



## USER INSTRUCTIONS

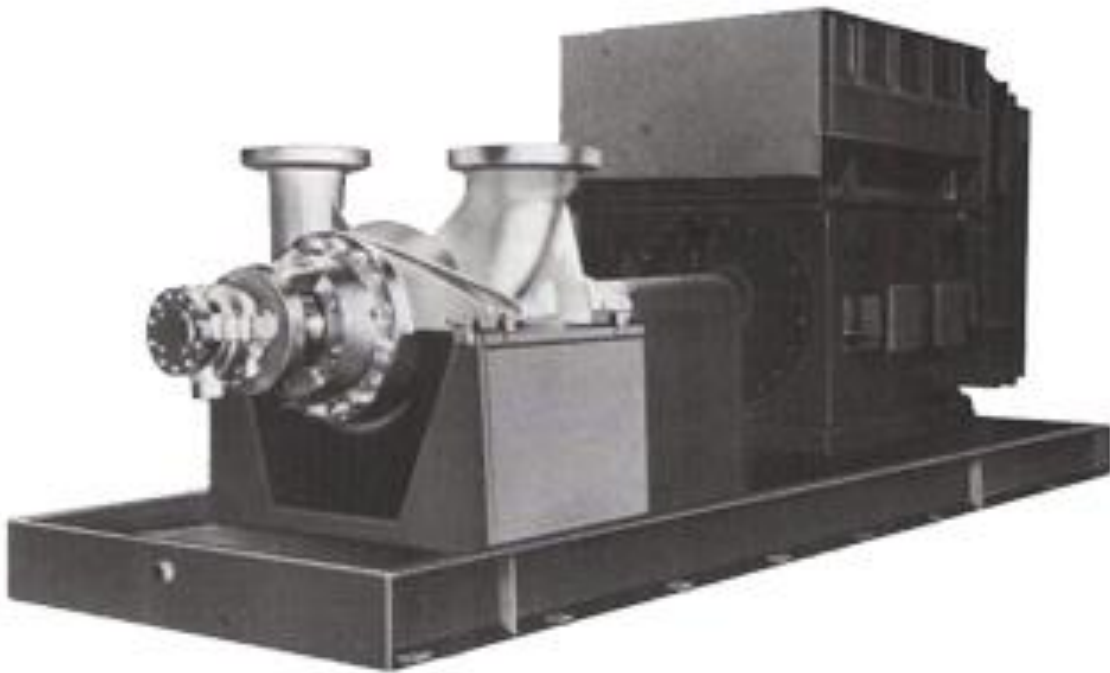
### ***Niigata Worthington™ WTB centrifugal pumps***

Between bearings, multi-stage, radially split, volute centrifugal pump

PCN=87900064 10-15 (E). Original instructions.

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***Installation  
Operation  
Maintenance***



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

***Experience In Motion***

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## 1 INTRODUCTION AND SAFETY

### 1.1 General



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

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

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

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



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

### 1.2 CE marking and approvals

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

Where applicable the Directives and any additional approvals cover important safety aspects relating to

machinery and equipment and the satisfactory provision of technical documents and safety instructions. Where applicable this document incorporates information relevant to these Directives and Approvals. To confirm the Approvals applying and if the product is CE marked, check the serial number plate markings and the Certification. (See section 9, Certification.)

### 1.3 Disclaimer

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

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

### 1.4 Copyright

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

### 1.5 Duty conditions

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




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


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


## 1.6 Safety

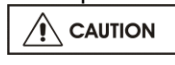
### 1.6.1 Summary of safety markings


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


 **DANGER** This symbol indicates electrical safety instructions where non-compliance will involve a high risk to personal safety or the loss of life.

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

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

 **CAUTION** This symbol indicates safety instructions where non-compliance will involve some risk to safe operation and personal safety and would damage the equipment or property.

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

 This symbol is used in safety instructions to remind not to rub non-metallic surfaces with a dry cloth; ensure the cloth is damp. It is used in safety instructions where non-compliance in the hazardous area would cause the risk of an explosion.

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


### 1.6.2 Personnel qualification and training


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

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


### 1.6.3 Safety action

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


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


 **GUARDS MUST NOT BE REMOVED WHILE THE PUMP IS OPERATIONAL**

The unit must not be operated unless coupling guard is in place. Failure to observe this warning could result in injury to operating personnel.

 **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 °C (482 °F), partial decomposition of fluoro-elastomers (example: Viton) will occur. In this condition these are extremely dangerous and skin contact must be avoided.

 **HANDLING COMPONENTS**

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

 **THERMAL SHOCK**

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

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





**HOT (and cold) PARTS**

If hot or freezing components or auxiliary heating 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. Drive motors and bearings may be hot.

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



**CAUTION PREVENT EXCESSIVE EXTERNAL PIPE LOAD**

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



**CAUTION ENSURE CORRECT LUBRICATION**

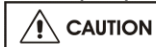
(See section 5, *Commissioning, startup, operation and shutdown*.)



**CAUTION START THE PUMP WITH OUTLET VALVE PARTLY OPENED**

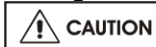
(Unless otherwise instructed at a specific point in the User Instructions.)

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*.)



**CAUTION 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.



**CAUTION 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 backpressure 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.



**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.**

**1.6.4 Products used in potentially explosive atmospheres**



Measures are required to:

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

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

**1.6.4.1 Scope of compliance**



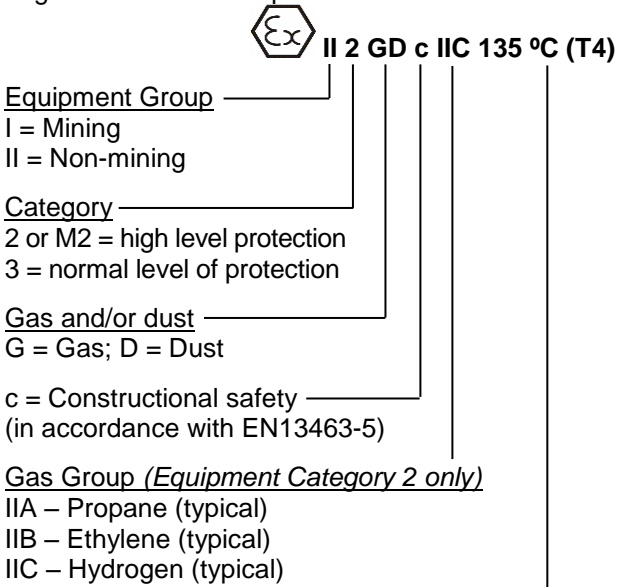
Use equipment only in the zone for which it is appropriate. Always check that the driver, drive coupling assembly, seal and pump equipment are suitably rated and/or certified for the classification of the specific atmosphere in which they are to be installed.

Where Flowserve has supplied only the bare shaft pump, the Ex rating applies only to the pump. The party responsible for assembling the pump set shall select the coupling, driver and any additional equipment, with the necessary CE Certificate/ Declaration of Conformity establishing it is suitable for the area in which it is to be installed.

The output from a variable frequency drive (VFD) can cause additional heating affects in the motor 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.



Maximum surface temperature (Temperature Class)  
(See section 1.6.4.3.)

**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 EN13463-1	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.**

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

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

Where there is any risk of the pump being run against a closed valve generating high liquid and casing external surface temperatures 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 vapor or gas to atmosphere the surrounding area must be well ventilated.

**1.6.4.5 Preventing sparks**

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

To avoid the potential hazard from random induced current generating a spark, the earth contact on the base plate 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, or separate documentation included with these User Instructions.

**1.7.2 Warning labels**

**FLOWSERVE**

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**WARNING**

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<b>ESSENTIAL PROCEDURES BEFORE STARTING:</b>	
INSTALL AND OPERATE EQUIPMENT IN ACCORDANCE WITH THE INSTRUCTION MANUAL SUPPLIED SEPARATELY.	
ENSURE UNIT ON A FIRM FOUNDATION AND THAT COUPLING FACES ARE IN CORRECT ALIGNMENT PRIOR TO, AND AFTER BOLTING BASEPLATE DOWN AND FIXING PIPEWORK. SEE MANUAL FOR TOLERANCES.	
ENSURE GUARDS ARE SECURELY IN PLACE.	
ENSURE CORRECT DRIVER DIRECTION OF ROTATION WITH COUPLING ELEMENT / PINS REMOVED * OTHERWISE SERIOUS DAMAGE MAY RESULT.	
ENSURE ALL EXTERNAL CONNECTIONS TO THE PUMPSHAFT SEALING AND DRIVER ARE CONNECTED AND OPERATIONAL.	
<b>WARNING THIS MACHINE MUST BE FILLED WITH OIL BEFORE STARTING.</b>	
FULLY PRIME UNIT AND SYSTEM DO NOT RUN UNIT DRY.	

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**FAILURE TO FOLLOW THESE PROCEDURES MAY RESULT IN PERSONAL INJURY AND/OR EQUIPMENT DAMAGE**

**1.8 Specific machine performance**

For performance parameters see section 1.5, *Duty conditions*. Pump performance data are summarized on pump data sheet which is included in proper section of "Job User's Instruction".

**1.9 Noise level**

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



The usual approach is to control 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 pressure level will exceed 80 or 85 dBA as applicable. 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 conditions, pipework design and acoustic characteristics of the building. The levels specified in the table 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 should be combined with the level for the driver obtained from the supplier. If the motor is driven by an inverter, it may show an increase in noise level at some speeds. Consult a noise specialist for the combined calculation.



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

**Typical sound pressure level, dBA,  $L_{pA}$  at 1 m reference 20  $\mu Pa$**

( $L_{WA}$  sound power re 1pW where the  $L_{pA} > 80$  dBA is available separately, consult Flowserve)

Motor size and speed		3 500 r/min		2 900 r/min		1 750 r/min		1 450 r/min	
		Pump only dBA	Pump and motor dBA	Pump only dBA	Pump and motor dBA	Pump only dBA	Pump and motor dBA	Pump only dBA	Pump and motor dBA
kW	(hp)								
<0.55	(<0.75)	67	67	65	65	63	63	63	63
0.75	(1)	67	67	65	65	63	63	63	63
1.1	(1.5)	68	68	67	67	65	65	63	63
1.5	(2)	68	68	67	67	65	65	63	63
2.2	(3)	70	70	69	69	66	67	64	64
3	(4)	71	71	71	71	66	67	64	64
4	(5)	72	72	72	72	66	67	64	64
5.5	(7.5)	74	74	73	73	67	68	65	66
7.5	(10)	75	75	73	74	67	68	65	66
11	(15)	76	76	74	75	71	72	69	70
15	(20)	77	77	76	76	71	72	69	70
18.5	(25)	78	78	77	78	72	72	70	72
22	(30)	79	79	78	78	72	72	70	72
30	(40)	81	81	80	81	74	74	72	74
37	(50)	82	82	80	81	74	74	72	74
45	(60)	82	82	81	82	77	77	75	76
55	(75)	83	83	82	83	77	77	75	76
75	(100)	84	85	83	84	78	78	76	76
90	(120)	85	86	84	85	78	79	76	77
110	(150)	85	86	85	86	80	81	78	79
132	(175)	86	87	85	86	80	81	78	79
150	(200)	87	88	86	87	80	81	78	79
160	(215)	88	89	87	88	84	85	82	82
200	(270)	88	89	87	88	86	87	84	85
300	(400)	89	90	88	90	87	88	86	87
315	(422)	89	90	88	90	87	88	86	87
355	(475)	89	90	88	90	88	Ⓢ	87	Ⓢ
500	(670)	90	91	89	90	88	Ⓢ	87	Ⓢ
1 000	(1 300)	90	91	89	91	88	Ⓢ	87	Ⓢ
1 500	(2 000)	91	92	90	91	89	Ⓢ	88	Ⓢ
2 000	(2 667)	91	92	90	91	89	Ⓢ	88	Ⓢ

Ⓢ Noise levels of machines in this range should be based on actual equipment selected.

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

## 2 TRANSPORT AND STORAGE

### 2.1 Consignment receipt and unpacking

Immediately after receipt of the equipment it must be checked against the delivery and 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 received in writing within one month of receipt of the equipment. Later claims cannot be accepted.

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

Each product has a unique serial number. Checks 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

#### 2.2.1 General instructions concerning handling

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

To lift machines or pieces with one or several suspension rings, only use hooks and chains in compliance with the local regulations concerning safety. Never put cables, chains or ropes directly on or in the suspension rings. Cables, chains or lifting ropes must never present excessive bending.

Never bend the lifting hooks, suspension rings, chains, etc., which should only be made to endure stresses within, calculated limits. Remember that the capacity of a lifting device decreases when the direction of the lifting force direction makes an angle with the device axis.

To increase the safety and the efficiency of the lifting device, all the lifting elements must be as perpendicular as possible. If necessary a lifting beam can be placed between the winch and the load.

When heavy pieces are lifted up, never stay or work under the load or in the area, which could be in the path of the load if it were to swing or fall away.

Never leave a load hanging from a winch. The acceleration or the slowing-down of lifting equipment must stay in the safety limits for the staff.

A winch must be positioned in such a way that the load will be raised perpendicularly. Where possible necessary precautions must be taken to avoid the swing of the load, using for example two winches making approximately the same angle, below 30°, with the vertical.

### 2.3 Lifting



Make sure that any equipment used to lift the pump or any of its components is capable of supporting the weights encountered. Make sure that all parts are correctly rigged before attempting to lift.



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 the general arrangement drawing included in the job user instructions.

#### 2.3.1 To lift unit

Pump, driver and baseplate can be lifted as a unit. Sling from all four (4) eye bolts provided on baseplate side rails. Failure to use all four (4) could result in permanent distortion of the baseplate. Use as long a sling as possible, or use a spreader arrangement.



***Coupling bolting and spacer piece must be removed from between pump and driver half couplings before lifting baseplate with pumping element.***

***To lift pump and baseplate, less driver, or baseplate alone, sling from all four (4) eye bolts.***



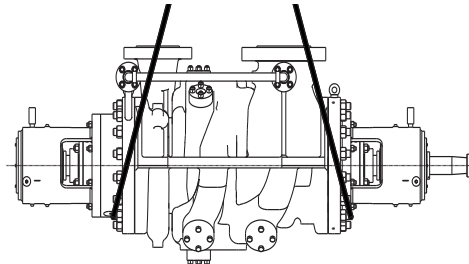
***Do not lift pump, motor, base plate unit by slinging from pump casing and or eye bolt on motor.***

#### 2.3.2 To lift driver

Refer to manufacturer's instructions.

#### 2.3.3 To lift complete pump only

Rig lifting straps at coupling end bearing bracket and outboard bearing bracket. Make sure straps are adjusted to obtain an even lift.



## 2.4 Storage



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

Electric motors (pump driver) should not be stored in damp places without special protection. (Refer to motor manufacturer's instructions.)

The pump may be stored as above for up to 6 months.

### 2.4.1 Long term storage

During extended periods of storage prior to installation, precautions must be taken to protect the pump from deterioration. The various parts of the pump are protected prior to shipment by applying varying grades of preservative to the parts. However, during shipment and handling the preservatives are subjected to conditions that can cause their removal. Also, during extended periods of time the preservatives may deteriorate. The listed procedures (2.4.1.1 to 2.4.1.5) should be followed to prevent deterioration of the pump during the extended storage period. These procedures may also be supplemented by the experience of the person(s) performing the tasks.

#### 2.4.1.1 Inspection upon arrival

When the pump is received it should be inspected for damage or other signs of rough handling. If any damage is found it should be reported to the carrier immediately. Inspect the preservative coating on various parts. If necessary, renew preservative in areas where it has been rubbed or scraped.

Inspect all painted surfaces. If necessary, touch up the areas where paint has been chipped or scraped.

Inspect all covers over pump openings and piping connections. If covers or seals for the covers are damaged or loose, they are to be removed and a visual inspection made of the accessible interior areas for accumulation of foreign materials or water. If necessary, clean and preserve the interior parts as noted above to restore the parts to the "as shipped" condition. Install or replace covers and fasten securely.

#### 2.4.1.2 Storage



If at all possible, the pump and its component parts should be stored indoors where they will be protected from the elements. In no case

should any pump element be subjected to extended periods of submergence or wetting prior to start up. If it is not possible to store the pump and its components indoors, precautions must be taken to protect them from the elements. Regardless of whether storage is indoors or outside, the storage area should be vibration free. All boxes marked for indoor storage should be stored indoors. When stored outdoors the pump and its components should be protected from dirt, dust, rain, snow, or other unfavorable conditions by heavy plastic sheets, canvas, waterproof burlap or other suitable coverings.

All equipment must be placed upon skids or blocks to prevent contact with the ground and surface contaminants. Equipment must be adequately supported to prevent distortion and bending.

The pump shaft should be rotated, in the direction of rotation, at least 1 and 1/4 turns each week during the storage period and any other periods of standby. When selecting a storage area the following points should be taken into consideration:

- a) The deterioration of the equipment will be proportionate to the class of storage provided.
- b) The expenses involved in restoring the equipment at time of installation will be proportionate to the class of storage provided.

#### 2.4.1.3 Inspection and maintenance

The stored equipment has to be placed on a periodic inspection schedule by the purchaser. The responsibility for setting up an inspection schedule rests with the purchaser and will be dependent upon the class of storage provided. It would be expected initially, inspection would occur weekly, and then depending on the inspection reports being favorable or unfavorable, inspection would continue weekly, monthly, or quarterly, as may be determined.

Each inspection should consist of a general surface inspection to assure that:

- a) Pump supports are firmly in place.
- b) Pump covers over openings are firmly in place.
- c) Pump coverings, plastic or tarps are firmly in place. Any holes or tears must be repaired to prevent entrance of dirt or water.
- d) Pump covers are periodically removed from openings and interior accessible areas inspected. If surface rusting has occurred, clean or coat with preservative.
- e) If rusting occurs on exterior surfaces clean and repaint or coat with preservative.
- f) Check individually wrapped parts for signs of deterioration. If necessary, renew preservative and wrapping.

Six months prior to the scheduled installation date, a Flowserve representative is to be employed to conduct an inspection. This inspection may include, not necessarily in its entirety and not limited to the following:

- a) An inspection of all periodic inspection records as kept on file by the purchaser, and all inspection reports that have been compiled during the storage period.
- b) An inspection of the storage area to determine the "as stored" condition of the equipment prior to any protection covers being removed.
- c) An inspection of the equipment with protective covers and flange covers removed.
- d) Depending upon the length of time the equipment was stored, the type of storage provided (i.e. **Indoor:** heated, unheated, ground floor, concrete floor. **Outdoors:** under roof, no roof, waterproof coverings, on concrete, on ground) and as a result of the inspection of (a), (b) and (c) above the Flowserve representative may require a partial or complete dismantling of the equipment.
- e) Dismantling may necessitate restoration of painted or preserved surfaces, and, or replacement of gaskets, O-rings, packing and bearings.
- f) All costs involved during inspection, dismantling, restoration, replacement of parts and reassembly will have to be accounted to the purchaser. All necessary labor, tools and cranes will be supplied by the purchaser.

Upon completion of the inspection the Flowserve representative shall submit a report to the purchaser, and to the Manager of Customer Service, stating in detail the results of the inspection.

One month prior to installation of the equipment, a Flowserve representative is to be employed to conduct a final inspection.

This inspection will be made to assure that the requirements of the six months inspection report were satisfactorily completed and that the equipment is ready for installation.

Upon completion of this inspection the Flowserve representative shall submit a final report to the purchaser, and to the Manager of Customer Service, advising the results of the final inspection.

All costs involved in conducting the final inspection will have to be accounted to the purchaser.

Prior to and during start up, any requirements for the services of a Flowserve representative will revert back to the original contract agreement for equipment purchased, with revised costing.

#### **2.4.1.4 Painting and preservation**

Paints and preservatives used are either Flowserve standard or 'special' as required by the contract specification. Refer to Flowserve for the description of paints and preservatives used on this order if needed.

#### **2.4.1.5 Associated equipment**

Motors, turbines, gears etc being supplied by Flowserve.

Generally rotors of associated equipment should be blocked to relieve bearing loads. Storage should be indoors and dry. See the specific manufacturer's storage requirements.

### **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 using an environmentally acceptable method and in accordance with local regulations. If the product contains substances which are harmful to the environment, these should be removed and disposed 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**

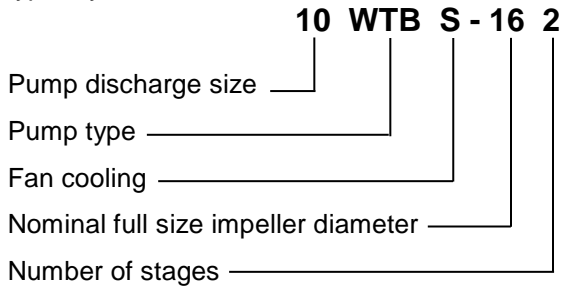
The WTB pumps are multi stage, double suction impeller, double volute, radially split, centerline mounted with top nozzles, heavy duty and volute type process pumps.

The different sizes available, combined with the choice of impellers, ensure optimum efficiency throughout the range.

Various options of construction materials and bearing types are available.

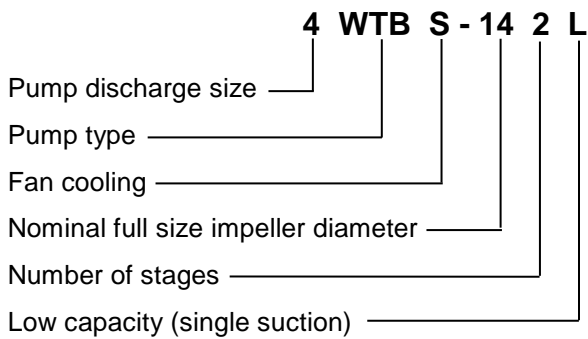
### 3.2 Nomenclature

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



The typical nomenclature above is the general guide to the WTB description. Identify the actual pump size and serial number from the pump nameplate. Check that this agrees with the applicable certification provided.

Low capacity, single suction WTB pump nomenclature.



### 3.3 Design of major parts

#### 3.3.1 Pump casing

The casing is radially split, double volute, heavy walled, centerline supported to achieve the safest and most simple sealing and centerline supported to maintain alignment at high temperature.

The suction and discharge nozzles are an integral part of casing. The casing volutes are designed for smooth flow with gradual change in velocity.

Wall thickness and casing shape are chosen for the maximum strength against stresses resulting from combined high working pressure and high allowable external loads on flanges.

The double volute casing minimizes the radial thrust on the pump rotor and gives longer life to the seals, bearings and wear rings.

#### 3.3.2 Impeller

The impeller in the WTB is of double or single suction first stage impeller and it is mounted with an clearance fit and keyed to the shaft, positively secured against axial clearance which provides for free axial thermal expansion of the shaft sleeve. (Reference 3.1.)

Impellers are designed to handle hot liquids close to their boiling points. The symmetric pressure distribution acting on impeller shrouds ensures complete axial balance of the rotor.

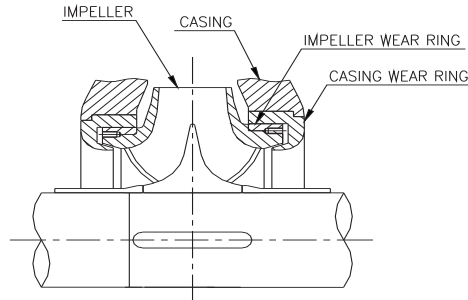


Figure 3-1

#### 3.3.3 Wearing rings

The suction head and the impeller are fitted with replaceable wear rings of hardened material. The rings are held in place by a press fit with locking pins on the casing and with threaded dowels on the impeller.

#### 3.3.4 Suction head

The suction head fastened to the casing with studs and nuts. It can be provided with a water jacket for cooling. The mating faces between casing and stuffing box are sealed by a confined gasket.

It is supplied with the mechanical seal consisting of a stationary and rotary seal ring. But also it can install the packing rings suitable for the conditions of service. The stuffing box head is adaptable to all types of commercial seals.

Note: for mechanical seal details refer to the manufacturer's instructions.

#### 3.3.5 Rotors

Shafts are of ample diameter, combined with the minimum bearing span to minimize shaft defectors especially when the pump is operating at off peak conditions.

Shafts are designed to meet API 610 latest Edition deflection and vibration requirements. Fully assembled rotors are dynamically balanced and can accommodate a wide variety of single or dual seal arrangements as standard.



### 3.3.6 Bearing housings

WTB pumps are equipped with heavy duty anti-friction bearings arranged for oil lubrication. The bearings are mounted in a bearing bracket which is bolted to the suction head with a male and female fit assuring rotor alignment.

Positive circulation of lubricating oil is assured by oil flinger and a trough on the inside of the bearing housing. Proper oil level is maintained by a constant level oiler.

The thrust bearing is a double-row, angular contact bearing mounted back-to-back. It is press fitted on the shaft and is secured axially with a nut and lock washer. The outer races are contained between a shoulder in the bearing bracket and the bearing bracket cover to prevent end movement.

The radial bearing is a single -row, deep-groove type bearing. The radial bearing is not constrained at the outer race which provides for free axial expansion of the shaft.

WTB pumps are also equipped with sleeve-ball and Sleeve-Kingsbury bearing configurations for high load applications.

### 3.3.7 Shaft seals

The mechanical seals are attached to the pump shaft. It seals the pumped liquid from the environment.

### 3.3.8 Driver

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

### 3.3.9 Coupling/coupling guards

Flexible spacer couplings are provided in various makes and models to suit customer preference. (Aluminium non-hinged guards are provided.)

### 3.3.10 Baseplate

Standard baseplates are welded steel, drain pan type in conformance with API 610 standardized dimensions. Horizontal driver alignment screws and vertical baseplate leveling screws are provided as required by API.

Special baseplates can be supplied to suit individual installation circumstances.

### 3.3.11 Accessories

Accessories may be fitted when specified by the customer.

Baseplates are fabricated and machined so as to guarantee the flatness and parallelism of pads as required by API standard. The requirement is met by supporting and clamping the baseplate at the foundation bolt holes only.

## 3.4 Performance and operating limits

This product has been selected to meet the specifications of your purchase order; see section 1.5. These pumps are furnished for a particular service condition. Changes in the hydraulic system may affect the pump's performance adversely.

This is especially true if the changes reduce the pressure at the suction flange or if the liquid temperature is increased. In case of doubt, contact the nearest Flowserve office.

### 3.4.1 Effect of specific gravity

Pump capacity and total head in meters (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-pressurizes the pump.

### 3.4.2 Effects of viscosity

The pump is designed to deliver rated capacity and rated head for a liquid with a particular viscosity. For a given flow rate the total head reduces with increased viscosity and increases with reduced viscosity. Also for a given flow rate the power absorbed increases with increased viscosity, and reduces with reduced viscosity.

When contemplating operation at some viscosity other than the one for which the pump was originally designed and or applied, the changed conditions should be referred to Flowserve for recommendations.



***When the pump is handling heavy viscous liquid, the temperature of the liquid must allow it to be pumped easily. Liquid may have to be heated prior to pump start-up.***

### 3.4.3 Changing the pump speed

Changing pump speed effects flow, total head, power absorbed, NPSHR, noise and vibration. Flow varies in direct proportion to pump speed. Head varies as speed ratio squared. Power varies as speed ratio cubed. If increasing speed it is important therefore to ensure the maximum pump working pressure is not exceeded, the driver is not overloaded, NPSHA > NPSHR, and that noise and vibration are within local requirements and regulations.

### 3.4.4 Net positive suction head (NPSH)

Any liquid, hot or cold, must be pushed into the impeller of the pump by absolute pressure, such as the atmospheric or vessel pressure from which the pump takes its suction.

The head in feet of liquid necessary to push the required flow into the pump is called Net Positive Suction Head. This value, more commonly called NPSH, is measured above the vapor pressure of the liquid at the pumping temperature.

There are two kinds of NPSH:  $NPSH_R$  is the head required by the pump to cover the losses in the pump suction - that is shown on the pump characteristic curve. The second,  $NPSH_A$ , is the head available in the system, taking into account friction loss in suction piping, valves, fittings etc. In all cases the  $NPSH_A$ , measured above vapor pressure, must exceed the  $NPSH_R$  in order to push the liquid into the pump. Failure to have this will result in both bad performance and mechanical damage to the pump, and in certain cases actual pump failure.

If any change in  $NPSH_A$  is proposed, ensure its margin over  $NPSH_R$  is 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.

### 3.4.5 Minimum continuous stable flow

The Minimum Continuous Stable Flow for the pump is stated on the data sheet.

### 3.4.6 Minimum flow control

In all cases, it is the customer's responsibility to supply a system and or control which assures that any pump within a system is not operated below its minimum flow condition. In many cases, this is not a problem because the system is operating within its own flow range to assure product delivery. A simple high pressure alarm, shut down and or bypass control can be used. However, in systems where product demand has high swings or where more than 100 % capacity units are desired to support a product system, additional care must be taken.

### 3.4.7 Thermal control

A thermal control of the unit can be provided by thermal sensors which read direct or "related to" fluid temperatures and respond accordingly by opening additional flow paths until the given unit re-establishes the acceptable temperature rise, and sets off alarms if


not achieved within reasonable/normal time periods. (High limit could actually shut down unit.)

### 3.4.8 Pressure and/or flow control


Pressure and or flow sensors can be used to hold the unit at higher flows by opening additional flow paths once a "high pressure limit" or "low flow limit" was indicated.

Upon system reaching increased flow a "low pressure limit" or "high flow limit" setting would close the bypass flow path. Care must be taken to allow for signal spread to avoid cyclic conditions.

### 3.4.9 Operating at reduced capacity

 Damage to the pump may result from prolonged operations at capacities less than minimum continuous stable flow as stated in the data sheet.

## 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 always be located as near as possible to the suction supply.

Install the unit close to the source of the liquid to be pumped.


Simplify the suction and discharge piping layout.

When selecting the location, be sure to allow adequate space for operation as well as for maintenance operations involving dismantling and inspections of parts.

Head room is an important consideration as an overhead lift of some type is required

### 4.2 Part assemblies

Motors may be supplied loose. 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.

 Prior to grouting, an initial alignment check in accordance with the alignment section of this document shall be performed to verify that coupling spacing and final alignment can be achieved without modifying the hold down bolts or the machine feet. This is necessary to ensure that the baseplate was not damaged during transportation.

### 4.3 Foundation

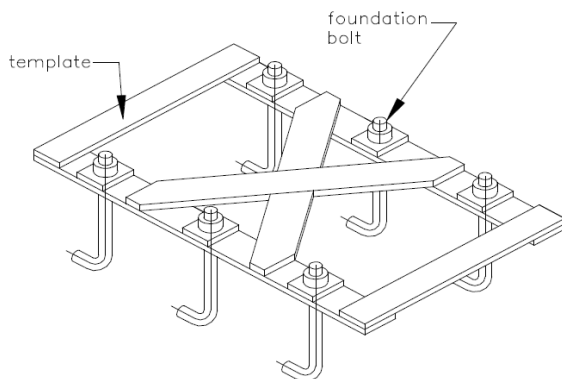


There are many methods of installing pump units to their foundations. The correct method depends on the size of the pump unit, its location and noise vibration limitations. Non-compliance with the provision of correct foundation and installation may lead to failure of the pump and, as such, would be outside the terms of the warranty.

The foundation should be sufficiently rigid and substantial to prevent any pump vibration and to permanently support the baseplate at all points.

The most satisfactory foundations are made of reinforced concrete. These should be poured well in advance of the installation to allow sufficient time for drying and curing.

The general arrangement drawing (in job user instructions) will furnish overall outline of pump baseplate, anchor bolt locations, size of bolts etc in order to provide proper shape to the primary concrete. Anchor bolts can be positioned by a special template (not supplied by Flowserve - see figure 4-1) or by the baseplate itself if proper pockets have been provided in primary concrete.

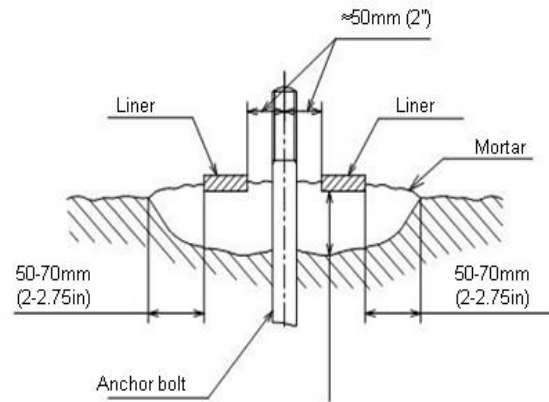


**Figure 4-1: template for hanging foundation bolts**

Figure 4-2 below illustrates an alternative foundation bolt arrangement which can be used in lieu of standard foundation bolts.

Allow a little more than the specified threaded bolt length above the rail of the baseplate. The excess can always be cut off if it is not needed.

A rough finish top surface is best when applying grout.

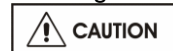


**Figure 4-2**

#### 4.3.1 Baseplate levelling

Before putting the unit on the foundation, thoroughly clean the top of the foundation. Break off any loose pieces of cement and roughen the top with a chisel to afford a good hold for grout.

In case of installation over a steel structure (platform) ensure that the top of the steel structure is cleaned and degreased.



In order to obtain the parallelism and flatness of pads required by API standard, the baseplate has to be properly leveled by leveling screws provided on it and clamping the baseplate at the foundation bolts only. (For proper detailed procedure refer to chapter 5 para 3.9.4 of API RP 686.)

**Note:**

Coupling bolting and spacer piece must be removed between the pump and driver half couplings before lifting baseplate with pumping element.

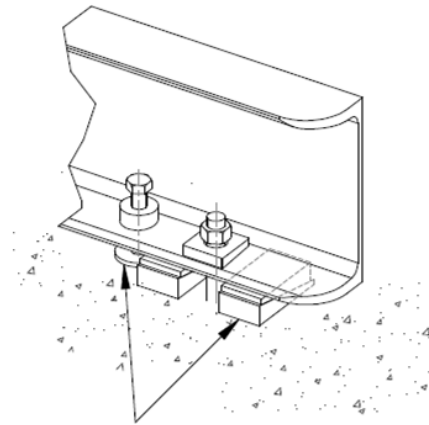
**Note:**

When the unit is mounted directly on structural steel framing, it should be located directly over as near as possible to the main building members, beams, or walls. A soleplate should be bolted or welded to the steel frame to guarantee the proper surface.

**Note:**

When lifting baseplate with pumping element, sling baseplate from all lifting lugs provided. (Refer to section 2.3.1.)

Prepare sufficient steel plates to be placed below each baseplate jacking screw furnished with the baseplate. The purpose of the plate is to spread the load of the screw without crushing the concrete below.



Not supplied

Figure 4-3

#### 4.3.2 Method of levelling baseplate using wedges or shims

- a) Level the baseplate by using a machinist's level on the machined surfaces of the pump and driver pads. Leveling is best achieved by adjusting the shim pack thickness under each holding bolt. Carefully raise the baseplate by using either the baseplate jacking screws provided or by levering with a suitable pinch bar or by installing a low level hydraulic jack.
- b) Adjust the shim pack thickness and lower the baseplate.
- c) Repeat this procedure in a logical manner at each bolt position until the baseplate is both straight and leveled. A degree of 0.20 mm/m (0.0025 in./ft) length is achievable on most units with a maximum of 0.40 mm/m length (0.005 in./ft).
- d) In case of installation on steel structures (like platforms) proceed with these extra steps:
  - Using a calibrated pin with a cone point mark the center of baseplate support pads mounting holes on the soleplate.
  - Lift and move away the pump skid.
  - Drill and tap the soleplate fixing holes.
  - Replace the pump skid so that the soleplate fixing holes align with the baseplate support pads mounting holes.
  - Level the unit as done previously (see points a, b, c).
- e) When the baseplate is level, pull down the foundation bolts so they are snug or tighten the fixing bolts in case of installation on steel structure. This may have disturbed the baseplate, so re-check the levels.

Ensure that shaft alignment as in section 4.5 can be achieved prior to grouting the baseplate.

## 4.4 Grouting

Build a dam around the foundation as shown in figure 4-4 after leveling the baseplate. It is a matter of personal preference whether the leveling wedges under the baseplate are removed after grouting. If you do not want to remove the wedges, carefully mark their locations before pouring grout.



**Before grouting, level the machined pads of the baseplate in both directions and perform a rough shaft/coupling alignment. Alignment after grout has set will not be possible if above is not satisfactorily completed.**

#### 4.4.1 Fully grouted baseplates

Use a good, high strength, non-shrink grout mix and install as per manufacturer's instructions. Holes are provided in the baseplate to permit pouring the grout and stirring while acting as air vents. Fill under the baseplate completely, stirring to assure correct distribution of the grout. Check to see that the grout flows under the edges of the baseplate evenly.

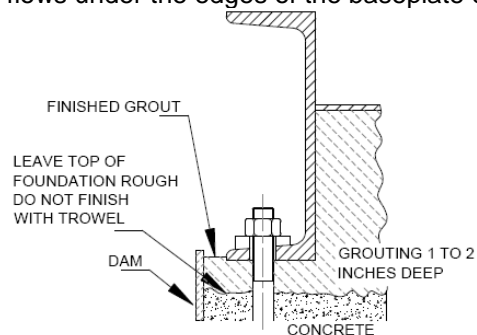


Figure 4-4

#### Note:

Do not vibrate baseplate when grouting, making sure baseplate is vented correctly and all areas are thoroughly puddled to prevent any resonant problems.

When the grout is thoroughly hardened, remove the dam and wedges, if desired, filling in the holes they leave with grout.

#### Note:

Pour grout until level reaches top of dam. Allow to dry sufficiently to prevent grout from overflowing while completing the remaining grouting.

#### 4.4.2 Baseplate not intended for grouting but installed on concrete foundations

According to figure 4-5 and 4-6 the baseplate will not be grouted but only a sealing shall be provided. During the preparation, as indicated on the general arrangement drawing, a certain number of openings into the sealing must be guaranteed. After the sealing, the blocks used to realize the openings must be removed.



Blocks have to be wider than the baseplate longitudinal beam in order to guarantee the opening for drainage.

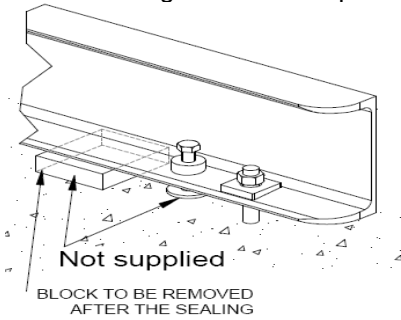


Figure 4-5

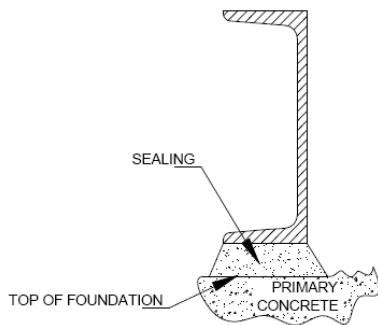


Figure 4-6

## 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.

### 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.

#### 4.5.2.1 Shaft/coupling alignment

**CAUTION** **Shaft alignment must be correct for successful operation. Rapid wear, noise, vibration and actual damage to the equipment may be caused by shaft misalignment. The shafts must be aligned within the limits given within this section.**

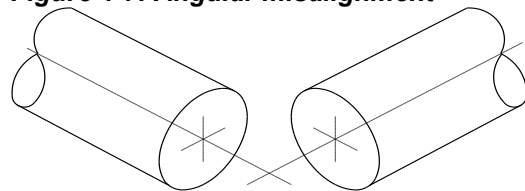
**Note:** Adjustment to correct the alignment in one direction may alter the alignment in another direction. Always check in all directions after making any adjustment.

Coupled equipment must be aligned to minimize unnecessary stresses in shafts, bearings and coupling. Flexible couplings will not compensate for appreciable misalignment. Foundation settling, thermal expansion or nozzle loads resulting in baseplate/foundation deflection and vibration during operation may require the full coupling misalignment capability.

#### 4.5.2.1.1 Types of misalignment

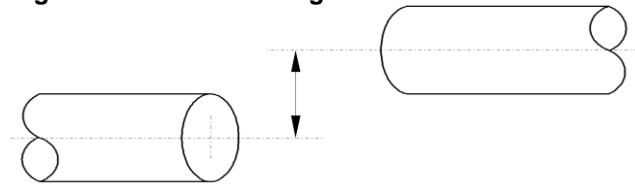
There are two types of shaft misalignment: angular and offset. Therefore, two sets of measurements and corrections are required. Both types of misalignment can occur in horizontal and vertical planes and are present in most applications.

#### Figure 4-7: Angular misalignment



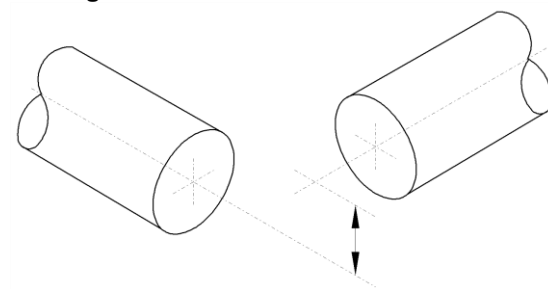
In angular misalignment, the center line of the shafts intersects, but is not on the same axis.

#### Figure 4-8: offset misalignment



In offset misalignment, the shaft center lines are parallel but do not intersect.

#### Figure 4-9: combination of offset and angular misalignment

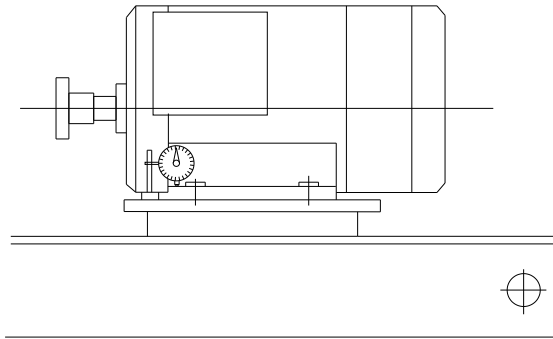


#### 4.5.2.2 Alignment using the reverse alignment method

The following practices are recommended when using the reverse method of alignment. These should be carried out prior to main alignment.



**Check for soft foot**



**Figure 4-10**

This is a check to ensure that there is no undue stress on the driver holding down bolts; owing to non-level baseplate or twisting. To check, remove all shims and clean surfaces and tighten down driver to the baseplate. Set a dial indicator as shown in figure 4-10 and loosen off the holding down bolt while noting any deflection reading on the dial test indicator. A maximum of 0.05 mm (0.002 in.) is considered acceptable but any more will have to be corrected by adding shims. For example, if the dial test indicator shows the foot lifting 0.15 mm (0.006 in.) then this is the thickness of shim to be placed under that foot. Tighten down and repeat the same procedure on all other feet until all are within tolerance.

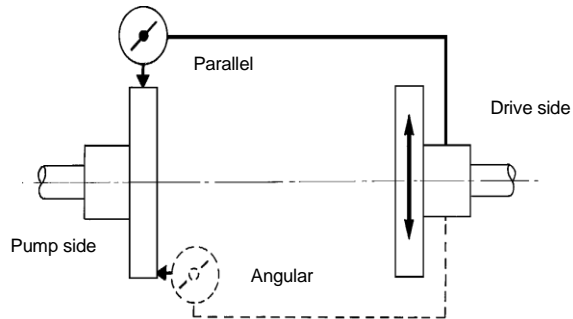
**Note:** If the driver is an electric motor with sleeve bearings then the magnetic center at which the rotor will run must be set. This is usually done by lining up a groove in the shaft to a pointer fixed to the motor body. (Refer to the motor manufacturer's instructions.)

**4.5.2.3 Alignment using a graph (reverse alignment)**

**⚠ 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.

The alignment is achieved by adding or removing shims under the motor feet and also moving the motor horizontally as required. In some cases where the alignment cannot be achieved it will be necessary to move the pump before recommencing the above procedure.



**Figure 4-11**

Maximum permissible misalignment at working temperature:

- Parallel 0.05 mm (0.002 in.) TIR
- Angular 0.05 mm (0.002 in.) TIR

Pumps with thick flanged non-spacer couplings can be aligned by using a straight-edge across the outside diameters of the coupling hubs and measuring the gap between the machined faces using feeler gauges, measuring wedge or calipers.

When the electric motor has sleeve bearings it is necessary to ensure that the motor is aligned to run on its magnetic centerline.



Refer to the motor manual for details.

A button (screwed into one of the shaft ends) is normally fitted between the motor and pump shaft ends to fix the axial position.

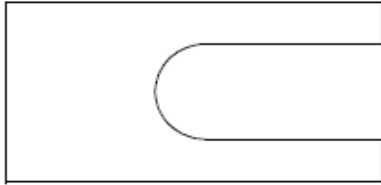
**⚠ CAUTION** If the motor does not run in its magnetic center the resultant additional axial force may overload the pump thrust bearing.



Complete piping as below and see section 4.7, *Final shaft alignment check*, up to and including section 5, *Commissioning, start-up, operation and shutdown*, before connecting driver and checking actual rotation.

**4.5.3 Shims**

The shims between the equipment feet and mounting surface should be clean and dry. This is especially critical for pumps in service for some time and need to be realigned. Water, dirt and rust may change the height of the shim pack over a period of time. Shims should be made large enough to support the weight of the equipment on its mounting foot. Do not use many thin shims as this may result in a spongy mounting.



**Figure 4-12; recommended shim design**

Move the equipment vertically by adding or removing the calculated thickness of shims. Torque the holding down bolts to the required values.

**4.5.4 Hot alignment – pump and driver dowels**

Pump hold down bolts are to be torqued down and dowel pins are to be located in pump feet. (This is only applicable if hot alignment is required.)

Refer to driver outline drawing and or driver instructions for driver doweling information.

A hot check can only be made after the unit has been in operation a sufficient length of time to assume its NORMAL operating temperature and conditions. If the unit has been correctly cold set, the offset misalignment will be within 0.05 mm TIR (0.002 in. TIR) and the angular misalignment will be within 0.05 mm TIR (0.002 in. TIR) when in operation. If not make adjustments.

**⚠ Do not attempt any maintenance, inspection, repair or cleaning in the vicinity of rotating equipment. Such action could result in injury to operating personnel.**

**⚠ Before attempting any inspection or repair on the pump the driver controls must be in the "off" position, locked and tagged to prevent restarting equipment and injury to personnel performing service on the pump.**

**4.5.5 Assemble coupling**

- a) Assemble coupling as per the manufacturer's instructions included in Appendix of this manual.
- b) Install coupling guard

**4.5.6 Installation check list**

- a) Level baseplate?
- b) Grout baseplate - check foundation bolts?
- c) Alignment shaft/coupling?
- d) Piping installed - correct vent, gauge, valve, suction strainer locations?
- e) All flange bolting correctly torqued with appropriate gaskets in place?
- f) Check shaft/coupling alignment again.
- g) Coupling guard correctly installed?

**4.6 Piping**



Never use the pump as a support for piping.

**4.6.1 General**

These units are furnished for a particular service condition. Changes in the hydraulic system may affect performance adversely. This is especially true if the changes reduce the pressure at the suction or if the liquid temperature is increased. In case of doubt contact Flowserve.

Suction and discharge piping should be of ample size, be installed in direct runs, and have a minimum of bends. Double bends must be avoided in suction line and a straight run of pipe, equal 5 to 10 times the pipe diameter is desired directly upstream of the suction nozzle.

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.



Provision must be made to support piping external to the pump to prevent excessive nozzle loads, maintain pump/driver alignment and avoid pipe induced vibrations.

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

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.



Ensure piping and fittings are flushed before use.



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

**4.6.2 Suction piping**

- a) The inlet pipe should be one or two sizes larger than the pump inlet bore and pipe bends should be as large radius as possible.

- b) Keep the suction pipe free of all air pockets. (Vent is required.)
- c) Pipework reducers should have a maximum total angle of divergence of 15 degrees.
- d) Use only eccentric reducers with the straight side on the top.
- e) Flow should enter the pump suction with uniform flow, to minimize noise and wear.
- f) A gate valve is recommended in the suction line.
- g) Except if considerable foreign matter is expected strainers are not recommended in inlet piping. (See section 4.6.2.1.)

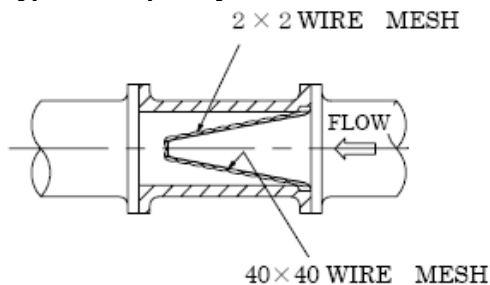
**4.6.2.1 Suction strainer**

If a temporary strainer is placed in the suction pipe to prevent lodging of foreign material in the impeller, a pipe spool of sufficient size should be provided with gauge taps to accommodate the suction strainer.

The strainer should be installed as close to the pump as possible. The open area of the strainer should have a minimum of a 3 to 1 ratio to the area of the pump inlet.

Pressure gauges should be installed on both sides of the strainer, so the pressure drop across the strainer can be measured when the unit is operated.

**Typical temporary suction strainer**



When the unit is started, the gauges on each side of the screen should be carefully watched. An increase in the differential pressure between the two gauges indicates that the screen is becoming clogged with dirt and scale. At this point, the pump should be shut down, and the screen cleaned and or replaced.

**Note:** *A spool piece should be installed in the suction line so that the suction strainer may be installed and removed with a pressure gauge between the strainer and pump. The net area of the strainer should be three to four times the area of the suction pipe. The net area is the free and clear total opening through the strainer.*

**4.6.2.2 Bypass line**



**Operation at low flows results in pump horsepower heating the liquid. A bypass may be required to prevent vaporization and subsequent pump damage. Refer to local Flowserve branch to determine if a bypass is required. Mechanical damage may result from continuous operation at flows less than specified.**

**4.6.3 Discharge piping**

- a) Install a check valve and a gate valve in the discharge pipe of the pump. When the pump is stopped, the check valve will protect the pump against excessive pressure and will prevent the pump from running backwards. The check valve should be installed between the gate valve and the pump nozzle in order to permit its inspection. Never throttle pump on suction side and never place a valve directly on the pump inlet nozzle.
- b) Pipework reducers should have a maximum total angle of divergence of 15 degrees.
- c) Only concentric reducers to be used.

**4.6.4 Drains and vents**

Pipe pump casing drains and vent to a convenient disposal point.

**4.6.5 Jacket piping**

The stuffing boxes are jacketed for water cooling and also the bearing brackets can be jacketed. They should be provided with cooling only if required by the operating conditions

**4.6.6 Pumps fitted with mechanical seals**

Single seals requiring re-circulation will normally be provided with auxiliary piping from pump casing already fitted. Symbols which Flowserve use on seal connections are as follows:

- Q - quench
- F - flush
- D - drain outlet

For specific information refer to the mechanical seal manufacturer's instructions.

**4.6.7 Final checks**

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

**4.7 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 there is no pipe strain on the coupling. If pipe strain exists, correct piping.

#### 4.8 Electrical connections



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



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



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



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



A device to provide emergency stopping must be fitted.

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

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



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

#### 4.9 Protection systems



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

If there is any possibility of the system allowing the pump to run against a closed valve or below minimum continuous safe flow a protection device

should be installed to ensure the temperature of the liquid does not rise to an unsafe level.

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

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

To prevent excessive surface temperatures at bearings it is recommended that temperature or vibration monitoring is carried out. See sections 5.7.4 and 5.7.5.

### **5 COMMISSIONING, START-UP, OPERATION AND SHUTDOWN**

The following procedures are presented to outline the most important steps involved in pump operation. Any modification of these procedures due to particular installation peculiarities should conform to good engineering practice.



**CAUTION** Never operate the pump with suction valve closed.

Never operate the pump unless it is filled with liquid and vented.

Never operate the pump unless a liquid source is available.

Never operate the pump with discharge valve closed or below the minimum specified flow rate. If reduced capacity operation is required on occasion, a recirculating line should be installed according to Flowserve recommendations.

Where possible avoid severe thermal shocks due to sudden changes of liquid temperature. Warm up the pump at all times before start-up if the pumped liquid is hot or subject to crystallize

Lubricate the unit prior to starting.

Do not operate the unit unless coupling guards are bolted in place.

Never operate the pump above the name plate conditions.

During pump operation, keep the vent and drain valves in closed position, to prevent any liquid from a high pressure point flowing into a low pressure point.

Do not wipe down in the vicinity of rotating parts. If unusual noise or high vibrations occur, secure the pump as soon as possible.

### 5.1 Pre-commissioning procedure

The following steps should be followed at initial startup and after the equipment has been overhauled:

- a) Prior to installing the pump, flush the suction side of the system to remove all deposit (slag, bolts etc).
- b) Ensure the pump and piping is clean. Before putting the pump into operation, the piping should be thoroughly back flushed to remove any foreign matter which may have accumulated during installation. Take all possible care not to contaminate your system.
- c) Install suction strainer if required. (See section 4.6.2.1.)
- d) Fill the bearing housings with the appropriate oil to the correct level. Bearings must receive a small amount of oil prior to starting to ensure adequate lubrication at start up. (Refer to section 5.1.1.)
- e) Turn pump rotor by hand or with a strap wrench to make sure it turns smoothly.
- f) Assure that correct seal piping has been installed and has not been damaged.



Most cartridge seals are equipped with a spacer between the gland plates and drive collar. This spacer must be removed before starting unit.

- g) Prior to coupling installation, bump start motor to check for correct rotation. If rotation is not correct refer to motor manual for appropriate connections to change rotation.



Shut down all power prior to change.

- h) Ensure coupling is correctly aligned and lubricated, and pump and driver are satisfactorily doweled. (Refer to section 4.5.)



**The unit must not be operated unless coupling guard is securely and completely bolted in place. Failure to observe the warning could result in injury to operating personnel.**

- i) Check torque of all bolting and the plugs for tightness.

### 5.1.1 Lubrication

Lubrication of bearing is by oil circulation into the bearing housing provided by oil ring, flinger or pure oil mist. A constant level oiler is normally furnished (except for pure oil mist lubrication) with the pump unless otherwise specified.

#### 5.1.1.1 Ball-ball lubrication

Before filling the bearing housing reservoir, flush out the housing thoroughly with safety solvent and a leading grade of flushing oil, compatible with the lubrication oil that will be used.

The oil level must be maintained at the correct level: lack of oil may cause overheating and failure of the bearings, while exceeding the correct level can result in leakage from the labyrinth seals. The constant level oiler can be adjusted by changing the height of the cross arms which support the glass reservoir, as illustrated for Trico oiler in section 5.1.2.

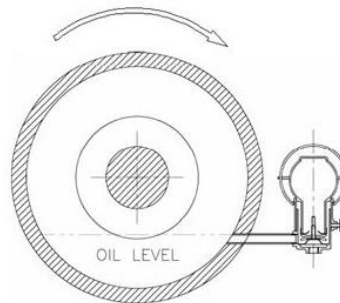


Figure 5-1

The oil circulation is ensured by a flinger according to the description as follows.

#### Radial bearing and thrust bearings side lubrication:

- The flinger splashes the oil from the oil sump to the bearing housing walls
- The oil is collected by the oil collector and reaches the line bearing through a hole
- The oil returns into the oil sump once it flows into the bearings

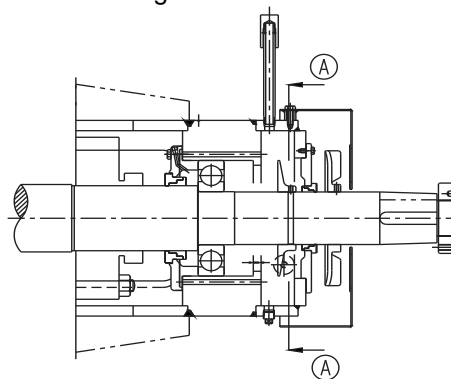
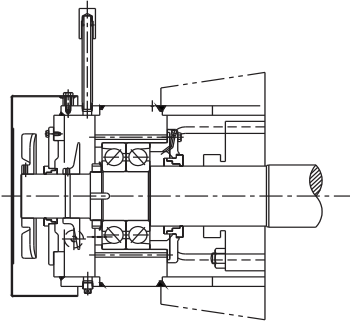
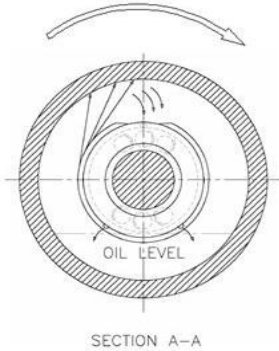


Figure 5-2a





**Figure 5-2b**



**Figure 5-3**

**5.1.1.2 Sleeve ball lubrication**

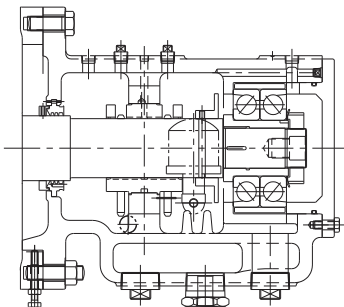
Before filling the bearing housing reservoir, flush out the housing thoroughly with safety solvent and a leading grade of flushing oil, compatible with the lubrication oil that will be used.

The oil level must be maintained at the correct level: oil lack may cause overheating and failure of the bearings, while exceeding the correct level can result in leakage from the labyrinth seals. The constant level oiler can be adjusted by changing the height of the cross arms which support the glass reservoir, as illustrated for Trico oiler in section 5.1.2.

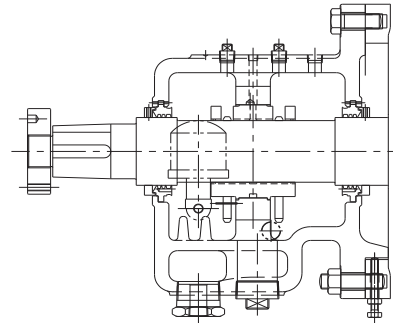
Oil circulation is ensured by an oil ring according to the following description.

*Line bearing and thrust bearings side lubrication:*

- The oil ring splash the oil from the oil sump to the bearings
- The oil circulates from oil sump to the oil unit inlet bearing housing via an oil unit



**Figure 5-4a**



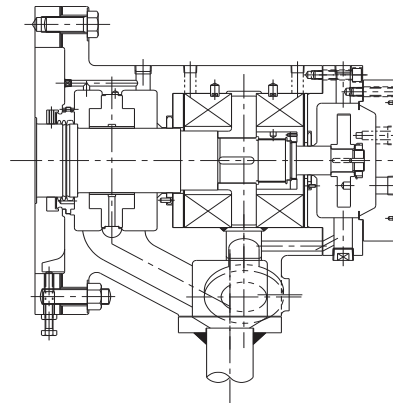
**Figure 5-4b**

**5.1.1.3 KTB Lubrication**

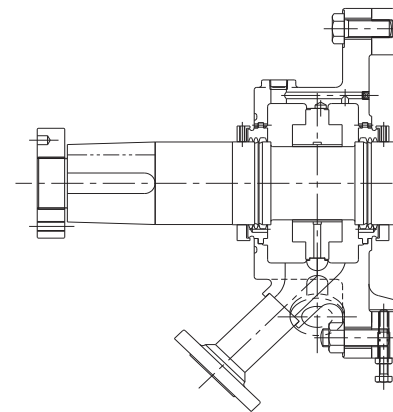
The oil circulation is ensured by a pressure system according to the description as follows.

*Line bearing and thrust bearing side lubrication:*

- High pressure oil pass through bearing housing hole to the bearings
- The oil circulates from oil sump to the oil unit inlet bearing housing via an oil unit



**Figure 5-5a**



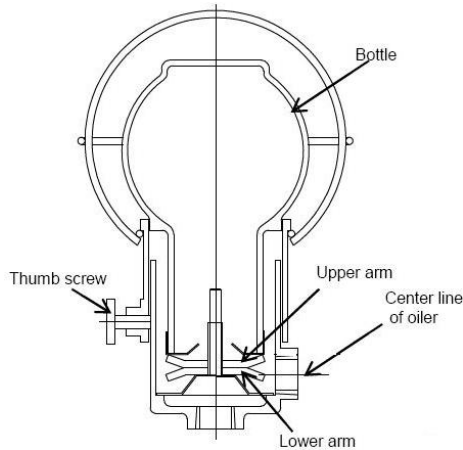
**Figure 5-5b**

**5.1.2 Trico oiler setting (standard)**

Trico is used only on ball-ball lubrication and sleeve ball lubrication:

- a) Initial fill via top of housing, using overflow plug to establish correct level.

- b) Release thumb screw and remove bottle. Establish a measurement from the center line of the oiler connection in bearing housing to the upper cross arm of 6 mm (0.24 in.); this can be obtained by completely screwing down the lower arm as illustrated on figure 5-6.
- c) Fill bottle with recommended oil and install on holder. Remove and fill bottle as many times as is required to fill the bearing housing up to the cross arm level and no air bubbles appear in the bottle.
- d) Remove bottle and ascertain the oil level. Adjust upper cross arm as required and lock in place with lower arm.



**Figure 5-6**

**CAUTION** Never fill reservoir through the air vent opening.

The constant level oil control maintains a constant level of oil in the reservoir. The control feeds only enough oil to maintain the required level. It operates on the liquid seal principle, feeding only when the level in the reservoir is low enough to break the liquid seal at the end of the shank, thus permitting air to enter the bottle. It will cease to feed when there is sufficient oil in the reservoir to cover the hole in the end of the shank.

**5.1.3 Inspection**

For ball-ball and sleeve ball lubrication inspect the oil level in the bearing housing at least once a day. Inspect the condition of the oil at least weekly. Oil is always subject to gradual deterioration from use and contamination from dirt and moisture which is the cause of premature bearing wear.

**CAUTION** For oil lubricated pumps, fill the bearing housing with the correct grade of oil to the correct level, i.e. constant level oiler bottle (standard configuration) and sight glass (when fitted on request).



**Figure 5-7; sight glass**

**5.1.4 Replenishment**

Replenish the oil in the oiler as required for ball- ball and sleeve ball. More frequent replenishment at high temperatures may be required.

**5.1.5 Oil change**

Frequency of oil change is dependent on pump service and environmental conditions. As a general guide, oil in the bearing housing should be changed every 4 000 operating hours, after the initial change.

**5.1.6 Lubrication specification**

The ideal bearing lubricant is a straight, well refined, neutral mineral, preferably of the turbine type. It should not contain free acid, chlorine sulphur or more than a trace of free alkali. It is suggested that the oil conform to the following physical characteristics.

## 5.2 Pump lubricants

### 5.2.1 Recommended oil lubricants

Centrifugal pump lubrication	Oil	Oil ring or flinger lubrication		Pure oil mist lubrication
	Lubrication service	Ball bearing		
	Type	Mineral oil (petroleum based)		Synthetic oil
	Viscosity mm <sup>2</sup> /s 40 °C [cSt]	46	68	100
	Oil temperature range * °C (°F)	-5 to 75 (up to 167)	up to 85 (up to 185)	-30 and above (59 and above)
	Approx. consumption continuous operation	0.2 litres/month	0.2 litres/month	0.2 litres/month
	First oil change	3 months	3 months	3 months
	Further oil changes	6 months	6 months	6 months
	Designation according to DIN51502 ISO VG	46	68	100
Oil companies and lubricants	CASTROL	Perfecto T46	Perfecto T68	-
	Esso	TERESSO 46	-	-
	LSC (for oil mist)	LSO 46 synthetic oil	LSO 68 synthetic oil	LSO 100 synthetic oil
	Mobil	Mobil DTE oil medium	Mobil DTE oil heavy medium	-
	CALTEX	REGAL OIL R & O46	REGAL OIL R & O68	
	Shell	Shell Turbo T46	Shell Turbo T68	

(\*) Note that it normally takes 2 hours for bearing temperature to stabilize and the final temperature will depend on the ambient, r/min, pumpage temperature and pump size. Also some oils have a greater Viscosity Index than the minimum acceptable of 95 (e.g. Mobil DTE13M) which may extend the minimum temperature capability of the oil. Always check the grade capability where the ambient is less than -5 °C (-23 °F).

If a synthetic lubricant (fire resistant fluid) is to be used instead of the normal type oil for the lubrication of bearings, gears etc., the material of all gaskets and O-rings in contact with the lubricant must be compatible with the lubricant. Normal gasket materials will usually swell and deteriorate when immersed in synthetic lubricants, also normal paints will peel from internal walls of reservoirs and bearing chambers.

In case of pure oil mist lubrication the lubricant oil should be rust and oxidation inhibited and stray mist suppressed, manufactured in accordance with good commercial practice. The viscosity should be ISO VG 100. Recommended oil suppliers are according to the previous list.

### 5.2.2 Recommended fill quantities

Please refer to our customer drawings and documents.

### 5.2.3 Bearing housing oil limitations

Recommended oil temperature at start up	15 °C (59 °F)
Desirable operating temperature	40 °C -70 °C (104 °F -158 °F)

When the starting temperature is below -10 °C (14 °F) for a long time it is recommended to use synthetic oil. Other drivers and gearboxes, if appropriate, should be lubricated in accordance with their manuals.



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.



### 5.2.4 Lubrication schedule

#### 5.2.4.1 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.


Based on the specified operating conditions and an ambient temperature of 43 °C (110 °F) for ring-oiled or splash systems, oil sump temperature below 82 °C (180 °F) is expected.

A continuously rising temperature, or an abrupt rise, indicates a fault.


### 5.3 Direction of rotation

 **CAUTION** Ensure the pump is given the same rotation as the pump direction arrow fit on the bearing housing. In any case the direction of rotation must be checked with the pump disconnected.


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

 **CAUTION** Ensure all electrical, hydraulic, pneumatic, sealant and lubrication systems (as applicable) are connected and operational.

 **CAUTION** Ensure the inlet pipe and pump casing are completely full of liquid before starting continuous duty operation.


 **CAUTION** *Before starting or while operating the pump, the casing and suction line must be completely filled with the liquid being pumped. The rotating parts depend on this liquid for lubrication and the pump may seize if operated without liquid.*


### 5.6 Starting the pump

- Close discharge valve if valve is not been closed, and then crack open to assure minimum flow. (Do not start unit with fully closed valve). On first starts care must be taken not to cause a system water hammer.
- Prepare the driver for startup in accordance with the driver manufacturer's instructions.
- Warm up pump (if applicable).
- Avoid severe thermal shocks to the pump as the result of sudden liquid temperature changes. The pump must be preheated prior to start up. Unless otherwise specified the thermal temperature of the casing must be within 55 °C (100 °F) of the temperature of the liquid to be pumped at time of startup.

Due to the heavy metal sections, the casing will lag the liquid temperature during such changes, and severe temperature stresses and subsequent misalignment of machined fits may result. Preheating is accomplished by circulating a small amount of hot fluid through the casing by utilizing vents, drains or bypass from discharge. Preheat pump slowly at a rate of 2-3 °C/m.


- Prime pump and ensure suction valve is open.

 **CAUTION** *Ensure flushing and/or cooling/heating liquid supplies (if required) are turned ON before starting the pump.*

 **CAUTION** *Before starting or while operating the pump, the casing and suction line must be completely filled with the liquid being pumped. The rotating parts depend on this liquid for lubrication and the pump may seize if operated without liquid.*


- Ensure pump recirculating line (if required) is open, clear and free of obstructions.
- Check that pump is vented by observing leakage from casing vent (when fitted) and seal piping vent. Close vent (if fitted) when liquid is emitted.
- Turn on cooling liquid and assure correct flow exists (to cooler, insert gland etc.) as specified.
- Double check pumps rotation by starting unit momentarily.

**Note:** *The direction of input shaft rotation is counter clockwise when facing pump shaft from coupling end. Ensure that the pump coasts down to a gradual stop.*

 **CAUTION** *If pump stops abruptly when driver is shut down, investigate for pump binding. Take necessary remedial action before resuming operation.*

- Start the driver and bring it up to speed quickly.
- As soon as the pump is up to rated speed slowly open discharge valve.
- This will avoid abrupt changes in velocity and prevent surging in the suction line.
- Perform the operating checks.

### 5.7 Operating checks

 **In the interest of operator safety the unit must not be operated above the nameplate conditions. Such operations could result in unit failure causing injury to operating personnel. Consult user instruction book for correct operation and maintenance of the pump and its supporting components.**

**CAUTION** *Operation at low flow results in the pump heating the liquid. A bypass may be required to prevent vaporisation and subsequent pump damage. Refer to local Flowserve branch to determine if a bypass is required. Mechanical damage may result from continuous operation at flows less than the specified minimum continuous stable flow.*

Immediately after start up and frequently during running, check the following:

- a) Check suction and discharge pressure gauges.
- b) Check pressure gauges on each side of suction strainer.
- c) Check for excessive leakage at seal areas.
- d) Check for unusual noises.
- e) Check oil level in bearing housing. (Refer to section 5.)

**CAUTION** *Operation of the unit without correct lubrication can result in overheating of the bearings, bearing failures, pump seizures and actual break-up of the equipment exposing operating personnel to physical injury.*

- f) Check for vibrations.
- g) Check for adequate flow of cooling liquids. Check for hot alignment: it is not necessary but preferable to make a "Hot" coupling alignment for high temperature. In the case that a "Hot" coupling alignment is applied, after the unit has been operated a sufficient period of time to reach normal operating temperature and condition, the unit is to be shut down and a "Hot" coupling alignment check must be made. (Refer to section 4.5.4.)

**5.7.1 Venting the pump**

**CAUTION** 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.

**5.7.2 Pumps fitted with mechanical seal**

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

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.

**5.7.3 Bearings**

**Ex** If the pumps are working in a potentially explosive atmosphere temperature and 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. (See section 5.2.4.1 for temperature limits.)

*When an oil temperature sensor is provided:*

- set the alarm at 72 °C (161.6 °F) and the trip at 82 °C (179.6 °F) for high ambient temperature and/or hot service

*When the bearing temperature sensor is provided:*

- set the alarm at 83 °C (181.4 °F) and the trip at 93 °C (199.4 °F)

It is important to keep a check on bearing temperatures. After start up, the temperature rise should be gradually reaching a maximum after approximately 1.5 to 2 hours. This temperature rise should then remain constant or marginally reduce with time.

**5.7.4 Normal vibration levels, alarm and trip**

For guidance, pumps generally fall under a classification for rigid support machines within the international rotating machinery standards and the recommended maximum levels 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.		WTB mm/s (in./sec) r.m.s.
Normal	N	≤ 3 (0.12)
Alarm	N x 1.25	≤ 6 (0.24)
Shutdown trip	N x 2.0	≤ 10 (0.4)

**5.7.5 Stop/start frequency**

About pump sets, check actual capability of the driver and control/starting system before commissioning.

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



### 5.8 Normal start up

The starting procedure to be followed for normal start up is the same as that for initial starting with the exception that step (i), section 5.6, *Check rotation*, does not have to be repeated as long as driver systems have not been changed since last pump operation.

### 5.9 Stopping the pump

- a) Shut down driver.



***The pump should be shut down rapidly to protect the internal wearing parts which are lubricated by the liquid being pumped.***

**Note:**

If pump stops abruptly when driver is shut down, investigate for pump binding. Take necessary remedial action before restarting pump.

- b) Close the pump discharge valve, while the suction valve normally remains open.  
 c) Close valve in bypass line and closed whenever possible, switch off flushing and or cooling liquid supplies.



- d) ***If pump is subjected to freezing temperatures the pump must be drained of liquid to prevent damage to the pump. For pumping hot liquid or fluid subject to crystallize, the flush supply must be maintained on completion of pumping, to avoid seal damage.***

**Note:**

In some installations the use of a check valve is not feasible due to the creation of pressure surges or water hammer as a result of the sudden closing of the valve under high discharge pressure. In such cases the discharge valve should be closed slowly prior to stopping the driver to eliminate the possibility of water hammer.

### 5.10 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 notes in section 3.4 may help the user decide how to evaluate the implications of any change. If in doubt contact your nearest Flowserve office.

## 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.)



***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"***.



**DANGER** Before attempting any inspection or repair on the pump, the driver controls must be in the "off" position, locked and tagged to prevent injury to personnel performing service on the pump.



Before attempting to disassemble pump, it must be isolated from the system, by closing suction and discharge valves, drained of liquid and cooled, if pump is handling hot liquid.

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) Check for any leaks from gaskets and seals. The correct functioning of the shaft seal must be checked regularly.
- c) Check bearing lubricant level, and if the hours run show a lubricant change is required.
- d) Check that the duty condition is in the safe operating range for the pump.
- e) Check vibration, noise level and surface temperature at the bearings to confirm satisfactory operation.
- f) Check dirt and dust is removed from areas around close clearances, bearing housings and motors.
- g) Check coupling alignment and re-align if necessary.

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

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

- a) Refer to section 7, *Faults; causes and remedies*, for fault diagnosis.
- b) Ensure equipment complies with the recommendations in this manual.
- c) Contact Flowserve if the problem persists.

### 6.2.1 Routine inspection Error! Bookmark not defined. (daily/weekly)



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

- a) Check suction and discharge gauges.
- b) Check for abnormal operating conditions (high/low temperature, flows, vibration and pressures etc.)
- c) Check motor current/driver power.
- d) Check that there is no abnormal fluid or lubricant leaks (static and dynamic seals) and that any sealant systems (if fitted) are full and operating normally.
- e) Check that shaft seal leaks are within acceptable limits.
- f) Check all lubricant levels, i.e. bearing housing oilers, seal plan, seal supply systems as applicable.

- g) On grease lubricated pumps, check running hours since last recharge of grease or complete grease change.
- h) Check any auxiliary supplies e.g. heating/cooling (if fitted) is functioning correctly.
- i) Check stand-by pump is at applicable temperature and available to start as required.



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


### 6.2.2 Periodic inspection (monthly)

- a) Check for lubricant contamination whether bearing oil, or seal oil (if applicable) by sample analysis.
- b) Check all paint or protective coatings.
- c) Check all power/instrument cable glands for tightness.



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

### 6.2.3 Periodic inspection (six monthly)

- a)  Check foundation bolts for security of attachment, corrosion. Check grouting for looseness, cracking or general distress.
- b) Change lubricants.
- c) Check calibration of instruments.
- d) The coupling should be checked for correct alignment and any worn driving elements.



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

### 6.2.4 Inspection (after 3 years)

- a) Check internal condition of pump and all ancillary pipework for corrosion/erosion.
- b) Check internal pump components for wear.
- c) Change bearings

### 6.2.5 Re-lubrication

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

#### 6.2.5.1 Oil lubrication



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 center of the glass window.

Refer to section 5.1.1 for methods of oil fill; section 5.2.1 for oil grade recommendations and section 5.2.4 for the schedule and temperature limits.

### 6.2.6 Mechanical seals

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

## 6.3 Spare parts

### 6.3.1 Ordering of spares

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

1. Pump serial number
2. Pump size
3. Part name (\*)
4. Part number (\*)
5. Number of parts required

(\* Taken from the cross section drawing stored with the job user instruction book and only in case not available see section 8.)

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-genuine part) will invalidate the pump's safety certification.

**Note:**

***If rings are ordered as repair parts after the pump has been put into service, undersized stationary rings or oversized impeller rings will not be furnished unless specifically requested by the customer.***

If undersize or oversize rings are desired, the amount of undersize or oversize required on the I.D. or the O.D. must be stated by the customer in the repair order.

It is recommended as insurance against delays that spare parts be purchased at the time the order for the complete unit is placed or as soon after receiving the pump as possible.

### 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.

## 6.4 Recommended spares (according to API)

*For start-up purposes:*

- 1 - set of bearings (line and thrust)
- 2 - sets of gaskets and O-ring
- 2 - wear rings set (2 rotating + 2 stationary)
- 1 - mechanical seals
- 1 - labyrinth set (drive and impeller end)

*For normal maintenance:*

- 1 - set of bearings (line and thrust)
- 2 - sets of gaskets and O-rings
- 2 - wear ring sets (2 rotating + 2 stationary)
- 1 - mechanical seals
- 1 - labyrinth and deflector set (drive and impeller end)
- 1 - shaft
- 1 - impeller

## 6.5 Tools required

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

*Readily available in standard tool kits, and dependent on pump size:*

- Open ended spanners (wrenches) to suit up to 2 in. (M 50) screws/nuts
- Socket spanners (wrenches), up to 2 in. (M 50) screws
- Allen keys, up to 10 mm (A/F)
- Range of screwdrivers
- Soft mallet

*More specialized equipment:*

- Bearing pullers
- Bearing induction heater
- Dial test indicator

For 3 stage pumps, special tools are provided for disassembling a diaphragm and other parts; please refer to the special tool list.

## 6.6 Fastener torques

Material	SUS304 SUS316	SS400 SF440A	S45C	SUS- 420J2	SNB7	SCM435
Proof stress N/mm <sup>2</sup>	200	250	350	550	750	800
Bolt size	Torque values, Nm					
M10	19.1	23.9	33.4	52.5	71.6	76.4
M12	32.5	40.6	56.9	89.3	121.8	130.0
M14	51.2	64.0	89.6	140.8	191.9	204.7
M16	74.9	93.6	131.1	206.0	280.9	299.6
M18	106.4	133.0	186.2	292.6	399.0	425.6
M20	121	152	213	334	455	486
M22	191	239	334	526	717	764
M24	250	313	438	688	939	1 001
M30	490	612	857	1 347	1 837	1 960
M36	843	1 054	1 475	2 318	3 161	3 372
M42	1 341	1 677	2 347	3 689	5 030	5 365
M48	2 012	2 515	3 520	5 532	7 544	8 047
M36X3	840	1 051	1 471	2 311	3 152	3 362
M42X3	1 315	1 643	2 301	3 616	4 930	5 259
M48X3	1 975	2 468	3 455	5 430	7 405	7 898

Torque values listed above are selected to achieve the correct amount of pre-stress in the threaded fastener. Maintenance personnel must ensure that threads are in good condition (free of burrs, galling, dirt etc) and that commercial thread lubricant is used. Torque should be periodically checked to ensure that it is at the recommended value.

## 6.7 Disassembly



Refer to section 1.6, *Safety*, before dismantling the pump.



**CAUTION** Before dismantling the pump for overhaul, ensure genuine Flowserve replacement parts are available.

**Note:**

Refer to sectional drawings for part numbers and identification.



**Before attempting to disassemble the pump, the pump must be isolated from the system, by closing suction and discharge valves, drained of liquid and cooled, if pump is handling hot liquid.**



**When the pump is handling "hot" liquid, extreme care must be taken to ensure the safety of personnel when attempting to drain pump. Hot pumps must be allowed to cool before draining.**



**When the pump is handling "caustic" liquid, extreme care must be taken to ensure the safety of personnel when attempting to drain pump.**

**Protective devices of suitable protective materials must be worn when draining pump.**



**Before attempting any maintenance work on pumps in vacuum service, pumps must be isolated from suction and discharge system then carefully vented to return pressure in pump casing to atmospheric pressure.**



**Remove the pipe plug(s) from the top of the bearing housing(s) and check to see that oil rings are riding free on the pump shaft and are not hung up. Failure to observe this caution could result in damage to or destruction of equipment.**

### 6.7.1 Disassembly procedure

Care must be exercised in the dismantling operation to prevent damages to internal parts of the pump. Lay out all parts in the same order in which they are removed for convenience at reassembly. Protect all machined faces against metal-to-metal contact and corrosion.

- Switch off, lock and tag the motor circuit breakers.
- Switch off, isolate and tag all instrumentation and monitoring equipment.
- Close the pump suction valve. If discharge valve has not already been closed this must be done prior to dismantling.
- Remove the pump coupling guard which is bolted to the baseplate.
- Remove the pump coupling spacer. (Refer to coupling instructions.)
- Drain the pump casing. This can be done by first opening the vent connections situated at the top of the casing and then opening the drains situated at the bottom of the casing.
- Drain the bearing housings oil by removing the drain plugs situated at the bottom of each bearing housing. Remove oilers.



**Use caution when draining hot oil from bearing housing to prevent burns/injury to personnel.**

- Disconnect and remove seal flush pipework and allow draining.
- It is advisable to thoroughly drain and dry off the base plate before attempting any maintenance work on the pump.



**This could eliminate the risk of slipping on a wet surface causing personal injury or mechanical damage.**

- Remove pump monitoring equipment, auxiliary services or any other plant or equipment that may interfere with safe dismantling of the pump.



- k) Loosen set screw securing coupling nut and remove nut.
- l) Remove pump coupling hub, using a puller. Remove coupling key.
- m) When cartridge type mechanical seals are used, loosen seal drive collar set screws. Insert first locking tab into seal sleeve groove. Consult mechanical seal manufacturer's instructions.
- n) Proceed now with the dismantling of the pump following the steps listed below. For location of parts refer to pump sectional drawing and part list.

## 6.7.2 Line bearing disassembly

### 6.7.2.1 Ball-ball

Remove the following parts starting at coupling end of pump in the order listed below.

- a) Remove deflector [40A] and its screws.
- b) Remove radial bearing outer cover [35A] and oil baffle [47A].
- c) Radial bearing outer cover gasket [73D].
- d) Oil flinger [62] and its screws.
- e) Unscrew deflector [40] screws and slide deflector [40] towards mechanical seal.
- f) Unbolt bearing cover [35] and oil baffle [47].
- g) Radial bearing inner cover gasket [73C].
- h) Pull out radial bearing housing [31].
- i) Radial bearing [16]. (Use bearing puller and apply force on the inner race and pull out line bearing).
- j) Remove gasket, oil baffle, bearing cover and deflector from the shaft.

**Note:**

***If fan cooled configuration remove fan cover [337A] and fan [229A] before following the above procedure.***

### 6.7.3 Sleeve-ball

- a) Remove all bolting and taper pins holding upper half of line bearing housing [31] and remove it. Use jack bolts and eyebolts for removal.
- b) Unbolt calibrated screws and remove top half sleeve bearing [16A].
- c) Slide oil rings [62B] onto shaft apart from lower half sleeve bearing.
- d) Carefully lift pump shaft just enough so that lower half sleeve bearing [16A] can be removed.
- e) Unbolt and remove lower half of line bearing housing [31].
- f) Unscrew set screws and remove inboard and outboard deflector [40 and 40A] and oil baffle [47 and 47A].
- g) Remove oil rings [62B].
- h) Remove bearing bracket [19A].

### 6.7.3.1 KTB

- a) Remove all bolting and taper pins holding upper half of line bearing housing [31] and remove it. Use jack bolts and eyebolts for removal.
- b) Remove top half bearing retainer [303].
- c) Carefully lift pump shaft just enough so that lower half bearing retainer [303] can be removed.
- d) Unbolt and remove lower half of line bearing housing [31].
- e) Unscrew set screws and remove inboard and outboard deflector [40 and 40A] and oil baffle [47 and 47A].
- f) Remove bearing bracket [19B].

## 6.7.4 Thrust bearing disassembly

### 6.7.4.1 Ball-ball

Remove the following parts starting at the outboard end of the pump in the order listed below.

- a) Outer bearing housing cover [37A].
- b) Bearing outer cover gasket [73D].
- c) Oil flinger and its screw [62A].
- d) Thrust bearing lock nut [22] and locking washer [69A].
- e) Unscrew deflector [40] screws and slide deflector [40] towards mechanical seal.
- f) Thrust bearing housing [33]. (Unscrew inner cover [37] first.)
- g) Thrust bearing [18] and bearing spacer [78].
- h) Thrust bearing inner cover gasket [73C].
- i) Bearing inner cover [37] and oil baffle [47].
- j) Deflector [40] and its screw.

**Note:**

***If fan cooled configuration remove fan cover [337] and fan [229] before following the above procedure.***

### 6.7.4.2 Sleeve-ball

- a) Remove bolts securing end cover to bearing housing and remove cover [37].
- b) Remove shim [206].
- c) Remove all bolting and taper pins holding upper half of thrust bearing housing [33] and remove it. Use jack bolts and eyebolts for removal.
- d) Unbolt calibrated screws and remove top half sleeve bearing [16A].
- e) Slide oil rings [62B] onto shaft apart from lower half sleeve bearing.
- f) Carefully lift pump shaft just enough so that lower half sleeve bearing can be removed.
- g) Unbolt and remove lower half of thrust bearing housing.
- h) Release locking tab of thrust bearing lock-washer. Loosen and remove thrust bearing lock nut [22] and lock-washer [69A].



- i) Remove thrust bearing assembly, using a puller that will bring pressure against inner bearing race (Thrust bearing [18], bearing collar [18A] and thrust collar sleeve [222A]).
- j) Remove flinger [62A].
- k) Remove oil rings [62B]. Unscrew set screws and remove oil baffle [47] and deflector [40].
- l) Remove bearing bracket [19B]

#### 6.7.4.3 KTB

- a) Remove bolts securing end cover to bearing housing and remove cover [197A] along with outboard gasket [73D].
- b) Release locking tab of thrust bearing lock-washer. Loosen and remove thrust bearing lock nut [22] and lock-washer [69A].
- c) Remove plate [4691].
- d) Remove bearing cover [197] and gasket [73C].
- e) Remove all bolting and taper pins holding upper half of thrust bearing housing [33] and remove it. Use jack bolts and eyebolts for removal.
- f) Remove top half bearing retainer [303A].
- g) Remove thrust shoes [303C], leveling plates [206B] and split base rings [508 and 508A]. (Refer to Kingsbury's instructions.)
- h) Unscrew set screws and remove thrust collar locking nut [4].
- i) Remove thrust collar [72] and key.
- j) Carefully lift pump shaft just enough so that lower half bearing retainer [303A] can be removed.
- k) Unbolt and remove lower half of thrust bearing housing [33].
- l) Unscrew set screws and remove oil baffle [47] and deflector [40].
- m) Remove thrust bearing shim [206C].
- n) Remove bearing bracket [19].

#### 6.7.5 Rotor disassembly

- a) Remove nuts [352] holding mechanical seal assembly [410A and 410B] to suction head [9] at inboard and stuffing box [11] outboard pump end respectively.
- b) Clean shaft and carefully withdraw complete seal cartridges from the shaft.
- c) Unbolt [351] holding suction head and remove suction head [9] along with throat bushing [63] and suction head ring [25]. Use jack screws provided for the initial start of removal. Support suction head using an eye bolt [350] and lifting gear, and remove from the casing ensuring that it does not swing down and damage the shaft.
- d) Unbolt [351] holding stuffing box and remove stuffing box [11] along with break down bushing [117] and stuffing box ring [27]. Use jack screws provided for the initial start of removal. Support stuffing box using an eye bolt and lifting gear,

and remove from the casing ensuring that it does not swing down and damage the shaft.

- e) Remove spiral wound gasket on either side [73].
- f) Remove outboard snap ring [401] of the pump.
- g) Remove distance or shaft sleeves [218B].
- h) Remove impeller [2C] along with impeller wear rings [8D and 8E]. Unscrew the impeller wear ring screws and remove the wear ring [8D and 8E].
- i) Remove third stage impeller key [32C].
- j) Remove cap nut [537] along with gasket [73J] and take out the lock bolt [536] and position bolt [536A] from the casing.
- k) Remove diaphragm [126] along with diaphragm ring [238 and 238A] and bushing [113].
- l) Remove the gasket sheet [73A].
- m) Remove split ring [385] and inter stage sleeve [219A].
- n) Remove impeller [2B] along with impeller wear rings [8B and 8C]. Unscrew the impeller wear ring screws and remove the wear ring [8B and 8C].
- o) Remove second stage impeller key [32B].
- p) Withdrawn rotor assembly from the casing.
- q) Remove inboard snap ring [401] and distance or shaft sleeves [218A].
- r) Remove impeller [2A] along with impeller wear rings [8 and 8A].
- s) Remove first impeller key [32A] and inter stage sleeve [219].
- t) Remove stage bushing [116] and case wear rings [7A and 7B].

**Note:**

***If the impeller grip the shaft before it is above the fit, do not attempt to force it the rest of the way, instead allow the assembly to cool to room temperature and then reheat the impeller until it is free.***

#### 6.8 Examination of parts



Used parts must be inspected before assembly to ensure the pump will subsequently run properly.

In particular, fault diagnosis is essential to enhance pump and plant reliability.

##### 6.8.1 Casing and covers

- a) Inspect for excessive wear, pitting, corrosion, erosion or damage and any sealing surface irregularities. Remove all scale and deposit in stuffing box water jackets by scraping and chemical treatment where necessary. New casing gasket should be installed whenever the pump is disassembled.
- b) Replace as necessary.

### 6.8.2 Impeller

- a) Remove worn impeller rings by mechanical turning.
- b) Slightly eroded parts can be repaired by welding. Dynamically balance impellers after any machine work. To balance remove metal from the front or back shroud of the impeller at the point of unbalance.

### 6.8.3 Mechanical seal

- a) Mechanical seal stationary and rotating faces should be inspected for signs of wear or cracks and replaced as necessary.
- b) It is recommended that when reassembling mechanical seal new O-rings and gaskets are used.
- c) Refer to manufacturers drawing for assembly of mechanical seal. Refer to mechanical seal section within this manual for further details.

### 6.8.4 Stuffing box bushings (if fitted)

- a) Check the stuffing box bushes and replace if cocked and or worn.
- b) To replace, chill the new bushings to -20 °C and install in the stuffing boxes.

### 6.8.5 Shaft

When the pump is dismantled, examine the shaft carefully. Its condition should be checked at the impeller hub fit, deflectors and at the bearings. The shaft may become damaged by rusting or pitting because of leakage along the shaft at the impeller or shaft sleeve. Anti-friction bearings improperly fitted to the pump shaft will cause the inner race to rotate on the shaft.

Check the shaft keyway for distortion.

Excessive thermal stresses or corrosion may loosen the impeller on the shaft and subject the keyway to excessive shock. Replace a shaft that is bent or distorted. Check a shaft that has been repaired for possible run out (maximum 0.050 mm). The shaft sleeve is subject to wear and may require replacement, depending on the severity of service.

Replace if grooved, pitted or worn.

### 6.8.6 Gaskets and O-rings

After dismantling, discard and replace.

### 6.8.7 Bearings

#### 6.8.7.1 Ball-ball

- a) It is recommended that bearings are not re-used after any removal from the shaft. In any case the bearings must be replaced after 25 000 operating hours.

- b) If the bearing cannot be removed with the tools available never use a torch under any circumstances. Split the outer ring with a small hand grinder, saw through the ball/roller retainer, and split the inner ring about three quarters through with a grinder and break with a cold steel chisel.

**Note:**

***Do not attempt to inspect condition of bearings until they have been cleaned.***

- c) Solvent for cleaning bearings should be in a clean container. Place bearings in solvent and let soak for a short time. Agitate the bearing around near the top of the container, giving it a turn now and then until it is clean. Rinse in a clean container of fresh solvent.

**Note:**

***Do not spin dirty bearings. Rotate them slowly while washing.***

- d) Dry thoroughly cleaned bearings. If an air hose is used for drying, make sure it is clean dry air.

**Note:**

***Do not allow the bearings to spin by force of air. Hold the inner and outer rings to prevent bearing from spinning.***

- e) Inspect bearings immediately. If there is any question on condition of a bearing do not hesitate to replace it. There are many conditions that contribute to the deterioration of the bearings. A qualified bearing representative should be consulted if there is any question of bearing condition.
- f) Inspected bearings which will be reused should be packed with new grease or dipped in clean lubricating oil, covered with clean lint free rags or other suitable covering and placed in a clean box or carton until ready for installation.

**Note:**

***Under no circumstances the bearings are to be left exposed.***

- g) Thoroughly flush and clean the oil passages, then coat the inner surfaces with a thin film of lubricating oil. Remove all scale and deposit in the water circulation space, if provided, by scraping and chemical treatment when necessary. Cover the bearing bodies to keep them clean until ready for installation.

#### 6.8.7.2 Sleeve-ball

Anti-friction bearings are slightly shrunk on the shaft and a pulling device must be used to remove them. The pulling jaws or fingers must be located behind the shoulder of the inner race.

Unless extreme care is used when removing an anti-friction bearing, the bearing may be damaged to the extent that is no longer useable.

Always check the bearing immediately after removal for any imperfections or any play between the races. It is recommended that new bearings be used for replacement of removed bearings since very often damage caused by removal cannot be detected until the pump is put into operation.

When mounting anti-friction bearings on the pump shaft remember that the satisfactory operation of anti-friction bearings requires that the inner be firmly held on the shaft so that it cannot turn on the shaft.

Care must be taken to keep the bearing clean and uncontaminated.

**Check the position of the bearing on the shaft with a feeler gage to make sure it is pressing firmly against the shoulder.**

**6.8.7.3 KTB**

*Babbitted sleeve bearings:*

The sleeve bearings supplied with the WTB pump are of the split type and are easily removed or installed.

When removed, they should be cleaned in a suitable solvent. Use rags or cloth, as waste leaves lint which might cause trouble in the bearing.

A poorly cleaned bearing will score and wear out rapidly. A bearing surface is not clean until a cloth wiped over it shows no soiling. Inspect all bearing parts after cleaning. Remove, with a scraper, any bruises on the Babbitt faces before reassembling.

**6.8.8 Labyrinths or bearing isolators (if fitted)**

- a) The lubricant, bearings and bearing housing seals are to be inspected for contamination and damage. If oil bath lubrication is utilized, these provide useful information on operating conditions within the bearing housing.
- b) If bearing damage is not due to normal wear and the lubricant contains adverse contaminants, the cause should be corrected before the pump is returned to service.
- c) Labyrinth seals and bearing isolators should be inspected for damage but are normally non-wearing parts and can be re-used.
- d) Bearing seals are not totally leak free devices. Oil from these may cause staining adjacent to the bearings.

**6.9 Assembly**

To assemble the pump refer to the sectional drawings, section 8, *Parts list and drawings*. Ensure threads, gasket and O-ring mating faces are clean.

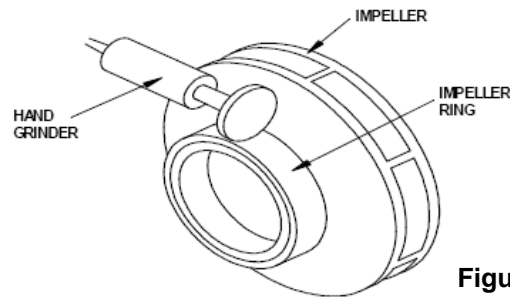
**6.9.1 Wear rings**

The impeller is fitted with both front and rear wear rings.

The impeller rings are renewable and should be replaced when badly grooved, and or when pump performance does not meet the system requirements. Whenever it becomes necessary to replace either wear ring, both rings involved (impeller and casing cover) must be ordered and replaced as a set as they are furnished standard size only. Spare impeller wear rings are supplied with a material stock over outside diameter which has to be machined off after rings fitting on impeller. If an impeller with its wear rings is ordered as spare, it will be supplied fully machined, including wear rings outside diameter, to original dimensions. Casing cover wear rings are always supplied fully machined. Be sure to re-establish the original running clearance between the two wear rings involved by machining the fitted impeller rings.

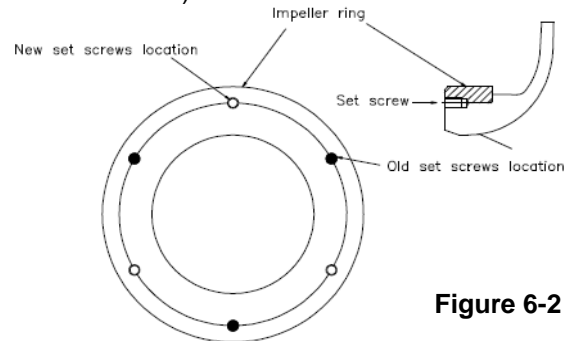
**6.9.1.1 Impeller wear rings**

- a) To remove impeller wear rings, mutually remove wear ring set screws or ground off tack weld. Rings can be machined off or grind two slots diametrically opposite across the width of the ring so it can be split apart. Use caution if ring is removed by grinding so as not to damage impeller hubs.



**Figure 6-1**

- b) Make sure ring fits on impeller are free of nicks or burrs. Heat new ring to 107 °C (225 °F) and install on impeller. Drill and tap new holes in impeller spaced half the circular distance from the previously used holes in the impeller. (See sketch below.)



**Figure 6-2**

**Note:** *Impeller wear rings when installed must be machined to establish original diameter and running clearance. Whenever an impeller has new wear rings fitted it must be dynamically balanced before being assembled. Refer to the cross sectional drawing for the requested running clearance.*

**Note:** *The impeller wear ring bore is relieved at one edge. Ensure that the ring is installed on the impeller so that the chamfered edge is sitting against the impeller.*

### 6.9.1.2 Casing cover wear rings

Each wear ring is locked against rotation with a cylindrical pin.

To remove the wear ring, press it out. If this method does not easily effect removal of the ring, it can be split apart. First, however, drill one or more holes in the face of the worn ring.

New rings to be installed must be shrunk by freezing to -20 °C (-4 °F) when installing in casing cover. Fit and secure with a locking pin. Replacement wear rings are furnished standard size in the bore. Check the running clearance between impeller and casing ring against the appropriate value.


### 6.9.2 Rotor assembly

**Note:** *Take care to mount the impeller so that the vane tips point away from the apparent flow direction*

- a) Install case wear rings [7A and 7B] and stage bushing [116] on to the casing.
- b) Place inter stage sleeve [219] and impeller key [32A] in relevant shaft [6] key way.
- c) Install impeller wear rings [8] on the impeller [2A].
- d) Heat and install impeller [2A] along with impeller wear rings [8 and 8A] to original positions against shaft [6] shoulder as in the removal procedure.
- e) Install distance sleeve [218A] and secure with the snap ring [401].
- f) Insert rotor assembly into the pump casing.
- g) Install key [32B] on to the shaft [6].
- h) Install second stage impeller [2B] along with the impeller wear rings [8B and 8C].
- i) Install inter stage sleeve [219A] and secure with split ring [385].
- j) Place gasket sheet [73A] on to the casing.
- k) Install diaphragm along with diaphragm bushing [113] and ring [238 and 238A].
- l) Insert position bolt [536A], lock bolt [536] and secure with the lock nut [537] and gasket [73J].

- m) Insert third stage impeller key [32C].
- n) Install third stage impeller [2C] along with the impeller wear rings [8D and 8E].
- o) Install distance sleeve [218B] and secure with the snap ring [401].
- p) Place spiral wound gasket [73] on either side of the casing.
- q) Install stuffing box [11] along with stuffing box ring [27] and break down bushing [117].
- r) Install suction head [9] along with suction head ring [25] and throat bushing [63].
- s) Install mechanical seal assembly [410A and 410B] at inboard and outboard of the pump, keep without bolting it.

**Note:** *Take care to mount the impeller so that the vane tips point away from the apparent flow direction.*

 **CAUTION** *Care must be taken not to nick or burr any components, especially running fits.*

### 6.9.3 Thrust bearing assembly

**Note:** *It is most important that all parts to be assembled have been thoroughly cleaned. Failure to comply may cause serious damage to the pump.*

#### 6.9.3.1 Ball-ball

Install the following parts starting at the outboard end of the pump in the order listed below:

- a) Insert deflector [40], oil baffle [47] and inner bearing housing cover [37] on to the shaft but do not bolt up the deflector or bearing inner cover at this stage.
  - b) Install new gasket [73C].
  - c) Install bearing spacer [78] and thrust duplex bearings [18] are mounted in back-to-back arrangement.
- Note:** *Heat the bearing uniformly by bearing heater to a temperature of 100 °C to 110 °C and quickly mount the bearing on the shaft.*
- d) Replace bearing lock-washer [69A] and bearing lock nut [22].
  - e) Assemble thrust bearing housing [33] to the stuffing box [11].
  - f) Bolt the inner bearing housing cover [37] in place after installing gasket [73C] and set the deflector [40].
  - g) Install oil flinger [62A]. The oil flinger is located on the shaft with the set screws and the indentation on the shaft.
  - h) Position outer bearing covers [37A]. Ensure that new gasket [73D] is fitted.



**Note:**

***If fan cooled configuration install fan [229] and fan cover [337] after following the above procedure.***

- i) Install nuts securing mechanical seal assembly on both ends of pump. Tighten nuts evenly.
- j) Finally set seal assemblies according to the manufacturer's instructions.

### **6.9.3.2 Sleeve-ball**

- a) Install bearing bracket [19B] on to the stuffing box.
- b) Insert deflector [40] and oil baffle [47] on to the shaft but do not bolt up the deflector at this stage.
- c) Keep oil ring [62B] in position on the shaft.
- d) Install oil flinger [62A]. The oil flinger is located on the shaft with the set screws and the indentation on the shaft.
- e) Lift and install lower halves of thrust bearing housings [33] against bearing bracket. Tighten all bolting.
- f) Install thrust duplex bearings assembly which is mounted in a back-to-back arrangement. (The thrust bearing [18], bearing collar [18A] and thrust collar sleeve [222A] is a loose fit on the shaft.)
- g) Fit lock washer [69A] and lock nut [22]. Tighten lock nut and lock tab on lock-washer.
- h) Pour a small amount of lubricating oil on lower halves of sleeve bearing linings. Raise shaft a slight amount and roll in lower halves of sleeve bearings [16A]. Position oil rings [62B] correctly.
- i) Install upper halves of sleeve bearings [16A] and tighten calibrated screws.
- j) Check that rotor turns freely by hand.
- k) Apply a liquid gasket to bearing body joint faces and install upper halves of thrust bearing housings. Secure with bolting and dowels.
- l) Fit O-ring [241] in place, install thrust bearing outer cover [37] and tighten bolting. Ensure new shim [206] is installed.
- m) Install nuts securing mechanical seal plate assembly to stuffing box at both ends of pump. Tighten nuts evenly.
- n) Finally set seal assemblies according the manufacturer's instructions.
- o) Turn rotor by hand to ensure there are no rubs or binding.

### **6.9.3.3 KTB**

- a) Install bearing bracket [19] on to the stuffing box.
- b) Insert deflector [40] and oil baffle [47] on to the shaft but do not bolt up the deflector at this stage.
- c) Install new shim [206C].
- d) Lift and install lower halves of thrust bearing housing [33] against bearing bracket. Tighten all bolting.

- e) Pour a small amount of lubricating oil on lower halves of bearing retainer. Raise shaft a slight amount and roll in lower halves of bearing retainer [303A].
- f) Pour a small amount of oil on upper halves of bearing retainer and install upper halves of bearing retainer [303A].
- g) Install thrust collar key and thrust collar [72].
- h) Install locknut [4] and pull up tight against thrust collar, then fit securing screws to lock nut.
- i) Install thrust bearings parts (split base rings, leveling plates and thrust shoes) according to Kingsbury's instructions.
- j) Apply a liquid gasket to bearing body joint faces and install upper halves of thrust bearing housing [33]. Secure with bolting and dowels.
- k) Install gasket [73C] and bearing cover [197].
- l) Install plate [4691].
- m) Fit lock washer [69A] and lock nut [22]. Tighten lock nut and lock tab on lock-washer.
- n) Install outboard gasket [73D] and end cover [197A].

### **6.9.4 Line bearing assembly**

#### **6.9.4.1 Ball-ball**

Install the coupling side parts of the pump in the following order listed below.

- a) Insert deflector [40], oil baffle [47] and inner bearing housing cover [35] onto the shaft but do not bolt up the deflector or bearing inner cover at this stage.
- b) Install new gasket [73C].
- c) Install radial bearing [16] on the shaft [6].
- d) Install the radial bearing housing [31] to the pump casing.
- e) Bolt the inner bearing housing cover [35] in place after installing gasket [73C] and set the deflector [40].
- f) Install oil flinger [62]. The oil flinger is located on the shaft with the set screws and the indentation on the shaft.
- g) Position outer bearing covers [35A] and oil baffle [47A]. Ensure that a new gasket [73D] is fitted.
- h) Install deflector [40A] and its screws.

**Note:**

***If fan cooled configuration install fan [229A] and fan cover [337A] after following the above procedure.***

- i) Install nuts securing mechanical seal plate assembly to stuffing box at both ends of pump. Tighten nuts evenly.
- j) Finally set seal assemblies according to the manufacturer's instructions.
- k) Turn rotor by hand to ensure there are no rubs or binding.



**6.9.4.2 Sleeve-ball**

- a) Install bearing bracket [19A].
- b) Insert deflector [40] and oil baffle [47] onto the shaft but do not bolt up the deflector at this stage.
- c) Keep oil ring [62B] in position on the shaft.
- d) Lift and install lower halves of radial bearing housing [31] against bearing bracket. Tighten all bolting.
- e) Pour a small amount of lubricating oil on lower halves of sleeve bearing linings. Raise shaft a slight amount and roll in lower halves of sleeve bearings [16A]. Position oil rings [62B] correctly.
- f) Install upper halves of sleeve bearings [16A] and tighten calibrated screws.
- g) Apply a liquid gasket to bearing body joint faces and install upper halves of radial bearing housing [31]. Secure with bolting and dowels.
- h) Install oil baffle [47A] and deflector [40A].
- i) Install nuts securing mechanical seal plate assembly to stuffing box at both ends of pump. Tighten nuts evenly.
- j) Finally set seal assemblies according to the manufacturer's instructions.
- k) Turn rotor by hand to ensure there are no rubs or binding.

**6.9.4.3 KTB**

- a) Install bearing bracket [19].
- b) Insert deflector [40] and oil baffle [47] on to the shaft but do not bolt up the deflector at this stage.
- c) Lift and install lower halves of radial bearing housing [31] against bearing bracket. Tighten all bolting.
- d) Pour a small amount of lubricating oil on lower halves of bearing retainer. Raise shaft a slight amount and roll in lower halves of bearings retainer [303].
- e) Pour a small amount of oil on upper halves of bearings retainer and install upper half bearing retainer [303].
- f) Apply a liquid gasket to bearing body joint faces and install upper halves of radial bearing housing [31]. Secure with bolting and dowels.
- g) Install oil baffle [47A] and deflector [40A].
- h) Install nuts securing mechanical seal plate assembly to stuffing box at both ends of pump. Tighten nuts evenly.
- i) Finally set seal assemblies according to the manufacturer's instructions.
- j) Turn rotor by hand to ensure there are no rubs or binding.

**6.9.5 Final assembly**

- a) Install coupling key and pump half coupling, coupling nut and coupling nut set screws.
- b) Check coupling/shaft alignment as described in section 4.5 and assemble coupling.
- c) Install coupling guard.
- d) Replace all auxiliary piping, instrumentation and pipe plugs.
- e) Install constant level oilers [77] and fill bearing housings to correct oil level.
- f) Pour grease into the coupling.
- g) Align the pump to the driver.
- h) Turn rotor by hand to ensure there are no rubs or binding.

## 7 FAULTS; CAUSES AND REMEDIES

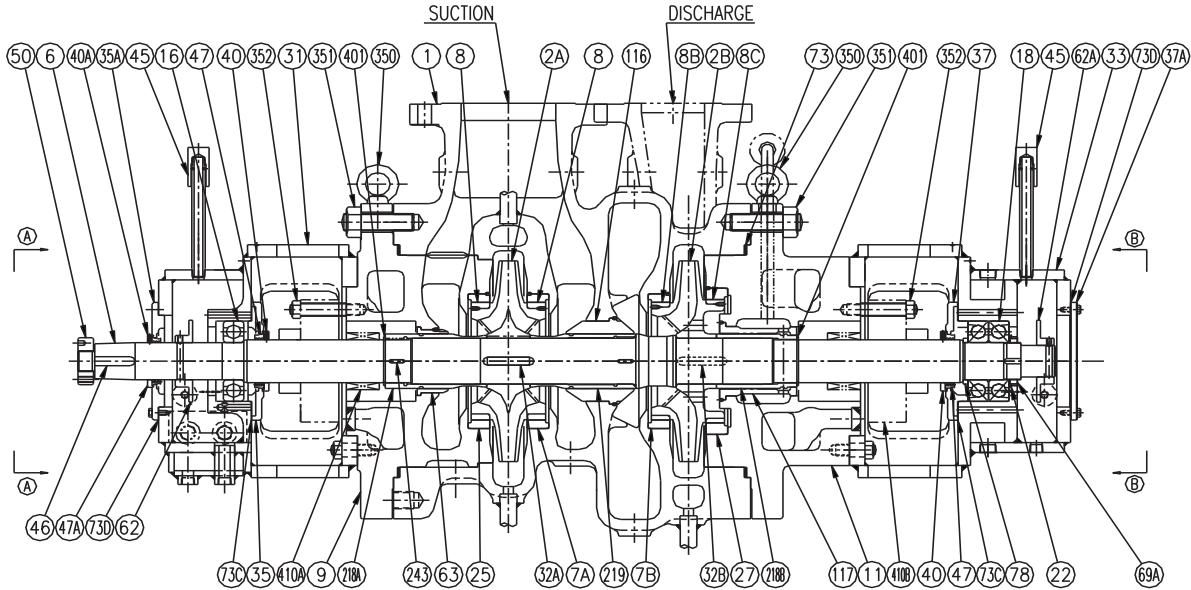
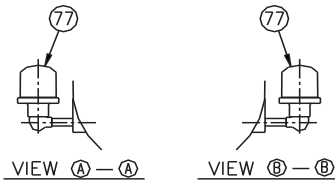
### FAULT SYMPTOM

↓ Pump overheats and seizes															
↓ Bearings have short life															
↓ Pump vibrates or is noisy															
↓ Mechanical seal has short life															
↓ Mechanical seal leaks excessively															
↓ Pump requires excessive power															
↓ Pump loses prime after starting															
↓ Insufficient pressure developed															
↓ Insufficient capacity delivered															
↓ Pump does not deliver liquid															
					<b>PROBLEM CAUSES</b>					<b>POSSIBLE REMEDIES</b>					
<b>A. System troubles</b>															
●										●	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 strainer/fittings
●	●				●	●				●	Insufficient margin between suction pressure and vapor pressure.				
				●	●	●				●	Excessive amount of air or gas in liquid.				Check and purge pipes and system.
				●	●	●				●	Air or vapor pocket in suction line.				Check suction line design for vapor pockets.
				●	●	●				●	Air leaks into suction line.				Check suction pipe is air tight.
				●	●	●				●	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 merged.				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 very high capacity				Measure value and check maximum permitted Remedy or CONSULT FLOWSERVE.
<b>B. Mechanical troubles</b>															
●	●	●	●	●	●						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.
	●	●	●	●	●						Shaft bent.				Check shaft runouts are within acceptable values. CONSULT FLOWSERVE.
●	●	●			●						Rotating part rubbing on stationary part internally				Check and CONSULT FLOWSERVE, if necessary.
●	●	●	●	●							Bearing worn				Replace bearings.

↓ 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									
					<b>PROBLEM CAUSES</b>			<b>POSSIBLE REMEDIES</b>	
				●	●	●	Wearing ring surfaces worn	Replace worn wear ring / surfaces.	
	●				●	●	Impeller damaged or eroded.	Replace or CONSULT FLOWSERVE for improved material selection.	
			●				Leakage under sleeve due to joint failure.	Replace joint and check for damage.	
		●	●	●			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 running off center because of worn bearings or misalignment.	Check misalignment and correct if necessary. If alignment satisfactory check bearings for excessive wear.	
●	●	●	●	●			Impeller 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 causing impeller to rub.	Check method of assembly, possible damage or state of cleanliness during assembly. Remedy or CONSULT FLOWSERVE, if necessary	
●	●	●					Excessive thrust caused by mechanical failure inside the pump.	Check wear condition of impeller, its clearances and liquid passages.	
	●	●					Excessive grease in ball bearings.	Check method of re-greasing.	
	●	●					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.	
<b>C. MOTOR ELECTRICAL PROBLEMS</b>									
	●			●	●	●	Wrong direction of rotation.	Reverse 2 phases at motor terminal box.	
				●		●	Motor running on 2 phases only.	Check supply and fuses.	
	●	●				●	Motor running too slow.	Check motor terminal box connections and voltage.	

## 8 PARTS LISTS AND DRAWINGS

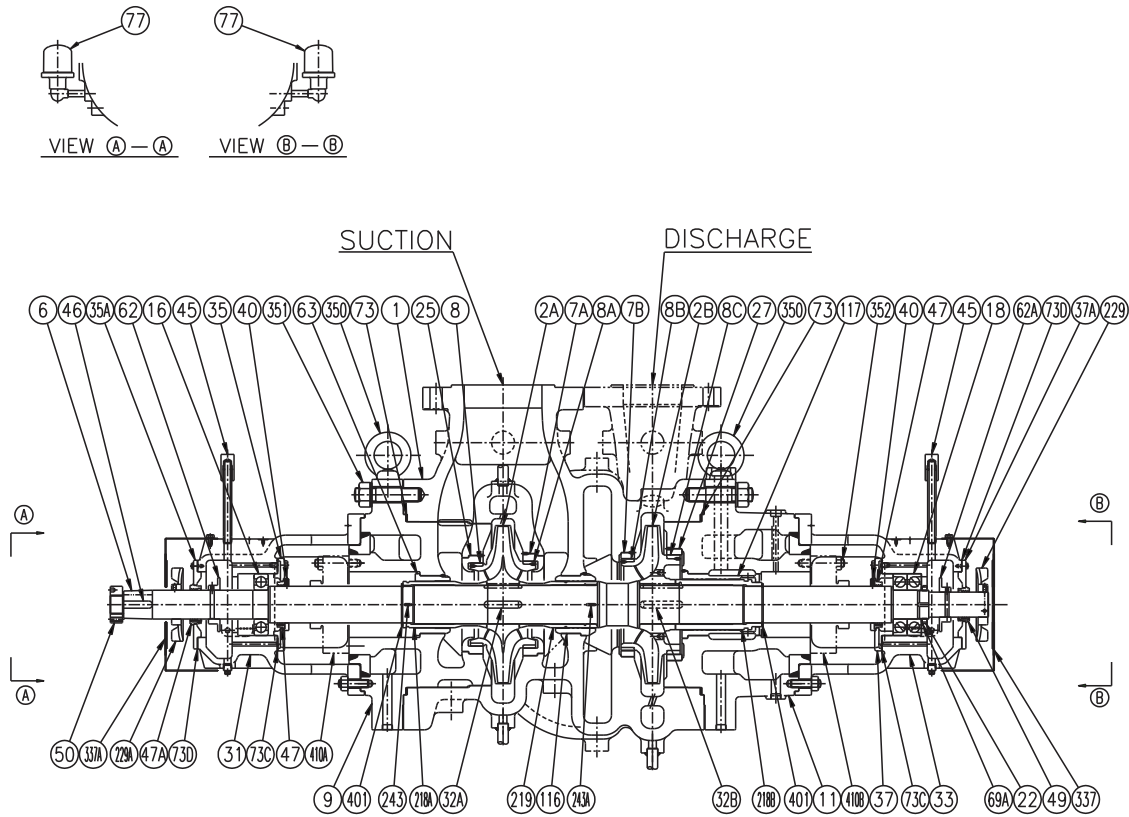
### 8.1 WTB ball bearing with flinger lubrication, oil baffle and water cooling



#### 8.1.1 Parts list

Part no.	Ref no.	Description	Quantity
1	1100	Casing	1
2A	2200.1	Impeller (1st)	1
2B	2200.2	Impeller (2nd)	1
6	2100	Shaft	1
7A	1500.1	Ring, casing (1st)	1
7B	1500.2	Ring, casing (2nd)	1
8	2300.1	Ring, impeller	2
8B	2300.2	Ring, impeller (2nd, front)	1
8C	2300.3	Ring, impeller (2nd, back)	1
9	1222	Head, suction	1
11	4100	Stuffing box	1
16	3010	Bearing, radial	1
18	3013	Bearing, thrust	1
22	3712	Nut, bearing	1
25	1500.3	Ring, suction head	1
27	1500.4	Ring, stuffing box	1
31	3200	Housing, radial bearing	1
32A	6700.1	Key (1st impeller)	1
32B	6700.2	Key (2nd impeller)	1
33	3230	Housing, thrust bearing	1
35	3266.1	Cover, bearing (radial)	1
35A	3266.2	Cover, bearing (radial)	1
37	3266.3	Cover, bearing (thrust)	1
37A	3266.4	Cover, bearing (thrust)	1
40	2540.1	Deflector	2
40A	2540.2	Deflector	1
45	6521	Air vent	2
46	6700.3	Key	1
47	4330.1	Oil baffle	2
47A	4330.2	Oil baffle	1
49	4330.3	Oil baffle	1
50	7411	Nut, coupling	1
62	3862.1	Flinger	1
62A	3862.2	Flinger	1
63	4132.1	Throat bushing	1
69A	6541	Washer, bearing	1
73	4590.1	Gasket, spiral wound	2
73C	4590.2	Gasket, sheet	2
73D	4590.3	Gasket, sheet	1
73E	4590.4	Gasket, sheet	1
77	3855	Constant level oiler	2
78	3710	Bearing spacer	1
116	1630	Bushing, stage	1
117	4132.2	Bushing, breakdown	1
218A	2460.1	Sleeve, distance (radial)	1
218B	2460.2	Sleeve, distance (thrust)	1
219	2410	Sleeve, inter stage	1
243	6700.4	Key, distance and interstage sleeve	2
350	-	Eye bolt	2
351	6572.1	Stud and nut	32
352	6572.2	Stud and nut	8
401	2530	Snap ring	2
410A	4200.1	Mechanical seal (radial)	1
410B	4200.2	Mechanical seal (thrust)	1

## 8.2 WTB ball bearing with flinger lubrication, oil baffle and fan cooling



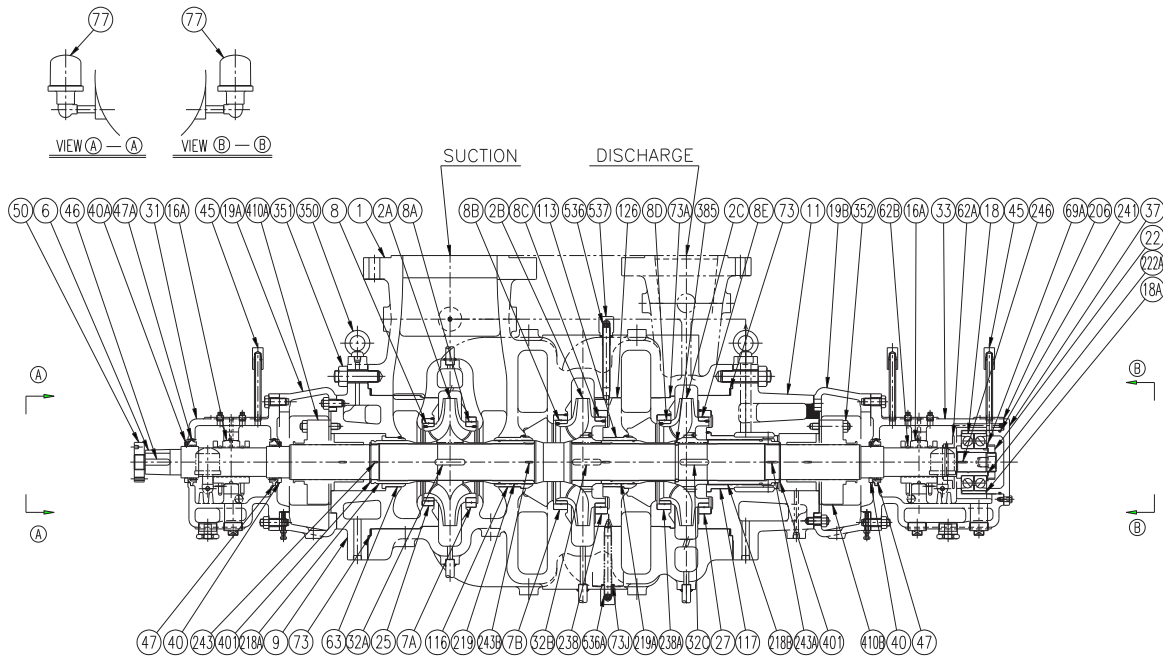
### 8.2.1 Parts lists

Part no.	Ref no.	Description	Quantity
1	1100	Casing	1
2A	2200.1	Impeller (1st)	1
2B	2200.2	Impeller (2nd)	1
6	2100	Shaft	1
7A	1500.1	Ring, casing (1st)	1
7B	1500.2	Ring, casing (2nd)	1
8	2300.1	Ring, impeller	1
8A	2300.2	Ring, impeller	1
8B	2300.3	Ring, impeller (2nd, front)	1
8C	2300.4	Ring, impeller (2nd, back)	1
9	1222	Head, suction	1
11	4100	Stuffing box	1
16	3010 3013	Bearing, radial	1
18	3013	Bearing, thrust	1
22	3712	Nut, bearing	1
25	1500.3	Ring, suction head	1
27	1500.4	Ring, stuffing box	1
31	3200	Housing, radial bearing	1
32A	6700.1	Key (1st impeller)	1
32B	6700.2	Key (2nd impeller)	1
33	3230	Housing, thrust bearing	1
35	3266.1	Cover, bearing (radial)	1
35A	3266.2	Cover, bearing (radial)	1
37	3266.3	Cover, bearing (thrust)	1
37A	3266.4	Cover, bearing (thrust)	1
40	2540	Deflector	2
45	6521	Air vent	2
46	6700.3	Key	1

47	4330.1	Oil baffle	2
47A	4330.2	Oil baffle	1
49	4330.3	Oil baffle	1
50	7411	Nut, coupling	1
62	3862.1	Flinger	1
62A	3862.2	Flinger	1
63	4132.1	Throat bushing	1
69A	6541	Washer, bearing	1
73	4590.1	Gasket, spiral wound	2
73C	4590.2	Gasket, sheet	2
73D	4590.3	Gasket, sheet	2
77	3855	Constant level oiler	2
116	1630	Bushing, stage	1
117	4132.2	Bushing, breakdown	1
218A	2460.1	Sleeve, distance (radial)	1
218B	2460.2	Sleeve, distance (thrust)	1
219	2410	Sleeve, inter stage	1
229	8161.1	Fan	1
229A	8161.2	Fan	1
243	6700.4	Key, distance sleeve	1
243A	6700.5	Key, distance sleeve	1
337	8162	Cover, fan	1
337A	8162	Cover, fan	1
350	-	Eye bolt	2
351	6572.1	Stud and nut	32
352	6572.2	Stud and nut	8
401	2530	Snap ring	2
410A	4200.1	Mechanical seal (radial)	1
410B	4200.2	Mechanical seal (thrust)	1



### 8.3 WTB sleeve-ball bearing with flinger lubrication, oil baffle and water cooling

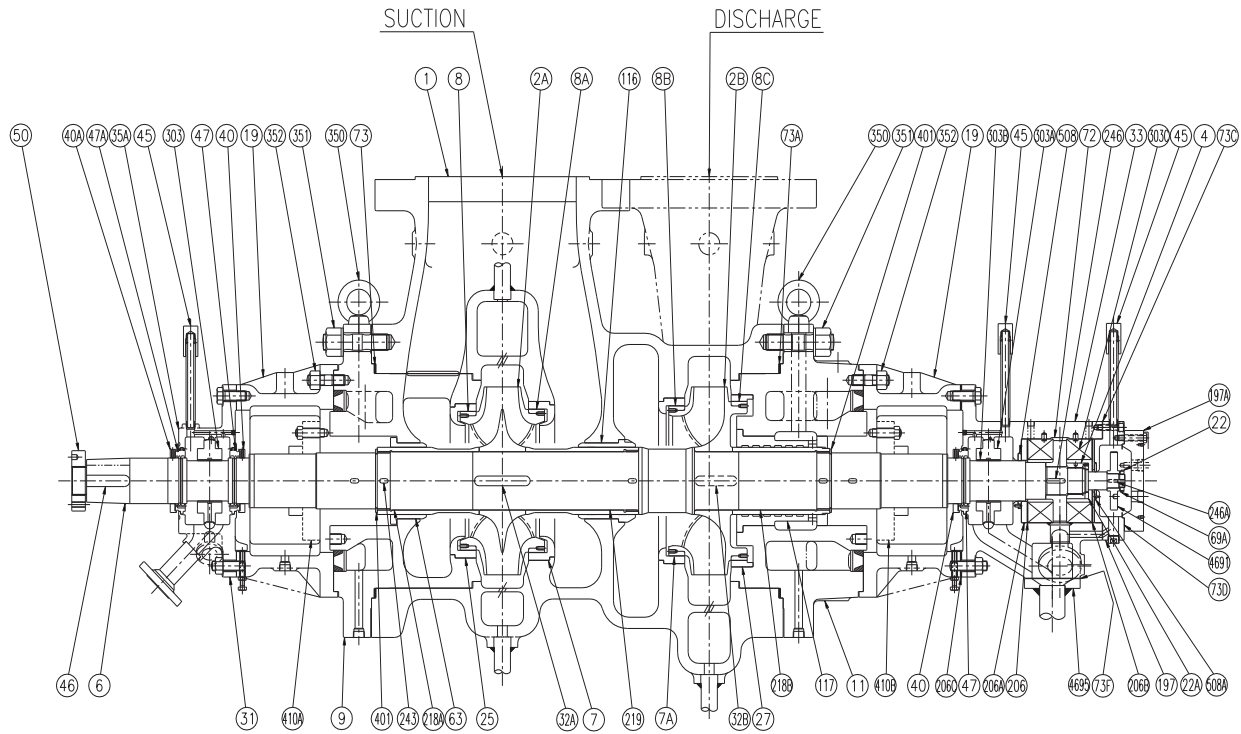


#### 8.3.1 Parts list

Part no.	Ref no.	Description	Quantity
1	1100	Casing	1
2A	2200.1	Impeller (1st)	1
2B	2200.2	Impeller (2nd)	1
2C	2200.3	Impeller (3rd)	1
6	2100	Shaft	1
7A	1500.1	Ring, casing (1st)	1
7B	1500.2	Ring, casing (2nd)	1
8	2300.1	Ring, 1st impeller front	1
8A	2300.2	Ring, 1st impeller back	1
8B	2300.3	Ring, 2nd impeller front	1
8C	2300.4	Ring, 2nd impeller back	1
8D	2300.5	Ring, 3rd impeller front	1
8E	2300.6	Ring, 3rd impeller back	1
9	1222	Head, suction	1
11	4100	Stuffing box	1
16A	3021	Journal bearing	2
18	3013	Bearing, thrust	1
18A	3031	Collar bearing	1
19A	3110.1	Bracket, bearing (radial)	1
19B	3110.2	Bracket, bearing (thrust)	1
22	3712	Nut, bearing	1
25	1500.3	Ring, suction head	1
27	1500.4	Ring, stuffing box	1
31	3200	Housing, radial bearing	1
32A	6700.1	Key (1st impeller)	1
32B	6700.2	Key (2nd impeller)	1
32C	6700.3	Key (3rd impeller)	1
33	3230	Housing, thrust bearing	1
37	3266	Cover, bearing (thrust)	1
40	2540.1	Deflector	1
40A	2540.2	Deflector	2
45	6521	Air vent	3
46	6700.4	Key	1
47	4330.1	Oil baffle	2
47A	4330.2	Oil baffle	1
50	7411	Nut, coupling	1

62A	3862	Flinger	1
62B	3861	Oil ring	4
63	4132.1	Throat bushing	1
69A	6541	Washer, bearing	1
73	4590.1	Gasket, spiral wound	2
73A	4590.2	Gasket, sheet	1
73J	4590.3	Gasket, spiral wound	3
77	3855	Constant level oiler	2
113	1620	Bushing, diaphragm	1
116	1630	Bushing, stage	1
117	4132.2	Bushing, breakdown	1
126	1460	Diaphragm	1
206	3126	Shim	1S
218A	2460.1	Sleeve, distance (radial)	1
218B	2460.2	Sleeve, distance (thrust)	1
219	2410.1	Sleeve, inter stage	1
219A	2410.2	Sleeve, inter stage	1
222A	2471	Sleeve, thrust collar	1
238	1500.5	Ring, diaphragm	1
238A	1500.6	Ring, diaphragm	1
241	4610	O-ring	1
243	6700.5	Key, distance sleeve	1
243A	6700.6	Key, distance sleeve	1
243B	6700.7	Key, inter stage sleeve	1
246	6700.8	Key, sleeve thrust collar	1
350	-	Eye bolt	2
351	6572.1	Stud and nut	32
352	6572.2	Stud and nut	8
385	2531	Split ring	1S
401	2530	Snap ring	2
410A	4200.1	Mechanical seal (radial)	1
410B	4200.2	Mechanical seal (thrust)	1
536	6820.1	Lock bolt	2
536A	6820.2	Position bolt	1
537	6415	Cap nut	3

### 8.4 WTB Sleeve-Kingsbury bearing with forced oil lubrication and oil baffle

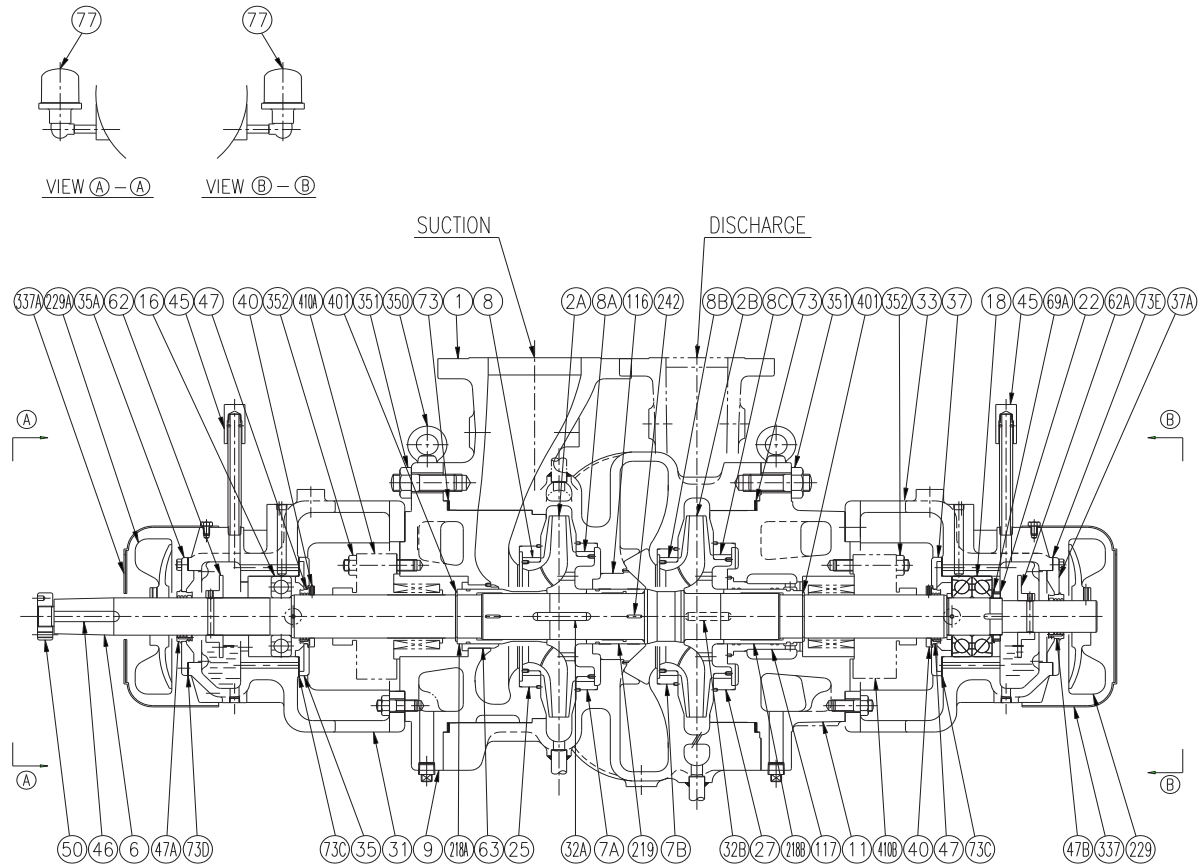


#### 8.4.1 Parts list

Part no.	Ref no.	Description	Quantity
1	1100	Casing	1
2A	2200.1	Impeller (1st)	1
2B	2200.2	Impeller (2nd)	1
4	3712.1	Nut, thrust collar	1
6	2100	Shaft	1
7	1500.1	Ring, casing (1st)	1
7A	1500.2	Ring, casing (2nd)	1
8	2300.1	Ring, impeller (1st front)	1
8A	2300.2	Ring, impeller (1st back)	1
8B	2300.3	Ring, impeller (2nd, front)	1
8C	2300.4	Ring, impeller (2nd, back)	1
9	1222	Head suction	1
11	4100	Stuffing box	1
19	3110	Bracket, bearing	2
22	3712.2	Nut, bearing	1
22A	3712.3	Lock nut	1
25	1500.3	Ring, suction head	1
27	1500.4	Ring, stuffing box	1
31	3200	Housing, radial bearing	1
32A	6700.1	Key (1st impeller)	1
32B	6700.2	Key (2nd impeller)	1
33	3230	Housing, thrust bearing	1
40	2540.1	Deflector (radial and thrust)	2
40A	2540.2	Deflector (radial)	1
45	6521	Air vent	3
46	6700.1	Key	1
47	4330.1	Oil baffle	2
47A	4330.2	Oil baffle	1
50	7411	Nut, coupling	1
63	4132.1	Throat bushing	1
69A	2905	Washer, bearing	1
72	3610	Thrust collar	1
73	4590.1	Gasket, spiral wound	1

73A	4590.2	Gasket, spiral wound	1
73C	4590.3	Gasket, sheet	1
73D	4590.4	Gasket, sheet	1
73F	4590.5	Gasket, sheet	1
116	1630	Bushing, stage	1
117	4132.2	Bushing, breakdown	1
197	3266.1	Cover, bearing	1
197A	3266.2	Cover, bearing/end	1
206	6196.1	Shim, thrust bearing	2S
206A	3645.1	Plate	1
206B	3645.2	Plate	1
206C	6196.2	Shim, thrust bearing	1
218A	2460.1	Sleeve, distance (radial)	1
218B	2460.2	Sleeve, distance (thrust)	1
219	2410	Sleeve, inter stage	1
243	6700.2	Key, distance and inter stage sleeve	3
246	6700.3	Key, thrust collar	1
246A	6700.4	Key, plate	1
303	3023.1	Bearing retainer	1S
303A	3023.2	Bearing retainer	1S
303B	3122	Bearing insert	2S
303C	3032	Bearing thrust	1S
350	-	Eye bolt	2
351	6572.1	Stud and nut	32
352	6572.2	Stud and nut	8
401	2530	Snap ring	2
410A	4200.1	Mechanical seal (radial)	1
410B	4200.2	Mechanical seal (thrust)	1
508	4010.1	Seal ring	1
508A	4010.2	Seal ring	1
4691	3645.3	Plate	1
4695	3272	Cover	1

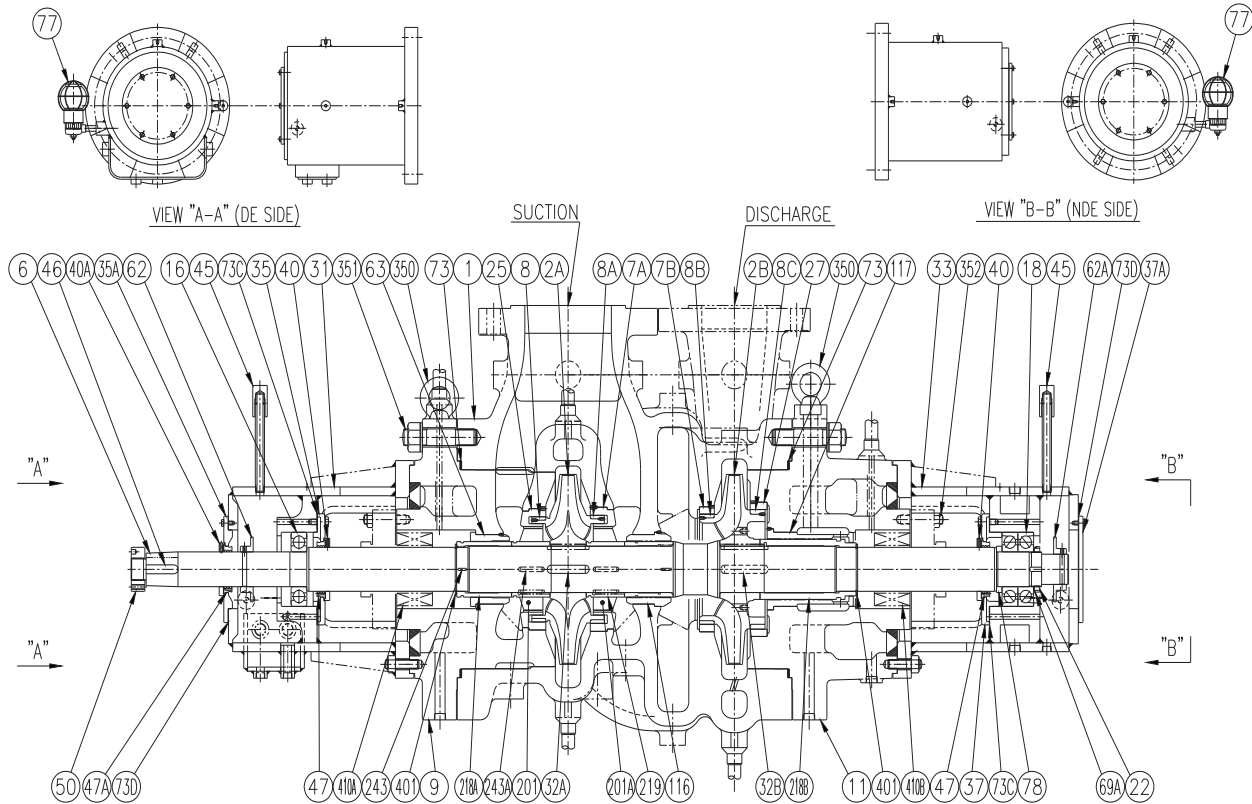
### 8.5 WTB single suction ball bearing with flinger lubrication, oil baffle and fan cooling



#### 8.5.1 Parts list

Part no.	Ref no.	Description	Quantity
1	1100	Casing	1
2A	2200.1	Impeller (1st)	1
2B	2200.2	Impeller (2nd)	1
6	2100	Shaft	1
7A	1500.1	Ring, casing (1st)	1
7B	1500.2	Ring, casing (2nd)	1
8	2300.1	Ring, impeller (1st, front)	1
8A	2300.2	Ring, impeller (2nd, back)	1
8B	2300.3	Ring, impeller 2nd, front)	1
8C	2300.4	Ring, impeller (2nd, back)	1
9	1222	Head suction	1
11	4100	Stuffing box	1
16	3010	Bearing, radial	1
18	3013	Bearing, thrust	1
22	3712	Nut, bearing	1
25	1500.3	Ring, suction head	1
27	1500.4	Ring, stuffing box	1
31	3200	Housing, radial bearing	1
32A	6700.1	Key (1st impeller)	1
32B	6700.2	Key (2nd impeller)	1
33	3230	Housing, thrust bearing	1
35	3266.1	Cover, bearing (radial)	1
35A	3266.2	Cover, bearing (radial)	1
37	3266.3	Cover, bearing (thrust)	1
37A	3266.4	Cover, bearing (thrust)	1
40	2540	Deflector	2
45	6521	Air vent	2
46	6700.3	Key	1
47	4330.1	Oil baffle	2
47A	4330.2	Oil baffle	1
47B	4330.3	Oil baffle	1
50	7411	Nut, coupling	1
62	3862.1	Flinger	1
62A	3862.2	Flinger	1
63	4132.1	Throat bushing	1
69A	6541	Washer, bearing	1
73	4590.1	Gasket, spiral wound	2
73C	4590.2	Gasket, sheet	2
73D	4590.3	Gasket, sheet	1
73E	4590.4	Gasket, sheet	1
77	3855	Constant level oiler	2
116	1630	Bushing, stage	1
117	4132.2	Bushing, breakdown	1
218A	2460.1	Sleeve, distance (radial)	1
218B	2460.2	Sleeve, distance (thrust)	1
219	2410	Sleeve, inter stage	1
229	8161.1	Fan	1
229A	9161.2	Fan	1
242	6700.4	Key, distance sleeve	2
337	8162	Cover, fan	1
337A	8162	Cover, fan	1
350	-	Eye bolt	2
351	6572.1	Stud and nut	32
352	6572.2	Stud and nut	8
401	2530	Snap ring	2
410A	4200.1	Mechanical seal (radial)	1
410B	4200.2	Mechanical seal (thrust)	1

### 8.6 WTB ball bearing with flinger lubrication, oil baffle, water cooling and coke crushers



#### 8.6.1 Parts list

Part no.	Ref no.	Description	Quantity
1	1100	Casing	1
2A	2200.1	Impeller (1st)	1
2B	2200.2	Impeller (2nd)	1
6	2100	Shaft	1
7A	1500.1	Ring, casing (1st)	1
7B	1500.2	Ring, casing (2nd)	1
8	2300.1	Ring, impeller	1
8A	2300.2	Ring, impeller	1
8B	2300.3	Ring, 2nd impeller front	1
8C	2300.3	Ring, 2nd impeller back	1
9	1222	Head suction	1
11	4100	Stuffing box	1
16	3010	Bearing, radial	1
18	3013	Bearing, thrust	1
22	3712	Nut, bearing	1
25	1500.3	Ring, suction head	1
27	1500.4	Ring, stuffing box	1
31	3200	Housing, radial bearing	1
32A	6700.1	Key (1st impeller)	1
32B	6700.2	Key (2nd impeller)	1
33	3230	Housing, thrust bearing	1
35	3266.1	Cover, bearing (radial)	1
35A	3266.2	Cover, bearing (radial)	1
37	3266.3	Cover, bearing (thrust)	1
37A	3266.4	Cover, bearing (thrust)	1
40	2540.1	Deflector	2
40A	2540.2	Deflector	1
45	6521	Air vent	2
46	6700.3	Key	1
47	4330.1	Oil baffle	2
47A	4330.2	Oil baffle	1
47B	4330.3	Oil baffle	1
50	7411	Nut, coupling	1
62	3862.1	Flinger	1
62A	3862.2	Flinger	1
63	4132.1	Throat bushing	1
69A	6541	Washer, bearing	1
73	4590.1	Gasket, spiral wound	2
73C	4590.2	Gasket, sheet	2
73D	4590.3	Gasket, sheet	2
77	3855	Constant level oiler	2
78	1680	Spacer, bushing	1
116	1630	Bushing, stage	1
117	4132.2	Bushing, breakdown	1
201	2215	Coke crusher	1
201A	2215	Coke crusher	1
218A	2460.1	Sleeve, distance (radial)	1
218B	2460.2	Sleeve, distance (thrust)	1
219	2410	Sleeve, inter stage	1
243	6700.4	Key, distance sleeve	2
243A	6700.5	Key, distance sleeve	2
350	-	Eye bolt	2
351	6572.1	Stud and nut	32
352	6572.2	Stud and nut	8
401	2530	Snap ring	2
410A	4200.1	Mechanical seal (radial)	1
410B	4200.2	Mechanical seal (thrust)	1

### **8.7 General arrangement drawing**

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

## **9 CERTIFICATION**

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

## **10 OTHER RELEVANT DOCUMENTATION AND MANUALS**

### **10.1 Supplementary User Instruction manuals**

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

### **10.2 Change notes**

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

### **10.3 Additional sources of information**

*Reference 1:*

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

*Reference 2:*

Pumping Manual, 9<sup>th</sup> edition, T.C. Dickenson, Elsevier Advanced Technology, United Kingdom, 1995.

*Reference 3:*

Pump Handbook, 2<sup>nd</sup> 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 B 31 3- Process Piping.





**Notes:**

**Notes:**



**Notes:**

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