General Technical Data and Calculations

General notes

The general technical data and calculations apply to all Roller Rail Systems, i.e., to all roller runner blocks and roller guide rails. Specific technical data relating to the individual roller runner blocks and roller guide rails is given separately.

Preload classes

To cater for the widest possible range of applications, Rexroth roller runner blocks (RB) are provided in different preload classes.

The following preload classes are available as standard:
- RB with preload class C2
- RB with preload class C3

Special version on request:
- RB with preload class C1, C4, C5

So as not to reduce the service life, the preload should not exceed 1/3 of the load on bearing F.

In general, the rigidity of the roller runner block rises with increasing preload.

Guide systems with parallel rails

In addition to the preload class, the permissible parallelism offset of the rails must also be taken into account (see “Selection of Accuracy Classes”).

Speed

$v_{max} = 4^{1)}$ m/s

1) Sizes:
55/85, 65/100, 65 FXS: 3 m/s
100 and 125: 2 m/s

Acceleration

$a_{max} = 150\ m/s^2$

Requirement:
The Roller Rail System must always be preloaded, even when operated under load!

Operating temperature range

-10 °C ... 80 °C

Brief peaks up to 100 °C are permitted.
For even lower sub-zero temperatures, please consult us.

Friction

The table lists reference values for the frictional force in a sealed and lubricated complete roller runner block.
When the roller runner block starts to move, the frictional force can be 1.5 to 2 times the given value, depending on the length of time it has been at a standstill, as well as the type, quantity and condition of the lubricant, and the amount of dirt that has accumulated on the roller guide rail.
This applies to all roller runner blocks in all preload classes.
The friction coefficient μ is approx. 0.0004 to 0.001 (excluding seal friction).

Size	Friction force F_R (N)
25	30
30	40
35	40
45	60
55	70
65	90
55/85	70
65/100	90
100	400[1)]
125	600[1)]

1) Directly after lubrication, the frictional drag will be approx. 50% higher.

Seals

The purpose of seals is to prevent dirt, chips, etc. from entering the roller runner block and thus shortening its service life.
It also prevents the lubricant from being dragged out.

Standard

Seals are fitted to Rexroth roller runner blocks as standard. They provide equal sealing performance on roller guide rails with and without cover strip.

FKM seals

FKM seals are optional accessories to be fitted by the customer.
They are for use in environments heavily soiled with fine dirt or metal particles.

- Use in applications involving the use of coolants or cutting fluids in addition to the presence of dirt and metal particles.
- Replaceable.

Scraper plates

Scraper plates are optional accessories to be fitted by the customer.

- For use in environments with hot metal chips or welding spatter.

General Technical Data and Calculations

Forces and load moments

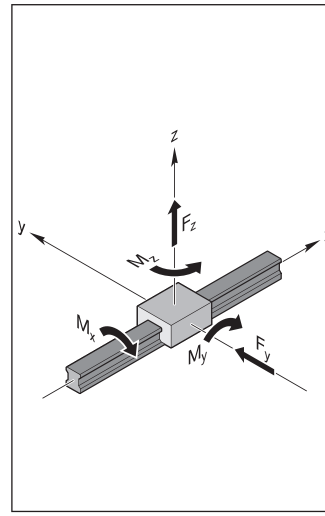
In Rexroth Roller Rail Systems the running tracks are arranged at a compression angle of 45°. This results in the same high load capacity of the entire system in all four major planes of load application. The roller runner blocks can be subjected to forces and to load moments.

Forces in the four major planes of load application

- Pull F_z (positive z-direction)
- Push $-F_z$ (negative z-direction)
- Side load F_y (positive y-direction)
- Side load $-F_y$ (negative y-direction)

Moments

- Moment M_x (about the x-axis)
- Moment M_y (about the y-axis)
- Moment M_z (about the z-axis)



Definition of load capacities

Dynamic load capacity C

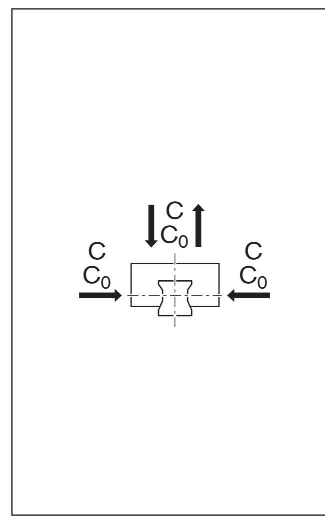
The radial loading of constant magnitude and direction which a linear rolling bearing can theoretically endure for a nominal life of 10^5 meters distance traveled (as per ISO 14728 Part 1).

Note: The dynamic load capacities given in the tables are above the ISO values. They have been proven in tests.

Static load capacity C_0

Static load in the load direction that corresponds to a calculated load in the center of the contact point with the greatest load between the rolling element and track zone (roller guide rail) of 4000 MPa.

Note: With this load on the contact point, a permanent overall deformation of the rolling element and track zone occurs, corresponding to around 0.0001 times the roller body diameter (as per ISO 14728 Part 1).



Definition of moment load capacities

Dynamic torsional moment load capacity M_t

Comparative dynamic moment about the longitudinal axis x which causes a load equivalent to the dynamic load capacity C.

Static torsional moment load capacity M_{t0}

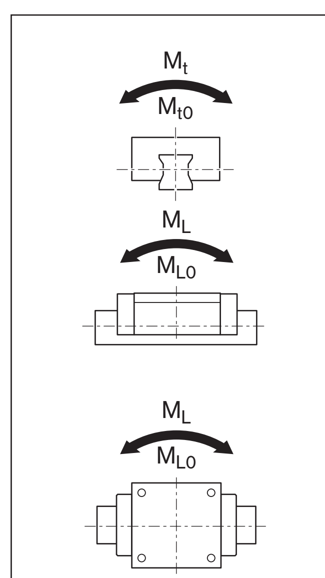
Comparative static moment about the longitudinal axis x which causes a load equivalent to the static load capacity C_0.

Dynamic longitudinal moment load capacity M_L

Comparative dynamic moment about the transverse axis y or the vertical axis z which causes a load equivalent to the dynamic load capacity C.

Static longitudinal moment load capacity M_{L0}

Comparative static moment about the transverse axis y or the vertical axis z which causes a load equivalent to the dynamic load capacity C_0.



Definition and calculation of the nominal life

The calculated service life which an individual linear rolling bearing, or a group of apparently identical rolling element bearings operating under the same conditions, can attain with a 90% probability, with contemporary, commonly used materials and manufacturing quality under conventional operating conditions (as per ISO 14728 Part 1) and optimal installation conditions.

Nominal life in meters

$$(1)\quad L_{10} = \left(\frac{C}{F_m}\right)^{10/3} \cdot 10^5\ \text{m}$$

Service life in operating hours at constant stroke length and stroke frequency

$$(2)\quad L_{h\,10} = \frac{L_{10}}{2 \cdot s \cdot n \cdot 60}\ \text{h}$$

If the stroke length s and the stroke frequency n are constant throughout the service life, the service life in operating hours can be calculated using formula (2).

Nominal life at variable speed

$$(3)\quad L_{h\,10} = \frac{L_{10}}{60 \cdot v_m}$$

Alternatively, the service life in operating hours at average speed v_m can be calculated using formula (3).
When the speed is varied in steps, this average speed v_m is calculated using the discrete time steps q_{tn} of the individual load levels (4).

$$(4)\quad v_m = \frac{|v_1| \cdot q_{t1} + |v_2| \cdot q_{t2} + \ldots + |v_n| \cdot q_{tn}}{100\ \%}$$

Modified life expectancy

$$L_{na} = a_1 \cdot \left(\frac{C}{F_m}\right)^{10/3} \cdot 10^5\ \text{m}$$

$$L_{ha} = \frac{L_{na}}{2 \cdot s \cdot n \cdot 60}\ \text{h}$$

If 90% probability is not sufficient, the nominal life values must be reduced by the factor a_1 as given in the table below.

Probability (%)	L_{na}	Factor a_1
90	L_{10a}	1.00
95	L_{5a}	0.64
96	L_{4a}	0.55
97	L_{3a}	0.47
98	L_{2a}	0.37
99	L_{1a}	0.25

Notes

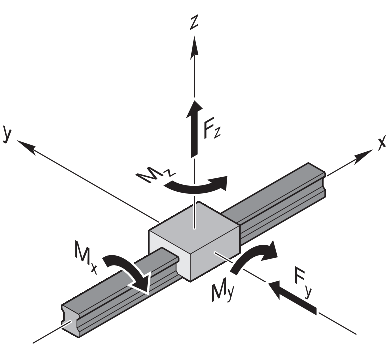
ISO 14728 Part 1 limits the applicability of formula (1) to equivalent dynamic loads $F_m < 0.5$ C. However, our tests have demonstrated that – under ideal operating conditions – this nominal life formula can be applied up to loads of $F_m = C$.
For stroke lengths less than 2 · roller runner block length B_1 (see dimension tables), a reduction in load capacity may have to be taken into account. Please consult us.

General Technical Data and Calculations

Load on bearings for calculation of nominal life

Combined equivalent load on bearing
With formula (5) all of the partial loads in a particular load case can be factored in to calculate the combined equivalent load on the bearing.

$$F_{comb} = |F_y| + |F_z| + C \cdot \frac{|M_x|}{M_t} + C \cdot \frac{|M_y|}{M_L} + C \cdot \frac{|M_z|}{M_L} \quad (5)$$

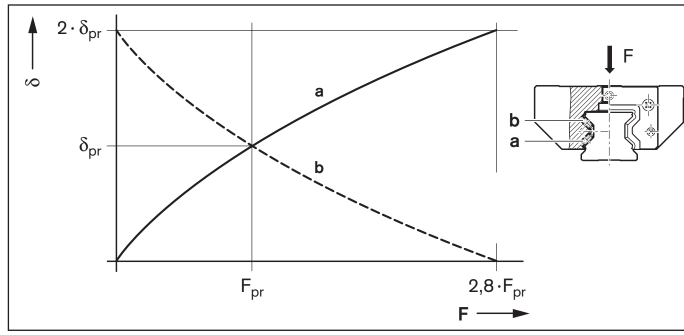


Notes
The calculation of the moment loads as shown in formula (5) applies only for applications with one single roller guide rail and one roller runner block. The formula is simpler for other combinations.

The forces and load moments shown in the coordinate system can also act in the opposite direction. An external load acting at an angle on the roller runner block is to be broken down into its F_y and F_z components, and these values are then to be used in formula (5). The structure of the roller runner block permits this simplified calculation.

Allowance for internal preload force F_{pr}
To increase the rigidity and accuracy of the guide system preloaded roller runner blocks should be used (see also “Selection of the preload class”).

When roller runner blocks in preload classes C2 and C3 are used, it may be necessary to take the internal preload force into account since the two rows of rollers a and b are designed to be oversized and are therefore preloaded against each other with an internal preload force F_{pr} which causes them to deform by the amount δ_{pr} (see chart).



a = loaded (lower) row of rollers
b = non-loaded (upper) row of rollers

δ = deformation of rollers at F
δ_{pr} = deformation of rollers at F_{pr}
F = load on the roller runner block
F_{pr} = internal preload force

Effective equivalent load on bearing
When an external load reaches 2.8 times the internal preload force F_{pr}, one row of rollers becomes preload-free.

Note
For highly dynamic load cases, the combined equivalent load on the bearings should be $F_{comb} < 2.8 \cdot F_{pr}$ in order to avoid damage to the rolling bearings due to slip.

$$F_{eff} = F_{comb} \qquad (6)$$

Case 1
$F_{comb} > 2.8 \cdot F_{pr}$
Here the internal preload force F_{pr} has no effect on the service life.

$$F_{eff} = \left(\frac{F_{comb}}{2.8 \cdot F_{pr}} + 1\right)^{3/2} \cdot F_{pr} \qquad (7)$$

Case 2
$F_{comb} \leq 2.8 \cdot F_{pr}$
The preload force F_{pr} is factored into the calculation of the effective equivalent load on bearing.

General Technical Data and Calculations

Equivalent dynamic load on bearing
For varying load levels, calculate the equivalent dynamic load on the bearings using formula (8).

$$(8)\quad F_m = \sqrt[\frac{10}{3}]{(F_{eff\,1})^{\frac{10}{3}} \cdot \frac{q_{s1}}{100\,\%} + (F_{eff\,2})^{\frac{10}{3}} \cdot \frac{q_{s2}}{100\,\%} + \ldots + (F_{eff\,n})^{\frac{10}{3}} \cdot \frac{q_{sn}}{100\,\%}}$$

Equivalent static load on bearing
For combined static external loads – vertical and horizontal – in conjunction with a static torsional or longitudinal moment load, calculate the equivalent static bearing on the load $F_{0\,comb}$ using formula (9).

$$(9)\quad F_{0\,comb} = |F_{0y}| + |F_{0z}| + C_0 \cdot \frac{|M_{0x}|}{M_{t0}} + C_0 \cdot \frac{|M_{0y}|}{M_{L0}} + C_0 \cdot \frac{|M_{0z}|}{M_{L0}}$$

Notes
The equivalent static load on the bearing $F_{0\,comb}$ must not exceed the static load capacity C_0. Formula (9) applies only when using a single roller guide rail.
An external load acting at an angle on the roller runner block is to be broken down into its F_{0y} and F_{0z} components, and these values are then to be used in formula (9).

Definitions and calculation for dynamic and static load ratios
The ratio between the load capacity of the roller runner block and the load applied to it can be used to pre-select the type of linear guide. The dynamic load ratio C/F_{max} and the static load ratio $C_0/F_{0\,max}$ should be chosen as appropriate for the application. This permits calculation of the required load capacity and selection of the guide rail size and roller runner block design style using the load capacity tables.

Recommended values for load ratios
The table below contains recommendations for load ratios.
The values are offered merely as a rough guide reflecting typical customer requirements (e.g. service life, accuracy, rigidity) by sector and application.

Case 1: Static load $F_{0\,max} > F_{max}$:

Case 2: Static load $F_{0\,max} < F_{max}$:

$$\text{Dynamic load ratio} = \frac{C}{F_{max}}$$

Case 1:
$$\text{Static load ratio} = \frac{C_0}{F_{0\,max}}$$

Case 2:
$$\text{Static load ratio} = \frac{C_0}{F_{max}}$$

Machine type/sector	Application example	C/F_{max}	$C_0/F_{0\,max}$
Machine tools	General	6 ... 9	> 4
	Turning	6 ... 7	> 4
	Milling	6 ... 7	> 4
	Grinding	9 ... 10	> 4
	Engraving	5	> 3
Rubber and plastics processing machinery	Injection molding	8	> 2
Woodworking and wood processing machines	Sawing, milling	5	> 3
Assembly /handling technology and industrial robots	Handling	5	> 3
Oil hydraulics and pneumatics	Raising/lowering	6	> 4

Static load safety factor S_0

Any design with rolling contact must be verified in relation to the static load safety factor. The static load safety factor for a linear guide is given by the following equation:

$$S_0 = \frac{C_0}{F_{0\,max}} \quad (10)$$

$F_{0\,max}$ represents the maximum load amplitude that can act on the linear guide. Here it is irrelevant whether the load only acts for a short time. It can represent a peak amplitude in a dynamic load spectrum. The data in the table apply to the design.

Conditions of use	**Static load safety factor S_0**
Overhead hanging arrangement und applications with high hazard potential	≥ 20
High dynamic stress at standstill, contamination.	8 - 12
Normal design of machines and plants, if all load parameters or connection accuracies are not known in full.	5 - 8
All load data are known in full. Shock-free movement is ensured.	3 - 5
If there are hazards for the health and safety of personnel, point 5.1.3 from DIN 637 is to be observed.	

Key to formulas

Symbols used in formulas	**Unit**	**Description**
a_1	–	Probability factor
C	N	Dynamic load capacity
C_0	N	Static load capacity (rating)
F_{max}	N	Maximum dynamic load
$F_{0\,max}$	N	Maximum static load
F_{comb}	N	Combined equivalent load on bearing
$F_{0\,comb}$	N	Static equivalent load on bearing
F_{eff}	N	Effective equivalent load on bearing
$F_{eff\,1-n}$	N	Uniform effective single loads
F_m	N	Equivalent dynamic load on bearing
F_{pr}	N	Preload force
F_y	N	External load due to a resulting force in the y-direction
F_{0y}	N	External load due to a static force in the y-direction
F_z	N	External load due to a resulting force in the z-direction
F_{0z}	N	External load due to a static force in the z-direction
M_t	Nm	Dynamic torsional moment load capacity[1)]
M_{t0}	Nm	Static torsional moment load capacity[1)]
M_L	Nm	Dynamic longitudinal moment load capacity[1)]
M_{L0}	Nm	Static longitudinal moment load capacity[1)]

Symbols used in formulas	**Unit**	**Description**
M_x	Nm	Load due to a resulting moment load about the x-axis
M_{0x}	Nm	Load due to a static moment load about the x-axis
M_y	Nm	Load due to a resulting moment load about the y-axis
M_{0y}	Nm	Load due to a static moment load about the y-axis
M_z	Nm	Load due to a resulting moment load about the z-axis
M_{0z}	Nm	Load due to a static moment load about the z-axis
L_{10}	m	Nominal life (travel)
$L_{h\,10}$	h	Nominal life (time)
L_{na}	m	Modified life expectancy (travel)
L_{ha}	h	Modified life expectancy (time)
n	min^{-1}	Stroke repetition rate (full cycles)
s	m	Stroke length
S_0	–	Static load safety factor
v_m	m/min	Average linear speed
v_1 ... v_n	m/min	Travel speed in phases 1 ... n
q_{t1} ... q_{tn}	%	Discrete time steps for v_1 ... v_n in phases 1 ... n

1) For values, see tables