Installation & Operating Manual

Slewing rings and gear rims
for industrial applications

Blade bearings, yaw bearings and main bearings
for wind turbines T-Solid ® and T-Solid 4IPC ®

IO SR 4.0

Prior to starting all work, read the operating manual!

This operating manual provides important instructions for working with the component. The specified instructions must be precisely followed, to protect yourself and others.
Inform yourself of the locally applicable accident prevention regulations and the general safety regulations.
The operating manual must be carefully read prior to starting any task! It is an integral part of the product and must be kept in the immediate vicinity of the component. It must be accessible to personnel at all times.
If this component is provided to a third party, ensure that the operating manual is provided with the component.
The illustrations in this manual are provided for the purpose of better understanding. They are not necessarily true to scale and can deviate from the actual design of the component.

Imostr. 1
91350 Gremsdorf, Germany

Tel.: +49 9193 6395-40
Fax: +49 9193 6395-4140

Email: mail@imo.de
Internet: www.imo.de

IMO Customer Service:
Tel.: +49 9193 6395-1200
E-mail: service@imo.de

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1 Structure and function

1.1 Brief description

Slewing rings are large diameter antifriction bearing. Slewing rings are used for the concurrent transmission of axial and radial forces, as well as the transmission of tilting moment. Slewing rings consist of an inner and outer ring, an integrated raceway system; inner or outer gearing systems are also available as an option. A functional seal seals off the raceway system on the upper and lower side.
In the slewing ring, rolling elements transfer the loads between the inner and outer ring. Force is transmitted to the mating structure through the bolts. Through holes or threaded holes are provided in the inner and outer ring for this purpose.

1.1.1 Applicable for wind turbines

The main bearings are designed for continuous operation, longer standstill periods without rotationt or blocking of the rotation is only permitted for servicing and then only for a few hours. When performing servicing work with blocked main bearings, make sure that the maintenance work is carried out as quickly as possible and without unnecessary interruptions. In particular, ensure that wind speeds of 4 m/s are not exceeded during the maintenance work to avoid damaging the main bearing.
Even when it is not in operation, it is important to ensure that the main bearing rotates easily and continues being supplied automatically with grease during this time. In order to ensure that this occurs, the wind turbine must be controlled in such a way that a minimum rotational speed of about 0.5 rpm is guaranteed.

1.2 Overview

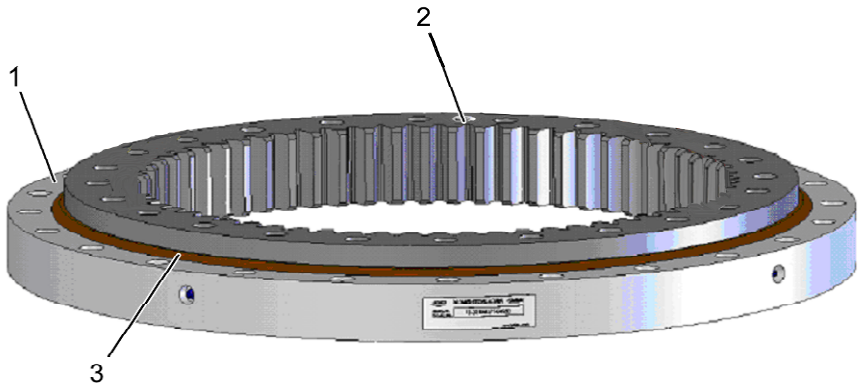

Fig. 1: Slewing ring with internal gearing

1 Outer ring
2 Inner ring
3 Seal

1.3 Intended use

⚠WARNING

The component is not designed for use in potentially explosive atmospheres. Misuse of the component may give rise to dangerous situations.

The component has been designed and manufactured to be used solely in accordance with this installation and operating manual.
The slewing ring is used

- for the transmission of low-friction rotation
- as a blade, yaw and main bearing in wind turbines

The gear rim is used for

- the transmission of torque between machine parts
- installation as a yaw gear rim in the friction bearings of wind turbines.

NOTE!
In this installation and operating manual, no distinction is made between slewing rings and gear rims. The instructions for slewing rings can thus also be applied to gear rims, where appropriate. In case of uncertainty, contact IMO Customer Service (⇨ page 2).

Modification, retooling or changing the construction or individual parts of the equipment with the objective of changing the area of application or usability of the component is not permitted, as this does not form part of the intended use.
All claims for damages of whatsoever nature arising from the improper use of the equipment are excluded.
The owner is solely liable for all damages arising from improper use.

2 General

2.1 Explanation of symbols

Warnings

Warnings in this operating manual are indicated by a warning symbol (⚠) and/or signal words. The scope and nature of the hazard is described with signal words.
The warnings must be strictly observed, and you must act with care to prevent accidents, personal injuries and damage to property as well as life-threatening injuries.

Warning symbol / signal word	Explanation
⚠ DANGER **or** **DANGER!**	Indicates an imminent dangerous situation that can result in death or serious injury if it is not avoided.
⚠ WARNING **or** **WARNING!**	Indicates a potentially dangerous situation that can result in death or serious injury if it is not avoided.
⚠ CAUTION **or** **CAUTION!**	Indicates a potentially dangerous situation that can result in slight or minor injuries if it is not avoided.
IMPORTANT **or** ***IMPORTANT!***	Indicates a potentially dangerous situation that can result in damage to property if it is not avoided.
Tips and recommendations	**Explanation**
ⓘ	Indicates useful tips and recommendations as well as information for efficient and trouble-free operation.

2.2 Limitation of liability

All the information and instructions in this operating manual were compiled after having had due regard to the applicable standards and regulations, the current state of the technology as well as our extensive experience.
The manufacturer assumes no liability for damages arising from:

- Failing to observe the instructions in this manual
- Improper use
- Using untrained personnel
- Unauthorized conversions
- Technical changes
- Using non-approved spare parts

In the case of special versions, orders for supplementary options or due to the latest technical changes, the actual scope of delivery may vary from the explanations and depictions provided in this manual.

In all other respects, the agreed obligations in the delivery contract, the general terms and conditions as well as the delivery conditions of the manufacturer and the legal provisions applicable at the time that the contract was concluded apply.
We reserve the right to make technical changes for the purpose of improving the performance characteristics and further development.

2.3 Copyright

The information contained in this operating manual and/or in all parts, sub-sections, or sections of this manual is the intellectual property of IMO GmbH & Co. KG, and is subject to German and international copyright legislation and other laws that protect intellectual property.
The information contained in this manual is provided to assist in the operation, maintenance and fault elimination of the units described herein.
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All rights and legal remedies remain expressly reserved. Infringements will be prosecuted.
IMO GmbH & Co. KG assumes no liability whatsoever for improper use of the information contained here by persons or legal entities, regardless of the location.
IMO GmbH & Co. KG reserves the right at any time and regardless of reason, to change or modify the information contained here, as well change and modify the turbine itself, with or without prior notice.

2.4 Original IMO parts

⚠WARNING

Only use original IMO parts! Use of non-authorized, wrong, or defective spare parts may cause damage, and failures, or can impair the safety of the device and thus cause severe or fatal injuries.

Purchase original IMO parts from authorized dealers or direct from the manufacturer (⇨ page 2).

2.5 IMO Customer Service

Our customer service organization is available for technical information (⇨ page 2).
Furthermore, our employees are always interested in new information and experiences in respect of the application our products, and which could prove valuable in improving these.

3 Security

This section provides an overview of all the important safety aspects for optimal protection of personnel, as well as for safe and trouble-free operation.
Failing to comply with the handling instructions and safety instructions in this manual can result in extremely dangerous situations.

3.1 Safety devices

Integration in an emergency-stop concept is required

The component is designed for utilization within a turbine. It does not have its own controller and does not have an autonomous emergency-stop function.
Before the component is placed in service, emergency-stop devices must be installed for the component and integrated in the safety chain of the turbine control system.

The emergency-stop devices must be connected in such a manner that dangerous situations for persons and property are excluded in the event of an interruption of the power supply or the activation of the power supply after an interruption.
The emergency-stop devices must always be freely accessible.

3.2 Special dangers

Residual risks are set out in the following section.

⚠WARNING

Follow the safety instructions listed here and the warning instructions in the other sections of this manual to reduce health hazards and to avoid dangerous situations.

VCI foil

DANGER! Keep out of reach of children and dispose of properly. If used improperly, there is danger of suffocation. Avoid skin and eye contact with VCI foil. Repeated or extended contact with skin may remove the natural oils of the skin and cause dermatitis.

Moving parts

WARNING! Do not reach into moving parts or handle moving parts during operation. Do not open covers when the device is in operation. Observe the follow-up time. Prior to opening the cover, ensure that all parts have come to a standstill. Wear tight-fitting protective work clothing in the danger zone. Rotating components and/or components with linear movements can cause serious injury!

Falling materials

WARNING! Never enter the danger zones during operation. During operation, heavy material may fall out of or be ejected out of the device in an uncontrolled manner and cause severe or even fatal injuries.

Dirt and loose objects

CAUTION! Always keep the work area clean. Remove objects that are not being used. Mark stumbling hazards with a black/yellow marking tape. Dirt and objects left lying around create a risk of slipping or stumbling and can cause serious injuries.

3.3 Responsibility of the owner

Owner

The owner is the person or entity that operates the component for commercial or economic purposes on its own behalf or that makes the device available to a third party for use or an application and during operation has the legal product responsibility to protect users and third parties.

The component is used in commercial applications. Consequently, the owner of the component is subject to the legal obligations in respect of occupational health and safety.
In addition to the safety instructions in this manual, the safety and accident prevention regulations and environmental protection provisions that apply to the area of application for the component must be complied with. In this regard:

- The owner must inform itself as to the applicable occupational health and safety regulations and the other risks that may exist at the installation site of the component due to the specific operating conditions must be identified in a risk analysis. The owner must compile operating instructions for the operation of the component using the information from the risk analysis.
- During the entire period that the component is used, the owner must ensure that its operating instructions are in accordance with the applicable legislation as amended from time to time and, if necessary, amend its operating instructions accordingly.
- The owner must clearly specify and determine the responsibilities for installation, operation, maintenance and cleaning.
- The owner must ensure that all employees who handle the component have read and understood this operating manual. In addition, the owner must train personnel at regular intervals and inform the personnel about the hazards.
- The owner must provide the personnel with the required protective equipment.

Moreover, the owner is responsible for ensuring that the component is always in perfect technical condition so that the following applies:

- The owner must ensure that the maintenance intervals specified in this operating manual are observed.
- The owner must have the function and completeness of all safety devices regularly inspected.

The seals in the slewing ring are subject to a certain amount of wear. From time to time, it is necessary to check the proper seating and function of the seals. Depending on the turbine runtime, it may also be necessary to replace the seals. The turbine manufacturer must accordingly ensure that there are sufficient space and access for inspecting and replacing the seals around the entire perimeter of the slewing ring.

3.4 Personnel requirements

Unauthorized person

WARNING! Unauthorized persons should not enter the work area! Unauthorized persons can cause dangerous situations.

Skilled personnel

Skilled personnel are personnel who due to their specialized training, skills and experience as well as their knowledge of the applicable requirements are capable of executing the tasks assigned to them and recognizing possible hazards on their own.

3.5 Personal protective equipment

Wearing personal protective equipment is required to minimize the health hazards when working with the device.

- Always wear the protective equipment necessary for the particular task when working with the component.
- Comply with the instructions that have been posted in the work area.

Always wear

For all tasks, always wear:

Protective work clothing
is tight-fitting work clothing with low resistance to tearing, with tight sleeves and without projecting parts. It is primarily used as a protection against entanglement by moving machine parts.
Do not wear rings, chains or other jewelery.

Safety footwear
for protection against heavy falling parts and slipping on slippery surfaces.

Protective gloves
to protect the hands from friction, abrasions, puncture wounds or deeper injuries as well as from contact with hot surfaces.

For special tasks wear

Special protective equipment is required when executing special tasks. Specific reference is made to this equipment in the individual sections. This special protective equipment is explained below:

Face protection
To protect the eyes and face from solvents.

Chemical-resistant protective gloves
To protect hands from aggressive substances.
Check the protective gloves for leaks prior to use. Clean the gloves before pulling them off, then store them in a well-ventilated location.

4 Transport, packaging, and storage

4.1 Instructions for transport

⚠WARNING **Never stand under suspended loads! Swinging or falling parts can cause injury or pose a life-threatening hazard.**

⚠WARNING **Carefully supervise the lifting processes and transport. Only use the transport methods described here. A life-threatening crushing injury can occur if the slewing ring falls.**

IMPORTANT **Proceed with caution when transporting objects! Comply with instruction symbols on the packages and only use the prescribed attachment points. Improper transport can cause significant damage.**

IMPORTANT **Avoid impact when transporting! Improper transport can cause significant damage.**

IMPORTANT **The applicable transport regulations must be observed. Only permissible load securing means may be used.**

4.2 Transport

Transport should be executed by skilled personnel only.

Transporting packages

Packages that are not attached to pallets can be transported with a forklift or forklift truck under the following conditions:

- The forklift or forklift truck must be designed for the weight of the transport units.
- The driver must be authorized to operate the forklift.

Attachment:

1. Place sufficiently long and wide extensions (e.g. of wood or metal) between the forks and the package so that the weight is distributed on the support surfaces.
2. Drive in the forks, with extensions if needed, far enough that they protrude on the opposite side.
3. If there is an eccentric center of gravity, ensure that the package cannot tip.
4. Lift the package and start the transport.

4.3 Loading pallets and crates

Transporting pallets/crates with a forklift

Fig. 2: Crate with one row of runners

Fig. 3: Crate with two rows of runners

Packages that are attached to pallets or packed in crates can be transported with a forklift under the following conditions:

- The forklift must be designed for the weight of the transport units.
- The driver must be authorized to operate the forklift.
- The pallet or crate must always be lifted from underneath.
- The lifting tackle must spread the load across the entire crate/pallet so that the crate/pallet is loaded evenly.
- The attachment point across the width of the crate/pallet is located next to the outermost runner toward the center. (See Fig. 2: Crate with one row of runners)
- A pallet is lifted from under the longitudinal runners (first row of square timber under the transported goods)
- Crates with only one row of runners are lifted from the base.
- Crates with two rows of runners are lifted from under the longitudinal runners (first row of square timber under the transported goods)

The center of gravity is usually located in the middle.

Attachment:

1. Drive the forklift with the forks between or under the deckboards of the pallet/crate.
2. Drive in the forks until they protrude on the opposite side.
3. If there is an eccentric center of gravity, ensure that the pallet/crate cannot tip.
4. Lift the package and start the transport.

4.4 Loading a "picked crate" with a crane

Fig. 4: "Picked crate" on a crane

Packages that are attached to pallets or packed in crates can be transported with a crane under the following conditions:

- Crane and lifting gear must be designed for the weight of the packages.
- The operator must be authorized to operate the crane.
- The picked crate is equipped with permanently fitted eye bolts/load rings that are used to attach lifting gear for lifting the crate.
- All eye bolts/load rings must be used simultaneously.

The "picked crate" can also be loaded from underneath in the normal way using a forklift of sufficient size/lifting capacity.

Attachment:

1. As shown in Fig. 4: "Picked crate" on a crane attach the ropes, straps, or multi-point suspension to the pallet or crate.
2. Ensure that the packages cannot be damaged by the lifting tackle. Use other lifting tackle if necessary.
3. Start the transport.

4.5 Attaching the eye bolts/load rings

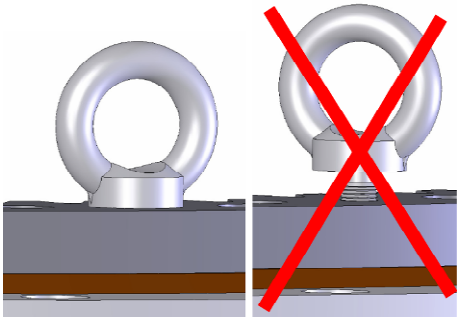


Fig. 5: Use the full thread length

1. Screw the eye bolts into the transport holes that are distributed uniformly on the perimeter of the slewing ring.

WARNING! Screw in the eye bolts to the full thread length! Improperly attached, unsuitable, or damaged eye bolts may cause the slewing ring to fall and cause life-threatening injuries.

2. Check whether the bolt insertion depth specified by the manufacturer for the eye bolts is observed. If a bolt insertion depth has not been specified, then a minimum bolt insertion depth of 1.5 x the bolt diameter must be selected.
3. Attach lifting gear to the eye bolts.

4.6 Loading a slewing ring or ring without a crate/pallet

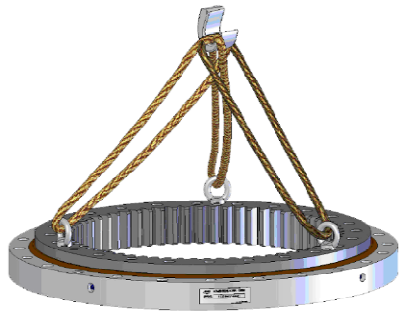


Fig. 6: Slewing ring without crate or pallet

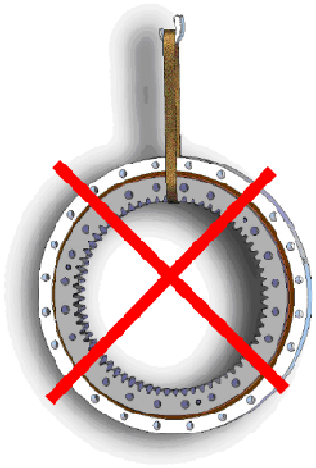


Fig. 7: Use suitable lifting gear/never transport product vertically

Unpacked slewing rings can be transported with suitable lifting gear using eye bolts under the following conditions:

- The lifting gear must be designed for the weight of the transport unit.
- The eye bolts must be designed for the weight of the transport unit.
- The slewing ring may only be transported by itself, without the attached parts of the mating structure.
- Observe the bolt insertion depth specified by the manufacturer for the eye bolts. If a bolt insertion depth has not been specified, then a minimum bolt insertion depth of 1.5 x the bolt diameter must be selected.
- Transport within the company should only be executed horizontally.
- Slewing rings or single rings not packed in a crate must be lifted by the transport holes.
- The transport holes are fitted with rotary eye bolts or load rings to which the lifting tackle is attached.
- All transport holes and therefore eye bolts/load rings must be used simultaneously.
- The transport holes are marked on the drawing as such. They are distributed evenly across the diameter and have dimensions appropriate to the weight of the slewing ring.

Under certain circumstances, transport and/or attachment instructions that go beyond the requirements outlined here may be affixed to the packages. Always observe these instructions!

4.7 Transport inspection/incoming goods inspection

Check the delivery immediately upon receipt to ensure that the delivery is complete and undamaged.
If there is obvious external damage, proceed as follows:

- Do not accept the delivery or only accept it with reservation.
- Note the extent of the damage on the transport documents or on the transport company's delivery note.
- Submit a complaint.

Report all defects within 2 working days of delivery of the goods. Claims to replace any defects in the delivery can only be submitted during this notice period.

4.8 Packaging

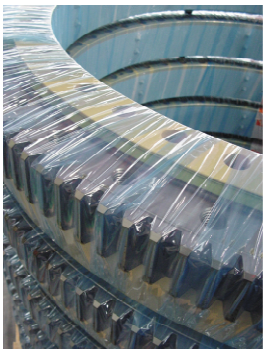


Fig. 8: VCI foil

The packaging should protect the slewing ring from transport damage and corrosion until the slewing ring is installed. The anti-corrosion agent functions according to the VCI method.

The packaging must not be destroyed or damaged, and it must only be removed just prior to installation.

The packaging of the slewing ring is adapted to the transport conditions specified by the customer. The duration of corrosion protection for standard packaging as well as for maritime freight packaging is 8 weeks including the freight period.
After this period, the customer must ensure that there is adequate corrosion protection.

IMPORTANT

- The slewing ring must only be unpacked when the temperature of the slewing ring corresponds to the ambient temperature. This prevents the formation of condensate on the slewing ring.
- The packaging does not provide corrosion protection when the slewing ring is in operation.

Fig. 9: Stiffening cross for transportation

The slewing rings are sometimes supplied with a stiffening cross for transportation. The following must be observed:

- Slewing rings must be stored on their side.
- Remove the stiffening cross for transportation just before installation.

Handling packing materials

If no separate agreement in respect of the handling of the packaging has been concluded, then separate the materials according to type and size and reuse or recycle the materials.
IMPORTANT! **Dispose of packing materials in an environmentally responsible manner. Environmental damage can be caused by improper disposal.**

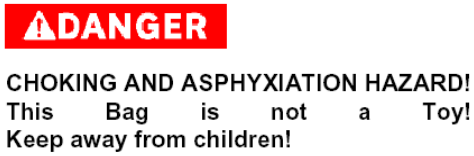
4.9 Symbols on the packaging

Contains no parts to be repaired by the user! Unauthorized opening of the unit invalidates the manufacturer's guarantee.

NO USER SERVICABLE PARTS INSIDE! UNAUTHORIZED OPENING OF THIS DEVICE VOIDS THE MANUFACTURER'S WARRANTY.

If packed in foil:

Danger!
Danger of suffocation!
This foil is not a toy!
Keep away from children!



4.10 Storage

Storage of packages

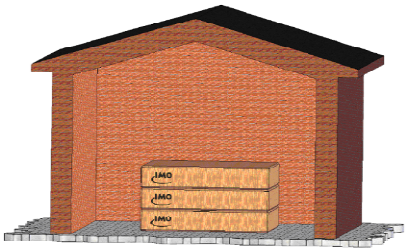


Fig. 10: Ensure protective storage

Only store packages under the following conditions:

- Always store packages under a roof.
- Protect against weathering, rain and UV light.
- Store on a firm, dry surface.
- Do not expose to aggressive media.
- Use stable intermediate layers when stacking.
- Do not stack packages without consulting IMO because the packages must be placed in stackable crates. Attention Stacking crates that are not designed to be stacked may cause the crates to collapse and packages to fall out. Risk of serious injury!
- Protect from direct sunlight.
- Avoid mechanical vibrations.
- Bearing temperature: 15° C (59° F) to 35° C (95° F).
- Relative air humidity: max. 60 %.
- Do not store in an upright position.
- If the storage time is longer than specified in the commission/order, the packaging must be checked regularly. Touch up or reapply corrosion protection as required.

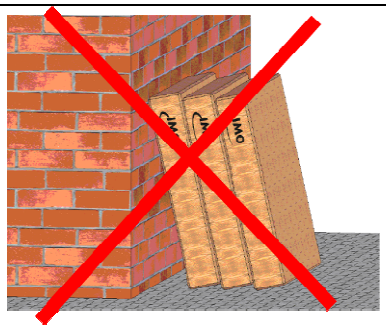


Fig. 11: Do not store in an upright position

Under certain circumstances, storage instructions are affixed to the packages that go beyond the requirements stated here. Always observe these instructions!

4.11 Storage of slewing rings with long-term preservation

IMPORTANT! **In this exceptional case, the slewing ring is not greased!** Prior to installation, the slewing ring must be greased according to these installation and maintenance instructions otherwise it may be damaged beyond repair.

In order to guarantee corrosion protection for up to 5 years, a thin film of VpCI 368 from the manufacturer Cortec Corporation is applied to all inside and outside profiles. In addition, the slewing ring is wrapped in VCI stretch foil and sealed in PE foil.

Two humidity indicators between the foils provide information about the relative air humidity within the packaging.

In order to prevent damage to the foils, the slewing ring is packed and fixed in a wooden crate.

This special packaging/preservation is suitable for a storage time of up to 5 years in closed, temperature-controlled rooms (>12 °C).

Transport, packaging, and storage

After receipt of the goods, the packaging condition must be checked, with further inspections in intervals of 6 months. The packing must be inspected to ensure that it is intact and the relative air humidity inside the packing must be checked. For this purpose, two humidity indicators are mounted on the top of the slewing ring opposite each other. The respective results must be documented in the test report.

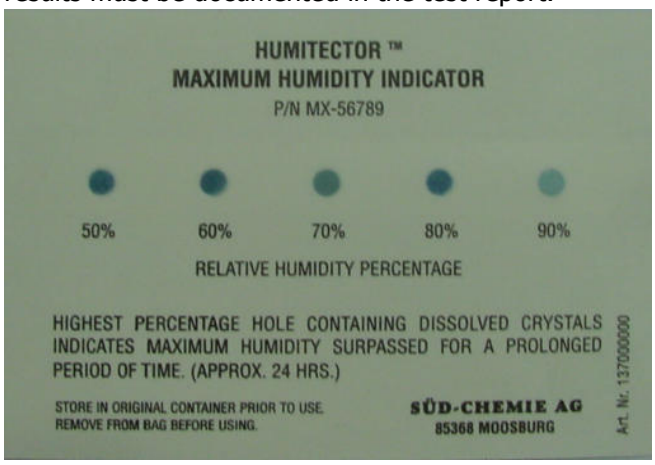


Fig. 12: Humidity indicator

Relative air humidity **%**	*Remark*
Up to 50	**ok**
From 60	*not ok*

If additional preserved storage is necessary after the expiry of 5 years, the long-term preservation must be replaced under the supervision of an IMO Service Team employee. Arrangements can also be made to return the slewing ring to IMO for the renewal of the preservation or alternatively, perform initial greasing on the ring in the event of impending use.
Failing to observe this inspection instruction will invalidate any warranty claims relating to long term preservation.

Note:
The VpCI 368 preserving agent is absorbed by grease and has a very good lubricant compatibility. The removal of the preserving agent from the raceway system before the initial greasing is accordingly not necessary.

5 Installation and commissioning

5.1 Security

⚠DANGER **Prior to starting work switch off all power supplies and safeguard them from being switched on again. If the power supply is switched on by unauthorized personnel, a life-threatening injury can occur for persons in the danger zone.**

⚠WARNING **Prior to starting work ensure that there is adequate free space for installation. Handle open, sharp-edged components carefully. Ensure order and cleanliness at the installation location! Parts and tools that are lying loose or on top of each other are accident hazards. Mount components properly. Maintain the prescribed bolt-tightening torque. Secure the components so that they do not fall down or fall over. Improper installation and commissioning may cause serious personal injury and/or property damage.**

⚠WARNING **Never stand under suspended loads! Swinging or falling parts can cause injury or pose a life-threatening hazard.**

⚠WARNING **Carefully supervise the lifting processes and transport. Only use the transport methods described here. A life-threatening crushing injury can occur if the components fall.**

IMPORTANT **Proceed with caution when transporting objects! Comply with instruction symbols on the packages and only use the prescribed attachment points. Improper transport can cause significant damage.**

IMPORTANT **Avoid impact when transporting! Improper transport can cause significant damage.**

IMPORTANT **Do not paint over the seals! Painting over the seals can cause significant damage.**

IMPORTANT **For coated slewing rings ensure that the coating is not damaged. If necessary consult with customer service (⇨ page 2).**

Personnel

- Only trained, skilled personnel may perform installation and commissioning work.

Personal protective equipment

Wear the following protective equipment for all installation and commissioning work:

- Protective work clothing
- Safety footwear
- Protective gloves

The warnings in this section make specific reference to additional protective equipment that is required for certain tasks.

5.2 Preparation

5.2.1 Unpacking the slewing ring

IMPORTANT

When cutting the VCI foil it must be ensured that plastic elements, such as seals, are not damaged. Slewing rings with visibly damaged seals must not be installed. Contact IMO for information on how to proceed in this case. The slewing ring must only be unpacked when the temperature of the slewing ring corresponds to the ambient temperature. This prevents the formation of condensate on the slewing ring.

5.2.2 Lubricating prior to commissioning

Slewing rings are lubricated in the factory prior to delivery. However, the slewing ring must still be lubricated prior to commissioning (⇨6.8.3, 6.8.4 & 6.8.6).

5.2.3 Cleaning the slewing ring and mating structure

Wear the following additional protective equipment for cleaning tasks:

Face protection
To protect the eyes and face from solvents.

Chemical-resistant protective gloves
To protect hands from aggressive substances.
Check the protective gloves for leaks prior to use. Clean the gloves before pulling them off, then store them in a well-ventilated location.

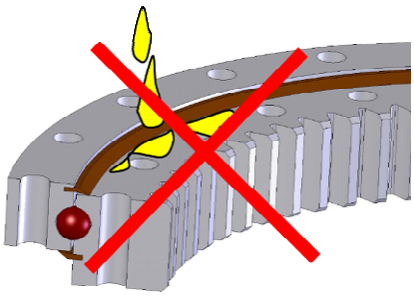


Fig. 13: Do not let cleaning agents get into the raceway systems

Cleaning:
IMPORTANT! **Use cold solvent that does not corrode the seal material. Ensure that the cleaning agent does not get into the slewing ring. Do not use a high-pressure cleaner to clean the slewing ring. Unsuitable trichloroethylene-based or perchloroethylene-based cleaning agents, or other aggressive cleaners damage the seal and can cause bearing damage.**
Always observe the relevant environmental protection guidelines.

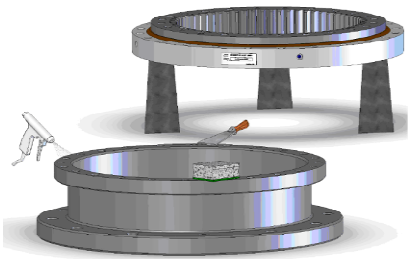


Fig. 14: Cleaning

- When using cleaning agents, ensure that there is adequate ventilation.
- Maintain a strict ban on smoking.
- Remove used grease, dust and dirt with a lint-free cloth.
- Remove foreign material from the support surface of the mating structure (including paint residues, welding beads, burrs).
- If necessary, clean the support surface of the slewing ring.
- Strictly comply with the industrial safety regulations.

5.2.4 Design of the mating structure

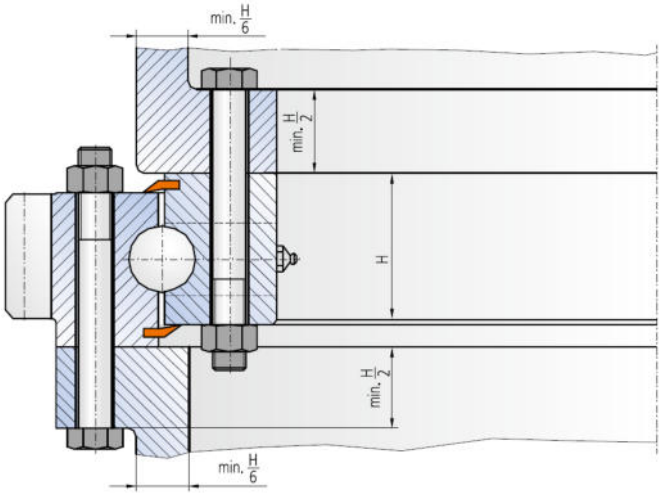


Fig. 15: Dimensions of the mating structure

The reliable transmission of existing loads and the trouble-free utilization of the slewing ring are achieved among other things by an adequately dimensioned mating structure.
In this regard, the mating structure must comply with certain minimum requirements for the slewing ring to function reliably:

- It must have sufficient rigidity, see Table 3 and Table 4
- The flatness requirements in the Installation and Operating Manual must be observed
- No stiffness discontinuities in the mating structure (e.g. no hard points due to transverse supports)
- Mounting surfaces at least rotated or face milled
- A cup-shaped structure is preferable
- All mounting bolts must be used
- The recommended bolt grade must be observed
- The mating structure must have a minimum strength of 500 N/mm^2, see Table 6.

Depending on the maximum load and the application, the solutions for the design of the mating structure may be very different.
If the mating structure has a cup-shaped structure, the flange thickness should at least amount to 50% of the ring height. The wall thickness of the cup should be at least 1/6 of the ring height.
In weight-critical applications, the flange thickness can only be reduced if appropriate reinforcement is provided and the specifications for the permissible flatness deviation and angular deviation as well as deformation can be observed under load. See Table 1 to Table 4 *for the relevant values.*

5.2.5 Design of the mating structure especially for slewing rings as blade bearings of wind turbines

For wind turbine blade bearings, it is recommended that the blade be secured to the inner ring of the slewing ring.

5.2.6 Determination of flatness deviation, angular deviation, and deformation

Determination of flatness deviation and angular deviation of the mating structure

The mating structure can be measured using a measuring plate and dial gauges.
Laser processes and measuring with 3D systems have also proven to be effective. These systems can be used without additional auxiliary materials and they can document the actual gradient of the mating structure as well as processing it accordingly.

Flatness deviation

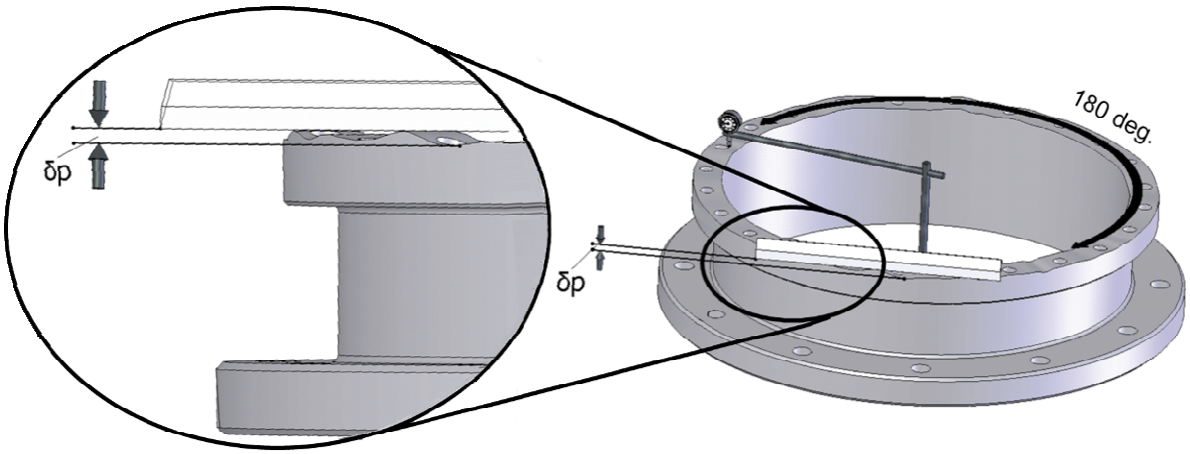


Fig. 16: Flatness deviation

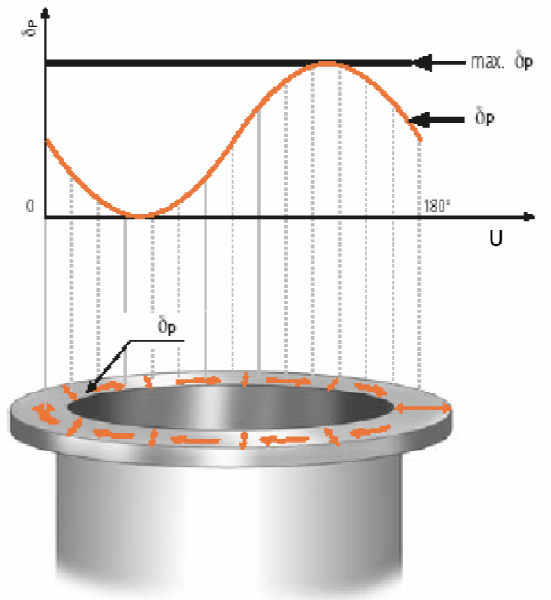


Fig. 17: Permissible flatness deviation of the mating structure

δp = flatness deviation
max. δp = maximum flatness deviation
U = circumference

- The maximum residual value for flatness deviation δp in the circumferential direction may only be reached once on half the circumference. The gradient must look like a sine curve that slowly rises or falls, i.e. contains no jumps.

Angular deviation

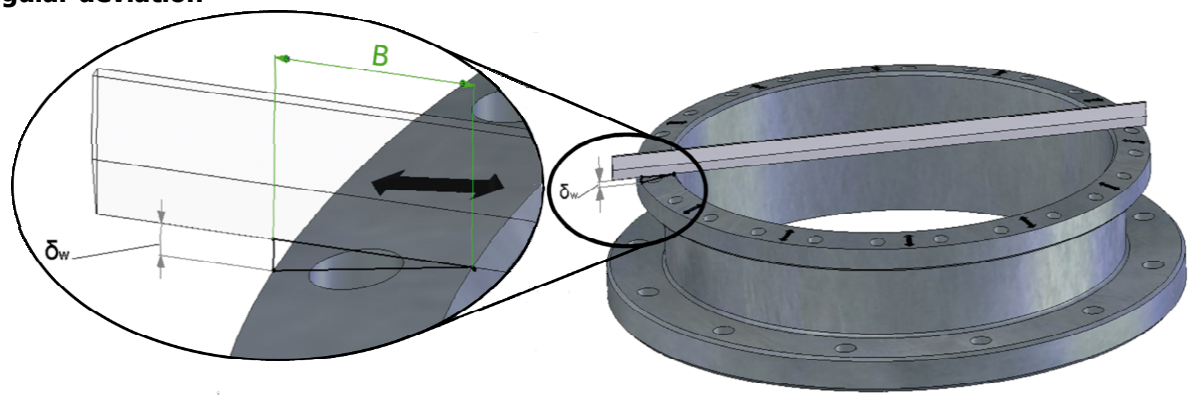


Fig. 18: Angular deviation

δw = angular deviation
B = flange width

- The permissible angular deviation δw = (tilting) is based on the actual flange width and may only be half the values set out in the tables below.

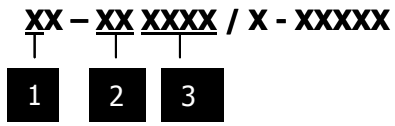


Fig. 19: Drawing number

The bearing design (1), the size of the rolling element diameter dw (2) and of the raceway diameter D_L (3) is contained in the drawing number and is shown on the accompanying documents or the type plate. In the bearing design (1), numbers 1 and 4 represent a ball slewing ring, while the number 3 represents a roller bearing or roller slewing ring. All the dimensions in the drawing number are metric measurements [mm].

For slewing rings that are between the specified sizes, always assume the smaller value. In respect of slewing rings that are larger than the largest diameter, use the largest specified value.

The slewing ring must be supported by the mating structure over the entire mounting surface of the respective ring.

In respect of preloaded ball slewing rings, use the values for the roller slewing rings.

Installation and commissioning

Permissible flatness deviations and angular deviations for standard version slewing rings

Metric:

Raceway diameter D_L [mm]	Up to	250	500	750	1000	1250	1500	1750	2000	2500	3000
Permissible flatness deviation including angular deviation per support surface [mm]	Ball	0.08	0.10	0.13	0.15	0.18	0.20	0.23	0.25	0.30	0.35
	Roller	0.06	0.08	0.09	0.10	0.11	0.13	0.14	0.15	0.17	0.20

Raceway diameter DL [mm]	Up to	3500	4000	4500	5000	5500	6000	6500	7000	7500	8000
Permissible flatness deviation including angular deviation per support surface [mm]	Ball	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85
	Roller	0.22	0.25	0.27	0.30	0.32	0.35	0.37	0.40	0.42	0.45

Table 1

Inches:

Raceway diameter D_L [mm]	Up to	250	500	750	1000	1250	1500	1750	2000	2500
Permissible flatness deviation including angular deviation per support surface [inches]	Ball	0.003	0.004	0.005	0.006	0.007	0.008	0.009	0.010	0.012
	Roller	0.002	0.003	0.004	0.004	0.004	0.005	0.006	0.006	0.007

Raceway diameter D_L [mm]	Up to	3000	3500	4000	4500	5000	5500	6000	6500	7000
Permissible flatness deviation including angular deviation per support surface [inches]	Ball	0.014	0.016	0.018	0.020	0.022	0.024	0.026	0.028	0.030
	Roller	0.008	0.009	0.010	0.011	0.012	0.013	0.014	0.015	0.016

Raceway diameter D_L [mm]	Up to	7500	8000							
Permissible flatness deviation including angular deviation per support surface [inches]	Ball	0.031	0.033							
	Roller	0.017	0.018							

Table 2

Determining the deformation of the mating structure

Under maximum operating load, a corresponding deformation of the mating structure occurs. The dimensions can be detected via dial gauges, laser measurement processes or 3D measuring systems.
The deformation can also be determined mathematically, e.g. with the finite element method, because taking measurements during operation is difficult in some cases.
Alternatively, you can also reference comparable measurements on test rigs.

Permissible deformation of the mating structure under maximum load for standard version slewing rings

Metric:

Raceway diameters D_L [mm]	**Up to**	**250**	**500**	**750**	**1000**	**1250**	**1500**	**1750**	**2000**
permissible deformation of the mating structure [mm]	Ball	0.16	0.21	0.30	0.36	0.46	0.54	0.65	0.74
	Roller	0.12	0.17	0.20	0.24	0.28	0.35	0.39	0.44

Raceway diameters D_L [mm]	**Up to**	**2500**	**3000**	**3500**	**4000**	**4500**	**5000**	**5500**	**6000**
permissible deformation of the mating structure [mm]	Ball	0.96	1.22	1.50	1.80	2.13	2.48	2.86	3.26
	Roller	0.55	0.70	0.82	1.00	1.15	1.35	1.53	1.76

Raceway diameters D_L [mm]	**Up to**	**6500**	**7000**	**7500**	**8000**				
permissible deformation of the mating structure [mm]	Ball	3.69	4.13	4.61	5.10				
	Roller	1.95	2.21	2.42	2.70				

Table 3

Inches:

Raceway diameter D_L [mm]	**Up to**	**250**	**500**	**750**	**1000**	**1250**	**1500**	**1750**	**2000**
Permissible deformation of the mating structure [inches]	Ball	0.006	0.008	0.012	0.014	0.018	0.021	0.026	0.029
	Roller	0.005	0.007	0.008	0.009	0.011	0.014	0.015	0.017

Raceway diameter D_L [mm]	**Up to**	**2500**	**3000**	**3500**	**4000**	**4500**	**5000**	**5500**	**6000**	**6500**
Permissible deformation of the mating structure [inches]	Ball	0.038	0.048	0.059	0.071	0.084	0.098	0.113	0.128	0.145
	Roller	0.022	0.028	0.032	0.039	0.045	0.053	0.060	0.069	0.077

Raceway diameter D_L [mm]	**Up to**	**7000**	**7500**	**8000**						
Permissible deformation of the mating structure [inches]	Ball	0.163	0.181	0.201						
	Roller	0.087	0.095	0.106						

Table 4

IMPORTANT

Deformation of the mating structure is the total of the axial deflection, tilting, and radial expansion (or radial constriction) of the mating structure under maximum load.

The flange thickness of the mating structure should be at least 50% of the slewing ring installation height.
Additional information on the design of the mating structure is provided in the IMO main catalogs, under the section "Technical fundamentals".

In respect of slewing rings that are between the specified raceway diameters, always assume the smaller value.
In respect of slewing rings that are larger than the largest diameter, use the largest specified value.

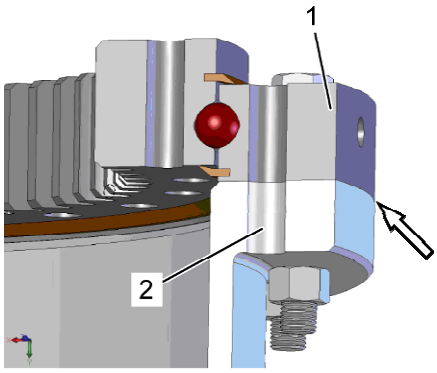


Fig. 20: Slewing ring fully supported

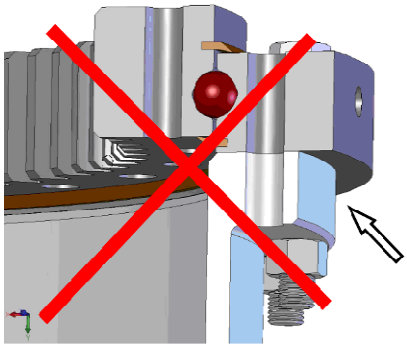


Fig. 21: Slewing ring not fully supported

The inner ring and outer ring of the slewing ring must always rest full width on the mating structure (Fig. 20).

5.2.7 Corrosion protection of the fastening holes and tapped holes

⚠ DANGER

- The lateral surfaces of all holes on a slewing ring must be permanently protected against corrosion. The execution of the corrosion protection must take into account the damage to such protection that occurs when bolting on items on site, in particular the rotor blades for example.
- Any corrosion protection applied in the factory by IMO must be also be checked after fitting the bolts and touched up if necessary.
- Corrosion of the holes can result in local stress cracks, which can cause cracks in the bearing rings and lead to bearing failure. Bearing failure can cause the entire structure to fail, such as the blade of a wind turbine falling, which may have catastrophic consequences.
- The surfaces of the mounting holes must not be mechanically damaged while installing the slewing rings or during their operation.

5.3 Installing the slewing ring

5.3.1 Hardness gap on the bearing rings

The hardness gap occurs during the raceway hardening and is located between the end and the beginning of inductive hardening. The hardness gap constitutes a zone with a reduced load carrying capacity and this must be specifically taken into consideration when positioning the slewing ring (⇨ section 5.3.2 "Positioning the slewing ring").
The position of the hardness gap on each of the bearing rings is defined or marked as follows:

5.3.1.1 For ball slewing rings:

	Slewing ring with internal gearing	Slewing ring with external gearing	Slewing ring without gearing
Inner ring	S-mark	Filling plug	S-mark or filling plug
Outer ring	Filling plug	S-mark	S-mark or filling plug

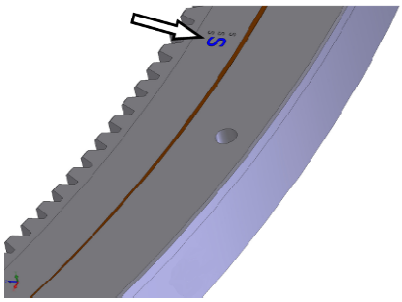


Fig. 22: S-mark

- S-mark:
  Stamped or sprayed onto the circle ring or outside diameter surface of the respective ring as a letter.

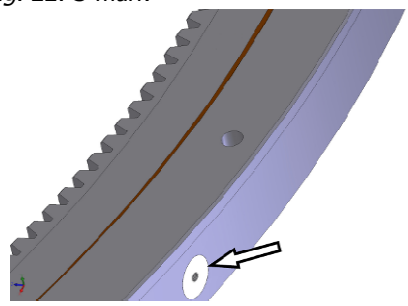


Fig. 23: Filling plug

- Filling plug:
  The hardness gap coincides with the filling plug, no other mark is present.

5.3.1.2 For roller bearings and designs without filling plug

- The hardness gap is always identified by an S-mark.

5.3.2 Positioning the slewing ring

⚠DANGER

The determination of main load zone must be carried out by skilled personnel with access to the analytical evaluations. Strictly comply with appropriate specifications! If the specifications are missing, consult the IMO Customer Service Department (⇨ page 2). Never determine the main load zone or position the slewing ring on your own. If not positioned correctly the slewing ring may fail suddenly and cause severe personal injury or material damage. Therefore strictly follow the steps described here for positioning.

When installing the slewing ring in turbines with lightning protection equipment, ensure that the distance between the discharger (lightning conductor) and the slewing ring is sufficient. The sparkover of the discharger may not damage the slewing ring. Current may not be conducted through the slewing ring.

IMPORTANT

For the positioning of the hardness gaps in the mating structure, adhere to the instructions of the system integrator or the wind turbine manufacturer!

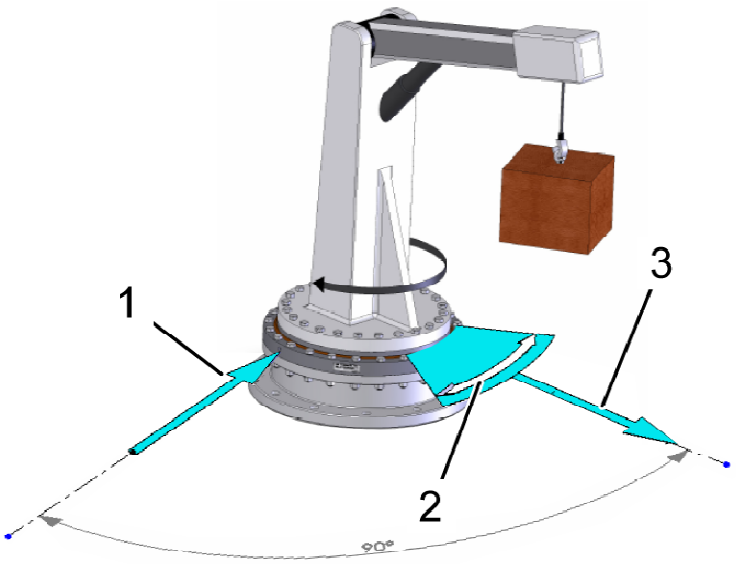


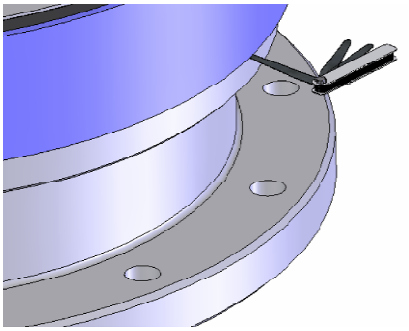
Fig. 24: Sample illustration for main load zone

CAUTION! The hardness gap (1) or the filling plugs in a slewing ring represent a zone of lessened load carrying capacity and must be taken into consideration appropriately in the configuration. Consequently place this marked point in a load-free zone or a reduced load zone if possible.

Procedure:

1. Determine the main load zone (3).

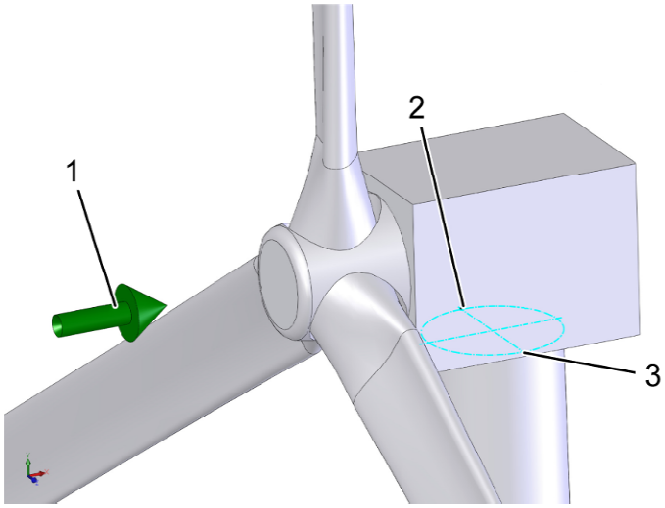
   The main load zone is the area of the slewing ring that is subject to the greatest stress in view of all the arising forces, torques and load scenarios.
   The main load zone (3) is normally in the slewing range (2).
   For details regarding the main load zone or the target position of the hardness gap, refer to the documents issued by the system integrator.
   If you have any queries in this regard, contact the system integrator.
2. Align the hardness gap on the slewing ring relative to the mating structure according to the instructions of the system integrator.
   The hardness gap (1) is normally arranged so that it is offset by 90° in relation to the main load zone (3).



3. Use a feeler gauge to check whether the support surface of the slewing ring is completely supported by the mating structure.
   If this is not the case, the support surface of the mating structure must be reworked (⇨ section 5.2.3 "Determining the flatness deviation, angular deviation and deformation").

Fig. 25: Check the support surface

5.3.2.1 Ideal positioning of the hardness gap of yaw bearings for wind turbines



(1) Geodesic main wind direction (direction of maximum wind speed)
(2) Hardness gap S – ring fastened to the yaw flange
(3) Hardness gap S – ring fastened to the machine housing

Fig. 26: Typical position of the hardness gap on the yaw bearing

5.3.2.2 Ideal positioning of the hardness gap of blade bearings for wind turbines

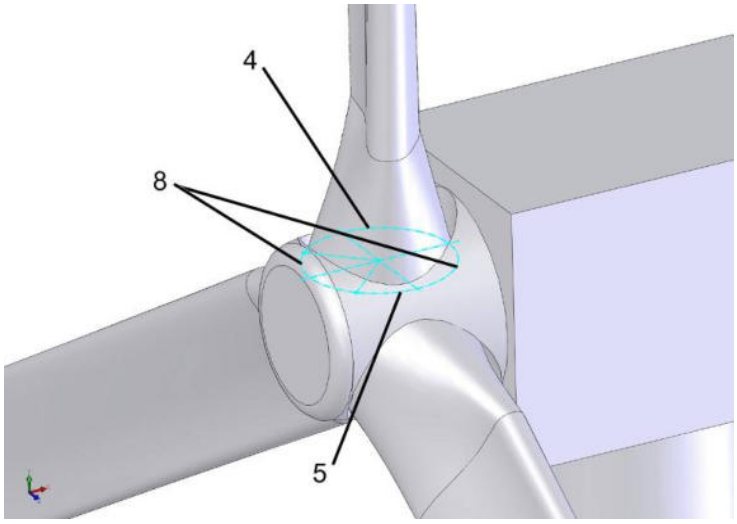


Fig. 27: Typical position of the hardness gap on the blade bearing with the blade in operating position

Blade bearing with blade in operating position:

(4) Hardness gap S – ring fastened to the blade
(5) Hardness gap S – ring fastened to the hub
(8) Main load zone tilting moment

5.3.2.3 Ideal positioning of the hardness gap of main bearings for wind turbines

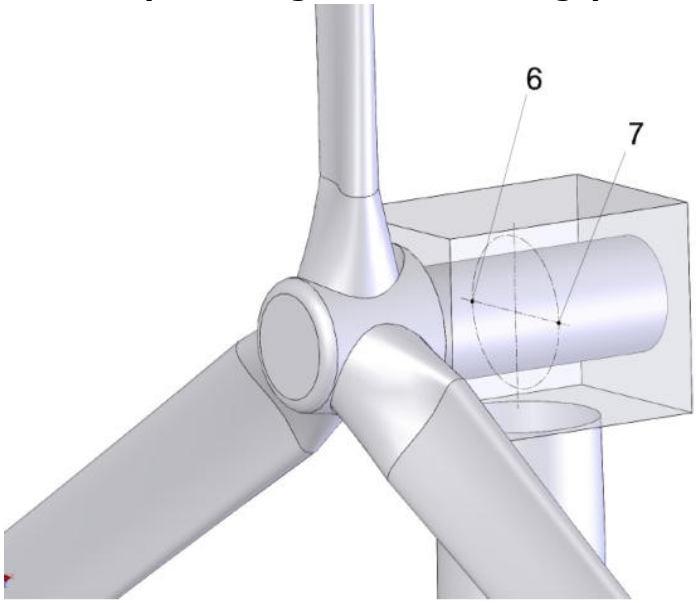


Fig. 28: Typical position of the hardness gap on the main bearing

Main bearing

For the ring fastened to the rotor: No specification for hardness gap position
For the ring fastened on the machine housing: Provide hardness gap for Pos. 6 or 7.
For standing inner ring: Position hardness gap at the bottom.

5.3.3 Bolting the slewing ring

IMPORTANT

The end customer or the owner must be instructed as to the tightening process that was used. This process must also be used when servicing the unit to check the bolted connection.

Normally, the mounting bolts are adequately secured through the correct assembly pre-tension.

If the specifications cannot be complied with, such as the use of fine threads or bolts of a different grade, etc., IMO Customer Service must be contacted (⇨ page 2).

Due to friction coefficient variations, the typical result is α_A = 1.5, which corresponds to torque-controlled tightening with a torque wrench, so that a controlled installation makes sense (cf. VDI 2230 2014, Table A8).

For mounting bolts from M30 or 1 1/8 - 7 UNC, we recommend using a hydraulic tensioning device (⇨ section "Tightening bolts with a hydraulic tensioning device").

⚠ DANGER

When installing and fastening the slewing ring in the turbine, the lateral surface of the holes must be permanently protected against corrosion. See also chapter 5.2.6!

⚠ DANGER

The following instructions must be strictly complied with, if not the entire structure may fail. Failure of the entire structure can cause severe personal injury or material damage:

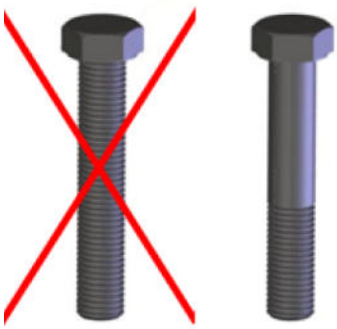


Fig. 29: Do not use continuous thread

Bolts:

- Use the quantity, size, quality and strength class in accordance with the IMO calculation or catalog.
- Only use **new** bolts of the quality class 10.9 EN ISO 898 (metric) or SAE grade 8.
- **Do not reuse** bolts, nuts and washers.
- Do not use split rings, spring washers, etc.
- Use bolts **without** a continuous thread to the head. See Fig. 30.
- Use a torque wrench or a hydraulic tensioning device to tighten the bolts.
  Impact screwdrivers may not be used as these can cause impermissible deviations between the bolt tightening forces.

Installation and commissioning

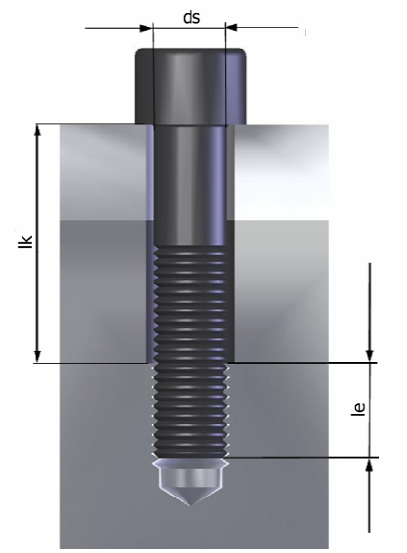
⚠ DANGER

The following instructions must be strictly complied with, if not the entire structure may fail. Failure of the entire structure can cause severe personal injury or material damage:

- If the permissible limiting surface pressure for various materials (see Table 5) is exceeded, washers for 10.9 EN ISO 898 screws with 300HV must be used (see DIN EN ISO 7089). If the material deviates, please contact the Application Engineering Department.

Material	Max. surface pressure	
	in N/mm²	in lbs/in²
S355/C45N	600	87023
46Cr4V/42CrMo4V	800	116030
X20Cr13	600	87023

Table 5



ds = bolt diameter
lk = grip length
le = insertion depth

Fig. 30: Mounting element

- Select the screw length so that the minimum bolt insertion depth is achieved and in ratio to the tensile strength of the mating structure (see Table 6).

Tensile strength R_m of the mating structure		Minimum bolt insertion depth (le)
in N/mm²	in lbs/in²	Strength class 10.9 EN ISO 898 / grade 8
< 500	< 72520	Mating structures are not permissible
500 to 700	72520 to 101525	le = 1.4*ds
700 to 900	101525 to 130535	le = 1.1*ds
over 900	over 130535	le = 0.9*ds

Table 6

- Maintain a clamp length ratio (grip length to the diameter of the bolt) of at least ≥ 5 to a maximum ≤ 10.

5.3.3.1 Procedure

IMPORTANT

Strictly comply with the procedure specified below to avoid impermissible deviations between the bolt tightening forces:
Fasten the slewing ring in an unstressed state.
First fasten the non-geared bearing ring, then fasten the geared bearing ring!

1. Lubricate the bolt threads as necessary.
   (e.g. with Anti-Seize Paste from WEICON GmbH & Co. KG or Micro PE dry solid lubricant film DF 977S from Microgleit Spezialschmierstoffe GmbH).
   Attention Do not lubricate the bolt thread when locking the bolt thread with adhesive!
2. Preload the bolts, with washers if required, crosswise in 3 steps, 30%, 80%, and 100% of the tightening torque, or the hydraulically applied preload force (see tables).
3. In this process, turn the unbolted ring several times. Repeat the procedure for the bearing ring that has not yet been bolted.

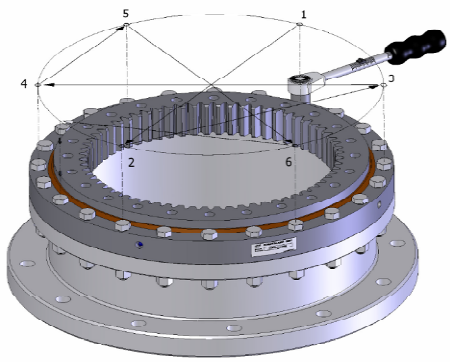


Fig. 31: Tighten crosswise

5.3.3.2 Tightening bolts with a torque wrench

For the calculation of the torques in Tables 7 to 10, the following applies:

- F_M and M_A calculated in accordance with VDI guideline 2230 (February 2003).
- Head friction coefficient - bolt μK=0.09 to 0.15.
- Thread friction coefficient - bolt μG=0.09 to 0.15 (bolt lubricated).
- Head dimension - hexagon head bolt DIN EN ISO 4014.
- The torque wrench has an assembly accuracy of less than ± 3%.
- 90% of the bolt yield strength is utilized.
- For calculation of the tensile stress area, the minimum dimensions of the flank and core diameters have been considered; Table 7 & 8 in accordance with tolerance class 6g from DIN 13-20 Table 9 & 10 in accordance with tolerance class 2A from ASME B1.1-2003.
- In respect of the torque for bolts larger than M30 or 1 ¼ UNC, please contact IMO Customer Service.

Installation and commissioning

5.3.3.2.1 Tightening torque for standard metric threads in accordance with DIN 13 strength class 10.9 EN ISO 898

Tightening torque M_A in Nm with incremental tightening

Mounting bolt dimensions	Step 1 30%	Step 2 80%	Step 3 100%	Minimum mounting preload force $F_{M\ min}$	Maximum mounting preload force $F_{M\ max}$
	Tightening torque M_A in Nm			in kN	in kN
M5	2	5	6.4	6.4	10.3
M6	3	9	11.2	9.1	14.6
M8	8	22	27.2	16.6	27.0
M10	16	43	53.8	26.4	43.1
M12	28	74	92.9	38.5	62.9
M14	45	119	149	53	87
M16	66	177	229	72	119
M18	96	256	320	89	145
M20	135	361	451	113	187
M22	184	492	615	140	233
M24	233	620	775	163	269
M27	341	910	1138	212	354
M30	465	1241	1551	259	431

Table 7

Tightening torque M_A in ft-lbs for incremental tightening

Mounting bolt dimensions	Step 1 30%	Step 2 80%	Step 3 100%	Minimum mounting preload force $F_{M\ min}$	Maximum mounting preload force $F_{M\ max}$
	Tightening torque M_A in ft-lbs			in lbs	in lbs
M5	1	4	4.7	1439	2316
M6	2	7	8.3	2046	3282
M8	6	16	20.1	3732	6070
M10	12	32	39.7	5935	9689
M12	21	55	69	8655	14140
M14	33	88	110	11870	19446
M16	49	131	163	16231	26752
M18	71	189	236	19896	32665
M20	100	266	332	25381	41972
M22	136	363	453	31518	52403
M24	171	457	572	36576	60451
M27	252	671	839	47749	79515
M30	343	915	1144	58315	96870

Table 8

5.3.3.2.2 Tightening torque for inch thread in accordance with ANSI B1.1 SAE grade 8

Tightening torque M_A in Nm with incremental tightening

Mounting bolt dimensions	Step 1 30%	Step 2 80%	Step 3 100%	Minimum mounting preload force $F_{M\ min}$	Maximum mounting preload force $F_{M\ max}$
	Tightening torque M_A in Nm			in kN	in kN
1/4 – 20 UNC	3	8	9.7	9.1	14.1
5/16 – 18 UNC	6	16	20.4	15.1	23.8
3/8 – 16 UNC	11	28	35.1	22.3	35.4
7/16 – 14 UNC	17	44	55.4	30.7	48.8
1/2 – 13 UNC	32	84	105	40	66
5/8 –12 UNC	63	167	209	64	105
3/4 – 10 UNC	111	295	368	96	157
7/8 – 9 UNC	177	473	591	132	218
1 – 8 UNC	266	708	886	173	287
1 1/8 – 7 UNC	377	1005	1257	219	362
1 1/4 – 7 UNC	528	1409	1761	278	462

Table 9

Tightening torque M_A in ft-lbs for incremental tightening

Mounting bolt dimensions	Step 1 30%	Step 2 80%	Step 3 100%	Minimum mounting preload force $F_{M\ min}$	Maximum mounting preload force $F_{M\ max}$
	Tightening torque M_A in ft-lbs			in lbs	in lbs
1/4 – 20 UNC	2	6	7.2	2046	3170
5/16 – 18 UNC	4	12	15.0	3395	5350
3/8 – 16 UNC	6	21	25.9	5013	7958
7/16 – 14 UNC	10	33	40.9	6902	10971
1/2 – 13 UNC	19	62	78	9060	14770
5/8 –12 UNC	37	123	154	14455	23695
3/4 – 10 UNC	65	217	272	21469	35362
7/8 – 9 UNC	105	349	436	29675	49053
1 – 8 UNC	157	523	653	38982	64498
1 1/8 – 7 UNC	222	741	927	49166	81268
1 1/4 – 7 UNC	312	1039	1299	62474	103907

Table 10

5.3.3.3 Tightening bolts with a hydraulic clamping fixture

Observe the operating manual for the hydraulic tensioning device! The operating manual of the hydraulic tensioning device sets out how hydraulic pressure is converted to pre-tensioning force.

⚠ DANGER	**Do not exceed the prescribed hydraulic pressure when preloading the bolts.** **The bolt pre-tension must not exceed 90% of the bolt yield strength (see tables).** **Excess hydraulic pressure can cause failure of the bolted union with the mating structure and may cause severe personal injury or material damage.**

IMPORTANT	**When using different threaded bolts, other strength classes or special tightening procedures, you must always consult IMO Customer Service (⇨ page 2).**
Comment concerning the tables	■ 90% of the bolt yield strength is utilized. ■ For calculation of the tensile stress area, the minimum dimensions of the flank and core diameters have been considered; Table 11 & 12 in accordance with tolerance class 6g from DIN 13-20 Table 13 & 14 in accordance with tolerance class 2A from ASME B1.1-2003. ■ A rebound of approx. 10-20% corresponds to α_a of approx. 1.2.
Controlled preloading of the bolts	In respect of 12.9 bolts, use a tensioning device that is one thread size larger and an interchangeable bushing with matching thread, i.e. the increased space requirements must also be considered when tensioning. The bolt pre-tension can be determined during assembly by measuring the bolt length in an installed state. Suitable methods for this are: ■ Ultrasonic test ■ Mechanical measurement (e.g. micrometer gauge) ■ Special bolts/nuts

5.3.3.3.1 Mounting preload force for standard metric threads in accordance with DIN 2510 strength class 10.9 EN ISO 898

Mounting preload force F_M in kN for incremental tightening

Mounting bolt Dimension	Step 1 30%	Step 2 80%	Step 3 100%
	Mounting preload force F_M [1)] in kN		
M24	85	227	284
M27	112	298	373
M30	137	364	455
M33	170	452	565
M36	200	533	666
M39	239	638	798
M42	275	734	917
M45	321	857	1071
M48	362	966	1207
M52	433	1155	1444
M56	500	1334	1668
M60	581	1550	1937
M64	660	1759	2199
M68	755	2012	2515

Table 11

Mounting preload force F_M in lbs for incremental tightening

Mounting bolt dimensions	Step 1 30%	Step 2 80%	Step 3 100%
	Mounting preload force F_M [1)] in lbs		
M24	19154	51077	63846
M27	25156	67083	83854
M30	30686	81830	102288
M33	38105	101614	127017
M36	44917	119778	149723
M39	53819	143518	179398
M42	61845	164920	206150
M45	72231	192616	240770
M48	81403	217076	271344
M52	97387	259699	324624
M56	112494	299985	374981
M60	130636	348364	435455
M64	148306	395484	494355
M68	169618	452316	565394

Table 12

F_M for hydraulic tensioning device preloaded to 90% of yield strength

5.3.3.3.2 Mounting preload force for inch thread in accordance with ANSI B1.1 SAE grade 8

Mounting preload force F_M in kN for incremental tightening

Mounting bolt Dimension	Step 1 30%	Step 2 80%	Step 3 100%
	Mounting preload force F_M [1] in kN		
1 – 8 UNC	93	248	310
1 1/8 – 7 UNC	117	312	390
1 1/4 – 7 UNC	149	398	497
1 3/8 – 6 UNC	178	474	592
1 1/2 – 6 UNC	216	577	721
1 3/4 – 5 UNC	293	780	975
2 – 4.5 UNC	385	1027	1284
2 1/4 – 4.5 UNC	501	1337	1671
2 1/2 – 4 UNC	617	1646	2058
2 3/4 – 4 UNC	763	2034	2542

Table 13

Mounting preload force F_M in lbs for incremental tightening

Mounting bolt dimensions	Step 1 30%	Step 2 80%	Step 3 100%
	Mounting preload force F_M [1] in lbs		
1 – 8 UNC	20907	55753	69691
1 1/8 – 7 UNC	26303	70140	87675
1 1/4 – 7 UNC	33519	89384	111730
1 3/8 – 6 UNC	39926	106470	133087
1 1/2 – 6 UNC	48626	129670	162087
1 3/4 – 5 UNC	65757	175351	219189
2 – 4.5 UNC	86596	230924	288655
2 1/4 – 4.5 UNC	112697	300525	375656
2 1/2 – 4 UNC	138797	370125	462657
2 3/4 – 4 UNC	171439	457171	571464

Table 14

[1] F_M for the hydraulic tensioning device, preloaded to 90% of the yield strength

5.3.4 Tilting clearance measurement

Tilting clearance increases as raceway system wear increases. In order to determine the amount by which the tilting clearance is to be increased, a reference measurement must be taken after installation and documented prior to commissioning. This is the only way to determine that changes have occurred.

In respect of wind turbines:

- If possible, take the measurement at wind speeds under 4 m/s.
- Record the wind speed.

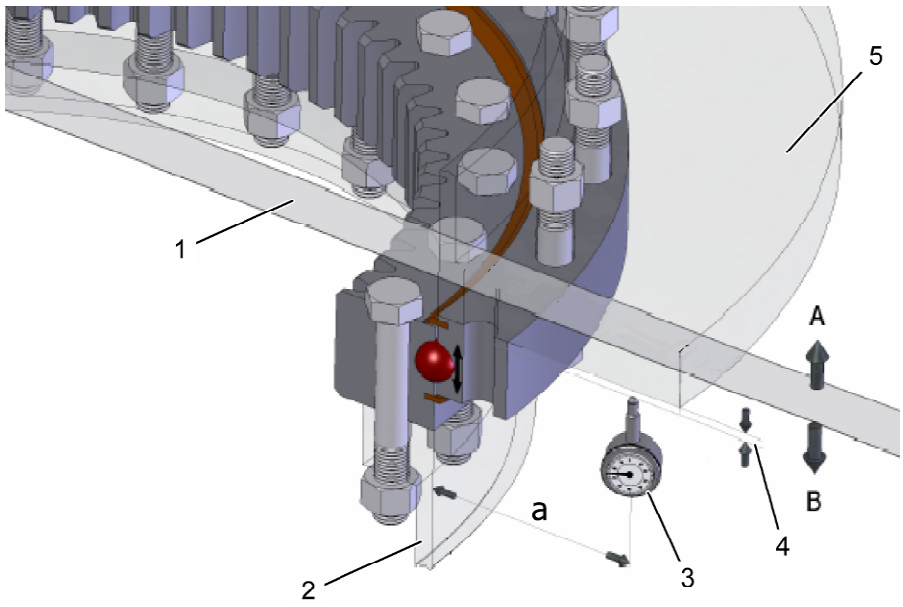


Fig. 32: Tilting clearance measurement arrangement

1 Main load direction A - B
2 Lower mating structure
3 Dial gauge
4 Tilting clearance
5 Upper mating structure

Procedure:

Tilting clearance measurement

1. Switch off the turbine and safeguard it from being restarted.
2. Permanently mark the measuring point on all bearing rings in the main load direction.
3. Attach the dial gauge as shown in Fig. 32.
4. Defined tilting moment, min. 50% of max. operating load, in direction "A".
5. Set dial gauge to zero.
6. Defined tilting moment, min. 50% of max. operating load, in direction "B".

↳ The displayed measured value m1 corresponds to the existing tilting clearance and serves as the base value that will be used for comparison at later inspections.

7. Log and document all the measured values.

- All subsequent inspections must be carried out at the same measuring point, with the same loads, at the same position of the bearing rings in relation to each other and in the same sequence.
- In respect of purely axial or radial loads, perform the tilting clearance check by applying an additional tilt load.

5.3.4.1 Tilting clearance measurement (axial) for 3-row roller slewing rings

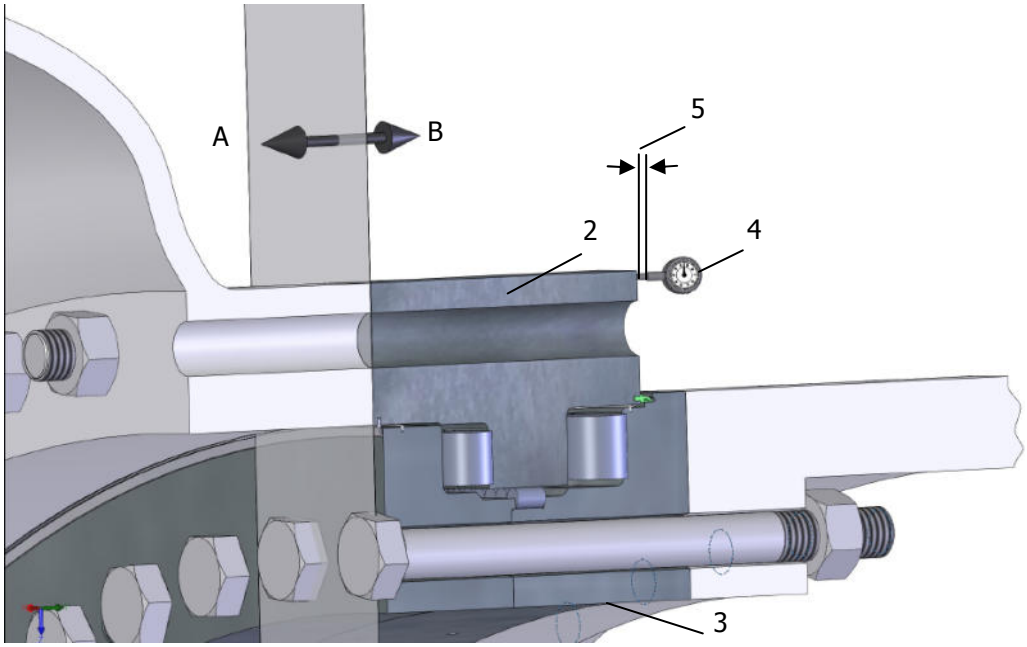


Fig 33: Axial tilting free clearance measurement

1 Main load direction A - B
2 Main bearing outer ring
3 Stationary inner ring
4 Dial gauge
5 Axial clearance

Procedure:

Tilting clearance measurement

1. Carry out the measurement as described under "Determining the tilting clearance".

5.3.5 Radial clearance measurement for 3-row roller slewing rings

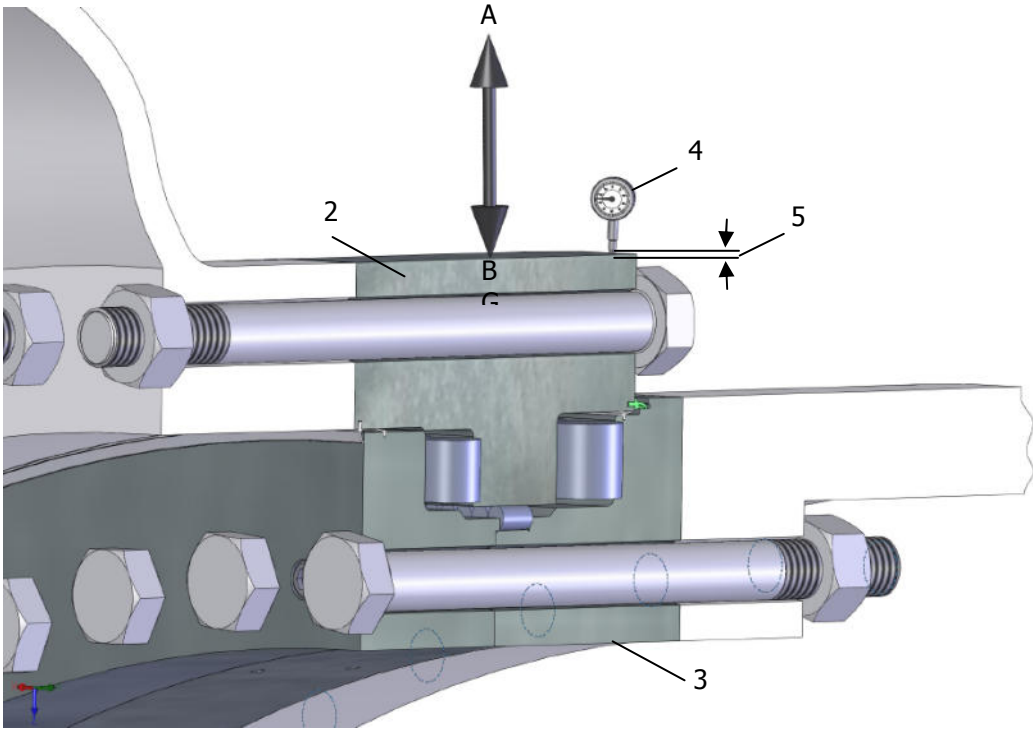


Fig 34: Radial clearance measurement

1 Main load direction A - B
2 Outer ring
3 Stationary inner ring
4 Dial gauge
5 Radial clearance

Procedure:

Radial clearance measurement

1. Switch off the turbine and safeguard it from being restarted.
2. Permanently mark the measuring point in the main load direction of the radial load.
3. Attach the dial gauge as shown in Fig. 34.
4. Apply the defined radial load in direction A. When doing so, you must compensate for the existing radial load.
5. Set dial gauge to zero.
6. Reduce the defined radial load to zero (only the external radial load is still active).
   The displayed measured value m1 corresponds to the existing radial clearance and serves as the base value that will be used for comparison at later inspections.

- Due to the deflection of the raceway systems and the mating structure, the values determined in this way may vary from the clearance specifications in the drawing and serve as reference values for the specified installation.

5.3.6 Determining the amount of settling

IMPORTANT

Measurement of the amount of settling is only permissible with predominantly axially loaded slewing rings.
Criterion: $M_{Kmax} < D_L / 4000 * F_{ax}$
In case of questions, please contact the IMO application engineering department.

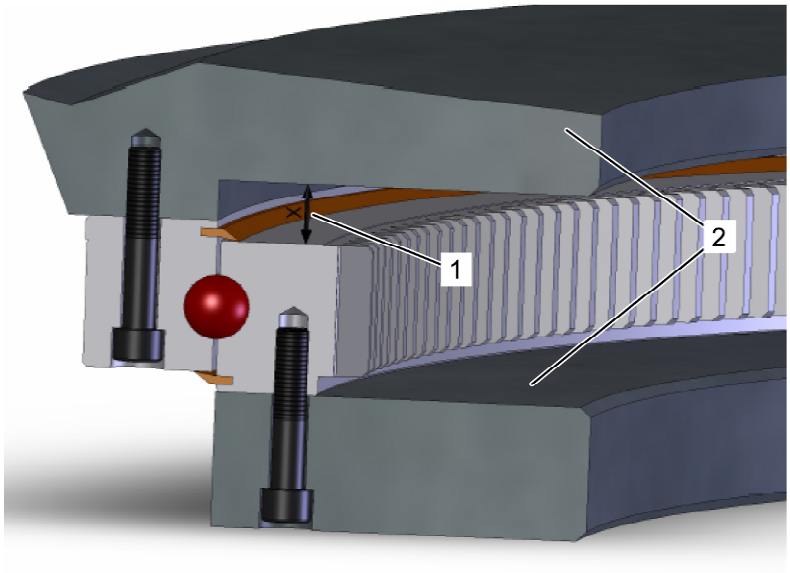


Fig. 35: Measuring points for determining the amount of settling

1 Measuring points for determining the amount of settling
2 Mating structures

Procedure:

Determining the amount of settling

- Apply markings to the bearing in the X-planes (⇨ Fig. 36) A-A, B-B, C-C, D-D on the inner and outer ring before installation.

Select the type and placement of the markings so that they can be found and remain accessible after completion of installation. The filling plug and hardness gap must be centered between two marking planes.

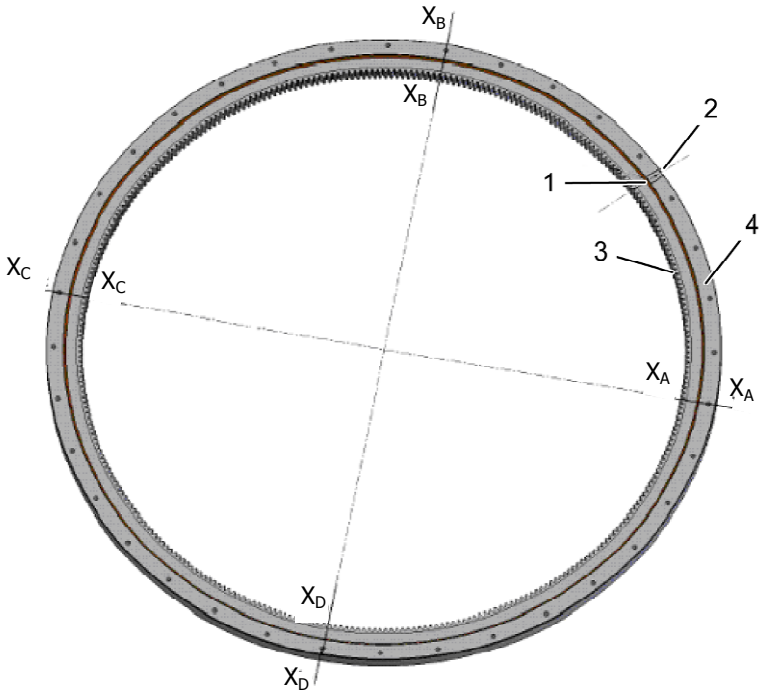


Fig. 36: Marking of the slewing ring

1 Hardness gap
2 Filling plug
3 Geared inner ring
4 Non-geared outer ring

- After installation and the attachment of all connecting components, the initial measurement is taken prior to the final commissioning of the turbine.
- Log and document all the measured values.
- Perform the measurement directly on the bearing if the installation permits this.
- The measuring points are in the four marking planes and the markings on the inner ring and outer ring must agree.
- After the initial measurement, the four values X_{AG} to X_{DG} are available (see also section 6.4.2 "Checking the tilting clearance and amount of settling").

If the slewing rings are to be primarily or exclusively subjected to radial loads, consult IMO Customer Service
(⇨ page 2).

5.3.6.1 Determination of the amount of settling for yaw bearings of wind turbines

- The rotor must be in the wind direction, the rotor blades are turned away from the wind. After installation and the attachment of all connecting components, the initial measurement is taken prior to commissioning the turbine. The wind speed should be less than 4 m/sec.
- Log and document all measured values including wind speed.
- Perform the measurement directly on the bearing if the installation permits this.
- The measuring points are in the four marking planes and the markings on the inner ring and outer ring must agree.
- After the initial measurement, the four values X_{AG} to X_{DG} are available (see also section 6.4.2 "Checking the tilting clearance and amount of settling").

5.3.7 Adjusting the circumferential backlash

During the installation of geared slewing rings and gear rims, the circumferential backlash between the slewing ring and pinion or between the annular gear and pinion must be adjusted.

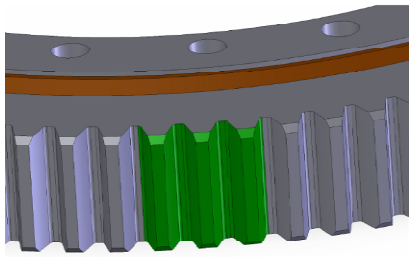


Fig. 37: Green mark

1. Adjust the circumferential backlash to the specified set point on the green marked point (the narrowest point of the gearing).

- The set point δ_f in mm is:
  δ_f = 0.03 to 0.04 x m
  m = modulus in mm (take from the drawing)
- The set point δ_f in inch is:
  δ_f = 0.03 to 0.04 x $1/P_d$
  P_d = diametral pitch in 1/inch (take from the drawing)

IMPORTANT

- **Do not exceed or undercut the specified set point. Failure to comply with this instruction may cause damage to the slewing ring.**
- **In respect of segment hardened gear tooth systems or segment gearing, pay attention to the proper position.**

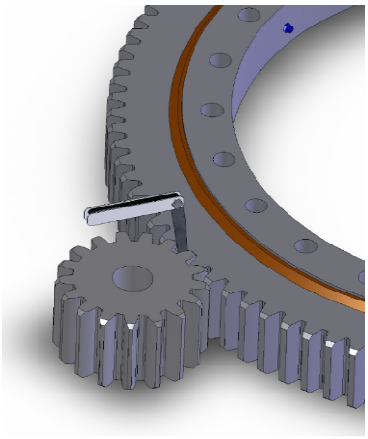


Fig. 38: Check the circumferential backlash with feeler gauge

2. Use a feeler gauge to measure the circumferential backlash.
   - If deviations to the specified values are determined at the narrowest point, the center distance must be corrected by sliding the drive motor with the pinion.
   - In respect of non-sliding pinions, correct the center distance by releasing, adjusting and retightening the slewing ring. If this is not possible, e.g. due to existing centering elements, contact the IMO Customer Service (⇨ page 2).
3. Move the slewing ring through the entire operating range. While doing so, ensure that there are no constrictions.

ℹ Depending on concentricity of the gears, the installation tolerances, the gearing dimensions, etc., significantly greater circumferential backlash values may arise at the widest point of the gear pairing.

ℹ In respect of the pinion, ensure that the modulus and the pressure angle correspond to that of the slewing ring. The relevant information is provided in the respective drawings.

ℹ In respect of slewing rings or gear rims in which the gearing is only hardened in one segment, ensure that the teeth under load are always in the area of the hardened segment. In this case, however, the circumferential backlash is also adjusted at the green mark.

WARNING! **For slewing rings where the gearing is only cut in one segment, ensure that limit stops are present so that the pinion never runs into the non-geared area. There is extreme risk of fracture. Improper installation and commissioning may cause serious personal injury and/or property damage.**

Recommended tooth flank backlash [mm] in the area of the narrowest point:

Modulus in mm	**4**	**5**	**6**	**8**	**10**
Permissible tooth flank backlash δ_f	0.12-0.16	0.15-0.20	0.18-0.24	0.24-0.32	0.30-0.40

Modulus in mm	**12**	**14**	**16**	**18**	**20**
Permissible tooth flank backlash δ_f	0.36-0.48	0.42-0.56	0.48-0.64	0.54-0.72	0.60-0.80

Modulus in mm	**22**	**24**	**25**	**28**	**30**
Permissible tooth flank backlash δ_f	0.66-0.88	0.72-0.96	0.75-1.00	0.84-1.12	0.90-1.20

Table 15

Recommended tooth flank backlash [inches] in the area of the narrowest point:

Modulus in mm	**4**	**5**	**6**	**8**	**10**
Permissible tooth flank backlash δ_f	0.0047-0.0063	0.0059-0.0079	0.0071-0.0094	0.0094-0.0126	0.0118-0.0157

Modulus in mm	**12**	**14**	**16**	**18**	**20**
Permissible tooth flank backlash δ_f	0.0142-0.0189	0.0165-0.0220	0.0189-0.0252	0.0213-0.0283	0.0236-0.0315

Modulus in mm	**22**	**24**	**25**	**28**	**30**
Permissible tooth flank backlash δ_f	0.0260-0.0346	0.0283-0.0378	0.0295-0.0394	0.0331-0.0441	0.0354-0.0472

Table 16

Recommended tooth flank backlash [inches] in the area of the narrowest point:

Diametral pitch in 1/in	**5**	**4**	**3.5**	**3**	**2.5**	**2**	**1.75**	**1.5**	**1**
Permissible tooth flank backlash δ_f	0.006-0.008	0.008-0.010	0.009-0.011	0.010-0.013	0.012-0.016	0.015-0.020	0.017-0.023	0.020-0.026	0.03-0.04

Table 17

CAUTION! For gears that are not listed in the table, contact IMO Customer Service (⇨ page 2). Insufficient circumferential backlash results in constraining forces (risk of fracture); premature gearing wear, and it can damage the pinion drive. Excessive circumferential backlash may cause oscillation, vibrations, and damage to the tooth flank.

5.4 Function test

- The slewing ring or gear rim must rotate uniformly. Deviations in the mating structure as well as the influence of exterior loads can significantly affect the friction torque.
- Move the installed slewing ring through the entire operating range several times. Check whether the slewing ring turns uniformly and without jerking.
- After the function test, check the tightening torque of the mounting bolts.

In respect of wind turbines:

- ***IMPORTANT!*** The owner must ensure that the loads on the main bearing are not unnecessarily increased by rotor imbalance or incorrect generator or rotor blade settings. Rotor imbalance can be caused by incorrectly adjusted rotor blades, uneven weight distribution of the individual rotor blades, ice on the rotor blades or the like. This can result in loads that lead to a considerable shortening of the service life.
- Main bearings are subject to a run-in process in the first three months. The bearing temperature must be documented during this time. Based on past experience, the temperature of main bearings is somewhat higher during the run-in phase. If the bearing temperature rises above 80° C during this phase, IMO Customer Service must be contacted (⇨ page 2).

- If the main bearings are subjected to a test run during installation or in

a test facility, it must be ensured that the bearings are sufficiently lubricated. If necessary, the area of the seal contact surfaces must be greased manually.

6 Maintenance

6.1. Security

⚠ DANGER

Prior to starting work switch off all power supplies and safeguard them from being switched on again.
When performing maintenance tasks there is a danger of the power supply being switched on without authorization. This poses a life-threatening hazard for persons in the danger zone.

⚠ WARNING

Prior to starting work ensure that there is adequate free space for installation. Ensure order and cleanliness at the installation location! Parts and tools that are lying loose or on top of each other are accident hazards! If components have been removed, ensure that they are properly re-installed, that all mounting elements are re-installed, and that all threaded connections are tightened with the specified bolt-tightening torque. Improper maintenance may cause serious injury or property damage.

Personnel

- Only qualified, skilled personnel may perform maintenance and inspection work.

Personal protective equipment

Wear the following personal protective equipment for all maintenance work:

- Protective work clothing
- Protective gloves
- Safety footwear

Environmental protection

Comply with the following instructions for environmental protection when performing maintenance work:

- Remove escaping, used or excess grease at all lubricating points where lubricant is applied by hand and dispose of it in accordance with the applicable local regulations.
- Collect used oil in suitable containers and dispose of it in accordance with the applicable local regulations.

6.2. Maintenance of slewing rings

- All maintenance must be performed by skilled, qualified personnel.
- In principle, all maintenance work must be recorded in the logbook.
- In the following sections, the maintenance tasks are described that are required for optimal and trouble-free operation.
- IMO Customer Service is available to answer your questions relating to maintenance tasks and maintenance intervals (⇨ page 2).

6.2.1. Relubrication intervals

⚠DANGER

Inadequate lubrication can severely restrict the functional capacity and the service life of the slewing ring and, in extreme cases, cause a malfunction.

- ℹ The main cause for the failure of slewing rings is inadequate lubrication!
- ℹ The relubrication intervals essentially depend on existing working and environmental conditions, as well as the version of the slewing ring.

IMPORTANT

If IMO provides more specific information for the maintenance or lubrication, the more specific information takes priority!

Slewing rings must always be relubricated:

- During commissioning.
- After every cleaning, e.g. hosing down with water, washing systems, etc.
- before and after longer periods of standstill, e.g. in respect of cranes and construction machines during the winter months.

Table 18 is valid for the following conditions:

- Operating temperature on the slewing ring in the range of -25° C to 70° C (-13° F to 158° F)
- The circumferential speed is within the permissible range.
- Low to moderate load.
- If increased wear is noticed, the maintenance intervals must be shortened.

IMPORTANT

- Precise relubrication intervals can only be determined by tests under operating conditions.
- If dry or hardened grease appears, the lubricating intervals must be shortened and old grease removed from the lubrication channels!

Work conditions	Lubricating interval
Dry and clean workshop (Lathes/robots, etc.)	Approx. every 300 operating hours, however at least every 6 months
Difficult conditions in open terrain (Cranes/excavators, etc.)	Every 100 to 200 operating hours, however at least every 4 months
Aggressive climactic conditions – maritime climates, desert environments, arctic climates, extremely polluted environments, ≥ 70 operating hours per week	Every 50 operating hours, however at least every 2 months
Extreme conditions, continuous operation (tunnel boring machines/steel plants/wind turbines)	Continuous lubrication (through central lubrication system or lubricators)

Table 18

6.3. Maintenance schedule for slewing rings

Interval	Maintenance task
Weekly	Visual inspection of the greasing of the slewing ring and gearing
	Check the seal
During commissioning and repeatedly after 1,000 operating hours or after 3 months at the latest	Check the bolt pre-tension and retighten if necessary
	Check and document the tilting clearance and settling
After Table 18	Lubricate the slewing ring and gearing
	Check the bolt pre-tension and retighten if necessary
	Check the tilting clearance and settling
	Check the grease collecting containers and replace if necessary

Table 19

6.4. Maintenance schedule for main bearings of wind turbines

Interval	Maintenance task
Weekly	Grease the main bearing using the central lubrication system
Weekly during the first 3 months	Check and document the bearing temperature
	Document the quantity of grease supplied and discharged and check the grease outlet holes for blockages. Remove any used grease blockages from the outlet channels If no grease arrives in the collection containers, please inform IMO Customer Service.
3 months after commissioning	Check the bolt pre-tension and retighten if necessary
	Check the tilting clearance and settling or use the monitoring system to record these
Every 6 months	Check the grease collecting containers and replace if necessary
	Clean the grease outlet holes
	Check the seal
Every 12 months	Check the bolt pre-tension and retighten if necessary
	Check the tilting clearance and settling
	Remove and store grease samples

Table 20

6.5. Cleaning

IMPORTANT

Only use cold solvent (e.g. diesel oil,) that does not corrode the seal material. Cleaning agents may not penetrate into the slewing ring. Do not use a high-pressure cleaner to clean the slewing ring. Cleaning agents that are not suitable damage the seal and can cause bearing damage.
Always observe the relevant environmental protection guidelines.

Wear the following additional protective equipment for cleaning tasks:

Face protection
To protect the eyes and face from solvents.

Chemical-resistant protective gloves
To protect hands from aggressive substances.
Check the protective gloves for leaks prior to use. Clean the gloves before pulling them off, then store them in a well-ventilated location.

- When using cleaning agents, ensure that there is adequate ventilation.
- Remove used grease, dust and dirt with a lint-free cloth.

6.6. Bolt pre-tension

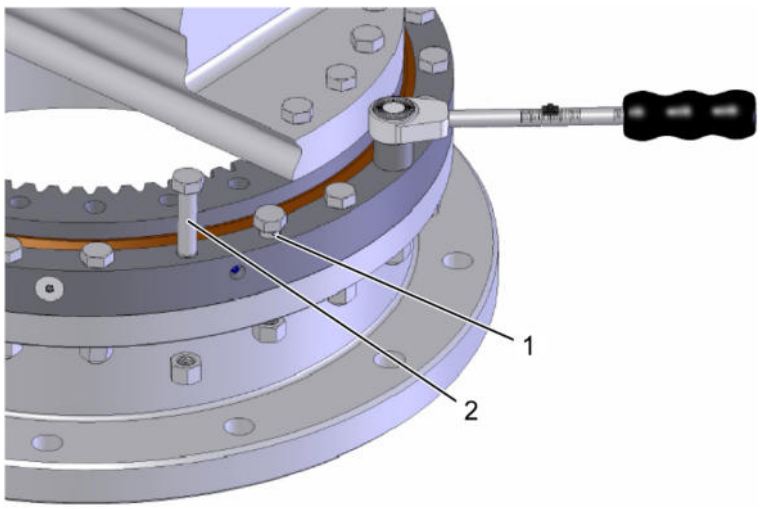


Fig. 39: Inspect the mounting bolts

1 Loosened bolt
2 Detached bolt

Only a specialist may carry this out.

- Special tools required:
  - Torque wrench
  - Hydraulic tensioning device
- After extreme loads (storms), the bolts must be checked separately.
- Replace loose and detached bolts or nuts and washers with new bolts or new nuts and washers.
- Use the same bolt size and bolt grade.

When checking the bolted connection, always use the same tightening procedure as specified for the installation of the slewing ring. If a hydraulic tensioning device was used to tighten the bolts, then a hydraulic tensioning device must also be used to check the bolt pre-tension.

6.7. Checking the tilting clearance and settling

Tilting clearance

The value m1 determined at the installation serves as the base value (see the section "Determining the tilting clearance").

- Determine the verification measurement value m_x as described in the section "Determining the tilting clearance".
- Subtract the base value m1 from the value m_x of the verification measurement:
  $\delta_k = m_x - m1 \leq 2 * S_{n\_perm.}$ $S_{n\_perm.}$ = see tab. 21

IMPORTANT

Do not exceed the specified value for tilting clearance increase.

⚠ WARNING

If the maximum permissible tilting clearance increase is reached, then the system must be brought to a standstill and the slewing ring must be replaced immediately, as safe operation can no longer be ensured.

Settling

The measured values X_{AG} to X_{DG} determined at installation serve as the base values (see chapter "Determining the settling ").

- Determine the settling as described in "Determining the settling".

IMPORTANT

Do not exceed the specified settling.

Base values	X_{AG}	X_{BG}	X_{CG}	X_{DG}
Minus the wear measurement	$X_{A1...n}$	$X_{B1...n}$	$X_{C1...n}$	$X_{D1...n}$

Security

	= Settling	$S_{A1...n}$	$S_{B1...n}$	$S_{C1...n}$	$S_{D1...n}$

Settling : Difference between the measured value of the initial measurement and the actual determined measured value at points A to D.

X_{AG} to X_{DG}: Values of the initial measurement

$X_{A1...n}$ to $X_{D1...n}$: Actual measured values

$S_n = X_G - X_n < S_{n\_perm.}$: Settling at position A to D

The maximum permissible removal clearance depends on many factors and must be specified individually for the respective turbine. However, the values in the tables below apply as the upper limit values at which the slewing ring must, in any event, be replaced.

Permissible amount of settling

Rolling element diameter dw [mm]	**12**	**16**	**20**	**25**	**32**	**40**	**45**	**50**	**60**	**70**	**80**	**100**
Ball removal clearance $S_{n\_perm.}$ [mm]	0.51	0.58	0.65	0.74	0.86	1.00	1.09	1.17	1.35	1.52	1.70	2.05
Ball removal clearance $S_{n\ perm.}$ [inches]	0.0201	0.0228	0.0256	0.0291	0.0339	0.0394	0.0429	0.0461	0.0531	0.0598	0.0669	0.0807
Roller removal clearance $S_{n\_perm.}$ [mm]	0.09	0.12	0.16	0.20	0.26	0.32	0.37	0.41	0.49	0.58	0.66	0.83
Roller removal clearance $S_{n\ perm.}$ [inches]	0.0035	0.0047	0.0063	0.0079	0.0102	0.0126	0.0146	0.0161	0.0193	0.0228	0.0260	0.0327

Table 21

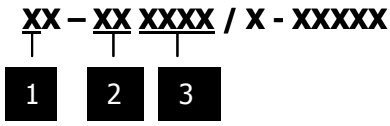


Fig. 40: Drawing number

The bearing design (1), the size of the rolling element diameter dw (2) and of the raceway diameter D_L (3) is contained in the drawing number and is shown on the accompanying documents or the type plate. In the bearing design (1), numbers 0, 1, 4 and 8 represent a ball slewing ring, while the number 3 represents a roller bearing or roller slewing ring. All the dimensions in the drawing number are metric measurements [mm].

6.8. Relubricating the slewing ring

DANGER

Inadequate lubrication can severely restrict the functional capacity and the service life of the slewing ring and, in extreme cases, cause a malfunction.

WARNING

Always follow the instructions provided by the manufacturer of the grease and comply with the applicable safety instructions when using lubricants.

- An automatic relubrication system significantly facilitates relubrication for the raceway system and the gearing. The functional safety as well as wear are improved.
- In this regard, please ensure that the lines are filled with grease at commissioning and that the storage tanks are regularly topped up with grease.
- Relubricate slewing rings after each cleaning and after longer periods of standstill. During periods of standstill, move all slewing rings once a day if possible.

Procedure for the relubrication

1. Apply grease consistently through all provided lubricating holes.
2. Use all provided grease outlet holes. Used grease residues must be cleaned from the holes on commissioning and every 6 months to ensure that grease can be discharged without difficulty.
3. Use the shortest possible lines with the largest cross section.
4. If collecting containers are used, observe the information in section 6.8.2.

6.8.1. Grease

The selection of the grease depends on the load, the operational conditions, the rotational speed and the availability of the lubricant. The lubricants listed in the table have been tested for compatibility by IMO and are approved for use with IMO seals and spacers.

Mixability

Before using a different grease, always check the mixability of the greases. Please always contact the grease manufacturer in this regard.

IMPORTANT

- Only new grease may be used for relubrication.
- The grease for the raceway and the gearing is prescribed by the turbine manufacturer and is specified in the order drawing or on the type plate of the slewing ring.
  If the order drawing or the type plate do not contain any special information about the grease, the slewing ring must be filled with a lubricant that has a KP2K-30 designation according to DIN 51502 (Rhenus LZN 2). See Table 22 for comparable grease .
- In principle, the manufacturer of the central lubrication system should be consulted to ensure that the lubricant is suitable for the lubrication system.
- Grease not included in the approved lubricants list may only be used with the explicit consent of the turbine manufacturer and IMO. If in doubt consult IMO Customer Service (⇨ page 2).
- **Using incorrect grease will invalidate any warranty claims and may damage the slewing ring!**

Grease for the raceway system instead of the IMO standard lubricant

Manufacturer	Product name	Operating temperature according to manufacturer in °C	Operating temperature according to manufacturer in °F
Aral	Aralub HLP 2	-30° C to +130° C	-22° F to 266° F
Avia	Avialith 2 EP	-30° C to +130° C	-22° F to 266° F
Bechem	High-Lub L 2 EP	-20 °C to +120 °C	-4 °F to 248 °F
BP	Energrease LS-EP 2	-25° C to +130° C	-13° F to 266° F

Security

Klüber	Klüberplex BEM 41-141	-40 °C to +150 °C	-40 °F to 302 °F
Klüber	Klüberplex BEM 41-301	-30° C to +120° C	-22° F to 266° F
Exxon Mobile	Mobil SHC Grease 460 WT	-30° C to +150° C	-22° F to 302° F
Rhenus	Rhenus LZN 2	-30° C to +130° C	-22° F to 266° F
Shell	Gadus S3 V220C	-20° C to +140° C	-4° F to 284° F

Table 22

Grease for the gearing

Manufacturer	Product name	Operating temperature according to manufacturer in °C	Operating temperature according to manufacturer in °F
Aral	Aralub LFZ 1	-30° C to +130° C	-22° F to 266° F
Bechem	Berulit GA 400	-20 °C to +120 °C	-4 °F to 248 °F
BP	Energol WRL	-20 °C to +120 °C	-4 °F to 248 °F
Fuchs Lubritech	Stabyl EOS E2	-40° C to +130° C	-40° F to 266° F
Klüber	Grafloson CA 908	-20 °C to +180 °C	-4 °F to 356 °F
Klüber	Klüberplex AG 11-462	-40 °C to +150 °C	-40 °F to 302 °F
Manke	Voler Compound 2000E	-30° C to +120° C	-22° F to 248° F
Rhenus	Norplex AKG 0	-20 °C to +200 °C	-4 °F to 392 °F

Table 23

6.8.2. Grease collecting container (collecting pockets)

IMPORTANT

- The use of collecting containers (collecting pockets or pouches) is recommended for reasons of environmental protection.
- If **no grease** is **discharged** into the collecting containers or if **dry or hard grease is discharged**:
  - **Immediately** clean the outlet openings!
  - Check the function of the entire lubricating system!

- Check the fill level of the collecting containers every 6 months, replace if necessary.
- Collecting containers must have a venting mechanism.
- Document maintenance tasks (grease quantity per tank, unblocked the grease outlet holes).
- The collecting containers must be replaced after a fill level of 50% is reached.
- If the filling containers remain empty, clean the grease outlet holes and check that they are unblocked. Check the function of the entire lubrication system. Make sure the required quantity of grease reaches the bearing and can then escape.
- Only grease from the turbine may be collected in the collecting containers.

If collecting containers are not used: Remove the escaping grease from the outlet side of the seal during maintenance tasks.

6.8.3. Manual relubrication of the raceway

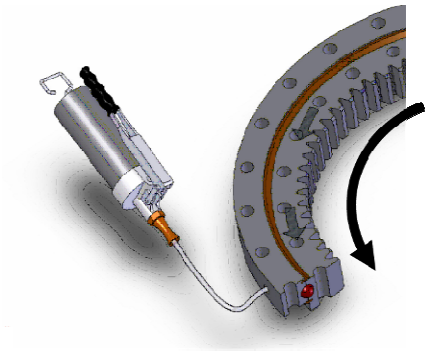


Fig. 41: Turn through when lubricating

- In succession, press grease into all grease nipples while simultaneously twisting the slewing ring all the way through, until a continuous collar of new grease forms under at least one seal.
- Ensure that old lubricant can escape without obstruction.
- During the regreasing process, turn the bearing rings toward each other. Comply with the accident prevention regulations s during this process.

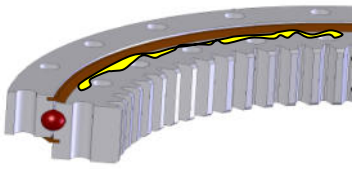


Fig. 42: Grease collar when greasing

6.8.4. Relubrication of slewing rings and main bearings for wind turbines

6.8.4.1. Relubrication of blade and yaw bearings

If no relubricating quantity has been specified on the system or in special IMO relubrication instructions, you can determine the weekly relubricating quantity m_{lb} for the raceway system of **four-point ball bearings** by means of the following equation:

$$\mathbf{m_{lb} = \frac{D_L * d_w^2}{150000} \left[\frac{Gramm}{Woche} \right]}$$

Equation for **T- Solid** and **T-Solid 4 IPC**:

$$\mathbf{m_{lb} = \frac{D_L * d_w^2}{75000} \left[\frac{Gramm}{Woche} \right]}$$

In respect of the gearing, this results in a weekly relubrication quantity m_{vz}:

$$\mathbf{m_{vz} = \frac{m * z * b}{5000} \left[\frac{Gramm}{Woche} \right]}$$

In which:
D_L = Raceway diameter of the rolling elements in mm
d_w = Rolling element diameter in mm
m = Modulus in mm
z = Tooth count of the slewing ring or the gear rim
b = Tooth width in mm

When relubricating blade and yaw bearings manually, relubricate at least after 3 months. In doing so, use 15x the quantity of m_{lb} and m_{vz}. It must be ensured that used grease can escape from the bearing. Grease outlet holes must be opened and cleaned.

On request, IMO can calculate the necessary relubrication quantities. Please contact IMO Customer Service (⇨ page 2) for this purpose.

6.8.4.2. Relubrication for main bearings in wind turbines

IMPORTANT

In respect of main bearings a central lubrication system with an integrated empty message is mandatory!
In the event of an empty signal or error message, the turbine must switch off automatically and the central lubrication system must be refilled with fresh grease.
Attention Only the greases specified in the drawing may be used.

Grease must always be supplied to the **main bearings** via a central lubrication system on a daily basis. Use the following equation to calculate the daily relubricating quantity:

$$\mathbf{m_H = \frac{D_L * d_W^2}{150000} \left[\frac{Gramm}{Tag} \right]}$$

6.8.4.3. Lubrication runs for T-Solid, T-Solid 4 IPC and four-point bearings, used as blade bearings

IMPORTANT

Blade bearings are only adjusted in certain operating modes. However, they often stand still in one position. To ensure a sufficient lubricating film and to avoid damage to the raceway due to a standstill (e.g. standstill markings, friction corrosion), it is essential that recurring lubrication runs are carried out as indicated below.

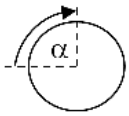
Small lubrication run	Large lubrication run
$\alpha = \frac{d_W * 688}{D_L}$	$\alpha = 90°$
Example representation of travel angle α:  α = Angle of lubrication run in degrees	
Table 24: Definition of lubrication runs	

Table 24

The equations from 6.8.4.1 apply to the relubrication quantities of blade and yaw bearings.

Frequency of the lubrication run for	Small lubrication run:	Large lubrication run:
Normal operation	1x daily	1x weekly
Out of operation for longer than one day	1x daily	----

Table 25

6.8.5. Relubrication of slewing rings for industrial applications

The range of uses and requirements for slewing rings in industrial applications is extremely broad. Please contact IMO Customer Service (⇨ page 2) for detailed recommendations relating to relubrication quantities.

6.8.6. Manual relubrication of the gearing

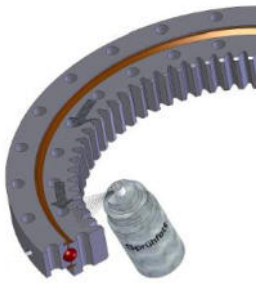


Fig. 43: Greasing the gearing

ℹ Ensure that foreign particles cannot get into the gearing.
The gearing must be adequately supplied with grease to avoid excessive wear and noise. The required quantity primarily depends on the lubrication system that is used.

Procedure:

1) Switch off the device and safeguard it from being restarted.
2) Remove excess and used grease.
3) Apply the fresh grease close to the pinion mesh.
4) Use a clean brush to apply grease to the gearing of the slewing ring. Instead of a brush, the grease can also be sprayed on or applied with a suitable lubricating device (e.g. lubricating pinion).

Adhesive lubricants have proven to be particularly effective for the gearing in open transmissions (e.g. Voler Compound 2000).
See table 23.

Automatic relubrication systems for the raceway system and the gearing significantly facilitate relubrication and sustainably improve the functional reliability.

6.9. Retrieval of grease samples

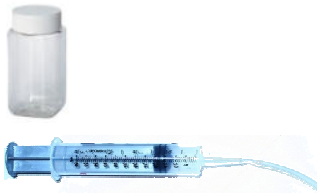


Fig. 44: Grease sample retrieval set

For an exact determination of the wear status, grease samples must be taken from all rings (inner and outer rings).
The grease sample retrieval set purchased from IMO comprises:

- Grease collecting container (volume ≥ 100ml)
- Grease gun with hose (volume ≥ 100ml)
- Self adhesive labels for labeling the grease collecting container.

Procedure for taking a grease sample:

1) Define the grease outlet holes of the slewing ring for retrieving samples. They should preferably be in the main load zone. If necessary, refer to the drawing.
2) Remove the grease collecting containers.
3) Attach a grease gun with a hose to a grease outlet hole. When extracting the grease, slide the hose further into the grease outlet hole.
4) Discharge the grease into a collecting container (one sample per container).
5) Mark the grease collecting container with a label. This must include: Serial number, drawing number, position of the removal hole.
6) Reattach the grease collecting containers.
7) Repeat the process for each accessible grease outlet hole, and replace the hose when switching from the inner to the outer ring.

6.10. Inspecting the seals

IMPORTANT

Damaged seals must be replaced immediately. If there is corrosion damage or functional impairment due to damaged seals not being replaced at the proper time, any warranty claims will be invalidated! Penetrating humidity may quickly cause corrosion in the raceway system and impairs safe operation.

- Replacement seals can be obtained from IMO (⇨ page 2), subject to the drawing number, serial number or the information on the type plate being provided.
- The replacement seals can be cut to the required length and installed with simple tools. IMO provides an appropriate manual.
- Small quantities of grease may escape through the seal to lubricate under the sealing lips. This is normal and does not constitute a defect.

If you have any questions, please contact IMO Customer Service (⇨ page 2). On request, IMO Customer Service will provide you with a video of the individual steps involved in replacing seals.

Applicable for main bearings in wind turbines:

If replacement is necessary, notify IMO in good time. Seals for main bearings are specially manufactured profiles that must be manufactured separately in order to replace them.
During the test run of main bearings, always ensure that there is sufficient lubrication of the raceway system and the sealing lips. The amount of relubrication required depends largely on the operating temperature of the main bearing. This must be clarified with the manufacturer of the grease .

6.11. Measures after successful maintenance

Execute the following steps after concluding maintenance tasks and before switching the system on:

1. Check all previously loosened bolted connections for firm seat.
2. Ensure that all previously removed protective devices and covers have been properly installed.
3. Ensure that all tools, materials, and other equipment have/has been removed from the work area.
4. Clean the work area and remove any substances that may have escaped, such as liquids, processing material, or similar items.
5. Ensure that all turbine safety devices are again functioning properly.

7. Dismantling

Opening the slewing ring without authorization will invalidate any warranty claims.

At the end of the service life, the slewing ring must be disassembled and disposed of in an environmentally responsible manner.

Personnel

- Only trained, skilled personnel may perform dismantling work.

7.1. Security

⚠WARNING

Prior to starting work ensure that there is adequate free space. Handle open, sharp-edged components carefully. Ensure order and cleanliness at the workstation! Parts and tools that are lying loose or on top of each other are accident hazards. Dismantle components properly. Pay attention to the high deadweight of some of the components. Use lifting gear if necessary. Secure the components so that they do not fall down or fall over. There is an injury hazard if the device is not dismantled properly. Consult with the manufacturer if there are questions.

⚠WARNING

Never stand under suspended loads! Swinging or falling parts can cause injury or pose a life-threatening hazard.

⚠WARNING

Carefully supervise the lifting processes and transport. Only use the transport methods described here. A life-threatening crushing injury can occur if the components fall.

IMPORTANT

Proceed with caution when transporting objects! Comply with instruction symbols on the packages and only use the prescribed attachment points. Improper transport can cause significant damage.

IMPORTANT

Avoid impact when transporting! Improper transport can cause significant damage.

7.2. Performing dismantling work

Prior to dismantling:

- Switch off the device or turbine and safeguard it from being restarted.
- Physically disconnect the device or turbine from all power supplies; discharge stored residual energy.
- Remove fuels and auxiliary materials, as well as residual processing materials and dispose of these items in an environmentally responsible manner.

Then clean the sub-assemblies and components properly and dismantle them, taking the applicable local occupational safety and environmental protection guidelines into consideration.

1. Unscrew the mounting elements of the geared bearing ring.
2. Remove the mating structure.
3. Unscrew the mounting elements of the non-geared bearing ring.
4. Remove the slewing ring.
5. If necessary, install a new slewing ring or replacement part (⇨ refer to chapter 5).

7.3. Disposal

IMPORTANT

Electrical scrap and electronic components, lubricants and other auxiliary materials are subject to treatment as special waste, and should only be disposed of by approved specialist companies! Improper disposal may cause environmental damage.

If a return or disposal agreement has not been concluded, then recycle the dismantled components by:

- Scrapping the metals.
- Sending the plastic elements for recycling.
- Sorting and disposing of the remaining components according to their materials.

Local municipal authorities or specialized disposal companies provide information on environmentally responsible disposal.

8. Technical data/type plate

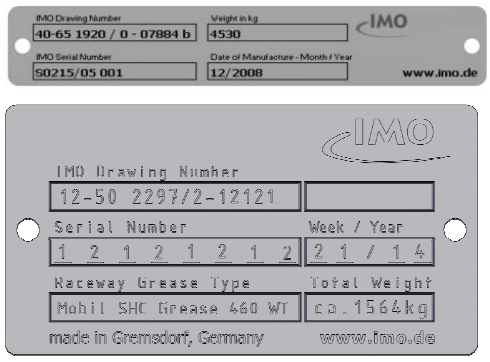


Fig. 45: Examples of IMO type plates

If slewing rings are supplied with a type plate, refer to the drawing of the slewing ring or gear rim for the position of the type plate. In the case of slewing rings, the type plate is usually on the non-geared ring and normally contains the following information:

- Manufacturer
- Drawing number
- Year of construction
- Serial number
- Possibly a barcode
- Possibly type of grease (raceway) for initial lubrication and relubrication

The design of the type plate may vary according to customer requirements.

IMO

www.imo.de

IMO Unternehmensgruppe

Werk I, Gremsdorf, Deutschland

Werk II, Gremsdorf, Deutschland

IMO GmbH & Co. KG
Imostr. 1
91350 Gremsdorf, Deutschland
Tel. +49 9193 6395-0
Fax +49 9193 6395-1140
mail@imo.de

Die Kontaktdaten unserer weltweiten Partner finden Sie unter: www.imo.de

000033/II/PDE/Apr13