Section 3 - Installation & Maintenance

The following instructions provide essential information for the proper application, installation, and maintenance of Kaydon slewing ring bearings. These instructions are divided into sections according to each of these disciplines and must be performed by qualified personnel.

Failure to adhere to these instructions may significantly impair the slewing ring bearing's ability to provide satisfactory service and may cause premature failure of the bearing as well as endanger safety of any personnel in the vicinity of the equipment.

Technical properties of slewing ring bearings are covered in Sections 2 and 4 of Kaydon Catalog 390.

Kaydon accepts no liability for:

1. Non-compliance to instructions provided in this Installation and Maintenance literature.

2. Failure to pass on content to third party.

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Installation & Maintenance

Installation & Maintenance

1. Design Considerations (Guidance for the Equipment Designer)

Slewing ring bearings, due to the nature of their design, have low structural stiffness making them highly susceptible to any distortions caused by the surrounding structures. Such distortions cause variations to the precisely designed and manufactured internal geometry of the bearing and will adversely affect performance and life.

1.1 Mounting Structure

Most component designs are a necessary compromise from the ideal to the practical. The design of mounting structures for large multiload bearings is no exception. Regardless, several criteria must be satisfied by the mounting structures, above and below the bearing, in order to obtain maximum bearing life and performance. Among these are stiffness, attachment, precision, accuracy, protection, and access.

The requirement for increased stiffness and higher precision surfaces is more critical under the following conditions:

- Increasing loads
- Increased frequency of operation
- Decreasing diameters
- Decreasing bearing cross sections
- Decreasing internal bearing clearance
- Decreasing torque limits

Protection of the bearing and accessibility for maintenance are critical to ensure bearing performance and longevity.

The following guidelines make reference to the bearing's rolling element diameter (D_w) and raceway diameter (D_p). During initial stages, the designer can use the following approximations. As required, contact Kaydon for the specific bearing assembly drawing for confirmation of the raceway diameter and other important design features.

$$D_w \approx 0.5 \cdot H_{min}$$

$$D_p \approx 0.5 \cdot (L_0 + L_i)$$

Kaydon recommends steel to fabricate any structures used in conjunction with its slewing ring bearings, unless otherwise specified. The actual steel material selected will vary as required by the final structure design and resulting stresses. The use of higher strength steels does not necessarily result in increased stiffness. The choice of material for the structure is the equipment designer's or manufacturer's.

1.1.1 Stiffness

The ideal bearing mounting would be infinitely rigid and isolate the bearing from localized loads and distortion. Recognizing this to be impractical, while still maintaining the original equipment design goals, Kaydon prepared Figures 3-1 to 3-3 (Deflection) showing maximum permissible deflections that typical four-point and eight-point ball bearings can withstand while maintaining correct function. Allowable circumferential deflection (δ_d) around the structure's mounting face is shown in Figure 3-1. There must be no abrupt changes in deflection. The maximum deflection error must be gradual, similar to a sinusodal wave pattern, and not occur in a span less than 90° and not more than once in 180°.

Another consideration is the allowable deflection from a true plane in a radial direction (δ_v), also referred to as dish or perpendicularity. For ball bearing designs this can be determined by using the following equation.

$$\delta_v \approx 0.003 \cdot D_w \cdot P$$

Where P = radial distance of mounting structure face

The maximum circumferential and radial deflection for roller bearing designs is 2/3 of that for the equivalent sized four-point ball bearing.

Reduction of the δ_d and δ_v values may be necessary due to certain application requirements such as lower rotational resistance or higher precision.

⚠ Equipment designs not complying to these requirements will adversely affect bearing performance, imposing concentrated loads on the bearing and adjoining fasteners. Concentration of loads results in higher loads on the rolling elements, raceways, and adjoining fasteners. This will lead to increased rotational resistance, decreased bearing and fastener life and a potentially unsafe working environment.

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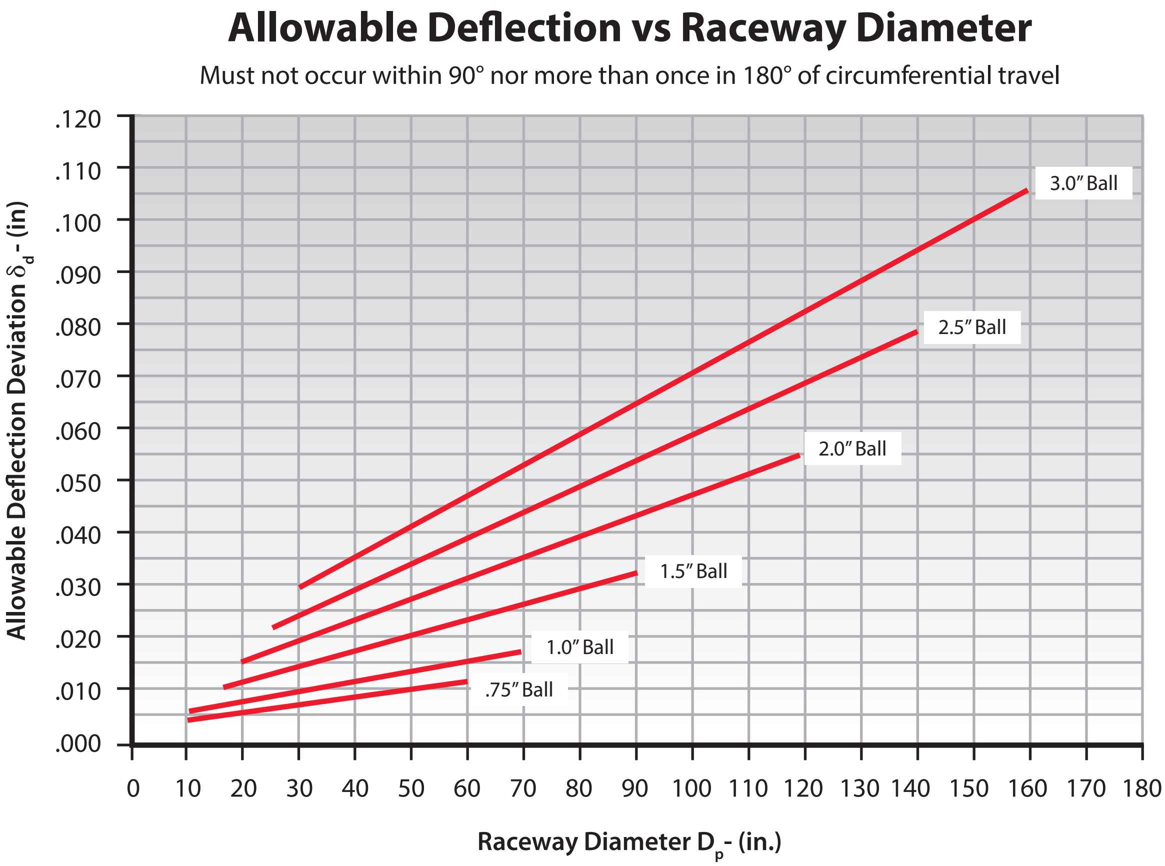

Figure 3-1

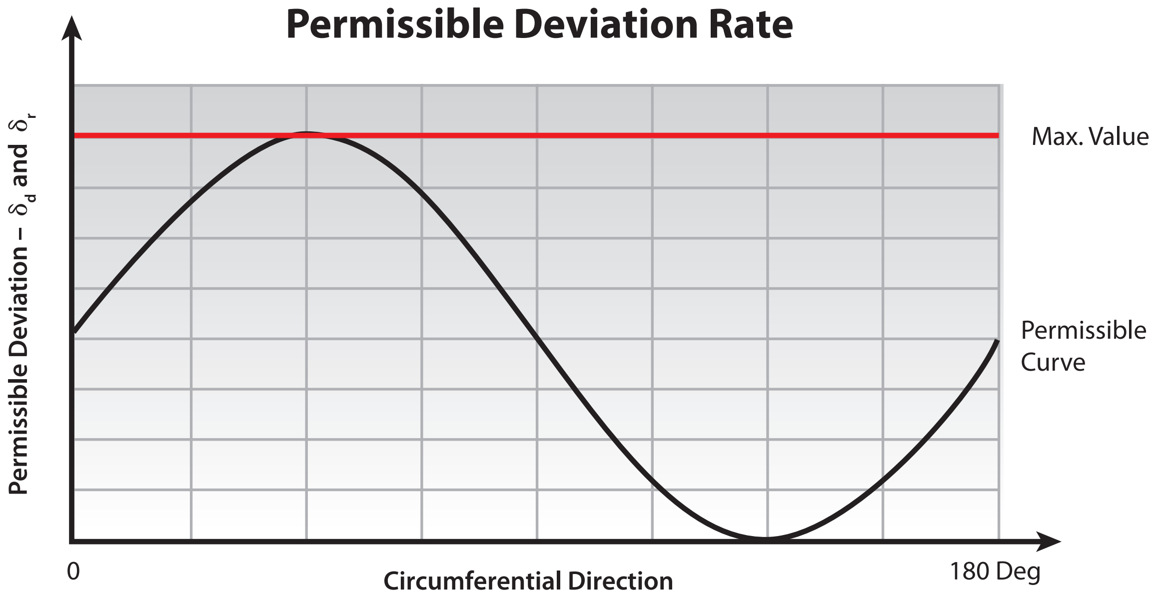

Figure 3-2

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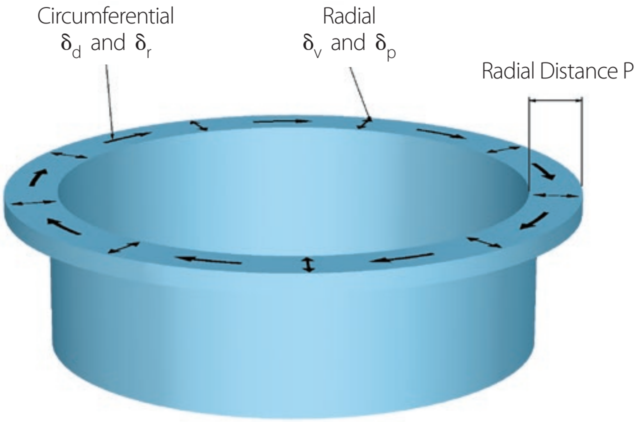
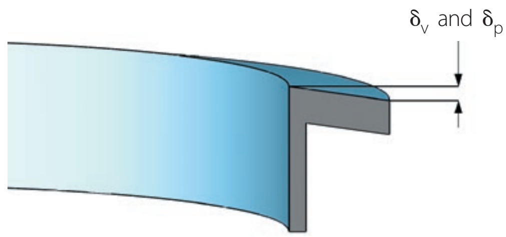




Mounting Structure Deviations

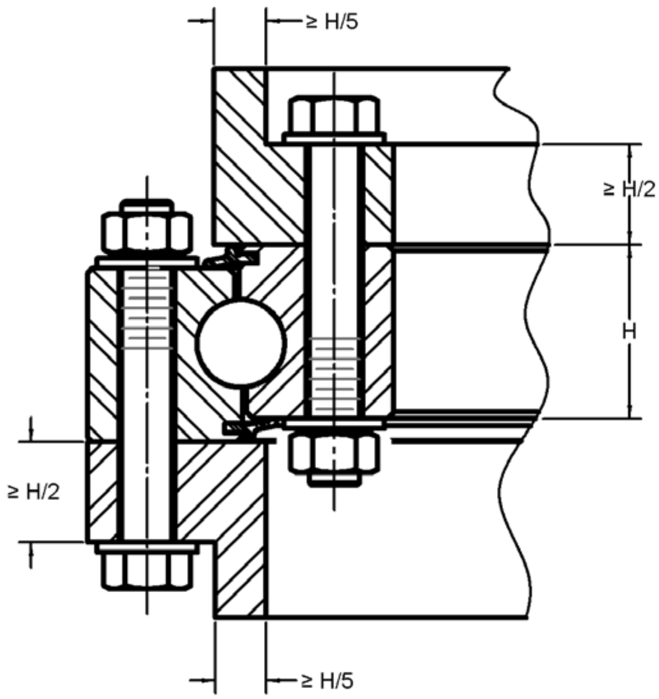
δ_d = circumferential deflection
δ_v = radial deflection
δ_r = circumferential flatness
δ_p = radial dish (perpendicularity)

Figure 3-3

⚠ Kaydon offers the following guidelines to assist designers. Failure to follow any of these may cause additional risk and/or premature failure. Therefore, testing of the overall configuration and bearing installation is required to validate the design. Extra caution is required during any testing, as failure of any component could lead to complete separation. This may result in injury or fatality to anyone in close proximity.

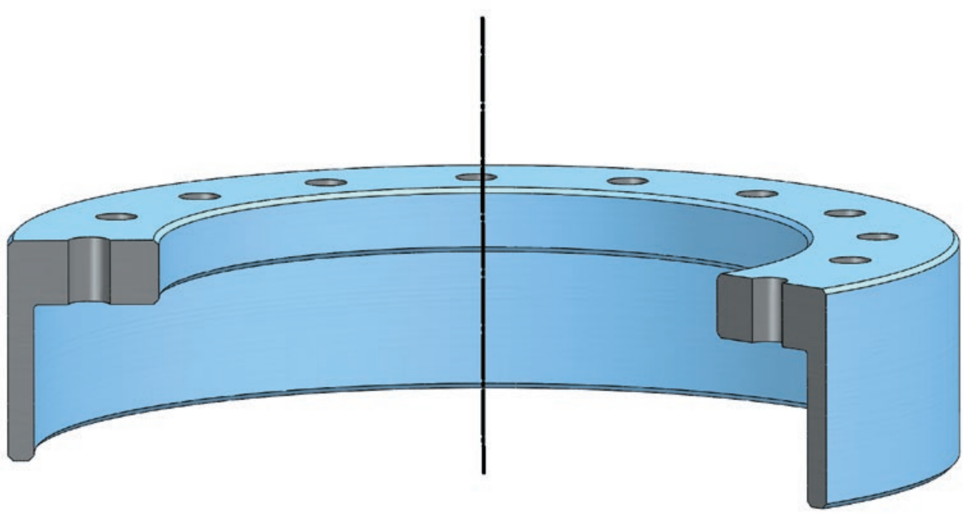
- A uniform vertical and tube-shaped structure with a flange on one end should be used, allowing adequate room for fastener installation and maintenance. This structure would be similar to the end of a flanged pipe with a diameter close to that of the bearing's raceway. Refer to Figure 3-5. For initial sizing, wall thickness of such tubing should be at least 1/5 the overall height of the adjacent bearing's ring. Refer to Figure 3-4.
- The mounting or structural plate supporting the bearing should have a finished thickness of 1/2 of the bearing ring height for single-row rolling element bearings and at least 1/3 of the bearing ring height for multi-row bearings. Generally, thinner mounting plates require more structural support and bracing to stiffen the overall design. The final thickness of plate required will vary depending on the overall configuration of the structure and load being applied. Testing, as mentioned above, is recommended.
- The face of the structure that supports the bearing must make contact with the complete mounting face of the bearing's ring and have surface finish 250 AA or better.
- Obtaining a uniform distribution of the load to the bearing is difficult when using a frame, welded structure, and gussets for structural support under the mating plate. Should it be necessary to use such a design, the frame and supporting structure must be oriented to provide as much support as possible directly below the bearing's raceway. Refer to Figures 3-6 and 3-7.
- If the immediate structure supporting the bearing consists of two plates, one welded atop the other, caution must be taken to avoid distortion of the plates during welding as it could result in undetected voids between them. Under load, the plates will deflect causing non-uniform and increased dynamic loads on the bearing and retaining bolts. Refer to Figure 3-8.
- Variation in the physical "grip length" of the bearing's mounting bolts is not permissible in the design of the mounting structure. The physical "grip length" is the distance from the bottom of the bolt head to the first thread of engagement. Such variation imposes a disproportionate amount of load on those having shorter grip length. This can lead to premature failure and/or separation of the assembly.
- Special attention needs to be given to stiffness of the gear drive mounting area. Designs having insufficient rigidity in this area will permit deflection and result in poor gear and pinion mesh alignment. Poor alignment can lead to premature failure of the pinion, gear, and gear drive.

Installation & Maintenance



Minimum Mounting Support Requirements

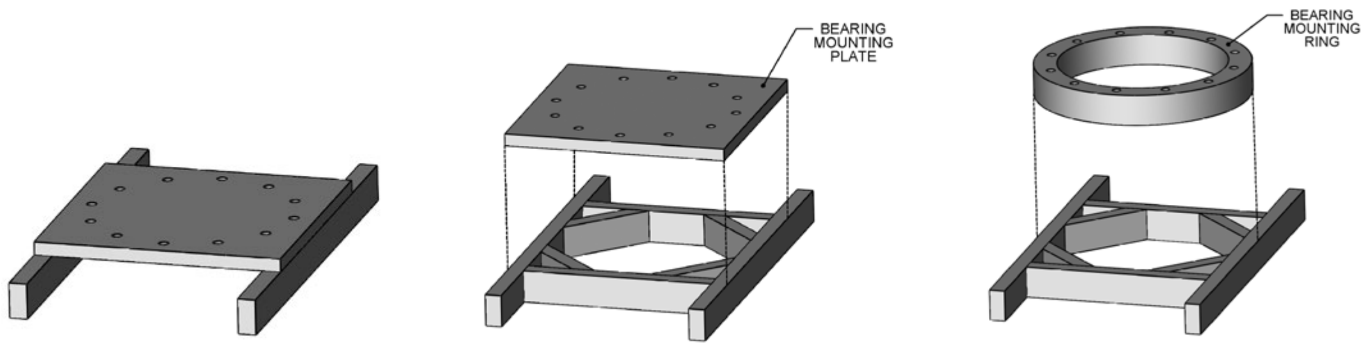
Figure 3-4



Vertical Tube with Flange for Mounting Support

Figure 3-5

Installation & Maintenance



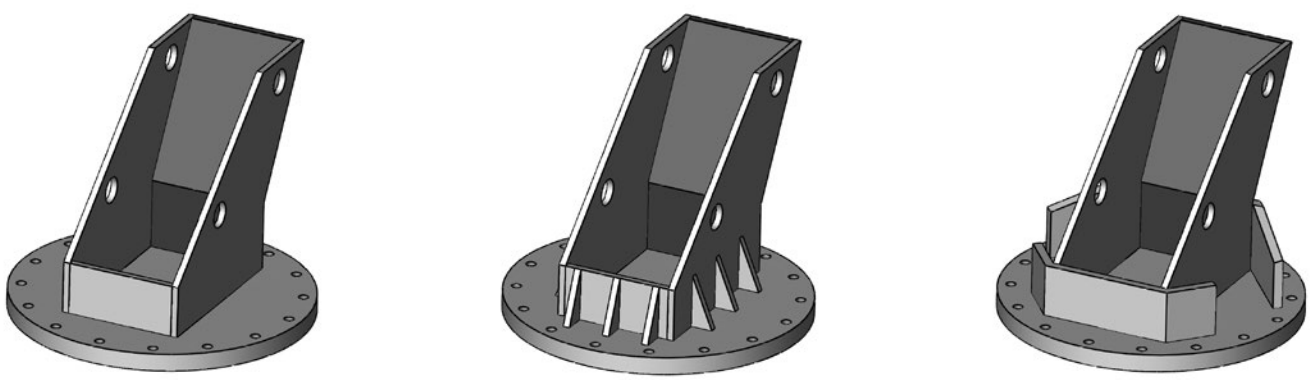
Frame without gussets near mounting holes requires thicker plate.

Gussets added near bearing mounting holes increase rigidity.

Gussets added near mounting holes and ring replace plate for additional rigidity.

Fabricated Frame & Structure Supports

Figure 3-6



Turnstile without braces lowers side plate and mounting plate rigidity, reducing load distribution around bolt pattern and bearing.

Turnstile with braces increases side plate and mounting plate rigidity and provides increased load distribution around bolt pattern and bearing.

Turnstile with braces located near bolt mounting holes increases side plate and mounting plate rigidity and provides additional load distribution around bolt pattern and bearing.

Fabricated Turnstiles

Figure 3-7

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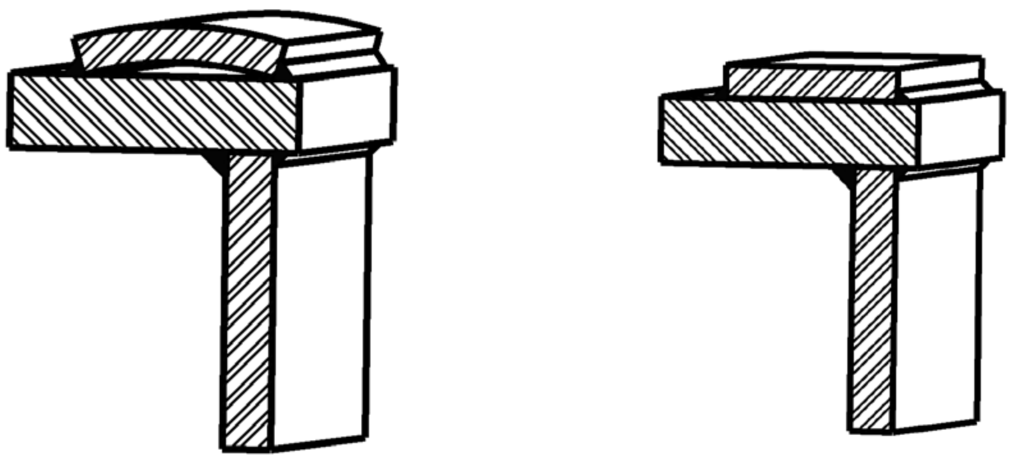

Welded Plates - Potential for Detrimental Distortion

Figure 3-8

1.1.2 Interface Features

1.1.2.1 Flatness

Bearing mounting surfaces must be machined flat after all welding and stress relief treatment on the structures is complete. If subsequent welding is necessary, it must be done to avoid distorting the previously machined mounting surface. The allowable degree of out-of-flatness in the circumferential direction (δ_r) for typical four-point and eight-point ball bearings is shown in Figure 3-9. Out-of-flatness, like distortion, must be gradual, reflecting a sinusodial wave pattern and not occur in a span less than 90° and not more than once in 180°.

In addition to flatness in the circumferential direction, the allowable dish or perpendicularity deviation (δ_p) in the radial direction must be determined. For ball bearing designs, this can be done using the following equation.

$$\delta_p \approx 0.001 \cdot D_w \cdot P$$

Where P = radial distance of mounting structure face

The allowable degree of out-of-flatness for roller bearings is 2/3 the limit for an equivalent-sized four-point ball bearing.

It may be necessary to reduce the δ_r and δ_p values in applications which require low rotational resistance or high precision.

Installation & Maintenance

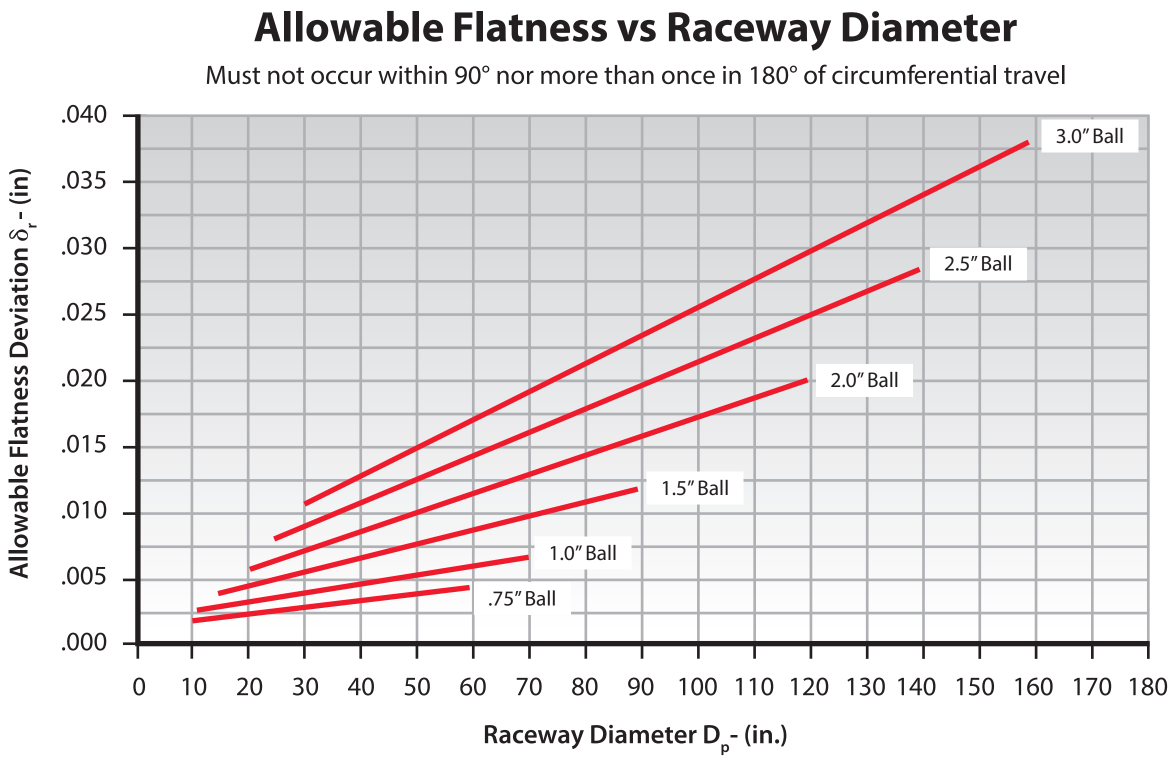

Figure 3-9

⚠ Kaydon does not recommend the use of grout or shims to compensate for excessive out-of-flatness.

1.1.2.2 Pilots

Pilots are sometimes used for accurate location of the bearing or to aid in retention of the bearing. If used, they must be round and accurately sized so that they do not distort the bearing. Consideration must also be given to their eccentricity and positioning tolerance relative to any hole patterns used in the structure and the interfacing bearing ring. Kaydon can provide the applicable bearing assembly drawing which includes interfacing tolerances.

1.1.2.3 Holes

Mounting holes and dowel holes, if any, must be within the true location tolerances required to prevent distortion of the bearing due to interference. Mounting hole location tolerance must account for eccentricity of the hole pattern relative to any pilot diameters. Through holes should be compatible with the location tolerance and of a diameter equivalent to those in the corresponding bearing ring. Kaydon can provide the applicable bearing assembly drawing which includes interface features and tolerances.

Bearings should never be used as drill jigs. They may be used as templates for transfer of hole location provided care is taken not to distort the bearing. Distortion is more likely to occur on bearings having thinner ring sections.

1.1.3 Protection

Kaydon bearings are designed to withstand normal operating environments. If the upper structure does not provide complete cover for the bearing, a separate seal or shield is recommended. Exposed gears should be shrouded if they are to be exposed to extremely dirty conditions. Shields and shrouds should be designed with cover doors, plugs, or other means of access to the bearing for maintenance purposes.

To further enhance protection, Kaydon can provide painting or plating options as required.

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1.1.4 Access (For Installation and Maintenance)

Like all mechanical components on a machine, the bearing must be accessible so that it can be properly maintained. The following must be considered.

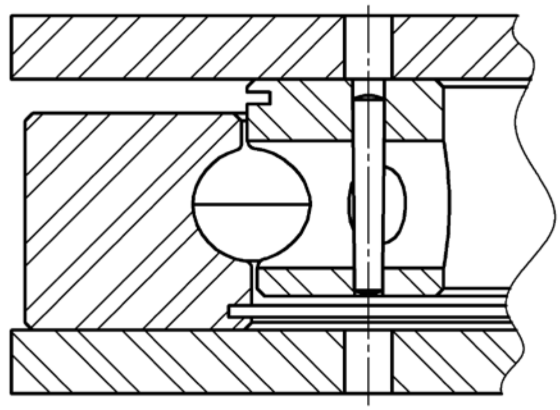
⚠ Mounting bolts require periodic checking and possibly retightening. Access to every mounting bolt must be readily available. Failure to properly maintain the mounting bolts may result in failure and injury to anyone in the vicinity.

Lubrication of the gear and internal components is required and convenient access to the gear and bearing grease fittings must be provided. It is recommended that remote lines to the bearing be added to allow rotation as grease is introduced to the raceways.

⚠ There may be rare occasions when it is desirable to inspect the bearing raceways and internal components. This should only be attempted by qualified personnel due to the potential for the bearing and structures to come apart. This can damage components and cause injury or fatality to anyone in the vicinity.

This inspection may be accomplished on typical slewing ring bearings by removal of the loading plug, excluding three-row roller designs.

While removal of the loading plug voids the warranty, it may be necessary. To accommodate access to the retention pin for the loading plug, the designer should include additional clearance or access holes above and below the retaining pin. See Figure 3-10.



Access holes for loading plug

Figure 3-10

1.1.5 Attachment

The method of attachment of Kaydon bearings to the support structure significantly affects its design. The preferred method is to use bolts in both rings. If you require assistance with applications where the attachment for one ring is to be done by welding, contact Kaydon.

1.1.5.1 Bolts

The preferred bolting arrangement is a full circle of uniformly spaced fasteners going through holes in both bearing races. This benefits both the bearing and the bolts. The bearing races are reinforced by the bolt tension. The resulting greater bolt grip length allows more accurate and uniform pretension, reducing fatique loading. However, it is not always practical to have all the mounting holes spaced exactly equal on all designs, due to interference with supporting structures or brackets. In such cases, the spacing between adjacent bolts may be shifted a few degrees either way to accommodate mounting hardware and assembly. Testing is recommended, as it is the only accurate method for determining bolt loads and validation of the overall joint configuration and assembly procedure.

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⚠ The bolt arrangement, quantity, size, and thread engagement of bolts are the responsibility of the equipment designer and manufacturer for the following reasons:

- There is no universally accepted method of analyzing the forces imposed on the bolts in a slewing ring bearing joint subjected to moment loading.
- The stiffness, uniformity, and final design of the structures to which the bearing is attached have an extremely high degree of influence on the load in the fasteners. Only the equipment designer or manufacturer can control this.
- The quality of the fastening hardware, method of tensioning, hardness of the surfaces under the bolt heads, and the use of thread lubricant are critical factors over which the equipment manufacturer has control.

We suggest that selection of the bolts should be made with the advice and assistance of the fastening hardware supplier, as bolt quality and recommended method of pretensioning and maintenance vary widely. Attention to details such as head/body fillet radius, thread form, finish, surface asperities, and freedom from cracks and other possibly fatal flaws are very important to the safety of the equipment and any personnel in the vicinity. The importance of adequate and uniform pretensioning is evident from the proliferation and technological advancement of devices such as:

- Turn of the nut indicators
- Preload indicating washers
- Torque wrenches with integral "yield" sensors
- Hydraulic bolt stretchers
- Ultrasonic measuring equipment
- To aid the designer in initial sizing, the following formula can be used to calculate the approximate load on the heaviest loaded bolt. This method is based upon past experience and yields results that have proved satisfactory for most applications. It is analogous to the method Kaydon uses to determine the load on the heaviest loaded rolling element within a bearing.

⚠ Kaydon makes no warranty, expressed or implied, regarding the adequacy of the bolts. The only certain way to determine the actual load is by testing, which is strongly recommended.

$$R_b = \frac{12 \cdot M_k \cdot F_f}{L \cdot n} \pm \frac{F_a}{n}$$

$$*F_s = \frac{\text{Bolt Proof Load Rating}}{R_b}$$

M_k = Moment load, (ft - lbs)

F_f = Flexibility factor. Use 3 for bearings and support structures of average stiffness.

F_a = Axial load, (lbs)

If the load is in tension, the sign is +.
If the load is in compression, the sign is –.
Refer to Figures 2-2 and 2-3.

L = Bolt circle diameter, (in)

n = Total number of evenly distributed bolts

R_b = Total load on heaviest loaded bolt, (lbs)

$*F_s$ = Factor of safety of bolts.
Minimum recommended value = 3

Bolt Proof Load

SAE J429, Grade 8 and ASTM A490; Coarse Threaded Series

Bolt Dia. (in)	Proof Load (lbs)
1/2	17,000
5/8	27,100
3/4	40,100
7/8	55,400
1	72,700
1 - 1/8	91,600
1 - 1/4	116,300
1 - 1/2	168,600

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If you determine that alteration to the mounting hole pattern is required for your bearing, Kaydon is available to provide assistance to help you select a mounting hole pattern for the bearing in question.

The following is a list of additional recommendations concerning bolts and their incorporation into the final equipment design. The items listed below are not all inclusive and further study on the subject is recommended. These recommendations are intended to provide the designer with a good basis from which to begin.

- High strength bolts with coarse threads and hexagon heads in accordance with SAE J429, Grade 8 or ASTM A490/A490M or ISO 898-1, Grade 10.9 tensioned to 70% of their yield strength.
- Where applicable, coarse threaded hex head nuts in accordance with SAE J995, Grade 8 or ASTM A563, Grade DH or ISO 898-2, Class 10.
- Hardened round flat steel washers in accordance with ASTM F436 under head of bolt and also nut.
- Use of hardware that identifies the manufacturer as well as proper SAE, ASTM or ISO grade designations.
- The ratio of the joint's clamp length (distance from the bottom of the bolt head to the first thread of engagement) to the nominal bolt diameter should equal 3.5 or greater. This ratio has a significant impact on embedment and the potential for loss of bolt tension and premature failure. A higher ratio is less prone to result in loss of bolt tension Lower ratios may prove unacceptable and require more frequent inspection of the bolts for proper tension. Testing is required for validation.
- Bolts threads should end short of the head by at least a distance equivalent to the body diameter.
- Equal clamp or grip length for all mounting bolts in a given ring.
- The thread engagement length between bolt and mating steel structure should be at least 1.25 times the nominal bolt diameter.
- A bolt should be used in every mounting hole.
- There should be a minimum of 6 free threads (not engaged) in the tensioned portion of the bolt.
- Performance of bench tests is recommended to validate that the method of bolt tensioning achieves the desired results prior to any equipment testing.

High strength socket head bolts (ASTM A574) are not preferred but have been successfully used in slewing ring bearing applications. These high strength bolts have a smaller head diameter which requires less space; however they also have less surface area under the head. This reduced surface area increases the potential for more variation in final bolt tension due to embedding and settling. High strength socket head bolts must be used in conjunction with a hardened washer and nut. The nut should be turned to achieve final bolt tension. If possible, use a hardened washer under the head as well as with the nut, to minimize embedment, settling, and loss of bolt tension that could result in premature bolt failure.

Calibrated tension indicating washers are acceptable.

Lockwashers are **NOT** recommended, because of potentially significant variations in frictional resistance, embedding, and loss of bolt tension leading to permature failure of the bolt. Additionally, locking compound on the threads, intended to prevent loosening, is **NOT** recommended. As mentioned in the maintenance section, the bolts require frequent inspection for proper tension. The most common method used to fulfill this requirement is measuring torque of the bolt. The use of locking compound can lead to a false conclusion that the bolt has the desired tension. Loss of the proper tension can lead to premature bolt failure, dismounting of the bearing and structure, damage to components, and injury or fatality to anyone in the vicinity.

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1.1.5.2 Welding

Attachment of bearings by welding is not favored and is limited to new applications in unusual situations. If additional assistance is required, we suggest that you contact the Kaydon Engineering Department for these applications.

1.2 Pinion and Gear Mesh

1.2.1 Pinion Design Considerations

If a bearing with an integral gear has been selected, the machine designer should work with a pinion manufacturer to select the appropriate mating pinion. It is important to be aware and consider all potential operating circumstances which could be detrimental to pinion and gear life.

A pinion supported only on one end is often selected for mating with slewing ring bearings. This is commonly referred to as an overhung pinion. Use of this type of arrangement whenever high gear tooth loads exist requires the designer to consider pinion modifications not commonly used with standard gear transmissions. We suggest that the following gear design modifications should be considered when selecting a mating pinion.

- **Addendum modification (profile shift).**

  This is especially important for pinions having fewer than 15 teeth for a Stub Involute tooth form and 19 teeth for a Full Depth Involute tooth form to avoid undercut, weakened tooth design, and to avoid tip or involute interference.

- **Profile and tip relief. Refer to Figures 3-11 & 3-12.**

  Higher dynamic loads, fewer pinion teeth, and support only on one end of the pinion increase potential for deflection of the gear and pinion teeth during operation. These conditions have a tendency to generate wear (scuffing) in the dedendum of the gear tooth, regardless of the teeth having correct profiles and theoretically compatible geometry. Scuffing generates metallic wear particles and weakens the gear tooth. This may prove detrimental to gear and pinion life depending on the operating circumstances.

- **Crowning or changing of the tooth thickness along its width.**

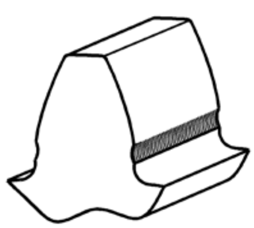
  This is considered a good practice for highly loaded gears as it allows better distribution of the stresses along the tooth face. For situations with over-hung pinion mounting, off-setting the crown should be considered to account for pinion and drive deflections and provide a more even stress distribution. Generally the thickest section along the tooth face is off-centered toward the unsupported end of the pinion.

- **Surface hardening of the pinion.**

  The pinion experiences more operating cycles than the gear teeth. Therefore, it requires a higher surface endurance life. This is accomplished by through hardening or selective hardening. When through hardening, care must be taken to prevent the pinion teeth from becoming too hard and brittle for the intended application and mating gear. Selective hardening of the pinion is an alternative when surface hardness and ductility are major design concerns. A hardness pattern that ends in the fillet area has significantly less strength than one that flows completely around the fillet and up both flanks. The heat treat methods to accomplish this include carburizing, nitriding, or induction hardening. In all cases, evaluation of the hardness pattern, including the transition area, is necessary to determine if it is appropriate for the intended use.

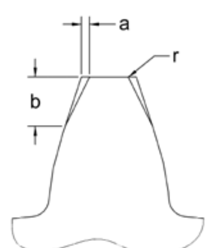
- **Quality**

  The pinion quality should be equivalent to or better than that of the mating gear.



Scuffing on Dedendum

Figure 3-11



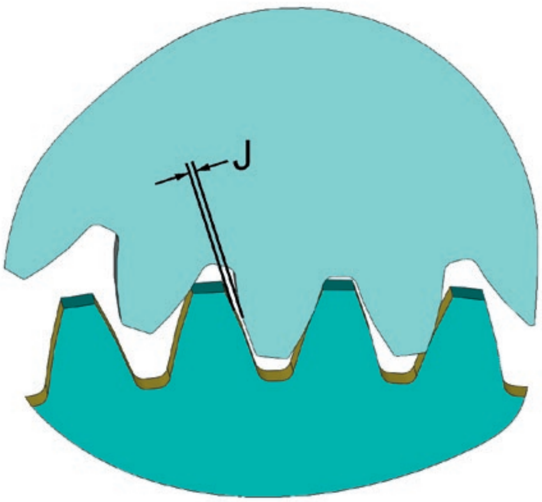
Flank Tip and Profile Relief

Figure 3-12

Installation & Maintenance

1.2.2 Backlash

Backlash is required for most geared slewing ring bearing applications. This is to accommodate manufacturing tolerances of the gears, mounting structures, lubrication, thermal expansion, and deflection of the components under dynamic loading. Refer to Figure 3-13.



Gear Assembly Backlash

Figure 3-13

In high ratio gearing, the larger of the two mating gears usually has its teeth thinned to accommodate this, and the smaller one is kept at nominal to maximize its tooth strength. The amount of tooth thinning, or backlash allowance, is shown on Kaydon's drawings, which may be obtained by contacting Kaydon. Typical backlash ranges are shown in Table 3-14. For module gears, use the approximate equivalent gear pitch diameter and diametral pitch as shown in the table.

The backlash should be measured just inside each end of the pinion and gear mesh to verify that proper alignment is obtained. Poor alignment can result in premature tooth wear and breakage. Consider any crowning of the pinion teeth when evaluating the alignment.

$$m = \frac{25.4}{P_d} = \text{module}$$

The designer or manufacturer needs to determine whether to use a fixed or adjustable center distance. Factors that influence this decision are skill level of assemblers, installation time, maintenance, and economics. The designer must also weigh potential for increased gear life versus additional cost incurred by requiring more stringent manufacturing tolerances or designing for an adjustable center distance.

Table 3-14

Gear Pitch Dia, D_2 (in.)	Minimum Backlash, J (in.)	Maximum Backlash (in.) Diametral Pitch (P_d)				
		1.5	1.75	2	2.5	3, 4, 5
20	0.014	0.029	0.027	0.025	0.023	0.022
30	0.015	0.030	0.028	0.026	0.024	0.023
40	0.016	0.031	0.029	0.027	0.025	0.024
60	0.018	0.033	0.031	0.029	0.027	0.026
80	0.020	0.035	0.033	0.031	0.029	0.028
100	0.022	0.037	0.035	0.033	0.031	0.030
120	0.024	0.039	0.037	0.035	0.033	0.032

Please see Section 3 of website version of catalog for pending additions to this table.

Installation & Maintenance

1.3 Mounting Examples

Kaydon bearings can be designed to suit a number of mounting arrangements. Following are illustrations of some basic arrangements. These can be varied to suit the requirements of a specific application. Such variations include types of holes, location and number of lube holes, omission of integral gears, and incorporation of special seals.

The mounting structures shown are intended to be illustrative only. Important details in design such as mounting plate thickness, location and number of stiffening members, and bolt lengths must be determined by the equipment designer as detailed in previous sections.

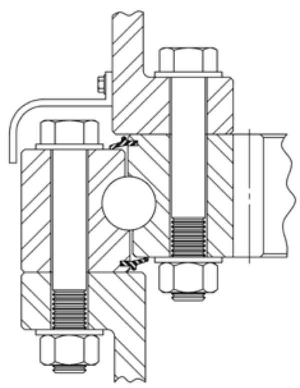


Figure 3-15

Pinion is attached to stationary outer race support and rotates the upper structure supported by the inner race. A shroud over the outer seal and bolts prevents contamination under extreme conditions.

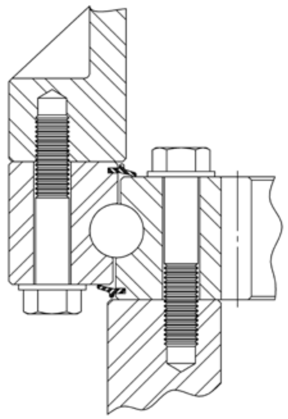


Figure 3-17

Pinion is attached to rotating upper structure carried by outer race. Location of gear on inner ring provides protection from harsh external conditions.

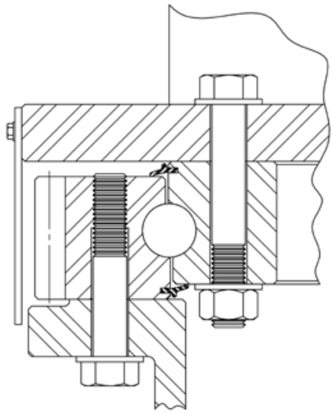


Figure 3-16

Inner race supports the rotating upper structure with pinion. An external shroud protects the gear teeth on the stationary outer race.

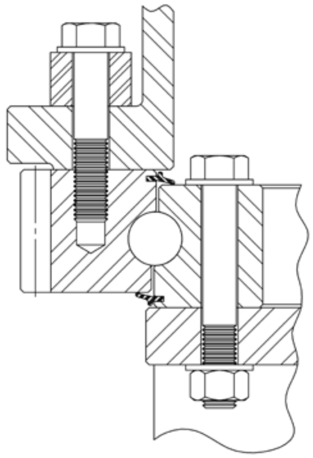


Figure 3-18

Pinion is attached to stationary inner race and rotates geared outer race carrying upper structure.

Installation & Maintenance

2. Installation and Maintenance Considerations (Guidance for the Equipment Builder)

2.1 Handling

Slewing ring bearings, like any other machine part, require careful handling. Use of safe operating practices and observation of all relevant legal regulations when handling, cleaning, and transporting are required. It is recommended that gloves be used whenever handling the bearing.

Transport the bearings only in the horizontal position, preferably safely secured to shipping pallets or in a container. When lifting a bearing, use eye bolts in the mounting holes or nonmetallic slings at three evenly distributed points around the bearing. Avoid any sudden acceleration or impact. If the bearing must be turned over, use nylon web slings or equivalent. Do not use chains or metallic mesh slings in contact with the bearing.

2.2 Storage

Kaydon slewing ring bearings are packed with general purpose grease at the factory, unless specified by the customer, and are sealed to exclude ordinary foreign matter. Keep the bearing packaged as originally received and in a horizontal position until all preparations have been made for its installation. If it is necessary to stack the bearings, then a stable intermediate layer with adequate strength to support the weight must be used between bearings. The overall stacked height must not exceed three feet. We recommend that you do not stack more than two high if the bearing is four feet or larger in diameter.

Outdoor storage is not recommended. If the bearing is not installed within one year of receiving it, the grease should be purged and replaced with fresh grease. External surfaces of slewing ring bearings, including the gear, are coated with a preservative oil to provide nominal protection during storage.

We suggest that you advise Kaydon if extended periods of storage are anticipated so that the bearings can be packaged appropriately.

2.3 Installation

It is important to recognize the vital role of the bearing/gear and the means for securing it to the equipment, whether it be with bolts or welds.

Detailed and clear instructions need to be prepared for the installer. When bolts are used as the means of attachment, tests need to be conducted to validate that the method of bolt pretensioning achieves the desired results. Confirm the bolts have the proper quality standard and manufacturer identification as prescribed by the designer.

If the bearing is to be attached by welding, conduct the necessary tests to prove that the specified joint will be strong enough to safely attach to the bearing.

Examine for and remove weld spatters, nicks, and burrs. If surfaces have been painted, remove the paint completely.

2.3.1 Preparation

Installation of the bearing and gear assembly should be done in a clean, dry, well-lit area. Mounting surfaces and pilots of the housings should be machined and wiped clean of paint, chips, dirt, and lint. Even "soft" material trapped between the mounting and bearing surfaces can result in high spots and affect bearing and bolt performance. When this has been done, examine for and remove weld spatter, paint, nicks and burrs and wipe clean again. The mounting faces need to be machined and in accordance with the limits prescribed in Part 1, Paragraph 1.1.2

⚠ Confirm that the bearing and all necessary and correct hardware are on-site before beginning the installation. Verify the bolts and mounting hardware are of the size, design, finish and quality specified by the designer. The bolts must have proper identification for the quality standard required. Using bolts that are not in conformance with those prescribed can lead to unsatisfactory bearing performance, premature failure, and a potentially fatal working environment . Refer to Part 1, Paragraph 1.1.5.1

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2.3.2 Positioning

If one ring has a pilot or dowel hole, it should be positioned and mounted first.

Consider alignment of gear's minimum backlash on structure so any necessary adjustments can be made.

Identify zones of maximum load on supporting structures to which the bearing will be secured. When in doubt, consult with the equipment designer for their instructions.

Examine and identify any damage to packaging prior to unwrapping the bearing; then it should be wiped clean and inspected.

⚠ Do not expose the seal area or any other bearing opening to pressurized cleaning.

Use only cleaning material that is compatible with the seal material and avoid getting debris or other material into the bearing. Visually inspect and confirm that there is no damage to the bearing, gear, seals, or grease fittings.

Remove any minor burrs from mounting surfaces that may have occurred in shipping or handling. Use a hand file, taking care to remove only as much material as necessary to ensure full contact of bearing surface with equipment mounting surface. Make sure all surfaces are wiped clean.

⚠ We recommend that the bearing not be disassembled without express approval of and instruction from Kaydon. Removal of the loading hole plug voids the warranty.

Lift or hoist the bearing into position, placing intended ring down on its supporting structure.

Align the mounting holes and orient the ring so the load plug and/or hardening gap location (identified by a "G") is 90° from the most heavily loaded zone.

Confirm the grease fittings or holes are located for easy access, or aligned with lubrication lines.

Using a gauge, verify the bearing is fully supported by the mounting structure. If not, then determine cause and correct.

2.3.3 Securing

For good load distribution and smooth, low torque operation, the bearing should be as round as possible when the bolts are tightened. The following procedure is provided as an aid in achieving that objective.

Install washers, nuts, and hand tighten bolts in the supported ring according to the instructions from designer. Make sure there is no interference or rubbing of the bolts in any of the holes. Do not distort the bearing in order to insert any bolts. Interference can cause inaccurate results and lead to premature failure of bearing and bolts.

Apply a moderate centered thrust load to the bearing and note the torque required to rotate the bearing.

⚠ Tighten all bolts in accordance with the equipment designer's instructions. Failure to follow the equipment designer's instructions could result in premature wear or catastrophic failure of the bearing and result in damage to equipment, personal injury, or death.

A common method is the use of star pattern tightening following the sequence below. This is usually done in 3 steps at approximately 30%, 80%, and 100% of the final torque or tension level prescribed by the equipment designer.

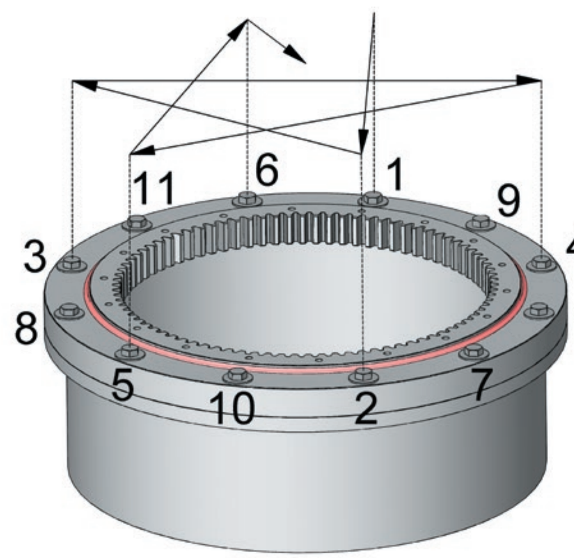

Figure 3-19

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Rotate the unsecured bearing ring several times after each step, checking for tight spots or a significant increase in torque over that initially noted. Either of these indicates the bearing is distorted. Determine and correct the cause.

Remove the centered thrust load previously applied to the bearing and prior to securing the other ring.

Position the other bearing support structure on the unsecured bearing ring.

This support structure should have minimal number of components attached, to keep weight and moment load low so the bolt tensioning operation is not adversely affected.

Align mounting holes and orient the ring so the load plug and/or hardening gap location (identified by a "G") is 90° from the most heavily loaded zone.

Using a gauge, verify the bearing fully supports the mating structure. If not, then determine cause and correct.

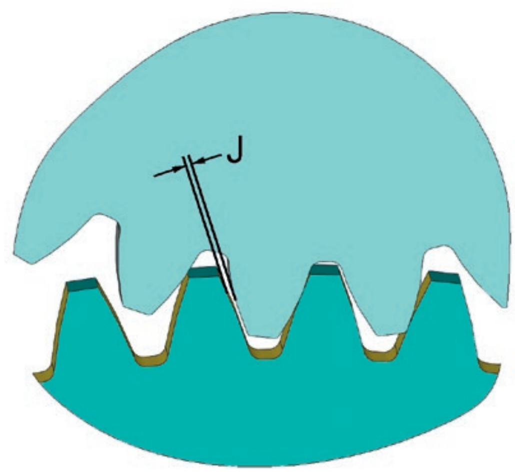
Insert and tighten bolts in second ring as done for secured ring. Continue to rotate and check bearing for tight or excessive torque during this operation.

Complete installation of all rotating components of significant weight, and check bearing for freedom of rotation. Excessive torque level, variation, or vibration is indicative of some unsatisfactory installation condition or component.

As permitted, inspect seals again for any damage.

2.3.4 Gear Backlash and Alignment

After mounting the bearing, mount the mating pinion. Check backlash of the gears. Pinions on adjustable centers should be set for proper backlash. Do this at point of minimum backlash on the gear, identified with yellow paint in the tooth space, and at both ends to confirm prescribed alignment exists. If either of these is not as prescribed by the designer, determine and correct the cause. Refer to Figure 3-20.



Gear Backlash

Figure 3-20

2.4 Post Installation

When the equipment has been completely assembled, and prior to testing, check bolt tension to ensure that it is in compliance with that specified by the designer. The equipment should be oriented to generate as little moment or radial load on the bearing as possible to avoid inaccuracy in readings. Document this orientation so it may be used for all future bolt inspections. Any loss of pretensioning must be determined and eliminated.

Measure and record initial bearing tilt (clearance) of equipment following guideline provided in Paragraph 2.5.7.

During and after validation testing, check bolt tension with equipment orientation as previously done and documented. Any loss of pretensioning must be determined and eliminated.

Follow Paragraph 2.5.1 for lubrication intervals of bearing and gear during testing.

Relubricate the bearing and gear prior to delivery of the machine. Introduce fresh grease into the bearing until grease is observed coming from under either seal. Rotate the bearing several times to ensure a complete fill. Repeat every 6 months on idle equipment or as recommended by the equipment designer.

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2.5 Maintenance

While Kaydon slewing ring bearings require minimal attention, what little they are given will pay big dividends in long life, high performance, and trouble-free service.

2.5.1 Lubrication

2.5.1.1 Bearing

Lubrication of the bearing is recommended every 100 operating hours for relatively slow rotating or oscillating applications such as backhoes, excavators, and cranes or as specified by the designer. In more rapidly moving or continuously rotating machinery such as trenchers, borers, and material distributors, the bearing should be lubricated every day, or every 8 hours of round-the-clock service. Refer to Section 3, page 44 for futher discussion on lubricants to use.

Idle equipment should not be neglected. Grease dries out and "breathing," due to temperature changes, can cause condensation within the bearing. Whether used or not, the bearing should have grease introduced every 6 months. The bearing should then be rotated a few revolutions to coat all surfaces with fresh grease.

2.5.1.2 Gear

There is a tendency to take much better care of the bearing than the gear. However, the meshing action and usual position of the gear tends to purge the lubricant; thus, the gear should be regreased frequently with a small amount of lubricant. A well-maintained gear will provide long, smooth, and quiet service. It is recommended that grease be introduced at the point of mesh of pinion and gear every 8 hours of slow or intermittent operation, and more often for rapidly or continuously rotating applications. Refer to Section 3, page 44 for further discussion on lubricants to use.

2.5.2 Bolts

⚠ The cyclic nature of loading on the mounting bolts gives rise to the possibility of their working loose or to inelastic deformation of the threads and other stressed surfaces. With the equipment in the same orientation as the initial testing during installation, the bolts should be checked by the end user within the first 200 to 300 operating hours. Should any loss of pretension be detected, the source must be determined and eliminated. The bolts should be checked again after each additional 200 to 300 hours of operation until loss is no longer detected, at which time the inspection frequency can be extended as specified by the designer.

2.5.3 Seals

Seals should be inspected during routine maintenance as recommended by the designer, but the interval should not exceed 6 months. Check for tears, breaks, or other signs of damage. Depending on the lubrication frequency and protection, it may be necessary to clean some areas to conduct this inspection. Carefully remove any buildup of debris around the seal and lubricate the bearing. There should be a small bead of grease around the seal edge indicating the bearing is receiving sufficient lubrication.

2.5.4 Cleaning

Cleaning should be done with material compatible with seals following all manufacturers' instructions for use, storage, and disposal. Take precautionary safety measures and use safe operating practices, observing all relevant legal regulations when handling.

Do not expose the seal area or any other bearing opening to pressurized cleaning.

2.5.5 Noise, Roughness and Vibration

⚠ Continued monitoring of equipment noise, roughness, and vibration during operation can assist in early detection of poor or unsafe components, structural failure, or poor bearing performance. The operator should be very familiar with the typical operating conditions generated by the equipment. Investigate and resolve any noted changes.

2.5.6 Torque

Monitoring rotational torque and any variation can not only be used to determine a bearing's condition, but can also provide early indication to a gear, joint, or other structural problem. To determine any change in torque, it is first

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necessary to record an initial measurement best done after testing and prior to the equipment going into service. Check torque every 700 hours of operation or every 12 months, whichever occurs first, and resolve the cause for any changes.

2.5.7 Tilt (Clearance)

Internal bearing clearance will increase with raceway and rolling element wear. The rate of wear, along with other key bearing performance criteria will enable the end user to monitor and determine the condition of the bearing and anticipate when replacement is required. A measurement of the bearing's axial movement (tilt) is a reliable indicator of the bearing's internal clearance.

⚠ To determine the amount of wear that has occurred, it is necessary to perform an initial tilt measurement before the equipment is put into service. Continued measurement of tilt, following the same documented procedure, is required to assist the equipment user in determining when a bearing requires removal. Tilt measurements should be taken every 700 hours of operation or every 12 months, whichever occurs first. Whenever the "increase in tilt" reaches 75% of that shown in Table 3-22, reduce the frequency of measurement to 300 hours. As the rate of wear increases, the period between measurements should decrease accordingly.

The following information is an outline for determining a bearing's tilt.

In order to perform the tilt measurement it is necessary to subject the bearing to a complete moment load reversal removing all clearance from "one side" but not exceeding 25% of maximum equipment rating. Contact Kaydon to discuss any alternative inspections.

- Orient the equipment so the bearing is subject to a moment load.
- Permanently mark the point where the dial indicator is to be positioned for measurement on the rotating and stationary structure. This should be in line with the main load or moment load.
- Without rotation of equipment, permanently mark three additional points on the stationary structure where future measurements will be taken. These should be at locations resulting in four total points all spaced 90° apart.
- Attach a dial indicator at the initial point to an exposed diameter of one ring, or as close as possible, so that it will record relative axial movement between the bearing rings. Accuracy of the dial indicator must be 0.001" or finer. Refer to Figure 3-21.
- Set the dial indicator to zero.
- Prepare to note movement and final reading of indicator during following step.
- Without rotating the bearing ring, apply force on the rotating structure and components in a manner so it causes a complete reversal of the moment load on the bearing.
- Record the final dial indicator reading.
- Remove the recently applied force permitting the original moment load to exist on the bearing.
- The dial indicator should return to zero. If it does not, identify and correct the cause.
- Remove the dial indicator and align the permanent mark on the rotating structure with one of the three marks previously put on the stationary structure.
- Use the same procedure to record measurements at this and the remaining two locations.
- Record these readings in a service manual or other secure document for future reference.
- Compare individual readings to the initial measurements recorded at the same relative location. The increase in tilt is the maximum difference observed.

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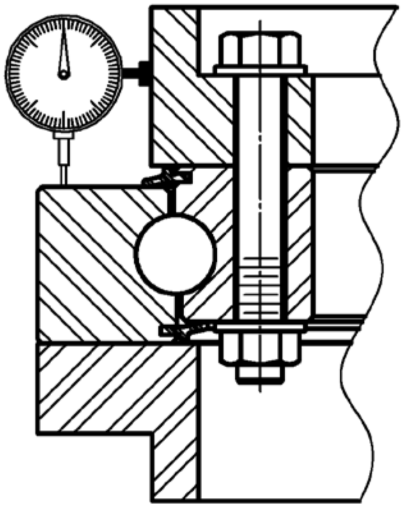

Tilt Measurement Position

Figure 3-21

The increase in tilt is the difference in the last reading taken and the initial reading taken prior to the equipment beginning service. The maximum permissible increase in tilt is shown in Table 3-22 according to rolling element type and diameter. Replace the bearing when the difference exceeds the values shown in Table 3-22. Contact Kaydon should there be additional questions.

2.5.8 Dismantling and Disposal

Should it be necessary to remove the bearing from the equipment, proceed in reverse order of that used for installation or as close as safely possible.

Contact a Kaydon representative concerning potential for repair or replacement. Disposal shall be in accordance with environmental and other local regulations applicable to the materials used.

TABLE 3-22

ALLOWABLE TILT INCREASE (in)		
	Rolling Element	
Diameter D_w	Style	
	Ball	Roller
(in)	(in)	(in)
0.625	0.030	0.010
0.750	0.035	0.012
0.875	0.040	0.013
1.000	0.045	0.016
1.125	0.050	0.018
1.250	0.055	0.020
1.375	0.060	0.022
1.500	0.065	0.024
1.750	0.075	0.028
2.000	0.080	0.032
2.250	0.090	0.036
2.500	0.100	0.040
2.750	0.110	—
3.000	0.115	—

Where D_w = Diameter of rolling element (refer to Page 25 to calculate D_w)

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3. Maintenance (Guidance for Equipment Owner and/or User)

Slewing ring bearings require routine maintenance to ensure optimum performance and that the life determined by the equipment designer is achieved. It is important to follow the service and maintenance recommendations contained in the equipment manufacturer's instruction manual.

3.1 Before Use

If there is no assurance that the bearing/gear has been lubricated within the past six months or after 100 hours of operation, introduce fresh grease according to the equipment manufacturer's instruction manual.

3.2 During Use

- Relubricate bearing and gear according to directions in the equipment manufacturer's instructions.
- Inspect seals, making certain that they are in proper position in grooves and intact.

⚠

- Verify tension of all mounting bolts is in accordance with Owner's Manual.

⚠

- Be alert to changes in torque, unusual sounds, and/or vibrations.

3.3 Grease Lubricants For Slewing Ring / Slewing Ring Bearings and Their Open Gears

Selection of the lubricants used in a slewing ring bearing and the integral open gear is dependent on the application. The designer of the equipment is responsible for selecting an appropriate lubricant and should consult a tribologist for assistance in selecting lubricants for use in the design.

Some of the more commonly used lubricants are shown in table below. These have been used in Kaydon slewing ring bearings when operated in NORMAL applications. Refer to Section 2 of this catalog for further explanation. The list contains commercially available greases from major lubricant manufacturers. The lubricant properties such as oil viscosity, extreme pressure additives, resistance to water washout, low water absorption, corrosion inhibition, and oxidation resistance found in this list of greases provides an example of some of the properties readily available in the market.

Kaydon slewing ring bearings are pre-lubricated with a lithium-based mineral oil grease conforming to NLGI No. 1 consistency with extreme pressure additives, unless specifically noted. Any grease inserted into the bearing must be compatible with this grease. Please refer to Section 3 of this catalog for suggested lubrication procedure and frequencies along with other valuable information concerning installation, care, and maintenance.

Table of Appropriate Grease Lubricants for Kaydon Slewing Ring Bearings and their Open Gears

Manufacturer	Internal Bearing Grease	Open Gear Grease
BP	Energrease LS-EP 1	------
Castrol	HD Lithium 1	Open Gear 800
Chevron	Dura-Lith EP 1	Chevron Open Gear Grease
ExxonMobil	Mobilux EP 1	Mobiltac 375NC (drum) Gearlube 375NC (spray can)
Klüber	Klüberplex BEM 41-141	Klüberplex AG 11-462
Lubricants USA (FINA)	Marson EPL 1	Marson Open Gear Lubricant
Shell	Alvania EP 1	Malleus GL
Texaco	Multifak EP 1	Crater 2X (asphaltic based)