3.6. Calculating the Average Load

In cases where the load applied to each LM block fluctuates under different conditions, such as an industrial robot holding a workpiece with its arm as it advances and receding with its arm empty, and a machine tool handling various workpieces, it is necessary to calculate the service life of the LM Block while taking into account such fluctuating loading conditions.
The average load (P_m) is the load under which the service life of the LM Guide is equivalent to that under varying loads applied to the LM blocks.
The basic equation for calculating the average load is indicated below.

where

$$P_m = \sqrt[3]{\frac{1}{L} \cdot \sum_{n=1}^{n} (P_n^3 \cdot L_n)}$$

P_m	: Average load	(N)
P_n	: Varying load	(N)
L	: Total distance traveled	(mm)
L_n	: Distance traveled under load P_n	(mm)

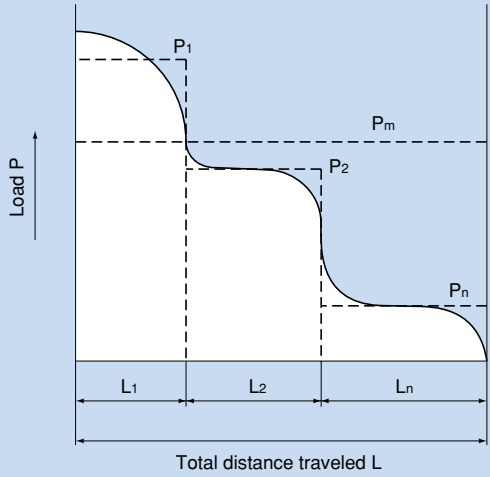
Note: The above equation or the equation (1) below applies when the rolling elements are balls.

① When the load varies in steps

where

$$P_m = \sqrt[3]{\frac{1}{L}(P_1^3 \cdot L_1 + P_2^3 \cdot L_2 \cdots\cdots + P_n^3 \cdot L_n)} \quad \cdots\cdots\cdots\cdots (1)$$

P_m	: Average load	(N)
P_n	: Varying load	(N)
L	: Total distance traveled	(mm)
L_n	: Distance traveled under load P_n	(mm)

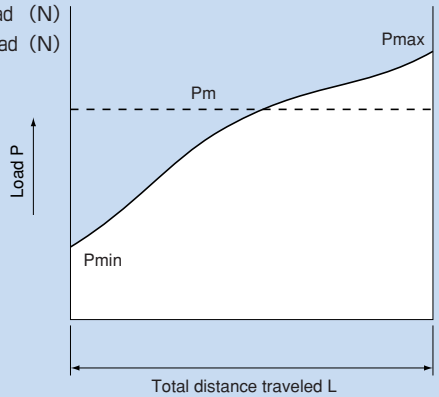


② When the load varies monotonously

where

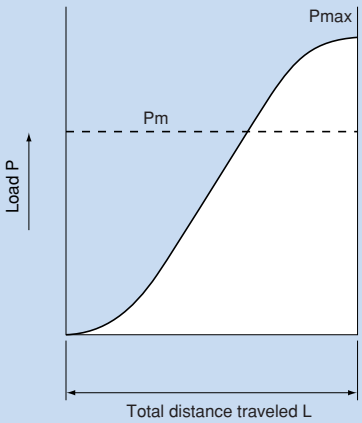
$$P_m \fallingdotseq \frac{1}{3}(P_{min} + 2 \cdot P_{max}) \quad \cdots\cdots\cdots(2)$$

P_{min} : Minimum load (N)
P_{max} : Maximum load (N)

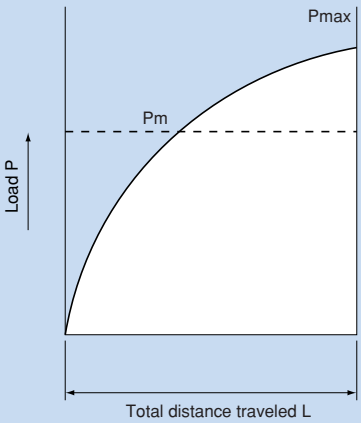


③ When the load varies sinusoidally

ⓐ $P_m \fallingdotseq 0.65P_{max}$ ·····(3)

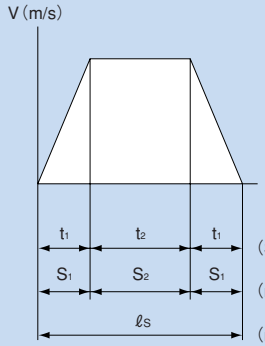


ⓑ $P_m \fallingdotseq 0.75P_{max}$ ·····(4)

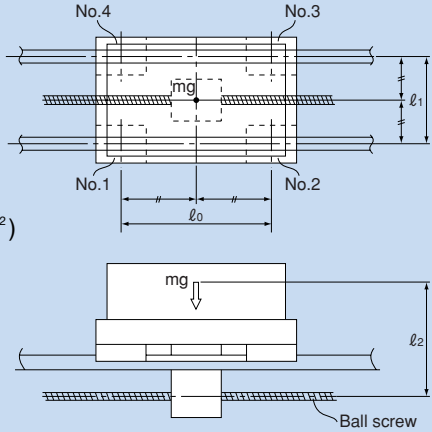


3.6.1. Example of Calculating the Average Load (1) - with Horizontal Mount and Acceleration/Deceleration Considered

[Service conditions]



$$\alpha_1 = \frac{v}{t_1} (m/s^2)$$



Load applied to the LM block

●During uniform motion ●During acceleration ●During deceleration

During uniform motion	During acceleration	During deceleration
$P_1 = +\frac{mg}{4}$	$Pa_1 = P_1 + \frac{m \cdot \alpha_1 \cdot \ell_2}{2 \cdot \ell_0}$	$Pd_1 = P_1 - \frac{m \cdot \alpha_1 \cdot \ell_2}{2 \cdot \ell_0}$
$P_2 = +\frac{mg}{4}$	$Pa_2 = P_2 - \frac{m \cdot \alpha_1 \cdot \ell_2}{2 \cdot \ell_0}$	$Pd_2 = P_2 + \frac{m \cdot \alpha_1 \cdot \ell_2}{2 \cdot \ell_0}$
$P_3 = +\frac{mg}{4}$	$Pa_3 = P_3 - \frac{m \cdot \alpha_1 \cdot \ell_2}{2 \cdot \ell_0}$	$Pd_3 = P_3 + \frac{m \cdot \alpha_1 \cdot \ell_2}{2 \cdot \ell_0}$
$P_4 = +\frac{mg}{4}$	$Pa_4 = P_4 + \frac{m \cdot \alpha_1 \cdot \ell_2}{2 \cdot \ell_0}$	$Pd_4 = P_4 - \frac{m \cdot \alpha_1 \cdot \ell_2}{2 \cdot \ell_0}$

Average load

$$P_{m1} = \sqrt[3]{\frac{1}{\ell_S} (Pa_1^3 \cdot s_1 + P_1^3 \cdot s_2 + Pd_1^3 \cdot s_3)}$$

$$P_{m2} = \sqrt[3]{\frac{1}{\ell_S} (Pa_2^3 \cdot s_1 + P_2^3 \cdot s_2 + Pd_2^3 \cdot s_3)}$$

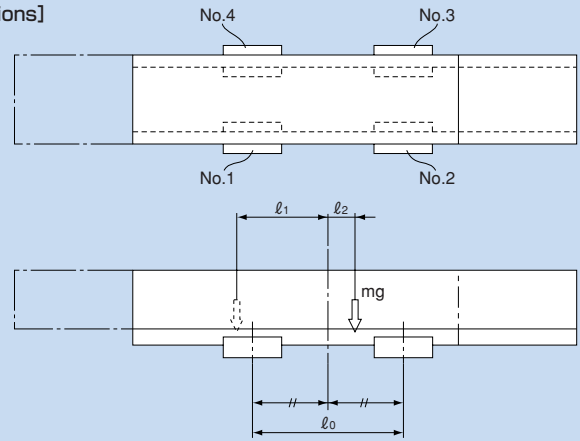
$$P_{m3} = \sqrt[3]{\frac{1}{\ell_S} (Pa_3^3 \cdot s_1 + P_3^3 \cdot s_2 + Pd_3^3 \cdot s_3)}$$

$$P_{m4} = \sqrt[3]{\frac{1}{\ell_S} (Pa_4^3 \cdot s_1 + P_4^3 \cdot s_2 + Pd_4^3 \cdot s_3)}$$

Note: Pa_n and Pd_n represent loads applied to each LM block. The suffix "n" indicates the block number in the diagram above.

3.6.2. Example of Calculating the Average Load (2) - When the Rails are Movable

[Service conditions]



Load applied to the LM block

●At the left of the arm

$$P_{\ell 1} = +\frac{mg}{4} + \frac{mg \cdot \ell_1}{2 \cdot \ell_0}$$

$$P_{\ell 2} = +\frac{mg}{4} - \frac{mg \cdot \ell_1}{2 \cdot \ell_0}$$

$$P_{\ell 3} = +\frac{mg}{4} - \frac{mg \cdot \ell_1}{2 \cdot \ell_0}$$

$$P_{\ell 4} = +\frac{mg}{4} + \frac{mg \cdot \ell_1}{2 \cdot \ell_0}$$

●At the right of the arm

$$P_{r1} = +\frac{mg}{4} - \frac{mg \cdot \ell_2}{2 \cdot \ell_0}$$

$$P_{r2} = +\frac{mg}{4} + \frac{mg \cdot \ell_2}{2 \cdot \ell_0}$$

$$P_{r3} = +\frac{mg}{4} + \frac{mg \cdot \ell_2}{2 \cdot \ell_0}$$

$$P_{r4} = +\frac{mg}{4} - \frac{mg \cdot \ell_2}{2 \cdot \ell_0}$$

Average load

$$P_{m1} = \frac{1}{3}\left(2 \cdot |P_{\ell 1}| + |P_{r1}|\right)$$

$$P_{m2} = \frac{1}{3}\left(2 \cdot |P_{\ell 2}| + |P_{r2}|\right)$$

$$P_{m3} = \frac{1}{3}\left(2 \cdot |P_{\ell 3}| + |P_{r3}|\right)$$

$$P_{m4} = \frac{1}{3}\left(2 \cdot |P_{\ell 4}| + |P_{r4}|\right)$$

Note: $P_{\ell n}$ and P_{rn} represent loads applied to each LM block. The suffix "n" indicates the block number in the diagram above.