Shipped from Japan in as little as 10 days Semi-custom

LT-X / LF-X

Interchangeable Miniature Ball Spline
Interchangeable compact ball splines that enable compact, high-speed equipment designs are now available as semi-custom orders. Products are shipped from Japan in as little as 10 days after ordering.

**Model LT-X [Cylindrical Type]**
The most compact type with a straight cylindrical nut. When transmitting torque, a key is driven into the body.

**Model LF-X [Flanged Type]**
The spline nut can be bolted to the housing using the flange, making assembly simple. It is suitable for locations where the housing may be deformed if a keyway is machined on its surface, or in locations where the housing width is narrow.

**Spline Shaft**
Interchangeable spline shaft that can be freely combined with LT-X/LF-X.

Select from three shapes recommended by us.

You can select the type of grease according to the application.

*For details about THK Original Grease products, see p. 6.*

<table>
<thead>
<tr>
<th>Model No.</th>
<th>Maximum shaft manufacturing length (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LT10X/LT13X</td>
<td>Normal grade: 1000, High accuracy grade: 500</td>
</tr>
<tr>
<td>LT16X/LT20X</td>
<td>Normal grade: 1500, High accuracy grade: 750</td>
</tr>
<tr>
<td>LT25X/LT30X</td>
<td>Normal grade: 3000, High accuracy grade: 1500</td>
</tr>
</tbody>
</table>

**Nut and spline shafts can be purchased separately**

Specify overall spline shaft length in 1 mm increments

---

Reduce Spare Parts Inventory with an Interchangeable Ball Spline

Failure in a single part of a system can result in large losses. In order to carry out repairs as quickly as possible, it is necessary to have numerous spare parts for every system. Interchangeable compact ball splines can be used as common spare parts, reducing the number of spare parts required.

Nuts and spline shafts are offered as single products, enabling easy replacement in case of breakage.
Failure in a single part of a system can result in large losses. In order to carry out repairs as quickly as possible, it is necessary to have numerous spare parts for every system. Interchangeable compact ball splines can be used as common spare parts, reducing the number of spare parts required.

**Interchangeable Compact Ball Spline**

The nut is more compact than the conventional Model LT/LF thanks to the new circulating pathways.

**Compact Nut Shape**

The nut is more compact than the conventional Model LT/LF thanks to the new circulating pathways.

**Nut Dimensions Comparison (LT/LT-X)**

Outer diameter up to 10% smaller. (Compared to the conventional model.) Enables a more compact design of core parts.

**Smooth Motion**

Reduced rolling resistance compared to the conventional Model LT/LF.

**High Speed**

Optimal ball circulation and high-speed motion thanks to new circulating pathways.

**Rolling Resistance Test**

- **Testing Method**
  - Item: Model No. LT16/LT16X
  - Speed: 10 mm/s
  - Lubricant: Lithium soap-based grease (AFB-LF Grease)
  - Orientation: Horizontal

**Test Result**

- Runs 10,000 km without abnormalities

**Shaft machining shape selection**

Select from three shapes recommended by us.

<table>
<thead>
<tr>
<th>Shape</th>
<th>Shaft shape</th>
<th>Center tap size (coarse) (select from the following sizes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Straight full spline</td>
<td>LT10X M3 M4, LT13X M4 M5, LT16X M6 M8, LT20X M8 M10, LT25X M10 M12, LT30X M14 M16</td>
</tr>
<tr>
<td>02</td>
<td>One end center tap</td>
<td>LT10X M3 M4, LT13X M4 M5, LT16X M6 M8, LT20X M8 M10, LT25X M10 M12, LT30X M14 M16</td>
</tr>
<tr>
<td>03</td>
<td>Both ends center tap</td>
<td>LT10X M3 M4, LT13X M4 M5, LT16X M6 M8, LT20X M8 M10, LT25X M10 M12, LT30X M14 M16</td>
</tr>
</tbody>
</table>

**Grease type selection**

You can select the type of grease according to the application.

<table>
<thead>
<tr>
<th>Name of grease</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFA</td>
<td>Low sliding friction</td>
</tr>
<tr>
<td>AFB-LF</td>
<td>Universal type</td>
</tr>
<tr>
<td>AFC</td>
<td>For fretting corrosion resistance</td>
</tr>
<tr>
<td>AFE-CA</td>
<td>For clean environments</td>
</tr>
<tr>
<td>AFF</td>
<td>For clean environments</td>
</tr>
<tr>
<td>AFG</td>
<td>For preventing heat generation</td>
</tr>
<tr>
<td>AFJ</td>
<td>For a wide range of speeds</td>
</tr>
<tr>
<td>L100</td>
<td>For clean environments/for high loads</td>
</tr>
<tr>
<td>L500</td>
<td>For high loads</td>
</tr>
</tbody>
</table>

*Please contact your local THK branch office separately about express delivery support/exact delivery dates.

*For details about THK Original Grease products, see p. 6.
What Is a Ball Spline?

Ball splines are linear motion guides that transmit torque while the nut moves with smooth linear motion caused by balls rolling along raceways precisely ground into the spline shaft.

Three Features of Ball Splines

1. High load capacity and long service life
2. Lightweight and compact
3. Linear and rotating mechanism

Unlike linear bushings, ball splines possess raceways. The rounded shape of these raceways closely resembles that of the balls, significantly increasing the load the ball spline can handle and enabling a high load capacity and long service life. Compared to linear bushings, the permissible load is 13 times greater, and the service life is 2,200 times greater.
2 Lightweight and compact

Ball splines can handle torque with one shaft, requiring fewer and smaller peripheral components than linear bushings and enabling machine cores to be made lighter and more cost-effective.

3 Linear and rotating mechanism

Ball splines can transmit torque with one shaft, enabling operations that combine linear motion and rotation.
Interchangeable ball splines that enable compact, high-speed core parts.

*This image is the Model LT-X.

**Sample Model Number Configuration**

**Spline nut**
- Model No.: LT-X: Cylindrical type, LF-X: Flanged type
- Seal symbol: No symbol: Without seal, UU: With end seal
- Accuracy symbol: No symbol: Normal grade, H: High accuracy grade
- Grease type: AFB-LF: Standard (no symbol), AFA, AFC, AFE-CA, AFF, AFG, AFJ, L100, L500
- Spline nut symbol

**Spline shaft**
- Model No.: LT20X - 500L, H - 03, M10, N10 (GK)
- Accuracy symbol: No symbol: Normal grade, H: High accuracy grade
- Overall spline shaft length (mm)
- Shaft ends (compatible with shapes 01, 02, 03)
- Interchangeability symbol
- Right tap diameter (compatible with shape 03)
- Left tap diameter (compatible with shapes 02, 03)
- Spline shaft symbol

**Selectable Semi-Custom Orders**

**Reduce Spare Parts Inventory with an Interchangeable Ball Spline**
Nuts and spline shafts are offered as single products, enabling easy replacement in case of breakage.

**Spline Shaft Length Can Be Specified in 1 mm Increments**
The overall shaft length can be specified in 1 mm increments. Select from three recommended shaft machining shapes.

*Use a spline nut and spline shaft with the same accuracy symbol.

*For details about semi-custom orders, see p. 8.
Contamination Prevention

*Ingress of dust or other foreign material into the spline nut will cause abnormal wear or shorten the service life, so it is necessary to take steps to prevent this from happening. When ingress of dust or other foreign material is a possibility, it is important to select a sealing device or contamination protection option suited to the service conditions. For ball splines, a highly wear-resistant special synthetic rubber seal is available as a contamination protection accessory.

Accuracy Standards

Table 1: Runout of the Spline Nut Outer Diameter in Relation to the Supporting Portion of the Spline Shaft

<table>
<thead>
<tr>
<th>Nominal shaft diameter</th>
<th>10</th>
<th>13, 16, 20</th>
<th>25, 30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall spline shaft length (mm)</td>
<td>Normal grade (H)</td>
<td>High accuracy grade (H)</td>
<td>Normal grade (H)</td>
</tr>
<tr>
<td>Above</td>
<td>200</td>
<td>315</td>
<td>13, 16, 20</td>
</tr>
<tr>
<td>Or less</td>
<td>-</td>
<td>200</td>
<td>59</td>
</tr>
<tr>
<td>200</td>
<td>315</td>
<td>83</td>
<td>54</td>
</tr>
<tr>
<td>315</td>
<td>400</td>
<td>103</td>
<td>88</td>
</tr>
<tr>
<td>400</td>
<td>500</td>
<td>123</td>
<td>82</td>
</tr>
<tr>
<td>500</td>
<td>630</td>
<td>151</td>
<td>102</td>
</tr>
<tr>
<td>630</td>
<td>800</td>
<td>190</td>
<td>-</td>
</tr>
<tr>
<td>800</td>
<td>1000</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1000</td>
<td>1250</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1250</td>
<td>1600</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 2: Perpendicularity of the Shaft End Face in Relation to the Supporting Portion of the Shaft

<table>
<thead>
<tr>
<th>Nominal shaft diameter</th>
<th>10</th>
<th>13, 16, 20</th>
<th>25, 30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal grade (No symbol)</td>
<td>Normal grade (H)</td>
<td>High accuracy grade (H)</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>22</td>
<td>9</td>
<td>11</td>
</tr>
<tr>
<td>13, 16, 20</td>
<td>27</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>25, 30</td>
<td>33</td>
<td>13</td>
<td></td>
</tr>
</tbody>
</table>

Table 3: Concentricity of the Part-Mounting Surface in Relation to the Supporting Portion of the Shaft

<table>
<thead>
<tr>
<th>Nominal shaft diameter</th>
<th>10</th>
<th>13, 16, 20</th>
<th>25, 30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal grade (No symbol)</td>
<td>Normal grade (H)</td>
<td>High accuracy grade (H)</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>41</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>13, 16, 20</td>
<td>46</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>25, 30</td>
<td>53</td>
<td>22</td>
<td></td>
</tr>
</tbody>
</table>

Table 4: Perpendicularity of the Flange-Mounting Surface in Relation to the Supporting Portion of the Shaft

<table>
<thead>
<tr>
<th>Nominal shaft diameter</th>
<th>10</th>
<th>13, 16, 20</th>
<th>25, 30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal grade (No symbol)</td>
<td>Normal grade (H)</td>
<td>High accuracy grade (H)</td>
<td></td>
</tr>
<tr>
<td>16, 20, 25, 30</td>
<td>39</td>
<td>16</td>
<td></td>
</tr>
</tbody>
</table>

Clearance in the Rotation Direction

The sum of clearances in the circumferential direction is standardized as the clearance in the rotation direction.

Standard Grease

Model LT-X/LF-X comes with grade 2 lithium-based grease (AFB-LF) as standard. AFB-LF Grease is a general-purpose grease that provides excellent extreme pressure resistance (AFB-LF) as standard. AFB-LF Grease is a general-purpose oil base oil and a lithium-based consistency enhancer.

Greasing Interval

The greasing interval varies depending on the usage conditions and environment. In general, it is recommended to re-grease every 100 km traveled (three to six months). If there is any change in the rotation direction, the greasing interval and amount of grease applied should be set using the table on the right to select the type of grease required for the application of your LM system.

THK Original Grease

THK provides various types of THK Original Grease needed for the lubrication of LM systems. They are available for various conditions and environments. Refer to the table on the right to select the type of grease according to the specific requirements of your LM system.
### Spline Nut Specification Table

#### LT-X (Cylindrical Type)

<table>
<thead>
<tr>
<th>Model No.</th>
<th>Spline nut dimensions</th>
<th>Keyway dimensions</th>
<th>Greasing hole</th>
<th>Spline nut mass</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nut outer diameter</td>
<td>Length</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>D</td>
<td>L</td>
<td>L₁</td>
<td>B</td>
</tr>
<tr>
<td>LT10X</td>
<td>19</td>
<td>0</td>
<td>-0.013</td>
<td>33</td>
</tr>
<tr>
<td>LT13X</td>
<td>23</td>
<td>0</td>
<td>-0.013</td>
<td>36</td>
</tr>
<tr>
<td>LT16X</td>
<td>28</td>
<td>0</td>
<td>-0.013</td>
<td>50</td>
</tr>
<tr>
<td>LT20X</td>
<td>32</td>
<td>0</td>
<td>-0.016</td>
<td>63</td>
</tr>
<tr>
<td>LT25X</td>
<td>40</td>
<td>0</td>
<td>-0.016</td>
<td>71</td>
</tr>
<tr>
<td>LT30X</td>
<td>45</td>
<td>0</td>
<td>-0.016</td>
<td>80</td>
</tr>
</tbody>
</table>

*The mass of the ball spline nut is the value of the ball spline nut without seals.

Unit: mm

#### LF-X (Flanged Type)

<table>
<thead>
<tr>
<th>Model No.</th>
<th>Spline nut dimensions</th>
<th>Greasing hole</th>
<th>Mounting hole</th>
<th>Spline nut mass</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nut outer diameter</td>
<td>Length</td>
<td>Flange outer diameter</td>
<td></td>
</tr>
<tr>
<td></td>
<td>D</td>
<td>L</td>
<td>L₁</td>
<td>L₂</td>
</tr>
<tr>
<td>LF10X</td>
<td>19</td>
<td>0</td>
<td>-0.013</td>
<td>33</td>
</tr>
<tr>
<td>LF13X</td>
<td>23</td>
<td>0</td>
<td>-0.013</td>
<td>36</td>
</tr>
<tr>
<td>LF16X</td>
<td>28</td>
<td>0</td>
<td>-0.013</td>
<td>50</td>
</tr>
<tr>
<td>LF20X</td>
<td>32</td>
<td>0</td>
<td>-0.016</td>
<td>63</td>
</tr>
<tr>
<td>LF25X</td>
<td>40</td>
<td>0</td>
<td>-0.016</td>
<td>71</td>
</tr>
<tr>
<td>LF30X</td>
<td>45</td>
<td>0</td>
<td>-0.016</td>
<td>80</td>
</tr>
</tbody>
</table>

*The mass of the ball spline nut is the value of the ball spline nut without seals.

Unit: mm
### Spline Shaft Specification Table

#### Spline Shaft
(Common to LT-X/LF-X)

#### Shaft Machining Shape

**Shape 01 (Straight full spline)**

**Shape 02 (One end center tap)**

**Shape 03 (Both ends center tap)**

#### Basic Load Rating / Basic Torque Rating / Static Permissible Moment
(Common to LT-X/LF-X)

<table>
<thead>
<tr>
<th>Model No.</th>
<th>Major diameter (\phi D_0)</th>
<th>Minor diameter (\phi d)</th>
<th>Ball center-to-center diameter (\phi dp)</th>
<th>Maximum shaft manufacturing length</th>
<th>Mass (kg/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Normal grade (No symbol)</td>
<td>High accuracy grade (H)</td>
</tr>
<tr>
<td>LT10X</td>
<td>16</td>
<td>13.3</td>
<td>13.8</td>
<td>1000</td>
<td>500</td>
</tr>
<tr>
<td>LT13X</td>
<td>20</td>
<td>17.9</td>
<td>21.1</td>
<td>1500</td>
<td>750</td>
</tr>
<tr>
<td>LT16X</td>
<td>26</td>
<td>22.4</td>
<td>26.4</td>
<td>3000</td>
<td>1500</td>
</tr>
<tr>
<td>LT20X</td>
<td>30</td>
<td>27</td>
<td>31.6</td>
<td>3000</td>
<td>1500</td>
</tr>
</tbody>
</table>

#### Basic Load Rating

<table>
<thead>
<tr>
<th>Model No.</th>
<th>Basic load rating (C)</th>
<th>Basic torque rating (C_T)</th>
<th>Static permissible moment (M_{ax}) (With seal)</th>
<th>Static permissible moment (M_{ax}) (Without seal)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(\text{kN})</td>
<td>(\text{kN})</td>
<td>(\text{N·m})</td>
<td>(\text{N·m})</td>
</tr>
<tr>
<td>LT10X</td>
<td>2.94</td>
<td>5.40</td>
<td>17.3</td>
<td>21.5</td>
</tr>
<tr>
<td>LT13X</td>
<td>4.16</td>
<td>6.96</td>
<td>17.1</td>
<td>28.7</td>
</tr>
<tr>
<td>LT16X</td>
<td>8.40</td>
<td>13.4</td>
<td>42.9</td>
<td>68.6</td>
</tr>
<tr>
<td>LT20X</td>
<td>10.5</td>
<td>18.6</td>
<td>68.4</td>
<td>117</td>
</tr>
<tr>
<td>LT25X</td>
<td>15.9</td>
<td>26.2</td>
<td>125</td>
<td>207</td>
</tr>
<tr>
<td>LT30X</td>
<td>20.8</td>
<td>34.0</td>
<td>196</td>
<td>319</td>
</tr>
</tbody>
</table>

\(S \times L\)

<table>
<thead>
<tr>
<th>Model No.</th>
<th>Unit: mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>LT10X</td>
<td>M3 x 6</td>
</tr>
<tr>
<td>LT13X</td>
<td>M4 x 8</td>
</tr>
<tr>
<td>LT16X</td>
<td>M6 x 10</td>
</tr>
<tr>
<td>LT20X</td>
<td>M8 x 16</td>
</tr>
<tr>
<td>LT25X</td>
<td>M10 x 20</td>
</tr>
<tr>
<td>LT30X</td>
<td>M14 x 28</td>
</tr>
</tbody>
</table>

### THK

8
Spline Shaft Strength Design

The spline shaft is a compound shaft capable of receiving a radial load and torque. When the load and torque are large, the spline shaft strength must be taken into account.

**Spline Shaft Receiving a Bending Load**

When a bending load is applied to the spline shaft, the spline shaft diameter is obtained by using formula (1).

\[
M = \sigma \cdot Z \quad \text{and} \quad Z = \frac{M}{\sigma} \quad \cdots (1)
\]

- **M**: Maximum bending moment acting on the spline shaft (N·mm)
- **\(\sigma\)**: Permissible bending stress of the spline shaft (98 N/mm²)
- **Z**: Section modulus of the spline shaft (mm³)

(Refer to the "Cross-sectional Characteristics of the Spline Shaft" table on p. 10)

For reference: Calculating the section modulus for one section of a circular shaft

\[
Z = \frac{\pi \cdot d^4}{32}
\]

- **Z**: Section modulus (mm³)
- **d**: Shaft outer diameter (mm)

**Spline Shaft Receiving a Torsion Load**

When a torsion load is applied on the spline shaft, the spline shaft diameter is obtained using formula (2).

\[
T = \tau_a \cdot Z_P \quad \text{and} \quad Z_P = \frac{T}{\tau_a} \quad \cdots (2)
\]

- **T**: Maximum torsion moment (N·mm)
- **\(\tau_a\)**: Permissible torsion stress of the spline shaft (49 N/mm²)
- **Z_P**: Polar section modulus of the spline shaft (mm³)

(Refer to the "Cross-sectional Characteristics of the Spline Shaft" table on p. 10)

For reference: Calculating the polar section modulus for one section of a circular shaft

\[
Z_P = \frac{\pi \cdot d^4}{16}
\]

- **Z_P**: Polar section modulus (mm³)
- **d**: Shaft outer diameter (mm)

When the Spline Shaft Simultaneously Receives a Bending Load and a Torsion Load

When the spline shaft receives a bending load and a torsion load simultaneously, calculate two separate spline shaft diameters: one for the equivalent bending moment (Me) and the other for the equivalent torsion moment (Te). Then, use the greater value as the spline shaft diameter.

**Equivalent bending moment**

\[
Me = \frac{M + \sqrt{M^2 + T^2}}{2} = \frac{M}{2} \left\{ 1 + \sqrt{1 + \left(\frac{T}{M}\right)^2} \right\} \quad \cdots (3)
\]

**Equivalent torsion moment**

\[
Te = \sqrt{M^2 + T^2} = M \cdot \sqrt{1 + \left(\frac{T}{M}\right)^2} \quad \cdots (4)
\]

**Torsional Rigidity of the Spline Shaft**

The torsional rigidity of the spline shaft is expressed as the torsion angle per meter of shaft length. Its value should be limited to within 1°/4.

\[
\theta = 57.3 \times \frac{T \cdot L}{G \cdot I_t} \quad \cdots (5)
\]

- **\(\theta\)**: Torsion angle (°)
- **L**: Spline shaft length (mm)
- **G**: Transverse elastic modulus (7.9 × 10⁴ N/mm²)
- **I_t**: Unit length (1000 mm)
- **b**: Polar moment of inertia (mm⁴)

(Refer to the "Cross-sectional Characteristics of the Spline Shaft" table on p. 10)
Deflection and Deflection Angle of the Spline Shaft

The deflection and deflection angle of the spline shaft need to be calculated using formulas that meet the relevant conditions. The formulas that correspond to each condition are shown below.

### Deflection and Deflection Angle Formulas

<table>
<thead>
<tr>
<th>Support method</th>
<th>Usage conditions</th>
<th>Deflection formula</th>
<th>Deflection angle formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Both ends free</td>
<td></td>
<td>( \delta_{\text{max}} = \frac{P\ell^3}{48EI} )</td>
<td>( i_1 = 0 ), ( i_2 = 0 )</td>
</tr>
<tr>
<td>Both ends fixed</td>
<td></td>
<td>( \delta_{\text{max}} = \frac{P\ell^3}{192EI} )</td>
<td>( i_1 = 0 ), ( i_2 = 0 )</td>
</tr>
<tr>
<td>Both ends free</td>
<td>Uniform load ( p )</td>
<td>( \delta_{\text{max}} = \frac{5p\ell^6}{384EI} )</td>
<td>( i_1 = \frac{p\ell^3}{24EI} )</td>
</tr>
<tr>
<td>Both ends free</td>
<td>Uniform load ( p )</td>
<td>( \delta_{\text{max}} = \frac{p\ell^3}{384EI} )</td>
<td>( i_1 = 0 ), ( i_2 = 0 )</td>
</tr>
<tr>
<td>One end fixed</td>
<td>Uniform load ( p )</td>
<td>( \delta_{\text{max}} = \frac{p\ell^3}{8EI} )</td>
<td>( i_1 = \frac{p\ell^3}{6EI} ), ( i_2 = 0 )</td>
</tr>
<tr>
<td>Both ends free</td>
<td>( \ell/2 )</td>
<td>( \delta_{\text{max}} = \frac{\sqrt{3M_0\ell^3}}{216EI} )</td>
<td>( i_1 = \frac{M_0\ell}{12EI} ), ( i_2 = \frac{M_0\ell}{24EI} )</td>
</tr>
<tr>
<td>Both ends fixed</td>
<td>( \ell/2 )</td>
<td>( \delta_{\text{max}} = \frac{M_0\ell^3}{216EI} )</td>
<td>( i_1 = \frac{M_0\ell}{16EI} ), ( i_2 = 0 )</td>
</tr>
</tbody>
</table>

\( \delta_{\text{max}} \): Maximum deflection (mm)
\( M_0 \): Moment (N·mm)
\( \ell \): Span (mm)
\( I \): Geometrical moment of inertia (mm^4)

(Refer to the "Cross-sectional Characteristics of the Spline Shaft" table below)

### Cross-sectional Characteristics of the Spline Shaft

<table>
<thead>
<tr>
<th>Nominal shaft diameter</th>
<th>Nominal section modulus (Z) (mm^3)</th>
<th>Nominal polar section modulus ( Z_p ) (mm^3)</th>
<th>Nominal polar moment of inertia ( I_p ) (mm^4)</th>
<th>Geometrical moment of inertia ( I ) (mm^4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>86.5</td>
<td>183.6</td>
<td>896.8</td>
<td>422.3</td>
</tr>
<tr>
<td>13</td>
<td>191.3</td>
<td>405.3</td>
<td>2574.6</td>
<td>1215.3</td>
</tr>
<tr>
<td>16</td>
<td>350.8</td>
<td>749.7</td>
<td>5844.5</td>
<td>2734.3</td>
</tr>
<tr>
<td>20</td>
<td>716.5</td>
<td>1498.0</td>
<td>14731.7</td>
<td>7043.9</td>
</tr>
<tr>
<td>25</td>
<td>1404.2</td>
<td>2932.9</td>
<td>30967.4</td>
<td>17288.2</td>
</tr>
<tr>
<td>30</td>
<td>2444.1</td>
<td>5086.3</td>
<td>75160.9</td>
<td>36115.8</td>
</tr>
</tbody>
</table>
Critical Speed of the Spline Shaft

When a ball spline shaft is used to transmit power while rotating, the rotation cycle nears the natural frequency of the spline shaft as the rotational speed of the shaft increases. This may cause resonance and eventually result in an inability to operate. Therefore, the maximum rotational speed of the shaft must be limited to a speed that is below the critical speed and does not cause resonance.

The critical speed of the spline shaft is obtained using formula (6). (It is multiplied by a safety factor of 0.8.)

If the shaft’s rotation cycle exceeds or nears the resonance point during operation, reconsider the spline shaft diameter.

**Critical Speed**

\[
N_c = \frac{60\lambda^2}{2\pi \cdot b^2} \cdot \sqrt{\frac{E \times 10^3 \cdot I}{\gamma \cdot A}} \times 0.8 \quad \text{·(6)}
\]

\[
I = \frac{\pi}{64} d^4 \quad \text{d: Minor diameter (mm)}
\]

\[
A = \frac{\pi}{4} d^2 \quad \text{d: Minor diameter (mm)}
\]

\[
\gamma: \text{Density (specific gravity) (7.85 \times 10^4 \text{kg/mm}^3)}
\]

\[
\lambda: \text{Factor according to the mounting method}
\]

(1) Fixed-free: \( \lambda = 1.875 \)

(2) Supported-supported: \( \lambda = 3.142 \)

(3) Fixed-supported: \( \lambda = 3.927 \)

(4) Fixed-fixed: \( \lambda = 4.73 \)

**Predicting the Service Life**

**Calculating the Static Safety Factor**

To calculate the load applied to the ball spline, you must first obtain the average load required to determine the service life and the maximum load needed to determine the static safety factor. In particular, if the system starts and stops frequently, if an impact load acts on the system, or if a large moment or torque caused by an overhung load is applied, it may experience an unexpectedly large load. When selecting a model number, it is necessary to confirm that the desired model is capable of supporting the required maximum load (whether stationary or in motion). The reference values for the static safety factor are shown in the table below.

\[
f_s = \frac{f_T \cdot f_C \cdot C_0}{P_{\text{max}}} \quad \text{·(7)}
\]

\[f_s: \text{Static safety factor}
\]

\[C_0: \text{Basic static load rating} \quad (N)
\]

\[P_{\text{max}}: \text{Maximum applied load} \quad (N)
\]

\[f_T: \text{Temperature factor}^*
\]

\[f_C: \text{Contact factor}^*
\]

*The basic static load rating is a static load of a defined direction and size where the sum of the permanent deformation of the ball and that of the raceway at the contact area under maximum stress is 0.0001 times the ball diameter.

**See the catalog for details of each factor.

**Static Safety Factor Standard Values (f_s)**

| Machine type | Load conditions | Lower limit of f_s
|--------------|-----------------|---------------------|
| General Industrial machinery | Without vibrations or impacts | 3.0 to 6.0
| | With vibrations or impacts | 4.0 to 7.0
| | With vibrations or impacts under combined loads | 5.0 to 8.0

*The standard values of the static safety factor may vary depending on usage conditions such as environment, lubrication status, mounting surface accuracy, and/or rigidity.
Nominal Life

The service life of the ball spline varies from unit to unit even if they are manufactured the same way and used in the same operating conditions. Therefore, the nominal life defined here is typically used as a guideline for obtaining the service life of a ball spline.

The nominal life is the total travel distance that 90% of a group of units can achieve without flaking (scale-like pieces on a metal surface) after individually running under the same conditions.

Calculating the Nominal Life

The nominal life of a ball spline varies with the type of load applied during operation: torque load, radial load, or moment load. The corresponding nominal life values are obtained using formulas (8) to (12) below. (The basic load ratings in these loading directions are indicated in the specification table for the corresponding model number.)

When a Torque Load Is Applied

\[
L = \left( \frac{f_T \cdot f_C}{f_w \cdot T_c} \right)^3 \times 50 \quad \text{(8)}
\]

When a Radial Load Is Applied

\[
L = \left( \frac{f_T \cdot f_C}{f_w \cdot P_c} \right)^3 \times 50 \quad \text{(9)}
\]

Calculating the Service Life Time

Once the nominal life \( L \) has been obtained with the formula above, the service life time can be obtained using formula (10) if the stroke length and the number of reciprocations per minute are constant.

\[
L_h = \frac{L \times 10^3}{2 \times \ell_S \times n_1 \times 60} \quad \text{(10)}
\]

When a Torque Load and a Radial Load are Applied Simultaneously

When a torque load and a radial load are applied simultaneously, calculate the nominal life by obtaining the equivalent radial load using formula (11) below.

\[
P_E = P_c + 4 \cdot \frac{T_c \times 10^3}{i \cdot dp \cdot \cos \alpha} \quad \text{(11)}
\]

When a Moment Load is Applied to a Single Nut or Two Nuts in Close Contact with Each Other

Calculate the nominal life by obtaining the equivalent radial load using formula (12) below.

\[
P_u = K \cdot M \quad \text{(12)}
\]

When a Moment Load and a Radial Load are Simultaneously Applied

Calculate the nominal life from the sum of the radial load and the equivalent radial load.

Equivalent Moment Factor

<table>
<thead>
<tr>
<th>Model No.</th>
<th>Equivalent factor: ( K )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Single nut</td>
</tr>
<tr>
<td>LT/LF10X</td>
<td>0.251</td>
</tr>
<tr>
<td>LT/LF13X</td>
<td>0.241</td>
</tr>
<tr>
<td>LT/LF16X</td>
<td>0.173</td>
</tr>
<tr>
<td>LT/LF20X</td>
<td>0.129</td>
</tr>
<tr>
<td>LT/LF25X</td>
<td>0.114</td>
</tr>
<tr>
<td>LT/LF30X</td>
<td>0.101</td>
</tr>
</tbody>
</table>
Precautions on Use

Handling

- Use at least two people to move any product weighing 20 kg or more, or use a cart or another method of conveyance. Otherwise, it may cause injury or damage to the unit.
- Do not disassemble the parts. This may result in loss of functionality.
- Tilting a spline nut or spline shaft may cause it to fall by its own weight.
- Take care not to drop or strike the ball spline. Otherwise, it may cause injury or damage to the unit. Even if there is no outward indication of damage, a sudden impact could prevent the unit from functioning properly.
- Wear appropriate safety gear, such as protective gloves and safety shoes, when handling the product.

Precautions on Use

- Prevent foreign materials, such as cutting chips or coolant, from getting inside the product. Failure to do so could damage the product.
- Prevent foreign materials, such as cutting chips, coolant, corrosive solvents, or water, from getting in the product by using a bellows or cover when the product is used in an environment where such a thing is likely.
- Do not use this product if the external temperature exceeds 80°C. This may deform or damage the resin or rubber parts.
- If foreign materials such as cutting chips adhere to the product, replenish the lubricant after washing the product.
- Very small strokes can inhibit the formation of an oil film between the raceways and the area of contact for the balls, resulting in fretting. Therefore, be sure to use a type of grease with high fretting resistance properties if the stroke will be small. We recommend periodically allowing the spline nut to stroke a distance roughly equal to its length to help ensure that a film forms between the raceway and balls.
- Do not forcibly drive a pin, key, or any other positioning device into the product. This could create indentations in the raceways and impair the product's function.
- Skewing or misalignment of the spline nut and the element that supports the spline shaft can drastically reduce the service life. Inspect the components carefully and make sure they are mounted correctly.
- When inserting the spline shaft into the spline nut, line up the spline shaft and the spline nut, and then put the shaft straight in while checking their relative positions. Note that forcibly inserting the shaft may cause balls to fall out. If the spline nut has seals or a preload, apply a lubricant to the outer surface of the spline shaft.
- Inserting and using the spline nut on the spline shaft while balls are missing could lead to premature failure of the product.
- If any balls fall out of the nut, contact THK. Do not use the product in that condition.
- When installing the spline nut into the housing, gently insert it using a jig so that you do not hit the side plates, end caps, or seals.
- Insufficient rigidity or accuracy of the mounting surface could cause an unexpected load to act on the ball spline, which could lead to a premature failure of the product. Therefore, give sufficient consideration to the rigidity and accuracy of the housing and base.
- If you want to have a flanged-type ball spline undergo additional machining, such as adding a dowel pin hole, contact THK.

Lubrication

- Thoroughly remove anti-rust oil and apply lubricant before using the product.
- Do not mix different lubricants. Even grease containing the same type of thickening agent may, if mixed, interact negatively due to disparate additives or other ingredients.
- When using the product in locations exposed to constant vibrations or in special environments such as in clean rooms, vacuums, and low/high temperatures, use a lubricant suitable for its use/environment.
- When lubricating products that do not feature a grease nipple or oil hole, directly coat the raceways with lubricant and perform several warm-up strokes to ensure that the grease permeates the interior.
- Grease viscosity can vary depending on the temperature. Keep in mind that the ball spline's sliding resistance and torque may be affected by changes in viscosity.
- Following greasing, stirring resistance of the grease can cause the ball spline to exhibit increased sliding resistance and torque. Before commencing operations, be sure to run the unit through several warm-up cycles to ensure that the grease is adequately integrated and dispersed.
- Excess grease may spatter after lubrication. Wipe off spattered grease as necessary.
- Grease deteriorates over time, which decreases the lubricity. Perform regular grease inspections and replenish grease based on frequency of use.
- The greasing interval varies depending on the usage conditions and environment. Grease the system approximately every 100 km of travel distance (3 to 6 months). The final greasing interval/amount should be set at the actual machine.
- When lubricating with oil, the lubricant may not get distributed throughout the ball spline depending on the mounting orientation. Contact THK for details.

Storage

When storing the ball spline, enclose it in the package designated by THK, and store it indoors and in a horizontal orientation while avoiding high temperatures, low temperatures, and high levels of humidity. Please note that if the product has been kept in storage for an extended period, the lubricant inside may have deteriorated. Please ensure that you replenish the lubricant before using.

Disposal

The product should be treated as industrial waste and disposed of appropriately.
Shipped from Japan in as little as 10 days - Semi-custom - LT-X/LF-X

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