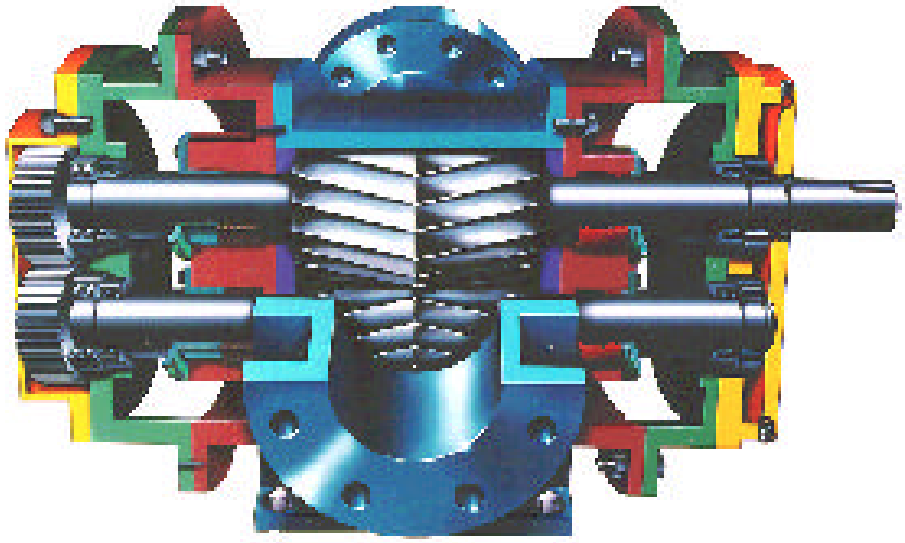
FLOWSERVE®

Pump Division



GEAREX ROTARY GEAR PUMPS
EXTERNAL & INTERNAL BEARING DESIGN

USER INSTRUCTIONS:
INSTALLATION, OPERATION, MAINTENANCE

User Instructions User Instructions 71569246 (2167B-E1)

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1 INTRODUCTION AND SAFETY

1.1 General

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

Flowserve'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.

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 11 Certification.)

1.3 Disclaimer

Information in these User Instructions is believed to be reliable. In spite of all the efforts of Flowserve Corporation to provide sound and all necessary information the content of this manual may appear insufficient and is not guaranteed by Flowserve as to its completeness or accuracy.

Flowserve manufactures products to exacting International Quality Management System Standards as certified and audited by external Quality Assurance 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 liquid pumped, 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:

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.

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.

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.)

PREVENT EXCESSIVE EXTERNAL PIPE LOAD

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

ENSURE CORRECT LUBRICATION

(See section 5 COMMISSIONING, START-UP, OPERATION AND SHUTDOWN.)

START THE PUMP WITH OUTLET VALVE PART OPENED

(Unless otherwise instructed at a specific point in the user instructions.)

This is recommended to minimize the risk of overloading and damaging the pump motor at full or zero flow. Pumps may be started with the valve further open only on installations where this situation cannot occur. The pump outlet control valve may need to be adjusted to comply with the duty following the run-up process. (See section *5 COMMISSIONING, START-UP, OPERATION AND SHUTDOWN*.)

NEVER RUN THE PUMP DRY

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 seal.

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

Operating at a flow rate higher than normal or at a flow rate with no back pressure on the pump may overload the motor and cause cavitation. Low flow rates may cause a reduction in pump/bearing life, overheating of the pump, instability and cavitation/ vibration.

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 siting of the pump, limiting personnel access and by operator training. If the liquid is flammable and/or explosive, strict safety procedures must be applied.

Gland packing must not be used when pumping hazardous liquids.

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

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

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

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

If the temperature is greater than 68 °C (175 °F) or below 5 °C (20 °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

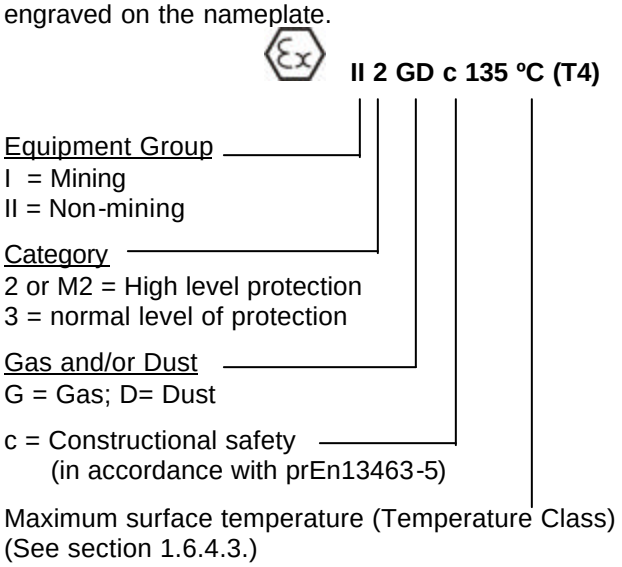
Use equipment only in the zone for which it is appropriate. Always check that the driver, drive coupling assembly, seal and pump equipment are suitably rated and/or certified for the classification of the specific atmosphere in which they are to be installed.

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 is covers the situation where electrical supply is from the VFD. This particular requirement still applies even if the VFD is in a safe area.

1.6.4.2 Marking

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



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 in the table that follows.

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

Temperature class to prEN 13463-1	Maximum surface temperature permitted	Temperature limit of liquid handled (* depending on material and construction variant - check which is lower)
T6	85 °C (185 °F)	Consult Flowserve
T5	100 °C (212 °F)	Consult Flowserve
T4	135 °C (275 °F)	115 °C (239 °F) *
T3	200 °C (392 °F)	180 °C (356 °F) *
T2	300 °C (572 °F)	275 °C (527 °F) *
T1	450 °C (842 °F)	400 °C (752 °F) *

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

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 it is recommended that users fit an external surface temperature protection device.

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

In dirty or dusty environments, regular checks must be made and dirt removed from areas around close clearances, bearing housings and motors.

1.6.4.4 Preventing the 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 the fitting of an appropriate dry run protection device is recommended (eg liquid detection or a power monitor).

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

1.6.4.5 Preventing sparks

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

To avoid the potential hazard from random induced current generating a spark, the earth contact on the baseplate must be used.

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, the installation of a liquid detection device is recommended.

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 Warning labels

WARNING
MECHANICAL SEAL FITTED
DO NOT ADJUST PUMP CLEARANCE WITHOUT REFERENCE TO MANUFACTURER'S INSTRUCTION MANUAL

MECHANICAL SEAL WARNING
P/N 2113931-001

WARNING
BEFORE STARTING THE PUMP ON SERVICE, CHECK TO ENSURE CORRECT ROTATION OF MOTOR. FAILURE TO DO THIS COULD RESULT IN SERIOUS DAMAGE TO THE EQUIPMENT.

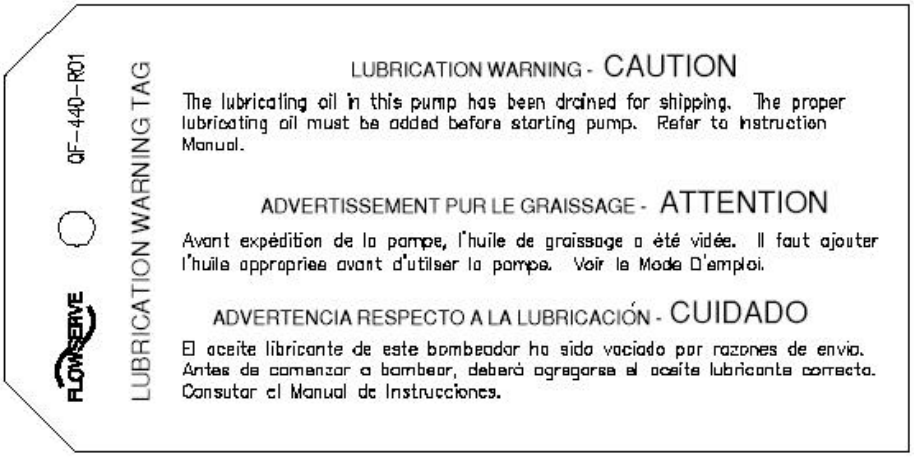
ROTATION WARNING
P/N 2113932-001

WARNING
BEFORE GROUTING, REALIGN THIS UNIT RECHECK ALIGNMENT BEFORE STARING, FAILURE TO DO THIS COULD RESULT IN SERIOUS DAMAGE TO THE EQUIPMENT. REFER TO INSTALLATION MANUAL AND, OR COUPLING INSTRUCTIONS FOR METHOD OF CHECKING ALIGNMENT.

GROUT WARNING
P/N 2113934-001

WARNING
THESE EYEBOLTS
ARE TO BE USED FOR LIFTING BEARING CARTRIDGE AND SHAFT ONLY.
DO NOT USE FOR LIFTING ENTIRE UNIT.

LIFTING WARNING
P/N 9901701-001



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

1.8 Specific machine performance

For performance parameters see section *1.5 Duty conditions*. When the contract requirement specifies these to be incorporated into User Instructions these are included here. Where performance data has been supplied separately to the purchaser these should be obtained and retained with these User Instructions if required.

1.9 Noise level

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

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

The dBA values are based on the noisiest ungeared electric motors that are likely to be encountered. They are Sound Pressure levels at 1 m (3.3 ft) from the directly driven pump, for "free field over a reflecting plane".

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

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

GEAREX pump size	Noise Level dbA @ 1 m (3.3 ft)	Pump speed -rpm
B1	77	1780
B2	77	1780
C1	77	1780
C2	79	1780
C3	79	1780
D1	81	1780
D2	82	1780
E1	83	1780
E2	85	1780
E3	87	1780
E4	87	1180
E5	87	1180
E6	89	885

2 TRANSPORT AND STORAGE

2.1 Consignment receipt and unpacking

Immediately after receipt of the equipment it must be checked against the delivery/shipping documents for its completeness and that there has been no damage in transportation. Any shortage and/or damage must be reported immediately to Flowserve Pump Division and must be received in writing within one month of receipt of the equipment. Later claims cannot be accepted.

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

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

2.2 Handling

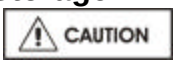
Boxes, crates, pallets or cartons may be unloaded using fork-lift vehicles or slings dependent on their size and construction.

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

2.3 Lifting

 A crane must be used for all pump sets 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 massplates.

2.4 Storage

2.4.1  Short-Term Storage

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

Wrap the exposed portions of the shaft and coupling to protect against sand, grit or other foreign matter. Oil lubricated units should be lubricated (refer to section *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 a water soluble oil or other suitable alternative. Particular attention should be given to the rotors, shafts and stuffing box. Install gasketed metal flange covers on the suction and discharge flanges (pipe plugs in the case of tapped connections).

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

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

 **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 "GEAREX" Pumps are single stage, positive displacement pumps especially designed for the petroleum industry 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 space between the pumping rotors (gear) teeth and the bores of the pump body. Recirculation of the liquid (slip) is prevented by the intermeshing of the paired pumping rotors and the maintaining of precise diametral and axial clearances between the pumping rotors and pump body. To eliminate hydraulic thrust, the pumping rotors are of double helical design.

The key assembly of the Gearex 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 one pumping rotor, plus the assorted hardware (locknuts, spacers) required for mounting. The timing gears maintain the clearance between the drive and driven pumping rotors, eliminate contact between the rotors and turn the driven shaft. Heavy duty roller bearings eliminate radial contact between the pumping rotors and the body bores and support the loading on the shafts produced by the pumping action. Fixed bearings at one end position the shafts axially and prevent contact between the ends of the pumping rotors and the bearing housings. Lubrication of the bearings is provided by the oil contained in the housings (sumps).

The bearing configuration provides a rear pull-out feature which permits the quick removal of the entire rotating element without disturbing the pump body or the driver. The use of a spacer type coupling between the pump and driver is necessary to apply this feature.

Standard shaft sealing is provided by packing which is factory installed with the gland requiring only minor adjustment prior to pump start-up. Mechanical seals are optional equipment and when provided 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 and options.

D-2

The letter indicates the “nominal pump size” and the digit is the sub category of size. In this case the D-2 size pump is the larger of the two D size pumps. The pump sizes range from B-1 to E-6 with several different casing sizes available in each basic pump size and different rotor widths available in each size.

3.3 Design of major parts

3.3.1 Pump casing

The pump casing is a casting with side suction and side discharge connections. It is a one piece pressure retaining casting with gasket connections to the seal housings and the suction and discharge flanges.

3.3.2 Pumping Gears

The pumping gears are double helical intermeshing gears, mounted to the drive and driven shafts to create a positive displacement pumping action inside the pump body.

3.3.3 Shaft

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

3.3.4 Timing Gears
The spur timing gears are mounted to the drive and driven shafts with accurately located keys to maintain the pumping gears 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 oil bath is provided at each end of the pump to lubricate the bearings and timing gears. An oil site gage is supplied in the gear housing and level holes in the front bearing housing to determine the oil levels.

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 can be supplied to fit standard packing or different mechanical seals.

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

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

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

3.4 Performance and operating limits
This product has been selected to meet the specifications of your purchase order (See section *1.5 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 (350 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. The margin between the available and required torque affects the time it takes the unit to reach full speed. If the torque required by the pump exceeds the torque capability of the drive at any run-up speed, the unit will not accelerate to full speed. Normally, this is not a problem with standard induction or synchronous motors provided the proper voltage is supplied at the motor.

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

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

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

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 percent 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.

TABLE OF ENGINEERING DATA

	MODEL		INTERNAL	EXTERNAL
SIZE B-1	SUCTION SIZE (STD.)		1-1/2 NPT	
	DISCHARGE SIZE (STD.)		1-1/2 NPT	
	OPERATING CLEARANCES (STD.) mm (in.)		0.1 – 0.15 (0.004 - 0.006)	
	WEIGHTS kg (lb)	PUMP	25 (55)	43 (95)
		ROT. ELEMENT	2.7 (6.0)	4.53 (10.0)
	SHAFT DIA. AT COUPLING mm (in.)		19.0 (0.750)	19.0 (0.750)
	SHAFT DIA. AT ST. BOX mm (in.)		19.0 (0.750)	25.40 (1.000)
	STUFFING BOX	BORE mm (in.)	34.92 (1.375)	38.10 (1.500)
		DEPTH mm (in.)	42.7 (1.68)	38.1 (1.50)
	NO. OF STUFFING BOXES		1	4
	PACKING	SIZE mm SQ. (in. SQ.)	7.9 (5/16)	6.3 (1/4)
		NO OF RINGS	5	24
	BEARINGS	FRONT	MCGILL MR-16	MCGILL MR-16
		REAR	MCGILL MR-16	
			TIMKEN 11590/11520	SKF 5203
	OIL SEALS	BRACKETS	N/A	NAT. 410120
		FRONT COVER	N/A	NAT. 509775
	APPROX. OIL FILL	FRONT L (qt)	N/A	0.09 (0.1)
		REAR L (qt)	N/A	0.2 (0.2)

	MODEL		INTERNAL	EXTERNAL
SIZE B-2	SUCTION SIZE (STD.)		3" - 150# FLANGED	
	DISCHARGE SIZE (STD.)		3" - 150# FLANGED	
	OPERATING CLEARANCES mm (in.)		0.1 - 0.15 (0.004 - 0.006)	
	WEIGHTS kg (lb)	PUMP	29 (65)	50 (110)
		ROT. ELEMENT	3.2 (7.0)	4.99 (11.0)
	SHAFT DIA. AT COUPLING mm (in.)		19.0 (0.750)	19.0 (0.750)
	SHAFT DIA. AT ST. BOX mm (in.)		19.0 (0.750)	25.40 (1.000)
	STUFFING BOX	BORE mm (in.)	34.92 (1.375)	38.10 (1.500)
		DEPTH mm (in.)	42.7 (1.68)	38.1 (1.50)
	NO. OF STUFFING BOXES		1	4
	PACKING	SIZE mm SQ. (in. SQ.)	7.9 (5/16)	6.3 (1/4)
		NO. OF RINGS	5	24
	BEARINGS	FRONT	MCGILL MR-16	MCGILL MR-16
		REAR	MCGILL MR-16	
			TIMKEN 11590/11520	SKF 5203
	OIL SEALS	BRACKETS	N/A	NAT. 410120
		FRONT COVER	N/A	NAT. 509775
	APPROX. OIL FILL	FRONT L (qt)	N/A	0.09 (0.1)
		REAR L (qt)	N/A	0.2 (0.2)

	MODEL		INTERNAL	EXTERNAL
SIZE C-1	SUCTION SIZE (STD.)		1-1/2 NPT	
	DISCHARGE SIZE (STD.)		1-1/2 NPT	
	OPERATING CLEARANCES (STD.) mm (in.)		0.15 - 0.2 (0.006 - 0.008)	
	WEIGHTS kg (lb)	PUMP	43 (95)	54 (120)
		ROT. ELEMENT	5.22 (11.5)	5.67 (12.5)
	SHAFT DIA. AT COUPLING mm (in.)		22.2 (.875)	23.81 (.9375)
	SHAFT DIA. AT ST. BOX mm (in.)		22.2 (.875)	31.75 (1.250)
	STUFFING BOX	BORE mm (in.)	34.92 (1.375)	44.45 (1.750)
		DEPTH mm (in.)	44.4 (1.75)	38.1 (1.50)
	NO. OF STUFFING BOXES		1	4
	PACKING	SIZE mm SQ. (in. SQ.)	6.3 (1/4)	6.3 (1/4)
		NO. OF RINGS	7	24
	BEARINGS	FRONT	NDH A5205TS	SJ-7234 IR-7234 RBC
		REAR	TIMKEN 12580/12520	SKF 5204
	OIL SEALS	BRACKETS	N/A	J.M. 8820LUP
		FRONT COVER	N/A	J.M. 10229LUP
	APPROX. OIL FILL	FRONT L (qt)	N/A	0.11 (0.12)
		REAR L (qt)	N/A	0.24 (0.25)

	MODEL		INTERNAL	EXTERNAL
SIZE C-2	SUCTION SIZE (STD.)		2" - 150# FLANGED	
	DISCHARGE SIZE (STD.)		2" - 150# FLANGED	
	OPERATING CLEARANCES mm (in.)		0.15 - 0.2 (0.006 - 0.008)	
	WEIGHTS kg (lb)	PUMP	45 (100)	61.2 (135)
		ROT. ELEMENT	5.90 (13.0)	6.80 (15.0)
	SHAFT DIA. AT COUPLING mm (in.)		22.2 (0.875)	23.81 (0.9375)
	SHAFT DIA. AT STUFFING BOX mm (in.)		22.2 (0.875)	31.75 (1.250)
	STUFFING BOX	BORE mm (in.)	34.92 (1.375)	44.45 (1.750)
		DEPTH mm (in.)	44.4 (1.75)	38.1 (1.50)
	NO. OF STUFFING BOXES		1	4
	PACKING	SIZE mm SQ. (in. SQ.)	6.3 (1/4)	6.3 (1/4)
		NO. OF RINGS	7	24
	BEARINGS	FRONT	NDH A5205TS	SJ-7234 IR-7234 RBC
		REAR	TIMKEN 12580/12520	SKF 5204
	OIL SEALS	BRACKETS	N/A	J.M. 8820LUP
		FRONT COVER	N/A	J.M. 10229LUP
	APPROX. OIL FILL	FRONT L (qt)	N/A	0.11 (0.12)
		REAR L (qt)	N/A	0.24 (0.25)

	MODEL		INTERNAL	EXTERNAL
SIZE C-3	SUCTION SIZE (STD.)		4" - 150# FLANGED	
	DISCHARGE SIZE (STD.)		4" - 150# FLANGED	
	OPERATING CLEARANCES (STD.) mm (in.)		0.15 – 0.2 (0.006 - 0.008)	
	WEIGHTS kg (lb)	PUMP	54 (120)	65.8 (145)
		ROT. ELEMENT	7.71 (17.0)	7.71 (17.0)
	SHAFT DIA. AT COUPLING mm (in.)		22.2 (0.875)	23.81 (0.9375)
	SHAFT DIA. AT ST. BOX mm (in.)		22.2 (0.875)	31.75 (1.250)
	STUFFING BOX	BORE mm (in.)	34.92 (1.375)	44.45 (1.750)
		DEPTH mm (in.)	44.4 (1.75)	38.1 (1.50)
	NO. OF STUFFING BOXES		1	4
	PACKING	SIZE mm SQ. (in. SQ.)	6.3 (1/4)	6.3 (1/4)
		NO. OF RINGS	7	24
	BEARINGS	FRONT	NDH A5205TS	SJ-7234, IR-7234 RBC
		REAR	TIMKEN 12580/12520	SKF 5204
	OIL SEALS	BRACKETS	N/A	J.M. 8820LUP
		FRONT COVER	N/A	J.M. 10229LUP
	APPROX. OIL FILL	FRONT L (qt)	N/A	0.11 (0.12)
		REAR L (qt)	N/A	0.24 (0.25)

	MODEL		INTERNAL	EXTERNAL
SIZE D-1	SUCTION SIZE (STD.)		3" - 150# FLANGED	
	DISCHARGE SIZE (STD.)		3" - 150# FLANGED	
	OPERATING CLEARANCES (STD.) mm (in.)		0.18 – 0.23 (0.007 - 0.009)	
	WEIGHTS kg (lb)	PUMP	113 (250)	127 (280)
		ROT. ELEMENT	21.3 (47.0)	21.8 (48.0)
	SHAFT DIA. AT COUPLING mm (in.)		38.10 (1.500)	34.92 (1.375)
	SHAFT DIA. AT ST. BOX mm (in.)		38.10 (1.500)	44.45 (1.750)
	STUFFING BOX	BORE mm (in.)	50.80 (2.000)	63.50 (2.500)
		DEPTH mm (in.)	44.4 (1.75)	60.4 (2.38)
	NO. OF STUFFING BOXES		1	4
	PACKING	SIZE mm SQ. (in. SQ.)	6.3 (1/4)	9.5 (3/8)
		NO. OF RINGS	7	24
	BEARINGS	FRONT	NDH A5208TS	MCGILL MR-28/MI-23
		REAR	TIMKEN 26885/26820	SKF 5207
	OIL SEALS	BRACKETS	N/A	J.M. 9854LUP
		FRONT COVER	N/A	J.M. 15099LUP
	APPROX. OIL FILL	FRONT L (qt)	N/A	0.24 (0.25)
		REAR L (qt)	N/A	0.47 (0.50)

	MODEL		INTERNAL	EXTERNAL
SIZE D-2	SUCTION SIZE (STD.)		4" - 150# FLANGED	
	DISCHARGE SIZE (STD.)		4" - 150# FLANGED	
	OPERATING CLEARANCES (STD.) mm (in.)		0.18 – 0.23 (0.007 - 0.009)	
	WEIGHTS kg (lb)	PUMP	136 (300)	143 (315)
		ROT. ELEMENT	23.1 (51.0)	24.0 (53.0)
	SHAFT DIA. AT COUPLING mm (in.)		38.10 (1.500)	34.92 (1.375)
	SHAFT DIA. AT ST. BOX mm (in.)		38.10 (1.500)	44.45 (1.750)
	STUFFING BOX	BORE mm (in.)	50.80 (2.000)	63.50 (2.500)
		DEPTH mm (in.)	44.4 (1.75)	60.45 (2.38)
	NO. OF STUFFING BOXES		1	4
	PACKING	SIZE mm SQ. (in. SQ.)	6.3 (1/4)	9.5 (3/8)
		NO. OF RINGS	7	24
	BEARINGS	FRONT	NDH A5208TS	MCGILL MR-28/MI-23
		REAR	TIMKEN 26885/26820	SKF 5207
	OIL SEALS	BRACKETS	N/A	J.M. 9854LUP
		FRONT COVER	N/A	J.M. 15099LUP
	APPROX. OIL FILL	FRONT L (qt)	N/A	0.24 (0.25)
		REAR L (qt)	N/A	0.47 (0.50)

	MODEL		INTERNAL	EXTERNAL
SIZE E-1	SUCTION SIZE (STD.)		4" - 150# FLANGED	
	DISCHARGE SIZE (STD.)		4" - 150# FLANGED	
	OPERATING CLEARANCES (STD.) mm (in.)		0.25 – 0.30 (0.010 - 0.012)	
	WEIGHTS kg (lb)	PUMP	210 (460)	220 (490)
		ROT. ELEMENT	40.4 (89.0)	46.27 (102.0)
	SHAFT DIA. AT COUPLING mm (in.)		47.62 (1.875)	42.862 (1.6875)
	SHAFT DIA. AT ST. BOX mm (in.)		47.62 (1.875)	53.98 (2.125)
	STUFFING BOX	BORE mm (in.)	66.68 (2.625)	73.02 (2.875)
		DEPTH mm (in.)	57.1 (2.25)	57.1 (2.25)
	NO. OF STUFFING BOXES		1	4
	PACKING	SIZE mm SQ. (in. SQ.)	9.5 (3/8)	9.5 (3/8)
		NO. OF RINGS	5	24
	BEARINGS	FRONT	NDH A5210TS	SKF 22309
		REAR	SKF 22309	SJ-8447,IR-8447C RBC
	OIL SEALS	BRACKETS	N/A	J.M. 6113LPD
		FRONT COVER	N/A	NAT410154
	APPROX. OIL FILL	FRONT L (qt)	N/A	0.24 (0.25)
		REAR L (qt)	N/A	0.71 (0.75)

	MODEL		INTERNAL	EXTERNAL
SIZE E-2,3,4	SUCTION SIZE (STD.)		6" - 150# FLANGED	
	DISCHARGE SIZE (STD.)		6" - 150# FLANGED	
	OPERATING CLEARANCES (STD.) mm (in.)		0.25 – 0.30 (0.010 - 0.012)	
	WEIGHTS kg (lb)	PUMP	230/250/270 (500/550/600)	260/270/300 (580/600/675)
		ROT. ELEMENT	43/49/54 (96/108/120)	50/55/61 (109/121/134)
	SHAFT DIA. AT COUPLING mm (in.)		47.62 (1.875)	42.862 (1.6875)
	SHAFT DIA. AT ST. BOX mm (in.)		47.62 (1.875)	53.98 (2.125)
	STUFFING BOX	BORE mm (in.)	66.68 (2.625)	73.02 (2.875)
		DEPTH mm (in.)	57.1 (2.25)	57.1 (2.25)
	NO. OF STUFFING BOXES		1	4
	PACKING	SIZE mm SQ. (in. SQ.)	9.5 (3/8)	9.5 (3/8)
		NO. OF RINGS	5	24
	BEARINGS	FRONT	NDH A5210TS	SKF 22309
		REAR	SKF 22309	SJ-8447,IR-8447C RBC
	OIL SEALS	BRACKETS	N/A	J.M. 6113LPD
		FRONT COVER	N/A	NAT410154
	APPROX. OIL FILL	FRONT L (qt)	N/A	0.24 (0.25)
		REAR L (qt)	N/A	0.71 (0.75)

	MODEL		INTERNAL	EXTERNAL
SIZE E-5,6	SUCTION SIZE (STD.)		8" - 150# FLANGED	
	DISCHARGE SIZE (STD.)		8" - 150# FLANGED	
	OPERATING CLEARANCES mm (in.)		0.25 – 0.30 (0.010 - 0.012)	
	WEIGHTS kg (lb)	PUMP	299/329 (660/725)	340/386 (750/850)
		ROT. ELEMENT	61/68 (135/151)	340/386 (750/850)
	SHAFT DIA. AT COUPLING mm (in.)		47.62 (1.875)	42.862 (1.6875)
	SHAFT DIA. AT ST. BOX mm (in.)		47.62 (1.875)	53.98 (2.125)
	STUFFING BOX	BORE mm (in.)	66.68 (2.625)	73.02 (2.875)
		DEPTH mm (in.)	57.1 (2.25)	57.1 (2.25)
	NO. OF STUFFING BOXES		1	4
	PACKING	SIZE mm SQ. (in. SQ.)	9.5 (3/8)	9.5 (3/8)
		NO. OF RINGS	6	24
	BEARINGS	FRONT	NDH A5210TS	SKF 22309
		REAR	NDH A5210TS, SKF 22210	SJ-8447, IR-8447C, RBC
	OIL SEALS	BRACKETS	N/A	J.M. 6113LPD
		FRONT COVER	N/A	NAT410154
	APPROX. OIL FILL	FRONT L (qt)	N/A	0.24 (0.25)
		REAR L (qt)	N/A	0.71 (0.75)

4 INSTALLATION

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

4.1 Location

The pump should be located to allow room for access, ventilation, maintenance and inspection 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 on V-belt driven units.

Refer to the general arrangement drawing for the pump set.

4.2 Part assemblies

Motors may be supplied loose on Gearex 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 methods*.

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 equal) 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 Fig. I). The sleeves should be securely anchored and designed to allow the bolts to be moved to conform with the holes in the baseplate. The bolts should be sufficiently long to allow for wedges or shims or levelling nuts under the baseplate, and a washer, heavy hex nut and hex jam nut for retention. Since baseplate levelling is performed after the foundation has cured, it is best to use extra long bolts which can be shortened after the installation is complete.

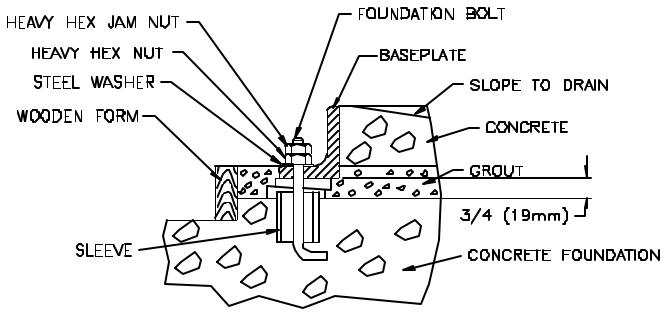


Figure 1

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 inches).

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 the impeller axial clearance (refer to Section *6 MAINTENANCE*) and that the rotor turns freely by hand.

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

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 checked immediately.

4.5.2 Alignment methods

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

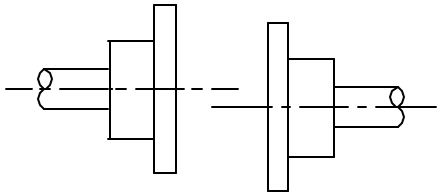
CAUTION The alignment MUST be checked. Although the pump will have been aligned at the factory it is most likely that this alignment will have been disturbed during transportation or handling. If necessary, align the motor to the pump, not the pump to the motor.

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

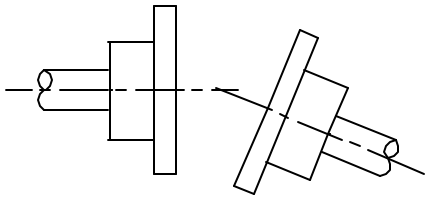
A flexible coupling is used to compensate for slight changes in alignment which occur during normal operation and is not used to correct for installation errors. Install the pump and driver half couplings in accordance with the coupling manufacturer's instructions. Note that the coupling hub faces are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

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



PARALLEL MISALIGNMENT– Shafts with axis parallel but not concentric



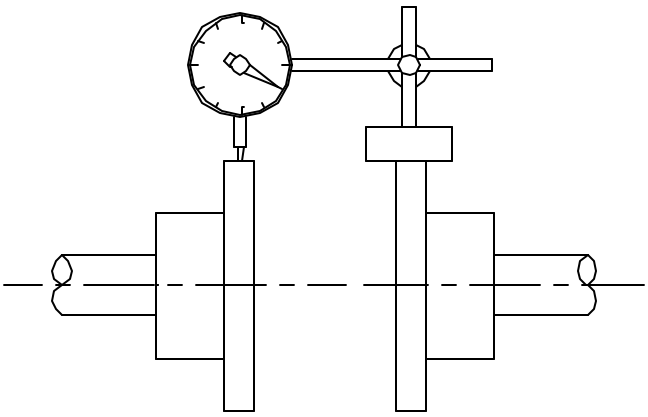
ANGULAR MISSALIGNMENT – Shafts with axis concentric but not parallel.

Figure 2

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, or with extension rods and a magnetic base. Before taking readings, ensure that the pump and driver mounting bolts are secure, and that the thrust bearing housing is properly aligned in the bearing frame or cartridge. (See Section *6 MAINTENANCE*).

Parallel Alignment:

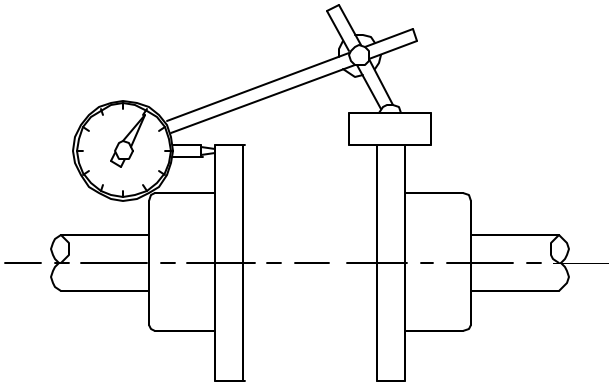


CHECKING PARALLEL MISALIGNMENT

Figure 3

Mount the magnetic base on the pump half coupling hub and place the dial indicator button on the outside diameter of the driver half coupling hub. (See Fig. 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. Repeat this procedure until the maximum total indicator reading (T.I.R.) is within 0.076 mm (0.003 inch.)

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 Fig. 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 inch per inch) of maximum hub diameter.



CHECKING ANGULAR MISALIGNMENT
Figure 4

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 runout 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.

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 Fig. 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.

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 four diameters of straight pipe on the pump suction between the elbow and inlet flange. See section 12.3 Additional sources of information for more detail.

g) Inlet strainers, when used, should have a net `free area' of at least three times the inlet pipe area.
h) Do not install elbows at an angle other than perpendicular to the shaft axis. Elbows parallel to the shaft axis will cause uneven flow.
i) Except in unusual circumstances strainers are not recommended in inlet piping. If considerable foreign matter is expected a screen installed at the entrance to the wet well is preferable.
j) Fitting an isolation valve will allow easier maintenance.
k) Never throttle pump on suction side and never place a valve directly on the pump inlet nozzle.

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

Gearex Pumps are of the positive displacement type and will build up considerable pressure 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 and gland leakage to a convenient disposal point.

4.7.5.2 Pumps fitted with gland packing
When suction pressure is below ambient pressure it is necessary to feed the gland packing with liquid to provide lubrication and prevent the ingress of air. This is normally achieved with a supply from the pump discharge volute to the stuffing box. A control valve is fitted in the line to enable the pressure to the gland to be controlled.

If the pumped liquid is dirty and cannot be used for sealing, a separate clean compatible liquid supply to the gland at 1 bar (15 psi) above suction pressure is recommended.

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

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

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

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

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

4.8 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
4.10.1 

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

4.10.2  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.

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

4.10.4 

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.

4.10.5  A device to provide emergency stopping must be fitted.

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

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

4.10.8 

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 5.9.4 Bearings and 5.9.5 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 overspeed protection devices as required.
5. Check all auxiliary piping circuits.
6. Check that the gland nuts of a packed pump are only finger tight and that the shaft can be turned by hand.

5.1.2 Freezing

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

5.1.3 Lubrication

5.1.3.1 External bearing pump

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.

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.

CAUTION In the case of product lubricated bearings the source of product supply should be checked against the order. There may be requirements for an external clean supply, particular supply pressure or the commencement of lubrication supply before pump start-up.

5.1.3.2 Internal bearing pump

Bearing lubrication is provided by the liquid being pumped. To further ensure circulation of fluid through the bearings, internal ports are provided in the bearing housings. These ports are located on the suction side of the pump only.

5.2 Pump lubricants

5.2.1 Typical 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
Petro Canada	GIREX 220	GIREX 68	GIREX 320

*Imperial Oil Limited (Canada)

5.2.2 Recommended fill quantities for external bearing pump

Refer to section *3.4 Performance and operating limits*.

5.2.3 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.

5.2.4 CAUTION Lubrication schedule for external bearing pump

5.2.4.1 Requirements for oil lubricated bearings

Normal oil change intervals are 4 000 operating hours or at least every 6 months. For pumps on hot service or in severely damp or corrosive atmosphere, the oil will require changing more frequently. Lubricant and bearing temperature analysis can be useful in optimizing lubricant change intervals.

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

The bearing temperature may be allowed to rise to 50 ºC (122 ºF).above ambient, but should not exceed 82 ºC (180 ºF). A continuously rising temperature, or an abrupt rise, indicate 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)).

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 (20 ° to 95 °F).

Oil should meet AGMA Standard 250.04 AGMA 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 (20 ° to 50 °F).

Oil should meet AGMA Standard 250.04 AGMA 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 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.

5.3 Direction of rotation

CAUTION Ensure the pump is given the same rotation as the pump direction arrow cast on 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 approximately 264 cubic metres (one gallon) 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 *8 FAULTS; CAUSES AND REMEDIES*, for fault diagnosis.

5.7 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 and pumping temperature.

5.8 Dowelling

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.

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 packed gland

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

Ex The gland must be adjusted evenly to give visible leakage and concentric alignment of the gland ring to avoid excess temperature. If no leakage takes place the packing will begin to overheat. If overheating takes place the pump should be stopped and allowed to cool before being re-started. When the pump is re-started, check to ensure leakage is taking place at the packed gland.

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

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

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

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

5.9.3 Pumps fitted with mechanical seal

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

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

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

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

5.9.4 Bearings

Ex If the pumps are working in a potentially explosive atmosphere temperature or vibration monitoring at the bearings is recommended

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

5.9.5 Normal vibration levels, alarm and trip

For guidance, pumps generally fall under a classification for rigid support machines within the International rotating machinery standards and the recommended maximum levels below are based on those standards.

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

Vibration velocity – unfiltered **mm/s (in./s) r.m.s.**		**GEAREX**	**VERTICAL GEAREX**
Normal	**N**	≤ 5.6 (0.22)	≤ 7.1 (0.28)
Alarm	**N** x 1.25	≤ 7.1 (0.28)	≤ 9.0 (0.35)
Shutdown trip	**N** x 2.0	≤ 11.2 (0.44)	≤ 14.2 (0.56)

5.9.6 Stop/start frequency

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

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

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

5.10 Stopping and shutdown

5.10.1 Short term

a) CAUTION Close the outlet valve, but ensure that the pump runs in this condition for no more than a few seconds.
b) Stop the pump.
c) Leave open the valve supplying auxiliary sealing fluid to maintain prime while the pump is idle.
d) 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 Close the outlet valve, but ensure that the pump runs in this condition for no more than a few seconds.
b) Stop the pump.
c) Switch off flushing and/or cooling/heating liquid supplies at a time appropriate to the process.
d) On pump with steam jackets, shut off steam flow and allow pump to cool.
e) 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. Refer to section *2.4.2 Long-term storage*.

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.

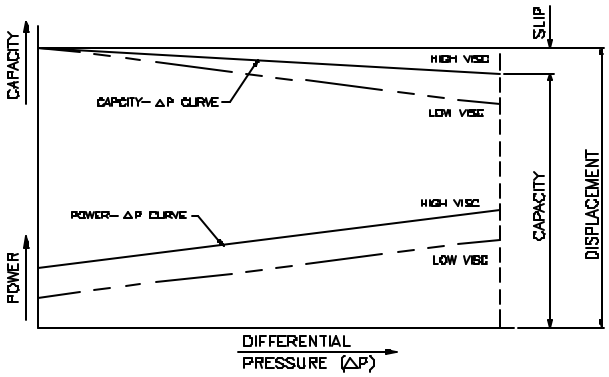


Figure 5

Any positive displacement gear 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 width and rotate at the correct speed. When the rotor width, speed and viscosity are known, a single curve can be drawn which shows the relationship between differential pressure and capacity. (Refer to Fig. 5). 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 width 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. The higher the viscosity of the liquid, the less the slip. The displacement less 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.

5.11.1 Specific gravity (SG)

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

5.11.2 Pump speed

Changing pump speed effects flow, total head, power absorbed, $NPSH_R$, noise and vibration. Flow varies in direct proportion to pump speed, head varies as speed ratio squared and power varies as speed ratio cubed. The new duty, however, will also be dependent on the system curve. If increasing the speed, it is important therefore to ensure the maximum pump working pressure is not exceeded, the driver is not overloaded, $NPSH_A > NPSH_R$, and that noise and vibration are within local requirements and regulations.

5.11.3 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.

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

5.11.5 Pressure surges
The pump must not be subjected to pressure surges such as may be caused by waterhammer 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 *1.6.2 Personnel qualification and training*.)

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

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

a) Any auxiliary systems installed must be monitored, if necessary, to ensure they function correctly.
b) Gland packings must be adjusted correctly to give visible leakage and concentric alignment of the gland follower to prevent excessive temperature of the packing or follower.

c) Check for any leaks from gaskets and seals. The correct functioning of the shaft seal must be checked regularly.
d) Check bearing lubricant level, and if the hours run show a lubricant change is required.
e) Check that the duty condition is in the safe operating range for the pump.
f) Check vibration, noise level and surface temperature at the bearings to confirm satisfactory operation.
g) Check dirt and dust is removed from areas around close clearances, bearing housings and motors.
h) Check coupling alignment and re-align if necessary.
i) 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 *8 FAULTS; CAUSES AND REMEDIES*, for fault diagnosis.
b) Ensure equipment complies with the recommendations in this manual.
c) Contact Flowserve if the problem persists.

6.2.1 Routine inspection (daily/weekly)

CAUTION The following checks should be made and the appropriate action taken to remedy any deviations:
a) Check operating behaviour. Ensure noise, vibration and bearing temperatures are normal.
b) Check that there are no abnormal fluid or lubricant leaks (static and dynamic seals) and that any sealant systems (if fitted) are full and operating normally.
c) Check that shaft seal leaks are within acceptable limits.
d) Check the level and condition of oil lubricant. On grease lubricated pumps, check running hours since last recharge of grease or complete grease change.
e) Check any auxiliary supplies eg heating/cooling (if fitted) are functioning correctly.

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

6.2.2 Periodic inspection (six monthly)

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

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

6.2.3 Re-lubrication

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

6.2.3.1 Oil lubrication

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

Refer to section *5.2.2 Recommended fill quantities for external bearing pump* for methods of oil fill and *5.2.5 Lubrication schedule for external bearing pump* for the schedule and temperature limits.

6.2.4 Mechanical seals

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

6.2.5 Gland packing

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

The stuffing box is normally supplied with a lantern ring to enable a clean or pressurised flush to the centre of the packing. If not required, this can be replaced by an extra two rings of packing.

To re-pack the stuffing box, remove the gland, the old packing and the lantern ring (if applicable). Ensure that all packing has been removed and that the stuffing box bore and shaft are clean and free of foreign material. If the shaft is worn or scored it should be repaired or replaced. On new units ensure that the lantern ring is not installed in the bottom of the stuffing box.

The use of precut die-moulded or mandrel-cut packing is recommended. Make sure that the packing to be installed is the correct grade and size. If in doubt, contact Flowserve or a reputable packing manufacturer.

When inserting packing always insert one ring at a time. Note that preformed packing rings should not be pulled straight apart. Instead the rings should be twisted sideways enough to get them around the shaft. Use the gland to push packing squarely into the box. Stagger the rings so that the joints are approximately 90 degrees apart.

Ensure that the lantern ring is aligned with the appropriate inlet/outlet ports and that the shaft can rotate by hand.

When installing the gland, tighten the gland nuts only finger tight. There must always be a small leakage, normally a minimum of 120 drops per minute to atmosphere to lubricate and cool the packing is required.

6.3 Spare parts

6.3.1 Ordering of spares

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

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

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

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

6.3.2 Storage of spares

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

For large quantities of Gearex pumps, it is advisable to refer to Marketing Department, Brantford, Ontario, Canada, 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.

RECOMMENDED SPARE PARTS

NAME OF PART	QTY.
Rear Bearings (set)	1
Front Bearings (set)	1
Gasket (set)	1
Timing Gear (set)	1
Packing (set)	1
Oil Seals (set))	1

6.4 Tools required

No special tools are required for assembly or disassembly.

6.5 Torques for fasteners

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

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

Thread Size (Inch)	Recommended Torque Values (Ft-lbs)
3/8	17
½	40
5/8	80
¾	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.

6.5.2 High strength steel bolts/nuts SAE grade 5

Thread Size (Inch	Recommended Torque Values (ft-lbs)
3/8	27
½	65
5/8	125
¾	225
7/8	365
1	545
1-1/8	675
1-1/4	950
1-3/8	1240
1-1/2	1430

6.6 Renewal clearances

6.6.1 Clearance data for cast iron pump

Pump Size	B	C	D	E
Centre Distance (inch)	1.750	2.125	3.375	4.375
Bore Diameter (inch)	2.250	2.625	4.190	5.413
Clearance x.001 inch	4 to 6	6 to 8	6 to 8	9 to 11

6.6.2 Clearance data for carbon and stainless steel pump

Pump Size	B	C	D	E
Centre Distance (inch)	1.750	2.125	3.375	4.375
Bore Diameter (inch)	2.260	2.635	4.200	5.423
Clearance x.001 inch Rotor/Bore	14 to 16	16 to 18	16 to 18	19 to 21
Clearance x.001 inch rotor End	4 to 6	6 to 8	6 to 8	9 to 11

Note that the clearance between the rotors and the body is controlled by the dimensions and tolerances on the manufacturing drawings. The rotor end clearance is controlled by the rotor position on the shaft, using an assembly jig, and the thickness of the front gasket (which is standardized at 0.38 mm (0.015 inch) thick).

6.7 Disassembly

Note that replacement materials should be available prior to disassembly to limit downtime.

6.7.1 Disassembly of external bearing pump

Refer to the sectional drawing in Section 12.3, Figure 1, at the end of this manual.

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 associates with the pump.
c) Flush the pump body and piping system if necessary.
d) Disconnect stuffing box and other auxiliary piping.
e) Drain the pump body and lube oil cavities.
f) Remove coupling guard and uncouple the pump from the driver.
g) Remove the pump half coupling. If a spacer coupling is not used, it will be necessary to remove either the pump or the driver from the baseplate to do this.
h) Remove the front (5) and rear (4) covers.
i) Remove the front bracket (from the pump. Mark the "top" of the bracket to facilitate reassembly. If the pump has mechanical seals, ensure that the bracket is drawn smoothly off the shafts without bumping. Note that if the pump is fitted with split brackets the bearing housing half (3A) can be separated from the seal housing to facilitate seal maintenance.
j) Remove the front bearing snap ring (24) and remove the bearing (14) from the bracket.
k) Back off the gland nuts and remove the glands/mechanical seals (40).
l) Remove the timing gear locknuts (19) and lockwashers (20).
m) Remove timing gears (13) and spacers (18) and note marks for reassembly.
n) Remove the rear bracket from the pump. Mark the "top" for reassembly. Note that if the pump is fitted with split brackets the bearing housing half (2A) can be separated from the seal housing to facilitate seal maintenance.
o) Remove the bearing snap ring (25) and remove the bearings (15).
p) Back off the gland nuts and remove glands/mechanical seals (40).
q) The shafts (10,11) and rotors (12) may now be removed from the pump body (1).
r) If fitted, remove the stuffing box restriction bushings from the shaft and remove rotor spacers if fitted.
s) The pumping rotors are pressed on and keyed to the shafts. They should not be disturbed unless replacement is necessary. If replacement is necessary, mark the shaft at each end of the rotor and remove from the shaft in a press.
t) Refer to section *6.8 Examination of parts*.

6.7.2 Disassembly of internal bearing pump

Refer to the sectional drawing in Section 12.3, Figure 2, at the end of this manual

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 associates with the pump.
c) Flush the pump body and piping system if necessary.
d) Disconnect stuffing box and other auxiliary piping.
e) Drain the pump.
f) Remove coupling guard and uncouple the pump from the driver.
g) Remove the pump half coupling. If a spacer coupling is not used, it will be necessary to remove either the pump or the driver from the baseplate to do this.
h) Remove front head (5) and bearing housing (2). If the pump is fitted with a mechanical seal, scribe

the location of the seal on the shaft, loosen set screws holding the rotating head to the shaft and remove seal .

i) Remove capscrews holding end cover (4) and bearing housing (3) to body (1). Remove rear cover (4). (Mark top to facilitate reassembly).
j) Remove rear bearing housing and rotating element together from the body.
k) Remove the locknuts (19) and lockwashers (20) from shafts.
l) Remove timing gears (13) and spacers (18) and mark for reassembly.
m) Remove bearing housing (3) from shafts.
n) Remove bearing outer races (16) from housings.
o) The pumping rotors are pressed on and keyed to the shafts. They should not be disturbed unless replacement is necessary. If replacement is necessary, mark the shaft at each end of the rotor and remove from the shaft in a press.
p) Refer to section *6.8 Examination of parts*.

6.8 Examination of parts

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

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.

b) Inspect bearings for wear and the presence of foreign matter. Replace if damaged or worn.
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 bore of stuffing box.
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 inch).

6.9 Assembly

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

Refer to the sectional drawing furnished with the pump or to the typical drawing in Section 12.3 of this manual. If a sectional is not available, it can be requested from the factory.

6.9.1 Reassembly of external bearing pump sizes B, C and D

a) Inspect all new parts. Remove all nicks and burrs which may have occurred in handling.
b) If new rotors are required, they should be installed on the shafts now. Apply anti-seize compound to the shafts at the rotor location. Fit the key into the shaft keyway. Slide the rotors onto the shafts from the end opposite the time gear location. (There is a reduced diameter lead on section here). Fit the rotor and shaft into a press and push the rotor on until it aligns with the reference marks scribed during disassembly.
c) Apply anti-seize compound to the shafts at the location of the front bearing inner race (16). Install the inner race on the shaft. Use an induction heater or hot oil bath to first heat the race. (90° C (200° F) recommended).
d) Temporarily install the timing gears (13) and keys (22) onto the shafts. (Spacers and locknuts, etc., are not required.)
e) Intermesh the drive and driven shafts, taking care to align the timing marks on the face of the timing gears. Slide the shaft assembly into the body and remove the timing gears and keys.
f) If rotor spacers are required, slide them onto the shafts and up against each end of the rotors.
g) Install the thrust bearings (15) in the rear bearing housing (2A).
h) Mount a new end flange gasket (50) on the rear of the body (1).
i) Mount the rear bracket (2) with oil seals (27) in place on the body, noting the top mark. If solid glands are used, they must be mounted in the bracket prior to this operation. Note that if the pump is fitted with split brackets the seal housing (2B) can be mounted first, then the seal assembly (don't tighten drive screws at this time) followed by the bearing half (2A).
j) If pumps are fitted with shaft mounted (non cartridge) mechanical seals, the rotating heads of the seals must be in the correct position on the shafts prior to mounting the brackets. If a new rotating element is being installed in the pump, do not mount mechanical seal heads at this time. Refer to section *6.10.1.1 External bearing pump*.
k) Replace the rear bracket to body capscrews (55) and tighten finger tight only.
l) Mount the timing gear spacers (18) and timing gears (13) on the appropriate shafts.
m) Install locknuts (19) and lockwashers (20).
n) Install a gasket (50) on the rear of the bracket (2) and install the rear cover (4).
o) If a new rotating element is being installed, refer to section *6.10.1.1 External bearing pump* before proceeding further.

p) Install the bearing outer races, oil seals, glands and/or seal seats in the front bracket if non cartridge seals are used. Mount a new gasket and install the front bracket, noting location of the top mark. Tighten capscrews finger tight only. Note that if the pump is fitted with split brackets the seal housing (2B) can be mounted first, then the seal assembly (don't tighten drive screws at this time) followed by the bearing half (2A).
q) Mount a new gasket (50) on the front of the bracket (3)and install the front cover (5) complete with lipseal (26).
r) Line up dowel pin holes in front and rear brackets and insert dowel pins (61). Tighten all capscrews(55). Pump should now turn freely. If the pump does not turn freely, refer to section *6.11 Free movement*.
s) Repack the stuffing boxes with new packing if so fitted.

6.9.2 Re-assembly of external bearing pump size E

Refer to typical sectional drawing Figure 3 in section 12.3 of this manual.

a) Inspect all new parts. Remove all nicks and burrs which may have occurred in handling.
b) If new rotors are required, they should be installed on the shafts now. Apply anti-seize compound to the shafts at the rotor location. Fit the key into the shaft keyway. Slide the rotors onto the shafts from the end opposite the time gear location. (There is a reduced diameter lead on section here). Fit the rotor and shaft into a press and push the rotor on until it aligns with the reference marks scribed during disassembly.
c) Apply anti-seize compound to the shafts at the location of the front inner race. Install the inner race on the shaft. Use an induction heater or hot oil bath to first heat the race. (90° C (200° F) recommended).
d) Temporarily install the timing gears and keys onto the shafts. (Spacers and locknuts, etc., are not required.)
e) Intermesh the drive and driven shafts, taking care to align the timing marks on the face of the timing gears. Slide the shaft assembly into the body and remove the timing gears and keys.
f) If rotor spacers are required, slide them onto the shafts and up against each end of the rotors.
g) Install the thrust bearings (14) in the front bracket (3).
h) Mount a new end flange gasket (50) on the front of the body.
i) Mount the front bracket, with oil seals (27) in place, on the body (1), noting the top mark. If pumps are fitted with mechanical seals, the rotating heads of the seals must be in the correct position on the shafts prior to mounting the brackets. If a new rotating element is being installed in the pump, do not mount seals at this time. Refer to section *6.10.1.1 External bearing pump*.
j) Install locknuts (20) and lockwashers (21).
k) Replace the front bracket to body capscrews (55) and tighten finger tight only.
l) Install the bearings (15) and oil seals (27) in the rear bracket along with glands and/or seal seats. Mount a new gasket (50) and install the bracket noting location of the top mark. Tighten capscrews finger tight only.
m) Mount the timing gear spacers (17), and timing gears (13) on the appropriate shafts.
n) Install locknuts (18) and lockwashers (19).
o) Install a gasket (50) on the rear of the bracket (2) and install the rear cover (4).
p) Install a new oil seal (28) in the front cover (5) and using a new gasket (50) install the cover on the front bracket (3).
q) Line up dowel pin holes in front and rear brackets and insert dowel pins (63). Tighten all capscrews and nuts. Pump should now turn freely. If the pump does not turn freely, refer to section *6.11 Free movement*.
r) Repack the stuffing boxes with new packing.

6.9.3 Reassembly of internal bearing pump

a) Inspect all new parts. Remove all nicks and burrs which may have occurred in handling.
b) If new rotors are required, they should be installed on the shafts now. Apply anti-seize compound to the shafts (10,11) at the location of the front bearing inner race. Fit the key (23) into the shaft keyway. Slide the rotors (12) onto the shafts from the end opposite the time gear location. (There is a reduced diameter lead on section here). Fit the rotor and shaft into a press and push the rotor on until it aligns with the reference marks scribed during disassembly.
c) Apply anti-seize compound to the shafts at the location of the front bearing inner race (15). Install the inner race on the shaft. Use an induction heater or hot oil bath to first heat the race. (90° C (200° F) recommended). Press the inner race on the shaft with the aid of a sleeve so that it remains square to the shaft.
d) Temporarily install the timing gears (13) and keys (22) onto the shafts. (Spacers and locknuts, etc., are not required.)
e) Intermesh the drive and driven shafts, taking care to align the timing marks on the face of the timing

gears. Slide the shaft assembly into the body (1) and remove the timing gears and keys.

f) If rotor spacers are required, slide them onto the shafts and up against each end of the rotors.

g) Install the thrust bearings (16) in the rear bearing housing and retain with snap ring (25).

h) Mount a new end flange gasket (50) on the rear of the body.

i) Slide the rear bearing housing assembly over the shafts and mount on the end of the body. (Note that the "top" mark is in the correct location. If a new rotating element is being installed in the pump, refer to section *6.10.1.2 Internal bearing pump*.

j) Re-install the timing gear spacers (18), keys (22), timing gears (13) and locknuts (19) and washers (20) as indicated by the marking done during disassembly. Tighten the locknuts snugly but avoid overtightening as the lockwasher anti-rotation tab could be damaged. Bend one lockwasher tang on each lockwasher to lock the nuts.

k) Withdraw the rear bearing housing and shaft assembly slightly from the body and check the end clearance of the rotor/rotor spacer and the bearing housing face. This should be equal to half the clearance listed in the Table of Engineering Data in this manual. If the measured clearance varies from the value listed by more than 25 per cent, it will be necessary to dismantle the unit and adjust the position of the rotors in the press. Failure to provide the correct dearance may result in pump seizure (clearances too tight) or poor hydraulic performance (clearance too large).

l) Mount a new gasket (50) on the rear bearing housing (3) and fit the rear cover (4). Replace all capscrews in the rear end finger tight only.

m) Install the front bearing outer race assemblies (14) into the front bearing housing (2).

n) Mount a new gasket (50) on the front of the body (1) and slide the front bearing housing into place, noting the position of the "top" mark.

o) If the pump is fitted with a mechanical seal, mount the rotating head on the drive shaft using the mark scribed at disassembly for location. Tighten all set screws securely.

p) Mount a new gasket (50) on the front of the bearing housing and install the front head (5). Install all capscrews finger tight.

q) Re-fit all alignment dowel pins (60).

r) Tighten all capscrews at rear end of pump.

s) While tightening all capscrews at the front of the pump, rotate the drive shaft by hand to check for binding. If the pump binds before the capscrews are tight, it will be necessary to install another gasket between the front bearing housing and body.

t) Install the seal stationary seat in the seal gland and install the gland on the front head.

u) If the pump has a packed stuffing box, install new packing and replace gland.

6.10 New rotating elements

6.10.1 Mechanical seal fitted pumps

6.10.1.1 External bearing pump

If a new rotating element is being installed, the pump should be assembled without mechanical seals up to and including step l) in section 6.9.1 or 6.9.2. The following procedure is then to be followed.

a) Using a straightedge, mark the point on the drive and driven shafts in line with the flange face on the front end of the body.

b) Remove the thrust bearing bracket to body capscrews and nuts, and pull the rotating element partially out from the rear of the pump with the rear bracket assembly intact.

c) Using a straightedge, mark the point on the shafts in line with the flange face of the rear bracket.

d) Remove the bracket assembly from the rotating element.

e) With the datum lines now marked on the shafts, refer to the applicable mechanical seal drawing for the required setting dimension.

f) Assemble the seals on the shafts and proceed with the steps outlined in section 6.9.1 or 6.9.2.

6.10.1.2 Internal bearing pump

If a new rotating element is being installed, the pump should be assembled without mechanical seals up to and including step l) in section 6.9.3. The following procedure is then to be followed.

a) Using a straightedge, mark the point on the drive shaft in line with the flange face on the front head.

b) Remove the front head.

c) With the datum lines now marked on the shafts, refer to the applicable mechanical seal drawing for the required setting dimension.

d) Assemble the seals on the shafts and proceed with the steps outlined in section 6.9.3.

6.11 Free movement

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

a) Remove front and rear head dowel pins.

b) Loosen all head to body capscrews except for the four corners at each end.

c) Check location of rotors in the body bores by reaching into the discharge flange and checking

the radial clearance between the rotors and the body bores with a feeler gauge.

d) Using a large mallet move the front and rear heads radially to equalize the clearance between the outside diameter of the pumping rotors and the body bores, checking for the pump to turn freely.

e) Once the pump is turning freely, tighten all head capscrews.

f) Continue with step r) in section 6.9.1, step q) in 6.9.2 or step s) in 6.9.3.

If the pump does not turn freely after executing this procedure it is due to incorrectly dimensioned parts or a timing problem. Contact the nearest Flowserve Service Representative for assistance. Section *Timing Gear replacement*, provides guidance in verifying the timing of the rotating element.

7 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 angular position on the shaft determines, in part, the critical clearance between the pumping rotors. Since the normal clearance of meshing rotors 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. The original rotor clearances are stamped on the pump body at the bracket flange. This number represents the total clearance. One half of it is the proper axial distance between the meshing rotor teeth.

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

1. For optimum results it is highly recommended that a set of timing stands as shown in Fig. 9 be manufactured.
2. Mount the rotor shafts intermeshed onto the timing stands resting the shafts on the bearing diameters. The bearings are not mounted on the shafts at this time.
3. Install the driven shaft timing gear key.
4. For “B” size units, proceed directly to step 15.
5. Slide the driven shaft timing gear partially onto its' respective shaft diameter, engaging the key.
6. Slide the drive shaft timing gear partially onto its' respective shaft diameter with the existing keyway 180° away from the shaft keyway, meshing with the driven shaft gear. (Fig. 6 & 7).
7. Place feeler gauges with a thickness equal to half of the total side clearance on each side of the rotor tooth on the drive shaft. This will eliminate contact between the drive and driven rotors.
8. Rotate the drive shaft gear in the direction of rotation of the pump until the teeth of both gears are in contact. (Fig. 8).
9. Place the drive shaft gear key into the keyway at a right angle to the shaft and against the timing gear face. (Fig. 8).
10. Scribe a line on both sides of the key on the time gear face. (Fig. 8)
11. Mark the position of the drive gear with respect to the driven gear with 3 punch marks. (Fig. 8).
12. Remove the drive gear from the shaft and cut a keyway the width as scribed.
13. Install the drive gear and key and intermesh with the driven gear according to the 3 punch marks.
14. Slide the timing gear lockwashers onto the shafts and fit the timing gear locknuts. Tighten securely.
15. Proceed to Reassembly step a).

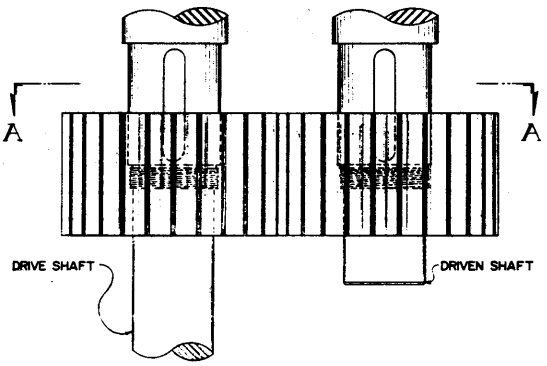
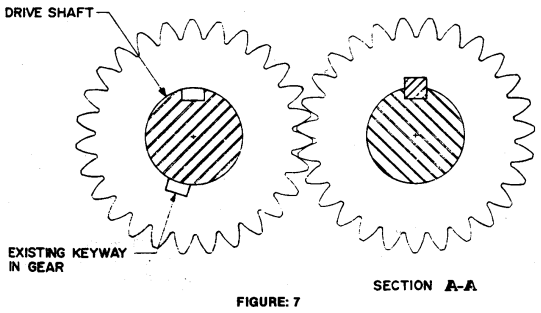
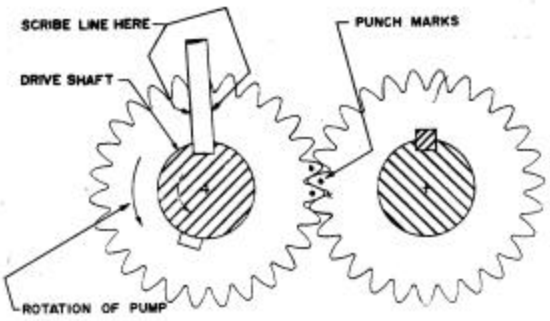


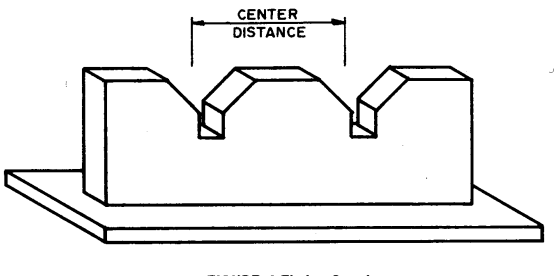
Figure 6



Section A-A
Figure 7



Section A-A
Figure 8



Timing Stand
Figure 9

Pump Size	Centre distance (inch)
B	1.750
C	2.125
D	3.375
E	4.375

Figure 10: Standard centre distance between drive and driven shafts

8 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 rotors and/or 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.

9 OPTIONAL EQUIPMENT AND ARRANGEMENTS

9.1 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.

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.

9.2 Vertical mountings

All fasteners used on the pump and on the baseplate of a vertically mounted unit should be assembled using LOCTITE 242 (blue) or equal. This is necessary to prevent the fasteners from vibrating loose, falling into sump and possibly being drawn into the pump causing internal damage.

10 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.

11 CERTIFICATION

Certificates, determined from the contract requirements will be provided with this manual. Examples are certificates for CE marking and ATEX marking. If required, copies of other certificates sent separately to the Purchaser should be obtained from Purchaser for retention with the User Instructions. See section *1.9 Noise level*, for details of typical noise certification.

12 OTHER RELEVANT DOCUMENTATION AND MANUALS

12.1 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.

12.2 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.

12.3 Additional sources of information

Reference 1:
NPSH for Rotordynamic Pumps: a reference guide, Europump Guide No. 1, Europump & World Pumps, Elsevier Science, United Kingdom, 1999.

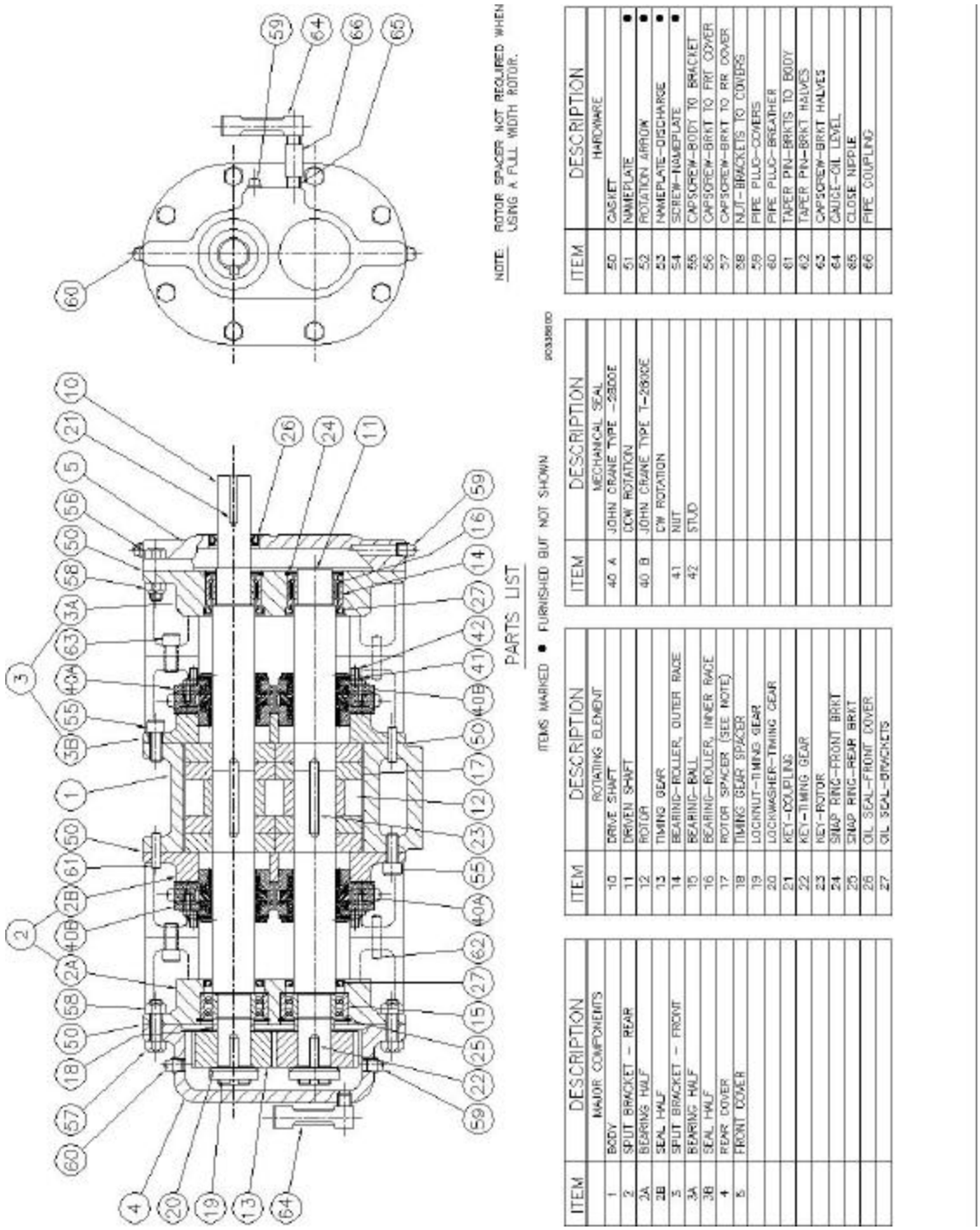
Reference 2:
Pumping Manual, 9th edition, T.C. Dickenson, Elsevier Advanced Technology, United Kingdom, 1995.

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

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

Reference 5:
ANSI B31.3 - Process Piping.

12.4 Sectional Drawings-Typical



NOTE: ROTOR SPACER NOT REQUIRED WHEN USING A FULL WIDTH ROTOR.

PARTS LIST

ITEMS MARKED ● FURNISHED BUT NOT SHOWN

ITEM	DESCRIPTION
	MAJOR COMPONENTS
1	BODY
2	SPLIT BRACKET – REAR
2A	BEARING HALF
2B	SEAL HALF
3	SPLIT BRACKET – FRONT
3A	BEARING HALF
3B	SEAL HALF
4	REAR COVER
5	FRONT COVER

ITEM	DESCRIPTION
	ROTATING ELEMENT
10	DRIVE SHAFT
11	DRIVEN SHAFT
12	ROTOR
13	TIMING GEAR
14	BEARING–ROLLER, OUTER RACE
15	BEARING–BALL
16	BEARING–ROLLER, INNER RACE
17	ROTOR SPACER (SEE NOTE)
18	TIMING GEAR SPACER
19	LOCKNUT–TIMING GEAR
20	LOCKWASHER–TIMING GEAR
21	KEY–COUPLING
22	KEY–TIMING GEAR
23	KEY–ROTOR
24	SNAP RING–FRONT BRKT
25	SNAP RING–REAR BRKT
26	OIL SEAL–FRONT COVER
27	OIL SEAL–BRACKETS

ITEM	DESCRIPTION
	MECHANICAL SEAL
40 A	JOHN CRANE TYPE 2300E
	CCW ROTATION
40 B	JOHN CRANE TYPE T–2900E
	CW ROTATION
41	NUT
42	STUD

ITEM	DESCRIPTION
	HARDWARE
50	GASKET
51	NAMEPLATE ●
52	ROTATION ARROW ●
53	NAMEPLATE–DISCHARGE ●
54	SCREW–NAMEPLATE ●
55	CAPSCREW–BODY TO BRACKET
56	CAPSCREW–BRKT TO FRT COVER
57	CAPSCREW–BRKT TO RR COVER
58	NUT–BRACKETS TO COVERS
59	PIPE PLUG–COVERS
60	PIPE PLUG–BREATHER
61	TAPER PIN–BRKTS TO BODY
62	TAPER PIN–BRKT HALVES
63	CAPSCREW–BRKT HALVES
64	GAUGE–OIL LEVEL
65	CLOSE NIPPLE
66	PIPE COUPLING

Figure 1: “B”, “C”, “D” External Bearing Pump

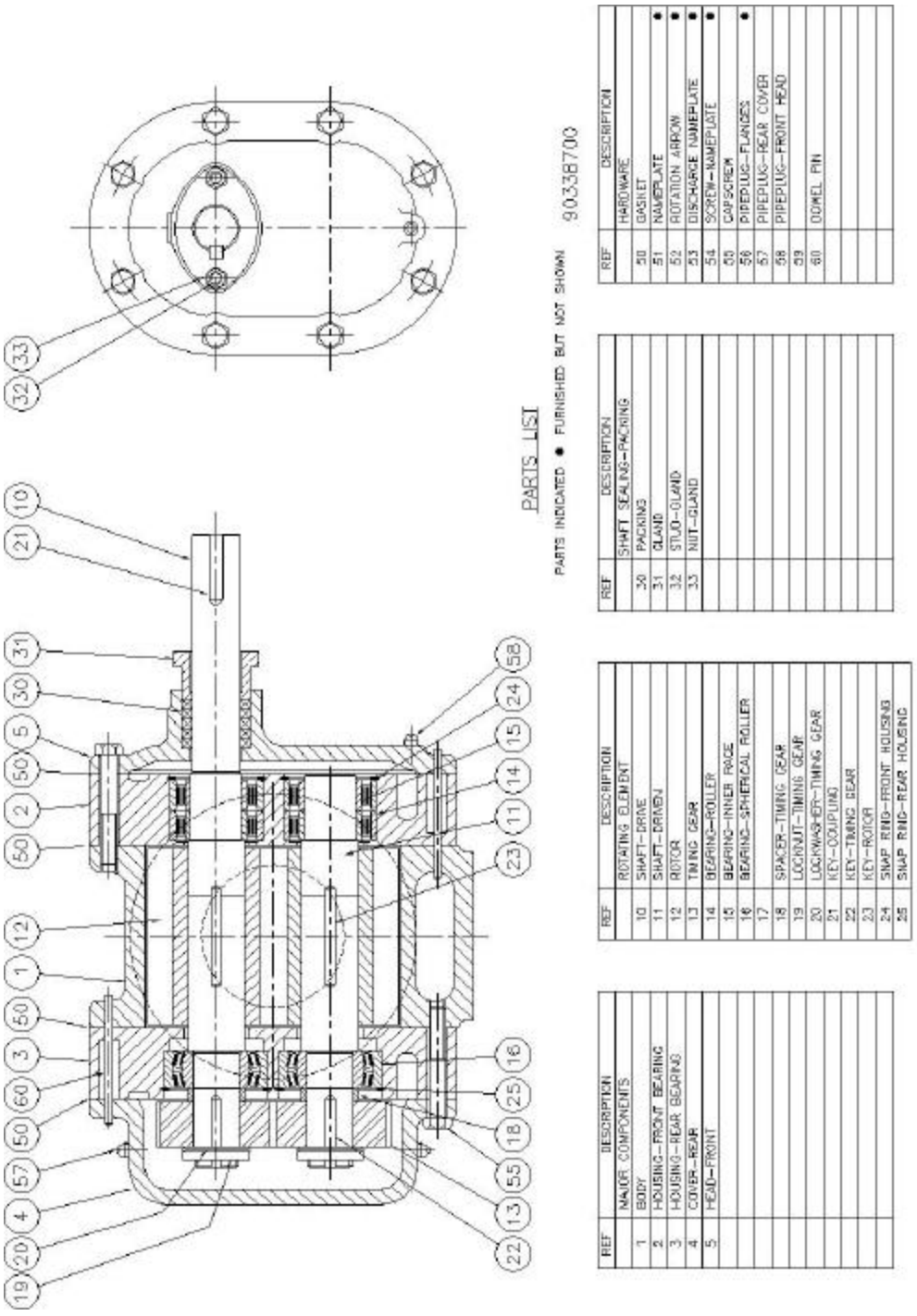


Figure 2: Internal Bearing Pump

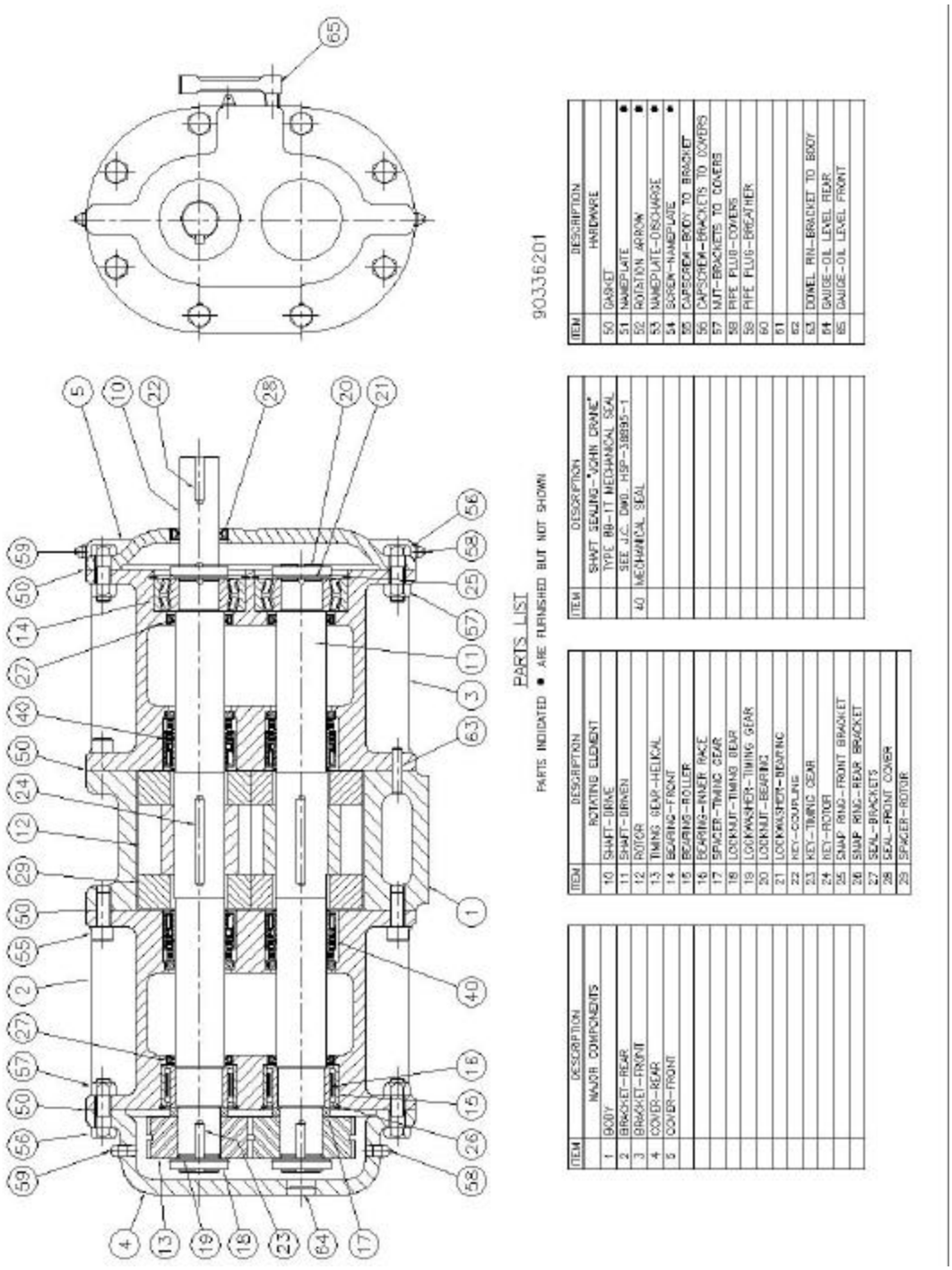


Figure 3: “E” External Bearing Pump

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