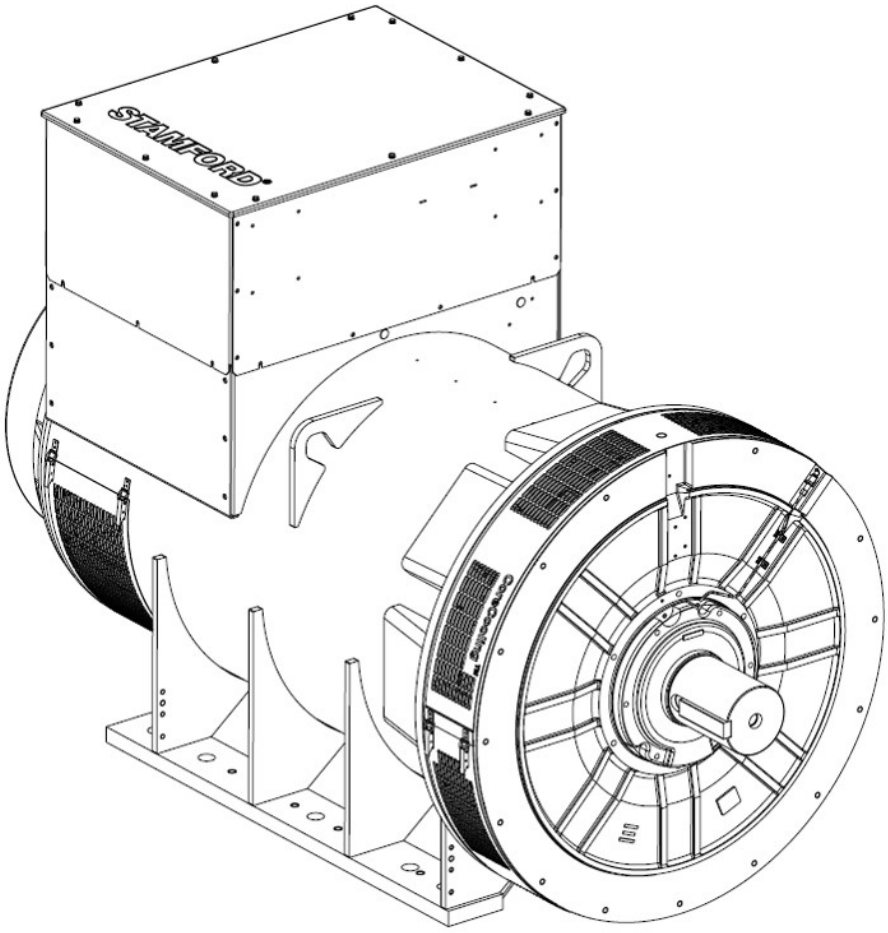
STAMFORD

S7 LV Alternators

# INSTALLATION, SERVICE AND MAINTENANCE MANUAL




English
Original Instructions

4-2023

A061S223 (Issue 5)

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# 1 Foreword

## 1.1 General

This manual forms part of the items supplied and is an important technical guide to the intended use of the alternator. It represents an essential source of information for the user and also for managers for the prevention of injuries and damage to the alternator. The general safety regulations, the specific regulations for the place of use and the precautions described in this document must be followed at all times.

**TABLE 1. COMPANY ADDRESSES**

| Company and European Authorized Representative Addresses | |
|---|---|
| Cummins Generator Technologies<br>Fountain Court<br>Lynch Wood<br>Peterborough<br>PE2 6FZ<br>United Kingdom | Cummins Generator Technologies<br>Bvd. Decebal 116A<br>Craiova,<br>Dolj<br>200746<br>Romania |

## 1.2 Legal

The alternator is the intellectual property of Cummins Generator Technologies LTD (also referred to as 'CGT' or 'the manufacturer' or by the brand names 'STAMFORD®' or 'AvK®' within this manual).

STAMFORD®, AvK® and STAMFORD VITA™, MX321™ and MX322™ are registered trademarks of Cummins Generator Technologies LTD. All rights to the alternator, the principle of the machine, the related drawings etc. lie with Cummins Generator Technologies LTD and are subject to copyright law. Copying is only permitted with prior written approval. Copyright Cummins Generator Technologies. All Rights reserved. Cummins and the Cummins logo are registered trademarks of Cummins Inc.

## 1.3 The Manual

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

Before operating the alternator, 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, and the use of non-approved parts, may invalidate the product warranty and lead to potential accidents.

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

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 (CGT) subsidiary.

| *NOTICE* |
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| **Information in this manual was correct when published. It may be superseded due to our policy of continuous improvement. Please visit www.stamford-avk.com for latest documentation.** |

 

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# 1.4 Manual Languages

The manuals for this product are available in the languages shown below, which can be found on the STAMFORD® AvK® website: **www.stamford-avk.com**.

**TABLE 2. MANUAL LANGUAGES**

| Language, Manual Type and Document Part Number | | |
|---|---|---|
| Arabic (ar-sa) | Owner | A061S270 |
| German (de-de) | Owner | A061S232 |
| English (en-us) | Owner | A061S225 |
| English (en-us) | Service[1] | A061S223 |
| Spanish (es-es) | Owner | A061S227 |
| French (fr-fr) | Owner | A061S229 |
| Italian (it-it) | Owner | A061S236 |
| Japanese (ja-jp) | Owner | A061S272 |
| Polish (pl-pl) | Owner | A061S264 |
| Portuguese (pt-pt) | Owner | A061S238 |
| Russian (ru-ru) | Owner | A061S258 |
| Swedish (sv-se) | Owner | A061S246 |
| Chinese (zh-cn) | Owner | A061S253 |

[1] Service manuals are only available in English (en-us), to authorized service providers who have completed Cummins accredited product training.

# 2 Safety Precautions

## 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 emphasize important or critical instructions.

**⚠ DANGER**

***Danger indicates a hazardous situation which, if not avoided, WILL result in death or serious injury.***

**⚠ WARNING**

***Warning indicates a hazardous situation which, if not avoided, COULD result in death or serious injury.***

**⚠ CAUTION**

***Caution indicates a hazardous situation which, if not avoided, COULD result in minor or moderate injury.***

***NOTICE***

**Notice refers to a method or practice which can result in product damage, or to draw attention to additional information or explanations.**

## 2.2 General Guidance

***NOTICE***

**These safety precautions are for general guidance and supplement your own safety procedures and all locally applicable laws and standards.**

***NOTICE***

**Ensure that all personnel are fully aware of location specific rules and procedures in case of accidents, incidents or emergencies.**

## 2.3 Training and Skill Requirements for Personnel

Operation, installation, service and maintenance procedures **must only** be carried out and supervised by experienced and qualified personnel, who have undertaken suitable training that has been appropriately assessed and recorded. These personnel **must at all times**; understand the procedures, be familiar with the equipment, be aware of any associated hazards and/or risks and be aware of the requirements of all site specific and locally applicable rules and regulations.

 

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## 2.4 Risk Assessment

A risk assessment has been performed on this product by CGT, however a separate risk assessment must be performed by the installer/operator/service/maintenance company to establish all site and personnel-related risks. All affected users must be trained on the identified risks. Access to the power plant/generator set during operation must be restricted to persons who have been trained on these risks; refer to **Section 2.2 on page 3** and **Section 2.3 on page 3**

## 2.5 Personal Protective Equipment (PPE)

All persons installing, operating, servicing, maintaining or working in or with a power plant or a generator set **must be**; trained in the safe use of, and wear the appropriate personal protective equipment as directed by the installer/operator/service/maintenance company risk assessment, refer to; **Section 2.4 on page 4** .

Minimum recommended personal protective equipment for installation, operation and service / maintenance or working in or with a power plant or a generator set includes:

Eye protection, face protection, ear protection, head protection, overalls that protect the lower arms and legs, safety shoes or safety boots and gloves.

**FIGURE 1. MINIMUM RECOMMENDED PERSONAL PROTECTIVE EQUIPMENT (PPE)**

## 2.6 Tools and Equipment

All personnel that undertake the, installation, operation, service or maintenance of the alternator must be trained in the safe use/operation of the tools/equipment/machinery they use, refer to; **Section 2.3 on page 3** .

All hand operated tools and power operated tools (either battery or mains powered) and large equipment such as, but not limited to; plant equipment/machinery (such as forklifts), lifting appliances (such as cranes/hoists and jacks) and their accessories (such as chains, straps hooks and shackles) used by personnel to undertake the, installation / operation / service / maintenance of the alternator must be:

- Included within the risk assessment carried out by the installer / operator / service / maintenance company, refer to; **Section 2.4 on page 4** .
- Suitable for the task and intended use and if required by the risk assessment be electrically insulated to withstand the alternator output voltage, refer to; alternator rating pate information.
- In a serviceable condition for safe use.

## 2.7 Safety Information Signs

Safety information signs are provided on the equipment to indicate hazards and emphasize instructions. Become familiar with the signs and the meaning before operating the equipment. To avoid injury, always take the necessary precautions. Sample signs are shown below, these may vary depending on the specification of the alternator.

**FIGURE 2. EXAMPLE WARNING SIGNS**

# 2.8 Alternator Danger Notices

**⚠ DANGER**

***Falling Mechanical Parts***

***Falling mechanical parts can cause serious injury or death by impact, crushing, severing or trapping. To prevent injury and before lifting:***

- ***Check the capacity, condition and attachment of lifting equipment (crane, hoists and jacks, including attachments to anchor, fix or support the equipment).***
- ***Check the capacity, condition and attachment of accessories for lifting (hooks, slings, shackles and eye bolts for attaching loads to lifting equipment).***
- ***Check the capacity, condition and attachment of lifting fixtures on the load.***
- ***Check the mass, integrity and stability (e.g. unbalanced or shifting center of gravity) of the load.***
- ***When available; Fit drive end and non-drive end transit fittings to prevent damage to bearings and prevent movement.***
- ***Keep the alternator horizontal when lifting.***
- ***Do not use the lifting points fitted to the alternator for lifting a complete generator set.***
- ***Do not use the lifting points fitted to the cooler for lifting the alternator or a complete generator set.***
- ***Do not remove the lifting label attached to one of the lifting points.***

**⚠ DANGER**

***Testing Live Electrical Conductors***

***Live electrical conductors can cause serious injury or death by electric shock and burns. To prevent injury:***

- ***Before removing covers over electrical conductors, shut down and isolate the generator set from all energy sources, remove stored energy and use lock out/tag out safety procedures.***

**⚠ DANGER**

***Live Electrical Conductors***

***Live electrical conductors can cause serious injury or death by electric shock and burns.***

***To prevent injury and before testing on or near live electrical conductors:***

- ***Assess risk and test on or near live conductors only if absolutely necessary.***
- ***Only trained, competent persons may test on or near live electrical conductors.***
- ***Do not test on or near live electrical conductors alone; another competent person must be present, trained to isolate energy sources and take action in an emergency.***
- ***Place warnings and prevent access by unauthorized persons.***
- ***Make sure that tools, test instruments, leads and attachments are designed, inspected and maintained for use on the maximum voltages likely under normal and fault conditions.***
- ***Test medium and high voltage (3.3 kV to 13.6 kV) alternators only with specialized instruments and probes, refer to; Tools and Equipment Chapter.***
- ***Take suitable precautions to prevent contact with live conductors including personal protective equipment, insulation, barriers and insulated tools.***

 

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**⚠ DANGER**

***Rotating Mechanical Parts***

***Rotating mechanical parts can cause serious injury or death by crushing, severing or trapping. To prevent injury:***

- ***Before operating the alternator, exposed couplings between the alternator and prime mover must be protected by a suitable guard/cover.***
- ***Before removing covers from rotating parts, shut down and isolate the generator set from all energy sources, remove stored energy and use lock out/tag out safety procedures.***
- ***Before undertaking service or maintenance tasks shut down and isolate the generator set from all energy sources, remove stored energy and use lock out/tag out safety procedures.***

**⚠ DANGER**

***Testing on Rotating Mechanical Parts***

***Rotating mechanical parts can cause serious injury or death by crushing, severing and trapping.***

***To prevent injury and before removing safety covers for testing on or near operational/live rotating mechanical parts:***

- ***Assess risk and test on or near uncovered rotating mechanical parts only if absolutely necessary.***
- ***Only trained, competent persons may test on or near uncovered rotating mechanical parts.***
- ***Do not test on or near uncovered rotating mechanical parts alone; another competent person must be present, trained to isolate energy sources and take action in an emergency.***
- ***Place warnings and prevent access by unauthorized persons.***
- ***Take suitable precautions to prevent contact with uncovered rotating mechanical parts including personal protective equipment and barriers.***

## 2.9 Alternator Warning Notices

**⚠ WARNING**

***Grounding***

***The alternator must be permanently grounded, unless the application or local regulations do not permit grounding, (for example: Maritime use). To avoid injury:***

- ***Parts of the alternator and installation on which inspections, servicing and repair work is carried out must be electrically isolated in accordance with all locally applicable rules and regulations..***
- ***Test the electrically isolated parts for electrical isolation using a suitable voltage tester, then ground and short-circuit and also isolate neighboring live parts.***
- ***In case of work on high-voltage assemblies, after electrically isolating connect the line cable to ground and short-circuit the components, e.g. capacitors, using a grounding bar.***

**⚠ WARNING**

***Arc-flash***

- ***An arc-flash event within the terminal box, on the alternator windings or at the customer cables exiting the terminal box can result in very hot and rapidly expanding gases, airborne molten copper and exposure to high UV from the flash. This can cause serious injury or death by burns and/or impact from flying debris, visual damage due to the high intensity flash and damage to hearing from the expanding pressure wave.***
- ***To prevent injury or death do not approach the alternator during operation unless wearing appropriate personal protective equipment, refer to; Safety Precaution Chapter.***
- ***Any operator working close to the alternator during operation must be trained in arc-flash hazard awareness.***

An arc-flash is a phenomenon where a flashover of electric current leaves its intended path and travels through the air from one conductor to another, or to ground. Arc-flash can be caused by many things, such as: material failure, corrosion, or incorrect installation.

It is the responsibility of the installer/operating company to carry out a risk assessment of arc-flash hazard as part of the complete installation, including connection to other energy sources.

When the alternator is connected to other energy sources, the arc-flash can exceed an arc-flash produced by an individual alternator. These additional energy sources can be electrical loads that store energy (e.g, transformers, capacitors etc.), alternators in parallel or coupled to a mains network.

While arc-flash in an alternator is rare, it is important that the installer/operating company take appropriate measures to ensure the safety of all personnel. In accordance with local electrical safe working practices, all personnel working around the running alternator must be trained in and aware of arc-flash hazards. Appropriate personal protective equipment must be worn when working within the vicinity of the alternator, refer to; Safety Precaution Chapter **Section 2.5 on page 4**.

**Medium Voltage (MV) and High Voltage (HV) Alternators**

For alternators that produce Medium Voltage (MV) or High Voltage (HV) the following applies:

MV and HV alternators ***may be fitted*** with two additional warning and information stickers and a pressure relief mesh vent(s) in the terminal box (the pressure relief mesh vent(s) may vary from the one shown in the image below).

**FIGURE 3. ARC-FLASH IMAGES**

If fitted, ensure the pressure relief mesh is secure and intact: Do not remove, obstruct or apply a load to the pressure relief mesh vent(s).

 

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**⚠ WARNING**

***Condensed Water***

***Operating an alternator with condensed water in the windings can cause serious injury by electric shock, burns or exposure to flying debris and particles. To prevent injury:***

- ***Use anti-condensation heaters (if fitted) to prevent condensation accumulating.***
- ***Before operating the alternator; check for condensed water. If condensed water is present, drain/remove the water, dry and inspect the alternator in accordance with the Maintenance and Servicing Chapter.***

**⚠ WARNING**

***Coupling an Alternator to a Prime Mover***

***Moving mechanical parts during generator set coupling can cause serious injury by crushing, severing or trapping. To prevent injury:***

- ***Personnel must keep limbs and body parts away from mating surfaces when coupling the alternator to a prime mover.***
- ***Personnel must keep limbs and body parts away from mating surfaces when installing large components, such as; cooling systems and fuel tanks on to the alternator/generator set.***

**⚠ WARNING**

***Hazardous Operating Environments (Explosive Atmospheres)***

***The use of the alternators in an explosive atmosphere can cause serious injury or death by burns and/or flying debris, particles and fumes. to prevent injury:***

- ***Do not install or operate the alternator in an area where the surrounding atmosphere is potentially explosive.***

**⚠ WARNING**

***Hot Surfaces and Fire***

***Contact with hot surfaces can cause serious injury and death by burns. A risk of fire exists where hot surfaces are contacted by combustible items. To prevent injury/fire:***

- ***Avoid contact with hot surfaces.***
- ***Always wear the appropriate personal protection equipment, refer to; Safety Precaution Chapter.***
- ***Ensure that no combustible materials (such as packaging) or flammable substances come in to contact with or are stored in close proximity to the anti-condensation heater (if fitted).***
- ***Ensure that no combustible material(s) or flammable substances come in to contact with or are stored in close proximity to the alternator or prime mover, including the cooling, ventilation and exhaust system(s) where applicable.***

**⚠ WARNING**

***Incorrect Electrical Installation and System Protection***

***Incorrect electrical installation and system protection can cause serious injury or death by electric shock and burns. To prevent injury:***

- ***All personnel who carry out; installation, service or maintenance work or who supervise such work being undertaken must be suitably experienced and qualified.***
- ***All personnel must comply with all locally applicable rules and regulations as well as site safety requirements, refer to; Safety Precaution Chapter.***

**⚠ WARNING**

***Incorrect or Improper Use***

***Incorrect or improper use of the alternator may result in serious injury, death or equipment damage. To prevent injury:***

- ***Always select the correct specification alternator for the intended use and application.***
- ***Ensure the alternator and prime mover are technically compatible and practically suitable for the intended application.***
- ***Always install the alternator in accordance with the original manual(s) and technical drawing(s) supplied with the alternator and comply with all locally applicable rules and regulations.***
- ***Ensure the alternator is operated in accordance with the manual(s) and within the limits of the alternator rating plate.***
- ***Do not use a damaged or defective alternator. Shut down and isolate the alternator set from all energy sources, remove stored energy and use lock out/tag out safety procedures. Prevent further use of the alternator until it is repaired and returned to a serviceable condition.***

**⚠ WARNING**

***Live Electrical Conductors***

***Live electrical conductors at the winding terminals after an insulation resistance test can cause serious injury or death by electric shock or burns. To prevent injury:***

- ***Always discharge the windings immediately after the test has concluded by shorting to earth through an earthing rod for:***
  1. ***A duration equal to the test duration.***
     ***or***
  2. ***5 minutes.***

***Whichever is the longer duration.***

**⚠ WARNING**

***Noise***

***Noise from a running alternator can cause serious injury by permanent hearing damage. To prevent injury:***

- ***Always wear appropriate personal protection equipment; refer to Safety Precaution Chapter.***

**⚠ WARNING**

***Reconnected Energy Source***

***Accidental reconnection of energy sources during service and maintenance work can cause serious injury or death by electric shock, burns, crushing, severing or trapping. To prevent injury:***

- ***Before starting any service and maintenance work, use appropriate lock out/tag out safety procedures to keep the generator set isolated from energy sources. Do not defeat or bypass the lock out/tag out safety procedures.***

 

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**⚠ WARNING**

***Safety Cover Removed***

***A hazard exposed when a safety cover is removed can cause serious injury or death.***

***To prevent injury:***

- ***Fit the safety labels at the locations shown on the back of the label sheet supplied.***
- ***Observe the safety labels.***
- ***Refer to the service manual before removing covers.***


**FIGURE 4. SAFETY LABEL**

**⚠ WARNING**

***Strong Magnetic Field***

***The strong magnetic field from a permanent magnet generator (PMG) or excitation boost system (EBS), can cause serious injury or death by interference with implanted medical devices. To prevent injury:***

- ***Do not work near a permanent magnet generator (PMG) or excitation boost system (EBS) if you have an implanted medical device.***

**⚠ WARNING**

***Enclosures***

***Alternators may be installed within an enclosure for environmental protection, noise reduction or transportation etc. If the alternator is operating within an enclosure; to prevent injury, asphyxiation or death:***

- ***Personnel must only enter the enclosure when the alternator is operating if they are wearing the appropriate protective equipment and have received appropriate training.***
- ***Personnel must, at all times; have a safe access route in to and out of the enclosure, sufficient ventilation and observe the alternator hazard zones.***
- ***Refer to; Safety Precaution Chapter.***

**⚠ WARNING**

***Exposure to Ejected Debris and Particles***

***Ejected debris and particles can cause serious injury or death by impact, severing or puncturing. Exposure to mechanically driven release of debris and particles exists in all directions (horizontally and vertically) in the areas surrounding the alternator air outlet(s), air inlets(s) and the open shaft end (also commonly known as the Drive End (DE)).***

***To prevent injury; observe the below points while the alternator is operating:***

- ***Keep away from the air inlet(s) and air outlet(s) when the alternator is running.***
- ***Do not position operator controls near the air inlet(s) or air outlet(s).***
- ***Do not cause overheating by running the alternator outside rating plate parameters.***
- ***Do not overload the alternator.***
- ***Do not run an alternator with excessive vibration.***
- ***Do not synchronize parallel alternators outside the specified parameters.***

**⚠ WARNING**

***Exposure to Particles and Fumes from an Alternator.***

***Particles and fumes can be released in all directions (horizontally and vertically) from where any ventilation opening is fitted. To avoid injury:***

- ***Avoid the areas around all ventilation openings, air intake(s) and air outlet(s) when the alternator is operating.***

**⚠ WARNING**

***Exposure to Particles and Fumes from Alternator Terminal Boxes.***

***Particles and fumes can be released in all directions (horizontally and vertically) from where any ventilation opening is fitted. To avoid injury:***

- ***Depending on the machine design, the pressure release flap can be located at different positions, orientations, and directions, according to alternator configuration.***
- ***It is important to identify the position(s) of the pressure release flap(s) and avoid them during alternator operation.***

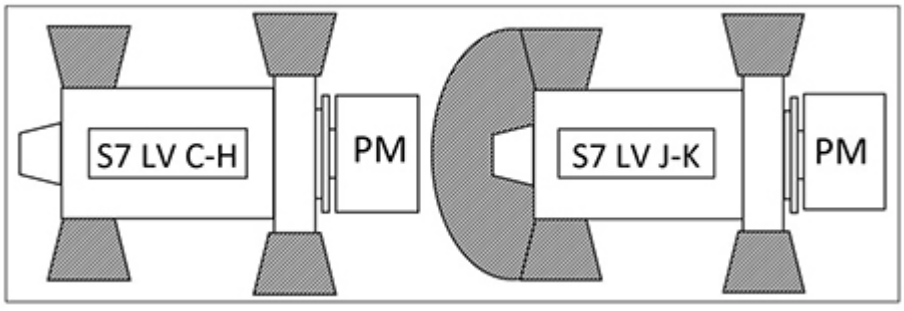


**FIGURE 5. S7 LV ALTERNATOR HAZARD ZONES**

[PM] = Prime Mover / Engine / Drive System

 

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## 2.10 Alternator Caution Notices

**⚠ CAUTION**

***Hazardous Substances***

***Contact with hazardous substances such as; oils, grease, lubricants, fuel, adhesive, desiccants (drying agents), battery acid, cleaning agents, solvent or corrosive substances, paint, polyester resin and/or plastic residues can cause minor or moderate injury by contact/inhalation. Prolonged/repetitive exposure may lead to more serious medical conditions developing. To prevent injury:***

- ***Always read and comply with the information provided by the product manufacturer, use, handle and store substances accordingly.***
- ***Always wear appropriate personal protection equipment, as per product manufacturer information and the Safety Precaution Chapter.***

**⚠ CAUTION**

***Missing Walkways and Handrails***

***Walkways and handrails removed for service and maintenance access can cause minor or moderate injury by slips, trips and falls. To prevent injury:***

- ***Before starting work, assess the risks, take precautions for safe working, place warnings and prevent access by unauthorized persons.***

**⚠ CAUTION**

***Dust & Airborne Particles/Fumes***

***Inhaling dust and other airborne particles/fumes can cause minor or moderate injury by irritating the lungs and eyes. Repetitive/prolonged exposure may cause serious chronic medical conditions to develop. To prevent injury:***

- ***Use mechanical vacuum extraction to remove dust and airborne particles/fumes where appropriate.***
- ***Ventilate the area appropriately.***
- ***Always wear the appropriate personal protection equipment, refer to; Safety Precaution Chapter.***

## 2.11 Automatic Voltage Regulator Safety Precautions

***NOTICE***

**The Automatic Voltage Regulator (AVR) may have danger, warning and caution notices in common with the alternator; refer to Safety Precaution Chapter.**

**Where the Automatic Voltage Regulator (AVR) has specific danger, warning or caution notices additional to the alternator they will be shown below and repeated in the applicable chapters.**

**⚠ DANGER**

***Battery Short Circuit***

***Sudden discharge of battery energy by short circuit can cause serious injury or death by electric shock and burns. To prevent injury:***

- ***Fit a 5 A fuse in circuit.***
- ***Use insulated leads and tools.***

**⚠ DANGER**

***Live Electrical Conductors***

***Live electrical conductors at output, AVR, AVR accessory terminals, and AVR heat sink can cause serious injury or death by electric shock and burns.***

- ***To prevent injury, take suitable precautions to prevent contact with live conductors, such as using insulation, barriers and insulated tools and use suitable personal protective equipment, refer to; Safety Precaution Chapter.***

 

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# 3 Safety Directives and Standards

## 3.1 General

STAMFORD® and AvK® alternators meet applicable national and international directives and standards relevant to alternators. The alternator must be operated within the limits specified in the relevant standards and within the parameters on the alternator rating plate.

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

This chapter includes EU/UK declaration template examples, where and if applicable.

All STAMFORD® and AvK® alternators are supplied with a declaration certificate that displays the product description and unique serial number.

## 3.2 Example: Declarations of Conformity and Incorporation

CGT products issue a Declaration of Conformity under the Low Voltage Directive 2006/95/EC. This Declaration is used for all complete products <1000VAC that do not require the customer to provide any additional components to ensure the product meets the health and safety requirements of the Directive.

CGT products issue a Declaration of Incorporation under the Machinery Directive 2006/42/EC. This Declaration is used for all products <1000VAC that are **not** complete and will require the customer to provide additional components to ensure the product meets the health and safety requirements of the Directive.

Alternators are supplied with a certificate that displays the product description and unique serial number.

Below are examples of both types of EU and UK 'Declarations of Conformity' and 'Declarations of Incorporation' that STAMFORD® and AvK® alternators are supplied with.

| ***NOTICE*** |
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| **If the certificate is lost, missing or damaged; please contact CGT customer services www.stamford-avk.com.** |

 

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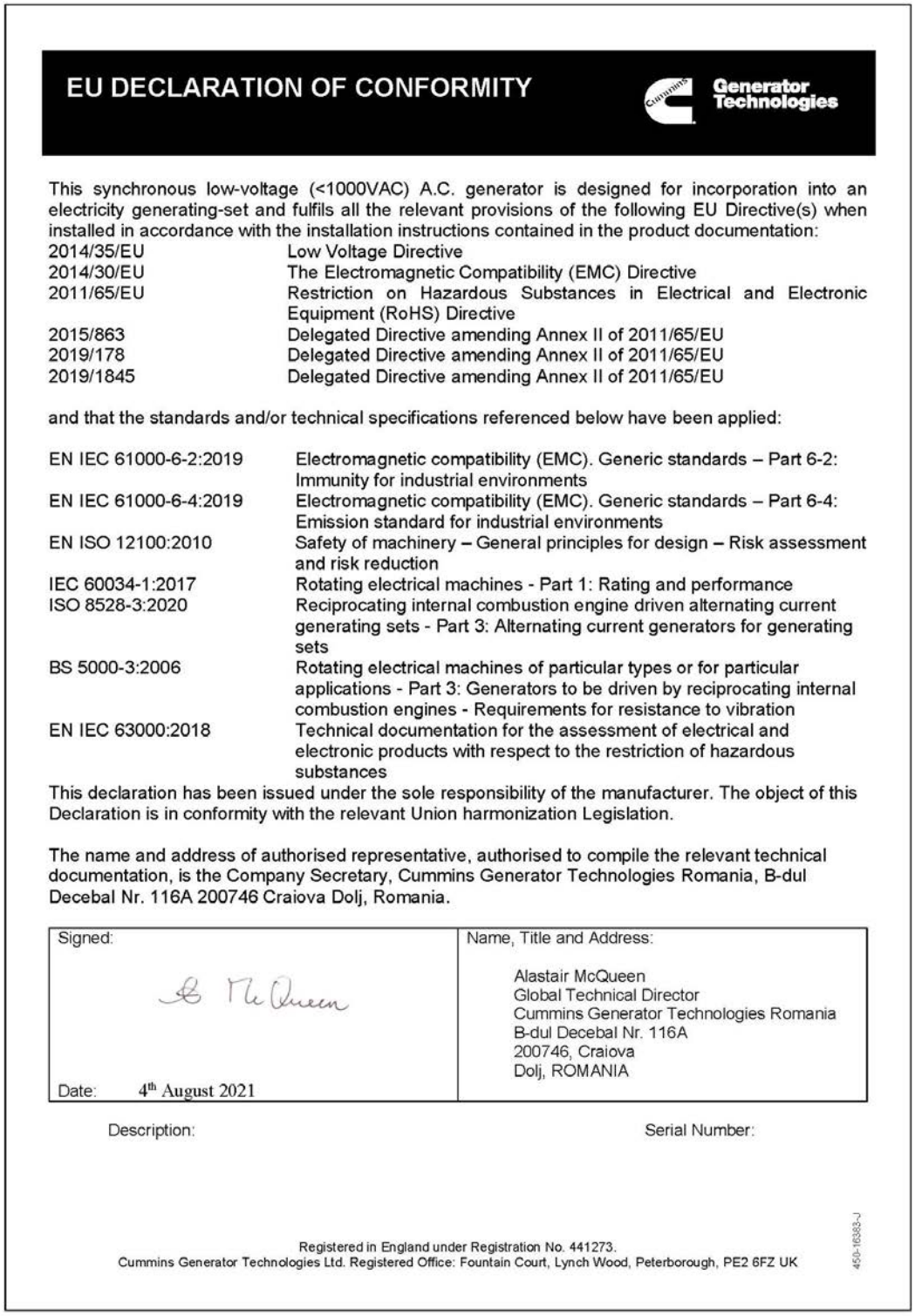


## EU DECLARATION OF CONFORMITY

Generator Technologies

This synchronous low-voltage (<1000VAC) A.C. generator is designed for incorporation into an electricity generating-set and fulfils all the relevant provisions of the following EU Directive(s) when installed in accordance with the installation instructions contained in the product documentation:

| | |
|---|---|
| 2014/35/EU | Low Voltage Directive |
| 2014/30/EU | The Electromagnetic Compatibility (EMC) Directive |
| 2011/65/EU | Restriction on Hazardous Substances in Electrical and Electronic Equipment (RoHS) Directive |
| 2015/863 | Delegated Directive amending Annex II of 2011/65/EU |
| 2019/178 | Delegated Directive amending Annex II of 2011/65/EU |
| 2019/1845 | Delegated Directive amending Annex II of 2011/65/EU |

and that the standards and/or technical specifications referenced below have been applied:

| | |
|---|---|
| EN IEC 61000-6-2:2019 | Electromagnetic compatibility (EMC). Generic standards – Part 6-2: Immunity for industrial environments |
| EN IEC 61000-6-4:2019 | Electromagnetic compatibility (EMC). Generic standards – Part 6-4: Emission standard for industrial environments |
| EN ISO 12100:2010 | Safety of machinery – General principles for design – Risk assessment and risk reduction |
| IEC 60034-1:2017 | Rotating electrical machines - Part 1: Rating and performance |
| ISO 8528-3:2020 | 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 |
| EN IEC 63000:2018 | Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances |

This declaration has been issued under the sole responsibility of the manufacturer. The object of this Declaration is in conformity with the relevant Union harmonization Legislation.

The name and address of authorised representative, authorised to compile the relevant technical documentation, is the Company Secretary, Cummins Generator Technologies Romania, B-dul Decebal Nr. 116A 200746 Craiova Dolj, Romania.

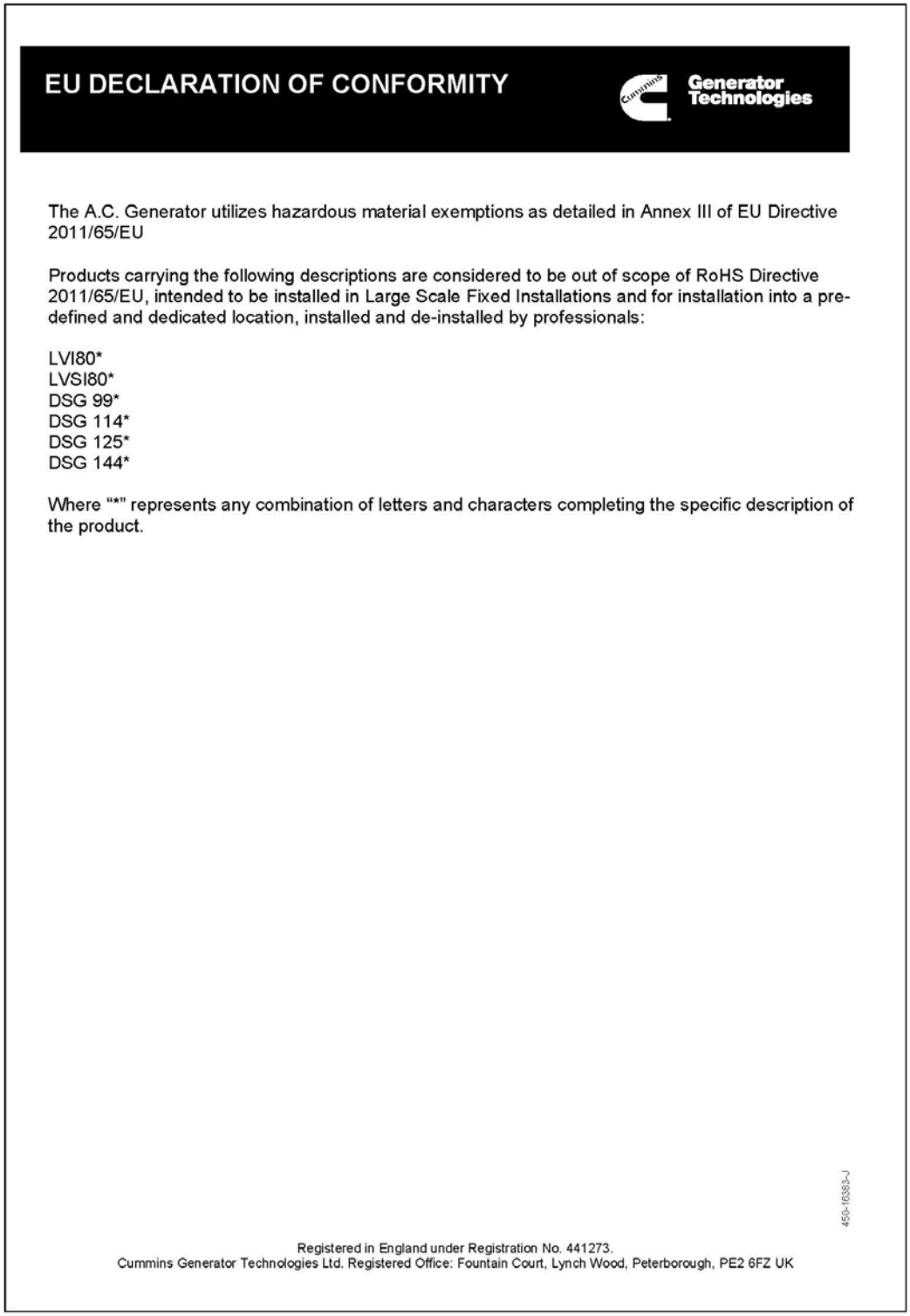
| Signed: | Name, Title and Address: |
|---|---|
| A McQueen<br>Date: 4th August 2021 | Alastair McQueen<br>Global Technical Director<br>Cummins Generator Technologies Romania<br>B-dul Decebal Nr. 116A<br>200746, Craiova<br>Dolj, ROMANIA |

Description: Serial Number:

Registered in England under Registration No. 441273.
Cummins Generator Technologies Ltd. Registered Office: Fountain Court, Lynch Wood, Peterborough, PE2 6FZ UK

450-16383-J

**FIGURE 6. EXAMPLE EU DECLARATION OF CONFORMITY - SHEET 1**



EU DECLARATION OF CONFORMITY

Generator Technologies

The A.C. Generator utilizes hazardous material exemptions as detailed in Annex III of EU Directive 2011/65/EU

Products carrying the following descriptions are considered to be out of scope of RoHS Directive 2011/65/EU, intended to be installed in Large Scale Fixed Installations and for installation into a pre-defined and dedicated location, installed and de-installed by professionals:

LVI80*
LVSI80*
DSG 99*
DSG 114*
DSG 125*
DSG 144*

Where "*" represents any combination of letters and characters completing the specific description of the product.

450-16383-J

Registered in England under Registration No. 441273.
Cummins Generator Technologies Ltd. Registered Office: Fountain Court, Lynch Wood, Peterborough, PE2 6FZ UK

**FIGURE 7. EXAMPLE EU DECLARATION OF CONFORMITY - SHEET 2**

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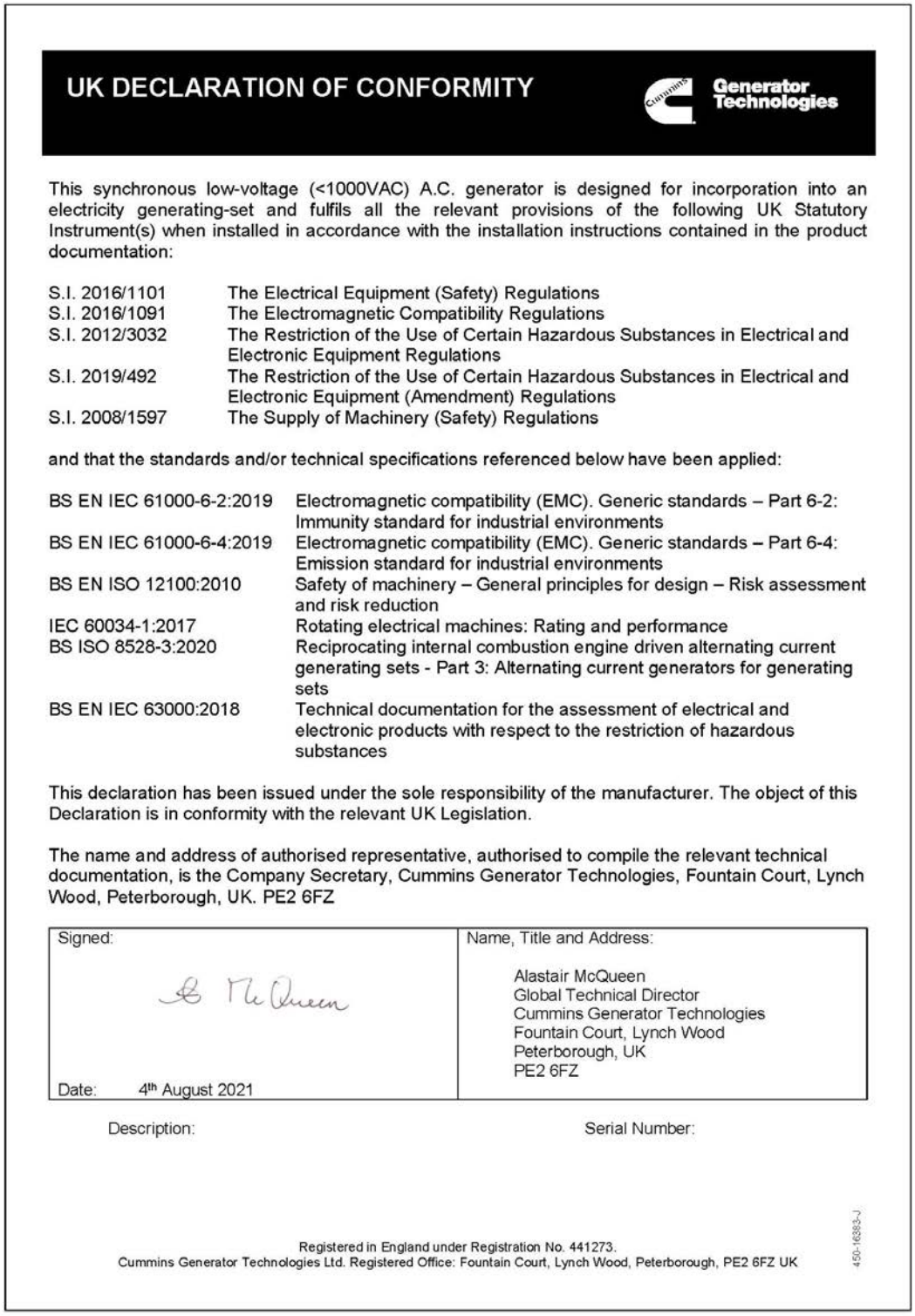

## UK DECLARATION OF CONFORMITY

Generator Technologies

This synchronous low-voltage (<1000VAC) A.C. generator is designed for incorporation into an electricity generating-set and fulfils all the relevant provisions of the following UK Statutory Instrument(s) when installed in accordance with the installation instructions contained in the product documentation:

| | |
|---|---|
| S.I. 2016/1101 | The Electrical Equipment (Safety) Regulations |
| S.I. 2016/1091 | The Electromagnetic Compatibility Regulations |
| S.I. 2012/3032 | The Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment Regulations |
| S.I. 2019/492 | The Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment (Amendment) Regulations |
| S.I. 2008/1597 | The Supply of Machinery (Safety) Regulations |

and that the standards and/or technical specifications referenced below have been applied:

| | |
|---|---|
| BS EN IEC 61000-6-2:2019 | Electromagnetic compatibility (EMC). Generic standards – Part 6-2: Immunity standard for industrial environments |
| BS EN IEC 61000-6-4:2019 | Electromagnetic compatibility (EMC). Generic standards – Part 6-4: Emission standard for industrial environments |
| BS EN ISO 12100:2010 | Safety of machinery – General principles for design – Risk assessment and risk reduction |
| IEC 60034-1:2017 | Rotating electrical machines: Rating and performance |
| BS ISO 8528-3:2020 | Reciprocating internal combustion engine driven alternating current generating sets - Part 3: Alternating current generators for generating sets |
| BS EN IEC 63000:2018 | Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances |

This declaration has been issued under the sole responsibility of the manufacturer. The object of this Declaration is in conformity with the relevant UK Legislation.

The name and address of authorised representative, authorised to compile the relevant technical documentation, is the Company Secretary, Cummins Generator Technologies, Fountain Court, Lynch Wood, Peterborough, UK. PE2 6FZ

| Signed: | Name, Title and Address: |
|---|---|
| A McQueen<br>Date: 4th August 2021 | Alastair McQueen<br>Global Technical Director<br>Cummins Generator Technologies<br>Fountain Court, Lynch Wood<br>Peterborough, UK<br>PE2 6FZ |

Description: Serial Number:

Registered in England under Registration No. 441273.
Cummins Generator Technologies Ltd. Registered Office: Fountain Court, Lynch Wood, Peterborough, PE2 6FZ UK

450-16383-J

**FIGURE 8. EXAMPLE UK DECLARATION OF CONFORMITY - SHEET 1**

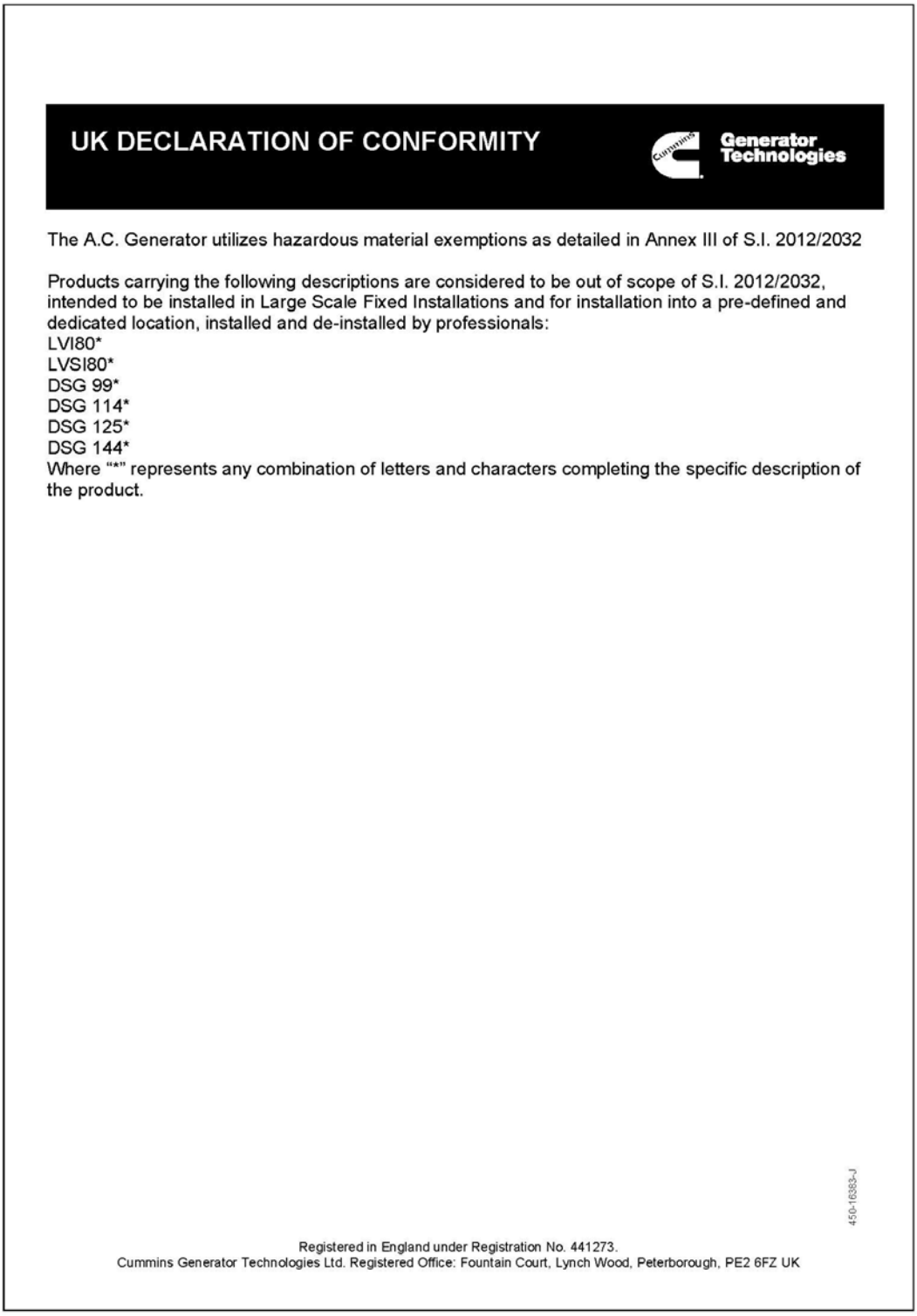


**FIGURE 9. EXAMPLE UK DECLARATION OF CONFORMITY - SHEET 2**

 

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## 2006/42/EC MACHINERY DIRECTIVE DECLARATION OF INCORPORATION OF PARTLY COMPLETED MACHINERY

Generator Technologies

Function: Synchronous A.C. generator >1000VAC designed for incorporation into an electricity generating-set.

The partly completed machinery supplied with this declaration:

- Is designed and constructed solely as a non-functional component to be incorporated into a machine requiring completion.
- Is designed to comply with the provisions of the following EU Directives so far as their level of build will allow:

  2014/30/EU The Electromagnetic Compatibility (EMC) Directive

- Must not be put into service within the European Community ("EC") until the final machinery into which it is to be incorporated has been declared in conformity with the Machinery Directive and all other applicable EC Directives.
- Is designed and constructed to comply with the essential health and safety requirements of the Machinery Directive 2006/42/EC listed on sheet 2 of this Declaration.

The relevant technical documentation is compiled in accordance with the provisions of part B of Annex VII of the Machinery Directive. All relevant information about the partly completed machinery will be provided, in writing, on a reasoned request by the appropriate national authority to its authorised representative. The name and address of authorised representative, authorised to compile the relevant technical documentation, is the Company Secretary, Cummins Generator Technologies Romania, B-dul Decebal Nr. 116A 200746 Craiova Dolj, Romania.

The undersigned representing the manufacturer:

| Signed: | Name, Title and Address: |
|---|---|
|  <br>Date: 4th August 2021 | Alastair McQueen<br>Global Technical Director<br>Cummins Generator Technologies Romania<br>B-dul Decebal Nr. 116A<br>200746 Craiova<br>Dolj, ROMANIA |

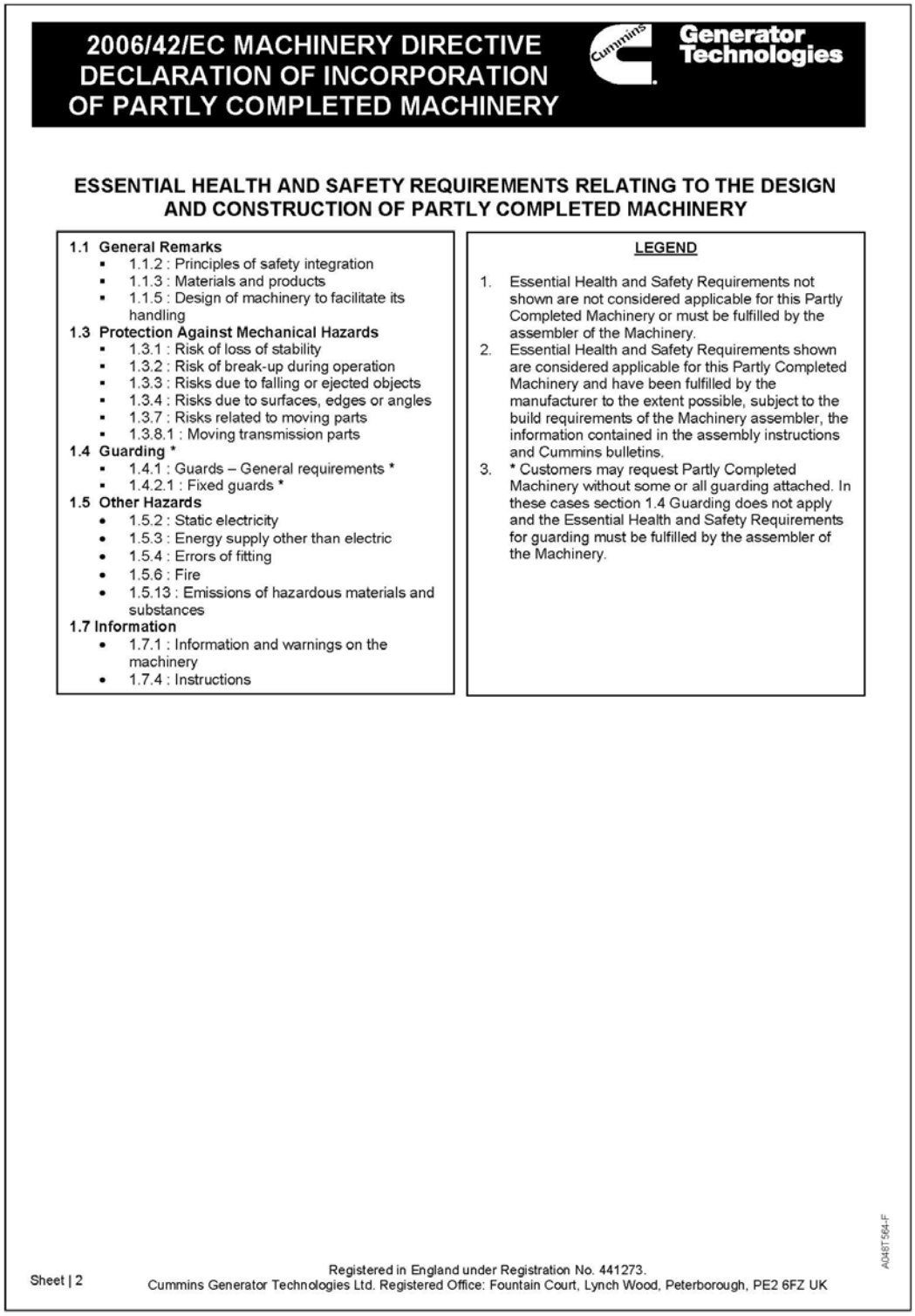
Description: Serial Number

A048T564-F





**FIGURE 10. EXAMPLE DECLARATION OF INCORPORATION (>1KV) - SHEET 1**



2006/42/EC MACHINERY DIRECTIVE
DECLARATION OF INCORPORATION
OF PARTLY COMPLETED MACHINERY

Generator Technologies

ESSENTIAL HEALTH AND SAFETY REQUIREMENTS RELATING TO THE DESIGN AND CONSTRUCTION OF PARTLY COMPLETED MACHINERY

**1.1 General Remarks**
- 1.1.2 : Principles of safety integration
- 1.1.3 : Materials and products
- 1.1.5 : Design of machinery to facilitate its handling

**1.3 Protection Against Mechanical Hazards**
- 1.3.1 : Risk of loss of stability
- 1.3.2 : Risk of break-up during operation
- 1.3.3 : Risks due to falling or ejected objects
- 1.3.4 : Risks due to surfaces, edges or angles
- 1.3.7 : Risks related to moving parts
- 1.3.8.1 : Moving transmission parts

**1.4 Guarding ***
- 1.4.1 : Guards – General requirements *
- 1.4.2.1 : Fixed guards *

**1.5 Other Hazards**
- 1.5.2 : Static electricity
- 1.5.3 : Energy supply other than electric
- 1.5.4 : Errors of fitting
- 1.5.6 : Fire
- 1.5.13 : Emissions of hazardous materials and substances

**1.7 Information**
- 1.7.1 : Information and warnings on the machinery
- 1.7.4 : Instructions

**LEGEND**

1. Essential Health and Safety Requirements not shown are not considered applicable for this Partly Completed Machinery or must be fulfilled by the assembler of the Machinery.
2. Essential Health and Safety Requirements shown are considered applicable for this Partly Completed Machinery and have been fulfilled by the manufacturer to the extent possible, subject to the build requirements of the Machinery assembler, the information contained in the assembly instructions and Cummins bulletins.
3. * Customers may request Partly Completed Machinery without some or all guarding attached. In these cases section 1.4 Guarding does not apply and the Essential Health and Safety Requirements for guarding must be fulfilled by the assembler of the Machinery.

A048T564-F

Sheet | 2

Registered in England under Registration No. 441273.
Cummins Generator Technologies Ltd. Registered Office: Fountain Court, Lynch Wood, Peterborough, PE2 6FZ UK

**FIGURE 11. EXAMPLE DECLARATION OF INCORPORATION (>1KV) - SHEET 2**

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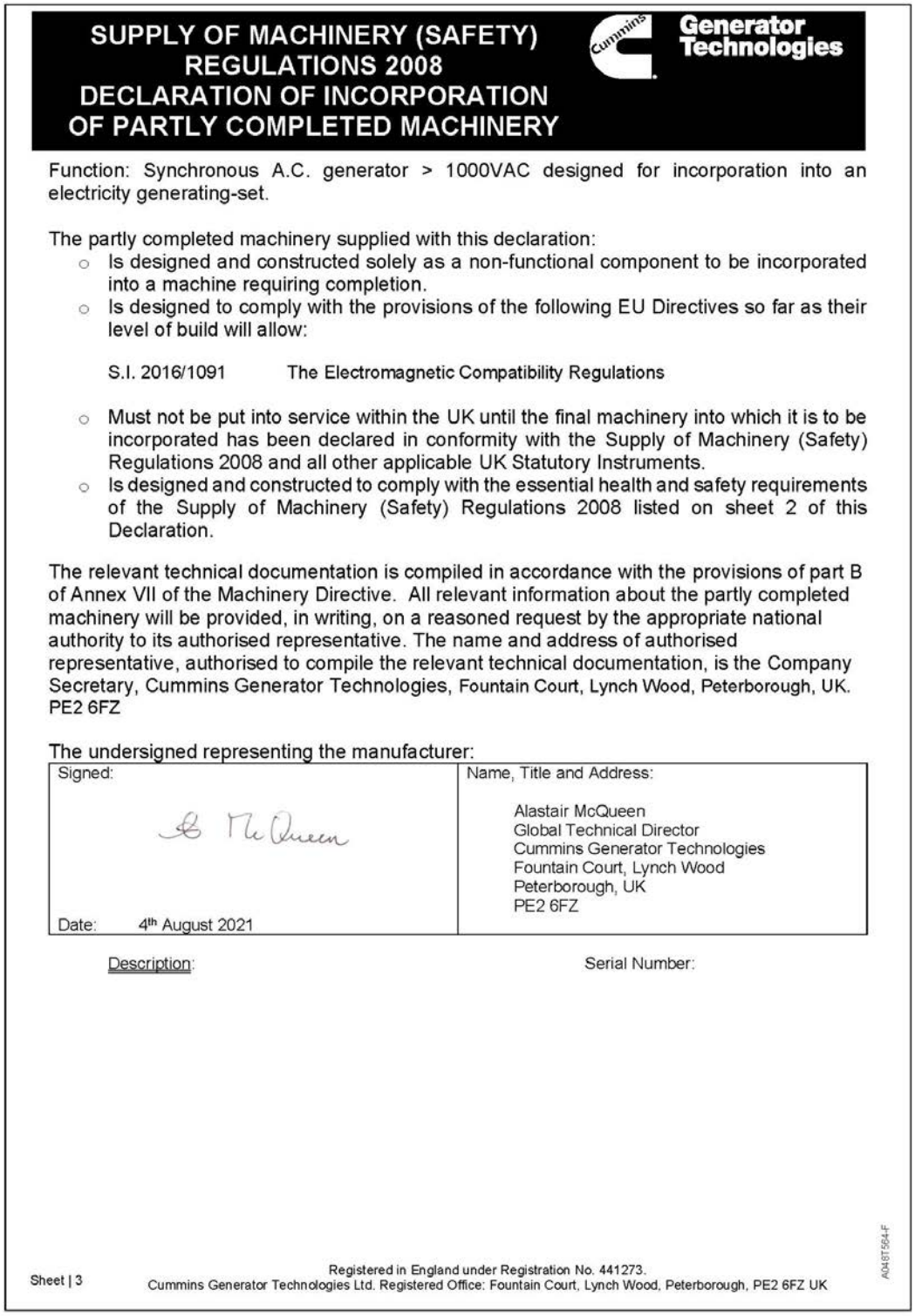


SUPPLY OF MACHINERY (SAFETY) REGULATIONS 2008
DECLARATION OF INCORPORATION OF PARTLY COMPLETED MACHINERY

Generator Technologies

Function: Synchronous A.C. generator > 1000VAC designed for incorporation into an electricity generating-set.

The partly completed machinery supplied with this declaration:

- Is designed and constructed solely as a non-functional component to be incorporated into a machine requiring completion.
- Is designed to comply with the provisions of the following EU Directives so far as their level of build will allow:

  S.I. 2016/1091 The Electromagnetic Compatibility Regulations

- Must not be put into service within the UK until the final machinery into which it is to be incorporated has been declared in conformity with the Supply of Machinery (Safety) Regulations 2008 and all other applicable UK Statutory Instruments.
- Is designed and constructed to comply with the essential health and safety requirements of the Supply of Machinery (Safety) Regulations 2008 listed on sheet 2 of this Declaration.

The relevant technical documentation is compiled in accordance with the provisions of part B of Annex VII of the Machinery Directive. All relevant information about the partly completed machinery will be provided, in writing, on a reasoned request by the appropriate national authority to its authorised representative. The name and address of authorised representative, authorised to compile the relevant technical documentation, is the Company Secretary, Cummins Generator Technologies, Fountain Court, Lynch Wood, Peterborough, UK. PE2 6FZ

The undersigned representing the manufacturer:

| Signed: | Name, Title and Address: |
|---|---|
| A McQueen<br>Date: 4th August 2021 | Alastair McQueen<br>Global Technical Director<br>Cummins Generator Technologies<br>Fountain Court, Lynch Wood<br>Peterborough, UK<br>PE2 6FZ |

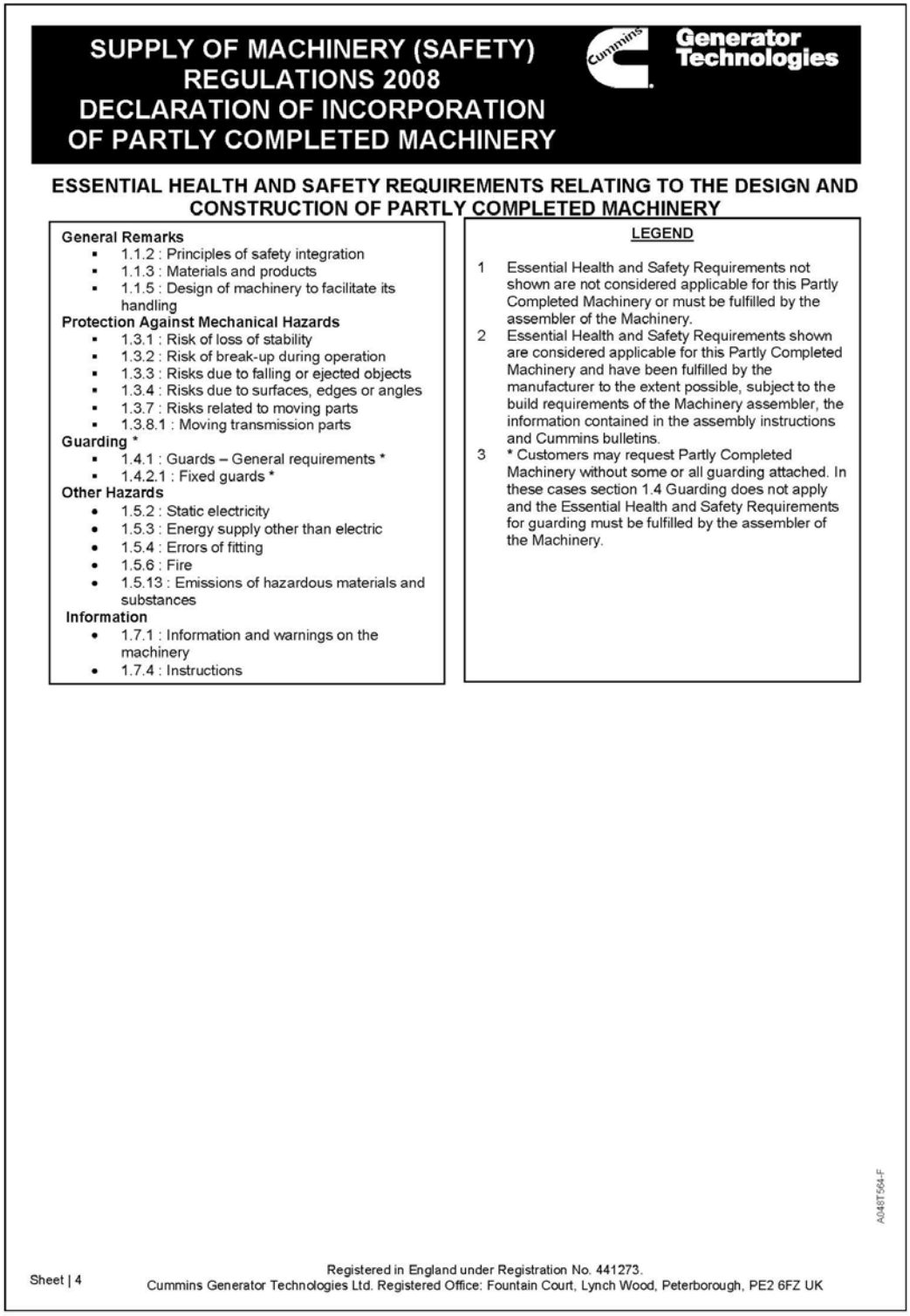
Description: Serial Number:

A048T564-F

Sheet | 3

Registered in England under Registration No. 441273.
Cummins Generator Technologies Ltd. Registered Office: Fountain Court, Lynch Wood, Peterborough, PE2 6FZ UK

**FIGURE 12. EXAMPLE DECLARATION OF INCORPORATION (>1KV) - SHEET 3**



SUPPLY OF MACHINERY (SAFETY) REGULATIONS 2008
DECLARATION OF INCORPORATION OF PARTLY COMPLETED MACHINERY

Generator Technologies

ESSENTIAL HEALTH AND SAFETY REQUIREMENTS RELATING TO THE DESIGN AND CONSTRUCTION OF PARTLY COMPLETED MACHINERY

**General Remarks**
- 1.1.2 : Principles of safety integration
- 1.1.3 : Materials and products
- 1.1.5 : Design of machinery to facilitate its handling

**Protection Against Mechanical Hazards**
- 1.3.1 : Risk of loss of stability
- 1.3.2 : Risk of break-up during operation
- 1.3.3 : Risks due to falling or ejected objects
- 1.3.4 : Risks due to surfaces, edges or angles
- 1.3.7 : Risks related to moving parts
- 1.3.8.1 : Moving transmission parts

**Guarding ***
- 1.4.1 : Guards – General requirements *
- 1.4.2.1 : Fixed guards *

**Other Hazards**
- 1.5.2 : Static electricity
- 1.5.3 : Energy supply other than electric
- 1.5.4 : Errors of fitting
- 1.5.6 : Fire
- 1.5.13 : Emissions of hazardous materials and substances

**Information**
- 1.7.1 : Information and warnings on the machinery
- 1.7.4 : Instructions

LEGEND

1 Essential Health and Safety Requirements not shown are not considered applicable for this Partly Completed Machinery or must be fulfilled by the assembler of the Machinery.

2 Essential Health and Safety Requirements shown are considered applicable for this Partly Completed Machinery and have been fulfilled by the manufacturer to the extent possible, subject to the build requirements of the Machinery assembler, the information contained in the assembly instructions and Cummins bulletins.

3 * Customers may request Partly Completed Machinery without some or all guarding attached. In these cases section 1.4 Guarding does not apply and the Essential Health and Safety Requirements for guarding must be fulfilled by the assembler of the Machinery.

A048T564-F

Sheet | 4

Registered in England under Registration No. 441273.
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**FIGURE 13. EXAMPLE DECLARATION OF INCORPORATION (>1KV) - SHEET 4**

 

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## 3.3 Additional Information for Electromagnetic Compatibility Compliance (EMC)

All STAMFORD® and AvK® alternators are designed to meet electromagnetic compatibility compliance emissions and immunity standards for industrial environments. Additional equipment may be required when the alternator is installed in residential, commercial, and light industrial environments.

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

Operation, installation, service and maintenance procedures must only be carried out by experienced and qualified personnel, who are familiar with the procedures and the equipment, who are aware of the requirements of all locally applicable rules and regulations and who have undertaken suitable training, refer to; **Section 2.3 on page 3**.

| *NOTICE* |
| --- |
| **Cummins Generator Technology is not liable for electromagnetic compatibility compliance if unauthorized parts, not of; STAMFORD® or AvK®brand(s), are used for maintenance, servicing or repairs.** |

## 3.4 Additional Information for Canadian Standards Association (CSA)

To comply with Canadian Standards Association (CSA) regulations, all external wiring and components must be rated to: At least the alternator rated voltage shown on the alternator rating plate.

# 4 Introduction

## 4.1 General Description

S7 alternators are of brushless rotating field design, available up to 690 V, 50 Hz (1500 RPM, 4 pole) or 60 Hz (1800 RPM, 4 pole), and built to meet BS5000 Part 3 and international standards.

## 4.2 Noise

**⚠ WARNING**

***Noise***

***Noise from a running alternator can cause serious injury by permanent hearing damage. To prevent injury:***

- ***Always wear appropriate personal protection equipment; refer to Safety Precaution Chapter.***

Maximum A-weighted noise emissions may reach 110 dB(A). Contact the supplier for application-specific details.

## 4.3 Alternator Name

**TABLE 3. S7 ALTERNATOR NAMING FORMAT**

| Example: | S | 7 | L | 1 | D | - | C | 4 | 2 |
|---|---|---|---|---|---|---|---|---|---|
| | STAMFORD Brand | Family Series | Voltage (L = low, M = medium, H = high) | Revision | Descriptor D = industrial, M = marine | | Core length (C, D, E, ...) | Number of poles | Number of bearings (1 = NDE, 2 = DE & NDE) |

## 4.4 Serial Number Location

A unique serial number is stamped into the drive end ring of the alternator frame and shown on two labels on the outside of the terminal box (if fitted).

## 4.5 Rating Plate

The fixed rating plate label states the intended operating parameters of the alternator.

 

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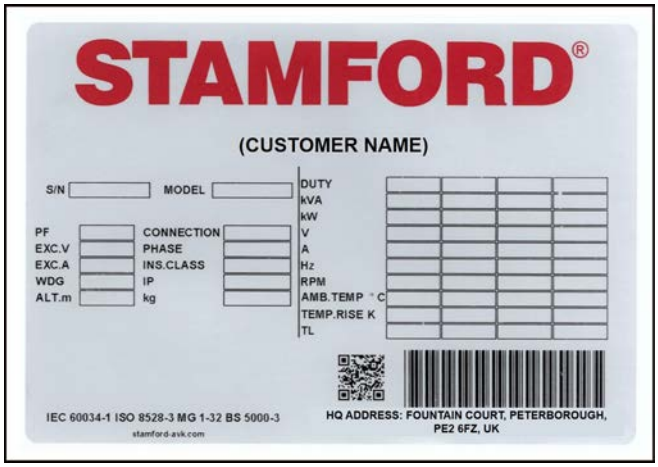


**FIGURE 14. GLOBAL STAMFORD AC ALTERNATOR RATING PLATE**

# 4.6 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 alternator is genuine by entering the unique 7 character hologram code at **www.stamford-avk.com/verify**.

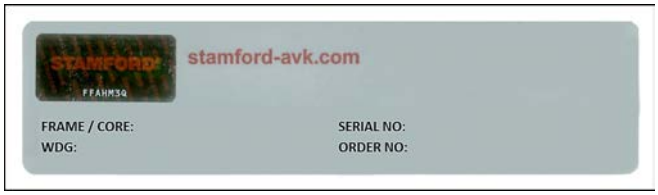


**FIGURE 15. TRACKING LABEL**


**FIGURE 16. DOTS VISIBLE IN LEFT, RIGHT, UPPER AND LOWER VIEWS OF 3D HOLOGRAM**

# 5 Lifting, Storage and Transportation

## 5.1 General Transport Guidance

**⚠ DANGER**

***Falling Mechanical Parts***

***Falling mechanical parts can cause serious injury or death by impact, crushing, severing or trapping. To prevent injury and before lifting:***

- ***Check the capacity, condition and attachment of lifting equipment (crane, hoists and jacks, including attachments to anchor, fix or support the equipment).***
- ***Check the capacity, condition and attachment of accessories for lifting (hooks, slings, shackles and eye bolts for attaching loads to lifting equipment).***
- ***Check the capacity, condition and attachment of lifting fixtures on the load.***
- ***Check the mass, integrity and stability (e.g. unbalanced or shifting center of gravity) of the load.***
- ***When available; Fit drive end and non-drive end transit fittings to prevent damage to bearings and prevent movement.***
- ***Keep the alternator horizontal when lifting.***
- ***Do not use the lifting points fitted to the alternator for lifting a complete generator set.***
- ***Do not use the lifting points fitted to the cooler for lifting the alternator or a complete generator set.***
- ***Do not remove the lifting label attached to one of the lifting points.***

Alternators can vary greatly, in shape, size, weight, and have different centers of gravity and require lifting, loading, lashing down / securing and unloading depending on model and specification. When loading a vehicle, transporting a load and unloading a vehicle, ensure the below points are followed:

- Comply with all locally applicable rules and regulations relating to transport operations at all times.
- Comply with all locally applicable rules and regulations relating to transport operations for the destination country and any countries that are transited through when applicable.
- Always follow industry best practice guidance.
- When lashing down / securing the alternator to a vehicle ensure that a sufficient number of appropriately configured restraints are used.
- Ensure that lashing down / securing restraints are not placed on or over sensitive components that may become damaged by the restraint.
- Ensure that lashing down / securing restraints are not positioned where damage to paintwork or information/warning labeling may occur. Protect these areas appropriately if restrains must be placed over them.
- All exposed or machined surfaces must be treated with an anti-corrosion product prior to transportation or storage.
- If required; consult with a transport specialist for advice.
- If required; the alternator should be supplied on a transport frame.

For specific product information, refer to: The general arrangement drawing, lifting label and transport information supplied with the alternator.

 

-

## 5.2 Lifting the Alternator

**⚠ DANGER**

***Falling Mechanical Parts***

***Falling mechanical parts can cause serious injury or death by impact, crushing, severing or trapping. To prevent injury and before lifting:***

- ***Check the capacity, condition and attachment of lifting equipment (crane, hoists and jacks, including attachments to anchor, fix or support the equipment).***
- ***Check the capacity, condition and attachment of accessories for lifting (hooks, slings, shackles and eye bolts for attaching loads to lifting equipment).***
- ***Check the capacity, condition and attachment of lifting fixtures on the load.***
- ***Check the mass, integrity and stability (e.g. unbalanced or shifting center of gravity) of the load.***
- ***When available; Fit drive end and non-drive end transit fittings to prevent damage to bearings and prevent movement.***
- ***Keep the alternator horizontal when lifting.***
- ***Do not use the lifting points fitted to the alternator for lifting a complete generator set.***
- ***Do not use the lifting points fitted to the cooler for lifting the alternator or a complete generator set.***
- ***Do not remove the lifting label attached to one of the lifting points.***

Lift the alternator by hooks or shackles attached 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 alternator mass shown on the label.

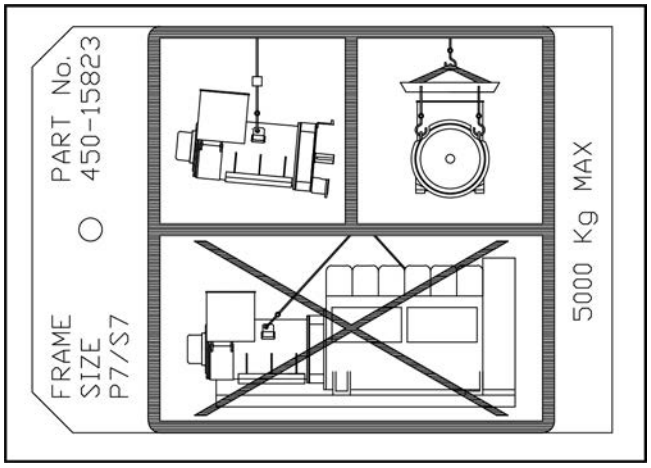


**FIGURE 17. LIFTING LABEL**

## 5.3 Alternator Dimensions

Dimensions are included in the data sheet specific to the alternator model. Refer to the rating plate to identify the alternator model.

***NOTICE***

**Data sheets are available from www.stamford-avk.com**

# 5.4 Storage

**⚠ WARNING**

***Condensed Water***

***Operating an alternator with condensed water in the windings can cause serious injury by electric shock, burns or exposure to flying debris and particles. To prevent injury:***

- ***Use anti-condensation heaters (if fitted) to prevent condensation accumulating.***
- ***Before operating the alternator; check for condensed water. If condensed water is present, drain/remove the water, dry and inspect the alternator in accordance with the Maintenance and Servicing Chapter.***

**⚠ WARNING**

***Hot Surfaces and Fire***

***Contact with hot surfaces can cause serious injury and death by burns. A risk of fire exists where hot surfaces are contacted by combustible items. To prevent injury/fire:***

- ***Avoid contact with hot surfaces.***
- ***Always wear the appropriate personal protection equipment, refer to; Safety Precaution Chapter.***
- ***Ensure that no combustible materials (such as packaging) or flammable substances come in to contact with or are stored in close proximity to the anti-condensation heater (if fitted).***
- ***Ensure that no combustible material(s) or flammable substances come in to contact with or are stored in close proximity to the alternator or prime mover, including the cooling, ventilation and exhaust system(s) where applicable.***

If the alternator will not be used immediately, it must be stored in a clean, dry, vibration-free environment. We recommend the use of anti-condensation heaters, when available.

If the alternator can be rotated, turn the rotor a minimum of 6 revolutions every month during storage.

# 5.5 Long-term Storage

When an alternator is stationary, in storage or otherwise, it may be subjected to environmental factors, such as vibration, humidity, temperature and airborne contaminant particles, that could degrade the bearing arrangements.

Contact CGT customer service **www.stamford-avk.com** for advice in advance if the alternator will be stationary for long periods.

# 5.6 After Storage

After a period of storage, carry out the pre-running checks to determine the condition of the windings. If the windings are damp or the insulation resistance is low, follow one of the drying out procedures, refer to; **Chapter 9 on page 55**.

Before putting the alternator into service, refer to the following table.

**TABLE 4. BEARING STORAGE**

| Bearing Type | Not Rotated during Storage | Rotated during Storage |
|---|---|---|

 

-

| | | |
|---|---|---|
| **Sealed Bearing(s)** | If stored less than 12 months, put the alternator into service.<br>If stored more than 12 months, replace the bearing(s) then put the alternator into service. | If stored less than 24 months, put the alternator into service.<br>If stored more than 24 months, replace the bearing(s) then put the alternator into service. |
| **Re-greasable Bearing(s)** | If stored less than 12 months, put the alternator into service.<br>If stored more than 12 months, replace the bearing(s) then put the alternator into service. | If stored less than 6 months, put the alternator into service.<br>If stored between 6 and 24 months, re-grease the bearing(s) during the first run then put the alternator into service.<br>If stored more than 24 months, replace the bearing(s) then put the alternator into service. |

# 5.7 Transportation Locking Devices

## 5.7.1 Single Bearing Alternator Transport Lock

Single bearing alternators may be supplied with a factory-fitted transport locking bar that is fastened to the **drive end** of the alternator. The drive end transportation locking bar provides protection from vibration and movement to the alternator bearings, during transportation.

If supplied;

- Drive end transportation locking bars should be fitted to the drive end of the alternator prior to the alternator being transported (whenever the alternator is not coupled to a prime-mover).
- Drive end transportation locking bars must be removed prior to rotating, coupling the alternator.
- Drive end transportation locking bars should be retained and should be re-fitted if the alternator is transported uncoupled from a prime mover.
- Drive end transportation locking bars may need to be removed if the alternator is put in to storage if the locking plate prevents the alternator from being rotated for periodic maintenance.

| ***NOTICE*** |
|---|
| **Failure to remove the transportation lock prior to rotating, coupling or operating the alternator could result in damage to the alternator.** |

## 5.7.2 Two Bearing Alternator Transport Lock

Two bearing alternators can be supplied with an optional, factory-fitted transport lock that is fastened on to the **non-drive end** of the alternator. The non-drive end transportation lock provides protection from vibration and movement to the alternator bearings. The non drive end lock should be used before and after coupling the alternator to a prime mover as it provides an additional level of protection when the generator set is being transported.

If supplied;

- Non-drive end transportation lock should be fitted to the alternator prior to the alternator being transported when both coupled or uncoupled to a generator set.
- Non-drive end transportation lock must be removed prior to rotating, coupling or operating the alternator.
- Non-drive end transportation lock must be retained with the alternator and should be re-fitted prior to further transportation of the alternator / coupled generator set.

- Non-drive end transportation lock may need to be removed if the alternator is placed in to storage; due to the locking plate preventing the alternator from being rotated for periodic maintenance.

| ***NOTICE*** |
| --- |
| **Failure to remove the transportation lock prior to rotating, coupling or operating the alternator could result in damage to the alternator or coupled generator set.** |

 

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# 6 Automatic Voltage Regulators (AVR)

## 6.1 Separately-Excited AVR Controlled Alternators

A separately-excited AVR receives power from a separate permanent magnet generator (PMG), mounted on the main alternator shaft. The AVR controls the alternator output voltage by automatic adjustment of the exciter stator field strength. The AVR excitation remains at full capability when sudden loads are applied to the alternator, giving superior motor starting, short circuit and EMC performance.

### 6.1.1 Permanent Magnet Generator (PMG) Excited - AVR Controlled Alternators

**⚠ WARNING**

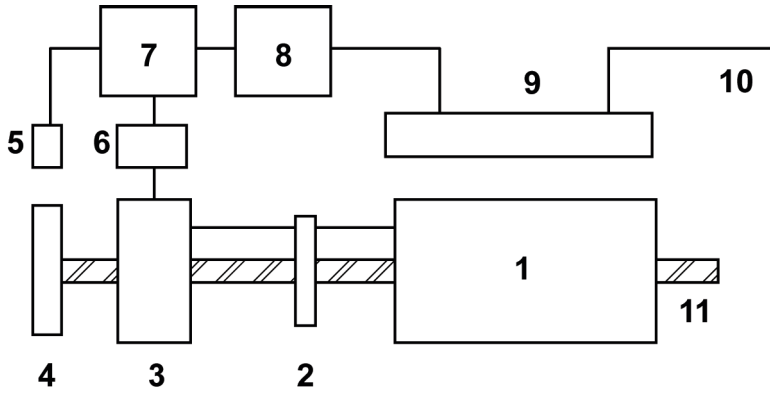
***Strong Magnetic Field***

***The strong magnetic field from a permanent magnet generator (PMG) or excitation boost system (EBS), can cause serious injury or death by interference with implanted medical devices. To prevent injury:***

- ***Do not work near a permanent magnet generator (PMG) or excitation boost system (EBS) if you have an implanted medical device.***

The AVR provides closed loop control by sensing the alternator output voltage at the main stator windings and adjusting the exciter stator field strength. Voltage induced in the exciter rotor, rectified by the rotating diodes, magnetises the rotating main field which induces voltage in the main stator windings. A separately-excited AVR is independently powered from a separate permanent magnet generator (PMG), mounted on the main alternator rotor shaft. Voltage is induced in the stator of the PMG by a rotor of permanent magnets.

**TABLE 5. PMG EXCITED AVR**




| No. | Description | No. | Description | No. | Description |
|---|---|---|---|---|---|
| 1 | Main field (rotor) | 5 | PMG armature (stator) | 9 | Main armature (stator) |
| 2 | Rotating diodes | 6 | Exciter field (stator) | 10 | Output |
| 3 | Exciter armature (rotor) | 7 | AVR | 11 | Rotor shaft |
| 4 | PMG field (rotor) | 8 | Isolating transformer (if fitted) | | |

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## 6.1.2 Separately-Excited AVR Types

### 6.1.2.1 MX341

The MX341 achieves voltage regulation of ±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 alternator output voltage rise when starting.

### 6.1.2.2 MX322™

The MX322™ achieves voltage regulation of ±0.5% 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 alternator output voltage rise when starting
- Three-phase r.m.s. voltage sensing
- Over-voltage protection with internal shutdown of the AVR output device
- Adjustable delayed response (dwell) of excitation voltage to speed changes, and
- Adjustable short-circuit or starting current limit (with optional current sensing transformer accessory).

### 6.1.2.3 DECS-150

The DECS-150 digital excitation control system is a microprocessor-based controller. DECS-150 offers a high powered and environmentally rugged solution for controlling the output of synchronous generators. DECS-150 is highly suitable for parallel, distributed generation, cogeneration, and peakshaving applications.

The AVR includes the following extra features:

- 0.25% voltage regulation accuracy
- Capable of supplying 10Adc at 63Vdc or 125Vdc using Pulse-width Modulation (PWM)
- A reliable design tolerant of non-linear loads of up to 40% Total Harmonic Distortion (THD)
- Four excitation control modes:
  - Automatic Voltage Regulation (AVR)
  - Field Current Regulation (FCR)
  - Power Factor Regulation (PF)
  - Var Regulation (var)
- Four limiting functions:
  - Over-excitation
  - Under-excitation
  - Stator current
  - Under-frequency
- Two Proportional Integral Derivative Controller (PID) stability groups with auto tuning.
- Multiple, configurable protection functions
- Three-phase voltage and current sensing

- Remote set-point control input accepts analogue voltage or current control signal
- Real-time metering
- Data logging and sequence of events
- Soft start and voltage build-up control
- USB powered for programming via BESTCOMS*Plus* software.

### 6.1.2.4 DM110

The DM110 digital excitation control system is a microprocessor-based controller. DM110 parameters are set and monitored with software on a connected personal computer (PC). When running without a PC, control status may be monitored by LED lamps on the controller.

The AVR includes the following extra features:

- Integrated power factor control
- Adjustable rate of voltage reduction with speed for (UFRO) protection
- Soft-start control of alternator output voltage rise when starting
- Three-phase r.m.s. voltage sensing
- Over-voltage protection with internal shutdown of the AVR output device
- Adjustable excitation limiting
- Full digital control.

### 6.1.2.5 UNITROL 1010

The Unitrol 1010 provides compact and reliable, automatic voltage regulation for synchronous generators with uninterrupted transfer between different modes of operation (AVR, FCR, PF, VAR). There are various built in control software functions with robust mechanical and electrical design to allow a wide range of applications. The Unitrol 1010 is highly integrated and suitable for harsh environment.

The AVR includes the following extra features:

- Wide range of power input voltage for AC and DC input
- Excitation current up to 10A continuous and 20A transient
- Stable and accurate regulation including highly disturbed voltages
- Three-phase voltage and current sensing
- Configurable measurements and inputs/outputs
- Soft start and voltage matching
- Adjustable excitation current limit
- Limiters to ensure safe and stable operation
- Intuitive and user-friendly commissioning tool, and
- Integrated power factor control.

## 6.2 AVR Accessories

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

 

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### 6.2.1 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 alternator voltage. The hand trimmer value and the adjustment range obtained is as defined in the **Technical Specification** chapter. Refer to wiring diagram before removing the shorting link and connecting the hand trimmer.

### 6.2.2 Droop Transformer (for parallel operation – alternator to alternator)

A droop transformer can be fitted in a defined position in the alternator main output wiring and connected to the AVR to enable parallel operation with other alternators. The adjustment range is as defined in the AVR manual. Refer to wiring diagram before removing the shorting link and connecting 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).

### 6.2.3 Power Factor Controller (PFC) (for parallel operation – alternator to mains utility)

An electronic control module is available for use with the AVR to provide power factor control of the alternator output. The module uses alternator voltage and output current as inputs and interfaces with the AVR to ensure the necessary flexibility of the alternator excitation and hence control of the exported (or imported) kVAr. This allows full closed-loop control of the alternator power factor at the point of connection into the mains utility. Other features allow the alternator (or alternators) to be automatically ‘voltage-matched’ prior to paralleling.

### 6.2.4 Current Limiting Transformers

Alternator 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 rises above a pre-set 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.

# 7 Application of the Alternator

It is the customer's responsibility to make sure that the selected alternator is suitable for the final application.

**⚠ WARNING**

***Incorrect or Improper Use***

***Incorrect or improper use of the alternator may result in serious injury, death or equipment damage. To prevent injury:***

- ***Always select the correct specification alternator for the intended use and application.***
- ***Ensure the alternator and prime mover are technically compatible and practically suitable for the intended application.***
- ***Always install the alternator in accordance with the original manual(s) and technical drawing(s) supplied with the alternator and comply with all locally applicable rules and regulations.***
- ***Ensure the alternator is operated in accordance with the manual(s) and within the limits of the alternator rating plate.***
- ***Do not use a damaged or defective alternator. Shut down and isolate the alternator set from all energy sources, remove stored energy and use lock out/tag out safety procedures. Prevent further use of the alternator until it is repaired and returned to a serviceable condition.***

## 7.1 Environment

The alternators are protected to IP23 as standard. IP23 is not adequate protection for use outdoors without additional measures.

**TABLE 6. ENVIRONMENTAL SPECIFICATION**

| | |
|---|---|
| **Ambient Temperature** | -15 °C to 40 °C (5 °F to 104 °F) |
| **Relative Humidity** | < 70% |
| **Altitude** | < 1000 m (3280 ft) |

The alternator has been designed for the environment shown in the table. The alternator can operate outside these conditions if it is rated accordingly; the nameplate gives details. If the operating environment is changed after purchase, refer to the factory for a revised alternator rating.

## 7.2 Air Flow

**TABLE 7. MINIMUM AIR FLOW AND MAXIMUM PRESSURE DIFFERENCE**

| Alternator type | Minimum Air flow, $m^3/s$ ($ft^3/min$) | | Maximum intake to outlet pressure difference, mm (in) water gauge |
|---|---|---|---|
| | 50 Hz | 60 Hz | |
| **S7 (C-H cores)** | 2.71 (5738) | 3.25 (6881) | 6 (0.25) |
| **S7 (J-K cores)** | 3.1 (6563) | 3.72 (7876) | 6 (0.25) |

Make sure that the air inlets and outlets are not obstructed when the alternator is running.

 

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## 7.3 Airborne Contaminants

**⚠ CAUTION**

***Dust & Airborne Particles/Fumes***

***Inhaling dust and other airborne particles/fumes can cause minor or moderate injury by irritating the lungs and eyes. Repetitive/prolonged exposure may cause serious chronic medical conditions to develop. To prevent injury:***

- ***Use mechanical vacuum extraction to remove dust and airborne particles/fumes where appropriate.***
- ***Ventilate the area appropriately.***
- ***Always wear the appropriate personal protection equipment, refer to; Safety Precaution Chapter.***

***NOTICE***

**Contaminants such as salt, oil, exhaust fumes, chemicals, dust, and sand will reduce the effectiveness of the insulation and the life of the windings. Consider using air filters and an enclosure to protect the alternator.**

## 7.4 Air Filters

Air filters trap airborne particulates above 5 microns. The filters must be cleaned or replaced regularly, depending on site conditions. Check the filters frequently to establish an appropriate service interval.

Alternators with factory-fitted filters are rated to account for the reduced flow rate of cooling air. If filters are retrofitted, the alternator rating must be reduced by 5%.

Air filters do not remove water. Keep the filters dry with additional protection. Wet filters further restrict airflow, causing the alternator to overheat and leading to premature failure of the insulation.

## 7.5 Humid Conditions

The water carrying capacity of air depends on temperature. If the air temperature falls below its saturation point, dew may form on the windings, reducing the electrical resistance of the insulation. In humid conditions, additional protection may be required even if the alternator is fitted inside an enclosure. Anti-condensation heaters are supplied on request.

## 7.6 Anti-Condensation Heaters

**⚠ DANGER**

***Testing Live Electrical Conductors***

***Live electrical conductors can cause serious injury or death by electric shock and burns. To prevent injury:***

- ***Before removing covers over electrical conductors, shut down and isolate the generator set from all energy sources, remove stored energy and use lock out/tag out safety procedures.***

**⚠ WARNING**

***Condensed Water***

***Operating an alternator with condensed water in the windings can cause serious injury by electric shock, burns or exposure to flying debris and particles. To prevent injury:***

- ***Use anti-condensation heaters (if fitted) to prevent condensation accumulating.***
- ***Before operating the alternator; check for condensed water. If condensed water is present, drain/remove the water, dry and inspect the alternator in accordance with the Maintenance and Servicing Chapter.***

**⚠ WARNING**

***Hot Surfaces and Fire***

***Contact with hot surfaces can cause serious injury and death by burns. A risk of fire exists where hot surfaces are contacted by combustible items. To prevent injury/fire:***

- ***Avoid contact with hot surfaces.***
- ***Always wear the appropriate personal protection equipment, refer to; Safety Precaution Chapter.***
- ***Ensure that no combustible materials (such as packaging) or flammable substances come in to contact with or are stored in close proximity to the anti-condensation heater (if fitted).***
- ***Ensure that no combustible material(s) or flammable substances come in to contact with or are stored in close proximity to the alternator or prime mover, including the cooling, ventilation and exhaust system(s) where applicable.***

Power to the anti-condensation heater is supplied from a separate source. Anti-condensation heaters raise the air temperature around the windings to deter condensation forming in humid conditions when the alternator is not operating. Best practice is to energize the heaters automatically when the alternator is off.

# 7.7 Enclosures

**⚠ WARNING**

***Enclosures***

***Alternators may be installed within an enclosure for environmental protection, noise reduction or transportation etc. If the alternator is operating within an enclosure; to prevent injury, asphyxiation or death:***

- ***Personnel must only enter the enclosure when the alternator is operating if they are wearing the appropriate protective equipment and have received appropriate training.***
- ***Personnel must, at all times; have a safe access route in to and out of the enclosure, sufficient ventilation and observe the alternator hazard zones.***
- ***Refer to; Safety Precaution Chapter.***

Fit an enclosure to protect the alternator from adverse environmental conditions.

- Make sure that air entering the alternator is of adequate flow rate, free from moisture and contaminants and below the maximum ambient temperature on the rating plate.
- The airflow should be modeled to identify and prevent hot air from re-circulating within the enclosure.
- Make sure there is sufficient access around the alternator for safe maintenance.

 

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# 7.8 Vibration

The alternators are designed to withstand the vibration levels encountered on generator 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 generator set).

| *NOTICE* |
| --- |
| **Exceeding either of the above specifications will have a detrimental effect on the life of the bearings and other components, and may invalidate the alternator warranty.** |

| *NOTICE* |
| --- |
| **The terminal box is designed to support the fitted busbars or terminals, transformers, load cables and auxiliary terminal box. Additional mass could cause excessive vibration and lead to failure of the terminal box enclosure and mounting. Refer to the Installation Manual to connect the load cables to the terminal box. Refer to CGT before fixing any additional mass to the terminal box.** |

## 7.8.1 Definition of BS5000–3

Alternators shall be capable of continuously withstanding linear vibration levels with amplitudes of 0.25 mm between 5 Hz and 8 Hz, and velocities of 9.0 mm/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.

## 7.8.2 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 generator set designs.

## 7.8.3 Vibration Frequencies

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

- 4-pole 1500 RPM 25 Hz
- 4-pole 1800 RPM 30 Hz

Vibrations induced in the alternator by the engine are complex. It is the responsibility of the generator set designer to ensure that the alignment and stiffness of the bedplate and mountings do not allow vibration to exceed BS5000 part 3 and ISO 8528 part 9 limits.

## 7.8.4 Linear Vibration Limits

**TABLE 8. S7 VIBRATION LEVEL MEASUREMENTS**

| Linear Vibration Levels As Measured On The Alternator - S7 | | | |
|---|---|---|---|
| **Engine Speed RPM ($min^{-1}$)** | **Power Output S (kVA)** | **Vibration Displacement RMS (mm)** | **Vibration Velocity RMS (mm/s)** |
| 1 300 ≤nr <2 000 | >250 | 0.32 | 20 |
| 720 ≤nr <1 300 | ≥250 but ≤1 250 | 0.32 | 20 |
| | >1 250 | 0.29 | 18 |
| The broad band is taken as 10 Hz - 1000 Hz | | | |

## 7.8.5 Linear Vibration Monitoring

We recommend using vibration analysing equipment to measure vibration at all of the 12 positions shown below. Check that vibration of the generator set is below the limits stated in the standards. If vibration is above the limits, the generator set builder should investigate the root causes and eliminate them. Best practice is for the generator 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.

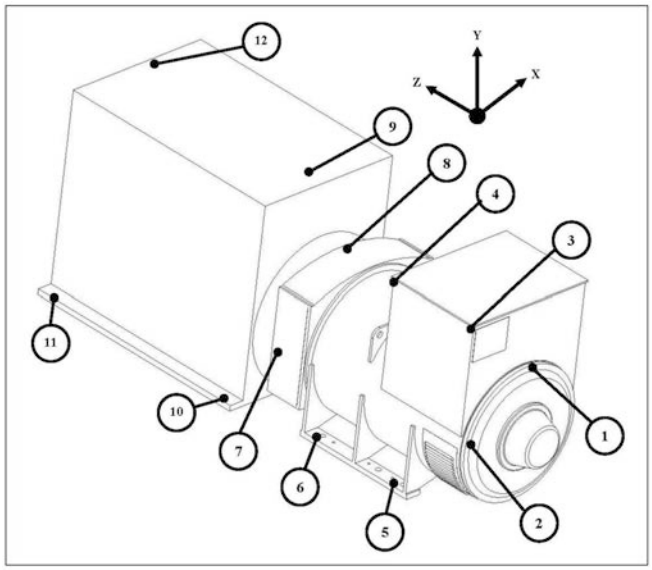


**FIGURE 18. VIBRATION MEASUREMENT LOCATIONS**

 

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### 7.8.6 Excessive Vibration

**⚠ WARNING**

***Exposure to Ejected Debris and Particles***

***Ejected debris and particles can cause serious injury or death by impact, severing or puncturing. Exposure to mechanically driven release of debris and particles exists in all directions (horizontally and vertically) in the areas surrounding the alternator air outlet(s), air inlets(s) and the open shaft end (also commonly known as the Drive End (DE)).***

***To prevent injury; observe the below points while the alternator is operating:***

- ***Keep away from the air inlet(s) and air outlet(s) when the alternator is running.***
- ***Do not position operator controls near the air inlet(s) or air outlet(s).***
- ***Do not cause overheating by running the alternator outside rating plate parameters.***
- ***Do not overload the alternator.***
- ***Do not run an alternator with excessive vibration.***
- ***Do not synchronize parallel alternators outside the specified parameters.***

If the measured vibration of the generator set is not within the limits:

1. Consult with the generator set manufacturer to reduce vibration to an acceptable level.
2. Contact CGT Customer Service to assess the impact on bearing and alternator life expectancy.

## 7.9 Bearings

### 7.9.1 Sealed Bearings

Inspect sealed-for-life bearings periodically, according to the recommended service schedule in this manual. Check for signs of wear, fretting or other detrimental features. Damage to seals, grease leakage or discoloration of the bearing races indicate that the bearing may need to be replaced.

### 7.9.2 Re-greasable Bearings

Each bearing housing is connected by a grease pipe to an external grease nipple. A label gives the grease type and quantity, and frequency for re-greasing. The recommended grease is a high specification synthetic compound that must not be mixed with grease of a different specification. Refer to the Service and Maintenance chapter for detailed instructions.

### 7.9.3 Bearing Life

Factors that reduce bearing life or lead to bearing failure include:

- Adverse operating conditions and environment.
- Stress caused by misalignment of the generator set.
- Vibration from the engine that exceeds the limits in BS 5000-3 and ISO 8528-9.
- Long periods (including transportation) when the alternator is stationary and subjected to vibration can cause false brinelling wear (flats on the balls and grooves on the races).
- Humid or wet conditions that cause corrosion and deterioration of the grease by emulsification.

## 7.9.4 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 generator set or engine service interval.

## 7.9.5 Bearing 'Service Life' Expectancy

Bearing manufacturers recognize that the service life of bearings depends on factors that are outside their control. Rather than quote a service life, practicable replacement intervals are 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: If 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 the bearings within 30,000 hours of operation.

If in doubt regarding any aspect of bearing life of a STAMFORD® alternator, contact the nearest authorized supplier of the alternator or contact CGT Customer Service.

## 7.9.6 Standby Applications

Run alternators in standby applications at no load for a minimum of 10 minutes every week. For alternators fitted with regreasable bearings, re-grease the bearings every 6 months, regardless of the number of accumulated running hours.

 

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# 8 Installation into the Generator Set

## 8.1 Generator Set Coupling

**⚠ WARNING**

***Coupling an Alternator to a Prime Mover***

***Moving mechanical parts during generator set coupling can cause serious injury by crushing, severing or trapping. To prevent injury:***

- ***Personnel must keep limbs and body parts away from mating surfaces when coupling the alternator to a prime mover.***
- ***Personnel must keep limbs and body parts away from mating surfaces when installing large components, such as; cooling systems and fuel tanks on to the alternator/generator set.***

***NOTICE***

**An optional transportation lock may be fitted to the non-drive end of the alternator. Ensure the transportation lock has been removed prior to rotating, coupling or operating the alternator.**

***NOTICE***

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

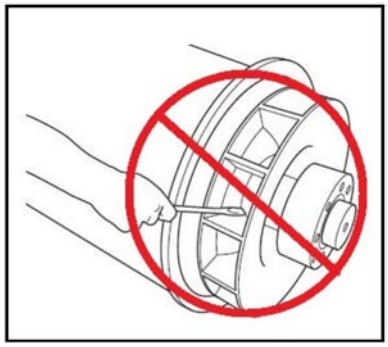

**FIGURE 19. DO NOT ROTATE WITH A LEVER**

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

Generator sets need a substantial flat continuous bedplate to suit the installation site floor loading, with engine and alternator 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 alternator rotor and engine output shaft must be coaxial (radial alignment) and perpendicular to the same plane (angular alignment). The axial alignment of the alternator and engine coupling must be within 0.5 mm, to allow for thermal expansion without unwanted axial force on the bearings at operating temperature.

Vibration can occur by flexing of the coupling. The alternator 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.

 

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Close-coupling of alternator and engine can increase the rigidity of the generator set. Both single and two bearing alternators can be close-coupled. The generator set builder must supply guarding for open-coupled applications.

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

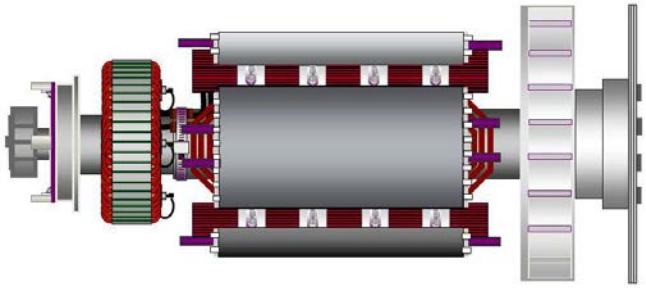

**FIGURE 20. SINGLE BEARING ALTERNATOR ROTOR SHOWING COUPLING DISCS BOLTED TO DRIVE END COUPLING HUB (AT RIGHT)**

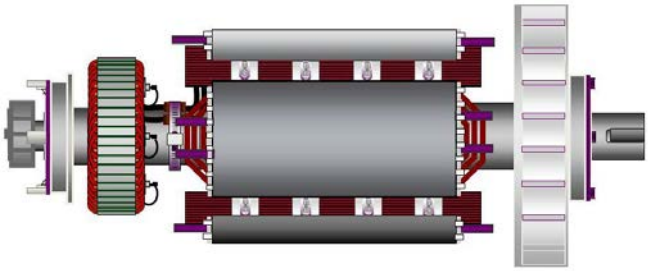

**FIGURE 21. TWO BEARING ALTERNATOR ROTOR SHOWING SHAFT WITH KEYWAY FOR FLEXIBLE COUPLING (AT RIGHT)**

# 8.2 Single Bearing

**⚠ DANGER**

***Falling Mechanical Parts***

***Falling mechanical parts can cause serious injury or death by impact, crushing, severing or trapping. To prevent injury and before lifting:***

- ***Check the capacity, condition and attachment of lifting equipment (crane, hoists and jacks, including attachments to anchor, fix or support the equipment).***
- ***Check the capacity, condition and attachment of accessories for lifting (hooks, slings, shackles and eye bolts for attaching loads to lifting equipment).***
- ***Check the capacity, condition and attachment of lifting fixtures on the load.***
- ***Check the mass, integrity and stability (e.g. unbalanced or shifting center of gravity) of the load.***
- ***When available; Fit drive end and non-drive end transit fittings to prevent damage to bearings and prevent movement.***
- ***Keep the alternator horizontal when lifting.***
- ***Do not use the lifting points fitted to the alternator for lifting a complete generator set.***
- ***Do not use the lifting points fitted to the cooler for lifting the alternator or a complete generator set.***
- ***Do not remove the lifting label attached to one of the lifting points.***

1. Remove the drive end transit bracket that keeps the rotor in place during transport before coupling to the engine.
2. Remove the air outlet covers from the drive end of the alternator to access the coupling and adaptor bolts.
3. Make sure the coupling discs are concentric with the adaptor.
4. Fit two alignment dowels into flywheel bolt holes 180 degrees apart to help align the disc and the flywheel.
5. Lift and offer the alternator to the engine, barring the engine over by hand to align discs and flywheel.
6. Engage the alignment dowels into coupling disc bolt holes and push the alternator towards the engine until the coupling discs are against the flywheel face.
7. Remove the rotor support bracket, if supplied.

***NOTICE***

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

8. Fit the adaptor bolts, using heavy gauge washers under the heads. Tighten the adapter bolts evenly around the adapter.
9. Check the torque of each bolt in a clockwise direction around the bolt circle to ensure all the bolts are tight. Refer to the engine manufacturer's manual for correct tightening torque.
10. Remove the alignment dowels. Fit the coupling bolts, using heavy gauge washers under the heads. Tighten the bolts to fix the coupling disc to the flywheel, in the sequence shown in **Figure 22 on page 48**.
11. Check the torque of each bolt in a clockwise direction around the bolt circle to ensure all the bolts are tight.
12. Replace all covers.

 

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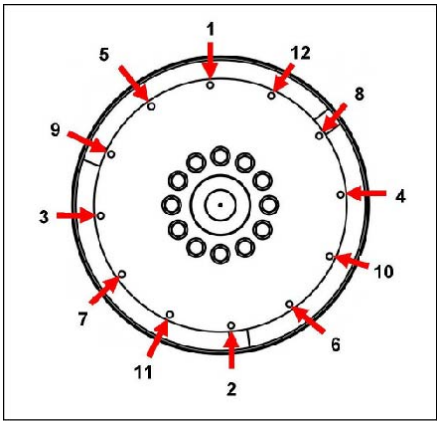


**FIGURE 22. FIXING SEQUENCE**

## 8.3 Two Bearing

A flexible coupling, designed to suit the specific engine/alternator 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 alternator up to the engine. Shim the alternator feet if necessary.

## 8.4 Pre-Running Checks

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

## 8.5 Insulation Resistance Test

**⚠ WARNING**

***Live Electrical Conductors***

***Live electrical conductors at the winding terminals after an insulation resistance test can cause serious injury or death by electric shock or burns. To prevent injury:***

- ***Always discharge the windings immediately after the test has concluded by shorting to earth through an earthing rod for:***
  1. ***A duration equal to the test duration.***
     ***or***
  2. ***5 minutes.***

***Whichever is the longer duration.***

***NOTICE***

**Disconnect the AVR and voltage transformers (if fitted) before this test. Disconnect and earth all RTD and Thermistor temperature sensors (if fitted) before this test.**

The resistance test must be carried out by a qualified person.

**TABLE 9. INSULATION RESISTANCE TEST VALUES**

| Alternator Voltage (kV) | Test Voltage (V) | Minimum Insulation Resistance (MΩ) | |
|---|---|---|---|
| | | In-Service Alternator | New Alternator |
| **≤1** | 500 | 5* | 10 |

You must dry out the alternator windings if the measured insulation resistance is less than the minimum value, refer to; Service & Maintenance Chapter**Chapter 9 on page 55**.

*For heavily contaminated windings and component conditions the minimum insulation resistance should be >1MΩ.

## 8.6 Insulation Resistance with Temperature

Minimum insulation resistance values are given for windings at 20 °C ambient, but insulation resistance may be measured at a higher temperature, T. For comparison with minimum values, multiply the measured insulation resistances $(IR)_T$ by the appropriate factor from the table below to give the equivalent values at 20 °C, $(IR)_{20}$.

**TABLE 10. WINDING TEMPERATURES AND INSULATION RESISTANCES**

| Winding Temperature, T (°C) for Measured $(IR)_T$ | Equivalent Insulation Resistance at 20 °C, $(IR)_{20}$ (MΩ) |
|---|---|
| **20** | 1 x $(IR)_T$ |
| **30** | 2 x $(IR)_T$ |
| **40** | 4 x $(IR)_T$ |
| **50** | 8 x $(IR)_T$ |
| **60** | 16 x $(IR)_T$ |
| **70** | 32 x $(IR)_T$ |
| **80** | 64 x $(IR)_T$ |

## 8.7 High Voltage Test

***NOTICE***

**Windings have been tested at high voltage during manufacture. Repeated high voltage tests may degrade the insulation and reduce operating life. If a further test is required at installation for customer acceptance, it must be done at a reduced voltage, V = 0.8 x (2 x Rated Voltage + 1000). Once in service, any further tests for maintenance purposes must be done after passing visual checks and insulation resistance tests, and at a reduced voltage, V = (1.5 x Rated Voltage).**

## 8.8 Direction of Rotation

The direction of rotation is shown by an arrow in the fan casting. If the alternator must run in the other direction, please seek advice from CGT Customer Service.

 

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## 8.9 Phase Rotation

Main stator output is connected for a phase sequence of U V W when the alternator runs clockwise, as viewed from the drive end. If the phase rotation must be reversed, the customer must re-connect the output cables in the terminal box. Contact CGT Customer Service for a circuit diagram of ‘reverse phase connections’.

## 8.10 Voltage and Frequency

Check that the voltage and frequency shown on the alternator rating plate meet the requirements of the generator set application. Refer to detailed instructions in the AVR manual for adjustments.

## 8.11 AVR Settings

The AVR is factory set for initial running tests. Check that the AVR settings are compatible with your required output. Refer to detailed instructions in the AVR manual for on- and off-load adjustments.

## 8.12 Electrical Connections

**⚠ WARNING**

***Incorrect Electrical Installation and System Protection***

***Incorrect electrical installation and system protection can cause serious injury or death by electric shock and burns. To prevent injury:***

- ***All personnel who carry out; installation, service or maintenance work or who supervise such work being undertaken must be suitably experienced and qualified.***
- ***All personnel must comply with all locally applicable rules and regulations as well as site safety requirements, refer to; Safety Precaution Chapter.***

***NOTICE***

**The terminal box is designed to support the fitted busbars or terminals, transformers, load cables and auxiliary terminal box. Additional mass could cause excessive vibration and lead to failure of the terminal box enclosure and mounting. Refer to CGT before fixing any additional mass to the terminal box. Panels must be removed to be drilled or cut, to prevent swarf entering the terminal box or alternator.**

Fault current curves and alternator reactance values are available on request from the factory so that the system designer can calculate the necessary fault protection and/or discrimination.

The installer must check that the alternator frame is bonded to the generator set bedplate, and must bond to site earth. If anti-vibration mounts are fitted between the alternator frame and its bedplate, a suitably-rated earth conductor must bridge across the anti-vibration mount.

Refer to wiring diagrams for electrical connection of the load cables. Electrical connections are made in the terminal box, constructed with removable panels to suit site-specific cable entry and glanding. Route single core cables through the insulated or non-magnetic gland plates supplied. Panels must be removed to be drilled or cut to prevent swarf entering the terminal box or alternator. After wiring, inspect the terminal box, remove all debris using a vacuum cleaner if necessary and check that no internal components are damaged or disturbed.

As standard, the alternator neutral is not bonded to the alternator frame. If required, neutral may be connected to the earth terminal in the terminal box, by a conductor of at least one half of the sectional area of a phase lead.

Load cables must be supported appropriately to avoid a tight radius at the point of entry into the terminal box, clamped at the terminal box gland, and allow at least ±25 mm movement by the alternator set on its anti-vibration mountings, without causing excessive stress to the cables and alternator load terminals.

The palm (flattened part) of load cable lugs must be clamped in direct contact with the main stator load output terminals so that the whole palm area conducts the output current. The tightening torque of M12 fasteners is 70 Nm or 90 Nm for M16 fasteners (main nut) and 45 Nm (lock nut).

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

Take precautions to prevent transient voltages generated by the connected load and/or the distribution system from causing damage to the alternator components.

To identify any possible risk, all aspects of the alternator'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 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 alternator is at risk from voltage surges or micro-interruptions, it is recommended that the installation includes adequate protection of the generation system, usually with surge arrestors and suppressors, to meet regulations and installation requirements. Best practice is to fit protective devices close to the output terminals. Refer to guidance from professional bodies and specialist equipment suppliers for further advice.

## 8.14 Embedded Applications

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

A typical Thermal Class for this duty is identified by ISO 8528 as a "basic continuous rating" (BR), Class 'F' rating - continuous duty. This offers the best operating efficiency, with low thermal stress for the winding insulation system.

Establish the operating voltage range of the local mains supply and the specified kVA, kVAr, and kW. Consider the full range of the required operating duty against the alternator operating chart (capability diagram). A co-generation application is a continuous fixed duty, always within the 'BR' category, and no overload capability is expected.

See **Table 11 on page 52** for the recommended level of protection for an embedded application.

 

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**TABLE 11. RECOMMENDED EMBEDDED APPLICATION PROTECTION LEVELS**

| Protection | Minimum | Optional |
|---|---|---|
| **Overcurrent** | X | |
| **Short Circuit** | X | |
| **Under Volts** | X | |
| **Over Volts** | X | |
| **Under Hz** | X | |
| **Over Hz** | X | |
| **Differential** | | X |
| **Earth Fault** | | X |
| **Stator Temperature Monitoring** | | 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 | |

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

If the overload and short circuit protection is provided by a circuit breaker, take care 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 alternator can tolerate. The overcurrent and short circuit settings must be set according to the alternator operating chart and not to the overcurrent/short circuit details supplied with the circuit breaker.

Alternator data sheets are available to help calculate these settings.

# 8.15 Varying Load

Under certain conditions, load variations can reduce alternator life.

Identify any possible risk, especially the following:

- Large capacitive loads (for example Power Factor Correction equipment) can affect alternator stability and cause pole slip.
- Stepped grid voltage variation (for example Tap Changing).

If the alternator is at risk from varying load, include adequate protection into the generator set system by under-excitation protection.

# 8.16 Synchronization

**⚠ WARNING**

***Exposure to Ejected Debris and Particles***

***Ejected debris and particles can cause serious injury or death by impact, severing or puncturing. Exposure to mechanically driven release of debris and particles exists in all directions (horizontally and vertically) in the areas surrounding the alternator air outlet(s), air inlets(s) and the open shaft end (also commonly known as the Drive End (DE)).***

***To prevent injury; observe the below points while the alternator is operating:***

- ***Keep away from the air inlet(s) and air outlet(s) when the alternator is running.***
- ***Do not position operator controls near the air inlet(s) or air outlet(s).***
- ***Do not cause overheating by running the alternator outside rating plate parameters.***
- ***Do not overload the alternator.***
- ***Do not run an alternator with excessive vibration.***
- ***Do not synchronize parallel alternators outside the specified parameters.***

## 8.16.1 Parallel or Synchronizing Alternators

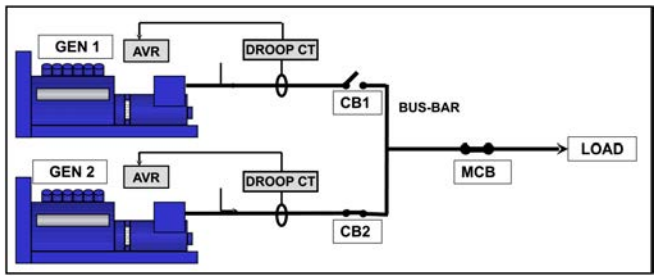


**FIGURE 23. PARALLEL OR SYNCHRONIZING ALTERNATORS**

The quadrature droop current transformer (Droop CT) gives a signal proportional to reactive current; the AVR adjusts excitation to reduce circulating current and allow each alternator to share reactive load. A factory-fitted droop CT is pre-set for 5% voltage drop at full-load zero power factor. Refer to the supplied AVR manual for droop adjustment.

- The synchronizing switch/breaker (CB1, CB2) must be of a type that will not cause “contact bounce” when it operates.
- The synchronizing switch/breaker must be adequately rated to withstand the continuous full load current of the alternator.
- The switch/breaker must be able to withstand the rigorous closing cycles during synchronizing and the currents produced if the alternator is paralleled out of synchronism.
- The closing time of the synchronizing switch/breaker must be under the control of the synchroniser settings.
- The switch/breaker must be capable of operation under fault conditions such as short circuits. Alternator data sheets are available.

***NOTICE***

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

 

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The method of synchronizing should be either automatic, or by check synchronizing. The use of manual synchronizing is not recommended. The settings on the synchronizing equipment should be such that the alternator will close smoothly. For the synchronizing equipment to achieve this, the phase sequence must match the parameters in the table below.

**TABLE 12. SYNCHRONIZING EQUIPMENT PARAMETERS**

| | |
|---|---|
| **Voltage Difference** | **+/- 0.5%** |
| **Frequency Difference** | 0.1 Hz/sec |
| **Phase Angle** | +/- 10° |
| **C/B Closing Time** | 50 ms |

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

# 9 Service and Maintenance

## 9.1 Recommended Service Schedule

Refer to; Safety Precautions in **Chapter 2 on page 3** before starting any service and maintenance activity.

Refer to; Parts Identification in **Chapter 12 on page 119** for an exploded view of components and fastener information.

The recommended service schedule shows the recommended service activities in table rows, grouped by alternator subsystem. Columns of the table show the types of service activity, whether the alternator must be running, and the service levels. Service frequency is given in running hours or time interval, whichever is sooner. A cross (X) in the cells where a row intersects the columns shows a service activity type and when it is required. An asterisk (*) shows a service activity done only when necessary.

All service levels in the recommended service schedule can be purchased directly from CGT Customer Service. For details of your nearest service outlet visit **www.stamford-avk.com**,

1. Proper service and repair are vital to the reliable operation of your alternator and the safety of anyone coming into contact with the alternator.
2. These service activities are intended to maximize the life of the alternator but shall not vary, extend or change the terms of the manufacturer's standard warranty or your obligations in that warranty.
3. Each service interval is a guide only, and developed on the basis that the alternator was installed and is operated in accordance with the manufacturer's guidelines. If the alternator is located and/or operated in adverse or unusual environmental conditions, the service intervals may need to be more frequent. The alternator should be continually monitored between services to identify any potential failure modes, signs of misuse, or excessive wear and tear.

 

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**TABLE 13. ALTERNATOR SERVICE SCHEDULE**

| System | SERVICE ACTIVITY<br>X = required<br>* = if necessary | Alternator running | TYPE | | | | SERVICE LEVEL | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Inspect | Test | Clean | Replace | Commission | Post Commission | 250 hrs / 0.5 year | Level 1 | 1000 hrs / 1 year | Level 2 | 10,000 hrs / 2 years | Level 3 | 30,000 hrs / 5 years |
| Alternator | Alternator rating | | X | | | | X | | | | | | | | |
| | Bedplate arrangement | | X | | | | X | | | | | | | | |
| | Coupling arrangement | | X | | | | X | | | | | * | | X | |
| | Environmental conditions and cleanliness | | X | | | | X | X | | X | | X | | X | |
| | Ambient temperature (inside & outside) | | | X | | | X | X | | X | | X | | X | |
| | Complete machine - damage, loose parts & earth bonds | | X | | | | X | X | | X | | X | | X | |
| | Guards, screens, warning and safety labels | | X | | | | X | X | | X | | X | | X | |
| | Maintenance access | | X | | | | X | | | | | | | | |
| | Electrical nominal operating conditions & excitation | X | | X | | | X | X | | X | | X | | X | |
| | Vibration* | X | | X | | | X | X | | X | | X | | X | |
| Windings | Condition of windings | | X | | | | X | X | | X | | X | | X | |
| | Insulation resistance of all windings (PI test for MV/HV) | | | X | | | X | * | | * | | X | | X | |
| | Insulation resistance of rotor, exciter and PMG | | | X | | | | X | | X | | | | | |
| | Temperature sensors | X | | X | | | X | X | | X | | X | | X | |
| | Customer settings for temperature sensors | | X | | | | X | | | | | | | | |

| System | SERVICE ACTIVITY<br>X = required<br>* = if necessary | Alternator running | TYPE | | | | SERVICE LEVEL | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Inspect | Test | Clean | Replace | Commission | Post Commission | 250 hrs / 0.5 year | Level 1 | 1000 hrs / 1 year | Level 2 | 10,000 hrs / 2 years | Level 3 | 30,000 hrs / 5 years |
| Bearings | Condition of bearings | | X | | | | X | | | | | | | X | |
| | Grease exhaust & trap | | | | X | | | X | | X | | X | | X | |
| | Grease in re-greasable bearing(s) | X | | | | X | | every 4000 to 4500 hours / 6 months | | | | | | | |
| | Sealed bearing(s) | | X | | | | | every 4000 to 4500 hours | | | | | | | |
| | Re-greasable & sealed bearing(s) | | | | | X | | | | | | * | | X | |
| | Temperature sensors | X | | X | | | X | X | | X | | X | | X | |
| | Customer settings for temperature sensors | | X | | | | X | | | | | | | | |
| Terminal Box | All alternator/customer connections and cabling | | X | | | | X | X | | X | | X | | X | |
| Controls & Auxiliaries | Initial AVR & PFC set up | X | | X | | | X | | | | | | | | |
| | AVR & PFC settings | X | | X | | | | X | | X | | X | | X | |
| | Customer connection of auxiliaries | | | X | | | X | | | X | | X | | X | |
| | Function of auxiliaries | | | X | | | X | X | | X | | X | | X | |
| | Synchronization settings | | X | | | | X | | | | | | | | |
| | Synchronization | X | | X | | | X | X | | X | | X | | X | |
| | Anti condensation heater | | | | | X | | | | | | * | | X | |
| Rectifier | Diodes and varistors | | X | | | | X | X | | X | | X | | | |
| | Diodes and varistors | | | | | X | | | | | | | | X | |
| Cooling | Air inlet temperature | X | | X | | | X | X | | X | | X | | X | |
| | Air flow (rate & direction) | X | X | | | | X | | | | | | | | |
| | Condition of fan | | X | | | | X | X | | X | | X | | X | |
| | Condition of air filter (where fitted) | | | X | | | X | X | | X | | X | | X | |
| | Air filters (where fitted) | | | | X | X | | | | * | | * | | * | |

* For stand-alone alternator only.

 

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# 9.2 Bearings

## 9.2.1 Introduction

**NOTICE**

**Do not overfill a bearing with grease; the bearing may be damaged.**

**Do not mix lubricant types. Change gloves to handle different lubricant**

**Assemble bearings in static- and dust-free conditions while wearing lint free gloves.**

**Store removed parts and tools in static- and dust-free conditions, to prevent damage or contamination.**

**A bearing is damaged by the axial force needed to remove it from the rotor shaft. Do not reuse a bearing.**

**A bearing is damaged if the insertion force is applied through the bearing balls. Do not press fit the outer race by force on the inner race, or vice versa.**

**Do not try to turn the rotor by levering against the cooling fan vanes. The fan will be damaged.**

The alternator rotor is supported by a bearing at the non-drive end (NDE) and by either a bearing or a coupling to the prime mover at the drive end (DE).

- Lubricate each re-greasable bearing according to the recommended service schedule with the correct quantity and type of grease, also shown on a label fitted at the grease nipple.
- Inspect each sealed bearing according to the recommended service schedule. Seek advice from CGT Customer Service if grease has leaked out of the bearing, notifying the bearing type and quantity leaked.

## 9.2.2 Safety

**⚠ DANGER**

***Rotating Mechanical Parts***

***Rotating mechanical parts can cause serious injury or death by crushing, severing or trapping. To prevent injury:***

- ***Before operating the alternator, exposed couplings between the alternator and prime mover must be protected by a suitable guard/cover.***
- ***Before removing covers from rotating parts, shut down and isolate the generator set from all energy sources, remove stored energy and use lock out/tag out safety procedures.***
- ***Before undertaking service or maintenance tasks shut down and isolate the generator set from all energy sources, remove stored energy and use lock out/tag out safety procedures.***

**⚠ WARNING**

***Hot Surfaces and Fire***

***Contact with hot surfaces can cause serious injury and death by burns. A risk of fire exists where hot surfaces are contacted by combustible items. To prevent injury/fire:***

- ***Avoid contact with hot surfaces.***
- ***Always wear the appropriate personal protection equipment, refer to; Safety Precaution Chapter.***
- ***Ensure that no combustible materials (such as packaging) or flammable substances come in to contact with or are stored in close proximity to the anti-condensation heater (if fitted).***
- ***Ensure that no combustible material(s) or flammable substances come in to contact with or are stored in close proximity to the alternator or prime mover, including the cooling, ventilation and exhaust system(s) where applicable.***

**⚠ WARNING**

***Exposure to Ejected Debris and Particles***

***Ejected debris and particles can cause serious injury or death by impact, severing or puncturing. Exposure to mechanically driven release of debris and particles exists in all directions (horizontally and vertically) in the areas surrounding the alternator air outlet(s), air inlets(s) and the open shaft end (also commonly known as the Drive End (DE)).***

***To prevent injury; observe the below points while the alternator is operating:***

- ***Keep away from the air inlet(s) and air outlet(s) when the alternator is running.***
- ***Do not position operator controls near the air inlet(s) or air outlet(s).***
- ***Do not cause overheating by running the alternator outside rating plate parameters.***
- ***Do not overload the alternator.***
- ***Do not run an alternator with excessive vibration.***
- ***Do not synchronize parallel alternators outside the specified parameters.***

**⚠ CAUTION**

***Hazardous Substances***

***Contact with hazardous substances such as; oils, grease, lubricants, fuel, adhesive, desiccants (drying agents), battery acid, cleaning agents, solvent or corrosive substances, paint, polyester resin and/or plastic residues can cause minor or moderate injury by contact/inhalation. Prolonged/repetitive exposure may lead to more serious medical conditions developing. To prevent injury:***

- ***Always read and comply with the information provided by the product manufacturer, use, handle and store substances accordingly.***
- ***Always wear appropriate personal protection equipment, as per product manufacturer information and the Safety Precaution Chapter.***

 

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| NOTICE |
| --- |
| **Do not overfill a bearing with grease; the bearing may be damaged.** |
| **Do not mix lubricant types. Change gloves to handle different lubricant** |
| **Assemble bearings in static- and dust-free conditions while wearing lint free gloves.** |
| **Store removed parts and tools in static- and dust-free conditions, to prevent damage or contamination.** |
| **A bearing is damaged by the axial force needed to remove it from the rotor shaft. Do not reuse a bearing.** |
| **A bearing is damaged if the insertion force is applied through the bearing balls. Do not press fit the outer race by force on the inner race, or vice versa.** |
| **Do not try to turn the rotor by levering against the cooling fan vanes. The fan will be damaged.** |

## 9.2.3 Re-Grease Bearings

### 9.2.3.1 Requirements

**TABLE 14. RE-GREASING: EQUIPMENT REQUIREMENTS**

| Requirement | Description |
| --- | --- |
| **Personal Protective Equipment (PPE)** | • Wear appropriate protective equipment as directed by site rules and risk assessment requirements. |
| **Consumables** | • Lint-free cleaning cloths<br>• Thin disposable gloves |
| **Parts** | • CGT recommended grease |
| **Tools** | • Grease gun (calibrated for volume or mass) |

### 9.2.3.2 Re-grease Method

**TABLE 15. REGREASING: GREASE QUANTITY**

| Bearing Type | Quantity of recommended grease | |
| --- | --- | --- |
| | Volume ($cm^3$) | Mass (g) |
| **Drive End (S7 Core length C to F)** | 93 | 89 |
| **Drive End (S7 Core length G to K)** | 126 | 121 |
| **Non-drive End (S7 Core length C to J)** | 78 | 75 |
| **Non-drive End (S7 K Core)** | 157 | 151 |

1. For each bearing, identify grease nipple, re-greasing label and bearing type.
2. Make sure the new grease is not contaminated. It must be a uniform whitish-beige colour of stiff consistency throughout.
3. Clean the grease gun nozzle and grease nipple.
4. Clean the grease exhaust.
5. Fit the grease gun to the grease nipple and add the correct quantity of grease.

6. Run the alternator for at least 60 minutes, off- or on-load.
7. Clean the grease exhaust.
8. Inspect the colour and consistency of grease expelled from the exhaust and compare with new grease - whitish-beige of stiff consistency.
9. Replace the bearing if the expelled grease is severely discoloured or absent.

## 9.2.4 Replace Bearings

Follow the steps below, in order:

1. Follow the **Remove Non-Drive End** section to access NDE bearing
2. If the DE bearing is to be replaced, follow the **Remove Drive End** section to access DE bearing.
3. Assemble and fit the new NDE bearing (and DE bearing, as required) onto the rotor shaft, following the **Assemble Bearing** section.
4. If the DE bearing has been replaced, follow the **Assemble Drive End** section to refit DE components.
5. Follow the **Assemble Non-Drive End** section to refit NDE components.

 

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## 9.2.4.1 Requirements

**TABLE 16. RE-GREASABLE BEARING REPLACEMENT REQUIREMENTS**

| Requirement | Description |
|---|---|
| **Personal Protective Equipment (PPE)** | • Wear appropriate protective equipment as directed by site rules and risk assessment requirements. |
| **Consumables** | • Lint-free cleaning cloths<br>• Thin disposable gloves<br>• Washing fluid<br>• Large plastic bags for storing parts<br>• White anti-static assembly surface |
| **Parts** | • NDE bearing<br>• DE bearing (if fitted)<br>• CGT-recommended grease<br>• CGT-recommended anti-fretting paste<br>• O-rings (if fitted)<br>• Wavy Washer<br>• Grease Flinger |
| **Tools** | • Grease gun (calibrated for volume or mass)<br>• Washing bowl and brush<br>• Induction heater (with protective sleeve on bar)<br>• Torque wrench<br>• Bearing removal tooling (see Spares and After Sales Service chapter)<br>• Rotor support packing (nylon strips 4 mm x 60 mm x core length)<br>• Hydraulic cylinder jack and pump<br>• M10 x 120 guide studs x 2 |

## 9.2.4.2 Sealed Bearing Replacement Requirements

**TABLE 17. SEALED BEARING REPLACEMENT REQUIREMENTS**

| | |
|---|---|
| **Personal Protective Equipment (PPE)** | • Wear appropriate protective equipment as directed by site rules and risk assessment requirements. |
| **Consumables** | • Thin disposable gloves<br>• Large plastic bags (to store parts) |
| **Parts** | • NDE bearing<br>• DE bearing (if fitted)<br>• CGT recommended anti-fretting paste<br>• O ring (if fitted)<br>• Wavy Washer (if fitted) |
| **Tools** | • Induction heater (with protective sleeve on bar)<br>• Torque wrench<br>• Bearing puller<br>• Rotor support packing |

## 9.2.4.3 Remove Non-Drive End

***NOTICE***

**Delicate exciter leads and temperature sensor leads may be fixed to the inside of the NDE bracket. Note the routing of leads and locations of all fasteners. Detach the leads carefully and keep all fasteners for re-use during assembly. Take care not to damage the leads when removing and storing the NDE bracket.**

1. Turn off the anti-condensation heater (if fitted) and isolate from supply.
2. Remove the PMG cover.
3. Remove the lower air inlet cover.
4. Remove the terminal box lid and upper side panel (left hand, viewed from NDE)
5. Remove the lower side panel (left hand, viewed from NDE) to improve access, cutting cable ties to release the exciter stator leads.
6. Unplug the PMG control cable.
7. Disconnect the grease pipe from the bearing cartridge and the NDE bracket.
8. Disconnect the heater.
9. Use a 10 mm open spanner to disconnect the RTD sensor for bearing temperature (if fitted) from the bearing.
10. Remove the PMG stator and PMG rotor together as an assembly.
11. Put the PMG assembly into a plastic bag. Seal the bag to protect the parts from debris.
12. Remove the PMG rotor location pin from the end of the rotor shaft, or use a bolt with a spacer inserted in the PMG rotor thread to prevent damage to the pin.
13. Remove the NDE bearing cap assembly.

 

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14. Turn the main rotor so that the NDE keyway is at the top of the rotor shaft. In this position, the lowest rotor pole is vertical and will support the rotor weight when the bearing is removed. If the rotor cannot be turned and no rotor pole is vertical, fit two rotor support packing pieces (see below) to support the lower two poles.
15. Disconnect F1 (red) and F2 leads at the AVR, cut cable ties and withdraw the leads to the exciter stator.
16. Remove fasteners from NDE bearing cartridge.
17. Fix two threaded guide studs at least 120 mm long into NDE bearing cartridge.
18. Remove fasteners from NDE bracket.
19. Insert two M10 jacking bolts part way into threaded holes on the NDE bracket horizontal centreline to open a gap for a shackle between the NDE bracket and the frame – approximately 10mm movement.
20. Fix a shackle to the NDE bracket and support with a crane sling.
21. Insert the jacking bolts fully to release the NDE bracket from the frame.
22. For alternators with a DE bearing, insert a rotor support packing piece into the air gap between the lowest rotor pole and the stator, along the full length of the rotor pole. When the NDE bearing is removed, the packing will keep the rotor near-horizontal to reduce non-radial loading on the other bearing.
23. Gently lower the crane sling to put the rotor weight onto the support packing and remove the sling.
24. Carefully slide the NDE bracket away from the alternator along the guide studs to avoid damaging the exciter stator windings on the exciter rotor.
25. Set aside the NDE bracket flat on the floor on wooden bearers, with the exciter stator face up.
26. Remove the guide studs.

## 9.2.4.4 Remove Drive End

1. Remove NDE components first, following **Remove Non-Drive End**.
2. Remove the DE air outlet screen and DE louvres.
3. Disconnect the alternator from the prime mover.
4. Disconnect the grease tube.
5. Disconnect the RTD sensor for bearing temperature (if fitted).
6. Remove the DE bearing cap.
7. Remove fasteners from the DE bearing cartridge.
8. Fix two threaded guide studs at least 120 mm long into the DE bearing cartridge.
9. Use a crane sling and lifting eye to support the DE bracket.
10. Remove fasteners from the DE bracket, including two bolts at the bottom of the DE bracket.
11. Release the DE bracket by tapping with a mallet away from the frame.
12. Carefully slide the DE bracket away from the alternator along the guide studs.
13. Remove the guide studs.

## 9.2.4.5 Assemble a Sealed Bearing

1. Remove and discard the wavy washer (NDE only).
2. Remove the circlip (NDE only).
3. Use the tooling and jack to remove the bearing and cartridge assembly from the main rotor shaft.
4. Prepare for assembly, by cleaning:
    a. Wipe clean the anti-static assembly surface, using solvent on lint free cloth.

b. Wash the bearing cartridge, wavy washer (NDE only) and the bearing cap and inspect for contamination.

c. Wipe off excess washing fluid with a lint free cloth and place all components on the clean anti-static assembly surface.

d. Thoroughly clean the external surface of the grease gun nozzle using a lint free cloth.

5. Prepare the bearing:

   a. Remove the bearing from its packaging.

   b. Wipe off the preservative oil with a lint free cloth from the surface of the inner and outer rings.

   c. Place the bearing on the clean anti-static assembly surface, with the bearing type identification markings face down.

6. Assemble the bearing components:

   a. Fit a new O ring in the groove in the bearing housing (NDE only).

   b. Without rubbing in, use a lint free cloth to smear anti-fretting paste in a thin coherent layer to the bearing housing circumference.

   c. Assemble the bearing into the bearing cartridge, by pressing **ONLY** on the bearing outer race. Ensure the bearing outer race contacts the location shoulder.

   d. Apply a small amount of grease to the grooved sealing surface in the bearing cap.

7. Fit the bearing components:

   a. Expand the bearing and cartridge assembly by heating to 90 to 100 ºC in the induction heater.

   b. Slide the bearing and cartridge assembly over the rotor shaft, pushing it firmly against the seating shoulder.

   c. Oscillate the assembly (including inner race) 45 degrees in both directions, to ensure bearing is seated. Hold the bearing in place while it cools and contracts onto the rotor shaft.

   d. Refit the circlip (NDE only) into the main rotor shaft groove.

   e. Fit the wavy washer (NDE only).

   f. Wait for the bearing and cartridge assembly to cool to ambient temperature.

   g. Fix the bearing cap to the bearing cartridge.

8. Record bearing change on the Service Report.

 

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## 9.2.4.6 Assemble a Re-greasable Bearing

**TABLE 18. INITIAL GREASING: GREASE QUANTITY**

| Bearing Type | Quantity of recommended grease | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Cartridge | | Bearing | | Bearing Cap | | TOTAL | |
| | Vol ($cm^3$) | Mass (g) | Vol ($cm^3$) | Mass (g) | Vol ($cm^3$) | Mass (g) | Vol ($cm^3$) | Mass (g) |
| **Drive End (S7 Core length C to F)** | 96 | 92 | 193 | 185 | 96 | 92 | **385** | **369** |
| **Drive End (S7 Core length G to K)** | 126 | 121 | 252 | 242 | 126 | 121 | **504** | **484** |
| **Non-drive End (S7 Core length C to J)** | 80 | 77 | 160 | 154 | 80 | 77 | **320** | **308** |
| **Non-drive End (S7 K Core)** | 157 | 151 | 314 | 302 | 157 | 151 | 628 | 604 |

1. Remove and discard the wavy washer (NDE only).
2. Use the tooling and jack to remove the grease flinger.
3. Remove the circlip (NDE only).
4. Use the tooling and jack to remove the bearing and cartridge assembly from the main rotor shaft.
5. Prepare for assembly, by cleaning:
    a. Wipe clean the anti-static assembly surface, using solvent on lint free cloth.
    b. Wash the bearing cartridge, wavy washer (NDE only) and the bearing cap and inspect for contamination.
    c. Wipe off excess washing fluid with a lint free cloth and place all components on the clean anti-static assembly surface.
    d. Thoroughly clean the external surface of the grease gun nozzle using a lint free cloth.
6. Prepare the bearing:
    a. Remove the bearing from its packaging.
    b. Wipe off the preservative oil with a lint free cloth from the surface of the inner and outer rings.
    c. Place the bearing on the clean anti-static assembly surface, with the bearing type identification markings face down.
7. Grease and assemble the bearing components:
    a. Fit a new O ring in the groove in the bearing housing (NDE only).
    b. Apply the specified quantity of grease to the back face of the bearing cartridge.
    c. Apply a small amount of grease to the grooved sealing surface in the cartridge.
    d. Without rubbing in, use a lint free cloth to smear anti-fretting paste in a thin coherent layer to the bearing housing circumference.
    e. Apply half the specified quantity of grease to the upper face of the bearing (without the bearing designation markings).
    f. Press the grease into the bearing, ensuring good penetration into the raceways and between the balls.

g. Assemble the bearing into the bearing cartridge, greased side first, by pressing **ONLY** on the bearing outer race. Ensure the bearing outer race contacts the location shoulder.

h. Apply the remaining half of the specified quantity of grease to the exposed side of the bearing.

i. Press the grease into the bearing, ensuring good penetration into the raceways and between the balls.

j. Apply the specified quantity of grease to the inside face of the bearing cap.

k. Fill the grease exhaust slot, with grease.

l. Apply a small amount of grease to the grooved sealing surface in the bearing cap.

m. Fill the grease pipe and grease nipple with grease.

8. Fit the bearing components:

   a. Expand the bearing and cartridge assembly by heating to 90 to 100 ºC in the induction heater.

   b. Slide the bearing and cartridge assembly over the rotor shaft, pushing it firmly against the seating shoulder.

   c. Oscillate the assembly (including inner race) 45 degrees in both directions, to ensure bearing is seated. Hold the bearing in place while it cools and contracts onto the rotor shaft.

   d. Refit the circlip (NDE only) into the main rotor shaft groove.

   e. Expand the grease flinger by heating to 110 °C in the induction heater.

   f. Slide the grease flinger over the rotor shaft and push it firmly against the bearing assembly. Hold the flinger in place while it cools and contracts onto the rotor shaft.

   g. Fit the wavy washer (NDE only).

   h. Wait for the bearing and cartridge assembly and flinger to cool to ambient temperature.

   i. Fit the bearing cap over the grease flinger and fix to the bearing cartridge.

9. Record bearing change on the Service Report.

## 9.2.4.7 Assemble Drive End

1. Slide the DE bracket onto the rotor shaft and locate over the DE bearing assembly.
2. Use a crane sling to lift the rotor and DE bracket at the drive end a small amount, to support the weight.
3. Refit the DE bracket onto the frame.
4. Refit the DE bearing cartridge to the DE bracket.
5. Refit the DE bearing cap.
6. Reconnect the grease pipe.
7. Reconnect the RTD sensor (if fitted).
8. Recouple the alternator to the prime mover.
9. Refit the DE air outlet screen and DE louvres.

 

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### 9.2.4.8 Assemble Non-Drive End

**NOTICE**

**Route the delicate exciter leads and temperature sensor leads carefully, and fix securely to the inside of the NDE bracket. Take care not to damage the leads when fitting the NDE bracket.**

1. Fix the threaded guide studs into the NDE bearing cartridge.
2. Slide the NDE bracket onto the rotor shaft, guide onto the studs and locate over the NDE bearing assembly.
3. Use a crane sling to lift the rotor and NDE bracket a small amount, to support the weight.
4. Remove the rotor support packing piece(s).
5. Fix the NDE bracket to the frame.
6. Remove the guide studs.
7. Fix the NDE bearing cartridge to the NDE bracket.
8. Gently lower the crane sling to put the rotor weight onto the bearing and remove the sling.
9. Turn the rotor by hand to check bearing alignment and free rotation.
10. Refit the NDE bearing cap assembly.
11. Refit the PMG rotor and the PMG stator.
12. Reconnect the control cable plug.
13. Reconnect the grease pipe.
14. Reconnect the RTD sensor (if fitted).
15. Secure the heater and exciter stator leads inside the alternator with heat stabilised cable ties.
16. Secure the leads with cable ties to the main stator leads and reconnect to the AVR.
17. Refit the PMG cover and lower air inlet cover.
18. Refit lower side panel, terminal box side panel and lid.
19. Reconnect the supply to the anti-condensation heater (if fitted).

# 9.3 Controls

## 9.3.1 Introduction

An operating alternator is a harsh environment for control components. Heat and vibration can cause electrical connections to loosen and cables to fail. Routine inspection and test can identify an issue before it becomes a failure that incurs unplanned downtime.

## 9.3.2 Safety

**⚠ DANGER**

***Testing Live Electrical Conductors***

***Live electrical conductors can cause serious injury or death by electric shock and burns. To prevent injury:***

- ***Before removing covers over electrical conductors, shut down and isolate the generator set from all energy sources, remove stored energy and use lock out/tag out safety procedures.***

**⚠ WARNING**

***Hot Surfaces and Fire***

***Contact with hot surfaces can cause serious injury and death by burns. A risk of fire exists where hot surfaces are contacted by combustible items. To prevent injury/fire:***

- ***Avoid contact with hot surfaces.***
- ***Always wear the appropriate personal protection equipment, refer to; Safety Precaution Chapter.***
- ***Ensure that no combustible materials (such as packaging) or flammable substances come in to contact with or are stored in close proximity to the anti-condensation heater (if fitted).***
- ***Ensure that no combustible material(s) or flammable substances come in to contact with or are stored in close proximity to the alternator or prime mover, including the cooling, ventilation and exhaust system(s) where applicable.***

**⚠ WARNING**

***Incorrect Electrical Installation and System Protection***

***Incorrect electrical installation and system protection can cause serious injury or death by electric shock and burns. To prevent injury:***

- ***All personnel who carry out; installation, service or maintenance work or who supervise such work being undertaken must be suitably experienced and qualified.***
- ***All personnel must comply with all locally applicable rules and regulations as well as site safety requirements, refer to; Safety Precaution Chapter.***

## 9.3.3 Connection Test Requirements

**TABLE 19. CONNECTION TEST REQUIREMENTS**

| Requirements | Description |
|---|---|
| **Personal Protective Equipment (PPE)** | • Wear appropriate protective equipment as directed by site rules and risk assessment requirements. |
| **Consumables** | • None |
| **Parts** | • None |
| **Tools** | • Insulation test meter<br>• Multimeter<br>• Torque wrench |

## 9.3.4 Inspect and Test

1. Remove the terminal box lid.
2. Check the tightness of fasteners securing the load cables.
3. Check that cables are firmly clamped at the terminal box gland, and allow ±25 mm movement by an alternator on anti-vibration mounts.
4. Check that all cables are anchored and unstressed within the terminal box.
5. Check all cables for signs of damage.

 

6. Check that AVR accessories and current transformers are correctly fitted, and cables pass centrally through current transformers (if fitted).
7. If an anti-condensation heater is fitted:
    a. Isolate the supply and measure the electrical resistance of the heater element(s). Replace the heater element if open circuit.
    b. Connect together both ends of the heater leads.
    c. Apply the test voltage between the winding and earth.
    d. Measure the insulation resistance after 1 minute (IR 1min).
    e. Discharge the test voltage.
    f. If the measured insulation resistance is less than the minimum acceptable level, replace the heater element. Refer to; **Table 20 on page 70** for values.
8. Test the supply voltage to the anti-condensation heater at the heater connection box. 120 VAC or 240 VAC. (depending on cartridge option and shown on a label) should be present when the alternator is stopped.
9. Check that the AVR and AVR accessories fitted in the terminal box are clean, securely fitted on anti-vibration mounts, and the cable connectors are firmly attached to the terminals.
10. For parallel operation, check that the synchronization control cables are securely connected.
11. Refit and secure the terminal box lid.

**TABLE 20. TEST VOLTAGE AND MINIMUM ACCEPTABLE INSULATION RESISTANCE FOR NEW AND IN-SERVICE ANTI-CONDENSATION HEATERS**

| Component | Test Voltage (V) | Minimum Insulation Resistance at 1 minute (MΩ) | |
|---|---|---|---|
| | | New | In-service |
| **Anti-condensation heater** | 500 | 10 | 1 |

# 9.4 Cooling System

## 9.4.1 Introduction

| *NOTICE* |
|---|
| **The values below are cumulative dependent on environmental conditions. Efficient cooling depends on maintaining the condition of the cooling fan, air filters and gaskets.** |

The alternators are designed to meet standards supporting EU Directives and UK Statutory Instruments, and are rated for the effect of operating temperature on winding insulation.

**BS EN 60085 (≡ IEC 60085) Electrical insulation – Thermal Evaluation and Designation** classifies insulation by the maximum operating temperature for a reasonable service life. Although chemical contamination and electrical and mechanical stresses also contribute, temperature is the dominant aging factor. Fan cooling maintains a stable operating temperature below the insulation class limit.

If the operating environment differs from the values shown on the rating plate, rated output must be reduced by

- 3% for class H Insulation for every 5 °C that the temperature of the ambient air entering the cooling fan exceeds 40 °C, up to a maximum of 60 °C.
- 3% for every 500 m increase in altitude above 1000 m, up to 4000 m, due to the reduced thermal capacity of lower density air, and

- 5% if air filters are fitted, due to restricted air flow.

## 9.4.2 Safety

**⚠ DANGER**

***Rotating Mechanical Parts***

***Rotating mechanical parts can cause serious injury or death by crushing, severing or trapping. To prevent injury:***

- ***Before operating the alternator, exposed couplings between the alternator and prime mover must be protected by a suitable guard/cover.***
- ***Before removing covers from rotating parts, shut down and isolate the generator set from all energy sources, remove stored energy and use lock out/tag out safety procedures.***
- ***Before undertaking service or maintenance tasks shut down and isolate the generator set from all energy sources, remove stored energy and use lock out/tag out safety procedures.***

**⚠ WARNING**

***Hot Surfaces and Fire***

***Contact with hot surfaces can cause serious injury and death by burns. A risk of fire exists where hot surfaces are contacted by combustible items. To prevent injury/fire:***

- ***Avoid contact with hot surfaces.***
- ***Always wear the appropriate personal protection equipment, refer to; Safety Precaution Chapter.***
- ***Ensure that no combustible materials (such as packaging) or flammable substances come in to contact with or are stored in close proximity to the anti-condensation heater (if fitted).***
- ***Ensure that no combustible material(s) or flammable substances come in to contact with or are stored in close proximity to the alternator or prime mover, including the cooling, ventilation and exhaust system(s) where applicable.***

**⚠ CAUTION**

***Dust & Airborne Particles/Fumes***

***Inhaling dust and other airborne particles/fumes can cause minor or moderate injury by irritating the lungs and eyes. Repetitive/prolonged exposure may cause serious chronic medical conditions to develop. To prevent injury:***

- ***Use mechanical vacuum extraction to remove dust and airborne particles/fumes where appropriate.***
- ***Ventilate the area appropriately.***
- ***Always wear the appropriate personal protection equipment, refer to; Safety Precaution Chapter.***

***NOTICE***

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

***NOTICE***

**Filters are designed to remove dust, not moisture. Wet filter elements can cause reduced air flow and overheating. Do not allow filter elements to get wet.**

 

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## 9.4.3 Cooling System Test Requirements

**TABLE 21. COOLING SYSTEM TEST REQUIREMENTS**

| Requirements | Description |
|---|---|
| **Personal Protective Equipment (PPE)** | • Wear appropriate protective equipment as directed by site rules and risk assessment requirements. |
| **Consumables** | • Lint-free cleaning cloths<br>• Thin disposable gloves |
| **Parts** | • Air filters (if fitted)<br>• Air filter sealing gaskets (if fitted) |
| **Tools** | • None |

## 9.4.4 Inspect and Clean

| *NOTICE* |
|---|
| **Do not apply oil to the filter.** |

1. Inspect the fan for damaged vanes and cracks.
2. If air filters are fitted:
   a. Remove air filters at the terminal box from their frames.
   b. Wash and dry the air filters and gaskets to remove contaminant particles.
   c. Inspect the filters and gaskets for damage and replace, as necessary.
   d. Install the filters and gaskets.
3. Reinstate the generator set for running.
4. Make sure the air inlets and outlets are not blocked.

# 9.5 Coupling

## 9.5.1 Introduction

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

The rotational axes of alternator rotor and engine output shaft must be coaxial (radial and angular alignment).

Torsional vibration can cause damage to internal combustion engine shaft-driven systems, if not controlled. The generator set manufacturer is responsible for assessing the effect of torsional vibration on the alternator: Rotor dimensions and inertia, and coupling details are available on request.

## 9.5.2 Safety

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

**⚠ WARNING**

***Coupling an Alternator to a Prime Mover***

***Moving mechanical parts during generator set coupling can cause serious injury by crushing, severing or trapping. To prevent injury:***

- ***Personnel must keep limbs and body parts away from mating surfaces when coupling the alternator to a prime mover.***
- ***Personnel must keep limbs and body parts away from mating surfaces when installing large components, such as; cooling systems and fuel tanks on to the alternator/generator set.***

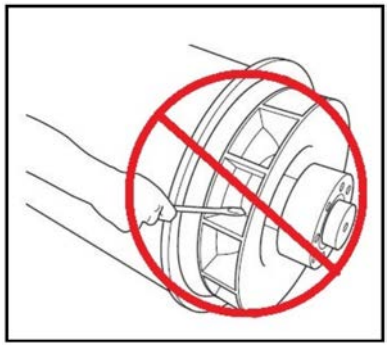

**FIGURE 24. DO NOT ROTATE THE ALTERNATOR ROTOR WITH A LEVER**

## 9.5.3 Coupling Test Requirements

**TABLE 22. COUPLING TEST REQUIREMENTS**

| Requirements | Description |
|---|---|
| **Personal Protective Equipment (PPE)** | • Wear appropriate protective equipment as directed by site rules and risk assessment requirements. |
| **Consumables** | • None |
| **Parts** | • None |
| **Tools** | • Dial gauge<br>• Torque wrench |

## 9.5.4 Inspect Mounting Points

1. Check the generator set bedplate and mounting pads are in good condition, not cracked.
2. Check that rubber in anti-vibration mounts has not perished.
3. Check vibration monitoring historical records for a trend of increasing vibration.

### 9.5.4.1 Single Bearing Coupling

1. Remove the DE adaptor screen and cover to access the coupling.
2. Check that the coupling discs are not damaged, cracked or distorted, and the coupling disc holes are not elongated. If any are damaged, replace the complete set of discs.
3. Check tightness of bolts fixing the coupling discs to the engine flywheel. Tighten in the sequence shown for alternator coupling in the Installation chapter, to the torque recommended by the engine manufacturer.

 

4. Replace the DE adaptor screen and drip proof cover.

# 9.6 Rectifier System

## 9.6.1 Introduction

The rectifier converts alternating current (AC) induced in the exciter rotor windings into direct current (DC) to magnetize the main rotor poles. The rectifier comprises two semi-circular annular positive and negative plates, each with three diodes. In addition to connecting to the main rotor, the DC output of the rectifier also connects to a matched pair of varistors (one at each end of the plates). These additional components protect the rectifier from voltage spikes and surge voltages that may be present on the rotor under various loading conditions of the alternator.

Diodes provide a low resistance to current in one direction only: Positive current will flow from anode to cathode, or another way of viewing it is that negative current will flow from cathode to anode.

The exciter rotor windings are connected to 3 diode anodes to form the positive plate and to 3 diode cathodes to form the negative plate to give full wave rectification from AC to DC. The rectifier is mounted on, and rotates with, the exciter rotor at the non-drive end (NDE).

## 9.6.2 Safety

**⚠ DANGER**

***Testing Live Electrical Conductors***

***Live electrical conductors can cause serious injury or death by electric shock and burns. To prevent injury:***

- ***Before removing covers over electrical conductors, shut down and isolate the generator set from all energy sources, remove stored energy and use lock out/tag out safety procedures.***

**⚠ DANGER**

***Rotating Mechanical Parts***

***Rotating mechanical parts can cause serious injury or death by crushing, severing or trapping. To prevent injury:***

- ***Before operating the alternator, exposed couplings between the alternator and prime mover must be protected by a suitable guard/cover.***
- ***Before removing covers from rotating parts, shut down and isolate the generator set from all energy sources, remove stored energy and use lock out/tag out safety procedures.***
- ***Before undertaking service or maintenance tasks shut down and isolate the generator set from all energy sources, remove stored energy and use lock out/tag out safety procedures.***

**⚠ WARNING**

***Incorrect Electrical Installation and System Protection***

***Incorrect electrical installation and system protection can cause serious injury or death by electric shock and burns. To prevent injury:***

- ***All personnel who carry out; installation, service or maintenance work or who supervise such work being undertaken must be suitably experienced and qualified.***
- ***All personnel must comply with all locally applicable rules and regulations as well as site safety requirements, refer to; Safety Precaution Chapter.***

## 9.6.3 Requirements

**TABLE 23. RECTIFIER SYSTEM: TEST AND REPLACE COMPONENT REQUIREMENTS**

| Requirement | Description |
|---|---|
| **Personal Protective Equipment (PPE)** | • Wear appropriate protective equipment as directed by site rules and risk assessment requirements. |
| **Consumables** | • Dow Corning silicone heat sink compound type 340 or similar |
| **Parts** | • Full set of three anode lead diodes and three cathode lead diodes (all from the same manufacturer)<br>• Two metal-oxide varistors (same type, same manufacturer, same voltage grading: A, B, C, D, E, F) |
| **Tools** | • Multimeter<br>• Insulation tester<br>• Torque wrench |

## 9.6.4 Test and Replace Varistors

1. Inspect both varistors.
2. Record varistor as faulty if there are signs of overheating (discoloration, blisters, melting) or disintegration. Check for loose connectors vs. varistor body.
3. Disconnect one varistor lead. Store fastener and washers.
4. Measure the resistance across each varistor. Good varistors have a resistance greater than 100 MΩ.
5. Record varistor as faulty if the resistance is short circuit or open circuit in either direction.
6. If either varistor is faulty, replace both varistors with a matched pair (same type, same manufacturer and same voltage grading: A, B, C, D, E, F) and replace all diodes.
7. Reconnect and check that all leads are secure, washers fitted and fasteners tight.

## 9.6.5 Test and Replace Diodes

| ***NOTICE*** |
|---|
| **Do not tighten a diode above the stated torque. The diode will be damaged.** |

1. Disconnect the lead of one diode where it joins the windings at the insulated terminal post. Store fastener and washers.
2. Measure the voltage drop across the diode in the forward direction, using the diode test function of a multimeter.
3. Measure the resistance across the diode in the reverse direction, using the 1000 VDC test voltage of an insulation tester.
4. Diode is faulty if the voltage drop in the forward direction is outside the range 0.3–0.9 VDC, or the resistance is below 20 MΩ in the reverse direction.
5. Repeat the tests for the five remaining diodes.
6. If any diode is faulty, replace the full set of six diodes (same type, same manufacturer):
    a. Remove diode(s).

 

-

b. Apply a small amount of heat sink compound **only** to the base of the replacement diode(s), not the threads.

c. Check polarity of diode(s).

d. Screw each replacement diode into a threaded hole in the rectifier plate.

e. Apply 2.6–3.1 Nm (23–27.4 in-lb) torque to give good mechanical, electrical and thermal contact.

f. Replace both varistors with a matched pair (same type, same manufacturer and same voltage grading: A, B, C, D, E, F)

7. Reconnect and check that all leads are secure, washers fitted and fasteners tight.

# 9.7 Temperature Sensors

## 9.7.1 Introduction

The alternators are designed to meet standards supporting EU Safety Directives, and recommended operating temperatures. Temperature sensors (where fitted) detect abnormal overheating of the main stator windings and bearing(s). Sensors are of two types: Resistance Temperature Detector (RTD) sensors, with three wires, and Positive Temperature Coefficient (PTC) thermistors, with two wires, which are connected to a terminal block in the auxiliary or main terminal box. The resistance of Platinum (PT100) RTD sensors increases linearly with temperature.

**TABLE 24. RESISTANCE (Ω) OF PT100 SENSOR BETWEEN 40 TO 180 °C**

| Temperature (°C) | | +1 °C | +2 °C | +3 °C | +4 °C | +5 °C | +6 °C | +7 °C | +8 °C | +9 °C |
|---|---|---|---|---|---|---|---|---|---|---|
| **40.00** | 115.54 | 115.93 | 116.31 | 116.70 | 117.08 | 117.47 | 117.86 | 118.24 | 118.63 | 119.01 |
| **50.00** | 119.40 | 119.78 | 120.17 | 120.55 | 120.94 | 121.32 | 121.71 | 122.09 | 122.47 | 122.86 |
| **60.00** | 123.24 | 123.63 | 124.01 | 124.39 | 124.78 | 125.16 | 125.54 | 125.93 | 126.31 | 126.69 |
| **70.00** | 127.08 | 127.46 | 127.84 | 128.22 | 128.61 | 128.99 | 129.37 | 129.75 | 130.13 | 130.52 |
| **80.00** | 130.90 | 131.28 | 131.66 | 132.04 | 132.42 | 132.80 | 133.18 | 133.57 | 133.95 | 134.33 |
| **90.00** | 134.71 | 135.09 | 135.47 | 135.85 | 136.23 | 136.61 | 136.99 | 137.37 | 137.75 | 138.13 |
| **100.00** | 138.51 | 138.88 | 139.26 | 139.64 | 140.02 | 140.40 | 140.78 | 141.16 | 141.54 | 141.91 |
| **110.00** | 142.29 | 142.67 | 143.05 | 143.43 | 143.80 | 144.18 | 144.56 | 144.94 | 145.31 | 145.69 |
| **120.00** | 146.07 | 146.44 | 146.82 | 147.20 | 147.57 | 147.95 | 148.33 | 148.70 | 149.08 | 149.46 |
| **130.00** | 149.83 | 150.21 | 150.58 | 150.96 | 151.33 | 151.71 | 152.08 | 152.46 | 152.83 | 153.21 |
| **140.00** | 153.58 | 153.96 | 154.33 | 154.71 | 155.08 | 155.46 | 155.83 | 156.20 | 156.58 | 156.95 |
| **150.00** | 157.33 | 157.70 | 158.07 | 158.45 | 158.82 | 159.19 | 159.56 | 159.94 | 160.31 | 160.68 |
| **160.00** | 161.05 | 161.43 | 161.80 | 162.17 | 162.54 | 162.91 | 163.29 | 163.66 | 164.03 | 164.40 |
| **170.00** | 164.77 | 165.14 | 165.51 | 165.89 | 166.26 | 166.63 | 167.00 | 167.37 | 167.74 | 168.11 |
| **180.00** | 168.48 | | | | | | | | | |

PTC thermistors are characterized by a sudden increase in resistance at a reference “switching” temperature. Customer-supplied external equipment may be connected to monitor the sensors and generate signals to raise an alarm and to shutdown the generator set.

**BS EN 60085 (≡ IEC 60085) Electrical insulation – Thermal Evaluation and Designation** classifies insulation of windings by the maximum operating temperature for a reasonable service life. To avoid damage to windings, signals should be set, appropriate to the insulation class shown on the alternator rating plate.

**TABLE 25. ALARM AND SHUTDOWN TEMPERATURE SETTINGS FOR WINDINGS**

| Windings Insulation | Max. Continuous Temperature (°C) | Alarm Temperature (°C) | Shutdown Temperature (°C) |
|---|---|---|---|
| **Class B** | 130 | 120 | 140 |
| **Class F** | 155 | 145 | 165 |
| **Class H** | 180 | 170 | 190 |

To detect overheating of bearings, control signals should be set according to the following table.

**TABLE 26. ALARM AND SHUTDOWN TEMPERATURE SETTINGS FOR BEARINGS**

| Bearings | Alarm Temperature (°C) | Shutdown Temperature (°C) |
|---|---|---|
| **Drive End Bearing** | 45 + maximum ambient | 50 + maximum ambient |
| **Non-drive End Bearing** | 40 + maximum ambient | 45 + maximum ambient |

## 9.7.2 Safety

**⚠ DANGER**

***Testing Live Electrical Conductors***

***Live electrical conductors can cause serious injury or death by electric shock and burns. To prevent injury:***

- ***Before removing covers over electrical conductors, shut down and isolate the generator set from all energy sources, remove stored energy and use lock out/tag out safety procedures.***

**⚠ WARNING**

***Hot Surfaces and Fire***

***Contact with hot surfaces can cause serious injury and death by burns. A risk of fire exists where hot surfaces are contacted by combustible items. To prevent injury/fire:***

- ***Avoid contact with hot surfaces.***
- ***Always wear the appropriate personal protection equipment, refer to; Safety Precaution Chapter.***
- ***Ensure that no combustible materials (such as packaging) or flammable substances come in to contact with or are stored in close proximity to the anti-condensation heater (if fitted).***
- ***Ensure that no combustible material(s) or flammable substances come in to contact with or are stored in close proximity to the alternator or prime mover, including the cooling, ventilation and exhaust system(s) where applicable.***

## 9.7.3 Test RTD Temperature Sensors

1. Remove the terminal box lid.
2. Identify the sensor leads at the terminal block and where each sensor is fitted
3. Measure the resistance between the white and each red wire of one sensor

 

4. Calculate the sensor temperature from the measured resistance
5. Compare calculated temperature with temperature indicated by external monitoring equipment (if available)
6. Compare alarm and shutdown signal settings (if available) with recommended settings
7. Repeat steps 3 to 7 for each sensor
8. Refit the terminal box lid.
9. Contact Cummins Customer Service Help Desk to replace faulty sensors.

### 9.7.4 Test PTC Temperature Sensors

1. Remove the auxiliary terminal box lid.
2. Identify the sensor leads at the terminal block and where each sensor is fitted.
3. Measure the resistance between the two wires.
4. Sensor is faulty if resistance shows open circuit (infinity Ω) or short circuit (zero Ω).
5. Repeat steps 3 to 5 for each sensor.
6. Stop the alternator and inspect the change in resistance as the stator winding cools.
7. Sensor is faulty if resistance does not change or change is not smooth.
8. Repeat steps 6 and 7 for each sensor.
9. Refit the auxiliary terminal box lid.
10. Contact Cummins Customer Service Help Desk to replace faulty sensors.

## 9.8 Windings

### 9.8.1 Introduction

| *NOTICE* |
| --- |
| **Disconnect all control wiring and customer load leads from alternator winding connections before conducting these tests.** |

| *NOTICE* |
| --- |
| **The Automatic Voltage Regulator (AVR) contains electronic components which would be damaged by high voltage applied during insulation resistance tests. The AVR must be disconnected before doing any insulation resistance test. Temperature sensors must be grounded to earth before doing any insulation resistance test.**<br>**Damp or dirty windings have a lower electrical resistance and could be damaged by insulation resistance tests at high voltage. If in doubt, test the resistance at low voltage (500 V) first.** |

Alternator performance depends on good electrical insulation of the windings. Electrical, mechanical and thermal stresses, and chemical and environmental contamination, cause the insulation to degrade. Various diagnostic tests indicate the condition of insulation by charging or discharging a test voltage on isolated windings, measuring current flow, and calculating the electrical resistance by Ohm's law.

When a DC test voltage is first applied, three currents can flow:

- **Capacitive Current:** To charge the winding to the test voltage (decays to zero in seconds),
- **Polarizing Current:** To align the insulation molecules to the applied electric field (decays to near-zero in ten minutes), and

- **Leakage Current:** Discharge to earth where the insulation resistance is lowered by moisture and contamination (increases to a constant in seconds).

For an insulation resistance test, a single measurement is made one minute after a DC test voltage is applied, when capacitive current has ended. For the polarization index test, a second measurement is made after ten minutes. An acceptable result is where the second insulation resistance measurement is at least double the first, because the polarization current has decayed. In poor insulation, where leakage current dominates, the two values are similar. A dedicated Insulation Tester takes accurate, reliable measurements and may automate some tests.

## 9.8.2 Safety

**⚠ DANGER**

***Testing Live Electrical Conductors***

***Live electrical conductors can cause serious injury or death by electric shock and burns. To prevent injury:***

- ***Before removing covers over electrical conductors, shut down and isolate the generator set from all energy sources, remove stored energy and use lock out/tag out safety procedures.***

**⚠ DANGER**

***Live Electrical Conductors***

***Live electrical conductors can cause serious injury or death by electric shock and burns.***

***To prevent injury and before testing on or near live electrical conductors:***

- ***Assess risk and test on or near live conductors only if absolutely necessary.***
- ***Only trained, competent persons may test on or near live electrical conductors.***
- ***Do not test on or near live electrical conductors alone; another competent person must be present, trained to isolate energy sources and take action in an emergency.***
- ***Place warnings and prevent access by unauthorized persons.***
- ***Make sure that tools, test instruments, leads and attachments are designed, inspected and maintained for use on the maximum voltages likely under normal and fault conditions.***
- ***Test medium and high voltage (3.3 kV to 13.6 kV) alternators only with specialized instruments and probes, refer to; Tools and Equipment Chapter.***
- ***Take suitable precautions to prevent contact with live conductors including personal protective equipment, insulation, barriers and insulated tools.***

**⚠ WARNING**

***Condensed Water***

***Operating an alternator with condensed water in the windings can cause serious injury by electric shock, burns or exposure to flying debris and particles. To prevent injury:***

- ***Use anti-condensation heaters (if fitted) to prevent condensation accumulating.***
- ***Before operating the alternator; check for condensed water. If condensed water is present, drain/remove the water, dry and inspect the alternator in accordance with the Maintenance and Servicing Chapter.***

 

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**⚠ WARNING**

***Exposure to Particles and Fumes from an Alternator.***

***Particles and fumes can be released in all directions (horizontally and vertically) from where any ventilation opening is fitted. To avoid injury:***

- ***Avoid the areas around all ventilation openings, air intake(s) and air outlet(s) when the alternator is operating.***

**⚠ WARNING**

***Live Electrical Conductors***

***Live electrical conductors at the winding terminals after an insulation resistance test can cause serious injury or death by electric shock or burns. To prevent injury:***

- ***Always discharge the windings immediately after the test has concluded by shorting to earth through an earthing rod for:***
  1. ***A duration equal to the test duration.***
     ***or***
  2. ***5 minutes.***

***Whichever is the longer duration.***

**⚠ WARNING**

***Incorrect Electrical Installation and System Protection***

***Incorrect electrical installation and system protection can cause serious injury or death by electric shock and burns. To prevent injury:***

- ***All personnel who carry out; installation, service or maintenance work or who supervise such work being undertaken must be suitably experienced and qualified.***
- ***All personnel must comply with all locally applicable rules and regulations as well as site safety requirements, refer to; Safety Precaution Chapter.***

## 9.8.3 Requirements

**TABLE 27. WINDING TEST REQUIREMENTS**

| Requirement | Description |
|---|---|
| **Personal Protective Equipment (PPE)** | • Wear appropriate protective equipment as directed by site rules and risk assessment requirements. |
| **Consumables** | • None |
| **Parts** | • None |
| **Tools** | • Insulation test meter<br>• Multimeter<br>• Milliohm meter or microohm meter<br>• Clamp ammeter<br>• Infrared thermometer<br>• Earth rod |

## 9.8.4 Test the Electrical Resistance of Windings

1. Stop the alternator.
2. Verify the electrical resistance of the exciter field (stator) winding:
   a. Disconnect the exciter field leads F1 and F2 from the AVR.
   b. Measure and record the electrical resistance between F1 and F2 leads with a multimeter.
   c. Reconnect the exciter field leads F1 and F2.
   d. Make sure the fasteners are secure.
3. Verify the electrical resistance of the exciter armature (rotor) winding:
   a. Mark the leads attached to diodes on one of the two rectifier plates.
   b. Disconnect all exciter rotor leads from all diodes at the rectifier.
   c. Measure and record the electrical resistance between pairs of marked leads (between phase windings). A specialist micro ohmmeter must be used.
   d. Reconnect all exciter rotor leads to the diodes.
   e. Make sure the fasteners are secure.
4. Verify the electrical resistance of the main field (rotor) winding:
   a. Disconnect the two main rotor d.c. leads from the rectifier plates.
   b. Measure and record the electrical resistance between the main rotor leads. A specialist micro ohmmeter must be used.
   c. Reconnect the two main rotor d.c. leads to the rectifier plates.
   d. Make sure the fasteners are secure.
5. Verify the electrical resistance of the main armature (stator) winding:
   a. Disconnect the leads of the main stator from the output terminals.
   b. Measure and record the electrical resistance between U1 and U2 leads and between U5 and U6 (if present). A specialist micro ohmmeter must be used.
   c. Measure and record the electrical resistance between V1 and V2 leads and between V5 and V6 (if present). A specialist micro ohmmeter must be used.
   d. Measure and record the electrical resistance between W1 and W2 leads and between W5 and W6 (if present). A specialist micro ohmmeter must be used.
   e. Reconnect the leads to the output terminals, as before.
   f. Make sure the fasteners are secure.
6. Verify the electrical resistance of the PMG armature (stator) winding:
   a. Disconnect the three PMG output leads P2, P3 and P4 from the AVR.
   b. Measure and record the electrical resistance between pairs of the PMG output leads, with a multimeter.
   c. Reconnect the three PMG output leads P2, P3 and P4 to the AVR.
   d. Make sure the fasteners are secure.
7. Refer to the winding resistance table in; **Chapter 13 on page 123** to verify the measured resistances of all windings agree with the reference values.

## 9.8.5 Test the Insulation Resistance of Windings

| *NOTICE* |
| --- |
| **The alternator must not be put into service until the minimum insulation resistance is achieved.** |

 

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**TABLE 28. TEST VOLTAGE AND MINIMUM ACCEPTABLE INSULATION RESISTANCE FOR NEW AND IN-SERVICE ALTERNATORS**

| Part | Test Voltage (V) | Minimum Insulation Resistance at 1 Minute (MΩ) | |
|---|---|---|---|
| | | New | In-Service |
| **Main Stator** | 500 | 10 | 5 |
| **PMG Stator** | 500 | 5 | 3 |
| **Exciter Stator** | 500 | 10 | 5 |
| **Exciter Rotor, Rectifier & Main Rotor Combined** | 500 | 10 | 5 |

1. Inspect the windings for mechanical damage or discoloration from overheating. Clean the insulation if there is hygroscopic dust and dirt contamination.
2. For main stators:
    a. Disconnect the neutral to earth conductor (if fitted).
    b. Connect together the three leads of all phase windings (if possible) or carry out the test at individual lead ends.
    c. Apply the test voltage from the table between any phase lead and earth.
    d. Measure the insulation resistance after 1 minute ($IR_{1min}$).
    e. Discharge the test voltage with an earth rod for five minutes.
    f. If the measured insulation resistance is less than the minimum acceptable value, dry the insulation, then repeat the method.
    g. Reconnect neutral to earth conductor (if fitted).
3. For PMG and exciter stators, and combined exciter and main rotors:
    a. Connect the ends of the winding together (if possible) or carry out the test at individual lead ends.
    b. Apply the test voltage from the table between the winding and earth.
    c. Measure the insulation resistance after 1 minute ($IR_{1min}$).
    d. Discharge the test voltage with an earth rod for five minutes.
    e. If the measured insulation resistance is less than the minimum acceptable value, dry the insulation, then repeat the method.
    f. Repeat the method for each winding.
    g. Remove the connections made for testing.

# 9.8.6 Dry the Insulation

Use the methods below to dry the insulation of the main stator windings. To prevent damage as water vapor is expelled from the insulation, make sure the winding temperature does not increase faster than 5 ºC per hour or exceed 90 ºC.

Plot the insulation resistance graph to show when drying is complete.

## 9.8.6.1 Dry with Ambient Air

In many cases, the alternator can be dried sufficiently using its own cooling system. Disconnect the cables from the X+ (F1) and XX- (F2) terminals of the AVR so there is no excitation voltage supply to the exciter stator. Run the generator set in this de-excited state. Air must flow freely through the alternator to remove the moisture. Operate the anti-condensation heater (if fitted) to assist the drying effect of the air flow.

After drying is complete, re-connect the cables between the exciter stator and AVR. If the generator set is not put into service immediately, turn on the anti-condensation heater (if fitted) and retest the insulation resistance before use.

### 9.8.6.2 Dry with Hot Air

Direct the hot air from one or two 1 to 3 kW electrical fan heaters into the alternator air inlet. Make sure each heat source at least 300 mm away from the windings to avoid scorching or over-heating damage to the insulation. Air must flow freely through the alternator to remove the moisture.

After drying, remove the fan heaters and re-commission as appropriate.

If the generator set is not put into service immediately, turn on the anti-condensation heaters (where fitted) and retest the insulation resistance before use.

### 9.8.6.3 Plot IR Graph

Whichever method is used to dry out the alternator, measure the insulation resistance and temperature (if sensors fitted) of the main stator windings every 15 to 30 minutes. Plot a graph of insulation resistance, IR (y axis) against time, t (x axis).

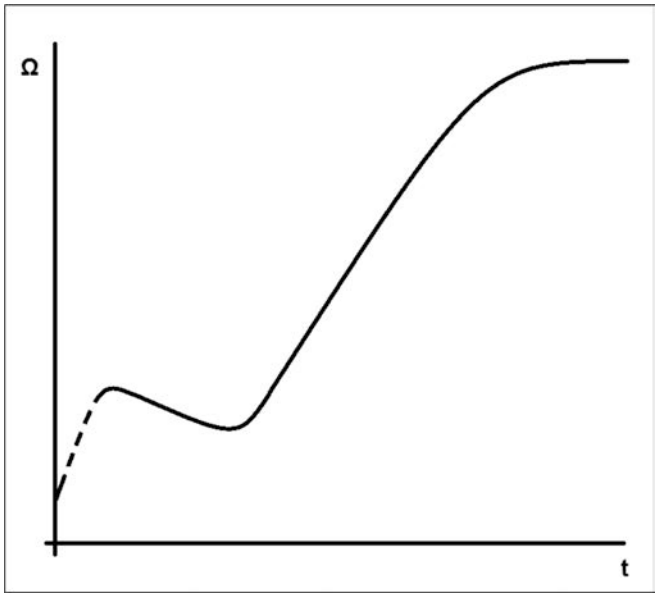


**FIGURE 25. INSULATION RESISTANCE GRAPH**

A typical curve shows an initial increase in resistance, a fall and then a gradual rise to a steady state; if the windings are only slightly damp the dotted portion of the curve may not appear. Continue drying for another hour after steady state is reached.

| *NOTICE* |
| --- |
| **The alternator must not be put into service until the minimum insulation resistance is achieved.** |

## 9.8.7 Clean the Insulation

Remove the main rotor to gain access to the main stator windings to remove dirt contamination. Cleaning of the alternator should be conducted using PH neutral clean, uncontaminated water. In the event of heavy contamination, it is permitted to use only Karcher RM81 detergent in conjunction with hot water jet wash. Methods to remove and assemble the drive end (DE) and non-drive end (NDE) support are included in the Replace Bearing section of Service and Maintenance chapter.

 

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### 9.8.7.1 Remove Main Rotor

**NOTICE**

**The rotor is heavy, with a small clearance to the stator. Windings will be damaged if the rotor drops or swings in the crane sling and hits the stator or frame. To avoid damage, fit support packing and carefully guide the rotor ends throughout. Do not allow the sling to touch the fan.**

**NOTICE**

**To remove the main rotor safely and easily, use the following special tools: a rotor extension stub shaft, a rotor extension tube (of similar length to the rotor shaft) and a height-adjustable V roller extension tube support. Refer to the factory for the availability and specification of these tools.**

1. Remove non-drive end bracket, see **Remove Non-Drive End** section.
2. For a two bearing alternator, remove drive end bracket, see **Remove Drive End** section.
3. For a one bearing alternator, remove drive end adapter as follows:
    a. Disconnect the alternator from the prime mover.
    b. Remove the DE adapter.
4. Fix the rotor shaft extension stub shaft to the main rotor at the non-drive end.
5. Fix the extension tube to the stub shaft.
6. Position the V roller support underneath the shaft extension tube, close to the alternator frame.
7. Raise the V roller support to lift the extension tube a small amount, to support the weight of the main rotor at the non-drive end.
8. Use a crane sling to lift the rotor at the drive end a small amount, to support its weight.
9. Carefully move the crane sling away so that the rotor withdraws from the alternator frame, as the extension tube rolls on the V rollers, until the rotor windings are fully visible.
10. Support the rotor on wooden blocks to prevent it rolling and damaging the windings.
11. Tightly bind the crane sling near the middle of the main rotor windings, near the rotor center of gravity.
12. Use a crane sling to lift the rotor a small amount, to test the rotor weight is balanced. Adjust the crane sling as necessary.
13. Carefully move the crane sling away so that the rotor withdraws completely from the alternator frame.
14. Lower the rotor onto wooden block supports and prevent it rolling and damaging the windings.
15. Remove the extension tube and stub shaft, as necessary.
16. Mark the position of the sling (to assist re-assembly) and remove the crane sling, as necessary.

### 9.8.7.2 Install Main Rotor

**NOTICE**

**The rotor is heavy, with a small clearance to the stator. Windings will be damaged if the rotor drops or swings in the crane sling and hits the stator or frame. To avoid damage, fit support packing between the rotor and stator and carefully guide the rotor ends throughout. Do not allow the sling to touch the fan.**

**NOTICE**

**To install the main rotor safely and easily, use the following special tools: a rotor extension stub shaft, a rotor extension tube (of similar length to the rotor shaft) and a height-adjustable V roller extension tube support. Refer to the factory for the availability and specification of these tools.**

1. Fix the rotor shaft extension stub shaft to the main rotor at the non-drive end (or to the NDE bearing cartridge on some alternator models).
2. Fix the extension tube to the stub shaft.
3. Tightly bind the crane sling near the middle of the main rotor windings near the rotor centre of gravity.
4. Use a crane sling to lift the rotor a small amount, to test the rotor weight is balanced. Adjust the crane sling as necessary.
5. Position the V roller support at the non-drive end, close to the alternator frame.
6. Carefully use the crane sling to insert the rotor into the alternator frame, extension tube first.
7. Guide the extension tube onto the V roller support. Adjust the height of the V roller support as necessary.
8. Insert the rotor into the alternator frame, until the crane sling meets the frame.
9. Lower the rotor onto wooden blocks to prevent it rolling and damaging the windings.
10. Reposition the crane sling at the drive end of the rotor shaft.
11. Use the crane sling to lift the rotor at the drive end a small amount, to support its weight.
12. Carefully move the crane sling towards the alternator frame, as the extension tube rolls on the V rollers, until the rotor windings are fully inserted.
13. Gently lower the crane sling to put the rotor weight onto the support packing and remove the sling.
14. For a two bearing alternator, refit drive end bracket, see **Assemble Drive End** section.
15. For a one bearing alternator, assemble the drive end as follows:
    a. Refit the DE adapter
    b. Couple the alternator to the prime mover.
    c. Refit the upper and lower air outlet screen covers.
16. Refit the non-drive end bracket, see **Assemble Non-Drive End** section.
17. Remove the rotor shaft extension tube.
18. Remove the rotor shaft extension stub shaft.
19. Remove the V roller support.

 

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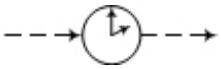
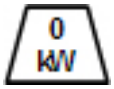
# 10 Fault Finding

## 10.1 Key to Symbols

**TABLE 29. KEY TO SYMBOLS**

| Symbol | Description |
|---|---|
|  | Red light emitting diode (LED) of automatic voltage regulator (AVR) is OFF |
|  | Red light emitting diode (LED) of automatic voltage regulator (AVR) is ON |
|  | Time delay |
|  | No output load applied (off-load) |
|  | Output load applied (on-load) |
|  | Diode |
|  | Fuse |
|  | Switch |
|  | Earth |
|  | Battery (observe polarity) |

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## 10.2 Safety

**⚠ DANGER**

***Live Electrical Conductors***

***Live electrical conductors can cause serious injury or death by electric shock and burns.***

***To prevent injury and before testing on or near live electrical conductors:***

- ***Assess risk and test on or near live conductors only if absolutely necessary.***
- ***Only trained, competent persons may test on or near live electrical conductors.***
- ***Do not test on or near live electrical conductors alone; another competent person must be present, trained to isolate energy sources and take action in an emergency.***
- ***Place warnings and prevent access by unauthorized persons.***
- ***Make sure that tools, test instruments, leads and attachments are designed, inspected and maintained for use on the maximum voltages likely under normal and fault conditions.***
- ***Test medium and high voltage (3.3 kV to 13.6 kV) alternators only with specialized instruments and probes, refer to; Tools and Equipment Chapter.***
- ***Take suitable precautions to prevent contact with live conductors including personal protective equipment, insulation, barriers and insulated tools.***

**⚠ DANGER**

***Live Electrical Conductors***

***Live electrical conductors at output, AVR, AVR accessory terminals, and AVR heat sink can cause serious injury or death by electric shock and burns.***

- ***To prevent injury, take suitable precautions to prevent contact with live conductors, such as using insulation, barriers and insulated tools and use suitable personal protective equipment, refer to; Safety Precaution Chapter.***

## 10.3 Introduction

This fault finding guide concerns the alternator - the synchronous a.c. alternator connected to the prime-mover (engine) by a mechanical coupling and connected to an electrical system by two, three or four power cables at an integral terminal block. This guide excludes:

- The prime-mover and its controls
- The generator set, its controls and wiring, and
- Panel instruments, circuit breakers and switchgear.

Fault finding relies on collecting information about symptoms, thinking of the most probable cause, then testing for it. This systematic method is progressed until the fault is isolated and eliminated, and minimizes the possibility of false diagnosis and unnecessary expense. Once you are sure that the problem lies with the a.c. alternator, follow this guide to diagnose and correct the fault.

**Before attempting to find and repair a fault, check for**:

- Physical symptoms, for example unusual noise, smoke or burning smell;
- Verbal or written reports that may indicate the source of the fault;
- Problems external to the alternator; and
- Faulty instrumentation, blown fuses or tripped circuit breakers.

Run the alternator only for the shortest time required to confirm the symptoms.

**With the alternator stopped, make a general inspection.**

- Check for any debris in the body of the alternator.
- Look for any obvious restrictions to rotation.
- Check the main terminals and control wiring for corroded or loose connections.

**To find the fault, you may need to**:

- Make a general inspection.
- Confirm the symptoms.
- Run the alternator unexcited.
- Run the alternator off-load, on-load or in parallel with other alternator(s).
- Disconnect and measure the resistance of windings and insulation.
- Test components from the rotating rectifier system.
- Disconnect the AVR and make adjustments to the AVR controls.

Do NOT assume that the AVR or control system is faulty until confirmed by test results.

If you are not qualified or competent to carry out these tasks then stop and seek further guidance.

**Also note:**

- Remove protective covers as needed for testing. Remember to replace the covers afterwards.
- Disable power to anti-condensation heaters (if fitted). Remember to reconnect the heaters afterwards.
- Disable features within the engine control protection systems (e.g. under-voltage protection) as needed to allow the engine to run during these tests. Enable the features afterwards.
- Always use a single independent instrument to make measurements. Do not rely on panel meters.

# 10.4 Recommended Fault Finding Equipment

## 10.4.1 Multimeter

The Multimeter is a comprehensive test instrument for measuring voltage, current and resistance. It should be capable of measuring the following ranges:-

- 0 to 250, 0 to 500, 0 to 1000 Volts (VAC)
- 0 to 25, 0 to 100, 0 to 250 Volts (VDC)
- 0 to 10 Amps (DC)
- 0 to 10 kiloOhms (kΩ) or 0 to 2 kiloOhms (kΩ)
- 0 to 100 kiloOhms (kΩ) or 0 to 20 kiloOhms (kΩ)
- 0 to 1 megaOhms (MΩ) or 0 to 200 kiloOhms (kΩ)

## 10.4.2 Tachometer or Frequency Meter

A tachometer is used to measure the shaft speed of the alternator and should be capable of measuring speeds between 0 and 5000 revolutions per minute, (RPM).

An alternative to the tachometer is the frequency meter. The alternator must be operating at its normal output voltage for a tachometer to be accurate.

 

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### 10.4.3 Insulation Tester

The insulation tester generates a voltage of 500V or 1000V, and is used to measure the resistance value of the insulation to earth (ground). It may be an electronic push button type, or a hand-cranked generator type.

### 10.4.4 Clamp-On Ammeter (clampmeter)

The clamp-on ammeter uses the transformer effect to measure current flowing in a conductor. A split magnetic core, in the form of a pair of jaws, is clamped to surround the conductor (single primary turn) Current flowing in secondary turns within the meter is measured. Useful ranges are

- 0 to 10, 0 to 50, 0 to 100, 0 to 250, 0 to 500 and 0 to 1000 Amps (AC).

### 10.4.5 Micro Ohmmeter

A micro ohmmeter is used to measure resistance values below 1.0 ohm. It is the only means of accurately measuring very low resistances, such as main stator and exciter rotor windings.

### 10.4.6 Tools and Spares

For efficient fault finding and to minimize downtime, anticipate likely problems and prepare tools and spares to fix the worst-case fault. Include:

- Comprehensive toolkit to remove/refit fasteners
- Torque wrench (of appropriate torque range to tighten fasteners)
- Spare replacement AVR, of appropriate type
- Electrical, flat-bladed screwdriver to adjust AVR controls
- Full set of rectifier diodes
- Torque wrench and accessories (of appropriate torque range and mechanical configuration to access and tighten diodes)
- Full set of rectifier varistors
- Remote hand trimmer
- Current transformer, if appropriate
- Voltage transformer, if appropriate
- Voltage transformer fuses, if appropriate
- Exciter rotor and stator, if appropriate
- PMG rotor and stator, if appropriate
- Rectifier diode, 5 A fuse, switch and battery to restore the residual voltage

## 10.5 Preparation

**Record details of the alternator (model, serial number, running time, voltage, AVR and main stator configuration), symptoms and observations[2] in a copy of the fault finding record** **Chapter 11 on page 117**.

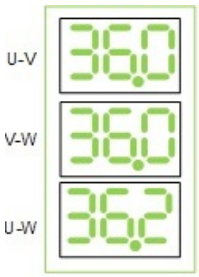
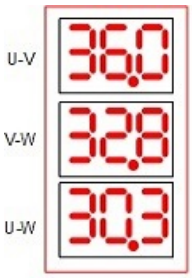
| | | |
|---|---|---|
| **From what you know, does the alternator work NORMALLY when OFF-LOAD (no output load)?** | **YES** | Check alternator on-Load **Section 10.8 on page 99**. |
| | **NO** | Check Un-excited phase and AVR voltages **Section 10.6 on page 91**. |

[2] The output voltage, stator configuration and AVR may be different from that shown on the nameplate. Record your **own** observations and measurements.

# 10.6 Check Un-excited Phase and AVR Voltages

**Check the alternator is safe to run:**

- Disconnect and isolate the power output cables from the alternator main terminals.
- Disconnect the exciter field wires (F1 and F2) from the AVR and make them safe.
- Start the alternator without output load, ‘Off-Load‘. Be prepared to STOP!
- Verify that the alternator speed is correct.
- Measure the alternator output voltage (phase to phase):[3] This is the residual voltage. Record your measurements on the fault finding record **Chapter 11 on page 117**.

<table>
<tr><td colspan="2">Are the phase voltages UNBALANCED by more than 1%? (see example below)</td><td>YES</td><td>Unbalanced residual voltage could indicate that there is a problem with the main stator winding and it is therefore unsafe to run the alternator under normal excitation:<br>Unbalanced residual voltage would not be caused by faulty AVR or faulty rotating rectifier components.</td></tr>
<tr><td>Balanced<br> 
</td><td>Unbalanced<br> 
</td><td rowspan="3">NO</td><td>ACTIONS:<br> 
<br>STOP THE ALTERNATOR<br>Take these recommended steps in order, until the cause is found.<br>1. Measure and verify the main stator insulation resistance<br>**Section 10.9.19 on page 114**.<br>2. Measure and verify the main stator resistance<br>**Section 10.9.14 on page 111**.</td></tr>
<tr><td colspan="2" rowspan="2"></td><td>The correct input voltage is essential for the AVR to operate.<br>For ‘SX’ and ‘AS‘ types, where the residual voltage starts the AVR, if the residual voltage is below the minimum level required then the alternator will fail to excite.<br>For ‘MX‘ AVRs and machines equipped with a permanent magnet generator (PMG) the residual voltage requirements do not apply.<br>The AVR Sensing Voltage is a fixed proportion of the main output voltage of the alternator which is used by the AVR for voltage control. If the sensing voltage is not a good and stable representation of the output then the AVR will not control the output correctly.</td></tr>
<tr><td>ACTIONS:<br>KEEP THE ALTERNATOR RUNNING<br>Measure the AVR Power Input and Sensing Voltages.<br>Record your measurements on the fault finding record<br>**Chapter 11 on page 117**.<br>Continue to the next question.</td></tr>
</table>

[3] Three-wire, single-phase alternators should be checked as two separate windings.

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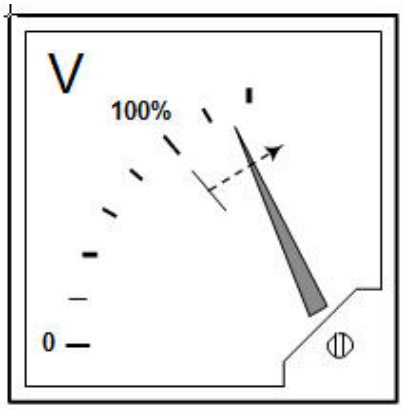
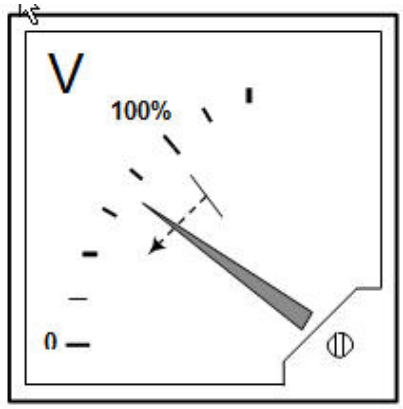
| | | |
|---|---|---|
| **Does the AVR Power Input Voltage reading (from the fault finding record) fail the requirement?** | **YES** | **ACTIONS:**<br>  <br>**STOP THE ALTERNATOR**<br>Take these recommended steps in order, until the cause is found.<br>1. Check the main stator output connections.<br>2. Restore the residual voltage<br>**Section 10.9.21 on page 115**. |
| | **NO** | Calculate $V_a$, $V_b$ and $V_{sen}$ and record your measurements on the fault finding record<br>**Chapter 11 on page 117**.<br>Continue to the next question. |

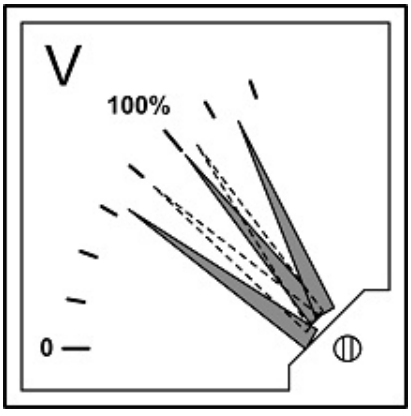
| | | |
|---|---|---|
| **Does the calculated AVR Sensing Voltage (from the fault finding record) fail the requirement?** | **YES** | **ACTIONS:**<br>  <br>**STOP THE ALTERNATOR**<br>Take these recommended steps in order, until the cause is found.<br>1. Check the main stator output connections.<br>2. Check AVR sensing transformer(s).<br>3. Check other AVR accessories. |
| | **NO** | The alternator should be safe to operate off-load. |
| | | **ACTIONS:**<br>  <br>**STOP THE ALTERNATOR**<br>1. Reconnect the main output cables to the alternator main terminals.<br>2. Reconnect the exciter field wires (F1 and F2) to the AVR.<br>3. Continue to off-load checks<br>**Section 10.7 on page 92**. |

# 10.7 Check Alternator Off-Load

1. Make sure the main output cables and exciter field wires are securely connected.
2. Start the alternator without output load, 'Off-Load ‘. Be prepared to STOP!
3. Verify that the alternator speed is correct.
4. Measure the main terminal output voltage.

| | | |
|---|---|---|
| **Is the voltage HIGH by more than +2%?**<br>  | **YES** | **ACTION:**<br>**KEEP THE ALTERNATOR RUNNING**<br>**High voltage** failure is indicated by:<br>• High voltage **continuously** by more than +2%, or<br>• High voltage for a short time then shuts down.<br>Continue to **Section 10.7.1 on page 94**. |
| | **NO** | Continue to the next question. |

| | | |
|---|---|---|
| **Is the voltage LOW by more than -2%?**<br>  | **YES** | **ACTION:**<br>**KEEP THE ALTERNATOR RUNNING**<br>**Low voltage** or **no voltage** failure is indicated by:<br>• Low voltage **continuously** by more than -2%, or<br>• Low voltage for a short time then shuts down.<br>Continue to **Section 10.7.2 on page 95**. |
| | **NO** | Continue to the next question. |

| | | |
|---|---|---|
| **Is the voltage UNSTABLE?**<br>  | **YES** | **ACTION:**<br>**KEEP THE ALTERNATOR RUNNING**<br>**Unstable voltage** failure is indicated by:<br>• Rhythmic instability<br>• Erratic instability with the AVR LED flickering<br>• Erratic instability with the AVR LED OFF, or<br>• Voltage drifting.<br>Continue to **Section 10.7.3 on page 97**. |
| | **NO** | Continue to the next question. |

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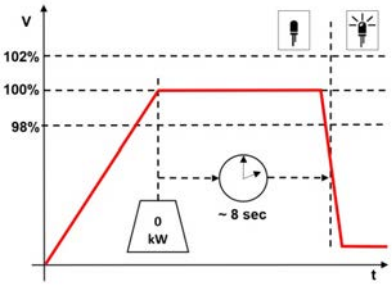
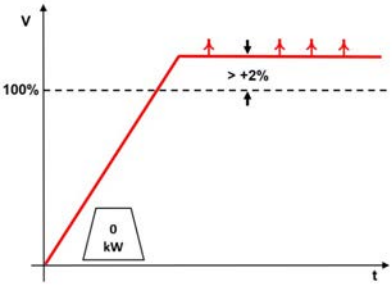
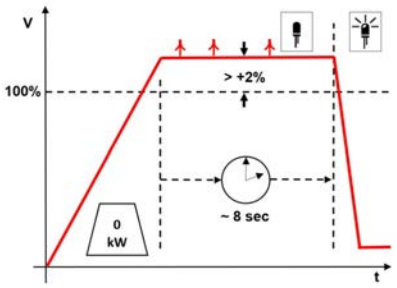
|---|---|---|
| **Is the voltage NORMAL for a short time, then shuts down?**<br>  | **YES** | The AVR has shut down in response to a fault within the alternator windings or rotating rectifier components.<br><br>**ACTION:**<br>**STOP THE ALTERNATOR**<br>Take these recommended steps in order, until the cause is found.<br>1. Check rotating rectifier components<br>**Section 10.9.9 on page 108**,<br>**Section 10.9.10 on page 110**.<br>2. Measure and verify the resistance of exciter windings<br>**Section 10.9.11 on page 111**,<br>**Section 10.9.12 on page 111**.<br>3. Measure and verify the resistance of main rotor **Section 10.9.13 on page 111**. |
| | **NO** | Continue to check alternator on-load **Section 10.8 on page 99**. |

## 10.7.1 Higher than Expected Voltage Off-Load

**The alternator produces higher than expected voltage:**

1. Start the alternator without output load, 'Off-Load '. Be prepared to STOP!
2. Verify that the alternator speed is correct.
3. Measure the main terminal output voltage.

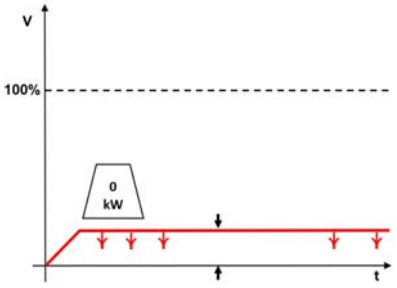
| | | |
|---|---|---|
| **Is the voltage CONTINUOUSLY HIGH by more than +2%?**<br>  | **YES** | It is unlikely to be a fault with the alternator windings or rotating rectifier components.<br><br>**ACTION:**<br>**STOP THE ALTERNATOR**<br>Take these recommended steps in order, until the cause is found.<br>1. Check and adjust remote hand trimmer (if fitted) **Section 10.9.5 on page 107**.<br>2. Check and adjust AVR VOLTS setting **Section 10.9.1 on page 103**.<br>3. Measure and verify AVR sensing voltage input **Section 10.9.7 on page 107**.<br>4. Replace the AVR. |
| | **NO** | Continue to the next question. |

| | | |
|---|---|---|
| **Is the voltage HIGH for a short time, then shuts down and the AVR LED is ON?**<br>  | **YES** | The AVR has shut down in response to a problem but it is unlikely to be a fault with the alternator windings or rotating rectifier components. |
| | | **ACTION:**<br>**STOP THE ALTERNATOR**<br>Take these recommended steps in order, until the cause is found.<br>1. Check and adjust remote hand trimmer (if fitted) **Section 10.9.5 on page 107**.<br>2. Check and adjust AVR VOLTS setting **Section 10.9.1 on page 103**.<br>3. Measure and verify AVR sensing voltage input **Section 10.9.7 on page 107**.<br>4. Replace the AVR. |
| | **NO** | **ACTION:**<br>**STOP THE ALTERNATOR**<br>Seek guidance from CGT Customer Support. |

## 10.7.2 Lower than Expected Voltage Off-Load

**The alternator produces lower than expected voltage:**

1. Start the alternator without output load, 'Off-Load ‘. Be prepared to STOP!
2. Verify that the alternator speed is correct.
3. Measure the main terminal output voltage.

| | | |
|---|---|---|
| **Is the voltage ZERO or VERY LOW?**<br>  | **YES** | **ACTION:**<br>**STOP THE ALTERNATOR**<br>Take these recommended steps in order, until the cause is found.<br>1. Check the main stator output connections.<br>2. Restore residual voltage (NOT applicable to machines with a PMG) **Section 10.9.21 on page 115**. |
| | **NO** | Continue to the next question. |

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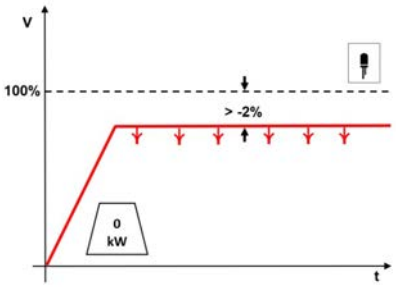
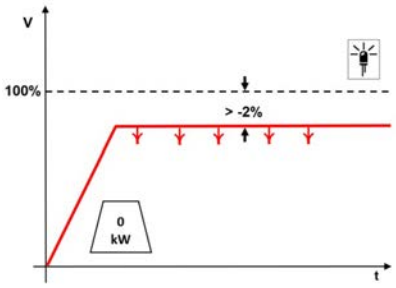
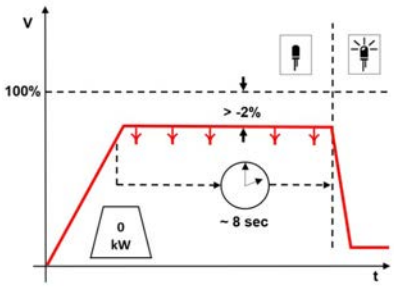
| | | |
|---|---|---|
| **Is the voltage CONTINUOUSLY LOW by more than -2% and the AVR LED is OFF?**<br>  | **YES** | It is unlikely to be a fault with the alternator main stator winding unless the phase voltages are unbalanced. |
| | | **ACTION:**<br>**STOP THE ALTERNATOR**<br>Take these recommended steps in order, until the cause is found.<br>1. Check and adjust remote hand trimmer (if fitted) **Section 10.9.5 on page 107**.<br>2. Check and adjust AVR VOLTS setting **Section 10.9.1 on page 103**.<br>3. Check the rotating rectifier components **Section 10.9.9 on page 108**, **Section 10.9.10 on page 110**.<br>4. Measure and verify the condition of the PMG stator winding (if fitted) **Section 10.9.15 on page 112**, **Section 10.9.20 on page 114**.<br>5. Replace the AVR. |
| | **NO** | Continue to the next question. |

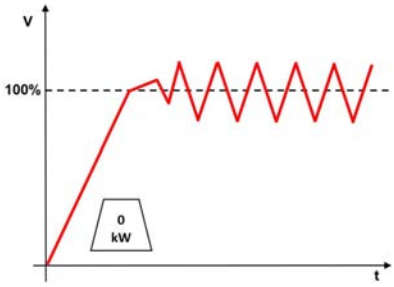
| | | |
|---|---|---|
| **Is the voltage CONTINUOUSLY LOW by more than -2% and the AVR LED is ON?**<br>  | **YES** | It is unlikely to be a fault with the alternator main stator winding unless the phase voltages are unbalanced. |
| | | **ACTION:**<br>**STOP THE ALTERNATOR**<br>Take these recommended steps in order, until the cause is found.<br>1. Adjust AVR UFRO setting **Section 10.9.2 on page 104**.<br>2. Check alternator (prime mover) rotational speed.<br>3. Replace the AVR. |
| | **NO** | Continue to the next question. |

| | | |
|---|---|---|
| **Is the voltage LOW for a short time, then shuts down and the AVR LED is ON?**<br>  | **YES** | It is unlikely to be a fault with the alternator main stator winding unless the phase voltages are unbalanced. |
| | | **ACTION:**<br>**STOP THE ALTERNATOR**<br>Take these recommended steps in order, until the cause is found.<br>1. Check rotating rectifier components **Section 10.9.9 on page 108**, **Section 10.9.10 on page 110**.<br>2. Replace the AVR. |
| | **NO** | **ACTION:**<br>**STOP THE ALTERNATOR**<br>Seek guidance from CGT Customer Support. |

## 10.7.3 Unstable Voltage Off-Load

**The alternator produces an unstable voltage output:**

1. Start the alternator without output load, 'Off-Load'. Be prepared to STOP!
2. Verify that the alternator speed is correct.
3. Measure the main terminal output voltage.

| | | |
|---|---|---|
| **Is the voltage varying in a regular RHYTHMIC way?**<br>  | **YES** | It is unlikely to be a fault with the alternator windings or rotating rectifier components. |
| | | **ACTION:**<br>**STOP THE ALTERNATOR**<br>Take these recommended steps in order, until the cause is found.<br>1. Verify that the prime mover speed is stable.<br>2. Check if the alternator is operating below its design voltage.<br>3. Check and adjust the AVR STAB setting **Section 10.9.3 on page 105**. |
| | **NO** | Continue to the next question. |

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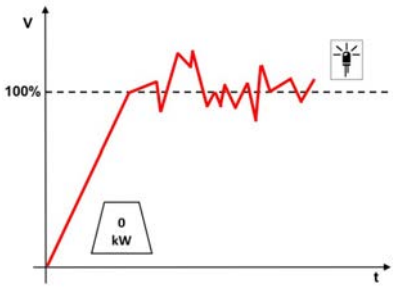
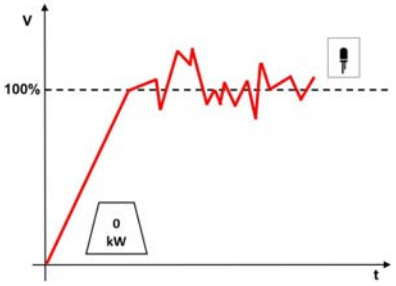
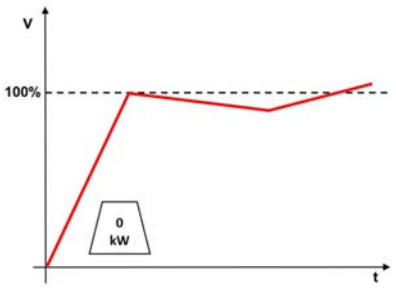
|---|---|---|
| **Is the voltage varying in an irregular ERRATIC way and the AVR LED is flickering?**<br>  | **YES** | It is most likely to be a poorly adjusted AVR UFRO setting. It is unlikely to be a fault with the alternator windings or rotating rectifier components.<br><br>**ACTION:**<br>**STOP THE ALTERNATOR**<br>Take these recommended steps in order, until the cause is found.<br>1. Check prime mover speed governing.<br>2. Check and adjust AVR UFRO setting<br>**Section 10.9.2 on page 104**. |
| | **NO** | Continue to the next question. |

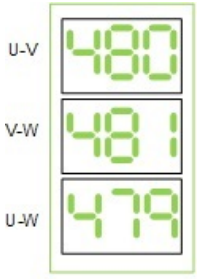
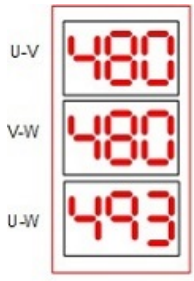
| | | |
|---|---|---|
| **Is the voltage varying in an irregular ERRATIC way and the AVR LED is OFF?**<br>  | **YES** | It is unlikely to be a fault with the rotating rectifier components.<br><br>**ACTION:**<br>**STOP THE ALTERNATOR**<br>**Erratic instability and AVR LED OFF** is corrected by taking the following steps, in order:<br>1. Check prime mover speed governing.<br>2. Check and adjust AVR STAB setting<br>**Section 10.9.3 on page 105**.<br>3. Measure and verify the insulation resistance of the exciter stator<br>**Section 10.9.16 on page 112**.<br>4. Measure and verify the insulation resistance of the PMG (if fitted) and/or auxiliary winding (if fitted). |
| | **NO** | Continue to the next question. |

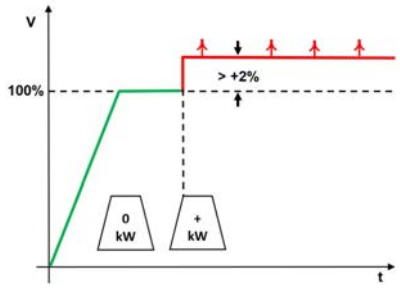
| | | |
|---|---|---|
| **Is the voltage DRIFTING, varying slowly over a long time?**<br>  | **YES** | **ACTION:**<br>**STOP THE ALTERNATOR**<br>**Voltage drifting** is corrected by taking the following steps, in order:<br>1. Check and adjust the remote hand trimmer<br>**Section 10.9.5 on page 107**.<br>2. Replace the faulty AVR. |
| | **NO** | **ACTION:**<br>**STOP THE ALTERNATOR**<br>Seek guidance from CGT Customer Support. |

# 10.8 Check Alternator On-Load

**Check the alternator with the output load applied, 'On-Load'.**

1. Start the alternator and apply the output load. Be prepared to STOP!
2. Make sure that the alternator speed is correct.
3. Measure the main terminal output voltage.

<table>
<tr><td colspan="2">Are the phase voltages UNBALANCED by more than 1%? (see example below)</td><td>YES</td><td>Unbalanced voltage would not be caused by a faulty AVR or faulty rotating rectifier components.</td></tr>
<tr><td>Balanced<br> 
</td><td>Unbalanced<br> 
</td><td></td><td>ACTIONS:<br> 
<br>STOP THE ALTERNATOR<br>Take these recommended steps in order, until the cause is found.<br>1. Check and correct the three-phase load balance.<br>2. Check and correct the distribution of single-phase loads.<br>3. Check main stator output connections for loose leads.<br>4. Measure and verify the main stator resistance Section 10.9.14 on page 111.</td></tr>
<tr><td colspan="2"></td><td>NO</td><td>Continue to the next question.</td></tr>
</table>

<table>
<tr><td>Is the voltage HIGH by more than +2% when load applied?<br> 
<br>A higher voltage than rated is present as soon as the alternator is loaded.</td><td>YES</td><td>ACTION:<br> 
<br>STOP THE ALTERNATOR<br>Check and correct the leading (capacitive) power-factor load.</td></tr>
<tr><td></td><td>NO</td><td>Continue to the next question.</td></tr>
</table>

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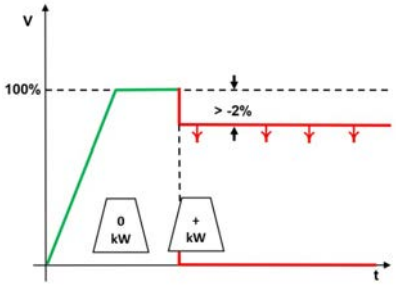
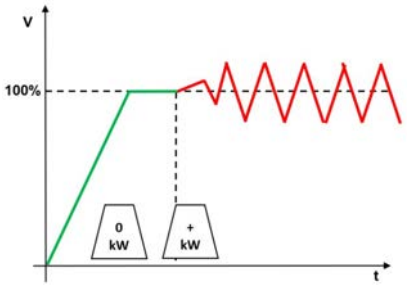
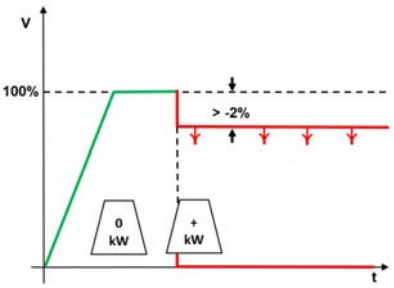
|---|---|---|
| **Is the voltage LOW by more than -2% when load applied?**<br>  | **YES** | **ACTION:**<br>**STOP THE ALTERNATOR**<br>**Low voltage** or **no voltage when applying load** is indicated by:<br>• Low voltage by more than -2% **continuously** after applying load;<br>• Low voltage by more than -2% **continuously** after applying load and AVR LED is ON;<br>• Low voltage by more than -2% **for a short time** after applying load, then shuts down and AVR LED is ON; or<br>• Normal voltage for a short time after applying load, then shuts down and AVR LED is ON.<br>Continue to **Section 10.8.1 on page 100**. |
| | **NO** | Continue to the next question. |

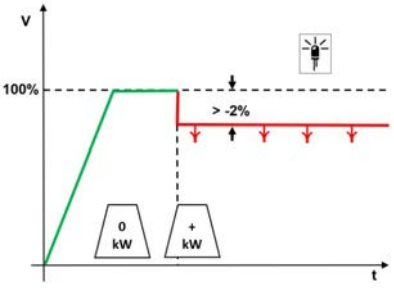
| | | |
|---|---|---|
| **Is the voltage UNSTABLE when load applied?**<br>  | **YES** | **ACTION:**<br>**STOP THE ALTERNATOR**<br>**Unstable voltage when applying load** is indicated by:<br>• Interaction between AVR, governor and/or load; or<br>• Waveform distortion caused by load. |
| | **NO** | **ACTION:**<br>**STOP THE ALTERNATOR**<br>Seek guidance from CGT Customer Support. |

## 10.8.1 Lower than Expected Voltage On-Load

**The alternator produces lower than expected voltage:**

1. Start the alternator and apply the output load, 'On-Load '. Be prepared to STOP!
2. Verify that the alternator speed is correct.
3. Measure the main terminal output voltage.

| | | |
|---|---|---|
| **Is the voltage CONTINUOUSLY LOW by more than -2% when load applied?**<br>  | **YES** | It is unlikely to be a fault with the alternator main stator winding unless the phase voltages are unbalanced. |
| | | **ACTION:**<br>**STOP THE ALTERNATOR**<br>Take these recommended steps in order, until the cause is found.<br>1. Check prime-mover load/speed response.<br>2. Check and adjust AVR VOLTS setting **Section 10.9.1 on page 103**.<br>3. Check rotating rectifier components **Section 10.9.9 on page 108** , **Section 10.9.10 on page 110**.<br>4. Check and adjust an AVR accessory **Section 10.9.4 on page 106**, **Section 10.9.5 on page 107**.<br>5. Check load for fault. |
| | **NO** | Continue to the next question. |

| | | |
|---|---|---|
| **Is the voltage CONTINUOUSLY LOW by more than -2% when load applied and the AVR LED is ON?**<br>  | **YES** | **ACTION:**<br>**STOP THE ALTERNATOR**<br>Take these recommended steps in order, until the cause is found.<br>1. Check prime-mover load/speed response.<br>2. Check and adjust AVR UFRO setting **Section 10.9.2 on page 104**. |
| | **NO** | Continue to the next question. |

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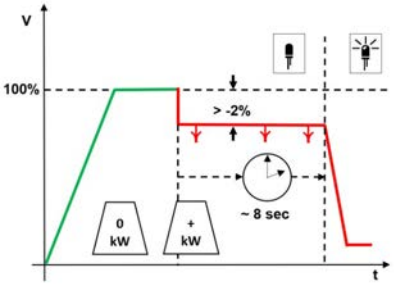
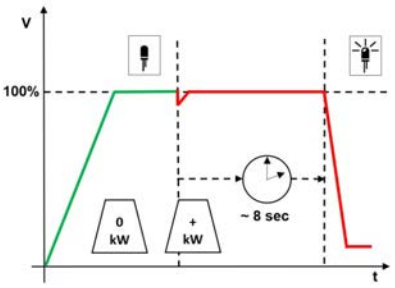
| | | |
|---|---|---|
| **Is the voltage LOW by more than -2% for a short time, then shuts down and the AVR LED is ON?**<br>  | **YES** | It is unlikely to be a fault with the alternator main stator winding unless the phase voltages are unbalanced. |
| | | **ACTION:**<br>**STOP THE ALTERNATOR**<br>Take these recommended steps in order, until the cause is found.<br>1. Check prime-mover load/speed response.<br>2. Check rotating rectifier components **Section 10.9.9 on page 108** , **Section 10.9.10 on page 110**.<br>3. Check for excessive load. |
| | **NO** | Continue to the next question. |

| | | |
|---|---|---|
| **Is the voltage NORMAL for a short time, then shuts down and the AVR LED is ON?**<br>  | **YES** | It is unlikely to be a fault with the alternator main stator winding unless the phase voltages are unbalanced. |
| | | **ACTION:**<br>**STOP THE ALTERNATOR**<br>Take these recommended steps in order, until the cause is found.<br>1. Check rotating rectifier components **Section 10.9.9 on page 108**, **Section 10.9.10 on page 110**.<br>2. Check for excessive load. |
| | **NO** | **ACTION:**<br>**STOP THE ALTERNATOR**<br>Seek guidance from CGT Customer Support. |

# 10.9 Procedures

**⚠ WARNING**

***Exposure to Ejected Debris and Particles***

***Ejected debris and particles can cause serious injury or death by impact, severing or puncturing. Exposure to mechanically driven release of debris and particles exists in all directions (horizontally and vertically) in the areas surrounding the alternator air outlet(s), air inlets(s) and the open shaft end (also commonly known as the Drive End (DE)).***

***To prevent injury; observe the below points while the alternator is operating:***

- ***Keep away from the air inlet(s) and air outlet(s) when the alternator is running.***
- ***Do not position operator controls near the air inlet(s) or air outlet(s).***
- ***Do not cause overheating by running the alternator outside rating plate parameters.***
- ***Do not overload the alternator.***
- ***Do not run an alternator with excessive vibration.***
- ***Do not synchronize parallel alternators outside the specified parameters.***

## 10.9.1 Adjust the AVR [VOLTS] Voltage Control

***NOTICE***

**Do not exceed the designed safe operating voltage, shown on the alternator rating plate.**

***NOTICE***

**Hand trimmer terminals may be above earth potential. Do not ground any of the hand trimmer terminals. Grounding hand trimmer terminals could cause equipment damage.**

**To set the output voltage AVR [VOLTS] control on the AVR:**

1. Check the alternator nameplate to confirm the designed safe operating voltage.
2. Set the **AVR [VOLTS]** control to 0%, the fully counter-clockwise position.

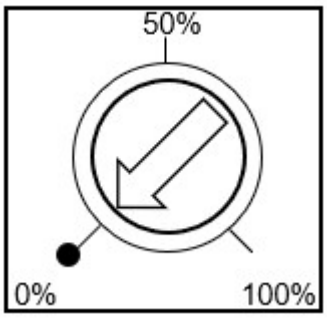



**FIGURE 26. AVR [VOLTS] CONTROL POTENTIOMETER 0%**

3. Check that the remote hand trimmer is fitted or terminals 1 and 2 are linked.

***NOTICE***

**If a remote hand trimmer is connected, set it to 50%, the midway position.**

4. Turn the **AVR [STAB]** control to 50%, the midway position.

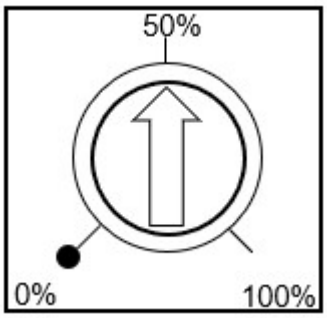



**FIGURE 27. AVR [STAB] CONTROL POTENTIOMETER 50%**

5. Start the alternator and set at the correct operating speed.
6. If the red Light Emitting Diode (LED) is illuminated, refer to the Under Frequency Roll Off **AVR [UFRO]** adjustment.
7. Adjust the **AVR [VOLTS]** control slowly clockwise to increase the output voltage.

| *NOTICE* |
| --- |
| **If the voltage is unstable set the AVR stability before proceeding, refer to; Section 10.9.3 on page 105.** |

8. Adjust the output voltage to the desired nominal value (VAC).
9. If instability is present at rated voltage, refer to the **AVR [STAB]** adjustment, then adjust **AVR [VOLTS]** again, if necessary.
10. If a remote hand trimmer is connected, check its operation.

| *NOTICE* |
| --- |
| **0% to 100% rotation corresponds to 90% to 110% VAC** |

The **AVR [VOLTS]** control is now set.

## 10.9.2 Adjust the AVR [UFRO] Under-Frequency Roll-Off Control

Below an adjustable frequency threshold ('knee' point), the AVR under-speed protection operates to reduce ('roll-off') the excitation voltage in proportion to alternator frequency. The AVR LED lights when UFRO operates.

1. Check the nameplate to confirm the frequency of the alternator.
2. Check that the jumper link or rotary switch selection (depending on AVR type) matches the alternator frequency.
3. Set the **AVR [UFRO]** control to 100%, the fully clockwise position.

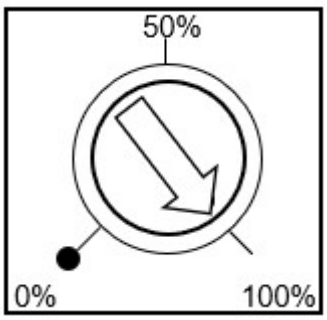



**FIGURE 28. AVR [URFO] CONTROL POTENTIOMETER 100%**

4. Start the alternator and set at the correct operating speed.
5. Verify that the alternator voltage is correct and stable.

| NOTICE |
| --- |
| **If the voltage is high / low / unstable, use method described in; Section 10.9.1 on page 103 or Section 10.9.3 on page 105 before proceeding.** |

6. Reduce the alternator speed to approximately 95% of correct operating speed. i.e. 47.5 Hz for 50 Hz operation, 57.0 Hz for 60 Hz operation.
7. Adjust the **AVR [UFRO]** control slowly counter-clockwise until the AVR LED lights.

**FIGURE 29. LED ILLUMINATED**

8. Adjust the **AVR [UFRO]** control slowly clockwise until the AVR LED is just OFF.

**FIGURE 30. LED EXTINGUISHED**

| NOTICE |
| --- |
| **Do not go past the point at which the LED is just OFF.** |

9. Adjust the alternator speed back to 100% nominal. The LED should be off.

**FIGURE 31. LED EXTINGUISHED**

The **AVR [UFRO]** control is now set.

## 10.9.3 Adjust the AVR [STAB] Stability Control

1. Check the nameplate to confirm the power rating of the alternator.
2. Check that the jumper link or rotary switch selection (depending on AVR type) matches the alternator power rating for optimal stability response.
3. Set the **AVR [STAB]** control to approximately 75% position.

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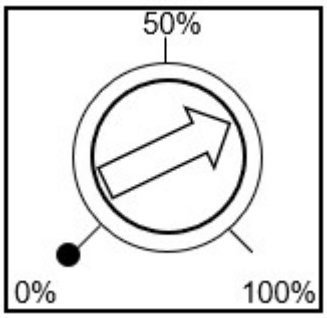


**FIGURE 32. AVR [STAB] CONTROL POTENTIOMETER 75%**

4. Start the alternator and set at the correct operating speed.
5. Verify that the alternator voltage is within safe limits.

| *NOTICE* |
| --- |
| **If the voltage is unstable, refer to; Section 10.9.1 on page 103 immediately.** |

6. Adjust the **AVR [STAB]** control slowly counter-clockwise until the output voltage becomes unstable.
7. Adjust the **AVR [STAB]** control slowly clockwise until the voltage is stable.
8. Adjust the **AVR [STAB]** control a further 5% clockwise.

| *NOTICE* |
| --- |
| **Readjust the voltage level if necessary, refer to; Section 10.9.1 on page 103.** |

The **AVR [STAB]** control is now set.

## 10.9.4 Adjust the AVR [DROOP] Voltage Droop Control for Parallel Operation (If CT is fitted)

A correctly fitted and adjusted droop current transformer (CT) allows the alternator to share reactive current for stable parallel operation.

1. Mount the Droop CT to the correct phase lead of the main output windings of the alternator.
2. Connect the two secondary leads marked S1 and S2 from the CT to the terminals S1 and S2 of the AVR.
3. Turn the **AVR [DROOP]** control to the midway position.
4. Start the alternator(s) and set at the correct operating speed and voltage.
5. Parallel the alternator(s) according to installation rules and procedures.
6. Set the **AVR [DROOP]** control to produce the required balance between individual alternator output currents. Set the AVR droop off-load and then check the currents when the output load is applied, on-load.
7. If the individual alternator output currents rise (or fall) in an uncontrolled way, isolate and stop the alternators then check that:
   - The droop transformer is fitted to the correct phase and in the correct polarity (see the machine wiring diagrams).
   - The droop transformer secondary S1 and S2 leads are connected to the AVR terminals S1 and S2.
   - The droop transformer is the correct rating.

## 10.9.5 Connect and Set the Remote Hand Trimmer

A remote hand trimmer is fitted to provide a convenient means of fine voltage adjustment (typically +/- 10% voltage) and can be useful in installations where multiple alternators are operated in parallel.

1. Mount the remote hand trimmer in the required physical location on the generator set.
2. Connect the remote hand trimmer as shown on the alternator wiring diagram (usually to AVR terminals 1 and 2). Check that clockwise rotation results in a reduction of the resistance across terminals 1 and 2.
3. Set the remote hand trimmer to the midway position.
4. Start the alternator(s) and set at the correct operating speed and voltage on the AVR voltage control.
5. Rotate the remote hand trimmer slowly counter-clockwise and clockwise to check the alternator output range.
6. If the operation of the trimmer is reversed then correct the wiring on the rear of the hand trimmer. Do not reverse the wiring to AVR terminals 1 and 2 (see step 2 above).

## 10.9.6 Measure and Verify the Residual Voltage (self-excited machines only)

Residual, or remanence, voltage is the small voltage produced by the alternator when the exciter field current is zero and the alternator is running at rated speed (while disconnected from any external load or supply).

1. Disconnect the exciter field leads F1 and F2 from the AVR and protect them during removal and handling.
2. Make sure there are no loads or external supplies connected to the alternator terminals.
3. Start the alternator and set at the correct operating speed.
4. Measure the voltage appearing at AVR input terminals 7 and 8 (or V and U). For AVRs SX460*, AS540* AS480* and AS440*, this voltage should be 6 VAC minimum.[4]
5. For DM730 and DM740 AVR types, this residual voltage value should be a minimum of 4 VAC.
6. If the measured voltage is below the minimum value, restore the residual voltage, as described in; **Section 10.9.21 on page 115**.

## 10.9.7 Measure and Verify the AVR Sensing Voltage

The AVR sensing voltage is a fixed proportion of the main output voltage of the alternator and is used by the AVR for voltage control. If the sensing voltage is not a good, stable representation of the output then the AVR will not control the output correctly.

The sensing voltage appearing at AVR terminals 6 (MX321™ only), 7 and 8 and can be measured safely at residual voltage levels.

1. Disconnect the exciter field leads F1 and F2 from the AVR and protect them during removal and handling.
2. Make sure there are no loads or external supplies connected to the alternator terminals.
3. Start the alternator and set at the correct operating speed.
4. Measure the voltage between pairs of AVR input terminals 7 and 8 ($V_{r78}$ for 1 phase sensing) or 6,7 and 8 ($V_{r67}$, $V_{r78}$, $V_{r86}$ for 3 phase sensing), according to AVR model.
5. Measure the continuity of fuse (if fitted), between sensing leads 6, 7 and 8, and the voltage sensing transformer assembly.
6. Ensure replacement fuse rating is correct and install fuses as necessary.
7. Measure voltage sensing transformer primary winding continuity.

[4] * Includes Underwriter's Laboratories (UL) derivatives i.e. SX460UL, AS480UL and AS440UL.

 

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8. Replace voltage sensing transformer, if required.

| NOTICE |
| --- |
| **The subscript 'r' indicates that the reading is measured with the alternator running without excitation, i.e. residual levels.** |

## 10.9.8 Measure and Verify the PMG Output Voltage

For correct AVR operation, the output of the PMG must be within specified voltage limits. If the PMG voltage is too low or too high, then the AVR may not control the alternator output correctly.

1. Disconnect the three PMG output leads (P2, P3 and P4) from the AVR input connections.
2. Connect a multimeter safely to the PMG output leads.
3. Start the alternator and run at the correct operating speed.
4. Measure the voltage between pairs of PMG output leads P2, P3 & P4 ($V_{P2P3}$, $V_{P3P4}$, $V_{P4P2}$).

For correct operation, the PMG output voltages should all be within the following table:

**TABLE 30. PMG PAIR VOLTAGE RANGE**

| Lower Limit (Volts) | PMG pairs | Upper limit (Volts) | Frequency (Hz) |
| --- | --- | --- | --- |
| 170 | $V_{p2p3}$ | 185 | 50 |
| 170 | $V_{p3p4}$ | 185 | 50 |
| 170 | $V_{p4p2}$ | 185 | 50 |
| 200 | $V_{p2p3}$ | 220 | 60 |
| 200 | $V_{p3p4}$ | 220 | 60 |
| 200 | $V_{p4p2}$ | 220 | 60 |

## 10.9.9 Check the Rotating Rectifier Diodes

1. Disconnect the lead of one diode where it joins the windings at the insulated terminal post, using a solder gun and wick or by removing the fastener (Use applicable method). Store fastener and washers.
2. Measure the voltage drop across the diode in the forward direction, using the diode test function of a multimeter.

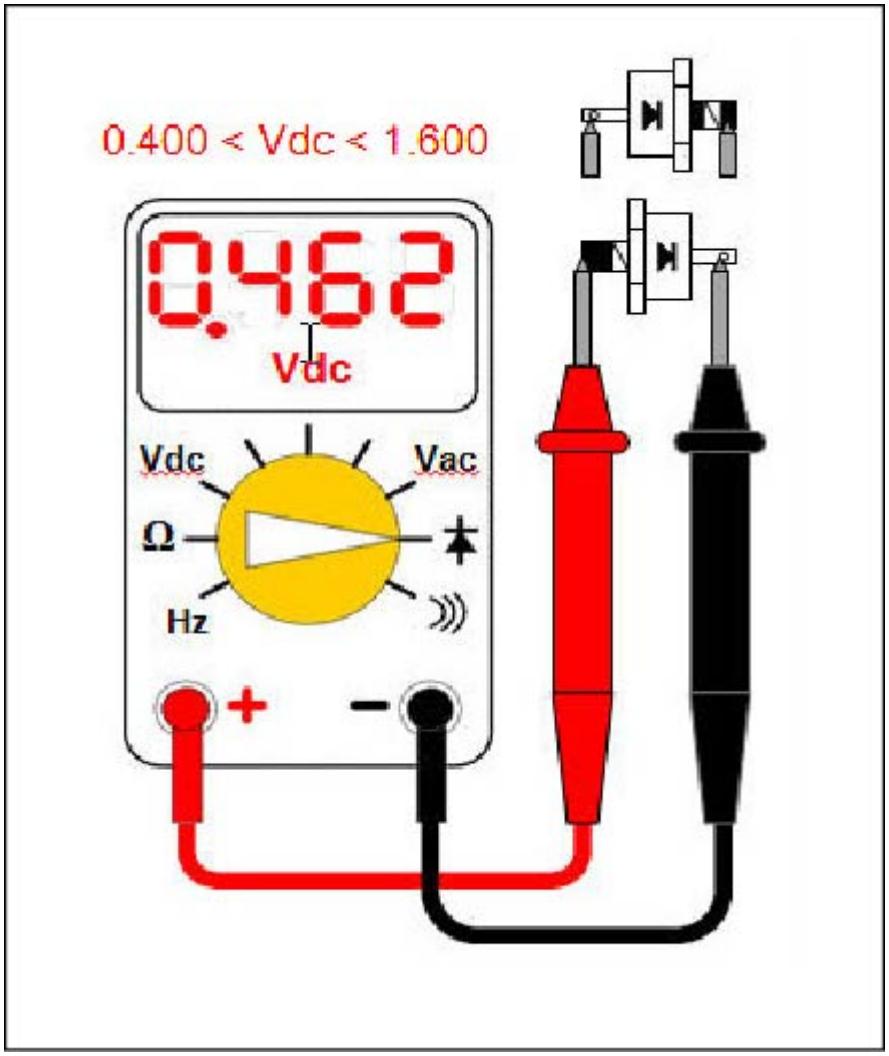


**FIGURE 33. DIODE VOLTAGE DROP MEASUREMENT**

3. Measure the resistance across the diode in the reverse direction, using the diode test function of a multimeter.

 

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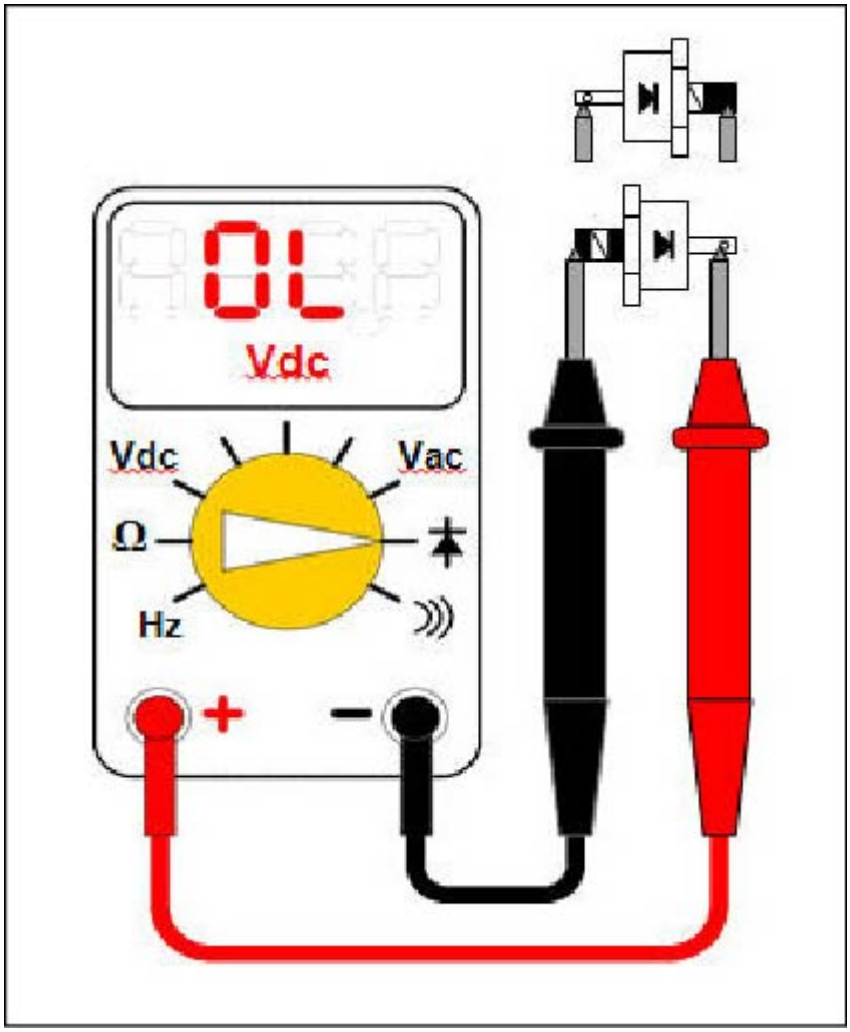


**FIGURE 34. DIODE RESISTANCE MEASUREMENT**

4. The diode is faulty if the voltage drop in the forward direction is outside the range 0.4 to 1.6 V, or if the resistance is below 20 MΩ in the reverse direction.
5. Repeat the previous steps for the five remaining diodes.
6. If any diode is faulty, replace the full set of six diodes (same type, same manufacturer) as follows:
    a. Remove the original diodes.
    b. Apply a small amount of heat sink compound **only** to the base of the replacement diodes, not the threads.
    c. Check polarity of the replacement diodes.
    d. Screw each replacement diode into a threaded hole in the rectifier plate.
    e. Tighten each diode to the torque specified in the alternator manual, to give good mechanical, electrical and thermal contact.
    f. Replace the single varistor (As applicable) or both varistors with a new matched pair (same type, same manufacturer and same voltage grading: A, B, C, D, E, F)
7. Using the appropriate method, reconnect and check that all leads are secure, washers fitted and fasteners tight.

## 10.9.10 Check the Rotating Rectifier Varistor(s)

1. Inspect the single or both varistors (As Applicable).

2. A varistor is faulty if there are signs of overheating (discolouration, blisters, melting) or disintegration.
3. Disconnect one varistor lead. Store fastener and washers.
4. Measure the resistance across each varistor. Good varistors have a resistance greater than 100 MΩ.
5. A varistor is faulty if the resistance is short circuit or open circuit in either direction.
6. If a varistor is faulty, replace the single varistor (As applicable) or both varistors with a matched pair (same type, same manufacturer and same voltage grading: A, B, C, D, E, F) and replace all diodes.
7. Reconnect and check that all leads are secure, washers fitted and fasteners tight.

## 10.9.11 Measure and Verify the Exciter Stator Resistance

1. Stop the alternator.
2. Disconnect the exciter field leads F1 (X+) and F2 (XX-) from the AVR.
3. Measure the electrical resistance between F1 and F2 leads with a multimeter.
4. Refer to the Technical Data **Chapter 13 on page 123** for specified values at 22 °C.
5. Reconnect the exciter field leads F1 and F2.
6. Record your measurement in a copy of the fault finding record **Chapter 11 on page 117**.
7. Replace the exciter stator if the measured resistance is out of specification.

## 10.9.12 Measure and Verify the Exciter Rotor Resistance

1. Stop the alternator.
2. Mark the leads attached to diodes on one of the two rectifier plates.
3. Disconnect all exciter rotor leads from all diodes at the rectifier.
4. Measure the electrical resistance between pairs of marked leads (between phase windings). A specialist micro ohmmeter must be used.
5. Refer to Technical Data **Chapter 13 on page 123** for specified values at 22 °C.
6. Reconnect all exciter rotor leads to the diodes.
7. Record your measurements in a copy of the fault finding record **Chapter 11 on page 117**.
8. Replace the full rotor/alternator if the measured resistance is out of specification.

## 10.9.13 Measure and Verify the Main Rotor Resistance

1. Stop the alternator.
2. Disconnect the two main rotor DC leads from the rectifier plates.
3. Measure the electrical resistance between the main rotor leads. A specialist micro ohmmeter must be used.
4. Refer to Technical Data **Chapter 13 on page 123** for specified values at 22 °C.
5. Reconnect the two main rotor DC leads to the rectifier plates.
6. Make sure the fasteners are secure.
7. Record your measurement in a copy of the fault finding record **Chapter 11 on page 117**.
8. Replace the full rotor/alternator if the measured resistance is out of specification

## 10.9.14 Measure and Verify the Main Stator Resistance

1. Stop the alternator.

 

2. Disconnect the leads of the main stator from the output terminals.
3. Measure and record the electrical resistance between U1 and U2 leads and between U5 and U6 (if present). A specialist micro ohmmeter must be used.
4. Measure and record the electrical resistance between V1 and V2 leads and between V5 and V6 (if present). A specialist micro ohmmeter must be used.
5. Measure and record the electrical resistance between W1 and W2 leads and between W5 and W6 (if present). A specialist micro ohmmeter must be used
6. Refer to Technical Data **Chapter 13 on page 123** for specified values at 22 °C.
7. Reconnect the leads to the output terminals, as before.
8. Make sure the fasteners are secure
9. Record your measurements in a copy of the fault finding record **Chapter 11 on page 117**.
10. Replace the stator with frame/alternator if the measured resistance is out of specification.

## 10.9.15 Measure and Verify the PMG Stator Resistance

1. Stop the alternator.
2. Disconnect the three PMG output leads P2, P3 and P4 from the AVR.
3. Measure the electrical resistance between pairs of the PMG output leads, with a multimeter.
4. The resistance phase-to-phase should be between approximately 2.5 Ω and 6 Ω at 22 °C. Refer to Technical Data **Chapter 13 on page 123** for specific values.
5. Reconnect the three PMG output leads P2, P3 and P4 to the AVR.
6. Make sure the fasteners are secure.
7. Record your measurements in a copy of the fault finding record **Chapter 11 on page 117**.

## 10.9.16 Measure and Verify the Exciter Stator Insulation Resistance

**TABLE 31. TEST VOLTAGE AND MINIMUM ACCEPTABLE INSULATION RESISTANCE FOR NEW AND IN-SERVICE ALTERNATORS**

| | Test Voltage (V) | Minimum Insulation Resistance at 1 minute (MΩ) | |
|---|---|---|---|
| | | New | In-service |
| **Exciter stator** | 500 | 10 | 5 |

1. Inspect the windings for mechanical damage or discolouration from overheating. Clean the insulation if there is hygroscopic dust and dirt contamination.
2. Connect together both ends of the winding (if possible).
3. Apply the test voltage from the table between the winding and earth.
4. Measure the insulation resistance after 1 minute ($IR_{1min}$).
5. Discharge the test voltage to earth for five minutes.
6. If the measured insulation resistance is less than the minimum acceptable value, dry the insulation, then repeat the method.
7. Repeat the method for each winding.
8. Remove the connections made for testing.
9. Record your measurements in a copy of the fault finding record **Chapter 11 on page 117**.

## 10.9.17 Measure and Verify the Exciter Rotor Insulation Resistance

**TABLE 32. TEST VOLTAGE AND MINIMUM ACCEPTABLE INSULATION RESISTANCE FOR NEW AND IN-SERVICE ALTERNATORS**

| | Test Voltage (V) | Minimum Insulation Resistance at 1 minute (MΩ) | |
|---|---|---|---|
| | | New | In-service |
| **Exciter rotor** | 500 | 10 | 5 |

1. Inspect the windings for mechanical damage or discolouration from overheating. Clean the insulation if there is hygroscopic dust and dirt contamination.
2. Connect together the three leads of all phase windings (if possible).
3. Apply the test voltage from the table between the winding and earth.
4. Measure the insulation resistance after 1 minute ($IR_{1min}$).
5. Discharge the test voltage to earth for five minutes.
6. If the measured insulation resistance is less than the minimum acceptable value, dry the insulation, then repeat the method.
7. Remove the connections made for testing.
8. Record your measurement in a copy of the fault finding record **Chapter 11 on page 117**.

## 10.9.18 Measure and Verify the Main Rotor Insulation Resistance

**TABLE 33. TEST VOLTAGE AND MINIMUM ACCEPTABLE INSULATION RESISTANCE FOR NEW AND IN-SERVICE ALTERNATORS**

| | Test Voltage (V) | Minimum Insulation Resistance at 1 minute (MΩ) | |
|---|---|---|---|
| | | New | In-service |
| **Exciter rotor, rectifier & main rotor combined** | 500 | 10 | 5 |

1. Inspect the windings for mechanical damage or discolouration from overheating. Clean the insulation if there is hygroscopic dust and dirt contamination.
2. Connect together both ends of the winding (if possible).
3. Apply the test voltage from the table between the winding and earth.
4. Measure the insulation resistance after 1 minute ($IR_{1min}$).
5. Discharge the test voltage to earth for five minutes.
6. If the measured insulation resistance is less than the minimum acceptable value, dry the insulation, then repeat the method.
7. Remove the connections made for testing.
8. Record your measurement in a copy of the fault finding record **Chapter 11 on page 117**.

 

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## 10.9.19 Measure and Verify the Main Stator Insulation Resistance

**TABLE 34. TEST VOLTAGE AND MINIMUM ACCEPTABLE INSULATION RESISTANCE FOR NEW AND IN-SERVICE ALTERNATORS**

| | Test Voltage (V) | Minimum Insulation Resistance at 1 minute (MΩ) | |
|---|---|---|---|
| | | New | In-service |
| **Main stator** | 500 | 10 | 5 |

1. Inspect the windings for mechanical damage or discolouration from overheating. Clean the insulation if there is hygroscopic dust and dirt contamination.
2. Disconnect the neutral to earth conductor (if fitted).
3. Disconnect and ground the auxiliary winding (if fitted).
4. Connect together the three leads of all phase windings (if possible).
5. Apply the test voltage from the table between any phase lead and earth.
6. Measure the insulation resistance after 1 minute ($IR_{1min}$).
7. Discharge the test voltage to earth for five minutes.
8. If the measured insulation resistance is less than the minimum acceptable value, dry the insulation, then repeat the method.
9. Reconnect neutral to earth conductor (if fitted).
10. Reconnect the auxiliary winding (if fitted).
11. Record your measurement in a copy of the fault finding record **Chapter 11 on page 117**.

## 10.9.20 Measure and Verify the PMG Stator Insulation Resistance

**TABLE 35. TEST VOLTAGE AND MINIMUM ACCEPTABLE INSULATION RESISTANCE FOR NEW AND IN-SERVICE ALTERNATORS**

| | Test Voltage (V) | Minimum Insulation Resistance at 1 minute (MΩ) | |
|---|---|---|---|
| | | New | In-service |
| **PMG stator** | 500 | 5 | 3 |

1. Inspect the windings for mechanical damage or discolouration from overheating. Clean the insulation if there is hygroscopic dust and dirt contamination.
2. Connect together the three leads of all phase windings (if possible).
3. Apply the test voltage from the table between the winding and earth.
4. Measure the insulation resistance after 1 minute ($IR_{1min}$).
5. Discharge the test voltage to earth for five minutes.
6. If the measured insulation resistance is less than the minimum acceptable value, dry the insulation, then repeat the method.
7. Repeat the method for each winding.
8. Remove the connections made for testing.
9. Record your measurement in a copy of the fault finding record **Chapter 11 on page 117**.

# 10.9.21 Restore the Residual Voltage

**⚠ DANGER**

***Live Electrical Conductors***

***Live electrical conductors at output, AVR, AVR accessory terminals, and AVR heat sink can cause serious injury or death by electric shock and burns.***

- ***To prevent injury, take suitable precautions to prevent contact with live conductors, such as using insulation, barriers and insulated tools and use suitable personal protective equipment, refer to; Safety Precaution Chapter.***

**⚠ DANGER**

***Battery Short Circuit***

***Sudden discharge of battery energy by short circuit can cause serious injury or death by electric shock and burns. To prevent injury:***

- ***Fit a 5 A fuse in circuit.***
- ***Use insulated leads and tools.***

**⚠ CAUTION**

***Hazardous Substances***

***Contact with hazardous substances such as; oils, grease, lubricants, fuel, adhesive, desiccants (drying agents), battery acid, cleaning agents, solvent or corrosive substances, paint, polyester resin and/or plastic residues can cause minor or moderate injury by contact/inhalation. Prolonged/repetitive exposure may lead to more serious medical conditions developing. To prevent injury:***

- ***Always read and comply with the information provided by the product manufacturer, use, handle and store substances accordingly.***
- ***Always wear appropriate personal protection equipment, as per product manufacturer information and the Safety Precaution Chapter.***

***NOTICE***

**Risk of permanent damage to the AVR. AVR will be destroyed if a battery is connected with incorrect polarity or without a diode of correct polarity in the circuit. Follow the sequence below carefully and check battery polarity before connecting to the AVR.**

The laminated steel core of the exciter stator retains a residual, or remanence, magnetism. Residual voltage, generated by the exciter rotor turning in this magnetic field, powers the AVR during alternator start-up. A minimum level of residual voltage is necessary for correct operation of an AVR without a PMG. Residual magnetism can be lost if

- The laminated core sustains a mechanical shock
- The exciter stator winding is replaced (rewound)
- Magnetism has decayed during storage for many years
- The residual magnetism is reversed by incorrect use of this procedure.

Restore lost, or weak, residual magnetism as follows:

 

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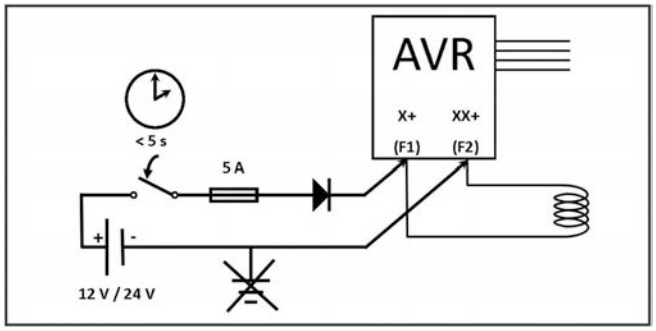
**FIGURE 35. TEMPORARY CIRCUIT TO RESTORE RESIDUAL VOLTAGE**




1. Securely place a fully-charged 12 VDC or 24 VDC lead-acid vehicle battery, near the alternator. The generator set starter battery can be used **only** if it is **completely** disconnected (including earth connection) after the engine is started.
2. Connect the temporary circuit shown in the figure above. A spare rectifier diode can be used but must be of the correct polarity. Use the diode test function of a multimeter, show in; **Section 10.9.9 on page 108** to identify the polarity of a diode.
3. Disconnect the output load from the alternator.
4. Run the alternator at rated speed off-load.
5. Close the switch for 5 seconds maximum to restore the residual magnetism.
6. Stop the alternator and remove the complete temporary circuit.
7. Run the alternator at rated speed off-load.
8. Measure the main terminal output voltage:
   - If alternator output builds to the rated voltage, the residual voltage has been restored.
   - If the alternator **does not** build to rated voltage, replace the faulty AVR. Repeat this procedure from step 1.
9. If this procedure has not restored the residual voltage, seek guidance from Cummins Generator Technologies Customer Service Department. For details of your nearest service outlet visit **www.stamford-avk.com**.

# 11 Fault Finding Record

| S7 Fault Finding Record | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Alternator Model** | | | | **Serial Number** | | | | **Running Time** | | hours | | |
| **Alternator Voltage, $V_G$ (VAC)** | 208 | 220 | 230 | 240 | 380 | 400 | | | | | | |
| | 415 | 440 | 480 | 600 | 690 | Other | | | | | | |
| **AVR Model** | MX341 | MX322™ | DECS 150 | UNITROL 1010 | | | | | | | | |
| | DM110 | | | | Other | | | | | | | |
| **Stator Connection** | Series-Star | Parallel-Star | Series-Delta | Single-Phase | Other | | | | | | | |
| **Fault Symptoms and Observations** | | | | | | | | | | | | |
| **Measurements** | **Residual Voltage, $V_A$ (VAC)** | $V_{rUV}$ = | $V_{rVW}$ = | $V_{rWU}$ = | $V_A = (V_{rUV} + V_{rVW} + V_{rWU})/3$ = | | | | | | | |
| | **AVR Power Input** | | | | | | **AVR Sensing** | | | | | |
| | **AVR Model** | **Terminals** | **Power Input Voltage (VAC)** | | | **Requirement (VAC)** | **Terminals** | **Sensing Voltage (VAC)** | | | | |
| | MX341 | P2<br>P3<br>P4 | $V_{P2P3}$ =<br>$V_{P3P4}$ =<br>$V_{P4P2}$ = | | | $170 < V_{P2P3} < 220$<br>$170 < V_{P3P4} < 220$<br>$170 < V_{P4P2} < 220$ | 2<br>3 | $V_B = V_{r23}$ = | | | | |
| | MX322™ | P2<br>P3<br>P4 | $V_{P2P3}$ =<br>$V_{P3P4}$ =<br>$V_{P4P2}$ = | | | $170 < V_{P2P3} < 220$<br>$170 < V_{P3P4} < 220$<br>$170 < V_{P4P2} < 220$ | 6<br>7<br>8 | $V_{r67}$ = | $V_{r78}$ = | $V_{r86}$ = | | |
| | | | | | | | | $V_B$ = $(V_{r67} + V_{r78} + V_{r86})/3$ = | | | | |
| | Other AVRs: Refer to CGT | | | | | | | | | | | |
| **Calculations** | **AVR Sensing Voltage, $V_{Sen}$ from measurements taken (VAC)** | | | | | **Requirement (VAC)** | | | | | | |
| | $V_{Sen} = V_G \times V_B / V_A$ =<br>Alternator voltage ($V_G$) x Sensing voltage ($V_B$) / Residual Voltage ($V_A$) = | | | | | $190 < V_{Sen} < 240$ | | | | | | |
| | **Exciter Stator** | **Exciter Rotor** | | **Main Rotor** | **Main Stator** | **PMG Stator** | | | | | | |

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| S7 Fault Finding Record | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Resistance (mΩ)** | $R$ = | $R_{UV}$ = | $R_{VW}$ = | $R_{UW}$ = | $R$ = | $R_{U1U2}$ = $R_{U5U6}$ = | $R_{V1V2}$ = $R_{V5V6}$ = | $R_{W1W2}$ = $R_{W5W6}$ = | $R_{P2P3}$ = | $R_{P3P4}$ = | $R_{P2P4}$ = |
| **Insulation Resistance (MΩ)** | $IR$ = | $IR_{UVW}$ = | | | $IR$ = | $IR_{UVW}$ = | | | $IR_{P2P3P4}$ = | | |
| **Engineer's Notes** | | | | | | | | | | | |

***This is an accurate record of observations and measurements completed according to the fault finding method***

| | | | | | |
|---|---|---|---|---|---|
| **Service Engineer** | *signature* | **Name** | *print* | **Date** | *DD/MM/YY* |
| **Owner/ Approver** | *signature* | **Name** | *print* | **Date** | *DDMM/YY* |

# 12 Parts Identification

## 12.1 S7 Single Bearing Alternator

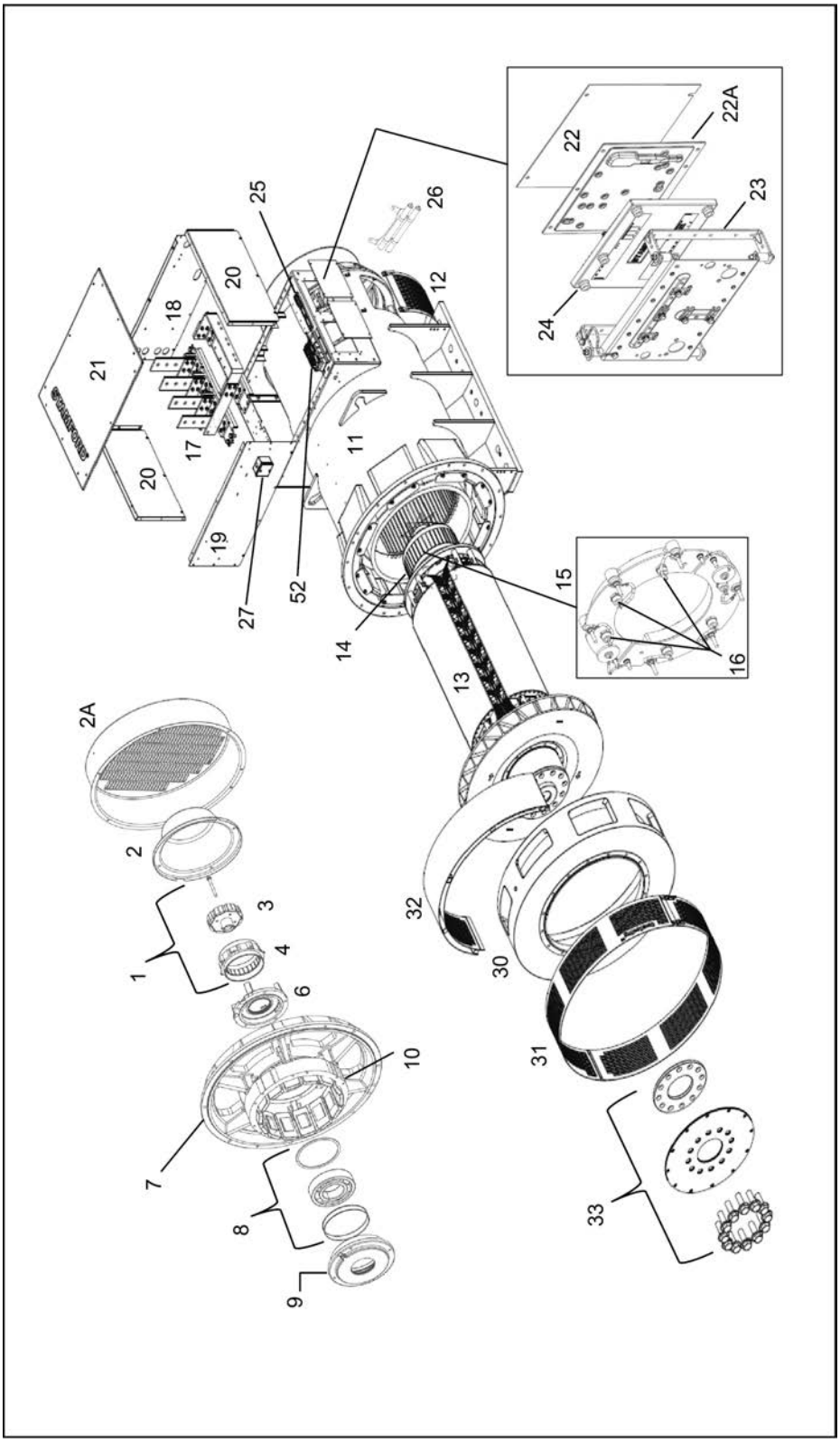


**FIGURE 36. S7 SINGLE BEARING ALTERNATOR**

 

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## 12.2 S7 Two Bearing Alternator

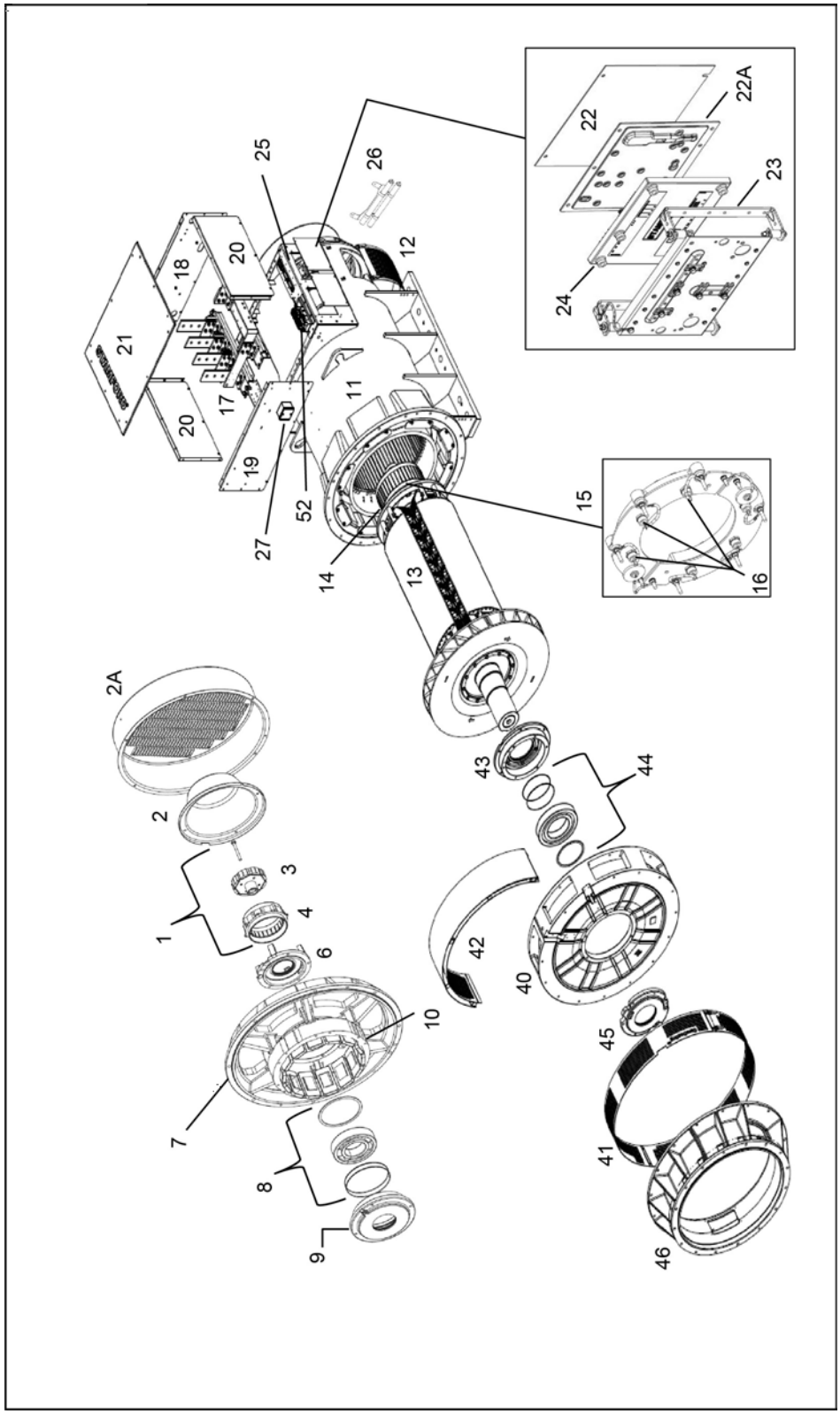


**FIGURE 37. S7 TWO BEARING ALTERNATOR**

# 12.3 S7 Parts and Fasteners

**TABLE 36. S7 PARTS AND FASTENERS**

| Reference | Component | Fastener | Quantity | Torque (Nm) |
|---|---|---|---|---|
| **1** | Complete PMG parts | - | - | - |
| **2/2a** | PMG Cover/Air Inlet Cover | M8 x 16 | 4 | 26 |
| **3** | PMG Rotor | M10 x 100 | 1 | 50 |
| **4** | PMG Stator | M6 x 45 | 4 | 10 |
| **6** | NDE Bearing Cap | M10 x 35<br>M10 x 75 (K core) | 5<br>7 (K core) | 50 |
| **7** | NDE Bracket | M12 x 40 | 8 | 95 |
| **8** | NDE Bearing | - | - | - |
| **9** | NDE Bearing Cartridge | M10 x 60 | 4<br>6 (K core) | 50 |
| **10** | Exciter Stator | M8 x 90<br>M8 x 120 (H&J cores)<br>M8 x 160 (K core) | 6 | 26 |
| **11** | Main Frame | - | - | - |
| **12** | Lower Air Inlet Cover | Split Pin | 4 | - |
| **13** | Main Rotor | - | - | - |
| **14** | Exciter Rotor | - | - | - |
| **15** | Rectifier Assembly | M6 x 100<br>M6 x 120 (H to K cores) | 4 | 10 |
| **16** | Diode/Varistor | - | - | 2.6 - 3.1 |
| **17** | Main Terminals | M12 x 40 | 12 | 40 - 50 |
| **18** | Terminal Box End Panel NDE | M6 x 16 | 10 | 10 |
| **19** | Terminal Box End Panel DE | M6 x 16 | 10 | 10 |
| **20** | Terminal Box Side Panel | M6 x 16 | 10 | 10 |
| **21** | Terminal Box Lid | M6 x 16 | 14 | 10 |
| **22/22a** | AVR Cover Plate/Plastic Cover Plate | M5 x 12 | 4 | 5 |
| **23** | AVR Mounting Bracket | M5 x 12 | 6 | 5 |
| **24** | AVR | M5 x 30 | 6 | 5 |
| **25** | Auxiliary Terminal Board | M6 x 25 | 8 | 10 |
| **26** | Anti-condensation Heaters | M5 x 16 | 2 | 5 |
| **27** | Heater Terminal Box | M5 x 12<br>M5 x 16 | 1<br>1 | 5 |

 

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| Reference | Component | Fastener | Quantity | Torque (Nm) |
|---|---|---|---|---|
| **30** | DE Adapter (1 bearing) | M12 x 50<br>M12 x 70 (foot web) | 12<br>4 | 95 |
| **31** | DE Air Outlet Screen (1 bearing) | Split Pin | 4 | - |
| **32** | Adaptor Top Cover - Marine (1 bearing) | Split Pin | 4 | - |
| **33** | DE Coupling Hub<br>and Coupling Discs (1 bearing) | M24 x 70<br>M30 x 90 (J core) | 12 | 822<br>1350 |
| **40** | DE Bracket (2 bearing) | M12 x 50<br>M12 x 70 (foot web) | 12<br>4 | 95 |
| **41** | DE Air Outlet Screen (2 bearing) | Split Pin | 4 | - |
| **42** | DE Bracket Top Cover - Marine (2 bearing) | Split Pin | 4 | - |
| **43** | DE Bearing Cartridge (2 bearing) | M10 x 55 | 4 | 50 |
| **44** | Complete DE Bearing parts | - | - | - |
| **45** | DE Bearing Cap | M10 x 35 | 5 | 50 |
| **46** | DE Adapter (2 bearing) | M12 x 45 | 16 | 95 |
| **52** | Isolation Transformer | - | - | - |

# 13 Technical Data

**NOTICE**

**Compare measurements with the technical data sheet and the test certificate supplied with the alternator.**

## 13.1 S7 Winding Resistances

**TABLE 37. S7 WINDING RESISTANCES**

| Alternator | Resistance of windings at 22 °C (measured values should be within 10%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Main Stator (lead - lead) (Ohms) | | | | | | Exciter Stator (Ohms) | Exciter Rotor, L-L (Ohms) | Main Rotor (Ohms) | PMG Stator, L-L (Ohms) |
| | 312 U1-U2 V1-V2 W1-W2 | 07 U1-U2 V1-V2 W1-W2 | 13 U1-U2 V1-V2 W1-W2 | 19 U1-U2 V1-V2 W1-W2 | 26 U1-U2 V1-V2 W1-W2 | 28 U1-U2 V1-V2 W1-W2 | | | | |
| **S7L1D-C4** | 0.0012 | 0.0016 | 0.0007 | 0.0027 | 0.0029 | n/a | 22.3 | 0.130 | 1.71 | 3.8 |
| **S7L1D-D4** | 0.0012 | 0.0017 | 0.0008 | 0.0024 | 0.0028 | n/a | 22.3 | 0.130 | 1.82 | 3.8 |
| **S7L1D-E4** | 0.0009 | 0.0013 | 0.0006 | 0.0020 | 0.0026 | n/a | 22.3 | 0.130 | 1.95 | 3.8 |
| **S7L1D-F4** | 0.0009 | 0.0013 | 0.0006 | 0.0027 | 0.0026 | n/a | 22.3 | 0.130 | 1.95 | 3.8 |
| **S7L1D-G4** | 0.0007 | 0.0013 | 0.0005 | 0.0014 | 0.0020 | n/a | 22.3 | 0.130 | 2.15 | 3.8 |
| **S7L1D-H4** | 0.0006 | 0.0010 | 0.0004 | 0.0015 | 0.0016 | n/a | 20.1 | 0.114 | 2.38 | 3.8 |
| **S7L1D-J4** | 0.0006 | n/a | 0.0004 | 0.0015 | 0.0016 | n/a | 20.1 | 0.114 | 1.84 | 3.8 |
| **S7L1D-K4** | 0.0005 | n/a | n/a | 0.0011 | n/a | n/a | 21.3 | 0.128 | 2.00 | 3.8 |

 

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# 14 Service Parts

Servicing and repairing your alternator with Genuine STAMFORD® parts is critical to ensure maximum life and reliability of your product. For further parts information and details of your nearest outlet visit **www.stamford-avk.com**.

## 14.1 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.

## 14.2 Customer Service

CGT service engineers are experienced professionals, trained extensively to deliver the best support possible. Our global service offers:

- On-site a.c. alternator commissioning
- On-site bearing maintenance & bearing condition monitoring
- On-site insulation integrity checks
- On-site AVR & accessories set-up

For details of your nearest service outlet visit **www.stamford-avk.com**.

## 14.3 Recommended Service Parts

In critical applications. If fitted, a set of these service spares should be held with the alternator.

**TABLE 38. S7 SERVICE PARTS**

| Part | Number |
|---|---|
| **Rectifier service kit (3 forward & 3 reverse diodes with varistors)** | RSK-6001 |
| **Rotating rectifier assembly** | 760-11216 |
| **MX322™ AVR** | A062Y338 |
| **MX341 AVR** | E000-23412/1P |
| **DM110 AVR** | E000-23800 |
| **DECS150 AVR** | A060B914 |
| **PMG repair kit** | 45-1082 |
| **Grease 400 gram tube** | 45-0281 |
| **S7 1 Bearing** | |
| **Sealed NDE bearing kit (core length C to J)** | 45-0418 |
| **Regreasable NDE bearing kit (core length C to J)** | 45-0336 |
| **S7 2 Bearing** | |
| **Regreasable DE bearing kit (core length C to F)** | 45-0335 |
| **Regreasable DE bearing kit (core length G to K)** | 45-0425 |

 

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| Part | Number |
|---|---|
| **Regreasable NDE bearing kit (core length C to J)** | 45-0336 |
| **Regreasable NDE bearing kit (core length K)** | 45-0407 |

## 14.4 Klüber Asonic GHY72 Grease

All bearings trials and calculated life expectancy are based on the use of Klüber Asonic GHY72.

# 15 End of Life Disposal

## 15.1 General Guidance

When disposing of an alternator, component parts or packaging:

1. Always process materials in accordance with all locally applicable rules and regulations.
2. Always process waste in an environmentally responsible manner, always reuse, reclaim and / or recycle materials wherever possible.
3. Consult with local specialized waste disposal / processing / recycling companies for assistance / advise in disposing of an alternator, component parts or packaging .

## 15.2 Packaging Material

After the alternator, replacement components or service items have arrived, the packing material must be disposed of.

- Wooden packaging can be recycled. However, wood treated with preservative chemicals must be processed appropriately. **Do not burn chemically treated wood.**
- All plastic packaging can be recycled.
- All paper and cardboard packaging can be recycled.
- Anti-corrosion agents that cover the surface of the alternator can be cleaned using a cleaning agent and a cloth. The cloth is to be disposed as contaminated waste, refer to **Section 15.4 on page 128**.
- Desiccants/drying agents are to be disposed of as hazardous waste, refer to **Section 15.4 on page 128**

## 15.3 Recyclable Material

Separate items containing recyclable base materials, such as; iron, copper and steel, by removing non-recyclable and/or hazardous materials from them such as oils, grease, lubricants, fuel, adhesive, desiccants (drying agents), battery acid, cleaning agents, solvent or corrosive substances, paint, polyester resin, insulation tape or plastics residues from all components.

- Items containing; iron, steel and copper can now be recycled via specialized material recycling companies.
- Separate the removed material in to hazardous waste and non-hazardous waste in accordance with local rules and regulations.
    - Dispose of any hazardous materials as hazardous waste, refer to **Section 15.4 on page 128**.
    - All non-hazardous materials that cannot be reused, re-purposed or recycled can now be processed as general waste.

 

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# 15.4 Hazardous or Contaminated Waste

**⚠ CAUTION**

***Hazardous Substances***

***Contact with hazardous substances such as; oils, grease, lubricants, fuel, adhesive, desiccants (drying agents), battery acid, cleaning agents, solvent or corrosive substances, paint, polyester resin and/or plastic residues can cause minor or moderate injury by contact/inhalation. Prolonged/repetitive exposure may lead to more serious medical conditions developing. To prevent injury:***

- ***Always read and comply with the information provided by the product manufacturer, use, handle and store substances accordingly.***
- ***Always wear appropriate personal protection equipment, as per product manufacturer information and the Safety Precaution Chapter.***

Waste material such as, but not limited to; oils, grease, lubricants, fuel, adhesive, desiccants (drying agents), battery acid, cleaning agents, solvent or corrosive substances, paint, polyester resin or plastic residues or articles contaminated with such substances may be considered hazardous waste by locally applicable regulations.

- Always handle, store, transport, process and dispose of these types of waste in accordance with locally applicable rules and regulations.
- Consult a specialized waste disposal company for assistance/advise in disposing of hazardous waste or contaminated articles if required.

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