World-Class Long Life

FA Tapered Roller Bearing

FA Treatment
Fine Austenite Strengthening

Drastically improved fatigue strength
Special heat treatment (FA treatment) with crystal grains of bearing steels reduced by half to those of conventional grain size

Pattern Diagram of Prior Austenite Grain Boundaries

FA treated Standard

Patent Pending

CAT. No. 3802/E
The "FA Tapered Roller Bearing" series is the successor to conventional small tapered roller bearings. It is an amalgam of the world’s first specialized heat treatment (i.e. FA treatment) and the technology developed through experience with optimizing internal bearing design.

**FA treatment (Fine Austenite Strengthening)**

- Extended life obtained through the specialized grain refinement processing of bearing steel
- FA-treated bearing steel exhibiting an average grain size approx. half that of conventional material grain size.

Prior-austenite grain microstructures
FA-Treated Bearing Performance (Compared to 4 Top NTN Tapered Roller Bearings)

1) Average bearing life was 3 times longer (under clean lubricant conditions).
2) Average bearing life was 14 times longer (under contaminated lubricant conditions).
3) Torque reduction greater than 10% within the practical speed range.
4) 25% improvement in seizure resistance with normal rotating speed and double the contact stress.
5) 50% reduction in loss of preload.
6) 50% reduction in the number of revolutions to achieve bearing stand height stabilization.
7) Improved indentation resistance (approximately 1.5 times).

What is an FA-Treated Tapered Roller Bearing?

NTN has most recently focused its attention on the processing technology that can improve the fatigue strength of bearing steel through grain refinement. Specifically, it has developed a specialized heat treatment process (i.e. FA treatment) that refines the prior austenite grain size of bearing steel by more than half that of conventionally used material. The "FA Tapered Roller Bearing" is a direct result of this technological development; offering improved indentation resistance and providing greatly extended bearing life even under contaminated lubrication conditions. Furthermore, by combining this "FA treatment" with the design work that was originally developed for ECO-Top tapered roller bearings (to optimize the internal design) the seizure resistance on the rib flange has been improved. The combination of these improvements results in a significant reduction of the required bearing size.

Note) FA treatment: Abbreviation of "Fine Austenite Strengthening" treatment

(1) Extended Life
- Enhanced rolling contact fatigue life through grain refinement.
- Optimized amounts of retained austenite via carbonitriding and improved resistance to surface-originating damage (due to contaminants) through grain refinement.
- Specialized crowning designed to provide optimal contact stress distribution under varying load conditions.

It is known that the bearing life ratio varies with the condition of the lubricant. However, even under contaminated conditions the FA-treated bearings lasted 14 times longer than the 4 Top tapered roller bearings and approximately 3 times longer when using clean lubricant.

(2) Optimal Design for Oil Film Formation
It is generally known, that 1) The rib of a tapered roller bearing slides when it comes in contact with the rolling elements and that 2) The ability of the rib to maintain an oil film of sufficient thickness greatly affects the performance and life of the bearing.

FA tapered roller bearings, exhibit a reduction in rotational torque, seizure resistance, and loss of preload by employing design technology that was originally developed for ECO-Top tapered roller bearings (to optimize the shape, roughness, and precision of the contact between the rib and roller components).

(3) Reduction in Bearing Stand Height Stabilization
When assembling tapered roller bearings under preload, it is necessary to rotate them sufficiently until the roller ends stabilize or properly seat against the surface of the rib flange. Thus, the fewer number of revolutions required before stabilization, the faster the preload can be adjusted, speeding up the assembly process.

Given the optimized internal design of the FA tapered roller bearings, the preload setting can be adjusted precisely within a shorter period of time. In fact, to reduce time, these units can be assembled and stabilized right out of the packaging (with the existing rust preventative oil) without the need for any additional gear oil.

(4) Improved Indentation Resistance
Commonly, when reducing bearing size, indentation resistance needs to be improved to prevent a reduction in the safety ratio (due to a drop in the load rating). With FA tapered roller bearings, the indentation depth is less than one ten thousandth of the roller diameter and does not hinder smooth rotation of the bearing (even if the unit is exposed to a static load safety ratio ($S_0$) = 0.6).
# Test Data

## (1) Life

### Table 1: Results of life test with clean oil

(Comparison test results using line contact type specimen)

<table>
<thead>
<tr>
<th></th>
<th>$L_{10}$ life, $\times (10^4$ cycle)</th>
<th>$L_{10}$ life ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>4Top</td>
<td>1,523</td>
<td>1.0</td>
</tr>
<tr>
<td>ECO-Top (ETA)</td>
<td>3,140</td>
<td>2.1</td>
</tr>
<tr>
<td>FA</td>
<td>4,290</td>
<td>2.8</td>
</tr>
</tbody>
</table>

*The $L_{10}$ life ratio is given with the life of 4Top as 1.0.*

### Table 2: Results of life test with contaminated oil

(Comparison test results using bearings)

<table>
<thead>
<tr>
<th>Test condition</th>
<th>4Top</th>
<th>ECO-Top (ETA)</th>
<th>FA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condition 1</td>
<td>$L_{10}$ life (h)</td>
<td>52.4</td>
<td>314.9</td>
</tr>
<tr>
<td></td>
<td>$L_{10}$ life ratio</td>
<td>1.0</td>
<td>6.0</td>
</tr>
<tr>
<td>Condition 2</td>
<td>$L_{10}$ life (h)</td>
<td>22.5</td>
<td>309.7</td>
</tr>
<tr>
<td></td>
<td>$L_{10}$ life ratio</td>
<td>1.0</td>
<td>13.8</td>
</tr>
</tbody>
</table>

*The $L_{10}$ life ratio is given with the life of 4Top as 1.0.*

### Line contact type life test conditions

- **Test rig**: NTN line contact type life test rig
- **Specimen**: $\phi 12 \times L12$, R480
- **Counter specimen**: $\phi 20$ roller [SUJ2 (SAE52100 EQUIVALENT)]
- **Load (kN)**: 13.74
- **Contact stress (MPa)**: $4155 (P_{\text{max}})$
- **Lubricating oil**: Turbine oil 68

### Bearing life test conditions

- **Test rig**: Bearing life test rig type VI
- **Test bearing**: 1 30206, 2 30306D
- **Test load**: 1 $F_r=17.64 \text{kN}, F_a=1.47 \text{kN}$, 2 $F_r=19.6 \text{kN}, F_a=13.72 \text{kN}$
- **Rotating speed**: 2000min$^{-1}$
- **Lubricating oil**: 1 Turbine oil 56, oil bath (30ml), 2 ATF oil bath (50ml)
- **Contaminants**: 1 50 μm or smaller: 90wt %, 100 to 180 μm: 10wt %, 2 50 μm or smaller: 75wt %, 100 to 180 μm: 25wt %
- **Calculated life**: 1 169h (no contaminants), 2 171h (no contaminants)

## (2) Rotational torque

### [Test Conditions]

<table>
<thead>
<tr>
<th>Bearing:</th>
<th>30206</th>
</tr>
</thead>
<tbody>
<tr>
<td>Axial load (kN)</td>
<td>4</td>
</tr>
<tr>
<td>Lubricating oil</td>
<td>Gear oil 70W90 (GL-4)</td>
</tr>
</tbody>
</table>

- **Fig. 1**: Condition 1 Results of life test for 30206 (With contaminated lubricant)
- **Fig. 2**: Condition 2 Results of life test for 30306D (With contaminated lubricant)
- **Fig. 3**: Rotational torque measurement results
(3) Seizure resistance

![Seizure resistance test results](image)

**Test Conditions**
- **Bearing**: 30206
- **Load**: \( P / C_r = 0.45 \)
- **Oil volume**: 40ml/min
- **Oil temperature**: 40±3°C

**Graph**: A graph illustrating the relationship between rotating speed (min⁻¹) and outer ring temperature (˚C) showing a plot of seizure and non-seizure points.

**Fig. 4 Seizure resistance test results**

(5) Early stabilization of bearing stand height

**Test Method**: With the bearing positioned as shown in Fig. 7, an axial load (weight A) is applied to rotate the inner ring, and the bearing stand height is measured for each revolution. The number of revolutions required for the bearing to stabilize is determined.

**Bearing**: 30206
- **Axial load**: 29.4N

![Stand height stabilization test method](image)

**Fig. 7 Stand height stabilization test method**

(4) Preload loss vs time

**Test Conditions**
- **Bearing**: 30206
- **Preload**: 4900N
- **Oil volume**: 60ml/min
- **Rotating speed**: 3000min⁻¹

**Graph**: A graph illustrating the relationship between preload (N) and operation (h) showing a plot of 4Top and FA tapered roller bearing.

**Fig. 6 Preload loss vs time test results**

(6) Indentation resistance

**Test Conditions**
- **Bearing**: 30306D
- **Load**: \( F_a = 215kN \)

**Graph**: A graph illustrating the relationship between indentation depth (㎛) and rolling contact stress (MPa) showing a plot of 4Top and FA tapered roller bearing.

**Fig. 9 Indentation depth measurement results**

**Example of downsizing**

- **Weight**
  - 0.398kg \( \Rightarrow \) 0.179kg (55%)
  - 20.75mm

**Applicable Bearing Size**

FA tapered roller bearings with outer diameter 145 or smaller are available. For details, please contact NTN.

**Fig. 8 Results of measuring number of revolutions until the bearing stabilizes**

**Fig. 5 Contact stress resistance test results**

**Fig. 7 Stand height stabilization test method**

**Fig. 9 Indentation depth measurement results**

4 Size Reduction by Employing FA Tapered Roller Bearings

As a result of improvement in bearing life, seizure resistance and indentation resistance, employment of FA tapered roller bearings will reduce the bearing size.

5 Applicable Bearing Size

FA tapered roller bearings with outer diameter 145 or smaller are available. For details, please contact NTN.