

## Symptoms and prevention measures

### (1) Premature Flaking

The repeated heavy stress cycle between the bearing raceway and rolling element surface results in fatigue cracks which become loosened from bearing materials.

#### Causes

- Abnormal axial load or excessive load caused by expanded shaft.
- Deflection or misalignment of shaft.
- Poor parallelism of inner and outer rings.
- Poor lubrication.

- Rusting, Nicks, Galling from dirt, etc.

#### Countermeasures

- Clearance fit for the outer ring of one bearing to allow the floating end to move freely axially.
- Correct alignment of shaft and bearing housing.
- Improve mounting and alignment.
- Carefully clean and handle shaft and housing.
- Review type and quantity of lubricant.



### (2) Seizure

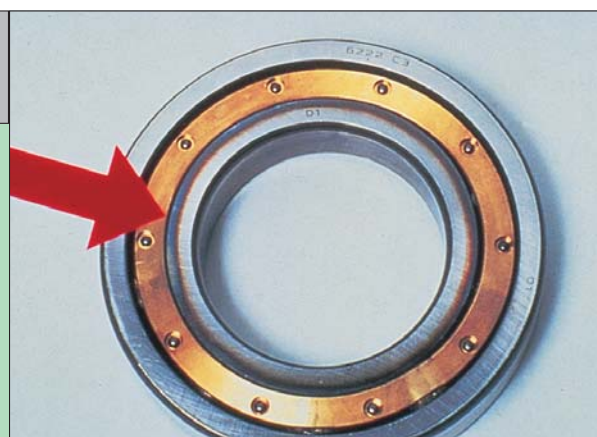
Bearing is seized up by excessive heat. Discoloration, softening and fusion of raceway and rolling element.

#### Causes

- Loss of clearance.
- Operating over limiting speed.
- Poor or improper lubricant.

#### Countermeasures

- Review fitting and bearing clearance.
- Review type of bearing.
- Select a proper lubricant, and feed it in proper quantity.



### (3) Breakage

Splits and cracks in the inner/outer ring or rolling element.

#### Causes

- Excessive interference fit.
- Bearing seat has larger corner radius than bearing.
- Excess clearance during operation.
- Excess impact load.

#### Countermeasures

- Check fits. Finish shaft and sleeve to higher accuracy.
- Make shaft corner radius smaller than that of the bearing.
- Check fits and bearing clearance.
- Re-check load conditions.



### (4) Indentation

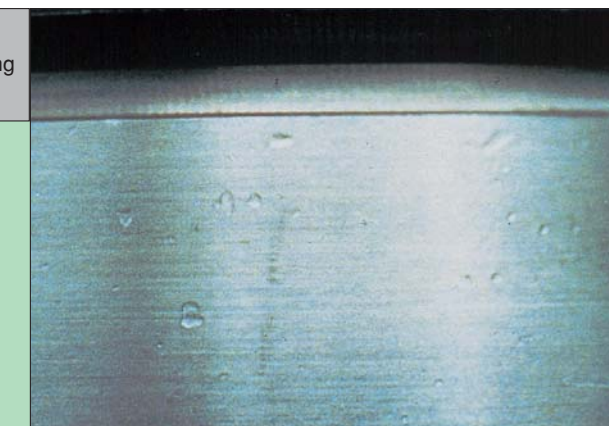
Brinelling, indentation and pear skin of bearing raceway and rolling element.

#### Causes

- Impact applied during mounting.
- Impact from dropped bearing.
- Contamination
- Load applied to bearing at rest in excess of static load rating.

#### Countermeasures

- Carefully handle the bearing.
- Clean shaft and housing.
- Improve the sealing.
- Re-check load conditions.



### (5) Fretting

Occurs when a small relative motion is repeatedly caused in non-rotating bearing. Fretting surface wear produces red colored particles at fitting surface.

#### Causes

- Vibration applied to bearing at rest (e.g. during shipment).
- Swing with smaller amplitude.
- Minute clearance on fit surface.
- Slight sliding during operation as a result reduced interference under a load.

#### Countermeasures

- Fit the shaft and housing during shipment.
- Apply a preload. Use oil for lubrication.
- Increase the interference.
- Apply oil.



### (6) Scoring

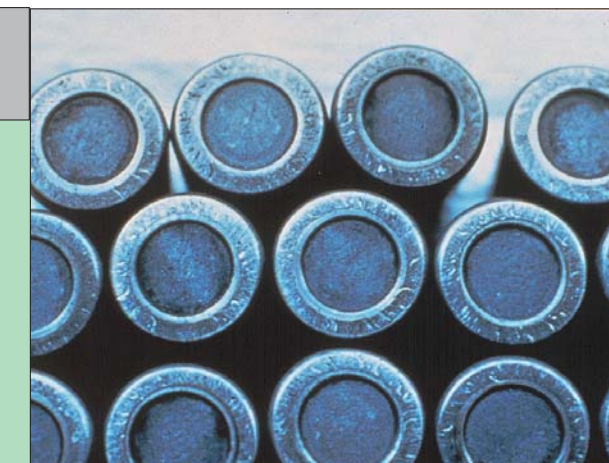
Metal to metal contact of bearing raceway, flange face, rolling element and retainer due to destruction of oil film.

#### Causes

- Incorrect lubrication.
- Contamination by foreign matter.
- Deflection or misalignment of shaft. Excessive axial load.
- Sharp speed increase at startup.

#### Countermeasures

- Review type and quantity of lubricant.
- Improve sealing and component cleaning.
- Correct mounting errors. Review load conditions.
- Change to smooth acceleration.



### (7) Smearing

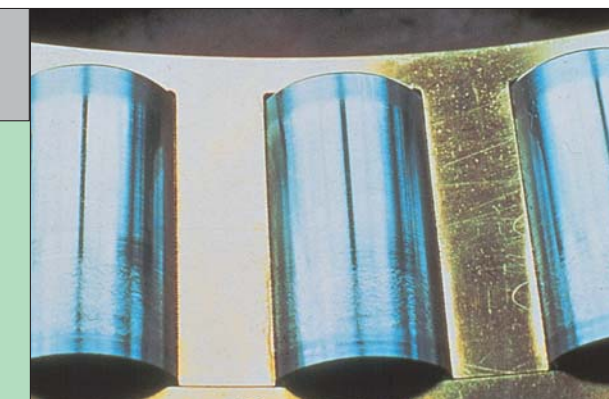
Metal to metal contact due to the destruction of oil film. Sliding motion between outer/inner ring and rolling element.

#### Causes

- Excess axial load.
- Misalignment of bearing.
- Poor lubrication.
- Intrusion and galling caused by foreign matter.
- High acceleration on start-up.

#### Countermeasures

- Correct mounting errors.
- Review the load condition.
- Select a proper lubricant, and feed it in proper quantity.
- Improve the sealing.
- Clean shaft and housing.
- Avoid sharp acceleration.





## Introduction

Thank you for using NACHI bearings and supporting our company.

This booklet provides the basics in bearing (rolling bearing) usage that you should be aware of prior to use.

As you know, a bearing supports the rotating members of a machine, complex or simple, and has a wide range of uses, from household appliances to large machinery and equipment. For decades, the standardization of bearings has progressed, and bearings have become familiar objects in our daily lives. Nevertheless, a bearing is an extremely fine and precise part that requires proper handling and usage.

Having good knowledge on the advantages and disadvantages of bearings, proper, safe usage, and daily cautions will allow you to take full advantage of their unique characteristics.

The booklet summarizes basic information on bearings for those who are already using a bearing as well as those who are planning to use them in the future.

Please read this booklet carefully, as it provides instructions for safe operation and how to get the longest use out of a bearing. For more detailed information, please contact NACHI Sales Division.

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## **[Safety Precautions]**

The following precautions should be followed in order to protect users and property from injury and severe damage.

★The following show the degree of possible injuries and damages when bearing is used incorrectly and inattentively.

 **Danger** Imminent danger of death or serious injury

 **Warning** Possible danger of death or serious injury

 **Caution** Possible injury or possible material damage

★The following signs show the meanings described below.

 **Always enforced**

 **Forbidden**

 **Caution**

 **Catalog Reference**



# Caution



Be sure to conduct the daily inspection of a bearing.

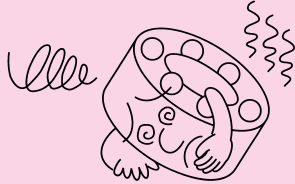
[Items to be Inspected]

- Vibration or Sound
- Temperature
- Condition of Lubricant (Change in color or Viscosity, Presence of Foreign Materials)
- Amount of Lubricant
- Amperage of Drive Motor

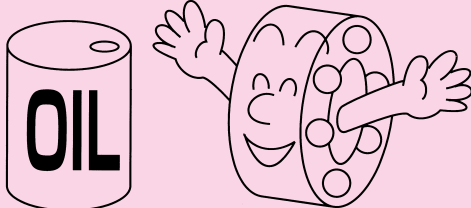


Always operate bearings below the allowable rotating speed.

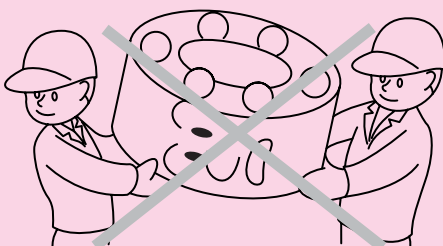
Use of bearings over their allowable rotating speed can cause damage due to excessive heat generation and seizure.



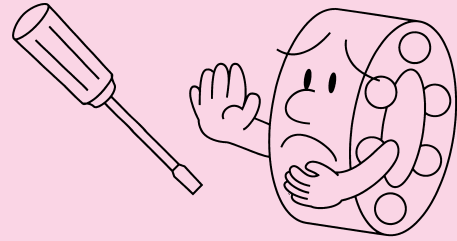
If the operational temperature exceeds 100°C, replenish the bearing with proper amount of lubricant two to three times a year.



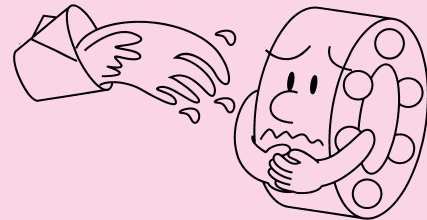
Large, heavy bearings must be transported with forklifts or hoists.



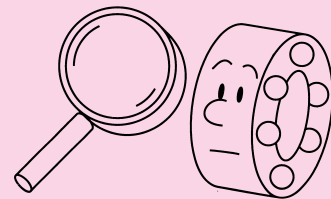
Do not attempt to disassemble to modify a bearing as it can lead to premature failure or equipment damage.



Do not allow water, metal pieces or dirt to enter the inside of bearings as it can cause damage to bearings.



Confirm that a lubricant is present in the bearing. Lack of a lubricant may generate heat, cause the bearing to seize and damage the bearing.



Store bearings under the following environment.

- Cool, dark area that is free of direct sunlight
- Dry area free of moisture
- Clean area free of dirt
- An area of 30 cm above the floor



Use the proper tools to install or remove bearings. Use a clean cloth to wipe off the tools and check them for crack, sharp edge, breakage, chipping or deformation prior to use.

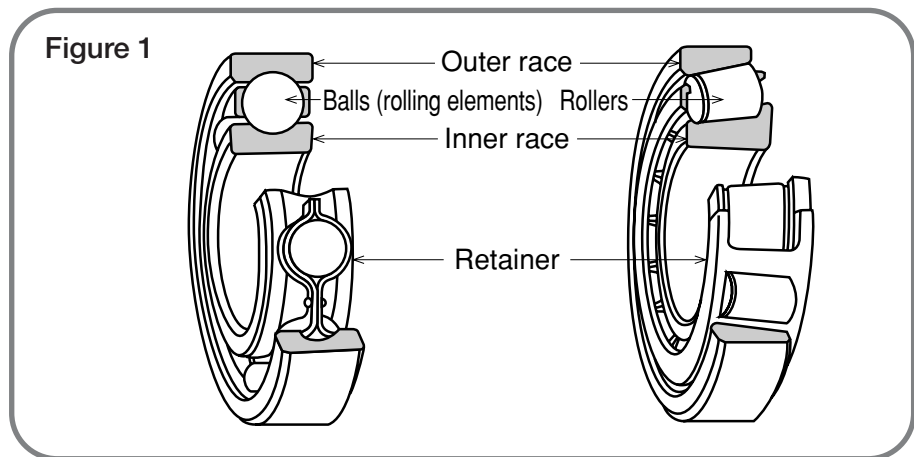
# Chapter 1: What are bearings?

Bearings are very easy to use, which makes their range of uses very broad. They are used in the rotating parts of many devices, beginning with household appliances such as vacuum cleaners, refrigerators and air conditioners and going on to include automobiles, railway cars, aircraft, construction equipment, and machine tools as well as large machinery and equipment.

\* The term "bearing" as used in this booklet is limited to ball bearings and roller bearings.

## 1-1 Structure of Bearings

Bearings are composed of two races (inner race and outer race), multiple balls or rollers rolling between them and a retainer that separates and guides the balls or rollers.



### Warning

In order for bearings to turn freely, smoothly and accurately, the inner and outer races and balls or rollers are manufactured with roundness and surface roughness of 1/1000 mm (1 micron). Therefore, a manufacturer carefully controls the handling of bearings to prevent them from rust, dirt and damage prior to delivery to the user. Please be aware that the bearings are precision parts and should be handled with care.

## 1-2 Bearing Types and Features

Bearings come in various configurations. Table 1 shows the features and a simple cross section of typical standard bearing types.

### Description of Symbols

- (1) Load carrying capacity ↑: Indicates a radial load, while ← → indicate that it can support an axial load.  
Axial load ←: Indicates that it can only receive a load in one direction, while ← → indicate that it can receive a load in both directions.
- (2) The relative thickness and length of the arrows indicates the approximate size of the load that can be supported.
- (3) High-speed rotation and Accuracy: ●: Indicates how easy it is to obtain those features.  
The more marks, the better suited the bearing is for the operating condition.



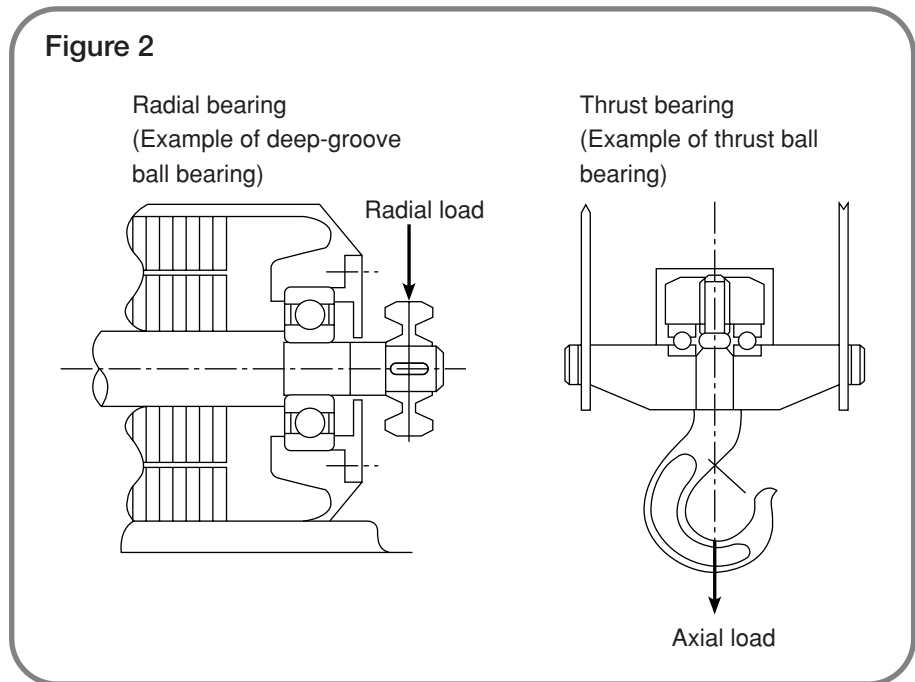
Table 1. Bearing Types and Features

		Types	Cross Sections	Features			
				Load carrying capacity	High-speed rotation	Accuracy	
Bearings	Radial Bearing	Ball Bearing	Deep-groove Ball Bearing				
			Angular Contact Ball Bearing				
			Duplex Mounting Angular Contact Ball Bearing				
			Double row Angular Contact Ball Bearing				
			Self-aligning Ball Bearing				
		Roller Bearing	Cylindrical Roller Bearing				
			Cylindrical Roller Bearing (with Guide Flange)				
			Needle Roller Bearing				
			Tapered Roller Bearing				
			Spherical Roller Bearing				
	Thrust Bearing	Ball Bearing	Thrust Ball Bearing				
		Roller Bearing	Spherical Roller Thrust Bearing				

### 1-3 Radial Bearings and Thrust Bearings

If the direction in which the bearing receives the primary load is perpendicular to the shaft, it is known as a radial bearing. If the direction is parallel, it is known as a thrust bearing.

Radial bearings mainly support loads in a radial direction, while thrust bearings mainly support loads in an axial (thrust) direction.



#### Caution

Thrust Ball Bearings can only receive a load in an axial direction.



#### Caution

Deep-groove Ball Bearings with two seals or two shields were greased at the time of manufacture, so they are ready for immediate use. Do not remove the seals or shields to replenish with grease.



#### Caution

The seals are made of oil-resistant and wear-resistant synthetic rubber. They are recommended for use between temperature  $-40$  to  $+120^{\circ}\text{C}$ . Please consult with NACHI engineering staff for operating temperature outside of the specified range.



#### Caution

The retainers can be made of mild steel, brass alloy or synthetic plastic. Retainers made of synthetic plastic are likely to change their shape and lose strength when exposed to temperature above  $120^{\circ}\text{C}$  or below  $-40^{\circ}\text{C}$ . For temperatures outside of this range, mild steel or brass alloy retainers are recommended.



#### Caution

Make sure that no moisture or foreign matter, i.e. contamination, enters inside the bearings.



## Chapter 2: Three Conditions to Maximize the Use of Bearing Capabilities

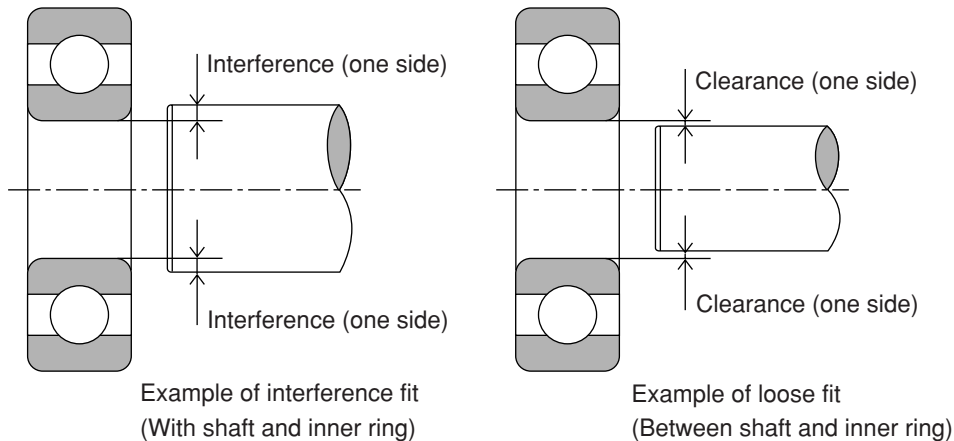
### 2-1 Fitting the Bearing with the Shaft and Housing

In order to make optimum use of bearing functions and capabilities, the fit\* between the shaft and inner ring as well as the housing and the outer ring must be appropriate. If there is clearance in the fitted sections during operations, this can result in displacement (known as "creep") in a circular direction between the shaft and inner ring (or between the outer ring and housing). Once creep occurs, it is difficult to stop.

This will result in marked wear on one of the joined surfaces and damage to the bearing, shaft and housing. In addition, the heat generation caused by slipping results in high operating temperatures, leading to seizing of the bearing or may even cause the lubricant to catch on fire.

- \* When assembling the shaft and the bore, they are assembled with interference or some clearance to move freely. This type of dimensional relationship between the parts is known as the fit. A fit with interference is known as an interference fit and a fit with clearance is known as a loose fit.

Figure 3



### Warning

To prevent creep, the bearing rings that support the rotating load must have an adequate interference fit. Clamping the bearing ring with a nut is not sufficient enough to prevent creep.

#### (1) Selecting the Fit

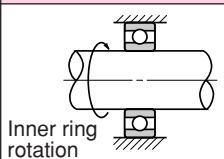

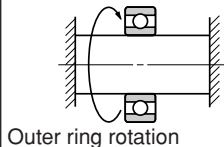

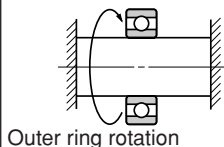
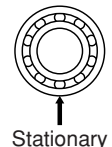
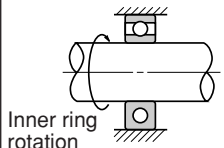

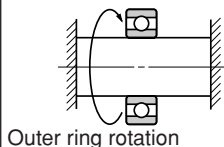
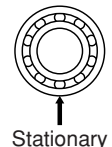
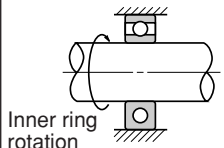

The fit classification between the shaft and inner ring as well as the housing and the outer ring must be determined while considering such factors as the direction and nature of the load applied to the bearing, the magnitude of the load, the operating temperature, the bearing installation /removal method, etc.



Refer to the NACHI catalog for proper fit values suggested for a specific use of a bearing and the detailed examination method of fit.

The method of choosing the fit classification is generally according to **Table 2**.

**Table 2**

Rotating Condition	Types of loads	Load Condition	Fit										
			Inner ring	Outer Ring									
 <p>Inner ring rotation</p>	 <p>Stationary</p>	Rotating Inner ring load Stationary Outer ring load	Interference fit	Loose fit									
 <p>Outer ring rotation</p>	 <p>Rotating</p>				 <p>Outer ring rotation</p>	 <p>Stationary</p>	Rotating Outer ring load Stationary Inner ring load	Loose fit	Interference fit	 <p>Inner ring rotation</p>	 <p>Rotating</p>	When the load direction is not constant such as when the load direction shifts or when there is an unbalanced load.	Rotating or stopped
 <p>Outer ring rotation</p>	 <p>Stationary</p>	Rotating Outer ring load Stationary Inner ring load	Loose fit	Interference fit									
 <p>Inner ring rotation</p>	 <p>Rotating</p>				When the load direction is not constant such as when the load direction shifts or when there is an unbalanced load.	Rotating or stopped	Indeterminate direction load	Interference fit	Interference fit				
When the load direction is not constant such as when the load direction shifts or when there is an unbalanced load.	Rotating or stopped	Indeterminate direction load	Interference fit	Interference fit									

**Caution**

If fit between the shaft and inner ring is an interference fit, and the amount of interference exceeds 1/1000 of the bearing bore diameter, the inner ring could break.

The maximum recommended interference is 1/1500 or less of the bearing bore diameter.

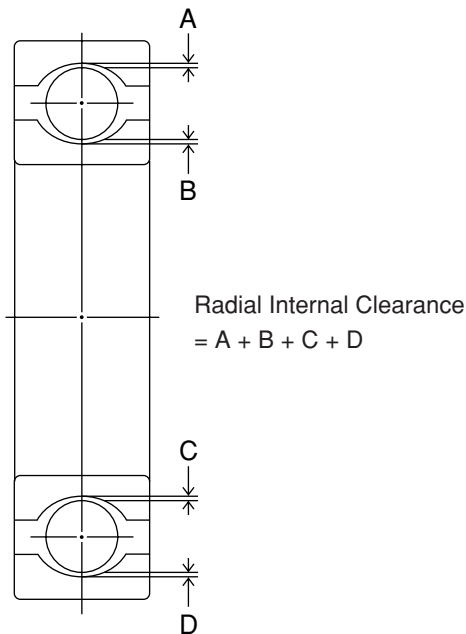
**2-2 Internal Clearance of a Bearing**

The internal clearance of a bearing during operation has a major influence on factors such as bearing life, noise, vibration, torque and heat generation. If the clearance is too large, it will cause an increase in noise and vibration. Conversely, if the clearance is too small, it is a negative clearance in which all the balls (or rollers) can undergo warping. This can also cause abnormal temperature rise and rapid decline in bearing life. For this reason, except for special applications, bearings under normal operation conditions should have clearance present during operation. Therefore the clearance designation CN (clearance normal) of the bearing should be selected so that proper clearance remains during operation under normal usage conditions.

- \* Normal usage conditions mean a condition in which there is an interference fit between the shaft and the inner ring, a loose fit between the housing and outer ring, and where the temperature difference between the inner and outer ring is between 5-10°C.



Figure 4



## Caution



Refer to the NACHI catalog for determining the clearance during operation.

The initial clearances prior to installing the bearings include CN (normal), C2 (less than CN) and C3 (more than CN). A selection can be made from one of these initial clearance designations to ensure the optimum clearance during operation is obtained.



## Caution

Check the clearance after mounting the bearing.

The clearance is reduced by approximately 80% of the interference amount, when there is an interference fit between the inner ring and the shaft or the outer ring and housing.

## 2-3 Lubrication of Bearings

Bearing lubrication is applied for the purpose of reducing wear, reducing friction, reducing temperature rise and preventing seizing.

Due care should be taken, as the lubrication method and appropriate lubricant selection will have a major influence on the overall performance and life of the bearings.



## Warning

Prior to operating any bearing, it must be confirmed that an adequate supply of lubricant is present in the bearing.

No lubricant in a bearing during operation could result immediate heat generation and seizure of a bearing.



## Caution



As operating temperature increases, the viscosity of a lubricant decreases and deterioration and evaporation of oil is accelerates. Therefore the operating temperatures must be kept as low as possible.

Select a proper lubricant (of proper viscosity, proper type of oil and additive, such as, extreme pressure, or anti-oxidation, etc.) and a proper method of lubrication for operating conditions.

For detail, please refer to the NACHI catalog.

Lubricants used for bearings are mainly oil and grease. In special cases, solid lubricants may be used such as molybdenum disulfide (MoS<sub>2</sub>), graphite and PTFE.

The properties required of lubricants are as follows

- No dirt or moisture
- Temperature stability
- High extreme-pressure characteristics
- Minimize wear
- Minimize Friction
- High mechanical stability
- Rust proofing properties

### (1) Lubricating Oil

It is important to select an oil having the correct viscosity in relation to operating conditions such as; bearing configuration, operational temperature, rotating speed and load.

If the viscosity is too low, oil film breaks can easily occur, causing two metal surfaces to come into direct contact with each other. This can cause surface deterioration (smearing) due to small burns and seizing. On the other hand, if the viscosity is too high, the rotational torque will increase and result in loss of input power and abnormal heating.

The selection standards in **Table 3** show the ISO viscosity grade (normal viscosity at 40°C) of lubricating oil under conditions such as bearing operating temperature, rotating speed (dn value) and load. In addition, the required minimum viscosity for the bearing operating temperature is shown in **Table 4**.

These values apply to general usage situations. Please consult with NACHI engineering for special operating conditions.

**Table 3. General Oil Selection Guide**

Bearing Operating Temperature (°C)	dn value	ISO viscosity grade (VG) of lubricating oil		Applicable bearing type(s)
		Normal Load	Heavy Load or Shock Load	
-30-0	Up to speed limit	22 32	46	All Types
0-60	Up to 15000	46 68	100	All Types
	15000-150000	32 46	68	All Types
	80000-150000	22 32	32	Excluding Thrust Ball Bearings
	150000-500000	10	22 32	Single Row Radial Ball Bearings Cylindrical Roller Bearing
60-100	Up to 15000	150	220	All Types
	15000-150000	100	150	All Types
	80000-150000	68	100 150	Excluding Thrust Ball Bearings
	150000-500000	32	68	Single Row Radial Ball Bearings Cylindrical Roller Bearing
100-150	Up to speed limit	320		All Types
0-60	Up to speed limit	46 68		Spherical Roller Bearing
60-100	Up to speed limit	150		

#### Remarks

1. Generally speaking, the heavier the load and the lower the rotating speed, the higher the viscosity of the lubricating oil.
2. The values in the table are applicable for oil bath lubrication and circulating oil lubrication.
3. The dn value is the product of the bore diameter d in mm and the rotating speed n in rpm.
4. For operating conditions beyond those specified in this table, please contact NACHI engineering.



**Table 4. Bearing Types and Proper Viscosity of Lubricating Oil**

Bearing Type	Minimum Viscosity at Operating Temperature mm <sup>2</sup> /s (cSt)
Deep-groove Ball Bearing Cylindrical Roller Bearing	13 or greater
Tapered Roller Bearing Spherical Roller Bearing	20 or greater
Spherical Roller Thrust Bearing	32 or greater



## Caution

Consult with NACHI Engineering staff when the operating temperatures are below -30°C or above +150°C.

### ① Amount of Oil

Shows the height of the oil surface under normal circumstances.

- ◇ Horizontal shaft: When the bearing is stopped, the oil level should be at the center of the lowest rolling element.
- ◇ Vertical shaft: When the bearing is stopped, 50% to 80% of the rolling element should be immersed in oil.

### ② Oil Changing Intervals

Generally speaking, for bearings operating at a temperature of about 50°C, the oil should be changed once a year. If the temperature is higher than 100°C, even if the oil has good heat stability, the oil should be changed two to three times a year.



## Caution

Oil should be changed immediately, if the properties of the oil deteriorate, or if there is any water or foreign matter present in the oil.

In order to maintain the lubricating properties of the oil, sampling of the oil should be carried out at regular intervals. These samples should be analyzed for any change in color, viscosity or the presence of foreign matter.

### (2) Grease

Grease is essentially a base oil mixed with a thickener to give it some consistency and contains performance enhancing additives.

- ◇ Thickener  
A sponge-like structure with weak bonding of fine fibers or particles.
- ◇ Base Oil  
Oil combined with thickener. Accounts for 80-90% of the grease content.
- ◇ Additives  
Agents in small amounts to impart high-pressure properties, rust proofing and anti-oxidizing properties.



## Caution

Sodium-based greases should not be used in applications where there is a high likelihood of moisture or the possibility of water splash. Sodium-based greases absorb water, become emulsified and flow out; therefore they are unsuitable for use in damp areas. For these types of application, greases with lithium-base or calcium-base are recommended, as they are more water-resistant.



## Caution

The grease manufacturer should be consulted whether it is acceptable or not to mix different greases.

There are different additives according to the grease manufacturers, grease brand or name. When incompatible greases are mixed, a chemical reaction could result, thereby causing a major change in the properties and most likely deterioration of grease.

Essentially, two good greases when mixed together can produce one, very bad grease.

## ⚠ Caution



The operating temperature ranges for most common grease types used or recommended by NACHI are referenced in the catalog. In case of operational temperatures outside these specified ranges, please consult with NACHI Engineering or the grease manufacturer.

### ① Amount of Grease

This varies according to bearing size. Generally speaking, grease is applied to the bearings and housings at a level that is 1/2 to 1/3 of their internal free space. Grease amount is reduced as rotating speed increases to prevent excessive heat generation due to churning of the grease.

## ⚠ Caution

If the operating temperatures do not stabilize after replenishing the grease or two to three hours after test operation, an abnormal operating condition may be present. First, stop the operation and verify the grease amount. Excessive grease will be churned by the rolling elements and generate excessive heat. If there is a grease-relief hole, open it so that excess grease can be discharged.

Consult with NACHI engineering if the internal free space of the bearing is not known.

It is possible to calculate the amount of grease in grams to be applied to the bearing from the bore diameter  $d$  in mm of the bearing. This formula applies to the case of a normal grease with a specific gravity of 0.9.

$$\text{Ball bearing} \\ Q = \frac{d^{2.5}}{900} (\text{g})$$

$$\text{Roller bearing} \\ Q = \frac{d^{2.5}}{350} (\text{g})$$

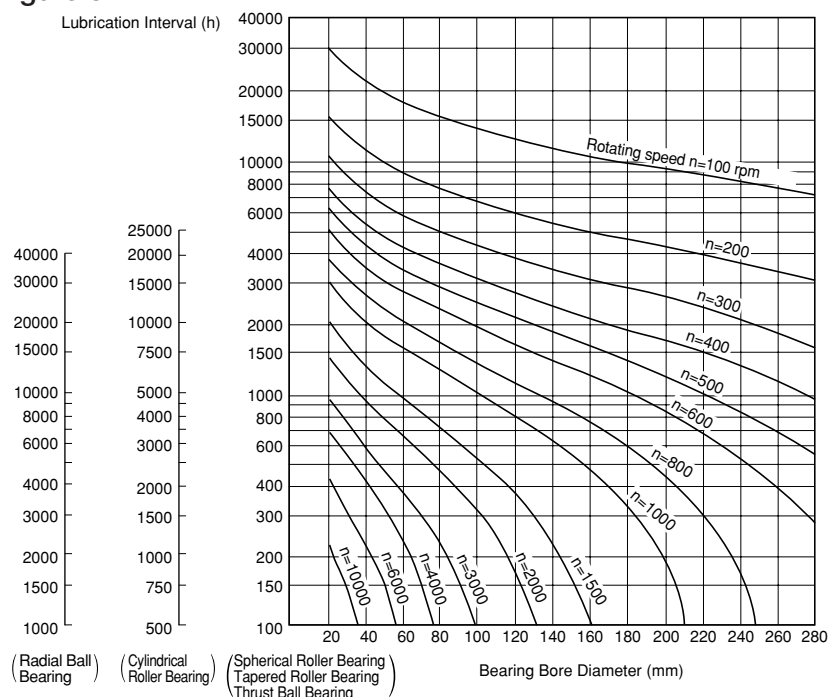
Since the specific gravity of fluorinated-base greases can be about 2. The specific gravity of these special greases must be confirmed in order to determine the correct grease amount.

### ② Grease Relubrication Intervals

The life of the grease can be roughly determined by factors such as bearing type, operating temperature, rotating speed, etc.

A simple guideline for grease life can be obtained from the graph in Figure 5.

Figure 5





## Reference: Limiting Speed of Bearings

The upper speed limit in revolutions per minute (rpm) at which a bearing can be used without causing excessive temperature increases or damage, according to testing, is known as the limiting speed.

The limiting speed varies according to the bearing type, size, lubrication method and applied load. The dimension tables in the catalog list the limiting speeds for the various bearing types. There are categories for oil and grease lubricants.

The values in the NACHI catalog are for properly lubricated radial bearings using horizontal shafts and thrust bearings using vertical shafts.

In addition, with sealed bearings, NSE (NSL) type for deep-groove ball bearings, the seal contacts the inner ring and slides along this surface. The limiting speeds derived from the upper sliding speed limit of the seal material, this is a lower value than that for bearings in which the seals and shield do not make contact the inner ring.



### Caution



When a bearing is operating at 75% or more of its limiting speed, it is critical, for grease lubricated bearings, that an appropriate grease type and grease amount be applied, and with oil lubricated bearings, that an appropriate method and oil selection be made. Incorrect lubricant selection, method and amount will result in excessive heat generation and premature bearing failure. Refer to the NACHI catalog for details.



### Caution

When operating bearings above their catalogued limiting speeds, a detailed analysis of the operating conditions, such as configuration, load, speed, lubricant type/method/amount, bearing type, tolerance class, internal clearance and retainer material/shape must be completed. Please consult with NACHI engineering in these situations.

## Chapter 3: From Installation to Daily Care of Bearings

### 3-1 Bearing Storage and Transportation

Bearings are precision parts.

It is important to handle them with care to prevent shock and damage. Also give due care to storage and transportation to prevent any contamination or rusting of the bearings.

#### (1) Bearing Storage

- Bearings should be stored in cool, dry locations out of direct sunlight.
- Do not place bearings directly on the floor. They should be stored at least 30 cm from the floor in locations where dirt does not accumulate.



#### Caution

Protecting bearings from dirt and rust is critical in selecting a storage location. Locations with frequent or large changes in temperature cause condensation to form on the bearings, which ultimately leads to rust.



#### Caution

Do not stack bearings too many layers high. Over stacking bearings could cause these items to fall, causing damage to the bearings themselves, or even worse, if these items fall when people are present, serious accident or injury could result.

- Proper management of bearing inventory requires that the bearings be used on a first in, first out basis. Arrange inventory so that items with the oldest packing dates can be used first.

#### (2) Bearing Transportation

Bearings should be transported carefully to prevent them from damage or falling. Impact from falling may dent or warp the bearings and damaged packing may allow dirt to get into the bearings.



#### Caution

Cartons containing many bearings or larger bearings should be handled with forklifts or hoists. Handling heavy items such as these by hand could result in muscle strain or back injury. Injury may result if an item falls or is dropped.



#### Caution

Large bearings must not be moved by rolling them on the floor. If a bearing should fall, it could not only damage the bearing, but cause serious injury as well.

## 3-2 Bearing Installation

### (1) Working Environment

Bearings should be installed in area that is free from dirt and moisture. There should not be any excessive fluctuations in temperature.

### (2) Handling of Bearings

Do not open the bearing's package until just prior to installation to minimize the potential of introducing contamination into the bearing.



#### Caution

Bearings should be covered with clean packaging paper if there is a short time between opening them and their installation. If it will be a longer time between opening bearings and their installation, they should be re-wrapped in clean packaging paper.



#### Caution

The rust inhibitor on bearings is generally compatible with most lubricants; therefore it is not necessary to clean new bearings prior to mounting them. If there is an excessive amount of rust inhibitor on the bearing surfaces it may be wiped off the bearing bore, outside diameter, and side faces with a clean cloth.



#### Caution

Bearings used in high-speed and precision applications, like spindles of machine tools or bearings requiring special lubricants may be cleaned prior to installation.

In these situations, a fresh supply of good quality kerosene may be used. In addition, a low-pressure showerhead with a filter or separate containers for initial washing and final washing should be used to avoid contaminating the bearings.



#### Caution

Bearing sets consisting of two or more angular ball bearings or tapered roller bearings should have the same production numbers and mounting direction mark on outer rings. (universal type bearings don't have direction marks).



#### Caution

If bearings with different production numbers are used together, or if their assembly direction is reversed, the resulting internal clearance or preload will be incorrect. If the internal clearance is too small, the operating temperature can increase, leading to seizing of the bearings. Conversely, if the internal clearance is too large, this can cause excessive vibration and poor running accuracy.



### (3) Checking the Shaft and Housing

Shafts and Housing must be inspected for nicks, cracks, burrs, or any other physical abnormalities. They must be measured to confirm correct size, roundness, taper, and surface roughness.



#### **Caution**



Refer to the NACHI catalog or consult with NACHI engineer to determine the recommended size and accuracy for shafts and housings.



#### **Caution**

Strict attention to the contact surface of oil seals should be made. A rough surface can cause oil seals to wear out, lubricant to leak, or dirt to enter the bearings, causing bearing damage in a short time.



#### **Caution**

In split bearing housings, over tightening or uneven tightening of the bolts may cause deformation of the housing and bearing. It is necessary to inspect these items to ensure no deformation has occurred.



#### **Caution**

Shafts and housings should be cleaned and dried to remove any excess oil prior to bearing installation.

#### (4) Bearing Installation

Errors in bearing installation can cause a reduction in accuracy and shorten bearing life, as well as reduce overall mechanical performance of the machines in which they are being installed.

The order of installation operations is as follows:

1. Pre-installation Preparation
2. Shaft and Housing Inspection
3. Unpacking the Bearing
4. Bearing Mounting
5. Bearing Lubrication

##### ① Preparations prior to Installation

- First choose a clean location

All of the necessary tools and equipment should be on hand before beginning any bearing mounting procedure.



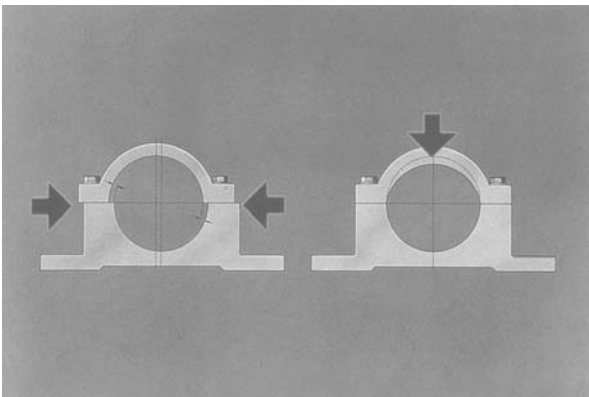
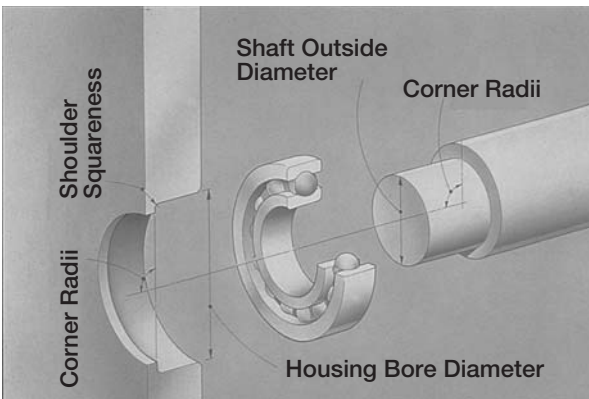
### Caution



Refer to the NACHI catalog for information on bearing mounting operations and special tools.

### Caution

Tools should be clean and inspected to ensure there are no cracks, sharp edges, breakage, chipping or deformation that may cause damage to the bearings or the mounting procedure to not be completed. Take the necessary steps to carry out these operations safely.



## ② Checking the Shaft and Housing

- Clean the shaft and housing sufficiently to remove any dirt or chips.  
Inspect for nicks, burrs or any signs of physical damage.

- Measure and record the values to confirm correct size, roundness, taper, and surface roughness, as well as shoulder squareness and corner radii for the shaft and housing to ensure they are within the designed specifications.

- Extreme care should be taken in the case of split housings to ensure correct alignment and deformation caused by over tightening or uneven tightening of mounting bolts.

## ③ Unpacking the Bearing

- Do not unpack the bearing until just before use.  
Handling bearings with bare hands or work gloves can cause rust or introduce dirt or contamination into the bearing. It is recommended that you use a clean pair of vinyl gloves. Dirty gloves are a possible source of dirt and contamination which may enter the bearing and cause future problems. Generally speaking, bearings should be used immediately after unpacking without being cleaned.



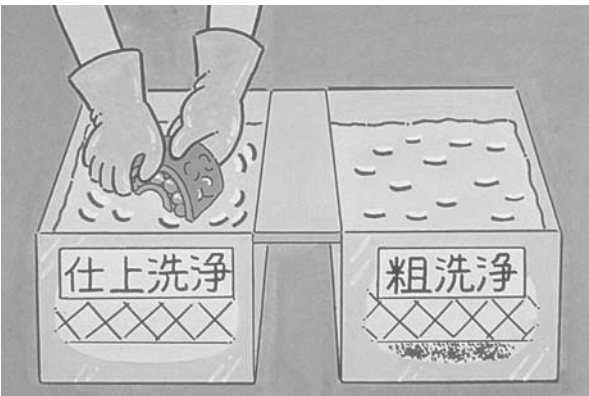


- When using bearings in high-speed and precision applications, like spindles of machine tools or bearings requiring special lubricants it may necessary to wash off the rust preventative prior to installation.

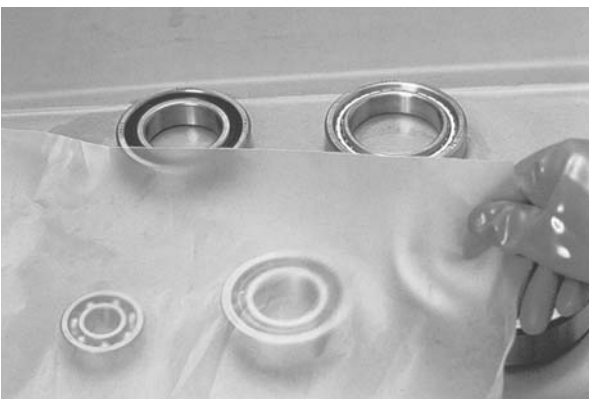
When reusing bearings after periodical maintenance, wash the bearings in the same way.



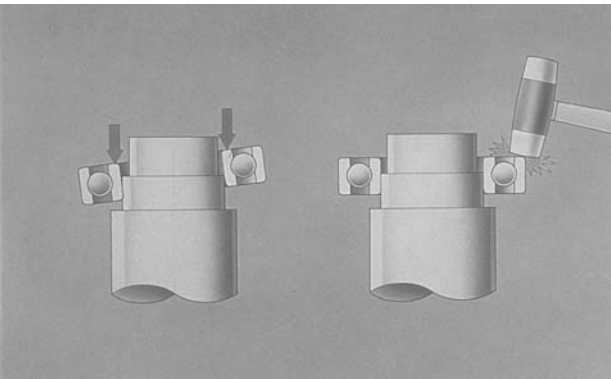
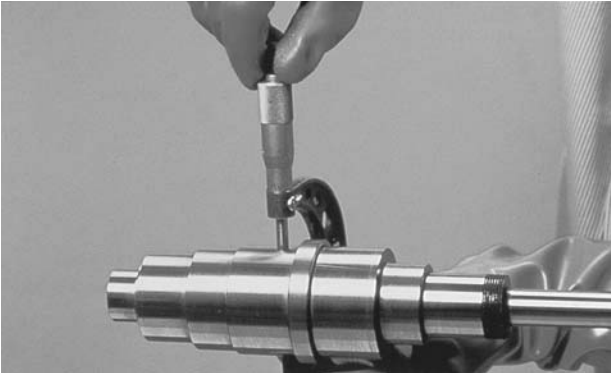
- In these situations, a fresh supply of good quality kerosene may be used under a low-pressure spray with a filter to avoid contaminating the bearings.



- If no spray nozzle is available, separate containers for initial washing and final washing should be used. Additionally, there should be a raised bottom made of mesh to keep bearings out of any dirt or particles that settle to the bottom of the containers.



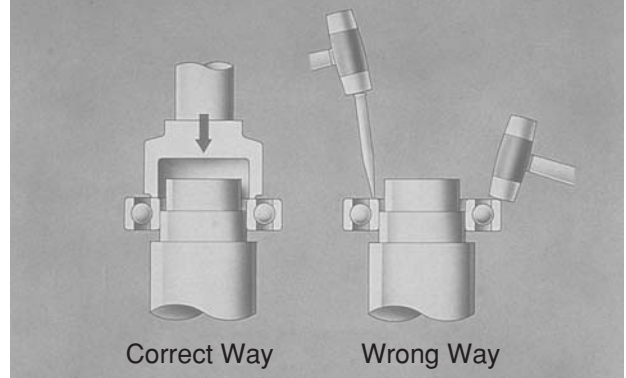
- After cleaning, the bearings should be covered or wrapped until they are mounted.



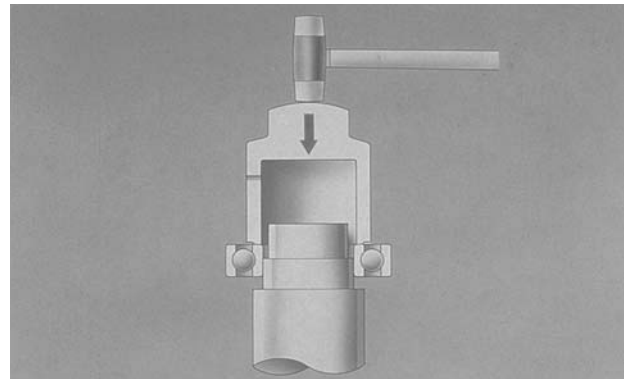
#### ④ Mounting to the Shaft

To mount a bearing on a shaft, there is the press-fit method, the thermal expansion method, or the adapter sleeve or the withdrawal sleeve method.

##### 【Press-fit method】



- When pressing a bearing onto a shaft with an interference fit, use a mounting dolly or fixture that corresponds to the size of the inner ring and press gently and evenly with a hydraulic press or jack.



- If a hydraulic press or jack is not available, use a mounting dolly or fixture with a closed end that corresponds to the size of the inner ring and drive the bearing on with a hammer. Be sure to use a plastic hammer to minimize shock.

- When any mounting force is applied to a bearing, it must be applied straight and evenly, making sure the bearing is not pressed in at an angle and that the force is being applied to only the ring that is being fitted.

### **Caution**

If excessive force is applied when pressing a bearing onto a shaft, stop the procedure, inspect for any possible causes, and correct the problem.

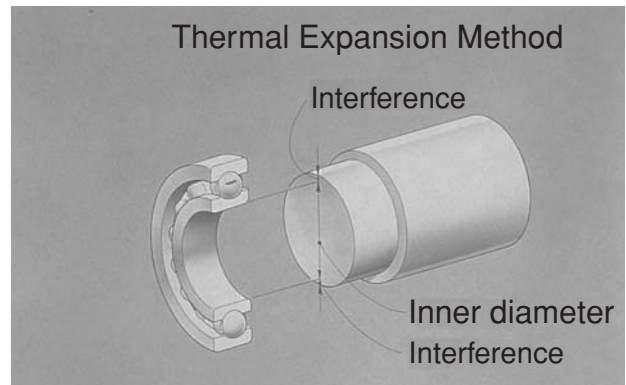
### **Caution**

When mounting a bearing on a shaft, force should never be applied to the outer ring, as this may cause damage to the rolling elements, retainer, and outer ring.

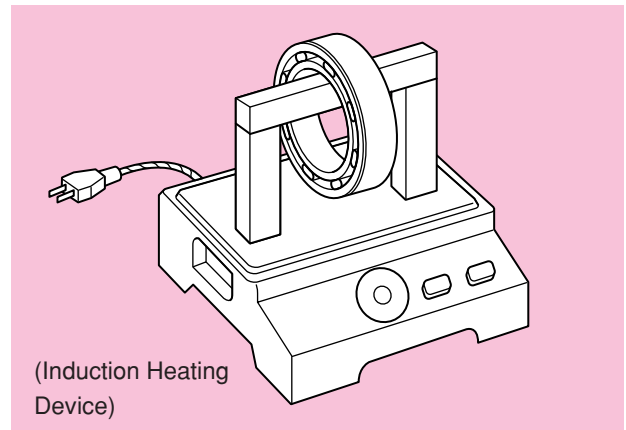
### 【Thermal Expansion Method】

In this method, the inner ring is heated so that it thermally expands and can then be easily slipped onto the shaft.

It is important to heat the bearing no more than necessary to slip it on the shaft easily, as mounting the bearing into the housing will only be delayed further until the bearing cools completely.



- An induction-heating device is used to heat the bearing. Some of these devices do not have an automatic demagnetizing function. In these cases, residual magnetism will remain in the bearing after heating and cause it to pick up ferrous particles, etc. It is necessary to demagnetize the bearing after heating it.
- A heated oil bath using high quality machine oil may also be used. In these devices the bearing should never be directly against the heat source and should be placed on a raised metal screen or hook. This method is not suitable for bearings that were greased at the time of manufacturing, such as double-sealed or double-shielded bearings.

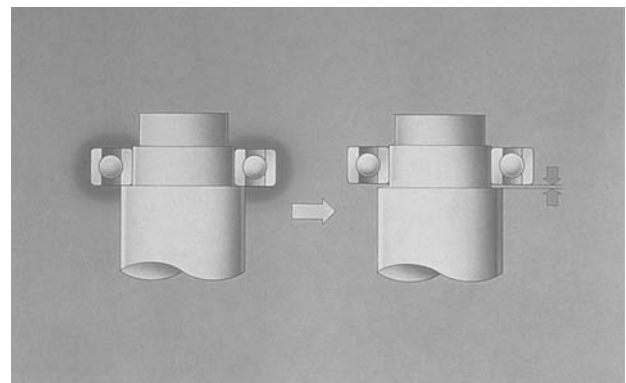


### ⚠ Caution

With the thermal expansion method, the bearing temperature should never exceed 120°C. Exceeding this temperature may reduce the hardness of the bearing steel and shorten the service life of the bearing. Never heat bearings with fire or direct heat from an electric heater, as these methods cannot maintain even heat output and temperature control.

### ⚠ Caution

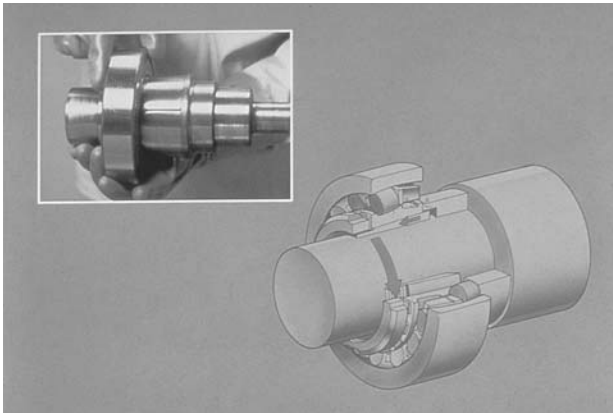
Never handle heated bearings with bare hands, serious burns and injury may result.



- The bearing should be mounted immediately after heating. If the bearing does not slip onto the shaft smoothly and easily, do not force it. In this case remove the bearing and reheat it. Otherwise the bearing may stop partway up the shaft and it will take far greater time and effort to remove and reinstall the bearing.

- As the bearing cools after mounting, sometimes clearance develops between the inner ring face and shaft shoulder. Make sure that there is no clearance and the bearing is tight against the shoulder. One method of preventing this clearance is to retighten the clamping nut while the bearing is still hot.





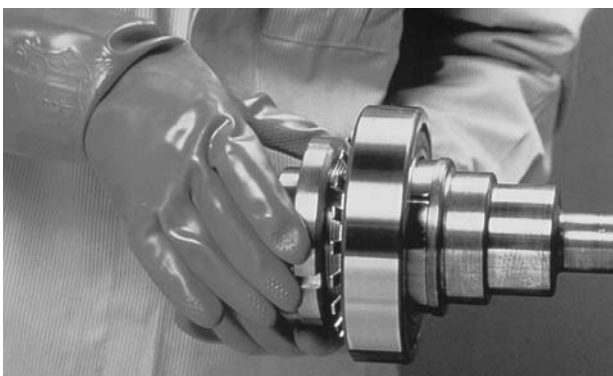
### 【Adapter or Withdrawal Sleeve Method】

With this method a tapered sleeve is inserted between the tapered bore of a bearing and the shaft, and then a locknut is used to drive the bearing up the sleeve, thus providing interference.

First measure the initial clearance of the bearing.

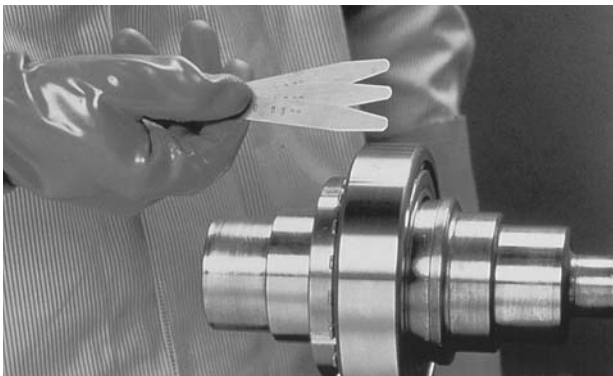
Slide the tapered sleeve on to the shaft, then slide the bearing on to the sleeve and then drive the bearing up the tapered sleeve with a locknut or press.

This process should be divided into several steps, measure the internal clearance of the bearing each time. The internal clearance at this time is now called residual clearance. The difference between the residual clearance and the initial clearance is used to determine the amount of interference.



- Strict attention should be paid to how far the bearing is driven up the sleeve.

If the bearing is driven up too far, problems such as overheating during operation, seizing of the bearing and inner ring fracture can occur. If the bearing is not driven up far enough, creep can develop between the sleeve and inner ring during operation.



- Select a feeler gauge the same thickness as the required residual clearance.



- Then tighten the locknut until the feeler gauge passes somewhat stiffly between the outer bearing ring and rollers.

### **Caution**

Tapered-bore Bearing is mounted to the shaft by pushing the bearing or sleeve to the shaft with a split-sleeve adapter or adapter sleeve. It is difficult to control the axial displacement. Therefore, it is better to push gradually while carefully monitoring the bearing residual clearance until the recommended value is achieved.

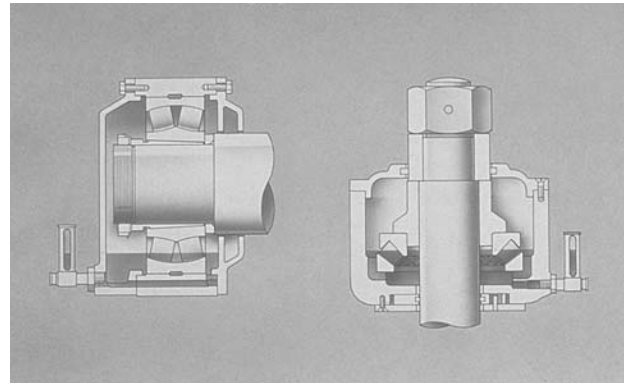


Refer to the NACHI catalog for the axial displacement and reduction in internal clearance values.

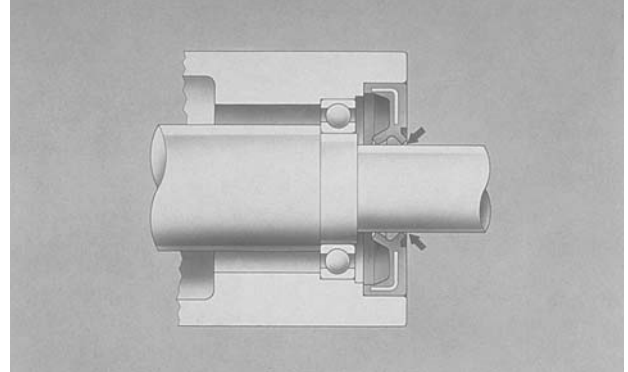
## ⑤ Applying Lubricant

- For Oil Lubricated Bearings - when using a bearing on a horizontal shaft application, the oil level should be at the middle of the lowest ball or roller.

In case of a vertical shaft application, the balls or rollers should be 50% to 80% immersed in oil.



- For Grease Lubricated Bearings -  
The grease fill amount should be between 1/3 and 1/2 of the bearing internal free space. In case of high-speed rotation, the amount of grease should be reduced.



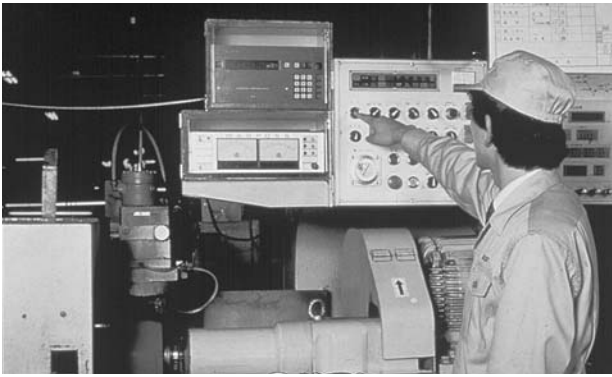
- Grease should be applied to sealing surfaces before operation. This will reduce heating and wear when it starts rotating.

### **Caution**

When assembling separable type bearings such as Cylindrical Roller Bearings and Tapered Roller Bearings, the rings are often matched after the inner ring is mounted to the shaft or the outer ring is mounted to the housing. Slowly align the rings being extremely careful not to damage the rollers and surrounding areas. Be sure that the outer ring does not come loose and fall out of the housing. Be extremely careful not to injure fingers during the assembly process.

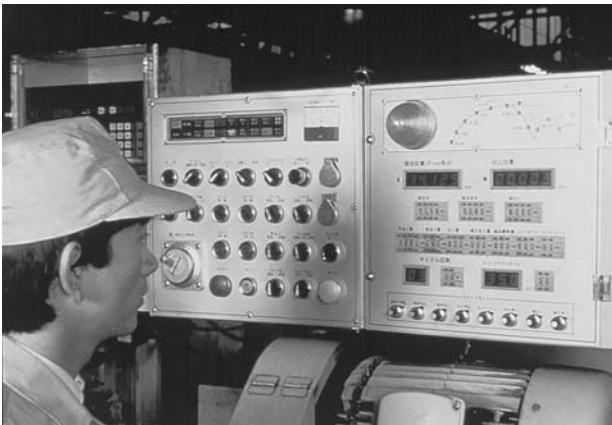
### 3-3 Test operation

In order to ensure safe equipment operation and long life, it is necessary to do a test operation after assembly.

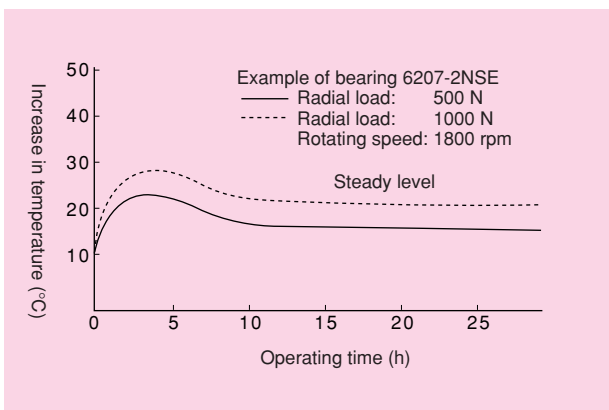


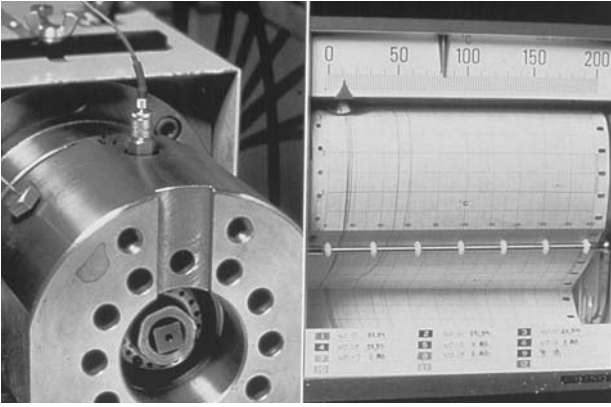
- After assembly is finished, you should never immediately start the equipment at maximum rotation speed.

- First operate manually or at low speeds and make sure that there is free rotation and no abnormal noise.



- If there are no initial problems, continue to operate while gradually increasing the speed up to the normal rotating speed with no load applied. Then make sure that the temperature has stabilized at a normal level. Also check the condition of the lubricant at this time.





- Temperature measurement methods include inserting a thermocouple into the oil hole for measurement or using a surface temperature thermometer.

Then use a vibration meter to confirm that there is no abnormal noise or vibration and complete the test operation.



- By checking for free rotation and noise at slow speeds, then temperature, noise, and vibration levels at normal operating speeds, correct assembly can be confirmed.



### 3-4 Daily Care of Bearings

Bearings simply do not break down one day. Before a breakdown occurs, symptoms such as abnormal noises, increased vibration and increased operating temperature will occur.

Because of this fact, it is very important to check and record the operating conditions of a bearing at regular intervals. With this information, problems will be detected and maintenance can be scheduled before catastrophic failure occurs.

The following items should be checked on a daily basis.

- ◆ Changes in vibration values, generation of strange noise
- ◆ Increase in temperature
- ◆ Changes in amount and condition of lubricant
- ◆ Changes in the electrical current value (Ammeter) of the drive motor.

Records of inspection results and trend control should be carried out as follows.

- i) Determine chart format for each inspection item
- ii) Determine the interval for inspections.
- iii) Determine the inspection method and equipment to be used for the inspections.
- iv) Carry out the inspections and record the data.
- v) Look for any changes in the data on the chart. (Use previous results to determine standard control values).
- vi) If the data goes outside the bounds of the standard control values, this is a sign of possible equipment breakdown. The cause of the problem should be determined and the equipment repaired as necessary.

#### ① Bearing Sound

A listening rod and/or vibration sensor should be used to check the sound quality of the bearings. If the sound is steady and clear, it can be considered normal.

The following are some examples of abnormal sounds produced by bearings and their typical causes that you can use as a reference.

Sound Features	Causes
◇ Continuous sounds Zaaaa Shaaa Jiiii	<ul style="list-style-type: none"> <li>• Deterioration of surface roughness on the raceway or rolling element</li> <li>• Surface damage on the raceway or rolling element</li> </ul>
◇ Buzzing tone Woo-woo Goo-Goo	<ul style="list-style-type: none"> <li>• Resonance, poor fit condition</li> <li>• Deformation of bearing ring, fluttering on the raceway or rolling element.</li> </ul>
◇ Indeterminate sounds Chiritchiri	<ul style="list-style-type: none"> <li>• Foreign matter (dirt)</li> </ul>
◇ Galling noise between metal surfaces Kii-kii Gii-gii Kin-kin	<ul style="list-style-type: none"> <li>• Galling between the roller and collar of roller bearings.</li> <li>• Insufficient operational clearance</li> <li>• Poor lubrication</li> </ul>
◇ Indeterminate Piri-Piri Pin-Pin	<ul style="list-style-type: none"> <li>• Creaking of fitting sections</li> <li>• Rasping on attachment surfaces</li> </ul>

In addition, one should pay attention when the following occurs:

- When noise increases suddenly.
- When noise is generally loud

\* The sound expressions above are very difficult to express in words. Consider the expressions above to be references. Observation of sound should take place at regular intervals at the same location.

## ② Vibration of Machinery and Equipment

Tracking vibration levels of machinery and equipment is a method of detecting problems with bearings.

Vibration measurements should be taken at regular intervals at the same location each time. If significant change is observed or if vibration levels suddenly increase, consider it to be abnormal and take proper steps to remedy the situation.

## ③ Temperature

Bearings always increase in temperature when they are running. The higher the rotating speed, the higher the temperature. When a certain time has elapsed, the maximum temperature is achieved, and then the temperature decreases slightly and stabilizes at some constant level.

If the temperature increases suddenly or continues to rise after a long time, this is an abnormal condition. You must stop the equipment, determine the cause and take proper steps to remedy the situation.

For this reason, it is necessary to measure the temperature at regular intervals at the same location.

## ④ Lubricant

Sample the lubricant and inspect for changes in color, viscosity, and the presence of dirt, foreign matter or metal particles.

## ⑤ Electric Current Draw

The electric current value of the drive motor increases immediately after starting operation, but then immediately decreases and returns to normal level. If a high current flow seems to be present at all times, consider it to be abnormal and take proper steps to remedy the situation.

## Chapter 4: Removing Bearings

Bearings are removed for routine maintenance, inspection or in case of breakdowns.

Especially when removing due to problems with bearings, the area around the bearings, the lubricant and the bearing themselves should be inspected. This can help to discover the cause of failure and areas for improvement in solving the problem.

### (1) How to Proceed with Removing of Bearings

- ① Bearing removal should be carried out by an experienced person or under the direction of an experienced person.
- ② Before starting, decide on concrete methods of completing the work.
- ③ Have the necessary bearing removal tools on hand.
- ④ When reusing or inspecting the bearings that have been removed, be careful to avoid any scratching or damage to the bearing raceway or rolling elements.
  - When removing the bearing from its housing, apply the removal force to the outer ring.
  - When removing the bearing from its shaft, apply the removal force to the inner ring.

### (2) Typical Methods of Removing Bearings

- Use a hand press or hydraulic press
- Use a special wrench
- Use a puller
- Use an induction heating device (inner ring)
- Use an oil injection method



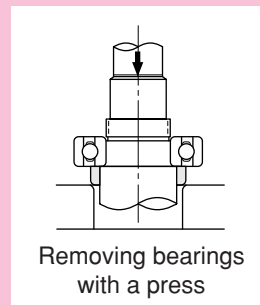
### Caution

Be sure to inspect the removal tools for cracks, sharp edges, breakage, chips or deformation.



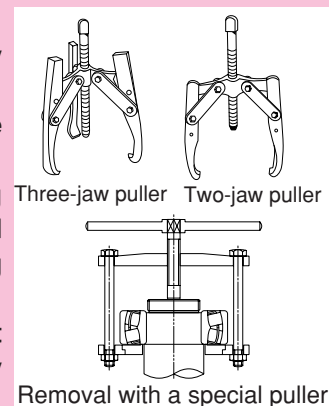
### Caution

- ① Using a press
  - Make sure that all the parts are stable and not wobbling or shaking.
  - Align the center of the shaft with the center of the ram when pressing the shaft.
  - Never hold the shaft or bearings by hand when the pressure is applied.
  - Install a tray to catch the shaft or bearing and to prevent them from falling on the floor.



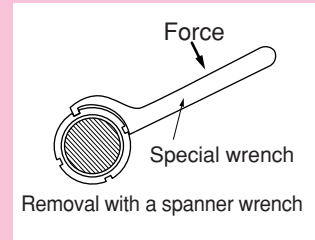
### Caution

- ② Using a puller
  - Make sure that the puller's jaws are definitely catching the sides of the bearing.
  - Align the end of the puller's load bolt with the center of the shaft.
  - If the puller's jaws start to come loose during the procedure, immediately stop, and reposition the jaws so they have good holding position and resume the procedure.
  - If the bearing does not come off the shaft under normal removal force, do not apply excessive force to the puller.
    - ⇒ Change to a different method, such as using a press.



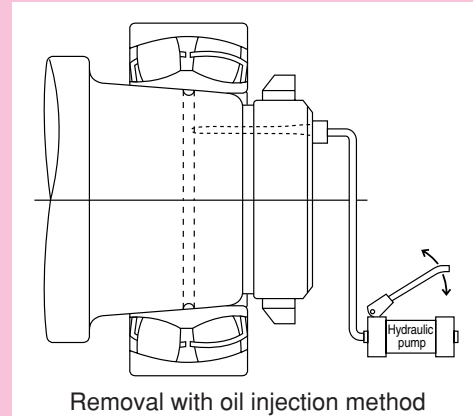
## Caution

- ③ Using a Special Wrench (removal sleeve)
- Use the correct size wrench suited for the locknut.
  - If the locknut is excessively tight, do not use a hammer to hit the handle of the wrench.



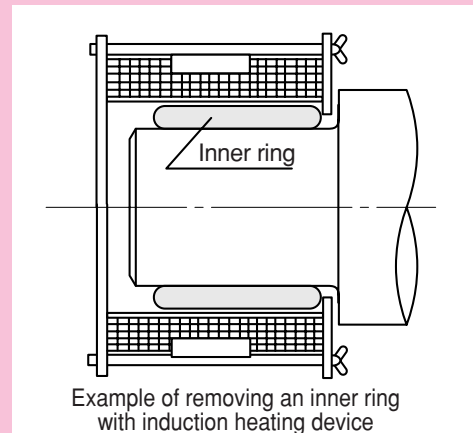
## Caution

- ④ Using Oil Injection
- Inject the oil slowly.
  - Stop injecting oil as soon as the inner ring moves in the shaft direction.
  - Tapered-bore bearings may fly off of the shaft very quickly. Be sure to install a nut on the end of the shaft to prevent the bearing from flying off.



## Caution

- ⑤ Using Induction Heating
- Never place flammable materials (such as oil and gas) near the work area.
  - If the bearing is to be reused, or if inspection is necessary, never heat to more than 120°C.
  - Never touch heated bearings or the surrounding parts with your bare hands.
  - Remove the bearing (inner ring) from the shaft immediately after heating it.



- ⇒ If the bearing (inner ring) becomes difficult to move during the removal process, stop and reheat the bearing (inner ring) before continuing.





## Chapter 5: What to Do with Bearings in the Following Situations



### If a bearing is damaged the following problems can occur:

- Increased noise and vibration levels
- Increased operating temperature
- Decreased machine precision

If any of these problems occur, immediately stop the equipment and check the bearings. If a bearing is used when something is wrong with it, damage to the equipment, such as fires, etc. can result.

If you suspect a bearing problem, verify the bearing selection, assembly and handling procedures to determine if there was an error and take proper corrective action.

All bearing damage involves matters that can be prevented beforehand. Keep the following six major causes and three major prevention measures in mind at all times for maximum performance from your bearings.

### Six major causes of damage

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The main causes of damage to bearings can be divided into six main categories.

- (1) Contamination with dirt and foreign matter
- (2) Abnormal load due to improper assembly
- (3) Shaft and housing fits are too large or too small
- (4) Improper lubricant or lubrication method
- (5) Improper design or poor quality of shaft and housing
- (6) Errors in selection of bearings

### Three main prevention measures

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- (1) Correct selection of bearings
- (2) Correct assembly and handling
- (3) Correct management of operations