FLOWSERVE

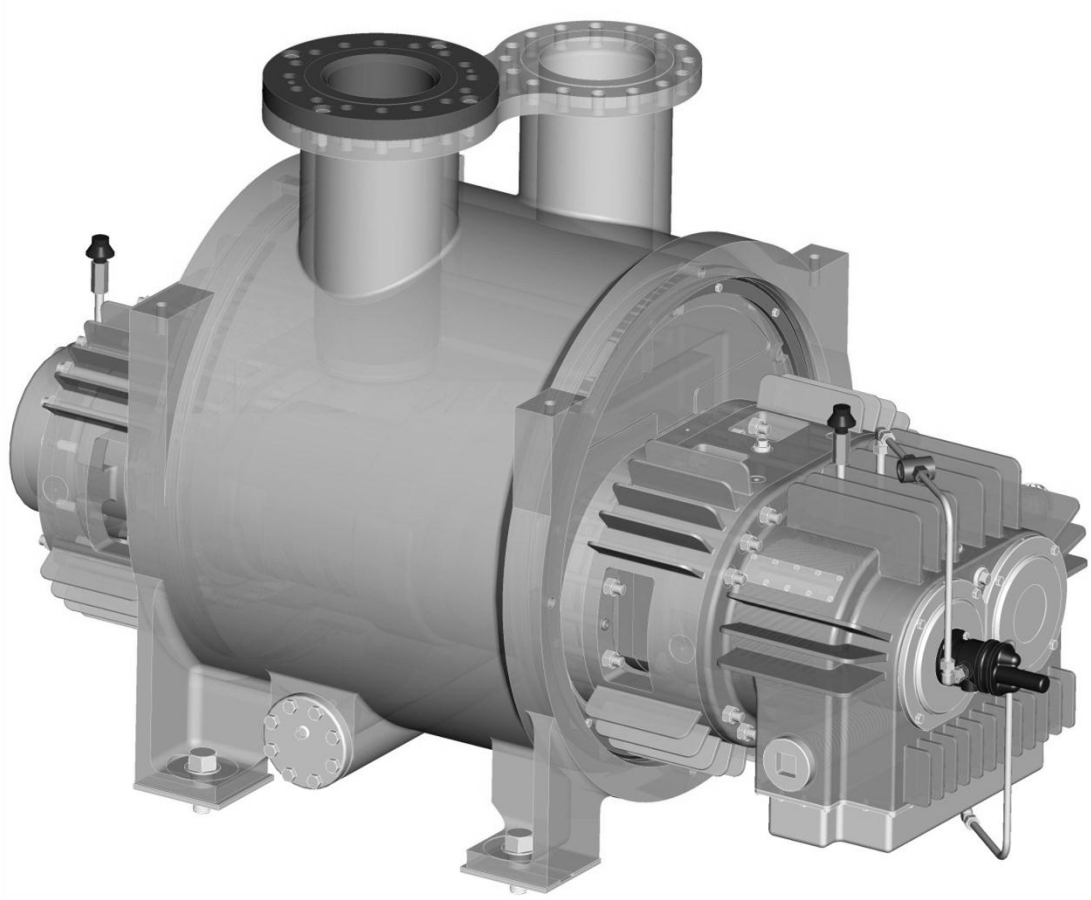
USER INSTRUCTIONS MANUAL

Sier-Bath® MP1

Multiphase Twin Screw Rotary Pumps

PCN= 26999958– 10/12 (E). Original instructions

User Instructions Manual



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

Experience In Motion

CONTENTS

INDEX

1 INTRODUCTION AND SAFETY

1.1 General

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

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

We are committed to continuous quality improvement and being at your service for any further information about the product in its installation and operation or about its support products, repair and diagnostic services.

These instructions are intended to facilitate familiarization with the product and its permitted use. Operating the product in compliance with these instructions is important to help ensure reliability in service and avoid risks. The instructions may not take into account local regulations; ensure such regulations are observed by all, including those installing the product. Always coordinate repair activity with operations personnel, and follow all plant safety requirements and applicable safety and health laws and regulations.

These instructions should be read prior to installing, operating, using and maintaining the equipment in any region worldwide. The equipment must not be put into service until all the conditions relating to safety noted in the instructions, have been met. Failure to follow and apply the present user instructions is considered to be misuse. Personal injury, product damage, delay or failure caused by misuse are not covered by the Flowserve warranty.

1.2 CE marking and approvals

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

Where applicable, the Directives and any additional Approvals, cover important safety aspects relating to machinery and equipment and the satisfactory provision of technical documents and safety instructions. Where applicable this document incorporates information relevant to these Directives. To establish approvals and if the product itself is CE marked, check the serial number plate and the Certification (See section 9 CERTIFICATION).

1.3 Disclaimer

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

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

1.4 Copyright

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 pumping, temperature or duty) it is requested that you/the user seek our written agreement before start up.

1.6 Safety

1.6.1 Summary of safety markings

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

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

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

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

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

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

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

1.6.2 Personnel qualification and training

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

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

1.6.3 Safety action

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

RELIEF VALVE PIPED BACK TO THE SUCTION PIPE REQUIRED

The Twin Screw Pumps are positive displacement pumps and will build up considerable pressure if discharge line is blocked.

Customer shall include a properly sized safety relief valve for the maximum expected flow at the maximum expected operating pressure + 10% or the maximum allowed working pressure (MAWP), whichever is the lowest. Safety relief valve shall be connected close to the discharge of the pump. The pipeline discharging from the safety relief valve should go back to the suction tank, if at all possible; if not, it could be connected to the suction line of the pump but only if well upstream so as to not create excessive combined pressure. This discharge line shall not be blocked at all. Customer shall also include additional provisions to stop the process if the discharge pressure is above the maximum allowable pressure criteria; the pump shall not be recirculating the flow for other than a very short time due to the safety risk of the temperature exceeding the allowable limit.

CAUTION PREVENT EXCESSIVE EXTERNAL PIPE LOAD

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

CAUTION ENSURE CORRECT LUBRICATION

CAUTION START THE PUMP WITH OUTLET VALVE FULLY OPENED

(Unless otherwise instructed at a specific point in the user instructions.) This is recommended to minimize the risk of overloading and damaging the pump motor at zero flow. The pump outlet control valve

may need to be adjusted to comply with the duty following the run-up process.

CAUTION NEVER RUN THE PUMP DRY

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

CAUTION DO NOT RUN THE PUMP AT ABNORMALLY HIGH FLOWRATES OR ABNORMALLY LOW/HIGH DIFFERENTIAL PRESSURES.
Operating at flow rates higher than specified can overload the motor and/or cause cavitation and vibration and/or low pressure at the seal chamber potentially affecting the mechanical seals. Low differential pressure may create too low bearings' loads and skidding. High differential pressure may create too high bearing loads. Both cases affect the bearings' life.

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

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

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

FLUORO-ELASTOMERS (When fitted.)
When a pump has experienced temperatures over 250 ºC (482 ºF), partial decomposition of fluoro-elastomers (e.g. Viton) will occur. In this condition these are extremely dangerous and skin contact must be avoided.

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

GUARDS MUST NOT BE REMOVED WHILE THE PUMP IS OPERATIONAL

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

NEVER APPLY HEAT TO REMOVE ROTOR
Trapped lubricant or vapour could cause an explosion.

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

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

1.6.4 Products used in potentially explosive atmospheres

Measures are required to:

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

The following instructions for pumps and pump units when installed in potentially explosive atmospheres must be followed to help ensure explosion protection. 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

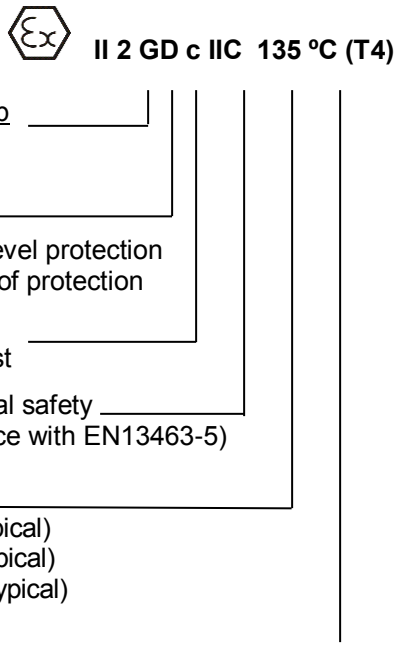
the specific atmosphere in which they are to be installed.

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 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 effects in the motor and so, for pumps sets with 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

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

The surface temperature on the pump is influenced by the temperature of the liquid handled. The maximum permissible liquid temperature depends on the temperature class and must not exceed the values listed in Table 1.

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

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

Table 1 Maximum permitted liquid temperature for pumps

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

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

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

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

If an explosive atmosphere exists during the installation, do not attempt to check the direction of rotation by starting the pump unfilled. Even a short run time may give a high temperature resulting from contact between rotating and stationary components.

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

Avoid mechanical, hydraulic or electrical overload by using motor overload trips, temperature monitor or a

power monitor and make routine vibration monitoring checks.

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

1.6.4.4 Preventing the build-up of explosive mixtures

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

Ensure the pump and relevant suction and discharge pipeline system is totally filled with liquid at all times during the pump operation, so that an explosive atmosphere is prevented.

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

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

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

1.6.4.5 Preventing sparks

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

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

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

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

1.6.4.6 Preventing leakage

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

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

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

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

If leakage of liquid to atmosphere can result in a hazard, install a liquid detection device.

1.6.4.7 Maintenance to avoid the hazard

 CORRECT MAINTENANCE IS REQUIRED TO AVOID POTENTIAL HAZARDS WHICH GIVE A RISK OF EXPLOSION

The responsibility for compliance with maintenance instructions is with the plant operator.

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

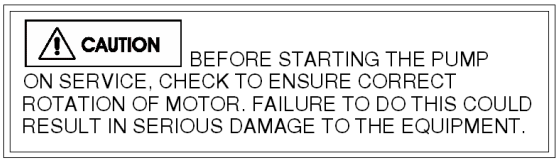
1.7 Nameplate and warning labels

1.7.1 Nameplate

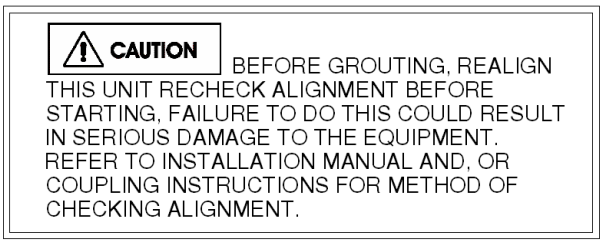
For details of nameplate, see the *Declaration of Conformity*.

1.7.2 Safety labels

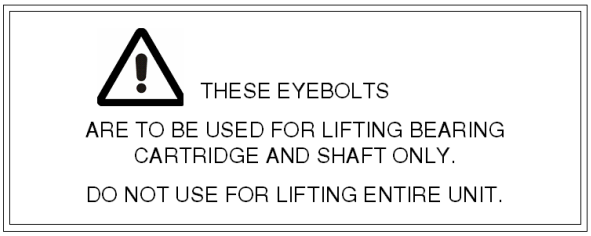
MECHANICAL SEAL WARNING
P/N 2113931-001



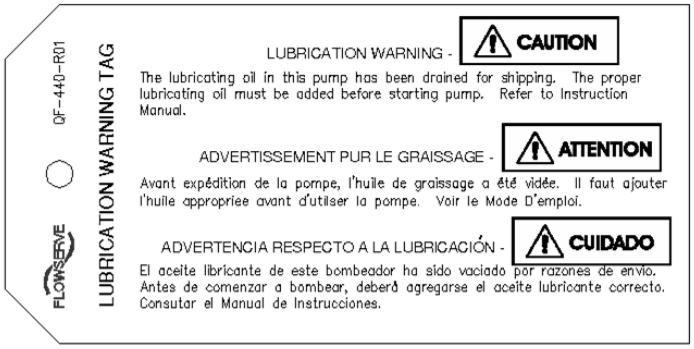
ROTATION WARNING
P/N 2113932-001



GROUT WARNING
P/N 2113934-001



LIFTING WARNING
P/N 9901701-001



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

1.8 Specific machine performance

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

1.9 Noise level

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

The usual approach is to control the exposure time to the noise or to enclose the machine to reduce emitted sound. You may have already specified a limiting noise level when the equipment was ordered, however if no noise requirements were defined, then attention is drawn to Table 2 to give an indication of equipment noise level so that you can take the appropriate action in your plant.

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

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

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

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

The values are in sound pressure level LpA at 1 m (3.3 ft) from the machine, for “free field conditions over a reflecting plane”.

For estimating sound power level LWA (re 1 pW) then add 14 dBA to the sound pressure value.

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

Table 2 Max Sound Levels of Pumps

Multiphase Twin Screw pump size	Sound Pressure Level dBA @ 1 m (3.3 ft)	Pump Speed rpm
MP1-150-xxx	90	1780
MP1-275-xxx	90	1780
MP1-380-xxx	90	1780
MP1-390-xxx	100	1780

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

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

Each product has a unique serial number. Check that this number corresponds with that advised; 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.

CAUTION The pump should be lifted with suitably sized and located slings. Do not use the shaft for lifting and take special care to prevent the pump from rotating in the slings due to unbalanced weight distribution. The angle between sling or ropes used for lifting must not exceed 60°.

2.3 Lifting

⚠ A crane must be used for all pump sets in excess of 25 kg (55 lb). Fully trained personnel must carry out lifting, in accordance with local regulations. The driver and pump weights are recorded on their respective nameplates or mass plates.

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

2.4 Storage

2.4.1 CAUTION Short-Term Storage

When it is necessary to store a pump for a short time before it can be installed, place it in a dry, cool location. Protect it thoroughly from moisture and condensation. Protective flange covers should not be removed until the pump is being installed.

Wrap the exposed portions of the shaft and coupling to protect against sand, grit or other foreign matter. Oil lubricated units should be lubricated (refer to section *5.1.3 Lubrication)* to protect the bearings. Grease lubricated units are lubricated at the factory during assembly. Turn the rotor over by hand at least once a week to maintain a protective film on the bearing components.

2.4.2 Long-term storage

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

The internal surfaces of the pump should be sprayed with a rust preventative, such as water soluble oil or other suitable alternative. Particular attention should be given to the integral shafts, rotors and stuffing box. Install gasketed metal flange covers on the suction and discharge flanges (pipe plugs in the case of tapped connections).

A rust inhibitor should be added to the lubricating oil of oil lubricated units to give additional protection without destroying the lubricating properties of the oil. For specific recommendations, consult your lubrication dealer. Grease lubricated units, which can be identified by the grease fitting at each bearing location, should be well lubricated prior to placing in storage. Small amounts of additional grease should be added at regular intervals during storage. Refer to Section *5.1.3 Lubrication* for additional information related to grease lubrication.

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

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

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

2.5 Recycling and end of product life

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

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

3 PUMP DESCRIPTION

3.1 Configurations

Flowserve Twin Screw Pumps are single stage, positive displacement pumps especially designed for the petroleum industries in the transfer of oils and other liquids of varying viscosities. The flow of liquid through the pump is accomplished by the progressive movement of sealed cavities formed by the intermeshing of matched pumping screws (one right hand, one left hand) rotating in the precision ground bores of the pump body. To balance the hydraulic thrust created by the pumping action, two sets of meshed screws are used, moving the liquid from both ends of the body to the discharge port located at the center of the body.

The key assembly of the screw pump is the rotating element. Each rotating element consists of a drive shaft and a driven shaft running on parallel axes at a fixed center distance. Each shaft holds bearings, one timing gear and two opposing pumping screws plus the assorted hardware (lock nuts, spacers) required for mounting. With integral design, the pumping screws and the shaft are an integral piece machined from a single steel bar. Precise clearances are maintained between meshing screws to limit the internal leakage (slip) in the pump. The timing gears maintain these clearances, prevent contact between the pumping screws and turn the driven shaft. Heavy duty roller bearings eliminate radial contact between the pumping screws and the body bores and support the loading on the shafts produced by the pumping action. Ball bearings position the shafts axially and prevent contact between the flanks (sides) of the meshing screws. Generally lubrication of the bearings is provided by oil contained in housings (sumps).

The rear timing gear configuration provides a rear pull-out feature which permits the quick removal of the entire rotating element without disturbing the pump body or the drive. (Refer to Section *6.8 Disassembly*). The use of a spacer type coupling between the pump and driver is necessary to apply this feature.

Shaft sealing is typically provided and installed by factory. Mechanical seals require no adjustment prior to or during pump operation.

All pumps are shop performance tested to ensure mechanical reliability and compliance with the specified conditions of service. They are carefully inspected and prepared for shipment. All exterior machined surfaces are coated with rust preventative and all openings are provided with covers or plugs.

3.2 Name structure

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

MP1-275-355

- MP indicates pump is for multiphase application
- 275 indicates screws OD in mm
- 355 indicates bore length in mm

3.3 Design of major parts

3.3.1 Pump casing

The pump casing is a casting with side suction and top discharge connections, or both connections on top. Refer to the Outline or General Arrangement drawings for further details. It is a two pieces (Outer Casing and Inner Casing or also typically named Liner) pressure retaining casting assembly, with gasket connections between the Outer and Inner Casing, as well as to the seal housings and the suction and discharge flanges.

3.3.2 Pumping Rotors

The pumping rotors (screws) are single start and mounted to a shaft in opposing configuration i.e. one left and one right hand rotor to each shaft. The intermeshing screws integral part of drive and driven shafts create a positive displacement pumping action inside the pump body.

3.3.3 Shaft
The drive shaft is mounted on bearings with the pumping rotor and timing gear mounted to the shaft. It has a keyed drive end. The driven shaft is also mounted on bearings with the pumping rotor and timing gear mounted to the shaft.

3.3.4 Timing Gears
The timing gears are mounted to the drive and driven shafts with accurately located keys to maintain the pumping rotors in mesh with no contact with each other.

3.3.5 Pump bearings and lubrication
Antifriction radial and thrust bearings are mounted on each shaft to support the induced loads. An external lube oil system and/or an oil bath might be provided at each end of the pump to lubricate the bearings and timing gears. An oil site gage might be supplied in the bearing housings.

Certain multiphase applications may require a separate lubrication and lube oil cooling system depending on the condition of service.

3.3.6 Stuffing box/seal housing
The stuffing box housing is doweled to both the pump casing and the bearing housing to ensure proper alignment. It is supplied to fit appropriate mechanical seals.

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

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

3.3.9 Accessories
Accessories may be fitted when specified by the customer.

3.4 Performance and operating limits

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

3.4.1 Operating limits

Pumped liquid temperature limits	up to +177 ºC (300 ºF)
Maximum ambient temperature	up to +50 ºC (122 ºF)
Maximum soft solids in suspension	up to 1% by volume
Maximum pump speed	Refer to the nameplate

3.4.2 Speed torque curves
To bring a rotary pump up to rated speed, the driver must be capable of providing more torque at each speed than required by the pump. Normally, this is not a problem with standard induction or synchronous motors, provided the proper voltage is supplied at the motor.

The margin between the available and required torque affects the time it takes the unit to reach full speed. If the torque required by the pump exceeds the torque capability of the drive at any run-up speed, the unit will not accelerate to full speed.

For pumps started at set system resistance conditions, 100 % full speed torque can be calculated by using the formula:

$$\text{Torque (Nm)} = 9545 \frac{\text{Power (kW)}}{\text{RPM}}$$

$$\text{Torque (lbf} \cdot \text{ft)} = 5250 \frac{\text{Power (hp)}}{\text{RPM}}$$

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

3.5 Table of Engineering Data (Table 3)

Table 3 Engineering data

PUMP SIZE	MP1-150-200	MP1-275-255	MP1-275-355	MP1-380-305
SHAFT/SCREW DESIGN	INTEGRAL	INTEGRAL	INTEGRAL	INTEGRAL
STD SUCTION SIZE	6 in.- 600#	10 in.- 300#	10 in. - 300#	10 in. - 300#
STD DISCHARGE SIZE	4 in. - 600#	110 in. - 300#	10 in. - 300#	10 in. - 300#
STD OD CLEARANCE mm (in.)	0.30/0.45 (0.012/0.018)	0.51/0.76 (0.020/0.030)	0.51/0.76 (0.020/0.030)	0.51/0.76 (0.020/0.030)
APPROX PUMP WEIGHT kg (lb.)	658 (1450)	4490 (9900)	5900 (12990)	6591 (14500)
ROT ELEMENT WEIGHT kg (lb.)	136 (300)	508 (1120)	670 (1470)	990 (2175)
MOMENT OF INERTIA kgm^2 (lb·in$^{2)}$	0.250 (855)	3.670 (12 540)	3.670 (12 540)	2.356 (8050)
SHAFT DIAMETER @ COUPLING mm (in.)	53.98 (2.125)	92.08 (3.625)	92.08 (3.625)	92.08 (3.625)
SHAFT TAPER @ COUPLING mm/m (in/ft.)	60 (¾)	40 (½)	40 (½)	40 (½)
SHAFT DIAMETER @ ST BOX mm (in.)	73.0 (2.875)	130.2 (5.125)	130.2 (5.125)	130.2 (5.125)
NO OF SEALING CHAMBERS	4	4	4	4
OIL FILL TIMING GEAR HSG liters (qt.)	3.0 (3.2)	21 (22.2)	21 (22.2)	3.4 (3.6)
OIL FILL BEARING HSG liters (qt.)	0.25 (0.26)	8.5 (9.0)	8.5 (9.0)	1.5 (1.6)

PUMP SIZE	MP1-390-305	MP1-380-355	MP1-390-610	MP1-390-406
SHAFT/SCREW DESIGN	INTEGRAL	INTEGRAL	INTEGRAL	INTEGRAL
STD SUCTION SIZE	10 in. - 1500#	10 in. - 300#	16 in. - 300#	16 in. - 600#
STD DISCHARGE SIZE	8 in. - 1500#	10 in. - 300#	16 in. - 300#	16 in. - 600#
STD OD CLEARANCE mm (in.)	0.51/0.76 (0.020/0.030)	0.51/0.76 (0.020/0.030)	0.76/0.89 (0.030/0.035)	0.76/0.89 (0.030/0.035)
APPROX PUMP WEIGHT kg (lb.)	8300 (18 300)	6804 (15 000)	10 500 (23 148)	10 560 (23 280)
ROT ELEMENT WEIGHT kg (lb.)	975 (2150)	1157(2550)	1009(4583)	7612 (3460)
MOMENT OF INERTIA kgm^2 (lbs·in$^{2)}$	12.759 (43 600)	14.354 (49 050)	25.433 (86 909)	18.041 (61 650)
SHAFT DIAMETER @ COUPLING mm (in.)	92.08 (3.625)	92.08 (3.625)	111.13 (4.375)	111.13 (4.375)
SHAFT TAPER @ COUPLING mm/m (in/ft.)	40 (½)	60 (¾)	40 (1/2)	40 (½)
SHAFT DIAMETER @ ST BOX mm (in.)	130.2 (5.125)	130.2 (5.125)	209.5 (8.25)	209.5 (8.25)
NO OF SEALING CHAMBERS	4	4	4	4
OIL FILL TIMING GEAR HSG liters (qt.)	3.4 (3.6)	3.4 (3.6)	3.4 (3.6)	3.4 (3.6)
OIL FILL BEARING HSG liters (qt.)	1.5 (1.6)	1.5 (1.6)	1.5 (1.6)	1.5 (1.6)

4 INSTALLATION

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

The recommended order of operations to install a pump skid is as follows:

a) Construct Foundation (Section 4.3)
b) Install Baseplate (Section 4.4)
c) Initial Alignment (Section 4.5)
d) Grouting (Section 4.6)
e) Fabrication and Installation of Piping (Section 4.7)
f) Final Shaft Alignment (Section 4.9)
g) Electrical Connections (Section 4.10)
h) Commissioning (Section 5.0)

4.1 Location

The pump should be located to allow room for access, ventilation, maintenance and inspection and should be as close as practicable to the supply of liquid to be pumped. There should be ample room to allow the use of an overhead crane or lifting device with sufficient capacity to lift the heaviest part of the unit. Simple suction and discharge piping layouts are desired. Allow sufficient room to facilitate the back pull-out feature.

Refer to the general arrangement drawing for the pump set.

4.2 Part assemblies

Motors may be supplied loose on Twin Screw pumps, typically on frame sizes 400 and above. It is the responsibility of the installer to ensure that the motor is

assembled to the pump and lined up as detailed in section *4.5.2 Alignment method*.

4.3 Foundation

CAUTION The foundation may consist of any material that will afford permanent, rigid support to the full area of the pump or driver supporting member. It should be of sufficient size and mass to absorb expected strains and shocks that may be encountered in service. Concrete foundations built on solid ground are desirable.

The purpose of foundation bolts is to anchor the pump unit securely to the foundation such that the foundation and pump assembly become a single structural unit. High strength steel foundation bolts (SAE Gr. 5 or better) of the specified diameter should be located according to the elevation drawing provided. Each bolt should be surrounded by a pipe sleeve two or three times the diameter of the bolt (see Figure 1). The sleeves should be securely anchored and designed to allow the bolts to be adjusted to conform to the holes in the baseplate. The bolts should be sufficiently long to allow for wedges or shims or levelling nuts under the baseplate, and a washer, heavy hex nut and hex jam nut for retention. Since baseplate levelling is performed after the foundation has cured, it is best to use extra-long bolts which can be shortened after the installation is complete.

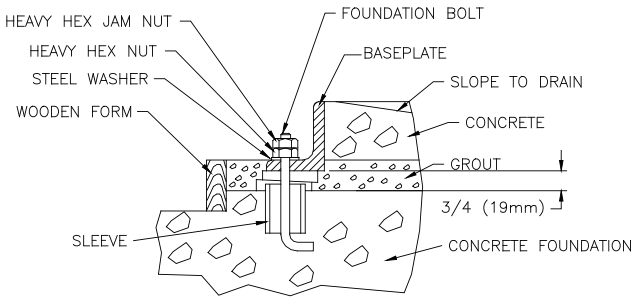


Figure 1 – Grout Installation

4.4 Baseplate installation

Position the baseplate and pump next to the foundation and clean the foundation surface thoroughly. Remove the rag packing from the pipe sleeves and place wedges or shims as close to the foundation bolts as possible. These may be omitted if a jacking nut on the foundation anchor bolts is preferred for levelling. Initial levelling should be within 0.75 mm (0.030 in.).

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

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

With the aid of a machinist's level, adjust the wedges, shims or jacking nuts to level the pump and driver mounting pads in each direction. Check to ensure that the suction and discharge flanges are plumb, level, and at the correct elevation. It is normal practice to set the mounting pads slightly low in order to permit lowering of units which may be required to suit future piping or minor changes. Place washers over the foundation bolts and install nuts. Tighten finger tight only. Check that the rotor turns freely by hand.

Note: Grout shall not be poured until an initial preliminary alignment of the pump and driver has been performed.

4.5 Initial alignment

4.5.1 Thermal expansion

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

4.5.2 Alignment methods

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

CAUTION The alignment MUST be checked.

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

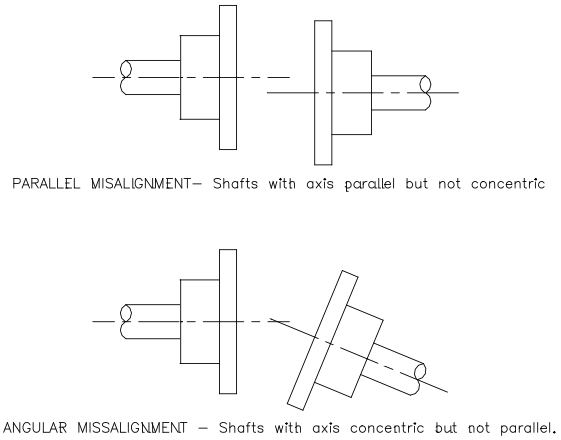


Figure 2 – Parallel and angular misalignment

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

A flexible coupling is used to compensate for slight changes in alignment which occur during normal operation and is not used to correct for installation errors. Install the pump and driver half couplings in accordance with the coupling manufacturer's instructions. Note that the coupling hub faces are not always mounted flush with the ends of the shafts. Place the driver on the baseplate such that the correct spacing is obtained between the two half couplings.

CAUTION **CHECK IF THERE IS A NEED TO SET THE ELECTRIC MOTOR MAGNETIC CENTER AND THE AXIAL ALIGNMENT BEFORE PROCEEDING WITH ANY PARALLEL AND ANGULAR ALIGNMENT. FAILURE TO DO SO MIGHT POSE SERIOUS RISKS TO THE RELIABLE OPERATION OF THE PUMP**.

In the case of high power electric motors having sleeve bearings, it might be necessary to run the motor to establish the rotor magnetic center before defining the axial setup of the pump. Consult the manufacturer's instruction manual of the motor for additional details.

The purpose of the alignment procedure is to ensure that there is no axial hunt/thrust nor eccentricity that might create unbalance, between the driver shaft (electric motor, gearbox, hydraulic power transmitter, vapour/gas turbine, engine, etc.) and the pump shaft that might affect or jeopardize the coupling mechanical performance, and that both shafts are in parallel and angular alignment under the normal operating conditions of load and temperature (See Figure 2).

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

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

Shaft alignment is greatly simplified by the use of a dial indicator with extension rods and a magnetic base, or using laser alignment devices. Before taking readings, ensure that the pump and driver mounting bolts are secure, and that the thrust bearing housing is properly aligned in the bearing frame or cartridge. (See Section *6 MAINTENANCE).*

Parallel Alignment:

Mount the magnetic base on the pump half coupling hub (either the face or the O/D as shown in the sketch) and place the dial indicator button on the outside diameter of the driver half coupling hub. (See Figure 3).

Note that the length of extension rods should be kept at a minimum to reduce deflection. Rotate the pump shaft and record the dial reading at the top, bottom and each side. Correct the parallel alignment by adding or removing shims under the driver and/or moving the driver horizontally.

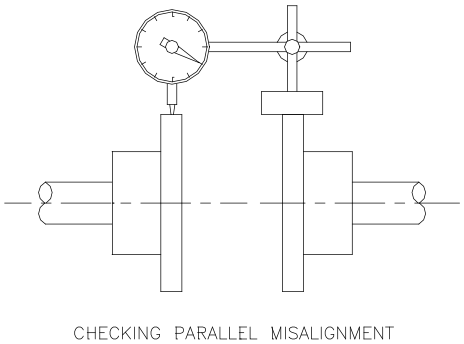
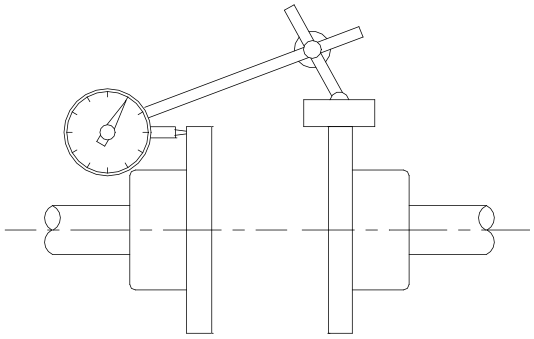


Figure 3 – Parallel Misalignment

Repeat this procedure until the maximum Total Indicator Reading (T.I.R.) is within 0.076 mm (0.003 in.).

Angular Alignment:
With the magnetic base mounted on the pump half coupling hub, move the dial indicator button to indicate on the face of the driver half coupling hub as close to the outside diameter as possible. (See Figure 4). Turn both shafts 360° and record the dial readings at 90° intervals. Adjust the shims under the motor as required and repeat the procedure until the angular alignment is within 0.0005 mm (T.I.R.) per mm (0.0005 in. per in.) of maximum hub diameter.



CHECKING ANGULAR MISALIGNMENT
Figure 4 – Angular Misalignment

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

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

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

When the electric motor has sleeve bearings it is necessary to ensure that the motor is aligned to run on its magnetic centreline. A button (screwed into one of the shaft ends) is normally fitted between the motor and pump shaft ends to fix the axial position.

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

4.5.3 Check for soft foot

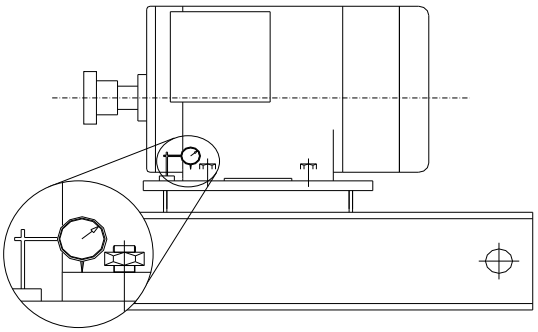


Figure 5 – Check for soft foot

This is a check to ensure that there is no undue stress on the driver holding down bolts; due to non-level baseplate or twisting. To check, remove all shims and clean surfaces and tighten down driver to the baseplate. Set a dial indicator as shown in Figure 5 and loosen off the holding down bolt while noting any deflection reading on the dial test Indicator - a maximum of 0.05 mm (0.002 in.) is considered acceptable but any more will have to be corrected by adding shims. For example, if the dial test indicator shows the foot lifting 0.15 mm (0.006 in.) then this is the thickness of shim to be placed under that foot. Tighten down and repeat the same procedure on all other feet until all are within tolerance.

⚠ Complete piping as below and see sections *4.9 Final shaft alignment check* up to and including section *5 COMMISSIONING, START-UP, OPERATION AND SHUTDOWN* before connecting driver and checking actual rotation.

4.6 Grouting

The purpose of grouting is to provide rigid support to the pump and driver by increasing the structural rigidity of the baseplate and making it an integral mass with the foundation.

Clean the roughed foundation surface and build a wooden form around the baseplate (see Figure 1). For initial grouting forms should be placed to isolate shims and levelling nuts. The foundation surface should be thoroughly saturated with water before grouting. A typical mixture for grouting-in a pump base is composed of one part pure Portland cement and two

parts of clean building sand with sufficient water to provide the proper consistency. The grout should flow freely but not be so wet as to cause the sand and cement to separate.

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

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

After the concrete has cured, and while the pump and driver are uncoupled, the driver rotation should be checked. Be sure that the driver is locked out after this check. Note that the required pump shaft rotation is marked on the front head of the pump (see section *5.3 Direction of rotation*)

4.7 Piping

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

4.7.1 Suction and discharge pipework

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

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

CAUTION Never use the pump as a support for piping.

CAUTION Excessive pipe loads and/or soft feet will cause serious damage to the pump. Verify both before pump is started.

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

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

Information regarding maximum allowable forces and moments on the suction and discharge flanges is provided on the General Arrangement drawing.

Suction and discharge piping and associated equipment should be supported and anchored near to but independent of the pump. If an expansion joint or non-rigid coupling must be used, a pipe anchor must be installed between it and the pump to ensure that any flange loads do not exceed the specified limits.

If operational difficulties are encountered, suction and discharge pressure readings must be determined to establish the cause of the problem. In anticipation of such problems, pressure taps, located in a straight section of pipe between the pump and first fitting should be provided on the suction and discharge lines.

CAUTION Ensure piping and fittings are flushed before use.

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

4.7.2 Suction piping

a) The suction piping should be as short and as direct as possible.
b) The inlet pipe should be one or two sizes larger than the pump inlet bore and pipe bends should be as large a radius as possible.
c) Pipework reducers should have a maximum total angle of divergence of 15 degrees.
d) On suction lift the piping should be inclined up towards the pump inlet with eccentric reducers incorporated to prevent air locks.
e) On positive suction, the inlet piping must have a constant fall towards the pump.
f) Flow should enter the pump suction with uniform flow, to minimize noise and wear. This is

particularly important on large or high-speed pumps which should have a minimum of two diameters of straight pipe on the pump suction between the elbow and inlet flange. See section 10.3 Additional sources of information for more detailed technical explanations on this piping design requirement.

g) Inlet strainers, when used, should have a net `free area' of at least three times the inlet pipe area.
h) Fitting an isolation valve will allow easier maintenance.
i) Never throttle pump on suction side.

4.7.3 Discharge piping

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

Pipework reducers should have a maximum total angle of divergence of 15 degrees. Fitting an isolation valve will allow easier maintenance.

4.7.4 Relief Valves

Twin Screw Pumps are of the positive displacement type; considerable pressure will develop in the discharge piping and inside of the pump if discharge line is blocked through closing of valve, etc. It is therefore necessary for the protection of the pump and discharge line to provide a relief valve. This should be piped back to the suction tank and not to the suction line.

4.7.5 Auxiliary piping

4.7.5.1 Drains

Pipe pump casing drains to a convenient disposal point, according to the appropriate safety, health and environment policies of the location for the pump's application.

4.7.5.2 Mechanical seals

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

If the seal requires an auxiliary quench then a connection must be made to a suitable source of liquid flow, low pressure steam or static pressure from a header tank. Recommended pressure is 0.35 bar (5 psi) or less. Check section *8.2 General arrangement drawing*.

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

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

4.7.6 Final checks

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

4.8 Pressure gauges

It is recommended that suitable suction and discharge pressure gauges be provided. Pressure readings are essential to resolving operational problems and are useful for monitoring pump performance.

4.9 Final shaft alignment check

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

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

4.10 Electrical connections

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

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

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

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

nameplate should be checked to ensure the power supply is appropriate.

A device to provide emergency stopping must be fitted.

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

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

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

4.11 Protection systems

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

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

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

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

To prevent excessive surface temperatures at bearings it is recommended that temperature or vibration monitoring are carried out. See sections 5.9.3 Bearings and 5.9.4 Normal vibration levels, alarm and trip.

The user should review the need for special operating procedures and protective devices peculiar to the particular installation involved. These may include special start-up and shut-down procedures, over-speed protection, temperature, flow and pressure interlocks, protection against automatic start-up in the event of power failure, surge protection, protection from freezing, lack of prime protection, temporary strainers in the suction line, vacuum breakers, etc.

Great care should be exercised during the erection of piping to keep lines clean and free of dirt, scale, threading or welding chips, etc. Such foreign matter entering the pump may cause scoring of the body bores and unnecessary breakdown and costly repairs.

For pumps having jacketed bodies, the jacket inlet piping should always be made at the lowest inlet point with the outlet at the top or highest point and the opposite configuration when using a gaseous heat transfer media. Provide a valve on the inlet piping so that flow may be regulated to control temperature.

5 COMMISSIONING, START-UP, OPERATION AND SHUTDOWN

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

5.1 Pre-commissioning procedure

5.1.1 Check-list

To avoid operational difficulties and to ensure a trouble free initial start-up, the following additional checks should be made.

1. Check that all piping has been properly bolted, anchored and braced. If the system is hydrostatically tested, ensure that the pump and other equipment is properly vented and adequately protected against excessive pressure. (See Sections *4.11 Protection systems* and *5.9.1 Venting the pump*.)
2. Flush the piping system, particularly the suction line, to ensure that all foreign material has been removed.
3. Check that all valves and automatic equipment are operating properly.
4. Ensure that drivers are provided with properly set over-load and/or over speed protection devices as required.
5. Check all auxiliary piping circuits.

5.1.2 Freezing

Precautions should be taken to prevent the liquid in the pump or associated piping from freezing.

5.1.3 Lubrication

In general, bearing lubrication is provided by lubricating oil contained in housings located at both ends of the pump.

CAUTION Fill the bearing housings with the correct grade of oil to the correct level, i.e. sight glass

or constant level oiler bottle or the level mentioned on sectional drawing.

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

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

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

In case of separate shaft mounted lube oil circulating pump, refer to general arrangement drawing for instructions

5.2 Lubricants

5.2.1 Typical oils

Table 4 – Typical lubricating oils

Company	Column "A"	Column "B"	Column "C"
Mobil	Mobil DTE Oil BB	MOBILGEAR 626	Mobil DTE Oil HH
Shell	OMALA Oil 220	OMALA Oil 68	OMALA Oil 460
Sunoco	SUNVIS 790 (220)	SUNVIS 747 (46)	SUNVIS 7150
Amoco	RYKON Oil No. 220	AMOGEAR No. 68	American Industrial Oil No. 460
Texaco	REGAL R&O 220	MEROPA 150	REGAL R&O 460
Arco	PENNANT NL 220	PENNANT NL 68	RUBILENE 460
Chevron	AW Machine Oil 220	EP Industrial Oil 46x	NL Gear Compound 460
Exxon	TERESSTIC N220	SPARTAN EP 68	TERESSTIC 460
***Esso**	TERESSO N220	SPARTAN EP 68	CYLESSO TK 460
	TERESSO 100	-	-
BP	ENERGOL HL 100	-	-
Petro Canada	GIREX 220	GIREX 68	GIREX 320

*Imperial Oil Limited (Canada)

5.2.2 Lubrication schedule

5.2.2.1 Requirements for oil lubricated bearings

Normal oil change intervals are 2500 operating hours or at least every 6 months whichever occurs first, depending on the temperature of the service, the service conditions, and quality of the lubricant regarding oxidation stability capability. For pumps on hot service or in severely damp or corrosive atmosphere, the oil will require changing more frequently. Lubricant analysis (change in appearance, odour, viscosity, oxidation, water/contaminants concentration, etc.), as well as bearing temperature analysis, can be useful in optimizing lubricant change intervals.

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

The bearing temperature may be allowed to rise to 50 ºC (90 ºF) above ambient, but should not exceed 82 ºC (180 ºF). An abrupt or continuously rising temperature may be indicating a fault.

Oils used in the bearing housing should meet the following requirements:

1. Oxidation Stability Specification per AGMA Standard 250.04 table 1, page 9.
2. Foam Suppression Specification per AGMA Standard 250.04 table 1, page 9.

At initial start-up, oil must be drained completely and replaced after one week or 100 hours running time (except for temperatures above 121 °C (250 °F)), or even earlier, after 50 hours running time.

An analysis of the expected operating temperatures should be conducted to determine the proper oil that should be used in the pump. It should be noted in the case of a large swing in ambient temperatures, it may require different types of oils are used for summer and winter. Unless otherwise noted by Flowserve engineering, the following information should be used to determine the proper oil to use in the pump and whether more than one type of oil may be required during yearly operation.

Recommended oils are:

For normal running temperatures between 10 ° and 65 °C (50 ° and 150 °F):
Indoor installations or outdoor summer conditions with ambient temperature of –5 ° to 35 °C (23 ° to 95 °F).

Oil should meet ISO 3448 VG 220 (former AGMA Standard 250.04 Lubricant No. 5), viscosity range 198 to 242 cSt at 40 °C.

Typical oils per Column "A" in Section 5.2.1. Change oil every six months or seasonally.

For winter running temperatures between –18 ° and 38 °C (0 ° and 100 °F):
Cold Starting conditions with ambient temperatures of –5 ° to 10 °C (23 ° to 50 °F).

Oil should meet ISO 3448 VG 68 (former AGMA Standard 250.04 Lubricant No. 2EP), viscosity range 60 to 75 cSt at 40 °C.

Typical oils per Column "B" in Section 5.2.1. Change oil every 6 months or seasonally.

For high temperature service between 60 ° and 120 °C (140 ° and 250 °F):
Oil should meet ISO 3448 VG 460 (former AGMA Standard 250.04 AGMA Lubricant No. 7), not compounded, viscosity range 414 to 506 cSt at 40 °C.

Typical oils per Column "C" in Section 5.2.1.

60 ° to 82 °C (140 ° to 180 °F) - change oil every four months

82 ° to 104 °C (180 ° to 220 °F) - change oil every two months

104 ° to 120 °C (220° to 250 °F) - change oil every month

For temperatures above 120 °C (250 °F):
Same requirements as for high temperature service between 60 ° and 120 °C (140 ° and 250 °F).

Initial start-up oil must be drained and replaced after 24 hours running time.

Change oil weekly.

Note**: For some applications, depending on conditions of service, separate shaft mounted lube oil circulation/cooling system is required; check the sectional drawing for recommended oils and oil levels if this condition applies.**

5.2.3 Oil levels
Check the Sectional, Outline, and General Arrangement drawings for bearing housing oil levels. For simple Oil Splash Lubrication systems, not having an external LOS, the oil levels are typically setup at the lowest level of the gear teeth around the pitch diameter on the gears housing end, and around the center of the lowest bearing roller on the bearing housing end. These levels are typically shown on the drawings as a dimension below the shaft centreline, or with a mark on the level oil gauge (if there is any), to facilitate the operation of setting up the oil levels before starting the pump to operation. Note that once the initial oil level is set in the gear housing it should be adjusted after start up following the directions in section 5.2.4. Pump packages including an external LOS might not require having an oil level setup.

5.2.4 Checking running oil level in gear housing
If the oil reservoir is filled to the level indicated on the column gauge (when pump is at running speed), ample lubrication will be provided for the timing gears and bearings contained in the housing.

However, if field operating conditions (temperature, etc.) vary considerably from standard, the level must be checked internally to insure proper lubrication. Follow the procedure as outlined below.

a) Remove the filler vent plug.
b) With the pump running at rated speed and operating temperature, the timing gears should pick up enough oil to create a fine mist throughout the gear case. Too much oil will cause overheating. Too little oil will cause gear and bearing failure. Adjust oil level until fine mist is present.
c) Replace vent filler and pipe plugs.
d) Repeat procedure periodically to ensure proper lubrication and extended pump life.

5.3 Direction of rotation

CAUTION Ensure the pump is given the same rotation as the pump direction arrow cast on, or affixed to, the pump casing.

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

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

5.4 Guarding

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

5.5 Priming and auxiliary supplies

Before starting any rotary pump it is absolutely necessary that both the pump and suction line be primed with liquid. This can be accomplished by one of the following methods:

1. Remove pipe plug from discharge side of body and install a temporary filling line. Pour appropriate amount of the liquid being pumped into the pump through this line while rotating the pump by hand in the opposite direction from that shown on the rotation arrow. This will cause the oil to work into the pumping rotors to help seal while priming. Turn temporary filling line down and direct into the baseplate drip pan or some other suitable container. Start the pump, running it in the rotation shown on the rotation arrow. When a solid stream of oil is achieved from the filling line, stop the pump, remove the piping and replace the pipe plug.

2. When the liquid supply level is above the pump discharge valve, it is primed by opening the suction and discharge valves. The in-flowing liquid will displace the air and fill the suction line, pump casing and discharge line up to the level of supply.

3. When the above two methods are unsuitable, it is necessary to vacuum prime the pump. This can be accomplished with a vacuum pump or air ejector. The priming line is attached to the upper most portions of the discharge / suction piping. To prime, close the discharge valve and do not start the driver until the pump and piping are full of liquid. Provision must be made to seal the stuffing box with sealing fluid to prevent in leakage of air.

It should be noted that if a valve is not provided on the discharge side of the pump it may be necessary to prime the entire system to avoid excessive power consumption on initial start-up.

5.6 Starting the pump

a) CAUTION Ensure flushing and/or cooling/ heating liquid supplies are turned ON before starting the pump.
b) OPEN the outlet valve.
c) OPEN all inlet valves.
d) Prime the pump.
e) Ensure all vent connections are closed before starting.
f) Start motor and check outlet pressure.
g) CAUTION Do not run the pump with the outlet valve closed.
h) If NO pressure, or LOW pressure, STOP the pump. Refer to section *7 FAULTS; CAUSES AND REMEDIES*, for fault diagnosis.

5.7 High temperature start up

In case of a high temperature start up, it is essential that the entire pump, including any product recirculation piping, has had time to achieve stability at the required operating temperature prior to start up. If the **entire** pump is not stable at the required operating temperature, it could cause distortions in the housings or body and may cause mechanical problems during start up or operation. The same precaution is also true of the recirculation piping. It is also imperative that the pump and recirculation piping be completely covered with securely fastened insulation.
In addition to the standard start up procedures outlined the following steps should be followed in high temperature applications.

1) An empty pump should first be filled with product at ambient temperature to avoid thermal shock. The pump should never be started empty or cold.
2) Steam or a heat transfer liquid should be circulated through the housing and body jackets as well as the recirculation piping jackets. The heating medium should be at the operating temperature and circulated at a rate which will produce a maximum temperature rise of approximately 65 °C per hour (117 °F per hour). A four hour heat soak period prior to start up is recommended.
3) An appropriate flow of the heat transfer medium is required during operation to ensure the pump is maintained at the operating temperature.

5.8 Post start-up

Once the unit has operated satisfactorily for several days, record as much information about these normal

operating conditions as possible. This data may be helpful in identifying and correcting changes in future performance before serious problems occur.

Typical data to be recorded is: serial number of pump and driver, suction pressure, discharge pressure, specific gravity, capacity, pump speed, amperage and voltage (each phase), seal liquid pressure, ambient temperature, pumping temperature, bearing temperatures, vibration etc.

After the unit has been running continuously about one week, the coupling halves of direct driven units should be given a final check for misalignment caused by pipe strains or temperature strains. If the alignment is correct, both the pump and driver should be dowelled to the baseplate. The pump should be dowelled with one dowel in each support foot. Refer to the manufacturer's manual for driver dowelling instructions.

5.9 Running the pump

5.9.1 Venting the pump

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

The pump can be vented by opening the plugs in the suction chamber.

There is a spot between the Suction Spool and the Outer Casing that cannot be vented before start-up. Being a Multi-Phase Pump, there is no need to fully vent the air from this location. There is no need to have a bleed point on the Outer Casing just to vent this pocket. The air or gas from this pocket might or might not disappear during operation; but this little air or gas trapped in this pocket should not pose a risk for the operation of the pump.

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

5.9.2 Pumps fitted with mechanical seal

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

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

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

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

5.9.3 Bearings

It is recommended that temperature and/or vibration monitoring at the bearings is done if the pumps are working in a potentially explosive atmosphere

If bearing temperatures are to be monitored it is essential that a benchmark temperature is recorded at the commissioning stage and after the bearing temperature has stabilized. Record the bearing temperature (t) and the ambient temperature (ta). Estimate the likely maximum ambient temperature (tb). Set the alarm at (t+tb-ta+5) °C [(t+tb-ta+10) °F] and the trip at 100 °C (212 °F) for oil lubrication.

5.9.4 Normal vibration levels, alarm and trip

For guidance, pumps generally fall under a classification for rigid support machines within the International rotating machinery standards and the recommended maximum levels in Table 5 are based on the API-676 standard, 3rd Edition.

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

Table 5 – Max. vibration limits

Condition		Vibration velocity – unfiltered mm/s (in./s) r.m.s.
Normal	**N**	≤ 5.5 (0.22)
Alarm	**N** x 1.25	≤ 6.9 (0.27)
Shutdown trip	**N** x 1.5	≤ 8.2 (0.32)

5.9.5 Stop/start frequency

Pump sets are normally suitable for the number of equally spaced stop/starts per hour shown in the Table 6. Check actual capability of the driver and control/starting system before commissioning.

Table 6 – Motor stop/starts per hour

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

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

5.10 Stopping and shutdown

5.10.1 Short term

a) CAUTION Never close the outlet valve prior to stopping the pump. Stop the driver.
b) Leave open the valve supplying auxiliary sealing fluid to maintain prime while the pump is idle.
c) On pumps with steam jacketed bodies and/or stuffing boxes, maintain steam flow to prevent pumping liquid from setting up in the internals of the pump.

5.10.2 Long term

a) CAUTION Never close the outlet valve prior to stopping the pump. Stop the driver.
b) Switch off flushing and/or cooling/heating liquid supplies at a time appropriate to the process.
c) On pump with steam jackets, shut off steam flow and allow pump to cool.
d) CAUTION For prolonged shut-downs and especially when ambient temperatures are likely to drop below freezing point, the pump and any cooling and flushing arrangements must be drained or otherwise protected.

5.11 Hydraulic, mechanical and electrical duty

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

5.11.1 Differential pressure

Each operator should study the performance curve supplied with the particular unit in question. This curve should indicate the design pressure, capacity, speed and viscosity (condition of service, COS, pumping conditions) for which the unit was sold.

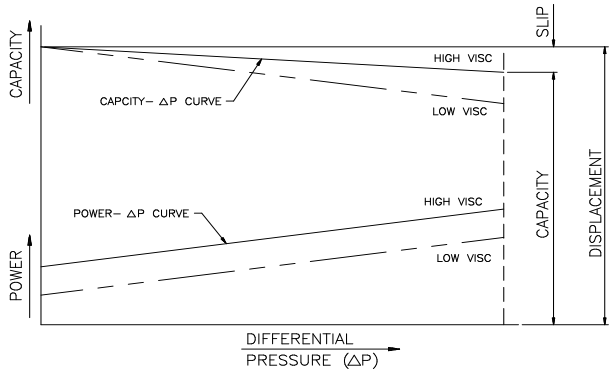


Figure 6 – D.P. vs. capacity relationship

Any positive displacement pump is suitable for a wide range of operating conditions, but to meet a specific condition of service the pumping rotors must be the correct pitch and rotate at the correct speed. When the rotor pitch, speed and viscosity are known, a single curve can be drawn which shows the relationship between differential pressure and capacity (Refer to Figure 6). Barring suction, system or mechanical troubles, the pump will operate at some point on this curve.

To operate at some point not on the capacity-differential pressure curve would require a different speed or a different viscosity liquid being pumped.

A positive displacement pump has a general characteristic that the flow decreases as the differential pressure across the pump increases. The pump operates against the resistance of the system and does not generate head as a centrifugal pump does. It will continue to operate if the system resistance increases (closing of discharge valve), building up internal pressure until failure of pressure containing parts. A suitably sized relief valve should be present in the discharge piping between the discharge valve and the pump.

Again, it should be noted that a positive displacement pump should never be started against a closed discharge valve nor should the discharge valve be closed prior to stopping the pump.

The capacity the pump produces at zero differential pressure (system resistance) is called the displacement of the pump and is not dependent on the viscosity of the liquid. It is a function of the size of the pump, the pitch of the pumping rotors and the pump speed. As the differential pressure increases, recirculation or slip is produced as liquid is forced back to suction through the internal clearances of the pump. The slip increases proportionally to the differential

pressure. The amount the slip increases is a function of the viscosity of the liquid and the higher the viscosity of the liquid, the lower the slip. The displacement minus the slip is the capacity the pump will produce.

Normal operation of the pump will eventually produce wear on internal components resulting in increased internal clearances. This will increase the slip and reduced performance may be experienced. At this point, rotating components may have to be refurbished or replaced to maintain original performance.

Never operate a positive displacement pump to any pressure in excess of the maximum pressure indicated on the nameplate. If the original conditions must be changed for any reason, consult Flowserve.

A multiphase pump is designed to handle two phases, one a liquid, the other a gas. At high Gas Void Fractions (GVF) sufficient liquid must be available for recirculation through the pump. The fluid is being recirculated so that it may form a seal between the pump's bores and the screw's outer diameter. Fluid is retained by the pump in the volume between the Inner Casing and Outer Casing. It enters the suction chamber by means of four orifice plugs in the Inner Casing.

At high gas void fractions like values of 100%, there will be a limited time that the pump can operate without overheating. If the pump is to be operated at very high Gas Void Fractions for extended periods, water must be injected into the suction line to limit the operating temperature of the pump. As a rough guide the amount of water to be injected will be approximately 4% of the pump's capacity.

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

5.11.3 Pump speed
Changing pump speed effects flow, power absorbed, $NPSH_R$, noise and vibration. Pump displacement varies in direct proportion to pump speed. However, the new duty will also be dependent on the system curve. If increasing the speed, it is important therefore to ensure the maximum pump working pressure is not exceeded, the driver is not overloaded, $NPSH_A$ > $NPSH_R$, and that noise and vibration are within local requirements and regulations.

5.11.4 Net positive suction head ($NPSH_A$)
NPSH available ($NPSH_A$) is a measure of the head or energy available in the pumped liquid, above its vapour pressure, at the pump suction branch.
NPSH required ($NPSH_R$) is a measure of the head required in the pumped liquid, above its vapour pressure, to prevent vaporization of the liquid. This phenomenon, called cavitation, can cause serious damage to the pump and adversely affect performance. It is important that $NPSH_A > NPSH_R$ to avoid vaporization of the liquid. The margin between $NPSH_A > NPSH_R$ should be as large as possible.

$NPSH_A$ is affected by changes in the liquid temperature and vapour pressure, the altitude of the installation, entrained gasses in the liquid, and the viscosity of the liquid.

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

5.11.5 Pumped flow
Pump displacement varies directly with speed. The slip or leakage from discharge to suction through the internal clearances varies with differential pressure and viscosity. The pumped flow is the displacement less the slip.

5.11.6 Pressure surges
The pump must not be subjected to pressure surges such as may be caused by water hammer or sudden check valve closure.

6 MAINTENANCE

6.1 General

⚠ It is the plant operator's responsibility to ensure that all maintenance, inspection and assembly work is carried out by authorized and qualified personnel who have adequately familiarized themselves with the subject matter by studying this manual in detail. (See also section 1.6 *Safety*.)

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 *5.10 Stopping and shutdown*.

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 SHUTDOWN* must be observed.

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

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

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

Do not spray air or compressed inert gas on skin.

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

Never use air or compressed inert gas to clean clothes.

Before working on the pump, take measures to prevent an uncontrolled start. Put a warning board on the starting device with the words: ***"Machine under repair: do not start"***.

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

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

6.2 Maintenance schedule

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

a) Any auxiliary systems installed must be monitored, if necessary, to ensure they function correctly.
b) Check for any leaks from gaskets and seals. The correct functioning of the shaft seal must be checked regularly.
c) Check bearing lubricant level, and if the hours run show a lubricant change is required.
d) Check that the duty condition is in the safe operating range for the pump.
e) Check vibration, noise level and surface temperature at the bearings to confirm satisfactory operation.
f) Check dirt and dust is removed from areas around close clearances, bearing housings and motors.
g) Check coupling alignment and re-align if necessary.
h) Rotate idle pump shafts by hand to check for free turning.

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

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

a) Refer to section *7 FAULTS; CAUSES AND REMEDIES* for fault diagnosis.
b) Ensure equipment complies with the recommendations in this manual.
c) Contact Flowserve if the problem persists.

6.2.1 Routine inspection (daily/weekly)

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

a) Check operating behaviour. Ensure noise, vibration and bearing temperatures are normal.
b) Check that there are no abnormal fluids or lubricant leaks (static and dynamic seals) and that any sealant systems (if fitted) are full and operating normally.
c) Check that shaft seal leaks are within acceptable limits.
d) Check the level and condition of oil lubricant. On grease lubricated pumps, check running hours

since last recharge of grease or complete grease change.

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

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

6.2.2 Periodic inspection (six monthly)

a) CAUTION Check foundation bolts for security of attachment and corrosion.

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

c) The coupling should be checked for correct alignment and worn driving elements.

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

6.2.3 Re-lubrication

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

6.2.3.1 Oil lubrication

CAUTION Maintaining the correct oil level is very important.

If the pump is supplied with a constant level oiler the oil level will be automatically maintained and as long as oil is visible in the glass bottle there is no need to refill. If however a sight glass has been fitted then regular checks should be made to ensure the level is maintained at the centre of the glass window.

Refer to section *5.2.2 Lubrication schedule* for the schedule and temperature limits and 5.2.3 *Oil levels* for methods of oil fill.

6.2.4 Mechanical seals

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

6.3 Spare parts

6.3.1 Ordering of spares

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

- Pump serial number
- Pump size
- Part name
- Part number – from Parts list provided separately
- Number of parts required

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

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

6.3.2 Storage of spares

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

For large quantities of Multiphase Twin Screw Pump parts, it is advisable to contact your local Flowserve Sales representative giving full detail of quantities, sizes and metallurgy.

The severity of the conditions of service, the extent to which repairs can be carried out in the field and the number of units installed will determine to a great extent the minimum number of spare parts which should be carried in stock at the site of the installation.

6.3.3 Returning parts

All materials for return to the factory must have a Return Material Authorization. Consult the nearest District Office or Factory Customer Service Dept. (CS) for shipping instructions and a 'Return Material Tag'.

Unnecessary delays are avoided when parts or equipment are returned to the factory using the correct procedure.

a) On receipt of the Return Material Number, mark or tag the material to be returned with this number. In cases where more than one part or box is returned, print or stencil your company name and the Return Material Number on each part or box. This will facilitate quick identification. Articles being returned should be carefully packed to prevent damage from handling or from exposure to weather.

b) Contact your nearest District Office, listing material to be returned and the reasons for returning it. Make sure you give the name of the part and the part number involved and the serial number of the equipment. Give the method and date of shipment. This will notify the factory that material is enroute.

c) Do not return parts without authorization.

6.4 Recommended spare parts

Table 7 – Recommended spare parts

NAME OF PART	QTY.
Bearings	1 set
Oil Seals	1 set
Gaskets	1 set
Mechanical Seal	1/1 set
O Rings	1 set

Note: Refer to the Recommended Spare Parts list furnished with the contract documentation for specific part numbers.

6.5 Tools required

No special tools are required for assembly or disassembly.

6.6 Torques for fasteners

Recommended torques for tightening the bolts and screws on the pumps are given in the following tables.

6.6.1 Carbon steel bolts/nuts SAE grade 2 (1)

Table 8 – SAE grade 2 torques values

Thread Size (in.)	Recommended Torque Values (Ft-lbs)
3/8	17
1/2	40
5/8	80
3/4	135
7/8	150
1	210
1-1/8	300
1-1/4	420
1-3/8	550
1-1/2	720

(1) These values are also suitable for 300 series stainless steel, Monel, Inconel, Hastelloy, B & C and Alloy 20 fasteners.

6.6.2 High strength steel bolts/nuts SAE grade 5

Table 9 – SAE grad 5 torque values

Thread Size (in.)	Recommended Torque Values (ft.lbs)
3/8	27
1/2	65
5/8	125
3/4	225
7/8	365
1	545
1-1/8	675
1-1/4	950
1-3/8	1240
1-1/2	1430

6.7 Renewal of clearances

Twin screw pumps are used in a variety of applications handling materials with a wide range of viscosities. As such, it is difficult to predict at exactly what point screw clearances are too large and the screws should be repaired or replaced. In low viscosity or high pressure applications, increased screw clearances may result in an unacceptable loss in hydraulic performance. On the other hand, in high viscosity or low pressure applications, the same change in screw clearance may result in very little change in pump hydraulic performance. Since increased clearance can result in lower pump performance, the flow capacity should be the guiding parameter to define when the screw to body bore clearance should be re-evaluated, and compared to the value shown in the Engineering Data section of this manual.

6.8 Disassembly

Note that replacements materials should be available prior to disassembly to limit downtime. Refer to sectional drawing shown in section *8 PARTS LIST AND DRAWINGS* of this manual and to the specific sectional drawing and/or parts list applicable to your pump.

6.8.1 Split bearing brackets

The split bracket provides a flanged joint between the seal housing half and the bearing housing half of the bracket. This joint allows full accessibility to the stuffing box for both machining and mechanical seal installation and maintenance. This is required for cartridge mounted seals.

With split brackets it is not necessary to remove the entire bracket to remove or inspect the seals. The bracket can be split at the intermediate joint to gain full access to the stuffing box, without disturbing the primary body to bracket joint. It is critical that the bracket halves be reassembled in the correct orientation and with the dowel pins snugly fitted.

SPECIAL NOTE: These brackets are machined as matched sets and as such are not interchangeable with similar components on this or other units. The

machined surface at the split joint should not be used as a reference surface for checking other aspects of bracket machining. The bracket halves are match marked to ensure correct assembly.

6.8.2 Disassembly

The following procedure is recommended for disassembling the entire pump. Steps “a” to “g” are mandatory all the times. Steps “h” to “k” are sufficient for removing only the Drive End (DE) mechanical seals. Steps “l” to ”s” are sufficient for removing only the Non Drive End (NDE) mechanical seals.

It is highly recommended to mark the parts as they come off the pump as DE or NDE, as well as **DR** (**D**rive**R** shaft) and **DN** (**D**rive**N** shaft), depending on where were they taken from. This might be needed if the pump will be re-assembled with some of the used parts still in good condition for re-use. Some parts as the seal housing - bearing housing assemblies might have been doweled during previous re-assemblies, as opposed to have been factory machine doweled. Spacers, if needed might have been specifically ground to properly set up the axial position of components, and they shall be installed in the same location or position. Other equivalent parts, as mechanical seals, bearings just settled in slightly different positions after hours of operation, due to the non-symmetrical way the loads are transferred to the components of these twin screw pumps.

The numbers beside each part name are referenced to the typical sectional drawing furnished in section *8 PARTS LIST AND DRAWINGS* of this manual. If the pump has additional parts specifically required for your application, and they are not shown on this typical sectional drawing, the specific sectional drawing for your application can be requested from the factory.

a) Ensure that the driver is locked out and cannot be accidentally started.
b) Ensure that the pump is isolated from the system by closing off all primary and auxiliary piping valves associated with the pump.
c) Flush the pump body and piping system if necessary.
d) Drain the pump body & lube oil cavities.
e) Drain the seal flush & drain lines. Then disconnect from seal
f) Remove coupling guard and uncouple the pump from the driver by removing the coupling spacer.
g) Remove the pump half coupling.
h) Remove the DE cover [3530.1] from the DE bearing housing [3459.1].
i) Remove the DE fasteners [6572.5] and the DE bearing housing [3459.1] from the inner casing [1110.1]. In this operation the radial bearings [3012.1] will come out with the DE bearing housing, but leaving their inner races on the shaft.
j) Remove the mechanical seals [4200.1 & 4200.2] from the DE of the pump.
k) Remove the DE seal housing [4110.1].
l) Remove the NDE cover [1610.1] from gear housing [1600.1].
m) Remove the thrust bearings retainer plates [8448.2] or the supernuts, depending on the design you have.
n) Remove the thrust bearings [3013.1] using a puller and eventually heating them up.
o) Remove the NDE fasteners [6572.3] and the gear housing [1600.1] from the NDE bearing housing [3459.1]. In this operation the timing gear bearings [3012.2] will come out with the NDE bearing housing, but leaving their inner races on the shaft.
p) Before removing timing gears [2300.1 & 2300.2] from the shafts, note that the stamped letters on their hubs are facing outboard. This is important when reassembling the pump. Remove the superbolt bearing locknuts [6580.1] and the timing gears [2300.1 & 2300.2].
q) Remove the NDE fasteners [6572.5] and the NDE bearing housing [3459.1] from the inner casing [1110.1].]. In this operation the radial bearings [3012.1] will come out with the NDE bearing housing, but leaving their inner races on the shaft.
r) Remove the mechanical seals [4200.1 & 4200.2] from the NDE of the pump.
s) Remove the NDE seal housing [4110.1].
t) Properly rig the drive shaft [2120.1] and the driven shaft [2140.1] together with slings as close as possible to the NDE of the screws. This is needed to simultaneously pull them off from the pump, by lifting them from the bottom of the inner casing bores, where they have been resting since the bearing housings were removed.

⚠ CAUTION **The slings should be used in a choke type arrangement for lifting. Since it will be difficult to exactly center the weight, use extreme caution while removing the screws as light pressure may be required to keep the screws balanced as they are removed from the bores.**

u) Use the slings to lift the screws just enough to release them from contacting the bores. Carefully start pulling them from the inner casing from the NDE, controlling the pulling action to avoid minimize contact or rub between the screws and the bores. Light contact should not damage any component.
v) Slowly move the screws out of the bores until the discharge section of the screws is just outside of the casing and allow the screws to rest on the

bores, to have the opportunity to move the location of the sling to a the middle section between the flights on the screws.

w) Carefully lift both screws to just raise them off the bottom of the bores. Please note the screws are not exactly balanced which will require light pressure to compensate right as the screws exit the bores. This is needed to prevent damage to screws or bores during the removal process.

x) Examine parts as recommended in section *6.10 Examination of parts*.

6.9 Removing inner casing from outer casing

If it is required to remove the inner casing [1110.1] from the outer casing [1110.2], follow this section. In this case the inner casing [1110.1] needs to be re-inserted to the outer casing before the final re-assembly.

To separate the Inner and Outer Casing the following procedure is to be followed after the disassembly.

a) Remove the pump suction spool piece [1800.1] from the casing assembly.

b) Remove the casing key [6700.2] from the liner and outer casing by removing the cap screw [6579.3] holding it in place.

c) Place the casing assembly made of the outer casing [1110.2] and inner casing [1110.1] on its DE, so that the locking ring [6548.2] and the shear ring [6548.1] are accessible from the top.

d) Remove locking ring [6548.2] from pump.

e) Remove shear ring [6548.1] from casing. It may be necessary to pry it out by means of set screws [6574.1] mounted in the shear ring.

f) Gently lift the inner casing [1110.1] from the outer casing [1110.2].

6.10 Examination of parts

a) Inspect the pumping rotors and body bores for excessive wear or damage.

Note: If the difference between the body bore diameter and the pumping rotor diameter is twice the quoted operating clearance or greater, an evaluation of the pump's performance may be required, to decide whether the screws and/or the inner casing must be refurbished or replaced.

b) Inspect bearings for wear and the presence of foreign matter. Replace if damaged or worn. Bearings manufacturer typically recommend replacing bearings anyway if you cannot control or guarantee they are free of debris or dirt that might have gotten inside of them during the disassembly or re-assembly process.

c) Inspect all gaskets and o-rings for damage. It is recommended that these items be replaced to avoid problems with reassembly.

d) Inspect and clean internal bores of seal housings.

e) Clean and inspect all gasketed surfaces.

f) Clean the shafts and inspect for corrosion, evidence of cracking, fatigue, or mechanical damage. Remove all nicks and burrs. Check that shafts are straight within 0.050 mm (0.002 in.).

6.11 Inserting inner casing into outer casing

Clean the mating surfaces of the inner casing [1110.1] & outer casing [1110.2], including grooves for sealing o-ring [4610.1] and shear ring [6548.1], before starting the insertion, to ensure that they are free of dirt & debris. All other pump parts shall be out from the inner casing before starting to insert the inner casing into the outer casing.

a) Ensure the four (4) orifice [6578.3] are installed into bottom of inner casing [1100.1].

b) Install anti-rotation inner casing key [6700.2] in outer casing [1110.2]. It may need to be held in place by temporary means while installing the inner casing into the outer casing.

c) Install new o-rings [4610.1 & 4610.2] onto inner casing [1110.1]. Use plain grease to hold them in place while the inner casing [1110.1] is inserted into the outer casing [1110.2].

d) Turn outer casing [1110.2] to lay on the NDE, having the anti-rotation inner casing key [6700.2] nearest to ground.

e) Carefully lower inner casing [1110.1] fitted with o-rings [4610.1 & 4610.2] into outer casing [1110.2] making sure to line up the keyways between the inner and outer casings. Install the cap screw to hold key if not installed earlier.

f) Install three oval set screws (5/16 in. X ¾ in. long) into the locking ring, if used [6548.2] & six into the shear ring [6548.1].

g) Install shear ring [6548.1] [segmented ring six pieces].

h) Apply a “never seize” type compound to the mating surfaces of the locking ring [6548.2] and the shear ring [6548.1].

i) Install locking ring [6548.2] and torque locking ring bolts (12, 7/16 in. socket head capscrews 2.5 in. long) to 20 ft·lbs.

j) Vertically lift up pump by the inner casing [1110.1] and re-torque locking ring bolts to 20 ft·lbs.
k) Put casing assembly back on its feet.
l) Insert suction spool piece [1800.1] fitted with o-rings [4610.5 & 4610.6] into pump suction. Bolt it down with fasteners [6579.1].

6.12 Re-assembly

CAUTION **Care must be taken during the assembly operation to avoid contamination of the parts with dirt, dust or other foreign matter.**

The numbers besides each part name are referenced to the typical sectional drawing furnished in Section *8 PARTS LIST AND DRAWINGS* of this manual. If the pump has additional parts specifically required for your application, and they are not shown on this typical sectional drawing, the specific sectional drawing for your application can be requested from the factory.

a) Inspect all new parts. Remove all nicks and burrs which may have occurred in handling. Make sure the **inner races** of the radial bearings [3012.1] and of the timing gear bearings [3012.2], and the speedi sleeves [2450.1 and 2450.2] are already mounted on the shafts.
b) Intermesh the drive shaft [2120.1] and the driven shaft [2140.1] together, taking care to line up the ends of the pumping screws. Carefully slide the shaft assembly into the pump body with the assistance of slings, paying attention to minimize or avoid strong contact or rub between the screws and the inner casing bores. Eventual but light contact should not damage any component.
c) Mount a new o-ring type gasket [4610.3] on the NDE seal housing [4110.1] groove. Use plain grease to facilitate keeping it in place while the seal housing is mounted and fastened to the inner casing [1110.1].
d) Attach the NDE seal housing [4110.1] to pump inner casing [1110.1], using dowel pins [6585.1] to properly set it up in the right place.
e) Mount mechanical seals [4200.1 and 4200.2] to the NDE seal housing [4110.1].
f) Mount the NDE bearing housing [3459.1] fitted with snap rings [2110.1], radial bearings [3012.1] outer races, cages and rolling elements assemblies only, along with lip seals [4300.2] in place; the inner races of the bearings must be mounted on the shafts. For this assembly operation use the dowel pins [6585.1] protruding from the seal housing [4110.1] to line up the bearing housing [3459.1]. Use NDE fasteners [6572.5], tightening them with the fingers only; do not torque these fasteners yet. Note the top mark on the bearing housing [3459.1], so that it will be replaced in the original position as assembled in the factory.

Note: DE and NDE bearing housings are very similar, but they might have been re-doweled to a different position from previous dis-assemblies or repairs. Care must be taken to avoid interchanging them to avoid dowelling problems.

g) Mount a new o-ring type gasket [4610.3] on the DE seal housing [4110.1] groove. Use plain grease to facilitate keeping it in place while the seal housing is mounted and fastened to the inner casing [1110.1].
h) Attach the DE seal housing [4110.1] to pump inner casing [1110.1], using dowel pin [6585.1] to properly set it up in the right place.
i) Mount the DE bearing housing [3459.1]] fitted with snap rings [2110.1], radial bearings [3012.1] outer races, cages and rolling elements assemblies only, along with oil seals [4300.2] in place; the inner races of the bearings must be mounted on the shafts. For this assembly operation use the dowel pins [6585.1] protruding from the seal housing [4110.1] to line up the bearing housing [3459.1]. Use DE fasteners [6572.5], tightening them with the fingers only; do not torque these fasteners yet. Note the top mark on the bearing housing [3459.1], so that it will be replaced in the original position as assembled in the factory.

Note: DE and NDE bearing housings are very similar, but they might have been re-doweled to a different position from previous disassemblies or repairs. Care must be taken to avoid interchanging them to avoid dowelling problems.

j) Make sure the dowel pins [6585.1] are properly inserted in the dowel pin holes of the NDE and DE seal housings [4110.1] and bearing housings [3459.1]; adjust as needed.
k) Tighten all capscrews and nuts fastening the DE and NDE seal housings [4110.1] and bearing housings [3459.1] to the inner casing [1110.1]. The pump should now turn freely. If pump does not turn freely, refer to section 6.13 [Free Movement].
l) Mount timing gears [2300.1 & 2300.2] onto the shafts in the exact location from which they were removed. Note then, when timing gears are installed correctly, original punch marks on teeth will line up per Figure 8. Lock the timing gears against the shaft shoulder with the superbolt nut [6580.1].
m) Mount a new flange gasket [4510.1] on the gear housing [1600.1] next to be assembled, to seal the

flat face joint between it and the NDE bearing housing [3459.1]. Use the NDE fasteners [6572.3] and plain grease to keep this gasket in place while mounting the gear housing to the already installed NDE bearing housing.

n) Mount gear housing [1600.1] to the NDE bearing housing [3459.1]. Tighten all NDE fasteners [6572.3]
o) Install the timing gear bearings [3012.2] outer races, cages and rolling elements assemblies only into the gear housing [1600.1]; the inner races of these bearings must have been mounted already on the shafts.
p) Slightly and evenly heat the thrust [ball] bearings [3013.1] inner races up to facilitate to mount them onto the shafts and into the gear housing [1600.1].
q) Install the thrust bearing retainer plates [8448.1] and lock them up using the fasteners [6579.2].
r) Install the NDE cap [1610.1]. If new bearings are being installed, check that the insertion length of the cap is greater than the recess in the gear housing bore by approximately 0.001 in. to 0.002 in., by measuring the length of the protrusion of the NDE cap [1610.1] from the face of closure to the gear housing [1600.1], and the recess from the face of the gear housing [1600.1] and the visible face of the outer race of the thrust bearings [3013.1]. Any larger and tightening of the rear cap capscrews will distort the cap. Any shorter and contact will not be made with the bearing by the cap.
s) Mount a new flange gasket [4510.1] on the DE bearing housing [3459.1].
t) Mount DE cover [3530.1] with lip seal [2450.1] in place, on the DE bearing housing [3459.1].
u) Re-verify that all dowel pins are in right place and re-verify and re-tighten all bolts and screws to their required torques.

6.13 Free movement

If the pump does not turn freely after reassembly, the following procedure should be observed.

a) The mechanical seal setting tabs may cause the pump to be difficult to turn. However, this should not prevent rotation of the rotating element.
b) Confirm the seal plates and bearing brackets are match marked to each other. It is important to install them in the same location as they were originally installed. These parts are machined as matched sets and ALWAYS use dowel pins to locate the two parts together.
c) Verify the faces of the seal plates, bearing brackets and timing gear housing are flat and parallel. Make sure to clean up any burrs that may have occurred during the repair process.
d) Occasionally there may be more than one set of dowel pin holes due to a prior repair. Make sure to use the current dowel pin holes to assure the proper screw/bore alignment.
e) Make sure the proper spacers are installed on the drive and driven shafts between the timing gear super nuts and the timing gear bearings. It is critical to ensure they are sitting flat against the shoulder of the respective shaft.
f) Remove the NDE cap(s) and confirm the axial clearance between the cap and the outer race of the bearings is 0.0005 in. to 0.0010 in. if there is a hard shim installed or the wavy springs are installed and provide tension.
g) Continue with step “l” from section *6.12 Re-assembly*.

If pump does not turn freely after executing Steps a through f, it is due to incorrectly dimensioned parts or a timing problem. Contact the nearest Flowserve Pumps Service Representative for assistance. Also see section *6.14 Timing gear replacement* of this manual provide guidance in verifying the timing of the rotating element.

6.14 Timing gear replacement

If new timing gears are to be installed on the rotating elements, they must be timed before key slotting. The reason for this is that the timing gear radial position on the shaft determines the critical axial clearance between the pumping screws. In the average screw pump, the change in clearance between the meshing screws is about 0.001 in. for each 0.004 in. distance in circumference at the pitch diameter of the timing gear. Since the normal axial clearance of meshing screws varies with the size of pump and viscosity of the fluid that the pump was designed for, very accurate key slotting is essential for proper operation.

To replace the timing gears, the following procedure should be used.

a) For optimum results it is highly recommended that a set of timing stands as shown in Figure 10 and Table 10 be manufactured.
b) Mount the shafts with the screws intermeshed onto the timing stands resting the shafts on the bearing diameters. The bearings are not mounted on the shafts at this time.
c) Install the driven shaft timing gear key [6700.1].
d) Slide the driven shaft timing gear [2300.2] partially onto its respective shaft diameter, engaging the key.
e) Slide the drive shaft timing gear [2300.1] partially onto its respective shaft diameter with the existing

keyway 180° away from the shaft keyway, meshing with the driven shaft gear [2300.2]. (Figure 7 and Figure 9).

f) Place feeler gauges with a thickness equal to half of the total side clearance on each side of one screw tooth on the drive shaft. This will eliminate contact between the drive and driven pumping screws.
g) Rotate the drive shaft gear [2300.1] in the direction of rotation of the pump until the teeth of both gears are in contact. (Figure 9).
h) Place the driver shaft gear key [6700.1] into the keyway at a right angle to the shaft and against the time gear face. (Figure 8).
i) Scribe a line on both sides of the key on the timing gear face (Figure 8).
j) Mark the position of the drive shaft gear [2300.1] with respect to the driven gear [2300.2] with 3 punch marks. (Figure 8).
k) Remove the drive shaft gear [2300.1] from the shaft and cut a keyway the width as scribed.
l) Install the drive shaft gear [2300.1] and key [6700.1] and intermesh with the driven gear [12] according to the three punch marks.
m) Lock the timing gears against the shaft shoulders with the superbolt nut [6580.1]. Tighten securely.

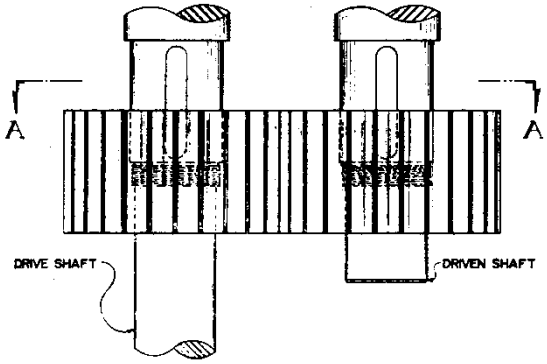


Figure 7

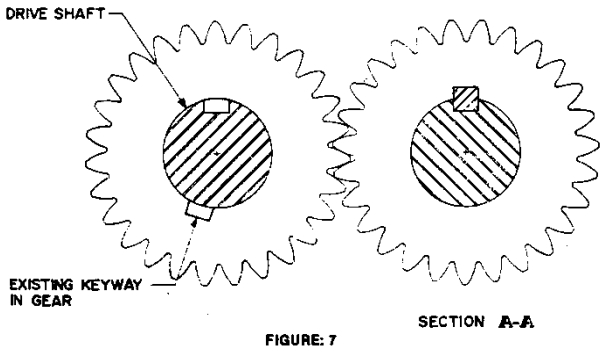


Figure 9

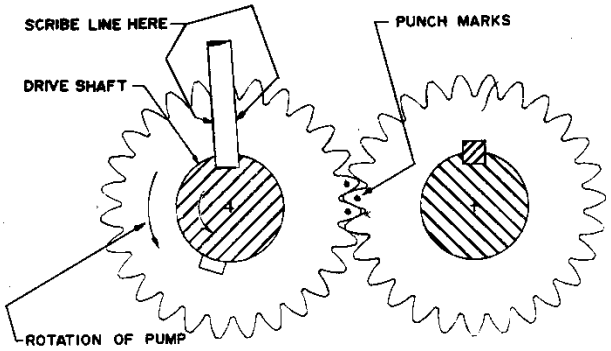


Figure 8

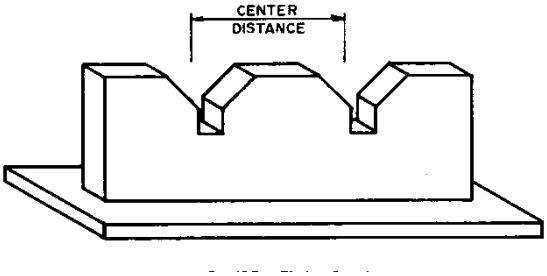


Figure 10 – Timing stand

Table 10 – Standard center distance between drive and driven screws

Pump Size	Center distance (in.]
MP1-150-xxx	4.500
MP1-275-xxx	8.250
MP1-380-xxx	12.000
MP1-390-xxx	12.000

7 FAULTS; CAUSES AND REMEDIES

FAULT SYMPTOM

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

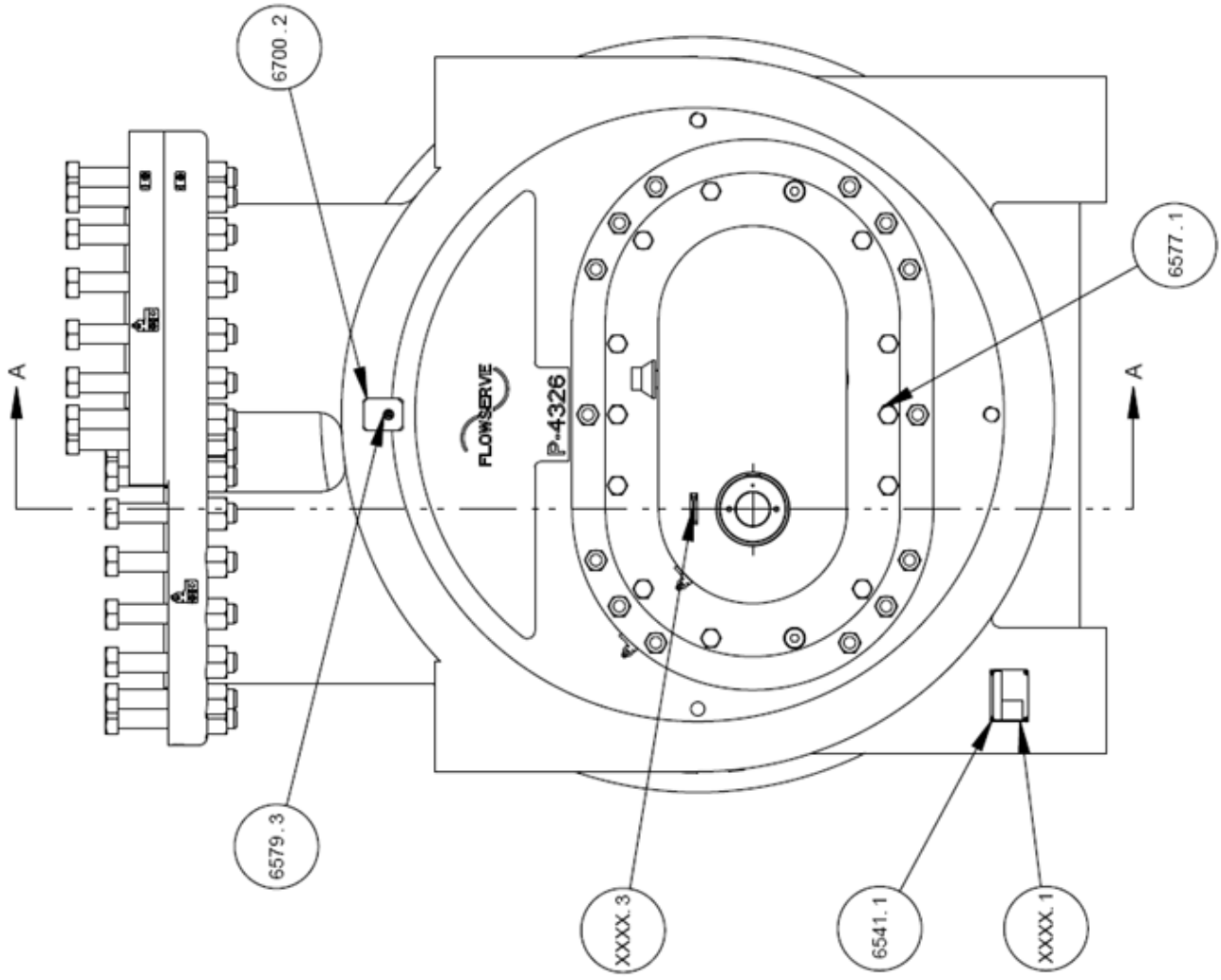
FAULT SYMPTOM

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

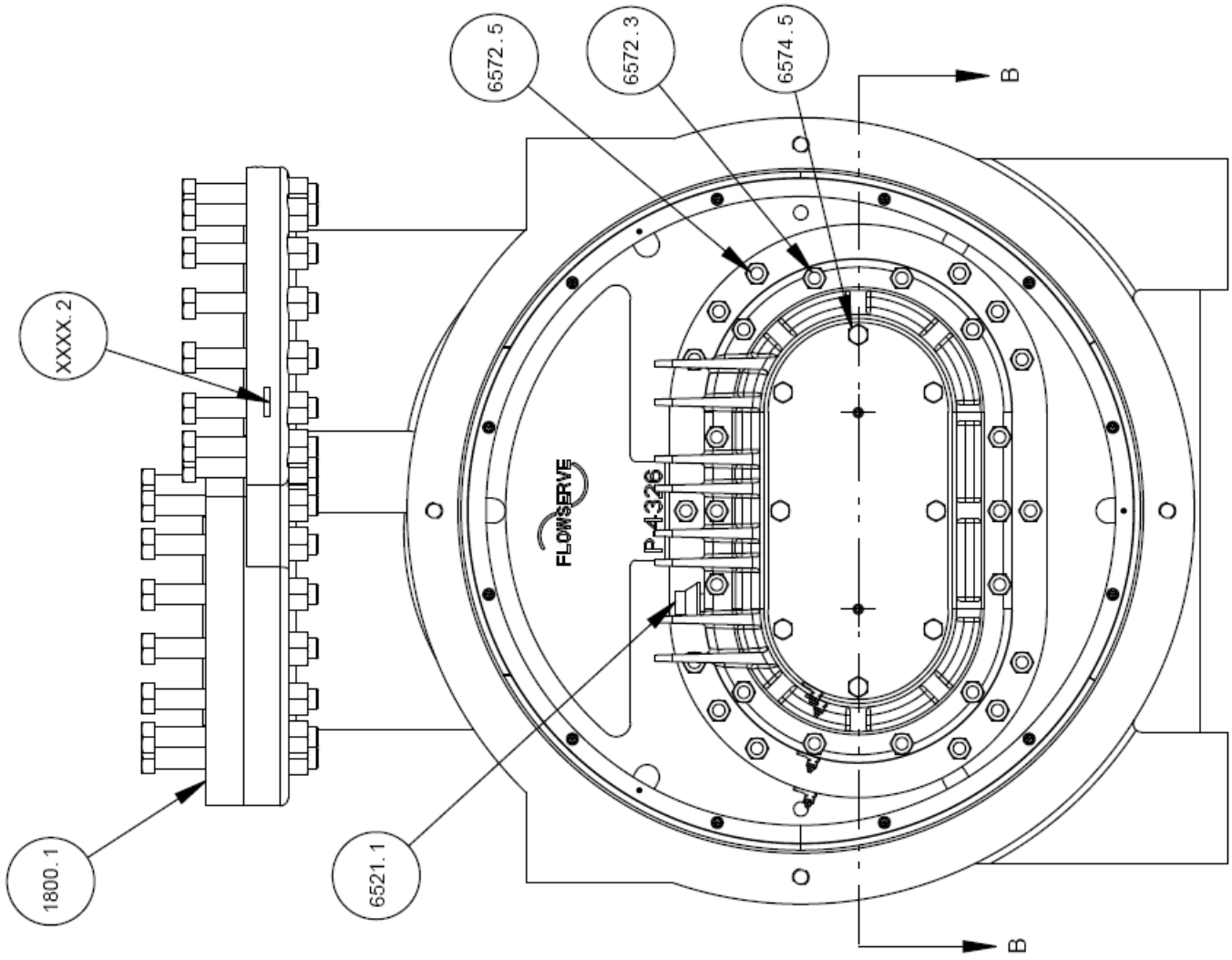
8 PARTS LIST AND DRAWINGS

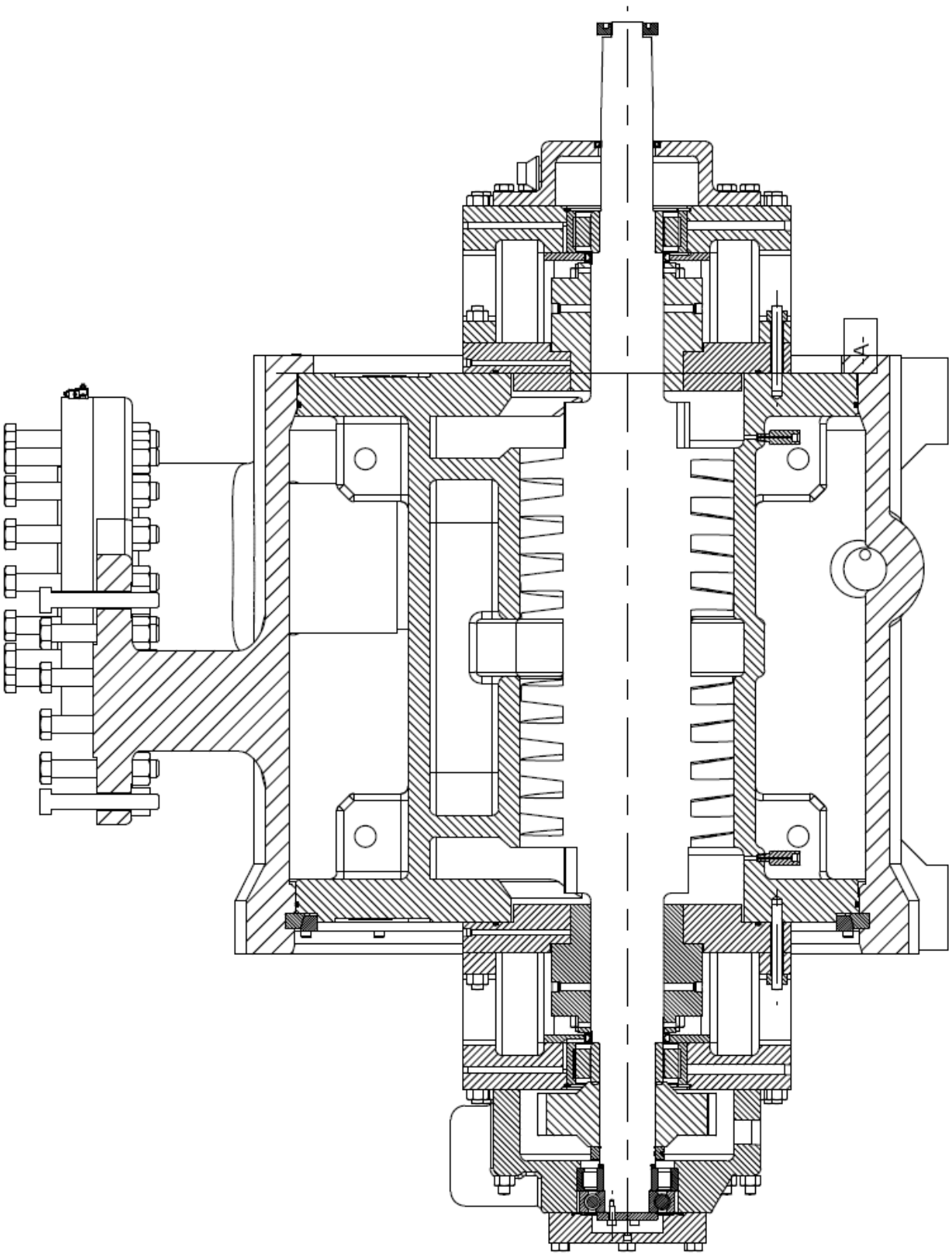
8.1 Sectional Drawing – Typical

REF NO	PART DESCRIPTION	QTY
6541.1	SELF TAPPING SCREW	4
6577.1	CAP SCREWS HH	12
6579.3	SHCS	1
6700.2	ANTI ROT. CASING KEY	1



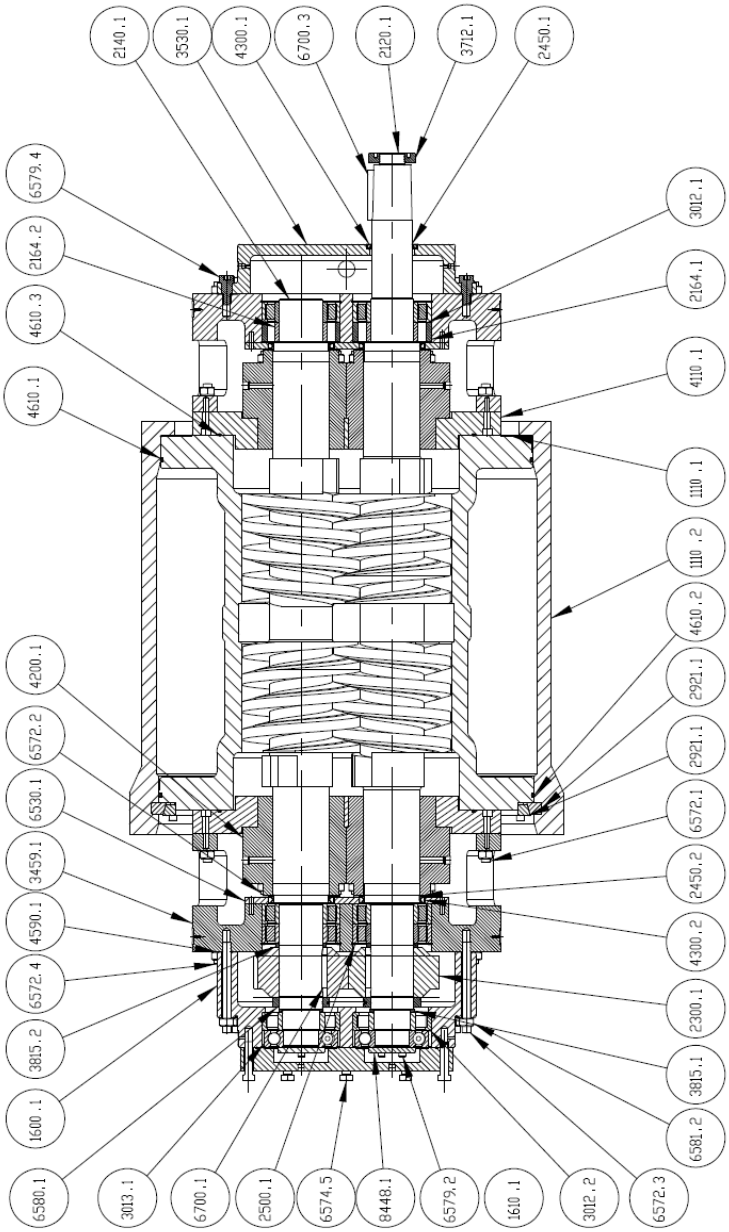
REF NO	PART DESCRIPTION	QTY
1800.1	SUCTION SPOOL PIECE	1
6521.1	OIL BREATHER	2
6572.3	STUDS	14
6572.5	STUDS	28
6574.5	CAP SCREWS	8





SECTION A-A

REF NO	PART DESCRIPTION	QTY
1110.1	INNER CASING	1
1110.2	OUTER CASING	1
1600.1	GEAR HOUSING	1
2110.1	SNAP RING	4
2120.1	DRIVE SHAFT	1
2140.1	DRIVEN SHAFT	1
2300.1	TIMING GEAR DRIVE	1
2300.2	TIMING GEAR DRIVEN	1
2450.1	SPEEDI SLEEVE	1
2450.2	SPEEDI SLEEVES	4
3012.1	BEARINGS	4
3012.2	BEARINGS	2
3013.1	BEARINGS	2
3459.1	BEARING HOUSING	2
3530.1	FRONT COVER	1
3712.1	COUPLING NUT	1
3815.1	SPACER GEAR HOUSING	2
4110.1	SEAL HOUSING	2
4200.1	MECHANICAL SEAL RH	2
4200.2	MECHANICAL SEAL LH	2
4300.1	LIP SEAL	1
4300.2	LIP SEALS	4
4510.1	GASKETS	2
4510.2	GASKETS	2
4610.X	O-RING	X
5251.1	WAVE SPRING	1
6530.1	BEARING RETAINER PLATE	2
6548.1	SHEAR RING	1
6548.2	LOCKING RING	1
6574.1	SHCS	12
6579.X	SHCS	X
6580.1	SUPERBOLT BEARING LOCKNUT	2
6581.X	HEX NUTS	X
6700.1	TIMING GEAR KEYS	2
6700.3	KEY - COUPLING	1
8448.1	RETAINER THRUST BEARING	2

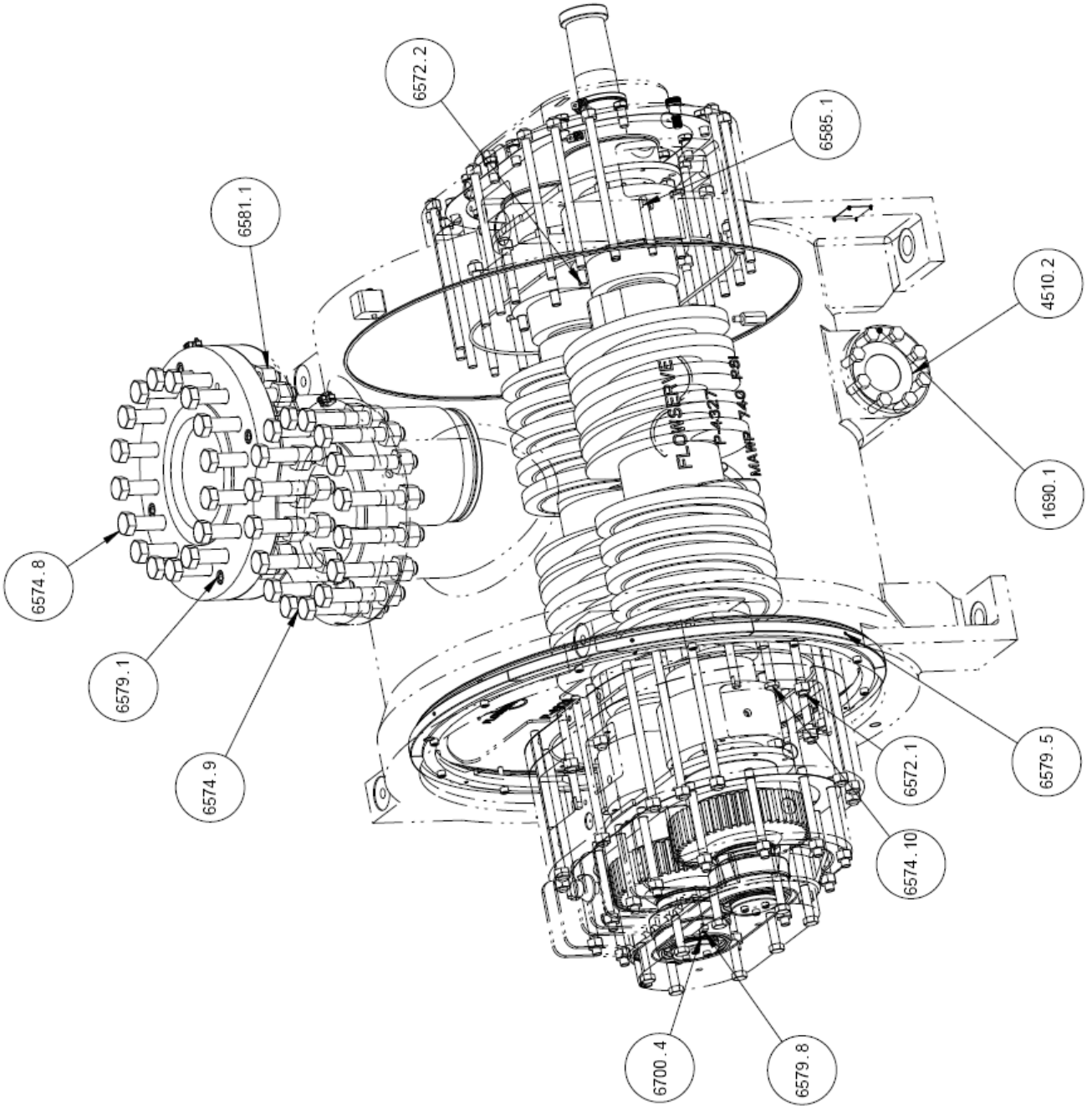


SECTION B-B

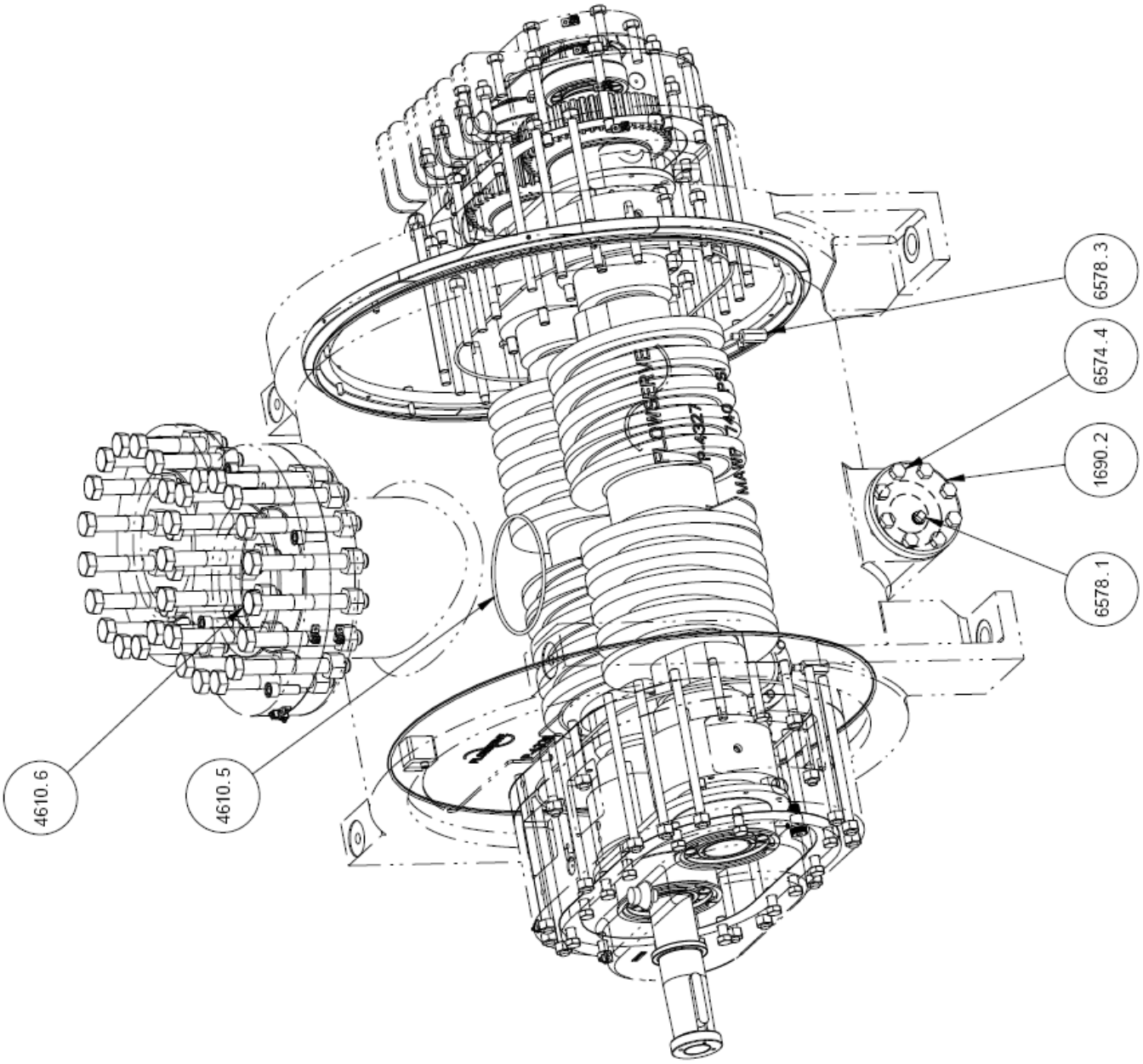
8.2 General Arrangement Drawing

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.

REF	PART DESCRIPTION	QTY
1690.1	NON DRIVE END COVER	1
4510.2	GASKETS	2
6572.X	STUDS	X
6574.X	CAP SCREWS	X
6579.X	SHCS	X
6875.8	TIMING GEAR DRIVEN	1
6581.X	HEX NUTS	X
6585.1	DOWEL PIN	4
6700.4	ANTI ROTATION KEY	1



REF NO	PART DESCRIPTION	QTY
1690.2	FLANGE BLIND	1
4610.X	O-RING	X
6574.X	CAP SCREWS	X
6578.1	PIPE PLUG	1
6578.3	ORIFICE	4



9 CERTIFICATION

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

10 OTHER RELEVANT DOCUMENTATION AND MANUALS

10.1 Supplementary User Instruction manuals

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

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

10.2 Change notes

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

10.3 Additional sources of information

Reference 1:
API Std 676, Positive Displacement Pumps – Rotary, Third Edition, 2009

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

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

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

Reference 5:
ANSI B31.3 - Process Piping.

11 OPTIONAL EQUIPMENT AND ARRANGEMENTS

11.1 Jacketed components.

For pumps equipped with jacketed bodies and/or stuffing boxes, the maximum allowable jacketed pressure is 8.6 bar (125 PSIG] for steam or other gaseous heat transfer media and 10.3 bar (150 PSIG] for liquid heat transfer media (Dowtherm, Therminol] unless otherwise specified on contract drawings. On jacketed bodies, using steam, the inlet connection should be at the highest connection on the body with the outlet at the lowest connection on the opposite end and side. This should be reversed when using a liquid heat transfer medium. It is the user's responsibility to ensure the normal steam temperature does not exceed the defined maximum permitted value for the particular Temperature Class.

There are two styles of jacket available, the integral type and the bolt on type. The integral type need only be connected as described whereas the bolt on type must be installed per instructions using the heat transfer cement supplied. Failure to do this will result in uneven heat distribution within the pump and may lead to premature failure.

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