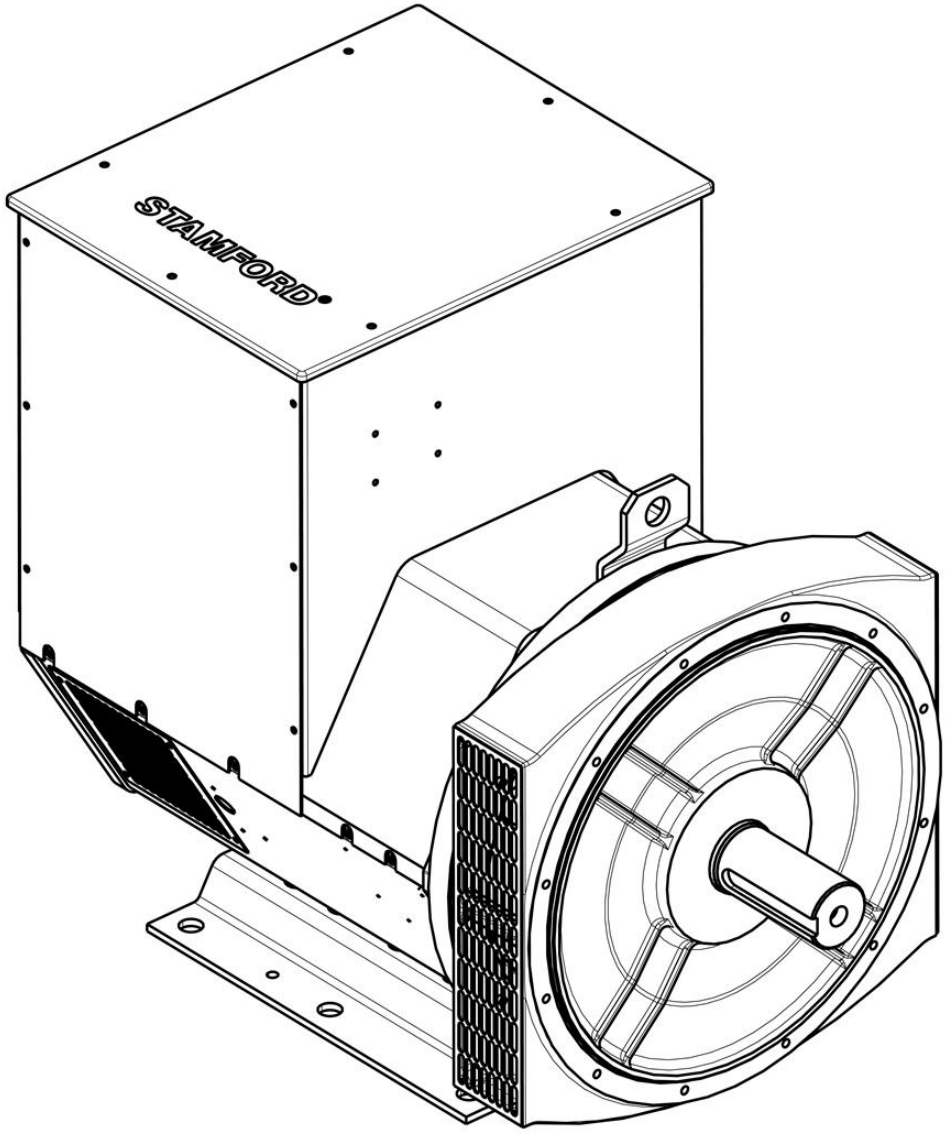
STAMFORD®

UC Alternators

INSTALLATION, SERVICE AND MAINTENANCE MANUAL



English
Original Instructions

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1 Foreword

1.1 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 subsidiary.

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 It may be superseded due to our policy of continuous improvement.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

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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 applicable laws and standards.

2.3 Skill Requirements of Personnel

Service and maintenance procedures must only be carried out by experienced and qualified engineers, who are familiar with the procedures and the equipment.

2.4 Risk Assessment

A risk assessment has been performed on this product by Cummins, however a separate risk assessment must be performed by the user/operating company to establish all 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.

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2.5 Personal Protective Equipment (PPE)

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

Recommended PPE includes:

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

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

2.6 Noise

⚠ WARNING

Noise

Noise from a running alternator can cause serious injury by permanent hearing damage.

To prevent injury, wear appropriate personal protection equipment (PPE).

Maximum A-weighted noise emissions may reach 106 dB(A). Contact the supplier for application-specific details.

2.7 Electrical Equipment

⚠ DANGER

Live Electrical Conductors

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

To prevent injury and before removing covers over electrical conductors, isolate the generator set from all energy sources, remove stored energy and use lock out/tag out safety procedures.

All electrical equipment can be dangerous if not operated correctly. Always install, service and maintain the alternator in accordance with this manual. Work that requires access to electrical conductors must comply with all applicable local and national electrical safety procedures for the voltages involved and any site specific rules. Always use genuine branded replacement parts.

2.8 Lock Out/Tag Out

⚠ 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 and before starting 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.

2.9 Lifting

⚠ 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.**

⚠ WARNING

Falling Mechanical Parts

Falling mechanical parts can cause serious injury or death by impact, crushing, severing or trapping.

To prevent injury and before lifting the alternator:

- **Do not lift the complete generator set by the alternator lifting fixtures.**
- **Keep the alternator horizontal when lifting.**
- **Fit drive end and non-drive end transit fittings to single bearing alternators to keep the main rotor in the frame.**

Do not remove the lifting label attached to one of the lifting points.

2.10 Alternator Operating Areas

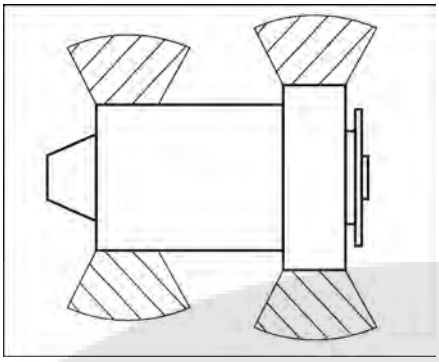
⚠ WARNING

Ejected Debris

Debris ejected during catastrophic failure can cause serious injury or death by impact, severing or stabbing.

To prevent injury:

- **Keep away from the air inlet and air outlet when the alternator is running.**
- **Do not put operator controls near the air inlet and air outlet.**
- **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.**



Always wear suitable PPE when working in the hatched areas shown in the diagram or directly in-line with any air inlet/outlet.

Make sure this consideration is captured in your risk assessment.

2.11 Hazard Warning Labels

⚠ 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.**

The generator set manufacturer is responsible for fitting the self-adhesive hazard warning labels supplied with the alternator.

Replace labels that are missing, damaged or painted over.

3 Safety Directives and Standards

STAMFORD Alternators meet applicable European safety directives, and national and international 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.

3.1 Low Voltage Directive: Declaration of Conformity

TABLE 1. LOW VOLTAGE DIRECTIVE: DECLARATION OF CONFORMITY

2006/95/EC LOW VOLTAGE DIRECTIVE **DECLARATION OF CONFORMITY**	Cummins Generator Technologies
This synchronous A.C. generator is designed for incorporation into an electricity generating-set and fulfils all the relevant provisions of the following EC Directive(s) when installed in accordance with the installation instructions contained in the product documentation:	
2006/95/EC **2004/108/EC**	**Low Voltage Directive** **The Electromagnetic Compatibility (EMC) Directive**
and that the standards and/or technical specifications referenced below have been applied:	
EN 61000-6-2:2005 **EN 61000-6-4:2007+A1:2011** **EN ISO 12100:2010** **EN 60034-1:2010** **BS ISO 8528-3:2005** **BS 5000-3:2006**	**Electromagnetic compatibility (EMC). Generic standards – Part 6-2: Immunity for industrial environments** **Electromagnetic compatibility (EMC). Generic standards – Part 6-4: Emission standard for industrial environments** **Safety of machinery – General principles for design – Risk assessment and risk reduction** **Rotating electrical machines - Part 1: Rating and performance** **Reciprocating internal combustion engine driven alternating current generating sets - Part 3: Alternating current generators for generating sets** **Rotating electrical machines of particular types or for particular applications - Part 3: Generators to be driven by reciprocating internal combustion engines - Requirements for resistance to vibration**
The name and address of authorised representative, authorised to compile the relevant technical documentation, is the Company Secretary, Cummins Generator Technologies Limited, 49/51 Gresham Road, Staines, Middlesex, TW18 2BD, U.K.	
Date: 01st February 2014  **Signed:**	**Name, Title and Address:** **Kevan J Simon** **Global Technical and Quality Director** **Cummins Generator Technologies** **Fountain Court** **Lynch Wood** **Peterborough, UK** **PE2 6FZ**
Description	Serial Number
Registered in England under Registration No. 441273. Cummins Generator Technologies Ltd. Registered Office: Barnack Road, Stamford, Lincolnshire PE9 2NB, England.	
DRAWING REF 450-16383-D	

-

3.2 Machinery Directive: Declaration of Incorporation

TABLE 2. MACHINERY DIRECTIVE: DECLARATION OF INCORPORATION - SHEET 1

2006/42/EC MACHINERY DIRECTIVE

DECLARATION OF INCORPORATION OF PARTLY COMPLETED MACHINERY

Cummins Generator Technologies

Function: Synchronous A.C. generator 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:**

  2004/108/EC The Electromagnetic Compatibility (EMC) Directive

  2006/95/EC Low Voltage 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 Limited, 49/51 Gresham Road, Staines, Middlesex, TW18 2BD, U.K.

The undersigned representing the manufacturer:

Date: 01st February 2014  **Signed:**	**Name, Title and Address:** **Kevan J Simon** **Global Technical and Quality Director** **Cummins Generator Technologies** **Fountain Court** **Lynch Wood** **Peterborough, UK** **PE2 6FZ**
Description	Serial Number

DRAWING REF 450-16388-D

TABLE 3. MACHINERY DIRECTIVE: DECLARATION OF INCORPORATION - SHEET 2

2006/42/EC MACHINERY DIRECTIVE

DECLARATION OF INCORPORATION OF PARTLY COMPLETED MACHINERY

Cummins 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.**

Registered in England under Registration No. 441273.

Cummins Generator Technologies Ltd. Registered Office: Barnack Road, Stamford, Lincolnshire PE9 2NB, England.

DRAWING REF 450-16388-D

3.3 Additional Information for EMC Compliance

STAMFORD alternators are designed to meet EMC 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.

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

NOTICE
Cummins Generator Technologies is not liable for EMC compliance if unauthorized parts, not of STAMFORD brand, are used for maintenance and servicing.

3.4 Additional Information for CSA Compliance

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

4 Introduction

4.1 General Description

The UC22/27 range of alternators is of brushless rotating field design, available up to 690V/50Hz (1500 RPM) or 60Hz (1800 RPM), and built to meet BS5000 Part 3 and international standards.

All the UC22/27 range are self-excited as standard with excitation power derived from the main output windings, using either the SX460 or AS440 AVR. The UC22 is also available with specific windings and a transformer controlled excitation system.

A permanent magnet generator (PMG) powered excitation system is available as an option using either the MX341 or MX321 AVR.

4.2 Alternator Name

TABLE 4. UC ALTERNATOR NAMING FORMAT

Example:	UC	22	-	UC	I	22	4	C	2
	Alternator model (UC22, UC27)			Alternator type (UC = standard, UCG = Grid Code compliant, UCD = dedicated, UC27 only)	Application (I = industrial, M = marine)	Frame size (22, 27)	Number of poles	Core length (A, B, C, ...)	Number of bearings (1 = NDE, 2 = DE & NDE)

4.3 Serial Number Location

A unique serial number is stamped into the drive end ring of the frame.

-

4.4 Rating Plate

⚠ WARNING

Ejected Debris

Debris ejected during catastrophic failure can cause serious injury or death by impact, severing or stabbing.

To prevent injury:

- **Keep away from the air inlet and air outlet when the alternator is running.**
- **Do not put operator controls near the air inlet and air outlet.**
- **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.**

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

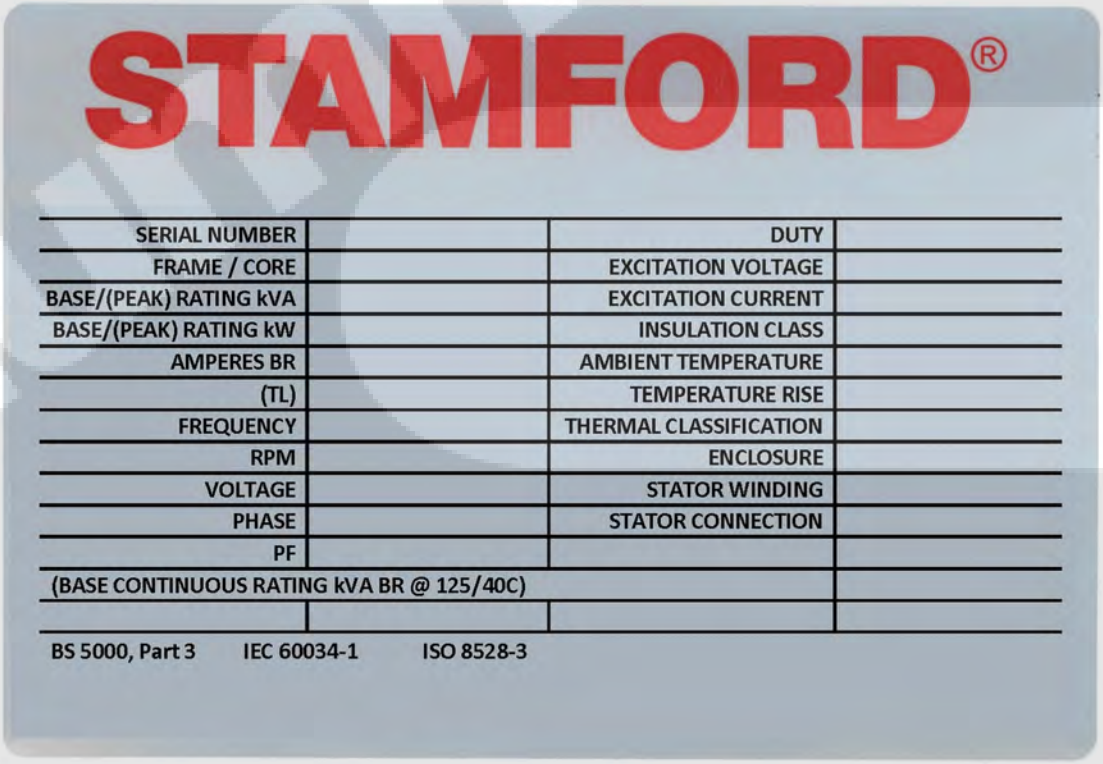


FIGURE 1. GLOBAL STAMFORD AC ALTERNATOR RATING PLATE

4.5 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**.

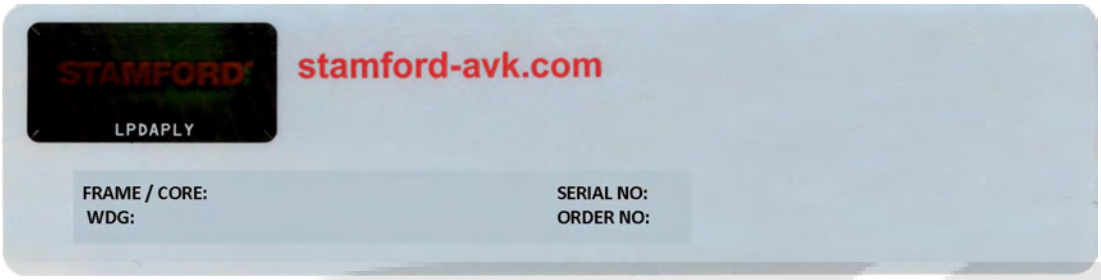


FIGURE 2. TRACKING LABEL

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

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5 Automatic Voltage Regulators (AVR)

Cummins Generator Technologies offer a selection of Automatic Voltage Regulators (AVRs) designed and built to achieve maximum performance from the range of STAMFORD brushless AC alternators. Self-excited and separately-excited types are available, from low-cost analogue to sophisticated digital control. All STAMFORD AVRs are encapsulated to provide environmental protection, and are mounted on anti-vibration mounts for added mechanical protection.

All STAMFORD AVRs have the following features:

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

AVR specification, installation and adjustment information is available in the AVR manual supplied with the alternator, or at **www.cumminsgeneratortechnologies.com**

NOTICE
AVR analogue inputs must be fully floating (galvanically isolated from ground), with an insulation strength of 500 V a.c.

5.1 Self-Excited AVR Controlled Alternators

5.1.1 Main Stator Powered AVR

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 self-excited AVR receives power from the alternator output terminals.

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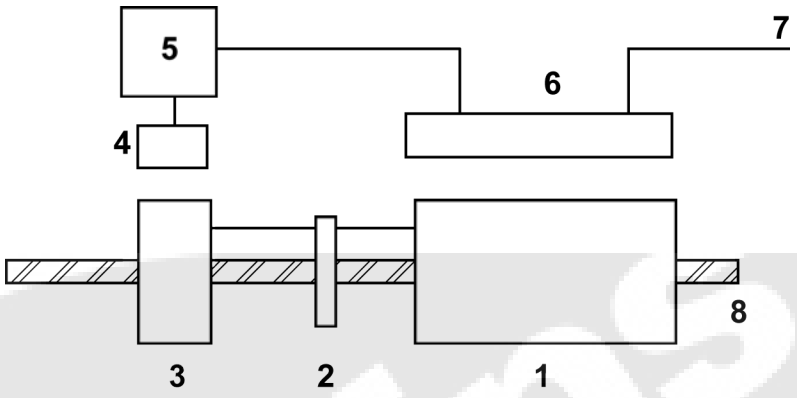


No.	Description	No.	Description
1	Main field (rotor)	5	AVR
2	Rotating diodes	6	Main armature (stator)
3	Exciter armature (rotor)	7	Output
4	Exciter field (stator)	8	Rotor shaft

5.1.2 Transformer-Controlled Alternators

The main stator provides power for excitation of the exciter stator via a transformer rectifier unit. The transformer combines voltage and current elements derived from the main stator output to form the basis of an open-loop control system, which is self regulating in nature. The system inherently compensates for load current magnitude and power factor and provides short circuit maintenance in addition to a good motor starting performance. Three-phase alternators normally have a three-phase transformer control for improved performance with unbalanced loads but a single-phase transformer option is available. No accessories can be provided with this control system.

5.1.3 Self-Excited

A self-excited AVR receives power from the alternator output terminals. The AVR controls the alternator output voltage by automatic adjustment of the exciter stator field strength.

5.1.3.1 SX460

The SX460 achieves voltage regulation of ±1.0%. The design employs surface mount technology, custom moldings and heatsink in a compact assembly.

The AVR includes the following extra features:

- connection of a link for low voltage (110 V to 120 V a.c.) sensing.

5.1.3.2 AS440

The AS440 achieves voltage regulation of ±1.0%. The design employs surface mount technology, custom moldings and heatsink in a compact assembly.

The AVR includes the following extra features:

- connections for excitation power from an auxilliary winding to support legacy alternators
- connections to an analogue signal from a power factor controller accessory for example, and
- 110V a.c. voltage sensing by selectable link accessory.

5.2 Separately-Excited AVR Controlled Alternators

5.2.1 Permanent Magnet Generator (PMG) excited - AVR controlled alternators

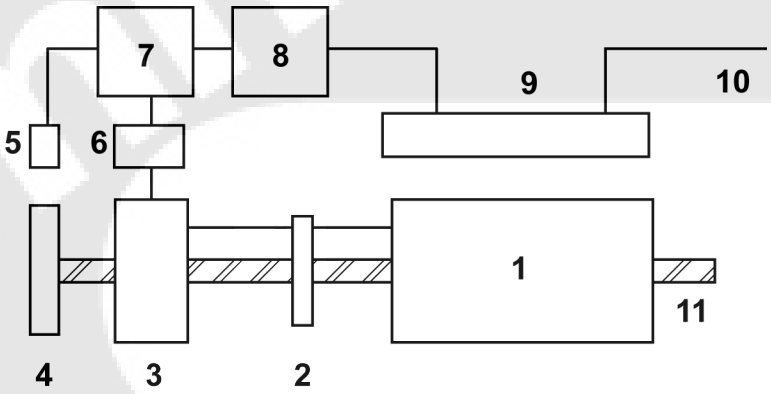
⚠ WARNING

Strong Magnetic Field

The strong magnetic field from a permanent magnet generator (PMG) can cause serious injury or death by interference with implanted medical devices.

To prevent injury, do not work near a PMG 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.



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)		

5.2.2 Separately-excited

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.

5.2.2.1 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.

5.2.2.2 MX321

The MX321 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).

5.3 AVR Accessories

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

5.3.1 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. Refer to wiring diagram before removing the shorting link and connecting the hand trimmer.

5.3.2 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 Technical Specification. 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).

5.3.3 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.

5.3.4 Low Voltage Link/Selector

The AS440 AVR can be configured for low voltage working. For operation between 100Vac and 120Vac fit a shorting link across terminals ‘La’ and ‘Lb’. In low-voltage operating mode the overload performance of the control system is reduced.

5.3.5 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 preset threshold (set on AVR) then the AVR will reduce the terminal voltage to restore the set current level. For unbalanced loads, operation is based on the highest of the three phase currents.

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6 Application of the Alternator

⚠ WARNING

Ejected Debris

Debris ejected during catastrophic failure can cause serious injury or death by impact, severing or stabbing.

To prevent injury:

- **Keep away from the air inlet and air outlet when the alternator is running.**
- **Do not put operator controls near the air inlet and air outlet.**
- **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.**

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

6.1 Environment

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

Ambient Temperature	-15 °C to 40 °C
Relative Humidity	< 70%
Altitude	< 1000 m

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.

6.2 Air Flow

TABLE 5. MINIMUM AIR FLOW AND MAXIMUM PRESSURE DROP

Alternator model and frequency	50 Hz	60 Hz	Maximum intake to outlet pressure drop, mm (in) water gauge
	Minimum Air flow, m^3/s (ft^3/min)		
UC22	0.216 (458)	0.281 (595)	6 (0.25)
UCD22	0.25 (530)	0.31 (657)	6 (0.25)
UC27	0.514 (1090)	0.617 (1308)	6 (0.25)
UCD27	0.58 (1230)	0.69 (1463)	6 (0.25)

Make sure that the air inlets and outlets are not blocked while the alternator is running.

-

6.3 Airborne Contaminants

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.

6.4 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.

6.5 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.

6.6 Anti-condensation Heaters

⚠ DANGER

Live Electrical Conductors

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

To prevent injury and before removing covers over electrical conductors, isolate the generator set from all energy sources, remove stored energy and use lock out/tag out safety procedures.

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.

6.7 Enclosures

Fit an enclosure to protect the alternator from adverse environmental conditions. Make sure that air entering the alternator is of adequate flowrate, free from moisture and contaminants, and below the maximum ambient temperature on the rating plate.

Make sure there is sufficient access around the alternator for safe maintenance.

6.8 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.

6.8.1 Definition of BS5000–3

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

6.8.2 Definition of ISO 8528-9

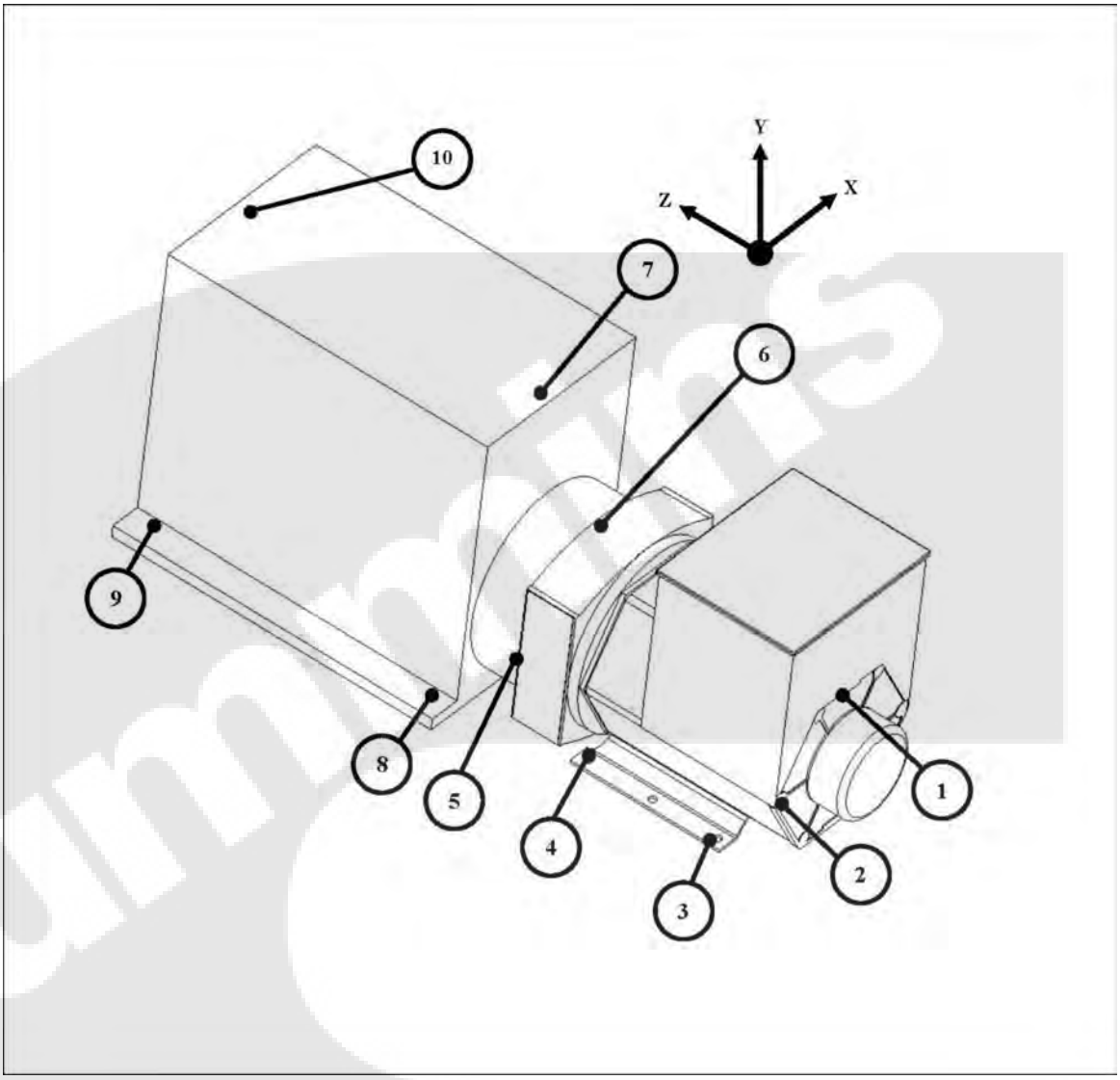
ISO 8528-9 refers to a broad band of frequencies; the broad band is taken to be between 10 Hertz and 1000 Hertz. The table below is an extract from ISO 8528-9 (Table C.1, value 1). This simplified table lists the vibration limits by kVA and speed for acceptable operation of standard generator set designs.

6.8.3 Linear Vibration Limits

Linear Vibration Levels As Measured On The Alternator - UC				
Engine Speed RPM (min^{-1})	Power Output S (kVA)	Vibration Displacement r.m.s. (mm)	Vibration Velocity r.m.s. (mm/s)	Vibration Acceleration r.m.s. (mm/s^2)
1300 ≤ RPM < 2000	10 < S ≤ 50	0.64	40	25
	50 < S ≤ 250	0.4	25	16
	250 < S	0.32	20	13
The broad band is taken as 10 Hz - 1000 Hz				

6.8.4 Linear Vibration Monitoring

We recommend using vibration analyzing equipment to measure vibration at the 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.



6.8.5 Excessive Vibration

⚠ WARNING

Ejected Debris

Debris ejected during catastrophic failure can cause serious injury or death by impact, severing or stabbing.

To prevent injury:

- **Keep away from the air inlet and air outlet when the alternator is running.**
- **Do not put operator controls near the air inlet and air outlet.**
- **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. The generator set manufacturer should change the generator set design to reduce the vibration levels as much as possible.

2. Contact Cummins Generator Technologies to assess the impact on bearing and alternator life expectancy.

6.9 Bearings

6.9.1 Sealed Bearings

Inspect sealed-for-life bearings periodically, according to the recommended service schedule. 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.

6.9.2 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) where the alternator is stationary and subjected to vibration can cause false brinelling wear (flats on the balls and grooves on the races)
- Very humid or wet conditions that cause corrosion and deterioration of the grease by emulsification.

6.9.3 Health Monitoring of the Bearings

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

6.9.4 Bearing 'Service Life' Expectancy

Bearing manufacturers recognise that 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.

UC alternator bearings are sealed for life and are not re-greasable.

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7 Installation into the Generator Set

7.1 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.cumminsgeneratortechnologies.com

7.2 Lifting the Alternator

⚠ WARNING
Falling Mechanical Parts **Falling mechanical parts can cause serious injury or death by impact, crushing, severing or trapping.** **To prevent injury and before lifting the alternator:** • **Do not lift the complete generator set by the alternator lifting fixtures.** • **Keep the alternator horizontal when lifting.** • **Fit drive end and non-drive end transit fittings to single bearing alternators to keep the main rotor in the frame.**

Before coupling, remove the drive end transit arrangement. After coupling, remove the non-drive end transit bar. 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.

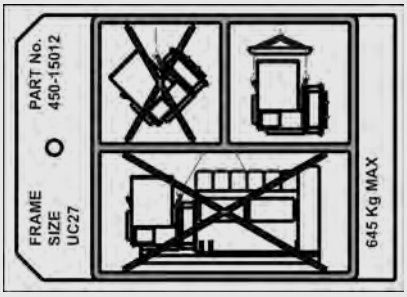


FIGURE 4. LIFTING LABEL

7.3 Storage

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

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

-

7.3.1 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 (see **Chapter 8 on page 37**).

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

TABLE 6.

	Not Rotated during Storage	Rotated during Storage
Sealed Bearing(s)	If stored less than 12 months, put the alternator into service. 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. 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. 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. If stored between 6 and 24 months, re-grease the bearing(s) during the first run then put the alternator into service. If stored more than 24 months, replace the bearing(s) then put the alternator into service.

7.4 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.

7.5 Side Loads

For belt-driven generators, make sure drive end and drive pulleys are aligned to avoid axial load on the bearings. We recommend screw type tensioning devices to allow accurate adjustment of belt tension whilst maintaining pulley alignment.

Belt and pulley guards must be provided by the generator set builder.

Important! Incorrect belt tensioning will result in excessive bearing wear.

2/4-Pole	Side Load		Shaft extension mm
	Kg	N	
UC22	408	4000	110
UC27	510	5000	140

7.6 Generator Set Coupling

7.6.1 Generator Set Coupling

⚠ WARNING

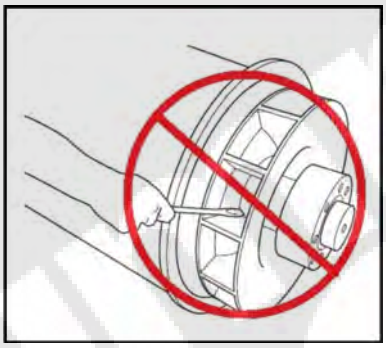
Moving Mechanical Parts

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

To prevent injury, keep arms, hands and fingers away from mating surfaces when coupling the generator set.

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.



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 140 kgm (1000 lbs ft). Check the maximum bending moment of the engine flange with the engine manufacturer.

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.

To prevent movement of the rotor during transport, single bearing alternators without a permanent magnet alternator (PMG) have a non-drive end (NDE) transit bracket fitted. Remove the NDE cover, remove the NDE transit bracket and fasteners, then refit the NDE cover before coupling the generator set.

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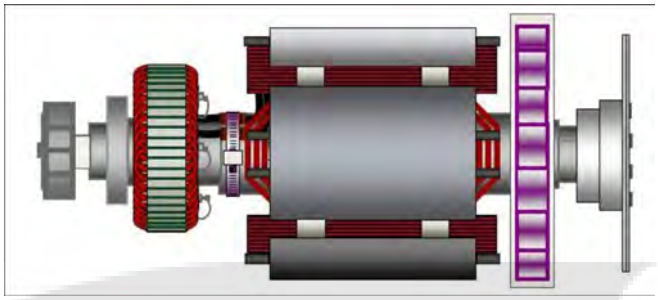


FIGURE 5. SINGLE BEARING ALTERNATOR ROTOR SHOWING COUPLING DISCS BOLTED TO DRIVE END COUPLING HUB (AT RIGHT)

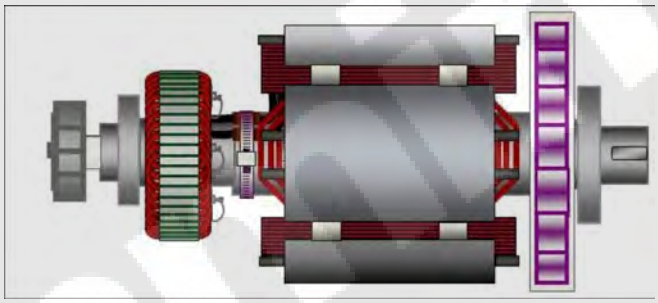


FIGURE 6. TWO BEARING ALTERNATOR ROTOR SHOWING SHAFT WITH KEYWAY FOR FLEXIBLE COUPLING (AT RIGHT)

7.6.2 Single Bearing

7.6.2.1 Single Bearing

⚠ WARNING

Falling Mechanical Parts

Falling mechanical parts can cause serious injury or death by impact, crushing, severing or trapping.

To prevent injury and before lifting the alternator:

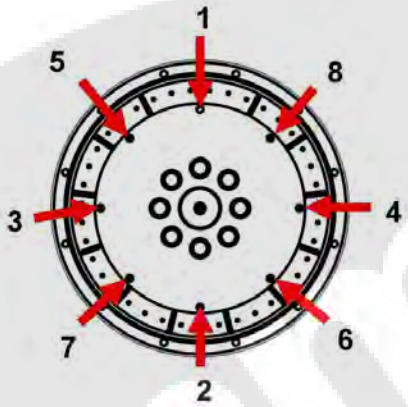
- **Do not lift the complete generator set by the alternator lifting fixtures.**
- **Keep the alternator horizontal when lifting.**
- **Fit drive end and non-drive end transit fittings to single bearing alternators to keep the main rotor in the frame.**

1. Remove the drive end transit bracket that keeps the rotor in place during transport.
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 spigot.
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.

NOTICE

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

7. Fit the adaptor bolts, using heavy gauge washers under the heads. Tighten the adapter bolts evenly around the adapter.
8. 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.
9. Remove the alignment dowels. Fit the coupling bolts, using heavy gauge washers under the heads.



10. Tighten the bolts to fix the coupling disc to the flywheel, in the sequence shown above.
11. Check the torque of each bolt in a clockwise direction around the bolt circle to ensure all the bolts are tight.
12. If a PMG is not fitted, remove the NDE transit bracket.
13. Replace all covers.

7.6.3 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.

7.7 Pre-Running Checks

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

7.8 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, discharge the windings by shorting to earth through an earthing rod for at least 5 minutes.

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.

Alternator Voltage (kV)	Test Voltage (V)	Minimum Insulation Resistance (MΩ)	
		In Service Alternator	New Alternator
Up to 1	500	5	10

You must dry out the alternator windings if the measured insulation resistance is less than the minimum value. See the Service & Maintenance section (**Chapter 8 on page 37**) of this manual.

7.8.1 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, $(IR)_{20}$.

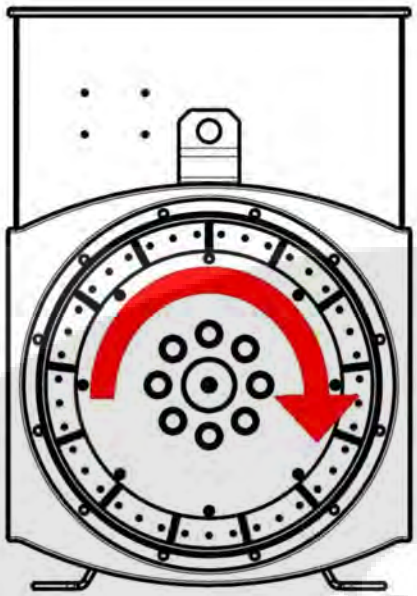
Winding Temperature, T (°C) for measured $(IR)_T$	Equivalent Insulation Resistance at 20°C, $(IR)_{20}$ (MΩ)
20	1 x $(IR)_T$
30	2 x $(IR)_T$
40	4 x $(IR)_T$
50	8 x $(IR)_T$
60	16 x $(IR)_T$
70	32 x $(IR)_T$
80	64 x $(IR)_T$

7.9 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).

7.10 Direction of Rotation

The fan is designed for clockwise rotation, as viewed from the drive end of the alternator (unless otherwise specified when ordered). If the alternator must run counter-clockwise, please seek advice from Cummins Generator Technologies.



7.11 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. Ask Cummins Generator Technologies for a circuit diagram of ‘reverse phase connections’.

7.12 Voltage and Frequency

Check that the voltage and frequency shown on the alternator rating plate meet the requirements of the generator set application.

7.13 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.

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. 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 generator set on its anti-vibration mountings, without causing excessive stress to the cables and alternator load terminals.

7.15 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, include adequate protection into the generation system, usually with surge arrestors and suppressors, to meet regulations and installation requirements.

Surge protection must reduce the peak voltage at the alternator of a transient pulse of 5 µs rise time to less than 1.25 x √2 x (2 x rated output voltage + 1000 V). Best practise is to fit protective devices close to the output terminals. Refer to guidance from professional bodies and specialist equipment suppliers for further advice.

7.16 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.

7.17 Synchronization

⚠ WARNING

Ejected Debris

Debris ejected during catastrophic failure can cause serious injury or death by impact, severing or stabbing.

To prevent injury:

- **Keep away from the air inlet and air outlet when the alternator is running.**
- **Do not put operator controls near the air inlet and air outlet.**
- **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.**

7.17.1 Parallel or Synchronizing Alternators

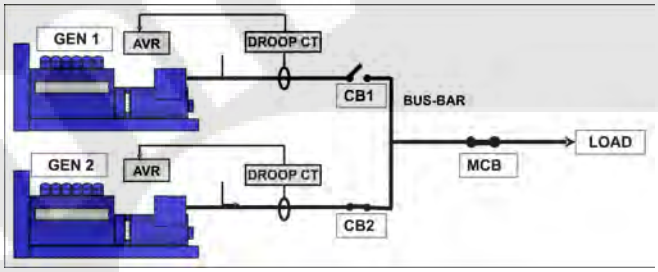


FIGURE 7. PARALLEL OR SYNCHRONIZING ALTERNATORS

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 withstanding the rigorous closing cycles during synchronizing and the currents produced if the alternator is paralleled out of synchronizm.
- The closing time of the synchronizing switch/breaker must be under the control of the synchronizer 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.

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.

-

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

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

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

8 Service and Maintenance

8.1 Recommended Service Schedule

Refer to Safety Precautions section (**Chapter 2 on page 3**) of this manual before starting any service and maintenance activity.

Refer to Parts Identification section (**Chapter 11 on page 89**) 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 Cummins Generator Technologies Customer Service Department,

Telephone: +44 1780 484732,

Email: service-engineers@cumminsgeneratortechnologies.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.

-

TABLE 7. ALTERNATOR SERVICE SCHEDULE

System	SERVICE ACTIVITY	Alternator running	TYPE				SERVICE LEVEL								
	X = required * = if necessary		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
Generator	Generator 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			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								
Bearings	Sealed bearing(s)		X				X	every 4000 to 4500 hours							
	Sealed bearing(s)					X						*		X	
	Temperature sensors	X		X			X	X		X		X		X	
	Customer settings for temperature sensors		X				X								
Terminal Box	All generator/customer connections and cabling		X				X	X		X		X		X	

System	SERVICE ACTIVITY X = required * = if necessary	Alternator running	TYPE Inspect	Test	Clean	Replace	SERVICE LEVEL 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
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			
	Three phase rectifier (if fitted)		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				*		*		*	

8.2 Bearings

8.2.1 Introduction

NOTICE

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).

- Refer to guidelines for bearings in the alternator applications (**Section 6.9 on page 25**) and storage (**Section 7.3**) sections of this manual.

- Inspect each bearing according to the recommended service schedule. Seek advice from CGT if grease has leaked out of the bearing, notifying the bearing type and quantity leaked.
- Replace each bearing according to the recommended service schedule by one of identical type (stamped on the bearing), sourced from the original equipment manufacturer (OEM). Contact CGT for advice if an exact replacement is not available.

8.2.2 Safety

⚠ DANGER

Rotating Mechanical Parts

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

To prevent injury and before removing covers over rotating parts, isolate the generator set from all energy sources, remove stored energy and use lock out/tag out safety procedures.

⚠ WARNING

Hot Surfaces

Skin contact with hot surfaces can cause serious injury by burns.

To prevent injury, wear appropriate personal protection equipment (PPE).

⚠ CAUTION

Grease

Skin contact with grease can cause minor or moderate injury by contact dermatitis.

To prevent injury, wear appropriate personal protection equipment (PPE).

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.

8.2.3 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.

8.2.3.1 Requirements

Sealed bearings

Personal Protective Equipment (PPE)	Wear mandatory site PPE. Wear heat-resistant gloves for handling heated parts.
Consumables	Thin disposable gloves
	Large plastic bags (to store parts)
Parts	NDE bearing
	DE bearing (if fitted)
	CGT recommended anti-fretting paste
	O rings (if fitted)
	Wavy Washer
	Grease Flinger
Tools	Induction heater (with protective sleeve on bar)
	Torque wrench
	Bearing removal tooling (refer to CGT for drawing A6180)
	Rotor support packing
	Hydraulic Cylinder Jack and Pump
	M10 x 120 guide studs x 2

8.2.3.2 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.

PMG, anti-condensation heaters and bearing temperature sensors are alternator options. Ignore references to these items if they are not fitted.

1. Turn off the anti-condensation heater and isolate from supply.
2. Remove the PMG or non-PMG cover.
3. Unplug the PMG control cable.
4. Remove the PMG stator and PMG rotor together as an assembly.
5. Put the PMG assembly into a plastic bag. Seal the bag to protect the parts from debris.
6. Remove the air inlet cover.
7. Disconnect the heater.
8. Disconnect F1 (red) and F2 leads at the AVR, cut cable ties and withdraw the leads to the exciter stator.
9. Remove the lifting bracket from the NDE bracket.
10. Turn the main rotor so that the lowest rotor pole is vertical and will support the rotor weight when the bearing is removed.
11. Loosen the fasteners on the horizontal centreline that secure the terminal box to the main frame.

12. Lift and support the terminal box so that the NDE bracket can be removed.
13. Refix the lifting bracket to the NDE bracket.
14. Fit suitable lifting equipment to the lifting bracket and support the NDE bracket.
15. Remove fasteners from NDE bracket.
16. Tap the NDE bracket with a mallet to release it from the frame.
17. Carefully slide the NDE bracket away from the alternator and set aside. Take care to avoid damaging the attached exciter stator windings on the exciter rotor.
18. Set aside the NDE bracket flat on the floor on wooden bearers, with the exciter stator face up.
19. Disconnect the RTD sensor for bearing temperature.

8.2.3.3 Remove Drive End

1. Remove NDE components first, following **Remove Non-Drive End**.
2. Remove the DE adapter cover.
3. Fit suitable lifting equipment to support the DE adapter.
4. Tap the DE adapter with a mallet to release it from the DE bracket.
5. Remove the DE adapter.
6. Remove the DE air outlet screen and DE louvres.
7. Disconnect the alternator from the prime mover.
8. Disconnect the RTD sensor for bearing temperature (if fitted).
9. Fit suitable lifting equipment to the lifting bracket to support the DE bracket.
10. Remove fasteners from the DE bracket.
11. Tap the DE bracket with a mallet to release it from the DE adapter ring.
12. Lower the DE bracket to put the rotor weight onto the main stator.
13. Carefully slide the DE bracket away from the alternator and set aside.

8.2.3.4 Fit The Bearing

1. Remove the circlip (NDE only).
2. Heat the bearing and use the bearing extraction puller to remove the old bearing from the rotor.
3. Fit the bearing components:
    a. Expand the bearing by heating to 90 to 100 ºC in the induction heater.
    b. Slide the bearing 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. Refit the wavy washer (DE only).
4. Record bearing change on the Service Report.

8.2.3.5 Assemble Drive End

1. Attach suitable lifting equipment to the lifting bracket and 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. Reconnect the RTD sensor (if fitted).
5. Recouple the alternator to the prime mover.
6. Refit the DE air outlet screen and DE louvres.

8.2.3.6 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.

PMG, anti-condensation heaters and bearing temperature sensors are alternator options. Ignore references to these items if they are not fitted.

1. Fit suitable lifting equipment to the lifting bracket and support the NDE bracket and exciter stator assembly.
2. Slide the NDE bracket onto the rotor shaft and locate over the NDE bearing.
3. Lift the NDE bracket a small amount to support the rotor weight.
4. Fix the NDE bracket to the frame.
5. Gently lower and remove the lifting equipment.
6. Turn the rotor by hand to check bearing alignment and free rotation.
7. Refit the PMG rotor and the PMG stator.
8. Reconnect the PMG control cable plug.
9. Reconnect the RTD temperature sensor.
10. Secure the heater and exciter stator leads inside the alternator with heat stabilised cable ties.
11. Secure the leads with cable ties to the main stator leads and reconnect to the AVR.
12. Refit the PMG cover and air inlet cover.
13. Refit the terminal box.
14. Reconnect the supply to the anti-condensation heater.

8.3 Controls

8.3.1 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.

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8.3.2 Safety

⚠ DANGER
Live Electrical Conductors **Live electrical conductors can cause serious injury or death by electric shock and burns.** **To prevent injury and before removing covers over electrical conductors, isolate the generator set from all energy sources, remove stored energy and use lock out/tag out safety procedures.**

8.3.3 Requirements

Personal Protective Equipment (PPE)	Wear mandatory site PPE
Consumables	None
Parts	None
Tools	Multimeter
	Torque wrench

8.3.4 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.
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. Test the supply voltage to the anti-condensation heater at the heater connection box. 120 V or 240 V a.c. (depending on cartridge option and shown on a label) should be present when the alternator is stopped.
8. Check that 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.
9. For parallel operation, check that the synchronization control cables are securely connected.
10. Refit and secure the terminal box lid.

8.4 Cooling System

8.4.1 Introduction

The alternators are designed to meet standards supporting EU Safety Directives, 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 500m increase in altitude above 1000m, 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.

Efficient cooling depends on maintaining the condition of the cooling fan, air filters and gaskets.

8.4.2 Safety

⚠ DANGER

Rotating Mechanical Parts

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

To prevent injury and before removing covers over rotating parts, isolate the generator set from all energy sources, remove stored energy and use lock out/tag out safety procedures.

⚠ WARNING

Hot Surfaces

Skin contact with hot surfaces can cause serious injury by burns.

To prevent injury, wear appropriate personal protection equipment (PPE).

⚠ CAUTION

Dust

Inhaling dust can cause minor or moderate injury by irritating the lungs. Dust can cause minor or moderate injury by irritating the eyes.

To prevent injury, wear appropriate personal protection equipment (PPE). Ventilate the area to disperse dust.

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.

8.4.3 Inspect and Clean

1. Inspect the fan for damaged vanes and cracks.
2. Remove air filters (at the fan and terminal box, if fitted) from their frames.
3. Wash and dry the air filters and gaskets to remove contaminant particles.

4. Inspect the filters and gaskets for damage and replace, as necessary.
5. Install the filters and gaskets.
6. Reinstate the generator set for running.
7. Make sure the air inlets and outlets are not blocked.

8.5 Coupling

8.5.1 Introduction

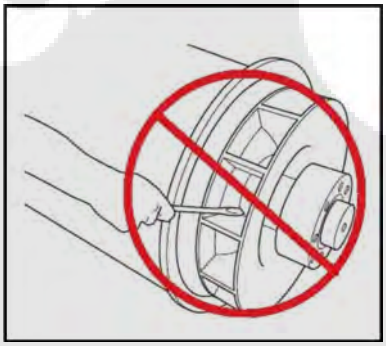
Efficient operation and long component life rely on minimizing mechanical stresses on the alternator. When coupled in a generator set, misalignment and vibration interactions with the prime mover engine can cause mechanical stress.

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.

8.5.2 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.



8.5.3 Requirements

Personal Protective Equipment (PPE)	Wear mandatory site PPE
Consumables	None
Parts	None
Tools	Dial gauge
	Torque wrench

8.5.4 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

8.5.4.1 Single Bearing Coupling

1. Remove the DE adapter 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 adapter screen and drip proof cover.

8.6 Rectifier System

8.6.1 Introduction

The rectifier converts alternating current (a.c.) induced in the exciter rotor windings into direct current (d.c.) to magnetize the main rotor poles. The rectifier comprises two semicircular 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 varistor. The varistor protects 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 a.c. to d.c. The rectifier is mounted on, and rotates with, the exciter rotor at the non-drive end (NDE).

8.6.2 Safety

⚠ DANGER

Live Electrical Conductors

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

To prevent injury and before removing covers over electrical conductors, 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 and before removing covers over rotating parts, isolate the generator set from all energy sources, remove stored energy and use lock out/tag out safety procedures.

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8.6.3 Requirements

Type	Description
Personal Protective Equipment (PPE)	Wear appropriate PPE.
Consumables	Loctite 241 thread locking adhesive
	Midland silicone heat sink compound type MS2623 or similar
Parts	Full set of three anode lead diodes and three cathode lead diodes (all from the same manufacturer)
	One metal-oxide varistor
Tools	Multimeter
	Insulation tester
	Torque wrench

8.6.4 Test and Replace Varistor

1. Inspect the varistor.
2. Record varistor as faulty if there are signs of overheating (discoloration, blisters, melting) or disintegration.
3. Disconnect one varistor lead. Store fastener and washers.
4. Measure the resistance across the varistor. Good varistors have a resistance greater than 100 MΩ.
5. Record the varistor as faulty if the resistance is short circuit or open circuit in either direction.
6. If the varistor is faulty, replace it and replace all diodes.
7. Reconnect and check that all leads are secure, washers fitted and fasteners tight.

8.6.5 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 $V_{d.c.}$ test voltage of an insulation tester.
4. Diode is faulty if the voltage drop in the forward direction is outside the range 0.3 to 0.9 V, 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 2.0 to 2.25 Nm (18 to 20 in-lb) torque to give good mechanical, electrical and thermal contact.

f. Replace the varistor.

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

8.7 Temperature Sensors

8.7.1 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 8. 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 characterised 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.

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TABLE 9. 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 10. 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

8.7.2 Safety

⚠ DANGER

Live Electrical Conductors
Live electrical conductors can cause serious injury or death by electric shock and burns.
To prevent injury and before removing covers over electrical conductors, isolate the generator set from all energy sources, remove stored energy and use lock out/tag out safety procedures.

⚠ WARNING

Hot Surfaces
Skin contact with hot surfaces can cause serious injury by burns.
To prevent injury, wear appropriate personal protection equipment (PPE).

8.7.3 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.

8.8 Windings

8.8.1 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.

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.

8.8.2 Safety

⚠ DANGER

Live Electrical Conductors

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

To prevent injury and before removing covers over electrical conductors, isolate the generator set from all energy sources, remove stored energy and use lock out/tag out safety procedures.

-

⚠ 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, discharge the windings by shorting to earth through an earthing rod for at least 5 minutes.**

8.8.3 Requirements

Type	Description
Personal Protective Equipment (PPE)	Wear mandatory site PPE
Consumables	None
Parts	None
Tools	Insulation test meter
	Multimeter
	Milliohm Meter or Micro Ohmmeter
	Clamp Ammeter
	Infrared thermometer

8.8.4 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 all of the star point leads of the main stator from the output neutral terminal.
    b. Connect together all U phase star point leads.
    c. Measure and record the electrical resistance between the connected U phase star point leads and the U phase output terminal. A specialist micro ohmmeter must be used.
    d. Connect together all V phase star point leads.
    e. Measure and record the electrical resistance between the connected V phase star point leads and the U phase output terminal. A specialist micro ohmmeter must be used.
    f. Connect together all W phase star point leads.
    g. Measure and record the electrical resistance between the connected W phase star point leads and the U phase output terminal. A specialist micro ohmmeter must be used.
    h. Reconnect all of the star point leads to the output neutral terminal, as before.
    i. Make sure the fasteners are secure.
6. Verify the electrical resistance of the PMG armature (stator) winding, if fitted:
    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 Technical Data (Chapter 12 on page 93) to verify the measured resistances of all windings agree with the reference values.

8.8.5 Test the Insulation Resistance of Windings

TABLE 11. 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
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).
    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 together both ends of the winding (if possible).

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.

8.8.6 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.

8.8.6.1 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.

8.8.6.2 Dry with Hot Air

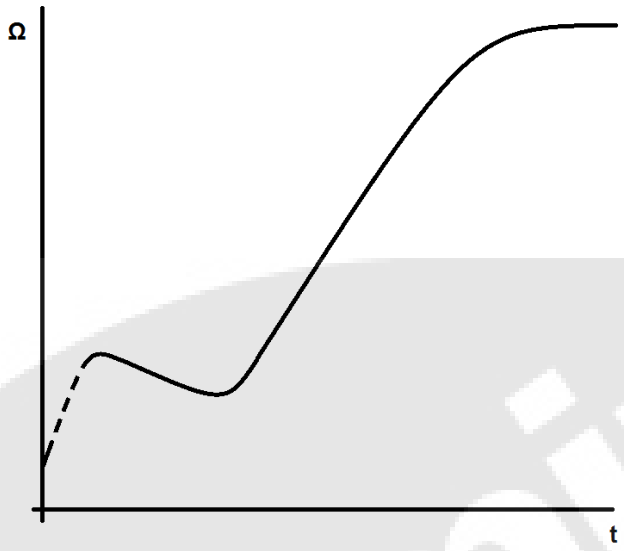
Direct the hot air from one or two 1 to 3 kW electrical fan heaters into the alternator air inlet. Make sure each heat source at least 300mm away from the windings to avoid scorching or over-heating damage to the insulation. Air must flow freely through the alternator to remove the moisture.

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.

8.8.6.3 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).



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.

8.8.7 Clean the Insulation

Remove the main rotor to gain access to the main stator windings to remove dirt contamination. Use clean warm water without detergents. Methods to remove and assemble the drive end (DE) and non-drive end (NDE) support are given in the Replace Bearing section of Service and Maintenance chapter.

8.8.7.1 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.

8.8.7.2 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 center 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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9 Fault Finding

9.1 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)

-

9.2 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.**
- **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 and AVR 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 including personal protective equipment, insulation, barriers and insulated tools.

9.3 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.

9.4 Recommended Fault Finding Equipment

9.4.1 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 ($V_{a.c.}$)
- 0 to 25, 0 to 100, 0 to 250 Volts ($V_{d.c.}$)
- 0 to 10 Amps ($A_{d.c.}$)
- 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)

9.4.2 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, (r/min).

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.

9.4.3 Insulation Tester (Megger)

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.

9.4.4 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 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 ($A_{a.c.}$).

9.4.5 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.

9.4.6 Tools and Spares

For efficient fault finding and to minimise 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
- 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

9.5 Preparation

Record details of the alternator (model, serial number, running time, voltage, AVR and main stator configuration), symptoms and observations[1] in a copy of the fault finding record **Chapter 10 on page 87**.

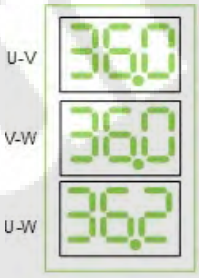
[1] The output voltage, stator configuration and AVR may be different from that shown on the nameplate. Record your **own** observations and measurements.

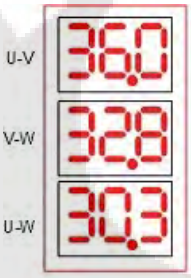
From what you know, does the alternator work NORMALLY when OFF-LOAD (no output load)?	**YES**	Check alternator on-Load **Section 9.8 on page 71**.
	NO	Check Un-excited phase and AVR voltages **Section 9.6 on page 63**.

9.6 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):[2] This is the residual voltage. Record your measurements on the fault finding record **Chapter 10 on page 87**.

<table>
<tr><td rowspan="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:
Unbalanced residual voltage would not be caused by faulty AVR or faulty rotating rectifier components.</td></tr>
<tr><td rowspan="2">Balanced
 

Unbalanced
 
</td><td>ACTIONS:
 

STOP THE ALTERNATOR
Take these recommended steps in order, until the cause is found.
1. Measure and verify the main stator insulation resistance
Section 9.9.20 on page 84.
2. Measure and verify the main stator resistance
Section 9.9.15 on page 81.</td></tr>
<tr><td>NO</td><td>The correct input voltage is essential for the AVR to operate.
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.
For 'MX' AVRs and machines equipped with a permanent magnet generator (PMG) the residual voltage requirements do not apply.
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.
ACTIONS:
KEEP THE ALTERNATOR RUNNING
Measure the AVR Power Input and Sensing Voltages.
Record your measurements on the fault finding record
Chapter 10 on page 87.
Continue to the next question.</td></tr>
</table>

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

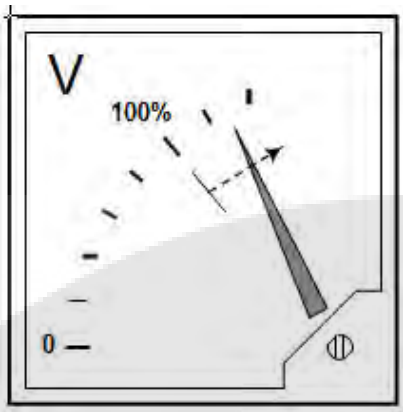
-

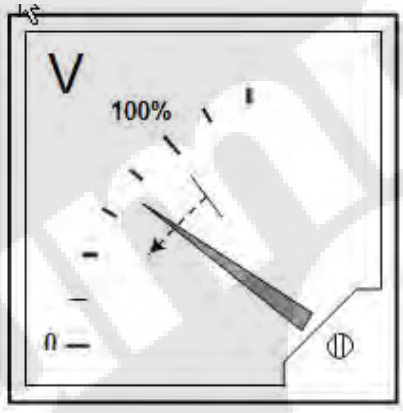
Does the AVR Power Input Voltage reading (from the fault finding record) fail the requirement?	**YES**	**ACTIONS:**  **STOP THE ALTERNATOR** Take these recommended steps in order, until the cause is found. 1. Check the main stator output connections. 2. Restore the residual voltage **Section 9.9.22 on page 85**.
	NO	Calculate V_a, V_b and V_{sen} and record your measurements on the fault finding record **Chapter 10 on page 87**. Continue to the next question.

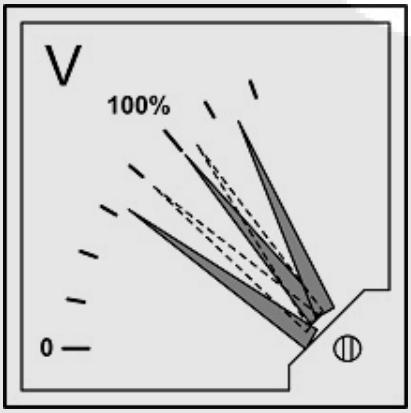
Does the calculated AVR Sensing Voltage (from the fault finding record) fail the requirement?	**YES**	**ACTIONS:**  **STOP THE ALTERNATOR** Take these recommended steps in order, until the cause is found. 1. Check the main stator output connections. 2. Check AVR sensing transformer(s). 3. Check other AVR accessories.
	NO	The alternator should be safe to operate off-load.
		ACTIONS:  **STOP THE ALTERNATOR** 1. Reconnect the main output cables to the alternator main terminals. 2. Reconnect the exciter field wires (F1 and F2) to the AVR. 3. Continue to off-load checks **Section 9.7 on page 64**.

9.7 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%? 	**YES**	**ACTION:** **KEEP THE ALTERNATOR RUNNING** **High voltage** failure is indicated by: • High voltage **continuously** by more than +2%, or • High voltage for a short time then shuts down. Continue to **Section 9.7.1 on page 66**.
	NO	Continue to the next question.

Is the voltage LOW by more than -2%? 	**YES**	**ACTION:** **KEEP THE ALTERNATOR RUNNING** **Low voltage** or **no voltage** failure is indicated by: • Low voltage **continuously** by more than -2%, or • Low voltage for a short time then shuts down. Continue to **Section 9.7.2 on page 67**.
	NO	Continue to the next question.

Is the voltage UNSTABLE? 	**YES**	**ACTION:** **KEEP THE ALTERNATOR RUNNING** **Unstable voltage** failure is indicated by: • Rhythmic instability • Erratic instability with the AVR LED flickering • Erratic instability with the AVR LED OFF, or • Voltage drifting. Continue to **Section 9.7.3 on page 69**.
	NO	Continue to the next question.

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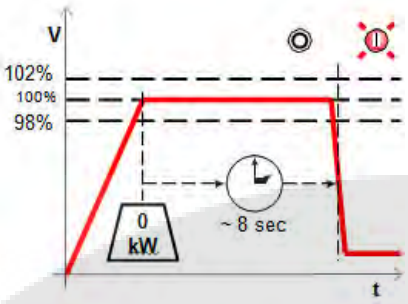
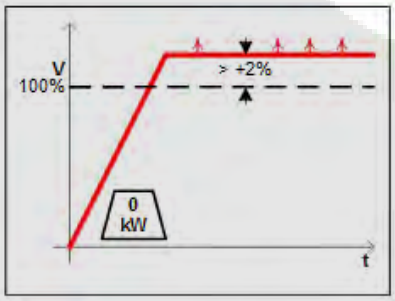
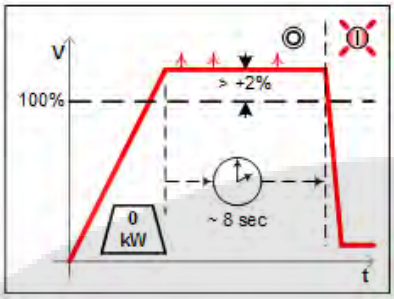
Is the voltage NORMAL for a short time, then shuts down? 	**YES**	The AVR has shut down in response to a fault within the alternator windings or rotating rectifier components. **ACTION:** **STOP THE ALTERNATOR** Take these recommended steps in order, until the cause is found. 1. Check rotating rectifier components **Section 9.9.10 on page 79**, **Section 9.9.11 on page 80**. 2. Measure and verify the resistance of exciter windings **Section 9.9.12 on page 81**, **Section 9.9.13 on page 81**. 3. Measure and verify the resistance of main rotor **Section 9.9.14 on page 81**.
	NO	Continue to check alternator on-load **Section 9.8 on page 71**.

9.7.1 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.

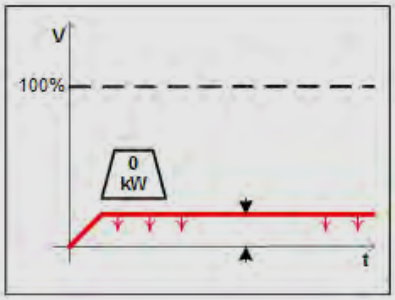
Is the voltage CONTINUOUSLY HIGH by more than +2%? 	**YES**	It is unlikely to be a fault with the alternator windings or rotating rectifier components. **ACTION:** **STOP THE ALTERNATOR** Take these recommended steps in order, until the cause is found. 1. Check and adjust remote hand trimmer (if fitted) **Section 9.9.6 on page 77**. 2. Check and adjust AVR VOLTS setting **Section 9.9.2 on page 74**. 3. Measure and verify AVR sensing voltage input **Section 9.9.8 on page 78**. 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? 	**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: **STOP THE ALTERNATOR** Take these recommended steps in order, until the cause is found. 1. Check and adjust remote hand trimmer (if fitted) **Section 9.9.6 on page 77**. 2. Check and adjust AVR VOLTS setting **Section 9.9.2 on page 74**. 3. Measure and verify AVR sensing voltage input **Section 9.9.8 on page 78**. 4. Replace the AVR.
	NO	**ACTION:** **STOP THE ALTERNATOR** Seek guidance from CGT Customer Support.

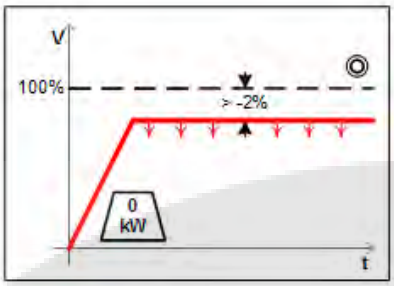
9.7.2 Lower then Expected Voltage Off-Load

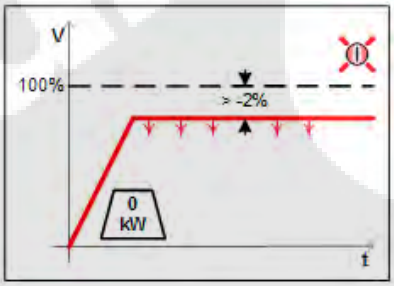
The alternator produces lower than expected voltage:

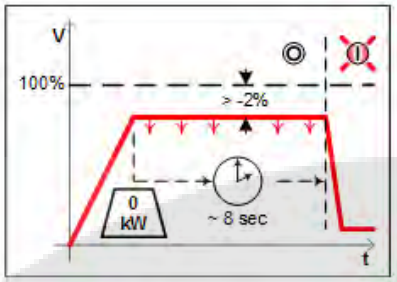
1. Start the alternator without output load, 'Off-Load '. Be prepared to STOP!
2. Verify that the alternator speed is correct.
3. Measure the main terminal output voltage.

Is the voltage ZERO or VERY LOW? 	**YES**	**ACTION:** **STOP THE ALTERNATOR** Take these recommended steps in order, until the cause is found. 1. Check the main stator output connections. 2. Restore residual voltage (NOT applicable to machines with a PMG) **Section 9.9.22 on page 85**.
	NO	Continue to the next question.

-

Is the voltage CONTINUOUSLY LOW by more than -2% and the AVR LED is OFF? 	**YES**	It is unlikely to be a fault with the alternator main stator winding unless the phase voltages are unbalanced.
		ACTION: **STOP THE ALTERNATOR** Take these recommended steps in order, until the cause is found. 1. Check and adjust remote hand trimmer (if fitted) **Section 9.9.6 on page 77**. 2. Check and adjust AVR VOLTS setting **Section 9.9.2 on page 74**. 3. Check the rotating rectifier components **Section 9.9.10 on page 79**, **Section 9.9.11 on page 80**. 4. Measure and verify the condition of the PMG stator winding (if fitted) **Section 9.9.16 on page 82**, **Section 9.9.21 on page 84**. 5. Replace the AVR.
	NO	Continue to the next question.

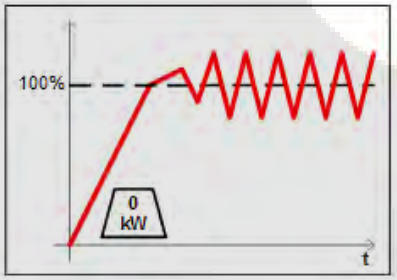
Is the voltage CONTINUOUSLY LOW by more than -2% and the AVR LED is ON? 	**YES**	It is unlikely to be a fault with the alternator main stator winding unless the phase voltages are unbalanced.
		ACTION: **STOP THE ALTERNATOR** Take these recommended steps in order, until the cause is found. 1. Adjust AVR UFRO setting **Section 9.9.3 on page 75**. 2. Check alternator (prime mover) rotational speed. 3. Replace the AVR.
	NO	Continue to the next question.

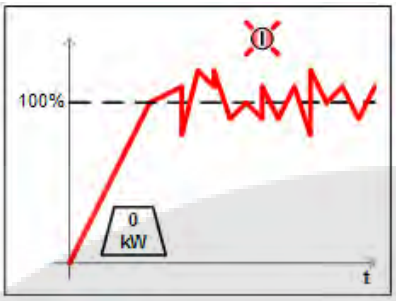
Is the voltage LOW for a short time, then shuts down and the AVR LED is ON? 	**YES**	It is unlikely to be a fault with the alternator main stator winding unless the phase voltages are unbalanced.
		ACTION: **STOP THE ALTERNATOR** Take these recommended steps in order, until the cause is found. 1. Check rotating rectifier components Section 9.9.10 on page 79, Section 9.9.11 on page 80. 2. Replace the AVR.
	NO	**ACTION:** **STOP THE ALTERNATOR** Seek guidance from CGT Customer Support.

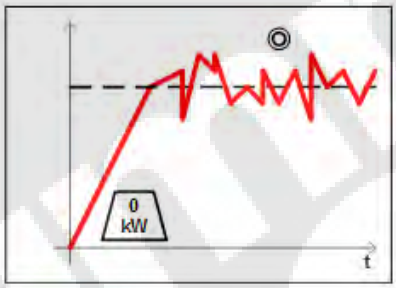
9.7.3 Unstable Voltage Off-Load

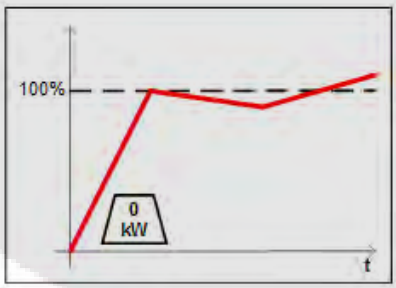
The alternator produces an unstable voltage output:

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? 	**YES**	It is unlikely to be a fault with the alternator windings or rotating rectifier components.
		ACTION: **STOP THE ALTERNATOR** Take these recommended steps in order, until the cause is found. 1. Verify that the prime mover speed is stable. 2. Check if the alternator is operating below its design voltage. 3. Check and adjust the AVR STAB setting Section 9.9.4 on page 76.
	NO	Continue to the next question.

Is the voltage varying in an irregular ERRATIC way and the AVR LED is flickering? 	**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. **ACTION:** **STOP THE ALTERNATOR** Take these recommended steps in order, until the cause is found. 1. Check prime mover speed governing. 2. Check and adjust AVR UFRO setting **Section 9.9.3 on page 75**.
	NO	Continue to the next question.

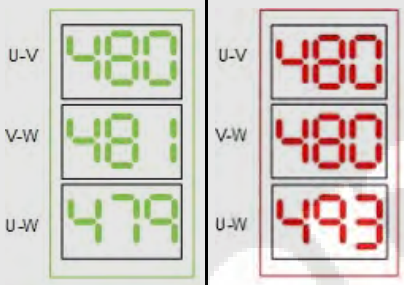
Is the voltage varying in an irregular ERRATIC way and the AVR LED is OFF? 	**YES**	It is unlikely to be a fault with the rotating rectifier components. **ACTION:** **STOP THE ALTERNATOR** **Erratic instability and AVR LED OFF** is corrected by taking the following steps, in order: 1. Check prime mover speed governing. 2. Check and adjust AVR STAB setting **Section 9.9.4 on page 76**. 3. Measure and verify the insulation resistance of the exciter stator **Section 9.9.17 on page 82**. 4. Measure and verify the insulation resistance of the PMG (if fitted) **Section 9.9.21 on page 84**.
	NO	Continue to the next question.

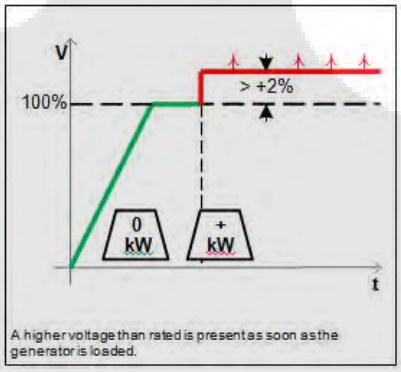
Is the voltage DRIFTING, varying slowly over a long time? 	**YES**	**ACTION:** **STOP THE ALTERNATOR** **Voltage drifting** is corrected by taking the following steps, in order: 1. Check and adjust the remote hand trimmer **Section 9.9.6 on page 77**. 2. Replace the faulty AVR.
	NO	**ACTION:** **STOP THE ALTERNATOR** Seek guidance from CGT Customer Support.

9.8 Check Alternator On-Load

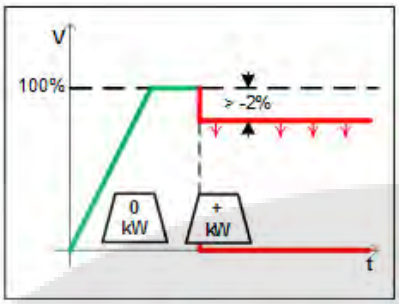
Check the alternator with the output load applied, 'On-Load'.

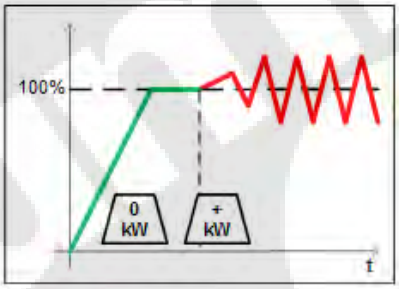
1. Start the alternator and apply the output load. Be prepared to STOP!
2. Make sure that the alternator speed is correct.
3. Measure the main terminal output voltage.

Are the phase voltages UNBALANCED by more than 1%? (see example below) **Balanced** / **Unbalanced** 	**YES**	Unbalanced voltage would **not** be caused by a faulty AVR or faulty rotating rectifier components. **ACTIONS:** **STOP THE ALTERNATOR** Take these recommended steps in order, until the cause is found. 1. Check and correct the three-phase load balance. 2. Check and correct the distribution of single-phase loads. 3. Check main stator output connections for loose leads. 4. Measure and verify the main stator resistance Section 9.9.15 on page 81.
	NO	Continue to the next question.

Is the voltage HIGH by more than +2% when load applied?  A higher voltage than rated is present as soon as the generator is loaded.	**YES**	**ACTION:** **STOP THE ALTERNATOR** Take these recommended steps in order, until the cause is found. 1. Adjust the AVR DROOP setting Section 9.9.5 on page 77. 2. Check and correct the leading (capacitive) power-factor load.
	NO	Continue to the next question.

-

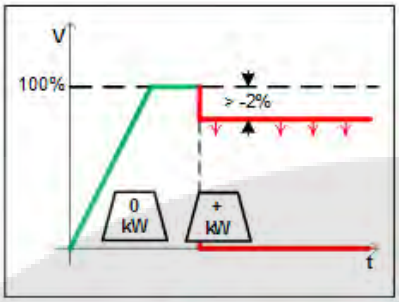
Is the voltage LOW by more than -2% when load applied? 	**YES**	**ACTION:** **STOP THE ALTERNATOR** **Low voltage** or **no voltage when applying load** is indicated by: • Low voltage by more than -2% **continuously** after applying load; • Low voltage by more than -2% **continuously** after applying load and AVR LED is ON; • Low voltage by more than -2% **for a short time** after applying load, then shuts down and AVR LED is ON; or • Normal voltage for a short time after applying load, then shuts down and AVR LED is ON. Continue to **Section 9.8.1 on page 72**.
	NO	Continue to the next question.

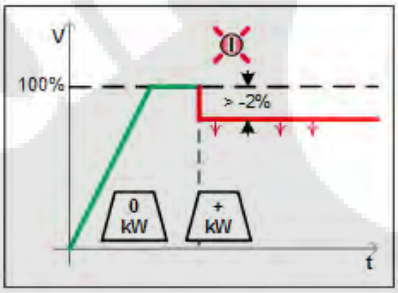
Is the voltage UNSTABLE when load applied? 	**YES**	**ACTION:** **STOP THE ALTERNATOR** **Unstable voltage when applying load** is indicated by: • Interaction between AVR, governor and/or load; or • Waveform distortion caused by load.
	NO	**ACTION:** **STOP THE ALTERNATOR** Seek guidance from CGT Customer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

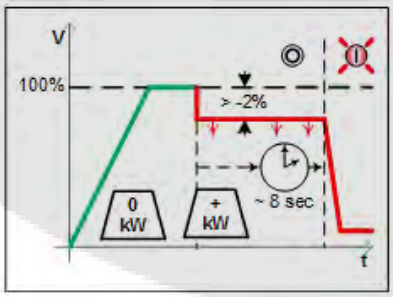
9.8.1 Lower than Expected Voltage On-Load

The alternator produces lower than expected voltage:

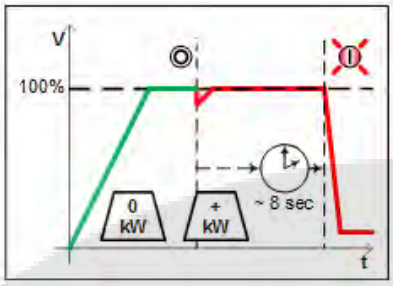
1. Start the alternator and apply the output load, 'On-Load '. Be prepared to STOP!
2. Verify that the alternator speed is correct.
3. Measure the main terminal output voltage.

Is the voltage CONTINUOUSLY LOW by more than -2% when load applied? 	**YES**	It is unlikely to be a fault with the alternator main stator winding unless the phase voltages are unbalanced.
		ACTION: **STOP THE ALTERNATOR** Take these recommended steps in order, until the cause is found. 1. Check prime-mover load/speed response. 2. Check and adjust AVR VOLTS setting Section 9.9.2 on page 74. 3. Check rotating rectifier components Section 9.9.10 on page 79 , Section 9.9.11 on page 80. 4. Check and adjust an AVR accessory Section 9.9.5 on page 77, Section 9.9.6 on page 77. 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? 	**YES**	**ACTION:** **STOP THE ALTERNATOR** Take these recommended steps in order, until the cause is found. 1. Check prime-mover load/speed response. 2. Check and adjust AVR UFRO setting Section 9.9.3 on page 75.
	NO	Continue to the next question.

Is the voltage LOW by more than -2% for a short time, then shuts down and the AVR LED is ON? 	**YES**	It is unlikely to be a fault with the alternator main stator winding unless the phase voltages are unbalanced.
		ACTION: **STOP THE ALTERNATOR** Take these recommended steps in order, until the cause is found. 1. Check prime-mover load/speed response. 2. Check rotating rectifier components Section 9.9.10 on page 79 , Section 9.9.11 on page 80. 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? 	**YES**	It is unlikely to be a fault with the alternator main stator winding unless the phase voltages are unbalanced.
		ACTION: **STOP THE ALTERNATOR** Take these recommended steps in order, until the cause is found. 1. Check rotating rectifier components **Section 9.9.10 on page 79**, **Section 9.9.11 on page 80**. 2. Check for excessive load.
	NO	**ACTION:** **STOP THE ALTERNATOR** Seek guidance from CGT Customer Support.

9.9 Procedures

⚠ WARNING

Ejected Debris

Debris ejected during catastrophic failure can cause serious injury or death by impact, severing or stabbing.

To prevent injury:

- **Keep away from the air inlet and air outlet when the alternator is running.**
- **Do not put operator controls near the air inlet and air outlet.**
- **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 sychronize parallel alternators outside the specified parameters.**

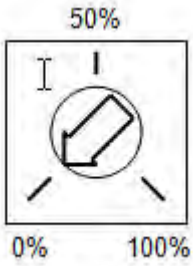
9.9.2 Set the AVR [VOLTS] Voltage Control

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.



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.
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 **Section 9.9.4 on page 76****.**

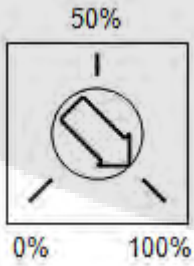
8. Adjust the output voltage to the desired nominal value (V_{ac}).
9. If instability is present at rated voltage, refer to the **AVR [STAB]** adjustment, then adjust **AVR [VOLTS]** again, if necessary.
10. If a remote hand trimmer is connected, check its operation.

NOTICE
0% to 100% rotation corresponds to 90 % to 110 % V_{ac}

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

9.9.3 Set the AVR [UFRO] Under-Frequency Roll-Off Control

1. Set the **AVR [UFRO]** control to 100%, the fully clockwise position.



2. Start the alternator and set at the correct operating speed.
3. Verify that the alternator voltage is correct and stable.

-

NOTICE

If the voltage is high / low / unstable, use method Section 9.9.2 on page 74 or Section 9.9.4 on page 76 before proceeding.

4. 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.
5. Adjust the **AVR [UFRO]** control slowly anticlockwise until the AVR LED lights.

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

NOTICE

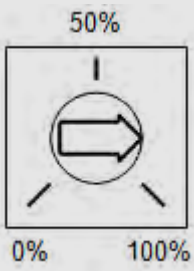
Do not go past the point at which the LED is just OFF.

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

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

9.9.4 Set 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.



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 go immediately to step 5.

6. Adjust the **AVR [STAB]** control slowly anticlockwise 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 (see Section 9.9.2 on page 74).

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

9.9.5 Set the AVR [DROOP] Voltage Droop Control for Parallel Operation

A correctly fitted and adjusted droop current transformer (CT) is essential 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.

9.9.6 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 counterclockwise 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).

-

9.9.7 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 make them safe.
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 P2 and P3). For AVRs SX460*, AS480*, AS440* and SX421, this voltage should be 6 $V_{a.c.}$ minimum.[3]
5. If the measured voltage is below the minimum value, restore the residual voltage **Section 9.9.22 on page 85**.

9.9.8 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 make them safe.
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 6,7 and 8 (V_{r67}, V_{r78}, V_{r86}).

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

9.9.9 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 these limits:

$170 < V_{p2p3} < 185$ @ 50 Hz,

$170 < V_{p3p4} < 185$ @ 50 Hz,

$170 < V_{p4p2} < 185$ @ 50 Hz, or

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

200 < V_{p2p3} < 220 @ 60 Hz,

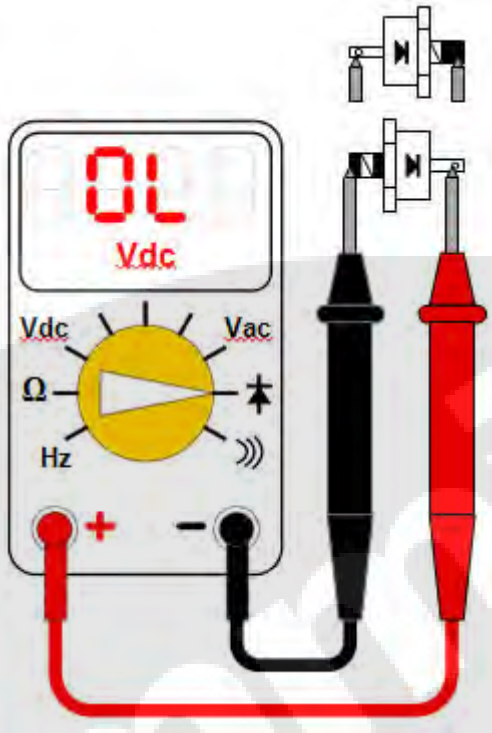
200 < V_{p3p4} < 220 @ 60 Hz,

200 < V_{p4p2} < 220 @ 60 Hz.

9.9.10 Check the Rotating Rectifier Diodes

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 diode test function of a multimeter.



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 Installation, Service and Maintenance manual, 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.

9.9.11 Check the Rotating Rectifier Varistors

1. Inspect both varistors.
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 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.

9.9.12 Measure and Verify the Exciter Stator Resistance

1. Stop the alternator.
2. Disconnect the exciter field leads F1 and F2 from the AVR.
3. Measure the electrical resistance between F1 and F2 leads with a multimeter.
4. The resistance should be between approximately 15 Ω and 20 Ω at 20 °C. Refer to the Technical Data chapter of the Installation, Service and Maintenance manual for specific values.
5. Reconnect the exciter field leads F1 and F2.
6. Record your measurement in a copy of the fault finding record **Chapter 10 on page 87**.

9.9.13 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. The resistance phase-to-phase should be between approximately 0.07 Ω and 0.20 Ω at 20 °C. Refer to the Technical Data chapter of the Installation, Service and Maintenance manual for specific values.
6. Reconnect all exciter rotor leads to the diodes.
7. Record your measurements in a copy of the fault finding record **Chapter 10 on page 87**.

9.9.14 Measure and Verify the Main Rotor Resistance

1. Stop the alternator.
2. Disconnect the two main rotor d.c. leads from the rectifier plates.
3. Measure the electrical resistance between the main rotor leads. A specialist micro ohmmeter must be used.
4. The resistance should be between approximately 0.4 Ω and 2.80 Ω at 20 °C. Refer to the Technical Data chapter of the Installation, Service and Maintenance manual for specific values.
5. Reconnect the two main rotor d.c. 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 10 on page 87**.

9.9.15 Measure and Verify the Main Stator Resistance

1. Stop the alternator.
2. Disconnect all of the star point leads of the main stator from the output neutral terminal.
3. Connect together all U phase star point leads.
4. Measure the electrical resistance between the connected U phase star point leads and the U phase output terminal. A specialist micro ohmmeter must be used.

5. Connect together all V phase star point leads.
6. Measure the electrical resistance between the connected V phase star point leads and the U phase output terminal. A specialist micro ohmmeter must be used.
7. Connect together all W phase star point leads.
8. Measure the electrical resistance between the connected W phase star point leads and the U phase output terminal. A specialist micro ohmmeter must be used.
9. The measured resistances should be between approximately 0.25 mΩ and 2.0 Ω at 20 °C. Refer to the Technical Data chapter of the Installation, Service and Maintenance manual for specific values.
10. Reconnect all of the star point leads to the output neutral terminal.
11. Make sure the fasteners are secure.
12. Record your measurements in a copy of the fault finding record **Chapter 10 on page 87**.

9.9.16 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 20 °C. Refer to the Technical Data chapter of the Installation, Service and Maintenance manual 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 10 on page 87**.

9.9.17 Measure and Verify the Exciter Stator Insulation Resistance

TABLE 12. 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 10 on page 87.

9.9.18 Measure and Verify the Exciter Rotor Insulation Resistance

TABLE 13. 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 10 on page 87.

9.9.19 Measure and Verify the Main Rotor Insulation Resistance

TABLE 14. 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 10 on page 87.

9.9.20 Measure and Verify the Main Stator Insulation Resistance

TABLE 15. 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. Connect together the three leads of all phase windings (if possible).
4. Apply the test voltage from the table between any phase lead and earth.
5. Measure the insulation resistance after 1 minute (IR_{1min}).
6. Discharge the test voltage to earth for five minutes.
7. If the measured insulation resistance is less than the minimum acceptable value, dry the insulation, then repeat the method.
8. Reconnect neutral to earth conductor (if fitted).
9. Record your measurement in a copy of the fault finding record Chapter 10 on page 87.

9.9.21 Measure and Verify the PMG Stator Insulation Resistance

TABLE 16. 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 10 on page 87.

9.9.22 Restore the Residual Voltage

⚠ DANGER

Live Electrical Conductors

Live electrical conductors at output and AVR 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 including personal protective equipment, insulation, barriers and insulated tools.

⚠ 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 and use insulated leads and tools.

⚠ WARNING

Battery Acid

Contact with battery acid can cause serious injury by chemical burns to eyes and skin.

To prevent injury, wear appropriate personal protection equipment (PPE). Put battery securely on a flat surface to avoid acid spills.

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.

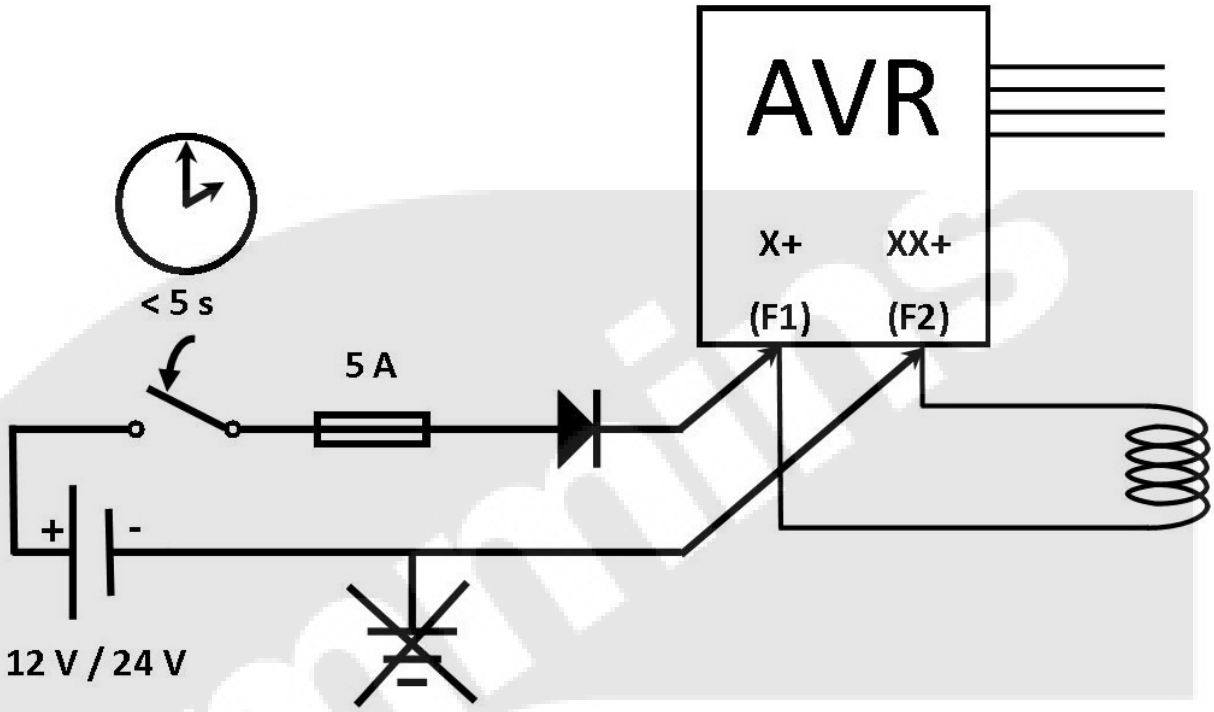
The laminated steel core of the exciter stator retains a residual, or remanence, magnetism. Residual voltage, generated by the exciter rotor turning in this magnetic field, powers the AVR during alternator start-up. A minimum level of residual voltage is necessary for correct operation of an AVR without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

-

FIGURE 8. TEMPORARY CIRCUIT TO RESTORE RESIDUAL VOLTAGE



1. Securely place a fully-charged 12 $V_{d.c.}$ or 24$V_{d.c.}$ 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 multi meter (see **Section 9.9.10 on page 79**) 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 CGT Customer Support.

10 Fault Finding Record

UC Fault Finding Record												
Alternator Model				**Serial Number**				**Running Time**		hours		
Alternator Voltage, V_G ($V_{a.c.}$)	208	220	230	240	380	400						
	415	440	480	600	690	Other						
AVR Model	SX460	AS440										
	MX341	MX321	MA330		Other							
Stator Connection	Series-Star	Parallel-Star	Series-Delta	Single-Phase	Other							
Fault Symptoms and Observations												
Measurements	**Residual Voltage, V_A ($V_{a.c.}$)**	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 ($V_{a.c.}$)**			**Requirement ($V_{a.c.}$)**	**Terminals**	**Sensing Voltage ($V_{a.c.}$)**				
	SX460 AS440	7 8*	V_{r78} =			$V_{r78} > 6$	7 8*	$V_B = V_{r78}$ =				
	MX341	P2 P3 P4	V_{P2P3} =	V_{P3P4} =	V_{P4P2} =	$170 < V_{P2P3} < 220$ $170 < V_{P3P4} < 220$ $170 < V_{P4P2} < 220$	2 3	$V_B = V_{r23}$ =				
	MX321	P2 P3 P4	V_{P2P3} =	V_{P3P4} =	V_{P4P2} =	$170 < V_{P2P3} < 220$ $170 < V_{P3P4} < 220$ $170 < V_{P4P2} < 220$	6 7 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 ($V_{a.c.}$)**									**Requirement ($V_{a.c.}$)**		
	$V_{Sen} = V_G \times V_B / V_A$ = 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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UC Fault Finding Record											
Resistance (mΩ)	R =	R_{UV} =	R_{VW} =	R_{UW} =	R =	R_U =	R_V =	R_W =	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

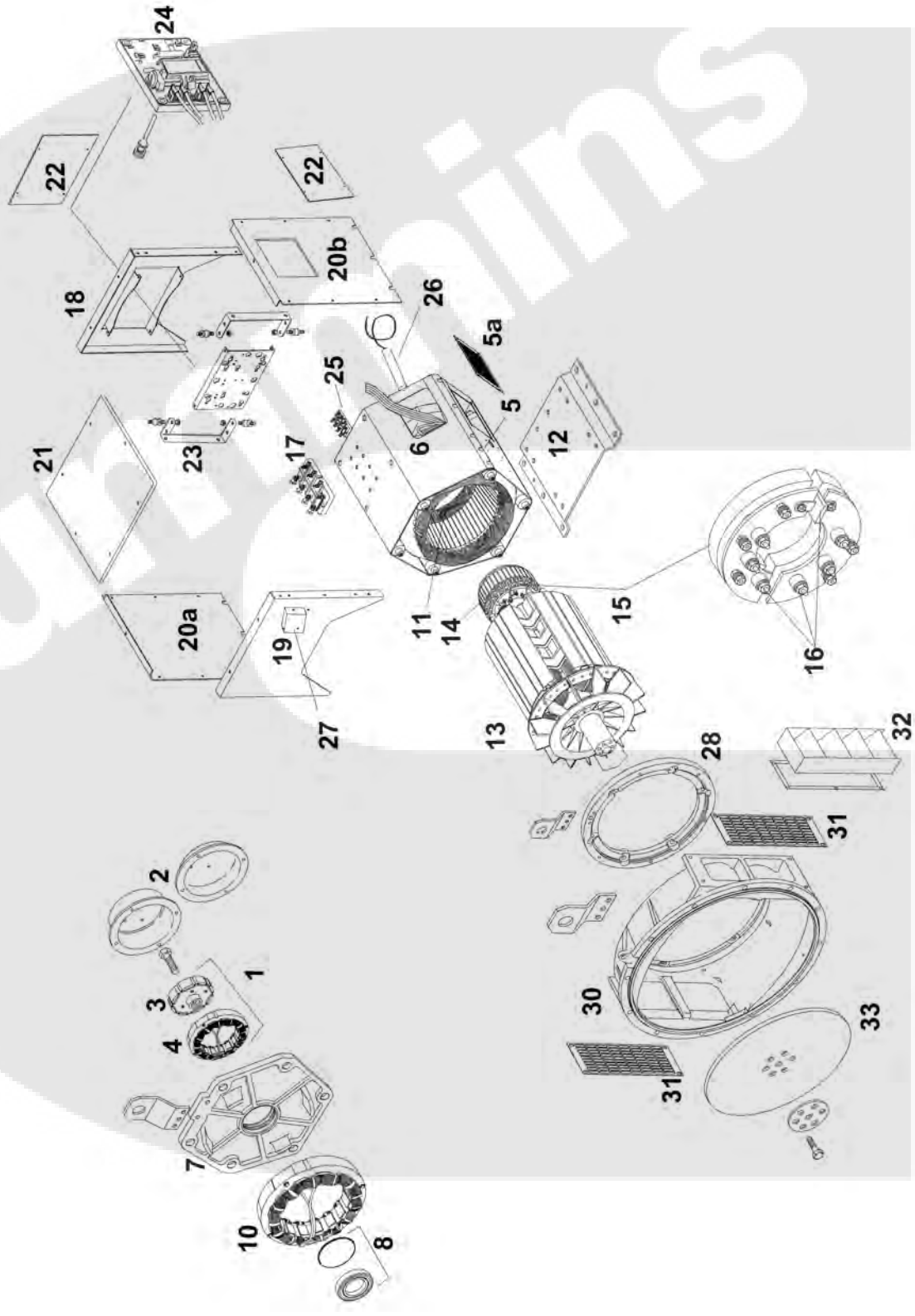
Service Engineer	*signature*	**Name**	*print*	**Date**	*dd/MMM/yy*
Owner/ Approver	*signature*	**Name**	*print*	**Date**	*dd/MMM/yy*

[4]

[4] * Power input and voltage sensing share terminals 7 and 8.

11 Parts Identification

11.1 UC Single Bearing Alternator



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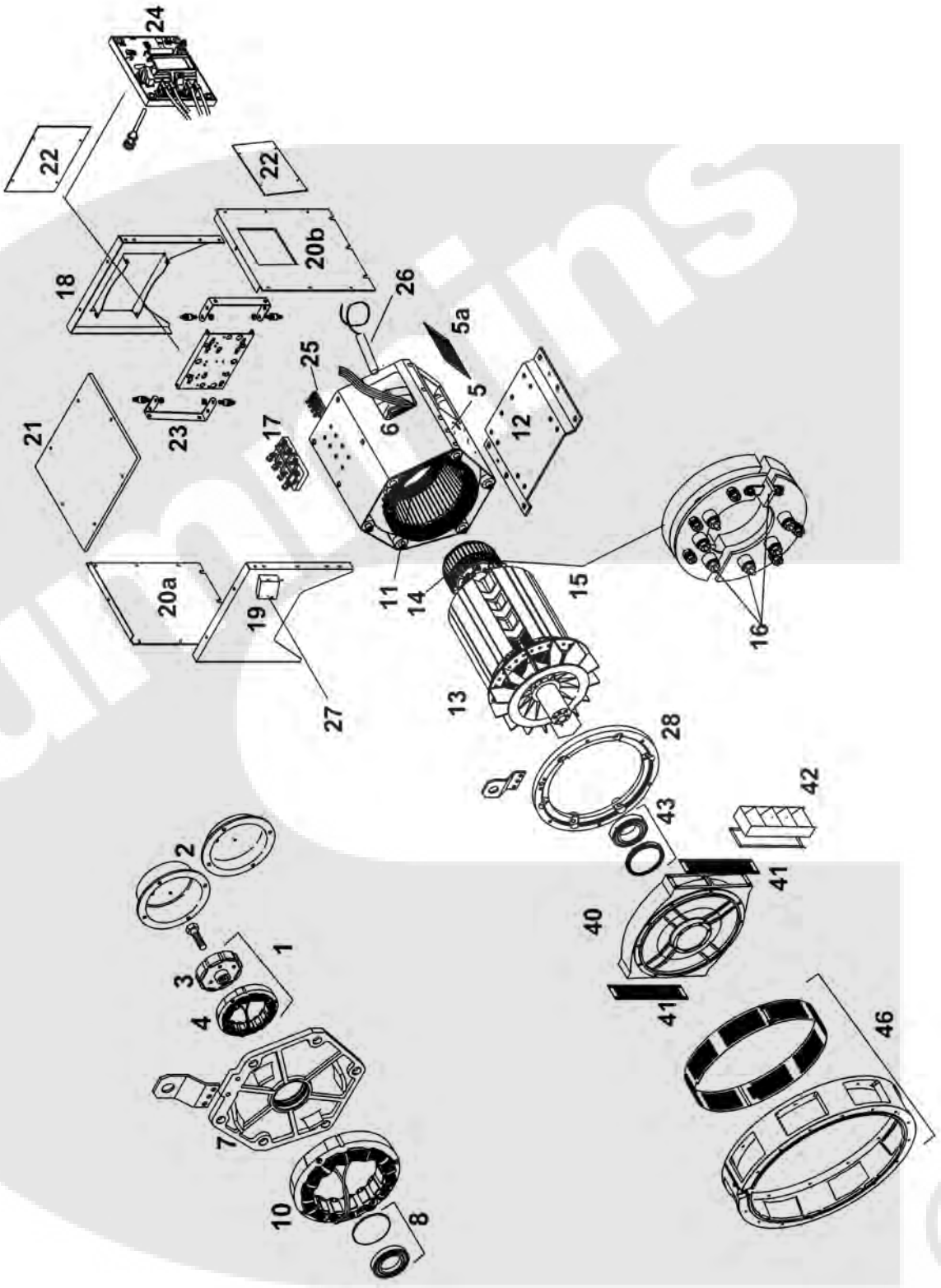
11.2 UC Two Bearing Alternator



11.3 UC Parts and Fasteners

TABLE 17. PARTS AND FASTENERS

Reference	Component	Fastener	Quantity	Torque (Nm)
1	Complete PMG parts	-	-	-
2	PMG Cover/non-PMG Cover	M5 / M6 x 12	4	5 / 10
3	PMG Rotor	M10 x 85	1	45
4	PMG Stator	M6	4	10
5	Main Stator Bottom Cover	M10 x 25 / 30	6 / 8	56 / 69
5a	Air Inlet Cover	M5 x 12	8	5
6	Main Stator Top Cover	M10 x 25 / 30	4	56 / 69
7	NDE Bracket	M8 x 25 / M10 x 30	6	28 / 56
8	Complete NDE Bearing parts	-	-	-
10	Exciter Stator	M6 x 45 / 55 / 75	4	10
11	Main Stator & Frame	-	-	-
12	Foot	M10 x 35 / 40	6	62 / 118
13	Main Rotor	-	-	-
14	Exciter Rotor	-	-	-
15	Rectifier Assembly	M6 x 40/50/60	4	8
16	Diode/Varistor	-	-	2.0-2.25
17	Main Terminals	M8 x 25 / 30	2	20
18	Terminal Box End Panel NDE	M6 x 12	12	10
19	Terminal Box End Panel DE	M6 x 12	12	10
20a / 20b	Terminal Box Side Panel	M10 x 25 / M12 x 25	6 / 8	10 / 69
21	Terminal Box Lid	M6 x 12	6	6
22	AVR Cover Plate	M5 x 12	6	5
23	AVR Mounting Bracket	M5 x 12	4	5
24	AVR	M5 x 12	4	5
25	Auxilliary Terminal Board	M6 x 25	8	10
26	Anti-condensation Heater	M4 x 12	2	hand
27	Heater terminal Box	M5 x 12	2	5
28	DE Adapter Ring	M8 x 25 / M10 x 30	6	56 / 56
30	DE Adapter (1 bearing)	M10 x 50/60	6	56
31	DE Air Outlet Screen (1 bearing)	M5 x 12	8	5
32	DE Louvres (1 bearing)	M5 x 12	8 / 12	5

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Reference	Component	Fastener	Quantity	Torque (Nm)
33	DE Coupling Hub and Coupling Discs (1 bearing)	M16	8	250
40	DE Bracket (2 bearing)	M12 x 40	8	95
41	DE Air Outlet Screen (2 bearing)	M5 x 12	12	5
42	DE Louvres (2 bearing)	M5 x 16	12	5
43	Complete DE Bearing parts (2 bearing)	-	-	-
46	DE Adapter (2 bearing)	M12 x 40	8	95
47	DE Adapter Screen (2 bearing)	M5 x 12	12	5

12 Technical Data

NOTICE
Compare measurements with the test certificate supplied with the alternator.

12.1 UC Winding Resistances

TABLE 18. AVR-CONTROLLED ALTERNATORS

Alternator	Resistance of windings at 20 °C (measured values should be within 10%)							
	Main Stator Windings, L-N (leads) (ohms)				Exciter Stator (ohms)	Exciter Rotor, L-L (ohms)	Main Rotor (ohms)	PMG Stator, L-L (ohms)
	311 (1 & 2) (5 & 6)	05 (1 & 2)	06 (1 & 2)	17 (1 & 2) (5 & 6)				
UC22C	0.09	0.045	0.03	0.14	21	0.142	0.59	2.6
UC22D	0.065	0.033	0.025	0.1	21	0.142	0.64	2.6
UC22E	0.05	0.028	0.02	0.075	20	0.156	0.69	2.6
UC22F	0.033	0.018	0.012	0.051	20	0.156	0.83	2.6
UC22G	0.028	0.014	0.01	0.043	20	0.156	0.94	2.6
UC27C	0.03	0.016	0.011	0.044	20	0.156	1.12	2.6
UC27D	0.019	0.01	0.007	0.026	20	0.156	1.26	2.6
UC27E	0.016	0.009	0.008	0.0025	20	0.182	1.34	2.6
UC27F	0.012	0.007	0.005	0.019	20	0.182	1.52	2.6
UC27G	0.01	0.006	0.004	0.013	20	0.182	1.69	2.6
UC27H	0.008	0.004	0.004	0.014	20	0.182	1.82	2.6
UCD27J	0.006	n/a	n/a	0.009	20	0.182	2.08	2.6
UCD27K	0.006	n/a	n/a	0.009	20	0.182	2.08	2.6

-

TABLE 19. TRANSFORMER-CONTROLLED ALTERNATORS

Alternator	Resistance of windings at 20 °C (measured values should be within 10%)								
	Main Stator 3 Phase Windings, L-N (ohms)					Exciter Stator (ohms)		Exciter Rotor, L-L (ohms)	Main Rotor (ohms)
	380 V 50 Hz	400 V 50 Hz	415 V 50 Hz	416 V 60 Hz	460 V 60 Hz	1 phase transformer, 1 or 3 phase generator	3 phase transformer, 3 phase generator		
UC22C	0.059	0.078	0.082	0.055	0.059	28	138	0.142	0.59
UC22D	0.054	0.056	0.057	0.049	0.054	28	138	0.142	0.64
UC22E	0.041	0.05	0.053	0.038	0.041	30	155	0.156	0.69
UC22F	0.031	0.032	0.033	0.025	0.031	30	155	0.156	0.83
UC22G	0.022	0.026	0.028	0.021	0.022	30	155	0.156	0.94

13 Service Parts

We recommend the use of genuine STAMFORD service parts supplied from an authorized service outlet. For details of your nearest service outlet visit www.cumminsgeneratortechnologies.com.

13.1 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.

13.2 Customer Service

Cummins Generator Technologies' 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

www.cumminsgeneratortechnologies.com

Email: service-engineers@cumminsgeneratortechnologies.com.

13.3 Recommended Service Parts

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

Part	Number
Diode Set (6 diodes with surge suppressor)	RSK2001
AS440 AVR	E000-24403/1P
MX321 AVR	E000-23212/1P
MX341 AVR	E000-23412/1P
SX460 AVR	E000-24602/1P
Anti-fretting paste	45-0280
Non drive end Bearing	UC22: 45-0867
	UC27: 45-0868
Drive end Bearing	UC22: 45-0365
	UC27: 45-0367
Transformer Controlled Generators (UC22 Only)	
Diode Set (6 diodes with varistor)	RSK2001
Three Phase Rectifier	E000 22016
Non drive end Bearing	UC22: 45-0867
Drive end Bearing	UC22: 45-0365

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14 End of Life Disposal

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

14.1 Recyclable material

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

The iron, steel and copper can now be recycled.

14.2 Items requiring specialist treatment

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

Forward the reclaimed materials for recycling.

14.3 Waste material

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

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