FLOWSERVE

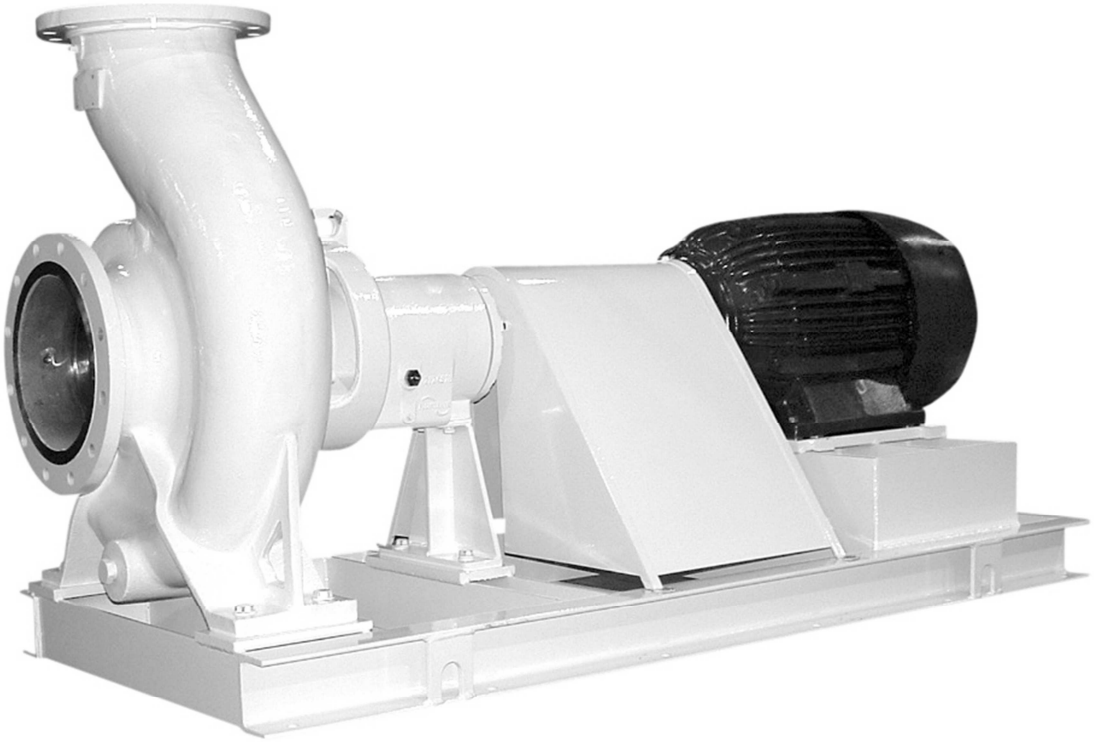
USER INSTRUCTIONS

FLOWSERVE
MARK 3 GROUP 4

Horizontal, end suction, centrifugal pumps for chemical process, water and general service

PCN= 71569286 08-12 (E)
Original Instructions

Installation
Operation
Maintenance



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

Experience In Motion

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1 INTRODUCTION AND SAFETY

1.1 General

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

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

Flowserve is 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 must 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. Failure to follow and apply the present user instructions is considered to be misuse. Personal injury, product damage, delay or failure caused by misuse are not covered by the Flowserve warranty.***

1.2 CE marking and approvals

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

Where applicable, the Directives and any additional Approvals, cover important safety aspects relating to machinery and equipment and the satisfactory provision of technical documents and safety instructions. Where applicable this document incorporates information relevant to these Directives and Approvals.

To confirm the Approvals applying and if the product is CE marked, check the serial number platemarkings and the Certification. (See section 9, *Certification*.)

1.3 Disclaimer

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

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

1.4 Copyright

1.5 Duty conditions

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

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

If the conditions of service on your purchase order are going to be changed (for example liquid pumped, temperature or duty) it is requested that you/the user

seek the written agreement of Flowserve before start up.

1.6 Safety

1.6.1 Summary of safety markings

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

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

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

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

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

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

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

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

1.6.2 Personnel qualification and training

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

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

1.6.3 Safety action

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

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

GUARDS MUST NOT BE REMOVED WHILE THE PUMP IS OPERATIONAL

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 (eg 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.

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 vapour 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 80℃ (176 ℉) or below - 5 ℃ (23 ℉) in a restricted zone, or excee ds local regulations, action as above shall be taken.***

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.

Gland packing must not be used when pumping hazardous liquids.

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

CAUTION NEVER RUN THE PUMP DRY

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

CAUTION 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 or 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*.)

CAUTION 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 mechanical seal.

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

1.6.4 Products used in potentially explosive atmospheres

Measures are required to:

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

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

1.6.4.1 Scope of compliance

Use equipment only in the zone for which it is appropriate. Always check that the driver, drive coupling assembly, 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 ATEX 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 IIC 135 ºC (T4)

Equipment Group
I = Mining
II = Non-mining

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

Gas and/or Dust
G = Gas; D= Dust

c = Constructional safety
(in accordance with En13463-5)

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

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

1.6.4.3 Avoiding excessive surface temperatures

ENSURE THE EQUIPMENT TEMPERATURE CLASS IS SUITABLE FOR THE HAZARD ZONE

Pumps have a temperature class as stated in the ATEX Ex rating on the nameplate. These are based on a maximum ambient of 40 ℃ (104 ℉); refer to Flowser ve for higher ambient temperatures.

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

Maximum permitted liquid temperature for pumps

Temperature class to EN13463-1	Maximum surface temperature permitted	Temperature limit of liquid handled
T6	85 ℃ (185 ℉)	65 ℃ (149 ℉) *
T5	100 ℃ (212 ℉)	80 ℃ (176 ℉) *
T4	135 ℃ (275 ℉)	115 ℃ (239 ℉) *
T3	200 ℃ (392 ℉)	180 ℃ (356 ℉) *
T2	300 ℃ (572 ℉)	275 ℃ (527 ℉) *
T1	450 ℃ (842 ℉)	400 ℃ (752 ℉) *

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

The operator is responsible to ensure that the specified maximum liquid temperature is not exceeded.

Temperature classification “Tx” is used when the liquid temperature varies and when the pump is required to be used in differently classified potentially explosive atmospheres. In this case the user is responsible for ensuring that the pump surface temperature does not exceed that permitted in its actual installed location.

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.

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

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

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

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 install an appropriate dry run protection device (eg liquid detection or a power monitor).

To avoid potential hazards from fugitive emissions of vapour 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.

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

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

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

Additional requirement for metallic pumps on non-metallic baseplates
When metallic components are fitted on a non-metallic baseplate they shall be individual grounded.

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, install a liquid detection device.

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 is adopted. (See section 6, *Maintenance.*

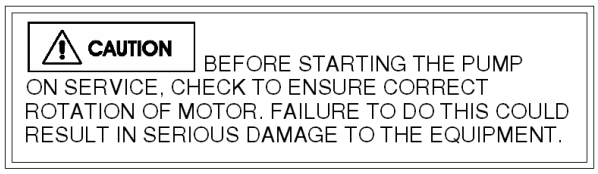
1.7 Nameplate and warning labels

1.7.1 Nameplate

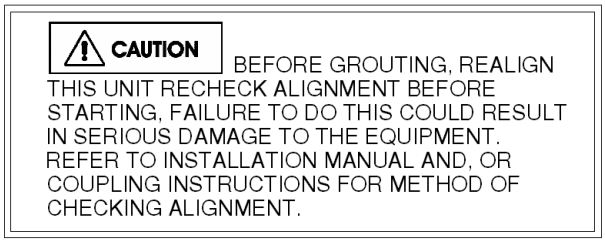
For details of nameplate, see the *Declaration of Conformity* or separate documentation included with these User Instructions

1.7.2 Safety labels

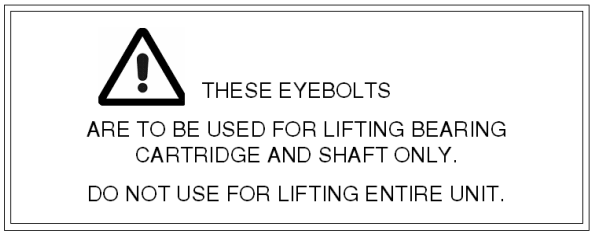
MECHANICAL SEAL WARNING
P/N 2113931-001



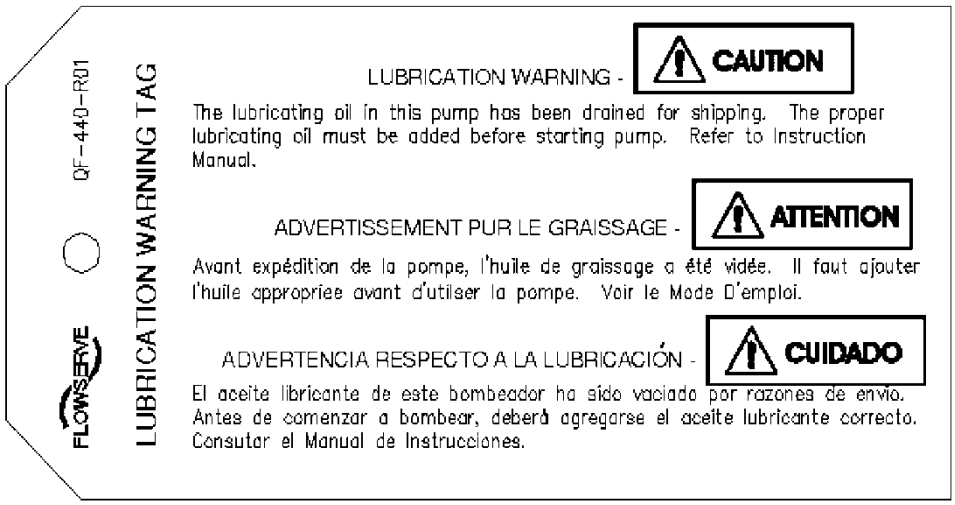
ROTATION WARNING
P/N 2113932-001



GROUT WARNING
P/N 2113934-001



LIFTING WARNING
P/N 9901701-001



LUBRICATION WARNING – QF-440-R01 (2124841)
Oil lubricated units only:

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

When pump noise level exceeds 85 dBA attention must be given to prevailing Health and Safety Legislation, to limit the exposure of plant operating personnel to the noise. The usual approach is to control exposure time to the noise or to enclose the machine to reduce emitted sound. You may have already specified a limiting noise level when the equipment was ordered, however if no noise requirements were defined then machines above a certain power level will exceed 85 dBA. In such situations consideration must be given to the fitting of an acoustic enclosure to meet local regulations.

Pump noise level is dependent on a number of factors, the type of motor fitted, the operating capacity, pipework design and acoustic characteristics of the building. The levels specified in the table below are estimated and not guaranteed.

The dBA values are based on the noisiest ungeared electric motors that are likely to be encountered. They are Sound Pressure levels at 1 m (3.3 ft) from the directly driven pump, for "free field over a reflecting plane". For estimating L_{wA} sound power level (re 1 *pW)* add 14dBA to the sound pressure value.

If a pump unit only has been purchased, for fitting with your own driver, then the "pump only" noise levels from the table should be combined with the level for the driver obtained from the supplier. If the motor is driven by an inverter, it may show an increase in noise level at some speeds. Consult a Noise Specialist for the combined calculation.

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

Motor size and speed kW (hp)	Typical sound pressure level L_{pA} at 1 m reference 20 µPa, dBA							
	1 750 r/min		1 450 r/min		1180 r/min		980 r/min	
	Pump only	Pump and motor	Pump only	Pump and motor	Pump only	Pump and motor	Pump only	Pump and motor
<0.55(<0.75)	62	64	62	64	60	62	60	64
0.75 (1)	62	64	62	64	60	62	60	64
1.1 (1.5)	64	64	62	63	62	64	60	63
1.5 (2)	64	64	62	63	62	64	60	63
2.2 (3)	65	66	63	64	63	66	61	64
3 (4)	65	66	63	64	63	66	61	64
4 (5)	65	66	63	64	63	66	61	64
5.5 (7.5)	66	67	64	65	64	67	63	65
7.5 (10)	66	67	64	65	64	67	63	65
11(15)	70	71	68	69	68	71	67	69
15 (20)	70	71	68	69	68	71	67	69
18.5 (25)	71	71	69	71	69	71	68	70
22 (30)	71	71	69	71	69	71	68	70
30 (40)	73	73	71	73	71	73	70	72
37 (50)	73	73	71	73	71	73	70	72
45 (60)	76	76	74	76	74	76	72	75
55 (75)	76	76	74	76	74	76	72	75
75 (100)	77	77	75	77	75	77	73	76
90 (120)	77	78	75	78	75	78	73	76
110 (150)	79	80	77	80	77	78	75	78
150 (200)	79	80	77	80	77	78	76	78
200 (270)	85	87	83	85	81	83	80	82
300 (400)	87	90	85	86	83	85	82	84

① The noise level of machines in this range will most likely be of values which require noise exposure control, but typical values are inappropriate.

Note: For 880 and 720 r/min reduce 980 r/min values by 2 dBA.

2 TRANSPORT AND STORAGE

2.1 Consignment receipt and unpacking

Immediately after receipt of the equipment it must be checked against the delivery/shipping documents for its completeness and that there has been no damage in transportation. Any shortage and/or damage must be reported immediately to Flowserve 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 side walls of the box or equipment.

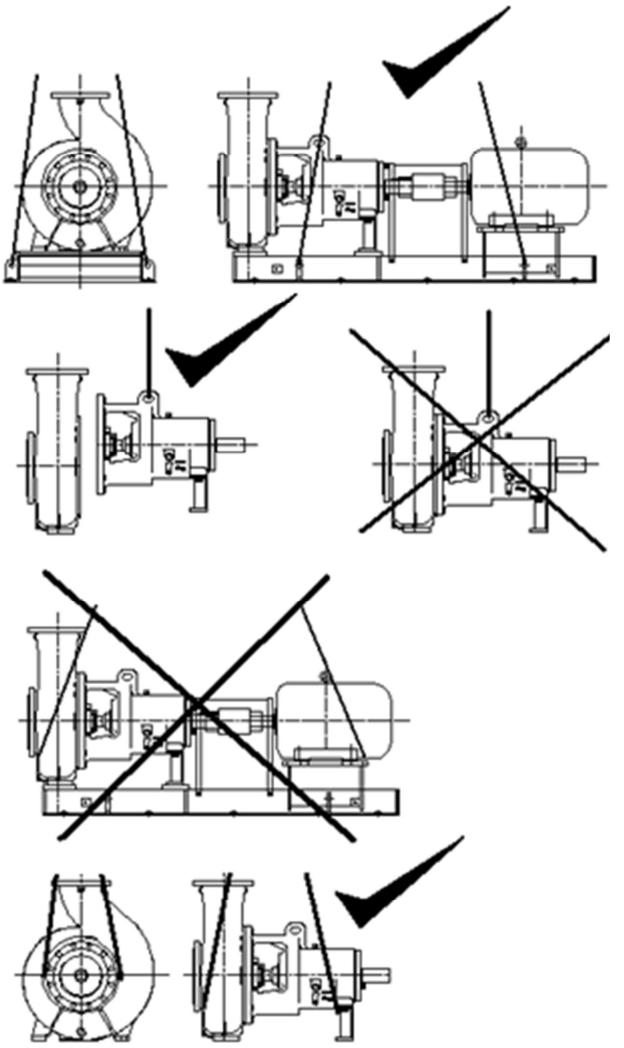
Each product has a unique serial number. Check that this number corresponds with that advised and always quote this number in correspondence as well as when ordering spare parts or further accessories.

2.2 Handling

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

The pump should be lifted with suitably sized and located slings. Do not use the shaft for lifting and take special care to prevent the pump from rotating in the slings due to unbalanced weight distribution.

2.3 Lifting



⚠ A crane must be used for all pump sets or components 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 the general arrangement drawing for the specific project. The table of engineering data in section 3.5 is for bare pump only and does not include the weight of the base, driver or auxiliary equipment.

The pump unit should be lifted as shown. Do not Use the driver, bare shaft pump or component lifting points to lift the complete machine.

Before lifting the driver alone, refer to the manufacturer's instructions

2.4 Storage

CAUTION

2.4.1 Short-Term Storage

When it is necessary to store a pump for a short time before it can be installed, place it in a dry, cool location. Protect it thoroughly from moisture and condensation. Protective flange covers should not be removed until the pump is being installed.
Wrap the exposed portions of the shaft and coupling to protect against sand, grit or other foreign matter. Oil lubricated units should be lubricated (refer to Section III) to protect the bearings. Grease lubricated units are lubricated at the factory during assembly. Turn the rotor over by hand at least once a week to maintain a protective film on the bearing components.

2.4.2 LONG-TERM STORAGE

More than precautions are required if long-term storage in excess of 90 days from factory shipment is unavoidable.

The internal surfaces of the pump should be sprayed with a rust preventative such as a water soluble oil or other suitable alternative. Particular attention should be given to the impeller, wear plate and stuffing box.

An optional method of protection is to suspend bags of desiccant material inside casing and completely seal all openings from the surrounding atmosphere. The stuffing box should be packed with clean, dry rags. Use of this method requires that the casing be initially free of liquid. The desiccant material should be checked at regular intervals to ensure that it has not absorbed excessive water vapour. A warning instruction, advising that the desiccant must be removed prior to installation should be wired to the pump.

A rust inhibitor should be added to the lubricating oil of oil lubricated units to give additional protection without destroying the lubricating properties of the oil. For specific recommendations, consult your lubrication dealer. Grease lubricated units, which can be identified by the grease fitting at each bearing location, should be well lubricated prior to placing in storage. Small amounts of additional grease should be added at regular intervals during storage. Refer to Section III for additional information related to grease lubrication.

Storage of pumps in areas of high ambient vibration should be avoided to prevent bearing damage due to brinelling. The risk of such damage can be reduced by frequent rotation of the shaft.

The pump half coupling and key should be removed from the shaft, coated with rust preventative and wrapped to prevent metal-to-metal contact. Exposed surfaces of the pump shaft should be protected with a rust preventative. All dismantled parts should be wrapped and tagged according to pump serial number and a record kept of their location.

CAUTION **Pumps covered with plastic should not be stored in a cool environment because resulting condensation can cause rusting**.

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

Flowserve "MARK 3" pumps are single stage, end suction centrifugal pumps specifically designed for the chemical process industry and consequently are ideally suited to many process fluids. A volute type casing with integrally cast feet and top centerline discharge nozzle is standard. The semi-open impeller with rear pump-out vanes is designed for high efficiency and prevents clogging. Sealing is provided at the impeller to shaft fit to prevent corrosion and thereby facilitate impeller removal. The thrust bearing housing uses a threaded adjustment that will permits precision bearing alignment and impeller setting. The back pull-out feature, typical of all MARK 3 pumps, permits quick removal of the entire rotor/frame assembly without disturbing the casing or driver.

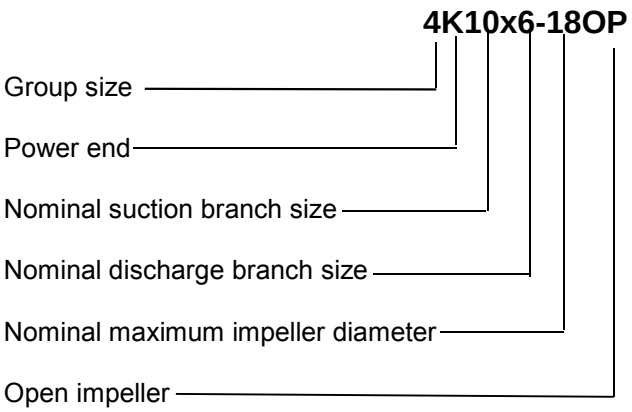
The pump is sealed using non-asbestos packing in the stuffing box, various mechanical seal designs as specified by the customer may be installed at the factory or retrofitted in the field.

All pumps are carefully inspected and prepared for shipment. All exterior machined surfaces are coated

with a rust preventative compound and openings are provided with covers or plugs. Shaft packing, when required, is shipped with the pump and should not be installed until the pump is ready to run. Mechanical seals, when provided, are factory installed and adjusted prior to shipment. The axial impeller running clearance is preset at the factory but should be checked prior to final alignment in case of tampering.

3.2 Name nomenclature

The pump size will be engraved on the nameplate. The following example explains how the pump name identifies the construction features and options.



3.3 Design of major parts

3.3.1 Pump casing

The pump casing is a volute type casing with integrally cast feet and top centerline discharge nozzle. It is a one piece pressure retaining casting with gasket connections to the stuffing box head and the suction and discharge flanges.

3.3.2 Impeller

The impeller is semi-open design, keyed to the shaft and secured with a contoured impeller nut. The vanes of the impeller are Francis type.

3.3.3 Shaft

The large diameter stiff shaft, mounted on bearings, has a keyed drive end.

3.3.4 Pump bearings and lubrication

Ball bearings are fitted as standard and may be either oil or grease lubricated. Oil lubrication is only available where the pump shaft is horizontal.

3.3.5 Bearing housing

For oil lubricated bearings, a bulls eye level gauge is supplied. Constant level oilers can also be fitted. Two grease nipples enable grease lubricated bearings to be replenished between major service intervals.

3.3.6 Stuffing box housing

The stuffing box housing has a spigot (rabbet) fit between the pump casing and bearing housing for optimum concentricity. The design enables a number of sealing options to be fitted.

3.3.7 Shaft seal

The mechanical seal(s), attached to the pump shaft, seals the pumped liquid from the environment. Gland packing may be fitted as an option.

3.3.8 Driver

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

3.3.9 Accessories

Accessories may be fitted when specified by the customer.

3.4 Performance and operating limits

This product has been selected to meet the specifications of your purchase order see section 1.5. The following data is included as additional information to help with your installation. It is typical, and factors such as temperature, materials, and seal type may influence this data. If required, a definitive statement for your particular application can be obtained from Flowserve.

3.4.1 Operating limits

Pumped liquid temperature limits	up to+177 ºC (350 ºF)
Minimum ambient temperature	-20 ºC (-4 ºF)
Maximum ambient temperature	+50 ºC (122 ºF)
Maximum soft solids in suspension	up to 7 % by volume
Maximum pump speed	Refer to the nameplate

3.4.2 Speed torque curves

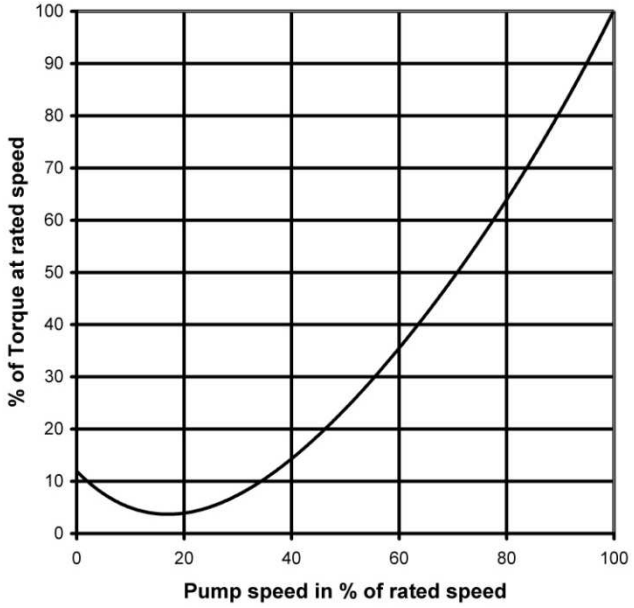
To bring a centrifugal pump up to rated speed, the driver must be capable of providing more torque at each speed than required by the pump. The margin between the available and required torque affects the time it takes the unit to reach full speed. If the torque required by the pump exceeds the torque capability of the drive at any run-up speed, the unit will not accelerate to full speed. Normally, this is not a problem with standard induction or synchronous motors provided the proper voltage is supplied at the motor.

For pumps started at shut valve conditions, 100 percent full speed torque can be calculated by using the formula:

$$\text{Torque (Nm)} = 9545 \frac{\text{Shutoff Power (kW)}}{\text{r/min}}$$

Torque (lbfx ft) = 5250 $\frac{\text{Shutoff Power (hp)}}{\text{r/min}}$

Torque required by the pump at any other speed during start-up can be determined from the curve. Note that the driver manufacturer usually bases 100 percent torque on the design power of the driver and consequently the speed-torque curves should be plotted in torque units (e.g. Nm) instead of percentage torque to avoid confusion.



3.4.3 MAXIMUM WORKING PRESSURES -bar (psi).

Above ambient temperature these maximum pressures shall be derated.

CAUTION Do not conduct a hydro test on the namplete pump set without the specific approval of Flowserve. While the duty requirement will have been covered, auxiliary items, flange drillings and suction pressure limits may impose a reduced static and dynamic pressure rating compared to that of the pump casting rating itself.

Note: all flanges are ANSI 125 (Cast Iron or Ductile Iron-flat faced) or ANSI 150 (Stainless-raised face) unless otherwise stated. All flange facings on the casings are 250 rms – circular finish

CONSTRUCTION	CAST IRON AND C.I.S.S. FITTED		STAINLESS STEEL 316,317L, WORTHITE, ETC.
TEMPERATURE ℃ (℉)	UP TO 12" DISCHARGE	14 TO 16" DISCHARGE	UP TO 16" DISCHARGE
-30 to 38 (-20 to100)	10.3 (150)	10.3 (150)	13.8 (200)
65 (150)	10.3 (150)	9.7 (140)	13.8 (200)
95 (200)	10.3 (150)	9.3 (135)	13.4 (195)
120 (250)	10.3 (150)	9.0 (130)	12.6 (185)
150 (300)	**Consult factory for applications in this range. Cast iron not recommended due to thermal shock risks.**		12.1 (175)
175 (350)			11.0 (160)

3.5 Table Of Engineering Data

3.5.1 (GROUP 4 - LIQUID END)

ENGINEERING DATA		4K8x4-18OP	4K10X8-18OP	4K12X10-18OP	4K10X6-18OP	4K14X12-18OP	4K14X14-18OP	4K16X16-18OP
		PUMP DATA						
SUCTION DIAMETER mm (in.)		200 (8)	250 (10)	300 (12)	250 (10)	350 (14)	350 (14)	400 (16)
DISCHARGE DIAMETER mm (in.)		100	200 (8)	250 (10)	150 (6)	300 (12)	350 (14)	400 (16)
CASINGTHICKNESS	C.I. mm (in.)	16 (0.63)	21 (0.82)	21 (0.82)	18 (0.69)	19 (0.75)	21 (0.82)	21 (0.82)
	S.S.mm (in.)	12 (0.50)	16 (0.63)	18 (0.69)	14(0.56)	16 (0.63)	18 (0.69)	18 (0.69)
CASING TYPE		SV	DV		SV	DV-DUAL VOLUTE		
GAUGE CONNECTION		1 / 2 NPT						
DRAIN CONNECTION		3/4 NPT	1 NPT			1 - 1 / 4 NPT		
NO. OF VANES		4					6	5
IMPELLER EYE AREA m^2 ($in.^2$)		0.020 (31.0)	0.036 (55.6)	0.043 (66.0)	0.029 (45.2)	0.076 (117)	0.083 (130)	0.108 (169)
MAX. SPHERE DIA. mm (in.)		28 (1.1)	56 (2.2)	68 (2.7)	48 (1.9)	97 (3.8)	41 (1.6)	41 (1.6)
WK^2 kg•m^2 (lb•$ft.^2$)		0.57 (13.6)	1.00 (23.9)	1.32 (31.3)	0.83 (19.8)	0.93 (22.0)	1.57 (37.2)	1.39 (33.0)
PUMP WT. kg (lb.)		473 (1040)	555 (1220)	718 (1580)	644 (1420)	816 (1800)	902 (1990)	1021 (2250)
Max. BACK PULLOUT WT kg (lb.)		340 (750)						
IMPELLER AXIAL FRONT CLEARANCE mm (in.)		0.38/0.50 (0.015 /0.020)						
MAXIMUMTEMPERATURE	NO COOLING	120 ℃ (250 ℉)						
	WITH COOLING	176 ℃ (350 ℉)						
		STUFFING BOX DATA – CBS						
O.D. SLEEVE mm (in.)		76.20 (3.000)			95.25 (3.750)			
STUFFING BOX BORE mm (in.)		101.6 (4.000)			127.0 (5.000)			
DEPTH OF BOX mm (in.)		99.0 (3.90)			122.2 (4.81)			
PACKING SIZE (in.)		1 /2 X 1 /2			5 / 8 X 5 / 8			
PACKING ARRANGEMENT	STD.	2L3						
	ALT.	3L2						
DISTANCE TO FIRST OBSTRUCTION (gland) mm (in.)		130 (5.11)			107 (4.21)			

3.6 Table of Engineering Data

3.6.1 (GROUP 4 - FRAME DETAILS)

ENGINEERING DATA		4K8x4-18OP	4K10X8-18OP	4K12X10-18OP	4K10X6-18OP	4K14X12-18OP	4K14X14-18OP	4K16X16-18OP
SHAFT AND BEARING DATA								
Dia. at Impeller	mm (in.)	50.8 (2.000)			69.9 (2.750)			
Dia. Under Sleeve	mm (in.)	66.68 (2.625)			82.55 (3.250)			
Dia. Between Brgs	mm (in.)	114.3 (4.50)						
Dia. at Coupling	mm (in.)	73.03 (2.875)						
Line Bearing		6220						
Thrust Bearing		7318 BUA (PAIRED BACK-TO-BACK)						
BEARING SPAN	mm (in.)	293.4 (11.55)						
Nom. Impeller Overhang	mm (in.)	312.2 (12.29)						
B10 Bearing Life		MINIMUM 3 YEARS						
Oil Sump Capacity*	l (US gal.)	5 (1.3)						

* Standard construction is oil lubrication.

3.7 Materials of Construction

3.7.1 (LIQUID END)

BASIC CONSTRUCTION	ALL IRON AIF	ALL 316 SS (SS)	IRON CASING SS FITTED (SSF)	317L SS	CD4MCUN	WORTHITE W
Casing, Stuff Box Head	ASTM A48 CL35A	ASTM A743 CF8M	ASTM A48 CL35A	ASTM A743 CG3M	ASTM A890 CD4MCUN	ASTM A743 CN7MS
Impeller	ASTM A48 CL30A	ASTM A743 CF8M	ASTM A743 CF8M	ASTM A743 CG3M	ASTM A890 CD4MCUN	ASTM A743 CN7MS
Impeller Nut	ASTM A743 CG3M	ASTM A743 CG3M	ASTM A743 CG3M	ASTM A743 CG3M	ASTM A890 CD4MCUN	ASTM A743 CN7M
Throat Bushing	ASTM A743 CF8M	ASTM A743 CF8M	ASTM A743 CF8M	ASTM A743 CG3M	ASTM A890 CD4MCUN	ASTM A743 CN7M
Shaft Sleeve	ASTM A743 CG3M *	ASTM A743 CG3M *	ASTM A743 CG3M *	ASTM A743 CG3M *	ASTM A890 CD4MCUN	ASTM A743 CN7M
Shaft	AISI 1045	AISI 1045	AISI 1045	AISI 1045	AISI 1045	AISI 316
Gland Halves	ASTM A743 CF8M	ASTM A743 CF8M	ASTM A743 CF8M	ASTM A743 CN7M	ASTM A890 CD4MCUN	ASTM A743 CN7M
Pipe Plugs (Liquid End)	C.I.	AISI 316	C.I.	A-20	A-20	A-20
Gland Studs And Nuts	AISI 316					
Impeller Key	AISI 316					
Packing	Synthetic Fibre					
Seal Cage Halves	ASTM A743 CG8M					ASTM A743 CN7M
Gaskets	Synthetic Fibre					
O-Rings (Liquid End)	BUNA-N (120° C MAX.)**					
Misc. Fastners,Parts	Steel					

* Nickel-Chrome-Boron Coated, except for units with mechanical seals.
** Viton will be used for all applications operating above 120°C.

4 INSTALLATION

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. Allow sufficient room to facilitate the back pull-out feature on V-belt driven units.

Refer to the general arrangement drawing for the pump set.

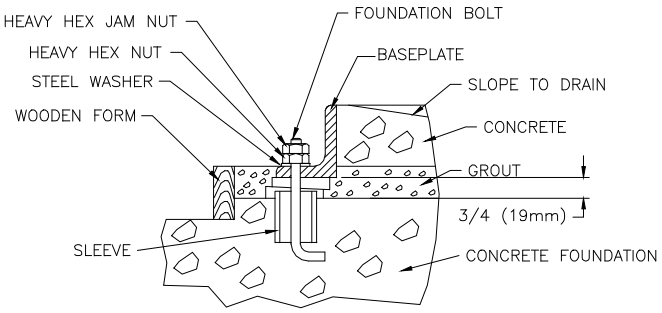
4.2 Part assemblies

Motors may be supplied loose on MARK 3 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.

4.3 Foundation

CAUTION The foundation may consist of any material that will afford permanent, rigid support to the full area of the pump or driver supporting member. It should be of sufficient size and mass to absorb expected strains and shocks that may be encountered in service. Concrete foundations built on solid ground are desirable. Use a concrete grade with a strength of approximately 20MPa (2900 PSI).

The purpose of foundation bolts is to anchor the pump unit securely to the foundation such that the foundation and pump assembly become a single structural unit. High strength steel foundation bolts (SAE Gr. 5 or equal) of the specified diameter should be located according to the elevation drawing provided. Each bolt should be surrounded by a pipe sleeve which is two or three times the diameter of the bolt. The sleeves should be securely anchored and designed to allow the bolts to be moved to conform with the holes in the baseplate. The bolts should be sufficiently long to allow for wedges or shims or levelling nuts under the baseplate, and a washer, heavy hex nut and hex jam nut for retention. Since baseplate levelling is performed after the foundation has cured, it is best to use extra long bolts that can be shortened after the installation is complete.



4.4 Baseplate installation

Position the baseplate and pump next to the foundation and clean the foundation surface thoroughly. Remove the rag packing from the pipe sleeves and place wedges or ships as close to the foundation bolts as possible. These may be omitted if a jacking nut on the foundation anchor bolts is preferred for levelling.

Remove the flange covers and check inside the pump nozzles for cleanliness. Kerosene is recommended as the best solvent for removing factory applied rust preventative. Ensure that all traces of rust preventative are removed from the discharge and suction flange faces, the exposed shafting and all coupling surfaces. Flush the pump internals of any rust preventative applied for long-term storage.

Lift the baseplate assembly, remove the shipping skids and clean the underside of the baseplate. Position the baseplate over the foundation and lower the unit over the foundation bolts and onto the wedges, shims or jacking nuts.

a) Level the pump baseplate assembly. If the baseplate has machined coplanar mounting surfaces, these machined surfaces are to be referenced when leveling the baseplate. This may require that the pump and motor be removed from the baseplate in order to reference the machined faces. If the baseplate is without machined coplanar mounting surfaces, the pump and motor are to be left on the baseplate. The proper surfaces to reference when leveling the pump baseplate assembly are the pump suction and discharge flanges. DO NOT stress the baseplate.

b) Do not bolt the suction or discharge flanges of the pump to the piping until the baseplate foundation is completely installed. If equipped, use leveling jackscrews to level the baseplate. If

jackscrews are not provided, shims and wedges should be used. (See Figure 4-5.) Check for levelness in both the longitudinal and lateral directions. Shims should be placed at all base anchor bolt locations. Do not rely on the bottom of the baseplate to be flat. Standard baseplate bottoms are not machined and it is not likely that the field mounting surface is flat.

c) After leveling the baseplate, tighten the anchor bolts. If shims were used, make sure that the baseplate was shimmed near each anchor bolt before tightening. Failure to do this may result in a twist of the baseplate, which could make it impossible to obtain final alignment.

d) Check the level of the baseplate to make sure that tightening the anchor bolts did not disturb the level of the baseplate. If the anchor bolts did change the level, adjust the jackscrews or shims as needed to level the baseplate.

e) Continue adjusting the jackscrews or shims and tightening the anchor bolts until the baseplate is level.

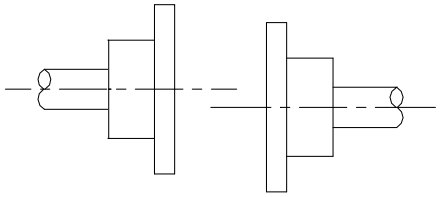
f) Check initial alignment. If the pump and motor were removed from the baseplate proceed with step g) first, then the pump and motor should be reinstalled onto the baseplate using Flowserve's factory preliminary alignment procedure as described in section 4.5, and then continue with the following. As described above, pumps are given a preliminary alignment at the factory. This preliminary alignment is done in a way that ensures that, if the installer duplicates the factory conditions, there will be sufficient clearance between the motor hold down bolts and motor foot holes to move the motor into final alignment. If the pump and motor were properly reinstalled to the baseplate or if they were not removed from the baseplate and there has been no transit damage, and also if the above steps where done properly, the pump and driver should be within 0.38 mm (0.015 in.) FIM (Full Indicator Movement) parallel, and 2.5 mm/m (0.0025 in./in.) FIM angular. If this is not the case, first check to see if the driver mounting fasteners are centered in the driver feet holes. If not, re-center the fasteners and perform a preliminary alignment to the above tolerances by shimming under the motor for vertical alignment, and by moving the pump for horizontal alignment.

g) Grout the baseplate. A non-shrinking grout should be used. Make sure that the grout fills the area under the baseplate. After the grout has cured, check for voids and repair them. Jackscrews, shims and wedges should be removed from under the baseplate at this time. If they were to be left in place, they could rust, swell, and cause distortion in the baseplate.

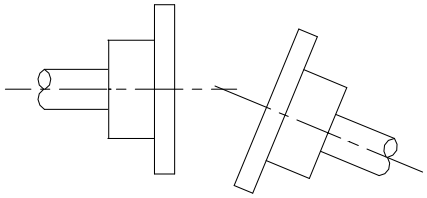
h) Run piping to the suction and discharge of the pump. There should be no piping loads transmitted to the pump after connection is made. Recheck the alignment to verify that there are no significant loads.

Check the impeller axial clearance and that the rotor turns freely by hand.

Note: Grout is not poured until an initial alignment of the pump and driver has been performed. See section 4.5



PARALLEL MISALIGNMENT– Shafts with axis parallel but not concentric



ANGULAR MISSALIGNMENT – Shafts with axis concentric but not parallel.

4.5 Initial alignment

The purpose of factory alignment is to ensure that the user will have sufficient clearance in the motor holes for final job-site alignment. To achieve this, the factory has designed the mounting holes with additional clearance to allow the pump to be aligned in the horizontal plane to the motor, There should be at least 1/16 clearance around the bolt. The coupling has been designed to have some overhang of the coupling hub (in most cases 1 or both hubs may be overhung between 0.0 and 3 mm (0 and 0.12 in) unless otherwise stated. This procedure ensures that there is sufficient clearance in the motor holes for the customer to field align the motor to the pump, to zero tolerance. This philosophy requires that the customer be able to place the base in the same condition as the factory. Thus the factory alignment will be done with the base sitting in an unrestrained condition on a flat and level surface. This standard also emphasizes the need to ensure the shaft spacing is adequate to accept the specified coupling spacer.

The factory alignment procedure is summarized below:

a) The baseplate is placed on a flat and level workbench in a free and unstressed position.
b) The baseplate is leveled as necessary. Leveling is accomplished by placing shims under the rails of the base at the appropriate anchor bolt hole locations. Levelness is checked in both the longitudinal and lateral directions.
c) The pump is put onto the baseplate, aligned and leveled. The rear foot piece under the bearing housing is adjustment as necessary by adding or removing shims [3126.1] between the foot piece and the bearing housing or at the baseplate.
d) The motor and appropriate motor mounting hardware is placed on the baseplate and the motor is checked for any planar soft-foot condition. If any is present it is eliminated by shimming.
e) The motor is fastened in place by tightening two diagonal motor mounting bolts.
f) The spacer coupling gap is verified. As indicated the gap may be adjusted to ensure adequate axial bolt clearance.
g) The parallel and angular vertical alignment is made by shimming under the motor.
h) The pump and motor shafts are then aligned horizontally, both parallel and angular, by moving the pump to the fixed motor. The pump feet are tightened down.
i) Both horizontal and vertical alignment is again final checked as is the coupling spacer gap.

See section 4.8, *Final shaft alignment*.

4.5.1 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.

4.5.2 Alignment methods

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.

4.5.2.1 Direct Driven Units

The importance of accurate alignment of pump and driver shafts cannot be overemphasized. IMPROPER ALIGNMENT IS THE PRIMARY CAUSE OF VIBRATION PROBLEMS AND REDUCED BEARING LIFE.

A flexible coupling is used to compensate for slight changes in alignment that occur during normal operation and is not used to correct for installation errors. Install the pump and driver half couplings in accordance with the coupling manufacturer's instructions. Note that the coupling hub faces are not always mounted flush with the ends of the shafts. Place the driver on the baseplate such that the correct spacing is obtained between the two half couplings. In the case of electric motors, such as those with sleeve bearings, it may be necessary to run the motor to establish the rotor magnetic center. Consult the manufacturer's instruction manual for details.

The purpose of the alignment procedure is to ensure that the pump and driver shafts are in parallel and angular alignment under the normal operating conditions of load and temperature.

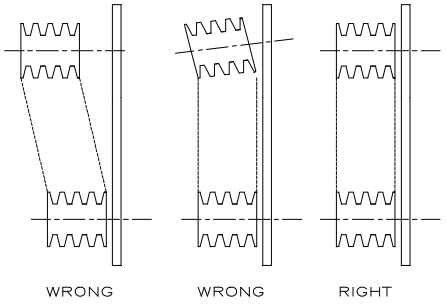
When the pump coupling and driver are assembled at the factory, the units are aligned prior to shipment. However, baseplates can be sprung or distorted during shipment or installation and the alignment must be checked before the unit is put in service. The coupling spacer must be removed to make this check.

For pumps and drivers that operate at different temperatures compensation must be made at the initial alignment stage (when the units are at the same temperature) to allow for thermal expansion during operation. Consult the instruction manual supplied with the driver for the manufacturer's recommendations.

Shaft alignment is greatly simplified by the use of a dial indicator, or with extension rods and a magnetic base. Before taking readings, ensure that the pump and driver mounting bolts are secure, and that the thrust bearing housing is properly aligned in the bearing frame or cartridge

4.5.2.2 V-Belt Drive Units:

Check that both sheaves are free of grease, rust, nicks or burrs. Install the correct size sheave on the pump shaft and locate the sheave axially to minimize overhang. Re-check the impeller axial clearance and ensure that the pump is properly secured to the baseplate. Install the driver on the adjustable base provided and install the driver sheave in line with the pump sheave. Ensure that the sheaves are tight on the shafts. With a dial indicator, check the runout on the periphery and face of each sheave to ensure that each is running true. Tighten the adjustable base and check that the driver rotation in the correct direction and that vibration levels are not unacceptable.



Checking V-Belt Sheave Alignment

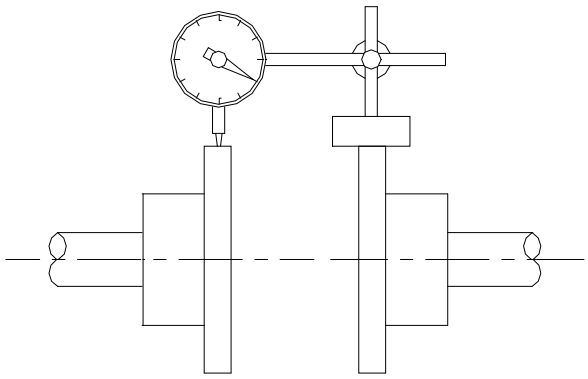
CAUTION Before starting the driver, refer to the manufacturer's instruction manual. The correct rotation of the pump shaft is marked on the pump casing or frame.

Check that all belts making up one drive set have matched code numbers. Loosen the adjustable base and install the belts in their proper grooves. Adjust the center distance between the sheaves to obtain proper belt tension. Check the alignment of the pump and driver sheaves with a taught string or straight edge. For proper alignment and the sheave faces must be parallel to each other and in line. Adjustments are made by slackening the belts, moving and retightening the drive or driver sheave, and repeating the above procedure.

When the sheaves are aligned that the shafts rotate freely by hand and install safety guard.

CAUTION Belt drives must not be used in ATEX Potentially explosive environments; refer to Flowserve.

4.5.3 Parallel Alignment:



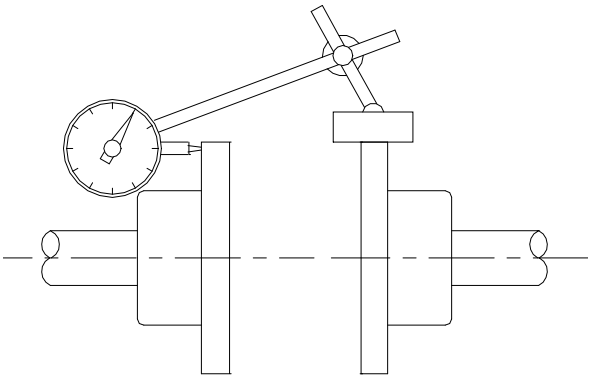
CHECKING PARALLEL MISALIGNMENT

Mount the magnetic base on the pump half coupling hub, either the face or O.D. as shown in the sketch. Place the dial indicator button on the outside diameter of the driver half coupling hub.

Note: The length of extension rods should be kept at a minimum to reduce deflection.

Rotate the pump shaft and record the dial reading at the top, bottom and each side. Correct the parallel alignment by adding or removing shims under the driver and/or moving the driver horizontally. Repeat this procedure until the maximum total indicator reading (T.I.R.) is within 0.08 mm (0.003 inch.)

4.5.4 Angular Alignment:



CHECKING ANGULAR MISALIGNMENT

Mount the magnetic base mounted on the pump half coupling hub, either face or O.D. as shown. Move the dial indicator button to indicate on the face of the driver half coupling hub as close to the outside diameter as possible. When convenient the indicator can be placed on the inside face to keep spans short. Turn both shafts 360° and record the dial readings at 90° intervals. Adjust the shims under the motor as

required and repeat the procedure until the angular alignment is within 0.0005 mm (T.I.R.) per mm (0.0005 in. per in.) of maximum hub diameter.

Repeat the checks on parallel and angular alignment, ensuring the mounting bolts are secure, until the unit is properly aligned. Note that correction in one direction may affect the alignment in another direction. Re-check the gap between the coupling hubs.

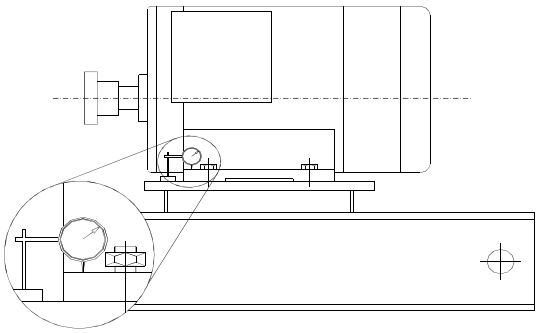
If any difficulty is encountered in achieving the recommended alignment tolerances, the run-out of the pump and driver shafts and each coupling hub diameter and face should be checked. Occasionally, due to practical and unavoidable manufacturing tolerance build-up associate with the pump, coupling and driver, it may be necessary to match up the two coupling hubs in the most advantageous relative angular position in order to achieve an acceptable alignment.

Do not install the coupling spacer or sleeve until grouting is complete and cured and the alignment is re-checked.

When the electric motor has sleeve bearings it is necessary to ensure that the motor is aligned to run on its magnetic centreline. 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 centre the resultant additional axial force may overload the pump thrust bearing.

4.5.5 Check for soft foot



This is a check to ensure that there is no undue stress on the driver holding down bolts; due to non-level baseplate or twisting. To check, remove all shims and clean surfaces and tighten down driver to the baseplate. Set a dial indicator as shown in sketch and loosen off the holding down bolt while noting any deflection reading on the dial test Indicator - a maximum of 0.05 mm (0.002 in.) is considered acceptable but any more will have to be corrected by adding shims. For example, if the dial test indicator shows the foot lifting 0.15 mm (0.006 in.) then this is the thickness of shim to be placed under that foot. Tighten down and repeat the same procedure on all other feet until all are within tolerance.

⚠ Complete piping as below and see sections 4.8, *Final shaft alignment check* up to and including section 5, *Commissioning, start-up, operation and shutdown* before connecting driver and checking actual rotation.

4.6 Grouting

The purpose of grouting is to provide rigid support to the pump and driver by increasing the structural rigidity of the baseplate and making it an integral mass with the foundation. Grouting should only be completed after baseplate has been levelled (4.4) and initial pump alignment (4.5).

Clean the roughed foundation surface and build a wooden form around the baseplate. For initial grouting forms should be placed to isolate shims and levelling nuts. The foundation surface should be thoroughly saturated with water before grouting. A typical mixture for grouting-in a pump base is composed of one part pure Portland cement and two parts of clean building sand with sufficient water to provide the proper consistency. The grout should flow freely but not be so wet as to cause the sand and cement to separate.

Thoroughly puddle the grout while pouring to eliminate air pockets and low spots. Pour sufficient grouting to ensure that the bottom surface of the baseplate is completely submerged. Do not fill isolated areas around the shims or levelling nuts. Once the grout has set sufficiently, remove the wooden forms and finish off the sides and top as desired. At the same time, roughen the grout surface inside the baseplate. Cover with wet burlap and allow the grout to cure for at least 40 hours.

After grouting has cured, shims and levelling nuts should be removed or backed off. Tighten down baseplate to the new grout to put bolts in tension and ensure rigidity of structure. Install jam nuts and cut the bolts to the desired length. Finish grouting isolated areas. Fill the baseplate including pump and driver support pedestals with concrete. Trowel and slope the surface to give suitable drainage.

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.

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 that 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

The table in 4.7.2 summarizes the maximum forces and moments allowed on MARK 3 Group 4 pump casings. Refer to Flowserve for other configurations.

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 Maximum forces and moments allowed on MARK 3, Group 4 pump flanges

Introduction: Flowserve Mark 3, Group 4 pumps are larger than those contained in ANSI/HI 9.6.2 and have been designed around the FRBH process pump. API 610 has been used as a reference for these pumps to establish the allowable forces and moments. Typically values are 2X API. The values shown in the table 4.7.2.2 are based on pumps mounted on grouted baseplates. These values should be factored based on material of construction and temperature. The table 4.7.2.1 has been adopted from Mark 3 manual (PCN 71569102) that uses data from ANSI/HI 9.6.2.6.

Table 4.7.2.1: Casing Material Correction Factors

		Material Group No.					
		1.0	2.2	2.8	3.8	3.17	Ti
Temp. ℃	Temp ℉	CI/DI	316/317L	CD4MCU	Hast. C	Wort h/A20	Titanium
-29	-20	0.89	1.00	1.00	1.00	0.83	0.89
38	100	0.89	1.00	1.00	1.00	0.83	0.89
93	200	0.78	0.86	1.00	1.00	0.72	0.86
150	300	0.73	0.78	0.92	1.00	0.65	0.81

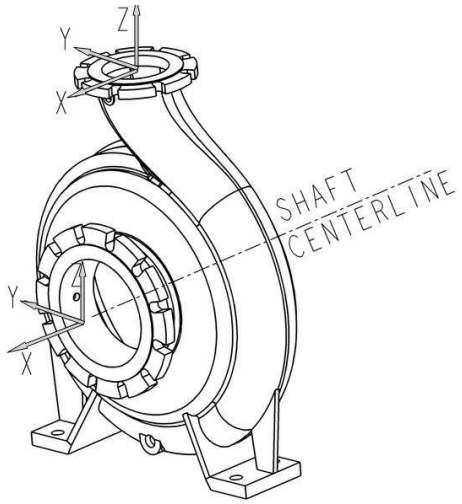


Table 4.7.2.2

Pump Size	Maximum forces (F) in N (lbf) and moments (M) in Nm (lbf•ft)											
	Suction						Discharge					
	Mx	My	Mz	Fx	Fy	Fz	Mx	My	Mz	Fx	Fy	Fz
4K8x4x18	3530 (2600)	1760 (1300)	2580 (1900)	4890 (1100)	3780 (850)	3100 (700)	1330 (980)	680 (500)	1000 (740)	1420 (320)	1160 (260)	1780 (400)
4K10x6x18	10040 (7400)	4880 (3600)	7200 (5600)	13340 (3000)	10680 (2400)	8900 (2000)	4600 (3400)	2360 (1740)	3560 (2600)	4980 (1120)	4100 (920)	6220 (1400)
4K10x8x18	10040 (7400)	4880 (3600)	7200 (5600)	13340 (3000)	10680 (2400)	8900 (2000)	7060 (5200)	3520 (2600)	5160 (3800)	7560 (1700)	6220 (1400)	9780 (2200)
4K12x10x18	12200 (9000)	5960 (4400)	9220 (6800)	16000 (3600)	13340 (3000)	10680 (2400)	10040 (7400)	4880 (3600)	7600 (5600)	10680 (2400)	8900 (2000)	13340 (3000)
4K14x12x18	12740 (9400)	6240 (4600)	9500 (7000)	16900 (4000)	14240 (3200)	11560 (2600)	12200 (9000)	5960 (4400)	9220 (7200)	13340 (3000)	10680 (2400)	16000 (3600)
4K14x14x18	12740 (9400)	6240 (4600)	9500 (7000)	16900 (4000)	14240 (3200)	11560 (2600)	12740 (9400)	6240 (4600)	9500 (7000)	14240 (3200)	11560 (2600)	17800 (4000)
4K16x16x18	14640 (10800)	7320 (5400)	10840 (8000)	20460 (4600)	16900 (3800)	13340 (1500)	14640 (10800)	7320 (5400)	10840 (8000)	16900 (3800)	13340 (3000)	20460 (4600)

Notes:
1) F = External force (tension or compression) M = External moment, clockwise or counter-clockwise
2) Forces and moments may be applied simultaneously in any direction
3) Correct values by material factor
4) Higher loads may be applicable, if direction and magnitude of individual loads are known, but these need written approval from Flowserve
5) Pumps must be on rigid foundations and baseplates must be fully grouted
6) Pump/baseplate should not used as pipe anchor. Expansion joints must be properly tied
7) The pump mounting bolt torques specified must be used to prevent relative movement between the pump casing and baseplate. (See section 6.6, *Fastener torques.*) The bolt material must have a minimum yield strength of 600 N/mm^2 (87 000 lb/in.^{2})

4.7.3 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 that should have a minimum of four diameters of straight pipe on the pump suction between the elbow and inlet flange. See section 10.3, *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.

4.7.4 Discharge piping

A non-return valve should be located in the discharge pipework to protect the pump from excessive back pressure 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.

4.7.5 Auxiliary piping

4.7.5.1 Drains

Pipe pump casing drains and gland leakage to a convenient disposal point.

4.7.5.2 Pumps fitted with gland packing

It is required that a clean water flush be provided to the packing to provide lubrication and to prevent the ingress of air. When the product is clean and free of solids this can be achieved with a supply from the pump discharge volute to the stuffing box (Plan 11). A control valve or orifice may be fitted in the line to enable the pressure to the gland to be controlled.

If the pumped liquid is dirty and cannot be used for sealing, a separate clean compatible liquid supply to the gland at a pressure equal to the estimated stuffing box pressure, Ps (psig).

$$Ps = \frac{0.6 \times TDH \times S.G.}{2.31} + \text{Suction Pressure}$$

TDH = total developed head at shut valve (feet)
S.G. = Specific Gravity of pump liquid
Suction Pressure = maximum suction pressure corrected for specific gravity (psig).

4.7.5.3 Pumps fitted with 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.

4.7.6 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.

The baseplate should be levelled and grouted by this stage.

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

a) Mount and level pump if appropriate. Level the pump by putting a level on the discharge flange. It may be necessary to adjust the bearing frame foot by adding or deleting shims [3126.1] between the foot piece and the bearing housing (or baseplate).

b) Check initial alignment. If pump and driver have been remounted or the specifications given below are not met, perform an initial alignment as described in section 4.5. This ensures there will be sufficient clearance between the motor hold down bolts and motor foot holes to move the motor into final alignment. The pump and driver should be within 0.38 mm (0.015 in.) FIM (full indicator movement) parallel, and 2.5 mm/m (0.0025 in./in.) FIM angular.

c) Run piping to the suction and discharge to the pump. There should be no piping loads transmitted to the pump after connection is made. Recheck the alignment to verify that there are no significant changes.

d) Perform final alignment. Check for soft-foot under the driver. An indicator placed on the coupling, reading in the vertical direction, should not indicate more than 0.05 mm (0.002 in.) movement when any driver fastener is loosened. Align the driver first in the vertical direction by shimming underneath its feet.

e) When satisfactory alignment is obtained the number of shims in the pack should be minimized. It is recommended that no more than five shims be used under any foot. Final horizontal alignment is made by moving the driver. Maximum pump reliability is obtained by having near perfect alignment. Flowserve recommends no more than 0.05 mm (0.002 in.) parallel, and 0.5 mm/m (0.0005 in./in.) angular misalignment. (See section 6.9.6)

f) Operate the pump for at least an hour or until it reaches final operating temperature. Shut the pump down and recheck alignment while the pump is hot. Piping thermal expansion may change the alignment. Realign pump as necessary.

4.9 Electrical connections

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

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

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

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

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

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 is 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

CAUTION ***These operations must be carried out by fully qualified personnel.***

5.1 Pre-commissioning procedure

5.1.1 Lubrication Methods

Determine the mode of lubrication of the pump set, eg grease, oil, product lubrication etc.

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

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 Oil Bath Lubrication

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 proper height.

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.

Approximate oil volumes are shown in section 5.2.3, *Pump and impeller data*.

5.1.3 Grease Lubrication

Grease lubricated pumps and electric motors are supplied pre-greased.

5.1.4 Oil Mist Lubrication

Mk3 Group 4 pumps may be lubricated by pure or purge oil mist. See comments below.

5.1.4.1 Purge Mist

In the case of purge mist an oil level is maintained in the bearing frame. No changes are required to be made to the pump, however, the oil level must be maintained at site glass center. Excess oil must be removed. Oil is injected outboard of each bearing.

5.1.4.2 Pure Oil Mist

In this method all oil is drained from the oil sump, this is sometimes referred to as a dry sump. Oil is injected outboard at each bearing. To use this method some modifications must be made to the pump. If pumps are shipped for standard oil or grease lubrication the pumps must be dismantled and reworked. All oil return grooves that permit movement of oil from outboard of each bearing back to the sump shall be blocked. These passages may be blocked using epoxy filler or other compounds compatible with the mist oil. Pressure inside the center of the bearing frame must be controlled, recommended pressure to be 25mm - 50mm (1”-2”) H_2O. Excessive will cause fogging and venting of oil through the bearing seals. High inboard pressures could result in poor mist distribution and could result in bearing failure as mist is not forced through the bearing. It is recommended that mist system operate for 24 hrs before starting of the pump to ensure bearing surfaces have been properly misted. Testing completed has used an oil viscosity of 100 cSt. For additional information refer to TR-3326, Pure Oil Mist lubrication of FRBH and R/M Slurry Pumps. Contact Flowserve engineering for copy or additional information such as reclassifier sizing.

5.2 Pump lubricants

5.2.1 Recommended oil lubricants

Centrifugal pump lubrication	Oil	Splash / force feed / purge oil mist lubrication			Pure oil mist
	Viscosity cSt @ 40 ºC	32	46	68	100
	Oil temperature range * ºC (ºF)	-5 to 65 (-23 to 149)	-5 to 78 (-23 to 172)	-5 and above (-23 and above)	-30 and above (59 and above)
	Designation to ISO 3448 and DIN51502	ISO VG 32 32 HL/HLP	ISO VG 46 46 HL/HLP	ISO VG 68 68 HL/HLP	ISO VG 100 –
Oil companies and lubricants	**BP**	BP Energol HL32 BP Energol HLP32	BP Energol HL46 BP Energol HLP46	BP Energol HL68 BP Energol HLP68	–
	Castrol	Perfecto T32	Perfecto T46	Perfecto T68	–
	DEA	Anstron HL32 Anstron HLP32	Anstron HL46 Anstron HLP46	Anstron HL68 Anstron HLP68	–
	Elf	OLNA 32 HYDRELEF 32 TURBELF 32 ELFOLNA DS32	TURBELF SA46 ELFOLNA DS46	TURBELF SA68 ELFOLNA DS68	–
	Esso	TERESSO 32 NUTO H32	TERESSO 46 NUTO H46	TERESSO 68 NUTO H68	–
	LSC (for oil mist)	LSO 32 Synthetic oil	LSO 46 Synthetic oil	LSO 68 Synthetic oil	LSO 100 Synthetic oil
	Mobil	Mobil DTE oil light Mobil DTE13M MobilDTE24	Mobil DTE oil medium Mobil DTE15M Mobil DTE25	Mobil DTE oil heavy medium Mobil DTE26	–
	Q8	Q8 Verdi 32 Q8 Haydn 32	Q8 Verdi 46 Q8 Haydn 46	Q8 Verdi 68 Q8 Haydn 68	–
	Shell	Shell Tellus 32 Shell Tellus 37 Shell Turbo T32	Shell Tellus 01 C 46 Shell Tellus 01 46 Shell Turbo T46	Shell Tellus 01 C68 Shell Tellus 01 68 Shell Turbo T68	–
	Texaco	Rando Oil HD 32 Rando Oil HD-AZ-32	Rando Oil 46 Rando Oil HD B-46	Rando Oil 68 Rando Oil HD C-68	–
	Total	Azolla ZS32	Azolla ZS46	Azolla ZS68	–
	Wintershall (BASF Group)	Wiolan HN32 Wiolan HS32	Wiolan HN46 Wiolan HS46	Wiolan HN68 Wiolan HS68	–

* Note that it normally takes 2 hours for bearing temperature to stabilize and the final temperature will depend on the ambient, r/min, pumpage temperature and pump size. Also some oils have a greater Viscosity Index than the minimum acceptable of 95 (eg Mobil DTE13M) which may extend the minimum temperature capability of the oil. Always check the grade capability where the ambient is less than -5 ºC (-23 ºF).

Most oils recommended for wet sump bearing housings contain foam inhibitors as well as antioxidants and anticorrosion additives normally unsuitable for oil misting. Compounded oils CANNOT be used for oil mist and anti-foam additives are to be avoided. The above LSC grades are recommended by Flowserve where Oil mist.

5.2.2 Recommended fill quantities

OIL SUMP CAPACITY	U.S. GAL.	1.3
	LITRES	5

Note: Where the pump is lubricated by oil mist the amount of oil mist supplied (m^3/h) is normally calculated to be at least the bearing bore diameter (mm) x the number of bearing rows / 25. The oil mist should consist of at least 0.025 - 0.04 % oil content. Where oil mist is utilized to lubricate bearings the pressure in the bearing housing must not exceed 0.01 barg (0.15 psi).

5.2.3 CAUTION Lubrication schedule

5.2.3.1 Oil lubricated bearings

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 50 ºC (90 ºF).above ambient, but should not exceed 82 ºC (180 ºF). A continuously rising temperature, or an abrupt rise, indicate a fault.

5.3 Direction of rotation

CAUTION Ensure the pump is given the same rotation as the pump direction arrow cast on the pump casing. Rotation is clockwise when the pump is viewed from the driver.

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.

5.4 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.

5.5 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.

5.5.1 Suction pressure above atmospheric pressure

Open vent connection (6521] on top of the pump upper casing to allow the trapped air to escape. Let liquid run out until free from air bubbles.

5.5.2 Suction lift with foot valve fitted

Fill suction pipe and casing with liquid at a pressure of 1 to 2 bar from an external source. Vent as described in section 5.5.1.

5.5.3 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.

5.6 Starting the pump

a) CAUTION Ensure flushing and/or cooling/ heating liquid supplies are turned ON before starting the pump.
b) CLOSE the outlet valve.
c) OPEN all inlet valves.
d) Prime the pump.
e) Ensure all vent connections are closed before starting.
f) Start motor and check outlet pressure.
g) If the pressure is satisfactory, SLOWLY open outlet control valve.
h) CAUTION Do not run the pump with the outlet valve closed for a period longer than 10 seconds.
i) If NO pressure, or LOW pressure, STOP the pump. Refer to section 7, *Faults; causes and remedies*, for fault diagnosis.

5.7 Running the pump

5.7.1 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.

5.7.2 Pumps fitted with packed gland

If the pump has a packed gland there must be some leakage from the gland. Gland nuts should initially be finger-tight only. Leakage should take place soon after the stuffing box is pressurised.

Ex The gland must be adjusted evenly to give visible leakage and concentric alignment of the gland ring [4120) to avoid excess temperature. If no

leakage takes place the packing will begin to overheat. If overheating takes place the pump should be stopped and allowed to cool before being re-started. Loosen the gland when the pump is re-started; check to ensure leakage is taking place at the packed gland.

If hot liquids are being pumped it may be necessary to slacken the gland nuts to achieve leakage.

The pump should be run for 30 minutes with steady leakage and the gland nuts tightened by 10 degrees at a time until leakage is reduced to an acceptable level, normally a minimum of 120 drops per minute is required. Bedding in of the packing may take another 30 minutes.

Care must be taken when adjusting the gland on an operating pump. Safety gloves are essential. Loose clothing must not be worn to avoid being caught up by the pump shaft. Shaft guards must be replaced after the gland adjustment is complete.

CAUTION Never run gland packing dry, even for a short time.

5.7.3 Pumps fitted with mechanical seal

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

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.

5.7.4 Bearings

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 (t) and the ambient temperature (ta). Estimate the likely maximum ambient temperature (tb). Set the alarm at (t+tb-ta+5)°C [(t+tb-ta+10)°F] and the trip at 100 °C (212 °F) for oil lubrication and 105 °C (220 °F) for grease lubrication.

It is important, particularly with grease lubrication, to keep a check 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. Refer to section 6.2.3.1 for further information.

5.7.5 Normal vibration levels, alarm and trip

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 trip 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.

Vibration velocity – unfiltered **mm/s (in./s) r.m.s.**		**MARK 3**
Normal	**N**	≤ 5.6 (0.22)
Alarm	**N** x 1.25	≤ 7.1 (0.28)
Shutdown trip	**N** x 2.0	≤ 11.2 (0.44)

5.7.6 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

Where duty and standby pumps are installed it is recommended that they are run alternately every week.

5.8 Stopping and shutdown

a) CAUTION Close the outlet valve, but ensure that the pump runs in this condition for no more than a few seconds.
b) Stop the pump.
c) Switch off flushing and/or cooling/heating liquid supplies at a time appropriate to the process.
d) CAUTION For prolonged shut-downs 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.

5.9 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.

5.9.1 Specific gravity (SG)

Pump capacity and total head in metres (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.

5.9.2 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, 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 vapour pressure, at the pump suction branch.

NPSH required ($NPSH_R$) is a measure of the head required in the pumped liquid, above its vapour pressure, to prevent the pump from cavitating. It is important that NPSHA > $NPSH_R$. 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 safe 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 5.8.

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

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

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

Do not spray air or compressed inert gas on skin.

Do not direct an air or gas jet towards other people.

Never use air or compressed inert gas to clean clothes.

Before working on the pump, take measures to prevent 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

⟨Ex⟩ 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) Gland packings must be adjusted correctly to give visible leakage and concentric alignment of the gland follower to prevent excessive temperature of the packing or follower.
c) Check for any leaks from gaskets and seals. The correct functioning of the shaft seal must be checked regularly.
d) Check bearing lubricant level, and if the hours run show a lubricant change is required.
e) Check that the duty condition is in the safe operating range for the pump.
f) Check vibration, noise level and surface temperature at the bearings to confirm satisfactory operation.
g) Check dirt and dust is removed from areas around close clearances, bearing housings and motors.
h) 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)

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

a) Check operating behaviour. 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 that shaft seal leaks are within acceptable limits.
d) Check the level and condition of oil lubricant. On grease lubricated pumps, check running hours since last recharge of grease or complete grease change.
e) Check any auxiliary supplies eg heating/cooling (if fitted) are functioning correctly.

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

6.2.2 Periodic inspection (six monthly)

a) ⚠ CAUTION Check foundation bolts for security of attachment and corrosion.
b) Check pump running records for hourly usage to determine if bearing lubricant requires changing.
c) The coupling should be checked for correct alignment and worn driving elements.

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

6.2.3 Re-lubrication

Lubricant and bearing temperature analysis can be useful in optimizing lubricant change intervals. In general however, the following is recommended.

6.2.3.1 Oil lubrication

⚠ 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 centre of the glass window.

Refer to section 5.1.1 for methods of oil fill, section 5.2.1 for oil grade recommendations and 5.2.3 for the schedule and temperature limits.

6.2.4 Mechanical seals

No adjustment is possible. When leakage reaches an unacceptable level the seal will need replacement.

6.2.5 Gland packing

The stuffing box split gland can be completely removed for re-packing or to enable the addition of extra rings of packing.

The stuffing box is normally supplied with a lantern ring to enable a clean or pressurised flush to the centre of the packing. If not required, this can be replaced by an extra 2 rings of packing.
There must always be a small leakage; normally a minimum of 120 drops per minute to atmosphere to lubricate and cool the packing is required.

Gland packing must not be used when pumping hazardous liquids.

6.3 Spare parts

6.3.1 Ordering of spares

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

1) Pump serial number
2) Pump size
3) Part name – taken from section 8
4) Part number – taken from section 8
5) Number of parts required

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

To ensure continued satisfactory operation, replacement parts to the original design specification should be obtained from Flowserve.
Any change to the original design specification (modification or use of a non-standard part) will invalidate the pump's safety certification.

6.3.2 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:

1 - complete set of gland packing
2 - shaft sleeves
1 - set of gaskets and seals
(optional: 2 - mechanical seals)

For 2 years operation:

1 - set of bearings (line and thrust)
2 - sets of gland packing
2 - shaft sleeves
2 - sets of gaskets and seals
2 - lantern rings
2 - casing wear rings
(optional: 2 - mechanical seals
2 - impeller wear rings)

For 4 years operation:

1 - set of bearings (line and thrust)
2 - sets of gland packing
2 - shaft sleeves
2 - sets of gaskets and seals
2 - lantern rings
2 - casing wear rings
1 – impeller (optional: 2 - mechanical seals)

6.5 Tools required

A typical range of tools that will be required to maintain these pumps is listed below.

Readily available in standard tool kits, and dependent on pump size:

Note: *All pumps are built with inch fasteners:*

- Open ended spanners (wrenches) to suit up to 1-7/8" screws/nuts
- Socket spanners (wrenches), up to 1-7/8" screws
- Allen keys, up to 3/8" (A/F)
- Range of screwdrivers
- Soft mallet

More specialized equipment:

- Bearing pullers
- Bearing induction heater
- Dial test indicator
- C-spanner (wrench) - for removing shaft nut. (If difficulties in sourcing are encountered, consult Flowserve.)

6.6 Fastener torques

CAUTION Non-metallic gaskets incur creep relaxation – retighten to the tightening torques provided.

All torques specified subject to a tolerance of +/- 10%

Bolt size	Torque Nm (lb•ft)	
	Pump feet fasteners	All other fasteners
M 16 (⅝ in.)	170 (125)	84 (62)
M 20 (¾ in.)	340 (250)	165 (120)
M 24 (⅞ in.)	590 (435)	285 (210)
M 27 (1 in.)	770 (570)	375 (275)
M 30 (1⅛ in.)	1 100 (810)	540 (400)
M 36 (1⅜ in.)	1 840 (1 350)	900 (660)
M 42 (1⅝ in.)	2 000 (1 475)	1 410 (1 040)
M 48 (1⅞ in.)	2 240 (1 650)	2 060 (1 500)

IMPELLER NUT TIGHTENING TORQUE		
FRAME 4K	Nm	lbf.ft.
	400	300

TIGHTENING TORQUE FOR STAINLESS STEEL STUDS WITH LUBRICATED THREADS		
THREAD SIZE	TIGHTENING TORQUE	
	Nm	ft. lb.
M10x1.5 (3/8–16UNC)	13	10
M12x1.75 (1/2–13UNC)	27	20
M16X2 (5/8-11UNC)	60	45
M20x2.5 (¾-10UNC)	100	75

6.7 Renewal clearances

As wear takes place between the impeller and casing the overall efficiency of the pump set will decrease. To maintain optimum efficiency it is recommended that the impeller be adjusted to maintain the impeller axial clearance as detailed in section 6.11 to clearance as detailed in table 3.5. Typically doubling the clearance can reduce performance by 5% depending on pump size and operating condition.

6.8 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.

To disassemble the pump consult the sectional drawings, see section 8, *Parts list and drawings*.

6.8.1 Rotor unit

The following procedure is recommended for removing and disassembling the back pull-out element (rotating assembly).

Note: Note that the replacement gaskets and similar consumable materials should be available since they will be required for reassembly.

a) Isolate motor and lock off electrical supply in accordance with local regulations.
b) Isolate suction and discharge valves.
c) Remove coupling guards and disconnect the coupling halves.
d) Drain pump casing. Remove any auxiliary piping if applicable.
e) Disconnect stuffing box, cooling water and auxiliary piping.
f) Drain the oil from the bearing frame [3130] if bearing frame is being dismantled.
g) Place the sling around the bearing frame [3130] and carefully take up the weight without straining the casing. Refer to Section 3 to determine hoist and sling requirements.
h) Release the thrust bearing housing [3240] hold down bolts and jam nuts. While rotating the pump shaft [6] by hand, tighten the three jacking screws evenly until the impeller [2200] lightly clamps the stuffing box head [4110] in place. This will simplify withdrawal of the rotating element from the casing.
   CAUTION Excessive clamping force could damage bearing races.
   Rotating the shaft helps to clear away solids which may be trapped between the impeller and stuffing box head.
i) Remove the bolts connecting the rear support foot [3134] to the baseplate.
j) Remove the frame to casing bolts
k) Withdraw the rotating element from the casing.

6.8.2 Stuffing box

6.8.2.1 Shaft seal - mechanical seal

📖 Refer to any special instructions supplied with the mechanical seal.

a) Remove seal cover screws and pull off seal cover complete with the stationary seal ring which is held in place by the O-ring seal.

b) The mechanical seal cover can also be removed by placing a wedge into the gland chamfer, as below:

6.8.2.2 Impeller and stuffing box

a) While preventing the shaft from rotating, remove the impeller nut [2912] that has a right hand thread.
b) Remove the impeller [2200] and impeller key [6700]. Normally, a slight tightening of the thrust gearing jacking screws will free the impeller and allow it to be removed. Except on the smaller sizes, there is a facility on the impeller hub to assist removal in difficult cases.

6.8.3 Shaft sleeve

a) Remove the shaft sleeve gasket [4590.3].
b) Remove the shaft sleeve [2445] if scored or worn.

6.8.4 Bearing housing

a) Remove the line bearing seal.
b) Remove the pump half coupling and coupling key [6710].
c) Remove the bearing frame support [3134].
d) Lift the bearing frame assembly into a vertical position with the thrust bearing housing [3240] up. Rest the bearing frame flange on heavy wooden blocks sufficiently high to ensure end of the shaft does not come into contact with the floor or table.
e) Remove the thrust bearing hold down bolts and remove shaft assembly for the bearing frame [3130].

6.8.5 Line bearing

a) Lay the shaft [2110] horizontal and support with wooden ‘V’ Blocks.
b) Only if necessary remove the line bearing [3011] from the shaft. Bearings removed and reused can easily be damaged and undetected until pump is put back in operation.

6.8.6 Thrust bearings

a) Lay the shaft [2110] horizontal and support with wooden ‘V’ Blocks.
b) Remove the thrust bearing clamp ring [2542] from the thrust bearing housing [3240].
c) Bend up the locking tab on the bearing lockwasher [6542] and remove the bearing locknut [3712] and lockwasher [6542].
d) Only if necessary remove the thrust bearings [3031] from the shaft. Bearings removed and reused can easily be damaged and undetected until pump is put back in operation

6.9 Examination of parts

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

In particular, fault diagnosis is essential to enhance pump and plant reliability.

6.9.1 Casing, seal housing and impeller

a) Inspect for excessive wear, pitting, corrosion, erosion or damage and any sealing surface irregularities.
b) Replace as necessary.
c) Inspect the impeller [2200] for excessive wear or damage. Inspect the casing [1112] and stuffing box head [4110] for damage or excessive thinning of wall sections due to wear or corrosion. Clean the internal surfaces to maintain pump efficiency.
d) Clean the internal bore of the stuffing box.

6.9.2 Shaft and sleeve [if fitted]

a) Replace sleeve if grooved, pitted or worn.
b) Clean the shaft and inspect for evidence of corrosion, evidence of cracking, fatigue or mechanical damage. Remove all burrs or nicks paying particular attention to the areas under the lip seals. Check that the shaft is straight within 0.002 inch (0.050 mm).

6.9.3 Gaskets and O-rings

After dismantling, discard and replace.

6.9.4 Bearings

a) It is recommended that bearings are not re-used after any removal from the shaft.
b) The plain liquid lubricated bearings may be re-used if both the bearing bush and bearing sleeve show no sign of wear, grooving or corrosion attack. (It is recommended that both the bush and sleeve are replaced at the same time.)

6.9.5 Bearing isolators, labyrinths or lip seals (if fitted)

a) The lubricant, bearings and bearing housing seals are to be inspected for contamination and damage. If oil bath lubrication is utilised, these provide useful information on operating conditions within the bearing housing.
b) 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.
c) Labyrinth seals and bearing isolators should be inspected for damage but are normally non-wearing parts and can be re-used.

d) Bearing seals are not totally leak free devices. Oil from these may cause staining adjacent to the bearings.

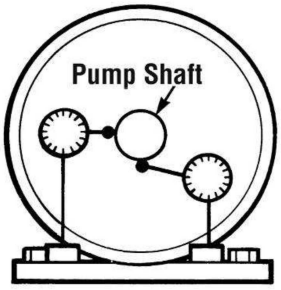
6.9.6 Installed pump

Complete pump installed.

Shaft movement caused by pipe strain

Pipe strain is any force put on the pump casing by the piping. Pipe strain should be measured as shown below. Install the indicators as shown before attaching the piping to the pump. The suction and discharge flanges should now be bolted to the piping separately while continuously observing the indicators. Indicator movement should not exceed 0.05 mm (0.002 in.).

Pipe strain movement

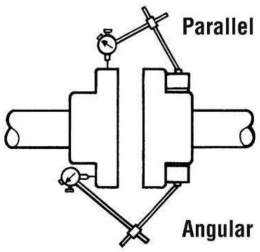


Alignment

Misalignment of the pump and motor shafts can cause the following problems:

- Failure of the mechanical seal
- Failure of the motor and/or pump bearings
- Failure of the coupling
- Excessive vibration/noise

The schematics below show the technique for a typical rim and face alignment using a dial indicator. It is important that this alignment be done after the flanges are loaded, and at typical operating temperatures.



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

See section 4.8 for recommended final shaft alignment limits.

Vibration analysis

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

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

Flowserve does not make vibration analysis equipment, however Flowserve strongly urges customers to work with an equipment supplier or consultant to establish an on-going vibration analysis program. See 5.7.5 regarding acceptance criteria.

6.10 Assembly

To assemble the pump consult the sectional drawings, see section 8, *Parts list and drawings*. Ensure threads, gasket and O-ring mating faces are clean. Apply thread sealant to non-face sealing pipe thread fittings.

6.10.1 Bearing housing

a) Lubricate the internal bores of the bearing frame [3130] with the same oil or grease used to lubricate the bearings.
b) Install the thrust bearing housing [3240] in the bearing frame [3130] to ensure a good sliding fit. Remove the thrust bearing housing from the frame.
c) Install the oil sight gauge [3856] and the drain lug in the bearing frame [3130] using Teflon pipe thread sealant. Install the vent plug [6521].

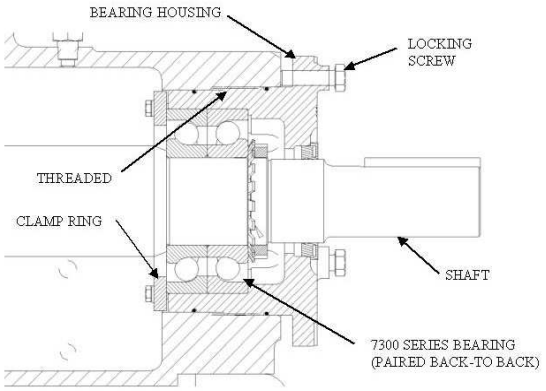
6.10.2 Line bearing

a) Pack the line bearing with grease if the bearings are being grease lubricated.
b) Lightly lubricate the shaft [2110] at the line bearing position. Install the line bearing [3011] on the shaft. Use an induction heated or hot oil bath to first heat the bearing [250° F

recommended], press the bearing on shaft with the aid of a sleeve designed to push the inner race only. Note that the bearing must remain square to the shaft during assembly and that the inner race must seat on the shaft shoulder. Protect the bearing by wrapping with a clean, lint free cloth.

6.10.3 Thrust bearing

a) Pack thrust bearing with grease if the bearings are being grease lubricated.
b) Place the thrust bearing clamp ring [2542] loosely over the shaft on the largest diameter.
c) Install the angular contact bearings [3031] on the shaft [2110] using the same procedure as described in step 6.10.2. The bearings are mounted back to back as shown.



Bearing arrangement

d) Slide the bearing lockwashers [6541] on the shaft and fit the bearing locknut [3712]. Tighten the locknut snugly and allow to cool. Check the tightness and bend one tab on the lockwasher into a slot in the locknut. Protect the bearings from contamination.
e) Carefully install the IN seal [4300.2] in the thrust bearing housing [3240] by pressing it squarely into the bore. The primary sealing lip [spring loaded] on seal should be installed facing the bearing. A small amount of sealant may be applied on the O.D. of the seal prior to its' installation.
f) Lubricate the O-rings [4610.3] with the bearing lubricant and assemble it into the groove of the outer circumference of the thrust bearing housing [3240].
g) Lubricate the inside bore of the thrust bearing housing [3240] and assemble it over the thrust bearings. Care must be taken to prevent damage of the seal on the shaft.
h) Using capscrews and lockwashers, attach the thrust bearing clamp ring [2542] to the thrust bearing housing [3240]. Lock the threads using Loctite 242 or equivalent.

Note: The thrust bearing clamp ring [2542] is provided with one extra hole midway between two adjacent bolt holes to permit free oil flow. On oil lubricated units, this hole must align with the cast oil return at the bottom of the thrust bearing housing bore. For grease lubricated units, this hole should be oriented away from the cast oil return slot at the bottom the thrust bearing housing bore.

Tighten the capscrews evenly ensuring that the clamp ring is not distorted and gap to the bearing housing is even all around. Tighten in accordance with section 6.6.

6.10.4 Frame assembly

a) Place the bearing frame in a vertical position with the large flange resting on wooden support blocks sufficiently high to allow the shaft from contacting the floor when it is installed.
b) Lift the shaft assembly into a vertical position and lower it into the bearing frame [3130].
c) Screw the thrust bearing housing into bearing frame housing at least 7 revolutions to prevent the assembly from coming apart when lifting.
d) Place the bearing frame assembly into a horizontal position.
e) Install the setscrews [6577].
f) Carefully install the INPRO seal [4300.2] in the line bearing frame [3130] by pressing it squarely into the bore. A small amount of sealant may be applied on the O-ring of the seal prior to its' installation.
g) Install the coupling key [6700] and tape to the shaft.
h) Mount a dial indicator to the bearing frame [3130] and indicate shaft under bearing frame flange (approx. mid way between impeller mounting face and end of sleeve area. Rotate shaft and check that run-out does not exceed 0.050 mm (0.002 in.).

6.10.5 Stuffing box

6.10.5.1 All

a) Install the gland studs [6572] using Loctite grade A or equivalent. The gland studs [6572] on water cooled stuffing boxes must be sealed with pipe sealant. If only two gland studs are used, the remaining two tapped holes must be plugged with set screws or short capscrews. To ensure proper sealing, the chamber can be tested to a design pressure of 75psi.
b) Press the stuffing box neck bush [4132] into the stuffing box [4110], ensuring that it seats squarely on the shoulder.
c) Lubricate the shaft [2110] at the impeller position,

check the fit of the impeller key [6710] in the shaft keyway and install the impeller [2200] onto the shaft to ensure that there is a good sliding fit. Remove the impeller [2200] and the impeller key [6710].

d) Install the O-ring [4610.2] into the impeller nut [2912] using grease or anti-seize compound to hold it in place during assembly.
e) Install the shaft sleeve [2445] onto the shaft [2110] and orientate the sleeve such that the keyways are aligned. Install the impeller key [6710] in the shaft.

6.10.5.2 Standard Packing

a) Assemble the stuffing box head [4110] over the shaft sleeve [2445] and orientate the lantern ring connections to auxiliary piping (Refer to Figure 6). These connections are normally placed on the vertical centerline for proper venting and draining as well as providing optimum gland stud access.
b) Push the stuffing box head [4110] back against the bearing frame flange face. Back off the thrust bearing housing to line up with the stuffing box with shaft sleeve. The shaft sleeve should be lined up with the stuffing box or fairly proud off the stuffing box by 0.060" [1.50mm].
c) Install the shaft gasket [4590.3] onto the shaft, ensuring that the outside diameter is no larger than the sleeve.

6.10.6 Impeller Installation

a) Install impeller [2200].
b) Apply a small quantity of Loctite 242 or equivalent to the exposed thread on the end of the shaft, and thread the impeller nut [2912] complete with O-ring [4610.2] onto the shaft.

Note: For units with mechanical seals, do not apply thread locking compound until seal axial setting has been established.

c) Tighten the impeller nut [2912] in accordance with the specific Impeller torque specified, see section 6.6. This is an essential step to properly seat the sleeve [2445] and compress the gasket [4590.3] to provide a seal and to prevent loosening of the impeller on the shaft.
d) Release the thrust bearing housing set screws [6577] and index the bearing housing [3240] to move the impeller in or out.

6.10.7 All pumps

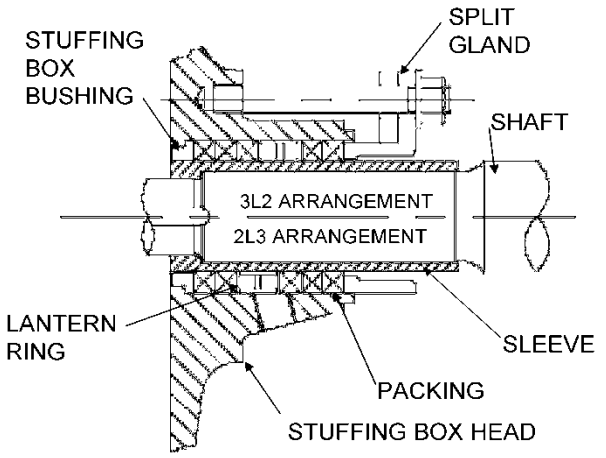
a) Smear anti-seize compound on the casing [1112] and stuffing box head [4110] rabbit fit (spigot) diameters to ease assembly and future disassembly.

6.10.8 Rotor unit

a) With a sling around the bearing frame placed so as to balance the weight, lift the frame/impeller assembly keeping the shaft horizontal.
b) Install the frame/impeller assembly into the casing [1112] by guiding the stuffing box head and bearing frame spigots squarely into the casing recess. Ensure that the gasket [4590.3] stays in position. If the fit becomes snug, use 4 equally spaced bolts to draw the assembly into the casing.
c) Install the casing frame bolts with washers and tighten in accordance with section 6.6.
d) Using the thrust bearing housing adjustment feature [Figure 1], move the impeller forward away from the stuffing box head [4110].
e) Attach the bearing frame support [3134] to the bearing frame [3130] using the capscrews and washers. Ensure that thread engagement is at least 1 diameter. Use Loctite 242 thread sealant.
f) Set the impeller front clearance in accordance with instruction earlier in this section of the manual.

6.10.9 Shaft seal

6.10.9.1 Gland packing



Standard Packed Box Arrangement

a) Insert one packing ring at a time into the stuffing box. Push the packing as far as possible into the packing bore.
b) Install additional rings as required, staggering the joints.
c) Once the first two or three rings of packing have been inserted, the two piece lantern ring [4134] must be installed. Push the lantern ring and previously installed packing. The ports in the lantern ring do not need to be aligned with the inlet/outlet ports.
d) Ensure that the shaft can be turned by hand.
e) Install the remaining rings of packing, alternating the joints.

Note: It may not be possible to insert the last ring in

the box and still insert the gland. In this case, omit the last ring of packing and install the gland. The last ring of packing should be installed after the pump has been in service and sufficient space is available.

f) Install the gland halves [4120], tighten the gland nuts [6581] only finger tight.

⚠ CAUTION New packing has to be run-in and it is good practice to start the pump with the stuffing box gland quite loose. Packing that is too tight in the box will cause undue friction, creating heat which will glaze the packing and possible score the shaft sleeves. To be effective, the packing must remain soft and pliable. If stuffing box friction is so great that the pump shaft cannot be turned by hand, the box is not properly packed.

6.10.9.2 Mechanical Seal

📖Refer to any special instructions supplied with the mechanical seal.

a) Before the mechanical seal can be installed, the pump must be assembled with the correct impeller running clearances (ie: all assembly steps above). A scribe mark is then placed on the circumference of the sleeve to mark the end of the box. This mark is used to locate the seal position referenced by the mechanical seal drawing provided.
b) After scribing the sleeve, remove the rotating element from the casing. Do not adjust the bearing housing.
c) Remove the impeller nut [2912], impeller [2200], impeller key [6710] and stuffing box head [4110]. Assemble the mechanical seal components, including gland plates, gaskets and rotating parts over the sleeve. Locate the seal relative to the scribed markings on the shaft sleeve [2445] as indicated by the seal manufacturers' instruction.
d) Remove lubricating compound from the impeller nut and shaft threads. Re-assemble components in accordance with original assembly procedure with the exception that Loctite 242 is applied to the impeller nut [2912] threads. Torque the impeller nut to the specified value, see section 6.6.
e) Assemble the mechanical seal gland plate and gasket and fasten using gland studs [6572]. Secure with nuts [6581] and tighten each by hand. Further tighten the nuts in accordance with section 6.6. Rotate the shaft to ensure that it turns freely without rubbing or binding.
f) Re-assemble the rotating element into the casing. Do not adjust the thrust bearing housing.

6.10.10 Final assembly

a) Lift the assembled pump onto the baseplate, position the casing feet over the tapped holes in the baseplate and clamp them.
b) Loosen the bolts that attach the rear support foot [3134] to the bearing frame [3130]. The rear support foot is designed with shim allowance measured vertically. Level the unit and align with the piping. Tighten the bolts attaching the casing feet to the baseplate in accordance with the specific torque specified, see section 6.6. Do not distort casing or frame.
c) Install the pump coupling or sheave as required.
d) Refer to Section 4, Installation and Section 5, Preparation for Operation.
e) It is recommended that the pump not be packed until required. Refer to stuffing box packing procedure in this section. Protect the stuffing box bore and seal area with clean dry rags.

Gland packing must not be used when pumping hazardous liquids.

6.11 Impeller axial clearance adjustment

Note: This procedure should not be used on units with mechanical seals if the design is such that a liquid seal cannot be maintained when the rotor is moved axially against the wear plate.

Unless seal is a cartridge design it may not be possible to adjust the shaft unless the pump is dismantled.

📖 Refer to any special instructions supplied with the mechanical seal

⚠ DANGER **NEVER ATTEMPT TO CHANGE THE CLEARANCE WHEN THE PUMP IS RUNNING.**

If the coupling has limited axial adjustment capability, the pump and driver must be uncoupled prior to adjusting the clearance in order to permit free movement.

A new impeller gasket [4590.3] must be installed whenever the impeller has been removed from the shaft.

6.11.1 Installation and clearance setting for impellers on Mark 3 Group 4 pump

⚠ The impeller could have sharp edges, which could cause an injury. It's very important to wear heavy gloves.

a) Install impeller [2200], see section 6.10.6.

b) Set the impeller clearance by loosening the set screws [6577] and rotating the thrust bearing housing [3240] to obtain the clearance. Turn the thrust bearing housing counter-clockwise until the impeller comes into light rubbing contact with the casing [1112]. Rotating the shaft at the same time will accurately determine this zero setting. Now, rotate the thrust bearing housing clockwise to get the proper clearance. Rotating the thrust bearing housing the width of one of the indicator patterns cast into the thrust bearing housing moves the impeller axially 0.1 mm (0.004 in). (Figure 2).

CAUTION It is recommended that two people install an impeller. The weight of an impeller greatly increases the chance of thread damage and subsequent lock-up concerns.

c) Determine how far to rotate the thrust bearing housing by dividing the desired impeller clearance by 0.10 (one indicator pattern). Tightening the set screws [6577] will cause the impeller to move 0.005 mm (0.002 in) closer to the casing because of the internal looseness in the thrust bearing housing threads. This must be considered when setting the impeller clearance. Rotate the thrust bearing housing clockwise the required amount to get the desired clearance to the casing. Lastly, tighten the set screws [6577] to lock the thrust bearing housing in place.

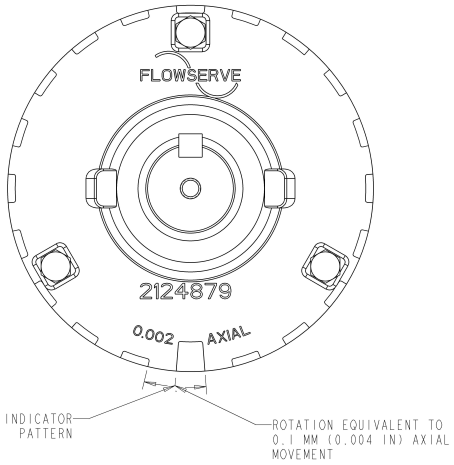


FIGURE 2

7 FAULTS; CAUSES AND REMEDIES

FAULT SYMPTOM

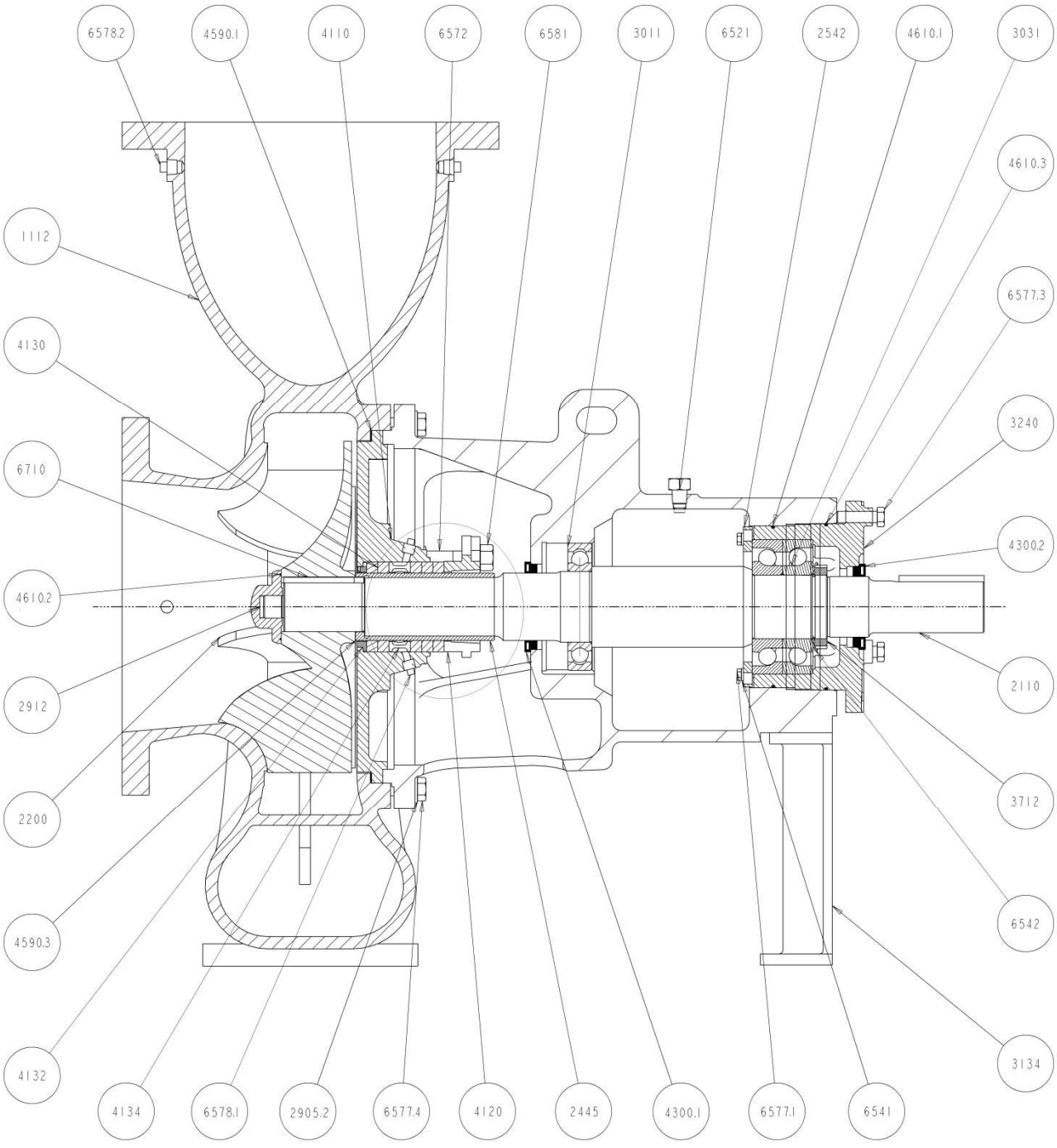
Pump overheats and seizes	Bearings have short life	Pump vibrates or is noisy	Mechanical seal has short life	Mechanical seal leaks excessively	Pump requires excessive power	Pump loses prime after starting	Insufficient pressure developed	Insufficient capacity delivered	Pump does not deliver liquid	POSSIBLE 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 vapour pressure.	
						●	●	●		Excessive amount of air or gas in liquid.	Check and purge pipes and system.
						●		●	●	Air or vapour pocket in suction line.	Check suction line design for vapour 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 run-outs are within acceptable values.

FAULT SYMPTOM

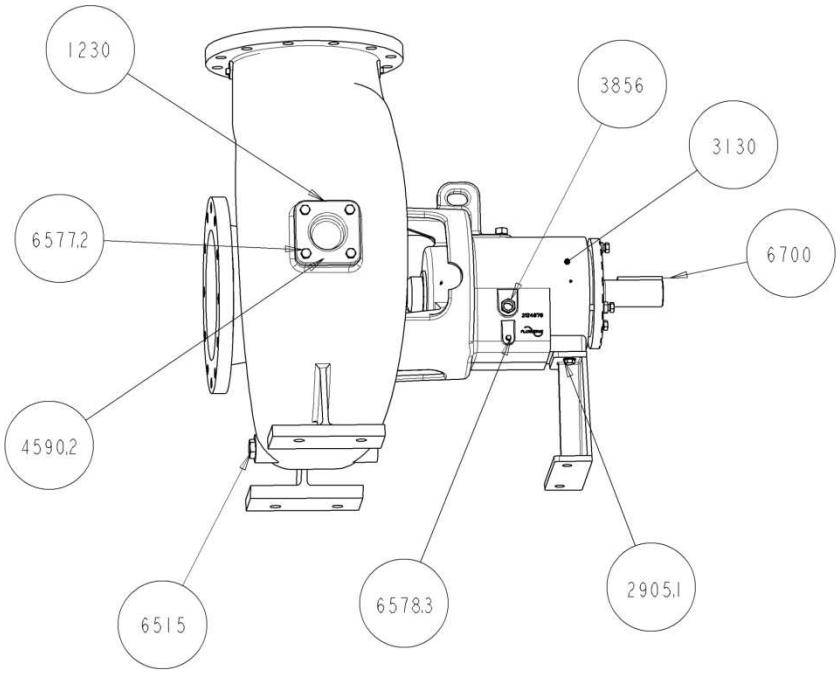
Pump overheats and seizes	Bearings have short life	Pump vibrates or is noisy	Mechanical seal has short life	Mechanical seal leaks excessively	Pump requires excessive power	Pump loses prime after starting	Insufficient pressure developed	Insufficient capacity delivered	Pump does not deliver liquid	POSSIBLE CAUSES	POSSIBLE REMEDIES
											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.
		●					●	●		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 centre.	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 centre 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.
	●	●								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.

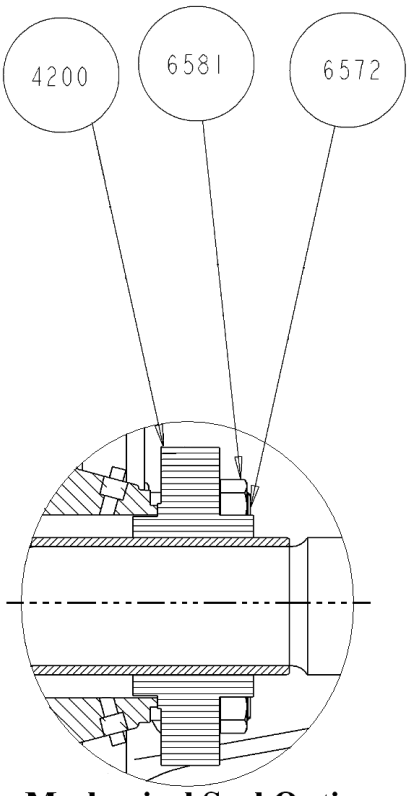
8 PARTS LIST AND DRAWINGS

8.1 Mark 3 Group 4 chemical pump sectional and parts list



Packing Option

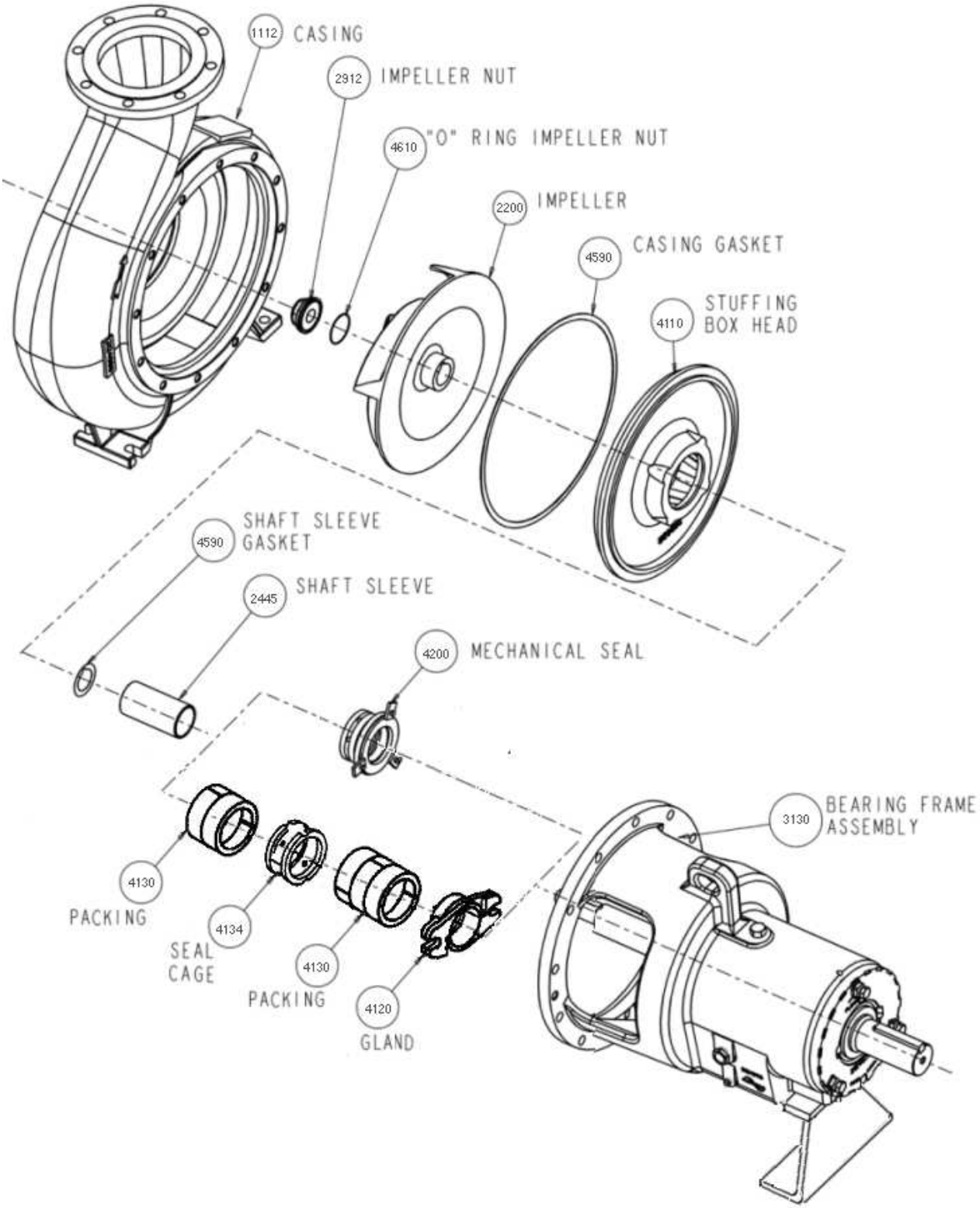




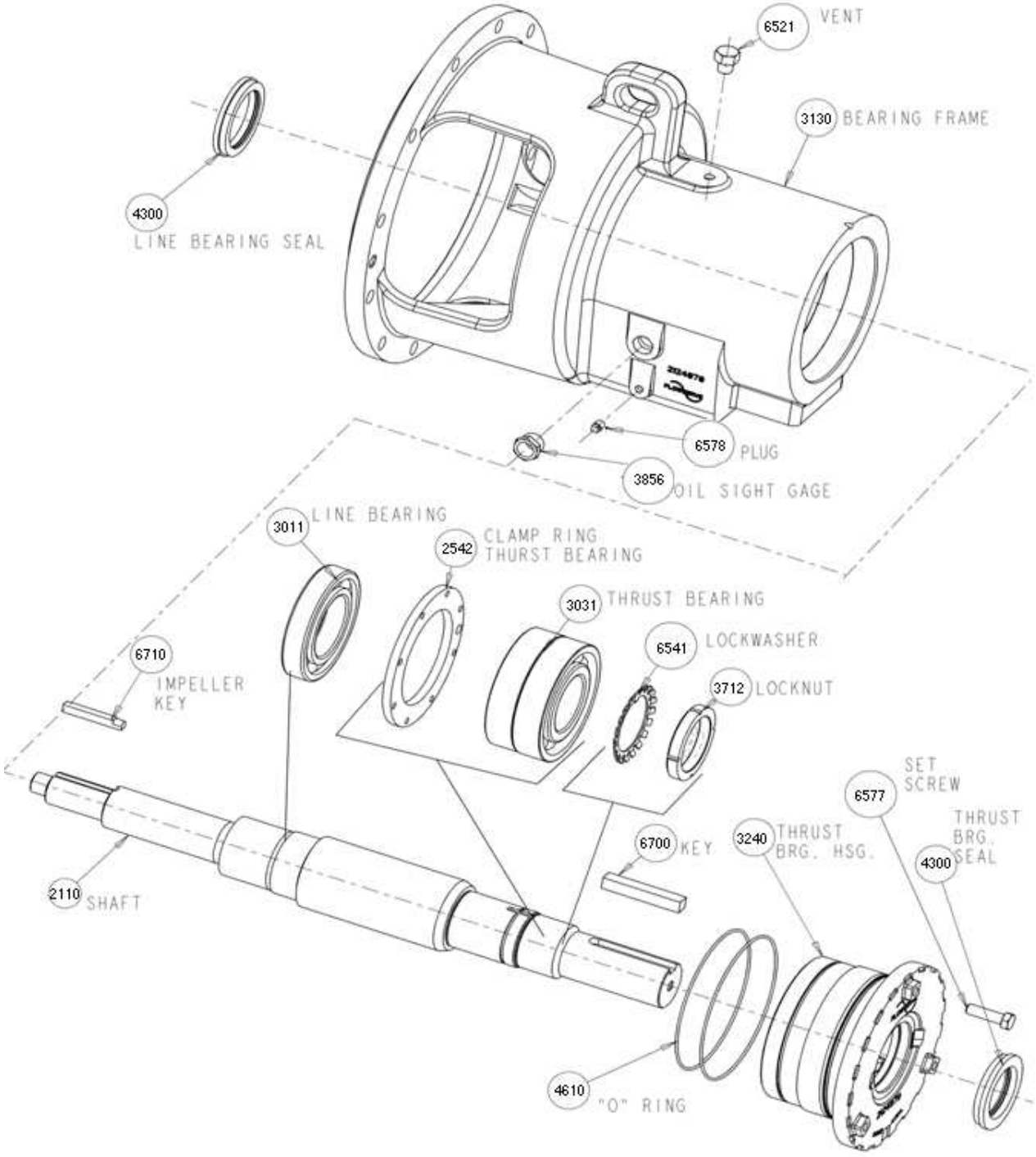
Mechanical Seal Option

Euro.	Description	Euro.	Description	Euro.	Description
1112	Casing	3856	Plug, Level Sight	6515	Plug, Drain
1230	Handhole Cover	4110	Stuffing Box	6521	Breather Plug
2110	Shaft	4120	Gland Halves	6541	Lockwasher
2200	Impeller	4130	Packing	6542	Lockwasher
2445	Shaft Sleeve	4132	Throat Bushing	6572	Stud
2542	Clamp Ring	4134	Seal Cage Halves	6577.1	Cap Screw Hex Head
2905.1	Washer	4200	Mechanical Seal	6577.2	Cap Screw Hex Head
2905.2	Washer	4300.1	Inpro Seal	6577.3	Cap Screw Hex Head
2912	Impeller Nut	4300.2	Inpro Seal	6577.4	Cap Screw Hex Head
3011	Radial Ball Bearing	4590.1	Gasket	6578.1	Plug, Pipe
3031	Thrust Bearing	4590.2	Gasket, Hand-hole	6578.2	Square Head Pipe Plug
3130	Bearing Frame	4590.3	Gasket, Sleeve	6578.3	Square Head Pipe Plug
3134	Support Foot	4610.1	O-Ring	6581	Hex Nut
3240	Thrust Brg.Hsg.	4610.2	O-Ring	6700	Key
3712	Lock Nut	4610.3	O-Ring	6710	Key, Sleeve

8.2 Mark 3 Group 4 chemical pump- liquid end exploded view



8.3 Mark 3 Group 4 chemical pump frame exploded view



8.4 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.

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.

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