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## Frictional coefficient (reference)

The frictional moment of rolling bearings can be easily compared with that of plain bearings. The frictional moment of rolling bearings can be obtained from their bore diameter, using the following equation :

$$M = \mu P \frac{d}{2} \dots\dots\dots (8-2)$$

where :

$M$  : frictional moment mN · m  
 $\mu$  : frictional coefficient  
 $P$  : load on the bearing N  
 $d$  : nominal bore diameter mm

The friction coefficient is greatly dependent on bearing type, bearing load, rotation speed and lubrication, etc.

Reference values for the friction coefficient during stable operation under normal operating conditions are listed in **Table 8-1**.

For plain bearings, the value is normally 0.01 to 0.02 ; but, for certain cases, it is 0.1 to 0.2.

**Table 8-1 Friction coefficient  $\mu$**

| Bearing type                               | Friction coefficient $\mu$ |
|--------------------------------------------|----------------------------|
| Deep groove ball bearing                   | 0.0010~0.0015              |
| Angular contact ball bearing               | 0.0012~0.0020              |
| Self-aligning ball bearing                 | 0.0008~0.0012              |
| Cylindrical roller bearing                 | 0.0008~0.0012              |
| Full complement type needle roller bearing | 0.0025~0.0035              |
| Needle roller and cage assembly            | 0.0020~0.0030              |
| Tapered roller bearing                     | 0.0017~0.0025              |
| Spherical roller bearing                   | 0.0020~0.0025              |
| Thrust ball bearing                        | 0.0010~0.0015              |
| Spherical thrust roller bearing            | 0.0020~0.0025              |



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### Bearing Friction

Rolling element bearings, such as ball bearings and roller bearings, are used in equipment primarily because they support the loads inherent to the machine's function at a much lower friction level than any oil film bearing, such as bronze or Babbitt. This reduces the power required to drive the equipment, lowering the initial cost of the prime mover and the energy to operate it. While sometimes generically referred to as "Anti-Friction" bearings, there is a small amount of friction or resistance to rotation in every ball and roller bearing. The sources of this friction are slight deformation of the rolling elements and raceways under load and sliding friction of the rolling elements against the cage and guiding surfaces. Different bearing types, because of their internal designs, result in slightly different amounts of internal friction.

Table III

| Bearing Type                           | Coefficient of friction - $\mu$ |
|----------------------------------------|---------------------------------|
| Deep Groove Ball Bearing               | .0015                           |
| Angular Contact Bearing                | .0020                           |
| Cylindrical Roller Bearing, Cage       | .0010                           |
| Cylindrical Roller Bearing, Full Comp. | .0020                           |
| Tapered Roller Bearing                 | .0020                           |
| Spherical Roller Bearing               | .0020                           |
| Ball Thrust Bearing                    | .0015                           |
| Cylindrical Roller Thrust Bearing      | .0050                           |
| Tapered Roller Thrust Brg. Cage        | .0020                           |
| Tapered Roller Thrust Brg. Full Comp.  | .0050                           |

Frictional force would simply be:  $\text{Force} = P \times \mu$

Another contributor to bearing internal friction is the lubricant, grease or oil, that is continually being pushed aside as the rolling elements circulate around the raceways. Coefficients of friction for the various types of bearings are based on a reference value of lubricant viscosity of 20 cSt/100SUS at the bearing's operating temperature. Coefficients of friction for different bearing types are shown in Table III.

If a more accurate calculation of bearing friction taking into account the effects of speed and lubrication is required for an application, please [contact](#) American's sales department. More important to the equipment designer than frictional force is the amount of frictional torque that must be overcome. This parameter can easily be calculated using the formula below:

$$\text{Torque} = \frac{P \times \mu \times d_m}{2}$$

where:

P = Equivalent Load on the bearing

$\mu$  = Coefficient of friction

$d_m$  = Pitch diameter of bearing

Lastly, the amount of power consumed by bearing friction can be easily calculated using the appropriate SI or Imperial formula knowing the resistance Torque and RPM.

### Vibration Frequency Factors

More and more manufacturers and end-users use vibrational analysis to monitor the operation of their equipment to detect the onset of component failure. The primary suspects are bearings and gears, two components that are subjected to the highest stresses in operation. However, other machine components subjected to cyclic stresses can also deteriorate and eventually fail. There is often a window of opportunity between deterioration and complete failure when the machine component will announce its condition by an increased level of vibration or noise. An increase in vibration level can affect the quality of the product produced, but the greatest value of vibrational monitoring is the early warning of an impending failure. This allows plant operators to schedule a convenient shutdown time and maintenance workers to efficiently plan the removal and replacement procedure. Another advantage of having foreknowledge of impending component failure is to be able to remove the component before total failure thus preventing pieces of the failed component from getting into and damaging other components.

A bearing, like a gear or other machine component, can predictably generate an impulse whose frequency is directly related to the input RPM of the machine. When the spectrum of a vibration monitoring indicates a higher than normal amplitude at a certain frequency, the analysis proceeds to match this frequency with the machine component that could

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produce this frequency, thus identifying the cause and eliminating other components from consideration.

Each typical bearing has four major components, and if damaged, can produce an impulse at different frequencies proportional to the operating RPM of the bearing. These bearing components are the cage, outer race, inner race, and rolling elements. American can supply, for every bearing that we make, Fundamental Frequency Factors for each of the four components. When multiplied by the RPM of the bearing, each factor would indicate the expected frequency or harmonics that would be picked up by vibrational analysis. This assumes a defect can occur on each bearing component, which might be the beginning of a fatigue spall, denting damage from the piece of another component, or some other type of wear or damage. The four Fundamental Frequency Factors are:

- $F_{\text{cage}}$
- $F_{\text{outer race}}$
- $F_{\text{inner race}}$
- $F_{\text{roller}}$

Manufacturers and users of equipment should be aware of the fundamental frequencies that each machine component can produce and keep on file all these values for reference purposes.

The Cage Factor,  $F_{\text{cage}}$ , is related to the number of revolutions the cage makes compared to the inner race of a radial bearing and the rotating race of a thrust bearing. For 90-degree thrust bearing, it is .500, while for most radial bearings it is slightly less than .500. A typical value might be .410, and what this means is the cage will make 41 revolutions for every hundred that the inner race makes.

The inner race and outer race factors relate to how often a Roller passes over a defect, such as a small spall or dent in the roller path. With a rotating inner race, the  $F_{\text{inner race}}$  value is always larger than the  $F_{\text{outer race}}$ . The rolling element factor,  $F_{\text{roller}}$  or  $F_{\text{ball}}$ , relates to the RPM of the element and the defect contacting both the inner race and outer race during each revolution. [Contact](#) American Roller Bearing's sales department for the Fundamental Frequency Factors for our bearings.

### ***Bearings We Offer***

American Roller Bearing primarily makes heavy duty bearings that are used in various industries in the US and around the world. Not only must our industrial class bearings provide long in-service life from a rolling fatigue criterion, but they must also hold together structurally from impacts, overloads, and occasional high-speed excursions. The design of every heavy-duty bearing has been optimized to this end, including our large bore bearings.

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