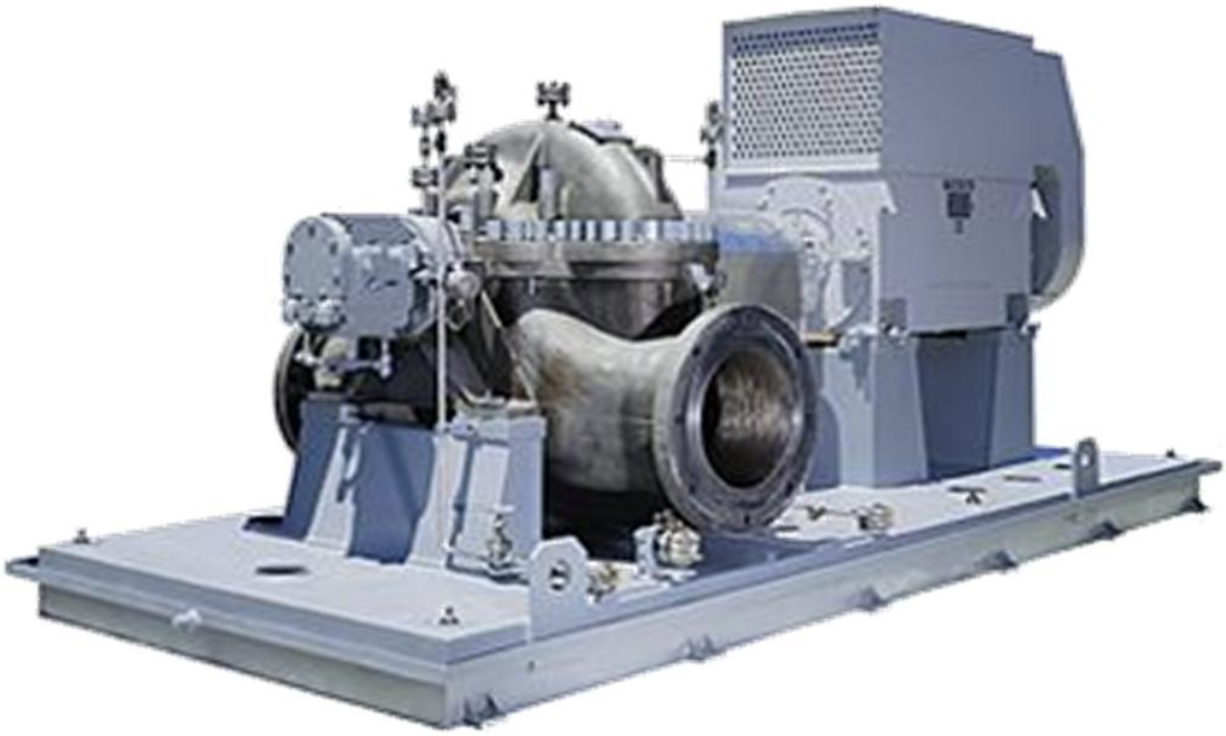
FLOWSERVE®

Pump Division



Type: DVSH

CENTRIFUGAL PUMPS

USER INSTRUCTIONS:
INSTALLATION, OPERATION, MAINTENANCE

User Instructions - 71569287 04/05 (E)

1 Introduction AND SAFETY 4
1.1 General 4
1.2 CE marking and approvals 4
1.3 Disclaimer 4
1.4 Copyright....4
1.5 Duty conditions 4
1.6 Safety....5
1.6.1 Summary of safety markings....5
1.6.2 Personnel qualification and training....5
1.6.3 Safety action 5
1.6.4 Products used in potentially explosive atmospheres 6
1.7 Nameplate and warning labels 8
1.7.1 Nameplate 8
1.7.2 Warning labels....8
1.8 Specific machine performance 9
1.9 Noise level 9
2 TRANSPORT AND STORAGE 9
2.1 Consignment receipt and unpacking 9
2.2 Handling....9
2.3 Lifting....9
2.4 Extended Storage 10
2.4.1 Storage area 10
2.4.2 Storage preferred (dry) ....**Error! Bookmark not defined.**
2.4.3 Storage non-preferred (wet) ....**Error! Bookmark not defined.**
2.5 Recycling and end of product life....11
3 PUMP DESCRIPTION....11
3.1 Configurations....11
3.2 Name nomenclature....12
3.3 Design of major parts....12
3.3.1 Pump casing 12
3.3.2 Rotating Element 12
3.3.3 Casing Wear rings. 12
3.3.4 Pump bearings....12
3.3.5 Mechanical seal....12
3.3.6 Driver 12
3.3.7 Accessories 12
3.4 Performance and operating limits....12
4 INSTALLATION....12
4.1 Location 12
4.2 Required equipment....12
4.3 Part assemblies 13
4.4 Foundation 13
4.4.1 Installation check list....13
4.4.2 Level the baseplate 13
4.5 Grouting 14
4.6 Alignment 14
4.6.1 Thermal expansion 14
4.6.2 Alignment methods 14
4.7 Piping 15
4.7.1 Suction and discharge pipework....16
4.7.2 Suction piping 16
4.7.3 Discharge piping 16
4.7.4 Auxiliary piping....17
4.7.5 Final checks....17
4.8 Final shaft alignment check 17
4.9 Electrical connections 17
4.10 Protection systems 17
5 COMMISSIONING, START-UP, OPERATION AND SHUTDOWN 18
5.1 Pre-commissioning procedure 18
5.1.1 Lubrication 18
5.1.2 Initial start up procedure 18
5.2 Pump lubricants 19
5.2.1 Recommended oil lubricants 19
5.2.2 Recommended fill quantities.... 19
5.2.3 Alarm and shutdown points. 19
5.3 Impeller clearance.... 20
5.4 Direction of rotation.... 20
5.5 Guarding 20
5.6 Priming and auxiliary supplies 20
5.6.1 Suction pressure above atmospheric pressure 20
5.6.2 Suction lift without foot valve 20
5.7 Starting the pump.... 20
5.8 Running or operation 21
5.8.1 Venting the pump.... 21
5.8.2 Mechanical seal 21
5.8.3 Bearings.... 21
5.8.4 Operating checks.... 21
5.8.5 Normal vibration levels, alarm and shutdown 22
5.8.6 Stop/start frequency.... 22
5.9 Stopping and shutdown 22
5.10 Hydraulic, mechanical and electrical duty 22
5.10.1 Specific gravity (SG) 22
5.10.2 Viscosity.... 22
6 MAINTENANCE.... 23
6.1 General 23
6.2 Maintenance schedule 24
6.2.1 Routine inspection (daily/weekly) 24
6.2.2 Periodic inspection (every six month) 24
6.3 Spare parts.... 24
6.3.1 Ordering of spares 24
6.3.2 Service instructions.... 25
6.3.3 Storage of spares 25
6.4 Recommended spares and consumable items 25
6.5 Tools required 25
6.6 Fastener torques 25
6.7 Disassembly.... 25
6.7.1 Dismantling procedure.... 25
6.7.2 Coupling removal.... 26
6.7.3 Thrust bearing removal.... 26
6.7.4 Plain bearing removal 26
6.7.5 Mechanical seal removal 26
6.7.6 Pump Casing Disassembly.... 27
6.7.7 Shaft Sleeve Removal 27
6.7.8 Rotating Element Disassembly.... 27
6.7.9 Impeller ring removal 27
6.7.10 Parting flange gasket.... 28
6.8 Examination of parts 28
6.9 Assembly.... 28
6.9.1 Rotating Element Reassembly 28
6.9.2 Pump Casing Reassembly 29
6.9.3 Pump Casing Gasket Fabrication and Installation 29

6.9.4 Rotating Element and Upper Casing Reinstallation 29
6.9.5 Shaft Settings Check 29
6.9.6 Mechanical Seal Installation 30
6.9.7 Thrust Bearing and Housing Reinstallation 30
6.9.8 Radial Bearing and Housing Reinstallation 30
6.9.9 Final Assembly 31
7 FAULTS; CAUSES AND REMEDIES 32
8 PARTS LIST AND DRAWINGS. 34
8.1 General arrangement drawing 34
8.2 Assembly drawing 34
9 Certification 36
10 OTHER RELEVANT DOCUMENTation and manuals 36
10.1 Supplementary user instruction manuals. 36
10.2 Change notes 36
10.3 Additional sources of information 36

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's 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, utilizing sophisticated quality techniques, and safety requirements.

We are committed to continuous quality improvement and being at your 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 and regulations.

These instructions should be 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.

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. To establish approvals and if the product itself is CE marked, check the serial number plate and the Certification. (See section 9, *Certification*.)

1.3 Disclaimer

Information in these User Instructions is believed to be reliable. In spite of all the efforts of Flowserve Corporation to provide sound and all necessary information the content of this manual may appear insufficient and is not guaranteed by Flowserve as to its completeness or accuracy.

Flowserve manufactures products to exacting International Quality Management System Standards as certified and audited by external Quality Assurance organizations. 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 authorized Flowserve parts and accessories is considered to be misuse. Damage or failure caused by misuse is not covered by 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

All rights reserved. No part of these instructions may be reproduced, stored in a retrieval system or transmitted in any form or by any means without prior permission of Flowserve Pump Division.

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 you/the user seek our written agreement 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:

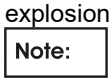

DANGER This symbol indicates electrical safety instructions where non-compliance would affect personal safety.


This symbol indicates safety instructions where non-compliance would affect personal safety.


This symbol indicates safety instructions where non-compliance would affect protection of a safe life environment.


This symbol indicates safety instructions where non-compliance would affect the safe operation or protection of the pump or pump unit.


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 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.)


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.


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


START THE PUMP WITH OUTLET VALVE PART OPENED
(Unless otherwise instructed at a specific point in the user instructions.)
This is recommended to minimize the risk of overloading and damaging the pump motor at full or zero flow. Pumps may be started with the valve further open only on installations where this situation cannot occur. The pump outlet control valve may need to be adjusted to comply with the duty following the run-up process. (See section 5, *Commissioning start-up, operation and shutdown*.)


NEVER RUN THE PUMP DRY


INLET VALVES TO BE FULLY OPEN WHEN PUMP IS RUNNING
Running the pump at zero flow or below the recommended minimum flow continuously will cause damage to the pump and the seal.


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 backpressure 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.


NEVER DO MAINTENANCE WORK WHEN THE UNIT IS CONNECTED TO POWER


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


DRAIN THE PUMP AND ISOLATE PIPEWORK BEFORE DISMANTLING THE PUMP

The appropriate safety precautions should be taken where the pumped liquids are hazardous.

⚠ FLUORO-ELASTOMERS (When fitted.)
When a pump has experienced temperatures over 250 ºC (482 ºF), partial decomposition of fluoro-elastomers (e.g. 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.

⚠ GUARDS MUST NOT BE REMOVED WHILE THE PUMP IS OPERATIONAL

⚠ 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.

⚠ HOT (and cold) PARTS
If hot or freezing components or auxiliary heating supplies can present a danger to operators and persons entering the immediate area action must be taken to avoid accidental contact. 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 68 °C (175 °F) or below 5 °C (20 °F) in a restricted zone, or exceeds local regulations, action as above shall be taken.

1.6.4 Products used in potentially explosive atmospheres

Ⓔx 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. Both electrical and non-electrical equipment must meet the requirements of European Directive 94/9/EC.

1.6.4.1 Scope of compliance

Ⓔx Use equipment only in the zone for which it is appropriate. Always check that the driver, drive coupling assembly, seal 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 affects in the motor and so, for pumps sets with a VFD, the ATEX Certification for the motor must state that it is 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 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 prEn13463-5)

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 of 40 °C (104 °F); refer to Flowserve for higher ambient temperatures.

The surface temperature on the pump is influenced by the temperature of the handled liquid. The maximum permissible liquid temperature depends on the temperature class and must not exceed the values in the table that follows.

The temperature rise at the seals and bearings and due to the minimum permitted flow rate is taken into account in the temperatures stated.

Temperature class to prEN 13463-1	Maximum surface temperature permitted	Temperature limit of liquid handled (* depending on material and construction variant - check which is lower)
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) *
T1	450 °C (842 °F)	400 °C (752 °F) *

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

If an explosive atmosphere exists during the installation, do not attempt to check the direction of rotation by starting the pump unfilled. Even a short run time may give a high temperature resulting from 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 it is recommended that users fit an external surface temperature protection device.

Avoid mechanical, hydraulic or electrical overload by using motor overload shutdowns, temperature monitor or a power monitor and make routine vibration monitoring checks.

In dirty or dusty environments, regular checks must be made and dirt removed from areas around close clearances, bearing housings and motors.

1.6.4.4 Preventing the build up of explosive mixtures



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

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

If the operation of the system cannot avoid this condition the fitting of an appropriate dry run Protection device is recommended (e.g. 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



To prevent a potential hazard from mechanical contact, the coupling guard must be non-sparking and anti-static for Category 2.

To avoid the potential hazard from random induced current generating a spark, the earth contact on the baseplate must be used.

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

The coupling must be selected to comply with 94/9/EC and correct alignment must be maintained.

1.6.4.6 Preventing leakage

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 ancillary systems.

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

If leakage of liquid to atmosphere can result in a hazard, the installation of a liquid detection device is recommended.

1.6.4.7 Maintenance to avoid the hazard

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.

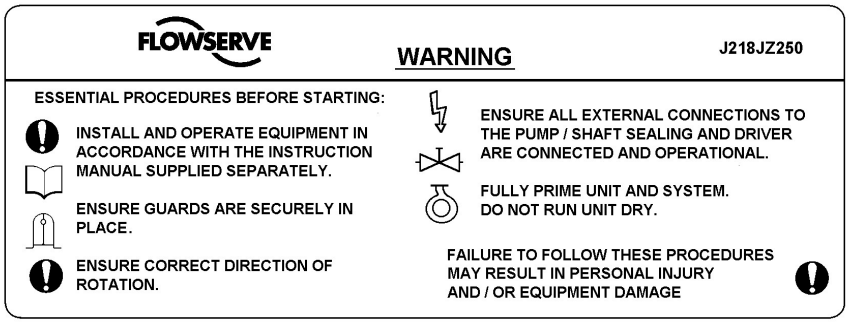
To avoid potential explosion hazards during maintenance, the tools, cleaning and painting materials used must not give rise to sparking or adversely affect the ambient conditions. Where there is a risk from such tools or materials, maintenance must be conducted in a safe area. It is recommended that a maintenance plan and schedule be adopted. (See section 6, *Maintenance.)*

1.7 Nameplate and warning labels

1.7.1 Nameplate

For details of nameplate, see the *Declaration of Conformity*.

1.7.2 Warning labels





Oil lubricated units only:

J218JZ262

WARNING	THIS MACHINE MUST BE FILLED WITH OIL BEFORE STARTING
ATTENTION	CETTE MACHINE DOIT ÊTRE REMPLIE D'HUILE AVANT LA MISE EN MARCHE
ACHTUNG	DIESE MASCHINE IST VOR DEM STARTEN MIT ÖL ZÜ FULLEN
WAARSCHUWING	DEZE MACHINE MOET VOOR HET STARTEN MET OLIE GEVULD WORDEN

CDC: 603 604 610 612 621 623 624

1.8 Specific machine performance

For performance parameters see section 1.5, *Duty conditions*. When the contract requirement specifies these to be incorporated into User Instructions these are included here. 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

PENDING.

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 Pump Division and must be received in writing within one month of receipt of the equipment. Later claims cannot be accepted.

Check any crate, boxes or wrappings for any accessories or spare parts that may be packed separately with the equipment or attached to sidewalls of the box or equipment.

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

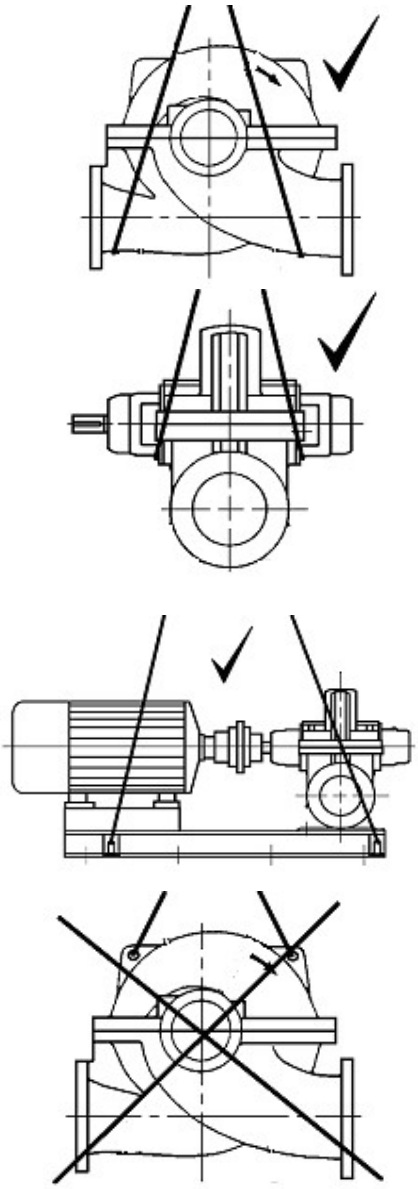
The pump is shipped to the job site assembled, and may be either mounted on its baseplate or shipped separately. If shipped separately, the pump will be suitably wrapped and mounted on skids or crated with all openings closed off and protected.

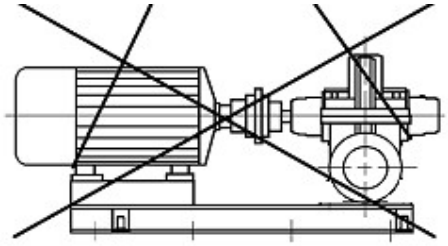
2.2 Handling

Boxes, crates, pallets or cartons may be unloaded using forklift vehicles or slings dependent on their size and construction.

2.3 Lifting

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





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 or massplates.

2.4 Storage

2.4.1 Short term storage and packaging

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.
- Inner surfaces of the beraring housing, shaft (area through bearing housing) and bearing are coated with Corted 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 Corted VCI-329 rust inhibitor, or equal.
- Exposed shaft are taped with Polywrap
- Flange covers are secured to both the suction and discharge flanges
- In some cases with assemblies ordered with external piping, components may be disassembled for shipment
- The pump must be stored in a covered, dry location

2.4.2 Long term storage and packaging

Note: The following information regarding receiving is only offered as a general guideline. Flowserve requires that all receiving be conducted in accordance with specifications set forth in Chapter 3, *Jobsite Receiving and Protection* from API recommended Practices 686/PIP REIE 686, First Edition.

During extended periods of storage prior to installation and from the time of installation until commercial operation, precautions must be taken to protect the pump from deterioration. The various parts of the pump are protected prior to shipment by applying varying grades of preservative and paint. However, during shipment and handling, the preservatives are subjected to conditions that can cause their removal. Also, during extended periods of time, the preservatives may deteriorate. The following procedures should be followed to prevent deterioration of the pump during the extended storage period. These procedures may also be supplemented by the experience of the person(s) performing the tasks.

It should be noted, that unless otherwise agreed to, full responsibility and costs associated with the storage and inspection of this equipment rests with the customer.

CAUTION If pump is equipped with a mechanical seal and is stored or has not been run for 1 year or more, the mechanical seal must be removed before start-up and faces re-lapped to guard against the possibility of seal leakage. When reinstalling the seal, new “o” rings and gaskets must be used.

2.4.3 Storage area

When selecting a storage area, the following should be taken into consideration:

a) The deterioration of the equipment will be proportionate to the class/type of storage provided.

b) The expenses involved in restoring the equipment at time of operation will be proportionate to the class/type of storage provided.

2.4.4 Rotor storage

It is recommended that pump rotor be stored in the pump. Rotors that cannot be stored in the pump must be supported close to impeller to eliminate sag that may cause rotor to take a permanent set. Rotors may also be stored vertically.

2.4.5 Customer inspection

The stored equipment is to be placed on a periodic inspection schedule by the customer.

Note: The responsibility for setting up an inspection and maintenance schedule rests with the customer and will be dependent upon the class/type of storage provided. It will be expected that initially inspection would occur weekly, then depending upon the inspection reports being

favorable or unfavorable, inspection would continue weekly, monthly, or quarterly, as may be determined. Inspection reports must be kept on file.

Every inspection should consist of a general surface inspection.

a) Pump supports are firmly in place.

b) Pump covers over openings are firmly in place.

c) Pump coverings, plastics or tarps, are firmly in place. Any holes or tears must be repaired to prevent entrance of dirt or water.

d) If rusting occurs on exterior surfaces, clean and repaint or re-coat with preservative.

CAUTION If storage is over one month, Instrumentation (Controls, Electrical devices, Temperature switches) should be removed and placed in a climate control environment if Instrumentation is not powered up.

2.4.5.1 Prior to installation

Six months prior to the scheduled installation date, a Flowserve representative is to be employed to conduct an inspection. All costs involved during inspection, dismantling, restoration, replacement of parts, and reassembly will be the responsibility of the customer. The customer will supply all necessary labor, tools, and cranes. This inspection will include (not necessarily in its entirety) but not be limited to the following:

a) An inspection of all periodic inspection records as kept on file by the customer, and all inspection reports that have been compiled during the storage period.

b) An inspection of the storage area to determine the “as stored” condition of the equipment prior to any protection being removed.

c) An inspection of the equipment with protection covers and flange covers removed.

d) Depending upon the length of time the equipment was stored, the class/type of storage provided, (i.e.: indoor, heated, unheated, ground floor, concrete floor, out-of-doors, under roof, no roof, waterproof coverings, on concrete, on ground) and as a result of the inspection of a, b and c above, Flowserve representative may require a partial or complete dismantling of the equipment.

e) Dismantling may necessitate restoration of painted or preserved surfaces, and/or replacement of gaskets, “O” rings and mechanical seal and bearings. Use only Flowserve Pump recommended replacement materials.

Upon completion of the inspection, The Flowserve representative shall submit a report to the Customer, and to the Manager of Customer Service, stating in detail the result of the inspection.

If there are any discrepancies identified, it is the customer's responsibility for correction before initial startup.

CAUTION Electric motors (pump driver) should not be stored in damp places without special protection (refer to *motor manufacturer’s instructions*).

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.

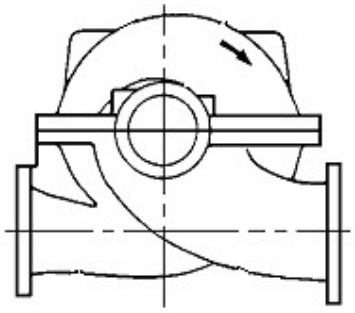
Make sure that hazardous substances are disposed of safely and that the correct personal protective equipment is used. The safety specifications must be in accordance with the current local regulations at all times.

3 PUMP DESCRIPTION

3.1 Configurations

The DVSH type pump is a single stage, double suction, horizontal split double volute type, with sleeve radial bearings and a duplex ball thrust bearing, centrifugal pump designed for water works, transfer, general service, pipeline and applications. It can be used with motor, steam turbine and gasoline or diesel engine drives.

The DVSH comes with the following configuration:



DVSH Horizontal suction and discharge nozzles (inline)

3.2 Name nomenclature

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

10X14A DVSH

"10" is the discharge nozzle size.

"14" is the impeller diameter

"A" is the hydraulic performance letter

"DVSH" is the pump type

The typical nomenclature above is the general guide to the DVSH configuration description. Identify the actual pump size and serial number from the pump nameplate. Check that this agrees with the applicable certification provided.

3.3 Design of major parts

3.3.1 Pump casing

The pump has its main casing gasket axial to the shaft allowing maintenance to the rotating element by removing the top half casing. Suction and discharge nozzles are integral with the bottom half and therefore remain undisturbed.

3.3.2 Rotating Element

The rotating element assembly consists of the pump shaft, impeller and its wear rings (when furnished), the casing wear rings, shaft sleeves, and throat bushings. The key driven impeller is installed on the pump shaft with a shrink fit and positioned by shaft sleeve/impeller nut.

3.3.3 Casing Wear rings.

The casing wear rings are positioned by tongue and groove fit with both halves of the casing, each of their tongues having an anti-rotation pin that engages a slot in the bottom half casing at the parting line.

3.3.4 Pump bearings

The sleeve bearings are carbon steel backed, Babbitt lined, sleeve-type insert bearings. The renewable bearing inserts are mounted in bearing housings kept from rotating by means of stop pins. The thrust ball bearing is two single-row angular-contact bearings, mounted back-to-back (stamping will be face-to-face) and is consequently capable of transmitting the thrust load in either direction. The thrust is transmitted through the shaft to the ball bearings and thence to the bearing housing and foundation. The linings and ball bearings are lubricated by use of oil rings.

3.3.5 Mechanical seal

The mechanical seal, attached to the pump shaft, seals the pumped liquid from the environment.

3.3.6 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, gearboxes. Refer to section 10.1 for more information.

3.3.7 Accessories

Accessories may be fitted when specified by the customer (Lube oil panel, control panel). Refer to section 10.1 for more information.

3.4 Performance and operating limits

This product has been selected to meet the specifications of your purchase order. Refer to section 10.4 *Customer Data Sheet.*

4 INSTALLATION

Ex Equipment operated in hazardous locations must comply with the relevant explosion protection regulations. See section 1.6.4, *Products used in potentially explosive atmospheres.*

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 Required equipment

n addition to common tools used in this type of work, the following should be available at the job site when installing or removing the pump, baseplate, and/or driver:

a) Lifting equipment

Lifting equipment of sufficient capacity to handle the equipment safely (see section 2.3). The approximate weight of the pump and other equipment supplied is normally given on the pump outline drawing section 8.

b) Steel blocks and wedges
Steel blocks and wedges (one each per foundation bolt) of 2" (50.8 mm) minimum thickness, for leveling baseplate. Blocks and wedges should be free of burrs. Shim packs can substitute for the wedges.

c) Grouting materials
Grouting materials, such as non-shrink grout, sufficient lumber for building a wooden trough to contain grout, and risers or funnels for guiding grout, normally provided by grouting contractor. A good oil paint is recommended for grout protective coating.

d) One dial indicator and suitably stiff bracket
One dial indicator and suitably stiff bracket having an arm of sufficient length to extend from the driver coupling hub to the pump coupling hub for performing coupling alignment.

4.3 Part assemblies

Motors may be supplied loose on DVSH pumps, typically on frame sizes 400 and above. It is the responsibility of the installer to ensure that the motor is assembled to the pump and lined up as detailed in section 4.5.2.

4.4 Foundation

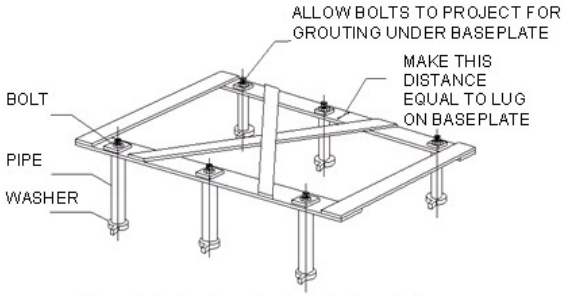
Note: The following information regarding foundation is only offered as a general guideline. Flowserve requires that all foundations be designed/installed in accordance with specifications set forth in Chapter 4, *Foundations* from API Recommended Practices 686/PIP REIE 686, First Edition.

The design of foundation is not the responsibility of Flowserve. It is therefore recommended that the customer consult a competent specialist skilled in the field of foundations, to insure proper design/installation of the foundation.

The foundation should be sufficiently rigid and substantial to prevent any pump vibration and to permanently support the baseplate at all points.

The most satisfactory foundations are made of reinforced concrete. These should be poured well in advance of the installation to allow proper time for drying and curing.

The General Arrangement Drawing will show required anchor bolt locations and size of bolts.

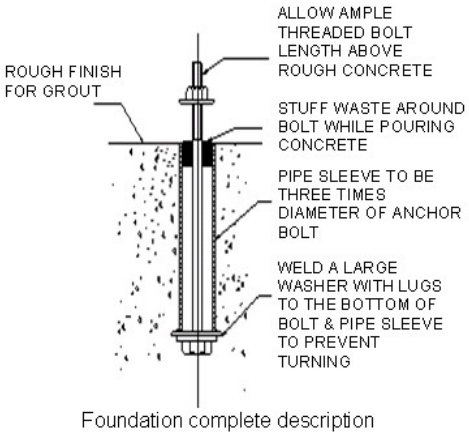


Template for hanging foundation bolts

The sketch illustrates a recommended foundation bolt arrangement, Notice the large washer with lugs at the bottom. It should be welded to the bolt and pipe sleeve to prevent turning.

Allow a little more than the specified threaded bolt length above the rail of the baseplate. The excess can always be cut off if it is not needed.

A rough finish top surface is best when applying grout.



Foundation complete description

4.4.1 Installation check list

a) Level Baseplate.

b) Preliminary Alignment.

c) Grout Baseplate - Check Foundation Bolts

d) Alignment Shaft/Coupling.
e) Piping installed – correct vent, gauge, value, and suction strainer locations?

f) Check Coupling Alignment.

g) Coupling guard correctly installed?

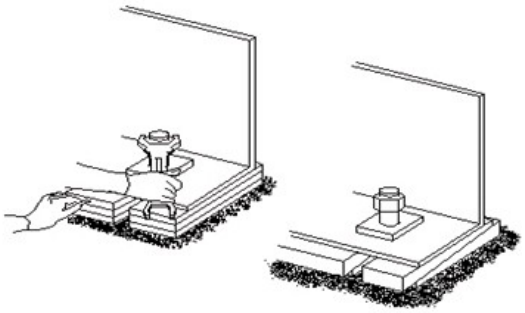
4.4.2 Level the baseplate

Note: The following information regarding leveling of equipment is only offered as a general guideline. Flowserve requires that all leveling of equipment be performed in accordance with specifications set forth in Chapter 5, *Mounting Plate Grouting* from API Recommended Practices 686/PIP REIE 686, First Edition.

Before putting the unit on the foundation, thoroughly clean the top of the foundation. Break off any loose pieces of cement and roughen the top with a chisel to afford a good hold for grout.

Note: When lifting baseplate with pump, sling baseplate from all lifting eyes provided. Failure to do this may result in permanent deformation of baseplate.

Prepare enough iron wedges or shims to be placed on each side of each foundation bolt. These wedges should be about 102 mm (4 in.) to 152 mm (6 in.) long by 51 mm (2 in.) to 76 mm (3 in.) wide and thick enough to allow for 32 mm (1-1/4 in.) of grout under the edge of the baseplate. Place wedges as shown in sketch.



Proper practice to level the baseplate

Level the baseplate by using a machinist's level on the machined surfaces of the pump and driver mounting pads. When the baseplate is leveled, pull down the foundation bolts so they are snug. Tightening the foundation bolts may have disturbed the baseplate; therefore, recheck with level and make necessary adjustments by wedges or shimming.

As a final baseplate alignment check on spacer type couplings, install a mounting bracket for dial indicator on driver hub. Fasten or clamp indicator on mounting bracket, so that dial indicator button is contacting the face of the pump half coupling, and zero the dial indicator.

Rotate the driver half coupling (in direction of pump rotation) 90°. Record this reading.

Repeat this procedure until readings have been taken at four 90-degree positions.

4.5 Grouting

Where applicable, grout in the foundation bolts.

After rechecking the coupling alignment, the baseplate should then be grouted in accordance with good engineering practice. Folded steel baseplates should be grouted to locate their packing pieces. If in any doubt, please contact your nearest Flowserve Service Center for advice.

Grouting provides solid contact between the pump unit and foundation prevents lateral movement of running equipment and dampens resonant vibrations.

Foundation bolts should only be fully tightened when the grout has cured.

4.6 Alignment

4.6.1 Thermal expansion

CAUTION The pump and motor will normally have to be aligned at ambient temperature and should be corrected to allow for thermal expansion at operating temperature. In pump installations involving high liquid temperatures, the unit should be run at the actual operating temperature, shut down and the alignment checked immediately.

4.6.2 Alignment methods

CAUTION ***Fully qualified personnel must carry out these operations.***

DANGER Ensure pump and driver are isolated electrically and the half couplings are disconnected.

CAUTION The alignment MUST be checked. Although the pump will have been aligned at the factory it is most likely that this alignment will have been disturbed during transportation or handling. If necessary, align the motor to the pump, not the pump to the motor.

The coupling alignment consists of angular and offset alignment procedures. Alignments should be checked at least three times:

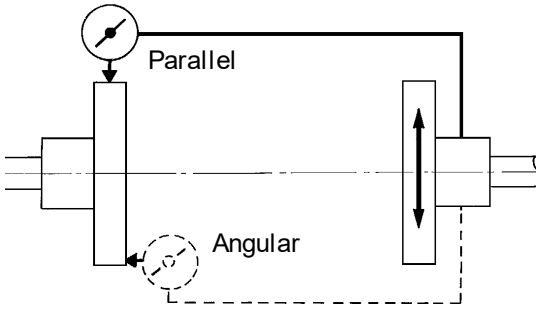
a) Preliminary
With foundation bolts and pump hold down bolts pulled tight, but prior to tightening driver hold down bolts.

b) Secondary
After the pump and driver are tightly bolted down. The suction and discharge pipes are connected.

c) Final (hot alignment check prior to doweling)
After pump has operated for at least twenty-four hours. The pump is still at operating temperature and pressure. When final alignment is completed, recheck the tightness of the pump and driver hold down bolts.

Alignment is achieved by adding or removing shims under the motor feet and also moving the motor horizontally as required. In some cases where the alignment cannot be achieved it will be necessary to move the pump before recommencing the above procedure.

For couplings with narrow flanges use a dial indicator as shown below to check both parallel and angular alignment.



Maximum permissible misalignment at working temperature:
Parallel 0.1 mm (0.004 in.) TIR
Angular 0.05 mm (0.002 in.) TIR

When the electric motor has sleeve bearings it is necessary to ensure that the motor is aligned to run on its magnetic centerline.

Refer to the motor manual for details.

Note: After establishing the offset alignment, recheck that angular alignment has not changed and that pump and driver anchor bolts are secure.

4.6.2.1 Laser alignment

The use of laser alignment greatly simplifies the alignment process. Because of equipment and software differences, this will only describe laser alignment in general steps.

a) Prior to alignment process the baseplate must be leveled.

b) Check for soft foot condition. Uneven base height, dirty or corroded feet or other irregularities

c) Rough align the pump and motor shafts with a straight edge.

d) Mount the laser emitter on the pump shaft, and the laser target on the motor shaft.

e) Link the shaft ends so they rotate together.

f) Adjust shim stack heights for vertical parallelism and angular alignment per laser unit's output. Make the necessary corrections by adding or by removing shims at the motor feet.

g) Adjust the motor position sideways for horizontal and angular alignment per the laser unit's output by using a soft mallet or adjusting screws.

h) Tighten all pump and motor feet fasteners.

i) Verify the final alignment

Flowserve recommends laser equipment for alignment.

A button (screwed into one of the shaft ends) is normally fitted between the motor and pump shaft ends to fix the axial position.

CAUTION If the motor does not run in its magnetic center the resultant additional axial force may overload the pump thrust bearing.

Complete piping as below and see sections 4.7, *Final shaft alignment check* up to and including section 5, *Commissioning, startup, operation and shutdown* before connecting driver and checking actual rotation.

4.7 Piping

CAUTION Protective covers are fitted to the pipe connections to prevent foreign bodies entering during transportation and installation. Ensure that these covers are removed from the pump before connecting any pipes.

With the pump baseplate grouted and firmly fastened to the foundation, the pump and driver installed, the main piping should then be connected to the pump proper. Piping-to-pump flange faces must mate flush and parallel without use of

excessive force. The piping forces supported by the pump must not displace the pump out of alignment. DO NOT use drifts or flange bolts to force alignment of piping. Provide piping supports close to the pump flanges to avoid vibration and strain on pump casing. To prevent possible damage, be certain that piping and suction and discharge cavities are thoroughly clean before connecting pump to piping.

4.7.1 Suction and discharge pipework

In order to minimize friction losses and hydraulic noise in the pipework it is good practice to choose pipework that is one or two sizes larger than the pump suction and discharge. Typically main pipework velocities should not exceed 2 m/s (6 ft/sec) suction and 3 m/s (9 ft/sec) on the discharge.

Take into account the available NPSH must be higher than the required NPSH of the pump.

CAUTION Never use the pump as a support for piping.

Maximum forces and moments allowed on the pump flanges vary with the pump size and type. To minimize these forces and moments that may, if excessive, cause misalignment, hot bearings, worn couplings, vibration and the possible failure of the pump casing, the following points should be strictly followed:

- Prevent excessive external pipe load
- Never draw piping into place by applying force to pump flange connections
- Do not mount expansion joints so that their force, due to internal pressure, acts on the pump flange

Refer to the General Arrangement drawing to get the maximum forces and moments allowed on DVSH pump casings.

CAUTION Ensure piping and fittings are flushed before use.

Ensure piping for hazardous liquids is arranged to allow pump flushing before removal of the pump.

4.7.2 Suction piping

a) The inlet pipe should be one or two sizes larger than the pump inlet bore and pipe bends should be as large a radius as possible.

b) Pipework reducers should have a maximum total angle of divergence of 15 degrees.

c) On suction lift the piping should be inclined up towards the pump inlet with eccentric reducers incorporated to prevent air locks.

d) On positive suction, the inlet piping must have a constant fall towards the pump.

e) Flow should enter the pump suction with uniform flow, to minimize noise and wear. This is particularly important on large or high-speed pumps which should have a minimum of four diameters of straight pipe on the pump suction between the elbow and inlet flange. See section 10.2, *Reference 1* for more detail.

f) Inlet strainers, when used, should have a net `free area' of at least three times the inlet pipe area.

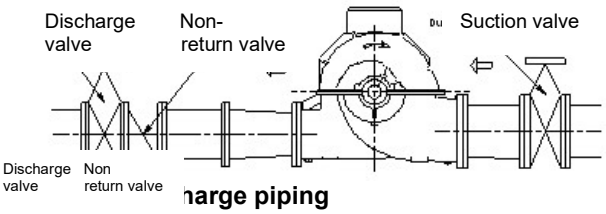
g) Do not install elbows at an angle other than perpendicular to the shaft axis. Elbows parallel to the shaft axis will cause uneven flow.

h) Except in unusual circumstances strainers are not recommended in inlet piping. If considerable foreign matter is expected a screen installed at the entrance to the wet well is preferable.

i) Fitting an isolation valve will allow easier maintenance.

j) Never throttle pump on suction side and never place a valve directly on the pump inlet nozzle.

Typical design.



harge piping

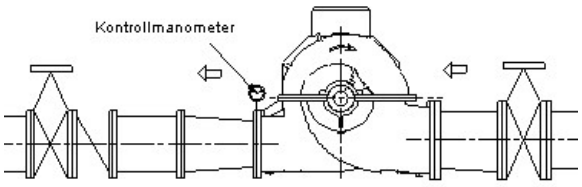
A non-return valve should be located in the discharge pipework to protect the pump from excessive backpressure and hence reverse rotation when the unit is stopped.

Pipework reducers should have a maximum total angle of divergence of 15 degrees.

Fitting an isolation valve will allow easier maintenance.

Typical design

Actual operating duty should be verified



4.7.4 Auxiliary piping

Install and connect required auxiliary instruments, wiring and piping as shown on *General Arrangement drawing* in section 8.

4.7.4.1 Drains

Pipe pump casing drains and vents be piped to a convenient disposal point.

4.7.4.2 Mechanical seals

Single seals requiring re-circulation will normally be provided with the auxiliary piping from pump casing already fitted.

If the seal requires an auxiliary quench then a connection must be made to a suitable source of liquid flow, low-pressure steam or static pressure from a header tank. Recommended pressure is 0.35 bar (5 psi) or less. Check *General Arrangement drawing*.

Special seals may require different auxiliary piping to that described above. Consult separate User Instructions and/or Flowserve if unsure of correct method or arrangement.

For pumping hot liquids, to avoid seal damage, it is recommended that any external flush/cooling supply be continued after stopping the pump.

4.7.5 Final checks

Check the tightness of all bolts in the suction and discharge pipework. Check also the tightness of all foundation bolts.

4.8 Final shaft alignment check

After connecting piping to the pump, rotate the shaft several times by hand to ensure there is no binding and all parts are free.

Recheck the coupling alignment, as previously described, to ensure no pipe strain. If pipe strain exists, correct piping.

4.9 Electrical connections

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

Ex 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. 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.

A device to provide emergency stopping must be fitted.

If not supplied pre-wired to the pump unit, the controller/starter electrical details will also be supplied within the controller/starter.

For electrical details on pump sets with controllers see the separate wiring diagram.

CAUTION See section 5.3, *Direction of rotation* before connecting the motor to the electrical supply.

4.10 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 or its associated sealing system can cause a hazard it is recommended that an appropriate leakage detection system be installed.

To prevent excessive surface temperatures at bearings it is recommended that temperature or vibration monitoring are carried out. See sections 5.7.4 and 5.7.5.

5 COMMISSIONING, START-UP, OPERATION AND SHUTDOWN

Note: Commissioning of all equipment must be performed in accordance with specifications set forth in Chapter 9, *Commissioning* from API Recommended Practices 686/PIP REIE 686, First Edition.

CAUTION ***Fully qualified personnel must carry out these operations.***

5.1 Pre-commissioning procedure

a) Never operate the pump with suction valve closed.

b) Never operate pump unless it is filled with liquid and vented.

c) Never operate the pump unless a liquid source is available.

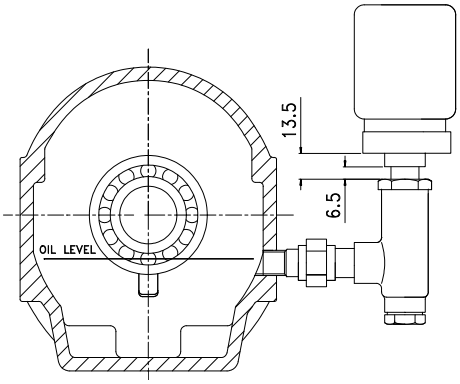
5.1.1 Lubrication

Determine the mode of lubrication of the pump set, e.g. oil, product lubrication etc.

CAUTION For oil lubricated pumps, fill the bearing housing with correct grade of oil to the correct level, i.e. sight glass or constant level oiler bottle.



When fitted with a constant level oiler, the bearing housing should be filled by unscrewing or hinging back the transparent bottle and filling the bottle with oil. Where an adjustable body Trico oiler is fitted this should be set to the height shown in the following diagram:



The oil filled bottle should then be refitted so as to return it to the upright position. Filling should be repeated until oil remains visible within the bottle.

CAUTION Maintaining the correct oil level is very important.

If the pump is supplied with a constant level oiler the oil level will be automatically maintained and as long as oil is visible in the glass bottle there is no need to refill. If however a sight glass has been

Fitted then regular checks should be made to ensure the level is maintained at the center of the glass window.

Refer to section 5.2.3 for methods of oil fill, section 5.2.1 for oil grade recommendations and 5.2.3 for the schedule and temperature limits.

Other drivers and gearboxes, if appropriate, should be lubricated in accordance with their manuals.

CAUTION In the case of product lubricated bearings the source of product supply should be checked against the order. There may be requirements for an external clean supply, particular supply pressure or the commencement of lubrication supply before pump start-up.

5.1.2 Initial start up procedure

a) Close discharge valve if a bypass system is used.

b) Prepare the driver for start-up in accordance with the manufacturer's instructions.

c) Warm-up pump.

Avoid severe thermal shocks to the pump as a result of sudden liquid temperature changes. The pump must be preheated prior to start-up. Unless otherwise specified, the external temperature of the casing must be within 55.6 °C (100 °F) of the temperature of the liquid to be pumped at time of

start-up. Due to the heavy metal sections, the casing will lag the liquid temperature during such changes, and severe temperature stresses and subsequent misalignment of machined fits may result. Pre-heating is accomplished by circulating a small amount of hot fluid through the casing by utilizing vents, drains or bypass from discharge. Preheat pump slowly at a rate not to exceed 55.6 °C (100 °F) per hour.

d) Prime pump and ensure pump suction valve is open.

CAUTION Before starting the pump, the casing and suction line must be completely filled with the liquid being pumped. The rotating parts depend on this liquid for lubrication, and the pump may seize if operated without liquid.

e) Ensure pump recirculating line (if required) is open and free of obstructions.

f) Check that pump is vented by observing leakage from casing vent and seal piping vent. Close vent when liquid is emitted.

g) Make sure mechanical seal piping is turned on.

h) Check pump rotation by starting unit momentarily. The direction of rotation is shown on *10.4, pump data sheet*. Note the pump coasts to a gradual stop.

5.2 Pump lubricants

5.2.1 Recommended oil lubricants

	Oil	Splash lubrication		Force feed lubrication
Centifugal pump lubrication	Viscosity mm ²/s 40 ºC	32	68	46
	Temp. maximum ºC (ºF)	65 (149)	80 (176)	-
	Designation according to DIN51502 ISO VG	HL/HLP 32	HL/HLP 68	HL/HLP 46
Oil companies and lubricants	**BP**	BP Energol HL32 BP Energol HLP32	BP Energol HL68 BP Energol HLP68	BP Energol HL46 BP Energol HLP46
	DEA	Anstron HL32 Anstron HLP32	Anstron HL68 Anstron HLP68	Anstron HL46 Anstron HLP46
	Elf	OLNA 32 HYDRELEF 32 TURBELF 32 ELFOLNA DS32	TURBELF SA68 ELFOLNA DS68	TURBELF SA46 ELFOLNA DS46
	Esso	TERESSO 32 NUTO H32	TERESSO 68 NUTO H68	TERESSO 46 NUTO H46
	Mobil	Mobil DTE oil light Mobil DTE13 MobilDTE24	Mobil DTE oil heavy medium Mobil DTE26	Mobil DTE oil medium Mobil DTE15M Mobil DTE25
	Q8	Q8 Verdi 32 Q8 Haydn 32	Q8 Verdi 68 Q8 Haydn 68	Q8 Verdi 46 Q8 Haydn 46
	Shell	Shell Tellus 32 Shell Tellus 37	Shell Tellus 01 C 68 Shell Tellus 01 68	Shell Tellus 01 C 46 Shell Tellus 01 46
	Texaco	Rando Oil HD 32 Rando Oil HD-AZ-32	Rando Oil 68 Rando Oil HD C-68	Rando Oil 46 Rando Oil HD B-46
	Wintershall (BASF Group)	Wiolan HN32 Wiolan HS32	Wiolan HN68 Wiolan HS68	Wiolan HN46 Wiolan HS46

Tilt-Pad Bearing	<107°C (225 °F)	107°C (225 °F)	115°C (240 °F)

5.2.2 Recommended fill quantities

Refer to the Assembly Drawing for bearing housing oil capacity:

5.2.3 Alarm and shutdown points.

Refer to the following for casing and bearing housing oil temperature limits:

Location	Normal	Alarm	Shutdown
Case Fluid	X	X + 1.5°C (35 °F)	X + 10°C (50 °F)
Journal Bearing	<82°C (180 °F)	88°C (190 °F)	96°C (205 °F)
Ball Bearing	<90°C (195 °F)	93°C (200 °F)	99°C (210 °F)

Normal oil change intervals are 4 000 operating hours or at least every 6 months. For pumps on hot service or in severely damp or corrosive atmosphere, the oil will require changing more frequently. Lubricant and bearing temperature analysis can be useful in optimizing lubricant change intervals.

The lubricating oil should be a high quality mineral oil having foam inhibitors. Synthetic oils may also be used if checks show that the rubber oil seals will not be adversely affected.

The bearing temperature may be allowed to rise to 96 ºC (205 ºF), but should not exceed 107 ºC (225ºF). A continuously raising temperature, or an abrupt rise, indicate a fault.

5.3 Impeller clearance

Please refer to the sectional drawing for ring and bushing clearance value.

5.4 Direction of rotation

CAUTION Ensure the pump is given the same rotation as the pump direction arrow mounted on the bearing housing.

To avoid dry running the pump must either be filled with liquid or have the flexible coupling disconnected before driver is switched on.

CAUTION If maintenance work has been carried out to the site's electricity supply, the direction of rotation should be re-checked as above in case the supply phasing has been altered.

5.5 Guarding

Guarding is supplied fitted to the pump set. If this has been removed or disturbed ensure that all the protective guards around the pump coupling and exposed parts of the shaft are securely fixed.

5.6 Priming and auxiliary supplies

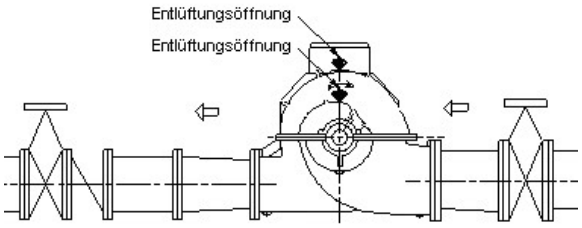
CAUTION Ensure all electrical, hydraulic, pneumatic, sealant and lubrication systems (as applicable) are connected and operational.

CAUTION Ensure the inlet pipe and pump casing are completely full of liquid before starting continuous duty operation.

5.6.1 Suction pressure above atmospheric pressure

Open vent connection on top of the pump upper casing to allow the trapped air to escape. Let liquid run out until free from air bubbles.

Possible vent/priming points



5.6.2 Suction lift without foot valve

Pump casing vents on the suction volute must be connected to an external vacuum pump priming system. If in doubt please consult Flowserve.

5.7 Starting the pump

CAUTION Ensure flushing and/or cooling/ heating liquid supplies are turned ON before starting the pump.

a) OPEN all inlet valves.

b) Prime the pump.

c) Crack open the outlet valve.

Ensure all vent connections are closed before starting.

d) Starting the driver (motor driven).

Prepare the driver for start-up in accordance with the manufacturer's instructions. Start the driver.

e) Starting the driver (turbine driven).

Prepare the turbine for start-up in accordance with the manufacturers instructions. Start the turbine and bring it up to speed quickly.

As soon as the pump is up to rated speed, slowly open discharge valve. This will avoid abrupt changes in velocity and prevent surging in the suction line.

f) When the pump is started, the pump's capacity must be between the minimum and maximum flow points. Failure to do so could damage the pump. The discharge valve must be opened or closed slowly to avoid abrupt changes in velocity and prevent surging in the suction line.

CAUTION Do not run the pump with the outlet valve closed.

g) If NO pressure, or LOW pressure, STOP the pump. Refer to section 7, *Faults; causes and remedies*, for fault diagnosis.

5.8 Running or operation

Do not wipe down in the vicinity of rotating parts, if unusual noise or vibrations occur, secure the pump as soon as possible.

The unit must not be operated unless coupling guard is bolted in place. Failure to observe this could result in injury to operating personnel.

When pump is equipped with manifolded vent and drain lines, each line must be equipped with an individual valve to prevent any liquid from a high pressure line flowing into a low pressure line. These valves must be kept in the closed position during pump operation.

Observe extreme caution when venting and/or draining hazardous liquids. Wear protective clothing in the presence of caustic, corrosive, volatile, flammable, or hot liquids. Do not breathe toxic vapors. Do not allow sparking, flames, or hot surfacing in vicinity of the equipment.

5.8.1 Venting the pump

Vent the pump to enable all trapped air to escape taking due care with hot or hazardous liquids.

Under normal operating conditions, after the pump has been fully primed and vented, it should be unnecessary to re-vent the pump.

5.8.2 Mechanical seal

Mechanical seals require no adjustment. Any slight initial leakage will stop when the seal is running.

Before pumping dirty liquids it is advisable, if possible, to run in the pump mechanical seal using clean liquid to safeguard the seal face.

CAUTION External flush or quench should be started before the pump is run and allowed to flow for a period after the pump has stopped.

CAUTION Never run a mechanical seal dry, even for a short time.

5.8.3 Bearings

Ex If the pumps are working in a potentially explosive atmosphere temperature or vibration monitoring at the bearings is recommended.

If bearing temperatures are to be monitored it is essential that a benchmark temperature is recorded at the commissioning stage and after the bearing temperature has stabilized. Record the bearing temperature.

It is important to keep a record on bearing temperatures. After start up the temperature rise should be gradual, reaching a maximum after approximately 1.5 to 2 hours. This temperature rise should then remain constant or marginally reduce with time. For any trouble refer to section 7, *Faults; causes and remedies*, for fault diagnosis.

5.8.4 Operating checks

CAUTION In the interest of operator safety, the unit must not be operated above the nameplate conditions. Such operation could result in unit failure causing injury to operating personnel.

CAUTION Operation at low flows results in pump Horse Power heating the liquid. A bypass may be required to prevent vaporization and subsequent pump damage. Mechanical damage may result from continuous operation at flows less than the minimum flow specified in the section 10.4 *Customer Data Sheet.*

Immediately after start-up, and frequently during running, check the following:

a) Check suction and discharge pressure gauges.

b) Check pressure gauges on each side of suction strainer.

c) Check for excessive leakage at Seal chamber gland area. There should be no visible leakage to the naked eye.

d) Check for unusual noises.

Eye protection required to perform this action.

f) Check oil level in pump bearing housings.

g) Check for adequate flow of cooling liquids.

h) After unit has been operated a sufficient length of time to reach normal operating temperature and condition, the unit is to be shut down and a "hot" coupling alignment check must be made. Refer to *shaft /coupling alignment* procedure.

⚠ ***Operation of the unit without appropriate lubrication can result in overheating of the bearings, bearing failures, pump seizures and actual breakdown of the equipment, exposing operating personnel to injury.***

5.8.5 Normal vibration levels, alarm and shutdown

For guidance, pumps generally fall under a classification for rigid support machines within the International rotating machinery standards and the recommended maximum levels below are based on those standards.

⚠ CAUTION Alarm and shutdown values for installed pumps should be based on the actual measurements (N) taken on the pump in the fully commissioned as new condition. Measuring vibration at regular intervals will then show any deterioration in pump or system operating conditions.

The following set points apply to DVSH Pumps, which use the sleeve/ball bearing arrangement.

a) Bearing housing vibration
- Normal: 2.5 to 7.6 mm/s (0.1 to 0.3 in./sec)
- Alarm: 10.2 mm/s (0.4 in./sec)
- Shutdown: 12.7 mm/s (0.5 in./sec)

b) Radial shaft vibration
- Normal: 0.038 mm (1.49 mils)
- Alarm: 0.076 mm (2.98 mils)
- Shutdown: 0.100 mm (4 mils)

c) Axial shaft vibration
- Normal: 0.203 mm (8 mils)
- Alarm: 0.254 mm (10 mils)
- Shutdown: 0.305 mm (12 mils)

5.8.6 Stop/start frequency

Pump sets are normally suitable for the number of equally spaced stop/starts per hour shown in the table below. Check actual capability of the driver and control/starting system before commissioning.

Motor rating kW (hp)	Maximum stop/starts per hour
Up to 15 (20)	15
Between 15 (20) and 90 (120)	10
Above 90 (120)	6

5.9 Stopping and shutdown

⚠ CAUTION Close the outlet valve, but ensure that the pump runs in this condition for no more than a few seconds.

⚠ CAUTION If pump stops abruptly when driver is shut down, investigate for pump binding. Take necessary remedial action before resuming operation.

a) Stop the pump.

b) Switch off flushing and/or cooling/heating liquid supplies at a time appropriate to the process.

⚠ CAUTION For prolonged shutdowns and especially when ambient temperatures are likely to drop below freezing point, the pump and any cooling and flushing arrangements must be drained or otherwise protected.

5.10 Hydraulic, mechanical and electrical duty

This product has been supplied to meet the performance specifications of your purchase order, however it is understood that during the life of the product these may change. The following notes may help the user decide how to evaluate the implications of any change. If in doubt contact your nearest Flowserve office.

5.10.1 Specific gravity (SG)

Pump capacity and total head in meters (feet) 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.

5.10.2 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 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.

5.9.3 Pump speed

Changing pump speed effects flow, total head, and power absorbed, $NPSH_R$, noise and vibration. Flow varies in direct proportion to pump speed, head varies as speed ratio squared and power varies as speed ratio cubed. The new duty, however, will also be dependent on the system

curve. If increasing the speed, it is important therefore to ensure the maximum pump working pressure is not exceeded, the driver is not overloaded, $NPSH_A > NPSH_R$, and that noise and vibration are within local requirements and regulations.

5.9.4 Net positive suction head ($NPSH_A$)
NPSH available ($NPSH_A$) is a measure of the head available in the pumped liquid, above its vapor pressure, at the pump suction branch.

NPSH required ($NPSH_R$) is a measure of the head required in the pumped liquid, above its vapor pressure, to prevent the pump from cavitating. It is important that $NPSH_A > NPSH_R$. The margin between $NPSH_A > NPSH_R$ should be as large as possible.

If any change in $NPSH_A$ is proposed, ensure these margins are not significantly eroded. Refer to the pump performance curve to determine exact requirements particularly if flow has changed. If in doubt please consult your nearest Flowserve office for advice and details of the minimum allowable margin for your application.

5.9.5 Pumped flow
Flow must not fall outside the minimum and maximum continuous flow shown on the pump performance curve and/or data sheet.

6 MAINTENANCE

6.1 General

⚠ It is the plant operator's responsibility to ensure that all maintenance, inspection and assembly work is carried out by authorized and qualified personnel who have adequately familiarized themselves with the subject matter by studying this manual in detail. (See also section 1.6.2.)

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.

⚠ ***Before attempting to disassemble pump, pump must be isolated from system, by closing suction and discharge system valves, drained of liquid and cooled, if pump is handling hot liquid.***

⚠ ***When pump is handling "hot" liquid, extreme care must be taken to ensure safety of personnel when attempting to drain pump. Hot pumps must be allowed to cool before draining.***

⚠ ***When pump is handling "caustic" liquid, extreme care must be taken to ensure safety of personnel when attempting to drain pump. Protective devices of suitable protective materials must be worn when draining pump.***

⚠ ***Before attempting any maintenance work on pumps in vacuum service, pumps must be isolated from suction and discharge system then carefully vented to return pressure in pump casing to atmospheric pressure.***

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.

⚠ ***Oil 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 guardrails 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 an uncontrolled start. Put a warning board on the starting device with the words:
"Machine under repair: do not start".

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

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

6.2 Maintenance schedule

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

a) Any auxiliary systems installed must be monitored, if necessary, to ensure they function correctly.

b) Check for any leaks from gaskets and seals. The correct functioning of the shaft seal must be checked regularly.

c) Check bearing lubricant level, and if the hours run show a lubricant change is required.

d) Check that the duty condition is in the safe operating range for the pump.

e) Check vibration, noise level and surface temperature at the bearings to confirm satisfactory operation.

f) Check dirt and dust is removed from areas around close clearances, bearing housings and motors.

g) Check coupling alignment and re-align if necessary.

Our specialist service personnel can help with preventative maintenance records and provide condition monitoring for temperature and vibration to identify the onset of potential problems.

If any problems are found the following sequence of actions should take place:

a) Refer to section 7, *Faults; causes and remedies*, for fault diagnosis.

b) Ensure equipment complies with the recommendations in this manual.

c) Contact Flowserve if the problem persists.

6.2.1 Routine inspection (daily/weekly)

 The following checks should be made and the appropriate action taken to remedy any deviations:

a) Check operating behavior. Ensure noise, vibration and bearing temperatures are normal.

b) Check that there are no abnormal fluid or lubricant leaks (static and dynamic seals) and that any sealant systems (if fitted) are full and operating normally.

c) Check the level and condition of oil lubricant. Check running hours since last complete oil change.

d) Check any auxiliary supplies e.g. heating/cooling (if fitted) are functioning correctly.

 Refer to the manuals of any associated equipment for routine checks needed.

6.2.2 Periodic inspection (every six month)

 Check foundation bolts for security of attachment and corrosion.

a) Check pump-running records for hourly usage to determine if bearing lubricant requires changing.

b) Check the vibration limits found in 5.8.5 and refer to section 7 in case of vibration exceeds the limits.

 Refer to the manuals of any associated equipment for periodic checks as needed.

6.3 Spare parts

6.3.1 Ordering of spares

Flowserve keeps records of all pumps that have been supplied. When ordering spares the following information should be quoted:

- Pump serial number
- Pump size
- Order number
- Part name – taken from section 8
- Part number – taken from section 8
- Number of parts required – taken from section 8

The pump size and serial number are shown on the pump nameplate.

Order number should be taken from 10.4 *Customer Data sheet.*

For 24-Hour part ordering service, call Flowserve Distribution Center at +1 800 526 3569.

To place an order, contact the nearest FLS office found at www.flowserve.com.

⚠ ***The use of parts other than Flowserve approved parts may create hazardous conditions over which Flowserve has no control. Such hazardous conditions can lead to injury, or result in damage to the equipment. Flowserve does not support nor will be responsible for the use of non-Flowserve furnished parts nor the use of materials that are not as originally furnished without the expressed written approval of Flowserve.***

6.3.2 Service instructions

For 24-hour emergency repair service, contact the Flowserve Service Department at +1 800 547 8671 or +1 908 859 7372 or contact the nearest Flowserve Service Center.

6.3.3 Storage of spares

Spares should be stored in a clean dry area away from vibration. Inspection and re-treatment of metallic surfaces (if necessary) with preservative is recommended at 6 monthly intervals.

6.4 Recommended spares and consumable items

For start up purposes:
- 2 - shaft sleeves
- 1 - set of gaskets and seals
- 2 - mechanical seals

For 2 years operation:
- 1 - set of bearings (line and thrust)
- 2 - shaft sleeves
- 2 - sets of gaskets and seals
- 2 - casing wear rings
- (Optional: 2 - mechanical seals
  2 - impeller wear rings)

For 4 years operation:
- 1 - set of bearings (line and thrust)
- 2 - shaft sleeves
- 2 - sets of gaskets and seals
- 2 - casing wear rings
- 1 - impeller
- (Optional: 2 - mechanical seals
  2 - impeller wear rings)

6.5 Tools required

Note: No special tools are required to assemble or disassemble the pump. Common mechanical tools are sufficient. However we recommend torque wrench to tighten all fasteners.

6.6 Fastener torques

For torque values for casing parting studs, refer to the table below:

Size (mm)	Size (in.)	lbf×ft	Nm
19	0.750	157	213
22	0.875	255	346
25	1.000	425	576
29	1.125	600	813
32	1.250	850	1152
35	1.375	1200	1626
38	1.500	1600	2168
41	1.625	1950	2642
44	1.750	2600	3526
48	1.875	3250	4404
51	2.000	3900	5285
57	2.250	5600	7588

For torque values for screws other than casing studs, refer to the table below:

Size (mm)	Size (in.)	lbf×ft	Nm
6	0.250	9	12
10	0.375	31	42
13	0.500	75	102
16	0.625	150	203
19	0.750	250	339
22	0.875	378	512
25	1.000	583	790
29	1.125	782	1060
32	1.250	1097	1486

6.7 Disassembly

⚠ Refer to section 1.6, *Safety*, before dismantling the pump.

CAUTION Before dismantling the pump for overhaul, ensure genuine Flowserve replacement parts are available.

Refer to sectional drawings in section 8 for part numbers and identification.

6.7.1 Dismantling procedure

a) Remove all auxiliary piping and instrumentation that will interfere with disassembly, and drain oil from bearing housings.

Use extreme caution not to expose maintenance personnel to hot liquids when removing auxiliary piping or draining bearing housings.

b) Remove temperature detectors (if supplied) from bearing housings.

c) When mechanical seals are used, loosen seal gland bolting.

6.7.2 Coupling removal

a) Remove coupling guard.
b) Remove coupling bolting and remove the spacer piece (if used).
c) Loosen set-screws in coupling nut and remove nut.

The use of a puller will be required to remove it from the shaft.

6.7.3 Thrust bearing removal

a) Loosen set-screw (optional) and slide deflector [2540] on pump shaft [2100] away from thrust bearing housing [3200.2].

b) Remove cap-screws securing end cover [3266] and gasket [4590.2]. Remove end cover [3266] and gasket [4590.2]. Discard gasket [4590.2].

c) Remove oil ring [3861.2] from sleeve oil ring retainer [2400].

d) Remove dowel pins and cap-screws securing top half of bearing housing [3200.2] to bottom half.

e) Using suitable lifting equipment remove the top half of bearing housing [3200.2].

f) Remove clamp strap [3121].

g) Loosen set-screws and remove sleeve oil ring retainer [2400].

h) Release tabs of lock-washer [6541.2], then remove lock-washer [6541.2] and lock-nut [3712.1].

i) Using a suitable puller, remove the ball bearings [3013] from pump shaft [2100]. Discard ball bearings [3013].

CAUTION If the bearings cannot be removed with the tools available never use a torch under any circumstances. Split the outer ring with a small hand grinder, saw through the ball/roller retainer, and split the inner ring about three quarters through with a grinder and break with a cold chisel while supporting the pump shaft below the inner race.

j) Remove top half of sleeve bearing [3020]. Move oil ring [3861.1] aside.

k) Remove bottom half of sleeve bearing [3020] by revolving it around the pump shaft [2100] while supporting the shaft [2100] to relieve weight and provide clearance.

l) With suitable lifting equipment supporting the bottom half bearing housing [3200.2], remove the dowel pins and cap-screws securing bearing housing [3200.2] half to pump casing and remove bottom half bearing housing [3200.2].

m) Remove remaining oil ring [3861.1] and deflector [2540] from pump shaft [2100]. Discard deflector O-ring [4610].

6.7.4 Plain bearing removal

a) Loosen set-screws (optional) securing deflectors [2540] to the pump shaft [2100]. Slide the deflector [2540] off the pump shaft [2100] and slide deflector [2540] on shaft away from radial bearing housing [3200.1]. Remove and discard deflectors O-ring [4610].

b) Remove dowel pins and cap-screws securing the top half of bearing housing [3200.1] to the bottom half.

c) With suitable lifting equipment remove the top half of bearing housing [3200.1].

d) Remove the top half of sleeve bearing [3020].

e) Remove both oil rings [3861.1].

f) Remove the bottom half of sleeve bearing [3020] by revolving it around the pump shaft [2100] while supporting the shaft [2100] to relieve weight and provide clearance.

g) With suitable lifting equipment supporting the bottom half bearing housing [3200.1], remove the dowel pins and cap-screws securing the bearing housing half to pump casing [1210.1] and remove the bottom half bearing housing.

h) Slide oil ring [3861.1] and deflector [2540] off pump shaft [2100]. Discard deflector O-ring [4610].

6.7.5 Mechanical seal removal

To remove mechanical seal [4200] from pump:

a) Install setting plates/eccentric washer in place.

b) Loosen drive collar.

c) Remove gland bolting.

d) Slide mechanical seal from shaft

Seal may be disassembled/inspected/reassembled per seal manufacturer's drawing and instructions in section 10 of this manual.

Note: After reassembly of seal, setting plates/eccentric washers must be removed before start-up.

6.7.6 Pump Casing Disassembly

a) Remove the cap nuts from casing studs.

b) Use back-off screws in the taps provided to break the casing gasket [4590.1] of the casing top half [1210.2] to the casing bottom [1210.1].

CAUTION Protect the casing-to-gasket mating surface. Scratching or scoring of the mating surface may cause leakage during pump operation.

c) Using suitable lifting equipment, remove the casing top half [1210.2] casing and place it carefully aside on a clean surface.

The cast lifting lugs provided on upper half casing are for lifting upper half casing only. Do not lift pump from these lugs.

d) Remove the rotating element from the bottom half of casing and place on V-blocks or other suitable supports. Refer to section 2.3 *Lifting*

e) Remove stuffing box bushings [4132] from shaft [2100] and casing wear ring [1500] from its fit on each end of impeller.

6.7.7 Shaft Sleeve Removal

Loosen the shaft sleeve set-screws and unscrew the shaft sleeve [2450.1] & [2450.2]. Removal of shaft sleeve should not require application of heat. If required, tap the sleeve with soft hammer to help break it loose.

Note: One sleeve is left hand threads.

6.7.8 Rotating Element Disassembly

The impeller and shaft sleeve are installed on the pump shaft with a shrink and slide fit. The shaft sleeve/impeller nut is secured by screwing into the pump shaft against the impeller. The Impeller shaft movement is prevented by its key. To facilitate removal and installation of the parts from the shaft, the shaft is machined in steps so that the largest diameter fit is at the center with decreasing diameter fits towards each end.

Wear heat resistant gloves when handling heated sleeves and impellers.

CAUTION Use neutral acetylene or map torch with a broad flame and rotate the heat for even distribution. Keep the flame away from pump shaft with a pipe sleeve or damp cloth.

CAUTION The use of Tempil-stick (controlled melting point material, product of Tempil Mfg. Co.) or equal product is recommended to obtain proper temperature of 204.4°C (400°F). Should an impeller or sleeve bind on the shaft during removal cool it and the shaft with an air blast, followed by a complete cooling with clear water. Reheat and try removal again. Avoid forcing the component off the shaft.
To disassemble the rotating element proceed to the impeller disassembly per the following procedure.

a) Apply heat (torch with fine tip) to periphery outer 38mm (1.5 in.) of impeller until temperature reaches 191°C (375°F) (minimum) to 204°C (400°F) (maximum). Use "tempilstick" to determine temperature.

b) Maintaining temperature between. (191°C – 204°C (375 °F – 400°F) at the periphery, apply heat down through the vane passages, thus heating the hub.

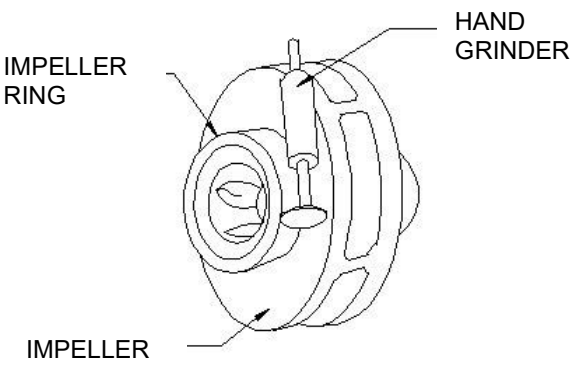
c) Do not apply heat directly to shaft; this will cause it to expand.

d) With periphery, shroud and hub at temperature, remove impeller.

e) If the impeller does not move freely off the shaft, additional heat may be necessary. This heating should be started at the periphery of the impeller, not the hub. (Additional heating of the hub area at this time will tighten the impeller on the shaft, not loosen it). If the impeller still fails to come free, the impeller and shaft should be allowed to cool completely and the heating process repeated, starting at Step a.

6.7.9 Impeller ring removal

Remove impeller rings by removing the set-screws from outside of the impeller [2200] and machine off, or grind two slots diametrical opposite across the face of the ring [2300] so it can be split apart. Exercise caution if rings are removed by grinding so as not to damage impeller hubs. See sketch



6.7.10 Parting flange gasket

Remove all traces of old gasket [4590.1] material. When using any tool to remove gasket material, do not gouge or machined surfaces. Use only Flowserve recommended replacement materials.

6.8 Examination of parts

a) Discard and provide replacement parts for all gaskets and o-rings removed during disassembly.

b) Wash all parts thoroughly in acetone or other suitable solvent. Air dry the parts, or dry the parts with a clean, lint-free cloth.

c) Check all parts for wear, erosion, or corrosion. Discard and provide replacement parts for all parts worn, eroded or corroded to the extent which would damage pump operation.

d) Using a micrometer, determine that the faces of the shaft-locating ring are ground parallel and perpendicular to the bore within 0.013 mm (0.0005 in.).

e) Determine that the pump shaft is free of dirt and burrs. Mount the shaft in a lathe (between centers, or on V-blocks, or on rollers (at bearing locations).

f) Use a dial indicator to check the shaft for runout. Total indicator reading at any point must not exceed 0.051 mm (0.002 in.).

g) Check the diametrical running clearances of wear rings and bearings (Refer to Pump Sectional Drawing, Section 8). The diametrical running clearances given are factory tolerances for a new or rebuilt pump.

h) It is recommended that ball bearings are not re-used after any removal from the shaft. The plain liquid lubricated bearings may be re-used if no sign of wear, grooving or corrosion attack.

i) The lubricant, bearings and bearing housing seals are to be inspected for contamination and damage. If oil bath lubrication is utilized, these provide useful information on operating conditions within the bearing housing.

j) If bearing damage is not due to normal wear and the lubricant contains adverse contaminants, the cause should be corrected before the pump is returned to service.

k) Labyrinth seals and bearing isolators should be inspected for damage but are normally non-wearing parts and can be re-used.

CAUTION Used parts must be inspected before assembly to ensure the pump will subsequently run properly.

6.9 Assembly

Thoroughly clean all parts and gasket seats before reassembly. Replace all gaskets with new ones; never reuse old gaskets. Reassemble the pump as directed in the following paragraphs. For parts identification and location, refer to Pump Sectional Drawing, Section 8.

6.9.1 Rotating Element Reassembly

Use any safe heating method and provide protection for personnel handling the heated components.

a) Replace impeller wear rings [2300] that may have been removed and secure with set-screws. These wear parts are a light press fit and may require heating or cooling to ease assembly. When heat is used, apply the heat evenly and use care to avoid overheating the parts.

b) Make sure impeller [2200] and pump shaft [2100] are clean. Replacement of the impeller on the shaft will require application of heat, however, if the impeller is heated, apply the heat slowly and evenly to obtain uniform expansion, and do not overheat the piece. When installing the impeller, first install key on the shaft. After the impeller is properly positioned against the shaft sleeve/shaft shoulder, use a spanner wrench to reinstall the shaft sleeve/impeller nuts (left-hand and right hand threaded) and securely tighten retaining screw.

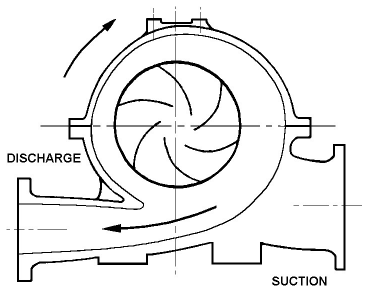
c) Balance the rotating element to the requirements given in API 9th Edition.

d) Complete the assembly of the rotating element by installing the remaining parts as follows:

e) Slip the casing wear rings [1500] over the impeller hubs before mounting the rotor unit into the lower half casing [1210.1], ensuring the pins in the rings locate into the holes in the casing.

f) Mount stuffing box bushings [4132] on pump shaft.

CAUTION Verify the impeller is not installed backwards.



6.9.2 Pump Casing Reassembly

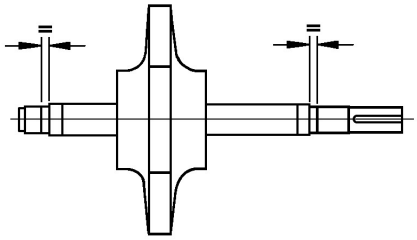
CAUTION Exercise extreme care in handling the casing halves in order not to damage the mating surfaces. Damaging these surfaces can cause serious operational difficulties.

When re-assembling the impeller on the shaft, it is important to mount the impeller so that the vane tips point away from the apparent flow direction.

The rotor always rotates towards the expanding section of the volute.

The two shaft sleeves and shaft nuts clamping the impeller define its position on the pump shaft [2100] and hence in the pump casing.

The correct axial position of the impeller [2200] and mechanical seals can be checked with the grooved checking marks on the pump shaft.



6.9.3 Pump Casing Gasket Fabrication and Installation

a) Clean both halves of pump casing at the split joint. If dowel pins are installed, remove them.

b) Remove the studs (if applicable) from the top half pump casing.

c) Place a thin coat of non-hardening sealer on the mating surface of the top casing half [1210.2]. This will prevent the gasket material [4590.1] from moving when forming the gasket.

d) Lay and clamp gasket in place on the top casing.

e) Remove the gasket from the upper casing [1210.2] and place on lower casing [1210.1].

f) Place the upper casing on the lower casing and cut or peen the outside casing contour.

g) Leave approximately 6.35 mm (0.25 in.) gasket material protruding from casing at seal chamber faces. Gasket will be trimmed after final installation of half in following paragraph.

h) Remove upper casing.

6.9.4 Rotating Element and Upper Casing Reinstallation

a) Lift the rotating element and center it over the casing bottom half [1210.1]. Before lowering it, rotate both casing wear rings [2300] and stuffing box bushings [4132] so that the locating pin of each piece is towards the top of the rotating element.

b) Slowly lower the rotating element assembly into the lower casing [1210.1] while fining the bushings, and casing wear rings [2300] with their respective grooves in the lower casing. Rotate the stuffing box bushings [4132] and wear rings one-quarter turn to engage their locating pin with the corresponding counter sink hole in the lower casing.

c) Place the upper casing on the lower casing and install the stud cap nuts. If removed, install the upper casing dowel pins. Tighten nuts to the torque value specified in section 6.6 *Fasteners torques.*

d) Cut the excess gasket material extending over each end of the casing flush with the casing.

6.9.5 Shaft Settings Check

If the bearing housings [3200], rotating element or shaft locating/adjusting ring have been altered or replaced, the radial and/or axial shaft settings

should be checked in accordance with procedure listed in Section 10.

6.9.6 Mechanical Seal Installation

a) Starting at either end of the pump and referencing the mechanical seal drawing in Section 10 verify that all visible o-rings [4610] are installed prior to installing the mechanical seal [4200].

b) Slide the seal cartridge onto pump shaft and into seal chamber. Secure the cartridge by installing its flat washers and nuts. Tighten nuts to value given in section 6.6 *Fasteners torques.*

c) Do not tighten the set-screws that lock the cartridge to the pump shaft until the pump is fully assembled.

d) Repeat the above procedure to install the seal cartridge on the other end of the pump.

6.9.7 Thrust Bearing and Housing Reinstallation

a) Slide deflector [2540] with a new o-ring [4610] installed in its bore on pump shaft so as not to interfere, with the installation of bearing housing [3200.2].

b) Lift, position and secure the bottom half bearing housing to pump casing with dowel pins and cap-screws. Tighten cap-screws to value specified in section 6.6 *Fasteners torques.*

c) Place inboard oil ring [3861.1] on pump shaft so that it will be located on the inboard side of sleeve bearing.

d) Using a piece of wood to pry on the pump shaft, lift the shaft [2100] as necessary to provide clearance and roll bottom half of sleeve bearing into bottom half bearing housing [3200.2].

e) Place the outboard oil ring [3861.1] on the pump shaft above the bottom half sleeve bearing then position both the inboard and outboard oil rings [3861.1] on the pump shaft [2100] to mate with the grooves in the top half sleeve bearing [3020]. Install top half sleeve bearing on bottom half sleeve bearing [3020].

f) Install locating ring on pump shaft against shoulder on pump shaft, then press duplex bearing, back to back on pump shaft against locating ring (Refer to Shaft Settings Check section).

g) Place strap clamp [3121] around bearing. Secure with screws and nuts.

h) Install lock-washer [6541.2] and locknut [3712.2]. Tighten locknut [3712.2] then secure it with lock-washer [6541.2] tabs.

i) Slide oil ring retainer [2400] on pump shaft [2100] against lock-nut [3712.2]. Secure retainer in place with set-screws.

j) Place oil ring [3861.2] on oil ring retainer [2400].

k) Place top half of bearing housing [3200.2] on bottom half housing and install cap-screws. Tighten cap-screws to value specified in section 6.6 *Fastener torques.*

l) Install outboard thrust bearing housing end cover [3266] with a new gasket [4590.2] and secure with cap-screws. Tighten cap-screws to value specified in section 6.6 *Fastener torques.*

m) Slide deflector [2540] on pump shaft against housing [3200.2], then back it off 0.79 mm (1/32 in.) and secure with set-screw (optional).

6.9.8 Radial Bearing and Housing Reinstallation

a) Place deflector [2540] with a new 0-ring [4610] installed in its bore and on the pump shaft [2100] so that it will not interfere with the installation of the bearing housing [3200.1].

b) Lift, position and secure bottom half bearing housing [3200.1] to pump casing with dowel pins and cap-screws. Tighten cap-screws to value specified in section 6.6 *Fastener torques.*

c) Place oil ring on pump shaft so that it will be located on the inboard side of sleeve bearing.

d) Using a piece of wood to pry on the pump shaft, lift the shaft as necessary to provide clearance and roll bottom half of sleeve bearing into bottom half bearing housing.

e) Place the outboard oil ring [3861.1] on the pump shaft [2100] above the bottom half sleeve bearing [3200.1], then position oil rings on the pump shaft to mate with the grooves in the top half sleeve bearing [3200.1]. Install top half sleeve bearing on bottom half sleeve bearing.

f) Place top half radial bearing housing [3200.1] on bottom half housing and install securing cap-screws. Tighten cap-screws to value specified in section 6.6 *Fastener torques.*

g) Slide deflector [2540] on pump shaft against housing, then back it off 1/32 in. (.79 mm) and secure to pump shaft with set-screw (optional).

h) Install a new 0-ring [4610] in bore of deflector [2540]. Slide outboard deflector on pump shaft [2100] against housing then back it off 0.79 mm (1/32 in.) and secure to pump shaft with set-screw (optional).

6.9.9 Final Assembly

a) Install coupling key [6700.1] in keyway on pump shaft [2100]. Align pump hub with key and place on shaft.

b) Install coupling lock-nut [3712.1] with lock-washer [6541.1] on end of pump shaft. Using a spanner wrench tighten nut until the hub touches mark previously scribed on shaft. Secure lock-nut by bending at least one tab of lock-washer into the slot of locknut.

c) If removed, reinstall the assembled pump on the baseplate and reconnect facility main piping.

d) If mechanical seals are installed, tighten drive collar set-screws. Disengage seal setting plates from rotating parts and secure in place.

e) Connect any piping and instrumentation removed.

f) Install pump coupling and perform driver-to-pump alignment in accordance with instructions in section four.

g) Provide lubricating oil to bearing housings before operating the pump.

7 FAULTS; CAUSES AND REMEDIES

FAULT SYMPTOM

Pump overheats and seizes	Bearings have short life	Pump vibrates or is noisy	Mechanical seal has short life	Mechanical seal leaks excessively	Pump requires excessive power	Pump loses prime after starting	Insufficient pressure developed	Insufficient capacity delivered	Pump does not deliver liquid	PROBABLE CAUSES	POSSIBLE REMEDIES
										A. System troubles	
●									●	Pump not primed.	Check complete filling. Vent and/or prime.
		●				●		●	●	Pump or suction pipe not completely filled with liquid.	
		●				●		●	●	Suction lift too high or level too low.	Check NPSHa>NPSHr, proper submergence, losses at strainers/fittings.
●		●						●	●	Insufficient margin between suction pressure and vapor pressure.	
						●	●	●		Excessive amount of air or gas in liquid.	Check and purge pipes and system.
						●		●	●	Air or vapor pocket in suction line.	Check suction line design for vapor pockets.
						●		●		Air leaks into suction line.	Check suction pipe is airtight.
						●		●		Air leaks into pump through mechanical seal, sleeve joints, casing joint or pipe plugs.	Check and replace faulty parts. CONSULT FLOWSERVE.
		●						●		Foot valve too small.	Investigate replacing the foot valve.
		●						●		Foot valve partially clogged.	Clean foot valve.
		●				●		●	●	Inlet of suction pipe insufficiently submerged.	Check out system design.
							●	●	●	Speed too low.	CONSULT FLOWSERVE.
					●					Speed too high.	CONSULT FLOWSERVE.
							●	●	●	Total head of system higher than differential head of pump.	Check system losses. Remedy or CONSULT FLOWSERVE.
					●					Total head of system lower than pump design head.	
					●					Specific gravity of liquid different from design.	Check and CONSULT FLOWSERVE.
					●		●	●		Viscosity of liquid differs from that for which designed.	
●		●								Operation at very low capacity.	Measure value and check minimum permitted. Remedy or CONSULT FLOWSERVE.
	●	●			●					Operation at high capacity.	Measure value and check maximum permitted. Remedy or CONSULT FLOWSERVE.
										B. Mechanical troubles	
●	●	●	●	●	●					Misalignment due to pipe strain.	Check the flange connections and eliminate strains using elastic couplings or a method permitted.
		●								Improperly designed foundation.	Check setting of baseplate: tighten, adjust, grout base as required.
	●	●	●	●	●					Shaft bent.	Check shaft runouts are within acceptable values. CONSULT FLOWSERVE.
●	●	●			●					Rotating part rubbing on stationary part internally.	Check and CONSULT FLOWSERVE, if necessary.
●	●	●	●	●						Bearings worn	Replace bearings.
					●		●	●		Wearing ring surfaces worn.	Replace worn wear ring/surfaces.

FAULT SYMPTOM

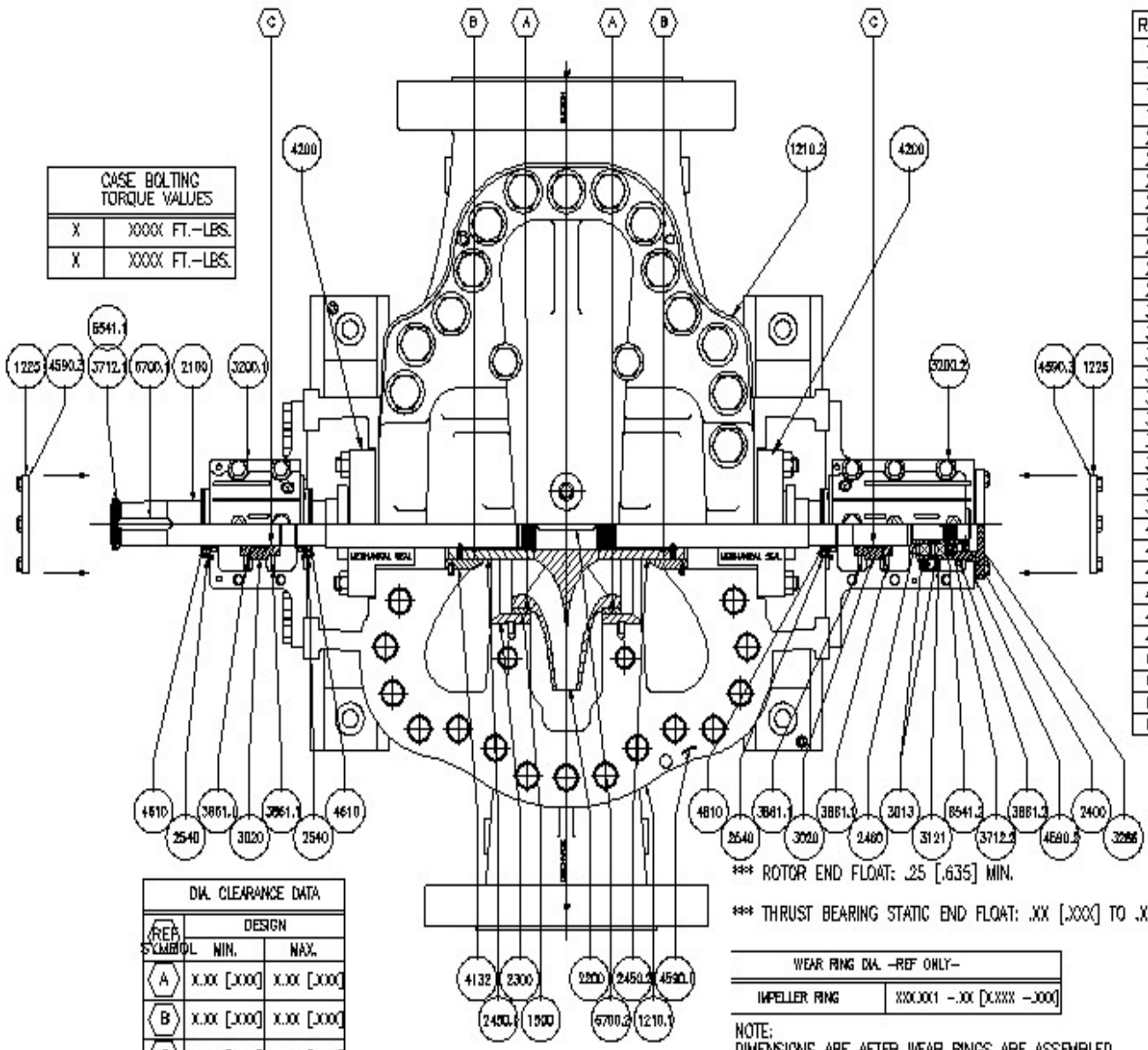
Pump overheats and seizes	Bearings have short life	Pump vibrates or is noisy	Mechanical seal has short life	Mechanical seal leaks excessively	Pump requires excessive power	Pump loses prime after starting	Insufficient pressure developed	Insufficient capacity delivered	Pump does not deliver liquid	PROBABLE CAUSES	POSSIBLE REMEDIES
		●					●	●		Impeller damaged or eroded.	Replace or CONSULT FLOWSERVE for improved material selection.
				●						Leakage under sleeve due to joint failure.	Replace joint and check for damage.
			●	●						Shaft sleeve worn or scored or running off center.	Check and renew defective parts.
			●	●	●					Mechanical seal improperly installed.	Check alignment of faces or damaged parts and assembly method used.
			●	●	●					Incorrect type of mechanical seal for operating conditions.	CONSULT FLOWSERVE.
●	●	●	●	●						Shaft running off center because of worn bearings or misalignment.	Check misalignment and correct if necessary. If alignment satisfactory check bearings for excessive wear.
●	●	●	●	●						Impeller out of balance resulting in vibration.	Check and CONSULT FLOWSERVE.
			●	●	●					Abrasive solids in liquid pumped.	
			●	●						Internal misalignment of parts preventing seal ring and seat from mating properly.	
			●	●						Mechanical seal was run dry.	Check mechanical seal condition and source of dry running and repair.
			●	●						Internal misalignment due to improper repairs causing impeller to rub.	Check method of assembly, possible damage or state of cleanliness during assembly. Remedy or CONSULT FLOWSERVE, if necessary.
●	●	●								Excessive thrust caused by a mechanical failure inside the pump.	Check wear condition of impeller, its clearances and liquid passages.
	●	●								Excessive grease in ball bearings.	Check method of regreasing.
	●	●								Lack of lubrication for bearings.	Check hours run since last change of lubricant, the schedule and its basis.
	●	●								Improper installation of bearings (damage during assembly, incorrect assembly, wrong type of bearing etc).	Check method of assembly, possible damage or state of cleanliness during assembly and type of bearing used. Remedy or CONSULT FLOWSERVE, if necessary.
	●	●								Damaged bearings due to contamination.	Check contamination source and replace damaged bearings.
										C. MOTOR ELECTRICAL PROBLEMS	
		●			●		●	●		Wrong direction of rotation.	Reverse 2 phases at motor terminal box.
					●			●		Motor running on 2 phases only.	Check supply and fuses.
	●	●						●		Motor running too slow.	Check motor terminal box connections and voltage.

8 PARTS LIST AND DRAWINGS.

8.1 General arrangement drawing

The typical general arrangement drawing and any specific drawings required by the contract will be sent to the Purchaser separately unless the contract specifically calls for these to be included into the User Instructions. If required, copies of other drawings sent separately to the Purchaser should be obtained from the Purchaser and retained with these User Instructions.

8.2 Assembly drawing



CASE BOLTING TORQUE VALUES	
X	XXXX FT.-LBS.
X	XXXX FT.-LBS.

REF NO.	DESCRIPTION	QTY
1210.1	CASING, HALF, LOWER	1
1210.2	CASING, HALF, UPPER	1
1225	PLATE, BRACKET	2
1500	WEAR RING, CASING	2
2100	SHAFT	1
2200	IMPELLER, DOUBLE SUCTION	1
2300	WEAR RING, IMPELLER	2
2400	SLEEVE, RING OIL RETAINER	1
2450.1	SLEEVE, SHAFT- R.H.	1
2450.2	SLEEVE, SHAFT- L.H.	1
2460	SPACER, LOCATING RING	1
2540	DEFLECTOR	3
3013	BEARING, BALL	2
3020	BEARING, SLEEVE	2
3121	CLAMP, STRAP, BEARING	1
3200.1	BEARING, HOUSING RADIAL	1
3200.2	BEARING, HOUSING THRUST	1
3266	BEARING, END COVER	1
3712.1	LOCKNUT, COUPLING	1
3712.2	LOCKNUT, BEARING	1
3861.1	RING, OIL	4
3861.2	RING, OIL	1
4132	BUSHING, STUFFING BOX	2
4200	MECHANICAL SEAL	2
4590.1	GASKET, CASE	1
4590.2	GASKET, BEARING COVER	4
4590.3	GASKET, BRACKET PLATE	2
4810	O-RING	3
6541.1	LOCKWASHER, COUPLING	1
6541.2	LOCKWASHER, BEARING	1
6700.1	KEY, COUPLING	1
6700.2	KEY, IMPELLER	1

DIA. CLEARANCE DATA		
REF SYMBOL	DESIGN MIN.	DESIGN MAX.
A	X.XX [.XXX]	X.XX [.XXX]
B	X.XX [.XXX]	X.XX [.XXX]
C	X.XX [.XXX]	X.XX [.XXX]

*** ROTOR END FLOAT: .25 [.635] MIN.

*** THRUST BEARING STATIC END FLOAT: .XX [.XXX] TO .XX [.XXX]

WEAR RING DIA. -REF ONLY-	
IMPELLER RING	XXX.XX1 -.XX [X.XXX -.XXX]

NOTE:
DIMENSIONS ARE AFTER WEAR RINGS ARE ASSEMBLED ON IMPELLER (DO NOT RE-MACHINE)

9 CERTIFICATION

Certificates, determined from the contract requirements will be provided with this manual. Examples are certificates for CE marking and ATEX marking. If required, copies of other certificates sent separately to the Purchaser should be obtained from Purchaser for retention with the User Instructions. See section 1.9, *Noise level*, for details of typical noise certification.

10 OTHER RELEVANT DOCUMENTATION AND MANUALS

10.1 Supplementary user instruction manuals.

Supplementary instruction determined from the contract requirements for inclusion into User Instructions such as for a driver, instrumentation, controller, sub-driver, seals, sealant system, mounting component etc are included under this section. If further copies of these are required they should be obtained from the purchaser for retention with these User Instructions.

Where any pre-printed set of User Instructions are used, and satisfactory quality can be maintained only by avoiding copying these, they are included at the end of these User Instructions such as within a standard clear polymer software protection envelope.

10.2 Change notes

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

10.3 Additional sources of information

Reference 1:
NPSH for Rotordynamic Pumps: a reference guide, Europump Guide No. 1, Europump & World Pumps, Elsevier Science, United Kingdom, 1999.

Reference 2:
Pumping Manual, 9th edition, T.C. Dickenson, Elsevier Advanced Technology, United Kingdom, 1995.

Reference 3:
Pump Handbook, 2nd edition, Igor J. Karassik et al, McGraw-Hill Inc., New York, 1993.

Reference 4:
ANSI/HI 1.1-1.5
Centrifugal Pumps - Nomenclature, Definitions, Application and Operation.

Reference 5:
ANSI B31.3 - Process Piping.

Reference 6:
American Petroleum Institute, API 610 10th Edition.

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