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प्रारंभिक मसौदा

रोलिंग बियरिंग्स का संस्थापन तथा रखरखाव — रीति संहिता

[IS 3090 *का पहला पुनरीक्षण*]

Preliminary Draft

Installation and Maintenance of Rolling Bearings — Code of Practice

[*First revision of* IS 3090]

ICS 21.100.20

Bearings Sectional Committee, PGD 13	Last date for Comment: 26 May 2024

NATIONAL FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards after the draft finalized by the Bearing Sectional Committee will be approved by the Production and General Engineering Division Council.

This Indian Standard originally published by the Indian Standards Institution on 3 April 1965. The first revision of this standard has been taken up to include the latest methods for installation and maintenance of rolling bearings being practiced across the globe.

The major changes in this revision are as follows:

a) New figures have been added;
b) Practices of fitting removal and cleaning have been updated;
c) Structure of the document has been updated.

Ball and roller bearings, collectively known as rolling bearings, are being used almost on all modern machines. To have full use of these bearings, it is necessary that these are installed with care and proper attention is paid to preventive maintenance. This standard is intended to serve as a guide to the users for the proper use of ball and roller bearings.

The composition of the Committee responsible for the formulation of this standard is given in Annex B.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 2022 'Rules for rounding off numerical values (*second revision*).' The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

CODE OF PRACTICE FOR INSTALLATION AND MAINTENANCE OF ROLLING BEARINGS

(*First Revision*)

1 SCOPE

This standard covers the code of practice for preparation, fitting, maintenance, lubrication and repairs of rolling bearings.

2 REFERENCES

IS	*Title*
2399 : 2019	Rolling Bearings — Vocabulary (*Second Revision*)
9193 : 1988	Specification for bearing pullers (*First Revision*)
17276 : 2019	Rolling Bearings — Damage and Failures — Terms, Characteristics and Causes

3 TERMINOLOGY

For the purpose of this standard the terms and definitions given in IS 2399 shall apply.

4 STORAGE

The following storage guidelines is suggested for the all the finished products (bearings, components and assemblies, hereinafter referred to as “Products”:

4.1 Clean and Dry Environment

Store bearings in a clean and dry environment to prevent contamination and corrosion. Avoid areas with excessive moisture, dust, or dirt that can damage the bearings.

4.2 Condensation prevention

It's important to prevent the formation of condensation water on the bearings during storage. To achieve this, maintain the following conditions:

a) Temperature range: The storage area temperature should be maintained between 0ºC (32ºF) and 40ºC (104ºF); temperature fluctuations should be minimized. Large temperature variations can lead to moisture condensation on the bearings.

b) Relative air humidity: Ensure that the relative air humidity in the storage area does not exceed 65%. Higher humidity levels increase the risk of condensation formation.

4.3 Original packaging

Store the bearings in their original packaging whenever possible, until they are ready to be placed into service.

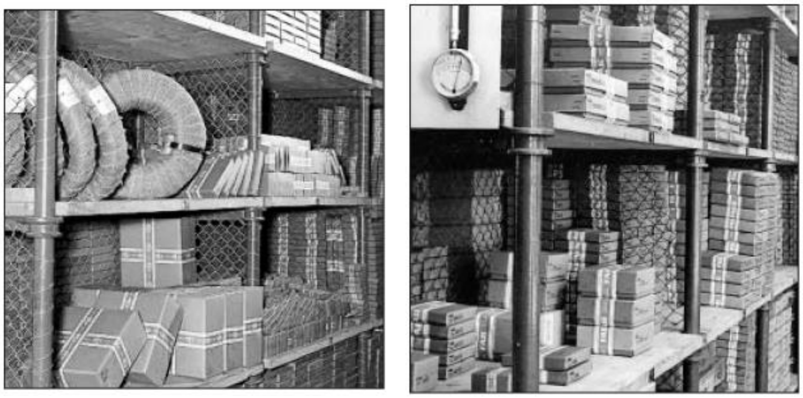


FIG. 1

a) The packaging is designed to protect the bearings against contamination and corrosion.
b) If the original packaging is damaged or unavailable, use suitable alternatives that provide similar protection.
c) Products should be stored in such a way that the packaging is not pierced, crushed or otherwise damaged.
d) After a Product is removed from its packaging, it should be placed into service as soon as possible.
e) When removing a Product that is not individually packaged from a bulk pack container, the container should be resealed immediately after the Product is removed.

4.4 Proper Identification and Labelling

Do not remove or alter any labels or stencil markings on the packaging. Clearly label and identify each bearing to maintain proper inventory management. This includes information such as part numbers, sizes, and other relevant specifications. Proper labelling helps prevent mix-ups and ensures the correct bearings are used during installation.

4.5 Handling

Handle bearings with care to avoid damage. Avoid dropping or subjecting them to excessive impact or pressure.

4.6 Rotation and Inventory Management

Implement a rotation system to ensure the usage of the oldest bearings first, following the FIFO (first in first out) system. This helps prevent the storage of bearings for extended periods, reducing the risk of degradation over time.

4.7 Avoid Excessive Loads

Do not stack heavy objects on top of bearing packages or containers. Excessive loads can lead to deformation or damage to the bearings.

4.8 Orientation

Large bearings should not be stored upright. Instead, they should be stored flat and supported over their entire circumference. This helps distribute the weight evenly and prevents deformation or damage.

4.9 Contamination and corrosion

Protect the bearings from exposure to aggressive media such as gases, mists, or aerosols of acids, alkaline solutions, or salts. These substances can cause corrosion and damage to the bearings. Keep the storage area clean and free from any contaminants that could potentially harm the bearings.

4.10 Sunlight exposure

Direct sunlight should be avoided as it can lead to temperature fluctuations and potential damage to the bearings. Store the bearings in a shaded area or use covers or blinds to protect them from direct sunlight.

4.11 Shelf life

Do not use Product that has exceeded its shelf life as defined in the product’s shelf life guidelines statement.

4.12 Vibrations

The storage area should be isolated from undue vibrations.

5 PREPARATORY

5.1 General Planning

5.1.1 *Work Planning*

Determine the type and size of the bearing required for the application. Identify the appropriate tools and equipment needed for mounting and dismounting. All tools including heating tanks/induction heater if required for heating bearings, collars, etc, shall be conveniently arranged to enable shrink fits to be employed. Establish a safe and organized work area with adequate lighting and accessibility.

5.1.2 *Cleanliness in Mounting*

Thoroughly clean the bearing housing and shaft to remove any dirt, debris, or old lubricant. Use appropriate cleaning agents and ensure that the surfaces are completely dry before mounting the bearing. Wear clean gloves and avoid touching the bearing surfaces directly with bare hands to prevent contamination. Only non-fluffier/lint free rags shall be used for wiping the parts since fibres from cotton waste or other loose material can be as destructive as other forms of extraneous matter.

5.1.3 *Surrounding Parts*

Inspect and clean the surrounding parts, such as seals, gaskets, and spacers, before mounting the bearing. Check for any signs of wear, damage, or misalignment that could affect the bearing's performance. Replace worn or damaged parts as necessary to ensure proper fit and alignment.

If 'felt washers' form part of the sealing devices, these shall be soaked, before use, in a light mineral oil or hot Vaseline until they are thoroughly impregnated. They shall not bind on the shaft as this may result in heating and scoring.

5.1.4 *Handling of Rolling Bearings before Mounting*

The bearings shall not be taken out of boxes or unwrapped until required for use, for they are apt to pick up dirt from benches or fine grit from atmosphere. The protective coating of special grease or oil shall not be removed unless special instructions to the contrary have been given by a responsible person or the bearing has become dirty. If cleaning is necessary, the methods described, in **9** should be adopted. Bearings shall never be kept on dirty benches. A clean piece of paper or other material shall be put under and over the bearings. Avoid dropping or mishandling bearings, as this can cause dents, scratches, or misalignment. Use proper lifting tools, such as slings or bearing pullers, to avoid excessive force or stress on the bearing.

5.1.5 *Selecting the Right Bearing*

Follow a guideline to select the correct bearing type, size, and design for the application. Consider factors such as load capacity, speed, temperature, and environmental conditions.

5.2 Fit

5.2.1 *Observe ring fits specified on the drawing*

The shop drawing or technical specifications will typically indicate the specific ring fits required for the bearings. Follow the instructions provided, whether it's a clearance fit, interference fit, or any other specified fit. Ensure that the selected bearings and their corresponding rings meet the required fit specifications.

5.2.2 *Check shaft and housing tolerances*

Verify the tolerances specified for the shaft and housing dimensions in the drawing. Use appropriate measuring tools, such as micrometer or calipers, to ensure that the shaft and housing dimensions meet the specified tolerances. This step is crucial to ensure proper alignment and fit of the bearings within the system.

5.2.3 *Check form tolerance of shaft and housing seats*

In addition to dimensional tolerances, it's important to check the form tolerance of the shaft and housing seats. The form tolerance refers to the geometric shape of the seats, such as roundness or flatness. Use measurement techniques such as roundness testers or surface profilometers to verify that the form of the seats complies with the specified tolerances.

5.2.4 *Check roughness of bearing seats*

The roughness of the bearing seats affects the surface finish and can impact the performance and longevity of the bearings. Use appropriate roughness measurement tools, such as a profilometer or surface roughness tester, to check the roughness of the bearing seats. Ensure that the roughness values meet the requirements specified in the drawing or industry standards.

5.2.5 *Tightening and torque*

If applicable, use a calibrated torque wrench to tighten the bearing or related components according to the manufacturer's specifications. Over-tightening or under-tightening can lead to premature failure or inadequate performance.

5.2.6 *Documentation*

Keep a record of the installation and maintenance activities performed, including dates, procedures, and any observations or issues encountered. This documentation can be valuable for future reference and troubleshooting.

5.2.7 *Do not rework rings*

It is generally recommended not to rework bearing rings. Bearings are precision-engineered components, and any modification or reworking of the rings can significantly affect their performance and reliability. If a bearing is found to be damaged or defective, it is usually best to replace it with a new one rather than attempting to rework it.

5.3 Inspecting bearing seat

For cylindrical seats, the following measurement instruments can be used:

5.3.1 *External micrometer for measuring shaft diameters*

An external micrometer is suitable for measuring the diameter of the shaft. It is a handheld instrument that provides accurate measurements. Ensure that the micrometer is properly calibrated and follow the manufacturer's instructions for correct usage.

FIG. 2

5.3.2 *Snap gauge for measuring cylindrical seats*

A snap gauge is a specialized tool used to ensure safe positioning and precise measurement of cylindrical seats. It helps determine if the seat meets the required diameter specifications. The gauge has a predetermined diameter marked on the master ring, which is used to set the gauge for measurement.

FIG. 3

5.3.3 *Internal micrometer for bore measurements*

An internal micrometer, also known as a bore micrometer, is used to measure the internal diameter or bore of a cylindrical seat. It provides accurate measurements and is suitable for checking the diameter and cylindricity of the seat.

FIG. 4

5.3.4 *Comparative measuring instruments for bore measurements*

Comparative measuring instruments, such as a bore gauge or bore micrometre, are commonly used for bore measurements. These instruments allow you to compare the measured bore diameter with a master ring or known standard to determine if the seat meets the required specifications.

FIG. 5

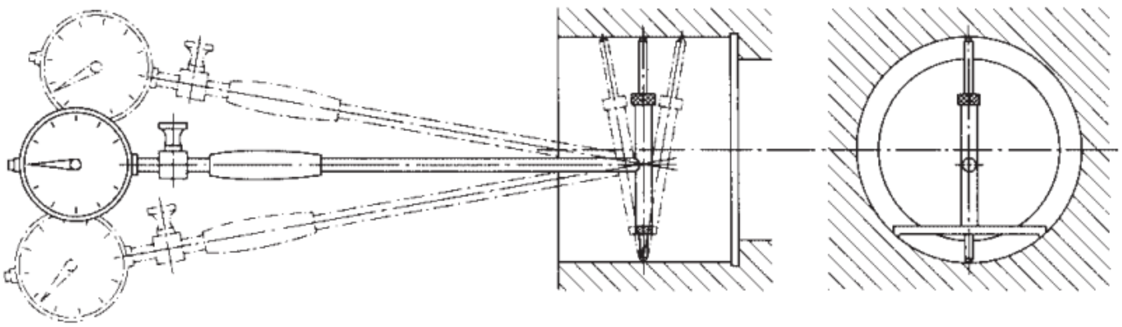


FIG. 6

When checking the cylindricity of shaft and housing seats, the diameter is typically measured in two cross-sections and multiple planes using a two-point measurement technique. This helps assess the roundness and cylindricity of the seat to ensure it meets the specified tolerances.

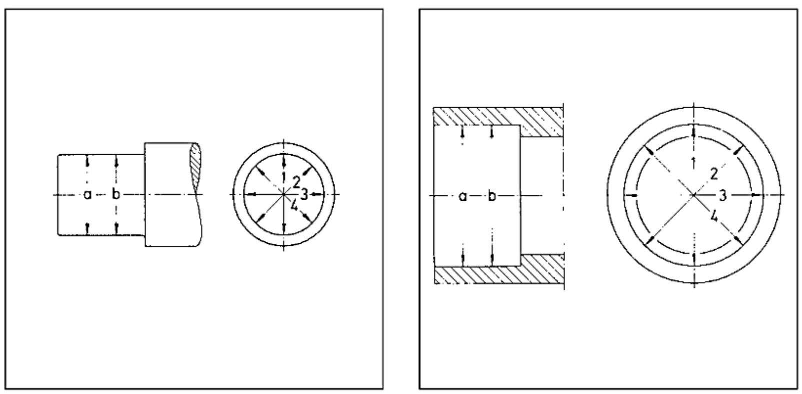


FIG. 7

Unless otherwise specified in the shop drawing, the cylindricity tolerance should not exceed half the diameter tolerance (two-point measurement).

5.4 Fitting of bearing on Shaft and housing

Fitting practices for bearings on shafts and housings are crucial to ensure proper functioning, longevity, and performance of rotating machinery. The correct fit prevents excessive wear, reduces vibration, and helps maintain the accuracy of the system. There are different types of fits based on the degree of interference between the bearing, shaft, and housing. The most common fits are classified as clearance fits, transition fits, and interference fits.

5.4.1 *Clearance Fit*

In a clearance fit, the bearing has some degree of play within the housing or on the shaft. It allows for easy assembly and disassembly but might result in increased vibration and reduced precision. Clearance fits are often used when thermal expansion is a concern.

5.4.2 *Transition Fit*

A transition fit falls between clearance and interference fits. It provides a balance between the two, allowing some degree of interference while still being relatively easy to assemble. Transition fits are often used when moderate precision is required.

5.4.3 *Interference Fit*

In an interference fit, the bearing is pressed onto the shaft or into the housing with a certain amount of force. This tight fit ensures better load distribution and reduced vibration but can be challenging to assemble and disassemble.

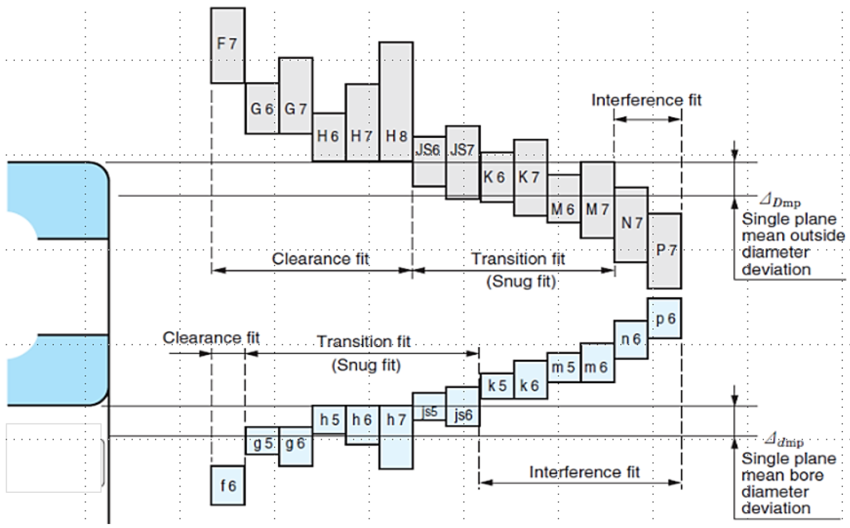


FIG. 8

6 FITTING

The usual and convenient procedure for mounting rolling bearings is first to fit them on the shaft and then to place the housings in position. When however, an outer ring has a tight fit in its housing and the inner ring a loose fit on the shaft, it is recommended that this procedure be reversed.

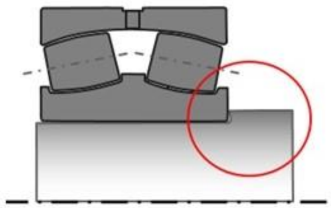
6.1 Shafts

6.1.1 *Preparation of shaft*

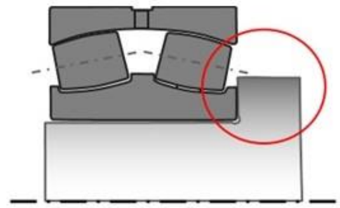
a) Burrs and other material between the back faces and the shoulders can prevent proper seating. This could lead to misalignment, hurting gear mesh and reducing bearing life. Burrs could also break loose during use and get trapped in the bearing. If necessary, lightly file the backing shoulder to ensure it is clean and flat.
b) Ensure that fillet radii are within specs, so cone/ inner ring can fully seat, and that the seat is square and clean.
c) Check the OD of the shaft at one point and then at 90° apart. This is to ensure there is no ovality (egg shape) in the shaft.
d) It is highly recommended that roller bearing shaft seats be ground to a surface finish of 1.6 µm (65 µin) Ra maximum. Ball bearing seats should be 0.8 µm (32 µin) for shafts under 5.08 cm (2 inches) and 1.6 µm (65 µin) for all other sizes.

e) Shaft Fillet & Shoulder Diameter:

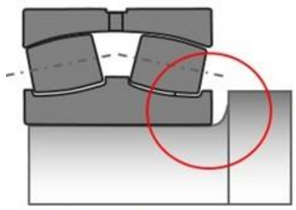
1) Too small a shoulder diameter results in insufficient support of the bearing (Fig 9a) and too large a shoulder diameter could interfere with the bearing (Fig 9b).
2) Improper fillet radius could impede the bearing from backing against the shoulder (Fig 9c). Hence care should be ensured to mitigate the same.



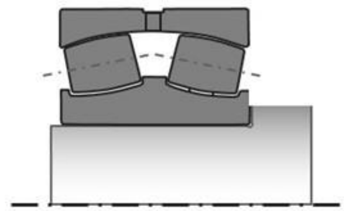
a) Shoulder diameter too small



b) Shoulder diameter too large



c) Shaft fillet diameter too large



d) Correct shaft shoulder diameter and fillet

FIG. 9 CORRECT SHAFT SHOULDER DIAMETER AND FILLET

6.1.2 With tight fits for cylindrical mating parts, considerable force may be necessary to drive an inner ring up to its locating shoulder. If pressure is applied to the outer ring while this is being done, severe permanent denting of the tracks by the rolling elements is likely to occur. Direct pressure against a thin inner-ring lip may cause fracture or, if the pressure comes on the cage, this may be badly distorted.

6.1.3 When the fit is not too tight a piece of hardwood or copper drift may be used as shown in Fig. 10. The end of the drift in contact with the inner ring shall be bevelled off to clear the periphery. When the rings have thin lips, light blows shall be given to the drift by a hammer, moving the drift round the ring taking care to see that no chips which break off the drift get into the bearing. Heavier blows may be given, when a mild-steel tube, of the right size with an end cap is used provided the tube is kept parallel to the shaft axis.

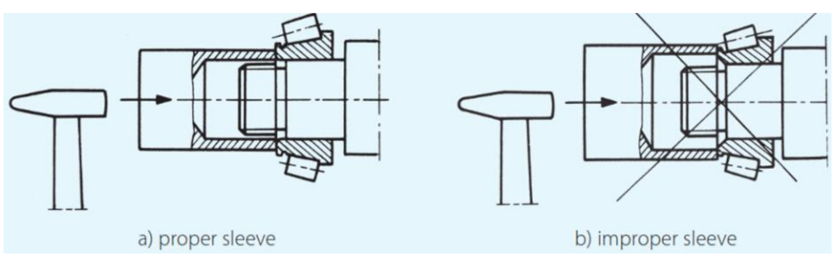


FIG. 10 USE OF DRIFT OR HARD WOOD FOR FITTING

6.1.3.1 An easy method of fitting an inner ring is to put the shaft under the ram of a hand screw mandrel press, using a tubular sleeve to transmit the pressure to the inner ring.

6.1.4 Where a fit proves to be tighter than specified, no attempt shall be made to reduce the diameter of the shaft by scraping or rubbing it with emery cloth or other similar material. Instead, the shaft may be corrected on a lathe or a grinding machine. If the fit be too slack, packing with strips of paper or tinfoil shall not be done, nor any attempt be made to raise the surface by a centre punch. If it is important to save the shaft, the seating may possibly be reduced a little, a bush shrunk on its outside and then ground or turned to size. An alternative method is to have the seating enlarged by metal spraying or plating, and then finished to size by grinding.

6.1.5 *Heat bearings to ease installations*

a) To fit a bearing over a tight shaft, the bearing can be heated to the temperatures mentioned below. These are all maximum times and temperatures. Overheating a bearing can damage the cage or seals, and very high heat can soften the steel. It can also take quite a while for the bearings to cool down, and that will slow down the replacement process.
   1) Standard product, metallic cage, no seals:
      200°F (93°C) for 24 hours
      250°F (121°C) for 8 hours
   2) Standard product, non-metallic cage and polymer or elastomer seals:
      200°F (93°C) 24 hours
   3) Precision product:
      150°F (66°C) 24 hours

b) All these temperatures and times are maximums. The cones or inner rings should be lubricated after being positioned on the shaft, then seated and cooled.

c) The ring shall be held axially against the shoulder until it cools; the shaft nut or some other suitable means being used for the purpose.

6.1.6 *Oil bath*

For heating the bearing, an oil-bath as shown in Fig. 11 may be used. Pure mineral oil or soluble oil may be used as heating medium. Soluble oil being preferable since it is safer and less expensive, although some types produce an objectionable odour when heated. The wire netting tray shown in the illustration prevents the bearing from contacting the bottom of the tank and may also be used for supporting them while they are being heated. Hanging the bearings on hooks suspended from a top crossbar prevents the necessity of probing about when removing them for fitting.

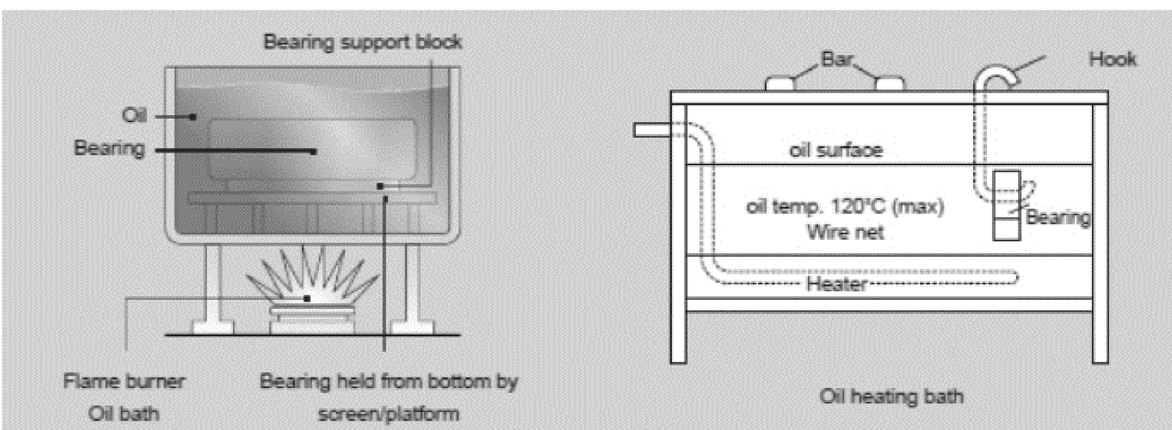


Fig. 11 Oil Bath for Heating the Bearing

6.1.7 *Lifting of bearings*

Bearings which have been heated in the manner described in **6.1.6** may be lifted out of the hot oil-bath by means of the scissor-tongs illustrated in Fig. 12. By gripping the outer ring in the manner shown, the operation of sliding the bearing into position on the shaft is facilitated. In order to avoid scratching of the outer ring tracks and rolling elements or damage to the cage, the claws shall only project inwards by a very small amount. An appliance of this kind is also useful for handling large and heavy bearings.

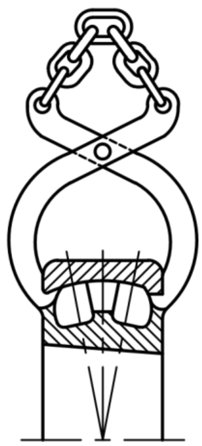


Fig. 12 Scissor-Tongs For Lifting The Bearing

6.1.8 *Induction heating*

As shown in Fig. 13, an electric induction apparatus may be used to heat the bearing. This is the fastest method of safely heating the bearings and most of the modern induction heaters have a shut-off option to prevent it from overheating. Take care to avoid heating the bearing to temperatures higher than 120ºC (250ºF).

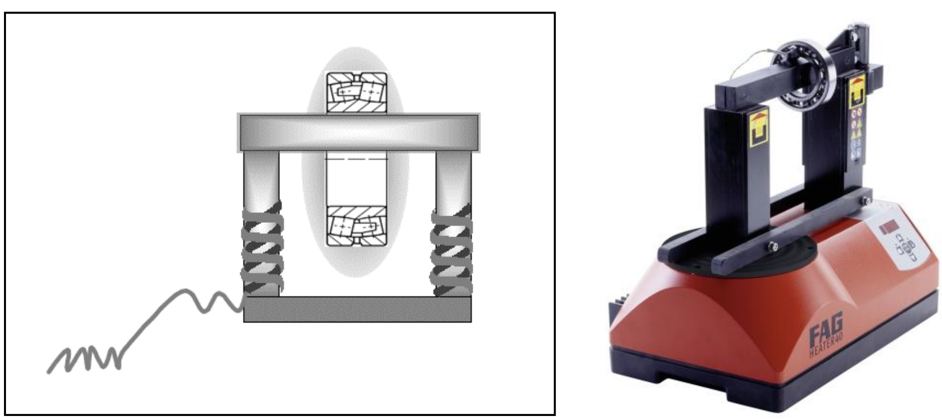


Fig. 13 Induction Heaters

6.1.9 *Torches*

Torches as shown in Fig. 14 should usually not be used to heat components. Most bearings have been hardened during manufacturing. Heating bearings with a torch can lead to differential heating and tends to draw the hardness out and leave the bearings soft and prone to failure. Torches can raise the temperature to several thousand degrees. If the steel is discoloured by the heat of the torch, then it has been annealed and has lost its hardness.

FIG. 14 AVOID TORCHES

6.1.10 *Protecting the bearings*

As soon as the bearing has cooled in position, the correct grade of grease or oil shall be applied forthwith to both the interior and the exterior surfaces. Unless preloading is intentional, in which case, the bearing may offer slight resistance to rotation, it shall rotate quite freely. Self-aligning bearing shall swivel easily in all directions. With roller bearing it is usually possible to check the diametric slackness after fitting by inserting feelers between the rolling elements and the outer ring track as shown in Fig 15. Lifting the outer ring meanwhile to take the weight off the feeler gauge. Attempts shall not be made to rotate the bearing while gauging the slackness, but the feeler shall be carefully slide over a roller. When tracks or rollers are convex or concave, misleading results are obtained unless the feeler passes through the narrowest gap. This check is seldom possible with ball bearings.

FIG. 15 CHECKING DIAMETRIC SLACKNESS BY FEELER GAUGE

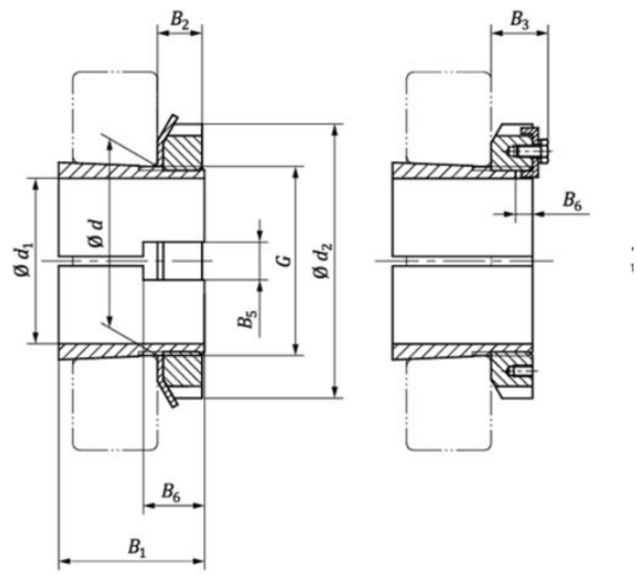
6.1.11 *Avoiding mixing of races*

Separable bearings, such as taper roller bearings and some of the cylindrical roller types and others, usually have their outer rings removed while the inner rings are being fitted. It is of the utmost importance to see that these outer rings do not get mixed up, and that each one goes back to its original mating inner ring otherwise the diametric slackness may be greatly altered. An outer ring shall be replaced in position without the use of force, being slightly rotated in the process to facilitate moving it into position. Use of force may scratch or dent both rollers and tracks.

6.1.12 *Adapter-sleeve mounting*

An adapter-sleeve mounting (*see* Fig. 16) is an easy method of securing a rolling bearing to a shaft without shoulders, but careful fitting is necessary. The following procedure is recommended:

a) Wipe the shaft.
b) Wipe the inside and outside of the sleeve.
c) Apply a trace of light oil to shaft and sleeve with a clean rag.
d) Arrange the component parts on the shaft so that the adapter nut tightens up in the direction opposite to that in which the shaft rotates. This is always advisable, if the nut is not provided with a locking device.



a) Adapter sleeve with locknut and lockwasher

b) Adapter sleeve with locknut and locking clip assembly

FIG. 16 ADAPTER SLEEVE MOUNTING (REFER IS16605 (PART 1) : 2018 FOR MORE DETAILS)

e) Where a bearing should be positioned accurately in relation to other shaft fittings, the auxiliary split sleeve is of assistance. When the bearing has been fitted, the auxiliary sleeve is removed.
f) The adapter sleeve may be moved along the shaft most easily without the bearing, and the operation is facilitated by opening up the sleeve slightly with the point of a screwdriver inserted in the slit.
g) By exerting finger pressure between the large end of the sleeve and the bearing inner ring, force the two together until the sleeve grips the shaft, then drive the bearing further on to the sleeve by light blows on hardwood drift, directed against various positions around the inner ring face, until the correct fit is obtained.
h) Finally, place the lock-washer (if any) in position, tighten up the nut, and lock for security.
j) In the last operation, guard against expanding the inner ring unduly, since the rolling elements in consequence might become jammed or the ring fractured. On the other hand, if the fit is too light the inner ring may loosen up in service and trouble may ensue. The bearing should rotate freely

after fitting, and if it is of the self-aligning type, its outer ring should lend itself to swivel in any direction.

k) After the bearing has been in operation, the nut may be tightened up slightly to take up any looseness in the fit that may have developed.

6.1.13 *Loose fit*

If a loose fit, sliding fit, or easy fit is specified without precise information about the shaft limits, it is well to remember that on a hardened and ground seating, ring creep has a less detrimental effect than on a soft and roughly finished one, but the looser the fit, the greater the shake and a rattling fit is not desirable. Loose fits for shaft seating are to be specified where axial adjustment of the inner ring has to be made or allowed for.

6.1.14 *Slack fit*

If the shaft rotates, the fit should be no slacker than necessary. If the shaft does not rotate, or the load is stationary, a slack fit is of less consequence, but even then, excessive play is undesirable. Distance sleeves, if used, shall slide freely on the shaft.

6.1.15 *Fit of thrust bearing*

The fit of the rotating ring of a thrust bearing on the shaft is not quite as important as the corresponding fit for a radial bearing, as there is less tendency for the thrust ring to creep when the complete bearing is fitted square with the shaft axis. Nevertheless, an interference fit is preferable. The sleeves of a double-acting thrust bearing shall have a close sliding fit.

6.2 Housings

Bearings are usually fitted in their housings after being placed on the shaft. The precise manner of introduction of bearings depends largely on the housing design, the position of other bearings and the character of the fit, and on whether the shaft is horizontal or vertical. The following suggestions may readily be adapted to suit different circumstances.

6.2.1 *Preparation of housing*

a) Inspect and prepare the bearing seat. Burrs and other material between the back faces and the shoulders can prevent proper seating (*see* Fig. 17). This could lead to misalignment, hurting gear mesh and reducing bearing life. Burrs could also break loose during use and get trapped in the bearing. If necessary, lightly file the backing shoulder to ensure it is clean and flat.

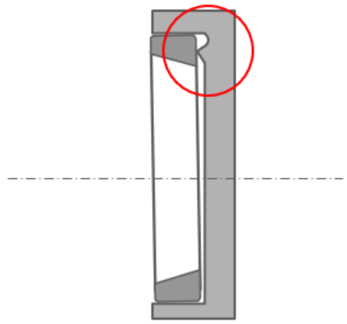


FIG. 17 OBSTRUCTIONS BETWEEN BACK FACE AND SHOULDER

b) Ensure that fillet radii are within specs, so cup/outer ring can fully seat, and that the seat is square and clean.
c) Check the housing bore for size. Take readings in two planes, 90° apart. For longer housings, it may be checked at three or four places, front to rear. Take four angular positions within each plane for diameter measurement (*see* Fig 18).
d) Check for roundness by comparing the two size measurements. The difference must not be greater than the bearing OD size tolerance.
e) For tapered roller bearings, if the bearing seat is wide, check for size in two planes axially as well.
f) Housing bores should be finished to 3.2 µm (125 µin) Ra maximum.

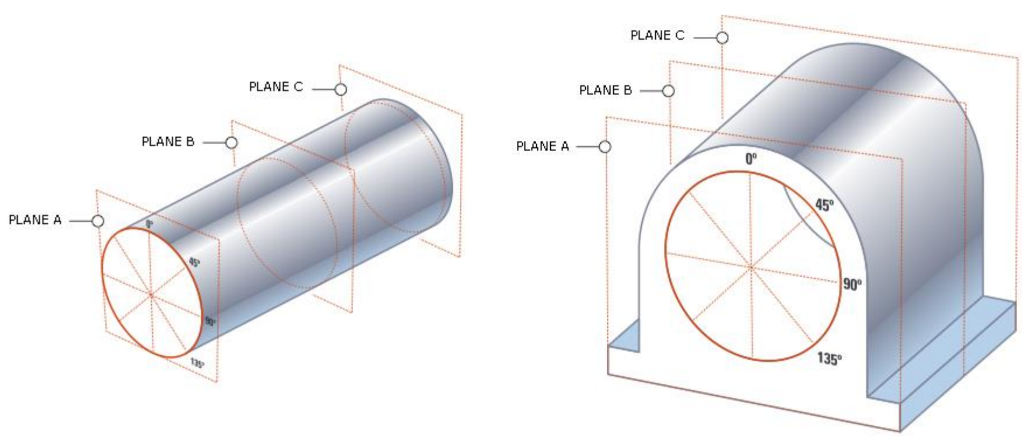


FIG. 18 DIAMETER MEASUREMENT OF HOUSING

6.2.2 *Tight fitting of outer ring*

If the outer rings are to be tight fitted into the housing, then they will need to be pressed with force. Depending on the fit, the outer ring can also be cooled with the help of Dry ice. Cooling with the help of liquid nitrogen is not suggested.

The Outer ring can be cooled to the following temperatures

- Standard product chilled to -55°C (-65°F)

- Precision product chilled to -30°C (-20°F)

Use bath of alcohol or antifreeze and dry ice

- If this method is used, wipe outer ring dry of frost or moisture and re-oil to prevent etch, corrosion or damage.

Check if the outer ring is properly seated and backed against the shoulder. It is possible that the outer ring may pull off as it starts to heat up after installation. Once the cup / outer ring is installed, wait for it to expand to room temperature. The bearing may pull away from the shoulder as it cools. Check to ensure you have a full seat against the shoulder with .002 in (.05 mm) shim stock or feeler gage between the cone / inner ring back face and the shoulder. If it is not fully seated, tap it into place with a rubber mallet or soft metal bar and hammer.

6.2.3 *Axial adjustment of outer ring of radial bearing*

If the outer ring of a radial bearing must be adjusted axially, the shaft shall be slowly rotated during the adjustment. As soon as noticeable resistance to rotation is felt, the rotation should be stopped, and the adjusting screws turned back slightly to ensure free running. This procedure is not to be followed if the bearings are preloaded.

6.2.4 *Avoiding scraping of housing*

If the fit of an outer ring proves to be very much tight and scraping is resorted to, this shall be done very carefully to avoid making the seating oval. With split housings it is bad practice to use shims at the joint for the purpose of obtaining a looser fit. If felt washers are cut at the joints, their ends shall not protrude into the joint. It should not be possible to put the cap of a housing the wrong way around, but if it is, it shall be ensured that it mates with the lower half correctly. Housing parts shall not be mixed, as it is unlikely that they are completely interchangeable.

6.2.5 *Correction of housing*

Where a fit is looser than specified, no attempt shall be made to correct it by inserting pieces of paper, tinfoil, etc, or by using grub screws to grip the outer rings. The housing may be corrected by metal-spraying its bore or boring it out slightly and fitting a liner, after which re-machining to size is necessary in both the cases.

6.2.6 *Use of shims*

Though the use of shims between a housing and its end covers is not good practice, owing to the likelihood of shims becoming lost or mixed with others during repairs, their use on occasions may be justified. When a replacement bearing is fitted, new shims differing in thickness from the old ones may probably be required. Further points to be borne in mind are:

a) Housing bases shall be fitted on truly flat surfaces or they may fracture when the holding-down bolts are tightened.
b) Soft wood shall not be used for packing up housing or else the base fitting strips may dig into the wood.
c) Outer rings in split housings shall not be gripped when in a tilted position, otherwise it will result in severe distortion of the ring.

d) There shall be no rubbing between adjacent faces of labyrinth seal or other metal parts. This usually results in excessive temperature rise.
e) Misalignment of the halves of flanged couplings cause heavy radial or axial load or both.
f) Expansion couplings which do not respond to shaft contraction or expansion, may cause excessive thrust load.
g) Only one bearing on a shaft that is the ‘locating or fixed’ bearing, as a rule has both inner and outer rings secured axially for shaft location (*see* Fig. 19). The other bearing is called ‘free or float’ bearing shall be free to move axially in their housings when the shaft expands or contracts.
An exception is made when two bearings are comparatively close together (see Fig. 20), or when a cylindrical roller bearing outer ring without thrust flanges has to be held endwise.
h) With a tight-fitting outer ring, it is especially important to ensure that it takes up its correct position in relation to its inner ring, otherwise it may result in heavy end-thrust and other detrimental effects.

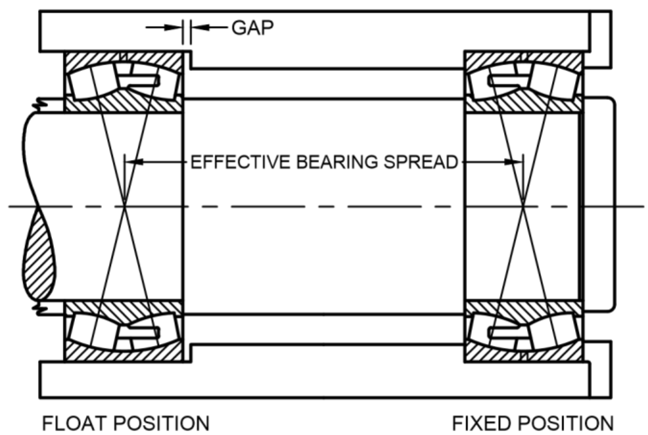


FIG. 19 AXIALLY SECURED RINGS OF LOCATING BEARING

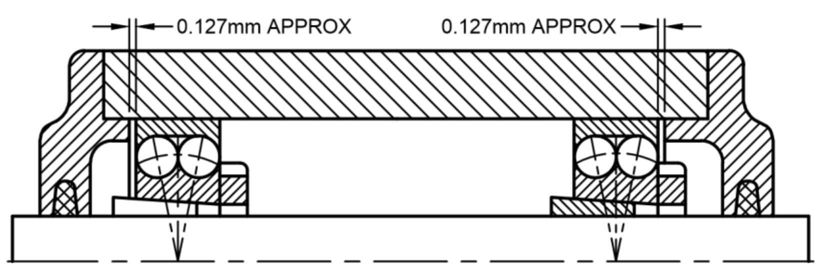


FIG. 20 EXCEPTION

6.2.7 *Use of mild steel tube*

The use of mild steel tube with an end cap for driving a tight-fitting outer ring into position is illustrated in Fig. 21. The inner face of the tube shall be held flat against the outer-ring face and the cap hit squarely.

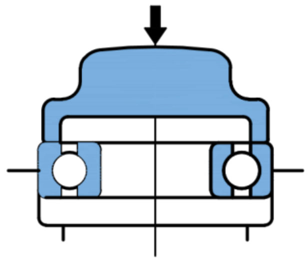


FIG. 21 MILD STEEL TUBE WITH AN END CAP FOR DRIVING AN OUTER RING

6.2.8 *Important types of tools*

Where an inner ring is already fitted to its shaft, a tool of the kind shown in Fig. 22 is of great help in driving a tight-fitting outer ring into place. Both annular surfaces of the tool are in the same plane and shall make simultaneous contact with both rings, the transmission of shock loads to the tracks through the balls being thus avoided, the same kind of tool may be employed as shown in Fig. 23, when the bearing has first been fitted into its housing and the inner ring is afterwards driven on to its shaft.

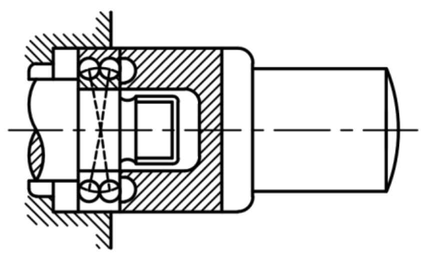


FIG. 22 TOOL FOR DRIVING OUTER RING

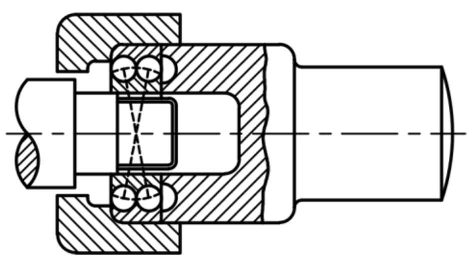


FIG. 23 TOOL FOR DRIVING INNER RING

6.2.9 *Avoiding transmission of shocks*

If a pulley, coupling, or other part has to be driven into position on the shaft after the bearings have been fitted, the free end of the shaft shall be held against a rigid support as shown in Fig. 24 to avoid transmission of the shocks caused by hammer blows to the bearings.

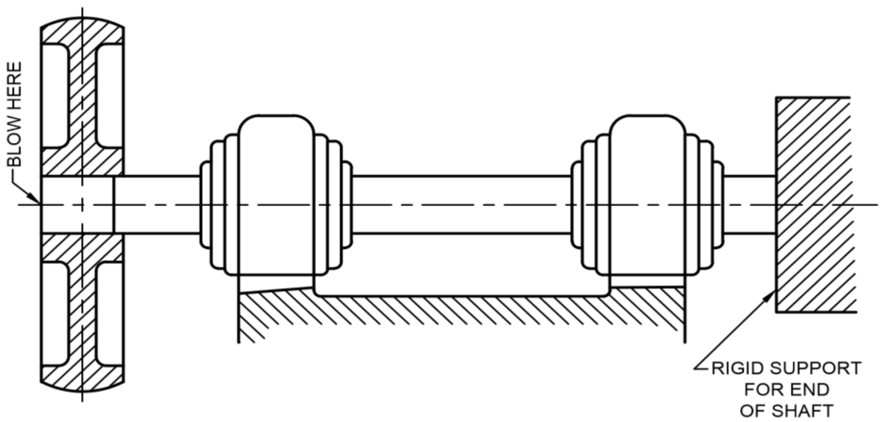


FIG. 24 RIGID SUPPORT FOR END SHAFT

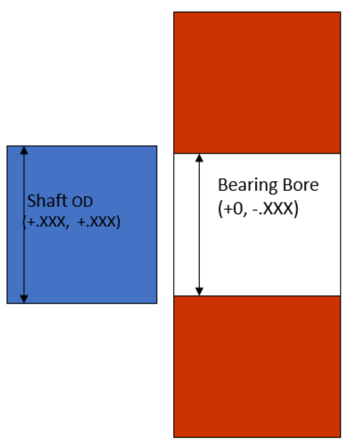
6.3 Important points of fit

Bearing fits address the radial interfaces between the bearing and its adjacent shaft and housing. Tight fits reduce the bearing's manufactured Radial Internal Clearance (RIC) which after mounting maybe called the "cold-mounted setting" or "mounted RIC".
For 95% of applications, the rotating bearing ring is tight fitted radially to its adjacent component. Most of the time that's the shaft and the inner ring. The convention is that whichever component (or bearing ring) is subjected to a constantly changing load location shall be tight fitted to its adjacent component.

If the shaft does not have a proper surface finish, it may risk in losing the fit. The surface finish for mounting/fitting may be taken as follows:

a) Ground Shaft: 1.6 micrometres (63 micro-inches)
b) Housing Bores: 3.2 micrometres (125 micro-inches)

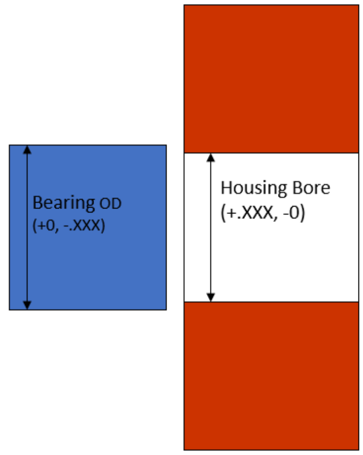
6.3.1 *Inner Ring Fitting Practice*



Max Fit = Bearing Bore (min) – Shaft OD (max)
Min Fit = Bearing Bore (max) – Shaft OD (min)

FIG. 25

6.3.2 *Outer Ring Fitting Practice*



Max Fit = Housing Bore (min) – Bearing OD (max)
Min Fit = Housing Bore (max) – Bearing OD (min)

FIG. 26

6.3.3 *Exceptional Cases*

Care must be ensured when bearing fitting is performed under the following conditions:

a) Light shaft and housing sections
b) Shafts other than steel
c) Nonferrous housings
d) Special assembly procedures
e) Rougher than normal surface finishes
f) Critical conditions
g) High speed application
h) Unusual thermal conditions
j) Unusual loading conditions

7.1 Disassembly Area

Start with a clean work area.

a) Clean the work area of debris or dirt that could find its way into the bearing.
b) Wipe any surface where the bearing will be placed to avoid contaminating the grease.

7.2 Bearing Removal

Each type of bearing design has a unique removal process. Regardless of the bearing type, the bearing must be removed with extreme care. If done incorrectly, you can damage the bearings, shafts or housings, requiring expensive repairs.

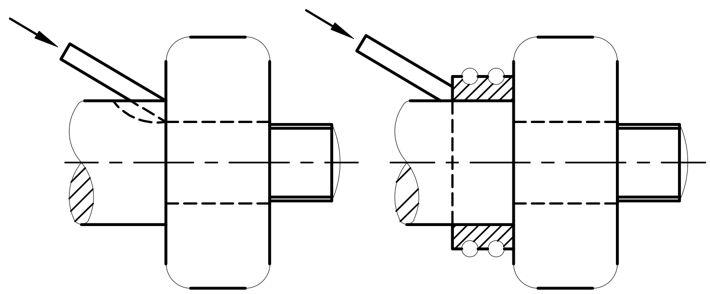
Unusual thermal conditions
Unusual loading conditions

7.3 Removal of Inner Ring

7.3.1 An inner ring is more easily fitted than withdrawn, when the fit is tight. It is often convenient to push the bearings off the shafts using a hammer and a drift as shown in Fig. 27a.

7.3.1.1 When the shaft has two or three grooves in which the end of the drift can be placed, but there is a danger of slipping of the drift and, when the blows are heavy, of fracturing the thin tip of the ring.

7.3.1.2 Another method is indicated in Fig. 27b for use when the outer diameter of inner ring is greater than the shaft-shoulder diameter. A short tube is placed between the ring and the drift, the ring being thus protected from the shock of the blows. The force of the blows is also better distributed. Where a whole tube cannot be brought into position, a split tube with its two halves secured together temporarily by wire or even a half-tube only, may be employed. These are only suitable for relatively light press fits.

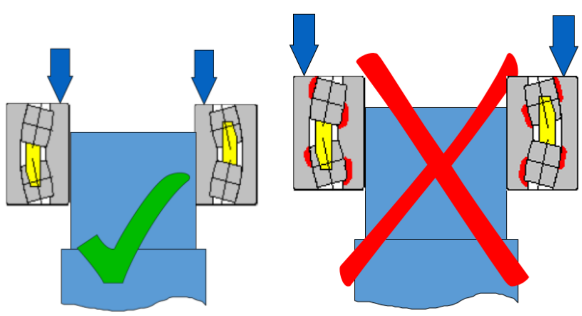


a) b)

FIG. 27 REMOVAL OF BEARING FROM SHAFT

7.3.1.3 Only a mild steel bar (1020 or 1040), drift or key stock is recommended to be used as a driver.

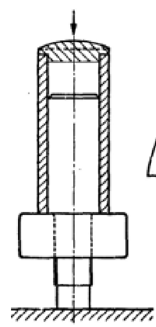
a) The hardened punch is typically as hard as the bearing material. Hence it can deform or damage a bearing.
b) Brass bars can splinter or flake, creating debris that can be trapped in the bearing or housing.
c) When pushing the back face of the cone / inner ring, use caution to make sure the bar does not contact the cage. Once the cage is damaged, the bearing must be scrapped (small bearings) or repaired (larger bearings).
d) While using drift, maintain alignment. Apply force to tight fitted member as shown in Fig. 28a. Applying force on the loose member may lead to high stress concentration in the bearing as shown in Fig 28b.



a) RIGHT WAY b) WRONG WAY

FIG. 28

7.3.2 A more satisfactory method for removal of inner rings is to use a capped tube (*see* Fig. 29). Better still would be to put the shaft in a screw press with a split tube between the inner ring and the press table (*see* Fig. 30).



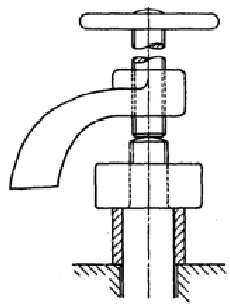


FIG. 29 FIG. 30

7.3.3 For smaller bearings, there are a variety of pullers available to assist with bearing removal (*see* Fig. 31). IS 9193 specifies the requirements for bearing pullers.

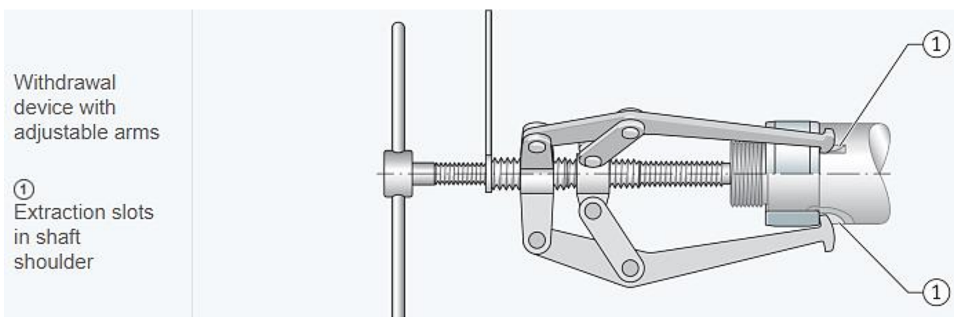


FIG. 31 BEARING PULLER

7.3.4 A useful puller device is shown in Fig. 32, In pullers for large bearings a ball thrust bearing may be used in place of the ball.

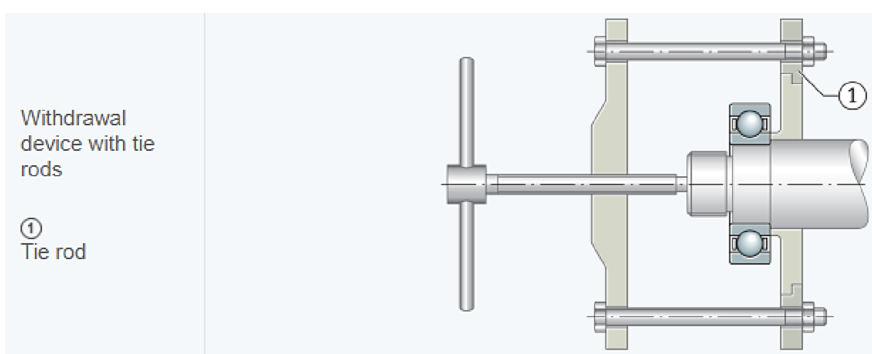


FIG. 32 PULLER DEVICE

7.3.5 A special tool for withdrawing a self-aligning roller bearing inner ring, the outer ring and rollers having been removed first, is shown in Fig. 33. The two halves of the split ring which accurately conform internally to the curvature of the roller track shall contact each other at the joint, to prevent nipping the tracks. Conical surfaces on the outside of the split ring and on the inside of the back puller-plate engage to hold the parts of the split ring together, and at the same time transmit the withdrawal force to the central flange of the bearing ring.

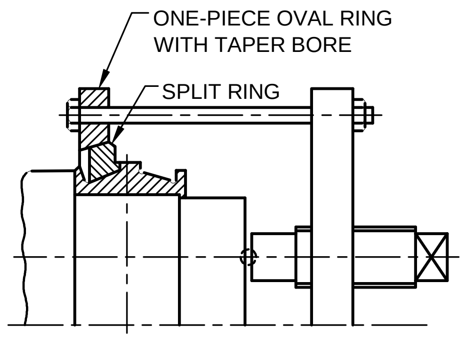


FIG. 33 TOOL FOR WITHDRAWING A SELF-ALIGNING ROLLER BEARING

7.3.6 To remove thin inner ring, such as those of needle-roller bearings, the puller shown in Fig. 34 will be particularly useful. It will be noted that provision shall be made in fixing the details of the bearing arrangement to allow the inner hook of the two T-shaped pieces to get behind the inner ring. These pieces fit into T-shaped slots in the puller tube and are held in place by the auxiliary ring shown.

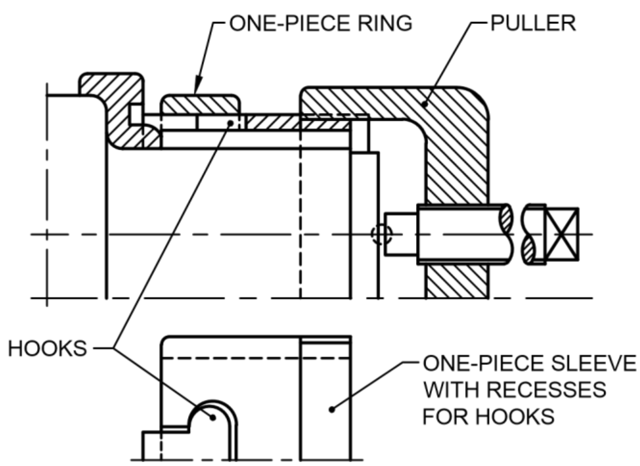


FIG. 34 PULLER FOR NEEDLE-ROLLER BEARINGS

7.3.7 Puller with hydraulic assist can be used for removing the bearing with inner race tightly fitted on the shaft. (*see* Fig. 35)

FIG. 35 PULLER WITH HYDRAULIC ASSIST

7.3.8 Hydraulic removal is an option if journal is so equipped. Mechanics of Hydraulic Removal is described below:

a) As hydraulic fluid is introduced, pressure is built up at the bore of the inner ring effectively expanding the inner ring to overcome the interference fit. The bearing will then seek the least resistance and move down the taper for easy removal. (*see* Fig. 36).

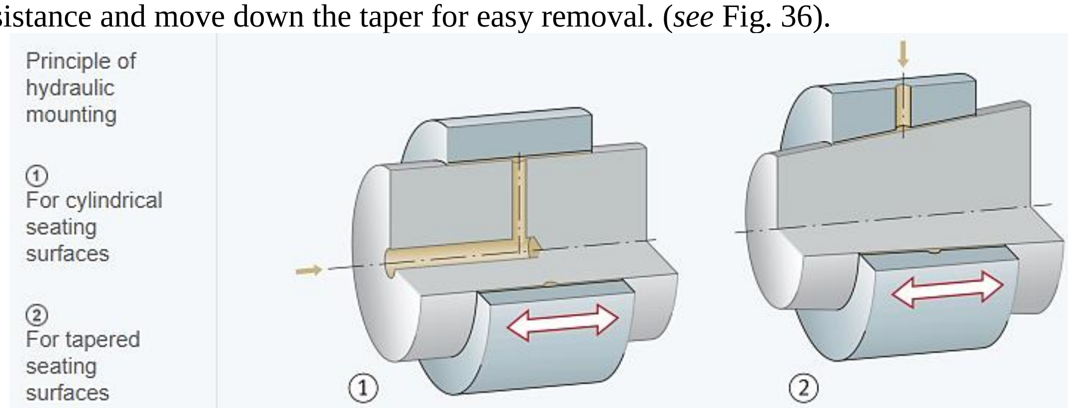


FIG. 36 MECHANICS OF HYDRAULIC REMOVAL

7.3.9 In difficult cases it may be necessary to heat the inner ring to facilitate its removal. Fig. 37 shows a method of applying heat by means of steam issuing out of suitably placed holes in a curved pipe encircling the inner ring. Owing to the use of steam, the bearing shall be washed in white spirit immediately after its removal and then thoroughly re-greased to prevent corrosion.

STEAM PIPE

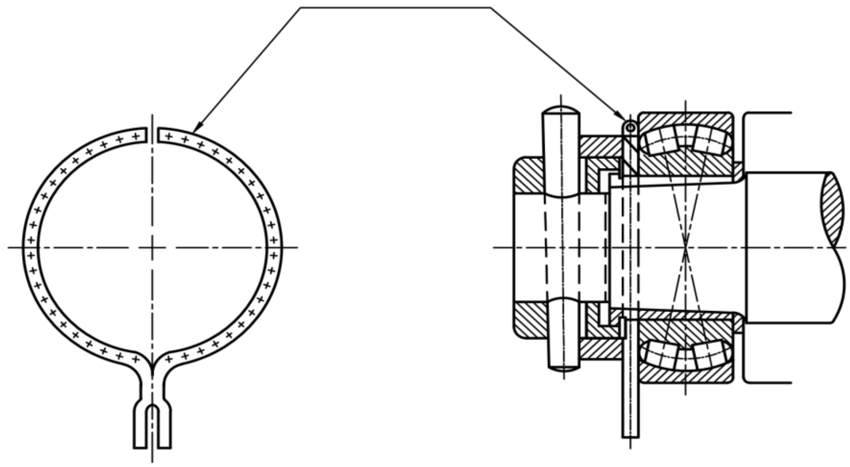


FIG. 37 HEATING INNER RING WITH STEAM

7.3.10 For bearings installed with a tight or press fit, or that have become locked in place on a shaft and cannot be removed with a mechanical puller, the inner ring of the bearing can be heated to ease removal. Heat lamps or other heating devices can be used. If a torch is used, it will change the properties of the bearing steel and the bearing must be discarded.

7.4 Removal of Housing

7.4.1 A simple and effective means of withdrawing a housing is shown in Fig. 38. This method makes use of holes tapped in the housing wall before the bearing is fitted, the holes being closed by short screws until the withdrawal screws are required.

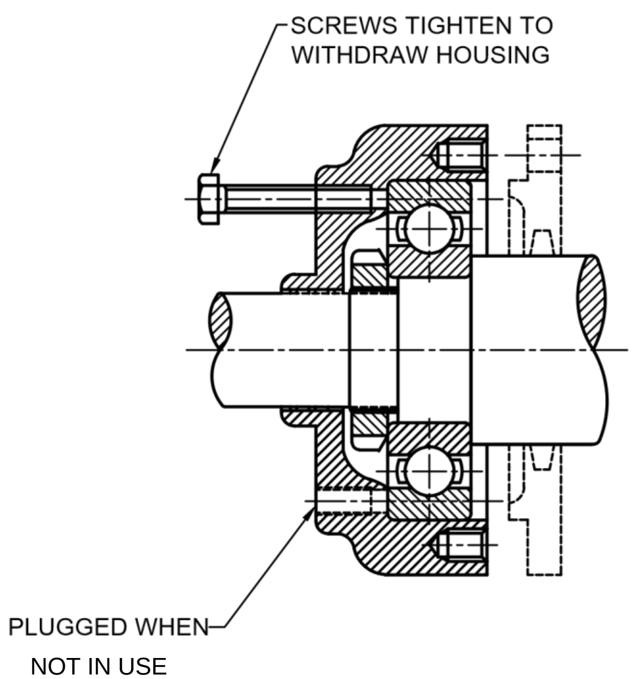


FIG. 38 WITHDRAWING A HOUSING

7.4.2 A method suitable for housing with through holes for end cover bolts is illustrated in Fig. 39. The important part here is the special nut; whose outer edge supports the bearing outer ring while the housing is being withdrawn. A cross-bar, with central screw for applying pressure pulls on the housing through the medium of the housing cover bolts as shown; when the cross-bar is not available, a hammer and a piece of hard wood may be used without danger to the bearing.

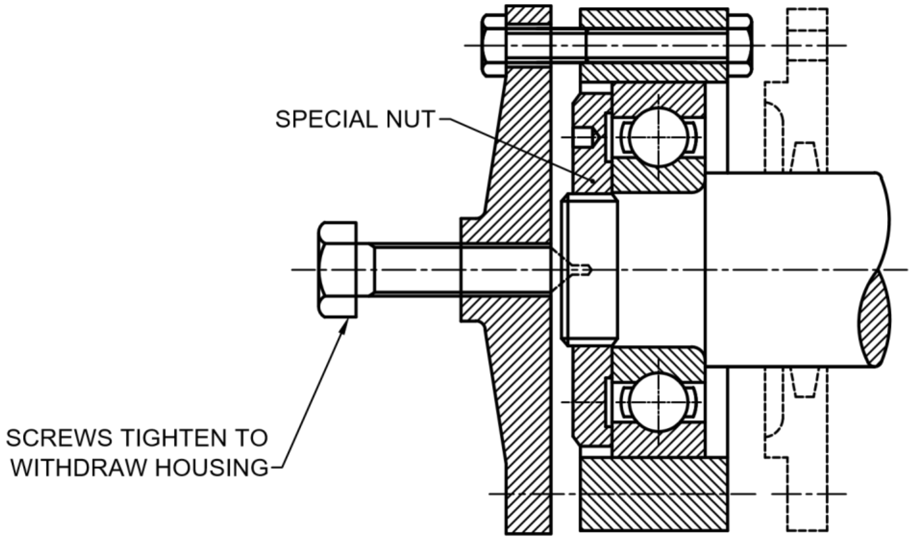


FIG. 39 HOUSING WITH THROUGH HOLES FOR END COVER BOLTS

7.4.3 In stubborn cases the fit may be loosened by heating the outside of the housing in some way, but there is always a risk of cracking the housing if the heating is not uniform all around. Too much time shall not be expended on this job, or the heat may be conducted to the bearing ring, which may then expand together with the housing. A blow lamp is the handiest source of heat but is to be used very carefully.

8 LIFTING LARGE BEARINGS

Large bearings can be lifted and moved using a variety of slings, hooks, chains and mechanical devices. Some large bearings are manufactured with tapped holes in the face of inner rings or outer rings. Eyebolts or other points of attachment can be inserted in these lifting holes (*see* Fig. 40).

FIG. 40 TAPPED HOLES FOR LIFTING

Many large bearings have threaded lifting holes in the cage ring that can be used to lift the inner ring assembly. A clean, heavy duty nylon sling provides one of the best means of handling large bearing components because it eliminates the possibility of burring or scratching. Regardless of what method is used to lift the bearings, use care to avoid damaging any of the bearing surfaces. Be especially cautious when lifting or moving bearings that are equipped with a cage. The cage is typically the most deformable component of the bearing and is more susceptible to damage.

9 CLEANING BEARINGS

9.1 After removing a bearing from a piece of equipment, thoroughly clean it to remove all scale, water, lubricant, debris and any other contaminants. Bearings must be cleaned thoroughly to allow for proper bearing inspection.

9.2 It is seldom necessary to clean bearings with the sole object of removing the rust preventive with which they are coated before being packed. Rust preventives with a petroleum-jelly base have certain lubricating qualities, and, in any case, since the amount used for the protection of bearing is small, no harm is done when they become mixed with the grease or oil used for lubrication. With small high-speed bearings, however, and a light oil or oil mist, as the lubricant, it may be justifiable to wash out the protective coating in order to prevent a possible initial rise in temperature due to its presence.

9.3 As a rule washing shall only be resorted to when bearings have become dirty, or when the mechanism in which they are to be used is so sensitive that even slight irregular resistance to rotation is not permissible.

9.4 The choice of any particular combination of various cleaning agents, depends on the number of bearings to be cleaned, the kind of the cleaning apparatus available and the risk of fire or fumes involved. The cleaning media most commonly used are:

a) Petrol,
b) Benzine,
c) Benzol (commercial benzine),
d) White spirit (low flashpoint),
e) Turpentine,
f) Paraffin,
g) Light spindle-oil,
h) Trichloroethylene,
i) Carbon tetrachloride,
j) Alkaline solutions, and
k) Compressed air.

Out of these the first four are most suitable for general use. White spirit is generally preferred since it is less volatile, so that the loss by evaporation and risk of fire are minimized.

9.4.1 In order to render petrol, benzene, and benzol less inflammable, they may be mixed in equal parts with good quality industrial (non-coloured) methylated spirit without appreciably affecting their cleaning properties.

9.4.2 Turpentine is a good cleaner, though not so effective as benzol. It leaves a tar-like residue, which is difficult to remove from cage pockets and other inaccessible surfaces. In general turpentine cannot be recommended for the washing of rolling bearings.

9.4.3 Commercial paraffin is less effective than any of the first five liquids mentioned, and because of its water content, tends to promote rusting. This effect may be obviated by mixing 1 to 2 percent lanoline or mineral oil with the paraffin. The resulting mixture is less harmful to the skin. In all cases the paraffin shall be free from acids.

9.4.4 Light spindle-oil is excellent if applied hot in the form of a jet. Its use obviates danger of corrosion, since the bearings are never in a dry state immediately after treatment, as is the case with most other agents.

9.4.5 Trichloroethylene and carbon tetrachloride are good degreasers, but leave surfaces so dry that they shall be oiled immediately, and the bearings shall not be touched by hand until this has been done. These cleaners do not remove carbonaceous matter. As trichloroethylene leaves a white deposit which tends to corrode the surfaces, all traces of this deposit shall be removed by thoroughly rinsing in oil. Both solvents are non-inflammable; but their vapours are dangerous if inhaled. Specially designed apparatus is necessary for their use.

9.4.6 Two to five percent hot soda solution or a three percent metasilicate solution may be used when nothing better is available. After this treatment, a washing in 2 percent soap solution helps temporarily to minimize corrosion. Steel parts so washed shall be rinsed with 0.1 percent boiling sodium nitrite solution; for cast iron parts 3 percent sodium nitrite solution is necessary. After the rinsing, bearings shall be dried by means of a jet of hot air, while they are slowly rotated, or by leaving them in an oven at 100°C for about 40 minutes. Immediately after drying suitable protection is necessary.

9.4.7 Compressed air may be used for dislodging loose particles of grit, provided that the air is dry. Usually, however, there is a certain amount of moisture in the air, and as this condenses when the air leaves the nozzle, precautions should be taken to exclude any possibility of rust formation.

NOTE — Never spin a bearing with compressed air. The rollers may be forcefully expelled creating a risk of serious bodily harm.

9.5 After any cleaning process it is necessary to protect the bearing by dipping them in hot petroleum jelly or oil, or by applying thoroughly the grease to be used that it reaches every part of the surfaces. In the latter case rotation of bearings is necessary while the grease is being applied.

9.6 Solid particles cannot be removed by simply immersing bearings in a cleaning bath; some kind of gentle wiping or mechanical agitation is necessary. When only small numbers of bearings have to be washed, perhaps the best method is to employ two separate baths, for which anyone of the liquids (a) to (d) listed in **9.4** is suitable. The first bath is used for preliminary washing, and the second for the final washing.

In the first bath, each bearing is moved about vigorously, without rotating it, since any trapped foreign matter might scratch the tracks or rolling elements. After as much as possible of the dirt has been removed this way, the bearing is transferred to the second bath. It is now rotated, gently at first, then faster until all trace of grit has been removed. The bearing is removed from the bath, surplus liquid shaken off dried and given a protective coating.

When a large number of bearings are to be cleaned, a bearing cleaning machine can be used. In these machines all the operations mentioned above are carried out in a closed chamber thus cleaning bearings quickly, effectively and without any spillage.

FIG. 41 BEARING CLEANING

9.7 When it is desirable that the last vestige of entrapped dust shall be removed, the condition envisaged can be approached by lightly fixing the inner ring of the bearing on the top end of a vertical spindle and then running the spindle at 1 000 to 3 000 rev/min and directing a fine jet of white spirit on the cage and the balls. The outer ring lags behind the inner, owing to the retarding effect of the jet, but the difference in speed is not so great as to give rise to any danger of scratched surfaces before the loose particles are dislodged. A suitable shield around the spindle is necessary to catch the spray, and a filter and collector should be added to clean and retrieve the used spirit.

9.7.1 The simplest and safest method is to apply a jet of hot light spindle-oil direct to the bearing. As the process is a bit messy, an enclosed cabinet with a window and with openings for the hands is necessary. The bearings may be laid flat on a perforated or corrugated tray, and the jet sprayed over them; it is better to place them on the top ends of stationary and vertical spindles and direct a jet on to the cage and balls so that it will cause rotation of the bearings but shall avoid high speed rotation.

9.8 Extreme Pressure Lubricants

These are to be used in gear boxes where the gear-tooth specific loads are high. They protect the tooth surfaces by depositing a thin protecting film under pressure. The same lubricant is often used to lubricate the bearings, on which a similar film is also deposited. Discoloration of the tracks by this film shall not be confused with discoloration due to other causes. This film has been found to be harmless by experiments so far conducted.

10. BEARING INSPECTION

10.1 After the bearing has been cleaned and dried, they need to be visually inspected. It is recommended to have good lighting and a magnifying glass for checking the bearing.

10.2 The various modes of bearing damage and failure as given in IS 17276 can be referred for Inspection. The first place to look is the large end of the roller at the rib-roller contact area. Check for scoring of the roller end.

10.3 A metal probe (*see* Fig. 42) is inserted in the small end of the cone to feel for damage on the cone race. However, a paper clip with a 90° bend in the end will serve the same purpose. It is slid in under the small end of the cage and worked back and forth across the cone race. Spalls and nicks can be caught easily with this tool.

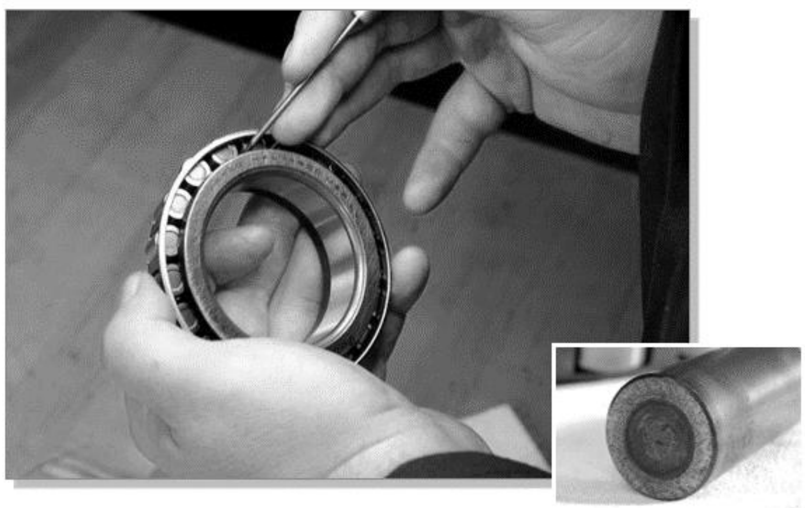


FIG. 42 METAL PROBE

10.4 For integral bearings (Spherical Roller Bearings), check the Radial Internal Clearance (RIC) using a feeler gauge. Increase in the RIC beyond the permissible limit calls for remedial action including replacement of the bearing.

11 TRIAL RUNS

11.1 All rotating parts shall first be turned slowly by hand, individually and collectively, to ascertain if there is undue resistance anywhere. The bearings shall be adequately lubricated before running at speed, even for a short time, and it is a good plan and is essential in most cases to make certain that the lubricant has reached every part. There is no difficulty with oil in this respect but where grease is used it shall be pressed between the interstices of the cage and rolling elements by hand, the bearing being rotated slowly to assist penetration. While the machine is running, the character of the sound from each bearing provides a good indication whether all is well or not.

11.2 Advanced monitoring of the health of the bearing system can be carried out with the help of the vibration monitoring equipment. There are three distinct types of defects which can be derived from the general appearance of a bearing vibration signature (frequency spectrum):

a) Smooth, continuous geometry defects (errors of form), such as out of roundness, lobbing, and chatter, tend to excite a single frequency.
b) Sharp, localized discontinuities, such as nicks, flats, cracks, and poor surface finish tend to excite all harmonics to one degree or another. In the time-domain, this type of signal would consist of a series of impulses.
c) A frictional problem, such as severe sliding or metal to metal contact (shallow undercut, large flat, etc.) will tend to excite all frequencies and thus result in an increase in the baseline of the signature. If sliding does take place, then the base of the peaks in the spectrum will tend to widen with a shifting of frequency. In the time-domain, this type of signal would appear as a set of random movements.

Frequent analysis of the oil or grease also will reveal the condition of the bearing. Microscopic analysis of the sample will help us identify different metallic and non-metallic particles. Based on the size / shape of the wear particle, the severity of rolling-contact fatigue wear can be estimated.

Another well-tried and useful way of isolating the sound from each bearing is to place the ear against one end of a short piece of wood, screw driver or the like and the other end against the bearing housing, or some form of amplifying stethoscope may be used. Housings should also be felt with the hand to discover if there is any undue rise in temperature. Some information as a guide for such tests are given in Table 1.

Table 1 Methods to Minimise Undue Rise of Temperature
(*Clause* 11.2)

Sl. No.	*Sound*	*Cause*	*Remedy*
1	Metallic note	Bearing dry	Clean the bearing and housing thoroughly, and re-lubricate
2	Pronounced low note	Track indentations	Fit new bearings
3	Irregular	Foreign matter	As for 1
4	Harsh	Tracks pitted or flaked	As for 2
5	Knocking	Rolling elements damaged or cracked ring	As for 2

6	Rumbling	a) Fluted tracks, due to vibration	As for 2
		b) Fluted tracks due to electric arcing	Fit new bearings and check electric insulation
7	Abnormal temperature rise can occur with bearings in all states from new condition to that of breakdown. Apart from damage to the bearing itself, the cause may be excessive lubricant, an inadequacy of heat-radiating housing-surfaces, too stiff a grease, too heavy an oil, too high speeds, too great loads or too tight fits.		

12 PROTECTION OF BEARINGS IN MACHINES WHILE BEING TRANSPORTED

12.1 Most greases set up slight corrosive or electrolytic action, where the rolling elements are in contact with the tracks and the bearings are stationary for a few months. In general, this action can be ignored, but if it is known that a machine will be stored for six months or more after erection, the procedure outlined below is advisable:

a) When fitting the bearings, their protective coatings should not be removed.
b) If only a very short test of the machine is to be made, further lubricant should not be added until the test is completed.
c) After the test, pure Vaseline is pressed into the bearing so that it reaches all the surfaces.
d) The housing is then packed with the grease required, for normal operation, to the usual height; and
e) Further running of the machine shall be avoided until it is put into service.

12.2 Bearing protection during the short period between the complete assembly of a machine and the commencement of operation at its destination shall also be provided for.

12.3 Where grease is used, a normal charge will doubtless have been given to each bearing during assembly, in which event no further attention is necessary, provided the machine is adequately covered during transit. Where oil is the lubricant the bearing will have received a protective coating during the trial run, and this can generally be relied upon for a week or two. When longer period is involved, a coating of pure Vaseline shall be applied, and instructions given to have this washed out later if necessary.

12.4 Vibration set up by jolting during transport is a more common cause of tracks indentation than is generally realised. When the bearing slackness is greater than the normal, the tracks are most likely to be indented from this cause and consequently to acquire the resulting characteristic marking.

12.5 In cases where a machine is dismantled prior to despatch, the same care shall be taken in repacking the bearings as was originally taken by the manufacturer and precautions against the entry of sawdust, shavings etc, into the housings are advisable, for there may be poor facilities for washing and cleaning where the machine will be reassembled.

13 MAINTENANCE

13.1 Lubrication

Lubrication is an important part of bearing assembly. In most cases, your bearings will be lubricated with grease. Some equipment uses oil bath, oil spray or other lube systems. The grease reduces friction between mating surfaces and it helps to keep the bearings and the equipment running cooler. The grease also helps to protect the bearings from debris and corrosion.

a) To hand grease a small bearing, place the grease in the palm of your hand and work it through the bearing.
b) In tapered roller bearings, work the grease from the large end of the rollers to the small end. Keep pushing the cone into the grease until it is forced out the small end.
c) Sometimes it is assumed that packing as much grease as possible into a bearing is good, but that’s not true. Over-greasing can be a problem. Fill roller bearings from 1/3 to 2/3 of their free volume.
d) In high-speed applications, over greasing will cause excess grease churning, resulting in extremely high temperatures. When grease gets too hot, it breaks down and stops doing its job.

13.2 The most important elements of successful and economic maintenance of rolling bearings are the periodical replenishing of lubricant and charging it completely at less frequent intervals. Some kind of record should be kept, since this is of great value for reference when it has to be decided whether the intervals may be lengthened or sometimes shortened.

13.2.1 It is advisable every time the lubricant is replenished to examine all the lubrication arrangements thoroughly to ascertain whether they are functioning as expected, and at the same time to examine the lubricant itself. Hardening or soiling of grease and charring of oil, point to some kind of trouble, which shall be set right at once.

13.2.2 Leakage of grease or oil from housing joints or through the seals is also an indication that something is wrong. The seals have possibly become inefficient through wear of felt washers, if used; or there may have been rubbing and wear of the labyrinth surfaces due to some constructional fault. Where grease seals are faultless, leakage may be due to disintegration of the grease, the free oil escaping through seals, not designed for retaining oil. This condition shall be remedied at once, since it means that the grease is faulty or that the temperature has been sufficiently high to melt it.

13.2.3 When removing old grease, a thin hardwood scoop may be used as it is less likely to scratch the rolling elements than a metal one. If the grease has hardened, benzine and not paraffin shall be used for cleaning. A small quantity of benzine is put into the lower half of the casing, allowed to soak for a few minutes, and then sponged out with a non-fluffy rag. When the bulk of the grease has been removed, some more fresh benzine is put in, the shaft is slowly turned, to allow the benzine to reach every part of the bearing. In bad cases, it is better to remove the housing completely, so as to enable bearing and housing to be treated separately.

13.2.4 The grease-can should be kept covered when not in use.

13.3 Machine repairs

13.3.1 Correct selection, fitting, and maintenance, together with correct housing design, ensure a satisfactory life for any rolling bearing, but eventually there comes a time when, for one reason or other; it may he fatigue, abuse or dismantling a machine for reasons not directly connected with the bearing, the bearing has to be removed from its seating. When the bearing is still in a good condition or is to be submitted for expert examination, the removal shall be executed as carefully as the original fitting was.

13.3.2 Indentation shall be avoided, grease shall not be wiped off, swarf shall not be picked up, and the bearing shall be wrapped in grease proof paper and properly placed in a box, if it has to be sent away. Samples of grease shall not be carried in cardboard boxes, as they absorb oil from the grease, thus making an analysis valueless.

13.3.3 Before dismantling bearings and associated parts, the fitter shall study arrangement drawings of the machine in order to discover the best procedure unless clear instructions have already been issued. All dismantled parts should be so arranged or marked that there shall be no doubt as to how the parts have to be reassembled.

13.3.4 Removal without damage to the bearings may be affected in various ways, depending on the bearing fit and the position and dimensions of adjacent parts. The appliances and methods described are for use with tight fits.

13.4 Bearing Repairs

13.4.1 It is often more economical to go in for a brand-new bearing than go to the expense of repairing an old one, partly because of the initial uncertainty concerning what will be necessary, the process of disassembling the parts, examining, regrinding where required. Fitting new roll elements and cages, does not lend itself to routine methods, and may well cost more than all the processes necessary to produce a new bearing.

13.4.2 Fatigue effects are not confined to surface material, but penetrate to some depth, so that merely grinding away surface blemishes cannot give a worn bearing an entirely new lease of life. Large and expensive bearings, however, are often worth the trouble of repairing, particularly when the damage is superficial, or when any wear that has taken place is due to abrasive action only. A fractured ring can often be replaced if other parts are undamaged.

13.4.3 Rolling elements are graded in groups with exceedingly fine tolerances, and only elements from the same group should be used in any one bearing. Putting in a ball or roller which is smaller or greater in diameter than the others will seriously jeopardise the remainder of the bearing's life.

13.4.4 Where the bore of a bearing is badly worn owing to creep or abrasive action, regrinding is possible but renders the bearing non-standard and may thus cause difficulty, in case replacement should become necessary later. At the same time the shaft seating may also have suffered and may require re-turning or regrinding. To restore the original fit, it is necessary to enlarge the shaft seating or reduce the bearing bore or both, by chromium or nickel plating the surfaces, metal spraying or fitting a sleeve and grinding to size. To take a sleeve of enough sectional depth, the shaft needs further reduction. This shall not be permitted, where the shaft is already weak.

13.4.5 Innumerable bearings are discarded because of apparently excessive diametric slackness, although many of them are capable of further efficient service. It is difficult to judge slackness by moving bearing rings by hand radially, axially, or angularly in relation to each other. Special measuring devices are essential for obtaining reliable values.

13.4.6 A common way of checking slackness in single-row rigid ball bearings is to rock the outer ring sideways in relation to the inner ring. This method gives an approximate notion of the actual slackness, if the movement obtained is compared with that of two other bearings of the same type and size, one having the maximum permissible slackness and the other the minimum. Excessive wear may be detected in this manner.

13.4.7 The checking of radial slackness in roller bearings by feeler gauges has already been described in **6.1.10.**