

MORRELL PRODUCT GUIDE: MECHANICAL

SUBJECT: Rexroth Star Linear Profile Ball Rail Basic Dynamic Capacity and Ball Chains

SECTION 1.0

L10 Life for Bearings

L10 life Bearings are often specified to give an "L10" life (outside the USA, it may be referred to as "B10" life.) This is the life at which ten percent of the bearings in that application can be expected to have failed due to classical fatigue failure (and not any other mode of failure like lubrication starvation, wrong mounting etc.), or, alternatively, the life at which ninety percent will still be operating. The L10 life of the bearing is theoretical life and may not represent service life of the bearing. Bearings are also rated using C0 (static loading) value.

The industry standard life calculation is based upon the work of Lundberg and Palmgren performed in 1947. The formula assumes the life to be limited by metal fatigue and that the life distribution can be described by a Weibull distribution.

After many years of testing, this life method is standardized today in ISO 281:1990/Amd 2:2000. It standardizes (Cd) Basic Dynamic Ratings of bearings based the below formula. In fact, in 1975 NASA published their "LIFE ANALYSIS OF HELICAL GEAR SETS USING LUNDBERG-PALMGREN THEORY."

$$\text{eq 1.0} \quad L_{10} = \left(\frac{C_d}{F_{eq}} \right)^3 \times 10^5 \text{ km}$$

$$\text{eq 2.0} \quad C_d = 552 \frac{(1 \pm \gamma)^{29/27} \alpha}{(1 \pm \gamma)^{1/4} \alpha} \left(\frac{\gamma}{\cos \alpha} \right) D^{29/27} l^{7/9} Z^{-1/4}$$

VARIABLES

eq 1.0 **L₁₀ = Linear Ball Bearing L10 Life in km**

eq 2.0 **C_d = Basic Dynamic Capacity**

F_{eq} = Equivalent Running Load

D = Ball Diameter

d_m = System Pitch Diameter

γ = D x [(cos α) / d_m]

α = Contact Angle (See Diagram 1.0)

l = 1.0 (Unless Rollers are not Ball Bearings)

Z = Number of Rolling Elements Per Row

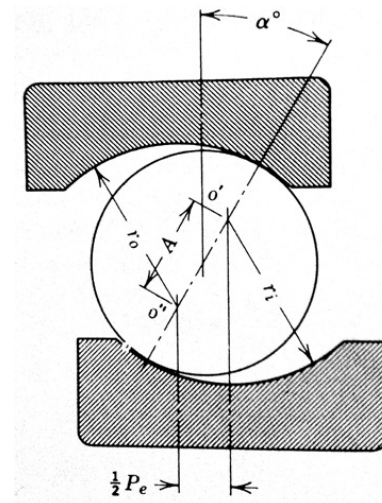


Diagram 1.0
Contact Angle α

Other factors that will de-rate the (Cd) Basic Dynamic Ratings of bearings are:

- 1) The quality of the bearing steel.
- 2) The hardness of the raceways and rolling elements based on a standard of Rockwell C 58 throughout the rolling element.

Note: To accommodate the improvements in bearing geometrical accuracies afforded by modern manufacturing methods and improvements in the model basic rolling bearing steel chemistries and metallurgies, both ANSI and ISO have included in the formulas for basic load rating a rating factor for contemporary, normally used material and manufacturing quality.

Diagram 2.0 shows how the linear bearing geometry can affect the contact angle used in the calculation of the (Cd) Basic Dynamic Ratings of bearings. The contact angle can be optimized to maximize the (Cd) Basic Dynamic Rating, but may limit the C0 (static loading) value due to shifts in the raceways during static loading which moves the position of the balls towards the raceway edge.

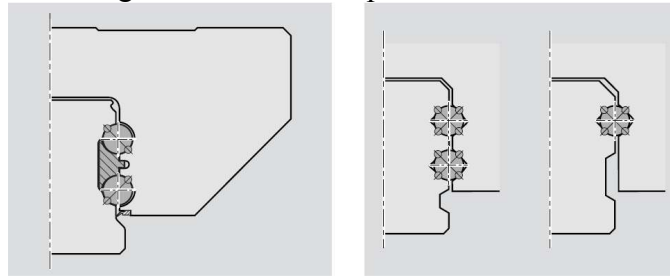


Diagram 2.0

These formulas are based on the compression and expansion of the rolling elements as they leave and re-enter the bearing load zones.

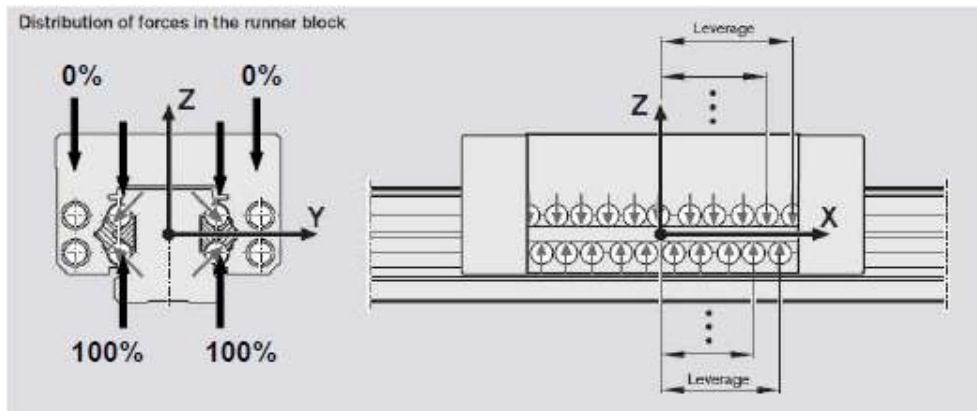


Diagram 3.0

Diagram 3.0 shows that as the balls circulate around the track, they move from the outside track to the inside raceways, in which they contact the ball rail raceway.

On the outside track, they are loaded at 0% of the equivalent running force, F_{eq} .

On the inside track, they are load at 100% of the equivalent running force, F_{eq} , where the balls compress down to an egg shape. This loading and unloading of the balls results in metal fatigue, which, over time, stops the bearings ability to continue rolling.

SECTION 2.0

L10 Life Comparison

Based on the published (Cd) Basic Dynamic Ratings of bearings, the below charts compare standard Rexroth Star Linear Bearings to its competitors. Please note that both the SHS-C and 411NA utilize ball chain technology.

TABLE 1.0
Published Rating of Basic Dynamic Capacities for 100,000km

	Star 1651	THK SHS-C	Thomson 411NA	NSK LAH-FL	INA KUYE	IKO LWH
Size 15 Cd (lbs)	1754	1749	2091	NA	1619	1662
Size 20 Cd (lbs)	4226	2837	3214	2534	2945	2587
Size 25 Cd (lbs)	5125	3943	4519	3747	4024	3586
Size 30 Cd (lbs)	7126	5496	6677	5210	6182	4996
Size 35 Cd (lbs)	9419	7583	9532	6959	8543	6620
Size 45 Cd (lbs)	15309	10064	13039	11776	15512	10099

TABLE 2.0
L10 Life in Millions Km based on 15% of the Star 1651 Cd (Basic Dynamic Capacity)

	Star 1651	THK SHS-C	Thomson 411NA	NSK LAH-FL	INA KUYE	IKO LWH
Size 15 L10 (263 lbs)	29.6	29.4	50.2	NA	23.3	25.2
Size 20 L10 (634 lbs)	29.6	9.0	13.0	6.4	10.0	6.8
Size 25 L10 (769 lbs)	29.6	13.5	20.3	11.6	14.3	10.2
Size 30 L10 (1069 lbs)	29.6	13.6	24.4	11.6	19.3	10.2
Size 35 L10 (1413 lbs)	29.6	15.5	30.7	11.9	22.1	10.3
Size 45 L10 (2296 lbs)	29.6	8.4	18.3	13.5	30.8	8.5

TABLE 3.0
L10 Life in Millions Km based on 30% of the Star 1651 Cd (Basic Dynamic Capacity)

	Star 1651	THK SHS-C	Thomson 411NA	NSK LAH-FL	INA KUYE	IKO LWH
Size 15 Cd (526 lbs)	3.7	3.7	6.3	NA	2.9	3.2
Size 20 Cd (1268 lbs)	3.7	1.1	1.6	0.8	1.3	0.8
Size 25 Cd (1538 lbs)	3.7	1.7	2.5	1.4	1.8	1.3
Size 30 Cd (2138 lbs)	3.7	1.7	3.0	1.4	2.4	1.3
Size 35 Cd (2826 lbs)	3.7	1.9	3.8	1.5	2.8	1.3
Size 45 Cd (4593 lbs)	3.7	1.1	2.3	1.7	3.9	1.1

TABLE 4.0
L10 Life Percentage - Star Linear Bearing vs. Competitor
i.e. Upon the same running loads, 1651 Size 25 will run 2.18 times longer than a THK SHS-C Size 25 before the metal fatigues.

	Star 1651	THK SHS-C	Thomson 411NA	NSK LAH-FL	INA KUYE	IKO LWH
Size 15	NA	100%	59%	NA	128%	116%
Size 20	NA	336%	231%	463%	285%	463%
Size 25	NA	218%	148%	264%	206%	285%
Size 30	NA	218%	123%	264%	154%	285%
Size 35	NA	195%	97%	247%	132%	285%
Size 45	NA	336%	161%	218%	95%	336%

SECTION 3.0

Ball Chains (Caged Rolling Elements)

Rexroth recommends using a ball chain particularly in applications calling for low noise levels.

Ball runner blocks can be equipped with a ball chain (Diagram 4.0) as an option. The ball chain prevents the balls from bumping into each other and ensures smoother travel.

This reduces the noise level. Runner blocks with ball chains have fewer load-bearing balls, which may result in **lower** load and load moment capacities.

Lower load capacities results in significantly lower L10 bearing lives, per section 1.0 and 2.0 on pages 1 & 2.

Some claims have been made that the ball chain extends the metal fatigue of rolling elements because the chain prevents the rolling elements from hitting. This is untrue. The forces from the balls hitting each other or rubbing is inconsequential as compared to the forces created from rolling elements entering and leaving the load zones as mentioned on page 2.



Ball chain (optional)
– Optimizes noise levels

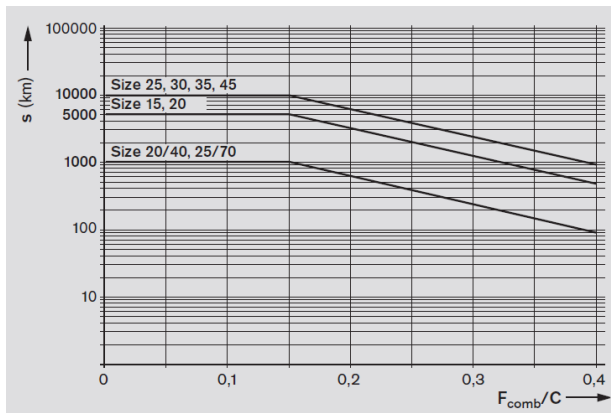
Diagram 4.0

SECTION 4.0

Rexroth Generation 20 Runner Block Re-Design

10 Million Meter Re-Lubrication Interval.

Rexroth runner blocks with a '-20' at the end of the model number include a generation 20 end module. There is minimal lubrication consumption due to an internal, integrated slow-release reservoir. Rolling elements are wiped with oil every pass shown in Diagram 5.



Graph 1.0



Diagram 5.0

Re-lubrication cycle is based on the cleanliness of the bearing during operation and loading.

Note: Graph 1.0 Shows 5 Million meters lube interval for 15 & 20.