**Technical Calculations**

**Calculation of Life Span of Linear Systems 1**

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**Allowable Load**

- **Basic Allowable Load Rating (C)**
  - Basic dynamic load rating is a constant load applied in a constant direction that will cause each linear system of the same series to travel (50×10−6) under the same conditions, without 90% of the material suffering damage from rolling contact fatigue.

- **Static Load Rating (C0)**
  - Basic static load rating is the static load exerted on contacting parts under maximum stress, at which the sum of the permanent deformation in the rolling element and rolling contact surface equals 0.001 times the diameter of the rolling element.

- **Allowable Static Moment (M0, M)**
  - Allowable static moment is a critical static moment load that acts upon a system at the loading moment. It is set in accordance with the permanent deformation in the basic static load rating C0.

- **Static Safety Factors (f)**
  - Static safety factors are given in Table-1. When a linear system is still or moving at low speed, basic static load rating C0 must be divided by f in accordance with the conditions of use.

**Table 1 - Static Safety Factor (Lower Limit of f)**

<table>
<thead>
<tr>
<th>Condition of Use</th>
<th>Lower Limit of f</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under Normal Operating Conditions</td>
<td>1~2</td>
</tr>
<tr>
<td>When Smooth Travel is Required</td>
<td>2~4</td>
</tr>
<tr>
<td>When Subjected To Vibrations or Impacts</td>
<td>3~5</td>
</tr>
</tbody>
</table>

- **Allowable Load (P)**: \( P = \frac{C}{f} \)
- **Allowable Moment (M)**: \( M = \frac{C_0}{f} \)

**Life Span**

- **Rated Life Span (L)**
  - When subjected to vibrations, impacts under normal operating conditions, the life span can be computed as a number of hours by obtaining the travel distance for a unit of time. It can be obtained by using the following formula, in which stroke length and stroke cycles are assumed to be constant.

\[
L = \frac{F \cdot \ell_s \cdot n}{2 \times 60} \quad \text{(2 hours / hr)}
\]

- **Rated Life Span (L)**
  - Rated Life Span (L) = \( L = \frac{P \cdot \ell_s \cdot n}{2 \times 60} \)
  - \( L \) : Rated Life Span (km)
  - \( P \) : Working Load (N)
  - \( \ell_s \) : Stroke Length (mm)
  - \( n \) : Revolutions per Minute (rpm)

**Friction Resistance and Required Thrust**

- **Rated Life Span (L)**
  - Using the following formula, the friction resistance required for thrust can be obtained from the load and the axial seal resistance specified by the system.

\[
F = \mu \cdot W \cdot F_r
\]

### **Table 2 - Dynamic Friction Coefficient**

<table>
<thead>
<tr>
<th>Type</th>
<th>Dynamic Friction Coefficient (μ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miniature Slide Guides</td>
<td>0.004~0.006</td>
</tr>
<tr>
<td>Medium Load Slide Guides</td>
<td>0.002~0.003</td>
</tr>
<tr>
<td>Slide Ways</td>
<td>0.001~0.003</td>
</tr>
<tr>
<td>Slide Blocks</td>
<td>0.001~0.003</td>
</tr>
<tr>
<td>Linear Bushings</td>
<td>0.002~0.003</td>
</tr>
<tr>
<td>Linear Ball Bushings</td>
<td>0.0008~0.0012</td>
</tr>
</tbody>
</table>

**Hardness Coefficient**

- **Rated Life Span (L)**
  - In a linear system, the shaft must be hard enough to withstand contact with the ball bearings. Unless sufficient hardness is provided, the allowable load can decrease, resulting in a short useful life. Compensate the rated life span with the hardness coefficient.

**Contact Coefficient**

- **Rated Life Span (L)**
  - In general, two or more linear systems are used with each shaft. Depending on the machining precision, the load exerted on each of the respective systems can vary. In this case, the load applied on each linear system changes depending on the machining precision, therefore it cannot be uniformly applied. As a result, allowable load per linear system changes depending on the number of linear systems in use. Compensate the rated life span with the contact coefficient in Table-2.

**Load Coefficient**

- **Rated Life Span (L)**
  - When calculating the load that acts on a linear system, it is necessary to work with precise figures for material weight, the force of inertia resulting from operating speed, load moment, various changes that occur over time, and so on. It is difficult to have accurate calculation for oscillating movement as beside the normal repetition of start and stop, other factors such as vibration and impact also need to be considered. Therefore, the life span calculation needs to be simplified using the load coefficient in Table-3.

**Linear Bushings**

- **Rated Life Span (L)**
  - Rated life span can be obtained as follows from the dynamic basic load rating and the load to the linear bushing.

\[
L = \frac{P \cdot \ell_s \cdot n}{2 \times 60} \quad \text{(2 hours / hr)}
\]

- **Linear Ball Bushings**
  - Rated life span can be obtained as follows from the basic dynamic load rating and the load to the linear ball bushing.

\[
L = \frac{P \cdot \ell_s \cdot n}{2 \times 60} \quad \text{(2 hours / hr)}
\]

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**Temperature Coefficient**

- **Rated Life Span (L)**
  - When temperature is in a linear system exceeds 107°C, the hardness of the system and the shaft become degraded. This decreases the allowable load to a greater extent than when the system is used at ambient temperature, and can shorten the life span. Compensate the rated life span with the temperature coefficient.

**Table 3 - Contact Coefficient**

<table>
<thead>
<tr>
<th>Number of Bearings per Shaft</th>
<th>Contact Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.00</td>
</tr>
<tr>
<td>2</td>
<td>0.81</td>
</tr>
<tr>
<td>3</td>
<td>0.72</td>
</tr>
<tr>
<td>4</td>
<td>0.60</td>
</tr>
<tr>
<td>5</td>
<td>0.50</td>
</tr>
</tbody>
</table>

**Table 4 - Load Coefficients**

<table>
<thead>
<tr>
<th>Condition of Use</th>
<th>No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low speed with no external vibration or impact</td>
<td>1.0~1.5</td>
</tr>
<tr>
<td>Medium speed with no external vibration or impact of comparable forces, dimensions</td>
<td>1.6~2.0</td>
</tr>
<tr>
<td>High speed with no external vibration or impact (hydrostatic)</td>
<td>2.0~3.5</td>
</tr>
</tbody>
</table>

**Linear Ball Bushings**

- **Rated Life Span (L)**
  - Rated life span can be obtained as follows from the basic dynamic load rating and the load to the linear ball bushing.

\[
L = \frac{P \cdot \ell_s \cdot n}{2 \times 60} \quad \text{(2 hours / hr)}
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