FLOWSERVE

USER INSTRUCTIONS

ESP2 Vertical Immersion Sump Pump

Installation
Operation
Maintenance

HOC3 Hydraulics

PCN=71569292 – 4-12 (E)
Original Instructions

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

Experience In Motion

CONTENTS

1 INTRODUCTION AND SAFETY

1.1 General

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

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

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 reliable. In spite of all the efforts of Flowserve Pump Division to provide sound and all necessary information the content of this manual may appear insufficient and is not guaranteed by Flowserve as to its completeness or accuracy.

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

1.4 Copyright

1.5 Duty conditions

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

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

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

1.6 Safety

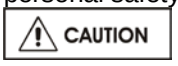
1.6.1 Summary of safety markings

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

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.

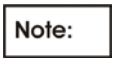

This symbol indicates “hazardous and toxic fluid” safety instructions where non-compliance would affect personal safety and could result in loss of life.



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.



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.

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).

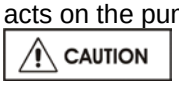
If complete protection is not possible, the machine access must be limited to maintenance staff only with clear visual warnings and indicators to those entering the immediate area. Note: bearing housings must not be insulated and drive motors and bearings may be hot.

If the temperature is greater than 68 °C (175 °F) or below 5 °C (20 °F) in a restricted zone, or exceeds local regulations, action as above shall be taken.

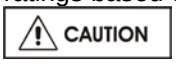
 HAZARDOUS LIQUIDS
When the pump is handling hazardous liquids care must be taken to avoid exposure to the liquid by appropriate pump placement, limiting personnel access and by operator training. If the liquid is flammable and/or explosive, strict safety procedures must be applied.

Gland packing must not be used when pumping hazardous liquids.

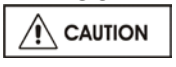
 PREVENT EXCESSIVE EXTERNAL PIPE LOAD
Do not use pump as a support for piping. Do not mount expansion joints, unless allowed by Flowserve in writing, so that their force, due to internal pressure, acts on the pump flange.

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

 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.

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

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

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

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

1.6.4 Products used in potentially explosive atmospheres

 Measures are required to:

- Avoid excess temperature
- Prevent 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

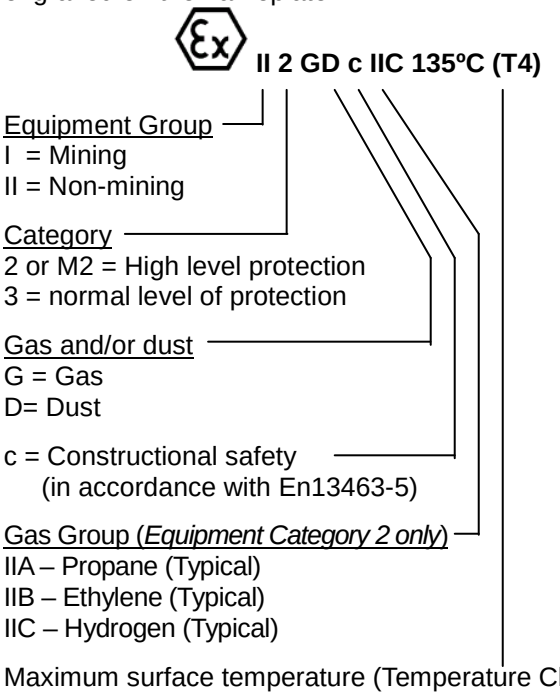
 Use equipment only in the zone for which it is appropriate. Always check that the driver, drive coupling assembly, seal and pump equipment are suitably rated and/or certified for the classification of the specific atmosphere in which they are to be installed.

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

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 °C (185 °F)	Consult Flowserve
T5	100 °C (212 °F)	Consult Flowserve
T4	135 °C (275 °F)	115 °C (239 °F) *
T3	200 °C (392 °F)	180 °C (356 °F) *
T2	300 °C (572 °F)	275 °C (527 °F) *
T1	450 °C (842 °F)	400 °C (752 °F) *

Maximum permitted liquid temperature for pumps with self-priming casing

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

The 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 and casing external surface temperature, it is recommended that users 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, regular checks must be made and dirt removed 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 can not avoid this condition it is recommended that you 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

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, the installation of a liquid detection device is recommended.

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.

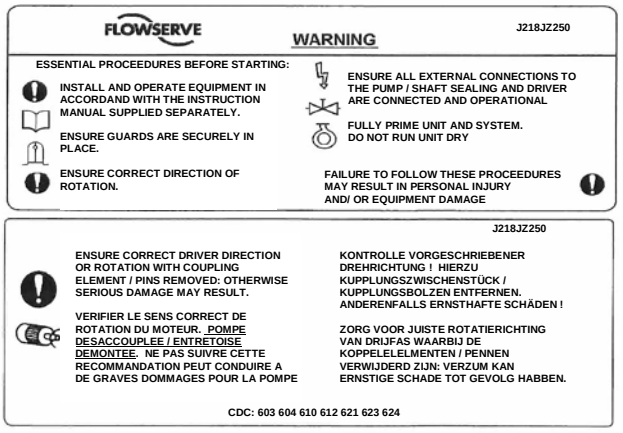
It is recommended that a maintenance plan and schedule is adopted. (See section 6, *Maintenance.)*

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 Noise level

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

Pump noise level is dependent on a number of factors - the type of motor fitted, the operating capacity, pipework design and acoustic characteristics of the building. Typical sound pressure levels measured in dB, and A-weighted are shown in the table below. The figures are indicative only, they are subject to a +3 dB tolerance, and cannot be guaranteed.

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

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

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

Typical sound pressure level, dBA, L_{pA} at 1 m reference 20 µPa

Motor size and speed kW (hp)	3550 r/min		2900 r/min		1750 r/min		1450 r/min	
	Pump and motor **dBA**	Pump only **dBA**	Pump and motor **dBA**	Pump only **dBA**	Pump and motor **dBA**	Pump only **dBA**	Pump and motor **dBA**	Pump only **dBA**
<0.55 (<0.75)	71	66	64	62	64	62	63	62
0.75 (1)	74	66	67	62	67	62	63	62
1.1 (1.5)	74	68	67	64	67	64	65	64
1.5 (2)	77	70	70	66	70	66	66	66
2.2 (3)	78	72	71	68	71	68	68	68
3 (4)	81	74	74	70	74	70	70	70
4 (5)	82	75	75	71	75	71	71	71
5.5 (7.5)	90	77	83	73	76	73	72	71
7.5 (10)	90	78	83	74	77	74	73	72
11 (15)	91	80	84	76	78	76	74	73
15 (20)	92	83	85	79	80	79	76	75
18.5 (25)	92	83	85	79	80	79	76	75
22 (30)	92	83	85	79	81	79	77	75
30 (40)	100	85	93	81	84	80	80	76
37 (50)	100	86	93	82	84	80	80	76
45 (60)	100	87	93	83	84	80	80	76
55 (75)	100	88	95	84	86	81	82	77
75 (100)	100	90	95	86	88	81	83	78
90 (120)	100	90	95	86	90	81	85	78
110 (150)	100	91	95	87	91	83	86	79
150 (200)	101	92	96	88	91	83	86	79
200 (270)	(1)	(1)	(1)	(1)	(1)	83	(1)	80
300 (400)	-	-	-	-	(1)	84	(1)	81

(1) Motors in this range are generally job specific and noise levels should be calculated based on actual equipment installed.
For 960 r/min reduce 1450 r/min values by 5 dBA.

2 TRANSPORT AND STORAGE

2.1 Consignment receipt and unpacking

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

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

2.2 Handling

Boxes, crates, pallets or cartons may be unloaded using fork lift vehicles or slings dependent on their size and construction. The unit should be stored in a level position with no strains applied.

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 eye bolts or cast-in lifting lugs to lift pump, motor and baseplate assemblies.

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

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).

Pump Weights

ESP2 Pump Size	Base Pump Wt. Kg (lb)	Kg (lb) per 0.15m (6 in.) Extra Length
Group 1		
1.5x1x6	136 (300)	3.6 (8)
3x1.5x6	139 (305)	3.6 (8)
3x2x6K	145 (320)	4.1 (9)
1.5x1x8	148 (325)	3.6 (8)
3x1.5x8	150 (330)	3.6 (8)
3x2x8	152 (335)	4.1 (9)
Group 2		
3x1.5x8	182 (400)	6.8 (15)
3x2x8	184 (405)	7.3 (16)
4x3x8	223 (490)	7.7 (17)
4x3x8L	223 (490)	7.7 (17)
2x1x10	182 (400)	6.8 (15)
3x1.5x10	223 (490)	6.8 (15)
3x2x10	232 (510)	7.3 (16)
4x3x10	286 (630)	7.7 (17)
4x3x10L	309 (680)	7.7 (17)
6x4x10	323 (710)	8.6 (19)
3x1.5x13	259 (570)	6.8 (15)
3x2x13	264 (580)	7.3 (16)
4x3x13	302 (665)	7.7 (17)
Group 3		
6x4x13	407 (895)	11.4 (25)
8x6x13	545 (1200)	15 (33)
10x8x13	616 (1355)	16.4 (36)
8x6x15	561 (1235)	15 (33)
10x8x15	645 (1420)	16.4 (36)

Note: Base pump lengths are 0.61m (2 ft.) for Group 1 & Group 2 pumps and 0.91m (3 ft.) for Group 3 pumps.

Note: On pumps equipped with grease lubricated shaft bearings, (3020.1 and 3020.2) take care not to flush the grease from the bearings.

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.

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

2.4.1 Short term storage and packaging

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

- All loose unmounted items are packaged in a water proof plastic bag or box.
- Inner surfaces of the bearing housing, shaft (area through bearing housing) and bearings are coated with Cortec VCI-329 rust inhibitor, or equal.
- Regreaseable bearings in the pump are packed with Keystone 81-EP-2 lithium-based grease for the thrust bearing (and the line shaft bearings when grease lubrication is used).
- 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
- Every three months the pump shaft should be rotated several revolutions to prevent brinelling of the thrust bearing and sticking of the seal faces (if fitted).

2.4.2 Long term storage and packaging

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

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

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

After unpacking, protection will be the responsibility of the user. Addition of oil to the bearing housing will remove the inhibitor. If units are to be idle for extended periods after addition of lubricants, inhibitor oils and greases should be used.

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.

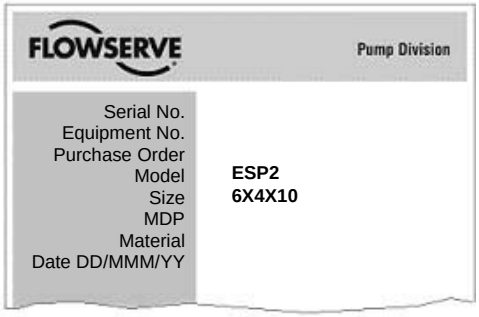
Make sure that hazardous substances are disposed of safely and that the correct personal protective equipment is used. The safety specifications must be in accordance with the current local regulations at all times.

3 DESCRIPTION

3.1 Configurations

The ESP2 vertical immersion sump pumps are separately coupled, metallic construction, single stage, centrifugal pumps for wet pit applications. The ESP2 wetted parts are available in a wide range of materials to handle most fluids. Vapor tight, vapor proof, and pressurized options are available.

Figure 3-1: Nameplate mounted to housing



3.2 Nomenclature

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

6 X 4 X 10

- "6" = *nominal suction port size* (in.)
- "4" = *Nominal discharge port size* (in.)
- *Nominal maximum impeller diameter.* "10" = 10 in.
- *Actual impeller size*
  "9.5" = 9 ½ in. diameter; "8.13" = 8 ⅛ in;
  "7.75" = 7 ¾ in

3.3 Design of major parts

3.3.1 Pump casing

Casings are either a single or double volute design with a centerline discharge.

3.3.2 Impeller

The impeller is an open design and is threaded to the end of the shaft.

3.3.3 Shaft

Solid shafting is supported on plain bearings with a thrust bearing located above the sump level.

3.3.4 Pump bearings and lubrication

Grease lubricated double row angular contact ball bearings are fitted as standard for the external thrust bearings. The plain bearings that support the shaft against radial loads can be lubricated either by external flush, product, or grease (see Fig. 3-4).

3.3.5 Bearing housing

The external bearing housing holds the thrust bearing and has lip seals to prevent ingress of contaminates to the bearing grease.

3.3.6 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.

3.3.7 Driver

The driver is normally a vertical electric motor.

3.3.8 Accessories

Accessories may be fitted when specified by the customer.

3.4 Performance and operation limits

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

The following data is included as additional information to help with your installation. It is typical, and factors such as liquid being pumped, temperature, 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 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 ESP pump models.

FIGURE 3-2: Minimum continuous flow

Pump size	MCF % of BEP		
	3500/2900 r/min	1750/1450 r/min	1180/960 r/min
Group 1			
1.5x1x6	10	10	10
3x1.5x6	10	10	10
3x2x6K	10	10	10
1.5x1x8	10	10	10
3x1.5x8	n.a.	10	10
3x2x8	n.a.	10	10
Group 2			
3x1.5x8	10	10	10
3x2x8	10	10	10
4x3x8	25	10	10
4x3x8L	n.a.	25	10
2x1x10	n.a.	25	10
3x1.5x10	n.a.	25	10
3x2x10	n.a.	25	10
4x3x10	n.a.	25	10
4x3x10L	n.a.	25	10
6x4x10	n.a.	25	10
3x1.5x13	n.a.	25	10
3x2x13	n.a.	25	10
4x3x13	n.a.	25	10
Group 3			
6x4x13	n.a.	25	10
8x6x13	n.a.	25	10
10x8x13	n.a.	25	10
8x6x15	n.a.	n.a.	25
10x8x15	n.a.	n.a.	25

3.4.2 Minimum suction pipe submergence

The minimum submergence is shown in Figures 3-3A and 3-3B below.

FIGURE 3-3A

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 in	0.30	0.55	1.07	2.65									
2 in		0.30	0.58	1.40	2.74								
3 in			0.30	0.79	1.52	2.38							
4 in				0.30	0.55	1.07	2.13						
6 in						0.43	0.76	1.19	1.83				
8 in								0.55	0.94	1.19	1.65		
10 in										0.64	0.85	1.22	1.52

FIGURE 3-3B

Minimum submergence (feet)

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

3.4.3 ESP2 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 enhances 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 & moly-disulphide-filled, with low cold flow, high tensile and elongation characteristics.

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

FIGURE 3-4: ESP2 Bearing selection

Bearing Material	Max. Product Temp.	Pumped Liquid	Lubricant	Shaft Material
CARBON	177°C (350°F)	Most clean acids, genera! chemical, cold or hot water, cleaning fluids, gasoline, kerosene, jet fuels	External Flush Product Lube	Steel or SS Steel or SS
BRONZE	82°C 180°F	Water and other compatible liquids	External Flush Product Lube Grease	Steel only Steel only Steel only
CAST IRON	82°C (180°F)	Water and other compatible liquids including alkaline caustics	External Flush Product Lube Grease	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

FIGURE 3-5: Engineering information

NOTE: All dimensions are in inches when applicable, except where noted.

	PUMP SIZE	1½x1x6	3x1½x6	3x2x6K	1½x1x8	3x1½x8	3x2x8	3x1½x8	3x2x8	4x3x8	4x3x8L	2½x1x10	3x1½x10	3x2x10	4x3x10	4x3x10L	6x4x10	3x1½x13	3x2x13	4x3x13	6x4x13	3x6x13	10x8x13	8x6x15	10x8x15
PUMP DATA	PUMP GROUP	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3
	SUCTION FLANGE	1.50	3.00	3.00	1.50	3.00	3.00	3.00	3.00	4.00	4.00	2.00	3.00	3.00	4.00	4.00	6.00	3.00	3.00	4.00	6.00	8.00	10.00	8.00	10.00
	DISCHARGE FLANGE AT MOUNTING PLATE(1)(2)	2.00 (1)	2.00 (1)	2.00	2.00 (1)	2.00 (1)	2.00	2.00 (1)	2.00	3.00	3.00	2.00 (1)	2.00 (1)	2.00	3.00	3.00	4.00	2.00 (1)	2.00	3.00	4.00	6.00	8.00	6.00	8.00
	MAX. IMP. DIAMETER	6.25	6.25	6.25	8.00	8.50	8.50	8.50	8.50	8.50	8.50	10.00	10.75	10.75	10.75	10.75	10.75	13.25	13.25	13.25	13.00	13.25	13.25	15.00	15.00
	IMP. EYE AREA (SQ. IN.)	2.76	4.68	6.51	3.14	4.91	6.47	4.91	6.47	11.79	11.82	3.54	7.06	8.61	12.56	12.56	23.75	7.07	8.30	15.07	28.27	50.20	58.50	50.20	65.50
	MAX. SPHERE SIZE	.39	.53	.56	.46	.50	.59	.50	.59	.78	.86	.28	.48	.58	.70	.97	1.02	.49	.57	.87	1.00	1.00	1.12	.94	1.25
	WR² (LB-FT²) IMPELLER ONLY	.10	.11	.14	.30	.38	.46	.38	.46	.52	.52	.95	1.10	1.10	1.30	1.30	1.80	2.60	2.90	3.20	4.50	6.00	8.10	10.20	12.00
CASING DATA	IMP. CLEARANCE—FRONT	.010	.010	.010	.010	.015	.015	.015	.015	.015	.015	.015	.015	.015	.015	.015	.015	.015	.015	.015	.020	.020	.020	.020	.020
	CASING THICKNESS	.32	.32	.32	.32	.32	.32	.32	.32	.35	.35	.35	.35	.38	.38	.38	.44	.44	.44	.44	.44	.56	.56	.56	.56
	CORROSION ALLOWANCE	.12	.12	.12	.12	.12	.12	.12	.12	.12	.12	.12	.12	.12	.12	.12	.12	.12	.12	.12	.12	.12	.12	.12	.12
PIT DEPTH	MINIMUM DEPTH (FEET)	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	3.0	3.0	3.0	3.0	3.0
	MAXIMUM DEPTH (FEET)	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
SHAFT AND COLUMN DATA	SHAFT DIA. @ SLEEVE BEARINGS	1.125	1.125	1.125	1.125	1.125	1.125	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.875	1.875	1.875	1.875	1.875
	SHAFT DIA. @ COUPLING	1.000	1.000	1.000	1.000	1.000	1.000	1.375	1.375	1.375	1.375	1.375	1.375	1.375	1.375	1.375	1.375	1.375	1.375	1.375	1.625	1.625	1.625	1.625	1.625
	KEYWAY SIZE	.25x.12	.25x.12	.25x.12	.25x.12	.25x.12	.25x.12	.31x.16	.31x.16	.31x.16	.31x.16	.31x.16	.31x.16	.31x.16	.31x.16	.31x.16	.31x.16	.31x.16	.31x.16	.31x.16	.62x.31	.62x.31	.62x.31	.62x.31	.62x.31
	BALL BEARING SIZE	5308	5308	5308	5308	5308	5308	5310	5310	5310	5310	5310	5310	5310	5310	5310	5310	5310	5310	5310	5313	5313	5313	5313	5313
	1ST CRITICAL SPEED, 3550 RPM	6000	6000	6000	6000	N/A	N/A	5555	5555	5555	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	1ST CRITICAL SPEED, 1750 RPM	2344	2344	2344	2344	2344	2344	2469	2469	2469	2469	2469	2469	2469	2469	2469	2469	2469	2469	2469	2500	2500	2500	N/A	N/A
	1ST CRITICAL SPEED, 1180 RPM	2344	2344	2344	2344	2344	2344	2469	2469	2469	2469	2468	2469	2469	2469	2469	2469	2469	2469	2469	2500	2500	2500	2500	2500
	COLUMN SIZE (NOM. DIA.)	2.50	2.50	2.50	2.50	2.50	2.50	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	6.00	6.00	6.00	6.00	6.00
	COLUMN THICKNESS	.203	.203	.203	.203	.203	.203	.237	.237	.237	.237	.237	.237	.237	.237	.237	.237	.237	.237	.237	.280	.280	.280	.280	.280
	STANDARD BEARINGS SPAN, 3550 RPM	30.00	30.00	30.00	30.00	N/A	N/A	36.00	36.00	36.00	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	STANDARD BEARINGS SPAN, 1750 RPM	48.00	48.00	48.00	48.00	48.00	48.00	48.00	48.00	48.00	48.00	48.00	48.00	48.00	48.00	48.00	48.00	48.00	48.00	48.00	60.00	60.00	60.00	N/A	N/A
	STANDARD BEARING SPAN, 1180 RPM	48.00	48.00	48.00	48.00	48.00	48.00	48.00	48.00	48.00	48.00	48.00	48.00	48.00	48.00	48.00	48.00	48.00	48.00	48.00	60.00	60.00	60.00	60.00	60.00
	BEARING LENGTH—ADAPTOR	4.25	4.25	4.25	4.25	4.25	4.25	5.25	5.25	5.25	5.25	5.25	5.25	5.25	5.25	5.25	5.25	5.25	5.25	5.25	6.50	6.50	6.50	6.50	6.50
	BEARING LENGTH—INTERMEDIATE	2.00	2.00	2.00	2.00	2.00	2.00	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	3.00	3.00	3.00	3.00	3.00

(1) Pumps with 1 or 1.5 inch casing discharge flange have 2" discharge pipe and flange size as standard.
(2) For next large discharge pipe size, use next large flange size. Only available on pumps with 2 or 3 inch casing discharge flange.

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, level 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, pump thrust and lineshaft bearings 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 assemble coupling and install 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 5.1.
- Vapor Proof and Pressurized design pumps are furnished with an upper stuffing box (4100). If the stuffing box does not already have the packing (4130) or seal (4200) installed, then they should be installed before the motor is mounted. See section 5.1.
- 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 (6110) 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 a tolerance of 2.5mm/m (0.03in/ft) level 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 Driver Mounting

a) Before the motor is installed, be sure to connect the motor half coupling and the pump half coupling 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 may be furnished. In this case the adapter must be installed before the motor can be mounted.

d) Locate the coupling and source of electrical power but DO NOT ASSEMBLE THE COUPLING AT THIS TIME.
e) 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 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.

f) **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.
g) Disconnect and lockout the power supply to the driver.
h) The coupling can now be fully installed and join the driver and pump shafts together (see section 5.4.2).
i) Install the coupling guarding (see section 5.5).

4.6 Piping

4.6.1 Discharge piping

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

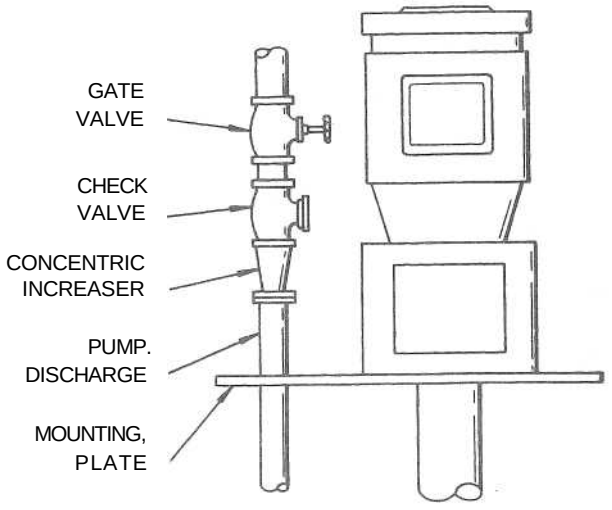
⚠ CAUTION Protective covers are fitted to both the suction and discharge flanges of the casing and must be removed prior to connecting the pump to any pipes.

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 could cause the impeller to unscrew from the shaft and should be avoided.

⚠ 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.

FIGURE 4-1



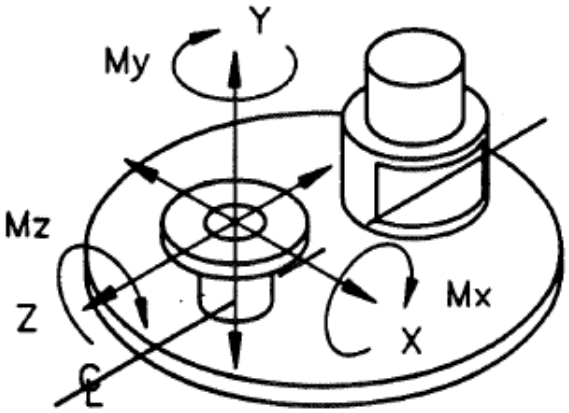
4.6.2 Suction piping

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.

4.6.3 Allowable piping loads

Discharge piping should be constructed to fit to the ESP discharge piping flange. The ESP 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 ESP2 nozzle loading



↑ Tension

↓ Compression

PUMP	Forces-Lbs.			Moments-Ft. Lbs.		
	Fx	Fy	Fz	Mx	My	Mz
1½ x 1 x 6	100	150	50	160	200	160
3 x 1½ x 6	110	200	60	175	210	170
3 x 2 x 6K	200	400	125	190	230	190
1½ x 1 x 8	90	150	45	165	200	165
3 x 1½ x 8	200	300	90	180	220	250
3 x 2 x 8	165	350	165	305	365	310
4 x 3 x 8	250	435	155	365	440	350
4 x 3 x 8L	250	435	155	365	440	350
2 x 1 x 10	265	425	265	305	390	500
3 x 1½ x 10	200	305	190	320	390	250
3 x 2 x 10	200	320	185	330	400	300
4 x 3 x 10	250	410	155	365	445	350
4 x 3 x 10L	250	410	155	365	445	350
6 x 4 x 10	250	450	185	375	450	350
3 x 1½ x 13	200	270	170	330	400	250
3 x 2 x 13	200	410	200	340	665	300
4 x 3 x 13	250	410	200	400	735	325
8 x 6 x 13	405	655	405	1250	625	1205
10 x 8 x 13	485	780	485	1500	625	1205
8 x 6 x 15	265	435	270	1500	625	1205
10 x 8 x 15	390	630	390	1625	625	1205

$$\frac{Fx}{Fxmax} + \frac{Fy}{Fymax} + \frac{Fz}{Fzmax} + \frac{Mx}{Mxmax} + \frac{My}{Mymax} + \frac{Mz}{Mzmax} \leq 1$$

4.6.4 Final pump 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.

4.6.5 Auxiliary piping

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

4.6.6 Mechanical seal and packing

Pumps supplied with vapor proof construction or pressurized design are furnished with an upper stuffing box (4100) equipped to take mechanical seals or packing (see vapor proof and pressurized design cross-sections in section 8). Installation instructions are in section 5.1.

4.7 Electrical connections

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

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

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

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

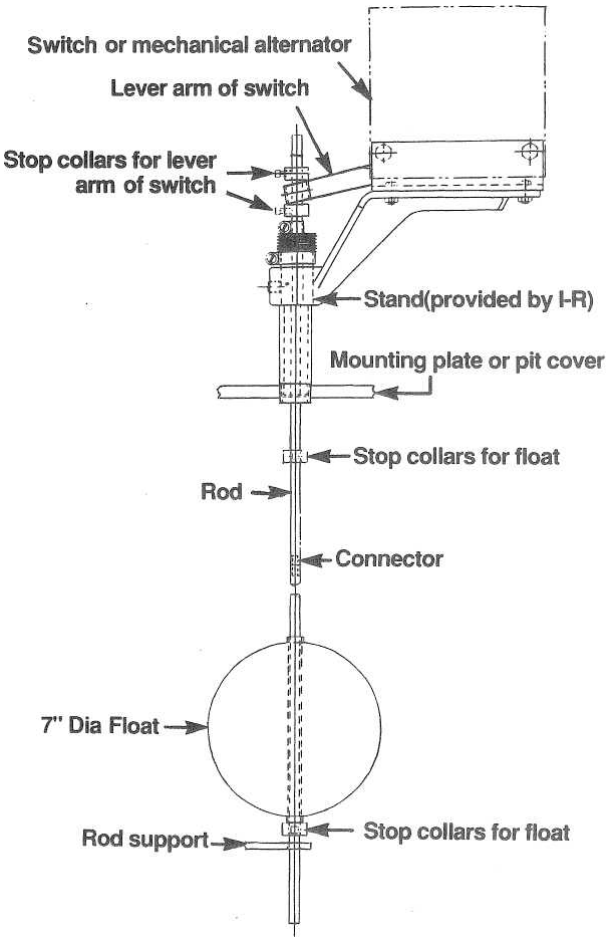
DANGER The motor must be wired up in accordance with the motor manufacturer's instructions (normally supplied within the terminal box) including any temperature, earth leakage, current and other protective devices as appropriate. The identification nameplate should be checked to ensure the power supply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

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

4.8 Level controls

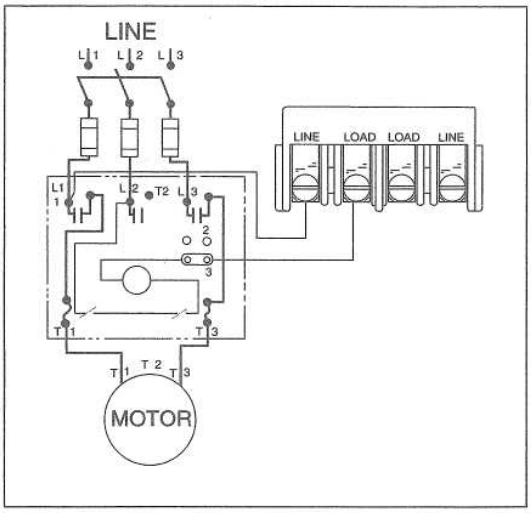
Assemble float control equipment per Figure 4-3 below. Wire the float controls following the diagrams on the next several pages. The stops should be set in accordance with maximum and minimum liquid levels desired and required. Float rods are furnished in kits of a standard length. The rod might have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

FIGURE 4-3

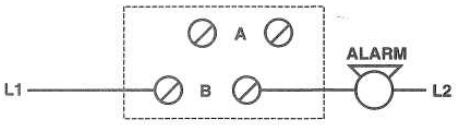


Some of the wiring diagrams are included on the following pages. If the wiring diagram needed is not included, contact control manufacturer for wiring instructions.

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)

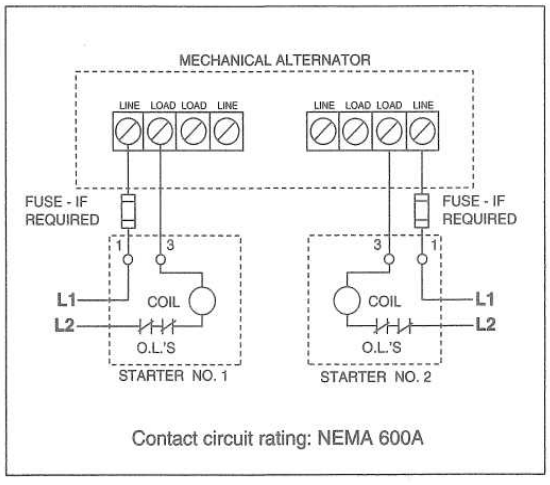


Circuit A closes on falling liquid level
Circuit B closes on rising liquid level

A.C. ELECTRICAL DATA

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)

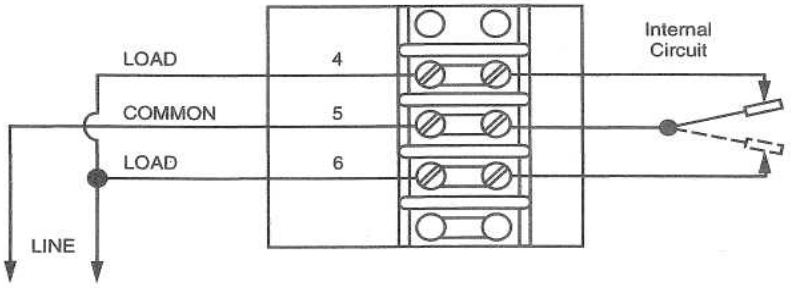


MAGNATROL®
FOR SINGLE FUNCTION (A10) SWITCHES
(Typical Only)

MAGNETROL
SPDT SWITCH MECHANISM

USE FOR MAGNETROL PART #'s:

A10 ____ ____ BAF
A10 ____ ____ BKM

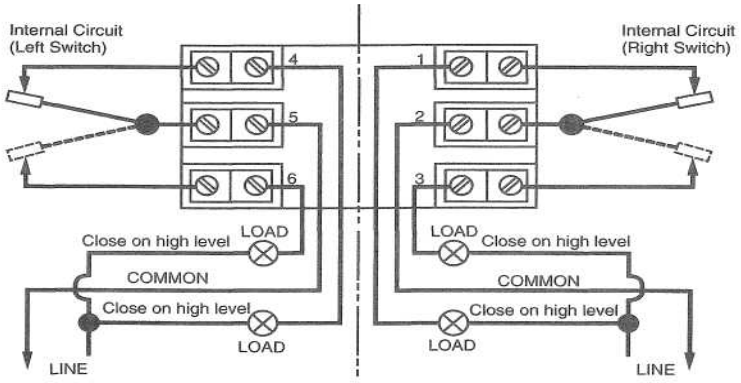


In this diagram, circuit between contacts 4 & 5 is made and circuit between contact 5 & 6 is broken at low liquid level. At high liquid level, circuit between contacts 4 & 5 is broken and circuit between contacts 5 & 6 is made.

MAGNETROL
DPDT SWITCH MECHANISM

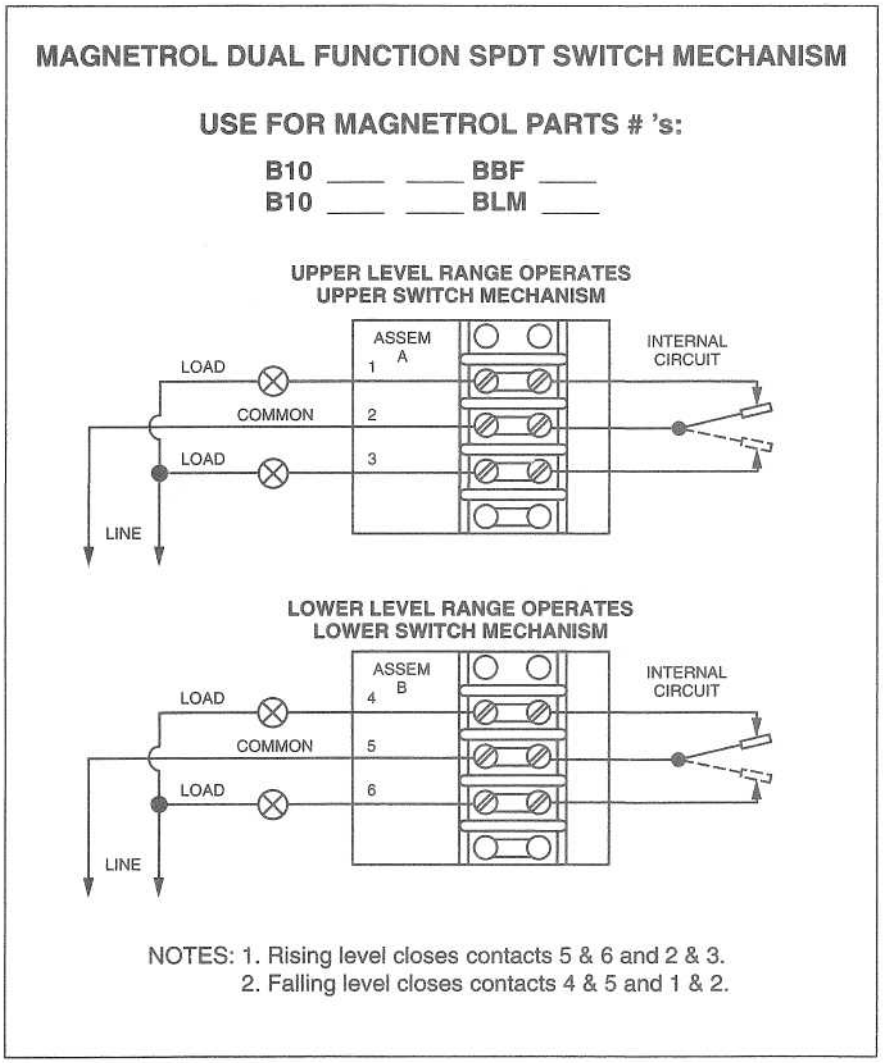
USE FOR MAGNETROL PART #'s:

A10 ____ ____ BDF
A10 ____ ____ BNM



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)



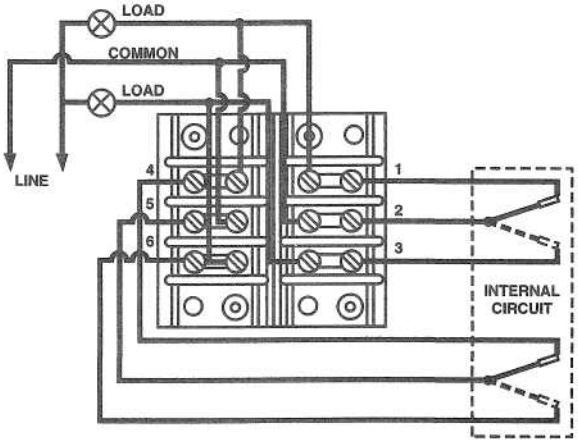
MAGNATROL®
FOR DOUBLE FUNCTION (B10) SWITCHES
(Typical Only)

MAGNETROL DUAL FUNCTION DPDT SWITCH MECHANISM

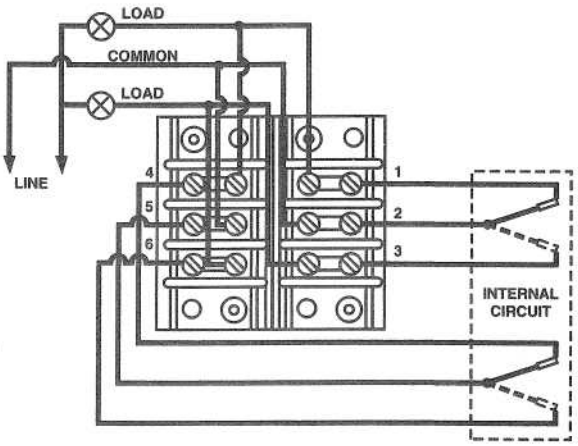
USE FOR MAGNETROL PARTS # 's:

B10 ____ ____ BEF ____
B10 ____ ____ BOM ____

UPPER LEVEL RANGE OPERATES
UPPER SWITCH MECHANISM

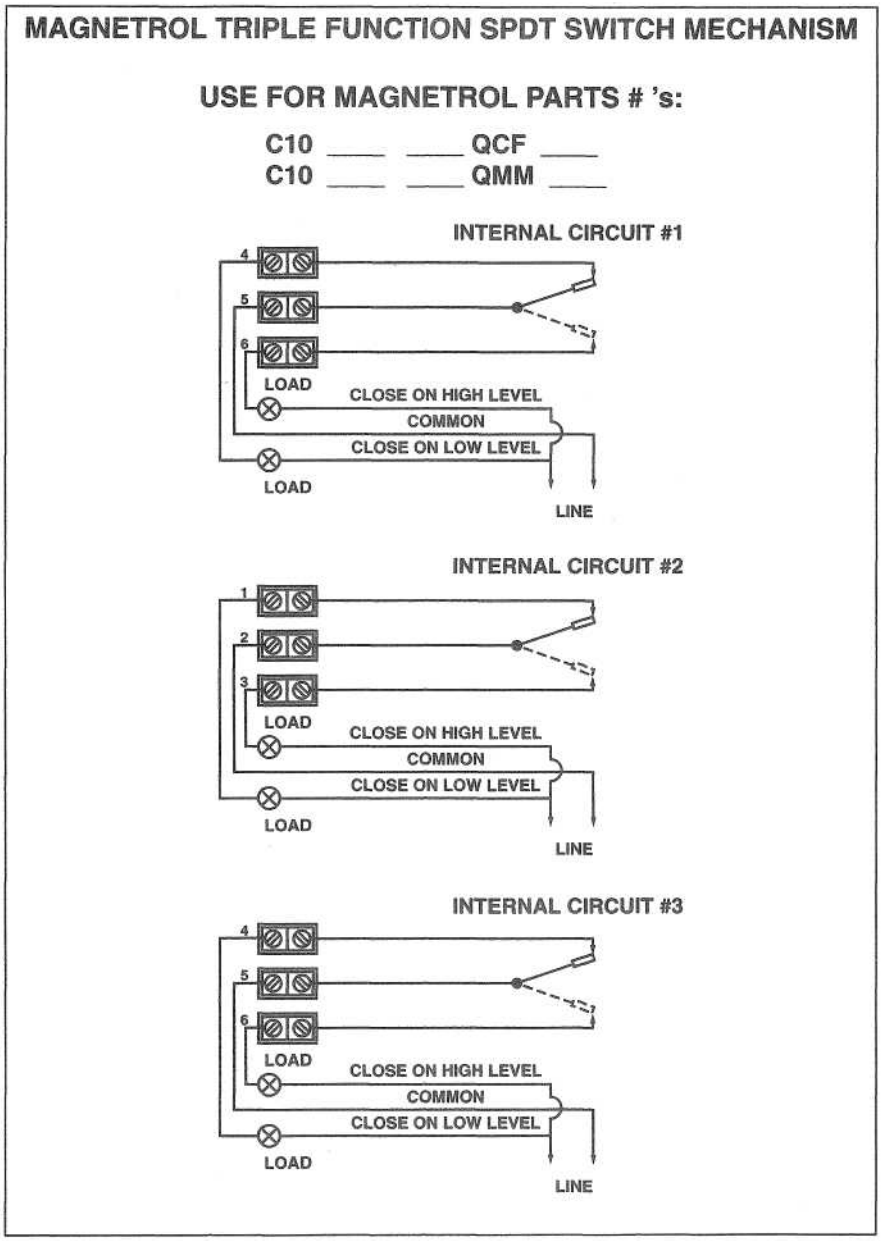


LOWER LEVEL RANGE OPERATES
LOWER SWITCH MECHANISM

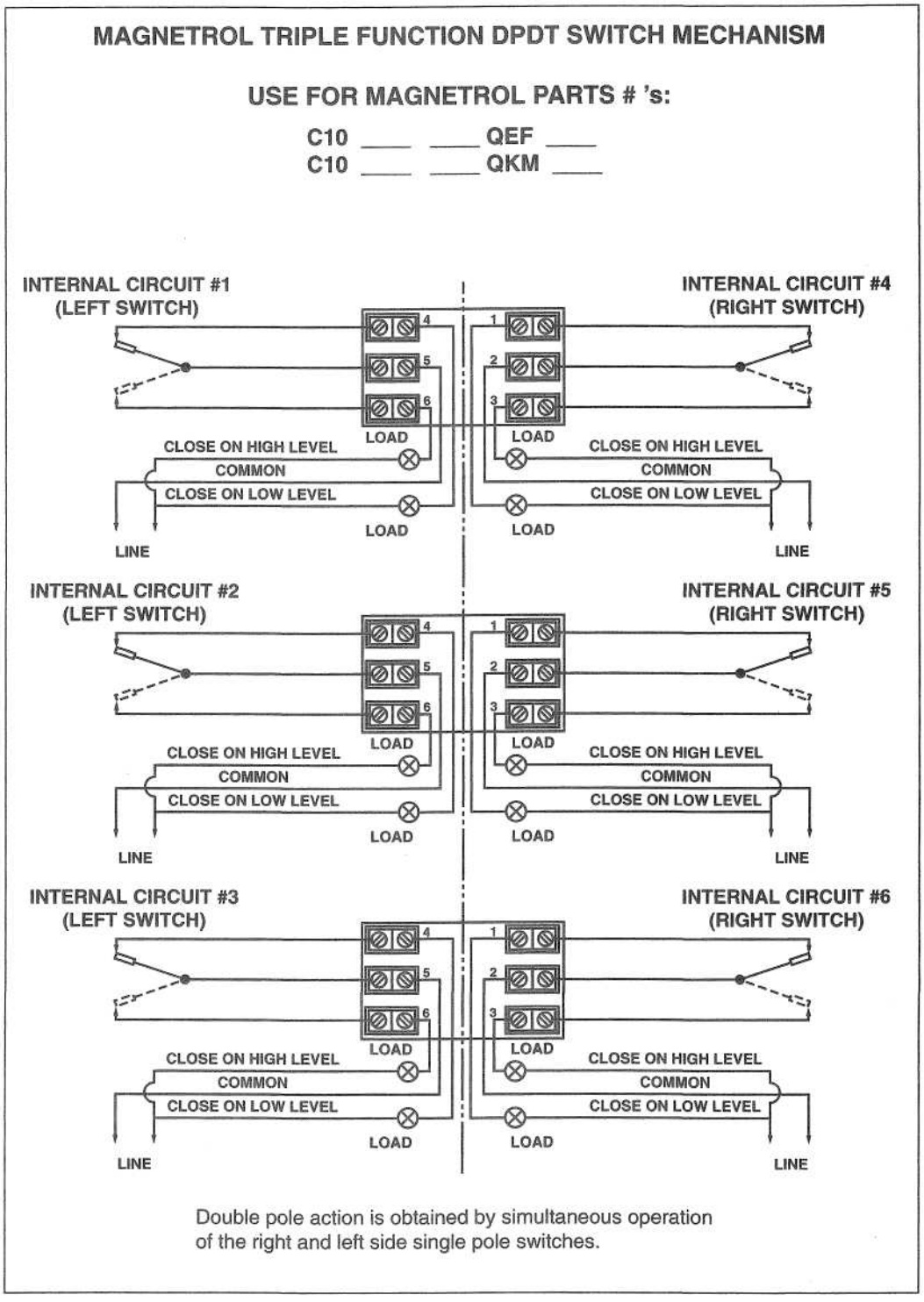


NOTES: 1. Rising level closes contacts 5 & 6 and 2 & 3.
2. Falling level closes contacts 4 & 5 and 1 & 2.

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



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

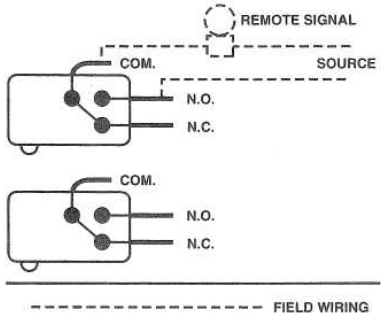


APEX SWITCH

(Typical Only)

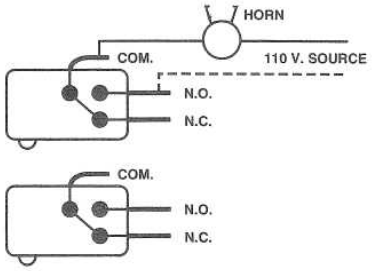
FOR HIGH LEVEL ALARM SWITCH MODELS:

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



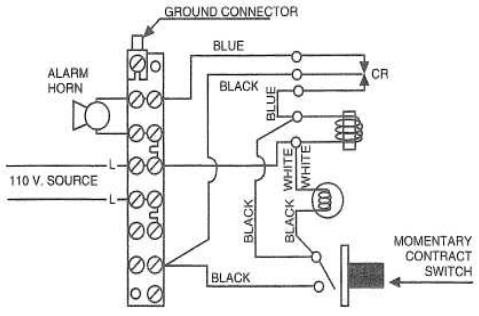
FOR HIGH LEVEL ALARM SWITCH MODELS:

LLC – 1H WITH HORN – NEMA 1



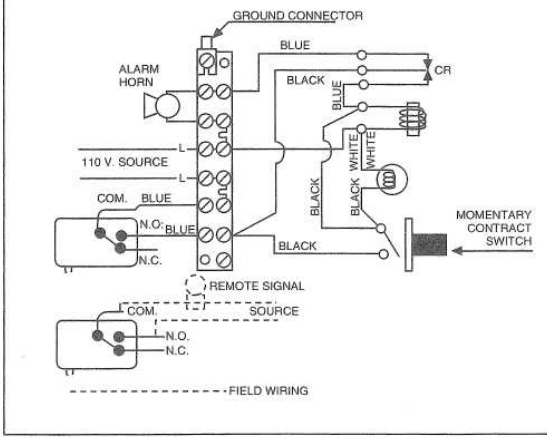
FOR ALARM PANEL MODELS:

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



4.9 Protection systems

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

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

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

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

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

5 COMMISSIONING, STARTUP, OPERATION AND SHUTDOWN

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

5.1 Pre-commissioning procedure

5.1.1 Pre start-up checks

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

- Pump and motor properly secured to the baseplate
- All fasteners tightened to the correct torque (see section 6.5)
- Coupling guard in place and not rubbing
- Rotation check (see sections 4.5 and 5.4). **This is absolutely essential**
- Impeller clearance setting
- Shaft seal (if supplied) properly installed
- Seal support system (if supplied) operational
- Bearing lubrication
- Pump instrumentation is operational

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.

5.1.2 Packing and mechanical seals

Pumps supplied with vapor proof construction or pressurized design are furnished with an upper stuffing box (4100) equipped to take mechanical seals or packing (See Vapor Proof and Pressurized Design cross-sections in section 8).

5.1.2.1 Installing mechanical seals

Mechanical seals (4200) are usually shipped separately to prevent damage during shipment. To install the seal some disassembly will be required (Split seals require no disassembly and only steps e. and f. should be followed).

a) Unbolt the support head (3160) from the bearing bracket (3130).
b) Unbolt the thrust bearing holder (3110) and disconnect the thrust bearing assembly (3712, 3031) (Do not remove the thrust bearing (3031) from the sleeve (3712)).
c) Remove the bearing bracket (3130).
d) If the pump comes with the gland (4120.2) already on the stuffing box (4100), then it must be removed at this time before the seal can be set in the stuffing box.
e) Temporarily wrap Teflon tape on the shaft threads to protect the seal from damage while being slid on the shaft.
f) CAREFULLY slip the seal (4200) onto the shaft (2100) and slide it down until it sets into the stuffing box (4100). DO NOT SET THE SEAL AT THIS TIME.
g) Slip the gland (4120.2) over top the stuffing box. Leave the gland and seal (4200) loose on the shaft for now.
h) Reassemble the bearing bracket (3130), then the thrust bearing assembly (3712, 3031), thrust bearing holder (3110), and finally the support head (3160).
i) The impeller must be set before the seal. Follow the directions listed in section 5.3.
j) Now the seal can be set. For the proper seal setting consult Figures 5.1 and 5.2. If the seal being used is not contained in the seal settings chart, follow the seal manufacturer's instructions and drawings furnished with the mechanical seal.

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.

FIGURE 5-1

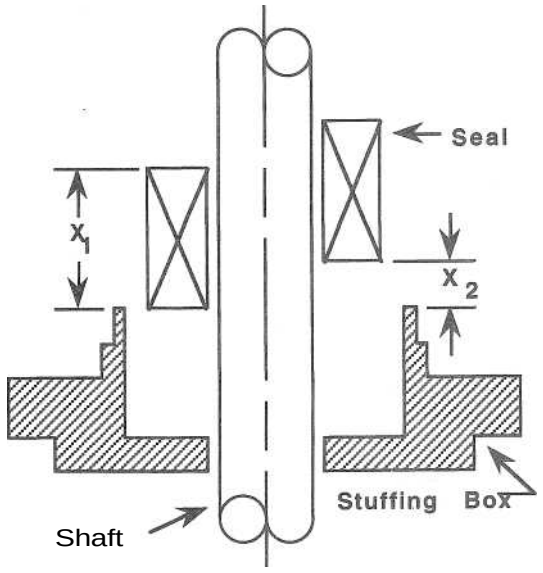


FIGURE 5-2

SEAL	X1 mm In.	SEAL	X2 mm In.	SEALS **REQUIRING** NO SETTING
Durametallic:		Durametallic:		John Crane:
Group 1 RAC	52.3	Group 1 PSS	0.0	T-1 double
	2.06	Group 2 PSS	0.0	1100
Group 2 RAC	52.3	Group 3 PSS	0.0	Cartridge T-1B
	2.06	Chesterton:		88
Group 3 RAC	71.4	Group 1 221	1.6	88S
	2.81		0.0625	28LD
Group 1 VO	73.2	Group 2 221	1.6	1215
	2.88		0.0625	2215
Group 2 VO	76.2	Group 3 221	1.6	**Flexibox:**
	3.00		0.0625	FFET
Group 3 VO		John Crane:		Sealol:
John Crane:		Group 1 8B2	44.5	611
Group 2 37FS	50		1.750	623
	1.968	Group 2 8B2	44.5	Borg-Warner:
Group 3 37FS	50		1.750	Uniseal I
	1.968	Group 3 8B2	44.5	Uniseal II
			1.750	Durametallic:
				X-100
				X-200
				P-50
				CRO double
				Chesterton:
				123
				155
				241
				255

5.1.2.2 Packing the stuffing box

Inspect the stuffing box to see if it contains packing. The pump normally leaves the factory with the stuffing box unpacked, and it must be packed before the pump is put into service. A complete set of packing cut to proper lengths is included with other loose parts in a box attached to the pump skid. The stuffing box should be packed in the following manner:

a) Remove (or raise out of the way) the stuffing box gland.

b) Carefully clean the stuffing box (with a lint free doth) clear of any scale build up and foreign matter which may have entered during shipment or storage.

c) In packing the stuffing box put in one ring at a time, pushing it well into place. Two rings of packing must be installed, and then the seal cage, then succeeding rings of packing until the box is filled. THE JOINTS OF SUCCEEDING RINGS MUST BE STAGGERED. See Figure 5.3 for additional packing information.

d) After the last ring of packing is in place, draw up the nuts on the gland (4120.1) evenly finger tight, then tighten nuts an extra 1/4 turn to initially set the packing. A slight amount of leakage through the gland is necessary for proper lubrication. Packing glands must never be tightened to the point where leakage from the packing is stopped.

e) Preserve any left over packing for future use. After the packing has been compressed under operating conditions, there may be enough room to allow another ring to be inserted.

CAUTION **There is a tapped hole leading into the stuffing box for the purpose of sealing the packing with liquid or grease. When the packing is compressed, the seal cage must be in line with this passage.**

CAUTION **Shutting off leakage flow from the packing will result in burned packing and scored shafts.**

FIGURE 5-3

Packing Information			
	Group 1	Group 2	Group 3
Packing size, square (inches)	0.31	0.31	0.38
Packing arrangement	2-C-3	2-C-3	2-C-3
Seal Cage width	0.50	0.75	0.50
Shaft Diameter	1.125	1.500	1375
	1.123	1498	1873

5.2 Bearing Lubrication

CAUTION Operation of the unit without proper lubrication can result in overheating of the bearings, bearing failures, pump seizures and actual breakup of the equipment exposing operation personnel to personal injury.

Check to see that connections are made to lubrication fittings at pump manifold (3869) on mounting plate (6110).

5.2.1 Line Shaft Bearings

Check to see that no damage has occurred to any lubrication lines above and below the mounting plate (6110) during shipment or installation. For number of bearings, refer to Figure 5-5 on next page.

5.2.1.1 External Flush Lubrication

a) Clean cool [<70C (160F)] liquid from an external source must be used when pumps are furnished with external flush lubrication connections.
b) Check to see that connections are made to lubrication fittings on pump manifold (3869) on mounting plate (6110) and that 1.9 LPM (0.5 gpm) of flushing fluid per bearing (See Figure 5-5) at 1.4 kg/cm^2 (20 PSIG) above maximum 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 (2025). 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 (6110) and for the adapter (1340.1) bearing (3020.2).
b) Check that 1.9 LPM (0.5 gpm) 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 with separators is available.

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 regreased prior to start-up through the grease fittings located in the manifold (3869) on the pump mounting plate (6110). Grease must be insoluble in the liquid being pumped. The recommended grease to be used is Keystone 81 EP-2 or an equivalent. Keystone 81 EP-2 is the grease that is packed in the bearing lubrication lines 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.

5.2.2 Thrust Bearing

The external thrust bearing will either be a regreaseable bearing (3031), in which case it will leave the factory with grease already packed, or it will be a shielded bearing (greased-for-life). For a regreaseable thrust bearing, it is suggested that the bearing be dregreased before starting the unit. A moisture-resistant, lithium-base grease of Number 2 consistency should be used. A shielded bearing will not need to be degreased, but will need to be replaced when it becomes excessively worn.

Note: Any unusual noise or vibration from the thrust bearing may mean the bearing is ready for replacement and the pump should be dismantled and bearing checked, and/or replaced.

5.2.3 Driver Bearings

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

FIGURE 5-4: Recommended lubricants

Line Shaft Bearings	External flush, product being pumped, or Keystone 81 EP-2 grease or equivalent
Thrust Bearing and motor	A moisture-resistant, lithium-base grease of Number 2 consistency.

FIGURE 5-5: Number of lineshaft 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 lineshaft bearing lubrication points, use the total quantity of lineshaft bearings on this sheet.
These spans meet the requirements of API 610, 7th Edition.

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 °C (220 °F).

FIGURE 5-6: Thrust bearing lubrication intervals*

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

* Assuming good maintenance and operation practices, and no contamination.
** Bearing housing skin temperature.

FIGURE 5-6a: Line bearing grease lubrication*

Pumpage	Clean	Contains abrasives
Interval	8 hours	4-6 hours

* Interval depends upon process conditions.
* Check grease cups daily.

Figure 5-6b: Line bearing lubrication amounts

Location	Amount
Intermediate Bearings [3020.1]	18 grams (0.63 oz.) 21 cm^3 (1.3 $in.^3$)
Bottom Bearing [3020.2]	11 grams (0.38 oz.) 47 cm^3 (2.9 $in.^3$)

Figure 5-6c: 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.

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 in Figures 5-6a and 5-6b.

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 systems. Consult your Flowserve representative for additional information.

Note: Grease for life bearings

Double shielded or double sealed bearings

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

5.3 Setting the Impeller Clearance

a) If not already done, turn off driver power and lock it out so that the driver cannot be started during impeller (2200) setting.
b) Rotate the shaft (2100) so that the impeller adjustment key (6700.3) is toward you.
c) Remove the retaining ring (2530.2) and key (6700.3) from the adjusting sleeve (1881).
d) Holding the shaft (2100) steady, turn the adjusting sleeve (3712) counterclockwise until the impeller (2200) is resting against the running face of the casing (1100).
e) Back the impeller (2200) off the casing (1100) by rotating the adjusting sleeve (3712) clockwise so that the next slot lines up with one of the shaft keyways:

For Groups 1 and 2, continue to rotate the sleeve (3712) in the same direction for another four or five combinations of shaft keyway/sleeve slots (22.5 degrees each - the keyway that lines up will alternate as the sleeve (3712) is turned).

For Group 3, continue to rotate the sleeve (3712) in the same direction for six or seven more combinations of shaft keyway/sleeve slots (the keyway that lines up will alternate as the sleeve (3712) 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.

5.4 Direction of rotation

5.4.1 Rotation check

CAUTION It is absolutely essential that the rotation of the motor be checked before connecting the shaft coupling. Incorrect rotation of the pump, for even a short time, can dislodge and damage the impeller, casing, shaft and shaft seal. All ESP pumps turn clockwise as viewed from the motor end. A direction arrow is cast on the front of the casing and support head [3160] as shown in Figure 5-7. Make sure the motor rotates in the same direction.

FIGURE 5-7

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.

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

5.5 Guarding

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

CAUTION The pump must not be operated without an approved coupling guard in place. Failure to observe this warning could result in injury to operating personnel.

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.

For ESP pumps, install the coupling guard with the connecting hardware.

5.6 Priming and auxiliary supplies

The fluid moving components (casing, impeller, and adaptor) of ESP pumps should be submerged during normal operation, so priming is not an issue.

Depending on the bearing lubrication options and the shaft sealing options, some auxiliary supply lines may need to be brought to the ESP pump. Check to see if any other connections need to be made to pump, such as injection water to stuffing box for seal or packing lubrication (when furnished) and make the required connections.

5.7 Starting the pump

All steps within section 4.0 “INSTALLATION” and section 5.1 "PRE-COMMISSION PROCEDURE" must be complete before initiating the pump starting procedure.

CAUTION 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.

After all pre-starting checks have been performed, the pump is ready to start. Observe the following procedure to put the pump into operation:

a) Rotate the pump shaft by hand through at least one complete revolution to see that there is no rub or bind.
b) Check the discharge piping and destination of the flow.
c) Check the sump liquid level. Liquid level must be sufficient enough to engulf the casing and adapter
d) Close, or leave open very slightly, the control valve in the discharge line.
e) If external flush-lubricated bearings are used, turn on water supply to the bearings.

f) Turn on other auxiliary lines (if required) such as stuffing box injection or mechanical seal flush.
g) Start the driver. If other than motor drive, bring the pump up to speed quickly.
h) As soon as the pump is up to rated speed, open the discharge valve slowly, to desired capacity or pressure keeping in mind the minimum continuous flow listed in section 3.4.
i) Check all joints and mechanical seal (if furnished) for leakage.
j) If packing is furnished, adjust the packing gland and flush flow.
k) Check for excessive vibration.
l) Monitor bearing temperature until it stabilizes.

CAUTION It is important that the discharge valve be opened within a short interval after starting the driver. Failure to do this could cause a dangerous build up of heat, and possibly an explosion.

5.8 Running or operation

5.8.1 Operating Checks

Costly shut-downs 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 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 or grease and sealing and cooling liquid flows, should be checked frequently.

5.8.2 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 3.4.1.)

5.8.3 Minimum thermal flow

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

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

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

Thermostats may be used to safeguard against 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. The bypass line must always enter the sump (pit) at a point below the liquid level to prevent air entrainment.

5.8.4 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.

5.8.5 Surging condition

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

5.8.6 Operation in sub-freezing conditions

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

CAUTION The pump unit must not be operated above the nameplate conditions. Such operation could result in unit failure and injury to personnel.

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	9.0 (0.35)	12.7 (0.50)
Shutdown	**N** x 2.0	11.3 (0.45)	16. (0.63)

5.9 Stopping and shutdown

CAUTION The pump should be shut down rapidly, especially on pumps equipped with product-lubricated bearings.

Pumps driven by electric motors do not require any special shut-down procedure. If turbine drive is used, the operator must manually trip the over speed trip to obtain rapid shut-down. Close the gate valve in the discharge line if maintenance work is to be done on pump.

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. 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.

5.10.5 Minimum submergence
Each ESP pump has a minimum submergence depending on the design conditions of that pump. See Figure 3-3 in section 3.4 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 wcompletely 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 1.6.2.)

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

On completion of work all guards and safety devices must be re-installed and made operative again. Before restarting the machine, the relevant instructions listed in section 5, *Commissioning, start up, operation and shut down* must be observed.

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

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

When air or compressed inert gas is used in the maintenance process, the operator and anyone in the vicinity must be careful and have the appropriate protection. Do not spray air or compressed inert gas on skin. Do not direct an air or gas jet towards other people. Never use air or compressed inert gas to clean clothes.

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

With electric drive equipment, lock the main switch open and withdraw any fuses. Put a warning sign on the fuse box or main switch:
"Machine under repair: do not connect."
Never clean equipment with flammable solvents or carbon tetrachloride. Protect yourself against toxic fumes when using cleaning agents.

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

6.1 Maintenance schedule

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

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

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.

- 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.

6.2.1 Ordering of spare parts

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

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

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

6.3 Recommended spares and consumable items

Figure 6-1 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.

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

			Class	
Part Number	Description	1	2	3
3031	Thrust bearing		1	1
---	Coupling			1
---	Motor complete (see note 3)			1
4120.1	Gland		1	1
3250	Bearing holder		Note1	Note1
6700.2	Pump key			1
2200	Impeller			1
2500	Seal ring for adapter			1
4200	Mechanical seal (optional)	1	1	1
3712	Adjusting sleeve			1
4610	Impeller o-ring			1
4134	Seal cage -- packed box		1	1
4590.1	Gasket -- casing	1	1	1
4590.3	Gasket -- stuffing box to upper column	1	1	1
---	Gasket -- mechanical seal (optional)	1	1	1
4590.5	Gasket -- column to mounting plate	1	1	1
4590.4	Gasket -- manifold to mounting plate		1	1
4130	Packing (optional)	Note1	Note1	Note1
4310.1	Klozure lip seal -- bearing body	1	1	1
4310.2	Klozure lip seal -- upper column	1	1	1
2100	Pump shaft (see note 2)			1
6531	Strainer			1
6541.3	Impeller washer -- Group 3		1	1
3020.1	Bearing -- intermediate		Note1	Note1
3020.2	Bearing -- adapter (bottom)		1	1
3110	Bearing body -- thrust bearing		1	1
4590.2	Gasket -- discharge pipe to casing flange	1	1	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.

6.4 Tools required

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

Standard hand tools SAE

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

Specialized equipment

- Bearing pullers
- Bearing induction heaters
- Dial indicators
- Spanner wrench

6.5 Fastener torques

FIGURE 6-2: Recommended maximum bolt torques

Item	Description	Group 1 non-lubricated	Group 2 non-lubricated	Group 3 non-lubricated
[6580.2]	Mechanical seal gland studs/nuts, with gasket	⅜ in. – 16 Nm (12 lbf•ft)	⅜ in. – 16 Nm (12 lbf•ft)	½ in. – 41 Nm (30 lbf•ft)
[6580.2]	Mechanical seal gland studs/nuts, with O-ring	⅜ in. – 27 Nm (20 lbf•ft)	⅜ in. – 27 Nm (20 lbf•ft)	½ in. – 54 Nm (40 lbf•ft)
[6580.1]	Casing studs/nuts and all other bolting	½ in. – 41 Nm (30 lbf•ft)	½ in. – 41 Nm (30 lbf•ft) ⅝ in. – 81 Nm (60 lbf•ft)	¾ in. – 136 Nm (100 lbf•ft) ⅞ in. – 217 Nm (160 lbf•ft)

Notes: 1. For lubricated or PTFE-coated threads, use 75% of the values given.
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 o-ring [4610] must be installed whenever the impeller has been removed from the shaft. Impeller clearance settings may be found in section 5.3. Impeller balancing instruction may be found in section 6.8.

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 an 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 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.

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

6.7 Disassembly

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

CAUTION Depending on the product being pumped, the pump should be washed down and decontaminated before any work is done on it.

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) Disconnect any external auxiliary piping connections.
e) Disconnect discharge piping from pump.
f) Disconnect coupling guard and coupling halves.
g) Disconnect driver and remove.
h) Unbolt pump mounting plate (6110) and lift pump (see Sections 2.3 and 4.4) from pit. Let the pump drain thoroughly before removing pump completely. Remove casing drain, 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
- For Groups 1 and 2 and 6x4x13: unscrew the flange (1245.2), locknut (3712), and loosen the lower locknut. Then the upper discharge pipe (1360) can be unscrewed.
- For Group 3 pumps (except the 6x4x13): unscrew the flange (1245.2). These pumps are furnished with the discharge pipe bolted to the mounting plate by a flange (1245.3) and four screws (6570.11). Remove the screws holding the flange to the mounting plate (6110).
- Both: 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 under side of the mounting plate (6110).

b) Remove bearing lubrication lines (3840.1).
c) Unbolt and remove the pump casing (1100). 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 counter-clockwise (looking in at the vanes) while holding the drive coupling with a strap wrench. 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. The impeller threads are sealed by an O-ring (4610) which should then be replaced.
e) Removing the thrust bearing:
- Pumps without Vapor Proof or Pressurized Construction: remove the thrust bearing by first unbolting the support head (3160). For groups 1 and 2 the support head will be disconnected from the mounting plate (6110) and 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.

- Now remove the thrust bearing holder (3110) and the thrust bearing assembly (3031, 3712) by unscrewing the sleeve (3712) from the shaft (2100).

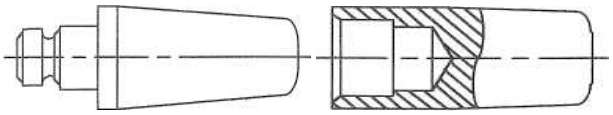
- Pumps with Vapor Proof or Pressurized Construction: first remove the support head (3160) from the bearing bracket (3130). Next remove the bearing body (3110) and the thrust bearing assembly (3031, 3712) by unscrewing the sleeve (3712) from the shaft (2100). For groups 1 and 2 the bearing bracket will be disconnected from the mounting plate (6110) and 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 support head 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.

f) Unbolt the gland 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. If the pump contains packing remove the packing at this time.
g) Now the stuffing box can be unbolted and removed gently from the shaft.
h) A shaft-bullet (See Figure 6-3) is recommended, but not required, for the next step. If a shaft bullet is to be used, attach the bullet in place of the impeller (2200). Remove the shaft (2100) from the remainder of the pump.

FIGURE 6.3 Shaft bullets



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

i) Unbolt and remove the adapter (1340.1).
j) Unbolt and remove the columns (1341.2) and the bearing holders (3250) until the upper column is reached (1341.1).
k) The shaft bearings should not be removed from their housings unless they are to be replaced. Table 6.1 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.
l) Intermediate shaft bearings (3020.1) can be pressed or driven out of their bearing holder (3250) when replacing.
m) 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) taking the seal ring (2500) with it.

FIGURE 6.4 Shaft, bearing, and bearing holder tolerances

Part	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		47.47 mm (1.869 in.)
3020	Group 1 Line Shaft Bearings		
	Solid Carbon	28.994 mm (1.1415 in.)	
	Metal-backed Carbon	28.689 mm (1.1295 in.)	
	Bronze	28.766 mm (1.1325 in.)	
	Rubber	28.766 mm (1.1325 in.)	
	Teflon	28.956 mm (1.1400 in.)	
	Iron	28.651 mm (1.1280 in.)	
	Group 2 Line Shaft Bearings		
	Solid Carbon	38.557 mm (1.5180 in.)	
	Metal-backed Carbon	38.329 mm (1.5090 in.)	
	Bronze	38.329 mm (1.5090 in.)	
	Rubber	38.367 mm (1.5105 in.)	
	Teflon	38.481 mm (1.5150 in.)	
	Iron	38.329 mm (1.5090 in.)	
	Group 3 Line Shaft Bearings		
	Solid Carbon	48.082 mm (1.8930 in.)	
	Metal-backed Carbon	47.854 mm (1.8840 in.)	
	Bronze	47.854 mm (1.8840 in.)	
	Rubber	47.892 mm (1.8855 in.)	
	Teflon	48.006 mm (1.8900 in.)	
	Iron	47.854 mm (1.8840 in.)	
3250 1340.1	Group 1 Bearing Holder/Adapter	41.288 mm (1.6255 in.)	
	Group 2 Bearing Holder/Adapter	50.813 mm (2.0005 in.)	
	Group 3 Bearing Holder/Adapter	66.688 mm (2.6255 in.)	

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 and cause vibration and wear in other parts of the pump. Be sure the o-ring (4610) 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.

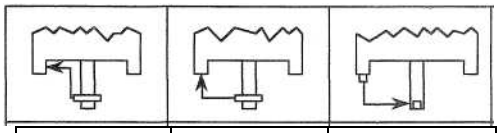
e) Inspect the casing (1100) thoroughly, removing all burrs and foreign matter. Check hydraulic passages for cleanliness.

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 6-5. Should any of these limits be exceeded, check with the driver manufacturer for recommended repair or replacement parts.

rrrrrrrrrr

FIGURE 6-5 Motor tolerances



A	B	C

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

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

Shaft whip is deflection where the centerline of the impeller is moving around the true axis of the pump. It is not caused by hydraulic force but rather by an imbalance with the rotating element. Shaft whip is very hard on the mechanical seal because the faces must flex with each revolution in order to maintain contact.

To minimize shaft whip it is imperative that the impeller is balanced. All impellers manufactured by Flowserve are balanced after they are trimmed. If for any reason, a customer trims an impeller, it must be re-balanced. See note 1 under Figure 6-19 regarding acceptance criteria.

6.8.3.4 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. See section 5.8.7 for guidance on vibration monitoring.resfdb

FIGURE 6-6

Topic	**ASME B73.1M standard mm (in.)**	**Suggested by major seal vendors mm (in.)**	**Suggested and/or provided by Flowserve mm (in.)**
Impeller Balance		See note 1	
Bearing housing Diameter (ID) tolerance at bearings	n/s		0.013 (0.0005)
Shaft endplay	n/s	0.05 (0.002)	0.05 (0.002)

n/s = not specified.

1. The maximum values of acceptable unbalance are: 1500 r/min: 40 g·mm/kg (1800 r/min: 0.021 oz-in/lb) of mass. 2900 rpm: 20 g·mm/kg (3600 rpm: 0.011 oz-in/lb) of mass. Flowserve performs a single plane spin balance on most impellers. The following impellers are exceptions: 10X8-13, 10X8-15. On these Flowserve performs a two plane dynamic balance, as required by the ASME B73.1M standard. All balancing, whether single or two plane, is performed to the ISO 1940 Grade 6.3 tolerance criteria.
2. The ASME B73.1M standard does not specify a recommended level of alignment. Flowserve recommends that the pump and motor shafts be aligned to within 0.05 mm (0.002 in.) parallel FIM (full indicator movement) and 0.0005 mm/mm (0.0005 in./in.) angular FIM. Closer alignment will extend MTBPM.

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.

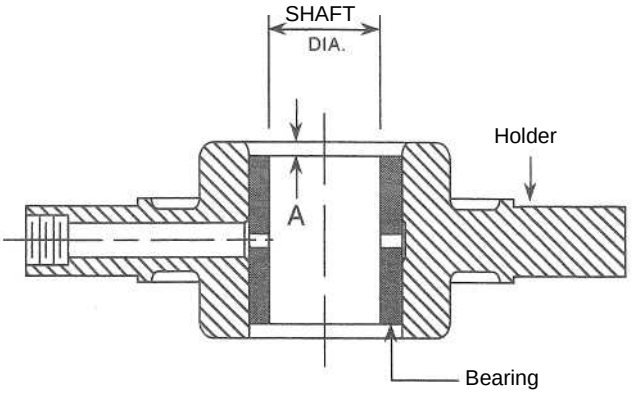
Note: Refer to Figure 6-5 for recommended bolt torques.

During reassembly be sure to use new gaskets and o-rings.

6.9.1 Replacing shaft sleeve bearings

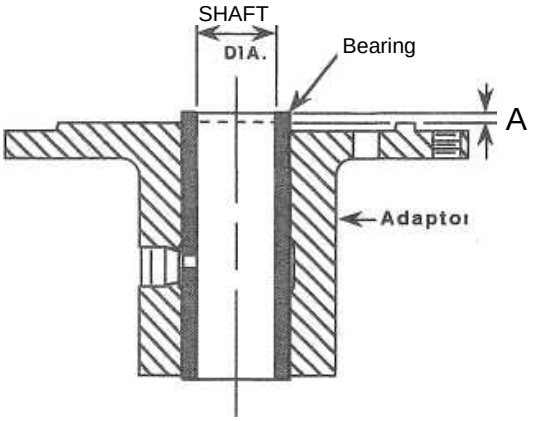
a) After removing the old intermediate bearings (3020.1) (see section 6.7.2) clean and deburr bearing holder bore. Apply a light coating of grease or oil to bearing holder bore and out-side diameter of new bearing. Carefully press new bearing into holder to "A" dimension in Figure 6-7.
b) After removing the adapter bearing (3020.2) (see section 6.7.2) clean and deburr adapter bore. Apply a light coating of grease or oil to bearing holder bore and outside diameters of new bearings. Carefully press the sealing ring and new bearing, respectively, into adapter to "A" dimension in Figure 6-8.
c) Be sure that all bearings (3020.1-.2) are now within their bearing holders (3250, 1340.1).

FIGURE 6-7 Intermediate bearing



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.)
47.63 mm (1.875 in.)	3.2 mm (.125 in.)

FIGURE 6-8 Adapter bearing



Shaft Diameter	A
28.58 mm (1.125 in.)	3.2 mm (.125 in.)
38.10 mm (1.500 in.)	9.5 mm (.375 in.)
47.63 mm (1.875 in.)	3.2 mm (.125 in.)

6.9.2 Inserting the shaft using a "shaft bullet" (see Figure 6-3)

a) **Standard and vapor tight construction:** connect the upper column (1341.1) to the mounting plate (6110). For Group 3, the upper column and support head (3160) must be bolted to the mounting plate at the same time. **Vapor proof or pressurized construction:** replace the upper column gasket (4590.5) and reconnect the upper column (1341.1) to the mounting plate (6110). For Group 3, the bearing bracket (3130) must be bolted to the mounting plate at the same time.

b) If intermediate bearings are used, reconnect the columns (1341.2) and intermediate bearing holders (3250).

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) **All designs (excluding Group 3 vapor proof and pressurized):** the pump shaft (2100) should now be inserted into the pump from the mounting plate side. **For Group 3 vapor proof and pressurized designs:** if the lip seal (4310.1) is still in the bearing bracket (3130), remove it at this time. Slide the shaft (2100) through the bearing bracket and down through the columns. Once the shaft has cleared the bearing bracket, replace or reinsert the lip seal into the bearing bracket.

6.9.3 Inserting the shaft without "shaft bullet"

a) **Standard and vapor tight construction:** connect the upper column (1341.1) to the mounting plate (6110). For Group 3, the upper column and support head (3160) must be bolted to the mounting plate at the same time. **Vapor proof or pressurized construction:** replace the upper column gasket (4590.5) and reconnect the upper column (1341.1) to the mounting plate (6110). For Group 3, the bearing bracket (3130) must be bolted to the mounting plate at the same time.

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

b) **All designs except Group 3 vapor proof and pressurized:** 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. **For Group 3 vapor proof and pressurized:** if the lip seal (4310.1) is still within the bearing bracket (3130), remove it at this time. Insert the shaft from the motor side of the pump through the bearing bracket (3130) and starter column (1341.1) until the shaft threads (for the thrust bearing - 3031) are about 3 inches from the starter column. Replace or reinsert the lip seal (4310.1) into the bearing bracket (3130).

c) Slide the first bearing holder (3250), with bearing in place, onto the end of the shaft (2100).

d) If intermediate bearings are used, then slide the rest of the columns (1341.2) and bearings (3020, 3250) onto the pump.

e) If no intermediate bearings are used on pump, or after they have all been installed, then slide the adapter (1340.1) onto the shaft (2100) and bolt to the starter column (1341.1).

6.9.4 Impeller installation

a) Insert a new o-ring (4610) at base of impeller (2200) threads.

b) Apply a light coat of grease or oil to impeller threads as to allow for ease of disassembly in the future.

c) Using a strap wrench to hold the drive coupling, screw impeller (2200) onto the end of the pump shaft (2100) clockwise until snugly fit.

CAUTION Do not attempt to use a crowbar as a lever as damage to the vanes may result.

6.9.5 Thrust Bearing Reassembly

(Vapor proof and pressurized designs)

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

- For Group 1 and 2 pumps: Reattach the stuffing box (4100) to the upper column. See section 6.9.6 "Packing" or section 6.9.7 "Mechanical Seal" for next steps.

- For Group 3 pumps: Push the shaft towards the mounting plate until the threads are lined up with the top of the column. Insert the stuffing box (4100) from the side and bolt to the column. If a mechanical seal is being used, push the shaft up from the adapter (1340.1) side while pushing the seal (4200) and gland (4120.2) onto the **Teflon taped** threaded end of the shaft from within the bearing bracket. If packing (4130) is being used, push the shaft up from the adapter (1340.1) end while pushing the gland (4120.1) onto the **Teflon taped** threaded end of the shaft. Leave the gland (4120.2) and mechanical seal, if furnished, loose on the shaft for now. DO NOT SET SEAL AT THIS TIME. See section 6.9.6 “Packing" or section 6.9.7 "Mechanical Seal" for the next steps.

6.9.5 Packing

a) If the pump is furnished with packing, put one ring in at a time.
b) Two rings should be inserted and then the seal cage (4134) and then the succeeding rings of packing until the box is filled.

CAUTION The joints of succeeding packing rings must be staggered and the seal cage must line up with the passage leading into the stuffing box for proper lubrication.

c) Now slide the gland (4120.1) over the shaft and draw up the nuts finger tight, then tighten nuts an extra 1/4 turn.
d) Reattach the thrust bearing assembly (3031, 3712).
e) Reattach the thrust bearing holder (3110).
f) Reattach the support head (3160).

6.9.5 Mechanical Seal

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

a) See section 5.1.2.1 for seal installation directions.
b) Connect the thrust bearing assembly (3031, 3712).
c) Reattach the thrust bearing holder (3110).
d) Reattach the support head (3160).

6.9.5 Casing and discharge piping

a) Place a new gasket (4590.1) on the gasket face of the adapter (1340.1) where the adapter and casing (1100) will line up.
b) Bolt the pump casing to the adapter
c) If the strainer (6531) had been removed for cleaning or replacement purposes, reattach strainer to suction flange of the casing.
d) Reconnect all bearing lubrication lines (3840.1).
e) **For Groups 1, 2, and 6x4x13:** At this point the lower locknut (3712) 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 (6110) 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.

f) Replace the gasket (4590.2) between the companion flange and the discharge flange of the casing and bolt back together.
g) The upper lock-nut 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.
h) **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 (6110).
i) Set the impeller clearance per Section 5.3.
j) See Section 4 and Section 5 for installation and startup instructions.

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 that is not covered by one of the examples, then 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. If not, redesign suction piping, holding number of elbows and number of planes to a minimum to avoid adverse flow rotation as it approaches the impeller.
●	●	●								System head greater than anticipated.	Reduce system head by increasing pipe size and/or reducing number of fittings. Increase impeller diameter. (Note: Increasing impeller diameter may require use of a larger motor.)
●	●		●							Entrained air. Air leak from atmosphere on suction side.	1. Check 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 end play.
	●	●								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.
					●					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.
						●				Too much flow.	System resistance to flow is too low. Close discharge valve more.

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**
					●				Brinelling of bearing identified by indentation on the ball races, usually caused by incorrectly applied forces in assembling the bearing or by shock loading such as hitting the bearing or drive shaft with a hammer.	When mounting the bearing on the drive shaft use a proper size ring and apply the pressure against the inner ring only. Be sure when mounting a bearing to apply the mounting pressure slowly and evenly.
					●				False brinelling of bearing identified again by either axial or circumferential indentations usually caused by vibration of the balls between the races in a stationary bearing.	1. Correct the source of vibration. 2. Where bearings are oil lubricated and employed in units that may be out of service for extended periods, the drive shaft should be turned over periodically to relubricate all bearing surfaces at intervals of one to three months.
					●				Thrust overload on bearing identified by flaking ball path on one side of the outer race or in the case of maximum capacity bearings, may appear as a spalling of the races in the vicinity of the loading slot. 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. Motor soft foot frame distortion. 2. Pump shaft bent and binding in sleeve bearings.

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8 PARTS LIST AND DRAWINGS

FIGURE 8-1: ESP2 major parts interchangeability

Part	Pump Size	1½x1x6	3x1½x6	3x2x6K	1½x1x8	3x1½x8	3x2x8	3x1½x8	3x2x8	4x3x8	4x3x8L	2x1x10	3x1½x10	3x2x10	4x3x10	4x3x10L	6x4x10	3x1½x13	3x2x13	4x3x13	6x4x13	8x6x13	10x8x13	8x6x15	10x8x15
	Pump Group	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3
2469	CASING	1	2	3	4	5	6	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
2584A	CASING GASKET	1	1	1	2	3	3	3	3	3	3	4	4	4	4	4	4	5	5	5	5	5	5	6	6
1129	IMPELLER	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
0014A	ADAPTER	1	1	1	2	3	3	4	4	4	4	5	5	5	5	5	5	6	6	6	7	8	8	9	9
1663	SEALING RING	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3
2845	STRAINER	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	2	2	3	2	3
2945A	INTER. BEARING	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3
2945B	ADAPTER BRG.	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3
2807	SHAFT	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3
2507A	UPPER COLUMN	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3
2507B	INTER. COLUMN	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3
1109A	BRG. HOLDER	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3
1063	SUPPORT HEAD	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3
1423A	DISC. PIPE	1	1	1	1	1	1	1	1	2	2	1	1	1	2	2	3	1	1	2	3	4	5	4	5
0561	COUPLING	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3
3114	BEARING BODY	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3
0127	BALL BEARING	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3
1881	ADJUST. SLEEVE	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3
2423	BRG. BRACKET	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3
20A11A	IMP. O-RING	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	3	4	4	4	4
0575	STUFF BOX	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3
0975A	GLAND	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3

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FIGURE 8-2: Group 1&2 sectional assembly

Ref. No.	Old P/N	DESCRIPTION
1340.1	0014	ADAPTOR
1232.1	0440	CLAMP -- LUBE PIPING
CPL	0561	COUPLING -- FLEXIBLE
1232.2	0576	COVER PLATE -- CLAMP
DRIVER	0743	DRIVER
1371	0767	ELBOW -- DISCHARGE
6700.1	11A9A	KEY -- DIRVER SHAFT
6700.2	11A9B	KEY -- PUMP SHAFT
6541.1	12A5	WASHER -- STRAINER
6541.2	12A5A	WASHER -- ADAPTER TO CASING
4610	20A11	O-RING -- IMPELLER
3031	0127	BEAIRNG -- THRUST
1245.1	26A8	FLANGE -- CASING
6515.1	30A7A	PLUG -- CASING DRAIN
6515.2	30A7B	PLUG -- CAISNG DISCHARGE
4590.2	32A11	GASKET -- CASING DISCHARGE
6570.1	35A2A	CAPSCREW -- SUPP HD TO MTR
6570.2	35A2B	CAPSCREW -- INTER. BRG
6570.3	35A2C	CAPSCREW -- COL. TO ADAPTOR
6570.4	35A2D	CAPSCREW -- DISCHARGE
6570.5	35A2E	CAPSCREW -- ADAPT. TO CASING
6570.6	35A2F	CAPSCREW -- STNR. TO ADAPTOR
6570.7	35A2G	CAPSCREW -- MFLD. TO MTG PLT
6570.8	35A2J	CAPSCREW -- BRG BODY TO COL.
6570.9	35A2P	CAPSCREW -- CLAMP
3712	36A7	LOCKNUT -- PIPE
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
6570.11	119A2A	CAPSCREW -- COL. TO MTG PLT
6570.12	119A2B	CAPSCREW -- SUPP HD - MTG PLT
2530.1	162A13	SNAP RING
3853.1	18A7B	NIPPLE -- PIPE
2530.2	181A13	RETAINING RING
3853.2	78A7	COUPING -- PIPE
3853.3	250A10B	FITTING GREASE (THRUST BRG)
3160	1063	SUPPORT HEAD
3840.1	1104	HOSE KIT -- LUBE PIPING
3250	1109	HOLDER -- BEARING
2200	1129	IMPELLER
3869	1264	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
3712	1881	SLEEVE -- ADJUSTING
6110	2025	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	2796A	LIP SEAL -- UPPER
4310.2	2796B	LIP SEAL -- LOWER
2100	2807	SHAFT
6531	2845	STRAINER
3020.1	2945A	BEARING -- INTERMEDIATE
3020.2	2945B	BEARING -- BOTTOM
3110	3114	BEARING BODY

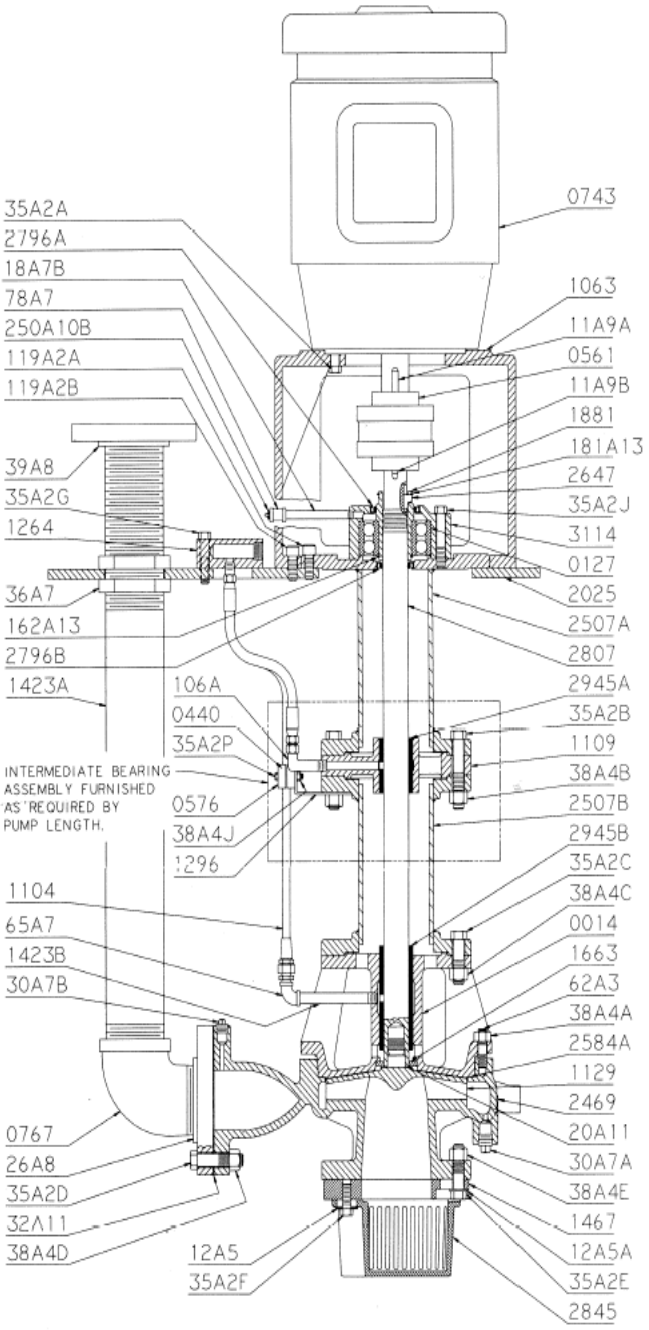


FIGURE 8-3: Group 3 section assembly

Ref. No.	Old P/N	DESCRIPTION
1340.1	0014	ADAPTOR
1232.1	0440	CLAMP -- LUBE PIPING
CPL	0561	COUPLING -- FLEXIBLE
1232.2	0576	COVER PLATE -- CLAMP
DRIVER	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
4610	20A11	O-RING -- IMPELLER
3031	0127	BEAIRNG -- THRUST
6515.1	30A7A	PLUG -- CASING DRAIN
6515.2	30A7B	PLUG -- CAISNG DISCHARGE
4590.2	32A11	GASKET -- CASING DISCHARGE
6570.1	35A2A	CAPSCREW -- SUPP HD TO MTR
6570.2	35A2B	CAPSCREW -- INTER. BRG
6570.3	35A2C	CAPSCREW -- COL. TO ADAPTOR
6570.4	35A2D	CAPSCREW -- DISCHARGE
6570.6	35A2F	CAPSCREW -- STNR. TO ADAPTOR
6570.7	35A2G	CAPSCREW -- MFLD. TO MTG PLT
6570.8	35A2J	CAPSCREW -- BRG BODY TO COL.
6570.9	35A2P	CAPSCREW -- 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	CAPSCREW -- SUPP HD - MTG PLT
2530.1	162A13	SNAP RING
3853.1	18A7B	NIPPLE -- PIPE
2530.2	181A13	RETAINING RING
3853.2	78A7	COUPING -- PIPE
3853.3	250A10B	FITTING GREASE (THRUST BRG)
3160	1063	SUPPORT HEAD
3840.1	1104	HOSE KIT -- LUBE PIPING
3250	1109	HOLDER -- BEARING
2200	1129	IMPELLER
3869	1264	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
3712	1881	SLEEVE -- ADJUSTING
6110	2025	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	2796A	LIP SEAL -- UPPER
4310.2	2796B	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	3114	BEARING BODY

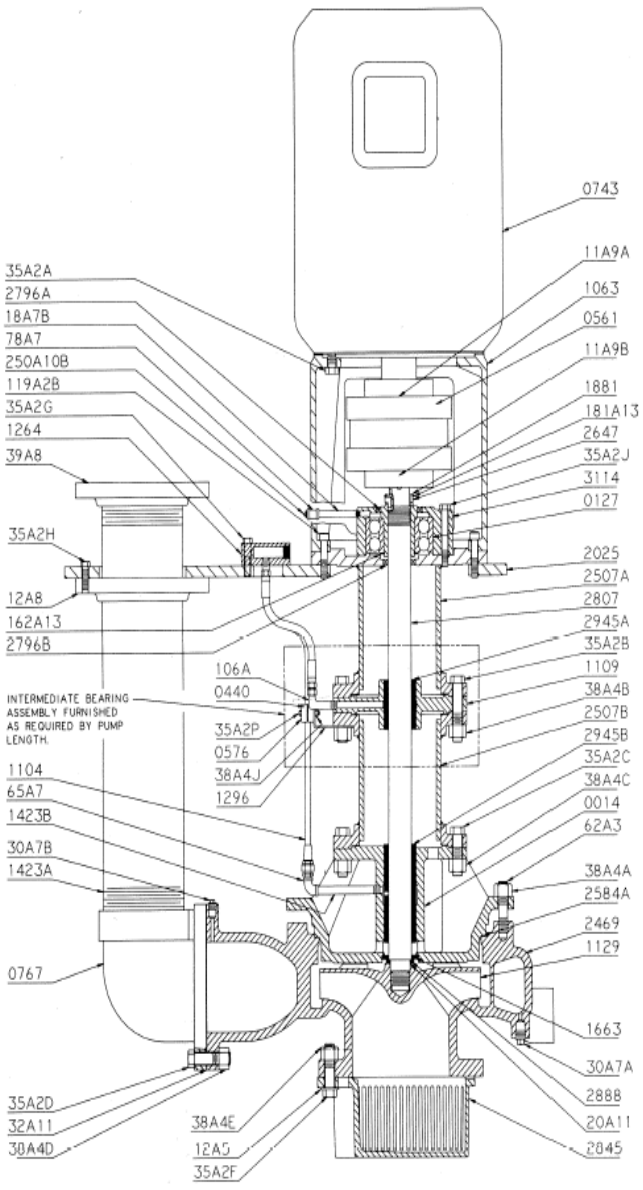
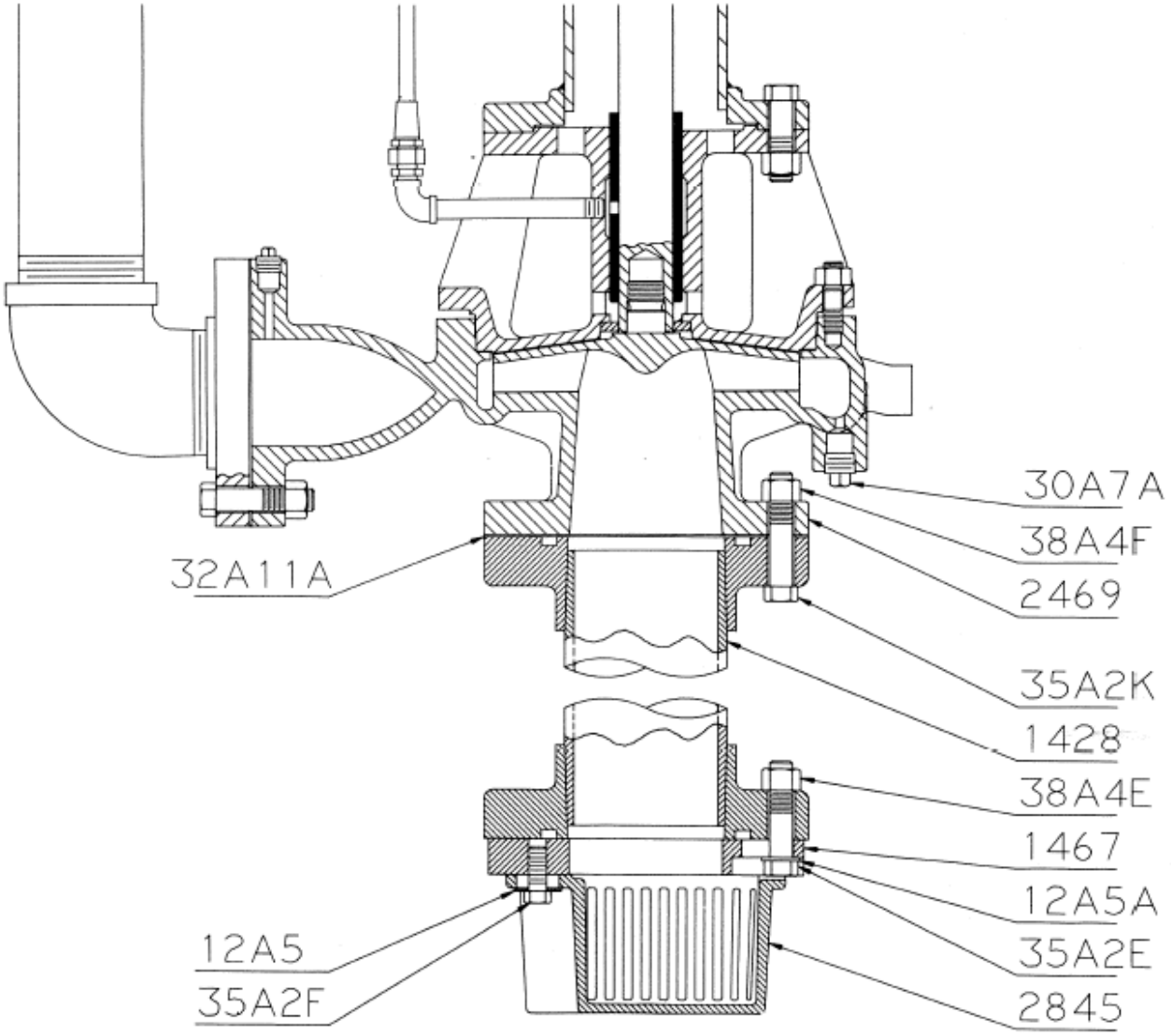
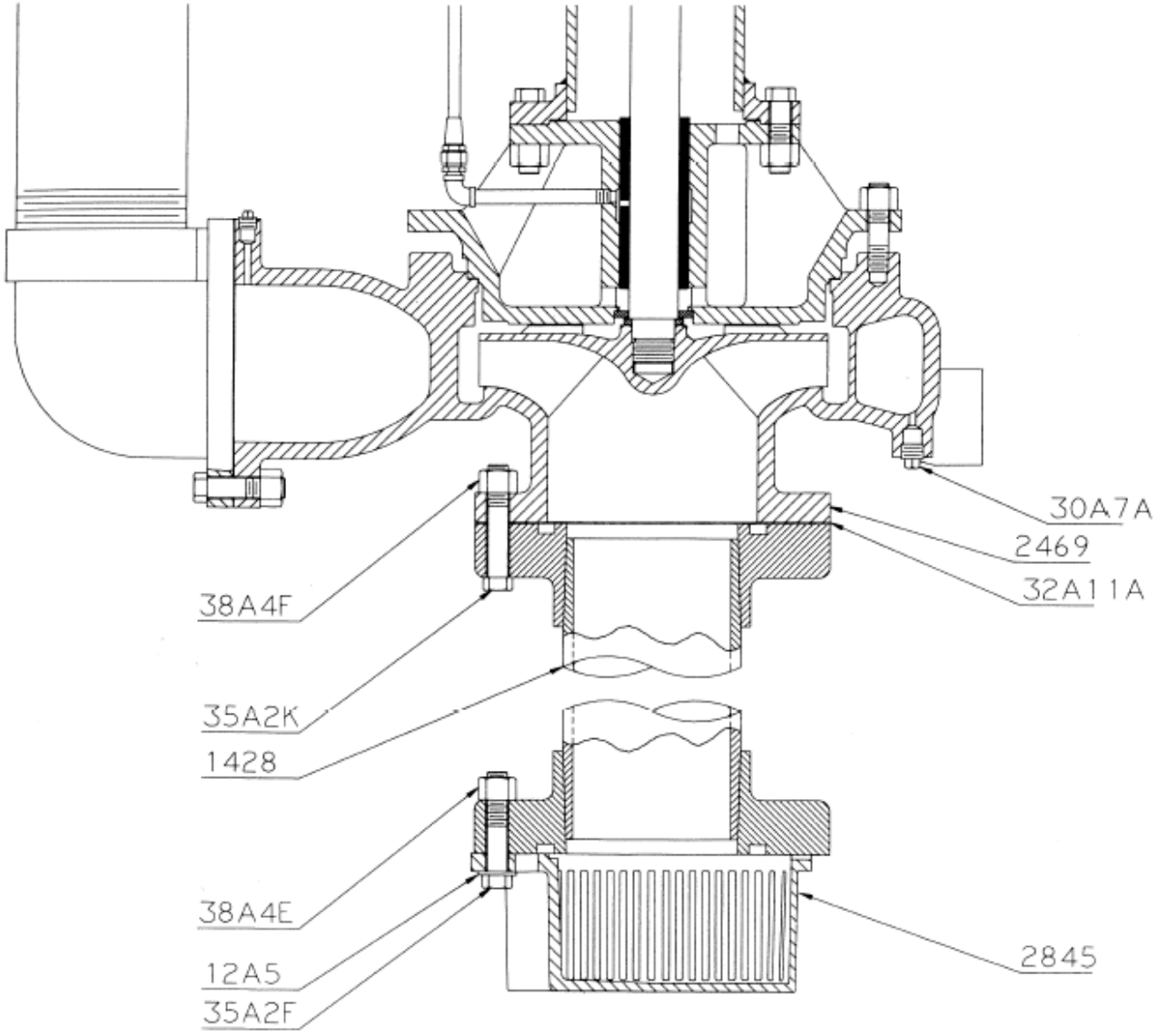


FIGURE 8-4: Group 1&2 tail pipe assembly



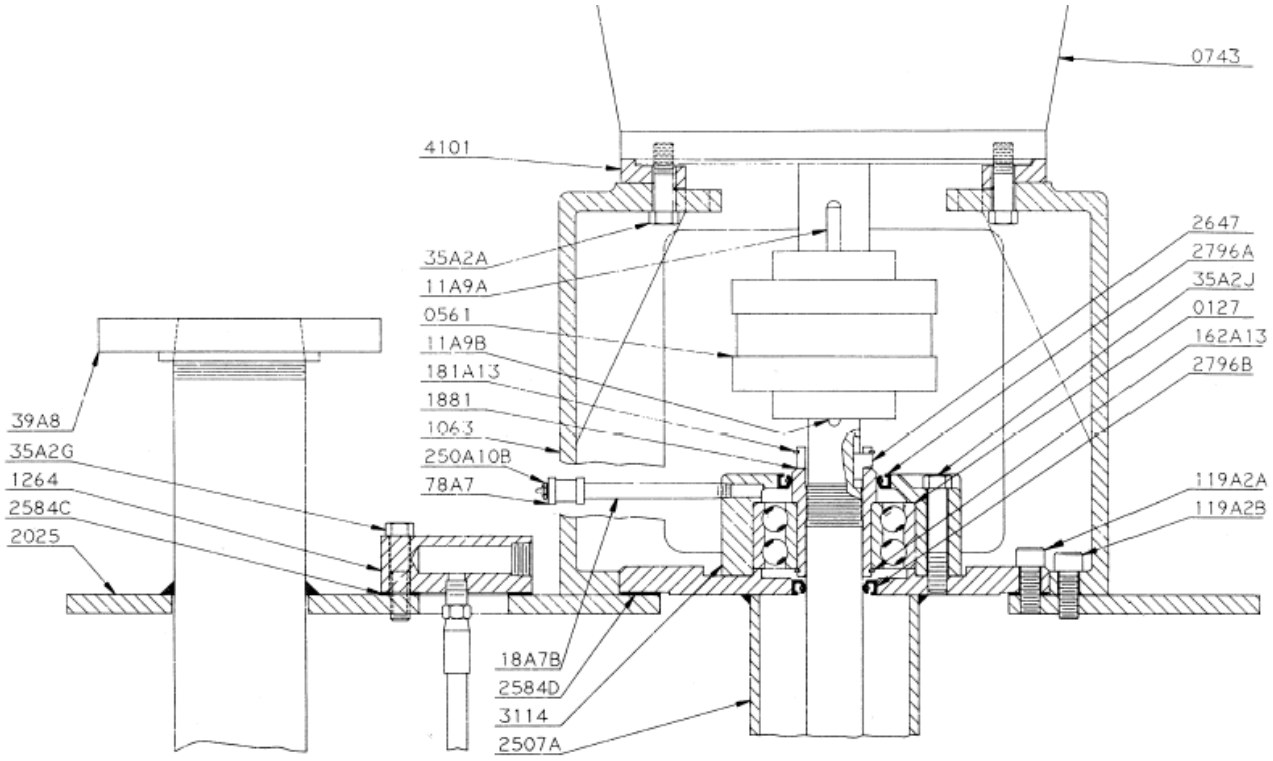
Ref. No.	Old P/N	DESCRIPTION
6541.1	12A5	WASHER -- STRAINER
6541.2	12A5A	WASHER -- ADAPTER TO CASING
6515.1	30A7A	PLUG -- CASING DRAIN
4590.6	32A11A	GASKET -- CASING SUCTION
6570.5	35A2E	CAPSCREW -- ADAPT. TO CASING
6570.6	35A2F	CAPSCREW -- STNR. TO ADAPTOR
6570.10	35A2K	CAPSCREW -- CASING TO TAILPIPE
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: Group 3 tail pipe assembly



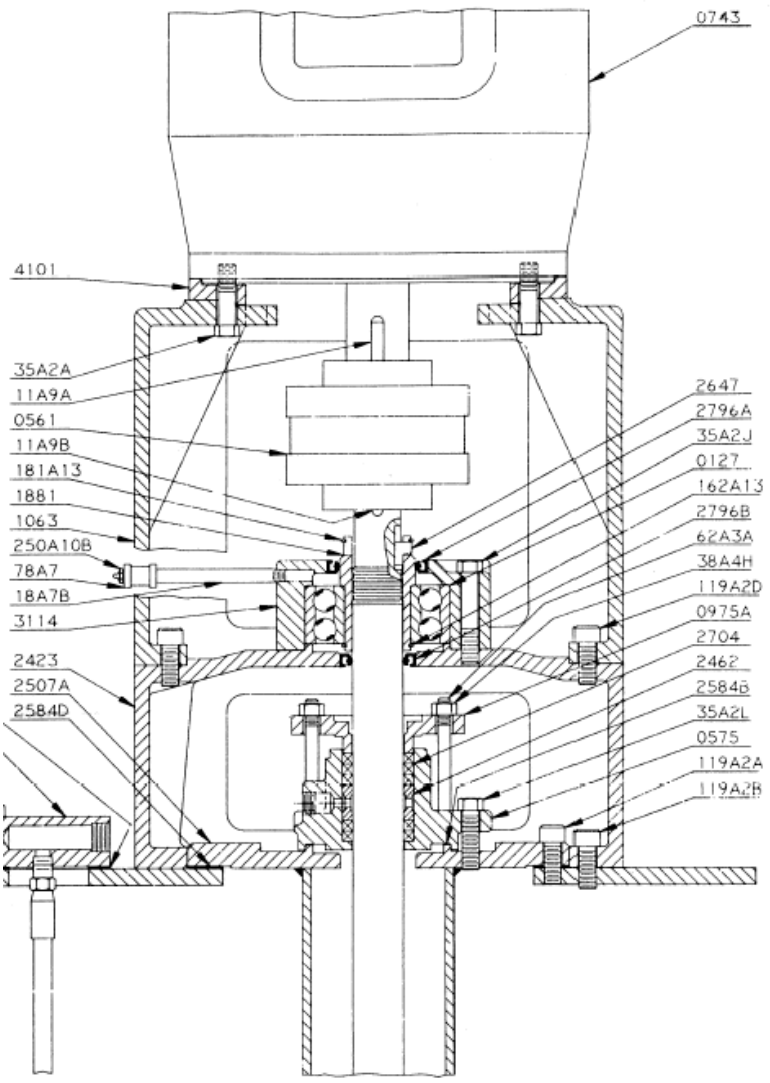
Ref. No.	Old P/N	DESCRIPTION
6541.1	12A5	WASHER -- STRAINER
6515.1	30A7A	PLUG -- CASING DRAIN
4590.6	32A11A	GASKET -- CASING SUCTION
6570.6	35A2F	CAPSCREW -- STNR. TO ADAPTOR
6570.10	35A2K	CAPSCREW -- CASING TO TAILPIPE
6580.5	38A4E	NUT -- HEX STRAINER
6580.7	38A4F	NUT -- HEX CASING TO TAILPIPE
1341.3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

FIGURE 8-6: Vapor-tight construction



Ref. No.	Old P/N	DESCRIPTION
CPL	0561	COUPLING -- FLEXIBLE
1232.2	0576	COVER PLATE -- CLAMP
DRIVER	0743	DRIVER
6700.1	11A9A	KEY -- DIRVER SHAFT
6700.2	11A9B	KEY -- PUMP SHAFT
3031	0127	BEAIRNG -- THRUST
6570.1	35A2A	CAPSCREW -- SUPP HD TO MTR
6570.7	35A2G	CAPSCREW -- MFLD. TO MTG PLT
6570.8	35A2J	CAPSCREW -- BRG BODY TO COL.
1245.2	39A8	FLANGE -- DISCHARGE
6570.11	119A2A	CAPSCREW -- COL. TO MTG PLT
6570.12	119A2B	CAPSCREW -- SUPP HD - MTG PLT
2530.1	162A13	SNAP RING
3853.1	18A7B	NIPPLE -- PIPE
2530.2	181A13	RETAINING RING
3853.2	78A7	COUPING -- PIPE
3853.3	250A10B	FITTING GREASE (THRUST BRG)
3160	1063	SUPPORT HEAD
3869	1264	MANIFOLD -- LUBE PIPING
3712	1881	SLEEVE -- ADJUSTING
6110	2025	MOUNTING PLATE
1341.1	2507A	COLUMN -- UPPER
4590.4	2584C	GASKET -- MANIFOLD TO MTG. PL.
4590.5	2584D	GASKET -- UPPER COL. TO MTG. PL.
6700.3	2647	GIB KEY
4310.1	2796A	LIP SEAL -- UPPER
4310.2	2796B	LIP SEAL -- LOWER
3110	3114	BEARING BODY
1340.3	4101	ADAPTER -- MOTOR (WHEN FURNISHED)

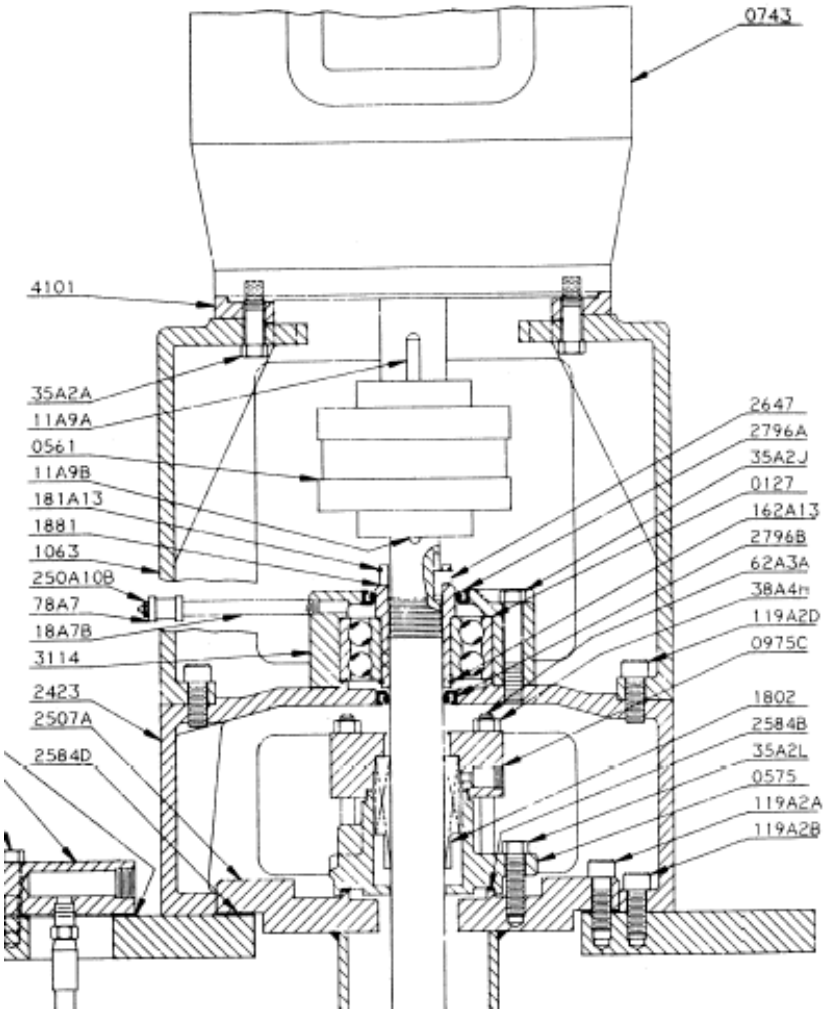
FIGURE 8-7: Vapor-proof construction



Ref. No.	Old P/N	DESCRIPTION
CPL	0561	COUPLING -- FLEXIBLE
4100	0575	STUFFING BOX
4120.1	0975A	GLAND
DRIVER	0743	DRIVER
6700.1	11A9A	KEY -- DIRVER SHAFT
6700.2	11A9B	KEY -- PUMP SHAFT
3031	0127	BEAIRNG -- THRUST
6570.1	35A2A	CAPSCREW -- SUPP HD TO MTR
6570.7	35A2G	CAPSCREW -- MFLD. TO MTG PLT
6570.8	35A2J	CAPSCREW -- BRG BODY TO COL.
6570.13	35A2L	CAPSCREW -- STUFF BOX TO COL.
6580.7	38A4H	NUT -- HEX
1245.2	39A8	FLANGE -- DISCHARGE
6572.2	62A3A	STUD -- GLAND
6570.11	119A2A	CAPSCREW -- COL. TO MTG PLT
6570.12	119A2B	CAPSCREW -- SUPP HD - MTG PLT
6570.14	119A2D	CAPSCREW -- SUPP HD TO BRG BKT
2530.1	162A13	SNAP RING
3853.1	18A7B	NIPPLE -- PIPE

2530.2	181A13	RETAINING RING
3853.2	78A7	COUPING -- PIPE
3853.3	250A10B	FITTING GREASE (THRUST BRG)
3160	1063	SUPPORT HEAD
3869	1264	MANIFOLD -- LUBE PIPING
3712	1881	SLEEVE -- ADJUSTING
6110	2025	MOUNTING PLATE
3130	2423	BRACKET -- BEARING
4134	2462	SEAL CAGE
1341.1	2507A	COLUMN -- UPPER
4590.3	2584B	GASKET -- STUFF BOX TO UPPER COL
4590.4	2584C	GASKET -- MANIFOLD TO MTG. PL.
4590.5	2584D	GASKET -- UPPER COL. TO MTG. PL.
6700.3	2647	GIB KEY
4130	2704	PACKING
4310.1	2796A	LIP SEAL -- UPPER
4310.2	2796B	LIP SEAL -- LOWER
3110	3114	BEARING BODY
1340.3	4101	ADAPTER -- MOTOR

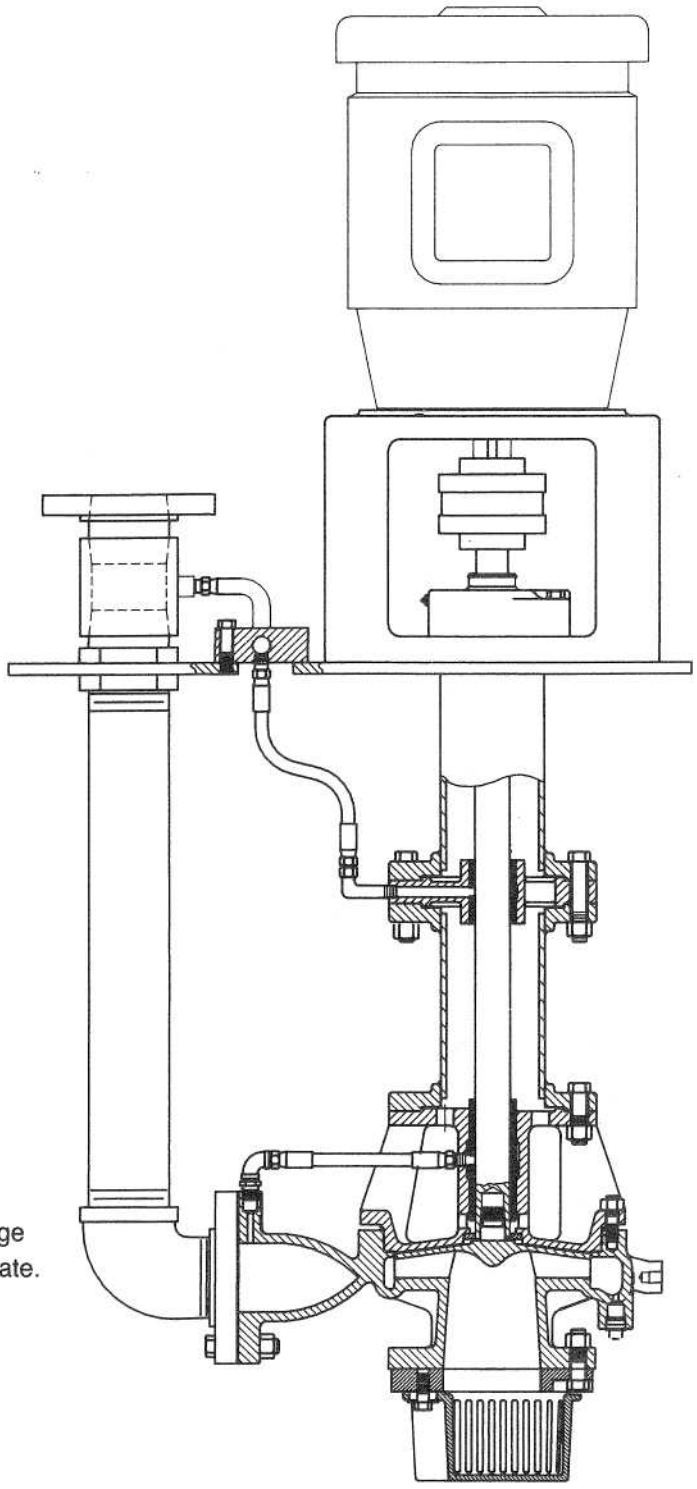
FIGURE 8-8: Pressurized design



Ref. No.	Old P/N	DESCRIPTION
CPL	0561	COUPLING -- FLEXIBLE
4100	0575	STUFFING BOX
4120.2	0975C	FLUSH GLAND
DRIVER	0743	DRIVER
6700.1	11A9A	KEY -- DIRVER SHAFT
6700.2	11A9B	KEY -- PUMP SHAFT
3031	0127	BEAIRNG -- THRUST
6570.1	35A2A	CAPSCREW -- SUPP HD TO MTR
6570.7	35A2G	CAPSCREW -- MFLD. TO MTG PLT
6570.8	35A2J	CAPSCREW -- BRG BODY TO COL.
6570.13	35A2L	CAPSCREW -- STUFF BOX TO COL.
6580.7	38A4H	NUT -- HEX
1245.2	39A8	FLANGE -- DISCHARGE
6572.2	62A3A	STUD -- GLAND
6570.11	119A2A	CAPSCREW -- COL. TO MTG PLT
6570.12	119A2B	CAPSCREW -- SUPP HD - MTG PLT
6570.14	119A2D	CAPSCREW -- SUPP HD TO BRG BKT
2530.1	162A13	SNAP RING
3853.1	18A7B	NIPPLE -- PIPE

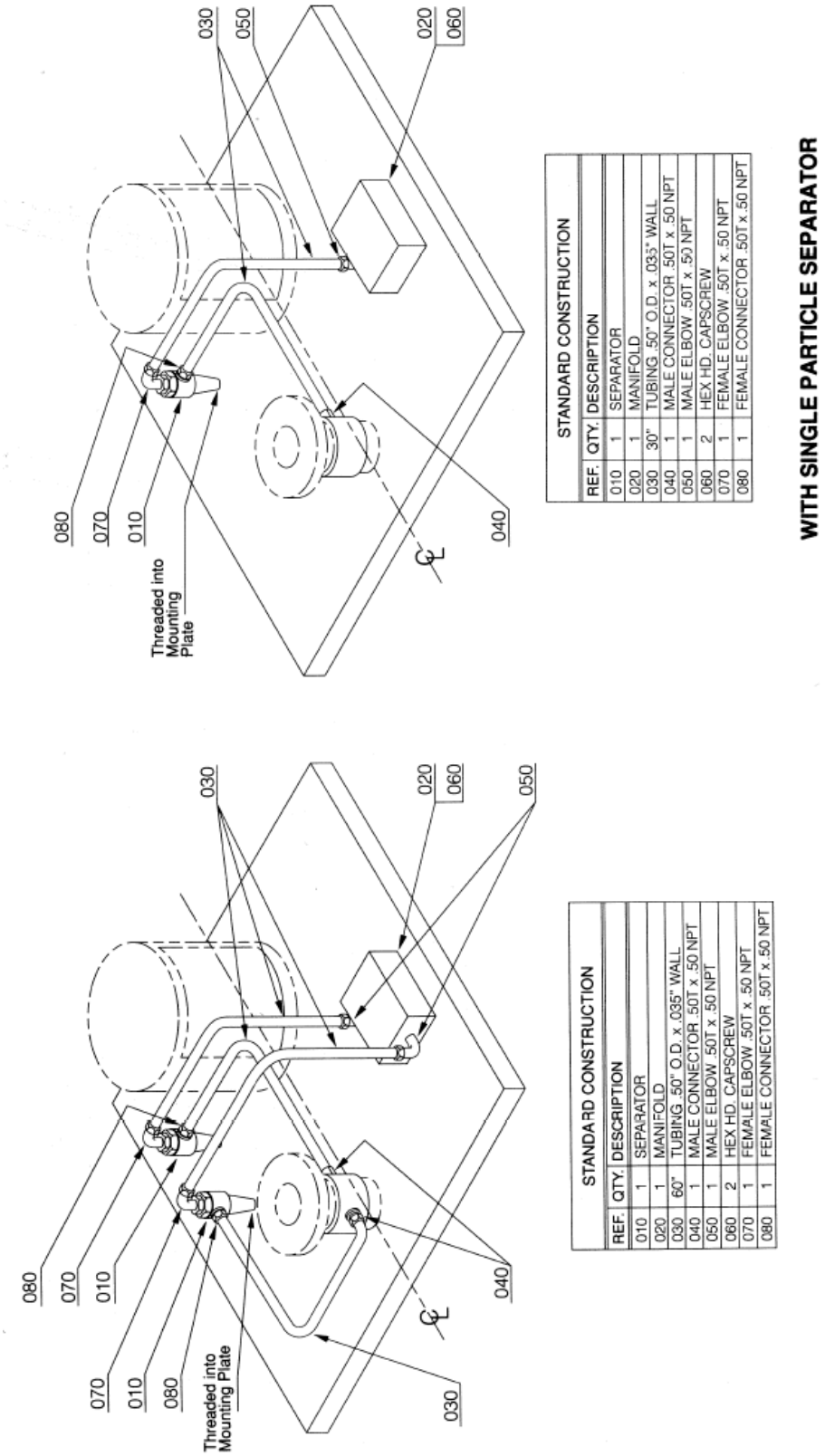
2530.2	181A13	RETAINING RING
3853.2	78A7	COUPING -- PIPE
3853.3	250A10B	FITTING GREASE (THRUST BRG)
3160	1063	SUPPORT HEAD
3869	1264	MANIFOLD -- LUBE PIPING
4200	1802	MECHANICAL SEAL
3712	1881	SLEEVE -- ADJUSTING
6110	2025	MOUNTING PLATE
3130	2423	BRACKET -- BEARING
1341.1	2507A	COLUMN -- UPPER
4590.3	2584B	GASKET -- STUFF BOX TO UPPER COL
4590.4	2584C	GASKET -- MANIFOLD TO MTG. PL.
4590.5	2584D	GASKET -- UPPER COL. TO MTG. PL.
6700.3	2647	GIB KEY
4310.1	2796A	LIP SEAL -- UPPER
4310.2	2796B	LIP SEAL -- LOWER
3110	3114	BEARING BODY
1340.3	4101	ADAPTER -- MOTOR

FIGURE 8-9: Product lubrication



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

FIGURE 8-10: Product lubrication separators



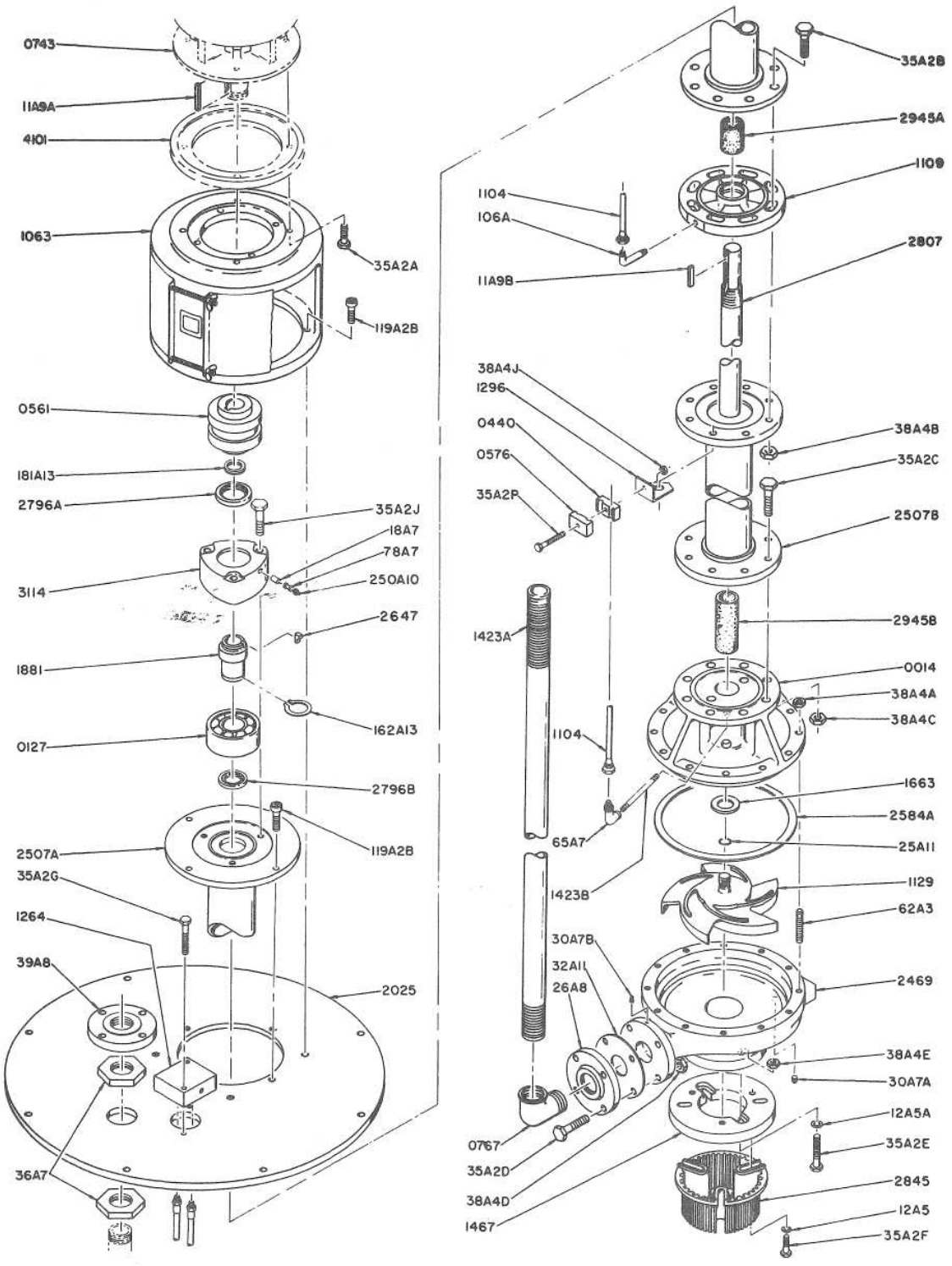
STANDARD CONSTRUCTION		
REF.	QTY.	DESCRIPTION
010	1	SEPARATOR
020	1	MANIFOLD
030	30"	TUBING .50" O.D. x .033" WALL
040	1	MALE CONNECTOR .50T x .50 NPT
050	1	MALE ELBOW .50T x .50 NPT
060	2	HEX HD. CAPSCREW
070	1	FEMALE ELBOW .50T x .50 NPT
080	1	FEMALE CONNECTOR .50T x .50 NPT

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

FIGURE 8-11: Exploded view



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, 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.

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

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

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

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

Notes:

Notes:

Your Flowserve factory contacts:

Flowserve Pump Division
3900 Cook Boulevard
Chesapeake, VA 23323-1626 USA

Telephone +1 757 485 8000
Fax +1 757 485 8149

Flowserve Pumps Limited
PO Box 17, Newark, Notts NG 24 3BU
United Kingdom

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

Your local Flowserve representative:

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

FLOWSERVE REGIONAL SALES OFFICES:

USA and Canada

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

Europe, Middle East, Africa

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

Latin America and Caribbean

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

Asia Pacific

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