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Function of a slewing ring bearing

A bearing serves as a connection between two adjacent structures, allowing rotation and transmission of load between them. In addition to satisfying this requirement, a slewing ring bearing typically includes features for simple and quick attachment to those adjacent structures, and commonly a feature to facilitate the mechanical rotation of one ring and its adjoining structure relative to the other.

Kaydon slewing ring bearings described in this catalog are typically used in applications where their ability to transmit relatively high loads is of primary importance. However, other potential application requirements such as rotational speed, protection from contamination, accuracy, frictional resistance, and the temperature range of the operating environment could have a significant impact in the selection of an appropriate slewing ring bearing.

The following sections discuss application criteria and provide a guideline for selecting a slewing ring bearing.

Upon request, Kaydon is available to assist in the selection of a Kaydon slewing ring bearing. If such assistance is requested, we suggest that you complete the SPECIFICATION DATA SHEET found in Section 6.

Suggested selection procedure

1. Review the following APPLICATION INFORMATION section before proceeding with bearing selection. The APPLICATION INFORMATION section is a guide for selecting a bearing used in a NORMAL APPLICATION as defined on page 16.

2. Determine the maximum bearing loads. These loads must include all dynamic and static loads imposed on the bearing. The loads in turn must be transposed to loads acting at the bearing's center. See Figure 2-1.

Some specific items to consider are:

- All applied forces to the bearing and gear. Not only the rated and working loads but also those that may occur when equipment is at rest, such as that due to wind for larger structures.
- Loads imposed during overload or testing situations.
- Loads imposed during assembly or disassembly.
- Weights of all members of the structure which are supported by the bearing.
- All possible combinations of maximum loads. A crane, for example, usually has a number of conditions of load versus working radii, both during use and at time of overload testing.

3. Multiply the calculated loads by the applicable service factor: See page 17.

4. If an integral gear is desired, determine the required gear capacity. As with the bearing loads, consideration must be given to all conditions that would generate potential gear loads; some examples include those while working, static, on incline, and overload testing. One must also consider the duty cycle at each of these conditions. See discussion about Torque on page 15 for assistance in determining bearing rotational resistance.

5. Determine the preferred mounting arrangement, considering the pinion and gear location as well as installation and continued maintenance of the bearing and retaining bolts. See Section 3.

6. Refer to the Product Overview and Selection Guide on pages 4&5, and then the individual bearing style sections for potential bearings.

7. ⚠ Make a preliminary selection by comparing the previously calculated bearing loads, including service factor, to the bearing's load rating curve. Ensure that all load combinations are below the curve. In many cases there will be a choice of several bearings meeting the required load ratings.

8. If applicable, check the gear rating of the selected bearing.

9. ⚠ Confirm that the mounting bolts, mounting plates, and joint arrangements are suitable for the installation. See pages 32 to 34.

10. The bearing you select must meet your design requirements.

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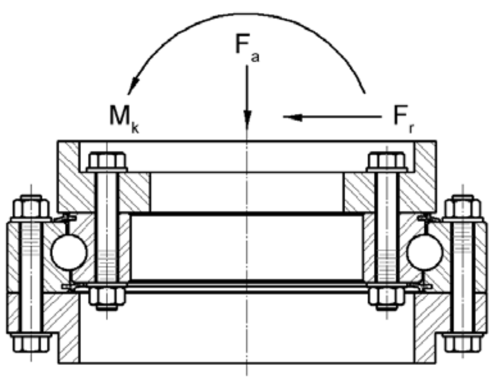
Application information

Load

A slewing ring bearing can be designed for use in applications where loads originate from a single direction or multiple directions relative to its axis of rotation. All of these loads can be resolved into four resultant loads acting on, about, or through the bearing's center. They are referred to as radial, axial, moment and torque. These are used to evaluate the size and capacity of the bearing and integral gear if one is incorporated. Three of these loads are visually depicted in Figure 2-1. The fourth, torque, acts in a manner as to try to rotate one of the bearing rings relative to the other.



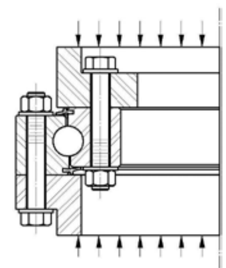
Resultant forces acting on or about bearing

Figure 2-1

Load originated by the equipment and work being conducted is transmitted to the bearing through the mounting structure and mounting bolts. While slewing ring bearings have the ability to accept all types of load combinations, they are primarily designed for loads aligned parallel to the bearing's axis of rotation. These axial or thrust loads originate from a source located at a distance from the bearing's axis of rotation and also generate a moment load about the bearing's center.

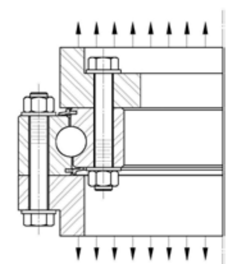
Typically, axial loads are applied in a manner that would tend to compress the bearing faces toward each other. See Figure 2-2. Such loads are distributed uniformly around the mounting structures and surface area of the mating bearing rings, permitting a more even load distribution to the rolling elements within. The result is a lower stress level on all components involved in the transmission of the load.

When the axial load is "suspended" from the bearing, it is concentrated predominantly in a smaller area around the bolts. This is a critical difference that must be considered in the design. See Figure 2-3.



Compression axial load

Figure 2-2



Tension (suspended) axial load

Figure 2-3

A load aligned perpendicular to the bearing's axis of rotation is referred to as radial. When the radial load originates from a source located above or below the bearing's rolling elements, it generates a moment load about the bearing's center. In applications where radial load is significant (defined as greater than 10% of any axial load) or the predominant load, our standard slewing ring bearings may require modified contact angles, ball separators, mounting hole configurations, or the addition of piloting diameters to accommodate these forces.

Speed

Slewing ring bearings are generally used where rotational speed is slow, intermittent, and oscillatory. The permissible speed limits for various Kaydon slewing ring bearings are shown on page 20.

Accuracy

The typical slewing ring bearing application does not require accurate positioning of the rotating structure relative to the stationary one. Therefore all bearings shown in this catalog, excluding the KH Series, are not supplied with diameter tolerances to permit accurate and repetitive positioning.

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Some applications require a high degree of accuracy and are dependent on the bearing to achieve it. Early consultation with Kaydon can lead to use of a slewing ring bearing furnished with the features necessary to provide the accuracy and repetitive positioning needed. Should a mechanical drive be required, making it integral to the bearing reduces the number of components involved, decreasing tolerance build-up that adversely affects accuracy.

Torque

In most applications of large-diameter bearings, the force required to overcome bearing friction, or resistance to rotation, is small compared to that required to overcome the inertia of the mass being supported provided the bearing is properly mounted and contains the standard internal clearance. Bearings include a minimal amount of clearance to minimize the possibility of tight spots resulting from ordinary imperfections in the mounting. Refer to Section 3 for detailed discussion. A bearing distorted by out-of-flat or out-of-round mounting surfaces may require an excessive amount of turning torque. The same is true for a bearing mounted on a structure which deflects locally under load. Other primary factors affecting bearing friction include contact angle, separator, seals and lubricant.

For relatively small loads, the slewing ring bearing may be rotated manually. However, for applications that involve high loads and torque or where manual rotation is undesirable or impractical, a mechanical means of rotating the bearing and desired mating member can usually be accommodated.

Features allowing mechanical rotation of the equipment include gears, sprockets, v-grooves, and timing belt teeth integral to one of the slewing ring bearing rings. The most common solution is to incorporate a gear on one of the slewing ring bearing rings as reflected in various bearing series throughout this catalog. This practice eliminates the need for a separate gear and the additional cost and installation requirements associated with it.

Environment

Slewing ring bearings are suitable for use indoors or outdoors, where conditions consist of indirect exposure to moisture and contamination, and the temperatures range from -40°F to +140°F (-40°C to +60°C). Operation beyond these temperature extremes may require changes of lubrication and non-metallic material used in the standard slewing ring bearings. Operation in very dirty or wet environments may require use of additional seals or shields on the mounting structure to limit exposure of the bearing.

Coatings

To enhance corrosion resistance, Kaydon has the capability to provide a painted surface, a zinc thermal spray coating, or other coatings as specified by the customer. Additionally, we offer Endurakote plating which provides corrosion resistance and is effective in increasing wear resistance in sliding surface contacts.

Mounting arrangement

A widely used method of attaching slewing ring bearings is to bolt through both races with fasteners spaced uniformly around the entire mounting face. It is recognized, however, that the equipment designer cannot always accommodate this type of arrangement and may require tapped holes and even special bolt patterns for assembly and maintenance reasons.

⚠ The designer is responsible for the mounting arrangement and validating the design.

Weld rings are another option for attaching one of the slewing ring bearing rings to its mating structure. The bearing is furnished with a low carbon steel weld ring or band welded to one race. The weld ring can then be welded to the machine without damage to the bearing, provided proper precautions are taken. As the use of weld rings is infrequent, they are not addressed in this catalog. For such designs contact Kaydon.

⚠ Welding the bearing, or welding near the bearing, can damage the bearing.

Lubrication

Grease is the typical lubricant used for slewing ring bearings. Periodic application of fresh lubricant into the

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bearing is required to reduce friction and wear, provide corrosion protection, displace contaminants, and enhance performance of the seals. One or more grease fittings or lubrication holes are provided in all slewing ring bearings for this purpose. Additional lube fittings or holes may be required and can be furnished on request.

Whenever the slewing ring bearing has an integral gear, it too requires periodic application of grease for optimum performance. For further discussion of lubrication see page 44 (Section 3).

Normal application

Special attention must be given to bearing selection whenever application conditions are different from those considered normal. For a "normal application" of slewing ring bearings, the following conditions should apply:

- Vertical axis of rotation
- Predominant compressive thrust and moment loading
- Radial load not in excess of 10% of the thrust load
- Intermittent rotation with pitch line velocity limited to 500 fpm for single row bearings and 300 fpm for multi-row bearings as shown in this catalog
- Operating temperature within -20°F to +140°F (-29°C to +60°C)
- Mounting surfaces machined and reinforced to limit deviation from a true plane to the levels indicated on pages 25 to 31, Figures 3-1 to 3-9
- Installation procedure to assure roundness of both races, such as by applying a centered thrust load while tightening the bolts using the alternating star pattern (see Section 3)
- Provision for periodic lubrication
- Provision for periodic checking of mounting bolts to verify their proper tension

Service factors

Refer to Table 2-4 for the appropriate application service factor. The load rating curves shown in this catalog have an application service factor of 1.00. To determine the required bearing rating, multiply the application service factor by the applied loads on the bearing.

Application service factors are based on a number of considerations, but primarily the frequency of use at higher vs. normal loads and potential for extreme or overload. If the intended equipment and application do not appear in Table 2-4, for initial sizing select a comparable application. If there is a question concerning this selection, contact Kaydon. If the application involves more frequent operation than indicated in the above paragraphs and definitive duty cycles for loads, speeds, and oscillation are available, complete and submit the Specification Data Sheet in Section 6. For such applications, the fatigue life of both the bearing and gear may dictate the designs required, and service factors should not be the sole criterion used for selection of a slewing ring bearing.

There is no industry-wide standard for rating the capacity of slewing ring bearings. As a result, it is not uncommon for bearing vendors' ratings and service factors to vary and still result in the same approximate bearing design and size for a given application. Also, these factors may be superseded by customer specification, FEA (Finite Element Analysis) classifications, or regulations by certifying authorities.

The equipment designer is responsible for determining the correct service factor. This can be done with the suggestions from and assistance of Kaydon, upon request.

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Table 2-4 - Service Factors

Application	Service Factor
Aerial Lift Devices – Aerial baskets, platforms, ladders, etc.	1.00
Amusement Rides	Alternate Criteria *
Coiler/Uncoiler	Alternate Criteria *
Conveyors	1.00
Cranes	
Mobile - (loads limited by machine stability)	
Normal construction duty (tire mounted)	1.00
Normal construction duty (crawler mounted)	1.10
Production duty such as scrap and ship yards	1.25
Forestry handling (logging)	1.50
Stacker cranes (must include dynamic forces as loads)	1.25
Pedestal or Tower - (loads not limited by machine stability)	
Loads continually monitored by safe load device	1.25
Applications with risk of sudden impact load application	1.50
Offshore	Alternate Criteria *
Excavators	
Load limited by tipping	1.25
Load limited by hydraulic pressure relief	1.50
Hook and Grab Rotators for Cranes	Alternate Criteria *
Index and Turnstile Tables – (include any shock loads for evaluation)	
Occasional use with intermittent rotation	1.00
Frequent use with intermittent rotation	1.25
Frequent use with intermittent rotation and impact loads	1.50
Continuous rotation	Alternate Criteria *
Industrial Manipulators and Robots	
Occasional service	1.00
Frequent service	1.25
Continuous service	Alternate Criteria *
Mining Shovels	Alternate Criteria *
Stacker -Reclaimer	Alternate Criteria *
Steel Mill	
EAF	Alternate Criteria *
Ladle Cars	Alternate Criteria *
Ladle Turrets	Alternate Criteria *
Steering Gear – (must include dynamic and shock loads due to transit forces)	
Pneumatic Tires	1.25
Solid Tires	1.50
Tunnel Boring Machine	Alternate Criteria *
Water Treatment Clarifiers, Thickeners, and Rotary Distributors	Alternate Criteria *
Wind Turbines	Alternate Criteria *

* As this application involves additional criteria, it requires use of an alternative method for evaluation and selection of the slewing ring bearing.

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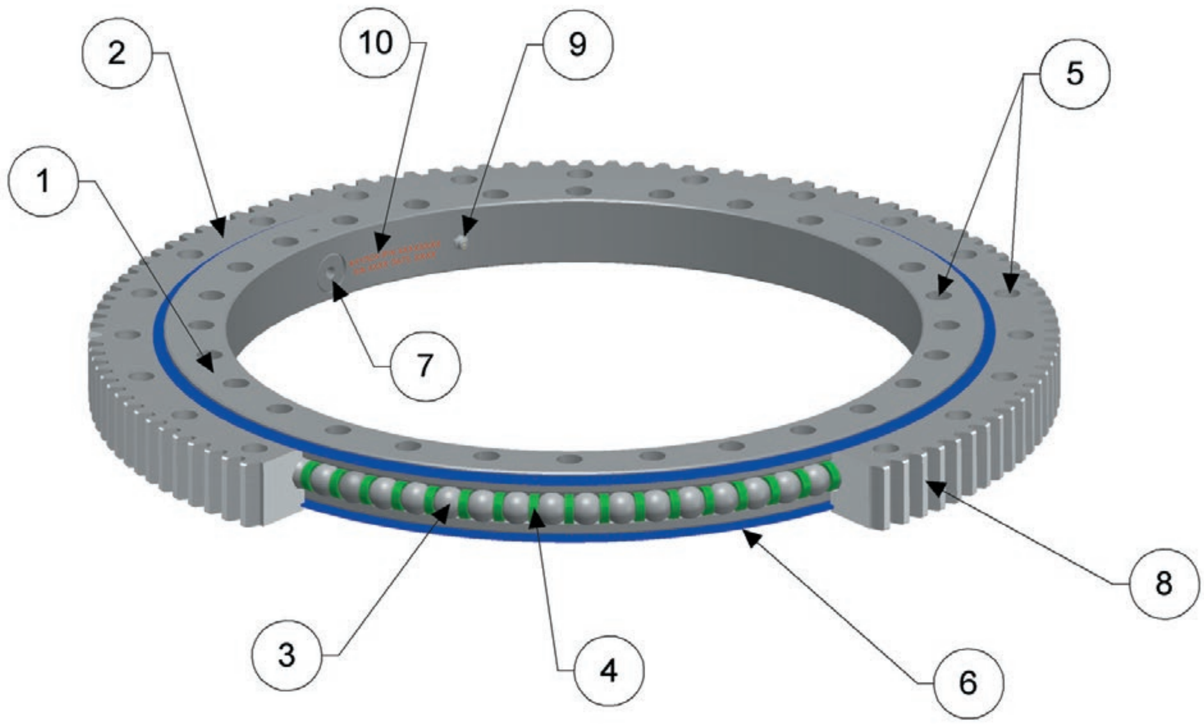
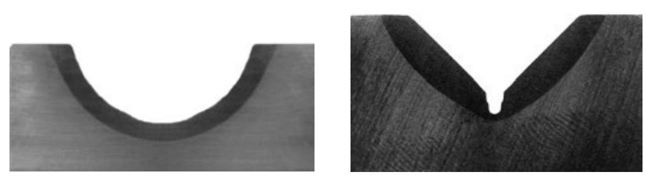
Slewing ring bearing features



Inner and outer rings (1 and 2)

The bearing consists of an inner and outer ring made of medium carbon steel. Each includes at least one precision raceway arranged to transfer loads and relative motion from one structure of the equipment to the other. The raceways are selectively hardened to the required surface and depth necessary to transmit high stresses imposed during operation of the equipment. Figure 2-5 reflects the typical hardness patterns of four-point ball (RK, HS, HT, MT, KH, and XT Series) and cross roller (XR Series) bearings. Multiple row bearings (DT and TR Series) receive similar treatment in their highly stressed raceways. In one location around the raceway, there is an unhardened area referred to as the hardness gap or "soft spot." This area is relieved to minimize the ability of the rolling element to apply stress on it. Only one side of each ring is manufactured to be mated with the supporting structure. One or both rings may include an integral drive mechanism such as gear or sprocket teeth to enable the mechanical advantage necessary to overcome rotational resistance and provide relative motion through the bearing.



Hardened Pattern for Ball Raceway | **Hardened Pattern for Roller Raceway**

Figure 2-5

Rolling elements (3)

Precision rolling elements enable relative rotation and transmit load between the inner and outer rings. Hardened chrome alloy steel balls or rollers may serve as the rolling elements. They are sized appropriately for the anticipated stresses and closely matched to provide uniform load distribution between the rings and minimize rotational resistance.

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Spacers (4)

Spacers separate the rolling elements and are designed to minimize friction, skidding, and jamming during rotation. These conditions occur as a result of load distribution and distortion of the mounting structures and bearing rings during operation of the equipment. Spacers are generally made of a plastic material compatible with typical lubricants and operating environments.

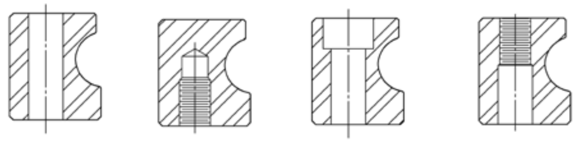
Occasionally for ball bearings, a ball of smaller size is placed between the larger load-carrying balls instead of a spacer. These are referred to as "spacer balls" and can provide a solution to a unique condition specific to a particular application. Where the application warrants, a separator is used in place of the spacers or spacer balls.

Mounting holes (5)

The ideal hole pattern for attaching both rings of the slewing ring bearing is a full circle of uniformly spaced through holes. It is recognized, however, that the equipment designer cannot always accommodate this type of arrangement and may require tapped holes and even special bolt patterns in one or both rings for assembly and maintenance reasons.

Kaydon has accommodated these special mounting requirements. Samples of these options are shown in Figure 2-6.

⚠ The equipment designer, manufacturer, or user is responsible for determining if the mounting design is adequate. Some methods employed in making this determination are to perform analysis and then tests to evaluate and validate the structure, fasteners, and joint for adequate strength and integrity to sustain the maximum and all repetitive loads possible.



Through Hole	Threaded Hole	Counter-Bored Hole	Far Side Threaded Hole

Figure 2-6

Seals (6)

A seal is included on each side of Kaydon slewing ring bearings for retention of lubricant and protection of the bearing from dust and small particle contamination. The seals are made of an elastomer material compatible with most general purpose lubricants having mineral oil and greases using lithium or calcium thickeners. If conditions require different sealing, Kaydon can provide details of additional options upon request.

Loading (Filler) Plug (7)

The rolling elements in Kaydon bearings may be inserted through a hole drilled radially through the non-geared race and then plugged. The plug is retained mechanically with a pin to assure proper orientation is maintained. TR Series bearings, however, do not have a loading plug as they require one of the rings be split for assembly of all the rolling elements. ⚠ Removal of the load plug voids the warranty.

Gear (8)

Slewing ring bearings can be supplied with gear teeth as an integral part of either the inner or outer ring. They are typically a standard full depth or stub involute spur gear having a 20° pressure angle with provision for backlash and conforming to AGMA Q6 quality.

However, where required, modifications of the basic tooth forms, pressure angles, and quality can be provided. For assembly purposes, the maximum point of gear runout is identified with yellow paint. Alternative methods may be applied upon request.

Grease Fitting (9)

At least one grease fitting is supplied in one of the bearing rings for periodic lubrication of the raceway and internal components. On designs with integral gear teeth, it is located in the non-geared ring. The number supplied typically increases with bearing diameter. More or less may be included upon request.

Identification (10)

Identification consists of the bearing part number and serial number. This information is located next to the filler plug.

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Slewing ring bearing properties

Load rating

The majority of slewing ring bearing applications require the bearing to transmit static load or high loads at slow rotation with operation being intermittent. In such applications, the fatigue life of the internal bearing complement is less of a concern than the bearing's static and infrequent load capability. Most bearing selection is based on the Kaydon load rating chart and an appropriate service factor for the intended application (see Service Factors Table 2-4, page 17).

Use of the Kaydon load rating charts requires compliance to all instructions and guidelines provided in the Installation and Maintenance section of this catalog; refer to pages 25 to 44.

⚠ Failure to follow above recommendations can severely limit ability of the bearing, retaining bolts, and adjacent mounting structures to safely transmit the indicated loads.

Load rating charts with a service factor of 1.00 are shown for all bearings listed in this catalog, except for the KH and XR Series. Bearings from either of these series are used where operating conditions and performance expectations require different selection criteria. To further assist the designer in making a KH or XR Series selection, ratings and performance results are provided.

If the application involves more frequent operation than indicated on page 16 and definitive duty cycles for loads, speeds, and oscillation are available, Kaydon can assist in bearing selection, upon request. If such assistance is requested, it is recommended that one complete and submit the Specification Data Sheet in Section 6.

For such applications, the fatigue life of both the bearing and gear may dictate the designs. As a result, service factors should not be the sole criterion used for selection of a slewing ring bearing.

Speed

The rotation of single-row slewing ring bearings such as the RK, HS, HT or MT Series should be intermittent and limited to a maximum pitch line speed of 500 feet per minute (fpm). For bearings with multiple rows of rollers such as the DT and TR Series, the maximum pitch line speed should be limited to 300 fpm on an intermittent basis. The KH and XR Series are appropriate to use for continuous rotation at 500 fpm and infrequent rotation up to 750 fpm. Modifications may be made to any of these bearings to permit continuous rotation and load at speeds exceeding the values given. Modifications may include change in internal clearance, contact angle, clearance, rolling element separation, or seals. If assistance is required, contact Kaydon for a bearing to meet your specific requirements.

Accuracy

All slewing ring bearings shown in this catalog, with the exception of the KH Series, are furnished with sufficient internal clearance to allow for some imperfections of mounting surfaces and for small amounts of deflection under load. They are not furnished with external diameters having a low tolerance to permit accurate positioning of the rotating structure relative to the stationary one. Upon request, Kaydon can supply bearings with reduced clearance or preload, reduced runout, and external diameters for location purposes.

The KH Series is provided with no internal clearance and closely held external diameters for those applications requiring additional accuracy. See page 72 for additional information concerning accuracy of the KH Series. If necessary, bearings can be furnished with reduced internal clearance to minimize "rock." Extra care should then be taken to assure the installed bearings will be round and flat to maximize bearing capacity and performance. See pages 25 to 31 (Installation & Maintenance).

Our standard integral gear is manufactured in accordance with AGMA Class Q6 quality, excluding the KH Series. Should the application warrant, gears can be supplied to AGMA Class Q11 quality. The integral gear supplied on the KH Series is in accordance with AGMA Class Q8 quality.

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Rotational friction (Torque)

The friction torque for a slewing ring bearing due to external loads can be estimated using the following equation. This assumes the bearing is mounted according to the guidelines provided in the Installation & Maintenance Section, pages 25 to 44 of this catalog. This is an estimate and is significantly influenced by fluctuations in critical features; therefore, it is advisable to account for additional torque when initially selecting the drive arrangement. Once some experience with the application has been accumulated, the drive arrangement can be altered accordingly. Also note, the equation is not valid when the application loads equal zero, as there will still be some rotational resistance due to the weight of the rotating components and frictional resistance of the seals and lubricant.

$$M_w = \frac{\mu\,(4.4M_k + F_a D_p + 2.2F_r D_p)}{2}$$

Where: M_w = bearing torque under load, (ft-lbs)

μ = friction coefficient

= .006 for RK, HS, HT, MT, KH, XT, and DT Series

= .004 for XR and TR Series

M_k = moment load, (ft-lbs)

F_a = axial load, (lbs)

F_r = radial load, (lbs)

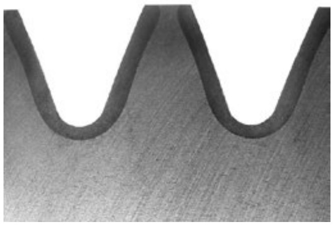
D_p = bearing pitch diameter, (ft)

Gear rating

Tangential gear tooth ratings are shown in the selection tables for each applicable bearing and gear combination. These ratings only consider bending fatigue strength being generated using the commonly accepted Lewis Equation. They are suitable for sizing when the application involves low speed and intermittent/oscillatory rotation. For applications with higher duty cycles, or frequent and rapid acceleration it may be necessary to use alternative methods, including surface fatigue for determining adequacy of the gear tooth design.

⚠ As a precaution it is recommended the machine designer verify the adequacy of the gear based on his own methods of calculation and past experience.

When additional surface endurance and bending strength are required, Kaydon can accommodate both by providing a gear with rounded fillet and selectively hardened flanks and root. See Figure 2-7. On occasion and where the application permits, a gear with only the tooth flanks hardened may be used. This increases tooth surface endurance, but may decrease the tooth bending strength depending on the initial and final configuration being evaluated.



Selective Hardened Flanks and Root

Figure 2-7