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Technical Article

Necessary Knowledge for Setting Two-Row Tapered Roller Bearings

in Wind Turbine Gearbox Applications

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Necessary Knowledge for Setting Two-Row Tapered Roller Bearings in Wind Turbine Gearbox Applications

Abstract

A growing number of wind gearbox models are now utilizing tapered roller bearings throughout the parallel shaft section to effectively manage radial and axial loading produced by helical gear geometry as well as torque reversals during operation.

This document provides an overview of three approaches to achieve the proper axial setting for a two-row tapered roller bearing assembly using a controlled spacer width. It also covers advantages and selection criteria for each type, including green spacer assembly, matched spacer assembly, and bore-compensated spacer assembly.

I. Application Configuration

The evolution of wind turbine gearbox designs has resulted in an increased number of tapered roller bearings being used throughout the parallel shaft section. This design change manages both the radial and axial loads produced by the helical gearing during operation.

These arrangements typically include a cylindrical roller bearing on one end of the shaft to serve as the float position to allow for thermal expansion, while a two-row tapered roller bearing is mounted on the opposite end of the shaft to serve as the fixed position and handle any resulting axial loads in either direction.

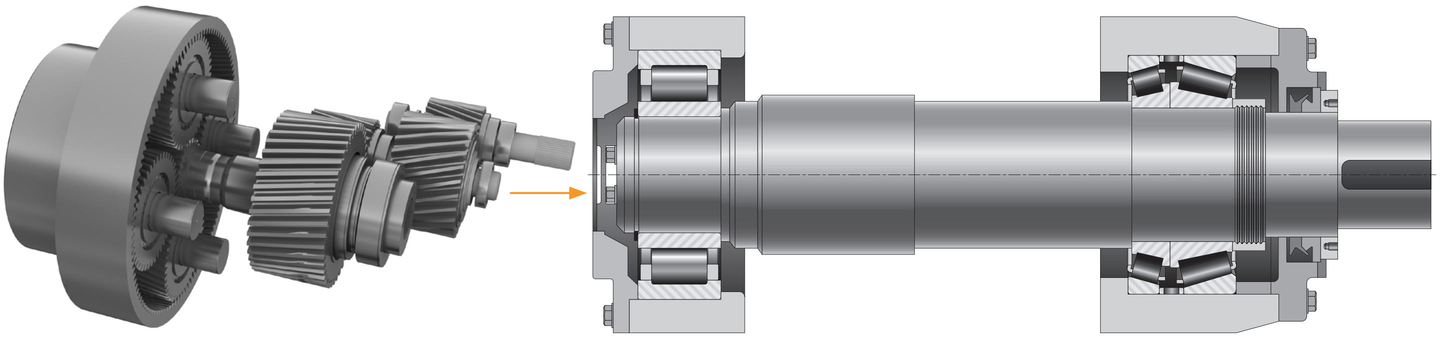

Figure 1: Sample Modern Wind Gearbox and Associated Parallel Shaft Configuration.

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II. Bearing Configuration

Although there are several ways to configure the two-row tapered roller bearings utilizing various spacers, the most common configuration used in wind gearbox applications is what Timken describes as the direct-mount configuration. This configuration is also referred to as a face-to-face, DF, or X arrangement depending on the region of the world or bearing supplier. As shown in the figure below, different bearing geometry can be used in each row to accommodate the operating conditions.

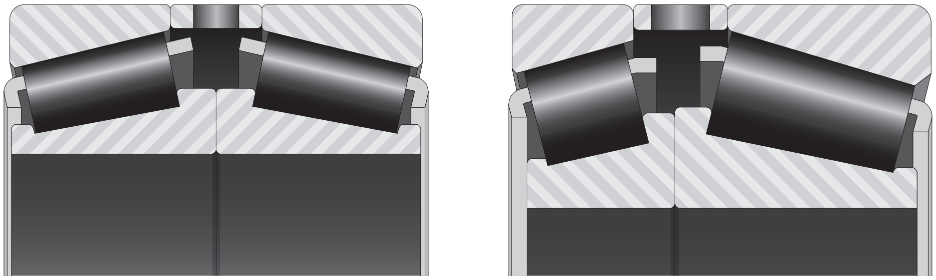


Figure 2: Common 2-Row TRB Configurations Used in Wind Gearbox Parallel Shaft Applications.

Regardless of the terminology used to describe the assembly or the internal geometry used from row to row, an outer ring spacer will typically be used to control the final location of each separable component in relation to one another. This spacer ultimately controls the final bearing setting which is unlike other bearing assembly types used in these applications.

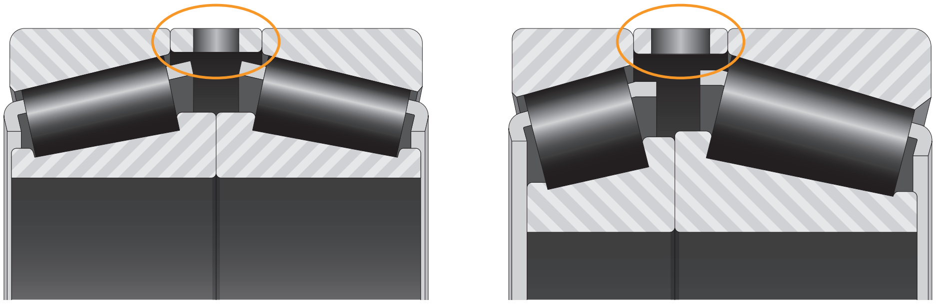


Figure 3: Common 2-Row TRB Configurations w/ Subject Spacer Highlighted.

This difference can lead to inconsistent or uncontrolled bearing settings without proper education and awareness, as many conventional arrangements using cylindrical, spherical, and ball bearing assemblies do not require manual setting control.

Improper bearing performance and premature damage can occur when the spacer final width is determined incorrectly due to inaccurate measurements, incorrect calculations, or inadequate machining capabilities.

III. Bearing Setting Methods

For service technicians and rebuilders, the trend toward two-row tapered roller bearings requires precise control to determine the assembly's final mounted setting. Unlike conventional bearing types, two-row tapered roller bearing designs are composed of separable components with an unlimited range of axial locations that can vary in relation to each other depending on the method used.

These separable components require an external means of controlling the final relative axial location and resulting mounted setting, which is commonly done by introducing a spacer component into the assembly. This spacer is machined to a controlled width by the installer, or by the bearing supplier during assembly production. Therefore, maintenance professionals often have questions about how to determine the correct spacer width and achieve the best mounted setting results. Without proper mounted setting control, the resulting stresses inside the bearing can become excessive or may result in unloaded conditions inside the bearing, leading to roller and cage damage.

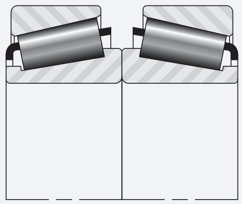
This document provides an overview of three approaches to set the final axial position for a two-row tapered roller bearing assembly using a controlled spacer width. It also covers advantages and selection criteria for each type, including: a green spacer assembly, a matched spacer assembly, and a bore-compensated spacer assembly.

Green Spacer Assemblies

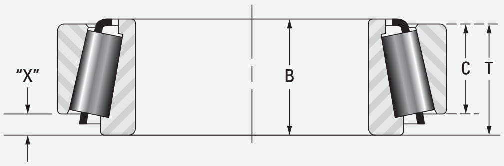
A green (or unground) spacer assembly is supplied with an intentionally wider (unfinished) spacer, allowing users to customize settings based on specific application requirements. Note that in some instances, bearings may be supplied without a spacer (typically when the user intends to produce or purchase one separately), in which case the bearing components and spacer are treated similarly. Two common methods of obtaining the target mounted setting for a green spacer assembly are the measurement-and-calculation method and the manual push-pull method.

Measurement-and-Calculation Method

The measurement-and-calculation method requires the user to know the actual measurements of the shaft OD, housing ID, bearing bore, and bearing outside diameter to determine the fitting practice for the mating component. These measurements may be obtained manually or from the bearing, shaft, and housing supplier. Second, the user must have the correct lateral loss factor(s) for the bearing assembly part number. This supports an accurate lateral (i.e. setting) loss calculation from any resulting interference fits. This is crucial as the losses due to tight fits are specific for the individual bearing contact angle, bearing component section, and associated shaft and housing materials and section thickness. In the final step, the spacer gap between the bearing components at zero unmounted setting must be calculated using assembly component physical measurements (also known as drop measurements) or from the bearing supplier. With the required bearing, shaft, and housing dimensions along with the correct lateral loss factors, the user can determine the final spacer width to reach the target nominal mounted setting.



2 SINGLE ROW BEARINGS MOUNTED BACK-TO-BACK



1. Place inner ring on surface plate with the large end of the bearing down, as shown in the illustration above.
2. Place the outer ring on the inner ring / roller assembly and oscillate to seat the rollers.
3. Measure the height (T) of each bearing in 4 places and average the readings.
4. Measure the width of the outer ring (C) and subtract from the height measurement to obtain the "X" dimension for each bearing.
5. Add the "X" dimensions for each bearing together to obtain the spacer length for zero unmounted setting.
6. Add the target unmounted setting dimension to the value from step 5 to get the required spacer length.

Gearbox Model:	Gearbox ABC
Bearing Part Number	Timken Assembly PN
Bearing Serial Number	
Shaft Serial Number	
Housing Serial Number	
	mm
Inner Ring Bore (A)	
Inner Ring Bore (C)	
Average	#DIV/0!
Outer Ring OD (A)	
Outer Ring OD (C)	
Average	#DIV/0!
Average Shaft Bearing Seat	
Shaft - Inner Ring Interference	#DIV/0!
Inner Ring Fit Lateral Loss	#DIV/0!
Average Housing Bearing Seat	
	#DIV/0!
Outer Ring Fit Lateral Loss	#DIV/0!
Target Mounted Setting	
Unmounted Setting	#DIV/0!
B Gap (Between Outer Rings @ Zero Unmounted Setting)	
Required Spacer Width	**#DIV/0!**

Figure 4: Sample Drop Measurement Process for 2TS-DM Assembly Spacer Distance (left) and Associated Sample Calculation Sheet for Collecting Assembly Dimensions and Determining Final Spacer Width (right).

Figure 5: Example of Push / Pull Method on Industrial Gearbox Application.

Push-Pull Method

Another way to determine the final spacer width utilizing a green spacer assembly is the manual push-pull method. This method requires the user to assemble the bearing components and the unground spacer with the mating shaft and housing to determine a baseline mounted setting value using dial indicators or similar measurement equipment. This baseline setting can then be compared to the target nominal mounted setting and determine the spacer width to be removed to achieve the target setting.

For the push-pull method the rollers must be seated completely and uniformly against the inner ring large rib face. It requires that no external components or loads interfere with the ability to obtain an accurate measurement of the axial shaft movement in both the push and pull steps of the process, sometimes requiring these adjacent components to be removed during the process. To ensure the rollers are seated fully seated and an accurate axial setting is obtained, an axial load must be applied to the shaft in one direction while the shaft is oscillated a minimum of 20 times before applying an axial load to the shaft in the opposite direction while oscillating the shaft again.

The total axial movement of the shaft is the bearing assembly mounted setting. The initial spacer width can then be increased or decreased to obtain the target mounted setting.

Assuming proper procedures, a green spacer makes it possible to achieve a tightly controlled final mounted setting. This is because the actual dimensions from the mating bearing components, the shaft, and the housing are included which removes most of the tolerances from the equation and this results in a tightly controlled mounted setting range.

However, inaccurate measurements, incorrect calculations, imprecise spacer grinding, mismatched mating components, or the inability to obtain an accurate push-pull measurement due to component size or adjacent component interference impacts the ability to achieve a high level of precision and consistency. This leads to an unpredictable possible mounted setting range that can lead to various performance related issues.

Matched Spacer Assemblies

A matched spacer assembly, also called a finish ground spacer assembly, is supplied with a fixed width spacer. This spacer is finished ground by the bearing supplier to a specific width based on an assumed set of component fitting practice values and a target nominal mounted setting value for the application.

For a matched spacer, the bearing supplier completes the bearing physical measurements to understand the spacer gap between components at zero unmounted setting and to determine the final spacer width needed to reach the target nominal mounted setting. The bearing supplier would use the assumed fitting practice range and the calculated lateral loss to determine the unmounted setting for the matched bearing assembly.

A matched spacer is considered the least accurate approach to obtaining a target nominal mounted setting, because the shaft, housing, bearing bore and bearing O.D. tolerances all have a direct effect on the total possible mounted setting. These are not accounted for on an individual combination of mating components, resulting in a relatively large possible mounted setting range.

The benefit of this type of assembly is that all bearing measurements and calculations and grinding of the final spacer width are completed by the bearing supplier.

Bore-Compensated Spacer Assemblies

A bore compensated assembly, also can be referred to as a variable unmounted setting assembly, is supplied with a fixed width spacer that has been pre-ground to a specific width based on an assumed set of component fitting practice values and a target nominal mounted setting for the application.

To begin, the bearing supplier completes drop measurements to determine the spacer gap between the components at zero unmounted setting and final spacer width to reach the target nominal mounted setting. The difference between this assembly type and a matched spacer, is the potential interference fit range between the shaft and inner ring bore is broken down into multiple groups. (If there is an interference fit between the housing bore and outer ring, that is also considered.). Because of this adjustment for fitting practices, a different unmounted setting value is selected based on the component bore dimension rather than using a single unmounted setting for the entire interference fit range. The result is a more tightly controlled selection of the final spacer width and a reduced mounted setting range.

Typically, the target mounted setting and shaft tolerance are obtained from the user or from an application engineering review. Engineering then performs calculations that cover the known inner ring fitting practice range and develops a table of unmounted setting values based on the bearing bore size. This table allows selection of a single unmounted setting based on the actual bearing bore measurement and associated shaft tolerance combination. The bearing supplier then completes the measurement process to determine the dimension of the spacer gap at zero unmounted setting and the final spacer width necessary to achieve the target nominal mounted setting.

Bore-compensated assemblies are considered more accurate than matched assemblies, because the bore tolerance variable and associated lateral loss are already accounted for in the spacer width calculation. However, this method cannot achieve the extreme accuracy of a properly controlled and processed green spacer assembly.

Note that this assembly type typically assumes a loose fit, or a very light interference fit between the bearing outer ring and housing. In other cases, special compensation matrices may be necessary to accommodate interference fits at both the bore and O.D. of the bearing assembly.

IV. Bearing Setting Method Comparison

Having covered three common approaches for obtaining a final axial setting for tapered roller bearing assemblies using an outer ring spacer, the following sections serve as a general comparison to highlight each option's advantage or disadvantage relative to the others.

Below is an example of the resulting mounted setting for each of the assembly type considering a single sample for a given set of assembly geometry. As a reminder, the bearing part number and its associated internal geometry along with the designed fitting practices have a direct effect on the results. Therefore, this example would not apply to different assemblies.

Sample Comparison Assumptions: Target Nominal Mounted Setting of 0.170 mm & ISO p6 Shaft Tolerance.

Green Spacer (Unground Spacer) Assemblies

- Approximate Mounted Setting Range: 0.170 mm ± Process, Measurement, and Calculation Variables (target tolerance of ± 0.025 mm or better).

Matched Spacer (Finish Ground Spacer) Assemblies

- Approximate Mounted Setting Range: 0.170 mm ± 0.110 mm.

Bore Compensated (Variable Unmounted Setting) Assemblies

- Approximate Mounted Setting Range: 0.170 mm ± 0.075 mm.

As the results show, each assembly type has a different total possible mounted setting range due to the inclusion or exclusion of dimensional tolerances in the final spacer width determination.

The results show the difference in the matched spacer and bore compensated spacer assembly results and the reduction in mounted setting range with the bore compensation method. However, with the green spacer, the overall range is dependent on the precision of the measurements, the accuracy of the calculations, the ability to perform accurate bearing setting validations, and the availability of a capable machine shop to finish grind the spacer width. If done correctly, the green spacer assembly can achieve a mounted range of as little as ± 0.025 mm from nominal. In contrast, if done incorrectly, the range can expand beyond the other two methods.

The following table explains the relative advantages of the assembly types. Each scenario will dictate which version is ideal for the situation and the selection might be different for each bearing build.

The final selection is frequently determined by the necessary or accepted level of mounted setting precision versus the installers experience, measurement capabilities and how much time they are willing to spend during preparation and installation.

In some cases, application conditions can tolerate a large range, therefore it may make sense to allow this range in exchange for a time savings during installation. A tightly controlled mounted setting range is critical in other scenarios, and the extra time for precise measurement and control is worthwhile.

These potential cases drive the final selection criteria.

	Preparation and Installation Efficiency	Preparation and Installation Risk	Possible Mounted Setting Range	Ease of Field Preparation
Green Spacer (Measurement & Calculation Method)	★★	★★	★★★★	★
Green Spacer (Push-Pull Method)	★	★	★★★	★
Matched Spacer	★★★	★★★	★	★★★★
Bore Compensated Spacer	★★★	★★★	★★	★★★★

Table 1: Comparison of Common 2-Row TRB Assembly Setting Methods. *On a four-point scale, one star is acceptable. Four stars is optimal.

V. Conclusion

In summary, three common approaches for obtaining a final axial setting for tapered roller bearing assemblies using spacers was explained. This information is provided to increase knowledge and awareness around various assembly setting practices commonly used throughout the industry.

Each configuration has advantages and disadvantages, therefore individual scenarios should be discussed with the bearing supplier to help determine the optimal approach for each case.

It is recommended to consult a qualified expert to review the described measurement, calculation and assembly procedures when installing bearings that rely on a finished spacer width to control the mounted setting. Your trusted adviser can provide the support and clarity needed to ensure a successful outcome that avoids major corrective work. As the use of two-row tapered roller bearing assemblies in wind turbine gearboxes becomes more prevalent, it is only a matter of time until such questions arise. Be sure to ask your bearing supplier about training and education that can put your team ahead of the curve.

VI. Cautions/Reminders

Bearings that use a spacer to control the final mounted setting may be unfamiliar to some, therefore it is suggested that the following guidance is kept in mind when maintaining or upgrading gearboxes:

- Do not use an old spacer in a new bearing assembly.
- Do not swap spacers between old and new assemblies.
- Do not install an assembly without a spacer unless another axial setting mechanism is present (e.g., spring-loaded system or component endcap).
- Never install a green spacer that has not been ground to proper width.
- Never assume a supplied spacer is the correct finished width upon receipt.
- Always take time to measure and / or verify.
- Consult with your bearing supplier with any questions or concerns related to bearing setting procedures.

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