Three Phase Induction Motors

T Line - Squirrel Cage Rotor
Top Drive Drilling Application

Installation, Operation and Maintenance Manual

Installation, Operation, and Maintenance Manual

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Dear Customer,

Thank you for acquiring a WEG motor. This product was developed with high levels of quality and efficiency to ensure an excellent performance.
Since electric motors play an important role in comfort and well being, they need to be identified and treated as driving machines, which features include certain handling procedures such as storage, installation, and maintenance.
All efforts were employed in order to ensure that all the information provided in this manual is accurate regarding the configurations and applications of the motor.
Therefore, careful reading of this manual before proceeding with the motor installation, operation or maintenance is highly recommended in order to ensure safe and continuous motor operation. In case of any remaining doubts, please contact WEG. Maintain this manual close to the motor at all times so it can be consulted whenever necessary.

ATTENTION

1. Following the procedures provided in this manual is mandatory to maintain a valid product warranty;
2. Motor installation, operation, and maintenance procedures must be performed only by qualified personnel.

NOTES

1. Total or partial reproduction of the information provided herein is allowed, provided that the source is properly referenced;
2. If this manual is lost, a PDF copy may be downloaded from the www.weg.net website, or an extra copy may also be provided by WEG.

WEG EQUIPAMENTOS ELÉTRICOS S.A.

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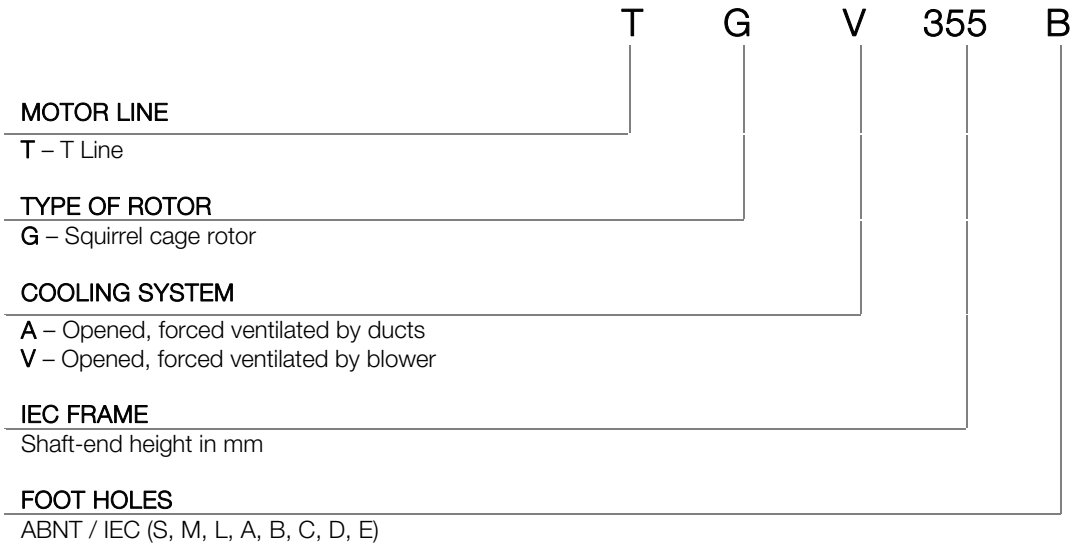
1 INTRODUCTION

This manual provides basic instructions for installation, operation and maintenance for three phase induction motors – T line applied to Top Drive Drilling Systems.
Motors are provided with specific documents (dimensional, connection diagram, data sheet, characteristic curves, etc.). Along with this manual, such documents must be carefully evaluated before proceeding to the installation, operation or maintenance of the motor.
In case of any additional clarifications regarding motors with constructive specialties, please contact WEG. All procedures and standards provided in this manual must be followed in order to ensure proper motor operation and safety of all personnel involved in its operation. Compliance to these procedures is equally important in order to ensure motor warranty. Therefore, careful reading of this manual before installing and operating the motor is recommended. In case of any additional clarifications, please contact WEG.

1.1 TERMINOLOGY



1.2 FUNCTIONAL DESCRIPTION

1.2.1 TGV model

The model **TGV Drilling Motor** is a force–ventilated, three–phase alternating–current induction motor designed for use in the oil and gas industry to power offshore and land-based drilling rigs. The normal function of the vertically mounted TGV motor is to provide power for electric top drives drillings.
Motor speed is VFD controlled by varying the frequency of the alternating current in the motor stator windings. The direction of rotation of the motor rotor is changed by reversing the phase rotation in the motor stator.
The motor is force-ventilated by a blower assembly that meets IP44 in the rig installation.

1.2.2 TGA model

The WEG **TGA Top Drilling Model** is a form-wound squirrel-cage inverter-rated AC induction motor designed and manufactured for use in oil and gas industry services.
TGA motors are built to endure the severe conditions founded in the Top Drive Systems applications. It´s vertical mounted and the motor speed is VFD controlled by varying the frequency of the alternating current in the motor stator windings. The direction of rotation of the motor rotor is changed by reversing the phase rotation in the motor stator.

1.3 SAFETY WARNINGS

The following safety warnings are used in this manual:

DANGER

Non compliance with the recommended procedures in this warning may lead to death, severe injuries and substantial property damage.

ATTENTION

Non compliance with the recommended procedures in this warning may lead to property damage.

NOTE

This provides relevant information for appropriate product operation and service.

2 GENERAL INSTRUCTIONS

All personnel working in the assembly, operation or maintenance of electrical installations, must be constantly informed and updated on the service safety instructions and standards and be advised to strictly comply with them. Before initiating any tasks, the personnel in charge is responsible for making sure that all points were duly observed and for alerting the respective staff about the dangers inherent to the task to be performed. When inappropriately applied, target of deficient maintenance, or even when handled by non-qualified personnel, such motors may cause severe personal and/or property damage. Therefore, it is recommended that these services are always performed by qualified personnel.

2.1 QUALIFIED PERSONNEL

The term qualified personnel represents those who, due to their training, experience, education level, knowledge of applicable standards, safety standards, accident prevention and knowledge of operating conditions, have been authorized by those in charge to execute all necessary tasks, and to recognize and avoid any possible danger.
Such qualified personnel must also know first aid procedures and must be able to provide such services, if necessary.
All operation, maintenance, and repair tasks are to be exclusively performed by qualified personnel.

2.2 SAFETY INSTRUCTIONS

DANGER

During operation, this equipment exposes energized or spinning parts that may present high voltage or high temperatures. Therefore, operation with open terminal boxes, unprotected couplings or incorrect handling, failing to comply with operating standards, may cause severe personal and property damage.

The personnel in charge of installation safety must ensure that:
- Only qualified personnel install and operate the equipment;
- Such personnel must have immediate access to this manual and other documents provided with the motor as well as perform tasks in strict compliance to the service instructions, relevant standards, and specific product documentation;

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 within the work site.

All qualified personnel must also observe:
- All technical data regarding allowed applications (operating conditions, connections and installation environment), provided in the catalog, purchase order documents, operating instructions, manuals, and other documentation;
- The specific determinations and conditions for local installation;
- The use of appropriate tools and equipment for handling and transportation;
- That the individual component protection devices are removed before the installation.

Individual parts must be stored in vibration-free environments, avoiding falls and ensuring their protection against aggressive agents and/or do not present risks to the safety of personnel.

2.3 MOTORS APPLIED IN HAZARDOUS AREAS

The specific hazardous area operation motors possess additional safety characteristics which are defined in specific rules for every type of risk area according to their classification.
The general requirements for equipment operating in hazardous areas are described in the following Brazilian and international standards, respectively:
IEC 60034-1 - Rotating Electrical Machines - Part 1: Rating and Performance
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
IEC 60079- 1 - Explosive Atmospheres - Part 1: Equipment Protection by Flameproof Enclosures 'd'
ABNT NBR IEC 60079-1 - Atmosferas Explosivas - Parte 1 - Proteção de Equipamento por Invólucro à Prova de Explosão ‘d’
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’
ABNT IEC 60079- 7 - Electrical Apparatus for Explosive Gas Atmospheres - Part 7: Increased Safety 'e'
ABNT NBR IEC 60079-7:2008 - Atmosferas Explosivas - Parte 7: Proteção de Equipamentos por segurança Aumentada "e"
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’
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

2.3.1 General Precautions

Before installing, operating, or performing maintenance in electric motors in hazardous areas, the following precautions must be adopted:
- Study and understand the standards provided in the ***“Motors applied in hazardous areas”*** item;
- Comply with all requirements established in the applicable standards.

2.3.2 Additional Precautions

- Shutdown the motor and wait until it comes to a complete halt before performing any maintenance, inspection, or reparation services;

- All existing protections must be installed and properly set before operating;
- Ensure that motors are duly grounded;
- Connection terminals must be duly connected, avoiding any type of poor contact that might generate heating or sparking.

NOTE

Comply with all other storage, transportation, installation and maintenance instructions provided in this manualand applicable to the type of motor at hand.

2.4 STANDARDS

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

Table 2.1: Standards applicable to three-phase induction motors

	IEC	NBR	NEMA
Specification	60034-1	7094	MG1-1,10,20
Dimensions	60072	5432	MG1-4,11
Tests	60034-2	5383	MG1-12
Levels of protection	60034-5	9884	MG1-5
Cooling	60034-6	5110	MG1-6
Constructive Forms	60034-7	5031	MG1-4
Noise	60034-9	7565	MG1-9
Mechanical vibration	60034-14	7094	MG1-7

2.5 ENVIRONMENT CHARACTERISTICS

The motors were designed for the following operating conditions:

- Ambient temperature -15ºC to +45ºC;
- Altitude: 1,000 m;
- Environment according to the motor protection degree.

Special operating conditions may be provided upon request, which must be specified in the purchase order and described on the nameplate and specific data sheet of every motor.

2.6 OPERATION CONDITION

In order for the product warranty to remain valid, the motor must be operated according to the rated data indicated on the nameplate, and all applicable standards and codes, as well as the information provided in this manual, must be followed.

2.7 VOLTAGE AND FREQUENCY

It is very important to ensure correct power supply to the motor. The conductors and the entire protection system must guarantee a power quality within established parameters to the motor terminals, according to the IEC60034-1 standard:

- Voltage: may vary within a ±10% range of rated value;
- Frequency: may vary within –5% to +3% range of rated value.

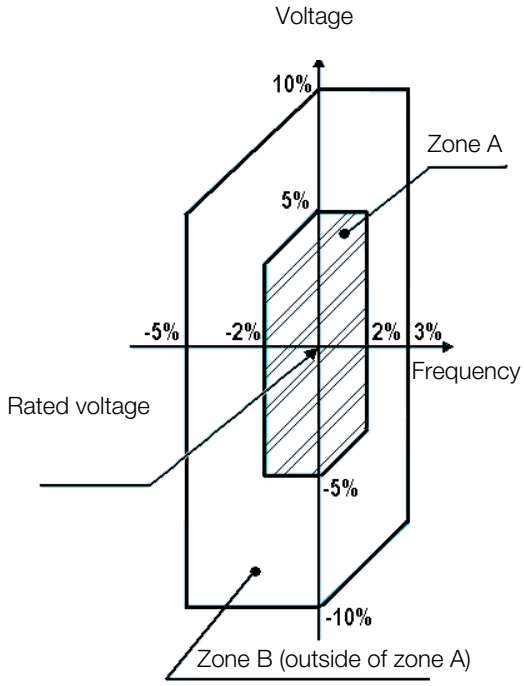


Figure 2.1: Voltage and frequency variation limits

The motor must be capable of performing its main function in Zone A continuously, but it may not completely meet its rated voltage and frequency performance characteristics (see rated characteristics point in Figure 2.1), when it may show some deviations. Increase in temperature may be greater than those from rated voltage and frequency.
The motor must be capable of performing its main function in Zone B. However, regarding rated voltage and frequency performance characteristics, it may show greater deviations than those in Zone A. Temperature increase may be higher than those identified in rated voltage and frequency and, most likely, greater than in Zone A.
Extended operation in the boundaries of Zone B is not recommended.

3 RECEIVING, STORAGE AND HANDLING

3.1 RECEIVING

All motors are tested and provided in perfect operating conditions. All machined surfaces must be protected against corrosion. Packages must be checked upon receipt for eventual damages during transportation.

ATTENTION

All damages must be immediately photographed, documented, and reported to the transportation company, to the insurance company and to WEG. Failure to comply with such procedures will void the product warranty.

ATTENTION

Parts supplied in additional packages must be checked upon receipt.

- When lifting a package (or container), the correct hoisting points, the weight indicated in the package or on the nameplate, and the operating capacity of the hoisting devices must be observed.
- Motors packed in wooden crates must always be lifted by their own eyebolts/lifting lugs or by a proper forklift, and must never be lifted by its wooden parts;
- The package must never be dropped. Carefully place it on the floor (without impact) to avoid bearing damage;
- Do not remove the grease-based corrosion protection from the shaft end, nor the closing plugs in junction box holes;
- These protections must remain in place until the final assembly. A complete visual inspection of the motor must be performed after removing the package;
- The shaft locking device must only be removed shortly before installing and storing the motor in a safe location for future transportation.

3.2 STORAGE

Any damage to the painting or to the protections against rust in the machined parts must be corrected.

ATTENTION

Space heaters (if any) must remain active during storage in order to avoid water condensation inside the motor.

3.2.1 Indoor storage

If the motor is not installed immediately after reception, it must remain inside the package and stored in a location protected against humidity, vapors, fast heat variations, rodents, and insects.
The motor must be stored in vibration-free locations in order to avoid bearing damage.

3.2.2 Outdoor storage

The motor must be stored in a dry location, free of flooding and vibrations.
Repair all damages to the packaging before storing the motor, which is necessary to ensure proper storage conditions.
Place the motor on platforms or foundations to protect it against land humidity and keep it from sinking into the soil. Free air circulation underneath the motor must be assured.
The cover or canvas used to protect the motor against the weather must not be in contact with its surfaces. In order to ensure free air circulation between the motor and such covers, place wooden blocks as spacers.

3.2.3 Extended storage

When the motor is stored for a long period of time before being operated, it is exposed to external agents, such as temperature fluctuations, moisture, aggressive agents, etc.
Empty spaces inside the motor, such as bearings, terminal boxes, and windings, are exposed to humidity, which can cause condensation and, depending on the degree of air contamination, aggressive substances may also penetrate these empty spaces.
Consequently, after long storage periods, the winding insulation resistance may drop below acceptable values. Internal components, such as rollers, may oxidize, and the lubricant power of the lubricant agent in the rollers may be adversely affected. All of these influences increase the risk of damages before starting up the motor.

ATTENTION

All preventive measures described in this manual, such as constructive aspects, maintenance, packaging, storage, and periodical inspections, must be followed and recorded, in order to maintain the product warranty.

The following instructions are valid for motors stored for long periods of time and/or were idle for two or more months before being operated.

3.2.3.1 Storage location

In order to ensure the best storage conditions for the motor during long periods of time, the chosen location must strictly meet the criteria described below.

3.2.3.1.1 Indoor storage

- The storage room must be closed and covered;
- The location must be protected against moisture, vapors, aggressive agents, rodents, and insects;
- The location must be free of corrosive gases, such as chlorine, sulphur dioxide, or acids;
- The environment must be free of continuous or intermittent vibrations;
- The environment must present an air-filtered ventilation system;

- Ambient temperature between 5°C and 60°C, and must not be subject to sudden temperature variations;
- Relative humidity <50%;
- Protection against dirt and dust accumulation;
- Fire detection system;
- The location must have power to supply the space heaters.

In case the storage location does not meet any of these requirements, WEG recommends that additional protections are incorporated to the motor packaging during the storage period, as follows:

- Closed wooden crate or similar with proper electrical installation, providing power to the space heaters.
- If there is risk of infestation and fungus growth, the package must be protected on the site by spraying or painting it with proper chemical agents;
- Package preparation must be carefully executed by experienced personnel.

3.2.3.1.2 Outdoor storage

Outdoor storage is not recommended

In case outdoor storage is unavoidable, the motor must be packed in a specific packaging for such condition, as follows:

- For outdoor storage, besides the packaging recommended for internal storage, the package must be covered with a protection against dust, moisture and other foreign materials, using a resistant canvas or plastic.
- The package must be placed on gratings or foundations, ensuring protection against dirt and moisture and keeping the motor from sinking into the soil;
- After the motor is covered, a shelter must be constructed in order to protect it against direct rain, snow and excessive sun heat.

ATTENTION

In case the motor remains stored for long periods of time, it is recommended to inspect it regularly as specified in item ***Maintenance Plan During Storage*** of this manual.

3.2.3.2 Separate parts

In case separate parts have been supplied (terminal boxes, covers, etc.), these must be packed as specified in items ***Indoor Storage*** and ***Outdoor Storage*** of this manual;
Air relative humidity inside package must not exceed 50%.

3.2.3.3 Space heaters (TGV model)

The motor space heaters must remain powered during storage to avoid moisture condensation inside the motor and ensuring that the windings insulation resistance remains within acceptable levels.

ATTENTION

The motor space heater must be powered on while it is stored in a place with temperatures < 5°C and air relative humidity >50%.

3.2.3.4 Insulation resistance

During the storage period, motor windings' insulation resistance must be measured and recorded quarterly, before the motor is installed.
Any eventual insulation resistance reduction must be investigated.

3.2.3.5 Exposed machined surfaces

All exposed machined surfaces (e.g. shaft end and flanges) are factory-protected with a temporary rust inhibitor.
This protection film must be reapplied at least twice a year or when removed and/or damaged.
Recommended Products:
Name: Dasco Guard 400 TX AZ, Manufacturer: D.A. Stuart Ltda
Name: TARP, Manufacturer: Castrol.

3.2.3.6 Bearings

The bearings are lubricated at the factory, in order to perform motor tests.
During the storage period, every two months, the shaft locking device must be removed and the shaft must be manually revolved in order to distribute grease inside the bearing and preserving good bearing conditions.
After 6 months of storage and before operating the motor, the bearings must be lubricated again.
If the motor remains stored for over 2 years, the bearings must be disassembled, cleaned, inspected, and lubricated.

3.2.3.7 Terminal box (TGV model)

When the insulation resistance in the motor windings is measured, the main junction box and the other terminal boxes (if any) must also be inspected, especially considering the following aspects:

- The inner part must be dry, clean, and free of any dust accumulation;
- The contact elements cannot be corroded;
- The sealing must remain under appropriate conditions;
- The cable inlets must be correctly sealed.

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

3.2.3.8 Preparation for commissioning

3.2.3.8.1 Cleaning

- Motor inner and outer parts must be free of oil, water, dust, and dirt. Motor inner part must be cleaned with compressed air at reduced pressure;
- 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. Oxidation and marks on bearing seats and on the shaft must be carefully removed.

3.2.3.8.2 Bearing lubrication

Use the specified lubricant to lubricate the bearings. Information on bearings and lubricants are indicated on the bearings' nameplate, and lubrication must be performed as described in item ***Bearing maintenance*** of this manual, always considering the proper type of bearing.

3.2.3.8.3 Checking the insulation resistance

Before operating the motor, the insulation resistance must be measured according to item ***Insulation resistance*** of this manual.

3.2.3.8.4 Others

Follow the remaining procedures described in item ***Commissioning*** of this manual before operating the motor.

3.2.3.9 Inspections and records during storage

Stored motors must be periodically inspected and inspection records must be filed.

The following points must be inspected:
1. Physical damage;
2. Cleanliness;
3. Signs of water condensation;
4. Protective coating conditions;
5. Paint conditions;
6. Signs of vermin or insect activity;
7. Satisfactory operation of space heaters. It is recommended that a signaling system or alarmis installed in the location in order to detect power interruption in the space heaters;
8. Record ambient temperature and air relative humidity around the motor, winding temperature (using RTDs), insulation resistance and polarization index;
9. The storage location must also be inspected to assert its compliance with the criteria described in the ***Storage plan*** item.

3.2.3.10 Maintenance Plan During Storage

During the storage period, motor maintenance must be performed and recorded in accordance with the plan described in Table 3.1.

Table 3.1: Storage plan

	Monthly	Every 2 months	Every 6 months	Every 2 years	Before operating	Note
Storage Location						
Inspect cleanliness conditions		X			X	
Inspect humidity and temperature conditions		X				
Check for signs of insect infestation		X				
Measure vibration levels	X					
Packaging						
Inspect physical damages			X			
Inspect the relative humidity inside the motor		X				
Replace dehumidifier in the package (if any)			X			Whenever necessary
Space heater (if any)						
Check operation conditions	X					
Complete motor						
Perform external cleaning			X		X	
Check paint conditions			X			
Check oxidation inhibitor on exposed machined parts			X			
Replace the oxidation inhibitor			X			
Windings						
Measure the insulation resistance		X			X	
Measure the polarization index		X			X	
Terminal box and grounding terminals						
Clean the terminal boxes' inner parts				X	X	TGV model
Inspect seals and sealing				X	X	
Inspect and retighten the grounding terminals				X	X	
Bearings						
Rotate the shaft		X				
Relubricate the bearing			X		X	
Disassemble and clean the bearing				X		

3.3 HANDLING

1. In order to move the motor, the shaft must be locked with the locking device supplied with the motor;
2. Use only the specific lifting lugs. provided for this purpose. If necessary, use a crossbeam to protect motor parts;
3. Never use the blower lifting lugs to lift the motor (if applicable);
4. Rated motor weight must be observed.
5. Do not jolt the motor when lifting it or drop it abruptly as that may cause damage to the bearings;
6. The eyebolts in the blowers, covers, terminal boxes, etc., are specifically designed for their respective component only;
7. Never lift the motor by the shaft;

ATTENTION

Steel cables, clevises and hoisting equipment must have capacity to support the motor weight.

4 INSTALLATION

4.1 INSTALLATION SITE

Motors must be installed in easily accessible places, allowing periodic inspections, local maintenance and, if necessary, removal for external services.
The following environment characteristics must be ensured:

- Clean and well-ventilated location;
- Other equipment or building must not block the motor ventilation;
- The area around and above the motor must be sufficient for its maintenance or handling;
- The environment must be in accordance with the motor protection level.

4.2 INSULATION RESISTANCE

4.2.1 Safety instructions

DANGER

In order to measure the insulation resistance, the motor must be shutdown.
The winding being tested must be connected to the frame and grounded until all residual electrostatic charges are removed. The capacitors must also be grounded (if any) before disconnecting and separating the terminals, and measure the insulation resistance with a megohmmeter.
Noncompliance with these procedures may result in personnel injuries.

4.2.2 General considerations

When motor is not immediately operated, it must be protected against moisture, high temperatures, and dirt, avoiding impacts to the insulation resistance.
Winding insulation resistance must be measured before operating the motor.
If the environment is too humid, the insulation resistance must be measured periodically during storage. It is difficult to establish fixed rules for the actual value of a motor insulation resistance, as it varies according to environmental conditions (temperature, humidity), machine cleanliness conditions (dust, oil, grease, dirt), and quality and condition of the insulating material used.
Evaluating periodical follow-up records is useful to conclude whether the motor is able to operate.

4.2.3 Measuring stator windings

The insulation resistance must be measured with a ***megohmmeter***. Test voltage for motor windings must be in accordance with Table 4.1 and the IEEE43 standard.

Table 4.1: Winding insulation resistance test voltage

Winding rated voltage (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 measuring the stator winding insulation resistance, verify if:

- the CTs secondary connections are not open (if applicable);
- All power cables are disconnected;
- The motor frame is grounded;
- The winding temperature was measured;
- All temperature sensors are grounded;

The stator windings' insulation resistance measurement must be carried out in the main terminal box.
The instrument (megohmmeter) must be connected between the motor frame and the winding. The frame must be grounded.

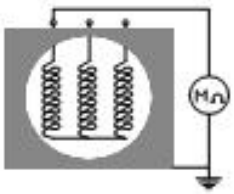


Figure 4.1: Megohmmeter connection

If the total winding measurement presents a value below recommended, the neutral connections must be opened and the insulation resistance of each phase must be separately measured.

ATTENTION

Much higher values may be frequently obtained in motors being operated for a long period of time. Comparison with values obtained in previous tests in the same motor, under similar load, temperature, and humidity conditions, may be an excellent parameter to evaluate the winding insulation conditions, instead of exclusively using the value obtained in a single test as basis. Significant or abrupt reductions are considered suspicious.

Table 4.2: Insulation resistance referential limits in electric machines

Insulation resistance value	Insulation evaluation
2MΩ or less	Bad
< 50MΩ	Dangerous
50...100MΩ	Regular
100...500MΩ	Good
500...1000MΩ	Very good
> 1000MΩ	Excellent

4.2.4 Minimum insulation resistance

If the insulation resistance measured is less than 100MΩ at 40ºC before operating the motor, the windings must be dried according to the following procedure:

- Disassemble the motor and remove the rotor and bearings;
- Heat the frame with the stator winding up to 130°C in an industrial oven for at least 8 hours (for motors above the 630 IEC or 104 frame NEMA series, at least 12 hours). Please contact WEG before employing other methods;
- Check if the insulation resistance is within acceptable values, according to Table 4.2. If not, please contact WEG.

4.2.5 Polarization index

The polarization index is traditionally defined by the relation between the insulation resistance measured for 10 min. and the insulation resistance measured for 1 min. This measurement procedure is always carried out at relatively constant temperatures.The polarization index allows the evaluation of the motor insulation conditions according to Table 4.3.

Table 4.3: Polarization index (relation between 10 minutes and 1 minute)

Polarization index	Insulation evaluation
1 or less	Bad
< 1.5	Dangerous
1.5 to 2.0	Marginal
2.0 to 3.0	Good
3.0 to 4.0	Very good
> 4.0	Excellent

DANGER

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

4.2.6 Conversion of measured values

The insulation resistance must be kept at 40°C. If the measurement is performed at a different temperature, it will be necessary to correct the reading to 40°C using an insulation resistance variation curve related to the temperature obtained from the motor itself. If this curve is not available, the approximate correction provided by the curve in Figure 4.2 according to the NBR 5383 / IEEE43 standard, may be employed.

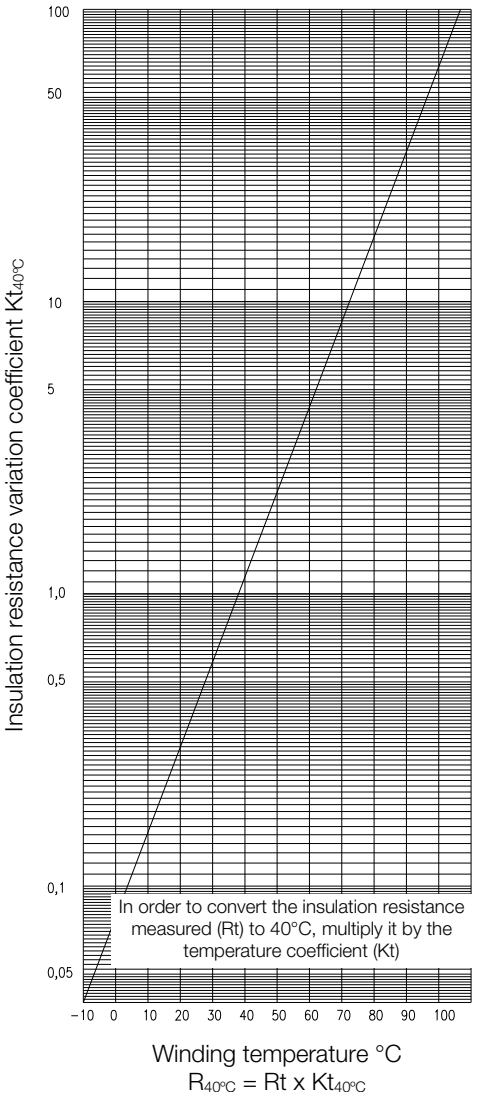


Figure 4.2: Insulation resistance variation coefficient according to the temperature

4.3 PROTECTIONS

Primarily, motor circuits have two types of protection: motor protection against overload/blocked rotor and circuit protection (terminal and distribution) against short circuit.
Motors used on a continuous basis must be protected against overload through a device integrated to the motor, or an independent protection device, that usually is a thermal relay with rated current equal or less than the value obtained by multiplying the supply rated current at the motor full load by:

- 1.25 for motors with service factor equal or greater than 1.15;
- 1.15 for motors with service factor equal to 1.0.

The motors also possess protection devices against overheating (in case of overload, motor locking, low voltage, lack of motor ventilation).

4.3.1 Thermal protection

Protection devices against overheating are installed in the stator windings, bearings and in other components that require temperature monitoring and thermal protection. These devices must be connected to an external temperature monitoring and protection system.

4.3.1.1 Temperature sensors

Thermo resistance (Pt100) - A calibrated resistance element. Its operation is based on the principle that a metallic conductor electric resistance varies linearly according to the temperature. The detector terminals must be connected to a control panel with a temperature meter.

NOTE

RTD thermoresistances allow monitoring through the absolute temperature informed by its instant resistance value. With this information, the relay may perform the reading of the temperature, as well as the alarm and shutdown parameterization, according to predetermined temperatures.

4.3.1.2 Winding temperature limits

The temperature at the winding hottest point must be kept below the insulation thermal class limit. The total temperature is composed by the ambient temperature plus temperature elevation (T), plus the difference between the average winding temperature and the winding hottest point temperature.
Ambient temperature is, by rule, 40°C at most. Working conditions above this value are considered special.
Table 4.4 displays the numeric values and the composition of the acceptable temperature at the winding hottest point.

Table 4.4: Insulation class

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

ATTENTION

If the motor is operating at temperatures above the limit values of the insulation thermal class, insulation useful life and, consequently, motor useful life will be significantly reduced or it may even result in motor blow out.

4.3.1.3 Alarm and shutdown temperatures

The temperature level to trigger alarm and shutdown must be parameterized at the lowest value possible. This temperature level may be determined by test results or through motor operating temperatures. Alarm temperature may be set at 10°C, above the machine full load operating temperature, always considering the local ambient temperature. Shutdown temperatures must not exceed maximum acceptable temperature for the stator winding insulation class and for the bearings (considering lubrication type and system).

Table 4.5: Maximum stator temperature

Temperature Class	Maximum adjustment temperatures for the protections (°C)	
	Alarm	Shutdown
F	130	155
H	155	180

Table 4.6: Maximum bearing temperature

Maximum adjustment temperatures for the protections (°C)	
Alarm	Shutdown
90	110

ATTENTION

Alarm and shutdown values may be defined based on experience. However, they must not exceed the maximum values indicated in Table 4.5 and Table 4.6.

ATTENTION

Motor protection devices are listed in the WEG diagram - Specific connection diagram for each motor.
Failure to use such devices is the user's exclusive responsibility and, in case of damages, may void the product warranty.

4.3.1.4 Temperature and ohmic resistance of Pt100 thermoresistors

Table 4.7 shows temperature values in function of the ohmic resistance measured for Pt100 thermoresistors.

Formula: $\frac{\Omega - 100}{0.386} = °C$

Table 4.7: Temperature X Resistance (Pt100)

° C	0	1	2	3	4	5	6	7	8	9
0	100.00	100.39	100.78	101.17	101.56	101.95	102.34	102.73	103.12	103.51
10	103.90	104.29	104.68	105.07	105.46	105.95	106.24	106.63	107.02	107.40
20	107.79	108.18	108.57	108.96	109.35	109.73	110.12	110.51	110.90	111.28
30	111.67	112.06	112.45	112.83	113.22	113.61	113.99	114.38	114.77	115.15
40	115.54	115.93	116.31	116.70	117.08	117.47	117.85	118.24	118.62	119.01
50	119.40	119.78	120.16	120.55	120.93	121.32	121.70	122.09	122.47	122.86
60	123.24	123.62	124.01	124.39	124.77	125.16	125.54	125.92	126.31	126.69
70	127.07	127.45	127.84	128.22	128.60	128.98	129.37	129.75	130.13	130.51
80	130.89	131.27	131.66	132.04	132.42	132.80	133.18	133.56	133.94	134.32
90	134.70	135.08	135.46	135.84	136.22	136.60	136.98	137.36	137.74	138.12
100	138.50	138.88	139.26	139.64	140.02	140.39	140.77	141.15	141.53	141.91
110	142.29	142.66	143.04	143.42	143.80	144.17	144.55	144.93	145.31	145.68
120	146.06	146.44	146.81	147.19	147.57	147.94	148.32	148.70	149.07	149.45
130	149.82	150.20	150.57	150.95	151.33	151.70	152.08	152.45	152.83	153.20
140	153.58	153.95	154.32	154.70	155.07	155.45	155.82	156.19	156.57	156.94
150	157.31	157.69	158.06	158.43	158.81	159.18	159.55	159.93	160.30	160.67

4.3.1.5 Space heater

When the motor is equipped with space heater to prevent water condensation in its interior during long idle periods, it must be assured that this space heater is activated immediately after the motor is shutdown and that it is turned off as soon as motor resumes operation.
Installed resistance supply voltage and power values are informed in the motor connection diagram and on the specific nameplate fixed to the motor.

4.4 COOLING

Only a correct motor and cooling system installation can ensure continuous operation without overheating.

4.4.1 TGA cooling system

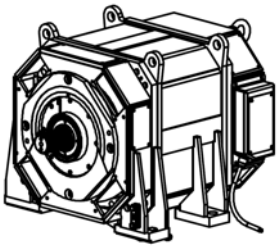


Figure 4.3: TGA cooling

The TGA motor is cooled by means of ducts. See the technical documentation to provide the ventilation according to flow and pressure recommended.

4.4.2 TGV cooling system

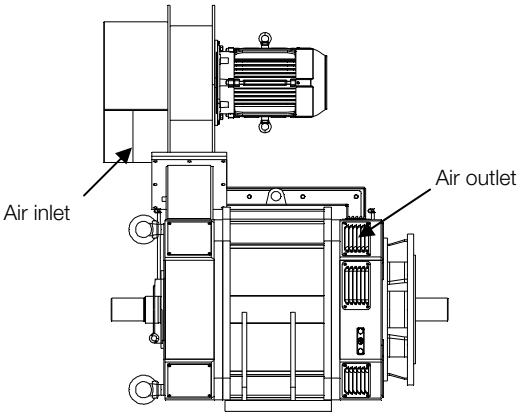


Figure 4.4: TGV cooling

The TGV motor cooling system is composed by a blower installed on top of the motor.

NOTE

The air inlets and outlets must never be blocked, since that could cause overheating of the motor or even its burning.

Ensure the correct direction of rotation of the radial fan by observing the indication of the arrow. Operation in the wrong direction of rotation considerably reduces the air flow, resulting in overheating of the motor.
Remove any object that may hinder the free internal or external air circulation through the motor.

4.5 ELECTRICAL CHARACTERISTICS

4.5.1 Electrical connections

4.5.1.1 Main connection

Connections to main terminals must be made according to the connection diagram of the motor.
Ensure that the power cables cross-section and insulation are appropriate for the motor current and voltage.
Stator and rotor terminal identifications and the corresponding connections are indicated in the motor-specific connection diagram, in compliance with the IEC60034-8 or NEMA MG1 standards.
The motor rotation direction may be altered by the inversion of any two phases. However, the motor must turn in the direction specified in the connection plate and in the nameplate fixed to the motor.

NOTE

The direction of rotation is defined by facing the shaft end on motor drive-end side.
Motors with a single direction of rotation must only turn in the indicated direction, since fans and other devices are unidirectional.
In order to operate the motor in the opposite direction, please contact WEG

ATTENTION

Before connecting the motor to the power grid, it is necessary to carefully measure the winding insulation resistance.

4.5.1.2 Grounding

The motor frame and terminal box (if any) must be grounded before connecting the motor to the power supply system.
Connect the cable metallic coating (if any) to the common grounding conductor. Cut the appropriate length of the grounding conductor and connect it to the existing terminal in the terminal box and/or the one in the frame.
Firmly fix all connections.

ATTENTION

Do not use steel washers or washers made of low electric conductivity materials to fix the terminals.

Before making the connections, apply protective grease in all connection contacts.
Insert all sealing rings in the respective grooves. Close the terminal box cover making sure that the sealing rings are placed correctly.

4.5.2 Connection diagram

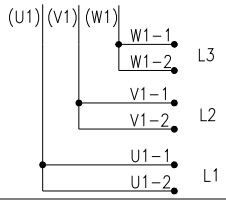
4.5.2.1 IEC60034-8 connection diagram

The connection diagrams below identify the terminals in the terminal box, and all possible connections to stator (phases) and rotor in three-phase ring induction motors. The numbers described in each diagram allow the identification of the connection diagram through a nameplate fixed to the motor including code numbers corresponding to the connection diagrams for stator and accessories.

3 ELECTRICAL TERMINALS	6 ELECTRICAL TERMINALS	6 ELECTRICAL TERMINALS - DAHLANDER				
9100 U V W L1 L2 L3	9101 Δ: W2 U2 V2 / U1 V1 W1 / L1 L2 L3 Y: W2 U2 V2 / U1 V1 W1 / L1 L2 L3	9102 Δ 1U 1V 1W 2W 2V 2U L1 L2 L3 LOWEST SPEED	9103 YY 1U 1V 1W 2W 2V 2U L1 L2 L3 HIGHEST SPEED	9104 Y 1U 1V 1W 2W 2V 2U L1 L2 L3 LOWEST SPEED	9105 YY 1U 1V 1W 2W 2V 2U L1 L2 L3 LOWEST SPEED	9106 Δ 1U 1V 1W 2W 2V 2U L1 L2 L3 HIGHEST SPEED
3 ELECTRICAL TERMINALS + NEUTRAL 9121 U V W N L1 L2 L3 N						

NOTE

When 2 or more of the connection cables are used in parallel with the purpose of dividing the electric current, they will be identified by an additional suffix separated by a hyphen, as shown in the following example:

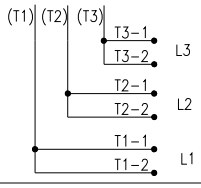


4.5.2.2 NEMA MG1 connection diagram

3 ELECTRICAL TERMINALS	6 ELECTRICAL TERMINALS	6 ELECTRICAL TERMINALS - DAHLANDER				
9200 T1 T2 T3 L1 L2 L3	9201 Δ: T6 T4 T5 / T1 T2 T3 / L1 L2 L3 Y: T6 T4 T5 / T1 T2 T3 / L1 L2 L3	9202 Δ T1 T2 T3 T6 T5 T4 L1 L2 L3 LOWEST SPEED	9203 YY T1 T2 T3 T6 T5 T4 L1 L2 L3 HIGHEST SPEED	9204 Y T1 T2 T3 T6 T5 T4 L1 L2 L3 LOWEST SPEED	9205 YY T1 T2 T3 T6 T5 T4 L1 L2 L3 LOWEST SPEED	9206 Δ T1 T2 T3 T6 T5 T4 L1 L2 L3 HIGHEST SPEED
3 ELECTRICAL TERMINALS + NEUTRAL 9221 T1 T2 T3 N L1 L2 L3 N						

NOTE

When 2 or more of the connection cables are used in parallel with the purpose of dividing the electric current, they will be identified by an additional suffix separated by a hyphen, as shown in the following example:



4.5.2.2.1 Direction of rotation

- The direction of rotation is indicated in the nameplate and may be noted by looking at the shaft end on the drive end of the motor. The direction of rotation must be checked before coupling the motor to the driven machine;
- Motors with connection and terminal identification described in items 4.5.2.1 and 4.5.2.2 of this manual have a **clockwise direction of rotation**;
- In order to reverse the direction of rotation, the connection of any of the two phases must be inverted;
- Motors with a single direction of rotation, as indicated on the nameplate and through an indicative plate fixed to the frame, have a unidirectional fan and must be operated only in the specified direction of rotation. To reverse direction of rotation of unidirectional motors, please contact WEG.

4.5.2.3 Accessory connection diagram

For correct installation of the accessories, please see the specific drawing of the connection diagram of the motor.

4.6 MECHANICAL CHARACTERISTICS

4.6.1 Base

- The base or structure in which the motor is installed must be sufficiently rigid, flat, free of external vibrations and capable of resisting the mechanical stress to which it will be submitted during start-up, or in case of short-circuit in the motor.
- If the base dimensioning is not carefully performed, serious vibration issues in the foundation block, motor, and driven machine may appear.
- The structural dimensioning of the base must be performed based on the dimension drawing, the information regarding mechanical stress on the foundations, and on the motor fixing form.

ATTENTION

Place shims with different thickness (total thickness of approximately 2mm) between the motor feet and the foundation support surfaces, in order to perform a precise vertical alignment.

NOTE

The user is responsible for the foundation dimensioning and construction.

4.6.2 Base loads

Based on Figure 4.5, base loads may be calculated by the following equations:

$$F_1 = +0.5.m.g. + \frac{(4C\,\max)}{(A)}$$

$$F_2 = +0.5.m.g. - \frac{(4C\,\max)}{(A)}$$

Where: F1 and F2 - Feet reaction on base (N)
t - gravity acceleration (9.81m/s^2)
m - Motor mass (kg)
Cmax - Maximum torque (Nm)
A - Obtained in the motor dimension drawing (m)

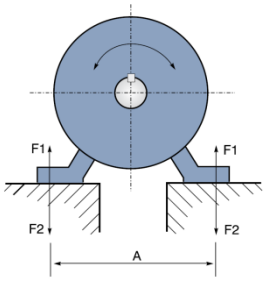


Figure 4.5: Base loads

4.6.3 Types of bases

4.6.3.1 Sliding base

In case of belt-driven operation, the motor must be assembled on a sliding base (rails) and the lower part of the belt must be tensioned.
The rail closest to the drive pulley is assembled in a way that the positioning bolt lies between the motor and the driven machine The other rail must be assembled with the bolt placed in the opposite position, as shown in Figure 4.6.
The motor is bolted on the rails and positioned on the foundation.
The drive pulley is then aligned in a way that its center is located on same plane as the center of the moving pulley, while the motor and machine shafts are perfectly parallel to each other.
The belt must not be excessively stretched. After the alignment, the rails are fixed.

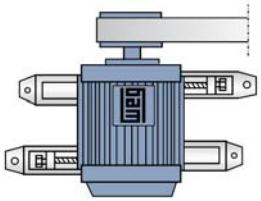


Figure 4.6: Sliding base

4.6.3.2 Metal base

The motor feet must be uniformly supported on the metal base in order to avoid deformations on the frame. Eventual height errors in the motor feet support surface may be corrected with shims (a 2mm maximum height is recommended).
Do not remove the machines from the common base for the alignment. The base must be leveled on the foundation itself by using a spirit level or other leveling instruments.
When a metal base is used to adjust the motor shaft end height with the driven machine shaft end, it must be leveled on the concrete base.
After base has been leveled, anchors tightened and couplings checked , the metal base and anchors are cemented.

4.6.3.3 Anchors

Anchors are devices for anchoring motors directly to the foundation when the motors are fitted with a flexible coupling. This type of coupling is characterized by the absence of stress on the bearings, besides presenting lower investment costs.
Anchors must not be painted and must be free of rust, since that would be harmful for the concrete adherence and would cause them to loosen.

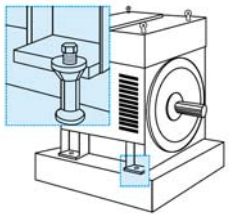


Figure 4.7: Anchors

4.6.4 Natural frequency of the base

In order to ensure a safe operation, in addition to a stable base, the motor must be accurately aligned with the coupled equipment and components assembled on its shaft, which need to be properly balanced.
After the motor is assembled and coupled, the relation between the natural foundation frequency is:

- Motor rotation frequency;
- Twice as much as the rotation frequency;
- Twice as much as the line frequency;

These natural frequencies must be as specified below:

- The foundation natural frequency ≥ +25% or ≤ -20% related to the frequencies provided above.
- The foundation higher order natural frequencies ≥ +10% or ≤ -10% related to the frequencies provided above.

4.6.5 Alignment and leveling

The motor must be correctly aligned with the driven machine, especially when direct coupling is used.
Incorrect alignment may result in bearing damage, generate excessive vibration and even in shaft rupture.
The alignment must be carried out according to the coupling manufacturer's recommendations.
Particularly for direct coupling, the motor and driven machine shafts must be axially and radially aligned, as illustrated in Figure 4.8 and Figure 4.9.

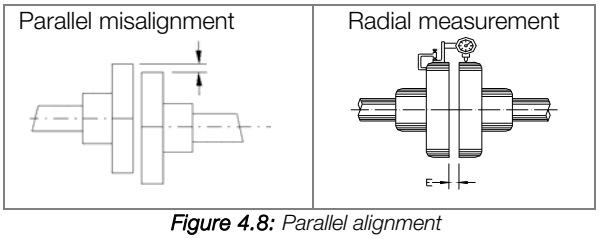


Figure 4.8: Parallel alignment

Figure 4.8 shows parallel misalignment of both shaft ends and the practical measuring procedure using adequate dial indicators.
Measurement is performed in 4 points with a 90° displacement from each other and with the two half-couplings spinning together in order to eliminate the effects due to support surface irregularities in the extremity of the dial indicator. Choosing a vertical point greater than 0°, half of the dial indicator measurement difference in the 0° and 180°points, represents a vertical coaxial failure. In case of deviation, the appropriate correction must be implemented by adding or removing assembly shims .
Half of the dial indicator measurement difference in the 90º and 270 º points represents a horizontal coaxial failure.
This measurement indicates when it is necessary to lift or lower the motor, or move it to the right or to the left on the driven side in order to eliminate the coaxial failure.
Half of the dial indicator maximum measurement difference in a complete rotation represents the maximum run out found.
The misalignment in the shaft complete spin cannot be greater than 0.03mm.
When flexible couplings are used, values that are greater than those indicated above are acceptable, provided that they do not exceed the acceptable value provided by the coupling manufacturer. Maintaining a safety margin for these values is recommended.

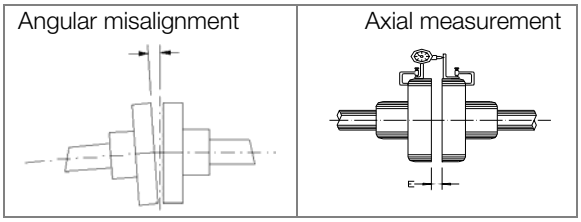


Figure 4.9: Angular alignment

Figure 4.9 illustrates the angular misalignment and the practical form to carry out this measurement procedure.
The measurement is performed in 4 points with a 90° displacement from each other and with the two half-couplings spinning together in order to eliminate the effects due to support surface irregularities in the extremity of the dial indicator. Choosing a vertical point greater than 0°, half of the dial indicator measurement difference in the 0° and 180° points represents a vertical misalignment. In case of deviation, it must be adequately corrected by adding or removing assembly shims under the motor feet.
Half of the dial indicator measurement difference in the 90° and 270° points represents a horizontal misalignment which must be adequately corrected by displacing the motor laterally/angularly.
Half of the dial indicator maximum measurement difference in a complete rotation represents the maximum angular misalignment found.
Misalignment in the shaft complete spin for rigid or semi-flexible coupling cannot be greater than 0.03mm.
When flexible couplings are used, values that are greater than those indicated above are acceptable, provided that they do not exceed the acceptable value provided by the coupling manufacturer.
Maintaining a safety margin for these values is recommended.
In the alignment /leveling process, the influence of the temperature over the motor and driven machine must be considered. Varying thermal expansions in components may alter the alignment /leveling status during the operation.

4.6.6 Couplings

Only appropriate couplings transmitting torque without generating transversal forces must be used.

For both flexible and rigid couplings, motor and driven machine shaft centers must be placed in a single line. Flexible coupling allows mitigation of residual misalignment effects and avoids vibration transferring between the coupled machines, which do not happen when rigid couplings are used.
Coupling must always be assembled or removed with the help of appropriate devices and never through rough devices such as hammers, mallets, etc.

ATTENTION

The pins, nuts, washers, and leveling shims may be supplied with the motor, when requested in the purchase order.

NOTES

The user is responsible for the motor installation.
WEG is not liable for damages to the motor, associated equipment and installation, occurred due to:

- Excessive vibration transmission;
- Incorrect installations;
- Incorrect alignments;
- Improper storage conditions;
- Noncompliance with instructions before start-up;
- Incorrect electrical connections.

4.6.6.1 Direct coupling

For the purposes of cost, space saving, absence of belt sliding, and increased safety against accidents, direct coupling would be preferable, whenever possible. Also, in case of transmission by turbo gear, direct coupling must be the preferred choice.

ATTENTION

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

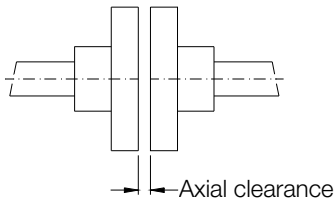


Figure 4.10: Axial clearance

4.6.6.2 Gear coupling

Misaligned gear couplings generate vibrations in the motor transmission itself. Therefore ensure that the shafts are perfectly aligned and, in case of transmissions by taper or helical gear, strictly parallel. in case of transmissions by gears that are straight and in a correctly adjusted angle.

Gear teeth meshing may be controlled by the insertion of a paper strip in which, after the gear spins once, the mark of all of the teeth will show.

4.6.6.3 Coupling by pulleys and belts

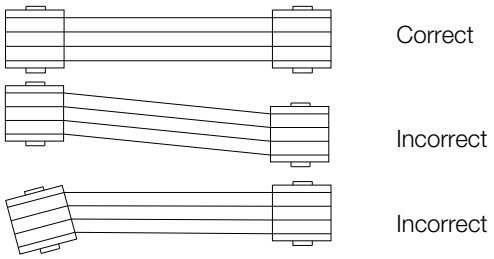


Figure 4.11: Coupling by pulleys and belts

When a speed reduction or increase is required, pulley transmission is indicated.
In order to avoid unnecessary radial stress on the bearings, the shafts and pulleys have to be perfectly aligned with each other. Skewed belts transmit alternating direction beats on the rotor, which may cause bearing damage.
Belt sliding may be avoided by applying a resinous material such as tar. Belt tension must be only enough to avoid sliding during operation.

NOTE

Belts with excessive tension increase the stress applied to the shaft end, causing vibrations and fatigue, which may cause shaft rupture.

Avoid using excessively small pulleys, as they cause bends on the motor shaft due to the belt traction force, which increases as pulley diameter decreases.

ATTENTION

In a specific pulley dimensioning case, WEG must be contacted in order to ensure a correct application.

NOTE

Always use properly balanced pulleys. Avoid key excess, as it represents an increase in the unbalancing mass. Non-compliance with this instruction will cause an increase in vibration levels.

After aligning the set and having assured a perfect alignment ***(both cold and hot),*** a motor fixation process must be performed in the anchor plate or in the base, as shown in Figure 4.12.

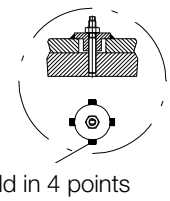


Figure 4.12: Motor fixation

5 STARTING

5.1 DOL STARTING

Whenever possible, the start-up of a three-phase induction motor must be direct (at full voltage) through a contactor. This start-up method is the simplest and most viable method, though it must only be used when the start-up current does not disrupt the power supply.
It is important to consider that the starting current in induction motors reaches values at the rate of 6 to 7 times the rated current. It is vital to ensure that such current (Ip) does not affect other consumers' power supplies, due to a higher voltage drop in the power supply.
This scenario is identified during one of the following three conditions:

a) When the power supply is ***"strong"*** enough and the motor starting current is insignificant related to the power supply capacity.
b) Motor start-up is always performed without any load, reducing start-up time and, consequently, the duration of the starting current and voltage drop, which is tolerable for other consumers.
c) When the direct start-up is properly authorized by the local power utility company.

Extremely high starting currents during the start-up may generate the following hazardous consequences:

a) High voltage drop in the power grid energy supply system, causing interferences in the equipment installed in this system;
b) Electric installation components (cables, contactors) must be over dimensioned, which generates high costs;
c) Fines applied by the power utility company that limit voltage drops in the power grid.

5.2 DOL STARTING FREQUENCY

Since induction motors have an elevated starting current, the time spent to accelerate high inertial charges results in a rapid motor temperature increase. If the interval between successive start-ups is too short, that would lead to a rapid winding temperature increase, reducing their useful life or even burning the windings. The NBR 7094 Standard establishes a minimum start-up regime which motors must be capable of meeting.

a) Two successive start-ups, being the first one with a cold motor, i.e. with its windings at ambient temperature, and the second one immediately after, but only after the motor has idled until rest;
b) A warm start up, i.e. with the windings at regime temperature.

The first condition simulates a scenario in which the motor first start-up is aborted, for instance, because of turning it off using the motor protection, when a second motor start-up is immediately allowed.
The second condition simulates a scenario of accidental motor shutdown while in normal operation, for instance, due to lack of energy in the power grid, when starting up the motor right after energy recovery is allowed.

5.3 BLOCKED-ROTOR CURRENT (Ip/In)

According to standard NBR 7094, the motor nameplate must indicate the I_P/I_n value, which is the relation between the blocked-rotor current and the rated current.

5.4 REDUCED CURRENT START-UP

In case a direct start-up is not possible, the following indirect start-up systems may be used to reduce the start-up current:

- With a star-delta starter;
- With a series-parallel switch;
- With a compensating switch or auto-transformer;
- With a static starter or soft starter;
- With a frequency inverter.

6 COMMISSIONING

6.1 PRELIMINARY INSPECTION

Before a motor initial start-up or after a long period of inactivity, the following items must be verified:

1. Motor fixation bolts must be tightened.
2. Measure the windings' insulation resistance, ensuring it is within recommended limits;
3. Check if the motor is clean and if the packaging, measuring instruments and aligning devices have been removed from the motor working area;
4. Coupling connecting components must be in perfect operating conditions, duly tightened and greased (if required);
5. The motor must be adequately aligned;
6. Ensure that the bearings are properly lubricated. The lubricant used must be the one recommended on the bearing nameplate.
7. Inspect the accessories' cable connections (thermal protectors, grounding, space heaters, etc.);
8. Ensure all electrical connections are in accordance with the motor connection diagram;
9. Ensure that the conductors are connected to the motor main terminals, and adequately tightened to prevent them from loosening or to avoid the occurrence of short-circuits;
10. Inspect the cooling system. Check the fans direction of rotation in blower-ventilated motors;
11. The motor air inlet and outlet must be unobstructed;
12. Mobile parts of the motor must be protected to prevent accidents;
13. Terminal box covers must be properly fitted;
14. All motor screws must be properly tightened ;
15. Verify if the power supply voltage and frequency are in accordance with the motor nameplate.

6.2 INITIAL START UP

After having performed all instructions provided above, the following procedure to perform the motor initial start-up must be followed:

1. Disconnect the space heaters;
2. Adjust all protections in the control panel;
3. Turn on the fans (motors with forced ventilation);
4. Slowly rotate the motor shaft to check if there are any parts being dragged and to identify unusual noises;
5. After the previous steps have been concluded, the motor start-up sequence may be initiated;
6. Check the direction of rotation with uncoupled motor;
7. In order to reverse the direction of rotation, the connection of any of the two phases must be inverted;
8. Keep the motor turning at a rated rotation speed and record bearing temperatures in 1 minute intervals until they become constant. Any sudden increase in bearing temperature indicates lubrication or friction surface issues
9. Monitor the temperatures and vibration. In case there is a significant variation in any of these values, shutdown the motor start-up process, identify possible causes and implement all appropriate corrections;
10. When the bearings' temperature stabilizes, the motor operation process may be resumed.

ATTENTION

Noncompliance with the procedures provided above may compromise the motor performance, cause damages and even lead to a motor blow out, voiding the product warranty.

6.3 OPERATION

6.3.1 General

After successful first start-up test, couple the motor to the driven load and resume the motor start-up procedure, as described below:

- Drive the coupled motor under load until it reaches its thermal stability and verify whether there are unusual noises or vibrations or excessive heating. If significant variations are identified in the vibrations between the initial operating condition and the condition upon reaching thermal stability, the alignment and leveling must be checked;
- Measure the absorbed electric current and compare it with the value indicated on the nameplate;
- In a continuous regime, with no load variation, the current value measured must not exceed the value indicated on the nameplate multiplied by the service factor;
- All measuring and control instruments and devices must be permanently monitored in order to detect occasional changes, determine the causes, and implement the appropriate corrections.

6.3.2 Temperatures

- Bearing , stator winding and cooling air temperatures must be monitored while the motor is operating;
- Bearing and stator winding temperatures must be stable within 4 to 8 hours of operation;
- Stator winding temperatures depend on the load. Therefore, the activated load power must also be monitored while the motor is operating.

6.3.3 Bearings

The system start-up, as well as the first hours of operation, must be carefully monitored.

Before starting the motor, verify:

- If the lubricant used complies with all specifications;
- Lubricant characteristics;
- If the bearing alarm and shutdown temperatures are set;
- During the first system start-up, it is important to inspect for unusual vibrations or noises;
- If the bearing is not running silently and smoothly, the motor must be immediately shutdown;
- The motor must operate for several hours until bearing temperatures stabilize within the previously mentioned limits;
- If the temperature rises above the limits, the motor must be immediately shutdown; bearings and temperature sensors must be inspected and the appropriate corrections must employed;

- After bearing temperatures stabilize, verify if there are any leaks in the plugs, gaskets and in the shaft end.

6.3.4 Vibration

Motors are balanced by the manufacturer according to the vibration thresholds established in the IEC60034-14, NEMA MG1 - Parte 7 and NBR 11390 standards (except when the purchase agreement specifically provides different thresholds).
Vibrations are measured vertically, horizontally and axially at the end and front bearings.
When a client sends the half coupling to WEG, the motor is balanced with the half coupling attached to the shaft. If not, according to the aforementioned standards, the motor is balanced using a half-key (that is, a bar of same width, length and height is used to fill the key groove during balancing).

Maximum motor operation vibration levels for drilling application is **4G**.

Te most frequent causes for vibrations are:
- Misalignment between the motor and the driven equipment;
- Inadequate fixation of the motor to the base, with ***"loose shims"*** under one or more of the motor feet, and loose fixation screws;
- Inadequate or not sufficiently strong base;
- External vibrations from other devices.

ATTENTION

Operating the motor with vibration levels above the values provided in table 6.3 may damage its useful life and/or performance.

6.3.5 Shutdown

Motor shutdown depends on its application, but the main recommendations are:
- Reduce the driven equipment load, if possible;
- Open the main circuit breaker;
- Turn on the space heaters (if any) in case that is not automatically performed by command devices;
- Shutdown the cooling system (if any).

DANGER

While the rotor is operating, and even after it is shutdown, touching any of its active parts is life threatening.

7 MAINTENANCE

7.1 GENERAL

When used appropriately, an adequate maintenance program for electric motors includes the following recommendations:

- Keep the motor and all related equipment clean;
- Routinely measure insulation levels;
- Routinely measure temperature (windings, bearings and cooling system);
- Check for occasional wearing effects, the bearings' useful life;
- Check ventilation systems to ensure air is flowing correctly;
- Measure the motor vibration levels;
- Check all of the motor accessories, protections and connections, ensuring that they are operating properly.
- In order to facilitate the heat exchange process with the environment, the frame must be kept clean and free of oil or dust accumulation in the external area;

Failure to comply with one of the recommendations provided above may result in unexpected equipment downtime. The frequency with which such inspections are performed depends on local application conditions.
The frequency with which such inspections are performed depends on local application conditions.
If the motor requires reconditioning or replacement of any damaged parts, please contact WEG.

ATTENTION

Whenever the motor needs to be moved, ensure that the shaft is properly locked to prevent bearing damage . Use the device provided with the motor to lock the shaft.

7.2 GENERAL CLEANING

- In order to facilitate the heat exchange process with the environment, the frame must be kept clean and free of oil or dust accumulation in the external area; The interior of the motor must also be kept clean, and free from dust, debris and oils.
- Use brushes or clean cotton cloths to clean. If the dust is not abrasive, an industrial vacuum cleaner must be used to remove the dirt from the fan cover and the excess dust on fan blades and on the frame.
- Debris impregnated with oil or moisture may be removed with a cloth soaked in the appropriate solvents.
- Cleaning the terminal boxes is also recommended. Terminals and connectors must be kept clean, rust-free and in perfect operating conditions. Avoid contact between connecting parts and grease or verdigris.

7.3 WINDING INSPECTION

The windings' insulation resistance must be regularly measured, especially during damp weathers or after prolonged motor shutdown. The windings must regularly undergo complete visual inspections, recording and repairing each and every damage or fault identified.
Low values or sudden variations in the insulation resistance must be carefully investigated.
At points where insulation resistance may be low (due to an excess of dust or moisture), it may be increased back to the required values by removing the dust and drying up humidity on the windings.

7.4 WINDING CLEANING

For satisfactory operation and longer useful life of insulated windings, it is recommended to keep them free of dirt, oil, metallic dust, contaminants, etc.
Therefore, the windings must be routinely inspected and cleaned, and must operate with clean air. If re-impregnation is required, please contact WEG.
The windings may be cleaned with an industrial vacuum cleaner equipped with a narrow, non-metallic tip or simply with a dry cloth.
For extremely dirty conditions, an adequate liquid solvent may be required for cleaning. This procedure must be quick to prevent prolonged exposure of the windings to solvent effects.
After being cleaned with solvents, the windings must be completely dried.
Measure insulation resistance and polarization index to ensure the windings are completely dry.
Winding drying time after cleaning varies depending on weather conditions such as temperature, humidity, etc.

DANGER

Most solvents used are highly toxic, flammable or both.
Solvents must not be applied to the flat parts of high voltage motor coils, as it may affect their protection against the corona effect.

Inspections

The following inspections must be performed after the windings are carefully cleaned:

- Check the connections and windings' insulation.
- Check if spacers, bindings, groove wedges, bandages and supports are fixed correctly.
- Check if there haven't been any ruptures; if there aren't damaged welds, short-circuits between turns and against the grounding on coils and connections. If any irregularities are identified, immediately contact WEG.
- Ensure that all cables are properly connected and that terminal fixation components are duly tightened. If required, re-tighten them.

Re-impregnation

If any layer of resin on the windings is damaged during cleaning or inspection, they must be corrected with adequate material (in this event, please contact WEG).

Insulation Resistance

Insulation resistance must be measured after all maintenance procedures have been performed.

ATTENTION

Before re-powering the motor, if it has not been operated for a long period, measuring the stator windings' insulation resistance and ensure that values measured are within the specified values.

7.5 COOLING SYSTEM MAINTENANCE

7.5.1 TGV model

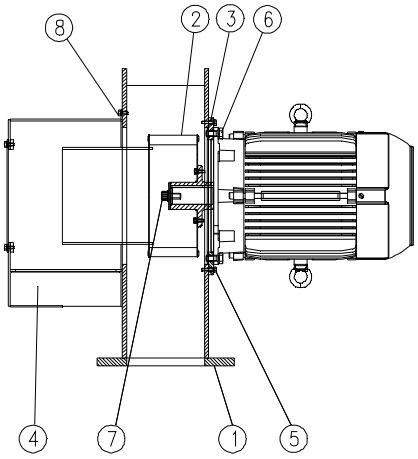


Figure 7.1: TGV Blower

1. Radial fan cover
2. Radial fan
3. Intermediate flange
4. Noise attenuator
5. Bolt for fan cover fixation
6. Bolt for motor fixation
7. Bolt for fan fixation
8. Bolt for attenuator fixation

7.6 MOTOR SHUTDOWN

The following procedures must be adopted if the motor is decommissioned for a long period of time:

- Activate the space heaters in order to maintain the temperature inside the motor slightly above ambient temperature, thus avoiding humidity condensation and a subsequent drop in the winding insulation resistance and oxidation of metallic parts.
- The radiators and all water tubing (if any) must be drained in order to reduce corrosion and suspended materials in cooling water.

Follow the remaining procedures described in the item Prolonged Storage, provided in this manual.

7.7 BEARING MAINTENANCE

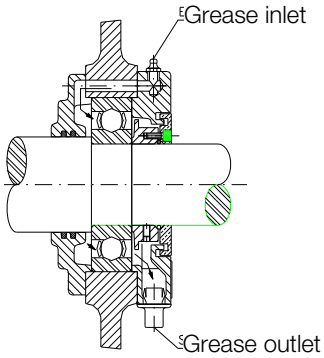


Figure 7.2: Grease lubricated rolling bearing

7.7.1 Lubrication instructions

The lubrication system was designed so that, during the bearing re-lubrication process, all old grease is removed from the ball races and expelled through a drain that allows grease drainage, but keeps dust or other harmful contaminants from getting inside the bearing. This drain also avoids rolling bearing damage by the well-known excessive re-lubrication problem. It is recommended to perform the lubrication process while the motor is running, in order to ensure grease renewal in the rolling bearing lodging. If that is not possible due to the presence of turning pieces near the grease gun (pulleys, etc.) that may risk the operator's physical integrity, proceed as follows:

- With the motor shutdown, inject approximately half of the total grease quantity to be used and operate the motor for approximately 1 minute in full rotation speed;
- shutdown the motor and inject the remaining grease. The injection of the entire amount of grease in an idle motor may cause part of the lubricant to penetrate into the inner part of the motor through the internal sealing of the bearing cover.

ATTENTION

It is important to clean the grease fittings before the lubrication process in order to avoid foreign materials from being dragged inside the rolling bearing.
For lubrication, use only a hand-held grease gun.

NOTE

Rolling bearing data, type and amount of grease and lubrication intervals are informed in the nameplate fixed to the motor. Check this information before initiating the lubrication process.

- The lubrication intervals informed on the nameplate consider a rolling bearing operating temperature of 70ºC.
- Based on the operating temperature rates listed below, apply the following correction factors to the rolling bearing lubrication intervals:
  - Operating temperature over 60ºC: 1.59.

- Operating temperature from 70ºC to 80ºC: 0.63.
- Operating temperature from 80ºC to 90ºC: 0.40.
- Operating temperature from 90ºC to 100ºC: 0.25
- Operating temperature from 100ºC to 110ºC: 0.16.

7.7.2 Grease type and quantify

Bearing re-lubrication must always be done with the **original grease**, specified on the bearing nameplate and in the motor documentation.

ATTENTION

WEG does not recommend the use of different types of greases, other than the motor original grease type.

7.7.3 Grease compatibility

Compatibility between several types of grease may eventually present an issue. One may say that different types of grease are compatible when the properties of the mix are within individual grease property categories. Generally, greases with the same type of soap are compatible; however, depending on the proportion of the mix, there may be incompatibility. Therefore, mixing different types of grease is not recommended without previously contacting the grease supplier or WEG. Some thickening agents and basic oils cannot be mixed since they do not form a homogeneous mixture. In this case, a tendency to hardening, or, otherwise, grease softening, or a fall in the resulting mix melting point cannot be ignored.

7.7.4 TGV Bearing parts

DE bearing

NDE Bearing

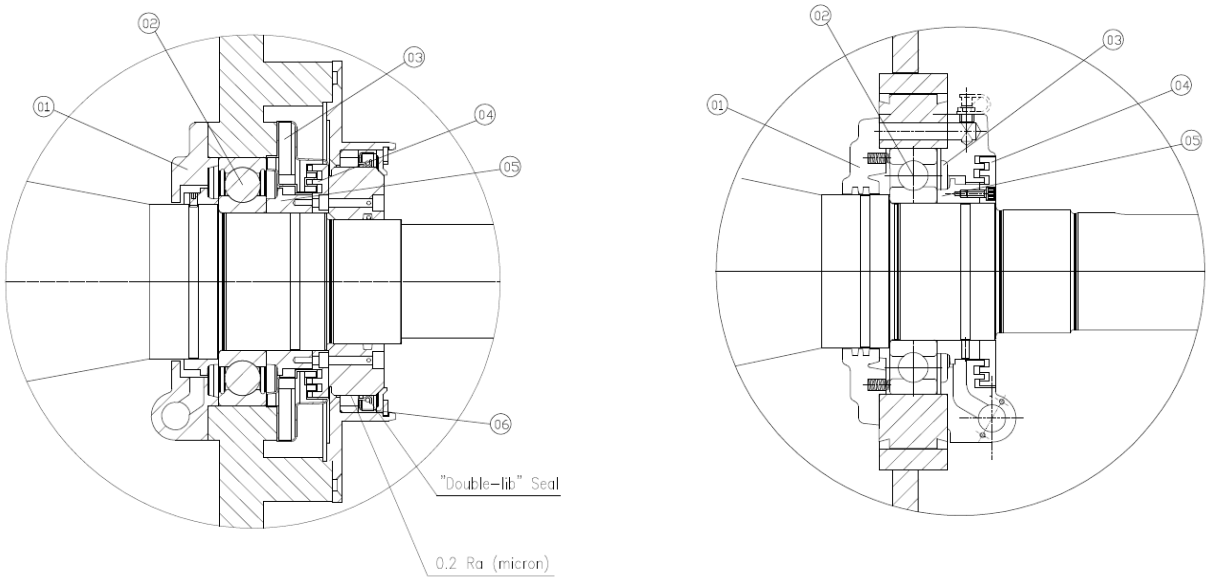


Figure 7.3: TGV bearings

DE and NDE bearing

10 Internal bearing cap

20 Rolling bearing

25 External bearing cap

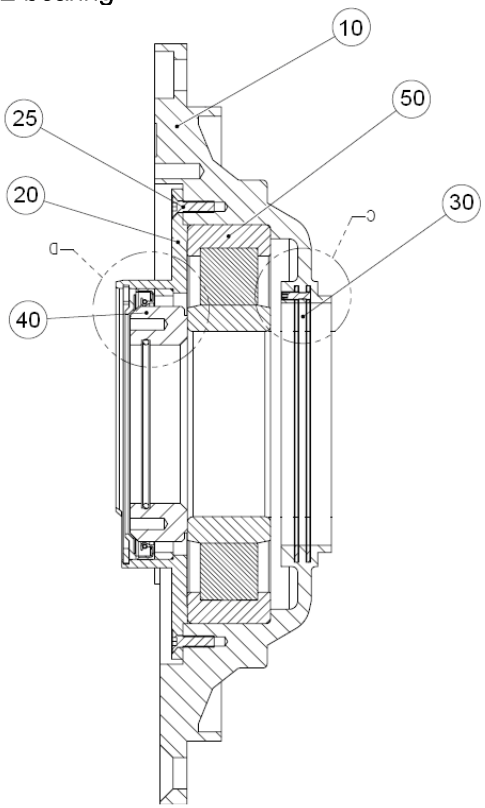
30 Labyrinth ring

40 Grease centrifuge

50 Seal ring

7.7.5 TGA Bearing parts

DE bearing



NDE bearing

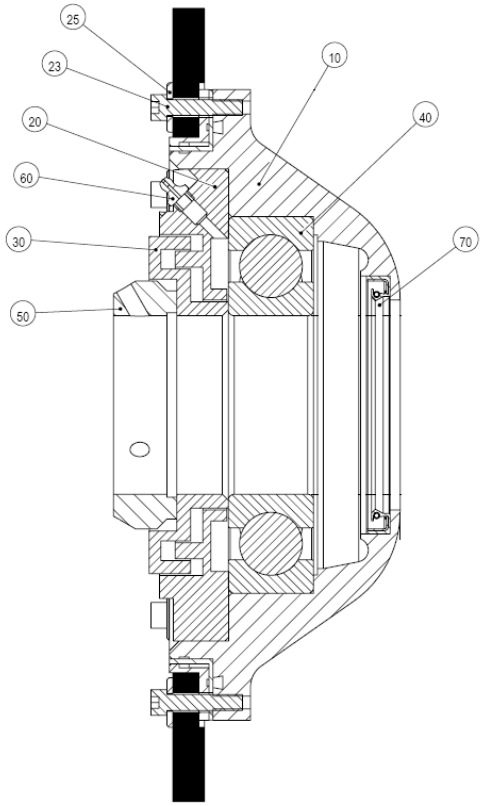


Figure 7.4: TGA Bearings

DE bearing

10 DE endshield set
20 External bearing cap
25 Screw
30 Labyrinth ring
40 Bush
50 Roller bearing

NDE bearing

10 DE endshield set
20 External bearing cap
23 Screw
25 Washer
30 Labyrint ring
40 Rolling bearing
50 Fixing screw nut
60 Grease nipple
70 Seal ring

7.7.6 Bearing disassembling and assembling

Before Disassembly:

1. Remove the grease inlet and outlet extension tubes;
2. Thoroughly clean the external part of the bearing;
3. Remove the temperature sensors from the bearing and, to avoid any damage to the bearing, arrange a support for the shaft.

Disassembly

Be particularly careful not to cause any damage to the balls, rollers and bearing surfaces and shafts. For bearing disassembly, use the appropriate tool and keep all parts in a clean and safe location:

Assembly

1. Thoroughly clean the bearings and inspect the disassembled parts and the interior of the fixing rings;
2. Ensure that the bearing surfaces, shafts and fixing rings are perfectly smooth;
3. Fill ¾ of the inner and outer fixing rings reservoir with the recommended grease (Figure 7.5) and lubricate the bearing with enough grease before assembling it;
4. Before assembling bearing on the shaft, heat it up to a temperature between 50ºC and 100ºC;
5. For a complete bearing assembly, follow the disassembly instructions in the opposite order.

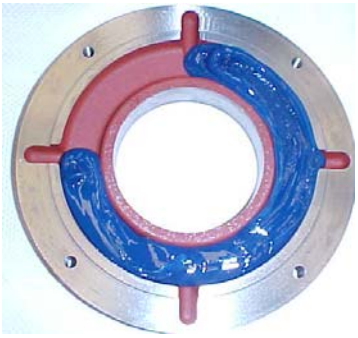


Figure 7.5: External bearing fixating ring

Bearing Replacement

the bearing disassemble process must always be performed with the appropriate tool (bearing puller). The puller clips must be applied over the inner ring side face or over an adjacent part.

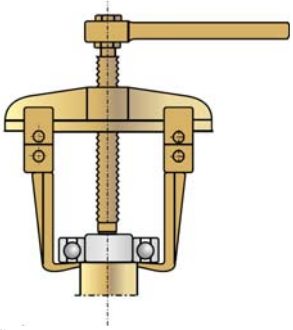


Figure 7.6: Bearing puller device

7.7.7 Bearing protection

7.7.7.1 Protection settings

ATTENTION

The following temperatures must be set in the bearing protection system:
Alarm 90ºC – Shutdown 110ºC
The alarm temperature must be set to 10ºC above the working temperature, and must never be higher than 110ºC.

8 MOTOR ASSEMBLY AND DISASSEMBLY

All repair, disassembly, and assembly services must only be performed by duly qualified and trained personnel. The disassembly and assembly sequence depends on the motor type.

NOTE

Repair services in motors applied in hazardous atmospheres must only be performed by duly qualified personnel, authorized by WEG to perform such services.

8.1 FULL DISASSEMBLY OF THE MOTOR

Before starting to disassemble the motor, make sure all the electric connections are disconnected.

Cooling system:
Before disassembling the motor, remove blower (TGV model)

Drive end side:
1. Remove temperature detectors, vibration sensors and from the bearing;
2. In order to prevent any damage to the rotor core, provide a support for the shaft/rotor;
3. Disassemble the drive end bearing according to the procedures described in this manual;
4. Remove the D-endshield.

Non-drive end side
1. Remove the device to remove old grease (if applicable) from the bearings;
2. Remove temperature detectors, vibration sensors (if applicable) from the NDE bearing;
3. Disassemble the non-drive end bearing according to the procedures described in this manual;
4. Remove the NDE-endshield.

Removing the rotor
The rotor must be removed by the drive end of the motor. Remove the rotor from the stator by using lifting cables or any other equivalent device. This procedure must be performed carefully in order to prevent the rotor from touching the stator or the stator coil heads.

ATTENTION

Any damaged part (cracks, dents on machined parts, faulty threads) must be preferably replaced, avoiding restorations. All services described herein must be performed by specialized and experienced personnel; otherwise, damages to the equipment may occur. If you have any questions, contact WEG.

8.2 MOTOR ASSEMBLY

In order to assemble the whole motor, follow the disassembly instructions in the reverse order.

8.3 BLOWER (TGV MODEL)

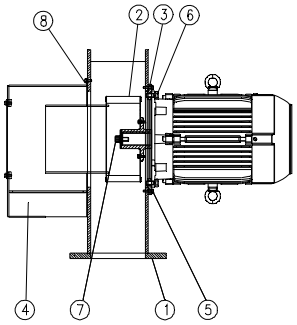


Figure 8.1: TGV blower

Disassembly of the blower:
1. Make sure all the electric connections as disconnected;
2. Remove the bolts (6) that fix the motor to the intermediate cover and remove the bolts that fix the motor feet to the motor base;
3. Remove the motor and the axial fan (2);
4. If necessary to remove the fan from the shaft, removing the bolt (7).

Assembly of the radial fan:
In order to assemble the motor and fan, follow the disassembly instructions in the reverse order.
Filter:
The filter must be inspected, cleaned or replaced periodically in order to ensure a continuous supply of fresh and clean air to the motor.

8.4 GENERAL RECOMMENDATIONS

ATTENTION

All services described herein must be performed by qualified and experienced personnel, in order to avoid damage to the equipment and personnel injuries. In case of doubts, please contact WEG.

8.6 SPARE PARTS

WEG recommends that the following spare parts are kept in stock:
- Front and rear bearing;
- Temperature sensors for each bearing;
- Space heater (if any);
- Filter felts (if any);

Spare parts must be stored in clean, dry, and well ventilated locations; and, if possible, at constant temperatures.

9 MAINTENANCE PLAN

The maintenance plan described in Table 9.1 is only referential, considering that the intervals between each maintenance intervention may vary according to the motor location and operation conditions.

Table 9.1: Maintenance plan

EQUIPMENT	Weekly	Monthly	Every 3 months	Every 6 months	Yearly	Every 3 years	Note
STATOR							
Stator visual inspection .					x		
Cleaning control.					x		
Groove wedges inspection.						x	
Stator terminals control.					x		
Measure the winding insulation resistance.					x		
ROTOR							
Cleaning control.					x		
Visual inspection.					x		
Shaft (wearing, incrustations) inspection.						x	
BEARINGS							
Noise, vibration, oil flow, leaking, and temperature control.	x						
Lubricant quality control.					x		
Inspection of bearing shells and shaft race. (sliding bearing).						x	
Lubricant change.							According to the period indicated on bearing nameplate.
Ventilation inspection.					x		
AIR FILTER (TGV model)							
Inspect and replace, if necessary.			x				
PROTECTION AND CONTROL EQUIPMENT							
Operation test.					x		
Value recording.	x						
Disassembly and operation test.						x	
COUPLING							
Alignment inspection.					x		Check it after the first week of operation.
Fixation inspection.					x		Check it after the first week of operation.
ENTIRE MOTOR							
Cleaning and vibration inspection.	x						
Condensed water draining.			x				
Screw tightening.					x		
terminal box cleaning.					x		
Electrical and grounding connection tightening.					x		

1) In the event excessive oxidation of the sacrificial anode is ascertained, its inspection frequency must be increased in order to determine the time of oxidation and to create a plan for a replacement schedule.

10 ABNORMALITIES, CAUSES AND SOLUTIONS

10.1 MOTORS

NOTE

The instructions in Table 10.1 merely present a basic list of abnormalities, causes and corrective measures. In case of doubts, please contact WEG.

Table 10.1: Basic list of abnormalities, causes and corrective measures

ABNORMALITY	POSSIBLE CAUSES	CORRECTIVE MEASURE
Motor does not start, coupled or uncoupled.	▪ At least two power cables are interrupted, with no voltage.	▪ Check the control panel, power supply cables, terminals and brush seating.
	▪ Locked rotor.	▪ Unlock the rotor;
	▪ Damaged bearing.	▪ Replace the bearing.
The motor starts at no-load, but fails when load is applied. It starts very slowly and does not reach the rated rotation.	▪ Load torque is too high during start-up.	▪ Do not apply load to the driven machine during start-up.
	▪ Power supply voltage is too low.	▪ Measure the power supply voltage and adjust the value correctly.
	▪ Large voltage drop in the power cables.	▪ Check the installation dimensioning (transformer, cable section, check relays, circuit breakers, etc.).
	▪ Rotor with defective or interrupted bars.	▪ Check and fix the rotor winding.
	▪ One power cable was interrupted after the start-up.	▪ Check the power cables.
After applying a load, the stator current varies with twice as much as the build-up frequency. The motor hums during start-up	▪ The rotor winding is interrupted.	▪ Check and fix the rotor winding.
The motor starts at no-load, but fails when load is applied. It starts very slowly and does not reach the rated rotation.	▪ Load torque is too high during start-up.	▪ Do not apply load to the driven machine during start-up.
Very high no-load current.	▪ Power supply voltage is too high.	▪ Measure the power supply and adjust the value correctly.
Localized hot spots on the stator winding.	▪ Short circuit between turns.	▪ Rewind.
	▪ Interruption of stator winding phases or parallel wires.	
	▪ Poor connection.	▪ Remake the connection.
Localized hot spots on the rotor.	▪ Rotor winding interruptions.	▪ Fix or replace the rotor windings.
Unusual noise during operation with load.	▪ Mechanical causes.	▪ The noise normally reduces when the motor speed decreases; see also: "noisy operation when uncoupled".
	▪ Electrical causes.	▪ The noise disappears when the motor is shutdown. Contact WEG.
When coupled, the noise appears. When uncoupled, the noise disappears.	▪ Defective transmission or driven machine components.	▪ Check the power transmission, coupling and alignment.
	▪ Gear transmission defect.	▪ Align the drive.
	▪ Unaligned/unleveled base.	▪ Realign/level the motor and the driven machine.
	▪ Incorrect balancing of the driven machine components.	▪ Perform a new balancing process.
	▪ Defective coupling.	▪ Repair the coupling.
	▪ Wrong motor rotation direction.	▪ Invert the 2-phase connection.

ABNORMALITY	POSSIBLE CAUSES	CORRECTIVE MEASURE
The stator winding heats up when operating under load.	▪ Insufficient cooling due to obstructed air pipes.	▪ Open and clean the air pipes.
	▪ Overloading	▪ Measure the stator current and reduce the load. Analyze the motor application.
	▪ High number of start-ups or very high moment of inertia.	▪ Reduce the number of start-ups.
	▪ Very high voltage with a subsequent increase in iron losses .	▪ Do not exceed the rated voltage by 110%, unless specifically stated on the nameplate.
	▪ Very low voltage and very high current	▪ Check the power supply voltage and the motor voltage drop.
	▪ Interruption on a power cable or winding phase.	▪ Measure the current in all phases and correct it, if necessary.
	▪ Rotor drags against the stator.	▪ Check the air gap, operating conditions (vibrations, etc.) and bearing conditions.
	▪ Operating conditions are not in compliance with the data provided in the nameplate.	▪ Maintain the operating conditions according to the nameplate or reduce the load.
	▪ Unbalance in the power supply voltage (burnt fuse, incorrect command).	▪ Check for voltage unbalancing or operate with only two phases and correct the issue.
	▪ Dirty windings.	▪ Clean.
	▪ Obstructed air ducts.	
	▪ Dirty air filters.	▪ Clean the filtering device.
	▪ Direction of rotation not compatible with the fan being used.	▪ Analyze the fan regarding the motor direction of rotation.
Noisy operation when uncoupled.	▪ Unbalance.	▪ The noise continues during deceleration after voltage is turned off; ▪ Execute a new balancing process.
	▪ Interruption in one phase of the stator winding.	▪ Measure all connection cables' currents.
	▪ Loose fixation screws.	▪ Tighten and lock the screws.
	▪ The balancing conditions of the rotor get worse after the coupling is mounted.	▪ Balance the coupling.
	▪ Foundation resonance.	▪ Adjust the foundation.
	▪ Deformed motor frame	▪ Check the base flatness.
	▪ Bent shaft.	▪ The shaft may have been bent; ▪ Check rotor balancing and run-out.
	▪ Non-uniform air gap.	▪ Check for shaft bending or bearing wearing.

10.2 BEARINGS

NOTE

The instructions in Table 10.2 merely present a basic list of issues related to bearings. In certain cases, a bearing analysis from the manufacturer is required in order to ascertain the cause of the defect.

Table 10.2: Basic list of issues related to bearings

DEFECT	POSSIBLE CAUSES	DETERMINATION AND ELIMINATION
The motor rumbles during operation.	▪ Damaged bearings.	▪ Replace the bearings.
Moderate noises in the bearings, dull points, formation of grooves on the races.	▪ Bearing mounted in a diagonal position.	▪ Recover the shaft seating and replace the bearing.
Bearing presents loud noises and increased heating.	▪ Cage corrosion, small chips in the grease, formation of cracks in the races due to the lack of grease, or any inadequate clearance in the bearing.	▪ Clean and re-apply grease according to the requirements. ▪ Replace the bearings.
Bearings heating up.	▪ Excessive grease.	▪ Remove the grease drainage plug and run the motor until the excess grease has been removed.
	▪ Excessive axial or radial belt strain .	▪ Reduce the belt strain.
	▪ Sagged shaft/excessive vibration.	▪ Correct the shaft and check the rotor balancing. Check the cause of the vibration and correct it.
	▪ Lack of grease.	▪ Add grease to the bearings.
	▪ Hardened grease causing the ball bearings to lock up.	▪ Replace the bearings.
	▪ Foreign bodies in the grease.	▪ Wash and lubricate the bearings.
Dark stains on one side of the ball race.	▪ Excessive axial strain.	▪ Examine driving and coupling connections.
Dark lines close together or transversal grooves in the races; Punctiform markings in the case of ball bearings.	▪ Current flow through bearings.	▪ Clean and replace the bearing insulation. Apply insulation, if applicable. ▪ Redirect the current to prevent it from passing through the bearing.
Grooves in the races. Dent in the division of cylindrical elements.	▪ External vibrations, especially when the motor has not been decommissioned for long periods of time. ▪ Lack of maintenance during storage.	▪ Occasionally rotate the rotor to another position, especially on spare motors.

ATTENTION

The motors described in this manual are constantly being improved; therefore, the information provided herein is subject to modification without prior notice.

11 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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