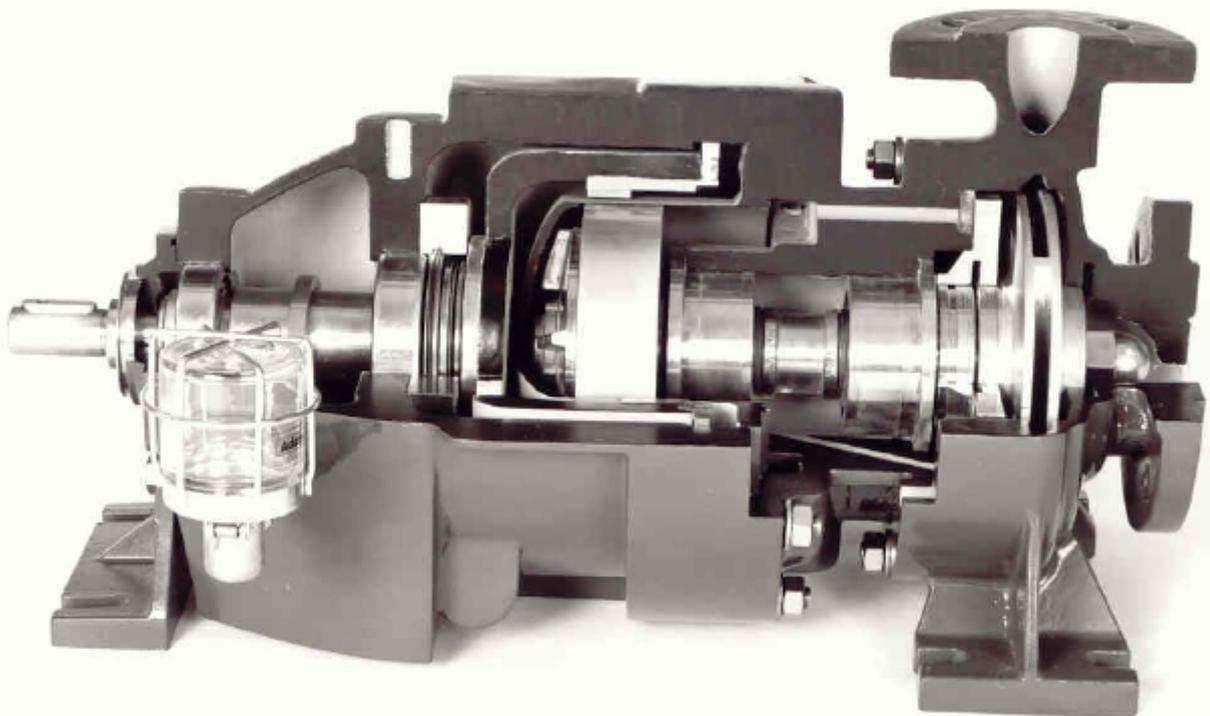


Installation, Operation and Maintenance Instructions

Type PRM
frame size 0, I, II



No. 44 NMR.E2.09/03



Pump sizes:	<u>Frame size 0</u>	<u>Frame size I</u>	<u>Frame size II</u>
	26/125	32/165	32/250
	26/170	32/210	40/250
	26/210	40/165	40/320
	40/125	40/210	50/250
	50/125	50/165	50/330
	65/125	50/210	65/165
			65/200
			65/250
			80/165
			80/200
			80/250
			100/200



DICKOW PUMPEN KG



EC Declaration of Conformity

as defined by EC-Machinery Directive 98/37 EG Annex II A
and by the EC-Explosion-Proof Directive 94/9/EG Annex XB

Herewith we declare that the pump unit, described in the data sheet,

Series „PRM“

complies with the following provisions applying to it

EC-Machinery Directive 98/37 EG, Annex I No. 1
EC-Explosion-Proof Directive 94/9/EG Annex II

Applied harmonized European standards in particular

DIN EN 809	EN 1127-1
DIN EN 292 Part 1	EN 13463-1
DIN EN 292 Part 2	EN 13463-5

Applied national technical standards and specifications in particular

DIN EN ISO 9906	VDMA 24276
DIN 24250	VDMA 24279
DIN 31001	API 685
DIN EN 22858	
DIN ISO 5199	
DIN EN 12723	

Importer in country of use

(Signature)

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2. GENERAL INFORMATIONS

2.1 INTRODUCTION

This manual provides instructions for the installation, operation and maintenance of the DICKOW-model NMR, sealless centrifugal pump with magnetic coupling.

IT IS ESSENTIAL THAT THIS MANUAL BE THOROUGHLY REVIEWED AND THAT COMPLETE COMPREHENSION OF THE MATTERS EXPLAINED HEREIN IS ATTAINED BEFORE ATTEMPTING INSTALLATION AND START-UP.

The design, materials and workmanship incorporated into the DICKOW-Pump are based on years of experience. They assure trouble-free service throughout the lifetime of the pump. However, like any rotating equipment, satisfactory performance depends on correct initial sizing, proper installation, periodic inspection, monitoring of operating conditions (temperature, vibration, flow) and prescribed maintenance. This Manual has been prepared to assist the operator in understanding the workings of the DICKOW-Pump and to assure proper installation, operation and maintenance.

2.2 LIMITED WARRANTY

DICKOW warrants that DICKOW-Pumps and Parts are free, upon installation and start-up per this Manual and under rated use and service, from defects in design, material, and workmanship for a period of one (1) year from date of installation, but not to exceed eighteen (18) months from date of shipment by DICKOW. This warranty does not cover

1. any loss or damage resulting from wear, corrosion, abrasion or deterioration due to normal use in rated service;
2. replacement of service items such as outer antifrictional bearings;
3. products or parts manufactured by others but furnished by DICKOW which, if defective, shall be repaired or replaced only to the extent of the original manufacturer's warranty;
4. any loss or damages to, or defects in any such products or parts resulting from the misuse or improper storage, installation or operation thereof; or
5. any loss or damages to, or defects in, any such products or parts resulting from any alteration or modification of the products or parts not expressly authorized and approved by DICKOW in writing.

DICKOW shall not be liable, directly or indirectly under any circumstances, in an amount greater than the purchase price nor for consequential or incidental damages, including, but not limited, to: any loss of business or profits, and labor, material or other charges, claims for losses or damages incurred or suffered from, in connection with, or in consequence of the working upon, alteration, or repair of any such defective products or parts by persons or firms other than DICKOW. DICKOW's liability for breach of warranty hereunder is limited solely to the repair or to the replacement, F.O.B. DICKOW facility, as the case may be, of any products or parts which shall have been determined by DICKOW, after written notice to DICKOW, and inspection by DICKOW within the warranty period, to be so defective when shipped by DICKOW.

THIS WARRANTY AND THE LIABILITY SET FORTH HEREIN ARE EXCLUSIVE AND IN LIEU OF ALL OTHER LIABILITIES AND WARRANTIES, EXPRESS OR IMPLIED, INCLUDING IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR PARTICULAR PURPOSE.

2.3 FACTORY INSPECTION

Before delivery, all pumps are performance-tested in our factory test area at the specified speed. Test liquid is water at 20°C (68°F). Test pressure and the specified service conditions (capacity, differential head and absorbed power) are documented and reconfirmed by a shop expert. Inspection certificates B according to EN 10204 (DIN 50049 3.1B), are available on request.

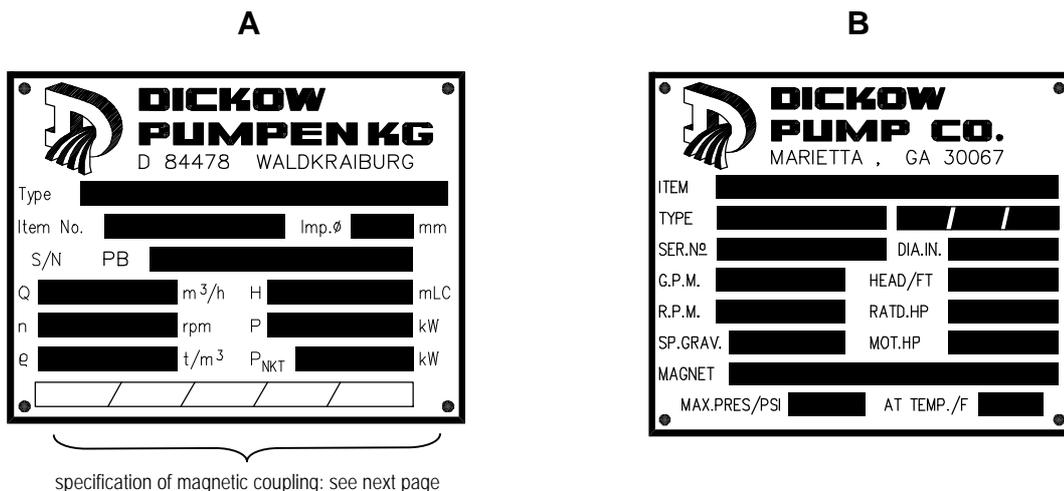
Certificates of further characteristics such as vibration, NPSH-value, noise level etc., are available if specified in the purchase order.

The hydraulic test is performed in accordance with EN ISO 9906, class 2, the pressure test is performed with 1,5-times the maximum operating pressure unless otherwise specified.

2.4 IDENTIFICATION

2.4.1 Name tag

A name tag is located on the bearing bracket of each pump providing the informations as below:
When ordering spare parts or when contacting our application engineers about problems, you need to state the pump model, size, serial number, and the item number of the required parts.



Name Tag „A“

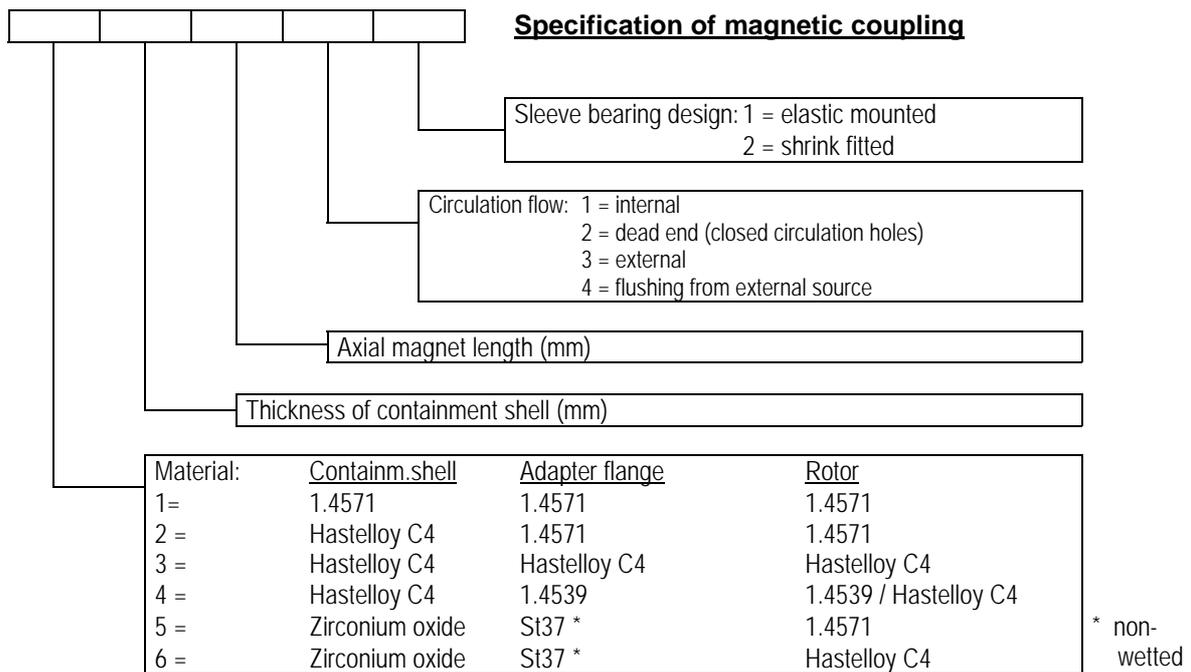
TYPE: Pump type and size
 P_{NKT}: Maximum transmissible coupling power at operating temp.
 IMP. Ø: Installed impeller diameter
 S/N PB: Pump serial No.
 RTD.PUMP DATA: According to your order

Name Tag „B“

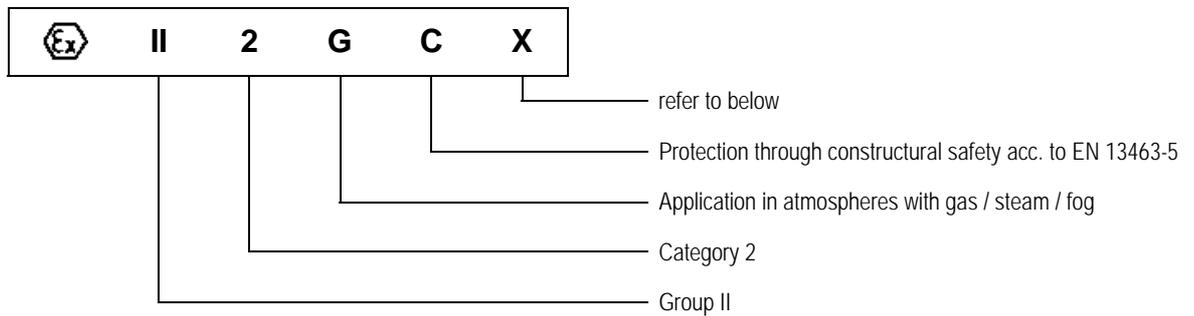
TYPE: Pump type and size - Suction / discharge / nom. impeller dia
 SER.NO: Pump serial No.
 DIA IN: Installed impeller diameter
 RTD. PUMP DATA: According to Purchase Order
 MAGNET: Axial magnet length
 MAX PRES/PSI: Maximum allowable pressure on containment shell at Temp/°F

Attention !

The rated motor power may not exceed the maximum transmissible power of the magnets, otherwise the magnets will slip during start-up.



2.4.2 Identification acc. to Explosion-Proof Directive



Since the effective maximum surface temperature does not depend on the according ignition source, but on the temperature of the pumped liquid, no identification ensues with a temperature class or a temperature. The symbol "X" has been integrated in the identification and the chapter 5.2 of this manual refers to the arising surface temperatures.

2.5 SAFETY

2.5.1 Symbol- and Notice Explanation

2.5.1.1 Work Safety Symbol



This symbol will be found in this manual at all remarks for operational safety, where risks for health and life of personnel may be posed. Please observe these points and be cautious in these cases. All cautions should also be passed on to other users. Apart from the cautions in this manual, the generally accepted safety rules must be adhered to.

2.5.1.2 Attention Notice

Attention !

To the items marked with ATTENTION in this manual, special attention must be paid in order to maintain a correct operating procedure and to avoid damage and destruction of the machines and/or other plant equipment.

2.5.2 Work Safety Instructions

2.5.2.1 Special Notice when handling magnetic parts

All magnetic driven pumps contain extremely strong magnets which may pose health risks. The following guidelines must always be observed.

2.5.2.2 Notice to risks of health and accidents



- When handling magnetic parts, danger from magnet fields is possible. Individuals with artificial cardiac pacemakers should keep distance from pumps with permanent-magnetic couplings and not perform any maintenance or other repairs on such machines.
- Individuals with implanted defibrillators, metallic prosthetic heart valves, internal wound clips (from surgery), prosthetic joints, metallic wiring, or other metallic prosthetic devices shall avoid working with, being in proximity of, or handling the magnets contained in the pumps.
- Individuals with sickle cell anemia or those with significant blood pressure elevation shall also avoid work on this unit. Individuals who have had previous surgeries (chest or head) and who do not know if they have metallic clips internally, should avoid work on this unit unless it can be firmly established by the physician that no metallic devices exist.
- The strong magnetic forces can cause parts and tools to slam together, injuring hands and fingers. Use of non-magnetic tools and special care is recommended.

2.5.2.3 General Notices

- Credit Cards:
Credit Cards or information on the credit card's magnetic tape can be erased and shall be kept away from the proximity of all magnets.
- Computers, computer tapes, computer discs:
Keep magnets away from computers, computer tapes and computer discs or any computer memory device to prevent damage.
- When handling magnets all watches should be removed. Magnets have affected the workings of mechanical spring driven watches as well as chip and electronically controlled watches.

2.5.2.4 General Instructions for pump's operation

The sealless pumps of type PRM are manufactured in accordance with state of the Art-Technology and are safe to operate. However, these units bear danger if they are inexpertly installed or handled. Each person who is in charge of assembly, installation, operating and maintenance of PRM-pumps in a plant, must have read and understood the complete manual and particularly item 2.5 „Safety“.

Special attention must be paid to the following points when operating the pump:



- Never operate pump without correctly installed coupling guard.
- When maintaining the pump, power supply to the driver must be interrupted and secured against unauthorized restart.

Attention !

- Never start pump without making sure it is primed and the pump and suction line is completely filled with liquid.
- Never run pump with discharge valve closed or below minimum flow.
- Never run pump dry.
- Never operate pump without safety devices installed.
- Never operate pump with suction valve closed or with clogged suction strainer.
- If it cannot be excluded that larger solids (>0,5 mm) will be contained in the pumped liquid, a filter must be provided on suction side.
Suction strainers must have a net „free area“ of at least six to seven times the suction pipe area. Screen with a mesh width of 480 micron is recommended. Pressure losses at rated capacity should not exceed 1 to 1,5 m (3 to 5 ft). There should be a minimum of two pipe diameters of straight pipe between strainer outlet and pump suction flange.

3. PUMP DESCRIPTION

3.1 APPLICATION / DEFINED USE

DICKOW-PRM-pumps are used where ever sealless design is required (i.e. when pumping dangerous, explosive or toxic liquids). Wear resistant sleeve bearings as well as the sealless design increase availability and reduce both maintenance and total costs of ownership. PRM-pumps are suitable for a temperature range of -50 to 300°C.

For the defined use of the pump it is absolutely necessary that the pump is constantly filled with liquid. The maximum speed is determined with 2900 rpm at 50 cycles and with 3500 rpm at 60 cycles.

3.2 CONSTRUCTION

The model PRM is a sealless single flow centrifugal pump of back-pull-out design with a closed impeller, driven by a synchronous magnetic coupling. The flange to flange dimensions meet the standards of DIN EN 22858.

Disassembly of the rotating hydraulic part, complete with magnetic coupling and bearing, is possible without loosening suction and discharge flange. The bearing bracket with the drive magnets can also be removed without stress-relieving the pump. This enables changing of the ball bearings without draining the pump. If spacer-type couplings (4.4.2) are used, the drive motor can remain on the baseplate while the hydraulic part or the bearing bracket is being disassembled.

3.2.1 Volute casing, part 102

The volute casing is sealed on drive side by the bearing housing. The bearing housing is screwed to the volute casing by studs. The pumped liquid is sealed from the atmosphere by a confined gasket. Replaceable wear rings are available in the standard configuration.

The volute casing can be delivered foot mounted or centerline mounted.

Complete drainage of the pump including the magnet area is possible through the drain connection at the bottom of the casing in the standard configuration. Pumps with dead-end operation or external flushing with closed internal circulation holes are provided with an additional drain connection at the bearing housing.

3.2.2 Impeller, part 233

The closed impeller is keyed to the pump shaft and secured by a cap nut with Heli-Coil insert, respectively by cheese head screws at frame 0. All impellers are dynamically balanced according to DIN ISO 1940 / part 1, grade G 2.5. The impellers are also hydraulically balanced such that no thrust loads will occur within the performance range.

3.2.3 Bearing housing, part 350 – internal circulation

The bearing housing connects the pump casing with the drive unit. The stationary wetted sleeve bearings are located in a common bore in the bearing housing hub.

Pumps in operation generate eddy currents in the metallic containment shell which heat up the product in the gap between rotor and containment shell. This heat is dissipated thru an internal circulation. The circulation flow leads from discharge to discharge and pressurizes the magnet end to prevent flashing of the pumped liquid in this area. This circulation plan ensures that no pumped liquid of elevated temperature enters the suction side through the impeller eye area. Therefore, handling of boiling liquids with low NPSH-requirements is possible.

The magnet area is self-venting: gas or air in the containment shell area escapes through the internal circulation holes which enable also complete drainage thru the volute casing. At dead end operation or external flushing, the additional technical data sheets and piping schemes (refer to page 1 "Pump Design Data") must be considered.

3.2.4 Bearing bracket, outer antifriction bearings

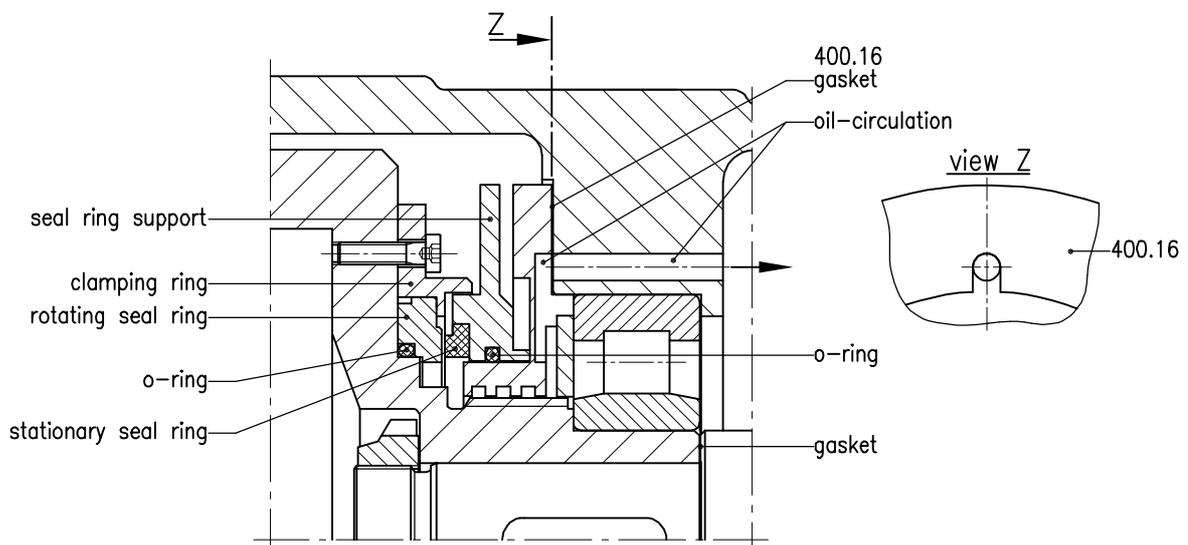
The drive shaft is carried in generously dimensioned oil lubricated antifriction bearings. The bearings are protected against the atmosphere by labyrinth seal and deflector. The oil level is controlled by constant level oiler with additional sight glass. The magnet area of the standard design is also sealed from the oil bath by a labyrinth seal. Since the bearing is not loaded by hydraulic forces, a service life of more than 1×10^6 operating hours can be expected.

3.2.5 Secondary containment

If desired, a mechanical stand-by seal can be supplied in lieu of the inboard labyrinth seal. This mechanical seal separates the magnet area from the oil bath and atmosphere, and forms - together with the closed bearing bracket - a secondary containment behind the containment shell.

The mechanical seal prevents uncontrolled product leakage to the atmosphere in case of containment shell damage. Connections for additional monitoring devices - for containment shell leakage and for the function of the secondary containment - are provided between containment shell and secondary containment. The secondary seal complies to the rated working pressure of the pump.

A subsequent modification is possible without remachining.



3.2.6 Sleeve bearings

The pump shaft, with impeller and driven inner magnets, is held in place by wetted sleeve bearings. Bearing material is highly wear resistant pure Silicon Carbide. The faces are provided with an additional diamond layer which tolerates short-time dry-running. The stationary sleeve bearings and the shaft sleeve are dimensioned such that the radial loads can be accepted. Due to the hydraulic balance, no thrust loads occur and therefore, the thrust bearings have the function only of start-up rings during operation.

The SiC-parts have an unlimited lifetime as long as a stable liquid film is provided between the bearing faces. That means, as long as the boiling point is not exceeded in the containment shell area and cavitation of the pump is avoided.

3.2.7 Magnet Coupling

DICKOW-Standard magnet material is Cobalt Samarium – Rare Earth (CoSm) providing a high energy density. The required power is transmitted to the impeller without shaft duct to the atmosphere, respectively without mechanical connection between pump shaft and drive shaft.

Energy is transmitted to the hermetically sealed liquid end by the outer drive magnets, passing motive force through the containment shell to the internal drive magnets. The inner magnet ring transmits the required torque direct to the impeller. Overload of the magnetic coupling and slipping will not effect demagnetization if a reliable monitoring device prevents overheating of the magnets. After shut down of the pump and elimination of the overload cause, the magnetic coupling gets its original capacity again.

Rotor and rotor cover are welded together such that the inner magnet elements are sealed against the pumped liquid.

3.2.8 Containment shell, part 817

The containment shell is bolted to the bearing housing and sealed from the atmosphere by a confined gasket. That means, the wetted area is hermetically sealed from the drive end or from the atmosphere. The containment shell is stressed by the pump pressure only, the required wall thickness depends on this pressure and also on the operating temperature. The shell is not used as additional bearing holder and thus, no dynamic stress occurs.

Containment shell material: refer to the name tag, item 2.4

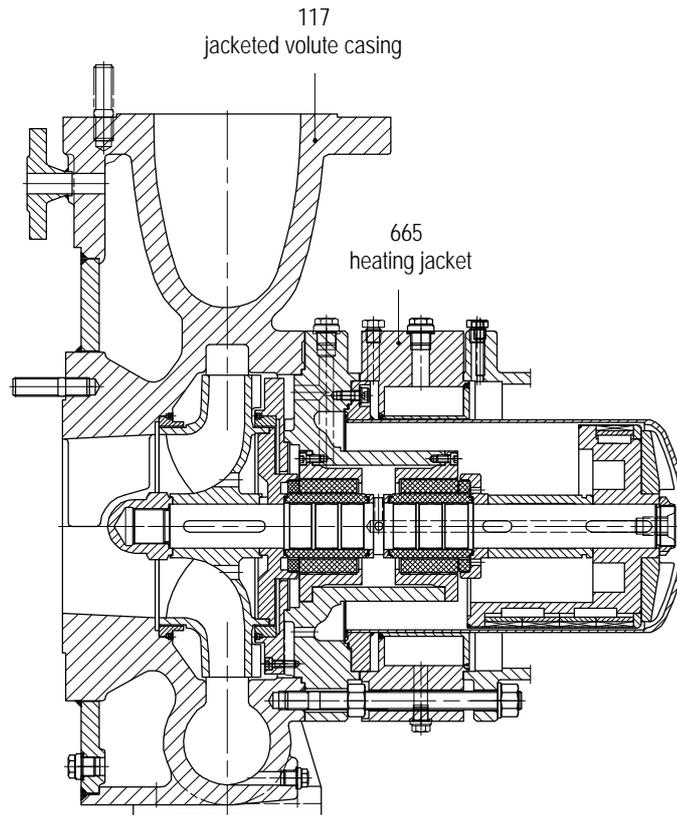


Damage of the containment shell through incorrect operation or insufficient monitoring can cause penetration of the product to the atmosphere. When handling dangerous products, appropriate safety- and monitoring devices must be provided.

3.2.9 Jacketed design

The jacketed design is applied in plants where the pumped liquid may cool down excessively or where the temperature of the liquid in the pump may drop below the solidification- respectively crystallisation point during downtime.

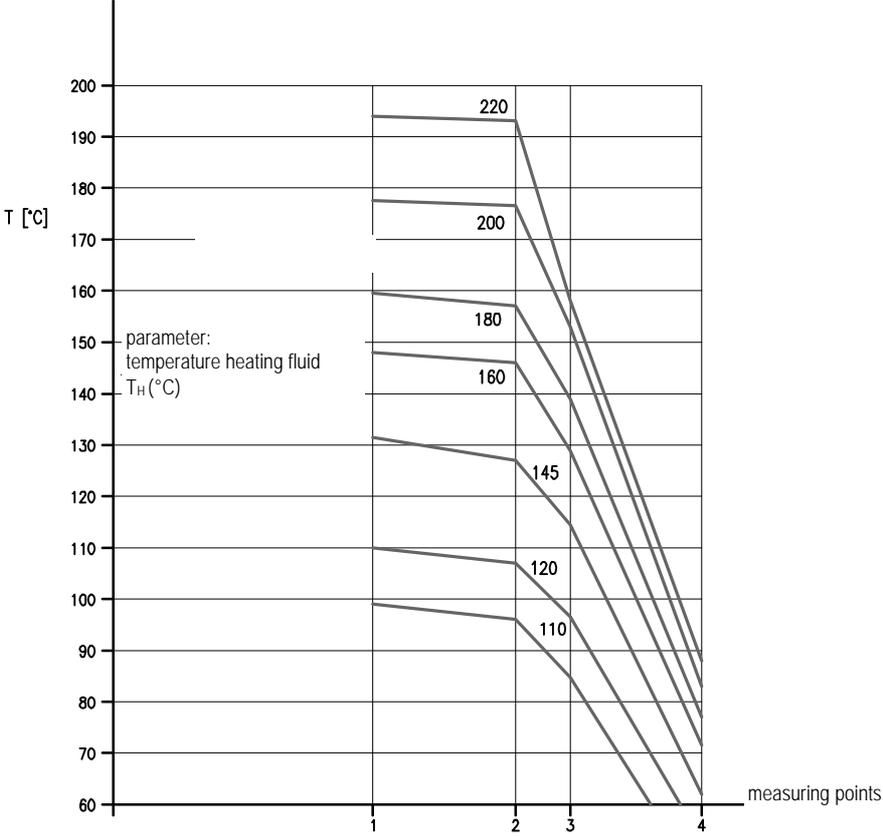
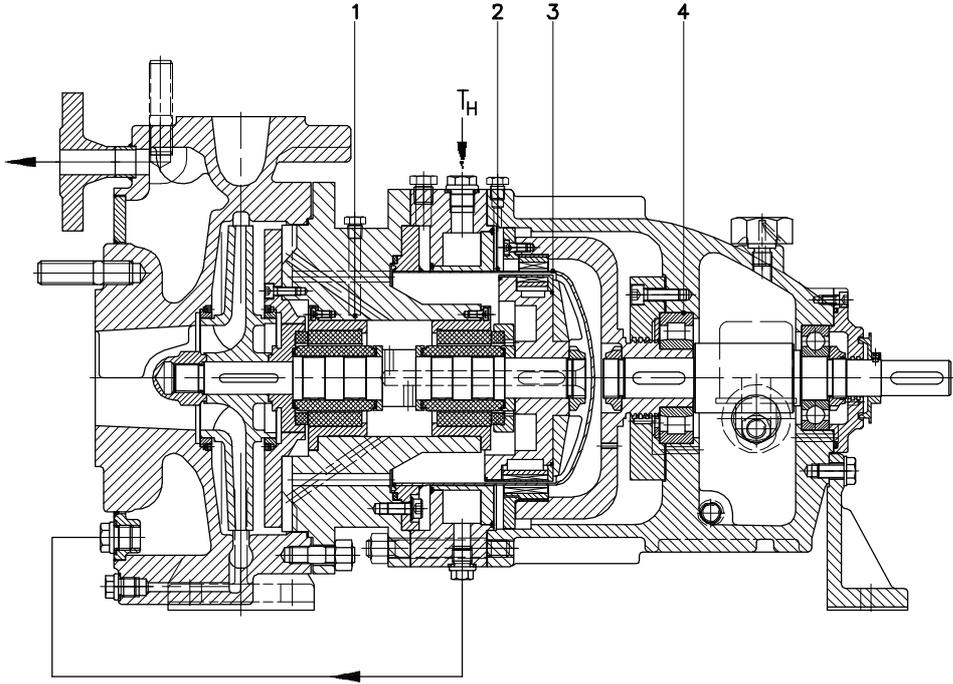
For heating fluid should for instance be used heating steam or thermal oil.



The heating chamber of the volute casing is designed such that the whole front side including the discharge flange is pressurized by the heating fluid. Only this grants a constant and entire heating up of the pumped liquid.

The generously dimensioned heating chamber is slid – as a separate component - onto the containment shell and screwed down to the bearing bracket /bearing housing. This construction excludes penetration of heating steam or thermal oil through leaking welds into the pumped liquid.

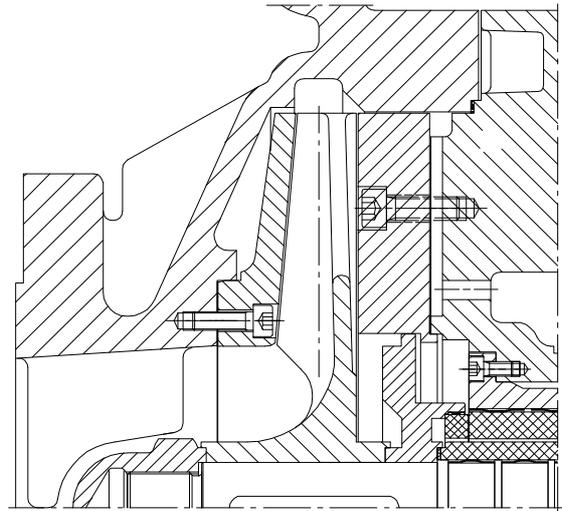
The following diagram shows the steady temperature curve within the pump. The measured temperatures will set at filled pump after about 1 1/2 hours.



If jacketed pumps are subject to the explosion proof directive 94/9/EG, the prevailing temperature class required special attention. The heating fluid must not exceed the allowable surface temperature of the specified temperature class.

3.2.10 Open Impeller design

The design with open impeller is used for handling aggressive polymerizing liquids which tend to lump and for gas contaminated liquids.



4. INSTALLATION

Attention !

Installation, foundation and maintenance of pumps handling inflammable liquids AI, AII, AIII, B and other pollutive products may only be performed by companies or their personnel who possess the permission acc. to the local state regulations regarding the water protection law.

4.1 RECEIVING THE PUMP

Inspect the pump as soon as it is received. Make notes of damaged or missing items on the receipt and freight bill. File any claims with the transportation company immediately. Check for identical speed on pump and motor name tag.

4.2 STORAGE REQUIREMENTS

Short Term - less than six months

DICKOW normal packaging procedure is designed to protect the pump during shipping. Upon receipt store in a covered and dry location.

Long Term - more than six months

Preservative treatment of machined surfaces will be required for pumps of material GGG40.3 or GS-C25. Store the pump in a sheltered dry place. Rotate shaft several times by hand every three months by removing the coupling guard. If required, disassemble and inspect prior to final installation. Refer also to driver manuals for their long term storage.

4.3 ALIGNMENT OF BASEPLATE / BASEFRAME ON THE FOUNDATION

Pre-condition for a proper and troublefree operation of the pump is the accurate assembly of the entire unit. Improper installation inevitably results into increased vibrations (5.4.1, item 3) and thus, to damage on the elastic coupling and the antifriction bearings. Therefore, the pump should be assembled by specially trained personnel only or by our own fitters.

If the pump is delivered completely mounted with motor a careful assembly is guaranteed. After examining the unit on site for possible transportation damage, the following steps should be taken:

- Alignment of baseplate or baseframe by means of a water level.
- Elimination of unevenness in the foundation by suitable supports.
- Checking respectively realignment of the coupling acc. to 4.4 after tightening the foundation bolts.

Attention !

The proper alignment of the entire unit prior to start-up is the responsibility of the owner only.

4.4 ALIGNMENT OF FLEXIBLE COUPLINGS, Brand „KTR / FLENDER“

If motor and coupling is mounted on site by the owner, the following must be observed:

Attention !

Before starting alignment procedure, remove pump support foot from bearing bracket. After final alignment assemble the support foot again, free of any stress.

Attention !

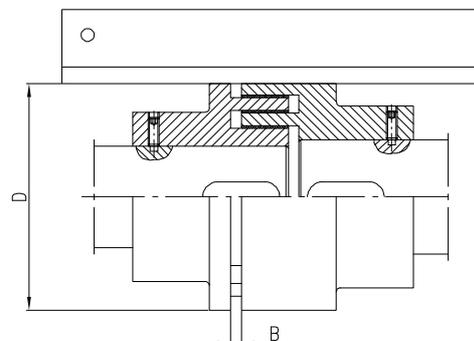
After inserting the keys into the shaft grooves, the coupling halves are to be slid onto the shaft ends on pump and motor side until they flush with the shaft surface. It is important that the hub halves are slid on without excessive force. Wedging by using a hammer inevitably causes damage to the bearings or sleeve bearings. After installation, the hub halves are to be secured by threaded pins. If both coupling halves are mounted, the alignment of pump- and motor shaft relative to each other must be checked. Depending on the coupling design, this is done as follows:

4.4.1 Standard couplings without spacer, PKZ / B

Alignment is made by placing a straight edge across both coupling halves at three points spaced by 120 degree intervals (shown in the drawing). Any possible displacement becomes visible as a light gap and must be corrected.

Coupling-Dia D (mm)	KTR B (mm)	FLENDER B (mm)
80 - 125	2 - 4	2 - 4
131 - 225	2 - 6	2 - 6
250 - 288	2 - 7	3 - 8

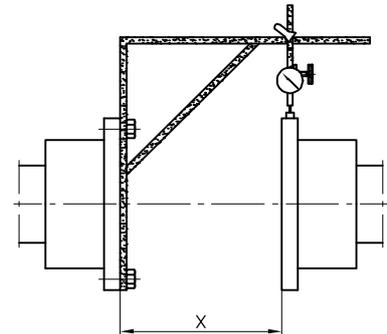
Coupling-Dia D (inch)	KTR B (inch)	FLENDER B (inch)
3.15 - 4.92	0.079 - 0.157	0.079 - 0.157
5.15 - 8.85	0.079 - 0.236	0.079 - 0.236
9.84 - 11.34	0.079 - 0.276	0.118 - 0.315



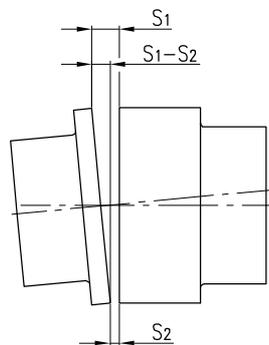
After the motor adapter screws are tightened finally, the coupling space "B" must be checked.

4.4.2 Spacer-type coupling, PKA / H

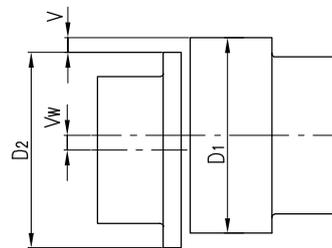
An alignment check is made by using a dial indicator as shown in the following drawing. The distance "X" between the pre-mounted coupling halves complies with the spacer length.



There are two forms of misalignment:



angular misalignment



parallel misalignment

Use the dial indicator as shown and determine the parallel misalignment V_w . Realign if V_w exceeds 0,1 mm. Place the dial indicator now at the coupling end and determine the angular misalignment $S_1 - S_2$.

The units are lined up if the following alignment error E_z is not exceeded:

The available angular misalignment is:

$$S_1 - S_2$$

The parallel misalignment V_w is

$$V_w = V - \left(\frac{D_2 - D_1}{2} \right)$$

The available error E_v is:

$$E_v = V_w + (S_1 - S_2)$$

Allowable misalignment E_z

$$E_z = 0,3 \text{ mm (0.012 inch) at } 3000\text{-}3500 \text{ min}^{-1}$$

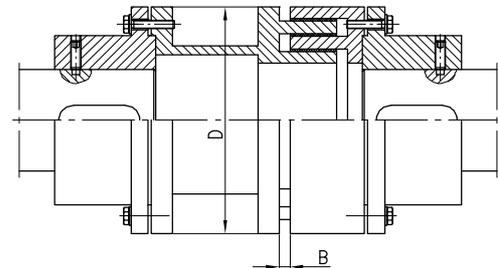
$$E_z = 0,5 \text{ mm (0.020 inch) at } 1500\text{-}1750 \text{ min}^{-1}$$

If one of the two errors is zero, the allowable deviation for the other error may be fully utilized.

Before mounting the distance sleeve, check direction of rotation of the driver (clockwise when viewing the shaft end of the pump). Assembly of the bipartite distance sleeve is done by joining both parts - which are provided with claws and rubber packages - by hand such that the gap "B" is zero. Insert these parts between the hub half faces on motor and pump side and fit them into the centrings. Screw both intermediate parts to the hub halves and tighten the screws evenly and cross wise.

Coupling-Dia D (mm)	KTR B (mm)	FLENDER B (mm)
80 - 86	4	4
97 - 195	5	5
200 - 288	6	6

Coupling-Dia D (inch)	KTR B (inch)	FLENDER B (inch)
3.15 - 3.39	0.157	0.157
3.82 - 7.68	0.197	0.197
7.87 - 11.34	0.236	0.236



After tightening the bolts, check the coupling space "B".

4.4.3 Special coupling design

When using couplings of different designs from other manufacturers, consider special alignment instructions that apply to such couplings.

4.4.4 Documentation according to Directive 94/9/EG

Couplings are required for a safe operation of the pumps. They are defined to transmit energy and therefore, are subject to the Explosion Proof Directive and will have a CE-marking. A declaration of conformity as well as an instruction manual will also be supplied.

4.5 COUPLING GUARD



Never operate pumps without properly mounted coupling guards (shock protection). If the coupling guard is manufactured and supplied by DICKOW, compliance with the valid technical safety requirements – such as proper stability, sufficient distance to rotating parts and no use of light metal for operation in hazardous areas - is guaranteed. If the coupling guard is provided by the user, it must be in accordance with the above mentioned requirements and meet the standard EN 809.

4.6 PIPING

Attention ! The pump must be stressfree connected to the piping. The connection flanges of the pipes must be in exact alignment with the pump flanges. Never draw piping into place by imposing force. If piping will be cleaned or flushed after installation, suction and discharge opening must be closed by blanks. No solids must get into the pump during standstill

General

1. All piping must be supported and line up naturally with the pump flange.
2. Do not make final connection of piping to pump unit until grout has hardened.
3. Piping that handles hot liquids, require proper installation of expansion loops so that linear expansion of piping will not cause misalignment.
4. Piping should be arranged to allow pump flushing and draining prior to the removal of pump for servicing.
5. Gasket installation and materials must be suitable for the service.
6. The allowable forces and moments must be considered.

4.6.1 Suction pipe

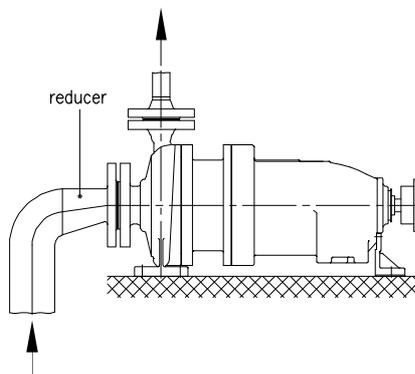
Attention ! When using sealless pumps, care must be taken for the NPSH-conditions. The suction piping requires careful design for these pumps. It is especially important that the available NPSH of the system is exactly determined.

NPSH-available \geq NPSH-required + minimum 0,5 m (1.5 – 2 ft)

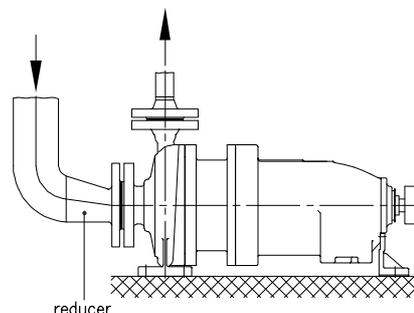
Suction pipe should be flushed before connection to the pump and the following be considered:

1. Use of elbows close to the pump suction flange should be avoided. There should be a minimum of 2 pipe diameters of straight pipe between the elbow and suction inlet..
2. Suction piping must never be of smaller diameter than the pump suction.
3. Reducers, if used, must be eccentric at pump suction flange as shown in the following drawing.

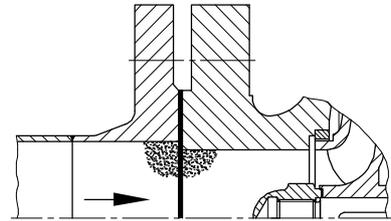
Suction lift conditions



Flooded suction conditions



4. If suction strainers are provided they must have a net „free area“ of at least six to seven times the suction pipe area. Recommended mesh width 480 micron. Pressure losses at rated capacity should not exceed 1 to 1,5 m (39 - 59"). There should be a minimum of two pipe diameters of straight pipe between strainer outlet and pump suction flange.
5. Separate suction lines are recommended when more than one pump is operating from the same suction vessel.
6. Never connect a larger suction pipe direct to the pump suction flange. Flow eddies reduce the free flow area of the pump. Additional losses reduce the calculated available NPSH, cavitation can occur.



Suction lift conditions

1. Suction pipe must continuously slope upwards towards pump suction to eliminate air pockets.
2. All joints must be air tight.
3. A foot valve should be provided to allow proper filling of pump and suction line before start-up.

Flooded suction conditions

1. An isolation valve should be installed in suction line to permit closing of the line for pump inspection and maintenance.
2. Suction pipe should slope gradually downwards to the suction flange to eliminate air pockets and to ensure a total venting during filling the piping.
3. The suction pipe shall be submerged sufficiently below the minimum liquid surface to prevent vortex and air entrapment at the source.

4.6.2 Discharge pipe

1. Isolation valve should be installed in discharge line to permit closing of the line for pump inspection and maintenance. If an additional check valve is foreseen, it should be placed between discharge flange and isolation valve.
2. Diffusers, if used, should be placed between discharge flange and isolation valve. Maximum allowable opening angle 8°.
3. Cushioning devices should be used to protect pump from surges and water hammer, if quick-closing valves are installed in system.
4. If a bypass pipe is provided for obtaining a minimum flow, lead the bypass back to the suction source - not to the pump suction pipe right in front of the suction flange. !
5. If the discharge pipe is equipped with an automatic control valve which closes under certain conditions (even at distance to the pump), an additional minimum flow bypass must be provided.

4.7 INSULATION

Insulation, if foreseen for pumps handling hot liquids, should cover the volute casing only. To avoid overheating of the magnets, heat dissipation by radiation must be guaranteed in the area of bearing housing 350 and bearing bracket 330. Thus, insulation of bearing housing and bearing bracket is not allowed. Insulation can also be required if the specification regarding maximum surface temperature within the explosion proofness must be fulfilled. This is especially the case if the liquid temperature exceeds the allowable temperature of the given temperature class.

4.8 SAFETY DEVICES

Attention ! All safety devices for temperature, vibration, leakage etc, mentioned in the cover sheet (page 1) must be properly connected to the motor circuit respectively the control panel before start-up. Consider special descriptions and wiring diagrams.

4.9 EARTHING CONNECTION

An earthing connection on the baseplate or frame is provided as standard. These earthing connections must be plugged in any case.

4.10 DRIVE MOTOR

The drive motor is an electric device and must be connected by skilled and trained personnel only. All applicable state and local laws and safety regulations must be observed.

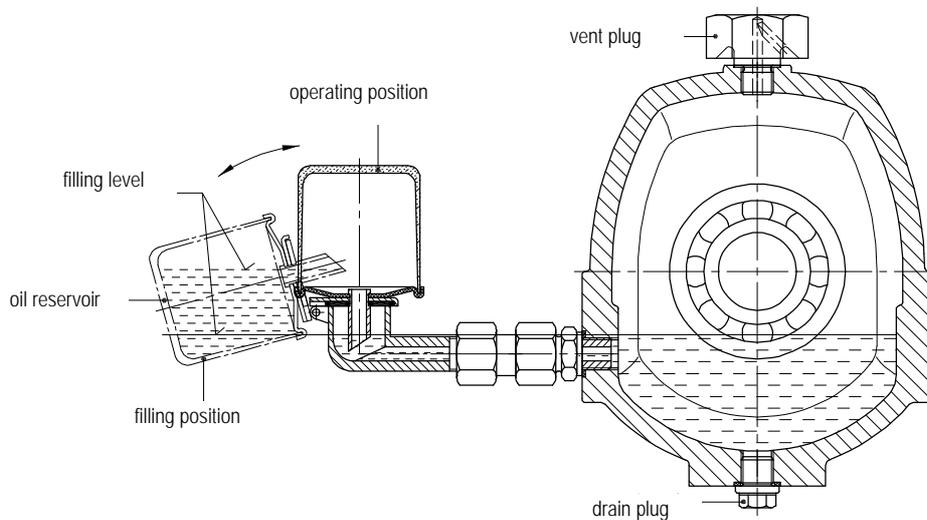
Attention ! The proper connection of the electric motor including the provided pump protection devices is the responsibility of the owner only.

5. OPERATION OF THE PUMP

5.1 START-UP PROCEDURE / LUBRICATION

When the before mentioned instructions have been performed, the protection strainer on suction side must be checked and possible blanks removed. The pump can then be put in operation as follows:

1. Before start-up, the bearing bracket must be filled with oil.
If start-up follows a longer storage period of the pump, it is recommended to fill the bearing bracket first with petrol and rotate the pump shaft several times by hand to clean the bearings from possible impurities.



For filling up, remove the vent plug 913 from the top of the bearing bracket. The oil is to be filled in - at back-folded constant level oiler - through the vent plug connection until the filling level reaches the connection elbow of the oiler. Then, fill the oil reservoir in accordance with above figure and put it back to upright position. The oil will now run from the oil reservoir into the bearing bracket until the required level is reached.

As long as the oil reservoir is filled with oil during operation, a sufficient oil filling in the bearing bracket is ensured. If the oil level in the reservoir drops down to about 1/3 of the total height, refilling is recommended.

After the first start-up of new pumps, the oil filling should be renewed after 200 operating hours, then once a year.

Filling volume:	Frame 0	0,5 litre
	Frame I	0,7 litre
	Frame II	0,8 litre

Symbols acc. to DIN 51502				
<div style="border: 1px solid black; width: 40px; height: 40px; display: flex; align-items: center; justify-content: center; margin: 0 auto;">C 36</div> <p>respect. HD 20W-20</p>	<p>Aral Vitam GF 46 (GF 36) *</p> <p>(up to now:) *</p>	<p>SHELL Rimula X X 20W-20</p>	<p>BP Energol VS 68 (ISO),</p> <p>BP Energol HLP 68 (ISO),</p> <p>BP Energol HD SAE 20W-20</p>	<p>ESSTIC 68 (50) *,</p> <p>ESSOLUBE HDX 20W/20</p> <p>(up to now) *</p>
Symbols acc. to DIN 51502				
<div style="border: 1px solid black; width: 40px; height: 40px; display: flex; align-items: center; justify-content: center; margin: 0 auto;">C 36</div> <p>respect. HD 20W-20</p>	<p>FINA CIRKAN 68 ISO,</p> <p>FINA SOLNA 68 ISO,</p> <p>PURFINA MOTOR OIL SAE 20W-20 **</p>	<p>RENOLIN 206,</p> <p>RENOLIN B 15,</p> <p>RENOLIN HD 20W-20</p>	<p>Mobil Vactra Oil Heavy Medium, Mobil HD 20W-20</p>	<p>Rando Oil 68,</p> <p>Ursa Oil P 68,</p> <p>Ursa Oil Extra Duty SAE 20W/20</p>

If above mentioned types are not available and no others are specified by the factory, any motor oil of a viscosity of 68 mm²/sec at 40°C (available at petrol stations) can be used.

2. Fill suction pipe and pump completely with liquid. Open suction valve. Open discharge valve partially or completely.
3. **Attention !** Pumps with heating jacket, type NMRb, need pre-heating prior to start-up. Remove coupling guard and turn the pump shaft by hand. Driver must be locked and secured against unauthorized re-start. If the coupling is blocked, the product inside the pump is not completely liquefied. A start-up at these conditions is not possible. Continue pre-heating until an easy shaft rotation is possible.
4. **Attention !** The magnet coupling is normally designed for direct-on-line starting. If star-delta starting is foreseen, contact our application engineers for checking start-up conditions. Star-delta-starting is normally only possible against closed discharge valve. Immediately after start-up, open discharge valve again.

5. **Attention !** A start-up against closed discharge valve must be avoided if ever possible, because in this case, the absorption of the magnet losses through the internal circulation in the containment shell area is not granted any more. If a start-up at closed discharge valve is required by technical reasons (i.e. at operational troubles), a bypass or a containment shell temperature monitor for automatic motor shut down must be installed. Non-observance of this instruction may cause dry running in the containment shell area (sleeve bearing failure), respectively demagnetization through inadmissible containment shell surface temperature.

Lead bypass lines back to the suction source only. Do not return it to the suction pipe, right in front of the suction flange.

6. If the above mentioned items have been checked, start the driver briefly to determine direction of driver rotation which must be clockwise when viewing the shaft end. Shut off and check for a smooth run down. The pump may not come to a jerky stop after shut off.
7. If the pump has come to a complete standstill and no problems have occurred, restart the pump.

Attention ! Immediately observe the pressure gauges. If discharge pressure is not quickly attained, stop driver, reprime and attempt to restart. Adjust discharge valve until rated flow is obtained.

8. **Attention !** Continued operation against closed discharge valve without an additional bypass will cause inadmissible temperatures within the pump. Damage of the sleeve bearing or overheating of the magnets through excessive containment shell surface temperature is possible.

5.2 OPERATION

1. **Attention !** Always adjust capacity with the valve in discharge line. Never throttle flow by suction valve.
2. Pump and motor should always operate steadily and free of vibrations (see 5.4.1, item 2)

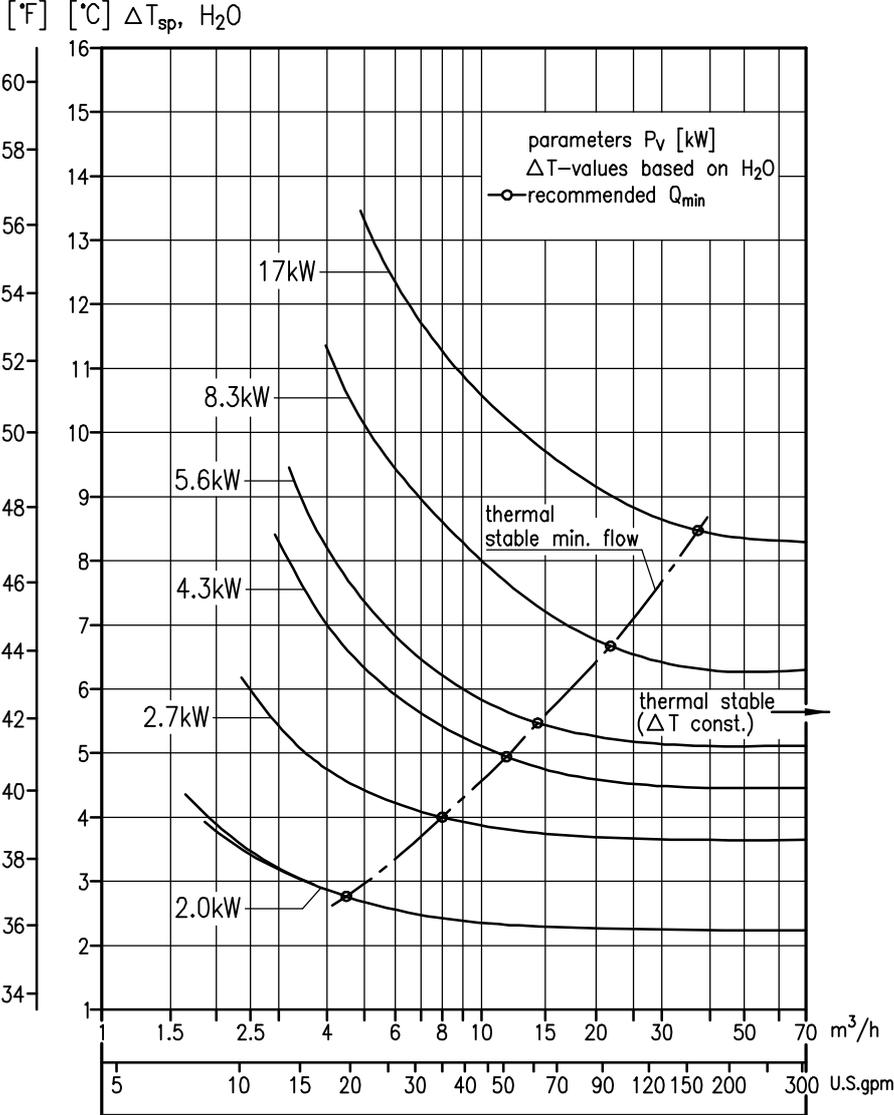
Attention ! A sudden increase of running noise is always a sign of possible trouble

3. The ampere load specified on the name tag of the drive motor must not be exceeded.
4. When operating with a capacity higher than rated and stamped on the pump name tag, make sure that NPSH-available > NPSH-required.
5. **Attention !** Never operate pump below the required minimum flow. The thermal stable minimum flow depends on the magnet losses (refer to pump data sheet respectively cover sheet, page 1) and on the physical properties of the pumped liquid (density, specific heat). When the pump is running in the range right of the minimum flow, a constant temperature in the containment shell area will be reached.

The following facts are relevant:

Minimum flow and temperature rise (depending on the magnet losses - refer to cover sheet, page 1) when handling water at 20°C (68°F) are displayed on the following drawing.

The containment shell surface temperatures resulting from the eddy currents can also be determined from this drawing.



Attention !

Independent from the determined minimum flow for a stable temperature curve, pumps may not be operated at capacities below 15% of BEP for the rated impeller.

Example

for calculating the allowable operating temperature within the limits of the Explosion Proof Directive 94/9/EG:

Given: Pumped liquid: Acetone, density $\delta = 790 \text{ kg/m}^3$, specific heat $C = 0,51 \text{ cal/g/}^\circ\text{C}$
 Magnet coupling: Magnetic losses $P_v = 2,8 \text{ kW}$
 Temperature class: T4

temperature class	max. allowable surface temperature	
T1	450°C	842°F
T2	300°C	572°F
T3	200°C	392°F
T4	135°C	275°F
T5	100°C	212°F
T6	85°C	185°F

Calculation of the allowable operating temperature is done step by step as follows:

- Determination of temperature increase $\Delta T_{Sp} \approx 4^\circ\text{C}$ at H_2O from the drawing on page 23 and conversion to the physical characteristics.

$$\begin{aligned} \Delta T_{Sp, Aceton} &= \Delta T_{Sp, H_2O} \times \frac{C_{H_2O}}{C_{Aceton}} \times \frac{\text{density}_{H_2O}}{\text{density}_{Aceton}} \\ &= 4 \times \frac{1}{0,51} \times \frac{1000}{790} = 9,9^\circ\text{C} \end{aligned}$$

- When determining the allowable operating temperature at pump application for a certain temperature class T, the standard EN 13436-1, 13.3.3 requires to consider a safety reduction of $\Delta T_S = -5^\circ\text{C}$ for the T-classes T6-T3 and $\Delta T_S = -10^\circ\text{C}$ for the T-classes T2/T1.

- From the known sizes it follows:

$$\begin{aligned} T_{zul} &= T_{T-KL} - ?T_{Sp,Produkt} - ?T_S = 135 - 9,9 - 5 \\ \underline{\underline{T_{zul} &= 120^\circ\text{C}}} \end{aligned}$$

Achtung !

In principle, the user of the pump must guarantee to maintain the liquid temperature. If the user is unable to do so, reliable measurements must be taken (e.g. temperature monitoring) to avoid excessive temperature rise in any case.

5.3 SHUT DOWN

1. Close valve on discharge side slowly.
2. **Attention !** Immediately after closing the valve, the driver must be turned off and checked for steady run-down.
3. Close valve on suction side.
4. Close heating pipes for jacketed pumps.
5. Empty the pump during shut-down in winter and protect it against frost.

5.4 PREVENTIVE MAINTENANCE

DICKOW-PRM-Pumps with magnet drive and oil lubricated antifriction bearings are designed to be maintenance-free and do not require any adjustments. But without doubt, a routine maintenance program can extend the lifetime of your pump and can prevent serious damage. Well maintained equipment will last longer and requires less repair. You should keep maintenance records to help pinpoint potential causes of problems.

5.4.1 Routine Maintenance

1. Temperature Monitoring

SiC-bearings with diamond like carbon layer have in principle an unlimited service life wear-resistant, corrosion-resistant) as long as boiling point is not exceeded which would cause flashing of the liquid between the sliding faces respectively dry run. The permanent magnets keep their magnetic forces for life unless inadmissible temperatures cause demagnetization. Inadmissible temperature increase can be caused by the following operating conditions:

- a) operation against closed discharge valve or below minimum flow,

Attention ! Operation against closed discharge valve can also happen if isolation valves in the downstream piping system close automatically at operational troubles.

- b) clogged circulation holes through solid particles,
- c) driver slips, respectively the magnetic coupling broke at start-up or decoupled through blocking of the driven rotor (breakdown of internal circulation).
- d) solid particles between rotor and stationary containment shell cause additional friction,
- e) dry running

All above mentioned possibilities cause a rapid rise of containment shell surface temperature. Therefore, it is recommended to monitor the temperature of containment shell surface in order to ensure an automatic switch off of the pump before serious damage occurs.

The DICKOW MAG-SAFE temperature monitoring system - reading the temperature direct on the heat source - provides a reliable protection against the above mentioned troubles. Common temperature probes PT100 work sufficiently only at properly filled pump and rotating inner magnet. A protection against item c) and e) is not provided.

2. Motor load control

In case of dry running or blocked impeller, the pump shaft only transmits the magnetic losses, the motor load drops nearly to zero. A power monitor can switch off the pump before magnet overheating or wrecked bearings will occur. These devices require no additional sensors or auxiliary pipes on the pump and can be installed in the motor circuit also subsequently. They can be considered as the most economic monitoring systems for magnetic coupled pumps.

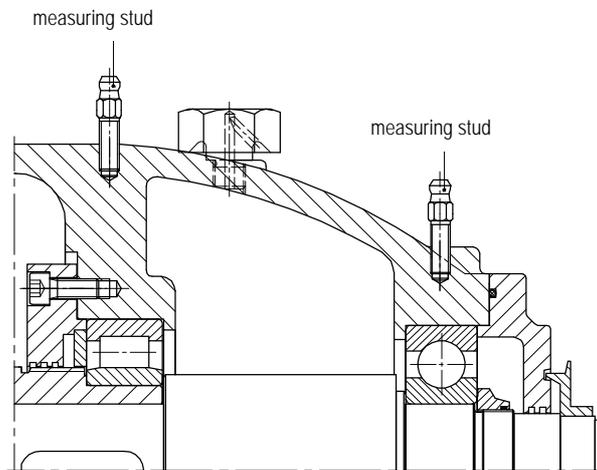
3. Vibration monitoring

All rotating pump parts are properly dynamically balanced, according to DIN ISO 1940/part1, grade G 2.5. During performance tests, we check pump vibration and ensure that a rate of velocity = 2,8 mm/s (0.11"/s) will not be exceeded. During operation a vibration rate of 4,5 mm/s (0.18"/s) is allowable. If this rate is exceeded, change ball bearings immediately.

If a vibration rate of more than 4,5 mm/s (0.18"/s) is noted at start-up of a new pump, the reason may be excessive stress from the piping connections or unstable foundation. Please improve before continuing operation.

The bearing brackets are supplied with four location holes M8 staggered by 90° for adapting measuring studs for vibration monitoring in accordance with the SMP-method (shock-pulse-method). It is recommended to perform vibration measurements in regular intervals and to keep records of the measured values.

Possible appearing damages to antifriction bearings can be recognized in time and serious failures of the containment shell can be avoided by a preventive replacement of the ball bearings.



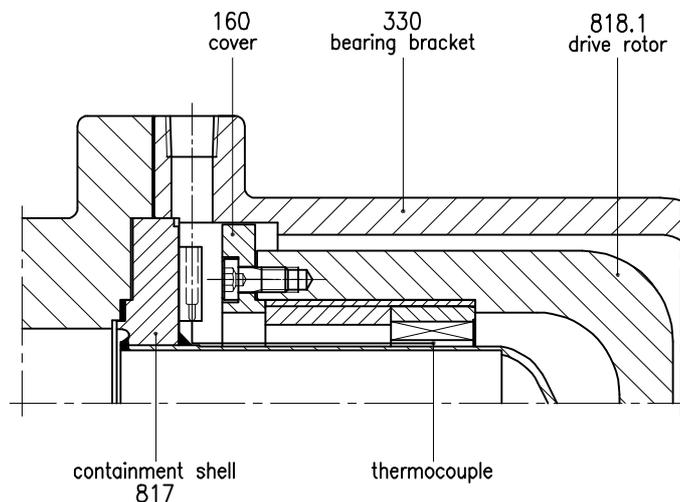
5.5 BEARING MAINTENANCE

Obtainment of a long service life requires careful monitoring and maintenance of the pump bearings. This includes for instance a constant check of the oil level in the bearing bracket and of the bearing temperature. The bearing temperature should not be more than 50°C (122°F) above the ambient temperature and not exceed 80°C (176°F).

The oil filling must be changed yearly. The vent holes in the vent screw must not get clogged.

To avoid damage of the containment shell by worn out ball bearings and eccentric rotation of the outer magnets, the PRM-pumps are fitted with a containment shell protection device. In case of eccentric running, the outer magnet coupling will first touch the bearing bracket and not get in contact with the containment shell due to the different clearances. Operators can recognize such upset conditions by increasing noise, vibration and/or power consumption, and switch off the driver before serious trouble occurs.

Containment Shell Protection Device



Continuous operation with worn out antifriction bearing causes wear of the cover 160 and increasing surface temperature at the bearing bracket 330 and consequently, reduces the clearance between outer magnet and containment shell. Using the MAG-SAFE pump protection, the outer magnets will cut the connection wire and switch off the pump. If no monitoring is provided, damage of the containment shell and penetration of the pumped liquid to the atmosphere will be the result. When handling dangerous liquids, appropriate safety devices must be foreseen

5.6 TROUBLE SHOOTING

Attention ! If the pump does not develop the required performance or if other unexpected things happen during start-up, please consider, that you bought a quality product carefully tested prior to delivery. Before calling DICKOW service personnel or disassembling the unit, please check carefully the pump's environment. Check simple things, such as forgotten blanks in the piping, motor and pump speed in accordance with the labels, wire connections in the terminal box. Make sure that control devices are properly connected and measuring instruments are calibrated.

5.6.1 No liquid delivered at start-up

Problem: Feed- or suction line is not completely vented or insufficiently filled.
Remedy: Fill again pump and suction line. Check foot valve in suction line.

Problem: Block valve in suction line is closed, blanks have not been removed.
Remedy: Open valve, remove blanks.

Problem: Feed- or suction line contain air pockets which cannot be eliminated by filling up because piping is incorrectly laid out.
Remedy: Check layout of the pipes. Suction line at suction lift conditions must continually slope upwards, at flooded suction conditions gradually slope downwards to the pump.

Problem: Pump does not come up to speed, magnet decouples. Motor is bigger than the rated coupling power according to the name tag.
Remedy: Use smaller motor or install stronger magnets. Check with application engineer.

Problem: Pump does not come up to speed, motor is smaller than rated coupling power.
Remedy: Check start-up conditions, ask DICKOW application engineer for improving start-up conditions.

Attention ! Switch off motor immediately when magnet coupling slips in order to prevent overheating of magnets.

Problem: Star-delta starting is foreseen, magnets decouple.
Remedy: Start the pump against closed discharge valve. Open valve again immediately after start-up. Check the suitability of star-delta-starting with our application engineer.

5.6.2 Pump does not obtain rated flow or head after start-up

Problem: Block valve in suction line is not opened completely.
Remedy: Open valve.

Problem: Motor speed is not identical with the pump speed according to the name tag.
Remedy: Change motor, check up with application engineer.

Problem: Strainer basket filter on suction side is clogged
Remedy: Clean the filter.

Problem: Suction pipe is leaking.
Remedy: Retighten flange connection on suction side.

Problem: Pump rotates in wrong direction.
Remedy: Change motor wiring.

Problem: Differential head of the system is higher than specified in the order and stamped on the name tag.

Remedy: Check with the application engineer whether the pump can at this stage be equipped with a larger impeller (check power rating of the motor).

Problem: Viscosity of pumping liquid is higher than stated in the order.

Remedy: Check with application engineer.

Problem: Capacity reduces at increasing operating temperature. NPSH-available < NPSH-required.

Remedy: Increase feed head by rising the liquid level on suction side, improve NPSH-available. Installation of inducer improves NPSH-required. Check with application engineer.

Problem: Pump cavitates.

Remedy: As described before.

Attention !

Cavitation creates slide bearing failure. Never operate pump under such upset conditions.

5.6.3 Motor requires excessive power

Problem: Differential head lower than rated.

Remedy: Throttle discharge valve to obtain the capacity according to the name tag. Correct impeller diameter (item 5.7)

Problem: Density or viscosity is higher than specified in the order.

Remedy: Check with the application engineer.

Problem: Motor speed is not identical with the pump speed according to the name tag.

Remedy: Change motor.

Attention !

If a motor with enlarged drive power is installed, the transmissible power of the magnet coupling as well as the start-up conditions with the new motor data must be checked. Contact application engineer.

5.6.4 Magnet slips during operation

Problem: Short time interruption of motor power. If power comes back before the pump has come to standstill, the high starting torque decouples the magnets.

Remedy: If power cut is conditioned by frequent thunder storms with lightening, relays must be installed such that a restart of the motor is possible only when the pump has come to a complete stop. At automatic controlled plants, power cut can be caused by overloaded relay. Analyse power consumption records for sudden peak currents.

5.6.5 Pump does not restart after a longer operating time

Problem: Magnets decouple.

Remedy: Check magnets with breakaway torque test acc. to section 7.1, item 3. Replace rotor if necessary.

Attention !

Permanent magnets keep their designed torque for life. Reduced torque capability is caused by overheating or by corroded protection cover. If overheating has occurred, install additional protection device or change operating conditions.

5.6.6 Pump is noisy and vibrates after start-up

Problem: Coupling between motor and pump is incorrectly mounted or aligned.

Remedy: Check and correct according to section 4.4/4.5.



Before removing the coupling guard and before starting any alignment procedure, make sure that driver is shut off and secured against unauthorized restart.

Problem: Base not rigid enough.

Remedy: Stabilize and support the area of pump- and motor feet.

Problem: Foundation bolts are loose.

Remedy: Tighten foundation bolts.

Problem: Pump cavitates.

Remedy: Refer to section 5.6.2 - NPSH-improvement.

5.6.7 Pump gets noisy and vibrates after a longer operating time

Problem: Outer antifriction bearings are worn out

Remedy: Replace antifriction bearings. Use brand new originally packed bearings only. Consider sizes, clearances and grease filling as specified in item 6.2.

5.6.8 Pump failure through damaged sleeve bearings

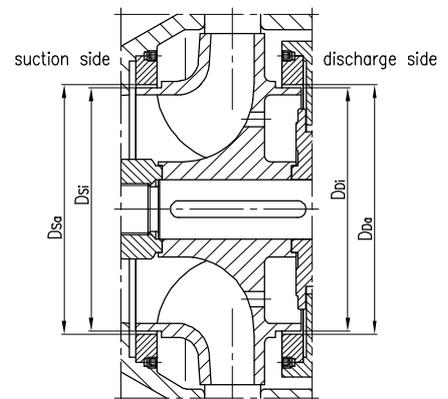
Attention !

Damage on the sleeve bearings is not caused through corrosion or wear. Reasons therefore are usually operating upsets. Careful analysis and elimination of possible causes are required. Consider the following notices for analysing the damage.

1. Start-up ring 500.1 on containment shell destroyed

Possible cause: After disassembling, abrasive solids such as welding residues, scales and sediments from the pipes were found inside the pump. These abrasives caused excessive wear and increase of the clearance on suction side and disturbed the balancing system within the pump. This kind of damage can also occur after a short operating time.

Remedy: Check clearance on impeller suction- and discharge side. If the diametrical clearance on suction side ($D_{sa} - D_{si}$) exceeds 0,2 mm (0.032"), replace wear ring and if required the impeller. Prior to re-installation of pump, the system must be flushed respectively cleaned.



Installation of protective filters is recommended.

2. Sleeve bearing 310.1 and shaft sleeve 524 destroyed

Possible cause: If no solids exist, damage of this kind can only be effected through exceeding boiling temperature in the containment shell area. Reasons therefore can be operation against closed valve, below minimum flow, clogged circulation holes, or insufficient pressurization when handling volatile liquids.

Remedy:

- Clean the circulation holes, check for possible modification to external circulation from discharge flange via cyclone separator or filter.
- Recalculate the safety against exceeding boiling point (contact application engineer).
- If possible, increase the pressurization by installing a larger impeller and orifice.
- Recalculate the minimum flow or install an additional bypass.
- Installation of the MAG-SAFE temperature monitoring device.

3. Start-up ring 500.5 or sleeve bearing destroyed

Possible cause: Damage of the start-up ring is a result of cavitation. If the NPSH-available drops below NPSH-required, uncontrolled additional thrust loads occur which cannot be absorbed by the balancing system in the pump. These forces effect vaporization of the liquid respectively dry run.

Remedy: Increase liquid level on suction side to improve NPSH-available. Improve NPSH-required by installation of an inducer (contact application engineer). Dropping below NPSH-value can also be caused through partly clogged filter on suction side. Clean the filter and protect the pump by monitoring the pressure loss in the filter. Cavitation can also appear if the pump operates – conditioned on insufficient pressure resistance in the discharge line - with a capacity higher than the rated capacity as per name tag or data sheet. Throttle discharge valve, respectively correct impeller diameter (refer to section 5.7).

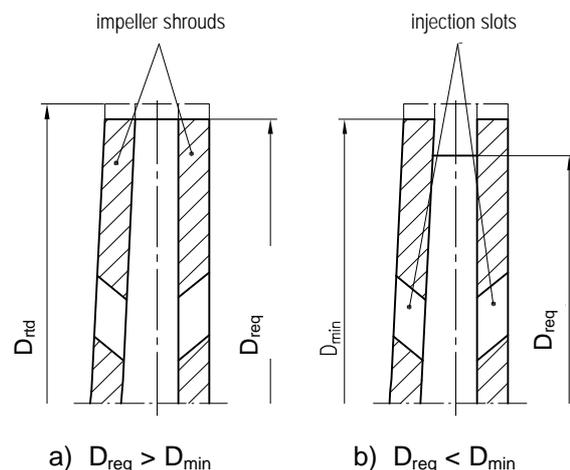
5.7 IMPELLER TRIMMING

5.7.1 Reduced impeller diameter required

Impellers of PRM-pumps are hydraulically balanced for reducing the thrust load. Additional to the wear rings, back vanes or injection slots on both impeller shrouds are provided. Depending on the available balancing devices, the impellers can be trimmed as follows:

1. Impeller with injection slots

D_{rtd} = Rated impeller dia
 D_{req} = Required impeller dia
 D_{min} = Minimum allowable shroud diameter



To avoid break down of the balancing system, the impeller diameter of the following pump sizes cannot be trimmed down.

Select required impeller diameter in accordance with the pump performance curve and the available process data. If required diameter > than minimum allowable shroud diameter, trim shrouds and impeller vanes in accordance with figure a). If required diameter < than minimum allowable diameter, trim shroud and blades to different diameters according to figure b).

Pump size	D _{min} (mm)	Pump size	D _{min} (mm)
26/125	130	40/210	150
26/170	130	40/250	210
26/210	160	40/320	260
32/165	135	50/210	170
32/210	170	50/250	210
32/250	190	50/330	260
40/165	130		

2. Impellers with back vanes

The following pump sizes are provided with back vanes:
50/165, 65/200, 65/250, 80/165, 80/200, 80/250, 100/200.

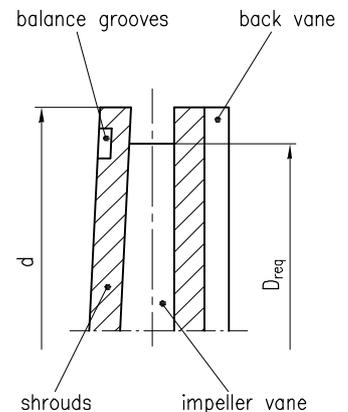
When trimming down impellers at these pump sizes, a certain relation between the diameters of impeller and back vane must always be maintained. Check with application engineer.

3. Impellers without additional balancing devices

Balancing at pump size 65/165 is done through the balancing holes only. In this case the impeller diameter can be corrected without limitation.

Attention !

Any existing unbalance is eliminated by sinks into the impeller shroud (balance grooves). It is recommended to trim the impeller shrouds only so far that the balance is maintained. Otherwise, the shroud must be rebalanced after correction. Non-observance may cause increased vibrations and damage to the slide bearings.



5.7.2 Increased impeller diameter required

When increasing the impeller diameter by more than 5%, suitability of the magnet coupling and motor power must be checked. If increase of motor power is also required, the start-up safety must be checked in accordance with the new motor data.

6. DISASSEMBLY / REASSEMBLY

6.1 REQUIRED TOOLS AND ACCESSORIES

TOOLS	Drawing No.		
	frame 0 *	frame I *	frame II *
Ring screw	M12		
Wrench adapter unit	03.60.807		03.60.808
Adapter	04.60.863	04.60.670	
Assembl.sleeve – bearing 321.1	04.60.724		04.60.725
Sleeve disassembling unit	04.60.721	04.60.804	
Key assembling unit	03.60.754	---	03.60.672
Assembl.sleeve – shaft sleeve 524	04.60.723	04.60.668	

*) Relation of pump and frame size, see section 9.

6.2 REPLACEMENT OF ANTIFRICTION BEARINGS

6.2.1 Complete pump to be removed from the piping system

The following instructions concern the replacement of the antifriction bearings if the pump will be removed from the piping system. In case the pressurized, wetted parts remain in the piping (disassembly of the bearing bracket acc. to Figure G), performance starts with item 4 under consideration of item 1 "Safety instructions".

- 

When replacing the outer antifriction bearings, the coupling guard must be removed in any case. Prior to this, the power supply to the motor must be interrupted and secured against unauthorized restart. Cool down the pump unit, stress relief the system, empty suction and discharge pipe. If dangerous contaminated water is handled, the pump must be thoroughly flushed before starting any disassembling work. In this case and when opening the pump, wear protecting clothes, gloves and eye glasses.

Attention !

Before removing the pump from the piping system, respectively before dismantling the bearing bracket, the constant level oiler must be demounted. The oil filling in the bearing bracket is to be drained by removing the drain plug 903.8 to avoid contamination of the outer magnets.

- Place the pump in upright position on a clean working table acc. to Figure A. Avoid damage to the flange surfaces.

- 

Secure the pump against overturning - danger of injury !
It is recommended to fasten the ring screw on the crane hook. (Figure A).

10. It is highly recommended to use the socket wrench/adapter unit 03.60.807 for loosening the shaft nut 921.2 (see Figure B).

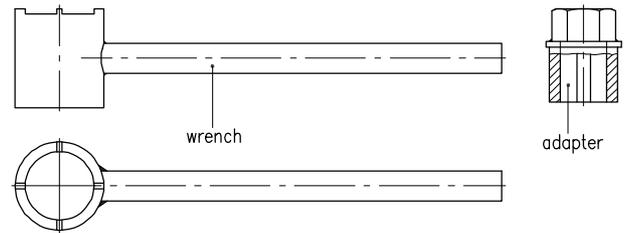


Figure B

Place the socket wrench such that the claws fit into the grooves of the shaft nut. Push the adapter onto the shaft end acc. to Figure C. Loosen and remove the shaft nut (left hand thread) by wrench.

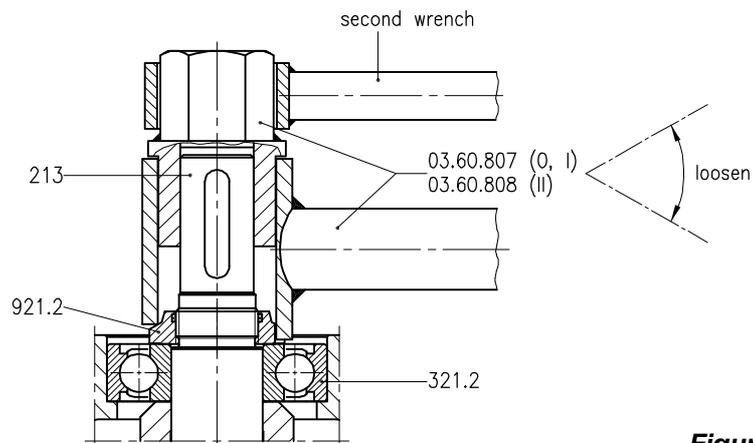


Figure C

11. Place the bearing bracket on the bench of a press or drilling machine, resting on non-magnetic blocks as shown in Figure D.

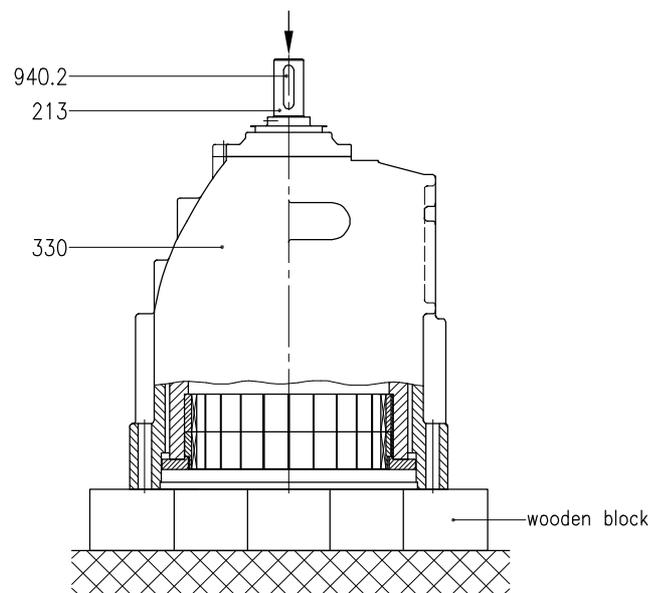


Figure D

12. Press the shaft with the drilling machine spindle down and out off the bearing seat 321.2. Remove the bearing bracket. 330.
13. Remove the bearing 321.2 remained in the bearing bracket by using a puller.

- 14. Remove the inner hexagon cap screw 914.6 and the bearing cover 360.2 on containment shell side. Press the outer ring of the roller bearing 322 out off its seat.
- 15. Clamp the drive shaft 213 with the drive rotor 818.1 in vertical position in a vice acc. to Fig. E.

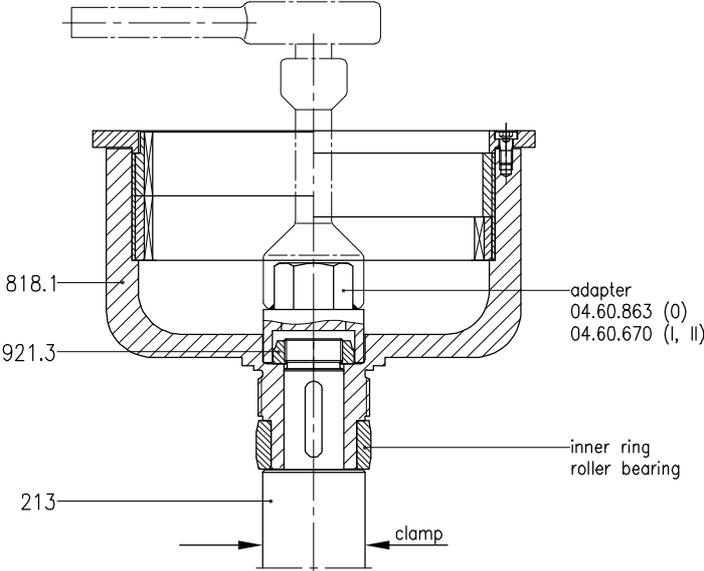


Figure E

- 16. Loosen and remove the shaft nut 921.3 using a socket wrench.
- 17. Pull off the drive rotor from the pump shaft.
- 18. Remove the inner ring of the roller bearing from the rotor hub using a puller.
- 19. When replacing the antifriction bearings, only brand new originally packed bearings must be used.

Frame size *	Antifriction Bearing	
	321.2	322
0	6306	NU 308 C3
I	6306	
II	6307	

* Coordination of pump size and bearing bracket acc. to "Interchangeability Chart", chapter 9.

20. For re-assembly, proceed according to Figure F as follows:

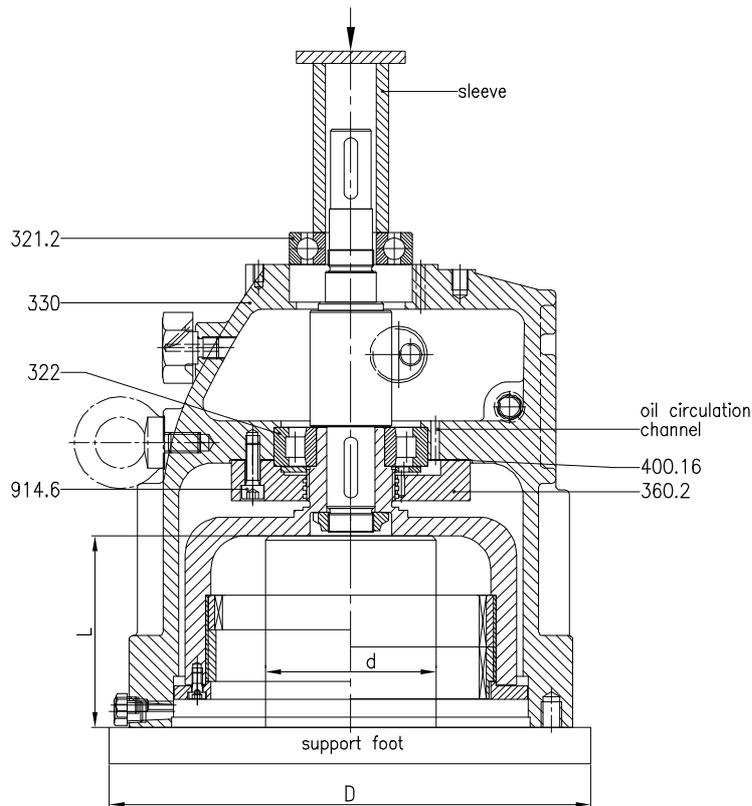


Figure F

21. Heat up the inner ring of the new roller bearing to 80-100°C (176-212°F). and push it onto the hub of the drive rotor 818.1 until limit
22. Press the outer ring of the new roller bearing into the location hole of the bearing bracket until limit. Fasten the bearing bracket 360.2 by the inner hexagon cap screws 914.6.

Attention !

Take care that the machined slot in the bearing cover and the gap in the gasket 400.16 is matching with the oil recirculation bore. Otherwise, the required oil circulation through the bearing is not granted anymore.

23. Push the drive rotor 818.1 onto the drive shaft 213 (see Figure E). Fasten the shaft nut 921.3 with a socket wrench.
24. Provide a non-magnetic support foot according to Figure F and place it on the bench of a press or drilling machine. Put the drive rotor with the pump shaft on the support foot.
25. Push on the bearing bracket 330 with the pre-mounted roller bearing 322 until limit.
26. Press the bearing 321.2 by using a sleeve into the bearing bracket 330 until it rests.
27. Reassemble the bearing bracket respectively the pump as explained before, reversing the disassembly process.
28. Never mount the complete bearing bracket to the pump without the guide rods.

6.2.2 Pressurized pump parts remain in the piping system

The separate bolting of the pressurized parts at PRM-pumps allows disassembly of the bearing bracket without draining the pump. After removing the hexagon nuts 920.7, the bearing bracket can be pulled off according to Figure G. The guide rods which come along with your pump protect containment shell and magnets from damage.

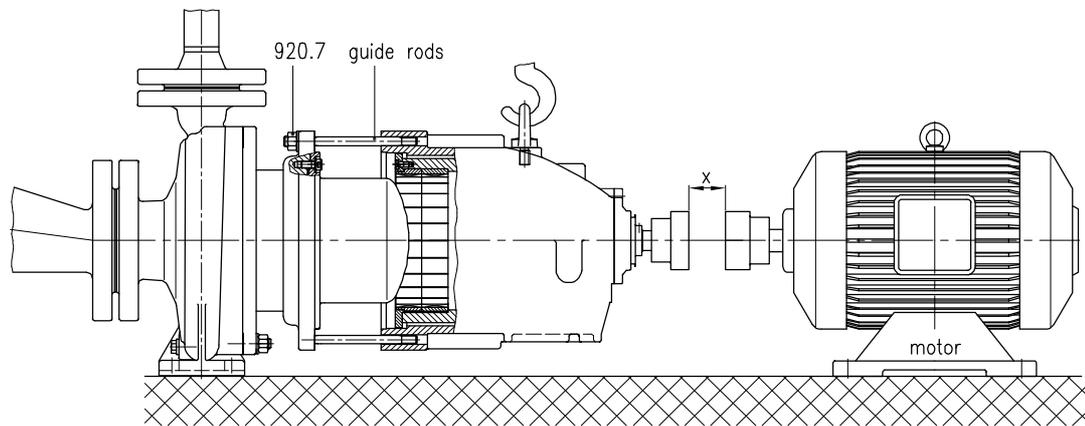


Figure G

If spacer-type couplings are used, the motor can also remain bolted on the baseplate. No electrical works required. For selecting spacer-type couplings, the extended spacer lengths "X" (different from DIN EN 22858) must be considered.

Frame size 0	X = 100 mm
I	X = 140 mm
Frame size II	X = 140 mm (up to 60 mm magnet length)
	X = 180 mm (from 70 to 120 mm magnet length)



Prior to removing the coupling guard, the power supply to the motor must be switched off and secured against unauthorized restart.

Attention !

Never remove the bearing bracket without the guide rods !

6.3 REPLACEMENT OF PUMP IMPELLER

Pump impeller can be replaced for trimming without disassembling the complete unit as follows:

1.



Replacing of the impeller requires removal of the coupling guard and disconnection of the pump from the piping system. It is important to consider the safety instructions according to section 6.2, item 1.

2. Place pump in vertical position as per Figure A. Consider safety instructions, section 6.2/item 3.

3. Remove hexagon nuts 920.2 between volute casing and bearing housing

4. Loosen the connection between bearing housing and volute casing by jack screws.
5. Remove complete rotating unit by crane and put it on a bench.
6. Clamp impeller, loosen and remove impeller nut 922 or inner hexagon cup screw 914.12 with a wrench (right hand thread). Don't use a hammer for loosening the impeller nut. This would destroy the sleeve bearing !
7. Remove impeller 233 by hand. It may be necessary to use a puller.
8. Trimming of the original impeller according to section 5.7 respectively installation of a new impeller.
9. Before reassembling the unit, the gasket 400.5 must be replaced and the sealing faces must be checked.

6.4 REPLACEMENT OF DRIVEN ROTOR AND SLEEVE BEARINGS

1.  Disassembly of driven rotor and sleeve bearings requires removal of the coupling guard and drainage of the pump. It is important to consider the safety instructions according to section 6.2, item 1. Before dismantling the pump, the work safety instructions according to 2.5.2.1, 2.5.2.2 and 2.5.2.3 must have been observed.
2. Remove the complete bearing bracket unit in accordance with item 6.2 (par. 2-6), protect outer magnets against damage.
3. Remove inner hexagon cup screw 914.7, loosen containment shell 817 by jack screws and remove it.
4. Loosen and remove hexagon nuts 920.2 between volute casing and bearing housing.
5. Loosen connection between bearing housing and volute casing by jack screws.
6. Remove bearing housing unit and clamp it in vertical position in a vice or a jaw chuck as per Figure H.

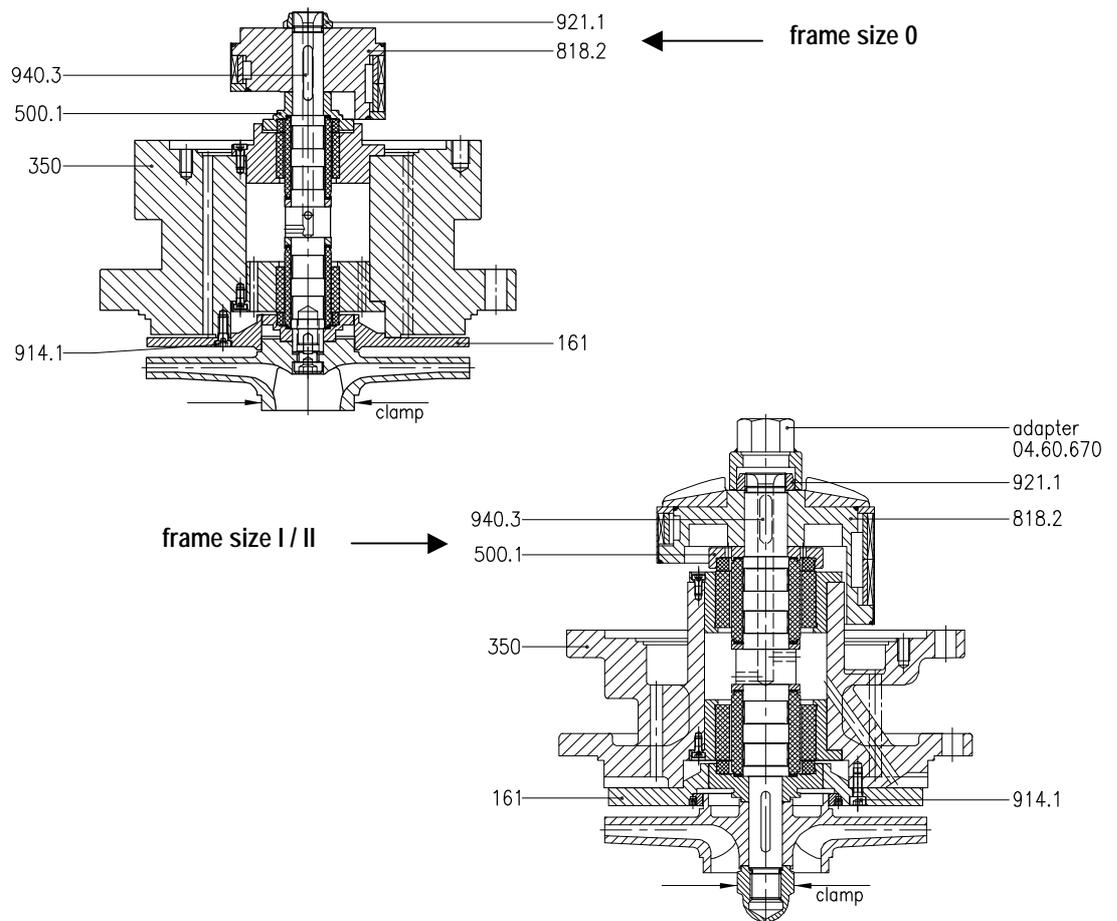


Figure H

When clamping the impeller, use protection cheeks to prevent damage to running surface.

7. Loosen and remove shaft nut 921.1 (left hand thread) with a pin spanner.
For rotors with rear impeller use adapter 04.60.724 and socket wrench.
8. Pull off the driven rotor 818.2, store it away from magnetic parts.
9. Remove key 940.3 carefully. Avoid damage to sleeve bearings. Pull off the start-up ring 500.1
10. Remove bearing housing 350, together with stationary sleeve bearings.
11. Loosen inner hexagon head bolts 914.1, remove casing cover 161 (see Fig. I).
At open impeller design, remove wear disk 556.2.

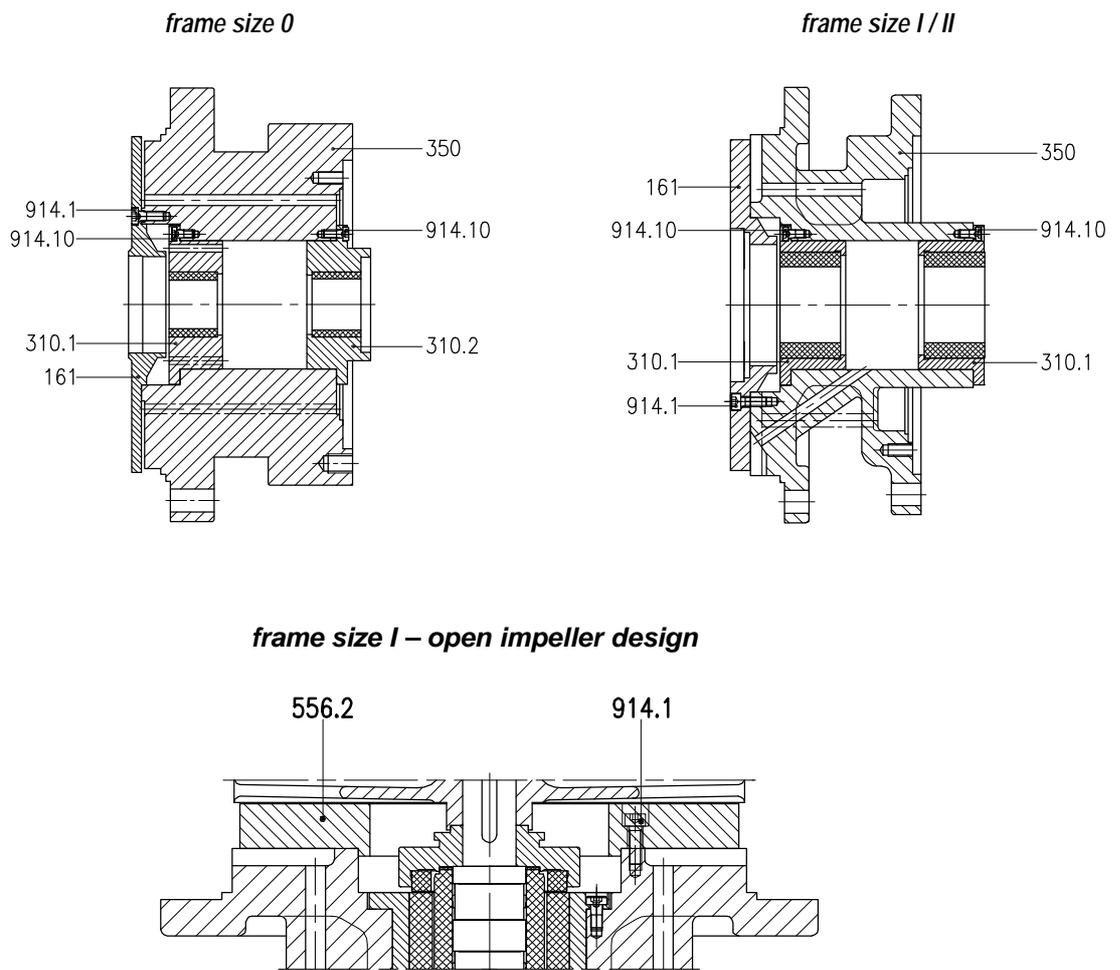


Figure I

12. Remove inner hexagon cap screws 914.10 and then the stationary sleeve bearing. Loosen connection between sleeve holder and bearing housing by using jack screws.
13. Clamp the pump shaft in vertical position in a vice or jaw chuck as per Figure J. Protect the impeller seat from damage.
14. Remove impeller nut 922 or inner hexagon cap screw 914.12 (right hand thread)
15. Remove impeller from pump shaft. If puller is required, it must be placed under the vanes to avoid damage to the impeller.
16. Remove key 940.1 and start-up ring 500.5

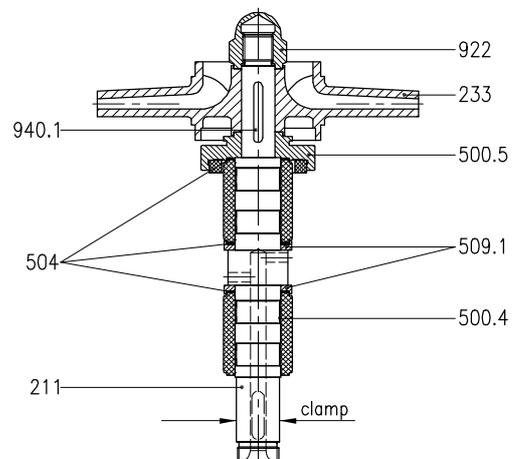


Figure J

6.5 DISASSEMBLY OF THE SiC-SHAFT SLEEVES

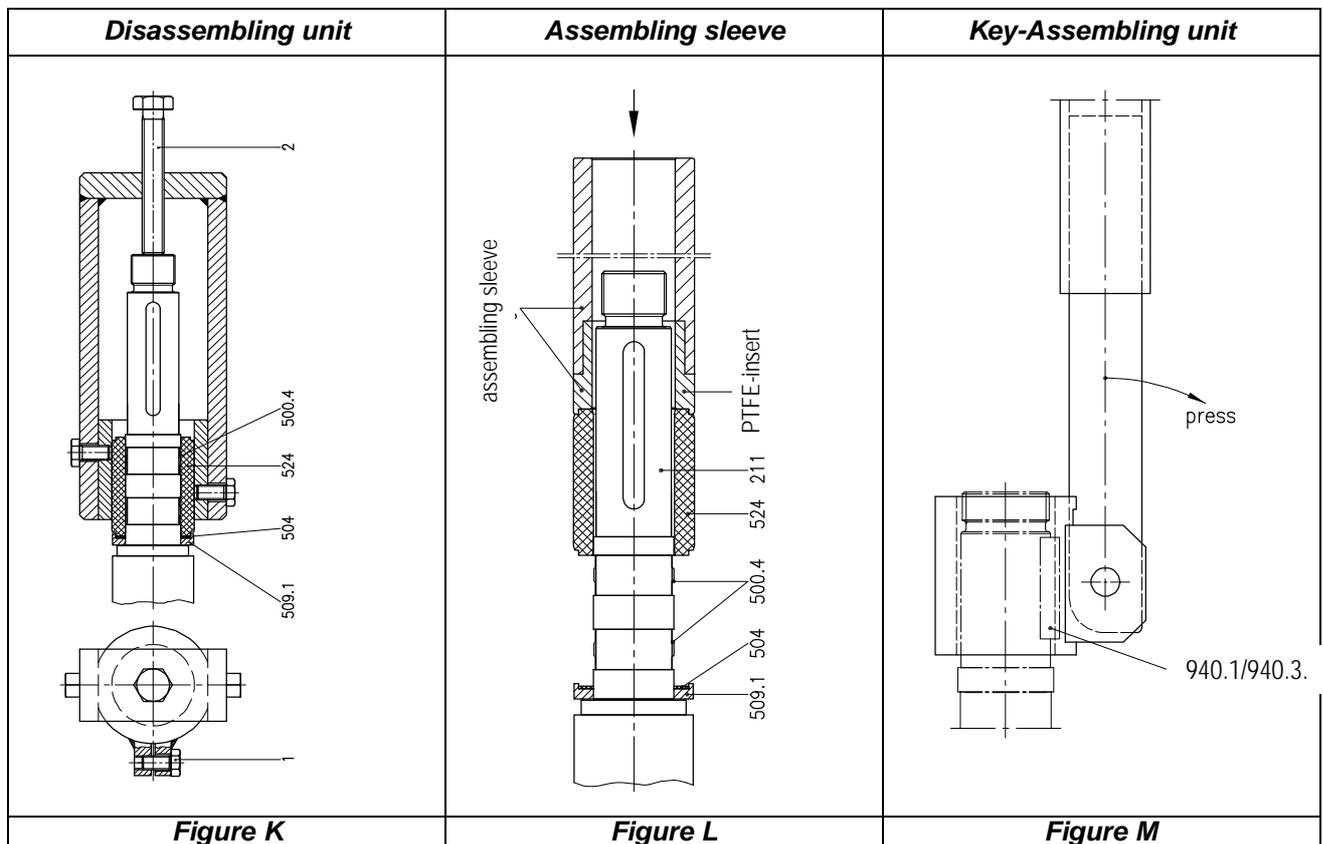
Check surfaces of the shaft sleeves. Surfaces must be free of cracks, pittings and mechanical damage. Also check the available clearances (see section 7 "Inspection") between shaft sleeves and stationary sleeve bearings.

If sleeves are worn out, remove them by using the sleeve disassembling unit according to Figure K as follows:

- Place the sleeve disassembling unit acc. to Fig. K.
- Clamp the unit by tightening bolt 1.
- Turn bolt 2 until the sleeve is completely removed from pump shaft.
- Remove the slotted tolerance rings 500.4 from pump shaft.



Regardless of careful draining and cleaning of the pump before disassembly, traces of pumped liquid will remain between shaft sleeve and pump shaft in the tolerance ring area. Protect skin and wear eye glasses when disassembling the shaft sleeve.



Frame size	Tool - Figure „K“	Tool - Figure „L“	Tool - Figure „M“
	Drawing No.		
0	04.60.721	04.60.723	03.60.754
I	04.60.804	04.60.668	---
II	04.60.804	04.60.668	03.60.672

6.6 REASSEMBLY OF HYDRAULIC PUMP PART

1. If the SiC-shaft sleeve has been replaced, the distance rings 504 and tolerance rings 500.4 must also be renewed. Before reassembling the renewed tolerance rings, the intermediate ring 509.1 and distance ring 504 must be positioned. Insert the new tolerance rings into the shaft grooves and then, push on the shaft sleeve until it rests on the upper tolerance ring. Slide on the assembling sleeve according to Figure L and press the sleeve down until it rests on the lower distance ring 504.

Only use PTFE-insert or similar quality in order to avoid damage of the SiC-sleeve. For easy handling, clamp the pump shaft in a jaw chuck placed on the work bench of a drilling machine and press the sleeve down by the spindle.

2. The impeller 233 and the start-up ring 500.5 are keyed to the pump shaft. The impeller nut 922 and the inner hexagon cap screw 914.12 is secured by a Heli-Coil-insert. The impeller nut 922 respectively the pump shaft 211 at frame size 0 are provided with screwed in Heli-Coil inserts. Before starting reassembling, check availability of the inserts (see Figure N).

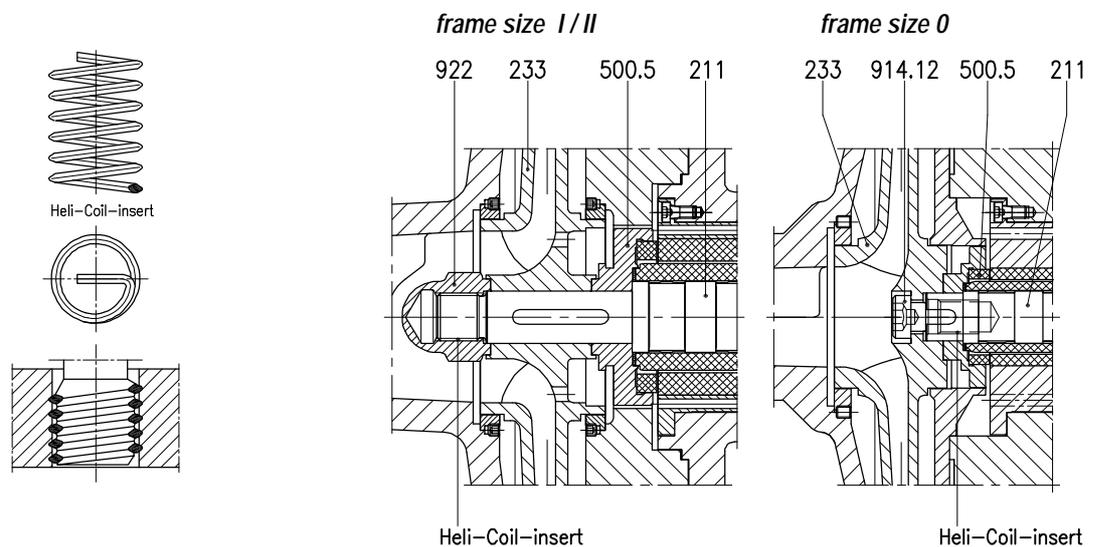


Figure N

3. For reassembling the unit, clamp the pump shaft with properly mounted sleeves in vertical position again according to Figure J. Push on the start-up ring 500.5, take care for the distance ring 504. Insert key 940.1 by using the key-assembling unit acc. to Figure M. Push on the impeller and secure it.
4. Clamp the assembled unit according to Figure H. Push on the bearing housing with the stationary sleeve bearings. Push on the start-up ring 500.1, take care for the distance ring 504.
5. Place the key 940.3 to the key way by hand. Use the key assembling unit to press the key to the bottom of the key way (see Figure M).
6. Continue further reassembly as previously described in reverse manner.

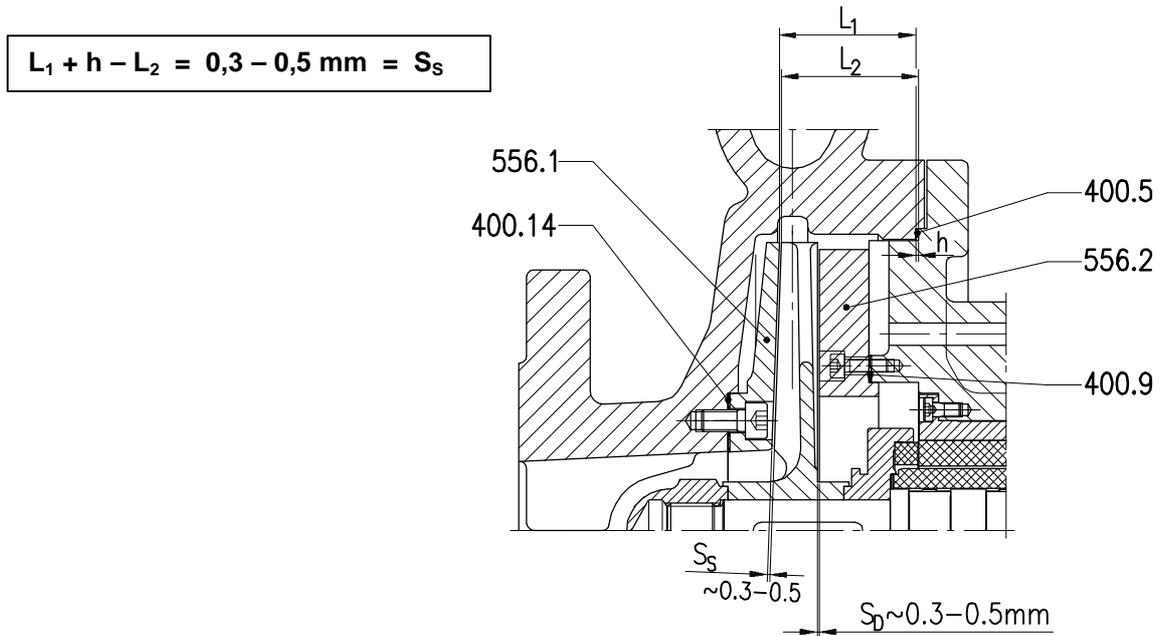
Attention !

Before starting reassembling, the used rotating parts must be inspected according to section 7 "Inspection" to insure proper running. Any parts that do not meet required criteria should be replaced.

6.7 OPEN IMPELLER DESIGN – NMRo

If the wear disk 556.2 on discharge side has been replaced or reworked and the open impeller has been reassembled, the gap S_D must be measured. The allowable value is 0,3 – 0,5 mm (0.0118 – 0.0197 inch). If this value is exceeded, an additional gasket is to be inserted according to the figure below.

After finally tightening the impeller nut and rechecking the gap S_D , measure the distance L_2 between impeller edge and gasket seat 400.5 in the intermediate casing. The distance between edge of wear disk 556.1 and gasket seat 400.5 in the volute casing must be adjusted by inserting gaskets 400.14 until the following is obtained:



6.8 TORQUE SETTINGS

Part No.	Designation	Nm	lbf ft
914.7	Inner hexagon cap screw – Containment shell	42	31
914.12	Inner hexagon cap screw – Impeller, frame 0	45	33
920.2	Hexagon nut - Casing Impeller Ø up to nominal 250 mm/10"	A4-70 = 40	A4-70 = 30
		8.8 = 80	8.8 = 59
	Impeller Ø up to nominal 320 mm/13"	A4-70 = 135	A4-70 = 100
		8.8 = 195	8.8 = 144
920.7	Hexagon nut - Bearing bracket	A4-70 = 40 8.8 = 80	A4-70 = 30 8.8 = 59
921.1	Shaft nut - frame 0 frame I / II	80	59
		90	67
921.2	Shaft nut - frame 0 / I frame II	120	89
		150	111
922	Impeller nut - frame I frame II	120	89
		136	100

7. INSPECTION

7.1 MAGNET ASSEMBLY

1. Driven rotor 818.2

Surface must be free of cracks and bulges. Check parallelism by a bevelled steel edge. Bulges are a sign of leaking rotor cover, pumped liquid causes corrosion on the inner magnets. Resistance of rotor cover must be checked.

If grooves or erosion on the rotor surface exceed a depth of 0,2 mm (0.0079 inch), the rotor must be replaced. In case of chemical attack or corrosion, the material resistance must be checked. Rear impellers must not have any signs of cracks or corrosion.

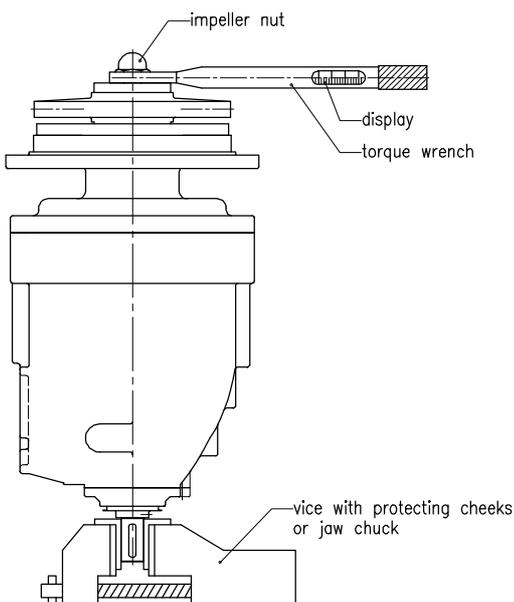
2. Drive rotor 818.1, outer magnets

Outer magnets must in general be replaced, if mechanical or chemical damage is visible (consequence of containment shell leakage). The ball bearing seats must be measured and the rotor must be replaced if the diameter is below 40,002 mm (1.5749 inch).

3. Torque Capacity

New magnets have the following torques, based on ambient temperature:

Place the complete rotating unit in vertical position according to the following drawing. Clamp the drive shaft in a jaw chuck. Measure the available torque by a suitable torque wrench.



Axial Magnet Length		Torque	
mm *	inch	Nm	ft lbf
18	0.71	19	14
36	1.42	38	28
20	0.79	41	30
30	1.18	63	47
40	1.58	90	67
50	1.97	115	85
60	2.36	138	102
70	2.76	165	122
80	3.15	190	141
90	3.40	210	155
100	3.94	235	174
110	4.33	260	192
120	4.73	280	207

* according to the name tag or the cover sheet, page 1

If the result is more than 10% below the nominal values (caused by overheating or corrosion), have the suitability checked by the factory or exchange the driven rotor.

7.2 IMPELLER / WEAR RINGS

The impeller must be free of corrosion and may not show any scouring or mechanical damage. The sliding surfaces in the wear ring area may not have any visible grooves. Impeller diameters have to be measured. The total clearance in new condition is 0,6 mm (0.0236 inch). If the clearance exceeds 0,8 mm (0.0315 inch), the wear ring must be replaced (section 5.6.8).

7.3 SILICON CARBIDE SLEEVE BEARINGS / SHAFT SLEEVES

The total clearance between shaft sleeve and the stationary sleeve bearing in new condition is:

max. 0,151 mm (0.0059 inch) at frame size 0

max. 0,194 mm (0.0076 inch) at frame size I/II.

If a clearance exceeds 0,215 mm (0.0085 inch), replacement is required.

Shaft sleeves, stationary sleeve bearings and start-up rings may not have any visible grooves, scales or other damages.

7.4 START-UP RINGS 500.1 / 500.5

The SiC-inserts of the start-up rings must be free of cracks, pittings, scales or other visual damages.

7.5 CONTAINMENT SHELL 817

Surface must be free of cracks. Replace if any groove or corrosion attack exceeds a depth of 0,2 mm (0.008 inch). In case of chemical attack, check material resistance. The seat for gasket 400.13 and the centring may not show any mechanical damage.

7.6 BEARING BRACKET 330 / BALL BEARING

Bearing bracket and support foot must not show any damages or cracks. If the bearing bracket got in contact with the pumped liquid check for corrosion. Ball bearing seats must be measured. The bearing bracket must be replaced if the following maximum bore diameters are exceeded:

Ball bearings must be in good condition. They must be replaced in general if the pump has been operating for a longer period. For replacing, only use new and originally packed bearings.

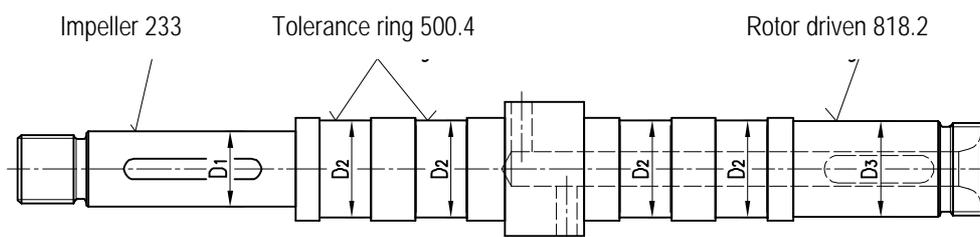
frame size	Location	Max. diameter		Location	Max. diameter	
		mm	inch		mm	inch
0	inboard	90,025	3.5443	outboard	72,021	2.8355
I		90,025	3.5443		72,021	2.8355
II		90,025	3.5443		80,021	3.1505

7.7 BEARING HOUSING 350

Check the internal circulation holes, check for corrosion. Seat for gasket 400.5 and 400.13 must not show any mechanical damage.

7.8 PUMP- DRIVE SHAFT 211 / 213

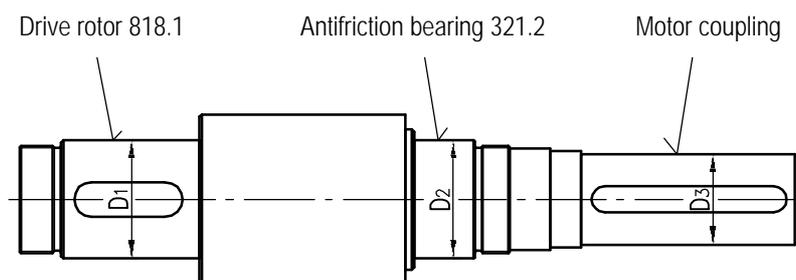
7.8.1 Pump shaft 211



Surfaces and threads must be free of cracks, pittings or any other visual damage. Check internal circulation holes, make sure they are open. Keyways should not show any deformations. Inspect the critical diameters as shown above. Replace if actual diameters are below the values indicated in the following table.

frame size	Minimum diameter D_1		Minimum diameter D_2		Minimum diameter D_3	
	mm	inch	mm	inch	mm	inch
0	19,98	0.7866	20,08	0.7906	19,98	0.7866
I	21,98	0.8654	28,08	1.1055	27,98	1.1016
II	27,98	1.1016	28,08	1.1055	27,98	1.1016

7.8.2 Drive shaft 213



Surfaces and threads must also be free of cracks, pittings or any other visual damages. Shaft nuts may not have any wear traces. Above mentioned dimensions must be measured. Keyways should not show any wear or deformations. The above mentioned diameters must be re-measured. Inspect above critical diameters, replace if anywhere below the stated dimensions.

frame size	Minimum diameter D_1		Minimum diameter D_2		Minimum diameter D_3	
	mm	inch	mm	inch	mm	inch
0	27,98	1.1016	30,00	1.1811	23,98	0.9441
I	27,98	1.1016	30,00	1.1811	23,98	0.9441
II	27,98	1.1016	35,00	1.3780	31,98	1.2591

8. RETURNING THE PUMP TO THE FACTORY



Pumps returned to the factory for overhauling or repair, may be disassembled or maintained by our service personnel only if the pumped liquid is clearly defined by the pump user. According to the „Decree for dangerous Goods“ a „Safety Data Sheet DIN 52900“ completely filled in must accompany the shipping documents.

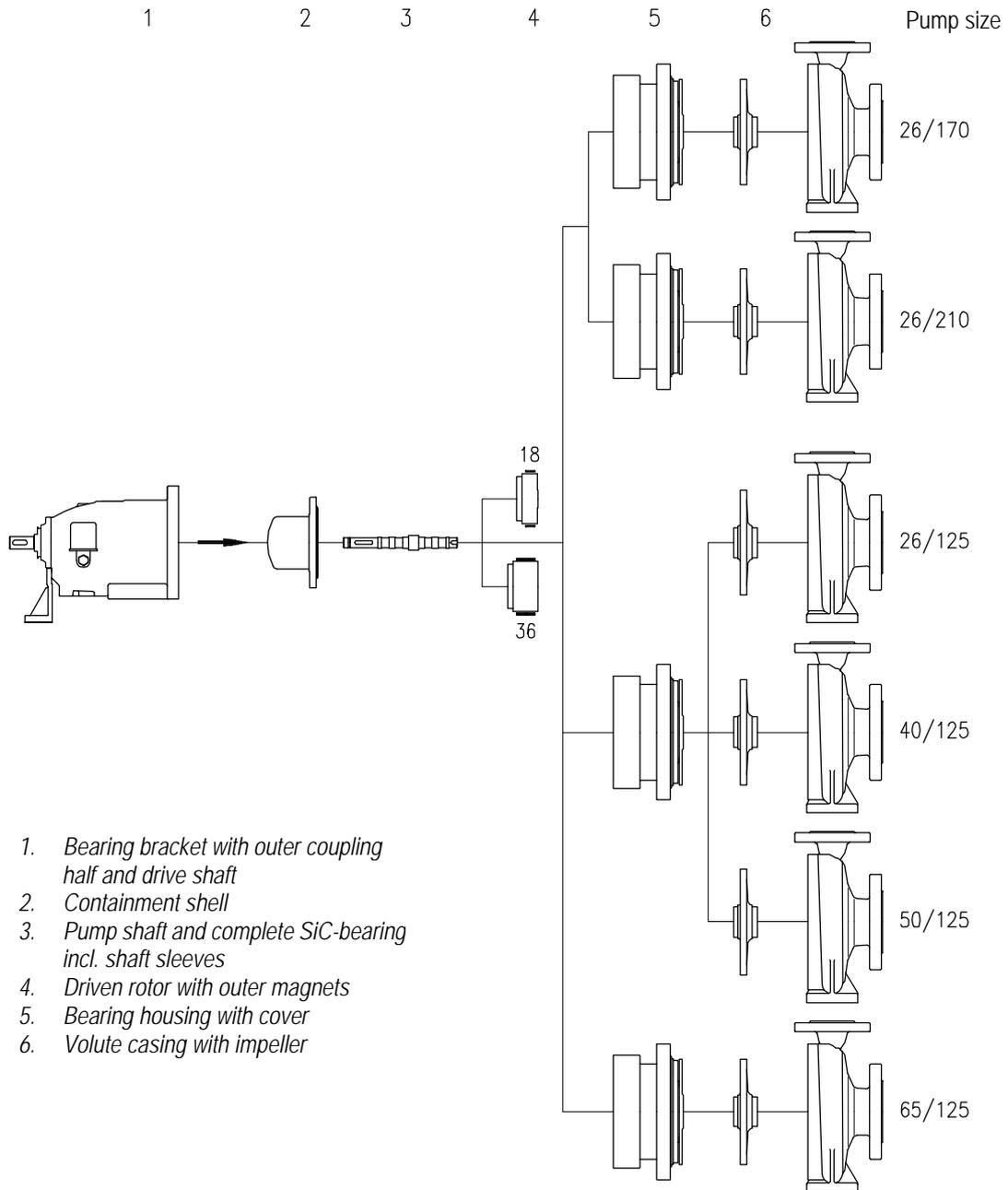
For non-toxic and non-explosive liquids, a transport control sheet with Attention Notice for danger and handling must be undetachable fixed on the pump (a copy attached to the delivery note).

Above work safety instructions apply also for complaints on new pumps which have already been in contact with liquid.

All pumps must be completely drained, flushed and neutralized before returning to the factory in order to avoid endangering of personnel, unnecessary costs for disposal and delay in handling.

9. INTERCHANGEABILITY CHART

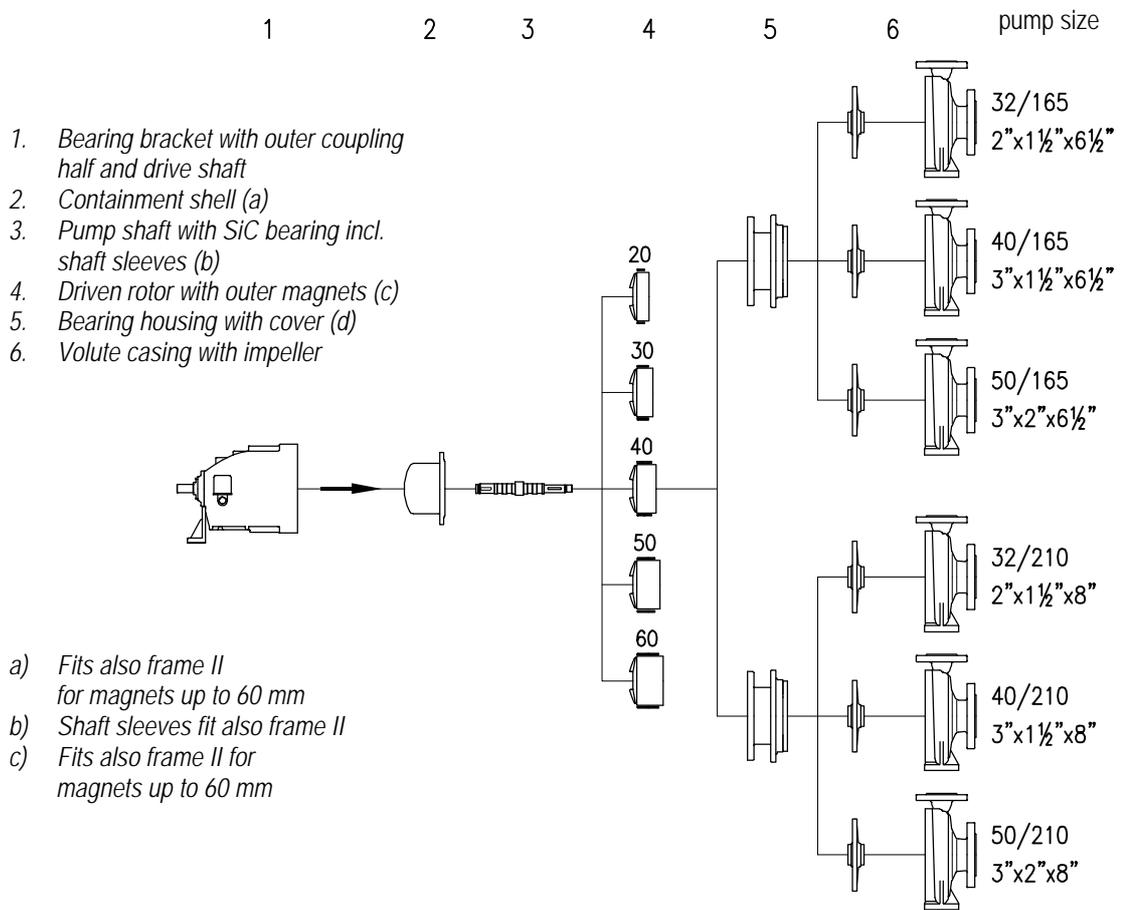
9.1 FRAME SIZE 0



*) based on ambient temperature

Magnet length mm	MAX. RATED MOTOR OUTPUT kW / HP *							
	60 cycles				50 cycles			
	3500 rpm		1750 rpm		2900 rpm		1450 rpm	
	kW	HP	kW	HP	kW	HP	kW	HP
18	7.0	9.4	3.5	4.7	5.8	7.8	2.9	3.9
36	14.0	18.8	7.0	9.4	11.6	15.6	5.8	7.8

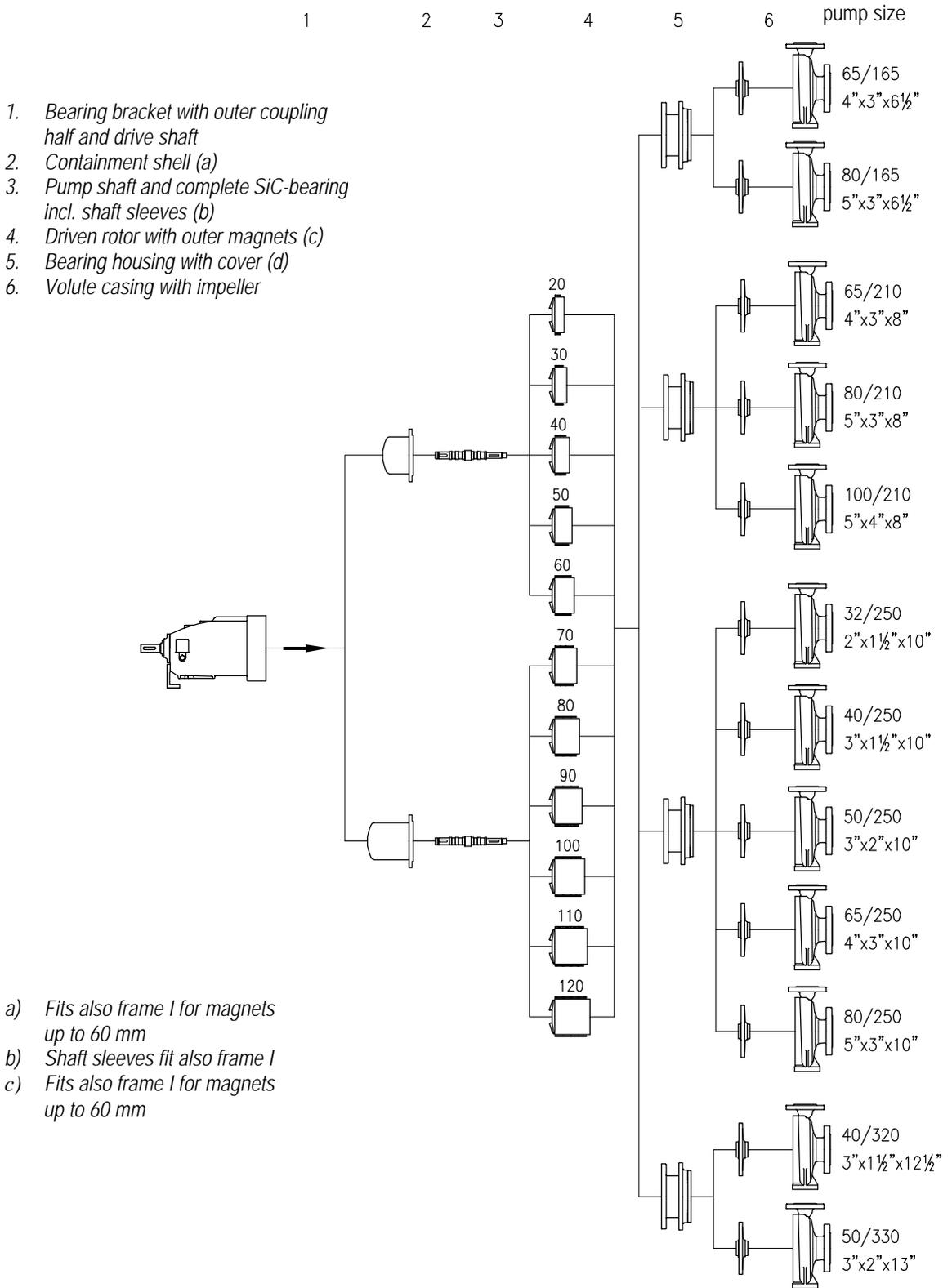
9.2 FRAME SIZE I



*) based on ambient temperature

Magnet length mm	MAX. RATED MOTOR OUTPUT kW / HP *							
	60 cycles				50 cycles			
	3500 rpm		1750 rpm		2900 rpm		1450 rpm	
	kW	HP	kW	HP	kW	HP	kW	HP
20	15,0	20,4	7,5	10,2	12,4	16,8	6,2	8,4
30	23,1	31,4	11,5	15,6	19,1	25,9	9,5	12,9
40	32,7	44,5	16,2	22,0	27,0	36,7	13,5	18,4
50	42,0	57,1	20,8	28,3	34,7	47,2	17,2	23,4
60	50,3	68,4	25,0	34,0	41,7	56,7	20,7	28,8

9.3 FRAME SIZE II

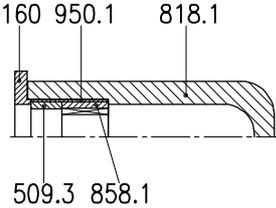
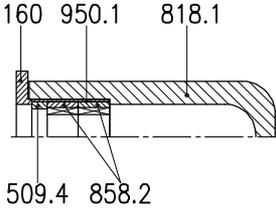
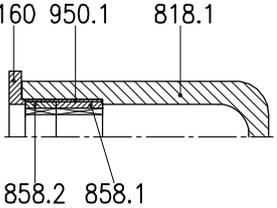
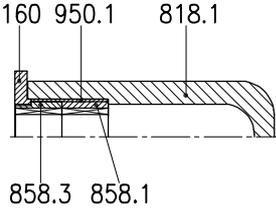
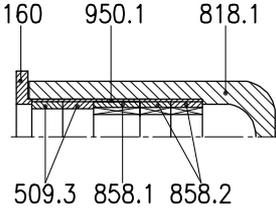
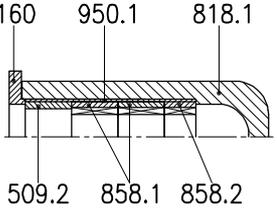
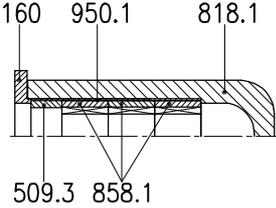
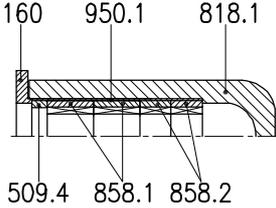
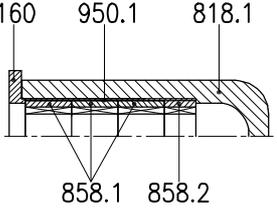


Rated motor output on the following page.

Magnet length mm	MAX. RATED MOTOR OUTPUT kW / HP *							
	60 cycles				50 cycles			
	3500 rpm		1750 rpm		2900 rpm		1450 rpm	
	kW	HP	kW	HP	kW	HP	kW	HP
20	15,0	20,4	7,5	10,2	12,9	16,8	6,2	8,3
30	23,1	31,4	11,5	15,6	19,1	26,0	9,5	12,9
40	32,7	52,3	16,2	22,0	27,0	36,7	13,5	18,3
50	42,0	57,0	20,8	28,3	34,7	47,2	17,2	23,4
60	50,3	68,4	25,0	34,0	41,7	56,7	20,7	28,1
70	60,2	81,9	30,0	40,8	50,0	68,0	24,8	33,7
80	69,5	94,5	34,6	47,0	57,5	78,2	28,6	38,9
90	76,7	104,3	38,2	52,0	63,5	86,3	31,6	43,0
100	86,0	117,0	42,8	58,2	71,0	96,5	35,5	48,3
110	95,0	129,0	47,5	64,6	78,7	107,0	39,2	53,3
120	102,5	139,4	51,0	69,3	84,8	115,3	42,3	57,5

* based on ambient temperature

Other possible axial magnet assemblings

<p style="text-align: center;"><u>30mm Magnet</u></p> 	<p style="text-align: center;"><u>40mm Magnet</u></p> 	<p style="text-align: center;"><u>50mm Magnet</u></p> 
<p style="text-align: center;"><u>60mm Magnet</u></p> 	<p style="text-align: center;"><u>70mm Magnet</u></p> 	<p style="text-align: center;"><u>80mm Magnet</u></p> 
<p style="text-align: center;"><u>90mm Magnet</u></p> 	<p style="text-align: center;"><u>100mm Magnet</u></p> 	<p style="text-align: center;"><u>110mm Magnet</u></p> 

**10.4 PARTS LIST and MATERIAL SPECIFICATION
for Standard design**

Part No.	Designation	Standard - Materials		
		PRMs	PRMhu	PRMh
102	Volute casing	GGG40.3	GS-C25	1.4515
160	Cover	St37	St37	St37
161	Casing cover	GG25	GG25	1.4571
183	Support foot	St/GG25	St/GG25	St/GG25
211	Pump shaft	1.4021	1.4021	1.4571
213	Drive shaft	1.4021	1.4021	1.4021
233	Impeller	GG25	GG25	1.4408
310	Sleeve bearing	1.4462/SiC-coat.	1.4462/SiC-coat.	1.4462/SiC-coat.
310.1	Sleeve bearing	1.4462/SiC-coat.	1.4462/SiC-coat.	1.4462/SiC-coat.
321.2	Radial roller bearing	St	St	St
322	Roller bearing	St	St	St
330	Bearing bracket	GGG40.3	GGG40.3	GGG40.3
350	Bearing housing	St 52.3	St 52.3	1.4571
360.1	Bearing cover	GG25	GG25	GG25
360.2	Bearing cover	St	St	St
400.5	Gasket	Novatec Premium	Novatec Premium	Novatec Premium
400.13	Gasket	Novatec Premium	Novatec Premium	Novatec Premium
400.15	Gasket	Novatec Premium	Novatec Premium	Novatec Premium
400.16	Gasket	Novatec Premium	Novatec Premium	Novatec Premium
400.17	Gasket	Novatec Premium	Novatec Premium	Novatec Premium
411.1	Joint ring	Top Chem 2000	Top Chem 2000	Top Chem 2000
411.3	Joint ring	Top Chem 2000	Top Chem 2000	Top Chem 2000
411.4	Joint ring	Top Chem 2000	Top Chem 2000	Top Chem 2000
411.12	Joint ring	PTFE	PTFE	PTFE
412.5	O-Ring	Viton	Viton	Viton
500.1	Start-up ring	1.4462/SiC	1.4462/SiC	1.4462/SiC
500.4	Tolerance ring	1.4310	1.4310	2.4610
500.5	Start-up ring	1.4462/SiC	1.4462/SiC	1.4462/SiC
504	Distance ring	Rotatherm	Rotatherm	Rotatherm
507.2	Defelctor	1.4571	1.4571	1.4571
509.1	Intermediate ring	1.4571	1.4571	1.4571
509.2	Intermediate ring	St37	St37	St37
512	Wear ring	GG25	GG25	1.4571
512.1	Wear ring	GG25	GG25	1.4571
512.2	Wear ring	GG25	GG25	1.4571
524	Shaft sleeve	SiC-coated	SiC-coated	SiC-coated
525	Spacer sleeve	1.4571	1.4571	1.4571
554.2	Washer	St	St	1.4571
554.7	Washer	St	St	1.4571
554.8	Washer	St	St	St
563	Guide rod	St	St	St

Part No.	Designation	Standard - Materials		
		PRMs	PRMhu	PRMh
638 642	Constant level oiler Oiler sight glass		St-galvanized / Al / glass St-galvanized / glass	
731.1 731.2	Pipe union Pipe union	C45 St	C45 St	C45 St
817 818.1 818.2 858.1 858.2 858.3	Containment shell Drive rotor Driven rotor Permanent magnet Permanent magnet Permanent magnet	1.4571 GGG40.3 1.4571 CoSm/St37 CoSm/St37 CoSm/St37	1.4571 GGG40.3 1.4571 CoSm/St37 CoSm/St37 CoSm/St37	1.4571 GGG40.3 1.4571 CoSm/St37 * CoSm/St37 * CoSm/St37 *
901.1 902.2 902.7 903.4 903.8 903.11 903.12 904.2 904.3 904.4	Hexagon cap screw Stud Stud Screwed plug Screwed plug Screwed plug Screwed plug Grub screw Grub screw Grub screw	4.6 8.8 8.8 St St St St 8.8 8.8 8.8	4.6 8.8 8.8 St St St St 8.8 8.8 8.8	4.6 A4-70 A4-70 1.4571 St St St A4 A4 8.8
913 914.1 914.5 914.6 914.7 914.8 914.10 914.12 919	Vent plug Inner hexagon cap screw Inner hexagon cap screw Ring screw	St 8.8 8.8 100 8.8 A4-70 A4-70 8.8 C15	St 8.8 8.8 100 8.8 A4-70 A4-70 8.8 C15	St 8.8 8.8 100 8.8 A4-70 A4-70 A4-70 C15
920.2 920.7 921.1 921.2 921.3 922	Hexagon nut Hexagon nut Shaft nut Shaft nut Shaft nut Impeller nut	4 4 1.4571 St St St	4 4 1.4571 St St St	A4 A4 1.4571 St St 1.4571
940.1 940.2 940.3 940.4	Key Key Key Key	1.4571 1.4571 1.4571 1.4571	1.4571 1.4571 1.4571 1.4571	1.4571 1.4571 1.4571 1.4571
950.1	Spring	St	St	St

*) CoSm = Cobalt Samarium