General Technical Data and Calculations

Definition of dynamic load capacity

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 DIN 636 Part 2).

Definition of static load capacity

The static loading in the direction of load which corresponds to a calculated stress of 4200 M_{Pa} at the center of the most heavily loaded rolling-element/raceway (rail) contact with a ball conformity of $f_r \leq 0.52$, and 4600 M_{Pa} with a ball conformity of $f_r \geq 0.6$.

Note:
With this contact stress, a permanent overall deformation of the rolling element and the raceway will occur at the contact point corresponding to approx. 0.0001 times the rolling element diameter (as per DIN 636 Part 2).

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 (to DIN 636 Part 2).

Calculate the nominal life L or L_h according to formula (1), (2) or (3):

Nominal life at constant speed

(1) $$L = \left(\frac{C}{F_m}\right)^3 \cdot 10^5$$

(2) $$L_h = \frac{L}{2 \cdot s \cdot n_s \cdot 60}$$

Nominal life at variable speed

(3) $$L_h = \frac{L}{3600 \cdot v_m}$$

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

C	=	dynamic load capacity	(N)
F_m	=	equivalent dynamic load	(N)
L	=	nominal life	(m)
L_h	=	nominal life	(h)
n_s	=	stroke repetition rate (full cycles)	(min^{-1})
$q_{t1}, q_{t2}...q_{tn}$	=	discrete time steps for $v_1, v_2...v_n$	(%)
s	=	length of stroke	(m)
$v_1, v_2...v_n$	=	travel speeds	(m/s)
v_m	=	average speed	(m/s)

Equivalent dynamic load on bearing for calculation of service life

If the bearing is subject to variable loads, the equivalent dynamic load F_m must be calculated according to formula (5):

F_m = equivalent dynamic load (N)
$F_{eff1}, F_{eff2} \ldots F_{effn}$ = discrete load steps (N)
$q_{s1}, q_{s2} \ldots q_{sn}$ = discrete travel steps for $F_{eff1}, F_{eff2} \ldots F_{effn}$ (%)

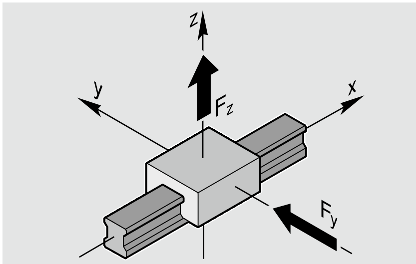
For variable load on bearing

(5)
$$F_m = \sqrt[3]{|F_{eff1}|^3 \cdot \frac{q_{s1}}{100\%} + |F_{eff2}|^3 \cdot \frac{q_{s2}}{100\%} + \ldots + |F_{effn}|^3 \cdot \frac{q_{sn}}{100\%}}$$

For combined load on bearing
The combined equivalent load on bearing F_{comb} resulting from combined vertical and horizontal external loads is calculated according to formula (6):

Note:
The structure of the Ball Rail System permits this simplified calculation.

(6)
$$F_{comb} = |F_y| + |F_z|$$

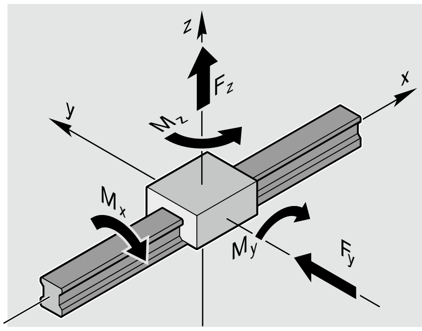


C = dynamic load capacity [2] (N)
F_{comb} = combined equivalent load on bearing (N)
F_y, F_z = dyn. external loads [1] (N)
M_L = dyn. longitudinal moment load capacity [2] (Nm)
M_t = dyn. torsional moment load capacity [2] (Nm)
M_x = dyn. torsional moment about the x-axis (Nm)
M_y = dyn. longitudinal moment load about the y-axis (Nm)
M_z = dyn. longitudinal moment load about the z-axis (Nm)

For combined load on the bearing in conjunction with a torsional moment
The combined equivalent load on bearing F_{comb} resulting from combined vertical and horizontal external loads in conjunction with a torsional moment is calculated according to formula (7):

Formula (7) applies only when using a single guide rail.

(7)
$$F_{comb} = |F_y| + |F_z| + C \cdot \frac{|M_x|}{M_t} + C \cdot \frac{|M_y|}{M_L} + C \cdot \frac{|M_z|}{M_L}$$

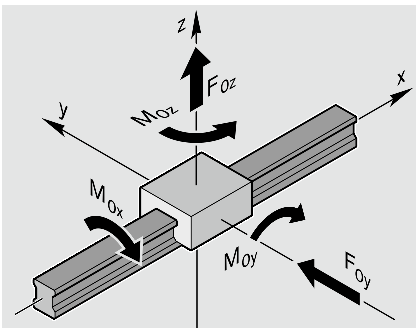


Equivalent static load on bearing

For combined static external loads – vertical and horizontal – in conjunction with a static torsional moment load, calculate the combined equivalent static load on the bearing F_{0comb} using formula (8).
The combined equivalent static load on the bearing F_{0comb} must not exceed the static load capacity C_0.

Formula (8) applies only when using a single guide rail.

(8)
$$F_{0comb} = |F_{0y}| + |F_{0z}| + C_0 \cdot \frac{|M_{0x}|}{M_{t0}} + C_0 \cdot \frac{|M_{0y}|}{M_{L0}} + C_0 \cdot \frac{|M_{0z}|}{M_{L0}}$$



C_0 = static load capacity [2] (N)
F_{0comb} = combined equivalent load on bearing (N)
F_{0y}, F_{0z} = stat. external load [1] (N)
M_{0x} = stat. torsional moment load about the x-axis (Nm)
M_{0y} = stat. longitudinal moment load about the y-axis (Nm)
M_{0z} = stat. longitudinal moment load about the z-axis (Nm)
M_{t0} = stat. torsional moment load [2] (Nm)
M_{L0} = stat. longitudinal moment load [2] (Nm)

1) An external load acting at an angle on the runner block is to be broken down into its F_y and F_z components, and these values are then are then to be used in formula.
2) See tables

Technical Data

Travel speed

$v_{max} = 3$ m/s

Speeds of up to 5 m/s are possible. Service life is limited by wear of plastic parts.

Acceleration

$a_{max} = 250$ m/s^2

Only with preloaded systems. For non-preloaded systems: $a_{max} = 50$ m/s^2

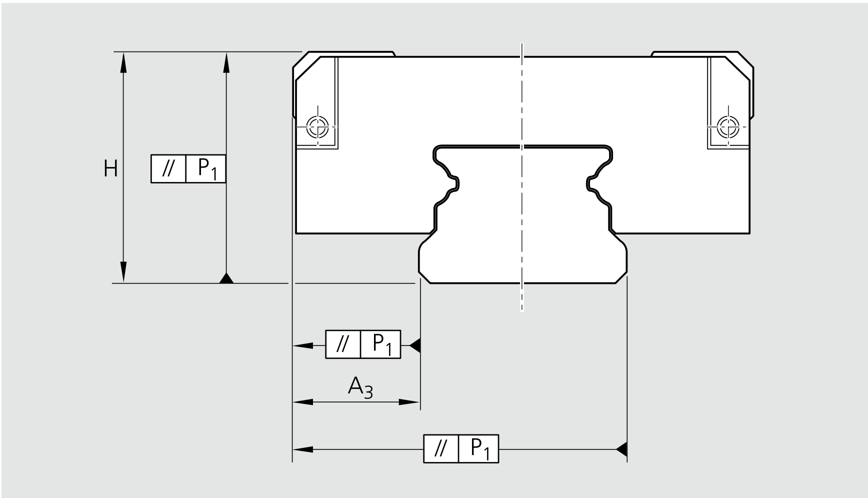
Operating temperature range

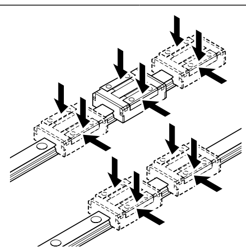
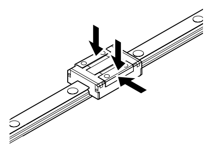
–10 °C ... 80 °C

Brief peaks up to100 °C are permissible.

Accuracy classes and their tolerances (µm)

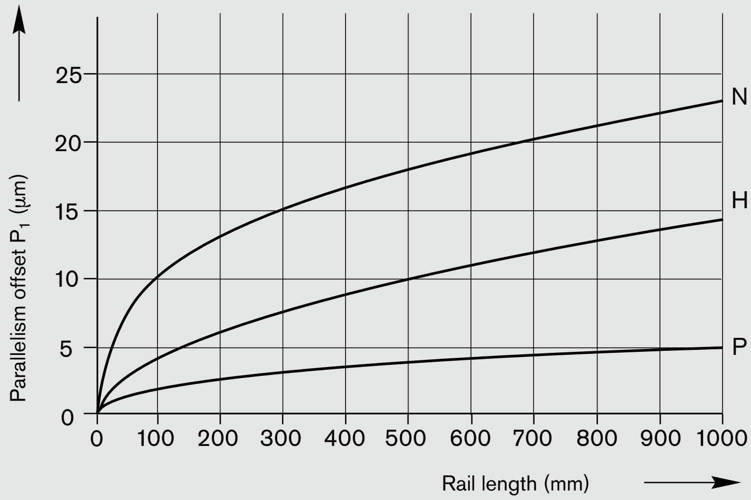
Miniature Ball Rail Systems are offered in 3 different accuracy classes.



Accuracy class	Dimensional tolerance (µm) H	A$_3$	Max. difference in dimensions H and A$_3$ on the same rail ΔH, ΔA$_3$ (µm)
P	± 10	± 10	7
H	± 20	± 20	15
N	± 30	± 30	20
			
Measured at middle of runner block[1)]	For any block/rail combination at any position on rail		For different runner blocks at same position on rail

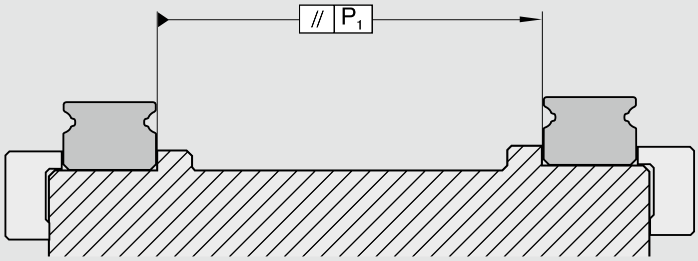
1) For dimensions H and ΔH, the middle of the runner block is calculated from the mean of the two measuring points shown.

Parallelism offset P_1 of the Ball Rail System in service



Parallelism offset of the installed rails

measured on the guide rails and on the runner blocks



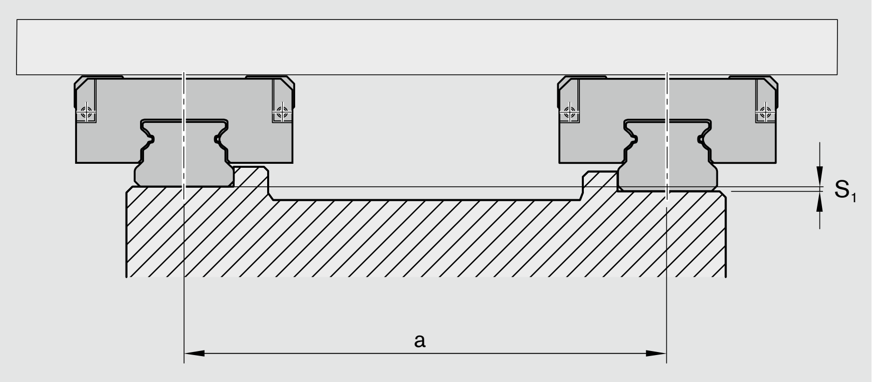
Size	Parallelism offset P_1 (mm)	
	Clearence	Preload
Standard Guide Rails R0445		
7	0.004	0.002
9/M3	0.005	0.002
12	0.008	0.004
15	0.017	0.008
20	0.025	0.016
Wide Guide Rails R0455		
9/M3	0.010	0.004
12 B	0.014	0.006
15 B	0.018	0.011

Technical Data

Vertical offset

Permissible vertical offset in transverse direction S_1

The permissible vertical offset S_1 includes the tolerance for dimension H (see accuracy classes).



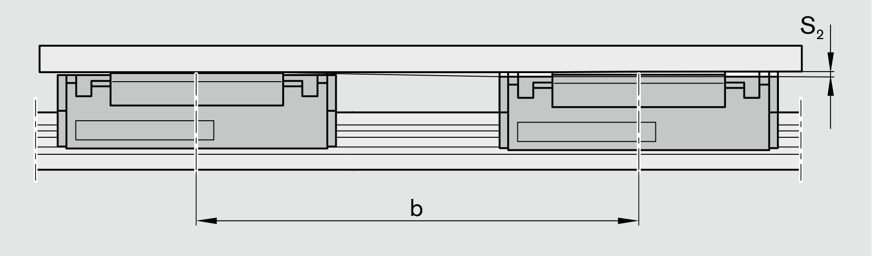
$$S_1 = a \cdot Y$$

S_1 = permissible vertical offset (mm)
a = distance between guide rails (mm)
Y = calculation factor

Calculation factor	For preload class	
	Clearance	Preload
Y	$3.0 \cdot 10^{-4}$	$1.5 \cdot 10^{-4}$

Permissible vertical offset in longitudinal direction S_2

The permissible vertical offset S_2 includes the tolerance "max difference of dimension H on the same rail" ΔH (see accuracy classes).



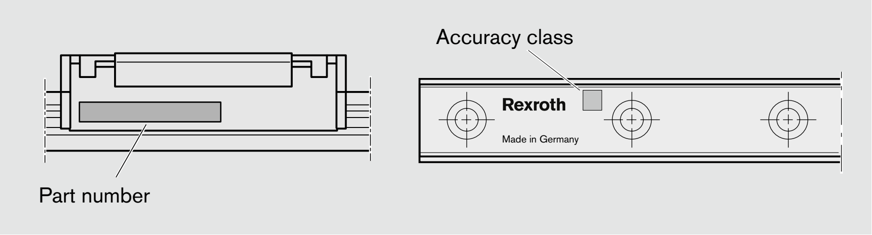
$$S_2 = b \cdot 7 \cdot 10^{-5}$$

S_2 = permissible vertical offset (mm)
b = distance between runner blocks (mm)

Preload and clearance

Preload class	Accuracy class			
	P		H	N
	1	1	9	9
Preload and clearance	~0 to moderate preload	~0 to moderate preload	~0 to moderate clearance	Moderate clearance to moderate preload

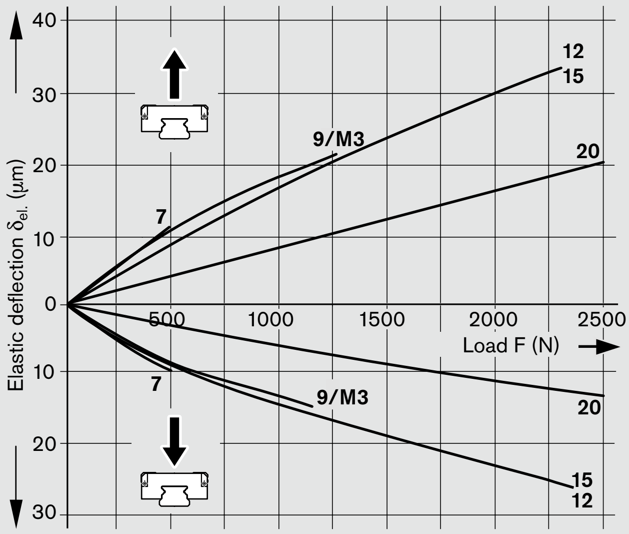
Markings on runner block and guide rail



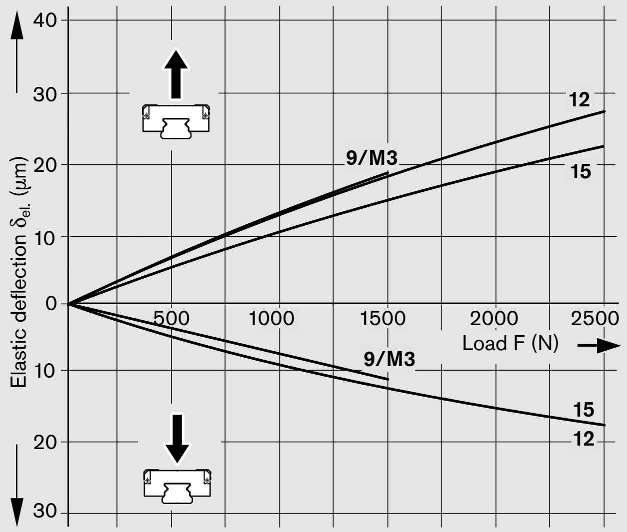
Rigidity of the Miniature Ball Rail System when preloaded

Runner block mounted with 4 screws, strength class 12.9

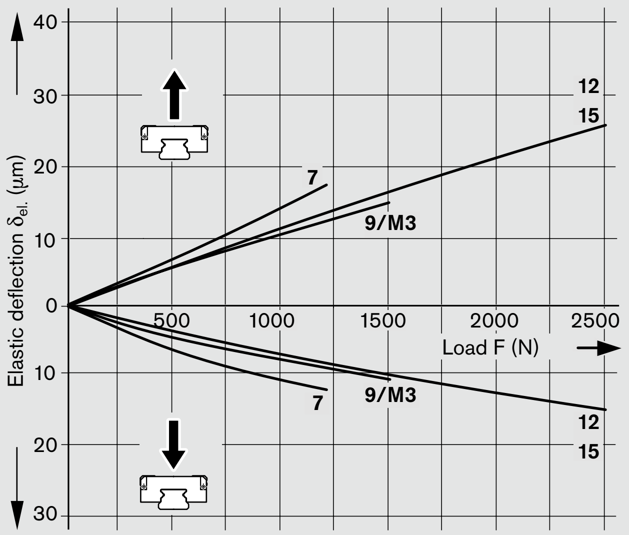
Standard runner block R0442



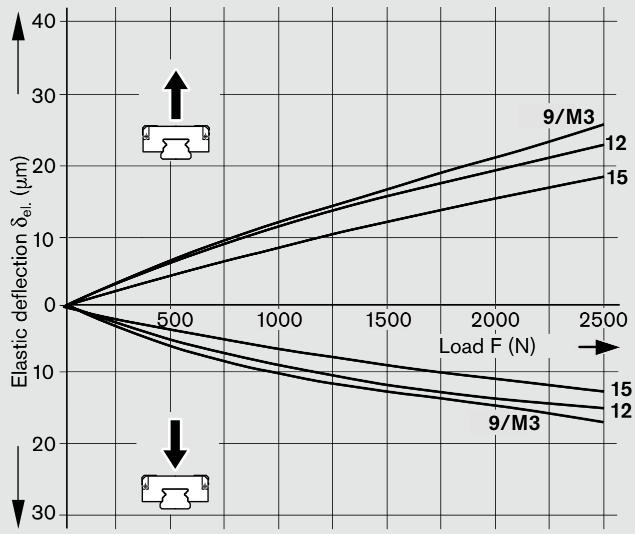
Wide runner block R0443



Long runner block R0444



Wide, long runner block R0441



Technical Data

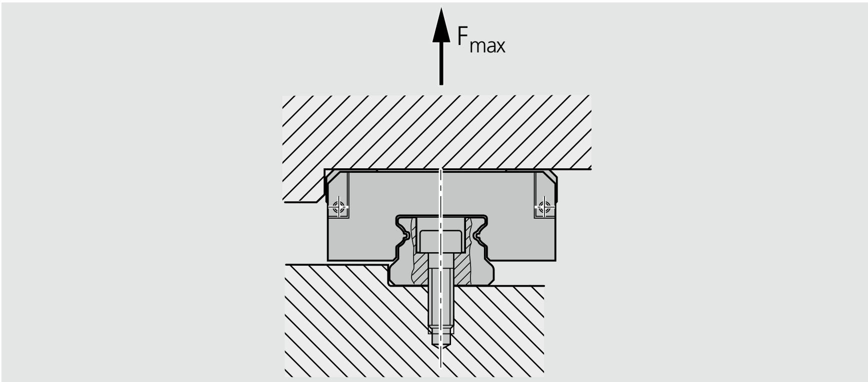
General Notes

The screw connections specified in the DIN 645-1 standard can be overstressed due to the high performance capability of profiled rail systems. The most critical point is the screw connection between the guide rail and the mounting base. If the lift-off loads (F) or moments (M_t) are higher than the respective load values given in the table, the screw connections must be recalculated separately.

The data applies for the following conditions:
- Mounting screw quality 12.9
- Screws tightened using a torque wrench
- Screws lightly oiled
  (For screws in quality 8.8, an approximation factor of 0.6 can be applied)

Miniature Ball Rail Systems

Guide Rails	**Runner blocks R0442**			**Runner blocks R0444**	
	Size	**$F_{max.}$** (N)	**$M_{tmax.}$** (Nm)	**$F_{max.}$** (N)	**$M_{tmax.}$** (Nm)
R0445	7	1000	3.2	1150	3.7
	12	–	–	4300	23.7
	15	3740	26.0	4280	30.0
	No restriction for sizes				
R0445	R0442:		9/M3, 12 and 20		
	R0444:		9/M3		
R0455	R0441,R0443:		9/M3, 12 and 15		



Friction and seals

The total frictional drag of the runner block is the sum of the frictional drag of the runner block and the frictional drag of the seals (see tables at right).

The runner blocks come standard with low-friction seals.
Part number: R044. ... **01**
(See "Part numbers for runner blocks" tables)

Special versions:
Runner blocks are also available with N seals (excellent wiping action).
Part number: R044. ... **00**
(otherwise as in "Part numbers for runner blocks" tables)

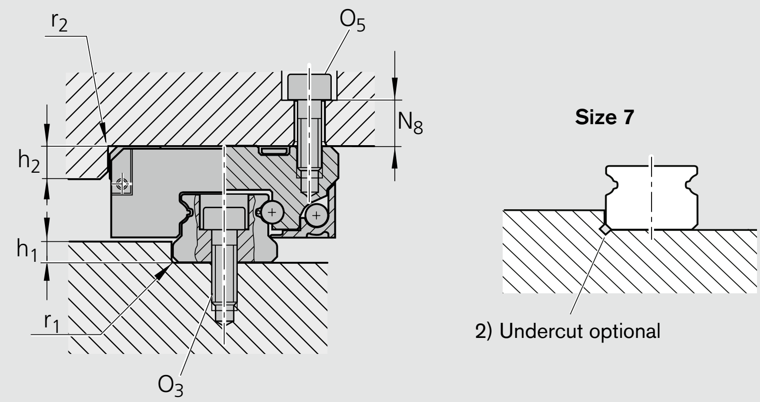
Sizes 15, 20, 9/M3 wide, 12 wide, 15 wide and long runner blocks sizes 9/M3, 12 and 15 have additional longitudinal seals for full sealing.

Size	**Frictional drag of runner blocks (without seals)**		**Frictional drag of seals**	
	with clearance (N)	**with preload** (N)	**Low-friction seal (-01)** (N)	**N-Seal (-00)** (N)
Standard runner block R0442				
7	< 0.1	< 0.1	~0	0.1
9/M3	< 0.1	< 0.1	~0	0.5
12	< 0.1	< 0.2	~0	0.9
15	< 0.2	< 0.4	~0	1.2[1)]
20	< 0.2	< 0.5	~0	1.5[1)]
Long runner block R0444				
7	< 0.1	< 0.3	~0	0.2
9/M3	< 0.2	< 0.4	~0	0.6[1)]
12	< 0.2	< 0.4	~0	0.9[1)]
15	< 0.2	< 0.5	~0	1.0[1)]
Wide runner block R0443				
9/M3	< 0.2	< 0.3	~0	1.4[1)]
12	< 0.2	< 0.3	~0	1.6[1)]
15	< 0.2	< 0.4	~0	1.8[1)]
Wide, long runner block R0441				
9/M3	< 0.2	< 0.4	~0	1.5[1)]
12	< 0.2	< 0.4	~0	1.8[1)]
15	< 0.2	< 0.5	~0	2.0[1)]

1) with longitudinal seal

Mounting Instructions

Reference edges, corner radii, screw sizes and tightening torques



Size	h_1 (mm)	r_1 max. (mm)	h_2 (mm)	r_2 max. (mm)	O_5 ISO 4762[1)] 4 pcs.	O_3 ISO 4762[1)] (rail)	N_8 (mm)
Standard runner block R0442							
7	1.2 $_{-0.1}$	0.1[2)]	2.2	0.3	M2x5	M2x5	3.0
9/M3	1.5 $_{-0.2}$	0.3	2.5	0.3	M3x8	M3x8	5.0
12	2.5 $_{-0.5}$	0.3	3.5	0.5	M3x8	M3x8	5.0
15	2.8 $_{-0.5}$	0.5	4.5	0.5	M3x8	M3x10	4.5
20	6.3 $_{-0.5}$	0.5	6.5	0.5	M4x12	M5x14	6.5
Long runner block R0444							
7	1.2 $_{-0.1}$	0.1[2)]	2.2	0.3	M2x5	M2x5	3.0
9/M3	1.0 $_{-0.1}$	0.3	2.5	0.3	M3x8	M3x8	5.0
12	2.0 $_{-0.2}$	0.3	3.5	0.5	M3x8	M3x8	5.0
15	2.8 $_{-0.5}$	0.5	4.5	0.5	M3x8	M3x10	4.5
Wide runner block R0443; wide, long R0441							
9/M3	1.8 $_{-0.2}$	0.3	2.5	0.3	M3x8	M3x8	5.5
12	2.8 $_{-0.5}$	0.5	3.0	0.4	M3x8	M4x10	4.5
15	2.8 $_{-0.5}$	0.5	4.5	0.5	M4x10	M4x12	6.0

1) Formerly DIN 912

Tightening torques for the mounting screws

μK = μG = 0.125

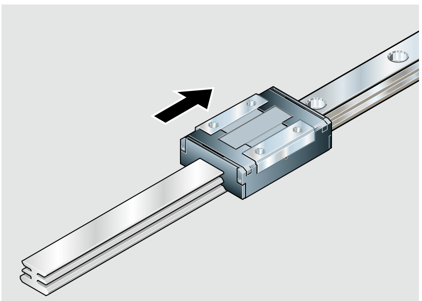
8.8		**M2**	**M3**	**M4**	**M5**
Nm	**A2-70**	0.35	1.1	2.0	3.9
	12.9	0.50	2.1	4.6	9.5

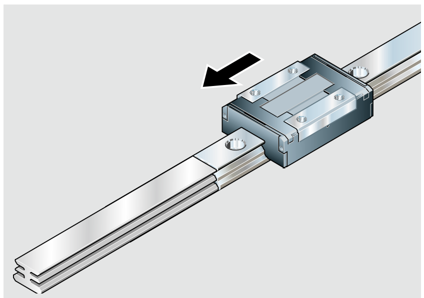
Note on installation

The runner blocks are delivered mounted on a plastic arbor.

– Position the runner block complete with the arbor at the head of the rail and push on; the arbor will thus be pushed out of the runner block.

When removing the runner block, carry out the above operations in reverse sequence.





Start-up and Maintenance

Start-up

Initial lubrication of runner blocks is necessary before Miniature Ball Rail Systems are put into service!

Runner blocks are available:
– prelubricated with a lithium soap grease, consistency class NLGI 00, Dynalub 520
– without initial lubrication for individual grease or oil lubrication.

Initial lubrication with grease

We recommend a grease lubricant per DIN 51825, class KP00K.
A grease of this type, Dynalub 520, is available in the following versions:
– Maintenance kit with 5 ml dispensing unit, part number R0419 090 01
– 400 g cartridge for use in grease guns, part number R3416 043 00

Note:
- Grease the runner block as per table.
- Move the runner block in the direction of the lube port used to distribute the grease evenly.
- Make sure there is a visible film of grease on the guide rail.

Initial lubrication with oil

We recommend the use of oils meeting the minimum requirements for CLP lubricant oils (DIN 51517, Part 3) or HLP hydraulic oils (DIN 51524, Part 2). The oil must have a viscosity of 100 mm^2/s at 40 °C.

- Follow the manufacturer's instructions.
- It is essential to check that the lubricant will reach all rolling elements in the installed condition (orientation).
- Apply oil until excess emerges.

⚠ **Add the entire oil quantity in one go!**

Maintenance

The maintenance intervals depend on the application and the ambient conditions.

Under normal conditions no in-service lubrication is required.

Cleaning

Dirt can settle and encrust on the guide rails, especially when these are not enclosed. This dirt must be removed to protect the seals.

- Always run a cleaning cycle before shutting down the machine.

In-service lubrication

Initial lubrication (long-term lubrication) is sufficient for 5,000 km travel where:
– $F < 0.1\ C$
– $v_m = 0.65$ m/s
– 90 mm stroke
– low-friction seals
- For in-service lubrication with grease or oil, follow instructions as for initial lubrication.

⚠ **The in-service lubrication intervals depend on ambient conditions, loading and type of load!**

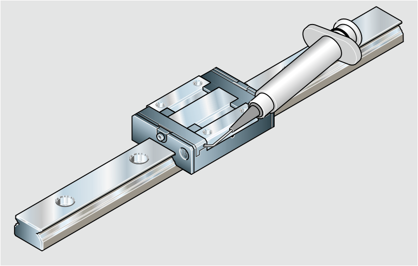
Ambient conditions include: swarf, metallic and other abrasion, solvents and temperature. Load types include vibrations, impacts and tilting.

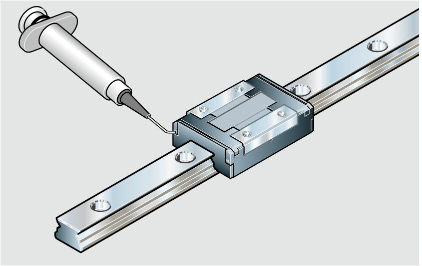
⚠ **The service conditions are unknown to the manufacturer. Users can only determine the in-service lubrication intervals with certainty by conducting in-house tests or by careful observation.**

⚠ **Do not allow guide rails or runner blocks to come into contact with water-based metalworking fluids!**

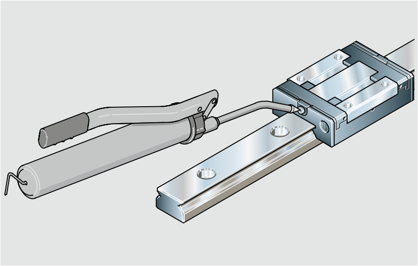
Maintenance kit

A **special syringe** is used to apply lubricant to the **lube ports** at the sides or end faces of the runner block (part number: R0419 090 01).





If the **funnel-type lube nipples** on the runner block end faces are preferred, use a **grease gun** instead.



Short stroke
(stroke < 2 runner block lengths)

See “Lubrication quantities and methods” for the method to be used for short-stroke applications.

For strokes < 0.5 runner block length, slide the runner block over 2 complete runner block lengths per lubrication cycle. If this is not possible, please consult us.

Lubrication Quantities and Methods

The lubrication method depends on the size, as given in the table:

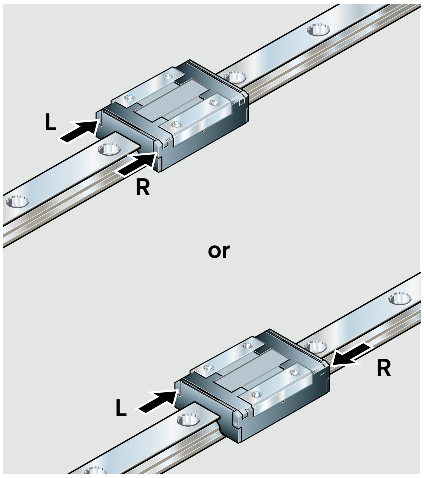
Size	Lubrication by Method 1	Method 2
Standard runner block R0442		
7	✓	
9/M3	✓	
12	✓	
15		✓
20		✓
Long runner block R0444		
7	✓	
9/M3	✓	
12	✓	
15		✓
Wide runner block R0443; wide, long R0441		
9/M3	✓	
12	✓	
15		✓

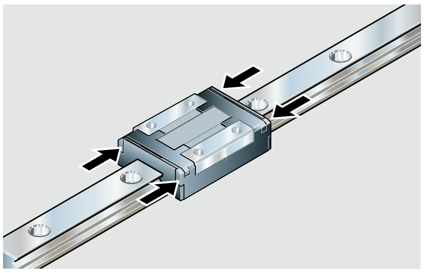
Method 1

Apply lubricant through the lube ports on the end face.

Size	Initial lubrication with grease Partial amount per side (L/R)* (cm³)	Total amount (L+R)* (cm³)
Standard runner block R0442		
7	0.025	0.05
9/M3	0.030	0.06
12	0.075	0.15
Long runner block R0444		
7	0.04	0.08
9/M3	0.045	0.09
12	0.12	0.24
Wide runner block R0443		
9/M3	0.040	0.08
12	0.075	0.15
Wide, long runner block R0441		
9/M3	0.060	0.12
12	0.11	0.22

For **short stroke** applications, apply the partial amount per side as given in the table to each end-face lube port.
* (L = left, R = right)

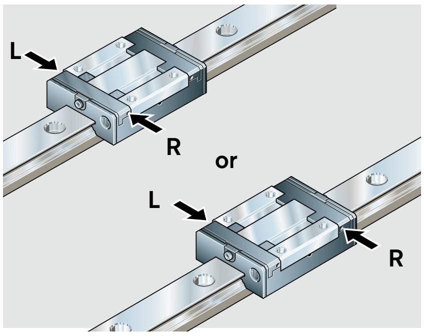


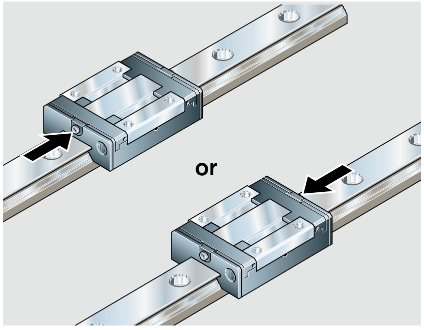


Method 2

Apply lubricant through the lube ports at the sides (partial amount per side) or the lube nipple on the end face (total amount).

Size	Initial lubrication with grease	
	Partial amount per side (L/R) (cm³)	Total amount via end face (cm³)
Standard runner block R0442		
15	0.06	0.12
20	0.09	0.18
Long runner block R0444		
15	0.10	0.20
Wide runner block R0443		
15 B	0.09	0.18
Wide, long runner block R0441		
15	0.13	0.26





For **short-stroke** applications, apply either the total amount as per table to each end-face lube nipple, or the partial amount per side as given in the table to each side lube port.