

APPLICATION GUIDELINE #26

(Avoiding Pre-Service Damage of Cylindrical Roller Bearings 'CRB')

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The following is derived from a paper written by Dan L. Leah, P. Eng (Engineering Manager, Western Region for NTN Bearing Corporation of Canada Ltd) and titled "Avoiding Electric Motor Drive End Bearing Problems".

Replacing a failed bearing is a costly exercise considering downtime, parts, labor and paperwork. It is especially aggravating if analysis later shows the failure could have been prevented. CRBs are widely used in the drive end of electric motors and the majority of these bearings returned for failure analysis, have come from this application. Occasionally, when a rebuilt motor is bench tested it is immediately rejected because of vibration and/or noise. The drive end CRB is frequently the culprit. A high percentage of bearings returned for analysis from this position ran for less than a minute and they generally exhibit one or two types of avoidable damage. Mechanical damage can happen during handling, shipping, storage, preparation for mounting, mounting and final assembly. It is safe to believe that bearings leave the factory in excellent condition.

Shipping and Handling: Given safe and careful carriers, avoiding shipping damage depends on the factory packaging. Heavy CRBs (bearings over 80 to 120 millimeters in bore size, depending on the series) should be shipped as separate components. If the bearing is shipped assembled any reasonable jolt or impact can cause brinelling or scuffing. Smaller bearings are shipped assembled because their mass is small and the probability of such damage is negligible. Dropping or otherwise mishandling any bearing will damage it. CRBs are particularly susceptible to rough handling and impact.

Storage: Bearings must be kept wrapped and should always be stored flat. Stores should be clean, dry and free from vibration and wide temperature fluctuations. Cleanliness cannot be over emphasized. Efforts to keep the store of bearings clean and well organized will pay off. Bearings that are shipped as separate components should not be assembled for storage. Unfortunately, this is a common practice because it saves shelf space. However, doing this presents an opportunity for contamination and scuffing of the bearing.

Preparation: The following will be standard procedure for the experienced installer:

- Leave the bearing wrapped until the last minute to reduce the chance of contaminating it.
- Review the assembly procedure.
- Work with clean hands, tools, rags, solvents and gloves.
- Clean the mating parts carefully. Do not wash out the bearing.
- Check the shaft and housing for size, roundness and taper. When checking size, ensure the part being measure and the micrometer are at the same temperature.
- If in doubt, check the shaft and housing shoulder fillet radii.
- Carefully unwrap the bearing and separate the components. (small CRBs) When separating the components, the separable ring must be rotated. Drawing the race straight off the rollers causes sliding between the race and rollers which can produce scuffs. Damage potential is high if the rings are even slightly cocked. Rotating the ring while removing it sets up a rolling contact which will prevent scuffing.

Inspection: The bearing should always be inspected before installation. A close look at the separable raceway is mandatory. It is a quick way to reliably assess the bearing's condition. The installer should look for the following types of damage:

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- **Brinelling:** A brinell is a dent caused by impact. In CRBs, axial dents will be visible on the raceway at roller spacing. When an impact occurs, the rollers are driven into the raceway, raising metal above the raceway and around the dent. Do not use.
- **Bruising – Light:** When smaller bearings are shipped assembled, the normal jostling of the shipment may cause soft impacts and light working of the roller/race contact. Under magnification, the light, roller spaced marks on the race are seen as superficial. There is no change in the light reflecting properties of the area as compared with the original grind finish. Light bruising is not cause for rejection.
- **Bruising – Heavy:** A more serious version of the above but not as bad as brinelling. Under good light, the bruised area appears shinier than the surrounding surface. The original grind finish is still visible. Do not use.
- **Contamination:** Bearings are sometimes withdrawn from stores and returned unused. If the packaging has been opened, the bearing should be inspected for contamination. If there is dirt present, the bearing should be thoroughly flushed with clean solvent, dried, re-oiled, and wrapped.
- **False Brinelling:** This is sometimes called "stationary vibration damage" and is a wear process. Because of its similar appearance to (true) brinelling, the two are often confused. Close examination will show there is no upset metal around the depressions in the raceway and the bottoms of the depressions are smooth. This damage occurs if a bearing is stored standing up in an area where there is vibration. Under load and vibration the lubricant is forced from between the rolling elements and race allowing metal to metal contact. The opposing asperities (microscopic peaks and valleys in the surface finish) touch and weld. Further vibration breaks the welds and material is physically removed. As time progresses, the rocking of the roller causes progressive wear of the loaded and unlubricated contact. The appearance of false brinelling differs from true brinelling in that the depressions in the raceway are smooth and there is no upset metal around them. This problem is commonly found in bearings that are assembled in standby 'spare' motors. Do not use.
- **Scuffing:** This damage results from sliding contact between a roller and a race and can happen with grease, oil, and factory rust inhibitor present. These axial scars are visible, and can be felt. The sliding friction has created enough localized heat to re-harden the affected areas. Scuffing can occur in shipping, handling and, most frequently during final assembly of the end bell.
- **Water Etching:** is characterized by roller spaced corrosion lines on the raceway(s) and also on the rollers. Moisture in the bearing cavity condenses around the roller/race contact and etches both components. Do not use.

In a dire emergency, the bearing might be made serviceable if all marks can be completely removed with 200 grit emery cloth. Even then there will probably be some noise and vibration. This technique may be used for bruises, water marks or light scuffs.

Installation: Normal fitting practice is to tight fit the inner ring and loose fit the outer ring. Rings under about 50 mm bore can be cold pressed onto the shaft. Larger rings need to be heated to facilitate assembly. Allowing for cooling during assembly and the heaviest fit condition, the temperature differential between the shaft and inner ring need not exceed 150°F. (~85°C.) The ring must be thoroughly heated but not overheated. An oil bath or oven where the temperature can be controlled is ideal. Bearing heaters are often used because they are easy and fast. The danger with the bearing heater is overheating which quickly can damage the bearing steel. The inner ring must be held against the shaft shoulder while cooling or it will back away as it contracts. Protect the race from contamination if the rotor is to be left sitting unassembled for any length of time.

Assembly: Most CRBs remain undamaged up to the point of assembly. Final assembly is a heavy, awkward and delicate job. Alignment of the end bell with the rotor is both difficult and critical. Poor alignment resulting in scuffing is frequently the cause of the bearing problem. As the two bearing parts are assembled, one component must be rotated. There is a generous chamfer on both sides of the separable race to make this operation easier. Do not force or apply any type of blow since this

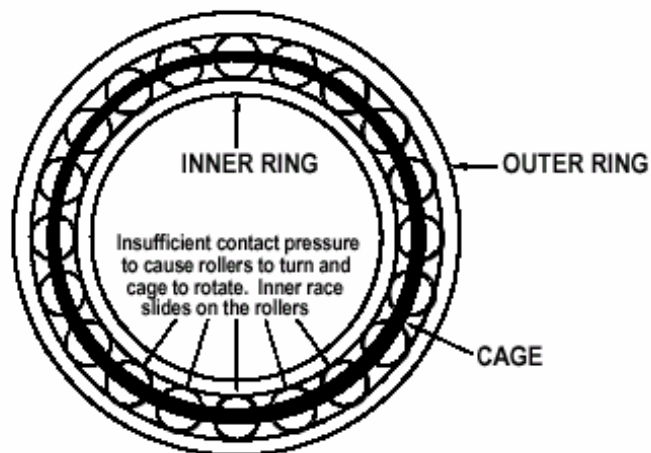
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will cause damage. Once the bearing is together there is no way of knowing how much damage, if any has been done. Assembly damage is characterized by roller spaced, triangular scuffs at the extreme edge of the raceway. The lead in chamfer will also show marks. When the rollers impact the chamfer, metal is upset and some may be peeled off and dragged onto the raceway. If the scuff runs into the roller track, noise and vibration will certainly result. Any metal debris will among other things, cause squealing.

Lubrication: Electric motor bearing must go from a standstill to several thousand rpm almost instantaneously. Some wear is unavoidable since a hydrodynamic lubricant film between the rollers and races has to be developed. Excessive startup wear can be avoided if the bearing has been properly greased and the rotor turned, so as to coat the rolling surfaces. Many greases are available, offering a wide range of viscosity's and numerous additive options. The appropriate grease is usually chosen from experience. However, if continual problems are experienced, the lubricant supplier should be consulted.

Bench Testing: Standard practice is to bench test the motor prior to shipment. This usually involves running the motor up to speed for a given period of time and checking for electrical characteristics, temperature, vibration, audible noise and coast down characteristics.

Skid: Skid is a problem encountered primarily in CRB's in electric motor applications. It is caused by insufficient load on the bearing during the bench test. As the test is typically conducted under no load, the only load experience by the CRB is roughly half the weight of the rotor. This modest load is rarely sufficient to force the rollers to roll, so sliding occurs between the inner race and rollers.



The condition is known as skidding and occurs in the roller bearing because of the low roller to race contact pressure. The sliding action or skidding prevents the development of an adequate lubricant film between the bearing components. Metal to metal contact takes place and the race and rollers are scored. Skidding damage can go undetected or it can cause a high pitched squeal which alerts the technician to the fact that something is wrong. Sometimes grease is added which temporarily reduces the noise but the bearing has been damaged and should be replaced. There are a number of factors, which dictate whether sliding or rolling will occur under

low-load conditions. These include cage design and material, the amount and type of grease in the bearing and the ambient temperature. Some might say "I never experienced this problem with XYZ brand bearings . . ." Perhaps not, but it can happen with any brand of cylindrical roller bearing. NO design is immune. Bear in mind that skidding can occur without being detected. To avoid this problem, it is suggested that the rotor be loaded. This can be done by adding weight to the rotor shaft by installing a sheave or heavy coupling half. The minimum recommended load to avoid skidding is 4% of the static load rating of the bearing (Cor), which can be found in the manufacturer's catalog. As a further aid to prevent skidding, we suggest that the roller bearing be washed in CLEAN SOLVENT, dried off with a lint free towel and oiled on all internal surfaces with thin oil (SAE 5 - 10) prior to installation. The grease can then be applied as normal. The oil film will keep the drag of the cage pockets to a minimum allowing the roller train to turn freely when the motor is started.

The premature failure of Cylindrical Roller Bearings is an expensive problem that is surprisingly widespread. With care taken at inspection, mounting, assembly and testing, these problems can be avoided.

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