Equipped with Caged-Ball Technology. Achieves high speed, low noise and long service life.
Caged Ball Spline

Equipped with Caged-Ball Technology.

Achieves high speed, low noise and long service life.
The caged-ball technology, developed by bringing together THK’s technologies and know-how, is now integrated in the new Ball Spline.
The integration of the ball cage enables the circulating motion of evenly spaced balls and high-speed response to be achieved. In addition, it eliminates collision and mutual friction between balls, and realizes low noise, pleasant running sound and low particle generation. As the grease retention is increased, long-term maintenance-free operation is also achieved.
Model SLS (medium-load type)
The circumference of the spline nut is shaped in a straight cylinder. Using a key, this model can be secured to the housing, or transmit a torque.

Model SLS-L (heavy-load type)
A heavy-load type with the same outer diameter as model SLS and a longer spline nut. It is optimal in cases where a large torque is applied in a small space, and in cases where an overhang load or moment is applied.

Model SLF
It can easily be assembled, and allows a shorter housing than securing it using a key.

Four Advantages Achieved with the Integration of the Caged-Ball Technology

High-speed Response
Models SLS/SLF adopt the caged-ball technology to enable the circulating motion of evenly spaced balls to be maintained and high-speed response to be achieved, the cycle time of the machine can be improved.

Low Noise, Pleasant Running Sound and Low Particle Generation
Models SLS/SLF adopt the caged-ball technology, they eliminate collision and mutual friction between balls, and realize low noise, pleasant running sound and low particle generation.

Long-term Maintenance-free Operation
Models SLS/SLF adopt the caged-ball technology to substantially increase the grease retention, thus achieving long-term maintenance-free operation.

Smooth Motion (Small Rolling Fluctuation)
Models SLS/SLF adopt the caged-ball technology and a new circulation method, thus achieving stable and smooth motion with small rolling fluctuation.

- Model SLS (SLS25 SLS30 SLS40 SLS50 SLS60 SLS70 SLS80 SLS100)
- Model SLS-L (SLS25L SLS30L SLS40L SLS50L SLS60L SLS70L SLS80L SLS100L)
- Model SLF (SLF25 SLF30 SLF40 SLF50 SLF60 SLF70 SLF80 SLF100)
**Caged Ball Spline**

### [High Speed]

- **Conditions**
  - Model tested: SLF50
  - Testing environment: 22 to 27.5°C
  - Stroke: 1000mm
  - Maximum speed: 200m/min
  - Acceleration/deceleration: 5G (49m/s²)
  - Applied load: Light preload (CL)
  - Lubricant: THK AFB-LF Grease

- **Test results**
  
  No anomaly after travelling 10,000 km

### [Low Noise, Pleasant Running Sound]

- **Conditions**
  - Shaft diameters: SLF50/LBF50
  - Stroke: 600mm
  - Speeds: 30, 50, 100, 150m/min
  - Measuring instrument: Noise level meter

- **Overview of the test machine**

- **Proximity sensor**
- **Noise level meter**
- **Specimen**
- **Drive unit**

### [Low Particle Generation]

- **Conditions**
  - Model tested: SLF50CL+350LP/LBS50CL+350LP
  - Speed: 30m/min
  - Stroke: 200mm
  - Amount of air supplied: 1/200sec
  - Lubricant: THK AFE-CA Grease

### [Smooth Motion (Small Rolling Fluctuation)]

- **Conditions**
  - Model No.: SLF50
  - Speed: 10 mm/sec
  - Applied load: Medium preload (CM)
  - Lubricant: THK AFB-LF Grease

---

**Noise level comparison**

- **Appearance of the test machine**
- **Measuring instrument**
- **Actuator**

**Caged Ball Spline model SLF**

**Ball Spline model LBS (full-ball type)**

**Rolling resistance test**

**SLF50**

- **Rolling resistance**
  - 1.5 [N]
### Accuracy Standards

#### Runout of the Spline Nut Circumference in Relation to the Support of the Spline Shaft

<table>
<thead>
<tr>
<th>Nominal shaft diameter</th>
<th>Overall spline shaft length (mm)</th>
<th>Accuracy</th>
<th>Runout (max)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Above or less</td>
<td>Normal</td>
<td>Upper</td>
</tr>
<tr>
<td>25,30</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40,50</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>60,70,80</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>800</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1200</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1600</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2500</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4000</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Perpendicularity of the Spline Shaft End Face in Relation to the Support of the Spline Shaft

<table>
<thead>
<tr>
<th>Nominal shaft diameter</th>
<th>Perpendicularity (max)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Normal grade</td>
</tr>
<tr>
<td>25,30</td>
<td>33</td>
</tr>
<tr>
<td>40,50</td>
<td>39</td>
</tr>
<tr>
<td>60,70,80</td>
<td>46</td>
</tr>
<tr>
<td>100</td>
<td>54</td>
</tr>
</tbody>
</table>

#### Concentricity of the Part-mounting in Relation to the Support of the Spline Shaft

<table>
<thead>
<tr>
<th>Nominal shaft diameter</th>
<th>Perpendicularity (max)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Normal grade</td>
</tr>
<tr>
<td>25,30</td>
<td>39</td>
</tr>
<tr>
<td>40,50</td>
<td>46</td>
</tr>
<tr>
<td>60,70,80</td>
<td>54</td>
</tr>
<tr>
<td>100</td>
<td>63</td>
</tr>
</tbody>
</table>

#### Straightness of the Flange-mounting Surface of the Spline Nut in Relation to the Support of the Spline Shaft

<table>
<thead>
<tr>
<th>Nominal shaft diameter</th>
<th>Perpendicularity (max)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Normal grade</td>
</tr>
<tr>
<td>25,30</td>
<td>39</td>
</tr>
<tr>
<td>40,50</td>
<td>46</td>
</tr>
<tr>
<td>60,70,80</td>
<td>54</td>
</tr>
<tr>
<td>100</td>
<td>63</td>
</tr>
</tbody>
</table>

---

**Table 2**

**Table 3**

**Table 4**

---

**Product Overview**

Caged Ball Spline (SLS/SLF)
Product Overview
Caged Ball Spline (SLS/SLF)

Clearance in the Rotation Direction

With the Ball Spline, the sum of clearances in the circumferential direction is standardized as the clearance in the rotational direction. Specific clearance values are standardized for each model, allowing you to select a clearance that meets the conditions. See the General Catalog for details.

<table>
<thead>
<tr>
<th>Nominal shaft diameter</th>
<th>Clearance in the rotational direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>25,30,40</td>
<td>+1 to -2</td>
</tr>
<tr>
<td>50,60</td>
<td>+2 to -4</td>
</tr>
<tr>
<td>70,80,100</td>
<td>+4 to -8</td>
</tr>
</tbody>
</table>

| Unit: μm |

Maximum Manufacturing Length of the Spline Shaft

<table>
<thead>
<tr>
<th>Nominal shaft diameter</th>
<th>Maximum Manufacturing Length: L</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>2000</td>
</tr>
<tr>
<td>30</td>
<td>2000</td>
</tr>
<tr>
<td>40</td>
<td>2000</td>
</tr>
<tr>
<td>50</td>
<td>2000</td>
</tr>
<tr>
<td>60</td>
<td>2000</td>
</tr>
<tr>
<td>70</td>
<td>2000</td>
</tr>
<tr>
<td>80</td>
<td>2000</td>
</tr>
<tr>
<td>100</td>
<td>2000</td>
</tr>
</tbody>
</table>

Material: S55C equivalent
Hardness: 58 to 64 HRC

Sectional Shape of the Spline Shaft

<table>
<thead>
<tr>
<th>Nominal shaft diameter</th>
<th>Major diameter φD0</th>
<th>Center distance φp</th>
<th>Minor diameter φd</th>
<th>Hole diameter φd4</th>
<th>Mass of the hollow shaft [kg/m]</th>
<th>Mass of the hollow shaft [kg/m]</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>25.2</td>
<td>21.6</td>
<td>12</td>
<td>3.51</td>
<td>2.62</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>30.2</td>
<td>25.8</td>
<td>16</td>
<td>5.05</td>
<td>3.47</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>40.6</td>
<td>35.2</td>
<td>22</td>
<td>9.18</td>
<td>6.19</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>50.5</td>
<td>44.4</td>
<td>25</td>
<td>14.45</td>
<td>10.58</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>61.0</td>
<td>54.0</td>
<td>32</td>
<td>21.23</td>
<td>14.90</td>
<td></td>
</tr>
<tr>
<td>70</td>
<td>71.0</td>
<td>62.8</td>
<td>32</td>
<td>28.57</td>
<td>21.19</td>
<td></td>
</tr>
<tr>
<td>80</td>
<td>80.8</td>
<td>71.3</td>
<td>52.5</td>
<td>37.49</td>
<td>30.48</td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>101.2</td>
<td>90.0</td>
<td>67.5</td>
<td>58.97</td>
<td>50.85</td>
<td></td>
</tr>
</tbody>
</table>

Table 7: Sectional Shape of the Spline Shaft of Models SLS/SLF
Unit: mm
Mounting method

For the fit between the spline nut and the housing, transition fit is commonly used. If the accuracy of the Ball Spline does not need to be very high, clearance fit is recommended.

<table>
<thead>
<tr>
<th>Housing Inner-diameter Tolerance</th>
<th>General conditions</th>
<th>H7</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>When clearance needs to be small</td>
<td>J6</td>
</tr>
</tbody>
</table>

Mounting Model SLS

● Examples of mounting the spline nut

- Mounting using a snap ring
- Mounting using a presser flange
- Mounting using a stop plate

Mounting Model SLF

● Example of mounting the spline nut

- Mounting using a flange

Precautions on mounting the product

● On both ends of the spline nut of Caged Ball Ball Spline model SLS, resin end caps are installed. Hitting them or pressing hard may cause damage. You must take care not to apply an excessive load.
● The fastening strength of the spline nut in the axial direction does not need to be very high. However, you must avoid retaining the spline only with a driving fit.

Designing the Strength of the Spline Shaft

The spline shaft of the Ball Spline 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.

<table>
<thead>
<tr>
<th>Nominal shaft diameter</th>
<th>Geometrical moment of inertia</th>
<th>Modulus section</th>
<th>Polar moment of inertia</th>
<th>Section modulus</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>Solid shaft 1.61 x 10^6</td>
<td>1.29 x 10^6</td>
<td>3.22 x 10^6</td>
<td>2.57 x 10^6</td>
</tr>
<tr>
<td></td>
<td>Hollow shaft 1.51 x 10^6</td>
<td>1.20 x 10^6</td>
<td>3.01 x 10^6</td>
<td>2.41 x 10^6</td>
</tr>
<tr>
<td>30</td>
<td>Solid shaft 3.33 x 10^6</td>
<td>2.22 x 10^6</td>
<td>6.65 x 10^6</td>
<td>4.43 x 10^6</td>
</tr>
<tr>
<td></td>
<td>Hollow shaft 3.00 x 10^6</td>
<td>2.00 x 10^6</td>
<td>6.01 x 10^6</td>
<td>4.00 x 10^6</td>
</tr>
<tr>
<td>40</td>
<td>Solid shaft 1.09 x 10^6</td>
<td>5.47 x 10^6</td>
<td>2.19 x 10^6</td>
<td>1.09 x 10^6</td>
</tr>
<tr>
<td></td>
<td>Hollow shaft 9.79 x 10^6</td>
<td>4.90 x 10^6</td>
<td>1.96 x 10^6</td>
<td>9.79 x 10^6</td>
</tr>
<tr>
<td>50</td>
<td>Solid shaft 2.71 x 10^6</td>
<td>1.08 x 10^6</td>
<td>5.41 x 10^6</td>
<td>2.17 x 10^6</td>
</tr>
<tr>
<td></td>
<td>Hollow shaft 2.51 x 10^6</td>
<td>1.01 x 10^6</td>
<td>5.03 x 10^6</td>
<td>2.01 x 10^6</td>
</tr>
<tr>
<td>60</td>
<td>Solid shaft 5.83 x 10^6</td>
<td>1.94 x 10^6</td>
<td>1.17 x 10^6</td>
<td>3.89 x 10^6</td>
</tr>
<tr>
<td></td>
<td>Hollow shaft 5.32 x 10^6</td>
<td>1.77 x 10^6</td>
<td>1.06 x 10^6</td>
<td>3.54 x 10^6</td>
</tr>
<tr>
<td>70</td>
<td>Solid shaft 1.06 x 10^6</td>
<td>3.02 x 10^6</td>
<td>2.11 x 10^6</td>
<td>6.04 x 10^6</td>
</tr>
<tr>
<td></td>
<td>Hollow shaft 1.82 x 10^6</td>
<td>4.55 x 10^6</td>
<td>3.64 x 10^6</td>
<td>9.10 x 10^6</td>
</tr>
<tr>
<td>80</td>
<td>Solid shaft 1.45 x 10^6</td>
<td>3.62 x 10^6</td>
<td>2.90 x 10^6</td>
<td>7.24 x 10^6</td>
</tr>
<tr>
<td></td>
<td>Hollow shaft 3.48 x 10^6</td>
<td>6.96 x 10^6</td>
<td>6.96 x 10^6</td>
<td>1.36 x 10^6</td>
</tr>
</tbody>
</table>
Product Overview
Caged Ball Spline (SLS/SLF)

[Spline Shaft Receiving a Bending Load]
When a bending load is applied to the spline shaft of a Ball Spline, obtain the spline shaft diameter using the
equation (1) below.

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

- \( M \) : Maximum bending moment acting on the spline shaft [N-mm]
- \( \sigma \) : Permissible bending stress of the spline shaft [98N/mm²]
- \( Z \) : Modulus section factor of the spline shaft [mm²]

[Splined Shaft Receiving a Torsion Load]
When a torsion load is applied on the spline shaft of a Ball Spline, obtain the spline shaft diameter using the
equation (2) below.

\[ T = \tau_a \cdot Z_P \quad \text{and} \quad Z_P = T \frac{1}{\tau_a} \quad \text{...... (2)} \]

- \( T \) : Maximum torsion moment [N-mm]
- \( \tau_a \) : Permissible torsion stress of the spline shaft [49N/mm²]
- \( Z_p \) : Polar modulus of section of the spline nut [mm²]

[When the Spline Shaft Simultaneously Receives a Bending Load and a Torsion Load]
When the spline shaft of a Ball Spline receives a bending load and a torsion load simultaneously, calculate two
separate spline shaft diameters: one for the equivalent bending moment (\( M_e \)) and the other for the equivalent
torsion moment (\( T_e \)). Then, use the greater value as the spline shaft diameter.

Equivalent bending moment

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

Equivalent torsion moment

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

[Rigidity of the Spline Shaft]
The rigidity of the spline shaft is expressed as a torsion angle per meter of shaft length. Its value should be limited
within 1°/4.

\[ \theta = 57.3 \times \frac{T \cdot L}{G \cdot I_p} \quad \text{...... (5)} \]

- \( \theta \) : Torsion angle [°]
- \( L \) : Spline shaft length [mm]
- \( G \) : Transverse elastic modulus [7.9×10⁴ N/mm²]
- \( I_p \) : Polar moment of inertia [mm⁴]
- \( t \) : Unit length [1000mm]
- \( l \) : Polar moment of inertia [mm²]
Deflection and Deflection Angle of the Spline Shaft

The deflection and deflection angle of the Ball Spline shaft need to be calculated using equations that meet the relevant conditions. Table 9 and Table 10 represent these conditions and the corresponding equations.

### Table 9: Deflection and Deflection Angle Equations

<table>
<thead>
<tr>
<th>Condition</th>
<th>Deflection equation</th>
<th>Deflection angle equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Both ends free</td>
<td>( \delta_{\text{max}} = \frac{P t^3}{48EI} )</td>
<td>( \psi_1 = 0 )</td>
</tr>
<tr>
<td>Both ends fastened</td>
<td>( \delta_{\text{max}} = \frac{P t^3}{16EI} )</td>
<td>( \psi_1 = 0 ) ( \psi_2 = 0 )</td>
</tr>
<tr>
<td>Uniform load ( p )</td>
<td>( \delta_{\text{max}} = \frac{5pt^3}{384EI} )</td>
<td>( \psi_1 = \frac{pt^3}{24EI} )</td>
</tr>
<tr>
<td>Uniform load ( p )</td>
<td>( \delta_{\text{max}} = \frac{pt^3}{384EI} )</td>
<td>( \psi_1 = 0 )</td>
</tr>
</tbody>
</table>

### Table 10: Deflection and Deflection Angle Equations

<table>
<thead>
<tr>
<th>Condition</th>
<th>Deflection equation</th>
<th>Deflection angle equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>One end fastened</td>
<td>( \delta_{\text{max}} = \frac{P t^3}{36EI} )</td>
<td>( \psi_1 = \frac{pt^3}{26EI} ) ( \psi_1 = 0 )</td>
</tr>
<tr>
<td>Uniform load ( p )</td>
<td>( \delta_{\text{max}} = \frac{pt^3}{66EI} )</td>
<td>( \psi_1 = \frac{pt^3}{66EI} ) ( \psi_1 = 0 )</td>
</tr>
<tr>
<td>Both ends free</td>
<td>( \delta_{\text{max}} = \frac{\sqrt{3}Mo t^3}{216EI} )</td>
<td>( \psi_1 = \frac{Mo t^3}{12EI} ) ( \psi_1 = \frac{Mo t^3}{24EI} )</td>
</tr>
<tr>
<td>Both ends fastened</td>
<td>( \delta_{\text{max}} = \frac{Mo t^3}{216EI} )</td>
<td>( \psi_1 = \frac{Mo t^3}{16EI} ) ( \psi_1 = 0 )</td>
</tr>
</tbody>
</table>

\( \delta_{\text{max}} \): Maximum deflection [mm]  
\( \psi_1 \): Deflection angle at supporting point  
\( M_0 \): Moment [N-mm]  
\( P \): Concentrated load [N]  
\( t \): Span [mm]  
\( p \): Uniform load [N/mm]  
\( I \): Geometrical moment of inertia [mm\(^4\)]  
\( E \): Modulus of longitudinal elasticity 2.06 \( \times 10^5 \) [N/mm\(^2\)]  
\( \psi_1 \): Deflection angle at loading point
When a Ball Spline shaft is used to transmit power while rotating, as the rotational speed of the shaft increases, the rotation cycle nears the natural frequency of the spline shaft. It may cause resonance and eventually result in inability to move. Therefore, the maximum rotational speed of the shaft must be limited to below the dangerous speed that does not cause resonance. The dangerous speed of the spline shaft is obtained using the equation (6). (0.8 is multiplied as a safety factor) If the shaft’s rotation cycle exceeds or nears the resonance point during operation, it is necessary to reconsider the spline shaft diameter.

**Dangerous Speed**

\[
N_c = \frac{60\lambda^2}{2\pi \cdot \ell_b} \sqrt{\frac{E \times 10^3 I}{r \cdot A}} \times 0.8 \quad \cdots (6)
\]

- \( N_c \) : Dangerous speed \([\text{min}^{-1}]\)
- \( \ell_b \) : Distance between two mounting surfaces \([\text{mm}]\)
- \( E \) : Young’s modulus \([2.06 \times 10^5 \text{N/mm}^2]\)
- \( I \) : Minimum geometrical moment of inertia of the shaft \([\text{mm}^4]\)
- \( \rho \) : Density (specific gravity) \([7.85 \times 10^{-6} \text{kg/mm}^3]\)
- \( A \) : Spline shaft cross-sectional area \([\text{mm}^2]\)

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

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

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

- \( \lambda \) : 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

[Nominal Life]
The service life of a Ball Spline varies from unit to unit even if they are manufactured through the same process and used in the same operating conditions. Therefore, the nominal life defined below is normally used as a guidepost for obtaining the service life of a Ball Spline. Nominal life is the total travel distance that 90% of a group of identical ball splines independently operating under the same conditions can achieve without showing flaking (scale-like pieces on a metal surface).

[Calculating the Nominal Life]
The nominal life of a Ball Spline varies with types of loads applied during operation: torque load, radial load and moment load. The corresponding nominal life values are obtained using the equations (7) to (10) 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

\[
L = \left( \frac{f_r \cdot f_c}{f_w} \cdot \frac{C_r}{T_c} \right)^3 \times 50 \quad (7)
\]

○ When a Radial Load is Applied

\[
L = \left( \frac{f_r \cdot f_c}{f_w} \cdot \frac{C}{P_c} \right)^3 \times 50 \quad (8)
\]

\[
L \quad \text{Nominal life [km]}
\]
\[
P_c \quad \text{Calculated radial load [N]}
\]
\[
C_r \quad \text{Basic dynamic torque rating [N-m]}
\]
\[
f_r \quad \text{Temperature factor}
\]
\[
T_c \quad \text{Calculated torque applied [N-m]}
\]
\[
f_c \quad \text{Contact factor}
\]
\[
C \quad \text{Basic dynamic load rating [N]}
\]
\[
f_w \quad \text{Load factor}
\]

○ When a Torque Load and a Radial Load are Simultaneously Applied

When a torque load and a radial load are simultaneously applied, calculate the nominal life by obtaining the equivalent radial load using the equation (9) below.

\[
P_E = P_c + \frac{4 \cdot T_c \times 10^3}{i \cdot dp \cdot \cos \alpha} \quad (9)
\]

\[
P_E \quad \text{Equivalent radial load [N]}
\]
\[
\cos \alpha \quad \text{Contact angle \( \alpha \)=Number of rows of balls under a load 40°}
\]
\[
dp \quad \text{Ball center-to-center diameter [mm]}
\]
When a Moment Load is Applied to a Single Nut or Two Nuts in Close Contact with Each Other

Obtain the equivalent radial load using the equation (10) below.

\[
P_u = K \cdot M \quad \text{(10)}
\]

- \(P_u\): Equivalent radial load [N]
- \(K\): Equivalent Factors (see Table 11)
- \(M\): Applied moment [N-mm]

However, \(M\) should be within the range of the static permissible moment.

When a Moment Load and a Radial Load are Simultaneously Applied

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

Moment Equivalent Factor

<table>
<thead>
<tr>
<th>Model No.</th>
<th>One spline nut</th>
<th>Two spline nuts in tight contact with each other</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLS/SLF25</td>
<td>0.187</td>
<td>0.030</td>
</tr>
<tr>
<td>SLS25L</td>
<td>0.148</td>
<td>0.027</td>
</tr>
<tr>
<td>SLS/SLF30</td>
<td>0.153</td>
<td>0.027</td>
</tr>
<tr>
<td>SLS30L</td>
<td>0.129</td>
<td>0.024</td>
</tr>
<tr>
<td>SLS/SLF40</td>
<td>0.114</td>
<td>0.021</td>
</tr>
<tr>
<td>SLS40L</td>
<td>0.102</td>
<td>0.019</td>
</tr>
<tr>
<td>SLS/SLF50</td>
<td>0.109</td>
<td>0.018</td>
</tr>
<tr>
<td>SLS50L</td>
<td>0.091</td>
<td>0.017</td>
</tr>
<tr>
<td>SLS/SLF60</td>
<td>0.080</td>
<td>0.015</td>
</tr>
<tr>
<td>SLS60L</td>
<td>0.072</td>
<td>0.014</td>
</tr>
<tr>
<td>SLS/SLF70</td>
<td>0.101</td>
<td>0.016</td>
</tr>
<tr>
<td>SLS70L</td>
<td>0.076</td>
<td>0.014</td>
</tr>
<tr>
<td>SLS/SLF80</td>
<td>0.083</td>
<td>0.013</td>
</tr>
<tr>
<td>SLS80L</td>
<td>0.072</td>
<td>0.012</td>
</tr>
<tr>
<td>SLS/SLF100</td>
<td>0.068</td>
<td>0.011</td>
</tr>
<tr>
<td>SLS100L</td>
<td>0.056</td>
<td>0.010</td>
</tr>
</tbody>
</table>

Calculating the Service Life Time

When the nominal life \(L\) has been obtained in the equation above, if the stroke length and the number of reciprocations per minute are constant, the service life time is obtained using the equation (11) below.

\[
L_h = \frac{L \times 10^3}{2 \times 2 \times n_1 \times 60} \quad \text{(11)}
\]

- \(L_h\): Service life time [h]
- \(\ell_s\): Stroke length [m]
- \(n_1\): Number of reciprocations per minute [min\(^{-1}\)]
**f<sub>T</sub>: Temperature Factor**

Since the service temperature of the Caged Ball Ball Spline is normally 80°C or below, \( f_T = 1.0 \).

**f<sub>c</sub>: Contact Factor**

When multiple spline nuts are used in close contact with each other, their linear motion is affected by moments and mounting accuracy, making it difficult to achieve uniform load distribution. In such applications, multiply the basic load rating (C) by the corresponding contact factor in Table 12.

Note: If uneven load distribution is expected in a large machine, take into account the respective contact factor indicated in Table 12.

<table>
<thead>
<tr>
<th>Number of spline nuts in close contact with each other</th>
<th>Contact factor ( f_c )</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>0.81</td>
</tr>
<tr>
<td>3</td>
<td>0.72</td>
</tr>
<tr>
<td>4</td>
<td>0.66</td>
</tr>
<tr>
<td>5</td>
<td>0.61</td>
</tr>
<tr>
<td>Normal use</td>
<td>1</td>
</tr>
</tbody>
</table>

**f<sub>W</sub>: Load Factor**

In general, reciprocating machines tend to involve vibrations or impact during operation. It is extremely difficult to accurately determine vibrations generated during high-speed operation and impact during frequent start and stop. When loads applied on a Ball Spline cannot be measured, or when speed and impact have a significant influence, divide the basic load rating (C or \( C_0 \)) by the corresponding load factor in Table 13.

Note: If uneven load distribution is expected in a large machine, take into account the respective load factor indicated in Table 13.

### Calculating the Static Safety Factor

When calculating the load applied to the Ball Spline, it is necessary to calculate the mean load used for service life calculation and the maximum load used for static safety factor calculation. In particular, if the start and stop are intensely repeated, a cutting load is applied, or a large moment resulting from an overhang load is applied, then an unexpectedly large load may be applied. When selecting a model, check whether the use is suitable for its maximum load (regardless of whether the product is stationary or operating) by calculating the static safety factor using the equation (12). Table 14 shows reference values for the static safety factor.

\[
f_s = \frac{C_0}{P_{\text{max}}} \quad (12)
\]

\( f_s \) : Static safety factor

\( C_0 \) : Basic static load rating [N]

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

* The basic static load rating refers to the static load with constant direction and magnitude at which the sum of the permanent deformation of the rolling element and the permanent deformation of the raceway is 0.0001 times the diameter of the rolling element at the contact point under the maximum stress.

### Reference Value of Static Safety Factor (\( f_s \))

<table>
<thead>
<tr>
<th>Machine using the product</th>
<th>Load conditions</th>
<th>Lower limit of ( f_s )</th>
</tr>
</thead>
<tbody>
<tr>
<td>General industrial machinery</td>
<td>Without vibration/impact</td>
<td>1.0 to 3.5</td>
</tr>
<tr>
<td></td>
<td>With vibration/impact</td>
<td>2.0 to 5.0</td>
</tr>
<tr>
<td>Machine tool</td>
<td>Without vibration/impact</td>
<td>1.0 to 4.0</td>
</tr>
<tr>
<td></td>
<td>With vibration/impact</td>
<td>2.8 to 7.0</td>
</tr>
</tbody>
</table>

* The reference value of static safety factor may vary depending on the service conditions such as service environment, lubrication state and accuracy, rigidity, etc. of the mounting section.
## Dimensional Table

### Caged Ball Spline (SLS/SLF)

#### Unit: mm

<table>
<thead>
<tr>
<th>Model No.</th>
<th>Outer diameter D</th>
<th>Tolerance</th>
<th>Length L</th>
<th>Keyway dimensions T</th>
<th>Greasing hole b</th>
<th>Spline nut dimensions d0</th>
<th>Basic torque rating Cr [N-m]</th>
<th>Basic load rating C [kN]</th>
<th>Static permissible moment Co [kN]</th>
<th>Mass [kg]</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLS525</td>
<td>37</td>
<td>0</td>
<td>60</td>
<td>70</td>
<td>5</td>
<td>3</td>
<td>33</td>
<td>2</td>
<td>25</td>
<td>219.9</td>
</tr>
<tr>
<td>SLS525L</td>
<td>37</td>
<td>0</td>
<td>60</td>
<td>70</td>
<td>5</td>
<td>3</td>
<td>33</td>
<td>2</td>
<td>25</td>
<td>219.9</td>
</tr>
<tr>
<td>SLS30</td>
<td>45</td>
<td>0</td>
<td>70</td>
<td>80</td>
<td>7</td>
<td>4</td>
<td>41</td>
<td>3</td>
<td>30</td>
<td>366.5</td>
</tr>
<tr>
<td>SLS30L</td>
<td>45</td>
<td>0</td>
<td>70</td>
<td>80</td>
<td>7</td>
<td>4</td>
<td>41</td>
<td>3</td>
<td>30</td>
<td>366.5</td>
</tr>
<tr>
<td>SLS40</td>
<td>60</td>
<td>0</td>
<td>90</td>
<td>100</td>
<td>10</td>
<td>5</td>
<td>55</td>
<td>3</td>
<td>40</td>
<td>818.9</td>
</tr>
<tr>
<td>SLS40L</td>
<td>60</td>
<td>0</td>
<td>90</td>
<td>100</td>
<td>10</td>
<td>5</td>
<td>55</td>
<td>3</td>
<td>40</td>
<td>818.9</td>
</tr>
<tr>
<td>SLS50</td>
<td>75</td>
<td>0.019</td>
<td>100</td>
<td>112</td>
<td>15</td>
<td>5</td>
<td>60</td>
<td>4</td>
<td>50</td>
<td>1373.4</td>
</tr>
<tr>
<td>SLS50L</td>
<td>75</td>
<td>0.019</td>
<td>100</td>
<td>112</td>
<td>15</td>
<td>5</td>
<td>60</td>
<td>4</td>
<td>50</td>
<td>1373.4</td>
</tr>
<tr>
<td>SLS60</td>
<td>90</td>
<td>0.019</td>
<td>127</td>
<td>140</td>
<td>18</td>
<td>6</td>
<td>68</td>
<td>4</td>
<td>60</td>
<td>2506.7</td>
</tr>
<tr>
<td>SLS60L</td>
<td>90</td>
<td>0.019</td>
<td>127</td>
<td>140</td>
<td>18</td>
<td>6</td>
<td>68</td>
<td>4</td>
<td>60</td>
<td>2506.7</td>
</tr>
<tr>
<td>SLS70</td>
<td>100</td>
<td>0.022</td>
<td>110</td>
<td>135</td>
<td>18</td>
<td>6</td>
<td>68</td>
<td>4</td>
<td>70</td>
<td>2806.3</td>
</tr>
<tr>
<td>SLS70L</td>
<td>100</td>
<td>0.022</td>
<td>110</td>
<td>135</td>
<td>18</td>
<td>6</td>
<td>68</td>
<td>4</td>
<td>70</td>
<td>2806.3</td>
</tr>
<tr>
<td>SLS80</td>
<td>120</td>
<td>0</td>
<td>140</td>
<td>155</td>
<td>20</td>
<td>7</td>
<td>80</td>
<td>5</td>
<td>80</td>
<td>4664.6</td>
</tr>
<tr>
<td>SLS80L</td>
<td>120</td>
<td>0</td>
<td>140</td>
<td>155</td>
<td>20</td>
<td>7</td>
<td>80</td>
<td>5</td>
<td>80</td>
<td>4664.6</td>
</tr>
<tr>
<td>SLS100</td>
<td>140</td>
<td>0.025</td>
<td>160</td>
<td>185</td>
<td>28</td>
<td>9</td>
<td>93</td>
<td>5</td>
<td>100</td>
<td>8922.3</td>
</tr>
<tr>
<td>SLS100L</td>
<td>140</td>
<td>0.025</td>
<td>160</td>
<td>185</td>
<td>28</td>
<td>9</td>
<td>93</td>
<td>5</td>
<td>100</td>
<td>8922.3</td>
</tr>
</tbody>
</table>

### Model SLS (Straight type)

- **Model number coding**
  - **2**: SLS50
  - **UU**: UU
  - **CL**: CL
  - **+700L**: +700L
  - **P**: P
  - **K**: K

- **Model No.**
- **Spline nut dimensions**
  - **Spline nut dimensions**
  - **Spline nut dimensions**
  - **Spline nut dimensions**

- **Symbol for clearance in the rotational direction**
  - (see page 5)

- **Contamination protection accessory symbol**
  - No symbol: No seal

- **Number of spline nuts on one shaft**
  - (no symbol for one nut)

- **Overall spline shaft length**
  - (in mm)

- **Accuracy symbol**
  - (see page 4)

- **Symbol for standard hollow spline shaft**
  - No symbol: Solid spline shaft

- **K**: Hollow spline shaft

---

**Contamination protection accessory symbol**

- **UU**: Rubber seal attached on both ends
- **U**: Rubber seal attached on either end

**Model number coding**

- **2**: SLS50
- **UU**: SLS50
- **CL**: SLS50L
- **+700L**: SLS50L
- **P**: SLS50L
- **K**: SLS50L

**Symbol for clearance in the rotational direction**

- (see page 5)

**Contamination protection accessory symbol**

- No symbol: No seal

- **UU**: Rubber seal attached on both ends
- **U**: Rubber seal attached on either end

**Model number coding**

- **2**: SLS50
- **UU**: SLS50
- **CL**: SLS50L
- **+700L**: SLS50L
- **P**: SLS50L
- **K**: SLS50L
### Model SLF (Flange type)

#### Spline nut dimensions

<table>
<thead>
<tr>
<th>Model No.</th>
<th>Outer diameter</th>
<th>Length</th>
<th>Flange diameter</th>
<th>Seal diameter</th>
<th>H</th>
<th>F</th>
<th>PCD</th>
<th>Mounting hole</th>
<th>d×d×xh</th>
<th>Basic torque rating</th>
<th>Basic load rating</th>
<th>Static permissible moment</th>
<th>Mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLF25</td>
<td>37</td>
<td>60</td>
<td>60</td>
<td>0.016</td>
<td>2</td>
<td>9</td>
<td>21</td>
<td>6.5×9.5×5.4</td>
<td>219.9</td>
<td>306.8</td>
<td>15.2</td>
<td>47.2</td>
<td>0.26</td>
</tr>
<tr>
<td>SLF30</td>
<td>45</td>
<td>70</td>
<td>70</td>
<td>0.020</td>
<td>3</td>
<td>10</td>
<td>25</td>
<td>6.6×11×6.5</td>
<td>366.5</td>
<td>513.3</td>
<td>25.4</td>
<td>31.5</td>
<td>0.45</td>
</tr>
<tr>
<td>SLF40</td>
<td>60</td>
<td>90</td>
<td>90</td>
<td>0.030</td>
<td>4</td>
<td>14</td>
<td>31</td>
<td>9×14×8.6</td>
<td>818.9</td>
<td>1135.4</td>
<td>42.6</td>
<td>52.6</td>
<td>1.06</td>
</tr>
<tr>
<td>SLF50</td>
<td>75</td>
<td>100</td>
<td>113</td>
<td>0.019</td>
<td>5</td>
<td>16</td>
<td>34</td>
<td>11×17.5×11</td>
<td>1373.4</td>
<td>1783.1</td>
<td>57.6</td>
<td>66.2</td>
<td>1.90</td>
</tr>
<tr>
<td>SLF60</td>
<td>90</td>
<td>127</td>
<td>129</td>
<td>0.030</td>
<td>6</td>
<td>18</td>
<td>45.5</td>
<td>11×17.5×11</td>
<td>2506.7</td>
<td>3321.0</td>
<td>87.8</td>
<td>103.0</td>
<td>3.08</td>
</tr>
<tr>
<td>SLF70</td>
<td>100</td>
<td>110</td>
<td>142</td>
<td>0.022</td>
<td>7</td>
<td>20</td>
<td>47.5</td>
<td>14×20×13</td>
<td>2986.3</td>
<td>3474.7</td>
<td>89.7</td>
<td>92.5</td>
<td>3.25</td>
</tr>
<tr>
<td>SLF80</td>
<td>120</td>
<td>140</td>
<td>168</td>
<td>0.040</td>
<td>8</td>
<td>22</td>
<td>48</td>
<td>16×23×15.2</td>
<td>4664.6</td>
<td>5477.4</td>
<td>128.8</td>
<td>127.7</td>
<td>5.82</td>
</tr>
<tr>
<td>SLF100</td>
<td>140</td>
<td>160</td>
<td>195</td>
<td>0.025</td>
<td>9</td>
<td>25</td>
<td>55</td>
<td>18×26×17.5</td>
<td>8922.3</td>
<td>10211.6</td>
<td>188.2</td>
<td>190.7</td>
<td>7.66</td>
</tr>
</tbody>
</table>

---

**Model number cording**

- **2**: Model No.
- **SLS50**: Number of spline nuts on one shaft (no symbol for one nut)
- **UU**: Symbol for clearance in the rotational direction (see page 5)
- **CL**: Contamination protection accessory symbol
- **+700L**: Overall spline shaft length (in mm)
- **P**: Accuracy symbol (see page 4)
- **K**: Symbol for standard hollow spline shaft

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**THK**

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**Model SLF (Flange type)**

- **SLF**: Spline nut dimensions
- **Model No.**: Unit: mm
- **Outer diameter**: D
- **Length**: L
- **Flange diameter**: D
- **Seal diameter**: d
- **H**: Mounting hole d×d×xh
- **F**: Basic torque rating [N-m]
- **PCD**: Basic load rating [kN]
- **C**: Static permissible moment [N-m]
- **Mass**: Spindle Nut [kg]
- **Mass**: Spindle shaft [kg/m]
Precautions on use

- The Spline Nut and the Spline Shaft
  - Do not remove the spline nut from the spline shaft unless it is necessary. If reinstalling the spline nut onto the spline shaft after inevitably removing the nut, align the ball position in the spline nut with the groove position of the spline shaft, and gradually insert the spline shaft straight into the spline nut. If the spline shaft is tilted when it is inserted, balls may fall out or the circulation part may be damaged.
  - If the spline shaft gets stuck halfway while being inserted into the nut, do not force the shaft into the nut, but pull it out once, recheck the ball position and the groove position of the spline shaft, then gradually insert the shaft straight into the nut.
  - After inserting the spline shaft into the spline nut, check whether the spline nut or the spline shaft smoothly moves. If the spline shaft was forcibly inserted, functional loss may have occurred even if the product looks intact.

- Handling
  - Do not disassemble the parts. Doing so may cause dust to enter the product or degrade the assembly accuracy.
  - Titting the spline nut or the spline shaft when they are assembled may cause it to fall by its own weight.
  - Do not drop or hit the Ball Spline. Doing so may damage it. Applying impact to the product may cause functional loss even if the product looks intact.

- Lubrication
  - Thoroughly remove anti-rust oil and feed a lubricant before using the product.
  - Do not mix lubricants of different physical properties.
  - In locations exposed to constant vibrations or in special environments such as clean rooms, vacuum, and low/high temperature, normal lubricants may not be used. Contact THK for details.
  - When planning to use a special lubricant, contact THK before using it.
  - When adopting oil lubrication, the lubricant may not be distributed throughout the product depending on the mounting orientation of nut. Contact THK for details.
  - Lubrication interval varies according to the conditions. Contact THK for details.

- Precautions on Use
  - Entrance of foreign material may damage the ball circulation part or cause functional loss. Prevent foreign material, such as dust and cutting chips, from entering the product.
  - When planning to use the product in an environment where the coolant penetrates into the spline nut, it may disrupt the function of the product depending on the type of the coolant. Contact THK for details.
  - Do not use the product at a temperature above 80°C.
  - If foreign material, such as dust or cutting chips, adheres to the product, replenish the lubricant after cleaning the product. For the type of the cleaning fluid to be used, contact THK.
  - When using the product in locations exposed to constant vibrations or in special environments such as clean rooms, vacuum, and low/high temperature, contact THK in advance.
  - Removing the nut from the shaft then reinstalling it onto the shaft may cause balls to fall. Take much care in handling the product.
  - If desiring additional machining, such as dowel hole, to the flange of Ball Spline Nut, please contact THK prior to ordering.

- Storage
  - When storing the Ball Spline, enclose it in a package designated by THK and store it in a horizontal orientation while avoiding high temperature, low temperature, and high humidity.
  - Do not remove the spline nut from the spline shaft unless it is necessary. If reinstalling the spline nut onto the spline shaft after the shaft was forcibly inserted, functional loss may have occurred even if the product looks intact.
  - Thoroughly remove anti-rust oil and feed a lubricant before using the product.
  - If foreign material, such as dust or cutting chips, adheres to the product, replenish the lubricant after cleaning the product. For the type of the cleaning fluid to be used, contact THK.
  - When using the product in locations exposed to constant vibrations or in special environments such as clean rooms, vacuum, and low/high temperature, contact THK in advance.
  - Removing the nut from the shaft then reinstalling it onto the shaft may cause balls to fall. Take much care in handling the product.

- Lubrication
  - Do not mix lubricants of different physical properties.
  - In locations exposed to constant vibrations or in special environments such as clean rooms, vacuum, and low/high temperature, normal lubricants may not be used. Contact THK for details.

- Precautions on Use
  - Entrance of foreign material may damage the ball circulation part or cause functional loss. Prevent foreign material, such as dust and cutting chips, from entering the product.
  - When planning to use the product in an environment where the coolant penetrates into the spline nut, it may disrupt the function of the product depending on the type of the coolant. Contact THK for details.
  - Do not use the product at a temperature above 80°C.
  - If foreign material, such as dust or cutting chips, adheres to the product, replenish the lubricant after cleaning the product. For the type of the cleaning fluid to be used, contact THK.
  - When using the product in locations exposed to constant vibrations or in special environments such as clean rooms, vacuum, and low/high temperature, contact THK in advance.
  - Removing the nut from the shaft then reinstalling it onto the shaft may cause balls to fall. Take much care in handling the product.
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  - Do not mix lubricants of different physical properties.
  - In locations exposed to constant vibrations or in special environments such as clean rooms, vacuum, and low/high temperature, normal lubricants may not be used. Contact THK for details.

- Precautions on Use
  - Entrance of foreign material may damage the ball circulation part or cause functional loss. Prevent foreign material, such as dust and cutting chips, from entering the product.
  - When planning to use the product in an environment where the coolant penetrates into the spline nut, it may disrupt the function of the product depending on the type of the coolant. Contact THK for details.
  - Do not use the product at a temperature above 80°C.
  - If foreign material, such as dust or cutting chips, adheres to the product, replenish the lubricant after cleaning the product. For the type of the cleaning fluid to be used, contact THK.
  - When using the product in locations exposed to constant vibrations or in special environments such as clean rooms, vacuum, and low/high temperature, contact THK in advance.
  - Removing the nut from the shaft then reinstalling it onto the shaft may cause balls to fall. Take much care in handling the product.
  - If desiring additional machining, such as dowel hole, to the flange of Ball Spline Nut, please contact THK prior to ordering.