

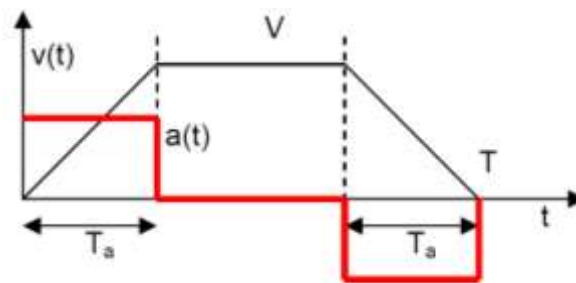
## Equivalent Operating Load

Jeff G. Johnson, Product Engineer  
 Thomson Industries, Inc.  
 540-633-3549  
[www.thomsonlinear.com](http://www.thomsonlinear.com)  
[Thomson@thomsonlinear.com](mailto:Thomson@thomsonlinear.com)

---

The formula for determining the equivalent operating load ( $F_{eq}$ ) is important. Many engineers will just use the nominal operating load ( $F$ ) when calculating the life of a ball screw but in extreme cases this may neglect some significant loads and forces such as those due to impact, shock, extreme acceleration / deceleration, externally applied loads, etc.

In the example used in [the article](#), I assumed a simple trapezoidal motion profile (See Figure 1) whereas the system was accelerating or decelerating approximately 9% of the time and was at constant velocity for 91% of the time.



**Figure 1 - Trapezoidal Motion Profile**

Figure 2 is an excerpt from the engineering section of the [Thomson catalog](#) and can be found in most ball screw texts. The equivalent force equation is given as:

$$F_{eq} = \left( \sum_{i=1}^n F_i^3 \times \frac{n_i}{n_{eq}} \times \frac{q_i}{100} \right)^{1/3}$$

Where:

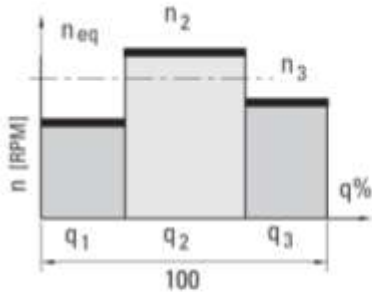
$F_{eq}$  = Equivalent Load  
 $n_{eq}$  = Equivalent Speed  
 $q$  = percentage of time

Since this is a constant velocity application, we will ignore the equivalent speed term and simplify the equivalent load equation as follows:

$$F_{eq} = \left( \sum_{i=1}^n F_i^3 \times \frac{q_i}{100} \right)^{1/3}$$

Solving this equation gives us the final answer of approximately 304 N.

**Simple rotational speed profile**



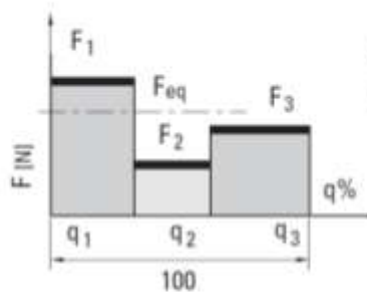
$$n_{eq} [\text{min}^{-1}] = \sum_{i=1}^n n_i \times \frac{q_i}{100}$$

**Modified Life**

$$L_{10} [\text{revolutions}] = \left[ \frac{C_{am}}{F_{eq}} \right]^3 \times 10^6$$

$$L_{h10} [\text{hours}] = \frac{L_{10}}{n_{eq} \times 60}$$

**Simple loading profile (1)**

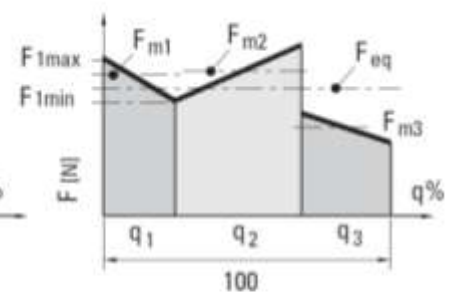


$$F_{eq} [N] = \left( \sum_{i=1}^n F_i^3 \times \frac{n_i}{n_{eq}} \times \frac{q_i}{100} \right)^{1/3}$$

**Parameters:**

- $n_{eq}$  = equivalent operating rotational speed [rpm]
- $F_{eq}$  = equivalent operating load [N]
- $C_{am}$  = dynamic load rating [N] (see specification tables) (Based on 1.0 million revolutions)

**Simple loading profile (2)**



$$F_{eq} [N] = \left( \sum_{i=1}^n F_{mi}^3 \times \frac{n_i}{n_{eq}} \times \frac{q_i}{100} \right)^{1/3}$$

**Figure 2 - Equivalent Force Equations**