

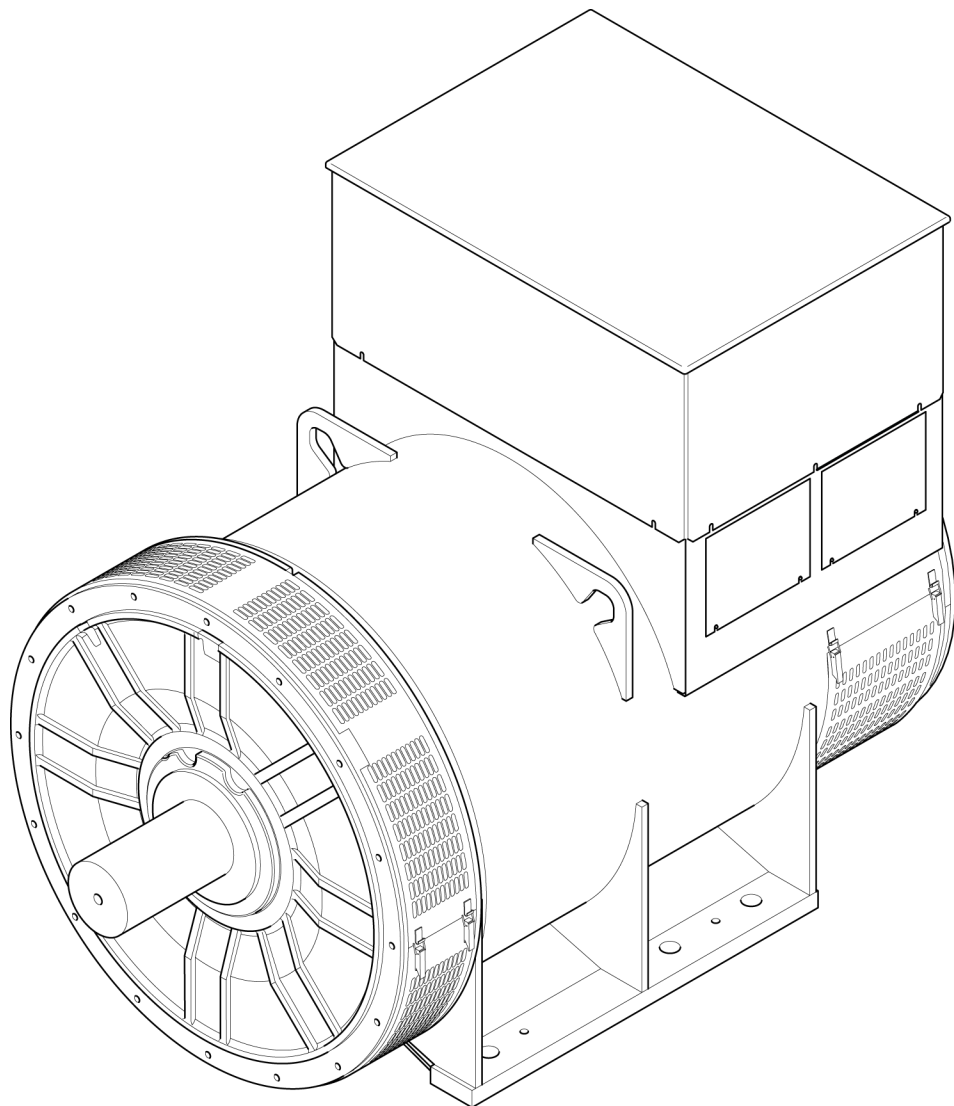


# دیزل نیرو

واردات و فروش انواع دیزل ژنراتورهای صنعتی

## P7 AC GENERATORS

### Installation, Servicing, and Maintenance





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# 1 Foreword

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## 1.1 The Manual

This manual contains guidance and instructions for the installation, servicing and maintenance of the generator.

Before operating the generator, read this manual and make sure that all personnel who work on the equipment have access to the manual and all additional documentation supplied with it. Misuse and failure to follow the instructions may invalidate the product warranty and lead to potential accidents.

This manual is an essential part of the generator. Make sure that the manual is available to all users throughout the life of the generator.

The manual is written for skilled electrical and mechanical technicians and engineers, who have prior knowledge and experience of generating equipment of this type. If in doubt, please seek expert advice or contact your local Cummins Generator Technologies subsidiary.

| NOTICE  |
|---|
| <b>Information in this manual was correct when published. It may be superseded due to our policy of continuous improvement. Please visit <a href="http://www.cumminsgeneratortechnologies.com">www.cumminsgeneratortechnologies.com</a> for latest documentation.</b> |

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## 2 Safety Precautions


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### 2.1 Safety Information and Notices used in this manual

Danger, Warning and Caution panels are used in this manual to describe the sources of hazards, their consequences and how to avoid injury. Notice panels emphasise important or critical instructions.

|  |
|--|
|  <b>DANGER</b>              |
| Danger indicates a hazardous situation which, if not avoided, <b>WILL</b> result in death or serious injury. |

|  |
|--|
|  <b>WARNING</b>               |
| Warning indicates a hazardous situation which, if not avoided, <b>COULD</b> result in death or serious injury. |


|   |
|---|
|  <b>CAUTION</b>                |
| Caution indicates a hazardous situation which, if not avoided, <b>COULD</b> result in minor or moderate injury. |

|   |
|---|
| <b>NOTICE</b>   |
| Notice refers to a method or practice which can result in product damage, or to draw attention to additional information or explanations. |

### 2.2 Skill Requirements of Personnel

|   |
|---|
|  <b>WARNING</b>  |
| Service and maintenance procedures should only be carried out by experienced and qualified engineers, who are familiar with the procedures and the equipment. |

### 2.3 Risk Assessment

|   |
|---|
|  <b>WARNING</b>  |
| A risk assessment should be performed by the user/operating company to establish all personnel related risks. All relevant personnel should be trained on identified risks. Access to the Power Plant/Generator Set during operation should be restricted to personnel that have been trained on these risks. |



## 2.4 Personal Protective Equipment (PPE)

### WARNING

All persons operating, servicing, maintaining or working in or with a power plant or a generating set must wear appropriate Personal Protective Equipment (PPE).

Recommended PPE includes:

- Ear and Eye Protection
- Head and face protection
- Safety footwear
- Overalls that protect the lower arms and legs

Ensure that all persons are fully aware of the emergency procedures in case of accidents.

## 2.5 Noise

### CAUTION

Generators emit noise. Ensure appropriate ear protection is worn at all times. Maximum A-weighted noise emissions may reach 110 dB(A). Contact supplier for application-specific details.

## 2.6 Electrical Equipment

### CAUTION

All electrical equipment can be dangerous if not operated correctly. Always install, service and maintain the generator in accordance with this manual.

Any Work that is likely to require access to electrical conductors must comply with all local and national electrical safety procedures that are applicable to the site and to the voltage levels involved as well as any site specific rules. Always use genuine 'STAMFORD' replacement parts.

## 2.7 Lock Out/Tag Out

### WARNING

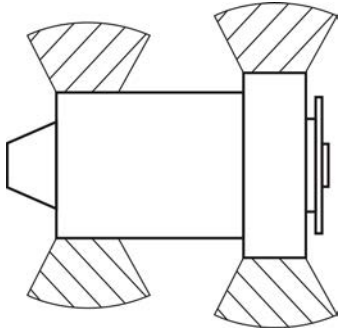
Isolate the generator from all sources of mechanical and electrical energy before servicing. Adopt a suitable lock-out/tag out process.

## 2.8 Lifting

### WARNING

The lifting points provided are designed for lifting the generator only. Do not lift the generating set (generator coupled to motive power source) by the generator's lifting points.

## 2.9 Generator Operating Areas



Operating in hatched areas or directly in-line with any air inlet/outlet should be avoided where possible. Always wear suitable PPE when working in these areas.

### ⚠ WARNING

Do not place controls within the vicinity of the air inlet/outlet of the machine and ensure personnel are restricted from these areas during operation. In the event of catastrophic failure, machine parts may exit these areas

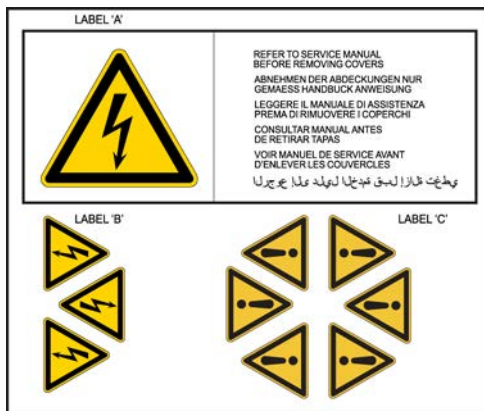
## 2.10 Hazard Warning Labels

Hazard warning labels are affixed to the generator.

If the original labels are missing, damaged or painted over, replace them with the spare set supplied in a wallet attached to the generator. Follow the instructions on the back of the labels.

### ⚠ WARNING

Labels are fixed to the generator to alert users to the type and source of potential hazards. The labels must be visible at all times. Always follow the label instructions to avoid risk of injury.



## 2.11 General Guidance


| NOTICE  |
|---|
| The above, constitutes generic guidance and should supplement your own safety procedures and all applicable laws and standards. |

# 3 Safety Directives and Standards

STAMFORD AC generators meet applicable European safety directives, and national and international standards relevant to generators. The generator must be operated within the limits specified in the relevant standards and within the parameters on the generator rating plate.

Marine generators meet the requirements of all the major marine classification societies.

## 3.1 European Directives: EC Declaration of Conformity

| EC Declaration of Conformity   |   | Generator Technologies               |
|--|---|--------------------------------------|
| This synchronous a.c. generator is designed for incorporation into an electricity generating set and fulfils all the relevant provisions of the following EC Directive(s) when installed in accordance with the installation instructions contained in the product documentation:  |   |                                      |
| 2006/95/EC   | Low Voltage Directive   |                                      |
| 2004/108/EC  | The EMC directive   |                                      |
| 2006/42/EC   | The Machinery Directive   |                                      |
| and that the standards and/or technical specifications referenced below have been applied:   |   |                                      |
| EN 61000-6-1:2007  | Electromagnetic compatibility (EMC). Generic standards – Part 6-1: Immunity for residential, commercial and light-industrial environments   |                                      |
| EN 61000-6-2:2005  | Electromagnetic compatibility (EMC). Generic standards – Part 6-2: Immunity for industrial environments   |                                      |
| EN 61000-6-4:2007  | Electromagnetic compatibility (EMC). Generic standards – Part 6-4: Emission standard for industrial environments  |                                      |
| EN ISO 12100-1:2003  | Safety of machinery - Basic concepts, general principles for design - Part 1: Basic terminology, methodology  |                                      |
| EN ISO 12100-1:2003  | Safety of machinery - Basic concepts, general principles for design -Part 2: Technical principles   |                                      |
| EN ISO 14121-1:2007  | Safety of machinery - Risk assessment - Part 1: Principles  |                                      |
| EN 60034-1:2004  | Rotating electrical machines - Part 1: Rating and performance   |                                      |
| BS ISO 8529-3:2005   | Reciprocating internal combustion engine driven alternating current generating sets - Part 3: Alternating current generators for generating sets  |                                      |
| BS 5000-3:2006   | Rotating electrical machines of particular types or for particular applications - Part 3: Generators to be driven by reciprocating internal combustion engines - Requirements for resistance to vibration |                                      |
| The manufacturer's authorised representative in the Community and person empowered to draw up this declaration and to compile the relevant technical documentation, on behalf of the manufacturer is Mr Jeffrey Matthews - Director Engineering, Cummins Generator Technologies, Barnack Road, Stamford, Lincolnshire, PE9 2NB, England. |   |                                      |
| Signed:  |    | Date: 21 <sup>st</sup> December 2009 |
| Description  |   | Serial Number                        |
| Registered in England under Registration No. 441273.<br>Cummins Generator Technologies Ltd, Registered Office: Barnack Road, Stamford, Lincolnshire PE9 2NB, England.  |   |                                      |

Each generator is CE marked and supplied with an EC Declaration of Conformity for incorporation into an electricity generating set. It is the responsibility of the generating set manufacturer to ensure that the complete generating set complies with EC Directives and standards.

Our authorized representative in the European Community is Mr Jeffrey Matthews, Engineering Director, Cummins Generator Technologies Ltd.

All STAMFORD generators meet the following Standards and Directives:

Directives:

- 2004/108/EC EMC Directive
- 2006/95/EC Low Voltage Directive
- 2006/42/EC Machinery Directive

Standards:

- EN 61000-6-1 Electromagnetic Compatibility, Generic Standards - Immunity for residential, commercial and light-industrial environments
- EN 61000-6-2 Electromagnetic Compatibility, Generic Standards - Immunity for industrial environments
- EN 61000-6-4 Electromagnetic Compatibility, Generic Standards - Emission standard for residential, commercial and light-industrial environments
- EN ISO 12100-1 Safety of Machinery, Basic concepts, general principles for design - Basic terminology, methodology
- EN ISO 12100-2 Safety of Machinery, Basic concepts, general principles for design - Technical principles
- EN ISO 14121-1 Safety of Machinery, Risk assessment - Principles
- EN 60034-1 Rotating electrical machines - Rating and performance
- BS ISO 8528-3 Reciprocating internal combustion engine driven alternating current generating sets - alternating current generators for generating sets
- BS 5000-3 Rotating electrical machines - Generators to be driven by reciprocating internal combustion engines - Requirements for resistance to vibration

| NOTICE  |
|---|
| <b>Once the generator is built into a generating set, it is the responsibility of the generating set manufacturer to ensure that the generating set complies with the relevant EC Directives.</b> |

## 3.2 Additional Information for EMC Compliance

STAMFORD generators are designed to meet EMC emissions and immunity standards for industrial environments. Document reference N4/X/011 outlines additional equipment that may be required when the generator is installed in residential, commercial and light industrial environments.

The installation 'earth/ground' arrangements require the connection of the generator frame to the site protective earth conductor using a minimum lead length.

Installation, maintenance and servicing must be carried out by adequately trained personnel fully aware of the requirements of the relevant EC directives.

| NOTICE   |
|--|
| <b>Cummins Generator Technologies is not liable for EMC compliance if unauthorised parts, not of STAMFORD brand, are used for maintenance and servicing.</b> |

# 4 Introduction

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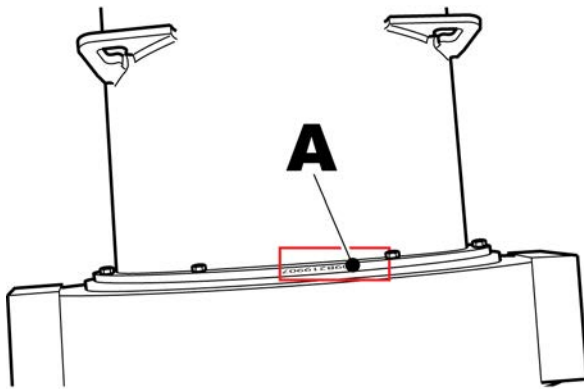
## 4.1 General Description - P7

P7 generators are of brushless rotating field design, available up to 660V/50Hz (1500 rpm) or 60Hz (1800 rpm), and built to meet BS5000 Part 3 and international standards.

P7 generators use a permanent magnet generator (PMG) excitation system using the MX341 or MX321 AVR.

## 4.2 Serial Number Location

The customer order number is stamped into the upper section of the drive end bracket. A unique serial number is shown on two labels on the outside of the terminal box.



## 4.3 Rating Plate

The self-adhesive rating plate label, supplied with the generator, must be fixed after the generator set is fully assembled and painted.

### WARNING

The generator could overheat if operated outside the parameters specified on the rating plate. Overheating can cause catastrophic failure and serious injury from ejected debris. Always operate the generator within the rated parameters.

## 4.4 Product Authentication

The STAMFORD high security, anti-counterfeit hologram is located on the Tracking Label. Check that the dots are visible around the STAMFORD logo when viewing the hologram from different angles and the word "GENUINE" appears behind the logo. Use a flashlight to see these security features in low ambient light. Check that the generator is genuine by entering the unique 7 character hologram code at [www.stamford-avk.com/verify](http://www.stamford-avk.com/verify).

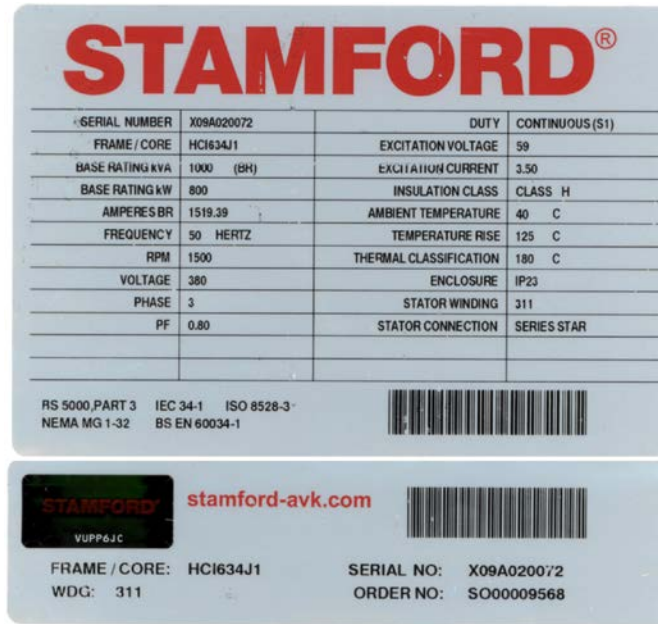


FIGURE 1. GLOBAL STAMFORD AC GENERATOR NAMEPLATE, COMPRISING RATING PLATE AND TRACKING LABEL



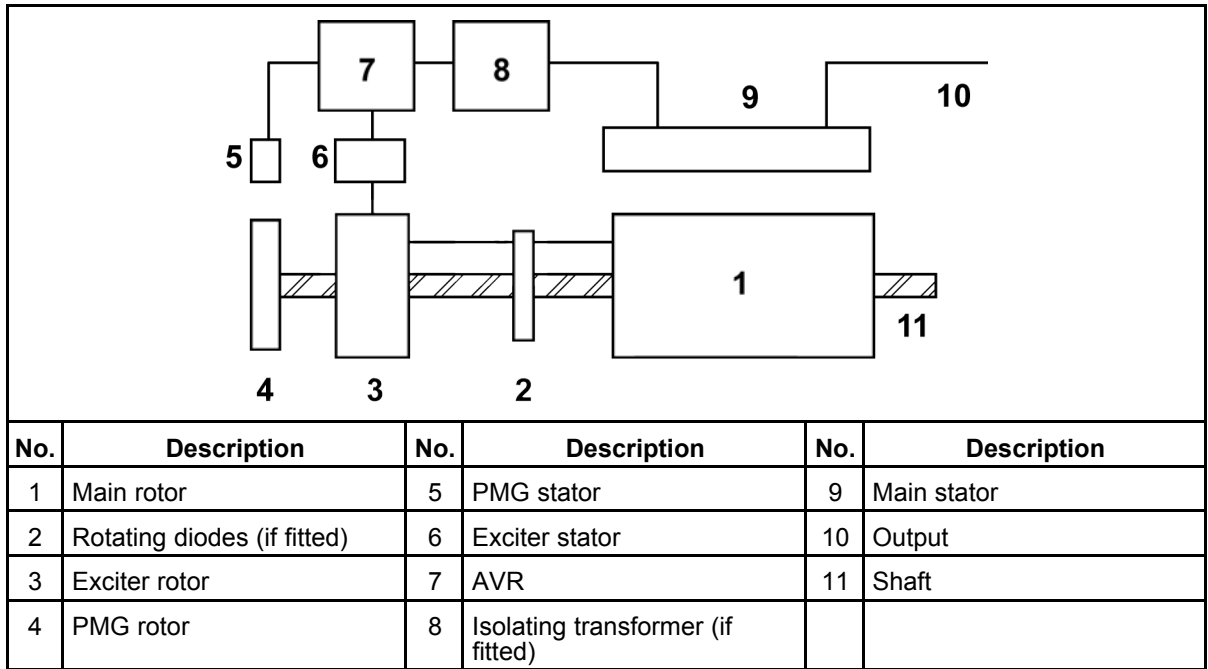
FIGURE 2. DOTS VISIBLE IN LEFT, RIGHT, UPPER AND LOWER VIEWS OF 3D HOLOGRAM

## 4.5 Separately-Excited AVR Controlled Generators

### 4.5.1 Permanent Magnet Generator (PMG) excited - AVR controlled generators

|   |
|---|
| <b>⚠ WARNING</b>  |
| <b>A Permanent Magnet Generator (PMG) has a strong magnetic field that could interfere with an implanted medical device, such as a pacemaker. Do not go near the PMG if you have an implanted medical device.</b> |

The Permanent Magnet Generator (PMG) provides power for the excitation of the exciter stator via the Automatic Voltage Regulator (AVR) which is the controlling device governing the level of excitation provided to the stator field. The AVR responds to a voltage-sensing signal derived, via DM110 or MA330 (where fitted), from the main stator winding. By controlling the low power of the exciter stator, control of the high power requirement of the main rotor is achieved through the rectified output of the exciter rotor.





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# 5 Automatic Voltage Regulators (AVR)

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Cummins Generator Technologies offer a selection of Automatic Voltage Regulators designed and built to achieve maximum performance from the range of STAMFORD brushless AC generators. Self-excited and separately-excited types are available, from low-cost analogue to sophisticated digital control. All STAMFORD AVR's are encapsulated to provide protection against moisture, salt and sand in the atmosphere, and are mounted on anti-vibration mounts for added mechanical protection.

All STAMFORD AVRs have the following features:

- connections to a remote hand trimmer accessory for fine control of the generator output voltage
- 'Under-Frequency Roll-Off' (UFRO) protection to reduce the generator output voltage if speed falls below a threshold, and
- connections to power factor and droop accessories for sharing reactive load in parallel with other generators or mains utility.

AVR specification, installation and adjustment information is available in the AVR manual supplied with the generator, or at [www.cumminsgeneratortechnologies.com](http://www.cumminsgeneratortechnologies.com)

| NOTICE   |
|--|
| If the supplied AVR is to be replaced by a different make, check its compatibility with Cummins Generator Technologies before use. |

## 5.1 Permanent Magnet Generator (Pilot) Types

For the ultimate in control, an AVR designed to operate with the permanent magnet generator (PMG) system is often specified. In this design, the AVR receives its power from a separate source in the form of a small PMG, mounted on the main generator shaft. The advantage of this arrangement is that the AVR power source is not affected by sudden loads applied to the generator, hence the excitation remains at full capability, providing superior motor starting and short circuit performance. By having a completely electrically isolated control system the generator is better able to meet the more stringent EMC performance requirements.

### 5.1.1 MX341

The MX341 achieves voltage regulation of  $\pm 1.0\%$  and protection against sustained over-excitation.

The AVR includes the following extra features:

- connections to an analogue signal from a power factor controller accessory, for example
- adjustable rate of voltage reduction with speed for (UFRO) protection
- soft-start control of generator output voltage rise when starting.

### 5.1.2 MX321

The MX321 achieves voltage regulation of  $\pm 0.5\%$ .

The AVR includes the following extra features:

- connections to an analogue signal from a power factor controller accessory, for example
- adjustable rate of voltage reduction with speed for (UFRO) protection
- soft-start control of generator output voltage rise when starting
- three-phase RMS voltage sensing
- over-voltage protection by shutdown and isolation
- adjustable delayed response (dwell) of excitation voltage to speed changes, and
- adjustable short-circuit or starting current limit (with optional current sensing transformer accessory).

## **5.2 AVR Accessories**

Accessories to support AVR functions are factory-fitted or supplied separately with instructions for fitting and wiring by a competent technician.

### **5.2.1 Hand Trimmer (for remote voltage adjustment)**

A hand trimmer can be fitted in a convenient position (typically in the generator set control panel) and connected to the AVR to provide fine adjustment of the generator voltage. The hand trimmer value and the adjustment range obtained is as defined in the Technical Specification. Refer to wiring diagrams to remove the shorting link and connect the hand trimmer.

### **5.2.2 Droop Transformer (for parallel operation – generator to generator)**

A droop transformer can be fitted in a defined position in the generator main output wiring and connected to the AVR to enable parallel operation with other generators. The adjustment range is as defined in the Technical Specification. Refer to wiring diagrams to remove the shorting link and connect the droop transformer. The droop transformer **MUST** be connected in the correct main output terminal for proper operation (details are as shown in the machine wiring diagram).

### **5.2.3 Power Factor Controller (for parallel operation – generator to mains utility)**

An electronic control module is available for use with the AVR to provide power factor control of the generator output. The module uses generator voltage and output current as inputs and interfaces with the AVR to ensure the necessary flexibility of the generator excitation and hence control of the exported (or imported) kVAr. This allows full closed-loop control of the generator power factor at the point of connection into the mains utility. Other features allow the generator (or generators) to be automatically 'voltage-matched' prior to paralleling. This accessory is not available with the AS480 AVR.

## 5.2.4 Current Limiting Transformers (MX321 AVR only)

Generator main output current can be electronically limited by connecting additional current transformers to the MX321 AVR. In any situation where the output current attempts to rise above a preset threshold (set on AVR) then the AVR will reduce the terminal voltage to restore the set current level. For unbalanced loads, operation is based on the highest of the three phase currents.

## 5.3 AVR Fault Finding

### WARNING

**Fault finding procedures present hazards, which can result in injury or death.**

Only personnel qualified to perform electrical and mechanical service should carry out these procedures. Ensure engine-starting circuits are disabled before commencing service or maintenance procedures.

Isolate any anti-condensation heater supply.

### NOTICE

**Before commencing any fault finding procedures examine all wiring for broken or loose connections.**

| Problem   | Action  |
|---|---|
| Voltage does not build-up to normal when starting the generator set.                | <ol style="list-style-type: none"> <li>1. Check link K1:K2 on AVR (not AS480) or auxiliary terminals: <ul style="list-style-type: none"> <li>- Replace if necessary and restart.</li> </ul> </li> <li>2. MX321 or MX341 only; <ul style="list-style-type: none"> <li>- Check the output from the PMG, Go to {Checking the PMG}.</li> </ul> </li> </ol>  |
| Voltage builds-up but is at an incorrect value.                                     | <ol style="list-style-type: none"> <li>1. Check AVR [VOLTS] control potentiometer setting: <ul style="list-style-type: none"> <li>- Correct if necessary.</li> <li>- Check 'Hand Trimmer' if one is fitted - adjust if necessary.</li> </ul> </li> <li>2. Check generator speed: <ul style="list-style-type: none"> <li>- Correct if necessary and restart.</li> </ul> </li> <li>3. Check AVR 'UFRO' indicator: <ul style="list-style-type: none"> <li>- If it is illuminated, Go to {UFRO Setting Procedure}.</li> </ul> </li> </ol> |
| Voltage is very slow to build up.   | <ol style="list-style-type: none"> <li>1. Check generator accelerates as expected: <ul style="list-style-type: none"> <li>- Correct if necessary and restart.</li> </ul> </li> <li>2. MX321 only; Check setting of ramp potentiometer: <ul style="list-style-type: none"> <li>- Correct if necessary and restart.</li> </ul> </li> </ol>  |
| Voltage rises and remains at a high level.  | <ol style="list-style-type: none"> <li>1. Check AVR wiring:</li> </ol>  |
| Voltage rises to a high level and then falls to a low level.                        | <ol style="list-style-type: none"> <li>1. Check AVR wiring:</li> </ol>  |
| Voltage is normal and then falls to a low level while the generator set is running. | <ol style="list-style-type: none"> <li>1. Check generator loading:</li> <li>2. Check machine Rotating Rectifiers</li> </ol>   |

| Problem   | Action  |
|---|---|
| Voltage is unstable either on no-load or with load.                 | <ol style="list-style-type: none"> <li>1. Check that the generator speed is stable:                             <ul style="list-style-type: none"> <li>- Correct if necessary and restart.</li> </ul> </li> <li>2. Check AVR wiring:</li> <li>3. Adjust the AVR [Stability] control slowly clockwise until steady.</li> </ol>   |
| Voltage falls to a low level when load is applied to the generator. | <ol style="list-style-type: none"> <li>1. Check generator speed is not dropping as load is applied:                             <ul style="list-style-type: none"> <li>- Correct if necessary and restart.</li> </ul> </li> <li>2. Check AVR 'UFRO' indicator:                             <ul style="list-style-type: none"> <li>- If it illuminates as load is applied, Goto {UFRO Setting Procedure}.</li> </ul> </li> </ol> |

If all the tests and checks listed above fail to locate the generator fault then it must be assumed that the AVR is faulty. There are no serviceable items on the AVR.

**The AVR should be replaced only by a genuine STAMFORD part.**

### 5.3.1 Checking The PMG (MA330, MX321 and MX341 AVR's only)

1. Start the generator set and run it at rated speed.
2. Measure the voltages at the AVR terminals P2, P3 and P4. These should be balanced and within the following ranges:
  - 50Hz generators: 170 ... 185VAC.
  - 60Hz generators: 200 ... 220VAC.
3. Stop the generator.
4. Measure the PMG winding resistances (at the connections under the PMG cover). These should be balanced and within the following range:
  - 4 pole generators: 2.6 ohms +/-10%
  - 6 pole generators: 5.6 ohms +/-10%
5. Use the results from tests 2) and 3) above together with the table below to identify the fault.

| PMG Voltages: |            | Phase/Phase Resistances: |                     |
|---------------|------------|--------------------------|---------------------|
|               |            | Correct                  | Incorrect           |
| Correct       | Balanced   | No fault with PMG        | Recheck resistances |
|               | Unbalanced | Connector ?              | Change PMG Stator   |
| Low           | Balanced   | Change PMG Rotor         | Change PMG Stator   |
|               | Unbalanced | Connector ?              | Change PMG Stator   |

### 5.3.2 UFRO Setting Procedure

1. Stop the generator.
2. Check that the AVR UFRO selection link is set for the required 50Hz or 60Hz operation.
3. Start the generator set and run it at rated speed.
4. If the voltage is now correct and the UFRO indicator is not illuminated, return to the fault finding procedure.

5. If the UFRO indicator is illuminated, continue as follows.
6. Adjust the [UFRO] control fully clockwise.
7. Set the generator speed at 95% of rated speed.  
For 50Hz installations: 1425rpm or 47.5Hz  
For 60Hz installations: 1710rpm or 57.0Hz
8. Adjust the [UFRO] control slowly counter-clockwise until the UFRO indicator just illuminates. Return the control slightly clockwise until the indicator is just extinguished.
9. The UFRO setting is now correct - return to the fault finding procedure.

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# 6 Application of the Generator

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It is the customers' responsibility to ensure that the sizing selection of the generator is suitable for the final application.

|  |
|--|
|  <b>CAUTION</b> |
| <b>Overloading the generator may lead to catastrophic failure.</b>                               |

## 6.1 Environment

STAMFORD generators are protected to IP23. IP23 is not adequate protection for use outdoors without additional measures.

|                            |                  |
|----------------------------|------------------|
| <b>Ambient Temperature</b> | <b>&lt;40 °C</b> |
| Humidity                   | <60%             |
| Altitude                   | <1000m           |

This table represents the normal operating conditions that the generator is designed for. Operation outside of these parameters is possible after due consideration and will be reflected on the generator nameplate. If the operating environment for the generator has changed after purchase, the rating of the generator needs to be revised, refer to the factory for details.

## 6.2 Air Flow

Ensure that the air inlets and outlets are not obstructed when the generator is running.

## 6.3 Airborne Contaminants

Contaminants such as salt, oil, exhaust fumes, chemicals, dust, sand, etc., will reduce the effectiveness of the insulation and lead to premature failure of the windings. Consider using air filters or an enclosure to protect the generator.

## 6.4 Air Filters

Filters present a restriction to the airflow so the rating of the generator must be reduced by 5%. If the filters are supplied, factory fitted, the rating on the nameplate will include the reduced rating. The filters can be retrofitted after delivery in which case the customer must apply the power reduction.

Air filters remove airborne particulates above 5 microns. The frequency of changing and cleaning the filters depend on the site conditions. We recommend that the filters are monitored frequently until a suitable cycle of change is established.



Air filters do not remove water. Additional protection must be employed to prevent the filters from getting wet. If the filters are allowed to get wet the airflow will be restricted and the generator will overheat. This will reduce the life expectancy of the insulation leading to premature failure of the generator.

## 6.5 Humid Conditions

The water carrying capacity of air depends on temperature. If the air temperature falls below its saturation point, dew can condense on the insulation of windings reducing its electrical resistance. In humid conditions additional protection may be required, even if the generator is fitted inside an enclosure.

## 6.6 Anti-condensation heaters

Anti-condensation heaters are designed to raise the temperature of the windings above the temperature of the surrounding material so that the condensation will not form on the windings. We recommend that anti-condensation heaters are fitted to all generators that are left switched off for any period of time. The best practice is to wire the heaters such that the heaters come on when the generator is switched off. This is particularly important in applications where high humidity is a significant problem.

## 6.7 Enclosures

An enclosure should be employed to protect the generator from adverse environmental conditions.

If the generator is to be fitted inside an enclosure, ensure that there is adequate airflow to support both the engine and the generator. Ensure that the generator air supply is clean (free from moisture and contaminants) and at or below the ambient temperature stated on the rating plate.

Also ensure that there are sufficient clearances around the generator for ease and safety of maintenance.

## 6.8 Vibration

STAMFORD generators are designed to withstand the vibration levels encountered on generating sets built to meet the requirements of ISO 8528-9 and BS 5000-3. (Where ISO 8528 is taken to be broad band measurements and BS5000 refers to the predominant frequency of any vibrations on the generating set).

| NOTICE  |
|---|
| <b>Exceeding either of the above specifications will have a detrimental effect on the life of the bearings and other components. This will invalidate the generator warranty.</b> |

### 6.8.1 Definition of BS5000–3

Generators shall be capable of continuously withstanding linear vibration levels with amplitudes of 0.25mm between 5Hz and 8Hz and velocities of 9.0mm/s rms between 8 Hz and 200 Hz, when measured at any point directly on the carcass or main frame of the machine. These limits refer only to the predominant frequency of vibration of any complex waveform.

### 6.8.2 Definition of ISO 8528-9

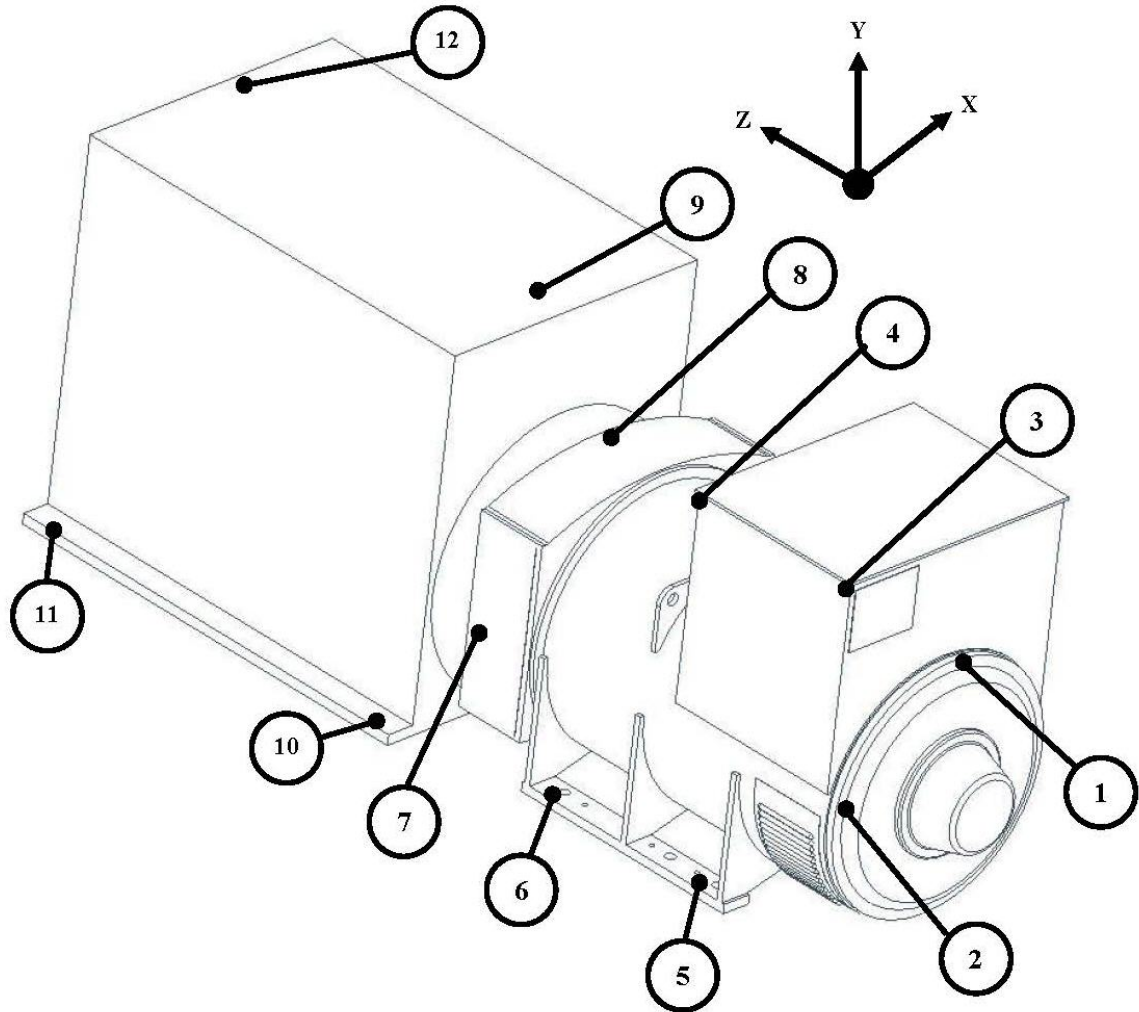
ISO 8528-9 refers to a broad band of frequencies; the broad band is taken to be between 10 Hertz and 1000 Hertz. The table below is an extract from ISO 8528-9 (Table C.1, value 1). This simplified table lists the vibration limits by kVA and speed for acceptable operation of standard generating set designs.

### 6.8.3 Linear Vibration Levels as Measured on the Generator - P7

| Linear Vibration Levels As Measured On The Generator - P7 |                            |  |  |  |
|---|----------------------------|--|--|--|
| Engine Speed<br>RPM<br>(min <sup>-1</sup> )               | Power Output<br>S<br>(kVA) | Vibration<br>Displacement<br>r.m.s. (mm) | Vibration<br>Velocity<br>r.m.s. (mm/s) | Vibration<br>Acceleration<br>r.m.s. (mm/s <sup>2</sup> ) |
| 1300 ≤ RPM ≤ 2000   | 250 < S                    | 0.32                                     | 20                                     | 13   |
| 720 ≤ RPM < 1300  | 250 < S ≤ 1250             | 0.32                                     | 20                                     | 13   |
|   | 1250 < S                   | 0.29                                     | 18                                     | 11   |
| The broad band is taken as 10 Hz - 1000 Hz                |                            |  |  |  |

### 6.8.4 Linear Vibration Monitoring

We recommend using vibration analysing equipment to measure vibration at the positions shown below. Check that vibration of the generating set is below the limits stated in the standards. If vibration is above the limits, the generating set builder should investigate the root causes and eliminate them. Best practice is for the generating set builder to take initial readings as a reference and for the user to periodically monitor vibration, according to the recommended service schedule, to detect a deteriorating trend.



## 6.8.5 Excessive Vibration levels

**⚠ CAUTION**

Excessive vibration can cause catastrophic failure of the generator, which could cause personal injury.

If the vibration levels of the generating set are not within the parameters quoted above:

1. Consult the genset builder; the genset builder should address the genset design to reduce the vibration levels as much as possible.
2. Contact Cummins Generator Technologies to understand the impact of not meeting the above levels on both bearing and generator life expectancy.

---

## 6.9 Bearings

### 6.9.1 Re-greasable Bearings

When re-greasable bearings are fitted the bearing housings incorporate fittings for pipe work to an external grease nipple. Generators with re-greasable bearings are supplied with information labels advising the user of grease type, re-lubrication frequency and the quality of grease to be used. These instructions must be followed. The grease used is a high specification synthetic compound that must not be mixed with grease of a different specification.

### 6.9.2 Bearing Life

Factors that affect bearing life:

- The life of a bearing in service is subject to the working conditions and the environment:
- High levels of vibration from the engine or misalignment of the set will stress the bearing and reduce its service life. Bearing life will be reduced if the vibration limits set out in BS 5000-3 and ISO 8528-9 are exceeded.
- Long stationary periods in an environment where the generator is subject to vibration can cause false brinelling, which puts flats on the balls and grooves on the races, leading to premature failure.
- Very humid or wet conditions can emulsify the grease causing deterioration of the grease and corrosion, leading to premature failure of the bearings.

### 6.9.3 Health Monitoring of the Bearings

We recommend that the user checks the bearing condition, using vibration monitoring equipment. Best practice is to take initial readings as a reference and periodically monitor the bearings to detect a deteriorating trend. It will then be possible to plan a bearing change at an appropriate generating set or engine service interval.

### 6.9.4 Bearing 'Service Life' Expectancy

Bearing manufacturers recognise that the "service life" of their bearings is dependent upon many factors that are not in their control; they cannot therefore quote a "service life", however, suggest practicable replacement intervals based on the L10 life of the bearing, the type of grease and the recommendations of the bearing and grease manufacturers.

For general-purpose applications: providing the correct maintenance is carried out, vibration levels do not exceed the levels stated in ISO 8528-9 and BS5000-3, and the ambient temperature does not exceed 50°C. Plan to replace bearings within 30,000 hours of operation.

If in doubt about any aspect of the 'bearing life' on STAMFORD generators, contact your nearest supplier of STAMFORD generators or contact the Stamford factory direct.

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# 7 Installation into the Generating Set

## 7.1 Lifting the Generator

Lift the generator by shackle and pin attachment to the lifting points (lugs or eyes) provided. A label attached to a lifting point shows the correct lifting arrangement. Use chains of sufficient length, and a spreader bar if necessary, to make sure that the chains are vertical when lifting. Make sure that the capacity of the lifting equipment is sufficient for the generator mass shown on the label.

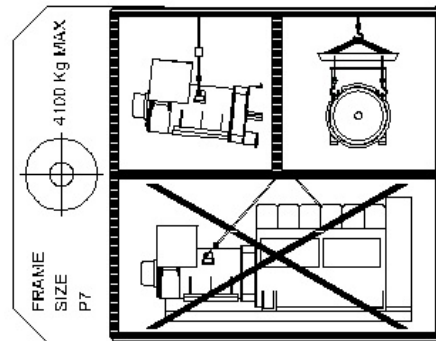


FIGURE 3. LIFTING LABEL

### ⚠ CAUTION

The generator lifting points are designed to lift the generator only. Do not lift the complete generating set (generator coupled to motive power source) by the generator lifting points. Keep the generator horizontal when lifting. Fit the transit bar to single bearing generators to keep the main rotor in the frame.

## 7.2 Storage

If the generator is not to be used immediately, it must be stored in a clean, dry, vibration free environment. We recommend the use of anti-condensation heaters.

### 7.2.1 After Storage

After a period of storage, carry out 'pre running checks' to determine the condition of the windings. If the winding are damp or the insulation is low, follow one of the 'drying out procedures', in the Service and Maintenance section of this manual.

If the generator has re-greasable bearings and has been in storage for 6 months or more, re-lubricate the bearings before use. If the bearings are sealed for life replace the bearings after 12 months in storage.

## 7.3 Generator Vibration, Frequency

The main vibration frequencies produced by the generator are as follows:

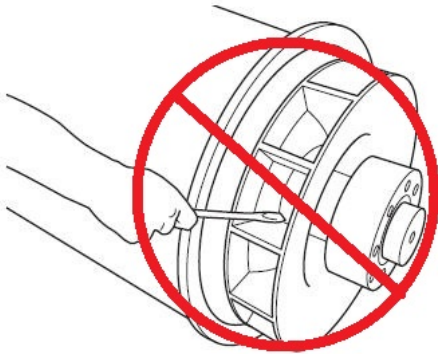
- 6-pole 1000 RPM 16⅔ Hz
- 6-pole 1200 RPM 20 Hz
- 4-pole 1500 RPM 25 Hz
- 4-pole 1800 RPM 30 Hz

However, vibrations induced by the engine are complex. It is the responsibility of the generating set designer to ensure that the alignment and stiffness of the bedplate and mountings do not exceed BS5000 part 3 and ISO 8528 part 9.

## 7.4 Generating Set Coupling

### NOTICE

**Do not attempt to rotate the generator rotor by levering against the vanes of the cooling fan. The fan is not designed to withstand such forces and will be damaged.**



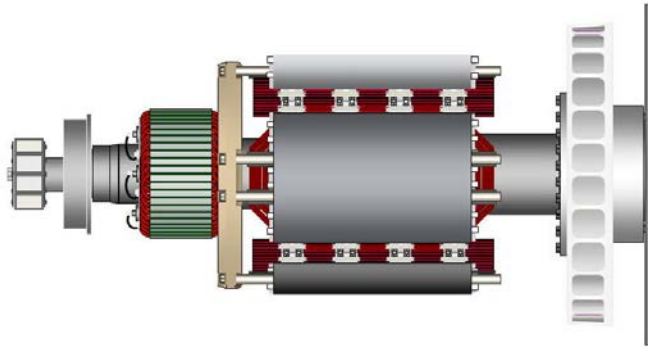
Efficient operation and long component life depend on minimising mechanical stresses on the generator. When coupled in a generating set, misalignment and vibration interactions with the prime mover engine can cause mechanical stress.

Generating sets need a substantial flat continuous bedplate to suit the installation site floor loading, with engine and generator mounting pads to make a firm base for accurate alignment. The height of all mounting pads must be within 0.25 mm for skid mounting, 3 mm for non-adjustable anti-vibration mounts (AVM) or 10 mm for adjustable height AVMs. Use shims to achieve level. The rotational axes of generator rotor and engine output shaft must be coaxial (radial alignment) and perpendicular to the same plane (angular alignment). The axial alignment of the generator and engine coupling must be within 0.5 mm, taking into account thermal expansion, to minimise unwanted axial force on the bearings at operating temperature.

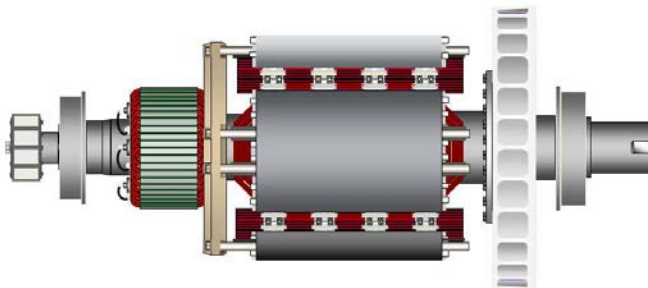
Vibration can occur by flexing of the coupling. The generator is designed for a maximum bending moment not exceeding 275 kgm (2000 lbs ft). Check the maximum bending moment of the engine flange with the engine manufacturer.

Close-coupling of generator and engine can increase the rigidity of the generating set. Both single and two bearing generators can be close-coupled.

To prevent rust during transit and storage, the generator frame spigot, rotor coupling plates and shaft extension have been treated with a rust preventative coating. Remove this before coupling the generating set.



**FIGURE 4. SINGLE BEARING GENERATOR ROTOR SHOWING COUPLING DISCS BOLTED TO DRIVE END COUPLING HUB (AT RIGHT)**



**FIGURE 5. TWO BEARING GENERATOR ROTOR SHOWING SHAFT WITH KEYWAY FOR FLEXIBLE COUPLING (AT RIGHT)**

### 7.4.1 Single Bearing

1. Check that the bracket which supports the rotor underneath the fan hub is fitted in position.
2. Position the generator close to the engine and remove the transit bar that keeps the rotor in place during transport.
3. Remove air outlet covers from the drive end of the generator to access the coupling and adaptor bolts.
4. Check that coupling discs are concentric with adaptor spigot. Adjust by suspending the rotor into position. Use alignment studs to ensure that the disc and the flywheel are in alignment.
5. Offer the generator to engine and engage both coupling discs and housing spigots at the same time, pushing generator towards engine until coupling discs are against flywheel face and the housing spigots are located.

#### **⚠ CAUTION**

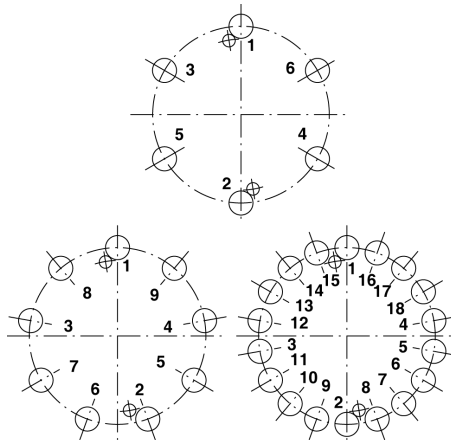
**Do not pull the generator to the engine using bolts through the flexible discs.**



6. On the engine ensure the distance from flywheel coupling mating face to the flywheel housing mating face is within 0.5mm of nominal dimension. This ensures there is no thrust applied to the engine or generator bearings. Ensure securing bolts are tightened to relevant torques.

|   |
|---|
| <b>⚠ CAUTION</b>  |
| <b>Failure to secure bolts can lead to excessive vibration, which in turn can lead to catastrophic generator failure.</b> |

7. Use heavy gauge washers to fit housing and coupling bolts. Tighten bolts evenly around assembly sufficiently to ensure correct alignment.



Torque the bolts in the above sequence according to the correct bolt patten.

Then check the torque in each bolt in a clockwise direction around the bolt circle to ensure all the bolts are properly torqued.

8. Tighten coupling disc to flywheel bolts. Refer to engine manufacturer's manual for correct tightening torque.
9. Remove the rotor support bracket.
10. Remove rotor aligning aids and replace all covers.

## 7.4.2 Two Bearing

A flexible coupling, designed to suit the specific engine/generator combination, is recommended to minimise torsional vibration effects.

If a close coupling adaptor is used the alignment of machined faces must be checked by offering the generator up to the engine. Shim the generator feet if necessary.

## 7.5 Pre-Running Checks

Before starting the generating set, test the insulation resistance of windings, check all connections are tight and in the correct location. Ensure the generator air path is clear of obstructions. Replace all covers.

## 7.6 Insulation Resistance Test

A resistance test by qualified personnel should be carried out based on the relevant operating voltage:

| <b>NOTICE</b>  |  |
|--|--|
| <b>The AVR should be disconnected during this test</b> |  |

| Voltage        | Test Voltage           | Minimum Required Insulation Resistance |     |
|----------------|------------------------|--|-----|
|                |                        | In Service                             | New |
| LV – up to 1kv | 500V Megger            | 5 MΩ                                   | 10  |
| MV – 1 - 4.6kv | 2500V motorized Megger | 50 MΩ                                  | 100 |
| HV – 4.6 - 20v | 5000V motorized Megger | 150 MΩ                                 | 300 |

Should the insulation resistance be less than the quoted limits, drying out the generator windings is essential. See the Service & Maintenance section of this Manual.

### 7.6.1 MV & HV Machines

| <b>NOTICE</b>   |  |
|---|--|
| <b>The AVR plus any voltage transformers should be disconnected. Any temperature detector devices (RTDs/Thermistors) should be disconnected and grounded during the test. Refer to the generator winding diagram for details.</b> |  |

The insulation resistance values quoted is for windings at an ambient temperature of 20 °C. Insulation resistance significantly reduces as winding temperatures increase, based on the assumption that IR reduces by 50% for every 10 °C increases in temperature, the reduction factors are:

| Temperature | Factor |
|-------------|--------|
| 20 °C       | 1.0    |
| 30 °C       | 0.5    |
| 40 °C       | 0.25   |
| 50 °C       | 0.125  |
| 60 °C       | 0.625  |
| 70 °C       | 0.313  |
| 80 °C       | 0.015  |

| <b>⚠ WARNING</b>   |  |
|--|--|
| <b>Insulation testing leaves a high voltage. Discharge windings by shorting to earth through an earthing rod for at least 5 minutes after testing.</b> |  |

## 7.6.2 H.V. Testing

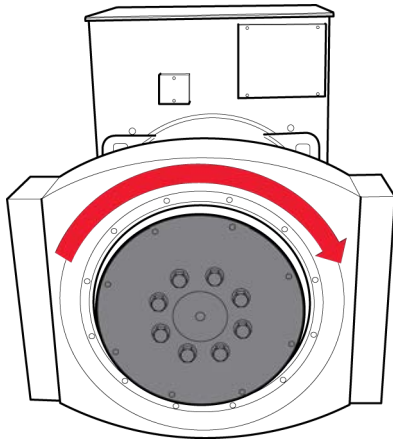
### NOTICE

The windings have been H.V. tested during manufacture and further H.V. testing may degrade the insulation with consequent reduction in operating life. Should it be necessary to demonstrate H.V. testing, for customer acceptance, the tests must be carried out at reduced voltage levels i.e. Test Voltage= 0.8 (2 X Rated Voltage + 1000)

This applies only to new machines, After being in service, testing levels should be further reduced to 1.5 x Rated Voltage for maintenance testing. This HV test should only be completed after megger tests and evaluation.

## 7.7 Direction of Rotation

The direction of rotation of the generator is designed to be clockwise as viewed from the drive end of the generator. If it needs to run in reverse direction, please seek advice from Cummins Generator Technologies.



## 7.8 Phase Rotation

The output from the generator will have a phase sequence of U V W with the generator running clockwise as viewed from the drive end. If the phase rotation of the generator has to be reversed, the customer must rearrange the output cables to a UVW configuration. Ask for a circuit diagram of 'reverse phase connections'.

## 7.9 Voltage and Frequency

Check that the voltage and frequency levels required for the generating set application are as indicated on the generator nameplate.

## 7.10 AVR adjustment

To make AVR selections and adjustments remove the AVR cover. The AVR is factory set and will give satisfactory performance during initial running tests. Subsequent voltage adjustment both on and off load may be required. Guidance can be found in the section for the relevant AVR.

## 7.11 Installation on Site

### NOTICE

**It is the responsibility of the end user and his contractors/subcontractors to ensure that the overall electrical installation and system protection meets the needs of any inspectorate, local electricity authority or safety rules, pertaining to the site location.**

Cables should be supported appropriately to avoid a tight radius at the point of entry into the terminal box panel and allow movement for the generator set on its anti vibration mountings without causing excessive stress to the cables and generator load terminals.

To enable the system designer to achieve the necessary protection and/or discrimination, fault current curves are available on request from the factory, together with generator reactance values to enable fault current calculations to be made.

### WARNING

**Incorrect installation and/or protective systems can result in personal injury and/or equipment damage. Installers must be qualified to perform electrical installation work.**

## 7.12 Grid Connection: Voltage Surges and Micro-Interruptions

Precautions should be taken to prevent transient voltages generated by the connected load and/or the distribution system from causing damage to the generator components.

To identify any possible risk, all aspects of the generator's proposed application should be considered, especially the following:

- Loads with characteristics that result in large load step changes.
- Load control by Switchgear, and power control by any method likely to generate transient voltage spikes.
- Distribution systems susceptible to external influences, such as overhead lines and lightning strikes.
- Applications involving parallel operation to a mains supply, where the risk of a mains disturbance in the form of a micro-interruption could occur.

If the generator is at risk of voltage surges or micro-interruptions adequate protection must be incorporated into the generation system. This is normally in the form of surge arrestors and suppressors.

## 7.13 Embedded Applications

These notes cover applications with the generator running in parallel with the mains utility such as CHP (sometimes called co-generation).

A typical Thermal Class for this duty would be as identified by ISO 8528 as a “basic continuous rating” (BR), Class ‘F’ rating - continuous duty. This will offer the best operating efficiency, along with low thermal stress levels for the winding insulation system.

The operating voltage range of the local mains supply must be established, and then considered in conjunction with the specified kVA, kVAr, and kWe. The full range of the required operating duty should then be considered against the generator’s operating chart (capability diagram). A co-generation application is a continuous fixed duty, always within the ‘BR’ category, and no overload capability is expected.

The recommended level of protection for an embedded application is detailed below.

| Protection   | Min | Option |
|--|-----|--------|
| Overcurrent  | X   |        |
| Short Circuit  | X   |        |
| Under Volts  | X   |        |
| Over Volts   | X   |        |
| Under Hz   | X   |        |
| Over Hz  | X   |        |
| Differential   |     | X      |
| Earth Fault  |     | X      |
| Stator RTDs  |     | X      |
| Vibration Monitoring                                   |     | X      |
| Bearing Condition Monitor                              |     | X      |
| Reverse Power  | X   |        |
| Excitation Loss  | X   |        |
| Power Factor Control                                   | X   |        |
| Voltage Matching                                       | X   |        |
| Mains Interruption (Vector Shift, Frequency Deviation) | X   |        |

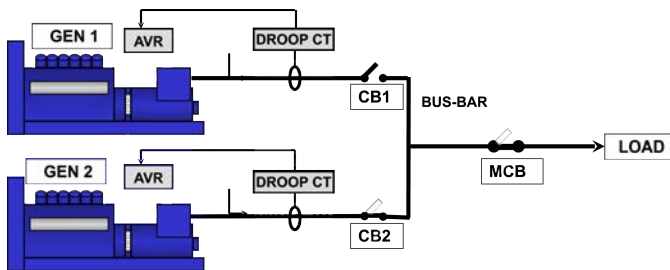
If the overload and short circuit protection is provided by a circuit breaker, care must be taken with the protection settings. Circuit breakers are normally designed for operation with the utility supply, which sustains higher and longer durations of fault level than the generator can tolerate. The circuit breaker’s overcurrent and short circuit settings should therefore be set according to the generators operating curves and not the overcurrent/short circuit details on the circuit breaker.

The generator overload and short circuit settings on the protection should be set so that they are below the thermal damage curve for the generator.

Generator data sheets are available to help calculate these settings.

## 7.14 Synchronisation

### 7.14.1 Parallel or Synchronizing AC Generators



- The synchronising switch/breaker should be of a type that will not cause “contact bounce” when it operates.
- The synchronising switch/breaker should be adequately rated to withstand the continuous full load current of the generator.
- The switch/breaker should be able to withstanding the rigorous closing cycles during synchronising and the currents produced if the generator is paralleled out of synchronism.
- The closing time of the synchronising switch/breaker should be under the control of the synchroniser settings.
- The switch/breaker should be capable of operation under fault conditions such as short circuits. Generator data sheets are available.

#### NOTICE

The fault level may include a contribution from other generators as well as from the grid/mains utility.

The method of synchronising should be either automatic, or by check synchronising. The use of manual synchronising is not recommended. The settings on the synchronising equipment should be such that the generator will close smoothly.

| The Phase sequence must match |            |
|-------------------------------|------------|
| Voltage difference            | +/- 0.5%   |
| Frequency difference          | 0.1 Hz/sec |
| Phase angle                   | +/- 10°    |
| C/B closing time              | 50 ms      |

The settings for the synchronising equipment to achieve this must be within these parameters.

The voltage difference when paralleling with the grid/mains utility is +/- 3% .

#### ⚠ CAUTION

Synchronising outside these parameters may result in catastrophic failure of the generator.

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# 8 Service & Maintenance

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## 8.1 Lock Out/Tag Out

 **WARNING**

Before any dissembling or assembling procedures are carried out ensure that the generating set is inhibited mechanically and isolated electrically.

 **WARNING**

Service and fault finding procedures present hazards, which can result in severe personal injury or death. Only personnel qualified to perform electrical and mechanical service should carry out these procedures.

 **WARNING**

The electrical supply to anti-condensation heaters must be isolated before attempting any work adjacent to the heater.

It is suggested that a suitable lock-out/tag out process is adopted.

If anti condensations heaters are defect repair by replacement. Access is available via the air inlets at the non-drive end.

## 8.2 Methods of Drying Out Generators

### 8.2.1 Cold Run

In many cases, the generator can be dried suitably using its own ventilation system. However, it should not be electrically live whilst this is being carried out. De-excite the machine as indicated in its circuit diagram. Operate the anti-condensation heater, where fitted, when drying out with the machine's own ventilation system. Run the machine in this condition until the minimum IR is achieved.

### 8.2.2 Blown Air Drying

During drying, air must be able to flow freely through the generator in order to carry off the moisture.

Direct hot air from two electrical fan heaters of around 1 – 3kW into the generator air inlet apertures. Ensure the heat source is at least 300mm away from the windings to avoid over heating and damage to the insulation.

Apply the heat and plot the insulation value at half hourly intervals. The process is complete when the parameters covered in the section entitled, '[Typical Drying Out Curve](#)', are met.

Remove the heaters, and re-commission as appropriate.

If the set is not to be run immediately ensure that the anti-condensation heaters are energised, and retest prior to running.



## 8.2.3 Short Circuit Method

### **⚠ DANGER**

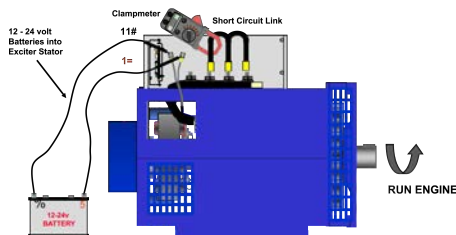
**Risk of electric shock. Do not touch line or neutral terminals during the short circuit run. Some winding designs may produce a voltage between the 3 shorted line terminals and the neutral.**

### **⚠ CAUTION**

**This process should only be performed by a qualified engineer.**

### **⚠ CAUTION**

**The short circuit must not be applied with the AVR connected in circuit. Current in excess of the rated generator current will cause damage to the windings.**



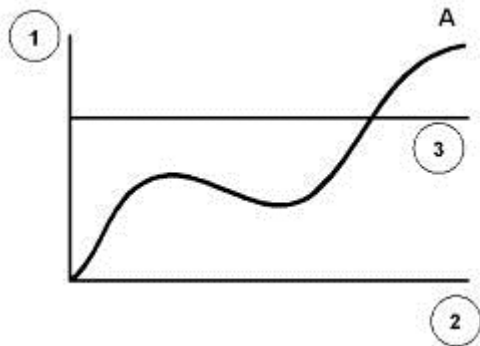
1. Bolt a short circuit of adequate current carrying capacity, across the main terminals of the generator. The shorting link should be capable of taking full load current.
2. Disconnect the cables from terminals “X” and “XX” of the AVR.
3. Connect a variable dc supply to the “X” (positive) and “XX” (negative) field cables. The dc supply must be able to provide a current up to 2.0 Amp at 0 - 24 Volts.
4. Position a suitable ac ammeter to measure the shorting link current.
5. Set the dc supply voltage to zero and start the generating set. Slowly increase the dc voltage to pass current through the exciter field winding. As the excitation current increases, so the stator current in the shorting link will increase. This stator output current level must be monitored, and not allowed to exceed 80% of the generator’s rated output current.

After every 30 minutes of this exercise:

1. Stop the generator and switch off the separate excitation supply, measure and record the stator winding IR values, and plot the results. The resulting graph should be compared with the classic shaped graph. This drying out procedure is complete when the parameters covered in the section entitled 'Typical Drying Out Curve' are met.
2. Once the Insulation Resistance is raised to an acceptable level, the dc supply may be removed and the exciter field leads “X” and “XX” re-connected to their terminals on the AVR.
3. Rebuild the genset, replace all covers and re-commission as appropriate.
4. If the set is not to be run immediately ensure that the anti-condensation heaters are energised, and retest the generator prior to running.

## 8.3 Typical Drying Out Curve

Whichever method is used to dry out the generator the resistance should be measured every half-hour and a curve plotted as shown



1. Y axis = Resistance
2. X axis = Time
3. Refer to One Megahom limit

The illustration shows a typical curve for a machine that has absorbed a considerable amount of moisture. The curve indicates a temporary increase in resistance, a fall and then a gradual rise to a steady state. Point 'A', the steady state, must be greater than 1.0 megahom. (If the windings are only slightly damp the dotted portion of the curve may not appear). For general guidance, expect that the typical time to reach point 'A' will be around 3 hours.

Drying should be continued after point "A" has been reached for at least one hour.

Values of insulation resistance significantly reduce as winding temperature increases, Therefore, the reference values can only be established with windings at a temperature of approximately 20°C.

If the IR value remains below the required values, even after the above drying methods have been carried out correctly, then a Polarisation Index test [PI] should be carried out.

### NOTICE

**The generator must not be put into service until the minimum values are achieved.**

## 8.4 Air Filters

Air filters for the removal of airborne particulate matter (dust) are offered as an addition to the standard build option. The filter elements do not remove water and therefore must not be allowed to get wet.

The frequency of filter maintenance will depend upon the severity of the site conditions. Regular inspection of the elements will be required to establish when cleaning is necessary.

### NOTICE

**Do not charge filters with oil.**

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**⚠ CAUTION**

**Only remove filter elements with the generator out of service, to avoid damage to the generator**

### **8.4.1 Air Filter Cleaning Procedure**

1. Remove the filter elements from the filter frames, taking care not to damage them.
2. Invert the filters dirty side down and agitate to remove particles of dirt. To remove stubborn particles, low-pressure air can be used in the reverse direction of flow. If necessary use a soft brush to gently brush off any remaining dirt particles.
3. Clean the sealing gaskets and surrounding area.
4. Visually check the condition of the filter elements and sealing gaskets, replace as necessary.
5. Ensure that the filter elements are dry before putting them back into service.
6. Carefully replace the filter elements.

## **8.5 Generator Cleaning**

Ensure generator is isolated prior to any cleaning operation. Avoid exposure of generator windings to cleaning agents.

# 9 Fault Finding

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## WARNING

**Fault finding procedures present hazards, which can result in injury or death. Only personnel qualified to perform electrical and mechanical service should carry out these procedures.**

Ensure engine-starting circuits are disabled before commencing service or maintenance procedures and refer to detailed AVR instructions. Always use insulated screwdrivers when adjusting AVR. Isolate any anti-condensation heater supply

## NOTICE

**Before commencing any fault finding procedures examine all wiring for broken or loose connections.**

| <p>Loss of voltage, excessive noise, overheating, high bearing temperatures and unstable operation from the generator are all symptomatic of a generator malfunction. However, these faults are often wrongly attributed to the generator because defects in other components or generator installation can produce the same symptoms.</p> <p>This checklist provides a comprehensive list of the most common symptoms related to the generator and its installation. Before replacing the generator, verify the problem by consulting the chart below. If after taking the appropriate action the problem still persists, please contact your nearest authorised MARKON/STAMFORD/AVK for advice</p> | High Voltage | Low voltage | No Voltage | Unstable Voltage | High excitation voltage | Incorrect power factor | Cracked panels | Generator noisy | High bearing temperature | Broken/Loose terminals | High Winding Temperature | High kVar | Unable to synchronise | Rapidly rising current |
|--|--------------|-------------|------------|------------------|-------------------------|------------------------|----------------|-----------------|--------------------------|------------------------|--------------------------|-----------|-----------------------|------------------------|
| <p>Incorrect AVR Sensing Voltage<br/>Check sensing supply voltage, repair or replace as necessary</p>  | •            | •           |            |                  |                         |                        |                |                 |                          |                        |                          |           |                       |                        |
| <p>AVR Volts Control or Hand Trimmer Incorrectly Set or Faulty<br/>Adjust as necessary, ensure engine speed is correct</p>   | •            | •           |            |                  | •                       |                        |                |                 |                          |                        |                          |           |                       |                        |
| <p>Sensing Transformer Faulty<br/>Check sensing supply</p>   | •            | •           |            |                  |                         |                        |                |                 |                          |                        |                          |           |                       |                        |
| <p>AVR Faulty<br/>Replace AVR and re-test</p>  | •            | •           | •          | •                | •                       | •                      |                |                 |                          |                        |                          | •         |                       |                        |
| <p>Loose, Broken, or Corroded Connections<br/>Check connections on auxiliary terminal board and AVR terminals<br/>Repair or replace as necessary</p>   | •            | •           | •          | •                | •                       | •                      |                |                 |                          |                        |                          | •         |                       |                        |
| <p>High Voltage on Load<br/>Unbalanced load, re-distribute load over all three phases</p>  | •            |             |            |                  |                         |                        |                |                 |                          |                        | •                        |           |                       |                        |
| <p>Leading Power Factor<br/>Correct power factor</p>   | •            |             |            | •                |                         |                        |                |                 |                          |                        |                          |           |                       |                        |
| <p>Voltmeter faulty or Sticking<br/>Check and verify voltage across machine output terminals with a multimeter</p>   | •            | •           | •          | •                |                         |                        |                |                 |                          |                        |                          |           |                       |                        |
| <p>Loss of Residual magnetism<br/>Restore residual magnetism in exciter stator</p>   |              |             | •          |                  |                         |                        |                |                 |                          |                        |                          |           |                       |                        |
| <p>Under Frequency Roll Off Protections Incorrectly Set<br/>Adjust as necessary</p>  |              | •           |            |                  |                         |                        |                |                 |                          |                        |                          |           |                       |                        |
| <p>Faulty Winding or Rotating Diodes<br/>Find and correct cause of failure, repair or replace winding and/or diodes as necessary</p>   |              | •           | •          | •                |                         |                        |                |                 |                          |                        |                          |           |                       |                        |
| <p>Surge Suppressor or main Rotating Diode Short Circuit<br/>Find and correct cause of failure, repair or replace with relevant service rectifier kit</p>  |              |             | •          |                  | •                       |                        |                |                 |                          |                        |                          |           |                       |                        |
| <p>Load applied to Generator During Run Up<br/>Follow correct procedure for applying load (self excited generator)</p>   |              |             | •          |                  |                         |                        |                |                 |                          |                        |                          |           |                       |                        |
| <p>AVR K1 and K2 Link Open Circuit<br/>Verify connection and take necessary action to repair</p>   |              |             | •          |                  |                         |                        |                |                 |                          |                        |                          |           |                       |                        |
| <p>AVR Stability Incorrectly Adjusted<br/>Adjust AVR until voltage stabilises</p>  |              |             |            | •                |                         |                        |                |                 |                          |                        |                          |           |                       |                        |
| <p>Intermittent Earth<br/>Check IR windings</p>  |              |             |            | •                |                         |                        |                |                 |                          |                        |                          |           |                       |                        |
| <p>Fluctuation in Load Current<br/>Check the load current on a stable supply and take necessary action</p>   |              |             |            | •                |                         |                        |                |                 |                          |                        |                          |           |                       |                        |
| <p>Faulty Exciter Rotor/Stator Winding<br/>Check resistance and IR of windings and replace if necessary</p>  |              |             |            |                  | •                       |                        |                |                 |                          |                        |                          |           |                       |                        |

FIGURE 6. ELECTRICAL FAULT FINDING CHART PRT 1

|  |              |             |            |                  |                         |                        |                |                 |                          |                        |                          |           |                       |                        |
|--|--------------|-------------|------------|------------------|-------------------------|------------------------|----------------|-----------------|--------------------------|------------------------|--------------------------|-----------|-----------------------|------------------------|
| <p>Loss of voltage, excessive noise, overheating, high bearing temperatures and unstable operation from the generator are all symptomatic of a generator malfunction. However, these faults are often wrongly attributed to the generator because defects in other components or generator installation can produce the same symptoms.</p> <p>This checklist provides a comprehensive list of the most common symptoms related to the generator and its installation. Before replacing the generator, verify the problem by consulting the chart below. If after taking the appropriate action the problem still persists, please contact your nearest authorised MARKON/STAMFORD/AVK for advice</p> | High Voltage | Low voltage | No Voltage | Unstable Voltage | High excitation voltage | Incorrect power factor | Cracked panels | Generator noisy | High bearing temperature | Broken/Loose terminals | High Winding Temperature | High KVar | Unable to synchronise | Rapidly rising current |
| <p>Non-Linear Loads<br/>Contact factory for further advice</p>   |              |             |            | •                |                         |                        |                |                 |                          |                        |                          |           |                       |                        |
| <p>Faulty Power factor Controller<br/>Check and Replace where necessary</p>  |              |             |            |                  | •                       | •                      |                |                 |                          |                        | •                        |           |                       |                        |
| <p>Faulty Main Rotor Winding<br/>Check resistance and IR of windings and replace if necessary</p>  |              |             |            |                  | •                       |                        |                |                 |                          |                        |                          |           |                       |                        |
| <p>PMG Damaged<br/>Find and correct cause of failure, repair or replace PMG as necessary</p>   |              | •           |            | •                |                         |                        |                |                 |                          |                        |                          |           |                       |                        |
| <p>Droopp CT Fitted or Connected Incorrectly<br/>Inspect fitting and connection and repair as necessary</p>  |              |             |            |                  |                         |                        |                |                 |                          |                        |                          |           |                       | •                      |
| <p>Fauky Winding RTD Probe<br/>Investigate RTD probe and repair or replace where necessary</p>   |              |             |            |                  |                         |                        |                |                 |                          |                        | •                        |           |                       |                        |
| <p>Overload<br/>Re-instate correct loading</p>   |              | •           |            |                  | •                       |                        |                |                 |                          |                        | •                        |           |                       |                        |
| <p>Excessive KVar<br/>Adjust load or power factor accordingly</p>  |              |             |            |                  | •                       |                        |                |                 |                          |                        | •                        | •         |                       |                        |
| <p>Phase Window<br/>Ensure phase window is within set parameters</p>   |              |             |            |                  |                         |                        |                |                 |                          |                        |                          |           |                       | •                      |
| <p>Phase Sequence Incorrect<br/>Investigate and rectify sequence</p>   |              |             |            |                  |                         |                        |                |                 |                          |                        |                          |           |                       | •                      |
| <p>Incorrect Selection of Control System<br/>Review selection and make necessary remedial actions</p>  |              |             |            |                  |                         |                        |                |                 |                          |                        |                          |           |                       | •                      |
| <p>Unstable Speed<br/>Regulate speed to meet necessary synchronising requirements</p>  |              |             |            | •                |                         |                        |                |                 |                          |                        |                          |           |                       | •                      |

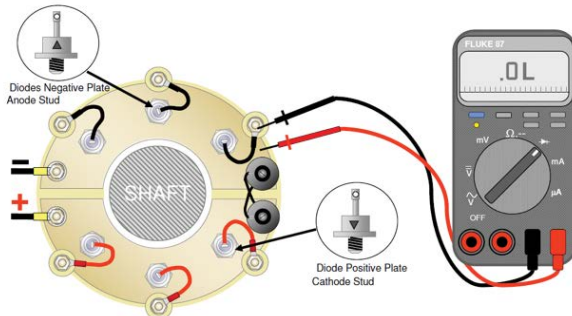
FIGURE 7. ELECTRICAL FAULT FINDING CHART PRT 2

| <p>Loss of voltage, excessive noise, overheating, high bearing temperatures and unstable operation from the generator are all symptomatic of a generator malfunction. However, these faults are often wrongly attributed to the generator because defects in other components or generator installation can produce the same symptoms.</p> <p>This checklist provides a comprehensive list of the most common symptoms related to the generator and its installation. Before replacing the generator, verify the problem by consulting the chart below. If after taking the appropriate action the problem still persists, please contact your nearest authorised MARKON/STAMFORD/AVK for advice</p> | High Voltage | Low voltage | No Voltage | Unstable Voltage | High excitation voltage | Incorrect power factor | Cracked panels | Generator noisy | High bearing temperature | Broken/Loose terminals | High Winding Temperature | High kVar | Unable to synchronise | Rapidly rising current |
|--|--------------|-------------|------------|------------------|-------------------------|------------------------|----------------|-----------------|--------------------------|------------------------|--------------------------|-----------|-----------------------|------------------------|
| Prime Mover Over Speed<br>Correct Speed  | •            |             |            |                  |                         |                        |                |                 |                          |                        |                          |           |                       |                        |
| Prime Mover Under Speed<br>Correct Speed   |              | •           |            |                  | •                       |                        |                |                 |                          |                        |                          |           |                       |                        |
| Prime Mover Unstable (hunting)<br>Check and rectify as necessary   |              |             |            | •                |                         |                        |                |                 |                          |                        |                          |           |                       |                        |
| Vibration<br>Check vibration levels are within the set standards   |              |             |            |                  |                         |                        | •              | •               | •                        | •                      |                          |           |                       |                        |
| Torsional Vibration<br>Genset manufacturer to conduct review of application  |              |             |            |                  |                         |                        |                | •               | •                        |                        |                          |           |                       |                        |
| Loose Panels<br>Check and rectify as necessary   |              |             |            |                  |                         |                        |                | •               |                          |                        |                          |           |                       |                        |
| Incorrect Bearing Greasing<br>Follow set procedure and recommendations   |              |             |            |                  |                         |                        |                | •               | •                        |                        |                          |           |                       |                        |
| Worn or Damaged Bearing<br>Investigate cause of bearing damage, replace where necessary  |              |             |            |                  |                         |                        |                | •               | •                        |                        |                          |           |                       |                        |
| Faulty Bearing RTD Probe<br>Investigate RTD probe and repair or replace where necessary  |              |             |            |                  |                         |                        |                |                 | •                        |                        |                          |           |                       |                        |
| Misalignment<br>Repair or replace any damaged components and correct alignment   |              |             |            |                  |                         |                        | •              | •               | •                        |                        |                          |           |                       |                        |
| PMG Damaged<br>Find and correct cause of failure, repair or replace PMG as necessary   |              | •           | •          | •                |                         |                        |                |                 |                          |                        |                          |           |                       |                        |
| Air Flow Inadequate<br>Check and restore airflow requirements as stated in generator data sheets   |              |             |            |                  |                         |                        |                |                 |                          |                        | •                        |           |                       |                        |
| Re-circulating Air Flow<br>Investigate cause of re-circulating air and take necessary remedial action  |              |             |            |                  | •                       |                        |                |                 | •                        |                        | •                        |           |                       |                        |
| Dirty Air Filters<br>Clean, repair or replace as necessary   |              |             |            |                  |                         |                        |                |                 |                          |                        | •                        |           |                       |                        |

FIGURE 8. MECHANICAL FAULT FINDING CHART

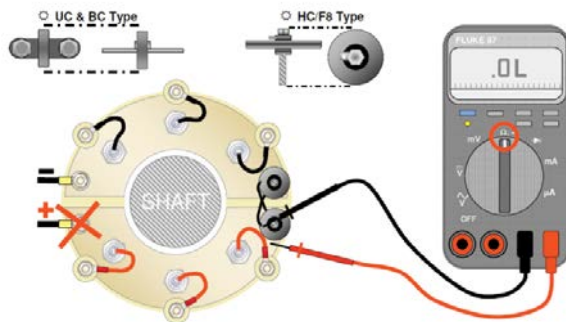
## 9.1 Fault Finding Procedure for Rotating Diodes and Surge Suppressor:

### 9.1.1 Check Rectifier Diodes



- Reverse the multimeter leads so that the Positive lead is on the Anode side of the diode, the Multimeter should now read OL. (no electron flow).
- A faulty diode will give a short circuit reading in both directions, or an open circuit reading in both directions, (usually because the solder joint has failed).

### 9.1.2 Testing the Surge Suppressor (Varistor)



- Disconnect one of the main rotor leads (+ or -)
- Switch the Multimeter to the position indicated for resistance " $\Omega$ " testing
- The Varistor should read Infinity in both directions, and has no polarity
- A faulty Varistor will be short circuit, or burnt (destroyed) by fault current

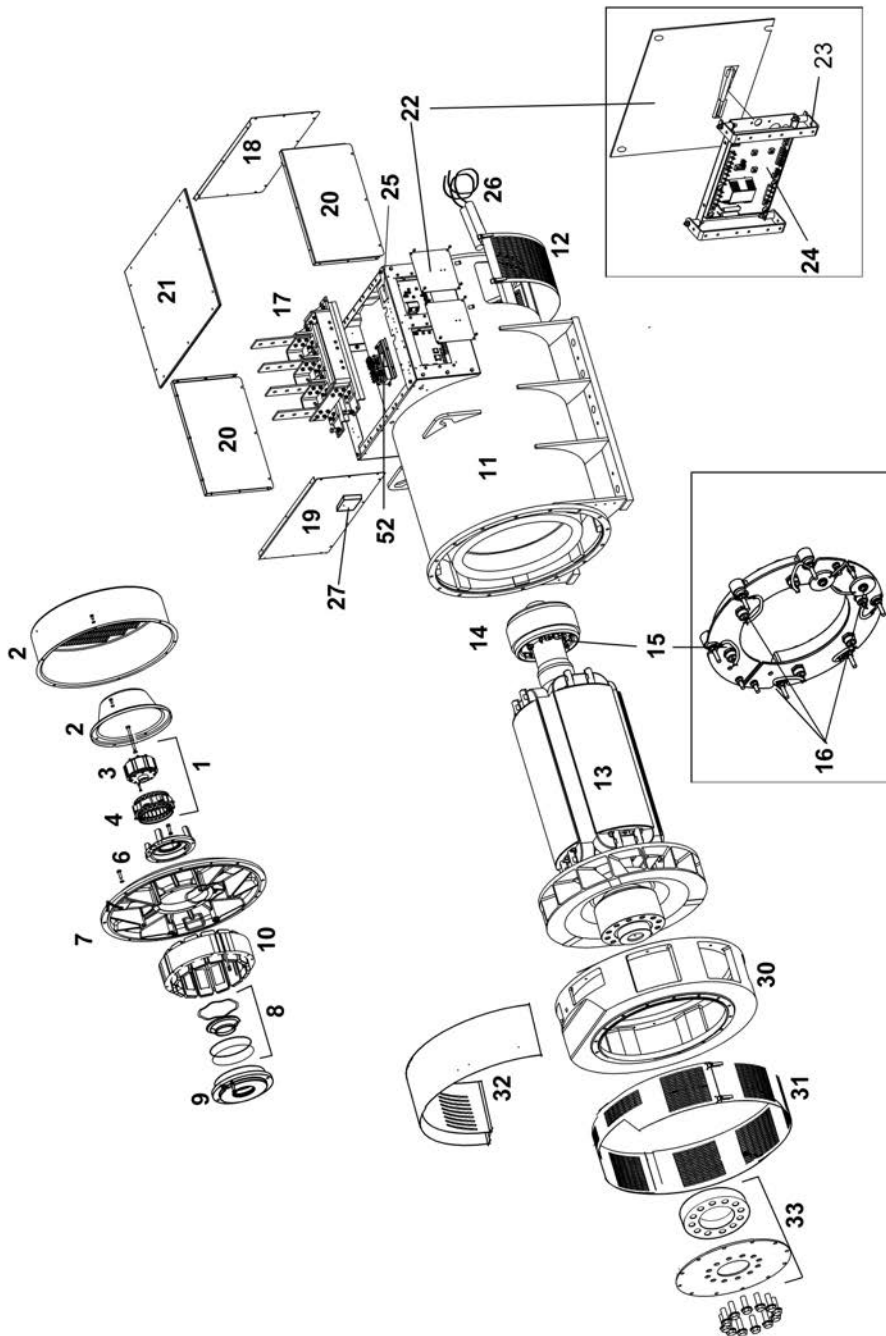


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# 10 Parts Identification

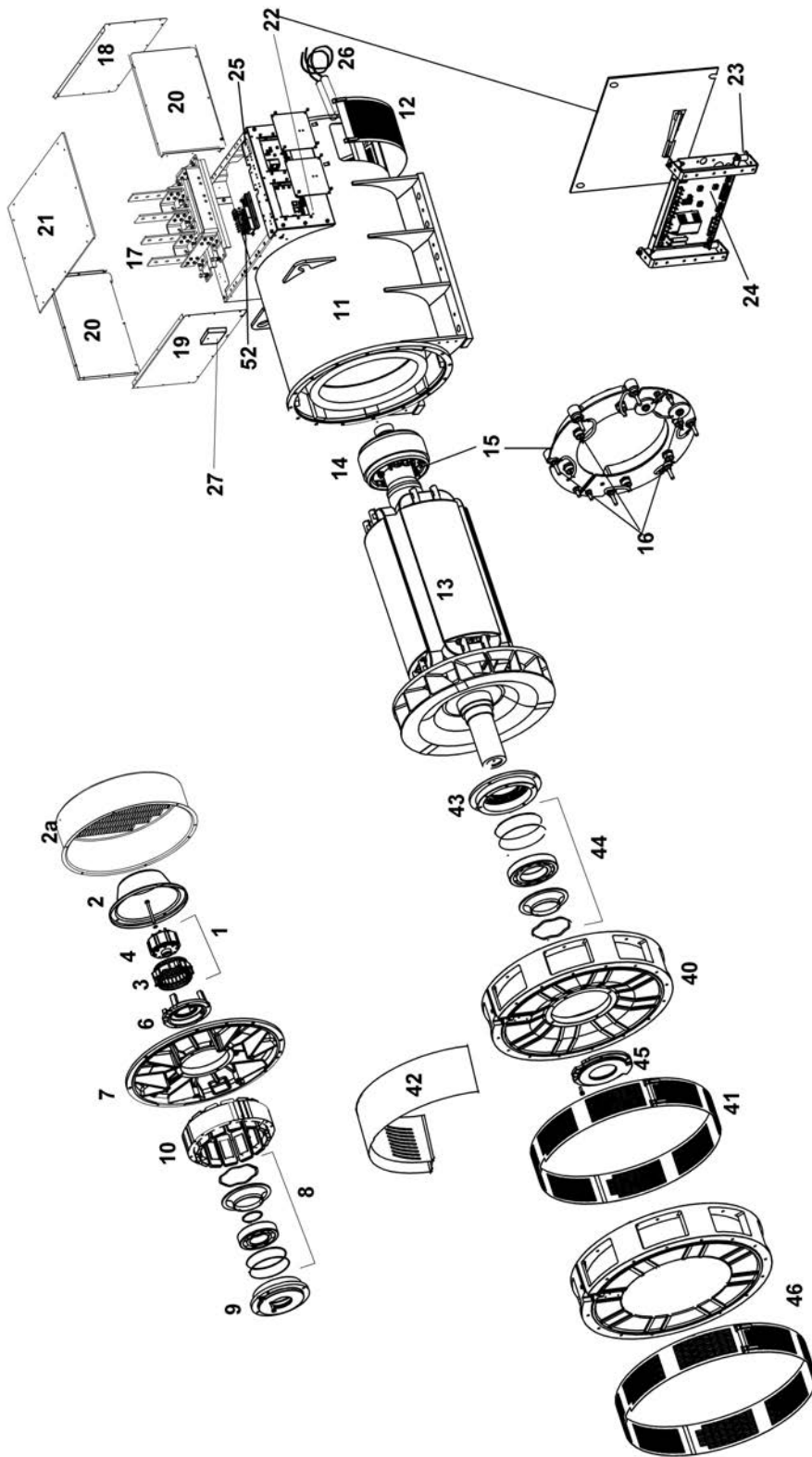
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# 10.1 P7 Single Bearing Generator



| No | Description                               | Parts     | Qty | No | Description                                | Parts  | Qty         | No | Description | Parts | Qty |  |
|----|---|-----------|-----|----|--|--|-------------|----|-------------|-------|-----|--|
| 1  | Complete P.M.G Uplift Kit                 | 45-0119A  | 1   | 23 | A.V.R Mounting bracket                     | 45-0742                                      | 1           |    |             |       |     |  |
| 2  | P.M.G Cover (Cover Included In Above Kit) | 760-10562 | 1   | 24 | A.V.R. MX341 (Series 3)                    | E000-23412/1P                                | 1           |    |             |       |     |  |
| 2a | N.D.E Air Inlet Cover G                   | 760-11279 | 1   |    |  | E000-23212/1P                                | 1           |    |             |       |     |  |
| 3  | N.D.E Air Inlet Cover G (Marine)          | 760-10965 | 1   | 25 | Auxiliary Terminal Board                   | 450-15489                                    | 2           |    |             |       |     |  |
| 4  | Current P.M.G Rotor/Stator Repair Kit     | 45-1082   | 1   | 26 | Heater 110-125 Volt                        | 45-0324                                      | 1           |    |             |       |     |  |
| 6  | Current P.M.G Rotor/Stator Repair Kit     | 45-1082   | 1   |    |  | 45-0325                                      | 1           |    |             |       |     |  |
| 7  | N.D.E Bracket Cap                         | 760-10823 | 1   |    |  | 45-1047                                      | 1           |    |             |       |     |  |
| 8  | N.D.E Bracket A-F                         | 760-10819 | 1   | 27 | Heater 220-260 Volt (G core)               | 45-1048                                      | 1           |    |             |       |     |  |
| 9  | N.D.E Bracket G                           | 760-11205 | 1   |    |  | 45-0024                                      | 1           |    |             |       |     |  |
| 10 | N.D.E Bearing Kit                         | 45-0336   | 1   | 30 | Terminal box for heaters                   | 45-1011                                      | 2           |    |             |       |     |  |
| 11 | N.D.E Bearing Cartridge                   | 760-10821 | 1   |    |  | D.E. Adaptor kit (SAE 0)                     |             |    |             |       |     |  |
| 12 | Exciter Stator A-F (75mm)                 | 366-40800 | 1   | 31 | D.E. Bracket (SAE 00)                      | 45-1012                                      | 1           |    |             |       |     |  |
| 13 | Exciter Stator G (100mm)                  | 760-1151  | 1   |    |  | D.E. Screen (included in adaptor kits)       | See item 30 | 1  |             |       |     |  |
| 14 | Main Stator Frame Assy                    | Q.M.S.N.  | 1   | 32 | Louvre Kit SAE 00 A-F                      | 45-1049                                      | 1           |    |             |       |     |  |
| 15 | N.D.E Air Inlet Cover (Industrial)        | 760-11274 | 1   |    |  | Louvre Kit SAE 00 G                          | 45-1050     | 1  |             |       |     |  |
| 16 | N.D.E Air Inlet Cover (Marine-louvered)   | 366-21200 | 1   | 33 | Louvre Kit SAE 0 A-F                       | 45-1051                                      | 1           |    |             |       |     |  |
| 17 | Main Rotor Assy                           | Q.M.S.N.  | 1   |    |  | Louvre Kit SAE 0 G                           | 45-1052     | 1  |             |       |     |  |
| 18 | Exciter Rotor A-F (75mm)                  | 760-1186  | 1   | 52 | Coupling Kit SAE 18 (standard)             | 45-0792                                      | 1           |    |             |       |     |  |
| 19 | Exciter Rotor A-F (100mm)                 | 760-1178  | 2   |    |  | Coupling Kit SAE 18 (special 12 hole)        | 45-1005     | 1  |             |       |     |  |
| 20 | Rotating Rectifier Assy                   | 760-11216 | 1   | 53 | Coupling Kit SAE 21                        | 45-0793                                      | 2           |    |             |       |     |  |
| 21 | Diode Fwd/Rev & Varistor Kit              | RSK-6001  | 1   |    |  | Coupling Kit SAE 24                          | 45-0794     | 1  |             |       |     |  |
| 22 | Main Terminal Board                       | Q.M.S.N.  | 1   | 54 | Isolation Transformer 2 to 1 (up to 480V)  | 450-42150                                    | 1           |    |             |       |     |  |
| 23 | Terminal Box Endpanel N.D.E               | 760-11185 | 1   |    |  | Isolation Transformer 2.5 to 1 (500 to 600V) | 450-41650   | 1  |             |       |     |  |
| 24 | Terminal Box Endpanel D.E                 | 760-11185 | 1   | 55 | Isolation Transformer 3 to 1 (601 to 720V) | 450-41750                                    | 1           |    |             |       |     |  |
| 25 | Terminal Box Side Panel                   | 760-11186 | 2   |    |  |  |             |    |             |       |     |  |
| 26 | Terminal Box Lid                          | 760-10663 | 1   |    |  |  |             |    |             |       |     |  |
| 27 | A.V.R. Cover Plate (Access)               | 450-15254 | 1   |    |  |  |             |    |             |       |     |  |
| 28 | A.V.R. Cover Plate (Blanking)             | 450-14310 | 1   |    |  |  |             |    |             |       |     |  |

## 10.2 P7 Two Bearing Generator



| No | Description                               | Common Parts | Qty | No | Description                                  | Common Parts  | Qty |
|----|---|--------------|-----|----|--|---------------|-----|
| 1  | Complete P.M.G Upfit Kit                  | 45-0119A     | 1   | 23 | A.V.R Mounting bracket                       | 45-0742       | 1   |
| 2  | P.M.G Cover (Cover Included In Above Kit) | 760-10562    | 1   | 24 | A.V.R. MX341 (Series 3)                      | E000-23412/1P | 1   |
| 2a | N.D.E Air Inlet Cover G                   | 760-11279    | 1   |    | A.V.R. MX321                                 | E000-23212/1P | 1   |
| 3  | N.D.E Air Inlet Cover G (Marine)          | 760-10965    | 1   | 25 | Auxiliary Terminal Board                     | 450-15489     | 2   |
| 4  | Current P.M.G Rotor/Stator Repair Kit     | 45-1082      | 1   | 26 | Heater 110-125 Volt                          | 45-0324       | 1   |
| 6  | Current P.M.G Rotor/Stator Repair Kit     | 45-1082      | 1   |    | Heater 220-260 Volt                          | 45-0325       | 1   |
| 7  | N.D.E Bracket Cap                         | 760-10823    | 1   |    | Heater 110-125 Volt (G core)                 | 45-1047       | 1   |
| 7  | N.D.E Bracket A-F                         | 760-10819    | 1   |    | Heater 220-260 Volt (G core)                 | 45-1048       | 1   |
| 8  | N.D.E Bracket G                           | 760-11205    | 1   | 27 | Terminal box for heaters                     | 45-0024       | 1   |
| 8  | N.D.E Bearing Kit                         | 45-0336      | 1   | 40 | D.E. Adaptor kit (SAE 0)                     | 45-1011       | 2   |
| 9  | N.D.E Bearing Cartridge                   | 760-10821    | 1   |    | D.E. Bracket (SAE 00)                        | 45-1012       | 1   |
| 10 | Exciter Stator A-F (75mm)                 | 366-40800    | 1   | 41 | D.E. Bracket screen top (industrial)         | 760-11392     | 1   |
| 10 | Exciter Stator G (100mm)                  | 760-1151     | 1   |    | D.E. Bracket screen bottom                   | 760-10930     | 1   |
| 11 | Main Stator Frame Assy                    | Q.M.S.N.     | 1   | 42 | Louvre kit A-F                               | 45-1053       | 1   |
| 12 | N.D.E Air Inlet Cover (Industrial)        | 760-11274    | 1   |    | Louvre kit G                                 | 45-1054       | 1   |
| 12 | N.D.E Air Inlet Cover (Marine-louvered)   | 366-21200    | 1   | 43 | D.E. Bearing cartridge A-E                   | 760-10829     | 1   |
| 13 | Main Rotor Assy                           | Q.M.S.N.     | 1   |    | D.E. Bearing cartridge F-G                   | 760-10923     | 1   |
| 14 | Exciter Rotor A-F (75mm)                  | 760-1186     | 1   | 44 | D.E. Bearing kit A-E                         | 45-0335       | 1   |
| 14 | Exciter Rotor A-F (100mm)                 | 760-1178     | 2   |    | D.E. Bearing kit F-G                         | 45-0425       | 2   |
| 15 | Rotating Rectifier Assy                   | 760-11216    | 1   | 45 | D.E. Bearing cap A-E                         | 760-10831     | 1   |
| 16 | Diode Fwd/Rev & Varistor Kit              | FSK-6001     | 1   |    | D.E. Bearing cap F-G                         | 760-10924     | 1   |
| 17 | Main Terminal Board                       | Q.M.S.N.     | 1   | 46 | 2 Brg adaptor kit (SAE 00)                   | 45-0715       | 1   |
| 18 | Terminal Box Endpanel N.D.E               | 760-11185    | 1   |    | 2 Brg adaptor kit (SAE 0)                    | 45-0716       | 1   |
| 19 | Terminal Box Endpanel D.E                 | 760-11185    | 1   |    | Isolation transformer 2 to 1 (up to 480V)    | 450-42150     | 1   |
| 20 | Terminal Box Side Panel                   | 760-11186    | 2   | 52 | Isolation transformer 2.5 to 1 (500 to 600V) | 450-41650     | 1   |
| 21 | Terminal Box Lid                          | 760-10663    | 1   |    | Isolation transformer 3 to 1 (601 to 720V)   | 450-41750     | 1   |
| 22 | A.V.R. Cover Plate (Access)               | 450-15254    | 1   |    |  |               |     |
| 22 | A.V.R. Cover Plate (Blanking)             | 450-14310    | 1   |    |  |               |     |

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# 11 Spares and After Sales Service

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We recommend the use of genuine STAMFORD service parts supplied from an authorised service outlet. For details of your nearest service outlet visit [www.stamford-avk.com](http://www.stamford-avk.com).

Aftermarket Help Desk

Phone: +44 (0) 1780 484744

Email: [parts.enquires@cummins.com](mailto:parts.enquires@cummins.com)

## 11.1 Recommended Service Parts

In critical applications a set of these service spares should be held with the generator.

| Part          | Number   |
|---------------|--|
| Diode Set     | RSK6001<br>(3 forward & 3 reverse diodes with Surge Suppressors) |
| MX321 AVR     | E000-23212/1P  |
| MX341 AVR     | E000-23412/1P  |
| Kluber Grease | 45-0281  |

## 11.2 Kluber Asonic GHY72 Grease

All bearings trials and calculated life expectancy are based on the use of Kluber Asonic GHY72. We recommend the use of this Ester Oil/Polyurea grease or an alternative grease with the same specification. The grease specification is available by request. Kluber has a worldwide distribution network, contact the manufacturers for your nearest stockist.

## 11.3 Parts Orders

When ordering parts the machine serial number or machine identity number and type should be quoted, together with the part description. The machine serial number can be found on the name plate or frame.

## 11.4 Customer Service

Cummins Generator Technologies' service engineers are experienced professionals, trained extensively to deliver the best support possible. Our global service offers:

- 24/7 response to service emergencies, 365 days of the year.
- On-site ac generator commissioning
- On-site bearing maintenance & bearing condition monitoring
- On-site insulation integrity checks
- On-site AVR & accessories set-up



- Multi-lingual local engineers

Customer Service Help Desk:

Phone: +44 1780 484732 (24 hours)

Email: [service-engineers@cumminsgeneratortechnologies.com](mailto:service-engineers@cumminsgeneratortechnologies.com)

# 12 End of Life Disposal

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Companies specialising in reclaiming material from scrap products can reclaim most of the iron, steel and copper from the generator. For more details, please contact STAMFORD Customer Service.

## 12.1 Recyclable material

Mechanically separate the base materials, iron, copper and steel, removing paint, polyester resin, and insulation tape and/or plastics residues from all components. Dispose of this 'waste material'

The iron, steel and copper can now be recycled.

## 12.2 Items requiring specialist treatment

Remove electrical cable, electronic accessories and plastic materials from the generator. These components need special treatment to remove the waste from the reclaimable material.

Forward the reclaimed materials for recycling.

## 12.3 Waste material

Dispose of waste material from both of the above processes via a specialist disposal company.

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