FLOWSERVE

USER INSTRUCTIONS

ESP3 Vertical Immersion Sump Pump

Installation
Operation
Maintenance

Mark 3 Standard, Lo-Flo and Recessed Impeller Hydraulics

PCN=26999943 – 08-11 (E)
Original Instructions

Experience In Motion

CONTENTS

1 INTRODUCTION AND SAFETY

1.1 General

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

Flowserve products are designed, developed and manufactured with state-of-the-art technologies in modern facilities. The unit is produced with great care and commitment to continuous quality control, 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/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, damage, delay or failure caused by misuse is 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 purchaser order. The acknowledgement of these conditions has been sent separately to the Purchaser. A copy should be kept with these instructions.

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

If the conditions of service on your purchase order are going to be changed (for example liquid pumped,

temperature or duty) it is requested that the user 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.)

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

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

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

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

GUARDS MUST NOT BE REMOVED WHILE THE PUMP IS OPERATIONAL

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 ℃ (176℉) or below -5 ℃ (23 ℉) 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 pump placement, limiting personnel access and by operator training. If the liquid is flammable and/or explosive, strict safety procedures must be applied.

Gland packing must not be used when pumping hazardous liquids.

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

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

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

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

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

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

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

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 drive element 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 buildup of explosive mixtures
- Prevent the generation of sparks
- Prevent leakages
- Maintain the pump to avoid hazard

The following instructions for pumps and pump units when installed in potentially explosive atmospheres must be followed to help ensure explosion protection. Both electrical and non-electrical equipment must meet the requirements of European Directive 94/9/EC.

1.6.4.1 Scope of compliance

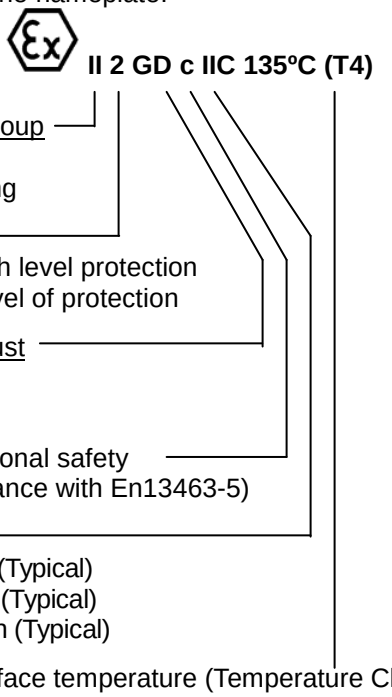
Use equipment only in the zone for which it is appropriate. Always check that the driver, drive coupling assembly, seal and pump equipment are suitably rated and/or certified for the classification of the specific atmosphere in which they are to be installed.

Where Flowserve has supplied only the bare shaft pump, the Ex rating applies only to the pump. The party responsible for assembling the pump set shall select the coupling, driver, seal 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 ºC (104 ºF); 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 (* depending on material and construction variant – check which is lower)
T6	85 ℃ (185 ℉)	Consult Flowserve
T5	100 ℃ (212 ℉)	Consult Flowserve
T4	135 ℃ (275 ℉)	115 ℃ (239 ℉) *
T3	200 ℃ (392 ℉)	180 ℃ (356 ℉) *
T2	300 ℃ (572 ℉)	275 ℃ (527 ℉) *
T1	450 ℃ (842 ℉)	400 ℃ (752 ℉) *

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

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

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

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

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.

1.6.4.4 Preventing the buildup of explosive mixtures

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

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

If the operation of the system cannot avoid this condition, 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.

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

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

1.6.4.6 Preventing leakage

Pumps with mechanical seal: 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 of the centrifugal pump to avoid a 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.

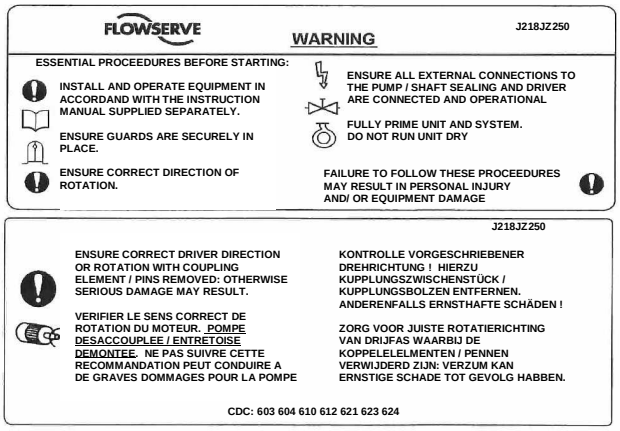
It is recommended that a maintenance plan and schedule is adopted. (See section 6, *Maintenance.)*

1.7 Name plate and safety labels

1.7.1 Nameplate

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

1.7.2 Safety labels



1.8 Specific machine performance

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

1.9 Noise level

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

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

Pump noise level is dependent on a number of operational factors, flow rate, pipe work design and acoustic characteristics of the building, and so the values given are subject to a 3 dBA tolerance and cannot be guaranteed.
Similarly the motor noise assumed in the "pump and motor" noise is that typically expected from standard and high efficiency motors when on load directly driving the pump. Note that a motor driven by an inverter may show an increased noise at some speeds.
If a pump unit only has been purchased for fitting with your own driver then the "pump only" noise levels in the table should be combined with the level for the driver obtained from the supplier. Consult Flowserve or a noise specialist if assistance is required in combining the values.

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". The values are representative of a non-submerged wet end.

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

Motor size and speed kW (hp)	Typical sound pressure level L_{pA} at 1 m reference 20 µPa, dBA							
	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 Pump Division 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 sidewalls of the box or equipment.

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

2.2 Handling

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

2.3 Lifting

CAUTION 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 or cast-in lifting lugs to lift pump, motor and mounting plate assemblies.

CAUTION Care must be taken to lift components or assemblies above the center of gravity to prevent the unit from flipping.

CAUTION Carefully sling ESP pumps so that bearing lubrication lines [3840.1] will not be bent or damaged when lifting.

It is advisable to raise the pump into the vertical position before uncrating. If this isn't possible, pumps over eight feet long must be supported at more than one place when raising to the vertical position. Use a support strap around the bottom column [1341.2] and on the motor support [3160]. Or lift use optionally supplied lifting eyes [6820] installed on mounting plate [6130].

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 un-mounted items are packaged in a water proof plastic bag and secured to the pallet.
- 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
- 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. 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.

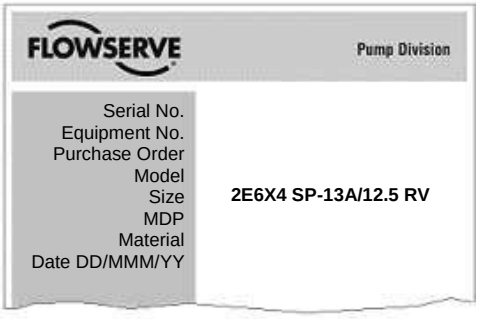
Make sure that hazardous substances are disposed of safely and that the correct personal protective equipment is used. The safety specifications must be in accordance with the current local regulations at all times.

3 DESCRIPTION

3.1 Configurations

The ESP3 vertical immersion sump pumps are separately coupled metallic construction single stage centrifugal pumps for wet pit applications. The ESP3 wetted parts are available in a wide range of materials to handle most fluids. Vapor-tight, vapor-proof, and pressurized construction options are available. The hydraulics utilized are from Mark 3 chemical process pumps.

Figure 3-1: Nameplate mounted to housing



3.2 Nomenclature

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

2 E 6 X 4 SP - 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*
  E = ESP3 Pump
- "6" = *nominal suction port size* (in.)
- "4" = *Nominal discharge port size* (in.)
- *Modifier for "specialty pumps"*
  SP = standard sump pump
  RSP = recessed impeller pump
  LFSP = Lo-Flo pump
- *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 ½ in. diameter; 8.13 = 8 ⅛ in.; 10.75 = 10 ¾ in.
  (Previous annotation: 124 = 12 $^{4}/_{8}$ or 12 ½ in. diameter; 83 = 8 ⅜ in.)
- *Impeller style*
  RV = reverse vane impeller; OP = Open impeller

3.3 Design of major parts

3.3.1 Pump casing
As used by the Mark 3 Product Line. Depending upon the installation, the casing feet may have been removed. Axial bolting retains the casing to the cover and compresses the sealing gasket.

3.3.2 Impeller
Depending on the product, the impeller is either reverse vane or open. The impeller is threaded to the end of the shaft

3.3.3 Shaft/sleeve
Solid and sleeved shafts are available. The shaft is threaded on the impeller end and keyed on the drive end.

3.3.4 Pump bearings and lubrication
The external thrust bearing is a grease-lubricated duplex angular contact ball bearing. The radial load line bearings are sleeve plain bearings lubricated by product, external flush or grease.

3.3.5 Bearing housing
The external housing contains grease ports and is sealed with lip seals.

3.3.6 Cover plate
The cover plate has a spigot (rabbet) fit between the pump casing and adapter for optimum concentricity. The cover plate holds the throttle bushing at the back of the impeller.

3.3.7 Shaft seal
There is no shaft seal required near the impeller since the pump is submerged. Only a small amount of pressurized fluid escapes through controlled leak paths from the backside of the impeller. Packing or a mechanical seal can be fitted above the sump level to provide vapor proof or pressurized options for the application.

3.3.8 Driver
The standard driver is a NEMA C-Face vertical electric motor. The motor must be equipped with a drip-cap when installed outdoors.

3.3.9 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 3-3 is the Alloy cross-reference chart. The chart is used to material group number which can be used to establish the pressure-temperature rating as discussed below. Not all materials may be available

3.4.2 Pressure-temperature ratings
The pressure–temperature (P-T) ratings for ESP3 pumps are shown in figures 3-4 and 3-5. Determine the appropriate casing “Material Group No.” in Figure 3-3. Interpolation may be used to find the pressure rating for a specific temperature.

Example:
The pressure temperature rating for a standard GP2-10” pump with Class 150 flanges and CF8M construction at an operating temperature of 149˚C is found as follows:

a) The correct pressure-temperature chart is Figure 3-4.
b) From Figure 3-3, the correct material group for CF8M is 2.2
c) From Figure 3-4, the pressure-temperature rating is 14.8 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.

3.4.3 Suction pressure limits
Pump suction pressure is limited by the maximum pump length and the maximum sump pressure of 3.45 bar (50 psi).

3.4.4 Minimum continuous flow
The minimum continuous flow (MCF) is based on a percentage of the *best efficiency point* (BEP). Figure 3-2 identifies the MCF for all ESP3 pump models with the exception of the Lo-Flo pump line; there is no MCF associated with this product line.

Figure 3-2: Minimum continuous flow

Pump size	MCF % of BEP		
	3500/2900 r/min	1750/1450 r/min	1180/960 r/min
1E3x2SP-62	20%	10%	10%
2E3x2SP-82	20%	10%	10%
2E4x3SP-82	20%	10%	10%
2E3x2SP-10A	30%	10%	10%
2E4x3SP-10	30%	10%	10%
2E6x4SP-10	40%	10%	10%
2E6x4SP-10H	n.a.	20%	10%
2E3x1.5SP-13	30%	10%	10%
2E3x2SP-13	40%	10%	10%
2E4x3SP-13	40%	20%	10%
2E4x3SP-13HH	n.a.	50%	30%
2E6x4SP-13A	60%	40%	10%
3E8x6SP-14A	n.a.	40%	15%
3E10x8SP-14	n.a.	40%	10%
3E6x4SP-16	n.a.	50%	10%
3E8x6SP-16	n.a.	50%	10%
3E10x8SP-16	n.a.	50%	10%
All other sizes	10%	10%	10%

Figure 3-3: Alloy cross-reference chart

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

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® Hastelloy is a registered trademark of Haynes International, Inc.
® Inconel and Monel are registered trademarks of International Nickel Co. Inc.

Figure 3-4 Class 150 Flanges

Temp	Material Group No.												
	1.0	1.1	2.1	2.2	2.8	3.17	3.2	3.4	3.5	3.7	3.8	Ti	Cr
˚C	bar												
-73			19.0	19.0	19.7	15.9	9.7	15.9	15.2	20.0	20.0	20.0	
-29	17.2	19.7	19.0	19.0	19.7	15.9	9.7	15.9	15.2	20.0	20.0	20.0	
-18	17.2	19.7	19.0	19.0	19.7	15.9	9.7	15.9	15.2	20.0	20.0	20.0	12.6
38	17.2	19.7	19.0	19.0	19.7	15.9	9.7	15.9	15.2	20.0	20.0	20.0	12.6
93	16.2	17.9	15.9	16.2	17.9	13.8	9.7	13.8	13.8	17.9	17.9	17.9	12.6
149	14.8	15.9	14.1	14.8	15.9	12.4	9.7	13.1	12.4	15.9	15.9	15.9	12.6
171	14.4	15.0	13.7	14.3	15.0	11.9	9.7	13.0	12.1	15.0	15.0	15.0	12.6
204	13.8	13.8	13.1	13.4	13.8	11.0	9.7	12.8	11.7	13.8	13.8	13.8	
260	11.7	11.7	11.7	11.7	11.7	10.3	9.7	11.7	11.0	11.7	11.7	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	Material Group No.												
	1.0	1.1	2.1	2.2	2.8	3.17	3.2	3.4	3.5	3.7	3.8	Ti	Cr
˚F	psi												
-100			275	275	285	230	140	230	220	290	290	290	
-20	250	285	275	275	285	230	140	230	220	290	290	290	
0	250	285	275	275	285	230	140	230	220	290	290	290	183
100	250	285	275	275	285	230	140	230	220	290	290	290	183
200	235	260	230	235	260	200	140	200	200	260	260	260	183
300	215	230	205	215	230	180	140	190	180	230	230	230	183
340	209	218	199	207	218	172	140	188	176	218	218	218	183
400	200	200	190	195	200	160	140	185	170	200	200	200	
500	170	170	170	170	170	150	140	170	160	170	170	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 3-5 Group2-13” Lo-Flo Pumps with Class 300 Flanges

Temp	Material Group No.											
	1.0	1.1	2.1	2.2	2.8	3.17	3.2	3.4	3.5	3.7	3.8	Ti
˚C	bar											
-73			31.0	31.0	31.0	24.1	17.4	24.1	27.6	31.0	31.0	31.0
-29	31.0	31.0	31.0	31.0	31.0	24.1	17.4	24.1	27.6	31.0	31.0	31.0
-18	31.0	31.0	31.0	31.0	31.0	24.1	17.4	24.1	27.6	31.0	31.0	31.0
38	31.0	31.0	31.0	31.0	31.0	24.1	17.4	24.1	27.6	31.0	31.0	31.0
93	29.1	28.3	25.9	26.7	29.8	20.9	17.4	21.3	26.1	31.0	31.0	27.5
149	27.4	27.5	23.3	24.1	27.5	18.7	17.4	19.9	24.4	30.2	30.2	24.0
204	25.5	26.6	21.3	22.2	25.4	16.9	17.4	19.3	22.7	29.2	29.2	20.5
260	24.0	25.2	19.7	20.7	23.8	15.7	17.4	19.1	22.1	27.5	27.5	17.0
316	22.5	23.1	18.7	19.4	23.0	14.5	17.4	19.1	21.9	25.0	25.0	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	Material Group No.											
	1.0	1.1	2.1	2.2	2.8	3.17	3.2	3.4	3.5	3.7	3.8	Ti
˚F	psi											
-100			450	450	450	350	252	350	400	450	450	450
-20	450	450	450	450	450	350	252	350	400	450	450	450
0	450	450	450	450	450	350	252	350	400	450	450	450
100	450	450	450	450	450	350	252	350	400	450	450	450
200	422	410	375	388	432	303	252	309	379	450	450	399
300	397	398	338	350	399	271	252	289	354	438	438	348
400	369	386	309	322	369	245	252	280	330	423	423	297
500	348	365	285	300	345	228	252	277	320	399	399	246
600	327	334	272	281	333	210	252	277	318	363	363	195
650	316	325	269	278				277	316	354	354	170
700		325	266	269				277	313	342	342	144

3.4.5 Minimum suction pipe submergence

The minimum submergence is shown in Figure 3-6.

Figure 3-6

Minimum submergence (meters)

Suct. Size	Flow (m^3/hr.)												
	6.8	11.4	20.5	45.5	79.5	136	273	341	500	568	727	1023	1250
1.5	0.30	0.55	1.07	2.65									
2		0.30	0.58	1.40	2.74								
3			0.30	0.79	1.52	2.38							
4				0.30	0.55	1.07	2.13						
6						0.43	.076	1.19	1.83				
8								0.55	0.94	1.19	1.65		
10										0.64	0.85	1.22	1.52

Minimum submergence (feet)

Suct. Size	Flow (USgpm)												
	30	50	90	200	350	600	1200	1500	2200	2500	3200	4500	5500
1.5	1.0	1.8	3.5	8.7									
2		1.0	1.9	4.6	9.0								
3			1.0	2.6	5.0	7.8							
4				1.0	1.8	3.5	7.0						
6						1.4	2.5	3.9	6.0				
8								1.8	3.1	3.9	5.4		
10										2.1	2.8	4.0	5.0

3.4.6 ESP3 Bearing Materials

- CARBON - Carbon graphite, especially developed for sump pump applications, is chemically inert. The self-lubricating properties of graphite present in the carbon bearings enhance its dry running capabilities.
- BRONZE - SAE 660 Bronze (grooved when grease lubricated).
- CAST IRON - ASTM A48 Class 30 iron (grooved when grease lubricated).
- RUBBER - Resilient compounded rubber, fluted to allow abrasives to wash away.
- VITON - Resilient Viton, fluted to allow handling of dirty corrosive liquids not able to be handled by carbon or rubber.
- TEFLON - Fiberglass & molybdenum disulphide filled, with low cold flow, high tensile and elongation characteristics.
- ARHT - Chemical and wear resistant bearing material developed by Greene, Tween & Co. (grooved when grease lubricated).

All bearing materials are enclosed in an AISI-316 shell (ex. Bronze, Cast Iron & ARHT). Higher alloys are available (grooved when grease lubricated).

Figure 3-7: ESP3 Bearing selection

Bearing Material	Max Temp	Liquid Pumped	Lubricant	Shaft Material
Carbon	177˚C 350˚F	Most clean acids, general chemicals, water, cleaning fluids, gasoline, kerosene, jet fuels	External flush Product Lube	Steel or SS Steel or SS
Bronze	82˚C 180˚F	Water and compatible liquids	External flush Product Lube Grease Lube	Steel only Steel only Steel only
Cast Iron	82˚C 180˚F	Water and compatible liquids including alkaline caustics	External flush Product Lube Grease Lube	Steel Steel Steel
Rubber	71˚C 160˚F	General abrasive liquids compatible with rubber	External flush Product Lube	SS only SS only
Teflon	177˚C 350˚F Liquid Lube	Clean acids not compatible with carbon	External flush Product Lube	SS only SS only
Teflon	82˚C 180˚F Grease Lube	Clean acids not compatible with carbon	Grease	SS only
Viton	149˚C 300˚F	Dirty acids not compatible with carbon or rubber	External flush Product Lube	SS only SS only
ARHT	121˚C 250˚F Liquid Lube	Dirty acids, hot water and chemicals compatible with PEEK	External flush Product Lube	SS only SS only
ARHT	82˚C 180˚F Grease Lube	Dirty acids and chemicals compatible with PEEK	Grease	SS only

Figure 3-8: Engineering information

Pump Group Size	GP1 – 1E	GP2 – 2E	GP3 – 3E
Ball Bearing Size	7308	7310	7313
1st Critical Speed @ 3550 span	6000	5555	n.a.
1st Critical Speed @ 1750 span	2344	2469	2833
1st Critical Speed @ 1180 span	2344	2469	2833
Std. Bearing Span @ 3550 rpm	760 mm (30 in.)	915 mm (36 in.)	n.a.
Std, Bearing Span @ 1750 rpm	1220 mm (48 in.)	1220 mm (48 in.)	1520 mm (60 in.)
Standard Bearing Span @ 1180 rpm	1220 mm (48 in.)	1220 mm (48 in.)	1520 mm (60 in.)
Shaft Diameter @ Sleeve Bearing	28.58 mm (1.125 in.)	38.10 mm (1.500 in.)	53.98 mm (2.125 in.)
Shaft Diameter @ Stuffing Box	28.58 mm (1.125 in.)	38.10 mm (1.500 in.)	47.63 mm (1.875 in.)
Shaft Diameter @ Coupling	25.4 mm (1.000 in.)	34.93 mm (1.375 in.)	41.28 mm (1.625 in.)
Keyway Size mm (in)	6.4 x 3.2 (1/4 x 1/8)	7.9 x 4.0 (5/16 x 5/32)	15.9 x 7.9 (5/8 x 5/16)
Nominal Impeller Clearance	.46 mm (0.018 in.)	.46 mm (0.018 in.)	.64 mm (0.025 in.)
Corrosion Allowance	3.2 mm (0.125 in.)	3.2 mm (0.125 in.)	3.2 mm (0.125 in.)
Minimum Pit Depth	.61 m (2.0 ft)	.61 m (2.0 ft)	.91 m (3.0 ft)
Maximum Pit Depth	6.10m (20.0 ft)	6.10 m (20.0 ft)	6.10 m (20.0 ft)

4 INSTALLATION

INSTALLATION AND START-UP CHECKLIST

1.	Check that the sump design will keep the liquid level within the proper range.	1 _____ _____
2.	Check that the pump location is accessible and has adequate ventilation.	2 _____ _____
3.	Verify that the pump and motor are suitable for the pump environment.	3 _____ _____
4.	Check the sump design to be sure it is adequate to support the complete pumping assembly.	4 _____ _____
5.	Verify the discharge piping meets Hydraulic Institute Standards for design and is properly supported.	5 _____ _____
6.	Install the suction strainer	6 _____ _____
7.	Install the liquid level controls.	7 _____ _____
8.	If pump was ordered for vapor proof or pressurized design, install sealing device.	8 _____ _____
9.	Lift the pump into place and tighten the mounting plate bolts.	9 _____ _____
10.	Install the motor on the pump, but do not connect the coupling or electric power.	10 _____ _____
11.	Connect the wiring to the liquid level indicators and pump controls, as required.	11 _____ _____
12.	Connect the discharge piping,	12 _____ _____
13.	Check that all auxiliary piping is connected	13 _____ _____
14.	Verify the pump is free of pipe strain by turning the shaft by hand.	14 _____ _____
15.	Verify the impeller setting.	15 _____ _____
16.	Lubricate the driver and pump as required using approved lubricants.	16 _____ _____
17.	Connect the wiring for the motor.	17 _____ _____
18.	Turn power ON and jog the driver to verify proper rotation; clockwise looking down.	18 _____ _____
19.	Turn power OFF and install the coupling element and coupling guard. Then turn power ON, but do not start the driver.	19 _____ _____

4.1 Location

The pump should be located to allow room for installation, access, ventilation, maintenance, and inspection with ample headroom for lifting. Refer to the general arrangement drawing for the pump set. If pump is furnished with external flush-lubricated bearings, the fluid lines must be accessible from the pump location.
Also important, especially in the larger flow units, is proper sump design. Liquid velocity approaching the pump should be one foot per second or less. When more than one pump is installed and used at the same time in the same sump, the location and spacing of the pumps are important. The guidelines for sump design and pump placement as outlined in the "Hydraulic Institute Standards" are recommended.

4.2 Part assemblies

- Pumps are shipped completely assembled except for driver, strainer [6531], float controls (if furnished), pit cover, and the mechanical seal [4200] or packing [4130] for the stuffing box on a vapor proof or pressurized design pump.
- When mechanical seals are furnished, they should be installed before the motor is put in place. Refer to seal installation instructions in section 6.9.5.
- Vapor Proof and Pressurized design pumps are furnished with an upper stuffing box [4110]. If the stuffing box doesn't already have the packing [4130] or seal [4200] installed, then they should be installed before the motor is mounted. See section 6.
- The driver will be mounted after the pump is installed.
- When the pump is shipped, all threads and all openings are covered. This protection should not be removed until installation. If the pump is removed from service, this protection should be reinstalled.

4.3 Foundation

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. Recommended mass of a concrete foundation should be three times that of the pump, motor and mounting plate. Supporting members must be sufficiently strong to prevent spring action and/or lateral movement.

4.4 Pump Mounting

The pump may be mounted directly on the pit using the pump mounting plate [6130] or in conjunction with a pit cover.

a) The pump was checked during assembly at the factory to make sure the pump shaft [2100] rotated freely by hand. Handling during shipment, storage, or preparation for installation could have caused distortions resulting in pump shaft binding. Check the shaft to make sure that it will rotate freely by hand.
b) Check all bolts and nuts for tightness, then carefully lower the assembled pump into the pit**,** taking care not to damage lube lines or float control equipment. Make sure that any equipment used to lift the pump or any of its components is capable of supporting the weights encountered. Make sure that all parts are properly rigged before attempting to lift.
c) Pump mounting plate and/or pit cover must maintain level within 1/8in/ft. from one side of the plate to the other, and be supported evenly at all points before being bolted down.
d) If the sump doesn't provide a level mounting surface for the pump, drive wedges under the mounting plate/pit cover until pump levels out. The wedges must be able to support the weight of the entire pumping assembly and hold the assembly steady enough that no excess vibration occurs.
e) Do not bolt the discharge flange of the pump to the piping until the baseplate foundation is completely installed.
f) Run piping to the discharge of the pump. There should be no piping loads transmitted to the pump after connection is made.

4.5 Mechanical seals and packing

Pumps supplied with vapor proof construction or pressurized designs are furnished with an upper stuffing box [4110] equipped to take mechanical seals or packing (see vapor proof and pressurized design cross-sections in section 8). Gas seals are typically of a canister design, thus the stuffing box is omitted. The canister seals are mounted directly to the upper column [1341.1]. Installation instructions can be found in section 6.9.5

4.5.1 Mechanical seal

Mechanical seals [4200] are typically installed 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. Installation instruction can be found in section 6

⚠ Failure to ensure that a seal is installed may result in serious leakage of vapor and 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.

4.5.2 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. Installation instructions can be found in section 6.

⚠ Failure to ensure that the packing is installed may result in serious leakage of vapor and of the pumped fluid.

4.6 Driver Mounting

a) Before the motor is installed, be sure to connect the motor half coupling hub and the pump half coupling hub onto their respective shafts.
b) Carefully lift the motor and place it on the support head [3160] of the pump.
c) Turn the motor frame to one of the four positions where the motor bolt holes line up to the support head [3160]. Select the position of the motor to suit the desired conduit box location. Install the motor hold down bolts [6570.1]. In some instances a motor adapter [1340.3] may be furnished. In this case the adapter must be installed before the motor can be mounted.
d) Motor to pump alignment is controlled by fits within the adapter and cannot be adjusted.
e) Locate the coupling and source of electrical power but DO NOT INSTALL THE COUPLING DRIVE ELEMENT AT THIS TIME.
f) Connect the motor terminals to the leads from the starter panel. Make sure the motor shaft and/or coupling is not touching any part of the pump shaft or pump half coupling. Rotate the motor shaft by hand to make sure it is free to rotate when energized.

⚠ **Never check driver rotation unless the pump and driver shafts are disconnected and physically separated. Failure to follow this instruction can result in serious damage to the pump and driver if rotation is in the wrong direction.**

g) **Jog the motor and check for proper rotation which should be clockwise when looking down on top of the motor.** If rotation is wrong, interchange any two motor connections on three-phase motors. On single-phase motors, follow the motor manufacturer's instructions. After changing the connections, again check the rotation to ensure that the direction is correct.
h) Disconnect and lockout the power supply to the driver.
i) The coupling can now be fully installed and join the driver and pump shafts together (see section 5.4.2).
j) Install the coupling guarding [7450.1-.2] (see section 5.5).

4.7 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.

4.7.1 General 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.

4.7.2 Suction piping

ESP pumps typically only have strainers attached to the suction flange of the pump casing. An option for an extension from the suction flange is available and is called a tailpipe (see section 8 for cross-sectional drawing). A tailpipe is useful for applications where there is adequate NPSH at the lowest sump level but the discharge pressure is critical and must be maintained at a maximum value compared to using a longer column and shaft. Pumps may air-bind if air is allowed to leak into the piping

4.7.3 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.

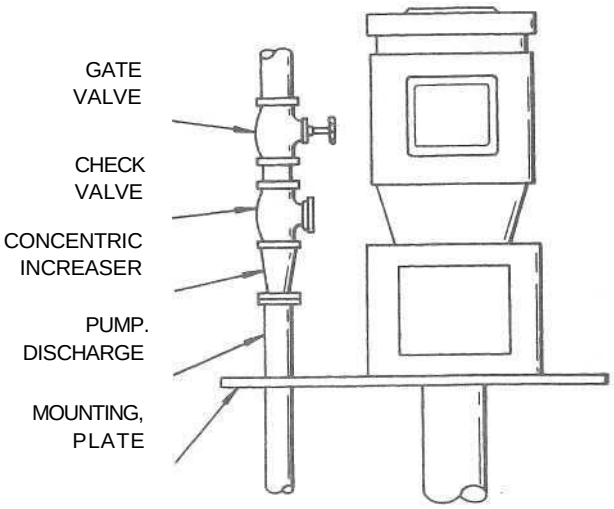
CAUTION When fluid velocity in the pipe is high, for example, 3 m/s (10 ft/sec) or higher, a rapidly closing discharge valve can cause a damaging pressure surge. A dampening arrangement should be provided in the piping.

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. It should be possible to install discharge bolts through mating flanges without pulling or prying either of the flanges. All piping must be tight.

a) Use discharge piping one size larger than the pump discharge.
b) Discharge piping should be well supported and connected to the pump such that no strain or weight of the piping is carried by the pump.
c) Check pump shaft for freedom of rotation by hand to make sure any discharge piping strain is not causing binding.
d) After the pump discharge, the increaser should be the first item in the discharge line, followed by the check valve and gate valve, respectively. See Figure 4-1.
e) It is recommended that pressure indicating devices be installed before and after the valves in the discharge line to verify the pump is not being run dry and that the discharge valves are not closed.

CAUTION The check valve is required to prevent back-flow through the pump on shut-down. This flow can reverse rotation of the pump, potentially damaging the pump, motor and associated equipment.

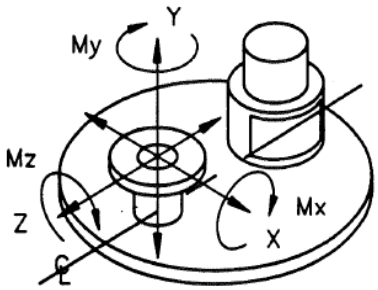
Figure 4-1



4.7.4 Allowable Nozzle Loads

Discharge piping should be constructed to fit to the ESP3 discharge piping flange. The ESP3 design can accommodate large piping loads without affecting the operation of the pump, but the installation should not impose unnecessary loads to the discharge flange. The allowable piping loads are shown in Figure 4.2.

Figure 4-2 ESP3 Nozzle Loading



↑ Tension

↓ Compression

$$\left|\frac{Fx}{Fx_{max}}\right| + \left|\frac{Fy}{Fy_{max}}\right| + \left|\frac{Fz}{Fz_{max}}\right| + \left|\frac{Mx}{Mx_{max}}\right| + \left|\frac{My}{My_{max}}\right| + \left|\frac{Mz}{Mz_{max}}\right| \leq 1$$

		Force N			Moments Nm		
Group	Size	Fx	Fy	Fz	Mx	My	Mz
1E	1.5x1LFSP-4	760	1270	760	414	441	414
1E	1.5x1SP-62	760	1270	760	414	441	414
1E	3x1.5SP-62	930	1560	930	515	542	515
1E	3x2SP-62	1110	1870	1110	610	644	610
1E	1.5x1SP-8	760	1270	760	414	441	414
1E	1.5x1LFSP-8	760	1270	760	414	441	414
1E	3x1.5SP-82	930	1560	930	515	542	515
1E	3x2SP-82	1110	1870	1110	610	644	610
2E	3x1.5SP-82	930	1560	930	515	542	515
2E	3x2SP-82	1110	1870	1110	610	644	610
2E	4x3SP-82	1380	2310	1380	759	800	759
2E	2x1SP-10A	760	1270	760	414	441	414
2E	2x1LFSP-10	760	1270	760	414	441	414
2E	3x1.5SP-10	930	1560	930	515	542	515
2E	2x2RSP-10	1110	1870	1110	610	644	610
2E	3x2SP-10	1110	1870	1110	610	644	610
2E	3x3RSP-10	1380	2310	1380	759	800	759
2E	4x3SP-10	1380	2310	1380	759	800	759
2E	4x3SP-10H	1380	2310	1380	759	800	759
2E	6x4SP-10\H	1780	2980	1780	976	1030	976
2E	3x1.5SP-13	930	1560	930	515	542	515
2E	3x1.5LFSP-13	930	1560	930	515	542	515
2E	3x2SP-13	1110	1870	1110	610	644	610
2E	4x3SP-13\HH	1380	2310	1380	759	800	759
2E	4x3RSP-13	1380	2310	1380	759	800	759
3E	6x4SP-13A	1780	2980	1780	976	1030	976
3E	6x4RSP-13	1780	2980	1780	976	1030	976
3E	8x6SP-14A	2340	3890	2340	1281	1356	1281
3E	10x8SP-14	2800	4670	2800	1539	1620	1539
3E	6x4SP-16\A	1780	2980	1780	976	1030	976
3E	8x6SP-16	2340	3890	2340	1281	1356	1281
3E	10x8SP-16\H	2800	4670	2800	1539	1620	1539

$$\left|\frac{Fx}{Fx_{max}}\right|+\left|\frac{Fy}{Fy_{max}}\right|+\left|\frac{Fz}{Fz_{max}}\right|+\left|\frac{Mx}{Mx_{max}}\right|+\left|\frac{My}{My_{max}}\right|+\left|\frac{Mz}{Mz_{max}}\right|\leq 1$$

		Force lbf			Moments lbf•ft		
Group	Size	Fx	Fy	Fz	Mx	My	Mz
1E	1.5x1LFSP-4	170	285	170	305	325	305
1E	1.5x1SP-62	170	285	170	305	325	305
1E	3x1.5SP-62	210	350	210	380	400	380
1E	3x2SP-62	250	420	250	450	475	450
1E	1.5x1SP-8	170	285	170	305	325	305
1E	1.5x1LFSP-8	170	285	170	305	325	305
1E	3x1.5SP-82	210	350	210	380	400	380
1E	3x2SP-82	250	420	250	450	475	450
2E	3x1.5SP-82	210	350	210	380	400	380
2E	3x2SP-82	250	420	250	450	475	450
2E	4x3SP-82	310	520	310	560	590	560
2E	2x1SP-10A	170	285	170	305	325	305
2E	2x1LFSP-10	170	285	170	305	325	305
2E	3x1.5SP-10	210	350	210	380	400	380
2E	2x2RSP-10	250	420	250	450	475	450
2E	3x2SP-10	250	420	250	450	475	450
2E	3x3RSP-10	310	520	310	560	590	560
2E	4x3SP-10	310	520	310	560	590	560
2E	4x3SP-10H	310	520	310	560	590	560
2E	6x4SP-10\H	400	670	400	720	760	720
2E	3x1.5SP-13	210	350	210	380	400	380
2E	3x1.5LFSP-13	210	350	210	380	400	380
2E	3x2SP-13	250	420	250	450	475	450
2E	4x3SP-13\HH	310	520	310	560	590	560
2E	4x3RSP-13	310	520	310	560	590	560
3E	6x4SP-13A	400	670	400	720	760	720
3E	6x4RSP-13	400	670	400	720	760	720
3E	8x6SP-14A	525	875	525	945	1000	945
3E	10x8SP-14	630	1050	630	1135	1195	1135
3E	6x4SP-16\A	400	670	400	720	760	720
3E	8x6SP-16	525	875	525	945	1000	945
3E	10x8SP-16\H	630	1050	630	1135	1195	1135

4.8 Final free rotation 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. If piping caused unit to be in a bind, correct piping to relieve strain on the pump.

4.9 Auxiliary piping

Check to see if any other connections need to be made to pump, such as fluid injection to stuffing box for seal or packing lubrication (when furnished) and make the required connections.

Check to see that connections are made to the lubrication fittings at pump manifold [3869] on mounting plate [6130]

4.10 Electrical connections

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

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

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

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

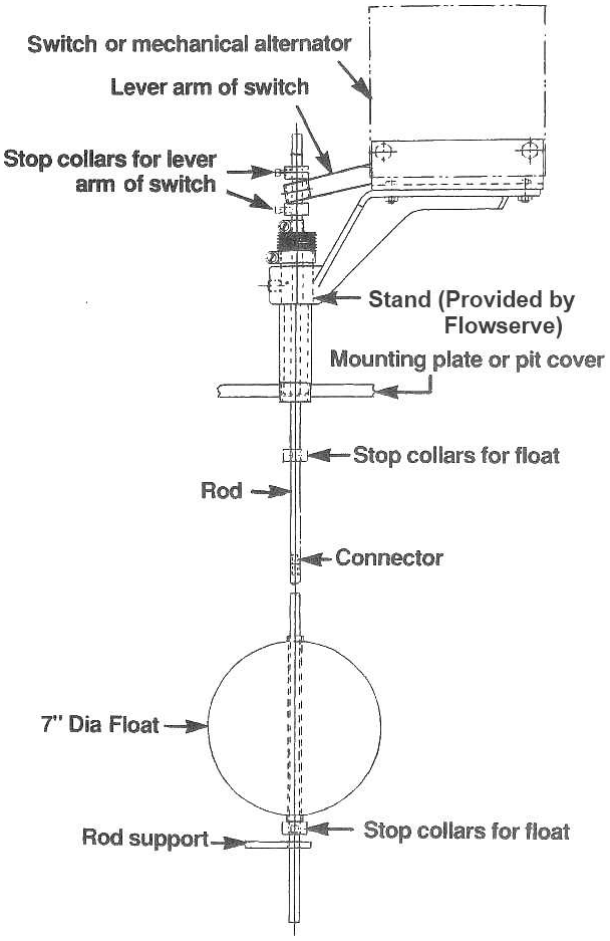
DANGER The motor must be wired up in accordance with the motor manufacturer's instructions (normally supplied within the terminal box) including any temperature, earth leakage, current and other protective devices as appropriate. The identification nameplate should be checked to ensure the power supply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

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

4.11 Level controls

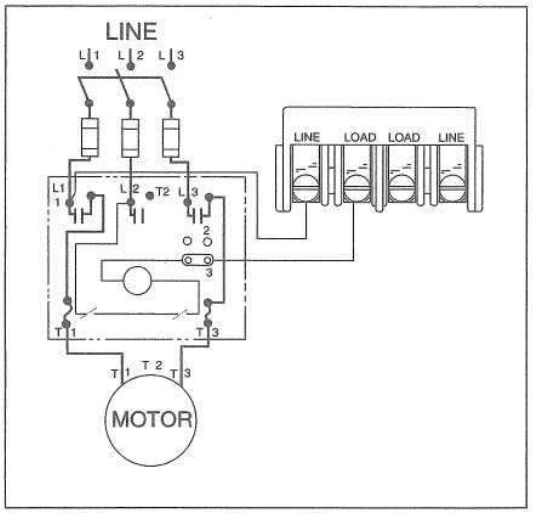
Assemble float control equipment per Figure 4-3 below. Wire the float controls following the diagrams on the next several pages. The stops should be set in accordance with maximum and minimum liquid levels desired and required. Float rods are furnished in kits of a standard length. The rod might have to be cut off to fit the particular installation.

Figure 4-3

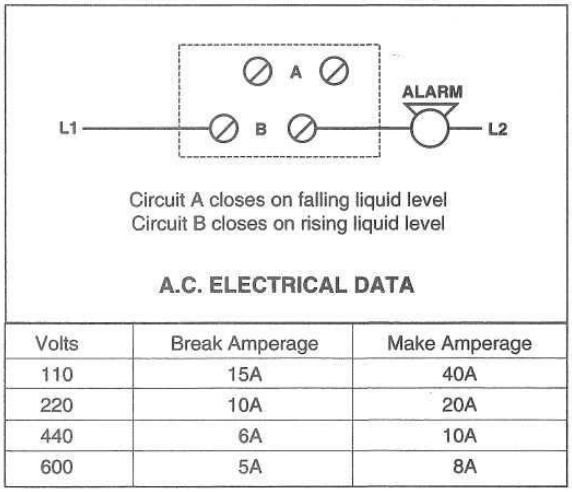


Some of the wiring diagrams are included on the following pages. If the wiring diagram needed is not included, contact control manufacturer for wiring instructions.

SQUARE "D" CLASS 9036
TYPE GG, DR, DW, GR AND GW - FLOAT SWITCH
(Typical Only)

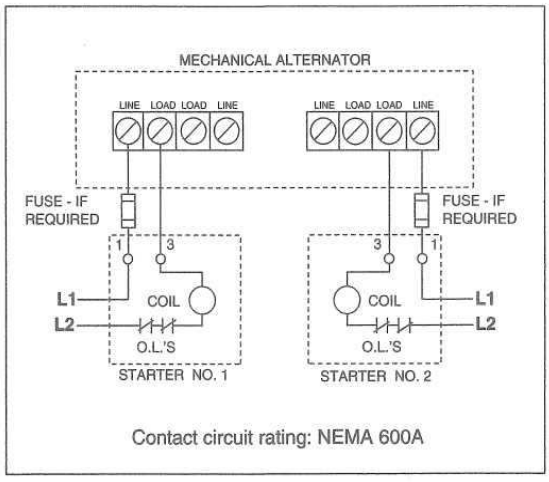


OPTIONAL SQUARE "D" FORM N5
HIGH LEVEL ALARM FOR USE WITH CLASS
9038 MECHANICAL ALTERNATOR (Typical Only)



Volts	Break Amperage	Make Amperage
110	15A	40A
220	10A	20A
440	6A	10A
600	5A	8A

SQUARE "D" CLASS 9038
TYPE AG, AW, AR - MECHANICAL
ALTERNATOR (Typical Only)

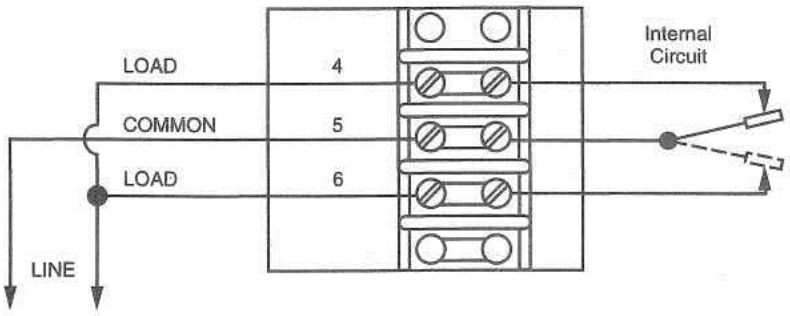


MAGNATROL®
FOR SINGLE FUNCTION (A10) SWITCHES
(Typical Only)

MAGNETROL
SPDT SWITCH MECHANISM

USE FOR MAGNETROL PART #'s:

A10 ____ ____ BKB

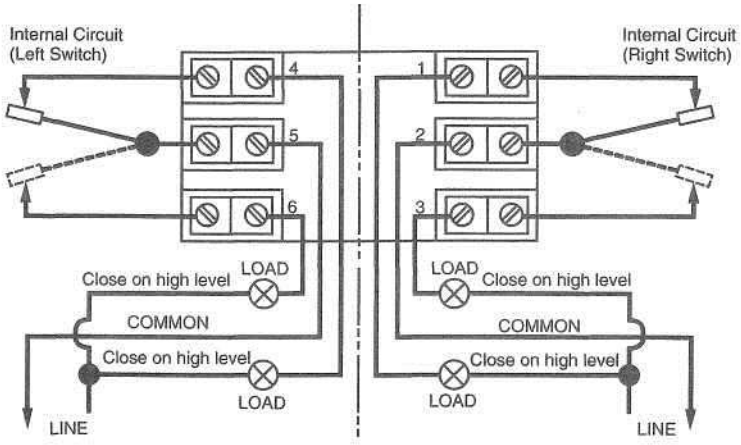


In this diagram, circuit between contacts 4 & 5 is made and circuit between contact 5 & 6 is broken at low liquid level. At high liquid level, circuit between contacts 4 & 5 is broken and circuit between contacts 5 & 6 is made.

MAGNETROL
DPDT SWITCH MECHANISM

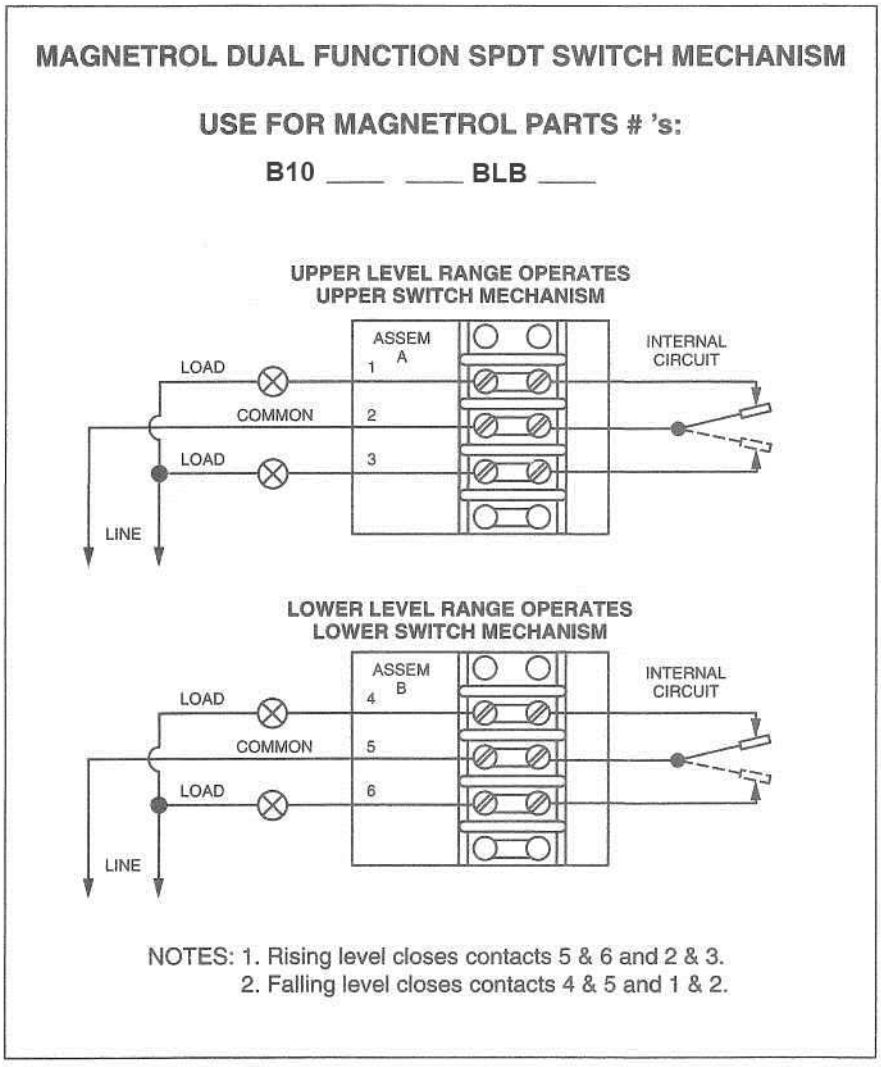
USE FOR MAGNETROL PART #'s:

A10 ____ ____ BNB
____ ____

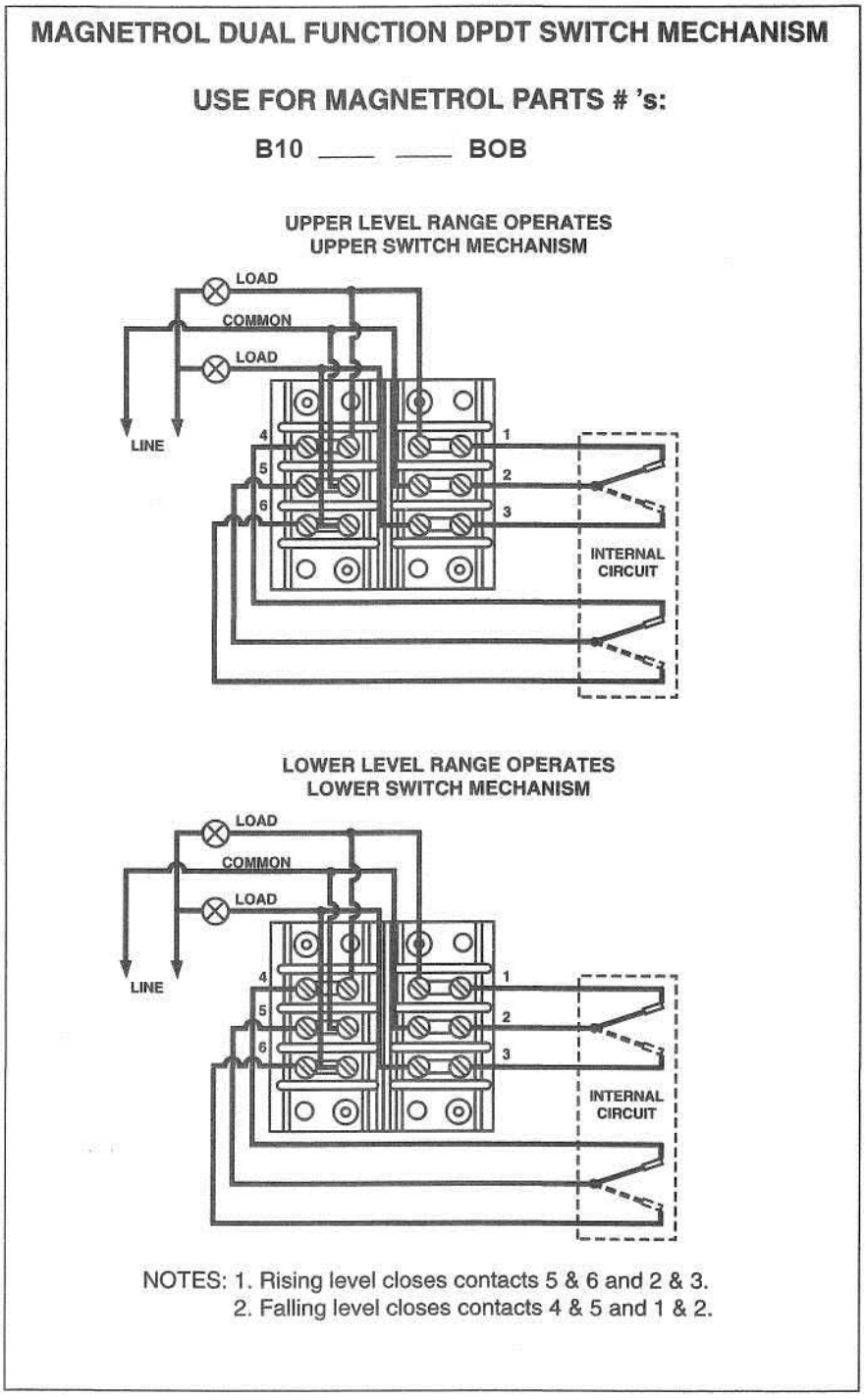


Double pole action is obtained by simultaneous operation of the right and left side single pole double throw switches.

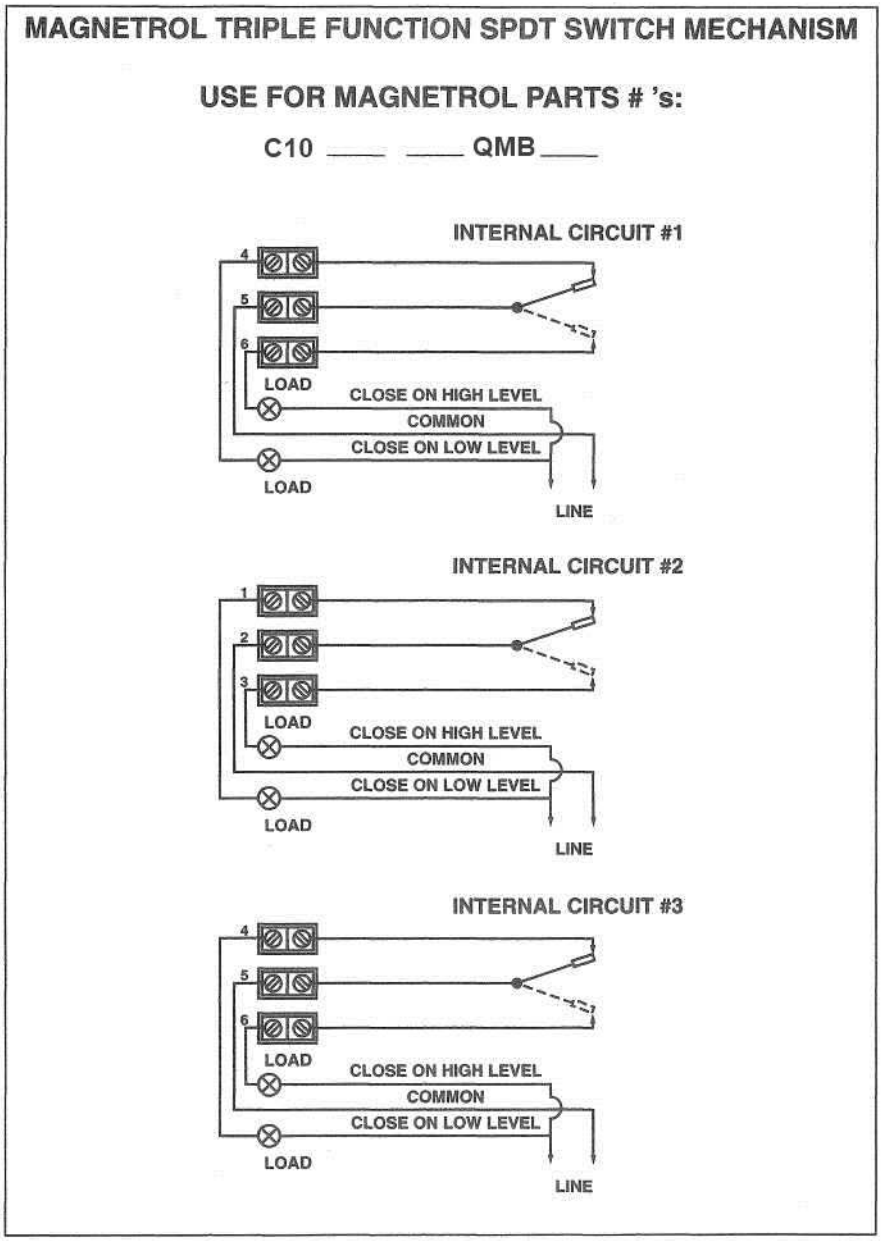
MAGNATROL®
FOR DOUBLE FUNCTION (B10) SWITCHES
(Typical Only)



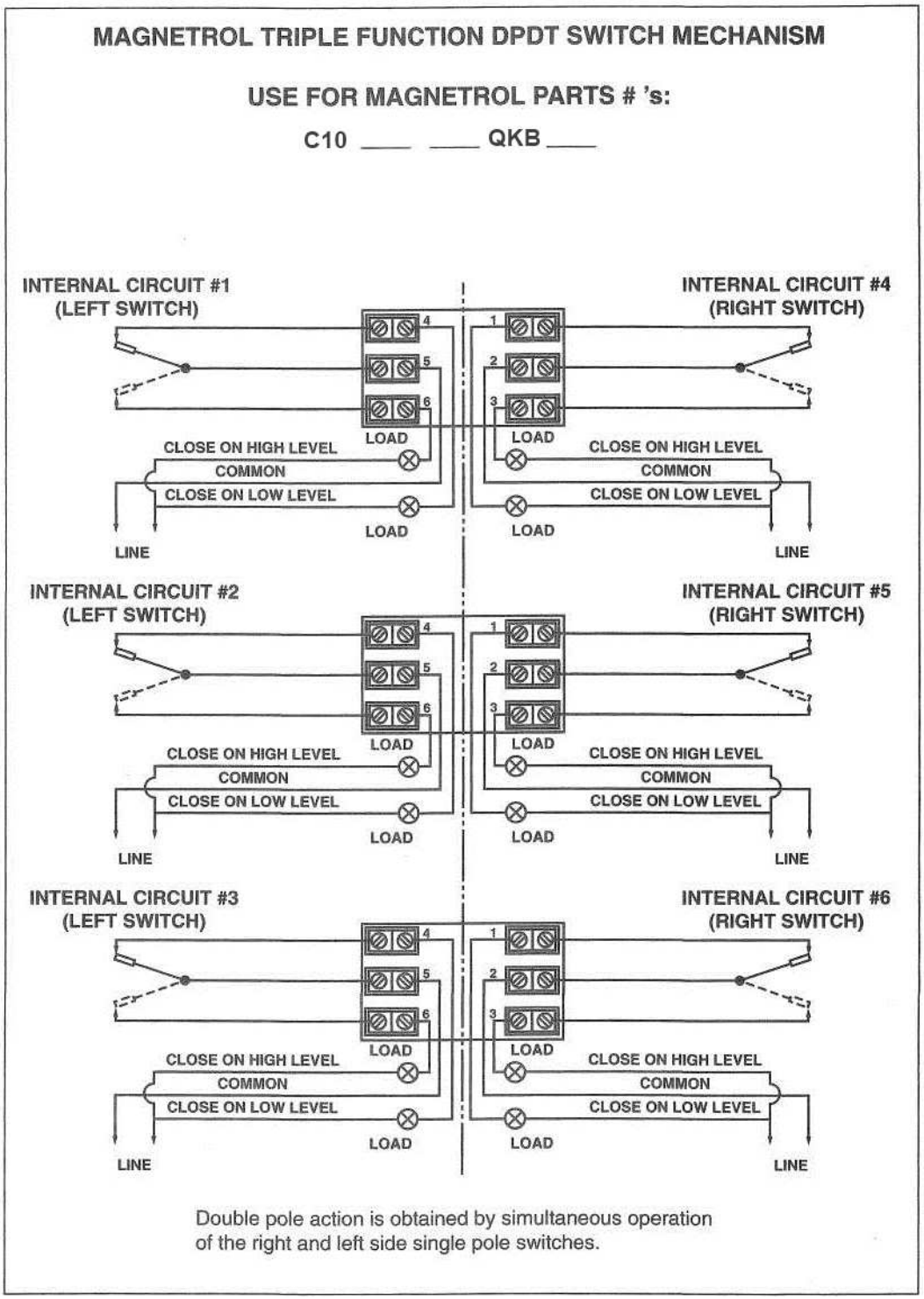
MAGNATROL®
FOR DOUBLE FUNCTION (B10) SWITCHES
(Typical Only)



MAGNATROL®
FOR TRIPLE FUNCTION (C10) SWITCHES
(Typical Only)



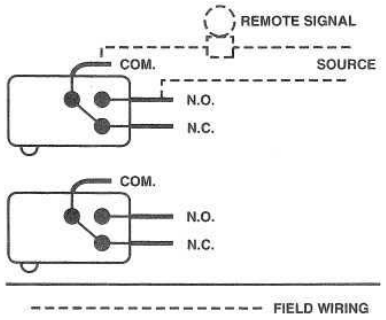
MAGNATROL®
FOR TRIPLE FUNCTION (C10) SWITCHES
(Typical Only)



APEX SWITCH
(Typical Only)

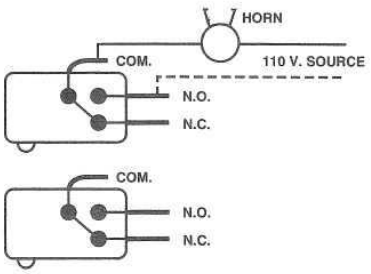
FOR HIGH LEVEL ALARM SWITCH MODELS:

LLC – 1A LESS HORN – NEMA 1
LLC – 1X LESS HORN – NEMA 3,4,7, and 9



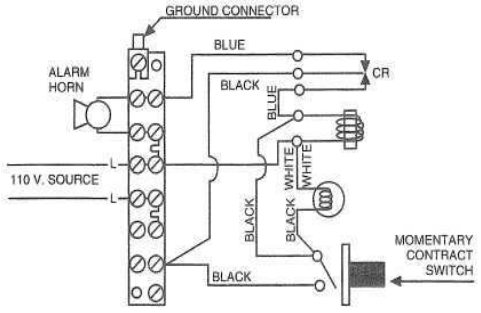
FOR HIGH LEVEL ALARM SWITCH MODELS:

LLC – 1H WITH HORN – NEMA 1



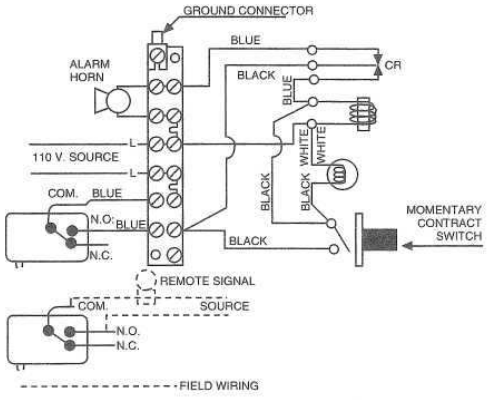
FOR ALARM PANEL MODELS:

LLC – 1AP –NEMA 1
LLC – 1APA – NEMA 4



FOR INTEGRAL HIGH LEVEL ALARM SWITCH AND PANEL MODELS:

LLC –1APS NEMA 1
LLC – 1APS4 NEMA 4



4.12 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.

- Motor properly secured to the support head
- 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
- Pump instrumentation is operational
- 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 Bearing Lubrication

Two types of bearings are used in the ESP3. Line shaft bearings are used to support pump shaft within the column. These plain bearings are lubricated by external flush, product lubrication or grease. Duplex angular contact bearings are used to support the coupling end of the shaft. These ball bearings support coupling loads and pump thrust. They are lubricated by bearing grease. See (5.2.3)

CAUTION Operation of the unit without proper lubrication can result in bearing failures, pump seizures and pump failure.

5.2.1 Line Shaft Bearings

Check to see that no damage has occurred to any lubrication lines above the mounting plate [6130] during shipment or installation. For number of bearings, refer to Figure 5-6. Check to see that connections are made to lubrication fittings at pump manifold [3869] on mounting plate [6130].

5.2.1.1 External Flush Lubrication

a) Clean liquid from an external source must be used when pumps are furnished with external flush lubrication connections. Liquid is typically supplied continuously during operation. Some bearings (such as carbon) can run without lubrication for short periods but lubrication is needed to dissipate heat and abrasives.
b) Check to see that connections are made to lubrication fittings on pump manifold [3869] on mounting plate [6130] and that 1.9 LPM (0.5 gpm) of flushing fluid per bearing, 3.0 LPM (0.8 gpm) for Group 3, (See Figure 5-6) at 1.4 kg/cm^2 to 5.6 kg/cm^2 (20 PSIG to 80 PSIG) above sump pressure.

CAUTION It is absolutely necessary that rubber bearings be wet at all times during operation.

5.2.1.2 Product Lubrication

When conditions warrant, the pump can be furnished with provisions for pumped product bearing lubrication. This is accomplished by means of a lubrication line from the discharge flange of the pump casing [1100] to the adapter bearing [3020.2], while the rest of the lines are run from the manifold [3869] on the pump mounting plate [6130]. In the case of a pumped-product lubricated pump with separators furnished, all lube lines will be run from the pump manifold [3869].

a) Check to see that connections are made to lubrication fittings at pump manifold [3869] on mounting plate [6130] and for the adapter [1340.1] bearing [3020.2].
b) Check that 1.9 LPM (0.5 gpm), 3.0 LPM (0.8 gpm) for Group 3, of pumped liquid per bearing (See Figure 5-5) at 1.4 kg/cm^2 (20 PSIG) for standard product lubricated pumps or 1.8 kg/cm^2 (25 PSIG) for product lubricated pumps with separators is available.
c) Changes in noise and vibration may indicate insufficient lubrication.

5.2.1.3 Grease Lubrication

Pumps furnished with grease-lubricated shaft bearings [3020.1-.2] will leave the factory with lube lines [3840.1] and bearings [3020.1-.2] already packed with grease. The grease used will be of a water-resistant nature. Each bearing should be re-greased prior to start-up through the grease fittings located in the manifold [3869] on the pump mounting plate [6130]. Grease must be insoluble in the liquid being pumped. The recommended grease to be used is Mobil Polyrex EP 2 or an equivalent. Bearing lubrication lines are filled with Polyrex EP 2 before the pump leaves the factory. Consult local lubricant suppliers for the type of grease most compatible with the liquid being pumped. The grease lubrication system is the same as the external flush system with the exception of the manifold [3869]. For grease lubrication the manifold contains grease fittings while the external flush manifold contains fluid line taps.

Grease lubricated line bearings require frequent lubrication. Grease lubricating systems may be utilized. Follow the manufacturer's instruction for proper use. Lubrication intervals and amounts can be found in Figures 5-2 and 5-3.

Flowserve offers two lubrication systems that significantly extend the line shaft bearing lubrication intervals. Individual 2 oz. grease cups per line shaft bearing and a fully automated progressive lubrication system. Consult your Flowserve representative for additional information.

5.2.2 Thrust Bearing

The external duplex angular contact thrust bearing [3031] may be lubricated through the grease fitting [3853.2]. Lubrication type, intervals and amount may be found in Figures 5-1, 5-4 and 5-5. The bearing will leave the factory with grease already packed.

A greased for-life option may be selected. In this case, NYLOS® rings will be added to control grease movement and the grease port will be plugged. A shielded bearing will not need to be re-greased, but will need to be replaced when it becomes excessively worn.

Note: Grease for life bearings
The replacement interval for these bearings is greatly affected by their operating temperature and speed.

5.2.3 Driver Bearings

Driver Bearings should be re-greased before starting the pump. Consult the manufacturer's directions for lubricating instructions.

Figure 5-1: Recommended Grease

Line Shaft Bearings	Mobil Polyrex EP 2, ConocoPhilips Polytac® EP or equivalent
Thrust Bearing	Mobil Polyrex EP 2, ConocoPhilips Polytac® EP (or compatible Polyurea with mineral oil)
Motor	Mobil Polyrex EM 2, ConocoPhilips Polytac® or equivalent

Figure 5-2: Line bearing lubrication intervals*

Service	**Clean**	**Contains abrasives**
Interval	8 Hours	4-6 hours

*Interval depends upon process conditions

Figure 5-3: Line bearing lubrication amounts

Location	**Amount**
Intermediate Bearings [3020.1]	18 grams (0.625 oz.) 21 cm^3 (1.3 in.^{3})
Bottom Bearing [3020.2]	11 grams (0.375 oz.) 47 cm^3 (2.9 in.^{3})

Figure 5-4: Ball bearing lubrication intervals*

Bearing Temperature	**Under 71 ℃ (160 ℉)**	**71-80 ℃ (160-175 ℉)**	**80-94 ℃ (175-200 ℉)**
Interval	6 months	3 months	1.5 months

*Assuming good maintenance and operation practices, and no contamination.
* Bearing Temperatures up to 16℃ (30 ℉) higher th an housing

Figure 5-5: Ball bearing lubrication amounts

Group Size	**Initial lube**	**Re-lubrication**
Group 1	50 g (1.8 oz.)	20 g (0.7 oz.)
Group 2	75 g (2.7 oz.)	30 g (1.1 oz.)
Group 3	115 g (4.1 oz.)	45 g (1.6 oz.)

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

⚠ CAUTION Do not overfill the motor or pump thrust bearings with grease. If too much grease is pumped into the bearings, they can overheat. The maximum temperature that a rolling element bearing should be exposed to is 105 ℃ (220 ℉).

Figure 5-6: Number of line shaft bearings for standard span

PIT DEPTH	GROUP 1		GROUP 2		GROUP 3 EXCEPT 6X4X13		GROUP 3 6X4X13	
	3600 RPM	1800 RPM	3600 RPM	1800 RPM	1800 RPM	1200 RPM	1800 RPM	1200 RPM
2'-0"	1	1	1	1				
2'-6"	1	1	1	1				
3'-0"	1	1	1	1	1			1
3'-6"	1	1	1	1	1	1	1	1
4'-0"	2	1	1	1	1	1	1	1
4'-6"	2	1	2	1	1	1	1	1
5'-0"	2	1	2	1	1	1	1	1
5'-6"	2	2	2	2	1	1	1	1
6'-0"	2	2	2	2	1	1	1	1
6'-6"	3	2	2	2	1	1	1	1
7'-0"	3	2	2	2	1	1	2	2
7'-6"	3	2	3	2	2	2	2	2
8'-0"	3	2	3	2	2	2	2	2
8'-6"	3	2	3	2	2	2	2	2
9'-0"	4	2	3	2	2	2	2	2
9'-6"	4	3	3	3	2	2	2	2
10'-0"	4	3	3	3	2	2	2	2
10'-6"	4	3	4	3	2	2	2	2
11'-0"	4	3	4	3	2	2	2	2
11'-6"	5	3	4	3	2	2	2	2
12'-0"	5	3	4	3	2	2	3	3
12'-6"	5	3	4	3	3	3	3	3
13'-0"	5	3	4	3	3	3	3	3
13'-6"	5	4	5	4	3	3	3	3
14'-0"	6	4	5	4	3	3	3	3
14'-6"	6	4	5	4	3	3	3	3
15'-0"	6	4	5	4	3	3	3	3
15'-6"	6	4	5	4	3	3	3	3
16'-0"	6	4	5	4	3	3	3	3
16'-6"	7	4	6	4	3	3	3	3
17'-0"	7	4	6	4	3	3	4	4
17'-6"	7	5	6	5	4	4	4	4
18'-0"	7	5	6	5	4	4	4	4
18'-6"	7	5	6	5	4	4	4	4
19'-0"	8	5	6	5	4	4	4	4
19'-6"	8	5	7	5	4	4	4	4
20'-0"	8	5	7	5	4	4	4	4
MAX. BRG. SPAN	30"	48"	36"	48"	60"	60"	60"	60"

Note: The above numbers include the bottom adapter bearing. For determining the required number of line shaft bearing lubrication points, use the total quantity of line shaft bearings on this sheet.

These spans meet the requirements of ANSI/API STANDARD 610, 11th Edition, Figure 37.

5.3 Impeller clearance

The impeller clearance was set at the factory. For reverse-vane and recessed impellers, the clearance is set to the cover while the open impeller clearance is set to the casing
The impeller setting may be checked or change due to wear. See Section 6.6.

5.4 Direction of rotation

5.4.1 Rotation check

⚠ It is absolutely essential that the rotation of the motor be checked before installing the coupling drive element. Incorrect rotation of the pump, for even a short time, can dislodge and damage the impeller, casing, shaft and shaft seal. All ESP3 3 pumps turn clockwise as viewed from the motor end (top). A direction arrow is cast on the support head [3160].

5.4.2 Coupling installation

⚠ CAUTION Turn off the driver power and lock it out so that the driver cannot be started during the coupling assembly. Non-spacer couplings are used. Mount coupling hubs/sheaves on pump and motor shafts prior to attaching motor to the support head.

⚠ CAUTION The coupling should be installed as advised by the coupling manufacturer. Pumps are shipped without the sleeve installed. If the sleeve has been installed then it must be removed prior to checking rotation. Remove all protective material from the coupling and shaft before installing the coupling.

5.5 Guarding

⚠ 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.

5.6 Priming and auxiliary supplies

A pump is said to be “primed” when the casing is submerged and 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 liquid level is above the pump casing. 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.

Depending upon the bearing lubrication and shaft seal option, some auxiliary supply lines may need to be brought to the pump. Check to see if any other connections need to be made to pump, such as fluid injection to stuffing box for seal or packing lubrication (when furnished) and make the required connections. Check to see that connections are made to the lubrication fittings at pump manifold [3869] on mounting plate [6130]

⚠ CAUTION Seals must never be run without lubrication. Abrasive lubrication will greatly reduce seal life.

5.7 Starting the pump

⚠ To avoid pump damage or injury to operating personnel during start-up and operation:

- DO NOT operate the pump outside of design parameters.
- DO NOT run with a closed discharge for more than one minute.
- DO NOT operate with safety devices (i.e. coupling guard) removed.
- DO NOT run the pump dry.

a) Ensure the pump is primed. (See section 5.6.) The sump liquid level must cover the casing and adapter. Minimum submergence number can be found in Figure 3-6.
b) All flush lines must be started and regulated.
c) Start the driver (typically, the electric motor).
d) Slowly open the discharge valve until the desired flow is reached, keeping in mind the minimum continuous flow listed in Figure 3-2.
e) Check all joints and mechanical seal (if furnished) for leakage.
f) If packing is furnished, adjust the packing gland and flush flow.
g) Check for excessive vibration.
h) Monitor bearing temperature until it stabilizes.

⚠ 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 buildup 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 ESP3 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 bearings and any equipment flushed with process fluid will be exposed to vapor, with no lubrication, and may score or seize to the stationary parts.

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

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

5.8.3 Reduced head

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

5.8.4 Surging condition

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

5.8.5 Operation in sub-freezing conditions

When using the pump in sub-freezing conditions where the pump is periodically idle, the sump should be properly drained or protected with thermal devices which will keep the liquid in the sump from freezing. External bearing and seal lubrication lines must be protected with thermal devices. High chrome iron pumps are not recommended for applications below -18 ℃ (0 ℉).

5.8.6 Operating Checks

Costly shutdowns will be avoided by making routine checks on pump operation.

a) Check to see if liquid is being discharged. A discharge pressure gauge is an easy way to check whether or not the liquid is being pumped. If, at any time, the gauge should drop near or to zero, or register an abnormally high pressure, shut down the pump immediately.
b) Observe pump for any abnormal noise or vibration. Especially check for any CHANGE in pump noise or vibration.
c) Bearing lubricating liquid, and sealing and cooling liquid flows, should be checked frequently.

5.8.7 Normal vibration levels, alarm and trip

Alarm and trip values for installed pumps should be based on the actual measurements (N) taken on site on the motors of vertical pumps in fully commissioned as new condition. The example (N) value is given for the preferred operating flow region (typically this may extend to 70 to 120% of the pump best efficiency point); outside the preferred flow region the actual vibration experienced may be multiplied by up to two.

These standard values can vary with the rotational speed and the power absorbed by the pump. For any special case, contact your nearest Flowserve office.

Measuring vibration at regular intervals will show any deterioration in pump or system operating conditions.

Vibration velocity – unfiltered		mm/s (in./s) r.m.s.	mm/s (in./s) Peak value
Normal	**N**	5.6 (0.22)	8.0 (0.31)
Alarm	**N** x 1.25	7.0 (0.28)	9.9 (0.39)
Shutdown	**N** x 2.0	11.3 (0.45)	16.0 (0.63)

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 and shut down the driver.

CAUTION The pump should be brought to zero speed rapidly, especially on pumps equipped with product-lubricated bearings.

Pumps driven by electric motors do not require any special shutdown procedure. If turbine drive is used, the operator must manually trip the over speed trip to obtain rapid shutdown

5.10 Hydraulic, mechanical and electrical duty

5.10.1 Net positive suction head (NPSH)

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

Net positive suction head - required ($NPSH_R$) is the decrease of fluid energy between the inlet of the pump, and the point of lowest pressure in the pump. This decrease occurs because of friction losses and fluid accelerations in the inlet region of the pump and particularly accelerations as the fluid enters the impeller vanes. The value for $NPSH_R$ for the specific pump purchased is given in the pump data sheet, and on the pump performance curve.
For a pump to operate properly the $NPSH_A$ must be greater than the $NPSH_R$. Good practice dictates that this margin should be at least 1.5 m (5 ft) or 20%, whichever is greater.

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

5.10.2 Specific gravity (SG)

Pump capacity and total head in meters (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. Product lubricated bearings require a minimum of viscosity of 0.4 cP; >0.6 cP is recommended for extended bearing life. Failure to maintain sufficient viscosity will result in a damaged shaft and bearings, and possibly a complete stopping of pumping. 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, $NPSH_R$, 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, $NPSH_A > NPSH_R$ and that noise and vibration are within local requirements and regulations.

The number of line shaft bearings (bearing spans) has been selected based upon the motor speed. These spans impact the stability of the shaft and determine it natural frequencies. The number of line shaft bearings can be found in Figure 5-6. The bearing spans and critical speeds can be found in Figure 3-8. The pump should not be operated above it designed operating speed as this may result in severe and damaging vibration.

The minimum speed for pump with product lube bearings is dictated by the ability of the discharge pressure to deliver lube to the bearings. Pumps with product lube line shaft bearings should not be operated at speeds that deliver less than 20 PSIG at the mounting plate or 25 PSIG if equipped with separator(s).

5.10.5 Minimum submergence
Each ESP3 pump has a minimum submergence depending on the design conditions of that pump. See Figure 3-6 to determine the minimum submergence based upon pump flow and suction size. All minimum submergence values are taken from the bottom of the strainer.

CAUTION If a tailpipe [1428] is used, the sump (pit) liquid level must engulf the casing and adapter completely during start-up.

6 MAINTENANCE

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.

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

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

Do not spray air or compressed inert gas on skin.

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

Never use air or compressed inert gas to clean clothes.

Before working on the pump, take measures to prevent 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

Ex 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.

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 other parts of the pump. 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.

CAUTION 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 support head. See figure 3-1.

6.3 Recommended spares and consumable items

Figure 6-2 shows the parts which are included in each of the following three classes of recommended spares:
CLASS 1 - MINIMUM - Suggested for Domestic Service when pump is handling clean non-corrosive liquids and where interruptions in continuity of service are not objectionable.
CLASS 2 - AVERAGE - Suggested for Domestic Service when pump is handling abrasive or corrosive liquids and where some interruptions in continuity of service are not objectionable.
CLASS 3 - MAXIMUM - Suggested for Export Marine or Domestic Service where interruptions in service are objectionable.

Our Sales Representative in your area will gladly review the class of spares best suited to meet your requirements. When ordering recommended spares, please provide information specified in section in 6.2.1.

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
- Snap ring pliers
- Spanner wrench
- Flowserve specialty tools (see below)

To simplify maintenance, it is recommended that specialty tools be purchased from Flowserve. Nose cones are available to ease assembly. These cones help guide assembly, protect threads and protect line shaft bearings. These tools can be ordered from your local Flowserve sales engineer or from a Flowserve distributor or representative.

Figure 6-1: Recommended spare parts
(Reference Figure 8-11)

Part Number	Description	Spare Parts Class		
		1	2	3
2100	Pump shaft (see note 2)			1
2200	Impeller			1
2500	Throttle Bushing for cover		1	1
3020.1	Bearing -- intermediate		Note1	Note1
3020.2	Bearing -- adapter (bottom)		1	1
3031	Thrust bearing		1	1
3110	Bearing body -- thrust bearing		1	1
3250	Bearing holder		Note1	Note1
3400	Adjusting sleeve			1
4120.1	Gland		1	1
4130	Packing (optional)	Note1	Note1	Note1
4134	Seal cage -- packed box		1	1
4200	Mechanical seal (optional)	1	1	1
4310.1	Klozure lip seal -- bearing body	1	1	1
4310.2	Klozure lip seal -- upper column	1	1	1
4590.1	Gasket -- casing	1	1	1
4590.2	Gasket -- Impeller	1	1	1
4590.3	Gasket -- discharge pipe to casing flange	1	1	1
4590.4	Gasket -- stuffing box to upper column	1	1	1
4590.5	Gasket -- mechanical seal (optional)	1	1	1
4590.6	Gasket -- column to mounting plate	1	1	1
4590.7	Gasket -- manifold to mounting plate		1	1
6531	Strainer			1
6700.2	Pump key			1
7200	Coupling			1
8000	Motor complete (see note 3)			1

Note 1: Check record card for quantity required.
Note 2: Check record card for length required.
Note 3: When ordering motor parts, give motor serial number and model number as read from the motor nameplate. Also furnish pump serial number.

6.5 Fastener torques

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

Item	Description	Group 1	Group 2	Group 3
[6570.2-.3]	Column/column/adaptor cap screws and nuts	⅝ in. – 122 Nm (90 ft-lb)	⅝ in. – 122 Nm (90 ft-lb)	¾ in. – 210 Nm (155 ft-lb)
[6570.5]	Discharge elbow/casing	½ in. – 61 Nm (45 ft-lb) ⅝ in. – 122 Nm (90 ft-lb)	½ in. – 61 Nm (45 ft-lb) ⅝ in. – 122 Nm (90 ft-lb)	⅝ in. – 122 Nm (90 ft-lb) ¾ in. – 210 Nm (155 ft-lb)
[6570.7]	Manifold/mounting plate cap screws	½ in. – 61 Nm (45 ft-lb)	½ in. – 61 Nm (45 ft-lb)	½ in. – 61 Nm (45 ft-lb)
[6580.9]	Bearing Body/column cap screws	⅜ in. – 24 Nm (18 ft-lb)	½ in. – 50 Nm (37 ft-lb)	½ in. – 50 Nm (37 ft-lb)
[6570.16]	Cap screw cover/adapter (token bolts)	⅜ in. – 27 Nm (20 ft-lb)	⅜ in. – 27 Nm (20 ft-lb)	⅜ in. – 27 Nm (20 ft-lb) ½ in. – 54 Nm (40 ft-lb)
[6572.2]	Gland packed box studs and nuts	⅜ in. – As required	½ in. – As required	½ in. – As required
[6572.3]	Gland seal chamber studs and nuts	⅜ in. – 19 Nm (14 ft-lb)	½ in. – 41 Nm (30 ft-lb)	½ in. – 41 Nm (30 ft-lb)
[6579.*]	Socket Head Cap screws – All locations	½ in. – 54 Nm (40 ft-lb)	½ in. – 54 Nm (40 ft-lb)	½ in. – 54 Nm (40 ft-lb)

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 balancing instruction may be found in section 6.8.

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

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

CAUTION 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.

CAUTION Do not attempt to tighten or loosen 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.

6.6.1 Impeller installation

The impeller is threaded to the shaft in a clockwise direction (right hand threads). Apply a coat of grease or anti-seize to the threads to allow for ease of disassembly in the future. Install a new impeller gasket [4590.2].

Using a strap wrench to hold the drive coupling, screw impeller [2200] onto the end of the pump shaft [2100] clockwise until snugly fit. A second strap wrench may be utilized to fully tighten the impeller and compress the impeller gasket [4590.2]. The gasket must be fully compressed to ensure an accurate and stable impeller setting.

If available, an impeller wrench may be utilized to tighten the impeller. Using the shaft key [6700.2], mount the impeller wrench to the end of the shaft. The impeller wrench is placed on the shaft at the coupling end with a key. With the impeller wrench in place, grasp the impeller in both hands (wear heavy gloves] and, with the impeller wrench handle to the left (viewed from the impeller end of the shaft) spin the impeller forcefully in a clockwise direction to impact the impeller wrench handle on the work surface to the right.

6.6.2 Impeller Removal

Remove the impeller [2200] by unscrewing it counter-clockwise (looking in at the vanes).

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

While holding the drive coupling with a strap wrench, unscrew the impeller. Do not attempt to use a crowbar as a lever to unscrew the impeller as damage to the vanes may result. Use a strap wrench or a piece of wood as a mallet. Discard the impeller gasket [4590.2]

If available, an impeller wrench may be utilized to loosen the impeller. Using the shaft key [6700.2], mount the impeller wrench 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].

6.6.3 Impeller Setting

Several types of impellers are available for the ESP3 product. Reverse vane and Recessed impellers are set off the rear cover. Open impellers and Lo-Flo impellers are set off the casing. Impeller setting is performed by adjusting the impeller to the correct surface as described above and then adjusting it to the correct gap. For services above 82 ℃ (180 ℉) add another two combinations of shaft keyway/sleeve slots to the values listed.

6.6.3.1 Reverse vane and Recessed impeller setting

a) Rotate the shaft [2100] so that the impeller adjustment key [6700.3] is toward you.
b) Remove the retaining ring [2530.2] and key [6700.3] from the adjusting sleeve [3400].
c) Holding the shaft [2100] steady, turn the adjusting sleeve [3400] clockwise until the impeller [2200] is resting against the running face of the cover [1220].

d) Back the impeller [2200] off the cover [1220] by rotating the adjusting sleeve [3400] counterclockwise so that the next slot lines up with one of the shaft keyways:
e) **For GP1 and 2 Pumps**, continue to rotate the sleeve [3400] in the same direction for an additional four or five combinations of shaft keyway/sleeve slots (22.5 degrees each - the keyway that lines up will alternate as the sleeve [3400] is turned).
For GP3 Pumps continue to rotate the sleeve [3400] in the same direction for another five or six combinations of shaft keyway/sleeve slots (22.5 degrees each - the keyway that lines up will alternate as the sleeve [3400] is turned)
f) Install the impeller adjustment key [6700.3] and retaining ring [2530.2] back into position.
g) Check for freedom of shaft [2100] rotation by turning by hand.

Note: As the reverse vane and Recessed Impellers are set from the read cover, these settings can be made in the shop. If setting is being performed in the shop, less casing, it is advisable to leave out the impeller gasket [4590.2] during impeller setting. This will ensure that the impeller is fully seated and will not tighten further in operation. The impeller gasket must be installed before the casing is installed.

6.6.3.2 Open and Lo-Flo impeller setting

a) Rotate the shaft [2100] so that the impeller adjustment key [6700.3] is toward you.
b) Remove the retaining ring [2530.2] and key [6700.3] from the adjusting sleeve [3400].
c) Holding the shaft [2100] steady, turn the adjusting sleeve [3400] counterclockwise until the impeller [2200] is resting against the running face of the casing [1100].
d) Back the impeller [2200] off the casing [1100] by rotating the adjusting sleeve [3400] clockwise so that the next slot lines up with one of the shaft keyways:
e) **For GP1 and 2 Pumps**, continue to rotate the sleeve [3400] in the same direction for an additional four or five combinations of shaft keyway/sleeve slots (22.5 degrees each - the keyway that lines up will alternate as the sleeve [3400] is turned).
For GP3 Pumps continue to rotate the sleeve [3400] in the same direction for another five or six combinations of shaft keyway/sleeve slots (22.5 degrees each - the keyway that lines up will alternate as the sleeve [3400] is turned)
f) Install the impeller adjustment key [6700.3] and retaining ring [2530.2] back into position.
g) Check for freedom of shaft [2100] rotation by turning by hand.

6.7 Disassembly

Use extreme care in removing and dismantling pump. Refer to pump assembly drawings for part nomenclature (see Section 8).

Lock out power to driver to prevent personal injury.

If Flowserve ESP3 pumps contain dangerous chemicals, it is important to follow plant safety guidelines to avoid personal injury or death.

6.7.1 Removing pump from pit

a) Close control valve in discharge line.
b) Lock out power supply to driver.
c) Disconnect all electrical connections.
d) Close all valves on auxiliary equipment and piping then disconnect all auxiliary piping.
e) Disconnect discharge piping from pump.
f) Remove coupling guard [7450.1-.2] and coupling halves [7200].
g) Disconnect driver [8000] and remove.
h) Unbolt pump mounting plate [6130] and lift pump (see Sections 2.3 and 4.4) from pit. Let the pump drain thoroughly before removing pump completely. Remove casing drain [6515.1], if supplied.
i) Remove liquid level controls (if any).
j) Lift the pump (see Sections 2.3 and 4.4) out of the pit and lay pump horizontally on supports.

CAUTION For units that are welded, the welded sections should not be disassembled unless the parts need to be replaced.

6.7.2 Pump disassembly

a) Pump discharge pipe removal

- ***Discharge pipes four inches and less***: Unscrew the flange [1245.2], locknut [3400], and loosen the lower locknut. Then the upper discharge pipe [1360] can be unscrewed.
Discharge pipes greater than four inches: Unscrew the flange [1245.2]. These pumps are furnished with the discharge pipe bolted to the mounting plate [6130] by a flange [1245.3] and four screws [6570.11]. Remove the screws holding the flange to the mounting plate [6130].
- The discharge pipe [1360] can then be removed by unbolting the elbow [1371] from the discharge of the casing [1100) and pulling the discharge pipe out from the underside of the mounting plate [6130].

b) Remove bearing lubrication lines [3840.1].
c) Unbolt and remove the pump casing [1100].
CAUTION The cove plate [1220] may only be held in place by the casing and could fall when the casing is removed.
If applicable, remove the two cap screws [6570.16] which attach the rear cover [1220] to the adapter. Carefully remove this part. The strainer [6531] does not need to be removed from the casing unless it is to be cleaned or replaced.
d) Remove the impeller [2200] by unscrewing it counterclockwise. See section 6.6.2 for instructions.

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

e) Remove the shaft sleeve [2400]
f) Remove the support head [3160].
Pumps without Vapor Proof or Pressurized Construction
For groups 1 and 2 the support head will be disconnected from the mounting plate [6130].
For group 3 the support head will be disconnected from the upper column [1341.1].
CAUTION For Group 3 pumps, any columns still attached to the pump at this time must be firmly supported. The upper column will disconnect from the mounting plate at the same time that the support head is disconnected.
Pumps with Vapor Proof or Pressurized Construction:
remove the support head [3160] from the bearing bracket [4310.2]
g) Remove coupling hub.
h) Pumps with Vapor Proof or Pressurized Construction:
If a cartridge type mechanical seal [4200] is used, the spacing clips or tabs should be installed prior to loosening the setscrews which attaches the seal to the shaft. This will ensure that the proper seal compression is maintained. It will also help prevent damage to the seal in the following steps.
i) Unbolt and remove the bearing body [3110]
j) Remove the retaining ring [2530.2] and key [6700.3] from the adjusting sleeve [3400].
k) Holding the shaft [2100] steady, turn the adjusting sleeve [3400] counterclockwise to remove the assembly from the shaft
l) Remove the bearing bracket [4310.2] for pump with Vapor Proof or Pressurized Construction only.
For groups 1 and 2 the bearing bracket will be disconnected from the mounting plate [6130]
For group 3 the bearing bracket will be disconnected from the upper column [1341.1].

CAUTION For Group 3 pumps, any columns still attached to the pump at this time must be firmly supported. The upper column will disconnect from the mounting plate at the same time that the bearing bracket is disconnected.

CAUTION Before the next procedure, be sure to cover the shaft threads with a Teflon tape for protection when sliding parts off the shaft to prevent the shaft threads from being damaged or causing damage to other parts.

m) Pumps with Vapor Proof or Pressurized Construction only.
Unbolt the gland [4120.1 or 4120.3] and carefully slide it off the end of the shaft. If the pump contains a seal, VERY CAREFULLY, slide the seal off of the shaft. Remove all seal components and discard all O-rings and gaskets. If the pump contains packing remove the packing at this time.
n) Now the stuffing box [4110] can be unbolted and removed gently from the shaft.
o) A shaft-nose cone (See Figure 6-3) is recommended, but not required, for the next step. If a shaft nose cone is to be used, attach the cone in place of the impeller [2200]. Remove the shaft [2100] from the remainder of the pump.

Figure 6-3 Shaft Nose Cones

Description	Dwg #	PCN
GP1 Shaft	BY60723A	75658104
GP2 Shaft	BY60724A	75658112
GP3-13" (2 piece)	BY60901A	75658120
GP3	BY60725A	75658138

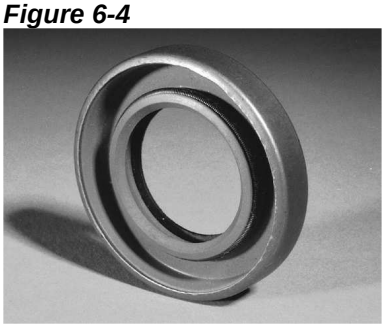
CAUTION Always remove the shaft by pulling it out through the mounting plate end as shaft threads may cause damage to the line shaft bearings if pulled through the casing end.

p) Unbolt and remove the adapter [1340.1].
q) Unbolt and remove the intermediate columns [1341.2] and the bearing holders [3250] until the upper column is reached [1341.1].
r) The shaft bearings should not be removed from their housings unless they are to be replaced. Figure 6.6 shows a listing of allowable bearing tolerances. If these tolerances are exceeded, either the bearings [3020.1-.2], shaft [2100], or bearing holder [3250] should be replaced.
s) Intermediate shaft bearings [3020.1] can be pressed or driven out of their bearing holder [3250] when replacing.
t) The adapter bearing [3020.2] may be removed by pressing or driving the bearing sleeve from the upper flange (column side) out through the lower end (casing side) of the adapter [1340.1].
u) Removal of bearings [3031] from adjusting sleeve [3400]. Remove snap ring [2530.2]. An arbor or hydraulic press may be used to remove the bearings from the adjusting sleeve. 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.

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

x) If lip seals [4310.1] and [4310.2] (see figure 6-4) are used, they should be removed and discarded.

Figure 6-4



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 must 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.

a) Inspect impeller [2200] for excessive wear and etching due to corrosion. Large nicks and deep pits will unbalance the impeller, cause vibration, and wear in other parts of the pump. Be sure the O-ring [4590.2] sealing surface and impeller threads are clean.
b) Check pump shaft [2100] for straightness.
c) Inspect the surface of the shaft in the bearing [3020.1-.2] areas to make sure it is smooth. It must be free of grooves, scratches, corrosion or wear.
d) Check ends of shaft for burrs. Make sure that shaft threads are clean.
e) Inspect the casing [1100] thoroughly, removing all burrs and foreign matter. Check hydraulic passages for cleanliness.
f) Check all other parts for burrs, wear, damage or corrosion.
g) Use a dial indicator to check the straightness of the shaft extension of the driver and check indicator readings against the values given in Figure 6-6. Should any of these limits be exceeded, check with the driver manufacturer for recommended repair or replacement parts.

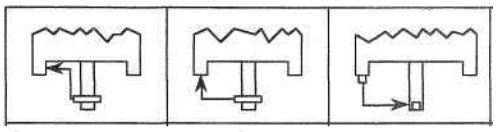


Figure 6-5 Motor tolerances

A	B	C

T.I.R. Dimensions -- mm (in.)

Frame Size	A	B	C
143-256TCV	0.10 (0.004)	0.10 (0.004)	0.05 (0.002)
284-286TSCV	0.10 (0.004)	0.10 (0.004)	0.08 (0.003)
324-445TSCV	0.18 (0.007)	0.18 (0.007)	0.08 (0.003)

h) Inspect inside of bearings [3020.1-.2] in the adapter [1340.1] and intermediate bearing holder(s) [3250]. Check for cracks, uneven or excessive wear, scoring or heat discoloration, and corrosion. Bearings should be replaced as described in Section 6.7.2.

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 6-6 whenever pump maintenance is performed. Each of these measurements is described in more detail on the following pages.

6.8.3.1 Shaft
Replace if grooved, pitted or worn, especially where the shaft rides in the sleeve bearings.

6.8.3.2 Bearings
It is recommended that rolling element bearings not be used after removal from the shaft.

6.8.3.3 Impeller balancing
To minimize shaft whip it is imperative that the impeller is balanced. All impellers manufactured by Flowserve are balanced after they are trimmed. If for any reason, a customer trims an impeller, it must be re-balanced.

The maximum values of acceptable unbalance are:

- Up to 1800 rpm: 40 g·mm/kg (0.021 oz-in/lb)
- Above1800 rpm: 20 g·mm/kg (0.011 oz-in/lb)

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.

6.8.3.4 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 strongly urges customers to work with an equipment supplier or consultant to establish an on-going vibration analysis program.

Figure 6-6 Line shaft bearing and bearing holder wear limits

Ref. Number	Description	Max. Inside Diameter	Min. Outside Diameter*
2100	Group 1 Shaft		28.42 mm (1.119 in.)
	Group 2 Shaft		37.95 mm (1.494 in.)
	Group 3 Shaft		53.82 mm (2.119 in.)
3020.1/3020.2	Group 1 Line Shaft Bearings		
	Carbon	28.994 mm (1.1415 in.)	
	ARHT	29.096 mm (1.1455 in.)	
	Bronze	28.766 mm (1.1325 in.)	
	Rubber	28.766 mm (1.1325 in.)	
	Teflon	28.956 mm (1.1400 in.)	
	Iron	28.766 mm (1.1325 in.)	
	Group 2 Line Shaft Bearings		
	Carbon	38.583 mm (1.5190 in.)	
	ARHT	38.545 mm (1.5175 in.)	
	Bronze	38.329 mm (1.5090 in.)	
	Rubber	38.329 mm (1.5090 in.)	
	Teflon	38.481 mm (1.5150 in.)	
	Iron	38.329 mm (1.5090 in.)	
	Group 3 Line Shaft Bearings		
	Carbon	54.458 mm (2.1450 in.)	
	ARHT	54.445 mm (2.1455 in.)	
	Bronze	54.204 mm (2.1350 in.)	
	Rubber	54.242 mm (2.1365 in.)	
	Teflon	54.356 mm (2.1410 in.)	
	Iron	54.204 mm (2.1350 in.)	
3250/1340.1	Group 1 Bearing Holder/Adapter	41.288 mm (1.6255 in.)	
	Group 2 Bearing Holder/Adapter	50.787 mm (1.9995 in.)	
	Group 3 Bearing Holder/Adapter	73.114 mm (2.8785 in.)	

****Shaft must not have grooves, nicks, scratches or other discontinuities at the bearing journal locations.***

Figure 6-7 Additional tolerances

Ref. Number	Description	Max. Diameter	Min. Diameter
3400	Adjusting Sleeve O.D. (under ball bearing)		
	Group 1	40.013 mm (1.5753 in.)	40.002 mm (1.5749 in.)
	Group 2	50.013 mm (1.9690 in.)	50.002 mm (1.9686 in.)
	Group 3	65.016 mm (2.5597 in.)	65.004 mm (2.5592 in.)
3110	Bearing Body I.D. (over ball bearing)		
	Group 1	90.04 mm (3.545 in.)	90.02 mm (3.544 in.)
	Group 2	110.03 mm (4.332 in.)	110.01 mm (4.331 in.)
	Group 3	140.03 mm (5.513 in.)	140.00 mm (5.512 in.)

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.

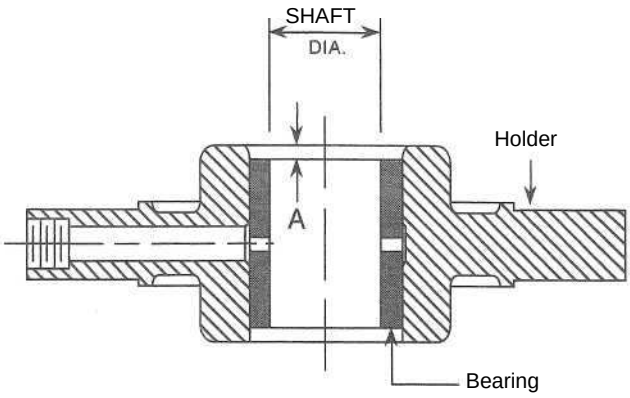
Flowserve has investigated and tested alternate sealants and has identified two that provide an effective seal, have the same chemical resistance as the tape, and will not plug flush systems. These are La-co Slic-Tite and Bakerseal. Both products contain finely ground PTFE particles in an oil-based carrier. 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 Replacing shaft sleeve bearings

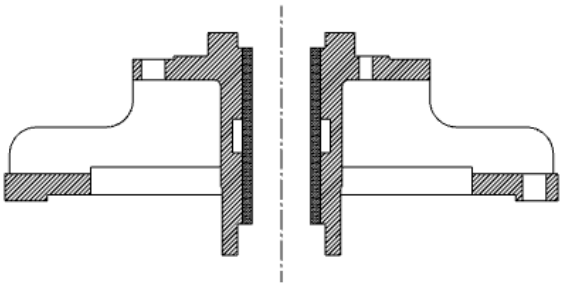
a) After removing the old intermediate bearings [3020.1] (see section 6.7.2) clean and deburr bearing holder bore and lubrication port. Apply a light coating of grease or oil to bearing holder bore and out-side diameter of new bearing. Carefully press new bearing into holder to "A" dimension in
Figure 6-8.
b) After removing the adapter bearing [3020.2] (see section 6.7.2) clean and deburr adapter bore and lubrication port. Apply a light coating of grease or oil to bearing holder bore and outside diameters of new bearings. Carefully press the new bearing into the adapter flush with the counter bore as shown in Figure 6-9.
c) Be sure that all bearings [3020.1-.2] are now within their bearing holders [3250, 1340.1].



Shaft Diameter	A
28.58 mm (1.125 in.)	3.2 mm (.125 in.)
38.10 mm (1.500 in.)	3.2 mm (.125 in.)
53.98 mm (2.125 in.)	3.2 mm (.125 in.)

Figure 6-8 Intermediate bearing

Figure 6-9 Adapter bearing



6.9.2 Assembling mounting plate, column(s), adapter and shaft

If a shaft nose cone is available, the mounting plate, column(s), intermediate bearing(s) and adapter may be assembled prior to shaft insertion. If a nose cone is not available, the pump must be built in section over the shaft. Use of a shaft nose cone is recommended.

a) **Standard and vapor tight construction:** connect the upper column [1341.1] to the mounting plate [6130]. For Group 3, the upper column and support head [3160] must be bolted to the mounting plate at the same time.

Note: In this configuration, the upper column contains a lip seal [4310.2] which is installed with the energizing spring down. Although installation is more difficult, it is beneficial to install the lip seal after shaft installation to prevent damage. Wrap the shaft thread with Teflon tape to protect lip seal from damage.

Vapor proof or pressurized construction: replace the upper column gasket [4590.5] and reconnect the upper column [1341.1] to the mounting plate [6130]. For Group 3, the bearing bracket [4310.2] must be bolted to the mounting plate at the same time.

Assembly with nose cone

b) If intermediate bearings are used, install the bearing holder [3250] and intermediate column [1341.2] and bolt them together. Repeat for each section.
c) Bolt the adapter [1340.1] back onto the last column in the pump.
d) Screw the shaft bullet onto the end of the shaft [2100] at the impeller end.

CAUTION Always insert the shaft from the mounting plate side of the pump. Never insert it from the adapter side because shaft threads may cause damage to the internal bearings.

e) The pump shaft [2100] should now be inserted into the pump from the mounting plate side. Standard and vapor tight construction require a lip seal [4310.2] in the upper column. If the lip seal is installed prior to the shaft, than ensure the lip seal and shaft are lubricated to prevent damage to the lip seal. The lip seal may be installed after the shaft is slid into place, but installation is more difficult (see section a) for details). Fill the cavity between the lips ½ to ⅔full

Assembly without nose cone

CAUTION It is important that the shaft and columns are well supported after the shaft is partially inserted as bending in the shaft may occur.

b) Insert the shaft from the motor side of the pump through the starter column [1341.1] until the shaft threads [for the thrust bearing - 3031] are about 3 inches from the starter column Standard and vapor tight construction require a lip seal [4310.2] in the upper column. If the lip seal is installed prior to the shaft, than ensure the lip seal and shaft are lubricated to prevent damage to the lip seal. The lip seal may be installed at the end of this sequence, but installation is more difficult (see section a) for details).
c) If intermediate bearing(s) are used, slide the bearing holder [3250] onto the end of the shaft [2100], followed by the column [1341.2] and bolt together. Repeat for each section.
d) Slide the adapter [1340.1] onto the shaft [2100] and bolt to the column [1341.1] or [1341.2].

6.9.3 Cover, Impeller and Casing Installation

a) Install the cover [1220] to the adapter [1340.1]. If applicable, hold the cover in place with cap screws [6570.16].
b) Install the impeller. Section 6.6 covers all aspects of impeller installation. Install a new gasket [4590.2], sleeve O-ring [4590.1] and lubricate threads.
c) Place a new gasket [4590.1] on the gasket face of the cover [1220] and bolt the casing [1100] to the adapter [1340.1]

6.9.4 Ball bearing/Adjusting Sleeve Assembly

Mounting of bearings must be done in a clean environment. Thrust bearing 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.

Pump Group Size	GP1 – 1E	GP2 – 2E	GP3 – 3E
Ball Bearing Size	7308	7310	7313

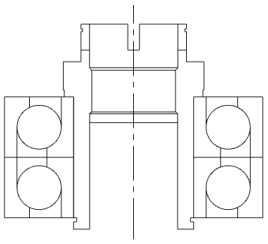
CAUTION Bearings have a slight interference fit which requires that they be pressed on the adjuster with an arbor or hydraulic press. Even force should be applied to only the inner race. Never press on the outer race, as the force will damage the balls and races.

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

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

Duplex angular contact bearings must be mounted face-to-face with the wider thrust sides of the outer races away from each other as shown in figure 6-10. Only bearings designed for universal mounting should be used. The SKF designation is “BEGAM”. NTN’s designation is “BL1G”.

Figure 6-10



a) Press the bearings [3031) onto the adjusting sleeve [3400) as shown in Figure 6-10. If the bearings have been heated for installation, the bearing should be pressed against the shoulder after the bearing has cooled below 38 ℃ (100 ℉).
b) Install snap ring [2530.2].
c) Pack the bearing with grease. See Figure 5-5.

6.9.5 Seal and packing installation (if equipped)

CAUTION Cover the shaft threads with a Teflon tape to prevent them from causing internal damage to other components.

a) Attach the stuffing box [4110] to the upper column [1341.1]. NOTE: Some cartridge (canister) seals are designed to bolt directly to the upper column and will not have a separate stuffing box.
b) Seal component installation
Component Seal that require setting:
Most component seals required setting. The impeller must be set and the shaft marked at box face before seal assembly can take place. The following steps will build the pump to the point the impeller can be set and the shaft marked. The pump must then be disassembled to the point that the seal can be installed and set according to the instruction included with the seal.

Figure 6-11 Typical Inside Component Seal

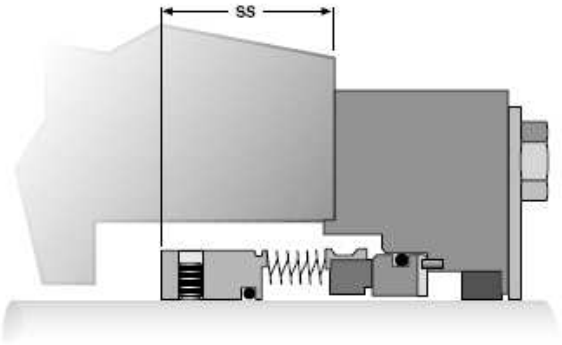
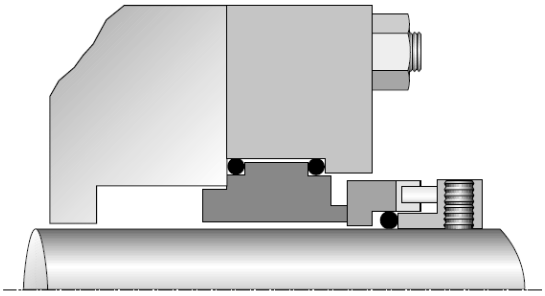
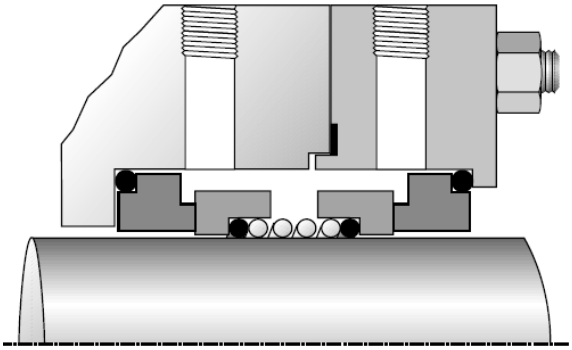


Figure 6-12 Typical Outside Component Seal



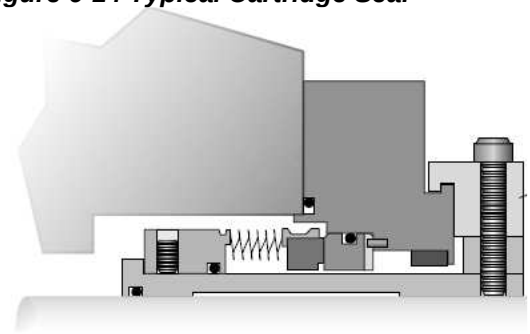
Component Seals that do not require setting:
Most double component seals do not required any settings. The seal may be installed at this point according to the instructions provided with the seal. Care must be taken that the seal rotor is lubricated properly so that it will be able to move on the shaft as the impeller is set in the following steps.

Figure 6-13 Typical Double Component Seal



Cartridge and Gas Canister seal:
CAREFULLY slip the seal [4200] onto the shaft [2100] and slide it down until it sets into the stuffing box [4110] or upper column [1341.1] on with Gas Canister type seals. DO NOT SET THE SEAL AT THIS TIME. Leave the gland nuts slightly loose.

Figure 6-14 Typical Cartridge Seal



Packing:
Install one ring at a time, pushing it well into place. Two rings of packing must be installed, the seal cage, then succeeding rings of packing until the box is filled.
NOTE: The joints of succeeding rings must be staggered. The taped hole in the stuffing box for packing lubrication must line up with the seal cage when the packing is compressed.
After the last ring of packing is in place, draw up the nuts [6580.8] on the gland [4120.1] evenly finger tight. Save additional packing rings as they may become necessary as the packing is tightened during operation.

Figure 6-15

Packing Information

		Group 1	Group 2	Group 3
Packing size, square		7.9 mm (0.31 in.)	7.9 mm (0.31 in.)	9.5 mm (0.38 in.)
Packing arrangement		2-C-3	2-C-3	2-C-3
Seal Cage width		12.7 mm (0.50 in.)	19.0 mm (0.75 in.)	12.7 mm (0.50 in.)
Shaft Diameter	Max.	28.58 mm (1.125 in.)	38.10 mm (1.500 in.)	47.63 mm (1.875 in.)
	Min,	28.52 mm (1.123 in.)	38.05 mm (1.498 in.)	47.57 mm (1.873 in.)

c) **GP1 and 2 Pumps:**
The lower lip seal [4310.2] should be installed with the spring down into the bearing bracket [3130]. Fill the cavity between the lips ½ to ⅔ full with bearing grease. Install the bearing bracket [3130] to the mounting plate [6130]
GP3 Pumps:
The bearing bracket [3130] has already been installed. The lower lip seal [4310.2] should be installed with the spring down into the bearing adapter plate [1340.4]. Fill the cavity between the lips ½ to ⅔ full with bearing grease. Install the bearing adapter plate [1340.4] onto the top of the bearing bracket [3130]. Temporarily hold the adapter bracket in place with cap screws.

d) Install bearing/adjusting sleeve assembly. Screw the adjusting sleeve [3400] to the shaft

e) Install O-ring [4590.2] and the bearing body [3110]. Secure with cap screws [6570.9].
The bearing body contains lip seal [4310.1]. The seal is installed with the spring down. Lubricate the lip seal with grease prior to placing over the shaft. Fill the cavity between the lips ½ to ⅔full.

f) Set the impeller as described in section 6.6.3

g) Set the seal.
Cartridge and Gas Canister seal:
Follow the instructions provided with the seal. Tighten the gland nuts [6580.8]. Tighten the seal sets screws to the shaft. Remove the seal setting clips.
Packing:
Ensure the gland nuts [6580.8] are evenly finger tight and then tighten and additional ¼ turn. Final tightness is set via leakage. A slight amount of leakage through the gland [4120.1] is necessary for proper lubrication. Packing glands must never be tightened to the point

where leakage from the packing is stopped.
Component seals that do not required setting:
Tighten the gland nuts [6580.8]

h) **Components seals that required setting:**
The following steps are only necessary for these types of seals.
- Put bluing on the shaft and mark the shaft at the face of the gland [4120.3]. This mark is used as a reference for setting the seal.
- Remove the bearing body installed in step e).
- Remove the adjusting sleeve installed [3400] in step d).
- Remove the bearing bracket [3130] or adapter bracket installed in step c).
- Install and set the seal according the instruction provided with the seal. Inside component seal may prove difficult to set. If necessary, remove the casing and impeller so that the shaft may be moved to allow access for setting the seal.
- Repeat steps c), d) and e).

CAUTION **Seals must never be run without lubrication. Abrasive lubrication will greatly reduce seal life.**
A variety of seal piping plans designed to suit certain pumping conditions and liquids are available.

6.9.6 Installation of ball bearings and housing
The following steps have previously been performed for pumps with seals.
a) Install bearing/adjusting sleeve assembly. Screw the adjusting sleeve [3400] to the shaft
b) Install O-ring [4610.2] and the bearing body [3110]. Secure with cap screws [6570.9]. The bearing body contains lip seal [4310.1]. The lip seal is installed with the spring down. Lubricate the lip seal with grease prior to placing over the shaft. Fill the cavity between the lips ½ to ⅔full.
c) Set the impeller as described in section 6.6.3

6.9.7 Installation of motor support head
GP1 and 2 Pumps:
For pumps without seals, attach the support head [3160] to the upper column [1341.1] with cap screws [6579.2].
For pumps with seals, attach the support head [3160] to the bearing bracket [4310.2] with cap screws [6579.4]
GP3 Pumps:
For pumps without seals, the support head has already been installed.
For pumps with seals, remove the cap screws temporarily holding the bearing adapter plate [1340.4] in place. Attach the support head to the adapter bracket with cap screws.

6.9.8 Discharge piping
a) If the strainer [6531] had been removed for cleaning or replacement purposes, reattach strainer to suction flange of the casing.
b) Reconnect all bearing lubrication lines [3840.1].
c) **For Groups 1, 2, and 6x4-13:** At this point the lower locknut [3400] should be screwed all the way down the threads on the upper end of the discharge pipe [1360]. The discharge elbow [1371] should be screwed onto the lower end of the discharge pipe (if not already). Check to see if the companion flange [1245.1] is still connected to the discharge elbow. Next, the discharge pipe should be slid up through the mounting plate [6130] until the companion flange lines up with the discharge flange of the casing [1100].

Note: To ensure a proper seal at the casing discharge flange, it is important that the companion flange is connected to the casing before the upper locknuts are tightened to against the mounting plate.

d) Replace the gasket [4590.2] between the companion flange and the discharge flange of the casing and bolt back together.
e) The upper locknut [6580.8] can now be screwed onto the threads at the upper end of the discharge pipe and both locknuts can be tightened against the mounting plate.
f) **For Group 3 (excluding 6x4x13):** The discharge pipe is attached the same way to the casing discharge flange (see step “f” above). The only difference in the assembly is that the Group 3 pipes have a flange [1245.3] welded to the discharge pipe [1360] that bolts to the underside of the mounting plate [6130].

6.9.9 Final Assembly
- Ensure ball bearing, line shaft bearings, and seal lubrication lines are installed
- Grease the thrust bearing [3031] with initial lube quantity found in figure 5-5.
- Follow the installation instruction in section 4.
- Follow the instruction found in section 5.
- Ensure all guards are in place.

7 FAULTS; CAUSES AND REMEDIES

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

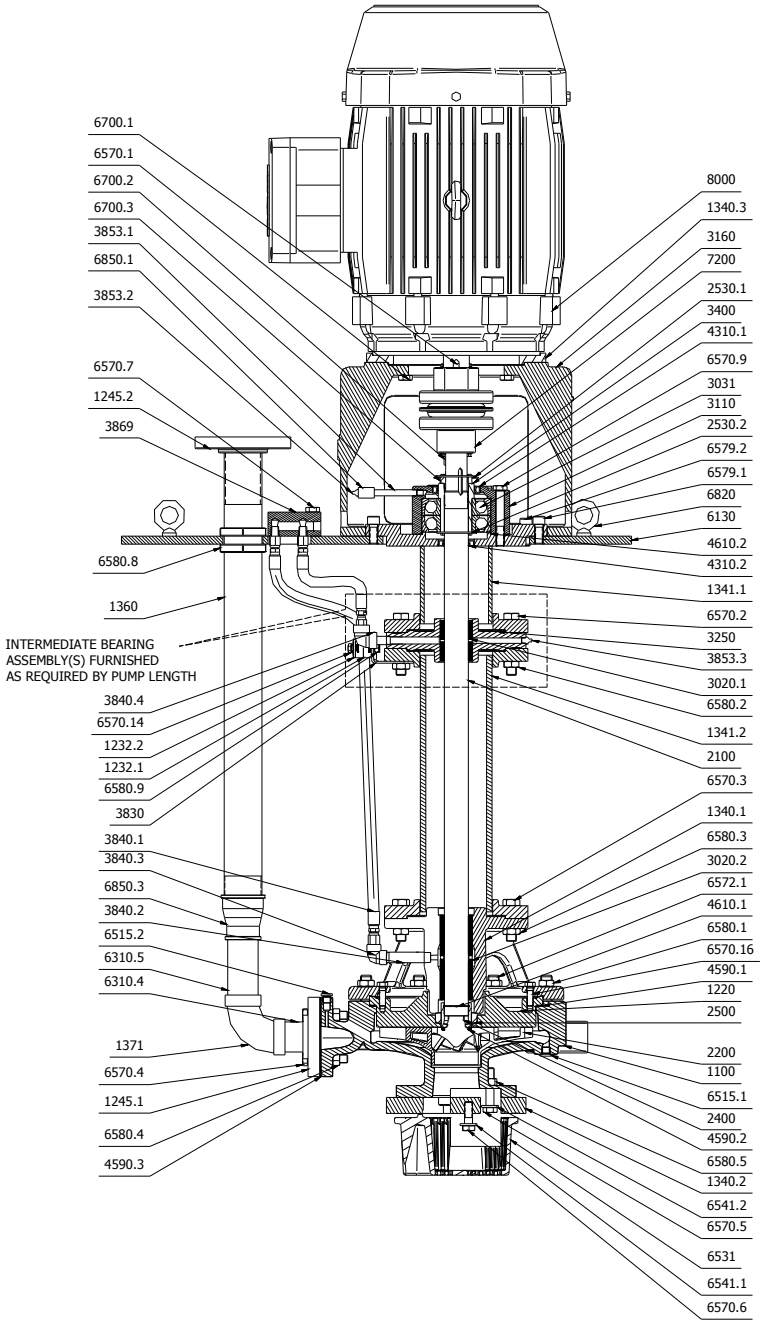
FAULT SYMPTOM

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 thrust bearing end	Pump uses too much power				**PROBABLE CAUSES**	**POSSIBLE REMEDIES**
●	●		●	●						Insufficient NPSH. (Noise may not be present.)	Recalculate NPSH available. It must be greater than the NPSH required by pump at desired flow. Increase low liquid level in the sump, lengthen pump or lower fluid temperature to increase the NPSHa.
●	●	●								System head greater than anticipated.	Reduce system head by increasing pipe size and/or reducing number of fittings. Increase impeller diameter. (Note: Increasing impeller diameter may require use of a larger motor.)
●	●		●							Entrained air. Air leak from atmosphere on suction side.	1. Check for air entrainment sources in the sump. 2. If vortex formation is observed in suction tank, install a vortex breaker. 3. Check for minimum submergence.
●	●									Entrained gas from process.	Process generated gases may require larger pumps.
●	●									Speed too low.	Check motor speed against design speed.
●	●	●				●				Direction of rotation wrong.	After confirming wrong rotation, reverse any two of three leads on a three phase motor. The pump should be disassembled and inspected before it is restarted.
●	●									Impeller too small.	Replace with proper diameter impeller. (NOTE: Increasing impeller diameter may require use of a larger motor.)
●	●									Impeller clearance too large.	Reset impeller clearance.
●	●	●								Plugged impeller, strainer or casing which may be due to a product or large solids.	1. Reduce length of fiber when possible. 2. Reduce solids in the process fluid when possible. 3. Consider larger pump. 4. Clean strainer.
●	●									Wet end parts (casing or impeller) worn, corroded or missing.	Replace part or parts.
●	●	●	●	●						Liquid level in sump too low.	If pump and bearing system has run dry for a long period, disassemble and inspect the pump before operation.
				●		●				Impeller rubbing.	1. Check and reset impeller clearance. 2. Check outboard bearing assembly for axial endplay. 2. Rapid temperature changes; increase impeller clearance.
	●	●								Damaged pump shaft, impeller.	Replace damaged parts.
●	●		●	●						Liquid vortexing in sump.	Add sump vortex breakers to avoid adverse fluid rotation as it approaches the impeller. Consult ANSI/HI 2.3.5
					●					Bearing contamination appearing on the raceways as scoring, pitting, scratching or rusting caused by adverse environment and entrance of abrasive contaminants from atmosphere.	1. Work with clean tools in clean surroundings. 2. Remove all outside dirt from housing before exposing bearings. 3. Use clean solvent and flushing oil. 4. Protect disassembled bearing from dirt and moisture. 5. Clean inside of bearing body before replacing bearing. 6. Check lip seals and replace as required. 7. Check all plugs and tapped openings for tightness.
						●				Speed too high.	Adjust VFD or install proper speed motor.

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 thrust bearing end ⇓ Pump uses too much power ⇓ ⇓ ⇓ ⇓										
									PROBABLE CAUSES	**POSSIBLE REMEDIES**
						●			Too much flow.	System resistance to flow is too low. Close discharge valve more. Reduce impeller diameter.
					●				Brinelling of bearing identified by indentation on the ball races, usually caused by incorrectly applied forces in assembling the bearing or by shock loading such as hitting the bearing or drive shaft with a hammer.	When mounting the bearing on the drive shaft use a proper size ring and apply the pressure against the inner ring only. Be sure when mounting a bearing to apply the mounting pressure slowly and evenly.
					●				False brinelling of bearing identified again by either axial or circumferential indentations usually caused by vibration of the balls between the races in a stationary bearing.	1. Correct the source of vibration. 2. In units that may be out of service for extended periods, the drive shaft should be turned over periodically to relubricate all bearing surfaces at intervals of one to three months.
					●				Thrust overload on bearing identified by flaking ball path on one side of the outer race or in the case of maximum capacity bearings, may appear as a spalling of the races in the vicinity of the loading slot. These thrust failures are caused by improper mounting of the bearing or excessive thrust loads.	Follow correct mounting procedures for bearings.
					●				Misalignment identified by fracture of ball retainer or a wide ball path on the inner race and a narrower cocked ball path on the outer race. Misalignment is caused by poor mounting practices or defective drive shaft. For example, bearing not square with the centerline or possibly a bent shaft due to improper handling.	Handle parts carefully and follow recommended mounting procedures. Check all parts for proper fit and alignment.
					●				Bearing damaged by electric arcing identified as electro- etching of both inner and outer ring as a pitting or cratering. Electrical arcing is caused by a static electrical charge emanating from belt drives, electrical leakage or short-circuiting.	1. Where current shunting through the bearing cannot be corrected, a shunt in the form of a slip ring assembly should be incorporated. 2. Check all wiring, insulation and rotor windings to be sure that they are sound and all connections are properly made. 3. Where pumps are belt driven, consider the elimination of static charges by proper grounding or consider belt material that is less generative.
					●				Bearing damage due to improper lubrication, identified by one or more of the following: 1. Abnormal bearing temperature rise. 2. A stiff cracked grease appearance. 3. A brown or bluish discoloration of the bearing races.	1. Be sure the lubricant is clean. 2. Be sure proper amount of lubricant is used. 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. Be sure the proper grade of lubricant is used.
						●			Liquid has higher viscosity or specific gravity than thought.	Analyze fluid being pumped and adjust it or pump driver.
						●			Binding in the pump or driver.	1. Clean column mating surfaces. 2. Pump shaft bent and binding in sleeve bearings.

8 PARTS LIST AND DRAWINGS

Figure 8-1: Group 1&2 sectional



PARTS LIST	
EUROPUMP_REF_NO	DESCRIPTION
1100	CASING
1220	COVER
1232.1	CLAMP - LUBE PIPING
1232.2	COVER PLATE - CLAMP
1245.1	FLANGE - COMPANION
1245.2	FLANGE - DISCHARGE
1340.1	ADAPTOR
1340.2	ADAPTOR - STRAINER
1340.3	ADAPTOR - MOTOR
1341.1	COLUMN - UPPER
1341.2	COLUMN - INTERMEDIATE
1360	PIPE - DISCHARGE
1371	ELBOW - DISCHARGE
2100	SHAFT
2200	IMPELLER
2400	SLEEVE
2500	THROTTLE BUSHING
2530.1	SNAP RING
2530.2	RETAINING RING
3020.1	BEARING - INTERMEDIATE
3020.2	BEARING - BOTTOM
3031	BEARING - THRUST
3110	BEARING BODY
3160	SUPPORT HEAD
3250	HOLDER - BEARING
3400	SLEEVE - ADJUSTING
3830	BRACKET - LUBE PIPING
3840.1	HOSE KIT - LUBE PIPING
3840.2	PIPE NIPPLE - LUBE LINE
3840.3	ELBOW - LUBE PIPING
3840.4	ELBOW - LUBE PIPING
3853.1	NIPPLE - PIPE
3853.2	FITTING GREASE (THRUST BRG)
3853.3	FITTING GREASE (BRG. HOUSING + ADAPTOR)
3869	MANIFOLD - LUBE PIPING
4310.1	LIP SEAL - UPPER
4310.2	LIP SEAL - LOWER
4590.1	GASKET - CASING
4590.2	GASKET - IMPELLER
4590.3	GASKET - DISCHARGE PIPE
4610.1	O-RING - SLEEVE
4610.2	O-RING - BEARING BODY
6130	MOUNTING PLATE
6310.4	NIPPLE - COMPANION
6310.5	NIPPLE - DISCHARGE
6515.1	PLUG - CASING DRAIN
6515.2	PLUG - CASING DISCHARGE
6531	STRAINER
6541.1	WASHER - STRAINER TO ADAPTOR
6541.2	WASHER - ADAPTER TO CASING
6570.1	CAP SCREW - SUPP HD TO MTR
6570.14	CAP SCREW - CLAMP
6570.16	CAP SCREW - TOKEN BOLTS
6570.17	CAP SCREW - COUPL.GUARD (NOT SHOWN)
6570.2	CAP SCREW - INTER. BRG
6570.3	CAP SCREW - COL. TO ADAPTOR
6570.4	CAP SCREW - DISCHARGE
6570.5	CAP SCREW - STNR. ADAPT. TO CASING
6570.6	CAP SCREW - STNR. TO ADAPTOR
6570.7	CAP SCREW - MANIFOLD. TO MTG PLT
6570.9	CAP SCREW - BRG BODY TO COL.
6572.1	STUD - CASING
6579.1	CAP SCREW - COL. TO MTG. PLT.
6579.2	CAP SCREW - SUPP HD TO MTG. PLT.
6580.1	NUT - HEX CASING STUD
6580.12	NUT - COUPLING GUARD (NOT SHOWN)
6580.2	NUT - HEX INTER. BRG
6580.3	NUT - COL. TO ADAPT.
6580.4	NUT - HEX CASING DISCHARGE
6580.5	NUT - HEX ADAPT. TO CASING
6580.8	LOCKNUT - PIPE
6580.9	NUT - HEX CLAMP
6700.1	KEY - DRIVER SHAFT
6700.2	KEY - PUMP SHAFT
6700.3	GIB KEY
6820	LIFTING EYE
6850.1	COUPLING - GREASE
6850.3	COUPLING - REDUCING
7200	COUPLING - FLEXIBLE
7450.1 & 7450.2	COUPLING GUARD (NOT SHOWN)
8000	DRIVER

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Figure 8-2: Group 3 sectional

Ref. No.	Old P/N	DESCRIPTION
1340.1	0014	ADAPTOR
1232.1	0440	CLAMP -- LUBE PIPING
7200	0561	COUPLING -- FLEXIBLE
1232.2	1220	COVER PLATE -- CLAMP
8000	0743	DRIVER
1371	0767	ELBOW -- DISCHARGE
6700.1	11A9A	KEY -- DIRVER SHAFT
6700.2	11A9B	KEY -- PUMP SHAFT
6541.1	12A5	WASHER -- STRAINER
1245.3	12A8	FLANGE -- DISCHARGE PIPE
4590.2	4590.2	O-RING -- IMPELLER
3031	3031	BEAIRNG -- THRUST
6515.1	30A7A	PLUG -- CASING DRAIN
6515.2	30A7B	PLUG -- CAISNG DISCHARGE
4590.2	32A11	GASKET -- CASING DISCHARGE
6570.1	35A2A	CAP SCREW -- SUPP HD TO MTR
6570.2	35A2B	CAP SCREW -- INTER. BRG
6570.3	35A2C	CAP SCREW -- COL. TO ADAPTOR
6570.4	35A2D	CAP SCREW -- DISCHARGE
6570.6	35A2F	CAP SCREW -- STNR. TO ADAPTOR
6570.7	35A2G	CAP SCREW -- MFLD. TO MTG PLT
6570.9	35A2J	CAP SCREW -- BRG BODY TO COL.
6570.11	35A2H	CAP SCREW -- FLG. TO MTG PLT
6570.14	35A2P	CAP SCREW -- CLAMP
6580.1	38A4A	NUT -- HEX CASING STUD
6580.2	38A4B	NUT -- HEX INTER. BRG
6580.3	38A4C	NUT -- HEX ADAPTOR
6580.4	38A4D	NUT -- HEX CASING DISCHARGE
6580.5	38A4E	NUT -- HEX STRAINER
6580.6	38A4J	NUT -- HEX CLAMP
1245.2	39A8	FLANGE -- DISCHARGE
6572.1	62A3	STUD -- CASING
3840.3	65A7	ELBOW -- LUBE PIPING
3840.4	106A	ELBOW -- LUBE PIPING
6570.12	119A2B	CAP SCREW -- SUPP HD - MTG PLT
2530.1	2530.1	SNAP RING
3853.1	18A7B	NIPPLE -- PIPE
2530.2	181A13	RETAINING RING
3853.2	78A7	COUPING -- PIPE
3853.3	3853.2	FITTING GREASE (THRUST BRG)
3160	1063	SUPPORT HEAD
3840.1	1104	HOSE KIT -- LUBE PIPING
3250	1109	HOLDER -- BEARING
2200	1129	IMPELLER
3869	3869	MANIFOLD -- LUBE PIPING
3830	1296	BRACKET -- LUBE PIPING
1360	1423A	PIPE -- DISCHARGE
3840.2	1423B	PIPE NIPPLE -- LUBE LINE
1340.2	1467	ADAPTOR -- STRAINER
2500	1663	SEALING RING -- ADAPTOR
3400	3400	SLEEVE -- ADJUSTING
6130	6130	MOUNTING PLATE
1100	2469	CASING
1341.1	2507A	COLUMN -- UPPER
1341.2	2507B	COLUMN -- INTERMEDIATE
4590.1	2584A	GASKET -- CASING
6700.3	2647	GIB KEY
4310.1	4310.1	LIP SEAL -- UPPER
4310.2	4310.2	LIP SEAL -- LOWER
2100	2807	SHAFT
6531	2845	STRAINER
6541.3	2888	IMPELLER WASHER
3020.1	2945A	BEARING -- INTERMEDIATE
3020.2	2945B	BEARING -- BOTTOM
3110	3110	BEARING BODY
1220	-	COVER (NOT SHOWN)
2400	-	SLEEVE (NOT SHOWN)
2500	-	THROTTLE BUSH. (NOT SHOWN)
4610.1	-	O-RING SLEEVE (NOT SHOWN)
4610.2	-	O-RING BRG. BODY (NOT SHOWN)
6570.16	-	CAP SCREW – TOKEN BOLT (NOT S)
6570.17	-	CAP SCREW – CPL GUARD (NOT SH)
6580.12	-	NUT – CPL GUARD (NOT SHOWN)
6820	-	LIFTING EYE (NOT SHOWN)
7450.1-.2	-	COULING GUARD (NOT SHOWN)

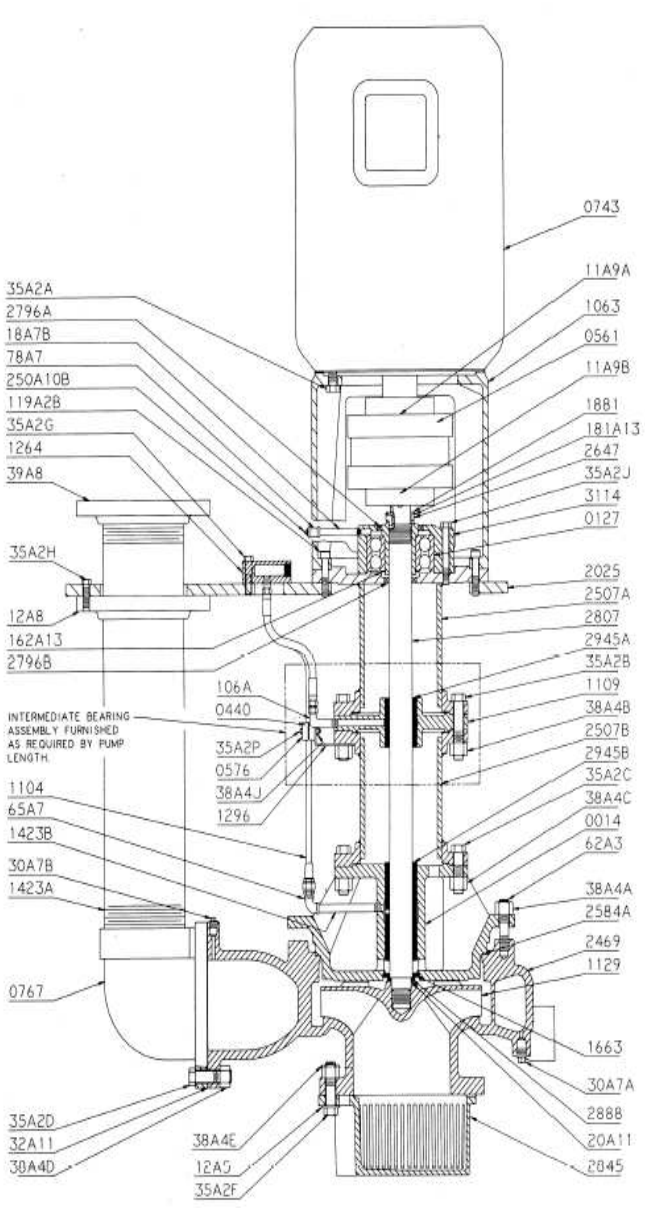
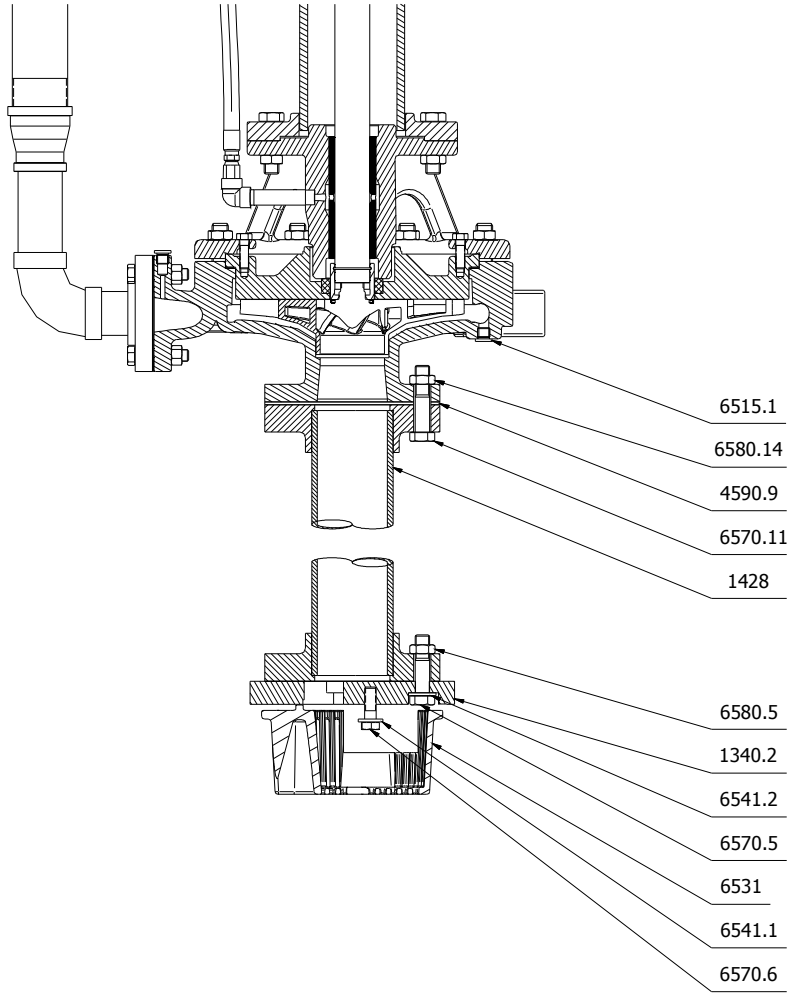


Figure 8-3: Group 1&2 tail pipe assembly



PARTS LIST	
EUROPUMP_REF_NO	DESCRIPTION
1340.1	ADAPTOR
1340.2	ADAPTOR - STRAINER
1428	TAILPIPE
4590.9	GASKET - TAILPIPE
6515.1	PLUG - CASING DRAIN
6531	STRAINER
6541.1	WASHER - STRAINER TO ADAPTOR
6541.2	WASHER - ADAPTER TO CASING
6570.5	CAP SCREW - STNR. ADAPT. TO CASING
6570.6	CAP SCREW - STNR. TO ADAPTOR
6570.11	CAP SCREW - TAILPIPE TO CASING
6580.5	NUT - HEX ADAPT. TO CASING
6580.14	NUT - HEX TAILPIPE TO CASING

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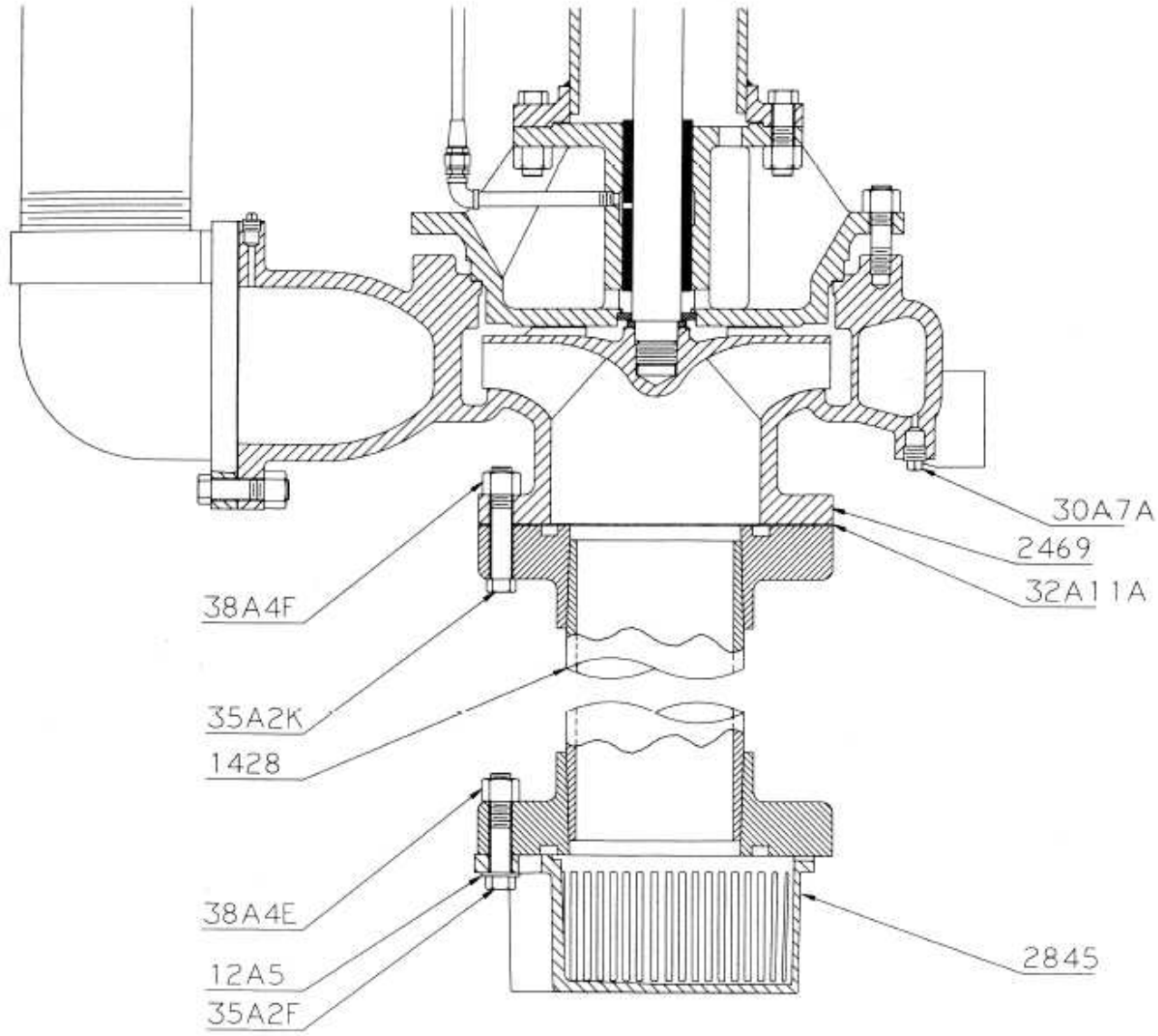
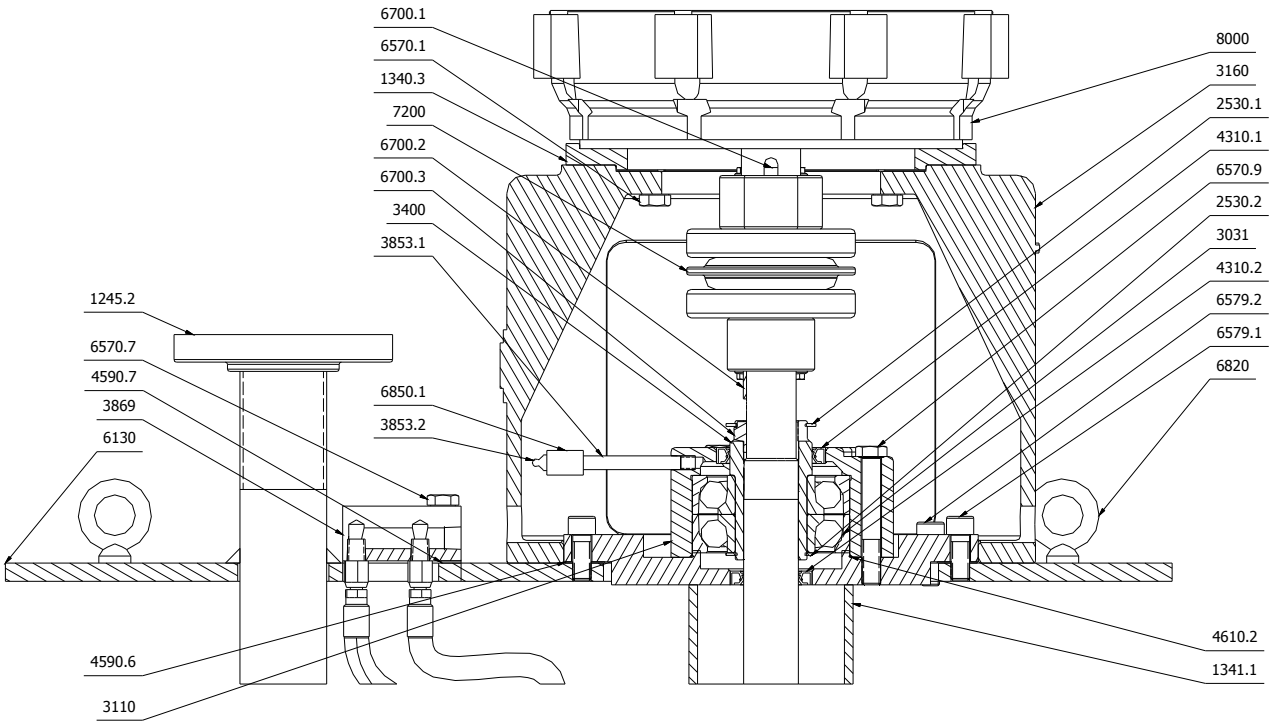
Figure 8-4: Group 3 tail pipe assembly



Ref. No.	Old P/N	DESCRIPTION
6541.1	12A5	WASHER -- STRAINER
6515.1	30A7A	PLUG -- CASING DRAIN
4590.6	32A11A	GASKET -- CASING SUCTION
6570.6	35A2F	CAP SCREW -- STNR. TO ADAPTOR
6570.10	35A2K	CAP SCREW -- CASING TO TAILPIPE
6580.5	38A4E	NUT -- HEX STRAINER
6580.7	38A4F	NUT -- HEX CASING TO TAILPIPE
1341.3	1428	TAIL PIPE ASSEMBLY
1340.2	1467	ADAPTOR -- STRAINER
1100	2469	CASING
6531	2845	STRAINER

Figure 8-5: Vapor-tight construction



PARTS LIST	
EUROPUMP_REF_NO	DESCRIPTION
3110	BEARING BODY
3160	SUPPORT HEAD
3400	SLEEVE - ADJUSTING
3853.1	NIPPLE - PIPE
3853.2	FITTING GREASE (THRUST BRG)
3869	MANIFOLD - LUBE PIPING
4310.1	LIP SEAL - UPPER
4310.2	LIP SEAL - LOWER
4590.6	GASKET - UPPER COL.TO MTG. PL.
4590.7	GASKET - MANIFOLD TO MTG.PL.
4610.2	O-RING - BEARING BODY
6130	MOUNTING PLATE
6570.1	CAP SCREW - SUPP HD TO MTR
6570.17	CAP SCREW - COUPL.GUARD (NOT SHOWN)
6570.7	CAP SCREW - MANIFOLD. TO MTG PLT
6570.9	CAP SCREW - BRG BODY TO COL.
6579.1	CAP SCREW - COL. TO MTG. PLT.
6579.2	CAP SCREW - SUPP HD TO MTG. PLT.
6580.12	NUT - COUPLING GUARD (NOT SHOWN)
6700.1	KEY - DRIVER SHAFT
6700.2	KEY - PUMP SHAFT
6700.3	GIB KEY
6820	LIFTING EYE
6850.1	COUPLING - GREASE
7200	COUPLING - FLEXIBLE
7450.1 & 7450.2	COUPLING GUARD (NOT SHOWN)
8000	DRIVER

PARTS LIST	
EUROPUMP_REF_NO	DESCRIPTION
1245.2	FLANGE - DISCHARGE
1340.3	ADAPTOR - MOTOR
1341.1	COLUMN - UPPER
2530.1	SNAP RING
2530.2	RETAINING RING
3031	BEARING - THRUST

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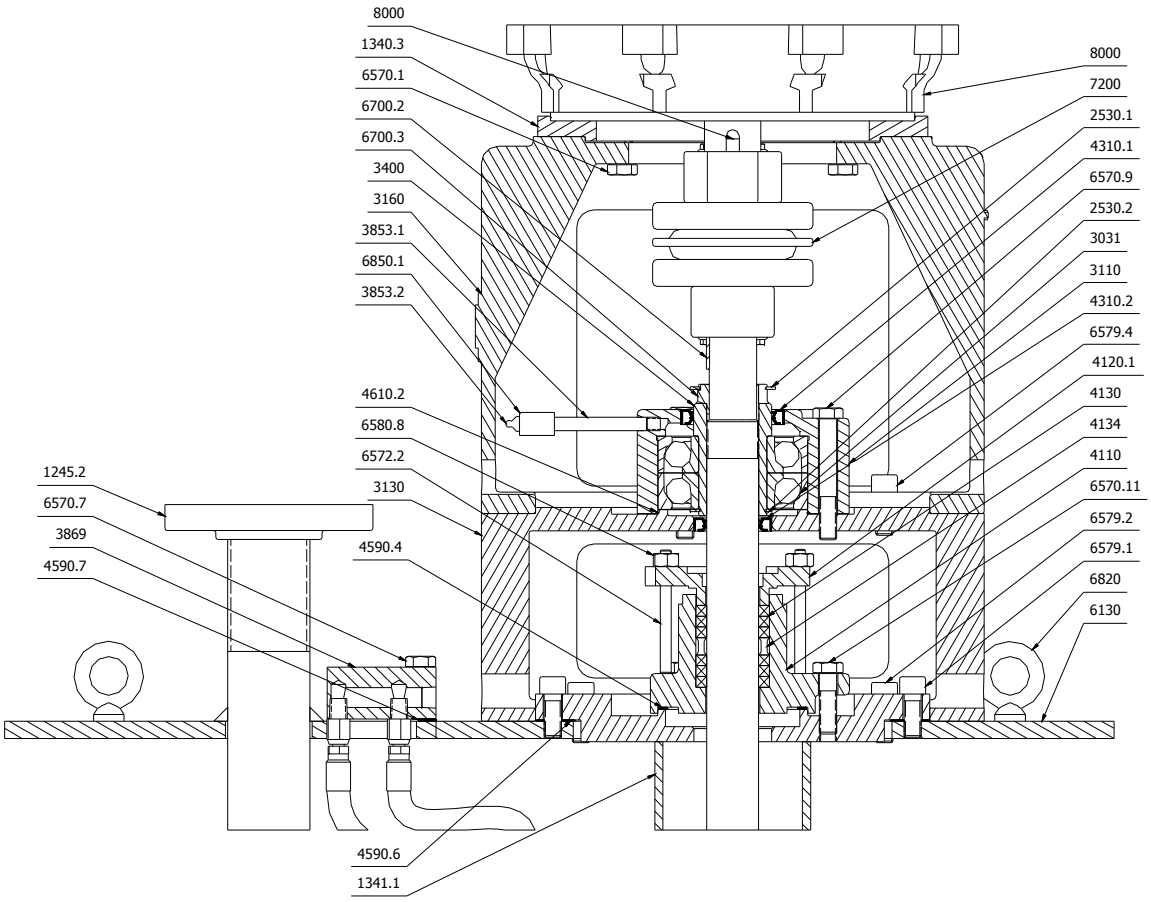
Figure 8-6: Vapor-proof construction



PARTS LIST	
EUROPUMP_REF_NO	DESCRIPTION
4310.1	LIP SEAL - UPPER
4310.2	LIP SEAL - LOWER
4590.4	GASKET - STUFF BOX TO UPPER COL
4590.6	GASKET - UPPER COL.TO MTG. PL.
4590.7	GASKET - MANIFOLD TO MTG.PL.
4610.2	O-RING - BEARING BODY
6130	MOUNTING PLATE
6570.1	CAP SCREW - SUPP HD TO MTR
6570.11	CAPSCREW - STUFF BOX TO COL
6570.17	CAP SCREW - COUPL.GUARD (NOT SHOWN)
6570.18	CAP SCREW - SEAL GUARD (NOT SHOWN)
6570.7	CAP SCREW - MANIFOLD. TO MTG PLT
6570.9	CAP SCREW - BRG BODY TO COL.
6572.2	STUD - GLAND
6579.1	CAP SCREW - COL. TO MTG. PLT.
6579.2	CAP SCREW - SUPP HD TO MTG. PLT.
6579.4	CAPSCREW - SUPP HD TO BRG BKT
6580.12	NUT - COUPLING GUARD (NOT SHOWN)
6580.13	NUT - SEAL GUARD (NOT SHOWN)
6580.8	NUT - HEX
6700.1	KEY - DRIVER SHAFT
6700.2	KEY - PUMP SHAFT
6700.3	GIB KEY
6820	LIFTING EYE
6850.1	COUPLING - GREASE
7200	COUPLING - FLEXIBLE
7450.1 & 7450.2	COUPLING GUARD (NOT SHOWN)
7450.3	SEAL GUARD (NOT SHOWN)
8000	DRIVER

PARTS LIST	
EUROPUMP_REF_NO	DESCRIPTION
1245.2	FLANGE - DISCHARGE
1340.3	ADAPTOR - MOTOR
1341.1	COLUMN - UPPER
2530.1	SNAP RING
2530.2	RETAINING RING
3031	BEARING - THRUST
3110	BEARING BODY
3130	BRG BRACKET
3160	SUPPORT HEAD
3400	SLEEVE - ADJUSTING
3853.1	NIPPLE - PIPE
3853.2	FITTING GREASE (THRUST BRG)
3869	MANIFOLD - LUBE PIPING
4110	STUFFING BOX
4120.1	GLAND
4130	PACKING
4134	SEAL CAGE

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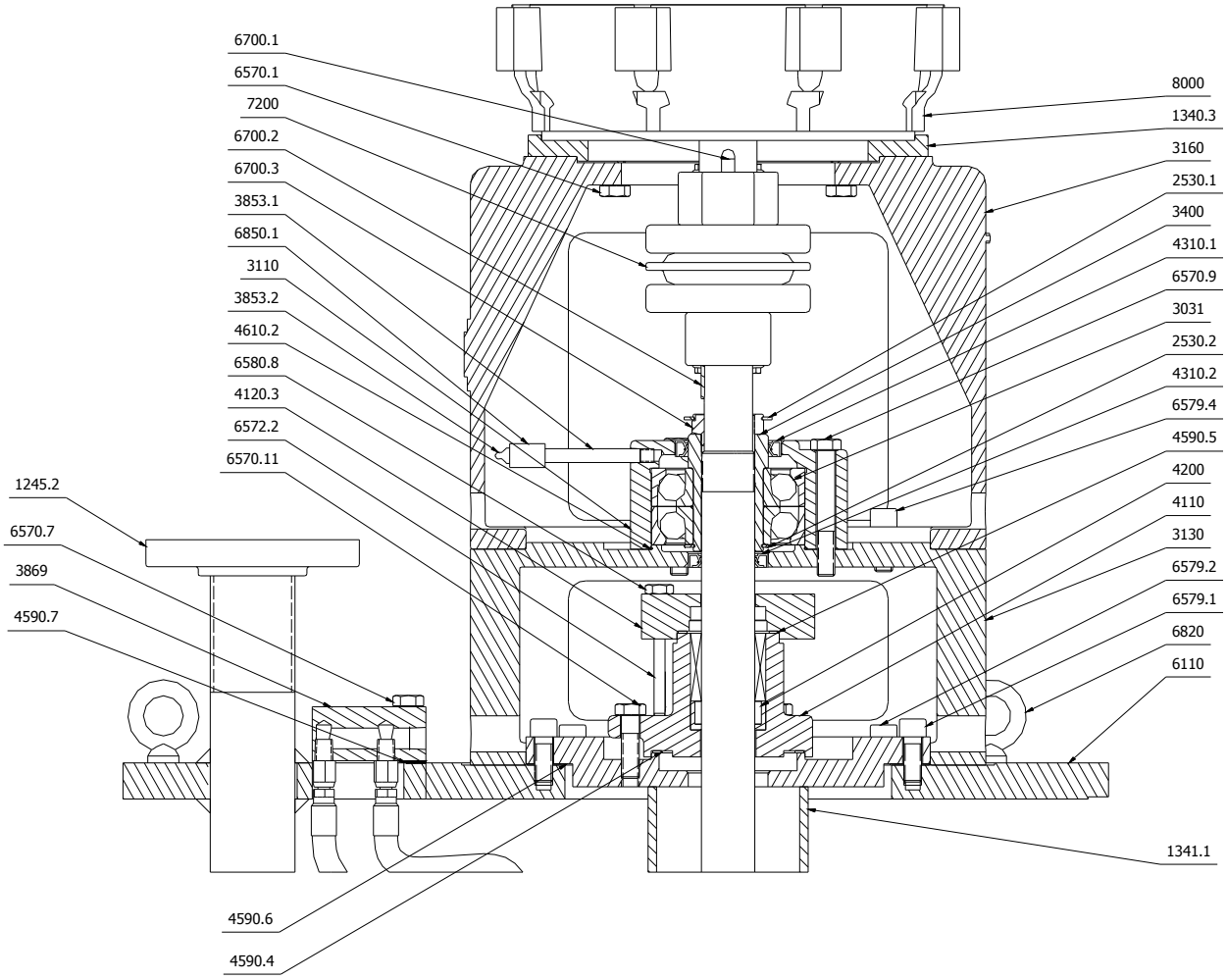
Figure 8-7: Pressurized design



PARTS LIST		PARTS LIST	
EUROPUMP_REF_NO	DESCRIPTION	EUROPUMP_REF_NO	DESCRIPTION
6110	MOUNTING PLATE	1245.2	FLANGE - DISCHARGE
6570.1	CAP SCREW - SUPP HD TO MTR	1340.3	ADAPTOR - MOTOR
6570.11	CAPSCREW - STUFF BOX TO COL	1341.1	COLUMN - UPPER
6570.17	CAP SCREW - COUPL.GUARD (NOT SHOWN)	2530.1	SNAP RING
6570.18	CAP SCREW - SEAL GUARD (NOT SHOWN)	2530.2	RETAINING RING
6570.7	CAP SCREW - MANIFOLD. TO MTG PLT	3031	BEARING - THRUST
6570.9	CAP SCREW - BRG BODY TO COL.	3110	BEARING BODY
6572.2	STUD - GLAND	3130	BRG BRACKET
6579.1	CAP SCREW - COL. TO MTG. PLT.	3160	SUPPORT HEAD
6579.2	CAP SCREW - SUPP HD TO MTG. PLT.	3400	SLEEVE - ADJUSTING
6579.4	CAPSCREW - SUPP HD TO BRG BKT	3853.1	NIPPLE - PIPE
6580.12	NUT - COUPLING GUARD (NOT SHOWN)	3853.2	FITTING GREASE (THRUST BRG)
6580.13	NUT - SEAL GUARD (NOT SHOWN)	3869	MANIFOLD - LUBE PIPING
6580.8	NUT - HEX	4110	STUFFING BOX
6700.1	KEY - DRIVER SHAFT	4120.3	FLUSH GLAND
6700.2	KEY - PUMP SHAFT	4200	MECHANICAL SEAL
6700.3	GIB KEY	4310.1	LIP SEAL - UPPER
6820	LIFTING EYE	4310.2	LIP SEAL - LOWER
6850.1	COUPLING - GREASE	4590.4	GASKET - STUFF BOX TO UPPER COL
7200	COUPLING - FLEXIBLE	4590.5	GASKET - MECH. SEAL GUARD
7450.1 & 7450.2	COUPLING GUARD (NOT SHOWN)	4590.6	GASKET - UPPER COL.TO MTG. PL.
7450.3	SEAL GUARD (NOT SHOWN)	4590.7	GASKET - MANIFOLD TO MTG.PL.
8000	DRIVER	4610.2	O-RING - BEARING BODY

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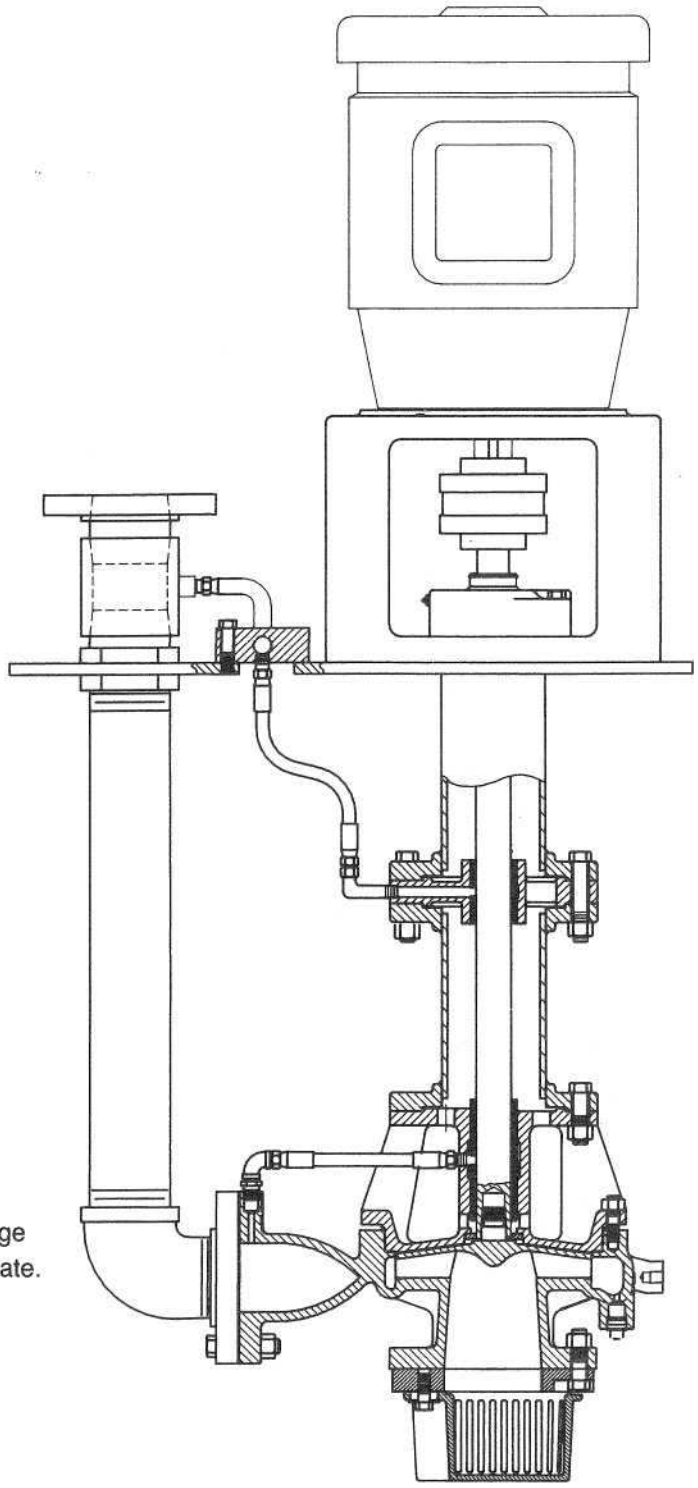
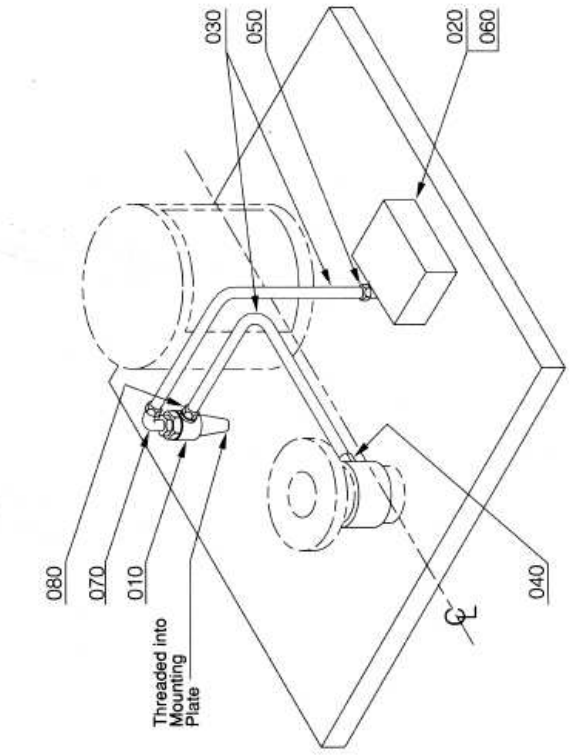
Figure 8-8: Product lubrication



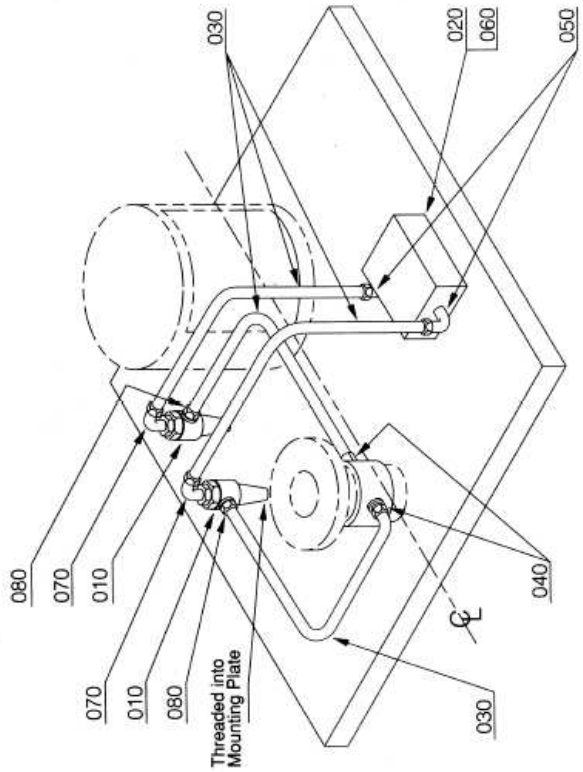
NOTE: 25 PSI minimum discharge pressure required at mounting plate.

Figure 8-9: Product lubrication separators



STANDARD CONSTRUCTION		
REF.	QTY.	DESCRIPTION
010	1	SEPARATOR
020	1	MANIFOLD
030	30"	TUBING .50" O.D. x .033" WALL
040	1	MALE CONNECTOR .50T x .50 NPT
050	1	MALE ELBOW .50T x .50 NPT
060	2	HEX HD. CAPSCREW
070	1	FEMALE ELBOW .50T x .50 NPT
080	1	FEMALE CONNECTOR .50T x .50 NPT

WITH SINGLE PARTICLE SEPARATOR



STANDARD CONSTRUCTION		
REF.	QTY.	DESCRIPTION
010	1	SEPARATOR
020	1	MANIFOLD
030	60"	TUBING .50" O.D. x .035" WALL
040	1	MALE CONNECTOR .50T x .50 NPT
050	1	MALE ELBOW .50T x .50 NPT
060	2	HEX HD. CAPSCREW
070	1	FEMALE ELBOW .50T x .50 NPT
080	1	FEMALE CONNECTOR .50T x .50 NPT

WITH DUAL PARTICLE SEPARATOR

8.1 General arrangement drawing

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

9 CERTIFICATION

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

10 OTHER RELEVANT DOCUMENTATION AND MANUALS

10.1 Supplementary User Instructions

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

10.2 Change notes

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

10.3 Additional sources of information

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

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

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

Specification for Vertical In-Line Centrifugal Pumps for Chemical Process, ASME B73.2M
The American Society of Mechanical Engineers, New York, NY.

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

American National Standard for Vertical Pumps for Nomenclature, Definitions, Design and Application (ANSI/HI 2.1-2.3)
Hydraulic Institute, 9 Sylvan Way, Parsippany, New Jersey 07054-3802.

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

Durco ESP3 Sales Bulletin (PS-10-24d)

Durco ESP3 Maintenance Checklist (FPD-1430)

Durco ESP3 PRM (FPD-1433)

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

Pump Handbook
3nd edition, Igor J. Karassik et al, McGraw-Hill, Inc., New York, NY, 2000.

Centrifugal Pump Sourcebook
2nd edition, John W. Dufour and William E. Nelson, McGraw-Hill Professional, Inc., New York, NY, 1992.

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

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