## ■ Allowable Load

•Basic Dynamic Load Rating(C)

Basic dynamic load rating is a constant load applied in a constant direction that enables each linear system of the same series to travel $50 \times 10^3$m under the same conditions, without 90% of the material suffering damage from rolling contact fatigue.

•Basic Static Load Rating(Co)

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 0.0001 times the diameter of the rolling element.

•Allowable Static Moment($M_P$, $M_Y$, $M_R$)

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 as in basic static load rating Co.

•Static Safety Factor($f_S$)

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

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

| Condition of Use | Lower Limit of $f_S$ |
|---|---|
| Under Normal Operating Conditions | 1~2 |
| When Smooth Travel is Required | 2~4 |
| When Subjected to Vibrations, Impacts | 3~5 |

| |
|---|
| Allowable Load(N) $\leq$ Co/$f_S$ |
| Allowable Moment(N·m) $\leq$ ($M_P$, $M_Y$, $M_R$)/$f_S$ |

$f_S$:Static Safety Factor   Co:Basic Static Load(N)
$M_P$, $M_Y$, $M_R$ : Static Allowable Moment(N·m)

## ■ Life Span

When a load is applied to a linear system, the system moves back and forth in a linear direction. In the process, repeated stress acts upon rolling elements and rolling contact surfaces, causing damage referred to as flaking from material fatigue. The life span of a linear system is measured in terms of the total travel distance covered by the system up until initial flaking occurs.

•Rated Life Span(L)

Rated life span is the total travel distance that each linear system of the same series can endure under the same conditions, without the occurrence of flaking in 90% of the system.

Rated life span can be obtained as follows from the basic dynamic load rating and various loads exerted on the linear system.

| | |
|---|---|
| For Ball Bearings | $L = \left(\dfrac{C}{P}\right)^3 \cdot 50$ |
| For Roller Bearings | $L = \left(\dfrac{C}{P}\right)^{10/3} \cdot 50$ |

L : Rated Life Span(km)
C : Basic Dynamic Load Rating(N)
P : Acting Load(N)

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•When actually using a linear system, the first thing you must do is to calculate the load. It is necessary to consider load also in terms of vibration and impact that occur during operation, as well as its distribution across the entire linear system as it moves back and forth in a linear direction. Calculations are not simple. Operating temperature also significantly influences useful life. When these parameters are taken into consideration, the above formula is transformed as follows:

| | |
|---|---|
| For Ball Bearings | $L = \left(\dfrac{f_H \cdot f_T \cdot f_C}{f_W} \cdot \dfrac{C}{P}\right)^3 \cdot 50$ |
| For Roller Bearings | $L = \left(\dfrac{f_H \cdot f_T \cdot f_C}{f_W} \cdot \dfrac{C}{P}\right)^{10/3} \cdot 50$ |

L  : Rated Life Span(km)
$f_H$ : Hardness Coefficient(See Fig.1)
C  : Basic Dynamic Load Rating(N)
$f_T$ : Temperature Coefficient(See Fig.2)
P  : Acting Load(N)
$f_C$ : Contact Coefficient(See Table3)
$f_W$ : Load Coefficient(See Table4)

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.

$$L_h = \frac{L \cdot 10^3}{2 \cdot \ell_s \cdot n_1 \cdot 60}$$

$L_h$  : Life Span Hours(hr)
$\ell_s$  : Stroke Length(m)
L  : Rated Life Span(km)
$n_1$  : Reciprocating Times per Minute(cpm)

## ■ Friction Resistance and Required Thrust

Using the following formula, the friction resistance(required thrust)can be obtained from the load and the seal resistance specified by the system.

$$F = \mu \cdot W + f$$

F : Friction Resistance(N)
μ : Dynamic Friction Coefficient
W: Weight Loaded
f  : Seal Resistance(2N~5N)

**Table-2 Dynamic Friction Coefficient**

| Type | Dynamic Friction Coefficient(μ) |
|---|---|
| Miniature Slide Guides | 0.004~0.006 |
| Medium Load Slide Guides | 0.002~0.003 |
| Slide Ways | 0.001~0.003 |
| Slide Tables | 0.001~0.003 |
| Linear Bushings | 0.002~0.003 |
| Linear Ball Bushings | 0.0006~0.0012 |

---

•Hardness Coefficient($f_H$)

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.

**Fig-1.  Hardness Coefficient**



Track Surface Hardness  HRC
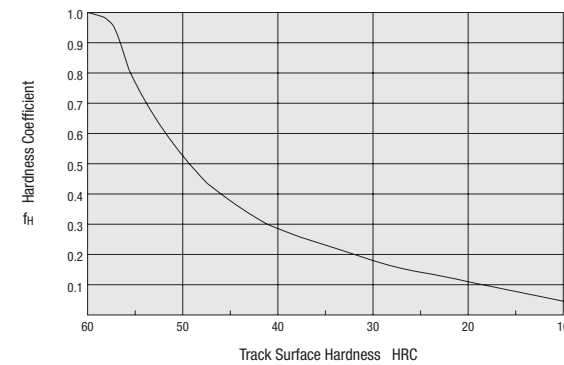
•Contact Coefficient($f_C$)

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 on one axis. Compensate the rated life span with the contact coefficient in Table-2.

•Load Coefficient($f_W$)

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. However, 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 can be obtained as follows from the basic dynamic load rating and the load to the linear bushing.

$$L = \left(\frac{f_H \cdot f_T \cdot f_C}{f_W} \cdot \frac{C}{P}\right)^3 \cdot 50$$

L  : Rated Life Span(km)          $f_H$ : Hardness Coefficient(See Fig.1)
C : Basic Dynamic Load Rating(N)  $f_T$ : Temperature Coefficient(See Fig.2)
P : Working Load(N)                $f_C$ : Contact Coefficient(See Table3)
$f_W$ : Load Coefficient(See Table4)

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 using the following formula, in which stroke length and stroke cycles are assumed to be constant.

$$L_h = \frac{L \cdot 10^3}{2 \cdot \ell_s \cdot n_1 \cdot 60}$$

$L_h$: Life Span Hours(hr)   $\ell_s$: Stroke Length(m)   L: Rated Life Span(km)
$n_1$: Reciprocating Times per Minute(cpm)

---

•Temperature Coefficient($f_T$)

When temperature in a linear system exceeds 100℃, 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.
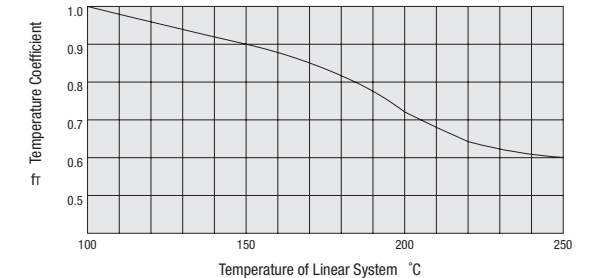
**Fig.-2  Temperature Coefficient**



Temperature of Linear System  ℃

**Table-3.  Contact Coefficient**

| Number of Bearings per Shaft | Contact Coefficient fc |
|---|---|
| 1 | 1.00 |
| 2 | 0.81 |
| 3 | 0.72 |
| 4 | 0.66 |
| 5 | 0.61 |

**Table-4.  Load Coefficients**

| Condition of Use | fw |
|---|---|
| Low speed with no external vibration or impact (Max. 15m/min) | 1.0~1.5 |
| Middle range speed with no exerted vibration or impact of considerable force(Max. 60m/min) | 1.5~2.0 |
| High speed with no external vibration or impact (Over 60m/min) | 2.0~3.5 |

### ■ 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.

$$L = \left(\frac{f_H \cdot f_T \cdot f_C}{f_W} \cdot \frac{C}{P}\right)^3 \cdot 50$$

L : Rated Life Span(km)          $f_H$ : Hardness Coefficient(See Fig.1)
C : Basic Dynamic Load Rating(N)  $f_T$ : Temperature Coefficient(See Fig.2)
P : Working Load(N)                $f_C$ : Contact Coefficient(See Table3)
$f_W$ : Load Coefficient(See Table4)

Life Span Hours
·For revolution and reciprocating motion

$$L_h = \frac{10^6 \cdot L}{60 \sqrt{(dm \cdot n)^2 + (10 \cdot S \cdot n_1)^2}/dm}$$

·For reciprocating motion

$$L_h = \frac{10^6 \cdot L}{600 \cdot S \cdot n_1/(\pi \cdot dm)}$$

$L_h$ : Life Span Hours(hr)   S : Stroke Length(mm)   n : Revolutions per Minute(rpm)
$n_1$ : Strokes Per Minute(cpm)
dm : Pitch Diameter of Ball(mm)≈1.15dr
·Revolution and reciprocal motion allowable values

| |
|---|
| DN≥dm·n+10·S·$n_1$ |