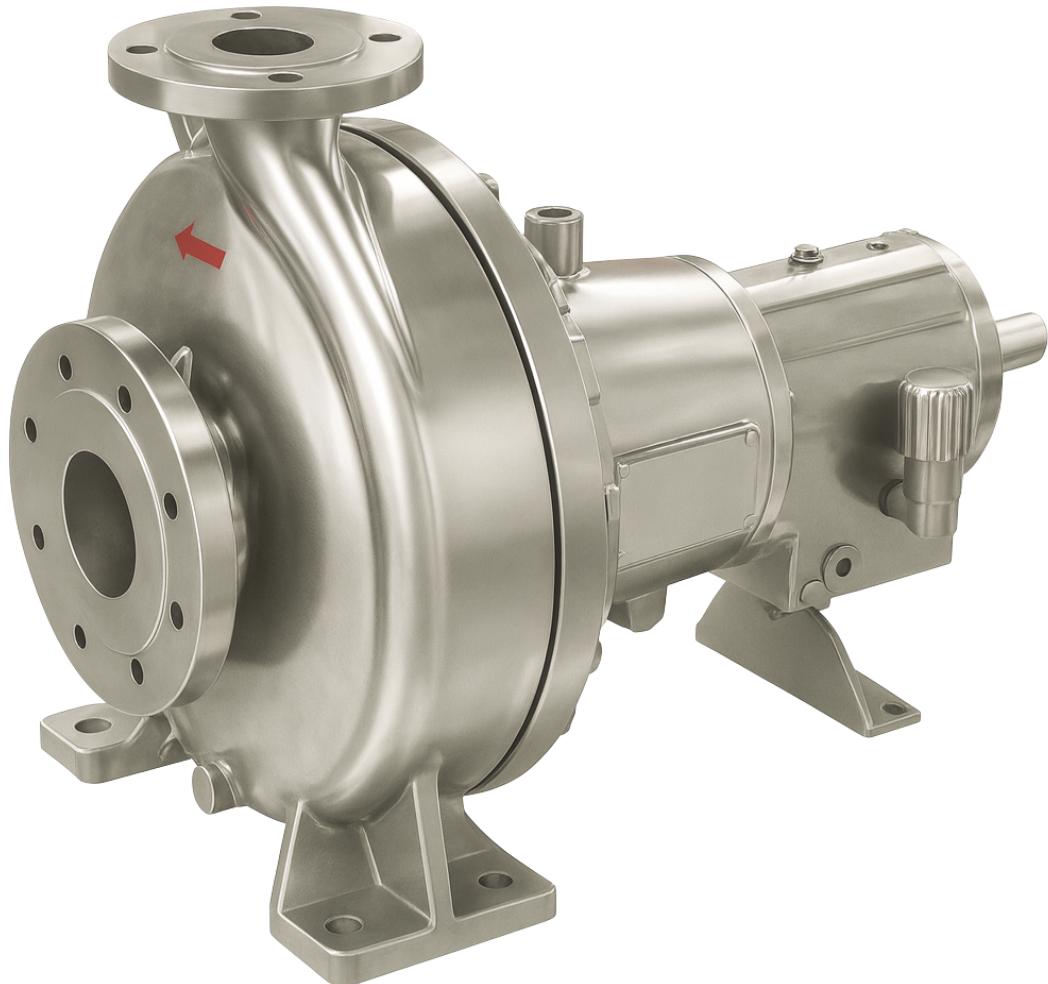


# USER INSTRUCTIONS

## **Durco Mark 3 Sealed ASME (ANSI) Chemical Process Pump (Equivalent)**

Mark 3 Standard, In-Line, Lo-Flo, Recessed  
Impeller, Unitized Self Priming and Sealmatic Pumps

## **Installation Operation Maintenance**



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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, utilizing sophisticated quality techniques, and safety requirements.

Flowserve is 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 plate markings and the Certification. (See section 9, *Certification*.)

### 1.3 Disclaimer

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

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

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

### 1.5 Duty conditions

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

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

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

 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 help 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 (Lock out.)

 GUARDS MUST NOT BE REMOVED WHILE THE PUMP IS OPERATIONAL

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

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

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

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

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

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



## HOT (and cold) PARTS

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

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



## HAZARDOUS LIQUIDS

When the pump is handling hazardous liquids care must be taken to avoid exposure to the liquid by appropriate siting 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.**



**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.



**NEVER RUN THE PUMP DRY OR WITHOUT PROPER PRIME (Casing flooded)**



**NEVER OPERATE THE PUMP WITH THE DISCHARGE VALVE CLOSED**

(Unless otherwise instructed at a specific point in the User Instructions.)

(See section 5, *Commissioning start-up, operation and shutdown.*)



**NEVER OPERATE THE PUMP WITH THE SUCTION VALVE CLOSED**

It should be fully opened when the pump is running.



**NEVER OPERATE THE PUMP AT ZERO FLOW OR FOR EXTENDED PERIODS BELOW THE MINIMUM CONTINUOUS FLOW**



**DO NOT RUN THE PUMP AT ABNORMALLY HIGH OR LOW FLOW RATES**

Operating at a flow rate higher than normal or at a flow rate with no back pressure on the pump may overload

the motor and cause cavitation. Low flow rates may cause a reduction in pump/bearing life, overheating of the pump, instability and cavitation/vibration.



**CAUTION**

**NEVER EXCEED THE MAXIMUM DESIGN PRESSURE (MDP) AT THE TEMPERATURE SHOWN ON THE PUMP NAMEPLATE**

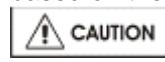


**CAUTION** ENSURE CORRECT

**LUBRICATION**

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

See section 3 for pressure versus temperature ratings based on the material of construction.



**CAUTION**

**THE PUMP SHAFT MUST TURN CLOCKWISE WHEN VIEWED FROM THE MOTOR END**

It is absolutely essential that the rotation of the motor be checked before installation of the coupling spacer and starting the pump. Incorrect rotation of the pump for even a short period can unscrew the impeller, which can cause significant damage.

### 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.

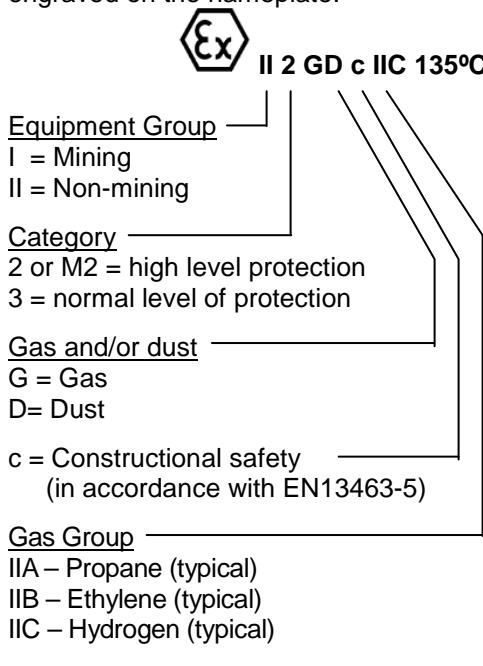
Where Flowserve has supplied only the bare shaft pump, the Ex rating applies only to the pump. The party responsible for assembling the ATEX pump set

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. On pump installations controlled by a VFD, the ATEX Certification for the motor must state that it covers the situation where electrical supply is from the VFD. This particular requirement still applies even if the VFD is in a safe area.

#### 1.6.4.2 Marking

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



#### 1.6.4.3 Avoiding excessive surface temperatures

 ENSURE THE EQUIPMENT TEMPERATURE CLASS IS SUITABLE FOR THE HAZARD ZONE

##### Pump liquid temperature

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

The surface temperature on the pump is influenced by the temperature of the liquid handled. The maximum permissible liquid temperature depends on the

temperature class and must not exceed the values in the table applicable below.

##### Maximum permitted liquid temperature for pumps

Temperature class to EN 13463-1	Maximum surface temperature permitted	Temperature limit of liquid handled
T6	85 °C (185 °F)	Consult Flowserve *
T5	100 °C (212 °F)	Consult Flowserve *
T4	135 °C (275 °F)	115 °C (239 °F) *
T3	200 °C (392 °F)	180 °C (356 °F) *
T2	300 °C (572 °F)	275 °C (527 °F) *
T1	450 °C (842 °F)	400 °C (752 °F) *

##### Maximum permitted liquid temperature for pumps with self priming casing

Temperature class to EN 13463-1	Maximum surface temperature permitted	Temperature limit of liquid handled
T6	85 °C (185 °F)	Consult Flowserve
T5	100 °C (212 °F)	Consult Flowserve
T4	135 °C (275 °F)	110 °C (230 °F) *
T3	200 °C (392 °F)	175 °C (347 °F) *
T2	300 °C (572 °F)	270 °C (518 °F) *
T1	450 °C (842 °F)	350 °C (662 °F) *

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

The 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 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..

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

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

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

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

#### ***Additional requirements for self-priming casing pumps***

Where the system operation does not ensure control of priming, as defined in these User Instructions, and the maximum permitted surface temperature of the T Class could be exceeded, install 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 that the pump and relevant suction and discharge piping system is totally filled with liquid at all times during the pumps operation so that an explosive atmosphere is prevented.

In addition, it is essential to make sure that seal chambers, auxiliary shaft seal systems and any heating and cooling systems are properly filled.

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

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

#### ***1.6.4.5 Preventing sparks***

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

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

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

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

#### ***Additional requirements for metallic pumps on non-metallic baseplates***

When metallic components are fitted on a non-metallic baseplate they must be individually earthed.

#### ***1.6.4.6 Preventing leakage***



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

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

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

Where there is the potential hazard of a loss of 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.

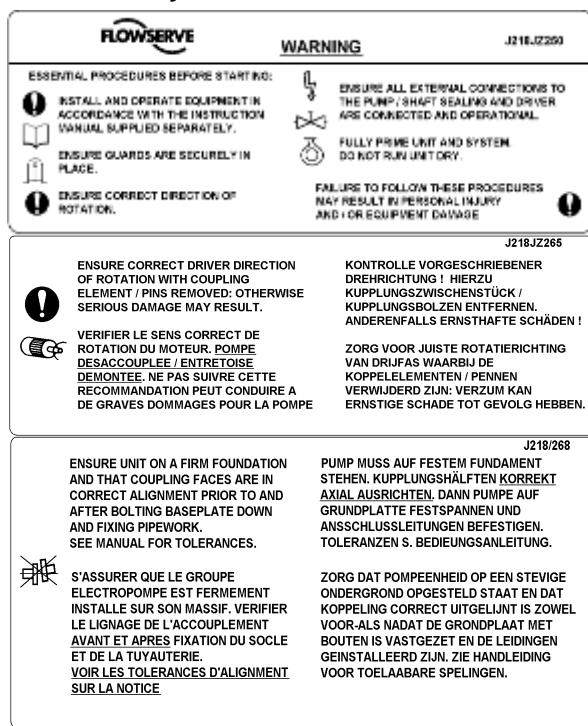
It is recommended that a maintenance plan and schedule is adopted. (See section 6, *Maintenance*.)

## 1.7 Name plate and safety labels

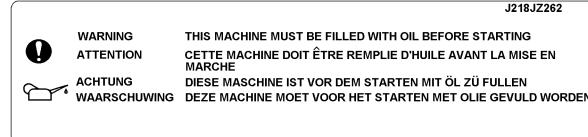
### 1.7.1 Nameplate

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

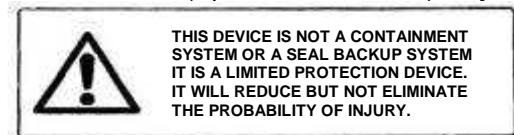
### 1.7.2 Safety labels



Oil lubricated units only:



DurcoShield™ (Splash/Shaft Guard) only:



## 1.8 Specific machine performance

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

## 1.9 Noise level

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

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

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

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

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

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

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

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

Motor size and speed kW (hp)	Typical sound pressure level $L_{pA}$ at 1 m reference 20 $\mu\text{Pa}$ , dBA							
	3 550 r/min		2 900 r/min		1 750 r/min		1 450 r/min	
	Pump only	Pump and motor	Pump only	Pump and motor	Pump only	Pump and motor	Pump only	Pump and motor
<0.55(<0.75)	72	72	64	65	62	64	62	64
0.75 (1)	72	72	64	66	62	64	62	64
1.1 (1.5)	74	74	66	67	64	64	62	63
1.5 (2)	74	74	66	71	64	64	62	63
2.2 (3)	75	76	68	72	65	66	63	64
3 (4)	75	76	70	73	65	66	63	64
4 (5)	75	76	71	73	65	66	63	64
5.5 (7.5)	76	77	72	75	66	67	64	65
7.5 (10)	76	77	72	75	66	67	64	65
11(15)	80	81	76	78	70	71	68	69
15 (20)	80	81	76	78	70	71	68	69
18.5 (25)	81	81	77	78	71	71	69	71
22 (30)	81	81	77	79	71	71	69	71
30 (40)	83	83	79	81	73	73	71	73
37 (50)	83	83	79	81	73	73	71	73
45 (60)	86	86	82	84	76	76	74	76
55 (75)	86	86	82	84	76	76	74	76
75 (100)	87	87	83	85	77	77	75	77
90 (120)	87	88	83	85	77	78	75	78
110 (150)	89	90	85	87	79	80	77	80
150 (200)	89	90	85	87	79	80	77	80
200 (270)	①	①	①	①	85	87	83	85
300 (400)					87	90	85	86

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

## 2 TRANSPORT AND STORAGE

### 2.1 Consignment receipt and unpacking

Immediately after receipt of the equipment it must be checked against the delivery/shipping documents for its completeness and that there has been no damage in transportation. Any shortage and/or damage must be reported immediately to Flowserve Solution group and must be received within ten days 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.

#### 2.3 Lifting



A crane must be used for all pump sets in excess of 25 kg (55 lb). Fully trained personnel must carry out lifting, in accordance with local regulations.

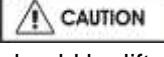
Slings, ropes and other lifting gear should be positioned where they cannot slip and where a balanced lift is obtained. The angle between sling or ropes used for lifting must not exceed 60°.



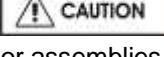
**CAUTION** Pumps and motors often have integral lifting lugs or eye bolts. These are intended for use in only lifting the individual piece of equipment.



**CAUTION** Do not use eye bolts or cast-in lifting lugs to lift pump, motor and baseplate assemblies.



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



**CAUTION** Care must be taken to lift components or assemblies above the center of gravity to prevent the unit from flipping. This is especially true with In-Line pumps.

### 2.3.1 Lifting pump components

#### 2.3.1.1 Casing [1100]

Use a choker hitch pulled tight around the discharge nozzle.

#### 2.3.1.2 Rear cover [1220]

Insert an eye hook in the drilled and tapped hole at the top of the cover. Use either a sling or hook through the eye bolt.

#### 2.3.1.3 Bearing housing [3200]

Group 1: insert a sling between the upper and lower support ribs between the housing barrel and the casing attachment flange. Use a choker hitch when slinging. (Make sure there are no sharp edges on the bottom side of the ribs that could cut the sling.)

Group 2 and 3: insert either a sling or hook through the lifting lug located on the top of the housing.

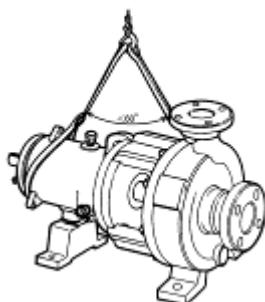
#### 2.3.1.4 Power end

Same as bearing housing.

#### 2.3.1.5 Bare pump

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

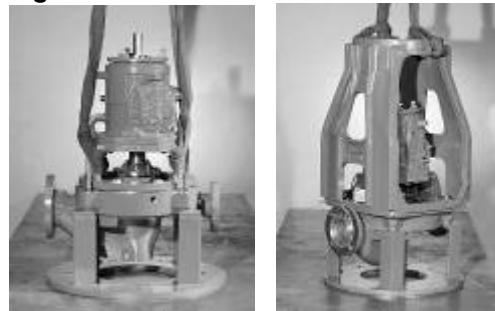
**Figure 2.1**



In-Line pumps: lift with two slings through the pump adapter on opposite sides of the shaft. (Figure 2-2.)

Bare pump with motor adapter (In-Line only): lift with two slings through the motor adapter shaft holes. This method is also used to lift the bare motor adapter. (Figure 2-2.)

**Figure 2.2**

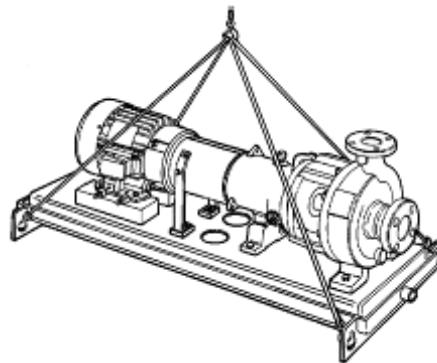


### 2.3.2 Lifting pump, motor and baseplate assembly

#### 2.3.2.1 Horizontal assemblies

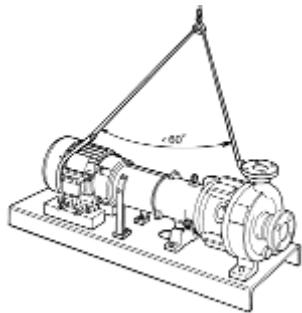
If the baseplate has lifting holes cut in the sides at the end (Type A Group 3, Type D and Type E bases) insert lifting S hooks at the four corners and use slings or chains to connect to the lifting eye. (Figure 2-3.) Do not use slings through the lifting holes.

**Figure 2.3**



For other baseplates, sling around the pump discharge nozzle, and around the outboard end of the motor frame using choker hitches pulled tight. (Figure 2-4.) T5000 type bases should not be lifted with motor attached (i.e. pump and base only).

**Figure 2.4**



The sling should be positioned so the weight is not carried through the motor fan hood. Make sure the completion of the choker hitch on the discharge nozzle is toward the coupling end of the pump shaft as shown in figure 2-4.

### **2.3.2.2 In-Line assemblies**

If the pump is to be lifted as a complete assembly, the motor lifting lugs must be used to ensure that the assembly does not flip over. Check with motor supplier for lifting lug capacities. If there is any uncertainty, the motor should be removed prior to moving the pump. (Figure 2-2.)

## **2.4 Storage**

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

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

### **2.4.1 Short term storage and packaging**

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

- All loose unmounted items are packaged in a water proof plastic bag and placed under the coupling guard
- Inner surfaces of the bearing housing, shaft (area through bearing housing) and bearings are coated with Cortec VCI-329 rust inhibitor, or equal.

**Note:**

Bearing housings are not filled with oil prior to shipment

- Regreasable bearings are packed with grease (EXXON POLYREX EM for horizontal pumps and EXXON UNIREX N3 for In-Line pumps)

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

### **2.4.2 Long term storage and packaging**

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

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

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

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

## **2.5 Recycling and end of product life**

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



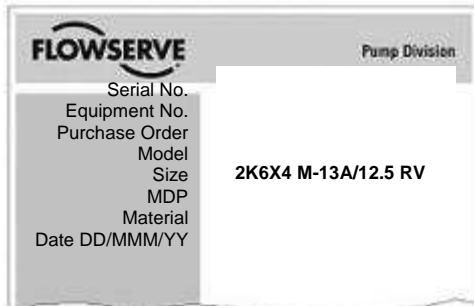
Make sure that hazardous substances are disposed of safely and that the correct personal protective equipment is used. The safety specifications must be in accordance with the current local regulations at all times.

### 3 DESCRIPTION

#### 3.1 Configurations

The Durco Mark 3 chemical process pumps are metallic, single stage, sealed, centrifugal pumps. The horizontal family conforms to ASME B73.1M, which has a centerline discharge and is represented by our Standard, Sealmatic, Unitized self-priming, Recessed impeller and Lo-Flo pump models. The vertical pump or In-Line conforms to ASME B73.2M.

Figure 3-1: Nameplate mounted to housing



The Prima<sup>3</sup>™ is an ANSI 3A power end adapted to other pump models from Flowserve as well as from other pump manufacturers. Only the information in this manual involving the ANSI 3A power end may be used when Installing, Operating or Maintaining a pump that has been upgraded to a Prima<sup>3</sup>™. All other information regarding the pump type must be obtained from the original pump manufacturer's User Instructions.

#### 3.2 Nomenclature

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

**2 K 6 X 4 M - 13 A /12.5 RV**

- **Frame size**  
"2" indicates a medium size pump frame (in this example, a Group 2)  
1 = Group 1 (small frame)  
2 = Group 2 (medium frame)  
3 = Group 3 (large frame)
- **Power end**  
K = Mark 3 style power end  
Mark 3A – Standard  
ANSI 3A – Optional (3 year guarantee)  
J = Mark 3 style PE arranged for Mark 2 wet end  
(No letter and no preceding number indicates a Mark 2 power end)  
HD = Heavy Duty variant of the Mark 3 power end  
(suffix)
- **"6" = nominal suction port size (in.)**

- **"4" = Nominal discharge port size (in.)**
- **Modifier for "specialty pumps"**  
Blank or no letter = standard pump  
M = Sealmatic  
R = recessed impeller  
US = unitized self-priming  
V = vertical In-Line  
LF = Lo-Flo
- **Nominal maximum impeller diameter.** "13" = 13 in.
- **Pump design variation**  
A = This pump has been redesigned from an earlier version. The impeller and casing are no longer interchangeable with the earlier version.  
H = This pump is designed for a higher flow capacity than another pump with the same basic designation. (Examples: 4X3-10 and 4X3-10H; 6X4-10 and 6X4-10H; 10X8-16 and 10X8-16H.)  
HH = This pump is designed for a higher head than another pump with the same basic designation. (Example: 4X3-13 and 4X3-13HH.)
- **Actual impeller size**  
"12.5" = 12 1/2 in. diameter; 8.13 = 8 1/8 in.;  
10.75 = 10 3/4 in.  
(Previous annotation: 124 = 12 4/8 or 12 1/2 in. diameter; 83 = 8 3/8 in.)
- **Impeller style**  
RV = reverse vane impeller; OP = Open impeller

#### 3.3 Design of major parts

##### 3.3.1 Pump casing

Removal of the casing is not required when performing maintenance of the rotating element. The pump is designed with a gasket perpendicular to the shaft allowing the rotating element to be easily removed (back pull out).

##### 3.3.2 Impeller

Depending on the product, the impeller is either reverse vane or open.

##### 3.3.3 Shaft/sleeve

Solid and sleeved shafts are available, supported on bearings, threaded impeller end and keyed drive end.

##### 3.3.4 Pump bearings and lubrication

Ball bearings are fitted as standard and may be either oil or grease lubricated.

##### 3.3.5 Bearing housing

Large oil bath reservoir.

##### 3.3.6 Seal chamber (cover plate)

The seal chamber has a spigot (rabbet) fit between the pump casing and bearing housing (adapter) 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 C-flange motor adapters

Available option for Mark3 group 1 and 2 and NEMA motors from 182TC to 405TSC frames. Motors above 324TSC must be short shaft type

### 3.3.10 Accessories

Accessories may be fitted when specified by the customer.

## 3.4 Performance and operation limits

This product has been selected to meet the specification of your purchase order. See section 1.5.

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

### 3.4.1 Alloy cross reference chart

Figure 3-2 is the Alloy cross-reference chart for all Mark 3 pumps.

**Figure 3-2: Alloy cross-reference chart**

Flowserve Material Code	Designation	Durco Legacy Codes	ACI Designation	Equivalent Wrought Designation	ASTM Specifications	Material Group No.
E3020	Ductile iron	DCI	None	None	A395, Gr. 60-40-18	1.0
E3033	High chrome iron	CR28	None	None	A532 class 3	Cr
E4027	High chrome iron	CR29	None	None	None	Cr
E4028	High chrome iron	CR35	None	None	None	Cr
C3009	Carbon steel	DS	None	Carbon steel	A216 Gr. WCB	1.1
C3062	Durco CF8	D2	CF8	304	A744, Gr. CF8	2.1
C3069	Durco CF3	D2L	CF3	304L	A744, Gr. CF3	2.1
C3063	Durco CF8M	D4	CF8M	316	A744, Gr. CF8M	2.2
C3067	Durco CF3M	D4L	CF3M	316L	A744, Gr. CF3M	2.2
C3107	Durcomet 100	CD4M	CD4MCuN	Ferralium®	A995, Gr. CD4MCuN	2.8
C4028	Durimet 20	D20	CN7M	Alloy 20	A744, Gr. CN7M	3.17
C4029	Durcomet 5	DV	None	None	None	2.2
K3005	Durco CY40	DINC	CY40	Inconel® 600	A494, Gr. CY40	3.5
K3007	Durco M35	DMM	M351	Monel® 400	A494, Gr. M35-1	3.4
K3008	Nickel	DNI	CZ100	Nickel 200	A494, Gr. CZ100	3.2
K4007	Chlorimet 2	DC2	N7M	Hastelloy® B	A494, Gr. N7M	3.7
K4008	Chlorimet 3	DC3	CW6M	Hastelloy® C	A494, Gr. CW6M	3.8
E3041	Duriron®	D	None	None	A518, Gr. 1	No load
E3042	Durichlor 51®	D51	None	None	A518, Gr. 2	No load
E4035	Superchlor®	SD51	None	None	A518, Gr. 2	No load
D4036	Durco DC8	DC8	None	None	None	-
H3004	Titanium	Ti	None	Titanium	B367, Gr. C3	Ti
H3005	Titanium-Pd	TiP	None	Titanium-Pd	B367, Gr. C8A	Ti
H3007	Zirconium	Zr	None	Zirconium	B752, Gr. 702C	Ti

® Duriron, Durichlor 51 and Superchlor are registered trademarks of Flowserve Corporation.

® Ferralium is a registered trademark of Langley Alloys.

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

® Inconel and Monel are registered trademarks of International Nickel Co. Inc.

### 3.4.2 Pressure-temperature ratings

The pressure-temperature (P-T) ratings for Mark 3 pumps are shown in figures 3-3 to 3-5. Determine the appropriate casing "Material Group No." in Figure 3-2. Interpolation may be used to find the pressure rating for a specific temperature.

Example:

The pressure temperature rating for an ANSI std. GP2-10" pump with Class 300 flanges and CF8M construction at an operating temperature of 149°C is found as follows:

- The correct pressure-temperature chart is Figure 3-5C.
- From Figure 3-2, the correct material group for CF8M is 2.2
- From Figure 3-5C, the pressure-temperature rating is 21.5 bar.



The maximum discharge pressure must be less than or equal to the P-T rating. Discharge pressure may be approximated by adding the suction pressure and the differential head developed by the pump.

**Figure 3-3 12x10-18HD Only**

Temp °C	Material Group No.												
	1.0	1.1	2.1	2.2	2.8	3.2	3.4	3.5	3.7	3.8	3.17	Ti	Cr
	bar												
-73			13.8	13.8	13.8	9.7	13.8	13.8	13.8	13.8	13.8	13.8	
-29	13.8	13.8	13.8	13.8	13.8	9.7	13.8	13.8	13.8	13.8	13.8	13.8	
-18	13.8	13.8	13.8	13.8	13.8	9.7	13.8	13.8	13.8	13.8	13.8	13.8	12.6
38	13.8	13.8	13.8	13.8	13.8	9.7	13.8	13.8	13.8	13.8	13.8	13.8	12.6
93	13.8	13.8	13.8	13.8	13.8	9.7	13.8	13.8	13.8	13.8	13.8	13.8	12.6
149	13.8	13.8	13.8	13.8	13.8	9.7	13.1	12.4	13.8	13.8	12.4	13.8	12.6
171	13.8	13.8	13.7	13.8	13.8	9.7	13.0	12.1	13.8	13.8	11.9	13.8	12.6
204	13.8	13.8	13.1	13.4	13.8	9.7	12.8	11.7	13.8	13.8	11.0	13.8	
260	11.7	11.7	11.7	11.7	11.7	9.7	11.7	11.0	11.7	11.7	10.3	11.7	

Temp °F	Material Group No.												
	1.0	1.1	2.1	2.2	2.8	3.2	3.4	3.5	3.7	3.8	3.17	Ti	Cr
	psi												
-100			200	200	200	140	200	200	200	200	200	200	
-20	200	200	200	200	200	140	200	200	200	200	200	200	
0	200	200	200	200	200	140	200	200	200	200	200	200	183
100	200	200	200	200	200	140	200	200	200	200	200	200	183
200	200	200	200	200	200	140	200	200	200	200	200	200	183
300	200	200	200	200	200	140	190	180	200	200	180	200	183
340	200	200	199	200	200	140	188	176	200	200	172	200	183
400	200	200	190	195	200	140	185	170	200	200	160	200	
500	170	170	170	170	170	140	170	160	170	170	150	170	

**Figure 3-4 Class 150 Flanges**

Temp °C	Material Group No.												
	1.0	1.1	2.1	2.2	2.8	3.2	3.4	3.5	3.7	3.8	3.17	Ti	Cr
	bar												
-73			19.0	19.0	19.7	9.7	15.9	15.2	20.0	20.0	15.9	20.0	
-29	17.2	19.7	19.0	19.0	19.7	9.7	15.9	15.2	20.0	20.0	15.9	20.0	
-18	17.2	19.7	19.0	19.0	19.7	9.7	15.9	15.2	20.0	20.0	15.9	20.0	12.6
38	17.2	19.7	19.0	19.0	19.7	9.7	15.9	15.2	20.0	20.0	15.9	20.0	12.6
93	16.2	17.9	15.9	16.2	17.9	9.7	13.8	13.8	17.9	17.9	13.8	17.9	12.6
149	14.8	15.9	14.1	14.8	15.9	9.7	13.1	12.4	15.9	15.9	12.4	15.9	12.6
171	14.4	15.0	13.7	14.3	15.0	9.7	13.0	12.1	15.0	15.0	11.9	15.0	12.6
204	13.8	13.8	13.1	13.4	13.8	9.7	12.8	11.7	13.8	13.8	11.0	13.8	
260	11.7	11.7	11.7	11.7	11.7	9.7	11.7	11.0	11.7	11.7	10.3	11.7	
316	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.7	
343	8.6	8.6	8.6	8.6			8.6	8.6	8.6	8.6		8.6	
371		7.6	7.6	7.6			7.6	7.6	7.6	7.6		7.6	

Temp °F	Material Group No.												
	1.0	1.1	2.1	2.2	2.8	3.2	3.4	3.5	3.7	3.8	3.17	Ti	Cr
	psi												
-100			275	275	285	140	230	220	290	290	230	290	
-20	250	285	275	275	285	140	230	220	290	290	230	290	
0	250	285	275	275	285	140	230	220	290	290	230	290	183
100	250	285	275	275	285	140	230	220	290	290	230	290	183
200	235	260	230	235	260	140	200	200	260	260	200	260	183
300	215	230	205	215	230	140	190	180	230	230	180	230	183
340	209	218	199	207	218	140	188	176	218	218	172	218	183
400	200	200	190	195	200	140	185	170	200	200	160	200	
500	170	170	170	170	170	140	170	160	170	170	150	170	
600	140	140	140	140	140	140	140	140	140	140	140	140	
650	125	125	125	125			125	125	125	125		125	
700		110	110	110			110	110	110	110		110	

**Figure 3-5A Group 2-13" In-Lines and Group 3 Pumps with Class 300 Flanges**

Temp °C	Material Group No.										
	1.1	2.1	2.2	2.8	3.2	3.4	3.5	3.7	3.8	3.17	Ti
	bar										
-73		24.1	24.1	24.1	17.4	24.1	24.1	24.1	24.1	24.1	24.1
-29	24.1	24.1	24.1	24.1	17.4	24.1	24.1	24.1	24.1	24.1	24.1
-18	24.1	24.1	24.1	24.1	17.4	24.1	24.1	24.1	24.1	24.1	24.1
38	24.1	24.1	24.1	24.1	17.4	24.1	24.1	24.1	24.1	24.1	24.1
93	22.0	20.1	20.8	23.2	17.4	21.3	22.9	24.1	24.1	20.9	21.4
149	21.4	18.1	18.8	21.4	17.4	19.9	21.4	23.5	23.5	18.7	18.7
204	20.7	16.6	17.3	19.8	17.4	19.3	19.9	22.7	22.7	16.9	15.9
260	19.6	15.3	16.1	18.5	17.4	19.1	19.3	21.4	21.4	15.7	13.2
316	17.9	14.6	15.1	17.9	17.4	19.1	19.2	19.5	19.5	14.5	10.5
343	17.4	14.4	14.9			19.1	19.0	19.0	19.0		9.1
371	17.4	14.2	14.4			19.1	18.9	18.3	18.3		7.7

Temp °F	Material Group No.										
	1.1	2.1	2.2	2.8	3.2	3.4	3.5	3.7	3.8	3.17	Ti
	psi										
-100		350	350	350	252	350	350	350	350	350	350
-20	350	350	350	350	252	350	350	350	350	350	350
0	350	350	350	350	252	350	350	350	350	350	350
100	350	350	350	350	252	350	350	350	350	350	350
200	319	292	301	336	252	309	332	350	350	303	310
300	310	263	272	310	252	289	310	341	341	271	271
400	300	241	250	287	252	280	288	329	329	245	231
500	284	222	233	268	252	277	280	310	310	228	191
600	260	211	219	259	252	277	278	282	282	210	152
650	253	209	216		277	276	275	275		132	
700	253	207	209		277	274	266	266		112	

**Figure 3-5B Group 2-13" Lo-Flo Pumps with Class 300 Flanges**

Temp °C	Material Group No.											
	1.0	1.1	2.1	2.2	2.8	3.2	3.4	3.5	3.7	3.8	3.17	Ti
	bar											
-73			31.0	31.0	31.0	17.4	24.1	27.6	31.0	31.0	24.1	31.0
-29	31.0	31.0	31.0	31.0	31.0	17.4	24.1	27.6	31.0	31.0	24.1	31.0
-18	31.0	31.0	31.0	31.0	31.0	17.4	24.1	27.6	31.0	31.0	24.1	31.0
38	31.0	31.0	31.0	31.0	31.0	17.4	24.1	27.6	31.0	31.0	24.1	31.0
93	29.1	28.3	25.9	26.7	29.8	17.4	21.3	26.1	31.0	31.0	20.9	27.5
149	27.4	27.5	23.3	24.1	27.5	17.4	19.9	24.4	30.2	30.2	18.7	24.0
204	25.5	26.6	21.3	22.2	25.4	17.4	19.3	22.7	29.2	29.2	16.9	20.5
260	24.0	25.2	19.7	20.7	23.8	17.4	19.1	22.1	27.5	27.5	15.7	17.0
316	22.5	23.1	18.7	19.4	23.0	17.4	19.1	21.9	25.0	25.0	14.5	13.4
343	21.8	22.4	18.5	19.2			19.1	21.8	24.4	24.4		11.7
371		22.4	18.3	18.5			19.1	21.6	23.6	23.6		9.9

Temp °F	Material Group No.											
	1.0	1.1	2.1	2.2	2.8	3.2	3.4	3.5	3.7	3.8	3.17	Ti
	psi											
-100			450	450	450	252	350	400	450	450	350	450
-20	450	450	450	450	450	252	350	400	450	450	350	450
0	450	450	450	450	450	252	350	400	450	450	350	450
100	450	450	450	450	450	252	350	400	450	450	350	450
200	422	410	375	388	432	252	309	379	450	450	303	399
300	397	398	338	350	399	252	289	354	438	438	271	348
400	369	386	309	322	369	252	280	330	423	423	245	297
500	348	365	285	300	345	252	277	320	399	399	228	246
600	327	334	272	281	333	252	277	318	363	363	210	195
650	316	325	269	278			277	316	354	354		170
700		325	266	269			277	313	342	342		144

**Figure 3-5C All other Class 300 Flanges**

Temp °C	Material Group No.										
	1.1	2.1	2.2	2.8	3.2	3.4	3.5	3.7	3.8	3.17	Ti
	bar										
-73		27.6	27.6	27.6	17.4	24.1	24.1	27.6	27.6	24.1	27.6
-29	27.6	27.6	27.6	27.6	17.4	24.1	24.1	27.6	27.6	24.1	27.6
-18	27.6	27.6	27.6	27.6	17.4	24.1	24.1	27.6	27.6	24.1	27.6
38	27.6	27.6	27.6	27.6	17.4	24.1	24.1	27.6	27.6	24.1	27.6
93	25.2	23.0	23.7	26.5	17.4	21.3	22.9	27.6	27.6	20.9	24.5
149	24.4	20.7	21.5	24.5	17.4	19.9	21.4	26.8	26.8	18.7	21.3
204	23.7	19.0	19.7	22.6	17.4	19.3	19.9	25.9	25.9	16.9	18.2
260	22.4	17.5	18.4	21.1	17.4	19.1	19.3	24.5	24.5	15.7	15.1
316	20.5	16.7	17.2	20.4	17.4	19.1	19.2	22.2	22.2	14.5	12.0
343	19.9	16.5	17.0			19.1	19.0	21.7	21.7		10.4
371	19.9	16.3	16.5			19.1	18.9	21.0	21.0		8.8

Temp °F	Material Group No.										
	1.1	2.1	2.2	2.8	3.2	3.4	3.5	3.7	3.8	3.17	Ti
	psi										
-100		400	400	400	252	350	350	400	400	350	400
-20	400	400	400	400	252	350	350	400	400	350	400
0	400	400	400	400	252	350	350	400	400	350	400
100	400	400	400	400	252	350	350	400	400	350	400
200	365	333	344	384	252	309	332	400	400	303	355
300	354	300	311	355	252	289	310	389	389	271	309
400	343	275	286	328	252	280	288	376	376	245	264
500	324	253	267	307	252	277	280	355	355	228	219
600	297	242	250	296	252	277	278	323	323	210	173
650	289	239	247			277	276	315	315		151
700	289	236	239			277	274	304	304		128

### 3.4.3 Suction pressure limits

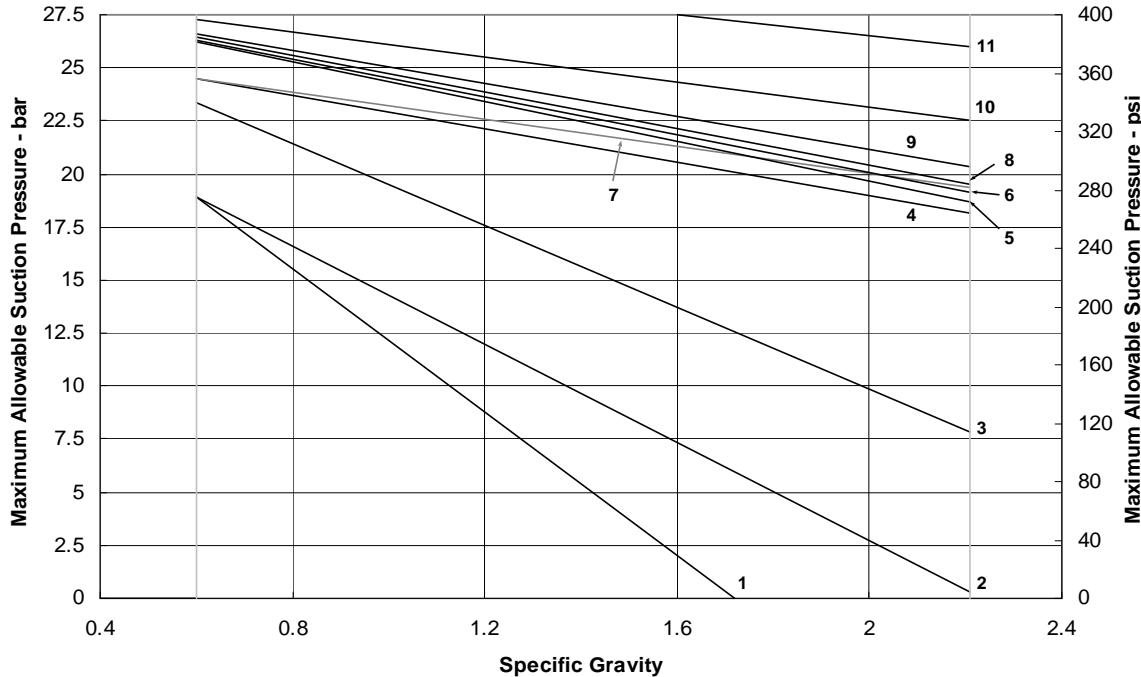
The suction pressure limits for Mark 3 pumps with reverse vane impellers is limited by the values given in figure 3-6 and by the P-T ratings.

Suction pressure for pump sizes 10x8-14, 8x6-16A, 10x8-16, 10x8-16H, and 12x10-18HD (up through 2.0 specific gravity) are limited only by the P-T ratings.

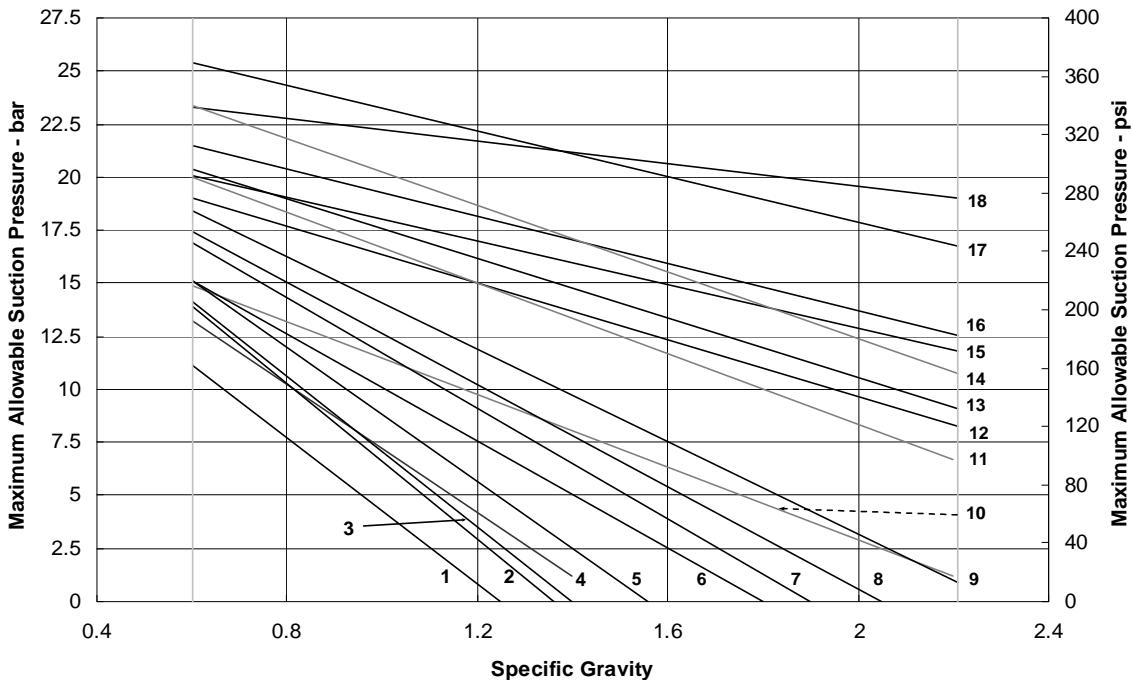
Suction pressure for pumps with open impellers are also limited only by the P-T ratings.

The suction pressure limits for Sealmatic pumps are determined by the repeller head capability found in Bulletin P-18-102e.

**Figure 3-6A: Suction pressure limits 1750 r/min**



**Figure 3-6B: Suction pressure limits 3500 r/min**



**Figure 3-7: Suction pressure reference numbers**

Pump Size	1750	3500
1K 1.5x1-6	7	10
1K 3x1.5-6	10	15
1K 3x2-6 and US-6	10	12
1K 2 x1.5V-6	PT	18
1K 1.5x1-8	7	6
1K 1.5x1.5US-8	PT	16
1K 3x1.5-8	4	4
1K 3x2V-7	PT	11
2K 3x2-8 and US-8	10	7
2K 4x3-8 and US-8	10	13
2K 2x1-10A	8	3
2K 2x1.5V-10A	8	3
2K 3x1.5-10A	10	17
2K 3x2-10A	10	14
2K 3x2V-10 In-Line	11	9
2K 4x3-10	6	2
2K 4x3-10H	3	na
2K 6x4-10	5	8
2K 6x4-10H	10	na
2K 3x1.5-13	9	5
2K 3x2-13	5	1
2K 4x3-13/13	1	na
2K 4x3-13/12	1	na
2K 4x3-13/11 max	1	2
2K 4x3-13HH	10	na
2K 6x4-13A	1	na
2K 6x4-13A/10.25	1	?
3K 8x6-14A	2	na
3K 10x8-14	PT	na
3K 6x4-16	PT	na
3K 8x6-16A	PT	na
3K 10x8-16 & 16H	PT	na
3K 10x8-17	3	na
12X10-18HD	PT	na
Recessed Impellers	PT	PT
Lo-Flo Pumps	PT	PT
Open Impellers	PT	PT

Notes:

1. Self-Primer and In-Line pumps not specifically listed above are to use the standard pump ratings given.  
For example: 2K 3x2V-13 and 2K 3x2US-13 pumps utilize the standard 2K 3x2-13 ratings.
2. P-T: Only limited by Pressure-Temperature ratings.
3. Open impeller pumps including the Lo-Flo and Recessed Impeller products are limited in suction pressure only by the Pressure-Temperature Ratings.
4. Sealmatic Pump suction pressure is limited by the repeller

### 3.4.4 Minimum continuous flow

The minimum continuous flow (MCF) is based on a percentage of the *best efficiency point* (BEP). Figure 3-8 identifies the MCF for all Mark 3 pump models with the exception of the Lo-Flo pump line; there is no MCF associated with this product line.

**Figure 3-8: Minimum continuous flow**

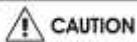
Pump size	MCF % of BEP		
	3500/2900 r/min	1750/1450 r/min	1180/960 r/min
1K3x2-6	20%	10%	10%
1K3x2-7	25%	10%	10%
2K3x2-8	20%	10%	10%
2K4x3-8	20%	10%	10%
2K3x2-10	30%	10%	10%
2K4x3-10	30%	10%	10%
2K6x4-10	40%	10%	10%
2K6x4-10H	n.a.	20%	10%
2K3x1.5-13	30%	10%	10%
2K3x2-13	40%	10%	10%
2K4x3-13	40%	20%	10%
2K4x3-13HH	n.a.	50%	30%
2K6x4-13	60%	40%	10%
3K8x6-14	n.a.	40%	15%
3K10x8-14	n.a.	40%	10%
3K6x4-16	n.a.	50%	10%
3K8x6-16	n.a.	50%	10%
3K10x8-16	n.a.	50%	10%
3K10x8-17	n.a.	50%	10%
3K12x10-18HD	n.a.	60%	10%
All other sizes	10%	10%	10%

### 3.4.5 Minimum suction pipe submergence

To avoid priming problems, consideration should be given to minimum suction pipe submergence when installing Unitized self-priming pumps.

## 4 INSTALLATION

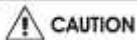
### Zirconium 702 or high chrome iron components



If any of the components of the pump have been made of zirconium or high chrome iron, the following precautionary measures should be followed:

- Use hand wrenches rather than impact wrenches
- This equipment should not be subjected to sudden changes in temperature or pressure
- Avoid striking this equipment with any sharp blows

### Zirconium 705 and high chrome iron components



Avoid any repair or fabrication welds on Zirconium 705 and high chrome iron components.

#### 4.1 Location

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

#### 4.2 Part assemblies

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

#### 4.3 Foundation

##### 4.3.1 Protection of openings and threads

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

##### 4.3.2 In-Line pump mounting

The Mark 3 In-Line can be supported in several ways:

- The pump may be supported by the piping; in which case it is recommended that the suction and discharge pipes be supported adjacent to the pump nozzles
- The pump may be supported under the casing foot or on the optional "pump stand"

The "pump stand" will allow the pump to free stand without the aid of piping. The pump stand may be bolted (and grouted) into place. In this case, the piping loads must be within the limits of the casing and of the "pump stand" as found in section 4.6.

The most advantageous method is the one that permits the pump to move with the piping. This eliminates problems due to thermal expansion, as the pump is designed to withstand forces that the piping is normally capable of transmitting.

##### 4.3.3 Rigid baseplates - overview

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

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

Figure 4-1

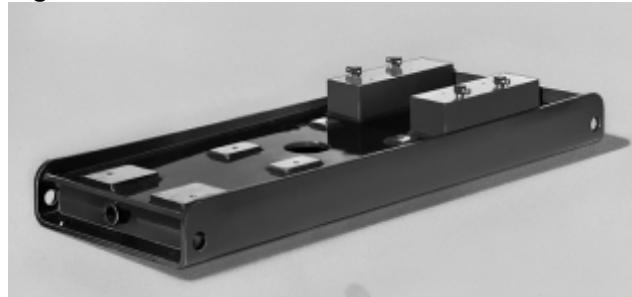


Figure 4-2



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

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

1. The baseplate must provide sufficient rigidity to assure the assembly can be transported and installed, given reasonable care in handling, without damage. It must also be rigid enough when properly installed to resist operating loads.
2. The baseplate must provide a reasonably flat mounting surface for the pump and driver. Uneven surfaces will result in a soft-foot condition that may make alignment difficult or impossible. Experience indicates that a baseplate with a top surface flatness of 1.25 mm/m (0.015 in./ft) across the diagonal corners of the baseplate provides such a mounting surface. Therefore,

this is the tolerance to which we supply our standard baseplate. Some users may desire an even flatter surface, which can facilitate installation and alignment. Flowserve will supply flatter baseplates upon request at extra cost. For example, mounting surface flatness of 0.17 mm/m (0.002 in./ft) is offered on the Flowserve Type E "Ten Point" baseplate shown in figure 4-1.

3. The baseplate must be designed to allow the user to final field align the pump and driver to within their own particular standards and to compensate for any pump or driver movement that occurred during handling. Normal industry practice is to achieve final alignment by moving the motor to match the pump. Flowserve practice is to confirm in our shop that the pump assembly can be accurately aligned. Before shipment, the factory verifies that there is enough horizontal movement capability at the motor to obtain a "perfect" final alignment when the installer puts the baseplate assembly into its original, top leveled, unstressed condition.

## 4.4 Baseplate Mounting

### 4.4.1 Stilt and spring mounted baseplates

Flowserve offers stilt and spring mounted baseplates. (See figure 4-2 for stilt mounted option.) The low vibration levels of Mark 3 pumps allow the use of these baseplates - provided they are of a rigid design. The baseplate is set on a flat surface with no tie down bolts or other means of anchoring it to the floor.

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

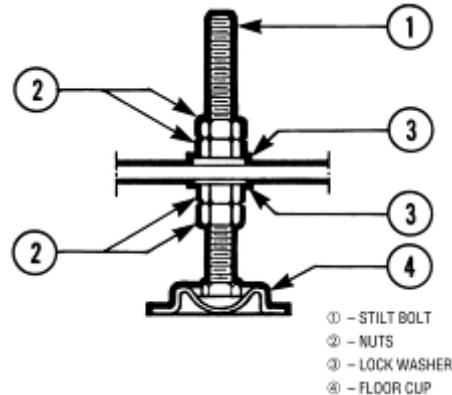
#### 4.4.1.1 Stilt mounted baseplate assembly instructions

Refer to figure 4-3.

- Raise or block up baseplate/pump above the floor to allow for the assembly of the stilts.
- Predetermine or measure the approximate desired height for the baseplate above the floor.
- Set the bottom nuts [2] above the stilt bolt head [1] to the desired height.
- Assemble lock washer [3] down over the stilt bolt.
- Assemble the stilt bolt up through hole in the bottom plate and hold in place.
- Assemble the lock washer [3] and nut [2] on the stilt bolt. Tighten the nut down on the lock washer.
- After all four stilts have been assembled, position the baseplate in place, over the floor cups [4] under each stilt location, and lower the baseplate to the floor.

- Level and make final height adjustments to the suction and discharge pipe by first loosening the top nuts and turning the bottom nuts to raise or lower the baseplate.
- Tighten the top and bottom nuts at the lock washer [3] first then tighten the other nuts.
- It should be noted that the connecting pipelines must be individually supported, and that the stilt mounted baseplate is not intended to support total static pipe load.

**Figure 4-3**



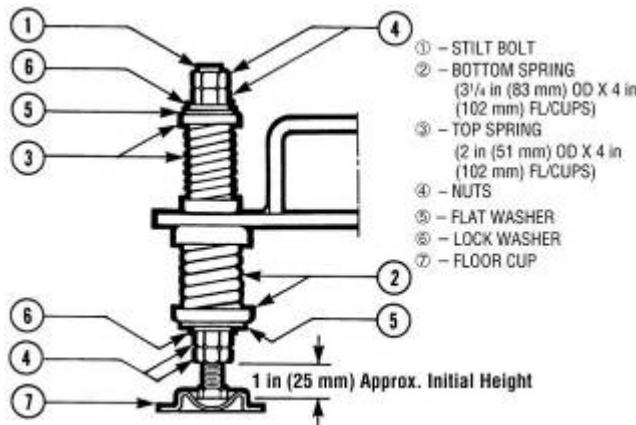
#### 4.4.1.2 Stilt/spring mounted baseplate assembly instructions

Refer to figure 4-4.

- Raise or block up baseplate/pump above the floor to allow for the assembly of the stilts.
- Set the bottom nuts [4] above the stilt bolt head [1]. This allows for 51 mm (2 in.) upward movement for the final height adjustment of the suction/discharge flange.
- Assemble the lock washer [6] flat washer [5] and bottom spring/cup assembly [2] down over the stilt bolt [1].
- Assemble the stilt bolt/bottom spring up through hole in the bottom plate and hold in place.
- Assemble top spring/cup assembly [3] down over stilt bolt.
- Assemble flat washer [5], lock washer [6] and nuts [4] on the stilt bolt.
- Tighten down top nuts, compressing the top spring approximately 13 mm (0.5 in.). Additional compression may be required to stabilize the baseplate.
- After all four stilts have been assembled, position the baseplate in place, over the floor cups [7] under each stilt location, and lower the baseplate down to the floor.
- Level and make final height adjustments to the suction and discharge pipe by first loosening the top nuts, and turning the bottom nuts to raise or lower the baseplate.

- j) Recompress the top spring to the compression established in step g) and lock the nuts in place.
- k) It should be noted that the connecting pipelines must be individually supported, and that the spring mounted baseplate is not intended to support total static pipe loads.

**Figure 4-4**



#### 4.4.1.3 Stilt/spring mounted baseplates - motor alignment

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

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

maintaining a level condition as measured from the pump discharge flange.

- f) Lock the stilt adjusters.

The remaining steps are as listed for new grouted baseplates.

#### 4.4.2 Mounting Grouted Baseplates

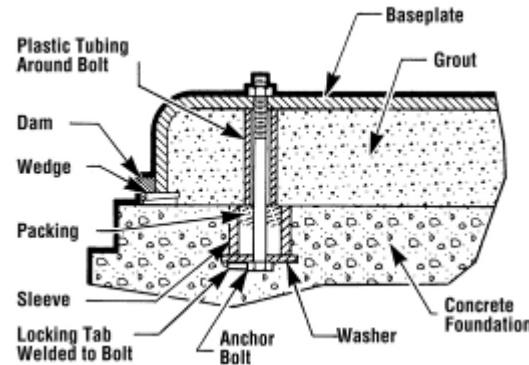
- a) The pump foundation should be located as close to the source of the fluid to be pumped as practical.
- b) There should be adequate space for workers to install, operate, and maintain the pump. The foundation should be sufficient to absorb any vibration and should provide a rigid support for the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

##### 4.4.2.1 Mounting Instructions - All Grouted Bases (Except T5000 Base)

**Note:**

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

**Figure 4-5**



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

- e) Do not bolt the suction or discharge flanges of the pump to the piping until the baseplate foundation is completely installed. If equipped, use leveling jackscrews to level the baseplate. If jackscrews are not provided, shims and wedges should be used. (See Figure 4-5.) Check for levelness in both the longitudinal and lateral directions. Shims should be placed at all base anchor bolt locations, and in the middle edge of the base if the base is more than 1.5 m (5 ft.) long. Do not rely on the bottom of the baseplate to be flat. Standard baseplate bottoms are not machined, and it is not likely that the field mounting surface is flat.
- f) After leveling the baseplate, tighten the anchor bolts. If shims were used, make sure that the baseplate was shimmed near each anchor bolt before tightening. Failure to do this may result in a twist of the baseplate, which could make it impossible to obtain final alignment.
- g) Check the level of the baseplate to make sure that tightening the anchor bolts did not disturb the level of the baseplate. If the anchor bolts did change the level, adjust the jackscrews or shims as needed to level the baseplate.
- h) Continue adjusting the jackscrews or shims and tightening the anchor bolts until the baseplate is level.
- i) Check initial alignment. If the pump and motor were removed from the baseplate proceed with step j) first, then the pump and motor should be reinstalled onto the baseplate using Flowserv's factory preliminary alignment procedure as described in section 4.5, and then continue with the following. As described above, pumps are given a preliminary alignment at the factory. This preliminary alignment is done in a way that ensures that, if the installer duplicates the factory conditions, there will be sufficient clearance between the motor hold down bolts and motor foot holes to move the motor into final alignment. If the pump and motor were properly reinstalled to the baseplate or if they were not removed from the baseplate and there has been no transit damage, and also if the above steps where done properly, the pump and driver should be within 0.38 mm (0.015 in.) FIM (Full Indicator Movement) parallel, and 0.0025 mm/mm (0.0025 in./in.) FIM angular. If this is not the case, first check to see if the driver mounting fasteners are centered in the driver feet holes. If not, re-center the fasteners and perform a preliminary alignment to the above tolerances by shimming under the motor for vertical alignment, and by moving the pump for horizontal alignment.
- j) Grout the baseplate. A non-shrinking grout should be used. Make sure that the grout fills the

area under the baseplate. After the grout has cured, check for voids and repair them. Jackscrews, shims and wedges should be removed from under the baseplate at this time. If they were to be left in place, they could rust, swell, and cause distortion in the baseplate.

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

#### **4.4.2.2 Mounting instructions Pump with C-flange motor adapter**

Refer to standard pump foundation for installation of grouted and adjustable type baseplates. It may be necessary to remove the pump from the baseplate to access the grout hole.

Refer to standard pump piping for piping recommendations.

Temporary supports (installed for shipping only) should be removed from under the motor.

### **4.5 Initial alignment**

#### **4.5.1 Horizontal initial alignment procedure**

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

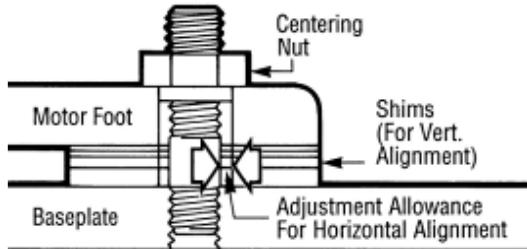
The factory alignment procedure is summarized below:

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

condition. If any is present it is eliminated by shimming.

- d) The motor feet holes are centered on the motor mounting fasteners. This is done by using a centering nut as shown in figure 4-9.

**Figure 4-9**



- e) The motor is fastened in place by tightening the nuts on two diagonal motor mounting studs.
- f) The pump is put onto the baseplate and leveled. The foot piece under the bearing housing is adjustable. It is used to level the pump, if necessary.

Mark 3A and ANSI 3A design

If an adjustment is necessary, add or remove shims [3126.1] between the foot piece and the bearing housing.

Mark 3 design (old)

If an adjustment is necessary, the adjuster nut [6576] is used to move the footpiece up or down.

- g) The spacer coupling gap is verified.
- h) The parallel and angular vertical alignment is made by shimming under the motor.
- i) The motor feet holes are again centered on the motor mounting studs using the centering nut. At this point the centering nut is removed and replaced with a standard nut. This gives maximum potential mobility for the motor to be horizontally moved during final, field alignment. All four motor feet are tightened down.
- j) The pump and motor shafts are then aligned horizontally, both parallel and angular, by moving the pump to the fixed motor. The pump feet are tightened down.
- k) Both horizontal and vertical alignment is again final checked as is the coupling spacer gap.

See section 4.8, *Final shaft alignment*.

#### 4.5.2 In-Line initial alignment procedure

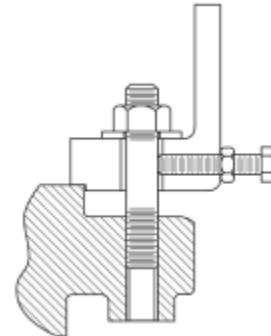
The factory alignment proceed procedure ensures that the unit may be aligned in the field. The initial alignment is no more than 0.38 mm (0.015 in.) parallel, and 0.0025 mm/mm (0.0025 in./in.) angular misalignment.

The Mark 3 In-Line incorporates motor alignment capabilities. Parallel alignment is achieved by moving the motor adapter and motor as an assembly

relative to the power end. Four adjustment screws (as shown in figures 4-10 and 4-11) allow for precise changes in parallel alignment. Angular alignment is controlled by machining tolerances, but cannot prevent uneven cover gasket compression.

- a) Check angular alignment. Additional torque may be applied to the appropriate casing bolts to correct angularity.
- b) Check parallel alignment within a plane defined by the adjusters at opposite corners of the motor adapter. To make corrections, the motor adapter nuts [6580.3] must be slightly loosened to allow the motor adapter to move. All adjusters except for the one in the desired direction of motor movement should be loosened during adjustment. Tighten the adjuster slowly against the stud until desired alignment numbers are reached.
- c) Check parallel alignment within a plane 90 degrees from the first. Corrections are made as described in the previous step.
- d) Several iterations between planes may be necessary. Tighten all fasteners and recheck alignment.

**Figure 4-10**



**Figure 4-11**



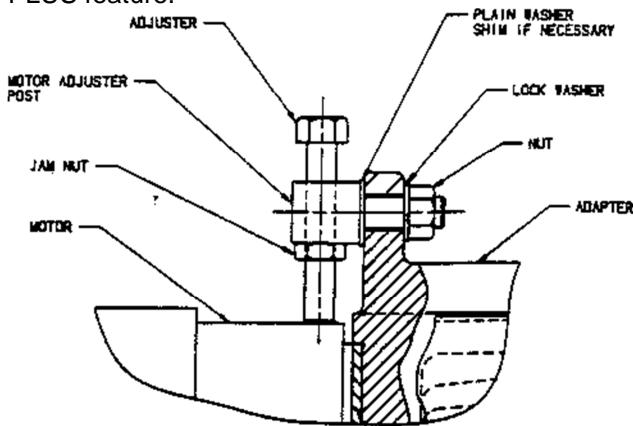
#### 4.5.3 C-Flange motor alignment

C-flange motor adapters provide a means of obtaining pump to motor alignment. A C-flange type motor is mounted on the pump bearing housing with the use of an intermediate adapter. Alignment is achieved through the use of machined locating and piloting surfaces on the bearing housing and adapter. Care should be taken to insure these surfaces are kept free from handling damage defects or dirt which will affect alignment.

Alignment between the pump shaft and motor shaft is built-in by the precise machining of the parts that position these shafts. Parallel alignment of .007 and angular alignment of .002 can be expected. Should a more refined alignment be desired, an optional alignment feature is available. See section 4.5.4

#### 4.5.4 C-Plus alignment feature

If the C-PLUS alignment feature is desired the spacer ring must be installed before the motor is assembled. The drawing below shows the components of the C-PLUS feature.



The motor mounting screws must be snug but not tight when attempting to adjust motor location. Depending on the size of motor it may be necessary to check the alignment with the motor fasteners tight. Corrections may be made until 0.002" TIR (or the desired) alignment is achieved. The adjusters, adjuster jam nuts and the motor fasteners should all be tightened. The indicator kit should be removed, the coupling and coupling guard properly installed

### 4.6 Piping

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

#### 4.6.1 Suction and discharge piping

All piping must be independently supported, accurately aligned and preferably connected to the pump by a short length of flexible piping. The pump should not have to support the weight of the pipe or compensate for misalignment. It should be possible to install suction and discharge bolts through mating flanges without pulling or prying either of the flanges. All piping must be tight. Pumps may air-bind if air is allowed to leak into the piping. If the pump flange(s) have tapped holes, select flange fasteners with thread engagement at least equal to the fastener diameter but that do not bottom out in the tapped holes before the joint is tight.

#### 4.6.2 Suction piping

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

Figure 4-12 illustrates the ideal piping configuration with a minimum of 10 pipe diameters between the source and the pump suction. In most cases, horizontal reducers should be eccentric and mounted with the flat side up as shown in figure 4-13 with a maximum of one pipe size reduction. Never mount eccentric reducers with the flat side down. Horizontally mounted concentric reducers should not be used if there is any possibility of entrained air in the process fluid. Vertically mounted concentric reducers are acceptable. In applications where the fluid is completely de-aerated and free of any vapor or suspended solids, concentric reducers are preferable to eccentric reducers.

Figure 4-12

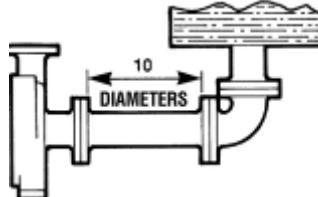
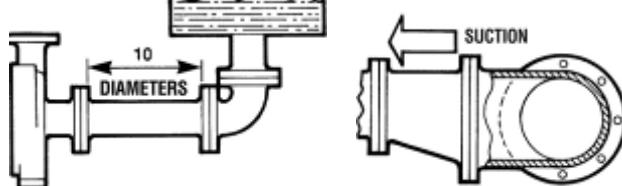


Figure 4-13



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

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

Refer to section 3.4 for performance and operating limits.

#### **4.6.2.1 Mark 3 Self-Priming Pumps**

The suction piping must be as short as possible and be as close to the diameter of the suction nozzle as is practical. The pump works by removing the air contained in the suction piping. Once removed, it operates exactly the same as a flooded suction standard pump. Longer and larger the suction pipes have a greater volume of air that has to be removed, resulting in longer priming time. The suction piping and seal chamber must be airtight to allow priming to occur. When possible, it is recommended that suction piping be sloped slightly towards the casing to limit priming fluid loss down the suction line during priming and shutdown.

#### **4.6.3 Discharge piping**

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



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

#### **4.6.3.1 Mark 3 Self-Priming Pumps**

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

#### **4.6.4 Allowable nozzle loads**

Flowserve chemical process pumps meet or exceed the allowable nozzle loads given by ANSI/HI 9.6.2. The following paragraphs describe how to calculate the allowable loads for each pump type and how to determine if the applied loads are acceptable. The first configuration covered is ASME B73.1M pumps, including the Mark 3 Standard, Sealmatic, Lo-Flo, Recessed Impeller, and Unitized Self-Priming pumps. The second configuration covered is the ASME B73.2M vertical, Mark 3 In-Line pump.

##### **4.6.4.1 Mark 3 horizontal pumps (ASME B73.1M)**

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

- a) Determine the appropriate casing "Material Group No." from figure 3-2.
- b) Find the "Casing material correction factor" in Figure 4-14 based upon the "Material Group No." and operating temperature. Interpolation may be used to determine the correction factor for a specific temperature.
- c) Find the "Baseplate correction factor" in Figure 4-15. The correction factor depends upon how the baseplate is to be installed.
- d) Locate the pump model being evaluated in Figure 4-19 and multiply each load rating by the casing correction factor. Record the "adjusted Figure 4-19 loads".
- e) Locate the pump model being evaluated in Figures 4-20 and 4-21 and multiply each load rating by the baseplate correction factor. Record the adjusted Figure 4-20 and 4-21 loads.
- f) Compare the "adjusted Figure 4-19 loads" to the values shown in figure 4-18. The lower of these two values should be used as the adjusted figure 4-18 values. *(The HI standard also asks that figure 4-18 loads be reduced if figure 4-20 or 4-21 values are lower. Flowserve does not follow this step.)*
- g) Calculate the applied loads at the casing flanges according to the coordinate system found in figure 4-16. The 12 forces and moments possible are  $F_{xs}$ ,  $F_{ys}$ ,  $F_{zs}$ ,  $M_{xs}$ ,  $M_{ys}$ ,  $M_{zs}$ ,  $F_{xd}$ ,  $F_{yd}$ ,  $F_{zd}$ ,  $M_{xd}$ ,  $M_{yd}$  and  $M_{zd}$ . For example,  $F_{xd}$  designates Force in the "x" direction on the discharge flange.  $M_{ys}$  designates the Moment about the "y"-axis on the suction flange.
- h) Figure 4-17 gives the acceptance criteria equations. For long coupled pumps, equation sets 1 through 5 must be satisfied. For close coupled and C-face pumps, only equation sets 1 and 2 must be satisfied.
- i) Equation set 1. Each applied load is divided by the corresponding adjusted figure 4-18 value. The absolute value of each ratio must be less than or equal to one.
- j) Equation set 2. The summation of the absolute values of each ratio must be less than or equal to two. The ratios are the applied load divided by the adjusted figure 4-19 values.
- k) Equation sets 3 and 4. These equations are checking for coupling misalignment due to nozzle loading in each axis. Each applied load is divided by the corresponding adjusted load from figure 4-20 and 4-21. The result of each equation must be between one and negative one.
- l) Equation set 5. This equation calculates the total shaft movement from the results of equations 3 and 4. The result must be less than or equal to one.

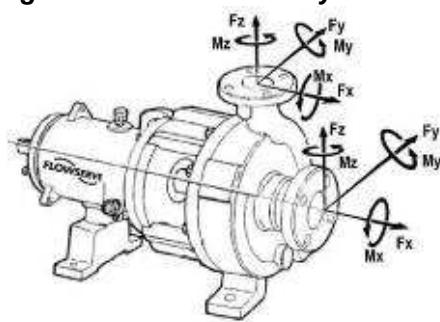
**Figure 4-14: Casing Material Correction Factors**

Temp °C	Temp °F	DCI	Carbon Steel	Material Group No.												Ti, Ti- Pd, Zr	High Chrome -18 to 171°C (0 to 340°F)
				1.0	1.1	2.1	2.2	2.4	2.8	3.2	3.4	3.5	3.7	3.8	3.17		
				Austenitic Steels				Nickel and Nickel Alloys									
				Type 304 and 304L	Type 316 and 316L	Type 321	CD-4MCu	Nickel	Monel	Inconel	Hast B.	Hast C.	Alloy 20				
-129	-200			1.00	1.00	1.00		0.50						0.83			
-73	-100			1.00	1.00	1.00	1.00	0.50	0.83	0.93	1.00	1.00	0.83	0.89			
-29	-20	0.89	1.00	1.00	1.00	1.00	1.00	0.50	0.83	0.93	1.00	1.00	0.83	0.89	0.65		
38	100	0.89	1.00	1.00	1.00	1.00	1.00	0.50	0.83	0.93	1.00	1.00	0.83	0.89	0.65		
93	200	0.83	0.94	0.83	0.86	0.93	1.00	0.50	0.74	0.88	1.00	1.00	0.72	0.86	0.65		
150	300	0.78	0.91	0.75	0.78	0.83	0.92	0.50	0.69	0.82	1.00	1.00	0.65	0.81	0.65		
205	400	0.73	0.88	0.69	0.72	0.69	0.85	0.50	0.67	0.77	0.98	0.98	0.58	0.69	0.65		
260	500	0.69	0.83	0.63	0.67	0.64	0.80	0.50	0.66	0.74	0.92	0.92	0.54	0.57			
315	600	0.65	0.76	0.60	0.63	0.60	0.77	0.50	0.66	0.74	0.84	0.84	0.50	0.45			
344	650	0.63	0.74	0.60	0.62	0.60			0.66	0.73	0.82	0.82		0.39			
370	700			0.74	0.59	0.60	0.58			0.66	0.73	0.79	0.79		0.33		

**Figure 4-15: Baseplate correction factors**

Base Type	Grouted	Bolted	Stilt Mounted
Type A	1.0	0.7	0.65
Type B - Polybase	1.0	n/a	0.95
Type C	n/a	1.0	1.0
Type D	1.0	0.8	0.75
Type E - PIP	1.0	0.95	n/a
Type T5000	1.0	n/a	n/a
Polyshield - baseplate/foundation	1.0	n/a	n/a

**Figure 4-16: Coordinate system**



**Figure 4-17: Acceptance criteria equations**

Set	Equations	Figure	Remarks
1	$\left  \frac{F_{xs}}{F_{xs\_adj}} \right  \leq 1.0, \left  \frac{F_{ys}}{F_{ys\_adj}} \right  \leq 1.0, \left  \frac{F_{zs}}{F_{zs\_adj}} \right  \leq 1.0, \left  \frac{M_{xs}}{M_{xs\_adj}} \right  \leq 1.0, \left  \frac{M_{ys}}{M_{ys\_adj}} \right  \leq 1.0, \left  \frac{M_{zs}}{M_{zs\_adj}} \right  \leq 1.0,$ $\left  \frac{F_{xd}}{F_{xd\_adj}} \right  \leq 1.0, \left  \frac{F_{yd}}{F_{yd\_adj}} \right  \leq 1.0, \left  \frac{F_{zd}}{F_{zd\_adj}} \right  \leq 1.0, \left  \frac{M_{xd}}{M_{xd\_adj}} \right  \leq 1.0, \left  \frac{M_{yd}}{M_{yd\_adj}} \right  \leq 1.0, \left  \frac{M_{zd}}{M_{zd\_adj}} \right  \leq 1.0$	Adjusted 4-18	Maximum individual loading
2	$\left  \frac{F_{xs}}{F_{xs\_adj}} \right  + \left  \frac{F_{ys}}{F_{ys\_adj}} \right  + \left  \frac{F_{zs}}{F_{zs\_adj}} \right  + \left  \frac{M_{xs}}{M_{xs\_adj}} \right  + \left  \frac{M_{ys}}{M_{ys\_adj}} \right  + \left  \frac{M_{zs}}{M_{zs\_adj}} \right  +$ $\left  \frac{F_{xd}}{F_{xd\_adj}} \right  + \left  \frac{F_{yd}}{F_{yd\_adj}} \right  + \left  \frac{F_{zd}}{F_{zd\_adj}} \right  + \left  \frac{M_{xd}}{M_{xd\_adj}} \right  + \left  \frac{M_{yd}}{M_{yd\_adj}} \right  + \left  \frac{M_{zd}}{M_{zd\_adj}} \right  \leq 2.0$	Adjusted 4-19	Nozzle stress, bolt stress, pump slippage
3	$A = \frac{F_{ys}}{F_{ys\_adj}} + \frac{M_{xs}}{M_{xs\_adj}} + \frac{M_{ys}}{M_{ys\_adj}} + \frac{M_{zs}}{M_{zs\_adj}} +$ $\frac{F_{yd}}{F_{yd\_adj}} + \frac{M_{xd}}{M_{xd\_adj}} + \frac{M_{yd}}{M_{yd\_adj}} + \frac{M_{zd}}{M_{zd\_adj}}$ $-1.0 \leq A \leq 1.0$	Adjusted 4-20	y-axis movement
4	$B = \frac{F_{xs}}{F_{xs\_adj}} + \frac{F_{zs}}{F_{zs\_adj}} + \frac{M_{xs}}{M_{xs\_adj}} + \frac{M_{ys}}{M_{ys\_adj}} + \frac{M_{zs}}{M_{zs\_adj}} +$ $\frac{F_{xd}}{F_{xd\_adj}} + \frac{F_{yd}}{F_{yd\_adj}} + \frac{F_{zd}}{F_{zd\_adj}} + \frac{M_{xd}}{M_{xd\_adj}} + \frac{M_{yd}}{M_{yd\_adj}} + \frac{M_{zd}}{M_{zd\_adj}}$ $-1.0 \leq B \leq 1.0$	Adjusted 4-21	z-axis movement
5	$\sqrt{A^2 + B^2} \leq 1.0$	-	Combined axis

**Figure 4-18: Maximum individual loading**

Pump size	Suction Flange						Discharge Flange					
	Forces N (lbf)			Moments Nm (lbf·ft)			Forces N (lbf)			Moments Nm (lbf·ft)		
	Fxs	Fys	Fzs	Mxs	Mys	Mzs	Fxd	Fyd	Fzd	Mxd	Myd	Mzd
1K 1.5x1-LF4	4 670 (1 050)	3 336 (750)	3 336 (750)	976 (720)	231 (170)	231 (170)	3 558 (800)	6 005 (1350)	13 344 (3 000)	556 (410)	556 (410)	556 (410)
1K 1.5x1-6	4 670 (1 050)	3 336 (750)	3 336 (750)	976 (720)	231 (170)	231 (170)	3 558 (800)	6 005 (1350)	13 344 (3 000)	556 (410)	556 (410)	556 (410)
1K 3x1.5-6	4 670 (1 050)	5 516 (1 240)	5 560 (1 250)	1 220 (900)	664 (490)	664 (490)	3 558 (800)	6 005 (1 350)	13 344 (3 000)	678 (500)	746 (550)	692 (510)
1K 3x2-6 and US-6	4 670 (1 050)	4 670 (1 050)	4 670 (1 050)	1 220 (900)	298 (220)	298 (220)	3 558 (800)	6 005 (1 350)	13 344 (3 000)	678 (500)	1 356 (1 000)	692 (510)
1K 1.5x1-8 and LF8	4 670 (1 050)	5 382 (1 210)	5 382 (1 210)	976 (720)	258 (190)	258 (190)	3 558 (800)	6 005 (1 350)	13 344 (3 000)	488 (360)	488 (360)	488 (360)
1K 1.5x1.5US-8	4 670 (1 050)	5 382 (1 210)	5 382 (1 210)	976 (720)	258 (190)	258 (190)	3 558 (800)	6 005 (1 350)	13 344 (3 000)	488 (360)	488 (360)	488 (360)
1K 3x1.5-8	4 670 (1 050)	5 516 (1 240)	5 560 (1 250)	1 220 (900)	664 (490)	664 (490)	3 558 (800)	6 005 (1 350)	13 344 (3 000)	597 (440)	597 (440)	597 (440)
2K 3x2-8 and US-8	12 010 (2 700)	6 005 (1 350)	6 672 (1 500)	1 763 (1 300)	814 (600)	814 (600)	6 227 (1 400)	6 005 (1 350)	14 456 (3 250)	895 (660)	895 (660)	895 (660)
2K 4x3-8 and US-8	12 010 (2 700)	6 005 (1 350)	6 672 (1 500)	1 763 (1 300)	475 (350)	475 (350)	6 227 (1 400)	6 005 (1 350)	14 456 (3 250)	1 627 (1 200)	1 980 (1 460)	936 (690)
2K 2x1-10A and LF10	10 408 (2 340)	4 270 (960)	4 270 (960)	1 722 (1 270)	298 (220)	298 (220)	6 227 (1 400)	6 005 (1 350)	14 456 (3 250)	895 (660)	895 (660)	895 (660)
2K 2x1.5US-10A	10 408 (2 340)	4 270 (960)	4 270 (960)	1 722 (1 270)	298 (220)	298 (220)	6 227 (1 400)	6 005 (1 350)	14 456 (3 250)	895 (660)	895 (660)	895 (660)
2K 2x2R-10	10 408 (2 340)	4 270 (960)	4 270 (960)	1 722 (1 270)	298 (220)	298 (220)	6 227 (1 400)	6 005 (1 350)	14 456 (3 250)	895 (660)	895 (660)	895 (660)
2K 3x1.5-10A	12 010 (2 700)	6 005 (1 350)	6 672 (1 500)	1 763 (1 300)	570 (420)	570 (420)	6 227 (1 400)	6 005 (1 350)	14 456 (3 250)	502 (370)	502 (370)	502 (370)
2K 3x2-10A	12 010 (2 700)	6 005 (1 350)	6 583 (1 480)	1 763 (1 300)	420 (310)	420 (310)	6 227 (1 400)	6 005 (1 350)	14 456 (3 250)	759 (560)	759 (560)	759 (560)
2K 3x2US-10	12 010 (2 700)	6 005 (1 350)	6 583 (1 480)	1 763 (1 300)	420 (310)	420 (310)	6 227 (1 400)	6 005 (1 350)	14 456 (3 250)	759 (560)	759 (560)	759 (560)
2K 3x3R-10	12 010 (2 700)	6 005 (1 350)	6 583 (1 480)	1 763 (1 300)	420 (310)	420 (310)	6 227 (1 400)	6 005 (1 350)	14 456 (3 250)	759 (560)	759 (560)	759 (560)
2K 4x3-10 and 10H	10 230 (2 300)	6 005 (1 350)	6 672 (1 500)	1 763 (1 300)	420 (310)	420 (310)	6 227 (1 400)	6 005 (1 350)	14 456 (3 250)	1 627 (1 200)	1 980 (1 460)	936 (690)
2K 4x3US-10H	10 230 (2 300)	6 005 (1 350)	6 672 (1 500)	1 763 (1 300)	420 (310)	420 (310)	6 227 (1 400)	6 005 (1 350)	14 456 (3 250)	1 627 (1 200)	1 980 (1 460)	936 (690)
2K 6x4-10 and 10H	12 010 (2 700)	6 005 (1 350)	6 672 (1 500)	1 763 (1 300)	1 492 (1 100)	1 492 (1 100)	6 227 (1 400)	6 005 (1 350)	14 456 (3 250)	1 627 (1 200)	2 034 (1 500)	936 (690)
2K 3x1.5-13 and LF13	12 010 (2 700)	6 005 (1 350)	6 672 (1 500)	1 763 (1 300)	909 (670)	909 (670)	6 227 (1 400)	6 005 (1 350)	14 456 (3 250)	719 (530)	719 (530)	719 (530)
2K 3x2-13	8 540 (1 920)	5 471 (1 230)	5 471 (1 230)	1 763 (1 300)	475 (350)	475 (350)	6 227 (1 400)	6 005 (1 350)	14 456 (3 250)	1 627 (1 200)	1 722 (1 270)	936 (690)
2K 3x2US-13	8 540 (1 920)	5 471 (1 230)	5 471 (1 230)	1 763 (1 300)	475 (350)	475 (350)	6 227 (1 400)	6 005 (1 350)	14 456 (3 250)	1 627 (1 200)	1 722 (1 270)	936 (690)
2K 4x3-13 and 13HH	12 010 (2 700)	6 005 (1 350)	6 672 (1 500)	1 763 (1 300)	542 (400)	542 (400)	6 227 (1 400)	6 005 (1 350)	14 456 (3 250)	1 627 (1 200)	2 034 (1 500)	936 (690)
2K 4x3US-13	12 010 (2 700)	6 005 (1 350)	6 672 (1 500)	1 763 (1 300)	542 (400)	542 (400)	6 227 (1 400)	6 005 (1 350)	14 456 (3 250)	1 627 (1 200)	2 034 (1 500)	936 (690)
2K 4x3R-13	12 010 (2 700)	6 005 (1 350)	6 672 (1 500)	1 763 (1 300)	542 (400)	542 (400)	6 227 (1 400)	6 005 (1 350)	14 456 (3 250)	1 627 (1 200)	2 034 (1 500)	936 (690)
2K 6x4-13A	12 010 (2 700)	6 005 (1 350)	6 672 (1 500)	1 763 (1 300)	1 763 (1 300)	1 492 (1 100)	6 227 (1 400)	6 005 (1 350)	14 456 (3 250)	1 627 (1 200)	2 034 (1 500)	936 (690)
2K 6x4US-13A	12 010 (2 700)	6 005 (1 350)	6 672 (1 500)	1 763 (1 300)	1 763 (1 300)	1 492 (1 100)	6 227 (1 400)	6 005 (1 350)	14 456 (3 250)	1 627 (1 200)	2 034 (1 500)	936 (690)
2K 6x4R-13	12 010 (2 700)	6 005 (1 350)	6 672 (1 500)	1 763 (1 300)	1 763 (1 300)	1 492 (1 100)	6 227 (1 400)	6 005 (1 350)	14 456 (3 250)	1 627 (1 200)	2 034 (1 500)	936 (690)
3K 8x6-14A	15 568 (3 500)	14 145 (3 180)	8 896 (2 000)	2 034 (1 500)	1 587 (1 170)	1 587 (1 170)	6 672 (1 500)	13 344 (3 000)	15 568 (3 500)	1 695 (1 250)	3 851 (2 840)	3 851 (2 840)
3K 10x8-14	15 568 (3 500)	14 145 (3 180)	8 896 (2 000)	2 034 (1 500)	2 712 (2 000)	2 915 (2 150)	6 672 (1 500)	13 344 (3 000)	15 568 (3 500)	1 695 (1 250)	3 851 (2 840)	3 851 (2 840)
3K 6x4-16	15 568 (3 500)	12 721 (2 860)	8 006 (1 800)	1 831 (1 350)	1 431 (1 055)	1 431 (1 350)	6 005 (1 350)	12 010 (2 700)	14 011 (3 150)	1 526 (1 125)	3 465 (2 555)	3 465 (2 555)
3K 8x6-16A	15 568 (3 500)	14 145 (3 180)	8 896 (2 000)	2 034 (1 500)	2 007 (1 480)	2 007 (1 480)	6 672 (1 500)	13 344 (3 000)	15 568 (3 500)	1 695 (1 250)	3 851 (2 840)	3 851 (2 840)
3K 10x8-16 and 16H	15 568 (3 500)	14 145 (3 180)	8 896 (2 000)	2 034 (1 500)	1 532 (1 130)	1 532 (1 130)	6 672 (1 500)	13 344 (3 000)	15 568 (3 500)	1 695 (1 250)	3 851 (2 840)	3 851 (2 840)
3K 10x8-17	15 568 (3 500)	14 145 (3 180)	8 896 (2 000)	2 034 (1 500)	1 532 (1 130)	1 532 (1 130)	6 672 (1 500)	13 344 (3 000)	15 568 (3 500)	1 695 (1 250)	3 851 (2 840)	3 851 (2 840)
3K 12x10-18HD	8000 (1800)	5340 (1200)	6670 (1500)	6100 (4500)	4610 (3400)	2980 (2200)	5340 (1200)	6670 (1500)	4450 (1000)	5020 (3700)	3800 (2800)	2440 (1800)

**Figure 4-19: Maximum combined loading**

Pump size	Suction Flange						Discharge Flange					
	Forces N (lbf)			Moments Nm (lbf·ft)			Forces N (lbf)			Moments Nm (lbf·ft)		
	Fxs	Fys	Fzs	Mxs	Mys	Mzs	Fxd	Fyd	Fzd	Mxd	Myd	Mzd
1K 1.5x1-LF4	8 985 (2 020)	3 336 (750)	3 336 (750)	2 481 (1 830)	231 (170)	231 (170)	8 985 (2 020)	6 005 (1 350)	27 756 (6 240)	556 (410)	556 (410)	556 (410)
1K 1.5x1-6	8 985 (2 020)	3 336 (750)	3 336 (750)	2 481 (1 830)	231 (170)	231 (170)	8 985 (2 020)	6 005 (1 350)	27 756 (6 240)	556 (410)	556 (410)	556 (410)
1K 3x1.5-6	8 985 (2 020)	5 516 (1 240)	9 385 (2 110)	3 105 (2 290)	664 (490)	664 (490)	8 985 (2 020)	6 005 (1 350)	27 756 (6 240)	746 (550)	746 (550)	692 (510)
1K 3x2-6 and US-6	8 985 (2 020)	4 670 (1 050)	4 670 (1 050)	3 105 (2 290)	298 (220)	298 (220)	8 985 (2 020)	6 005 (1 350)	27 756 (6 240)	1 397 (1 030)	1 397 (1 030)	692 (510)
1K 1.5x1-8 and LF8	8 985 (2 020)	5 382 (1 210)	5 382 (1 210)	2 481 (1 830)	258 (190)	258 (190)	8 985 (2 020)	6 005 (1 350)	27 756 (6 240)	488 (360)	488 (360)	488 (360)
1K 1.5x1.5US-8	8 985 (2 020)	5 382 (1 210)	5 382 (1 210)	2 481 (1 830)	258 (190)	258 (190)	8 985 (2 020)	6 005 (1 350)	27 756 (6 240)	488 (360)	488 (360)	488 (360)
1K 3x1.5-8	8 985 (2 020)	5 516 (1 240)	7 295 (1 640)	3 105 (2 290)	664 (490)	664 (490)	8 985 (2 020)	6 005 (1 350)	27 756 (6 240)	597 (440)	597 (440)	597 (440)
2K 3x2-8 and US-8	12 010 (2 700)	6 005 (1 350)	11 076 (2 490)	5 058 (3 730)	814 (600)	814 (600)	8 763 (1 970)	6 005 (1 350)	27 756 (6 240)	895 (660)	895 (660)	895 (660)
2K 4x3-8 and US-8	12 010 (2 700)	6 005 (1 350)	8 184 (1 840)	5 058 (3 730)	475 (350)	475 (350)	8 985 (2 020)	6 005 (1 350)	27 756 (6 240)	1 980 (1 460)	1 980 (1 460)	936 (690)
2K 2x1-10A and LF10	10 408 (2 340)	4 270 (960)	4 270 (960)	4 936 (3 640)	298 (220)	298 (220)	8 985 (2 020)	6 005 (1 350)	27 756 (6 240)	895 (660)	895 (660)	895 (660)
2K 2x1.5US-10A	10 408 (2 340)	4 270 (960)	4 270 (960)	4 936 (3 640)	298 (220)	298 (220)	8 985 (2 020)	6 005 (1 350)	27 756 (6 240)	895 (660)	895 (660)	895 (660)
2K 2x2R-10	10 408 (2 340)	4 270 (960)	4 270 (960)	4 936 (3 640)	298 (220)	298 (220)	8 985 (2 020)	6 005 (1 350)	27 756 (6 240)	895 (660)	895 (660)	895 (660)
2K 3x1.5-10A	12 010 (2 700)	6 005 (1 350)	8 496 (1 910)	5 058 (3 730)	570 (420)	570 (420)	8 629 (1 940)	6 005 (1 350)	27 756 (6 240)	502 (370)	502 (370)	502 (370)
2K 3x2-10A	12 010 (2 700)	6 005 (1 350)	6 583 (1 480)	5 058 (3 730)	420 (310)	420 (310)	8 985 (2 020)	6 005 (1 350)	27 756 (6 240)	759 (560)	759 (560)	759 (560)
2K 3x2US-10	12 010 (2 700)	6 005 (1 350)	6 583 (1 480)	5 058 (3 730)	420 (310)	420 (310)	8 985 (2 020)	6 005 (1 350)	27 756 (6 240)	759 (560)	759 (560)	759 (560)
2K 3x3R-10	12 010 (2 700)	6 005 (1 350)	6 583 (1 480)	5 058 (3 730)	420 (310)	420 (310)	8 985 (2 020)	6 005 (1 350)	27 756 (6 240)	759 (560)	759 (560)	759 (560)
2K 4x3-10 and 10H	10 230 (2 300)	6 005 (1 350)	7 295 (1 640)	5 058 (3 730)	420 (310)	420 (310)	8 985 (2 020)	6 005 (1 350)	27 756 (6 240)	1 980 (1 460)	1 980 (1 460)	936 (690)
2K 4x3US-10H	10 230 (2 300)	6 005 (1 350)	7 295 (1 640)	5 058 (3 730)	420 (310)	420 (310)	8 985 (2 020)	6 005 (1 350)	27 756 (6 240)	1 980 (1 460)	1 980 (1 460)	936 (690)
2K 6x4-10 and 10H	12 010 (2 700)	6 005 (1 350)	27 756 (6 240)	5 058 (3 730)	1 492 (1 100)	1 492 (1 100)	8 985 (2 020)	6 005 (1 350)	27 756 (6 240)	4 204 (3 100)	4 204 (3 100)	936 (690)
2K 3x1.5-13 and LF13	12 010 (2 700)	6 005 (1 350)	13 611 (3 060)	5 058 (3 730)	909 (670)	909 (670)	8 985 (2 020)	6 005 (1 350)	27 756 (6 240)	719 (530)	719 (530)	719 (530)
2K 3x2-13	8 540 (1 920)	5 471 (1 230)	5 471 (1 230)	5 058 (3 730)	475 (350)	475 (350)	8 985 (2 020)	6 005 (1 350)	27 756 (6 240)	1 980 (1 460)	1 980 (1 460)	936 (690)
2K 3x2US-13	8 540 (1 920)	5 471 (1 230)	5 471 (1 230)	5 058 (3 730)	475 (350)	475 (350)	8 985 (2 020)	6 005 (1 350)	27 756 (6 240)	1 980 (1 460)	1 980 (1 460)	936 (690)
2K 4x3-13 and 13HH	12 010 (2 700)	6 005 (1 350)	10 631 (2 390)	5 058 (3 730)	542 (400)	542 (400)	8 985 (2 020)	6 005 (1 350)	27 756 (6 240)	2 346 (1 730)	2 346 (1 730)	936 (690)
2K 4x3US-13	12 010 (2 700)	6 005 (1 350)	10 631 (2 390)	5 058 (3 730)	542 (400)	542 (400)	8 985 (2 020)	6 005 (1 350)	27 756 (6 240)	2 346 (1 730)	2 346 (1 730)	936 (690)
2K 4x3R-13	12 010 (2 700)	6 005 (1 350)	10 631 (2 390)	5 058 (3 730)	542 (400)	542 (400)	8 985 (2 020)	6 005 (1 350)	27 756 (6 240)	2 346 (1 730)	2 346 (1 730)	936 (690)
2K 6x4-13A	12 010 (2 700)	6 005 (1 350)	27 756 (6 240)	5 058 (3 730)	6 753 (4 980)	1 492 (1 100)	8 985 (2 020)	6 005 (1 350)	27 756 (6 240)	2 915 (2 150)	2 915 (2 150)	936 (690)
2K 6x4US-13A	12 010 (2 700)	6 005 (1 350)	27 756 (6 240)	5 058 (3 730)	6 753 (4 980)	1 492 (1 100)	8 985 (2 020)	6 005 (1 350)	27 756 (6 240)	2 915 (2 150)	2 915 (2 150)	936 (690)
2K 6x4R-13	12 010 (2 700)	6 005 (1 350)	27 756 (6 240)	5 058 (3 730)	6 753 (4 980)	1 492 (1 100)	8 985 (2 020)	6 005 (1 350)	27 756 (6 240)	2 915 (2 150)	2 915 (2 150)	936 (690)
3K 8x6-14A	28 289 (6 360)	14 145 (3 180)	22 596 (5 080)	12 163 (8 970)	1 587 (1 170)	1 587 (1 170)	28 289 (6 360)	14 145 (3 180)	59 870 (13 460)	9 194 (6 780)	5 221 (3 850)	3 851 (2 840)
3K 10x8-14	28 289 (6 360)	14 145 (3 180)	59 870 (13 460)	12 163 (8 970)	3 322 (2 450)	2 915 (2 150)	28 289 (6 360)	14 145 (3 180)	59 870 (13 460)	12 163 (8 970)	9 790 (7 220)	3 851 (2 840)
3K 6x4-16	28 289 (6 360)	14 145 (3 180)	20 327 (4 570)	12 163 (8 970)	1 431 (1 055)	1 431 (1 055)	25 465 (5 725)	12 720 (2 860)	53 888 (12 115)	8 272 (6 100)	4 699 (3 465)	3 465 (2 555)
3K 8x6-16A	28 289 (6 360)	14 145 (3 180)	29 713 (6 680)	12 163 (8 970)	2 007 (1 480)	2 007 (1 480)	28 289 (6 360)	14 145 (3 180)	59 870 (13 460)	8 895 (6 560)	5 044 (3 720)	3 851 (2 840)
3K 10x8-16 & 16HH	28 289 (6 360)	14 145 (3 180)	22 818 (5 130)	12 163 (8 970)	1 532 (1 130)	1 532 (1 130)	28 289 (6 360)	14 145 (3 180)	59 870 (13 460)	12 163 (8 970)	12 285 (9 060)	3 851 (2 840)
3K 10x8-17	28 289 (6 360)	14 145 (3 180)	22 818 (5 130)	12 163 (8 970)	1 532 (1 130)	1 532 (1 130)	28 289 (6 360)	14 145 (3 180)	59 870 (13 460)	12 163 (8 970)	12 285 (9 060)	3 851 (2 840)
3K 12x10-18HD	8000 (1800)	5340 (1200)	6670 (1500)	6100 (4500)	4610 (3400)	2980 (2200)	5340 (1200)	6670 (1500)	4450 (1000)	5020 (3700)	3800 (2800)	2440 (1800)

**Figure 4-20: Maximum Y-axis loading for shaft deflection**

Pump size	Suction Flange						Discharge Flange					
	Forces N (lbf)			Moments Nm (lbf·ft)			Forces N (lbf)			Moments Nm (lbf·ft)		
	Fxs	Fys	Fzs	Mxs	Mys	Mzs	Fxd	Fyd	Fzd	Mxd	Myd	Mzd
Group 1		-8 896 (-2 000)		1 220.4 (900)	1 627.2 (1 200)	1 695 (1 250)		6 672 (1 500)		-678 (-500)	2 034 (1 500)	1 695 (1 250)
Group 2		-15 568 (-3 500)		1 762.8 (1 300)	1 762.8 (1 300)	4 068 (3 000)		11 120 (2 500)		-1 627 (-1 200)	2 034 (1 500)	4 068 (3 000)
Group 3		-22 240 (-5 000)		2 034 (1 500)	2 712 (2 000)	5 424 (4 000)		13 344 (3 000)		-1 695 (-1 250)	6 780 (5 000)	5 424 (4 000)

**Figure 4-21: Maximum Z-axis loading for shaft deflection**

Pump size	Suction Flange						Discharge Flange					
	Forces N (lbf)			Moments Nm (lbf·ft)			Forces N (lbf·ft)			Moments Nm (lbf·ft)		
	Fxs	Fys	Fzs	Mxs	Mys	Mzs	Fxd	Fyd	Fzd	Mxd	Myd	Mzd
Group 1	4 670 (1 050)		-5 560 (-1 250)	2 034 (1 500)	1 627 (1 200)	-3 390 (-2 500)	3 558 (800)	8 896 (2 000)	-13 344 (-3 000)	-2 034 (-1 500)	1 356 (1 000)	-3 390 (-2 500)
Group 2	15 568 (3 500)		-6 672 (-1 500)	2 034 (1 500)	1 763 (1 300)	-4 746 (-3 500)	6 227 (1 400)	11 120 (2 500)	-14 456 (-3 250)	-2 034 (-1 500)	2 915 (2 150)	-4 746 (-3 500)
Group 3	15 568 (3 500)		-8 896 (-2 000)	2 034 (1 500)	5 560 (4 100)	-5 424 (-4 000)	6 672 (1 500)	17 792 (4 000)	-15 568 (-3 500)	-2 034 (-1 500)	6 780 (5 000)	-5 424 (-4 000)

#### 4.6.4.2 Mark 3 In-Line pumps (ASME B73.2M)

##### 4.6.4.2a Pump mounting

Review "Pump mounting" in section 4.3.

The pump may be mounted such that it is free to move with the piping. The pump may be supported by the piping, so that it is free to move in all directions. The pump may also be supported underneath the casing or by the optional pump stand which is not bolted to the foundation. In these cases, the pump is free to move with the piping in all directions except for vertically downward.

The above mounting methods are recommended as they reduce the piping loads applied to the pump. In these cases, nozzle loads are limited only by the casing limitations.

The pump may also be rigidly mounted, with the optional pump stand bolted to the foundation. In this case pump movement is restricted and piping loads are applied to both the pump and stand. In this case, nozzle loads are limited by both the casing and pump stand limitations.

##### 4.6.4.2b Casing limitations

To simplify or eliminate additional calculations, the In-Line casing may be treated as a spool of schedule 40 pipe with a diameter equal to the discharge, length equal to the face to face dimension (SD) and material equal to that of the casing. In cases where pump movement is limited, the constraint may be placed at the center of the spool. Stress in the pump flanges

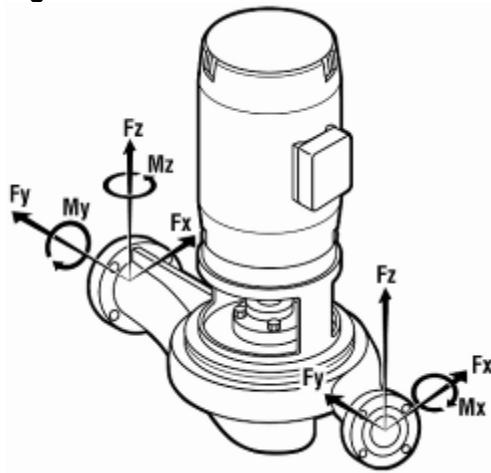
and bolting should not be ignored. This method allows for the use of automated piping programs to determine the acceptability of loads.

The casing limitations can also be determined by ANSI/HI 9.6.2. All information necessary to complete the evaluation is given below. For complete details please review the standard.

- Determine the appropriate casing "Nozzle load material group" from figure 3-2.
- Find the "Casing material correction factor" in figure 4-14 based upon the "Nozzle load material group" and operating temperature. Interpolation may be used to determine the correction factor for a specific temperature.
- Multiply the allowable loads found in figure 4-23 by the material correction factor. Record the adjusted loads.
- Calculate the applied piping loads at the center of the casing flanges according to the coordinate system found in figure 4-22. The 12 forces and moments possible are Fxs, Fys, Fzs, Mxs, Mys, Mzs, Fxd, Fyd, Fzd, Mxd, Myd and Mzd. For example, Fxd designates force in the "x" direction on the discharge flange. Mys designates the moment about the "y"-axis on the suction flange.
- The absolute value of the applied suction load divided by the corresponding adjusted load must be less than or equal to one. Also, the absolute value of the applied discharge load divided by the corresponding adjusted load must be less than or equal to one. *For example:*

$$\left| \frac{F_{xs}}{F_{x\_adj}} \right| \leq 1.0, \quad \left| \frac{F_{yd}}{F_{y\_adj}} \right| \leq 1.0, \quad \left| \frac{M_{zd}}{M_{z\_adj}} \right| \leq 1.0,$$

Figure 4-22



#### 4.6.4.2c Pump stand limitations

In cases where the pump is rigidly mounted by the pump stand, both the casing limitations and the pump stand limitations must be satisfied. Due to the limited load capacity of the pump stands, it may be necessary to restrain the piping to prevent loads.

- Ensure all applied loads are within the allowable limits of the casing.
- Translate the flange loads using the formulae found in figure 4-24. Dimensional variables  $S_{RS}$ ,  $S_{RD}$  and  $R_S$  can be found in figure 4-23.
- Calculate  $F_T$  and  $F_N$  using the formulae found in figure 4-24.
- $F_T$  and  $F_N$  must be less than  $F_{TMAX}$  and  $F_{NMAX}$  found in figure 4-25.
- $F_T$  and  $F_N$  must meet the combination formulae found in figure 4-25.

Figure 4-23: Dimensional data and casing limitations

	Dimensions m (ft)				Allowable casing loads (suction or discharge)					
	SD	SRd	SRs	Rs	Fx	Fy	Fz	Mx	My	Mz
2x1.5V-6	0.381 (1.25)	0.191 (0.625)	0.191 (0.625)	0.163 (0.53)	1 824 (410)	17 685 (3 976)	1 824 (410)	692 (510)	976 (720)	692 (510)
2x1.5V-8	0.432 (1.42)	0.229 (0.75)	0.203 (0.67)	0.163 (0.53)	1 601 (360)	17 685 (3 976)	1 601 (360)	692 (510)	976 (720)	692 (510)
3x2V-7	0.432 (1.42)	0.203 (0.67)	0.229 (0.75)	0.163 (0.53)	2 824 (635)	28 147 (6 328)	2 824 (635)	1 120 (900)	1 722 (1 270)	1 120 (900)
3x1.5V-8	0.483 (1.58)	0.226 (0.74)	0.254 (0.83)	0.163 (0.53)	1 601 (360)	17 685 (3 976)	1 601 (360)	692 (510)	976 (720)	692 (510)
2x1.5V-10A	0.483 (1.58)	0.229 (0.75)	0.254 (0.83)	0.197 (0.65)	1 423 (320)	17 685 (3 976)	1 423 (320)	692 (510)	976 (720)	692 (510)
3x2V-10	0.508 (1.67)	0.241 (0.79)	0.267 (0.88)	0.197 (0.65)	2 402 (540)	28 147 (6 328)	2 402 (540)	1 120 (900)	1 722 (1 270)	1 120 (900)
4x3V-10	0.635 (2.08)	0.292 (0.96)	0.343 (1.13)	0.197 (0.65)	2 823 (638)	28 147 (6 328)	2 823 (638)	1 803 (1 330)	2 549 (1 880)	1 803 (1 330)
3x1.5V-13	0.61 (2.00)	0.292 (0.96)	0.318 (1.04)	0.248 (0.81)	1 134 (255)	17 685 (3 976)	1 134 (255)	692 (510)	976 (720)	692 (510)
3x2V-13	0.61 (2.00)	0.292 (0.96)	0.318 (1.04)	0.248 (0.81)	2 002 (450)	28 147 (6 328)	2 002 (450)	1 120 (900)	1 722 (1 270)	1 120 (900)
4x3V-13	0.711 (2.33)	0.33 (1.08)	0.381 (1.25)	0.248 (0.81)	2 535 (570)	28 147 (6 328)	2 535 (570)	1 803 (1 330)	2 549 (1 880)	1 803 (1 330)
6x4V-13	0.762 (2.50)	0.356 (1.17)	0.406 (1.33)	0.248 (0.81)	2 891 (650)	83 195 (18 704)	2 891 (650)	2 210 (650)	3 119 (1 630)	2 210 (2 300)

Figure 4-24: Pump stand load translation formulae

Forces	Moments
$F_{xc} = F_{xs} + F_{xd}$	$M_{xc} = M_{xs} + M_{xd} + (F_{zs} \times SR_s) - (F_{zd} \times SR_d)$
$F_{yc} = F_{ys} + F_{yd}$	$M_{yc} = M_{ys} + M_{yd}$
$F_{zc} = F_{zs} + F_{zd}$	$M_{zc} = M_{zs} + M_{zd} - (F_{xs} \times SR_s) + (F_{xd} \times SR_d)$
$F_T = \sqrt{\left[  F_{xc}  + \left( 0.707 \times \frac{M_{zc}}{R_s} \right) \right]^2 + \left[  F_{yc}  + \left( 0.707 \times \frac{M_{zc}}{R_s} \right) \right]^2} \leq F_{TMAX}$	
$F_N =  F_{zc}  + \frac{ M_{xc}  +  M_{yc} }{0.707 R_s} \leq F_{N\_MAX}$	

**Figure 4-25: Allowable stand loads**

	$F_T$ MAX in N (lbf)	$F_N$ MAX in N (lbf)	Combination loading in N (lbf)
GP1 pumps	8 020 (1 800)	108 531 (24 400)	$F_N + (13.556) F_T \leq 108 531$ $F_N + (13.556) F_T \leq 24 400$
GP2 V-10 pumps	8 129 (1 827)	120 115 (27 004)	$F_N + (0.0019) F_T^2 - (0.941) F_T \leq 120 115$ $F_N + (0.0086) F_T^2 - (0.941) F_T \leq 27 004$
GP2 V-13 pumps	6 792 (1 535)	140 461 (31 579)	$F_N + (0.0018) F_T^2 + (8.453) F_T \leq 140 461$ $F_N + (0.0079) F_T^2 + (8.453) F_T \leq 31 579$

#### 4.6.5 Pump and shaft alignment check

After connecting the piping, rotate the pump drive shaft clockwise (viewed from motor end) by hand several complete revolutions to be sure there is no binding and that all parts are free. Recheck shaft alignment (see section 4.5). If piping caused unit to be out of alignment, correct piping to relieve strain on the pump.

#### 4.6.6 Auxiliary piping

##### 4.6.6.1 Mechanical seal

When the pump is intended to be equipped with a mechanical seal, it is Flowserve standard practice to install the mechanical seal in the pump prior to shipment. Specific order requirements may specify that the seal be shipped separately, or none be supplied. It is the pump installer's responsibility to determine if a seal was installed. If a seal was supplied but not installed, the seal and installation instructions will be shipped with the pump.

**CAUTION** Failure to ensure that a seal is installed may result in serious leakage of the pumped fluid.

Seal and seal support system must be installed and operational as specified by the seal manufacturer.

The stuffing box/seal chamber/gland may have ports that have been temporarily plugged at the factory to keep out foreign matter. It is the installer's responsibility to determine if these plugs should be removed and external piping connected. Refer to the seal drawings and or the local Flowserve representative for the proper connections.

##### 4.6.6.2 Packing

When the pump is intended to be equipped with shaft packing, it is not Flowserve standard practice to install the packing in the stuffing box prior to shipment. The packing is shipped with the pump. It is the pump installer's responsibility to install the packing in the stuffing box.

**CAUTION** Failure to ensure that the packing is installed may result in serious leakage of the pumped fluid.

#### 4.6.6.3 Piping connection – seal/packing support system

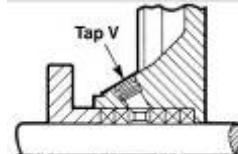
**CAUTION** If the pump has a seal support system it is mandatory that this system be fully installed and operational before the pump is started.

If packing is used:

##### 4.6.6.3a Packing lubrication

Water, when compatible with the pumpage, should be introduced into tap V (figure 4-26) at pressure 69 to 103 kPa (10 to 15 lbf/in.<sup>2</sup>) above the stuffing box pressure. The gland should be adjusted to give a flow rate of 20 to 30 drops per minute for clean fluid. For abrasive applications, the regulated flow rate should be 0.06 to 0.13 l/s (1 to 2 US gpm)

**Figure 4-26**



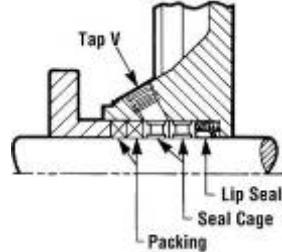
Grease lubrication, when compatible with the liquid being pumped, may be used. Again, introduced into tap V.

In non-abrasive applications the liquid being pumped may be sufficient to lubricate the packing without need for external lines. Tap V should be plugged.

##### 4.6.6.3b Abrasive packing arrangement

The installation procedures are the same as the standard packing with some exceptions. A special lip seal is installed first, followed by two seal cage assemblies, then two of the packing rings provided (figure 4-27). A flush line from a clean external source should be connected via tap V, in the top of the stuffing box.

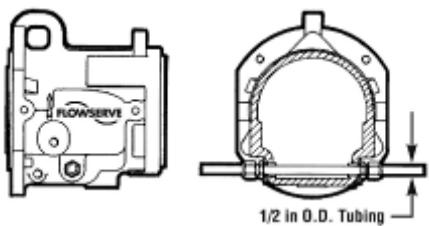
**Figure 4-27**



#### 4.6.6.4 Piping connection - bearing housing cooling system

Make connections as shown below. Liquid at less than 32 °C (90 °F) should be supplied at a regulated flow rate of at least 0.06 l/s (1 US gpm).

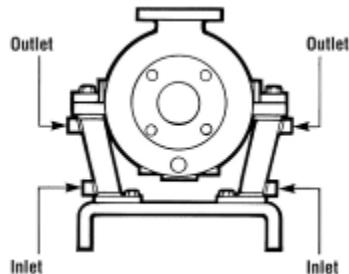
Figure 4-28



#### 4.6.6.5 Piping connection - support leg cooling for centerline mounting option

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

Figure 4-29



#### 4.6.6.6 Piping connection - heating/cooling fluid for jacketed cover/casing

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

Figure 4-30

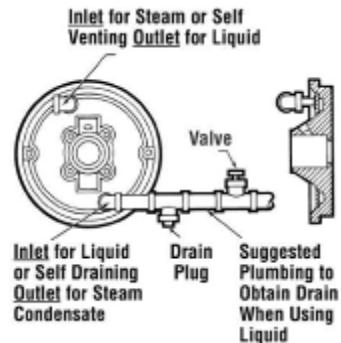
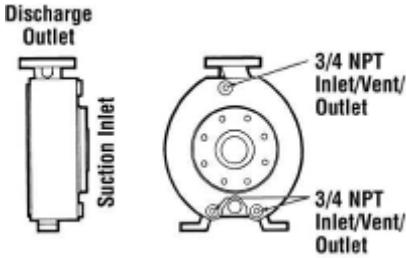


Figure 4-31



#### Notes:

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

#### 4.6.6.7 Piping connection - Oil mist lubrication system

The piping connections for an oil mist lubrication system are shown below.

Figure 4-32

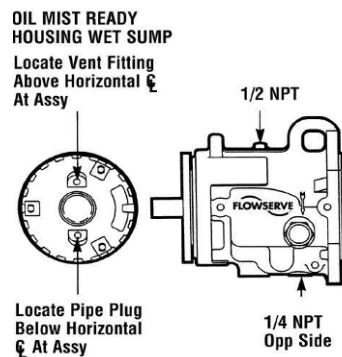
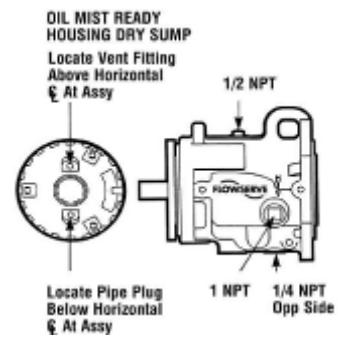


Figure 4-33



## 4.7 Electrical connections

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

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

 It is important to be aware of the EUROPEAN DIRECTIVE on electromagnetic compatibility when wiring up and installing equipment on site.

Attention must be paid to ensure that the techniques used during wiring/installation do not increase electromagnetic emissions or decrease the electromagnetic immunity of the equipment, wiring or any connected devices. If in any doubt contact Flowserve for advice.

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

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

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

## 4.8 Final shaft alignment check

### 4.8.1 Horizontal pumps

- Level baseplate if appropriate.
- Mount and level pump if appropriate. Level the pump by putting a level on the discharge flange. If not level, adjust the footpiece as follows:

#### Mark 3A and ANSI 3 design

Add or delete shims [3126.1] between the

footpiece and the bearing housing.

#### Mark 3 design

Use the adjuster nut [6576] to adjust the footpiece up or down.

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

#### Stilt mounted baseplates

If initial alignment cannot be achieved with the motor fasteners centered, the baseplate may be twisted. Slightly adjust (one turn of the adjusting nut) the stilts at the driver end of the baseplate and check for alignment to the above tolerances. Repeat as necessary while maintaining a level condition as measured from the pump discharge flange.

- 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.
- Perform final alignment. Check for soft-foot under the driver. An indicator placed on the coupling, reading in the vertical direction, should not indicate more than 0.05 mm (0.002 in.) movement when any driver fastener is loosened. Align the driver first in the vertical direction by shimming underneath its feet.
- When satisfactory alignment is obtained the number of shims in the pack should be minimized. It is recommended that no more than five shims be used under any foot. Final horizontal alignment is made by moving the driver. Maximum pump reliability is obtained by having near perfect alignment. Flowserve recommends no more than 0.05 mm (0.002 in.) parallel, and 0.0005 mm/mm (0.0005 in./in.) angular misalignment. (See section 6.8.4.7)
- 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.

#### 4.8.2 Close Coupled Pumps

Alignment between the pump shaft and motor shaft is built in by precise machining of the parts that position these shafts. Parallel alignment of 0.18 mm (0.007 in.) and angular alignment of 0.002 mm/mm (0.002 in./in.) can be expected. If a more refined alignment is desired, it can be accomplished with the "C-Plus" optional alignment feature.

The C-Plus option requires that a spacer as shown in section 8.9 be installed. Four adjusting screws are used to push on the motor mounting studs to achieve parallel alignment. The motor mounting fasteners must be snug, but not tight during alignment. It may be necessary to check the motor alignment with motor fasteners tight. Corrections may be made until the desired alignment is achieved. The motor fasteners, adjusters and jam nuts should be tight.

#### 4.8.3 In-Line pumps

The final field alignment follows the same procedure as the initial alignment as described in section 4.5.2. Maximum pump reliability is obtained by having near perfect alignment. Flowserve generally recommends no more than 0.05 mm (0.002 in.) parallel, and 0.0005 mm/mm (0.0005 in./in.) angular misalignment. However, the Mark 3 In-Line, with its integral motor adapter, is designed to maintain alignment despite nozzle loads and thermal expansion. Therefore, the Mark 3 In-Line *does not* require a more precise alignment than the coupling manufacturer recommends, and misalignment in excess of that stated above *may* be acceptable depending on the coupling used. See the coupling manufacturer's instructions for details.

### 4.9 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 is carried out.

## 5 COMMISSIONING, STARTUP, OPERATION AND SHUTDOWN



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

### 5.1 Pre-commissioning procedure

#### 5.1.1 Pre start-up checks

Prior to starting the pump it is essential that the following checks be made. These checks are all described in detail in the *Maintenance* section of this manual.

- Pump and motor properly secured to the baseplate
- Remove the temporary motor supports installed for shipping close coupled pumps
- All fasteners tightened to the correct torque
- Coupling guard in place and not rubbing
- Rotation check, see section 5.4.

**This is absolutely essential**

- Impeller clearance setting
- Shaft seal properly installed
- Seal support system operational
- Bearing lubrication
- Bearing housing cooling system operational
- Support leg cooling for centerline mounting option operational
- Heating/cooling for jacketed casing/cover operational
- Pump instrumentation is operational
- Pump is primed
- Rotation of shaft by hand

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

## 5.2 Pump lubricants

### 5.2.1 Oil bath

Oil bath is available on all product lines with the exception of the In-Line pump. The standard bearing housing bearings are oil bath lubricated and are not lubricated by Flowserve. Before operating the pump, fill the bearing housing to the center of the oil sight glass with the proper type oil. (See figure 5.2 for approximate amount of oil required - do not overfill.)

On the Mark 3A design, an optional oil slinger is available. The oil slinger is not necessary; however, if used, it provides an advantage by allowing a larger tolerance in acceptable oil level. Without an oil slinger, the oil level in the bearing housing must be maintained at  $\pm 3$  mm ( $\pm \frac{1}{8}$  in.) from the center of the sight glass. The sight glass has a 6 mm ( $\frac{1}{4}$  in.) hole in the center of its reflector. The bearing housing oil level must be within the circumference of the center hole to ensure adequate lubrication of the bearings.

See Figure 5.3 for recommended lubricants. **DO NOT USE DETERGENT OILS.** The oil must be free of water, sediment, resin, soaps, acid and fillers of any kind. It should contain rust and oxidation inhibitors. The proper oil viscosity is determined by the bearing housing operating temperature as given in figure 5.5.

To add oil to the housing, clean and then remove the vent/breather [6521] at the top of the bearing housing, pour in oil until it is visually half way up in the sight glass [3856]. Fill the constant level oiler bottle, if used, and return it to its position. The correct oil level is obtained with the constant level oiler in its lowest position, which results in the oil level being at the top of the oil inlet pipe nipple, or half way up in the sight glass window. Oil must be visible in the bottle at all times.

Note that on ANSI 3A™ power ends there is no constant level oiler and no vent/breather (replaced by a plug). As stated above, proper oil level is the center of the "bull's eye" sight glass [3856]. (See figure 5.1.)

**Figure 5.1**



In many pumping applications lubricating oil becomes contaminated before it loses its lubricating qualities or breaks down. For this reason it is recommended that the first oil change take place after approximately 160 hours of operation, at which time, the used oil should be examined carefully for contaminants. During the initial operating period monitor the bearing housing operating temperature. Record the external bearing housing temperature. See figure 5.6 for maximum acceptable temperatures. The normal oil change interval is based on temperature and is shown in figure 5.7.

**Figure 5.2: Amount of oil required**

Pump	Mark 3	Mark 3A
Group 1	148 ml (5 fl. oz.)	251 ml (8.5 fl. oz.)
Group 2	560 ml (19 fl. oz.)	946 ml (32 fl. oz.)
Group 3	1419 ml (48 fl. oz.)	1419 ml (48 fl. oz.)
Grp 3-HD	n/a	1005 ml (34 fl. oz.)

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

Where the ambient temperature is very low, special lubricants are required. Where oil lubrication is utilized and the ambient is less than -5 °C (23 °F) ensure the oil pour point is at least 15 °C (27 °F) lower than the ambient, or use oil class SAE 5W-50 or API-SJ and ensure the upper operating range of the oil is then not exceeded. ISO VG 46 oil is generally selected for an initial lubrication schedule.

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

**Figure 5.3: Recommended oil lubricants**

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

\* Note that it normally takes 2 hours for bearing temperature to stabilize and the final temperature will depend on the ambient, r/min, pumpage temperature and pump size. Also some oils have a 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 °C (23 °F).

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

\*\* Normal compounded oils CANNOT be used with oil mist as anti-foam additives need to be avoided. Most oils recommended for wet splash lubrication contain foam inhibitors as well as antioxidants and anticorrosion additives, so they are unsuitable for oil mist. Some synthetic lubricants may attack the Nitrile seals used in a regular bearing housing. The LSC LSO oils are recommended for oil mist applications. We recommend using Royal Purple SYN FILM in one of the above ISO VG designations if synthetic oil is required for splash bath lubrication to avoid changing to Viton seals in the bearing housing

**Figure 5.4: Recommended grease lubricants**

Mineral oil	Quality mineral oil with rust and oxidation inhibitors. Mobil DTE heavy/medium (or equivalent)
Synthetic	Royal Purple or Conoco SYNCON (or equivalent). Some synthetic lubricants require Viton O-rings.
Grease	Mobile POLYREX EM (or compatible) – horizontal Polyurea with mineral oil EXXON Unirex N3 (or compatible) – In-Line Lithium Complex with mineral oil
Food grade	Klübersynth UH1 64-62. (NLGI 2)
Low temp.	Aeroshell 22

**Figure 5.5: Oil viscosity grades**

Maximum oil temperature	ISO viscosity grade	Minimum viscosity index
Up to 60 °C (140 °F)	32	95
Up to 71 °C (160 °F)	46	95
Up to 80 °C (175 °F)	68	95
Up to 94 °C (200 °F)	100	95

**Figure 5.6: Max external housing temperature**

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



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

**Figure 5.7: Lubrication intervals\***

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

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

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

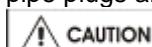
\*\*\* Bearing Temperatures up to 16°C (30 °F) higher than housing.

## 5.2.2 Grease

### 5.2.2.1 Regreasable

#### Single shielded regreasable bearings

When the grease lubrication option is specified, single shielded bearings, grease fittings and vent pipe plugs are installed inboard and outboard.



**CAUTION** The orientation of the bearing shields is different for horizontal pumps (Standard, Sealmatic, Unitized, Recessed, and Lo-Flo - see figure 5.8) and In-Line pumps (see figure 5.9).

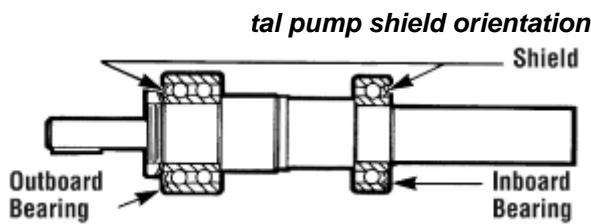
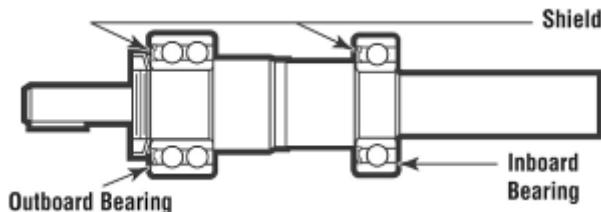


Figure 5.9: In-line pump shield orientation

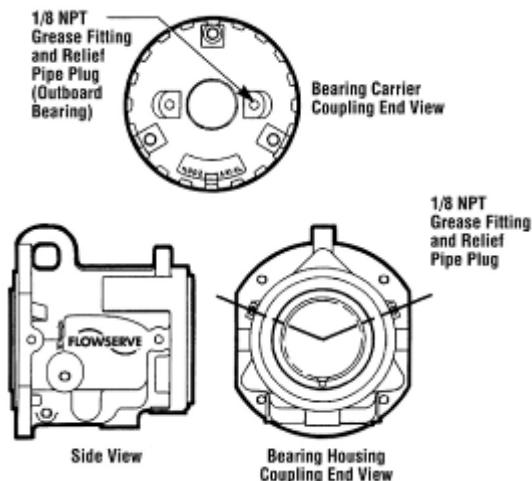


Horizontal pump bearings are packed with Exxon POLYREX EM grease prior to assembly. For relubrication, a grease with the same type base (polyurea) and oil (mineral) should be used. In the case of the In-Line pump the bearings are packed with Exxon Unirex N3 grease. For relubrication, a grease with the same type base (lithium) and oil (mineral) should be used. To regrease, remove the pipe plug from both the inboard and outboard bearing location. (See figure 5.10.) After relubricating the bearings three times, it is typically recommended that the bearing housing is cleaned out.



To regrease bearings under coupling guard, stop pump, lock the motor, remove coupling guard, and then regrease the bearings.

Figure 5.10: Regreasable configuration



The amount of grease required for horizontal pumps is shown in figure 5.11

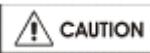
Figure 5.11 Grease lubrication amounts

Horizontal lubrication amounts		
Housing	Initial lube	Relubrication
Group 1 inboard	Until grease comes out of plug	7.5 cm <sup>3</sup> (0.46 in. <sup>3</sup> )
Group 1 outboard		14 cm <sup>3</sup> (0.85 in. <sup>3</sup> )
Group 1 duplex	34 cm <sup>3</sup> (2.1 in. <sup>3</sup> )	17 cm <sup>3</sup> (1.0 in. <sup>3</sup> )
Group 2 inboard	Until grease comes out of plug	17 cm <sup>3</sup> (1.0 in. <sup>3</sup> )
Group 2 outboard		28 cm <sup>3</sup> (1.7 in. <sup>3</sup> )
Group 2 duplex	68 cm <sup>3</sup> (4.1 in. <sup>3</sup> )	34 cm <sup>3</sup> (2.1 in. <sup>3</sup> )
Group 3 inboard	Until grease comes out of plug	30 cm <sup>3</sup> (1.8 in. <sup>3</sup> )
Group 3 outboard		54 cm <sup>3</sup> (3.3 in. <sup>3</sup> )
Group 3 duplex	115 cm <sup>3</sup> (7.0 in. <sup>3</sup> )	60 cm <sup>3</sup> (3.7 in. <sup>3</sup> )

#### In-Line lubrication amounts

Housing location	New bearing	Relubrication
Group 1 inboard	10 cm <sup>3</sup> (0.6 in. <sup>3</sup> )	7.5 cm <sup>3</sup> (0.46 in. <sup>3</sup> )
Group 1 outboard	20.5 cm <sup>3</sup> (1.3 in. <sup>3</sup> )	14 cm <sup>3</sup> (0.85 in. <sup>3</sup> )
Group 2 inboard	16.4 cm <sup>3</sup> (1.0 in. <sup>3</sup> )	17 cm <sup>3</sup> (1.0 in. <sup>3</sup> )
Group 2 outboard	47.4 cm <sup>3</sup> (2.9 in. <sup>3</sup> )	28 cm <sup>3</sup> (1.7 in. <sup>3</sup> )

If new bearings are not lubricated, they should be packed prior to installation and the housing lubricated as described above.



Do not fill the housing with oil when greased bearings are used. The oil will leach the grease out of the bearings and the life of the bearings may be drastically reduced.

#### 5.2.2.2 Grease for life

##### Double shielded or double sealed bearings

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

#### 5.2.3 Oil mist

To further limit dirt ingress and dewpoint issues within the bearing housing, a  $1\frac{1}{2}$ " connection is available for a low pressure instrument air or nitrogen supply where applicable.

The inlet port for all horizontal pumps is the plugged  $\frac{1}{2}$  in. NPT located at the top of the bearing housing. A vent fitting has been supplied on the bearing carrier as well as a plugged  $\frac{1}{4}$  in. NPT bottom drain on the bearing housing. See section 4.6.6.7, *Oil mist lubrication system*. Do not allow oil level to remain above the center of the bearing housing sight glass window with purge mist (wet sump) systems.

The optional oil slinger must not be used with an oil mist system.

There are two inlet ports for In-Line pumps. In addition to the connection described above a second inlet is made at the 1/8in. NPT plugged port on the bearing carrier [3240]. A vent fitting has been supplied on the bearing carrier as well as a plugged 1/8 in. NPT bottom drain on the bearing housing for Group 1 pumps and on the adapter [1340] for Group 2 pumps.



**CAUTION** The pressure shall be **0.01-0.02 bar (0.14-0.29 psi)**.

### 5.3 Impeller clearance

The impeller clearance was set at the factory based on the application temperature at the time the pump was purchased (see figure 5.12). For reverse-vane and recessed impellers, the clearance is set to the cover while the open impeller clearance is set to the casing. If the process temperature changes the impeller clearance must be reset, see section 6.6.

**Figure 5.12: Impeller clearance settings**

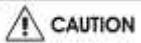
Temperature °C (°F)	Clearance mm (in.)
< 93 (200)	0.46 ± 0.08 (0.018 ± 0.003)
93 to 121 (200 to 250)	0.53 (0.021)
122 to 149 (251 to 300)	0.61 (0.024)
150 to 176 (301 to 350)	0.69 (0.027)
177 to 204 (351 to 400)	0.76 (0.030)
205 to 232 (401 to 450)	0.84 (0.033)
>232 (450)	0.91 (0.036)

**Notes:**

1. For 3x1.5-13 and 3x2-13 at 3500 rpm add 0.08 mm (0.003 in.).
2. Rotation of bearing carrier from center of one lug to center of next results in axial shaft movement of 0.1 mm (0.004 in.).
3. Reverse vane impeller set to cover, open impeller to casing.

### 5.4 Direction of rotation

#### 5.4.1 Rotation check

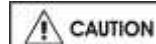


**CAUTION** It is absolutely essential that the rotation of the motor be checked before connecting the shaft coupling. Incorrect rotation of the pump, for even a short time, can dislodge and damage the impeller, casing, shaft and shaft seal. All Mark 3 pumps turn clockwise as viewed from the motor end. A direction arrow is cast on the front of the casing as shown in figure 5.13. Make sure the motor rotates in the same direction.

**Figure 5.13**

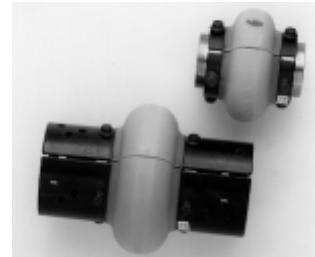


#### 5.4.2 Coupling installation



**CAUTION** The coupling (figure 5.14) should be installed as advised by the coupling manufacturer. Pumps are shipped without the spacer installed. If the spacer has been installed to facilitate alignment, then it must be removed prior to checking rotation. Remove all protective material from the coupling and shaft before installing the coupling.

**Figure 5.14**



### 5.5 Guarding



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

**Note:**

In member countries of the EU and EFTA, it is a legal requirement that fasteners for guards must remain captive in the guard to comply with the Machinery Directive 2006/42/EC. When releasing such guards, the fasteners must be unscrewed in an appropriate way to ensure that the fasteners remain captive.

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

### uard - standard

The standard coupling guard for all Mark 3 pumps is the "clam shell" design and is shown in figure 5.15. It is hinged at the top and it can be removed by loosening one of the foot bolts and sliding the support leg out from under the cap screw. Note that the foot is slotted. The leg can then be rotated upward and half of the guard can be disengaged (unhinged) from the other. Only one side of the guard needs to be removed. To reassemble simply reverse the above procedure.

**Figure 5.15**

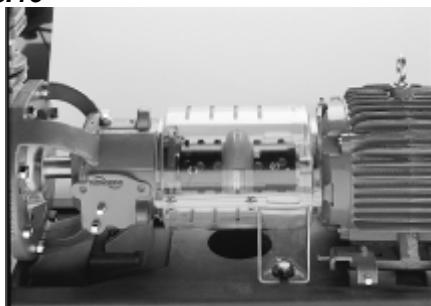


The coupling guard shown in figure 5.15 conforms to the USA standard ASME B15.1, "Safety standard for mechanical power transmission apparatus." Flowserv manufacturing facilities worldwide conform to local coupling guard regulations.

### 5.5.2 ClearGuard™ - optional

Flowserv offers as an option a ClearGuard™, which allows you to see the condition of the coupling (see figure 5.16). This guard can be used in place of the existing clamshell guard described above. Disassembly of the ClearGuard™ is accomplished by removing the fasteners that hold the two guard halves together followed by removing the foot bolts and rotating the support leg out of the slot on the guard.

**Figure 5.16**



### 5.5.3 Trimming instructions

In order to correctly fit the pump/motor configuration, each guard must be trimmed to a specific length. This trimming is done on the motor end of the guard.

- a) Measure minimum distance from the center of mounting hole in the baseplate to the motor.

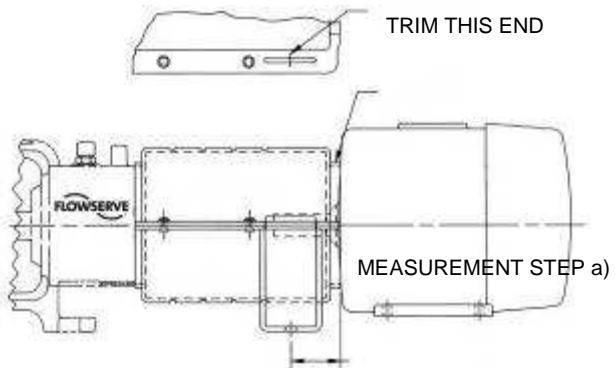
If clam shell guard proceed to step c

- b) Locate a reference center in the slot of the ClearGuard™ coupling guard flange, see figure 5.17. Transfer the length measurement to the guard using this reference center.
- c) Trim the motor end of the guard according to the above measurement. Trimming is best done with a band saw, but most other types of manual or power saws give acceptable results. Care must be taken to ensure that there is no gap larger than 6 mm (0.24 in.) between the motor and the coupling guard.

**Note:**

- d) If motor diameter is smaller than guard diameter, trim guard so that it extends over the end of the motor as far as possible.
- e) Deburr the trimmed end with a file or a sharp knife if ClearGuard™. Care must be taken to eliminate all sharp edges.

REFERENCE CENTER  
TRIM THIS END



### 5.5.4 Assembly instructions

#### Clam shell guard

- a) Mount support leg to each clam shell, figure 5.15.
- b) Attach one half of the guard to the baseplate.
- c) Engage the tabs of guard halves together.
- d) Attach the second support leg to the baseplate.

#### ClearGuard™

- a) Place the bottom and top halves of the guard around the coupling.
- b) Install the support legs by inserting and then rotating the tab on the leg through the slot in the guard until it comes through and locks the top and bottom halves of the guard together.
- c) Attach the support legs to the baseplate using the fasteners and washers provided.
- d) Install fasteners in the holes provided to secure the guard flanges together.

## **d auxiliary supplies**

The Mark 3 standard, Sealmatic, Recessed Impeller, Lo-Flo, and In-Line centrifugal pump will not move liquid unless the pump is primed. A pump is said to be "primed" when the casing and the suction piping are completely filled with liquid. Open discharge valves a slight amount. This will allow any entrapped air to escape and will normally allow the pump to prime, if the suction source is above the pump. When a condition exists where the suction pressure may drop below the pump's capability, it is advisable to add a low-pressure control device to shut the pump down when the pressure drops below a predetermined minimum.

The Mark 3 Unitized self-priming centrifugal pumps have a slightly different requirement regarding priming. The initial priming liquid must be added to the pump casing until the liquid has reached the bottom of the suction nozzle. Once the initial prime is in place, the pump will automatically replenish itself and additional priming liquids are not normally needed. If liquid is lost, additional priming liquid may be needed.

### **5.7 Starting the pump**

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

### **5.8 Running or operation**

#### **5.8.1 Minimum continuous flow**

Minimum continuous stable flow is the lowest flow at which the pump can operate and still meet the bearing life, shaft deflection and bearing housing vibration limits documented in the latest version of ASME B73.1M. Pumps may be operated at lower flows, but it must be recognized that the pump may exceed one or more of

these limits. For example, vibration may exceed the limit set by the ASME standard. The size of the pump, the energy absorbed, and the liquid pumped are some of the considerations in determining the minimum continuous flow (MCF).

The minimum continuous flow (capacity) is established as a percentage of the *best efficiency point* (BEP). (See section 3.4.4.)

#### **5.8.2 Minimum thermal flow**

All Mark 3 pumps also have a *minimum thermal flow*. This is defined as the minimum flow that will not cause an excessive temperature rise. Minimum thermal flow is application dependent.



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

Avoid running a centrifugal pump at drastically reduced capacities or with discharge valve closed for extended periods of time. This can cause severe temperature rise and the liquid in the pump may reach its boiling point. If this occurs, the mechanical seal will be exposed to vapor, with no lubrication, and may score or seize to the stationary parts. Continued running under these conditions when the suction valve is also closed can create an explosive condition due to the confined vapor at high pressure and temperature.

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

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

#### **5.8.3 Reduced head**

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

#### **5.8.4 Surging condition**

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

### **sub-freezing conditions**

When using the pump in sub-freezing conditions where the pump is periodically idle, the pump should be properly drained or protected with thermal devices which will keep the liquid in the pump from freezing. High chrome iron pumps are not recommended for applications below -18 °C (0 °F).

## **5.9 Stopping and shutdown**

### **5.9.1 Shutdown considerations**

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

### **5.9.2 Shutdown Mark 3 Self-Priming**

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

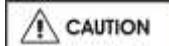
## **5.10 Hydraulic, mechanical and electrical duty**

### **5.10.1 Net positive suction head (NPSH)**

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

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

For a pump to operate properly the NPSH<sub>A</sub> must be greater than the NPSH<sub>R</sub>. Good practice dictates that this margin should be at least 1.5 m (5 ft) or 20%, whichever is greater.



**CAUTION**

Ensuring that NPSH<sub>A</sub> is larger than NPSH<sub>R</sub> by the suggested margin will greatly enhance pump performance and reliability. It will also reduce the likelihood of cavitation, which can severely damage the pump.

### **5.10.2 Specific gravity (SG)**

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

### **5.10.3 Viscosity**

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

### **5.10.4 Pump speed**

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

### **5.10.5 Pumped flow**

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



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.)

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

Guard fasteners must remain captive during dismantling of guards, as described in section 5.5.

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 the pump from being accidentally started. Place a warning sign on the starting device:

***"Machine under repair: do not start."***

With electric drive equipment, lock the main switch open and withdraw any fuses. Put a warning sign on the fuse box or main switch:

***"Machine under repair: do not connect."***

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

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

## **6.1 Maintenance schedule**



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

- a) Any auxiliary systems installed must be monitored, if necessary, to ensure they function correctly.
- b) Gland packing 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 the remaining hours before 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

### **6.1.1 Preventive maintenance**

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

### **6.1.2 Need for maintenance records**

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

### **6.1.3 Cleanliness**

One of the major causes of pump failure is the presence of contaminants in the bearing housing. This contamination can be in the form of moisture, dust, dirt and other solid particles such as metal chips. Contamination can also be harmful to the mechanical seal (especially the seal faces) as well as

p. For example, dirt in the impeller threads could cause the impeller to not be seated properly against the shaft. This, in turn, could cause a series of other problems. For these reasons, it is very important that proper cleanliness be maintained. Some guidelines are listed below.

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

## 6.2 Spare parts

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



Prior to resizing impellers in high chrome iron and nickel, please consult your local Flowserve sales representative.

### 6.2.1 Ordering of spare parts

Flowserve keeps records of all pumps that have been supplied. Spare parts can be ordered from your local Flowserve sales engineer or from a Flowserve distributor or representative. When ordering spare parts the following information should be supplied:

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

The pump size and serial number can be found on the nameplate located on the bearing housing. See figure 3-1.

## 6.3 Recommended spares and consumable items

Mechanical process fluid seals, bearing housing lip seals, bearings, shafting, impeller, and gaskets.

## 6.4 Tools required

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

### Standard hand tools SAE

- Hand wrenches
- Socket wrenches
- Allen wrenches
- Soft mallet
- Screwdrivers

### Specialized equipment

- Bearing pullers
- Bearing induction heaters
- Dial indicators
- Spanner wrench
- Flowserve Mark 3 tool kit (see below)

To simplify maintenance, it is recommended that the Flowserve Mark 3 tool kit (shown in figure 6-1) is used. This tool kit includes a handy impeller wrench, which simplifies installation and removal of the impeller. It also contains "nose cones" which protect shaft threads and O-rings during maintenance. This tool kit can be ordered from your local Flowserve sales engineer or from a Flowserve distributor or representative.

**Figure 6.1**



## torques

**Figure 6-2: Recommended bolt torques for lubricated or PTFE coated fasteners**

Item	Description		Group 1	Group 2	Group 3
[6570.12]	Bearing retainer cap screws - standard bearings		n/a	n/a	5/16 in. - 16 Nm (12 lbf·ft)
[6570.12]	Bearing retainer cap screws - duplex bearings	Standard Power End	3/16 in. - 6 Nm (4 lbf·ft)	3/16 in. - 6 Nm (4 lbf·ft)	5/16 in. - 16 Nm (12 lbf·ft)
[6570.12]		HD Power End	n/a	n/a	1/4 in. - 11 Nm (8 lbf·ft)
[6570.5]	Bearing housing/adapter cap screws and nuts		n/a	1/2 in. - 54 Nm (40 lbf·ft)	5/8 in. - 122 Nm (90 lbf·ft)
[6580.2]	Mechanical seal gland studs/nuts, with gasket		5/16 in. - 16 Nm (12 lbf·ft)	5/16 in. - 16 Nm (12 lbf·ft) 1/2 in. - 54 Nm (40 lbf·ft)	1/2 in. - 41 Nm (30 lbf·ft)
[6580.2]	Mechanical seal gland studs/nuts, with O-ring		5/16 in. - 27 Nm (20 lbf·ft)	5/16 in. - 27 Nm (20 lbf·ft) 1/2 in. - 54 Nm (40 lbf·ft)	1/2 in. - 54 Nm (40 lbf·ft)
[6580.1]	Casing studs/nuts		1/2 in. - 41 Nm (30 lbf·ft)	1/2 in. - 41 Nm (30 lbf·ft) 5/8 in. - 81 Nm (60 lbf·ft)	3/4 in. - 136 Nm (100 lbf·ft) 7/8 in. - 217 Nm (160 lbf·ft)
[6570.2]	Cap screw cover/adapter (token bolts)		5/16 in. - 27 Nm (20 lbf·ft)	5/16 in. - 27 Nm (20 lbf·ft)	1/2 in. - 54 Nm (40 lbf·ft)
[6570.3]	Bearing carrier set screws		5/16 in. - 16 Nm (12 lbf·ft)	1/2 in. - 41 Nm (30 lbf·ft)	1/2 in. - 41 Nm (30 lbf·ft)
[6570.4]	Cap screw foot	Standard Power End	1/2 in. - 54 Nm (40 lbf·ft)	3/4 in. - 217 Nm (160 lbf·ft)	1 in. - 300 Nm (228 lbf·ft)
[6570.4]		HD Power End	n/a	n/a	1/2 in. - 54 Nm (40 lbf·ft)
[6570.13]	Cap screws - repeller cover to cover		n/a	5/16 in. - 16 Nm (12 lbf·ft)	1/2 in. - 41 Nm (30 lbf·ft)
[6570.15]	Cap screw - bearing housing		1/2 in. - 54 Nm (40 lbf·ft)	1/2 in. - 54 Nm (40 lbf·ft)	n/a
[3712]	Bearing Locknut -	Standard Power End -	27 +4/-0 Nm (20 +5/-0 lbf·ft)	54 +7/-0 Nm (40 +5/-0 lbf·ft)	95 +7/-0 Nm (70 +5/-0 lbf·ft)
		HD Power End	n/a	n/a	102 +7/-0 Nm (75 +5/-0 lbf·ft)

**Notes:** 1. For non-lubricated/coated threads, add 25% to the values given above. 2. Gasket joint torque values are for unfilled PTFE gaskets. Other gasket materials may require additional torque to seal. Exceeding metal joint torque values is not recommended.

## 6.6 Setting impeller clearance and impeller replacement

A new impeller gasket [4590.2] must be installed whenever the impeller has been removed from the shaft. Impeller clearance settings may be found in section 5.3. Impeller balancing instruction may be found in section 6.8.

**Note:**

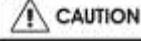
Mark 3 Unitized Self-Priming pumps required that the outside diameter of the impeller be 3mm (0.125 in.) from the casing cutwater. If this close clearance is not maintained the pump may not prime.



Do not adjust the impeller clearance with the seal set. Doing so may result in seal leakage and/or damage.



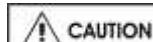
The impeller could have sharp edges, which could cause an injury. It is very important to wear heavy gloves.



It is recommended that two people install a Group 3 impeller. The weight of a Group 3 impeller greatly increases the chance of thread damage and subsequent lock-up concerns.



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



**CAUTION**

Care should be taken in the handling of high chrome iron impellers

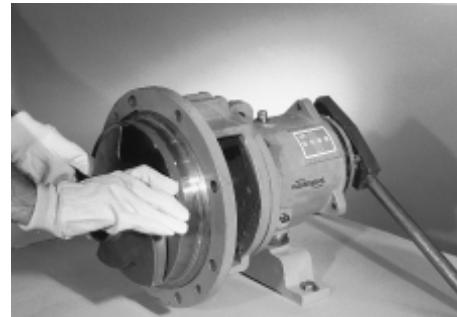
Install the impeller [2200] by screwing it onto the shaft (use heavy gloves) until it firmly seats against the shaft shoulder.

Tighten the impeller with the impeller wrench from the Flowserve Mark 3 tool kit. To do this, grasp the impeller in both hands and, with the impeller wrench handle to the left (viewed from the impeller end of the shaft - figure 6-3) spin the impeller forcefully in a clockwise direction to impact the impeller wrench handle on the work surface to the right (figure 6-4).

**Figure 6.2**



**Figure 6.3**



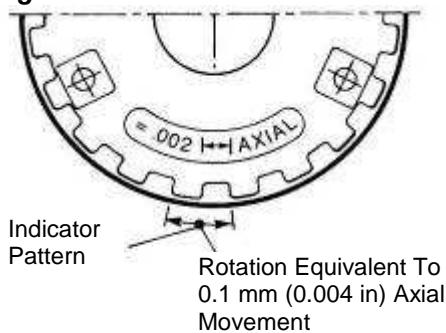
### 6.6.1 Installation and clearance setting for reverse vane impellers on Mark 3 Standard, Unitized self-priming, In-Line and open vane impeller on the Recessed impeller pump

Flowserve reverse vane impellers and Recessed open impellers are set off the cover. This allows the impeller to be set without the casing.

Set the impeller clearance by loosening the set screws [6570.3] and rotating the bearing carrier [3240] to obtain the proper clearance. Turn the bearing carrier counter-clockwise until the impeller comes into light rubbing contact with the rear cover. Rotating the shaft at the same time will accurately determine this zero setting. Now, rotate the bearing carrier clockwise to get the proper clearance. Refer to figure 5.12 for the proper impeller clearance based on the operating temperature for the application.

Rotating the bearing carrier the width of one of the indicator patterns cast into the bearing carrier moves the impeller axially 0.1 mm (0.004 in.). (See figure 6-5.)

Figure 6.4



Determine how far to rotate the bearing carrier by dividing the desired impeller clearance by 0.1 mm (0.004 in.) (one indicator pattern). Tightening the set screws [6570.3] will cause the impeller to move 0.05 mm (0.002 in.) closer to the rear cover because of the internal looseness in the bearing carrier threads. This must be considered when setting the impeller clearance. Rotate the bearing carrier clockwise the required amount to get the desired clearance to the cover.

**Note:** Lastly, uniformly tighten the set screws [6570.3] in incremental steps up to the final torque value to lock the bearing carrier in place.

Figure 6.5



**Example:** If a pump was to be placed in a service with an operating temperature of 100 °C (212 °F) the impeller setting would be 0.53 mm (0.021 in.) off the rear cover plate. Since it is necessary to add 0.05 mm (0.002 in.) for the movement caused by tightening the set screws an adjustment of 0.58 mm (0.023 in.) is needed. First turn the bearing carrier counter-clockwise until the impeller comes into light rubbing contact with the rear cover. To determine the number of indicator patterns that you will need to rotate the carrier, divide 0.10 into the desired setting:  
 $0.58 / 0.10 = 5.8$  (0.023 / 0.004 = 5.8). Rotate the bearing carrier clockwise 6 indicator patterns which will give a clearance of 0.60 mm (0.024 in.).

Flowserve suggests that a felt tip pen be used to mark an initial reference point on the bearing housing and the bearing carrier as shown in figure 6-6. Then make a second mark on the bearing carrier 6 indicator patterns counter-clockwise from the initial reference point. Rotate the bearing carrier clockwise until the second mark on the bearing carrier lines up with the initial reference point mark on the bearing housing. Lastly, uniformly tighten the set screws [6570.3] in incremental steps up to the final torque value to lock the bearing carrier in place.

### 6.6.2 Installation and clearance setting for front vane open style impeller on Mark 3 Standard, Unitized self-priming, Lo-Flo, and Inline pumps

Like all front vane open style impellers, the Flowserve open impeller clearance must be set off the casing. The casing must be installed to accurately set the impeller clearance. (Realizing that this can be very difficult, Flowserve strongly promotes the use of reverse vane impellers, which do not require the presence of the casing to be properly set.)

Attach the power end/rear cover plate assembly to the casing. Now set the impeller clearance by loosening the set screws [6570.3] and rotating the bearing carrier [3240] to obtain the proper clearance. Turn the bearing carrier clockwise until the impeller comes into light

rubbing contact with the casing. Rotating the shaft at the same time will accurately determine this zero setting. Now, rotate the bearing carrier counter-clockwise to get the proper clearance. Refer to figure 5.12 for the proper impeller clearance.

Rotating the bearing carrier the width of one of the indicator patterns cast into the bearing carrier moves the impeller axially 0.1 mm (0.004 in.). (See figure 6-5.)

Determine how far to rotate the bearing carrier by dividing the desired impeller clearance by 0.1 mm (0.004 in.) (one indicator pattern). Tightening the set screws [6570.3] will cause the impeller to move 0.05 mm (0.002 in.) away from the casing because of the internal looseness in the bearing carrier threads. This must be considered when setting the impeller clearance. Rotate the bearing carrier counter-clockwise the required amount to get the desired clearance to the casing.

**Note:** Lastly, uniformly tighten the set screws [6570.3] in incremental steps up to the final torque value to lock the bearing carrier in place.

See section 5.3 for impeller clearance settings.

**Example:** If a pump was to be placed in a service with an operating temperature of 150 °C (302 °F) the impeller setting would be 0.69 mm (0.027 in.) off the casing. Since it is necessary to subtract 0.05 mm (0.002 in.) for the movement caused by tightening the set screws an adjustment of 0.64 mm (0.025 in.) is needed. First, turn the bearing carrier clockwise until the impeller comes into light rubbing contact with the casing. To determine the number of indicator patterns that you will need to rotate the carrier, divide 0.10 into the desired setting;  $0.64 / 0.10 = 6.4$  (.025 / 0.004 = 6.3). Rotate the bearing carrier counter-clockwise 6.5 indicator patterns which will give a clearance of 0.65 mm (0.026 in.). Flowserve suggests that a felt tip pen be used to mark an initial reference point on the bearing housing and the bearing carrier as shown in figure 6-6. Then make a second mark on the bearing carrier 6.5 indicator patterns clockwise from the initial reference point. Rotate the bearing carrier counter-clockwise until the second mark on the bearing carrier lines up with the initial reference point mark on the bearing housing. Lastly, uniformly tighten the set screws [6570.3] in incremental steps up to the final torque value to lock the bearing carrier in place. The impeller is now set for an impeller setting of 0.7 mm (0.028 in.) off the casing.

The above procedure is fairly straightforward when doing the final setting of the impeller. However it can be quite laborious when doing the preliminary setting in order to establish the location of the mechanical seal. For this reason, the following practice is recommended. Before the pump is taken out of service, adjust the impeller until it touches the casing and then rotate the bearing carrier until the desired impeller clearance is obtained. Identify this location on the bearing carrier and then rotate the bearing carrier until the impeller contacts the rear cover. Record the distance from the desired impeller clearance setting to when the impeller contacts the rear cover. The pump is now removed from the casing and taken to the shop for maintenance. When it is time to set the seal, the impeller is simply set off the rear cover by the same distance recorded earlier.

**Note:**

The above technique is only applicable if all of the original pump components are reinstalled. If the casing, cover, impeller or shaft is replaced this method must not be used.

### 6.6.3 Installation and clearance setting for Sealmatic pumps.

Install the repeller [2000.1] and covers [1220 and 1220.1] as described in section 6.9.3. Install a seal guide from the Mark 3 tool kit to hold the repeller in place. Set the repeller 0.38 to 0.51 mm (0.015 to 0.020 in.) off the cover following the instruction above in section 6.6.1. Uniformly tighten the set screws [6570.3] in incremental steps up to the final torque value to lock the bearing carrier in place. Remove the seal guide and install the impeller. Check the impeller setting with a feeler gage. The gap should be 0.38 to 0.51 mm (0.015 to 0.020 in.). If the gap is outside of the correct setting, it may be readjusted to get the beat gap at the repeller and impeller.

## 6.7 Disassembly

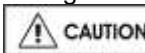
### 6.7.1 Power end removal

- Before performing any maintenance, disconnect the driver from its power supply and lock it off line.
- CAUTION** Lock out power to driver to prevent personal injury.
- Close the discharge and suction valves, and drain all liquid from the pump.
- Close all valves on auxiliary equipment and piping, then disconnect all auxiliary piping.
- Decontaminate the pump as necessary.

**CAUTION**

If Flowserve Mark 3 pumps contain dangerous chemicals, it is important to follow plant safety guidelines to avoid personal injury or death.

- e) Remove the coupling guard. (See section 5.5.)
- f) Remove the spacer from the coupling. Close coupled pumps required that the motor be removed from the pump assembly. The motor must be fully supported and the jackscrews [6575] loose before removal.
- g) Remove casing fasteners [6580.1]. On GP1 In-Line pumps the studs [6572.1] must be removed.
- h) Remove the fasteners holding the bearing housing foot to the baseplate (not applicable on In-Line pumps).
- i) Move the power end, rear cover, and seal chamber assembly away from the casing. On In-Line pumps the simplest method of power end removal is to first remove the motor and motor adapter with a crane. However this is often not practical and the power end must be removed by hand. This operation is illustrated in figures 6-7, 6-8 and 6-9. Discard the casing/cover gasket [4590.1].



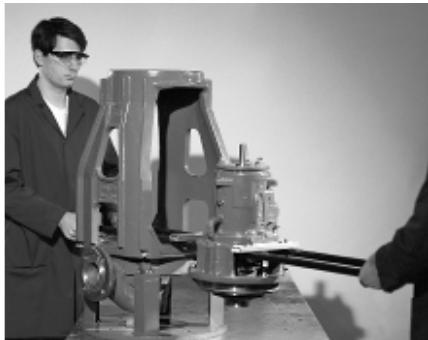
The power end and rear cover assembly is heavy. It is important to follow plant safety guidelines when lifting it.

- j) Transport the assembly to the maintenance shop.

**Figure 6.6**



**Figure 6.7**



**Figure 6.8**



### 6.7.2 Pump disassembly

- a) Remove the coupling hub from the pump shaft [2100]. Close coupled pumps require the motor adapter [3160] be removed.
- b) Using the shaft key [6700], mount the impeller wrench from the Flowserve Mark 3 tool kit (figure 6-1) to the end of the shaft. With the wrench handle pointing to the left when viewed from the impeller end, grasp the impeller [2200] firmly with both hands (wear heavy gloves). By turning the impeller in the clockwise direction move the wrench handle to the 11 o'clock position and then spin the impeller quickly in a counter-clockwise direction so that the wrench makes a sudden impact with a hard surface on the bench. After several sharp raps, the impeller should be free. Unscrew the impeller and remove from the shaft. Discard the impeller gasket [4590.2].



**Do not apply heat to the impeller. If liquid is entrapped in the hub, an explosion could occur.**

- c) If a cartridge type mechanical seal [4200] is used (figure 6-10), the spacing clips or tabs should be installed prior to loosening the set screws which attaches the seal to the shaft or removing it from the cover. This will ensure that the proper seal compression is maintained.

**Figure 6.9**



- d) Remove the seal or packing gland nuts [6580.2] if so equipped.

- e) Remove the cover.

All pumps except Sealmatic

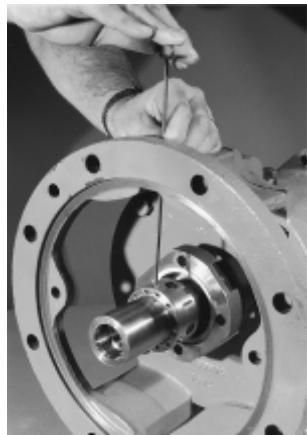
Remove the two cap screws [6570.2] which attach the rear cover [1220] to the adapter. Carefully remove this part.

Sealmatic pump only

Remove the cap screws that hold the rear cover [1220] to the repeller cover [1220.1]. For Group 3 pumps remove the capscrews [6570.2] that hold the rear cover [1220] to the adapter [1340]. Remove the cover. The repeller is now exposed [2200.1] and should be free to slip from the shaft. In the event it is stuck, the repeller can be pried off by the use of 2 screwdrivers wedged between the repeller [2200.1] and the repeller cover [1220.1].

- f) If a component type inside mechanical seal [4200] is used, loosen the set screws on the rotating unit and remove it from the shaft (see figure 6-11). Then pull the gland [4120] and stationary seat off the shaft. Remove the stationary seat from the gland. Discard all O-rings and gaskets.

**Figure 6.10**



- g) If a component type outside mechanical seal is used, remove the gland and the stationary seat. Remove the stationary seat from the gland. Loosen the set screws in the rotating unit and remove it from the shaft. Discard all O-rings and gaskets.
- h) If packing [4130] is used, remove it and the seal cage [lantern ring, 4134]. Remove the gland [4120].

- i) If the pump has a hook type sleeve [2400] it can now be removed. Unit now appears as shown in figure 6-12.

**Figure 6.11**



- j) If the power end is oil lubricated, remove the drain plug [6569.1] and drain the oil from the bearing housing [3200].
- k) If the pump has lip seals, a deflector [2540] will be present. Remove it.
- l) Loosen the three set screws [6570.3] on the bearing carrier [3240]. The bearing carrier must be completely unscrewed from the bearing housing.

**Note:**

Do not pry against the shaft.)

Mark 3A and ANSI 3A design

The face of the bearing carrier has three square lugs that protrude from the surface. The bearing carrier is turned by using an open end wrench on one of the square lugs as shown in figure 6-13.

Mark 3 design

On Group 1 and 2 pumps the bearing carrier is turned by using a strap wrench, with the strap located around the outside diameter of the carrier face. On Group 3 pumps, the bearing carrier is turned by using a spanner wrench to engage the cogs on the outside diameter of the bearing carrier.

**Figure 6.12**



- m) Because the O-rings [4610.2] will cause some resistance in removing the bearing carrier assembly from the housing, hold the bearing carrier flange firmly and with slight rotation, pull it out of the bearing housing. The bearing carrier assembly with the shaft and bearings should come free. This unit will appear as shown in figure 6-14. Further disassembly is not required unless the bearings are to be replaced.

**Figure 6.13**



- n) Remove the snap ring [2530] (see figure 6-15) on Group 1 and 2 pumps, or the bearing retainer [2530.1] on Group 3 pumps.

**Figure 6.14**



**Note:**

Group 1 and 2 pumps equipped with duplex angular contact bearings use a bearing retainer [2530.1] instead of the snap ring. Remove the carrier from the bearing.

- o) The bearing locknut [3712] and lockwasher [6541.1] may now be removed from the shaft [2100]. Discard the lockwasher.
- p) An arbor or hydraulic press may be used to remove the bearings [3011 and 3013] from the shaft. It is extremely important to apply even pressure to the inner bearing race only. Never apply pressure to the outer race as this exerts excess load on the balls and causes damage.



Applying pressure to the outer race could permanently damage the bearings.

- q) The Mark 3A design has an optional oil slinger [2541] located between the bearings. If present, inspect it for damage or looseness. Remove if it needs to be replaced.

- r) On Group 2 and 3 pumps, the bearing housing [3200] must be separated from the bearing housing adapter [1340]. The adapter O-ring [4610.1] should be discarded.

***Mark 3A and ANSI 3A design***

This is accomplished by removing the cap screws [6570.5], which thread into the bearing housing.

***Mark 3 In-Line design***

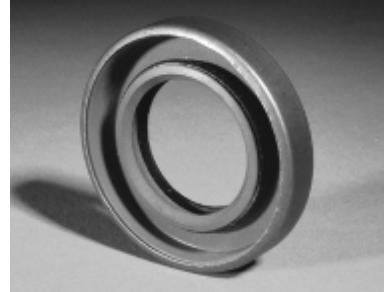
There is no adapter o-ring [4610.1] when an oil drain tap is supplied in the adapter.

***Mark 3 design***

This is accomplished by removing the hex nuts [6580.8] and the cap screws [6570.5].

- s) If lip seals [4310.1] and [4310.2] (see figure 6-16) are used, they should be removed from the bearing carrier and adapter and discarded.

**Figure 6.15**



- t) If the bearing isolators are removed from either the bearing carrier or adapter they must not be reused, discard appropriately.
- u) If magnetic seals are used, maintain the seals as specified by the manufacturer.

***Mark 3 and Mark 3A design***

Remove the Trico oiler/site gage [3855] (figure 6-17) and oil level tag (figure 6-18) from the bearing housing.

***ANSI 3A design***

Remove the site gage [3856] (figure 5.1) and oil level tag (figure 6-18) from the bearing housing.

**Figure 6.16**



**Figure 6.17**



*"Oil level must be maintained at center of sight glass".  
Save these parts for reuse.*

## 6.8 Examination of parts

### 6.8.1 Cleaning/inspection

All parts should now be thoroughly cleaned and inspected. New bearings, O-rings, gaskets, and lip seals should be used. Any parts that show wear or corrosion should be replaced with new genuine Flowserve parts.



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

### 6.8.2 Critical measurements and tolerances

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

### 6.8.3 Parameters that should be checked by users

Flowserve recommends that the user check the measurements and tolerances in figure 6-19 whenever pump maintenance is performed. Each of these measurements is described in more detail on the following pages.

### 6.8.4 Additional parameters checked by Flowserve

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

#### 6.8.4.1 Shaft and sleeve (if fitted)

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

#### Diameter/tolerance, under bearings

In order to ensure proper fit between the shaft and bearings, verify that both the inboard (IB) and outboard (OB) shaft diameter is consistently within the minimum/maximum values shown in figure 6-20. A micrometer should be used to check these outside diameter (OD) dimensions on the shaft.

#### 6.8.4.2 Bearings

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

#### Diameter/tolerance, inside diameter

In order to ensure proper fit between bearings and the shaft, verify that the inside diameter (ID) of both the IB and OB bearing are consistently within the minimum/maximum values shown in figure 6-20. An inside caliper should be used to check these ID diameters on the bearings.

#### Diameter/tolerance, outside diameter

In order to ensure proper fit between bearings and the bearing housing, verify that the OD on both the IB and OB bearings are consistently within the minimum/maximum values shown in figure 6-21. A micrometer should be used to check these outside diameter (OD) dimensions on the bearings.

#### 6.8.4.3 Impeller balancing

Shaft whip is deflection where the centerline of the impeller is moving around the true axis of the pump. It is not caused by hydraulic force but rather by an imbalance with the rotating element. Shaft whip is very hard on the mechanical seal because the faces must flex with each revolution in order to maintain contact. To minimize shaft whip it is imperative that the impeller is balanced. All impellers manufactured by Flowserve are balanced after they are trimmed. If for any reason, a customer trims an impeller, it must be re-balanced. See note 1 under figure 6-19 regarding acceptance criteria.

#### 6.8.4.4 Bearing housing/carrier

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

#### Diameter/tolerance, at bearing surface

In order to ensure proper fit between the bearing housing/carrier and the bearings, verify that the ID of both the IB and OB bearing surfaces are consistently within the minimum/maximum values shown in figure 6-21. An inside caliper should be used to check these ID dimensions in the bearing housing.

**Figure 6.18**

Topic	ASME B73.1M standard mm (in.)	Suggested by major seal vendors mm (in.)	Suggested and/or provided by Flowserve mm (in.)
<b>Shaft</b> Diameter tolerance, under bearings	n/s		0.005 (0.0002)
<b>Impeller</b> Balance		See note 1	
<b>Bearing housing</b> Diameter (ID) tolerance at bearings	n/s		0.013 (0.0005)
<b>Power end assembly</b> Shaft runout Shaft sleeve runout Radial deflection - static Shaft endplay	0.05 (0.002) 0.05 (0.002) n/s n/s	0.03 (0.001) 0.05 (0.002) 0.076 (0.003) 0.05 (0.002)	0.05 (0.002) 0.05 (0.002) 0.05 (0.002)
<b>Seal chamber</b> Face squareness to shaft Register concentricity	0.08 (0.003)	0.03 (0.001) 0.13 (0.005)	0.08 (0.003) 0.13 (0.005)
<b>Complete pump</b> Shaft movement caused by pipe strain Alignment Vibration at bearing housing	n/s n/s See note 3	0.05 (0.002)	0.05 (0.002) See note 2 See note 3

n/s = not specified.

1. The maximum values of acceptable unbalance are:

1500 r/min: 40 g-mm/kg (1800 r/min: 0.021 oz-in/lb) of mass.

2900 rpm: 20 g-mm/kg (3600 rpm: 0.011 oz-in/lb) of mass.

Flowserve performs a single plane spin balance on most impellers. The following impellers are exceptions: 10X8-14, 10X8-16 and 10X8-16H. On these Flowserve performs a two plane dynamic balance, as required by the ASME B73.1M standard. All balancing, whether single or two plane, is performed to the ISO 1940 Grade 6.3 tolerance criteria.

2. The ASME B73.1M standard does not specify a recommended level of alignment. Flowserve recommends that the pump and motor shafts be aligned to within 0.05 mm (0.002 in.) parallel FIM (full indicator movement) and 0.0005 mm/mm (0.0005 in./in.) angular FIM. Closer alignment will extend MTBPM. For a detailed discussion of this subject see the *Alignment* section of this manual.

3. The ASME B73.1M, paragraph 5.1.4.

**Figure 6.19**

OB Brg/Shaft mm (in.)	Group 1	Group 2	Group 3	Group 3HD
Bearing	30.000/29.990 (1.1811/1.1807)	50.000/49.987 (1.9685/1.9680)	70.000/69.985 (2.7559/2.7553)	75.000/74.985 (2.9528/2.9522)
Shaft	30.013/30.003 (1.1816/1.1812)	50.013/50.003 (1.9690/1.9686)	70.015/70.002 (2.7565/2.7560)	75.016/75.004 (2.9534/2.9529)
Fit	0.023T/0.003T (0.0009T/0.0001T)	0.026T/0.003T (0.0010T/0.0001T)	0.030T/0.002T (0.0012T/0.0001T)	0.031T/.004T (.0012T/.0001T)
IB Brg/Shaft mm (in.)	Group 1	Group 2	Group 3	Group 3HD
Bearing	35.000/34.989 (1.3780/1.3775)	50.000/49.987 (1.9685/1.9680)	70.000/69.985 (2.7559/2.7553)	85.000/84.975 (3.3465/3.3455)
Shaft	35.014/35.004 (1.3785/1.3781)	50.013/50.003 (1.9690/1.9686)	70.015/70.002 (2.7565/2.7560)	85.019/85.004 (3.3472/3.3466)
Fit	0.025T/0.004T (0.0010T/0.0001T)	0.026T/0.003T (0.0010T/0.0001T)	0.030T/0.002T (0.0012T/0.0001T)	.044T/.004T (.0017T/.0001T)

**Figure 6.20**

OB Brg/Carrier mm (in.)	Group 1	Group 2	Group 3	Group 3HD
Bearing	71.999/71.986 (2.8346/2.8341)	110.000/109.985 (4.3307/4.3301)	150.000/149.979 (5.9055/5.9047)	160.000/159.975 (6.2992/6.2982)
Carrier	71.999/72.017 (2.8346/2.8353)	110.007/110.022 (4.3310/4.3316)	150.002/150.030 (5.9056/5.9067)	160.043/160.002 (6.3009/6.2993)
Fit	0.031L/0.000L (0.0012L/0.0000L)	0.037L/0.007L (0.0015L/0.0003L)	0.051L/0.002L (0.0020L/0.0001L)	.068L/.002L (.0027L/.0001L)
IB Brg / Housing mm (in.)	Group 1	Group 2	Group 3	Group 3HD
Bearing	71.999/71.986 (2.8346/2.8341)	110.000/109.985 (4.3307/4.3301)	150.000/149.979 (5.9055/5.9047)	150.000/149.975 (5.9055/5.9045)
Housing	71.999/72.017 (2.8346/2.8353)	110.007/110.022 (4.3310/4.3316)	150.007/150.025 (5.9058/5.9065)	150.025/150.007 (5.9065/5.9058)
Fit	0.031L/0.000L (0.0012L/0.0000L)	0.037L/0.007L (0.0015L/0.0003L)	0.046L/0.007L (0.0018L/0.0003L)	.050L/.007L (.0020L/.0003L)

#### 6.8.4.5 Power end

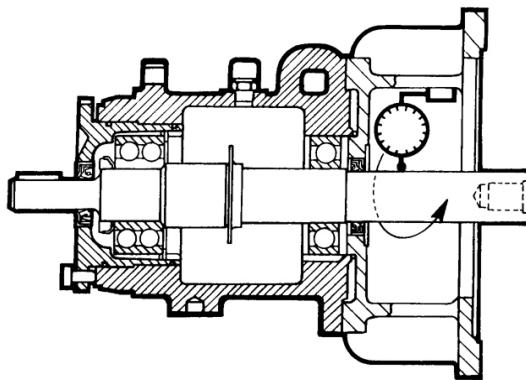
Assembled bearing housing, carrier, bearings, and shaft.

##### Shaft/shaft sleeve run-out

Shaft run-out is the amount the shaft is "out of true" when rotated in the pump. It is measured by attaching a dial indicator to a stationary part of the pump so that its contact point indicates the radial movement of the shaft surface as the shaft is rotated slowly. If a shaft sleeve is used then shaft sleeve run-out must be checked. It is analogous to shaft run-out. Measurement of shaft run-out/shaft sleeve run-out will disclose any out of roundness of the shaft, any eccentricity between the shaft and the sleeve, any permanent bend in the shaft, and/or any eccentricity in the way the shaft or bearings are mounted in the bearing housing.

Shaft run-out can shorten the life of the bearings and the mechanical seal. The following diagram shows how to measure shaft/shaft sleeve run-out. Note that both ends need to be checked. The run-out should be 0.025 mm (0.001 in.) FIM or less.

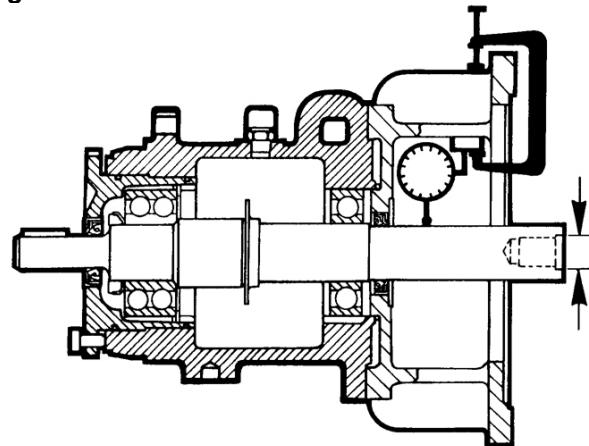
**Figure 6.21** Diagram



##### Radial deflection - static

Radial movement of the shaft can be caused by a loose fit between the shaft and the bearing and/or the bearing and the housing. This movement is measured by attempting to displace the shaft vertically by applying an upward force of approximately 4.5 kg (10 lb) to the impeller end of the shaft. While applying this force, the movement of an indicator is observed as shown in the following diagram. The movement should be checked at a point as near as possible to the location of the seal faces. A movement of more than 0.05 mm (0.002 in.) is not acceptable.

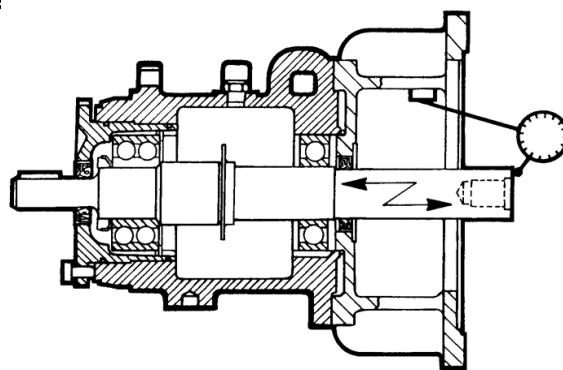
**Figure 6.22** Deflection



##### Shaft endplay

The maximum amount of axial shaft movement, or endplay, on a Durco pump should be 0.05 mm (0.002 in.) and is measured as shown below. Observe indicator movement while tapping the shaft from each end in turn with a soft mallet. Shaft endplay can cause several problems. It can cause fretting or wear at the point of contact between the shaft and the secondary sealing element. It can also cause seal overloading or underloading and possibly chipping of the seal faces. It can also cause the faces to separate if significant axial vibration occurs.

**Figure 6.23** Endplay



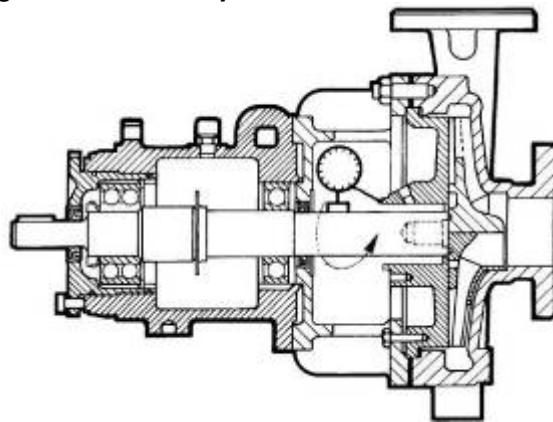
#### 6.8.4.6 Seal chamber

Assembled power end and rear cover.

##### Face squareness to shaft

Also referred to as "Seal chamber face run-out." This run-out occurs when the seal chamber face is not perpendicular to the shaft axis. This will cause the gland to cock, which causes the stationary seat to be cocked, which causes the seal to wobble. This run-out should be less than 0.08 mm (0.003 in.) and should be measured as shown below:

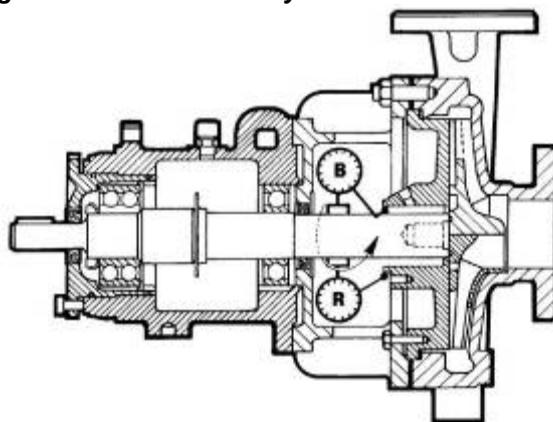
**Figure 6.24 Face squareness**



Register concentricity

An eccentric seal chamber bore or gland register can interfere with the piloting and centering of the seal components and alter the hydraulic loading of the seal faces, resulting in reduction of seal life and performance. The seal chamber register concentricity should be less than 0.13 mm (0.005 in.). The diagram below shows how to measure this concentricity.

**Figure 6.25 Concentricity**



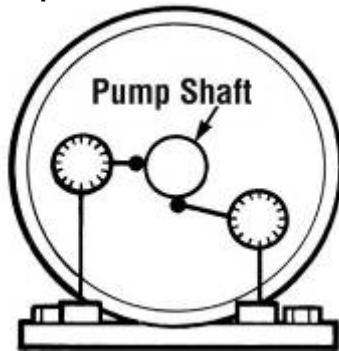
**6.8.4.7 Installed pump**

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.).

**Figure 6.26 Pipe strain movement**



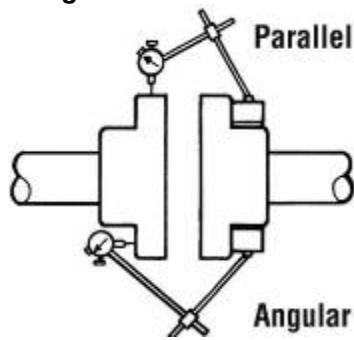
Alignment

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. If proper alignment cannot be maintained a C-flange motor adapter and/or stilt/spring mounting should be considered.

**Figure 6.27 Alignment**



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

See section 4.8 for recommended final shaft alignment limits.

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 note 3 under figure 6-19 regarding acceptance criteria.

## 6.9 Assembly of pump and seal



**CAUTION** It is important that all pipe threads be sealed properly. PTFE tape provides a very reliable seal over a wide range of fluids, but it has a serious shortcoming if not installed properly. If, during application to the threads, the tape is wrapped over the end of the male thread, strings of the tape will be formed when threaded into the female fitting. These strings can then tear away and lodge in the piping system.

If this occurs in the seal flush system, small orifices can become blocked effectively shutting off flow. For this reason, Flowserve does not recommend the use of PTFE tape as a thread sealant.

Flowserve has investigated and tested alternate sealants and has identified two that provide an effective seal, have the same chemical resistance as the tape, and will not plug flush systems. These are La-co Slic-Tite and Bakerseal. Both products contain finely ground PTFE particles in an oil based carrier. They are supplied in a paste form which is brushed onto the male pipe threads. Flowserve recommends using one of these paste sealants.

Full thread length engagement is required for all fasteners.

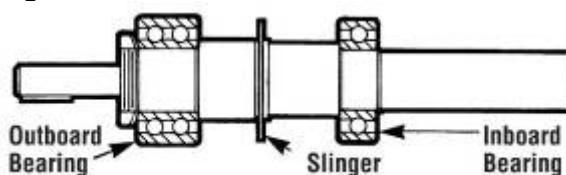
**Note:**

Refer to figure 6-2 for recommended bolt torques.

### 6.9.1 Power end assembly

The Mark 3A design has an optional oil slinger. If the slinger was removed during disassembly, install a new slinger [2541]. (See figure 6-29.)

**Figure 6.28**



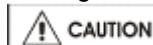
#### 6.9.1.1 Bearing installation

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

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

The chart shown in figure 6-30 gives the SKF part numbers for bearings in Flowserve Mark 3 pumps. Note that the term "inboard bearing" refers to the bearing

nearest to the casing. "Outboard bearing" refers to the bearing nearest to the motor. (See figure 6-29.)



**CAUTION** Both bearings have a slight interference fit which requires that they be pressed on the shaft with an arbor or hydraulic press. Figure 6-20 identifies the bearing fits. Even force should be applied to only the inner race. Never press on the outer race, as the force will damage the balls and races.

An alternate method of installing bearings is to heat the bearings to 93 °C (200 °F) by means of an oven or induction heater. With this approach the bearing must be quickly positioned on the shaft.

Never heat the bearings above 110 °C (230 °F). To do so will likely cause the bearing fits to permanently change, leading to early failure.

- Install the inboard bearing [3011] on the shaft [2100].

#### Mark 3A and ANSI 3A design

The inboard bearing must be positioned against the shoulder as shown in figure 6.29.

#### Mark 3 design

On Group 1 and Group 2 shafts, the inboard bearing must be located as shown in figure 6.31. On Group 3 shafts position the inboard bearing against the shoulder.

Figure 6.29 Flowserv Mark 3 bearings

Group	Type of bearing	Inboard single row, deep groove <sup>5</sup>	Outboard double row, angular contact, deep groove <sup>5 &amp; 9</sup>	Optional outboard duplex angular contact <sup>5</sup>
1	Oil bath/mist - open <sup>1</sup>	6207-C3	5306-AC3 or 3306-AC3	7306-BECBY
	Regreasable - single shielded <sup>2</sup>	6207-ZC3	5306-AZC3 or 3306-AZC3	NA <sup>6</sup>
	Greased for life - double shielded <sup>3</sup>	6207-2ZC3	5306-A2ZC3 or 3306-A2ZC3	NA <sup>7</sup>
	Sealed for life - double sealed <sup>4</sup>	6207-2RS1C3	5306-A2RSC3 or 3306-A2RS1C3	NA <sup>7</sup>
2	Oil bath/mist - open <sup>1</sup>	6310-C3	5310-AC3 (AHC3) or 3310-AC3	7310-BECBY
	Regreasable - single shielded <sup>2</sup>	6310-ZC3	5310-AZC3 or 3310-AZC3	NA <sup>6</sup>
	Greased for life - double shielded <sup>3</sup>	6310-2ZC3	5310-A2ZC3 or 3310-A2ZC3	NA <sup>7</sup>
	Sealed for life - double sealed <sup>4</sup>	6310-2RS1C3	5310-A2RSC3 or 3310-A2RS1C3	NA <sup>7</sup>
3	Oil bath/mist - open <sup>1</sup>	6314-C3	5314-AC3 or 3314-AC3	7314-BECBY
	Regreasable - single shielded <sup>2</sup>	6314-ZC3	5314-AZC3 or 3314-AZC3	NA <sup>6</sup>
	Greased for life - double shielded <sup>3</sup>	6314-2ZC3	5314-A2ZC3 or 3314-A2ZC3	NA <sup>7</sup>
	Sealed for life - double sealed <sup>4</sup>	6314-2RS1C3	5314-A2RSC3 or 3314-A2RS1C3	NA <sup>7</sup>
3-HD	Oil bath/mist - open <sup>1</sup>	NUP217ECP C13	NA <sup>7</sup>	7315-BECBY
	Regreasable - single shielded <sup>2</sup>	NA <sup>7</sup>	NA <sup>7</sup>	NA <sup>7</sup>
	Greased for life - double shielded <sup>3</sup>	NA <sup>7</sup>	NA <sup>7</sup>	NA <sup>7</sup>
	Sealed for life - double sealed <sup>4</sup>	NA <sup>7</sup>	NA <sup>7</sup>	NA <sup>7</sup>

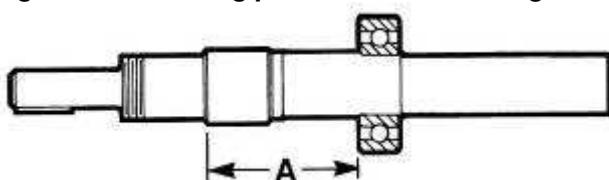
**Notes:**

1. These bearings are open on both sides. They are lubricated by oil bath or oil mist.
2. These bearings are pre-greased by Flowserv. Replacement bearings will generally not be pre-greased, so grease must be applied by the user. They have a single shield, which is located on the side next to the grease buffer, or reservoir. The bearings draw grease from the reservoir as it is needed. The shield protects the bearing from getting too much grease, which would generate heat. The grease reservoir is initially filled with grease by Flowserv. Lubrication fittings are provided, to allow the customer to periodically replenish the grease, as recommended by the bearing and/or grease manufacturer.
3. These bearings are shielded on both sides. They come pre-greased by the bearing manufacturer. The user does not need to re-grease these bearings. The shields do not actually contact the bearing race, so no heat is generated.
4. These bearings are sealed on both sides. They come pre-greased by the bearing manufacturer. The user does not need to re-grease these bearings. The seals physically contact and rub against the bearing

race, which generates heat. These bearings are not recommended at speeds above 1750 r/min.

5. The codes shown are SKF codes. Inboard and outboard bearings have the C3, greater than "normal" clearance. These clearances are recommended by SKF to maximize bearing life.
6. Regreasable - single shielded bearings are not available in the duplex configuration; however, open oil bath-type bearings can be used for the regreasable configuration. These bearings must be pre-greased during assembly. Lubrication fittings are provided, to allow the user to periodically replenish the grease, as recommended by the bearing and/or grease manufacturer.
7. Not available.
8. All bearing configurations are supplied only with steel cages
9. SKF - the 5300 and 3300 bearing series are identical and therefore can be used interchangeably.
10. Group 3-HD: Duplex angular contact bearings standard in outboard position.

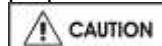
Figure 6.30 Bearing position - Mark 3 design



Mark 3 standard shaft		Mark 3 duplex bearing shaft	
Group	A	Group	A
1	68 mm (2 <sup>11</sup> / <sub>16</sub> in.)	1	61 mm (2 <sup>3</sup> / <sub>8</sub> in.)
2	139 mm (5 <sup>15</sup> / <sub>32</sub> in.)	2	129 mm (5 <sup>3</sup> / <sub>32</sub> in.)
3	NA	3	*
3-HD	NA	3-HD	*

\* Inboard bearing located against shoulder.

If the power end is equipped with single shielded regreasable bearings, see figures 5.7 and 5.8 for proper orientation of the shields



The orientation of the bearing shields is different for horizontal pumps (figure 5.7) and In-Line pumps (figure 5.8).

- Install the outboard bearing retaining device onto the shaft.

*Double row bearings*

Place the snap ring [2530] onto the outboard end of the shaft and slide down to the inboard bearing.

**Note:**

The proper orientation of the snap ring must be assured in this step. The flat side of the snap ring must face away from the inboard bearing.

*Duplex angular contact bearings*

Place the bearing retainer [2530.1] onto the outboard end of the shaft and slide down to the inboard bearing.

**Note:**

The proper orientation of the bearing retainer must be assured in this step. The small side of the retainer must face away from the inboard bearing.

- Install the outboard bearing.

*Double row bearings*

Install the outboard bearing [3013] firmly against the shoulder as shown in figure 6.29. If hot bearing mounting techniques are used, steps

must be taken to ensure the outboard bearing is firmly positioned against the shaft shoulder. The outboard bearing, while still hot, is to be positioned against the shaft shoulder.

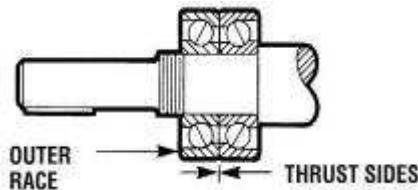
**Duplex angular contact bearings**

Duplex angular contact bearings must be mounted back-to-back with the wider thrust sides of the outer races in contact with each other as shown in figure 6.32. Only bearings designed for universal mounting should be used. The SKF designation is "BECB". NTN's designation is "G".

**Note:**

A special shaft is required when using duplex angular contact bearings (standard on group 3-HD pumps).

**Figure 6.31**



The orientation of the bearing shields is different for horizontal pumps (figure 5.7) and In-Line pumps (figure 5.8).



It must be understood that fixtures and equipment used to press the bearing must be designed so no load is ever transmitted through the bearing balls. This would damage the bearing.

d) After the bearing has cooled below 38 °C (100 °F) the bearing should be pressed against the shaft shoulder. Figure 6.33 identifies the approximate force needed to seat the bearing against the shaft shoulder. If a press is not available the locknut [3712] should be installed immediately after the bearing is placed on the shaft and tightened to ensure the bearing remains in contact with the shaft shoulder. The locknut should then be retightened repeatedly during the time the bearing is cooling. Once cool the locknut should be removed.

**Figure 6.32**

Pump	Press force N (lbf)	Locknut torque Nm (lbf·ft)
Group 1	5 780 (1 300)	27 +4/-0 (20 +5/-0)
Group 2	11 100 (2 500)	54 +7/-0 (40 +5/-0)
Group 3	20 000 (4 500)	95 +7/-0 (70 +5/-0)
Group 3-HD	20 000 (4 500)	102 +7/-0 (75 +5/-0)

e) Install lockwasher [6541.1] and locknut [3712]. The locknut should be torqued to the value shown in figure 6.33. One tang on the lockwasher must be bent into a corresponding groove on the locknut.

**6.9.1.2 Bearing housing seals**

**Lip seals**

If lip seals were used (see figure 6.16), install new lip seals in the bearing carrier [3240] and the housing [3200 - Group 1] or the adapter [1340 - Group 2 and 3]. The lip seals [4310.1 and 4310.2] are double lip style, the cavity between these two lips should be  $\frac{1}{2}$  to  $\frac{2}{3}$  filled with grease. When installing this part, the large metal face on the lip seal must face away from the bearings.

**Labyrinth seals**

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

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

Install the inboard seal in the bore of the bearing housing (Group 1) or adapter (Group 2 and Group 3) with the single expulsion port positioned at the 6 o'clock position.

Install the outboard seal in the bore of the bearing carrier. There are no orientation issues since this is a multiport design seal.

**Magnetic seals**

Follow the installation instructions provided by the manufacturer.

**6.9.1.3 Bearing carrier/power end assembly**

- Install new O-rings [4610.2] onto the bearing carrier. Be sure to use the correct size O-rings. (The Mark 3 and Mark 3A bearing carriers use different O-rings.)
- Slide the bearing carrier [3240] over the outboard bearing [3013].
- Install the outboard bearing retaining device.

**Double row bearings on Group 1 and 2 pumps**

Slide the snap ring [2530] in place with its flat side against the outboard bearing and snap it into its groove in the bearing carrier.

**Duplex angular contact bearings on Group 1 and 2 pumps; all bearings on Group 3 pumps**

Slide the bearing retainer [2530.1] against the outboard bearing and install and tighten the socket head capscrews [6570.12]. See figure 6.2 for correct torque values.



**CAUTION** Never compress the snap ring unless it is positioned around the shaft and between the bearings. In this configuration, it is contained therefore if it should slip off the compression tool it is unlikely to cause serious injury.

- d) The shaft, bearings, and bearing carrier assembly (figure 6.14) can now be installed into the bearing housing [3200]. The bearing carrier [3240] should be lubricated with oil on the O-rings and threads before installing the assembly into the bearing housing. Thread the bearing carrier into the bearing housing by turning it clockwise to engage the threads. Thread the carrier onto the housing until the carrier flange is approximately 3 mm ( $\frac{1}{8}$  in.) from the housing. Install the set screws [6570.3] loosely.
- e) Reinstall any tags, plugs, site gages and oiler.  
*Mark 3 and Mark 3A design*  
Install the following items onto the bearing housing; oil level tag (figure 6.18) and combination Trico oiler/site gage [3855], vent/breather [6521] and drain plug [6569.1].
- f) *ANSI 3A design*  
Install the following items onto the bearing housing; oil level tag (figure 6.18) and site gage [3855], plug [6521] and magnetic drain plug [6569.4].
- f) On Group 2 and 3 pumps, assemble the bearing housing adapter [1340] to the bearing housing [3200]. Be sure to install a new O-ring [4610.1].  
*Mark 3 In-Line design*  
The adapter O-ring [4610.1] should not be installed if there is a drain tap in the adapter [1340]. This tap is present on pumps with regreasable bearings and most oil mist applications.
- f) *Mark 3A and ANSI 3A design*  
Thread the capscrews [6570.5] through the adapter and into the tapped holes in the bearing housing.
- f) *Mark 3 design*  
Use the capscrews [6570.5] and hexnuts [6580.8]. Orient the bearing housing adapter with the two holes for capscrews [6570.5] on a horizontal line.
- g) If the pump has lip seals, install the deflector [2540].
- h) If the pump is equipped with a hook type sleeve [2400], slip it into place over the impeller end of the shaft [2100].

## 6.9.2 Wet end assembly

### 6.9.2.1 Cartridge mechanical seals

Review the seal assembly instructions and drawings provided by the seal manufacturer.

- a) Install a nose cone on the end of the shaft and then slide the cartridge seal [4200] onto the shaft until it lightly touches the bearing housing [3200] or adapter [1340]. See figure 6.10.
- b) Install the rear cover plate [1220] to the bearing housing (Group 1) or the bearing housing adapter (Group 2 and 3) by using the capscrews [6570.2]. Now install the cartridge seal gland to the rear cover plate [1220] using studs [6572.2] and nuts [6580.2].
- c) Install the impeller [2200] as instructed in section 6.6. Care should be taken in the handling of high chrome iron impellers.
- d) Tighten set screws on the seal to lock the rotating unit to the shaft. Finally, remove centering clips from the seal.

### 6.9.2.2 Component type mechanical seal

Review the seal assembly instructions and drawings (seal set dimension) provided by the seal manufacturer.

In order to properly set a component seal it is necessary to first locate the shaft in its final axial position. This is accomplished in the following manner.

- a) Install the rear cover plate [1220] to the bearing housing (Group 1) or the bearing housing adapter (Group 2 and 3) by using the capscrews [6570.2].
- b) Install and set the impeller [2200] clearance as outlined in section 6.6. Put blueing on the shaft/sleeve in the area near the face of the seal chamber (rear cover 1220). Scribe a mark on the shaft at the face of the seal chamber (figure 6.34).

**Figure 6.33**



- c) Remove the impeller and seal chamber (rear cover) following the instructions given in section 6.7 and install a nose cone onto the end of the shaft.

#### Single internal seal installation

- d) Place the gland [4120] and stationary seat onto the shaft until it lightly touches the bearing housing (Group 1) or adapter (Group 2 and 3).
- e) Install a gland gasket [4590.3] into the gland. (See figure 6-35.)

**Figure 6.34**



- f) Locate the rotary seal unit onto the shaft (or sleeve) according to the set dimension provided by the seal manufacturer. Tighten set screws on the seal to lock the rotating unit to the shaft/sleeve.
- g) Install the rear cover plate [1220] to the bearing housing (Group 1) or the bearing housing adapter (Group 2 and 3) by using the capscrews [6570.2].
- h) Attach the gland/seat to the rear cover plate [1220] using studs [6572.2] and nuts [6580.2].

#### Single external seal installation

Carry out steps a) to c), above.

- d) Locate the rotary seal unit onto the shaft/sleeve according to the set dimension provided by the seal manufacturer. Tighten set screws on the seal to lock the rotating unit to the shaft/sleeve.
- e) Attach the gland [4120] and stationary seat onto rear cover plate [1220] using studs [6572.2] and nuts [6580.2].
- f) Install the rear cover plate [1220] to the bearing housing (Group 1) or the bearing housing adapter (Group 2 and 3) by using the capscrews [6570.2].

#### Double seal installation

Carry out steps a) to c), above.

- d) Place the gland [4120] and stationary seat onto the shaft until it lightly touches the bearing housing (Group 1) or adapter (Group 2 and 3). Install a gland gasket [4590.3] into the gland. (See figure 6-28.)
- e) Locate the rotary seal unit onto the shaft/sleeve according to the set dimension provided by the seal manufacturer. Tighten set screws on the seal to lock the rotating unit to the shaft/sleeve. Install a stationary seat into the rear cover plate [1220].
- f) Install the rear cover plate [1220] to the bearing housing (Group 1) or the bearing housing adapter (Group 2 and 3) by using the capscrews [6570.2].
- g) Attach the gland/seat to the rear cover plate [1220] using studs [6572.2] and nuts [6580.2].

- h) Install the impeller [2200] as instructed in section 6.6. Remember that the impeller clearance is already set. It cannot be changed at this point without resetting the seal.

#### **6.9.2.3 Packing**

##### Split gland installation

- a) Install the rear cover plate [1220] to the bearing housing (Group 1) or the bearing housing adapter (Group 2 and 3) by using the capscrews [6570.2].
- b) Install and set the impeller [2200] clearance as outlined in section 6.6.
- c) Install the packing rings [4130] and seal cage halves [4134] into the stuffing box as shown in figures 4-23 and 4-24. Always stagger the end gaps 90 degrees to ensure a better seal. To speed installation of each ring, have an assistant turn the pump shaft in one direction. This movement of the shaft will tend to draw the rings into the stuffing box.
- d) A split gland [4120] is an assembly of two matched gland halves that are bolted together. Unbolt the gland halves and install the gland halves around the shaft. Bolt the halves together to form a gland assembly.
- e) Now install the gland assembly [4120] using studs [6572.2] and nuts [6580.2].
- f) Lightly snug up the gland. Final adjustments must be made after the pump has begun operation.

##### One piece Gland installation

- a) Install the gland [4120] over shaft until it lightly touches the bearing housing (Group 1) or adapter (Group 2 and 3).
- b) Install the rear cover plate [1220] to the bearing housing (Group 1) or the bearing housing adapter (Group 2 and 3) by using the capscrews [6570.2].
- c) Install and set the impeller [2200] clearance as outlined in section 6.6.
- d) Install the packing rings [4130] and seal cage halves [4134] into the stuffing box as shown in figure 4-24. Always stagger the end gaps 90 degrees to ensure a better seal. To speed installation of each ring, have an assistant turn the pump shaft in one direction. This movement of the shaft will tend to draw the rings into the stuffing box.
- e) Now attach the gland [4120] to the cover using studs [6572.2] and nuts [6580.2].
- f) Lightly snug up the gland. Final adjustments must be made after the pump has begun operation.

#### **6.9.2.4 Reassembly - Sealmatic with Checkmatic seal**

- a) Remove any sharpness of edge at wet end of shaft with #400 emery cloth.
- b) Clean all exposed surfaces of the wet end of the shaft.
- c) Install a shaft guide tool from the Flowserve tool kit (see figure 6.1). Do not lubricate surfaces.
- d) Slide one lip seal onto the shaft with a lip facing away from the bearing housing.
- e) Position the O-ring [4610.10] over the tail of the lip seal (see section 8-3). Slide it all the way to the bearing housing.
- f) Clean all surfaces of the gland, and install the ceramic into the gland.
- g) Slide gland/ceramic seat assembly onto the shaft and move it back to the lip seal.
- h) Slide a second lip seal onto the shaft, with the lip facing the bearing housing, all the way to the ceramic seat. Position the O-ring [4610.10] over the tail of the lip seal. (See section 8-3).
- i) Reinstall the repeller cover, repeller, rear cover, and impeller as instructed in section 6.9.3.
- j) The Checkmatic gland must now be moved forward toward the impeller, pushing the forward lip ahead of it. It is important that the forward lip be firmly loaded against the seat when the gland is seated. Care must be taken to maintain even pressure on both sides of the gland, keeping the lip seal/ceramic seal faces perpendicular to the shaft.
- k) Tighten the gland nuts evenly.
- l) Finally, the rear lip must be slipped forward and tight against the seat. Care should be taken so as not to damage the seal face.

#### **6.9.2.5 Reassembly - Sealmatic with dry running seal**

Component seals will generally require that the wet end is assembled as described in 6.9.3 so that the impeller may be set prior to seal installation. Review the seal assembly instructions and drawings provided by the seal manufacturer. Section 6.9.2.2 contains the general assembly sequences for component seals.

#### **6.9.2.6 Reassembly - Sealmatic with FXP seal**

- a) Remove any sharpness of edge at wet end of shaft with #400 emery cloth.
- b) Clean all exposed surfaces of the wet end of the shaft.
- c) Install a shaft guide tool from the Flowserve tool kit (see figure 6.1).
- d) Insert the O-rings into the grooves on the inside diameter of the seal rotor.

- e) Slide the drive collar onto the shaft until it contacts the bearing housing (pins facing away from bearing housing).
- f) Lubricate the O-rings and shaft with non-abrasive liquid hand soap and slide the seal rotor onto the shaft until it contacts the rotor drive collar. The notches on the back side of the rotor should face toward the bearing housing.
- g) Place repeller cover face down on workbench and set the Teflon disk against the gland surface (i.e. end of stuffing box). Attach gland to repeller cover and screw on gland nuts finger-tight.
- h) Reinstall the repeller cover, repeller, rear cover, and impeller as instructed in section 6.9.3.
- i) Tighten gland nuts fully. Slide the seal rotor forward until it contacts the Teflon disk. Slide the drive collar forward until its pins are fully engaged in the slots on the back side of the seal rotor.
- j) Preload the seal by applying even pressure on the back of the drive collar in order to push it and the seal rotor into the Teflon disk. The rotor and drive collar should be moved approximately 3mm (1/8 in.) into the Teflon disk. Tighten the drive collar setscrews while maintaining pressure on the back of the drive collar.
- k) Once the pump is flooded, check the seal to ensure it is not leaking. If the seal leaks, repeat step j) above, applying only enough pressure to the drive collar to stop the leak. Do not over tighten the seal.

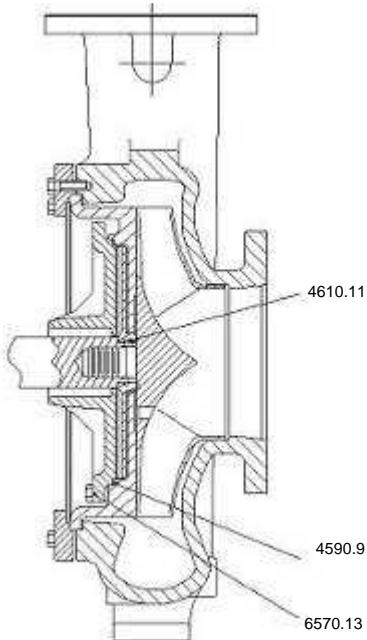
#### **6.9.3 Sealmatic pump: installation of repeller cover, repeller, cover, and impeller**

Group 2 pumps, see figure in section 8-3.

Group 3 pumps see figure 6.36.

- a) For Group 2 pumps, install the repeller cover to the adapter using capscrews [6570.2]. For Group 3 pumps install the repeller cover [1220.1] over the shaft and push it all the way back until it touches the bearing housing.
- b) Install a new repeller O-ring [4610.11] into the repeller groove. Lubricate the O-ring with liquid soap.
- c) Install the slip-on repeller [2200.1] onto the shaft.
- d) Install the repeller cover/cover gasket [4590.9].
- e) For Group 2 pumps, install the cover [1220] to the repeller cover using capscrews [6570.13]. For Group 3 pumps, Install the cover [1220] to the adapter. Attach to the adapter using capscrews [6570.2]. Attach the repeller cover to the cover using the capscrews [6570.13].
- f) The repeller and impeller may now be set following the instructions given in section 6.6.3.

**Figure 6.35**



#### **6.9.4 Close coupled final assembly**

- a) Install the motor adapter [3160] onto the bearing housing using three screws [6570.15].
- b) Install unit into casing as described in section 6.9.5.
- c) Level the unit with the adjustable support feet [3134]. Eliminate soft foot with by adjusting the support feet and or rotating the motor adapter slightly. Bolt the unit to the baseplate and tighten the support feet set screws [6570.17].
- d) Reinstall the motor, coupling and coupling guard.

#### **6.9.5 Reassemble to casing**

- a) Install a new rear cover gasket [4590.1] between the rear cover plate [1220] and the casing [1100].
- b) Use studs [6572.1] and nuts [6580.1] to complete the rebuild of your Flowserve Mark 3 pump.

**Figure 6-29**

Item	Part name
4610.11	Repeller O-ring
4590.9	Gasket – repeller cover
6570.13	Capscrew

## 7 FAULTS; CAUSES AND REMEDIES

The following is a guide to troubleshooting problems with Flowserve Mark 3 pumps. Common problems are analyzed and solutions offered. Obviously, it is impossible to cover every possible scenario. If a problem exists that is not covered by one of the examples, then refer to one of the books listed in section 10 *Additional sources of information* or contact a Flowserve sales engineer or distributor/representative for assistance.

## FAULT SYMPTOM

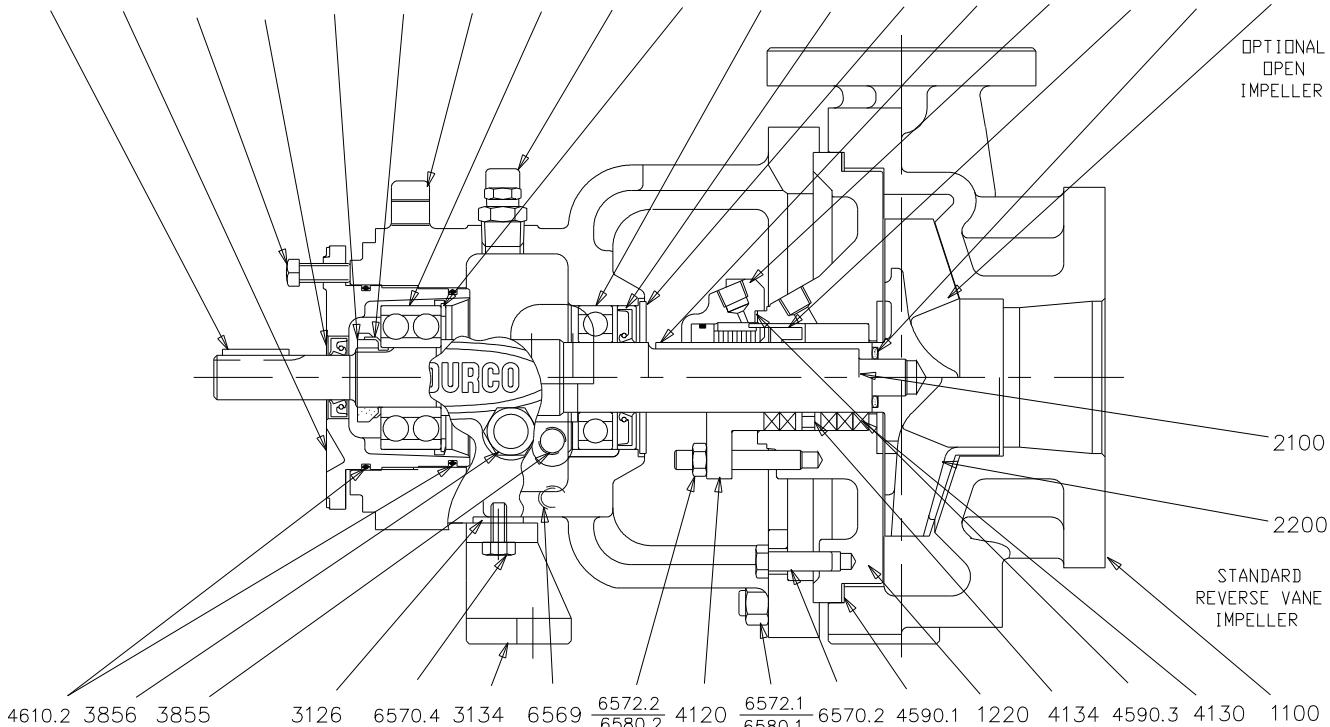
Pump not reaching design flow rate	
Pump not reaching design head (TDH)	
No discharge or flow with pump running	
Pump operates for short period, then loses prime	
Excessive noise from wet end	
Excessive noise from power end	
POSSIBLE CAUSES	
• • • •	Insufficient NPSH. (Noise may not be present.)
• • •	System head greater than anticipated.
• • •	Entrained air. Air leak from atmosphere on suction side.
• •	Entrained gas from process.
• •	Speed too low.
• • •	Direction of rotation wrong.
• •	Impeller too small.
• •	Impeller clearance too large.
• • •	Plugged impeller, suction line or casing which may be due to a product or large solids.
• •	Wet end parts (casing cover, impeller) worn, corroded or missing.
• •	Not properly primed.
• •	Impeller rubbing.
• •	Damaged pump shaft, impeller.
•	Abnormal fluid rotation due to complex suction piping.
•	Bearing contamination appearing on the raceways as scoring, pitting, scratching or rusting caused by adverse environment and entrance of abrasive contaminants from atmosphere.
POSSIBLE REMEDIES	
	Recalculate NPSH available. It must be greater than the NPSH required by pump at desired flow. If not, redesign suction piping, holding number of elbows and number of planes to a minimum to avoid adverse flow rotation as it approaches the impeller.
	Reduce system head by increasing pipe size and/or reducing number of fittings. Increase impeller diameter. (note: Increasing impeller diameter may require use of a larger motor.)
	1. Check suction line gaskets and threads for tightness. 2. If vortex formation is observed in suction tank, install vortex breaker. 3. Check for minimum submergence
	Process generated gases may require larger pumps.
	Check motor speed against design speed.
	After confirming wrong rotation, reverse any two of three leads on a three phase motor. The pump should be disassembled and inspected before it is restarted.
	Replace with proper diameter impeller. (NOTE: Increasing impeller diameter may require use of a larger motor.)
	Reset impeller clearance.
	1. Reduce length of fiber when possible. 2. Reduce solids in the process fluid when possible. 3. Consider larger pump.
	Replace part or parts.
	Repeat priming operation, recheck instructions. If pump has run dry, disassemble and inspect the pump before operation.
	1. Check and reset impeller clearance. 2. Check outboard bearing assembly for axial end play.
	Replace damaged parts.
	Redesign suction piping, holding the number of elbows and planes to a minimum to avoid adverse fluid rotation as it approaches the impeller.
	1. Work with clean tools in clean surroundings. 2. Remove all outside dirt from housing before exposing bearings. 3. Handle with clean dry hands. 4. Treat a used bearing as carefully as a new one. 5. Use clean solvent and flushing oil. 6. Protect disassembled bearing from dirt and moisture. 7. Keep bearings wrapped in paper or clean cloth while not in use. 8. Clean inside of housing before replacing bearings. 9. Check oil seals and replace as required. 10. Check all plugs and tapped openings to make sure that they are tight.

Pump not reaching design flow rate																		
↓ Pump not reaching design head (TDH)																		
↓ No discharge or flow with pump running																		
↓ Pump operates for short period, then loses prime																		
↓ Excessive noise from wet end																		
↓ Excessive noise from power end																		
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↓																		
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<table border="1"> <thead> <tr> <th>POSSIBLE CAUSES</th> <th>POSSIBLE REMEDIES</th> </tr> </thead> <tbody> <tr> <td>Brinelling of bearing identified by indentation on the ball races, usually caused by incorrectly applied forces in assembling the bearing or by shock loading such as hitting the bearing or drive shaft with a hammer.</td> <td>When mounting the bearing on the drive shaft use a proper size ring and apply the pressure against the inner ring only. Be sure when mounting a bearing to apply the mounting pressure slowly and evenly.</td> </tr> <tr> <td>False brinelling of bearing identified again by either axial or circumferential indentations usually caused by vibration of the balls between the races in a stationary bearing.</td> <td>1. Correct the source of vibration. 2. Where bearings are oil lubricated and employed in units that may be out of service for extended periods, the drive shaft should be turned over periodically to relubricate all bearing surfaces at intervals of one to three months.</td> </tr> <tr> <td>Thrust overload on bearing identified by flaking ball path on one side of the outer race or in the case of maximum capacity bearings, may appear as a spalling of the races in the vicinity of the loading slot. (Please note: maximum capacity bearings are not recommended in Mark 3 pumps.) These thrust failures are caused by improper mounting of the bearing or excessive thrust loads.</td> <td>Follow correct mounting procedures for bearings.</td> </tr> <tr> <td>Misalignment identified by fracture of ball retainer or a wide ball path on the inner race and a narrower cocked ball path on the outer race. Misalignment is caused by poor mounting practices or defective drive shaft. For example, bearing not square with the centerline or possibly a bent shaft due to improper handling.</td> <td>Handle parts carefully and follow recommended mounting procedures. Check all parts for proper fit and alignment.</td> </tr> <tr> <td>Bearing damaged by electric arcing identified as electro- etching of both inner and outer ring as a pitting or cratering. Electrical arcing is caused by a static electrical charge emanating from belt drives, electrical leakage or short circuiting.</td> <td>1. Where current shunting through the bearing cannot be corrected, a shunt in the form of a slip ring assembly should be incorporated. 2. Check all wiring, insulation and rotor windings to be sure that they are sound and all connections are properly made. 3. Where pumps are belt driven, consider the elimination of static charges by proper grounding or consider belt material that is less generative.</td> </tr> <tr> <td>Bearing damage due to improper lubrication, identified by one or more of the following: 1. Abnormal bearing temperature rise. 2. A stiff cracked grease appearance. 3. A brown or bluish discoloration of the bearing races.</td> <td>1. Be sure the lubricant is clean. 2. Be sure proper amount of lubricant is used. The constant level oiler supplied with Durco pumps will maintain the proper oil level if it is installed and operating properly. In the case of greased lubricated bearings, be sure that there is space adjacent to the bearing into which it can rid itself of excessive lubricant, otherwise the bearing may overheat and fail prematurely. 3. 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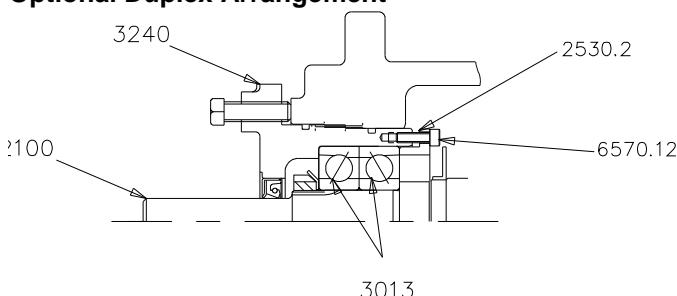
## 8 PARTS LIST AND DRAWINGS

### 8.1 Standard Mark 3 pump, Group 1

6700 3240 6570.3 4310.2 3712 6541 3200 3013 6521 2530.1 3011 4310.1 2540 2400 4120 4200 4590.2 2200

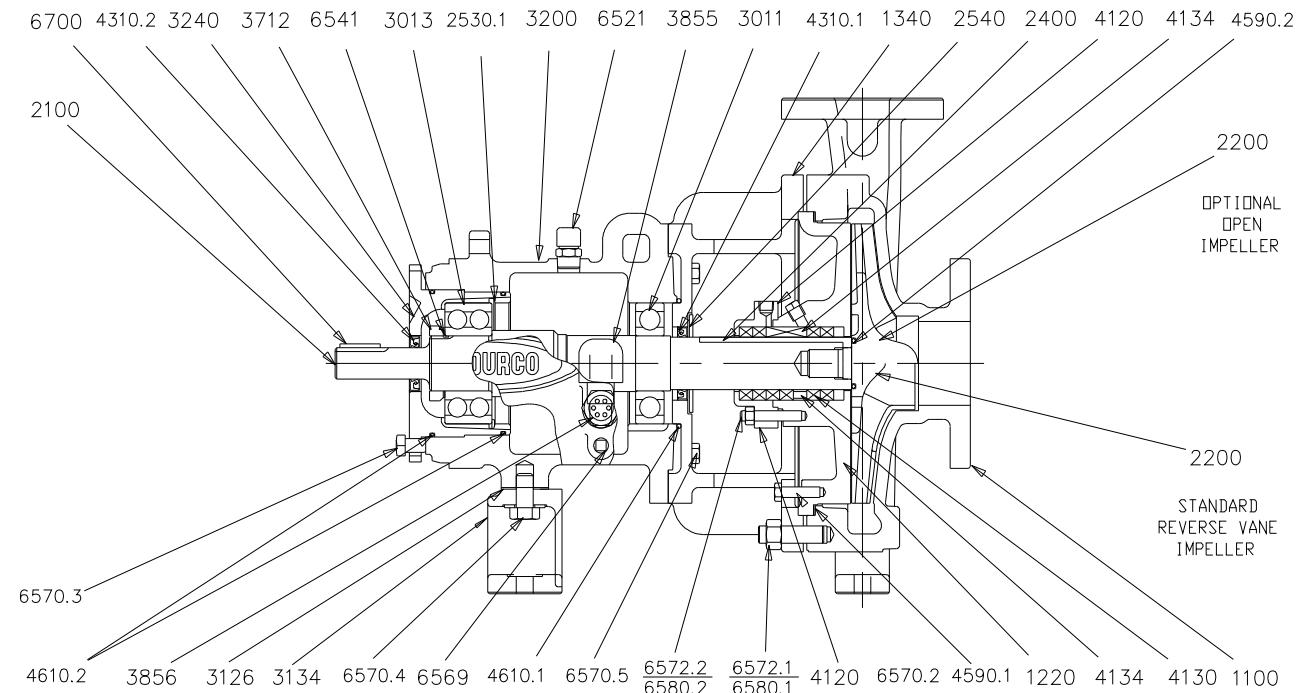


#### Optional Duplex Arrangement



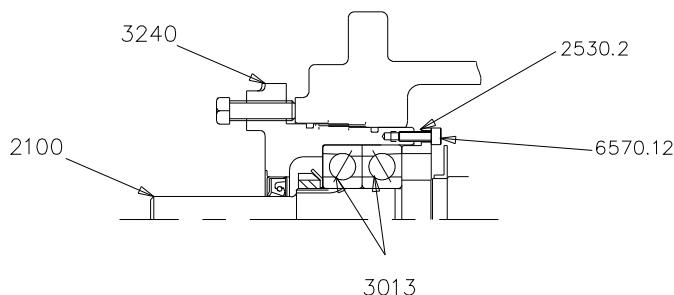
Item	Description	3200	Bearing housing	4610.2	O-ring - bearing carrier
1100	Casing	3240	Bearing carrier	6521	Bearing housing vent/breather (on ANSI 3A™ power ends replaced by a plug)
1220	Cover	3712	Bearing locknut	6541.1	Lockwasher - bearing
1340	Adapter - bearing housing	3855	Constant level oiler (not shown)	6569.1	Plug - bearing housing drain
2100	Shaft	3856	Sight gage - bearing housing	6570.12	Screw - clamp
2200	Impeller	4120	Gland	6570.2	Screw - cover/adapter
2400	Sleeve, optional	4130	Packing - optional	6570.3	Screw - bearing carrier set
2530.1	Retaining ring - bearing	4134	Seal cage - packing optional,	6570.4	Screw - foot
2530.2	Retaining ring - clamp type	4200	Mechanical seal	6570.5	Screw - bearing housing
2540	Deflector - inboard optional	4310.1	Oil seal inboard	6572.1	Stud - casing
2541	Oil flinger - optional	4310.2	Oil seal outboard	6572.2	Stud - gland
3011	Ball bearing - inboard	4590.1	Gasket - cover	6580.1	Nut - casing
3013	Ball bearing - outboard	4590.2	Gasket - impeller	6580.2	Nut - gland
3126.1	Shim	4590.3	Gasket - Gland	6700	Key - shaft/coupling
3134	Support foot	4610.1	O-ring - adapter		

## 8.2 Standard Mark 3 pump, Group 2 and 3



### Group 2 Optional duplex bearing arrangement\*\*

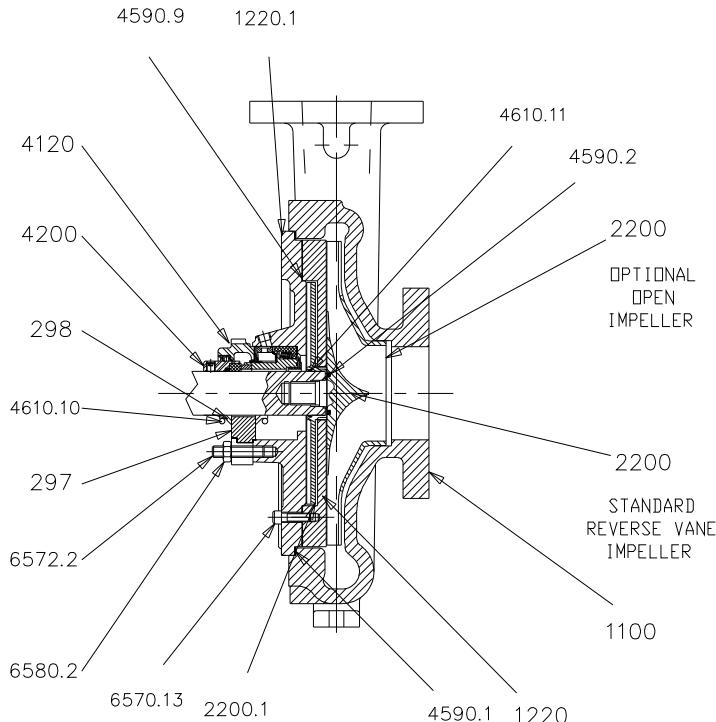
### Group 3 Standard bearing clamp arrangement



Item	Description	3200	Bearing housing	4610.2	O-ring - bearing carrier
1100	Casing	3240	Bearing carrier	6521	Bearing housing vent/breather (on ANSI 3A™ power ends replaced by a plug)
1220	Cover	3712	Bearing locknut	6541.1	Lockwasher - bearing
1340	Adapter - bearing housing	3855	Constant level oiler (not shown)	6569.1	Plug - bearing housing drain
2100	Shaft	3856	Sight gage - bearing housing	6570.12	Screw - clamp
2200	Impeller	4120	Gland	6570.2	Screw - cover/adapter
2400	Sleeve, optional	4130	Packing - optional (not shown)	6570.3	Screw - bearing carrier set
2530.1	Retaining ring - bearing	4134	Seal cage - packing optional,	6570.4	Screw - foot
2530.2	Retaining ring - clamp type	4200	Mechanical seal	6570.5	Screw - bearing housing
2540	Deflector - inboard optional	4310.1	Oil seal inboard	6572.1	Stud - casing
2541	Oil flinger - optional	4310.2	Oil seal outboard	6572.2	Stud - gland
3011	Ball bearing - inboard	4590.1	Gasket - cover	6580.1	Nut - casing
3013	Ball bearing - outboard	4590.2	Gasket - impeller	6580.2	Nut - gland
3126.1	Shim	4590.3	Gasket - gland	6700	Key - shaft/coupling
3134	Support foot	4610.1	O-ring - adapter		

\*\* Standard on group 3-HD.

### 8.3 Mark 3 Sealmatic pump, Group 2

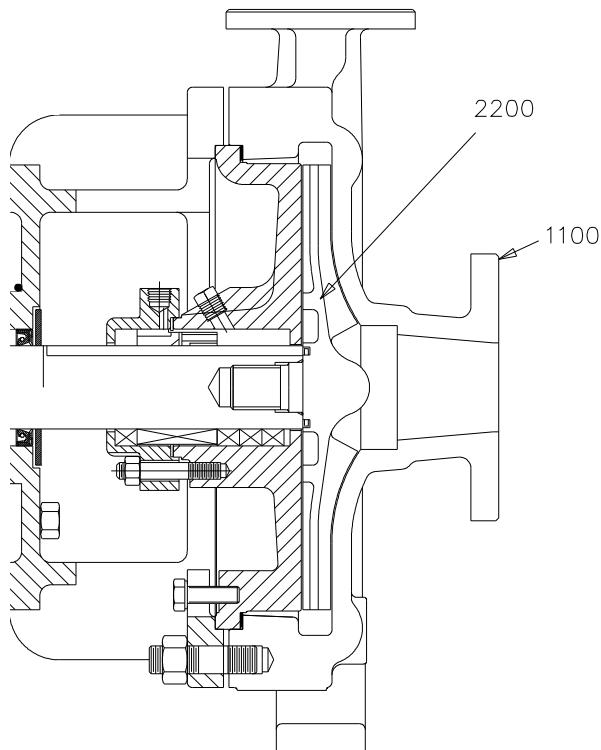


Item	Description
297	Seat
298	Lipseal
1100	Casing
1220	Cover
1220.1	Cover - repeller
2200	Impeller
2200.1	Repeller
4120	Gland
4200	Mechanical seal
4590.1	Gasket - cover
4590.2	Gasket - impeller
4590.9	Gasket - repeller cover
4610.10	O-ring - lipseal
4610.11	O-ring - repeller
6570.13	Screw - repeller cover
6572.2	Stud - gland
6580.2	Nut - gland

**Notes:**

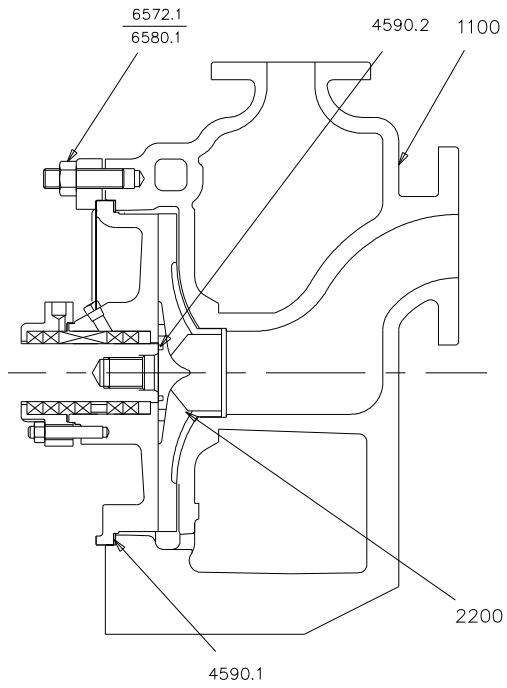
See figures 6-30 GP3 Sealmatic wet end.

### 8.4 Mark 3 Lo-Flo, Group 2

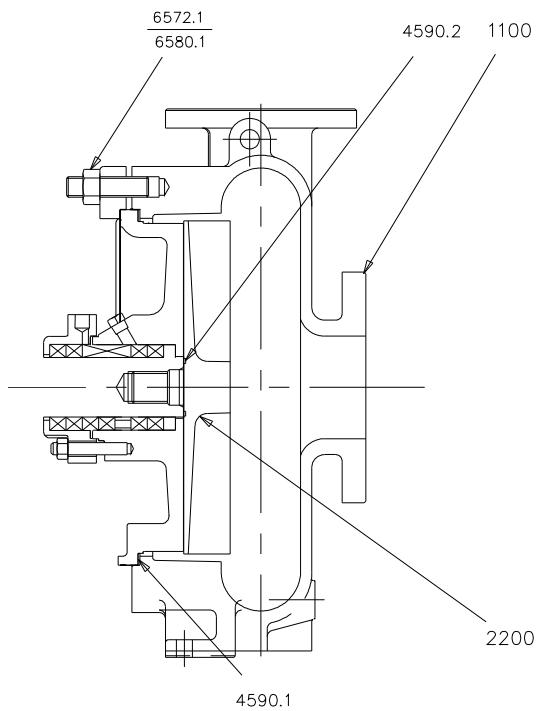


Item	Description
1100	Casing
1220	Cover

## 8.5 Mark 3 Unitized Self Priming pump, Group 2

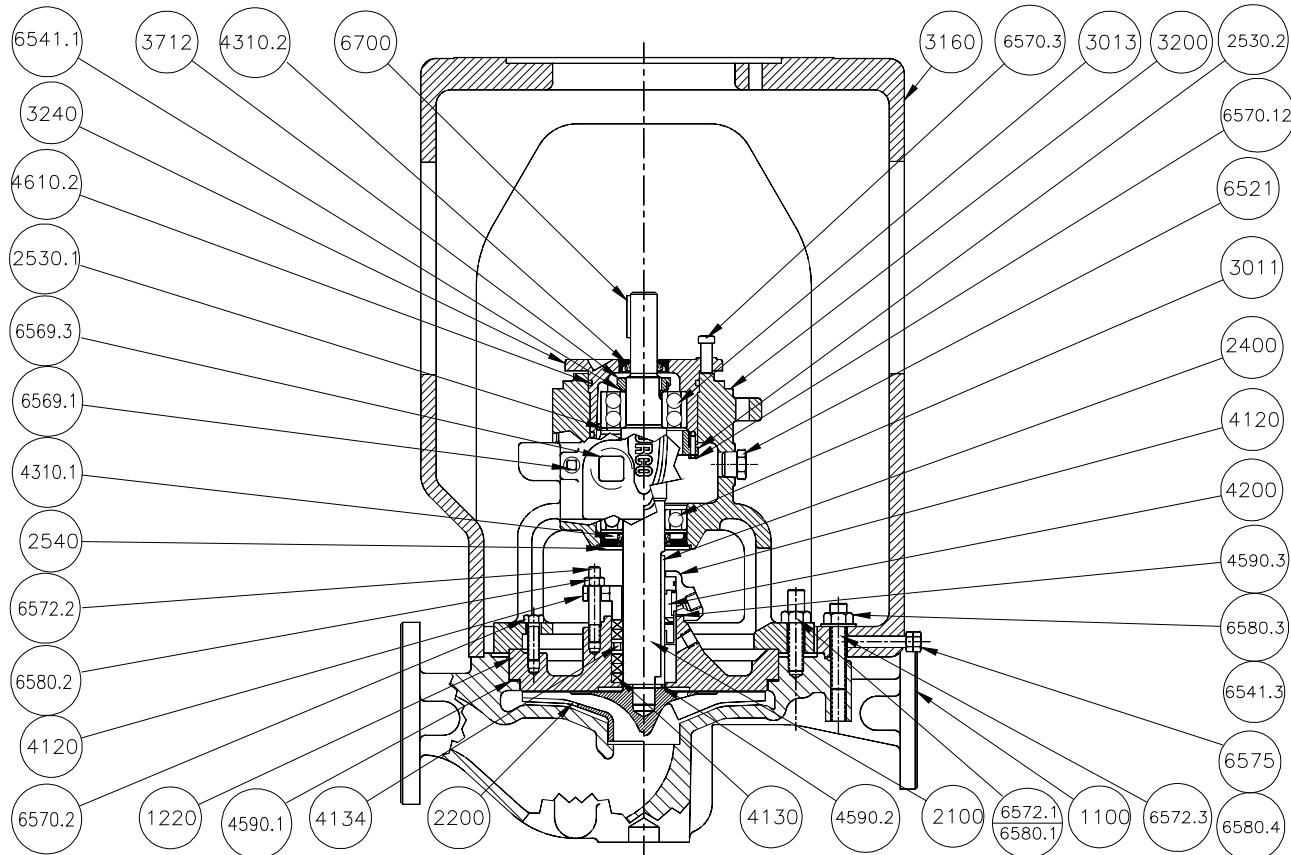


## 8.6 Mark 3 Recessed Impeller pump, Group 2



Item	Description
1100	Casing
2200	Impeller
4590.1	Gasket – cover
4590.2	Gasket - impeller
6572.1	Stud - casing
6580.1	Nut - casing

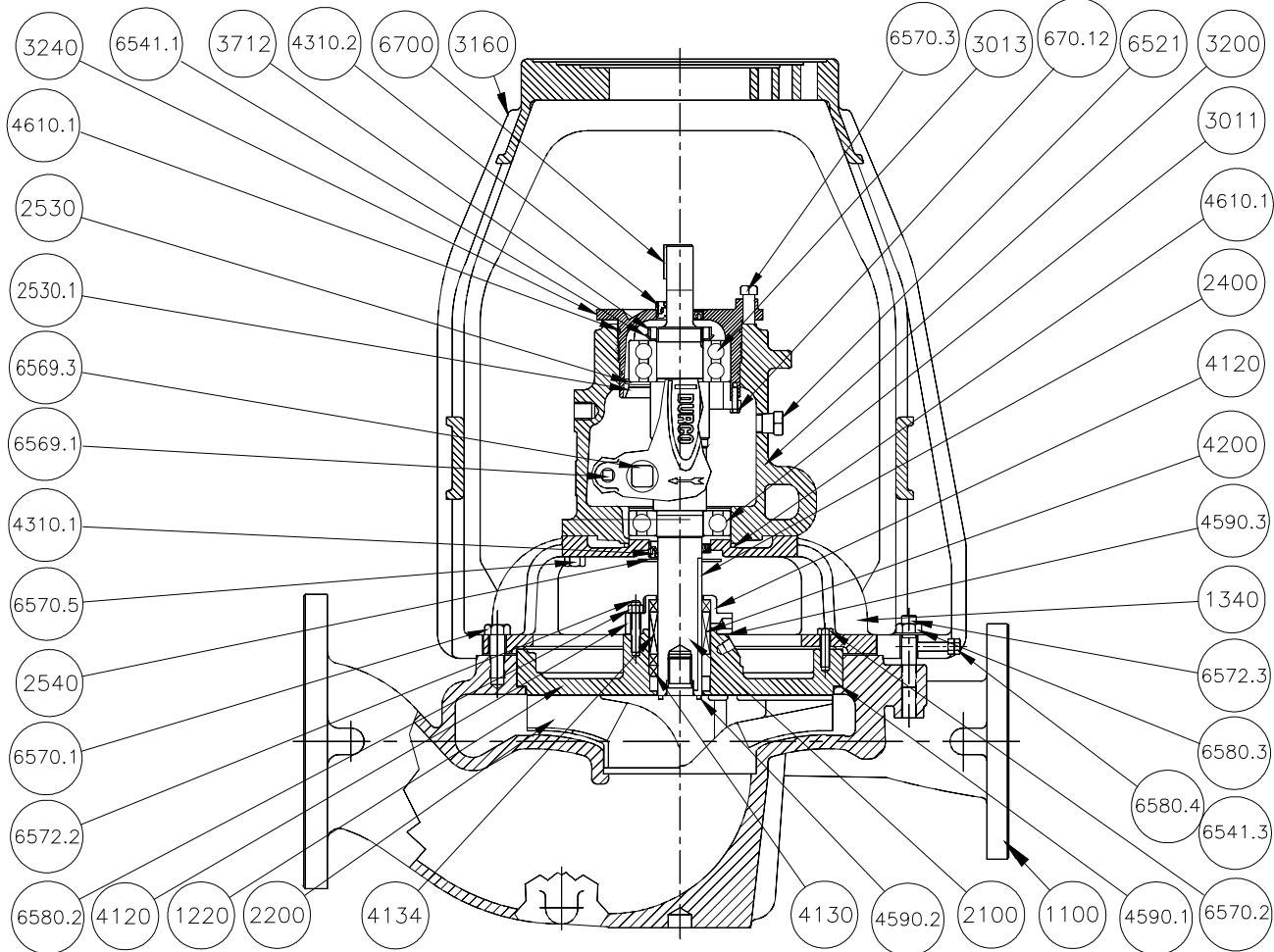
## 8.7 Mark 3 In-Line pump, Group 1



Item	Description	4120	Gland	6570.3	Screw - bearing carrier set
1100	Casing	4130	Packing - optional	6570.12	Screw - clamp
1220	Cover	4134	Seal cage - packing optional,	6570.15*	Screw - pump stand
2100	Shaft	4200	Mechanical seal	6572.1	Stud - casing
2200	Impeller	4310.1	Oil seal inboard	6572.2	Stud - gland
2400	Sleeve, optional	4310.2	Oil seal outboard	6572.3	Stud - pedestal casing
2530.1	Retaining ring - bearing	4590.1	Gasket - cover	6575	Jackscrew
2530.2	Retaining ring - clamp type	4590.2	Gasket - impeller	6580.1	Nut - casing
2540	Deflector - inboard optional	4590.3	Gasket - Gland	6580.2	Nut - gland
3011	Ball Bearing - inboard	4610.2	O-ring - bearing carrier	6580.3	Nut - pedestal casing
3013	Ball Bearing - outboard	6521	Plug - Bearing housing vent	6580.4	Nut - Jackscrew jam nut
3160	Motor pedestal	6541.1	Lockwasher - bearing	6700	Key - shaft/coupling
3170*	Pump stand	6541.3	Washer		
3200	Bearing housing	6569.1	Plug		
3240	Bearing carrier	6569.3	Plug - Sight gage		
3712	Bearing locknut	6570.2	Screw - cover/adapter		

\*Not Shown

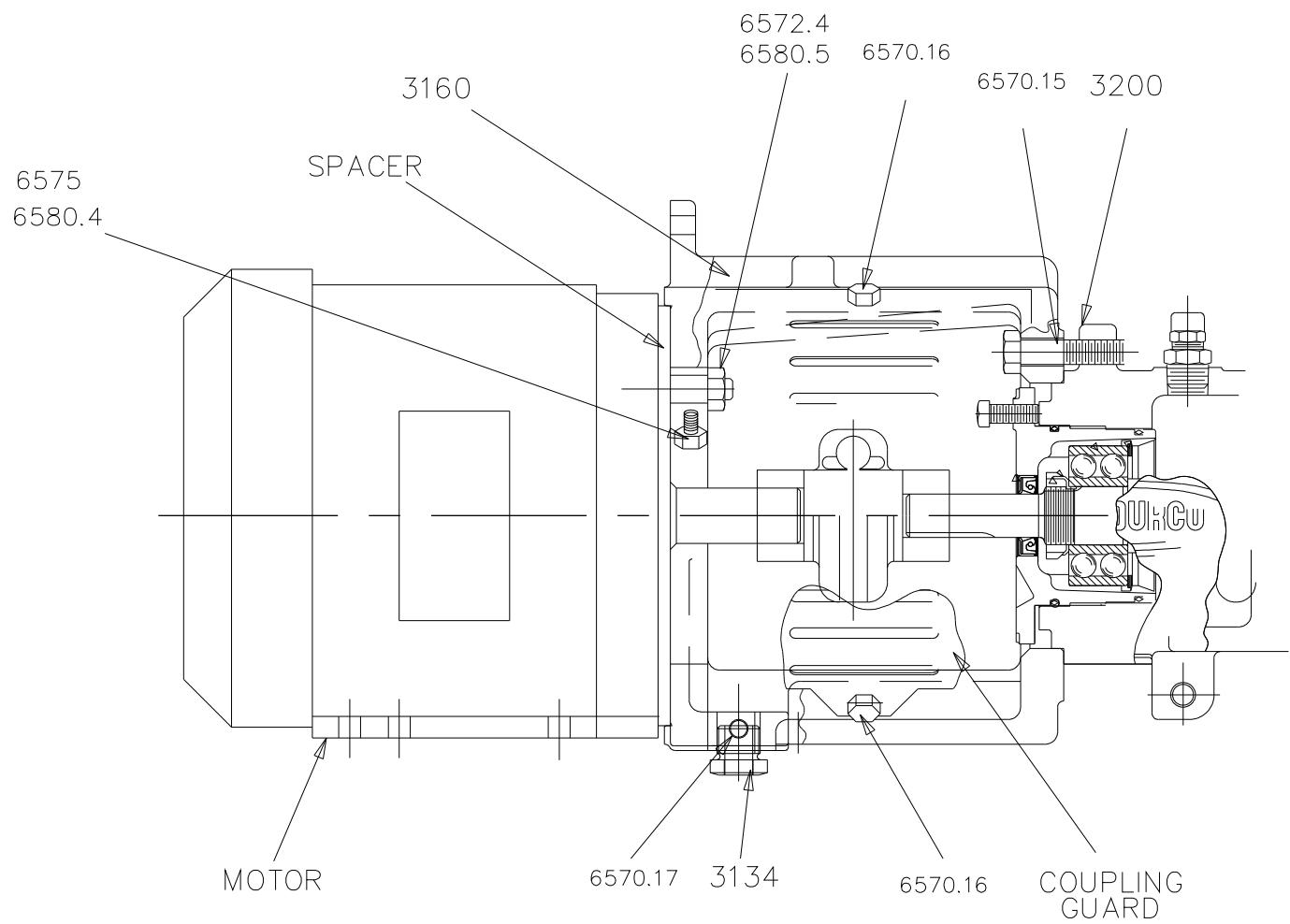
## 8.8 Mark 3 In-Line pump, Group 2



Item	Description	3712	Bearing locknut	6569.3	Plug – sight gage
1100	Casing	4120	Gland	6570.1	Screw - casing
1220	Cover	4130	Packing - optional	6570.2	Screw - cover/adapter
1340	Adapter - bearing housing	4134	Seal cage – packing optional,	6570.3	Screw - bearing carrier set
2100	Shaft	4200	Mechanical seal	6570.5	Screw - bearing housing
2200	Impeller	4310.1	Oil seal inboard	6570.12	Screw - clamp
2400	Sleeve, optional	4310.2	Oil seal outboard	6570.15*	Screw – pump stand
2530.1	Retaining ring - bearing	4590.1	Gasket - cover	6572.2	Stud - gland
2530.2	Retaining ring - clamp type	4590.2	Gasket - impeller	6572.3	Stud – pedestal casing
2540	Deflector - inboard optional	4590.3	Gasket - gland	6575	Jackscrew
3011	Ball bearing - inboard	4610.1	O-ring - adapter	6580.2	Nut - gland
3013	Ball bearing - outboard	4610.2	O-ring - bearing carrier	6580.3	Nut – pedestal casing
3160	Motor pedestal	6521	Plug - Bearing housing vent	6580.4	Nut – Jackscrew jam nut
3170*	Pump stand	6541.1	Lockwasher - bearing	6700	Key - shaft/coupling
3200	Bearing housing	6541.3	Washer		
3240	Bearing carrier	6569.1	Plug		

\*Not Shown

## 8.9 Mark 3 C-Face Adapter, Group 1 and 2



Item	Description	6570.17	6570.16
3134	Support foot	6572.4	Stud - motor
3160	Motor pedestal - C-Face	6575	Jackscrew
3200	Bearing housing	6580.4	Nut - jackscrew
6570.15	Screw - bearing housing	6580.5	Nut - motor
6570.16	Screw - coupling guard		