FLOWSERVE *USER INSTRUCTIONS*

# *Flowserve*
# *FRBH, FRBHX & FRBHS*

**CENTRIFUGAL PAPER STOCK AND PROCESS PUMPS**

***Installation***
***Operation***
***Maintenance***

***PCN= 71569178 25-09***
***Original Instructions***



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

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

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

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

## 1.2 CE marking and approvals

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

Where applicable, the Directives and any additional Approvals, cover important safety aspects relating to machinery and equipment and the satisfactory provision of technical documents and safety instructions. Where applicable this document incorporates information relevant to these Directives and Approvals.

To confirm the Approvals applying and if the product is CE marked, check the serial number plate-markings and the Certification. (See section 9, *Certification*.)

## 1.3 Disclaimer

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

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

## 1.4 Copyright

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

## 1.5 Duty conditions

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

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

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

## 1.6 Safety

### 1.6.1 Summary of safety markings

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

DANGER This symbol indicates electrical safety instructions where non-compliance 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

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

FLUORO-ELASTOMERS (When fitted.)
When a pump has experienced temperatures over 250 ºC (482 ºF), partial decomposition of fluoro-elastomers (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 vapour could cause an explosion.

HOT (and cold) PARTS
If hot or freezing components or auxiliary heating supplies can present a danger to operators and persons entering the immediate area, action must be taken to avoid accidental contact. If complete protection is not possible, the machine access must be limited to maintenance staff only, with clear visual

warnings and indicators to those entering the immediate area. Note: bearing housings must not be insulated and drive motors and bearings may be hot.

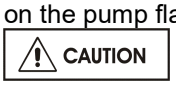
***If the temperature is greater than 80°C (176 °F) or below - 5 °C (23 °F) in a restricted zone, or exceeds local regulations, action as above shall be taken.***

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

***Gland packing must not be used when pumping hazardous liquids.***



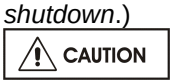
PREVENT EXCESSIVE EXTERNAL PIPE LOAD
Do not use pump as a support for piping. Do not mount expansion joints, unless allowed by Flowserve in writing, so that their force, due to internal pressure, acts on the pump flange.



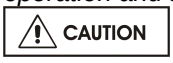
NEVER RUN THE PUMP DRY



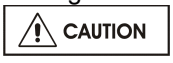
ENSURE CORRECT LUBRICATION
(See section 5, *Commissioning, start-up, operation and shutdown*.)



START THE PUMP WITH OUTLET VALVE PART OPENED
(Unless otherwise instructed at a specific point in the user instructions.)
This is recommended to minimize the risk of overloading and damaging the pump motor at full or zero flow. Pumps may be started with the valve further open only on installations where this situation cannot occur. The pump outlet control valve may need to be adjusted to comply with the duty following the run-up process. (See section 5, *Commissioning start-up, operation and shutdown*.)



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



DO NOT RUN THE PUMP AT ABNORMALLY HIGH OR LOW FLOW RATES
Operating at a flow rate higher than normal or at a flow rate with no back pressure on the pump may overload the motor and cause cavitation. Low flow rates may cause a reduction in pump/bearing life, overheating of the pump, instability and cavitation/ vibration.

1.6.4 Products used in potentially explosive atmospheres

 Measures are required to:

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

The following instructions for pumps and pump units when installed in potentially explosive atmospheres must be followed to help ensure explosion protection. For ATEX, both electrical and non-electrical equipment must meet the requirements of European Directive 2014/34/EU. Always observe the regional legal Ex requirements; Ex electrical items outside the EU may be required certified to other than ATEX (example: IECEx, UL).

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/ATEX 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.

**II 2 GD Ex h IIC T4 Gb**

Equipment Group
I = Mining
II = Non-mining

Category
2 or M2 = High level protection
3 = normal level of protection

Gas and/or Dust
G = Gas; D= Dust

h = Ignition Protection Method

Gas Group (*Equipment Category 2 only*)
IIA – Propane (typical)
IIB – Ethylene (typical)
IIC – Hydrogen (typical)

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

EPL
Marking in accordance with the Equipment Protection Level defined in EN ISO 80079-36 & 37

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.

***Maximum permitted liquid temperature for pumps***

| Temperature class to EN ISO 80079-36 | Maximum surface temperature permitted | Temperature limit of liquid handled |
|---|---|---|
| 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 temperature rise at the seals and bearings and due to the minimum permitted flow rate is taken into account in the temperatures stated.

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

Temperature classification “T4…T1” is used when the liquid temperature varies and when the pump is required to be used in differently classified potentially explosive atmospheres. In this case the user is responsible for ensuring that the pump surface temperature does not exceed that permitted in its actual installed location.

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

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

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

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

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, install an appropriate dry run protection device (eg liquid detection or a power monitor).

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

1.6.4.5 ***Preventing sparks***

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

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

 Make sure that the connection between pump and baseplate is electrically conductive.

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

For ATEX, the coupling must be selected to comply with 2014/34/EU and correct alignment must be maintained.

***Additional requirement for metallic pumps on non-metallic baseplates***
When metallic components are fitted on a non-metallic baseplate they must be individually grounded.

1.6.4.6 ***Preventing leakage***

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

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

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

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

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

1.6.4.7 ***Maintenance to avoid the hazard***

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

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

To avoid potential explosion hazards during maintenance, the tools, cleaning and painting materials used must not give rise to sparking or adversely affect the ambient conditions. Where there is a risk from such tools or materials, maintenance must be conducted in a safe area.

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

## 1.7 Nameplate and warning labels

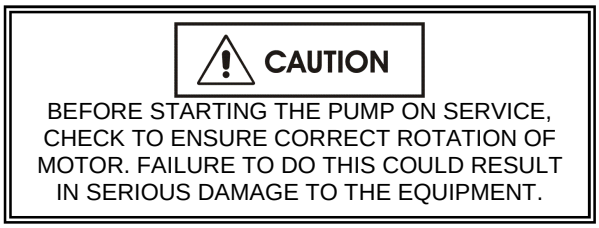
### 1.7.1 Nameplate

For details of nameplate, see the *Declaration of Conformity* or separate documentation included with these User Instructions

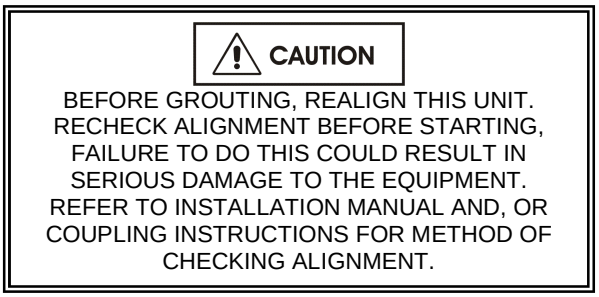
### 1.7.2 Warning labels




**MECHANICAL SEAL WARNING**
**P/N 2113931-001**



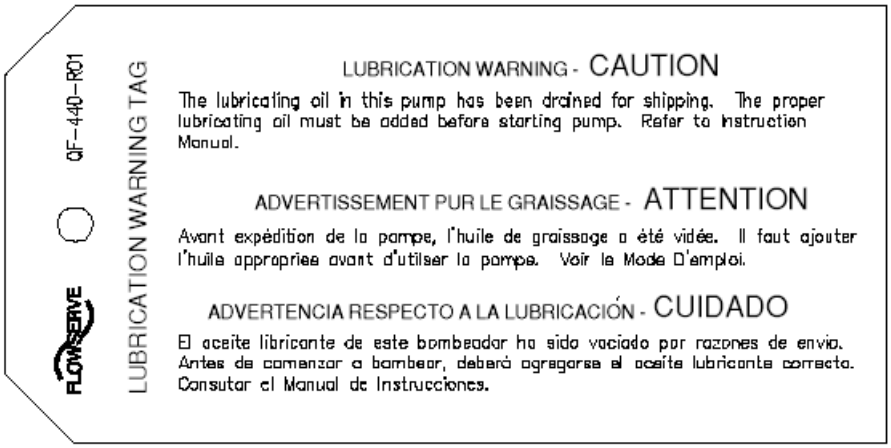

**ROTATION WARNING**
**P/N 2113932-001**




**GROUT WARNING**
P/N 2113934-001




**LIFTING WARNING**
P/N 9901701-001




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

### 1.8 Specific machine performance

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

### 1.9 Noise level

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

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

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

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

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

| **Motor size and speed kW (hp)** | **Typical sound pressure level $L_{pA}$ at 1 m reference 20 µPa, dBA** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **1 750 r/min** | | **1 450 r/min** | | **1180 r/min** | | **980 r/min** | |
| | Pump only | Pump and motor | Pump only | Pump and motor | Pump only | Pump and motor | Pump only | Pump and motor |
| <0.55(<0.75) | 62 | 64 | 62 | 64 | 60 | 62 | 60 | 64 |
| 0.75 (1) | 62 | 64 | 62 | 64 | 60 | 62 | 60 | 64 |
| 1.1 (1.5) | 64 | 64 | 62 | 63 | 62 | 64 | 60 | 63 |
| 1.5 (2) | 64 | 64 | 62 | 63 | 62 | 64 | 60 | 63 |
| 2.2 (3) | 65 | 66 | 63 | 64 | 63 | 66 | 61 | 64 |
| 3 (4) | 65 | 66 | 63 | 64 | 63 | 66 | 61 | 64 |
| 4 (5) | 65 | 66 | 63 | 64 | 63 | 66 | 61 | 64 |
| 5.5 (7.5) | 66 | 67 | 64 | 65 | 64 | 67 | 63 | 65 |
| 7.5 (10) | 66 | 67 | 64 | 65 | 64 | 67 | 63 | 65 |
| 11(15) | 70 | 71 | 68 | 69 | 68 | 71 | 67 | 69 |
| 15 (20) | 70 | 71 | 68 | 69 | 68 | 71 | 67 | 69 |
| 18.5 (25) | 71 | 71 | 69 | 71 | 69 | 71 | 68 | 70 |
| 22 (30) | 71 | 71 | 69 | 71 | 69 | 71 | 68 | 70 |
| 30 (40) | 73 | 73 | 71 | 73 | 71 | 73 | 70 | 72 |
| 37 (50) | 73 | 73 | 72 | 74 | 71 | 73 | 70 | 72 |
| 45 (60) | 76 | 76 | 75 | 77 | 74 | 76 | 72 | 75 |
| 55 (75) | 77 | 80 | 76 | 78 | 74 | 76 | 73 | 75 |
| 75 (100) | 78 | 81 | 77 | 79 | 75 | 77 | 74 | 76 |
| 90 (120) | 79 | 82 | 78 | 80 | 77 | 79 | 76 | 78 |
| 110 (150) | 80 | 83 | 79 | 81 | 78 | 80 | 77 | 79 |
| 150 (200) | 82 | 84 | 80 | 83 | 79 | 81 | 78 | 80 |
| 200 (270) | 87 | 90 | 86 | 89 | 85 | 87 | 84 | 86 |
| 300 (400) | 89 | 92 | 88 | 91 | 87 | 89 | 86 | 88 |

① The noise level of machines in this range will most likely be of values which require noise exposure control, but typical values are inappropriate.

**Note:** For 880 and 720 r/min reduce 980 r/min values by 2 dBA.

## 2 TRANSPORT AND STORAGE

### 2.1 Consignment receipt and unpacking

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

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

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

### 2.2 Handling

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

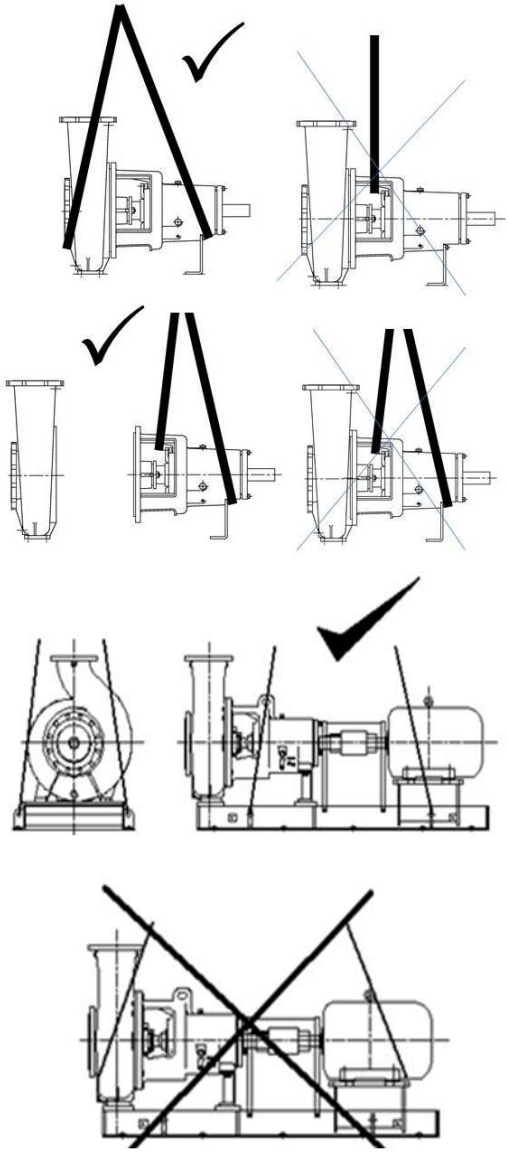
The pump should be lifted with suitably sized and located slings. Do not use the shaft for lifting and take special care to prevent the pump from rotating in the slings due to unbalanced weight distribution.

### 2.3 Lifting

A crane must be used for all pump sets or components 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 for the specific project. The table of engineering data in section 3.5 is for bare pump only and does not include the weight of the base, driver or auxiliary equipment.

The pump unit should be lifted as shown. Do not Use the driver, bare shaft pump or component lifting points to lift the complete machine.

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



### 2.4 Storage

CAUTION

#### 2.4.1 Short-Term Storage

When it is necessary to store a pump for a short time before it can be installed, place it in a dry, cool location. Protect it thoroughly from moisture and condensation. Protective flange covers should not be removed until the pump is being installed.
Wrap the exposed portions of the shaft and coupling to protect against sand, grit or other foreign matter. Oil

lubricated units should be lubricated (refer to Section III) to protect the bearings. Grease lubricated units are lubricated at the factory during assembly. Turn the rotor over by hand at least once a week to maintain a protective film on the bearing components.

### 2.4.2 LONG-TERM STORAGE

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

The internal surfaces of the pump should be sprayed with a rust preventative such as a water soluble oil or other suitable alternative. Particular attention should be given to the impeller, wear plate and stuffing box.

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

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

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

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

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

### 2.5 Recycling and end of product life

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

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

## 3 PUMP DESCRIPTION

### 3.1 Configurations

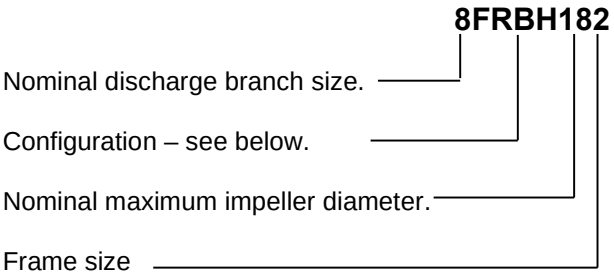
Flowserve "FRBH" pumps are single stage, end suction centrifugal pumps specifically designed for the pulp and paper industry and consequently are ideally suited to many process fluids. A volute type casing with integrally cast feet and top centerline discharge nozzle is standard. The semi-open impeller with rear pump-out vanes is capable of passing pulpy material and solids of a limited size. Sealing is provided at the impeller to shaft fit to prevent corrosion and thereby facilitate impeller removal. The rigid three point thrust bearing housing support permits precision bearing alignment. The back pull-out feature, typical of all FRBH pumps, permits quick removal of the entire rotor/frame assembly without disturbing the casing or driver.

The pump is sealed using non-asbestos packing in the stuffing box. An optional hydrodynamic seal, commonly referred to as an expeller is available and various mechanical seal designs as specified by the customer may be installed at the factory or retrofitted in the field.

All pumps are carefully inspected and prepared for shipment. All exterior machined surfaces are coated with a rust preventative compound and openings are provided with covers or plugs. Shaft packing, when required, is shipped loose with the pump and should not be installed until the pump is ready to run. Mechanical seals, when provided, are factory installed and adjusted prior to shipment. The axial impeller running clearance is pre-set at the factory but should be checked prior to final alignment in case of tampering.

### 3.2 Name nomenclature

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




FRBH – standard construction
FRBHS - recessed impeller
FRBHX – expeller seal installed
Suffix codes after the pump name generally describe hydraulic variations, special impeller or casing volute

### 3.3 Design of major parts

#### 3.3.1 Pump casing

The pump casing is a volute type casing with integrally cast feet and top centerline discharge nozzle. It is a one piece pressure retaining casting with gasket connections to the stuffing box head and the suction and discharge flanges.

#### 3.3.2 Impeller

The impeller is semi-open design, keyed to the shaft and secured with a contoured impeller nut. The vanes of the impeller are Francis type however, the “S” configuration utilizes straight radial vanes to reduce blockage. The impeller of the FRBHS pump is recessed away from volute to reduce shear.

#### 3.3.3 Shaft

The large diameter stiff shaft, mounted on bearings, has a keyed drive end and impeller mount.

#### 3.3.4 Pump bearings and lubrication

Ball bearings are fitted as standard and may be either oil or grease lubricated. Special bearing configurations may be provided.

Oil lubrication is only available where the pump shaft is horizontal.

#### 3.3.5 Bearing housing

For oil lubricated bearings, a bulls eye level gauge is supplied. Constant level oilers can also be fitted. Two grease nipples enable grease lubricated bearings to be replenished between major service intervals.

#### 3.3.6 Stuffing box housing

The stuffing box housing has a spigot (rabbet) fit between the pump casing and bearing housing for optimum concentricity. The design enables a number of sealing options to be fitted.

#### 3.3.7 Shaft seal

The mechanical seal(s), attached to the pump shaft, seals the pumped liquid from the environment. Gland packing may be fitted as an option. The “FRBHX” model is fitted with an optional dynamic or expeller seal for certain applications.

#### 3.3.8 Driver

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

#### 3.3.9 Accessories

Accessories may be fitted when specified by the customer.

### 3.4 Performance and operating limits

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

#### 3.4.1 Operating limits

| | |
|---|---|
| Pumped liquid temperature limits | up to+177 ºC (350 ºF) |
| Maximum ambient temperature | up to +50 ºC (122 ºF) |
| Maximum soft solids in suspension | up to 7 % by volume |
| Maximum pump speed | Refer to the nameplate |

3.4.2 **Speed torque curves**

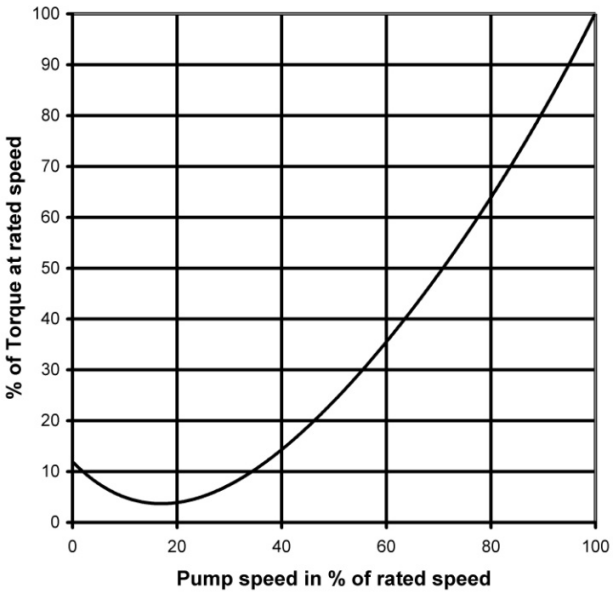
To bring a centrifugal pump up to rated speed, the driver must be capable of providing more torque at each speed than required by the pump. The margin between the available and required torque affects the time it takes the unit to reach full speed. If the torque required by the pump exceeds the torque capability of the drive at any run-up speed, the unit will not accelerate to full speed. Normally, this is not a problem with standard induction or synchronous motors provided the proper voltage is supplied at the motor.

For pumps started at shut valve conditions, 100 percent full speed torque can be calculated by using the formula:

$$\text{Torque (N-m)} = 9545 \frac{\text{Shutoff Power (kW)}}{\text{r/min}}$$

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

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




3.4.3 **MAXIMUM WORKING PRESSURES -bar (psi).**

Above ambient temperature these maximum pressures shall be de-rated.

**CAUTION** Do no conduct a hydro on the complete pump set without the specific approval of Flowserve. While the duty requirement will have been covered, auxiliary items, flange drillings and suction pressure limits may impose a reduced static and dynamic pressure rating compared to that of the pump casting rating itself.

Note: all flanges are dimensionally compatible with ANSI 125 (Cast Iron or Ductile Iron-flat faced) or ANSI 150 (Stainless-raised face) unless otherwise stated. All flange facings on the casings are 250 rms – circular finish (Stock Finish)

| CONSTRUCTION | CAST IRON AND C.I.S.S. FITTED | | | STAINLESS STEEL 316,317L, WORTHITE, ETC. | |
|---|---|---|---|---|---|
| TEMPERATURE $^{O}$C ($^{O}$F) | UP TO 12" DISCHARGE | 14 TO 16" DISCHARGE | 18 TO 20" DISCHARGE | UP TO 16" DISCHARGE | 18 TO 20" DISCHARGE |
| -30 to 38 (-20 to100) | 10.3 (150) | 10.3 (150) | 6.2 (90) | 13.8 (200) | 8.3 (120) |
| 65 (150) | 10.3 (150) | 9.7 (140) | 6.2 (90) | 13.8 (200) | 8.3 (120) |
| 95 (200) | 10.3 (150) | 9.3 (135) | 6.2 (90) | 13.4 (195) | 8.3 (120) |
| 120 (250) | 10.3 (150) | 9.0 (130) | 6.2 (90) | 12.6 (185) | 8.3 (120) |
| 150 (300) | **Consult factory for applications in this range. Cast iron not recommended due to thermal shock risks.** | | | 12.1 (175) | 8.3 (120) |
| 175 (350) | | | | 11.0 (160) | 7.6 (110) |

## 3.5 **Table Of Engineering Data**

### 3.5.1 **FRAMES 1 & 2 - LIQUID END**

| **ENGINEERING DATA** | | 2FRBH121 | 3FRBH121 | 3FRBH101 | 4FRBH111 | 6FRBH111 | 3FRBH141 | 4FRBH141 | 6FRBH142 | 8FRBH152 | 3FRBH182 | 4FRBH182 | 8FRBH182 | 10FRBH182 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **PUMP DATA** | | | | | | | | | | | | | | |
| SUCTION DIA. mm (in.) | | 76 (3) | 102 (4) | 152 (6) | 152 (6) | 203 (8) | 152 (6) | 152 (6) | 203 (8) | 254 (10) | 152 (6) | 203 (8) | 153 (10) | 305 (12) |
| DISCHARGE DIA. mm (in.) | | 51 (2) | 76 (3) | 76 (3) | 102 (4) | 152 (6) | 76 (3) | 102 (4) | 152 (6) | 203 (8) | 76 (3) | 102 (4) | 203 (8) | 153 (10) |
| CASING THICKNESS mm (in.) | C.I. | 11.2 (.44) | 11.2 (.44) | 11.2 (.44) | 11.2 (.44) | 11.2 (.44) | 11.2 (.44) | 11.2 (.44) | 17.5 (.69) | 17.5 (.69) | 16 (.63) | 16 (.63) | 20.8 (.82) | 20.8 (.82) |
| CASING THICKNESS mm (in.) | S.S. | 9.7 (.38) | 9.7 (.38) | 9.7 (.38) | 9.7 (.38) | 9.7 (.38) | 9.7 (.38) | 9.7 (.38) | 14.2 (.56) | 16 (.63) | 12.7 (.50) | 12.7 (.50) | 16 (.63) | 17.5 (.69) |
| CASING TYPE | | SV - SINGLE VOLUTE | | | | | | | | DV | SV | | DV | |
| GAUGE CONNECTION | | 1 / 4 NPT | | | | | | | 1 / 2 NPT | | | | | |
| DRAIN CONNECTION | | 3 / 8 NPT | 1 / 2 NPT | | | | | | | | 3 / 4 NPT | | | 1" NPT |
| NO. OF VANES | | 4 | | | | | | | | | | | | |
| IMP. EYE AREA $cm^2$ ($in.^2$) | | 34 (5.2) | 61 (9.5) | 93 (14.4) | 137 (21.3) | 214 (33.2) | 127 (19.7) | 182 (28.2) | 247 (38.3) | 361 (56) | 183 (28.3) | 200 (31.0) | 359 (55.6) | 555 (86.0) |
| MAX. SPHERE DIA. mm (in.) | | 12.7 (.5) | 17.8 (.7) | 25.4 (1.0) | 30.5 (1.2) | 43.2 (1.7) | 25.4 (1.0) | 35.6 (1.4) | 38.1 (1.5) | 55.9 (2.2) | 19.1 (.75) | 27.9 (1.1) | 55.9 (2.2) | 68.6 (2.7) |
| $WK^2$ kg x $m^2$ ( lb x $ft^2$) | | .07 (1.7) | .08 (1.9) | .07 (1.6) | .08 (1.9) | .12 (2.8) | .19 (4.6) | .27 (6.5) | .34 (8.2) | .48 (11.5) | .51 (12.0) | .53 (12.5) | .88 (20.8) | 1.19 (28.2) |
| *PUMP WEIGHT kg (lb.) | | 195 (430) | 202 (445) | 202 (445) | 227 (500) | 302 (665) | 231 (510) | 270 (595) | 513 (1130 | 617 (1360) | 476 (1050) | 522 (1150) | 739 (1630) | 912 (2010) |
| MAX. BACK PULLOUT WT. kg (lb.) | | 181 (400) | | | | | | | 318 (700) | | | | | |
| IMPELLER AXIAL CLEARANCE mm (in.) | | .38 - .51 (.015 - .020) | | | | | | | .38 - .51 (.015 - .020) | | | | | |
| Impeller Clearance Recessed Impeller mm (in.) | | 1.3 (0.05) from back of Impeller | | | | | | | 1.3 (0.05) from back of Impeller | | | | | |
| MAXIMUM TEMPERATURE | NO COOLING | 121°C (250°F) | | | | | | | 121°C (250°F) | | | | | |
| | WITH COOLING | 177°C (350°F) | | | | | | | 177°C (350°F) | | | | | |
| MAX. HYDRO PRESSURE | C.I. | 12.1 bar (175 psi) | | | | | | | 15.5 bar (225 psi) | | | | | |
| | S.S. | 20.7 bar (300 psi) | | | | | | | 20.7 bar (300 psi) | | | | | |
| **STUFFING BOX DATA** | | | | | | | | | | | | | | |
| O.D. SLEEVE mm (in.) | | 50.80 (2.000) | | | | | | | 76.20 (3.000) | | | | | |
| STUFF. BOX BORE mm (in.) | | 69.85 (2.750) | | | | | | | 101.60 (4.000) | | | | | |
| DEPTH OF BOX mm (in.) | | 77.5 (3.05) | | | | | | | 99.1 (3.90) | | | | | |
| PACKING SIZE mm (in.) | | 9.5 x 9.5 (3 / 8 X 3 / 8) | | | | | | | 12.7 x 12.7 (1 / 2 X 1 / 2) | | | | | |
| PACKING ARRANGEMENT | STD. | 2L3 | | | | | | | 2L3 | | | | | |
| | ALT. | 3L2 | | | | | | | 3L2 | | | | | |
| DISTANCE TO FIRST OBSTRUCTION mm (in.) | | 57.1 (2.25) | | | | | | | 71.1 (2.80) | | | | | |
| B.C.D. FIRST OBSTRUCTION mm (in.) | | 1 / 2 UNC ON 107.9 BCD (1 / 2 UNC ON 4.25 BCD) | | | | | | | 5 / 8 UNC ON 152.4 BCD (5 / 8 UNC ON 6.00 BCD) | | | | | |

### 3.5.2 **FRAMES 1 & 2 - FRAME DETAILS**

| ENGINEERING DATA | 2FRBH121 | 3FRBH121 | 3FRBH101 | 4FRBH111 | 6FRBH111 | 3FRBH141 | 4FRBH141 | 6FRBH | 8FRBH152 | 3FRBH182 | 4FRBH182 | 8FRBH182 | 10FRBH182 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **SHAFT AND BEARING DATA** | | | | | | | | | | | | | |
| DIA. AT IMPELLER mm (in.) | 28.58 (1.125) | | 34.93 (1.375) | | | | | 50.80 (2.000) | | | | | |
| DIA. UNDER SLEEVE mm (in.) | 41.27 (1.625) | | | | | | | 66.68 (2.625) | | | | | |
| DIA. BETWEEN BEARINGS mm (in.) | 63.5 (2.50) | | | | | | | 91.9 (3.62) | | | | | |
| DIA. AT COUPLING mm (in.) | 41.27 (1.625) | | | | | | | 63.50 (2.500) | | | | | |
| LINE BEARING | 6311 | | | | | | | 6316 | | | | | |
| THRUST BEARING | 7309 BUA | | | | | | | 7314 BUA | | | | | |
| BEARING SPAN mm (in.) | 193.8 (7.63) | | | | | | | 279.4 (11.00) | | | | | |
| NOM. IMPELLER OVERHANG mm (in.) | 207.8 (8.18) | | 204.7 (8.06) | | | | | 245.4 (9.66) | | | | | |
| B10 BEARING LIFE | MINIMUM 3 YEARS | | | | | | | | | | | | |
| **BEARING SEALS** | | | | | | | | | | | | | |
| THRUST BEARING LIP SEAL | C / R 16246 NAT. 473010 | | | | | | | C / R 24982 NAT. 417449 | | | | | |
| LINE BEARING LIP SEAL | C / R 19832 NAT. 472492 | | | | | | | NAT. 417350 | | | | | |
| THRUST BEARING O-RING | #249 | | | | | | | #263 | | | | | |
| LINE BEARING O-RING | #246 | | | | | | | #259 | | | | | |

### 3.5.3 **FRAME 3 - LIQUID END**

| ENGINEERING DATA | | 4FRBH183 | 8FRBH183 | 10FRBH183 | 6FRBH183 | 12FRBH183 | 14FRBH183 | 16FRBH183 | 6FRBH223 | 8FRBH223 | 18FRBH223 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **PUMP DATA** | | | | | | | | | | | | |
| SUCTION DIAMETER | mm (in.) | 203 (8) | 254 (10) | 305 (12) | 254 (10) | 356 (14) | 356 (14) | 406 (16) | 254 (10) | 305 (12) | 457 (18) | |
| DISCHARGE DIAMETER | mm (in.) | 102 (4) | 203 (8) | 254 (10) | 152 (6) | 305 (12) | 356 (14) | 406 (16) | 152 (6) | 203 (8) | 457 (18) | |
| CASING | C.I. mm (in.) | 16.0 (.63) | 20.8 (.82) | 20.8 (.82) | 17.5 (.69) | 19.0 (.75) | 20.8 (.82) | 20.8 (.82) | 19.0 (.75) | 20.8 (.82) | 17.3 (.68) | |
| THICKNESS (IN) | S.S. mm (in.) | 12.7 (.50) | 16.0 (.63) | 17.5 (.69) | 14.2 (.56) | 15.7 (.62) | 17.5 (.69) | 17.5 (.69) | 16.0 (.63) | 17.5 (.69) | 14.2 (.56) | |
| CASING TYPE | | SV | DV | | SV | DV-DUAL VOLUTE | | | SV | | DV | |
| GAUGE CONNECTION | | 1 / 2 NPT | | | | | | | | | | |
| DRAIN CONNECTION | | 3/4 | | 1 NPT | | 1 - 1 / 4 | | | 1 NPT | | 1.5 | |
| NO. OF VANCES | | 4 | | | | | 6 | 5 | 4 | | 5 | |
| IMPELLER EYE AREA | $cm^2$ ($in.^2$) | 200 (31.0) | 359 (55.6) | 426 (66.0) | 292 (45.2) | 755 (117) | 839 (130) | 1090 (169) | 352 (54.4) | 564 (87.4) | 1510 (234) | |
| MAX. SPHERE DIA. | mm (in.) | 27.9 (1.1) | 55.9 (2.2) | 68.6 (2.7) | 48.3 (1.9) | 96.5 (3.8) | 40.6( 1.6) | 40.6 (1.6) | 50.8 (2.0) | 61 (2.4) | 61 (2.4) | |
| $WK^2$ | kg x $m^2$ ( lb x $ft^2$) | 0.57 (13.6) | 1.01 (23.9) | 1.32 (31.3) | .83 (19.8) | .93 (22.0) | 1.57 (37.2) | 1.39 (33.0) | 1.64 (38.8) | 1.88 (44.5) | 3.91 (92.9) | |
| PUMP WT. | kg (lb.) | 602 (1328) | 820 (1808) | 992 (2188) | 644 (1420) | 816 (1800) | 903 (1990) | 1021 (2250) | 848 (1870) | 984 (2170) | 1429 (3150) | |
| MAX. BACK PULLOUT WT. | kg (lbs.) | 590 (1300) | | | | | | | | | | |
| IMPELLER AXIAL CLEARANCE | mm (in.) | .38 - .51 (.015 / .020) | | | | | | | | | | |
| MAXIMUM TEMPERATURE | NO COOLING | 121°C (250°F) | | | | | | | | | | |
| | WITH COOLING | 177°C (350°F) | | | | | | | | | | |
| **STUFFING BOX DATA** | | | | | | | | | | | | |
| O.D. SLEEVE | mm (in.) | 76.20 (3.000) | | | | 95.25 (3.750) | | | | | | |
| STUFFING BOX BORE | mm (in.) | 101.60 (4.000) | | | | 127.00 (5.000) | | | | | | |
| DEPTH OF BOX | mm (in.) | 99.06 (3.90) | | | | 122.2 (4.81) | | | | | | |
| PACKING SIZE | mm (in.) | 12.7 X 12.7 (1 /2 X 1 /2) | | | | 15.9 X 15.9 (5 / 8 X 5 / 8) | | | | | | |
| PACKING ARRANGEMENT | STD. | 2L3 | | | | | | | | | | |
| | ALT. | 3L2 | | | | | | | | | | |
| DISTANCE TO FIRST OBSTRUCTION | mm (in.) | 106.9 (4.21) | | | | | | | | | | |
| & B.C.D. FIRST OBSTRUCTION | mm (in.) | 3/4 UNC ON 196.9 BCD<br>3 / 4 UNC ON 7.75 BCD | | | | | | | | | | |

### 3.5.4 **FRAMES 3 - FRAME DETAILS**

| ENGINEERING DATA | 4FRBH183 | 8FRBH183 | 10FRBH183 | 6FRBH183 | 12FRBH183 | 14FRBH183 | 16FRBH183 | 6FRBH223 | 8FRBH223 | 18FRBH223 |
|---|---|---|---|---|---|---|---|---|---|---|
| **SHAFT AND BEARING DATA** | | | | | | | | | | |
| DIA. AT IMPELLER mm (in.) | 50.80 (2.000) | | | 69.85 (2.750) | | | | | | |
| DIA. UNDER SLEEVE mm (in.) | 66.68 (2.625) | | | 82.55 (3.250) | | | | | | |
| DIA. BETWEEN BEARINGS mm (in.) | 114.3 (4.50) | | | | | | | | | |
| DIA. AT COUPLING mm (in.) | 73.03 (2.875) | | | | | | | | | |
| LINE BEARING | 6320 | | | | | | | | | |
| THRUST BEARING | 7318 BUA | | | | | | | | | |
| BEARING SPAN mm (in.) | 293.4 (11.55) | | | | | | | | | |
| NOM. IMPELLER OVERHANG mm (in.) | 312.2 (12.29) | | | | | | | | | |
| B10 BEARING LIFE | MINIMUM 3 YEARS | | | | | | | | | |
| **BEARING SEALS** | | | | | | | | | | |
| THRUST BEARING LIP SEAL | NAT. 417191 | | | | | | | | | |
| LINE BEARING LIP SEAL | C / R 37389 NAT. 415379 | | | | | | | | | |
| THRUST BEARING O-RING | #269 | | | | | | | | | |
| LINE BEARING O-RING | #267 | | | | | | | | | |

### 3.5.5 FRAME 4 - LIQUID END

| ENGINEERING DATA | | | 12FRBH234 | 14FRBH244 | 16FRBH244 | 18FRBH224 | 20FRBH244 | 18FRBH274 | 20FRBH304 | 24FRBH304 |
|---|---|---|---|---|---|---|---|---|---|---|
| **PUMP DATA** | | | | | | | | | | |
| SUCTION DIAMETER | mm<br>(in.) | | 356<br>(14) | 508<br>(20) | 457<br>(18) | 457<br>(18) | 508<br>(20) | 457<br>(18) | 508<br>(20) | 610<br>(24) |
| DISCHARGE DIA | mm<br>(in.) | | 305<br>(12) | 356<br>(14) | 406<br>(16) | 457<br>(18) | 508<br>(20) | 457<br>(18) | 508<br>(20) | 610<br>(24) |
| CASING | C.I. mm<br>(in.) | | 19.0<br>(.75) | 19.0<br>(.75) | 19.0<br>(.75) | 17.3<br>(.68) | 22.4<br>(.88) | 22.4<br>(.88) | 22.4<br>(.88) | 25.4<br>(1.0) |
| THICKNESS | S.S. mm<br>(in.) | | 16.0<br>(.63) | 16.0<br>(.63) | 16.0<br>(.63) | 14.2<br>(.56) | 19.0<br>(.75) | 19.0<br>(.75) | 19.0<br>(.75) | 22.5<br>(.88) |
| CASING TYPE | | DV - DUAL VOLUTE | | | | | | | | |
| GAUGE CONNECTION | | 1 / 2 NPT | | | | | | | | |
| DRAIN CONNECTION | | | 3/4 | 1.5 | | | | | | |
| NO. OF VANES | | | 4 | 6 | | 5 | | | 7 | 7 |
| IMPELLER EYE AREA | $cm^2$<br>($in.^2$) | | 742<br>(115) | 1258<br>(195) | 2110<br>(327) | 1510<br>(234) | 1800<br>(279) | 1419<br>(220) | 1774<br>(275) | 1400<br>(217) |
| MAX. SPHERE DIA. | mm<br>(in.) | | 76.2<br>(3.0) | 53.3<br>(2.1) | 48.3<br>(1.9) | 61<br>(2.4) | 53.3<br>(2.1) | 68.6<br>(2.7) | 58.4<br>(2.3) | 65.8<br>(2.6) |
| $WK^2$ | kg x $m^2$<br>( lb x $ft^2$) | | 3.29<br>(78.1) | 4.89<br>(116) | 4.96<br>(118) | 4.0<br>(95.0) | 5.05<br>(120.0) | 5.91<br>(140) | 16.81<br>(399) | 19.13<br>(454) |
| PUMP WT. | kg<br>(lb.) | | 1247<br>(2750) | 1565<br>(3450) | 1653<br>(3645) | 1429<br>(3150) | 1669<br>(3680) | 2023<br>(4460) | 2517<br>(5550) | 2812<br>(6200) |
| MAX. BACK PULLOUT WT. | kg<br>(lbs.) | | 726<br>(1600) | | | | | 862<br>(1900) | | |
| IMPELLER AXIAL CLEARANCE | mm<br>(in.) | .38 - .51<br>(.015 - .020) | | | | | | | | |
| MAXIMUM TEMPERATURE | NO COOLING | 121°C<br>(250°F) | | | | | | | | |
| | WITH COOLING | 177°C<br>(350°F) | | | | | N/A | | | |
| **STUFFING BOX DATA** | | | | | | | | | | |
| O.D. SLEEVE | mm<br>(in.) | 120.65<br>(4.750) | | | | | | | | |
| STUFFING BOX BORE | mm<br>(in.) | 152.40<br>(6.000) | | | | | | | | |
| DEPTH OF BOX | mm<br>(in.) | 127<br>(5.0) | | | | | | | | |
| PACKING SIZE | mm<br>(in.) | 15.9 x 15.9<br>(5 / 8 X 5 / 8) | | | | | | | | |
| PACKING ARRANGEMENT | 2L3 | 2L3 | | | | | | | | |
| | 3L2 | 3L2 | | | | | | | | |
| DISTANCE TO FIRST OBSTRUCTION | mm<br>(in.) | 123.2<br>(4.85) | | | | | | | | |
| & B.C.D. FIRST OBSTRUCTION | mm<br>(in.) | 3 / 4 UNC ON 222.3 BCD<br>(3 / 4 UNC ON 8.75 BCD) | | | | | | | | |

### 3.5.6 **FRAMES 4 - FRAME DETAILS**

| ENGINEERING DATA | | 12FRBH234 | 14FRBH244 | 16FRBH244 | 18FRBH224 | 20FRBH244 | 18FRBH274 | 20FRBH304 | 24FRBH304 |
|---|---|---|---|---|---|---|---|---|---|
| **SHAFT AND BEARING DATA** | | | | | | | | | |
| DIA. AT IMPELLER | mm (in.) | 92.08 (3.625) | | | | | | | |
| DIA. UNDER SLEEVE | mm (in.) | 107.95 (4.250) | | | | | | | |
| DIA. BETWEEN BEARINGS | mm (in.) | 127.0 (5.00) | | | | | 146.1 (5.75) | | |
| DIA. AT COUPLING | mm (in.) | 98.43 (3.875) | | | | | | | |
| LINE BEARING | | 22222C | | | | | 22226C | | |
| THRUST BEARING | | 7322 BUA | | | | | | | |
| BEARING SPAN | mm (in.) | 279.0 (11.00) | | | | | 538.5 (21.20) | | |
| NOM. IMPELLER OVERHANG | mm (in.) | 347.0 (13.66) | | | | | | | |
| B10 BEARING LIFE | | MINIMUM 3 YEARS | | | | | | | |
| **BEARING SEALS** | | | | | | | | | |
| THRUST BEARING LIP SEAL | | NAT. 417511 | | | | | | | |
| LINE BEARING LIP SEAL | | C / R 37389 NAT. 415379 | | | | | C/R 42419 NAT. 416556 | | |
| THRUST BEARING O-RING | | #276 | | | | | | | |
| LINE BEARING O-RING | | #264 | | | | | #269 | | |

3.6 **Materials of Construction – liquid end**

| BASIC CONSTRUCTION | ALL IRON AIF | ALL 316 SS (SS) | IRON CASING SS FITTED (SSF) | CD4MCUN | 317L SS | WORTHITE W |
|---|---|---|---|---|---|---|
| CASING,STUFF BOX HD. AND WEAR PLATE | ASTM A48 CL35 | ASTM A743 CF8M | ASTM A48 CL35 | ASTM A890 CD4MCUN | ASTM A743 CG3M | ASTM A743 CN7MS |
| IMPELLER | ASTM A48 CL30 | ASTM A743 CF8M | ASTM A890 CD4MCUN | ASTM A890 CD4MCUN | ASTM A743 CG3M | ASTM A743 CN7MS |
| IMPELLER NUT | ASTM A890 CD4MCUN | ASTM A743 CG3M | ASTM A890 CD4MCUN | ASTM A890 CD4MCUN | ASTM A743 CG3M | ASTM A743 CN7MS |
| THROAT BUSHING | ASTM A890 CD4MCUN | ASTM A743 CF8M | ASTM A890 CD4MCUN | ASTM A890 CD4MCUN | ASTM A743 CG3M | ASTM A743 CN7MS |
| SHAFT SLEEVE | ASTM A743 CG3M * | ASTM A743 CG3M * | ASTM A743 CG3M * | ASTM A890 CD4MCUN | ASTM A743 CG8M * | ASTM A743 CN7MS |
| SHAFT | AISI 1045 | AISI 1045 | AISI 1045 | AISI 1045 | AISI 1045 | AISI 316 |
| GLAND HALVES | ASTM A890 CD4MCUN | ASTM A743 CF8M | ASTM A890 CD4MCUN | ASTM A890 CD4MCUN | ASTM A743 CN7M | ASTM A743 CN7MS |
| PIPE PLUGS (LIQUID END) | C.I. | AISI 316 | C.I. | A-20 | A-20 | A-20 |
| GLAND STUDS AND NUTS | AISI 316 | | | | | |
| IMPELLER KEY | AISI 316 | | | | | |
| WEAR PLATE STUDS & NUTS | AISI 316 | | | | | |
| PACKING | SYNTHETIC FIBRE | | | | | |
| SEAL CAGE HALVES | ASTM A743 CG8M | | | | | ASTM A743 CN7MS |
| GASKETS | SYNTHETIC FIBRE | | | | | |
| O-RINGS (LIQUID END) | BUNA-N ( 120º C MAX.)** | | | | | |
| MISC. FASTNERS, PARTS | STEEL | | | | | |

* Nickel-Chrome-Boron Coated, except for units with mechanical seals.
** Viton will be used for all applications operating above 120ºC.

# 4 INSTALLATION

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

### 4.1 Location

The pump should be located to allow room for access, ventilation, maintenance and inspection with ample headroom for lifting and should be as close as practicable to the supply of liquid to be pumped. Allow sufficient room to facilitate the back pull-out feature on V-belt driven units.

Refer to the general arrangement drawing for the pump set.

### 4.2 Part assemblies

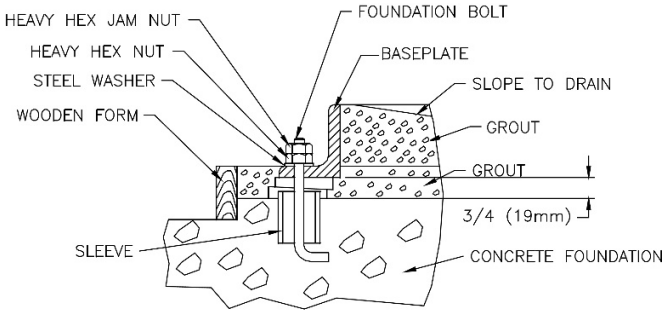
Motors may be supplied loose on FRBH pumps, typically on frame sizes 400 and above. It is the responsibility of the installer to ensure that the motor is assembled to the pump and lined up as detailed in section 4.5.2.

### 4.3 Foundation

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

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

### 4.4 Baseplate installation




#### 4.4.1 Grouted baseplates

Position the baseplate and pump next to the foundation and clean the foundation surface thoroughly. Remove the rag packing from the pipe sleeves and place wedges or shims as close to the foundation bolts as possible. These may be omitted if a jacking nut on the foundation anchor bolts is preferred for levelling. Initial levelling should be within 0.75 mm (.030 inches).

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

Lift the baseplate assembly, remove the shipping skids and clean the underside of the baseplate. Position the baseplate over the foundation and lower the unit over the foundation bolts and onto the wedges, shims or jacking nuts. Larger bases may be equipped with levelling screws.

a) Level the pump baseplate assembly. If the baseplate has machined coplanar mounting surfaces, these machined surfaces are to be referenced when leveling the baseplate. This may require that the pump and motor be removed from the baseplate in order to reference the machined faces. If the baseplate is without machined coplanar mounting surfaces, the pump and motor are to be left on the baseplate. The proper surfaces to reference when leveling the pump baseplate assembly are the pump suction and discharge flanges. DO NOT stress the baseplate.

b) Do not bolt the suction or discharge flanges of the pump to the piping until the baseplate foundation is completely installed. If equipped, use leveling jackscrews to level the baseplate. If jackscrews are not provided, shims and wedges should be used. (See Figure 4-5.) Check for

levelness in both the longitudinal and lateral directions. Shims should be placed at all base anchor bolt locations. Do not rely on the bottom of the baseplate to be flat. Standard baseplate bottoms are not machined and it is not likely that the field mounting surface is flat.

c) After leveling the baseplate, tighten the anchor bolts. If shims were used, make sure that the baseplate was shimmed near each anchor bolt before tightening. Failure to do this may result in a twist of the baseplate, which could make it impossible to obtain final alignment.

d) Check the level of the baseplate to make sure that tightening the anchor bolts did not disturb the level of the baseplate. If the anchor bolts did change the level, adjust the jackscrews or shims as needed to level the baseplate.

e) Continue adjusting the jackscrews or shims and tightening the anchor bolts until the baseplate is level.

f) Check initial alignment. If the pump and motor were removed from the baseplate proceed with step g) first, then the pump and motor should be reinstalled onto the baseplate using Flowserve's factory preliminary alignment procedure as described in section 4.5, and then continue with the following. As described above, pumps are given a preliminary alignment at the factory. This preliminary alignment is done in a way that ensures that, if the installer duplicates the factory conditions, there will be sufficient clearance between the motor hold down bolts and motor foot holes to move the motor into final alignment. If the pump and motor were properly reinstalled to the baseplate or if they were not removed from the baseplate and there has been no transit damage, and also if the above steps where done properly, the pump and driver should be within 0.38 mm (0.015 in.) FIM (Full Indicator Movement) parallel, and 2.5 mm/m (0.0025 in./in.) FIM angular. If this is not the case, first check to see if the driver mounting fasteners are centered in the driver feet holes. If not, re-center the fasteners and perform a preliminary alignment to the above tolerances by shimming under the motor for vertical alignment, and by moving the pump for horizontal alignment.

g) Grout the baseplate. A non-shrinking grout should be used. Make sure that the grout fills the area under the baseplate. After the grout has cured, check for voids and repair them. Jackscrews, shims and wedges should be removed from under the baseplate at this time. If they were to be left in place, they could rust, swell, and cause distortion in the baseplate. Refer to section 4.6.

h) Run piping to the suction and discharge of the pump. There should be no piping loads transmitted to the pump after connection is made. Recheck the alignment to verify that there are no significant loads.

Check the impeller axial clearance and that the rotor turns freely by hand.

**Note: Grout is not poured until base plate has been levelled and initial alignment of the pump and driver has been performed.**

4.4.2 **Spring Mounted Baseplate**

Note: **The term isolator and springs or spring assemblies may be used interchangeably through this document. The supplier designates the assembly as the isolator which consists of several components, one of which is the spring itself.**

Foundation requirements: The foundation for spring mounted baseplates must be flat and smooth to ensure proper setting of the springs. It is not necessary to have the area levelling to within tight tolerance but the flatter the better. It is recommended that the maximum variation should be less than ¼" otherwise spring loading and pump levelling may not be achieved and operation of equipment could be affected. Some shimming may be permitted but it is not recommended.

4.4.2.1 When the pump equipment is received, it should be placed on a flat surface such as the foundation where the pump will be installed. Shipping and handling may have distorted the base, so initial levelling will be needed. Ensure that the driver pads are level to the pump pads. Since the bottom of the base is not machined shims and blocks must be fitted under the edge of the base in the areas of the spring pads. Levelling the base will be the same as if the base is being installed in more traditional methods. It is recommended that the motor and pump pads be flat and level within 0.16mm/m [0.002"/ft] otherwise a soft foot condition could exist.

4.4.2.2 The base is designed to be filled with grout to ensure adequate mass, inertia and stiffness. It is important that step 1 be completed prior to filling base with grout as levelling the pads can not be completed after baseplate has been grouted.

4.4.2.3 Fill the baseplate with grout noting that the weight of grout has been estimated and is shown on the pump general arrangement. It is recommended that the mass be within +/- 2% of that shown. Generally, more mass will not be detrimental to the design but could mean the nominal spring compression may be more. The springs have been designed for a certain amount of deflection but the springs do have and will require adjustment. This will be discussed later.

4.4.2.4 Allow the grout to harden. Drying time required will be specified by the concrete/grout supplier.

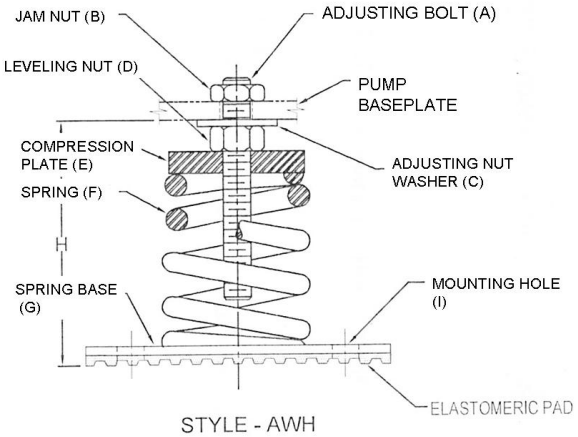
4.4.2.5 If base plate in rough position it will be necessary to move so that springs can be mounted. The followings steps to mount the springs have been provided by the isolator (spring) manufacturer (VMC) and adapted to Flowserve's pumps.

4.4.2.6 Isolators are shipped fully assembled and are to be placed and arranged in accordance with the installation (general arrangement) drawing.

4.4.2.7 Set isolators on the floor/foundation or sub-base, ensuring that all isolator centerlines match equipment mounting holes.

4.4.2.8 In most cases the isolators will be same model and size. If multiple sizes of isolators are to be used the detail and pattern will be shown on the pump's general arrangement drawing. Each isolator should be tagged and labelled. The springs themselves are color coded for easy identification.

4.4.2.9 Remove jam nut "B" from the adjusting bolt "A", turn adjusting nut "D" to adjust to set distance from top of adjusting bolt to adjusting washer "C" to 2". The working height "H" for this installation will roughly as shown on the general arrangement drawing. The spring will be compressed when loaded but some levelling/adjustment of item "E" will be required.



STYLE - AWH

4.4.2.10
Position equipment/pump base assembly over isolators and lower onto the adjusting nut washer "C".

4.4.2.11
Reassemble jam nut "B" but do not tighten.

4.4.2.12
Install motor in approximate position in order to have springs compressed in near to final state

4.4.2.13
The spring is welded to the base plate "G" and the compression plate "E" is threaded. To adjust the level turn the adjusting nut "D" to achieve the design height as shown on the general arrangement drawing and equipment level.

4.4.2.14
The isolators are equipped with mounting holes so that they may be fastened into position. Once equipment has been properly positioned in the installation, the holes may be marked. Each spring element may be removed one at a time to drill for lag screws. It is suggested that the complete assembly may be removed to provide better access. It is recommended that the driver be removed separately. If an individual isolator is being removed it is advised that a block or shim be placed under the base to maintain stability without overloading other elements.

4.4.2.15
Once the isolator has been secured the base assembly and driver may be reinstalled. Final levelling can take place once all equipment is mounted.

4.4.2.16
All flexible equipment connections (ie piping, flush lines and electrical conduits) can now be connected.

4.4.2.17
The coupling spacer is the last item to be installed followed by the protective guard.

**Note: other sections in the user manual deal with alignment and pump start-up procedures.**

## 4.5 Initial alignment

The purpose of factory alignment is to ensure that the user will have sufficient clearance in the motor holes for final job-site alignment. To achieve this, the factory has designed the mounting holes with additional clearance to allow the pump to be aligned

in the horizontal plane to the motor, There should be at least 1/16 clearance around the bolt. The coupling has been designed to have some overhang of the coupling hub (in most cases 1 or both hubs may be overhung between 0.0 and 3 mm (0 and 0.12 in) unless otherwise stated. This procedure ensures that there is sufficient clearance in the motor holes for the customer to field align the motor to the pump, to zero tolerance. This philosophy requires that the customer be able to place the base in the same condition as the factory. Thus, the factory alignment will be done with the base sitting in an unrestrained condition on a flat and level surface. This standard also emphasizes the need to ensure the shaft spacing is adequate to accept the specified coupling spacer.

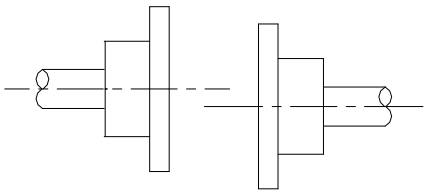
The factory alignment procedure is summarized below:

a) The baseplate is placed on a flat and level workbench in a free and unstressed position.
b) The baseplate is leveled as necessary. Leveling is accomplished by placing shims under the rails of the base at the appropriate anchor bolt hole locations. Levelness is checked in both the longitudinal and lateral directions.
c) The pump is put onto the baseplate, aligned and leveled. The rear foot piece under the bearing housing is adjusted as necessary by adding or removing shims [3126.1] between the foot piece and the bearing housing or at the baseplate.
d) The motor and appropriate motor mounting hardware is placed on the baseplate and the motor is checked for any planar soft-foot condition. If any is present it is eliminated by shimming.
e) The motor is fastened in place by tightening two diagonal motor mounting bolts.
f) The spacer coupling gap is verified. As indicated the gap may be adjusted to ensure adequate axial bolt clearance.
g) The parallel and angular vertical alignment is made by shimming under the motor.
h) The pump and motor shafts are then aligned horizontally, both parallel and angular, by moving the pump to the fixed motor. The pump feet are tightened down.
i) Both horizontal and vertical alignment is again final checked as is the coupling spacer gap.

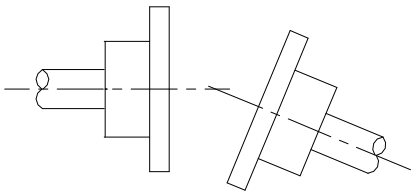
See section 4.8, *Final shaft alignment*.

### 4.5.1 Thermal expansion

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



PARALLEL MISALIGNMENT– Shafts with axis parallel but not concentric



ANGULAR MISSALIGNMENT – Shafts with axis concentric but not parallel.

### 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 Direct Driven Units:

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

A flexible coupling is used to compensate for slight changes in alignment that occur during normal operation and is not used to correct for installation errors. Install the pump and driver half couplings in accordance with the coupling manufacturer's instructions. Note that the coupling hub faces are not always mounted flush with the ends of the shafts. Place the driver on the baseplate such that the correct spacing is obtained between the two half couplings. In the case of electric motors, such as those with sleeve bearings, it may be necessary to

run the motor to establish the rotor magnetic center. Consult the manufacturer's instruction manual for details.

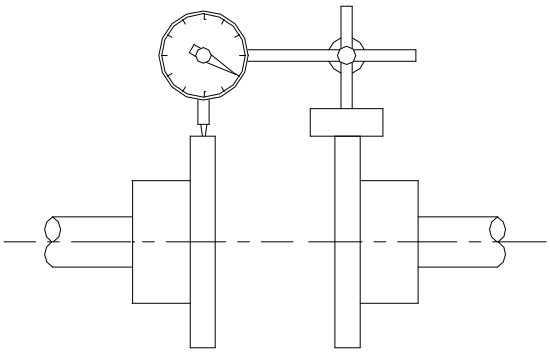
The purpose of the alignment procedure is to ensure that the pump and driver shafts are in parallel and angular alignment under the normal operating conditions of load and temperature.

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

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

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

### 4.5.3 **Parallel Alignment:**



CHECKING PARALLEL MISALIGNMENT

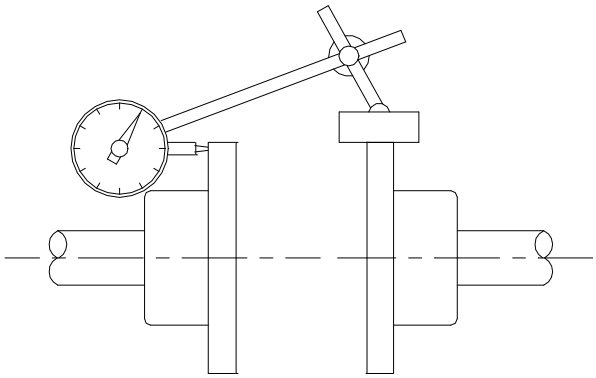
Mount the magnetic base on the pump half coupling hub, either the face or O.D. as shown in the sketch. Place the dial indicator button on the outside diameter of the driver half coupling hub.

**Note:** The length of extension rods should be kept at a minimum to reduce deflection.

Rotate the pump shaft and record the dial reading at the top, bottom and each side. Correct the parallel alignment by adding or removing shims under the driver and/or moving the driver horizontally. Repeat this procedure until the maximum total indicator reading (T.I.R.) is within 0.08 mm (0.003 inch.)

### 4.5.4 **Angular Alignment:**

Mount the magnetic base mounted on the pump half coupling hub, either face or O.D. as shown. Move the dial indicator button to indicate on the face of the driver half coupling hub as close to the outside diameter as possible. When convenient the indicator can be placed on the inside face to keep spans short. Turn both shafts 360° and record the dial readings at 90° intervals. Adjust the shims under the motor as required and repeat the procedure until the angular alignment is within 0.0005 mm (T.I.R.) per mm (0.0005 inch per inch) of maximum hub diameter.



CHECKING ANGULAR MISALIGNMENT

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

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

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

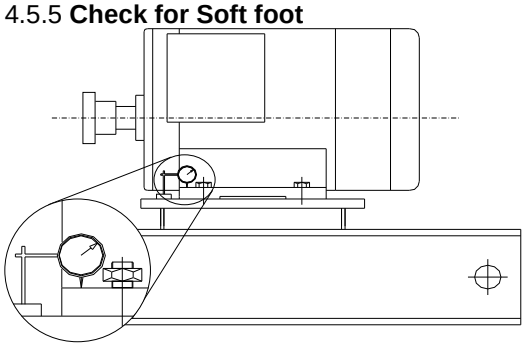
When the electric motor has sleeve bearings it is necessary to ensure that the motor is aligned to run

on its magnetic centerline. 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 sections 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.

4.5.5 **Check for Soft foot**

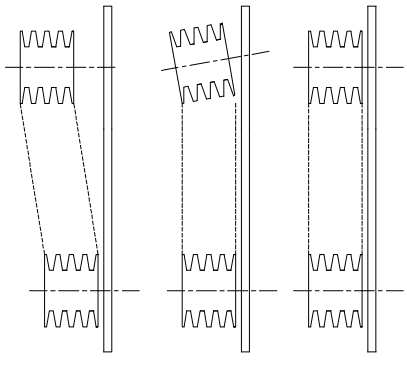


This is a check to ensure that there is no undue stress on the driver holding down bolts; due to non-level baseplate or twisting. To check, remove all shims and clean surfaces and tighten down driver to the baseplate. Set a dial indicator as shown in sketch and loosen off the holding down bolt while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

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

4.5.6 **V-Belt Drive Units:**

Check that both sheaves are free of grease, rust, nicks or burrs. Install the correct size sheave on the pump shaft and locate the sheave axially to minimize overhang. Re-check the impeller axial clearance and ensure that the pump is properly secured to the baseplate. Install the driver on the adjustable base provided and install the driver sheave in line with the pump sheave. Ensure that the sheaves are tight on the shafts. With a dial indicator, check the runout on the periphery and face of each sheave to ensure that each is running true. Tighten the adjustable base and check that the driver rotation in the correct direction and that vibration levels are not unacceptable.




CHECKING V–BELT SHEAVE ALIGNMENT

Checking V-Belt Sheave Alignment:

CAUTION Before starting the driver, refer to the manufacturer's instruction manual. The correct rotation of the pump shaft is marked on the pump casing or frame.

Check that all belts making up one drive set have matched code numbers. Loosen the adjustable base and install the belts in their proper grooves. Adjust the center distance between the sheaves to obtain proper belt tension. Check the alignment of the pump and driver sheaves with a taught string or straight edge. For proper alignment and the sheave faces must be parallel to each other and in line. Adjustments are made by slackening the belts, moving and retightening the drive or driver sheave, and repeating the above procedure.

When the sheaves are aligned, check that the shafts rotate freely by hand and install safety guard.

Belt drives must not be used in ATEX Potentially explosive environments; refer to Flowserve.

4.6 **Grouting**

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

Clean the roughed foundation surface and build a wooden form around the baseplate. For initial grouting forms should be placed to isolate shims and levelling nuts. The foundation surface should be thoroughly saturated with water before grouting. A typical mixture for grouting-in a pump base is composed of one part pure Portland cement and two parts of clean building sand with sufficient water to provide the proper consistency. The grout should flow freely but not be so wet as to cause the sand and cement to separate.

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

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

## 4.7 Piping

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

### 4.7.1 Suction and discharge pipework

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

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

CAUTION **Never use the pump as a support for piping.**

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

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

The table in 4.7.2 summarizes the maximum forces and moments allowed on FRBH pump casings. Refer to Flowserve for other configurations.

CAUTION Ensure piping and fittings are flushed before use.

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

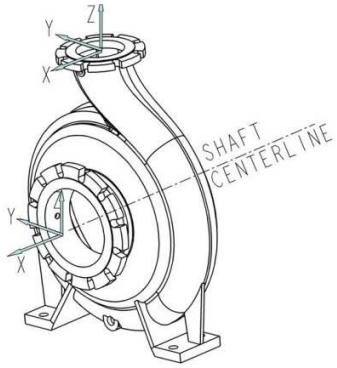
### 4.7.2 Maximum forces and moments allowed on FRBH pump flanges

**Introduction:** API 610 has been used as a reference for these pumps to establish the allowable forces and moments. Typically, values are 1X API. The values shown in the table 4.7.2.2 are based on pumps mounted on grouted baseplates. These values should be factored based on material of construction and temperature. The table 4.7.2.1 has been adopted using data from ANSI/HI 9.6.2.6.

**Table 4.7.2.1: Casing Material Correction Factors**

| | | Material Group No. | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1.0 | 2.2 | 2.8 | 3.8 | 3.17 | Ti |
| Temp. °C | Temp °F | CI/DI | 316/317L | CD4MCUN | Hast. C | Worth/A20 | Titanium |
| -29 | -20 | 0.89 | 1.00 | 1.00 | 1.00 | 0.83 | 0.89 |
| 38 | 100 | 0.89 | 1.00 | 1.00 | 1.00 | 0.83 | 0.89 |
| 93 | 200 | 0.78 | 0.86 | 1.00 | 1.00 | 0.72 | 0.86 |
| 150 | 300 | 0.73 | 0.78 | 0.92 | 1.00 | 0.65 | 0.81 |

### 4.7.2.2 **Maximum forces and moments allowed on FRBH pump flanges**




Maximum forces (F) in N (lbf) and moments (M) in Nm (lbf•ft)

| Pump Size | Suction | | | | | | Discharge | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mx | My | Mz | Fx | Fy | Fz | Mx | My | Mz | Fx | Fy | Fz |
| 2FRBH121 | 950 (700) | 470 (350) | 720 (530) | 1330 (300) | 1070 (240) | 580 (130) | 460 (340) | 230 (170) | 350 (260) | 710 (160) | 580 (130) | 890 (200) |
| 3FRBH121 | 1330 (980) | 680 (500) | 1000 (740) | 1780 (400) | 1420 (320) | 1160 (260) | 950 (700) | 470 (350) | 720 (530) | 1070 (240) | 890 (200) | 1330 (300) |
| 3FRBH101 | 1330 (980) | 680 (500) | 1000 (740) | 1780 (400) | 1420 (320) | 1160 (260) | 950 (700) | 470 (350) | 720 (530) | 1070 (240) | 890 (200) | 1330 (300) |
| 4FRBH111 | 2300 (1700) | 1180 (870) | 1760 (1300) | 3110 (700) | 2490 (560) | 2050 (460) | 1330 (980) | 680 (500) | 1000 (740) | 1420 (320) | 1160 (260) | 1780 (400) |
| 6FRBH111 | 3530 (2600) | 1760 (1300) | 2580 (1900) | 4890 (1100) | 3780 (850) | 3110 (700) | 2300 (1700) | 1180 (870) | 1780 (1300) | 2490 (560) | 2050 (460) | 3110 (700) |
| 3FRBH141 | 2300 (1700) | 1180 (870) | 1760 (1300) | 3110 (700) | 2490 (560) | 2050 (460) | 950 (700) | 470 (350) | 720 (530) | 1070 (240) | 890 (200) | 1330 (300) |
| 4FRBH141 | 2300 (1700) | 1180 (870) | 1760 (1300) | 3110 (700) | 2490 (560) | 2050 (460) | 1330 (980) | 680 (500) | 1000 (740) | 1420 (320) | 1160 (260) | 1780 (400) |
| 6FRBH142 | 3530 (2600) | 1760 (1300) | 2580 (1900) | 4890 (1100) | 3780 (850) | 3110 (700) | 2300 (1700) | 1180 (870) | 1780 (1300) | 2490 (560) | 2050 (460) | 3110 (700) |
| 8FRBH152 | 5020 (3700) | 2440 (1800) | 3800 (2800) | 6670 (1500) | 5340 (1200) | 4450 (1000) | 3530 (2600) | 1760 (1300) | 2580 (1900) | 3780 (850) | 3110 (700) | 4890 (1100) |
| 3FRBH182 | 2300 (1700) | 1180 (870) | 1760 (1300) | 3110 (700) | 2490 (560) | 2050 (460) | 950 (700) | 470 (350) | 720 (530) | 1070 (240) | 890 (200) | 1330 (300) |
| 4FRBH182/3 | 3530 (2600) | 1760 (1300) | 2580 (1900) | 4890 (1100) | 3780 (850) | 3110 (700) | 1330 (980) | 680 (500) | 1000 (740) | 1420 (320) | 1160 (260) | 1780 (400) |
| 8FRBH182/3 | 5020 (3700) | 2440 (1800) | 3800 (2800) | 6670 (1500) | 5340 (1200) | 4450 (1000) | 3530 (2600) | 1760 (1300) | 2580 (1900) | 3780 (850) | 3110 (700) | 4890 (1100) |
| 10FRBH182/3 | 6100 (4500) | 2980 (2200) | 4610 (3400) | 8000 (1800) | 6670 (1500) | 5340 (1200) | 5020 (3700) | 2440 (1800) | 3800 (2800) | 5340 (1200) | 4450 (1000) | 6670 (1500) |
| 6FRBH183 | 5020 (3700) | 2440 (1800) | 3800 (2800) | 6670 (1500) | 5340 (1200) | 4450 (1000) | 2300 (1700) | 1180 (870) | 1780 (1300) | 2490 (560) | 2050 (460) | 3110 (700) |
| 12FRBH183 | 6370 (4700) | 3120 (2300) | 4750 (3500) | 8900 (2000) | 7120 (1600) | 5780 (1300) | 6100 (4500) | 2980 (2200) | 4610 (3400) | 6670 (1500) | 5340 (1200) | 8000 (1800) |
| 14FRBH183 | 6370 (4700) | 3120 (2300) | 4750 (3500) | 8900 (2000) | 7120 (1600) | 5780 (1300) | 6370 (4700) | 3120 (2300) | 4750 (3500) | 7120 (1600) | 5780 (1300) | 8900 (2000) |
| 16FRBH183 | 7320 (5400) | 3660 (2700) | 5420 (4000) | 10230 (2300) | 8450 (1900) | 6670 (1500) | 7320 (5400) | 3660 (2700) | 5420 (4000) | 8450 (1900) | 6670 (1500) | 10230 (2300) |
| 6FRBH223 | 5020 (3700) | 2440 (1800) | 3800 (2800) | 6670 (1500) | 5340 (1200) | 4450 (1000) | 2300 (1700) | 1180 (870) | 1780 (1300) | 2490 (560) | 2050 (460) | 3110 (700) |
| 8FRBH223 | 6100 (4500) | 2980 (2200) | 4610 (3400) | 8000 (1800) | 6670 (1500) | 5340 (1200) | 3530 (2600) | 1760 (1300) | 2580 (1900) | 3780 (850) | 3110 (700) | 4890 (1100) |
| 18FRBH223/4 | 8200 (6050) | 4200 (3100) | 6100 (4500) | 11570 (2600) | 9650 (2170) | 7560 (1700) | 8200 (6050) | 4200 (3100) | 6100 (4500) | 9610 (2160) | 7560 (1700) | 11570 (2600) |
| 12FRBH234 | 6370 (4700) | 3120 (2300) | 4750 (3500) | 8900 (2000) | 7120 (1600) | 5780 (1300) | 6100 (4500) | 2980 (2200) | 4610 (3400) | 6670 (1500) | 5340 (1200) | 8000 (1800) |
| 14FRBH244 | 7320 (5400) | 3660 (2700) | 5420 (4000) | 10230 (2300) | 8450 (1900) | 6670 (1500) | 6370 (4700) | 3120 (2300) | 4750 (3500) | 7120 (1600) | 5780 (1300) | 8900 (2000) |

| | Suction | | | | | | Discharge | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 16FRBH244 | 8200 (6050) | 4200 (3100) | 6100 (4500) | 11570 (2600) | 9650 (2170) | 7560 (1700) | 7320 (5400) | 3660 (2700) | 5420 (4000) | 8450 (1900) | 6670 (1500) | 10230 (2300) |
| 18FRBH274 | 8200 (6050) | 4200 (3100) | 6100 (4500) | 11570 (2600) | 9650 (2170) | 7560 (1700) | 8200 (6050) | 4200 (3100) | 6100 (4500) | 9610 (2160) | 7560 (1700) | 11570 (2600) |
| 20FRBH304 | 9080 (6700) | 4750 (3500) | 6780 (5000) | 12900 (2900) | 10720 (2410) | 8450 (1900) | 9080 (6700) | 4750 (3500) | 6780 (5000) | 10760 (2420) | 8450 (1900) | 12900 (2900) |
| 24FRBH304 | 10850 (8000) | 5830 (4300) | 8130 (6000) | 15480 (3480) | 13120 (2950) | 10230 (2300) | 10850 (8000) | 5830 (4300) | 8130 (6000) | 13080 (2940) | 10230 (2300) | 15660 (3520) |

**Notes:**

1) F = External force (tension or compression) M = External moment, clockwise or counter-clockwise
2) Forces and moments may be applied simultaneously in any direction
3) Values apply to all materials
4) Higher loads may be applicable, if direction and magnitude of individual loads are known, but these need written approval from Flowserve
5) Pumps must be on rigid foundations and baseplates must be fully grouted
6) Pump/baseplate should not used as pipe anchor. Expansion joints must be properly tied
7) The pump mounting bolt torques specified must be used to prevent relative movement between the pump casing and baseplate. (See section 6.6, *Fastener torques*.) The bolt material must have a minimum yield strength of 600 $N/mm^2$ (87 000 $lb/in.^2$)

4.7.3 **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 a radius as possible.
b) Pipework reducers should have a maximum total angle of divergence of 15 degrees.
c) On suction lift the piping should be inclined up towards the pump inlet with eccentric reducers incorporated to prevent air locks.
d) On positive suction, the inlet piping must have a constant fall towards the pump.
e) Flow should enter the pump suction with uniform flow, to minimize noise and wear. This is particularly important on large or high-speed pumps that should have a minimum of four diameters of straight pipe on the pump suction between the elbow and inlet flange. See section 10.3, *Reference 1* for more detail.
f) Inlet strainers, when used, should have a net `free area' of at least three times the inlet pipe area.
g) Do not install elbows at an angle other than perpendicular to the shaft axis. Elbows parallel to the shaft axis will cause uneven flow.
h) Except in unusual circumstances strainers are not recommended in inlet piping. If considerable foreign matter is expected a screen installed at the entrance to the wet well is preferable.
i) Fitting an isolation valve will allow easier maintenance.
j) Never throttle pump on suction side and never place a valve directly on the pump inlet nozzle.

4.7.4 **Discharge piping**

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

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

4.7.5 **Auxiliary piping**

4.7.5.1 ***Drains***

Pipe pump casing drains and gland leakage to a convenient disposal point.

4.7.5.2 ***Pumps fitted with gland packing***

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

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

*4.7.5.3* ***Pumps fitted with mechanical seals***

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

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

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

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

4.7.6 **Final checks**

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

4.8 **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.

The baseplate should be levelled and grouted by this stage.

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

a) Mount and level pump if appropriate. Level the pump by putting a level on the discharge flange. It may be necessary to adjust the bearing frame foot by adding or deleting shims [3126.1] between the foot piece and the bearing housing (or baseplate) .
b) Check initial alignment. If pump and driver have been remounted or the specifications given below are not met, perform an initial alignment as described in section 4.5. This ensures there will be sufficient clearance between the motor hold down bolts and motor foot holes to move

the motor into final alignment. The pump and driver should be within 0.38 mm (0.015 in.) FIM (full indicator movement) parallel, and 2.5 mm/m (0.0025 in./in.) FIM angular.

c) Run piping to the suction and discharge to the pump. There should be no piping loads transmitted to the pump after connection is made. Recheck the alignment to verify that there are no significant changes.

d) Perform final alignment. Check for soft-foot under the driver. An indicator placed on the coupling, reading in the vertical direction, should not indicate more than 0.05 mm (0.002 in.) movement when any driver fastener is loosened. Align the driver first in the vertical direction by shimming underneath its feet.

e) When satisfactory alignment is obtained the number of shims in the pack should be minimized. It is recommended that no more than five shims be used under any foot. Final horizontal alignment is made by moving the driver. Maximum pump reliability is obtained by having near perfect alignment. Flowserve recommends no more than 0.05 mm (0.002 in.) parallel, and 0.5 mm/m (0.0005 in./in.) angular misalignment. (See section 6.9.6)

f) Operate the pump for at least an hour or until it reaches final operating temperature. Shut the pump down and recheck alignment while the pump is hot. Piping thermal expansion may change the alignment. Realign pump as necessary.

## 4.9 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.

4.9.4 **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.

## 4.10 Protection systems

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

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

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

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

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

# 5 COMMISSIONING, START-UP, OPERATION AND SHUTDOWN

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

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

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

## 5.1 Pre-Commissioning procedure

### 5.1.1 Lubrication Methods

Determine the mode of lubrication of the pump set: grease, oil, product lubrication etc.

CAUTION For oil bath lubricated pumps, fill the bearing housing with correct grade of oil to the correct level; validate by sight glass or constant level oiler bottle.

### 5.1.2 Oil Bath Lubrication

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

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

Approximate oil volumes are shown in section 5.2.3, *Recommended Fill Capacities*.

### 5.1.3 Grease Lubrication

Grease lubricated pumps and electric motors are supplied pre-greased.

### 5.1.4 Oil Mist Lubrication

FRBH pumps may be lubricated by pure or purge oil mist. See comments below.

#### 5.1.4.1 *Purge Mist*

In the case of purge mist an oil level is maintained in the bearing frame. No changes are required to be made to the pump, however, the oil level must be maintained at site glass center. Excess oil must be removed. Oil is injected outboard of each bearing.

#### *5.1.4.2 Pure Oil Mist*

In this method all oil is drained from the oil sump, this is sometimes referred to as a dry sump. Oil is injected outboard at each bearing. To use this method some modifications must be made to the pump. If pumps are shipped for standard oil or grease lubrication the pumps must be dismantled and reworked. All oil return grooves that permit movement of oil from outboard of each bearing back to the sump must be block. These passages may be blocked using epoxy filler or other compounds compatible with the mist oil. Pressure inside the center of the bearing frame must be controlled to 25mm (1”) $H_2O$ or less. Pressures greater than this may result in excessive venting of oil through outboard seals and could result in bearing failure as mist is not forced through the bearing. It is recommended that mist system operate for 24 hrs before starting of the pump to ensure bearing surfaces have been properly misted. Testing completed has used an oil viscosity of 100 Cst. For additional information refer to TR-3326, Pure Oil Mist lubrication of FRBH and R/M Slurry Pumps.

## 5.2 Pump lubricants

### 5.2.1 Recommended oil lubricants

| | Oil | Splash lubrication | | Force feed lubrication |
|---|---|---|---|---|
| Centifugal pump lubrication | Viscosity mm ²/s 40 ºC | 32 | 68 | 46 |
| | Temp. maximum ºC (ºF) | 65 (149) | 80 (176) | - |
| | Designation according to DIN51502 ISO VG | HL/HLP 32 | HL/HLP 68 | HL/HLP 46 |
| Oil companies and lubricants | **BP** | BP Energol HL32<br>BP Energol HLP32 | BP Energol HL68<br>BP Energol HLP68 | BP Energol HL46<br>BP Energol HLP46 |
| | **DEA** | Anstron HL32<br>Anstron HLP32 | Anstron HL68<br>Anstron HLP68 | Anstron HL46<br>Anstron HLP46 |
| | **Elf** | OLNA 32<br>HYDRELEF 32<br>TURBELF 32<br>ELFOLNA DS32 | TURBELF SA68<br><br>ELFOLNA DS68 | TURBELF SA46<br><br>ELFOLNA DS46 |
| | **Esso** | TERESSO 32<br>NUTO H32 | TERESSO 68<br>NUTO H68 | TERESSO 46<br>NUTO H46 |
| | **Mobil** | Mobil DTE oil light<br>Mobil DTE13<br>MobilDTE24 | Mobil DTE oil heavy medium<br><br>Mobil DTE26 | Mobil DTE oil medium<br>Mobil DTE15M<br>Mobil DTE25 |
| | **Q8** | Q8 Verdi 32<br>Q8 Haydn 32 | Q8 Verdi 68<br>Q8 Haydn 68 | Q8 Verdi 46<br>Q8 Haydn 46 |
| | **Shell** | Shell Tellus 32<br>Shell Tellus 37 | Shell Tellus 01 C 68<br>Shell Tellus 01 68 | Shell Tellus 01 C 46<br>Shell Tellus 01 46 |
| | **Texaco** | Rando Oil HD 32<br>Rando Oil HD-AZ-32 | Rando Oil 68<br>Rando Oil HD C-68 | Rando Oil 46<br>Rando Oil HD B-46 |
| | **Wintershall (BASF Group)** | Wiolan HN32<br>Wiolan HS32 | Wiolan HN68<br>Wiolan HS68 | Wiolan HN46<br>Wiolan HS46 |

### 5.2.2 Recommended grease lubricants

| Grease | Grease nipples | |
|---|---|---|
| | **NLGI 2 *** | **NLGI 3 **** |
| Temp. range ºC (ºF) | -20 to +100<br>(-4 to +212) | -20 to +100<br>(-4 to +212) |
| Designation according to DIN | K2K-20 | K2K 30 |
| **BP** | Energrease LS2 | Energrease LS3 |
| **DEA** | Glissando 20 | Glissando 30 |
| **Elf** | Elfmulti 2 | Elfmulti 3 |
| **Esso** | Beacon 2 | Beacon 3 |
| **Mobil** | Mobilux 2 | Mobilux 3 |
| **Q8** | Rembrandt 2 | Rembrandt 3 |
| **Shell** | Alvania Fett G2<br>Alvania Fett R2 | Alvania R3 |
| **Texaco** | Multilak 20<br>Multilak EP2 | Multilak 30<br>Multilak EP3 |
| **Wintershall (BASF Group)** | Wiolub LFK 2 | - |
| **SKF** | LGMT 2 | LGMT 3 |
| **Silkolene** | G55/T | G56/T |

* NLGI 2 is an alternative grease and is not to be mixed with other grades

** Factory packed bearings for the temperature range with grease nipples

### 5.2.3 Recommended fill quantities

**TABLE 5.2.3 OIL AND GREASE QUANTITIES**

| BEARING FRAME SIZE NO. | *OIL SUMP CAPACITY* | | INITIAL GREASE CAPACITIES | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | THRUST BEARING | | | LINE BEARING | | |
| | U.S. GAL. | LITRES | OZ. | CU. IN. | CU. CM. | OZ. | CU. IN. | CU. CM. |
| 1 | 0.4 | 1.5 | 6 | 7.3 | 120 | 10 | 12.1 | 200 |
| 2 | 0.9 | 3.5 | 18 | 22.0 | 361 | 19 | 23.2 | 380 |
| 3 | 1.3 | 5.0 | 34 | 41.5 | 680 | 28 | 34.1 | 559 |
| 4 | 1.5 | 6.0 | 36 | 56.1 | 917 | 31 | 37.8 | 620 |

### 5.2.4 CAUTION 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.

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

5.2.4.2 ***Grease lubricated bearings***

When grease nipples are fitted, one charge between grease changes is advisable for most operating conditions; 2 000 hours interval. See 6.2.3.1 for additional information.

Normal intervals between grease changes are 4 000 hours or at least every 6 months.
The characteristics of the installation and severity of service will determine the frequency of lubrication. Lubricant and bearing temperature analysis can be useful in optimising lubricant change intervals.

The bearing temperature may be allowed to rise to 55 ºC (131 ºF) above ambient but should not exceed 95 °C (204 °F). For most operating conditions a quality grease having a lithium soap base and NLGI consistency of No 2 or No 3 is recommended. The drop point should exceed 175 ºC (350 ºF).

CAUTION Never mix greases containing different bases, thickeners or additives.

### 5.3 Direction of rotation

CAUTION Ensure the pump is given the same rotation as the pump direction arrow cast on the pump casing. Rotation is clockwise when the pump is viewed from the driver.

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. Fasteners for guards must remain captive in the guard to comply with the Machinery Directive 2006/42/EC. When releasing guards, the fasteners must be unscrewed in an appropriate way to ensure that the fasteners remain captive. Whenever guarding is removed or disturbed ensure that all the protective guards are securely refitted prior to start-up.

### 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.

#### 5.5.1 Suction pressure above atmospheric pressure

Horizontal pumps: Open suction line to pump, open vent connection in discharge pipe above pump to allow air to escape.

Vertical pumps: open vent connection in discharge pipe at top plate and allow air to vent from pump casing and discharge piping.

5.5.2 **Suction lift with foot valve fitted**
Fill suction pipe and casing with liquid at a pressure of 1 to 2 bar from an external source. Vent as described in section 5.5.1.

5.5.3 **Suction lift without foot valve**
Pump casing vents on the suction volute must be connected to an external vacuum pump priming system. If in doubt, please consult Flowserve.

5.6 **Starting the pump**

a) CAUTION Ensure flushing and/or cooling/ heating liquid supplies are turned ON before starting the pump.
b) CLOSE the outlet valve.
c) OPEN all inlet valves.
d) Prime the pump.
e) Ensure all vent connections are closed before starting.
f) Start motor and check outlet pressure.
g) If the pressure is satisfactory, slowly OPEN outlet control valve.
h) CAUTION Do not run the pump with the outlet valve closed for a period longer than 30 seconds.
i) If NO pressure, or LOW pressure, STOP the pump. Refer to section 7, *Faults; causes and remedies*, for fault diagnosis.

5.7 **Operating the pump**

5.7.1 **Venting the pump**

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

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

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

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

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

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

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

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

5.7.3 **Pumps fitted with mechanical seal**
Mechanical seals require no adjustment. Any slight initial leakage will stop when the seal is run in.

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

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

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

5.7.4 **Bearings**

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

If bearing temperatures are to be monitored, it is essential that a benchmark temperature is recorded at the commissioning stage and after the bearing temperature has stabilized. Record the bearing temperature (t) and the ambient temperature (ta). Estimate the likely maximum ambient temperature (tb). Set the alarm at (t+tb-ta+5)°C [(t+tb-ta+10)°F] and the trip at 100 °C (212 °F) for oil lubrication and 105 °C (220 °F) for grease lubrication.

It is important, particularly with grease lubrication, to keep a check on bearing temperatures. After start-up, the temperature rise should be gradual, reaching a maximum after approximately 1.5 to 2 hours. This temperature rise should then remain constant or marginally reduce with time. Refer to section 6.2.3.1 for further information.

### 5.7.5 Normal vibration levels, alarm and trip

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

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

| Vibration velocity – unfiltered **mm/s (in./s) r.m.s.** | | **FRBH, FRBHX & FRBHS** |
|---|---|---|
| Normal | **N** | ≤ 5.6 (0.22) |
| Alarm | **N** x 1.25 | ≤ 7.1 (0.28) |
| Shutdown trip | **N** x 2.0 | ≤ 11.2 (0.44) |

### 5.7.6 Stop/start frequency

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

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

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

## 5.8 Stopping and shutdown

a) CAUTION Close the outlet valve, but ensure that the pump runs in this condition for no more than a few seconds.
b) Stop the pump.
c) Switch off flushing and/or cooling/heating liquid supplies at a time appropriate to the process.
d) CAUTION For prolonged shut-downs and especially when ambient temperatures are likely to drop below freezing point, the pump and any cooling and flushing arrangements must be drained or otherwise protected.

## 5.9 Hydraulic, mechanical and electrical duty

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

### 5.9.1 Specific gravity (SG)

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

### 5.9.2 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. It is important that checks are made with your nearest Flowserve office if changes in viscosity are planned.

### 5.9.3 Pump speed

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

### 5.9.4 Net positive suction head ($NPSH_A$)

NPSH available ($NPSH_A$) is a measure of the head available in the pumped liquid, above its vapour pressure, at the pump suction branch.

NPSH required ($NPSH_R$) is a measure of the head required in the pumped liquid, above its vapour pressure, to prevent the pump from cavitating. It is important that $NPSH_A > NPSH_R$. The margin between $NPSH_A > NPSH_R$ should be as large as possible.

If any change in $NPSH_A$ is proposed, ensure these margins are not significantly eroded. Refer to the

pump performance curve to determine exact requirements particularly if flow has changed. If in doubt, please consult your nearest Flowserve office for advice and details of the minimum allowable margin for your application.

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

# 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.)

Any work on the machine must be performed when it is at a standstill. It is imperative that the procedure for shutting down the machine is followed, as described in section 5.8.

On completion of work all guards and safety devices must be re-installed and made operative again.

Before restarting the machine, the relevant instructions listed in section 5, *Commissioning, start up, operation and shut down* must be observed.

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

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

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

Do not spray air or compressed inert gas on skin.

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

Never use air or compressed inert gas to clean clothes.

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

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

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

## 6.2 Maintenance schedule

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

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

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

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

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

6.2.1 **Routine inspection (daily/weekly)**

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

a) Check operating behaviour. Ensure noise, vibration and bearing temperatures are normal.
b) Check that there are no abnormal fluid or lubricant leaks (static and dynamic seals) and that any sealant systems (if fitted) are full and operating normally.
c) Check that shaft seal leaks are within acceptable limits.
d) Check the level and condition of oil lubricant. On grease lubricated pumps, check running hours since last recharge of grease or complete grease change.
e) Check any auxiliary supplies such as heating/cooling (if fitted) are functioning correctly.

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

6.2.2 **Periodic inspection (six monthly)**

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

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

6.2 3 **Re-lubrication**

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

***6.2.3.1 Grease lubrication***

CAUTION See section 5.2.2 for grease recommendations.

Re-greasing quantities for each bearing are contained in the table below. Please note that standard pumps are oil lubricated. Grease only when factory installed grease fittings are supplied.

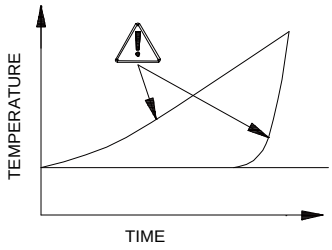
**Table 6.2.3.1 Bearing Regreasing Quantities**

| BRG. FRAME SIZE | THRUST BEARING | | | LINE BEARING | | |
|---|---|---|---|---|---|---|
| | OZ. | CU. IN. | CU. CM. | OZ. | CU. IN. | CU. CM. |
| 1 | 1 | 1.2 | 20 | 2 | 2.4 | 40 |
| 2 | 3 | 3.6 | 60 | 4 | 4.9 | 80 |
| 3 | 7 | 8.5 | 140 | 5 | 6.1 | 100 |
| 4 | 9 | 11.0 | 180 | 6 | 7.3 | 120 |

***Regrease*** - via grease nipples every 2 000 hours or sooner depending on the severity of the application.

It is important not to under or over grease the bearings as this will lead to overheating and premature failure.

a) Grease lubricated bearing housings have grease nipples fitted in the bearing covers.
b) Move the axial seal ring back so the gap between the pump shaft and bearing cover can be seen.
c) Connect grease gun to the nipple.
d) Press grease into the bearing housing until the first signs of it appear in the gap between the housing and shaft, then stop greasing.
e) V-rings should be seated at the proper distance from the sealing surface to avoid overheating.
f) The maximum allowable operating temperatures for anti-friction bearings will vary from unit to unit, depending on ambient and fluid temperature. The rise above ambient should not normally exceed 55 °C (131 °F) or a combined maximum of 95 °C (204 °F).
g) A continuously rising temperature or an abrupt temperature rise indicates a problem. If these symptoms occur, stop the pump immediately and investigate the cause.




***Grease change*** - every 4 000 hours or sooner depending on the severity of the application.

a) Remove the bearing housing from the rotor assembly.
b) Brush the bearing housing with hot kerosene (100 to 115 °C/212 to 240 °F) or other non-toxic solvent.

c) Clean and flush out the housing with a light mineral oil.
d) Do not use waste oil to clean the housing.

*To clean the bearings:*
a) Wipe off as much grease as possible with a clean lint-free cloth.
b) Brush bearings with hot kerosene (80 to 90 °C/ 175 to 195 °F) while gently spinning the outer bearing ring.
c) Spin each ball to ensure that it is clean.

*To remove badly oxidized grease which refuses to come off:*
a) Support the rotor in a vertical position and immerse the bearing in hot kerosene or a mixture of alcohol and light mineral solvent.
b) Gently spin the bearing outer ring.
c) Dry and re-flush the bearing with clean light oil.
d) It is important not to under or over grease the bearings as this will lead to overheating and premature failure. It is recommended that the bearings be filled with grease using a suitable spatula. In addition, the housings should be no more than half filled.

### *6.2.3.2 Oil lubrication*

CAUTION Maintaining the correct oil level is very important.

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

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

### 6.2.4 **Mechanical seals**

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

### 6.2.5 **Gland packing**

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

The stuffing box is normally supplied with a lantern ring to enable a clean or pressurised flush to the centre of the packing. If not required, this can be replaced by an extra 2 rings of packing.

There must always be a small leakage, normally a minimum of 120 drops per minute to atmosphere to lubricate and cool the packing is required.

6.2.5.2 Expeller Packing

For the expeller gland option, the expeller seals the stuffing box during operation and the packing seals when the pump is shut down. To lubricate the packing grease must be injected. For this reason the stuffing box is fitted with a standard grease nipple. The stuffing box should be packed with 2 rings at the bottom of the box followed by split lantern rings and 1 ring of packing. Details for packing installation described previously for the water-flushed gland also applies.

The packing and lantern rings are not installed into the stuffing box at the factory.

**TABLE 6.2.5.2 - Expeller Greasing**

| FRAME NO. | INITIAL | | | REGREASING | | |
|---|---|---|---|---|---|---|
| | OZ. | CU. IN. | CU. CM. | OZ. | CU. IN. | CU. CM. |
| 1 | 0.8 | 1.0 | 16 | 0.2 | 0.3 | 4 |
| 2 | 1.3 | 1.5 | 26 | 0.4 | 0.5 | 8 |
| 3 | 2.9 | 3.5 | 58 | 0.6 | 0.8 | 12 |
| 4 | 3.7 | 4.5 | 74 | 0.8 | 1.0 | 16 |

## 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 and type
3) Part name – taken from section 8
4) Part number – taken from the job sectional or section 8
5) Number of parts required

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

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

### 6.3.2 Storage of spares

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

## 6.4 Recommended spares and consumable items

*For start-up purposes:*
1 - complete set of gland packing
2 - shaft sleeves
1 - set of gaskets and seals
(optional: 2 - mechanical seals)

*For 2 years operation:*
1 - set of bearings (line and thrust)
2 - sets of gland packing
2 - shaft sleeves
2 - sets of gaskets and seals
2 - lantern rings
2 - casing wear rings
(optional: 2 - mechanical seals
2 - impeller wear plates)

*For 4 years operation:*
1 - set of bearings (line and thrust)
2 - sets of gland packing
2 - shaft sleeves
2 - sets of gaskets and seals
2 - lantern rings
2 - casing wear plates
1 – impeller
(optional: 2 - mechanical seals
1 – wear plate)

## 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 M 48 screws/nuts
- Socket spanners (wrenches), up to M48 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
- C-spanner (wrench) - for removing shaft nut. (If difficulties in sourcing are encountered, consult Flowserve.)

## 6.6 Fastener torques

**CAUTION** Non-metallic gaskets incur creep relaxation – retighten to the tightening torques provided.

| Bolt size | Torque Nm (lb•ft) | |
|---|---|---|
| | Pump feet fasteners | All other fasteners |
| M 16 (⅝ in.) | 170 (125) | 84 (62) |
| M 20 (¾ in.) | 340 (250) | 165 (120) |
| M 24 (⅞ in.) | 590 (435) | 285 (210) |
| M 27 (1 in.) | 770 (570) | 375 (275) |
| M 30 (1⅛ in.) | 1 100 (810) | 540 (400) |
| M 36 (1⅜ in.) | 1 840 (1 350) | 900 (660) |
| M 42 (1⅝ in.) | 2 000 (1 475) | 1 410 (1 040) |
| M 48 (1⅞ in.) | 2 240 (1 650) | 2 060 (1 500) |

| TIGHTENING TORQUE FOR STAINLESS STEEL STUDS WITH LUBRICATED THREADS | | |
|---|---|---|
| THREAD SIZE | TIGHTENING TORQUE | |
| | Nm. | Ft. lbs. |
| M10x1.5 (3/8–16UNC) | 13 | 10 |
| M12x1.75 (1/2–13UNC) | 27 | 20 |
| M16X2 (5/8-11UNC) | 60 | 45 |
| M20x2.5 (¾-10UNC) | 100 | 75 |

### 6.7 Renewal clearances

As wear takes place between the impeller and wear plate the overall efficiency of the pump set will decrease. To maintain optimum efficiency, it is recommended that the impeller be adjusted to maintain the impeller axial clearance as detailed in section 3.5, Table of Engineering Data. Typically doubling the clearance can reduce performance by 5% depending on pump size and operating condition.

### 6.8 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.

To disassemble the pump, consult the job sectional drawing, general sectional drawing (see section 8), and *Parts list*.

#### 6.8.1 Rotor unit

The following procedure is recommended for removing and disassembling the back pull-out element (rotating assembly).

Note: Note that the replacement gaskets and similar consumable materials should be available since they will be required for reassembly.

a) Isolate motor and lock off electrical supply in accordance with local regulations.
b) Isolate suction and discharge valves.
c) Remove coupling guards and disconnect the coupling halves.
d) Drain pump casing. Remove any auxiliary piping if applicable.
e) Disconnect stuffing box, cooling water and auxiliary piping.
f) Drain the oil from the bearing bracket [3130] if bearing frame is being dismantled.
g) Place the sling around the bearing bracket [3130] and carefully take up the weight without straining the casing. Refer to Section 3 to determine hoist and sling requirements.
h) Loosen the set screws holding the deflector [2540] on the shaft.
i) Release the thrust bearing bracket [3230] hold down bolts and jam nuts. While rotating the pump shaft [2110] by hand, tighten the three jacking screws evenly until the impeller [2200] lightly clamps the stuffing box head [4100] in place. In the case of expeller pumps the same will hold for the housing [4110]. This will simplify withdrawal of the rotating element from the casing.

CAUTION Excessive clamping force could damage bearing races.
Rotating the shaft helps to clear away solids which may be trapped between the impeller and stuffing box head.

j) Remove the bolts connecting the rear support foot [3134] to the baseplate.
k) Remove the frame to casing bolts
l) Withdraw the rotating element from the casing.

CAUTION For FRBHS designs, there is a loose adapter [1340] that spaces the bearing bracket [3130] from the pump casing [1110]. This item may stay lodged within the casing or could be removed with the rotating element. Once the rotating element is removed locate this item and remove it to a safe location.

#### 6.8.2 Stuffing box

##### 6.8.2.1 *Shaft seal - gland packing*

a) Remove gland nuts and gland halves [4121]
b) Lever out gland ring [4130] using its grip groove.
c) Remove gland packing rings [4130] and lantern rings [4134] using a bent wire.

##### 6.8.2.2 *Shaft seal - mechanical seal*

Refer to any special instructions supplied with the mechanical seal.

a) Remove seal cover screws and pull off seal cover complete with the stationary seal ring which is held in place by the O-ring seal.
b) The mechanical seal cover can also be removed by placing a wedge into the gland chamfer, as below:

##### 6.8.2.3 *Impeller and stuffing box*

a) While preventing the shaft from rotating, remove the impeller nut [2912] that has a right-hand thread.
b) Remove the impeller [2200] and impeller key [6700]. Normally, a slight tightening of the thrust gearing jacking screws will free the impeller and allow it to be removed. Except on the smaller sizes, there is a facility on the impeller hub to assist removal in difficult cases.
c) Remove the expeller housing [4110] & radial impeller [2250] and/or stuffing box head [4100] as applicable to pump construction.

#### 6.8.3 Shaft sleeve

a) Remove the shaft sleeve gasket [4590].
b) Remove the shaft sleeve [2445] if scored or worn.

#### 6.8.4 Bearing housing

a) Remove the deflector [2540] and the line bearing cover.
b) Remove the pump half coupling and coupling key [6700].

c) Remove the support foot [3134].
d) Lift the bearing frame assembly into a vertical position with the thrust bearing housing [3230] up. Rest the bearing frame flange on heavy wooden blocks sufficiently high to ensure end of the shaft does not come into contact with the floor or table.
e) Remove the thrust bearing hold down bolts and remove shaft assembly for the bearing bracket [3130].

### 6.8.5 Line bearing

a) Lay the pump shaft [2110] horizontal and support with wooden 'V' Blocks.
b) Only if necessary, remove the radial ball bearing [3011] from the shaft. Bearings removed and reused can easily be damaged and undetected until pump is put back in operation,

### 6.8.6 Thrust bearings

a) Lay the pump shaft [2110] horizontal and support with wooden 'V' Blocks.
b) Remove the thrust bearing clamping ring [2542] from the thrust bearing bracket [3230].
c) Bend up the locking tab on the bearing nut lockwasher [6541] and remove the bearing lock-nut [3712] and lockwasher [6541].
d) Only if necessary remove the thrust bearings [3031] from the shaft. Bearings removed and reused can easily be damaged and undetected until pump is put back in operation

### 6.8.7 Wear plate

a) The wear plate can be removed from the casing if required. The wear plate is secured in place using studs and hex nuts.

## 6.9 Examination of parts

CAUTION 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.

### 6.9.1 Casing, seal housing and impeller

a) Inspect for excessive wear, pitting, corrosion, erosion or damage and any sealing surface irregularities.
b) Replace as necessary.
c) Inspect the impeller [2200] and the wear plate [1915] for excessive wear or damage. Remove the wear plate from the pump casing [1110] if necessary.
d) Inspect the pump casing [1110] and stuffing box head [4100] for damage or excessive thinning of wall sections due to wear or corrosion. Clean the internal surfaces to maintain pump efficiency.
e) Inspect the stuffing box neck bush [4132] and remove if damaged or worn. Clean the internal bore of the stuffing box.

### 6.9.2 Shaft and sleeve (if fitted)

a) Replace sleeve if grooved, pitted or worn.
b) Clean the shaft and inspect for evidence of corrosion, evidence of cracking, fatigue or mechanical damage. Remove all burrs or nicks paying particular attention to the areas under the lip seals. Check that the shaft is straight within 0.002 inch (0.050 mm).

### 6.9.3 Gaskets and O-rings

After dismantling, discard and replace.

### 6.9.4 Bearings

a) It is recommended that bearings are not re-used after any removal from the shaft.
b) The plain liquid lubricated bearings may be re-used if both the bearing bush and bearing sleeve show no sign of wear, grooving or corrosion attack. (It is recommended that both the bush and sleeve are replaced at the same time.)

### 6.9.5 Bearing isolators, labyrinths or lip seals (if fitted)

a) The lubricant, bearings and bearing housing seals are to be inspected for contamination and damage. If oil bath lubrication is utilised, 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.

## 6.10 Assembly

To disassemble the pump, consult the job sectional drawing, general sectional drawing (see section 8), and *Parts list*.

Ensure threads, gasket and O-ring mating faces are clean. Apply thread sealant to non-face sealing pipe thread fittings.

### 6.10.1 Bearing housing

a) Lubricate the internal bores of the bearing bracket [3130] with the same oil or grease used to lubricate the bearings.
b) Install the thrust bearing housing [3230] in the

bearing bracket [3130] to ensure a good sliding fit. Remove the thrust bearing housing from the frame.

c) Install the oil sight gauge [3856] and the drain lug in the bearing bracket [3130] using Teflon pipe thread sealant. Install the threaded plug (vent plug) [6578].

### 6.10.2 **Line bearing**

a) Pack the line bearing with grease if the bearings are being grease lubricated.

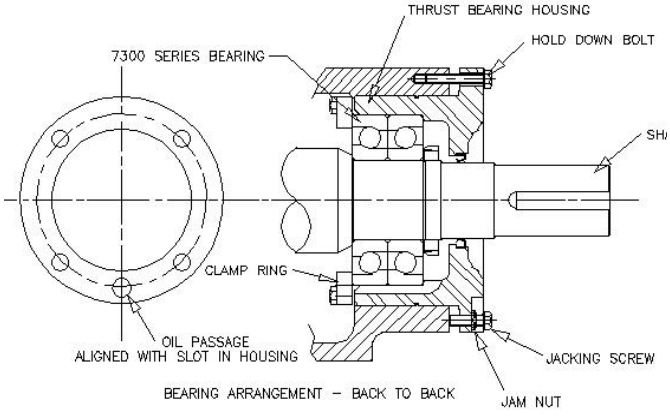
b) Lightly lubricate the pump shaft [2110] at the line bearing position. Install the radial ball bearing [3011] on the shaft. Use an induction heated or hot oil bath to first heat the bearing [250° F recommended], press the bearing on shaft with the aid of a sleeve designed to push the inner race only. Note that the bearing must remain square to the shaft during assembly and that the inner race must seat on the shaft shoulder. Protect the bearing by wrapping with a clean, lint free cloth.

### 6.10.3 **Thrust bearing**

a) Pack thrust bearing with grease if the bearings are being grease lubricated.

b) Place the thrust bearing clamping ring [2542] loosely over the shaft on the largest diameter.

c) Install the angular contact bearings [3031] on the pump shaft [2110] using the same procedure as described in step 6.10.2. The bearings are mounted back to back as shown.




d) Slide the bearing lockwashers [6541] on the shaft and fit the bearing lock nut [3712]. Tighten the locknut snugly and allow to cool. Check the tightness and bend one tab on the lockwasher into a slot in the locknut. Protect the bearings from contamination.

e) Carefully install the lip seal [4300.1] in the thrust bearing housing [3230] by pressing it squarely into the bore. The primary sealing lip [spring loaded] on seal should be installed facing the bearing. A small amount of sealant may be applied on the O.D. of the seal prior to its' installation.

f) Install the square head plug or grease fitting on the tapped hole in the thrust bearing housing flange. Lubricate the O-ring [4610.4] with the bearing lubricant and assemble it into the groove of the outer circumference of the thrust bearing housing [3230].

g) Lubricate the inside bore of the thrust bearing housing [3230] and assemble it over the thrust bearings. Care must be taken to prevent damage of the seal on the shaft.

h) Using capscrews and lockwashers, attach the thrust bearing clamping ring [2542] to the thrust bearing housing [3230]. Lock the threads using Loctite 242 or equivalent.

**Note:** The thrust bearing clamping ring [2542] is provided with one extra hole midway between two adjacent bolt holes to permit free oil flow. On oil lubricated units, this hole must align with the cast oil return at the bottom of the thrust bearing housing bore. For grease lubricated units, this hole should be oriented away from the cast oil return slot at the bottom the thrust bearing housing bore.

Tighten the capscrews evenly ensuring that the clamp ring is not distorted and gap to the bearing housing is even all around. Tighten in accordance with Table 6.6.

### 6.10.4 **Frame assembly**

#### 6.10.4.1 ***Frame 1, 2 & 3***

a) Place the bearing frame in a vertical position with the large flange resting on wooden support blocks sufficiently high to allow the shaft from contacting the floor when it is installed.

b) Lift the shaft assembly into a vertical position and lower it into the bearing bracket [3130]. Note the square head plug (or grease fitting in the thrust bearing housing [3230] must align with the threaded plug [6578] in the bearing bracket [3130].

#### 6.10.4.2 ***Frame 4 for 18FRBH274 & 20FRBH304 only***

a) Assemble the adapter [1340] to the bearing bracket [3130].

#### 6.10.4.3 ***Frame 4 only***

a) Place the shaft assembly in a vertical position with the thrust bearing housing [3230] resting on the flange face and supported by blocks or clamps. Access to one through hole in the thrust bearing housing is required to attach one bolt.

b) Lift the bearing bracket assembly [3130] vertically and lower over the shaft assembly. Manually guide the line bearing outer race into the bearing frame bore. Ensure that the thrust bearing housing [3230] and frame [3130] are oriented as in Step 6.10.4.1 b). This will ensure that the oil return slot in the thrust bearing housing [3230] is properly located.

6.10.4.4 ***All frames***

a) Install at least one thrust bearing housing to bearing frame hold down cap screws complete with lockwasher to prevent the assembly from coming apart when lifting.
b) Place the bearing frame assembly into a horizontal position.
c) Install the remaining cap screws and lockwashers. Assemble the jam nuts on the jacking screws and assemble these into the thrust bearing housing [3230].
d) Carefully install the lip seal [4300] in the bearing cover [3260] by pressing it squarely into the bore. The primary sealing lip [spring loaded] on seal should be installed facing the bearing. A small amount of sealant may be applied on the O.D. of the seal prior to its installation.
e) Lubricate the o-ring [4610.3] and assemble into the groove of the line bearing cover.
f) Assemble the line bearing cover [3260] over the shaft and squarely into the bearing frame bore. Fasten to the bearing frame with cap screws, washers and hex nuts. Tighten firmly, but not excessively.
g) Assemble the deflector [2540] loosely over the shaft but do not tighten the set screws.
h) Install the coupling key [6700] and tape to the shaft.
i) Mount a dial indicator to the bearing frame [3130] and indicate shaft under bearing frame flange (approx. mid way between impeller mounting face and end of sleeve area. Rotate shaft and check that runout does not exceed 0.002 inch (0.050 mm).

6.10.5 **Stuffing box**

6.10.5.1 ***All***

a) Install the gland studs [6573] using Loctite grade A or equivalent. Install the square head plugs [211 in the stuffing box as required using pipe sealant.
b) The gland studs [6573] on water cooled stuffing boxes must be sealed with pipe sealant. If only two gland studs are used, the remaining two tapped holes must be plugged with set screws or short cap screws. To ensure proper sealing, the chamber can be tested to a design pressure of 75psi.
c) Press the stuffing box neck bush [4132] into the stuffing box [4100], ensuring that it seats squarely on the shoulder.
d) Lubricate the pump shaft [2110] at the impeller position, check the fit of the impeller key [6700] in the shaft keyway and. Install the impeller [2200] onto the shaft to ensure that there is a good sliding fit. Remove the impeller [2200] and the impeller key [6700].
e) Install the o-ring [4610] into the impeller nut [2912] using grease or anti-seize compound to hold it in place during assembly.
f) Install the shaft sleeve [2445] onto the shaft [2110] and orientate the sleeve such that the keyways are aligned. Install the impeller key [6700] in the shaft.

6.10.5.2 ***Standard packing***

a) Assemble the stuffing box head [4100] over the shaft sleeve [2445] and orientate the lantern ring connections to auxiliary piping (Refer to Figure 6). These connections are normally placed on the vertical centerline for proper venting and draining as well as providing optimum gland stud access.
b) Push the stuffing box head [4100] back against the bearing frame flange face. Back off the thrust bearing housing jacket screws and tighten the thrust bearing hold down screws to slide the rotor assembly forward such that the end face of the shaft sleeve [2445] protrudes beyond the box face.
c) Install the shaft gasket [4590.2] onto the shaft, ensuring that the outside diameter is no larger than the sleeve.

6.10.5.3 ***Optional expeller seal-frame 1, 2 & 3***

a) Assemble the stuffing box [4100] over the shaft sleeve [2445] and into the bearing bracket [3130] register. Orient the grease fitting to suit the installation. Note that if the optional solid gland with lip seal design is used, it must be installed first.
b) Assemble the o-ring [4610.2] into the groove of the stuffing box [4100].
c) Adjust the pump shaft [2110] forward to ensure that the Radial impeller [2250] when installed will not bind against the stuffing box head [4100].
d) Assemble the gasket [4590] on to the shaft against the shaft sleeve [2445]. A small amount of grease may be used to hold the gasket while other parts are assembled.
e) Install the expeller [2250] onto the shaft sleeve [2445] vales first.

6.10.5.4 ***Optional expeller seal-frame 4***

a) Assemble the stuffing box [4100] over the shaft sleeve [2445] and into the bearing bracket [3130] register. Orient the grease fitting to suit the installation. Note that if the optional solid gland with lip seal design is used, it must be installed first.
b) Assemble the o-ring [4610.2] into the groove of the stuffing box [4100].
c) Adjust the pump shaft [2110] forward to ensure that the radial impeller [2250] when installed will not bind against the stuffing box head [4100].
d) Assemble the o-ring [4610.5] in the bore of the radial impeller [2250].
e) Install the drive impeller key [6700] on the pump shaft [2110].
f) Install the radial impeller [2250] onto the shaft sleeve [2445] vanes first.
g) Install the o-ring [4610.5] in the groove of the expeller hub face.

6.10.6 **Impeller Installation**

a) Adjust the rotor assembly such that the radial impeller [2250] is recessed within the stuffing box cavity. Assemble the expeller housing [4110] onto the stuffing box [4100].
b) Install impeller [2200].
c) Apply a small quantity of Loctite 242 or equivalent to the exposed thread on the end of the shaft, and thread the impeller nut [2912] complete with o-ring [4610] onto the shaft.

**Note:** For units with mechanical seals, do not apply thread locking compound until seal axial setting has been established.

d) Tighten the impeller nut [2912] in accordance with Table 6.6. This is an essential step to properly seat the shaft sleeve [2445] and compress the gasket [4590.2] to provide a seal and to prevent loosening of the impeller on the shaft.
e) Release the thrust bearing housing hold down bolts and tighten the jacking screws to pull the impeller back to the stuffing box head [4100]. The stuffing box head must not be rigidly clamped.

6.10.7 **Wear plate**

a) Install the studs [6572] in the wear plate [1915] using Loctite grade A or equivalent. Place the sealing washer [4590.1] over the studs [6572] and install the wear plate into the pump casing [1110]. Secure wear plate [1915] in place using hex nuts and washers using Loctite 242 or equivalent. Tighten in accordance with Table tables in section 6.6.

**CAUTION**

Excessive or uneven tightening torque may distort wear plate affecting impeller running clearances or result in broken studs.

b) Stand the casing on it's feet.
c) Smear a small amount of grease or anti-seize compound over one face of the gasket [4590.3] and place it on the stuffing box head [4100] with coated face against flange.

**Note:** Some sizes, as identified in Section I use an o-ring in place of a gasket.

**6.10.8 FRBHS only**

a) Take spacer and install gasket [4590.3] with a small amount of grease on the face that will mate inside the pump casing [1110].
b) Smear anti-seize compound on the pump casing [1110] and adapter [1340] rabbit fit (spigot) diameters to ease assembly and future disassembly.
c) Install the adapter/gasket [1340/4590.3] into the pump casing [1110].

**CAUTION** This piece is loose so caution must be exercised when moving around the casing.

6.10.9 **All pumps except FRBHS**

a) Smear anti-seize compound on the pump casing [1110] and stuffing box head [4100] rabbit fit (spigot) diameters to ease assembly and future disassembly.

6.10.10 **Rotor unit**

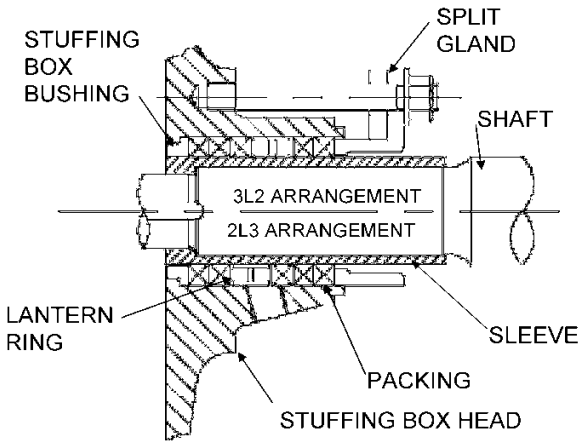
a) With a sling around the bearing frame placed so as to balance the weight, lift the frame/impeller assembly keeping the shaft horizontal.
b) Install the frame/impeller assembly into the pump casing [1110] by guiding the stuffing box head and bearing frame spigots squarely into the casing recess. Ensure that the gasket [4590.3] stays in position. If the fit becomes snug, use 4 equally spaced bolts to draw the assembly into the casing.
c) Install the casing frame bolts with washers and tighten in accordance with Table 6.6.
d) Using the thrust bearing housing adjustment feature [Figure 8], move the impeller forward away from the stuffing box head [4100].
e) Attach the bearing frame support foot [3134] to the bearing bracket [3130] using the cap screws and washers. Ensure that thread engagement is at least 1 diameter. Use Loctite 242 thread sealant.

**Note:** lockwashers should not be used to ensure proper thread engagement with standard bolting.

f) Set the impeller front clearance in accordance with instruction earlier in this section of the manual.

6.10.11 **Shaft seal**

6.10.11.1 ***Packing***




**Standard Packed Box Arrangement**

a) Insert one packing ring at a time into the stuffing box. Push the packing as far as possible into the packing bore.
b) Install additional rings as required, staggering the joints.

c) Once the first two or three rings of packing have been inserted, the two-piece lantern ring [4134] must be installed. Push the lantern ring and previously installed packing. The ports in the lantern ring do not need to be aligned with the inlet/outlet ports.
d) Ensure that the shaft can be turned by hand.
e) Install the remaining rings of packing, alternating the joints.

**Note:** It may not be possible to insert the last ring in the box and still insert the gland. In this case, omit the last ring of packing and install the gland. The last ring of packing should be installed after the pump has been in service and sufficient space is available.

f) Install the gland halves [4121], tighten the gland nuts [6580] only finger tight.

**CAUTION** New packing has to be run-in and it is good practice to start the pump with the stuffing box gland quite loose. Packing that is too tight in the box will cause undue friction, creating heat which will glaze the packing and possible score the shaft sleeves. To be effective, the packing must remain soft and pliable. If stuffing box friction is so great that the pump shaft cannot be turned by hand, the box is not properly packed.

6.10.11.2 ***Mechanical seal***

Refer to any special instructions supplied with the mechanical seal.

a) Before the mechanical seal can be installed, the pump must be assembled with the correct impeller running clearances (ie: all assembly steps above). A scribe mark is then placed on the circumference of the sleeve to mark the end of the box. This mark is used to locate the seal position referenced by the mechanical seal drawing provided.
b) After scribing the sleeve, remove the rotating element from the casing. Do not adjust the bearing housing.
c) Remove the impeller nut [2912], impeller [2200], impeller key [6700] and stuffing box head [4100]. Assemble the mechanical seal components, including gland plates, gaskets and rotating parts over the sleeve. Locate the seal relative to the scribed markings on the shaft sleeve [2445] as indicated by the seal manufacturers' instruction.
d) Remove lubricating compound from the impeller nut and shaft threads. Re-assemble components in accordance with original assembly procedure with the exception that Loctite 242 is applied to the impeller nut [2912] threads. Torque the nut in accordance with information below.

| MINIMUM IMPELLER NUT TIGHTENING TORQUE | | |
|---|---|---|
| FRAME | Ft. lbs. | Nm. |
| 1 | 100 | 140 |
| 2 | 300 | 400 |
| 3 | 300 | 400 |
| 4 | 550 | 750 |

e) Assemble the mechanical seal gland plate and gasket and fasten using gland studs [6573]. Secure with nuts [6580] and tighten each by hand. Further tighten the nuts in accordance with Table in 6.6. Rotate the shaft to ensure that it turns freely without rubbing or binding.
f) Re-assemble the rotating element into the casing. Do not adjust the thrust bearing housing.
g) Set the deflector [2540] at the line bearing cover [3260] so that they do not contact when the shaft is rotated. Lock in place with the setscrews provided.

6.10.12 **Final assembly**

a) Lift the assembled pump onto the baseplate and position the casing feet over the tapped holes in the baseplate.
b) On all sizes except the 18FRBH-274, loosen the bolts that attach the read support foot [3134] to the bearing bracket [3130]. Level the unit and align with the piping. Tighten the bolts attaching the casing feet to the baseplate in accordance with Table 6.6 using for tightening torques. Do not distort casing or frame.
c) Install the pump coupling or sheave as required.
d) Refer to Section 4, Installation and Section 5, Preparation for Operation.
e) It is recommended that the pump not be packed until required. Refer to stuffing box packing procedure in this section. Protect the stuffing box bore and seal area with clean dry rags.

6.11 **Impeller axial clearance adjustment**

6.11.1 **FRBH and FRBHX Units**

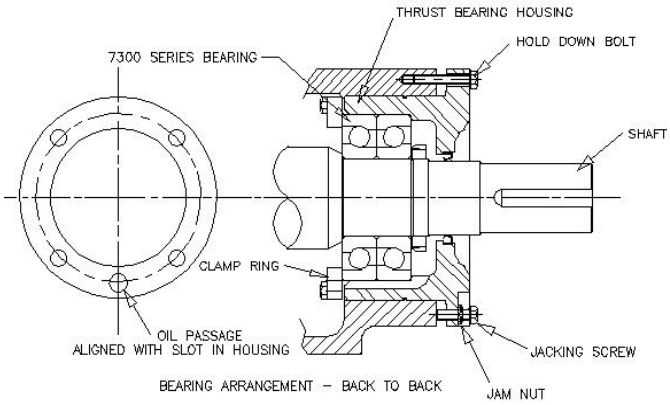
**Note:** This procedure should not be used on units with mechanical seals if the design is such that a liquid seal cannot be maintained when the rotor is moved axially against the wear plate.

Unless seal is a cartridge design it may not be possible to adjust the shaft unless the pump is dismantled.

Refer to any special instructions supplied with the

mechanical seal

**DANGER NEVER ATTEMPT TO CHANGE THE CLEARANCE WHEN THE PUMP IS RUNNING.**




If the coupling has limited axial adjustment capability, the pump and driver must be uncoupled prior to adjusting the clearance in order to permit free movement.

a) Loosen the two set screws retaining the deflector [2540] and check that the deflector is free to move axially on the shaft.
b) Loosen the thrust bearing housing jam nuts and back off the three jacking screws at least 1.5 mm (0.060 inch).
c) Move the rotor towards the wear plate [1915] by tightening the three hold-down capscrews evenly and uniformly until the impeller [2200] just touches the wear plate. This can be best established by rotating the shaft and stopping the forward motion at the first sign of rubbing. If the shaft cannot be rotated, back off the bearing housing with the jacking screws until a just detectable rub is obtained. Check that the gap between the two machined faces of the thrust bearing housing [3230] and the bearing frame [3130] are parallel within 0.08 mm (0.003 in.). Adjust the jack screws and hold down capscrews as required to achieve this parallelism. When the impeller [2200] just touches the wear plate [1915] and the thrust bearing housing [3230] is parallel to the bearing cover [3130] the axial clearance between the impeller and wear plate is zero.

6.11.1.1 Option1

a) Place a dial indicator, set to end of pump shaft [2110] or on housing [3230] face.
b) Set indicator reading to zero (0).
c) Note required impeller clearance.

6.11.1.2 Option 2

a) Measure and record the axial gap between the thrust bearing housing flange and bearing frame end face. Determine the required impeller axial running clearance from Section I and add this to the above measurement to establish the required gap setting.

6.11.1.3

a) Loosen the thrust bearing housing hold down capscrews slightly and tighten the jack screws. Until the required dial indicator reading (6.11.1.1) or housing gap reading (6.11.1.2) is achieved.
b) Alternately and gradually tighten the hold down capscrews and jack screws until the required gap setting is achieved at each hold down capscrew location. Note that the gap at each jack screw will be slightly larger as a result of minor elastic distortion of the thrust bearing housing flange caused by the high pre-load forces. The gap setting at any set of screws must be the same within 0.08 mm (0.003 in.). Careful attention to this procedure will help ensure long thrust bearing life.
c) While preventing the jack screws from rotating, tighten the jam nuts to lock them in position.
d) Adjust the axial position of the deflector [2540] so that it is clear of the line bearing cover [3260] by approximately 0.75mm [0.03 in.) and tighten the setscrews firmly. Excessive tightening may mar the shaft.
e) Manually rotate the shaft to ensure that there is no rubbing or binding.
f) On belt driven units, adjust the pump or driver sheave to maintain belt alignment. (Refer to Section 4.5.2.2).
g) Check the alignment on direct driven units (refer to Section 4) and reassemble the coupling components.
h) Replace any safety guards that may have been removed.

6.11.2 **FRBHS Units**

End Clearance adjustment is performed in a similar manner to the FRBH pump except that impeller clearance is set from the back. Instead of adjusting the impeller from the wearplate it is necessary to set it from the stuffing box head [4100].

# 7 FAULTS; CAUSES AND REMEDIES

**FAULT SYMPTOM**

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

## FAULT SYMPTOM

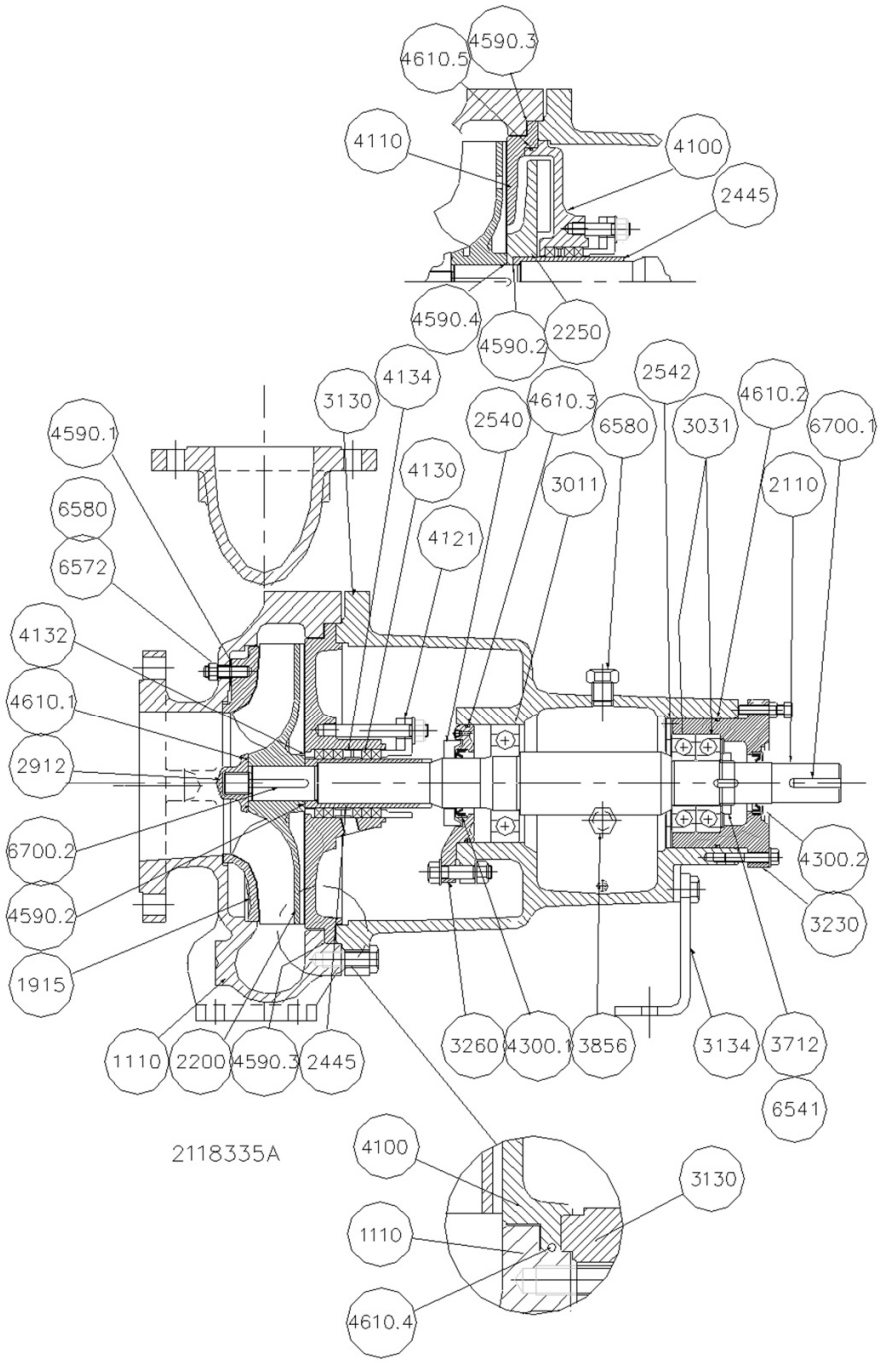
| Pump overheats and seizes | Bearings have short life | Pump vibrates or is noisy | Mechanical seal has short life | Mechanical seal leaks excessively | Pump requires excessive power | Pump loses prime after starting | Insufficient pressure developed | Insufficient capacity delivered | Pump does not deliver liquid | PROBABLE CAUSES | POSSIBLE REMEDIES |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ● | ● | ● | ● | ● | ● | | | | | 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. |
| ● | ● | ● | ● | ● | | | | | | Bearings worn | Replace bearings. |
| | | | | | ● | | ● | ● | | 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. |
| | | | ● | ● | | | | | | Shaft sleeve worn or scored or running off centre. | Check and renew defective parts. |
| | | | ● | ● | ● | | | | | Mechanical seal improperly installed. | Check alignment of faces or damaged parts and assembly method used. |
| | | | ● | ● | ● | | | | | Incorrect type of mechanical seal for operating conditions. | CONSULT FLOWSERVE. |
| ● | ● | ● | ● | ● | | | | | | Shaft running off centre 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 a mechanical failure inside the pump. | Check wear condition of impeller, its clearances and liquid passages. |
| | ● | ● | | | | | | | | Excessive grease in ball bearings. | Check method of regreasing. |
| | ● | ● | | | | | | | | Lack of lubrication for bearings. | Check hours run since last change of lubricant, the schedule and its basis. |

**FAULT SYMPTOM**

| Pump overheats and seizes | Bearings have short life | Pump vibrates or is noisy | Mechanical seal has short life | Mechanical seal leaks excessively | Pump requires excessive power | Pump loses prime after starting | Insufficient pressure developed | Insufficient capacity delivered | Pump does not deliver liquid | PROBABLE CAUSES | POSSIBLE REMEDIES |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | ● | ● | | | | | | | | Improper installation of bearings (damage during assembly, incorrect assembly, wrong type of bearing etc). | Check method of assembly, possible damage or state of cleanliness during assembly and type of bearing used. Remedy or CONSULT FLOWSERVE, if necessary. |
| | ● | ● | | | | | | | | Damaged bearings due to contamination. | Check contamination source and replace damaged bearings. |
| | | | | | | | | | | **C. MOTOR ELECTRICAL PROBLEMS** | |
| | | ● | | | ● | | ● | ● | | Wrong direction of rotation. | Reverse 2 phases at motor terminal box. |
| | | | | | ● | | | ● | | Motor running on 2 phases only. | Check supply and fuses. |
| | ● | ● | | | | | | ● | | Motor running too slow. | Check motor terminal box connections and voltage. |

# 8 PARTS LIST AND DRAWINGS

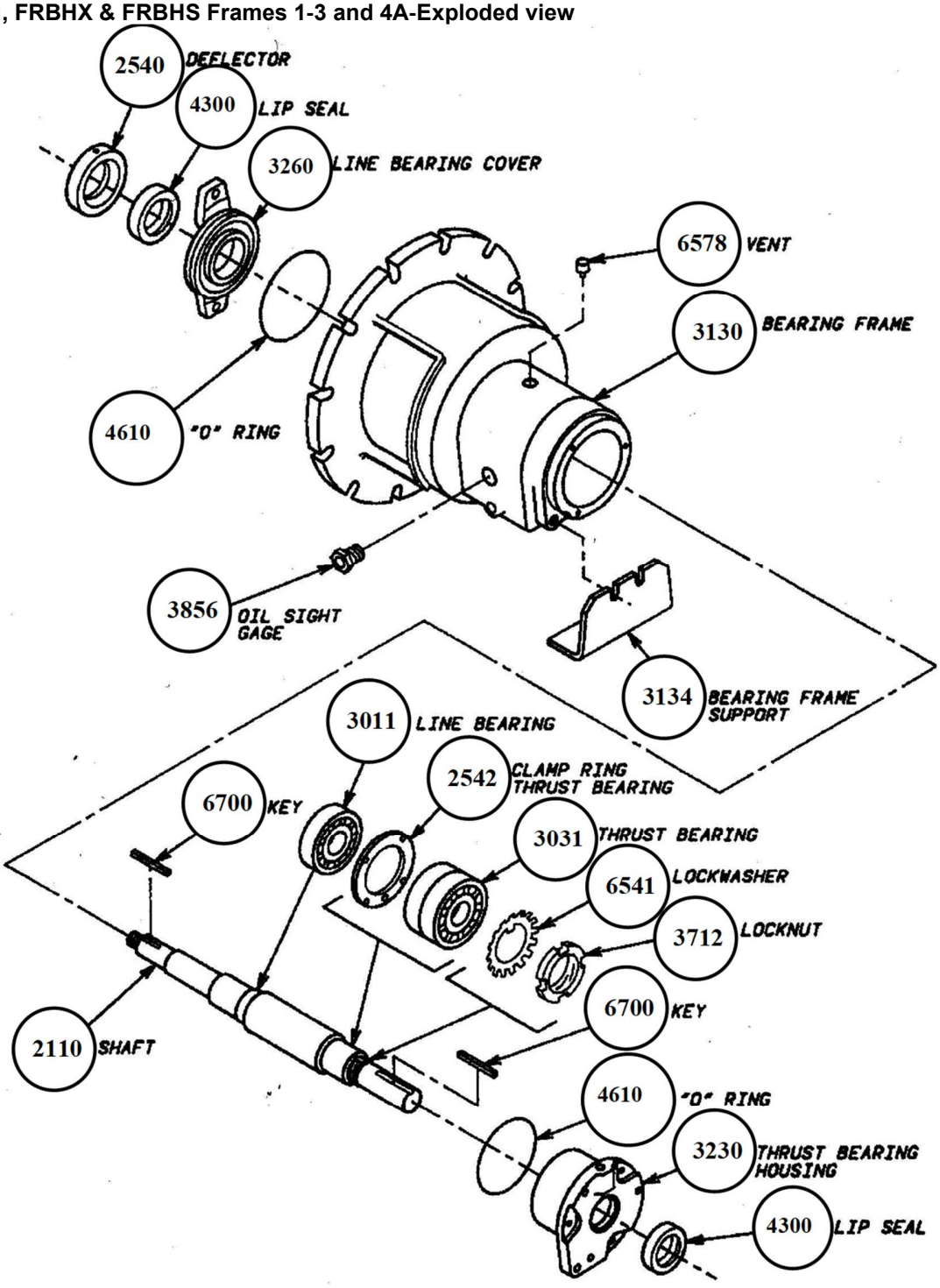
## 8.1 FRBH & FRBHX Frames 1-3 and 1 pc Frame 4 with parts list




* 2FRBH121 & 3FRBH121 PUMPS USE AN O-RING INSTEAD OF GASKETS.

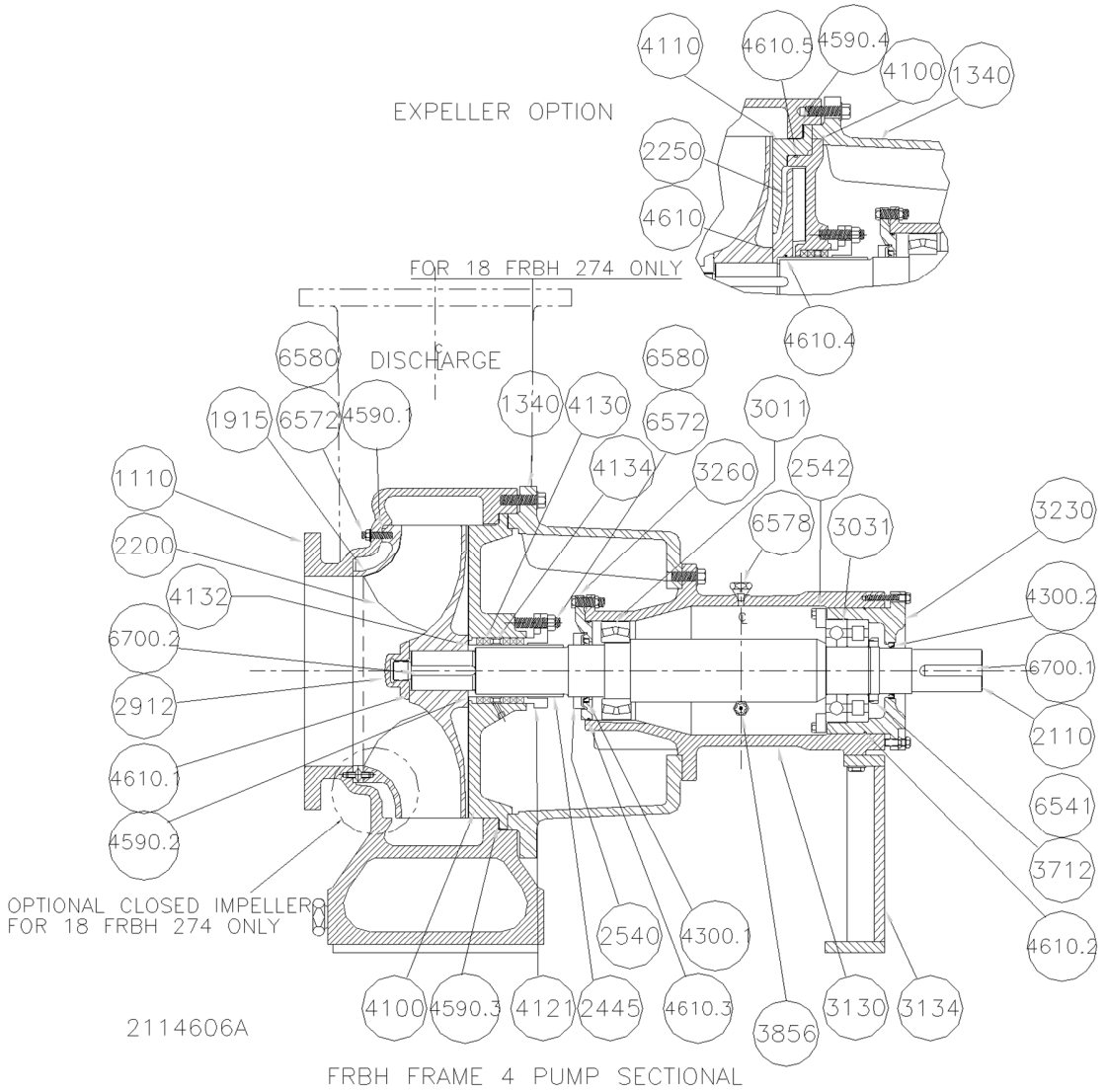
| Ref. | Description |
|---|---|
| 1110 | Pump casing |
| 1915 | Wear plate |
| 2110 | Pump shaft |
| 2200 | Impeller |
| 2250 | Radial flow impeller, Expeller |
| 2445 | Shaft sleeve |
| 2540 | Deflector |
| 2542 | Clamping Ring |
| 2912 | Impeller nut |
| 3011 | Radial ball bearing |
| 3031 | Thrust bearing |
| 3130 | Bearing Bracket |
| 3134 | Support foot |
| 3230 | Thrust brg.Hsg. |
| 3260 | Bearing cover |
| 3712 | Bearing lock nut |
| 3856. | Oil site gauge |
| 4100 | Stuffing box |
| 4110 | Expeller Housing |
| 4121 | Gland, split |
| 4130 | Packing |
| 4132 | Neck bush |
| 4134 | Lantern Ring |
| 4300.1 | Radial lip seal |
| 4300.2 | Radial lip seal |
| 4590.1 | Gasket, wearplate |
| 4590.2 | Gasket, sleeve |
| 4590.3 | Gasket, Casing |
| 4590.4 | Gasket, Impeller |
| 4610.1 | O-ring, imp.nut |
| 4610.2 | O-ring, thrust brg |
| 4610.3 | O-ring, Line brg. |
| 4610.4 | O-ring, Stuffing Box |
| 4610.5 | O-ring, Expeller Hsg. |
| 6541 | Lockwasher |
| 6572 | Stud, wear plate |
| 6580 | Nut, wearplate |
| 6700.1 | Key, coupling |
| 6700.2 | Key, impeller |

8.2 **FRBH, FRBHX & FRBHS Frames 1-3 and 4A-Exploded view**




**FRBH FRAME ASSEMBLY (EXCEPT SIZE 4B)**

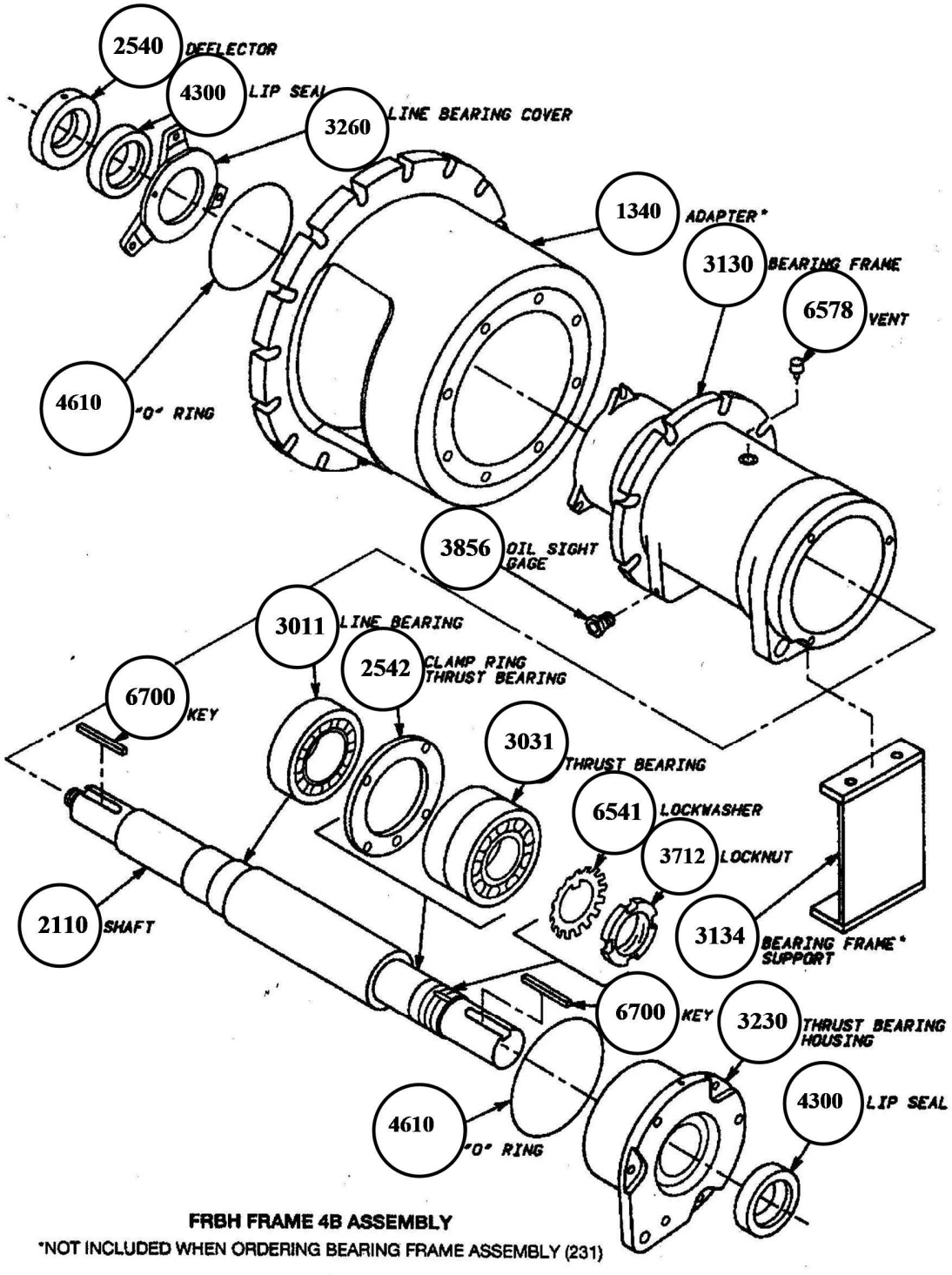
## 8.3 **FRBH & FRBHX Frame 4 with – 2 pc. Frame**




FRBH FRAME 4 PUMP SECTIONAL

| Ref. | Description | Ref. | Description | Ref. | Description |
|---|---|---|---|---|---|
| 1110 | Pump casing | 3230 | Thrust Brg. hsg. | 4590.3 | Gasket, Casing |
| 1340 | Adapter | 3260 | Bearing cover | 4590.4 | Gasket, Impeller |
| 1915 | Wear plate | 3712 | Bearing lock nut | 4610.1 | O-ring, imp.nut |
| 2110 | Pump shaft | 3856 | Oil site gauge | 4610.2 | O-ring, thrust brg |
| 2200 | Impeller | 4100 | Stuffing Box | 4610.3 | O-ring, Line brg. |
| 2250 | Radial Impeller | 4110 | Expeller Housing | 4610.4 | O-ring, Stuffing Box |
| 2445 | Shaft sleeve | 4121 | Gland, split | 4610.5 | O-ring, Expeller Hsg. |
| 2540 | Deflector | 4130 | Packing | 6541 | Lockwasher |
| 2542 | Clamping ring | 4132 | Neck bush | 6572 | Stud, wear plate |
| 2912 | Impeller Nut | 4134 | Lantern Ring | 6580 | Nut, wear plate |
| 3011 | Radial ball bearing | 4300.1 | Radial lip seal, Line brg. | 6700.1 | Key, coupling |
| 3031 | Thrust bearing | 4300.2 | Radial lip seal ,Thrust brg. | 6700.2 | Key, impeller |
| 3130 | Bearing bracket | 4590.1 | Gasket, wearplate | | |
| 3134 | Support foot | 4590.2 | Gasket, sleeve | | |

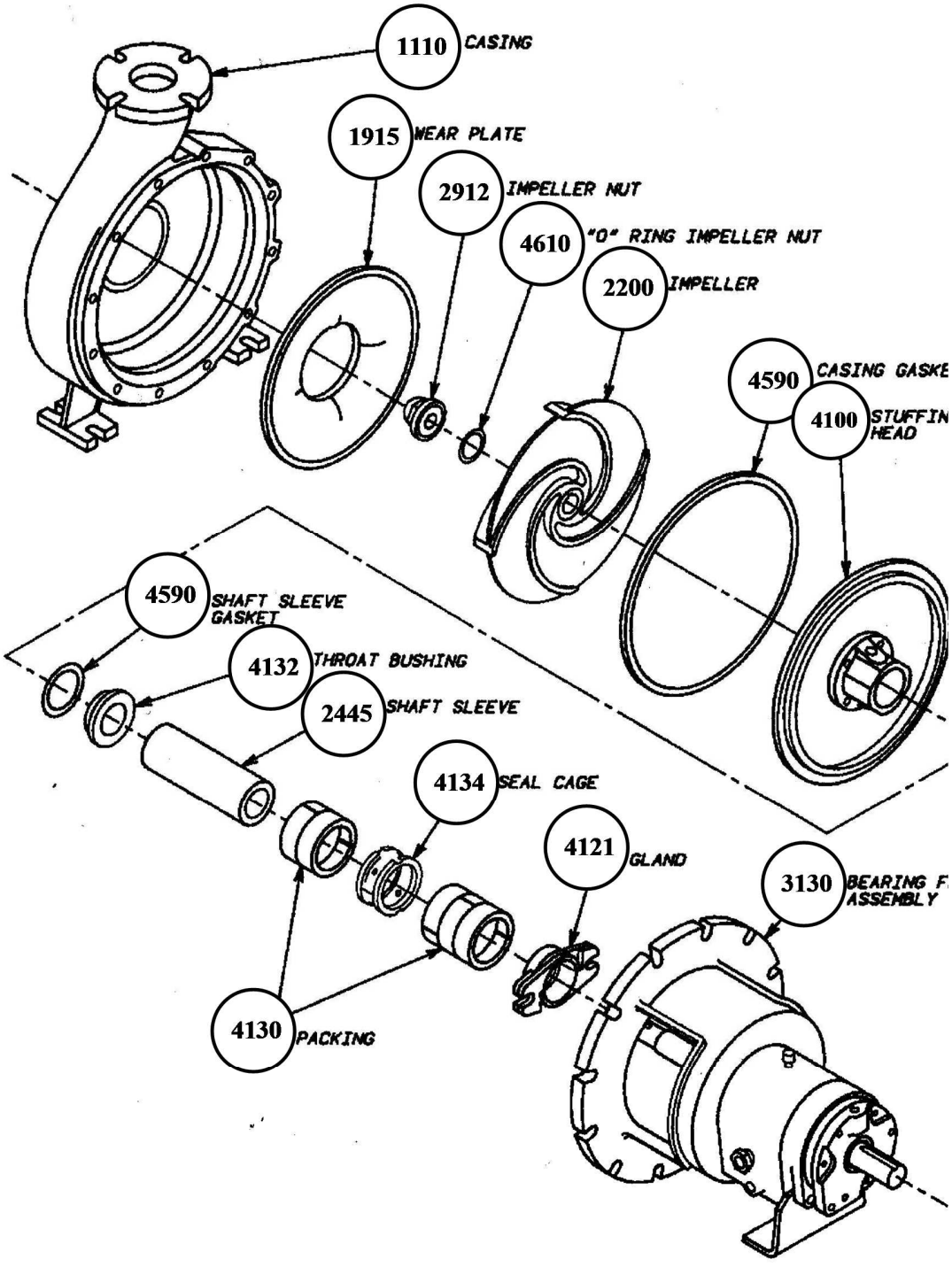
## 8.4 FRBH, FRBHX & FRBHS - Frame assembly-B4B (2 piece Frame)-Exploded View




**FRBH FRAME 4B ASSEMBLY**

*NOT INCLUDED WHEN ORDERING BEARING FRAME ASSEMBLY (231)

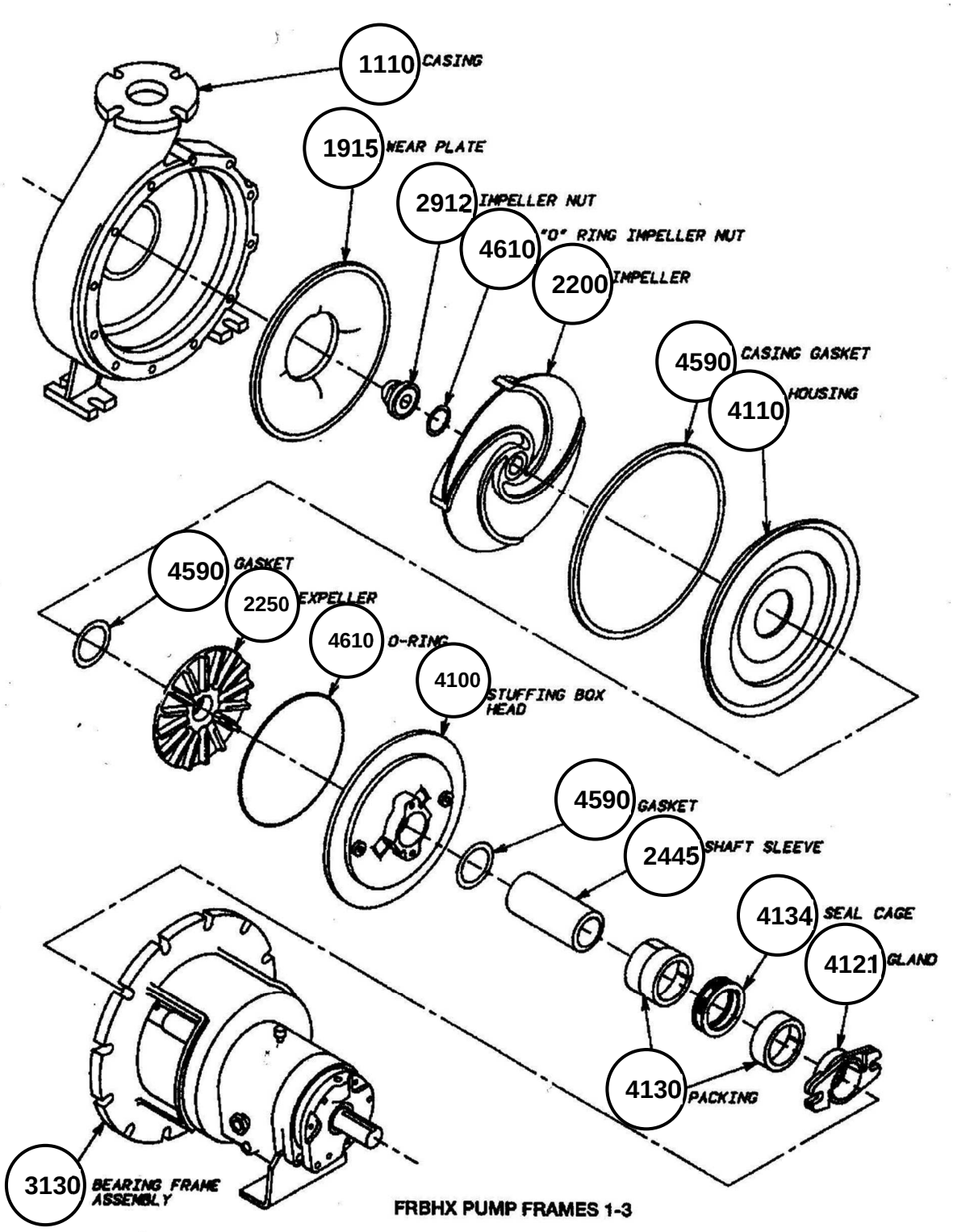
8.5 **FRBH Frames 1-4- liquid end Exploded View**




**STANDARD FRBH PUMP (WITH 1 PC. FRAME)**

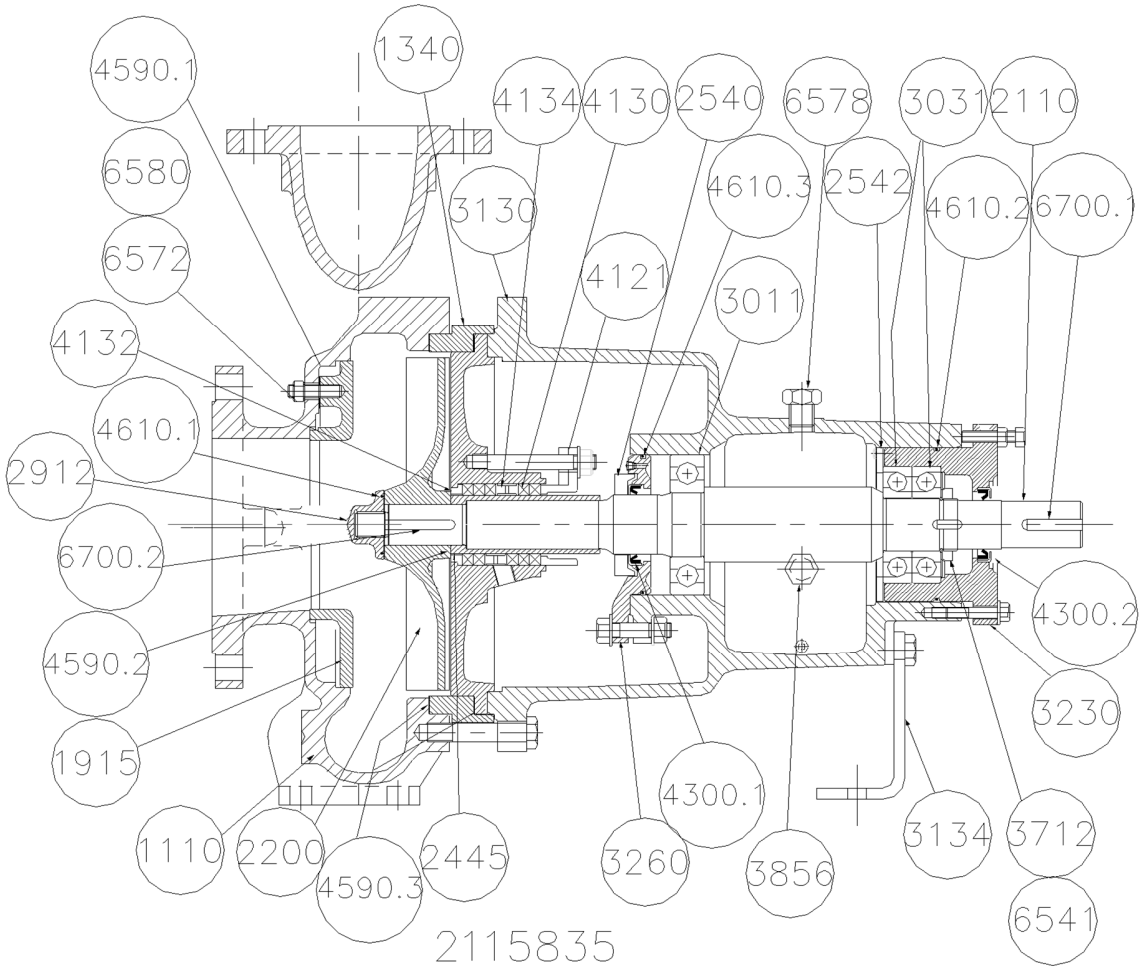
Where the Expeller is utilized see 8.4.1 for the parts list and exploded view.

8.6 **FRBHX - Exploded view**




FRBHX PUMP FRAMES 1-3

8.7 **FRBHS Sectional and Parts List**




| Ref. | Description | Ref. | Description | Ref. | Description |
|---|---|---|---|---|---|
| 1110 | Pump casing | 3230 | Thrust brg.Hsg. | 4590.3 | Gasket, casing |
| 1340 | Adapter | 3260 | Bearing Cover | 4610.1 | O-ring, imp.nut |
| 1915 | Wear plate | 3712 | Bearing lock nut | 4610.2 | O-ring, thrust brg |
| 2110 | Pump shaft | 3856 | Oil site gauge | 4610.3 | O-ring, Line brg. |
| 2200 | Impeller | 4100 | Stuffing box | 6541 | Lockwasher |
| 2445 | Shaft sleeve | 4121 | Gland, split | 6572 | Stud, wear plate |
| 2540 | Deflector | 4130 | Packing | 6580 | Nut, wear plate |
| 2542 | Clamping ring | 4132 | Neck bush | 6700.1 | Key, coupling |
| 2912 | Impeller Nut | 4134 | Lantern Ring | 6700.2 | Key. impeller |
| 3011 | Radial ball bearing | 4300.1 | Radial lip seal, Line brg. | | |
| 3031 | Thrust bearing | 4300.2 | Radial lip seal, Thrust brg. | | |
| 3130 | Bearing bracket | 4590.1 | Gasket, wearplate | | |
| 3134 | Support foot | 4590.2 | Gasket, sleeve | | |

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

## 10 OTHER RELEVANT DOCUMENTATION AND MANUALS

### 10.1 Supplementary User Instruction manuals

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

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

### 10.2 Change notes

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

### 10.3 Additional sources of information

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

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

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

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

*Reference 5:*
ANSI B31.3 - Process Piping.

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