base | | 0.00 | 00/00/00 | | |
| | Resident logic | | 0.00 | 00/00/00 | | |
| | Regulation | | 0.00 | | | |
| | Protection | | 0.00 | | | |
| | Engine | | 0.00 | | | |
| - 1 - Identification application | | - 2 - Printing | | - 3 - Access management | | |

### 6.3.6.4. Operating menus

**Operation**

This main screen displays all the main electrical parameters of the generating set.
It is the general operating and monitoring screen for the generating set.
This screen can also be displayed by pressing the indicator displaying the operation mode of the generating set.
The frequency, U23 voltage, active and reactive power indicators, can be displayed in analog or digital form. Switching from one mode to another is performed by pressing the desired indicator.

**Navigation reference: 1.1**



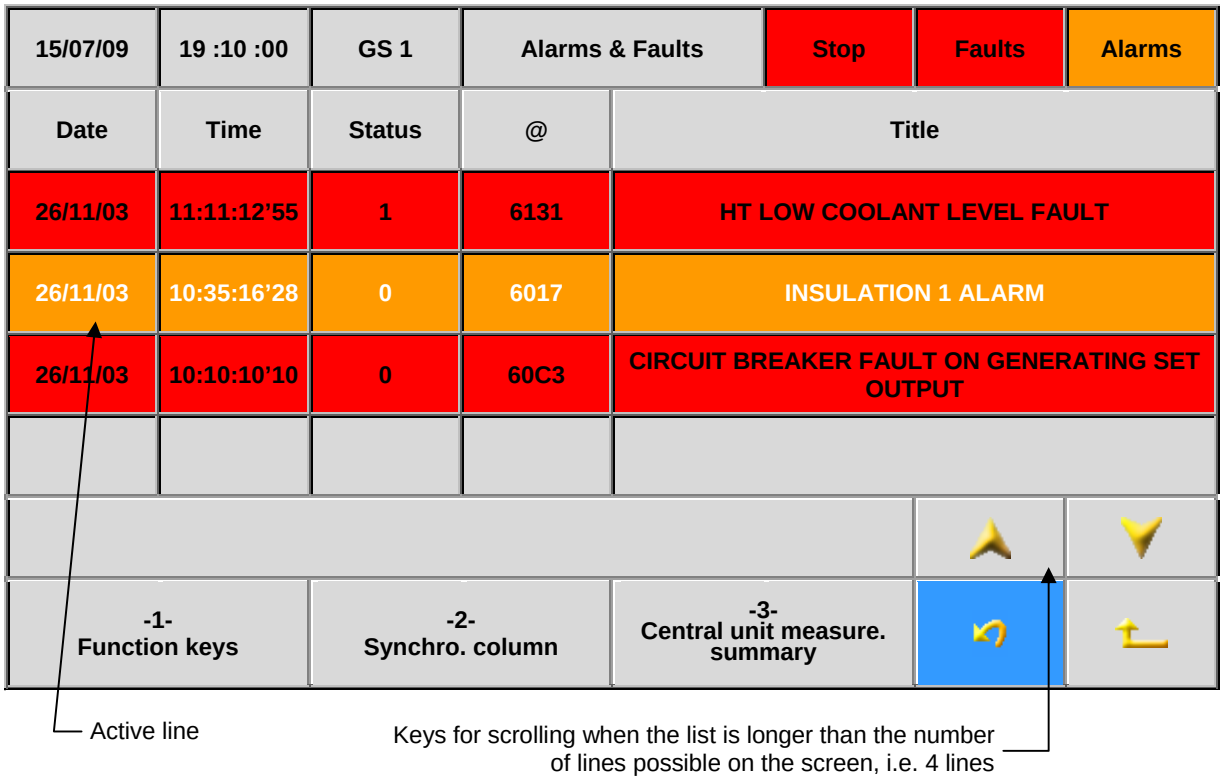

In the needle dials the nominal values are in blue

| | |
|---|---|
| Important | The speed and voltage adjustment keys are only displayed for coupled applications in manual mode. |

**Alarms and faults**

This menu can also be called directly by pressing the flashing **"Alarms"** and **"Faults"** keys on the upper band.
This screen allows the user to view the list of faults present on the installation.
The first two columns give details of the date and time that the fault appeared.
The **"Status"** column indicates whether the fault is still present **"1"**, or not present **"0"**.
The "**@**" column gives the address of the variable associated with the fault.
The **"Text"** column identifies the type of fault.
A line with a red background characterises a fault and a line with an orange background characterises an alarm.

**Navigation reference: 1.6**




To clear a fault, it is necessary to:

- check that the fault has disappeared (status **0**) and whether it is necessary to eliminate its causes
- select the line in question; the text on the line is displayed in white
- press the **"Reset"** key on the keypad; the line is deleted.

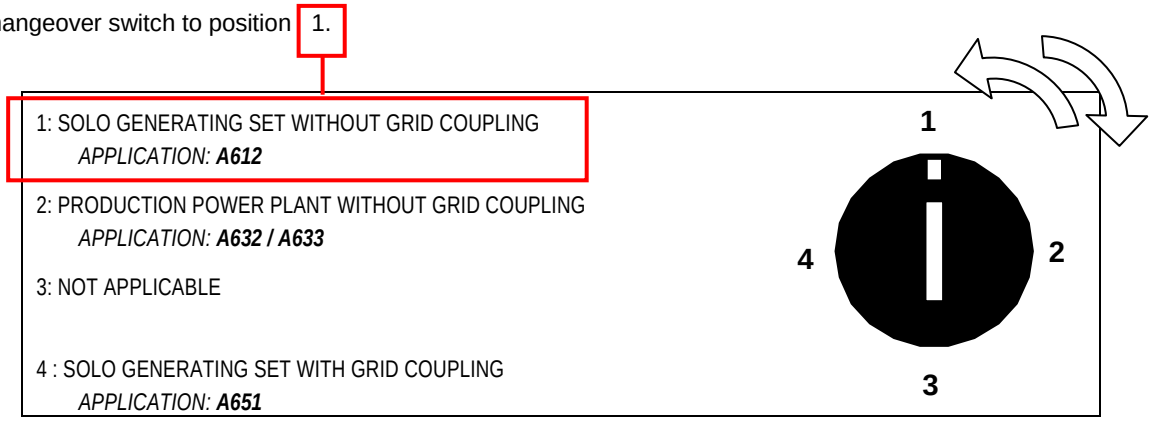
| | |
|---|---|
| Important | When a fault is displayed, its effect on the operation remains active even if its cause has disappeared. When in Manu or Auto mode, if the user wants to clear a fault with a "stopped" clearance mode, a screen will inform the user to switch to stop mode. |

### 6.3.7 Rental configurations

#### 6.3.7.1. Choice of application configuration

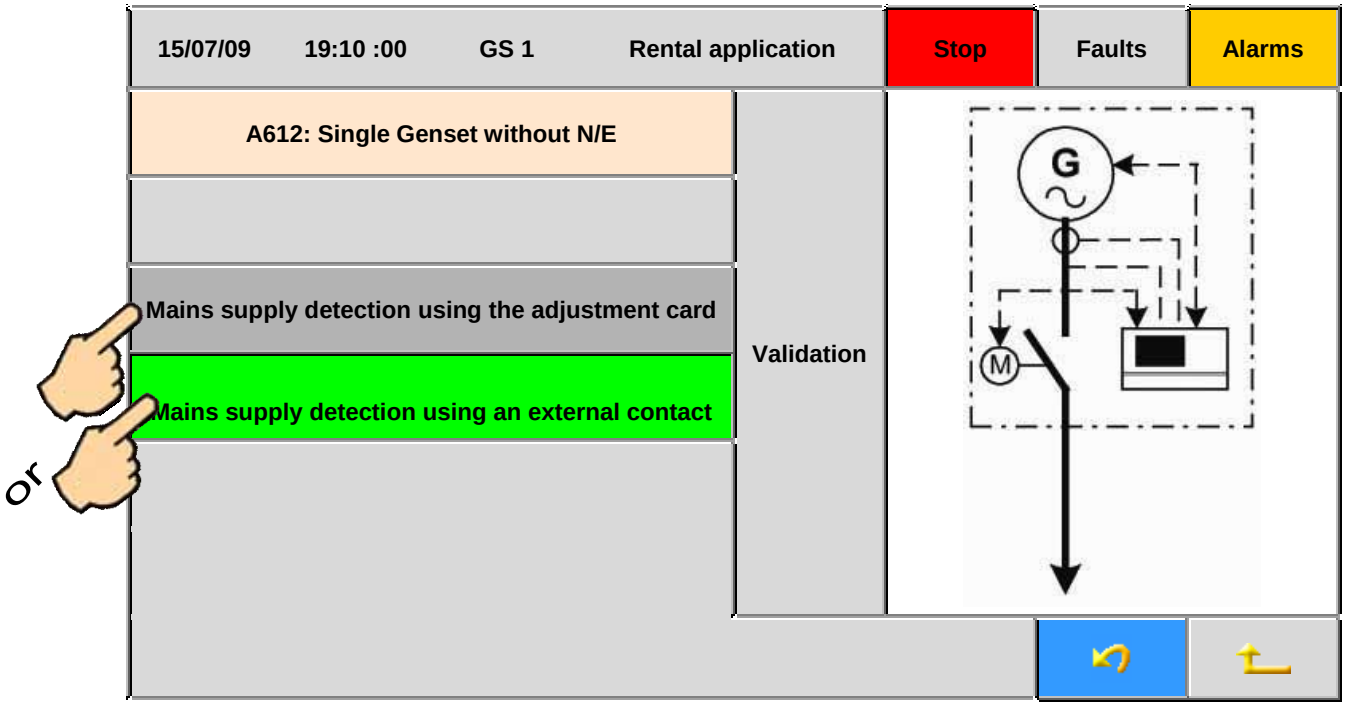
**Solo generating set Without inverter (A612)**

1. Turn off the battery isolator switch.
2. Check that the emergency stop buttons are activated.
3. Press the “STOP” button on the KERYS.
4. Turn the changeover switch to position 1.




(If the switch is already set to “**1**”, turn the switch and return to position ‘‘**1**’’)

After changeover, the screen below appears.



5. Select the configuration of the mains detection of the generating set by clicking directly on the touch screen.

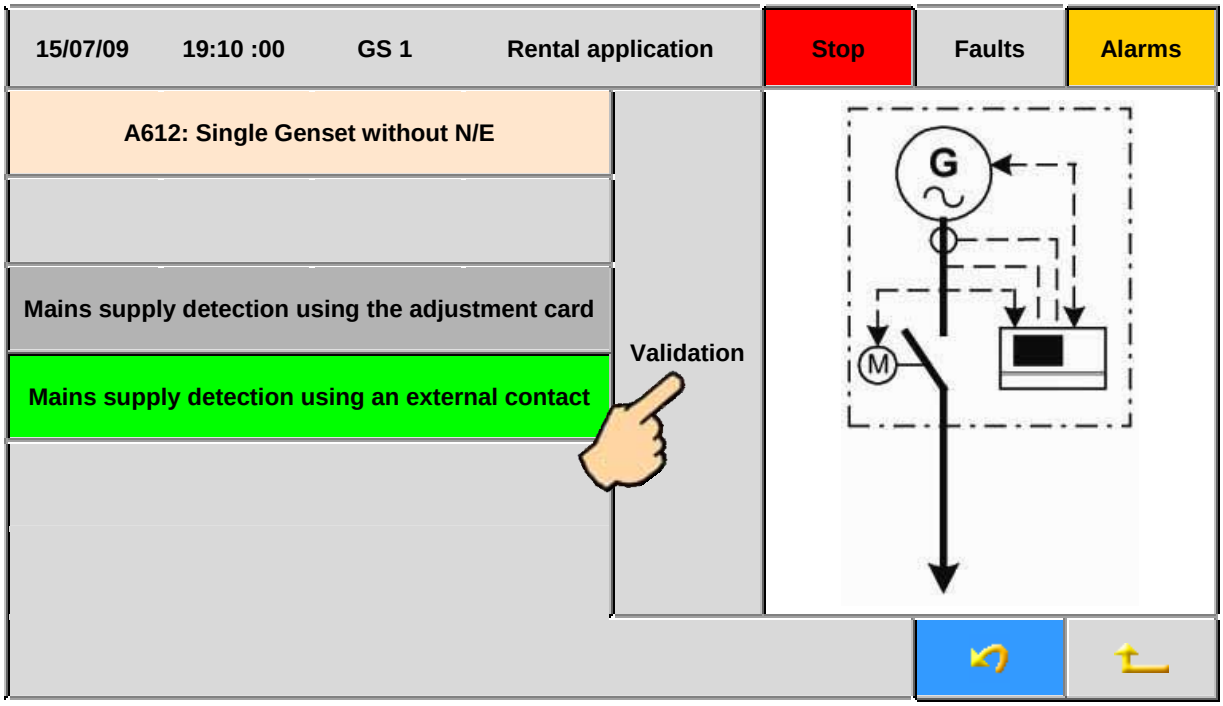
   ✓ For a **mains detection by means of the regulation card** you must select the configuration **"Mains supply detection using the adjustment card"** and connect the voltage reference to the terminals **Xcbc1 - 1-2-3**.

   ✓ For **mains detection by an external switch** you must select the configuration **"Mains supply detection using an external contact"** and connect the external switch to the terminals **Xcbc3 - 34-35**.

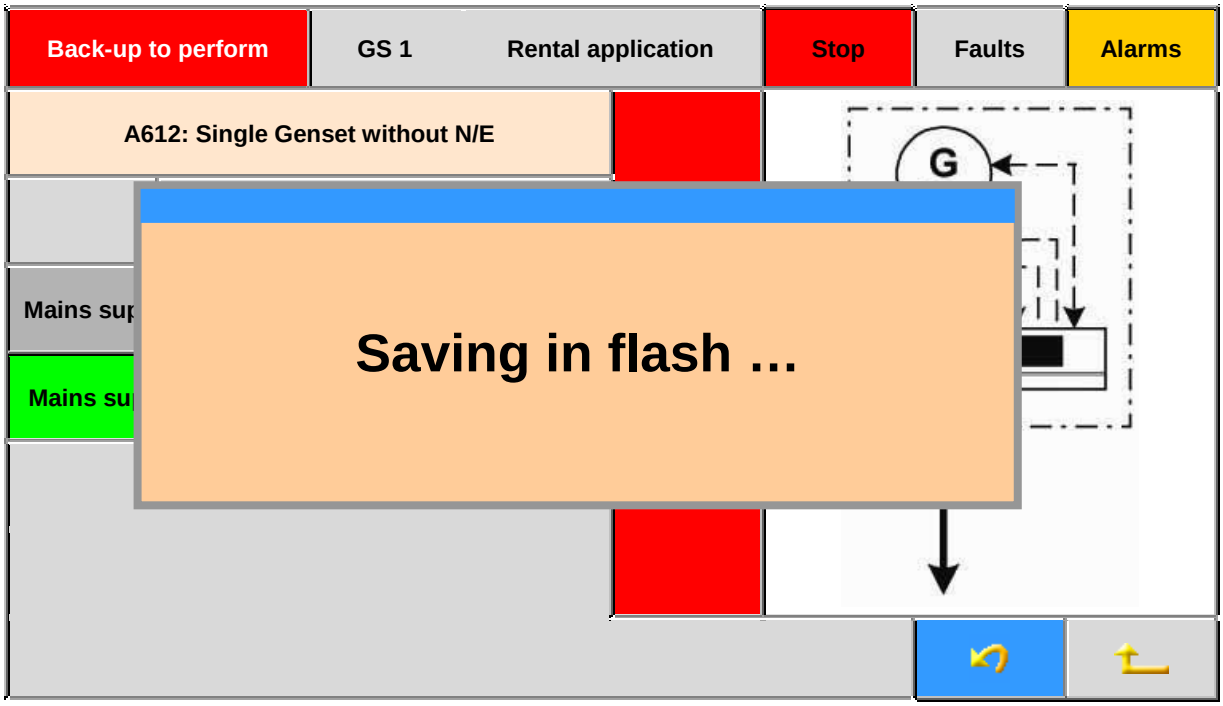
   ✓ For **starting by means of an external switch** you must select the configuration **"Mains supply detection using an external contact"** and connect the external switch to the terminals **Xcbc3 - 32-33**.

   ✓ For **solo starting**, in the absence of a mains connection, you must select the configuration **"Mains supply detection using an external contact"**. **No connection** is necessary.

| | |
|---|---|
| **Important** | **N.B. selecting detection depends on the connection made according to Section "Connections of the generating sets".** |




6. Press "Validation" on the touch screen.

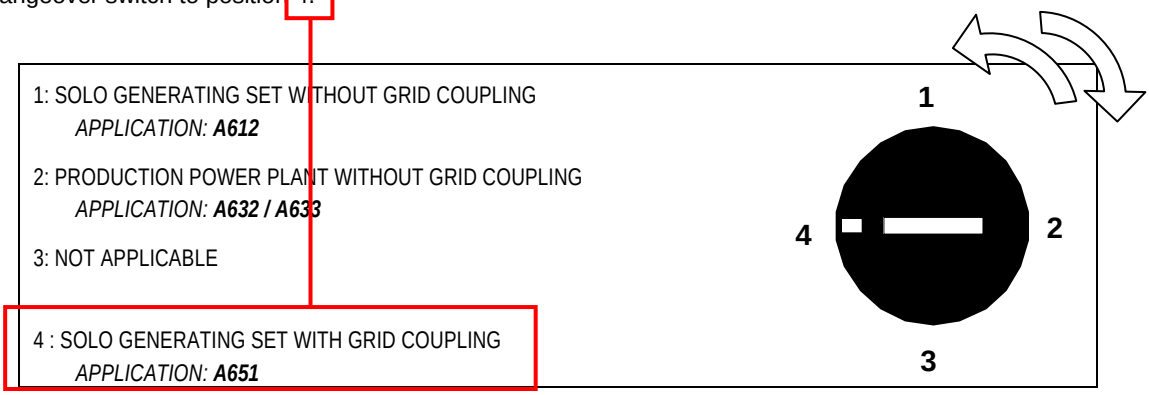



7. The KERYS saves your new configuration.
8. After return to the KERYS home screen,

| | |
|---|---|
| Important | **The configuration will only be taken into account if the following operations are carried out:**<br>✓ **Turn on the battery isolator switch.**<br>✓ **Wait 5 seconds.**<br>✓ **Turn off the battery isolator switch.** |

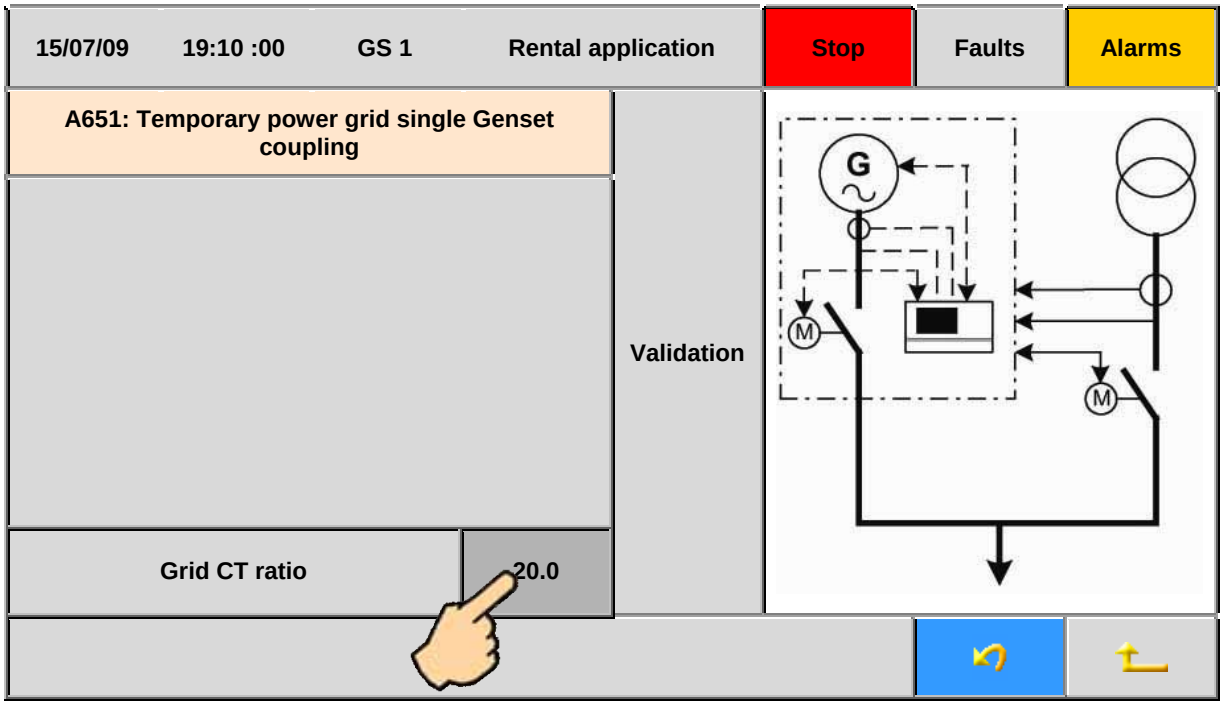
## Solo generating set, CRF coupling (A651)

1. Turn off the battery isolator switch.
2. Check that the emergency stop buttons are activated.
3. Press the “STOP” button of the KERYS.
4. Turn the changeover switch to position 4.

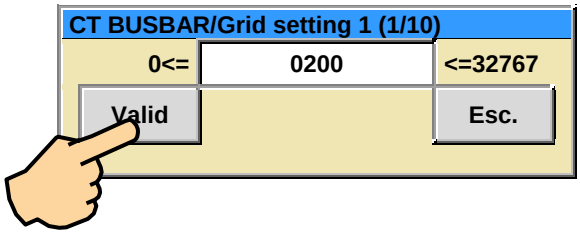



(If the switch is already set to “**4**”, turn the switch and return to position ‘‘**4**’’)

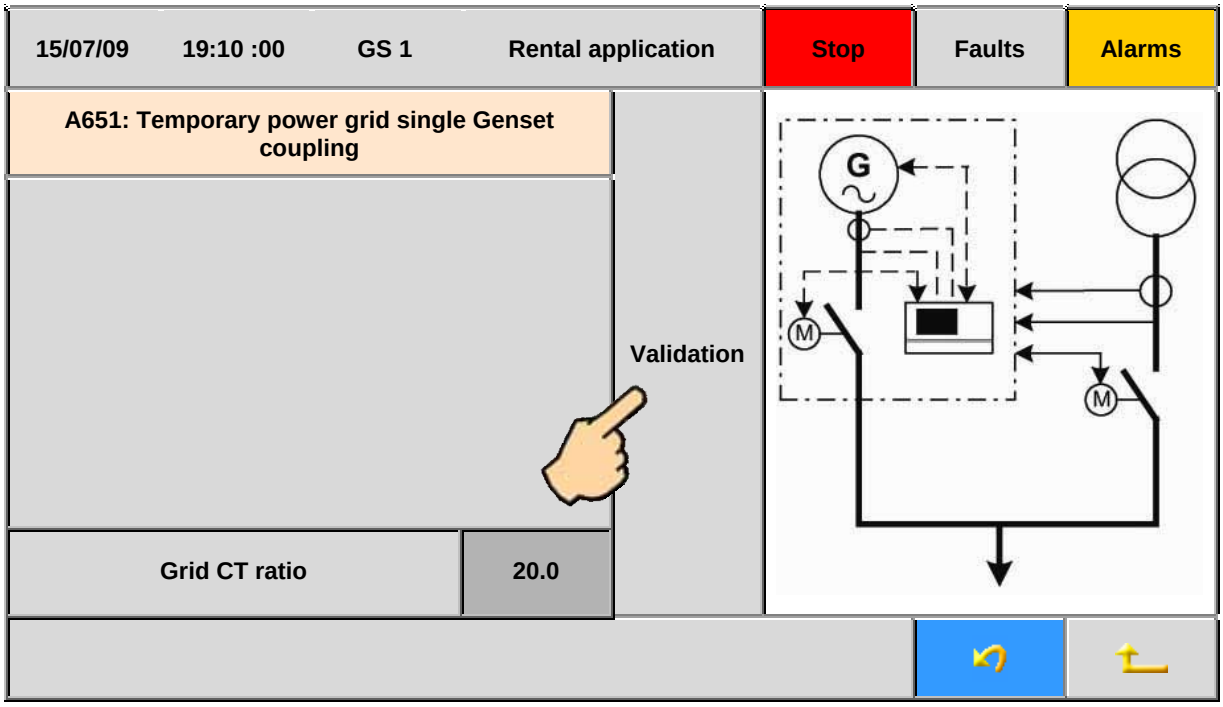
After changeover, the screen below appears.



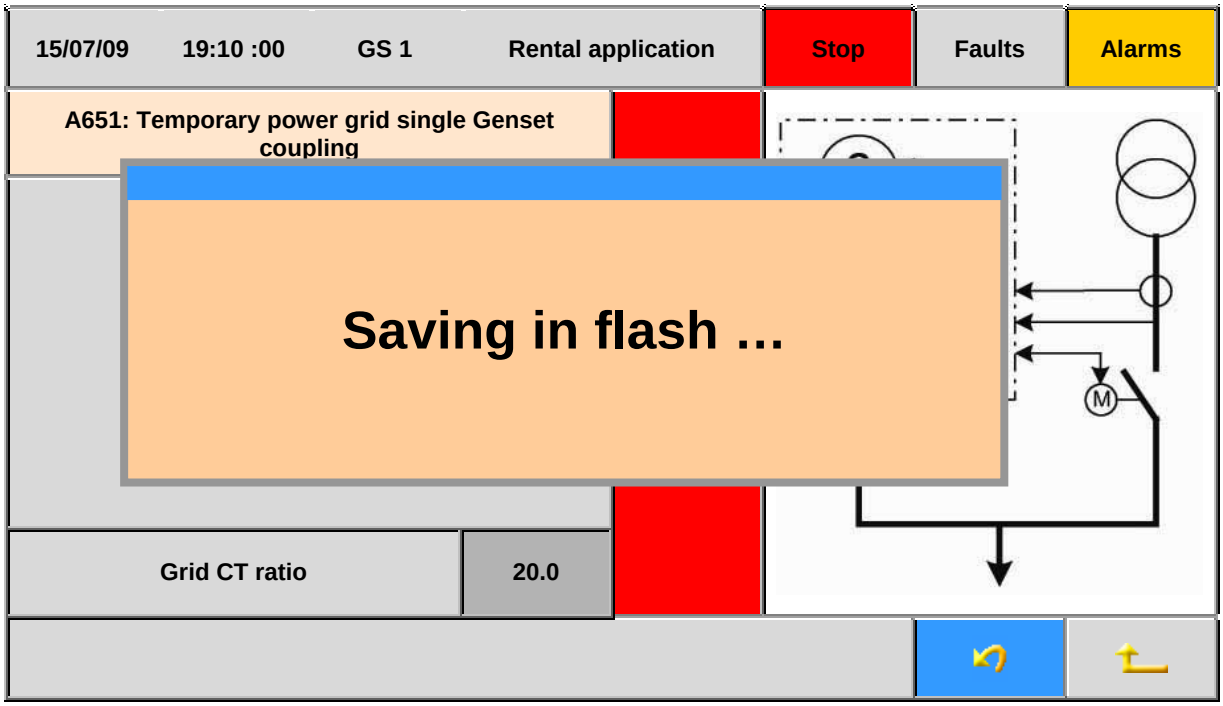

5. To enter the value of the grid current transformer ratio: press the **"GRID CT RATIO"** button on the touch screen.
   ✓ Using the alphanumeric keys of the MICS KERYS: enter the value of the CT ratio in tenths.
   Example: CT = 100A/5A (calculation: 100/5 =***20***; ***20***x10=**200**) value to be entered **200**.


6. Then press "**VALID**" .




7. Press the “Validation” button on the touch screen.



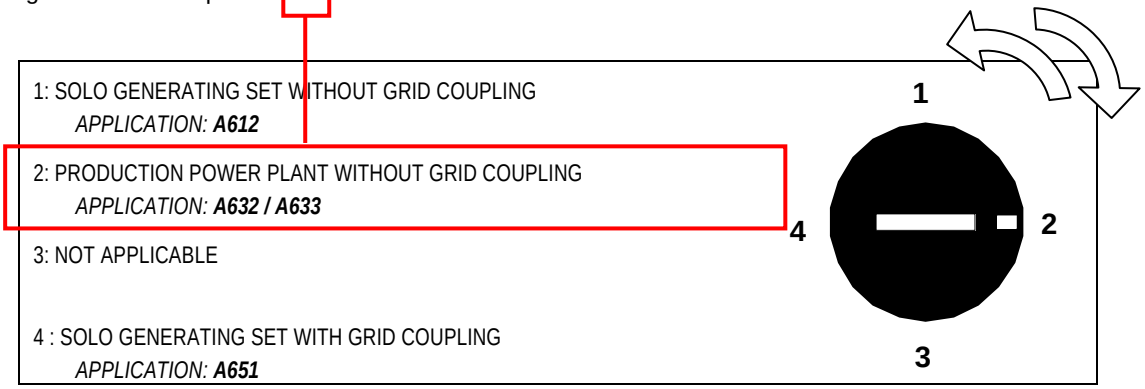

8. The KERYS saves your new configuration.

9. After return to the KERYS home screen,

| | |
|---|---|
| Important | **The configuration will only be taken into account if the following operations are carried out:**<br>✓ **Turn on the battery isolator switch.**<br>✓ **Wait 5 seconds.**<br>✓ **Turn off the battery isolator switch.** |

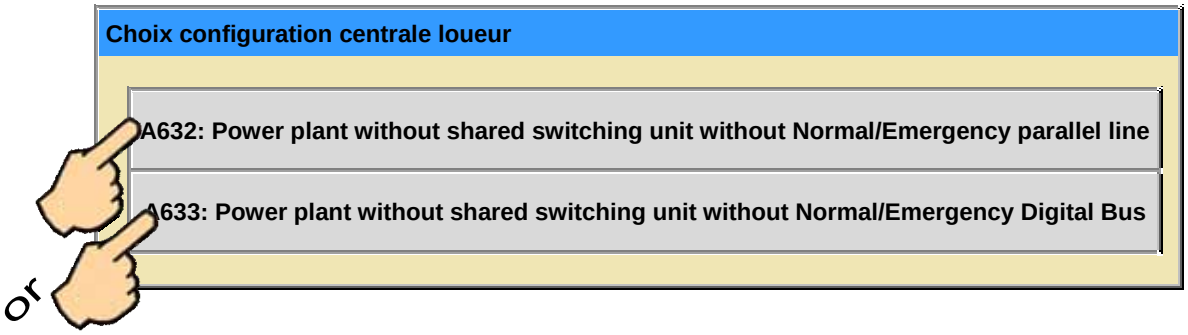
**Power plant Without common part and without inverter (A632-A633)**

1. Turn off the battery isolator switch.
2. Check that the emergency stop buttons are activated.
3. Press the “STOP” button on the KERYS.
4. Turn the changeover switch to position 2.



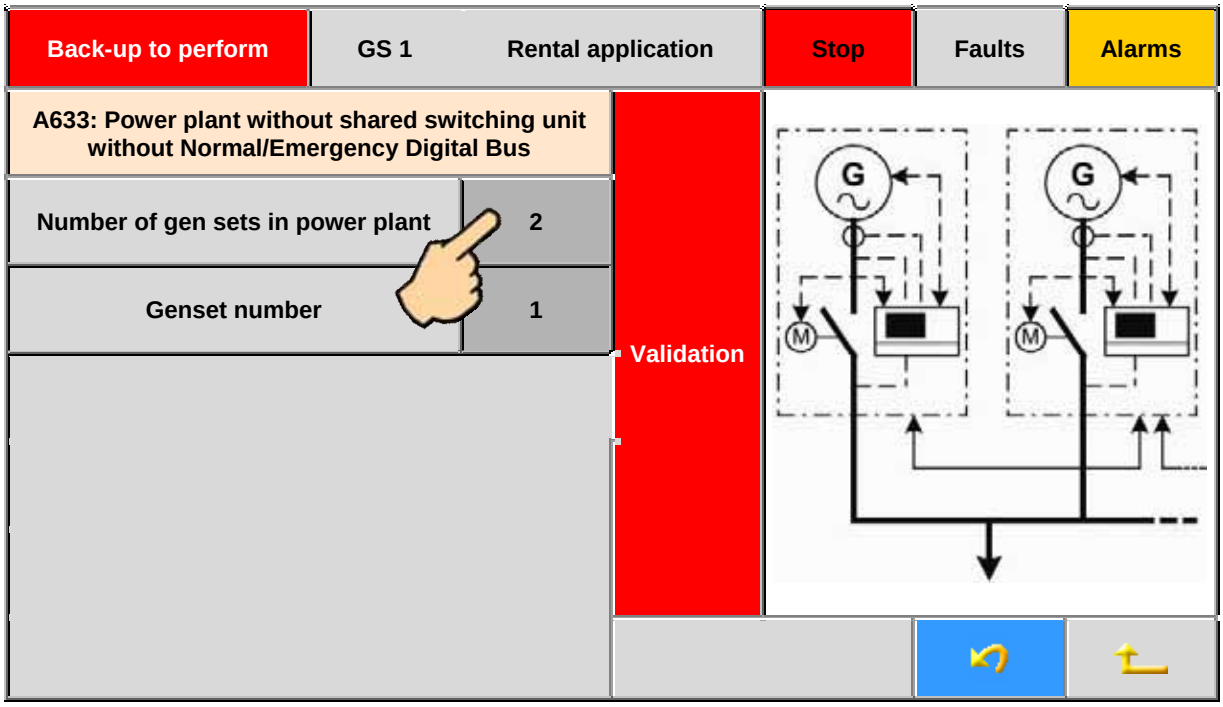

(If the switch is already set to “**2**”, turn the switch and return to position ‘‘**2**’’)

After changeover, the screen below appears.

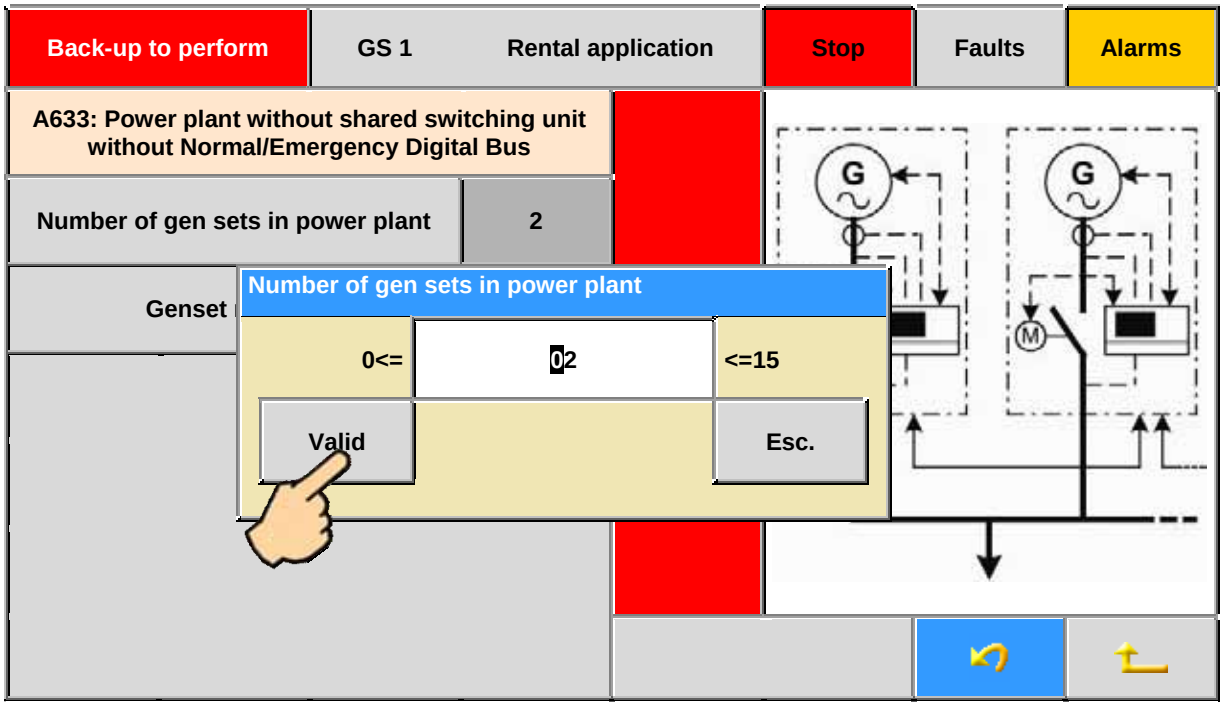



5. Select the configuration “**A632: Power plant without shared switching unit without Normal/Emergency parallel line”** by directly clicking on the touch screen.
   Select the configuration “**A633: Power plant without shared switching unit without Normal/Emergency Digital Bus”** by clicking directly on the touch screen.

| | |
|---|---|
| Important | **N.B. selecting detection depends on the connection made according to Section 5. “Connections of the generating sets”.** |

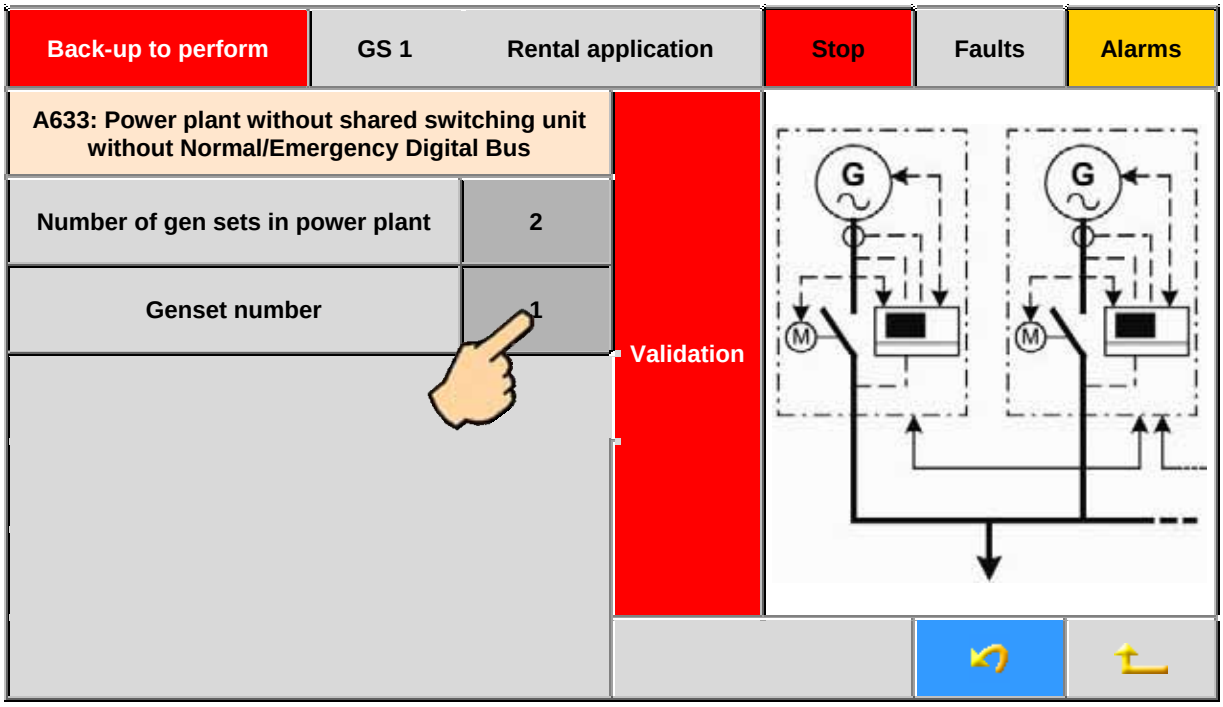



6. Press the generating set number on the touch screen.

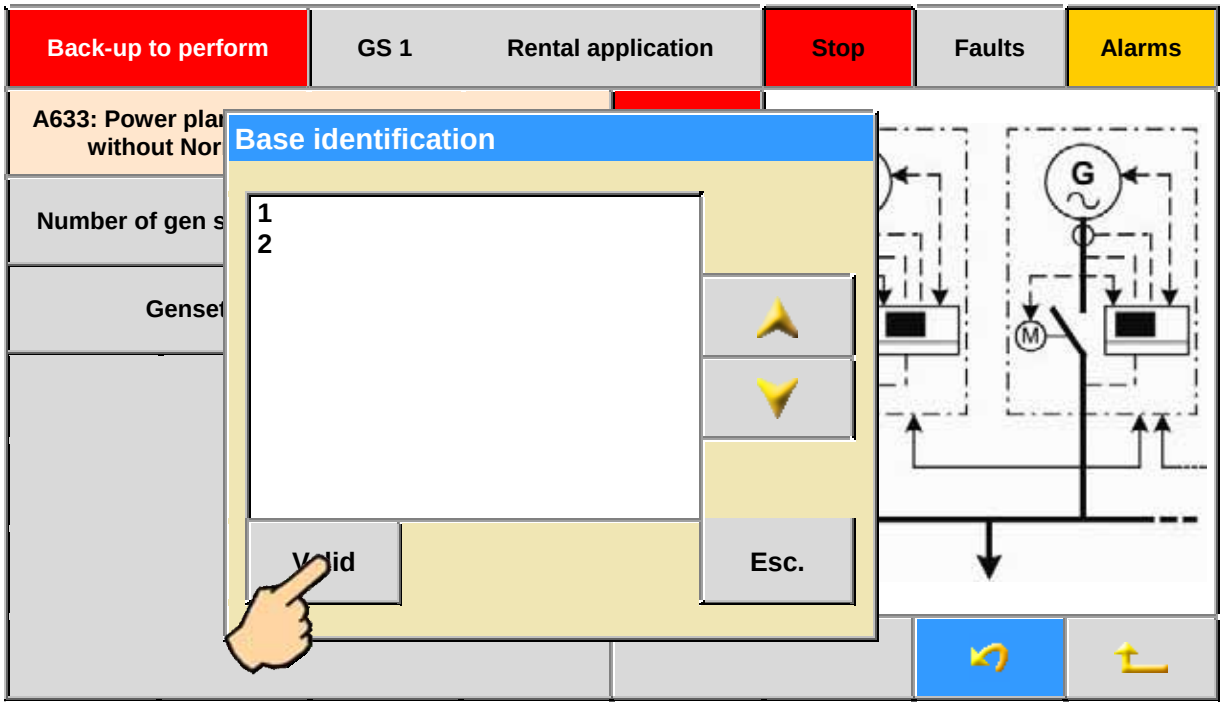



7. Enter the number of generating sets in the power plant using the numeric keypad.
   Start with “0” if the number is less than 10 generating sets.
   E.g.: 2 generating sets ⇨ enter 0 then 2; 10 generating sets ⇨ enter 1 then 0.

8. Press “Valid” to confirm the entry.



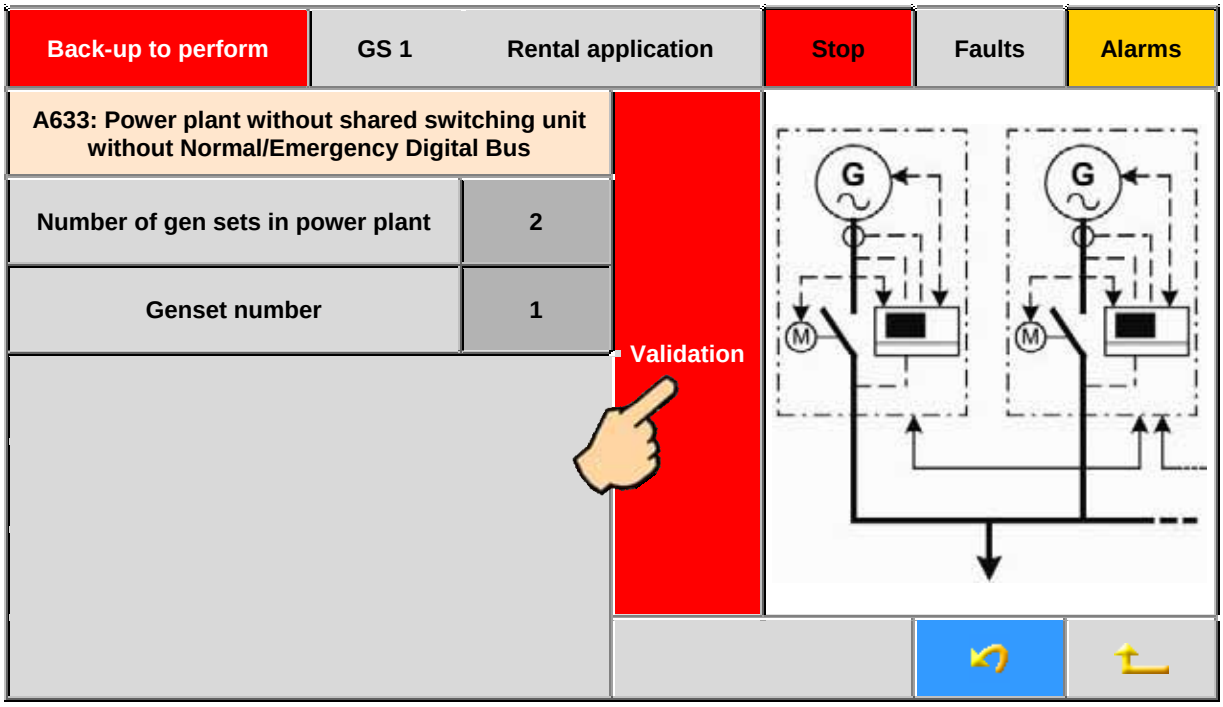

9. Press the generating set number on the touch screen.



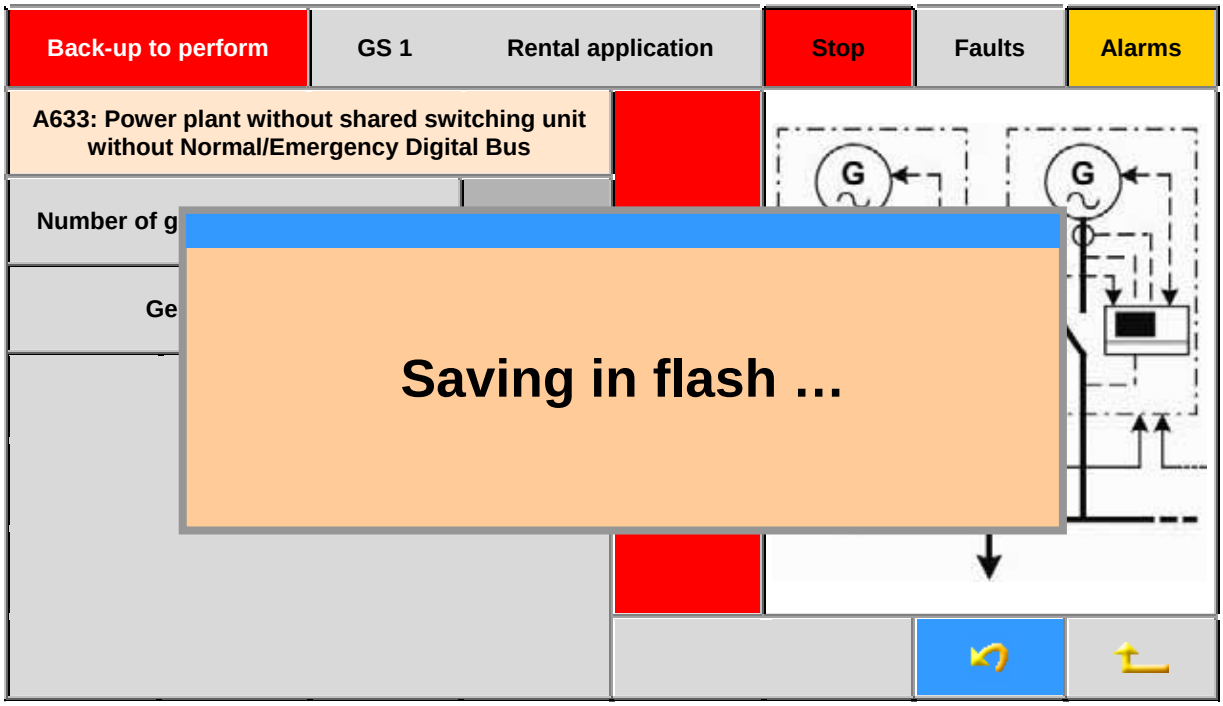

10. Select the number of the generating set with the arrows.

| | |
|---|---|
| Important | **The number of the generating set determines its type of connection, see the section “Electrical connections”** |

11. Press “Valid” to confirm the entry.




12. Press “Validation" on the touch screen.




13. The Kerys saves your new configuration.

14. After returning to the Kerys home screen,

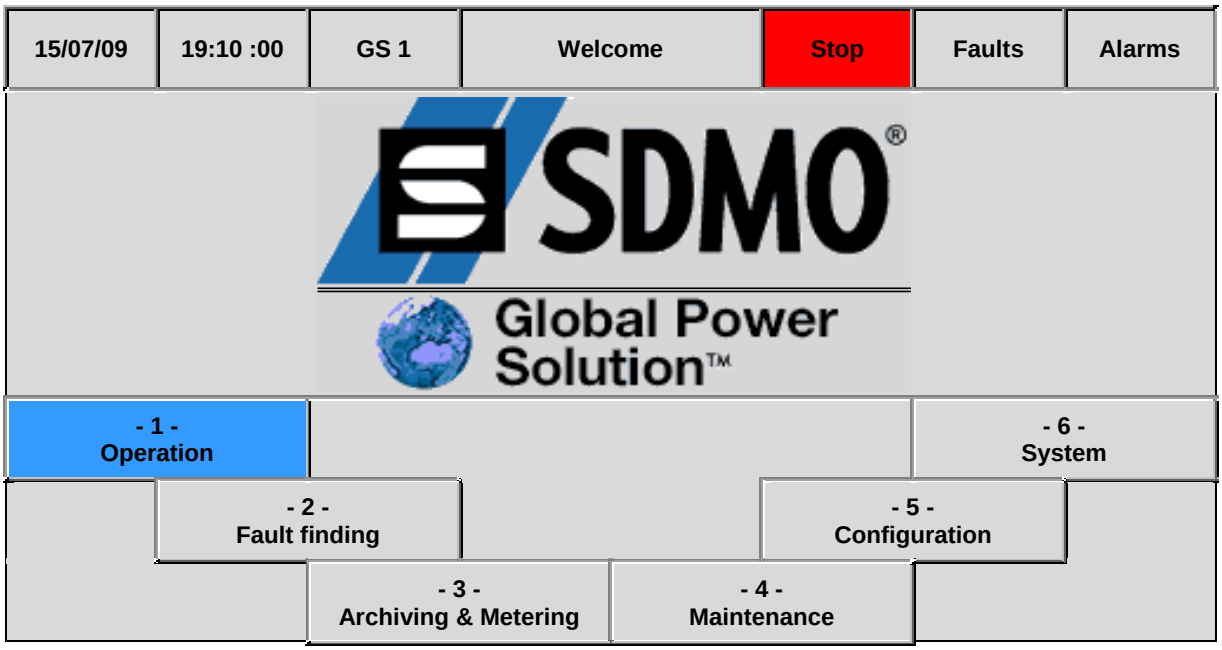
| | |
|---|---|
| Important | **The configuration will only be taken into account if the following operations are carried out:**<br>✓ **Turn on the battery isolator switch.**<br>✓ **Wait 5 seconds.**<br>✓ **Turn off the battery isolator switch.** |

| | |
|---|---|
| Important | **Operations to be carried out on each generating set of the power plant.** |

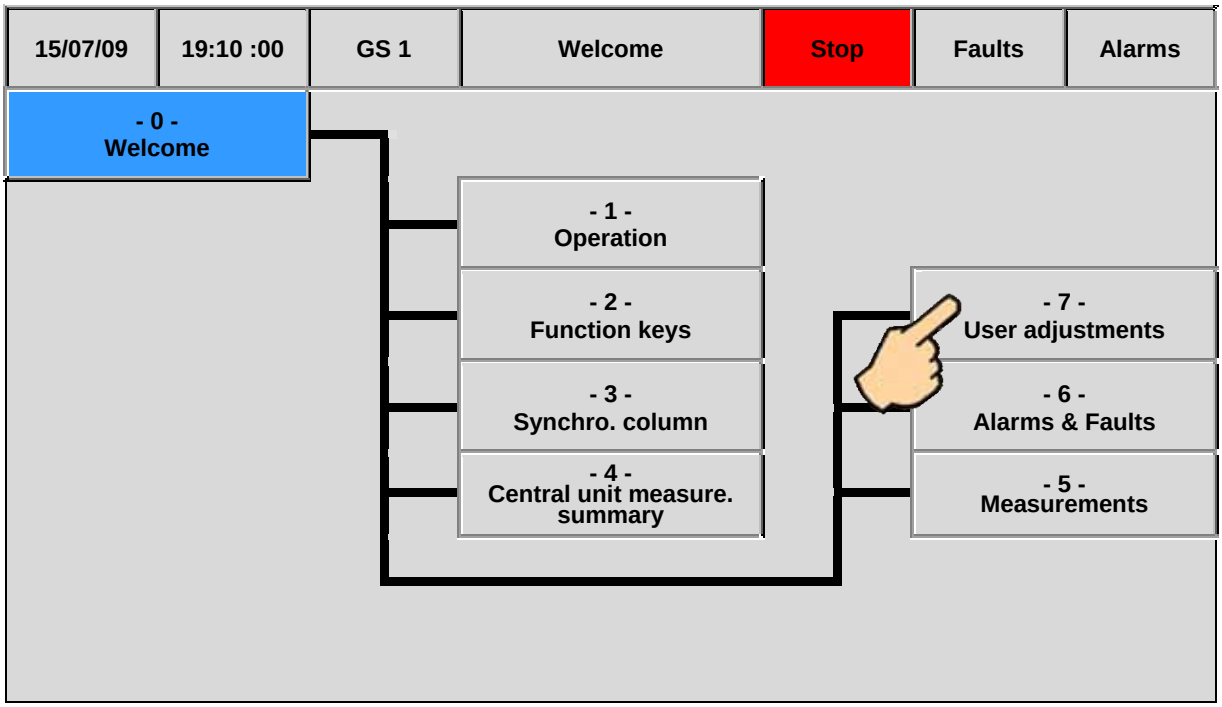
### 6.3.8 Use

#### 6.3.8.1. Choice of priority generating set in power plant (if equipped)

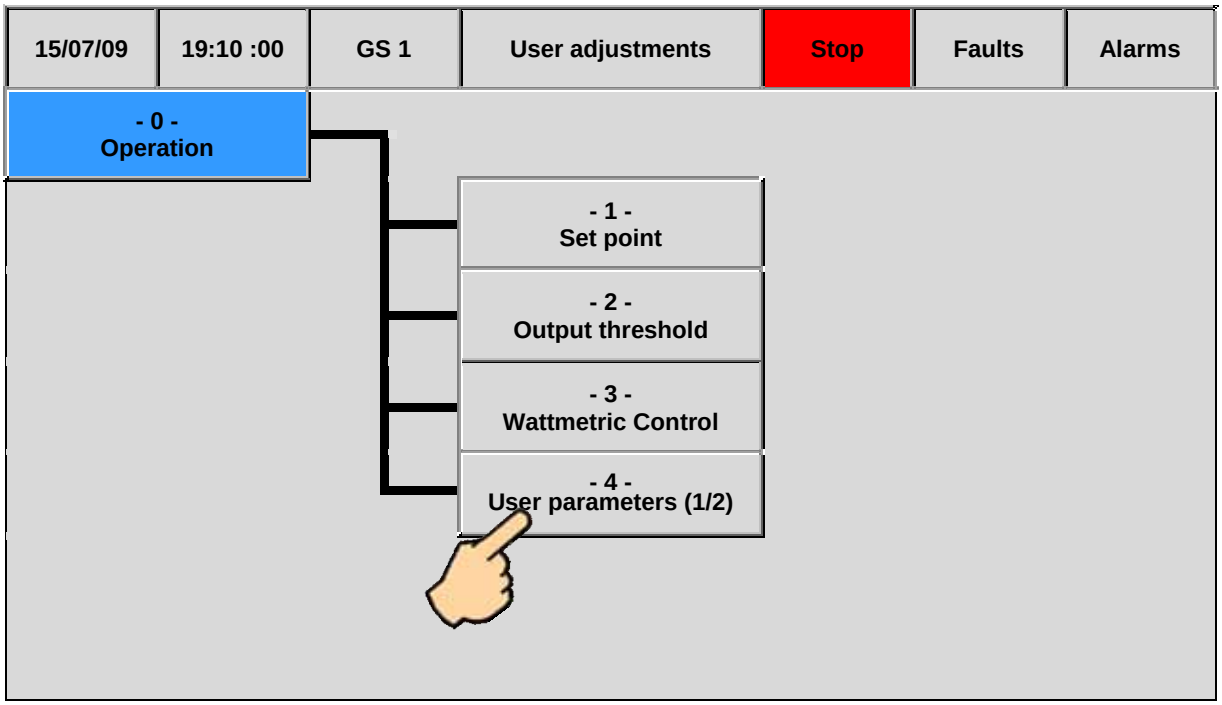
**Mnemonic aid info for menus:**
**"1" – "7" – "4" – "3" – "GS selection" "Priority selection" "Valid"**



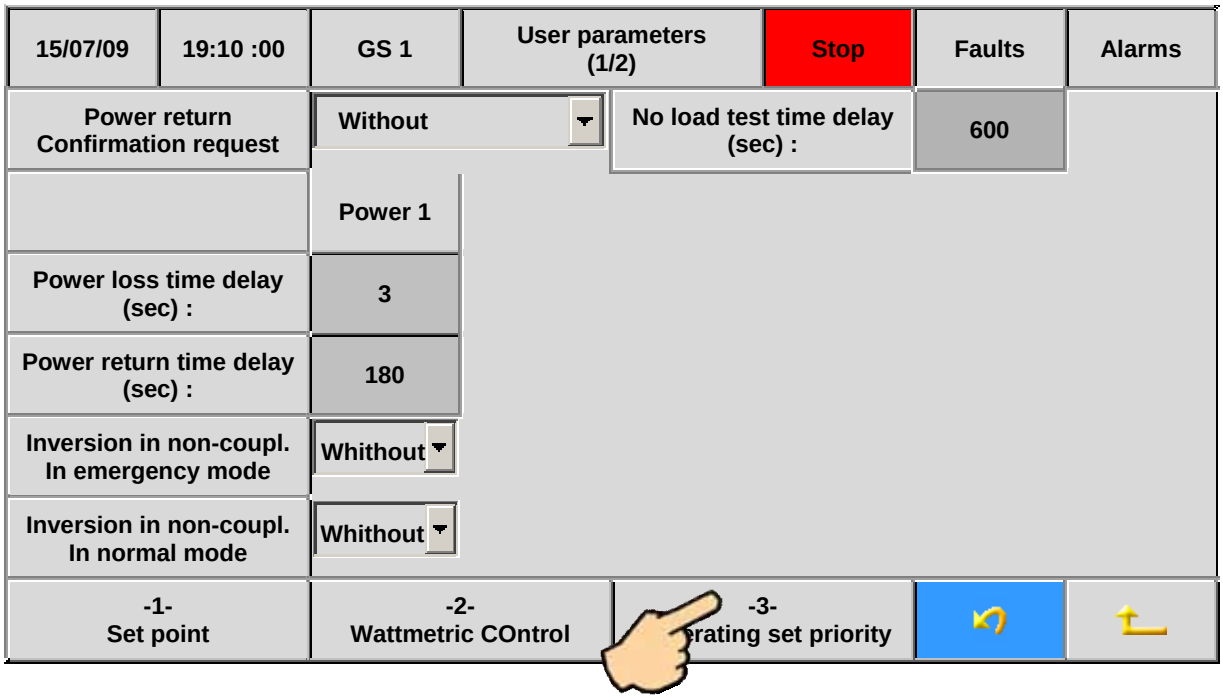

1. Press "Operation" on the touch screen.



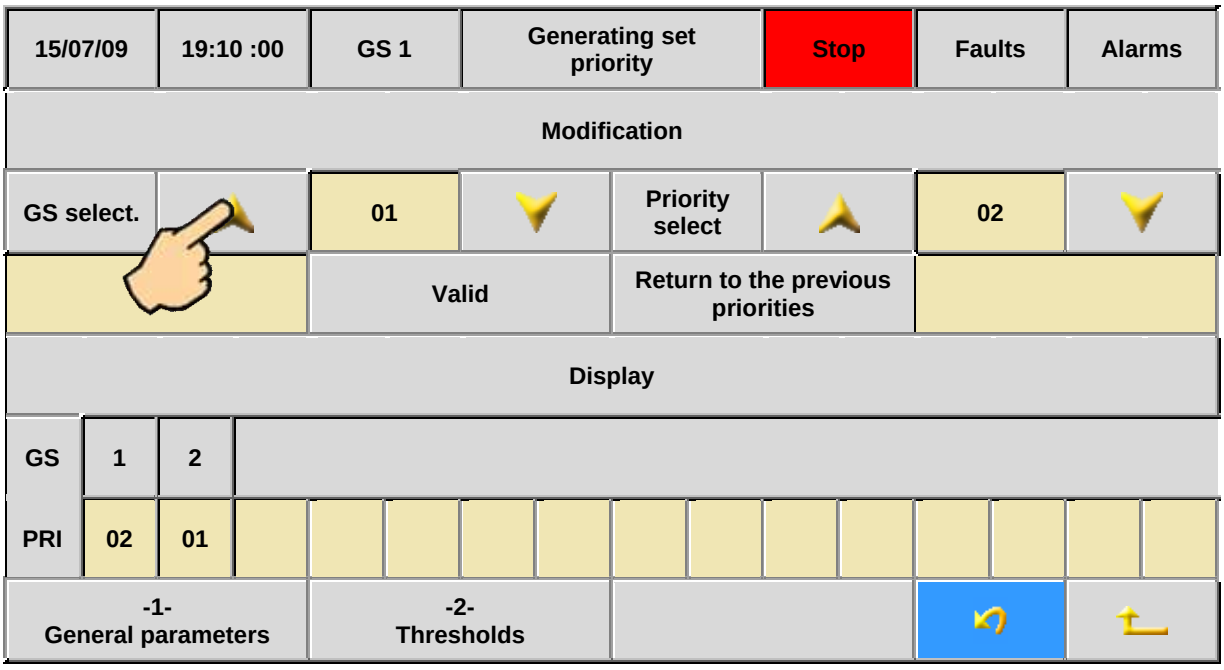

2. Press “User settings” on the touch screen.



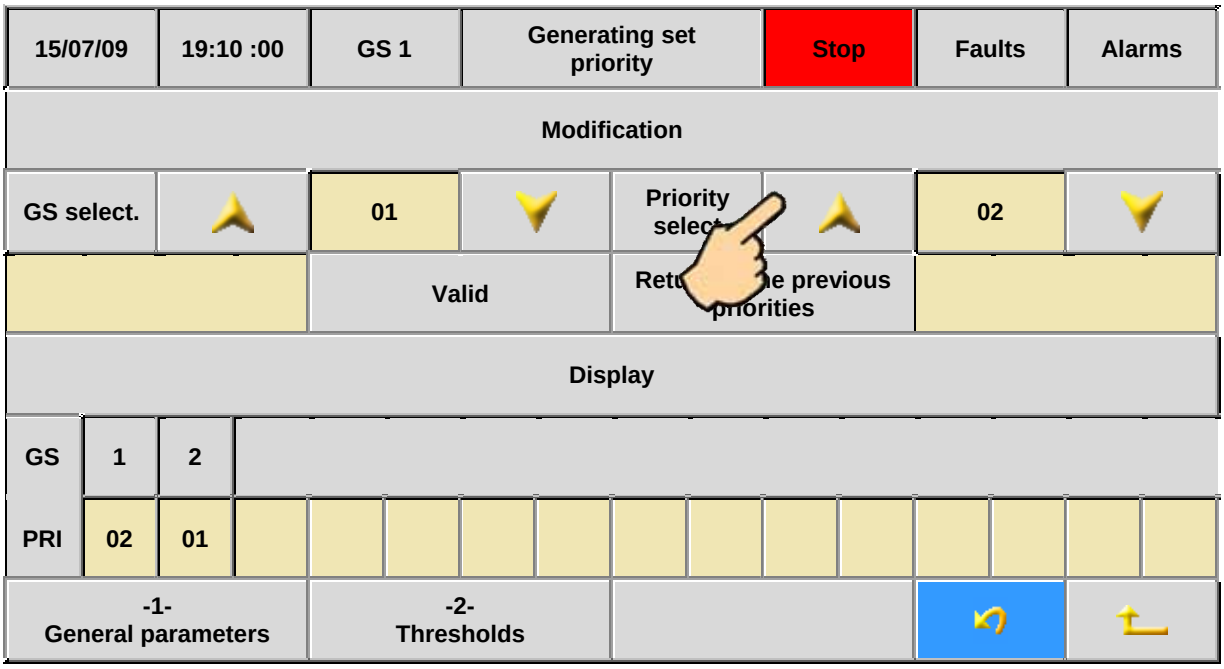

3. Press “User parameters (1/2)” on the touch screen.



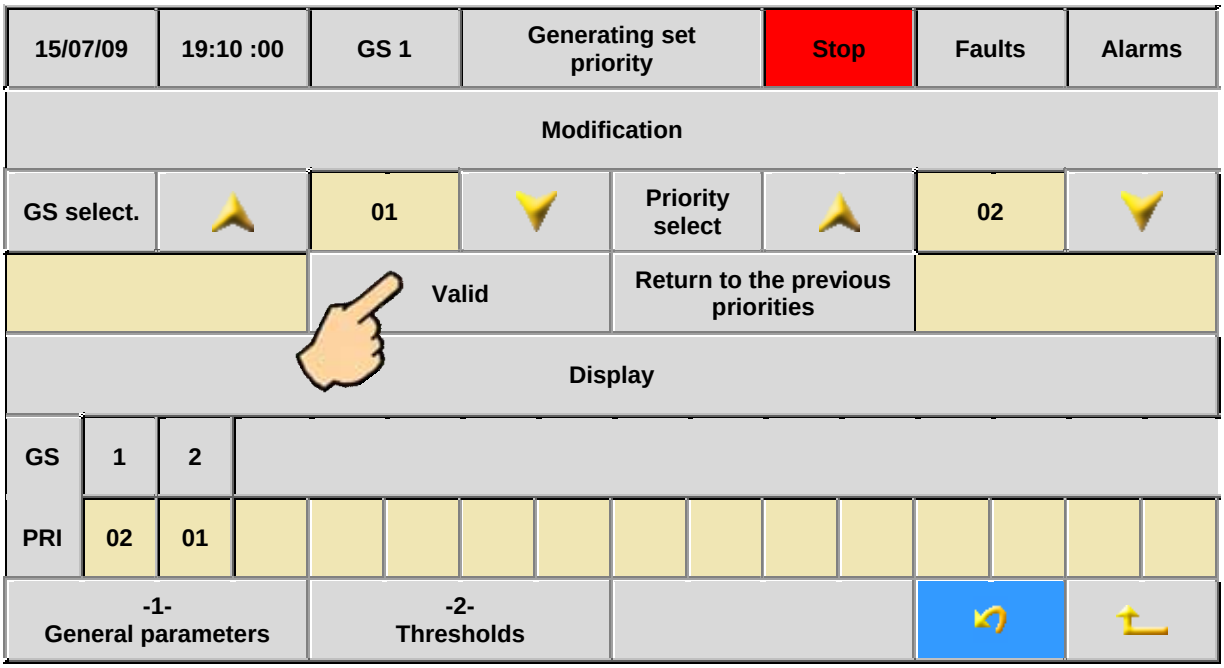

4. Press “Generating set priority” on the touch screen.



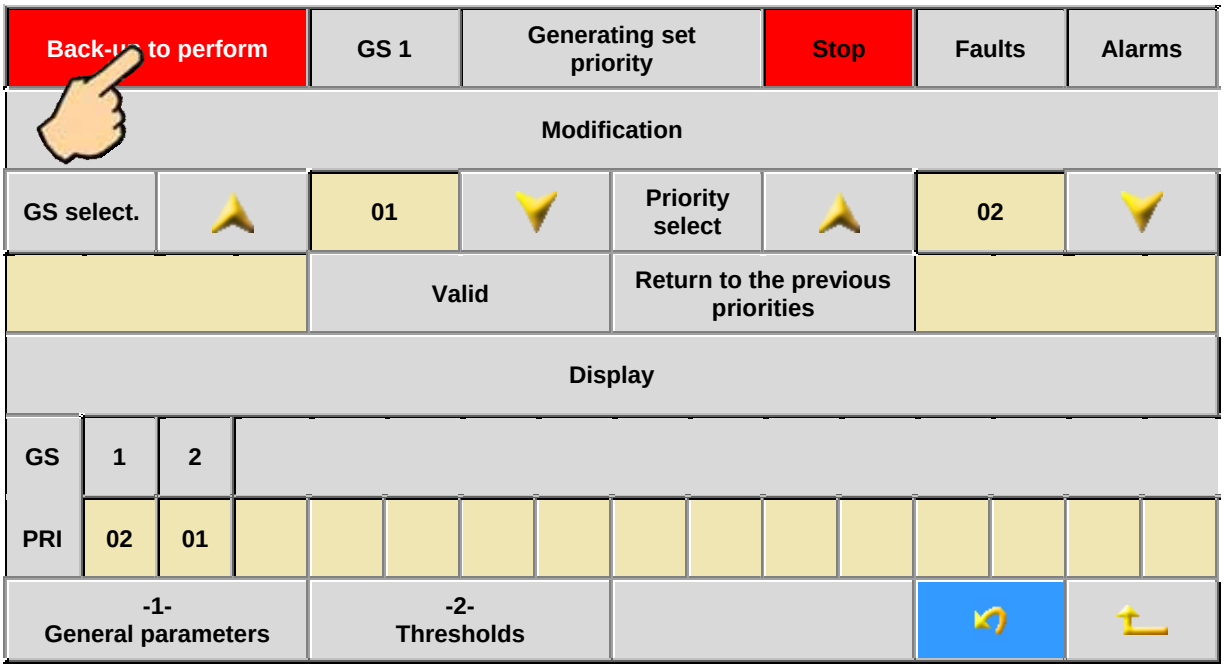

5. Press the selection arrows on the touch screen to select the generating set.



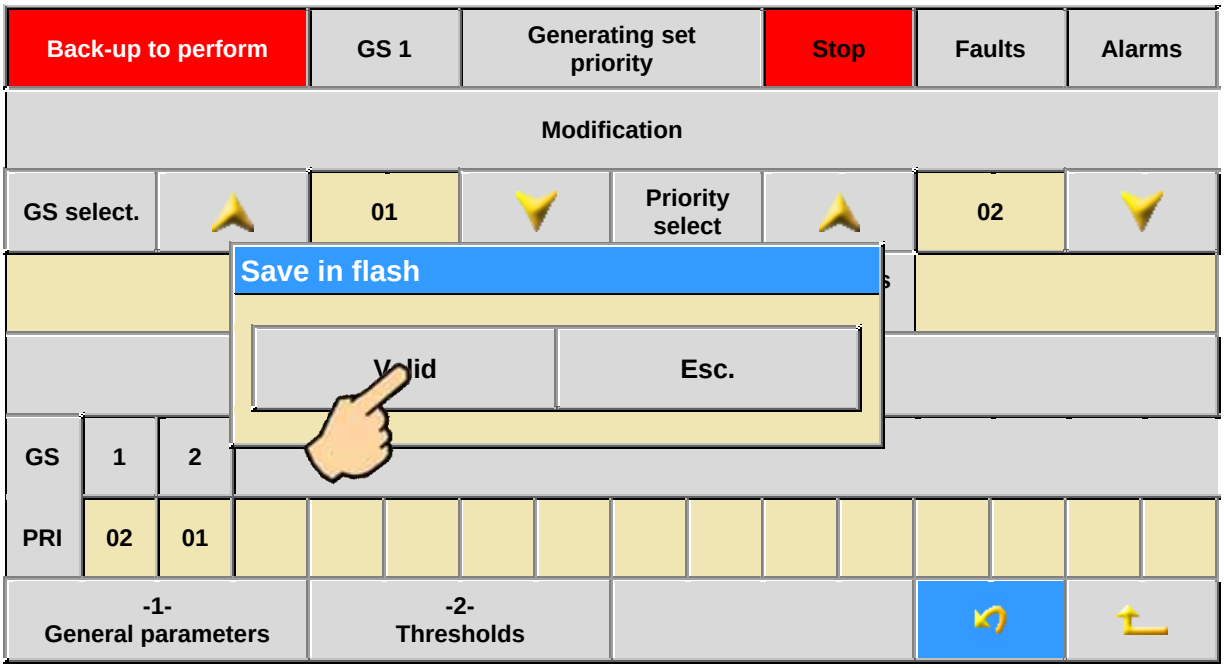

6. Press the selection arrows on the touch screen to select the priority of the generating set selected.



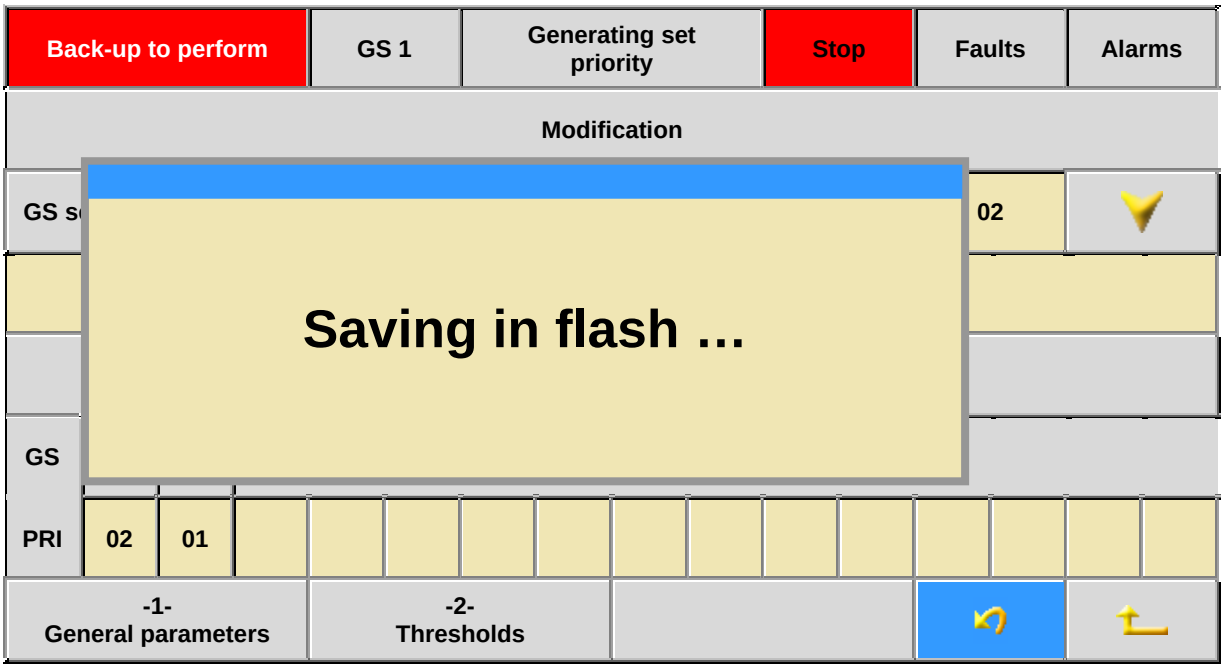

7. Press “Valid” on the touch screen.



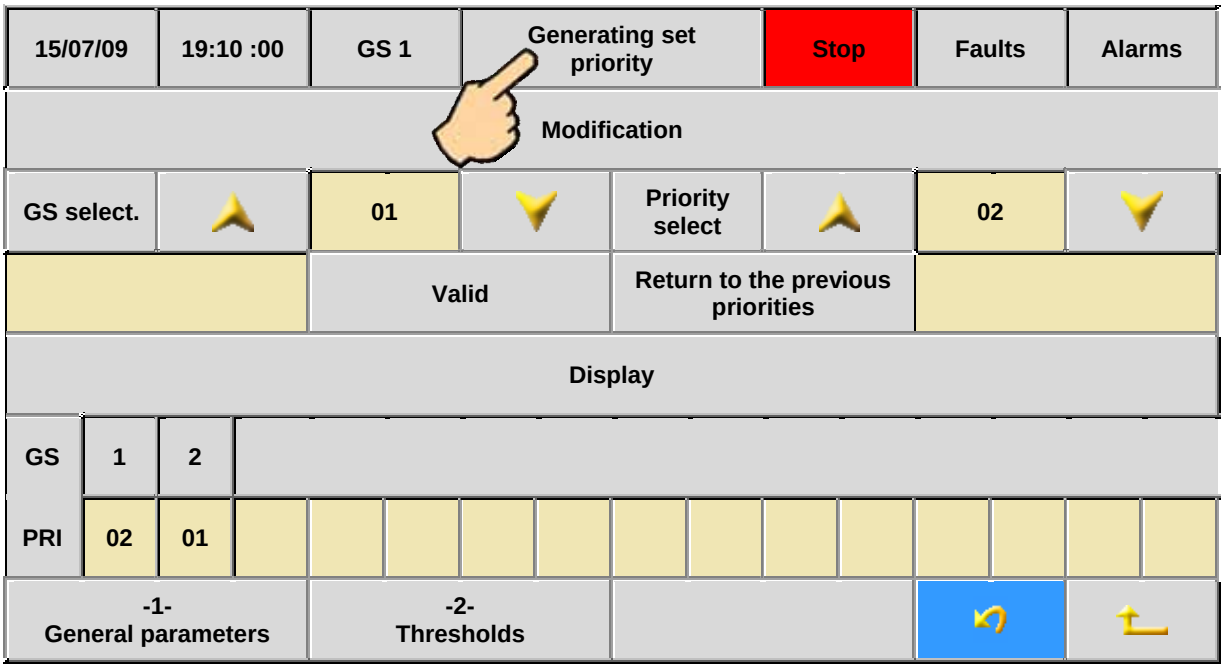

8. Press “Save" on the touch screen.




9. Press “Valid” on the touch screen.




10. The Kerys saves your new configuration.




11. Press “Generating set priority” on the touch screen to return to the home screen.

| | |
|---|---|
| **Important** | **The configuration will only be considered valid if the following operations are carried out:**<br>✓ **Open the battery cutout.**<br>✓ **Wait 5 seconds.**<br>✓ **Close the battery cutout.** |

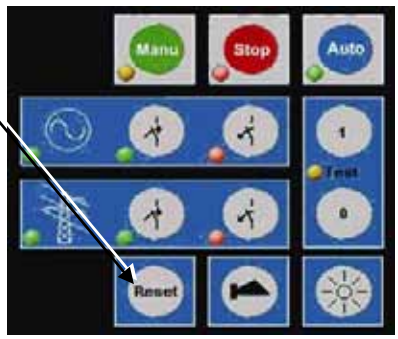
### 6.3.8.2. Starting, tests and stop

**In manual mode**

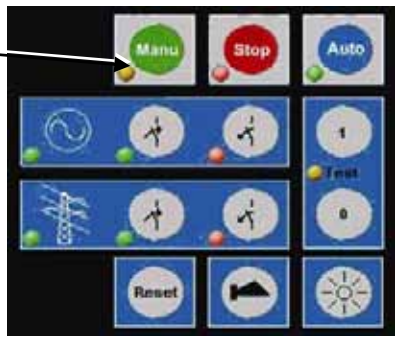
**Starting**


If faults are present, the fault management screen can be accessed by pressing **Reset**.

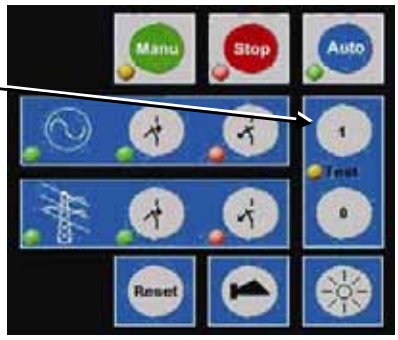
Refer to the section “Alarms and Faults” in the “Operating menus” to eliminate the faults.




If no faults are present, manual mode can be activated by pressing **Manu**.

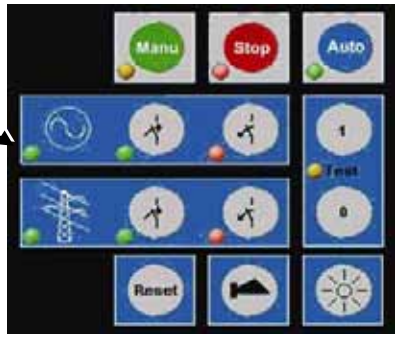


The manual start-up phase will begin once **key 1** in the test keypad is pressed.



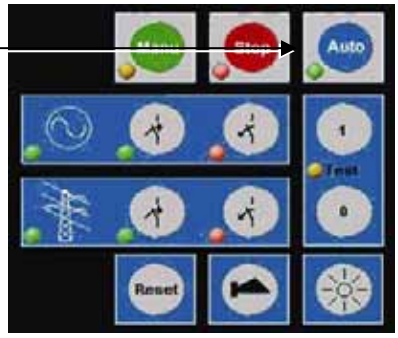

The start-up request is maintained until the generating set starts (it is not necessary to keep key 1 pressed).
This method may not, under any circumstances, be used to turn the engine over manually.

During the start-up phase and until the alternator voltage and speed of the generating set stabilise, the green LED under the generating set symbol flashes and then lights up permanently once the phase is complete.

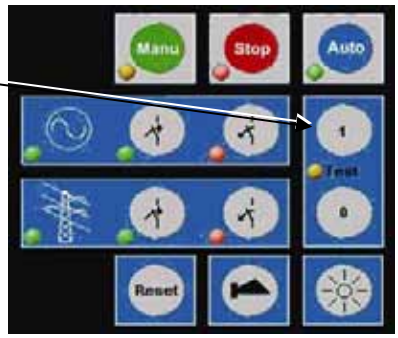



## Tests

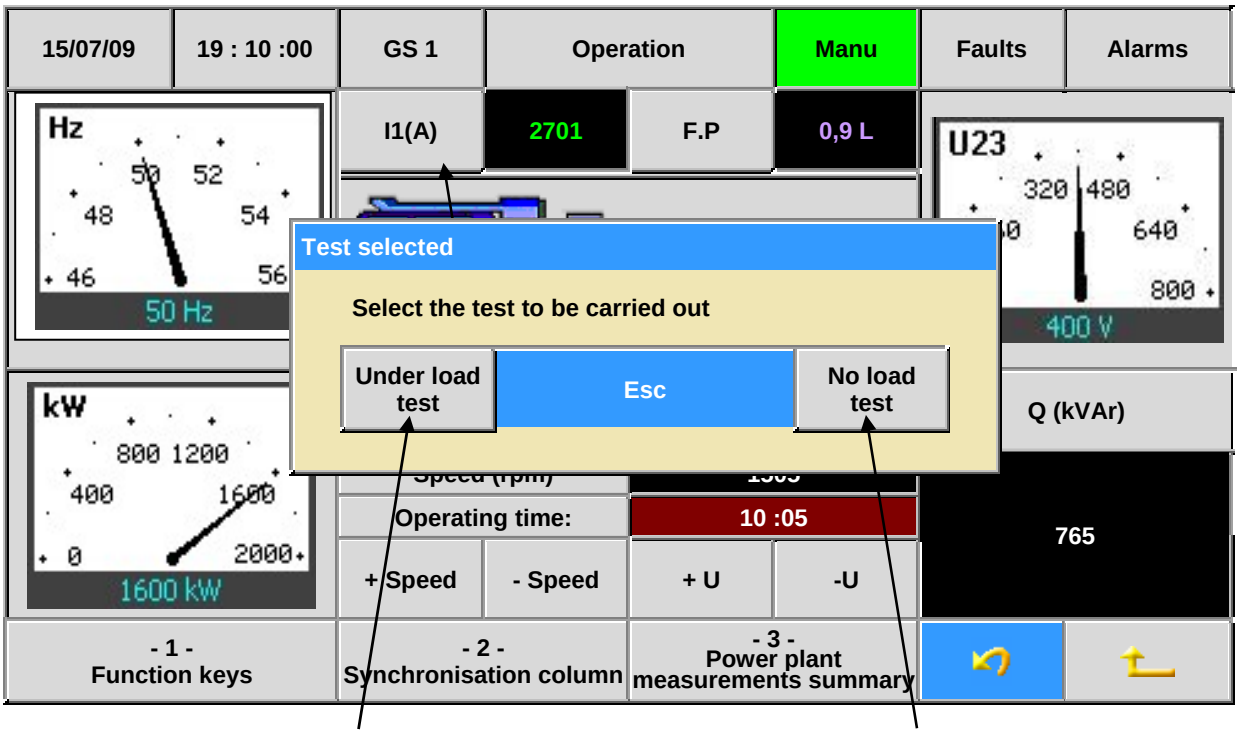
If no faults are present, automatic mode can be activated by pressing **Auto.**




The test starting phase is then initiated after pressing **1** on the test keypad.



Pressing **1** on the test keypad brings up the following window for selecting the test type.

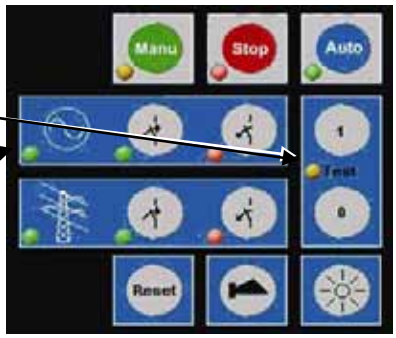



Using the KERYS Tactil Man-Machine Interface, the under load test is started by pressing the corresponding key.

Using the KERYS Tactil Man-Machine Interface, the off load test is started by pressing the corresponding key.

After validation of the test, the **orange LED** on the test keypad lights up steady.

During the start-up phase, and until the alternator voltage and generating set speed stabilise, the **green LED** underneath the symbol for the generating set flashes and becomes steady at the end of this phase.

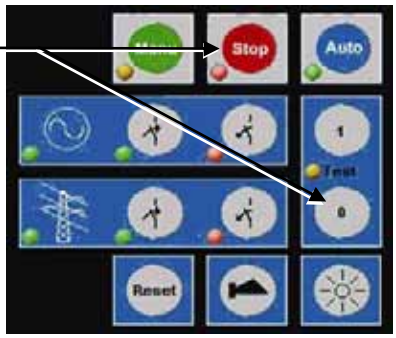



The installation is then controlled via the programmable controller in accordance with the configuration of the application:

- normal/emergency source switchover
- grid coupling
- etc.

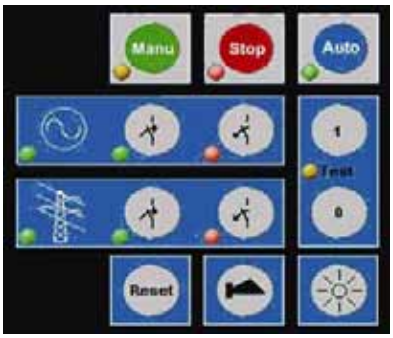
| | |
|---|---|
| Important | The Normal/Emergency switchover with grid coupling is only possible by carrying out a load test.<br>The purpose of the off load test is to start a single GS or to couple a power plant (x generating sets) to the emergency busbar. |

At any time the generating set may be stopped by pressing **Stop** or by pressing **0** on the test keypad.




| | |
|---|---|
| Important | Pressing **Stop** may interrupt the power supply, depending on its status when the key is pressed (e.g. isolated grid operation).<br>The generating set will stop after a cooling delay (180 seconds by default). |

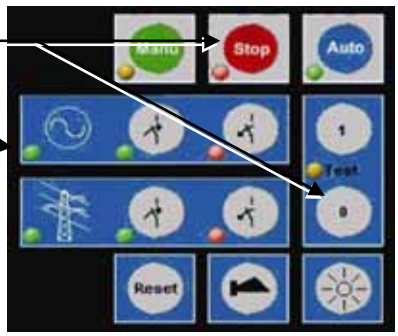
The **green LED** underneath the generating set symbol goes out to indicate that the generating set has stopped.




## Switching off

The generating set may be stopped at any time by pressing **Stop** or **0** on the test keypad.

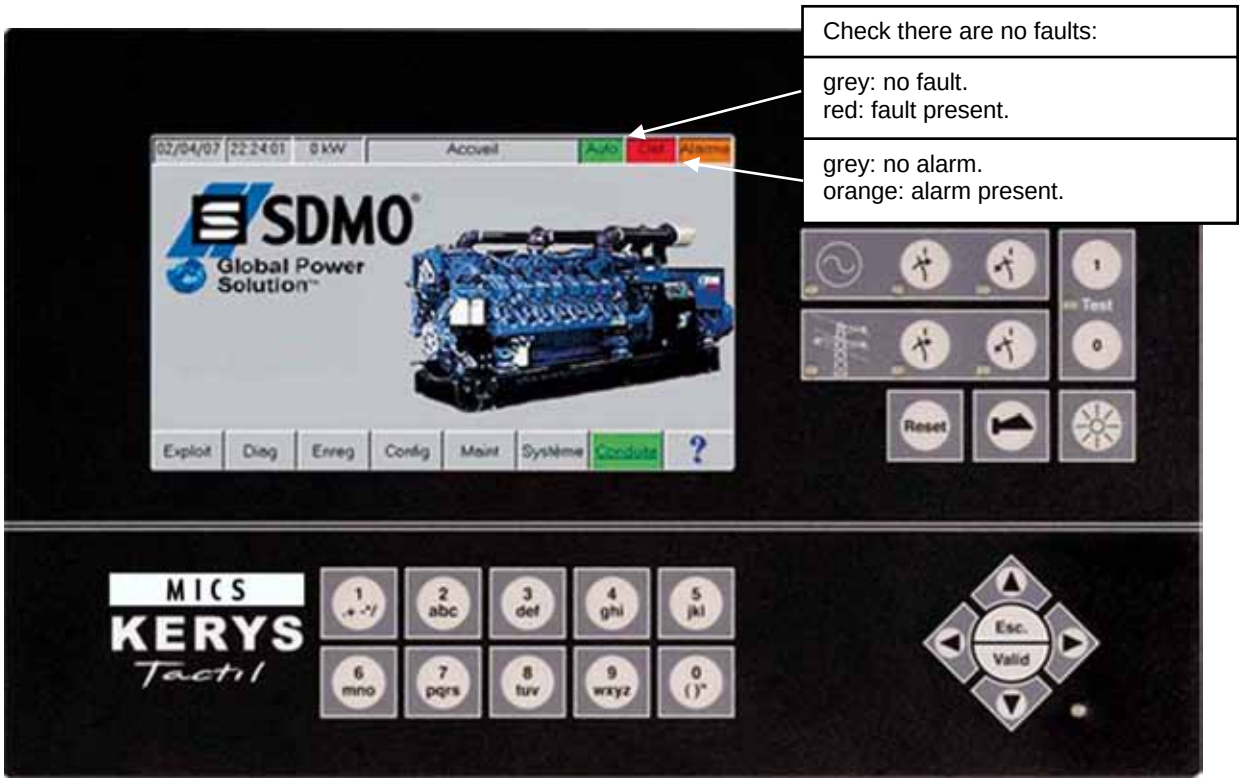
The green LED underneath the generating set symbol goes out to indicate that the generating set has stopped.




| | |
|---|---|
| Important | Pressing **Stop** stops the generating set immediately.<br><br>Pressing **0** does not stop the generating set immediately (generating set stabilisation time delay). |

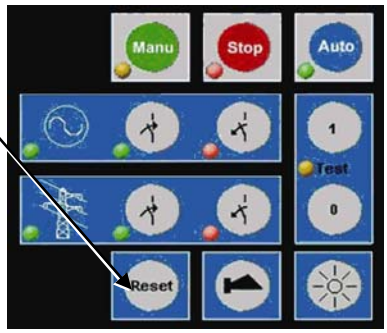
**In automatic mode**

## Starting

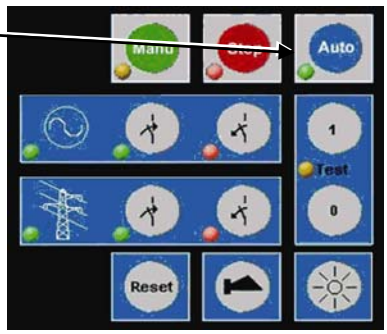



If faults are present, the fault management screen can be accessed by pressing **Reset.**

Refer to the section “Alarms and Faults” in the Operating menus” to eliminate the faults.




If no faults are present, manual mode can be activated by pressing **Auto.**




In AUTO mode, except for the test functions, the generating set starts as a result of an external command which may be triggered by various sources:

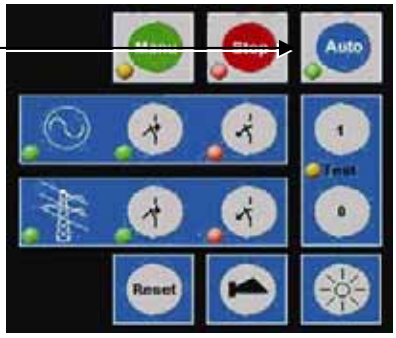
- power loss
- EJP command (France only)
- client command.

The installation is then controlled via the automatic systems in accordance with the configuration of the application:

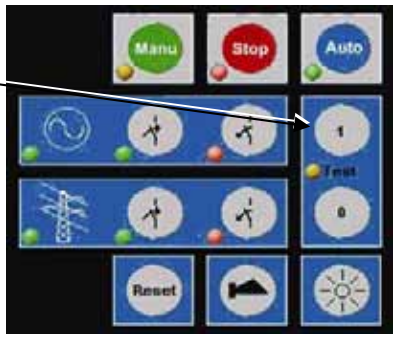
- inversion of normal/emergency source
- grid coupling
- etc.

## Tests

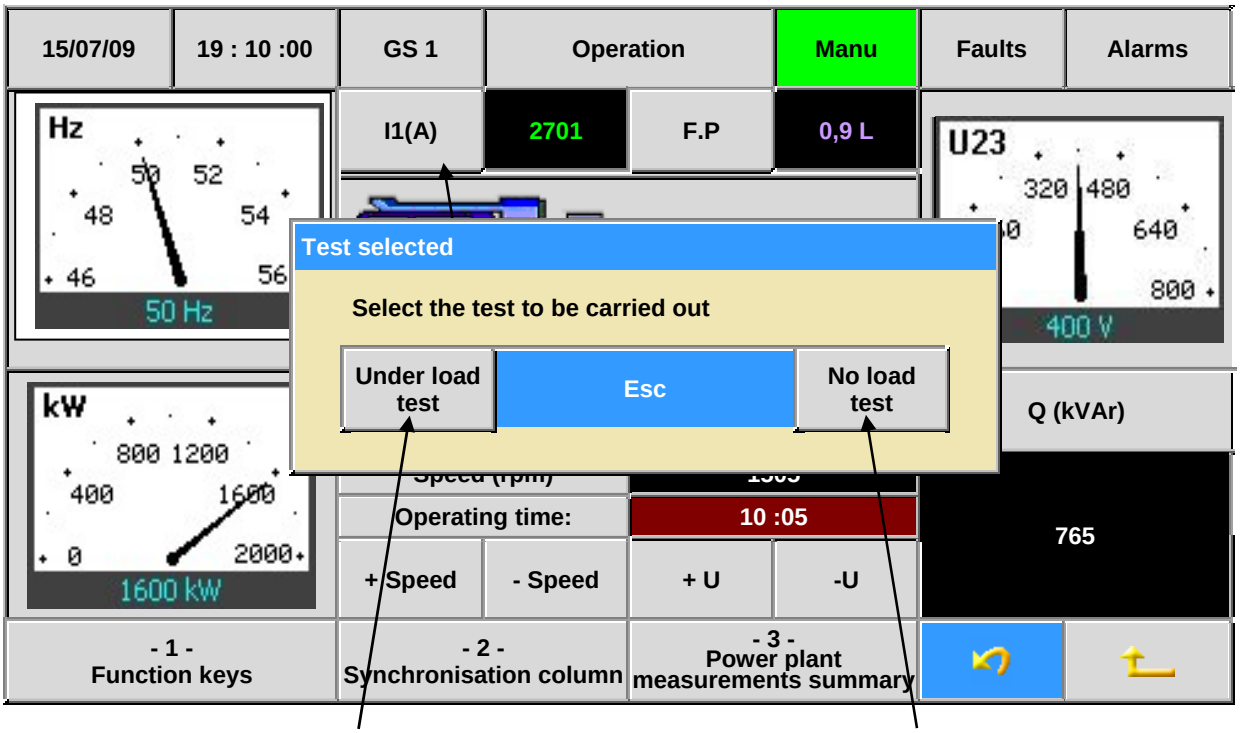
If no faults are present, automatic mode can be activated by pressing **Auto.**




The test starting phase is then initiated after pressing **1** on the test keypad.




Pressing **1** on the test keypad brings up the following window for selecting the test type.

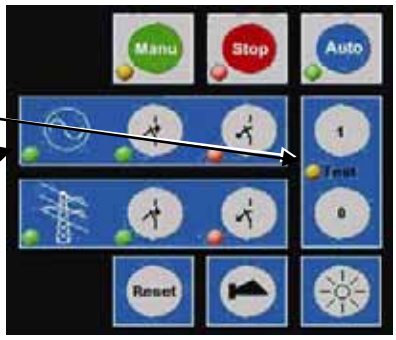



Using the KERYS Tactil Man-Machine Interface, the under load test is started by pressing the corresponding key.

Using the KERYS Tactil Man-Machine Interface, the off load test is started by pressing the corresponding key.

After validation of the test, the **orange LED** on the test keypad lights up steady.

During the start-up phase, and until the alternator voltage and generating set speed stabilise, the **green LED** underneath the symbol for the generating set flashes and becomes steady at the end of this phase.

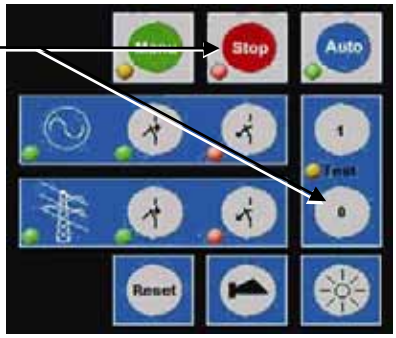



The installation is then controlled via the programmable controller in accordance with the configuration of the application:

- normal/emergency source switchover
- grid coupling
- etc.

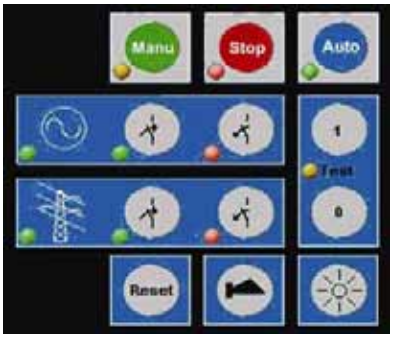
| | |
|---|---|
| Important | The Normal/Emergency switchover with grid coupling is only possible by carrying out a load test.<br>The purpose of the off load test is to start a single GS or to couple a power plant (x generating sets) to the emergency busbar. |

At any time the generating set may be stopped by pressing **Stop** or by pressing **0** on the test keypad.



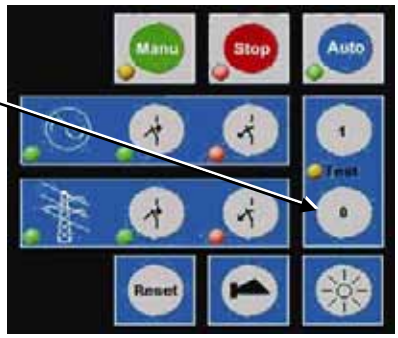

| | |
|---|---|
| Important | Pressing **Stop** may interrupt the power supply, depending on its status when the key is pressed (e.g. isolated grid operation).<br>The generating set will stop after a cooling delay (180 seconds by default). |

The **green LED** underneath the generating set symbol goes out to indicate that the generating set has stopped.



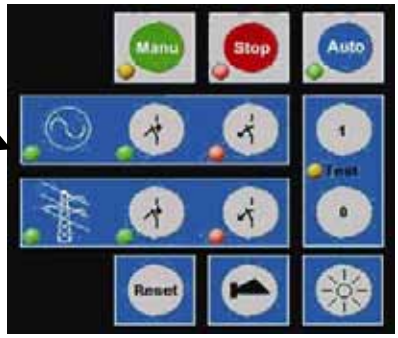
### Switching off

The generating set may be stopped at any time by pressing **0** on the test keypad.




| | |
|---|---|
| Important | Pressing **Stop** may cause an interruption in the power supply depending on its status when the button is pressed (e.g. isolated grid operation).<br>The generating set will stop after the cooling delay (180 seconds by default). |

The **green LED** underneath the generating set symbol goes out to indicate that the generating set has stopped.




## 6.3.8.3. Rental options

**Damper valve (Optional)**

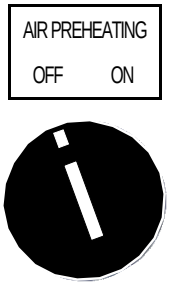
❶ If the generating set stops when the valve damper is closed, repair the fault.

❷ Display the fault according.

❸ Press “Reset” to clear the fault after it has been repaired.

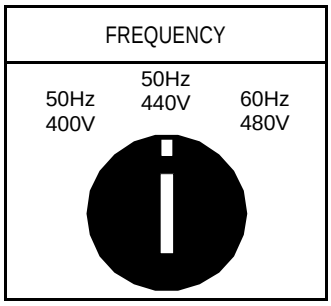

❹ If faults persist, repair them.

**Air preheating (Optional)**
Turn the switch to “ON” to initiate preheating of the generating set.

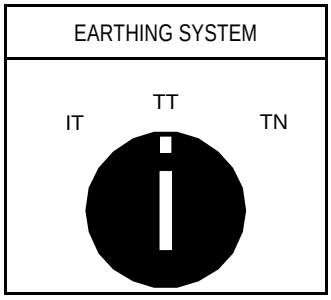



| | |
|---|---|
| **Important** | **In the case of a power plant, the position of the air preheating switches must NECESSARILY be the same on all the switches of the generating sets in the power plant.** |

**Bi-frequency (Optional)**
Turn the switch to the desired frequency and voltage.




**Earthing system**
Turn the switch to the desired earthing system.




1: IT
2: TN (TNS)
3: TT (TT or EDF APPLICATION)

| | |
|---|---|
| **Important** | **The EDF earthing system is only used in the so-called rental configurations.**<br>**The switch must necessarily correspond to the wiring described in the section on “Connection of the generating sets”.** |

# 7. Maintenance schedule

## 7.1. Reminder of use

The maintenance interval frequency and the operations to be carried out are outlined in the maintenance schedule, given as a guideline.
N.B. the environment in which the generating set is operating determines this schedule.
If the generating set is used in extreme conditions, shorter intervals between maintenance procedures should be observed
These maintenance intervals only apply to generating sets running on fuel, oil and coolant which conform to the specifications given in this manual.

## 7.2. Engine

| Component | Operation | Every day | 50 hrs / 12 months | First 150 hrs | 50-600 hrs / 12 months | 400 hrs / 12 months | 800 hrs / 12 months |
|---|---|---|---|---|---|---|---|
| Engine and engine compartment | Inspect | ● | | | | | |
| Air filter indicator | Check (1) | ● | | | | | |
| Oil level | Check and top up | ● | | | | | |
| Coolant level | Check and top up | ● | | | | | |
| Fuel pre-filter | Drain the water and sediment | | ● | | | | |
| Engine oil | Drain (2) | | | ● | ● | | |
| Oil filter/by-pass filter | Replace (3) | | | | ● | | |
| Fuel pre-filter | Replace | | | | ● | | |
| Fuel filter | Replace | | | | ● | | |
| Driven unit belts | Check/adjust | | | | | ● | |
| Batteries | Check the electrolyte level | | | | | ● | |
| Turbocharging air pipe | Check that there are no leaks | | | | | | ● |
| Fuel pre-filters | Check | | | | | | ● |

(1) The filter should be replaced every 12 months.
(2) First recommended oil change. The oil used must be of a good quality. The oil service intervals vary depending on the oil grade and the fuel sulphur content. (see engine appendix).
(3) The filters must be replaced every time the oil is changed.

| Component | Operation | 1000 hrs / 6 months | 2000 hrs | 12 months | 8000 hrs / 36 months | 10000 hrs / 48 months |
|---|---|---|---|---|---|---|
| Coolant filter | Replace (4) | ● | | | | |
| Turbocharger | Check* | | ● | | | |
| Valve clearance | Check/adjust * (5) | | ● | | | |
| EMS 2 system | Check with the service tool * | | | ● | | |
| Engine | Carry out a general inspection * | | | ● | | |
| Air filter lining | Check/replace | | | ● | | |
| Engine | Clean and repaint | | | ● | | |
| Driven unit belts | Replace | | | | ● | |
| Cooling system | Check/clean * | | | | | ● |
| Coolant (4) | Replace * | | | | | ● |

* This procedure should only be carried out by one of our agents.
(4) Do not replace the filter when draining the coolant.
(5) Adjust the valve clearance after 250 hours of operation following a complete reconditioning of the engine.

## 7.3. Alternator

- After 20 hours in operation, check the tightness of all the mounting bolts, the general condition of the machine and the various electrical connections of the installation.
- The bearings fitted on the machine are greased for life to around the service life of the grease (depending on use) = 20 000 hours or 3 years.

## 8. Battery

| | |
|---|---|
|  | Fit the battery so that it is properly ventilated.<br>Maintenance should only be carried out by qualified personnel.<br>If replacing the batteries, use the same type of batteries. Do not throw the old battery in the fire.<br>Only use insulated tools (the operator should not be wearing a watch, chain or any metal object).<br>Never use sulphuric acid or acid water to top up the electrolyte level. Use an approved battery fluid.<br>Batteries release oxygen and hydrogen gas, which are flammable.<br>Never bring flames or sparks near the battery (risk of explosion).<br>Discharge any static electricity before handling the batteries by first touching an earthed metal surface.<br>Do not use the battery when the fluid level is below the minimum required level Using a battery with a low electrolyte level could result in an explosion.<br>Do not short the battery terminals with a tool or other metal object.<br>When disconnecting battery cables, remove the cable from the negative (-) terminal first. When reconnecting the battery, connect the positive lead (+) first.<br>Charge the battery in a well-ventilated place, with all the filler caps opened.<br>Ensure that the battery terminals are correctly tightened. A loose cable clamp can cause sparks that could result in an explosion. |
| **Danger** | Before servicing electrical components or performing electric welding, set the battery switch to the [OFF] position or disconnect the battery negative cable (-) to cut off the electrical current.<br>Electrolyte contains dilute sulphuric acid. Careless handling of the battery causing contact with sulphuric acid could damage your eyesight or cause burns.<br>Wear safety goggles and rubber gloves when working with the battery (topping-up fluid, charging, etc.)<br>If electrolyte comes into contact with your skin or clothes, wash it off immediately with plenty of water, then carefully wash the area with soap.<br>If electrolyte comes into contact with your eyes, rinse immediately with plenty of water and seek medical attention as soon as possible.<br>If electrolyte is accidentally swallowed, gargle with plenty of water and drink large quantities of water. Consult a doctor immediately.<br>Large quantities of electrolyte should be rinsed off using a neutralising agent. A common method is to use a solution of 500g of bicarbonate of soda diluted in 4 litres of water. The bicarbonate of soda solution should be added until the reaction has finished (lather). The remaining liquid should be rinsed off with water and left to dry. |

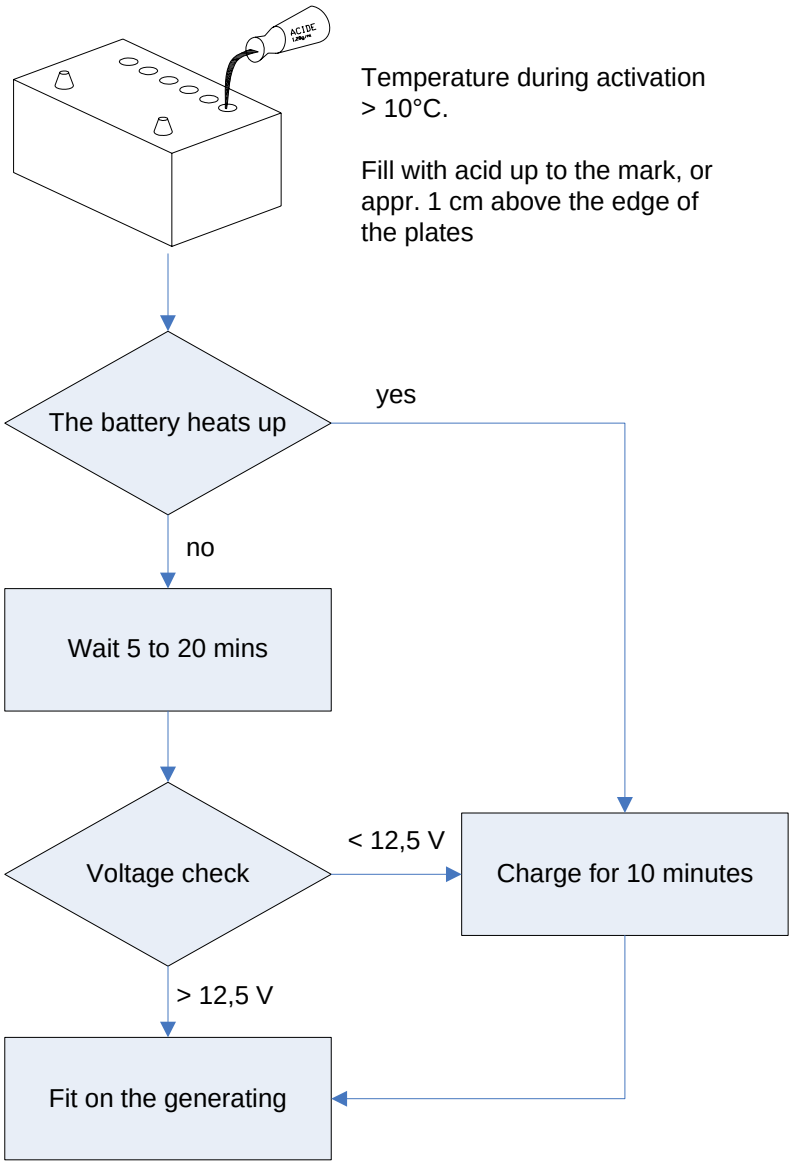
- ✓ Dry batteries do not require any servicing
- ✓ Batteries ready for use must be recharged at the latest when the acid density drops below 1.20.

### 8.1. Storage and transport

- ✓ Batteries ready for use must be stored in a cool and dry place (frost-free) protected from the sun (self-discharge).
- ✓ Batteries must be transported and stored vertically (risk of acid spillage)
- ✓ Leave the terminal cover on the positive terminal

## 8.2. Battery setting into service

- ✓ Batteries filled with acid have a density of 1.28 g/ml, and are charged.
- ✓ For dry batteries, fill each part of the battery with acid to the maximum level marker, or to 15 mm above the plates. Leave the battery to rest for 20 minutes.
- ✓ Before fitting the battery, switch off the engine and any current consumer; clean the terminals and coat them slightly with grease. When connecting, first connect the positive terminal (+) and then the negative terminal (-).




## 8.3. Check

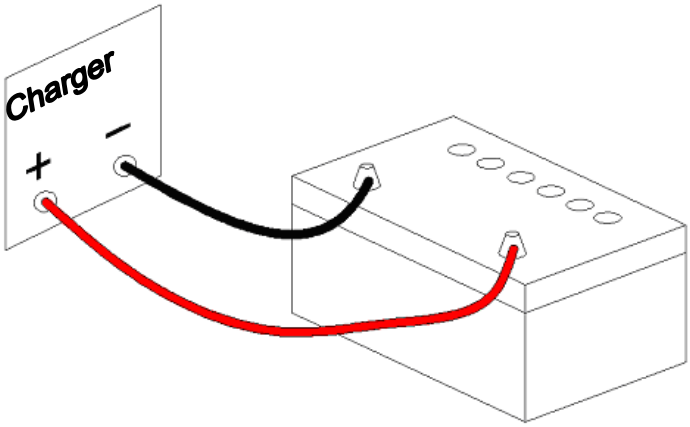
| Acid density | Charge status | Voltage when idle | |
|---|---|---|---|
| 1.27 | 100% | Above 12.60 V | |
| 1.25 | 80% | 12.54 V | |
| 1.20 | 60% | 12.36 V | **From 50 % recharge** |
| 1.19 | 40% | 12.18 V | **Risk of sulphation** |
| 1.13 | 20% | Under 11.88 V | **Unusable** |

## 8.4. Load preconization

✓ Highly discharged or sulphated batteries (formation of whitish lead sulphate deposit on the plates, which becomes hard and insoluble to acid; this deposit reduce the active surface of the plates, and increases their internal resistance) can no longer regenerate or be charged in a generating set.

| | |
|---|---|
| Important | A discharged battery should be recharged immediately, or else it will suffer irreparable damage. |

Battery charge




When several batteries are connected together, the following points should be checked:
✓ Are the batteries connected in series?
✓ Has the correct voltage been chosen? 1 battery x 12 V , 3 x 36V batteries.
✓ Adjust the charge current to the lowest battery.
✓ The power difference between the batteries must be as low as possible.

Example of charge:
✓ 12V 60 Ah battery = charging current 6 A.
✓ Charge status: 50% (acid density 1.21/voltage when idle 12.30V).
✓ The battery is short 30 Ah, and this must be recharged.
✓ Charge factor: 1.2.
✓ Ah x 1.2 = 36 Ah to be charged.
✓ Charging current: 6A approximately 6 hours charging required.

Recharging is complete when the battery voltage and the acid density stop increasing.

→ The charging current must always be 1/10$^{th}$ of the nominal capacity of the battery.

The power of the charger must be suitable for the battery to be charged and the charging time available.
You need to use an automatic charger able to provide a sufficient voltage and charging current, as well as a compensation voltage to handle spontaneous battery discharge.

## 8.5. Faults and remedies

| Fault observed | Probable origin | Measures or observations |
|---|---|---|
| The acid heats up when a new battery is filled | - Incorrect composition<br>- Incorrect storage<br>- Prolonged storage in a damp place | - Cool<br>- Charge<br>- Check the acid density |
| The acid escapes through the filler holes | - Battery overflow during filling | - Reduce the battery fluid level |
| Acid level too low | - Battery tray not leaktight<br>- Significant gas formation caused by too high a charging voltage | - Replace the battery<br>- Check the charger and repair if necessary. |
| Acid level too low<br>Incorrect operation from start-up | - Insufficient charge<br>- Short circuit in the current circuit<br>- Consumption fault | - Recharge<br>- Check the electrical installation |
| Acid density too high | - The battery has been filled with acid instead of water | - Reduce the acid level and fill with distilled water. Repeat the operation if need be. |
| Starting problems<br>Starting test incorrect | - Battery empty<br>- Battery used up or faulty<br>- Capacity too low<br>- Battery sulphated | - Recharge the battery<br>- Fit a new battery |
| Battery terminals melted | - Incorrect electrical connection<br>- Incorrect battery wiring | - Tighten the ends of the battery cables, or replace them if necessary |
| One or two cells release a lot of gas at high charge | - Cell(s) faulty | - Fit a new battery |
| The battery discharges very quickly | - Charge status too low<br>- Short circuit in the current circuit<br>- High self-discharge (for example: through electrolyte contamination)<br>- Sulphation (storage of discharged battery) | - Check the charge<br>- Replace the battery |
| Short service life | - Incorrect battery part no.<br>- Too many repeated deep discharges<br>- Battery stored too long without charge | - Define the correct battery part no. for the recommended use<br>- Think about charging the battery using a regulator |
| High water consumption | - Overload<br>- Charging voltage too high | - Check the charger (voltage regulator) |
| The battery explodes | - Spark after battery charging<br>- Short circuit<br>- Connection or disconnection during charging<br>- Internal fault (for example: interruption) and low electrolyte level | - Replace the battery (beware of fire and sparks)<br>- Ensure there is sufficient ventilation |

# 9. Appendix

## 9.1. Appendix A – Engine user and maintenance manual

# Users guide and and maintenance manual

VOLVO

Generating set and industrial engines 9 liter (EMS 2)

TAD941GE

| | |
|---|---|
| 7745269 (11-2005) | 33522062701_1_1 |

# OPERATOR'S MANUAL

## Generating set and industrial engines

### 9 liter (EMS 2)

# Table of contents

# Safety information

Read this chapter very carefully. It has to do with your safety. This describes how safety information is presented in the instruction book and on the product. It also gives you an introduction to the basic safety rules for using and looking after the engine.

**Check that you have received the correct instruction book before you read on. If not, please contact your Volvo Penta dealer.**

Incorrect operation can lead to personal injury and damage to products or property. So read the instruction book through very carefully before you start the engine or do any maintenance or servicework. If there is still something which is unclear or if you feel unsure about it, please contact your Volvo Penta dealer for assistance.

 This symbol is used in the instruction book and on the product, to call your attention to the fact that this is safety information. Always read such information very carefully.

Safety texts in the instruction book have the following order of priority:

 **WARNING!** Warns for the risk of personal injury, major damage to product or property, or serious malfunctions if the instruction is ignored.

 **IMPORTANT!** Is used to call attention to things which could cause damage or malfunctions to product or property.

**NOTE!** Is used to call attention to important information, to facilitate work operations or handling.

 This symbol is used on our products in some cases and refers to important information in the instruction book. Make sure that warning and information symbols on the engine are clearly visible and legible. Replace symbols which have been damaged or painted over.

# Safety rules for operation and maintenance

## ⚠ Daily checks

Make it a habit to always give the engine and engine bay a visual check before operation **(before the engine is started)** and after driving **(when the engine has been stopped)**. This helps you to quickly discover whether any leakage of fuel, coolant, oil or any other abnormal event has happened, or is about to happen.

## ⚠ Fuel filling

There is always a risk of fire and explosion during fuel filling. Smoking is not permissible, and the engine should be stopped.

Never over-fill the tank. Shut the tank cap securely.

Only use the fuel recommended in the instruction book. The wrong grade of fuel can cause malfunctions or stop the engine. In a diesel engine, it can also cause the injection pump to bind and the engine will over-rev, entailing a strong risk of personal injury and machinery damage.

## ⚠ Carbon monoxide poisoning

Only start the engine in a well- ventilated area. When operated in a confined space, exhaust fumes and crankcase gases must be ventilated.

## ⚠ Operation

The engine must not be operated in environments which contain explosive media since none of the electrical and mechanical components are explosion proof.

Going close to a running engine is a safety risk. Hair, fingers, loose clothes, or dropped tools can catch on rotating components and cause severe injury.

When engines are supplied without touch guards, all rotating components and hot surfaces must be protected after installation in their application, if necessary for personal safety.

## ⚠ Ignition lock

If the instrument panel does not have a key switch, the engine room must be lockable, to prevent unauthorized persons from starting the engine. Alternatively, a lockable main switch can be used.

## ⚠ Care and maintenance

**Knowledge**

The instruction book contains instructions for doing the most common service and maintenance tasks in a safe and correct manner. Read them carefully before starting work.

Literature for more major tasks is available from your Volvo Penta dealer.

Never do a job if you are not entirely sure about how to do it. Please contact your Volvo Penta dealer and ask for assistance instead.

**Stop the engine**

Stop the engine before opening or removing the engine hatch/hood. Care and maintenance work should be done with the engine stopped unless otherwise specified.

Prevent the engine from being started by pulling out the starter key and cutting the current with the battery isolator. Lock them in the “Off” position. Fix a notice by the operator’s seat to say that work is in progress.

Working with, or going close to a running engine is a safety risk. Hair, fingers, loose clothes, or dropped tools can catch on rotating components and cause severe injury. Volvo Penta recommends that all service work which requires the engine to be running should be done by an authorized Volvo Penta workshop.

# Safety rules for operation and maintenance (contd.)

**Lifting the engine**

The existing lugs on the engine should be used for lifting. Always check that the lifting devices are in good condition and that they have the correct capacity for the lift (engine weight together with auxiliaries, if fitted). For safety at work, the engine should be lifted with an adjustable lifting boom. All chains or cables should be parallel to each other and should be as square as possible to the top of the engine. Please note that auxiliary equipment installed on the engine could change its center of gravity. Special lifting devices may then be needed to obtain the correct balance and safe handling. Never carry out work on an engine that is **only** suspended in a lifting device.

**Before starting**

Re-install all guards which have been removed during service work, before re-starting the engine. Make sure that there are no tools or other objects left behind on the engine.

Never start a turbocharged engine without the air filter in place. The rotating compressor turbine in the turbocharger can cause severe injury. There is also a risk that foreign bodies could be sucked in and cause machinery damage.

## ⚠ Fire and explosion

**Fuel and lubrication oil**

All fuel, most lubricants and many chemicals are flammable. Always read and observe the advice on the packages.

Work on the fuel system must be done with the engine cold. Fuel leakage and spills on hot surfaces or electrical components can cause fires.

Store oil and fuel soaked rags and other flammable material in a fire-proof manner. In certain circumstances, oil soaked rags can self-ignite.

Never smoke when filling fuel, lubrication oil or when close to fuel filling stations or the engine bay.

**Non-original spare parts**

Components in fuel systems and electrical systems on Volvo Penta engines are designed and manufactured to minimize the risk of explosions and fire, in accordance with applicable legal requirements.

The use of non-original spare parts can cause an explosion or fire.

**Batteries**

Batteries contain and give off an explosive gas, especially when charged. This gas is very flammable and highly explosive.

Smoking, open flames or sparks must never occur in or near to batteries or the battery locker.

Incorrect connection of a battery cable or start cable can cause a spark which can be sufficient, in its turn, to make the battery explode.

**Start spray**

Never use start spray or similar preparations to help in starting an engine with air pre-heating (glow plugs / starting heater). They may cause an explosion in the inlet manifold. Danger of personal injury.

## ⚠ Hot surfaces and fluids

A hot engine always offers the risk of burns. Be on your guard against hot surfaces: the exhaust manifold, turbocharger, oil pan, charge air pipe, starting heater, hot coolant and hot lubricating oil in pipes, hoses etc.

## ⚠ Chemicals

Most chemicals, such as glycol, rust preventer, conservation oils, degreasers etc. are hazardous. Always read and observe the advice on the packages.

Some chemicals, such as conservation oils, are flammable and alsodangerous to breathe. Ensure good ventilation and use a protective mask for spraying. Always read and observe the advice on the packages.

Store chemicals and other hazardous material out of the reach of children. Hand in surplus or used chemicals to a recycling station for destruction.

## ⚠ Lubrication system

Hot oil can cause burns. Avoid skin contact with hot oil. Make sure that the oil system is de-pressurized before starting work. Never start or run the engine with the oil filler cap removed, because of the risk of oil spillage.

## ⚠ Cooling system

Avoid opening the coolant filling cap when the engine is hot. Steam or hot coolant can spray out at the same time as the pressure built up is lost.

If the filler cap, coolant hose etc., still has to be opened or removed when the engine is hot, undo the filler cap slowly and carefully, to let the pressure out before removing the filler cap completely and starting work. Note that the coolant can still be hot and cause scalding.

## ⚠ Fuel system

Always protect your hands when searching for leaks. Fluids which leak under pressure can force their way into body tissue and cause severe injury. There is a risk of blood poisoning (septicemia).

Always cover the alternator if it is located beneath the fuel filters. Fuel spillage can damage the alternator.

## ⚠ Electrical system

**Cut the current**

Before any work is done on the electrical system, the engine must be stopped and the current cut by switching off the main switch(es). External current supply for engine heaters, battery chargers or other auxiliary equipment connected to the engine must be disconnected.

**Batteries**

Batteries contain a highly corrosive electrolyte. Protect your eyes, skin and clothes during charging and other handling of batteries. Always use protective goggles and gloves.

If acid comes into contact with your skin, wash at once with soap and a lot of water. If you get battery acid in your eyes, flush at once with a lot of cold water, and get medical assistance at once.

## ⚠ Electric welding

Remove the positive and negative cables from the batteries. Then disconnect all cables connected to the alternator.

Disconnect both connectors from the engine control module.

Always connect the welder earth clamp to the component to be welded, and as close as possible to the weld site. The clamp must never be connected to the engine or in such a way that current can pass through a bearing.

**When welding is completed:** Always connect the alternator cables to the alternator **and connectors to the engine control module before** the battery cables are put back.

# Introduction

This instruction book has been prepared to give you the greatest possible benefit from your Volvo Penta industrial engine. It contains the information you need to be able to operate and maintain the engine safely and correctly. Please read the instruction book carefully and learn to handle the engine, controls and other equipment in a safe manner before you start the engine.

⚠ **IMPORTANT!** This instruction book describes the engine and equipment sold by Volvo Penta. Variations in appearance and function of the controls and instruments may occur in certain variants. In these cases, please refer to the instruction book for the relevant application.

## Environmental responsibility

All of us want to live in a clean, healthy environment, where we can breathe clean air, see healthy trees, have clean water in lakes and seas, and be able to enjoy the sunlight without fearing for our health. Unfortunately, this is not a matter of course these days, it is something all of us must work for.

As an engine manufacturer, Volvo Penta has particular responsibility and for this reason, environmental care is an obvious foundation of our product development. Volvo Penta has a wide engine program these days, where considerable progress has been made in reducing exhaust fumes, fuel consumption, engine noise etc.

We hope that you will want to preserve these values. Always observe the advice in the instruction book about fuel grades, operation and maintenance, to avoid unnecessary environmental impact. Please contact your Volvo Penta dealer if you notice any changes such as increased fuel consumption or increased exhaust smoke.

Please remember to always hand in hazardous waste such as drained oil, coolant, old batteries etc. for destruction at an approved recycling facility.

If we all pull together, we can make a valuable contribution to the environment together.

## Running in

**The engine must be “run in” during its first 10 hours, as follows:**

Use the engine in normal operation. Full load should only be applied for short periods. Never run the engine for a long period of time at constant speed during this period.

Higher oil consumption is normal during the first 100-200 hours of operation. For this reason, check the oil level more frequently than normally recommended.

When an opening clutch is installed, this should be checked more carefully during the first days. Adjustment may need to be done to compensate bedding in of the friction plates.

## Fuel and oils

Only use the grades of fuels and oils recommended in the instruction book (please refer to the “Maintenance” chapter under the fuel and lubrication system headings). Other grades of fuel and oils can cause malfunctions, increased fuel consumption and eventually even shorten the life of the engine.

Always change the oil, oil filter and fuel filter at the specified intervals.

## Maintenance and spare parts

Volvo Penta engines are designed for maximum reliability and long life. They are built to withstand a demanding environment, but also to have the smallest possible environmental impact. These qualities are retained through regular service and use of Volvo Penta original spare parts.

Volvo Penta has a world-wide network of authorized dealers. They are Volvo Penta product specialists, and have the accessories, original spares, test equipment and special tools needed for high quality service and repair work.

**Always observe the maintenance intervals in the instruction book, and remember to note the engine/transmission identification number when you order service and spare parts.**

## Certified engines

**If you own an emission certified engine, which is used in an area where exhaust emissions are regulated by law, it is important to be aware of the following:**

Certification means that an engine type has been checked and approved by the relevant authority. The engine manufacturer guarantees that all engines made of the same type are equivalent to the certified engine.

**This makes special demands on the care and maintenance you give your engine, as follows:**

- Maintenance and service intervals recommended by Volvo Penta must be complied with.
- Only Volvo Penta original spares may be used.
- Service to injection pumps, pump settings and injectors must always be done by an authorized Volvo Penta workshop.
- The engine must not be converted or modified, except for the accessories and service kits which Volvo Penta has developed for the engine.
- No installation changes to the exhaust pipe and engine air inlet ducts may be done.
- No seals on the engine may be broken by unauthorized persons.

The general advice in the instruction book about operation, care and maintenance applies.

⚠ **IMPORTANT!** Neglected or poor care/service, and use of non-original spareparts means that AB Volvo Penta can no longer be responsible for guaranteeing that the engine complies with the certified version.

Damage, injury and/or costs which arise from this will not be compensated by Volvo Penta.

## Warranty

Your new Volvo Penta industrial engine is covered by a limited warranty, under the conditions and instructions compiled in the Warranty and Service book.

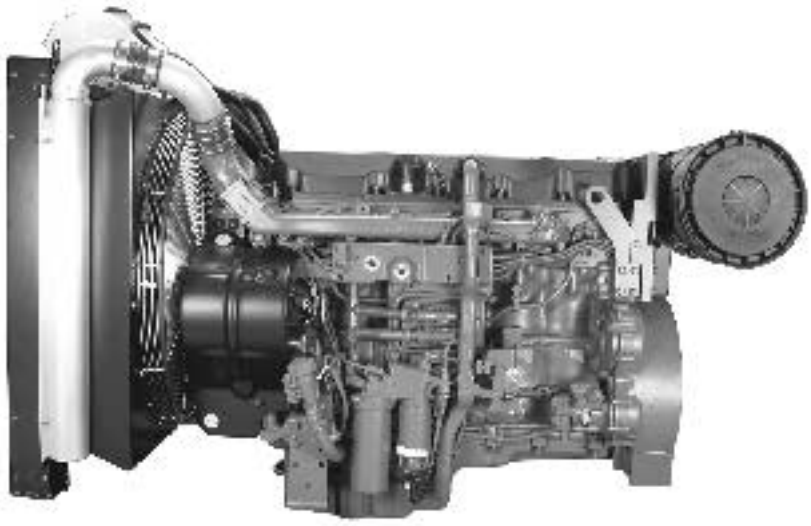
Please note that AB Volvo Penta's liability is limited to the specification in the Warranty and Service book. Read it carefully, as soon as possible after delivery. This contains important information such as the warranty card,
service intervals, maintenance, which it is the responsibility of the owner to know, check and carry out. If this is not done, AB Volvo Penta may fully or partly refuse to honor its warranty undertakings.

**Please contact your Volvo Penta dealer if you have not received a Warranty and Service book, or a customer copy of the warranty card.**

# Introduction

TAD940GE, TAD941GE, TAD940VE, TAD941VE, TAD942VE, TAD943VE, TAD950VE, TAD951VE and TAD952VE are in-line, direct injected, 6-cylinder industrial diesel engines. TAD950VE, TAD951VE have TAD952VE have internal EGR (Exhaust Gas Recirculation).

All engines are equipped with electronically controlled fuel management (EMS 2), turbocharger, intercooler, thermostatically controlled cooling systems and electronic speed control.



## Technical description

**Engine and engine block**

- The engine block and cylinder head are manufactured of alloyed cast iron
- Seven bearing induction hardened crankshaft
- Replaceable wet cylinder liners
- Cast aluminum pistons with oil cooling
- Three piston rings, with a “keystone” type top ring
- Induction hardened, overhead, seven bearing camshaft with .
- Four valves per cylinder
- Replaceable valve seats and valve guides

**Fuel system**

- Microprocessor based fuel supply control unit (EMS 2)
- Gear driven fuel supply pump
- Centrally located unit injectors with electromagnetically controlled fuel valves
- Spin-on secondary fuel filter and water trap
- IEGR (Internal Exhaust Gas Recirculation) TAD950VE, TAD951VE, TAD952VE

**Lubrication system**

- Water cooled oil cooler
- Gear driven oil pump
- Two full flow filters and a spin-on bypass filter

**Turbocharging system**

- Turbocharger

**Cooling system**

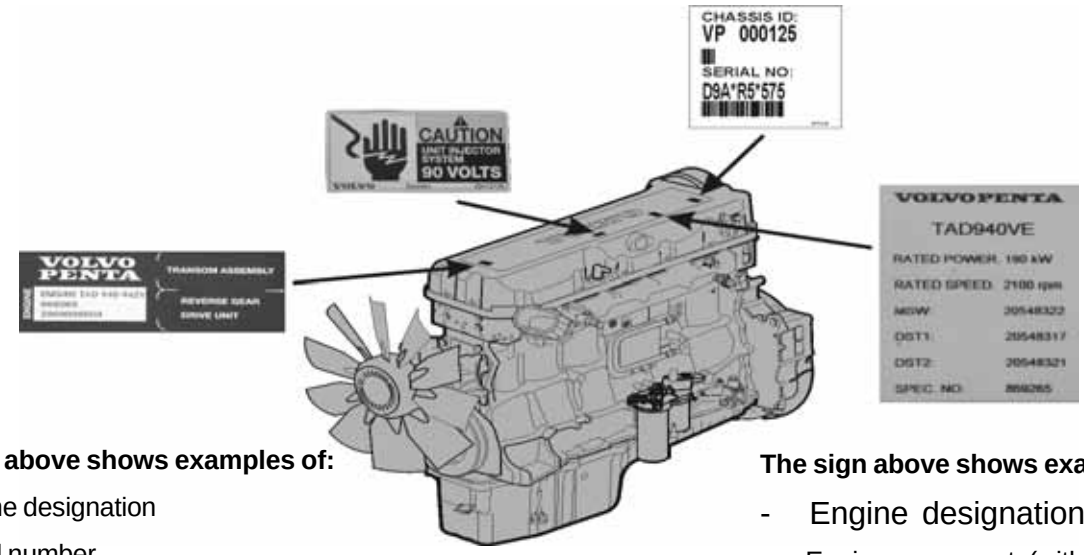
- Radiator with expansion tank
- Air cooled intercooler
- Belt-driven water pump
- Piston thermostat

**Electrical system**

- 24V electrical system
- Alternator with charge sensor
  80 A (110 A and 140 A optional)
- Engine mounted extra stop (AUX STOP)

# Identification numbers

## Location of engine signs




**The sign above shows examples of:**

- Engine designation
- Serial number
- Specification number

**The sign above shows examples of:**

- Engine designation
- Engine power, net, (without fan)
- Max. engine speed
- Main software
- Data set 1
- Data set 2
- Product number

**Explanation of engine designation:**

E.g. TAD940GE/TAD940VE

T – Turbo

A – Air to air intercooler

D – Diesel engine

9 – Cylinder volume, liter

4 – Generation

0 – Version

G – Generator unit engine

V – Stationary and mobile operation

E – Emission control

# EMS 2

EMS 2 (Engine Management System) is an electronic system with CAN communication (Controller Area Network) for diesel engine control. The system has been developed by Volvo Penta and includes fuel control and diagnostic function.

### Summary

The system includes sensors, control unit and unit injectors. The sensors send input signals to the control unit, which controls the unit injectors in its turn.

### Input signals

The control unit receives input signals about engine operating conditions etc. from the following components:

– coolant temperature sensor
– charge pressure / charge temperature sensor
– crankcase pressure sensor
– position sensor, camshaft
– speed sensor, flywheel
– coolant level sensor
– oil level and temperature sensor
– oil pressure sensor
– fuel pressure sensor
– water in fuel indicator

### Output signals

The control module uses the input signals to control the following components:

– unit injectors
– starter motor
– main relay
– pre-heating relay

Information from the sensors provides exact information about current operation conditions and allows the processor in the control unit to calculate the correct fuel injection volume and timing, check engine status etc.

### Fuel control

The engine fuel requirement is analyzed up to 100 times per second. The amount of fuel injected into the engine and the injection advance are fully electronically controlled, via fuel valves and the unit injectors.

This means that the engine always receives the correct volume of fuel in all operating conditions, which offers lower fuel consumption, minimal exhaust emissions etc.

### Diagnostic function

The task of the diagnostic function is to discover and localize any malfunctions in the EMS 2 system, to protect the engine and to ensure operation in the event of serious malfunction.

If a malfunction is discovered, this is announced by warning lamps, a flashing diagnostic lamp or in plain language on the instrument panel, depending on the equipment used. If a fault code is obtained as a flashing code or in plain language, this is used for guidance in any fault tracing. Fault codes can also be read by Volvo's VODIA tool at authorized Volvo Penta workshops.

If there is a serious malfunction, the engine will be shut down altogether, or the control unit will reduce the power delivered (depending on application). Once again, a fault code is set for guidance in any fault tracing.

# Instrument, EMS 2

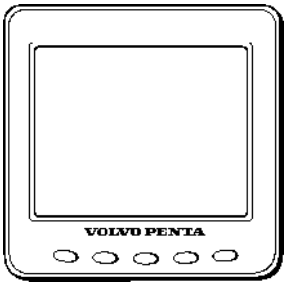
**NOTE!** All instruments are accessories.


## CIU - Control Interface Unit

The CIU is the “translator” between the EMS 2 control unit and the customer’s own control panel. The CIU has two serial communication links, a fast one and a slow one.

The fast one is a so-called CAN link. All data related to instruments, indication lamps, connectors and potentiometers is controlled by this link.

The slow link manages diagnostic information for flashing codes etc.




## DU - Display Unit

The DU is an instrument panel which shows engine working values graphically on an LCD screen. It consists of an computerised unit for permanent installation in a control panel.

The DU is connected between the engine control unit and the CIU or DCU.

## Easy Link instrument (only together with a CIU)

The following “Easy Link” instruments are available:

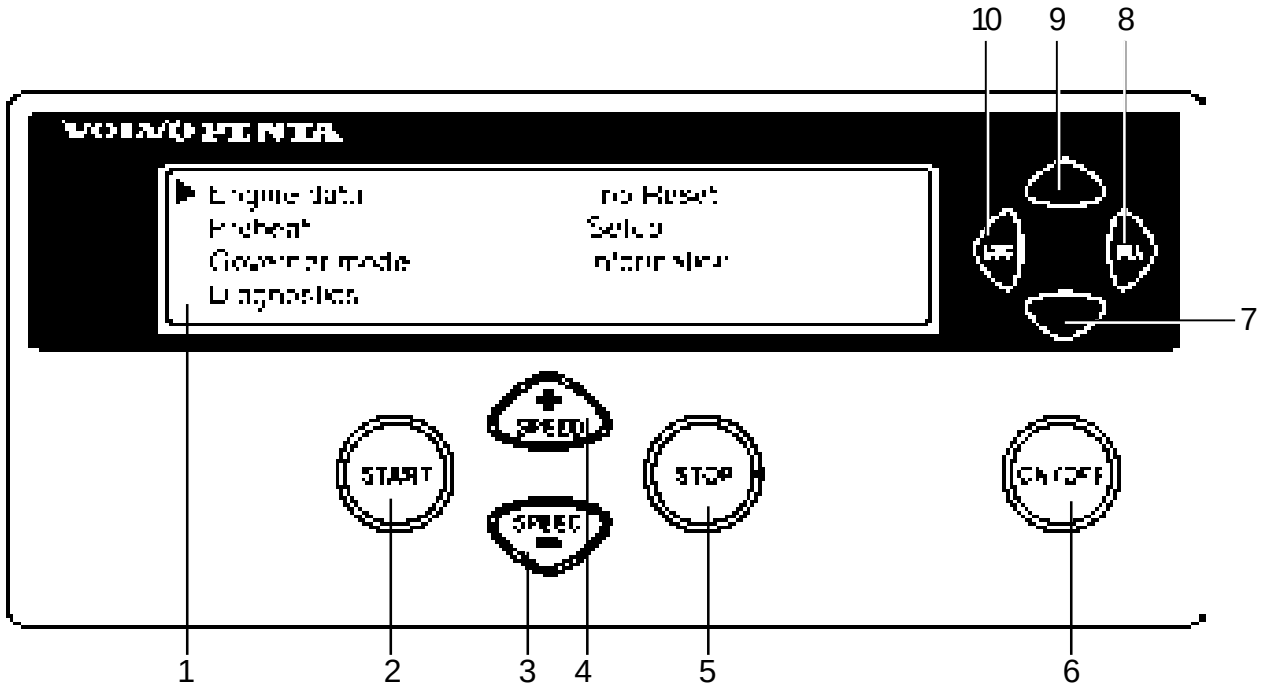
– Engine speed / hours counter (fault codes are also displayed on the tachometer display when the diagnostic button is pressed)
– Coolant temperature
– Oil pressure
– Oil temperature
– Battery voltage
– Alarm panel
– Turbo pressure

# DCU (Display Control Unit)

The DCU (Diesel Control System) control panel is available as an optional accessory for the EMS (Engine Management System) electronic control system. The DCU is a digital instrument panel which communicates with the engine control unit. DCU has several functions, such as: engine control, monitoring, diagnostics and parameter setting.

The menus in the DCU system can be used to check, and in some cases to set a number of different functions in the EMS system.

**NOTE!** The menus and illustrations shown here are the English version. The language can be changed, however. Please refer to the “Setup” menu.




1. LED display
2. START. Starts the engine
3. SPEED -. Reduces engine speed
4. SPEED +. Increases engine speed
5. STOP. Stops the engine
6. ON/OFF. Starts and stops the system
7. Scroll downwards in menus
8. SEL. Selects in menus
9. Scroll upwards in menus
10. ESC. Return to previous menu selection

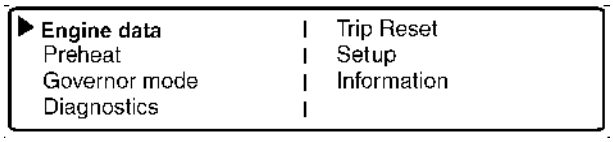
## Start

When the DCU panel is started up, the “Engine Data” menu is displayed. Press “ESC” to come to the main menu.

## Menus

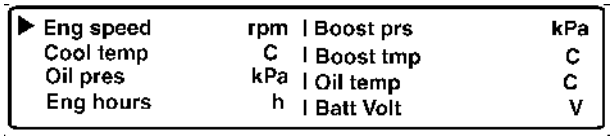
There are several sub-menus under each main menu. There is not space for all the menu choices on the display. To scroll through the menus, use the “7” and “9” buttons on the display. Press the “SEL” button, no. “8” to make a selection. Please refer to the illustration on the previous page.

**NOTE!** The “Setup” menu can be used to select the language that you want to use on the display.




### Main menu

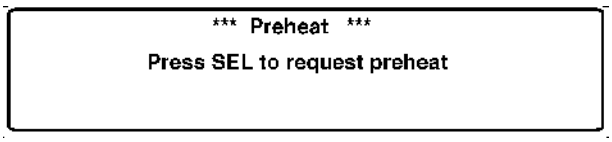
- **Engine data**, relevant engine data.
- **Preheat**, manual activation of pre-heating
- **Governor mode**, activation of droop.
- **Diagnostics**, shows fault codes in plain language.
- **Trip reset**, resets trip data
- **Setup**, parameter setting
- **Information**, shows the data for the applicable hardware, software, data set and engine identification of the engine and DCU




### Engine data

shows relevant engine data.

- Engine speed, can be controlled with the “SPEED +” and “SPEED –” buttons (rpm)
- Charge pressure (kPa)
- Coolant temperature (°C)
- Charge air temperature (°C)
- Oil pressure (kPa)
- Oil temperature (°C)
- Engine hours (h)
- Battery voltage (V)
- Fuel consumption (l/h)
- Instantaneous fuel consumption (trip fuel) (l)

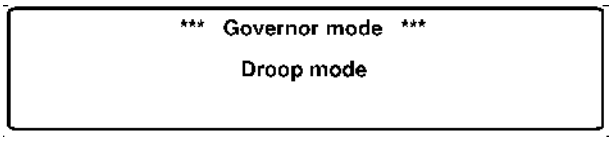



## Preheat

manual activation of pre-heating. When it is activated, the EMS system senses when started if pre-heating is needed. For automatic pre-heating, please refer to the “Setup” / “Pre-heat on ignition” menu.

The pre-heating time is adjusted to suit the engine temperature, and can last for up to 50 seconds both before and after starting. Also refer to “Starting procedure, EMS 2”.

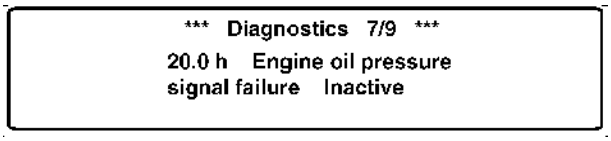
- Press “SEL”, the text “Preheat requested” is displayed.
- The display automatically returns to the “Engine Data” menu.




## Governor mode

activates/shuts off droop. To set the droop level, please refer to the “Setup” / “Governor gradient” or “Governor droop” menus.

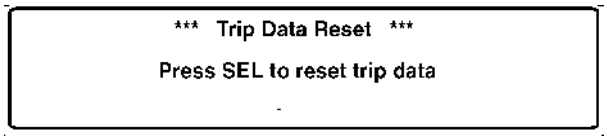
- Select “Isochronous mode” or “Droop mode” with the SEL button.




## Diagnostics

shows the error list containing the 10 latest active and inactive faults. The fault code are shown as text on the display.

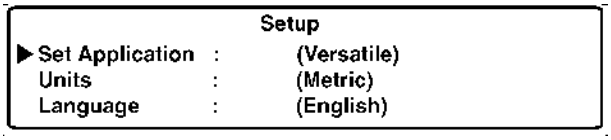
- Scroll through the error list with the arrow keys.




## Trip reset

resets trip data, such as fuel consumption.

- Press the SEL button to reset trip data.

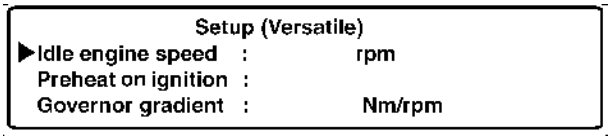



## Setup

parameter setting in the engine's control systems. Different menus appear under "Customer parameter", depending on whether you select "Versatile" or "Genset" from "Set application".

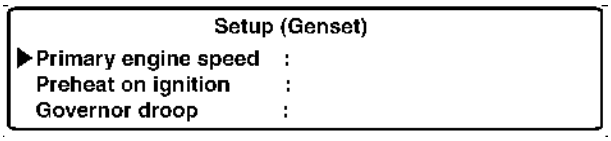
The parameters that can be set / selected (choice is made with the SEL button) are:

- **Set application**, setting of "Versatile" or "Genset". Different menus appear under "Customer parameter", depending on what is chosen here.
- **Unit**, selection of units of measurement (metric or US units)
- **Language**, selection of the language shown in the display. You can choose between English, French, German and Spanish.
- **Stop energized to**, setting for the external stop input. Activated at "Stop" or "Run".
  **"Stop"**: The stop input must be connected to voltage to stop the engine.
  **"Run"**: The stop input must be connected to voltage to run the engine.
- **Customer parameter**, alarm limit setting. Please refer to "Customer parameter / Versatile" and "Customer parameter / Genset".
- **Throttle input setting**, setting of speed control and voltage limits. See "Throttle input setting".
- **Display setting**, display setting. See "Display setting".



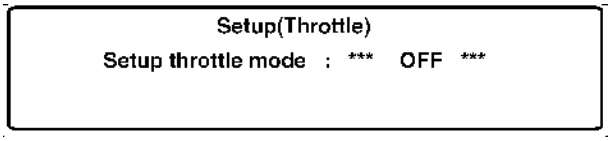

## Customer parameter / Versatile

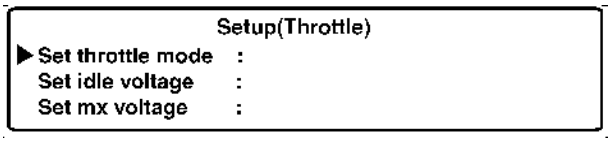
- **Idle engine speed** - setting idling speed
- **Preheat on ignition** - activation of automatic preheating. The engine control system senses if preheating is needed and activates it directly when switched on.
- **Governor gradient (Nm/rpm)** - setting the droop level, when this has been activated. Please refer to "Governor droop" in the main menu for activation.
- **Oil temp warning limit (°C)** - setting the alarm limit for the oil temperature.
- **Coolant temp warning limit (°C)** - setting the alarm limit for the coolant temperature.




## Customer parameter / Genset

- **Primary engine speed** - selection of engine speed, 1500 or 1800 rpm.
- **Preheat on ignition** - activation of automatic pre-heating. The engine control system senses if pre-heating is needed and activates it directly when switched on.
- **Governor droop (%)** - setting the droop level, when this has been activated. Please refer to “Governor droop” in the main menu for activation.
- **Overspeed limit (%)** - setting the speed for the excess speed alarm, % of set engine speed.
- **Overspeed shutdown** - activation of engine shut down when the excess speed alarm is activated. Please refer to “Overspeed limit” to activate the alarm limit for the excess speed alarm.
- **Oil temp warning limit (°C)** - setting the alarm limit for the oil temperature.
- **Coolant temp limit (°C)** - setting the alarm limit for the coolant temperature.

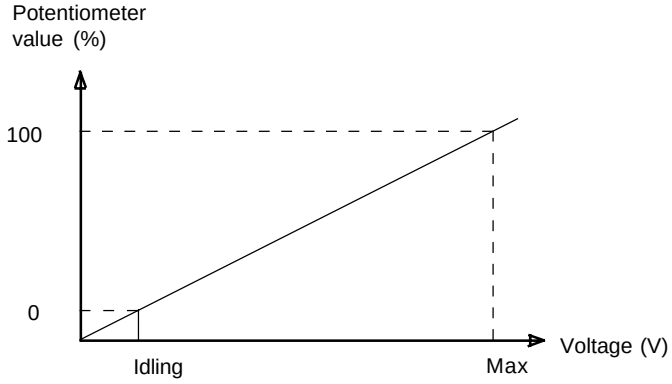


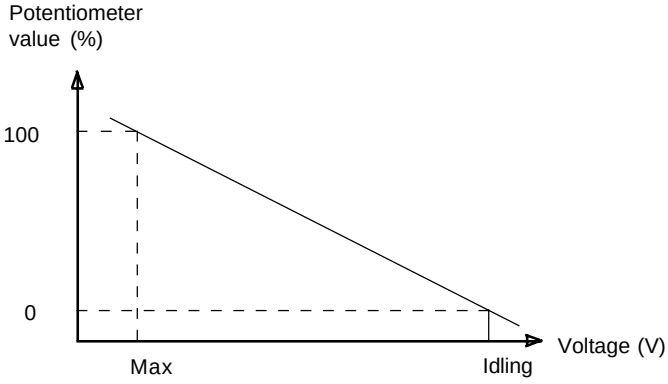



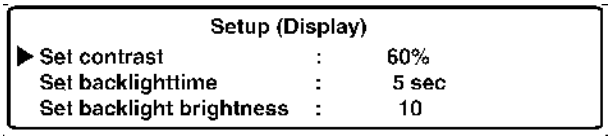

## Throttle input setting

speed control setting (throttle operation).

- **Set throttle mode** -
  “OFF” - engine speed is controlled via the DCU panel.
  “ext throttle input” - engine speed is controlled with a potentiometer (accelerator).
  “ext voltage input” - engine speed is controlled by an external unit.
- **Set idle voltage (V)** - setting the voltage level at idle.
- **Set max voltage (V)** - setting the voltage level at maximum speed.



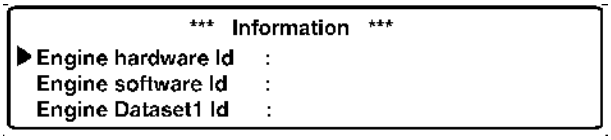






## Display setting

settings for the display. Adjustment is done with the “7” and “9” buttons, please refer to the DCU panel in the illustration.

- **Set contrast (%)** - display contrast adjustment.
- **Set backlight time (sec)** - sets the time (in seconds) for background illumination in the display. The light is then switched off if the panel is not used.
- **Set backlight brightness** - adjustment of illumination strength in the display.




## Information

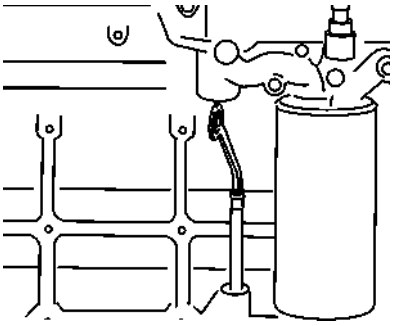
shows the data for the engine and DCU.

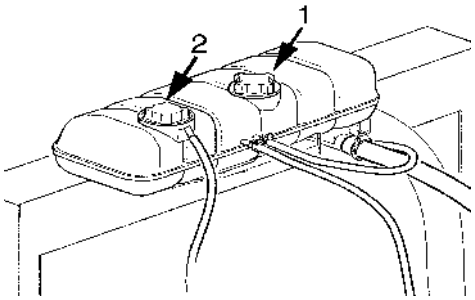
- **Engine hardware ID** - part number of the engine control module
- **Engine software ID** - part number of the software in the engine control module
- **Engine dataset1 ID** - part number of engine data set 1.
- **Engine dataset2 ID** - part number of engine data set 2.
- **Vehicle ID** - chassis number
- **DCU hardware ID** - part number of the DCU.
- **DCU software ID** - part number of the software in the DCU.
- **DCU dataset1 ID** - part number of DCU data set 1.
- **DCU dataset2 ID** - part number of DCU data set 2.

# Starting the engine

Make it a habit to give the engine and engine bay a visual check before starting. This will help you to discover quickly if anything abnormal has happened, or is about to happen. Also check that instruments and warning displays show normal values after you have started the engine.

⚠ **WARNING!** Never use start spray or similar products as a starting aid. Explosion risk!






## Before starting

- Check that the oil level is between the MAX and MIN marks. Please refer to the “Maintenance, lubrication system” chapter:
- Open the fuel taps.
- Check that no leakage of oil, fuel or coolant occurs.
- Check the air filter pressure drop indicator. Please refer to the “Maintenance, Engine, general” chapter:
- Check the coolant level and that the radiator is not blocked externally. Please refer to the “Maintenance, cooling system” chapter:

⚠ **WARNING!** Do not open the filler cap (1) when the engine is hot. Steam or hot fluid could spray out.

**NOTE!** Only open filler cap (1). Do not open filler cap (2).

- Turn the main switch(es) on.

⚠ **IMPORTANT!** Never disconnect the current with the main switch(es) when the engine is running. This can damage the alternator.

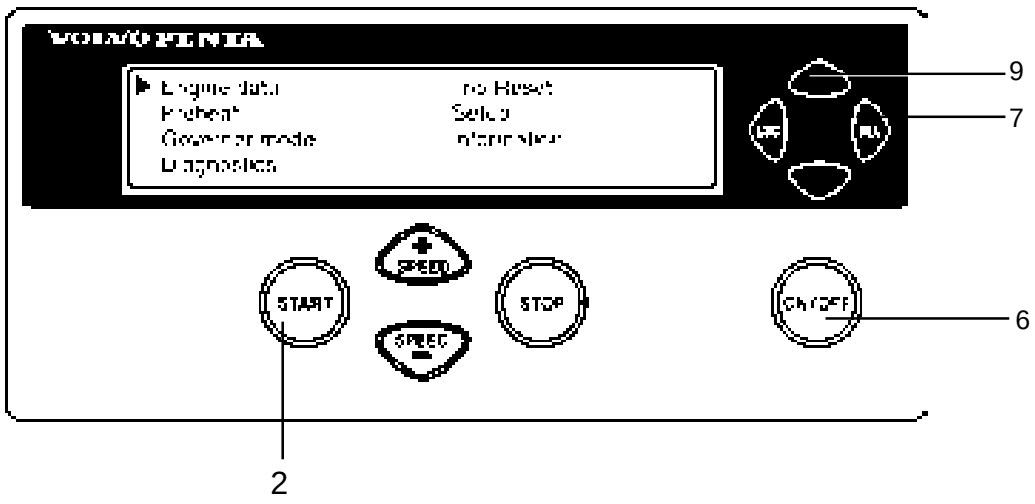
- Move the engine speed control to idle, and release the opening clutch/gearbox if installed.

## Starting method EMS 2

The pre-heating time is adjusted to suit the engine temperature, and can last for up to 50 seconds both before and after starting.

The starter motor connection time is maximized to 30 seconds. After that, the starter motor circuit is cut for 80 seconds to protect the starter motor against over-heating.

**NOTE!** Preheating must be activated at temperattures below 0°.




**With pre-heating**

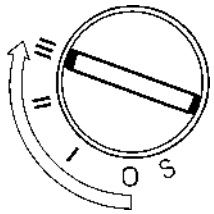
1. Depress the “ON/OFF” button (6).
2. Press the “SEL” button (7) to come to the main menu.
3. Scroll down to **Preheat** with button (9). Press the “SEL” button (7).
4. In the pre-heat menu, press the “SEL” button (7) to select pre-heating. The text “Preheat active please wait” is shown in the display.
5. Wait until the text has gone out and then press the “START” button (2).

**Without pre-heating**

1. Depress the “ON/OFF” button (6).
2. Press the “START” button (2).

Leave the engine to idle for the first 10 seconds. Then warm the engine up at low speed and under low load.

⚠ **IMPORTANT!** Never race the engine when it is cold.




## Volvo Penta starter switch

**(standard pre-heating setting)**

1. Turn the key to position “I” and check the warning lamps
2. Position “**II**”. Pre-heating is activated (pre-heating is optional). Wait until the pre-heating indication lamp goes out. Pre-heating time depends on engine temperature.
3. Start the engine in position “**III**”. Release the key back to position “**I**” immediately after the engine has started.

**NOTE!** The engine has a built-in starter interlock to prevent involuntary engagement of the starter motor when the engine is running. To do a new start attempt, the key must first be turned back to position “**O**”.

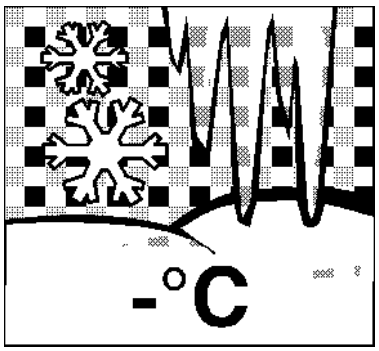
Let the engine run at 500-700 rpm for the first 10 seconds. Then warm the engine up at low speed and under low load.

⚠ **IMPORTANT!** Never race the engine when it is cold.

**Alternative pre-heating:**

**(set by the supplier)**

1. Turn the key to position “**I**” and check the indication lamps. Pre-heating is activated automatically (pre-heating is optional). Pre-heating time depends on engine temperature.
2. Start the engine in position “**III**”. Release the key back to position “**I**” immediately after the engine has started.




## Starting in extreme cold

Certain preparations must be made to facilitate engine starting, and in some cases to make starting possible at all.

Use a winter grade fuel (of a well-known make) which has been approved for the relevant temperature. This reduces the risk of wax deposits in the fuel system. At extremely low temperatures, the use of a fuel heater is recommended.

For fully acceptable lubrication, a synthetic engine oil of recommended viscosity for the relevant temperature should be used. Please refer to the “Maintenance, lubrication system” chapter: Synthetic lubricants are able to manage a wider temperature range than mineral-based lubricants.

Pre-heat the coolant with a separately installed electric engine heater. In extreme cases, a diesel-burning engine heater may be needed. Ask your Volvo Penta dealer for advice.

⚠ **IMPORTANT!** Make sure that the cooling system is filled with a glycol mixture. Please refer to the “Maintenance, cooling system” chapter:

The batteries should be in good condition. Cold weather reduces battery capacity. Increased battery capacity may be necessary.

## Never use start spray

⚠ **WARNING!** Never use start spray or similar products as a starting aid. They may cause an explosion in the inlet manifold. Personalinjury could also be caused.

## Starting with auxiliary batteries

⚠ **WARNING!** Batteries (especially auxiliary batteries) contain hydrogen which is highly explosive in contact with air. A spark, which can be formed if the auxiliary batteries are wrongly connected, is enough to make a battery explode and cause damage.

1. Check that the auxiliary batteries are connected (series or parallel) so that the rated voltage corresponds to the engine system voltage.
2. First connect the red (+) jumper cable to the auxiliary battery, then to the flat battery. Then connect the black (–) jumper cable to the auxiliary battery, and lastly to a place which **is some distance away from the flat batteries,** e.g. at the main switch on the negative cable or the negative cable terminal on the starter motor.
3. Start the engine.

⚠ **WARNING!** Do not move the connections when you attempt to start the engine (risk of arcing), and do not stand and lean over one of the batteries.

4. Remove the jumper cables in the reverse order from installation.

⚠ **WARNING!** The ordinary cables to the standard batteries must not be loosened on any condition.

# Operation

Correct operation technique is very important for both fuel economy and engine life. Always let the engine warm up to normal operating temperature before operating at full power. Avoid sudden throttle openings and operation at high engine speeds.

## Checking instruments

Check all instruments directly after starting, and then regularly during operation.

⚠ **IMPORTANT!** On engines which operate continuously, the lubrication oil level must be checked, at least every **24 hours**. Please refer to the “Maintenance, lubrication system” chapter:

## Fault indication

If the EMS 2 system receives abnormal signals from the engine, the control unit generates fault codes and alarms, in the form of lamps and audible warnings. This is done by means of CAN signals to the instrument.

More information about fault codes and fault tracing is found in the “Diagnostic function” chapter.

## Operation at low load

Avoid long-term operation at idle or at low load, since this can lead to increased oil consumption and eventually to oil leakage from the exhaust manifold, since oil will seep past the turbocharger seals and accompany the induction air into the inlet manifold at low turbo boost pressure.

One consequence of this is that carbon builds up on valves, piston crowns, exhaust ports and the exhaust turbine.

At low load, the combustion temperature is so low that full combustion of the fuel can not be ensured, which means that the lubrication oil can be diluted by diesel fuel, and the exhaust manifold will eventually leak oil.

**If the following points are done as a complement to normal maintenance, there will be no risk of malfunctions caused by operation at low load.**

- Reduce operation at low load to a minimum. If the engine is regularly test run without load once a week, operation duration should be limited to 5 minutes.
- Run the engine at full load for about 4 hours once a year. Carbon deposits in the engine and exhaust pipe can then be burned off.

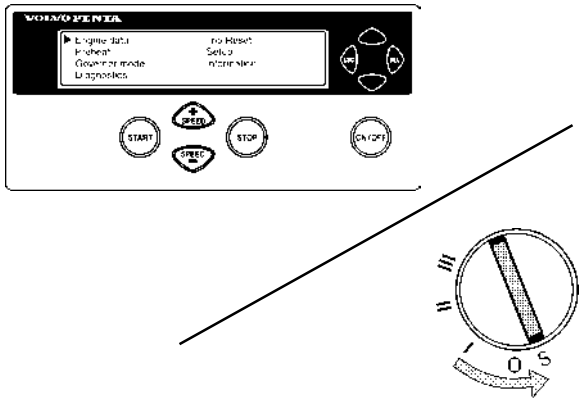
# Stopping the engine

During longer breaks in operation, the engine must be warmed up at least once every fortnight. This prevents corrosion att acks in the engine. If you expect the engine to be unused for two months or more, it must be laid up: Please refer to the chapter entitled “Laying up”.

⚠ **IMPORTANT!** If there is a risk of frost, the coolant in the cooling system must have sufficient frost protection. Please refer to the “Maintenance, cooling system” chapter: A poorly charged battery can freeze and burst.


## Before stopping

Let the engine run for a few minutes without loading before stopping it. This permits the temperature inside the engine to even up, “after-boiling” is avoided, at the same time as the turbocharger cools somewhat. This contributes to long service life without malfunctions.



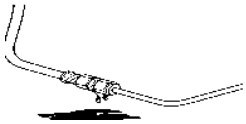

## Stop

- Disengage the clutch (if possible).
- Press the “STOP” button / turn the key to “S”.

## After stopping

- Check the engine and engine bay for leakage**.**
- Turn off the main switches before any long stoppage.
- Carry out maintenance in accordance with the schedule.

⚠ **WARNING!** Working with, or going close to a running engine is a safety risk. Watch out for rotating components and hot surfaces.



## Extra stop

The extra stop (AUX STOP) is on the left of the engine, above the control module. Please refer to “Maintenance, Component location”.

⚠ **WARNING!** Working with, or going close to a running engine is a safety risk. Watch out for rotating components and hot surfaces.

# Maintenance schedule

## General

Your Volvo Penta engine and its equipment are designed for high reliability and long life. It is built so as to have minimal environmental impact. If given preventive maintenance, according to the maintenance schedule, and if Volvo Penta original spares are used, these properties are retained and unnecessary malfunctions can be avoided.

## MAINTENANCE SCHEDULE

⚠ **WARNING!** Before you start to do any maintenance work, read the “Maintenance” chapter carefully. This contains instructions for doing work in a safe and correct manner.

⚠ **IMPORTANT!** When both operation and calendar time are specified, do the maintenance job at the interval which is reached first. Maintenance points marked ☐ must be done by an authorized Volvo Penta workshop.

### Daily, before first start

- Engine and engine bay, general inspection ..... page 27
- Air filter indicator, inspection [1] ..... page 29
- Oil level, checking and filling ..... page 31
- Coolant, checking level ..... page 35

[1] Change the air filter every 24 months.

### Every 50 hours / at least every 12 months

- Primary fuel filter. Drain water/contamination ..... page 41

### After the first 150 hours

- Engine oil, changing [1] ..... page 31

[1] **NOTE!** An oil change is recommended, change the oil to a grade recommended by Volvo Penta.

### After the first 1000 hours

☐ Double rocker arm (iEGR) inspection/adjustment [1] ..... not shown

[1] Then every 4000 hours. Only TAD950VE, TAD951VE and TAD952VE.

### Every 50-600 hours / at least every 12 months

- Engine oil, changing [1] ..... page 31
- Oil filter/By-pass filter, change [2] ..... page 32
- Primary fuel filter, change ..... page 40
- Fuel filter, changing ..... page 40

[1] Oil change intervals vary, depending on oil grade and sulfur content of the fuel. Please refer to page 30.
[2] Change the filters during each oil change.

### Every 400 hours / at least every 12 months

- Fuel tank (sludge trap), drain. ..... not shown
- Drive belts, inspection ..... page 28-29
- Batteries, checking the electrolyte level ..... page 43

### Every 800 hours / at least every 12 months

- Charge air pipe, leakage check. 27
- Primary fuel filter, check ..... not shown

### Every 1000 hours / at least every 6 months

- Coolant filter, changing [1] ..... page 37

[1] Not at same time as coolant change.

### Every 2000 hours

- ☐ Turbocharger, check ..... not shown
- ☐ Valve clearance, inspection/adjustment ..... not shown

### Every 4000 hours

- ☐ Double rocker arm (iEGR) inspection/adjustment [2] ..... not shown

### Every 12 months

- ☐ EMS 2 system. Inspection with diagnostic tool (VODIA) ... please refer to the “VODIA User’s Guide”
- ☐ Engine, general inspection ..... page 27
- Engine, cleaning/painting ..... not shown
- Inspection, tank ventilation, change. ..... not shown
- Inspection, air compressor, change. ..... not shown
- Air filter inserts, check/change ..... page 29

### Every 36 months or every 8000 hours

- Drive belts, change ..... page 28-29

### Every 48 months or every 10000 hours

- ☐ Cooling system, inspection/cleaning ..... page 35
- ☐ Coolant, changing ..... page 35-36

## Newly renovated engine:

### After the first 250 hours

- ☐ Valve clearance, adjustment ..... not shown

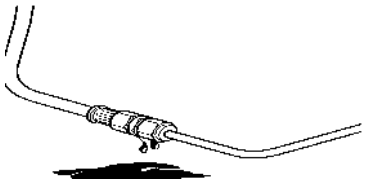
# Maintenance

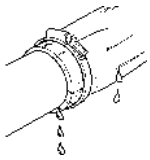
This chapter describes how the specified maintenance points should be done. Read them carefully before starting work. The times when maintenance points need to be attended to are given in the previous chapter: Maintenance schedule.

⚠ **WARNING!** Read through the safety advice for care and maintenance work in the “Safety information” chapter before starting work.

⚠ **WARNING!** Care and maintenance work should be done with the engine stopped unless otherwise specified. Make it impossible to start the engine by removing the ignition key and cutting the system voltage with the main switch. Working with, or going close to a running engine is a safety risk. Watch out for rotating components and hot surfaces.

## Engine, general





### General inspection

Make it a habit to give the engine and engine bay a visual check **before the engine is started** and **after operation, when the engine has been stopped**. This will help you to discover quickly if anything abnormal has happened, or is about to happen.

Look especially carefully at oil, fuel and coolant leakage, loose screws, worn or poorly tensioned drive belts, loose connections, damaged hoses and electrical cables. This inspection only takes a few minutes and can prevent serious malfunctions and expensive repairs.

⚠ **WARNING!** Deposits of fuel, oils and grease on the engine or in the engine bay are a fire hazard and must be removed as soon as they are discovered.

⚠ **IMPORTANT!** If you discover a leakage of oil, fuel or coolant, investigate the cause and fix the fault before you start the engine.

⚠ **IMPORTANT!** Remember the following when washing with a high pressure washer: Never aim the water jet at radiators, intercoolers, seals, rubber hoses or electrical components.

### Charge air pipe, leakage check

Inspect the condition of the charge air hoses, hose unions and clamp condition for cracks and other damage. Change as necessary.

⚠ **IMPORTANT!** Torque the clamps to 9 ±2 Nm (6.5 ±1.4 lbf-ft).

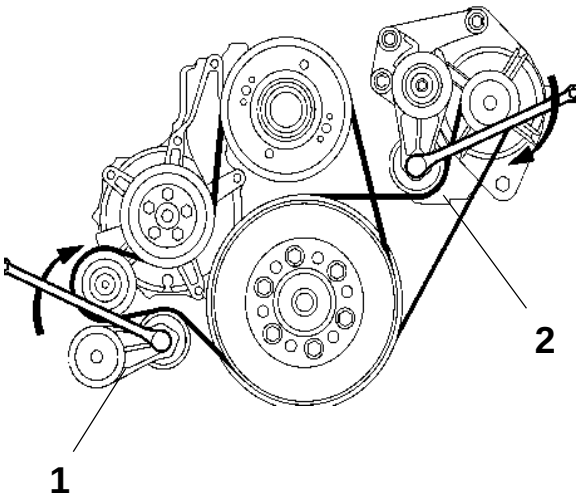
## Drive belt/Alternator belt, inspection

Inspection should be done after operation, when the belts are hot.

It should be possible to press the alternator belts and drive belts down about 3-4 mm (0.12-0.16") between the pulleys.

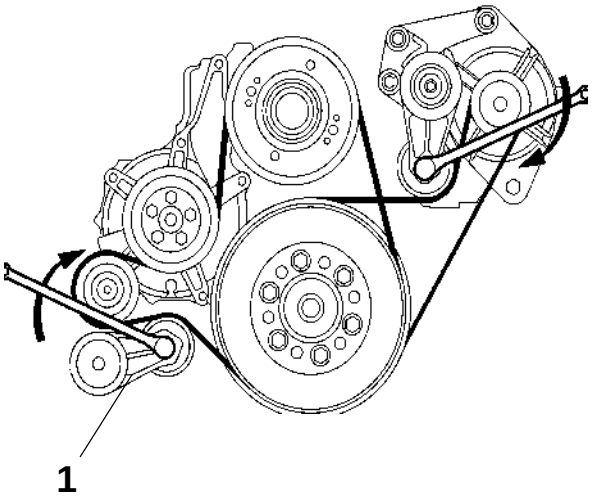
The alternator belts and drive belts have automatic belt tensioners and do not need to be adjusted. Check the condition of the drive belts. Change as necessary, please refer to “Alternator belt, change” and “Drive belt, change”.

## Alternator belts, changing



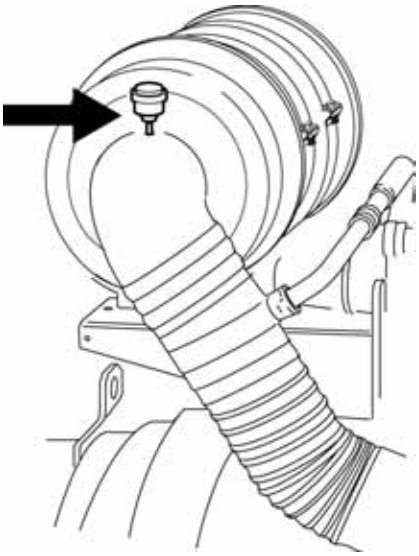

⚠ **IMPORTANT!** Always change a drive belt which appears worn or cracked.

1. Disconnect the main switch(es) and check that the engine is not connected to system voltage.
2. Remove the protective grating and the outer fan ring round the cooling fan.
3. Remove the protective plates round the drive belts.
4. Insert a 1/2" spanner in the belt tensioner (1). Lift the wrench up and lift the water pump drive belt off.
5. Insert a 1/2" spanner in the belt tensioner (2). Press the wrench down and remove the alternator belt.
6. Check that the pulleys are clean and undamaged.
7. Press the 1/2" wrench in the belt tensioner (2) down and install the new alternator drive belt.
8. Lift the 1/2" wrench in the belt tensioner (1) and re-install the water pump drive belt.
9. Install the protective plates round the drive belts.
10. Install the protective grating and the outer fan ring round the cooling fan.
11. Start the engine and do a function check.




## Drive belt, changing

1. Disconnect the main switch(es) and check that the engine is not connected to system voltage.
2. Remove the protective grating and the outer fan ring round the cooling fan.
3. Remove the protective plates round the drive belts.
4. Insert a 1/2" spanner in the belt tensioner (1). Lift the wrench and remove the drive belt.
5. Thread the drive belt round the fan and remove it.
6. Check that the pulleys are clean and undamaged.
7. Thread the new drive belt over the fan.
8. Lift the 1/2" wrench and install the new drive belt.
9. Install the protective plates round the drive belts.
10. Install the protective grating and the outer fan ring round the cooling fan.
11. Start the engine and do a function check.



## Air filter. Check/change.

Change the air filters when the indicator remains in the red field after the engine has been stopped. Reinstate the pressure drop indicator after changing the filter, by pressing in the button.

**NOTE!** Scrap the old filters. No cleaning or re-use is permissible.

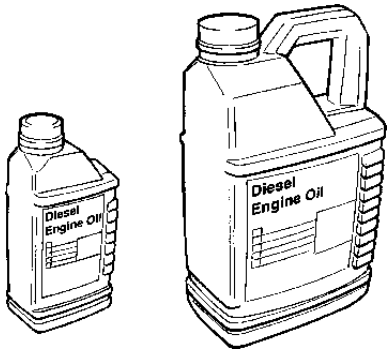
⚠ **IMPORTANT!** In continuous operation, the filters should be checked every 8 hours.
When used in extremely dirty environments, such as coal mines, rock crushing mills, you must use special air filters.

## Lubrication system

Oil change intervals can vary from **50 to 600 hours,** depending on the grade of lubrication oil and the sulfur content of the fuel. **Note that oil change intervals must never exceed a period of 12 months.**

If you want longer oil change intervals than given in the table below, the condition of the oil must be checked by the oil manufacturers through regular oil testing.

**NOTE!** The oil filters must be changed during each oil change.

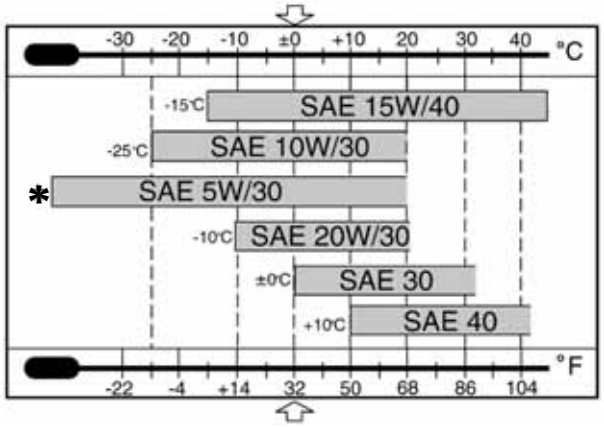



| Oil grade | Sulfur content in fuel, by weight | | |
|---|---|---|---|
| | < 0.5 % | 0.5 – 1.0 % | > 1.0 %[1] |
| | Oil change interval: Reached first in operation | | |
| VDS-3 | 600 hours / 12 month | 300 hours / 12 month | 150 hours / 12 month |
| VDS-2 **and** ACEA E7 [2]<br>VDS-2 **and** Global DHD-1 [2]<br>VDS-2 **and** API CI-4 [2]<br>VDS-2 **and** API CH-4 [2] | 400 hours / 12 month | 200 hours / 12 month | 100 hours / 12 month[3] |
| VDS **and** ACEA E3 [2]<br>ACEA: E7, E5, E4<br>API: CI-4, CH-4, CG-4 | 200 hours / 12 month | 100 hours / 12 month | 50 hours / 12 month[3] |

[1] If sulfur content is > 1.0 % by weight, use oil with TBN > 15.
[2] Lubrication oil must comply with both requirements. Note. API: CG-4 or CH-4 can be approved in markets outside Europe (instead of ACEA A3).
[3] Use oil with TBN 14-20.

**NOTE!** Mineral based oil, either fully or semi-synthetic, can be used on condition that it complies with the quality requirements above.

**VDS = Volvo Drain Specification**
**ACEA = Association des Constructeurs Européenne d'Automobiles**
**API = American Petroleum Institute**
**TBN = Total Base Number**



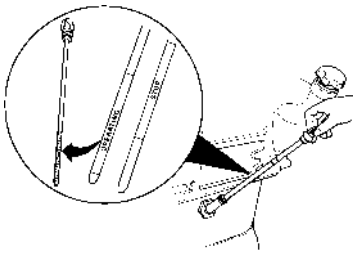

## Viscosity

Select the viscosity from the adjacent table, for the appropriate continuous ambient air temperature.

*Refers to synthetic or semi-synthetic oils.

## Oil change volume

Please refer to the "Technical Data" chapter.



## Oil level, checking and filling

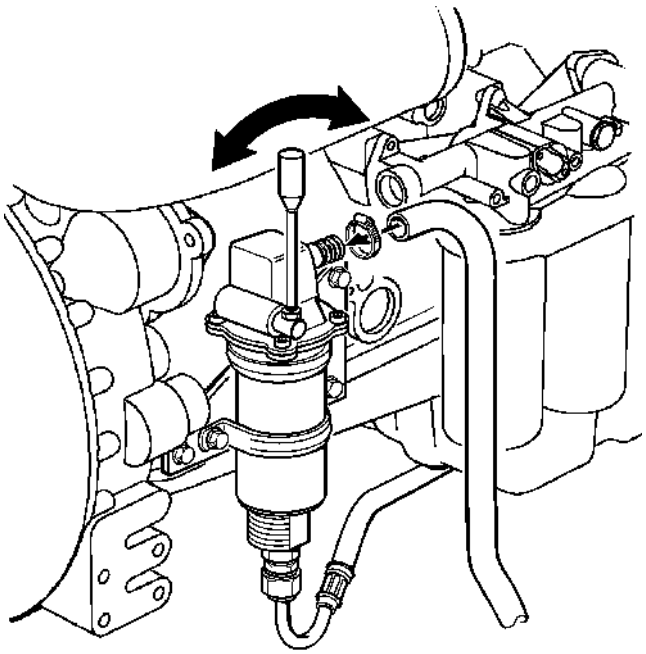
The oil level must be inside the marked area on the dipstick and must be checked daily before the first start.

Top up with oil via the filler opening on the left side of the engine.

Check that the correct level has been achieved. Wait for a few minutes to allow the oil to run down into the sump.

⚠ **IMPORTANT!** Do not fill up above the maximum oillevel. Only use a recommended grade of oil. (please refer to previous page).

**NOTE!** The oil level sensor only measures the oil level at the time when the ignition is turned on. In other words, not continually during operation.



## Engine oil, changing

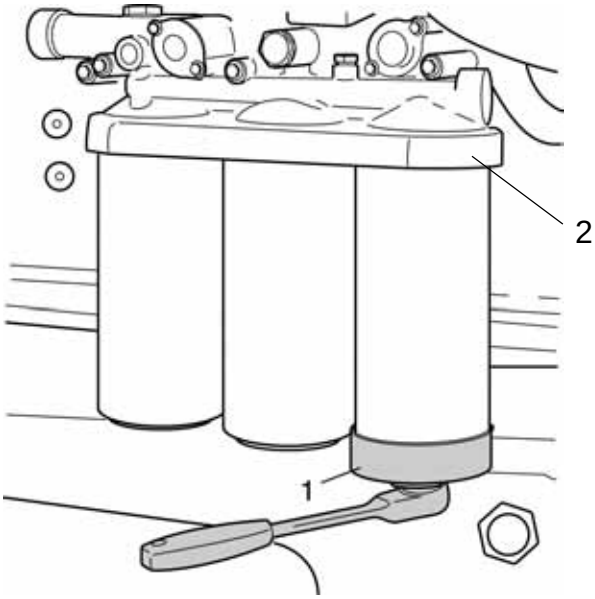
⚠ **WARNING!** Hot oil and hot surfaces can cause burns.

**NOTE!** Oil changes must be done when the engine is warm.

1. Connect the drain hose to the oil drain pump and check that no leakage can occur.
2. Pump the oil out (or remove the bottom drain plug and drain the engine oil).

**NOTE!** Collect the old oil and oil filters, and hand them to a re-cycling station for destruction.

3. Remove the drain hose (or install the bottom drain plug).
4. Fill up with engine oil. Change volume, please refer to the “Technical Data” chapter.




## Oil filter/By-pass filter, change

⚠ **WARNING!** Hot oil and hot surfaces can cause burns.

1. Clean the oil filter bracket.
2. Remove all oil filters with a suitable oil filter remover (1).
3. Clean the mating surface of the oil filter bracket. Make sure that no pieces of old oil seal are left behind. Carefully clean round the inside of the protective rim (2).
4. Put a thin layer of engine oil on the seal rings of the new fuel filters.
5. Install the new oil filters. Tighten the two full-flow filters (on the right of the illustration) 1/2–3/4 turns after they just touch. Tighten the bypass filter 3/4–1 turn after it just touches.
6. Top up with engine oil, start the engine and let it run for 20-30 seconds.
7. Shut the engine off, check the oil level and top up the engine oil as necessary.
8. Check sealing round the oil filters.

## Cooling system

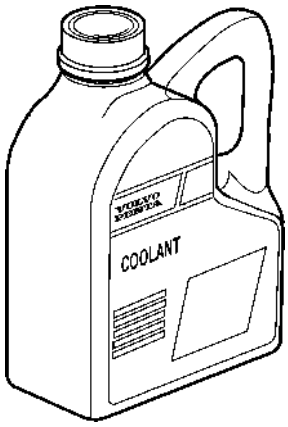
The cooling system ensures that the engine works at the right temperature. It is a closed system and must therefore always be filled with a mixture of at least 40% concentrated coolant and 60% water, to offer protection from interior corrosion, cavitation and frost bursting.

We recommend that you use **"Volvo Penta Coolant, Ready Mixed"**, or **"Volvo Penta Coolant"** (concentrated) mixed with **pure** water acc. to the specification, please refer to "Coolant. Mixing". This grade of coolant is the only one that is developed for and approved by Volvo Penta.

The coolant should contain a good grade of ethylene glycol and a suitable chemical formula for full engine protection. The use of only an anti-corrosion preparation is not permissible for use in Volvo Penta engines. Never use water by itself as the coolant.

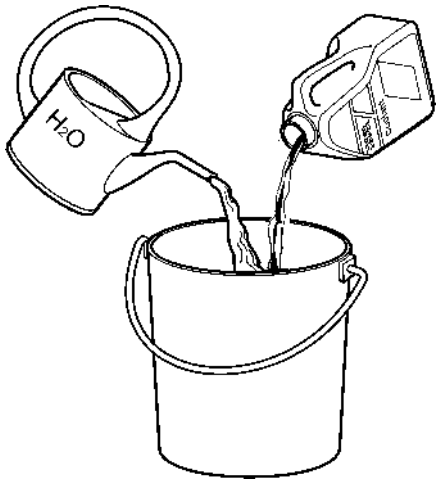
⚠ **IMPORTANT!** Coolant fluid should be used all year round. This also applies in areas where there never is any risk of frost, to give the engine full corrosion protection.
Future warranty claims related to engine and accessories may be refused if an unsuitable coolant has been used, or if the recommendation for coolant mixture has not been observed.

**NOTE!** The corrosion protection additives become less effective as time passes, which means that the coolant must be changed. Please refer to the "Maintenance Schedule". The cooling system should be flushed when the coolant is changed, please refer to "Cooling system. Flushing".




**"Volvo Penta Coolant"** is concentrated coolant that should be mixed with water. It has been prepared to work best with Volvo Penta engines and offers excellent protection against frost and cavitation damage, plus frost bursting.

**"Volvo Penta Coolant, Ready Mixed"** is ready-mixed coolant, 40% "Volvo Penta Coolant" and 60% water. This mixture protects the engine from corrosion damage, cavitation damage and frost bursting down to -28°C (-18.4°F).




## Coolant. Mixing

⚠ **WARNING!** All glycol is hazardous and pollutes the environment. Do not swallow it!
Glycol is flammable.

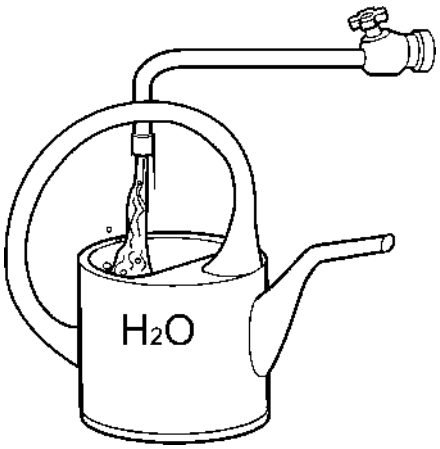
⚠ **IMPORTANT!** Ethylene glycol must not be mixed with other types of glycol.

**Mix:**
**40% "Volvo Penta Coolant" (conc. coolant)**
**60% water**

This mixture prevents against internal corrosion, cavitation and frost bursting down to about -28°C (-18.4°F). (at 60% glycol concentration, the freezing point is lowered to -54°C (-65.2°F)). Never mix more than 60% concentrate (Volvo Penta Coolant) in the coolant. This will give reduced frost protection and poorer cooling effect, with a consequent risk of overheating.

⚠ **IMPORTANT!** The coolant must be mixed with pure water, use distilled – de-ionized water. The water must comply with the requirements specified by Volvo Penta, please refer to "Water quality".

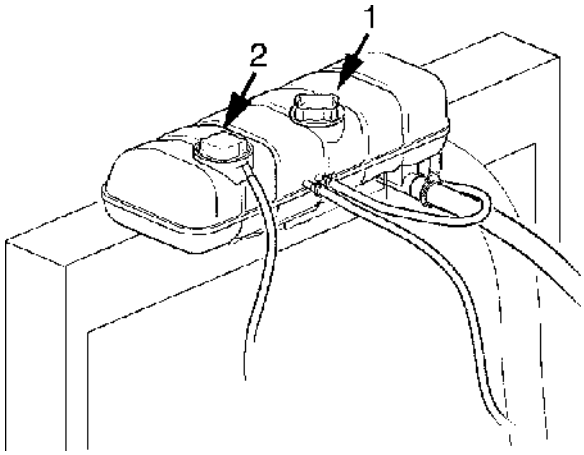
⚠ **IMPORTANT!** It is extremely important that the correct concentration of coolant is put in the system. Mix in a separate clean vessel before filling the cooling system. Make sure that the liquids mix.




## Water quality

**ASTM D4985:**

| | |
|---|---|
| Total solid particles | < 340 ppm |
| Total hardness: | < 9.5° dH |
| Chloride | < 40 ppm |
| Sulfate | < 100 ppm |
| pH value | 5.5–9 |
| Silica (acc. to ASTM D859) | <20 mg $SiO_2$/l |
| Iron (acc. to ASTM D1068) | < 0.10 ppm |
| Manganese (acc. to ASTM D858) | < 0.05 ppm |
| Conductivity (acc. to ASTM D1125) | < 500 µS/cm |
| Organic content, $COD_{Mn}$ (acc. to ISO8467) | <15 mg$KMnO_4$/l |




## Coolant, inspection

⚠ **WARNING!** Do not open the filler cap (1) when the engine is warm, except in emergencies. Steam or hot fluid could spray out.

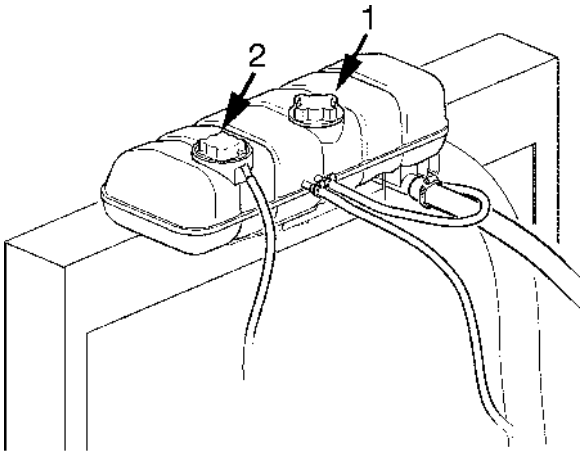
**NOTE!** Only open filler cap (1). Do not open filler cap (2).

The coolant level must be higher than the MIN marking. Check the coolant level daily before starting. Top up with coolant as necessary, please refer to Coolant, filling.

## Cooling system, filling

⚠ **WARNING!** Do not open the filler cap (1) when the engine is warm, except in emergencies. Steam or hot fluid could spray out.

**NOTE!** Do not open filler cap (2).




**Filling a completely empty system**

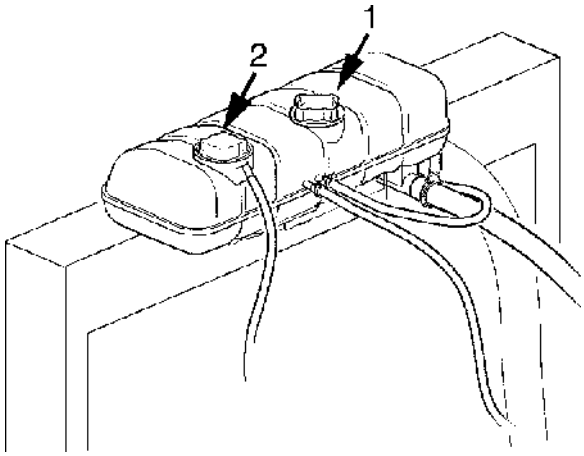
1. Open filler cap (1).
2. Check that all drain points are closed.

**NOTE!** Only use the coolant recommended by Volvo Penta.

3. Mix the correct amount of coolant in advance, to ensure that the cooling system is completely filled.
4. Fill up with coolant, so that the level ends up between the MIN and MAX markings. **Do not start the engine until the system is vented and completely filled.**

   Filling should be done with the engine stationary. Fill up slowly, to allow the air to flow out.
5. Start the engine when the cooling system has been completely filled and vented. Open any venting taps some while after starting, to allow shut-in air to escape.

   If a heating unit is connected to the engine cooling system, the heat control valve should be opened and the installation vented during filling.
6. Stop the engine after about an hour and check the coolant level. Top up as necessary.




## Coolant. Draining

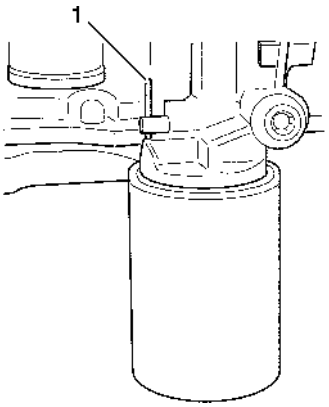
The engine must be stopped before draining, and the filler cap unscrewed.

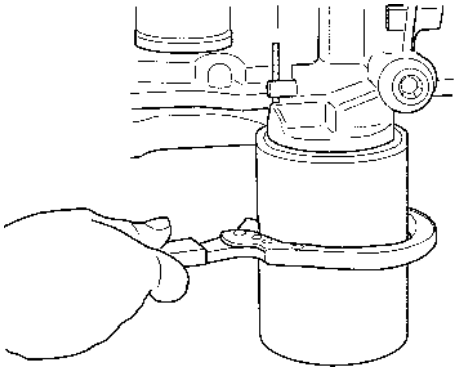
⚠ **WARNING!** Do not open the filler cap (1) when the engine is warm, except in emergencies. Steam or hot fluid could spray out.

**NOTE!** Do not open filler cap (2).

On engines which are to be laid up or put in storage, the engine cooling system should not be drained. The coolant contains corrosion-inhibiting additives.

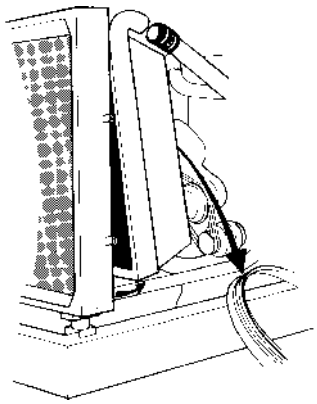
1. Remove the filler cap (1).
2. Open all drain points. Drain the coolant from the radiator and engine block, using the drain hose. The drain nipples are situated under the radiator on the right side of the engine block.
3. Check that all coolant drains out. Deposits may be found inside the drain plug/tap, and need to be cleared away. There is otherwise a risk that coolant could remain and cause frost damage. Check whether the installation has any further taps or plugs at the lowest points of the cooling water pipes.
4. Shut any taps and check that the spring-loaded covers on the nipples close completely. Install the rubber plugs.



## Coolant filter, changing

1. Turn the tap (1) 90° to stop the flow through the coolant filter.
2. Remove the coolant filter with a suitable extractor. Make sure that no residue from the old seal remains in the housing.
3. Put a thin layer of engine oil on the new coolant filter seal. Screw the coolant filter on by hand until the seal comes into contact with the mating surface of the filter bracket. Then tighten the coolant filter a further 1/2 turn.
4. Turn the tap (1) 90° to release the flow through the coolant filter again.
5. Start the engine and do a leakage check.
6. Switch the engine off and check the coolant level. Please refer to “Coolant level, check”.



## Intercooler. External cleaning

Remove guards as necessary, to access the radiator.

Clean with water and a mild detergent. Use a soft brush. Be careful to ensure that the radiator matrix is not damaged. Re-install the components.

⚠ **IMPORTANT!** Do not use a high pressure power washer.

## Cooling system, cleaning

Cooling performance is reduced by deposits in the radiator and cooling galleries. The cooling system should be cleaned out when the coolant is changed.

⚠ **IMPORTANT!** Cleaning must not be done if there is any risk of the cooling system freezing, since the cleaning solution does not have any frost prevention ability.

1. Empty the cooling system. Please refer to “Cooling system, draining”.
2. Put a hose into the filling hole in the expansion tank and flush with **pure** water, which complies with Volvo Penta specifications, please refer to the “Water Quality” chapter, until the water which runs out is completely clear.
3. If there should still be some contamination left after flushing for a long time, cleaning can be done with coolant. Otherwise, continue as in item 8 below.
4. Fill the cooling system with 15-20% mixture of concentrated coolant. Only use Volvo Penta recommended concentrated coolant, mixed with **pure** water.
5. Drain the coolant after 1-2 days of operation.

**NOTE!** To prevent suspended material from settling back in the system, emptying should be done rapidly, within the space of 10 minutes, when the engine has not been standing still for a long time. Remove the filler cap and possibly the lower radiator hose to increase the speed of emptying.

6. Flush the system at once, very carefully, with **pure** hot water to stop dirt from settling on the inner surfaces again. Flush until the water that runs out is completely clean. Make sure that any heater controls are set to full heating during emptying.
7. If contamination should still be left after a long period of flushing, you can do a clean-out with Volvo Penta radiator cleaner, followed by finishing-off with Volvo Penta neutralizer. Carefully follow the instructions on the package. Otherwise, continue as in item 8 below.
8. When the cooling system is completely free from contamination, close the drain taps and plugs.
9. Fill up with Volvo Penta recommended coolant, following the instructions in the chapters entitled “Coolant, mixing” and “Coolant, filling”.

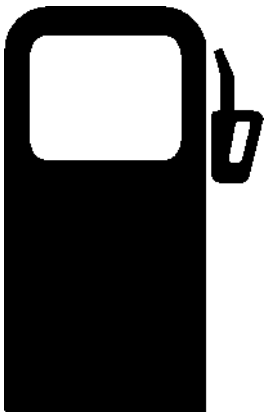
⚠ **IMPORTANT!** It is extremely important that the correct concentration and volume of coolant is put in the system. Mix in a separate clean vessel before filling the cooling system. Make sure that the liquids mix.

# Fuel system

Only use the grades of fuel recommended in the fuel specification below. Always observe the greatest cleanliness during re-fueling and work on the fuel system.

All work on the injection system of the engine must be done by an authorized workshop.

⚠ **WARNING!** Fire hazard. Work on the fuel system must be done with the engine cold. Fuel spills on hot surfaces or electrical components can cause fires. Store fuel-soaked rags in a fire-proof manner.



## Fuel specification

The fuel must at least comply with national and internationalstandards for commercially supplied fuels, such as:

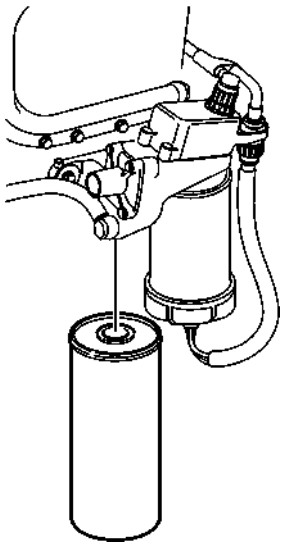
**EN590** (with nationally adapted environmental and coldrequirements)

**ASTM D 975 No 1 - D and 2 - D.**

**JIS KK 2204**

**Sulfur content:** Complying with legal requirements in each country.content exceeds 0.5 percent by weight, the **oil change intervals** must be changed. Please refer to the “Lubrication system” heading.

Extremely low sulfur content fuel (urban diesel in Sweden and city diesel in Finland) can cause a loss of up to 5% of power and an increase in fuel consumption of about 2–3 %.



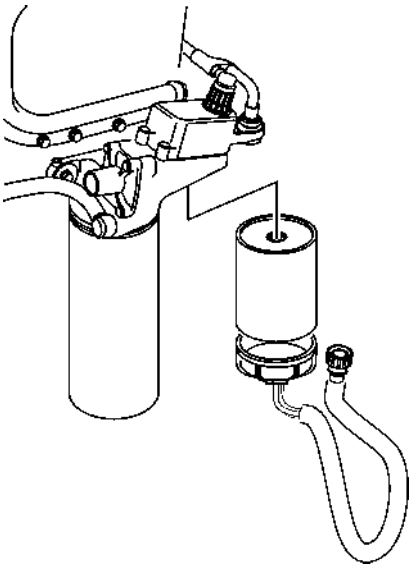
## Fuel filter, changing

**NOTE!** Do not fill the new fuel filter with fuel before assembly. There is a risk that contamination could get into the system and cause malfunctions or damage.

⚠ **WARNING!** The fuel filter must be changed when the engine is cold, to avoid the risk of fire due to spilled fuel on hot surfaces.

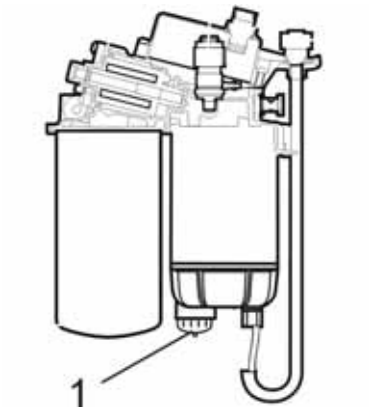
1. Clean round the fuel filter.
2. Remove the filter with a suitable filter remover. Collect any spilled fuel in a collection vessel.
3. Clean the filter mating surface on the filter bracket.
4. Lubricate the seal with diesel fuel and install the new fuel filter. Tighten the fuel filter in accordance with the instructions on the fuel filter.
5. If necessary, vent the fuel system, please refer to “Fuel System, Venting”.

**NOTE!** If a water trap is installed: change the filter in it at the same time as the fuel filter, and clean the water trap in the plastic bowl under the filter with a soft rag.



## Primary fuel filter, change

1. Undo the cable from the water trap sensor.
2. Remove the water trap filter from the filter bracket. Collect any spilled fuel in a collection vessel.
3. Remove the lower part of the water trap from the filter.
4. Clean the lower part of the water trap with a soft rag. Check that the drain hole in the lower part is not blocked.
5. Install a new seal on the lower part and lubricate the seal with diesel fuel. Re-install the lower part of the filter.
6. Lubricate the seal with diesel fuel. Screw the filter onto the filter bracket by hand until the rubber seal just touches the mating surface. Then tighten a further half turn, no more.
7. Connect the cable to the water trap sensor.
8. If necessary, vent the fuel system, please refer to “Fuel System, Venting”.



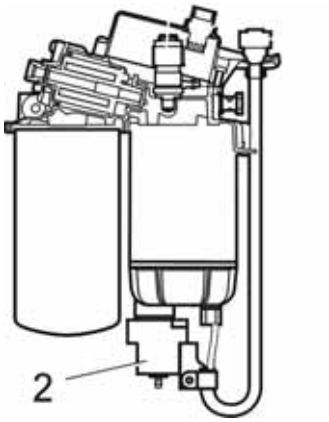

## Draining condensate, fuel system

With mechanical drain nipple:

1. Open the drain nipple (1) in the base of the primary fuel filter.

**NOTE!** Put a collection vessel under the fuel filter, collect the condensate and fuel.

3. Press the electric feed pump switch until water-free fuel starts to run out. Please refer to “Component positions”.
2. Tighten the drain nipple (1).




With electric drain nipple (only as an option on VE engines):

1. Activate the electric drain nipple (2) at the base of the primary fuel filter, to open it.

**NOTE!** Put a collection vessel under the fuel filter, collect the condensate and fuel.

2. Press the electric feed pump switch until water-free fuel starts to run out. Please refer to “Component positions”.
3. Switch off the electric drain nipple (2) at the base of the primary fuel filter, to close it.

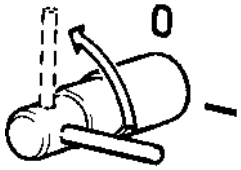
## Venting the fuel system

1. Check whether there is enough fuel in the tank, and that any fuel taps are open.
2. Turn the ignition on.
3. The fuel system is vented by depressing the electric feed pump switch for 1 to 2 minutes. Please refer to “Component positions”. Air is vented to the tank via the fuel return pipe. No venting nipples need to be opened.
4. Start the engine. Let the engine run at slow idle for about 10 minutes.
5. Do a leakage and function check.

## Electrical system

The engine is equipped with a 2-pole electrical system and an alternator. System voltage is 24V.

⚠ **WARNING!** Before any work is done on the electrical system, the engine must be stopped and the current cut by switching off the main switch(es). All connections to equipment such as battery chargers or other auxiliary equipment must be broken.




### Main switch

The main switches must never be disconnected before the engine has been stopped. If the circuit between the alternator and the battery is disconnected when the engine is running, the alternator and electronics can be damaged. The charging circuits must never be re-connected with the engine running, for the same reason.

⚠ **IMPORTANT!** Never disconnect the current with the main switch(es) when the engine is running.

### Circuit breaker

The engine is equipped with a 10 A circuit breaker which cuts the current if overloaded.

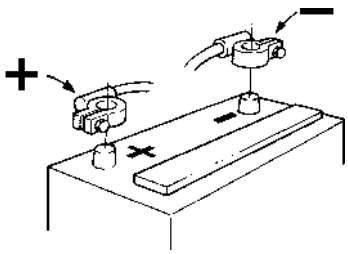
The circuit breaker is located on the left-hand side of the engine, on the left of the control unit.

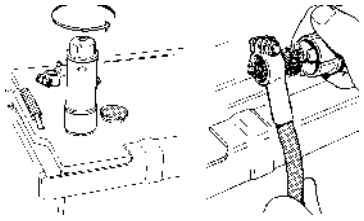
**Note.** The engine stops if **the fuse** trips.

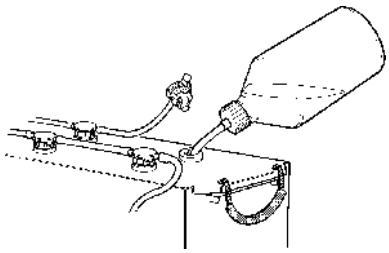
If the circuit breaker trips frequently, an authorized Volvo Penta workshop should be contacted to investigate the cause of the overload.


### Electrical connections

Check that electrical connections are dry, free from oxide and that they are securely tightened. Spray these connections as necessary with water-repellent spray (Volvo Penta universal oil).







## Battery. Maintenance

⚠ **WARNING!** Fire and explosion hazard. Batteries must never be exposed to open flames or sparks.

⚠ **WARNING!** Never confuse the positive and negative poles on the batteries. Risk of arcing and explosion.

⚠ **WARNING!** Battery electrolyte is highly corrosive. Always protect your eyes, skin and clothes when handling batteries. Always use protective goggles and gloves. If acid comes into contact with your skin, wash at once with soap and a lot of water. If you get battery acid in your eyes, flush at once with a lot of water, and get medical assistance at once.

### Connection and disconnection

When you connect batteries, first connect the + cable (red) to the + pole on the battery. Then connect the – cable (black) to the – pole on the battery

When you disconnect batteries, connect the – cable (black) first, then the + cable (red).

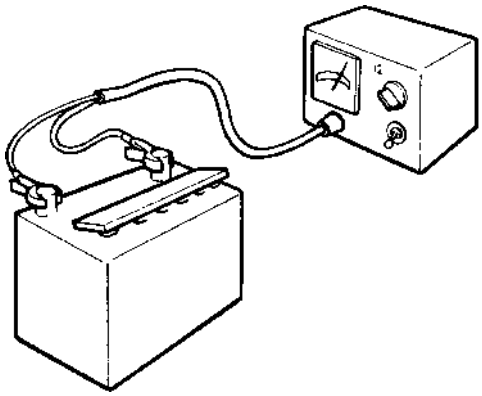
### Cleaning

Keep the batteries dry and clean. Contamination and oxide on the batteries and battery poles can cause stray currents, voltage drop and discharge, especially in wet weather. Remove oxidation from the battery poles and terminals, using a brass brush. Tighten the terminals securely and grease them with terminal grease or Vaseline.

### Filling

The electrolyte level should be 5 - 10mm (0.2-0.4") above the cell plates in the battery. Fill up with **distilled water** if necessary: After filling, the battery should be charged for at least 30 minutes by running the engine at fast idle.

**NOTE!** Some maintenance-free batteries have special instructions, which must be observed.



## Batteries, charging

⚠ **WARNING!** Explosion risk! Hydrogen is given off when batteries are charged. This forms an explosive mixture with air. A short circuit, open flame or spark could cause a violent explosion. Ventilate well.

⚠ **WARNING!** Battery electrolyte is highly corrosive. Protect your eyes, skin and clothes. Always use protective goggles and gloves. If acid comes into contact with your skin, wash at once with soap and a lot of water. If you get battery acid in your eyes, flush at once with a lot of cold water, and get medical assistance at once.

Charge batteries if they have become discharged. If the engine is not used for a longer period of time, the batteries should be fully charged, then possibly trickle charged (please refer to the battery manufacturer's recommendations). Batteries are damaged by being left discharged, and can also freeze and burst easier in cold weather.

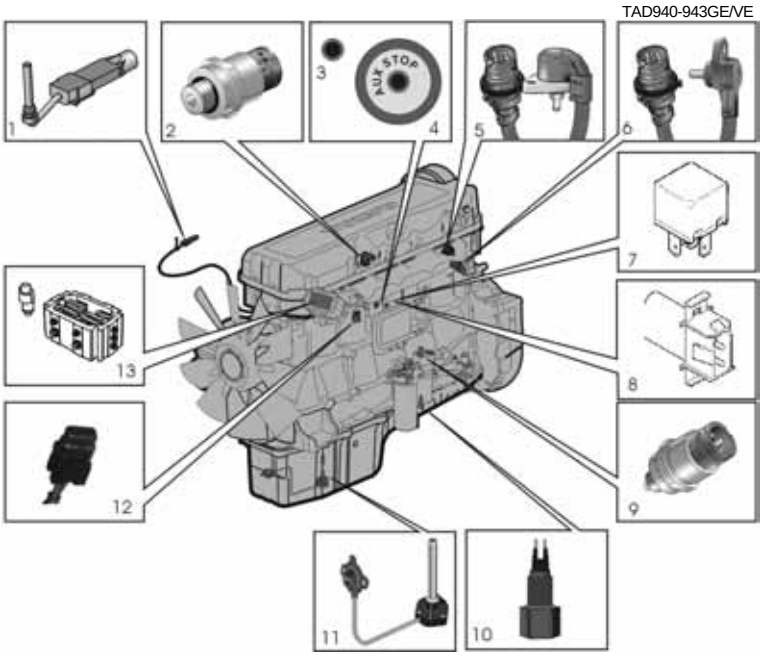
⚠ **IMPORTANT!** Observe the instruction manual for the battery charger carefully. To avoid the risk of electrochemical corrosion when an external charger is connected, the battery cables should be removed from the batteries before the charger is connected.

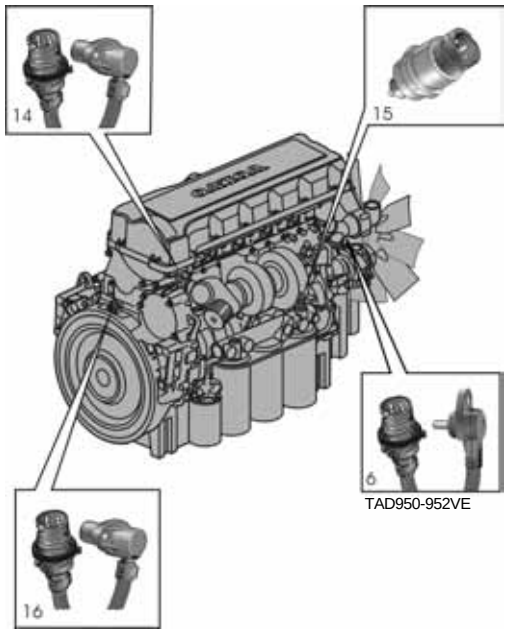
During charging, unscrew the cell plugs but leave them in the plug holes. Ventilate well, especially if the batteries are charged in an enclosed space.

⚠ **WARNING!** Always cut the charge current **before** the battery charger clamps are undone. Never confuse the positive (+) and negative (-) poles on the batteries. This can cause serious arcing and can cause an explosion.

For so-called **quick charging** , there are special rules. Quick charging can shorten battery life, and should therefore be avoided.

## Component location




1. Coolant level sensor
2. Crankcase pressure sensor
3. Electric feed pump switch
4. Extra stop
5. Charge pressure / charge temperature sensor
6. Coolant temperature sensor
   **NOTE!** Please note that there are different locations, depending on model.
7. Main relay
8. Diagnostic connector
   2-pin: TAD940-43VE, TAD940-TAD941GE
   6-pin: TAD950-52VE
9. Fuel pressure sensor
10. Sensor, water in fuel

10a. Solenoid valve, drainage, water trap (optional), not shown in illustration

11. Oil level and temperature sensor (installed inside the oil pan)
12. Main circuit breaker 10 A
13. Air pre-heater with pre-heating relay
14. Camshaft position sensor
15. Oil pressure sensor
16. Flywheel position and speed sensor

# Laying up

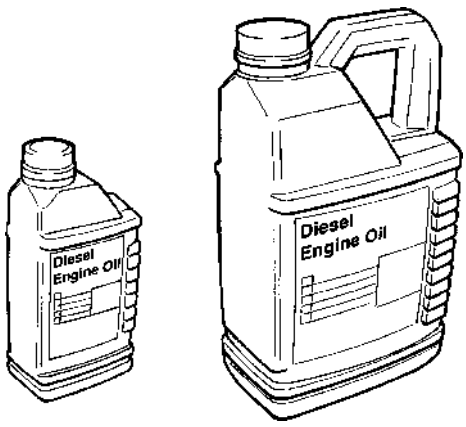
The engine and other equipment must be laid up to prevent damage if they are not used for two months or more. It is important that this is done in the correct manner, and nothing is forgotten. For this reason, we have compiled a check list of the most important points.

Before the engine is taken out of service for a long period of time, an authorized Volvo Penta workshop should check it over.
Have any faults and deficiencies attended to, so that the equipment is in order, ready for the next start.

⚠ **WARNING!** Before you start to do any maintenance work, read the “Maintenance” chapter carefully. This contains instructions for doing work in a safe and correct manner.

⚠ **WARNING!** Some conservation oils are flammable. Some are also dangerous to breathe. Ensure good venti lation. Use a protective mask for spraying.

⚠ **IMPORTANT!** Remember the following when washing with a high pressure washer: Never aim the water jet at seals, rubber hoses or electrical components.




## Conservation

- **For up to 8 months’ stoppage:**
  Change the oil and oil filter on the engine, then warm it up afterwards.

  **More than 8 months’ stoppage:**

  Conserve the lubrication and fuel systems with conservation oil. **Please refer to the instruction on the next page**.
- Check that the coolant offers sufficient frost protection. Top up as necessary. Alternatively, you can drain the coolant (also drain the coolant filter).
- Drain any water and contamination from the fuel filters and fuel tank. Fill the fuel tank completely, to avoid condensation.
- Disconnect the battery cables, clean and charge the batteries. Trickle charge the batteries while the equipment is laid up. **A poorly charged battery can freeze and burst**.
- Clean the outside of the engine. Do not use a high pressure washer for engine cleaning. Touch up paint damage with Volvo Penta original paint.
- Spray the components of the electrical system with water-repellent spray.
- Check and rust-proof any control cables.
- Put a note on the engine with the date, type of conservation and the conservation oil used.
- Cover over the air filter, exhaust pipe and engine ifnecessary.

## Removing conservation preparations

- Remove any covers from the engine, air filter and exhaust pipe.
- Top the engine up with the correct grade of oil, if necessary. Install a new oil filter if the filter was not changed during conservation.
- Install new fuel filters and vent the fuel system.
- Check the drive belt(s).
- Check the condition of all rubber hoses, and check the tightness of the hose clamps.
- Close the drain taps and install any draining plugs.
- Check the coolant level. Top up as necessary.
- Connect the fully charged batteries.
- Start the engine and warm it up at fast idle with no loading.
- Check that no oil, fuel or coolant leakage occurs.

### Conservation of the lubrication and fuel systems for more than 8 months' stoppage:

- Drain the engine oil and fill up with **conservation oil*** to just over the MIN marking on the dipstick.
- Connect the fuel suction and return hoses to a 1/3 full jerrican containing **conservation oil*** and 2/3 diesel fuel.
- Vent the fuel system.
- Start the engine and run at a fast idle until about 2 liters (2 US quart) of the fluid in the jerrican have been used. Stop the engine and connect the ordinary fuel pipes.
- Drain the engine's conservation oil.
- Follow the other instructions on the previous page.

***** Conservation oils are sold by oil companies.

# Fault tracing

A number of symptoms and possible causes of engine malfunctions are described in the table below. Always contact your Volvo Penta dealer if any problems occur which you can not solve by yourself.

⚠ **WARNING!** Read through the safety advice for care and maintenance work in the chapter entitled “Safety-information” before you start work.

## Symptoms and possible causes

| | |
|---|---|
| ☀ The diagnosis button lamp flashes | Please refer to the “Diagnostic information” chapter |
| Engine can not be stopped | 2, 5 |
| Starter motor does not rotate | 1, 2, 3, 4, 5, 6, 7, 24 |
| Starter motor rotates slowly | 1, 2 |
| Starter motor rotates normally but engine does not start | 8, 9, 10, 11, |
| Engine starts but stops again | 8, 9, 10, 11, 13 |
| Engine does not reach correct operating speed at full throttle | 9, 10, 11, 12, 13, 21, 25, 26 |
| Engine runs roughly | 10, 11 |
| High fuel consumption | 12, 13, 15, 25 |
| Black exhaust smoke | 12, 13 |
| Blue or white exhaust smoke | 14, 15, 22 |
| Too low lubrication oil pressure | 16 |
| Excessive coolant temperature | 17, 18, 19, 20 |
| Too low coolant temperature | 20 |
| No, or poor charge | 2, 23 |

1. Flat batteries
2. Poor contact/open circuit in cables
3. Main switch turned off
4. Circuit breaker in junction box faulty
5. Faulty ignition lock
6. Faulty main relay
7. Faulty starter motor/solenoid
8. Lack of fuel:
   – fuel taps closed
   – fuel tank empty/wrong tank connected
9. Blocked primary fuel filter / secondary fuel filter (because of contamination, or paraffin fraction separation in fuel at low temperature)
10. Air in the fuel system
11. Water/contamination in fuel
12. Faulty unit injector
13. Insufficient air supply to engine:
    – blocked air filter
    – air leakage between turbo and engine inlet manifold
    – fouled compressor section in turbocharger compressor
    – faulty turbocharger compressor
    – poor engine bay ventilation
14. Excessive coolant temperature
15. Too low coolant temperature
16. Too low oil level
17. Coolant level too low
18. Air in the coolant system
19. Faulty circulation pump
20. Defective thermostat
21. Blocked intercooler
22. Too high oil level
23. Alternator drive belt slips
24. Water entry into engine
25. High back pressure in exhaust system
26. Break in “Pot+“ cable to pedal

# Diagnostic function

The diagnostic function monitors and checks that the EMS 2 system functions normally.

The diagnostic function has the following tasks:

- Discover and localize malfunctions
- Notify that malfunctions have been discovered
- Give advice in fault finding

## Fault code

If the diagnostic function discovers a malfunction in the EMS 2 system, this is reported by means of fault codes/fault cause on the instruments.

Both inactive (rectified) and active (un-mended) faults are stored in the control unit.

Please refer to the “Operation” heading for reading fault codes.

All fault codes are found in the fault code list, with information about the reason, reaction and measures to be taken. Please refer to the “Fault codes” chapter.

**NOTE!** All instruments are optional

### Active faults

**DCU (Display Control Unit) / DU (Display Unit)**

- text” !! ENGINE WARNING !!” is shown on the display.

**NOTE!** You can choose the language used for the information presented on the.

**CIU (Control Interface Unit)**

- the diagnostic lamp starts to flash.
- **“Easy-link” instrument** (requires a CIU)
  - warning lamp on the alarm panel lights up
  - after the diagnostic button has been pressed, the fault code is shown as text on the tachometer display.

**DU (Display Unit)**

- Either “WARNING!” or “ALARM STOP” (a buzzer sounds) will be shown on the display, depending on the severity of the fault.

**NOTE!** You can choose the language used for the information presented on the.

- Fault codes can also be read by means of the **VODIA** tool. Please refer to the “VODIA User’s Guide” for advice on use.

At the same time, the fault is stored in the control unit memory. When the fault has been attended to and the ignition is switched off and on again, the fault disappears as active.

### Inactive faults

- DCU - the fault is indicated as passive
- CIU - the diagnostic lamp goes out
- DU - the fault message disappears (inactive faults can not be read)
- “Easy Link” - the warning lamp on the alarm panel turns off

## Effect on engine

Engines are affected differently, depending on the severity of the fault discovered by the diagnostic function.

A fault message in the form of a fault code is always generated when a malfunction is discovered by the diagnostic function.

Engines are affected differently, depending on the severity of the fault.

- The engine is not affected
- Engine idles
- Engine torque is restricted to a certain amount
- Engine is stopped

# Operation

When a malfunction has occurred and the diagnostic system has generated one or more fault codes, these are read out differently, depending on the equipment used. Please refer to “Fault codes”.

**If the system indicates that a fault code has been set:**

1. Cut engine speed to idle, or shut the engine off.
2. **For DCU/DU**
   Read the fault code set from the display, please refer to “Reading fault cause via the DCU” or “Reading fault cause via DU”.

   **For CIU**
   Press the diagnostic button and read the fault code that has been set, by observing the flashing of the diagnostic lamp. Please refer to “Reading fault codes via the diagnostic lamp, CIU”
3. Look up the fault code/cause in the “Fault Code” chapter and take the recommended measures.

## Reading fault cause via the DCU (Display Control Unit)

When a fault code is set, the following text is shown on the display:

“!! ENGINE WARNING !!”

alternated with

“Press SEL for information”.

**NOTE!** You can choose the language used for the information presented on the.

**Read the fault code as follows:**

1. Press the SEL button (to come to the error list.
   The fault list shows:
   - Operation hours
   - Fault cause
   - Active/inactive
2. Look up the fault code in the “Fault Code” chapter and take the recommended measures.
3. Press the ESC button to leave the fault list.

**NOTE!** To enter the fault list when no fault code has been set, press the SEL button and select “Diagnostics” from the menu.

## Reading fault cause via the DU (Display Unit)

Depending on the severity of the faults, one of the following messages will appear on the display: “**WARNING!**” or “**ALARM STOP**” (a buzzer sounds).

1. Press any button to come to the fault list.

   The fault list shows:
   - Operation hours
   - Fault cause
2. Look up the fault code in the “Fault Code” chapter and take the recommended measures.
3. Press **ACK** to confirm the fault code. The display background will change color (the buzzer stops sounding).
4. Press **EXIT** to leave the fault list.

## Reading fault codes via the diagnostic lamp on the instrument panel, CIU

When the system has discovered a malfunction, the diagnostic lamp starts to flash. If the diagnostic button is depressed and then released, a fault code is flashed out.
The fault code consists of two groups of flashes, separated by a pause of two seconds. A fault code is obtained by counting the number of flashes in each group.

**Example:** ☼☼ pause ☼☼☼☼ = Fault code 2.4

The fault code is stored and can be read as long as the malfunction remains. You can find information about cause, reaction and actions in the “Fault Code” chapter.

**Read the fault code as follows:**

1. Press the diagnostic button.
2. Release the diagnostic button and make a note of the fault that is flashed out.
3. Repeat items 1-2. A new fault code is flashed out if more are stored. Repeat until the first fault code is repeated.
4. Look up the fault code in the “Fault Code” chapter and take the recommended measures.

**NOTE!** When the first fault code is repeated, all fault codes have been read out.
If the diagnostic button is pressed after the fault has been mended and the fault codes have been erased, code 1.1 “No fault” will be displayed.

## Reading fault codes via ”Easy Link” instrument (only with CIU)

When the system has discovered a malfunction, the diagnostic lamp starts to flash and the fault code will show in the display of the tachometer.

1. Press the diagnostic button, the fault code will show in the display of the tachometer.
2. Look up the fault code in the “Fault Code” chapter and take the recommended measures.
3. When the fault has been attended to, the fault code disappears from the display and the diagnostic lamp goes out.

## Erasing fault codes

Fault codes must be erased by means of the VODIA tool.

# Fault codes

⚠ **WARNING!** Read through the safety advice for care and maintenance work in the “Safety information” chapter before you start work.

**NOTE!** Reading the fault codes below, such as **Code 2.1. PID 97.** means that **2.1** is the flashing code indicated by the diagnostic lamp on the instrument box. **PID 97** is read with the VODIA diagnostic tool. Please refer to “Reading fault codes”.

**NOTE!** Please refer to “Wiring schedule CIU and DCU” for references to the sleeves in the electrical connectors on the engine control unit.

### Code 1.1 No faults

There are no active faults.

### Code 2.1, PID / SPN 97, Water in fuel

**Cause:**

- Water in fuel.

**Reaction:**

- None.

**Remedy:**

- Empty the primary fuel filter.

### Code 2.2, PID / SPN 111. Coolant level

**Cause:**

- Low coolant level.

**Reaction:**

- Warning indication.
- Engine control module reduces engine power (unless the protection has been shut off with the VODIA diagnostic tool).

**Remedy:**

- Check the coolant level.
- Check coolant level monitor function.

### Code 2.3, PID / SPN 111. Coolant level sensor

**Cause:**

- Short circuit to positive (+).
- Fault in sensor.

**Reaction:**

- None.

**Remedy:**

- Check that the coolant level sensor cable is not damaged.
- Check coolant level sensor function.

### Code 2.4. SID21 / SPN 637 Flywheel speed sensor

**Cause:**

- No signal.
- Abnormal frequency.
- “Intermittent” signal from the sensor.
- Fault in sensor.

**Reaction:**

- Engine is very difficult to start and runs roughly when it starts.

**Remedy:**

- Check that the sensor connector is correctly installed.
- Check that the engine speed sensor cable is not damaged.
- Check that the engine speed sensor is correctly installed in the flywheelhousing.
- Check engine speed sensor function.

### Code 2.5. SID22 / SPN 636 Camshaft drive speed sensor

**Cause:**

- No signal.
- Abnormal frequency.
- Fault in sensor.

**Reaction:**

- Engine takes longer to start than normal. Engine runs normally when running.

**Remedy:**

- Check that the engine speed sensor connector is correctly installed.
- Check that the engine speed sensor cable is not damaged.
- Check that the engine speed sensor is correctly installed in the upper timing gear cover.
- Check engine speed sensor function.

### Code 2.6, PID / SPN 190, Code 2.6 Engine speed

**Cause:**

- Engine speed too high.

**Reaction:**

- None.

**Remedy:**

- After the engine has stopped, look for the reason for the high speed.

### Code 2.8, PPID 132 / SPN 608, Speed potentiometer connected to CIU

**Cause:**

- Shorted to plus (+) or minus (-).
- Fault in sensor.

**Reaction:**

- Engine goes to idle.

  If you release the accelerator first, and the press it down again, the engine can be forced to run using the idle contact.

**Remedy:**

- Check that the potentiometer has been connected correctly.
- Check that the cable harness to the potentiometer has not been damaged.
- Check the potentiometer function.

### Code 2.9, PID / SPN 97, Indicator for water in fuel

**Cause:**

- Short circuit
- Open circuit.
- Fault in indicator.

**Reaction:**

- None.

**Remedy:**

- Check the indicator cables for breaks and short circuits.
- Check indicator function. Change indicator as necessary

### Code 3.1, PID / SPN 100, Oil pressure sensor

**Cause:**

- Short circuit to positive (+) or earth (ground) (–).
- Open circuit.

**Reaction:**

- None.

**Remedy:**

- Check that the oil pressure sensor cable is not damaged.
- Check that the oil pressure sensor is correctly connected.

### Code 3.2. PID / SPN 105 Charge air temperature sensor

**Cause:**

- Short circuit to positive (+) or earth (ground) (–).
- Open circuit.

**Reaction:**

- None.

**Remedy:**

- Check that the charge air temperature sensor connector is correctly installed.
- Check that the charge air temperature sensor cable is not damaged.
- Check that the charge air temperature sensor is correctly installed.
- Check charge air temperature sensor function.

### Code 3.3. PID / SPN 110 Coolant temperature sensor

**Cause:**

- Short circuit to positive (+) or earth (ground) (–).
- Open circuit.

**Reaction:**

- Preheating is also activated when the engine is hot.

**Remedy:**

- Check that the coolant temperature sensor connector is correctly installed.
- Check that the coolant temperature sensor cable is not damaged.
- Check that the coolant temperature sensor is correctly installed.
- Check coolant temperature sensor function.

### Code 3.4. PID / SPN 106/102. Charge pressure sensor

**Cause:**

- Short circuit to positive (+) or earth (ground) (–).
- Open circuit.

**Reaction:**

- Engine smokes more than normally during acceleration/load increase.

**Remedy:**

- Check that the charge pressure sensor connector is correctly installed.
- Check that the charge pressure sensor cable is not damaged.
- Check that the charge pressure sensor is correctly installed.
- Check charge pressure sensor function.

### Code 3.5, PID / SPN 106/102, Charge pressure

**Cause:**

- Charge pressure too high

**Reaction:**

- Engine control module reduces engine power (unless the protection has been shut off with the VODIA diagnostic tool).

**Remedy:**

- Check turbocharger compressor function.
- Check charge pressure sensor function.
- Check fuel volume/injector.

### Code 3.6, PID / SPN 94, Fuel pressure sensor

**Cause:**

- Short circuit to positive (+) or earth (ground) (–).
- Open circuit.

**Reaction:**

- None.

**Remedy:**

- Check that the fuel pressure sensor connector is correctly installed.
- Check that the fuel pressure sensor cable is not damaged.
- Check that the fuel pressure sensor is correctly installed.
- Check fuel pressure sensor function.

### Code 3.7, PID / SPN 175, Oil temperature sensor

**Cause:**

- Shorted to plus (+) or minus (-).
- Break.

**Reaction:**

- None.

**Remedy:**

- Check that the cable harness to the oil temperature sensor has not been damaged.
- Check that the oil temperature sensor has been connected correctly.

### Code 3.8, PID / SPN 94, Fuel pressure

**Cause:**

- Low supply pressure.

**Reaction:**

- None.

**Remedy:**

- Check if it is possible to build up pressure with the hand pump.
- Check the fuel filter.
- Check the fuel pre-filter.

### Code 3.9, PID / SPN 158, Battery voltage, EMS

**Cause:**

- Faulty alternator.
- Faulty battery, battery cables.

**Reaction:**

- None.

**Remedy:**

- Check the supply voltage from the control unit.

### Code 4.8, PPID 6/ SPN 520195, Stop input EMS

**Cause:**

- Short circuit to negative (-).
- Open circuit.

**Reaction:**

- Engine can only be stopped with the auxiliary stop.

**Remedy:**

- Check that the starter switch connections are not damaged.

### Code 5.2, PPID 4 / SPN 520194, Starter input CIU

**Cause:**

- Shorted to minus (-).
- Activated for too long.

**Reaction:**

- The engine cannot be started.
- The engine starts immediately when ignition is turned on.

**Remedy:**

- Check that connections to the ignition key have not been damaged.
- Check that the cable harness to the ignition key has not been damaged.

### Code 5.3, PPID 6/ SPN 970, Stop input CIU

**Cause:**

- Short circuit to negative (-).
- Open circuit.
- Activated for too long time.

**Reaction:**

- Engine can only be stopped with the auxiliary stop (AUX STOP) on engine.
- Engine stops. A fault code is displayed for 40 seconds and the engine can not be started during this time. When a fault code is active, the engine can be started but not stopped.

**Remedy:**

- Check that the starter switch connections are not damaged.
- Check that the ignition switch cable is not damaged.

### Code 5.4, PID 45/ SPN 626, Preheating relay

**Cause:**

- Short circuit to positive (+) or earth (ground) (–).
- Open circuit.

**Reaction:**

- Preheating can not be activated.
- Preheating is constantly connected.

**Remedy:**

- Check that the relay input cable is not damaged.
- Check relay function.

### Code 5.7, PID / SPN 98, Oil level

**Cause:**

- Oil level is too low.

**Reaction:**

- Warning indication.

**Remedy:**

- Check the oil level.

### Code 5.8, PID / SPN 175, Oil temperature

**Cause:**

- Oil temperature is too high

**Reaction:**

- Warning indication.
- The engine control module limits engine output (unless protection has been turned off with the diagnosis tool VODIA).

**Remedy:**

- Check the oil level.
- Check the oil temperature.
- Check the oil temperature sensor function.

### Code 5.9, PID / SPN 98, Oil level sensor

**Cause:**

- Shorted to plus (+) or minus (-).
- Break.

**Reaction:**

- None.

**Remedy:**

- Check that the cable harness to the oil level sensor has not been damaged.
- Check the oil level sensor function.

### Code 6.1, PID / SPN 110, Coolant temperature

**Cause:**

- Coolant temperature is too high.

**Reaction:**

- Engine control module reduces engine power (unless the protection has been shut off with the VODIA diagnostic tool).

**Remedy:**

- Check the coolant level.
- Check the intercooler (cleanliness).
- Check if there is air in the cooling system.
- Check the pressure cap on the expansion tank.
- Check coolant temperature sensor function.
- Check thermostat function.

### Code 6.2, PID / SPN 105, Charge air temperature

**Cause:**

- Charge air temperature is too high.

**Reaction:**

- Engine control module reduces engine power (unless the protection has been shut off with the VODIA diagnostic tool).

**Remedy:**

- Check the coolant level.
- Check the intercooler (cleanliness).
- Check charge air temperature sensor function.
- Check the function of the thermostat.

### Code 6.3. PPID 3 / SID 39 / SPN 677 Start output EMS / SID 39 / SPN Start motor relay

**Cause:**

- Shorted to plus (+) or minus (-).
- Activated for too long.

**Reaction:**

- The engine cannot be started.
- The engine starts immediately when ignition is turned on.

**Remedy:**

- Check that connections to the ignition key have not been damaged.
- Check that the cable harness to the ignition key has not been damaged.

### Code 6.4. PPID 231 / SPN 639. Data link (CAN). CIU

**Cause:**

- Faulty data link (CAN), CIU.

**Reaction:**

- Instruments and warning lamps stop working.

**Remedy:**

- Check that the 8-pin connector is not damaged.
- Check that the cables between the CIU and the engine management unit are not damaged.

### Code 6.5. PPID 231 / SPN 639. Data link (CAN), EMS 2

**Cause:**

- Internal fault in control module.

**Reaction:**

- Engine not operating: engine can not be started. Engine operating: engine idles and can only be stopped with the auxiliary stop (AUX-stop).

**Remedy:**

- Check that the 8-pin connector is not damaged.
- Check that the cables between the CIU and the engine management unit are not damaged.
- Check that sleeves 11 and 12 in the connector on the CIU are not damaged.

### Code 6.6, PID / SPN 100, Oil pressure

**Cause:**

- Oil pressure is too low.

**Reaction:**

- Engine control module reduces engine power (unless the protection has been shut off with the VODIA diagnostic tool).

**Remedy:**

- Check oil level.
- Check that the air filters are not blocked.
- Check system pressure valves and safety valves in the oil system.
- Check oil pressure sensor function.

### Code 6.7, PPID 8 / SPN 520192, Piston cooling pressure

**Cause:**

- Piston cooling pressure is too low.

**Reaction:**

- Engine stopped. The fault code is de-activated at engine speeds below 1000 rpm.

**Remedy:**

- Check that the oil pressure in the engine exceeds 175 kPa (25.4 psi).

### Code 6.8, PPID 8 / SPN 520192, Piston cooling pressure sensor

**Cause:**

- Shorted to plus (+) or minus (-).
- Break.

**Reaction:**

- None.

**Remedy:**

- Check that the piston cooling pressure sensor contact is correctly installed.
- Check that the cable harness to the piston cooling pressure sensor has not been damaged.
- Check the piston cooling pressure sensor functionality.

### Code 6.9, PID / SPN 158, Battery voltage, CIU

**Cause:**

- Short circuit to negative (-).
- Faulty alternator.
- Faulty battery, battery cables.

**Reaction:**

- Problems in engine starting.

**Remedy:**

- Check the supply voltage from the control unit.
- Check the battery.
- Check the alternator.
- Check the 8-pin contact.

### Code 7.1. SID 1 / SPN 651. Injector, cylinder #1

**Cause:**

- Electrical fault.
- Faulty compression or injector.

**Reaction:**

- Engine runs on 5 cylinders.
- Abnormal sound.
- Reduced performance.

**Remedy:**

- Check that the injector cables are not damaged.
- Check that the injector connections are not damaged.
- Check fuel supply pressure.
- Check the valve clearance.
- Do a compression test and check cylinder #1.

### Code 7.2. SID 2 / SPN 652. Injector, cylinder #2

**Cause:**

- Electrical fault.
- Faulty compression or injector.

**Reaction:**

- Engine runs on 5 cylinders.
- Abnormal sound.
- Reduced performance.

**Remedy:**

- Check that the injector cables are not damaged.
- Check that the injector connections are not damaged.
- Check fuel supply pressure.
- Check the valve clearance.
- Do a compression test and check cylinder #2.

### Code 7.3. SID 3 / SPN 653 Injector, cylinder #3

**Cause:**

- Electrical fault.
- Faulty compression or injector.

**Reaction:**

- Engine runs on 5 cylinders.
- Abnormal sound.
- Reduced performance.

**Remedy:**

- Check that the injector cables are not damaged.
- Check that the injector connections are not damaged.
- Check fuel supply pressure.
- Check the valve clearance.
- Do a compression test and check cylinder #3.

### Code 7.4. SID 4 / SPN 654 Injector, cylinder #4

**Cause:**

- Electrical fault.
- Faulty compression or injector.

**Reaction:**

- Engine runs on 5 cylinders.
- Abnormal sound.
- Reduced performance.

**Remedy:**

- Check that the injector cables are not damaged.
- Check that the injector connections are not damaged.
- Check fuel supply pressure.
- Check the valve clearance.
- Do a compression test and check cylinder #4.

### Code 7.5. SID 5 / SPN 655 Injector, cylinder #5

**Cause:**

- Electrical fault.
- Faulty compression or injector.

**Reaction:**

- Engine runs on 5 cylinders.
- Abnormal sound.
- Reduced performance.

**Remedy:**

- Check that the injector cables are not damaged.
- Check that the injector connections are not damaged.
- Check fuel supply pressure.
- Check the valve clearance.
- Do a compression test and check cylinder #5.

### Code 7.6. SID 6 / SPN 656 Injector, cylinder #6

**Cause:**

- Electrical fault.
- Faulty compression or injector.

**Reaction:**

- Engine runs on 5 cylinders.
- Abnormal sound.
- Reduced performance.

**Remedy:**

- Check that the injector cables are not damaged.
- Check that the injector connections are not damaged.
- Check fuel supply pressure.
- Check the valve clearance.
- Do a compression test and check cylinder #6.

### Code 7.7, PID / SPN 153 Crankcase ventilation pressure

**NOTE!** Only TAD950-952VE.

**Cause:**

- Crankcase ventilation pressure too high.

**Reaction:**

- The engine is shut down (if the protection has not been shut off by the parameter tool).

**Remedy:**

- Check whether the crankcase ventilation is blocked.
- Check whether cylinder liner, piston or piston rings are worn or damaged.

### Code 7.8. PID / SPN 153. Crankcase ventilation pressure sensor

**Cause:**

- Shorted to plus (+) or minus (-).
- Break**.**

**Reaction:**

- None.

**Remedy:**

- Check that the crankcase ventilation pressure sensor contact is correctly installed.
- Check that the cable harness to the crankcase ventilation pressure sensor has not been damaged.
- Check crankcase ventilation pressure sensor function.

### Code 9.2. SID250 / SPN 608 Faulty data link (J1587)

**Cause:**

- Faulty data link.

**Reaction:**

- None.

**Remedy:**

- Check that the 8-pin connector is not damaged.
- Check that the cables between the CIU/DCU and the engine management unit are not damaged.

### Code 9.3. SID 232 / SPN 620 Power supply to sensor

**Cause:**

- Shortcut.
- Fault in sensor.

**Reaction:**

- Faulty values in oil pressure and charge air pressure sensors.
- Fault code for oil pressure- and charge air pressure sensor.
- Low engine output.
- The instrument shows zero oil pressure and boost pressure.

**Remedy:**

- Check that the cable harness to oil pressure and charge air pressure sensor has not been damaged.
- Check oil pressure and charge air pressure sensors.

### Code 9.8, SID 253 / SPN 630 Data set memory EEPROM, CIU

**Cause:**

- Internal fault in control module
- Programming faulty.

**Reaction:**

- Engine does not start.

**Remedy:**

- Re-program the control module. If the fault remains, change the control module.

### Code 9.8. PPID 254 / SPN 629 Fault in control unit, CIU

**Cause:**

- Faulty EEPROM, CIU.
- Faulty flash memory, CIU.
- Fault in control module, CIU

**Reaction:**

- CIU returns to factory setting.
- Engine goes to idle.
- Engine can not be started.

**Remedy:**

- Re-program the unit

### Code 9.9, SID 240 / SPN 639, Memory fault

**Cause:**

- Memory fault in engine management system.

**Reaction:**

- Engine might not start.

**Remedy:**

- Re-program the unit.
- Change engine control unit (EMS).

### Code 9.9, SID 253 / SPN 630 Data set memory EEPROM, EMS

**Cause:**

- Internal fault in control module
- Programming faulty.

**Reaction:**

- Engine does not start.

**Remedy:**

- Re-program the control module. If the fault remains, change the control module.

### Code 9.9. SID 254 / SPN 629 Control module EMS

**Cause:**

- Internal fault in control module.

**Reaction:**

- Engine misfires.
- Engine does not start.

**Remedy:**

- Change engine control unit.

### PPID 19 / SPN 2791, Internal EGR

**Cause:**

- Fault in cable harness (boost pressure sensor).
- Mechanical fault on the IEGR

**Reaction:**

- Engine control module reduces engine power (unless the protection has been shut off with the VODIA diagnostic tool).

**Remedy:**

- Check cable harness (boost pressure sensor).
- Check the IEGR.

# Technical data

## General

| Type designation | **TAD940GE** | **TAD941GE** |
|---|---|---|
| Power, Prime/Stand-by | Please refer to the sales literature | |
| Torque, Prime/Stand-by | Please refer to the sales literature | |
| | | |
| Compression ratio | 20.2:1 | 17.4:1 |
| Low idle (rpm) | 600-1200 | 600-1200 |
| High idle (rpm) | 1500-1620<br>1800-1920 | 1500-1620<br>1800-1920 |
| Highest full load speed (rpm) | 1500/1800 | 1500/1800 |
| No. of valves | 24 | 24 |
| No. of cylinders | 6 | 6 |
| Cylinder bore, mm (inch) | 120 (4.72) | 120 (4.72) |
| Stroke, mm (inch) | 138 (5.43) | 138 (5.43) |
| Swept volume, $dm^3$ (US quart) | 9.36 (9.89) | 9.36 (9.89) |
| Weight, dry, kg (lb) | 1015 (2238) | 1015 (2238) |
| Weight, wet, kg (lb) | 1065 (2348) | 1065 (2348) |
| Injection sequence | 1-5-3-6-2-4 | 1-5-3-6-2-4 |
| | | |

| Type designation | **TAD940VE** | **TAD941VE** | **TAD942VE** | **TAD943VE** |
|---|---|---|---|---|
| Power | Please refer to the sales literature | | | |
| Torque | Please refer to the sales literature | | | |
| | | | | |
| Compression ratio | 20.2:1 | 20.2:1 | 20.2:1 | 20.2:1 |
| Low idle (rpm) | 600 | 600 | 600 | 600 |
| High idle (rpm) | 2250 | 2250 | 2250 | 2250 |
| | | | | |
| No. of valves | 24 | 24 | 24 | 24 |
| No. of cylinders | 6 | 6 | 6 | 6 |
| Cylinder bore, mm (inch) | 120 (4.72) | 120 (4.72) | 120 (4.72) | 120 (4.72) |
| Stroke, mm (inch) | 138 (5.43) | 138 (5.43) | 138 (5.43) | 138 (5.43) |
| Swept volume, $dm^3$ (US quart) | 9.36 (9.89) | 9.36 (9.89) | 9.36 (9.89) | 9.36 (9.89) |
| Weight, dry, kg (lb) | 1015 (2238) | 1015 (2238) | 1015 (2238) | 1015 (2238) |
| Weight, wet, kg (lb) | 1065 (2348) | 1065 (2348) | 1065 (2348) | 1065 (2348) |
| Injection sequence | 1-5-3-6-2-4 | 1-5-3-6-2-4 | 1-5-3-6-2-4 | 1-5-3-6-2-4 |
| | | | | |

| Type designation | **TAD950VE** | **TAD951VE** | **TAD952VE** |
|---|---|---|---|
| Power | Please refer to the sales literature | | |
| Torque | Please refer to the sales literature | | |
| | | | |
| Compression ratio | 20.2:1 | 20.2:1 | 20.2:1 |
| Low idle (rpm) | 600 | 600 | 600 |
| High idle (rpm) | 2250 | 2250 | 2250 |
| | | | |
| No. of valves | 24 | 24 | 24 |
| No. of cylinders | 6 | 6 | 6 |
| Cylinder bore, mm (inch) | 120 (4.72) | 120 (4.72) | 120 (4.72) |
| Stroke, mm (inch) | 138 (5.43) | 138 (5.43) | 138 (5.43) |
| Swept volume, $dm^3$ (US quart) | 9.36 (9.89) | 9.36 (9.89) | 9.36 (9.89) |
| Weight, dry, kg (lb) | 1015 (2238) | 1015 (2238) | 1015 (2238) |
| Weight, wet, kg (lb) | 1065 (2348) | 1065 (2348) | 1065 (2348) |
| Injection sequence | 1-5-3-6-2-4 | 1-5-3-6-2-4 | 1-5-3-6-2-4 |
| | | | |

# Lubrication system

**Oil,** change volume, including filter change,
..... 35 liter (37.0 US quart)

**Oil pressure, hot engine,** at operating speed

| | |
|---|---|
| TAD940-943VE, TAD940-941GE ..... | 300-550 kPa (44-80 psi) |
| TAD950-952VE ..... | 350-600 kPa (51-87 psi) |
| ..... | |
| at idle, min ..... | 270 kPa (39 psi) |

| | |
|---|---|
| Oil grade ..... | Please refer to the specification under “Maintenance. |
| Viscosity ..... | Please refer to the specification under “Maintenance. |

**Oil filter**

| | |
|---|---|
| Full flow filter ..... | 2 |
| Turbo filter (By-pass filter) ..... | 1 |

**Lube oil pump**

| | |
|---|---|
| Type ..... | Gear driven |

# Fuel system

**Feed pump**

| | |
|---|---|
| Supply pressure at 600 rpm ..... | min 100 kPa (14.5 psi) |
| Supply pressure at 1200 rpm ..... | min 300 kPa (43.5 psi) |
| Supply pressure at full load ..... | min 300 kPa (43.5 psi) |

By - pass valve

| | |
|---|---|
| Opening pressure ..... | 400-550 kPa (58-79.7 psi) |

# Fuel specification

The fuel must comply with national and international standards for commercially supplied fuels, such as:

**EN 590** (with nationally adapted environmental and cold requirements)

**ASTM D 975 No 1 - D and 2 - D**

**JIS KK 2204**

**Sulfur content:** Complying with legal requirements in each country.

Low density fuel (urban diesel in Sweden and city diesel in Finland) can cause a loss of up to 5% of power and an increase in fuel consumption of about 2-3%.

## Cooling system

| | |
|---|---|
| Type | Pressurized, sealed |
| Pressure cap, max. opening pressure | 75 kPa (10.8 psi) |
| Volume (engine) | 17 liter (17.9 US quart) |
| Volume (engine + radiator and hoses) | 24 liter (25.3 US quart) |

**Thermostat**

| | |
|---|---|
| Quantity | 1 pcs. |
| Opening temperature | 82° C (179.5°F) |

## Electrical system

| | |
|---|---|
| System voltage | 24V |
| Alternator | |
| voltage/max. current density | 28V / 80A |
| power app. | 2200 W |
| Alternative generating equipment (optional): | |
| voltage/max. current density | 28V / 100A |
| power app. | 2800 W |
| and | |
| voltage/max. current density | 28V / 140A |
| power app. | 4000 W |
| Battery capacity | 2 pcs. series connected 12V, max. 180 Ah |
| Battery electrolyte specific gravity at +25°C (77.0°F): | |
| fully charged battery | 1.28 g/cm$^3$ (1.24 g/cm$^3$)* |
| re- charge battery at | 1.20 g/cm$^3$ (1.20 g/cm$^3$)* |

***Note.** Applies to batteries with tropical acid.

# Notes

# Notes

ENG

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Yes please,

I would like an operator's manual in English at no charge.

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***Please note that this offer is valid for 12 months from the date of delivery of the engine, after this it is subject to availability.***

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**Name**

**Anschrift**

**Land**

***Bitte beachten Sie, dass das Angebot für die Dauer von 12 Monaten ab dem Lieferdatum des Motors gilt, danach nur noch bis zum Aufbrauchen des Lagerbestandes.***

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Oui merci,

**Je souhaite recevoir un manuel d'instructions gratuit en français.**

Numéro de publication: 7745262

**Nom**

**Adresse**

**Pays**

***Noter que l'offre est valable 12 mois à partir de la date de livraison du moteur, puis seulement dans la mesure des stocks disponibles.***

VOLVO PENTA

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http://www.volvopenta.com/manual/coupon

Sí gracias,

**deseo recibir gratuitamente un libro de instrucciones en español.**

**Número de publicación: 7745263**

**Nombre**

**Dirección**

**País**

***Observe que la oferta es válida durante 12 meses a partir de la fecha de entrega del motor. A partir de la fecha de finalización de la oferta, la misma es válida siempre que haya existencias.***

**VOLVO PENTA**

**42200/615001/155099900192**

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http://www.volvopenta.com/manual/coupon

Sì, grazie,

**desidero ricevere gratuitamente un manuale d'istruzioni in lingua italiana.**

**Public. No.: 7745264**

**Nome e Cognome**

**Indirizzo**

**Paese**

***Notare che la validità dell'offerta è garantita solo per 12 mesi dalla consegna del motore, dopodiché si procederà fino ad esaurimento scorte.***

**VOLVO PENTA**

**42200/615001/155099900192**

SWE

**Posta eller faxa kupongen till:**
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**Beställningen kan även göras via internet:**
http://www.volvopenta.com/manual/coupon

**Ja tack,**

jag vill kostnadsfritt ha en instruktionsbok på svenska.

**Publikationsnummer: 7745258**

Namn

Adress

Land

**Observera att erbjudandet gäller i 12 månader från motorns leveransdatum, därefter endast i mån av tillgång.**

**VOLVO PENTA**

**42200/615001/155099900192**

DUT

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http://www.volvopenta.com/manual/coupon

## Ja graag,

**Ik wil kosteloos een instructieboek in het Nederlands ontvangen.**

**Publicatienummer: 7745266**

**Naam**

**Adres**

**Land**

***Denk eraan dat de aanbieding geldt tot 12 maanden na levering van de motor, daarna nog slechts indien beschikbaar.***

VOLVO PENTA

42200/615001/155099900192

FIN

**Postita tai faksaa kuponki osoitteella:**
Document & Distribution Center
Order Department
ARU2, Dept. 64620
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Ruotsi
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**Tilauksen voi tehdä myös Internetissä:**
http://www.volvopenta.com/manual/coupon

## Kyllä kiitos,

**haluan suomenkielisen ohjekirjan veloituksetta.**

**Julkaisunumero: 7745264**

**Nimi**

**Osoite**

**Maa**

***Ota huomioon, että tarjous on voimassa 1 vuoden ajan moottorin luovutuspäivämäärästä, sen jälkeen vain tuotteen saatavuuden perusteella.***

VOLVO PENTA

42200/615001/155099900192

POR

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**A encomenda também pode ser feita através da Internet:**
http://www.volvopenta.com/manual/coupon

## Sim, obrigado(a)!

**Gostaria de receber gratuitamente um manual de instruções em português.**

**Número de publicação: 7745267**

**Nome**

**Endereço**

**País**

***Notar que a oferta é válida por um período de 12 meses a partir da data de entrega do motor. Depois desse período, a oferta é válida consoante a disponibilidade.***

VOLVO PENTA

42200/615001/155099900192

GRE

Ταχυδρομήστε αυτό το κουπόνι στην παρακάτω διεύθυνση ή στείλτε το με φαξ στον παρακάτω αριθμό φαξ:
Document & Distribution Center
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Μπορείτε επίσης να δώσετε την παραγγελία σας μέσω του Internet, στη διεύθυνση:
http://www.volvopenta.com/manual/coupon

**Ναι,**

**Θα ήθελα ένα αντίτυπο του εγχειριδίου χρήσης στην αγγλική γλώσσα χωρίς καμιά χρέωση.**

**Αριθμός έκδοσης: 7745268**

**Όνομα**

**Διεύθυνση**

**Χώρα**

*Παρακαλούμε σημειώστε ότι αυτή η προσφορά ισχύει για 12 μήνες από την ημερομηνία παράδοσης της μηχανής. Μετά θα είναι θέμα διαθεσιμότητας.*

VOLVO PENTA

42200/615001/155099900192

RUS

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Заказы также можно размещать через Интернет:
http://www.volvopenta.com/manual/coupon

**Да, пожалуйста,**

**Я бы хотел иметь бесплатное руководство оператора на русском языке.**
**Номер издания: 77455269**

**Имя**

**Адрес**

**Страна**

***К Вашему сведению, это предложение действительно в течение 12 месяцев от даты поставки двигателя; в дальнейшем оно зависит от наличия.***

VOLVO PENTA

42200/615001/155099900192

## 9.2. Appendix B - Alternator user and maintenance manual

**User guide and maintenance manual**

# LEROY SOMER

# Alternator

## LSA46.2 L6 - L9
## LSA46.2 M3 - M5
## LSA46.2 VL12
## 46.2 SHUNT, AREP & PMG

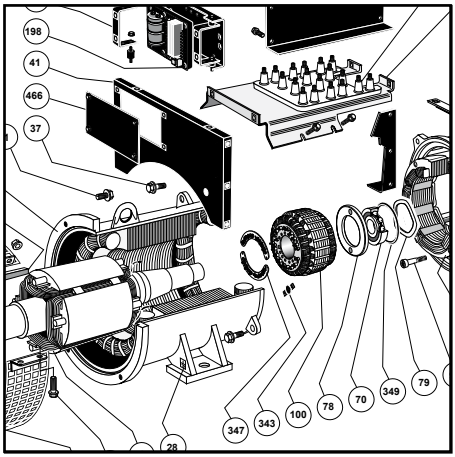
3856 h
01/01/2011

33522061001_6_1

LEROY SOMER

3856 en - 2011.01 / h

This manual is to be given to the end user




# LSA 46.2 - 4 POLES

## ALTERNATORS

### Installation and maintenance

203/276

# LSA 46.2 - 4 POLES
## ALTERNATORS

**This manual concerns the alternator which you have just purchased.**

**We wish to draw your attention to the contents of this maintenance manual.**

### SAFETY MEASURES

Before using your machine for the first time, it is important to read the whole of this installation and maintenance manual.

All necessary operations and interventions on this machine must be performed by a qualified technician.

Our technical support service will be pleased to provide any additional information you may require.

The various operations described in this manual are accompanied by recommendations or symbols to alert the user to the potential risk of accidents. It is vital that you understand and take notice of the different warning symbols used.

WARNING

**Warning symbol for an operation capable of damaging or destroying the machine or surrounding equipment.**

**Warning symbol for general danger to personnel.**

**Warning symbol for electrical danger to personnel.**

### WARNING SYMBOLS

We wish to draw your attention to the following 2 safety measures which must be complied with:

**a) During operation, do not allow anyone to stand in front of the air outlet guards, in case anything is ejected from them.**

**b) Do not allow children younger than 14 to go near the air outlet guards.**

A set of self-adhesive stickers depicting the various warning symbols is included with this maintenance manual. They should be positioned as shown in the drawing below once the machine has been fully installed.

**WARNING**
**The alternators must not be put into service until the machines in which they are to be incorporated have been declared compliant with Directives EC and plus any other directives that may be applicable.**

Note: LEROY-SOMER reserves the right to modify the characteristics of its products at any time in order to incorporate the latest technological developments. The information contained in this document may therefore be changed without notice.

# LSA 46.2 - 4 POLES
## ALTERNATORS

**CONTENTS**

# LSA 46.2 - 4 POLES
# ALTERNATORS

## 1 - RECEIPT

### 1.1 - Standards and safety measures

Our alternators comply with most international standards.
See the EC Declaration of Incorporation on the last page.

### 1.2 - Inspection

On receipt of your alternator, check that it has not suffered any damage in transit. If there are obvious signs of knocks, contact the transporter (you may be able to claim on their insurance) and after a visual check, turn the machine by hand to detect any malfunction.

### 1.3 - Identification

The alternator is identified by means of a nameplate fixed on the machine (see drawing).
Make sure that the nameplate on the machine conforms to your order.
The machine name is defined according to various criteria, for example :
LSA 46.2 M5 C6/4 -
- LSA : name used in the PARTNER range
  M : Marine
  C : Cogeneration
  T : Telecommunications
- 46.2 : machine type
- M5 : model
- C : excitation system
  (C : AREP / J : SHUNT or PMG / E : COMPOUND)
- 6/4 : winding number / number of poles.

#### 1.3.1 - Nameplate

So that you can identify your machine quickly and accurately, we suggest you write its specifications on the nameplate below.

### 1.4 - Storage

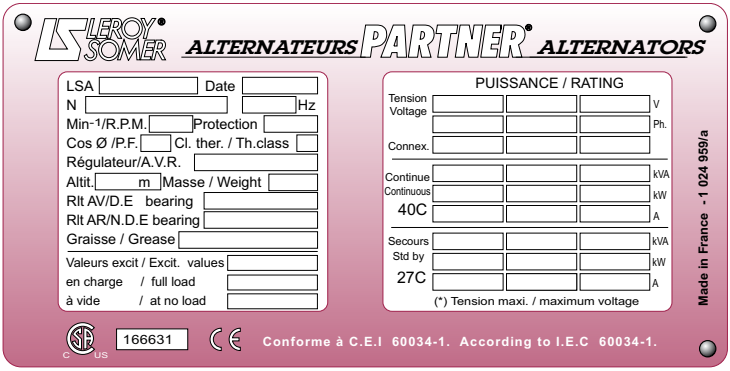
Prior to commissioning, machines should be stored :
- Away from humidity (< 90%); after a long period of storage, check the machine insulation (section 3.2.1). To prevent the bearings from becoming marked, do not store in an environment with significant vibration.

### 1.5 - Application

These alternators are mainly designed to produce electricity in the context of applications involving the use of generators.

### 1.6 - Contraindications to use

Use of the machine is restricted to operating conditions (environment, speed, voltage, power, etc) compatible with the characteristics indicated on the nameplate.



# LSA 46.2 - 4 POLES
## ALTERNATORS

## 2 - TECHNICAL CHARACTERISTICS

### 1.1 - Electrical characteristics

The LSA 46.2 alternator is a machine without sliprings or revolving armature brushes, wound as “2/3 pitch”, 6 or 12-wire, with class H insulation and a field excitation system available in either SHUNT, AREP or «PMG» version (see diagrams and AVR manuals).

#### 2.1.1 - Electrical options

- Stator temperature detection sensors
- Bearing sensors (PTC, PT100, etc)
- Space heater

Interference suppression conforms to standard EN 55011, group 1, class B (Europe).

### 2.2 - Mechanical characteristics

- Steel frame
- Cast iron end shields
- Protected ball bearings, greased for life
- Mounting arrangements:

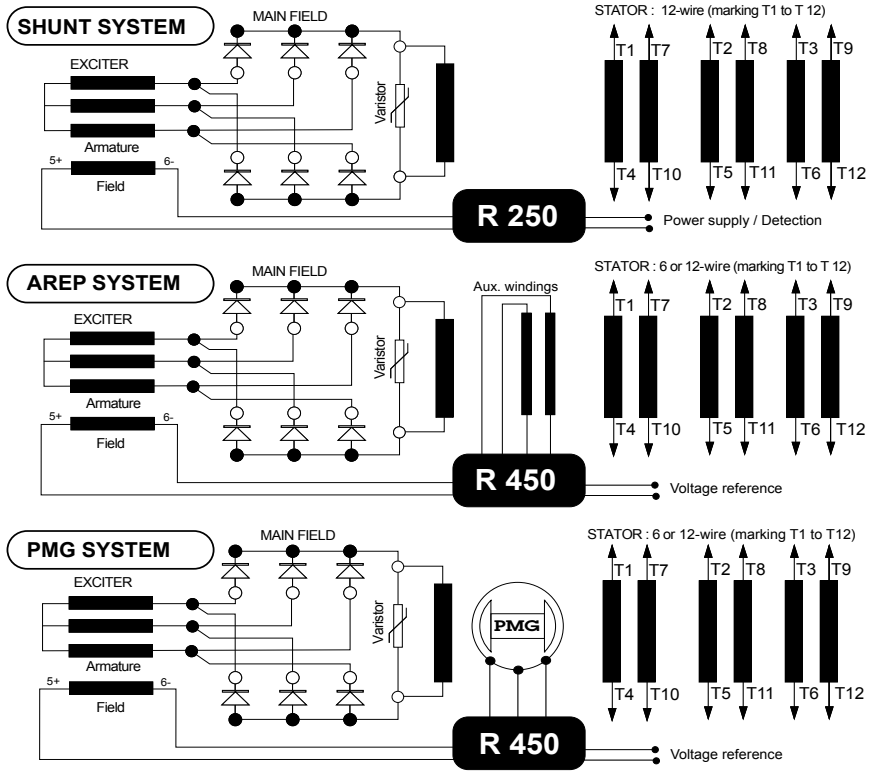
IM 1201 (MD 35) foot and flange mounted, single-bearing with SAE coupling disc.

IM 1001 (B 34) double-bearing with SAE flange and standard cylindrical shaft extension.

- Drip-proof machine, self-cooled
- Degree of protection: IP 23

#### 2.1.1 - Mechanical options

- Air inlet filter
- Regreasable ball bearings
- IP 44 protection



# LSA 46.2 - 4 POLES
# ALTERNATORS

## 3 - INSTALLATION

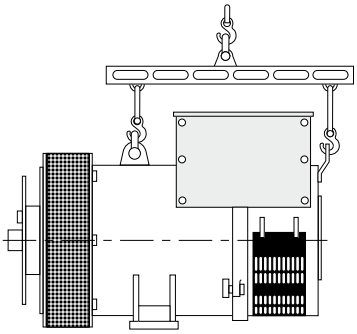
**Personnel undertaking the various operations indicated in this section must wear personal protective equipment appropriate for mechanical and electrical hazards.**

### 3.1 - Assembly

**All mechanical handling operations must be undertaken using suitable equipment and the machine must be horizontal. Check how much the machine weighs (see 4.8.3.) before choosing the lifting tool.**

#### 3.1.1 - Handling

The generously-sized lifting rings are for handling the alternator alone. They must not be used to lift the genset. The choice of lifting hooks or handles should be determined by the shape of these rings. Choose a lifting system which respects the integrity and the environment of the alternators.



**During this operation, do not allow anyone to stand under the load.**

#### 3.1.2 - Coupling

**3.1.2.1 - Single-bearing alternator**

Before coupling the machines, check that they are compatible by:
- undertaking a torsional analysis of the transmission,
- checking the dimensions of the flywheel and its housing, the flange, coupling discs and offset.

WARNING

**When coupling the alternator to the prime mover, do not use the fan to turn the alternator or rotor.**
**The holes of the coupling discs should be aligned with the flywheel holes by cranking the engine.**
**Make sure the alternator is securely bedded in position during coupling.**
Check that there is lateral play on the crankshaft.

**3.1.2.2 - Double-bearing alternator**

- Semi-flexible coupling

Careful alignment of the machines is recommended, checking that the lack of concentricity and parallelism of both parts of the coupling do not exceed 0.1 mm.
**This alternator has been balanced with a 1/2 key.**

#### 3.1.3 - Location

The room where the alternator is placed must be ventilated to ensure that the ambient temperature cannot exceed the data on the nameplate.

### 3.2 - Checks prior to first use

#### 3.2.1 - Electrical checks

**Under no circumstances should an alternator, new or otherwise, be operated if the insulation is less than 1 megohm for the stator and 100,000 ohms for the other windings.**

# LSA 46.2 - 4 POLES
## ALTERNATORS

There are 2 possible methods for restoring the above minimum values.
a) Dry out the machine for 24 hours in a drying oven at a temperature of 110 °C (without the regulator).
b) Blow hot air into the air intake, having made sure that the machine is rotating with the exciter field disconnected.
**Note :** Prolonged standstill: In order to avoid these problems, we recommend the use of space heaters, as well as turning over the machine from time to time. Space heaters are only really effective if they are working continuously while the machine is stopped.

**WARNING**

**Ensure that the alternator has the degree of protection matching the defined environmental conditions.**

### 3.2.2 - Mechanical checks

Before starting the machine for the first time, check that:
- all fixing bolts and screws are tight.
- the cooling air is drawn in freely.
- the protective grilles and housing are correctly in place.
- the standard direction of rotation is clockwise as seen from the shaft end (phase rotation in order 1 - 2 - 3).
For anti-clockwise rotation, swap 2 and 3.
- the winding connection corresponds to the site operating voltage (see section 3.3).

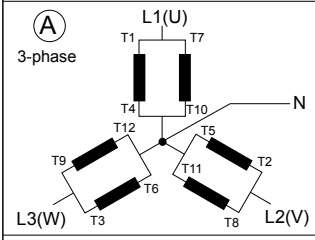
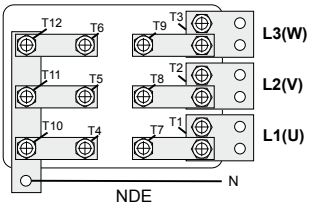
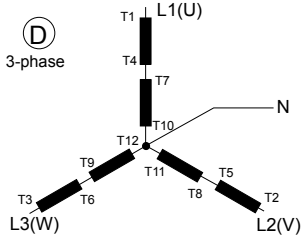
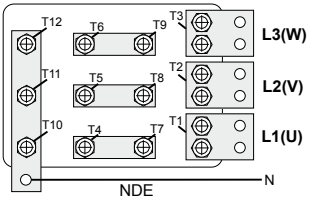
## 3.3 - Terminal connection diagrams

To modify the connection, change the position of the stator cables on the terminals. The winding code is specified on the nameplate.

### 3.3.1 - Terminal connection: 12 wire

The connection accessories are detailed in section 5.3.3.

**Any intervention on the alternator terminals during reconnection or checks should be performed with the machine stopped.**

| Connection codes | Voltage L.L | | | Factory connection |
|---|---|---|---|---|
|  | Winding | 50 Hz | 60 Hz |  |
| | 6 | 190 - 208 | 190 - 240 | |
| | 7 | 220 | - | |
| | 8 | - | 190 - 208 | |
| | R 250 voltage detection :<br>0 => (T8) / 110 V => (T11)<br>R 450 voltage detection :<br>0 => (T3) / 220 V => (T2) | | | |
|  | Winding | 50 Hz | 60 Hz |  |
| | 6 | 380 - 415 | 380 - 480 | |
| | 7 | 440 | - | |
| | 8 | - | 380 - 416 | |
| | R 250 voltage detection :<br>0 => (T8) / 110 V => (T11)<br>R 450 voltage detection :<br>0 => (T3) / 380 V => (T2) | | | |
| | 9 | 500 | 600 | |
| | Winding 9 : R 450 voltage detection + transformer (See specific diagram AREP or SHUNT) | | | |

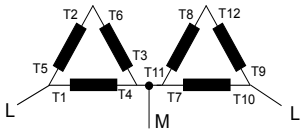
In case of reconnection, ensure that AVR voltage detection is correct !
The factory can supply a set of flexible shunts and special connection links as an option for making these connections. (*).

# LSA 46.2 - 4 POLES
## ALTERNATORS

### Connection codes

**FF**

1 phase




Voltage LM = 1/2 voltage LL

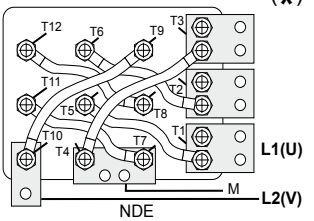
### Voltage L.L

| Winding | 50 Hz | 60 Hz |
|---|---|---|
| 6 | 220 - 240 | 220 - 240 |
| 7 | 240 - 254 | - |
| 8 | - | 220 - 240 |

⚠ R 250 voltage detection :
0 => (T4) / 110 V => (T1)
R 450 voltage detection :
0 => (T10) / 220 V => (T1)

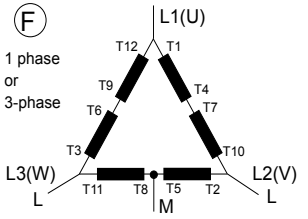
### Factory connection

(*)




**F**

1 phase
or
3-phase

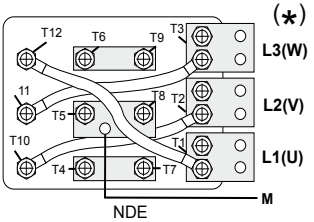



Voltage LM = 1/2 voltage LL

| Winding | 50 Hz | 60 Hz |
|---|---|---|
| 6 | 220 - 240 | 220 - 240 |
| 7 | 240 - 254 | - |
| 8 | - | 220 - 240 |

⚠ R 250 voltage detection :
0 => (T8) / 110 V => (T11)
R 450 voltage detection :
0 => (T3) / 220 V => (T2)

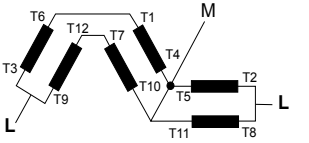
(*)




Operating phases L2 (V), L3 (W) single phase

**G**

1 PH

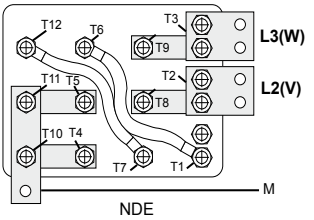



Voltage LM = 1/2 voltage LL

| Winding | 50 Hz | 60 Hz |
|---|---|---|
| 6 | 220 - 240 | 220 - 240 |
| 7 | 250 - 260 | - |
| 8 | 200 | 220 - 240 |

⚠ R 250 voltage detection :
0 => (T8) / 110 V => (T11)
R 450 voltage detection :
0 => (T3) / 220 V => (T2)

(*)

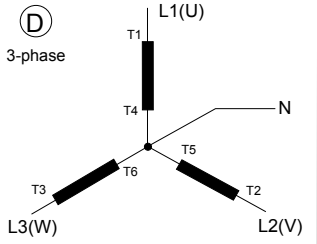



⚠ In case of reconnection, ensure that AVR voltage detection is correct !
The factory can supply a set of flexible shunts and special connection links as an option for making these connections. (*).

# LSA 46.2 - 4 POLES
# ALTERNATORS

### 3.3.2 - Terminal connection: 6 wire (not possible with the R 250)

**Connection codes**



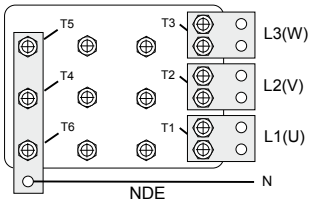

**Voltage L.L**

| Winding | 50 Hz | 60 Hz |
|---|---|---|
| 6S | 380 - 415 | 380 - 480 |
| 7S | 440 | - |
| 8S | - | 380 - 416 |

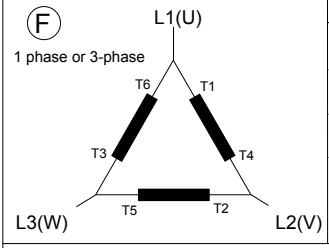
⚠ R 450 voltage detection :
0 => (T3) / 380 V => (T2)

| Winding | 50 Hz | 60 Hz |
|---|---|---|
| 9S | - | 600 |

**Factory connection**

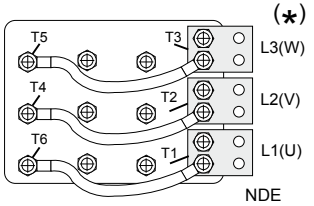



Winding 9 : R 450 voltage detection + transformer (See specific diagram)




| Winding | 50 Hz | 60 Hz |
|---|---|---|
| 6S | 220 - 240 | 220 - 277 |
| 7S | 240 - 254 | - |
| 8S | - | 220 - 240 |

⚠ R 450 voltage detection :
0 => (T3) / 220 V => (T2)

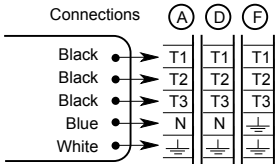



Operating phases : L2 (V), L3 (W) single phase

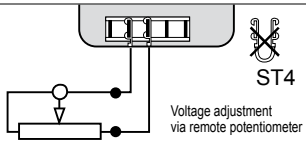
⚠ In case of reconnection, ensure that the AVR voltage detection is correct !
The factory can supply a set of flexible shunts and special connection links as an option for making these connections. (*).

### 3.3.3 - Option connection diagram

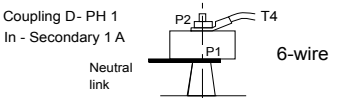
**R 791 T interference suppression kit** (standard for CE marking)

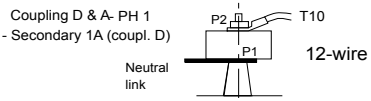



**Remote voltage potentiometer**

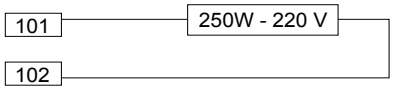



**Current transformer connection (optional)**

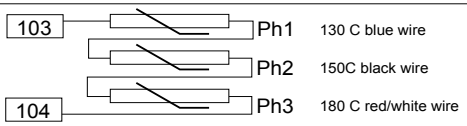



**Anti condensation heater**




**Thermistor (PTC) temperature**

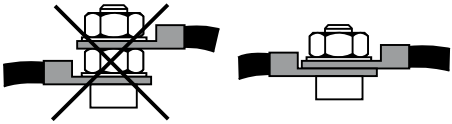


### 3.3.4 - Connection checks

**Electrical installations must comply with the current legislation in force in the country of use.**

Check that:

- The residual circuit-breaker conforms to legislation on protection of personnel, in force in the country of use, and has been correctly installed on the alternator power output as close as possible to the alternator. (In this case, disconnect the wire of the interference suppression module linking the neutral).
- Any protection devices in place have not been tripped.
- If there is an external AVR, the connections between the alternator and the cabinet are made in accordance with the connection diagram.
- There is no short-circuit phase-phase or phase-neutral between the alternator output terminals and the generator set control cabinet (part of the circuit not protected by circuitbreakers or relays in the cabinet).
- The machine should be connected with the busbar separating the terminals as shown in the terminal connection diagram.



### 3.4 - Commissioning

**The machine can only be started up and used if the installation is in accordance with the regulations and instructions defined in this manual.**

The machine is tested and set up at the factory. When first used with no load, make sure that the drive speed is correct and stable (see the nameplate). With the regreasable bearing option, we recommend greasing the bearings at the time of commissioning (see 4.2.3).

On application of the load, the machine should achieve its rated speed and voltage; however, in the event of abnormal operation, the machine setting can be altered (follow the adjustment procedure in section 3.5). If the machine still operates incorrectly, the cause of the malfunction must be located (see section 4.4).

### 3.5 - Setting up

**The various adjustments during tests must be made by a qualified engineer.**

**Ensure that the drive speed specified on the nameplate is reached before commencing adjustment.**

**After operational testing, replace all access panels or covers.**

**The AVR is used to make any adjustments to the machine.**

## 4 - SERVICING - MAINTENANCE

### 4.1 - Safety measures

**Servicing or troubleshooting must be carried out strictly in accordance with instructions so as to avoid the risk of accidents and to maintain the machine in its original state.**

**All such operations performed on the alternator should be undertaken by personnel trained in the commissioning, servicing and maintenance of electrical and mechanical components, who must wear personal protective equipment appropriate for mechanical and electrical hazards.**

Before any intervention on the machine, ensure that it cannot be started by a manual or automatic system and that you have understood the operating principles of the system.

### 4.2 - Routine maintenance

#### 4.2.1 - Checks after start-up

After approximately 20 hours of operation, check that all fixing screws on the machine are still tight, plus the general state of the machine and the various electrical connections in the installation.

#### 4.2.2 - Bearings

As standard, the alternator is fitted with permanently greased bearings. As an option, they may be regreasable. It is advisable to lubricate the alternator during operation. Time intervals and quantity of grease are given in the table below.

| NDE/DE bearing | 6316 C3 | 6315 C3 |
|---|---|---|
| Quantity of grease | 33 g | 30 g |
| Regreasing interval | 4000 H | 4500 H |

Lubrication intervals are given for grease type: LITHIUM - standard - NLGI 3.

In the factory, the grease used for lubrication is: ESSO - Unirex N3.

Before using another grease, check for compatibility with the original one. Monitor the temperature rise in the bearings (see section 4.4).

#### 4.2.3 - Electrical servicing

Commercially-available volatile degreasing agents can be used.

**WARNING**

**Do not use: trichlorethylene, perchlorethylene, trichloroethane or any alkaline products.**

**These operations must be performed at a cleaning station, equipped with a vacuum system that collects and flushes out the products used.**

The insulating components and the impregnation system are not at risk of damage from solvents. Avoid letting the cleaning product run into the slots.

Apply the product with a brush, sponging frequently to avoid accumulation in the housing. Dry the winding with a dry cloth. Let any traces evaporate before reassembling the machine.

#### 4.2.4 - Mechanical servicing

**WARNING**

**Cleaning the machine using water or a highpressure washer is strictly prohibited. Any problems arising from such treatment are not covered by our warranty.**

Degreasing: Use a brush and detergent (suitable for paintwork).

Dusting: Use an air gun.

If the machine is fitted with air inlet and outlet filters, the maintenance personnel should clean them routinely at regular intervals. In the case of dry dust, the filter can be cleaned using compressed air and/or replaced if it is clogged.

After cleaning the alternator, it is essential to check the winding insulation (see sections 3.2 and 4.8).

### 4.3 - Fault detection

If, when commissioned, the alternator does not work normally, the source of the malfunction must be identified (see sections 4.4 and 4.5).

## 4.4 - Mechanical defects

| Fault | | Action |
|---|---|---|
| Bearing | Excessive temperature rise in one or both bearings (bearing temperature more than 80 °C) with or without abnormal bearing noise | - If the bearing has turned blue or if the grease has turned black, change the bearing<br>- Bearing not fully locked (abnormal play in the bearing cage)<br>- Check the end shield alignment (flange not properly fitted) |
| Abnormal temperature | Excessive temperature rise in the alternator housing (more than 40° C above the ambient temperature) | - Air flow (intake-outlet) partially clogged or hot air is being recycled from the alternator or engine<br>- Alternator operating at too high a voltage (> 105% of Un on load)<br>- Alternator overloaded |
| Vibration | Excessive vibration | - Misalignment (coupling)<br>- Defective mounting or play in coupling<br>- Rotor balancing fault (Engine - Alternator) |
| | Excessive vibration and humming noise coming from the machine | - Phase imbalance<br>- Stator short-circuit |
| Abnormal noise | Alternator damaged by a significant impact, followed by humming and vibration | - System short-circuit<br>- Mis-paralleling<br>Possible consequences:<br>- Broken or damaged coupling<br>- Broken or bent shaft extension<br>- Shifting and short-circuit of revolving field winding<br>- Fan fractured or coming loose on shaft<br>- Irreparable damage to rotating diodes, AVR, surge suppressor |

## 4.5 - Electrical faults

| Fault | Action | Effect | Check/Cause |
|---|---|---|---|
| No voltage at no load on start-up | Connect a new battery of 4 to 12 volts to terminals E- and E+, respecting the polarity, for 2 to 3 seconds | The alternator builds up and its voltage is still correct when the battery is removed | - Lack of residual magnetism |
| | | The alternator builds up but its voltage does not reach the rated value when the battery is removed | - Check the connection of the voltage reference to the AVR<br>- Faulty diodes<br>- Armature short-circuit |
| | | The alternator builds up but its voltage disappears when the battery is removed | - Faulty AVR<br>- Field windings open circuit (check winding)<br>- Revolving field coil open circuit (check the resistance) |
| Voltage too low | Check the drive speed | Correct speed | Check the AVR connections (AVR may be faulty)<br>- Field windings short-circuited<br>- Rotating diodes burnt out<br>- Revolving field coil short-circuited<br>- Check the resistance |
| | | Speed too low | Increase the drive speed (do not touch the AVR voltage pot. (P2) before running at the correct speed) |
| Voltage too high | Adjust AVR voltage potentiometer | Adjustment ineffective | Faulty AVR |
| Voltage oscillations | Adjust the AVR stability potentiometer | If no effect: try normal or fast stability modes (ST2) | - Check the speed: possibility of cyclic irregularity<br>- Loose connections<br>- Faulty AVR<br>- Speed too low when on load (or AVR LAM set too high) |
| Voltage correct at no load and too low when on load | Run at no load and check the voltage between E+ and E- on the AVR | Voltage between E+ and E- (DC) SHUNT / AREP / PMG < 10V | - Check the speed (or AVR LAM set too high) |
| | | Voltage between E+ and E- SHUNT / AREP / PMG > 15V | - Faulty rotating diodes<br>- Short-circuit in the revolving field coil. Check the resistance.<br>- Faulty exciter armature. Check the resistance. |
| Voltage disappears during operation | Check the AVR, the surge suppressor, the rotating diodes, and replace any defective components | The voltage does not return to the rated value | - Exciter winding open circuit<br>- Faulty exciter armature<br>- Faulty AVR<br>- Revolving field coil open circuit or short-circuited |

### 4.5.1 - Checking the winding

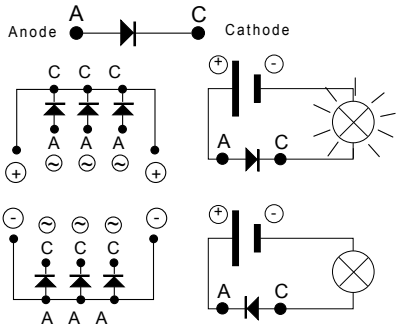
You can check the winding insulation by performing a high voltage test. In this case, you must disconnect all AVR wires.

**WARNING**

**Damage caused to the AVR in such conditions is not covered by our warranty.**

### 4.5.2 - Checking the diode bridge

A diode in good working order should allow the current to flow only in the anode-to-cathode direction.

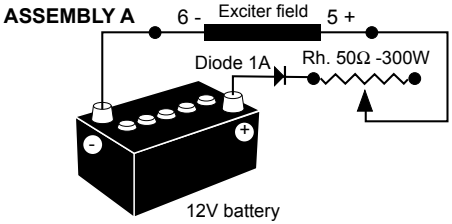



### 4.5.3 - Checking the windings and rotating diodes using separate excitation

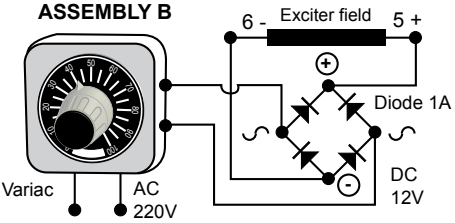
**During this procedure, make sure that the alternator is disconnected from any external load and inspect the terminal box to check that the connections are fully tightened.**

1) Stop the unit, disconnect and isolate the AVR wires.
2) There are two ways of creating an assembly with separate excitation.

**Assembly A:** Connect a 12 V battery in series with a rheostat of approximately 50 ohms - 300 W and a diode on both exciter field wires (5+) and (6-).



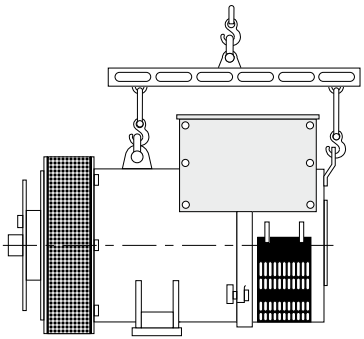

**Assembly B:** Connect a "Variac" variable power supply and a diode bridge on both exciter field wires (5+) and (6-).
Both these systems should have characteristics which are compatible with the field excitation power of the machine (see the nameplate).
3) Run the unit at its rated speed.
4) Gradually increase the exciter field current by adjusting the rheostat or the variac and measure the output voltages on L1 - L2 - L3, checking the excitation voltage and current at no load (see the machine nameplate or ask for the factory test report). When the output voltage is at its rated value and balanced within 1% for the rated excitation level, the machine is in good working order. The fault therefore comes from the AVR or its associated wiring (ie. sensing, auxiliary windings).



## 4.6 - Dismantling, reassembly (see sections 5.4.1. & 5.4.2.)

WARNING

**During the warranty period, this operation should only be carried out in an LEROY-SOMER approved workshop or in our factory, otherwise the warranty may be invalidated.**
**Whilst being handled, the machine should remain horizontal (rotor not locked in position). Check how much the machine weighs (see 4.8.3) before choosing the lifting method.**



### 4.6.1 - Tools required

To fully dismantle the machine, we recommend using the tools listed below:
- 1 ratchet spanner + extension
- 1 torque wrench
- 1 set of flat spanners: 8 mm, 10 mm, 18 mm
- 1 socket set: 8, 10, 13, 16, 18, 21, 24, 30 mm
- 1 socket with male ferrule: 5 mm
- 1 puller

### 4.6.2 -Screw tightening torque

See section 5.4.

### 4.6.3 - Access to diodes

- Open the air intake grille (51).
- Disconnect the diodes.
- Check the 6 diodes, change the diode bridges if necessary.

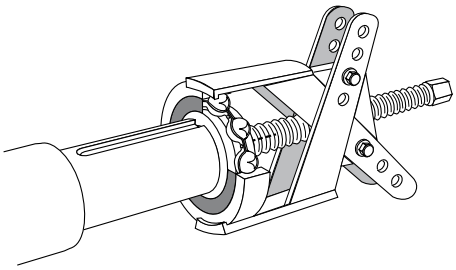
### 4.6.4 - Access to connections and the regulation system

Access directly by removing the top of the cover (48) or the AVR access door (466).

### 4.6.5 - Replacing the NDE bearing

- Remove the box lid (48) and the NDE panel (365) and remove the 2 screws from the part (122).
- Disconnect the stator outputs (T1 to T12).
- Disconnect the auxiliary winding wires AREP (X1,X2,Z1,Z2).
- Disconnect the exciter wires (5+,6-).
- Remove the air inlet louvre (51).

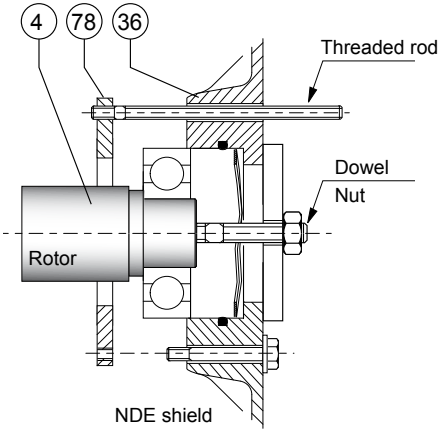
If using a single-bearing or double-bearing machine with the regreasable bearing option:
- Remove the bearing (78) thrust screws (72).
- Remove all 4 screws (37).
- Remove the shield (36).
- Take out the antifriction bearing (70) using a puller with a central screw (see drawing below).



- Fit the new antifriction bearing onto the shaft after heating it by induction to approximately 80 °C.
- Mount the new preloading (wavy) washer (79) + the new “O” ring seal (349) in the shield (36) and coat the bearing seat with adhesive paste (see After Sales Service).

If using a single-bearing or double-bearing machine with the regreasable bearing option:
- Screw a threaded rod into the thrust bearing (78).
- Refit the end shield on the machine using a dowel and nut in the shaft extension (see drawing).

- Slide the threaded rod into the shield hole to make it easier to assemble (see basic diagram).




- Fit the thrust bearing screws (78), remove the threaded rod, fit the other screw and tighten up the assembly.
- Tighten the 4 bearing screws (37).
- Reconnect wires.
- Fit the 2 support screws (122).
- Fit the air inlet louvre (51).
- Replace the cover.

**WARNING**

**When dismantling the shields, you will need to change the antifriction bearings, the "O" ring seal, the preloading (wavy) washer and adhesive paste.**

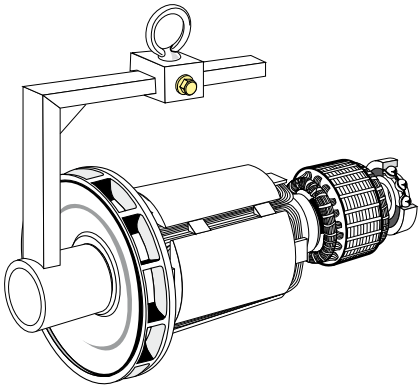
#### 4.6.6 - Replacing the DE bearing

- Remove the air outlet grille (33).
- Remove the 6 screws (31) from the DE shield and the 3 screws (62) from the inner bearing retainer.
- Remove the shield (30).
- Take out the ball bearing (60) using a puller with a central screw (see section 4.6.5).
- Fit the new bearing, after heating it by induction to approximately 80 °C.
- Screw a threaded rod into the thrust bearing (68).
- Refit the shield (30) on the machine.
- Slide the threaded rod into the shield hole to make it easier to assemble (see basic diagram).
- Tighten the bottom thrust bearing screws (78), remove the threaded rod and fit the other screws.
- Tighten the 6 shield screws (31).
- Refit the air outlet grille (33).

#### 4.6.7 - Dismantling the rotor assembly

- Remove the NDE shield (36) as described in section 4.6.5.
- Remove the DE shield (30) as described in section 4.6.6 if it is a double-bearing machine.
- Support the DE rotor (4) with a strap or with a support constructed in accordance with the following drawing.
- Move the strap as the rotor moves in order to distribute the weight over it.

**WARNING**



**When dismantling the rotor involves changing parts or rewinding, the rotor must be rebalanced.**

#### 4.6.8 - Reassembling the machine

- Mount the rotor (4) in the stator (1) (see drawing above) taking care not to knock the windings.

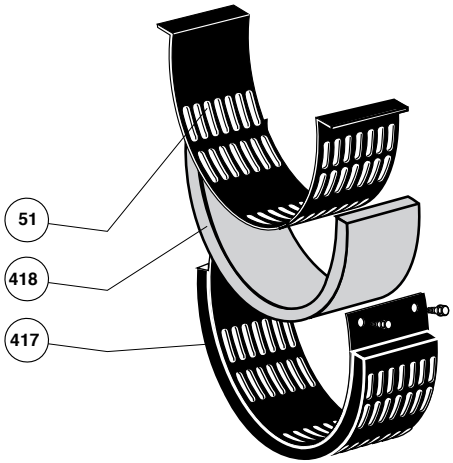
If using a single-bearing or double-bearing machine with the regreasable bearing option:
- Mount the new preloading (wavy) washer (79) + the new “O” ring seal (349) in the shield (36).
- Screw a threaded rod into the thrust bearing (78).
- Refit the shield (36) on the machine using a dowel and nut in the shaft extension (see diagram).
- Slide the threaded rod into the shield hole to make it easier to assemble (see diagram).
- Fit the thrust bearing screws (78), remove the threaded rod, fit the other screw and tighten up the assembly.
- Tighten the 4 bearing screws (37).
- Reconnect exciter wires E+, E-.
- Finish reassembling the cover.
- Refit the flange (30) on the stator (1).
- Tighten the screws (31).

If using a double-bearing machine:
- Mount the new preloading (wavy) washer (79) + the new “O” ring seal (349) in the shield (36).
- Refit the shield (36) on the machine using a dowel and nut in the shaft extension (see diagram).
- Tighten the 4 shield screws (37).
- Reconnect exciter wires E+, E-.
- Finish reassembling the cover.
- Screw a threaded rod into the thrust bearing (68).
- Refit the shield (30) on the machine.
- Slide the threaded rod into the shield hole to make it easier to assemble (see basic diagram).
- Fit the thrust bearing screws (68), remove the threaded rod, fit the other screw and tighten up the assembly.
- Tighten the 6 shield screws (31).
- Refit the air outlet grille (33).
- Check that the machine assembly is correctly mounted and that all screws are tightened.

### 4.6.9 - Dismantling and reassembly of the filters

- Remove the grille (417) then take out the filter (418). Change the filter if necessary; please refer to section 4.2.5 for cleaning the filter.

To replace, follow the instructions in reverse order.




## 4.7 - Installation and maintenance of the PMG

For the LSA 46.2, the PMG reference is: PMG 2.
See the PMG manual ref : 4211.

## 4.8 - Table of characteristics

Table of average values
Alternator - 4 poles - 50 Hz - Standard winding No. 6.
(400V for the excitation values)
The voltage and current values are given for no-load operation and operation at rated load with separate field excitation.
All values are given to within ± 10% and may be changed without prior notification (for exact values, consult the test report).

### 4.8.1 - LSA46.2 average values

**Resistances at 20 °C (Ω)**

| LSA 46.2 | Stator L/N | Rotor | Field | Armature |
|---|---|---|---|---|
| M3 | 0.022 | 0.23 | 8.8 | 0.035 |
| M5 | 0.0182 | 0.24 | 8.8 | 0.035 |
| L6 | 0.0148 | 0.264 | 8.8 | 0.035 |
| L9 | 0.012 | 0.295 | 8.8 | 0.035 |
| VL12 | 0.0085 | 0.343 | 10 | 0.037 |

**Resistance of AREP auxiliary windings at 20 °C (Ω)**

| LSA 46.2 | Auxil wdg: X1, X2 | Auxil wdg: Z1, Z2 |
|---|---|---|
| M3 | 0.24 | 0.4 |
| M5 | 0.215 | 0.36 |
| L6 | 0.185 | 0.36 |
| L9 | 0.19 | 0.32 |
| VL12 | 0.17 | 0.32 |

**Field excitation current i exc (A)**
Symbols : “i exc”: excitation current of the exciter field

| LSA 46.2 | No load | At rated load |
|---|---|---|
| M3 | 1.1 | 4 |
| M5 | 1.1 | 3.8 |
| L6 | 1.1 | 4.1 |
| L9 | 1.2 | 4 |
| VL12 | 1.1 | 3.5 |

For 60 Hz machines, the “i exc” values are approximately 5 to 10 % lower.

### 4.8.2 - Voltage of auxiliary windings at no load

| LSA 46.2 | Auxil wdg: X1, X2 | Auxil wdg: Z1, Z2 |
|---|---|---|
| 50 Hz | 70 V | 10 V |
| 60 Hz | 85 V | 12 V |

### 4.8.3 - Table of weights

(values given for information only)

| LSA 46.2 | Total weight (kg) | Rotor (kg) |
|---|---|---|
| M3 | 600 | 250 |
| M5 | 700 | 260 |
| L6 | 800 | 290 |
| L9 | 850 | 320 |
| VL12 | 1000 | 380 |

**After operational testing, it is essential to replace all access panels or covers.**

## 5 - SPARE PARTS

### 5.1 - First maintenance parts

Emergency repair kits are available as an option.
They contain the following items:

| Emergency kit SHUNT | ALT 472 KS 001 |
|---|---|
| AVR R 250 | - |
| Diode bridge assembly | - |
| Surge suppressor | - |

| Emergency kit AREP | ALT 461 KS 001 |
|---|---|
| AVR R 450 | - |
| Diode bridge assembly | - |
| Surge suppressor | - |

| Single-bearing kit | ALT 471 KB 002 |
|---|---|
| Non drive end bearing | - |
| «O» ring | - |
| Preloading (wavy) washer | - |

| Double-bearing kit | ALT 471 KB 001 |
|---|---|
| Non drive end bearing | - |
| Drive end bearing | - |
| «O» ring | - |
| Preloading (wavy) washer | - |

### 5.2 - Technical support service

Our technical support service will be pleased to provide any additional information you may require.

When ordering spare parts, you should indicate the complete machine type, its serial number and the information given on the nameplate.

Address your enquiry to your usual contact.

Part numbers should be identified from the exploded views and their description from the parts list.
Our extensive network of service centres can dispatch the necessary parts without delay.

To ensure correct operation and the safety of our machines, we recommend the use of original manufacturer spare parts.

In the event of failure to comply with this advice, the manufacturer cannot be held responsible for any damage.

### 5.3 - Accessories

#### 5.3.1 - Space heater for use when stopped

The space heater must run as soon as the alternator stops. It is installed at the rear of the machine. Its standard power is 250W with 220V or 250W with 110V on request.

**Warning: the power supply is present when the machine has stopped.**

#### 5.3.2 - Temperature sensors with thermistors (PTC)

These are thermistor triplets with a positive temperature coefficient installed in the stator winding (1 per phase). There can be a maximum of 2 triplets in the winding (at 2 levels: warning and trip) and 1 or 2 thermistors in the shields.
These sensors must be linked to adapted sensing relays (supplied optionally).
Cold resistance of cold thermistor sensors: 100 to 250 Ω per sensor.

#### 5.3.3 - Connection accessories

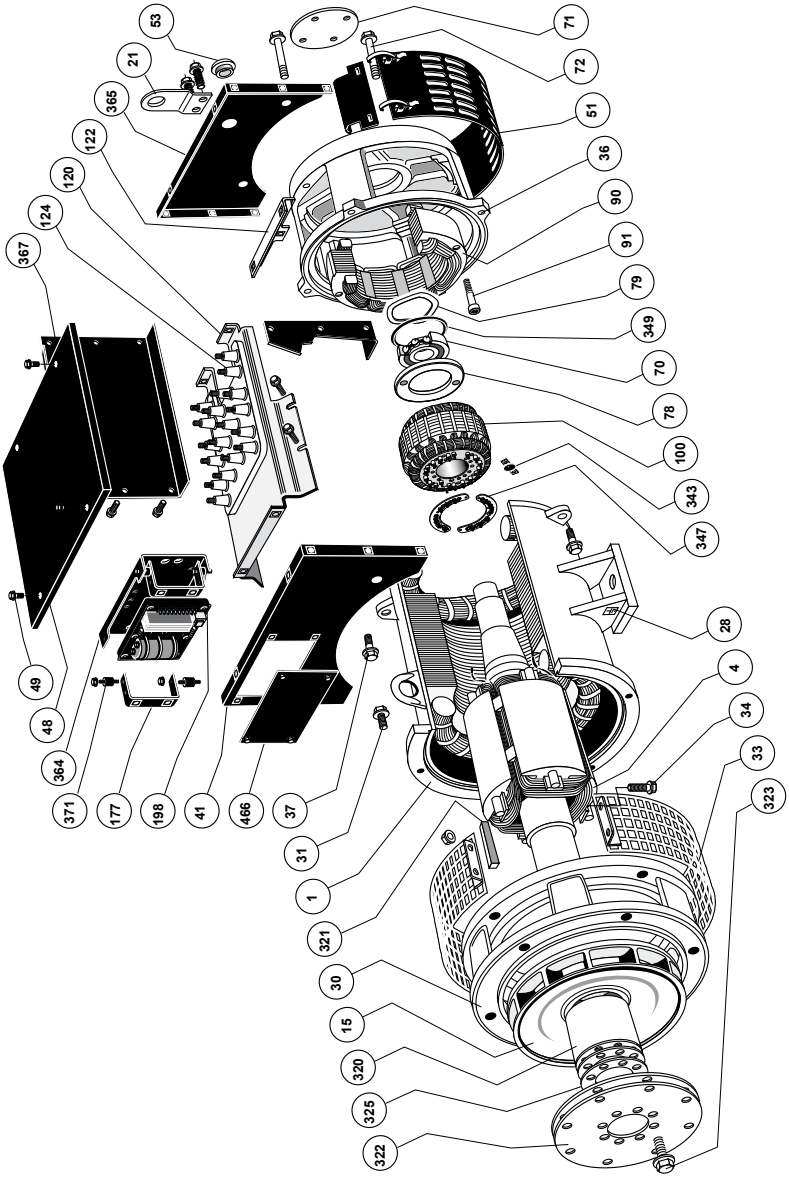
- 6-wire machines : coupling (F)
- 12-wire machines : coupling (A), (F .F), (F)

**After operational testing, it is essential to replace all access panels or covers.**

# LSA 46.2 - 4 POLES
# ALTERNATORS

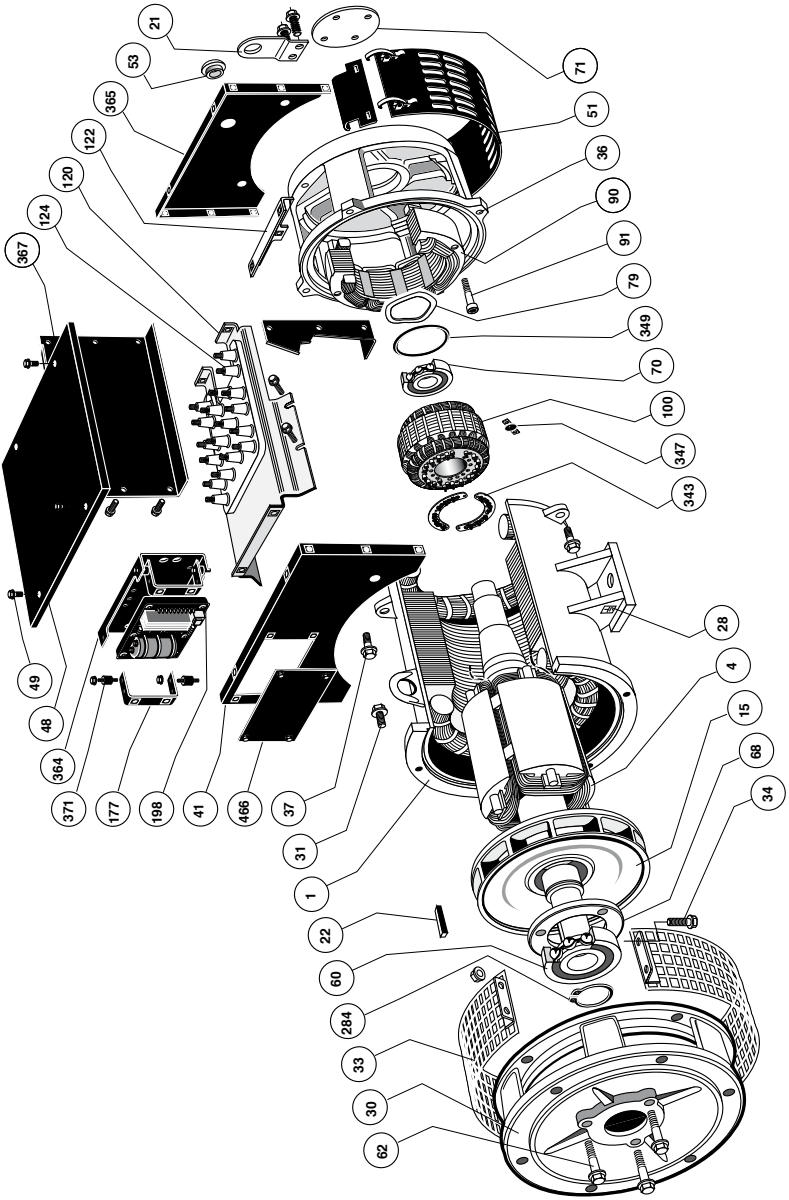
## 5.4 - Exploded view, parts list and tightening torque

### 5.4.1 - LSA 46.2 single-bearing



# LSA 46.2 - 4 POLES
# ALTERNATORS

### 5.4.2 - LSA 46.2 double-bearing



# LSA 46.2 - 4 POLES
## ALTERNATORS

| Ref. | Qty | Description | Screw Ø | Torque N.m | Ref. | Qty | Description | Screw Ø | Torque N.m |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | Stator assembly | - | - | 90 | 1 | Exciter field | - | - |
| 4 | 1 | Rotor assembly | - | - | 91 | 4 | Fixing screws | M6 | 10 |
| 15 | 1 | Fan | - | - | 100 | 1 | Exciter armature | - | - |
| 21 | 1 | Lifting ring | - | - | 120 | 1 | Terminal plate support | - | - |
| 22 | 1 | Shaft extension key | - | - | 122 | 1 | Plate support | - | - |
| 28 | 1 | Earth terminal | M10 | 20 | 124 | 1 | Terminal plate | M12 | 35 |
| 30 | 1 | Drive end shield | - | - | 177 | 2 | AVR support bracket | - | - |
| 31 | 6 or 4 | Fixing screws | M14 | 80(*) | 198 | 1 | Voltage regulator (AVR) | - | - |
| 33 | 1 | Protective grille | - | - | 284 | 1 | Circlips | - | - |
| 34 | 2 | Fixing screws | M6 | 5 | 320 | 1 | Coupling sleeve | - | - |
| 36 | 1 | Exciter end shield | - | - | 321 | 1 | Sleeve key | - | - |
| 37 | 4 | Fixing screws | M12 | 50 | 322 | 3 | Coupling disc | - | - |
| 41 | 1 | Cover front panel | - | - | 323 | 6 | Fixing screw | M16 | 230 |
| 48 | 1 | Cover top panel | - | - | 325 | - | Spacer shim | - | - |
| 49 | - | Cover screws | M6 | 5 | 343 | 1 | Diode bridge assembly | M6 | 4 |
| 51 | 1 | Air intake grille | - | - | 347 | 1 | Protection varistor (+ PCB) | - | - |
| 53 | 1 | Plug | - | - | 349 | 1 | “O” ring | - | - |
| 60 | 1 | Drive end bearing | - | - | 364 | 1 | AVR support | - | - |
| 62 | 3 or 4 | Fixing screws | M8 | 20 | 365 | 1 | Cover rear panel | - | - |
| 68 | 1 | Inner bearing retainer | - | - | 367 | 2 | Side panel | - | - |
| 70 | 1 | Non drive end bearing | - | - | 371 | 4 | Damper | - | - |
| 71 | 1 | Cover | - | - | 416 | 1 | Filter | - | - |
| 72 | 2 | Fixing screws | M8 | 20 | 417 | 1 | Filter support | - | - |
| 78 | 1 | Inner bearing retainer | - | - | 466 | 2 | AVR inspection door | - | - |
| 79 | 1 | Preloading (wavy) washer | - | - | | | | | |

(*) 80 N.m in M / 190 N.m in L, VL

**Electric Power Generation Division**

# Declaration of CE compliance and incorporation

This Declaration applies to the generators designed to be incorporated into machines complying with the Machinery Directive Nr 2006/42/CE dated 17 May 2006.

MOTEURS LEROY-SOMER
Boulevard Marcellin Leroy
16015 ANGOULEME
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MOTEURS LEROY-SOMER
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45800 St Jean de Braye
France

Declares hereby that the electric generators of the types LSA 36 – 37– 40 – 42.2 – 43.2 – 44.2 – 46.2 – 47.2 – 49.1 – 50.2 – 51.2, as well as their derivatives, manufactured by Leroy Somer or on Leroy Somer's behalf, comply with the following International Standards and Directive :

- EN and IEC 60034 -1 and 60034 -5
- ISO 8528 – 3 " Reciprocating internal combustion engine driven alternating current generating sets. Part 3. Alternating current generators for generating sets "
- Low Voltage Directive Nr 2006/95/CE dated 12 December 2006.

Furthermore, these generators, designed in compliance with the Machine Directive Nr 2006/42, are therefore able to be incorporated into Electrical Gen-Sets complying with the following International Directives :

- Machinery Directive Nr 2006/42/CE dated 17 May 2006
- EMC Directive Nr 2004/108/CE dated 15 December 2004, as intrinsic levels of emissions and immunity are concerned

WARNING :

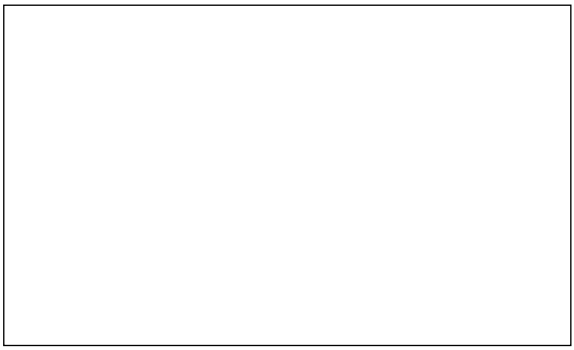
The here above mentioned generators should not be commissioned until the corresponding Gen-Sets have been declared in compliance with the Directives Nr 2006/42/CE et 2004/108/CE, as well as with the other relevant Directives.

Leroy Somer undertakes to transmit, in response to a reasoned request by the national authorities, relevant information on the generator.

**Technical Managers**
P Betge – J.Begué

4152 en – 2010.11 / d

# LSA 46.2 - 4 POLES
## ALTERNATORS



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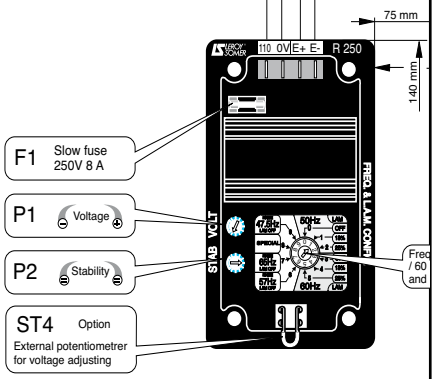
4067 en - 2009.05 / b

This manual is to be given to the end user




# R250

## A.V.R.

## Installation and maintenance

227/276

# R250
# A.V.R.

**This manual concerns the alternator A.V.R. which you have just purchased.**

**We wish to draw your attention to the contents of this maintenance manual. By following certain important points during installation, use and servicing of your A.V.R., you can look forward to many years of trouble-free operation.**

## SAFETY MEASURES

Before using your machine for the first time, it is important to read the whole of this installation and maintenance manual.

All necessary operations and interventions on this machine must be performed by a qualified technician.

Our technical support service will be pleased to provide any additional information you may require.

The various operations described in this manual are accompanied by recommendations or symbols to alert the user to potential risks of accidents. It is vital that you understand and take notice of the following warning symbols.

WARNING

**Warning symbol for an operation capable of damaging or destroying the machine or surrounding equipment.**

**Warning symbol for general danger to personnel.**

**Warning symbol for electrical danger to personnel.**

Note : LEROY-SOMER reserves the right to modify the characteristics of its products at any time in order to incorporate the latest technological developments.
The information contained in this document may therefore be changed without notice.

# R250
# A.V.R.

**SUMMARY**



**Any maintenance or breakdown operations on the A.V.R. are to be done by personnel trained on commisioning, servicing and maintenance for the electrical and mechanical elements.**

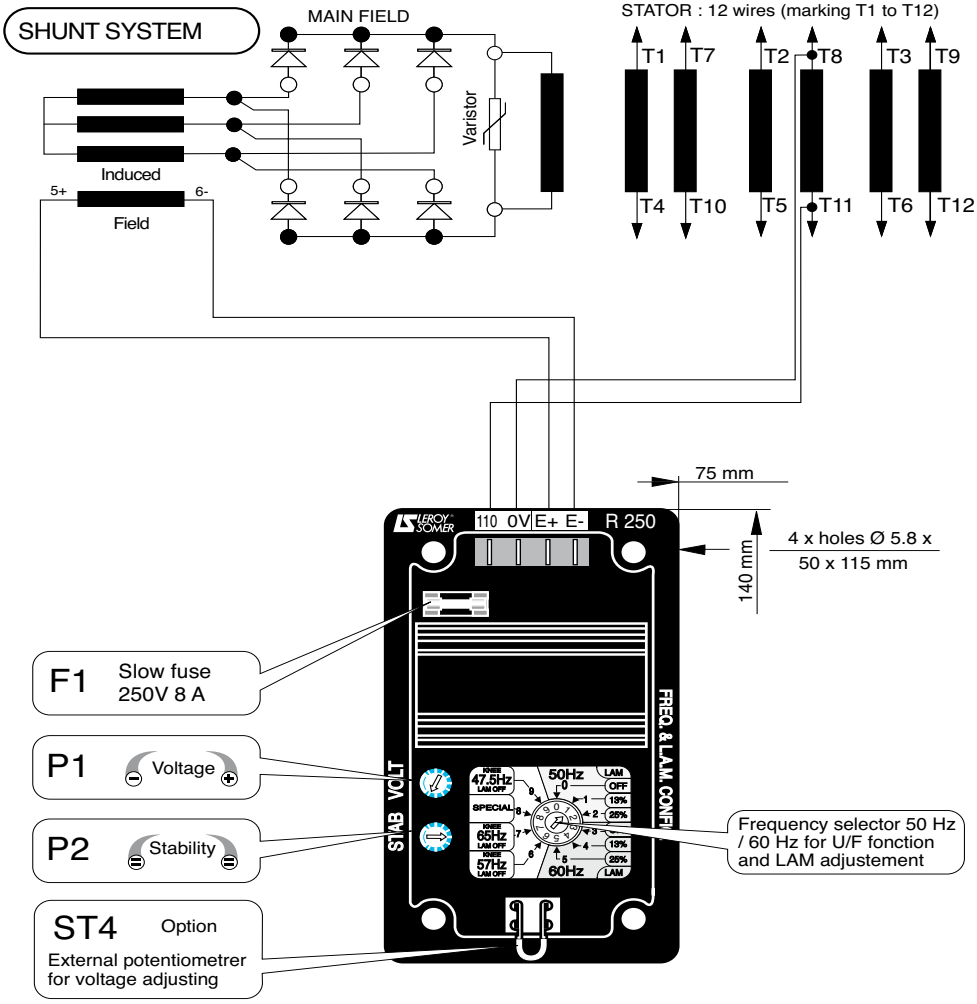
The R250 is an IP00 product. It must be installed inside a unit so that this unit's cover can provide IP20 minimum total protection (it must only be installed on LS alternators in the appropriate location so that when viewed externally, it has a higher degree of protection than IP20).

## 1 - SUPPLY

### 1.1 - SHUNT excitation system

The SHUNT excitation alternator is auto-excited with a **R 250** voltage regulator.

The regulator controls the excitation current according to the alternator's output voltage. With a very simple conception, the SHUNT excitation alternator does not have a short circuit capacity.



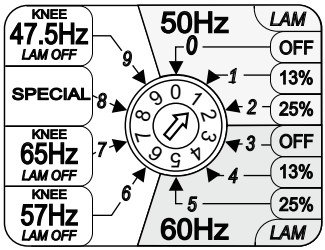
## 2 - R250 A.V.R.

### 2.1 - Characteristics

- Storage: -55°C; +85°C
- Operation: -40°C; +70°C
- Voltage regulation: around ± 0,5 %.
- Supply range/voltage detection 85 to 139 V (50/60Hz).
- Rapid response time (500 ms) for a transient voltage variation amplitude of ± 20 %.
- Voltage setting **P1**.
- Stability setting **P2**.
- Power supply protected by 8 A fuse, replacement product: Ferraz-Shawmut T084013T fast-blow fuse, 8 A FA 250 V, breaking capacity 30 kA.

### 2.2 - U/F Fonction and LAM

The threshold position (50 Hz - 60 Hz) to action the U/F fonction as well as the LAM setting type is selected using the potentionmeter.




**WARNING: The jumper settings must correspond to the rated operating frequency (see the nameplate on the alternator).**
**Risk of destruction for the alternator.**

The threshhold position and LAM fonction settings are done with the jumper.

**Operating at 50 Hz: (U/F gradient)**

**0**: threshold at 48 Hz without LAM for impacts between 30 and 40% of the rated load.

**1**: threshold at 48 Hz with LAM 13% for impacts between 40 and 70% of the rated load.

**2**: threshold at 48 Hz with LAM 25% for impacts > 70% of the rated load.

**Operating at 60 Hz: (U/F gradient)**

**3**: threshold at 58 Hz without LAM for impacts between 30 and 40% of the rated load.

**4**: threshold at 58Hz with LAM 13% for impacts 40 and 70% of the rated load.

**5**: threshold at 58Hz with LAM 25% for impacts > 70% of the rated load.

**Specific operating**

**6**: threshold at 57Hz without LAM for speed variations at a steady state > 2 Hz

**7**: threshold at 65Hz without LAM for variable speed and tractelec / gearlec (U/F gradient).

**8**: special: the factory setting 48Hz 2U/F gradient ; a special programme is possible on request. This programme must be specified before ordering, during the project study.

**9**: threshold at 47.5 Hz without LAM for speed variations at a steady state > 2 Hz.
For hydraulic applications, it is advisable to select:
- position 0 for 50 Hz
- position 3 for 60 Hz

## 2.3 - R250 A.V.R. option

Potentiometer for voltage setting, 1000 W / 0,5 W min: setting range ± 5 %.
- Remove the **ST4** jumper.

**For wiring up the external potentiometer; the "earth" wires must be isolated as well as the potentiometer terminals (wires at the same voltage as the power).**

## 2.4 - LAM characteristics (Load Acceptance Module)

### 2.4.1 - Voltage drop

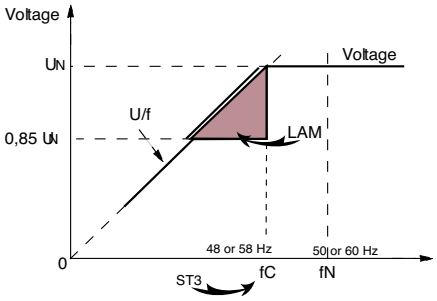
The LAM system is integrated in the A.V.R. It is active as standard. It can be adjusted to 13% or 25%.

- Role of the «LAM» (Load Adjustment Module):

On application of a load, the rotation speed of the generator set decreases. When it passes below the preset frequency threshold, the LAM causes the voltage to drop by approximately 13% or 25% and consequently the amount of active load applied is reduced by approximately 25% to 50%, until the speed reaches its rated value again.

Hence the "LAM" can be used either to reduce the speed variation (frequency) and its duration for a given applied load, or to increase the applied load possible for one speed variation (turbo-charged engines).
To avoid voltage oscillations, the trip threshold for the "LAM" function should be set approximately 2 Hz below the lowest frequency in steady state.

It is advised to use the "LAM" at 25% for load impacts > at 70% of the genset rated power.

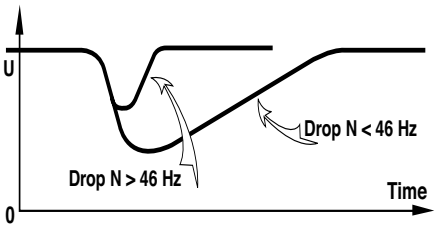



### 2.4.2 - Gradual voltage return function

During load impacts, the function helps the genset to return to its rated speed faster thanks to a gradual increase in voltage according to the following principles:

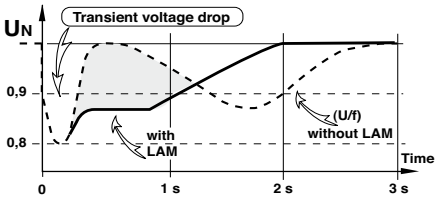
- if the speed drops between 46 Hz and 50 Hz, the rated voltage follows a fast gradient as it is restored.

- if the speed drops below 46 Hz, since the engine needs more help, the voltage follows a slow gradient as it returns to the reference value.

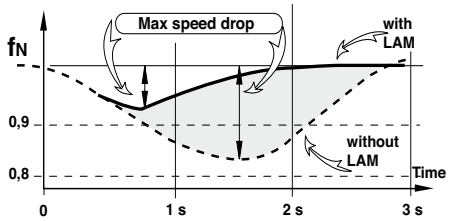


## 2.5 - Typical effects of the LAM with a diesel engine or without a LAM (U/F only)

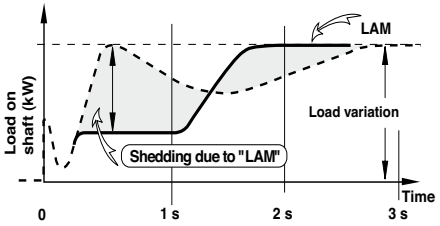
### 2.5.1 - Voltage




### 2.5.2 - Frequency




### 2.5.3 - Power



## 3 - INSTALLATION - COMMISSIONING

### 3.1 - Electrical checks on the AVR

- Check that all connections have been made properly as shown in the attached wiring diagram.

- Check that the position of the jumper corresponds to the operating frequency.

- Check whether the ST4 jumper or the remote adjustment potentiometer have been connected.

### 3.2 - Settings

**The different settings made during the trial are to be done by qualified personnel. Respecting the load speed specified on the nameplate is vital in order to start a settings procedure. After operational testing, replace all access panels or covers.**
**The only possible settings on the machine are to be done with the A.V.R.**

#### 3.2.1 - R250 settings (SHUNT system)

Initial potentiometer positions

- voltage setting potentiometer **P1** for the A.V.R.: full left

- remote voltage setting potentiometer: in the middle.

Operate the alternator at its rated speed: if the voltage does not rise it is necessary to re-magnatise the magnetic circuit.

- slowly adjust the voltage potentiometer of the A.V.R. **P1** until the output voltage reaches its rated value.

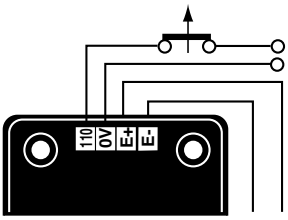
- Stability setting with **P2**.

#### 3.2.2 - Special type of use

**WARNING**

**Excitation circuit E+, E- must not be left open when the machine is running: A.V.R. damage will occur.**

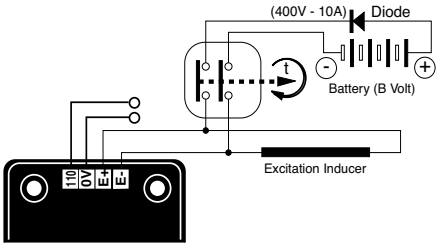
##### 3.2.2.1 - R250 field weakening (SHUNT)




The exciter is switched off by disconnecting the A.V.R. power supply (1 wire - 0 or 110V).
Contact rating: 16A - 250V AC

**Do not reclose the power supply until the voltage has reached a value ≤15% of the rated voltage (approximately 5 seconds after opening)**

##### 3.2.2.2 - R250 field forcing




**The battery must be isolated from the mass.**

**Exciter field may be at line potential.**

## 3.3 - Electrical faults

| Fault | Action | Effect | Check/cause |
|---|---|---|---|
| No voltage at no load on start-up | Connect a new battery of 4 to 12 volts to terminals E- and E+ respecting the polarity for 2 to 3 seconds | The alternator starts up and its voltage is still correct when the battery is removed. | - Lack of residual magnetism |
| | | The alternator starts up but its voltage does not reach the rated value when the battery is removed. | - Check the connection of the voltage reference to the A.V.R.<br>- Faulty diodes<br>- Induced short circuit |
| | | The alternator starts up but its voltage disappears when the battery is removed | - Faulty A.V.R.<br>- Exciter field short-circuited<br>- Short-circuit in the main field. Check the resistance |
| Voltage too low | Check the drive speed | Correct speed | Check the A.V.R. connections (A.V.R. may be faulty)<br>- Field windings short-circuited<br>- Rotating diodes burnt out<br>- Main field winding short-circuited<br>- Check the resistance |
| | | Speed too low | Increase the drive speed<br>(Do not touch the A.V.R. pot (P1) before returning to the correct speed.) |
| Voltage too high | Adjust A.V.R. potentiometer | Adjustment ineffective | - Faulty A.V.R.<br>- 1 faulty diode |
| Voltage oscillations | Adjust A.V.R. stability potentiometer | | - Check the speed: possibility of cyclic irregularity<br>- Loose terminals<br>- Faulty A.V.R.<br>- Speed too low on load (or U/F gradient set too high) |
| Voltage correct at no load and too low when on load (*) | Run at no load and check the voltage between E+ and E- on the A.V.R. | | - Check the speed (or U/F gradient set too high) |
| | | | - Faulty rotating diodes<br>- Short-circuit in the main field. Check the resistance<br>- Faulty induced excitaion |
| **(*) Warning:** For single-phase operation, check that the sensing wires coming from the A.V.R. are correctly connected to the operating terminals (see the alternator manual). | | | |
| Voltage disappears during operation | Check the A.V.R., the surge suppressor, the rotating diodes and replace any defective components | The voltage does not return to the rated value | - Exciter winding open circuit<br>- Faulty induced excitation<br>- Faulty A.V.R.<br>- Main field open circuit or short-circuited |

**Warning: after setting-up or trouble-shooting, replace all access panels or covers.**

## 4 - SPARE PARTS

### 4.1 - Designation

| Description | Type | Code |
|---|---|---|
| A.V.R. | R 250 | AEM 110 RE 019 |

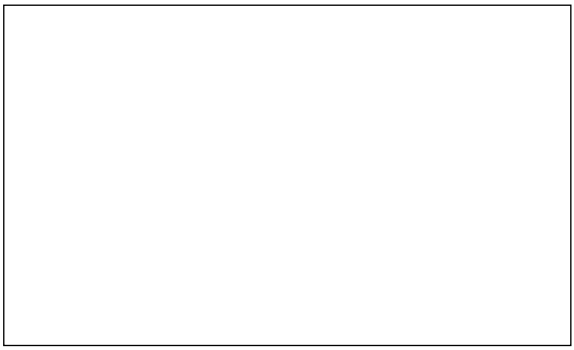
### 4.2 - Technical support service

Our technical support service will be pleased to help you with any information needed.

For replacement part orders, it is necessary to indicate the type and the code number of the A.V.R.

Please contact your usual correspondant.

An extensive network of service centres is available to rapidly supply any necessary parts.
In order to ensure the correct operation and safety of our machines, we strongly recommend that original manufacturer's spare parts are used.
Failure to do so, will discharge the manufacturer from liabilty in the case of damage.



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LEROY SOMER

4531 en - 2010.10 / c

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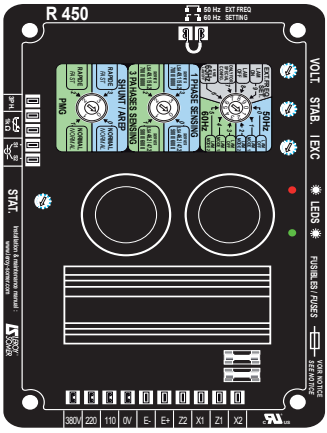



# R 450

## AVRs

## Installation and maintenance

239/276

# R 450
## AVRs

**This manual concerns the alternator AVR which you have just purchased.**

**We wish to draw your attention to the contents of this maintenance manual. By following certain important points during installation, use and servicing of your AVR, you can look forward to many years of trouble-free operation.**

### SAFETY MEASURES

Before using your machine for the first time, it is important to read the whole of this installation and maintenance manual.

All necessary operations and interventions on this machine must be performed by a qualified technician.

Our technical support service will be pleased to provide any additional information you may require.

The various interventions described in this manual are accompanied by recommendations or symbols to alert the user to potential risks of accidents. It is vital that you understand and take notice of the various warning symbols used.

**WARNING**

**Warning symbol for an operation capable of damaging or destroying the machine or surrounding equipment.**

**Warning symbol for general danger to personnel.**

**Warning symbol for electrical danger to personnel.**

Note: LEROY-SOMER reserves the right to modify the characteristics of its products at any time in order to incorporate the latest technological developments. The information contained in this document may therefore be changed without notice.

# R 450
## AVRs

**CONTENTS**



**All servicing or repair operations performed on the AVR should be undertaken by personnel trained in the commissioning, servicing and maintenance of electrical and mechanical components.**

# R 450
## AVRs

## 1 - GENERAL INFORMATION

### 1.1 - Description

The R450 AVR is supplied in a casing designed to be mounted on a panel with dampers.

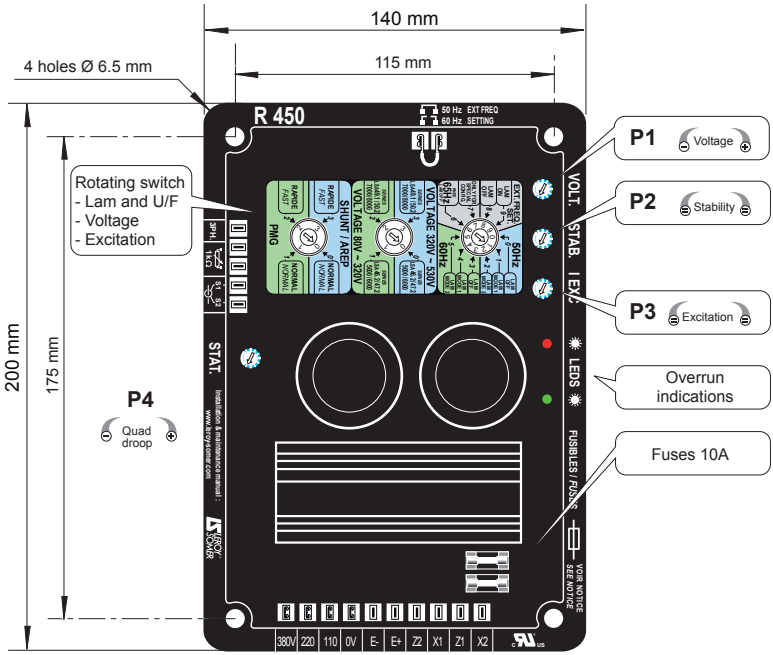
- Operating temperature: - 30°C to + 65° C.
- Storage temperature: - 55°C to + 85°C.
- Shocks on the base: 9 g depending on the 3 axes.
- Vibrations: less than 10 Hz, 2 mm half-peak amplitude 10 Hz to 100 Hz: 100 mm/s, above 100 Hz: 8 g.

**WARNING**

**The AVR is IP00, it must be incorporated in an environment which ensures it a IP20 protection.**

### 1.2 - Characteristic

The connection is realised by “Faston” connectors and the voltage sensing is single - phase.



## 2 - POWER SUPPLY

Both the SHUNT/AREP & PMG excitation systems are controlled by the AVR.

### 2.1 - AREP excitation system

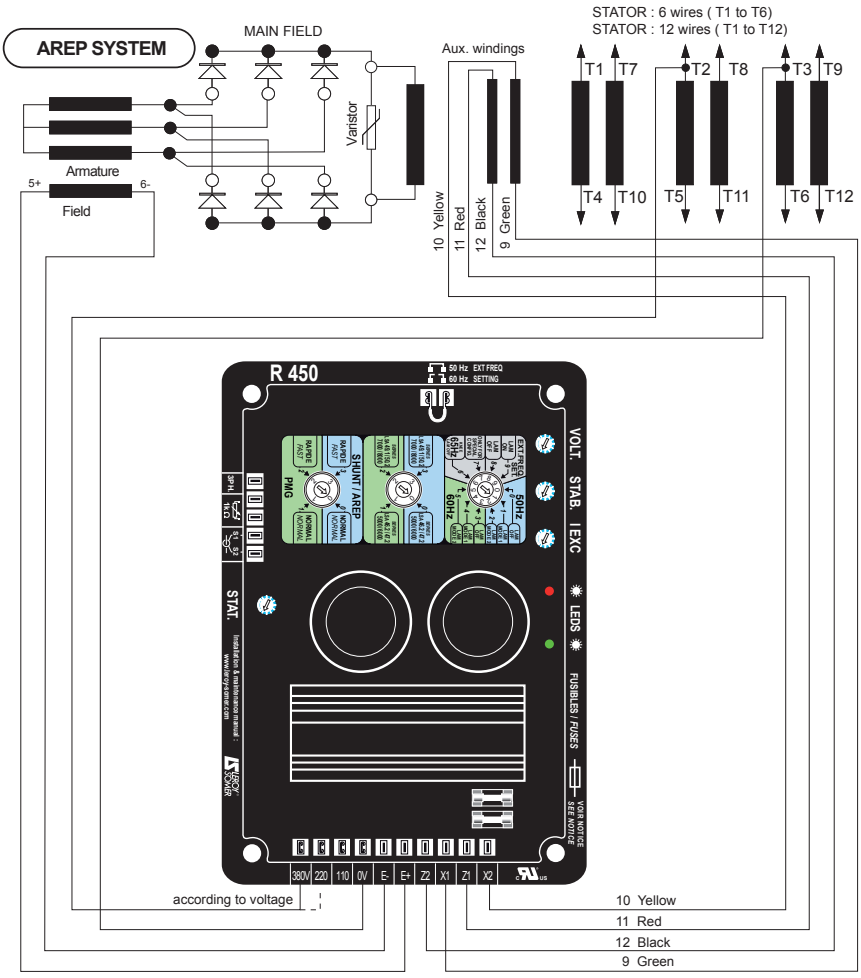
With **AREP** excitation, the electronic AVR is powered by two auxiliary windings which are independent of the voltage sensing circuit.

The first winding has a voltage proportional to the alternator main voltage (Shunt characteristic), the second one has a voltage proportional to the stator current (compound characteristic : Booster effect).

The power supply voltage is rectified and filtered before being used by the AVR monitoring transistor.

This system provides the machine with a short-circuit current capacity of 3 IN for 10 s.

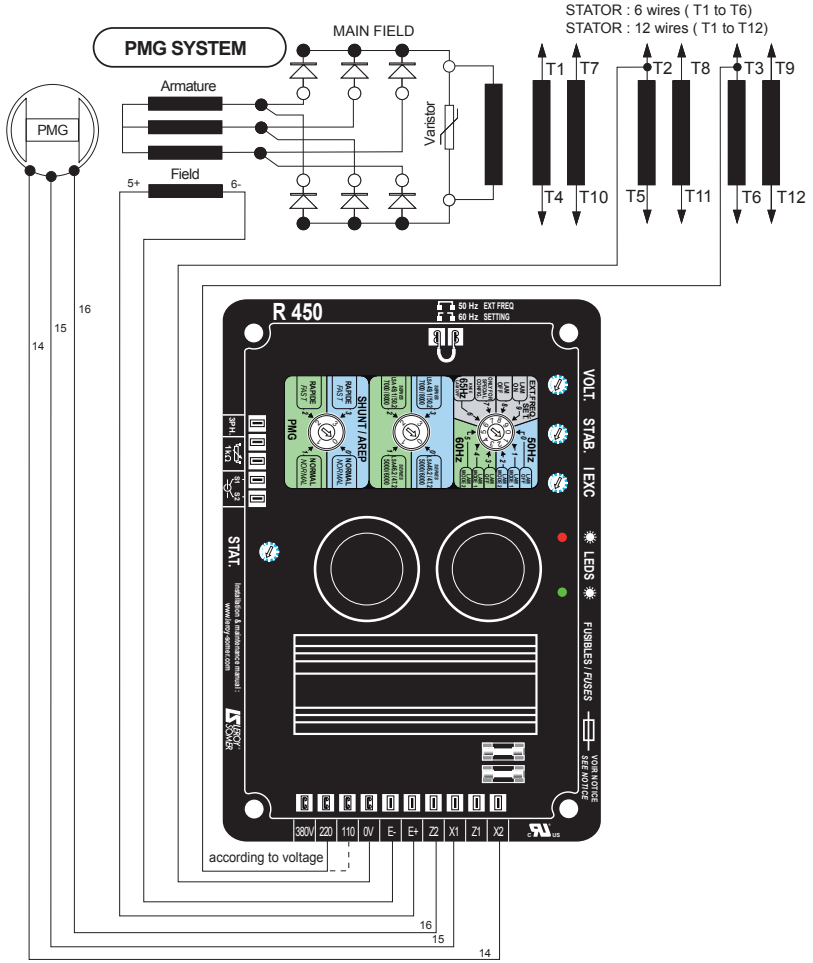
The rotating switch should be in the AREP position (see 3.2.3).



## 2.2 - PMG excitation system

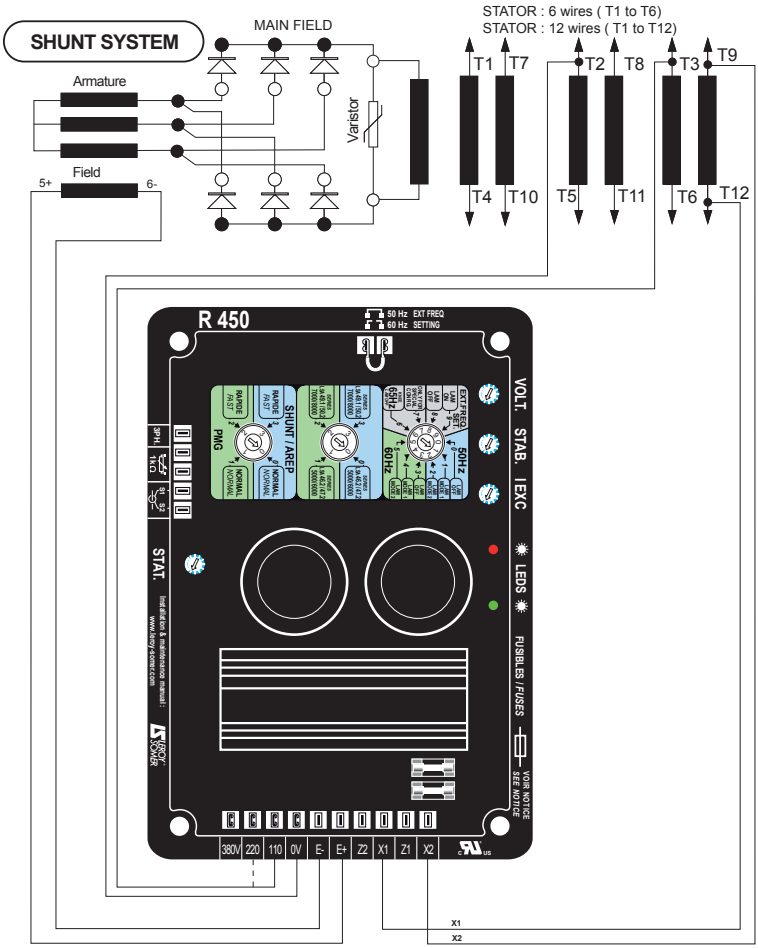
With **PMG** excitation, a permanent magnet generator (PMG) added to the alternator supplies the AVR with voltage which is independent of the main alternator winding. This system provides the machine with a short-circuit current capacity of 3 IN for 10 s.

The AVR monitors the alternator output voltage by adjusting the excitation current. The rotating switch should be in the PMG position (see 3.2.3).



## 2.3 - SHUNT or separate excitation system

With SHUNT excitation, the AVR is powered by the main winding (100V to 140V - 50/60 Hz ) by using X1, X2 on the AVR.
The rotating switch should be in the SHUNT/ AREP position (see 3.2.3).



## 3 - TECHNICAL CHARACTERISTICS

### 3.1 - Electrical characteristics

- maximum power supply: 150V - 50/60 Hz
- Rated overload current: 10 A - 10 s
- Electronic protection:

- In the case of a short-circuit, the excitation current is reduced to a value less than 1A after 10 s

- In the event of loss of voltage reference, the excitation current is reduced to a value less than 1A after 1s for AREP/SHUNT, 10 s for PMG.

- In the event of overexcitation, the current is reduced as indicated in the next diagram (see 3.2.1.4).

- Fuses: F1 on X1 and F2 on Z2 10A, 250V.
- Voltage sensing
  - 0-110 V terminals = 95 to 140 V
  - 0-220 V terminals = 170 to 260 V
  - 0-380 V terminals = 340 to 528 V

For other voltages, a transformer should be used.

- Voltage regulation:± 0.5%.
- Current sensing: (parallel operation): input S1, S2 intended for 1 C.T. < 2.5 VA cl1, secondary 1 A or 5 A.

### 3.2 - Configurations:

#### 3.2.1 - Settings

#### 3.2.1.1 - Voltage

Voltage adjustment via potentiometer **P1** in the ranges described in the table below:

| For 50 and 60 Hz | Max. |
|---|---|
| High range | 320V < Un ≤ 530 V |
| Low range | 80 V ≤ Un ≤ 320 V |

**WARNING**

**The allowed adjustment range is ±5%; when the setting exceeds these limits, please check that it is conform with the power table.**

#### 3.2.1.2 - Quadrature droop:

Quadrature droop adjustment via potentiometer **P4** within a range :

- from 0 to 8% with a PF=0.8 for 400V applications.
- From 0 to 14% with a PF=0.8 for 240V applications.
- From 0 to 8% for 110V applications with a step-up transformer (ratio of 4) placed on the voltage reference.

The potentiometer **P4** has a non linear response. Then, when a 1A secondary CT is connected the effective range starts from the the second 1/3 of **P4** range and in the case of a 5A secondary CT the effective range starts from the first 1/3.

When a 5A CT is used, the adjustment range is higher, so **P4** must be set to the first 1/4 (anti-clockwise) and then progressively increase it.

**WARNING**

**The CT must be connected.**

#### 3.2.1.3 - Stability:

Stability adjustment via potentiometer **P2.** Selection of rotating switch according to the machine type and the response time as indicated in paragraph 3.2.3.

#### 3.2.1.4 - Excitation limitation:

Excitation limitation adjustment via potentiometer **P3** as described below.

The excitation current limitation threshold in steady state is set by a potentiometer at 110% of the rated value. The adjustment is made by the operator during the on-load test at rated power by tuning the potentiometer.

When the excitation current exceeds this value, a counter is activated at the speed of one record per second for 90 s. When this time is elapsed, the current is reduced to the value of the rated excitation current. If in the meantime the excitation current drops below the threshold value, the counter counts down at the same speed.

**WARNING**

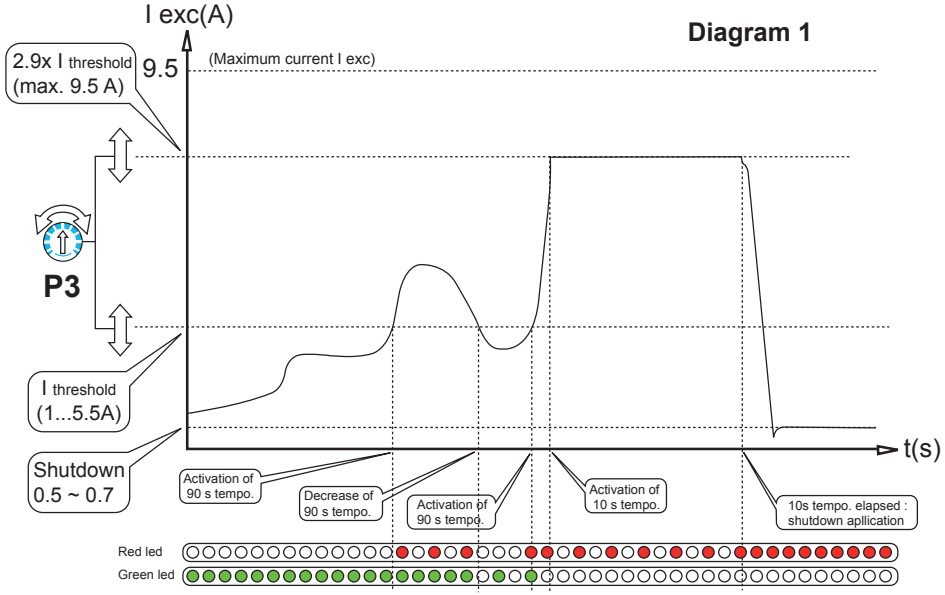
**The limitation threshold must be adjustable between 1 and 5.5 A. The genset breaker must be open during the short circuit. If the genset is restarted in short circuit, there is a excitation build up during 10s again at the maximum value.**

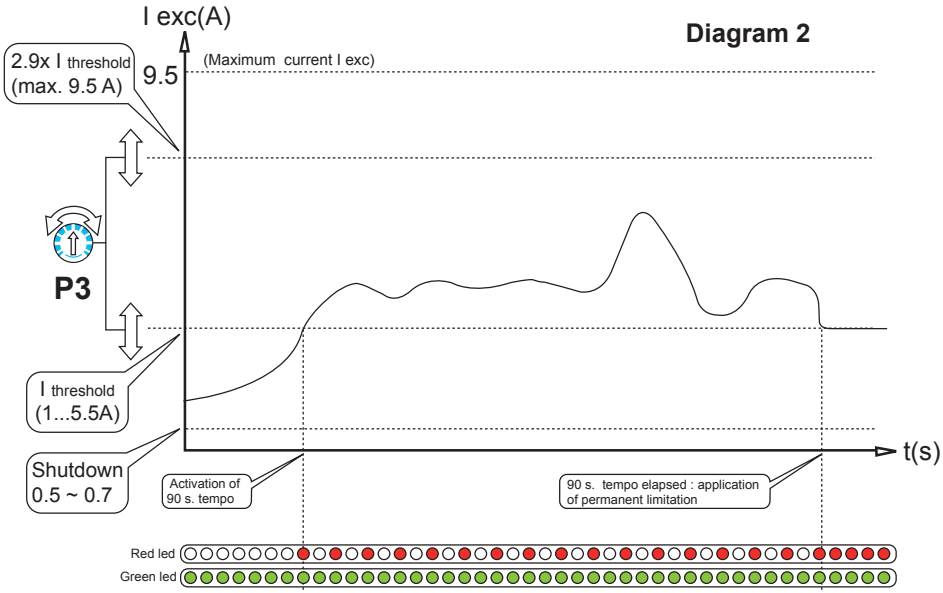
**Operation between 3 and 6 In when short-circuited:**
The excitation current ceiling during a short-circuit equals 2.9 times the fixed threshold when setting the permitted excitation ceiling in continuous operation. When the threshold is exceeded for a period = 10 s the current is reduced to a value between 0.5 and 0.7 A (shutdown).
In all operating conditions the maximum excitation current must be limited to 9 A ± 0.5 A.

**Overrun indications:**

**One green LED:**
- Lights up when the excitation current is below the continuous operation threshold
It signals the AVR normal operation.
- Turns off when the excitation current ceiling used to obtain short-circuit operation is reached and when the excitation current is reduced to the shutdown value.
- Flashes when the over excitation counter is decrementing.
NB: After an obvious short-circuit, the voltage is limited to 70% of the rated voltage. This avoids overvoltages on machines whose no-load excitation current is below the “lower current” threshold (only in AREP).

**Diagram 1**






**One red LED:**
- Lights up simultaneously with the green led when the continuous operation threshold is reached for more than 90 s and the excitation current is reduced to the continuous operation threshold. It is used to set the excitation current ceiling
- Turns off when the excitation current is less than the setting value (< 110% In)
- Flashes when the excitation current is above the continuous operation threshold during less than 90 s.

**Green LED** stays on,
- flashes when the excitation current has reached the ceiling in < 10s with PMG excitation.
- ftays on if Iexc = I Shutdown.

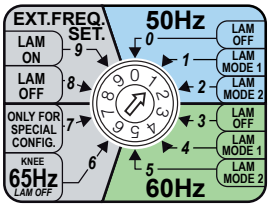
**WARNING**

**If the overload protection is activated, a voltage drop possibly exceeding 10% of the reference voltage will be observed.**

**The AVR does not provide undervoltage protection. The customer will need to make sure that their installation is correctly protected against under-voltages.**

**During load shedding, an overvoltage is observed, which will disappear in a few seconds.**

### 3.2.2 - Rotating switch selection: LAM and U/F

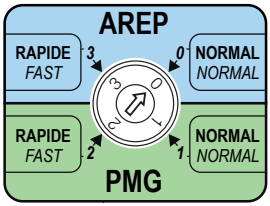



**- Pos 0:** Change in the voltage according to the U/F ratio, knee-point position at 48 Hz.
**- Pos 1:** Change in the voltage according to the 2U/F, knee-point position at 48 Hz.
**- Pos 2:** Change in the voltage according to the self auto-adaptating LAM combined with 2U/F, knee-point position at 48 Hz.
**- Pos 3:** Change in the voltage according to the U/F ratio, knee-point position at 58 Hz
**- Pos 4:** Change in the voltage according to the 2U/F, knee-point position at 58 Hz.
**- Pos 5:** Change in the voltage according to the self auto-adaptating LAM combined with 2U/F, knee-point position at 58 Hz.
**- Pos 6:** Change in the voltage according to the U/F ratio, knee-point position at 65 Hz (Tractelec application and variable speed above 1800 rpm).
**- Pos 7:** Special (not used).
**- Pos 8:** Change in the voltage according to the U/F ratio, knee-point position at 48 Hz or 58 Hz according to selection of the frequency by an external contact.
**- Pos 9:** Change in the voltage according to LAM 1, knee-point position at 48 Hz or 58 Hz according to selection of the frequency by an external contact

**WARNING**

**For Pavers and hydraulic applications, select positions 0 (50 Hz) or 3 (60 Hz).**

### 3.2.3 Rotating switch: excitation type and time response




0: AREP excitation and normal time response.

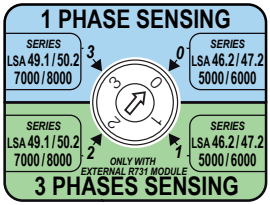
3: AREP excitation and fast time response.

1: PMG excitation and normal time response.

2: PMG excitation and fast time response.

**For SHUNT applications, AREP excitation must be selected.**

### 3.2.4 Rotating switch: voltage sensing




0: Single phase sensing
- LSA46.2/47.2 series.

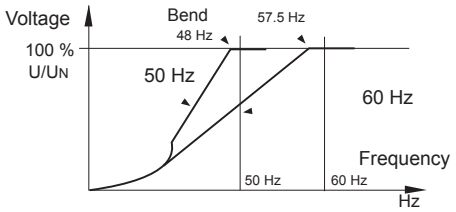
3: Single phase sensing
- LSA49.1/50.2 series.

1: Three-phase sensing with optional module R731
- LSA46.2/47.2 series.

2: Three-phase sensing with optional module R731
- LSA49.1/50.2 series.

## 3.3 - U/F and LAM function

### 3.3.1 - Frequency variation compared with voltage (without LAM)




### 3.3.2 - LAM (Load Acceptance Module) characteristics

#### 3.3.2.1 - Voltage drop

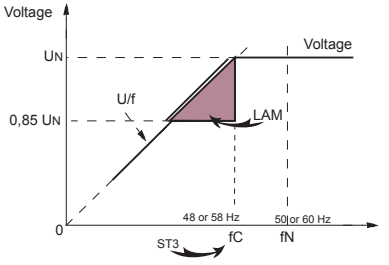
The LAM system is integrated in the AVR. As standard it is active.

Role of the LAM:

On application of a load, the genset rotation speed decreases. When it falls below the preset frequency threshold, the LAM causes the voltage to drop proportionately to the frequency (LAM1) or to the active power (LAM2) depending the the rotating switch position. This reduces the active load scale applied until the speed returns to its rated value.

Hence the LAM can be used either to reduce the speed variation (frequency) and its duration for a given applied load, or to increase the applied load possible for one speed variation (turbo-charged engine).

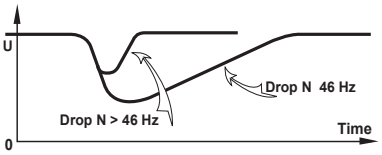
To avoid voltage oscillations, the trip threshold for the LAM function should be set approximately 2 Hz below the rated frequency.




#### 3.3.2.2 - Soft voltage recovery function

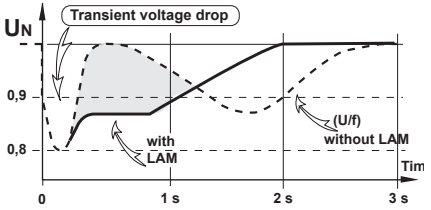
During load impacts, the function helps the genset to return to its rated speed faster with a gradual increase in voltage according to the principle:

- If the speed drops between 46 and 50 Hz (in 50Hz operation), the rated voltage is recovered by following a fast gradient.
- If the speed drops below 46 Hz, since the engine needs more help, the voltage follows a slow gradient as it returns to the reference value.

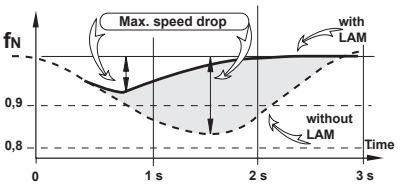



## 3.4 - Typical effects of the LAM with a diesel engine with or without a LAM (U/F only)

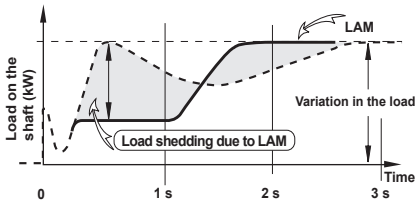
### 3.4.1 - Voltage




### 3.4.2 - Frequency



### 3.4.3 - Power




## 3.5 - AVR options

**- Current transformer** for parallel operation of...../1 A or 5 A according to the potentiometer P4 position.

**- Voltage transformer** (adaptation)

**- Remote voltage adjustment potentiometer:** 1 k Ω, 0.5 W min: adjustment range ± 5% (range limited by internal voltage potentiometer P1). (A 470 Ω potentiometer can also be used to extend the adjustment range).

**The potentiometer input must be isolated. Do not connect it to the ground.**

**- R 731 module** : 3-phase voltage sensing 200 to 500 V, compatible with parallel operation in balanced installations.

**- R 734 module** : 3-phase current and voltage sensing for parallel operation on unbalanced installations (unbalance > 15%).

**- R 726 module**: regulation system changed to “4 - function” (see the maintenance manual and connection diagram).

- PF regulation (2F) .
- Equalization of voltages before paralleling (3 F).
- Possibility of coupling to the mains of alternators already running in parallel (4F).

**- R729 module**: same as R726 with additional functions.

- Detection of a diode fault.
- 4-20 mA input.
- Possibility of kVAR regulation.

**- Voltage control:** with an **isolated** D.C. current source applied to the terminals used for the external potentiometer:

- Internal impedance 1.5 kΩ.
- A variation of ± 0.5 V corresponds to a voltage adjustment of ± 10%.

## 4-INSTALLATION-COMMISSIONING

### 4.1 - Electrical checks on the AVR

- Check that all connections have been made properly as shown in the attached wiring diagram.
- Check the rotating switches selections
  - frequency,
  - type of alternator,
  - normal position (response time),
  - external potentiometer,
  - rated voltage,
  - secondary current of the CT used,
  - type of excitation.
- R450 optional operating modes

### 4.2 - Setting up

**The various adjustments during tests must be made by a qualified engineer. It is essential that the drive speed specified on the nameplate is reached before commencing adjustment. After operational testing, replace all access panels or covers.**

**The AVR is used to make any adjustments to the machine.**

#### 4.2.1 - Setting up the R450

**Before using the AVR, make sure that the rotating switches have been correctly configured with AREP/SHUNT or PMG excitation**

**a)** Initial potentiometer settings (see table below)

| Action | Factory setting | Pot. |
|---|---|---|
| Voltage minimum fully anti-clockwise | 400 V - 50 Hz |   |
| Stability | Not set (centre position) |   |
| Excitation ceiling - Factory-sealed | 10 A maximum |   |
| Voltage quadrature droop (// operation with C.T.) - 0 quadrature droop fully anti-clockwise | Not set (fully anti-clockwise) |   |

**Stability adjustments in standalone operation**

**b)** Install a D.C. analogue voltmeter (needle dial) cal. 100 V on terminals F+, F- and an A.C. voltmeter cal. 300 - 500 or 1000 V on the alternator output terminals.

**c)** Check the rotating switch selection.

**d)** Voltage potentiometer P1 at minimum, fully anti-clockwise.

**e**) Stability potentiometer P2 around 1/3 in from the anti-clockwise stop.

**f**) Start the engine and set its speed to a frequency of 48 Hz for 50 Hz, or 58 for 60 Hz.

**g**) Set the output voltage to the desired value using P1.
- Rated voltage $U_N$ for solo operation (eg. 400 V)
- Or $U_N$ + 2 to 4% for parallel operation with C.T. (eg. 410 V -)

If the voltage oscillates, use P2 to make adjustments (try both directions), observing the voltage between F+ and F- (approx. 10 V D.C.). The best response time is obtained at the limit of the instability. If no stable position can be obtained, try selecting the fast position.

**h**) Check LAM operation: depending on the rotating switch selection.

**i**) Vary the frequency (speed) around 48 or 58 Hz according to the operating frequency, and check the change in voltage from that observed previously (~ 15%).

**j**) Readjust the speed of the genset to its rated no-load value.

Adjustments in parallel operation
Before starting work on the alternator, make sure that the speed droop is identical for all engines.

**k**) Preset for parallel operation (with C.T. connected to S1, S2)
- Potentiometer **P4** (quadrature droop) in 1/4 position in the case of 5A CT and at 1/2 position in the case of 1A CT.
Apply the rated load (PF = 0.8 inductive).
The voltage should drop by 2 to 3% (400 V).
If it increases, check that neither V and W nor S1 and S2 have been reversed.

**l**) The no-load voltages should be identical for all the alternators intended to run in parallel.
- Couple the machines in parallel.
- By adjusting the speed, try to obtain 0 kW power exchange.
- By altering the voltage setting P1 on one of the machines, try to cancel (or minimise) the current circulating between the machines.
- From now on, do not touch the voltage settings.

**m**) Apply the available load (the setting is only correct if a reactive load is available)
- By altering the speed, match the kW (or divide the rated power of the units proportionally)
- By altering the quadrature droop potentiometer **P4**, match or divide the currents.

### 4.2.2 - Max. excitation adjustment (excitation ceiling)

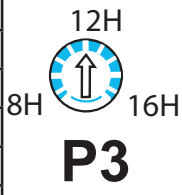
In standard setting, the potentiometer P3 is in maximum position.

However, for applications requiring an overload protection (see 3.2.1.4), the excitation ceiling must be adjusted by using the following procedures in AREP and PMG.

**Method 1 :**
-Connect the AVR to the alternator
-apply load to 110% of rated machine rated at PF=0.8, the green led is on and the red one is off.
-record the excitation current value
-adjust P3 until obtaining the red led flashing, the green one is always on.
-decrease the load to 100% and make sure that the red led is off.
- Increase the load at 115%, check that the red LED flashes during 90 seconds and that the excitation current is brought back to the above adjusted value ($I_{ex\ adjusted}$).

**Method 2 :**
The rated excitation current (see machine plate) must be multiplied by 1.1 and the obtained value is used to set the potentiometer P3 at the right position.
The following table must be used.

| Position of P3 | I exc (A) |
|---|---|
| 8h | 1 |
| 9h | 1.55 |
| 10h | 1.95 |
| 11h | 2.5 |
| 12h | 3.15 |
| 13h | 3.65 |
| 14h | 4.25 |
| 15h | 4.7 |
| 16h | 5.15 |




NB: In the case of a permanent short-circuit, the excitation current must reach 2.9 x $I_{ex}$ adjusted (limited to 9.5A), during 1 second in AREP or 10 seconds in PMG and shuts down to a value less than 1A.

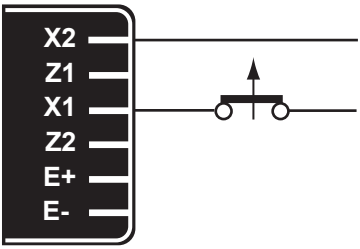
**When the excitation current is set to the rated value, a voltage dip is observed in excitation current limit when the limitation is activated and the current limit is reached**.

#### 4.2.3 - Special type of use

**WARNING**

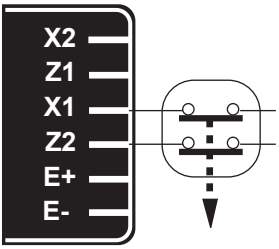
**The excitation circuit F+, F- must not be left open when the machine is running: this will irreparably damage the AVR.**

#### 4.2.3.1 - R450 (SHUNT) field weakening




The exciter is switched off by disconnecting the AVR power supply (1 wire - X1 or X2)
Contact rating: 16 A - 250 V A.C.

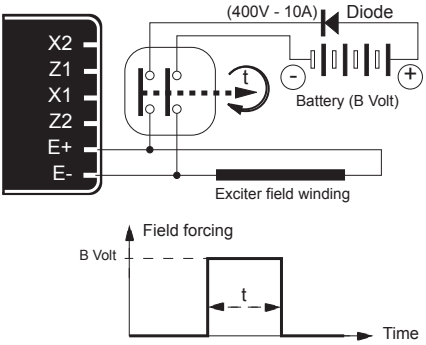
#### 4.2.3.2 - R450 (AREP/PMG) field weakening




The exciter is switched off by disconnecting the AVR power supply (1 wire on each auxiliary winding) - contact rating 16 A - 250 V A.C.
Connection is identical for resetting the AVR internal protection.

**If field weakening is used, provide field forcing.**

#### 4.2.3.3 - R450 field forcing




| Applications | B Volt | Time t |
|---|---|---|
| Guaranteed voltage build-up | 12 (1A) | 1 - 2 s |
| Parallel operation, de-energized | 12 (1A) | 1 - 2 s |
| Parallel operation, at standstill | 12 (1A) | 5 - 10 s |
| Frequency starting | 12 (1A) | 5 - 10 s |
| Sustained voltage on overload | 12 (1A) | 5 - 10 s |

## 4.3 - Electrical faults

| Fault | Action | Measurements | Check/Cause |
|---|---|---|---|
| No voltage at no load on start-up | Connect a new battery of 4 to 12 V to terminals F- and F+, respecting the polarity, for 2 to 3 seconds | The alternator builds up and its voltage is still correct when the battery is removed | - Lack of residual magnetism |
| | | The alternator builds up but its voltage does not reach the rated value when the battery is removed | - Check the connection of the voltage reference to the AVR<br>- Faulty diodes<br>- Armature short-circuit |
| | | The alternator builds up but its voltage disappears when the battery is removed | - Faulty AVR<br>- Field windings disconnected<br>- Revolving field coil open circuit. Check the resistance |
| Voltage too low | Check the drive speed | Correct speed | - Check the AVR connections and settings (AVR faulty)<br>- Field windings short-circuited<br>- Rotating diodes burnt out<br>- Revolving field coil short-circuited<br>- Check the resistance |
| | | Speed too low | Increase the drive speed<br>(Do not touch the AVR voltage pot. (P1) before running at the correct speed) |
| Voltage too high | Adjust AVR voltage potentiometer | Adjustment ineffective | - Faulty AVR<br>- 1 faulty diode |
| Voltage oscillations | Adjust AVR stability potentiometer | If no effect: try normal/fast recovery modes | - Check the speed: possibility of cyclic irregularity<br>- Loose connections<br>- Faulty AVR<br>- Speed too low when on load (or U/F knee-point set too high) |
| Voltage correct at no load and too low when on load (*) | Run at no load and check the voltage between F+ and F- on the AVR | Voltage between F+ and F- AREP/PMG < 10 V | - Check the speed<br>(or U/F knee-point set too high) |
| | | Voltage between F+ and F- AREP/PMG > 15 V | - Faulty rotating diodes<br>- Short-circuit in the revolving field coil. Check the resistance<br>- Faulty exciter armature |
| **(*) Caution:** For single-phase operation, check that the sensing wires coming from the AVR are correctly connected to the operating terminals. | | | |
| Voltage disappears during operation (**) | Check the AVR, the surge suppressor, the rotating diodes, and replace any defective components | The voltage does not return to the rated value | - Exciter winding open circuit<br>- Faulty exciter armature<br>- Faulty AVR<br>- Revolving field coil open circuit or short-circuited<br>- Overload (see LED) |
| **(**) Caution:** Internal protection may be activated (overload, open circuit, short-circuit) | | | |

**Caution: After operational testing or troubleshooting, replace all access panels or covers.**

## 5 - SPARE PARTS

### 5.1 - Designation

| Description | Type | Code |
|---|---|---|
| Voltage regulator (AVR) | R 450 | AEM 110 RE 031 |

### 5.2 - Technical support service

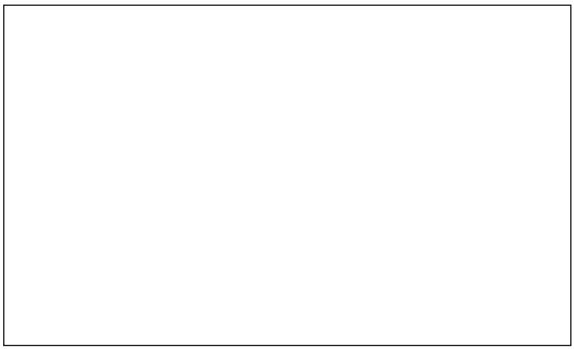
Our technical support service will be pleased to provide any additional information you may require.

When ordering spare parts, you should indicate the AVR type and code number.

Address your enquiry to your usual contact.

Our extensive network of service centres can dispatch the necessary parts without delay.
To ensure correct operation and the safety of our machines, we recommend the use of original manufacturer spare parts.
In the event of failure to comply with this advice, the manufacturer cannot be held responsible for any damage.

LEROY SOMER®



www.leroy-somer.com

## 9.3. Appendix C - Common spare parts

GenPARTS

# R350C2
# *Rental Power*

## VOLVO
## TAD941GE

**ENGINE**

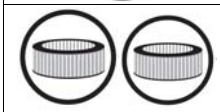
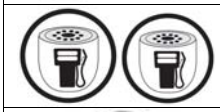
| | | |
|---|---|---|
| Radiator filler cap | 330051142 | X 1 |
| Radiator pressure cap | 330052078 | X 1 |
| Thermostat | 330051467 | X 1 |
| Thermostat seal | 330051539 | X 1 |
| Fan belt | 330051419 | X 1 |
| Rocker cover seal | 330051468 | X 1 |
| Water temperature sensor | 330051466 | X 1 |
| Oil pressure sensor | 330051465 | X 1 |
| Alternator belt | 330051418 | X 1 |

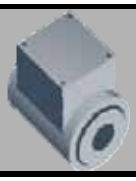
**GENLUB**

| | | |
|---|---|---|
| x 25 L | 330910094 | X 1 |
| x 208 L | 330910095 | |

**GENCOOL**

| | | |
|---|---|---|
| x 20 L | 330910098 | X 1 |
| x 60 L | 330910099 | |
| x 210 L | 330910100 | |

| | | |
|---|---|---|
|  | 330560243 | x 1 |
|  | 330570109 + 330570110 | X 1 |
|  | 330510015 + 330560617 | x 1 |
|  | 330560551 | x 2 |
|   | 330560634 | x 1 |



# LEROY-SOMER LSA462VL12

ALTERNATOR

| | | |
|---|---|---|
| Diode bridge | 330410126 | x 1 |
| Varistor | 330410109 | X 1 |

| | |
|---|---|
| Note | For all technical assistance or spare part requests, contact your nearest SDMO agent. |

## 9.4. Appendix D - List of John Deere - Volvo and Perkins fault codes.

| SPN | CID | SID | PID | PPID | FMI | John Deere | Volvo | Perkins | Description | Comment |
|---|---|---|---|---|---|---|---|---|---|---|
| **28** | | | | | | | | | **Throttle #3 Position** | |
| | | | | | 3 | ■ | | | Throttle Voltage high, short to V+ | Short to V+ |
| | | | | | 4 | ■ | | | Throttle Voltage low, short to V- | Short to V- |
| **29** | | | | | | | | | **Throttle #2 Position** | |
| | | | | | 3 | ■ | | | Throttle Voltage high, short to V+ | Short to V+ |
| | | | | | 4 | ■ | | | Throttle Voltage low, short to V- | Short to V- |
| | | | | | 14 | ■ | | | Throttle voltage out of range | |
| **84** | | | | | | | | | **Vehicle speed** | |
| | | | | | 2 | ■ | | | Vehicle invalid or missing | Not possible with Genset application |
| | | | | | 31 | ■ | | | Vehicle speed mismatch | |
| **91** | **91** | | **91** | **132** | | | ■ | | **Accelerator pedal position** | **FMI not determined for all VOLVO's** |
| | | | | | 3 | ■ | | | Throttle Voltage high, short to V+ | Not possible with genset application, codes declared by the CAN J1587 for VOLVO. |
| | | | | | 4 | ■ | | | Throttle Voltage low, short to V- | |
| | | | | | 7 | ■ | | | Throttle calibration invalid | |
| | | | | | 8 | ■ | | ■ | PWM throttle abnormal pulse width | |
| | | | | | 9 | ■ | | | Throttle invalid (CAN value) | |
| | | | | | 10 | ■ | | | Throttle voltage out of range low | |
| | | | | | 13 | ■ | | | Throttle calibration aborted | |
| | | | | | 14 | ■ | | | Throttle voltage out of range | |
| **94** | | | **94** | | | | ■ | | **Fuel rail pressure sensor** | |
| | | | | | 1 | ■ | ■ | | Fuel supply pressure extremely low | |
| | | | | | 3 | ■ | ■ | | Fuel rail pressure input voltage high | Short to V+ |
| | | | | | 4 | ■ | | | Fuel rail pressure input voltage low | Short to V- |
| | | | | | 5 | | ■ | | Fuel rail pressure sensor open circuit | |
| | | | | | 10 | ■ | | | Fuel rail pressure lost detected | |
| | | | | | 13 | ■ | | | Fuel rail pressure higher than expected | |
| | | | | | 16 | ■ | | | Fuel supply pressure moderately high | |
| | | | | | 17 | ■ | | | Fuel rail pressure not developed | |
| | | | | | 18 | ■ | | | Fuel supply pressure moderately low | |
| **97** | | | **97** | | | | ■ | | **Water in fuel sensor** | |
| | | | | | 0 | ■ | ■ | | Water in fuel continuously detected | |
| | | | | | 3 | ■ | ■ | | Water in fuel input voltage high | Short to V+ |
| | | | | | 4 | ■ | | | Water in fuel input voltage low | Short to V- |
| | | | | | 16 | ■ | | | Water in fuel detected | |
| | | | | | 31 | ■ | | | Water in fuel detected | |
| **98** | | | **98** | | | | ■ | | **Oil level sensor** | |
| | | | | | 1 | | ■ | | Oil level value below normal | |
| | | | | | 3 | | ■ | | Oil level sensor input voltage high | Short to V+ |
| | | | | | 4 | | ■ | | Oil level sensor input voltage low | Short to V- |
| | | | | | 5 | | ■ | | Oil level sensor open circuit | |

| SPN | CID | SID | PID | PPID | FMI | John Deere | Volvo | Perkins | Description | Comment |
|---|---|---|---|---|---|---|---|---|---|---|
| **100** | **100** | | **100** | | | | ■ | | **Oil pressure sensor** | |
| | | | | | 1 | ■ | ■ | | Engine oil pressure extremely low | |
| | | | | | 3 | ■ | ■ | ■ | Oil pressure sensor input voltage high | Short to V+ |
| | | | | | 4 | ■ | | ■ | Oil pressure sensor input voltage low | Short to V- |
| | | | | | 5 | | ■ | | Oil pressure sensor open circuit | |
| | | | | | 17 | | | ■ | Engine oil pressure low | |
| | | | | | 18 | ■ | | ■ | Engine oil pressure moderately low | |
| | | | | | 31 | ■ | | | Oil pressure detected, motor stopped | |
| **102** | **273** | | **102** | | | | ■ | | **Manifold air pressure sensor** | |
| | | | | | 0 | | ■ | | Manifold air pressure above normal | |
| | | | | | 1 | | ■ | | Manifold air pressure below normal | |
| | | | | | 2 | ■ | | | Incoherent measurement of the oil pressure | |
| | | | | | 3 | ■ | ■ | ■ | Manifold air pressure sensor input voltage high | Short to V+ |
| | | | | | 4 | ■ | ■ | ■ | Manifold air pressure sensor input voltage low | Short to V- |
| | | | | | 15 | | | ■ | Manifold air pressure moderately low | |
| | | | | | 16 | | | ■ | Manifold air pressure low | |
| **103** | | | | | | | | | **Turbo speed sensor** | |
| | | | | | 0 | ■ | | | Turbo speed too high | |
| | | | | | 5 | ■ | | | Turbo speed sensor circuit open | |
| | | | | | 6 | ■ | | | Sensor shorted to earth | Short to V- |
| | | | | | 8 | ■ | | | Speed signal invalid | |
| | | | | | 31 | ■ | | | Intermittent problem with speed information | |
| **105** | | | **105** | | | | ■ | | **Manifold air temperature sensor** | |
| | | | | | 0 | ■ | ■ | | Manifold air temperature extremely high | |
| | | | | | 3 | ■ | | | Manifold air temperature sensor input voltage high | |
| | | | | | 4 | ■ | ■ | | Manifold air temperature sensor input voltage low | |
| | | | | | 5 | | ■ | | Manifold air temperature sensor open circuit | |
| | | | | | 15 | ■ | | | Air temperature very high. | |
| | | | | | 16 | ■ | | | Manifold air temperature moderately high | |
| **106** | | | **106** | | | | ■ | | **Air inlet pressure sensor** | |
| | | | | | 0 | | ■ | | Air inlet pressure above normal | |
| | | | | | 3 | | ■ | | Air inlet pressure sensor input voltage high | |
| | | | | | 5 | | ■ | | Air inlet pressure sensor open circuit | |

| SPN | CID | SID | PID | PPID | FMI | John Deere | Volvo | Perkins | Description | Comment |
|---|---|---|---|---|---|---|---|---|---|---|
| **107** | | | **107** | | | | ■ | | **Air filter differential pressure sensor** | |
| | | | | | 0 | ■ | ■ | | Air filter restriction high | |
| | | | | | 3 | | ■ | | Air filter differential pressure sensor input voltage high | |
| | | | | | 4 | | ■ | | Air filter differential pressure sensor input voltage low | |
| | | | | | 5 | | ■ | | Air filter differential pressure sensor open circuit | |
| | | | | | 31 | ■ | | | Air filter restriction high | |
| **108** | **274** | | **108** | | | | ■ | | **Barometric pressure sensor** | **Not use with EDC III and EMS2** |
| | | | | | 2 | ■ | | | Air pressure invalid | |
| | | | | | 3 | | | ■ | High barometric pressure sensor short to high | |
| | | | | | 4 | | | ■ | High barometric pressure sensor short to low | |
| | | | | | 17 | | | ■ | High barometric pressure | ECM option, sensor not connected |
| **110** | **110** | | **110** | | | | ■ | | **Coolant temperature sensor** | |
| | | | | | 0 | ■ | ■ | ■ | Coolant temperature extremely high | |
| | | | | | 3 | ■ | ■ | ■ | Coolant temperature sensor input voltage high | |
| | | | | | 4 | ■ | ■ | ■ | Coolant temperature sensor input voltage low | |
| | | | | | 5 | | ■ | | Coolant temperature sensor open circuit | |
| | | | | | 15 | ■ | | ■ | Coolant temperature high least severe | |
| | | | | | 16 | ■ | | ■ | Coolant temperature moderately high | |
| | | | | | 17 | ■ | | | Water temperature very low | |
| | | | | | 31 | ■ | | | Coolant temperature high | |
| **111** | | | **111** | | | | | | **Coolant level sensor** | |
| | | | | | 0 | | ■ | | Engine coolant level low | |
| | | | | | 1 | ■ | | | Engine coolant level low | |
| | | | | | 3 | ■ | ■ | | Coolant level sensor input voltage high | |
| | | | | | 4 | ■ | | | Coolant level sensor input voltage low | |
| **153** | | | **153** | | | | | | **Crankcase pressure sensor** | |
| | | | | | 0 | | ■ | | Value above normal | |
| | | | | | 3 | | ■ | | Crankcase pressure sensor input voltage high | |
| | | | | | 5 | | ■ | | Crankcase pressure sensor open circuit | |
| **157** | | | | | | | | | **Fuel pressure sensor in the common rail** | |
| | | | | | 1 | ■ | | | Fuel pressure too low | |
| | | | | | 3 | ■ | | | Input voltage of the pressure sensor high | Short to V+ |
| | | | | | 4 | ■ | | | Input voltage of the pressure sensor low | Short to V- |
| | | | | | 10 | ■ | | | Loss of fuel pressure detected | |
| | | | | | 16 | ■ | | | Fuel pressure moderately high | |
| | | | | | 17 | ■ | | | Fuel ramp pressure not reached | |
| | | | | | 18 | ■ | | | Oil pressure moderately low | |

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|---|---|---|---|---|---|---|---|---|---|---|
| **158** | | | **158** | | | | | | **Battery voltage sensor** | |
| | | | | | 1 | | ■ | | Voltage above normal | |
| | | | | | 17 | ■ | | | ECU power down error | |
| **160** | | | | | | | | | **Wheel speed sensor** | |
| | | | | | 2 | ■ | | | Wheel speed input noise | |
| **164** | | **164** | | | | | | | **Injection pressure control** | |
| **168** | **168** | | | | | | | | **Electrical system voltage** | |
| | | | | | 2 | | | ■ | Electrical system voltage low | |
| **172** | **172** | | **172** | | | | | | **Ambient air temperature sensor** | **Inlet air temperature sensor for PERKINS** |
| | | | | | 3 | | | ■ | Ambient air temperature sensor input voltage high | Inlet air temperature sensor input voltage high |
| | | | | | 4 | | ■ | ■ | Ambient air temperature sensor input voltage low | Inlet air temperature sensor input voltage low |
| | | | | | 5 | | ■ | | Ambient air temperature sensor open circuit | |
| | | | | | 15 | | | ■ | | High Inlet air temperature alarm-warning |
| | | | | | 16 | | | ■ | | High Inlet air temperature alarm-action alert |
| **174** | **174** | | | | | | | | **Fuel temperature sensor** | |
| | | | | | 0 | ■ | | | Fuel temperature high most severe | |
| | | | | | 3 | ■ | | ■ | Fuel temperature sensor input voltage high | |
| | | | | | 4 | ■ | | ■ | Fuel temperature sensor input voltage low | |
| | | | | | 15 | ■ | | ■ | Fuel temperature high | |
| | | | | | 16 | ■ | | ■ | Fuel temperature moderately high | |
| | | | | | 31 | ■ | | | Fuel temperature sensor faulty | |
| **175** | | | **175** | | | | | | **Oil temperature sensor** | |
| | | | | | 0 | | ■ | | Oil temperature extremely high | |
| | | | | | 3 | | ■ | | Oil temperature sensor input voltage high | |
| | | | | | 4 | | ■ | | Oil temperature sensor input voltage low | |
| | | | | | 5 | | ■ | | Oil temperature sensor open circuit | |
| **177** | | | | | | | | | **Transmission oil temperature sensor** | |
| | | | | | 9 | ■ | | | Transmission oil temperature invalid | Not possible with Genset application |
| **189** | | | | | | | | | **Rated engine speed** | |
| | | | | | 0 | ■ | | | Engine speed de rated | |
| | | | | | 31 | ■ | | | Engine speed de rated | |
| **190** | **190** | | **190** | | | | ■ | | **Engine speed sensor** | |
| | | | | | 0 | ■ | | ■ | Overspeed extreme | |
| | | | | | 2 | | | ■ | Engine speed sensor data intermittent | |
| | | | | | 9 | | | ■ | Engine speed sensor abnormal update | |
| | | | | | 11 | | | ■ | Engine speed sensor signal lost | |
| | | | | | 12 | | | ■ | Engine speed sensor signal lost | |
| | | | | | 15 | | | ■ | Overspeed | |
| | | | | | 16 | ■ | | ■ | Overspeed moderate | |

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|---|---|---|---|---|---|---|---|---|---|---|
| **228** | **261** | | | | | | | | **Speed sensor calibration** | |
| | | | | | 13 | | | ■ | Engine timing abnormal calibration | |
| **252** | **252** | | | | | | | | **Software** | |
| | | | | | 11 | | | ■ | Incorrect engine software | |
| **234** | **253** | | | | | | | | **Check system parameters** | |
| | | | | | 2 | | | ■ | Incorrect parameters | |
| **281** | **281** | | | | | | | | **Action alert output status** | |
| | | | | | 3 | | | ■ | Action alert output open/short to B+ | |
| | | | | | 4 | | | ■ | Action alert output short to ground | |
| | | | | | 5 | | | ■ | Action alert output open circuit | |
| **282** | **282** | | | | | | | | **Overspeed output status** | |
| | | | | | 3 | | | ■ | Overspeed output open/short to B+ | |
| | | | | | 4 | | | ■ | Overspeed output short to ground | |
| **285** | **285** | | | | | | | | **Coolant temperature output status** | |
| | | | | | 3 | | | ■ | Coolant temperature lamp open/short to B+ | |
| | | | | | 4 | | | ■ | Coolant temperature lamp short to ground | |
| **286** | **286** | | | | | | | | **Oil pressure output status** | |
| | | | | | 3 | | | ■ | Oil pressure output open/short to B+ | |
| | | | | | 4 | | | ■ | Oil pressure output short to ground | |
| | | | | | 5 | | | ■ | Oil pressure output open circuit | |
| **323** | **323** | | | | | | | | **Shutdown output status** | |
| | | | | | 3 | | | ■ | Shutdown output open/short to B+ | |
| | | | | | 4 | | | ■ | Shutdown output short to ground | |
| | | | | | 5 | | | ■ | Shutdown output open circuit | |
| **324** | **324** | | | | | | | | **Warning output status** | |
| | | | | | 3 | | | ■ | Warning output open/short to B+ | |
| | | | | | 4 | | | ■ | Warning output short to ground | |
| | | | | | 5 | | | ■ | Warning output open circuit | |
| **412** | | | | | | | | | **Temperature sensor in the EGR valve.** | |
| | | | | | 0 | ■ | | | Temperature in the EGR extremely high | |
| | | | | | 3 | ■ | | | Input voltage of the temperature sensor high | Short to V+ |
| | | | | | 4 | ■ | | | Input voltage of the temperature sensor low | Short to V- |
| | | | | | 15 | ■ | | | Temperature in the EGR high | |
| | | | | | 16 | ■ | | | Temperature in the EGR moderately high | |
| **443** | **443** | | | | | | | | **ENGINE RUN output status** | |
| | | | | | 3 | | | ■ | Engine run output open/short to B+ | |
| | | | | | 4 | | | ■ | Engine run output short to B- | |
| **523** | | | | | | | | | **Gear selection** | |
| | | | | | 9 | ■ | | | Gear selection invalid | Not possible with Genset application |

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|---|---|---|---|---|---|---|---|---|---|---|
| **608** | | **250** | | | | ■ | | | **Data link faulty J1587 Start/Stop redundancy / J1939 communication bus** | |
| **608** | | | | **132** | | ■ | | | **Redundancy of the accelerator** | |
| **608** | | | | **98** | | ■ | | | **Redundancy of the Stop/start information** | |
| **611** | | | | | | | | | **Injector wiring status** | |
| | | | | | 3 | ■ | | | Injector wiring shorted to power source | |
| | | | | | 4 | ■ | | | Injector wiring shorted to ground | |
| **620** | **262** | **232** | | | | | ■ | | **5 Volt sensor power supply** | **FMI not informed by VOLVO** |
| | | | | | 3 | ■ | | ■ | Sensor power supply open/short to B+ | |
| | | | | | 4 | ■ | | ■ | Sensor power supply short to ground | |
| **626** | | | **45** | | | | ■ | | **Start enable device (intake heater and ether)** | |
| | | | | | 3 | | ■ | | Start enable device output short to B+ | Not used, the control panel is in charge of managing the start enable device |
| | | | | | 4 | | ■ | | Start enable device output short to ground | |
| | | | | | 5 | | ■ | | Start enable device output open circuit | |
| **627** | | | | | | | | | **Power supply** | |
| | | | | | 1 | ■ | | | Injector supply voltage problem | For 6125HF070 only |
| | | | | | 4 | ■ | | | ECU unswitched power missing | For 6068HF275 VP44 only |
| | | | | | 18 | ■ | | | Battery voltage below the operating voltage | For John DEERE Tiers III |
| **628** | | **240** | | | | | ■ | | **Memory fault in EMS2** | |
| **629** | | **254** | | | | | ■ | | **ECU status/controller error** | **CIU module status** |
| | | | | | 2 | | ■ | | RAM cell test failure | |
| | | | | | 8 | | ■ | | CPU watchdog reset test failure | |
| | | | | | 11 | | ■ | | Main and fuelling ASIC test fail | |
| | | | | | 12 | ■ | ■ | | RAM address test failure | |
| | | | | | 13 | ■ | ■ | | Watchdog trip failure | |
| | | | | | 19 | ■ | | | ECU to injection pump communication error | Possible only with 6068HF475 VP44 |
| **630** | | **253** | | | | | ■ | | **Data set memory EEPROM** | |
| **632** | | | | | | | | | **Injection status** | |
| | | | | | 2 | ■ | | | Fuel shutoff error | |
| | | | | | 5 | ■ | | | Fuel shutoff non-functional | |
| **636** | | **21** | | | | | | | **Pump position sensor/Cam position sensor/Speed sensor CAM** | Pump position or CAM position in function of the type of injection |
| | | | | | 2 | ■ | ■ | | Pump position sensor/cam position sensor input noise | |
| | | | | | 3 | | ■ | | Permanent loss of signal | |
| | | | | | 5 | ■ | | | High impedance of the position sensor or circuit open | |
| | | | | | 6 | ■ | | | Sensor short to ground | |
| | | | | | 8 | ■ | ■ | | Pump position sensor/cam position sensor input missing | |
| | | | | | 9 | | ■ | | Not informed by VOLVO | |
| | | | | | 10 | ■ | | | Pump position sensor/cam position sensor input pattern error | |

| SPN | CID | SID | PID | PPID | FMI | John Deere | Volvo | Perkins | Description | Comment |
|---|---|---|---|---|---|---|---|---|---|---|
| **637** | | **22** | | | | | | | **Crank position sensor/Speed sensor flywheel** | |
| | | | | | 2 | ■ | ■ | | Crank position input noise | |
| | | | | | 3 | | ■ | | Permanent loss of signal | |
| | | | | | 5 | ■ | | | High impedance of the position sensor or open circuit | |
| | | | | | 6 | ■ | | | Sensor short to ground | |
| | | | | | 7 | ■ | | | Crank position/Cam position out of synchronisation | |
| | | | | | 8 | ■ | ■ | | Crank position input missing | |
| | | | | | 9 | | ■ | | Not informed by VOLVO | |
| | | | | | 10 | ■ | | | Crank position sensor input pattern error | |
| **639** | **247** | **231** | | | | | | | **Communication status** | |
| | | | | | 2 | | ■ | | Bus Off error | |
| | | | | | 9 | | ■ | | Passive bus error | |
| | | | | | 11 | | ■ | | Data registers read back failure | |
| | | | | | 12 | | ■ | | Loss of message error | |
| | | | | | 13 | ■ | | | Bus CAN error | |
| **640** | | | | | | | | | **Engine shutdown vehicle status** | |
| | | | | | 11 | ■ | | | Engine shutdown vehicle request invalid | |
| | | | | | 31 | ■ | | | Engine shutdown vehicle request | |
| **641** | | | | | | | | | **Status of the Turbo with variable geometry** | |
| | | | | | 4 | ■ | | | Supply voltage of the Turbo actuator low | |
| | | | | | 12 | ■ | | | Error in communication between the ECU and the TGV actuator | |
| | | | | | 13 | ■ | | | Error in position of the TGV | |
| | | | | | 16 | ■ | | | Temperature of the actuator moderately high. | |
| **651** | **1** | **1** | **651** | | | | ■ | | **Cylinder #1 injector status** | |
| | | | | | 0 | ■ | | | Injector outside specifications | Recalibration of the injectors required |
| | | | | | 1 | ■ | | | Injector outside specifications | Recalibration of the injectors required |
| | | | | | 2 | | ■ | | Short circuit high side to B+ | |
| | | | | | 3 | | ■ | | Short circuit high side to low side or low side to B+ | |
| | | | | | 4 | | ■ | | Short circuit high or low side to ground | |
| | | | | | 5 | ■ | ■ | | Cylinder #1 circuit open | |
| | | | | | 6 | ■ | | | Cylinder #1 circuit shorted | |
| | | | | | 7 | ■ | ■ | ■ | Cylinder #1 balancing error/mechanical failure | |
| | | | | | 11 | | ■ | ■ | Cylinder #1 unknown error/mechanical failure | |

| SPN | CID | SID | PID | PPID | FMI | John Deere | Volvo | Perkins | Description | Comment |
|---|---|---|---|---|---|---|---|---|---|---|
| **652** | **2** | **2** | **652** | | | | ■ | | **Cylinder #2 injector status** | |
| | | | | | 0 | ■ | | | Injector outside the specifications | Recalibration of the injectors required |
| | | | | | 1 | ■ | | | Injector outside the specifications | Recalibration of the injectors required |
| | | | | | 2 | | ■ | | Short circuit high side to B+ | |
| | | | | | 3 | | ■ | | Short circuit high side to low side or low side to B+ | |
| | | | | | 4 | | ■ | | Short circuit high or low side to ground | |
| | | | | | 5 | ■ | ■ | | Cylinder #2 circuit open | |
| | | | | | 6 | ■ | | | Cylinder #2 circuit shorted | |
| | | | | | 7 | ■ | ■ | | Cylinder #2 balancing error/mechanical failure | |
| | | | | | 11 | | ■ | | Cylinder #2 unknown error/mechanical failure | |
| **653** | **3** | **3** | **653** | | | | ■ | | **Cylinder #3 injector status** | |
| | | | | | 0 | ■ | | | Injector outside the specifications | Recalibration of the injectors required |
| | | | | | 1 | ■ | | | Injector outside the specifications | Recalibration of the injectors required |
| | | | | | 2 | | ■ | | Short circuit high side to B+ | |
| | | | | | 3 | | ■ | | Short circuit high side to low side or low side to B+ | |
| | | | | | 4 | | ■ | | Short circuit high or low side to ground | |
| | | | | | 5 | ■ | ■ | | Cylinder #3 circuit open | |
| | | | | | 6 | ■ | | | Cylinder #3 circuit shorted | |
| | | | | | 7 | ■ | ■ | ■ | Cylinder #3 balancing error/mechanical failure | |
| | | | | | 11 | | ■ | ■ | Cylinder #3 unknown error/mechanical failure | |
| **654** | **4** | **4** | **654** | | | | ■ | | **Cylinder #4 injector status** | |
| | | | | | 0 | ■ | | | Injector outside the specifications | Recalibration of the injectors required |
| | | | | | 1 | ■ | | | Injector outside the specifications | Recalibration of the injectors required |
| | | | | | 2 | | ■ | | Short circuit high side to B+ | |
| | | | | | 3 | | ■ | | Short circuit high side to low side or low side to B+ | |
| | | | | | 4 | | ■ | | Short circuit high or low side to ground | |
| | | | | | 5 | ■ | ■ | | Cylinder #4 circuit open | |
| | | | | | 6 | ■ | | | Cylinder #4 circuit shorted | |
| | | | | | 7 | ■ | ■ | ■ | Cylinder #4 balancing error/mechanical failure | |
| | | | | | 11 | | ■ | ■ | Cylinder #4 unknown error/mechanical failure | |

| SPN | CID | SID | PID | PPID | FMI | John Deere | Volvo | Perkins | Description | Comment |
|---|---|---|---|---|---|---|---|---|---|---|
| **655** | **5** | **5** | **655** | | | | ■ | | **Cylinder #5 injector status** | |
| | | | | | 0 | ■ | | | Injector outside the specifications | Recalibration of the injectors required |
| | | | | | 1 | ■ | | | Injector outside the specifications | Recalibration of the injectors required |
| | | | | | 2 | | ■ | | Short circuit high side to B+ | |
| | | | | | 3 | | ■ | | Short circuit high side to low side or low side to B+ | |
| | | | | | 4 | | ■ | | Short circuit high or low side to ground | |
| | | | | | 5 | ■ | ■ | | Cylinder #5 circuit open | |
| | | | | | 6 | ■ | | | Cylinder #5 circuit shorted | |
| | | | | | 7 | ■ | ■ | ■ | Cylinder #5 balancing error/mechanical failure | |
| | | | | | 11 | | ■ | ■ | Cylinder #5 unknown error/mechanical failure | |
| **656** | **6** | **6** | **656** | | | | ■ | | **Cylinder #6 injector status** | |
| | | | | | 0 | ■ | | | Injector outside the specifications | Recalibration of the injectors required |
| | | | | | 1 | ■ | | | Injector outside the specifications | Recalibration of the injectors required |
| | | | | | 2 | | ■ | | Short circuit high side to B+ | |
| | | | | | 3 | | ■ | | Short circuit high side to low side or low side to B+ | |
| | | | | | 4 | | ■ | | Short circuit high or low side to ground | |
| | | | | | 5 | ■ | ■ | | Cylinder #6 circuit open | |
| | | | | | 6 | ■ | | | Cylinder #6 circuit shorted | |
| | | | | | 7 | ■ | ■ | ■ | Cylinder #6 balancing error/mechanical failure | |
| | | | | | 11 | | ■ | ■ | Cylinder #6 unknown error/mechanical failure | |
| **676** | | **39** | | | | | | | **Glow plug relay status** | |
| | | | | | 3 | ■ | | | Glow plug relay voltage high | |
| | | | | | 5 | ■ | | | Glow plug relay voltage low | |
| **677** | | **39** | | **3** | | | | | **Start relay status** | |
| | | | | | 3 | | ■ | | Start relay control short circuit to high | |
| | | | | | 4 | | ■ | | Start relay control short circuit low | |
| | | | | | 5 | | ■ | | Start relay control open circuit | |
| **678** | **41** | | | | | | | | **8 Volt power supply** | |
| | | | | | 3 | | | ■ | ACM 8 Volt DC supply open/short to B+ | |
| | | | | | 4 | | | ■ | ACM 8 Volt DC supply open/short to ground | |

| SPN | CID | SID | PID | PPID | FMI | John Deere | Volvo | Perkins | Description | Comment |
|---|---|---|---|---|---|---|---|---|---|---|
| **679** | | **42** | | | | ■ | | | **Regulation sensor of the injection pressure control** | |
| **723** | **342** | | | | | | | | **Secondary speed sensor** | |
| | | | | | 2 | | | ■ | Secondary engine speed sensor data intermittent | |
| | | | | | 11 | | | | Secondary engine speed sensor loss of signal | |
| | | | | | 12 | | | | Loss of signal/sensor failure | |
| **729** | | **70** | | | | | | | **Inlet air heater signal/Preheat detection** | |
| | | | | | 3 | ■ | | | Inlet air heater signal high | |
| | | | | | 5 | | | | Inlet air heater signal low | |
| **810** | | | | | | | | | **Vehicle speed** | |
| | | | | | 2 | ■ | | | Calculated vehicle speed input noise | Not possible with Genset application |
| **861** | **861** | | | | | | | | **Diagnostic output status** | |
| | | | | | 3 | | | ■ | Diagnostic output open/short to B+ | |
| | | | | | 4 | | | | Diagnostic output short to ground | |
| **898** | | | | | | | | | **CAN throttle status** | |
| | | | | | 9 | ■ | | | Speed value invalid or missing | |
| **970** | | | | **6** | | | | | **Auxiliary engine shutdown switch status EMS** | |
| | | | | | 2 | ■ | | | Auxiliary engine shutdown switch signal invalid | Not used |
| | | | | | 31 | | | | Auxiliary engine shutdown switch active | |
| **971** | | | | | | | | | **External engine de rate switch status** | |
| | | | | | 31 | ■ | | | External engine de rate switch active | Not used |
| **1069** | | | | | | | | | **Tire size status** | |
| | | | | | 2 | ■ | | | Tire size error | Not possible with Genset application |
| | | | | | 9 | | | | Tire size invalid | |
| | | | | | 31 | | | | Tire size error | |
| **1075** | | | | | | | | | **Feed pump of the fuel circuit** | |
| | | | | | 5 | ■ | | | High impedance at the terminals of the pump or open circuit | |
| | | | | | 6 | | | | Pump coil short to ground | |
| | | | | | 12 | | | | Pump defective | |
| **1076** | | | | | | | ■ | | **Fuel Injection pump status** | |
| | | | | | 0 | ■ | | | Pump control valve closure too long | Injection DE10 |
| | | | | | 1 | | | | Pump control valve closure too short | Injection DE10 |
| | | | | | 2 | | | | Pump detected defect | Injection VP44 |
| | | | | | 3 | | | | Pump solenoid current high | Injection DE10 |
| | | | | | 5 | | | | Pump solenoid circuit open | Injection DE10 |
| | | | | | 6 | | | | Pump solenoid circuit severely shorted | Injection DE10 |
| | | | | | 7 | | | | Pump control valve closure not detected | Injection DE10 |
| | | | | | 10 | | | | Pump solenoid circuit moderately shorted | Injection DE10 |
| | | | | | 13 | | | | Pump current decay time invalid | Injection DE10 |

| SPN | CID | SID | PID | PPID | FMI | John Deere | Volvo | Perkins | Description | Comment |
|---|---|---|---|---|---|---|---|---|---|---|
| **1077** | | | | | | | | | **Fuel injection pump controller status** | |
| | | | | | 7 | ■ | | | Attempting to fuel without command | |
| | | | | | 11 | ■ | | | Pump supply voltage out of range | |
| | | | | | 12 | ■ | | | Pump self test error | |
| | | | | | 19 | ■ | | | Pump detected communication error | |
| | | | | | 31 | ■ | | | Pump initiated engine protection | |
| **1078** | | | | | | | | | **ECU/Pump timing status** | |
| | | | | | 7 | ■ | | | ECU/Pump timing moderately out of synchronisation | |
| | | | | | 11 | ■ | | | ECU/Pump timing speed out of synchronisation | |
| | | | | | 31 | ■ | | | ECU/Pump timing extremely out of synchronisation | |
| **1079** | | **232** | | | | | | | **Sensor supply voltage (+5 Volt)** | **Analog throttle reference** |
| | | | | | 3 | ■ | | | Sensor supply voltage high | > 5,5 Volt |
| | | | | | 4 | ■ | | | Sensor supply voltage low | < 4,44 Volt |
| **1080** | | **211** | | | | | | | **Sensor supply voltage (Oil pressure, Coolant temp, fuel pressure)/+5V sensor supply 2** | |
| | | | | | 3 | ■ | | | Sensor supply voltage high | > 5,5 Volt |
| | | | | | 4 | ■ | | | Sensor supply voltage low | < 4,40 Volt |
| **1109** | | | | | | | | | **Engine/ECU status** | |
| | | | | | 31 | ■ | | | Engine shutdown warning | |
| **1110** | | | | | | | | | **Engine status** | |
| | | | | | 31 | ■ | | | Engine shutdown | |
| **1111** | **268** | | | | | | | | **Check parameters** | |
| | | | | | 2 | | | ■ | Programmed parameter fault | |
| **1136** | | | | **55** | | | ■ | | **ECU Temperature** | |
| | | | | | 0 | ■ | | | ECU temperature extremely high | |
| | | | | | 16 | ■ | | | ECU temperature moderately high | |
| **1172** | | | | | | | | | **Input temperature of the TGV compressor** | |
| | | | | | 3 | ■ | | | Input voltage of the temperature sensor high | Short to V+ |
| | | | | | 4 | ■ | | | Input voltage of the temperature sensor low | Short to V- |
| **1180** | | | | | | | | | **Input temperature of the TGV turbine** | |
| | | | | | 0 | ■ | | | Turbine temperature extremely high | Short to V+ |
| | | | | | 16 | ■ | | | Turbine temperature moderately high | Short to V- |
| **1184** | | | **173** | | | | | | **Exhaust gas temperature sensor** | |
| **1239** | | | | **96** | | | ■ | | **Status of the pressure system of the common rail** | |
| **1347** | | | | | | | | | **Pump control valve status** | **Pump control valve #1 status for 6081HF070** |
| | | | | | 3 | ■ | | | Pump control valve current high | |
| | | | | | 5 | ■ | | | Pump control valve error/mismatch | |
| | | | | | 7 | ■ | | | Fuel rail pressure control error | |
| | | | | | 10 | ■ | | | Pump control valve fuel flow not detected | |

| SPN | CID | SID | PID | PPID | FMI | John Deere | Volvo | Perkins | Description | Comment |
|---|---|---|---|---|---|---|---|---|---|---|
| **1348** | | | | | | | | | **Pump control valve #2 status** | **Only for 6081HF070** |
| | | | | | 5 | ■ | | | Pump control valve #2 error/mismatch | |
| | | | | | 10 | ■ | | | Pump control valve #2 fuel flow not detected | |
| **1485** | | | **1485** | **5** | | | | | **Pump power relay status** | **ECU main relay of VOLVO EMS/EDC** |
| | | | | | 2 | ■ | | | Pump power relay fault | |
| | | | | | 3 | | ■ | | | ECU main relay short circuit high |
| **1568** | | | | | | | | | **Torque curve selection** | |
| | | | | | 2 | ■ | | | Torque curve selection invalid | |
| | | | | | 4 | ■ | | | Torque curve input voltage high | |
| | | | | | 9 | ■ | | | Torque curve selection missing | |
| **1569** | | | | | | | | | **Fuel supply status** | |
| | | | | | 31 | ■ | | | Fuel de rate | |
| **1639** | | | | | | | | | **Fan speed sensor** | |
| | | | | | 1 | ■ | | | Fan speed signal missing | Not possible with Genset application |
| | | | | | 2 | ■ | | | Fan speed signal erratic | |
| | | | | | 16 | ■ | | | Fan speed higher than expected | |
| | | | | | 18 | ■ | | | Fan speed lower than expected | |
| **2000** | | | | | | | | | **ECU status** | |
| | | | | | 6 | ■ | | | Vehicle ID missing | |
| | | | | | 13 | ■ | | | Security violation | |
| **2630** | | | | | | | | | **Air temperature at the air cooler outlet** | |
| | | | | | 0 | ■ | | | Air temperature extremely high | |
| | | | | | 3 | ■ | | | Sensor input voltage high | Short to V+ |
| | | | | | 4 | ■ | | | Sensor input voltage low | Short to V- |
| | | | | | 15 | ■ | | | Air temperature high | |
| | | | | | 16 | ■ | | | Air temperature moderately high | |
| **2659** | | | | | | | | | **Flow level of the EGR valve** | |
| | | | | | 2 | ■ | | | Calculated EGR flow not valid | |
| | | | | | 15 | ■ | | | Calculated EGR flow rather high | |
| | | | | | 17 | ■ | | | Calculated EGR flow rather low | |
| **2790** | | | | | | | | | **Air temperature at turbo compressor outlet** | |
| | | | | | 16 | ■ | | | Temperature at compressor outlet moderately high | |
| **2791** | | | | **19** | | | ■ | | **Statuses of the EGR valve** | |
| | | | | | 2 | ■ | | | Valve position signal not valid | |
| | | | | | 3 | ■ | | | Input voltage of the position sensor high | Short to V+ |
| | | | | | 4 | ■ | | | Input voltage of the position sensor low | Short to V- |
| | | | | | 7 | ■ | | | Inability of the EGR valve to reach the expected position | |
| | | | | | 13 | ■ | | | The EGR valve is out of calibration | |
| | | | | | 31 | ■ | | | Error in position of the EGR valve | |

| SPN | CID | SID | PID | PPID | FMI | John Deere | Volvo | Perkins | Description | Comment |
|---|---|---|---|---|---|---|---|---|---|---|
| **2795** | | | | | | | | | **Position of TGV actuator** | |
| | | | | | 7 | ■ | | | The actuator does not respond or is not in the expected position | |
| **3509** | | | | | | | | | **Common supply voltage of the sensors, output #1** | |
| | | | | | 3 | ■ | | | Supply voltage of the sensor too high | Exceeding +5 volts |
| | | | | | | ■ | | | Supply voltage of the sensor shorted to ground | |
| **3510** | | | | | | | | | **Common supply voltage of the sensors, output #2** | |
| | | | | | 3 | ■ | | | Supply voltage of the sensor too high | Exceeding +5 volts |
| | | | | | | ■ | | | Supply voltage of the sensor shorted to ground | |
| **3511** | | | | | | | | | **Common supply voltage of the sensors, output #3** | |
| | | | | | 3 | ■ | | | Supply voltage of the sensor too high | Exceeding +5 volts |
| | | | | | | ■ | | | Supply voltage of the sensor shorted to ground | |
| **3512** | | | | | | | | | **Common supply voltage of the sensors, output #4** | |
| | | | | | 3 | ■ | | | Supply voltage of the sensor too high | Exceeding +5 volts |
| | | | | | | ■ | | | Supply voltage of the sensor shorted to ground | |
| **3513** | | | | | | | | | **Common supply voltage of the sensors, output #5** | |
| | | | | | 3 | ■ | | | Supply voltage of the sensor too high | Exceeding +5 volts |
| | | | | | | ■ | | | Supply voltage of the sensor shorted to ground | |
| **520192** | | | | **8** | | | ■ | | **Cooling status of the piston** | |
| **520194** | | | | **4** | | | ■ | | **Status of the starting request input** | |
| **520195** | | | | **6** | | | ■ | | **Stop request on CIU** | |

**SAE J1939-73 : March 2004**
FMI and Description

**FMI=0—DATA VALID BUT ABOVE NORMAL OPERATIONAL RANGE - MOST SEVERE LEVEL**
The signal communicating information is within a defined acceptable and valid range, but the real world condition is above what would be considered normal as determined by the predefined most severe level limits for that particular measure of the real world condition (*Region e* of the signal range definition) Broadcast of data values is continued as normal. Broadcast of data values is continued as normal.

**FMI=1—DATA VALID BUT BELOW NORMAL OPERATIONAL RANGE - MOST SEVERE LEVEL**
The signal communicating information is within a defined acceptable and valid range, but the real world condition is below what would be considered normal as determined by the predefined least severe level limits for that particular measure of the real world condition (*Region e* of the signal range definition). Broadcast of data values is continued as normal.

**FMI=2—DATA ERRATIC, INTERMITTENT OR INCORRECT**
Erratic or intermittent data includes all measurements that change at a rate that is not considered possible in the real world condition and must be caused by improper operation of the measuring device or its connection to the module. Broadcast of data value is substituted with the “error indicator” value.
Incorrect data includes any data not received and any data that is exclusive of the situations covered by FMIs 3, 4, 5 and 6. Data may also be considered incorrect if it is inconsistent with other information collected or known about the system.

**FMI=3—VOLTAGE ABOVE NORMAL, OR SHORTED TO HIGH SOURCE**
a. A voltage signal, data or otherwise, is above the predefined limits that bound the range (*Region e* of the signal range definition). Broadcast of data value is substituted with the “error indicator” value.
b. Any signal external to an electronic control module whose voltage remains at a high level when the ECM commands it to low. Broadcast of data value is substituted with the “error indicator” value.

**FMI=4—VOLTAGE BELOW NORMAL, OR SHORTED TO LOW SOURCE**
a. A voltage signal, data or otherwise, is below the predefined limits that bound the range (Region e of the signal range definition). Broadcast of data value is substituted with the “error indicator” value.
b. Any signal external to an electronic control module whose voltage remains at a low level when the ECM commands it to high. Broadcast of data value is substituted with the “error indicator” value.

**FMI=5—CURRENT BELOW NORMAL OR OPEN CIRCUIT**
a. A current signal, data or otherwise, is below the predefined limits that bound the range (Region e of the signal range definition). Broadcast of data value is substituted with the “error indicator” value.
b. Any signal external to an electronic control module whose current remains off when the ECM commands it on. Broadcast of data value is substituted with the “error indicator” value.

**FMI=6—CURRENT ABOVE NORMAL OR GROUNDED CIRCUIT**
a. A current signal, data or otherwise, is above the predefined limits that bound the range. (*Region e* of the signal range definition). Broadcast of data value is substituted with the “error indicator” value.
b. Any signal external to an electronic control module whose current remains on when the ECM commands it off. Broadcast of data value is substituted with the “error indicator” value.

**FMI=7—MECHANICAL SYSTEM NOT RESPONDING OR OUT OF ADJUSTMENT**
Any fault that is detected as the result of an improper mechanical adjustment or an improper response or action of a mechanical system that, with a reasonable confidence level, is not caused by an electronic or electrical system failure. This type of fault may or may be directly associated with the value of general broadcast information.

**FMI=8—ABNORMAL FREQUENCY OR PULSE WIDTH OR PERIOD**
To be considered in cases of FMI 4 and 5. Any frequency or PWM signal that is outside the predefined limits which bound the signal range for frequency or duty cycle (outside *Region b* or the signal definition). Also if the signal is an ECM output, any signal whose frequency or duty cycle is not consistent with the signal which is emitted. Broadcast of data value is substituted with the “error indicator” value.

**FMI=9—ABNORMAL UPDATE RATE**
Any failure that is detected when receipt of data via the data link or as input from a smart actuator or smart sensor is not at the update rate expected or required by the ECM (outside *Region c* of the signal range definition). Also any error that causes the ECM not to send information at the rate required by the system. This type of fault may or may be directly associated with the value of general broadcast information.

**FMI=10—ABNORMAL RATE OF CHANGE**
Any data, exclusive of the abnormalities covered by FMI 2, that is considered valid but whose data is changing at a rate that is outside the predefined limits that bound the rate of change for a properly functioning system (outside *Region c* of the signal range definition). Broadcast of data values is continued as normal.

**FMI=11—ROOT CAUSE NOT KNOWN**
It has been detected that a failure has occurred in a particular subsystem but the exact nature of the fault is not known. Broadcast of data value is substituted with the “error indicator” value.

**FMI=12—BAD INTELLIGENT DEVICE OR COMPONENT**
Internal diagnostic procedures have determined that the failure is one which requires the replacement of the ECU, used here to mean the packaged unit that includes some microprocessor and its associated components and circuits. It can be assumed that the communications subsystem is not the part that has failed, and the manufacturer has determined that there is no serviceable component smaller than the ECU involved in the failure. Broadcast of data value is substituted with the “error indicator” value if appropriate, as there may or may not be any broadcast involved. This error is to include all internal controller trouble codes that can not be caused by connections or systems external to the controller.

**FMI=13—OUT OF CALIBRATION**
A failure that can be identified to be the result of not being properly calibrated. This may be the case for a subsystem which can identify that the calibration attempting to be used by the controller is out of date. Or it may be the case that the mechanical subsystem is determined to be out of calibration. This failure mode does not relate to the signal range definition as do many of the FMIs.

**FMI=14—SPECIAL INSTRUCTIONS**
“Special Instructions” is the FMI to be used when the on-board system can isolate the failure to a small number of choices but not to a single point of failure. When the FMI is used, there is clear necessity for the service technician to take some action to complete the specific diagnosis, and the manufacturer has provided instructions for the completion of that diagnosis. There are two cases where this will be used: 1. for emission-related diagnostics where the particular failure cannot be separated between a sensor out of range and the case where the actual value is at the edge of a diagnostic region, and 2. for the older SPN 611 to 615 where the problem is in determining which of two or more circuits (which may interact) is the one that needs repair.
SPNs 611 through 615 are defined as “System Diagnostic Codes” and are used to identify failures that cannot be tied to a specific field replaceable component. Specific subsystem fault isolation is the goal of any diagnostic system, but for various reasons this cannot always be accomplished. These SPNs allow the manufacturer some flexibility to communicate non-“specific component” diagnostic information. Since SPNs 611-615 use the standard SPN/FMI format it allows the use of standard diagnostic tools, electronic dashboards, satellite systems and other advanced devices that scan Parameter Groups containing the SPN/FMI formats. Because manufacturer defined codes are not desirable in terms of standardization, the use of these codes should only occur when diagnostic information cannot be communicated as a specific component and failure mode.
Possible reasons for using a System Diagnostic Code include:

1. Cost of specific component fault isolation is not justified, or
2. New concepts in Total Vehicle Diagnostics are being developed, or
3. New diagnostic strategies that are not component specific are being developed.

Due to the fact that SPNs 611-615 are manufacturer defined and are not component specific, FMIs 0-13 and 15-31 have little meaning. Therefore, FMI 14, “Special Instructions”, is usually used. The goal is to refer the service personnel to the manufacturer's troubleshooting manual for more information on the particular diagnostic code. This failure mode does not relate to the signal range definition as do many of the FMIs. This type of fault may or may be directly associated with the value of general broadcast information.

**FMI=15—DATA VALID BUT ABOVE NORMAL OPERATING RANGE - LEAST SEVERE LEVEL**
The signal communicating information is within a defined acceptable and valid range, but the real world condition is above what would be considered normal as determined by the predefined least severe level limits for that particular measure of the real world condition (*Region i* of the signal range definition). Broadcast of data values is continued as normal.

**FMI=16—DATA VALID BUT ABOVE NORMAL OPERATING RANGE - MODERATELY SEVERE LEVEL**
The signal communicating information is within a defined acceptable and valid range, but the real world condition is above what would be considered normal as determined by the predefined moderately severe level limits for that particular measure of the real world condition (*Region k* of the signal range definition). Broadcast of data values is continued as normal.

**FMI=17—DATA VALID BUT BELOW NORMAL OPERATING RANGE - LEAST SEVERE LEVEL**
The signal communicating information is within a defined acceptable and valid range, but the real world condition is below what would be considered normal as determined by the predefined least severe level limits for that particular measure of the real world condition (*Region h* of the signal range definition). Broadcast of data values is continued as normal.

**FMI=18—DATA VALID BUT BELOW NORMAL OPERATING RANGE - MODERATELY SEVERE LEVEL**
The signal communicating information is within a defined acceptable and valid range, but the real world condition is below what would be considered normal as determined by the predefined moderately severe level limits for that particular measure of the real world condition (*Region j* of the signal range definition). Broadcast of data values is continued as normal.

**FMI=19—RECEIVED NETWORK DATA IN ERROR**
Any failure that is detected when the data received via the network is found substituted with the “error indicator” value (i.e. FE16, see J1939-71). This type of failure is associated with received network data. The component used to measure the real world signal is wired directly to the module sourcing the data to the network and not to the module receiving the data via the network. The FMI is applicable to *Region f* and *g* of the signal range definition. This type of fault may or may be directly associated with the value of general broadcast information.

**FMI=20-30—RESERVED FOR SAE ASSIGNMENT**

**FMI=31—CONDITION EXISTS**
Used to indicate that the condition that is identified by the SPN exists when no more applicable FMI exists or in cases when the reported SPN name spells out the component and a non-standard failure mode. This type of fault may or may be directly associated with the value of general broadcast information. This FMI will mean “not available” when the associated SPN is also “not available” as when the remainder of the packet is filled with binary ones after all data has been transmitted.