CSL ~~Bearing~~ Behring

Alcohol Transfer

Slop ~~Ethanol~~ Pumps
PO Number 440070980
Job Number C19279

Equipment Tags PM-VS33A19-01/02
Durco BG1.5x1-82 Guardian

JACOBS Signature: mcallip 08/12/2019 3:16:25 PM

Code B - Reviewed as Noted, Revise and Submit Certified, Proceed with Fabrication

No Responsibility Assumed For Accuracy of Shop Dimensions

Motors need to be confirmed and documented to be Class 1 Div 2 compliant.

Superior Industrial Equipment
1609 Afton Rd | Sycamore, IL 60178
Phone: 815-899-8900 | Fax: 815-899-8898

Table of Contents

Superior Industrial Equipment
1609 Afton Rd | Sycamore, IL 60178
Phone: 815-899-8900 | Fax: 815-899-8898

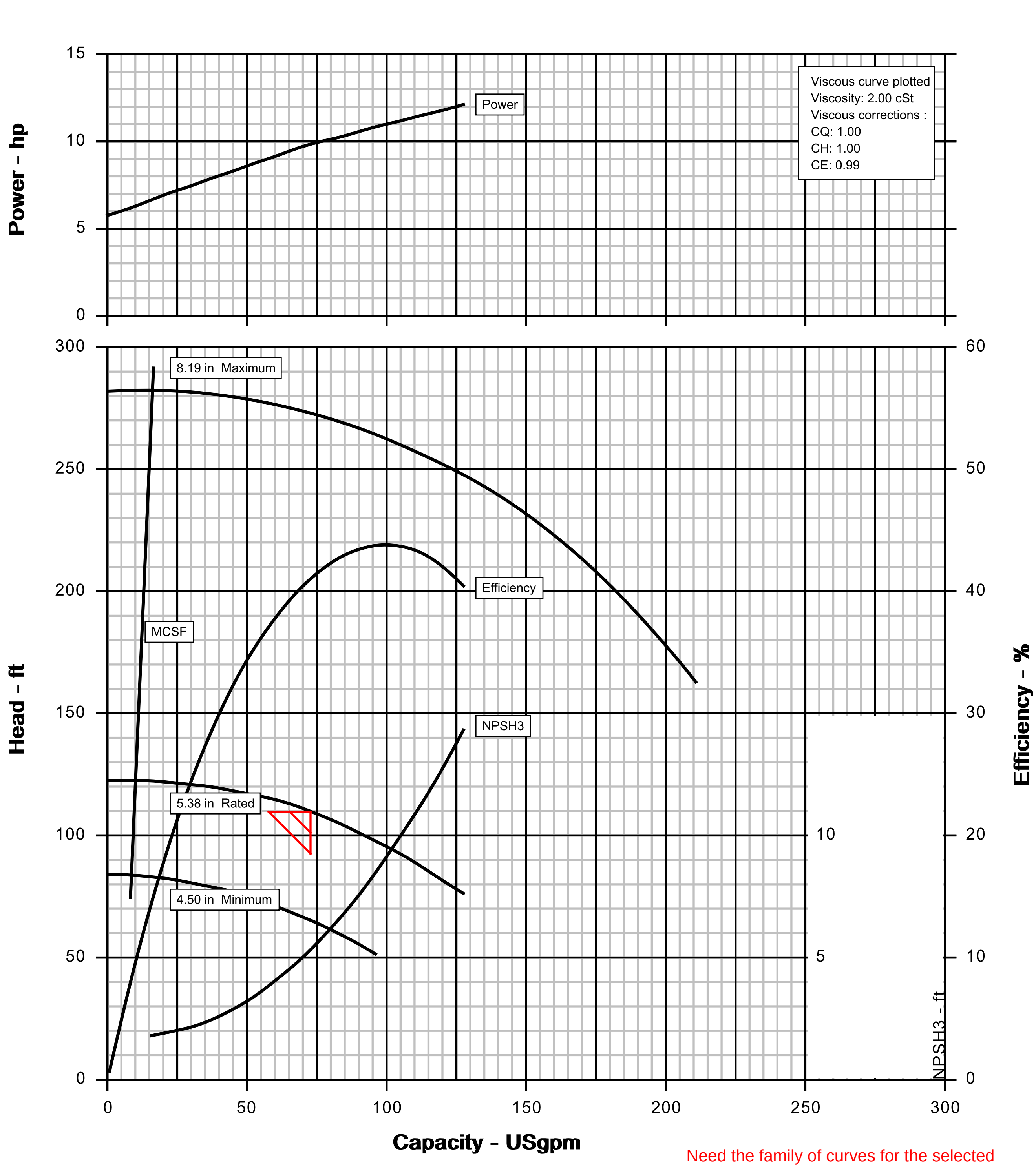
FLOWSERVE

Pump size & type / Stages	: BG1.5X1-82 M3GD / 1
Based on curve no.	: MIII7040AV
Impeller diameter	: 5.38 in

Customer	: Superior Industrial Equipment	Capacity	: 72.6 USgpm
Item number	: PM-VS33A19-01/02	Head	: 109.90 ft
Service	: Slop Alcohol Transfer Pumps	Density / Specific gravity	: - / 2.000
Flowserve reference	: 1901798749	Pump speed	: 3500 rpm
Date	: July 22, 2019	Ns / Nss	: 760 / 7660 (US units)
		Test tolerance	: ANSI/HI 14.6 Grade 1E

Can you also list LPM (275 LPM)

CURVES ARE APPROXIMATE, PUMP IS GUARANTEED FOR ONE SET OF CONDITIONS; CAPACITY, HEAD, AND EFFICIENCY.



Need the family of curves for the selected impeller from the minimum pump speed to 100% speed with the associated power at that speed. We need this as we are installing external power monitoring on the VFD.

Affinity v2.14.6

FLOWSERVE

Hydraulic Datasheet

Customer	: Superior Industrial Equipment	Pump / Stages	: BG1.5X1-82 M3GD / 1
Customer reference	: QC10873	Based on curve no.	: MIII7040AV
Item number	: PM-VS33A19-01/02	Flowserve reference	: 1901798749
Service	: Slop Alcohol Transfer Pumps	Date	: July 22, 2019

Operating Conditions

Capacity	: 72.6 USgpm
Water capacity (CQ=1.00)	: 72.6 USgpm
Normal capacity	: -
Total developed head	: 109.90 ft
Water head (CH=1.00)	: 109.90 ft
NPSH available (NPSHa)	: 46.6 ft
NPSHa less NPSH margin	: -
Maximum suction pressure	: 2.1 psig

Liquid

Liquid type	: Other
Temperature / Specific gravity	: 32 °F / 2.000
Solid Size - Actual / Limit	: - / -
Viscosity / Vapor pressure	: 2.00 cSt / 0.16 psia

Materials / Specification

Material column code	: D4
Containment shell material	: C276
Pump specification	: ANSI B73.1

Other Requirements

Hydraulic selection : No specification

Construction : No specification

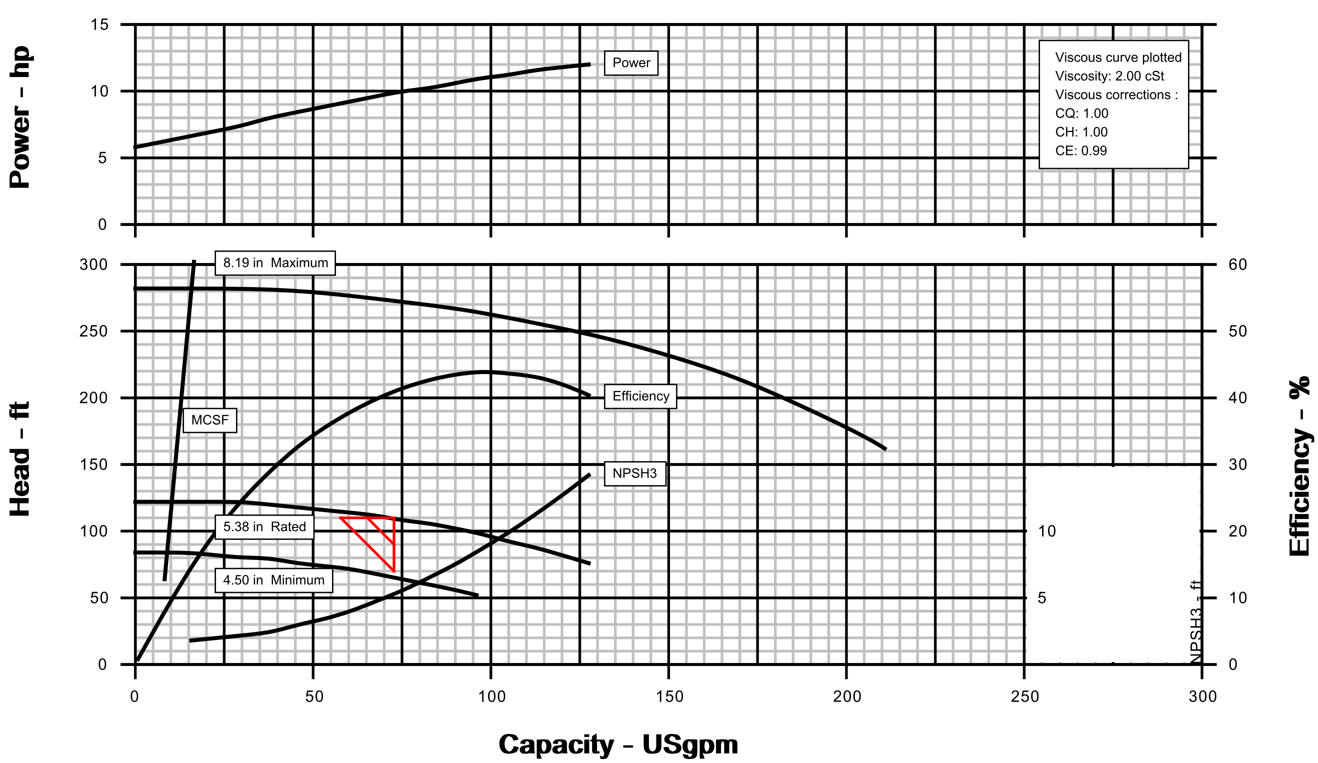
Test tolerance : ANSI/HI 14.6 Grade 1E

Driver Sizing : Max Power(MCSF to EOC) not using SF

Performance

Hydraulic power	: 4.03 hp	Impeller diameter	
Pump speed	: 3500 rpm	Rated	: 5.38 in
Pump overall efficiency (CE=0.99)	: 41.1 %	Maximum	: 8.19 in
		Minimum	: 4.50 in
NPSH required (NPSH3)	: 5.3 ft	Ns / Nss	: 760 / 7660 (US units)
Rated brake power	: 9.82 hp	Minimum continuous flow	: 10.4 USgpm
Maximum brake power	: 12.1 hp	Maximum head at rated diameter	: 122.59 ft
Driver power rating	: 15.0 hp / 11.2 kW	Flow at BEP	: 100.3 USgpm
Casing working pressure	: 108.2 psig	Flow as % of BEP	: 72.4 %
(based on shut off @ cut dia/rated SG)		Efficiency at normal flow	: -
Maximum allowable	: 275.0 psig	Impeller diameter ratio (rated/max)	: 65.6 %
Hydrostatic test pressure	: 413.0 psig	Head rise to shut off	: 11.5 %
Estimated rated seal chamber pressure	: -	Total head ratio (rated / max) / (max / rated)	: 40.2 % / 248.6 %

CURVES ARE APPROXIMATE, PUMP IS GUARANTEED FOR ONE SET OF CONDITIONS; CAPACITY, HEAD, AND EFFICIENCY.



FLOWSERVE

Confirm this impeller is acceptable for pumping trace (0.25% max) amounts of filter aid (Celite 574)

Construction Datasheet

Customer	: Superior Industrial Equipment	Pump / Stages	: BG1.5X1-82 M3GD / 1
Customer reference	: QC10873	Based on curve no.	: MIII7040AV
Item number	: PM-VS33A19-01/02	Flowserve reference	: 1901798749
Service	: Slop Alcohol Transfer Pumps	Date	: July 22, 2019

Construction

Nozzles	Size	Rating	Face	Position
Suction	1.50	150#	RF	End
Discharge	1.00	150#	RF	Top

Flange drilled according to	: ANSI 150
Casing mounting / Casing split	: Foot / Radial
Impeller type	: Reverse Vane
Pump bearing type/number (Radial)	: N/A / Close-Coupled
Pump bearing type/number (Thrust)	: N/A / Close-Coupled
Auxiliary housing bearing type (Radial)	: -
Auxiliary housing bearing type (Thrust)	: -
Bearing lubrication	: -
Rotation (view from coupling)	: CW per Hyd. Institute
Jacketed casing required	: No
Jacketed casing cover required	: No
Casing drain tap	: Yes

Materials

Casing	: 316 SS
Casing cover	: 316 SS BrgHolder
Casing gasket/seal	: TM
Impeller	: 316 SS
Wear ring (Casing / Impeller)	: N/A / N/A
Inducer	: N/A
Pump shaft	: 316 SS
Sleeve journal	: BO1-SC3
Bearing bracket	: N/A Close Coupled
Drive bearing	: SC3/Bushing
Pump bearing (Radial / Thrust)	: - / -
Auxiliary bearing (Radial / Thrust)	: - / -
Containment shell	: C276
Inner magnet material / Outer magnet material	: HLHL / Steel
Shell gasket/o-ring	: G01 VA Viton
Skid ring	: Non-metallic

Magnetic Drive

Driver size / Moment	: B/1.0 inch / -
Build specification	: Standard Temperature
Bearing flush	: Internal Flush

Baseplate, Coupling and Guard

Baseplate type	: A Foundation
Baseplate material	: 304 SS
Coupling manufacturer	: Not Supplied
Coupling material (hubs/spacer)	: N/A / -
Coupling guard material	: Not Provided

Sound Pressure (dBA @ 1.0 m)

Driver, expected	: -
Pump & driver, estimated	: 80 Pump only

Driver Information

Manufacturer	: -
Power	: 15.0 hp / 11.2 kW
Service factor (requested / actual)	: 1.15 / 1.0
Synchronous speed	: 3600 rpm
Orientation / Mounting	: Horizontal / -
Driver type	: NEMA
Efficiency class	: -
Driver construction type	: ODP
Frame size / Material	: 254TC / -
Enclosure	: -
Driver mount bolt circle	: NEMA C=7.25"
Hazardous area class	: -
Explosion 'T' rating	: -
Volts / Phase / Hz	: 460 / 3 / 60 Hz
Amps-full load/locked rotor	: - / -
Motor starting	: Direct on line (DOL)
Driver insulation	: F
Temperature rise	: 80 °C
Bearings	: Ball
Driver lubrication	: Grease
Motor mounted by	: Flowserve
Elevated ambient temperature	: -
Space heaters supplied	: -
VIK compliant	: No
Frequency converter ready	: -
Designed for VFD	: -
Terminal box position	: Consult Factory
Insulated motor bearings	: -

Cl 1 Div 2 required.

Weights (Approx.)

Bareshaft pump (net)	: 158.0 lb
Baseplate (net)	: 163.0 lb
Driver (net)	: -
Shipping gross weight/volume	: 369.2 lb / 9.35 cu.ft

Paint

Pump paint	: FLS St'd PU Topcoat
Driver paint	: Supplier Standard
Baseplate paint	: N/A

Monitoring Equipment

Power monitor	: None	Seal pressure monitor	: N/A
Shell temperatur...	: None	Liquid temperature mo...	: None

Testing

Hydrostatic test	: Non witnessed	Vibration test	: No
Performance test	: Non witnessed	PMI documentation	: No
NPSH test	: Non witnessed	Pump visual inspection	: No
Balanced impeller	: G6.3		

Notes

316 SS Bearing Holder Material

-

-

#148 Baseplate

-

No Cust insp/Docs by Factory.

FLOWSERVE

Full Page GA Drawing

Dimensions certified for construction when properly endorsed below.
Refer to factory for any "*" dimensions.
DO NOT SCALE DRAWING

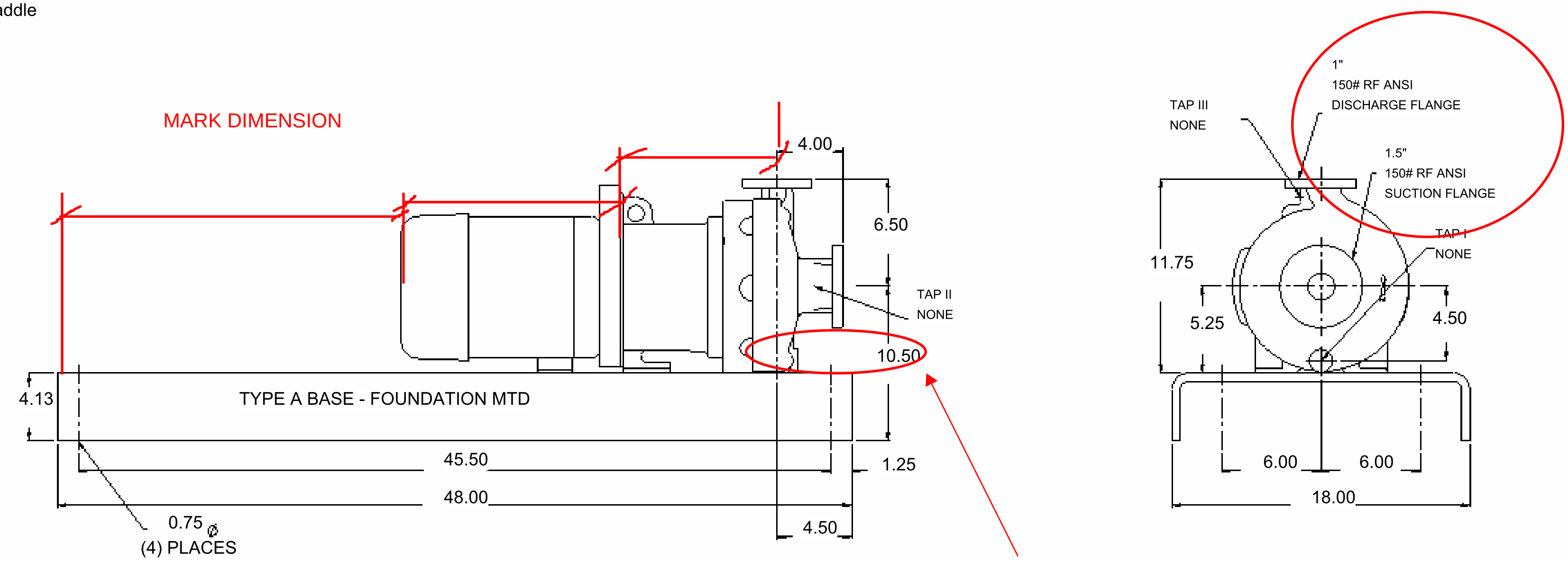
NOTES:
1. Consult pump I.O.M. before installing the pump.
2. Installation dimensions are +/- .13" (3mm), unless otherwise noted.
3. Foundation bolts and piping should not be set rigidly before receipt of equipment.
4. Allow a minimum of .75" (19mm) under baseplate for adjustment and grouting.
5. All holes in flanges straddle centerlines.
6. Piping, foundations, and systems are the responsibility of others. Flowserve Pump Division data and comments are offered as an aid, but Flowserve Pump Division cannot assume responsibility for the system design or operation. It is recommended that a specialist skilled in this area be consulted to ensure a successful installation.
7. Dimension shown from bottom of base to centerline of pump includes any blocks under pump, as necessary.

Pump Shaft Dia at Cplg: 0.875"

SPECIFY THE ALLOWABLE NOZZLE LOADS TO BE FOLLOWED AS PER FIGURE 4-13.
SPECIFY THE PUMP NUMBER TO MATCH THE TABLE

P&ID TO BE UPDATED TO MATCH THE SUCTION AND DISCHARGE SIZE

MARK DIMENSION



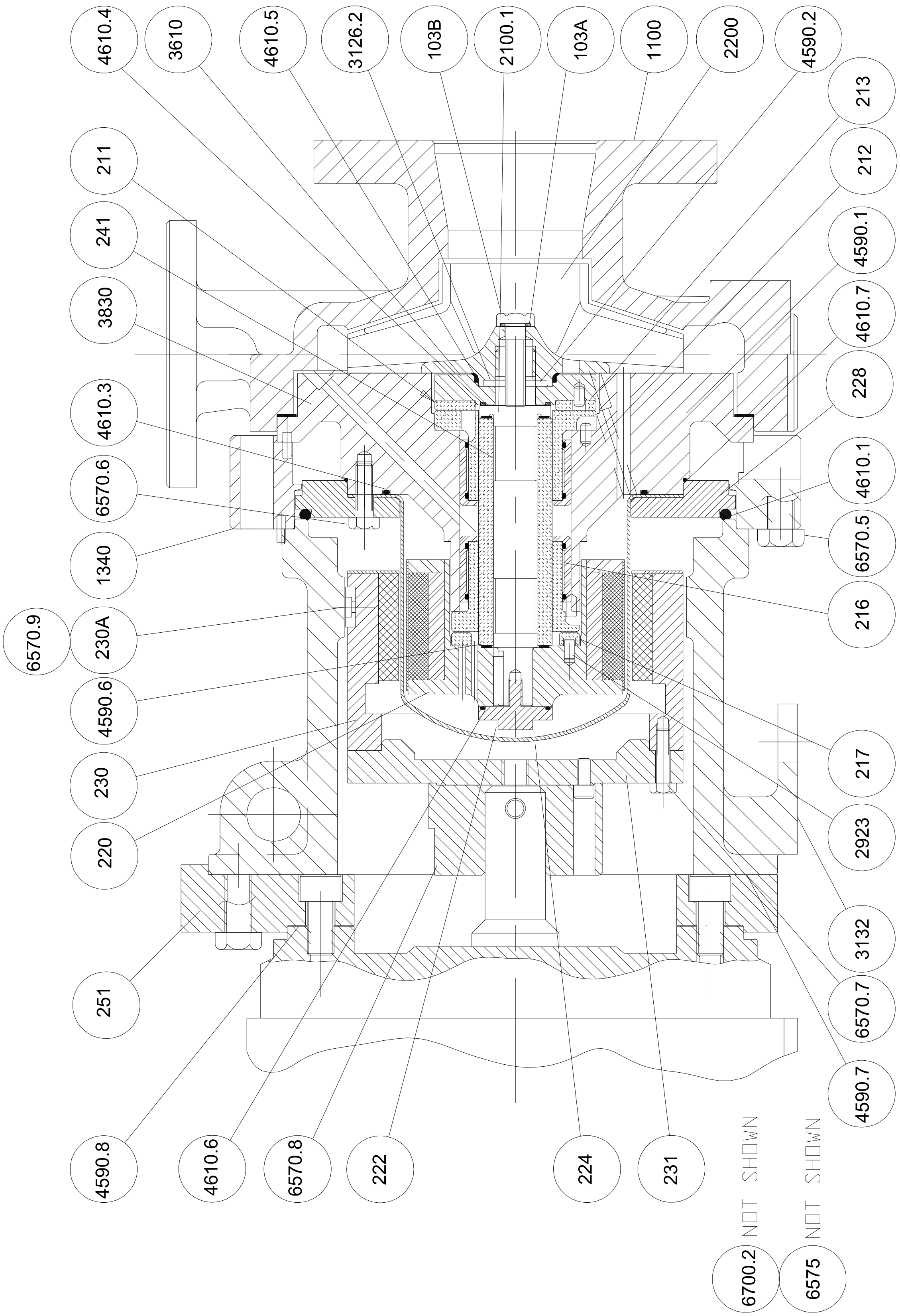
CASING DRAIN CONNECTION MISSING

Ta -20°C to + 40°C

-

Customer	: Superior Industrial Equipment	Pump size & type	: BG1.5X1-82 M3GD	Drawing number	: -
Item number	: PM-VS33A19-01/02	Pump speed / Stages	: 3500 rpm / 1	Date	: July 22, 2019
Service	: Slop Alcohol Transfer Pumps	Flow / Head	: 72.6 USgpm / 109.90 ft	Certified by / Date :	: -
Customer PO #	: -	Driver power / Frame	: 15.0 hp / 11.2 kW / 254TC	Seal type	: -
Flowserve reference	: 1901798749	Volts / Phase / Hz	: 460 / 3 / 60 Hz	Seal flush plan	: -

8.3 Cutaway - Guardian G & H Series - Group 1 – close coupled



8.3.1 Parts list - Guardian G & H Series - Group 1 – close coupled

Parts list - Guardian G & H Series - Group 1 – close coupled

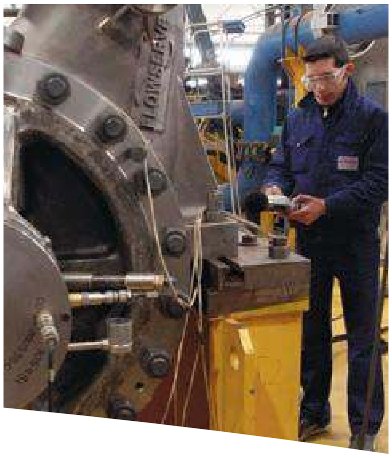
Item	Qty	Description	Item	Qty	Description	Item	Qty	Description
211	1	Journal - Inboard	1340	1	Adapter	4610.4	1	O-ring
212	1	Bushing - Inboard	2100.1	1	Shaft	4610.5	1	O-ring
213	1	Journal - Sleeve	2200	1	Impeller	4610.6	1	O-ring
216	1	Bushing - Outboard	2913	1	Impeller Screw	4610.7	1	O-ring
217	1	Journal - Outboard	2923	8	Pin	4610.8	1	O-ring
220	1	Magnet Assy - Inner	3126.2	n/a	Shim	6570.5	4	Screw
222	1	Cap – Pump Shaft	3132	1	Bearing Bracket Lantern	6570.6	6	Screw
224	1	Containment Shell	3610	1	Thrust Collar	6570.7	4	Screw
228	1	Retainer Ring	3830	1	Holder	6570.9	4	Screw
230	1	Magnet Assy - Outer	4590.1	1	Gasket	6570.10	4	Screw
230A	4	Rub Pad	4590.2	1	Gasket	6570.11	4	Screw
231	1	Flange – Outer Magnet	4590.6	2	Gasket	6572.1	8	Stud
241	2	Tolerance Ring	4590.7	1	Gasket	6575	4	Jackscrew
245	1	Hub and Hardware	4590.8	1	Gasket	6580.1	8	Nut
251	1	Motor Flange	4610.1	1	O-ring	6700.1	1	Key
1100	1	Casing	4610.3	1	O-ring			

FLOWSERVE

Durco® Guardian

ASME (ANSI) Magnetic Drive Pump

Experience In Motion



Pump Supplier to the World

Flowserve is the driving force in the global industrial pump marketplace. No other pump company in the world has the depth or breadth of expertise in the successful application of pre-engineered, engineered, and special purpose pumps and systems.

Life Cycle Cost Solutions

Flowserve provides pumping solutions that permit customers to reduce total life cycle costs and improve productivity, profitability and pumping system reliability.

Market-Focused Customer Support

Product and industry specialists develop effective proposals and solutions directed toward market and customer preferences. They offer technical advice and assistance throughout each stage of the product life cycle, beginning with the initial inquiry.

Broad Product Lines

Flowserve offers a wide range of complementary pump types, from pre-engineered process pumps to highly engineered and special purpose pumps and systems. Pumps are built to recognized global standards and customer specifications.

Pump designs include:
- Single-stage process
- Between bearings single-stage
- Between bearings multistage
- Vertical
- Submersible motor
- Positive displacement
- Nuclear
- Specialty

Product Brands of Distinction

ACEC™ Centrifugal Pumps

Aldrich™ Pumps

Byron Jackson® Pumps

Calder™ Energy Recovery Devices

Cameron™ Pumps

Durco® Process Pumps

Flowserve® Pumps

IDP® Pumps

INNOMAG® Sealless Pumps

Lawrence Pumps®

Niigata Worthington™ Pumps

Pacific® Pumps

Pleuger® Pumps

Scienco™ Pumps

Sier-Bath® Rotary Pumps

TKL™ Pumps

United Centrifugal® Pumps

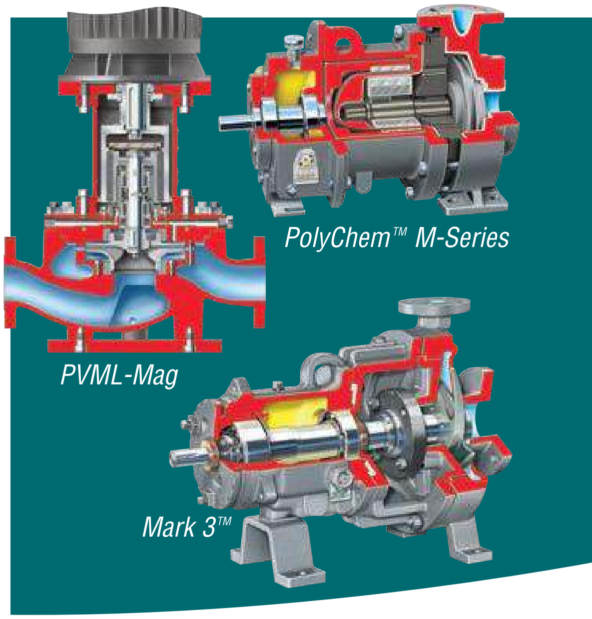
Western Land Roller™ Irrigation Pumps

Wilson-Snyder® Pumps

Worthington® Pumps

Worthington Simpson™ Pumps

Durco Guardian ASME (ANSI) Magnetic Drive Pump



A Leader in Sealless Pump Technology

Flowserve Durco Guardian sealless pump technology offers superior, leak-free performance in the most demanding services. Compliant with ASME (ANSI) B73.1-2001 dimensional standards, the Guardian magnetic drive pump is designed for simplicity and reliability in even the toughest emission-free services.

Reliability and Performance

The Guardian magnetic drive pump possesses numerous reliability and performance enhancing features, including:

- Rugged silicon carbide bushings and journals
- Proven Mark 3 casing and impeller
- Optimized internal lubrication path

Broad Applications

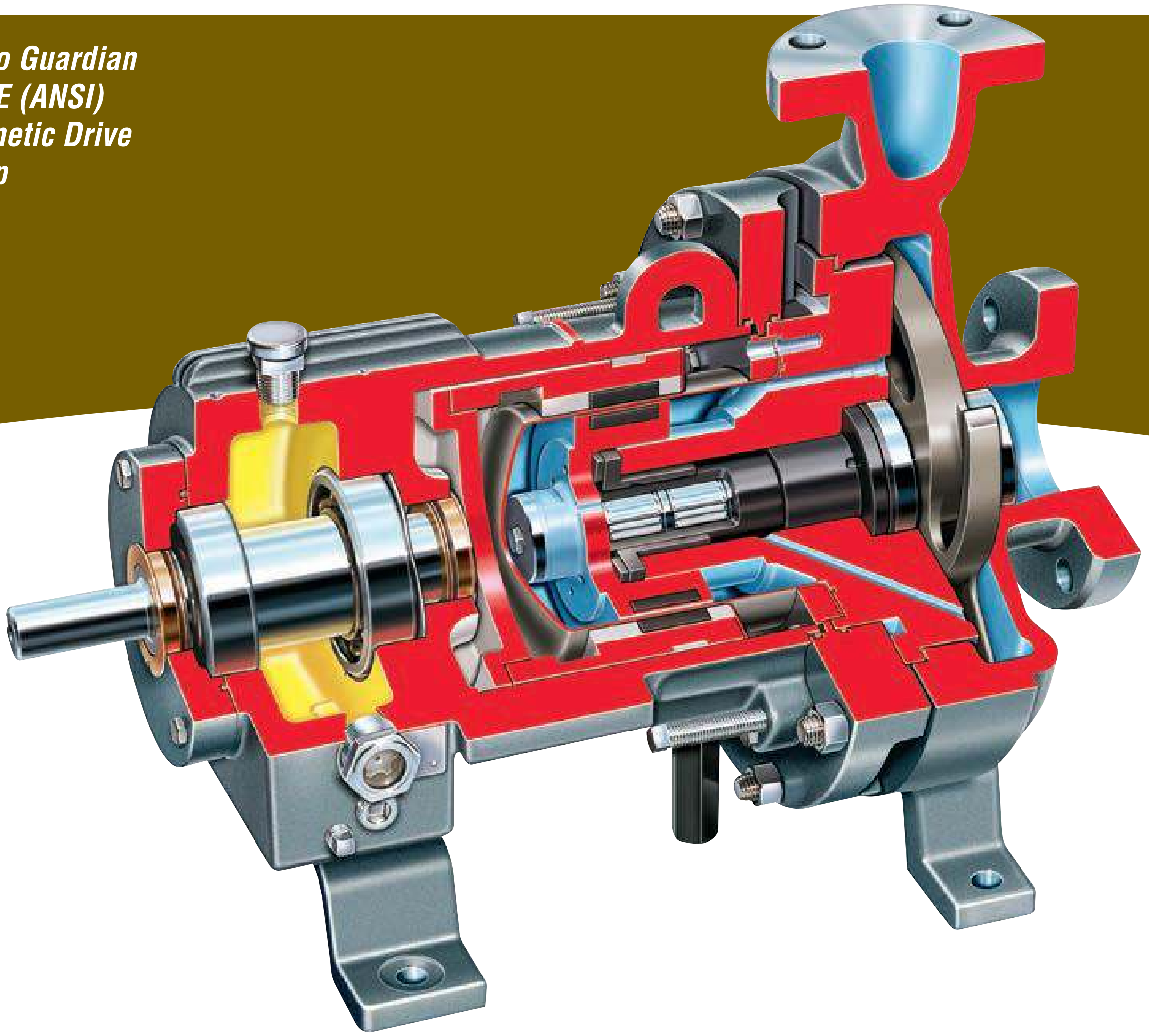
- Acid transfer
- Aquariums
- Chlor-alkali
- Corrosive services
- Difficult-to-seal liquids
- Flammable liquids
- Organic chemicals
- Polymers
- Solvents
- Toxic services
- Ultrapure liquids
- Valuable liquids
- Water treatment

Complementary Pump Designs

In addition to the Guardian magnetic drive pump, Flowserve also can provide the following pump designs:

- Mark 3 ASME (ANSI) standard, chemical process pump
- Mark 3 ISO standard, chemical process pump
- CPXS ISO magnetic drive, chemical process pump
- PVML-Mag API vertical in-line, magnetic drive pump
- PolyChem M-Series ASME (ANSI) non-metallic, magnetic drive pump
- ERPN-Mag magnetic drive process pump

Durco Guardian ASME (ANSI) Magnetic Drive Pump



The Flowserve Durco Guardian is a horizontal, magnetic drive pump designed for simplicity and reliability in emission-free services. It is compliant with ASME (ANSI) B73.1-2001 dimensional standards, ASME (ANSI) B73.3-2003 sealless pump standards and HI 5.1-5.6 1992 standards.

Available in 18 sizes, the Guardian uses the same casing and reverse vane impeller as the Flowserve Durco Mark 3 ASME (ANSI) standard pump. This interchangeability of wet end parts provides consistent hydraulic performance and allows pumps to easily be converted from sealed to sealless configurations.

Operating Parameters

- Flows to 375 m^3/h (1650 gpm)
- Heads to 215 m (700 ft)
- Pressures to 24 bar (350 psi)
- Temperatures to 290°C (550°F)
- Motor sizes to 93 kW (125 hp) at 60 Hz

Exclusive Reverse Vane Impeller provides constant inner bearing lubrication, predictable thrust characteristics and lowest average NPSHR.

Hastelloy® C-276 Containment Shell provides excellent corrosion resistance and meets Section VIII of the ASME Pressure Vessel Code.

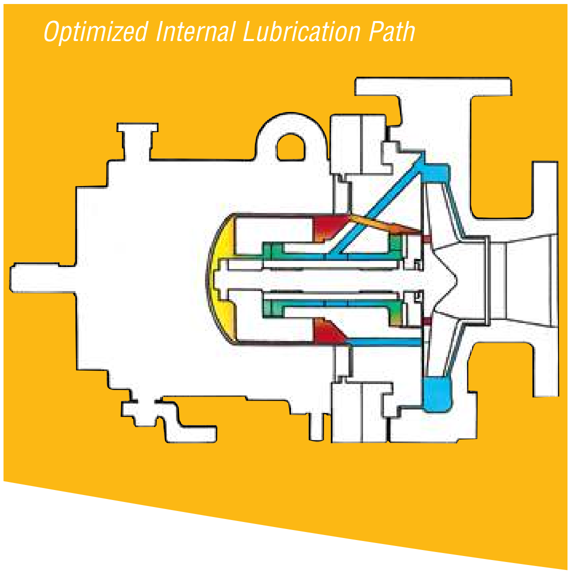
Samarium Cobalt Rare Earth Magnets in synchronous drive design eliminate slippage and permit high-temperature application.

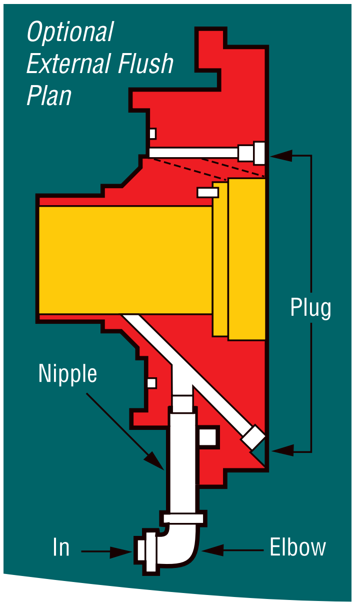
Silicon Carbide Bushings and Journals resist wear and corrosion. Optional materials are available for special application needs.

Precise Running Clearances protect the containment shell from potential damage.

Jackbolts offer added safety and facilitate maintenance.

® Hastelloy is a registered trademark of Haynes International, Inc.





Optimized Internal Lubrication Path for Superior Cooling and Performance

The Durco Guardian magnetic drive pump features a highly engineered internal lubrication path designed to deliver superior cooling and efficient pump performance. By introducing the coolest possible fluid to the bushings and journals, the Guardian achieves optimum lubrication, cooling and performance.

First, high-pressure process fluid is introduced to the silicon carbide bushings and journals via injection ports near the impeller discharge. Spiral and radial grooves on the bushings facilitate proper lubrication of the components. Then pressure forces the fluid into the gap between the inner magnet and the containment shell, where it dissipates heat generated by eddy currents. Finally, fluid enters the lower pressure region behind the impeller via return ports.

High-Temperature Design

The Guardian is capable of handling service temperatures to 290°C (550°F). Stationary silicon carbide bushings are cartridge mounted using tolerance rings to compensate for thermal expansion. O-rings protect tolerance rings from corrosion. Cartridges are pre-assembled at the factory and slip-fit into the bearing holder.

Available External Flush Plan

An external flush plan is available with the Guardian to extend the pump's application range. By introducing a clean, compatible flush fluid or a filtered bypass flush into the containment shell area, the Guardian can handle otherwise difficult process conditions.

Standard and Contained Back Pullout

The Guardian offers end users the convenience and safety of standard and contained back pullout.

- Standard back pullout facilitates general maintenance and inspection. The casing stays in-line and the piping connections remain intact.
- Contained back pullout facilitates drive end maintenance. The process fluid remains fully confined, thereby eliminating the need to drain or purge the pump. Furthermore, maintenance personnel are safe from exposure to potentially harmful process fluids.

Standard Back Pullout

Contained Back Pullout

Options and Technical Data

Guardian Close-Coupled Pump

KW941 Pump Power Monitor

Instrumentation Options

- Fiber-optic leak detection
- Containment shell temperature probe
- Process temperature probe
- Pressure transducers
- Flow switches
- Vibration probes

Materials of Construction

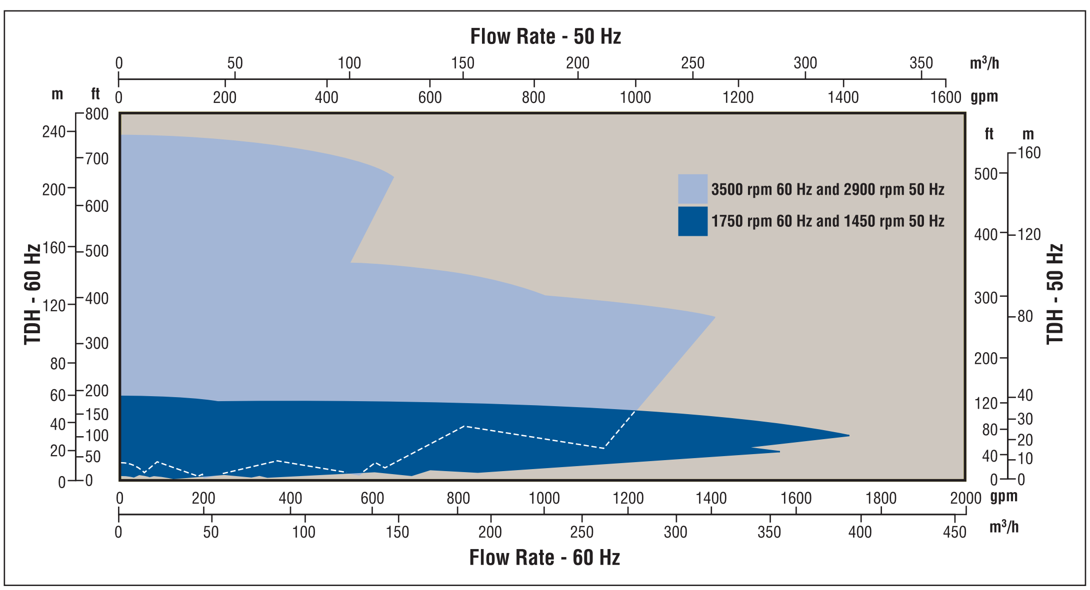
The Guardian is available in a wide range of materials to suit application needs. The accompanying chart lists the most common materials of construction.

Other Options

- Close-coupled configuration
- Self-priming configuration
- Labyrinth oil seals
- KW941 Pump Power Monitor

Guardian Alloy Code	Specification
D4 (316SS)	ASTM A744, Gr. CF8M
D20 (Alloy 20)	ASTM A744, Gr. CN7M
DC3 (Hastelloy C)	ASTM A494, Gr. CW6M
Alternate materials of construction such as titanium and Hastelloy B-2 can be supplied for special application needs.	

Guardian Range Chart



Global Service and Technical Support

Life Cycle Cost Solutions

Typically, 90% of the total life cycle cost (LCC) of a pumping system is accumulated after the equipment is purchased and installed. Flowserve has developed a comprehensive suite of solutions aimed at providing customers with unprecedented value and cost savings throughout the life span of the pumping system. These solutions account for every facet of life cycle cost, including:

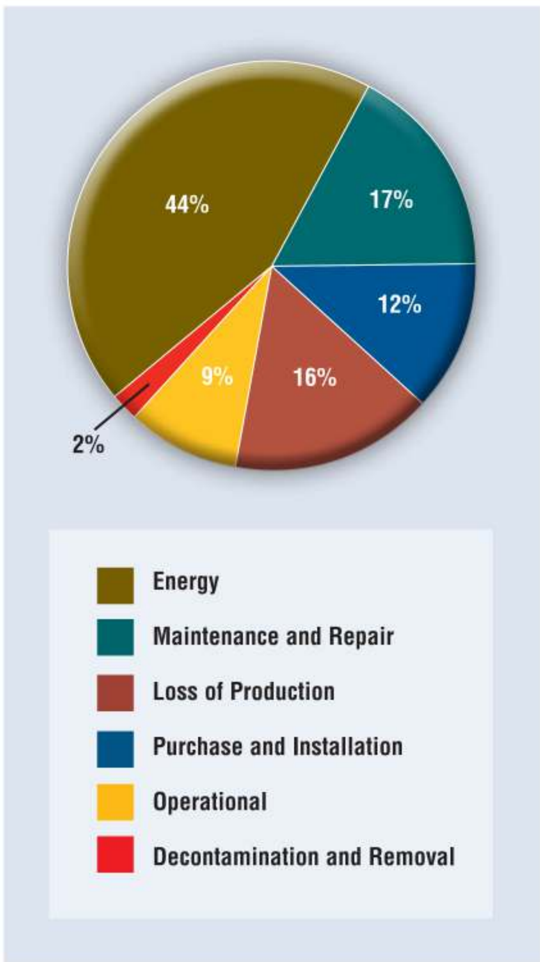
Capital Expenses
- Initial purchase
- Installation

Operating Expenses
- Energy consumption
- Maintenance
- Production losses
- Environmental
- Inventory
- Operating
- Removal

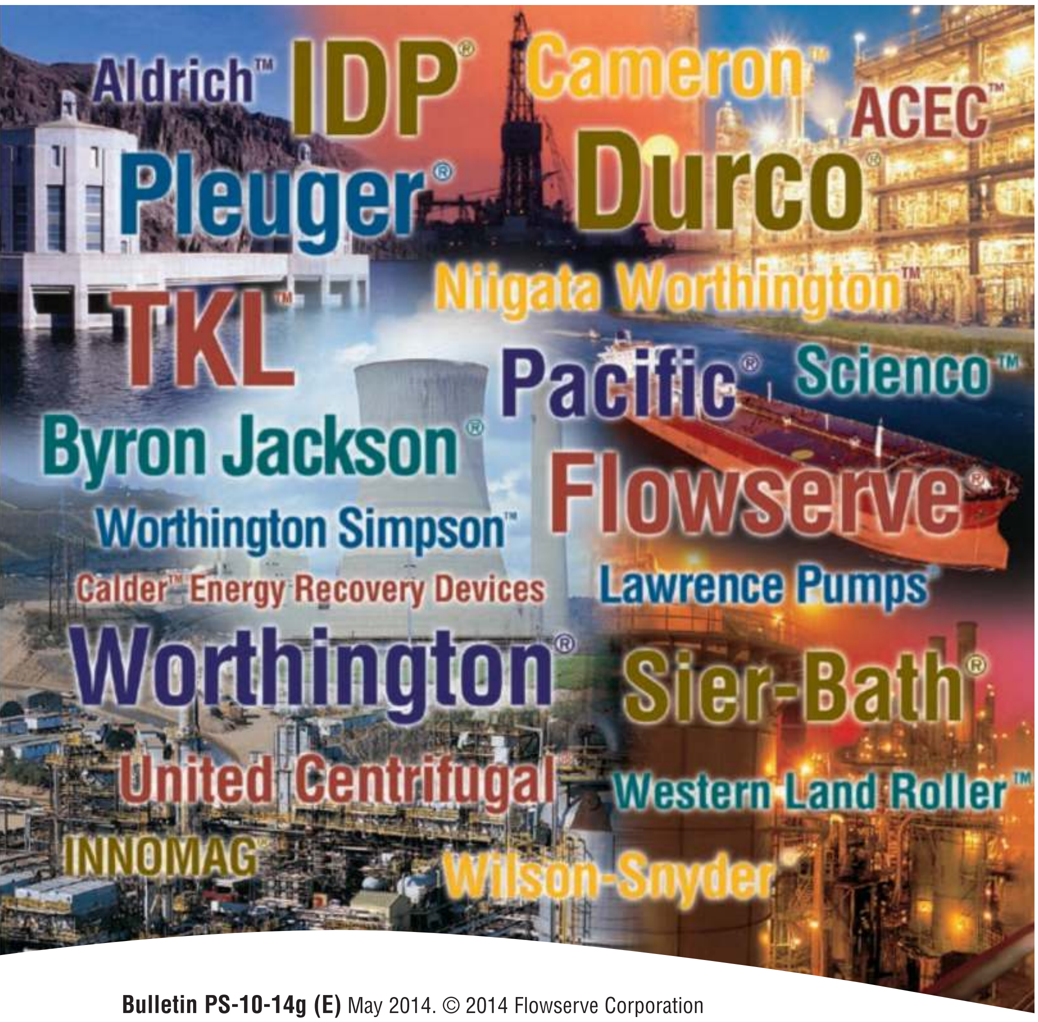
Innovative Life Cycle Cost Solutions

- New Pump Selection
- Turnkey Engineering and Field Service
- Energy Management
- Pump Availability
- Proactive Maintenance
- Inventory Management

Typical Pump Life Cycle Costs[1]



[1] While exact values may differ, these percentages are consistent with those published by leading pump manufacturers and end users, as well as industry associations and government agencies worldwide.



USA and Canada
Flowserve Corporation
5215 North O'Connor Blvd.
Suite 2300
Irving, Texas 75039-5421 USA
Telephone: +1 937 890 5839

Europe, Middle East, Africa
Flowserve Corporation
Parallelweg 13
4878 AH Etten-Leur
The Netherlands
Telephone: +31 76 502 8100

Latin America
Flowserve Corporation
Martín Rodriguez 4460
B1644CGN-Victoria-San Fernando
Buenos Aires, Argentina
Telephone: +54 11 4006 8700
Telefax: +54 11 4714 1610

Asia Pacific
Flowserve Pte. Ltd.
10 Tuas Loop
Singapore 637345
Telephone: +65 6771 0600
Telefax: +65 6862 2329

To find your local Flowserve representative:

For more information about Flowserve Corporation, visit www.flowserve.com or call +1 937 890 5839.

USER INSTRUCTIONS

Guardian Sealless Metallic Pumps

ANSI Standard, Close-Coupled and Unitized Self-Primer

Single stage, end suction, centrifugal, chemical process pumps

PCN=71569212 08-11 (E) (Based on P-20-502.)
Original instructions.

Installation
Operation
Maintenance

⚠ These instructions must be read prior to installing, operating, using and maintaining this equipment.

Experience In Motion

CONTENTS

1 INTRODUCTION AND SAFETY

1.1 General

These instructions must always be kept close to the product's operating location or directly with the product.

Flowserve products are designed, developed and manufactured with state-of-the-art technologies in modern facilities. The unit is produced with great care and commitment to continuous quality control, utilising sophisticated quality techniques, and safety requirements.

Flowserve is committed to continuous quality improvement and being at service for any further information about the product in its installation and operation or about its support products, repair and diagnostic services.

These instructions are intended to facilitate familiarization with the product and its permitted use. Operating the product in compliance with these instructions is important to help ensure reliability in service and avoid risks. The instructions may not take into account local regulations; ensure such regulations are observed by all, including those installing the product. Always coordinate repair activity with operations personnel, and follow all plant safety requirements and applicable safety and health laws/regulations.

These instructions must read prior to installing, operating, using and maintaining the equipment in any region worldwide. The equipment must not be put into service until all the conditions relating to safety noted in the instructions, have been met. Failure to follow and apply the present user instructions is considered to be misuse. Personal injury, product damage, delay or failure caused by misuse are not covered by the Flowserve warranty.

1.2 CE marking and approvals

It is a legal requirement that machinery and equipment put into service within certain regions of the world shall conform with the applicable CE Marking Directives covering Machinery and, where applicable, Low Voltage Equipment, Electromagnetic Compatibility (EMC), Pressure Equipment Directive (PED) and Equipment for Potentially Explosive Atmospheres (ATEX).

Where applicable, the Directives and any additional Approvals, cover important safety aspects relating to machinery and equipment and the satisfactory provision of technical documents and safety instructions. Where applicable this document incorporates information relevant to these Directives and Approvals.
To confirm the Approvals applying and if the product is CE marked, check the serial number plate markings and the Certification, (See section 9, *Certification*.)

1.3 Disclaimer

Information in these User Instructions is believed to be complete and reliable. However, in spite of all of the efforts of Flowserve Corporation to provide comprehensive instructions, good engineering and safety practice should always be used.

Flowserve manufactures products to exacting International Quality Management System Standards as certified and audited by external Quality Assurance organisations. Genuine parts and accessories have been designed, tested and incorporated into the products to help ensure their continued product quality and performance in use. As Flowserve cannot test parts and accessories sourced from other vendors the incorrect incorporation of such parts and accessories may adversely affect the performance and safety features of the products. The failure to properly select, install or use authorised Flowserve parts and accessories is considered to be misuse. Damage or failure caused by misuse is not covered by the Flowserve's warranty. In addition, any modification of Flowserve products or removal of original components may impair the safety of these products in their use.

1.4 Copyright

1.5 Duty conditions

This product has been selected to meet the specifications of your purchaser order. The acknowledgement of these conditions has been sent separately to the Purchaser. A copy should be kept with these instructions.

The product must not be operated beyond the parameters specified for the application. If there is any doubt as to the suitability of the product for the application intended, contact Flowserve for advice, quoting the serial number.

If the conditions of service on your purchase order are going to be changed (for example liquid pumped, temperature or duty) it is requested that the user seek written agreement of Flowserve before start up.

1.6 Safety

1.6.1 Summary of safety markings

These User Instructions contain specific safety markings where non-observance of an instruction would cause hazards. The specific safety markings are:

DANGER This symbol indicates electrical safety instructions where non-compliance will involve a high risk to personal safety or the loss of life.

This symbol indicates safety instructions where non-compliance would affect personal safety and could result in loss of life.

This symbol indicates "hazardous and toxic fluid" safety instructions where non-compliance would affect personal safety and could result in loss of life.

CAUTION This symbol indicates safety instructions where non-compliance will involve some risk to safe operation and personal safety and would damage the equipment or property.

This symbol indicates "strong magnetic field" safety instructions where non-compliance would affect personal safety, pacemakers, instruments, or stored data sensitive to magnetic fields.

This symbol indicates explosive atmosphere zone marking according to ATEX. It is used in safety instructions where non-compliance in the hazardous area would cause the risk of an explosion.

This symbol is used in safety instructions to remind not to rub non-metallic surfaces with a dry cloth; ensure the cloth is damp. It is used in safety instructions where non-compliance in the hazardous area would cause the risk of an explosion.

Note: This sign is not a safety symbol but indicates an important instruction in the assembly process.

1.6.2 Personnel qualification and training

All personnel involved in the operation, installation, inspection and maintenance of the unit must be qualified to carry out the work involved. If the personnel in question do not already possess the necessary knowledge and skill, appropriate training and instruction must be provided. If required the operator may commission the manufacturer/supplier to provide applicable training.

Always coordinate repair activity with operations and health and safety personnel, and follow all plant safety requirements and applicable safety and health laws and regulations.

1.6.3 Safety action

This is a summary of conditions and actions to prevent injury to personnel and damage to the environment and to equipment. For products used in potentially explosive atmospheres section 1.6.4 also applies.

HIGH MAGNETIC FIELDS
Great care should be taken when assembling/ dismantling magnetic rotors, where fitted, because of the very high forces which can be created by the magnets.
Persons with pacemakers and any instrumentation etc sensitive to magnetic fields should be kept well away from the magnetic drive unit during dismantling.

DANGER NEVER DO MAINTENANCE WORK WHEN THE UNIT IS CONNECTED TO POWER

DRAIN THE PUMP AND ISOLATE PIPEWORK BEFORE DISMANTLING THE PUMP
The appropriate safety precautions should be taken where the pumped liquids are hazardous.

FLUOROELASTOMERS (When fitted.)
When a pump has experienced temperatures over 250 ºC (482 ºF), partial decomposition of fluoroelastomers (example: Viton) will occur. In this condition these are extremely dangerous and skin contact must be avoided.

HANDLING COMPONENTS
Many precision parts have sharp corners and the wearing of appropriate safety gloves and equipment is required when handling these components. To lift heavy pieces above 25 kg (55 lb) use a crane appropriate for the mass and in accordance with current local regulations.

NEVER OPERATE THE PUMP WITHOUT THE COUPLING GUARD AND ALL OTHER SAFETY DEVICES CORRECTLY INSTALLED

GUARDS MUST NOT BE REMOVED WHILE THE PUMP IS OPERATIONAL

HOT (and cold) PARTS

If hot or freezing components or auxiliary heating equipment can present a danger to operators and persons entering the immediate area, action must be taken to avoid accidental contact (such as shielding). If complete protection is not possible, the machine access must be limited to maintenance staff only with clear visual warnings and indicators to those entering the immediate area.

Note: Bearing housings must not be insulated and drive motors and bearings may be hot.

If the temperature is greater than 80 °C (175 °F) or below -5 °C (23 °F) in a restricted zone, or exceeds local regulations, action as above shall be taken.

THERMAL SHOCK
Rapid changes in the temperature of the liquid within the pump can cause thermal shock, which can result in damage or breakage of components and should be avoided.

NEVER APPLY HEAT TO REMOVE IMPELLER
Trapped lubricant or vapor could cause an explosion.

CAUTION ALWAYS USE THE JACKBOLTS TO SEPARATE THE POWER END FROM THE WET END ASSEMBLIES

CAUTION PREVENT EXCESSIVE EXTERNAL PIPE LOAD
Do not use pump as a support for piping. Do not mount expansion joints, unless allowed by Flowserve in writing, so that their force, due to internal pressure, acts on the pump flange.

CAUTION ENSURE CORRECT LUBRICATION
(See section 5, *Commissioning, startup, operation and shutdown*.)

CAUTION NEVER EXCEED THE MAXIMUM DESIGN PRESSURE (MDP) AT THE TEMPERATURE SHOWN ON THE PUMP NAMEPLATE
See section 3 for pressure versus temperature ratings based on the material of construction.

Ex CAUTION NEVER OPERATE THE PUMP WITH THE DISCHARGE VALVE CLOSED
(Unless otherwise instructed at a specific point in the user instructions.)
See section 5, *Commissioning start-up, operation and shutdown*.

Ex CAUTION NEVER RUN THE PUMP DRY OR WITHOUT PROPER PRIME (Casing Flooded)
Operating the magnetic coupling dry may cause immediate damage to the containment shell and bearings.

CAUTION NEVER OPERATE THE PUMP WITH THE SUCTION VALVE CLOSED
It should be fully opened when the pump is running.

CAUTION NEVER OPERATE THE PUMP AT ZERO FLOW OR FOR EXTENEDED PERIODS BELOW THE MINIMUM CONTINUOUS FLOW

CAUTION DO NOT START THE PUMP WITHOUT PROPER LUBRICATION
Refer to bearing lubrication in Section 5.2.

Ex CAUTION THE PUMP SHAFT MUST TURN CLOCKWISE WHEN VIEWED FROM THE MOTOR END
It is absolutely essential that the rotation of the motor be checked before installation of the coupling spacer and starting the pump. Incorrect rotation of the pump for even a short period can unscrew the impeller, which can cause significant damage.

CAUTION GUARDIAN G & H SERIES PUMPS ARE SIZED BASED ON A SPECIFIC APPLICATION.
In the event the user elects to operate this pump in a service other than what it was originally sized for, a Flowserve sales engineer should be contacted to evaluate the new application.

Ex CAUTION DO NOT RUN THE PUMP AT ABNORMALLY HIGH OR LOW FLOW RATES
Operating at a flow rate higher than normal or at a flow rate with no back pressure on the pump may overload the motor and cause cavitation. Low flow rates may cause a reduction in pump/bearing life, overheating of the pump, instability and cavitation/vibration.

CAUTION EXCESSIVE PUMP NOISE OR VIBRATION
This may indicate a dangerous condition. The pump must be shut down immediately.

HAZARDOUS LIQUIDS
When the pump is handling hazardous liquids care must be taken to avoid exposure to the liquid by appropriate pump placement, limiting personnel access and by operator training. If the liquid is flammable and/or explosive, strict safety procedures must be applied.

1.6.4 Products used in potentially explosive atmospheres

Measures are required to:

- Avoid excess temperature
- Prevent build up of explosive mixtures
- Prevent the generation of sparks
- Prevent leakages
- Maintain the pump to avoid hazard

The following instructions for pumps and pump units when installed in potentially explosive atmospheres must be followed to help ensure explosion protection. For ATEX, both electrical and non-electrical equipment must meet the requirements of European Directive 94/9/EC. . Always observe the regional legal Ex requirements eg Ex electrical items outside the EU may be required certified to other than ATEX eg IECEx, UL.

1.6.4.1 Scope of compliance

Use equipment only in the zone for which it is appropriate. Always check that the driver, drive coupling assembly, and pump equipment are suitably rated and/or certified for the classification of the specific atmosphere in which they are to be installed.

Where Flowserve has supplied only the bare shaft pump, the Ex rating applies only to the pump. The party responsible for assembling the pump set shall select the coupling, driver, and any additional equipment, with the necessary CE Certificate/ Declaration of Conformity establishing it is suitable for the area in which it is to be installed.

The output from a variable frequency drive (VFD) can cause additional heating effects in the motor. On pump sets controlled by a VFD, the ATEX Certification for the motor must state that it covers the situation where electrical supply is from the VFD. This particular requirement still applies even if the VFD is in a safe area.

1.6.4.2 Marking

An example of ATEX equipment marking is shown below. The actual classification of the pump will be engraved on the nameplate.

II 2 GD c IIC 135 ºC (T4)

Equipment Group
I = Mining
II = Non-mining

Category
2 or M2 = high level protection
3 = normal level of protection

Gas and/or dust
G = Gas
D = Dust

c = Constructional safety
(in accordance with EN13463-5)

Gas Group
IIA – Propane (typical)
IIB – Ethylene (typical)
IIC – Hydrogen (typical)

Maximum surface temperature (Temperature Class) (see section 1.6.4.3.)

1.6.4.3 Avoiding excessive surface temperatures

ENSURE THE EQUIPMENT TEMPERATURE CLASS IS SUITABLE FOR THE HAZARD ZONE

Pumps have a temperature class as stated in the ATEX Ex rating on the nameplate. These are based on a maximum ambient temperature of 40 °C (104 °F). Refer to Flowserve for higher ambient temperatures.

Maximum permitted liquid temperature for pumps

Temperature class to EN13463-1	Maximum surface temperature permitted	Temperature limit of liquid handled
T6	85 °C (185 °F)	Consult Flowserve
T5	100 °C (212 °F)	Consult Flowserve
T4	135 °C (275 °F)	115 °C (239 °F) *
T3	200 °C (392 °F)	180 °C (356 °F) *
T2	300 °C (572 °F)	275 °C (527 °F) *

Maximum permitted liquid temperature for pumps with self priming casing

Temperature class to EN13463-1	Maximum surface temperature permitted	Temperature limit of liquid handled
T6	85 °C (185 °F)	Consult Flowserve
T5	100 °C(212 °F)	Consult Flowserve
T4	135 °C (275 °F)	110 °C (230 °F) *
T3	200 °C (392 °F)	175 °C (347 °F) *
T2	300 °C (572 °F)	270 °C (518 °F) *

* The tables only takes the ATEX temperature class into consideration. Pump design or material, as well as component design or material, may further limit the maximum working temperature of the liquid.

The responsibility for compliance with the specified maximum liquid temperature is with the plant operator.

Temperature classification "Tx" is used when the liquid temperature varies and the pump could be installed in different hazardous atmospheres. In this case the user is responsible for ensuring that the pump surface temperature does not exceed that permitted in the particular hazardous atmosphere.

Do not attempt to check the direction of rotation with the coupling spacer fitted due to the risk of severe contact between rotating and stationary components.

Where there is any risk of the pump being run against a closed valve generating high liquid and casing external surface temperatures fit an external surface temperature protection device.

Avoid mechanical, hydraulic or electrical overload by using motor overload trips or a power monitor and perform routine vibration monitoring.

In dirty or dusty environments, make regular checks and remove dirt from areas around close clearances, bearing housings and motors.

Additional requirements for self-priming casing pumps
Where the system operation does not ensure control of priming, as defined in the User Instructions, and the maximum permitted surface temperature of the T Class could be exceeded, the user shall install an external surface temperature protection device.

1.6.4.4 Preventing the build up of explosive mixtures

Ex ENSURE PUMP IS PROPERLY FILLED AND VENTED AND DOES NOT RUN DRY

Ensure that the pump and relevant suction and discharge piping is totally filled with liquid at all times during the pumps operation so that an explosive atmosphere is prevented. In addition, it is essential to make sure that any heating and cooling systems are properly filled.

If the operation of the system can not avoid this condition fit an appropriate dry run protection device (example: liquid detection or a power monitor).

To avoid potential hazards from fugitive emissions of vapor or gas to atmosphere, the surrounding area must be well ventilated.

1.6.4.5 Preventing sparks

Ex To prevent a potential hazard from mechanical contact, the coupling guard must be non-sparking for category 2 equipment.

To avoid the potential hazard from random induced current generating a spark, the baseplate must be properly grounded.

Avoid electrostatic charge. Do not rub non-metallic surfaces with a dry cloth; ensure the cloth is damp.

For ATEX the coupling must be selected to comply with 94/9/EC. Correct alignment must be maintained.

Additional requirements for pumps on non-metallic baseplates
When metallic components are fitted on a non-metallic baseplate they must be individually earthed.

1.6.4.6 Preventing leakage

Ex The pump must only be used to handle liquids for which it has been approved to have the correct corrosion resistance.

Avoid entrapment of liquid in the pump and associated piping due to closing of suction and discharge valves, which could cause dangerous excessive pressures to occur if there is heat input to the liquid. This can occur if the pump is stationary or running.

Bursting of liquid containing parts due to freezing must be avoided by draining or protecting the pump and auxiliary systems.

Where there is the potential hazard of a loss of external flush, the fluid must be monitored.

If leakage of liquid to atmosphere can result in a hazard, install a liquid detection device.

1.6.4.7 Maintenance to avoid a hazard

Ex CORRECT MAINTENANCE IS REQUIRED TO AVOID POTENTIAL HAZARDS WHICH GIVE A RISK OF EXPLOSION

The responsibility for compliance with maintenance instructions is with the plant operator.

To avoid potential explosion hazards during maintenance, the tools, cleaning and painting materials used must not give rise to sparking or adversely affect the ambient conditions. Where there is a risk from such tools or materials, maintenance must be conducted in a safe area.

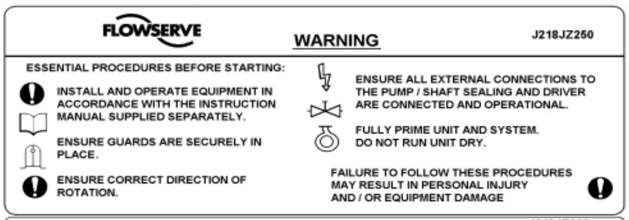
It is recommended that a maintenance plan and schedule be implemented. See section 6, *Maintenance.*

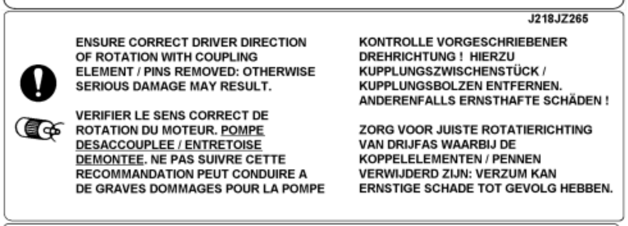
1.7 Nameplate and warning labels

1.7.1 Nameplate

For details of nameplate, see Declaration of Conformity and section 3.

1.7.2 Warning labels





Oil lubricated units only

1.8 Specific machine performance

For performance parameters see section 1.5, *Duty conditions*. Where performance data has been supplied separately to the purchaser these should be obtained and retained with these User Instructions if required.

1.9 Noise level

Attention must be given to the exposure of personnel to the noise, and local legislation will define when guidance to personnel on noise limitation is required, and when noise exposure reduction is mandatory. This is typically 80 to 85 dBA.

The usual approach is to control the exposure time to the noise or to enclose the machine to reduce emitted sound. You may have already specified a limiting noise level when the equipment was ordered, however if no noise requirements were defined, then attention is drawn to the following table to give an indication of equipment noise level so that you can take the appropriate action in your plant.

Pump noise level is dependent on a number of operational factors, flow rate, pipework design and acoustic characteristics of the building, and so the values given are subject to a 3 dBA tolerance and cannot be guaranteed.

Similarly the motor noise assumed in the “pump and motor” noise is that typically expected from standard and high efficiency motors when on load directly driving the pump. Note that a motor driven by an inverter may show an increased noise at some speeds.

If a pump unit only has been purchased for fitting with your own driver then the “pump only” noise levels in the table should be combined with the level for the driver obtained from the supplier. Consult Flowserve or a noise specialist if assistance is required in combining the values.

For units driven by equipment other than electric motors or units contained within enclosures, see the accompanying information sheets and manuals.

It is recommended that where exposure approaches the prescribed limit, then site noise measurements should be made.

The values are in sound pressure level L_{pA} at 1 m (3.3 ft) from the machine, for “free field conditions over a reflecting plane”.

For estimating sound power level L_{WA} (re 1 pW) then add 14 dBA to the sound pressure value.

Motor size and speed kW (hp)	Typical sound pressure level, L_{pA} at 1 m reference 20 μPa (dBA)							
	3550 r/min		2900 r/min		1750 r/min		1450 r/min	
	Pump only	Pump and motor	Pump only	Pump and motor	Pump only	Pump and motor	Pump only	Pump and motor
<0.55 (<0.75)	72	72	64	65	62	64	62	64
0.75 (1)	72	72	64	66	62	64	62	64
1.1 (1.5)	74	74	66	67	64	64	62	63
1.5 (2)	74	74	66	71	64	64	62	63
2.2 (3)	75	76	68	72	65	66	63	64
3 (4)	75	76	70	73	65	66	63	64
4 (5)	75	76	71	73	65	66	63	64
5.5 (7.5)	76	77	72	75	66	67	64	65
7.5 (10)	76	77	72	75	66	67	64	65
11 (15)	80	81	76	78	70	71	68	69
15 (20)	80	81	76	78	70	71	68	69
18.5 (25)	81	81	77	78	71	71	69	71
22 (30)	81	81	77	79	71	71	69	71
30 (40)	83	83	79	81	73	73	71	73
37 (50)	83	83	79	81	73	73	71	73
45 (60)	86	86	82	84	76	76	74	76
55 (75)	86	86	82	84	76	76	74	76
75 (100)	87	87	83	85	77	77	75	77

Note: for 1 180 and 960 r/min reduce 1 450 r/min values by 2 dBA. For 880 and 720 r/min reduce 1 450 r/min values by 3 dBA.

2 TRANSPORT AND STORAGE

2.1 Consignment receipt and unpacking

Immediately after receipt of the equipment it must be checked against the delivery/shipping documents for its completeness and that there has been no damage in transportation. Any shortage and/or damage must be reported immediately to Flowserve and must be received in writing within 10 days of receipt of the equipment. Later claims cannot be accepted.

Check all crates, boxes or wrappings for any accessories or spare parts that may be packed separately from the equipment or attached to side walls of the box or equipment.

Each product has a unique serial number. Check that this number corresponds with that advised and quote this number in correspondence as well as when ordering spare parts or further accessories.

2.2 Handling

Boxes, crates, pallets or cartons may be unloaded using fork-lift vehicles or slings depending on their size and construction.

2.3 Lifting

CAUTION Pumps and motors often have integral lifting lugs or eye bolts. These are intended for use in only lifting the individual piece of equipment. **NEVER use eye bolts or cast-in lifting lugs to lift pump, motor and baseplate assemblies**.

⚠ A crane must be used for all pump sets in excess of 25 kg (55 lb). Fully trained personnel must carry out lifting in accordance with local regulations. The driver and pump weights are recorded on their respective nameplates.

CAUTION Care must be taken to lift components or assemblies above the center of gravity to prevent the unit from flipping. The angle between slings or ropes used for lifting must never exceed 60°.

2.3.1 Lifting pump components

2.3.1.1 Casing [1100]

Use a choker hitch pulled tight around the discharge nozzle.

2.3.1.2 Bearing housing [3200]

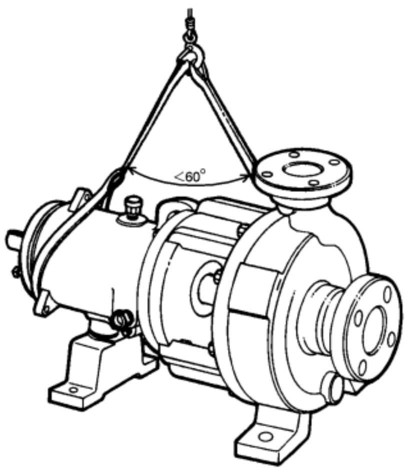
Insert either a sling or hook through the lifting lug located on the top of the housing.

2.3.1.3 Power end
Same as bearing housing.

CAUTION To avoid distortion, the pump unit should be lifted as shown.

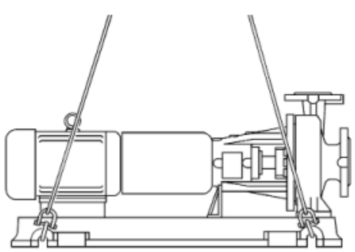
2.3.1.4 Bare pump
Sling around the pump discharge nozzle and around the outboard end of the bearing housing with separate slings. Choker hitches must be used at both attachment points and pulled tight. Make sure the completion of the choker hitch on the discharge nozzle is toward the coupling end of the pump shaft as shown in Figure 2-1. The sling lengths should be adjusted to balance the load before attaching the lifting hook.

Figure 2.1



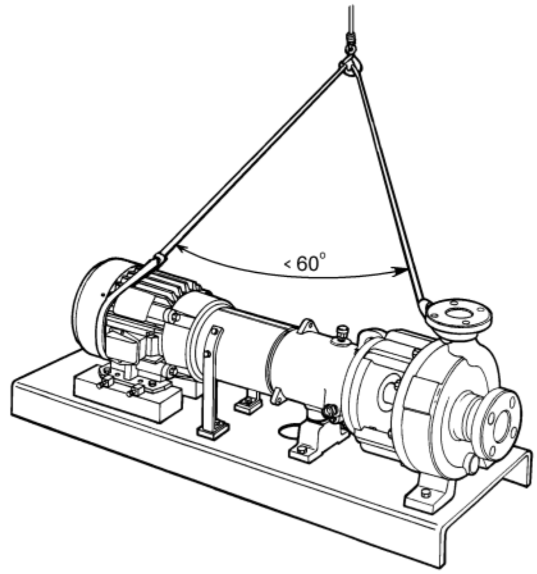
2.3.1.5 Lifting pump, motor and baseplate assembly
If the baseplate has lifting holes cut in the sides at the end insert lifting S hooks at the four corners and use slings or chains to connect to the lifting eye as shown in Figure 2-2. Do not use slings through the lifting holes.

Figure 2.2



For other baseplates, sling around the pump discharge nozzle, and around the outboard end of the motor frame using choker hitches pulled tight. (Figure 2-1.)

Figure 2.3



The sling should be positioned so the weight is not carried through the motor fan housing. Make sure the completion of the choker hitch on the discharge nozzle is toward the coupling end of the pump shaft as shown in Figure 2-1.

2.4 Storage

CAUTION Store the pump in a clean, dry location away from vibration. Leave flange covers in place to keep dirt and other foreign material out of pump casing. Turn the pump shaft at regular intervals to prevent brinelling of the bearings.

The pump may be stored as above for up to 6 months. Consult Flowserve for preservative actions when a longer storage period is needed.

2.4.1 Short term storage
Normal packaging is designed to protect the pump and parts during shipment and for dry, indoor storage for up to six months or less. The following is an overview of our normal packaging:

- All loose unmounted items are packaged in a water proof plastic bag and placed under the coupling guard. Larger items are boxed and metal banded to the baseplate. For pumps not mounted on a baseplate, the bag and/or box is placed inside the shipping container.
- Inner surfaces of the bearing housing, shaft (area through bearing housing) and bearings are coated with Cortec VCI-329 rust inhibitor, or equal.

  Note: Bearing housings are not filled with oil prior to shipment.)

- The internal surfaces of ferrous casings, covers, flange faces, and the impeller surface are sprayed with Cortec VCI-389, or equal.
- Exposed shafts are taped with Polywrap.
- Flange covers are secured to both the suction and discharge flanges.
- Assemblies ordered with external piping, in some cases components may be disassembled for shipment.
- The pump must be stored in a covered, dry location.

2.4.2 Long term storage

Long term storage is defined as more than six months, but less than 12 months. The procedure Flowserve follows for long term storage of pumps is given below. These procedures are in addition to the short term procedure:

- Each assembly is hermetically (heat) sealed from the atmosphere by means of tack wrap sheeting and rubber bushings (mounting holes).
- Desiccant bags are placed inside the tack wrapped packaging.
- A solid wood box is used to cover the assembly.

This packaging will provide protection for up to twelve months from humidity, salt laden air, dust etc.

After unpacking, protection will be the responsibility of the user. Addition of oil to the bearing housing will remove the inhibitor. If units are to be idle for extended periods after addition of lubricants, inhibitor oils and greases should be used. Every three months, the pump shaft should be rotated approximately 10 revolutions.

2.5 Recycling and end of product life

At the end of the service life of the product or its parts, the relevant materials and parts should be recycled or disposed of using an environmentally acceptable method and in accordance with local regulations. If the product contains substances that are harmful to the environment, these should be removed and disposed of in accordance with current local regulations. This also includes the liquids and/or gases that may be used in the "seal system" or other utilities.

⚠ Make sure that hazardous substances are disposed of safely and that the correct personal protective equipment is used. The safety specifications must be in accordance with the current local regulations at all times.

3 DESCRIPTION

3.1 Configurations

The Durco G and H Series Magnetic Drive chemical process pump are end suction, single stage, centrifugal pumps. The horizontal family conforms to ASME B73.3M, which has a centerline discharge and is represented by our Standard long-coupled, Close-coupled (Group 1 only), and Unitized self-priming variants.

3.2 Nomenclature

The pump size will be engraved on the nameplate typically as below:

BG 1.5 x 1 - 62/5.00 RV

- "BG" refers to the magnetic coupling size – see Table 3-2.
- "1.5" refers to the suction diameter (1.5 in.)
- "1" refers to the discharge diameter (1.0 in.)
- "62" refers to nominal impeller diameter (6 & 2/8 in.)
- "5.00" refers to actual impeller diameter (5.00 in)
- "RV" refers to Reverse Vane impeller. (Open impeller design not available on Guardian G & H series pumps.)

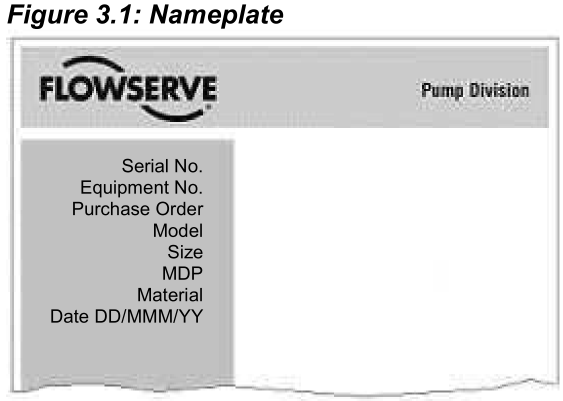
Pump design variation:

A = This pump has been redesigned from an earlier version. The impeller and casing are no longer interchangeable with the earlier version.

H = This pump is designed for a higher flow capacity than another pump with the same basic designation. (Examples: 4X3-10 and 4X3-10H; 6X4-10 and 6X4-10H).

An example of the nameplate used on the Guardian G & H Series pump is shown below. This nameplate, which is always mounted on the Guardian G & H Series bearing housing, is shown in Figure 3-1.

Figure 3.1: Nameplate



3.3 Design of major parts

3.3.1 Pump casing and impeller

Removal of the casing is not required when performing maintenance of the rotating element. The pump is designed with a gasket perpendicular to the shaft allowing the rotating element to be easily removed (back pull out). The impeller is reverse vane; there is no option for an open impeller.

3.3.2 Magnetic coupling

See Figure 3-2 for magnetic coupling static torque values. Outer and inner magnets are separated by a containment shell which isolates the process fluid from the atmosphere. When the motor drives the outer magnet, the attraction between the outer and inner magnet causes the pump shaft and impeller to rotate. See Figure 3-3. This "magnetic coupling" is produced by alternating polarities between the magnet pairs on the inner and outer magnet assemblies. The alternating magnet polarity also causes repulsion between adjacent magnets and prevents the coupling from slipping or decoupling. (See Figure 3-4.)

Figure 3-2: Magnetic coupling static torque values

Pump size	Pump prefix	Magnet length	Torque at 20 ºC (68 ºF) Nm (lbf·in.)
Group 1	AG/AH	0.5 in.	12 (110)
	BG/BH	1.0 in.	33 (290)
	CG/CH	1.5 in.	57 (500)
	DG/DH	2.0 in.	75 (660)
	JG/JH	2.5 in.	92 (810)
Group 2	JG/JH	0.5 in.	23 (200)
	KG/KH	1.0 in.	57 (500)
	LG/LH	1.5 in.	99 (870)
	MG/MH	2.0 in.	138 (1220)
	NG/NH	2.5 in.	175 (1540)
	PG/PH	3.0 in.	220 (1940)
	QG/QH	3.5 in.	257 (2270)

Figure 3-3: Magnetic drive schematic (shaded areas rotate)

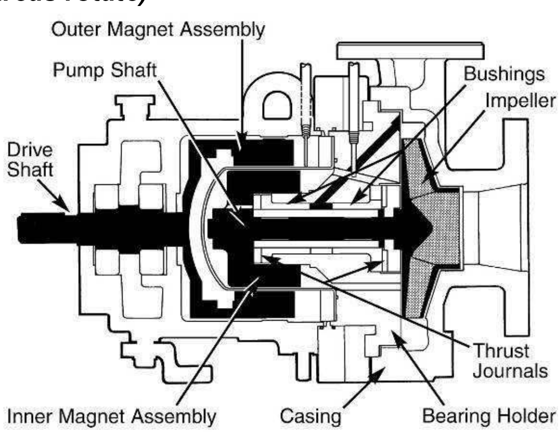
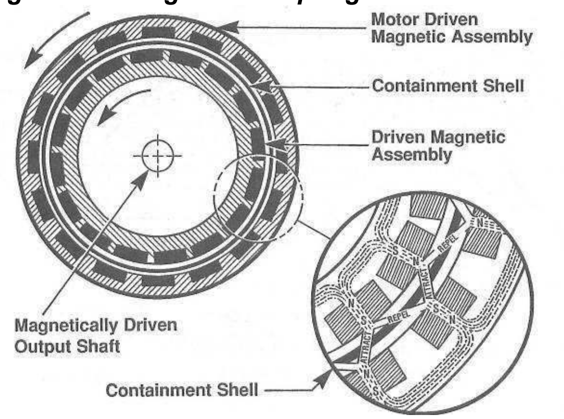


Figure 3-4: Magnetic coupling



3.3.3 Inner rotating assembly

The wetted, inner rotating assembly consisting of the inner magnet, pump shaft and impeller is supported radially by bushings. The bushings also carry radial and axial loading from the impeller. A small amount of process fluid circulates in the containment area to lubricate these bearings and cool the containment shell.

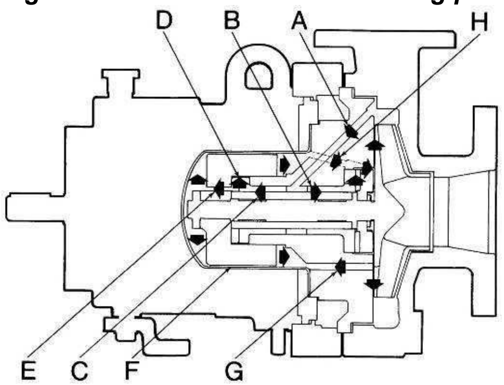
3.3.4 Lubrication and cooling path

Referring to Figure 3-5, the process fluid enters the containment area through two lubrication holes in the bearing holder (A). The fluid is divided at this point with a small portion providing lubrication to the inboard bushing and thrust journal before returning to low pressure (B). The remaining portion moves across the outboard bushing (C) at which point it is divided with a portion lubricating the outboard thrust journal (D) and the remaining passing through holes in the inner magnet assembly (E). The process fluid cools the containment shell (F) before mixing with flow entering from two holes in the bearing holder (G). The mixed flow then returns to the process flow through the two return lubrication holes (H).

Two of the holes in the bearing holder (G) are located at the six and twelve o'clock position to vent and drain the containment area during startup and shutdown.

This circulation path ensures positive flow and lubrication to the bushings and thrust journals with the coolest fluid, i.e. before cooling the containment shell.

Figure 3-5: Lubrication and cooling path



3.3.5 Power end bearings and lubrication
Ball bearings are fitted as standard on long-coupled pumps and may be either oil or grease lubricated. Close coupled pumps utilize the motor bearings for support of the outer magnet.

3.3.6 Bearing housing
Large oil bath reservoir. (Long-coupled pumps only.)

3.3.7 Driver
The driver is normally an electric motor. Different drive configurations may be fitted such as internal combustion engines, turbines, hydraulic motors etc driving via couplings, belts, gearboxes, drive shafts etc.

3.3.8 Accessories
Accessories may be fitted when specified by the customer.

3.4 Performance and operation limits
This product has been selected to meet the specification of your purchase order see section 1.5.

The following data is included as additional information to help with your installation. It is typical, and factors such as liquid being pumped, temperature, and material of construction may influence this data. If required, a definitive statement for your application can be obtained from Flowserve.

3.4.1 General temperature limits
See Figures 3-6 and 3-7 for general temperature limits for Guardian G & H series pumps.

3.4.2 Pressure-temperature ratings
The pressure-temperature ratings for Guardian G & H series pumps are shown in Figures 3-9A and 3-9B. To determine which casing material group to reference, identify the appropriate casing “Material Group No.” in Figure 3-8. Interpolation may be used to find the pressure rating for a specific temperature.

⚠ The maximum discharge pressure must be less than or equal to the P-T rating. Discharge pressure may be approximated by adding the suction pressure and the differential head developed by the pump. The suction pressure limit for Guardian G & H series pumps is limited by the P-T rating.

Example. The pressure temperature rating for a Guardian pump with Class 300 flanges and CF8M construction at an operating temperature of 149 ˚C is found as follows:

a) From Figure 3-8, the correct material group for CF8M is 2.2.
b) From Figure 3-9B, the pressure-temperature rating is 21.5 bar.

3.4.3 Alloy cross reference chart
Figure 3-8 is the alloy cross-reference chart for all Guardian G & H series pumps.

3.4.4 Minimum continuous flow
The minimum continuous flow (MCF) is based on a percentage of the *best efficiency point* (BEP). Figure 3-10 identifies the MCF for all G & H series Guardian pumps.

3.4.5 Minimum suction pipe submergence
The minimum submergence for Unitized self-priming pumps is shown in Figure 3-11 and 3-12.

Figure 3-6: Temperature limitations, long coupled pumps

Temperature	Limitations
-73 ºC to -29 ºC (-100 ºF to -20 ºF)	• G or H Series acceptable • Group 1 or 2 pumps acceptable • Review material and elastomer limitations • Replace iron and steel pressure containing components with stainless steel. Contact your Flowserve representative for details
-29 ºC to 121 ºC (-20 ºF to 250 ºF)	• G or H Series acceptable • Group 1 or 2 pumps acceptable • Review material and elastomer limitations
121 ºC to 177 ºC (250 ºF to 350 ºF)	• H Series only • Group 1 or 2 pumps acceptable • Review material and elastomer limitations
177 ºC to 287 ºC (350 ºF to 550 ºF)	• H Series only • Group 1 rated to 287 ºC (550 ºF) • **Group 2 rated to 232 ºC (450 ºF)!** • Review material and elastomer limitations • Centerline mounting recommended for services over 177 ºC (350 ºF) • Labyrinth seals recommended for services over 218 ºC (425 ºF) • Finned oil cooler recommended for services over 190 ºC (375 ºF)

Figure 3-7: Temperature limitations, close coupled pumps (Group 1 only)

Temperature	Limitations
-73 ºC to -29 ºC (-100 ºF to -20 ºF)	• G or H Series acceptable • Review material and elastomer limitations • Replace iron and steel pressure containing components with stainless steel. Contact your Flowserve representative for details
-29 ºC to 121 ºC (-20 ºF to 250 ºF)	• G or H Series acceptable • Review material and elastomer limitations
121 ºC to 177 ºC (250 ºF to 350 ºF)	• H Series only • Review material and elastomer limitations
177 ºC to 204 ºC (350 ºF to 400 ºF)	• H Series only • **Maximum allowable process fluid temperature is 204 ºC (400 ºF)** • Review material and elastomer limitations • Centerline mounting recommended for services over 177 ºC (350 ºF)

Figure 3-8: Alloy cross-reference chart

Flowserve material code	Designation	Durco legacy codes	ACI designation	Equivalent wrought designation	ASTM specifications	Material Group No.
E3020	Ductile iron	DCI	None	None	A395, Gr. 60-40-18	1.0
E3033	High chrome iron	CR28	None	None	A532 class 3	Cr
E4027	High chrome iron	CR29	None	None	None	Cr
E4028	High chrome iron	CR35	None	None	None	Cr
C3009	Carbon steel	DS	None	Carbon steel	A216 Gr. WCB	1.1
C3062	Durco CF8	D2	CF8	304	A744, Gr. CF8	2.1
C3069	Durco CF3	D2L	CF3	304L	A744, Gr. CF3	2.1
C3063	Durco CF8M	D4	CF8M	316	A744, Gr. CF8M	2.2
C3067	Durco CF3M	D4L	CF3M	316L	A744, Gr. CF3M	2.2
C3107	Durcomet 100	CD4M	CD4MCuN	Ferralium®	A995, Gr. CD4MCuN	2.8
C4028	Durimet 20	D20	CN7M	Alloy 20	A744, Gr. CN7M	3.17
C4029	Durcomet 5	DV	None	None	None	2.2
K3005	Durco CY40	DINC	CY40	Inconel® 600	A494, Gr. CY40	3.5
K3007	Durco M35	DMM	M351	Monel® 400	A494, Gr. M35-1	3.4
K3008	Nickel	DNI	CZ100	Nickel 200	A494, Gr. CZ100	3.2
K4007	Chlorimet 2	DC2	N7M	Hastelloy® B	A494, Gr. N7M	3.7
K4008	Chlorimet 3	DC3	CW6M	Hastelloy® C	A494, Gr. CW6M	3.8
E3042	Durichlor 51®	D51	None	None	A518, Gr. 2	No load
E4035	Superchlor®	SD51	None	None	A518, Gr. 2	No load
H3004	Titanium	Ti	None	Titanium	B367, Gr. C3	Ti
H3005	Titanium-Pd	TiP	None	Titanium-Pd	B367, Gr. C8A	Ti
H3007	Zirconium	Zr	None	Zirconium	B752, Gr. 702C	Ti

® Duriron, Durichlor 51 and Superchlor are registered trademarks of Flowserve Corporation.
® Ferralium is a registered trademark of Langley Alloys.
® Hastelloy is a registered trademark of Haynes International, Inc.
® Inconel and Monel are registered trademarks of International Nickel Co. Inc.
Note: some materials listed above may not be available for use in some parts of Guardian pumps.

Figure 3-9A: All Guardian G & H series pumps with class 150 flanges

Temp °C (°F)	Material Group No.												
	1.0	1.1	2.1	2.2	2.8	3.2	3.4	3.5	3.7	3.8	3.17	Ti	Cr
	bar (psi)												
-73 (-100)	–	–	19.0 (275)	19.0 (275)	19.7 (285)	9.7 (140)	15.9 (230)	15.2 (220)	20.0 (290)	20.0 (290)	15.9 (230)	20.0 (290)	–
-29 (-20)	17.2 (250)	19.7 (285)	19.0 (275)	19.0 (275)	19.7 (285)	9.7 (140)	15.9 (230)	15.2 (220)	20.0 (290)	20.0 (290)	15.9 (230)	20.0 (290)	–
-18 (0)	17.2 (250)	19.7 (285)	19.0 (275)	19.0 (275)	19.7 (285)	9.7 (140)	15.9 (230)	15.2 (220)	20.0 (290)	20.0 (290)	15.9 (230)	20.0 (290)	12.6 (183)
38 (100)	17.2 (250)	19.7 (285)	19.0 (275)	19.0 (275)	19.7 (285)	9.7 (140)	15.9 (230)	15.2 (220)	20.0 (290)	20.0 (290)	15.9 (230)	20.0 (290)	12.6 (183)
93 (200)	16.2 (235)	17.9 (260)	15.9 (230)	16.2 (235)	17.9 (260)	9.7 (140)	13.8 (200)	13.8 (200)	17.9 (260)	17.9 (260)	13.8 (200)	17.9 (260)	12.6 (183)
149 (300)	14.8 (215)	15.9 (230)	14.1 (205)	14.8 (215)	15.9 (230)	9.7 (140)	13.1 (190)	12.4 (180)	15.9 (230)	15.9 (230)	12.4 (180)	15.9 (230)	12.6 (183)
171 (340)	14.4 (209)	15.0 (218)	13.7 (199)	14.3 (207)	15.0 (218)	9.7 (140)	13.0 (188)	12.1 (176)	15.0 (218)	15.0 (218)	11.9 (172)	15.0 (218)	12.6 (183)
204 (400)	13.8 (200)	13.8 (200)	13.1 (190)	13.4 (195)	13.8 (200)	9.7 (140)	12.8 (185)	11.7 (170)	13.8 (200)	13.8 (200)	11.0 (160)	13.8 (200)	–
260 (500)	11.7 (170)	11.7 (170)	11.7 (170)	11.7 (170)	11.7 (170)	9.7 (140)	11.7 (170)	11.0 (160)	11.7 (170)	11.7 (170)	10.3 (150)	11.7 (170)	–
316 (600)	9.7 (140)	9.7 (140)	9.7 (140)	9.7 (140)	9.7 (140)	9.7 (140)	9.7 (140)	9.7 (140)	9.7 (140)	9.7 (140)	9.7 (140)	9.7 (140)	–

Figure 3-9B: All Guardian G & H series pumps with class 300 flanges

Temp °C (°F)	Material Group No.											
	1.0	1.1	2.1	2.2	2.8	3.2	3.4	3.5	3.7	3.8	3.17	Ti
	bar (psi)											
-73 (-100)	–	–	24.1 (350)	24.1 (350)	24.1 (350)	17.4 (252)	24.1 (350)	24.1 (350)	24.1 (350)	24.1 (350)	24.1 (350)	24.1 (350)
-29 (-20)	24.1 (350)	24.1 (350)	24.1 (350)	24.1 (350)	24.1 (350)	17.4 (252)	24.1 (350)	24.1 (350)	24.1 (350)	24.1 (350)	24.1 (350)	24.1 (350)
-18 (0)	24.1 (350)	24.1 (350)	24.1 (350)	24.1 (350)	24.1 (350)	17.4 (252)	24.1 (350)	24.1 (350)	24.1 (350)	24.1 (350)	24.1 (350)	24.1 (350)
38 (100)	24.1 (350)	24.1 (350)	24.1 (350)	24.1 (350)	24.1 (350)	17.4 (252)	24.1 (350)	24.1 (350)	24.1 (350)	24.1 (350)	24.1 (350)	24.1 (350)
93 (200)	22.6 (328)	22.0 (319)	20.1 (292)	20.8 (301)	23.2 (336)	17.4 (252)	21.3 (309)	22.9 (332)	24.1 (350)	24.1 (350)	20.9 (303)	21.4 (310)
149 (300)	21.3 (309)	21.4 (310)	18.1 (263)	18.8 (272)	21.4 (310)	17.4 (252)	19.9 (289)	21.4 (310)	23.5 (341)	23.5 (341)	18.7 (271)	18.7 (271)
204 (400)	19.8 (287)	20.7 (300)	16.6 (241)	17.3 (250)	19.8 (287)	17.4 (252)	19.3 (280)	19.9 (288)	22.7 (329)	22.7 (329)	16.9 (245)	15.9 (231)
260 (500)	18.7 (271)	19.6 (284)	15.3 (222)	16.1 (233)	18.5 (268)	17.4 (252)	19.1 (277)	19.3 (280)	21.4 (310)	21.4 (310)	15.7 (228)	13.2 (191)
316 (600)	17.5 (254)	17.9 (260)	14.6 (211)	15.1 (219)	17.9 (259)	17.4 (252)	19.1 (277)	19.2 (278)	19.5 (282)	19.5 (282)	14.5 (210)	10.5 (152)

Note: temperature limitations in these charts take into account material choice only. Actual temperature limitations of the Guardian pump may be different depending on pump size, model, or elastomers used. Refer to Section 3.4.1 for specific temperature limitations of Guardian pumps independent of material choice.

Figure 3-10: Minimum continuous flow

Pump size	MCF % of BEP		
	3 500/2 900 r/min	**1 750/1 450 r/min**	**1 180/960 r/min**
1K3x2-6	20 %	10 %	10 %
2K3x2-8	20 %	10 %	10 %
2K4x3-8	20 %	10 %	10 %
2K3x2-10	30 %	10 %	10 %
2K4x3-10	30 %	10 %	10 %
2K6x4-10	40 %	10 %	10 %
2K6x4-10H	n.a.	20 %	10 %
2K3x1.5-13	30 %	10 %	10 %
2K3x2-13	40 %	10 %	10 %
2K4x3-13	40 %	20 %	10 %
2K6x4-13	60 %	40 %	10 %
All other sizes	10 %	10 %	10 %

Figure 3-11: Minimum submergence

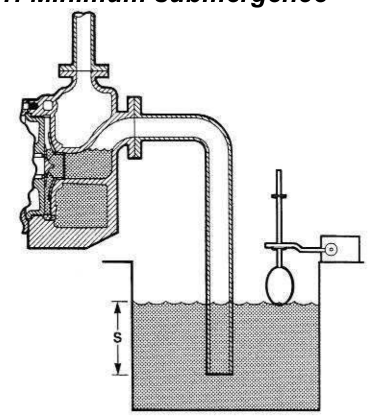
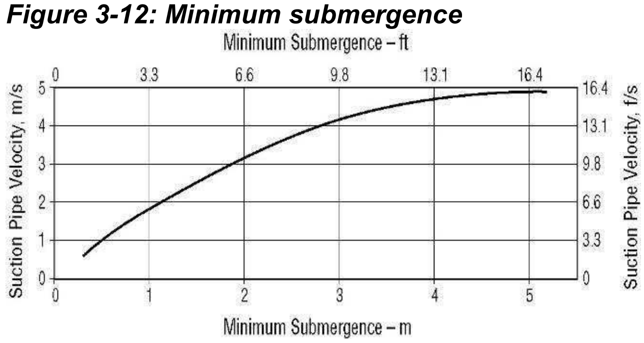


Figure 3-12: Minimum submergence



3.4.6 Viscosity limitations

The allowable viscosity range for Guardian G & H series pumps is 0.25 cP to 300 cP. Please consult your Flowserve representative for services with viscosities less than 0.25 cP.

3.4.7 Entrained solids

For process fluids with entrained solids the following restrictions apply to the solids particles:

- 300 micron (0.012 in.) maximum diameter
- Less than 3.0 % solids by weight
- 2 Moh hardness or less (roughly equivalent to gypsum)
- No ferrous particles

4 INSTALLATION

4.1 Location

The pump should be located to allow room for access, ventilation, maintenance, and inspection with ample headroom for lifting and should be as close as practicable to the supply of liquid to be pumped.

Refer to the general arrangement drawing for the pump set.

4.2 Part assemblies

The supply of motors and baseplates are optional. As a result, it is the responsibility of the installer to ensure that the motor is assembled to the pump and aligned as detailed in section 4.5 and 4.8.

4.3 Foundation

Protection of openings and threads

When the pump is shipped, all threads and all openings are covered. This protection/covering should not be removed until installation. If, for any reason, the pump is removed from service, this protection should be reinstalled.

4.3.1 Rigid baseplates - overview

The function of a baseplate is to provide a rigid foundation under a pump and its driver that maintains alignment between the two. Baseplates may be generally classified into two types:

- Foundation-mounted, grouted design (Figure 4-1)
- Stilt mounted, or free-standing (Figure 4-2)

Figure 4-1: Foundation mounted baseplate

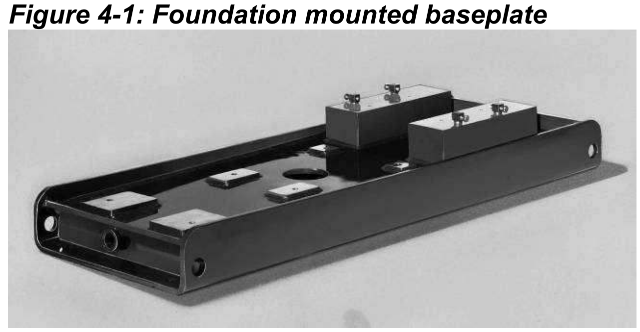


Figure 4-2: Stilt mounted baseplate

Baseplates intended for grouted installation are designed to use the grout as a stiffening member. Stilt mounted baseplates, on the other hand, are designed to provide their own rigidity. Therefore, the designs of the two baseplates are usually different.

Regardless of the type of baseplate used, it must provide certain functions that ensure a reliable installation. Three of these requirements are:

- The baseplate must provide sufficient rigidity to assure the assembly can be transported and installed, given reasonable care in handling, without damage. It must also be rigid enough when properly installed to resist operating loads.
- The baseplate must provide a reasonably flat mounting surface for the pump and driver. Uneven surfaces will result in a soft-foot condition that may make alignment difficult or impossible. Flowserve's experience indicates that a baseplate that has a top surface flatness of 1.25 mm/m (0.015 in./ft) across the diagonal corners of the baseplate provides such a mounting surface. Therefore, this is the tolerance to which we supply our standard baseplate. Some users may desire an even flatter surface, which can facilitate installation and alignment. Flowserve will supply flatter baseplates upon request at extra cost. For example, mounting surface flatness of 0.17 mm/m (0.002 in./ft) is offered on the Flowserve Type E "Ten Point" baseplate shown in Figure 4-1.
- The baseplate must be designed to allow the user to final field align the pump and driver to within their own particular standards and to compensate for any pump or driver movement that occurred during handling. Normal industry practice is to achieve final alignment by moving the motor to match the pump. Flowserve's practice is to confirm in our shop that the pump assembly can be accurately aligned. Before shipment, the factory verifies that there is enough horizontal movement capability at the motor to obtain a "perfect" final alignment when the installer puts the baseplate assembly into its original, top leveled, unstressed condition.

4.3.2 Stilt and spring mounted baseplates

Flowserve offers stilt and spring mounted baseplates. (See Figure 4-2 for stilt mounted option.) The low vibration levels of Guardian G & H series pumps allow the use of these baseplates - provided they are of a rigid design. The baseplate is set on a flat surface with no tie down bolts or other means of anchoring it to the floor.

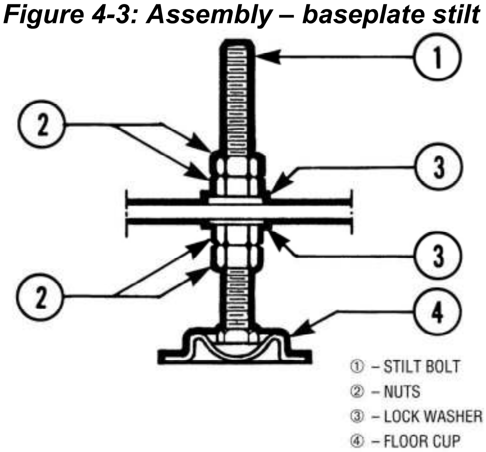
General instructions for assembling these baseplates are given below. For dimensional information, please refer to the appropriate Flowserve "Sales Print."

4.3.2.1 Stilt mounted baseplate assembly instructions

Refer to Figure 4-3.

a) Raise or block up baseplate/pump above the floor to allow for the assembly of the stilts.
b) Predetermine or measure the approximate desired height for the baseplate above the floor.
c) Set the bottom nuts (item 2) above the stilt bolt head (item 1) to the desired height.
d) Assemble lock washer (item 3) down over the stilt bolt.
e) Assemble the stilt bolt up through hole in the bottom plate and hold in place.
f) Assemble the lock washer (item 3) and nut (item 2) on the stilt bolt. Tighten the nut down on the lock washer.
g) After all four stilts have been assembled, position the baseplate in place, over the floor cups (item 4) under each stilt location, and lower the baseplate to the floor.
h) Level and make final height adjustments to the suction and discharge pipe by first loosening the top nuts and turning the bottom nuts to raise or lower the baseplate.
i) Tighten the top and bottom nuts at the lock washer (item 3) first then tighten the other nuts.
j) It should be noted that the connecting pipelines must be individually supported, and that the stilt mounted baseplate is not intended to support total static pipe load.

Figure 4-3: Assembly – baseplate stilt



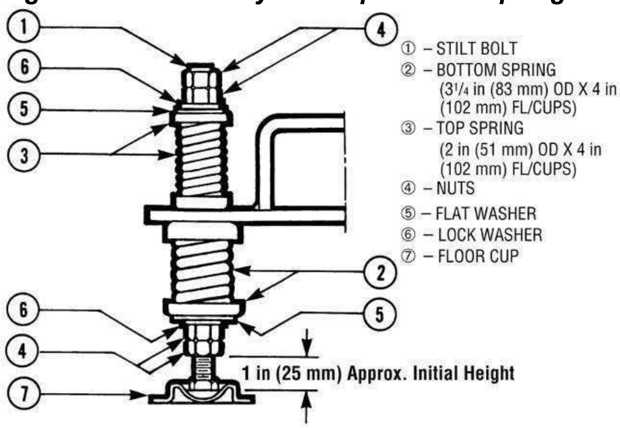
4.3.2.2 Stilt/spring mounted baseplate assembly instructions

Refer to Figure 4-4

a) Raise or block up baseplate/pump above the floor to allow for the assembly of the stilts.
b) Set the bottom nuts (item 4) above the stilt bolt head (item 1). This allows for 51 mm (2 in.) upward movement for the final height adjustment of the suction/discharge flange.

c) Assemble the lock washer (item 6) flat washer (item 5) and bottom spring/cup assembly (item 2) down over the stilt bolt (item 1).
d) Assemble the stilt bolt/bottom spring up through hole in the bottom plate and hold in place.
e) Assemble top spring/cup assembly (item 3) down over stilt bolt.
f) Assemble flat washer (item 5), lock washer (item 6) and nuts (item 4) on the stilt bolt.
g) Tighten down top nuts, compressing the top spring approximately 12 mm (0.5 in.).
h) After all four stilts have been assembled, position the baseplate in place, over the floor cups (Item 7) under each stilt location, and lower the baseplate down to the floor.
i) Level and make final height adjustments to the suction and discharge pipe by first loosening the top nuts, and turning the bottom nuts to raise or lower the baseplate.

Figure 4-4: Assembly – baseplate stilt/spring



j) To make the stilt bolts more stable, tighten down on the top nuts, compressing the top spring approximately 12 mm (0.5 in), and lock the nuts in place.
k) It should be noted that the connecting pipelines must be individually supported, and that the spring mounted baseplate is not intended to support total static pipe loads.

4.3.2.3 Stilt/spring mounted baseplates - motor alignment

The procedure for motor alignment on stilt or spring mounted baseplates is similar to grouted baseplates. The difference is primarily in the way the baseplate is leveled.

a) Level the baseplate by using the stilt adjusters. (Shims are not needed as with grouted baseplates.) After the base is level, it is locked in place by locking the stilt adjusters.
b) Next the initial pump alignment must be checked. The vertical height adjustment provided by the stilts allows the possibility of slightly twisting the baseplate. If there has been no transit damage or twisting of the baseplate during stilt height adjustment, the pump and driver should be within 0.38 mm (0.015 in.) parallel, and 0.0025 mm/mm (0.0025 in./in.) angular alignment. If this is not the case, check to see if the driver mounting fasteners are centered in the driver feet holes.
c) If the fasteners are not centered there was likely shipping damage. Re-center the fasteners and perform a preliminary alignment to the above tolerances by shimming under the motor for vertical alignment, and by moving the pump for horizontal alignment.
d) If the fasteners are centered, then the baseplate may be twisted. Slightly adjust (one turn of the adjusting nut) the stilts at the driver end of the baseplate and check for alignment to the above tolerances. Repeat as necessary while maintaining a level condition as measured from the pump discharge flange. Lock the stilt adjusters.

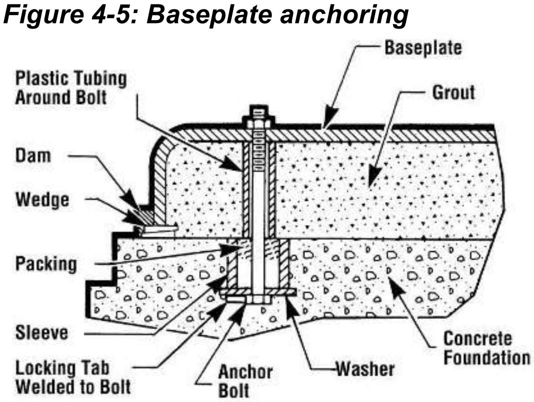
The remaining steps are as listed for new grouted baseplates.

4.4 Grouting

a) The pump foundation should be located as close to the source of the fluid to be pumped as practical.
b) There should be adequate space for workers to install, operate, and maintain the pump. The foundation should be sufficient to absorb any vibration and should provide a rigid support for the pump and motor.
c) Recommended mass of a concrete foundation should be three times that of the pump, motor and base. Refer to figure 4-5.

Note: Foundation bolts are imbedded in the concrete inside a sleeve to allow some movement of the bolt.

Figure 4-5: Baseplate anchoring



d) Level the pump baseplate assembly. If the baseplate has machined coplanar mounting surfaces, these machined surfaces are to be referenced when leveling the baseplate. This may require that the pump and motor be removed from the baseplate in order to reference the machined faces. If the baseplate is without machined coplanar mounting surfaces, the pump and motor are to be left on the baseplate. The proper surfaces to reference when leveling the pump baseplate assembly are the pump suction and discharge flanges. DO NOT stress the baseplate.
e) Do not bolt the suction or discharge flanges of the pump to the piping until the baseplate foundation is completely installed. If equipped, use leveling jackscrews to level the baseplate. If jackscrews are not provided, shims and wedges should be used. (See Figure 4-5.) Check for levelness in both the longitudinal and lateral directions. Shims should be placed at all base anchor bolt locations, and in the middle edge of the base if the base is more than 1.5 m (5 ft.) long. Do not rely on the bottom of the baseplate to be flat. Standard baseplate bottoms are not machined, and it is not likely that the field mounting surface is flat.
f) After leveling the baseplate, tighten the anchor bolts. If shims were used, make sure that the baseplate was shimmed near each anchor bolt before tightening. Failure to do this may result in a twist of the baseplate, which could make it impossible to obtain final alignment.
g) Check the level of the baseplate to make sure that tightening the anchor bolts did not disturb the level of the baseplate. If the anchor bolts did change the level, adjust the jackscrews or shims as needed to level the baseplate.
h) Continue adjusting the jackscrews or shims and tightening the anchor bolts until the baseplate is level.
i) Check initial alignment. If the pump and motor were removed from the baseplate proceed with step j) first, then the pump and motor should be reinstalled onto the baseplate using Flowserve's factory preliminary alignment procedure as described in section 4.5, and then continue with the following. As described above, pumps are given a preliminary alignment at the factory. This preliminary alignment is done in a way that ensures that, if the installer duplicates the factory conditions, there will be sufficient clearance between the motor hold down bolts and motor foot holes to move the motor into final alignment. If the pump and motor were properly reinstalled to the baseplate or if they were not removed from the baseplate and there has been no transit damage, and also if the above steps where done properly, the pump and driver should be within 0.38 mm (0.015 in.) FIM (Full Indicator Movement) parallel, and 0.0025 mm/mm (0.0025 in./in.) FIM angular. If this is not the case, first check to see if the driver mounting fasteners are centered in the driver feet holes. If not, re-center the fasteners and perform a preliminary alignment to the above tolerances by shimming under the motor for vertical alignment, and by moving the pump for horizontal alignment.
j) Grout the baseplate. A non-shrinking grout should be used. Make sure that the grout fills the area under the baseplate. After the grout has cured, check for voids and repair them. Jackscrews, shims and wedges should be removed from under the baseplate at this time. If they were to be left in place, they could rust, swell, and cause distortion in the baseplate.
k) Run piping to the suction and discharge of the pump. There should be no piping loads transmitted to the pump after connection is made. Recheck the alignment to verify that there are no significant loads.

4.5 Initial alignment

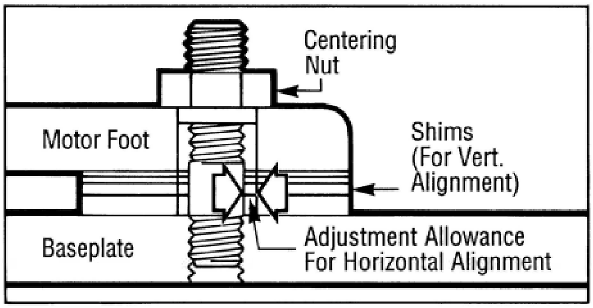
4.5.1 Horizontal initial alignment procedure

The purpose of factory alignment is to ensure that the user will have full utilization of the clearance in the motor holes for final job-site alignment. To achieve this, the factory alignment procedure specifies that the pump be aligned in the horizontal plane to the motor, with the motor foot bolts centered in the motor holes. This procedure ensures that there is sufficient clearance in the motor holes for the customer to field align the motor to the pump, to zero tolerance. This philosophy requires that the customer be able to place the base in the same condition as the factory. Thus the factory alignment will be done with the base sitting in an unrestrained condition on a flat and level surface. This standard also emphasizes the need to ensure the shaft spacing is adequate to accept the specified coupling spacer.

The factory alignment procedure is summarized below:
a) The baseplate is placed on a flat and level workbench in a free and unstressed position.
b) The baseplate is leveled as necessary. Leveling is accomplished by placing shims under the rails of the base at the appropriate anchor bolt hole locations. Levelness is checked in both the longitudinal and lateral directions.
c) The motor and appropriate motor mounting hardware is placed on the baseplate and the motor is checked for any planar soft-foot condition. If any is present it is eliminated by shimming

d) The motor feet holes are centered on the motor mounting fasteners. This is done by using a centering nut as shown in Figure 4-6.

Figure 4-6: Motor centering fastener



e) The motor is fastened in place by tightening the nuts on two diagonal motor mounting studs.
f) The pump is put onto the baseplate and leveled. The foot piece under the bearing housing is adjustable. It is used to level the pump, if necessary. If an adjustment is necessary, add or remove shims [3126.1] between the foot piece and the bearing housing.
g) The spacer coupling gap is verified.
h) The parallel and angular vertical alignment is made by shimming under the motor.
i) The motor feet holes are again centered on the motor mounting studs using the centering nut. At this point the centering nut is removed and replaced with a standard nut. This gives maximum potential mobility for the motor to be horizontally moved during final, field alignment. All four motor feet are tightened down.
j) The pump and motor shafts are then aligned horizontally, both parallel and angular, by moving the pump to the fixed motor. The pump feet are tightened down.
k) Both horizontal and vertical alignment is again final checked as is the coupling spacer gap.

See section 4.8 for Final Shaft Alignment

4.6 Piping

⚠ CAUTION The protective covers are fitted to both the suction and discharge flanges of the casing and must be removed prior to connecting the pump to any pipes.

4.6.1 4.6.1 Suction and discharge piping

All piping must be independently supported, accurately aligned and preferably connected to the pump by a short length of flexible piping. The pump should not have to support the weight of the pipe or compensate for misalignment. It should be possible to install suction and discharge bolts through mating flanges without pulling or prying either of the flanges.

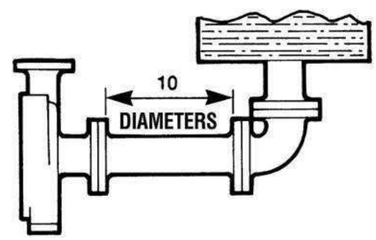
All piping must be tight. Pumps may air-bind if air is allowed to leak into the piping. If the pump flange(s) have tapped holes, select flange fasteners with thread engagement at least equal to the fastener diameter but that do not bottom out in the tapped holes before the joint is tight.

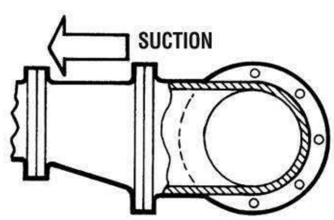
4.6.2 Suction piping

To avoid NPSH and suction problems, suction piping must be at least as large as the pump suction connection. Never use pipe or fittings on the suction that are smaller in diameter than the pump suction size.

Figure 4-7 illustrates the ideal piping configuration with a minimum of 10 pipe diameters between the source and the pump suction. In most cases, horizontal reducers should be eccentric and mounted with the flat side up as shown in Figure 4-8 with a maximum of one pipe size reduction. Never mount eccentric reducers with the flat side down. Horizontally mounted concentric reducers should not be used if there is any possibility of entrained air in the process fluid. Vertically mounted concentric reducers are acceptable. In applications where the fluid is completely deaerated and free of any vapor or suspended solids, concentric reducers are preferable to eccentric reducers

Figures 4-7 and Figure 4-8





Avoid the use of throttling valves and strainers in the suction line. Start up strainers must be removed shortly before start up. When the pump is installed below the source of supply, a valve should be installed in the suction line to isolate the pump and permit pump inspection and maintenance. However, never place a valve directly on the suction nozzle of the pump.

Refer to the Durco Pump Engineering Manual and the Centrifugal Pump IOM Section of the Hydraulic Institute Standards for additional recommendations on suction piping. (See section 10.)

Refer to section 3.4 for performance and operating limits.

4.6.2.1 Guardian self-priming pumps

The suction piping must be as short as possible and be as close to the diameter of the suction nozzle as is practical. The pump works by removing the air contained in the suction piping. Once removed, it operates exactly the same as a flooded suction standard pump. Longer and larger suction pipes have a greater volume of air that has to be removed, resulting in longer priming time. The suction piping and seal chamber must be airtight to allow priming to occur. When possible, it is recommended that suction piping be sloped slightly towards the casing to ensure no fluid is lost down the suction line during priming.

4.6.3 Discharge piping

Install a valve in the discharge line. This valve is required for regulating flow and/or to isolate the pump for inspection and maintenance.

⚠ CAUTION When fluid velocity in the pipe is high, for example, 3 m/s (10 ft/s) or higher, a rapidly closing discharge valve can cause a damaging pressure surge. A dampening arrangement should be provided in the piping.

4.6.3.1 Guardian self-priming pumps

During the priming cycle, air from the suction piping is evacuated into the discharge piping. There must be a way for this air to vent. If air is not able to freely vent out the discharge pipe, it is typically recommended to install an air bleed line. The air bleed line is typically connected from the discharge pipe to the sump. Care must be taken to prevent air from re-entering suction pipe.

4.6.4 Allowable nozzle loads

Flowserve chemical process pumps meet or exceed the allowable nozzle loads given by ANSI/HI 9.6.2. The following paragraphs describe how to calculate the allowable loads for each pump type and how to determine if the applied loads are acceptable. The configuration covered is for ASME B73.3 pumps, including the Guardian G & H series.

4.6.4.1 Guardian G & H series pumps (ASME B73.3)

The following steps are based upon ANSI/HI 9.6.2. All information necessary to complete the evaluation is given below. For complete details please review the standard.

a) Determine the appropriate casing “Material Group No.” from figure 3-8.
b) Find the “Casing material correction factor” in Figure 4-9 based upon the “Material Group No.” and operating temperature. Interpolation may be used to determine the correction factor for a specific temperature.
c) Find the “Baseplate correction factor” in Figure 4-10. The correction factor depends upon how the baseplate is to be installed.
d) Locate the pump model being evaluated in Figure 4-14 and multiply each load rating by the casing correction factor. Record the “adjusted Figure 4-14 loads”.
e) Locate the pump model being evaluated in Figures 4-15 and 4-16 and multiply each load rating by the baseplate correction factor. Record the adjusted Figure 4-15 and 4-16 loads.
f) Compare the “adjusted Figure 4-14 loads” to the values shown in figure 4-13. The lower of these two values should be used as the adjusted figure 4-13 values. *(The HI standard also asks that figure 4-13 loads be reduced if figure 4-15 or 4-16 values are lower. Flowserve does not follow this step.)*
g) Calculate the applied loads at the casing flanges according to the coordinate system found in figure 4-11. The 12 forces and moments possible are Fxs, Fys, Fzs, Mxs, Mys, Mzs, Fxd, Fyd, Fzd, Mxd, Myd and Mzd. For example, Fxd designates Force in the “x” direction on the discharge flange. Mys designates the Moment about the “y”-axis on the suction flange.
h) Figure 4-12 gives the acceptance criteria equations. For long coupled pumps, equation sets 1 through 5 must be satisfied. For close coupled pumps, only equation sets 1 and 2 must be satisfied.
i) <u>Equation set 1</u>. Each applied load is divided by the corresponding adjusted figure 4-13 value. The absolute value of each ratio must be less than or equal to one.
j) <u>Equation set 2.</u> The summation of the absolute values of each ratio must be less than or equal to two. The ratios are the applied load divided by the adjusted figure 4-14 values.
k) <u>Equation sets 3 and 4.</u> These equations are checking for coupling misalignment due to nozzle loading in each axis. Each applied load is divided by the corresponding adjusted load from figure 4-15 and 4-16. The result of each equation must be between one and negative one.
l) <u>Equation set 5.</u> This equation calculates the total shaft movement from the results of equations 3 and 4. The result must be less than or equal to one.

Figure 4-9: Casing material correction factors

Temp °C	**Temp °F**	**Material Group No.**													
		1.0	1.1	2.1	2.2	2.4	2.8	3.2	3.4	3.5	3.7	3.8	3.17	Ti	Cr
				Austenitic steels				Nickel and nickel alloys							
		DCI	Carbon Steel	Type 304 and 304L	Type 316 and 316L	Type 321	CD-4MCu	Nickel	Monel	Inconel	Hast B	Hast C	Alloy 20	Ti, Ti-Pd, Zr	High Chrome -18 to 171 °C (0 to 340 °F)
-129	-200	-	-	1.00	1.00	1.00	-	0.50	-	-	-	-	0.83	-	-
-73	-100	-	-	1.00	1.00	1.00	1.00	0.50	0.83	0.93	1.00	1.00	0.83	0.89	-
-29	-20	0.89	1.00	1.00	1.00	1.00	1.00	0.50	0.83	0.93	1.00	1.00	0.83	0.89	0.65
38	100	0.89	1.00	1.00	1.00	1.00	1.00	0.50	0.83	0.93	1.00	1.00	0.83	0.89	0.65
93	200	0.83	0.94	0.83	0.86	0.93	1.00	0.50	0.74	0.88	1.00	1.00	0.72	0.86	0.65
150	300	0.78	0.91	0.75	0.78	0.83	0.92	0.50	0.69	0.82	1.01	1.01	0.65	0.81	0.65
205	400	0.73	0.88	0.69	0.72	0.69	0.85	0.50	0.67	0.77	0.98	0.98	0.58	0.69	0.65
260	500	0.69	0.83	0.63	0.67	0.64	0.80	0.50	0.66	0.74	0.92	0.92	0.54	0.57	-
315	600	0.65	0.76	0.60	0.63	0.60	0.77	0.50	0.66	0.74	0.84	0.84	0.50	0.45	-

Note: see specific temperature limitations of Guardian pumps in Sections 3-6 and 3-7.

Figure 4-10: Baseplate correction factors

Base type	**Grouted**	**Bolted**	**Stilt mounted**
Type A	1.0	0.7	0.65
Type B - Polybase	1.0	NA	0.95
Type C	N/A	1.0	1.0
Type D	1.0	0.8	0.75
Type E - PIP	1.0	0.95	N/A
Polyshield - baseplate /foundation	1.0	N/A	N/A

Figure 4-11: Coordinate system

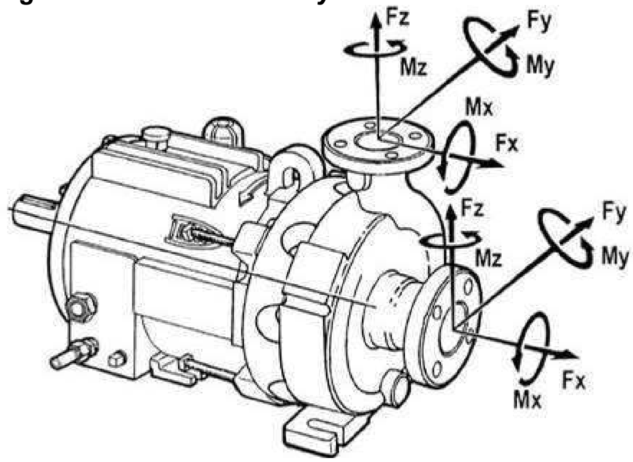


Figure 4-12: Acceptance criteria equations

Set	Equations	Figure	Remarks
1	$\left\|\frac{F_{xs}}{F_{xs\_adj}}\right\| \le 1.0, \left\|\frac{F_{ys}}{F_{ys\_adj}}\right\| \le 1.0, \left\|\frac{F_{zs}}{F_{zs\_adj}}\right\| \le 1.0, \left\|\frac{M_{xs}}{M_{xs\_adj}}\right\| \le 1.0, \left\|\frac{M_{ys}}{M_{ys\_adj}}\right\| \le 1.0, \left\|\frac{M_{zs}}{M_{zs\_adj}}\right\| \le 1.0,$ $\left\|\frac{F_{xd}}{F_{xd\_adj}}\right\| \le 1.0, \left\|\frac{F_{yd}}{F_{yd\_adj}}\right\| \le 1.0, \left\|\frac{F_{zd}}{F_{zd\_adj}}\right\| \le 1.0, \left\|\frac{M_{xd}}{M_{xd\_adj}}\right\| \le 1.0, \left\|\frac{M_{yd}}{M_{yd\_adj}}\right\| \le 1.0, \left\|\frac{M_{zd}}{M_{zd\_adj}}\right\| \le 1.0$	Adjusted 4-15	Maximum individual loading
2	$\left\|\frac{F_{xs}}{F_{xs\_adj}}\right\| + \left\|\frac{F_{ys}}{F_{ys\_adj}}\right\| + \left\|\frac{F_{zs}}{F_{zs\_adj}}\right\| + \left\|\frac{M_{xs}}{M_{xs\_adj}}\right\| + \left\|\frac{M_{ys}}{M_{ys\_adj}}\right\| + \left\|\frac{M_{zs}}{M_{zs\_adj}}\right\| +$ $\left\|\frac{F_{xd}}{F_{xd\_adj}}\right\| + \left\|\frac{F_{yd}}{F_{yd\_adj}}\right\| + \left\|\frac{F_{zd}}{F_{zd\_adj}}\right\| + \left\|\frac{M_{xd}}{M_{xd\_adj}}\right\| + \left\|\frac{M_{yd}}{M_{yd\_adj}}\right\| + \left\|\frac{M_{zd}}{M_{zd\_adj}}\right\| \le 2.0$	Adjusted 4-16	Nozzle stress, bolt stress, pump slippage
3	$A = \frac{F_{ys}}{F_{ys\_adj}} + \frac{M_{xs}}{M_{xs\_adj}} + \frac{M_{ys}}{M_{ys\_adj}} + \frac{M_{zs}}{M_{zs\_adj}} +$ $\frac{F_{yd}}{F_{yd\_adj}} + \frac{M_{xd}}{M_{xd\_adj}} + \frac{M_{yd}}{M_{yd\_adj}} + \frac{M_{zd}}{M_{zd\_adj}}$ $-1.0 \le A \le 1.0$	Adjusted 4-17	y-axis movement
4	$B = \frac{F_{xs}}{F_{xs\_adj}} + \frac{F_{zs}}{F_{zs\_adj}} + \frac{M_{xs}}{M_{xs\_adj}} + \frac{M_{ys}}{M_{ys\_adj}} + \frac{M_{zs}}{M_{zs\_adj}} +$ $\frac{F_{xd}}{F_{xd\_adj}} + \frac{F_{yd}}{F_{yd\_adj}} + \frac{F_{zd}}{F_{zd\_adj}} + \frac{M_{xd}}{M_{xd\_adj}} + \frac{M_{yd}}{M_{yd\_adj}} + \frac{M_{zd}}{M_{zd\_adj}}$ $-1.0 \le B \le 1.0$	Adjusted 4-18	z-axis movement
5	$\sqrt{A^2 + B^2} \le 1.0$	-	Combined axis movement

Note: All of the above equations are found by dividing the applied piping loads by the **adjusted** figure values.

Figure 4-13: Maximum individual loading

Pump size	Suction flange						Discharge flange					
	Forces N (lbf)			Moments Nm (lbf•ft)			Forces N (lbf)			Moments Nm (lbf•ft)		
	Fxs	Fys	Fzs	Mxs	Mys	Mzs	Fxd	Fyd	Fzd	Mxd	Myd	Mzd
1K 1.5x1-6	4 670 (1 050)	3 330 (750)	3 330 (750)	970 (720)	230 (170)	230 (170)	3 560 (800)	6 000 (1 350)	13 340 (3 000)	550 (410)	550 (410)	550 (410)
1K 3x1.5-6	4 670 (1 050)	5 510 (1 240)	5 560 (1 250)	1 220 (900)	660 (490)	660 (490)	3 560 (800)	6 000 (1 350)	13 340 (3 000)	680 (500)	740 (550)	690 (510)
1K 3x2-6	4 670 (1 050)	4 670 (1 050)	4 670 (1 050)	1 220 (900)	300 (220)	300 (220)	3 560 (800)	6 000 (1 350)	13 340 (3 000)	680 (500)	1 350 (1 000)	690 (510)
1K 1.5x1-8 & 1K 1.5x1.5US-8	4 670 (1 050)	5 380 (1 210)	5 380 (1 210)	970 (720)	260 (190)	260 (190)	3 560 (800)	6 000 (1 350)	13 340 (3 000)	490 (360)	490 (360)	490 (360)
1K 3x1.5-8	4 670 (1 050)	5 510 (1 240)	5 560 (1 250)	1 220 (900)	660 (490)	660 (490)	3 560 (800)	6 000 (1 350)	13 340 (3 000)	600 (440)	600 (440)	600 (440)
2K 3x2-8	12 000 (2 700)	6 000 (1 350)	6 670 (1 500)	1 760 (1 300)	810 (600)	810 (600)	6 220 (1 400)	6 000 (1 350)	14 450 (3 250)	890 (660)	890 (660)	890 (660)
2K 4x3-8	12 000 (2 700)	6 000 (1 350)	6 670 (1 500)	1 760 (1 300)	470 (350)	470 (350)	6 220 (1 400)	6 000 (1 350)	14 450 (3 250)	1 630 (1 200)	1 980 (1 460)	930 (690)
2K 2x1-10A & 2K 2x1.5US-10A	10 400 (2 340)	4 270 (960)	4 270 (960)	1 720 (1 270)	300 (220)	300 (220)	6 220 (1 400)	6 000 (1 350)	14 450 (3 250)	890 (660)	890 (660)	890 (660)
2K 3x1.5-10A	12 000 (2 700)	6 000 (1 350)	6 670 (1 500)	1 760 (1 300)	570 (420)	570 (420)	6 220 (1 400)	6 000 (1 350)	14 450 (3 250)	500 (370)	500 (370)	500 (370)
2K 3x2-10A & 2K 3x2US-10	12 000 (2 700)	6 000 (1 350)	6 580 (1 480)	1 760 (1 300)	420 (310)	420 (310)	6 220 (1 400)	6 000 (1 350)	14 450 (3 250)	760 (560)	760 (560)	760 (560)
2K 4x3-10, 10H & 2K 4x3US-10H	10 230 (2 300)	6 000 (1 350)	6 670 (1 500)	1 760 (1 300)	420 (310)	420 (310)	6 220 (1 400)	6 000 (1 350)	14 450 (3 250)	1 630 (1 200)	1 980 (1 460)	930 (690)
2K 6x4-10 and 10H	12 000 (2 700)	6 000 (1 350)	6 670 (1 500)	1 760 (1 300)	1 490 (1 100)	1 490 (1 100)	6 220 (1 400)	6 000 (1 350)	14 450 (3 250)	1 630 (1 200)	2 030 (1 500)	930 (690)
2K 3x1.5-13	12 000 (2 700)	6 000 (1 350)	6 670 (1 500)	1 760 (1 300)	910 (670)	910 (670)	6 220 (1 400)	6 000 (1 350)	14 450 (3 250)	720 (530)	720 (530)	720 (530)
2K 3x2-13 & 2K 3x2US-13	8 540 (1 920)	5 470 (1 230)	5 470 (1 230)	1 760 (1 300)	470 (350)	470 (350)	6 220 (1 400)	6 000 (1 350)	14 450 (3 250)	1 630 (1 200)	1 720 (1 270)	930 (690)
2K 4x3-13, 13HH & 2K 4x3US-13	12 000 (2 700)	6 000 (1 350)	6 670 (1 500)	1 760 (1 300)	540 (400)	540 (400)	6 220 (1 400)	6 000 (1 350)	14 450 (3 250)	1 630 (1 200)	2 030 (1 500)	930 (690)
2K 6x4-13A	12 000 (2 700)	6 000 (1 350)	6 670 (1 500)	1 760 (1 300)	1 760 (1 300)	1 490 (1 100)	6 220 (1 400)	6 000 (1 350)	14 450 (3 250)	1 630 (1 200)	2 030 (1 500)	930 (690)

Figure 4-14: Maximum combined loading

Pump size	Suction flange						Discharge flange					
	Forces N (lbf)			Moments Nm (lbf•ft)			Forces N (lbf)			Moments Nm (lbf•ft)		
	Fxs	Fys	Fzs	Mxs	Mys	Mzs	Fxd	Fyd	Fzd	Mxd	Myd	Mzd
1K 1.5x1-6	8 980 (2 020)	3 330 (750)	3 330 (750)	2 480 (1 830)	230 (170)	230 (170)	8 980 (2 020)	6 000 (1 350)	27 700 (6 240)	550 (410)	550 (410)	550 (410)
1K 3x1.5-6	8 980 (2 020)	5 510 (1 240)	9 380 (2 110)	3 100 (2 290)	660 (490)	660 (490)	8 980 (2 020)	6 000 (1 350)	27 700 (6 240)	740 (550)	740 (550)	690 (510)
1K 3x2-6	8 980 (2 020)	4 670 (1 050)	4 670 (1 050)	3 100 (2 290)	300 (220)	300 (220)	8 980 (2 020)	6 000 (1 350)	27 700 (6 240)	1 400 (1 030)	1 400 (1 030)	690 (510)
1K 1.5x1-8 & 1K 1.5x1.5US-8	8 980 (2 020)	5 380 (1 210)	5 380 (1 210)	2 480 (1 830)	260 (190)	260 (190)	8 980 (2 020)	6 000 (1 350)	27 700 (6 240)	490 (360)	490 (360)	490 (360)
1K 3x1.5-8	8 980 (2 020)	5 510 (1 240)	7 290 (1 640)	3 100 (2 290)	660 (490)	660 (490)	8 980 (2 020)	6 000 (1 350)	27 700 (6 240)	600 (440)	600 (440)	600 (440)
2K 3x2-8	12 000 (2 700)	6 000 (1 350)	11 070 (2 490)	5 060 (3 730)	810 (600)	810 (600)	8 760 (1 970)	6 000 (1 350)	27 700 (6 240)	890 (660)	890 (660)	890 (660)
2K 4x3-8	12 000 (2 700)	6 000 (1 350)	8 180 (1 840)	5 060 (3 730)	470 (350)	470 (350)	8 980 (2 020)	6 000 (1 350)	27 700 (6 240)	1 980 (1 460)	1 980 (1 460)	930 (690)
2K 2x1-10A & 2K 2x1.5US-10A	10 400 (2 340)	4 270 (960)	4 270 (960)	4 930 (3 640)	300 (220)	300 (220)	8 980 (2 020)	6 000 (1 350)	27 700 (6 240)	890 (660)	890 (660)	890 (660)
2K 3x1.5-10A	12 000 (2 700)	6 000 (1 350)	8 500 (1 910)	5 060 (3 730)	570 (420)	570 (420)	8 630 (1 940)	6 000 (1 350)	27 700 (6 240)	500 (370)	500 (370)	500 (370)
2K 3x2-10A & 2K 3x2US-10	12 000 (2 700)	6 000 (1 350)	6 580 (1 480)	5 060 (3 730)	420 (310)	420 (310)	8 980 (2 020)	6 000 (1 350)	27 700 (6 240)	760 (560)	760 (560)	760 (560)
2K 4x3-10, 10H & 2K 4x3US-10H	10 230 (2 300)	6 000 (1 350)	7 290 (1 640)	5 060 (3 730)	420 (310)	420 (310)	8 980 (2 020)	6 000 (1 350)	27 700 (6 240)	1 980 (1 460)	1 980 (1 460)	930 (690)
2K 6x4-10 and 10H	12 000 (2 700)	6 000 (1 350)	27 700 (6 240)	5 060 (3 730)	1 490 (1 100)	1 490 (1 100)	8 980 (2 020)	6 000 (1 350)	27 700 (6 240)	4 200 (3 100)	4 200 (3 100)	930 (690)
2K 3x1.5-13	12 000 (2 700)	6 000 (1 350)	13 600 (3 060)	5 060 (3 730)	910 (670)	910 (670)	8 980 (2 020)	6 000 (1 350)	27 700 (6 240)	720 (530)	720 (530)	720 (530)
2K 3x2-13 & 2K 3x2US-13	8 540 (1 920)	5 470 (1 230)	5 470 (1 230)	5 060 (3 730)	470 (350)	470 (350)	8 980 (2 020)	6 000 (1 350)	27 700 (6 240)	1 980 (1 460)	1 980 (1 460)	930 (690)
2K 4x3-13, 13HH & 2K 4x3US-13	12 000 (2 700)	6 000 (1 350)	10 630 (2 390)	5 060 (3 730)	540 (400)	540 (400)	8 980 (2 020)	6 000 (1 350)	27 700 (6 240)	2 340 (1 730)	2 340 (1 730)	930 (690)
2K 6x4-13A	12 000 (2 700)	6 000 (1 350)	27 700 (6 240)	5 060 (3 730)	6 750 (4 980)	1 490 (1 100)	8 980 (2 020)	6 000 (1 350)	27 700 (6 240)	2 910 (2 150)	2 910 (2 150)	930 (690)

Figure 4-15: Maximum Y-axis loading for shaft deflection

Pump size	Suction flange						Discharge flange					
	Forces N (lbf)			Moments Nm (lbf•ft)			Forces N (lbf)			Moments Nm (lbf•ft)		
	Fxs	Fys	Fzs	Mxs	Mys	Mzs	Fxd	Fyd	Fzd	Mxd	Myd	Mzd
Group 1	-	-8 860 (-2 000)	-	1 220 (900)	1 630 (1 200)	1 690 (1 250)	-	6 670 (1 500)	-	-680 (-500)	2 030 (1 500)	1 690 (1 250)
Group 2	-	-15 570 (-3 500)	-	1 760 (1 300)	1 760 (1 300)	4 070 (3 000)	-	11 120 (2 500)	-	-1 630 (-1 200)	2 030 (1 500)	4 070 (3 000)

4.6.4.2 Figure 4-16: Maximum Z-axis loading for shaft deflection

Pump size	Suction flange						Discharge flange					
	Forces N (lbf)			Moments Nm (lbf•ft)			Forces N (lbf)			Moments Nm (lbf•ft)		
	Fxs	Fys	Fzs	Mxs	Mys	Mzs	Fxd	Fyd	Fzd	Mxd	Myd	Mzd
Group 1	4 670 (1 050)	-	-5 560 (-1 250)	2 030 (1 500)	1 630 (1 200)	-3 390 (-2 500)	3 560 (800)	8 860 (2 000)	-13 340 (-3 000)	-2 030 (-1 500)	1 350 (1 000)	-3 390 (-2 500)
Group 2	15 570 (3 500)	-	-6 670 (-1 500)	2 030 (1 500)	1 760 (1 300)	-4 740 (-3 500)	6 220 (1 400)	11 120 (2 500)	-14 450 (-3 250)	-2 030 (-1 500)	2 910 (2 150)	-4 740 (-3 500)

4.6.5 Auxiliary equipment

4.6.5.1 External flush option E01

Flush option E01 is the use of a recirculation from discharge or an external process compatible source through the driven section and a return to process.

Referring to Figure 4-17, determine the inlet location for the flush fluid. It should be in either location "1JI" or "1HI" (1JI is standard). Hook up external flush lines and make sure the required inlet pressure ensures that liquid is flowing into the pump (1.0 to 1.4 bar [15 to 20 psi] margin over containment shell pressure). The external flush should start running either before the pump is rotating or when the pump starts to rotate.

CAUTION If flush option E01 is specified, failure to provide external flush before starting the motor/pump could result in bearing damage.

CAUTION Always install a check valve in the inlet flush line as close to the pump as possible to avoid reverse flow in the flush line.

Figure 4-17: External flush inlet locations

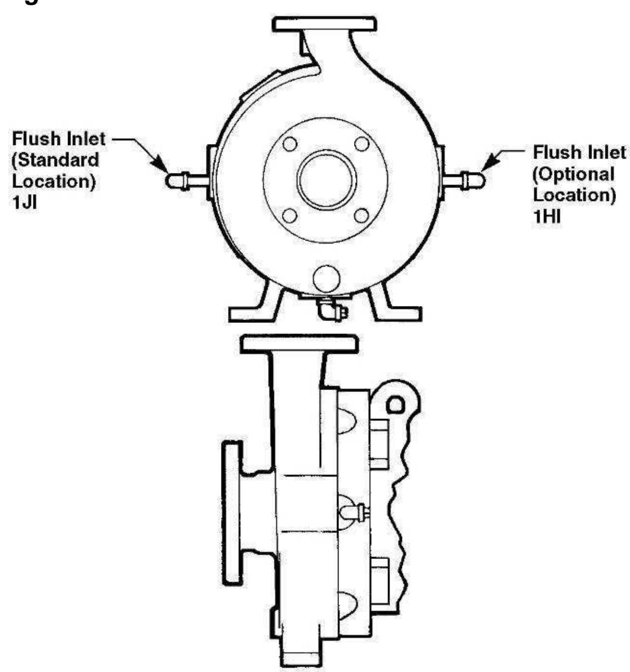


Figure 4-18: External flush option code E01

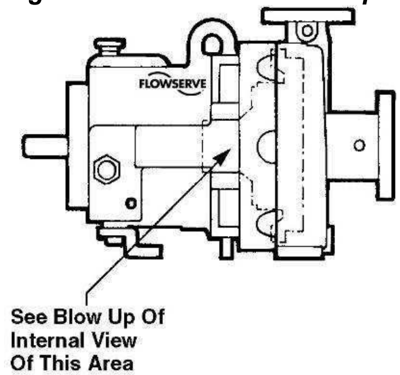
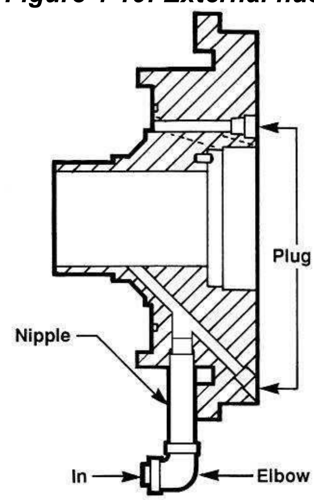


Figure 4-19: External flush – cutaway view



4.6.5.2 Piping connection - bearing housing cooling system

Make connections as shown below. Liquid at less than 32 ℃ (90 ℉) should be supplied at a regulate d flow rate of at least 0.06 l/s (1 gpm).

Figure 4-20: Oil cooler - Group 1 schematic

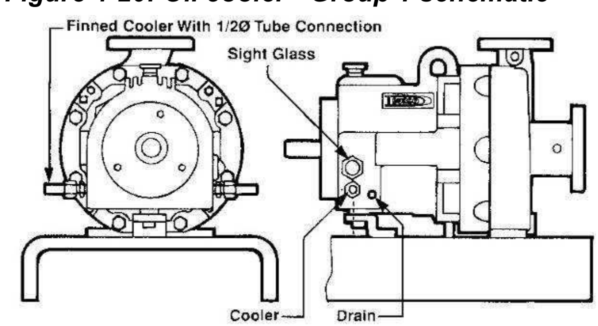
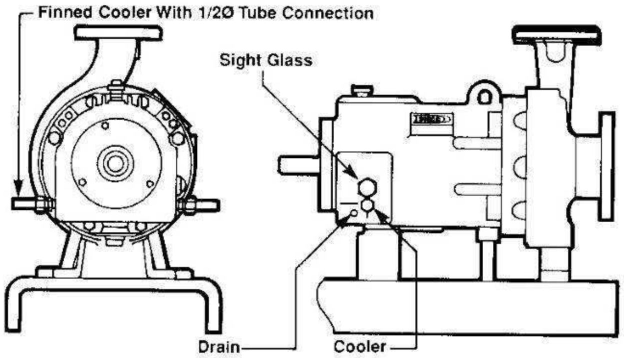


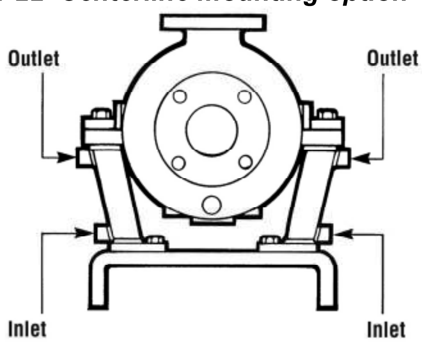
Figure 4-21: Oil cooler - Group 2 schematic



4.6.5.3 Piping connection - support leg cooling for centerline mounting option

If the casing is centerline mounted, and the process temperature is over 178 °C (350 °F), then the casing support legs may need to be cooled. Cool water - less than 32 °C (90 °F) - should be run through the legs at a flow rate of at least 0.06 l/s (1 gpm) as shown below.

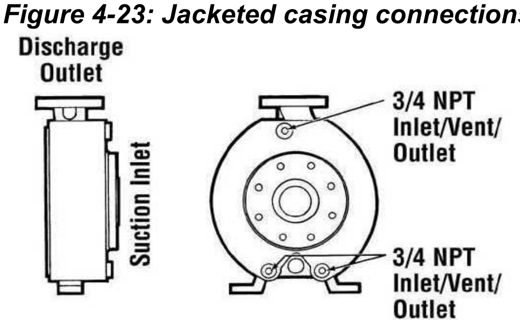
Figure 4-22 Centerline mounting option



4.6.5.4 Piping connection - Heating/cooling fluid for jacketed/casing

The piping connections for jacketed casings are shown below. The flow rate of the cooling water - less than 32 °C (90 °F) - should be at least 0.13 l/s (2 gpm) .

Figure 4-23: Jacketed casing connections



Notes:
1. When circulating steam, use top hole for inlet. Both bottom holes must be plumbed together for outlet, to ensure draining both sides of jacket.
2. When circulating liquid use both bottom holes as inlets. Use top hole as outlet.

4.6.5.5 Piping connection - oil mist lubrication system

The piping connections for an oil mist lubrication system are shown below in Figures 4-24 and 4-25.

Figure 4-24: Oil mist connections – labyrinth style oil seals (standard)

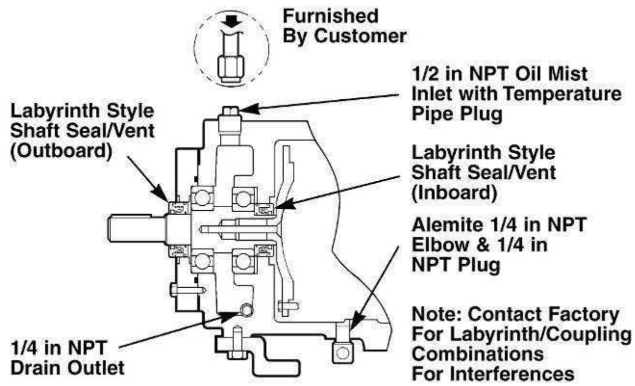
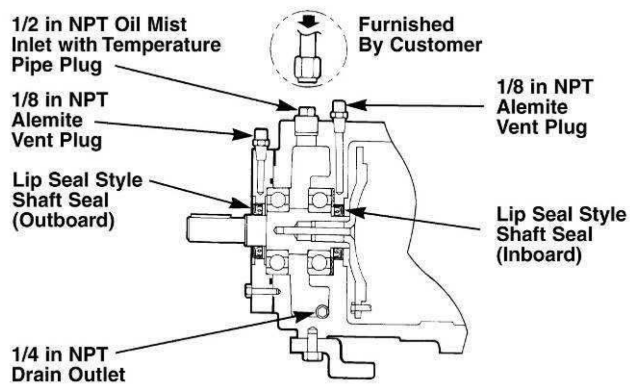


Figure 4-25: Oil mist connections – lip seals (optional)



4.7 Electrical connections

DANGER Electrical connections must be made by a qualified Electrician in accordance with relevant local national and international regulations.

It is important to be aware of the EUROPEAN DIRECTIVE on potentially explosive areas where compliance with IEC60079-14 is an additional requirement for making electrical connections.

It is important to be aware of the EUROPEAN DIRECTIVE on electromagnetic compatibility when wiring up and installing equipment on site. Attention must be paid to ensure that the techniques used during wiring/installation do not increase electromagnetic emissions or decrease the electromagnetic immunity of the equipment, wiring or any connected devices. If in any doubt contact Flowserve for advice.

DANGER The motor must be wired up in accordance with the motor manufacturer's instructions (normally supplied within the terminal box) including any temperature, earth leakage, current and other protective devices as appropriate. The identification nameplate should be checked to ensure the power supply is appropriate.

CAUTION See section 5.4, *Direction of rotation* before connecting the motor to the electrical supply.

CAUTION For close coupled pumps it is necessary to wire the motor with flexible conduit of sufficient length to allow the motor/power end assembly to be moved back from the casing for maintenance.

4.8 Final shaft alignment check

a) Level baseplate if appropriate.
b) Mount and level pump if appropriate. Level the pump by putting a level on the discharge flange. If not level, adjust the footpiece by adding or deleting shims [3126.1] between the footpiece and the bearing housing.
c) Check initial alignment. If pump and driver have been remounted or the specifications given below are not met, perform an initial alignment as described in Section 4.5. This ensures there will be sufficient clearance between the motor hold down bolts and motor foot holes to move the motor into final alignment. The pump and driver should be within 0.38 mm (0.015 in.) FIM (Full Indicator Movement) parallel, and 0.0025 mm/mm (0.0025 in./in.) FIM angular.
   Stilt mounted baseplates: If initial alignment cannot be achieved with the motor fasteners centered, the baseplate may be twisted. Slightly adjust (one turn of the adjusting nut) the stilts at the driver end of the baseplate and check for alignment to the above tolerances. Repeat as necessary while maintaining a level condition as measured from the pump discharge flange.
d) Run piping to the suction and discharge to the pump. There should be no piping loads transmitted to the pump after connection is made. Recheck the alignment to verify that there are no significant changes.
e) Perform final alignment. Check for soft-foot under the driver. An indicator placed on the coupling, reading in the vertical direction, should not indicate more than 0.05 mm (0.002 in.) movement when any driver fastener is loosened. Align the driver first in the vertical direction by shimming underneath its feet. When satisfactory alignment is obtained the number of shims in the pack should be minimized. It is recommended that no more than five shims be used under any foot. Final horizontal alignment is made by moving the driver. Maximum pump reliability is obtained by having near perfect alignment. Flowserve recommends no more than 0.05 mm (0.002 in.) parallel, and 0.0005 mm/mm (0.0005 in./in.) angular misalignment. (See Section 6.8.4.2.)
f) Operate the pump for at least an hour or until it reaches final operating temperature. Shut the pump down and recheck alignment while the pump is hot. Piping thermal expansion may change the alignment. Realign pump as necessary.

4.9 Protection systems

Ex The following protection systems are recommended particularly if the pump is installed in a potentially explosive area or is handling a hazardous liquid. If in doubt consult Flowserve.

If there is any possibility of the system allowing the pump to run against a closed valve or below minimum continuous safe flow a protection device should be installed to ensure the temperature of the liquid does not rise to an unsafe level.

If there are any circumstances in which the system can allow the pump to run dry, or start up empty, a power monitor should be fitted to stop the pump or prevent it from being started. This is particularly relevant if the pump is handling a flammable liquid.

If leakage of product from the pump can cause a hazard it is recommended that an appropriate leakage detection system is installed.

To prevent excessive surface temperatures at bearings it is recommended that temperature or vibration monitoring are carried out.

Auxiliary equipment – instrumentation

4.9.1 Leak detection

An intrinsically-safe, optical leak detection system is available for Guardian G & H series pumps. Contact your local Flowserve Sales office or Distributor/ Representative for more details.

4.9.2 Temperature probes

Optional temperature probes are available to monitor both the external shell surface and the internal fluid in the containment shell (Figure 4-26). Refer to Figure 4-27 to determine the instrument location for probe type.

Wiring diagrams: refer to Figure 4-26 for both Type J and RTD designs.

Figure 4-26: Temperature probe wiring diagram – Guardian G & H Series

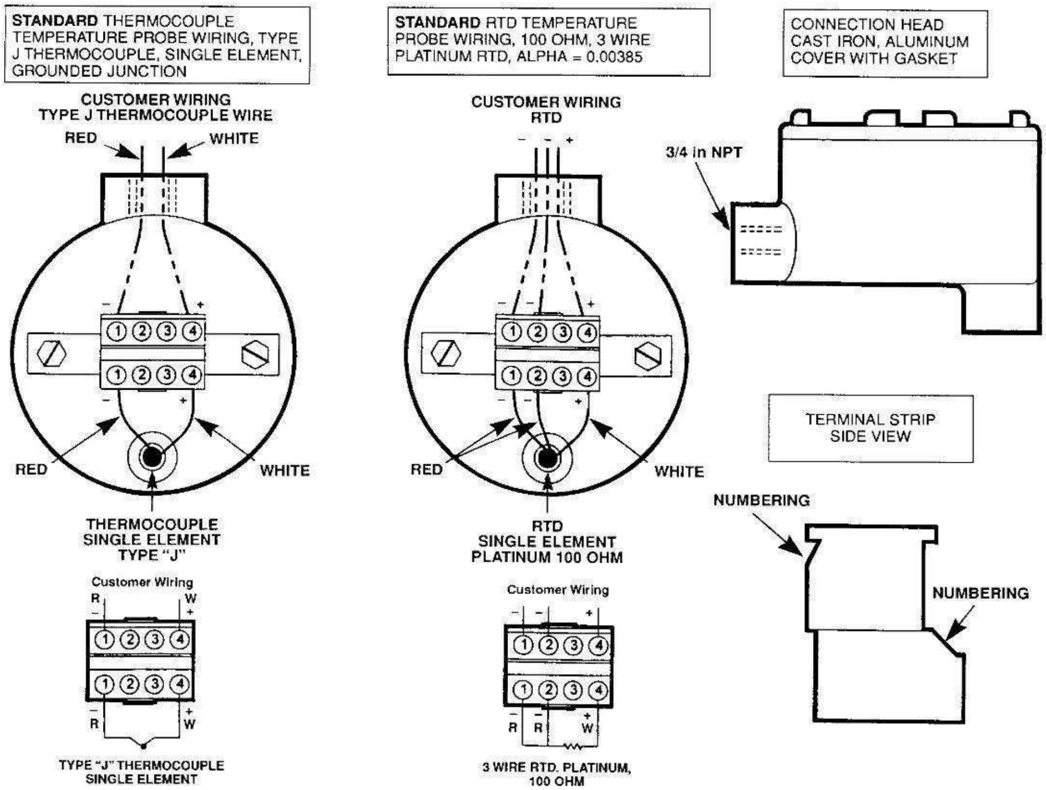
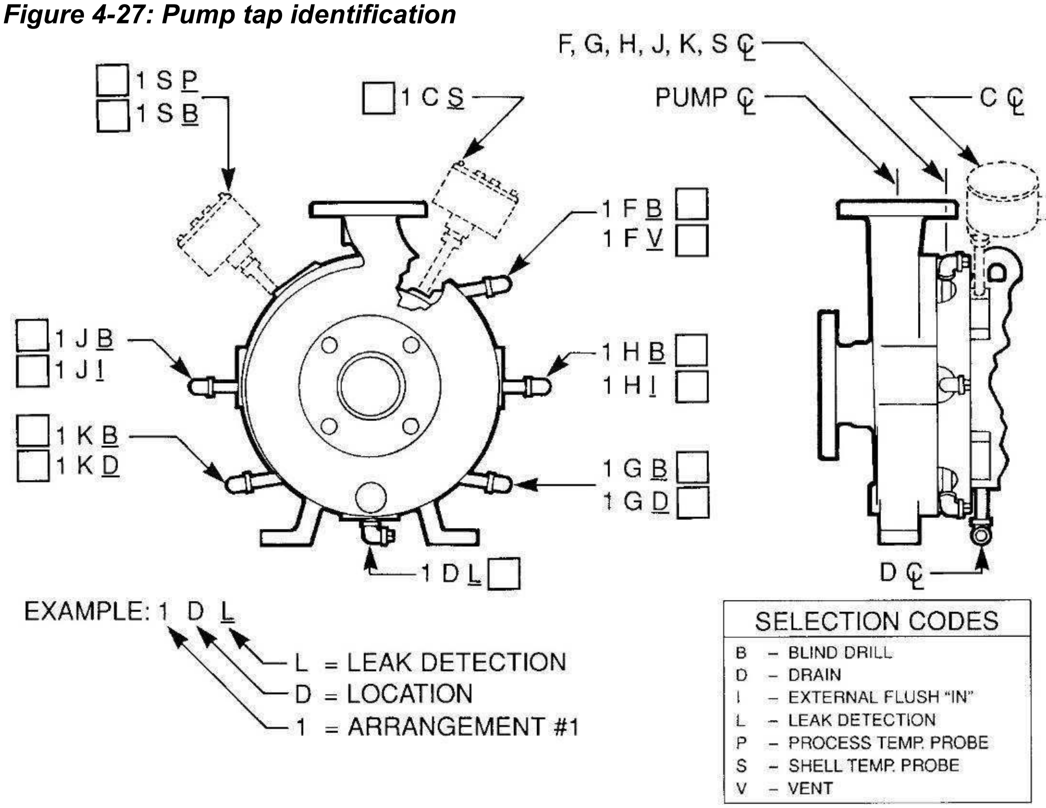


Figure 4-27: Pump tap identification



5 COMMISSIONING, STARTUP, OPERATION AND SHUTDOWN

5.1 Pre-commission procedure

Pre start-up checks
Prior to starting the pump it is essential that the following checks be made. These checks are all described in detail in the Maintenance Section of this manual.

- Pump and motor properly secured to the baseplate
- All fasteners tightened to the correct torque, see section 6.5
- Coupling guard in place and not rubbing
- Rotation check, see section 5.4.
  This is absolutely essential
- Impeller clearance setting, see section 6.6
- Bearing lubrication, see section 5.2
- Bearing housing cooling system operational
- Support leg cooling for centerline mounting option operational
- Heating/cooling for jacketed casing operational
- Pump instrumentation is operational
- Pump is primed
- Rotation of shaft by hand
- Remove temporary motor supports installed for shipping (close-coupled pumps only)

As a final step in preparation for operation, it is important to rotate the shaft by hand to be certain that all rotating parts move freely, and that there are no foreign objects in the pump casing.

5.2 Pump lubricants

5.2.1 Oil bath

The standard bearing housing bearings are oil bath lubricated and are not lubricated by Flowserve. Before operating the pump, fill the bearing housing to the center of the oil sight glass with the proper type oil. (See Figure 5-1 for approximate amount of oil required - do not overfill.)

The oil level in the bearing housing must be maintained at ±3 mm (±$^1/_8$ in.) from the center of the sight glass. The sight glass has a 6 mm (¼ in.) hole in the center of its reflector. The bearing housing oil level must be within the circumference of the center hole to ensure adequate lubrication of the bearings.

See Figure 5-2 for recommended lubricants. DO NOT USE DETERGENT OILS. The oil must be free of water, sediment, resin, soaps, acid and fillers of any kind. It should contain rust and oxidation inhibitors. The proper oil viscosity is determined by the bearing housing operating temperature as given in Figure 5-3.
To add oil to the housing, clean and then remove the vent plug [6521] at the top of the bearing housing, pour in oil until it is visually half way up in the sight glass [3856]. Fill the constant level oiler bottle, if used, and return it to its position. The correct oil level is obtained with the constant level oiler in its lowest position, which results in the oil level being at the top of the oil inlet pipe nipple, or half way up in the sight glass window. Oil must be visible in the bottle at all times.

Note that on ANSI 3A™ power ends there is no constant level oiler. As stated above, proper oil level is the center of the “bull’s eye” sight glass [3856].

In many pumping applications lubricating oil becomes contaminated before it loses its lubricating qualities or breaks down. For this reason it is recommended that the first oil change take place after approximately 160 hours of operation, at which time, the used oil should be examined carefully for contaminants. During the initial operating period monitor the bearing housing operating temperature. Record the external bearing housing temperature. See Figure 5-4 for maximum acceptable temperatures. The normal oil change interval is based on temperature and is shown in Figure 5-5.

Figure 5-1: Amount of oil required

Pump	Guardian G & H Series pumps
Group 1	240 ml (8.1 oz)
Group 2	545 ml (18.4 oz)

Figure 5-2: Recommended oil lubricants

	Oil	**Splash / force feed / purge oil mist/ pure oil mist lubrication**		
Centrifugal pump lubrication	Viscosity cSt @ 40 ºC	32	**46**	68
	Oil temperature range *	-5 to 65 ºC (23 to 149 ºF)	**-5 to 78 ºC (23 to 172 ºF)**	-5 to 80 ºC (23 to 176 ºF)
	Designation to ISO 3448 and DIN51524 part 2	ISO VG 32 32 HLP	**ISO VG 46 46 HLP**	ISO VG 68 68 HLP
Oil companies and lubricants	**BP Castrol** †	Energol HLP-HM 32	**Energol HLP-HM 46**	Energol HLP-HM 68
	ESSO †	NUTO HP 32	**NUTO HP 46**	NUTO HP 68
	ELF/Total †	ELFOLNA DS 32 Azolla ZS 32	**ELFOLNA DS 46 Azolla ZS 46**	ELFOLNA DS 68 Azolla ZS 68
	LSC (for oil mist)**	LSO 32 (Synthetic oil)	**LSO 46 (Synthetic oil)**	LSO 68 (Synthetic oil)
	ExxonMobil †	Mobil DTE 24	**Mobil DTE 25**	Mobil DTE 26
	Q8 †	Q8 Haydn 32	**Q8 Haydn 46**	Q8 Haydn 68
	Shell †	Shell Tellus 32	**Shell Tellus 46**	Shell Tellus 68
	Chevron Texaco †	Rando HD 32	**Rando HD 46**	Rando HD 68
	Wintershall (BASF Group) †	Wiolan HS32	**Wiolan HS46**	Wiolan HS68
	Fuchs †	Renolin CL 32	**Renolin CL 46**	Renolin CL 68

* Note that it normally takes 2 hours for bearing temperature to stabilize and the final temperature will depend on the ambient, r/min, pumpage temperature and pump size. Also some oils have a very low pour point and good viscosity index which extend the minimum temperature capability of the oil. Always check the grade capability where the ambient is less than -5 ºC (23 ºF).

† Use LSC for oil mist. Oil parameters provide flash point >166 ºC (331 ºF), density >0.87 @ 15 ºC (59 ºF), pour point of -10 ºC (14 ºF) or lower.

** Normal compounded oils CANNOT be used with oil mist as anti-foam additives need to be avoided. Most oils recommended for wet splash lubrication contain foam inhibitors as well as antioxidants and anticorrosion additives, so they are unsuitable for oil mist. Some synthetic lubricants may attack the Nitrile seals used in a regular bearing housing.

Figure 5-3: Oil viscosity grades

Maximum oil temperature	**ISO viscosity grade**	**Minimum viscosity index**
Up to 71 °C (160 °F)	46	95
71-80 °C (160-175 °F)	68	95
80-94 °C (175-200 °F)	100	95

Figure 5-4: Maximum external housing temperatures

Lubrication	**Temperature**
Oil bath	82 °C (180 °F)
Oil mist	82 °C (180 °F)
Grease	94 °C (200 °F)

CAUTION The maximum temperature that the bearing can be exposed to is 105 °C (220 °F).

Figure 5-5: Lubrication intervals *

Lubricant	**Under 71 °C (160 °F)**	**71-80 °C (160-175 °F)**	**80-94 °C (175-200 °F)**
Mineral oil	6 months	3 months	1.5 months
Synthetic oil **	18 months	18 months	18 months

* Assuming good maintenance and operation practices, and no contamination.

** May be increased to 36 months with ANSI 3A™ power end.

5.2.2 Grease for life double shielded or double sealed bearings

These bearings are packed with grease by the bearing manufacturer and should not be relubricated. The replacement interval for these bearings is greatly affected by their operating temperature and speed. Shielded bearings typically operate cooler.

5.2.3 Oil mist

When optional oil mist lubricated bearings are specified, the bearing housing is furnished with a plugged 1/2 in. NPT top inlet for connection to the user's oil mist supply system, a vent fitting in the bearing cover, and a plugged 1/4 in. NPT bottom drain. See *Oil Mist Lubrication System* in Section 4.6.5.5.

Do not allow oil level to remain above the center of the bearing housing sight glass window with purge mist (wet sump) systems.

5.3 Impeller clearance

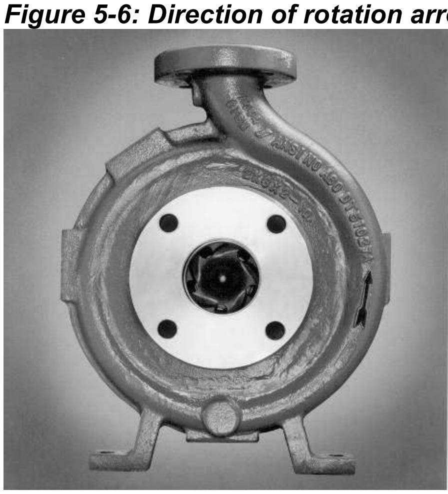
For Guardian G & H series pumps the impeller clearance is set to the bearing holder at 0.45 mm (0.018 in.) regardless of operating temperature. Clearance is set by adding or removing shims located between the impeller and thrust collar. See Section 6.6 for instructions on how to set the impeller.

5.4 Direction of rotation

5.4.1 Rotation check, long-coupled pumps

CAUTION It is absolutely essential that the rotation of the motor be checked before connecting the shaft coupling. Incorrect rotation of the pump, for even a short time, can dislodge and damage the impeller, casing, shaft and shaft seal. All Guardian G & H series pumps turn clockwise as viewed from the motor end. A direction arrow is cast on the front of the casing as shown in Figure 5-6. Make sure the motor rotates in the same direction.

Figure 5-6: Direction of rotation arrow



5.4.2 Rotation check, close-coupled pumps

This check will require operating the pump briefly, so the pump must be filled with liquid. Never run a centrifugal pump dry. To check rotation, perform the following steps:

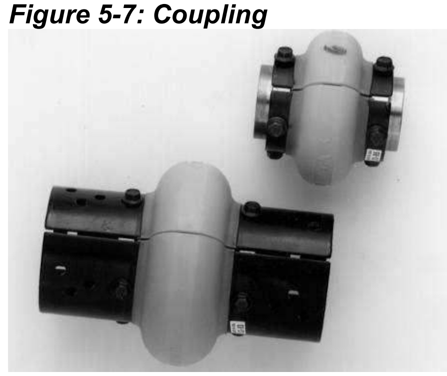
a) Open the suction and discharge valves to allow the pump to fill with liquid.
b) While watching the motor fan, bump the motor. The proper direction of rotation for the pump is clockwise as viewed from the motor end. A direction arrow cast on the front of the casing as shown in Figure 5-6.

   DANGER NEVER DO MAINTENANCE WORK WHEN THE UNIT IS CONNECTED TO POWER (Lock Out).
c) If the motor rotates in the wrong direction, reverse any two of the three leads to the motor (3 phase current). Bump the motor again to ensure the proper direction of rotation.

5.4.3 Coupling installation

CAUTION The coupling (Figure 5-7) should be installed as advised by the coupling manufacturer. Pumps are shipped without the spacer installed. If the spacer has been installed to facilitate alignment, then it must be removed prior to checking rotation. Remove all protective material from the coupling and shaft before installing the coupling.

Figure 5-7: Coupling



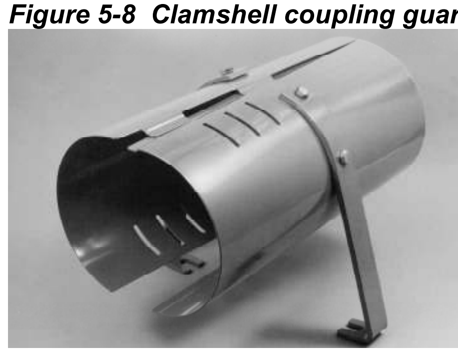
5.5 Guarding

CAUTION Power must never be applied to the driver when the coupling guard is not installed.

5.5.1 Clam shell guard - standard

The standard coupling guard for all Guardian G & H series pumps is the “clam shell” design and is shown in Figure 5-8. It is hinged at the top and it can be removed by loosening one of the foot bolts and sliding the support leg out from under the cap screw (note that the foot is slotted). The leg can then be rotated upward and half of the guard can be disengaged (unhinged) from the other. Note that only one side of the guard needs to be removed. To reassemble simply reverse the above procedure.

Figure 5-8 Clamshell coupling guard



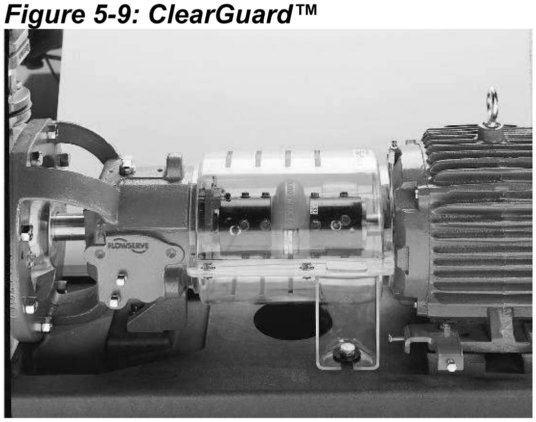
Flowserve coupling guards are safety devices intended to protect workers from inherent dangers of the rotating pump shaft, motor shaft and coupling. It is intended to prevent entry of hands, fingers or other body parts into a point of hazard by reaching through, over, under or around the guard. No standard coupling guard provides complete protection from a disintegrating coupling. Flowserve cannot guarantee their guards will completely contain an exploding coupling.

The coupling guard shown in Figure 5-8 conforms to the USA standard ASME B15.1, *"Safety Standard for Mechanical Power Transmission Apparatus."* Flowserve manufacturing facilities worldwide conform to local coupling guard regulations.

5.5.2 ClearGuard™ - option

Flowserve offers as an option a ClearGuard™, which allows you to see the condition of the coupling. (See Figure 5-9.) This guard can be used in place of the existing clamshell guard described above. The following instructions enable the user to properly fit this guard to the pump and motor.

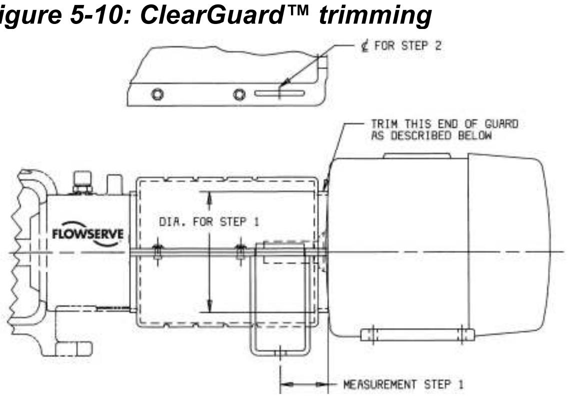
Figure 5-9: ClearGuard™



5.5.2.1 Trimming and assembly instructions

In order to correctly fit the pump/motor configuration, each ClearGuard must be trimmed to a specific length. This trimming is done on the motor end of the guard as described below. (See Figure 5-10.)

Figure 5-10: ClearGuard™ trimming



5.5.2.2 Trimming instructions

a) Measure minimum distance from the center of mounting hole in the baseplate to the motor at diameter as shown above.
b) Locate a reference center of the slot in the coupling guard flange. Transfer measurement from Step a) to the guard using this reference center.
c) Trim the motor end of guard according to the above measurement. Trimming is best done with a band saw, but most other types of manual or power saws give acceptable results. Care must be taken to ensure that there is no gap larger than 6 mm (0.24 in.) between the motor and the coupling guard.
d) Note: If motor diameter is smaller than guard diameter, trim guard so that it extends over the end of the motor as far as possible.
e) Deburr the trimmed end with a file or a sharp knife. Care must be taken to eliminate all sharp edges.

5.5.2.3 Assembly instructions

f) Place the bottom and top halves of the ClearGuard around the coupling.
g) Install the support legs by inserting and then rotating the top flange of the leg through the slot in the shell flange until it comes all the way through and locks the top and bottom together.
h) Attach the support legs to the baseplate using the fasteners and washers provided.
i) Install fasteners in the holes provided to secure the guard flanges together.

5.6 Priming and auxiliary supplies

The standard Guardian G & H series pumps will not move liquid unless the pump is primed. A pump is said to be "primed" when the casing and the suction piping are completely filled with liquid. Open discharge valves a slight amount. This will allow any entrapped air to escape and will normally allow the pump to prime, if the suction source is above the pump. When a condition exists where the suction pressure may drop below the pump's capability, it is advisable to add a low-pressure control device to shut the pump down when the pressure drops below a predetermined minimum.

The Guardian Unitized self-priming centrifugal pumps have a slightly different requirement regarding priming. The initial priming liquid must be added to the pump casing until the liquid has reached the bottom of the suction nozzle. Once the initial prime is in place, the pump will automatically replenish itself and additional priming liquids are not normally needed. If liquid is lost, additional priming liquid may be needed.

5.7 Starting the pump

a) Open the suction valve to full open position. It is very important to leave the suction valve open while the pump is operating. Any throttling or adjusting of flow must be done through the discharge valve. Partially closing the suction valve can create serious NPSH and pump performance problems.
⚠ CAUTION Never operate pump with both the suction and discharge valves closed. This could cause an explosion.
b) Ensure the pump is primed. (See section 5.6.)
c) All cooling, heating, and flush lines must be started and regulated.
d) Start the driver (typically, the electric motor).
e) Slowly open the discharge valve until the desired flow is reached, keeping in mind the minimum continuous flow listed in section 3.4.
⚠ CAUTION It is important that the discharge valve be opened within a short interval after starting the driver. Failure to do this could cause a dangerous build up of heat, and possibly an explosion.

5.8 Running or operation

5.8.1 Minimum continuous flow

Minimum continuous stable flow is the lowest flow at which the pump should be operated. The minimum continuous flow (capacity) is established as a percentage of the *best efficiency point* (BEP). See section 3.4.4.

5.8.2 Minimum thermal flow

All Guardian G & H series pumps also have a *minimum thermal flow*. This is defined as the minimum flow that will not cause an excessive temperature rise. Minimum thermal flow is application dependent.

⚠ CAUTION Do not operate the pump below minimum thermal flow, as this could cause an excessive temperature rise. Contact a Flowserve Sales Engineer for determination of minimum thermal flow.

Avoid running a centrifugal pump at drastically reduced capacities or with discharge valve closed for extended periods of time. This can cause severe temperature rise and the liquid in the pump may reach its boiling point. If this occurs, the internal process-lubricated bearings will be exposed to vapor, with no lubrication, and may be damaged or fail within a very short period of time. Continued running under these conditions when the suction valve is also closed can create an explosive condition due to the confined vapor at high pressure and temperature.

Thermostats may be used to safeguard against over heating by shutting down the pump at a predetermined temperature.

Safeguards should also be taken against possible operation with a closed discharge valve, such as installing a bypass back to the suction source. The size of the bypass line and the required bypass flow rate is a function of the input horsepower and the allowable temperature rise.

5.8.3 Reduced head

Note that when discharge head drops, the pump's flow rate usually increases rapidly. Check motor for temperature rise as this may cause overload. If overloading occurs, throttle the discharge.

5.8.4 Surging condition

A rapidly closing discharge valve can cause a damaging pressure surge. A dampening arrangement should be provided in the piping.

5.8.5 Operation in sub-freezing conditions

When using the pump in sub-freezing conditions where the pump is periodically idle, the pump should be properly drained or protected with thermal devices which will keep the liquid in the pump from freezing.

5.9 Stopping and shutdown

5.9.1 Shutdown considerations

When the pump is being shutdown, the procedure should be the reverse of the start-up procedure. First, slowly close the discharge valve, shutdown the driver, then close the suction valve. Remember that closing the suction valve while the pump is running is a safety hazard and could seriously damage the pump and other equipment.

5.9.2 Shutdown Guardian self-priming

At shutdown, the liquid in the discharge piping falls back into the priming chamber and washes through the impeller into the suction. The backflow creates a siphon effect in the casing until the liquid level falls below the bottom of the suction nozzle. The inertia of the flow pulls fluid from the priming chamber to a level lower than the initial priming fill. Though the level is lower, there is still sufficient fluid in the priming chamber to allow the pump to reprime itself.

5.10 Hydraulic, mechanical and electrical duty

5.10.1 Net positive suction head (NPSH)

Net positive suction head - available ($NPSH_A$) is the measure of the energy in a liquid above the vapor pressure. It is used to determine the likelihood that a fluid will vaporize in the pump. It is critical because a centrifugal pump is designed to pump a liquid, not a vapor. Vaporization in a pump will result in damage to the pump, deterioration of the *Total differential head* (TDH), and possibly a complete stopping of pumping.

Net positive suction head - required ($NPSH_R$) is the decrease of fluid energy between the inlet of the pump, and the point of lowest pressure in the pump. This decrease occurs because of friction losses and fluid accelerations in the inlet region of the pump and particularly accelerations as the fluid enters the impeller vanes. The value for $NPSH_R$ for the specific pump purchased is given in the pump data sheet, and on the pump performance curve.

For a pump to operate properly the $NPSH_A$ must be greater than the $NPSH_R$. Good practice dictates that this margin should be at least 1.5 m (5 ft) or 20%, whichever is greater.

CAUTION Ensuring that $NPSH_A$ is larger than $NPSH_R$ by the suggested margin will greatly enhance pump performance and reliability. It will also reduce the likelihood of cavitation, which can severely damage the pump.

5.10.2 Specific gravity (SG)

Pump capacity and total head in meters (ft) of liquid do not change with SG, however pressure displayed on a pressure gauge is directly proportional to SG. Power absorbed is also directly proportional to SG. It is therefore important to check that any change in SG will not overload the pump driver or over pressurize the pump.

5.10.3 Viscosity

For a given flow rate the total head reduces with increased viscosity and increases with reduced viscosity. Also for a given flow rate the power absorbed increases with the increased viscosity, and reduces with reduced viscosity. It is important that checks are made with your nearest Flowserve office if changes in viscosity are planned.

5.10.4 Pump speed

Changing the pump speed affects flow, total head, power absorbed, NPSHr, noise and vibration levels. Flow varies in direct proportion to pump speed. Head varies as speed ratio squared. Power varies as speed ratio cubed. If increasing speed it is important to ensure the maximum pump working pressure is not exceeded, the driver is not overloaded, NPSHa>NPSHr and that noise and vibration are within local requirements and regulations.

6 MAINTENANCE

⚠ It is the plant operator's responsibility to ensure that all maintenance, inspection and assembly work is carried out by authorised and qualified personnel who have adequately familiarized themselves with the subject matter by studying this manual in detail. (See also section 1.6.)

⚠ MAGNETIC FIELD PRESENT

This equipment may affect electronic equipment or other devices that are influenced by magnetic fields. Because magnetic drive pumps contain powerful magnets, anyone with a pacemaker MUST NOT disassemble these pumps nor enter areas where disassembled pumps are likely to be. Also, keep all credit cards, bank cards, watches, computer disks and anything else which can be damaged by magnetic fields away from these pumps when disassembled.

Any work on the machine must be performed when it is at a standstill. It is imperative that the procedure for shutting down the machine is followed, as described in section 5.9.

On completion of work all guards and safety devices must be re-installed and made operative again.

Before restarting the machine, the relevant instructions listed in section 5, *Commissioning, start up, operation and shut down,* must be observed.

CAUTION ***Oil and grease leaks may make the ground slippery. Machine maintenance must always begin and finish by cleaning the ground and the exterior of the machine.***

If platforms, stairs and guard rails are required for maintenance, they must be placed for easy access to areas where maintenance and inspection are to be carried out. The positioning of these accessories must not limit access or hinder the lifting of the part to be serviced.

When air or compressed inert gas is used in the maintenance process, the operator and anyone in the vicinity must be careful and have the appropriate protection.

Do not spray air or compressed inert gas on skin. Do not direct an air or gas jet towards other people. Never use air or compressed inert gas to clean clothes.

Before working on the pump, take measures to prevent the pump from being accidentally started. Place a warning sign on the starting device:
"Machine under repair: do not start".

With electric drive equipment, lock the main switch open and withdraw any fuses. Put a warning sign on the fuse box or main switch:
"Machine under repair: do not connect".

Never clean equipment with flammable solvents or carbon tetrachloride. Protect yourself against toxic fumes when using cleaning agents.

Refer to the parts list shown in section 8 for item number references used throughout this section.

6.1 Maintenance schedule

It is recommended that a maintenance plan and schedule be implemented, in accordance with these User Instructions, to include the following:

- Any auxiliary systems installed must be monitored, if necessary, to ensure they function correctly.
- Check for any leaks from gaskets and seals.
- Check bearing lubricant level, and the remaining hours before a lubricant change is required.
- Check that the duty condition is in the safe operating range for the pump.
- Check vibration, noise level and surface temperature at the bearings to confirm satisfactory operation.
- Check dirt and dust is removed from areas around close clearances, bearing housings and motors.
- Check coupling alignment and align if needed.

6.1.1 Preventive maintenance

The following sections of this manual give instructions on how to perform a complete maintenance overhaul. However, it is also important to periodically repeat the *Pre start-up checks* listed in section 5.1. These checks will help extend pump life as well as the length of time between major overhauls.

6.1.2 Need for maintenance records

A procedure for keeping accurate maintenance records is a critical part of any program to improve pump reliability. There are many variables that can contribute to pump failures. Often long term and repetitive problems can only be solved by analyzing these variables through pump maintenance records.

6.1.3 Cleanliness

One of the major causes of pump failure is the presence of contaminants in the bearing housing. This contamination can be in the form of moisture, dust, dirt and other solid particles such as metal chips. Dirt in the impeller threads could cause the impeller to not be seated properly against the shaft. This, in turn, could cause a series of other problems. For these reasons, it is very important that proper cleanliness be maintained. Some guidelines are listed below:

- After draining the oil from the bearing housing, periodically send it out for analysis. If it is contaminated, determine the cause and correct.
- The work area should be clean and free from dust, dirt, oil, grease etc.
- Hands and gloves should be clean.
- Only clean towels, rags, and tools should be used.

6.2 Spare parts

The decision on what spare parts to stock varies greatly depending on many factors such as the criticality of the application, the time required to buy and receive new spares, the erosive/corrosive nature of the application, and the cost of the spare part. Section 8 identifies all of the components that make up each pump addressed in this manual. Please refer to the *Flowserve Mark 3 Pump Parts Catalog* for more information. A copy of this book can be obtained from your local Flowserve Sales Engineer or Distributor/Representative.

CAUTION Prior to resizing impellers in nickel, please consult your local Flowserve sales representative.

6.2.1 Ordering of spare parts

Flowserve keeps records of all pumps that have been supplied. Spare parts can be ordered from your local Flowserve Sales Engineer or from a Flowserve Distributor or Representative. When ordering spare parts the following information should be supplied:

1) Pump serial number
2) Pump size and type
3) Part name – see section 8
4) Part item number – see section 8
5) Material of construction (alloy)
6) Number of parts required

The pump size and serial number can be found on the name plate located on the bearing housing. (See Figure 3-1.)

6.3 Recommended spares and consumables

On very critical services, where downtime is especially crucial it may be best to stock spare pumps or the rotating assembly, allowing complete service to be quickly restored. The damaged assembly can be taken to a shop, repaired and stored for back-up.

6.4 Tools required

Do not perform maintenance on a steel workbench. The magnets present in the pump are strongly attracted to ferrous materials. Use a non-magnetic (such as wood or plastic) workbench instead. The use of non magnetic tools is also recommended. See Figure 6-1 for a list of recommended maintenance tools.

Figure 6-1: Recommended maintenance tools – Guardian G & H Series pumps

Task	Section	Group 1	Group 2
Power end back pullout	6.7.1	¾ in. open end wrench 5/8 in. socket 9/16 in. socket	¾ in. open end wrench 5/8 in. socket 9/16 in. socket
Complete pullout	6.7.2	¾ in. open end wrench ¾ in. socket	¾ in. open end wrench 15/16 in. socket
Disassembly /assembly	6.7.3 to 6.9.5	Torque wrench Arbor or bench press Rubber mallet Durco impeller wrench Coupling key 1-1/2 in. open end wrench 7/16 in. wrench 3/16 in. hex head wrench ¾ in. socket ½ in. socket	Torque wrench Arbor or bench press Rubber mallet Durco impeller wrench Coupling key 1-5/8 in. open end wrench 9/16 in. wrench 1/2 in. wrench 5/16 in. hex head wrench 9/16 in. socket Spanner wrench

6.5 Fastener torques

See Figure 6-2 for recommended fastener torques for Guardian G & H series pumps.

Figure 6-2: Recommended bolt torques

Item	Description	Group 1 Nm (lbf•ft)	Group 2 Nm (lbf•ft)
222	Pump shaft cap	34 (25)	47 (35)
6570.3	Bearing housing cap to bearing housing	11 (8)	41 (30)
6570.4	Bearing housing foot to bearing housing	34 (25)	127 (94)
6570.5	Bearing housing to adapter	15 (11)	15 (11)
6570.6	Containment shell to bearing holder	15 (11)	34 (25)
6570.8	Outer magnet flange to power end shaft	7 (5)	7 (5)
6580.1	Pump casing to adapter (1/2 in.)	34 (25)	34 (25)
6580.1	Pump casing to adapter (5/8 in.)	n/a	61 (45)

6.6 Setting impeller clearance

A new impeller gasket [4590.2] must be installed whenever the impeller has been removed from the shaft. Impeller clearance settings may be found in Section 5.3

6.6.1 Installation and clearance setting for Guardian G & H series reverse vane impellers

Install the impeller [2200] by screwing it onto the shaft (use heavy gloves) until it firmly seats against the shaft shoulder.

CAUTION The impeller could have sharp edges, which could cause an injury. It is very important to wear heavy gloves.

Tighten the impeller with the impeller wrench from the Flowserve Mark 3 tool kit. To do this, grasp the impeller in both hands and, with the impeller wrench handle to the left (viewed from the impeller end of the shaft) spin the impeller forcefully in a clockwise direction to impact the impeller wrench handle on the work surface to the right.

6.6.2 Setting the impeller clearance

a) Temporarily tighten the impeller [2200] to the pump shaft [2100.1]. Turn the impeller in a clockwise direction until the impeller is firmly seated but only hand tight.

   CAUTION Do not attempt to tighten the impeller on the shaft by hitting the impeller with a hammer or any other object or by inserting a pry bar between the impeller vanes. Serious damage to the impeller may result from such actions.

b) Place the entire assembly vertically on the workbench with the impeller down and supporting the weight of the assembly. Measure the minimum clearance between the bearing holder face [3830] and the impeller [2200] with a feeler gauge without forcing the impeller away from the face. Measure the clearance between the bearing holder and ALL THE VANES to determine closest vane. Use the smallest measurement as your guide and record this number.

c) The Guardian Magnetic Drive requires a clearance of 0.45 ±0.08mm (0.018 ±0.003 in.), regardless of operating temperature, between the closest impeller vane and the face of the bearing holder. Determine the number of shims that must be placed between the impeller and the thrust collar by subtracting the minimum clearance between the bearing holder and the impeller from the thickness of the impeller shims already inserted. Add 0.45 mm (0.018 in.) to this difference. This number is the thickness of shims that are required to adjust the impeller.

For example, if the initial measurement between the closest impeller vane and the bearing holder face is 0.75 mm (0.030 in.), and the thickness of the shims already inserted is 1.00 mm (0.040 in.), use

1.00 mm – 0.75 mm = 0.25 mm
(0.040 in. – 0.030 in. = 0.010 in.)

Next, add 0.45 mm (0.018 in.) to 0.25 mm (0.010 in.) to determine the thickness of the shims required to adjust the impeller properly.

0.25 mm + 0.45 mm = 0.70 mm
(0.010 in. + 0.018 in. = 0.028 in.)

A combination of shims equal to 0.70 mm (0.028 in.) thickness would then be required to set the impeller properly.

d) Set the assembly back to horizontal. Remove the impeller and the 1.00 mm (0.040 in.) combination of shims from the pump shaft. Removal should only require using your hands since the impeller was only hand tightened. If necessary, use the Durco impeller wrench to hold the shaft stationary.
e) Place the required number of shims against the shoulder in the thrust collar [3610] or thrust collar ring [207]. Thread the impeller back onto the pump shaft and tighten as described in step 1. Make sure the shims sit flat between mating faces.
f) Recheck the impeller clearance as described in step b). If the distance is more or less than required, repeat steps c) through f) until clearance is correct.
g) When the clearance is properly set, set the assembly back to horizontal. Remove the impeller and thrust collar [3610].
   Group 1. Place the thrust collar/pump shaft O-ring [4610.4] in the groove on the back side of the thrust collar. Stretch the thrust collar ring/O-ring [4610.5] over the hub on the backside of the impeller.
   Group 2. Remove the thrust collar ring and shims from the thrust collar. Place the thrust collar/ring O-ring [4610.5] into the O-ring groove on the shimming side of the thrust collar. Using an arbor press, press the thrust collar ring and shims into the thrust collar. In order to keep the shims from falling out of the thrust collar during this press, the ring should be placed on the work surface with the thrust collar on top of it. Place the thrust collar/pump shaft O-ring [4610.4] into the groove on the pump shaft side of the thrust collar. Place the thrust collar into the bearing holder [3830] so the thrust journal sits flat on the grooved portion of the T-shaped bushing [3300.1].
h) Install new impeller gasket (4590.2) and tighten the impeller until it is firmly seated.
   CAUTION Failure to tighten the impeller sufficiently may allow liquid to reach the impeller thread. Additionally, a loose impeller will be tightened when the pump is started, but may be very difficult to remove later.
   Note: The impeller will be difficult to turn because there is deformation of the O-rings during seating of the impeller.

6.7 Disassembly

a) Before performing any maintenance, disconnect the driver from its power supply and lock it off line.
   CAUTION Lock out power to driver to prevent personal injury.
b) Close the discharge and suction valves, and drain all liquid from the pump.
c) Close all valves on auxiliary equipment and piping, then disconnect all auxiliary piping.
d) Decontaminate the pump as necessary.
   CAUTION If Flowserve Guardian G & H series pumps contain dangerous chemicals, it is important to follow plant safety guidelines to avoid personal injury or death.

6.7.1 Power end removal without breaking process containment

At this point, it may be necessary to detach some of the instrumentation.

By following the steps in sections 6.7.1.1 or 6.7.1.2, the process fluid is contained and the power end can be completely removed. This procedure does not preclude the use of personal protective gear. Personnel should follow their standard plant safety practices.

6.7.1.1 Long-coupled Guardian G & H series pumps

Figure 6-3A: Power end removal with process contained by wet end

a) Remove coupling guard.
b) Remove the spacer coupling.
c) Loosen the cap screw(s) holding the bearing housing foot to the baseplate.
d) To remove the power end from the wet end, remove the four (4) bearing housing/adapter fasteners [6570.5]. The magnetic coupling will remain connected due to the radial and axial forces of the magnets.
e) Screw the four (4) square head jackbolts [6575] in the bearing housing through the threaded taps until each comes into contact with the adapter. Continue to screw all jackbolts in evenly to detach the wet end from the power end. (Figure 6-3A.)

CAUTION Do not attempt to remove the power end by any other method. The magnetic force can cause severe personal injury.

CAUTION Be sure to separate the inner and outer magnet assemblies evenly. Cocking of the two can result in serious damage to the magnets and/or containment shell. It is best to alternatively give each bolt a turn to ensure proper and even separation.

Note: Depending on pump size and magnet length, it may be necessary to move the motor to complete step e).

f) To disassemble the power end, follow steps a) through g) in Section 6.7.5.

6.7.1.2 Close-coupled Guardian G & H series pumps

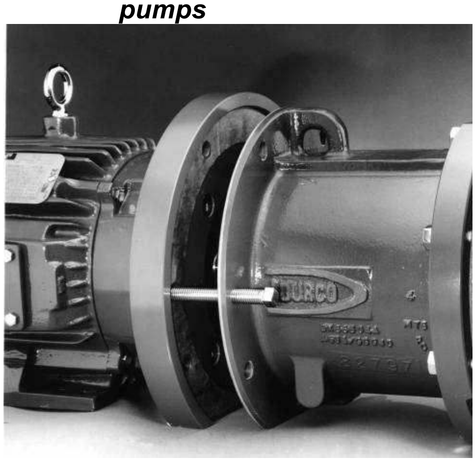


Figure 6-3B

a) Loosen the fasteners (if applicable) holding the motor to the baseplate.
b) Remove the four (4) fasteners [6570.10] that hold the motor flange [251] to the lantern [3132].
c) Engage the two (2) square head jackscrews [6575] that are located at the 3 o'clock and 9 o'clock positions on the lantern [3132] until each jackscrew comes in contact with the motor flange [251]. Continue to screw both jackscrews evenly to disengage the motor from the wet end of the pump. (See Figure 6-3B.) It is best to alternate from one jackscrew to the other to ensure even separation.

CAUTION Do not attempt to remove the motor/outer magnet assembly from the wet end by any other method. The magnetic force can cause severe personal injury.

d) To complete the disassembly of the close-coupled drive end, see Section 6.7.5.2.

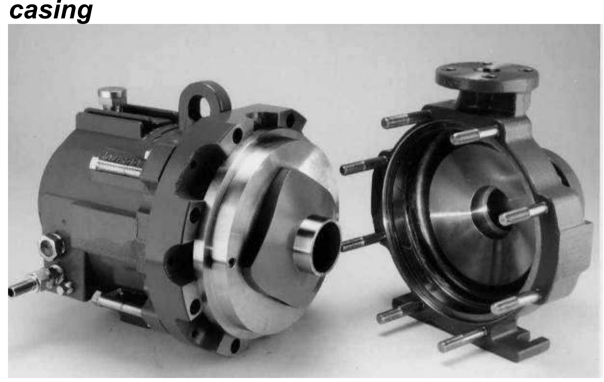
6.7.2 Removing the entire pump assembly from the casing

Small amounts of liquid may be trapped in the casing and/or containment area. Proper decontamination is the responsibility of the user.

Drain and flush the pump before proceeding to Sections 6.7.2.1 or 6.7.2.2. The Guardian Magnetic Drive pump is designed to handle corrosive, toxic, and hazardous process fluids and may need to be decontaminated prior to any disassembly.

6.7.2.1 Long-coupled Guardian G & H series pumps

Figure 6-4: Removing entire pump assembly from casing



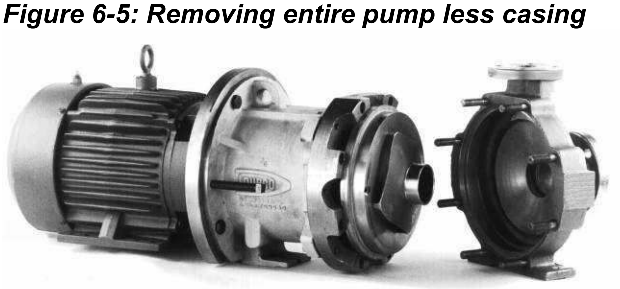
a) Remove the spacer from the spacer coupling.
b) For the larger pumps, attach lifting equipment to the pump. Place the equipment in light tension to support the pump when it is removed from the casing.
c) All maintenance can be performed without casing removal from the piping. To remove the back pullout pump assembly from the casing, remove all casing fastener nuts [6580] from the casing/adapter fasteners [6572]. (Figure 6-4.)
d) Remove the cap screw(s) holding the bearing housing foot to the baseplate.
e) Move the back pullout pump assembly toward the motor and rotate the unit out, leaving the casing in place. (Figure 6-4.)

In the event the pump assembly is lodged in the casing, two jackscrew locations 180 degrees apart are provided on the adapter [1340]. Inspect the casing [1100] and the face of the bearing holder for wear, corrosion, or defects. Remove the bearing holder/casing gasket [4590.1]. It is recommended that all O-rings and gaskets be replaced each time the pump is disassembled.

f) The entire pump without the casing [1100] can now be moved to the repair shop.

6.7.2.2 Close-coupled Guardian G & H series pumps

Figure 6-5: Removing entire pump less casing



a) Drain and flush the pump. The Guardian Magnetic Drive pump is designed to handle corrosive, toxic, and hazardous process fluids and may need to be decontaminated prior to any disassembly.
b) Remove the motor/outer magnet assembly by following the steps outlined in Section 6.7.1.2.
c) All maintenance can be performed without removing the casing from the piping. To remove the pump assembly from the casing, remove all casing fastener nuts [6580] from the casing/adapter fasteners [6572].
d) Remove the capscrew holding the lantern foot to the baseplate (if applicable).
e) Move the pump assembly back from the casing and rotate the unit out of the casing. (Figure 6-5.) In the event the pump assembly is lodged in the casing, two jackscrew locations 180 º apart are provided on the adapter [1340].
f) Inspect the casing [1100] and the face of the bearing holder [3830] for wear, corrosion, or defects. Remove the bearing holder/casing gasket [4590.1]. It is recommended that all o-rings and gaskets be replaced each time the pump is disassembled.
g) The entire pump without the casing [1100] can now be moved to the repair shop.
h) To remove the lantern [3132] from the wet end, orient the back pullout assembly vertically on the impeller. (Figure 6-6.) Remove the four (4) lantern/adapter fasteners [6570.5]. Remove the lantern [3132] by lifting it straight up from the adapter [1340].

Figure 6-6: Lantern removal

CAUTION The lantern [3132] is manufactured from ductile cast iron and may attach to the containment shell [224] upon removal due to attraction of the inner magnet assembly.

i) The entire pump without the casing [1100] can now be moved to the repair shop.

6.7.3 Detaching the wet end from the power end

At this point, it may be necessary to detach some of the instrumentation.

a) To remove the power end from the wet end, remove the four (4) bearing housing/adapter fasteners [6570.5]. (Figures 6-3A & B.) The magnetic coupling will remain connected due to the magnetic forces.
b) Screw the four (4) square head jackbolts [6575] in the bearing housing [3200] through the threaded holes until each comes into contact with a recessed hole in the adapter [1340]. For close coupled pumps, there are only two (2) jackbolts [6575]. Continue to screw all jackbolts in evenly to detach the wet end from the power end.

Do not attempt to remove the power end from the wet end by any other method. The magnetic force can cause severe personal injury.

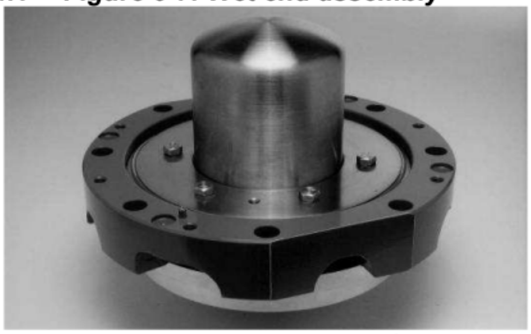
CAUTION Be sure to separate the inner and outer magnet assemblies evenly. Cocking of the two can result in serious damage to the magnets and/or containment shell. It is best to alternately give each bolt a turn to ensure proper and even separation.

6.7.4 Disassembling the wet end

Handle the journal and bushing materials with care. These parts are easily chipped and damaged.

a) Remove the six (6) retainer ring/containment shell fasteners [6570.6]. Remove the retainer ring [228]. In case the retainer ring [228] is lodged in place, two jackscrew locations are provided to aid in removal. (Figure 6-7.)

6.7.4.1 Figure 6-7: Wet end assembly



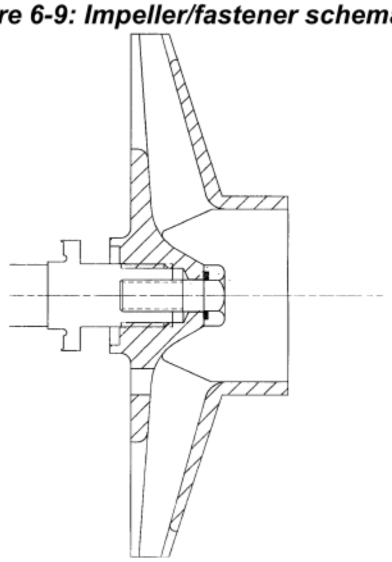
b) Remove and discard retainer ring/bearing housing O-ring [4610.1]. Remove the adapter [1340] from the bearing holder. Remove and discard O-ring [4610.7].

c) Remove the containment shell [224]. Remove the bearing holder/containment shell O-ring [4610.3] from the bearing holder [3830] and discard. (Figure 6-8.)

Figure 6-8: Containment shell removal

Close-coupled pumps ONLY. Before removing impeller from the pump shaft, the impeller fastener [2913] and O-ring [4610.8] must be removed from the center of the impeller. (See Figure 6-9.)

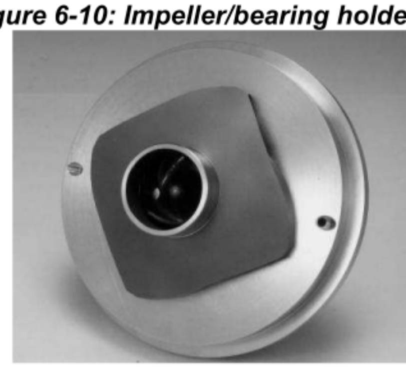
Figure 6-9: Impeller/fastener schematic



d) Remove impeller [2200] from pump shaft [2100.1]. Remove the impeller by rapping the impeller vane carefully with a hard rubber or leather mallet while holding the inner magnet stationary.
Group 1. To hold inner magnet stationary, place a wrench on the flats at the rear of the inner magnet (the impeller threads are right hand).
Group 2 (JG/JH - MG/MH couplings). To hold inner magnet stationary, place a wrench on the flats at the rear of the inner magnet (the impeller threads are right hand).
Group 2 (NG/NH - QG/QH couplings). To hold inner magnet stationary, place an adjustable spanner wrench in the two 5 mm (3/16 in.) diameter holes at the rear of the inner magnet.

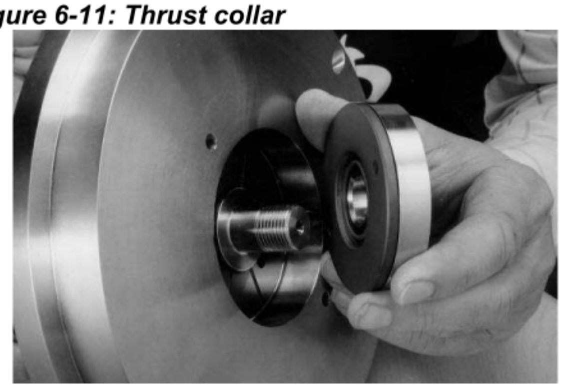
Be careful not to contact the bearing holder face while removing the impeller. Do not bend the impeller vanes. (Figure 6-10.)

Figure 6-10: Impeller/bearing holder



e) ***Group 1.*** Remove the thrust collar [3610] and thrust journal [211] from the bearing holder [3830]. (Figure 6-11.)
Group 2. Remove the thrust collar [3610], thrust collar ring [207] and thrust journal [211] from the bearing holder [3830].

Figure 6-11: Thrust collar



f) Remove the thrust collar/ring O-ring [4610.5] and the thrust collar/pump shaft O-ring [4610.4] from the thrust collar and discard. Save and protect the impeller setting shims [3126.2] for reassembly.

g) Remove the inner magnet [220] and pump shaft (2100.1) from the bearing holder [3830]. Keep the shaft in line with the bearing holder as it is removed so as to avoid cocking the assembly in the holder. (Figure 6-12.) Avoid prying or tapping the assembly when removing.

Figure 6-12: Inner magnet/shaft assembly

h) Remove the T-shaped outboard bushing [216] from the bearing holder [3830]. (Figure 6-13.) H Series pumps utilize an alloy cartridge to hold both the inboard [212] and outboard bushing [216] in the bearing holder. These cartridges are assembled at the factory. Do not attempt to disassemble bushing from cartridge. (Figure 6-14.)

Figure 6-13: Bearing holder with outboard bushing

Note: Group 1 inboard and outboard bushings and thrust journals are NOT interchangeable.

Group 2 inboard and outboard bushings are interchangeable – be sure to mark inboard vs. outboard upon removal for later evaluation.

Group 2 inboard and outboard thrust journals are NOT interchangeable.

Remove the inboard T-shaped bushing [212] from the bearing holder.

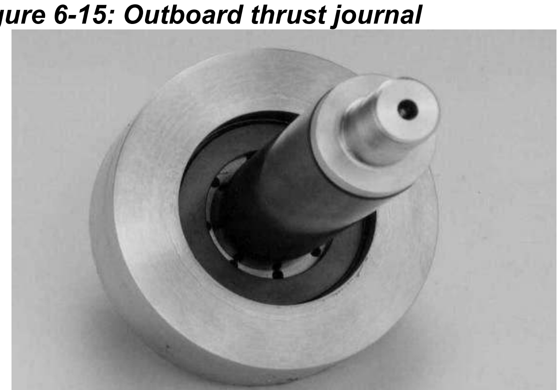
Figure 6-14: Bushings

Note: If disassembly of the inner magnet assembly/pump shaft is required, follow steps i) and j). Disassembly is necessary if the pump shaft [2100.1] or inner magnet [220] needs to be replaced. Otherwise, skip to Section 6.7.5.

Note: Newer Guardian pumps have shaft caps [222] that are LEFT HAND thread. These are indicated by an "LH" stamped into the end of the cap. Older pumps that do not have the "LH" marking utilize right hand threads. All replacement shafts/caps will have left hand threads.

i) Unscrew the pump shaft cap [222]. Remove the cap/inner magnet O-ring [4610.6] and discard. Pull the pump shaft out and remove the pump shaft key [6700.2]. Remove the pump shaft gasket [4590.6] and discard. Remove the silicon carbide thrust journal [217] from the inner magnet assembly [220]. (Figure 6-15.) If the silicon carbide journal is lodged in place, use the two holes in the inner magnet to push the journal out. If the pump shaft or pump shaft journal [213] does not need replacement, stop here and do not perform step j) because the wet end disassembly is complete. However, if the pump shaft or pump shaft journal does need replacement, proceed to step j).

Figure 6-15: Outboard thrust journal



⚠ Wear eye/hand protection as shaft journal is broken.

j) To remove the pump shaft journal [213] from the pump shaft [2100.1]. (Figure 6-16.) Wrap the part in a rag and strike the pump shaft journal [213] with a hard object to break it. Remove the shaft gasket [4590.6] and discard. (Figure 6-17.) Remove the tolerance rings [241] and discard.
   CAUTION Do not reuse the tolerance rings.
   The disassembly of the wet end is now complete.

Figure 6-16: Group 1 pump shaft/journal assembly

Figure 6-17: Group 1 shaft with mounted tolerance rings

Figure 6-18: Group 2 shaft with mounted tolerance rings

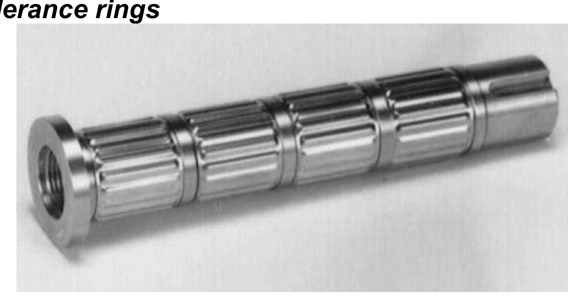


Figure 6-19: Group 1 shaft with unmounted tolerance rings

Figure 6-20: "Oil level must be maintained at center of sight glass"

6.7.5 Disassembling the power end

CAUTION Be aware of strong magnetic forces of the outer magnets. Keep magnetic material away from these magnets. Observe previous warnings concerning these magnets.

6.7.5.1 Long-coupled Guardian G & H series pumps

Figure 6-21: Power end major components

Note: This procedure is necessary if the outer magnet assembly, anti-friction bearings or oil seals must be replaced. See Figure 6-52 for recommendations on ball bearing relubrication intervals.

a) Drain the oil in the bearing housing by removing the bearing housing drain plug [6569.1]. Put the bearing housing drain plug back into place after the bearing housing is drained.
b) Remove reverse rotation screw [6570.8] with hex head wrench. The threads are right hand.
c) Unscrew the outer magnet/flange assembly [230/231] from the drive shaft [2100.2]. Mount the drive shaft/coupling key [6700] and a Durco impeller wrench on the shaft. With the wrench handle pointing to the right when viewed from the magnet side of the bearing housing [3200], grasp the magnet firmly.

Spin it rapidly in a counterclockwise direction so that the wrench handle makes a solid impact with the work surface to the left of the housing. After several sharp raps, the outer magnet/flange assembly should be free and easily removed. It is recommended that the magnet assemblies be stored in plastic bags to avoid the necessity to clean later.

Note: The threads are right hand.

d) Remove the three (3) bearing cover fasteners [6570.3] and bearing cover [3260]. Remove the bearing cover/bearing housing O-ring [4610.2] and discard. Pull the drive shaft and bearing assembly out of the bearing housing in one straight motion. Avoid cocking the assembly in the housing. Remove the wavy washer [127A]. (Figure 6-21.)
e) If the pump is provided with oil lip seals, it is recommended that these items be replaced during each pump rebuild. Lip seals [4310.1, 4310.2] can be removed from the bearing housing using an arbor press or tapped out using a flat punch.
f) If necessary, remove the bearing housing foot [3134] by unscrewing the footpiece fastener [6570.4] from the bearing housing. A shim [3126.1] may also be present.
g) If the ball bearings [3011, 3013] need to be replaced, remove the bearings from the drive shaft. If the bearings are to be replaced and the drive shaft reused, extra care should be taken so as not to damage the drive shaft. Remove the bearings with a bearing puller. Even pressure should be applied to the inner bearing race only. It is recommended that the bearings not be reused if they are removed from the drive shaft.

CAUTION Keep contaminants out of the bearing housing and bearings.

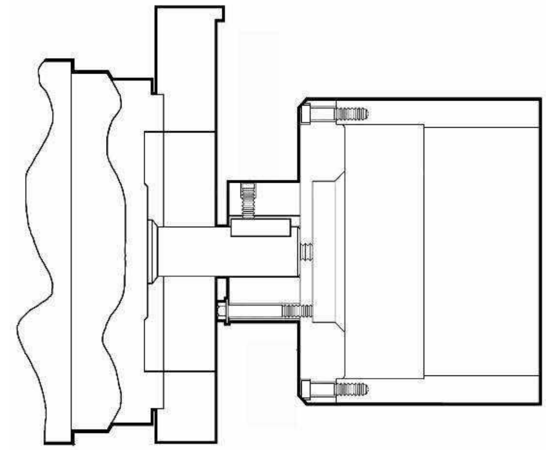
h) The power end disassembly is complete.

6.7.5.2 Close-coupled Guardian G & H series pumps – outer magnet/motor disassembly

Note: This procedure is necessary only if the outer magnet assembly [230/231] or motor must be replaced.

a) Loosen the set screw the attaches the outer magnet assembly [230/231] to the motor shaft. (See Figure 6-22.)
b) Remove the outer magnet assembly [230/231] from the motor shaft. As a disassembly aide, a threaded hole has been provided in the center of the outer magnet flange [231] to enable the outer magnet flange to be jacked off of the motor shaft. One of the square head jackscrews [6575] from the lantern [3132] can be used for this step.
c) Remove the fasteners that attach the outer magnet flange [231] to the hub [245].
d) To remove the motor flange [251] from the motor, remove the four (4) motor flange/motor fasteners [6570.11].

Figure 6-22: Outer magnet/motor assembly



e) Outer magnet/motor disassembly is complete.

6.8 Examination of parts

Cleaning/inspection

Clean all of the parts using a non-flammable solvent cleaner and inspect them for damage, wear and corrosion. Replace worn with new genuine Flowserve parts. Clean all the O-ring grooves thoroughly and remove any burrs from the grooves. The pump shaft journal should be carefully inspected. Particular attention should be given to the impeller threads, lip seals, magnetic coupling and all bearings.

CAUTION It is important that only non-flammable, non-contaminated cleaning fluids are used. These fluids must comply with plant safety and environmental guidelines.

Critical measurements and tolerances

To maximize reliability of pumps, it is important that certain parameters and dimensions are measured and maintained within specified tolerances. It is important that all parts be checked. Any parts that do not conform to the specifications should be replaced with new Flowserve parts.

Parameters that should be checked by users

Flowserve recommends that the user check the following measurements and tolerances whenever pump maintenance is performed. Each of these measurements is described in more detail on the following pages.

6.8.1 Wet end

a) Inspect the casing, impeller, bearing holder and inner magnet for wear, corrosion and defects.
b) Inspect the pins in the inner magnet, bearing holder and thrust collar for diametrical wear. The nominal diameter of these pins is 4.737 mm (0.1865 in.). Replace these pins if diametrical wear exceeds 0.508 mm (0.020 in.). These pins must be press fit using an arbor press. The height of the pins above the surface they are pressed into must not exceed 2.92 mm (0.115 in.) but not be less than 2.16 mm (0.085 in.).
c) Inspect the bushings and thrust journals for wear. Measure the thickness of the inboard thrust journal and the thickness of the flange on the inboard bushing. The nominal thicknesses for these parts can be found in Figure 6-23. If the sum of the axial wear on these two parts exceeds 0.38 mm (0.015 in.), replace these parts immediately. Repeat this inspection for the outboard bushing and outboard thrust journal. The sum of the axial wear must not exceed 0.38 mm (0.015 in.) on the outboard components.
d) Inspect the shaft journal and bushings for diametrical wear. Total diametrical wear must not exceed 0.610 mm (0.024 in.). Measure the outside diameter of the shaft journal and the inside diameter of the bushings. The nominal diameters for these parts can be found in Figure 6-23. If the sum of the wear on the shaft journal and its corresponding bushing exceeds the allowable diametrical wear, identify the worn parts and replace them immediately.

Figure 6-23: Wet end bearings allowable wear

Total axial allowable wear			0.38 mm (0.015 in.)		
Total diametrical allowable wear			0.61 mm (0.024 in.)		
BUSHING AND JOURNAL DIMENSIONS AS NEW					
	Thrust journal thickness I.B.	Thrust journal thickness O.B.	Bushing flange thickness	Bushing I.D.	Shaft journal O.D.
Group 1	4.737 (0.1865)	6.337 (0.2495)	9.45 (0.372)	34.938 (1.3755)	34.87 (1.373)
Group 2	4.737 (0.1865)	4.737 (0.1865)	9.45 (0.372)	47.377 (1.8755)	47.536 (1.8715)

Note: Dimensions shown above are in millimeters (inches).

e) Inspect the containment shell to ensure the allowable corrosion limit has not been exceeded. The containment shell thickness is 1.27 mm (0.050 in.) as new and the allowable corrosion is 0.635 mm (0.025 in.), 150 lb Class [0.508 mm (0.020 in.), 300 lb Class].
f) All wet end O-rings and gaskets must be replaced. Inspect O-ring grooves for integrity. It is good practice to replace all O-rings.

6.8.2 Power end

a) Inspect the outer magnet rub pads for wear. The height of the rub pads above the magnet outer diameter is 1.0 mm (0.04 in.) as new. If wear is greater than 0.5 mm (0.02 in.), then the rub pads should be replaced. The primary cause of worn rub pads is an anti-friction bearing failure.
b) Inspect the anti-friction bearings for scoring, pitting, scratching and rusting.

CAUTION Use of replacement parts not provided by Flowserve may result in premature pump failure, excessive damage to equipment, or personal injury. Use of non OEM or remanufactured parts voids all warranties provided.

Additional parameters checked by Flowserve

The parameters listed below are somewhat more difficult to measure and/or may require specialized equipment. For this reason, they are not typically checked by our customers, although they are monitored by Flowserve during the manufacturing and/or design process.

6.8.3 Shaft

Replace if grooved, pitted or worn. Prior to mounting bearings or installing the shaft into the bearing housing, check the following parameters.

6.8.3.1 Diameter/tolerance, under bearings

In order to ensure proper fit between the shaft and bearings, verify that both the inboard (IB) and outboard (OB) shaft diameter is consistently within the minimum/maximum values shown in Figure 6-24. A micrometer should be used to check these outside diameter (OD) dimensions on the shaft.

Figure 6-24

		Group 1	Group 2
IB and OB bearing/ shaft mm (in.)	Bearing	35.000/34.989 (1.3780/1.3775)	50.000/49.987 (1.9685/1.9680)
	Shaft	35.014/35.004 (1.3785/1.3781)	50.013/50.003 (1.9690/1.9686)
	Fit	0.025T/0.004T (0.0010T/0.0001T)	0.026T/0.003T (0.0010T/0.0001T)

6.8.4 Bearings

It is recommended that bearings not be re-used after removal from the shaft. Prior to mounting bearings, check the following parameters.

6.8.4.1 Diameter/tolerance, inside diameter

In order to ensure proper fit between bearings and the shaft, verify that the inside diameter (ID) of both the IB and OB bearing are consistently within the minimum/maximum values shown in Figure 6-24. An inside caliper should be used to check these ID diameters on the bearings.

6.8.4.2 Diameter tolerance, outside diameter
In order to ensure proper fit between bearings and the bearing housing, verify that the OD on both the IB and OB bearings are consistently within the minimum/maximum values shown in Figure 6-25. A micrometer should be used to check these outside diameter (OD) dimensions on the bearings.

Figure 6-25

		Group 1	Group 2
IB and OB bearing/ housing mm (in.)	Bearing	79.992/79.987 (3.1493/3.1491)	110.000/109.985 (4.3307/4.3301)
	Housing	80.020/80.005 (3.1504/3.1498)	110.023/110.007 (4.3316/4.3310)
	Fit	0.033L/0.013L (0.0013L/0.0005L)	0.038L/0.008L (0.0015L/0.0003L)

6.8.5 Impeller balancing
Shaft whip is deflection where the centerline of the impeller is moving around the true axis of the pump. It is not caused by hydraulic force but rather by an imbalance with the rotating element. Shaft whip can be very hard on the wetted bearings due to the resulting vibration imparted into the pump. To minimize shaft whip it is imperative that the impeller is balanced.

All impellers manufactured by Flowserve are balanced after they are trimmed. If for any reason, a customer trims an impeller, it must be re-balanced.

The maximum values of acceptable unbalance are:
- 1 500 r/min: 40 g·mm/kg
  (1 800 r/min: 0.021 oz-in/lb) of mass.
- 2 900 rpm: 20 g·mm/kg
  (3 600 rpm: 0.011 oz-in/lb) of mass.

Flowserve performs a single plane spin balance on all Guardian impellers. All balancing is performed to the ISO 1940 Grade 6.3 tolerance criteria.

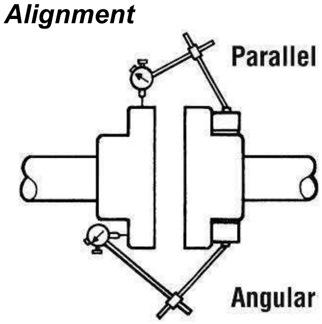
6.8.6 Bearing housing
Prior to installing the shaft into the bearing housing, check the following parameters.

6.8.6.1 Diameter/tolerance, at bearing surface
In order to ensure proper fit between the bearing housing and the bearings, verify that the ID of both the IB and OB bearing surfaces are consistently within the minimum/maximum values shown in Figure 6-25. An inside caliper should be used to check these ID dimensions in the bearing housing.

6.8.6.2 Alignment
Misalignment of the pump and motor shafts can cause the following problems:
- Failure of the motor and/or pump bearings
- Failure of the coupling
- Excessive vibration/noise

The schematics below show the technique for a typical rim and face alignment using a dial indicator. It is important that this alignment be done after the flanges are loaded, and at typical operating temperatures. If proper alignment cannot be maintained a stilt/spring mounting should be considered.

Alignment



Many companies today are using laser alignment which is a more sophisticated and accurate technique. With this method a laser and sensor measure misalignment. This is fed to a computer with a graphic display that shows the required adjustment for each of the motor feet.

See section 4.8 for recommended final shaft alignment limits.

6.8.6.3 Vibration analysis
Vibration analysis is a type of condition monitoring where a pump's vibration "signature" is monitored on a regular, periodic basis. The primary goal of vibration analysis is extension on MTBPM. By using this tool Flowserve can often determine not only the existence of a problem before it becomes serious, but also the root cause and possible solution.

Modern vibration analysis equipment not only detects if a vibration problem exists, but can also suggest the cause of the problem. On a centrifugal pump, these causes can include the following: unbalance, misalignment, defective bearings, resonance, hydraulic forces, cavitation and recirculation. Once identified, the problem can be corrected, leading to increased MTBPM for the pump.

Flowserve does not make vibration analysis equipment, however Flowserve strongly urges customers to work with an equipment supplier or consultant to establish an on-going vibration analysis program.

6.9 Assembly of pump

CAUTION It is important that all pipe threads be sealed properly. Flowserve does not recommend the use of PTFE tape as a thread sealant.

Flowserve has investigated and tested alternate sealants and has identified two that provide an effective seal, have the same chemical resistance as the tape. These are La-co Slic-Tite and Bakerseal. Both products contain finely ground PTFE particles in an oil based carrier. They are supplied in a paste form which is brushed onto the male pipe threads. Flowserve recommends using one of these paste sealants.

Full thread length engagement is required for all fasteners.

Note: Refer to Figure 6-2 for recommended bolt torques.

6.9.1 Power end assembly

6.9.1.1 Bearing installation

Mounting of bearings on shafts must be done in a clean environment. Bearing and power end life can be drastically reduced if even very small foreign particles work their way into the bearings. Wear clean gloves.

Bearings should be removed from their protective packaging only immediately before assembly to limit exposure to possible contamination. After removing the packaging they should only come in contact with clean hands, fixtures, tools and work surfaces.

The chart shown in Figure 6-26 gives the SKF part numbers for bearings in Flowserve Guardian G & H Series pumps. Note that the term "inboard bearing" refers to the bearing nearest to the casing. "Outboard bearing" refers to the bearing nearest to the motor.

a) New ball bearings and lip seals should be installed if the old ones were removed. It is good practice to replace both components whenever a pump is disassembled. Both the inboard and outboard ball bearings [3011, 3013] have a slight interference fit on the drive shaft [2100.2].
b) In order to mount open bearings (oil bath and oil mist lubricated) on the shaft, heat the bearings uniformly to 93 °C (200 °F) with an induction heater or clean oven.

   CAUTION Use insulating gloves while handling hot bearings.

Figure 6-26: Flowserve Guardian G & H Series power end bearings

Group	Type of bearing	Inboard and outboard single row, deep groove [3]
1	Oil bath/mist – open [1]	6307-C3
	Greased for life - double shielded [2]	6307-2ZC3
2	Oil bath/mist – open [1]	6310-C3
	Greased for life - double shielded [2]	6310-2ZC3

1. These bearings are open on both sides. They are lubricated by oil bath or oil mist.
2. These bearings are shielded on both sides. They come pre-greased by the bearing manufacturer. The user does not need to regrease these bearings. The shields do not actually contact the bearing race, so no heat is generated.
3. The codes shown are SKF codes. Inboard and outboard bearings have the C3, greater than "normal" clearance. These clearances are recommended by SKF to maximize bearing life. All bearing configurations are supplied only with steel cages

c) Quickly slide the bearings onto the drive shaft and position them firmly against the drive shaft shoulder. The inboard and outboard bearings are interchangeable. Let the bearings cool for at least one hour before proceeding further.

An alternate installation procedure for the open bearings is to follow the method described for sealed and shielded bearings below:

a) Sealed or shielded bearings (i.e. greased for life) should be mounted on the shaft by pressing on the inner race until the bearings rest firmly against the drive shaft shoulder.
b) When the bearings are pressed, even force should be applied to the inner race only. Never press the outer race, as the force will damage the balls and races.
c) After the bearings have been mounted, check for ease of rotation.

6.9.1.2 Power end assembly – long-coupled Guardian G & H series pumps

a) Clean the interior surfaces of the bearing housing and bearing cover using a non-flammable solvent cleaner. Press the inboard lip seal [4310.1] into the bearing housing [3132], and the outboard lip seal [4310.2] into the bearing cover [3260]. Metal shield on lip seal to face the outside environment.
b) Place the wavy washer [127A] in the bearing housing. Slide the drive shaft [2100.2] and bearings into the bearing housing [3200]. (Figure 45.)

   Note: The outboard bearing protrudes out of the bearing housing until the bearing cover is in place. When the bearing cover fasteners are tightened, the wavy washer in the bearing bore will compress, thus placing the bearings in their final position.

c) Place a new bearing cover/bearing housing O-ring [4610.2] in the bearing cover [3260] and temporarily hold it in place with a small amount of grease. Place the bearing cover [3260] onto the bearing housing and secure it with the three (3) bearing cover fasteners [6570.3]. Make sure the bearing housing drain plug [6569.1] is in place in the bearing housing.
d) Remove any material that has been attracted to the outer magnet assembly. There are close clearances between the rotating magnetic assembly and adjacent stationary parts. For reliability, it is important that foreign matter be removed.
e) Attach the outer magnet flange [231] to the outer magnet [230] using hex head cap screws [6570.7]. Screw the outer magnet flange assembly [230/231] onto the drive shaft [2100.2]. Mount the drive shaft/coupling key [6700] and a Durco impeller wrench on the shaft. Using gloves, grasp the magnet firmly and with the wrench handle pointing to the left when viewed from the magnet side of the bearing housing [3200], spin the outer magnet and flange assembly rapidly in a clockwise direction to impact the impeller wrench handle on the work surface to the right. After several sharp raps, the outer magnet assembly should be tight.

   Note: The threads are right hand.
f) Insert the socket head cap screw [6570.8] into the center of the outer magnet flange and tighten. (The threads are right hand.)
g) The assembly of the power end is complete.

6.9.1.3 Labyrinth seals

The following are general installation instructions regarding the VBXX Inpro seal. Follow the instructions provided with the seal by the manufacturer.

The elastomer O-ring located on the OD of the seal has been sized to overfill the groove in which it is located. When installing the seal into its corresponding housing, in addition to compressing the o-ring a certain amount of material may shear off. This sheared material should be removed. An arbor press should be used to install the seal.

Install the inboard seal in the bore of the bearing housing with the single expulsion port positioned at the 6 o'clock position.

Install the outboard seal in the bore of the bearing cap with the single expulsion port positioned at the 6 o'clock position.

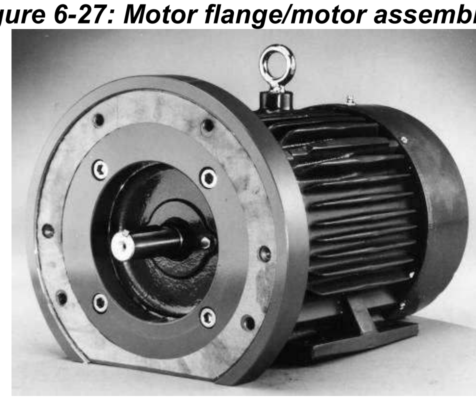
6.9.1.4 Magnetic seals

Follow the installation instructions provided by the manufacturer.

6.9.1.5 Outer magnet/motor assembly – close-coupled Guardian

a) Attach the new motor gasket [4590.8] to the motor flange [251].
b) Mount the motor flange [251] onto the motor and secure it with the four (4) motor flange/motor fasteners [6570.11]. (See Figure 6-27.)

Figure 6-27: Motor flange/motor assembly



c) Attach the hub [245] to the outer magnet assembly [230/231] using the four (4) hub fasteners. (See Figure 6-22.)
d) Place the key on the motor shaft and mount the outer magnet assembly [230/231] to the motor shaft by sliding the attached hub [245] over the motor shaft. It is critical that the face of the motor shaft contact the outer magnet flange [231]. This ensures the proper axial location of the outer magnet assembly. (See Figure 6-22.)
e) Tighten the set screw into the hub to secure the outer magnet assembly [230/231] to the motor shaft.

6.9.2 Wet end assembly

a) To place the inboard, (T-shaped) bushing [212] in the bearing holder [3830] properly, use grease, silicone or other process compatible lubricant to temporarily hold the bushing in place. Put grease on the back side of the thrust face (the flat face). This is done to hold the bushing in place when the pump shaft is inserted through the bushings. Align the bushing with the bearing bore and insert it as straight as possible. Make sure both pins rest in the groove on the back face of the bushing. Avoid cocking the bearings in order to prevent damage during installation. If the bushings do not go in easily, remove the bushing gently and try again. If the bushing still does not slide in, check for any burrs or nicks that may be present in the bearing holder and remove them with sandpaper.

b) Place the outboard, (T-shaped) bushing [216] in the outboard end of the bearing holder temporarily securing it in the same manner as the inboard bushing.

Special instructions for installing Guardian H series cartridge type bushings

In some instances Guardian H series cartridge type bushings can be difficult to install into the bearing holder due to the tight tolerance between cartridge sleeve and the bearing holder bore. For these cases, use the following procedure to install these bushings.

Note: This procedure is only necessary for H series Guardian pumps with cartridge-type bushings. For G series Guardian pumps, skip to step i).

c) Heat bearing holder to approximately 71-93 °C (160-200 °F) with a ball bearing induction heater or in a clean oven.

CAUTION Use caution when handling hot parts. Wear insulated gloves.

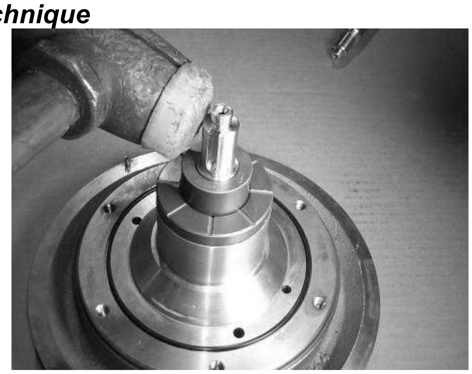
d) While the bearing holder is still hot, place the outboard cartridge bushing into the bearing holder, seating it fully and engaging the slots of the bushing with the tabs/pins of the bearing holder. The bushing should drop freely into the bearing holder.

e) Repeat step d) above with the inboard cartridge bushing.

f) With the two bushings installed in the bearing holder, place the shaft/shaft journal assembly into the outboard bushing, sliding it through the inboard bushing until it just protrudes from the other side of the inboard bushing. If the shaft will not slide through into the inboard bushing, proceed to step g). Otherwise, proceed to step i).

g) With the shaft inserted as far as it will go, use a soft mallet to *very gently* tap around the side of the keyed end of the shaft/journal from several directions. (See figure 6-28.) This will help align the bore of the outboard bushing with the inboard, allowing the shaft/journal to drop into the inboard bushing.

Figure 6-28: Guardian H series bushing alignment technique

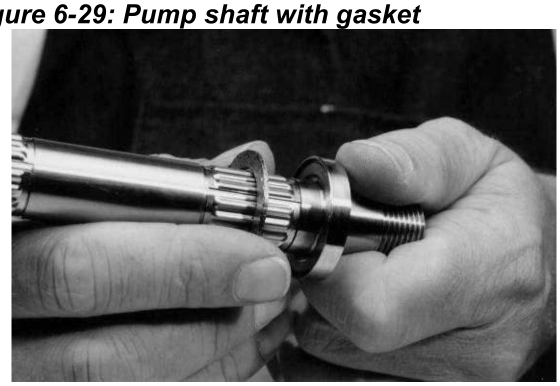


h) Rotate the shaft/journal several times to ensure it spins freely. If it does not, continue to turn the shaft/journal while *very gently* tapping on its side as in step g). This should fully align the bushings and the shaft.

i) Proceed to step j) to complete assembly of the wet end of the pump.

j) Place the outboard thrust journal [217] into the inner magnet assembly. Align the journal with the locating pins and temporarily secure it in place with lubricant.

Figure 6-29: Pump shaft with gasket



k) If the pump shaft/pump shaft journal assembly has been disassembled, follow step k). Otherwise, proceed to step n). Install the pump shaft tolerance rings [241] onto the pump shaft. Do so by first sliding them over the keyed end of the shaft. Second, expand the tolerance ring in order to slide it onto the shaft. This can be accomplished by inserting a screwdriver inside the ring and prying it open. JUST EXPAND THE TOLERANCE RING. BE CAREFUL NOT TO BEND THE TOLERANCE RING. After the tolerance ring is on the shaft, slide it towards the impeller end of the shaft until it seats into the groove closest to the keyed end of the shaft (this will aid in installing additional tolerance rings). Perform the same procedure of expanding the other tolerance ring(s) as the first and slide it down the shaft. Slide it over the first tolerance ring and continue until it seats in its respective groove. (Figure 6-30 and 6-31.)

Figure 6-30: Group 1 pump shaft with mounted tolerance rings

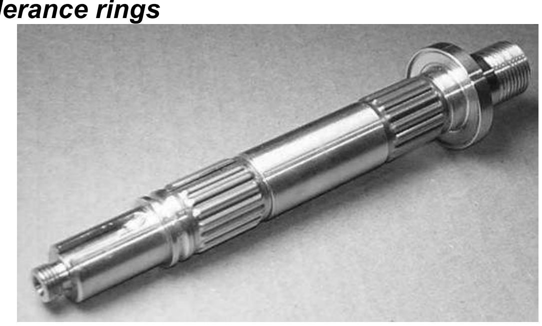


Figure 6-31: Group 2 pump shaft with mounted tolerance rings

CAUTION Tolerance rings may have sharp edges.

l) Install the pump shaft gasket [4590.6] into the flat bottomed groove located on the flanged portion of the pump shaft [2100.1]. Hold it in place with lubricant. (Figure 6-40.)

m) Using an arbor press, press the pump shaft journal [213] onto the pump shaft [2100.1] using the following procedure. DO NOT PRESS ON THE PUMP SHAFT JOURNAL. PRESS ONLY ON THE PUMP SHAFT.

First, set the pump shaft journal on a flat surface below the arbor.
Group 1. The flat surface must have a hole approximately 0.8-0.9 in. (20-23 mm) in diameter that is at least 1.5 in. (38 mm) deep.
Group 2. The flat surface must have a hole approximately 1.4-1.5 in. (36-38 mm) in diameter that is at least 1.5 in. (38 mm) deep.

Align the pump shaft journal [213] so that the hole in the flat surface is in the center of the pump shaft journal bore. Make sure the pump shaft journal is supported and cannot cock during the pressing operation.

Note: The flat surface must have a hole in it to allow the shaft to pass completely through the pump shaft journal during the pressing operation. Otherwise, the shaft would bottom out on the work surface before it is completely pressed through the pump shaft journal.

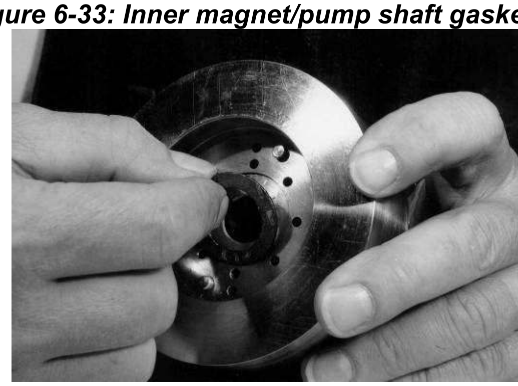
Note: An alternate method of pressing the pump shaft into the pump shaft journal is to use a bench vise. Make sure the pump shaft and pump shaft journal are not cocked relative to each other during the pressing operation.

Second, insert the keyed end of the shaft into the pump shaft journal. Press the pump shaft through the journal until the pump shaft gasket butts up against the pump shaft journal. Make sure the arbor pressing face is relatively flat so as not to cock the shaft in the pump shaft journal. (Figure 6-32.)

Figure 6-32: Pump shaft/journal assembly

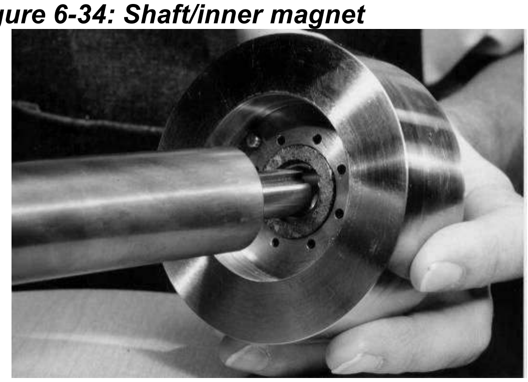
n) Place a new inner magnet/pump shaft gasket [4590.6] into the groove on the inner magnet assembly [220]. (Figure 6-33.).

Figure 6-33: Inner magnet/pump shaft gasket



Slide the pump shaft journal assembly [213/2100.1] into the inner magnet assembly. (Figure 6-34.) Insert the pump shaft key [6700.2] into the key slot of the shaft.

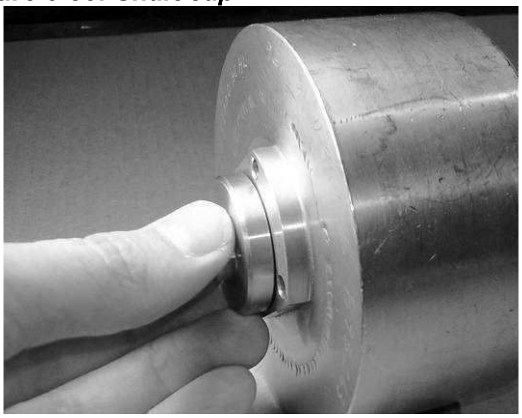
Figure 6-34: Shaft/inner magnet



Place a new cap/inner magnet O-ring [4610.6] in the O-ring groove in the pump shaft cap [222]. Thread the cap onto the end of the pump shaft to secure the pump shaft to the inner magnet assembly. (Figure 6-35.)

Note: Newer Guardian pumps use shaft caps [222] that have a LEFT HAND thread (i.e. tighten counter-clockwise). These are indicated by an "LH" stamped into the end of the cap. Older pumps that do not have the "LH" marking utilize right hand threads. All future replacement shafts/caps will have left hand threads.

Figure 6-35: Shaft cap



Group 1. To tighten the pump shaft cap, place one wrench on the flats on the back of the inner magnet and use a torque wrench on the pump shaft cap.

Group 2 (JG/JH-MG/MH couplings). To tighten the pump shaft cap, place one wrench on the flats on the back of the inner magnet and use a torque wrench on the pump shaft cap.

Group 2 (NG/NH-QG/QH couplings). To tighten the pump shaft cap, place an adjustable spanner wrench in the two 5 mm (3/16 in.) diameter holes on the back of the magnet and use a torque wrench on the pump shaft cap.

o) Slide the pump shaft/inner magnet assembly through the bushings CAREFULLY and SLOWLY. (Figure 6-36.)

Figure 6-36 Inner magnet/shaft assembly installation

Group 1. Temporarily place shims [3126.2] on the impeller side of the thrust collar [3610]. (Figure 6-37.) Shims are used to adjust the impeller clearance. Adjustment will be completed in Section 6.9.4.

Group 2. On Group 2 pumps, the shims are sandwiched between the thrust collar [3610] and thrust collar ring [207]. Place the shims into the counterbore on the thrust collar ring [207] and hold them in place with lubricant. (Figure 6-38.) Place the assembly into the thrust collar. (Figure 6-39.)

Figure 6-37: Group 1 thrust collar with shims

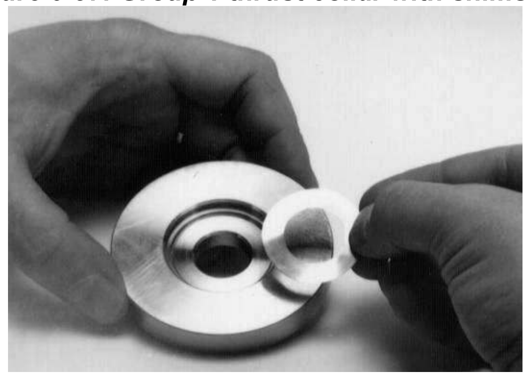


Figure 6-38: Group 2 Thrust Ring with Shims

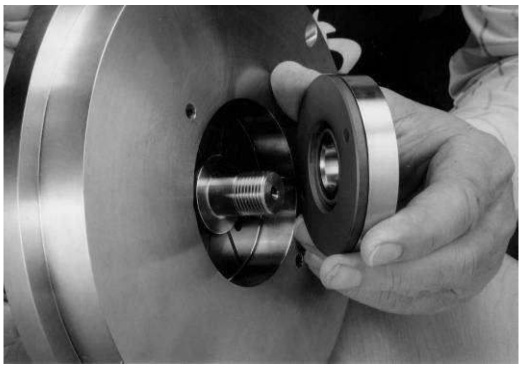
CAUTION Make sure the shims sit flat against the flat surface in the collar ring for Group 2. If they do not sit flat, the impeller may deform them during the next assembly step.

Figure 6-39 Group 2 Thrust collar/ring

p) Install the inboard thrust journal [211] into the thrust collar [3610] (using an appropriate lubricant to hold it in place). (Figure 6-40.) Place the thrust collar into the bearing holder [3830] so the thrust journal sits flat on the grooved portion of the T-shaped bushing [212]. (Figure 6-41.)

Figure 6-40: Thrust collar

Figure 6-41: Thrust collar



q) Thread the impeller on HAND TIGHT ONLY to secure the pump shaft and inner magnet assembly to the bearing holder. (Figure 6-42.) Do not install impeller gasket [4590.2] and O-ring [4610.5 and 4610.4] at this time.

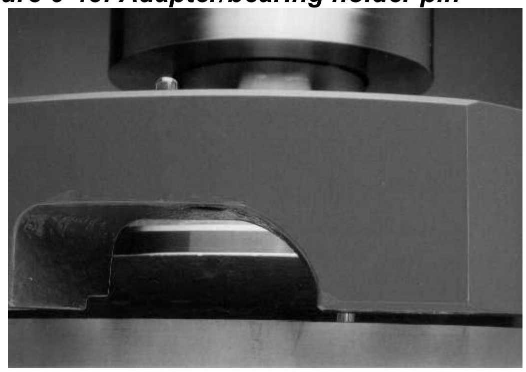
Group 1. Make sure that the shims seat flat between the impeller and the thrust collar when threading the impeller onto the shaft. If the impeller rubs the face of the bearing holder [3830], add more shims in the thrust collar.
Close-coupled pumps ONLY. After reassembly of the impeller to the pump shaft, the impeller fastener [2913] and O-ring [4610.8] must be threaded through the center of the impeller [2200] into the pump shaft [2100.1]. The impeller fastener torque should be 34 Nm (25 ft•lbs).

Figure 6-42: Impeller/bearing holder

r) Place the entire wet end assembly vertically on the workbench with the impeller down and supporting the weight of the assembly. Adjust the impeller clearance as described in Section 6.9.4.

s) Install adapter [1340] to bearing holder [3830].
Note: Orientation of the adapter to the bearing holder is vital for the proper operation of the pump (venting and draining of the containment area). Therefore, these parts have been pinned to ensure the proper radial location. (Figure 6-43.)

Figure 6-43: Adapter/bearing holder pin



t) ***Group 1.*** Stretch bearing holder/retainer O-ring [4610.7] over holder and place in outer notch of holder.
Group 2. Place the bearing housing/adapter O-ring [4610.1] and bearing holder/adapter O-ring [4610.7] into the O-ring grooves on the inner diameter of the adapter.
u) Put the bearing holder/containment shell O-ring [4610.3] into the groove on bearing holder [3830]. Making sure the O-ring sits properly in the groove, place containment shell [224] and retaining ring [228] onto the assembly. (Figure 6-44.)
v) Secure the assembly with six (6) retainer ring/ bearing holder fasteners [6570.6]. Tighten the bolts in a diagonally alternating pattern. (Figure 6-44.)
w) ***Group 1.*** Stretch retainer ring/adapter O-ring [4610.1] over the outer diameter of the retainer ring [228].

Figure 6-44: Containment shell with retaining ring

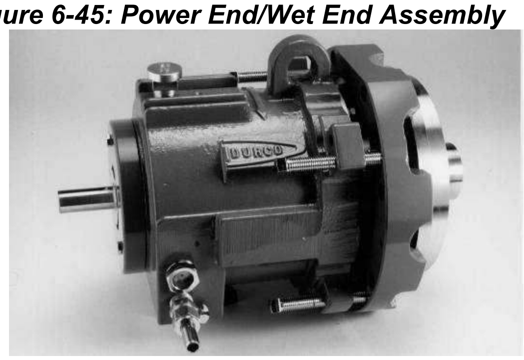
6.9.3 Mounting the wet end to the power end

6.9.3.1 Long-coupled Guardian G & H series pumps

⚠ Keep your fingers away from the pinch point where the bearing housing and adapter meet as the jackbolts are threaded. The magnetic forces draw the power end and wet end together with great force.

a) This step must be performed with the wet end assembly and bearing housing in the horizontal position. Thread the square head jackbolts [6575] completely through the threaded holes in the bearing housing [3200]. (The entire length of the bolts must be threaded through the holes.) Slide the wet end assembly into the bearing housing until the jackbolts slide into the recesses in the adapter [1340].
b) Turn the jackbolts [6575] counterclockwise to allow the wet end of the pump to slide into the power end. Turn the bolts one to two turns in a diagonally alternating pattern to prevent binding. This procedure ensures that the wet end is inserted evenly without damaging the magnets or the containment shell. (Figure 6-45.)

Figure 6-45: Power End/Wet End Assembly



c) Back out the jackbolts until the adapter butts up to the bearing housing [3200]. Make sure that the adapter [1340] and the bearing housing sit flat against one another. Insert the four (4) bearing housing/adapter fasteners [6570.5] and tighten them in an alternating pattern. Make sure the jackbolts do not interfere with the tightening of these bolts.

6.9.3.2 Close-coupled Guardian G & H series pumps – lantern assembly to the wet end

a) Make sure the lantern/retainer o-ring [4610.1] is in place in the wet end.
b) Orient the wet end vertically on the work surface. (Figure 6-46.) Align the lantern [3132] such that the roll pin in the adapter [1340] is aligned with the mating hole in the lantern [3132]. Place the lantern into adapter making sure the lantern seats flat on the adapter. Insert the four (4) lantern/adapter fasteners [6570.5] and tighten in an alternating pattern.
c) The wet end assembly can now be assembled to the outer magnet/motor assembly.

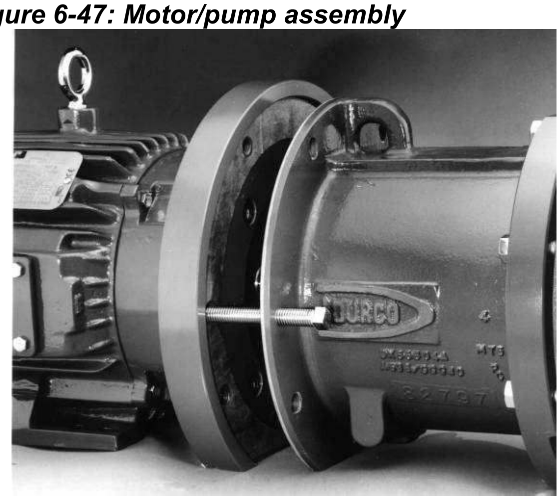
Figure 6-46: Lantern assembly to wet end

6.9.3.3 Close-coupled Guardian G & H series pumps – drive end to the wet end assembly

⚠ Keep your fingers away from the pinch point where the lantern [3132] and motor flange [251] meet as the jackscrews are threaded. Magnetic forces draw the drive end and wet end together with great force.

a) This step must be performed with the wet end assembly and motor assembly in the horizontal position. Thread the square head jackscrews [6575] completely through the threaded holes in the lantern [3132]. The entire length of the jackscrews must be threaded through the holes.
b) Install a lantern gasket [4590.7] on the face of the motor flange [251].
c) Slide the motor assembly toward the wet end assembly until the jackscrews slide into the recess in the motor flange. (See Figure 6-47.)

Figure 6-47: Motor/pump assembly



d) Turn the jackscrews [6575] counterclockwise to allow the outer magnet/motor assembly to slide over the containment shell [224]. Turn the screws one to two turns in an alternating pattern to prevent binding.
e) Back out jackscrews until the lantern [3132] butts up to the motor flange [251]. Make sure that the lantern and motor flange sit flat against one another. Insert the four (4) motor flange/lantern fasteners [6570.10] and tighten them in an alternating pattern. Make sure the jackscrews [6575] do not interfere with the tightening of these bolts.

6.9.4 Adjusting the Impeller

a) Temporarily tighten the impeller [2200] to the pump shaft [2100.1]. Turn the impeller in a clockwise direction until the impeller is firmly seated but only hand tight.

   CAUTION Do not attempt to tighten the impeller on the shaft by hitting the impeller with a hammer or by inserting a pry bar between the impeller vanes. Serious damage to the impeller may result from these actions.
b) Place the entire assembly vertically on the workbench with the impeller down and supporting the weight of the assembly. Measure the minimum clearance between the bearing holder face [3830] and the impeller [2200] with a feeler gauge without forcing the impeller away from the face. Measure the clearance between the bearing holder and ALL THE VANES to determine closest vane. Use the smallest measurement as your guide and record this number.
c) The Guardian Magnetic Drive requires a clearance of 0.45 mm (0.018 in.) ± 0.08 mm (0.003 in.), regardless of operating temperature, between the closest impeller vane and the face of the bearing holder. Determine the number of shims that must be placed between the impeller and the thrust collar by subtracting the minimum clearance between the bearing holder and the impeller from the thickness of the impeller shims already inserted. Add 0.45 mm (0.018 in.) to this difference. This number is the thickness of shims that are required to adjust the impeller.

   For example, if the initial measurement between the closest impeller vane and the bearing holder face is 0.75 mm (0.030 in.), and the thickness of the shims already inserted is 1.00 mm (0.040 in.), subtract
   0.75 mm (0.030 in.) from 1.00 mm (0.040 in.).

   1.00 mm – 0.75 mm = 0.25 mm
   (0.040 in. – 0.030 in. = 0.010 in.)

   Next, add 0.45 mm (0.018 in.) to 0.25 mm (0.010 in.) to determine the thickness of the shims required to adjust the impeller properly.

   0.25 mm + 0.45 mm = 0.70 mm
   (0.010 in. + 0.018 in. = 0.028 in.)

   A combination of shims equal to 0.70 mm (0.028 in.) thickness would then be required to set the impeller properly.
d) Set the assembly back to horizontal. Remove the impeller and the 1.00 mm (0.040 in.) combination of shims from the pump shaft. Removal should only require using your hands since the impeller was only hand tightened. If necessary, use the Durco impeller wrench to hold the shaft stationary.
e) Place the required number of shims against the shoulder in the thrust collar [3610] or thrust collar ring [207]. Thread the impeller back onto the pump shaft and tighten as described in step a). Make sure the shims sit flat between mating faces.
f) Recheck the impeller clearance as described in step b). If the distance is more or less than required, repeat steps c) thru f) until clearance is correct.
g) When the clearance is properly set, set the assembly back to horizontal. Remove the impeller and thrust collar [3610].

   Group 1. Place the thrust collar/pump shaft O-ring [4610.4] in the groove on the back side of the thrust collar. Stretch the thrust collar ring/ O-ring [4610.5] over the hub on the backside of the impeller.

   Group 2. Remove the thrust collar ring and shims from the thrust collar. Place the thrust collar/ring O-ring [4610.5] into the O-ring groove on the shimming side of the thrust collar. Using an arbor press, press the thrust collar ring and shims into the thrust collar. In order to keep the shims from falling out of the thrust collar during this press, the ring should be placed on the work surface with the thrust collar on top of it. Place the thrust collar/pump shaft O-ring [4610.4] into the groove on the pump shaft side of the thrust collar. Place the thrust collar into the bearing holder [3830] so the thrust journal sits flat on the grooved portion of the T-shaped bushing [212].
h) Install new impeller gasket [4590.2] and tighten the impeller until it is firmly seated.

   CAUTION Failure to tighten the impeller sufficiently may allow liquid to reach the impeller thread. Additionally, a loose impeller will be tightened when the pump is started, but may be very difficult to remove later.

Note: The impeller will be difficult to turn because there is deformation of the O-rings during seating of the impeller.

6.9.5 Mounting the drive assembly to the casing

a) Before mounting the drive assembly to the pump casing, drive the studs [6572] into the appropriate tapped holes. Place a new bearing holder/casing gasket [4590.1] on the gasket face of the bearing holder.
b) Move the drive assembly into position in front of the casing. Slide the drive assembly into the casing and thread the eight (8) casing fastener nuts [6580] onto the casing/adapter fasteners [6572]. Torque these bolts in an alternating pattern.
c) If the pump flange(s) have tapped holes, select flange fasteners with thread engagement at least equal to the fastener diameter but that do not bottom out in the tapped holes before the joint is tight.
d) Secure the bearing housing foot with appropriate fastener(s).

7 FAULTS; CAUSES AND REMEDIES

The following is a guide to troubleshooting problems with Flowserve Guardian G & H series pumps. Common problems are analyzed and solutions offered. Obviously, it is impossible to cover every possible scenario. If a problem exists that is not covered by one of the examples then refer to one of the books listed in section 10, *Additional sources of information* or contact a Flowserve sales engineer or distributor/representative for assistance.

FAULT SYMPTOM

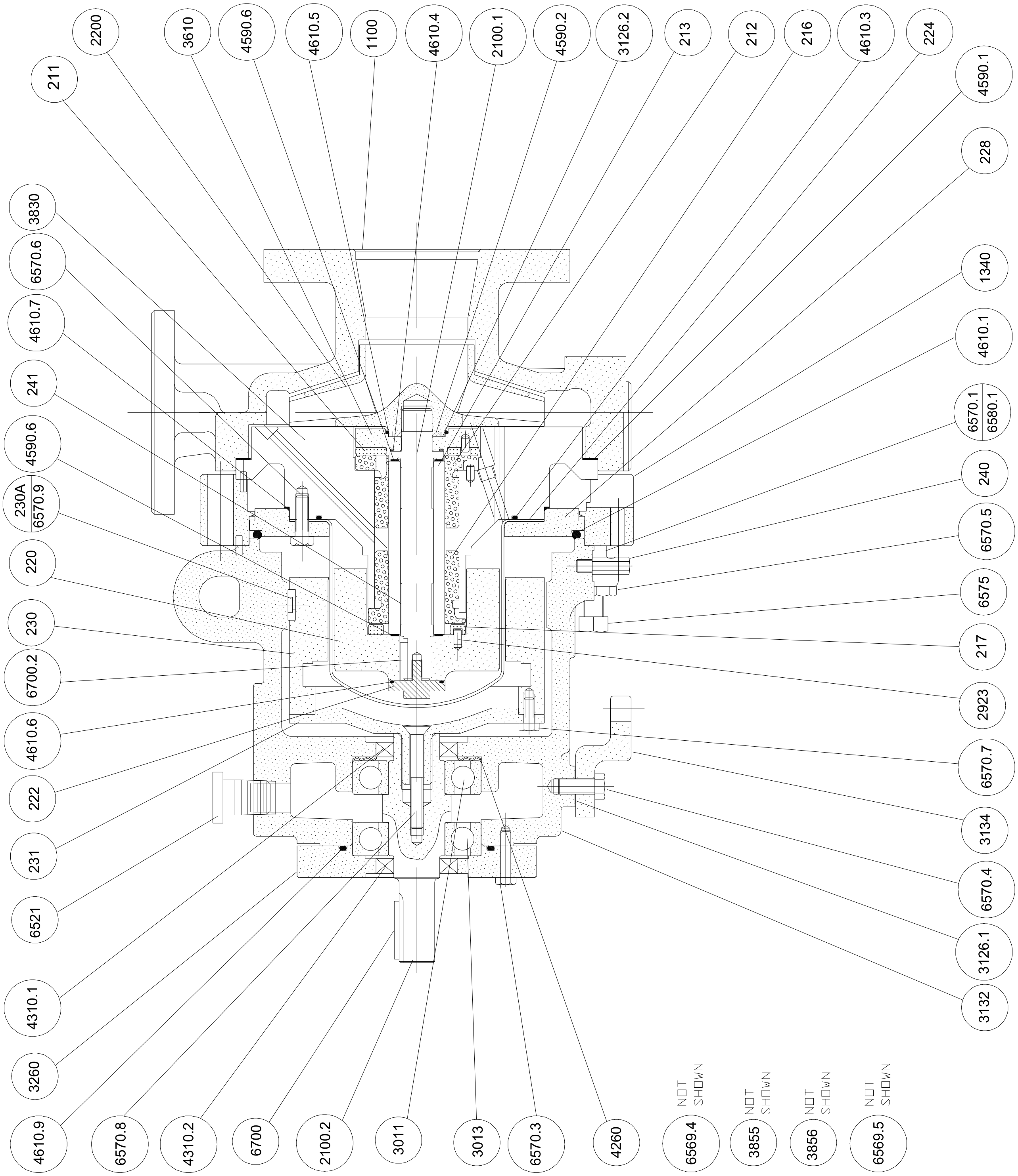
Pump not reaching design flow rate	Pump not reaching design head (TDH)	No discharge or flow with pump running	Pump operates for short period, then loses prime	Excessive noise from wet end	Excessive noise from power end	Pump exhibits increased or higher than anticipated power consumption	Pump exhibits decreased or lower than anticipated power consumption			**POSSIBLE CAUSES**	**POSSIBLE REMEDIES**
●	●		●	●						Insufficient NPSH. (Noise may not be present.)	Recalculate NPSH available. It must be greater than the NPSH required by pump at desired flow. If not, redesign suction piping, holding number of elbows and number of planes to a minimum to avoid adverse flow rotation as it approaches the impeller.
●	●	●					●			System head greater than anticipated.	Reduce system head by increasing pipe size and/or reducing number of fittings. Increase impeller diameter. (note: Increasing impeller diameter may require use of a larger motor.)
●	●		●							Entrained air. Air leak from atmosphere on suction side.	1. Check suction line gaskets and threads for tightness. 2. If vortex formation is observed in suction tank, install vortex breaker. 3. Check for minimum submergence
●	●									Entrained gas from process.	Process generated gases may require larger pumps.
●	●						●			Speed too low.	Check motor speed against design speed.
●	●	●								Direction of rotation wrong.	After confirming wrong rotation, reverse any two of three leads on a three phase motor. The pump should be disassembled and inspected before it is restarted.
●	●						●			Impeller too small.	Replace with proper diameter impeller. (NOTE: Increasing impeller diameter may require use of a larger motor.)
●	●						●			Impeller clearance too large.	Reset impeller clearance.
●	●	●								Plugged impeller, suction line or casing which may be due to a product or large solids.	1. Reduce length of fiber when possible. 2. Reduce solids in the process fluid when possible. 3. Consider larger pump.
●	●						●			Wet end parts (casing cover, impeller) worn, corroded or missing.	Replace part or parts.
	●	●					●			Not properly primed.	Repeat priming operation, recheck instructions. If pump has run dry, disassemble and inspect the pump before operation.
				●		●				Impeller rubbing.	1. Check and reset impeller clearance. 2. Check outboard bearing assembly for axial end play.
	●	●				●				Damaged bushings, pump shaft, thrust journals, or impeller.	Replace damaged parts.
				●						Abnormal fluid rotation due to complex suction piping.	Redesign suction piping, holding the number of elbows and planes to a minimum to avoid adverse fluid rotation as it approaches the impeller.
		●		●			●			Magnetic coupling decoupled due to excessive temperature or excessive horsepower requirements.	1. Check process temperature to verify it's within operating limits of pump. 2. Check horsepower required by the process to verify it is within the operating limits of the coupling size. 3. Replacement of the magnet assemblies may be necessary if the magnets overheated and were permanently damaged. A static torque test of the magnetic coupling may be necessary. Contact your Flowserve representative for details.
				●		●				Inner magnet rubbing bearing holder.	Check for damaged or worn pump shaft and bushings.

Pump not reaching design flow rate	Pump not reaching design head (TDH)	No discharge or flow with pump running	Pump operates for short period, then loses prime	Excessive noise from wet end	Excessive noise from power end	Pump exhibits increased or higher than anticipated power consumption	Pump exhibits decreased or lower than anticipated power consumption			POSSIBLE CAUSES	POSSIBLE REMEDIES
					●	●				Bearing contamination appearing on the raceways as scoring, pitting, scratching or rusting caused by adverse environment and entrance of abrasive contaminants from atmosphere.	1. Work with clean tools in clean surroundings. 2. Remove all outside dirt from housing before exposing bearings. 3. Handle with clean dry hands. 4. Treat a used bearing as carefully as a new one. 5. Use clean solvent and flushing oil. 6. Protect disassembled bearing from dirt and moisture. 7. Keep bearings wrapped in paper or clean cloth while not in use. 8. Clean inside of housing before replacing bearings. 9. Check oil seals and replace as required. 10. Check all plugs and tapped openings to make sure that they are tight.
					●	●				Brinelling of bearing identified by indentation on the ball races, usually caused by incorrectly applied forces in assembling the bearing or by shock loading such as hitting the bearing or drive shaft with a hammer.	When mounting the bearing on the drive shaft use a proper size ring and apply the pressure against the inner ring only. Be sure when mounting a bearing to apply the mounting pressure slowly and evenly.
					●	●				False brinelling of bearing identified again by either axial or circumferential indentations usually caused by vibration of the balls between the races in a stationary bearing.	1. Correct the source of vibration. 2. Where bearings are oil lubricated and employed in units that may be out of service for extended periods, the drive shaft should be turned over periodically to relubricate all bearing surfaces at intervals of one to three months.
					●	●				Thrust overload on bearing identified by flaking ball path on one side of the outer race or in the case of maximum capacity bearings, may appear as a spalling of the races in the vicinity of the loading slot. (Please note: maximum capacity bearings are not recommended in Mark 2I pumps.) These thrust failures are caused by improper mounting of the bearing or excessive thrust loads.	Follow correct mounting procedures for bearings.
					●	●				Misalignment identified by fracture of ball retainer or a wide ball path on the inner race and a narrower cocked ball path on the outer race. Misalignment is caused by poor mounting practices or defective drive shaft. For example, bearing not square with the centerline or possibly a bent shaft due to improper handling.	Handle parts carefully and follow recommended mounting procedures. Check all parts for proper fit and alignment.
					●	●				Bearing damaged by electric arcing identified as electro- etching of both inner and outer ring as a pitting or cratering. Electrical arcing is caused by a static electrical charge emanating from belt drives, electrical leakage or short circuiting.	1. Where current shunting through the bearing cannot be corrected, a shunt in the form of a slip ring assembly should be incorporated. 2. Check all wiring, insulation and rotor windings to be sure that they are sound and all connections are properly made. 3. Where pumps are belt driven, consider the elimination of static charges by proper grounding or consider belt material that is less generative.
					●	●				Bearing damage due to improper lubrication, identified by one or more of the following: 1. Abnormal bearing temperature	1. Be sure the lubricant is clean. 2. Be sure proper amount of lubricant is used. The constant level oiler supplied with Durco pumps will maintain the proper oil level if it is installed and operating properly. In the case of greased

Pump not reaching design flow rate	Pump not reaching design head (TDH)	No discharge or flow with pump running	Pump operates for short period, then loses prime	Excessive noise from wet end	Excessive noise from power end	Pump exhibits increased or higher than anticipated power consumption	Pump exhibits decreased or lower than anticipated power consumption			POSSIBLE CAUSES	POSSIBLE REMEDIES
										rise. 2. A stiff cracked grease appearance. 3. A brown or bluish discoloration of the bearing races.	lubricated bearings, be sure that there is space adjacent to the bearing into which it can rid itself of excessive lubricant, otherwise the bearing may overheat and fail prematurely. 3. Be sure the proper grade of lubricant is used.
					●	●				Outer magnet assembly rubbing bearing housing.	1. Check integrity of ball bearings. 2. Make sure drive shaft is not bent. 3. Make sure outer magnet assembly has not come unscrewed due to incorrect motor rotation.

8 PARTS LIST AND DRAWINGS

8.1 Cutaway – Guardian G & H Series – Group 1 – long coupled

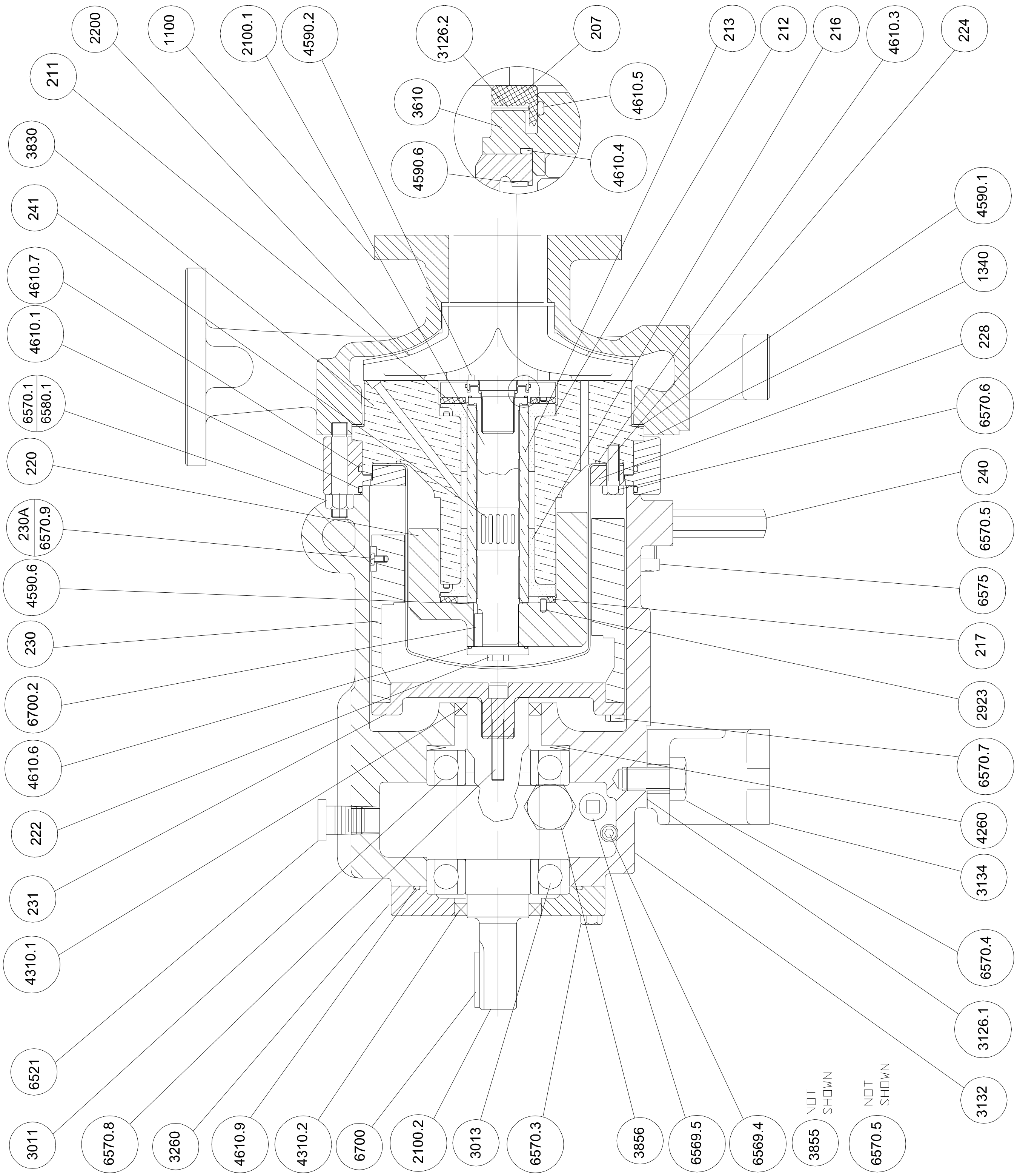


8.1.1 Parts list – Guardian G & H Series – Group 1 – long coupled

Parts list – Guardian G & H Series – Group 1 – long coupled

Item	Qty	Description	Item	Qty	Description	Item	Qty	Description
200B	1	Tag – Oil Level	2923	8	Pin	4610.4	1	O-ring
211	1	Journal – Inboard	3011	1	Ball Bearing	4610.5	1	O-ring
212	1	Bushing – Inboard	3013	1	Ball Bearing	4610.6	1	O-ring
213	1	Journal – Sleeve	3126.1	n/a	Shim	4610.7	1	O-ring
216	1	Bushing – Outboard	3126.2	n/a	Shim	4610.9	1	O-ring
217	1	Journal – Outboard	3134	1	Support Foot	6521	1	Vent Plug
220	1	Magnet Assy – Inner	3200	1	Bearing Housing	6569.1	1	Plug
222	1	Cap – Pump Shaft	3260	1	Bearing Cover	6569.5	1	Plug
224	1	Containment Shell	3610	1	Thrust Collar	6570.3	3	Screw
228	1	Retainer Ring	3830	1	Holder	6570.4	1	Screw
230	1	Magnet Assy – Outer	3855	1	Constant Level Oiler	6570.5	4	Screw
230A	4	Rub Pad	3856	1	Sight Oil Gauge	6570.6	6	Screw
231	1	Flange – Outer Magnet	4260	1	Spring	6570.7	4	Screw
240	1	Support – Housing	4310.1	1	Lip Seal	6570.8	1	Screw
241	2	Tolerance Ring	4310.2	1	Lip Seal	6570.9	4	Screw
1100	1	Casing	4590.1	1	Gasket	6572.1	8	Stud
1340	1	Adapter	4590.2	1	Gasket	6575	4	Jackscrew
2100.1	1	Shaft	4590.6	2	Gasket	6580.1	8	Nut
2100.2	1	Shaft	4610.1	1	O-ring	6700.1	1	Key
2200	1	Impeller	4610.3	1	O-ring	6700.2	1	Key

8.2 Cutaway - Guardian G & H Series - Group 2 – long coupled

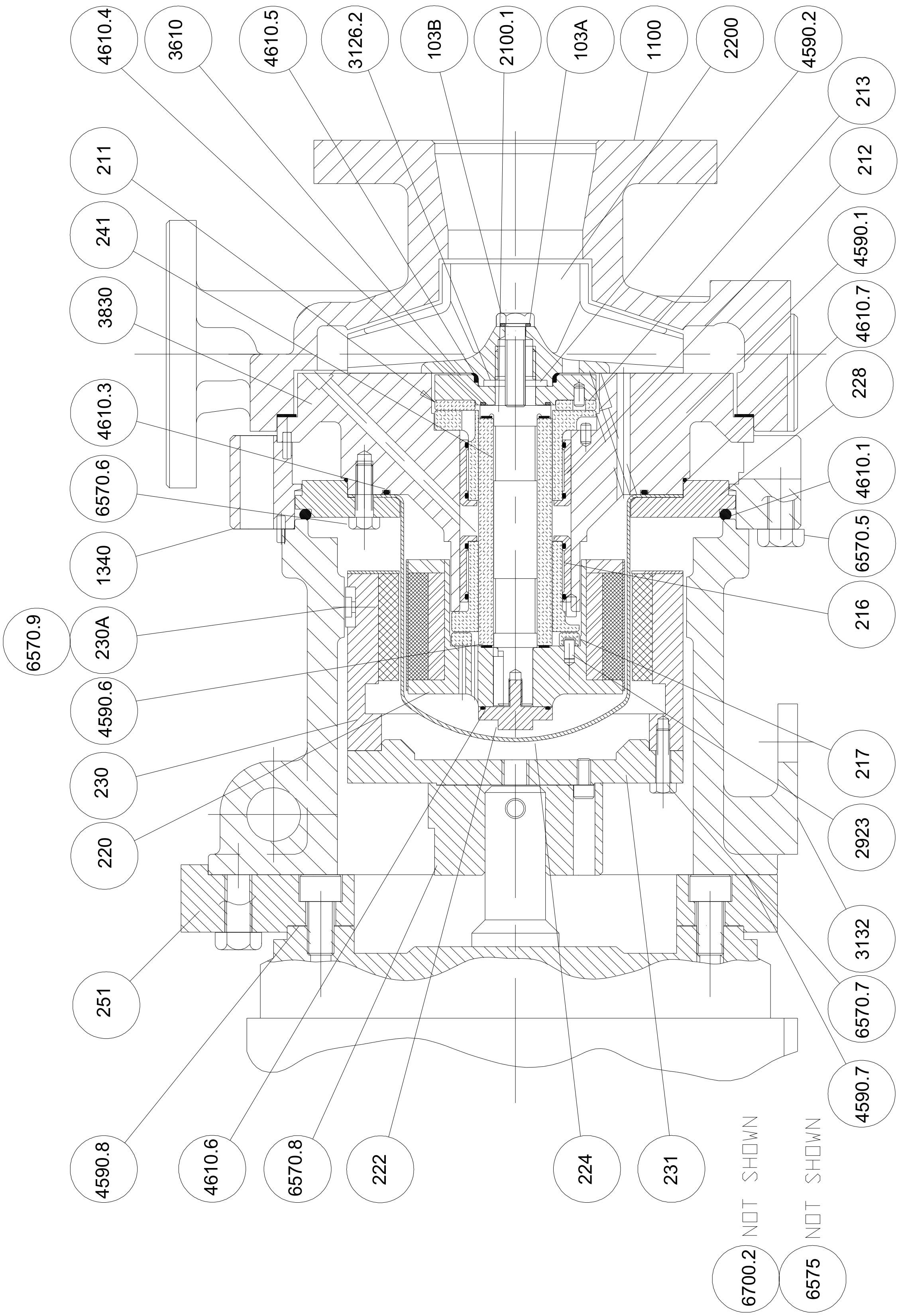


8.2.1 Parts list - Guardian G & H Series - Group 2 – long coupled

Parts list - Guardian G & H Series - Group 2 – long coupled

Item	Qty	Description	Item	Qty	Description	Item	Qty	Description
200B	1	Tag – Oil Level	2200	1	Impeller	4610.3	1	O-ring
207	1	Ring – Thrust Collar	2923	8	Pin	4610.4	1	O-ring
211	1	Journal - Inboard	3011	1	Ball Bearing	4610.5	1	O-ring
212	1	Bushing - Inboard	3013	1	Ball Bearing	4610.6	1	O-ring
213	1	Journal - Sleeve	3126.1	n/a	Shim	4610.7	1	O-ring
216	1	Bushing - Outboard	3126.2	n/a	Shim	4610.9	1	O-ring
217	1	Journal - Outboard	3134	1	Support Foot	6521	1	Vent Plug
220	1	Magnet Assy - Inner	3200	1	Bearing Housing	6569.1	1	Plug
222	1	Cap – Pump Shaft	3260	1	Bearing Cover	6569.5	1	Plug
224	1	Containment Shell	3610	1	Thrust Collar	6570.3	3	Screw
228	1	Retainer Ring	3830	1	Holder	6570.4	1	Screw
230	1	Magnet Assy - Outer	3855	1	Constant Level Oiler	6570.5	4	Screw
230A	8	Rub Pad	3856	1	Sight Oil Gauge	6570.6	6	Screw
231	1	Flange – Outer Magnet	4260	1	Spring	6570.7	6	Screw
240	1	Support - Housing	4310.1	1	Lip Seal	6570.8	1	Screw
241	4	Tolerance Ring	4310.2	1	Lip Seal	6570.9	8	Screw
1100	1	Casing	4590.1	1	Gasket	6572.1	8	Stud
1340	1	Adapter	4590.2	1	Gasket	6575	4	Jackscrew
2100.1	1	Shaft	4590.6	2	Gasket	6580.1	8	Nut
2100.2	1	Shaft	4610.1	1	O-ring	6700.1	1	Key
						6700.2	1	Key

8.3 Cutaway - Guardian G & H Series - Group 1 – close coupled



8.3.1 Parts list - Guardian G & H Series - Group 1 – close coupled

Parts list - Guardian G & H Series - Group 1 – close coupled

Item	Qty	Description	Item	Qty	Description	Item	Qty	Description
211	1	Journal - Inboard	1340	1	Adapter	4610.4	1	O-ring
212	1	Bushing - Inboard	2100.1	1	Shaft	4610.5	1	O-ring
213	1	Journal - Sleeve	2200	1	Impeller	4610.6	1	O-ring
216	1	Bushing - Outboard	2913	1	Impeller Screw	4610.7	1	O-ring
217	1	Journal - Outboard	2923	8	Pin	4610.8	1	O-ring
220	1	Magnet Assy - Inner	3126.2	n/a	Shim	6570.5	4	Screw
222	1	Cap – Pump Shaft	3132	1	Bearing Bracket Lantern	6570.6	6	Screw
224	1	Containment Shell	3610	1	Thrust Collar	6570.7	4	Screw
228	1	Retainer Ring	3830	1	Holder	6570.9	4	Screw
230	1	Magnet Assy - Outer	4590.1	1	Gasket	6570.10	4	Screw
230A	4	Rub Pad	4590.2	1	Gasket	6570.11	4	Screw
231	1	Flange – Outer Magnet	4590.6	2	Gasket	6572.1	8	Stud
241	2	Tolerance Ring	4590.7	1	Gasket	6575	4	Jackscrew
245	1	Hub and Hardware	4590.8	1	Gasket	6580.1	8	Nut
251	1	Motor Flange	4610.1	1	O-ring	6700.1	1	Key
1100	1	Casing	4610.3	1	O-ring			

9 CERTIFICATION

Certificates, determined from the contract requirements are provided with these instructions where applicable. Examples are certificates for CE marking and ATEX marking etc. If required, copies of other certificates sent separately to the Purchaser should be obtained from Purchaser for retention with these User Instructions.

10 OTHER RELEVANT DOCUMENTATION AND MANUALS

10.1 Supplementary User Instructions

Supplementary instructions such as for a driver, instrumentation, controller, seals, sealant systems etc are provided as separate documents in their original format. If further copies of these are required they should be obtained from the supplier for retention with these User Instructions.

10.2 Change notes

If any changes, agreed with Flowserve Pump Division, are made to the product after it is supplied, a record of the details should be maintained with these User Instructions.

10.3 Additional sources of information

The following are excellent sources for additional information on Flowserve Mark 3 pumps, and centrifugal pumps in general.

Pump Engineering Manual
R.E. Syska, J.R. Birk,
Flowserve Corporation, Dayton, Ohio, 1980.

Specification for Horizontal End Suction Centrifugal Pumps for Chemical Process, ASME B73.1M
The American Society of Mechanical Engineers,
New York, NY.

Specification for Sealless Horizontal End Suction Metallic Centrifugal Pumps for Chemical Process, ASME B73.3
The American Society of Mechanical Engineers,
New York, NY.

American National Standard for Centrifugal Pumps for Nomenclature, Definitions, Design and Application (ANSI/HI 1.1-1.3)
Hydraulic Institute, 9 Sylvan Way, Parsippany,
New Jersey 07054-3802.

American National Standard for Centrifugal Pumps for Installation, Operation, and Maintenance (ANSI/HI 1.4)
Hydraulic Institute, 9 Sylvan Way, Parsippany,
New Jersey 07054-3802.

Flowserve Durco Pump Parts Catalog.

Flowserve Guardian Sales Bulletin.

Flowserve Sealless Process Pump Technical Bulletin (P-20-501).

RESP73H Application of ASME B73.1M-1991, Specification for Horizontal End Suction Centrifugal Pumps for Chemical Process, Process Industries Practices
Construction Industry Institute, The University of Texas at Austin, 3208 Red River Street, Suite 300, Austin, Texas 78705.

Pump Handbook
2nd edition, Igor J. Karassik et al, McGraw-Hill, Inc., New York, NY, 1986.

Centrifugal Pump Sourcebook
John W. Dufour and William E. Nelson,
McGraw-Hill, Inc., New York, NY, 1993.

Pumping Manual, 9th edition
T.C. Dickenson, Elsevier Advanced Technology, Kidlington, United Kingdom, 1995.

NOTES:

NOTES:

Your Flowserve factory contact:

Flowserve Pump Division
3900 Cook Boulevard
Chesapeake, VA 23323-1626 USA
Telephone +1 757 485 8000
Fax +1 757 485 8149

Flowserve GB Limited
PO Box 17, Newark, Notts NG24 3EN
United Kingdom

Telephone (24 hours) +44 (0)1636 494 600
Sales & Admin Fax +44 (0)1636 705 991
Repair & Service Fax +44 (0)1636 494 833
E-mail inewark@flowserve.com

Your local Flowserve representative:

To find your local Flowserve representative please use the Sales Support Locator System found at www.flowserve.com

FLOWSERVE REGIONAL SALES OFFICES:

USA and Canada
Flowserve Corporation
5215 North O'Connor Blvd.,
Suite 2300
Irving, Texas 75039-5421, USA
Telephone +1 972 443 6500
Fax +1 972 443 6800

Europe, Middle East, Africa
Flowserve FSG – Italy
Worthing S.r.l.
Via Rossini 90/92
20033 Desio (Milan), Italy
Telephone +39 0362 6121
Fax +39 0362 628 882

Latin America and Caribbean
Flowserve Corporation
6840 Wynnwood Lane
Houston, Texas 77008, USA
Telephone +1 713 803 4434
Fax +1 713 803 4497

Asia Pacific
Flowserve Pte. Ltd
10 Tuas Loop
Singapore 637345
Telephone +65 6771 0600
Fax +65 6862 2329

DATA SHEET

Three Phase Induction Motor - Squirrel Cage

Customer :

Product line	: W22 NEMA Premium Efficiency Three-Phase	Product code :	12447060
		Catalog # :	01536ET3E254TC-W22

Frame	: 254/6TC	Locked rotor time	: 45s (cold) 25s (hot)
Output	: 15 HP (11 kW)	Temperature rise	: 80 K
Poles	: 2	Duty cycle	: Cont.(S1)
Frequency	: 60 Hz	Ambient temperature	: -20°C to +40°C
Rated voltage	: 208-230/460 V	Altitude	: 1000 m.a.s.l.
Rated current	: 38.0-34.4/17.2 A	Protection degree	: IP55
L. R. Amperes	: 255-230/115 A	Cooling method	: IC411 - TEFC
LRC	: 6.7x(Code G)	Mounting	: F-1
No load current	: 10.3-12.0/6.00 A	Rotation[1]	: Both (CW and CCW)
Rated speed	: 3530 rpm	Noise level[2]	: 72.0 dB(A)
Slip	: 1.94 %	Starting method	: Direct On Line
Rated torque	: 3.04 kgfm	Approx. weight[3]	: 121 kg
Locked rotor torque	: 220 %		
Breakdown torque	: 270 %		
Insulation class	: F		
Service factor	: 1.25		
Moment of inertia (J)	: 0.0530 kgm²		
Design	: B		

Needs to be Class 1 Div 2, provide Class 1 Div 2 motor and certification.

Output	25%	50%	75%	100%
Efficiency (%)	89.2	89.5	91.0	91.0
Power Factor	0.51	0.77	0.85	0.88

Foundation loads

Max. traction : 80 kgf

Max. compression : 200 kgf

		Drive end	Non drive end
Bearing type	:	6309 C3	6209 C3
Sealing	:	V'Ring	V'Ring
Lubrication interval	:	19000 h	20000 h
Lubricant amount	:	13 g	9 g
Lubricant type	:	Mobil Polyrex EM	

Notes

This revision replaces and cancel the previous one, which must be eliminated.
(1) Looking the motor from the shaft end.
(2) Measured at 1m and with tolerance of +3dB(A).
(3) Approximate weight subject to changes after manufacturing process.
(4) At 100% of full load.

These are average values based on tests with sinusoidal power supply, subject to the tolerances stipulated in NEMA MG-1.

Rev.	Changes Summary	Performed	Checked	Date

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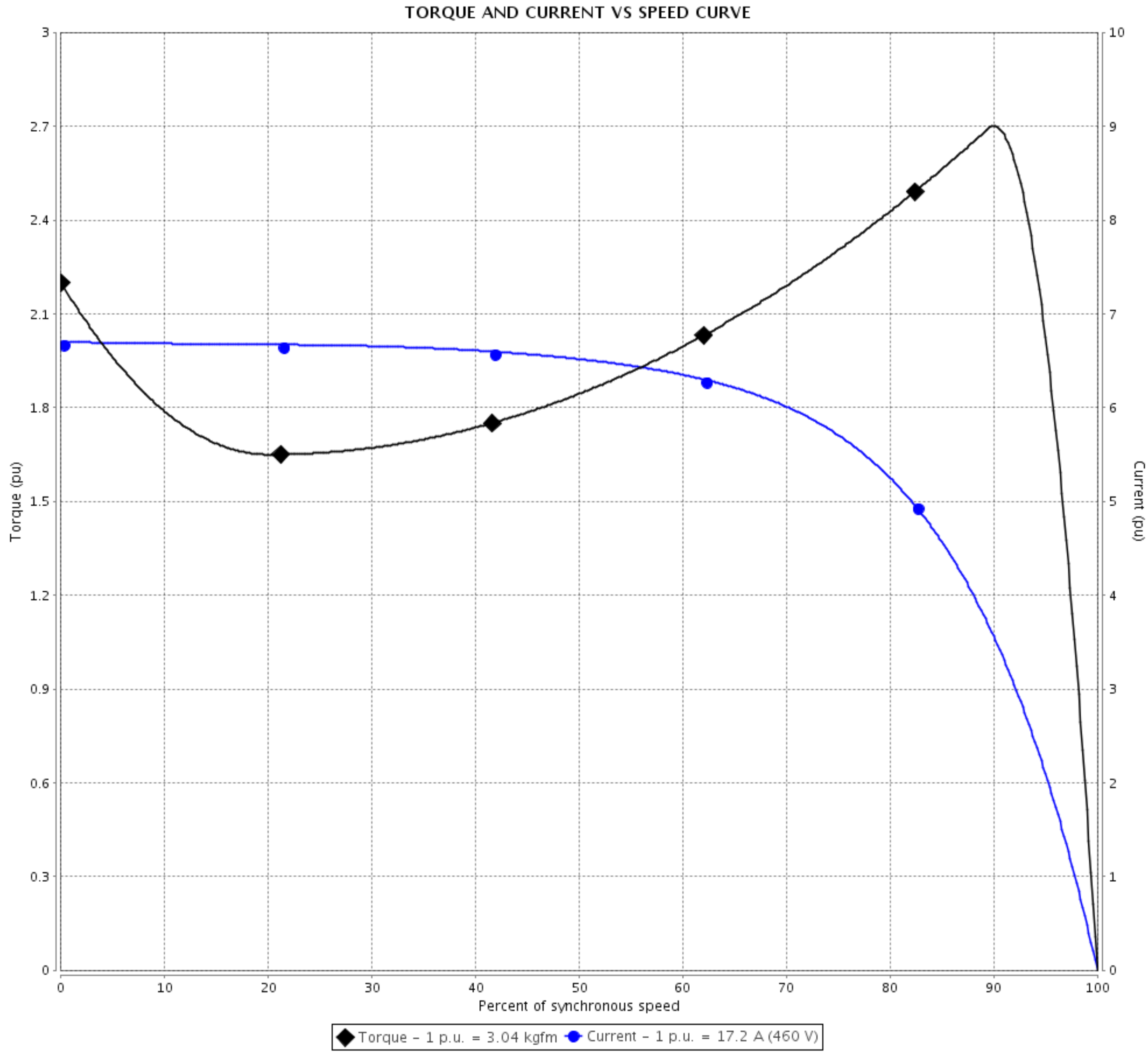
TORQUE AND CURRENT VS SPEED CURVE

Three Phase Induction Motor - Squirrel Cage

Customer	:		
Product line	: W22 NEMA Premium Efficiency Three-Phase	Product code :	12447060
		Catalog # :	01536ET3E254TC-W22



Performance	: 208-230/460 V 60 Hz 2P		
Rated current	: 38.0-34.4/17.2 A	Moment of inertia (J)	: 0.0530 kgm²
LRC	: 6.7	Duty cycle	: Cont.(S1)
Rated torque	: 3.04 kgfm	Insulation class	: F
Locked rotor torque	: 220 %	Service factor	: 1.25
Breakdown torque	: 270 %	Temperature rise	: 80 K
Rated speed	: 3530 rpm	Design	: B
Locked rotor time	: 45s (cold) 25s (hot)		

Rev.	Changes Summary	Performed	Checked	Date

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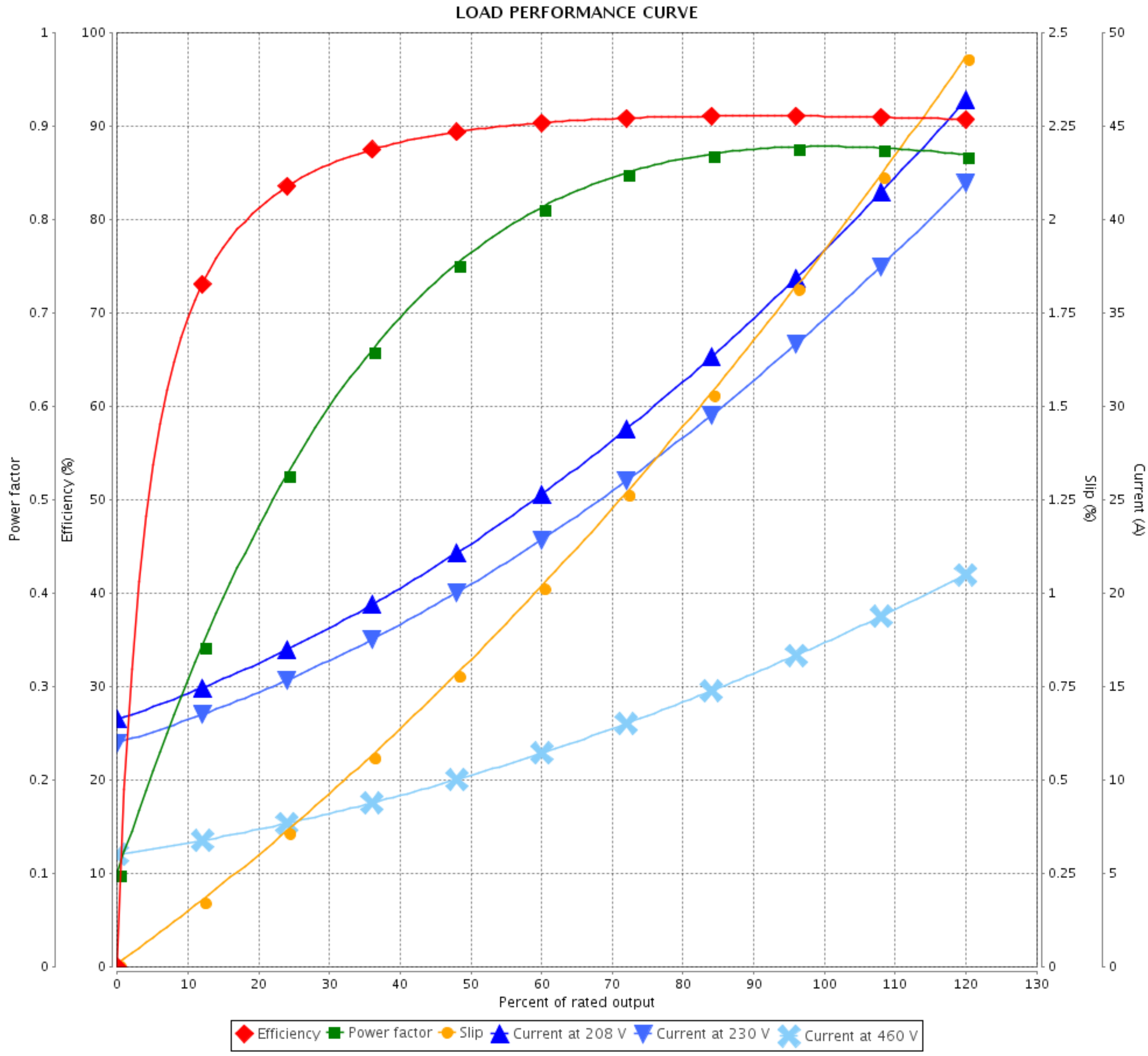
Date	24/07/2019		2 / 3	

LOAD PERFORMANCE CURVE

Three Phase Induction Motor - Squirrel Cage

Customer	:

Product line	: W22 NEMA Premium Efficiency Three-Phase	Product code :	12447060
		Catalog # :	01536ET3E254TC-W22



Performance	: 208-230/460 V 60 Hz 2P		
Rated current	: 38.0-34.4/17.2 A	Moment of inertia (J)	: 0.0530 kgm²
LRC	: 6.7	Duty cycle	: Cont.(S1)
Rated torque	: 3.04 kgfm	Insulation class	: F
Locked rotor torque	: 220 %	Service factor	: 1.25
Breakdown torque	: 270 %	Temperature rise	: 80 K
Rated speed	: 3530 rpm	Design	: B

Rev.	Changes Summary	Performed	Checked	Date

Performed by				
Checked by			Page	Revision
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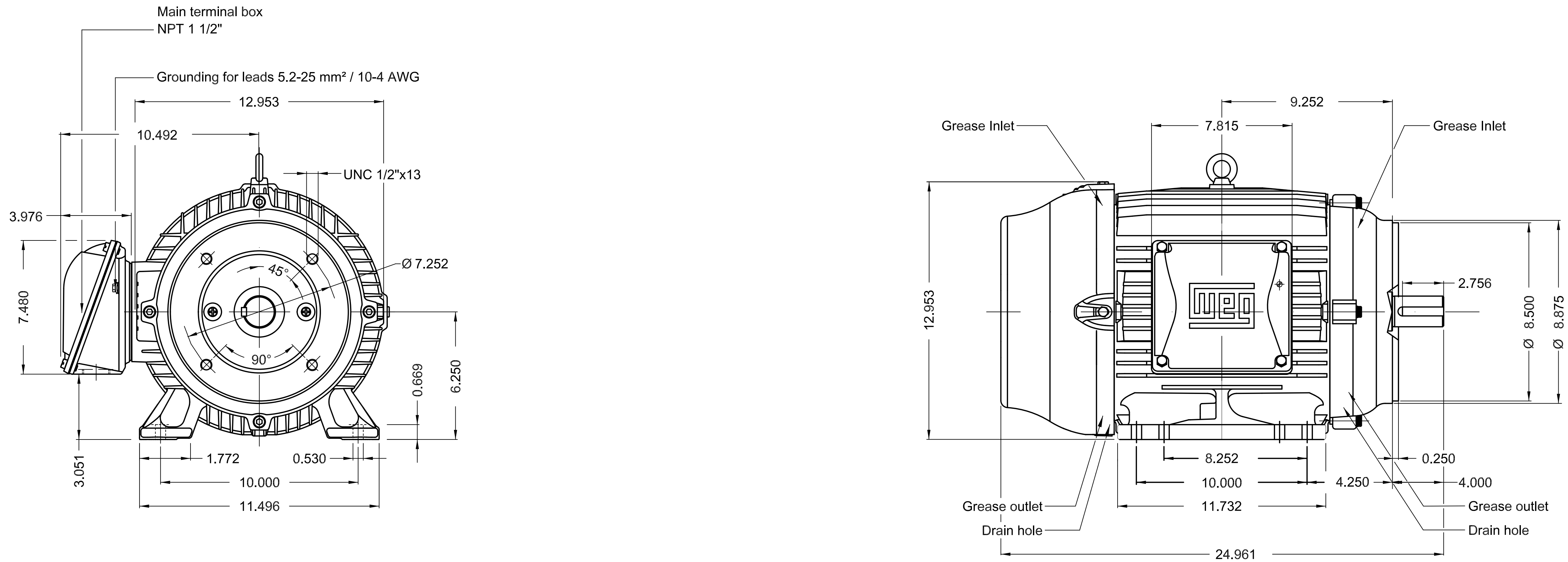


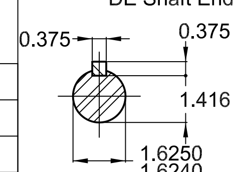
Without vertical jackscrews

Color RAL 5009

Painting plan 203A

Mounting B34R(D)

DE Shaft End



15 HP 02 Poles 60Hz

ECM	LOC	SUMMARY OF MODIFICATIONS	EXECUTED	CHECKED	RELEASED	DATE	VER
							A

EXECUTED	USERADMIN	THREE PHASE W22 MOTOR - NEMA PREMIUM EFF FRAME 254/6TC IP55 TEFC	PREVIEW
CHECKED			WDD
RELEASED			
REL DT.		WMO Jaragua do Sul Product Engineering	SHEET 1 / 1

Dimensions in inches

A3

XME

MODEL 01536ET3E254TC-W22
MADE IN BRAZIL
12447060

WEG W22 NEMA Premium®
CC029A
Inverter Duty Motor
Severe Duty

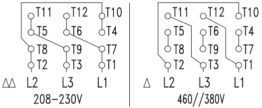
c UL us 3PT9 LISTED

FOR SAFE AREA
MOD.TE1BF0X0N

For 60Hz: Class I, Div 2, Gr. A, B, C and D – T3
Class I, Zone 2, IIC – T3
Class II, Div 2, Gr. F and G – T4
For 60Hz use on PWM, Gr. A, B, C, D and F,
VT 1000:1, CT 20:1, 1.0SF, T3A

C SP® US
Energy Verified

PH 3	FR 254/6TC	HP(kW) 15.0(11.0)	Hz 60
V 230/460	A 34.4/17.2	RPM 3530	DES B
NEMA NOM EFF 91.0 %	INS. CL. F ΔT 80 K	IP55	
ENCL TEFC	DUTY CONT.	AMB. 40°C	
CODE G	PF 0.88	SF 1.25	SFA 43.0/21.5
USABLE @208V 38.0 A SF 1.15 SFA 43.7			
15HP 11kW 50Hz 380V 20.7A 2910RPM SF1.00 EFF 89.5% (IE2)			



→ 6309-C3
→ 6209-C3

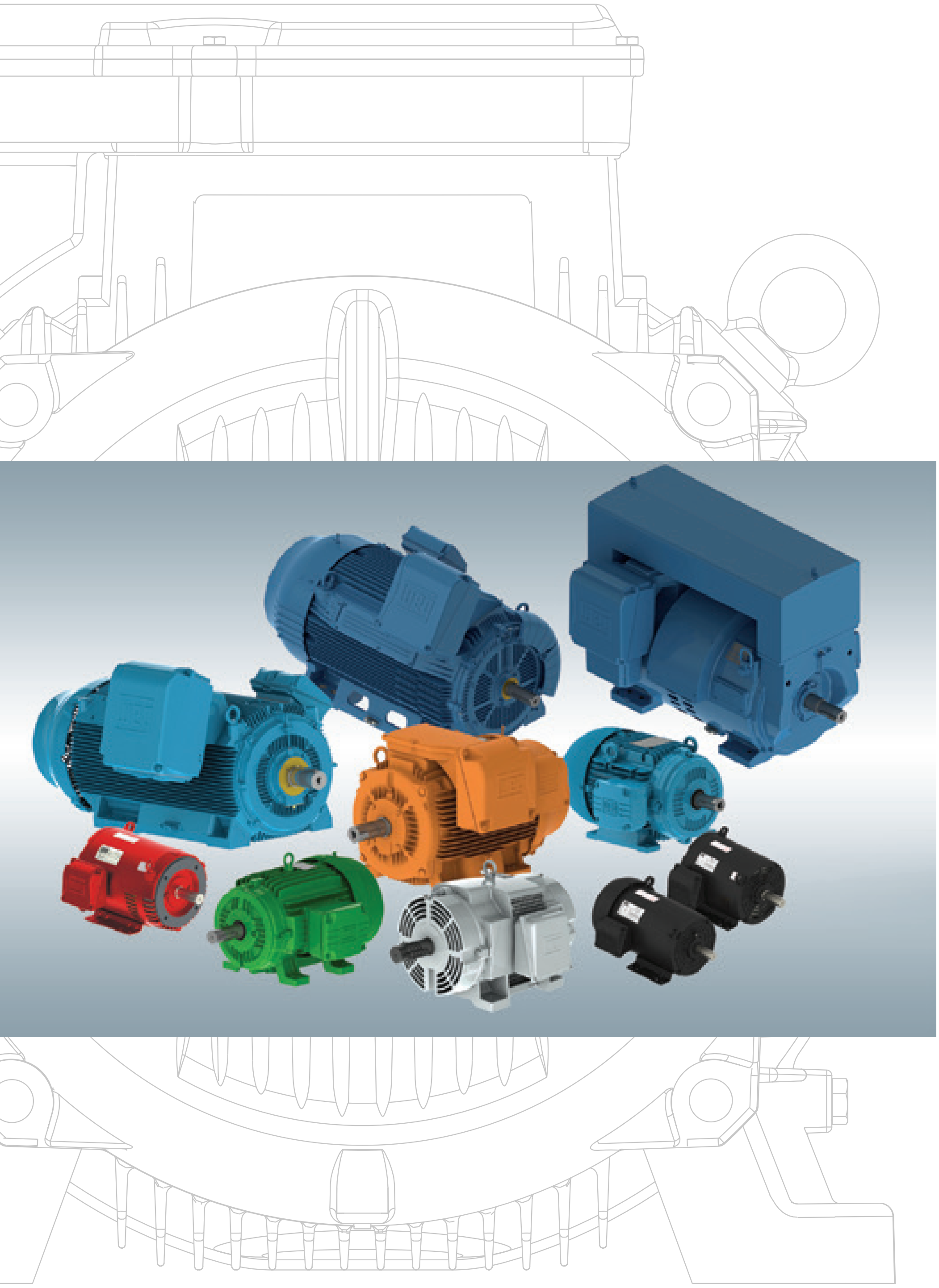
MOBIL POLYREX EM
13 g 19000 h

ALT 1000 m.a.s.l.

267 Lbs

Class 1 Div 2 required

Installation, operation and maintenance manual of electric motors



INSTALLATION, OPERATION AND MAINTENANCE MANUAL OF ELECTRIC MOTORS

This manual provides information about WEG induction motors fitted with squirrel cage, permanent magnet or hybrid rotors, low, medium and high voltage, in frame sizes IEC 56 to 630 and NEMA 42 to 9606/10.
The motor lines indicated below have additional information that can be checked in their respective manuals:
- Smoke Extraction Motors;
- Electromagnetic Brake Motors;
- Hazardous Area Motors.

These motors meet the following standards, if applicable:
- NBR 17094-1: Máquinas Elétricas Girantes - Motores de Indução - Parte 1: trifásicos.
- NBR 17094-2: Máquinas Elétricas Girantes - Motores de Indução - Parte 2: monofásicos.
- IEC 60034-1: Rotating Electrical Machines - Part 1: Rating and Performance.
- NEMA MG 1: Motors and Generators.
- CSA C 22.2 N°100: Motors and Generators.
- UL 1004-1: Rotating Electrical Machines - General Requirements.

If you have any questions regarding this manual please contact your local WEG branch, contact details can be found at www.weg.net.

TABLE OF CONTENTS

ENGLISH

1. TERMINOLOGY

Balancing: the procedure by which the mass distribution of a rotor is checked and, if necessary, adjusted to ensure that the residual unbalance or the vibration of the journals and/or forces on the bearings at a frequency corresponding to service speed are within specified limits in International Standards.
[ISO 1925:2001, definition 4.1]

Balance quality grade: indicates the peak velocity amplitude of vibration, given in mm/s, of a rotor running free-in-space and it is the product of a specific unbalance and the angular velocity of the rotor at maximum operating speed.

Grounded Part: metallic part connected to the grounding system.

Live Part: conductor or conductive part intended to be energized in normal operation, including a neutral conductor.

Authorized personnel: employee who has formal approval of the company.

Qualified personnel: employee who meets the following conditions simultaneously:
- Receives training under the guidance and responsibility of a qualified and authorized professional;
- Works under the responsibility of a qualified and approved professional.

Note*: The qualification is only valid for the company that trained the employee in the conditions set out by the authorized and qualified professional responsible for training.*

ENGLISH

2. INITIAL RECOMMENDATIONS

Electric motors have energized circuits, exposed rotating parts and hot surfaces that may cause serious injury to people during normal operation. Therefore, it is recommended that transportation, storage, installation, operation and maintenance services are always performed by qualified personnel.
Also the applicable procedures and relevant standards of the country where the machine will be installed must be considered.
Noncompliance with the recommended procedures in this manual and other references on the WEG website may cause severe personal injuries and/or substantial property damage and may void the product warranty.

For practical reasons, it is not possible to include in this Manual detailed information that covers all construction variables nor covering all possible assembly, operation or maintenance alternatives.
This Manual contains only the required information that allows qualified and trained personnel to carry out their services. The product images are shown for illustrative purpose only.

For *Smoke Extraction Motors*, please refer to the additional instruction manual 50026367 available on the website www.weg.net.

For brake motors, please refer to the information contained in WEG 50021973 brake motor manual available on the website www.weg.net.

For information about permissible radial and axial shaft loads, please check the product technical catalogue.

The user is responsible for the correct definition of the installation environment and application characteristics.

During the warranty period, all repair, overhaul and reclamation services must be carried out by WEG authorized Service Centers to maintain validity of the warranty.

2.1. WARNING SYMBOL

Warning about safety and warranty.

2.2. RECEIVING INSPECTION

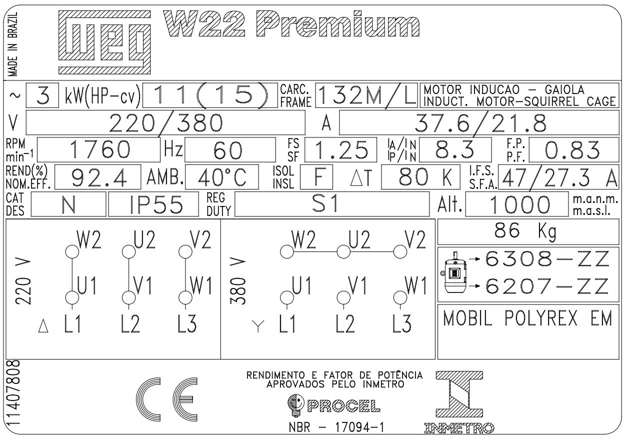
All motors are tested during the manufacturing process.
The motor must be checked when received for any damage that may have occurred during the transportation. All damages must be reported in writing to the transportation company, to the insurance company and to WEG. Failure to comply with such procedures will void the product warranty.
You must inspect the product:

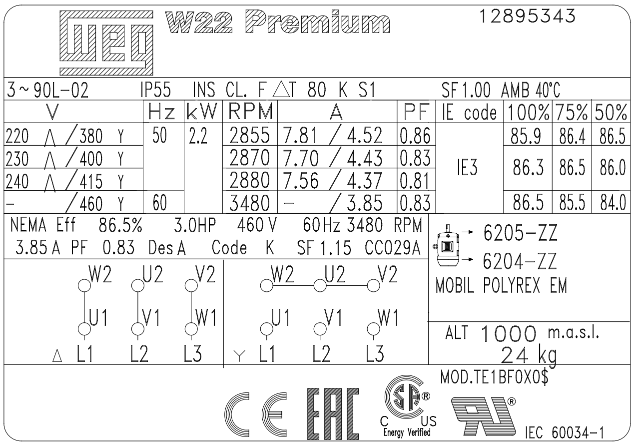
- Check if nameplate data complies with the purchase order;
- Remove the shaft locking device (if any) and rotate the shaft by hand to ensure that it rotates freely;
- Check that the motor has not been exposed to excessive dust and moisture during the transportation.

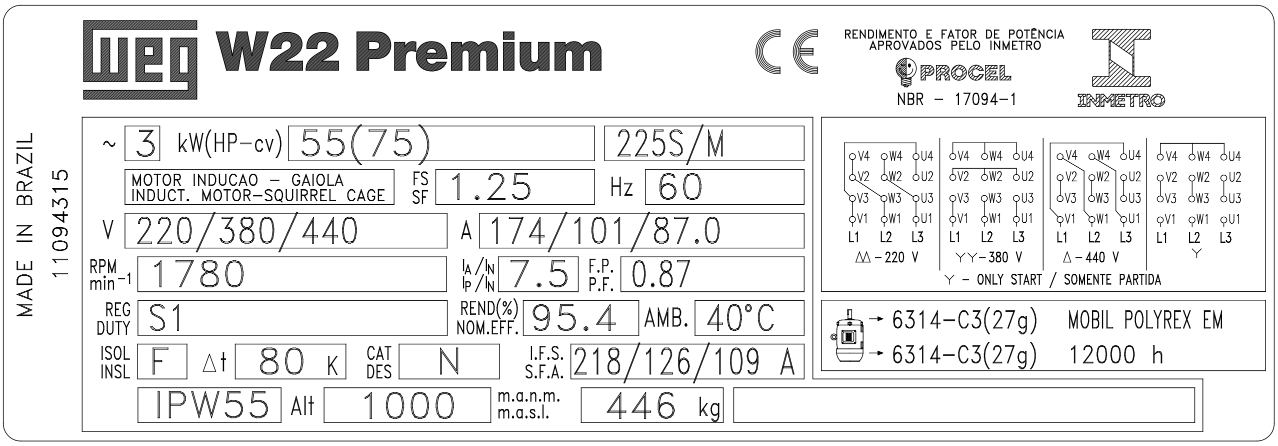
Do not remove the protective grease from the shaft, or the plugs from the cable entries. These protections must remain in place until the installation has been completed.

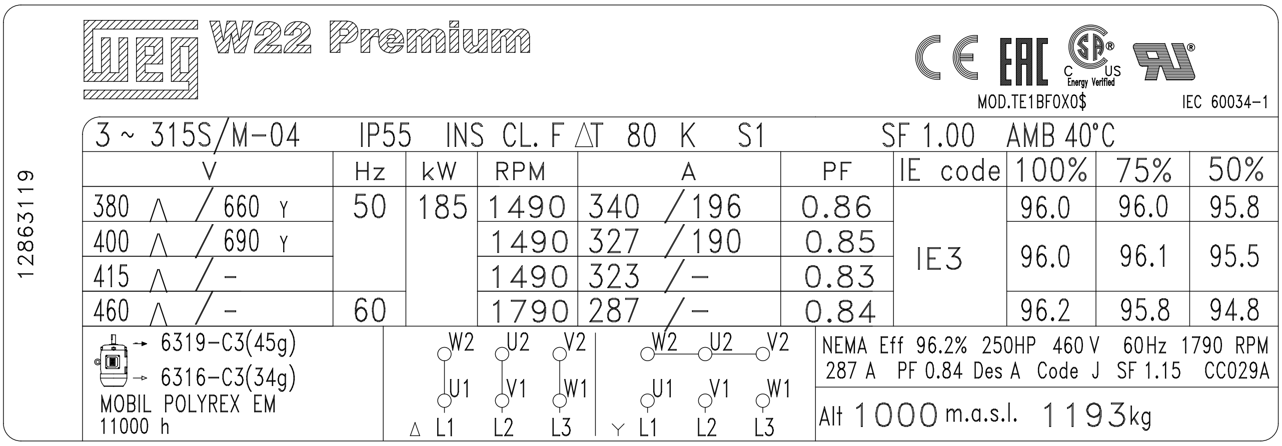
2.3. NAMEPLATES

The nameplate contains information that describes the construction characteristics and the performance of the motor. Figure 2.1 and Figure 2.2 show nameplate layout examples.









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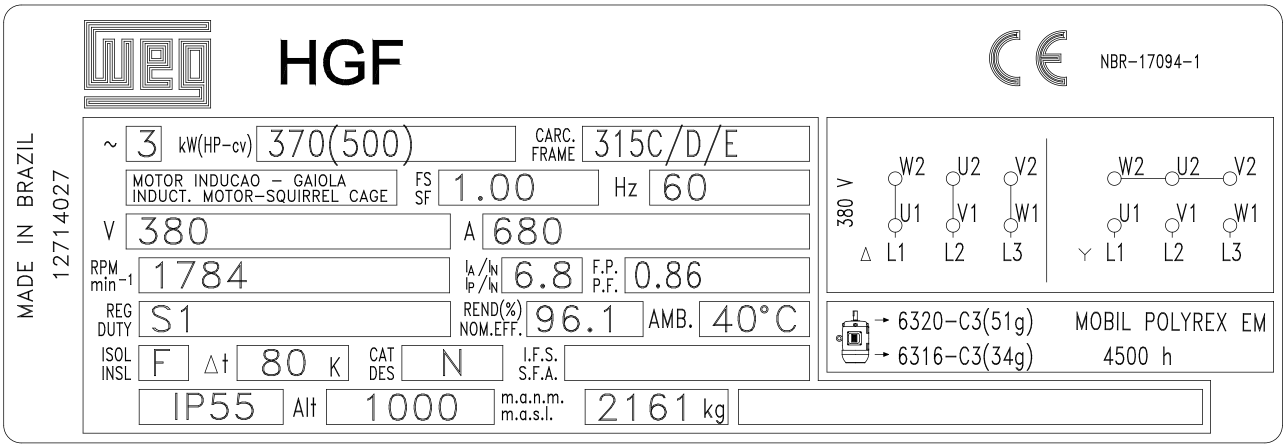

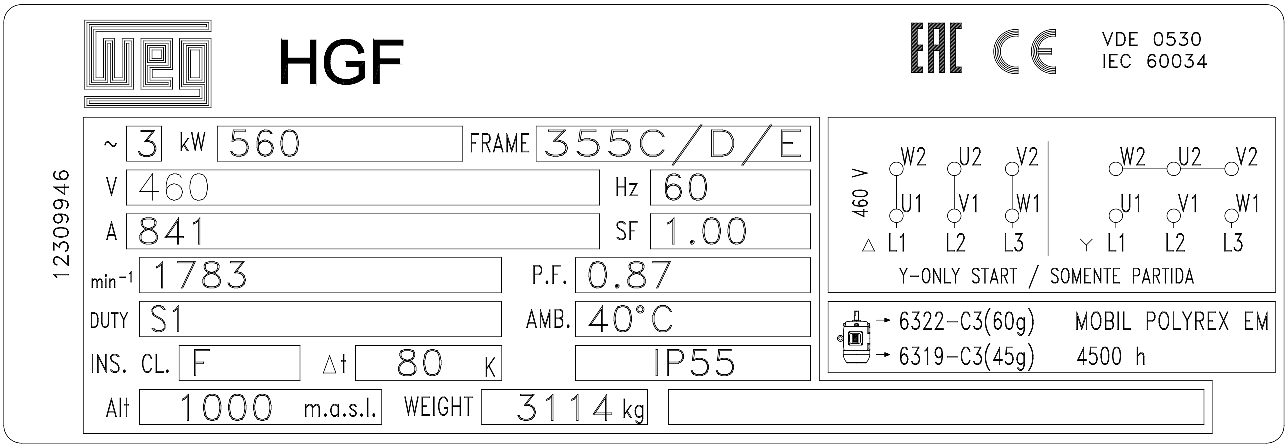

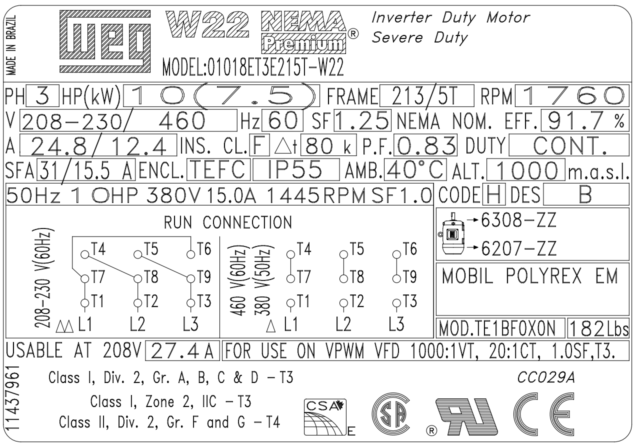

***Figure 2.1** - IEC motor nameplate*

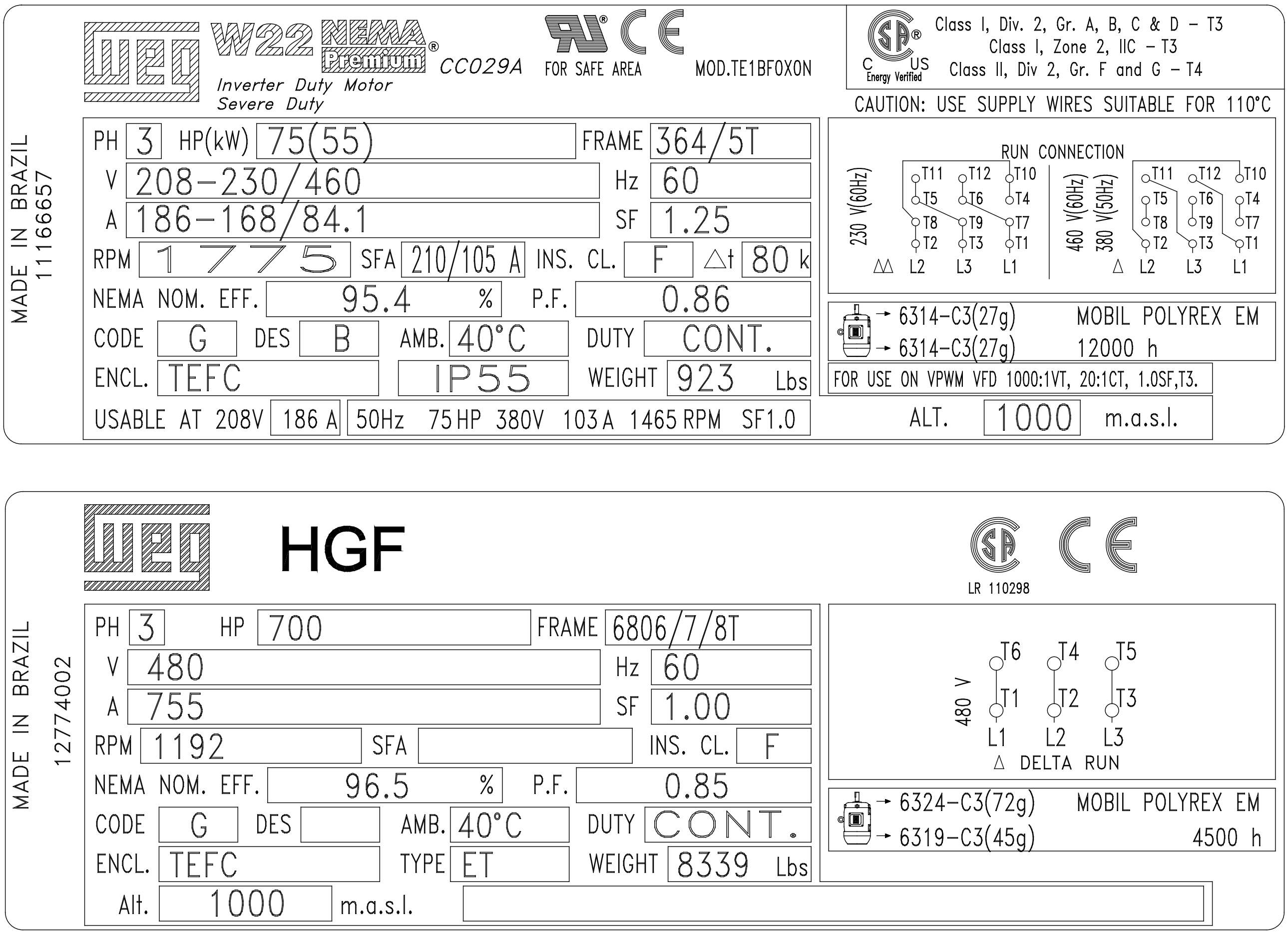

Figure 2.2 *- NEMA motor nameplate*

ENGLISH

3. SAFETY INSTRUCTIONS

The motor must be disconnected from the power supply and be completely stopped before conducting any installation or maintenance procedures. Additional measures should be taken to avoid accidental motor starting.

Professionals working with electrical installations, either in the assembly, operation or maintenance, should use proper tools and be instructed on the application of standards and safety requirements, including the use of Personal Protective Equipment (PPE) that must be carefully observed in order to reduce risk of personal injury during these services.

Electric motors have energized circuits, exposed rotating parts and hot surfaces that may cause serious injury to people during normal operation. It is recommended that transportation, storage, installation, operation and maintenance services are always performed by qualified personnel.

Always follow the safety, installation, maintenance and inspection instructions in accordance with the applicable standards in each country.

4. HANDLING AND TRANSPORT

Individually packaged motors should never be lifted by the shaft or by the packaging. They must be lifted only by means of the eyebolts, when supplied. Use always suitable lifting devices to lift the motor. Eyebolts on the frame are designed for lifting the machine weight only as indicated on the motor nameplate. Motors supplied on pallets must be lifted by the pallet base with lifting devices fully supporting the motor weight.

The package should never be dropped. Handle it carefully to avoid bearing damage.

Eyebolts provided on the frame are designed for lifting the machine only. Do not use these eyebolts for lifting the motor with coupled equipment such as bases, pulleys, pumps, reducers, etc..

Never use damaged, bent or cracked eyebolts. Always check the eyebolt condition before lifting the motor.

Eyebolts mounted on components, such as on end shields, forced ventilation kits, etc. must be used for lifting these components only. Do not use them for lifting the complete machine set.

Handle the motor carefully without sudden impacts to avoid bearing damage and prevent excessive mechanical stresses on the eyebolts resulting in its rupture.

To move or transport motors with cylindrical roller bearings or angular contact ball bearings, use always the shaft locking device provided with the motor.
All HGF motors, regardless of bearing type, must be transported with shaft locking device fitted.
Vertical mounted motors with oil-lubricated bearings must be transported in the vertical position. If necessary to move or transport the motor in the horizontal position, install the shaft locking device on both sides (drive end and non-drive end) of the motor.

4.1. LIFTING

Before lifting the motor ensure that all eyebolts are tightened properly and the eyebolt shoulders are in contact with the base to be lifted, as shown in Figure 4.1. Figure 4.2 shows an incorrect tightening of the eyebolt.
Ensure that lifting machine has the required lifting capacity for the weight indicated on the motor nameplate.

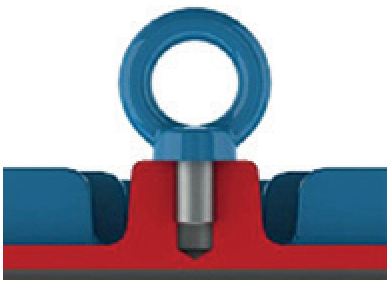

Figure 4.1 *- Correct tightening of the eyebolt*

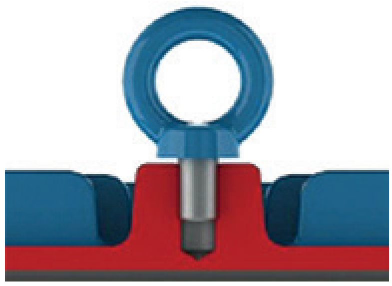

Figure 4.2 *- Incorrect tightening of the eyebolt*

The center-of-gravity may change depending on motor design and accessories. During the lifting procedures the maximum allowed angle of inclination should never be exceeded as specified below.

4.1.1. Horizontal motors with one eyebolt

For horizontal motors fitted with only one eyebolt, the maximum allowed angle-of-inclination during the lifting process should not exceed 30º in relation to the vertical axis, as shown in Figure 4.3.

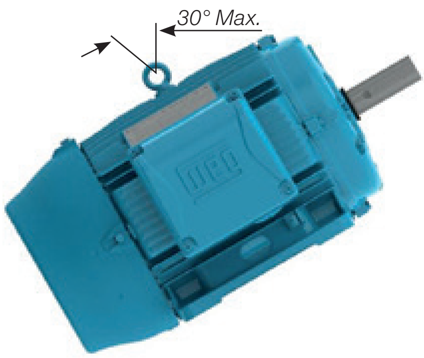

Figure 4.3 *- Maximum allowed angle-of-inclination for motor with one eyebolt*

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4.1.2. Horizontal motor with two eyebolts

When motors are fitted with two or more eyebolts, all supplied eyebolts must be used simultaneously for the lifting procedure.

There are two possible eyebolt arrangements (vertical and inclined), as shown below:

- For motors with vertical lifting eyebolts, as shown in Figure 4.4, the maximum allowed lifting angle should not exceed 45° in relation to the vertical axis. We recommend to use a spreader beam for maintaining the lifting elements (chain or rope) in vertical position and thus preventing damage to the motor surface;

Figure 4.4 *- Maximum resulting angle for motors with two or more lifting eyebolts*

- For HGF, W40 and W50 motors, as shown in Figure 4.5, the maximum resulting angle should not exceed 30° in relation to the vertical axis;

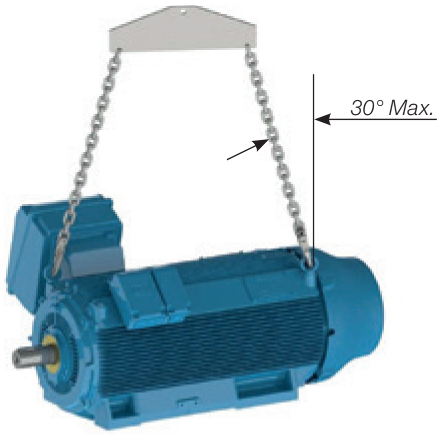

Figure 4.5 *- Maximum resulting angle for horizontal HGF, W40 and W50 motors*

- For motors fitted with inclined eyebolts, as shown in Figure 4.6, the use of a spreader beam is required for maintaining the lifting elements (chain or rope) in vertical position and thus preventing damage to the motor surface.

Figure 4.6 *- Use of a spreader beam for lifting*

4.1.3. Vertical motors

For vertical mounted motors, as shown in Figure 4.7, the use of a spreader beam is required for maintaining the lifting element (chain or rope) in vertical position and thus preventing damage to the motor surface.

Figure 4.7 *- Lifting of vertical mounted motors*

Always use the eyebolts mounted on the top side of the motor, diametrically opposite, considering the mounting position. See Figure 4.8.

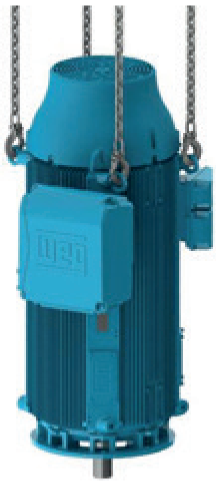

Figure 4.8 *- Lifting of HGF and W50 motors.*

4.1.3.1. Procedures to place W22 motors in the vertical position

For safety reasons during the transport, vertical mounted Motors are usually packed and supplied in horizontal position.
To place W22 motors fitted with eyebolts (see Figure 4.6), to the vertical position, proceed as follows:

1. Ensure that the eyebolts are tightened properly, as shown in Figure 4.1;
2. Remove the motor from the packaging, using the top mounted eyebolts, as shown in Figure 4.9;

Figure 4.9 *- Removing the motor from the packaging*

3. Install a second pair of eyebolts, as shown in Figure 4.10;

Figure 4.10 *- Installation of the second pair of eyebolts*

4. Reduce the load on the first pair of eyebolts to start the motor rotation, as shown in Figure 4.11. This procedure must be carried out slowly and carefully.

Figure 4.11 *- End result: motor placed in vertical position*

These procedures will help you to move motors designed for vertical mounting. These procedures are also used to place the motor from the horizontal position into the vertical position and vertical to horizontal.

4.1.3.2. Procedures to place HGF and W50 motors in the vertical position

HGF motors are fitted with eight lifting points: four at drive end and four at non-drive end. W50 motors are fitted with nine lifting points: four at drive end, one in the central part and four at non-drive end. The motors are usually transported in horizontal position, however for the installation they must be placed in the vertical position.
To place an these motors in the vertical position, proceed as follows:

1. Lift the motor by using the four lateral eyebolts and two hoists, see Figure 4.12;

Figure 4.12 *- Lifting of HGF and W50 motors with two hoists*

2. Lower the hoist fixed to motor drive end while lifting the hoist fixed to motor non-drive end until the motor reaches its equilibrium, see Figure 4.13;

Figure 4.13 *- Placing HGF and W50 motors in vertical position*

3. Remove the hoist hooks from the drive end eyebolts and rotate the motor 180° to fix the removed hooks into the two eyebolts at the motor non-drive end, see Figure 4.14;

Figure 4.14 *- Lifting HGF and W50 motors by the eyebolts at the non-drive end*

4. Fix the removed hoist hooks in the other two eyebolts at the non-drive end and lift the motor until the vertical position is reached, see Figure 4.15.

Figure 4.15 *- HGF and W50 motors in the vertical position*

These procedures will help you to move motors designed for vertical mounting. These procedures are also used to place the motor from the horizontal position into the vertical position and vertical to horizontal.

4.2 Procedures to place W22 vertical mount motors in horizontal position

To place W22 vertical mount motor in horizontal position, proceed as follows:

1. Ensure that all eyebolts are tightened properly, as shown in Figure 4.1;

2. Install the first pair of eyebolts and lift the motor as shown in Figure 4.16;

Figure 4.16 - *Install the first pair of eyebolts*

3. Install the second pair of eyebolts, as shown in Figure 4.17;

Figure 4.17 - *Install the second pair of eyebolts*

4. Reduce the load on the first pair of eyebolts for rotating the motor, as shown in Figure 4.18. This procedure must be carried out slowly and carefully;

Figure 4.18 - *Motor is being rotated to horizontal position*

5. Remove the first pair of eyebolts, as shown in Figure 4.19.

Figure 4.19 - *Final result: motor placed in horizontal position*

5. STORAGE

If the motor is not installed immediately, it must be stored in a dry and clean environment, with relative humidity not exceeding 60%, with an ambient temperature between 5 °C and 40 °C, without sudden temperature changes, free of dust, vibrations, gases or corrosive agents. The motor must be stored in horizontal position, unless specifically designed for vertical operation, without placing objects on it. Do not remove the protection grease from shaft end to prevent rust.

If the motor are fitted with space heaters, they must always be turned on during the storage period or when the installed motor is out of operation. Space heaters will prevent water condensation inside the motor and keep the winding insulation resistance within acceptable levels. Store the motor in such position that the condensed water can be easily drained. If fitted, remove pulleys or couplings from the shaft end (more information are given on item 6).

The space heaters should never be energized when the motor is in operation.

5.1. EXPOSED MACHINED SURFACES

All exposed machined surfaces (like shaft end and flange) are factory-protected with temporary rust inhibitor. A protective film must be reapplied periodically (at least every six months), or when it has been removed and/or damaged.

5.2. STORAGE

The stacking height of the motor packaging during the storage period should not exceed 5 m, always considering the criteria indicated in Table 5.1:

Table 5.1 *- Max. recommended stacking height*

Packaging type	Frame sizes	Maximum stacking quantity
Cardboard box	IEC 63 to 132 NEMA 143 to 215	Indicated on the top side of the cardboard box
Wood crate	IEC 63 to 315 NEMA 48 to 504/5	06
	IEC 355 NEMA 586/7 and 588/9	03
	W40 / W50 / HGF IEC 315 to 630 W40 / W50 / HGF NEMA 5000 to 9600	Indicated on the packaging

Notes:
1) Never stack larger packaging onto smaller packaging;
2) Align the packaging correctly (see Figure 5.1 and Figure 5.2);

Figure 5.1 *- Correct stacking*

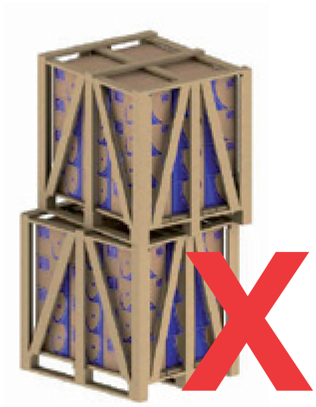

Figure 5.2 *- Incorrect stacking*

ENGLISH

3) The feet of the crates above should always be supported by suitable wood battens (Figure 5.3) and never stand on the steel tape or without support (Figure 5.4);

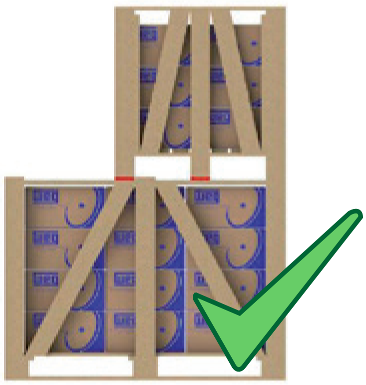

Figure 5.3 - Correct stacking

Figure 5.4 - Incorrect stacking

4) When stacking smaller crates onto longer crates, always ensure that suitable wooden supports are provided to withstand the weight (see Figure 5.5). This condition usually occurs with motor packaging above IEC 225S/M (NEMA 364/5T) frame sizes.

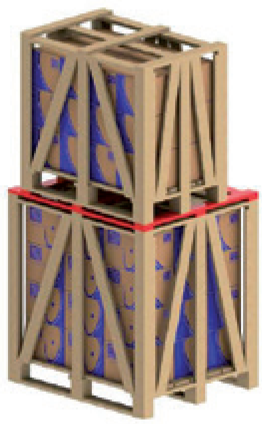

***Figure 5.5** - Use of additional battens for stacking*

5.3 BEARINGS

5.3.1 Grease lubricated bearings

We recommend rotating the motor shaft at least once a month (by hand, at least five revolutions, stopping the shaft at a different position from the original one). If the motor is fitted with shaft locking device, remove it before rotating the shaft and install it again before performing any handling procedure. Vertical motors may be stored in the vertical or in horizontal position. If motors with open bearings are stored longer than six months, the bearings must be relubricated according to item 8.2 before commissioning of the motor.
If the motor is stored for longer than 2 years, the bearings must be replaced or removed, washed, inspected and relubricated according to item 8.2.

5.3.2 Oil lubricated bearings

The motor must be stored in its original operating position and with oil in the bearings. Correct oil level must be ensured. It should be in the center of the sight glass.
During the storage period, remove the shaft locking device and rotate the shaft by hand every month, at least five revolutions, thus achieving an even oil distribution inside the bearing and maintaining the bearing in good operating conditions. Reinstall the shaft locking device every time the motor has to be moved.
If the motor is stored for a period equal or longer than the oil change interval, the oil must be replaced according to Item 8.2, before starting the operation. If the motor is stored for a period of over two years, the bearings must be replaced or removed, washed according to manufacturer instructions, checked and relubricated according to Item 8.2. The oil of vertical mounted motors is removed to prevent oils leaks during the transport. After receiving the motor the bearings must be lubricated.

5.3.3 Oil Mist lubricated bearings

The motor must be stored in horizontal position. Lubricate the bearings with ISO VG 68 mineral oil in the amount indicated in the Table 5.2 (this is also valid for bearings with equivalent dimensions). After filling with oil, rotate the shaft by hand, at least five revolutions)
During the storage period, remove the shaft locking device (if any) and rotate the shaft by hand every week, at least five revolutions, stopping it at a different position from the original one. Reinstall the shaft locking device every time the motor has to be moved. If the motor is stored for a period of over two years, the bearings must be replaced or removed, washed according to manufacturer instructions, checked and relubricated according to item 8.2.

Table 5.2 - *Amount of oil per bearing*

Bearing size	Amount of oil (ml)	Bearing size	Amount of oil (ml)
6201	15	6309	65
6202	15	6311	90
6203	15	6312	105
6204	25	6314	150
6205	25	6315	200
6206	35	6316	250
6207	35	6317	300
6208	40	6319	350
6209	40	6320	400
6211	45	6322	550
6212	50	6324	600
6307	45	6326	650
6308	55	6328	700

The oil must always be removed when the motor has to be handled. If the oil mist system is not operating after installation, fill the bearings with oil to prevent bearing rusting. During the storage period, rotate the shaft by hand, at least five revolutions, stopping it at a different position from the original one. Before starting the motor, all bearing protection oil must be drained from the bearing and the oil mist system must be switched ON.

5.3.4 Sleeve bearing

The motor must be stored in its original operating position and with oil in the bearings. Correct oil level must be ensured. It should be in the middle of the sight glass. During the storage period, remove the shaft locking device and rotate the shaft by hand every month, at least five revolutions, and at 30 rpm, thus achieving an even oil distribution inside the bearing and maintaining the bearing in good operating conditions. Reinstall the shaft locking device every time the motor has to be moved.
If the motor is stored for a period equal or longer than the oil change interval, the oil must be replaced, according to Item 8.2, before starting the operation.

If the motor is stored for a period longer than the oil change interval, or if it is not possible to rotate the motor shaft by hand, the oil must be drained and a corrosion protection and dehumidifiers must be applied.

5.4. INSULATION RESISTANCE

We recommend measuring the winding insulation resistance at regular intervals to follow-up and evaluate its electrical operating conditions. If any reduction in the insulation resistance values are recorded, the storage conditions should be evaluated and corrected, where necessary.

5.4.1. Insulation resistance measurement

We recommend measuring the winding insulation resistance at regular intervals to follow-up and evaluate its electrical operating conditions. If any reduction in the insulation resistance values are recorded, the storage conditions should be evaluated and corrected, where necessary.

The insulation resistance must be measured in a safe environment.

The insulation resistance must be measured with a megohmmeter. The machine must be in cold state and disconnected from the power supply.

To prevent the risk of an electrical shock, ground the terminals before and after each measurement. Ground the capacitor (if any) to ensure that it is fully discharged before the measurement is taken.

It is recommended to insulate and test each phase separately. This procedure allows the comparison of the insulation resistance between each phase. During the test of one phase, the other phases must be grounded. The test of all phases simultaneously evaluates the insulation resistance to ground only but does not evaluate the insulation resistance between the phases.
The power supply cables, switches, capacitors and other external devices connected to the motor may considerably influence the insulation resistance measurement. Thus all external devices must be disconnected and grounded during the insulation resistance measurement.
Measure the insulation resistance one minute after the voltage has been applied to the winding. The applied voltage should be as shown in Table 5.3.

Table 5.3 *- Voltage for the insulation resistance*

Winding rated voltage (V)	Testing voltage for measuring the insulation resistance (V)
< 1000	500
1000 - 2500	500 - 1000
2501 - 5000	1000 - 2500
5001 - 12000	2500 - 5000
> 12000	5000 - 10000

The reading of the insulation resistance must be corrected to 40 °C as shown in the Table 5.4.

Table 5.4 *- Correction factor for the insulation resistance corrected to 40 °C*

Measuring temperature of the insulation resistance (°C)	Correction factor of the insulation resistance corrected to 40 °C	Measuring temperature of the insulation resistance (°C)	Correction factor of the insulation resistance corrected to 40 °C
10	0.125	30	0.500
11	0.134	31	0.536
12	0.144	32	0.574
13	0.154	33	0.616
14	0.165	34	0.660
15	0.177	35	0.707
16	0.189	36	0.758
17	0.203	37	0.812
18	0.218	38	0.871
19	0.233	39	0.933
20	0.250	40	1.000
21	0.268	41	1.072
22	0.287	42	1.149
23	0.308	43	1.231
24	0.330	44	1.320
25	0.354	45	1.414
26	0.379	46	1.516
27	0.406	47	1.625
28	0.435	48	1.741
29	0.467	49	1.866
30	0.500	50	2.000

The motor insulation condition must be evaluated by comparing the measured value with the values indicated in Table 5.5 (corrected to 40 °C):

***Table 5.5** - Evaluation of the insulation system*

Limit value for rated voltage up to 1.1 kV (MΩ)	Limit value for rated voltage above 1.1 kV (MΩ)	Situation
Up to 5	Up to 100	Dangerous. The motor can not be operated in this condition
5 to 100	100 to 500	Regular
100 to 500	Higher than 500	Good
Higher than 500	Higher than 1000	Excellent

The values indicated in the table should be considered only as reference values. It is advisable to log all measured values to provide a quick and easy overview on the machine insulation resistance.
If the insulation resistance is low, moisture may be present in the stator windings. In this case the motor should be removed and transported to a WEG authorized Service Center for proper evaluation and repair (This service is not covered by the warranty). To improve the insulation resistance through the drying process, see section 8.4.

6. INSTALLATION

The insulation resistance must be measured in a safe environment.

Check some aspects before proceeding with the installation:

1. Insulation resistance: must be within the acceptable limits. See item 5.4.
2. Bearings:
   If the motor is installed without running immediately, proceed as described in item 5.3.
3. Operating conditions of the start capacitors: If single-phase motors are stored for a period of over two years, it is recommended to change the start capacitors before motor starting since they lose their operating characteristics.
4. Terminal box:
   a. the inside of the terminal box must be clean and dry;
   b. the contacts must be correctly connected and corrosion free. See 6.9 and 6.10;
   c. the cable entries must be correctly sealed and the terminal box cover properly mounted in order to ensure the degree of protection indicated on the motor nameplate.
5. Cooling: the cooling fins, air inlet and outlet openings must be clean and unobstructed. The distance between the air inlet openings and the wall should not be shorter than ¼ (one quarter) of the diameter of the air inlet. Ensure sufficient space to perform the cleaning services. See item 7.
6. Coupling: remove the shaft locking device (where fitted) and the corrosion protection grease from the shaft end and flange just before installing the motor. See item 6.4.
7. Drain hole: the motor must always be positioned so the drain hole is at the lowest position (If there is any indication arrow on the drain, the drain must be so installed that the arrow points downwards).
   Motors supplied with rubber drain plugs leave the factory in the closed position and must be opened periodically to allow the exit of condensed water. For environments with high water condensation levels and motor with degree of protection IP55, the drain plugs can be mounted in open position (see Figure 6.1).
   For motors with degree of protection IP56, IP65 or IP66, the drain plugs must remain at closed position (see Figure 6.1), being opened only during the motor maintenance procedures.
   The drain system of motors with Oil Mist lubrication system must be connected to a specific collection system (see Figure 6.12).

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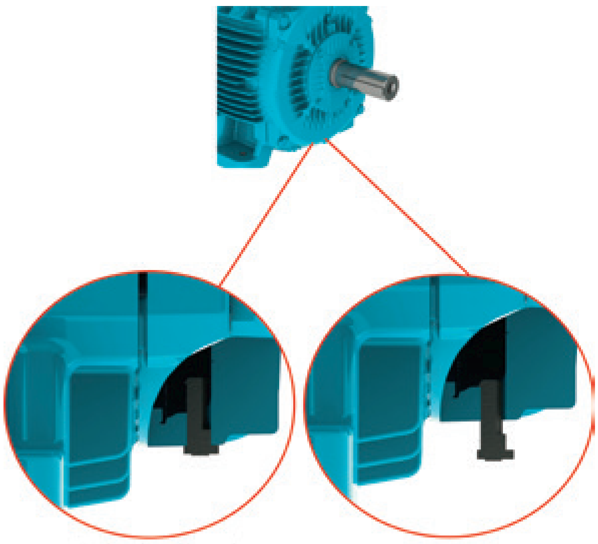

Figure 6.1 *- Detail of the rubber drain plug mounted in closed and open position*

8.Additional recommendations:

a. Check the direction of motor rotation, starting the motor at no-load before coupling it to the load;
b. Vertical mounted motors with shaft end down must be fitted with drip cover to protect them from liquids or solids that may drop onto the motors;
c. Vertical mounted motors with shaft end up should be fitted with water slinger ring to prevent water ingress inside the motor.
d. The fixing elements mounted in the threaded through holes in the motor enclosure (for example, the flange) must be properly sealed.

Remove or fix the shaft key before starting the motor.

Changes on the motor construction (features), such as installation of extended grease fittings or modification of the lubrication system, installation of accessories at alternative locations, etc., can be carried out only after prior written consent from WEG.

6.1. FOUNDATIONS

The foundation is the structure, structural element, natural or prepared base, designed to withstand the stresses produced by the installed equipment, ensuring safe and stable performance during operation. The foundation design should consider the adjacent structures to avoid the influences of other installed equipment and no vibration is transferred through the structure

The foundation must be flat and its selection and design must consider the following characteristics:

a) The features of the machine to be installed on the foundation, the driven loads, application, maximum allowed deformations and vibration levels (for instance, motors with reduced vibration levels, foot flatness, flange concentricity, axial and radial loads, etc. lower than the values specified for standard motors).

b) Adjacent buildings, conservation status, maximum applied load estimation, type of foundation and fixation and vibrations transmitted by theses constructions.

If the motor is supplied with leveling/alignment bolts, this must be considered in the base design.

Please consider for the foundation dimensioning all stresses that are generated during the operation of the driven load.
The user is responsible for the foundation designing and construction.

The foundation stresses can be calculated by using the following equations (see Figure 6.2):

$$F_1 = 0,5 * g * m - (4 * T_b / A)$$
$$F_2 = 0,5 * g * m + (4 * T_b / A)$$

Where:

F_1 and F_2 = lateral stresses (N);
g = gravitational acceleration (9,8 m/s^2);
m = motor weight (kg);
T_b = breakdown torque (Nm);
A = distance between centerlines of mounting holes in feet or base of the machine (end view) (m).

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The motors may be mounted on:
- Concrete bases: are most used for large-size motors (see Figure 6.2);
- Metallic bases: are generally used for small-size motors (see Figure 6.3).

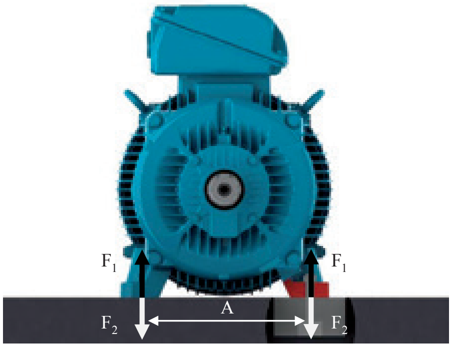

Figure 6.2 *- Motor installed on concrete base*

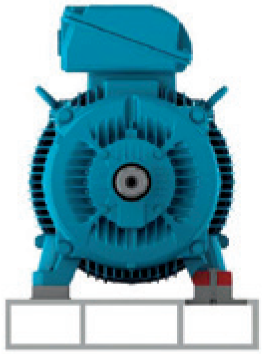

Figure 6.3 *- Motor installed on metallic base*

The metallic and concrete bases may be fitted with sliding system. These types of foundations are generally used where the power transmission is achieved by belts and pulleys. This power transmission system is easier to assemble/disassemble and allows the belt tension adjustment. Other important aspect of this foundation type is the location of the base locking screws that must be diagonally opposite. The rail nearest the drive pulley is placed in such a way that the positioning bolt is between the motor and the driven machine. The other rail must be placed with the bolt on the opposite side (diagonally opposite), as shown in Figure 6.4 .

To facilitate assembly, the bases may have the following features:
- Shoulders and/or recesses;
- Anchor bolts with loose plates;
- Bolts cast in the concrete;
- Leveling screws;
- Positioning screws;
- Steel & cast iron blocks, plates with flat surfaces.

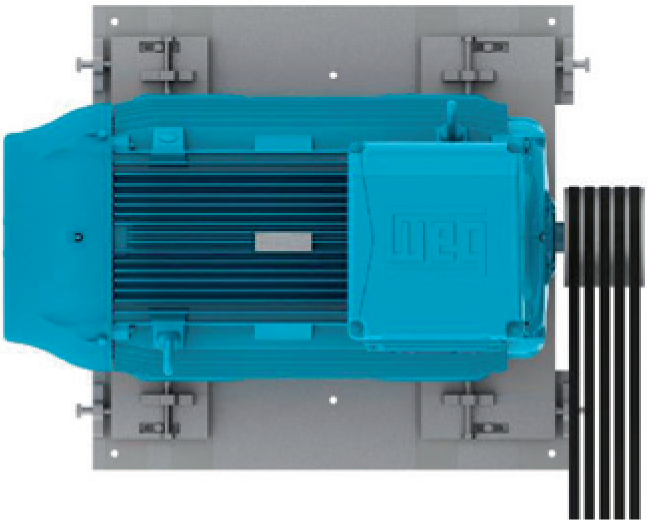

Figure 6.4 *- Motor installed on sliding base*

After completing the installation, it is recommended that all exposed machined surfaces are coated with suitable rust inhibitor.

6.2. MOTOR MOUNTING

Footless motors supplied with transportation devices, according to Figure 6.5, must have their devices removed before starting the motor installation.

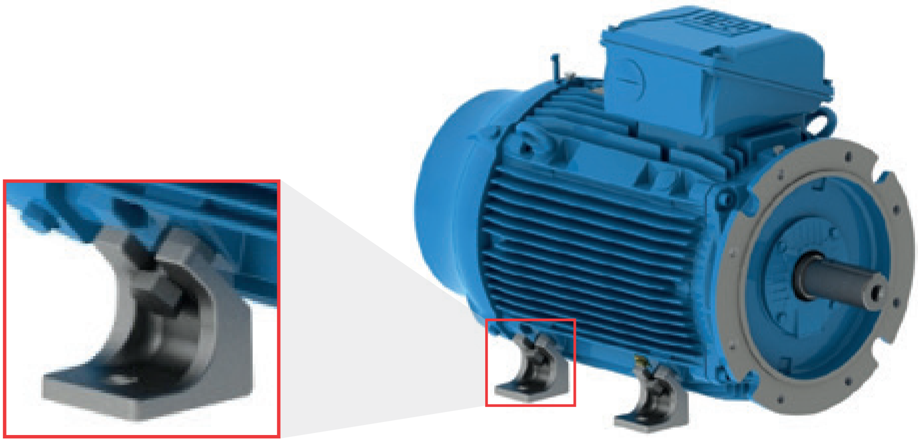

Figure 6.5 *- Detail of the transportation devices for footless motors*

6.2.1. Foot mounted motors

The drawings of the mounting hole dimensions for NEMA or IEC motors can be checked in the respective technical catalogue.
The motor must be correctly aligned and leveled with the driven machine. Incorrect alignment and leveling may result in bearing damage, generate excessive vibration and even shaft distortion/breakage.
For more details, see section 6.3 and 6.6. The thread engagement length of the mounting bolt should be at least 1.5 times the bolt diameter. This thread engagement length should be evaluated in more severe applications and increased accordingly.
Figure 6.6 shows the mounting system of a foot mounted motor indicating the minimum required thread engagement length.

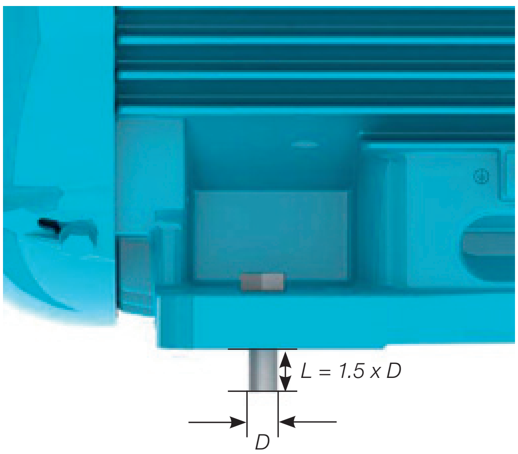

Figure 6.6 *- Mounting system of a foot mounted motor*

6.2.2. Flange mounted motors

The drawings of the flange mounting dimensions, IEC and NEMA flanges, can be checked in the technical catalogue.
The coupling of the driven equipment to the motor flange must be properly dimensioned to ensure the required concentricity of the assembly.
Depending on the flange type, the mounting can be performed from the motor to the driven equipment flange (flange FF (IEC) or D (NEMA)) or from the driven equipment flange to the motor (flange C (DIN or NEMA)).
For the mounting process from the driven equipment flange to the motor, you must consider the bolt length, flange thickness and the thread depth of the motor flange.

If the motor flange has tapped through-holes, the length of the mounting bolts must not exceed the tapped through-hole length of the motor flange, thus preventing damage to the winding head.

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For flange mounting the thread engagement length of the mounting bolt should be at least 1.5 times the bolt diameter. In severe applications, longer thread engagement length may be required.
In severe applications or if large motors are flange mounted, a foot or pad mounting may be required in addition to the flange mounting (Figure 6.7). The motor must never be supported on its cooling fins.

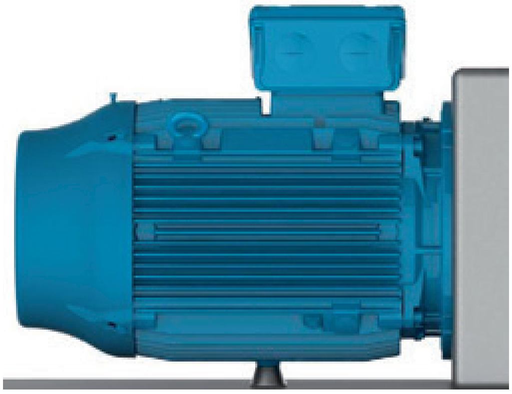

Figure 6.7 *- Mounting method of flange mounted motors with frame base support*

Note:
When liquid (for example oil) is likely to come into contact with the shaft seal, please contact your local WEG representative.

6.2.3. Pad mounted motors

Typically, this method of mounting is used in axial fans. The motor is fixed by tapped holes in the frame. The dimensions of these tapped holes can be checked in the respective product catalogue. The selection of the motor mounting rods/bolts must consider the dimensions of the fan case, the installation base and the thread depth in the motor frame.
The mounting rods and the fan case wall must be sufficiently stiff to prevent the transmission of excessive vibration to the machine set (motor & fan). Figure 6.8 shows the pad mounting system.

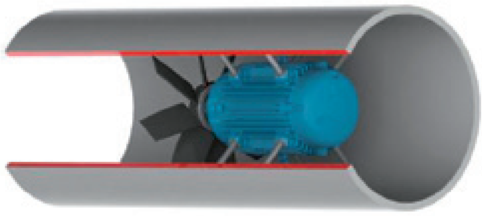

Figure 6.8 *- Mounting of the motor inside the cooling duct*

6.3. BALANCING

Unbalanced machines generate vibration which can result in damage to the motor. WEG motors are dynamically balanced with “half key” and without load (uncoupled). Special balancing quality level must be stated in the Purchase Order.

> The transmission elements, such as pulleys, couplings, etc., must balanced with “half key” before they are mounted on the motor shaft.

The balance quality grade meets the applicable standards for each product line.

The maximum balancing deviation must be recorded in the installation report.

6.4. COUPLINGS

Couplings are used to transmit the torque from the motor shaft to the shaft of the driven machine. The following aspects must be considered when couplings are installed:

- Use proper tools for coupling assembly & disassembly to avoid damages to the motor and bearings;
- Whenever possible, use flexible couplings, since they can absorb eventual residual misalignments during the machine operation;
- The maximum loads and speed limits informed in the coupling and motor manufacturer catalogues cannot be exceeded;
- Level and align the motor as specified in sections 6.5 and 6.6, respectively.

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Remove or fix the shaft key firmly when the motor is operated without coupling in order to prevent accidents.

6.4.1. Direct coupling

Direct coupling is characterized when the Motor shaft is directly coupled to the shaft of the driven machine without transmission elements. Whenever possible, use direct coupling due to lower cost, less space required for installation and more safety against accidents.

Do not use roller bearings for direct coupling, unless sufficient radial load is expected.

6.4.2. Gearbox coupling

Gearbox coupling is typically used where speed reduction is required.
Make sure that shafts are perfectly aligned and strictly parallel (in case of straight spur gears) and in the right meshing angle (in case of bevel and helical gears).

6.4.3. Pulley and belt coupling

Pulleys and belts are used when speed increase or reduction between motor shaft and driven load is required.

Excessive belt tension will damage the bearings and cause unexpected accidents such as breakage of the motor shaft.

6.4.4. Coupling of sleeve bearing motors

Motors designed with sleeve bearings must be operated with direct coupling to the driven machine or a gearbox. Pulley and belts can not be applied for sleeve bearing motors.

Motors designed with sleeve bearings have 3 (three) marks on the shaft end. The center mark is the indication of the magnetic center and the 2 (two) outside marks indicate the allowed limits of the rotor axial movement, as shown in Figure 6.9.
The motor must be so coupled that during operation the arrow on the frame is placed over the central mark indicating the rotor magnetic center. During start-up, or even during operation, the rotor may freely move between the two outside marks when the driven machine exerts an axial load on the motor shaft. However, under no circumstance, the motor can operate continuously with axial forces on the bearing.

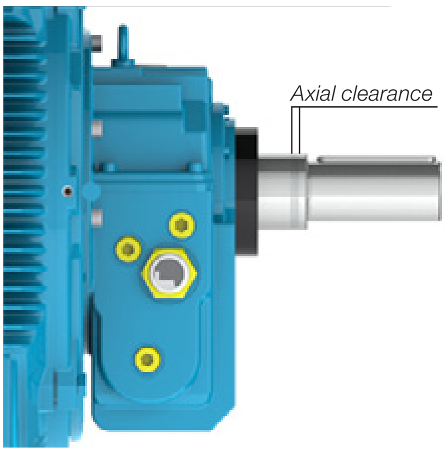


***Figure 6.9** - Axial clearance of motor designed with sleeve bearing*

For coupling evaluation consider the maximum axial bearing clearance as shown in Table 6.1.
The axial clearance of the driven machine and coupling influence the maximum bearing clearance.

Table 6.1 *- Clearance used for sleeve bearings*

Bearing size	Total axial clearance (mm)
9*	3 + 3 = 6
11*	4 + 4 = 8
14*	5 + 5 =10
18	7,5 + 7,5 = 15

** For Motors in accordance with API 541, the total axial clearance is 12.7 mm*

The sleeve bearings used by WEG were not designed to support axial load continuously.
Under no circumstance must the motor be operated continuously at its axial clearance limits.

6.5. LEVELING

The motor must be leveled to correct any deviations in flatness arising from the manufacturing process and the material structure rearrangement. The leveling can be carried out by a leveling screw fixed on the motor foot or on the flange or by means of thin compensation shims. After the leveling process, the leveling height between the motor mounting base and the motor cannot exceed 0.1 mm.
If a metallic base is used to level the height of the motor shaft end and the shaft end of the driven machine, level only the metallic base relating to the concrete base.

Record the maximum leveling deviations in the installation report.

6.6. ALIGNMENT

The correct alignment between the motor and the driven machine is one of the most important variables that extends the useful service life of the motor. Incorrect coupling alignment generates high loads and vibrations reducing the useful life of the bearings and even resulting in shaft breakages. Figure 6.10 illustrates the misalignment between the motor and the driven machine.

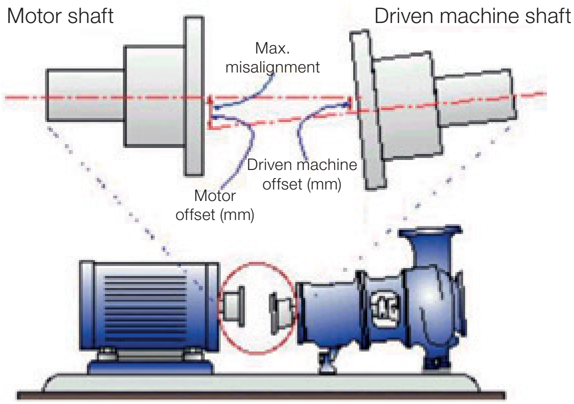
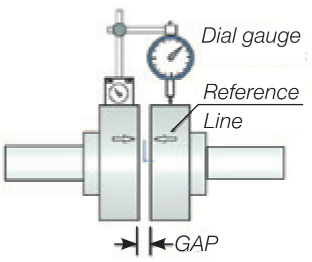


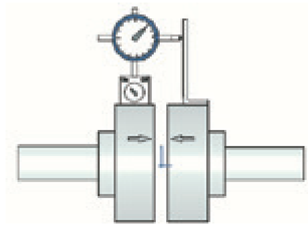
Figure 6.10 *- Typical misalignment condition*

Alignment procedures must be carried out using suitable tools and devices, such as dial gauge, laser alignment instruments, etc.. The motor shaft must be aligned axially and radially with the driven machine shaft.

The maximum allowed eccentricity for a complete shaft turn should not exceed 0.03 mm, when alignment is made with dial gauges, as shown in Figure 6.11. Ensure a gap between couplings to compensate the thermal expansion between the shafts as specified by the coupling manufacturer.



Parallel alignment



Angular alignment

Figure 6.11 *- Alignment with dial gauge*

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If alignment is made by a laser instrument, please consider the instructions and recommendations provided by the laser instrument manufacturer.
The alignment should be checked at ambient temperature with machine at operating temperature.

The coupling alignment must be checked periodically.

Pulley and belt couplings must be so aligned that the driver pulley center lies in the same plane of the driven pulley center and the motor shaft and the shaft of the driven machine are perfectly parallel.
After completing the alignment procedures, ensure that mounting devices do not change the motor and machine alignment and leveling resulting into machine damage during operation.

It is recommended to record the maximum alignment deviation in the Installation Report.

6.7. CONNECTION OF OIL LUBRICATED OR OIL MIST LUBRICATED MOTORS

When oil lubricated or oil mist lubricated motors are installed, connect the existing lubricant tubes (oil inlet and oil outlet tubes and motor drain tube), as shown in Figure 6.12. The lubrication system must ensure continuous oil flow through the bearings as specified by the manufacturer of the installed lubrication system.

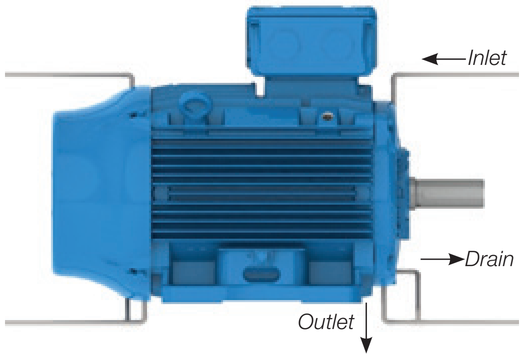

Figure 6.12 *- Oil supply and drain system of oil lubricated or oil mist lubricated motors*

6.8. CONNECTION OF THE COOLING WATER SYSTEM

When water cooled motors are installed, connect the water inlet and outlet tubes to ensure proper motor cooling. According to item 7.2, ensure correct cooling water flow rate and water temperature in the motor cooling system.

6.9. ELECTRICAL CONNECTION

Consider the rated motor current, service factor, starting current, environmental and installation conditions, maximum voltage drop, etc. to select appropriate power supply cables and switching and protection devices. All motors must be installed with overload protection systems. Three-phase motors should be fitted with phase fault protection systems.

Before connecting the motor, check if the power supply voltage and the frequency comply with the motor nameplate data. All wiring must be made according to the connection diagram on the motor nameplate. Please consider the connection diagrams in the Table 6.2 as reference value.
To prevent accidents, check if motor has been solidly grounded in accordance with the applicable standards.

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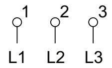
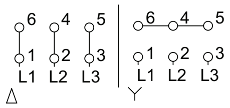
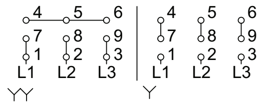
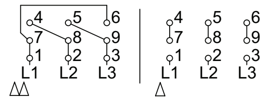
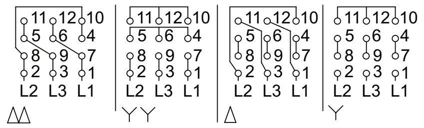
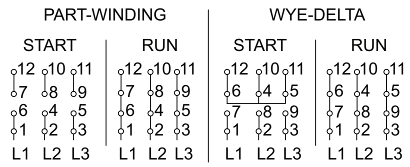
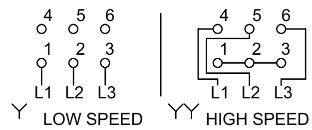
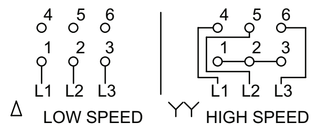
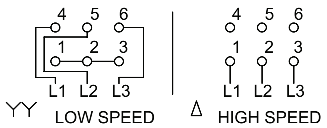
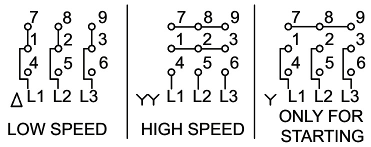
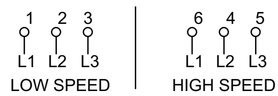
Table 6.2 - Typical connection diagram for three-phase motors.

Configuration	Quantity of leads	Type of connection	Connection diagram
Single speed	3	-	
	6	Δ - Y	
	9	YY - Y	
		ΔΔ - Δ	
	12	ΔΔ - YY - Δ - Y	
		Δ - PWS Part-winding start	
Double speed Dahlander	6	YY - Y Variable Torque	
		Δ - YY Constant Torque	
		YY - Δ Constant Output	
	9	Δ - Y - YY	
Double speed Double winding	6	-	

Equivalent table for lead identification													
Lead identification on the wiring diagram		1	2	3	4	5	6	7	8	9	10	11	12
Single speed	NEMA MG 1 Part 2	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12
	IEC 60034-8	U1	V1	W1	U2	V2	W2	U3	V3	W3	U4	V4	W4
	JIS (JEC 2137) - up to 6 terminals	U	V	W	X	Y	Z						
	JIS (JEC 2137) - above 6 terminals	U1	V1	W1	U2	V2	W2	U5	V5	W5	U6	V6	W6
Double speed (Dahlander / Double winding)	NEMA MG 1 Part 2[1)]	1U	1V	1W	2U	2V	2W	3U	3V	3W	4U	4V	4W
	IEC 60034-8	1U	1V	1W	2U	2V	2W	3U	3V	3W	4U	4V	4W
	JIS (JEC 2137)	1U	1V	1W	2U	2V	2W	3U	3V	3W	4U	4V	4W

1) NEMA MG 1 Part 2 defines T1 to T12 for two or more winding, however WEG adopts 1U to 4W.

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WARNING - Local Standards have priority on the definition of the connection standards.

The connections presented below are a reference for the connection of the customer's power cables on low voltage motors with terminal block. The terminal blocks presented below are the standard for each product line, however variations may occur.
It is recommended the use of terminals made of electrolytic copper or brass, similar to the terminals used on the motors cables.

W21 and W22

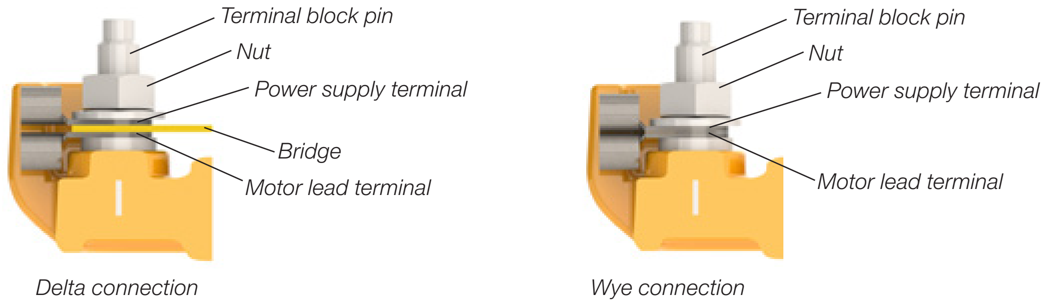


Figure 6.13 *- Connetion for W21 and W22 motors with terminal block*

W50 and HGF

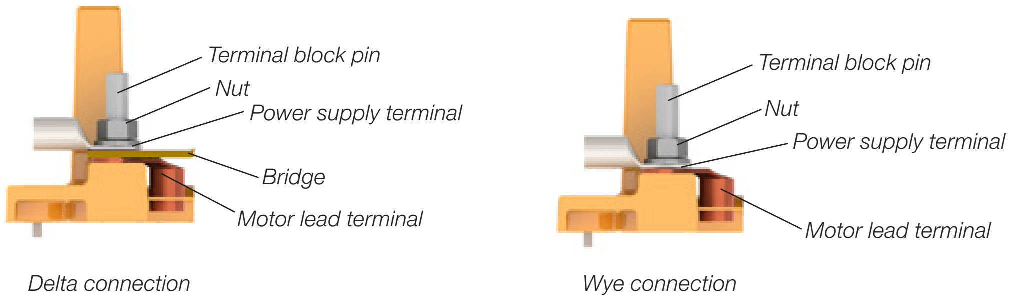
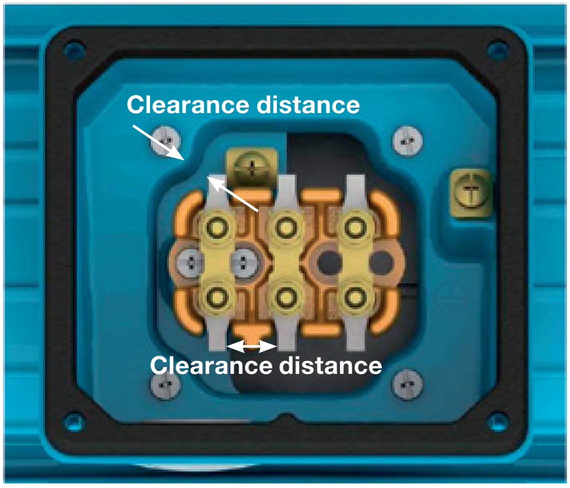


Figure 6.14 *- Connetion for W50 and HGF motors with terminal block*

If motors are supplied without terminal blocks, insulate the cable terminals with suitable insulation material that meets the power supply voltage and the insulation class indicated on the motor nameplate.

Ensure correct tightening torque for the power cable and grounding connections as specified in Table 8.11

The clearance distance (see Figure 6.15) between non-insulated live parts with each other and between grounded parts must be as indicated in Table 6.3.



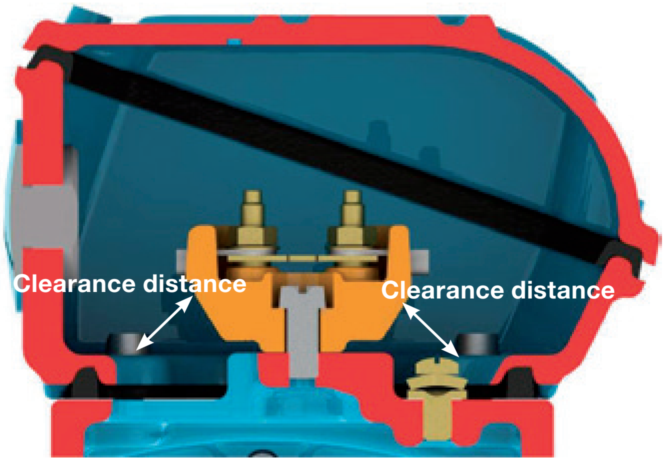


Figure 6.15 *- Clearance distance representation*

Table 6.3 *- Minimum clearance distance (mm) x supply voltage*

Voltage	Minimum clearance distance (mm)
U ≤ 440 V	4
440 < U ≤ 690 V	5.5
690 < U ≤ 1000 V	8
1000 < U ≤ 6900 V	45
6900 < U ≤ 11000 V	70
11000 < U ≤ 16500 V	105

Even when the motor is off, dangerous voltages may be present inside the terminal box used for the space heater supply or winding energization when the winding is used as heating element.
Motor capacitors will hold a charge even after the power has been cut off. Do not touch the capacitors and/or motor terminals, before discharging the capacitors completely.

After the motor connection has been completed, ensure that no tool or foreign body has been left inside the terminal box.

Take the required measures in order to ensure the degree of protection indicated on the motor nameplate:
- unused cable inlet holes in the terminal boxes must be properly closed with blanking plugs;
- components supplied loose (for example, terminal boxes mounted separately) must be properly closed and sealed.

The cable inlets used for power supply and control must be fitted with components (for example, cable-glands and conduits) that meet the applicable standards and regulations in each country.

If the motor is fitted with accessories, such as brakes and forced cooling systems, these devices must be connected to the power supply according to the information provided on their nameplates and with special care as indicated above.

All protection devices, including overcurrent protection, must be set according to the rated machine conditions. These protection devices must protect the machine against short circuit, phase fault or locked rotor condition. The motor protection devices must be set according to the applicable standards.

Check the direction of rotation of the motor shaft. If there is no limitation for the use of unidirectional fans, the shaft rotation direction can be changed by reversing any two of the phase connections. For single-phase motor, check the connection diagram indicated on the motor nameplate.

6.10. CONNECTION OF THE THERMAL PROTECTION DEVICES

If the motor is supplied with temperature monitoring devices, such as, thermostat, thermistors, automatic thermal protectors, Pt-100 (RTD), etc., they must be connected to the corresponding control devices as specified on the accessory nameplates. The non-compliance with this procedure may void the product warranty and cause serious material damages.

Do not apply test voltage above 2.5 V on thermistors and current above 1 mA on RTDs (Pt-100) according to IEC 60751 standard.

Figure 6.16 and Figure 6.17 show the connection diagram of the bimetal thermal protector (thermostats) and thermistors, respectively.

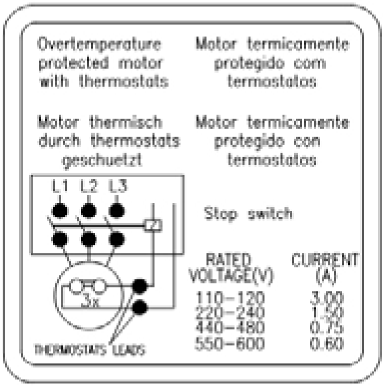


Figure 6.16 *- Connection of the bimetal thermal protectors (thermostats)*

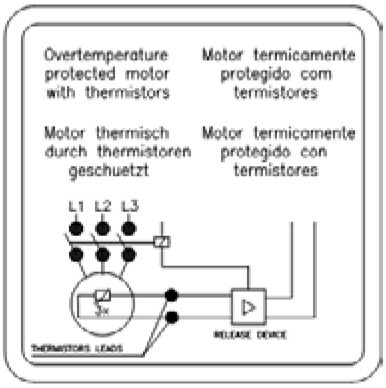


Figure 6.17 *- Thermistor connection*

The alarm temperature limits and thermal protection shutdowns can be defined according to the application; however these temperature limits can not exceed the values in Table 6.4.

Table 6.4 *- Maximum activation temperature of the thermal protections*

Component	Insulation class	Maximum temperature of the protection setting (°C)	
		Alarm	Tripping
Winding	B	-	130
	F	130	155
	H	155	180
Bearing	All	110	120

Notes*:*
1) The number and type of the installed protection devices are stated on the accessory nameplate of the motor.
2) If the motor is supplied with calibrated resistance, (for example, Pt-100), the motor protection system must be set according to the operating temperatures indicated in Table 6.4.

6.11. RESISTANCE TEMPERATURE DETECTORS (PT-100)

The thermocouples Pt-100 are made of materials, whose resistance depends on the temperature variation, intrinsic property of some materials (usually platinum, nickel or copper), calibrated resistance. Its operation is based on the principle that the electric resistance of a metallic conductor varies linearly with the temperature, thus allowing a continuous monitoring of the motor warm-up through the controller display ensuring a high level of precision and answer stability. These devices are widely used for measuring temperatures in various industry sectors.
In general these devices are used in installations where precise temperature control is required, for example, in installation for irregular or intermittent duty.
The same detector may be used for alarm and tripping purposes.

Table 6.5 and Figure 6.18 show the equivalence between the Pt-100 resistance and the temperature.

Table 6.5 *- Equivalence between the Pt-100 resistance and the temperature*

°C	Ω	°C	Ω	°C	Ω	°C	Ω	°C	Ω
-29	88.617	17	106.627	63	124.390	109	141.908	155	159.180
-28	89.011	18	107.016	64	124.774	110	142.286	156	159.553
-27	89.405	19	107.404	65	125.157	111	142.664	157	159.926
-26	89.799	20	107.793	66	125.540	112	143.042	158	160.298
-25	90.193	21	108.181	67	125.923	113	143.420	159	160.671
-24	90.587	22	108.570	68	126.306	114	143.797	160	161.043
-23	90.980	23	108.958	69	126.689	115	144.175	161	161.415
-22	91.374	24	109.346	70	127.072	116	144.552	162	161.787
-21	91.767	25	109.734	71	127.454	117	144.930	163	162.159
-20	92.160	26	110.122	72	127.837	118	145.307	164	162.531
-19	92.553	27	110.509	73	128.219	119	145.684	165	162.903
-18	92.946	28	110.897	74	128.602	120	146.061	166	163.274
-17	93.339	29	111.284	75	128.984	121	146.438	167	163.646
-16	93.732	30	111.672	76	129.366	122	146.814	168	164.017
-15	94.125	31	112.059	77	129.748	123	147.191	169	164.388
-14	94.517	32	112.446	78	130.130	124	147.567	170	164.760
-13	94.910	33	112.833	79	130.511	125	147.944	171	165.131
-12	95.302	34	113.220	80	130.893	126	148.320	172	165.501
-11	95.694	35	113.607	81	131.274	127	148.696	173	165.872
-10	96.086	36	113.994	82	131.656	128	149.072	174	166.243
-9	96.478	37	114.380	83	132.037	129	149.448	175	166.613
-8	96.870	38	114.767	84	132.418	130	149.824	176	166.984
-7	97.262	39	115.153	85	132.799	131	150.199	177	167.354
-6	97.653	40	115.539	86	133.180	132	150.575	178	167.724
-5	98.045	41	115.925	87	133.561	133	150.950	179	168.095
-4	98.436	42	116.311	88	133.941	134	151.326	180	168.465
-3	98.827	43	116.697	89	134.322	135	151.701	181	168.834
-2	99.218	44	117.083	90	134.702	136	152.076	182	169.204
-1	99.609	45	117.469	91	135.083	137	152.451	183	169.574
0	100.000	46	117.854	92	135.463	138	152.826	184	169.943
1	100.391	47	118.240	93	135.843	139	153.200	185	170.313
2	100.781	48	118.625	94	136.223	140	153.575	186	170.682
3	101.172	49	119.010	95	136.603	141	153.950	187	171.051
4	101.562	50	119.395	96	136.982	142	154.324	188	171.420
5	101.953	51	119.780	97	137.362	143	154.698	189	171.789
6	102.343	52	120.165	98	137.741	144	155.072	190	172.158
7	102.733	53	120.550	99	138.121	145	155.446	191	172.527
8	103.123	54	120.934	100	138.500	146	155.820	192	172.895
9	103.513	55	121.319	101	138.879	147	156.194	193	173.264
10	103.902	56	121.703	102	139.258	148	156.568	194	173.632
11	104.292	57	122.087	103	139.637	149	156.941	195	174.000
12	104.681	58	122.471	104	140.016	150	157.315	196	174.368
13	105.071	59	122.855	105	140.395	151	157.688	197	174.736
14	105.460	60	123.239	106	140.773	152	158.061	198	175.104
15	105.849	61	123.623	107	141.152	153	158.435	199	175.472
16	106.238	62	124.007	108	141.530	154	158.808	200	175.840

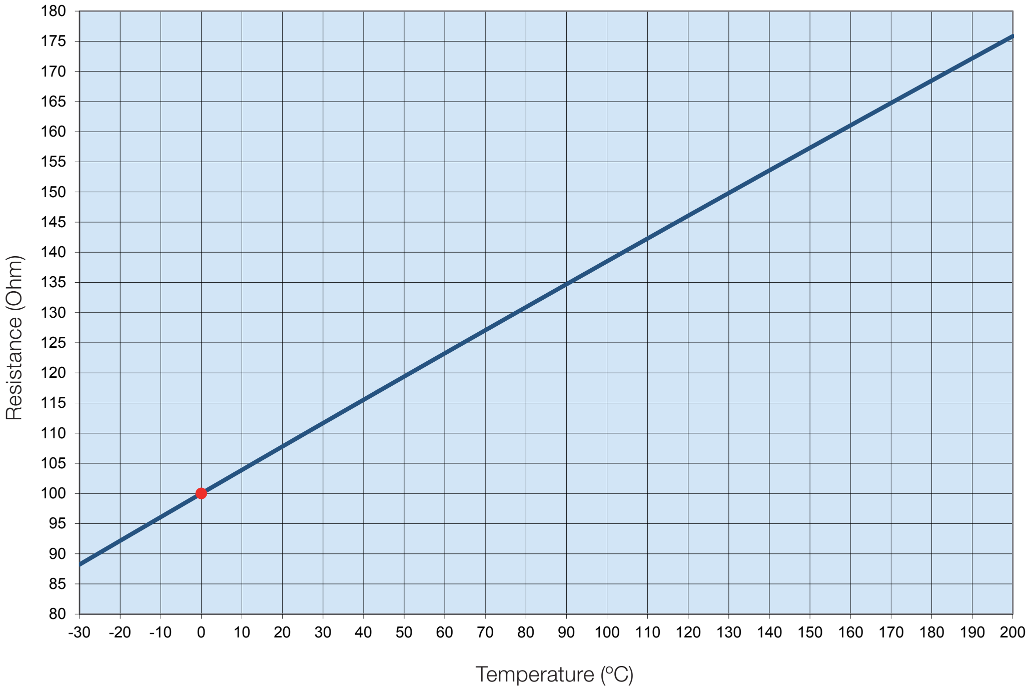


Figure 6.18 *- Ohmic resistance of the Pt-100 x temperature*

6.12. CONNECTION OF THE SPACE HEATERS

Before switching ON the space heaters, check if the space heaters connection have been made according to the connection diagram shown on the space heater nameplate. For motors supplied with dual voltage space heaters (110-127/220-240 V), see Figure 6.19.

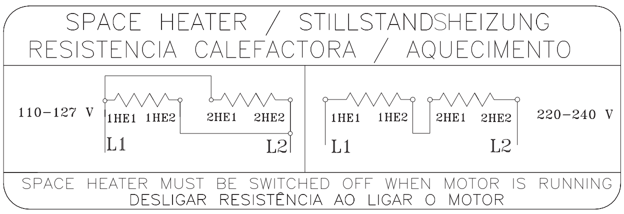


Figure 6.19 *- Dual voltage space heater connection*

The space heaters should never be energized when the motor is in operation.

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6.13. STARTING METHODS

Whenever possible, the motor starting must be Direct On Line (DOL) at rated voltage. This is the most simple and feasible starting method. However, it must only be applied when the starting current does not affect the power supply. Please consider the local electric utility regulations when installing a motor.
High inrush current may result in:
a) high voltage drop in the power supply line creating unacceptable line disturbance on the distribution system;
b) requiring oversized protection system (cables and contactor) increasing the installation costs.

If DOL starting is not allowed due to the reasons mentioned above, an indirect starting method compatible with the load and motor voltage to reduce the starting current may be used.
If reduced voltage starters are used for starting, the motor starting torque will also be reduced.

Table 6.6 shows the possible indirect starting methods that can be used depending on the number of the motor leads.

***Table 6.6** - Starting method x number of motor leads*

Number of leads	Possible starting methods
3 leads	Autotransformer Soft-starter
6 leads	Star-Delta Autotransformer Soft-starter
9 leads	Series/Parallel Part winding Autotransformer Soft-starter
12 leads	Star-Delta Series/Parallel Part winding Autotransformer Soft-starter

Table 6.7 shows examples of possible indirect starting methods to be used according to the voltage indicated on the motor nameplate and the power supply voltage.

***Table 6.7** - Starting methods x voltage*

Nameplate voltage	Operating voltage	Star-delta	Autotransformer starting	Starting by series/ parallel switch	Part-winding starting	Starting by Soft-starter
220/380 V	220 V 380 V	YES NO	YES YES	NO NO	NO NO	YES YES
220/440 V	220 V 440 V	NO NO	YES YES	YES NO	YES NO	YES YES
230/460 V	230 V 460 V	NO NO	YES YES	YES NO	YES NO	YES YES
380/660 V	380 V	YES	YES	NO	NO	YES
220/380/440 V	220 V 380 V 440 V	YES NO YES	YES YES YES	YES YES NO	YES YES NO	YES YES YES

The WQuattro line motors must be started direct on-line (DOL) or driven by a frequency inverter in scalar mode.

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6.14. MOTORS DRIVEN BY FREQUENCY INVERTER

The operation with frequency inverter must be stated in the Purchase Order since this drive type may require some changes of the motor design.

Wmagnet Motors must only be driven by WEG frequency inverter.

The frequency inverter used to drive motors up to 690 V must be fitted with Pulse With Modulation (PWM) with vector control.

When a motor is driven by a frequency inverter at lower frequencies than the rated frequency, you must reduce the motor torque to prevent motor overheating. The torque reduction (derating torque) can be found in the item 6.4 of the "Technical Guidelines for Induction Motors driven by PWM Frequency inverters" available on the site www.weg.net.

If the motor is operated above the rated frequency, please note:
- That the motor must be operated at constant output;
- That the motor can supply max. 95% of its rated output;
- Do not exceed the maximum speed and please consider:
  - max. operating frequency stated on the additional nameplate;
  - mechanical speed limitation of the motor.

Information on the selection of the power cables between the frequency inverter and the motor can be found in the item 6.4 of the "Technical Guidelines for Induction Motors driven by PWM Frequency inverters" available at www.weg.net.

6.14.1. Use of dV/dt filter

6.14.1.1. Motor with enameled round wire

Motors designed for rated voltages up to 690 V, when driven by frequency inverter, do not require the use of dV/dT filters, provided that following criteria are considered.

Criteria for the selection of motors with round enameled wire when driven by frequency inverter				
Motor rated votage [1]	Peak voltage at the motor terminals (max)	dV/dt inverter output (max)	Inverter Rise Time [2] (min.)	MTBP [2] Time between pulses (min)
Vnom < 460 V	≤ 1600 V	≤ 5200 V/µs	≥ 0,1 µs	≥ 6 µs
460 ≤ Vnom < 575 V	≤ 2000 V	≤ 6500 V/µs		
575 ≤ Vnom ≤ 1000 V	≤ 2400 V	≤ 7800 V/µs		

***Notes**:*
1. For the application of dual voltage motors, example 380/660 V, consider the lower voltage (380 V).
2. Information supplied by the inverter manufacturer.

6.14.1.2. Motor with prewound coils

Motors with prewound coils (medium and high voltage motors regardless of frame sizes, and low voltage motors from IEC 500 / NEMA 800 frame on), designed for the use with frequency inverters, do not require the use of filters, provided they comply with the criteria in Table 6.8.

***Table 6.8** - Criteria to be considered when using motor with prewound coils to be drive by frequency inverters*

Motor rated voltage	Type of modulation	Turn to turn insulation (phase-phase)		Phase-ground insulation	
		Peak voltage at the motor terminals	dV/dt at the motor terminals	Peak voltage at the motor terminals	dV/dt at the motor terminals
690 < Vnom ≤ 4160 V	Sinusoidal	≤ 5900 V	≤ 500 V/µs	≤ 3400 V	≤ 500 V/µs
	PWM	≤ 9300 V	≤ 2700 V/µs	≤ 5400 V	≤ 2700 V/µs
4160 < Vnom ≤ 6600 V	Sinusoidal	≤ 9300 V	≤ 500 V/µs	≤ 5400 V	≤ 500 V/µs
	PWM	≤ 14000 V	≤ 1500 V/µs	≤ 8000 V	≤ 1500 V/µs

6.14.2. Bearing insulation

Only the motors in IEC frame size 400 (NEMA 680) and larger are supplied, as standard, with insulated bearing. If motor must be driven by frequency inverter, insulate the bearing according to Table 6.9.

Table 6.9 *- Recommendation on the bearing insulation for inverter driven motors*

Frame size	Recommendation
IEC 315 and 355 NEMA 445/7 to L5810/11	■ Insulated bearing/end shield ■ Grounding between shaft and frame by grounding brush
IEC 400 and larger NEMA 680 and larger	■ Insulated NDE bearing ■ Grounding between shaft and frame by grounding brush

When motors are supplied with shaft grounding system, monitor the grounding brush constantly during its operation and, when it reaches the end of its useful life, it must be replaced by another brush with the same specification.

6.14.3. Switching frequency

The minimum inverter switching frequency must not be lower than 2.5 kHz and should not exceed 5 kHz.

The non-compliance with the criteria and recommendations indicated in this manual may void the product warranty.

6.14.4. Mechanical speed limitation

Table 6.10 shows the maximum speeds allowed for motors driven by frequency inverter.

Table 6.10 *- Maximum motor speed (in rpm)*

Frame size		DE-bearing	Maximum speed for standard motors
IEC	NEMA		
63-90	143/5	6201 6202 6203 6204 6205	10400
100	-	6206	8800
112	182/4	6207	7600
		6307	6800
132	213/5	6308	6000
160	254/6	6309	5300
180	284/6	6311	4400
200	324/6	6312	4200
225-630	364/5-9610	6314	3600
		6315	3600
		6316	3200
		6319	3000
		6218	3600
		6220	3600
		6320	2200
		6322	1900
		6324	1800
		6328	1800
		6330	1800
		6224	1800
		6228	1800

Note:
To select the maximum allowed motor speed, consider the motor torque derating curve.

For more information on the application of frequency inverters, contact WEG or check the "Technical Guidelines for Induction Motors driven by PWM Frequency inverters" available at www.weg.net.

7. COMMISSIONING

7.1. INITIAL START-UP

After finishing the installation procedures and before starting the motor for the first time or after a long period without operation, the following items must be checked:

- If the nameplate data (voltage, current, connection diagram, degree of protection, cooling system, service factor, etc.) meet the application requirements;
- If the machine set (motor + driven machine) has been mounted and aligned correctly;
- If the motor driving system ensures that the motor speed does not exceed the max. allowed speed indicated in Table 6.10;
- Measure the winding insulation resistance, making sure it complies with the specified values in item 5.4;
- Check the motor rotation direction;
- Inspect the motor terminal box for damage and ensure that it is clean and dry and all contacts are rust-free, the seals are in perfect operating conditions and all unused threaded holes are properly closed thus ensuring the degree of protection indicated on the motor nameplate;
- Check if the motor wiring connections, including grounding and auxiliary equipment connection, have been carried out properly and are in accordance with the recommendations in item 6.9;
- Check the operating conditions of the installed auxiliary devices (brake, encoder, thermal protection device, forced cooling system, etc.);
- Check bearing operating conditions. If the motors are stored and/or installed for more than two years without running, it is recommended to change the bearings, or to remove, wash, inspect and relubricate them before the motor is started. If the motor is stored and/or installed according to the recommendations described in item 5.3, lubricate the bearings as described in item 8.2. For the bearing condition evaluation, it is recommended to use of the vibration analysis techniques: Envelope Analysis or Demodulation Analysis.
- For roller bearing motors with oil lubrication, ensure:
  - The oil level should be in the center of the sight glass (see Figure 8.1 and 8.2);
  - That if the motor is stored for a period equal or longer than the oil change interval, the oil must be changed before starting the motor.
- When motors are fitted with sleeve bearings, ensure:
  - Correct oil level for the sleeve bearing. The oil level should be in the center of the sight glass (see Figure 8.3);
  - That the motor is not started or operated with axial or radial loads;
  - That if the motor is stored for a period equal or longer than the oil change interval, the oil must be changed before starting the motor.
- Inspect the capacitor operating condition, if any. If motors are installed for more than two years, but were never commissioned, it is recommended to change the start capacitors since they lose their operating characteristics;
- Ensure that the air inlet and outlet opening are not blocked. The minimum clearance to the nearest wall (L) should be at least ¼ of the fan cover diameter (D), see Figure 7.1. The intake air temperature must be at ambient temperature.

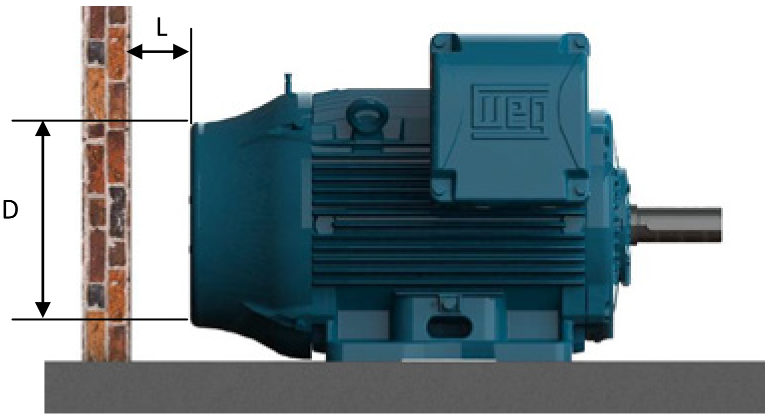

Figure 7.1*- Minimum clearance to the wall*

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Please consider the minimum distances shown in the Table 7.1 as reference value;

***Table 7.1** - Minimum distance between the fan cover and wall*

Frame size		Distance between the fan cover and the wall (L)	
IEC	**NEMA**	**mm**	**inches**
63	-	25	0.96
71	-	26	1.02
80	-	30	1.18
90	143/5	33	1.30
100	-	36	1.43
112	182/4	41	1.61
132	213/5	50	1.98
160	254/6	65	2.56
180	284/6	68	2.66
200	324/6	78	3.08
225 250	364/5 404/5	85	3.35
280	444/5 445/7 447/9	108	4.23
315	L447/9 504/5 5006/7/8 5009/10/11	122	4.80
355	586/7 588/9 5807/8/9 5810/11/12	136	5.35
400	6806/7/8 6809/10/11	147	5.79
450	7006/10	159	6.26
500	8006/10	171	6.73
560	8806/10	185	7.28
630	9606/10	200	7.87

- Ensure correct water flow rate and water temperature when water cooled motors are used. See item 7.2;
- Ensure that all rotating parts, such as pulleys, couplings, external fans, shaft, etc. are protected against accidental contact.

Other tests and inspections not included in the manual may be required, depending on the specific installation, application and/or motor characteristics.

After all previous inspections have been carried out, proceed as follows to start the motor:

- Start the motor on no-load (if possible) and check the motor direction of rotation. Check for the presence of any abnormal noise, vibration or other abnormal operating conditions;
- Ensure the motor starts smoothly. If any abnormal operating condition is noticed, switch off the motor, check the assembly system and connections before the motor is started again;
- If excessive vibrations are noticed, check if the motor mounting bolts are well tightened or if the vibrations are not generated and transmitted from adjacent installed equipment. Check the motor vibration periodically and ensure that the vibration limits are as specified in item 7.2.1;
- Start the motor at rated load during a short time and compare the operating current with the rated current indicated on the nameplate;
- Continue to measure the following motor variables until thermal equilibrium is reached: current, voltage, bearing and motor frame temperature, vibration and noise levels;
- Record the measured current and voltage values on the Installation Report for future comparisons.

As induction motors have high inrush currents during start-up, the acceleration of high inertia load requires an extended starting time to reach full speed resulting in fast motor temperature rise. Successive starts within short intervals will result in winding temperature increases and can lead to physical insulation damage reducing the useful life of the insulation system. If the duty cycle S1 / CONT. is specified on the motor nameplate, this means that the motor has been designed for:

- Two successive starts: first start from cold condition, i. e., the motor windings are at room temperature and the second start immediately after the motor stops;
- One start from hot condition, i. e., the motor windings are at rated temperature.

The Troubleshooting Chart in section 10 provides a basic list of unusual cases that may occur during motor operation with the respective corrective actions.

7.2. OPERATING CONDITIONS

Unless otherwise stated in the Purchase Order, electric motors are designed and built to be operated at altitudes up to 1000 meters above sea level and in a temperature range from -20 °C to +40 °C. Any deviation from the normal condition of motor operation must be stated on the motor nameplate. Some components must be changed if the ambient temperature is different from the specified one. Please contact WEG to check the required special features.

For operating temperatures and altitudes differing from those above, the factors indicated in Table 7.2 must be applied to the nominal motor power rating in order to determine the derated available output (Pmax = Pnom x correction factor).

Table 7.2 *- Correction factors for altitude and ambient temperature*

T (°C)	Altitude (m)								
	1000	1500	2000	2500	3000	3500	4000	4500	5000
10							0.97	0.92	0.88
15						0.98	0.94	0.90	0.86
20					1.00	0.95	0.91	0.87	0.83
25				1.00	0.95	0.93	0.89	0.85	0.81
30			1.00	0.96	0.92	0.90	0.86	0.82	0.78
35		1.00	0.95	0.93	0.90	0.88	0.84	0.80	0.75
40	1.00	0.97	0.94	0.90	0.86	0.82	0.80	0.76	0.71
45	0.95	0.92	0.90	0.88	0.85	0.81	0.78	0.74	0.69
50	0.92	0.90	0.87	0.85	0.82	0.80	0.77	0.72	0.67
55	0.88	0.85	0.83	0.81	0.78	0.76	0.73	0.70	0.65
60	0.83	0.82	0.80	0.77	0.75	0.73	0.70	0.67	0.62
65	0.79	0.76	0.74	0.72	0.70	0.68	0.66	0.62	0.58
70	0.74	0.71	0.69	0.67	0.66	0.64	0.62	0.58	0.53
75	0.70	0.68	0.66	0.64	0.62	0.60	0.58	0.53	0.49
80	0.65	0.64	0.62	0.60	0.58	0.56	0.55	0.48	0.44

Motors installed inside enclosures (cubicles) must be ensured an air renewal rate in the order of one cubic meter per second for each 100 kW installed power or fraction of installed power. Totally Enclosed Air Over motors - TEAO (fan and exhaust / smoke extraction) are supplied without cooling fan and the manufacturer of the driven machine is responsible for sufficient motor cooling. If no minimum required air speed between motor fins is indicated on the motor nameplate, ensure the air speed indicated in the table 7.3 is provided. The values shown in Table 7.3 are valid for 60 Hz motors. To obtain the minimum air speed for 50 Hz motors, multiply the values in the table by 0.83.

Table 7.3 *- Minimum required air speed between motor fins (metres/second)*

Frame		Poles			
IEC	NEMA	2	4	6	8
63 to 90	143/5	13	7	5	4
100 to 132	182/4 to 213/5	18	12	8	6
160 to 200	254/6 to 324/6	20	15	10	7
225 to 280	364/5 to 444/5	22	20	15	12
315 to 450	445/7 to 7008/9	25	25	20	15

The voltage and frequency variations may affect the performance characteristics and the electromagnetic compatibility of the motor. The power supply variations should not exceed the values specified in the applicable standards. Examples:

- ABNT NBR 17094 - Parts 1 and 2. The motor has been designed to supply the rated torque for a combined variation in voltage and frequency:
  - Zone A: ±5% of the rated voltage and ±2% of the rated frequency;
  - Zone B: ±10% of the rated voltage and +3% -5% of the rated frequency.

When operated continuously in Zone A or B, the motor may show performance variations and the operating temperature may increase considerably. These performance variations will be higher in Zone B. Thus it is not recommended to operate the motor in Zone B during extended periods.

- IEC 60034-1. The motor has been designed to supply the rated torque for combined variation in voltage and frequency:
  - Zone A: ±5% of the rated voltage and ±2% of the rated frequency;
  - Zone B: ±10% of the rated voltage and +3% -5% of the rated frequency.

When operated continuously in Zone A or B, the motor may show performance variations and the operating temperature may increase considerably. These performance variations will be higher in Zone B. Thus it is not recommended to operate the motor in Zone B during extended periods. For multivoltage motors (example 380-415/660 V), a ±5% voltage variation from the rated voltage is allowed.

- NEMA MG 1 Part 12. The motor has been designed to be operated in one of the following variations:
  - ±10% of the rated voltage, with rated frequency;
  - ±5% of the rated frequency, with rated voltage;
  - A combined variation in voltage and frequency of ±10%, provided the frequency variation does not exceed ±5%.

If the motor is cooled by ambient air, clean the air inlet and outlet openings and cooling fins at regular intervals to ensure a free airflow over the frame surface. The hot air should never be returned to the motor. The cooling air must be at room temperature limited to the temperature range indicated on the motor nameplate (if no room temperature is specified, please consider a temperature range between -20 °C and +40 °C).

Table 7.4 shows the minimum required water flow for water cooled motors considering the different frame sizes and the maximum allowed temperature rise of the cooling water after circulating through the motor. The inlet water temperature should not exceed 40 °C.

***Table 7.4** - Minimum required water flow and the maximum allowed temperature rise of the cooling water after circulating through the motor*

Frame size		Flow rate (litres/minute)	Maximum allowed water temperature rise (°C)
IEC	NEMA		
180	284/6	12	5
200	324/6	12	5
225	364/5	12	5
250	404/5	12	5
280	444/5 445/7 447/9	15	6
315	504/5	16	6
355	586/7 588/9	25	6

Motors fitted with oil mist lubrication systems can be operated continuously for a maximum of one hour after the failure of the oil pumping system.

Considering the sun's heat increases the operating temperature, externally mounted motors should always be protected from direct sunlight exposure.

Each and every deviation from the normal operating condition (tripping of the thermal protection, noise and vibration level increase, temperature and current rise) should be investigated and corrected by WEG Authorized Service Centers.

Motors fitted with cylindrical roller bearings require a minimum radial load to ensure a normal operation. For information regarding the radial preload, please contact WEG.

7.2.1.Limits of vibration

The vibration severity is the maximum vibration value measured at all positions and in all directions as recommended in the standard IEC 60034-14. Table 7.5 specifies the limits of the maximum vibrations magnitudes according to standard IEC 60034-14 for shaft heights IEC 56 to 400, for vibrations grades A and B. The vibration severity limits in Table 7.5 are given as RMS values (Root Mean Square values or effective values) of the vibration speed in mm/s measured in free suspension condition.

***Table 7.5** - Recommended limits for the vibration severity according to standard IEC 60034-14*

Shaft height [mm]	$56 \leq H \leq 132$	$132 \leq H \leq 280$	$H > 280$
Vibration grade	Vibration severity on elastic base [mm/s RMS]		
A	1.6	2.2	2.8
B	0.7	1.1	1.8

***Notes**:*
1 - The values in Table 7.5 are valid for measurements carried out with decoupled machines (without load) operated at rated voltage and frequency.
2 - The values in Table 7.5 are valid regardless of the direction of rotation of the machine.
3 - The values in Table 7.5 are not applicable to single-phase motors, three-phase motors powered by a single-phase system or to machines mounted in situ or coupled with inertia flywheels or to loads.

According to NEMA MG 1, the allowed vibration limit for standard motors is 0.15 in/s (peak vibration in in/s).

***Note**:*
For the load operation condition, the use of the standard ISO 10816-3 is recommended for evaluating the motor vibration limits. In the load condition the motor vibration will be influenced by several factors, such as, type of the coupled load, condition of the motor fixation, alignment condition under load, structure or base vibration due to other equipments, etc..

8. MAINTENANCE

The purpose of the maintenance is to extend the useful life of the equipment. The non-compliance with one of these previous items can cause unexpected machine failures.

If motors with cylindrical roller or angular contact bearings are to be transported during the maintenance procedures, the shaft locking device must always be fitted. All HGF motors, regardless of the bearing type, must always be transported with the shaft locking device fitted.

All repairs, disassembly and assembly related services must be carried out only by qualified and well-trained personnel by using proper tools and techniques. Make sure that the machine has stopped and it is disconnected from the power supply, including the accessory devices (space heater, brake, etc.), before any servicing is undertaken.
The company does not assume any responsibility or liability for repair services or maintenance operations executed by non-authorized Service Centers or by non qualified service personnel. The company shall have no obligation or liability whatsoever to the buyer for any indirect, special, consequential or incidental loss or damage caused or arising from the company's proven negligence

8.1. GENERAL INSPECTION

The inspection intervals depend on the motor type, application and installation conditions. Proceed as follows during inspection:

- Visually inspect the motor and coupling. Check if abnormal noises, vibrations, excessive heating, wear signs, misalignment or damaged parts are noticed. Replace the damaged parts as required;
- Measure the insulation resistance according to the item 5.4;
- Clean the motor enclosure. Remove oil spills and dust accumulation from the motor frame surface to ensure a better heat transfer to the surrounding ambient;
- Check cooling fan condition and clean the air inlet & outlet openings to ensure a free air flow over the motor;
- Investigate the actual condition of the seals and replace them, if required;
- Drain the condensed water from inside the motor. After draining, reinstall the drain plugs to ensure the degree of protection as indicated on the motor nameplate. The motor must always be positioned so the drain hole is at the lowest position (see item 6);
- Check the connections of the power supply cables, ensuring the correct clearance distance between live and grounded parts, as specified in Table 6.3;
- Check if the tightening torque of the bolted connections and mounting bolts meets the tightening torque specified in Table 8.11;
- Check the status of the cable passages, the cable gland seals and the seals inside the terminal box and replace them, if required;
- Check the bearing operating conditions. Check for the presence of any abnormal noise, vibration or other abnormal operating conditions, like motor temperature rise. Check the oil level, the lube oil condition and compare the workings hours with the informed life time;
- Record and file all changes performed on the motor.

Do not reuse damaged or worn parts. Damaged or worn parts must be replaced by parts supplied by the manufacturer and must be installed as if they were the original parts.

8.2. LUBRICATION

Proper lubrication plays a vital role in the motor performance. Only use the grease or oil types, amounts and lubrication intervals recommended for the bearings. This information is available on the motor nameplate and the lubrication procedures must be carried out according to the type of lubricant (oil or grease).
When the motor is fitted with thermal protection devices for bearing temperature control, consider the operating temperature limits shown in Table 6.4.
The maximum operating temperature of motors used in special applications may differ from those shown in Table 6.4. The grease and oil disposal should be made in compliance with applicable laws in each country.

Please contact WEG when motors are to be installed in special environments or used for special applications.

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8.2.1. Grease lubricated rolling bearings

Excess grease causes bearing overheating, resulting in bearing failure.

The lubrication intervals specified in Table 8.1, Table 8.2, Table 8.3, Table 8.4, Table 8.5, Table 8.6, Table 8.7 and Table 8.8 consider an absolute temperature on the bearing of 70 °C (up to frame size IEC 200 / NEMA 324/6) and 85 °C (for frame size IEC 225 / NEMA 364/5 and above), the motor running at rated speed, a motor mounted in horizontal position and greased with Mobil Polyrex EM grease. Any variation of the parameters listed above must be evaluated.

Table 8.1 *- Lubrication intervals for ball bearings*

Frame		Poles	Bearing designation	Amount of grease (g)	Lubrication intervals (hours)					
					ODP (Open Drip Proof)		W21 TEFC (Totally Enclosed Fan Cooled)		W22 TEFC (Totally Enclosed Fan Cooled)	
IEC	NEMA				50 Hz	60 Hz	50 Hz	60 Hz	50 Hz	60 Hz
90	143/5	2	6205	4	-	-	20000	20000	25000	25000
		4								
		6								
		8								
100	-	2	6206	5	-	-	20000	20000	25000	25000
		4								
		6								
		8								
112	182/4	2	6207/ 6307	9	-	-	20000	20000	25000	25000
		4								
		6								
		8								
132	213/5	2	6308	11	-	-	20000	18400	25000	23200
		4					20000	20000	25000	25000
		6								
		8								
160	254/6	2	6309	13	20000	20000	18100	15700	22000	20000
		4					20000	20000	25000	25000
		6								
		8								
180	284/6	2	6311	18	20000	20000	13700	11500	17000	14000
		4					20000	20000	25000	25000
		6								
		8								
200	324/6	2	6312	21	20000	20000	11900	9800	15000	12000
		4					20000	20000	25000	25000
		6								
		8								
225 250 280 315 355	364/5 404/5 444/5 445/7 447/9 L447/9 504/5 5008 5010/11 586/7 588/9	2	6314	27	18000	14400	4500	3600	5000	4000
		4			20000	20000	11600	9700	14000	12000
		6					16400	14200	20000	17000
		8					19700	17300	24000	20000
		2	6316	34	14000	*Upon request	3500	*Upon request	4000	*Upon request
		4			20000	20000	10400	8500	13000	10000
		6					14900	12800	18000	16000
		8					18700	15900	20000	20000
		2	6319	45	*Upon request					
		4			20000	20000	9000	7000	11000	8000
		6					13000	11000	16000	13000
		8					17400	14000	20000	17000
		4	6322	60	20000	20000	7200	5100	9000	6000
		6					10800	9200	13000	11000
		8					15100	11800	19000	14000

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Table 8.2 *- Lubrication intervals for cylindrical roller bearings*

Frame		Poles	Bearing designation	Amount of grease (g)	LUBRICATION INTERVALS (hours)					
					ODP (Open Drip Proof)		W21 TEFC (Totally Enclosed Fan Cooled)		W22 TEFC (Totally Enclosed Fan Cooled)	
IEC	NEMA				50 Hz	60 Hz	50 Hz	60 Hz	50 Hz	60 Hz
160	254/6	2	NU309	13	20000	19600	13300	9800	16000	12000
		4				20000	20000	20000	25000	25000
		6								
		8								
180	284/6	2	NU311	18	18400	12800	9200	6400	11000	8000
		4			20000	20000	20000	19100	25000	25000
		6						20000		
		8								
200	324/6	2	NU312	21	15200	10200	7600	5100	9000	6000
		4			20000	20000	20000	17200	25000	21000
		6						20000		25000
		8								
225 250 280 315 355	364/5 404/5 444/5 445/7 447/9 L447/9 504/5 5008 5010/11 586/7 588/9	4	NU314	27	17800	14200	8900	7100	11000	9000
		6			20000	20000	13100	11000	16000	13000
		8					16900	15100	20000	19000
		4	NU316	34	15200	12000	7600	6000	9000	7000
		6			20000	19000	11600	9500	14000	12000
		8				20000	15500	13800	19000	17000
		4	NU319	45	12000	9400	6000	4700	7000	5000
		6			19600	15200	9800	7600	12000	9000
		8			20000	20000	13700	12200	17000	15000
		4	NU322	60	8800	6600	4400	3300	5000	4000
		6			15600	11800	7800	5900	9000	7000
		8			20000	20000	11500	10700	14000	13000

Table 8.3 *- Lubrication intervals for ball bearings - HGF line*

Frame		Poles	Bearing designation	Amount of grease (g)	Lubrication intervals (hours)	
IEC	NEMA				50 Hz	60 Hz
315L/A/B and 315C/D/E	5006/7/8T and 5009/10/11T	2	6314	27	3100	2100
		4 - 8	6320	50	4500	4500
			6316	34	4500	4500
355L/A/B and 355C/D/E	5807/8/9T and 5810/11/12T	2	6314	27	3100	2100
		4 - 8	6322	60	4500	4500
			6319	45	4500	4500
400L/A/B and 400 C/D/E	6806/7/8T and 6809/10/11T	2	6315	30	2700	1800
		4 - 8	6324	72	4500	4500
			6319	45	4500	4500
450	7006/10	2	6220	31	2500	1400
		4	6328	93	4500	3300
			6322	60	4500	4500
		6 - 8	6328	93	4500	4500
			6322	60	4500	4500
500	8006/10	4	6330	104	4200	2800
			6324	72	4500	4500
		6 - 8	6330	104	4500	4500
			6324	72	4500	4500
500	8006/10	4	6330	104	4200	2800
			6324	72	4500	4500
		6 - 8	6330	104	4500	4500
			6324	72	4500	4500
560	8806/10	4 - 8	*Upon request			
630	9606/10	4 - 8				

Table 8.4 *- Lubrication intervals for cylindrical roller bearings - HGF line*

Frame		Poles	Bearing designation	Amount of grease (g)	Lubrication intervals (hours)	
IEC	NEMA				50 Hz	60 Hz
315L/A/B and 315C/D/E	5006/7/8 and 5009/10/11	4	NU320	50	4300	2900
		6 - 8			4500	4500
355L/A/B and 355C/D/E	5807/8/9 and 5810/11/12	4	NU322	60	3500	2200
		6 - 8			4500	4500
400L/A/B and 400C/D/E	6806/7/8 and 6809/10/11	4	NU324	72	2900	1800
		6 - 8			4500	4500
450	7006/10	4	NU328	93	2000	1400
		6			4500	3200
		8			4500	4500
500	8006/10	4	NU330	104	1700	1000
		6			4100	2900
		8			4500	4500
560	8806/10	4	NU228 + 6228	75	2600	1600
		6 - 8		106	4500	4500
630	9606/10	4	NU232 + 6232	92	1800	1000
		6		120	4300	3100
		8		140	4500	4500

Tabela 8.5 *- Lubrication intervals for ball bearings - W50 line*

	Frame		Poles	D.E. Bearing	Amount of grease (g)	50 Hz (h)	60 Hz (h)	N.D.E. Bearing	Amount of grease (g)	50 Hz (h)	60 Hz (h)
	IEC	NEMA									
Horizontal mounting Ball bearings	315 H/G	5009/10	2	6314	27	4500	3500	6314	27	4500	3500
			4 - 8	6320	50		4500	6316	34		4500
	355 J/H	5809/10	2	6314	27		3500	6314	27		3500
			4 - 8	6322	60		4500	6319	45		4500
	400 L/K and 400 J/H	6806/07 and 6808/09	2	6218	24	3800	2500	6218	24	3800	1800
			4 - 8	6324	72	4500	4500	6319	45	4500	4500
	450 L/K and 450 J/H	7006/07 and 7008/09	2	6220	31	3000	2000	6220	31	3000	2000
			4	6328	93	4500	3300	6322	60	4500	4500
			6 - 8				4500				
Vertical mounting Ball bearings	315 H/G	5009/10	2	7314	27	2500	1700	6314	27	2500	1700
			4	6320	50	4200	3200	6316	34	4500	4500
			6 - 8			4500	4500				
	355 J/H	5809/10	2	7314	27	2500	1700	6314	27	2500	1700
			4	6322	60	3600	2700	6319	45	4500	3600
			6 - 8			4500	4500				4500
	400 L/K and 400 J/H	6806/07 and 6808/09	2	7218	24	2000	1300	6218	24	2000	1300
			4	7324	72	3200	2300	6319	45	4500	3600
			6			4500	4300				4500
			8				4500				
	450 L/K and 450 J/H	7006/07 and 7008/09	2	7220	31	1500	1000	6220	31	1500	1000
			4	7328	93	2400	1700	6322	60	3500	2700
			6			4100	3500			4500	4500
			8			4500	4500				

Tabela 8.6 *- Lubrication intervals for cylindrical roller bearings - W50 line*

	Frame		Poles	D.E. Bearing	Amount of grease (g)	50 Hz (h)	60 Hz (h)	N.D.E. Bearing	Amount of grease (g)	50 Hz (h)	60 Hz (h)
	IEC	NEMA									
Horizontal mounting Roller bearings	315 H/G	5009/10	4	NU320	50	4300	2900	6316	34	4500	4500
			6 -8			4500	4500				
	355 J/H	5809/10	4	NU322	60	3500	2200	6319	45		
			6 - 8			4500	4500				
	400 L/K and 400 J/H	6806/07 and 6808/09	4	NU324	72	2900	1800				
			6 - 8			4500	4500				
	450 L/K and 450 J/H	7006/07 and 7008/09	4	NU328	93	2000	1400	6322	60		
			6			4500	3200				
			8				4500				

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Tabela 8.7 - Lubrication intervals for ball bearings - W40 line

	Frame		Poles	D.E. Bearing	Amount of grease (g)	50 Hz (h)	60 Hz (h)	N.D.E. Bearing	Amount of grease (g)	50 Hz (h)	60 Hz (h)
	IEC	NEMA									
Horizontal mounting Ball bearings	315G/F	5010/11	2	6314	27	4500	4500	6314	27	4500	4500
			4 - 8	6319	45	4500	4500	6314	27	4500	4500
	355 J/H	L5010/11	2	6218	24	4500	4500	6218	24	4500	4500
			4 – 8	6224	43	4500	4500	6218	24	4500	4500
	400 J/H	L5810/11	2	6220	31	4500	3800	6220	31	4500	3800
			4 – 8	6228	52	4500	4500	6220	31	4500	4500
	450 K/J	L6808/09	2	6220	31	4500	3800	6220	31	4500	3800
			4 – 8	6228	52	4500	4500	6220	31	4500	4500

Tabela 8.8 - Lubrication intervals for cylindrical roller bearings - W40 line

	Frame		Poles	D.E. Bearing	Amount of grease (g)	50 Hz (h)	60 Hz (h)	N.D.E. Bearing	Amount of grease (g)	50 Hz (h)	60 Hz (h)
	IEC	NEMA									
Horizontal mounting Roller bearings	315G/F	5010/11	4 - 8	NU319	45	4500	4500	6314	27	4500	4500
	355 J/H	L5010/11	4 – 8	NU224	43	4500	4500	6218	24	4500	4500
	400 J/H	L5810/11	4 – 8	NU228	52	4500	3300	6220	31	4500	4500
	450 K/J	L6808/09	4 – 8	NU228	52	4500	3300	6220	31	4500	4500

For each increment of 15 °C above the bearing temperature, the relubrication intervals given in the Table must be halved. The relubrication interval of motors designed by the manufacturer for mounting in horizontal position, but installed in vertical position (with WEG authorization), must be halved.
For special applications, such as: high and low temperatures, aggressive environments, driven by frequency inverter (VFD - frequency inverter), etc., please contact WEG about the required amount of grease and the relubrication intervals.

8.2.1.1. Motor without grease fitting

Motors without grease fittings must be lubricated in accordance with the existing Maintenance Plan. Motor disassembly must be carried out as specified in Item 8.3. If motors are fitted with shielded bearings (for example, ZZ, DDU, 2RS, VV), these bearings must be replaced at the end of the grease service life.

8.2.1.2. Motor with grease fitting

To lubricate the bearings with the motor stopped, proceed as follows:
- Before lubricating, clean the grease nipple and immediate vicinity thoroughly;
- Lift grease inlet protection;
- Remove the grease outlet plug;
- Pump in approximately half of the total grease indicated on the motor nameplate and run the motor for about 1 (one) minute at rated speed;
- Switch-off the motor and pump in the remaining grease;
- Lower again the grease inlet protection and reinstall the grease outlet protection.

To grease the motor while running, proceed as follows:
- Before lubricating, clean the grease nipple and immediate vicinity thoroughly;
- Pump the total grease indicated on the motor nameplate;
- Lower again the grease inlet protection.

For lubrication, use only manual grease gun.

If Motors are provided with a spring device for grease removal, the grease excess must be removed by pulling the rod and cleaning the spring until the spring does not remove more grease.

8.2.1.3. Compatibility of the Mobil Polyrex EM grease with other greases

The Mobil Polyrex EM grease has a polyurea thickener and a mineral oil and it is not compatible with other greases.
If you need another type of grease, contact WEG.
It is not recommended to mix different types of greases. In such a case, clean the bearings and lubrication channels before applying new grease.
The used grease must have in its formulation corrosion and oxidation inhibitors.

8.2.2. Oil lubricated bearings

To change the oil of oil lubricated motor proceed as follows:

- Switch-off the motor;
- Remove threaded oil drain plug;
- Open the valve and drain the oil;
- Close the drain valve again;
- Reinstall the threaded oil drain plug;
- Fill-up with the type and amount of oil as specified on the nameplate;
- Check oil level. The oil level is OK when the lubricant can be viewed approximately in the center of the sight glass;
- Reinstall oil inlet plug;
- Check for oil leaks and ensure that all not used threaded plugs are closed with plugs.

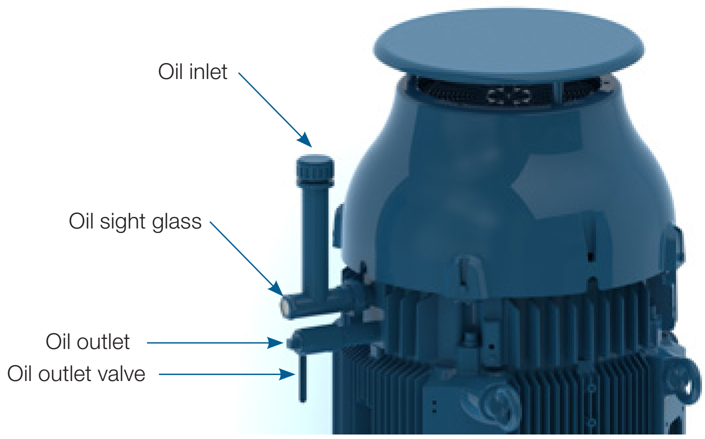

***Figure 8.1** - Oil lubricated bearing - vertical mounting*

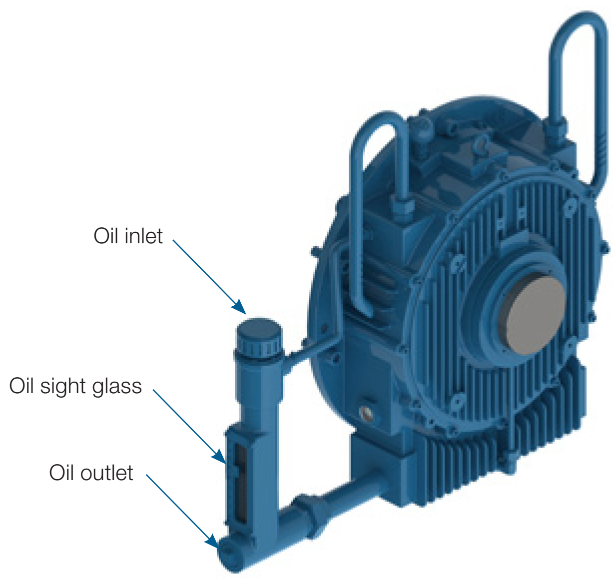

***Figure 8.2** - Oil lubricated bearing - horizontal mounting*

The bearing lubricating oil must be replaced as specified on the nameplate or whenever changes in the oil properties are noticed. The oil viscosity and pH must be checked periodically. The oil level must be checked every day and must be kept in the center of the sight glass.
Please contact WEG, when oils with different viscosities should be used.

***Note**:*
The HGF vertical mounted motors with high axial thrust are supplied with grease lubricated DE-bearings and with oil lubricated NDE-bearings. The DE-bearings must be lubricated according to recommendations in item 8.2.1. Table 8.9 specifies the oil type and the amount of oil required for this motor lubrication.

***Table 8.9** - Oil properties for HGF vertical mounted motors with high axial thrust*

Mounting - high axial thrust	Frame		Poles	Bearing designation	Oil (liters)	Interval (h)	Lubricant	Lubricant specification
	IEC	NEMA						
	315L/A/B e 315C/D/E	5006/7/8T e 5009/10/11T	4 - 8	29320	20	8000	FUCHS Renolin DTA 40 / Mobil SHC 629	ISO VG150 mineral oil with antifoam and antioxidant additives
	355L/A/B e 355C/D/E	5807/8/9T e 5810/11/12T	4 - 8	29320	26			
	400L/A/B e 400C/D/E	6806/7/8T e 6809/10/11T	4 - 8	29320	37			
	450	7006/10	4 - 8	29320	45			

8.2.3. Oil mist lubricated bearings

Check the service conditions of the seals and if replacement is required use only original components. Clean the seal components before assembly (bearing caps, end shields, etc.).
Apply joint sealant between the bearing caps and end shields. The joint sealant must be compatible with the used lubricating oil. Connect the oil lubricant tubes (oil inlet and oil outlet tubes and motor drain tube), as shown in Figure 6.12.

8.2.4. Sleeve bearings

The lubricating oil of sleeve bearings must be changed at the intervals specified in Table 8.10. To replace the oil, proceed as follows:

- NDE-bearing: remove the protection plate from the fan cover;
- Drain the oil through the drain hole located at the bottom of the bearing (see Figure 8.3);
- Close the oil drain hole;
- Remove the oil inlet plug;
- Fill the sleeve bearing with the specified oil and with the amount of oil specified in;
- Check the oil level and ensure it is kept close to the center of the sight glass;
- Install the oil inlet plug;
- Check for oil leaks.

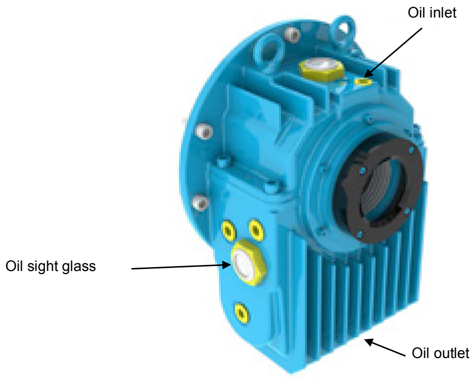

***Figure 8.3 -** Sleeve bearing*

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Table 8.10 - Oil properties for sleeve bearings

Frame		Poles	Bearing designation	Oil (liters)	Interval (h)	Lubricant	Lubricant specification
IEC	NEMA						
315	5000	2	9-80	2.8	8000	FUCHS Renolin DTA 10	ISO VG32 mineral oil with antifoam and antioxidant additives
355	5800						
400	6800						
450	7000						
315	5000	4 - 8	9-90	2.8	8000	FUCHS Renolin DTA 15	ISO VG46 mineral oil with antifoam and antioxidant additives
355	5800		9-100				
400	6800		11-110	4.7			
450	7000		11-125				
500	8000						

The lubricating oil must be replaced as specified on the nameplate or whenever changes on the oil properties are noticed. The oil viscosity and pH must be checked periodically. The oil level must be checked every day and kept in the center of the sight glass.
Please contact WEG, when oils with different viscosities are to be used.

8.3. MOTOR ASSEMBLY AND DISASSEMBLY

All repair services on motors should be always performed by qualified personnel and in accordance with the applicable laws and regulations in each country. Always use proper tools and devices for motor disassembly and assembly.

Disassembly and assembly services can be carried out only after the motor has been disconnected from the power supply and is completely stopped.

Dangerous voltages may be present at the motor terminals inside the terminal box since capacitors can retain electrical charge for long periods of time even when they are not connected directly to a power source or when space heaters are connected to the motor or when the motor windings are used as space heaters. Dangerous voltages may be present at the motor terminals when they are driven by frequency inverter even when they are completely stopped.

Record the installation conditions such as terminal connection diagram, alignment / leveling conditions before starting the disassembly procedures. These records should be considered for later assembly.

Disassemble the motor carefully without causing scratches on machined surfaces or damaging the threads.

Assemble the motor on a flat surface ensuring a good support base. Footless motors must be fixed/locked on the base to prevent accidents.

Handle the motor carefully to not damage the insulated components such as windings, insulated rolling bearings, power cables etc..

Seal elements, such as joint seals and bearing seals should always be replaced when wear or damage is noticed.
Motors with degree of protection higher than IP55 are supplied with joint and screw seal Loctite 5923 (Henkel) Clean the components and apply a new coat of Loctite 5923 on the surfaces before assembly.

For the W50 and HGF motor lines provided with axial fans, the motor and the axial fan have different markings for indicating the direction of rotation for prevent incorrect assembly.
The axial fan must be assembled so that the indicative arrow for direction of rotation is always visible, viewing the non-drive end side. The marking indicated on the axial fan blade, CW for clockwise direction of rotation or CCW for counterclockwise direction of rotation, indicates the direction of rotation of the motor viewing the drive end side.

8.3.1. Terminal box

Proceed as follows to remove the terminal box cover and to disconnect/connect the power supply cables and the cables of the accessory devices:

- Ensure that during the screw removal the terminal box cover does not damage the components installed inside the terminal box;
- If the terminal box cover is fitted with lifting eyebolt, lift the terminal box cover always by its lift eyebolt;
- If motors are supplied with terminal blocks, ensure the correct tightening torque on the motor terminals as specified in Table 8.11;
- Ensure that the cables do not contact sharp edges;
- Ensure that the original IP degree of protection is not changed and is maintained as indicate on the motor nameplate. The power supply cables and the control cables must always be fitted with components (cable glands, conduits) that meet the applicable standards and regulations of each country;
- Ensure that the pressure relief device is in perfect operating condition, if provided. The seals in the terminal box must be in perfect condition for reuse and must be reinstalled correctly to ensure the specified degree of protection;
- Ensure the correct tightening torque for the securing bolts of the terminal box cover as specified in Table 8.11.

Table 8.11 *- Tightening torque for the securing bolts [Nm]*

Screw type and seal	M4	M5	M6	M8	M10	M12	M14	M16	M20
Hex bolt/hex socket bolt (rigid joint)	-	3,5 to 5	6 to 9	14 to 20	28 to 40	45 to 70	75 to 110	115 to 170	230 to 330
Combined slotted screw (rigid joint)	1,5 to 3	3 to 5	5 to 10	10 to 18	-	-	-	-	-
Hex bolt/hex socket bolt (flexible joint)	-	3 to 5	4 to 8	8 to 15	18 to 30	25 to 40	30 to 45	35 to 50	-
Combined slotted screw (flexible joint)	-	3 to 5	4 to 8	8 to 15	-	-	-	-	-
Terminal blocks	1 to 1,5	2 to 4 1)	4 to 6,5	6,5 to 9	10 to 18	15,5 to 30	-	30 to 50	-
Grounding terminals	1,5 to 3	3 to 5	5 to 10	10 to 18	28 to 40	45 to 70	-	115 to 170	

Note: 1) For 12-pin terminal block, apply the minimum torque of 1.5 Nm and maximum torque of 2.5 Nm.

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8.4. DRYING THE STATOR WINDING INSULATION

Dismantle the motor completely. Remove the end shields, the rotor with the shaft, the fan cover, the fan and the terminal box before the wound stator with the frame is transferred to the oven for the drying process. Place the wound stator in the oven heated to max. 120 °C for two hours. For larger motors a longer drying time may be required. After the drying process has been concluded, allow the stator to cool to room temperature. Measure the insulation resistance again as described in item 5.4. Repeat the stator drying process if the required insulation resistance does not meet the values specified in Table 5.3. If the insulation resistance does not improve despite several drying processes, evaluate the causes of the insulation resistance drop carefully and an eventual replacement of the motor winding may be required. If in doubt contact WEG.

To prevent electrical shock, discharge the motor terminals immediately before, and after each measurement. If the motor is equipped with capacitors, these must be discharged before beginning any repair.

8.5. SPARE PARTS

When ordering spare parts, always provide complete motor designation, indicating the motor type, the code number and the serial number, which are stated on the motor nameplate.

Spare parts must always be purchased from WEG authorized Service Centers. The use of non-original spare parts can cause motor failure, performance drop and void the product warranty.

The spare parts must be stored in a clean, dry and properly ventilated room, with relative air humidity not exceeding 60%, with ambient temperature between 5 °C and 40 °C, free of dust, vibrations, gases, corrosive smokes and at constant temperature. The spare parts must be stored in their normal mounting position without placing other components onto them.

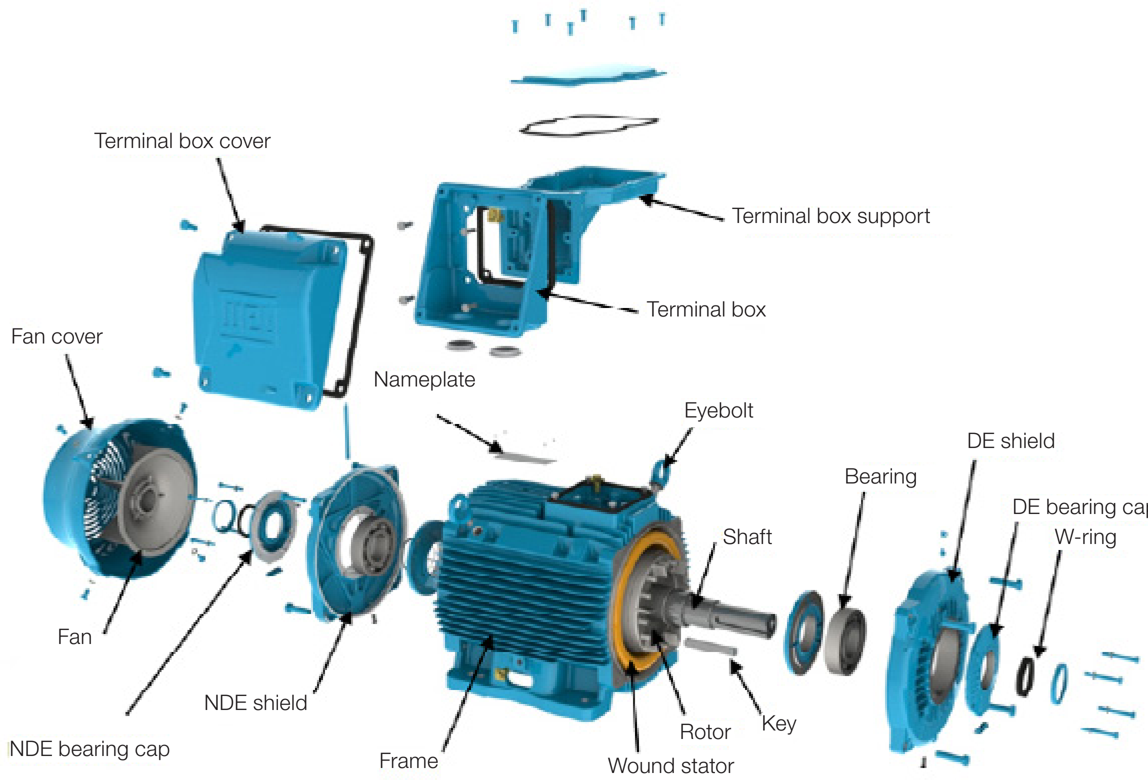

Figure 8.4 - Exploded view of the components of a W22 motor

9. ENVIRONMENTAL INFORMATION

9.1. PACKAGING

WEG electric motors are supplied in cardboard, plastic or wooden packaging. These materials can be recycled and must be disposed according to the applicable laws and regulations in each country. All wood used in the packaging of WEG motors come from the company reforestation program and is not submitted to any chemical conservation treatment.

9.2. PRODUCT

Electric motors consist mainly of ferrous metals (steel plates and cast iron), non ferrous metals (copper and aluminum) and plastic materials.

In general, electric motors have relatively long service live. However when they must be discarded, WEG recommends to dismantle the motor, sort the different materials and send them for recycling.

No-recyclable materials should be disposed of at industrial landfills according to the applicable environmental laws and regulations in each country, or co-processed in cement kilns or incinerated.

The recycling service providers, the disposal in industrial landfills, the waste co-processing or the incineration process must be properly authorized by the state environment agency to carry out these activities.

10. TROUBLESHOOTING CHART X SOLUTIONS

This troubleshooting chart provides a basic list of problems that may occur during motor operation, possible causes and recommended corrective actions. In case of doubts, please contact WEG Service Center.

Problem	Possible cause	Corrective action
Motor does not start, neither coupled nor decoupled	Power cables are interrupted	Check the control panel and the motor power supply cables
	Blown fuses	Replace blown fuses
	Wrong motor connection	Correct the motor connection according to connection diagram
	Locked rotor	Check motor shaft to ensure that it rotates freely
The motor starts at no-load, but fails when load is applied. It starts very slowly and does not reach the rated speed	Load toque is too high during start-up	Do not start the motor on load
	Too high voltage drop in the power cables	Check the installation dimensioning (transformer, cable cross section, relays, circuit breakers, etc.)
Abnormal/excessive noise	Defective transmission component or defective driven machine	Check the transmission force, the coupling and the alignment
	Misaligned / unleveled base	Align / level the motor with the driven machine
	Unbalanced components or unbalanced driven machine	Balance the machine set again
	Different balancing methods used for motor and coupling balancing (halve key, full key)	Balance the motor again
	Wrong motor direction of rotation	Reverse the direction of rotation
	Loose bolts	Retighten the bolts
	Foundation resonance	Check the foundation design
	Damaged bearings	Replace the bearings
Motor overheating	Insufficient cooling	Clean air inlet and outlet and cooling fins
		Check the minimum required distance between the fan cover and nearest walls. See item 7
		Check air temperature at inlet
	Overload	Measure motor current, evaluate motor application and if required, reduce the load
	Number of starts per hour is too high or the load inertia moment is too high	Reduce the number of starts per hour
	Power supply voltage too high	Check the motor power supply voltage. Power supply voltage must not exceed the tolerance specified in item 7.2
	Power supply voltage too low	Check the motor power supply voltage and the voltage drop. Power supply voltage must not exceed the tolerance specified in item 7.2
	Interrupted power supply	Check the connection of the power cables
	Voltage unbalance at the motor terminals	Check for blown fuses, wrong commands, voltage unbalance in the power line, phase fault or interrupted power cables
	Direction of rotation is not compatible with the unidirectional fan	Check if the direction of rotation matches the rotation arrow indicated on end shield
Bearing overheating	Excessive grease/oil	Clean the bearing and lubricate it according to the provided recommendations
	Grease/oil aging	
	The used grease/oil does not matches the specified one	
	Lack of grease/oil	Lubricate the bearing according to the provided recommendations
	Excessive axial or radial forces due to the belt tension	Reduce the belt tension
		Reduce the load applied to the motor

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ARGENTINA
WEG EQUIPAMIENTOS ELECTRICOS S.A.
Sgo. Pampiglione 4849
Parque Industrial San Francisco, 2400 - San Francisco
Phone: +54 (3564) 421484
www.weg.net/ar

AUSTRALIA
WEG AUSTRALIA PTY. LTD.
14 Lakeview Drive, Scoresby 3179, Victoria
Phone: +03 9765 4600
www.weg.net/au

AUSTRIA
WATT DRIVE ANTRIEBSTECHNIK GMBH*
Wöllersdorfer Straße 68
2753, Markt Piesting
Phone: + 43 2633 4040
www.wattdrive.com

LENZE ANTRIEBSTECHNIK GES.M.B.H*
Ipf - Landesstrasse 1
A-4481 Asten
Phone: +43 (0) 7224 / 210-0
www.lenze.at

BELGIUM
WEG BENELUX S.A.*
Rue de l'Industrie 30 D, 1400 Nivelles
Phone: +32 67 888420
www.weg.net/be

BRAZIL
WEG EQUIPAMENTOS ELÉTRICOS S.A.
Av. Pref. Waldemar Grubba, 3000, CEP 89256-900
Jaraguá do Sul - SC
Phone: +55 47 3276-4000
www.weg.net/br

CHILE
WEG CHILE S.A.
Los Canteros 8600,
La Reina - Santiago
Phone: +56 2 2784 8900
www.weg.net/cl

CHINA
WEG (NANTONG) ELECTRIC MOTOR MANUFACTURING CO. LTD.
No. 128# - Xinkai South Road, Nantong Economic & Technical Development Zone, Nantong, Jiangsu Province
Phone: +86 513 8598 9333
www.weg.net/cn

COLOMBIA
WEG COLOMBIA LTDA
Calle 46A N82 - 54
Portería II - Bodega 6 y 7
San Cayetano II - Bogotá
Phone: +57 1 416 0166
www.weg.net/co

DENMARK
WEG SCANDINAVIA DENMARK*
Sales Office of WEG Scandinavia AB
Verkstadgatan 9 - 434 22
Kumgsbacka, Sweden
Phone: +46 300 73400
www.weg.net/se

FRANCE
WEG FRANCE SAS *
ZI de Chenes - Le Loup13 / 38297 Saint Quentin Fallavier, Rue du Morellon - BP 738 / Rhône Alpes, 38 > Isère
Phone: + 33 47499 1135
www.weg.net/fr

GREECE
MANGRINOX*
14, Grevenon ST.
GR 11855 - Athens, Greece
Phone: + 30 210 3423201-3

GERMANY
WEG GERMANY GmbH*
Industriegebiet Türnich 3
Geigerstraße 7
50169 Kerpen-Türnich
Phone: + 49 2237 92910
www.weg.net/de

GHANA
ZEST ELECTRIC MOTORS (PTY) LTD.
15, Third Close Street Airport Residential Area, Accra
Phone: +233 3027 66490
www.zestghana.com.gh

HUNGARY
AGISYS AGITATORS & TRANSMISSIONS LTD.*
Tó str. 2. Torokbalint, H-2045
Phone: + 36 (23) 501 150
www.agisys.hu

INDIA
WEG ELECTRIC (INDIA) PVT. LTD.
#38, Ground Floor, 1st Main Road, Lower Palace, Orchards, Bangalore, 560 003
Phone: +91 804128 2007
www.weg.net/in

ITALY
WEG ITALIA S.R.L.*
Via Viganò de Vizzi, 93/95
20092 Cinisello Balsamo, Milano
Phone: + 39 2 6129 3535
www.weg.net/it

FERRARI S.R.L.*
Via Cremona 25 26015
Soresina (CR), Cremona
Phone: + 39 (374) 340-404
www.ferrarisrl.it

STIAVELLI IRIO S.P.A.*
Via Pantano - Blocco 16 - Capalle
50010 , Campi Bisenzio (FI)
Phone: + 39 (55) 898.448
www.stiavelli.com

JAPAN
WEG ELECTRIC MOTORS JAPAN CO., LTD.
Yokohama Sky Building 20F, 2-19-12 Takashima, Nishi-ku, Yokohama City, Kanagawa, Japan 220-0011
Phone: + 81 45 5503030
www.weg.net/jp

MEXICO
WEG MEXICO, S.A. DE C.V.
Carretera Jorobas-Tula
Km. 3.5, Manzana 5, Lote 1
Fraccionamiento Parque Industrial - Huehuetoca, Estado de México - C.P. 54680
Phone: +52 55 53214275
www.weg.net/mx

NETHERLANDS
WEG NETHERLANDS *
Sales Office of WEG Benelux S.A.
Hanzepoort 23C, 7575 DB Oldenzaal
Phone: +31 541 571090
www.weg.net/nl

PORTUGAL
WEG EURO - INDÚSTRIA ELÉCTRICA, S.A.*
Rua Eng. Frederico Ulrich, Sector V, 4470-605 Maia, Apartado 6074, 4471-908 Maia, Porto
Phone: +351 229 477 705
www.weg.net/pt

RUSSIA
WEG ELECTRIC CIS LTD*
Russia, 194292, St. Petersburg, Prospekt Kultury 44, Office 419
Phone: +7 812 3632172
www.weg.net/ru

SOUTH AFRICA
ZEST ELECTRIC MOTORS (PTY) LTD.
47 Galaxy Avenue, Linbro Business Park - Gauteng Private Bag X10011 Sandton, 2146, Johannesburg
Phone: +27 11 7236000
www.zest.co.za

SPAIN
WEG IBERIA INDUSTRIAL S.L.*
C/ Tierra de Barros, 5-7
28823 Coslada, Madrid
Phone: +34 91 6553008
www.weg.net/es

SINGAPORE
WEG SINGAPORE PTE LTD
159, Kampong Ampat, #06-02A KA PLACE. 368328
Phone: +65 68581081
www.weg.net/sg

SWEDEN
WEG SCANDINAVIA AB*
Box 27, 435 21 Mölnlycke
Visit: Designvägen 5, 435 33 Mölnlycke, Göteborg
Phone: +46 31 888000
www.weg.net/se

SWITZERLAND
BIBUS AG*
Allmendstrasse 26
8320 – Fehraltorf
Phone: + 41 44 877 58 11
www.bibus-holding.ch

UNITED ARAB EMIRATES
The Galleries, Block No. 3, 8th Floor, Office No. 801 - Downtown Jebel Ali 262508, Dubai
Phone: +971 (4) 8130800
www.weg.net/ae

UNITED KINGDOM
WEG (UK) Limited*
Broad Ground Road - Lakeside Redditch, Worcestershire B98 8YP
Phone: + 44 1527 513800
www.weg.net/uk

ERIKS *
Amber Way, B62 8WG
Halesowen, West Midlands
Phone: + 44 (0)121 508 6000

BRAMMER GROUP *
PLC43-45 Broad St, Teddington TW11 8QZ
Phone: + 44 20 8614 1040

USA
WEG ELECTRIC CORP.
6655 Sugarloaf Parkway, Duluth, GA 30097
Phone: +1 678 2492000
www.weg.net/us

VENEZUELA
WEG INDUSTRIAS VENEZUELA C.A.
Centro corporativo La Viña Plaza, Cruce de la Avenida Carabobo con la calle Uzlar de la Urbanización La Viña / Jurisdicción de la Parroquia San José - Valencia
Oficinas 06-16 y 6-17, de la planta tipo 2, Nivel 5, Carabobo
Phone: (58) 241 8210582
www.weg.net/ve

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