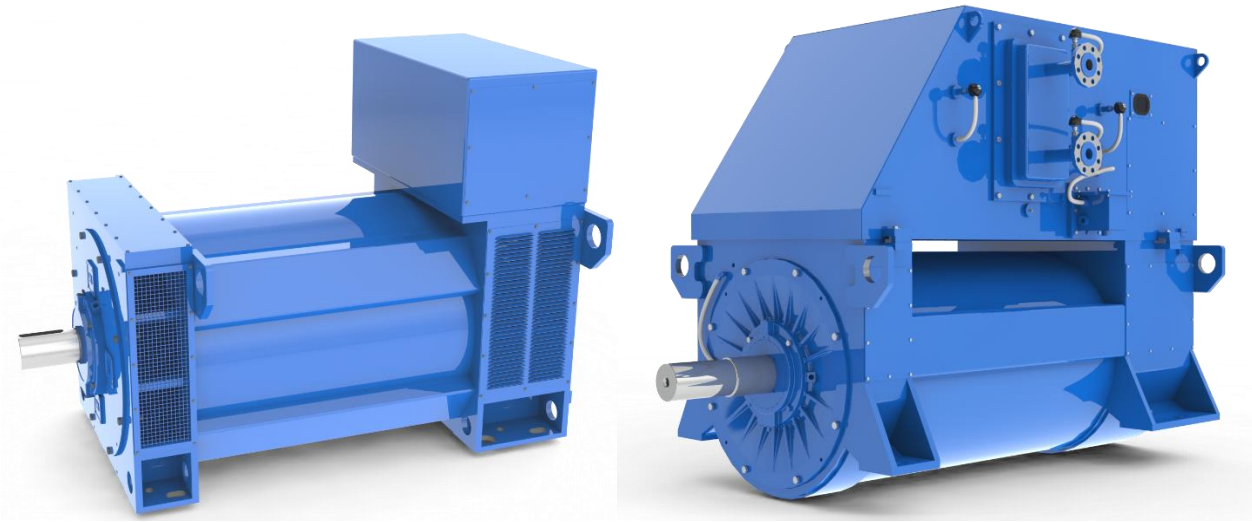
Driving efficiency and sustainability

Synchronous Alternators used in explosive atmospheres

Models: GPW, GSW, GPA, GSA, GPF, GSF

Installation, Operation and Maintenance Manual



Installation, Operation and Maintenance Manual

Models: GPW, GPA, GPF, GSW, GSA, GSF

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Dear Customer,

Thank you for purchasing the WEG alternator. It is a product developed with quality and efficiency levels that ensure optimal performance.
Electricity plays a role of major importance for the comfort and well-being of humanity. Since the alternator is responsible for generating this energy, it must be identified and treated as a machine whose characteristics require certain care, including storage, installation, operation and maintenance.
All efforts were made to ensure the information contained herein is accurate regarding the configurations and use of the alternator.
Thus, we recommend reading this manual carefully before installing, operating and servicing the alternator in order to ensure a safe and continuous operation of the alternator and guarantee the personnel's and installations' safety. If you need any further information, please, contact WEG.
Keep this manual always near the alternator, so it can be referred to whenever necessary.

ATTENTION

1. It is imperative to follow the procedures contained in this manual for the warranty to be valid;
2. The procedures for installation, operation and maintenance of the alternator must be carried out by qualified people.

NOTE

1. Reproduction of the information contained in this manual, in whole or in part, is permitted provided that the source is mentioned;
2. If this manual is lost, a copy in electronic format may be obtained at www.weg.net or you may request WEG a printed copy.

WEG EQUIPAMENTOS ELÉTRICOS S.A.

INDEX

1 INTRODUCTION

This manual is intended to provide the necessary information on synchronous alternators GPW, GPA, GPF, GSW, GSA, GSF models. Alternators with special features can be supplied with specific documents (drawings, wiring diagrams, characteristic curves, etc.). These documents must be carefully studied together with this manual before installing, operating or servicing the alternator.
Contact WEG if it is necessary further explanations. All procedures and standards contained in this manual must be observed in order to ensure the correct operation of the alternator and the safety of the professionals involved in its operation. Observing these procedures is also important to ensure the warranty of the alternator. Thus, we recommend reading this manual thoroughly before installing and operating the alternator. If applicable further information if necessary, contact WEG.

ATTENTION

In case of replacement of the components mentioned in this manual, the manufacturing date must be checked against the manual review date.

1.1 SAFETY WARNINGS IN THE MANUAL

In this manual are used the following safety warnings:

DANGER

Failure to observe the procedures recommended in this warning may result in substantial property damage, serious injury or death.

ATTENTION

Failure to observe the procedures recommended in this warning may result in property damage.

NOTE

The text with this warning is intended to provide important information for the correct understanding and proper operation of the product.

EX

Additional information about alternators for explosive atmospheres.

1.2 TERMINOLOGY

G P W 450

ALTERNATOR SERIES
G - Synchronous Machines for generator groups

EXCITATION CHARACTERISTICS
P - Brushless alternator with auxiliary exciter (PMG)
S - Brushless alternator without auxiliary exciter

COOLING SYSTEM
A - Open self-ventilated
F - Closed with air-air heat exchanger
W - Closed with air-water heat exchanger

FRAME - IEC
450 to 630

2 GENERAL INSTRUCTIONS

Professionals who work with electrical installations, either in their assembly, operation or maintenance, must be continuously updated and informed about safety rules and recommendations concerning the service and are advised to observe them strictly. Before beginning any job, the person in charge must make sure that all the safety measures were properly taken and warn the operators of the dangers inherent to the task performed. Alternators of this kind, if improperly used or poorly serviced, or when service by unqualified people, may cause serious personal injury and/or material damage. Therefore, it is recommended that these services be always performed by qualified people.

2.1 QUALIFIED PEOPLE

The term qualified person means those who, due to their training, experience, education level, knowledge of applicable standards, specifications, safety standards, accident prevention and knowledge of the operating conditions, have been authorized by the people in charge to execute all necessary services, and who are able to recognize and avoid any possible danger. Those qualified people must also know first aid procedures and be able to provide that if necessary. It is assumed that the entire commissioning, maintenance and repair work is made by qualified people only.

2.1.1 Explosive atmospheres

EX

It is recommended that the persons responsible for the application of alternators in hazardous areas be properly trained on their correct application.

2.2 SAFETY INSTRUCTIONS

DANGER

During operation, this equipment has energized or rotating parts exposed, which may present high voltage or high temperatures.
Thus, the operation with terminal boxes open, unprotected couplings, or incorrect operation, disregarding the operating standards, may cause serious injury and property damage.

ATTENTION

When devices and equipment are used outside the industrial environment, the user must ensure the safety of the equipment by adopting proper protection and safety measures during installation (for example, keep people away, avoid contact of children, etc.).

Those responsible for the safety in the installation must ensure that:
- Only qualified people install and operate the equipment;
- Those people have this manual at hand and other documents supplied with the alternator, as well as perform the work strictly observing the service instructions, relevant standards and specific documentation of the products.

ATTENTION

Failure to comply with installation and safety standards may void the product warranty.
Firefighting equipment and first aid notices must be available in visible and easily accessible locations at the work site.

Qualified personnel must also observe:
- All the technical data regarding the allowed applications (operating conditions, connections and installation environment), included in the catalog, in the purchase order documents, in the operating instructions, in manuals and all other documentation;
- The specific regulations and conditions for the local installation;
- The use of suitable tools and equipment for handling and transportation;
- That the protective devices of the individual components are removed shortly before installation.

Individual parts must be stored in vibration-free environments, avoiding falls and ensuring their protection against aggressive agents and/or that they do not jeopardize people.

2.3 GENERATORS APPLIED IN EXPLOSIVE ATMOSPHERES

EX

Alternators specified to operate in hazardous areas have additional safety features, which are defined in specific standards for each kind of hazardous area, according to their classification.

The general requirements for equipment that operate in hazardous areas are described in the following standards:
- **EN/IEC 60079-0** - Electrical Apparatus for Explosive Gas Atmospheres - Part 0: General Requirements;
- **ABNT NBR IEC 60079-0** - Atmosferas Explosivas - Parte 0: Equipamentos - Requisitos Gerais;
- **EN/IEC 60034-1** - Rotating Electrical Machines - Part 1: Rating and Performance;
- **EN/IEC 60079- 2** - Electrical Apparatus for Explosive Gas Atmospheres. Part 2: Pressurized Enclosures 'p';
- **ABNT NBR IEC 60079-2** - Atmosferas Explosivas - Parte 2: Proteção de Equipamento por Invólucro Pressurizado ‘p’;
- **EN/IEC 60079- 7** - Electrical Apparatus for Explosive Gas Atmospheres - Part 7: Increased Safety 'e';
- **ABNT NBR IEC 60079-7** - Atmosferas Explosivas - Parte 7: Proteção de Equipamentos por segurança Aumentada "e";
- **ABNT NBR IEC 60079-11** – Atmosferas Explosivas – Parte 11 - Proteção de equipamento por segurança intrínseca "i";
- **EN/IEC 60079-11** - Explosive atmospheres - Part 11: Equipment protection by intrinsic safety “I”;

- **ABNT NBR IEC 60079-14** – Atmosferas Explosivas – Parte 14 - Seleção e montagem de instalações elétricas;
- **EN/IEC 60079-14** – Electrical apparatus for gas explosive atmospheres – Part 14 – Electrical installation in hazardous areas (others than mines);
- **ABNT NBR IEC 60079-14** – Equipamentos elétricos para atmosferas explosivas – Parte 14 – Instalação elétrica em áreas classificadas (exceto minas);
- **EN/IEC 60079-15** - Explosive Atmospheres - Part 15 - Protection by Type of Protection 'n';
- **ABNT NBR IEC 60079-15** - Equipamentos Elétricos para Atmosferas Explosivas - Parte 15: Construção, Ensaio e Marcação de Equipamentos Elétricos com Tipo de Proteção 'n';
- **EN/IEC 60079-17** - Explosive Atmospheres - Part 17: Electrical Installations Inspection and Maintenance
- **ABNT NBR IEC 60079-17** - Atmosferas Explosivas - Parte 17: Inspeção e Manutenção de Instalações Elétricas;
- **EN/IEC 60079-19** - Explosive atmospheres - Part 19: Equipment repair, overhaul and reclamation.
- **ABNT NBR IEC 60079-19** – Atmosferas Explosivas – Parte 19 - Revisão e recuperação de equipamentos.

2.4 STANDARDS

Alternators are specified, designed, manufactured and tested according to the following standards:

Table 2.1: Applicable Standards

	IEC	NBR	ISO
Specification	60034-1	5117	
Dimensions	60072	5432	
Tests	60034-4	5052	
Degree of protection	60034-5	9884	
Cooling	60034-6	5110	
Mounting	60034-7	5031	
Noise	60034-14	5117	8528

2.5 ENVIRONMENT

In accordance with IEC-60034.1, and ABNT 5117, the ambient operating conditions for which the alternators were designed are as follows:

1. Ambient temperature: – 15 ºC to + 40 ºC;
2. Altitude (m.a.s.l.): up to 1000 m;
3. Environments according to the degree of protection of the alternator.

Special environment conditions are described on the nameplate and specific data sheet of the alternator.

ATTENTION

In order to use water-cooled alternators at temperatures below 0 °C, antifreeze additives must be used in the water.

2.5.1 Aggressive and/or sea environments

The standard industrial alternator should not be used in aggressive environments, since this will be subject to weather action that can cause corrosion of mechanical parts and a decrease in insulation resistance of the coils and as a result, the alternator burning. In these situations, WEG is not liable for damage that may occur in the alternator, not characterizing the product warranty as the warranty certificate of WEG.

2.6 OPERATING CONDITIONS

For the warranty of the product to be valid, the alternator must operate according to the rated data, follow applicable standards and codes and the information contained herein.

2.6.1 Application in explosive atmosphere

EX

The application of alternators in explosive atmospheres is only allowed when they were designed, built and certified for such application.

2.6.2 Special application conditions

EX

The "X" symbol next to the certificate number, informed on the alternator nameplate, indicates that it requires special installation, application and/or maintenance conditions, which are described in the Conformity Certificate.
For reference, the conformance certificate is provided with this manual.
Failure to comply with these requirements jeopardizes the safety of the product and of the installation.

3 RECEIVING, STORAGE AND HANDLING

3.1 RECEIVING

All alternators are tested and are supplied in proper operating condition. The machined surfaces are protected against corrosion. The package must be inspected immediately upon receipt so as to check whether it suffered any damage during transport.

ATTENTION

Any damage must be photographed, documented and reported immediately to the carrier, the insurer and WEG. Failure to observe this procedure will void the warranty.

ATTENTION

Parts supplied in additional packs must be checked upon receipt.

- When lifting the package, observe the proper lifting points, the weight stated in the documentation and / or on the nameplate, as well as the capacity and operation of the lifting devices;
- Alternators packed in wooden crates must always be raised by their own eyebolts or by a proper forklift, but never by the wood;
- The package can never be overturned. Place it on the ground carefully (without impacts) to avoid damage to the bearings;
- Do not remove the grease protections against corrosion from the shaft end, coupling discs and flange, or the plugs closing the holes of the terminal box;
- These protections must remain in place until the moment of the final assembly. After unpacking, you must perform a complete visual inspection on the alternator;
- The shaft locking system must be removed just before the installation and stored in a safe place to be used in a future transportation of the alternator.

3.1.1 Additional Precautions

EX

In order to ensure the protection degree, the terminal box must be kept closed. Before putting the alternator into operation, check the cleanliness and moisture conditions inside the terminal box.

3.2 STORAGE

Any damage to the paint or protection against rust of the machined parts must be corrected.

ATTENTION

During storage, the space heaters (if applicable) must remain connected to prevent water condensation inside the alternator.

3.2.1 Storage in sheltered environment

If the alternator is not installed immediately upon receipt, it must remain in the package and stored in a place protected from moisture, steam, rapid temperature changes, rodents, insects and other agents that may damage the machine.
For the bearings not to be damaged, the alternator must be stored in places free from vibration.

3.2.2 Storage in unprotected environment

The alternator should be stored in a dry place, free from floods and vibration.
Repair any damage in the package before storing the alternator, which is needed to ensure proper storage conditions.
Position the alternator on platforms or foundations that ensure protection against soil moisture and prevent it from sinking into the ground. It must be ensured free air circulation underneath the alternator.
The cover or canvas used to protect the alternator against the weather must not be in contact with its surfaces. To ensure the free air circulation between the alternator and such covers, use wooden blocks as spacers.

3.2.3 Extended storage

When the alternator is stored, the empty spaces inside it, in the bearings, in the terminal box and windings are exposed to air humidity, which can condense.
Depending on the type and degree of air pollution, also aggressive substances can penetrate these empty spaces.
As a result, after prolonged storage, the resistance of the winding insulation can fall below the acceptable values.
Internal components, such as bearings, may oxidize and the lubrication capacity of the lubricant may be affected.
All these influences increase the risk of damage before the operation of the alternator.

ATTENTION

To avoid losing the warranty of the alternator, it must be ensured that all preventive measures described in this manual are observed and recorded.

The instructions outlined below are valid for alternators that are stored for long periods and/or are out of operation for a period of two months or more.

3.2.3.1 Storage location

To ensure the best storage conditions of the alternator for long periods, the location must comply strictly with the criteria described below.

3.2.3.1.1 Storage in sheltered environment

- The environment must be closed and covered;
- The local must be protected against moisture, vapors, aggressive agents, rodents and insects;
- There can't be the presence of corrosive gases such as chlorine, sulfur dioxide or acids;
- The environment must be free of continuous or intermittent vibration;
- The environment must feature ventilation system with air filter;
- Ambient temperature between 5 °C and 60 °C, seeing that sudden temperature variations must not occur;
- Air relative humidity < 50%;
- Feature a dirt and dust prevention system;
- Feature fire detection system;
- It must be provided with electricity to supply the space heaters (if applicable).

If applicable of these requirements is not met in the storage place, WEG suggests that additional protections be incorporated to the package of the alternator during the storage period, as follows:

- Closed wooden box or similar package with electrical wiring that allows the space heaters (if applicable) to be energized;
- If there is a risk of infestation and fungus formation, the package must be protected in the storage place by spraying it or painting it with appropriate chemicals;
- The preparation of the package must be done carefully by a qualified person.

3.2.3.1.2 Unprotected storage environment

It is not recommended to store the alternator in an unprotected place.
If the storage in unprotected environment cannot be avoided, the alternator must be packed in specific package for this condition, as follows:

- For storage in unprotected environment, besides the recommended package for internal storage, the package must be covered with a protection against dust, moisture and other foreign materials, using for this purpose a piece of canvas or sturdy plastic;
- Place the package on platforms or foundations that ensure protection against moisture and prevent it from sinking into the ground;
- Once the alternator is covered, a shelter should be erected to protect it from direct rain, snow or excessive heat from the sun.

ATTENTION

If the alternator is kept in storage for long periods, it is recommended to regularly inspect it as specified in item 3.2.3.13 of this manual.

3.2.3.2 Parts

- If parts are supplied separately (terminal boxes, covers, etc.), these parts must be packed as specified in items 3.2.3.1.1 and 3.2.3.1.2;
- The air relative humidity inside the package must not exceed 50%;
- The bearings must not be subject to shocks, falls or storage with vibration or humidity, which can cause dents on the internal tracks or on the balls, reducing the useful life.

3.2.3.3 Space heaters

The space heaters of the alternator (if applicable) must remain energized during the storage period so as to avoid moisture condensation inside the alternator and thus ensure that the winding insulation resistance remains at acceptable levels.

3.2.3.4 Insulation resistance

During the storage period, the stator, rotor and exciter winding insulation resistance of the alternator must be measured and recorded every three months and prior to the installation of the alternator.
Any drop in the value of the insulation resistance must be investigated.

3.2.3.5 Exposed machined surfaces

All exposed machined surfaces (for example, shaft end, flange, coupling disk) are protected at the factory with a temporary protective agent (rust inhibitor).
This protective coating must be reapplied at least every 6 months or when it is removed and/or damaged.
Recommended Product:
Name: Anticorit BW protective oil, Manufacturer: Fuchs

3.2.3.6 Bearings

The rolling bearings are lubricated at the factory for testing.
During the storage period, every two months the locking device must be removed from the shaft and the shaft rotated manually to keep the good conditions of the bearing. After 6 months of storage and before start-up, the rolling bearings must be relubricated. If the alternator is kept in storage for over two years, the rolling bearings must be cleaned, inspected and relubricated so as to ensure their integrity.

ATTENTION

If you cannot turn the shaft of the alternator, as recommended, check the conditions of the rolling bearing before the commissioning of the alternator.

3.2.3.7 Terminal box

When the alternator winding insulation resistance is measured, the main terminal box and the other terminal boxes must be inspected, considering especially the following aspects:

- The inside must be dry, clean and free of dust accumulation;
- The contacts cannot present corrosion;
- The seals must be in proper conditions;
- The cable inputs must be properly sealed according to the machine degree of protection.

If applicable of these items is not correct, the parts must be cleaned or replaced.

3.2.3.8 Inspections and records during storage

Stored alternators must be periodically inspected and inspection records must be filed.
The following points must be inspected:
1. Physical damages;
2. Cleanliness;
3. Signs of water condensation;
4. Conditions of the protective coating of the machined parts;
5. Paint conditions;
6. Signs of worms or insect action;
7. Satisfactory operation of space heaters (if any). It is recommended that a signaling system or alarm be installed in the location in order to detect power interruption in the space heaters;
8. It is recommended to record the ambient temperature and air relative humidity around the machine, winding temperature, insulation resistance and polarization index;
9. The storage location must also be inspected so as to ensure its compliance with the criteria described in the item 3.2.3.1.

3.2.3.9 Preparation for commissioning

3.2.3.9.1 Cleaning

- Alternator inner and outer parts must be free of oil, water, dust and dirt;
- Remove the rust inhibitor from the exposed surfaces with a cloth damped in a petroleum-based solvent;
- Make sure the bearings and cavities used for lubrication are free of dirt and the cavity plugs are correctly sealed and tightened. Oxidations and marks on the bearings and shaft seats should be carefully removed.

3.2.3.9.2 Bearing lubrication

Use the specified lubricant to lubricate the bearing.
The information on bearings and lubricants, as well as the procedure for lubrication, are described in item 0 of this manual.

3.2.3.9.3 Checking the insulation resistance

ATTENTION

Before operating the alternator, the insulation resistance must be measured according to the item “Insulation resistance” of this manual.

3.2.3.10 Cooling system

For water-cooled alternators, if they remain out of operation for a long time, it must be ensured the water runs freely in the alternator cooling circuit before starting it again.

3.2.3.11 Air-water heat exchanger

- When starting the motor, ensure that the water circulates freely through the radiator;
- The radiator bolts should be tightened with torques of 40 to 50Nm;
- Make sure that there is no water leakage. Check the radiator gaskets, and replace if necessary;
- Check the heat exchanger sealing rubbers and replace them if necessary.

3.2.3.12 Others

Follow the other procedures described in the item 5 in this manual before performing the start-up of the alternator.

3.2.3.13 Maintenance Plan during storage

During the storage period, the alternator maintenance must be performed and recorded according to the plan described in Table 3.1.

Table 3.1: Storage plan

	Monthly	Every two months	Every six months	Every two years	Before commissioning	NOTE
Storage location						
Inspect the cleaning conditions		X			X	
Inspect the humidity and temperature conditions		X				
Check signals of aggressive agents		X				
Package						
Inspect physical damage			X			
Inspect relative humidity inside		X				
Change the dehumidifier in the package (if any)			X			Whenever necessary
Space heaters						
Check the operating conditions	X					
Complete alternator						
Perform external cleaning			X		X	
Perform internal cleaning					X	
Check the paint conditions			X			
Check the oxidation inhibitor on exposed parts			X			Replace the inhibitor, if necessary
Windings						
Measure the insulation resistance		X			X	
Measure polarization index		X			X	
Terminal boxes and ground terminals						
Clean the inside of the terminal boxes				X	X	
Inspect the seals				X	X	
Tighten the terminal connections					X	in accordance with tightening torque informed in this manual
Bearings						
Turn the shaft of the alternator		X				
Relubricate the bearing			X		X	
Disassemble, clean, inspect and relubricate the bearing				X	X	If the storage period is longer than 2 years

3.3 HANDLING

Proper handling

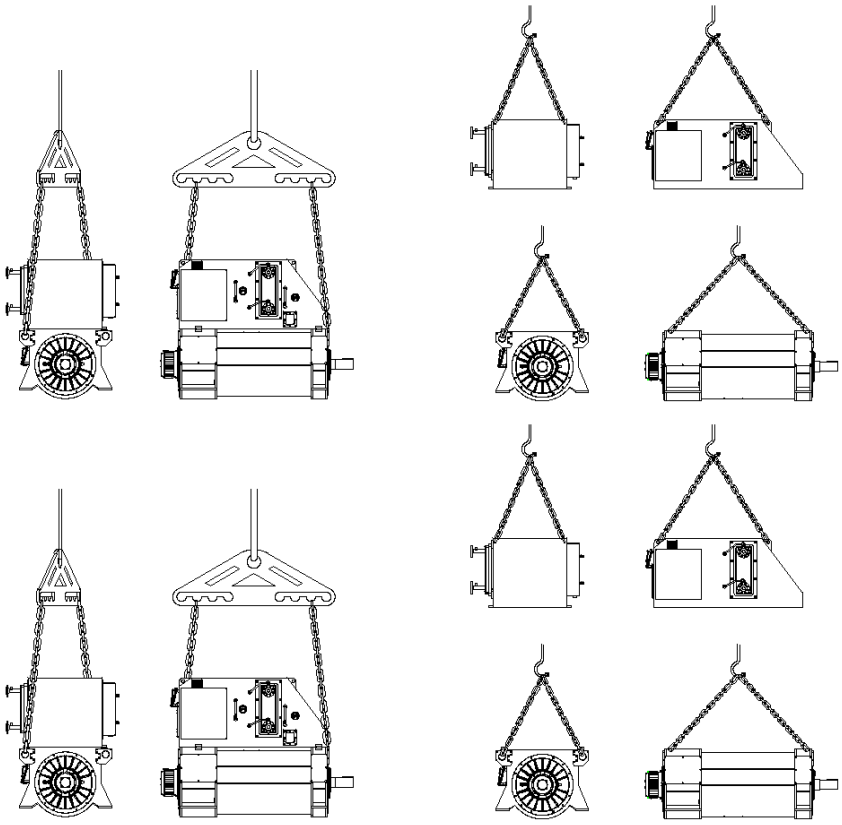


Figure 3.1: Proper handling

Improper handling

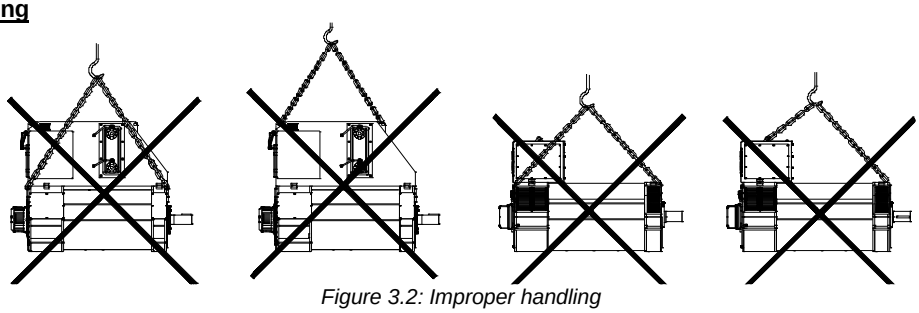


Figure 3.2: Improper handling

- The alternator was designed with eyebolts for lifting. These eyebolts are designed to lift only the alternator; additional loads are not permitted;
- Cables and lifting devices must be appropriate.

NOTES

- Observe the weight informed.
- Do not lift and do not put the alternator on the ground suddenly to avoid damage to the bearings.
- To lift the alternator, use only the existing eyebolts. If you necessary, use a beam to protect parts of the alternator.
- The eyebolts on the covers, bearings, terminal box, etc., are intended to handle these components only.
- Never use the shaft to lift the alternator.
- To move the alternator, the shaft must be locked with the locking device supplied with the alternator.

ATTENTION

Steel cables, clevises and lifting equipment must be appropriate and able to withstand the weight of the alternator so as to avoid accidents, damage to the alternator and injuries.

4 INSTALLATION

4.1 INSTALLATION LOCATION

The alternator must be installed in easily accessible locations, which allow the execution of periodic inspections, local maintenance and, if necessary, the removal of the alternator for external services.
The following environmental features must be provided:

- The alternator must receive fresh and clean air and the location must allow the easy exhaust of the air from the operating environment, preventing air recirculation;
- The alternator must not aspire the exhaust from the diesel engine, because soot is an electric conductor and shortens the life of the insulation, which can cause the burning of the alternator;
- The installation of other equipment or walls must not hinder or obstruct the ventilation of the alternator;
- There must be space enough around and above the alternator for servicing or handling it;
- The environment must comply with the alternator degree of protection.

NOTE
The shaft-locking device (used to protect the rotor/stator against damage during transportation) must only be removed right before coupling it to the driving machine.

4.2 DIRECTION OF ROTATION

Alternators can operate in both directions of rotation.
The phase sequence is set ***clockwise rotation*** (facing the shaft end of the alternator - drive end).
The alternator terminals are marked in such a way that the sequence of the terminals U, V and W matches the phase sequence R, S and T or L1, L2 and L3, when the rotation is clockwise.
In the case of alternators that need to operate in the **counterclockwise** direction, the phase sequence must be changed (if required). It is recommended to check the direction of rotation and phase sequence required before the start-up of the alternator.

ATTENTION
Wrong phase sequence may cause damage to the equipment supplied by the alternator. In the case of operation in parallel with other alternators and/or network, they must have the same phase sequence.

4.3 DEGREE OF PROTECTION

It is essential to observe the degree of protection of the alternator in relation to the installation environment so as to ensure the proper performance and long life of the equipment.

4.4 COOLING

Open alternators

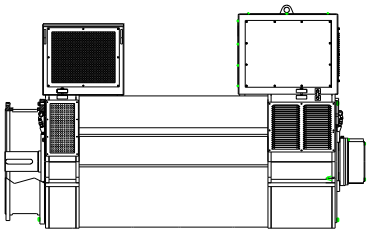


Figure 4.1: IC01 Cooling

Open alternators are cooled by the internal fan.

Closed alternators

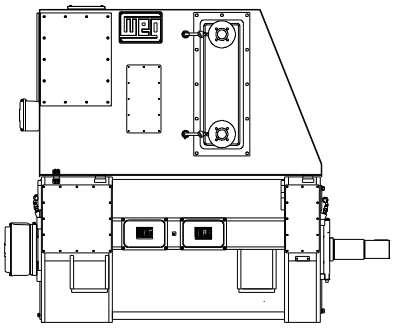


Figure 4.2: IC81W Cooling

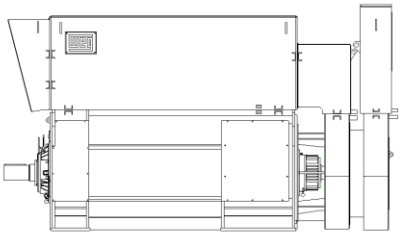


Figure 4.3: IC611 Cooling

Closed alternators are cooled through the air-water heat exchanger (IC81W) or air-air heat exchanger (IC611). The water supply system for alternators IC81W must be installed by the user, meeting the characteristics of the heat exchanger nameplate.

ATTENTION

- In order to ensure the proper operation and prevent the overheating of the alternator, the data of the cooling system informed on the nameplate must be strictly observed;
- Water or air inputs and outputs must not be blocked in order to prevent overheating and even the burning of the alternator.

4.4.1 Characteristics of the cooling water

Always use treated industrial water with the following characteristics:

- ph: 7.0 to 8;
- Chlorides: < 50 ppm;
- Iron content: < 0.3 ppm
- Hardness: < 150 ppm
- Alkalinity: < 200 ppm
- Conductivity: < 400 µS/cm;
- Sulfate: < 50 ppm;
- Nitrate: < 10 ppm;
- Ammonia: < 10 ppm;
- Maximum size of charged particles in the water: ≤ 0.1mm.

ATTENTION

For cooling the alternator, a closed-circuit water system must be used, and the water must meet the characteristics specified in item above.
Add additives to the cooling water in proper quantities for protection against corrosion and seaweed growth. The type and number of additives used must be specified by the manufacturer of these additives and in accordance with the environmental conditions where the alternator is installed.
In order to use the alternator in environments with temperatures below 0 ºC, glycol-based antifreeze additives must be added to the cooling water.

NOTE

In vertically mounted radiators, the water inlet must always be at the bottom and the water outlet at the top of the radiator.

4.4.2 Heat exchangers for applications with sea water

ATTENTION

In the case of heat exchangers for applications with seawater, the materials in contact with water (pipes and mirrors) must be resistant to corrosion.
Furthermore, the heat exchangers may be fitted with sacrificial anodes (for example, zinc or magnesium), as shown in Figure 4.4. In this application, the anodes are corroded during operation, protecting the heads of the exchanger.
In order to maintain the integrity of the heat exchanger heads, these anodes must be replaced periodically according to the corrosion rate appears presented.

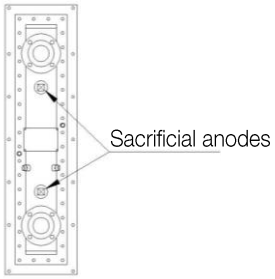


Figure 4.4: Heat exchanger with sacrificial anodes

NOTE

The type, quantity and position of the sacrificial anodes may vary from application to application.

4.4.3 Cooling water temperature

Alternators cooled by air-water heat exchangers are able to operate with a temperature of the cooling water in the input as specified in the project and informed on the heat exchanger nameplate.

4.4.4 Protective devices

The protective devices of the cooling system must be monitored periodically as described in the item 4.6 of this manual.

4.5 INSULATION RESISTANCE

4.5.1 Safety instructions

DANGER

Before measuring the insulation resistance, the alternator must be stopped and disconnected from the charge and the voltage regulator disconnected.
The winding being tested must be connected to the frame and to the ground for a period until removing the residual electrostatic charge.
Failure to observe these procedures may result in personal injury.

4.5.2 General considerations

When the alternator is not immediately put into operation, it must be protected against moisture, high temperature and dirt, thus avoiding damages to the insulation.
The insulation resistance of the windings is measured before commissioning.
If the environment is too humid, it is necessary to check it periodically during storage. It is difficult to determine rules for the real value of the insulation resistance of a machine, since it varies with environmental conditions (temperature, humidity), conditions of machine cleaning (dust, oil, grease, dirt) and quality and conditions the insulating material used.
The assessment of the periodic monitoring records is useful to conclude whether the alternator is able to operate.

NOTE

The insulation resistance must be measured using a MEGOHMMETER.

4.5.3 Measuring the stator winding

The test voltage for the stator windings of the alternator must be as per Table 4.1 in accordance with standard IEEE43.

Table 4.1: Voltage for measuring the insulation resistance

Rated voltage of the winding (V)	Insulation resistance test Continuous voltage (V)
< 1000	500
1000 - 2500	500 -1000
2501 - 5000	1000 - 2500
5001 - 12000	2500 - 5000
> 12000	5000 - 10000

Before making the measurement on the stator winding, check the following:

- If all cables are disconnected from the charge;
- If the voltage regulator is disconnected.
- If the alternator frame and the windings not measured are grounded;
- If the temperature of the winding was measured;
- If all temperature sensors are grounded.

The measurement of the insulation resistance of the stator windings must be done in the main terminal box. The meter (megohmmeter) must be connected between the alternator frame and the winding. The frame must be grounded and the three phases of the stator winding remain connected to the neuter point, as shown below:

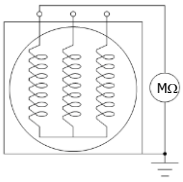


Figure 4.5: Measurement on the three phases

When possible, each phase must be isolated and tested separately. The separate test allows a comparison between the phases. When a phase is tested, the other two phases must be grounded on the same ground of the frame, as shown below.

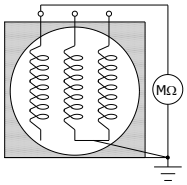


Figure 4.6: Measurement in separate phases

4.5.4 Measurement on the winding of the rotor, exciter and accessories

Measurement on the rotor winding:

- Disconnect the cables of the rotor from the diode cluster;
- Connect the insulation resistance meter (megohmmeter) between the rotor winding and the shaft of the alternator. The measurement current cannot pass through the bearings.

Measurement of the stator winding of the main exciter.

- Disconnect the power cables from the exciter;
- Connect the insulation resistance meter (megohmmeter) between the exciter stator winding and the alternator frame.

Measurement on the rotor winding of the main exciter.

- Disconnect the cables of the exciter rotor from the diode cluster;
- Connect the insulation resistance meter (megohmmeter) between the rotor winding and the shaft of the alternator. The measurement current cannot pass through the bearings.

Measurement of the stator winding of the auxiliary exciter (PMG) - alternators model GP-:

- Disconnect the cables that connect the auxiliary exciter to the voltage regulator;
- Connect the insulation resistance meter (megohmmeter) between the stator winding of the auxiliary exciter and the alternator frame.

ATTENTION

The test voltage for the rotor, main exciter, auxiliary exciter and space heaters must be 500 Vdc and 100 Vdc for other accessories. It is not recommended to measure the insulation resistance of thermal protectors.

On machines that are already in operation, higher values of insulation resistance can be measured, compared to the initial values of commissioning.
The comparison with values obtained in previous tests on the same machine, in similar load, temperature and humidity conditions is as a better indication of the insulation conditions than the value obtained in a single test, seeing that any sudden reduction is considered suspicious.

Table 4.2: Referential limits of the insulation resistance in electrical machines

Insulation resistance value	Insulation assessment
2 MΩ or lower	Dangerous
< 50 MΩ	Bad
50...100 MΩ	Regular
100...500 MΩ	Good
500...1000 MΩ	Very Good
> 1000 MΩ	Excellent

4.5.5 Minimum insulation resistance

- If the measured insulation resistance is below 100 MΩ at 40 ° C, the windings must be carefully inspected and cleaned or, if necessary, dried according to the following procedure before the machine goes into operation:
- Disassemble the alternator by removing the rotor and bearings;
- Place the components that have the winding with low insulation resistance in an industrial oven and heat it up to a temperature of 130 °C and keep this temperature for at least 08 hours.
- Check if the insulation resistance achieved is within the acceptable values, in accordance with Table 4.2, otherwise contact WEG.

4.5.6 Conversion of the measured values

The insulation resistance measured on the windings shall be converted to 40 ° C using the correction factor provided in Figure 4.7 (IEEE43 standard) and applying the following formula:

$$R_C = Kt \, . \, Rt$$

Where:
R40 = referred insulation resistance at 40 ° C
Kt = Insulation resistance correction factor as a function of temperature, as shown in Figure 4.7;
Rt = measured insulation resistance.

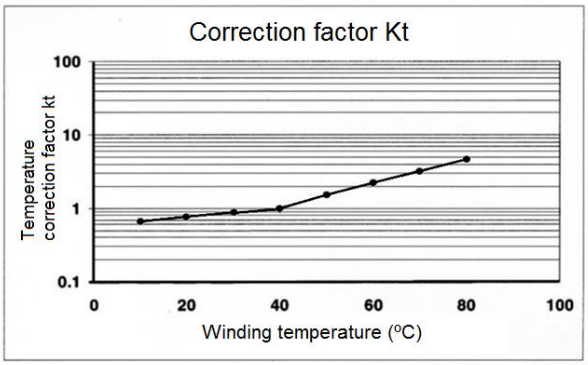


Figure 4.7: Insulation resistance correction factor due to temperature

The values used to generate the curve of Figure 4.7 are shown in Table 4.1.

Table 4.1: Correction factors (Kt) due to temperature

t (ºC)	Correction factors kt
10	0,7
20	0,8
30	0,9
40	1,0
50	1,5
60	2,3
70	3,3
80	4,6

4.5.7 Polarization Index (P.I.)

The polarization index is defined by the ratio between the insulation resistance measured in 10 minutes and the insulation resistance measured in 1 minute. This measurement procedure is always carried out at relatively constant temperatures.
The polarization index allows the assessment of the alternator insulation conditions.

DANGER

In order to avoid accidents, the winding must be grounded immediately after measuring the insulation resistance.

4.5.8 Recommended Minimum Values

According to IEEE-43 Standard, the recommended minimum values for winding insulation resistance (R.I.) and Polarization Index (I.P.) are shown in Table 4.3:

Table 4.2: Minimum R.I. e I.P values

Winding voltage	Minimum R.I. (converted to 40ºC)	Minimum I.P.
Up to 1000 V	5 MΩ	Not applicable
Greater than 1000 V	100 MΩ	2

4.6 PROTECTIONS

4.6.1 Protections – explosive atmospheres

Protection devices for explosive atmosphere alternators must always remain switched on and adjusted according to EN 60079-14, DIN VDE0165 and NBR5410 standards. If not indicated otherwise, the alternators are designed for S1 duty (continuous). All protections, including those for overcurrent, must be set based on the alternator rated conditions. This protection must also protect the alternator in case of short-circuit (i.e., in case of locked rotor). Windings in delta (Δ) connection must be protected against phase loss. To do so, connect the relay in series with the winding phases and set it for 0.58 times the rated current. All the winding and bearing protections must always be on and adjusted correctly.
Heavy starts Ex-eb: alternators that will be submitted to conditions with acceleration time > 1.7 x tE time must be protected with an overcurrent protection device as the indications in the certificate of conformity.

EX

For explosive atmosphere alternators, the maximum tripping time of the protection device must not, in case of overload or locked rotor, exceed the time indicated in the certificate of conformity and the t_E time indicated on the alternator nameplate.

4.6.2 Thermal protections

The alternators have protection devices against temperature rise, installed on the main stator coils and bearings, as follows:
Thermoresistance (RTD) - It is a calibrated resistance element. Its operation is based on the principle that the electrical resistance of a metallic conductor varies linearly with temperature. The terminals of the detector must be connected to a control panel, which includes a temperature meter.

NOTE

The RTD-type thermoresistance allows monitoring the absolute temperature. With this information, the relay can perform the reading of the temperature, as well as the parameterization for alarm and shutdown according to the preset temperatures.

The following formula is used to convert into temperature the value of the ohmic resistance measured by the thermoresistance type Pt 100.

$$\text{Formula: } \frac{\Omega - 100}{0{,}386} = ºC$$

Where: Ω = ohmic resistance measured on the PT-100
The protective devices, when requested, are listed in the specific wiring diagram of each alternator. Failure in using these devices is the user's sole responsibility, and may result in loss of warranty in case of damage.

4.6.2.1 Temperature limits for the windings

The temperature of the hottest spot of the winding must be kept below the limit of insulation thermal class. The total temperature is composed of the ambient temperature with the temperature rise (T), plus the difference between the average temperature of the winding and the hottest spot of the winding. The ambient temperature is typically at most 40 °C. Above this value, the working conditions are considered special.
Table 4.3 shows the numerical values and the composition of the acceptable temperature of the hottest spot of the winding for insulation classes F and H.

Table 4.3: Insulation class

Insulation class		F	H
Ambient temperature	°C	40	40
T = temperature rise (resistance method)	°C	105	125
Difference between the hottest spot and the average temperature	°C	10	15
Total: temperature of the hottest point	°C	155	180

ATTENTION

If the alternator operates with winding temperatures above the limits of the thermal class, the life of the insulation and hence of the alternator is reduced substantially, or it may even burn.

4.6.2.2 Thermal protections for the bearings

The temperature sensors installed on the bearings are intended to protect them from damage due to operation with over temperature.

4.6.2.3 Alarm and shutdown temperatures

The alarm and shutdown temperatures must be set as low as possible. These temperatures can be determined based on the results of tests or through the alternator operating temperature. The alarm temperature can be set at 10 °C above the alternator operating temperature at full load considering the highest ambient temperature of the local.

ATTENTION

The alarm and trip values may be determined as a result of experience, but they must not exceed the values indicated in the alternator wiring diagram.

ATTENTION

The alternator protection devices are listed in the WEG drawing – Wiring diagram. Not using these devices is the sole responsibility of the user and, in case of damage to the alternator, it will void the warranty.

4.6.3 Space heater

The space heater used to prevent condensation of water during long periods without operation must be programmed to be always energized after the shutdown of the alternator and to be de-energized before the alternator goes into operation.
The dimensional drawing and a specific nameplate on the alternator indicate the supply voltage and the power of the installed space heaters.

ATTENTION

If the space heaters remain energized while the machine is in operation, the winding may be damaged.

4.6.4 Diode protection

The rotating diodes bridge of the main exciter has an varistor installed to protect against overvoltage and/or voltage surge. In case of failure of these components, they must be replaced.

4.6.5 Protections on the voltage regulator

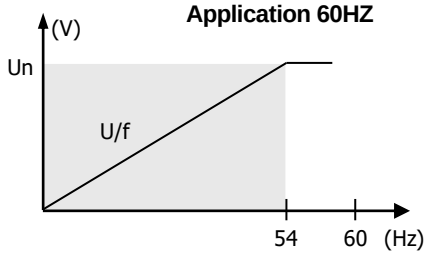
4.6.5.1 Protection against underfrequency

In order to put the alternator into operation, the protection against underfrequency of the voltage regulator must be set at 90% of the rated frequency (it comes set from the factory) or the voltage regulator must remain turned off until the group reaches the rated speed, avoiding excitation overcurrent of the alternator.

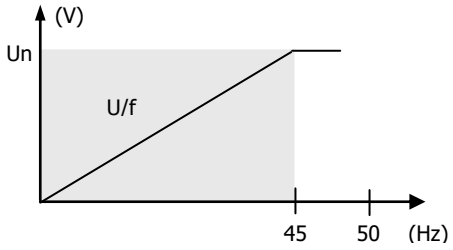
NOTE

The other protections of the voltage regulator are described in its specific manual.

Application 60HZ



Application 50HZ



4.7 VOLTAGE REGULATOR

The electronic voltage regulator is designed to keep the voltage of the alternator constant regardless the load.
It may be assembled in the terminal box of the alternator or on the control panel.

ATTENTION

Check, in the Manual of the voltage regulator, the connecting terminals, the wiring diagram and the setting parameters.
A wrong connection may cause the burning of the regulator and/or the alternator windings.
Defects caused by this reason are not covered by the warranty.

For further technical details on operation, functions, connections, settings, anomalies, etc., refer to the voltage regulator specific manual.

4.8 AUXILIARY EXCITER

WEG alternators GP_ model are manufactured with the auxiliary exciter mounted in its back, which is responsible for feeding the power circuit of the voltage regulator and keeping the power supply of the voltage regulator, even in case of short circuit on bus.

NOTE

Because the alternator maintains high SCC, an overcurrent relay must be installed to open the main breaker in no more than 20 s, under penalty of burning the alternator.

4.9 ELECTRICAL ASPECTS

4.9.1 Electrical connections

The alternator electrical connections are responsibility of the end user and must be carried out by qualified people.
The connection diagrams are provided along with the technical documentation of the alternator.

4.9.1.1 Main connection

The location of stator terminal box is identified in the specific alternator DIMENSIONAL DRAWING.
Make sure the cross section and insulation of the main connection cables are suitable for the alternator current and voltage.
The alternator must rotate in the rotation direction specified on the nameplate and on the sign arrow affixed to the alternator drive end.

NOTE

The rotation direction is, by convention, determined looking to the shaft end at the alternator drive end.
Alternators with a single rotation direction must only rotate in the indicated direction.
In order to operate the alternator in the rotation direction opposite to the specified, consult WEG.

ATTENTION

Before making the connections between the alternator and the power supply, it is necessary to perform a careful measurement of the winding insulation resistance.

4.9.1.2 Grounding

The alternators must always be grounded with a cable of proper section by using the terminal located in one of its feet.

4.9.1.3 Electronic voltage regulator

The electronic voltage regulator must be correctly adjusted before operating the alternator.
In order to change the connections or settings, refer to the voltage regulator manual.

ATTENTION

In order to change the operating frequency of the voltage regulator, refer to its manual.

4.9.1.4 Additional information

EX

Alternators for explosive atmospheres must be fitted with proper cable lugs and spring washers. Observe the minimum isolation distance between the cables during the connection.
Before closing the terminal box, make sure that all nuts on the terminals and the ground connections are well tightened and that all the seals, including the certified ones, of the cable outlets are in perfect conditions and correctly installed.
The wire gauge of the connection cables must be in accordance with the alternator documentation.
Cable inlets not used in the terminal box must be properly closed with certified plugs, according to the protection type for the hazardous area, the EPL (equipment protection level, according to IEC 60079-0 and 60079-14 standards) and the degree of protection indicated on the alternator nameplate.
Main connection cable inlets, as well as those for control, must use components (cable glands, conduits, etc.) that comply with the standards and regulations in force in each country.

EX

Check the rated characteristics on the alternator nameplate.
Dimension the power cables according to the alternator rated current, considering the environmental factors (such as ambient temperature, type of installation, etc.).

4.9.1.5 Terminal identification

The identification of the alternator and accessory terminals is provided in the specific wiring diagram of each alternator.

4.9.1.6 Electrical connection of the voltage regulator

- In order to perform correctly the electrical connections of the alternator to the voltage regulator, refer to the manual of the voltage regulator.
- The model of the used voltage regulator depends on the characteristics of the alternator and the desired application. Therefore, the electrical connections to the alternator and the identification of the terminals may differ from one model to another.

4.9.2 Accessories

4.9.2.1 Excitation and sensing

- The auxiliary exciter (PMG) provides AC voltage to supply the power circuit of the voltage regulator, which is responsible for rectifying and controlling the excitation of the alternator.
- The voltage regulator responds to the voltage signal of the sensing transformer, connected to the stator terminals of the alternator by controlling the excitation voltage and keeping constant the alternator voltage.

4.9.2.2 Parallel operation

- For two or more alternators operate in parallel, the voltage regulator should be able to control or allow the reactive control (VAR) during operation.
- Is necessary a current transformer (paralleling CT) for the voltage regulator control the reactive power. This paralleling circuit is necessary to control the reactive power flow between the alternators connected in parallel.

4.9.2.3 Differential protection

- Current transformers (CTs) for differential protection (when supplied) are installed in the neutral of the alternator. The signal from the secondary of these transformers must feeding the differential protection relay, comparing with the CTs installed on phases of the alternator or on the control panel and protection of the generation system.
  The secondary of these CTs must have the same characteristics.

ATTENTION

Should ensure that all CTs are correctly connected to the system or with the secondary short-circuited when the alternator go into operation.

4.10 ADDITIONAL COMPONENTS

EX

Any component added to the alternator by the user, such as cable glands, plugs, encoders, etc., must comply with the type of enclosure protection, the “equipment protection level” (EPL) and the protection degree of the alternator, according to the standards indicated on the product certificate.

4.11 MECHANICAL ASPECTS

4.11.1 Bases and foundations

- The dimensioning of the bases must be performed to confer rigidity to the structure, avoiding amplification of the vibration levels of the set. The base must have a flat surface against the feet of the alternator in order to prevent deformations on the frame.
- The base must always be leveled in relation to the ground (floor). The leveling is obtained by placing shims between the base and the floor.
- The shims for leveling must cover at least 80% of the surface area of contact with the feet.
- The material of the leveling shims must provide the same rigidity of the basis.

4.11.2 Alignment and leveling

The alternator must be perfectly aligned with the driving machine, especially in cases of direct coupling

ATTENTION

An incorrect alignment may damage the bearings, cause vibration and break the shaft.

The alternator must be correctly aligned with the driving, especially in cases of direct coupling.
The alignment must be done according to the recommendations of the coupling manufacturer.
It is necessary to make the parallel and angular alignment of the alternator, as shown in Figure 4.8 and Figure 4.9.

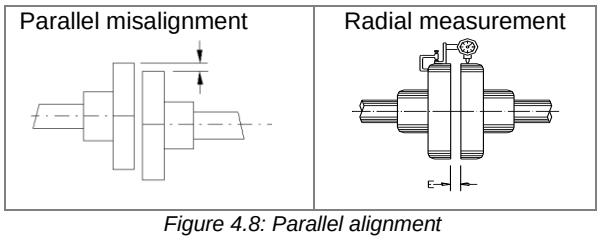


Figure 4.8: Parallel alignment

Figure 4.8 shows the parallel misalignment of the two shaft ends and the practical way to measure it by using suitable dial gauges. The measurement is made in four points at 90º, with the two half-couplings rotating together so as to eliminate the effects of surface irregularities on the dial gauge contact surface. Choosing the upper vertical point 0º, half the difference of the dial gauge measurement in points 0º and 180 represents the vertical coaxial error. This must be properly corrected by adding or removing shims. Half the difference of the dial gauge measurement in points 90° and 270° represents the horizontal coaxial error. Thus, we get an indication of how much it is necessary to raise or lower the alternator or move it to the right or left on the drive end in order to eliminate the coaxial error. Half the difference of the dial gauge measurement in a full revolution represents the maximum eccentricity. **The maximum acceptable eccentricity for rigid or semi-flexible coupling is 0.03 mm.** Where flexible couplings are used, higher values than those aforementioned are acceptable, but they must not exceed the value given by the coupling manufacturer. It is recommended to keep a safety margin in these values.

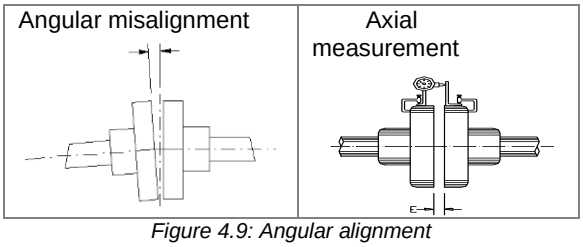


Figure 4.9: Angular alignment

Figure 4.9 shows the angular misalignment and the practical way of measuring it. The measurement is made in four points at 90º, with the two half-couplings rotating together so as to eliminate the effects of surface irregularities on the dial gauge contact surface. Choosing the upper vertical point 0º, half the difference of the dial gauge measurement in points 0º and 180º represents the vertical misalignment. This must be properly corrected by adding or removing shims.
Half the difference of the dial gauge measurement in points 90° and 270° represents the horizontal misalignment. This must be properly corrected with the lateral/angular movements of the alternator.
Half the maximum difference of the dial gauge measurement in a full revolution represents the maximum angular misalignment. **The maximum acceptable misalignment for rigid or semi-flexible coupling is 0.03 mm.** Where flexible couplings are used, higher values than those aforementioned are acceptable, but they must not exceed the value given by the coupling manufacturer.
It is recommended to keep a safety margin for these values. In alignment/leveling, it is important to consider the effect of temperature of the alternator and of the driving machine. Different levels of expansion of the coupled machines can change the alignment/leveling during the operation.

4.11.3 Coupling

It must be used coupling that optimize the vibration level of the set.

ATTENTION

Carefully align the shaft ends, using a flexible coupling whenever possible, leaving a minimum clearance of 3 mm between the couplings.

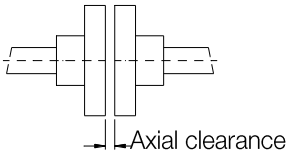


Figure 4.10 - Axial clearance

NOTE

The user is responsible for the installation of the alternator. WEG is not responsible for damages to the alternator, associated equipment and installation which occurred due to:

- Excessive transmitted vibrations;
- Poor installations;
- Alignment failures;
- Improper storage conditions;
- Noncompliance with the instructions before start-up;
- Incorrect electrical connections.

4.12 PURGE AND PRESSURIZATION SYSTEM

In alternators with Ex “p” protection, the purge and pressurization system is integral part of the alternator. For the proper installation and operation of the system, refer to the specific manual of this equipment, supplied with the alternator. The pressurization/purge data is also informed on the equipment specific nameplate and certificate of conformity.

5 START-UP

5.1 PRELIMINARY INSPECTION

Before the first start-up or after a long time out of operation, check:

1. If the alternator is clean and if the packaging materials and protective elements were removed;
2. If the connection parts of the coupling are in perfect conditions and well-greased and tightened where necessary;
3. If the alternator is aligned;
4. If the bearings are properly lubricated and in working condition;
5. If the cables of the accessories are connected;
6. If the windings insulation resistance has the prescribed value;
7. If all objects, such as tools, measuring instruments and alignment devices, were removed from the alternator operation place;
8. If the alternator is properly fixed;
9. If the electrical connections are in accordance with the wiring diagram of the alternator;
10. If the voltage regulator is properly connected and adjusted according to its installation manual;
11. If the conductors of the line are properly connected to the main terminals so as to prevent a short circuit or disconnection;
12. If the alternator is properly grounded;
13. If the cooling system is working.
14. If the air inputs and outputs are clear;
15. If the water inputs and outputs are clear (alternators with air-water heat exchanger);
16. Manually rotate the assembly in order to ascertain whether there is no interference in the air gap. After the alternator is driven with no load, it must rotate smoothly without strange noises.

5.2 INITIAL OPERATION

In addition to following the safety instructions given in item 2.2 of this manual, in order to perform the first start-up of the alternator, the following procedure must be adopted:

a) Make sure that the alternator terminals are disconnected from the load by removing the fuses on the panel or placing the circuit breaker in the "off" position;
b) Turn off the space heaters of the alternator, before starting it;
c) Disconnect the voltage regulator.

ATTENTION

The PID gains of the voltage regulator shall be correctly adjusted to allow a rapid and appropriate load variation response.

d) Rotate the assembly and check for strange noises;
e) Drive the alternator up to the rated speed and verify noises and vibration, and check all protective devices;

After following the procedures described above and solving any problems that may have occurred (see item 0), turn off the set.

f) With the alternator completely stopped, connect the voltage regulator, activate the set and make the necessary adjustments. The manual of the voltage regulator describes the procedures for the available settings (stability, voltage, U/F).
g) Close the main circuit breaker, apply load, and monitor the alternator current, making sure that it is within the specification.
h) Check the vibration and temperature levels of the set and monitor the measuring instruments (current, voltage and frequency). If there is significant variation in the vibration of the set between the initial condition and after the temperature stabilizes, it is necessary to reassess the alignment/leveling of the set.

ATTENTION

All measuring and control instruments must be under constant observation so that any changes in operation can be detected and remedied.

5.2.1 Ex “p” Alternators

EX

In alternators with Ex “p” protection, before starting the alternator, the purge and pressurization device must be turned on according to the instructions contained in its operation manual. The alternator enclosure must be purged, thus expelling any flammable gas which may have entered the alternator when it was not pressurized. The purge time is defined during the alternator certification process by means of the so-called purge test and informed on the nameplate attached to the alternator.
The alternator must be pressurized before starting and during its operation.

DANGER

The operation of the Ex “p” alternator without pressurization is potentially dangerous. It must only be permitted when the alternator interior and exterior are admittedly free of flammable gases. Such operating condition is the sole responsibility of the user.

5.2.2 Temperatures

The temperatures of the bearings, stator winding and cooling water (if applicable) must be monitored while the alternator is operation. These temperatures must stabilize within 4 to 8 hours of operation.
The temperature of the stator winding depends on the load; therefore, the supplied load must also be monitored during the operation of the alternator.

5.2.3 Bearings

The start-up of the system, and the first hours of operation must be continuously monitored.

- Watch for vibration or abnormal noise. If the bearing does not work in a silent and smooth way, the alternator must be stopped immediately, the cause found and corrected.
- The alternator must operate for some hours until the bearing temperature stabilizes within the limits mentioned in this manual.
- If the bearing temperature rises, the alternator must be stopped in order to check the bearings and temperature sensors.
- After reaching the bearing working temperature, check for leaks through the plugs, gaskets or shaft end.

5.2.4 Radiator

In alternators with air-water heat exchanger, the following procedures must be followed during the first start-up:

- Control the temperature in the input and output of the radiator and, if necessary, correct the water flow;
- Adjust the water pressure to just overcome the resistance in the pipes and radiator;
- To control the operation of the alternator, it is recommended to record the air and water temperatures in the input and output of the radiator at certain intervals;
- Recording or signaling (buzzer, light bulbs) instruments can be installed in certain places.

Verification of the radiator performance

- In order to control the operation, it is recommended that the water and air temperature in the input and output of the radiator be measured and recorded periodically.
- The performance of the radiator is expressed by the difference in temperatures between cold water and cold air during normal operation. This difference must be checked periodically. If it is observed an increase in this difference after a long period of normal operation, it may be a sign that the radiator must be cleaned.
- A reduction in the performance or damage to the radiator can also occur due to accumulation of air inside it. In this case, bleeding the air from the radiator and water pipes can correct the problem.
- The pressure difference on the water side can be considered an indicator of the need for cleaning the radiator.

It is also recommended to measure and record the values of the water pressure difference before and after the radiator. Periodically, the new values must be compared to the original value, and an increase in the pressure difference indicates the need for cleaning the radiator.

5.3 SHUTDOWN

a) Before stopping the alternator, open the main circuit breaker to disconnect the load;
b) Turn off the voltage regulator (if possible);
c) Reduce the speed of the alternator until it comes to a full stop;
d) In alternators with air-water heat exchanger, after the alternator stops completely, close the valve of the cooling water.
e) Turn on the space heaters if the alternator remains stopped for a long period.

DANGER

Even after de-excitation, there is still voltage at the terminals of the machine. Therefore, only after the full stop of the equipment, it is allowed to perform any work.
The noncompliance with the procedure above implies risk of death.

5.4 PARALLEL ALTERNATORS

5.4.1 Parallel to each other and/or to the line

Minimum requirements for operation of the alternators in parallel, not including the driving machine control:

1. The alternator must have the same operating voltage of the alternator or another network;
2. The voltage regulator must permit the operation of the alternator in parallel;
3. Add a parallel CT to one of the phases of the alternator and make the electrical connection according to the manual of the voltage regulator.
4. Have a panel suitable for protection and operation of the alternators in parallel.
5. The synchronization and setting of the real power must be imposed by the speed control of the primary machine.

In case high neutral currents appear, use a ground coil or open the neutral connection of one of the alternators. This happens especially when the alternators are not equal or when they feed loads with high harmonic content.

ATTENTION

This type of installation must be performed by qualified technical staff.
For transient operations in parallel (e.g., loading ramp) in which the alternator will operate in the single mode after a period in parallel, the parallel CT must be short-circuited, since it is unnecessary for this operation.

6 MAINTENANCE

Maintenance procedures must be performed so as to ensure the proper performance of the equipment. The frequency of the inspections will largely depend on the application local conditions and operating conditions. Failure to comply with one of the items listed below may lead to the reduction of the alternator life, unnecessary stops and/or damage to the facilities.

6.1 EMERGENCY GENERATOR GROUPS

To ensure reliability and maintenance of the insulation level, alternators used in emergency generators must be placed in operation and, if possible, receive load 2 to 3 hours each month.

6.2 CLEANING

The frame, multi-leaf dampers, grids and fan covers must be kept clean, without accumulation of oil or dust on the outside to facilitate the heat exchange with the environment. Also, the inside of the alternators must be kept clean and free of dust, debris and oil. In order to clean them, brushes or clean cotton rags must be used. If the dust is not abrasive, an air gun must be used to blow the dirt off from the fan cover and eliminate all the accumulation of dust contained on the fan blades and frame. The debris impregnated with oil or humidity can be cleaned with cloth moistened in a suitable solvent. The terminals in the terminal box must be clean, free of rust, in perfect mechanical condition and without deposits of grease or verdigris.

6.3 NOISE

The noise must be observed daily. In case of anomalies, the alternator must be stopped and the causes must be investigated and corrected.

6.4 VIBRATION

Maximum vibration level for the alternator under load: 20 mm/s (RMS), according to standard ISO-8528.

ATTENTION

After torquing or disassembling any machine screw, it is necessary to apply Loctite.

6.5 PURGE AND PRESSURIZATION SYSTEM

For alternators with Ex “p” protection type, the maintenance procedure of the purge and pressurization system is described in the specific equipment manual. Regular inspection of the machine general conditions, of the pressurization system and the internal pressure of the equipment are extremely important. The frequency of these inspections is indicated in the “MAINTENANCE PLAN” of this manual.

ATTENTION

The purge and pressurization equipment setting is done at the factory and must not be changed. The alteration of this setting compromises the equipment operation, besides voiding the alternator warranty. Any abnormality must be informed to WEG.

6.6 BEARINGS

The temperature control on the bearings is also part of routine maintenance of the alternators.
The temperature can be controlled permanently with thermometers placed outside the bearing, or through thermoresistances.
The alarm and shutdown temperatures for the bearings can be adjusted respectively for 110 °C and 120 °C.

6.6.1 Lubrication

The bearings must be relubricated **annually** or according to the lubrication intervals reported on the nameplate of the bearings fixed on the alternator and to the technical documentation, prevailing whichever occurs first.

6.6.1.1 Type and amount of grease

The relubrication of the bearings must always be made with the **original grease**, specified on the bearing nameplate and the documentation of the alternator.

ATTENTION

1. When the bearing is opened, inject the new grease through the grease nipple to expel the old grease found in the grease input tube and insert the new grease in the bearing, in the inner ring and outer ring, filling ¾ of the empty spaces.
2. Never clean the roller with cotton-based cloths, because they leave some lint as solid particles.
3. It is important to perform a proper lubrication, that is, to apply the grease correctly and in a suitable quantity, because both poor lubrication and excessive lubrication adversely affect the bearing.

NOTE

WEG is not responsible for the change of grease or for any damages arising from the exchange.

6.6.1.2 Instructions for lubrication

NOTE

The data of the rolling bearings, quantity and type of grease and lubrication intervals are informed in a nameplate fixed on the alternator. Check this information before performing the lubrication.

The lubrication system is designed in such a way that during the relubrication of the bearings, all the old grease is removed from the rolling bearings tracks and expelled through a drain, which enables the exit, but prevents the entering of dust or other harmful contaminants.
This drain also prevents damage to the bearings by the well-known problem of excessive lubrication.

It is advisable to perform the lubrication with the alternator in operation, to ensure the renewal of grease in the bearing housing.
If this is not possible due to the presence of rotating parts near the nipple (pulleys, etc.), which can put the operator in danger, proceed as follows:

- With the alternator stopped, inject approximately half the total amount of grease recommended and operate the alternator for approximately 1 minute at full speed;
- Stop the alternator and inject the remaining grease. The injection of all grease with the alternator stopped may cause penetration of the lubricant into the alternator.

ATTENTION

It is important to clean the grease nipples prior to lubrication so as to prevent foreign materials from being dragged into the bearing.

- The lubrication intervals informed on the plate consider a working temperature of the bearing of 70 °C.

Based on the operating temperature ranges listed below, apply the following correction factors for the lubrication of bearings:

- Operating temperature below 60 °C: 1.59.
- Operating temperature 70 °C to 80 ºC: 0.63.
- Operating temperature 80 °C to 90 ºC: 0.40.
- Operating temperature 90 °C to 100 ºC: 0.25
- Operating temperature 100 °C to 110 ºC: 0.16.

6.6.1.3 Relubrication of bearing with the alternator operating

6.6.1.3.1 Bearing with grease outlet by runoff drain

1. Remove the cover of the drain;
2. Clean with a cotton cloth around the hole of the grease nipple;
3. With the alternator running, inject grease until new grease begins to flow from the drain or until the amount of grease informed on the bearing nameplate have been injected;
4. Run the alternator for time enough to eliminate the excess of grease through the drain;
5. Inspect the bearing temperature to make sure that there was no significant change;
6. Put the cover of the drain back in place.

6.6.1.3.2 Bearings with grease outlet by a drawer and rod

1. Before starting the lubrication of the bearing, clean the grease nipple with a cotton cloth;
2. Remove the drawer and rod to remove the old grease, clean the drawer and put it back;
3. With the alternator running, inject the amount of grease specified on the nameplate of the bearings using a manual grease gun;
4. The excess of grease comes out through the bearing lower drain and is deposited in the drawer;
5. Maintain the alternator running long enough for the grease excess to drain;
6. This grease must be removed by pulling the rod and cleaning the drawer. This procedure must be repeated as many times as necessary until the drawer no longer retains grease;

Inspect the bearing temperature to ensure that there was no significant change.

6.6.2 Bearing

ATTENTION

For safety reasons, the change of bearings must be done with the alternator disconnected from the driving machine.

To change the bearings on the alternator, it is necessary to disassemble the alternator completely.

6.6.2.1 Bearing replacement

The disassembly of the bearings must always be done with the use of appropriate tools (bearing puller).

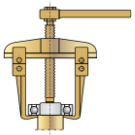


Figure 6.1: Bearing extractor

ATTENTION

A bearing must only be removed from the shaft when absolutely necessary.

Instructions:

1. The puller jaws must be placed on the side surface of the bearing internal ring or on an adjacent part.
2. Before the installation of the new bearings, the shaft seats must be cleaned and slightly lubricated.
3. The bearings must be heated up to a temperature between 50 °C and 100 °C to facilitate the assembly.

6.6.3 Sleeve bearings

6.6.3.1 Bearing data

The characteristic data, such as oil flow, quantity and type, are indicated on the bearing nameplate and must be strictly observed; otherwise, overheating and damages to the bearings may occur.
The hydraulic installation (for bearings with forced lubrication) and the oil supply for the alternator bearings are responsibilities of the user.

6.6.3.2 Bearing installation and operation

For information on the bill of materials, assembly and disassembly instructions, and maintenance details, refer to the specific installation and operation manual of the bearings.

6.6.3.3 Oil change

Self-lubricated bearings
The bearing oil change must be done according to the intervals, which depend on the bearing operating temperatures, shown in Table 6.1:

Table 6.1: Oil change intervals

Bearing operating temperature	Bearing oil change intervals
Below 75 ºC	20,000 hours
Between 75 and 80 ºC	16,000 hours
Between 80 and 85 ºC	12,000 hours
Between 85 and 90 ºC	8,000 hours
Between 90 and 95 ºC	6,000 hours
Between 95 and 100 ºC	4,000 hours

Bearings with external oil circulation
The oil of the bearings must be changed every 20,000 hours of operation or whenever the lubricant presents modifications in its characteristics. The oil viscosity and pH must be checked periodically.

NOTE

The oil level must be inspected daily, and it must remain in the middle of the oil sight glass.

The bearings must be lubricated with the specified oil, respecting the flow rate informed on their nameplate;
All threaded holes that are not used must be closed with plugs and no fitting may present leaks.
The oil level is reached when the lubricant can be seen approximately in the middle of the sight glass. The use of a larger amount of oil will not damage the bearing, but it can cause leaks through the shaft seals.

ATTENTION

The care with the lubrication will determine the useful life of the bearings and the safety in the alternator operation.
Therefore, the following recommendations must be observed:

- The selected lubricant oil must be the one with proper viscosity for the operating temperature of the bearings; That must be observed at every oil change or during periodical maintenances;
- Never use or mix hydraulic oil with the lubricant oil of the bearings;
- Lack of lubricant, due to incomplete filling or non-monitoring of the level, can damage the bearing shells;
- The minimum oil level is reached when the lubricant can be seen in the lower part of the sight glass with the alternator stopped.

6.6.3.4 Bearing seal

Make visual inspections of the sealing, making sure that the dragging marks of the seal on the shaft do not compromise its integrity, checking for cracks and broken parts. Cracked or broken parts must be replaced.
In case of bearing maintenance, in order to assemble the seal, it is necessary to carefully clean the seal contact surfaces and its enclosure and cover the sealing with a non-hardening component (i.e. **Curil T**). The two halves of the labyrinth taconite seal must be joined by a garter spring.
The drain holes located in the lower half of the seal must be cleaned and unobstructed.
Improper installation can damage the sealing and cause oil leakage.

ATTENTION

For further information about the dismounting and mounting of sleeve bearing seals, refer to the specific manual of this equipment.

6.6.3.5 Sleeve bearing operation

The system start, as well as the first hours of operation, must be monitored carefully.
Before starting, check:

- If the oil inlet and outlet tubes (if any) are, clean. Clean the tubes by pickling, if necessary;
- If the used oil complies with the specification on the nameplate;
- The lubricant characteristics;
- The oil level;
- The alarm and trip temperatures set for the bearing.

During the first start, it is necessary to stay alert for unusual vibrations or noises. If the bearing does not operate in a silent and smooth way, the alternator must be shut down immediately.
The alternator must operate for several hours until the bearing temperatures stabilize. In case of overheating of the bearings, the alternator must be shut down for inspection of the bearings and temperature sensors.
Check if there is no oil leak through the plugs, gaskets or shaft end.

6.6.3.6 Sleeve bearing maintenance

The sleeve bearing maintenance includes:

- Periodic checking of the oil level and its lubricating conditions;
- Checking the bearing noise and vibration levels;
- Monitoring of the operating temperatures and retightening of the fastening and mounting screws;
- In order to facilitate the heat exchange with the environment, the frame must be kept clean, without external dust or oil accumulation;
- The NDE bearing is electrically insulated. The spherical seat surfaces of the bearing shell on the frame are covered with insulating material. Never remove this cover;
- The anti-rotation pin is also insulated, and the seals are made of non-conducting material;
- Temperature control devices that are in contact with the bearing shell must also be properly insulated.

6.6.4 Adjustment of protections

ATTENTION

The following temperatures must be set in the bearing protection system:
ALARM: 110 ºC OFF: 120 ºC
The alarm temperature should be set at 10 ºC above the working temperature, not exceeding the limit of 110 ºC.

6.6.4.1 Disassembly/assembly of the sleeve bearing temperature sensors

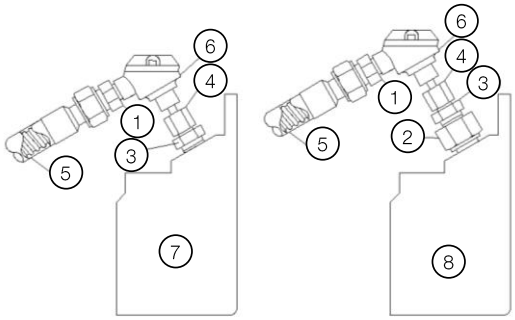


Figure6.2: Pt100 on the bearings

Figure6.2 legend:
1. Reduction nipple
2. Insulating adapter
3. Locknut
4. Bulb
5. Flexible metal tube
6. Pt-100 temperature sensor
7. Non-insulated bearing
8. Insulated bearing

Disassembly instructions:
If it is necessary to remove the Pt100 for bearing maintenance, proceed according to the following instructions:
- Remove the Pt100 carefully, locking the locknut (3), and unscrewing just the Pt100 from the bulb (4);
- Parts (2) and (3) must not be disassembled.

Assembly instructions:

ATTENTION

Before assembling the Pt100 on the bearing, check if it does not contain marks of knock or any other damage that may compromise its operation.

- Insert the Pt100 into the bearing;
- Restrain the locknut (3) with a wrench;
- Screw it in the bulb (4), adjusting it so that the tip of the Pt100 touches the outer surface of the bearing.

NOTES

- The assembly of the Pt100 on non-insulated bearings must be done directly on the bearing, without the insulating adapter (2);
- The tightening torque to assemble the Pt100 and the adapters must not exceed 10Nm.

6.7 MAINTENANCE OF THE EXCITER

6.7.1 Exciter

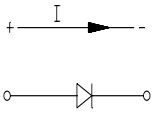
For the proper performance of its components, the alternator exciter must be kept clean.
Check the insulation resistance of the windings of the main exciter and auxiliary exciter periodically so as to determine the insulation conditions, following the procedures described herein.

6.7.2 Diode test

Diodes are components that last for a long time and do not require frequent tests. If the alternator presents a defect, which indicates a diode fault or an increase in the field current for the same load condition, then the diodes must be tested in accordance with the following procedure:
1. Disconnect all the diodes from the exciter rotor winding;
2. With an ohmmeter, measure the resistance of each diode in both directions.

NOTE

When testing the diodes, observe the polarity of the test terminals in relation to the diode polarity.
The polarity of the diode is indicated by an arrow on its housing.



The current conduction must occur only in the anode-cathode direction, i.e., in the condition of direct polarization.

The diode is considered good when you have low ohmic resistance (up to approximately 100 Ω) in its direct polarization and high resistance (approx. 1 MΩ) in the opposite direction. Defective diodes have ohmic resistance of 0 Ω or greater than 1 MΩ in both directions. In most cases, the test method which uses an ohmmeter to the diodes is enough to identify faults in the diodes. However, in some extreme cases it may be necessary to apply the rated blocking voltage and/or current circulation in order to detect a fault in the diodes. Due to all the work required to perform these tests, if you are not sure of the conditions of the diodes, it is recommended replace them.

6.7.3 Diode Replacement

In order to replace the diodes, proceed as follows:
- Disconnect the six diodes from the exciter rotor winding;
- Install three new diodes of the same polarity (AND or CTD) in one of connecting bridges;
- Install, on the other connecting bridge, three new diodes with polarity opposite to that of the three diodes previously installed;
- Fix all the diodes, tightening them with a torque wrench, observing the torques of Table 6.1;
- Make the connections of the diodes with the exciter rotor winding.

ATTENTION

It is vital that the tightening torques indicated be observed so that the diodes will not be damaged in the assembly.

Table 6.1: Tightening torque of the diodes

Thread of the diode base (mm)	Torque wrench number (mm)	Tightening torque (mm)
M6	11	2
M8	17	4
M12	24	10
M16	32	30

6.7.4 Varistor test

The varistor is the device installed between the two diode connecting bridges and is intended to protect the diodes against overvoltage.
To test the operating conditions of the varistor, an ohmmeter can be used. The resistance of a varistor must be very high (± 20,000 ohm).
In case of damages to the varistor or if the resistance is very low, it must be replaced.

6.7.5 Varistor replacement

In order to replace the varistor, WEG recommends that you observe the following recommendations:
1. Replace the damaged varistor by a new varistor identical to the original one;
2. In order to replace the varistor, loosen the screws that fasten it to the diode connecting bridges ;
3. When removing the varistor, observe carefully how the components were assembled so that the new varistor will be installed the same way;
4. Before mounting the new varistor, make sure that all the contact surfaces of the components are clean, leveled and smooth so as to ensure a perfect contact between them;
5. Fix the new varistor by tightening the screws that fasten it to the connecting bridges just enough to make a good electrical connection.

6.8 AIR FLOW

The air inputs and outputs of the alternator must be kept clear, so that the heat exchange is efficient. If the heat exchange is hindered, the alternator will overheat and the winding may be damaged (burning of the alternator).

6.9 MAINTENANCE OF THE COOLING SYSTEM

- The tubes of the air-air heat exchanger (if applicable) must be kept clean and clear to ensure a perfect heat exchange. In order to remove the dirt accumulated in the tubes, a rod with a round brush on the tip may be used.
- In case of air-water heat exchangers, periodic cleaning in the radiator pipes is necessary in order to remove any fouling.

NOTE

If the alternator is equipped with filters in the air input and/or output, they must be cleaned with compressed air.
If the dust is difficult to remove, wash the filter with cold water and mild detergent and then dry it in the horizontal position.

6.9.1 Maintenance of the radiators

If clean water is used, the radiator can remain in operation for several years without the need for cleaning. With dirty water, you need to clean it every **12 months**. The level of dirt in the radiator can be detected by the increase in the air temperature in the output. When the temperature of the cold air, under the same operating conditions, exceeds the specified value, it can be assumed that the pipes are dirty.
If corrosion is found, it is necessary to provide adequate protection (i.e., zinc anodes, plastic cover with plastic, epoxy or other similar protecting products) in order to prevent greater damages to the parts already affected. The external surface of all radiator parts must be always kept in good condition.

Instructions for removing and servicing the radiator
The removal of the heat exchanger for maintenance must follow the following steps:
1. Close all the water input and output valves after the ventilation is stopped;
2. Drain the water through the radiator drain plugs;
3. Remove the heads, keeping the screws, nuts and washers and seals (gaskets) in a safe place;
4. Brush the tubes inside carefully with nylon brushes for removing residues. If during the cleaning damages to the radiator tubes are found, they can be repaired;
5. Reassemble the heads, replacing the gaskets, if necessary.

6.10 ALTERNATOR OUT OF OPERATION

The following special care must be taken if the alternator will remain for a long period out of operation:
- Connect the space heaters for the temperature inside the alternator to be kept slightly above the ambient temperature, thereby preventing condensation and consequent decrease in the winding insulation resistance and oxidation of metal parts.
- All the radiators and water pipes (if applicable) must be drained to reduce corrosion and deposit of materials suspended in the cooling water.

Follow the remaining procedures described in item 3.2.3 of this manual.

Storage of the radiator after operation
When the radiator remains out of operation for a long period, it must be drained and dried. Drying can be done with preheated compressed air. During the winter, if there is danger of freezing, the radiator must be drained, even when it is out of operation for a short period, in order to prevent deformation or damage.

NOTE

During short stops, it is preferable to maintain the water flow at low speeds instead of stopping its circulation, thus ensuring that harmful compounds such as ammonia and hydrogen sulfide are taken out of the heat exchanger and do not settle inside.

6.11 SHAFT GROUNDING DEVICE

A brush for ground the shaft is a device use to prevent the flow of electrical current through the bearings. The brush is placed in contact with the shaft and connected to the alternator frame, which must be grounded.
The types of shaft grounding used on WEG alternators are:

6.11.1 Grounding with internal brush

The shaft grounding is made with internal brush, according to Figure 6.3

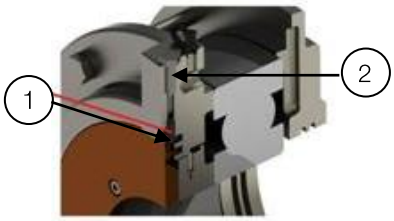


Figure 6.3: Internal brush for shaft grounding

Legend of Figure 6.3
1. Grounding brush
2. Brush fixing screw

Procedure to replace the brush
- Remove the screw (2)
- Remove the wear brush (1)
- Install a new brush and the fixing screw.

6.11.2 Grounding with external brush

The shaft grounding is made with internal brush, according to Figure 6.4:

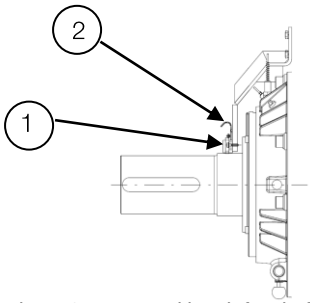


Figure 6.4: External brush for shaft grounding

Legend of Figure 6.4
1. Grounding brush
2. Pressure spring of brush-holder

Procedure to replace the brush
- Remove the pressure spring (2)
- Remove the wear brush (1)
- Install a new brush and the pressure spring.

ATTENTION

The brush must be monitored constantly during operation, and at the end of its useful life, it must be replaced by another of the same quality (grain).
In order to ensure a perfect contact of the grounding brush shaft, this oil, and any residue between the shaft and the brush, must be removed before placing the alternator start-up.

6.12 COMPLETE CHECKUP

The frequency of checkups must be defined according to the environment where the alternator is installed. The more aggressive the environment (dirt, oil, sea breeze, dust, etc.), the shorter the checkup interval, as follows:
- Clean the dirty windings with a brush;
- Use a cloth moistened in a suitable solvent to remove grease, oil and other impurities from the winding;
- Dry with dry air;
- Blow compressed air through the ventilation channels on the lamination core of the stator, rotor and on the bearings.

NOTE

The compressed air must always be blown after the cleaning never before.

- Drain the condensed water;
- Clean the inner part of the terminal box;
- Measure the insulation resistance.

ATTENTION

If complete checkups are not performed, dirt will build up inside the alternators. The operation under these conditions may reduce the life of the machine and cause unwanted downtime and additional costs to restore the equipment.

7 DISASSEMBLY AND ASSEMBLY OF THE ALTERNATOR

ATTENTION

All the repair, disassembly and assembly services must be performed only by properly qualified and trained professionals; otherwise, equipment damage and personal injury may occur. If any further explanations are necessary, consult WEG. The disassembly and assembly sequences depend on the alternator model. Always use proper tools and devices. Any damaged part (cracks, dents on machined parts, faulty threads) must be replaced, avoiding restorations.

7.1 QUALIFIED PROFESSIONAL

EX

The repair services on alternators applied in explosive atmospheres must be carried out only by qualified professionals authorized by WEG to perform such jobs.

7.2 DISASSEMBLY

Below are some recommendations that must be observed when disassembling an alternator:

1. Always use proper tools and devices to disassemble the alternator;
2. Before disassembling the alternator, disconnect the water cooling and lubrication tubing (if applicable);
3. Disconnect the electric connections and accessories;
4. Remove the heat exchanger and noise suppressor (if applicable);
5. Remove the bearing temperature sensors and grounding brush;
6. In order to prevent damages to the rotor, provide a support for supporting the shaft in the drive and non-drive ends;
7. For disassembling the bearings, follow the procedures described in this manual;
8. The removal of the rotor from inside the alternator must be done with a suitable device and with extreme care so that the rotor does not drag on the stator lamination core or coil heads, preventing damages.

7.3 ASSEMBLY

Below are some cautions that must be taken when assembling an electric alternator:

1. Always use proper tools and devices for assembling the alternator;
2. For assembling the alternator, follow the disassembly procedures in the reverse order;

It is recommended that any damaged part (cracks, dents on the machined parts, damaged threads) be replaced, avoiding repairing the parts.

7.4 SPARE PARTS

WEG recommends keeping in stock the following spare parts:

- DE bearing;
- NDE bearing;
- Temperature sensor for DE bearing;
- Temperature sensor for NDE bearing;
- Space heater;
- Felt for filter (if applicable);
- Diode set
- Varistor
- Voltage regulator
- Shaft grounding brush

The spare parts must be stored in a clean, dry and well-ventilated environment, if possible, at constant temperature.

7.5 TIGHTENING TORQUES

Table 7.1 and Table 7.2 shows the tightening torques of the screws recommended for assembling the generator.

Table 7.1: Screw tightening torque for metal/metal parts

Material / Resistance class		Carbon Steel / 8.8 or above		Stainless steel / A2 – 70 or above	
% Yield Strength		70%		70%	
Lubricant		Dry	Molycote 1000	Dry	Molycote 1000
Diam	Pitch (mm)	Screws tightening torque (Nm)			
M4	0,7	2,1	1,8	1,8	1,3
M5	0,8	4,2	3,6	3,6	2,7
M6	1	8	6	6,2	4,5
M8	1,25	19,5	15	15	11
M10	1,5	40	29	30	22
M12	1,75	68	51	52	38
M14	2	108	81	84	61
M16	2	168	126	130	94
M18	2,5	240	174	180	130
M20	2,5	340	245	255	184
M22	2,5	470	335	350	251
M24	3	590	424	440	318
M27	3	940	621	700	466
M30	3,5	1170	843	880	632
M33	3,5	1730	1147	1300	860
M36	4	2060	1473	1540	1105
M42	4,5	3300	2359	2470	1770
M48	5	5400	3543	4050	2657

Table 7.2: Screw tightening torque for metal/isolated parts

Material / Resistance class		Carbon Steel / 8.8 or above		Stainless steel / A2 – 70 or above	
% Yield Strength		40%		40%	
Lubricant		Dry	Molycote 1000	Dry	Molycote 1000
Diam	Pitch (mm)	Screws tightening torque (Nm)			
M4	0,7	1	1	1	1,3
M5	0,8	2	2	1,7	2,7
M6	1	4,4	3	3,4	4,5
M8	1,25	10,7	7,5	8,3	11
M10	1,5	21	15	16,5	22
M12	1,75	37	26	28	38
M14	2	60	42	46	61
M16	2	92	65	72	94
M18	2,5	132	90	100	130
M20	2,5	187	126	140	184
M22	2,5	260	172	190	251
M24	3	330	218	240	318
M27	3	510	320	390	466
M30	3,5	640	433	480	632
M33	3,5	950	590	710	860
M36	4	1130	758	840	1105
M42	4,5	1800	1213	1360	1770
M48	5	2970	1822	2230	2657

NOTE

The resistance class is normally indicated on the head of hex bolts.

7.6 GENERAL RECOMMENDATIONS

ATTENTION

All services described herein must be carried out by qualified and experienced persons, otherwise, damages to property or personal injuries may occur. If any further explanations are necessary, contact WEG.

8 MAINTENANCE PLAN

The maintenance plan detailed in Table 8.1 is referential, considering that the intervals between each maintenance intervention may vary according to the alternator location and operation conditions. For associated equipment, such as the voltage regulator and control / protection panel, the specific manuals must also be consulted.

Table 8.1: Maintenance plan

DAILY	
▪ Whole alternator	▪ Inspect noise, vibration, bearing and winding temperature
MONTHLY	
▪ Whole alternator	▪ Measure noise, vibration, bearing and winding temperature ▪ Verify winding insulation resistance ▪ Inspect cooling system – air and water flow
▪ Bearings	▪ Inspect the bearings visually
▪ Protection and control equipment	▪ Verify the operation ▪ Record the measurement values ▪ Monitor the excitation current, making sure that is according to the value informed in the alternator data sheet.
▪ Air-water heat exchanger	▪ Inspect the sacrificial anodes (when use sea water)
▪ Air filter (if any)	▪ Inspect and, if necessary, clean or change it
EACH 6 MONTH	
▪ Whole alternator	▪ Verify and retighten the alternator fixation screws ▪ Inspect and, if necessary, clean the alternator internally and externally
▪ Bearings[1]	▪ Inspect and, if necessary, relubricate the bearings
▪ Exciter	▪ Inspect and, if necessary, clean the exciter compartment ▪ Inspect diodes and varistors
▪ Electrical connections	▪ Retighten the electrical connection terminals ▪ Inspect the electrical connections of the voltage regulator ▪ Inspect the accessories electrical connections
▪ Grounding	▪ Inspect and retighten the grounding connections ▪ Inspect the shaft grounding brush and replace it, if necessary
YEARLY (FULL INSPECTION)	
▪ Whole alternator	▪ Visual inspection ▪ Thorough cleaning of the alternator
▪ Rotor, stator and exciter	▪ Visual inspection, cleaning, verify terminals, measure insulation resistance
▪ Bearings[1]	▪ Inspect the lubricant quality and relubricate when necessary
▪ Air-water heat exchanger	▪ Inspect the coolers, ▪ Inspect the sacrificial anodes (if any) ▪ Inspect and, if necessary, change the gaskets of the heat exchanger heads
▪ Protection and control equipment	▪ Inspect the connections ▪ Test the operation
▪ Connection boxes and grounding	▪ Inspect and clean the inner of the connection boxes ▪ retighten the screws and grounding connections
▪ Coupling	▪ Inspect the alignment and retighten the coupling screws
▪ Filter (if any)	▪ Inspect and, if necessary, clean or replace
EVERY 3 YEARS (TOTAL REVISION)	
▪ Whole alternator	▪ Alternator whole inspection ▪ Verify parts and components
▪ Rotor, stator and exciter windings	▪ Clean the windings ▪ Inspect windings and check the fastening of the wedges on slots ▪ Inspect the winding electrical connections
▪ Rotor	▪ Inspect the shaft (wear, fouling)
▪ Bearings[1,2]	▪ Clean the bearings and, if necessary, replace them ▪ Inspect shaft seat and, if necessary, restore
▪ Protection, monitoring and control equipment	▪ Test the operation
▪ Air-water heat exchanger	▪ Clean the coolers

1. Check the lubrication intervals and amount of grease in the bearing nameplate and technical documentation.
2. The bearing replace must be carried out according to the lifetime reported in the alternator technical documentation.

NOTE

The checks and tasks described in the table above must be performed according to item 6 of this manual.

INSPECTIONS EVERY 2 YEARS (ACCORDING TO NBR IEC60079-17 STANDARD) Ex ALTERNATORS		Ex "e"			Ex "ec"			Ex "t"		
CHECK WHETHER:		Degree of inspection[1]								
		D	A	V	D	A	V	D	A	V
A	**EQUIPMENT**									
1	The equipment is appropriate for the requirements of EPL / Installation location zone	x	x	x	x	x	x	x	x	x
2	The equipment group is correct	x	x		x	x		x	x	
3	The equipment temperature class is correct (only for gas)	x	x		x	x				
4	The maximum surface temperature of the equipment is correct							x	x	
5	The equipment protection degree (IP code) is appropriate for the protection level /group/conductivity	x	x	x	x	x	x	x	x	x
6	The identification of the equipment circuit is correct	x			x			x		
7	The identification of the equipment circuit is available	x	x	x	x	x	x	x	x	x
8	The enclosure, the glass parts and seals, and/or glass/metal sealing compounds are satisfactory	x	x	x	x	x	x	x	x	x
9	There are no damages or unauthorized modifications	x			x			x		
10	There are no evidences of unauthorized modifications		x	x		x	x		x	x
11	The screws, cable inlet devices (direct or indirect) and sealing plugs are of the correct type and completely tightened									
	▪ Physical verification	x	x		x	x		x	x	
	▪ Visual verification			x			x			x
14	**The condition of the enclosure gaskets is satisfactory**	x			x			x		
15	**There is no evidence of water or dust ingress into the enclosure, according to the IP degree of protection**	x			x			x		
17	The electrical connections are tightened	x			x			x		
18	Unused terminals are fastened	x			x					
19	The encapsulated switching devices and hermetically sealed devices are not damaged				x					
20	Encapsulated components are not damaged	x			x					
21	Explosion-proof components are not damaged	x			x					
25	Breathers and drains are satisfactory	x	x		x	x				
29	Alternator fans have proper clearance from the enclosure and/or covers; the cooling system is not damaged; the alternator foundation do not have signs of cracks	x	x	x	x	x	x	x	x	x
30	The cooling air circulation is not obstructed	x	x	x	x	x	x	x	x	x
31	**The insulation resistance (RI) of the alternator windings is satisfactory**	x			x			x		
B	**INSTALLATION – GENERAL REQUIREMENTS**									
1	The type of cable is appropriate	x			x			x		
2	There are no evident damages to the cables	x	x	x	x	x	x	x	x	x
3	The sealing of the bundles, ducts and/or conduits is satisfactory	x	x	x	x	x	x	x	x	x
5	The integrity of the conduit system and the interfaces with the mixed systems are maintained	x			x			x		
6	The grounding connections, including any supplementary grounding connections are satisfactory (e.g., the connections are tightened and the conductors have a proper gauge)									
	▪ Physical inspection	x			x			x		
	▪ Visual inspection		x	x		x	x		x	x
7	The impedance of the fault circuit (TN system) or the grounding resistance (IT system) is satisfactory	x			x			x		
8	The automatic electrical protection devices operate within the permitted limits	x			x			x		
9	The automatic electrical protection devices are correctly calibrated (no possibility of auto- reset)	x			x			x		
10	The specific conditions of safe use (if any) are meet	x			x			x		
11	The ends of cables that are not used have proper finishing	x			x			x		
13	The installation of converters with variable voltage/frequency is in accordance with the documentation	x	x		x	x		x	x	

INSPECTIONS EVERY 2 YEARS (ACCORDING TO NBR IEC60079-17 STANDARD) Ex ALTERNATORS		Ex "e"			Ex "ec"			Ex "t"		
CHECK WHETHER:		Degree of inspection[1]								
		D	A	V	D	A	V	D	A	V
B	**INSTALLATION – HEATING SYSTEM**									
14	The temperature sensors are operating according to the manufacturer documentation	x						x		
15	The safety trip devices operate according to the manufacturer documentation	x						x		
16	The setting of the safety trip device is locked	x	x							
17	The reset of the safety trip device of a heating system is only possible by means of a tool	x	x							
18	The automatic reset is not possible	x	x							
19	The reset of a safety trip device under fault conditions is avoided	x								
20	The safety trip device is independent from the control system	x								
21	The level switch is installed and properly adjusted, if required	x								
22	The flow switch is installed and properly adjusted, if required	x								
	INSTALLATION – ALTERNATORS									
23	The protection devices operate within the permitted limits of t_E or t_A	x								
C	**ENVIRONMENT**									
1	The equipment is properly protected against corrosion, bad weather, vibration and other adverse factors	x	x	x	x	x	x	x	x	x
2	There is no improper accumulation of dust or dirt	x	x	x	x	x	x	x	x	x
3	The electrical insulation is clean and dry	x			x			x		
[1] Degree of inspection D = Detailed, A = Accurate, V = Visual										
Note: For items B7 and B8, the possibility of the flammable mixture presence in the surroundings of the equipment must be taken into account when using electrical testing equipment										

INSPECTIONS EVERY 2 YEARS (ACCORDING TO NBR IEC60079-17 STANDARD) Ex "p" Alternators				
CHECK WHETHER:		Degree of inspection[1]		
		D	A	V
A	**EQUIPMENT**			
1	The equipment is appropriate for the requirements of EPL / installation local zone	x	x	x
2	The equipment group is correct	x	x	
3	The equipment temperature class or the surface temperature is correct	x	x	
4	The identification of the equipment circuit is correct	x		
5	The identification of the equipment circuit is available	x	x	x
6	The enclosure, the glass parts and seals, and/or glass/metal sealing compounds are satisfactory	x	x	x
7	There are no unauthorized modifications	x		
8	There are no visible unauthorized modifications		x	x
B	**INSTALLATION**			
1	The type of cable is adequate	x		
2	There are no evident damages to the cables	x	x	x
3	The grounding connections, including any supplementary grounding connections, are satisfactory (e.g., the connections are tightened and the conductors have proper gauge) ▪ Physical inspection ▪ Visual verification	x	x	x
4	The impedance of the fault circuit (TN system) or the grounding resistance (IT system) is satisfactory	x		
5	The automatic electrical protection devices operate within the permitted limits	x		
6	The automatic electrical protection devices are correctly set	x		
7	The inlet temperature of the protection gas is below the maximum specification	x		
8	The ducts, pipes and enclosures are in good conditions	x	x	x
9	The protection gas is substantially free from contaminants	x	x	x
10	The pressure or flow of the protection gas is adequate	x	x	x
11	The indicators of pressure and/or flow, alarms and interlocks operate properly	x		
12	The conditions of the particle and spark barriers of the gas exhaust ducts, located in hazardous areas, are satisfactory	x		
13	The specific conditions of use (if any) are meet	x		
C	**ENVIRONMENT**			
1	The equipment is properly protected against corrosion, bad weather, vibration and other adverse factors	x	x	x
2	There is no improper accumulation of dust or dirt	x	x	x
[1] Degree of inspection D = Detailed, A = Accurate, V = Visual				

NOTE

- Detailed inspection encompasses the aspects covered by the accurate inspection and, furthermore, it identifies defects (loose terminals, for example) which can only be detected by opening the enclosure, and by using, if necessary, testing equipment and tools;
- Accurate inspection encompasses the aspects covered by the visual inspection and, furthermore, it identifies defects (loose screws, for example) which can only be detected with the aid of access equipment, such as ladders and tools;
- Visual inspection identifies, without using access equipment or tools, defects that are evident, such as the absence of a screw.

9 TROUBLESHOOTING

Below are listed some anomalies that may occur on the alternator in operation, as well as the correct procedure for verification and correction.

9.1 ELECTRICAL ANOMALIES

THE ALTERNATOR WILL NOT EXCITE	
CAUSE	**CORRECTIVE PROCEDURE**
Power supply of voltage regulator with faulty	▪ Verify the power supply of the voltage regulator
Field signal inverted	▪ Verify the field signal (F+ e F-)
Driving speed is not correct	▪ Measure the speed and regulate it
Interruption in the main excitation circuit	▪ Check the continuity of exciter connection cables ▪ Perform measurements on all the diodes and replace defective diodes.
Voltage regulator defective	▪ Replace the voltage regulator.
Varistor defective	▪ If defective, the varistor must be replaced, or, if there are no spare parts, remove it temporarily.
ALTERNATOR WILL NOT EXCITE UP TO THE RATED VOLTAGE	
CAUSE	**CORRECTIVE PROCEDURE**
Rotating diodes defective	▪ Replace the diodes.
Incorrect speed	▪ Measure the speed of the primary machine and adjust it.
Supply of the voltage regulator is not within the voltage range determined by the manufacturer.	▪ Check the power supply of the voltage regulator.
VOLTAGE BELOW RATED WITH NO LOAD	
CAUSE	**CORRECTIVE PROCEDURE**
Speed below rated	▪ Measure the drive machine speed and adjust
Voltage regulator no adjusted	▪ Check the voltage reading of the voltage regulator software with the alternator phases voltage ▪ Check the PT sensing voltage to the alternator ▪ Adjust the PT ratio ▪ Adjust the sensing voltage of the voltage regulator
Rotating diodes defective	▪ Replace the diodes
OVERVOLTAGE WITH NO LOAD	
CAUSE	**CORRECTIVE PROCEDURE**
Power thyristor of the regulator defective.	▪ Replace the regulator.
Sensing transformer of the regulator defective	▪ Measure the sensing voltage at the voltage regulator terminals
Voltage regulator no adjusted	▪ Check the PT ratio ▪ Check the voltage reading of the voltage regulator software with the alternator voltage ▪ Adjust the PT ratio ▪ Adjust the sensing voltage of the voltage regulator
Incompatible voltage regulator software	▪ If replacing the voltage regulator, make sure that the software versions are compatible or choose to manually parameterization
OSCILLATION IN THE ALTERNATOR VOLTAGE	
CAUSE	**CORRECTIVE PROCEDURE**
PID gain of the voltage regulator is no adjusted	▪ Check signal stability for the field generated by the voltage regulator and adjust PID gains
Oscillations in the speed of the drive machine	▪ Check and eliminate speed oscillations
SHARP VOLTAGE DROP WITH LATER RECOVERY: (BLINKS)	
CAUSE	**CORRECTIVE PROCEDURE**
Incorrect setting of the stability	▪ Adjust the instability correctly in the voltage regulator
Alternator operating in single mode with the parallelism system activated.	▪ Shut down the parallelism system
Momentary overload	▪ Check the load and adjust the rated data of the alternator
VOLTAGE DISCHARGE WHEN ENTERING THE LOAD	
CAUSE	**CORRECTIVE PROCEDURE**
Connection of the signal CT inverted on voltage regulator	▪ Invert the CT connection
LARGE VOLTAGE DROP WHEN SUBJECT TO LOAD	
CAUSE	**CORRECTIVE PROCEDURE**
Speed drop of the drive machine	▪ Observe the speed comportment of the driving machine
Voltage regulator no adjusted	▪ Check the PID gain adjust of the voltage regulator ▪ Check the actuation of the voltage regulator limiters
Diodes defectives	▪ Check the diodes and replace them, if necessary
Field winding defective	▪ Check the field winding

9.2 MECHANICAL ANOMALIES

OVERHEATING OF THE BEARING	
CAUSE	CORRECTIVE PROCEDURE
Bearing defective	▪ Replace the bearing
Excess or lack of lubrication in the bearing	▪ Check the lubrication of the bearing
Incorrect lubricant	▪ Use the lubricant according to bearing nameplate
Excessive axial clearance	▪ Correct the axial clearance
OVERHEATING ON ALTERNATOR WINDINGS	
CAUSE	**CORRECTIVE PROCEDURE**
Air input or output partially blocked	▪ Clear the air passages
Hot air is returning to the alternator	▪ Direct the hot air out of the alternator installation environment
Overload on the alternator	▪ Check the load and adjust the rated data of the alternator
Over excitation.	▪ Check the alternator excitation current and compare with the rated data. Correct it (if necessary).
Radiator with incorrect temperature, flow or pressure	▪ Check and adjust the water characteristics of the radiator
EXCESSIVE VIBRATION	
CAUSE	**CORRECTIVE PROCEDURE**
Misalignment	▪ Adjust the alignment of the alternator with the driving machine
Assembly defect	▪ Check for assembly problems of the alternator and correct them (feet fixation, coupling, flange, etc.)
Excessive clearance in the coupling	▪ Correct the clearance in the coupling

ATTENTION

The machines included in this manual are in continuous improvement, so the information in this manual is subject to change without previous notice.

9.3 ADDITIONAL INFORMATION

Necessary spare parts of the pressurization system (Ex”p” alternators):

Table 9.1: Optional spare parts

Relief valve (RLV)
Filter kit for S0015/275 filter/regulator
Purge flow sensor
Minimum pressure sensor
Intermediate pressure sensor
CLAPS sensor
Pressure megger – air pressure (0-10 barg)
Miniature megger – logical pressure (0-4 barg)
IS battery - for electronic timer module

EX

For correct and safe alternator maintenance, it is recommended the use of new and genuine parts. It is not advisable to repair damaged or worn parts.
In order to install accessories (vibration sensors, thermometers, temperature sensors, pressure switches, etc.) on Ex “p” alternators, make sure those devices are properly sealed, thus preventing pressure loss of the enclosure.

EU Declaration of Conformity

Manufacturers:
WEG Equipamentos Elétricos S.A.
Av. Prefeito Waldemar Grubba, 3000
89256-900 - Jaraguá do Sul – SC – Brazil
www.weg.net

WEG Industrie (India) PVT. LTD.
Plot n° E-20 (North), SIPCOT Industrial Complex
Phase II – Expansion II.
Mornapalli Village, Hosur 635 109
Tamil Nadu - India
www.weg.net/in

WEG MEXICO, S.A. DE C.V
Carretera Jorobas - Tula Km 3.5, Manzana 5,
Lote 1, Fraccionamiento Parque Industrial Huehuetoca,
Municipio de Huehuetoca, C.P. 54680,
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Contact person: Luís Filipe Oliveira Silva Castro Araújo
Authorised Representative in the European Union
www.weg.net/pt

The manufacturer declares under sole responsibility that:

WEG synchronous and asynchronous motors, WEG generators and their components used for following lines:

M..., W60, WGM, G...S and AN10

.....

when installed, maintained and used in applications for which they were designed, and in compliance with the relevant installation standards and manufacturer's instructions, comply with the provisions of the following relevant European Union harmonization legislation, wherever applicable:

ATEX Directive	2014/34/EU
Low Voltage Directive	2014/35/EU*;
EU Ecodesign Directive	(EU)2019/1781* as amended by Comission Regulation (EU)2021/341; Directive 2009/125/EC*;
RoHS Directive	2011/65/EU* and its amendments (including Directive 2015/863/EU);
Machinery Directive	(EU)2023-1230**;
EMC Directive	2014/30/EU (electric motors are considered inherently benign in terms of electromagnetic compatibility).

EN 60034-1:2010 + AC:2010 / EN 60034-2-1:2014 / EN IEC 60034-3:2020/ EN IEC 60034-5:2020 / EN 60034-8:1993/ EN 60034-7:2022 + AC:2023:03 / EN 60034-8:2007 + A1:2014 / EN 60034-9:2005 + A1:2007 /EN 60034-11:2004/ EN 60034-12:2017/EN IEC 60034-14:2018 / EN 60034-30-1:2014/ EN 60204-1:2018 /EN IEC 60204-11:2019 / CLC IEC/TS 60034-30-2:2021 / EN 61800-5-1: 2007+A1:2017+A11:2021 / EN IEC 61800-3: 2018 / EN IEC 63000:2018 / CLC IEC/TS 60034-26:2024 and IEC 60034-30-3:2024.

* Electric motors designed for use with a voltage rating higher than 1000V are not considered under the scope.
** Low voltage electric motors are not considered under the scope and electric motors designed for use with a voltage rating higher than 1000V are considered partly completed machinery and are supplied with a

Declaration of Incorporation:

The products above cannot be put into service until the machinery into which they have been incorporated has been declared in conformity with the Machinery Directive.

A Technical Documentation for the products above is compiled in accordance with part B of annex VII of Machinery Directive (EU)2023-1230.

We undertake to transmit, in response to a reasoned request by the national authorities, relevant information on the partly completed machinery identified above through WEG authorised representative established in the European Union. The method of transmission shall be electronic or physical method and shall be without prejudice to the intellectual property rights of the manufacturer.

EDSON JOSE KOSHINSKI:02103921933
Assinado de forma digital por EDSON JOSE KOSHINSKI:02103921933
Dados: 2025.10.03 10:23:05 -03'00'

Signed for and on behalf of the manufacturer:
Edson Jose Koshinski
Global Engineering Director

Jaraguá do Sul, October 03rd , 2025

DEC7225-Rev02 - English

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11 ENVIRONMENTAL INFORMATION

11.1 PACKAGE

The alternators are supplied in cardboard, polymer, wood or metal packages. Those materials are recyclable or reusable and must be properly disposed according to the current regulations of each country. All wood used in the packaging of WEG alternators comes from reforestation and receives anti-fungal treatment.

11.2 PRODUCT

The alternators, under the constructive aspect, are manufactured primarily with ferrous metals (steel, cast iron), nonferrous metals (copper, aluminum) and plastic. The electric alternator, in general, is a product that has a long service life; however, when it must be disposed, WEG recommends that the materials of the packaging and of the product be properly separated and sent for recycling.
The non-recyclable materials must be properly disposed according to the environmental regulations, i.e., in industrial landfill, co-processed in cement kilns or incinerated. The service providers of recycling, disposal in industrial landfills, co-processing or incineration of waste must be properly licensed by the environmental agency of each state to carry out these activities.

11.3 HAZARDOUS WASTE

Grease and oil waste used to lubricate the bearings should be disposed, according to the instructions of the relevant environmental agencies, because its improper disposal can cause impacts to the environment.

12 SERVICE NETWORK

To consult the Service Network, access the website www.weg.net.

13 WARRANTY

These products, when operated under the conditions stipulated by WEG in the operating manual for such product, are warranted against defects in workmanship and materials for twelve (12) months from start-up date or eighteen (18) months from manufacturer shipment date, whichever occurs first.
However, this warranty does not apply to any product which has been subject to misuse, misapplication, neglect (including without limitation, inadequate maintenance, accident, improper installation, modification, adjustment, repair or any other cases originated from inadequate applications).
The company will neither be responsible for any expenses incurred in installation, removal from service, consequential expenses such as financial losses nor transportation costs as well as tickets and accommodation expenses of a technician when this is requested by the customer.
The repair and/or replacement of parts or components, when effected by WEG within the Warranty period do not give Warranty extension, unless otherwise expressed in writing by WEG.
This constitutes WEG's only warranty in connection with this sale and is in lieu of all other warranties, expressed or implied, written or oral.
There are no implied warranties of merchantability or fitness for a particular purpose that apply to this sale.
No employee, agent, dealer, repair shop or other person is authorized to give any warranties on behalf of WEG nor to assume for WEG any other liability in connection with any of its products.
In case this happens without WEG's authorization, Warranty is automatically cancelled.

LIABILITY

Except as specified in the foregoing paragraph entitled "Warranty Terms for Engineering Products", the company shall have no obligation or liability whatsoever to the purchaser, including, without limitation, any claims for consequential damages or labor costs, by reason of any breach of the express warranty described therein.
The purchaser further hereby agrees to indemnify and hold the company harmless from any causes of action (other than cost of replacing or repairing the defective product as specified in the foregoing paragraph entitled "Warranty Terms for Engineering Products"), arising directly or indirectly from the acts, omissions or negligence of the purchaser in connection with or arising out of the testing, use, operation, replacement or repair of any product described in this quotation and sold or furnished by the company to the purchaser.

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NOTES

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