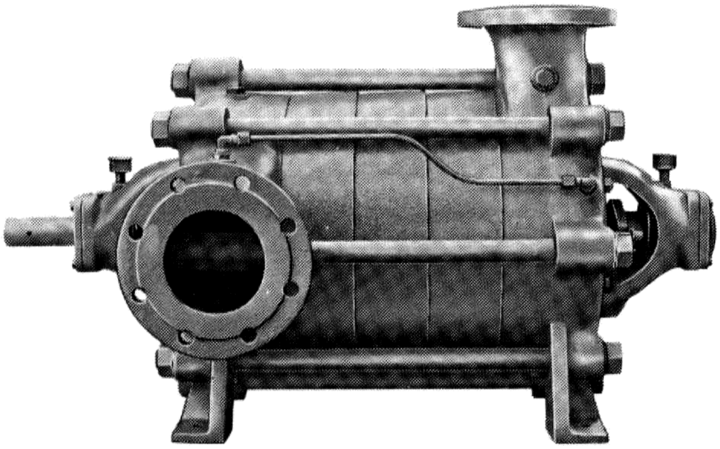
KSB WK

High Pressure Centrifugal Pumps



LINE: **MULTISTAGE**

Application

KSB WK pump is recommended for boiler feed, water supply, condense and circulation of hot water.

Design

Horizontal radically split multistage with side suction, and tops discharge.
Casings are sealed with O'-Rings and held together by external tie bolts. Pump feet are integrally cast on the suction and discharge casing.

Designation

KSB WK 80 / 7

- KSB – Trade Mark
- WK – Model / Type
- 80 – Discharge Nozzle Nominal Diameter (mm)
- 7 – Stage (Quantity)

Operating Data

Sizes	- DN 40 to 125 (1 ½" to 5")
Flow	- to 1,760 gpm (400 m³/h)
Head	- to 2,296 ft (700 m)
Temperature	- to 392º F (200º C)
Speed	- to 4,500 rpm

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Introduction

WK pumps are high-pressure horizontal centrifugal pumps. In accordance with the latest state of the art of pump design and construction, our pumps combine favorable hydraulic characteristics with a long service life, reliability of operation and simple maintenance and operation.
A pre-requisite for trouble-free operation of the pumps is the careful observance of the recommendations contained in this operating instruction manual. It should therefore always be at the disposal of the personnel entrusted with the erection, maintenance and operation of the pump.
It goes without saying that the pumps should only be operated under the duty conditions specified (see data sheet). The terms of our Guarantee naturally apply within this range of conditions. Our Guarantee will become invalid if the pumps are dismantled, either completely or partially, without our prior consent. The first assembly and dismantling of the pump should be carried out by skilled fitters and erectors, and this also applies to the initial start-up (commissioning) of the pumping set.

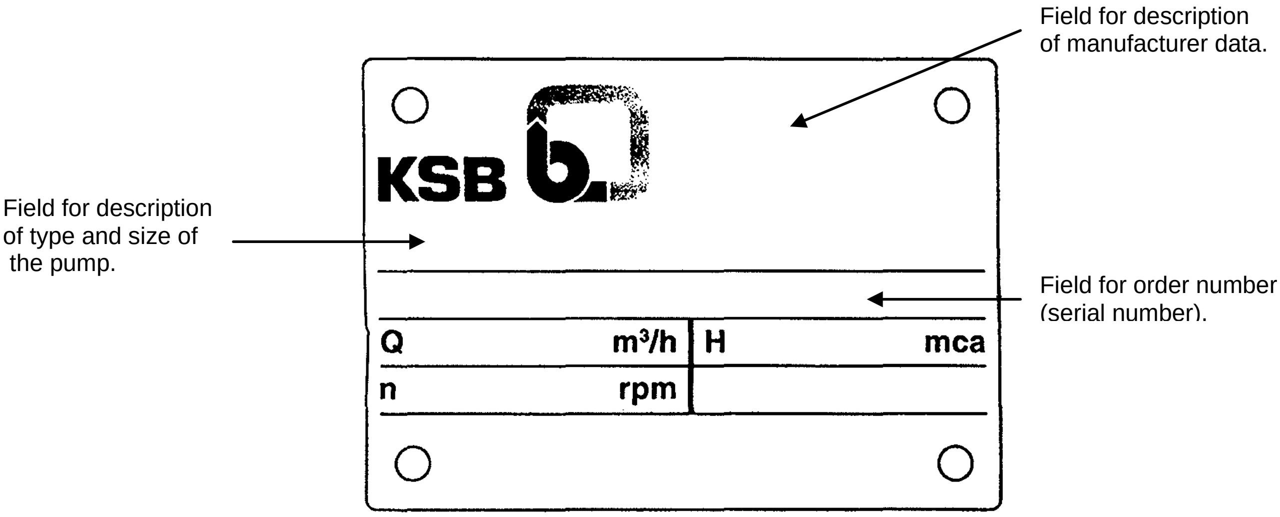


Fig.1

1. Pump Construction

(For ítem numbers see section 16 sectional drawings.)

1.1 Casing

WK high-pressure centrifugal pumps are single or multistage centrifugal pumps with a radials split casing. This consists of the suction and discharge casings (106 and 107) together with a number of stages casing (108). If the extraction of a given quantity of the liquid pumped at one or more intermediate pressures is required, the corresponding stage casings can be provided with extraction (bleeder nozzles. The individual casing components are sealed off against one another by flat gasket (400.2) and clamped together by tiebolts (905). The diffusers (171.1 and 171.2) are arranged in the
stage casings an in the discharge casing respectively (108 and 107 respectively). They are centered in the casings at their outer periphery and secured against twisting.
The stuffing box housings (451) and bearing housings (350) are flanged onto the suction and discharge casings respectively (106 and 107) and attached by studs (902.1).
The stuffing box housing (451) are sealed off from the suction and discharge casings respectively (106 or 107) by a flat gasket (400.3). On pumps fitted with special hot water stuffing boxes or with mechanical seals, the shaft seal is surrounded by a cooling water compartment, which is sealed off against atmosphere by the cooling cover (165) with flat gasket (400.3) and O-ring (412.4).
(See Fig.2).

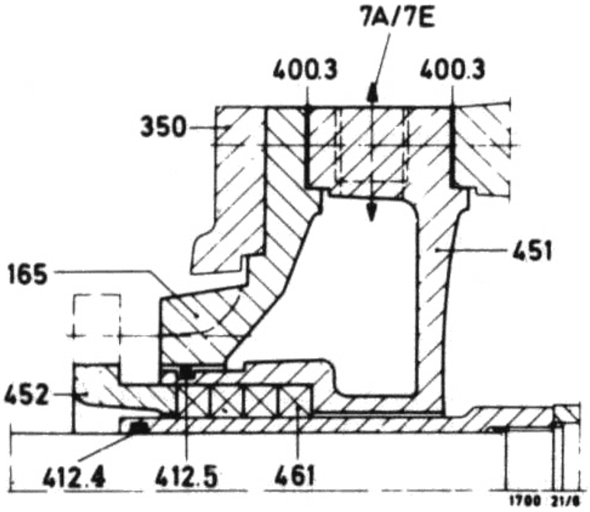


Fig. 2 - Stuffing box housing with cooling compartment cover

Depending on the number of stages and on the temperature of the product pumped, the pump feet are integrally cast onto the suction and discharge casings (106 and 107) either at the bottom, or at shaft centerline height. The suction nozzle can be arranged to point horizontally to the left or right hand side, or vertically upwards, if the pump feet are arranged at the bottom of the pump; if they are arranged at shaft centerline height, the suction nozzle can only be arranged to point vertically upwards.
The discharge nozzle points radials upward on both types of pump feet arrangement.
In order to achieve a favorable NPSH required, the suction nozzles on all sizes of pump are made one nominal size larger than the discharge nozzles. The flange construction is specified in the data sheet.

1.2 Rotor

All the rotating components assembled on the shaft make up the complete pump rotor (see Fig.3 and 4).
The shaft (210) transmits the torque generated by the driver onto the impellers. The impellers (230) are mounted in sequence on shaft (210) and they all point in the same direction. They are secured against twisting by keys.
The narrow clearance gap between impeller neck and casing wear ring (502) at the suction and discharge end of each impeller prevents the equalization of pressure between one stage and the next.

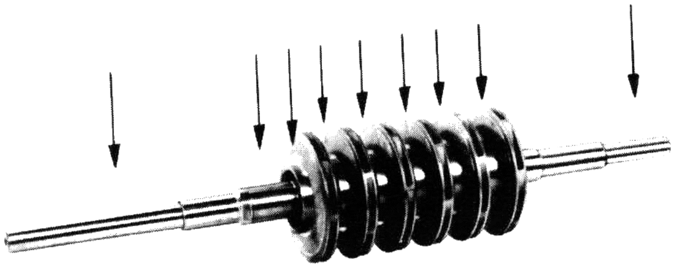


Fig. 3 - Assembled rotor

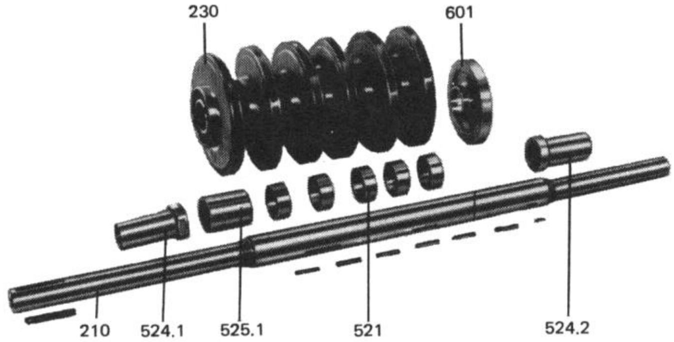


Fig. 4 - Dismantled rotor

The shaft (210) is protected inside the pump against attack by the fluid pumped by means of spacer steeves (525.1/.2) and stage steeves (521). The stage sleeves also serve to locate the impellers axially on the shaft. The shaft (210) is protected by the shaft protecting sleeves (524.1/.2) in the region of the shaft seal. These protecting sleeves are screwed onto shaft (210) by means of screw threads with opposed hand to the direction of rotation of the shaft.
In order to balance the axial thrust, throttling passages are arranged at the impeller necks at the suction and discharge end of each impeller, and additional balance holes are provided in the impeller cheeks at the discharge end (see Fig. 5).
A fixed bearing absorbs the residual axial thrust generated, and also locates the rotor in the axial position; in the standard bearing construction, this bearing consists of a deep groove ball bearing (321), and in the pump construction with heavy duty bearing housing it consists of two angular contact ball bearings (320).

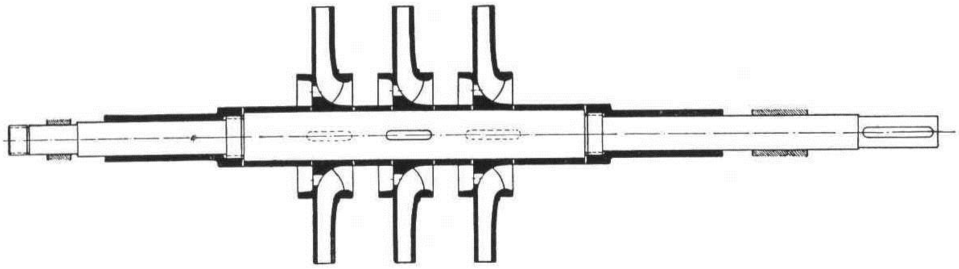


Fig. 5 - Rotor

1.3 Bearing Arrangement

WK pumps are fitted with different types of bearings and bearing housings, depending on the total head (generated pressure) of the pump. In the case of low total heads, the standard bearing construction is provided. In the case of higher total heads, the heavy duty bearing construction is provided to absorb the increased residual thrust.
he pump manufacturer decides which type of bearing arrangement shaft is provided.

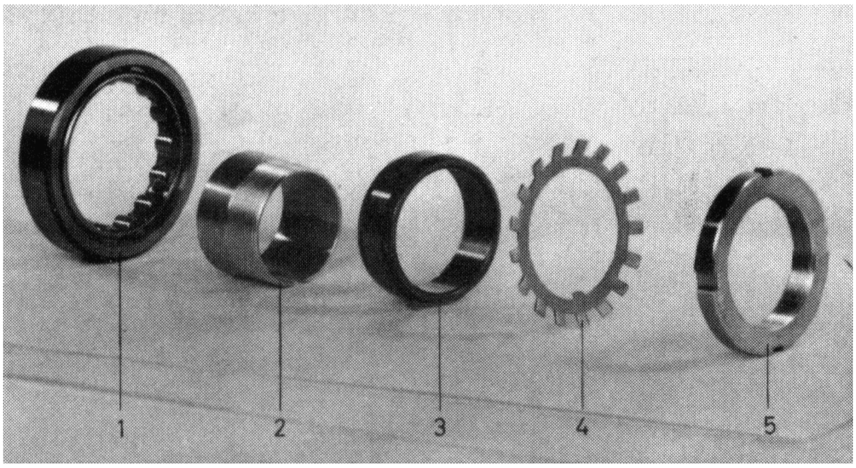


Fig. 6 - Individual bearing components (drive end)

Part 1 = Outer race with cage and rollers
Part 2 = Clamping sleeve
Part 3 = Inner bearing race
Part 4 = Tab washer
Part 5 = Ring nut for clamping sleeve

Standard Bearing Construction:

Drive end: 1 cylindrical roller bearing in accordance with DIN 5412 (see Fig. 6) with clamping sleeve in accordance with DIN 5415 and standard bearing housing.
Front end: 1 deep groove ball bearing in accordance with DIN 625 and standard bearing housing (see Figs. 7 and 8).

Standard Construction

Pump size	40	50	65	80	100	125
Drive end: designation in accordance with DIN 5412	NU 206 K C 3	NU 207 K C 3	NU 207 K C 3	NU 208 K C 3	NU 208 K C 3	NU 210 K C 3
Clapping sleeve in accordance with DIN 5415	H 206	H 207	H 207	H 208	H 208	H 210
Front end: designation in accordance with DIN 625	6403/C 3	6404/C 3	3306/C 3	6405/C 3	6405/C 3	6406/C 3
Oil fill in litters	0,16	0,18	0,18	0,25	0,25	0,28

Table 1 - Bearing and oil requirement table

See Fig. 10 “Bearing and oil requirement table” for precise bearing designation and size for the individual pump sizes. Thrower (507) on shaft (210) prevent the penetration of any leakage liquid from the stuffing box into the bearing housings.

1.4 Lubrication

1.4.1 Oil Lubrication

Standard construction WK pumps are provided with oil splash lubrication. The antifriction bearings are slightly submerged in the oil sump, ensuring perfectly satisfactory lubrication at all times. The max. oil level is automatically attained during topping up when oil starts pouring out of the overflow holes in the bearing covers (360/361).

On request, we can fit constant level oilers (638), which will necessitate the sealing of the shaft against the bearing housing by means of felt rings (422.1) (see Figs. 7 to 9).

Oil quality: Machinery oil possessing good air release properties and corrosion prevention characteristics; kinematics viscosity 36 cST approx. = 4.8º E at 50º C; flash point 150º C minimum; pour point lower than – 20º C.

Lubrication times: First oil change after the first 500 hours of operation, subsequent oil changes after every 3000 hours of operation approx., but at least once a year.

Topping up of the oil fill at least once a month.

The bearing temperature may be allowed to rise up to 40º C above room temperature, but should not exceed 80º.

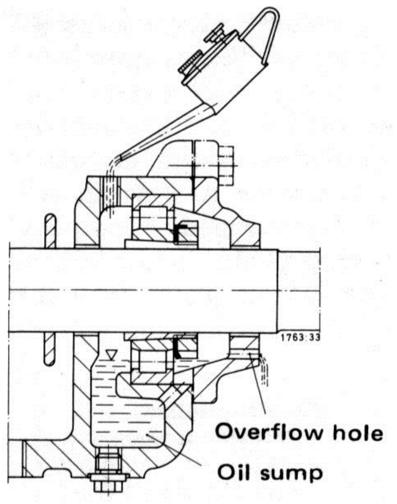


Fig. 7 - Oil splash lubrication

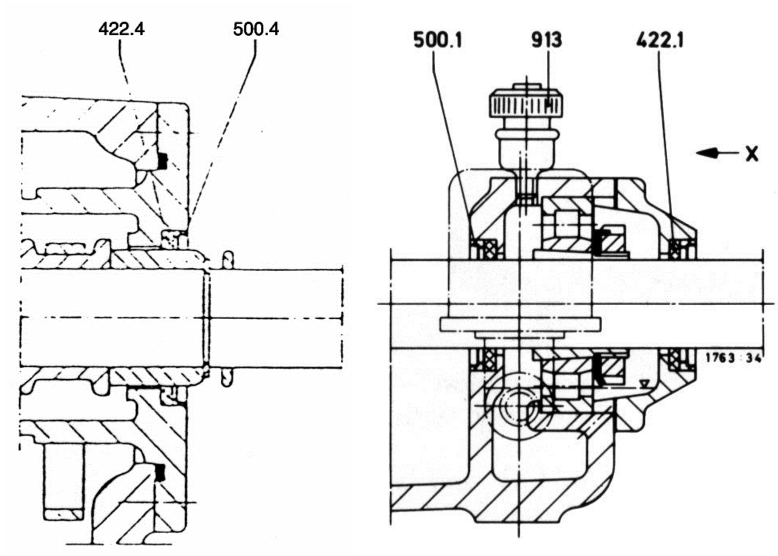


Fig .8 - Construction with constant level oilier and sealing of the bearing housing

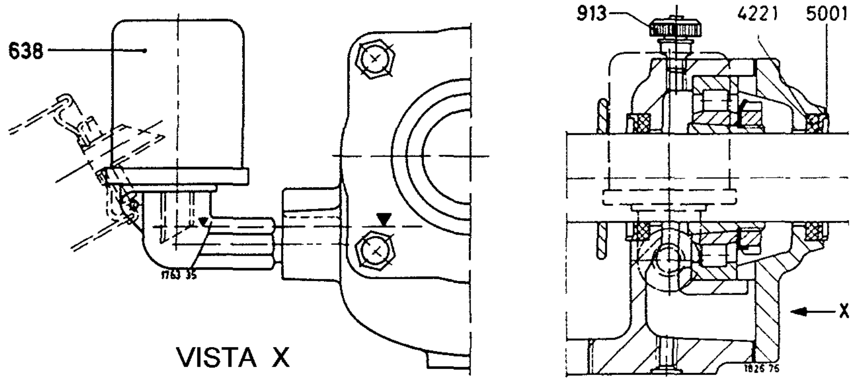


Fig .9 - Constant level oilier, viewed from X

1.4.2 Grease Lubrication

Portable (mobile) pumps, and installed on board ship have grease-lubricated bearings (see Fig. 10). Use a good quality lithium soap ball and roller bearing grease, free of resin and acid, and possessing rust preventive properties. The grease should have a penetration number situated between 2 and 3, corresponding to a worked penetration situated between 220 and 295 mm/10.
Its drop point should be not less then 175º C.

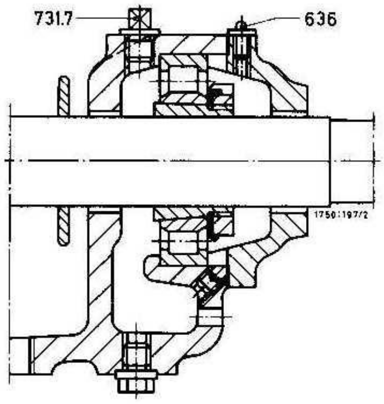


Fig. 10 - Grease-lubrication bearing construction

The bearing temperature may be allowed to rise up to 40ºC above room temperature, but should not exceed 80ºC. The grease fill will last for 1500 hours of operation, i.e. for 2 years approx. If the operating conditions are arduous, the bearings should be serviced once a year. A grease fill amounts to 10-20 grams of grease, depending on the pump size. The pump bearings are packed with grease at our Works before dispatch.

1.5 Shaft Seal

The shaft is sealed at its outlets through the casings by soft-packed stuffing boxes or by mechanical seals.
If the pump is fitted with special stuffing boxes, mechanical seals can be fitted in lieu of soft packing (or vice-versa) at any time during the service life of the pump, with a minimum of machining of the cooling compartment covers. On the other hand, the fitting of mechanical seals to pumps equipped with standard or hot water type soft-packed stuffing boxes necessitates the fitting of new pump components. Particulars can be obtained from the pump manufacturer.

1.5.1 Stuffing Boxes

Soft-packed stuffing boxes reduce the flow of leakage liquid at the clearance gap between casing and shaft protecting sleeve when the pressure inside the pump is higher than atmospheric. Conversely, on pumps, which operate on suction lift, the soft-packed stuffing box prevents the ingress of air into the pump. Sealing is effected by means of soft packing (461.1) arranged in a number of rings in the annular space between the stuffing box housing (451) and the shaft protecting sleeve (524.1/.2) and lightly compressed by the stuffing box gland (452).

Caution:
On pumps, which have a right discharge pressure, the stuffing box at the discharge end is relieved of pressure, via a balance liquid line, down to the suction pressure,
provided that the differential pressure across the pump exceeds 2 bar. This ensures that the stuffing boxes at the suction and discharge ends of the pump have the same
admission pressure. This arrangement applies to pump sizes 40 to 65 if the discharge pressure exceeds 20 bar and to pump sizes 80 to 125 if the discharge pressure exceeds 15 bar.
Single stage pumps require no special pressure relief even at high discharge pressures. The pressure is relieved via the balance holes in the impeller.

Soft-packed stuffing box. "Standard" (N) construction.
Standard construction with 4 packing ring (461.1), used for temperatures of the fluid pumped up to 105ºC. The stuffing box compartment cannot be cooled.

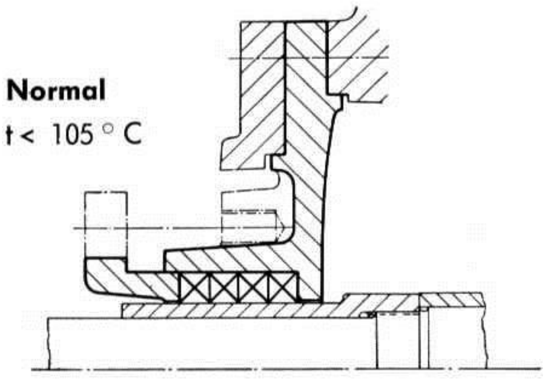


Fig. 11 - “Standard” (N) construction stuffing box

Soft-packed stuffing box, “Hot Water”(HW) construction.
Construction with 4 packing rings (461.1) and cooling of the stuffing box compartment. Used for temperatures of the fluid pumped in excess of 105ºC up to 230ºC max.

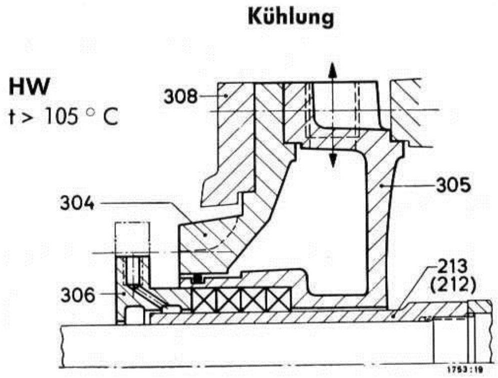


Fig. 12 - “Hot Water” (HW) construction stuffing box

Special stuffing box, “Extra-deep”(V) construction
Construction with 7 packing ring (461.1) and cooling of the stuffing box compartment, used mainly in process industry applications.

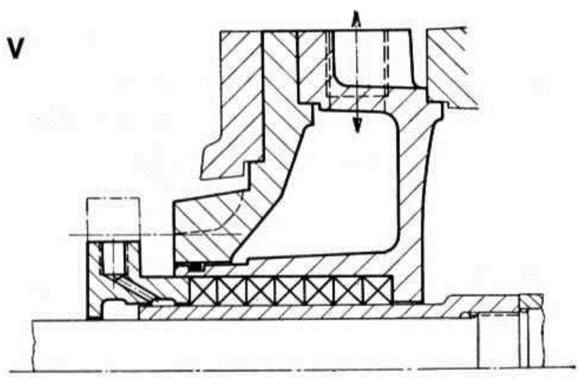


Fig. 13 - Special soft-packed stuffing box “Extra deep” (V)

Special stuffing box, “VSM” construction
VSM is the abbreviation (in German) of “Extra deep with lantern ring at the center”.
Construction with 5 packing rings (461.1) and one lantern ring (458) arranged at the center of the packing compartment; used mainly for operation under vacuum or suction lift, and where malodorous fluids are pumped .

For operation under vacuum, the lantern ring (458) is fed with a sealing liquid, and it prevents the ingress of air into the pump.

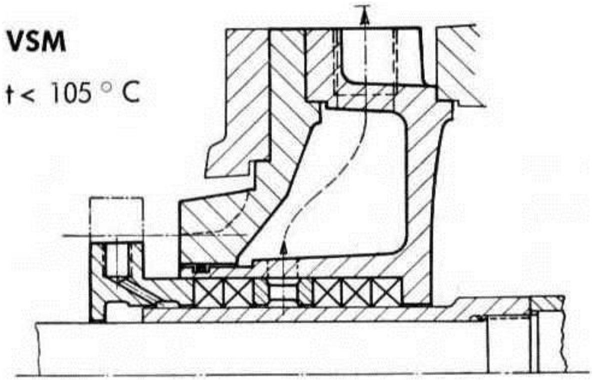


Fig. 14 - Special stuffing box VSM

Special stuffing box, "VSH" constructed
VSH is the abbreviation (in German) for "Extra deep with lantern ring at the bottom of the box."
This construction with 5 packing ring (461.1) and a lantern ring (458) arranged at the bottom of the packing compartment is used where fluids containing abrasive particles are pumped. The flushing liquid, which should be fed through the lantern ring (458) at a pressure of at least 1 to 4 bar (max.) above the suction pressure, penetrates inside the pump and protects the stuffing box packing (461.1) against abrasive substances.

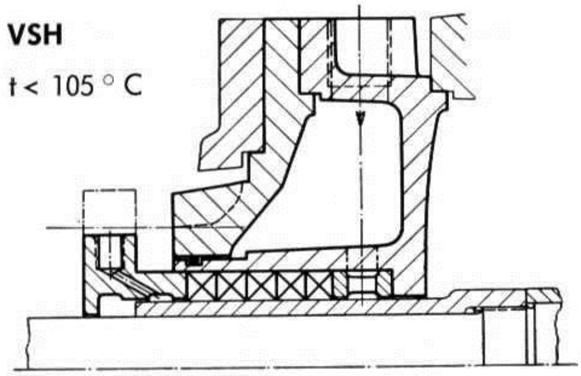


Fig. 15 - Special stuffing box VSH

1.5.1.1 Cooling Liquid for Stuffing boxes

Treated cooling water, which does not tend to precipitate salts causing hardness out of solution should be used as cooling liquid. The cooling water should be allowed to flow out freely and visibly, so that it can be checked at any time in respect of flow and temperature. The temperature differential between cooling water inlet and outlet should not exceed 10ºC. The max. permissible cooling water outlet temperature should not exceed 50ºC. The cooling water pressure should be situated between 1 bar min. and 10-bar max.
An isolating valve should be incorporated in the cooling water supply line, to enable the rate of flow of cooling water to be adjusted, and the supply of cooling water to be turned off when the pump is shut down. The cooling water should only be turned off after the temperature of the fluid inside the pump has dropped to below 80ºC.

1.5.1.2 Packing the Stuffing Boxes

Caution:
The pump is dispatched from our Works with the stuffing boxes unpacked. An adequate supply of packing material is supplied loose with the pump.
The stuffing box will only be able to perform its vital function satisfactorily on condition that it is carefully packed and properly maintained as prescribed.

Before packing, thoroughly clean stuffing box gland (452), packing compartment and shaft protecting sleeve (524.1/.2).

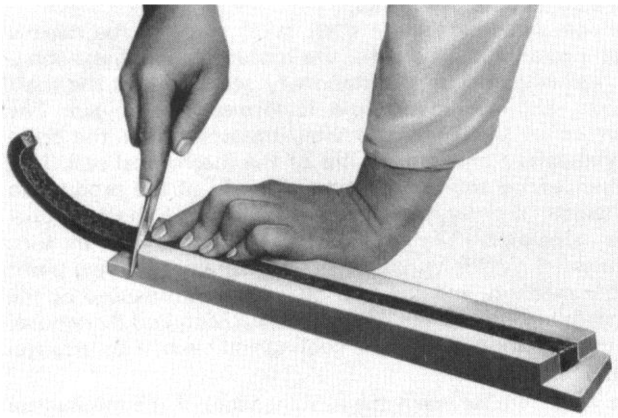


Fig. 16 - Cutting the packing rings to length

To cut the packing rings to correct length, use a suitable wooden cutting jig (we can supply same on request), to ensure that the packing rings butts come into correct contact with one another (see Fig. 16).

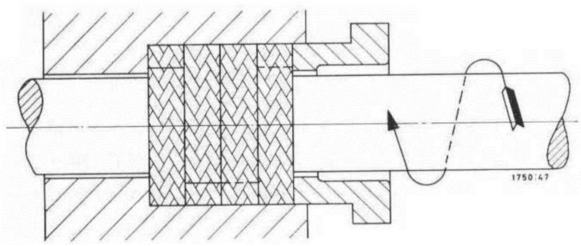


Fig. 17 - Stuffing box packing

If the packing rings are either long or too short, the stuffing box will not be able to perform its function properly. In the case of asbestos-graphite packing material, the rubbing faces of the individual rings should be lightly coated with molybdenum disulfide before insertion in the packing compartment. The first packing ring is then inserted and pushed home into the compartment with the aid of the stuffing box gland.
The following packing rings are then inserted into the packing compartment one by one, making sure that the butt joint of each ring is offset 90ºC approx. in relation to the butt joint of the preceding ring; the individual rings are pushed home into the packing compartment with the aid of the stuffing box gland (see Figs. 17 and 18). The packing rings should only be pressed lightly against one another. They should be inserted in the packing compartment in such a way that a clear gap of 6 to 8mm is left at the outer end of the compartment for the positive guidance of the stuffing box gland.

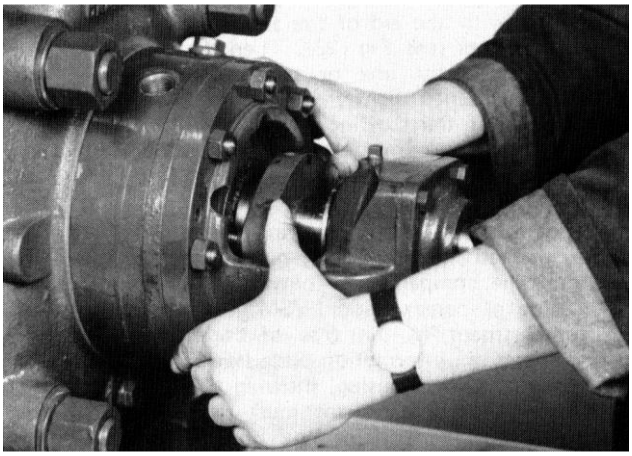


Fig. 18 - Insertion of packing rings with the aid of the stuffing box gland

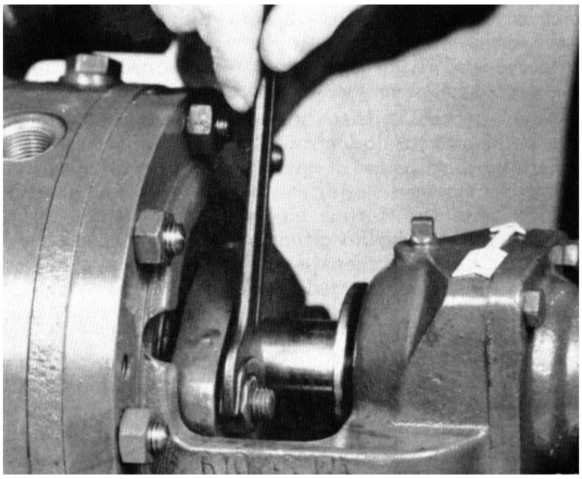


Fig. 19 - Tightening the stuffing box gland

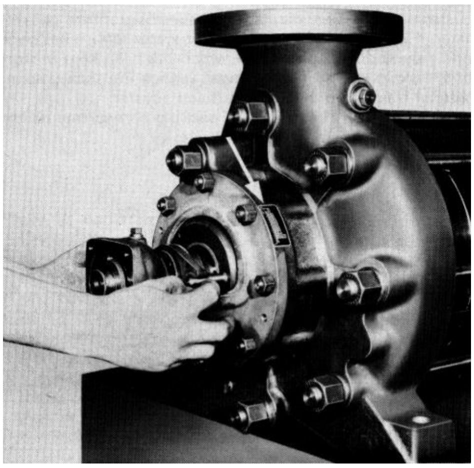


Fig. 20 - Information plate regarding lantern ring

The inserted packing rings should then be compressed moderately with the aid of the stuffing box gland (452) and of the nuts (see Fig. 19). Then the nuts should be slackened again by one to two complete turns, and there-after tightened lightly by hand. The correct and even seating of the stuffing box gland (452) should be checked when the pump is subjected to suction pressure, by inserting a feeler gauge between the gland (452) and the shaft protecting sleeve (524.1/.2).
In the case of the special stuffing boxes, a lantern ring is also inserted in the packing compartment, viz. at the center of the compartment (between the packing rings) in the case of construction “VSM”, and at the bottom of the compartment in the case of construction “VSH”. In these cases, an information plate (see Fig. 20) is affixed to the stuffing box housing, showing the position of the lantern ring. The lantern ring must register beneath the drilled hole in the stuffing box housing, to enable the sealing or flushing liquid to flow through the hole and the
ring. The sealing or flushing liquid pressure should be 1 to 4 bars above the pressure reigning in the packing compartment of the stuffing box.
The packing of the stuffing boxes should be carried out with great care, to avoid an excessively high radial pressing force of the packing rings against the shaft protecting sleeve, which night damage the latter. If the shaft-protecting sleeve is scored or grooved, even new packing cannot be expected to last very long in service.
A newly packed stuffing box should leak profusely at first. If this leakage does not cease of its own accord after a relatively short period of operation, the nuts on the gland should be tightened slowly and evenly while the pump is running until the stuffing box only drips slightly. Make sure that the stuffing box glands (452) are tightened evenly and not askew, as otherwise the shaft protecting sleeves (524.1/.2) might be damaged (see Fig. 19). The leakage rate in service of a soft-packed stuffing box should amount to 3 to 5 litters/hour approx.
If the newly packed stuffing boxes start to smoke when the pump is started up for the first time, the pump should be switched off. If the smoking persists the pump has been
started up again and operated several times in succession, the nuts on the gland should be slackened slightly, or the stuffing box should be inspected if necessary.

1.5.1.3 Packing Material

When selecting the packing material, make sure it is compatible with the fluid pumped (consult the manufacturer in case of doubt).
In steam generating plants, the asbestos-graphite packing material specially developed for hot water service has given good results. Packing material, which has been kept in store for a certain period, has a longer service life than packing material fresh from the packing manufacturer.

1.5.2 Mechanical Seals

Mechanical seals can be fitted as shaft seals in lieu of soft-packed stuffing boxes. If it is intended to replace soft-packed stuffing boxes by mechanical seals after the pump has been in service for some time, it is necessary for the pump to be equipped with stuffing box housings (451) for “V” special stuffing boxes. It is also necessary to re-machine two tapped holes in the cooling cover (165) for the attachment of the sealing cover (471).

Construction and Mode of Operation
The mechanical seal consists of the rotating components fastened onto shaft sleeve (523), which usually include a spring-loaded rotating seal ring (472), and of the stationary seal ring (475) fastened in the sealing cover (471). The rotating seal ring is sealed against the shaft by means of the shaft sleeve, whilst the stationary seat ring is sealed in the coverlet by an O-ring.

The actual sealing of the shaft takes place in the narrow axial clearance gap between the rubbing faces of the rotating seal ring and of the stationary seal ring. As the shaft rotates, a thin film of fluid is formed in this gap.
The presence of this film is of vital importance for the operation safety and service life of the mechanical seal. It is influenced by the lubricating properties of the product to be sealed, and by the effective removal of the frictional heat generated. The lubricating properties are in turn influenced by the viscosity, temperature and boiling point of the medium, and the frictional heat is influenced by the pressure to be sealed off, and its removal by the adoption of suitable cooling and circulation arrangements.
The fluid film between the rubbing faces of the mechanical seal rings must be completely free of solid particles of any kind at all times. Suitable steps must therefore be taken to prevent any solids from penetrating in the gap between the rubbing faces, particularly during the initial commissioning period, when the product pumped is likely to be contaminated.
When mechanical seals are fitted to the pump, the shaft seal at the discharge end is relieved of pressure, down to suction pressure, via a balance liquid line. This ensures that the same pressure reigns in both seals, at the suction and discharge end of the pump.
Pumps fitted with mechanical seals are provided with an end ring (500.3) inserted in the coverplate (471), which creates an additional compartment at the atmospheric end. Because of the narrow clearance gap between this ring and the shaft, it is made of non-sparking material. The compartment formed by this ring protects the rubbing faces of the mechanical seal against the ingress
of dust and sand, and also prevents an excessive leakage of product to atmosphere in the event of failure (breakdown) of the mechanical seal.
This compartment can also be fed with quenching fluid for additional cooling and sealing purposes. In this case, the end ring (500.3) must be replaced by a shaft sealing ring (420).
The standard mechanical seal fitted to WK pumps is a single-acting, balanced mechanical seal dependent on the direction of rotation. For temperature of the medium pumped up to 120º C, it is not necessary to provide circulation facilities, and for temperatures from 180ºC up to 230ºC max., circulation facilities with cooling of the circulation liquid should be provided (see Fig. 25). If the operating temperature is situated between 120ºC and 180ºC, then pump manufacturer should be consulted.
Caution: O-ring of EP (ethylene-propylene rubber) must on no account be allowed to come in contact with grease or oil.

Cooling and Circulation
The heat generated by the rubbing faces of the mechanical seal must be carried away.
Depending on the nature and temperature of the product pumped, various methods of doing this have been evolved, and the temperature stability of the elastomers used (i. e. of the sealing elements) plays its part in this context.
The pressure of the circulation liquid should be from 1 to 4 a bar above pump suction pressure approx.

1. For temperature of the product pumped below 70ºC, measured at the pump discharge nozzle, it is not necessary to cool the seal housing or the circulation liquid. Uncooked product is tapped from a stage casing (or exceptionally from the discharge casing) and fed into the mechanical seal via the circulation line and via the sealing cover (471), and returned to the inside of the pump. The rate of flow of the circulation liquid is adjusted by means of a flow controller (see Fig. 21).
2. For temperatures of the product from 70ºC to 120ºC, the jacket of the seal housing must be cooled (cooling liquid connections 7 A an 7 E).
3. For temperatures situated from 120 to 180ºC, both the jacket and the stationary seal ring must be cooled (stationary seal ring of K shape). Treated water, e.g. cold condense, should preferably be used to cool the stationary seal ring.

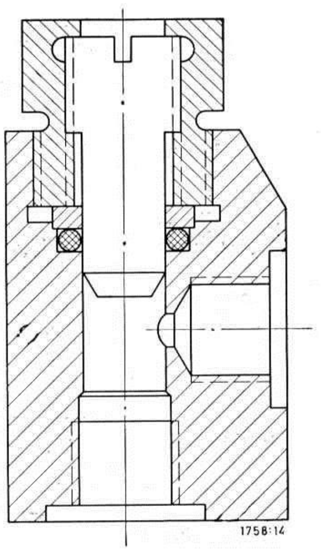


Fig. 21 - Flow controller

4. For temperatures of the product within the range 180ºC to 230ºC, jacket cooling and circulation are provided. The circulation liquid is tapped from a stage casing and cooled down in a heat exchanger, its rate of flow is adjusted by means of a flow controller, then it is fed into the seal via connection 12 E on the seal coverplate and returned to the inside of the pump.

The corresponding piping arrangement is illustrated in the certified piping and circulation diagram.

1.6 Coupling

The pump is connected to the driver by a flexible coupling. Fig. 22 illustrates the type of coupling most frequently used.

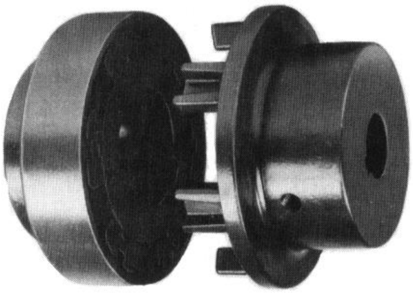


Fig. 22 - Flexible coupling

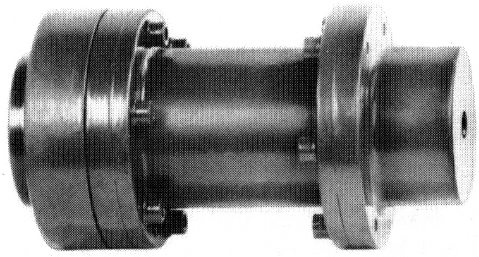


Fig. 23 - Spacer-type flexible coupling

Spacer-type couplings (see Figs. 23 and 24) enable inspections and minor repairs (e. g. the fitting of new bearings or shaft protecting sleeves) to be carried out without removing the driver.

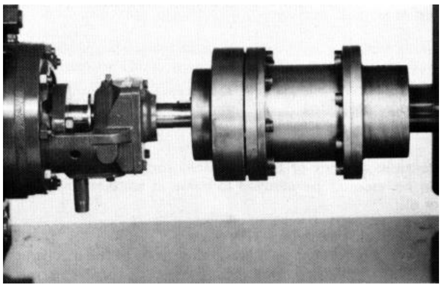


Fig. 24 - Mounted spacer-type flexible coupling

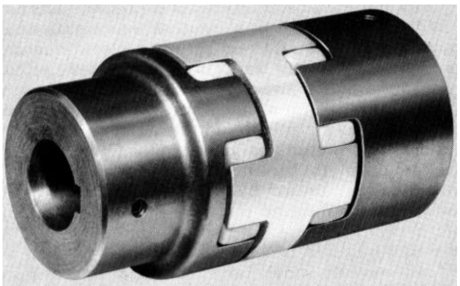


Fig. 25 - Highly flexible coupling

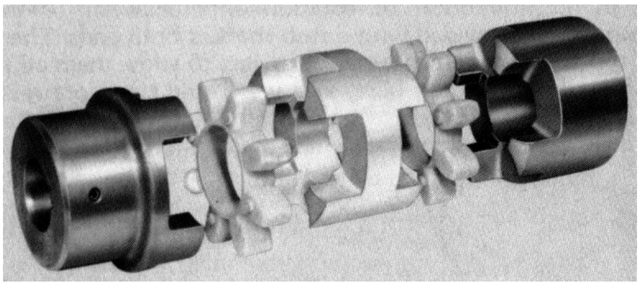


Fig. 26 - Highly flexible coupling

Highly flexible couplings (see Figs. 25 and 26) must be used if the operating conditions are particularly severe – e.g. high operating temperatures combined with pump feet arranged at the bottom of the pump.
All couplings require a very careful alignment of the pump and driver shafts, because faulty alignment (either insufficient concentricity or parallelism of the shafts) cannot be fully absorbed by, the flexibility of the coupling at the high rotational speeds prevailing.

2. Operation mode of the Pump

The fluid flows through the suction casing towards the impeller at a given pressure. Energy is transmitted to the fluid by the impeller, which is fitted with vanes. From the impeller, the fluid flows into diffuser, where kinetic energy is converted into potential energy, increasing the pressure rise still further.

The return guide vanes arranged on the discharge end cheek of the diffuser (171.1) guide the fluid under hydraulically favorable conditions towards the eye of the following stage impeller (230). This process is repeated from one stage to the next, and the pressure rises by the same amount in each stage, viz. by the stage-generated pressure. After leaving the final stage diffuser (171.2), the fluid flows through the discharge casing (107) into the discharge line connected to this casing.
The generated pressure creates an axial thrust on the pump rotor of single and multistage centrifugal pumps.
By the provision of narrow throttling gaps between the impeller necks and the casing wear rings at either side of each impeller, equal size lateral impeller spaces, and therefore almost identical pressure conditions are created at the suction and discharge ends of each impeller (see Fig. 27).

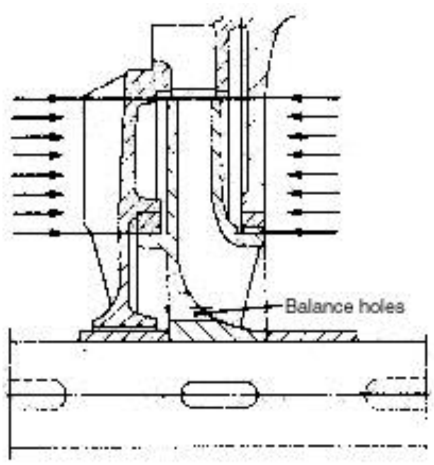


Fig. 27 - Axial forces acting on impeller

The balance holes in the discharge side impeller cheeks ensure a compensation of pressures between the suction and discharge sides of the impellers in the region situated between the impeller hub and the throttling gap, thus again preventing the creation of any appreciable axial thrust in this region of the impeller. Any residual axial thrust is absorbed by the fixed bearing in the discharge end bearing housing. This fixed bearing also locates the axial rotor position.

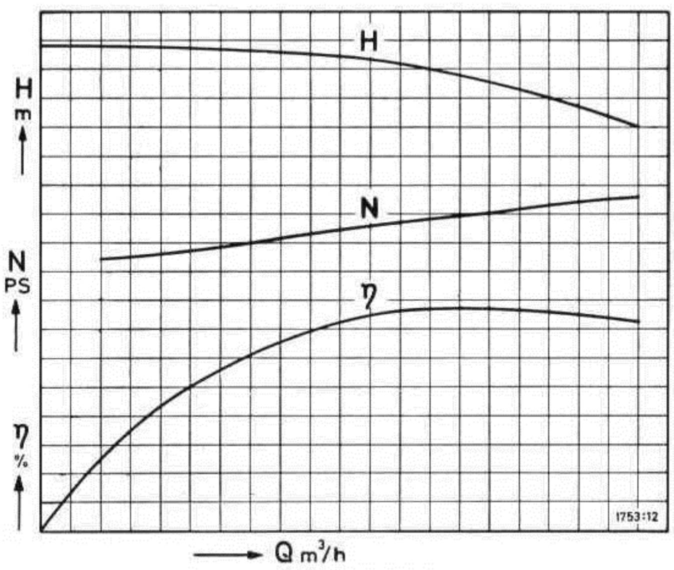


Fig. 28 - Characteristic for constant pump rotational speed

As can be seen in the diagram (Fig. 28), the power absorbed by the pump does not decrease proportionately with decreasing rate of flow, but remains relatively high at the pump shutoff point (capacity Q = O).
This absorbed power is almost wholly converted into heat inside the pump, and this heating up process can lead to rapid evaporation of the fluidinside the pump particularly if the driving motor is powerful and the fluid pumped is hot; this happens at the pump shutoff point (Q = O) and at very low rates of flow.
In order to avoid such evaporation, which might damage the pump, it is necessary to ensure a given minimum rate of flow through the pump at all times, which removes the heat generated.

For this purpose, an automatic recirculation valve (combined with a non-return valve) is provided (see section 9.3.1); this valve automatically opens a by-pass line when the rate of flow drops below a given pre-set value. If such a valve is not incorporated in the plant, the pump must not be operated beloe a given minimum rate of flow, nor must it be allowed to run against a closed discharge valve. After start-up against a closed discharge valve, the latter should be opened immediately. If the pump handles a hot fluid or a fluid with a low boiling point (highly volatile), or if it operates on suction lift, steps must be taken to ensure that the fluid at the pump inlet nozzle has attained the pressure prescribed in the Confirmation of Order, in order to prevent vapor formation and the resulting damage caused by cavitation particularly the disintegration of the first stage impeller).
If the backpressure is too low, the capacity of the pump will increase unduly, and the danger then arises of overloading and overheating of the driving motor.

3. Drive

The driver is usually connected to the stub shaft at the suction end of the pump. The direction of rotation is clockwise viewed from the driver onto the pump. On request, the drive can be arranged at the discharge end of the pump (direction of rotation anticlockwise) or the pump can be provided with a stub shaft at both ends.
There are too many different types of drivers to allow them all to be described in detail here, and we would therefore refer you to the operating instructions for the driver, published by the driver manufacturer, which are attached.

4. Transport

If the pump is supplied as a unit bolted onto a baseplate, the ropes for handling and transport should be slung under the pump and driver as illustrated in Fig. 29.

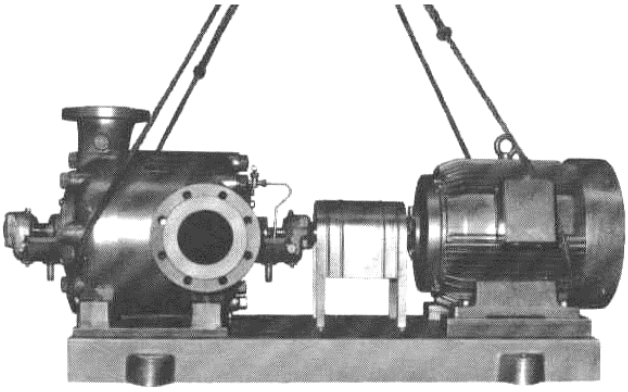


Fig. 29 - Slinging the ropes under the pump and driver mounted on a combined baseplate

If the pump is supplied with a short baseplate or without a baseplate, the ropes should be slung under the tiebolts as illustrated in Fig. 30.
Caution:
When slinging the ropes for transport, never sling them under the pump stub shafts or under the bearing brackets.

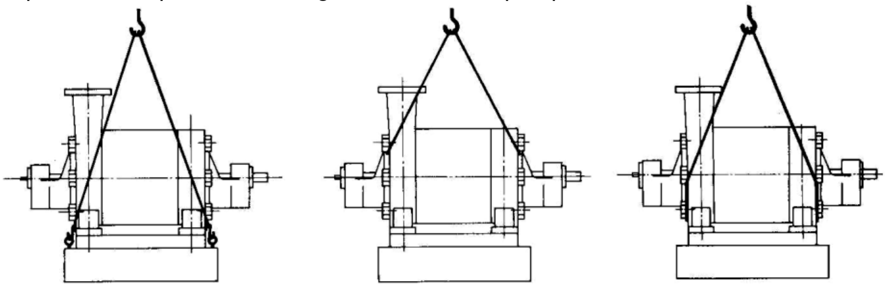


Fig. 30 - Slinging the ropes on a pump with short baseplate (Fig. 4)

5. Painting

Standard construction pumps operating at temperatures below 90ºC are provided with a coat of primer and a topcoat of synthetic resin base blue enamel paint (RAL 5002). If the operating temperature exceeds 90ºC, the “hot”pump components, i.e. casing, pressure gauge piping and tiebolts are provided with a coat of aluminum paint.

All the “cold” pump components, viz. the baseplate, bearing housings etc. receive a coat of primer and a top coat of blue enamel paint (RAL 5002).
Special painting to customer’s specification can be carried out on request in accordance with the Confirmation of Order. All bright parts and surfaces on the pump are coated with oil or grease.

6. Condition of Equipment as Supplied

The following constructions can be supplied on request (see order confirmation for certified and binding data):
1. Pump without baseplate.
2. Pump mounted on short baseplate.
   (Designed to accommodate pump only).
3. Pump and driver mounted on combined baseplate.

The internal interconnecting piping for the pressure relief of the shaft seal, and any cooling liquid supply and drain lines or sealing liquid lines, in so far as required, are already laid at our works prior to dispatch, up to the limit of the Extent of Supply. The coupling and coupling guard are already mounted on the pump.
When a pump is supplied mounted on a combined baseplate, only the pump is doweled to the baseplate, after having been aligned with the driver.
The driver should be doweled on site with cylindrical dowel pins after the final alignment on site.

Caution:
1. The pump bearings are not filled with oil.
2. The stuffing boxes are not packed.

All openings are plugged with PVC caps.

7. Accessories

As a general rule, the following items are supplied loose with the pump:
1 set of binding bolts (only supplied loose if the pump is supplied without a baseplate)
1 set of foundation bolts (if the pump is supplied with a baseplate)
On request, the following items can be supplied, amongst others:
Pressure gauge holder or pressure gauge bridge
Pressure gauge
Pressure vacuum gauge
Stop valve for pressure gauge
Coupling extractor device
1 set of shims and packing plates for leveling up
1 wooden cutting jig for packing rings
1 set of special tools

8. Installing the Pumping Set

8.1 Description of Site prior to Commencement of Erection

When our erection staff arrive on site, the pump foundation must have been checked for dimensional conformity with our foundation drawing data by the site management, and cleared for erection to proceed. The foundation and its immediate surroundings must be in a suitable condition to enable the efficient and speedy erection of the pump and accessories to proceed without hindrance.
Our erection staff must be able to make use of customer’s hoisting gear. e. g. the engine room crane etc. for transport and erection if required.
Our erection staff will check the correct orientation of the foundations in relation to the space axis after clearance for erection has been given. The site management is responsible for the zero point marking of the foundations (see “Conditions of Erection”).
The areas for the packing plates (shims) should now be marked out and trued up in accordance with the foundation drawing. Then thick packing plates should be laid in position and leveled up with a spirit level.
The packing plates should lie flush on the foundation and be leveled up as truly horizontal as possible to facilitate the subsequent alignment and leveling up of the complete pumping set as accurately as possible. The exact height is of less importance at this stage, because any difference in heights can be compensated by the insertion of shims of varying thickness when the set itself is leveled up. Three-point support should be adopted for the preliminary leveling up.

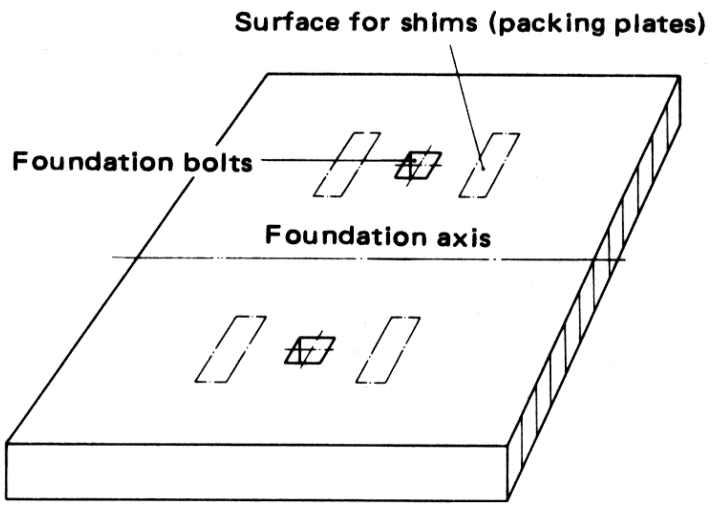


Fig. 31 - Preparation of foundation

8.2 Installation and preliminary leveling up

The pumping set should only be placed on the foundation after the latter has set quite firmly, and the preparations for the foundation described above should be carefully followed. Before placing the set on the foundation suspend the foundation bolts in the baseplate. Then fix the longitudinal and lateral directions and the correct height, and then carry out a preliminary leveling up with the aid of a spirit level, and grout in the foundation bolts.

8.3 Aligning the Coupling

If the bare shaft pump is supplied, i.e. the motor or gearboxes are not mounted; the flexible coupling should be pre-heated to 100-120ºC approx. in an oil bath before mounting on the stub shafts. The flexible elements should be removed beforehand.

Caution:
Never drive the half coupling onto the shaft by hammer blows. Always use a pusher device to mount it on the shaft (see Fig. 32).

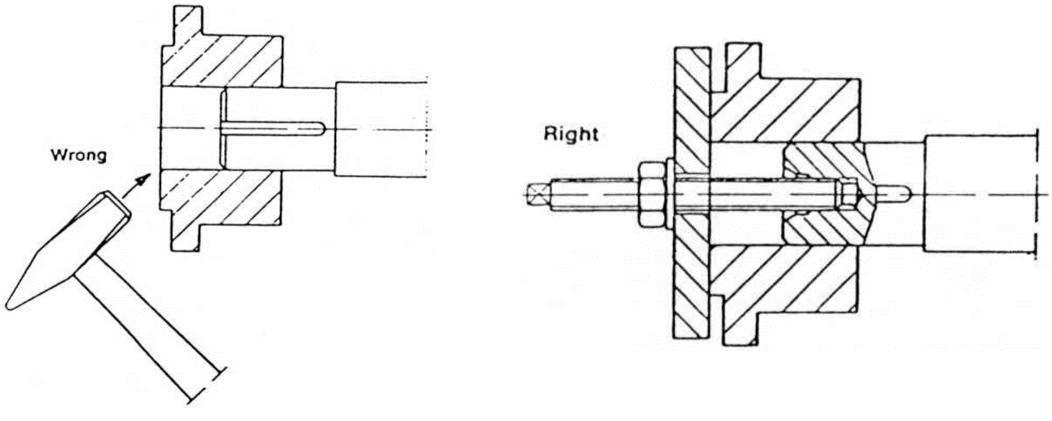


Fig. 32 - Mounting the coupling

In order align the shafts, the pump and driver should be pushed towards each other until the two coupling halves are separated by the axial gap specified in the foundation or installation drawing.
The preliminary alignment of the coupling is effected by means of a short straight edge and feeler gauge.

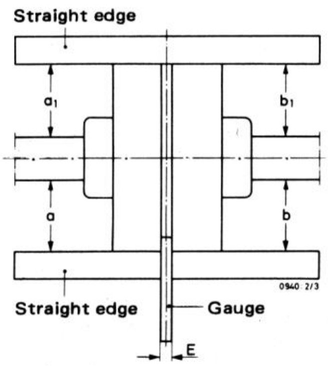


Fig. 33 - Aligning the coupling by means of a straight edge and gauge

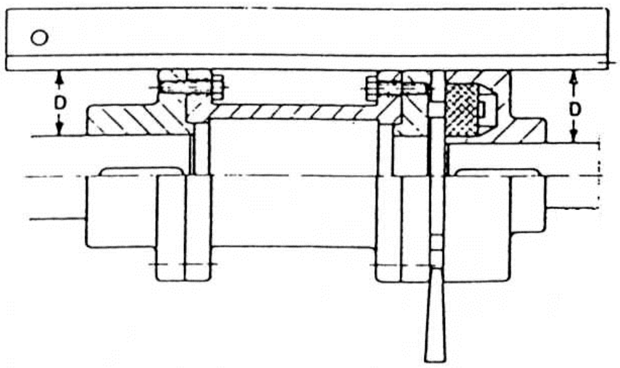
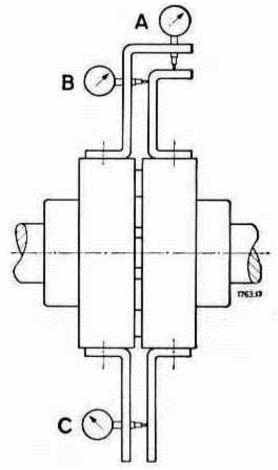


Fig. 34 - Aligning the spacer-type coupling by means of a straight edge and gauge

Check the axial gap "E" at various points around the periphery, with the aid of a feeler gauge, and place a short straight edge across the outer diameter of the two coupling halves, forming a bridge. If the gap "E" remains constant around the periphery and if the straight edge lies flush at all points, the preliminary alignment can be considered satisfactory (see Figs. 40 and 41).
The accurate coupling alignment requires the manufacture of a coupling alignment jig. This can be made from 20 x 20 flat bar steel or similar; the jig should be attached to the shafts (see Fig. 35).



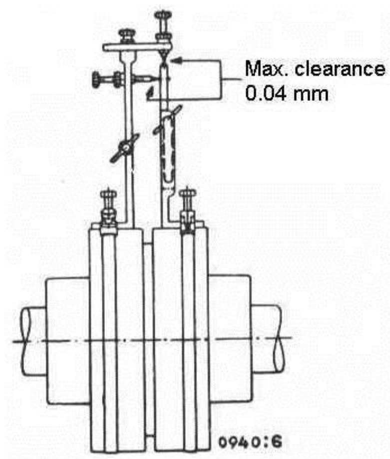


Fig. 35 - Coupling alignment jig

The coupling can be considered correctly aligned with the aid of the jigs illustrated if the difference measured does not exceed 0,04 mm both in the radial and axial directions, measurements being taken in 4 planes at 90º intervals. The coupling alignment check should be repeated after the piping has been connected to the pump.

8.4 Grouting in the Baseplate

After alignment of the coupling, the holes for the foundation bolts and the baseplate should be grouted in with a quick-setting cement mortal in 1:2 ratio (1 part of cement to 2 parts sand and gravel). Make sure that all the boxes in the baseplate are completely filled with the cement mortar, and that no cavities remain.
The foundation bolts should be tightened evenly and firmly after the grout has set firmly. Then check with the aid of a dial micrometer that the alignment is still correct.

8.5 Final Alignment

After all the pipelines have been connected, and the direction of rotation check has been carried out (with the pump disconnected from the driver), the final alignment of the pumping set should be effected. The same procedure should be followed as for the preliminary alignment, i.e. the relevant alignment jigs with 3 dial micrometers should be used, and the measurements previously described should be carried out at the various shaft positions (see section 8.3. "Aligning the Couplings").

Caution:
The pump feet must be pulled tight against their seating on the baseplate. The alignment can be considered satisfactory if the dimensional deviations do not exceed 0,04 mm both in the case of the radial measurement and in the case of the axial difference measurement (see section "Alignment").
The final measurement readings should be entered in the system of coordinates on the erection checklist. Any necessary height adjustments should be effected by inserting shims of appropriate thickness under the feet of the individual machines.

9. Piping

The main piping should be connected to the pump with out transmitting any stresses or strains onto the latter. Any appreciable piping forces, which are transmitted to the baseplate via the pump, can detrimentally affect the alignment and the running of the pump. Such forces should therefore be kept to a minimum at all costs.

9.1 Suction Lift Line and Positive Suction Head Line

The pipeline connected to the suction casing (106) is called either a suction lift line or a (positive) suction headline, depending on whether the pressure at the pump inlet is below or above atmospheric pressure. This line should be kept as short as possible (see Figs. 36 and 37).
Suction lift lines should rise all the way towards the pump; they should also be absolutely leak-tight and be laid in such a way as to prevent the formation of air pockets at any point (see Fig. 36).

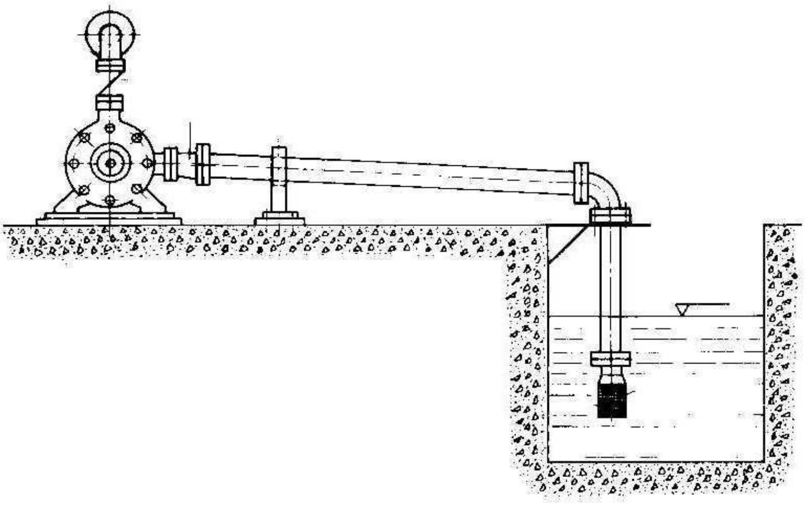


Fig. 36 - Suction lift line

The nominal size of the pump suction flange is no accurate guide to the size of the suction lift line. The latter should be sized, as a first approximation, to give a velocity of 2-m/sec. approx. In principle, every pump should be equipped with its own individual suction lift line. If this is not feasible for particular reasons, the common suction lift line should be sized for as low a velocity as possible, and preferably for a constant velocity right up to the last pump on the line (see Fig. 37).

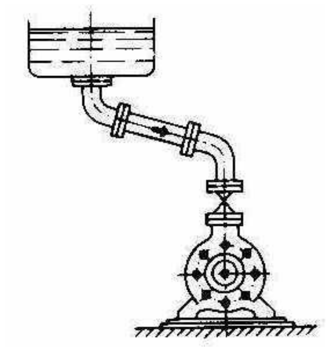


Fig. 37 - Suction head line

In addition, pumps connected to a common suction lift line should be equipped with VSM stuffing boxes.
If the suction lift line is buried, it should be hydrostatic ally tested at 3 to 4 bars before burial.
The same remarks as above apply to the nature and lying of (positive) suction headlines. Horizontal lengths of suction headlines should however be laid with a slightly rising stop towards the suction vessel. If it is not feasible to avoid apexes in the suction headline, each apex should be equipped with a vent cock. It is also advisable to avoid any appreciable length of horizontal suction head line laid close beneath the suction vessel, because of the danger of evaporation (see Fig. 38).

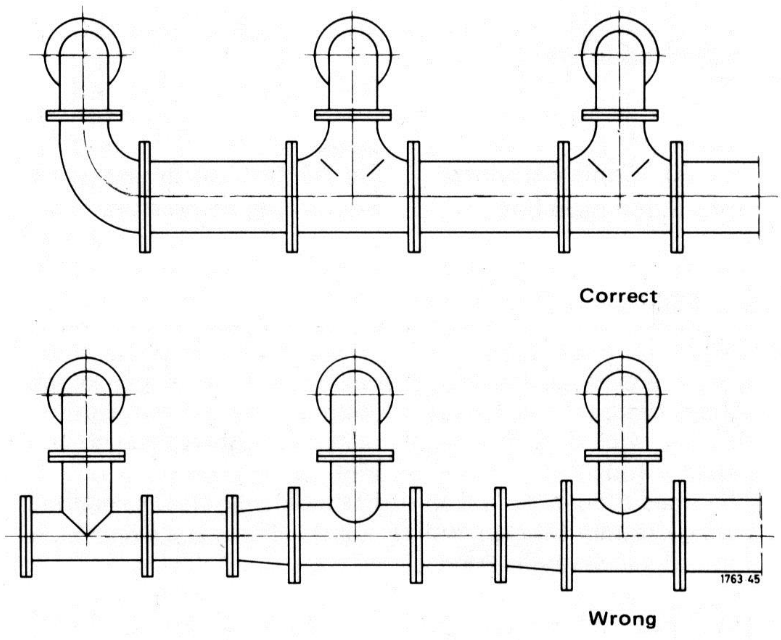


Fig. 38 - Common suction lift line for several pumps

9.1.1 Strainers in Suction Head Line/Suction Lift Line

Before a new pumping installation is commissioned all the vessels, piping and connections should be thoroughly cleaned, flushed through and blown through. It often happens that welding beads, pipe scale and other dirt only become detached from inside the piping after a considerable period of service: they must therefore be prevented from penetrating inside the pump by the provision of a strainer in the suction head or suction lift line. This strainer should have a free area of holes equal to 3 times the pipe cross-section area approach, in order to avoid excessive pressure drop when foreign bodies tend to clog the strainer.
Conical (hat-shaped) strainers have given good results in service (see DIN 4189); they should have a woken wire insert of corrosion-resistant material with a 1.0-mm mesh width of 0.5-mm diameter wire. The fine strained should precede the coarse strainer in respect of direction of flow of the fluid. During the initial period of commissioning, the suction pressure should be kept under frequent observation. If the NPSH available is found to decrease, this may be due to clogged strainers (the pressure drop across the strainer should be measured with the aid of a differential pressure gauge). The strainers should then be cleaned (see Figs. 39 and 40).
Unless anything to the contrary has been specified, the max. Permissible pressure drop across the strainer should not exceed 3 metros.

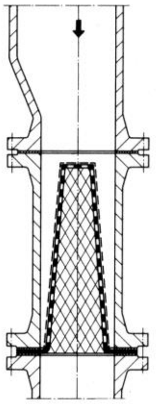


Fig. 39 - Conical strainer for suction head line

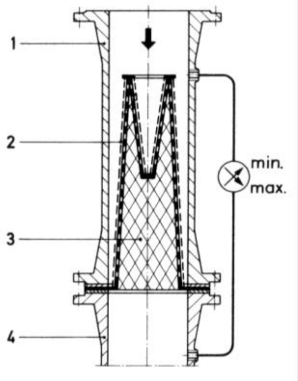


Fig. 40 - Conical strainer with monitoring of pressure drop

9.2 Isolating Valves

An isolating valve (gate valve) should be provided in the suction lift line, to enable the supply of fluid to a pump to be shut off if necessary. An isolating valve should also be incorporated in the discharge line of every pump, as close as possible to the pump itself. This valve can be used to adjust the operating point (rate of flow) apart from its function of isolating the discharge line. Isolating valves in suction headlines should only be used to isolate the line (in the event of repairs etc.). They must always remain fully open when the pump is running. If the pump operates under vacuum or suction lift, the isolating valve should be provided with a sealing liquid connection or with a closed water seal, to prevent any ingress of air into stuffing box of the valve stem. To facilitate venting, the isolating ales should be fitted in the line with their stem horizontal.

9.3 Non-Return Valves (in the discharge line)

A check valve or non-return valve should be incorporated between the pump and the isolating valve. Depending on the circumstances, this can be either a check valve, or a non-return valve or an automatic recirculation valve.
The object of the non-return valve is to prevent a reflux of fluid through Th. pump when the latter stops suddenly. A blocked or leaky non-return valve may cause the pump to rotate in reverse slackening the shaft protecting sleeves and damaging the pump.

9.3.1 Automatic Recirculation Valve

The Schroeder system automatic recirculation valve (minimum flow device) is a safety device, the purpose of which has already been explained in section 2 “Mode of Operation of Pump”. If should always be installed immediately downstream of the pump, always upstream of the isolating valve, and always vertical, with the direction of flow from bottom to top (see Fig. 41).
Each automatic recirculation valve is supplied in accordance with the operating conditions of the pump concerned.

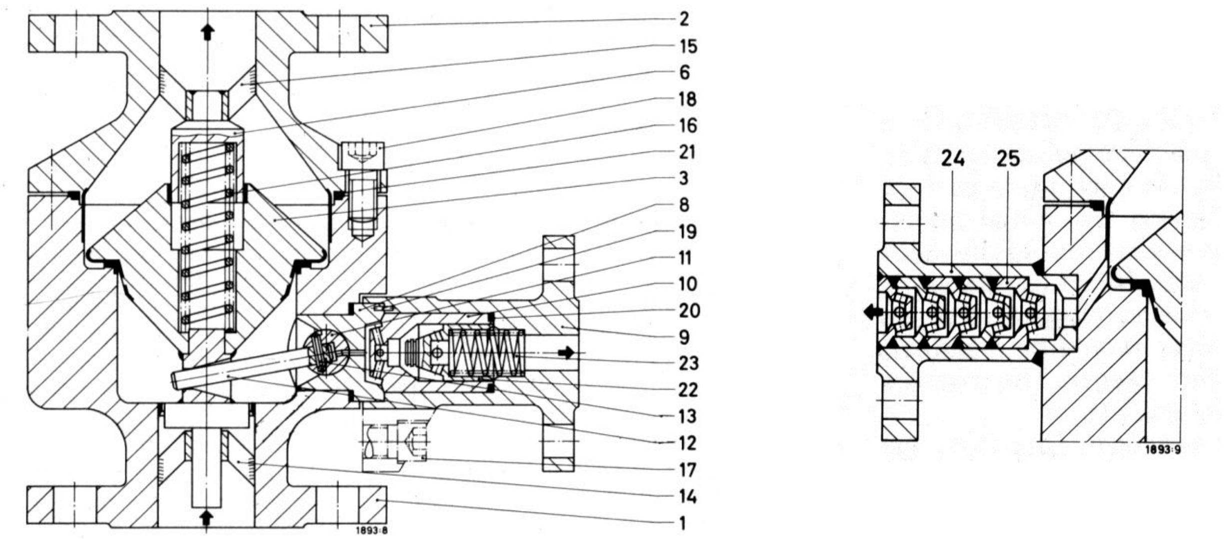


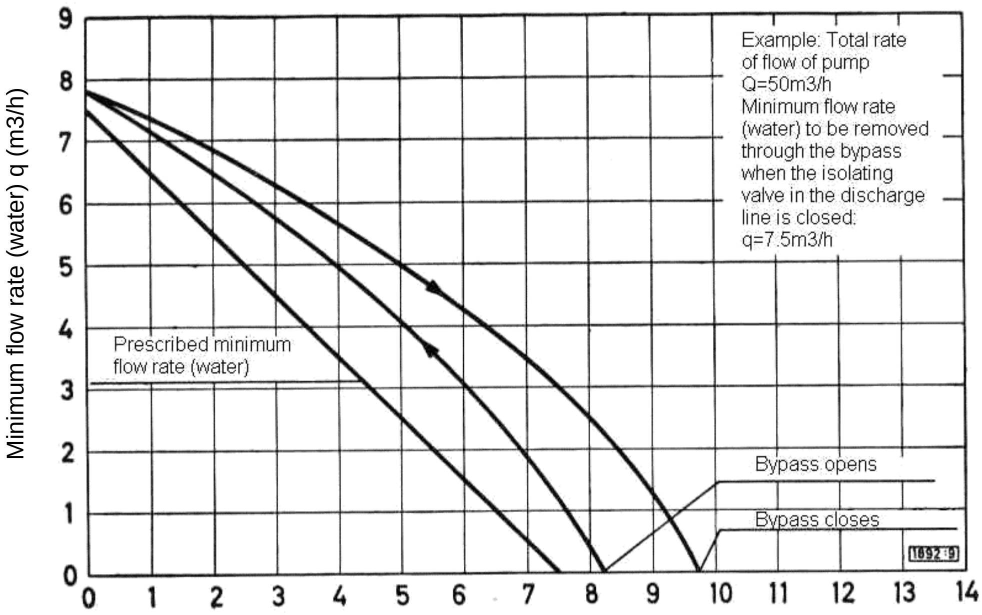
Fig. 41 - Automatic recirculation valve

Part Designation
nº
1 Bottom half of body
2 Top half of body
3 Valve cone
6 Guide shank
8 Slide valve head
9 Nozzle
10 Throttle
11 Rotary slide valve
12 Lever
13 Taper grooved dowel pin
14 Bottom spider

Part Designation
nº
15 Top spider
16 Cylindrical helical spring
17 Socket head cap screws
18 Socket head cap screws
19 Taper grooved dowel pin
20 O-ring
21 *) O-ring
22 Valve
23 Cylindrical helical spring
24 Manual operation nozzle
25 Multistage throttle

*) Not applicable for temperatures above 130ºC and valve pressure ratings above NP 100 (metal-to-metal sealing provided)
Parts 8-13 (complete leak-off nozzle) can be replaced individually.

The greater the flow of fluid, the higher the valve cone is lift by the fluid pumped. A connecting rod in the shape of a lever – slide valve lever – is connected at one end to the other end to the shutoff valve (slide valve) on the bypass (leak-off) outlet. As the valve cone rises and falls, the shutoff valve is actuated by this lever, and the penning of the bypass is controlled in such a way that the bypass closes when the rate of flow has attained a given value, and opens when it drops below this value. The minimum flow rate is calculated and adjusted so as to avoid any excessive overheating inside the pump (see Fig. 42).



Rate of flow of pump Q (m3/h) downstream of automatic recirculation valve

Fig. 42

9.4 Final Coupling Check

After completion of the piping assembly, the coupling alignment should be checked once more (see section 8.3 “Aligning the Coupling”). It must be possible to rotate the pump rotor without effort by hand at the coupling, when the stuffing boxes are not packed. If the alignment is satisfactory (no misalignment having taken place), the driver can be doweled with cylindrical dowel pins.

9.5 Measuring Instruments

Each pump should be equipped with two pressure gauges, one at the suction nozzle and the other at the discharge nozzle; their measuring range should be suitable for the prevalent pressure conditions, and they should be provided with a stop cock or stop valve. If the suction conditions demand it (e.g. suction), the gauge on the suction nozzle should be a pressure vacuum gauge (measuring instruments can be supplied by us on request – see Fig. 43).

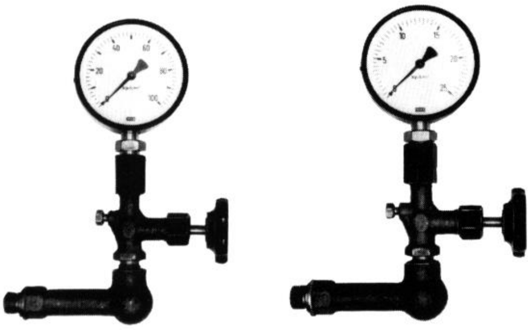


Fig. 43 - Arrangement of measuring instruments

10. Commissioning

10.1 Preliminary Remarks regarding Commissioning

If the initial start-up does not take place immediately after the erection of the pumping set, but only weeks or even months later, it will be necessary to carry out the following checks once again before start-up:

1. Renewed direction of rotation check of driver with pump disconnected from driver.
   Even a relatively short start-up run in reverse rotation may result in damage to the pump. The overstepped trip check of the turbine on turbine-driven pumps should also be carried out with the turbine disconnected from the pump.
2. Check correct coupling alignment again.
3. Dismantle pump bearings, clean them and re-assemble them (as described in section 11.”Dismantling the Pump”).
4. Fill in oil, or check grease fills respectively.
5. Pack the stuffing boxes (see section 1.5.1. “Stuffing Boxes”).

10.2 Start-up

1. Check oil level in pump bearings, if necessary top up the oil fill until oil starts pouring out of the over flow hole.
2. Check condition of stuffing boxes (452.1/452.2). The stuffing box gland should penetrate deep enough in the stuffing box to ensure positive guidance, and must not be tightened askew (see section 1.5.1. “Stuffing Boxes”).
3. In the case of a mechanical seal with internal circulation, open flow controller fully (only applies to the initial start-up).
4. Turn on cooling liquid supply and check that it flows away freely.
5. Open suction valve fully.
6. Leave isolating valve in discharge line closed for the time being.
7. The pump must be completely primed with the product pumped. Before it is started up for the first time, the pump should be vented through the connection on the discharge pressure gauge, or through the vent valves, if provided. The discharge line should also be vented through valves situated at the apex of the line.
8. Open the shut-off valve on the minimum flow line of the automatic recirculation valve and lock it opens, to prevent unintentional closure. If the automatic recirculation valve is equipped with a manual operation line, open the valve in this line. If a check valve or nom-return valve is incorporated, and if the pump is to be started up against an open discharge valve, make sure that the nom-return valve is closed as a result of the back pressure (e.g. the boiler pressure). If the full backpressure does not reign at the time of start-up, the pump should only be started up against a closed discharge valve.
9. Check suction pressure and temperature. Check whether the saturation condition of the fluid pumped reigns inside the pump, with the saturation curve. No vapor formation must be allowed to take place inside the pump.
10. When starting up for the first time, and also after a prolonged plant shutdown, start up the driver with the pump coupled to it, then switch off the driver again immediately. Check that the rotor runs down to a standstill smoothly and lightly, and check that the pump bearings are being supplied with oil. The pump rotor must not stop with a sudden jerk.
11. In the case of a turbine-driven pump, run the pump up to full speed rapidly.
12. Watch the discharge pressure, to make sure the pump attains the prescribed discharge pressure.
13. If applicable, close the manually operated minimum flow line when the operating rotational speed has been attained. Check whether minimum flow line becomes warm.
14. Adjust rate of flow of cooling liquid for the mechanical seal by means of the flow controller. The temperature at the mechanical seal should not exceed 70ºC.
15. Open isolating valves in the discharge line.

Caution:

If the pump is commissioned on hot fluid, the casing will heat up more rapidly than the tiebolts (905) because of its direct contact with the fluid pumped. The casing will become longer as result of thermal expansion. The pre-stressing of the tiebolts will increase and the surface pressure (contact pressure) on the flat gaskets will attain a maximum value. Under such stress conditions, the gaskets, which are still new, will bed themselves down. When the pump has warmed up all over, the tiebolts (905) may suffer such a reduction in pre-stressing that the pump may start leaking at the stage casings specially in the case of pumps with a large number of stages. In order to avoid such leakage, the tiebolts (905) should be tightened up after the first few “hot”starts on a new or reconditioned pump.

10.3 Operation and Supervision of Pump

1. Pumps operating at constant speed may usually be operated at the point of optimum efficiency, at total heads up to 90% of design head, providing that the suction head and the motor horsepower are adequate.
2. Pumps operating at variable (controlled) speed may only be operated within the range indicated in the pump-operating diagram below. It should be noted that the throughput, which can be, achieved decreases with decreasing speed and pressure (see. Fig. 44).

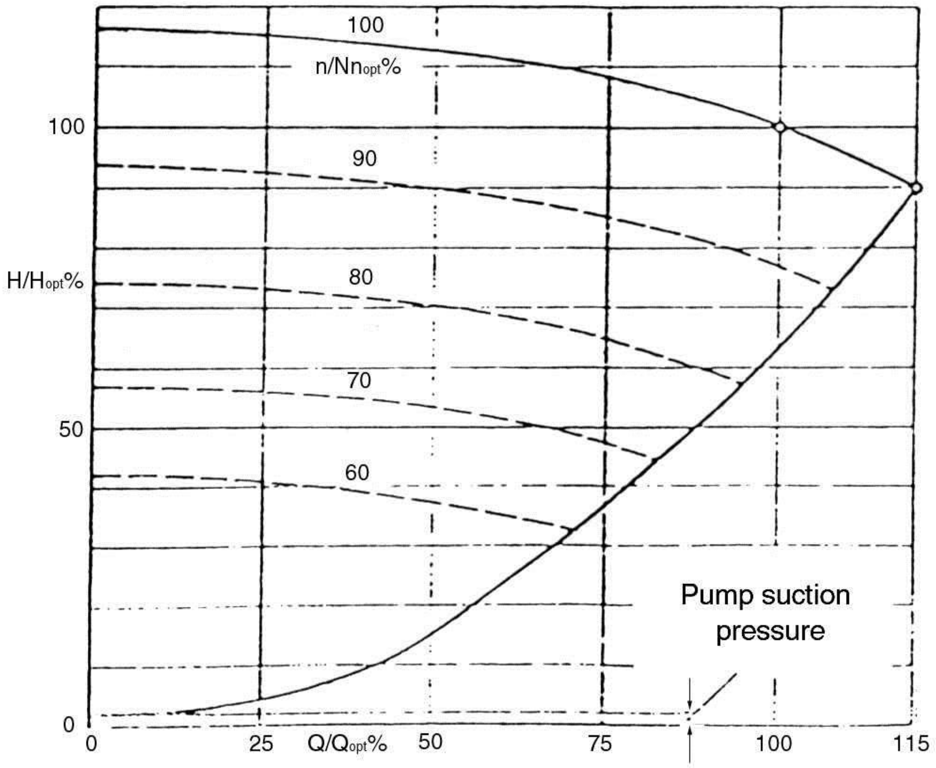


Fig. 44 - Pump operating diagram

3. When filing the boiler, the operating limits specified in 1. and 2. Above should not be exceeded, i.e. the discharge valve should partially closed to ensure that the pressure does not fall below the minimum discharge pressure corresponding to the particular speed or capacity at which the pump is operated at the time. If the rate of flow drops below the minimum flow, the minimum flow device starts operating. Any prolonged operation within the response range of the minimum flow device should be avoided as far as possible, because this will cause premature wear on the control and throttling organs.

10.4 Shutting the Pump down

1. Close isolating valve (gate valve or globe valve) in the discharge line. If applicable, check the opening point of the minimum flow device from time to time.
2. Swish off driver and watch the pump run down smoothly to a standstill. The pump rotor should not stop with a sudden jerk.
3. If applicable, turn off the sealing, circulation or flushing liquid.
4. The cooling liquid supply can be partially throttled, but is should only be turned off completely when the temperature inside the pump, measured at the pump nozzle, has dropped below 80ºC. The suction valve should remain open unless the pump is being taken out of service for a prolonged period and is being drained.

10.5 Preserving the Pump

If the pump is taken out of service for a prolonged period, it is advisable to dismantle it completely. Proceed as described in section 11. “Dismantling”. All components should be thoroughly cleaned, dried, and all bright parts coated with grease. Thereafter the pump should be reassembled. All apertures on the pump should be plugged with wooden stoppers soaked in oil or blanked off with wooden cover plates fitted with O-rings. A sachet filled with silicagel (silicagel absorbs moisture) should be attached to the inside faces of the oil-soaked wooden cover plates on the suction and discharge nozzles (i.e.
Inside the nozzles). The packing should be removed from the stuffing box compartments and these should be sealed by oil-soaked wooden half tubes, each provided with two O-rings, in order to prevent the penetration of moisture (not applicable to pumps fitted with mechanical seals).

Caution:
Only use acid free oils and greases when preserving the pump.

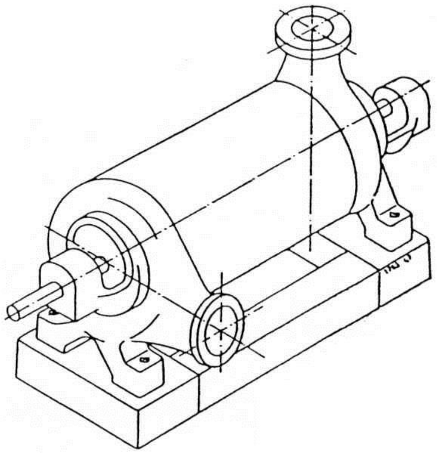


Fig. 45 - Transport frame, pump feet at shaft centerline height

10.6 Sending the Pump back to our Works

If the pump is sent back to our Works for repairs or overhaul, it should be dispatched completely assembled in order to prevent any possible damage to the sealing faces during transport. All pipe connections and flanges should be plugged or blanked off, after the pump has been drained. The pump should be securely mounted on a transport frame for dispatch (see Figs. 45 and 46).

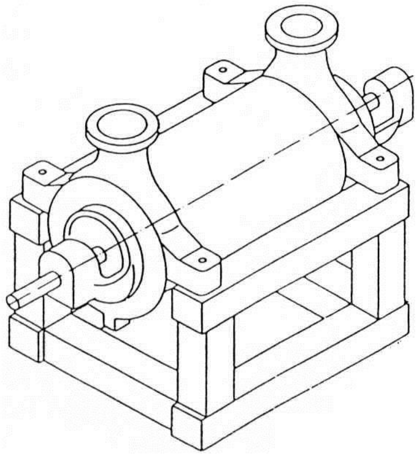


Fig. 46 - Transport frame, pump feet at bottom

11. Dismantling the Pump

11.1 Preparations prior to Dismantling

1. Close all isolating valves in the suction and discharge lines, and also, if applicable, in the cooling liquid, sealing liquid or flushing liquid lines, and drain the pump via the drain aperture (6 B) in the suction and discharge casings (106 and 107).
2. Dismantle and remove cooling liquid, sealing liquid or flushing liquid lines.
3. Pull out stuffing box gland (452) and remove stuffing box packing (461.1).
4. Disconnect coupling (see section 1.6. “Couplings”). Check pump alignment at the coupling and make a note of the measurements (see section 8.3. “Alignment”).
5. If the pump is to be dismantled completely, unscrew the fixing bolts on the suction and discharge lines and on the pump feet, and remove the pump from the baseplate.
6. Drain off the oil fills in the bearing housings by unscrewing drain plug (903.4/5).

11.2 Dismantling the Bearings

11.2.1 Dismantling the Drive End Bearing

1. Pull of the half coupling with the aid of an extractor (see Figs. 47 and 48).

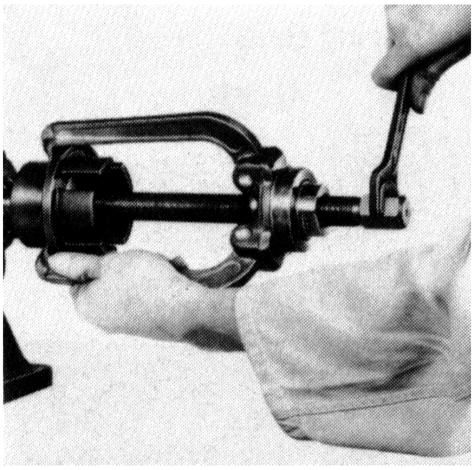


Fig. 47 - Wheel pulled

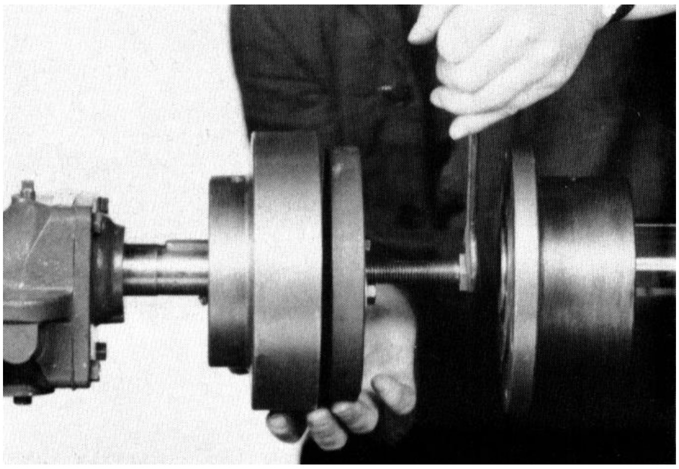


Fig. 48 - Pulling off the coupling hub

2. Remove bearing cover (360)
3. Bend back tab washer between ring nut of clamping sleeve and cylindrical roller bearing (322) (see Fig. 49).

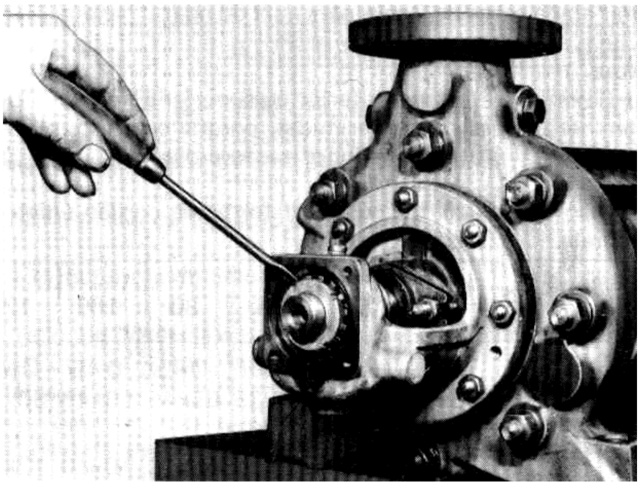


Fig. 49 - Bending back the lock washer

4. Slacken ring nut of clamping sleeve (52-1) by a few turns (see Fig. 50).

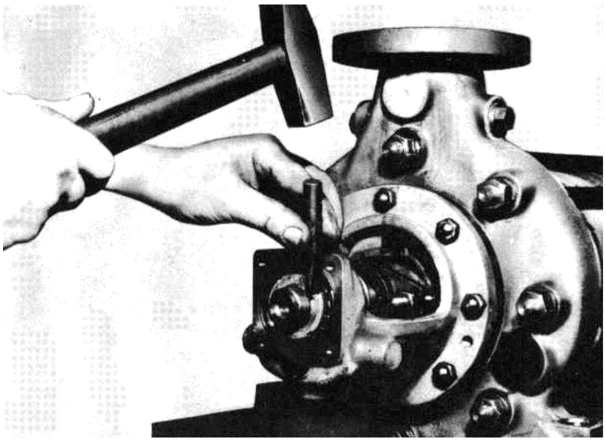


Fig. 50 - Slackening the ring nut

5. Loosen clamping sleeve (52-1) on shaft (210) by gentle taps on the end face of the ring nut.

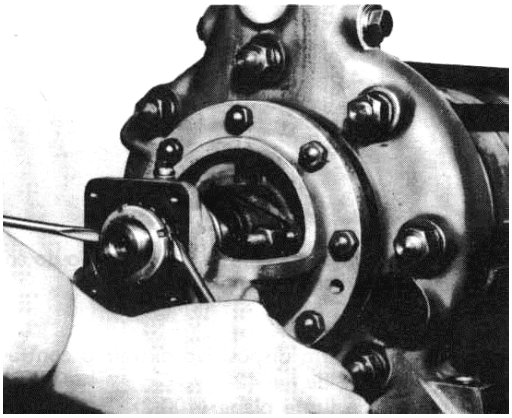


Fig. 51 - Forcing out the inner components of the cylindrical roller bearing

6. Pull out inner race of cylindrical roller bearing (322 together with clamping sleeve (52-1) from bearing housing (350) (see Figs. 51 and 52).

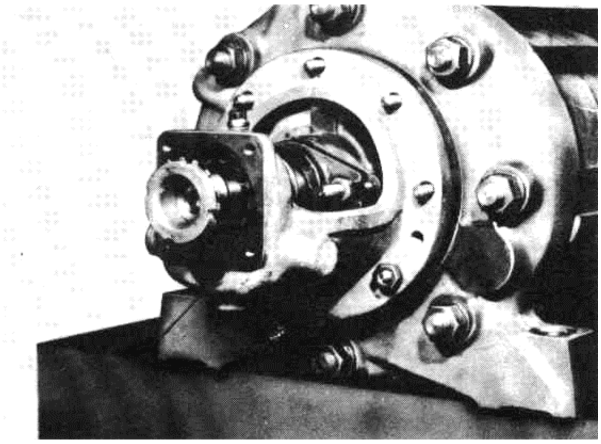


Fig. 52 - Dismantled inner components of cylindrical roller bearing

7. Unscrew and remove hex, nuts (920.2) from stud bolts (902.1) in the suction casing (106) in order to dismantle the bearing housing and stuffing box housing (see Figs. 53 and 54).

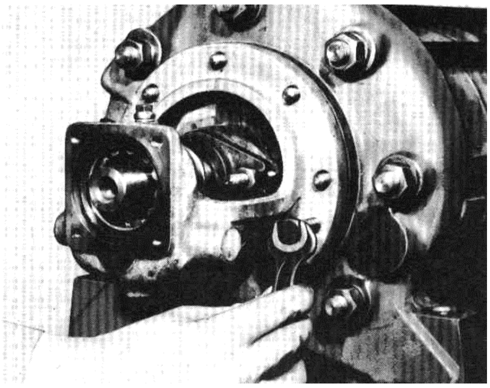


Fig. 53 - Forcing off the bearing housing

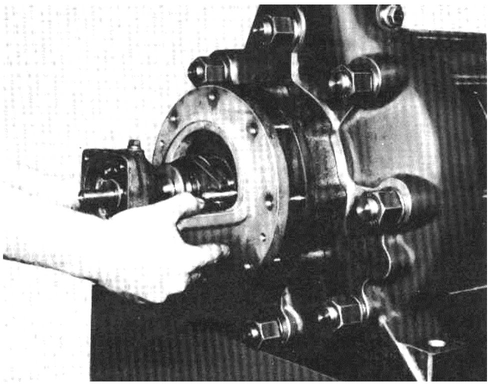


Fig. 54 - Removing the bearing housing (350) together with outer race of cylindrical roller bearing (322)

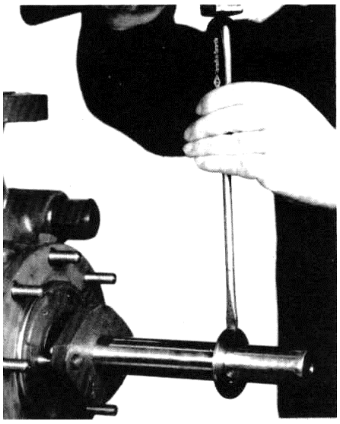


Fig. 55 - Stripping off the thrower

8. On pump size 150 which is fitted with a cylindrical roller bearing without clamping sleeve, the bearing housing (350), including the outer race of the bearing and the spacer bush (543) are removed after unscrewing the hex nuts (920.4), then inner race of the bearing and the spacer sleeve (525.4) are pulled off the shaft, and the circlip (932) removed.

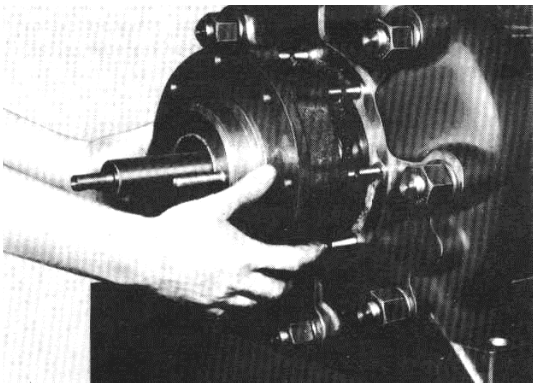
11.2.2 Dismantling the Front End Bearing

1. Remove bearing end cover (361) together with gasket (400.4).
2. Unscrew hex shaft nut (920.4) and remove it from the shaft.
3. Unscrew and remove hex nuts (920.2) from stud's (902.1) in discharge casing (107), in order to dismantle the bearing housing and stuffing box housing.
4. Force off bearing housing together with deep froove ball bearing (321) by means of long forcing screws until the housing and bearing can be pulled off the shaft without effort.
5. Inspect condition of deep groove ball bearing (321) and if necessary remove it from bearing housing (350).
6. Strip thrower (507) off the shaft.

11.3 Removing the Shaft Seal

11.3.1 Soft-packed Stuffing Box Construction

1. Pull stuffing box gland (452) off the shaft.
2. Force off and remove stuffing box housing (451). On pumps equipped with cooled stuffing boxes, force off and remove the stuffing box housing (451) including cooling cover (165) (see Fig. 56).



3. Slacken shaft protecting sleeve (524.2) and remove it from shaft (210) (see Fig. 57).

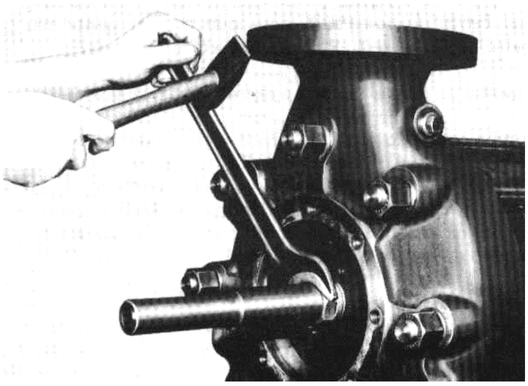


Fig. 57 - Slackening shaft protecting sleeve (524.2)

11.3.2 Mechanical seal construction

See specific instruction of mechanical seal manufacturer.

11.4 Dismantling the Pump Casing

1. The stage casings (108) should be numbered consecutively in respect of their positions in relation to one another before dismantling, to ensure that the suction casing (106), the stage casings (108) and the discharge casing (107) are all reassembled in the correct sequence in relation to one another during reassemble (see Fig. 58).

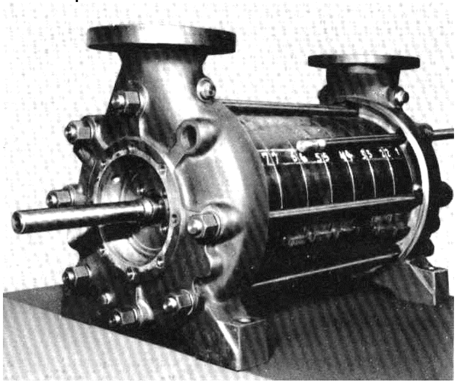


Fig. 58 - Identification of casing components and removal of tiebolts

2. Unscrew nuts (920.1) at discharge end of tiebolts (905) and pull the tiebolts out of the suction and discharge casings (see Fig. 57).
3. Underpin the pump at the stage casing (108) with wooden blocks or an erection trestle; so as to free the component, which is to be dismantled next.

4. Force discharge-casing (107) together with final stage diffuser (171.2) off stage casing (108) and lift it off (see Figs. 59 and 60).

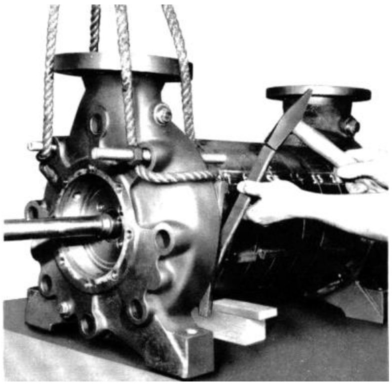


Fig. 59 - Forcing off the stage casing

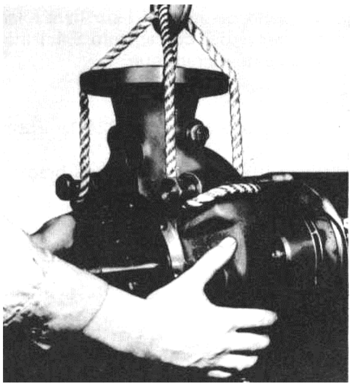


Fig. 60 - Lifting off the stage casing

5. Dismantle in sequence impellers (230), stage casings (108) together with diffusers (171.1), keys and stage sleeves (521) (see Figs. 61 and 62).

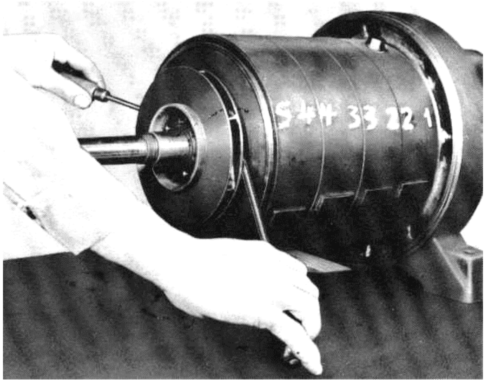


Fig. 61 - Forcing off the impeller

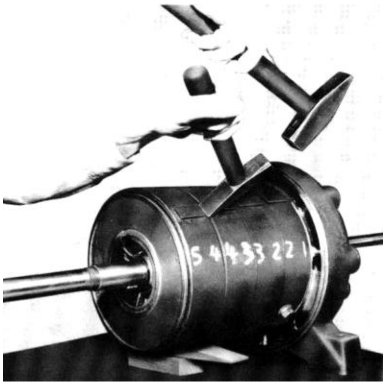


Fig. 62 - Slackening and removing the stage casing

6. When the last stage casing (108) has been dismantled pull shaft (210) together with last impeller (230), spacer sleeve (525.1) and shaft protecting sleeve (524.1) out of the suction casing (see Fig. 63).

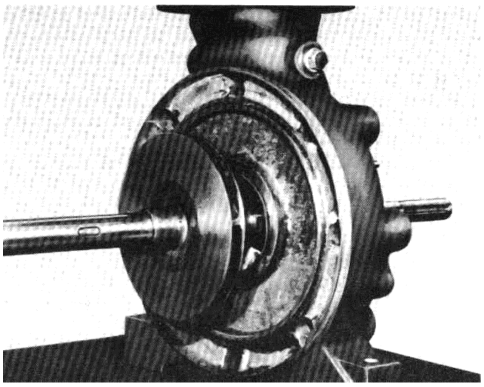


Fig. 63 - Removing the shaft together with first stage impeller

7. Pull impeller (230), spacer sleeve (525.1) and shaft protecting sleeve (524.1) off the shaft (see Fig. 64).

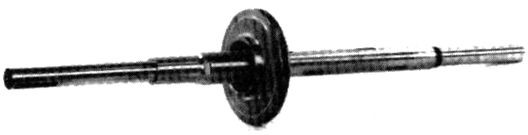


Fig. 64 - Dismantled shaft with impeller, spacer sleeve and shaft protecting sleeve

8. Stack the stage casings on top of one another in correct order. The contact faces should be protected by wooden strips or thick cardboard during stacking, to avoid any damage (see Fig. 65).

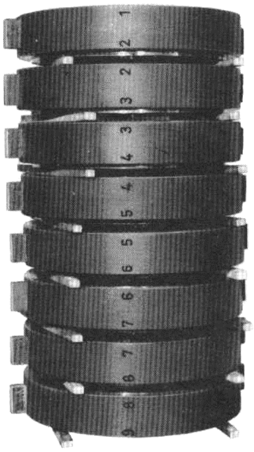


Fig. 65 - Stacking the stage casings on top of one another

11.5 Inspection of individual Pump Components

1. Shaft (210)
   Check true running (out-of-round) between centers on a lathe. Max. permissible out-of-round (shaft whip):
   0.03 mm. In principle a bent shaft should never be straightened out, either warm or cold, but replaced by a new shaft if the permissible shaft whip is exceeded.
   Caution: Make sure the shaft is accurately centered on the lathe, as otherwise erroneous measurement results will be obtained.
2. Stage Casings (108)
   Examine all contact faces for flawless condition. The plane parallelism of the contact faces must be checked at 4 points around the circumference. The deviation should not exceed 0.05 mm. Touch up any damaged contact faces on a lathe. The surface roughness must not exceed Ra = 1.6 µm.
3. Bearings (322)
   The bearing should be replace by new ones even if there are only slight discoloration or rust specks or signs of damage on the contact faces (tracks and balls or rollers). The outer race of the cylindrical roller bearing should be inserted as illustrated in Fig. 66.

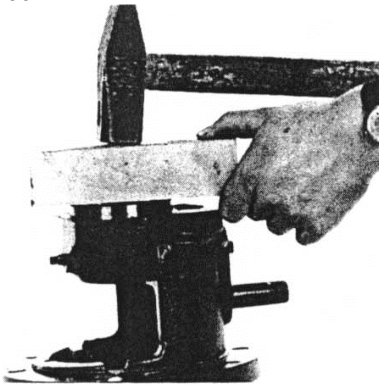


Fig. 66 - Inserting the outer race of the roller bearing

   Observe the greatest cleanliness when mounting the bearing (322). If the existing bearings are to be used again, they should be cleaned with petrol (gasoline) or benzol. After washing, they should immediately be sprayed with oil.
4. Impellers (230), Spacer Sleeves (525), Stage Sleeves (521), Casing Wear Rings (502) and Diffusers (171). Inspect the impeller (230) for signs of damage by solids entrained with the fluid pumped.

<table>
<tr><td colspan="2" rowspan="2"></td><td colspan="2">“As new” clearance for material alternative</td><td colspan="2">Max. permissible clearance value for material alternative</td></tr>
<tr><td>Cast iron and nodular iron

mm on dia.</td><td>Chrome steel throughout and bronze

mm on dia.</td><td>Cast iron and nodular iron

mm on dia.</td><td>Chrome steel throughout and bronze

mm on dia.</td></tr>
<tr><td colspan="2">Casing wear ring – impeller neck</td><td>0,30</td><td>0,40</td><td>1,0</td><td>1,0</td></tr>
<tr><td colspan="2">Diffuser – stage sleeve</td><td>0,30</td><td>0,35</td><td>1,0</td><td>1,0</td></tr>
<tr><td colspan="2">Discharge casing – spacer sleeve</td><td>0,30</td><td>0,35</td><td>1,0</td><td>1,0</td></tr>
<tr><td rowspan="2">Shaft – suction casing</td><td>Suction head operation</td><td>1,0</td><td>1,0</td><td>2,0</td><td>2,0</td></tr>
<tr><td>Suction lift operation</td><td>0,3</td><td>0,35</td><td>0,8</td><td>0,8</td></tr>
</table>

Table 2 - Rotor clearances

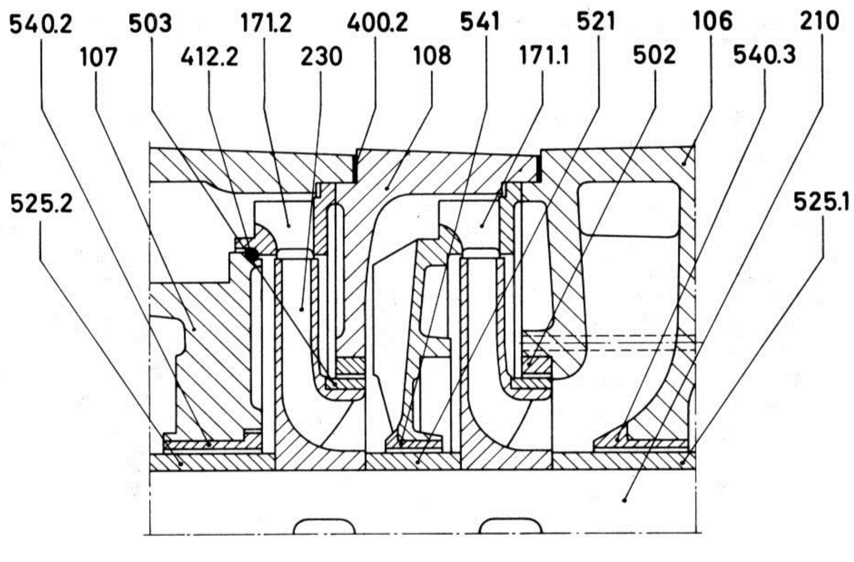


Fig. 67 - Alternative material construction in chrome steel throughout

The impeller necks – in the case of material construction 12% Cr. (chrome steel construction throughout) these are provided with impeller wear rings (503) – and the casing wear rings (502), stage sleeves and diffuser in the case of chrome steel construction throughout the latter are provided with stage bushes (541) – should all be examined for signs of radial galling (seizure). The spacer sleeve (525.1) should be examined for signs of galling in the suction casing (see Fig. 66). If any galling has been ascertained, and if it can be eliminated by touching up on a lathe, the increase in clearance which results must not exceed the max. Permissible values listed in Table 2 “Rotor Clearances”. If the touching up work on the components results in a clearance in excess of the max. permissible value, new components should be fitted, and the “as new” clearances listed in Fig. 78 should be re-established. The increase in clearance must be adjusted to the same value at all the throttling gaps on the pump. In principle, if the clearances have been exceed at one or more places inside the pump body, and new wear parts have to be fitted at those places, it is advisable to fit new wear parts at all the other places as well.

5. Shaft Protecting Sleeves (524.1/.2) or Shaft Sleeves (523.1/.2) respectively

These may only be touched up very slightly. If the damage is more then superficial, new shaft protecting sleeves should be fitted.

6. Cooling compartments of Stuffing Box Housings (451)
   If applicable, and if a cooling liquid supply is connected to them, inspect the compartments and clean them.
7. Coupling
   If the flexible elements show signs of wear after a prolonged period of operation, replace it by new ones in good time.

11.6 Dynamic Balancing of Pump Rotor

If certain rotor components are replace by new ones or are touched up, or if a new shaft is fitted, the pump rotor of pump sizes 40 to 100 must be subjected to an out-of-round check, and, in addition, the pump rotor of pump sizes 125 and 150 must be dynamically balanced, if possible at max. operating speed, but in any event at 1000 1/min minimum. The max. permissible residual eccentricity should not exceed 5 µm.
For the dynamic balancing test, the rotor should be assemble as follows:

Assembly from Drive End
Slip shaft protecting sleeve (524.1) or shaft sleeve (523.1) respectively onto the shaft without O-ring (412.3) and pull it tight against the shaft shoulder. Mount coupling half with the aid of a pusher device.

Assembly from Front End
Mount spacer sleeve (525.1), key and firths stage impeller (230) onto the shaft.
Mount stage sleeves (521), keys and impellers (230) of the remaining stages onto the shaft in their correct sequence.

Caution: Remember to mount the impellers in accordance with their correct stage sequence.

Slip spacer bush (525.2) shaft sleeve (523.2) or shaft protecting sleeve (524) respectively onto shaft (210) with out O-ring (412.3), and pull them tight against the hub of the last stage impeller (230).

Before dynamic balancing, the pump rotor should be checked for out-of-round in the region of the impeller necks (230) of the spacer and stage sleeves (525.1 and 521) and of the bearings (see Fig. 68). The measured out-of-round value at any of these places should not exceed 0.03 mm. Before final assembly in the pump, the pump rotor must be dismantled again, in reverse sequence to the assembly described above.

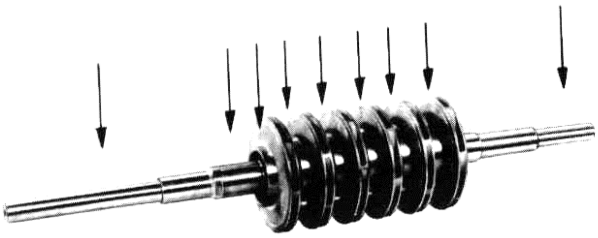


Fig. 68 - Rotor assembled for dynamic balancing

12. Assembly of the pump

12.1 Preparations prior to Reassemble

Before reassemble of ring section pumps, the axial face-to-face length “E” of each stage casing (108) and of the corresponding impeller (230) with stage sleeve (521) must be measured. Any discrepancy in lengths must be compensated by machining the stage sleeve (521) only, and the end result must be E1 = E2 taking the thickness of flat gasket (400.2) into account (see Fig. 69).

If machining of the stage sleeve is required, it should be shortened at both end faces in one and the same clamping on the machine tool. The permissible end face wobble (deviation from plane parallelism) is 5 µm. Make sure not to damage the contact faces on the casing components, diffusers, impellers, spacer and stage sleeves before and during assembly. All pump components, particularly **the end contact faces**, should be thoroughly cleaned. If new impellers are fitted, or if the old ones are touched up, the rotor must be balanced dynamically.

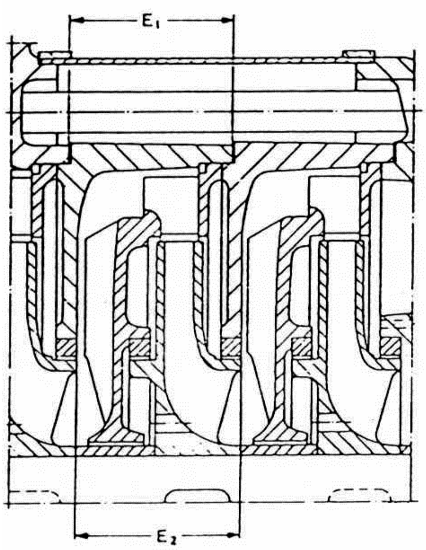


Fig. 69 - Measuring the stages

12.2 Assembling the Pump Casing

1. Before assembly of the rotor components, coat the shaft (210) with molybdenum disulfide.
2. Slip the shaft protecting sleeve (524.1) onto shaft (210) after inserting O-ring (412.3), and pull it tight against the shaft shoulder. Mount spacer sleeve (525.1), key and first stage impeller (230) onto shaft (210) (see Fig. 70).

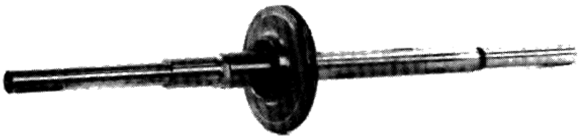


Fig. 70 - Shaft with first stage impeller

3. Insert shaft (210) together with spacer sleeve (525.1) and impeller (230) into suction casing (106) (see Fig. 71).

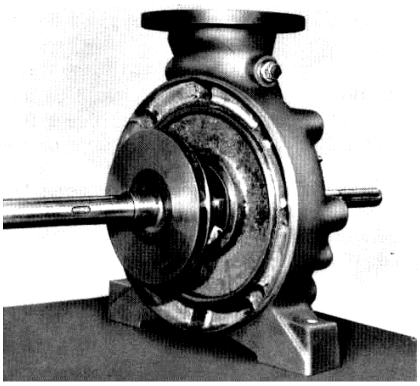


Fig. 71 - Shaft with first stage impeller inserted into suction casing

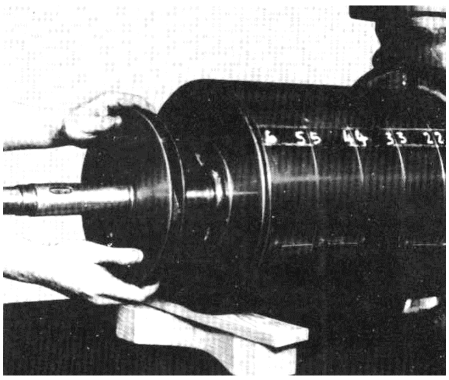


Fig. 72 - Mounting the impeller

4. Mount stage-casing (108) together with inserted diffuser (171.1) and flat gasket (400.2), and slip stage sleeve (521) onto the shaft (see Fig. 72).

5. Mount all the following stages in similar fashion each stage consists of stage casing (108), diffuser (171.1), casing wear ring (502), flat gasket (400.2), impeller (230), key and stage sleeve (521). Underpin the stage casing (108) in turn after assembly (see Fig. 73).

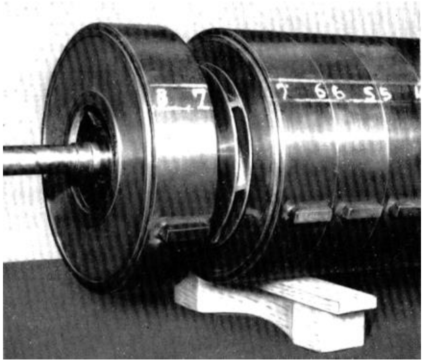


Fig. 73 - Mounting the stage casings

6. After assembly of each individual stage, check the total axial clearance “Sa 1 + Sa 2” of the pump rotor (approx. 6 mm, see Fig. 74).

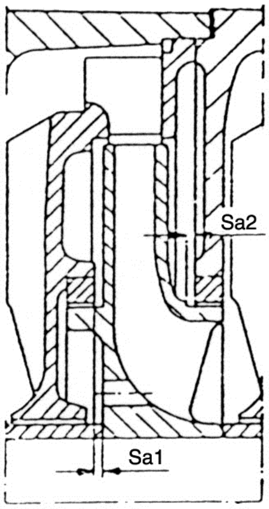


Fig. 74 - Checking the total axial clearance

7. Mount discharge casing (107) with inserted final stage diffuser (171.2) and O-ring (412.2) (see Fig. 75).

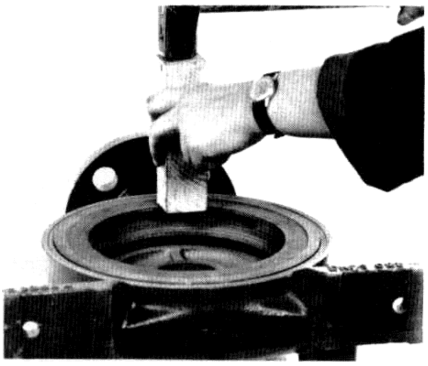


Fig. 75 - Inserting the diffuser in the discharge casing

Size	Number of stages	Torque	Number of stages	Torque
40	1 – 10	7,5 kg.m	11 – 16	8,0 kg.m
50	1 – 10	8,5 kg.m	11 – 15	10,0 kg.m
65	1 – 10	12,0 kg.m	11 – 14	15,0 kg.m
80	1 – 8	20,0 kg.m	9 – 12	23,0 kg.m
100	1 – 8	25,0 kg.m	9 – 11	27,0 kg.m
125	1 – 6	30,0 kg.m	7 – 10	32,0 kg.m
150	1 – 6	35,0 kg.m	7 – 8	37,0 kg.m

Table 3 - Tightening torque for the tie bolts

8. Insert tiebolts (905) with nuts (920.1) and washers (550) from the suction end.
9. **At the suction end**, screw on all the hex. nuts (920.1) on tiebolts (905) and screw them down to median position. Insert the tiebolts (905) from the suction end, after having slipped on the washers.
10. **At the discharge end**, the screw threads of the tiebolts and the washers should be coated with molybdenum disulfide. The hex. nuts (920.1) should be tightened by hand with a standard short spanner to ensure intimate contact of the stage casing (108) at their sealing faces.
11. Slip the spacer sleeve onto the shaft until it abuts against the hub of the final stage impeller.
12. Place the pump on the baseplate. The pump feet must seat flush on the baseplate. Tighten hex. nuts (920.1) on the tiebolts at the discharge end evenly on the cross.
13. Tighten nuts (920.1) on the tiebolts (905) at the discharge end. Then slacken the nuts at the discharge end again until seating is loose, and tighten them again by hand with the aid of a short hammering spanner until contact is established. Then tighten the nuts firmly with the aid of a torque spanner (see Table 3).

12.3 Assembly of the shaft seal

12.3.1 Pump Construction with Soft-packed Stuffing Box

1. Slip shaft protecting sleeve (524.2) onto shaft (210) after insertion of O-ring (412.3), and pull it tight against spacer sleeve (525.2) (see Fig. 76).

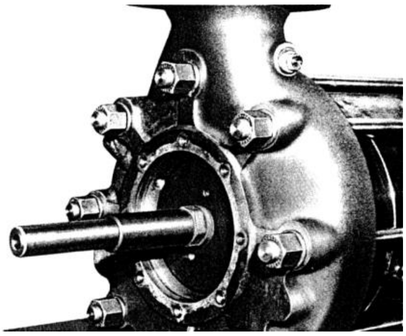


Fig. 76 - Mounting the shaft protecting sleeve

2. Mount stuffing box housing (451) with flat gasket (400.3). In the case of pumps equipped with cooled stuffing boxes, mount the stuffing box housing (451) together with cooling compartment cover (165) (see Fig. 76).

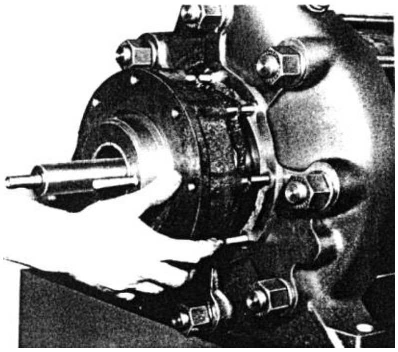


Fig. 77 - Mounting the stuffing box housing

3. Slip the stuffing box gland (452) loosely on shaft (210) but do not insert it in the stuffing box compartment.
4. Slip thrower (507) onto the shaft.

12.3.2 Pump Construction with Mechanical Seal

See specific mechanical seal drawing and its assembly instructions.

12.4 Assembly of Bearings

12.4.1 Assembly of Front End Bearing Standard Bearing Construction

1. Mount thrower (507) onto shaft (210).
2. Slip bearing housing (350) onto the shaft and onto the studs on discharge casing (107), and fasten it the nuts (920.2) (see Fig. 78).

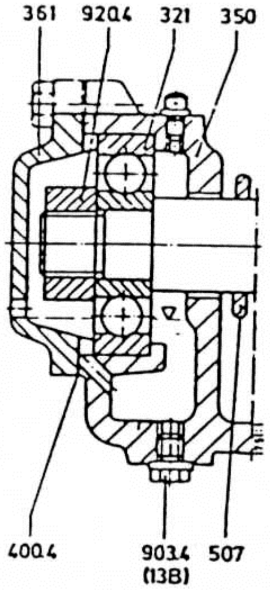


Fig. 78 - Bearing construction, pump sizes 40 to 125

3. Mount deep groove ball bearing (321).
4. Screw hex. shaft nuts (920.4) onto the shaft and tighten it.
5. Mount bearing end cover (361) and gasket (400.4).
6. Seal the oil drain apertures (13 B) by means of threaded plug (903.4).
7.

12.4.2 Assembly of Drive End Bearing

1. Mount thrower (507) on shaft (210).
2. If necessary, insert outer race of cylindrical roller bearing (322) in the bearing housing (see Fig. 79).

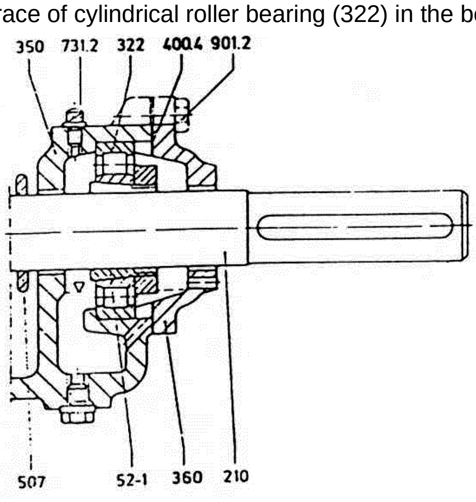


Fig. 79 - Bearing construction pump sizes 40 to 125

3. Mount bearing housing (350) together with outer race of cylindrical roller bearing (322) and tighten hex. nuts (920.2) evenly (see Fig. 80).

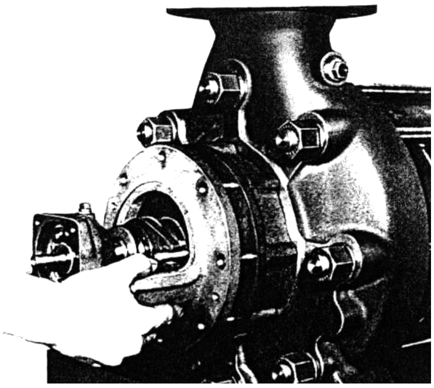


Fig. 80 - Mounting the bearing housing

4. Slip clamping sleeve (52-1) together with bearing inner race, lock washer and ring nut onto shaft (210) until the rear end face of the inner bearing race lies in the same plane as the outer end face of the outer race of cylindrical roller bearing (322). Then tighten the ring nut and make sure the components of the cylindrical roller bearing do not slide out of position in relation to each other whilst the nut is being tightened (see Figs. 81 and 82).

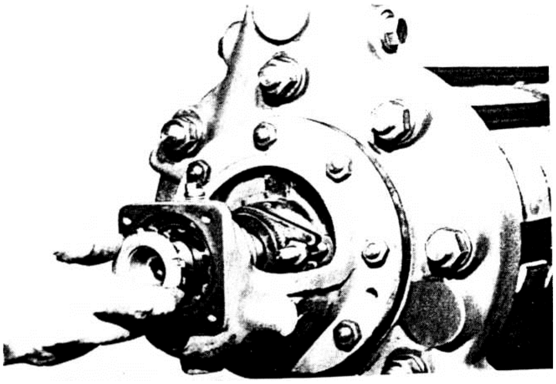


Fig. 81 - Mounting the inner race of the cylindrical roller bearing with clamping sleeve

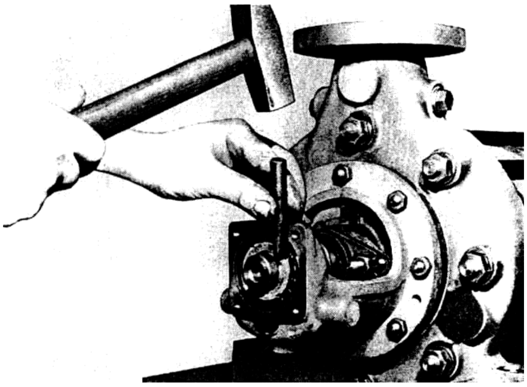


Fig. 82 - Tightening the ring nut

5. Bend down the tabs on the lock washer (see Fig. 83).

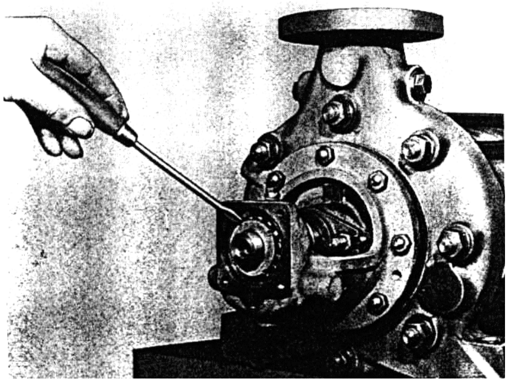


Fig. 83 - Bending down the tabs on the lock washer

6. Mount bearing cover (360) and flat gasket (400.4) (see Fig. 84).

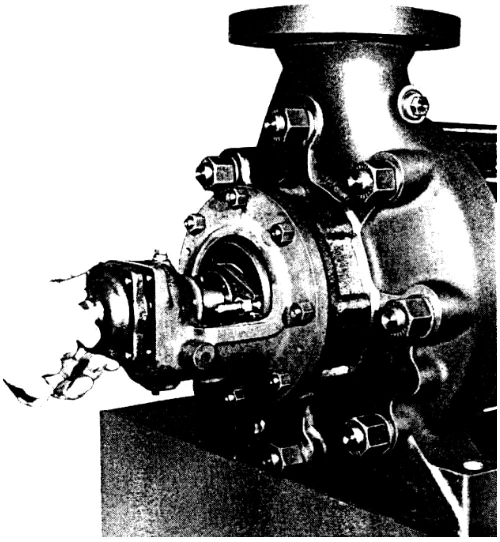


Fig. 84 - Mounting the bearing cover

13. Operating Troubles, Causes and Remedies

Caution: Before remedying operating troubles, check all measuring instruments used for reliability and accuracy.

13.1 Operating Troubles

Cause and suggested remedy, see sections 17.2 and 17.3.

1. Pump fails to deliver liquid	1, 2, 3, 4, 5, 7, 8, 12, 13
2. Pump delivers insufficient liquid	1, 2, 3, 4, 5, 8, 12, 13, 19, 20, 21
3. Total head is too low	3, 4, 5, 7, 8, 10, 12, 19, 20, 21
4. Sudden interruption of delivery shortly after start-up	1, 2, 3, 4, 9, 11, 13
5. Absorbed power is excessively high	6, 7, 9, 10, 17, 19
6. Excessive leakage at stuffing box	14, 16, 18, 22, 23, 24, 25, 28, 29
7. Life of packing is too short	14, 16, 18, 22, 23, 24, 25, 26, 27, 28, 29
8. Pump vibrates or runs noisily	2, 3, 4, 11, 13, 14, 15, 16, 17, 18, 20, 24, 32, 33
9. Life of bearings is too short	14, 16, 17, 25, 31, 32, 33, 34
10. Excessively high temperature inside the pump. Rotor fouls the casing or seizes	1, 3, 4, 7, 9, 11, 13, 14, 16, 18, 19, 20, 24, 30, 32
11. Too high a rate of leakage liquid at the mechanical seal, or too short a mechanical seal life	14, 16, 18, 24, 25, 35, 36, 37, 38, 39, 40

Table 4

13.2 Cause of Damage (the numbers listed below correspond with the code numbers of section 17.1).

Faults at the Suction End

1. Pump not properly vented, air pocket in suction line, vapor bubble at suction end, lines not properly vented.
2. Pump or suction line incompletely primed with fluid.
3. Insufficient pressure differential between suction pressure and vapor pressure, NPSH required is not attained (observe rate of pressure decrease).
4. Mouth of suction line too close to surface of liquid level in the suction vessel, or liquid level in vessel too low.

General Faults in the Installation

5. Rotational speed too low, or rate of minimum flow through by-pass excessive.
6. Rotations speed too high.

7. Reverse rotation.
8. Total head required for the system be higher then total head generated by the pump at duty point (backpressure too high).
9. Total head required for the system is lower then total head generated by the pump (pump operates beyond the performance limit curve).
10. Specific gravity of fluid pumped is different from figure specified originally (different operating temperature).
11. Operation at very low rate of flow (fault in minimum flow device, rate of minimum flow is too low).
12. Pumps cannot possibly operate in parallel under these conditions.

Mechanical Faults

13. Foreign bodies lodged in impeller.
14. Pump misalign or incorrectly aligned, or shifting of foundation.
15. Resonance, or interference by other machines via the foundation.
16. Shaft is bent.
17. Rotating elements foul the stationary elements, pump runs very rough.
18. Bearings badly worn.
19. Casing wear rings badly worn.
20. Impeller damages or disintegrated.
21. Faulty casing seal (excessive internal loss at throttling gap, rotor clearances exceeded due to wear), so that an excessive loss arises, or water leaks through the casing patron. Water leaks out of metallic sealing face to atmosphere.
22. Shaft or shaft protecting sleeves worn or scored, O-ring damaged.
23. Stuffing box badly packed. Packing material of unsuitable quality.
24. Shaft chatters because bearings are worn or because shaft is misalign.
25. Rotor vibrates.
26. Stuffing box gland is tightened excessively, no fluid available to lubricate the packing.
27. Defect in cooling liquid supply to water-cooled stuffing box gland.
28. Excessive clearance gap between stuffing box gland and shaft protecting sleeve. Packing is squeezed into gap beneath the gland.
29. Dirt or sand in cooling liquid fed to stuffing box gland causes scoring of shaft protecting sleeve.
30. Excessively high axial thrust.
31. Insufficient quantity of oil in bearing housing, unsuitable oil quality, dirty oil, waters in the oil.
32. Faulty bearing assembly (damage during assembly, wrong assembly).
33. Dirt in the bearings.
34. Ingress of water into bearing housing.
35. Rubbing faces of mechanical seal worn or scored, O-rings damage.
36. Seal incorrectly assembled. materials unsuitable.
37. Surface pressure in sealing gaps too high, no fluid available for lubrication and cooling.
38. Fault in cooling liquid supply system to mechanical seal.
39. Excessively large gap between cooling housing and spacer sleeve. Temperature in the cooling circuit rises excessively.
40. Dirt in cooling circuit of mechanical seal leads to scoring of mechanical seal rubbing faces.

13.3 Suggested Remedies

If after a breakdown has occurred, one of the causes listed in section 17.2. has been established as the cause, and the matter has been put right or the cause of the trouble eliminated it is recommended, prior to decommissioning the set, to check the effortless rotation of the pump rotor by hand, kith the driver disconnected (unless the pump had to be dismantled in any case, because of the damage). Check that the pump runs smoothly and quietly after recommissioning.

Cause 1. Open vent valves or pressure gauge vent screws, open isolating valves in minimum flow device circuit. Check lay out of pipelines to ensure that fluid flows smoothly.

Cause 2. Prime pumps and piping again, and vent them thoroughly.
Check layout of pipelines.

Cause 3. Check isolating valves and strainers in suction line. The instrument readings taken must be accurate. Consult manufacturer.

Cause 4. Check water level in reservoir and examine possibility of altering it. Raise water level; alter mouth of suction line.
The nozzle should not project too high inside the reservoir, and it should be shape so as to promote favorable flow characteristics.

Cause 5. Increase speed if pump is turbine
Driven. Refer to manufacturer, if pump is motor driven. Check operation of minimum flow device.

Cause 6. Decrease speed, if pump is turbine
Driven. Refer to manufacturer if pump is motor driven.

Cause 7. Cross over two phase leads on the motor.
Cause 8. Increase rotational speed. Fit larger diameter impellers. Increase number of stages. Refer to manufacturer.
Cause 9. Adjust pressure conditions by means of discharge valve. After rotational speed, after impeller diameter, refer to manufacturer.
Cause 10. Check temperature of fluid pumped; take steps outlined in 9. Above.
Cause 11. Check operation of minimum flow device. Refer to manufacturer.
Cause 12. Check condition of individual machines. Refer to manufacturer.
Cause 13. Clean out pump, check condition of suction system (check suction line and strainers).
Cause 14. Realign pumping set when cold.
Cause 15. Refer to manufacturer.
Cause 16. Fit a new shaft. On no account straighten out a bent shaft.
Cause 17. Dismantle pump.
Cause 18. Check quiet running of pumps. Check coupling alignment (when cold). Check oil quality and cleanliness.
Cause 19. Fit new casing wear rings. Check out-round (true running) of rotor. Check presence of foreign bodies in the pump (see also item 16).
Cause 20. Fit new impeller. Check suction head (cavitation). Check system for presence of foreign bodies (see also item 16).
Cause 21. Replace damaged components by new ones.
Cause 22. Replace damaged components by new. Check shaft-protecting sleeves for true running (out-of-round). Check suitability of packing material used. Check that gland is not tightened askew and observes rate of leakage.
Cause 23. Carefully repack stuffing box. Check suitability of packing material used.
Cause 24. Realign coupling (when cold). Fit new bearings. Check rotor for signs of damage.
Cause 25. Check suction pressure (cavities). Check coupling alignment. Check pump internals for presence of foreign bodies.
Cause 26. Repack stuffing box. Tighten gland lightly only. Allow slightly higher rate of gland leakage. Check suitability of packing material used.
Cause 27. Check unobstructed flow through cooling liquid feed line.
Cause 28. Fit an end ring or a new stuffing box gland. Check condition of shaft protecting sleeve.
Cause 29. Use treated cooling liquid. Fit filters in cooling liquid lines.
Cause 30. Check rotor clearances. Check axial adjustment (position) of rotor.
Cause 31. Check oil quality and quantity.
Cause 32. Check bearing components for signs of damage and assemble them correctly.
Cause 33. Thoroughly clean bearings, bearing housing, and check condition of bearing oil seal.
Cause 34. Remove all rust from bearings and bearing brackets.
Change the oil fill.
Cause 35. Replace damage components by new ones. Check rotating components for out-of-round. Check suitability of materials used. Make sure all seal components seal accurately, and look out for leakage.
Cause 36. Carefully insert seal. Check materials for suitability.
Cause 37. Measure the seal a new. Refer to manufacturer.
Cause 38. Check unobstructed flow through cooling liquid supply line.
Cause 39. Fit a new bush or a space sleeve in the cooling housing.
Cause 40. Use treated cooling liquid. Incorporate filters in the cooling liquid line.

14. Spare Parts

When ordering spare parts, always please quote the item numbers, and designations of the items concerned, and the Works serial number of the pump, in order to avoid any queries and delays in delivery. The Works serial number of the pump can be obtained from the title page of the present instruction manual, or from the rating plate on the pump.
We recommend keeping the following spare parts in stock in order to be in a position to remedy rapidly any operating trouble which might arise.

Part Nº		Quantity for pump construction with: Standard stuffing box	Special stuffing boxes HW, V, VSM, VSH	Mechanical seal	Remark
210	Shaft with keys	1	1	1	*)
230	Impeller	S	S	S	*)
321	Deep groove ball bearing	1	1	1	
322	Cylindrical roller bearing	1	1	1	
400.1	Flat gasket	1	1	1	
400.2	Flat gasket	S	S	S	
400.3	Flat gasket	2	4	4	
400.4	Flat gasket	2	2	2	
400.6	Flat gasket	-	-	2	
412.2	O-ring	1	1	1	
412.3	O-ring	2	2	2	*)
412.4	O-ring	-	2	2	
412.22	O-ring	-	-	2	
422.2	Felt ring	1	1	1	Only when bearing is sealed
461.1	Stuffing box packing (in metres)	2	2	-	
472 to 477	Mechanical seal, complete	-	-	2	
502	Casing wear ring	S	S	S	
521-	Stage sleeve	S-1	S-1	S-1	*)
523.1	Shaft sleeve	-	-	1	*)
523.2	Shaft sleeve	-	-	1	*)
524.1	Shaft protecting sleeve	1	1	-	*)
524.2	Shaft protecting sleeve	1	1	-	*)
525.1	Spacer sleeve	1	1	1	*)
540.1	Bush	1	1	1	Only on material alternative 12% Cr
540.2	Bush	1	1	1	Only on material alternative 12% Cr
540.3	Bush	1	1	1	Only on material alternative 12% Cr
541	Stage bush	S-1	S-1	S-1	
52-1	Clamping sleeve, complete	1	1	1	

S = Number of stages

Table 5

*) Parts for complete pump rotor.
The latter should be assembled and dynamically balanced, and kept in stock as a complete spare part.

15. Check List

Pre-requisites for Initial Commissioning

Check direction of rotation of driver with pump disconnected.
Check correct alignment of pumping set with appropriate alignment jigs and dial micrometers.
Check that the stuffing box gland seats squarely and has sufficient guidance (with the is of a feeler gauge, check that the gap between the shaft protecting sleeve and the stuffing box gland remains the same around the circumference).
If mechanical seal are fitted, check that the circulation lines are vented at the apex.
Check that the system is primed with the fluid pumped, and thoroughly vented via the vent valve in the discharge line (if provided), and via the vent screws of the pressure gauge valve (suction pressure-discharge pressure).
Check that the valves in the minimum flow line are opened.
Check that the valve in the manually operated line of the minimum flow device is opened.
Check that oil has been filled in the bearing housings, and that the required oil level has been attained (by oil pouring out of the overflow holes).
Observe the start-up procedure for the driver.

If the operating temperature exceeds 150ºC, check that the main valve in the cooling liquid supply line is fully open, and that the fluid flows through freely, also check that the throttling valves in the cooling liquid lines are fully open.
Check that the isolating valve in the suction headline is fully open.
Check that the isolating valve in the discharge line is closed.

Initial Start-up with Cold Water

Switch on driver for a short instant, and switch it off again immediately. Check that rotor runs down smoothly and evenly to a standstill.
Switch driver on again. Check quiet running of pump.
Observe the stuffing boxes (they should not run too hot).
Make sure that the pump runs smoothly and quietly, and that the stuffing boxes function correctly.
On pumps fitted with mechanical seals, keep a check on the temperature in the circulation lines.
Keep a check on the pressure gauge indications (suction and discharge pressures).
If the pump is turbine driven, run up the turbine to full operating speed as rapidly as possible, and make sure the pump runs quietly during this time.

Priming the Boiler:

Crack the isolating valve in the discharge line open slowly (remember lag of servo-actuated valves). Run the pump within the confines of the limitation curve of the operating diagram (see section 10.3. “Pump Operation and Supervision”).

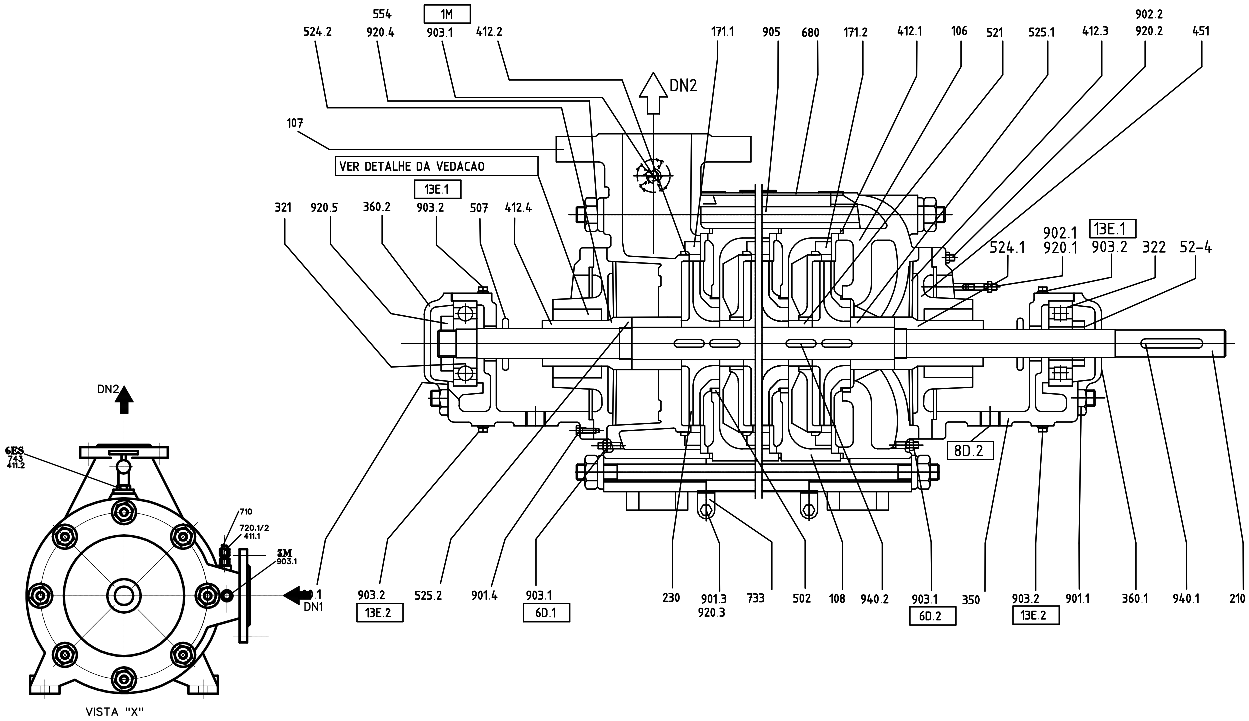
Initial Operation with Hot Fluid:

When the nominal temperature of the fluid pumped has been attained, adjust the flow cooling liquid supply. This should be done by throttling the individual valves in the internal cooling liquid piping system in such a way that a temperature differential of 10ºC max. is set up between the cooling liquid inlet and outlet.
During operation, check the pressure drop across the strainer in the suction lift or suction headline. When the max. permissible pressure drop value has been reached; switch off the pumping set and cleans the strainer.

Supervision of Operation and Maintenance

During operation, the pump should be kept under careful observation. The following measurement values should be checked at frequent intervals:
Suction pressure
Suction temperature
Pump discharge pressure
Temperature at pump discharge nozzle
Bearing temperatures
Stuffing box leakage
Temperature of mechanical seals
Cooling liquid temperature at cooler outlet
(Max. temperature differential 10ºC)
Check that the pump runs smoothly and quietly at all times, and check the pressure drop across the suction headline by differential pressure measurement.
We recommend keeping a log book on pump operation, to supervise the pumps more closely the following data should be entered in this log book at hourly intervals rate of flow, suction pressure, discharge pressure temperature of fluid pumped and rotational speed. The times of start-up and shutdown should also be recorded, so that the total number of hours of operation of the feed pump can be ascertained at any time.
The oil level and oil quality should be checked, reps. tested, after the first 200 hours of operation. There after the oil level and oil quality should be checked at least once a month.

16. Sectional Drawings and List of Components



Basic construction WK 40 to 125

Quantity per pump	Part Nº	Designation	Quantity per pump	Part Nº	Designation	Quantity per pump	Part Nº	Designation
1	106	Suction casing	1	422.2	Felt ring	2	636	Grease nipple
1	107	Discharge casing	2	451	Stuffing box housing	2	633	Constant level oilier
S-1	108	Stage casing	2	452	Stuffing box gland	1	680	Cladding
2	165	Cooling cover	2	458	Lantern ring	2	720.3	Double nipple
S-1	171.1	Diffuser	2	461.1	Stuffing box packing	2	731.2	Plug
1	171.2	Final stage diffuser	2	500.1	End ring	8	901.2	Hex. head bolt
1	210	Shaft	2	500.4	Ring	4	901.4	Hex. head bolt
S	230	Impeller bearing	SX2	502	Casing wear ring [1])	16	902.1	Stud
1	321	Deep groove ball bearing	SX2	503	Impeller wear ring [1]) [2])	4	902.2	Stud
1	322	Cylindrical roller bearing	2	507	Thrower	8	902.3	Stud
2	350	Bearing housing	S-1	521	Stage sleeve	2	903.1	Threaded plug
1	360	Bearing cover	1	524.1	Shaft protecting sleeve	2	903.2	Threaded plug
1	361	Bearing end cover	1	524.2	Shaft protecting sleeve	2	903.4	Threaded plug
S-1	400.2	Flat gasket	1	525.1	Spacer sleeve	1	903.5	Threaded plug
2	400.3	Flat gasket	1	525.2	Spacer sleeve	1	903.12	Threaded plug
2	400.4	Flat gasket	1	540.2	Bush [1])	8	905	Tie bolt
2	412.2	O-ring	1	540.3	Bush [1])	2	913	Hex. nut
2	412.3	O-ring	S-1	541	Stage bush [1])	16	920.2	Hex. nut
2	412.4	O-ring	16	550	Disc	4	920.3	Hex. nut
2	422.1	Felt ring	1	52-1	Clamping sleeve			

7A	Cooling liquid outlet
7E	Cooling liquid Intel
8B	Leakage liquid drain
10A	Sealing liquid outlet
10E	Sealing liquid inlet
13B	Flushing liquid inlet
11E	Oil drain

[1]) Material alternative with 12% Cr.
[2]) Only supplied in conjunction with part nº 230 (impeller)

[ ] recommended spare parts
S Number of stages