Miniature Linear Guidance Sets

With Cylindrical Roller Flat Cages

Foreword

The machine and plant building industry is showing a strongly contrasting development: On the one hand, machinery and plant is becoming increasingly smaller and more compact, while on the other hand its performance capacity is continually increasing.
This has a direct influence on the machine components used and must be taken into consideration in the design of the linear guidance systems.

This particularly affects bearing arrangements in the miniature field, since achieving small size at the same time as high rigidity and load carrying capacity have long been incompatible differences.

For complex requirements too

In order to fulfil such complex requirements as comprehensively as possible, we have developed special miniature guidance systems, such as miniature linear guidance sets with cylindrical roller flat cages.

These linear guidance systems are ready-to-fit and are designed for use as linear locating bearing arrangements. They are also available by agreement in a corrosion-resistant design. Due to their compact design, they can often be used to replace guidance systems that require significantly more space.

The units are produced in numerous guideway lengths, giving highly cost-effective overall designs.

High load carrying capacity due to line contact

Compared with guidance systems based on balls, the roller units have significantly higher load carrying capacity. The reason is that balls are in point contact with the raceways, whereas cylindrical rollers are in line contact.

Guidance systems with cylindrical roller flat cages are therefore used in preference where the units must have particularly high load carrying capacity and rigidity while operating over limited short stroke lengths.

Replacement for ...

TPI 162, Miniature Linear Guidance Sets replaces MAI 79.
The data in the catalogue represent the current level of technology and manufacture as of September 2008. They reflect not only progress in rolling bearing technology but also the experience gathered in practical applications.

Any information in previous publications that does not concur with the data in this TPI is therefore invalid.

Safety guidelines and symbols

High product safety

Our products correspond to the current level of research and technology. If the bearing arrangement is designed correctly, the products are handled and fitted correctly and as agreed and if they are maintained as instructed, they do not give rise to any direct hazards.

Follow instructions

This publication describes standard products. Since these are used in numerous applications, we cannot make a judgement as to whether any malfunctions will cause harm to persons or property.

It is always and fundamentally the responsibility of the designer and user to ensure that all specifications are observed and that all necessary safety information is communicated to the end user. This applies in particular to applications in which product failure and malfunction may constitute a hazard to human beings.

Definition of guidelines and symbols

The warning and hazard symbols are defined along the lines of ANSI Z535.6–2006.

The meaning of the guidelines and symbols is as follows.

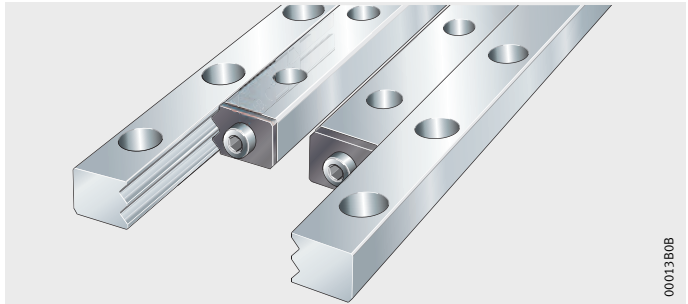**!** If they are not observed, damage or malfunctions in the product or the adjacent construction will occur.

Miniature linear guidance sets

Miniature linear guidance set

RWS1808

00013B0B

Guideways

RWT

00013B0C
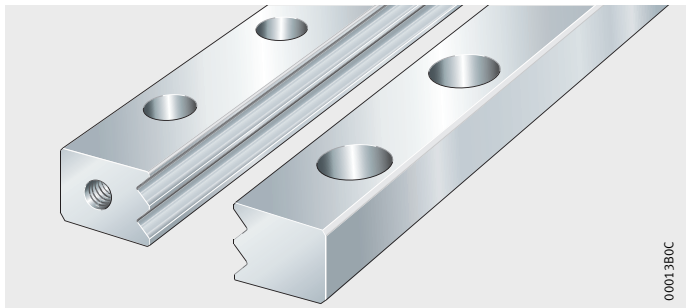
Standard accessories
Cylindrical roller flat cage
End pieces

HR

00013B0D

End pieces

00013B0E
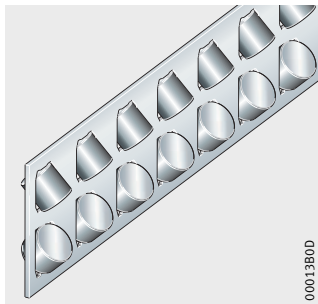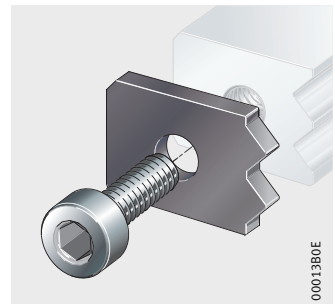
Miniature linear guidance sets

Features

Miniature linear guidance sets with cylindrical roller flat cages are ready-to-fit locating bearings for limited stroke lengths and are preloaded during fitting.

Due to their compact design, they can often be used to replace guidance systems that require significantly more space.
The units are produced in numerous carriage and guideway lengths, giving very cost-effective overall designs.

Since the distance between the elements of the guidance system can be varied, they can be easily matched to predetermined adjacent constructions.

Due to their smooth running and high running accuracy, they are also suitable for applications having very high requirements for accuracy.

A unit comprises at least one inner and one outer guideway pair of equal or unequal length, cylindrical roller flat cages and end pieces.

Load carrying capacity

The sets can support forces from all directions, apart from the direction of motion, and moments about all axes.
Due to the arrangement of the rolling elements, they can transmit loads at a contact angle of 45°.

Line contact

In miniature linear guidance sets RWS1808, two rows of rolling elements are in line contact with the raceways.
Due to the line contact, these guidance systems have very high load carrying capacity and rigidity.

O or X arrangement

Miniature linear guidance sets have cylindrical rollers in an O or X arrangement, *Figure 1*.

The O arrangement has higher rigidity and is better suited to supporting tilting moments than the X arrangement.
The arrangement can be changed by transposing the cages.

① O arrangement
② X arrangement

Figure 1
Rolling elements
in O and X arrangements
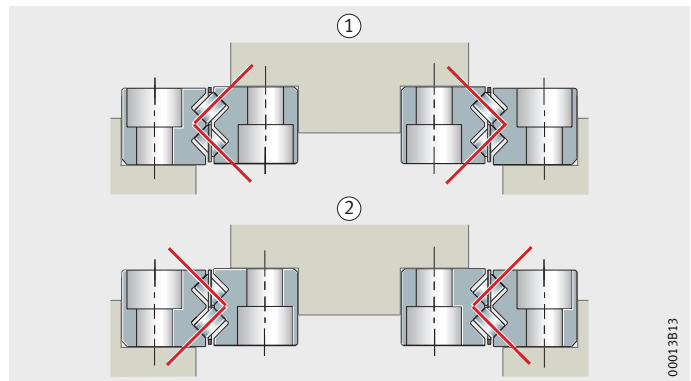
Miniature linear guidance sets

Corrosion-resistant   The miniature linear guidance sets are also available by agreement in a corrosion-resistant design.

⚠ Corrosion-resistant steels may nevertheless undergo various forms of localised corrosion and corrosion involving loss of surface material.

If very high levels of corrosion resistance are required, the suitability of the units for the specific application must be investigated.

Applications   The guidance systems are particularly suitable for:
- short stroke lengths
- low-friction motion
- oscillating movements
- high loads where high rigidity is also required
- and very high accuracy requirements.

Guideways

The guideways are made from through hardened steel and are ground on all sides, *Figure 2*. The raceways for the rolling elements are ground to very high precision.

The guideways are screw mounted from above to the adjacent construction. They have fixing holes with counterbores for the screw heads. This hole type can be used in combination with insert nuts ESM.

The guideways have a locating face for mounting.

RWT

Figure 2
Guideways
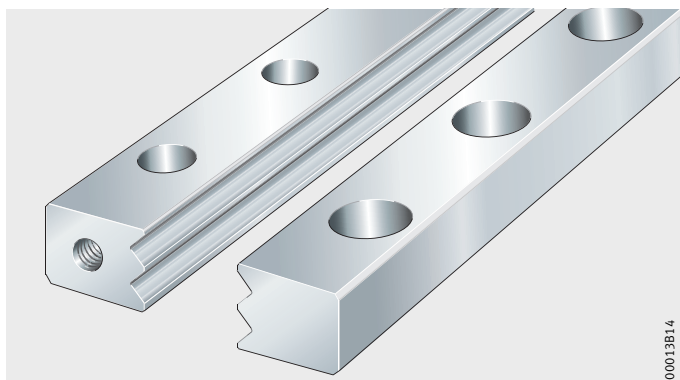
Flat cages

The cages are of a two-row design, *Figure 3*.

The strip used in the manufacture of the cylindrical roller flat cages is made from corrosion-resistant steel.
The cylindrical rollers conform to DIN 5 402-1.

⚠ Under high load in particular, there is a risk of cage creep.
This must be prevented, otherwise the guidance system can be damaged or destroyed.

HR

Figure 3
Flat cage
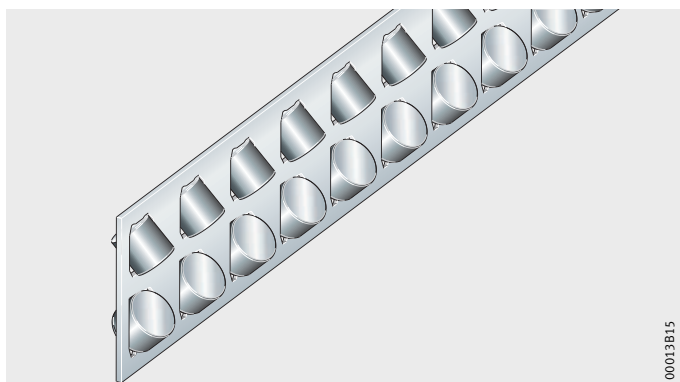
Miniature linear guidance sets

Sealing
End pieces on the end faces of the carriages protect the raceways against contamination.

!   The raceways must be kept clean at all times.
If the end pieces used as standard are not adequate for this purpose, additional seals must be provided in the adjacent construction.

Lubrication
The units are supplied ungreased and must be lubricated using oil or grease through the guideway. The units are supplied with a preservative. The preservative is compatible with oils and greases.

!   The raceways and cages must be oiled or greased before initial operation and protected against solid and liquid contaminants.

Operating temperature
Miniature linear guidance sets with cylindrical roller flat cages are suitable for operating temperatures between −20 °C and +120 °C.

Standard accessories

End pieces
The end pieces are made from steel. They limit the travel of the cage and protect the rolling element system against contamination.

!   The end pieces should not be used to limit the stroke.
This can damage the guidance system.

Design and safety guidelines

Load carrying capacity

The size of the guidance unit is determined by the load carrying capacity of the individual elements.

The load carrying capacity is described in terms of the:
- basic dynamic load rating C
- basic static load rating C_0
- static moment ratings M_{0x}, M_{0y}, M_{0z}.

! The basic load ratings are lower at operating temperatures above +120 °C. For information on the reduction in the basic load ratings, please contact us.
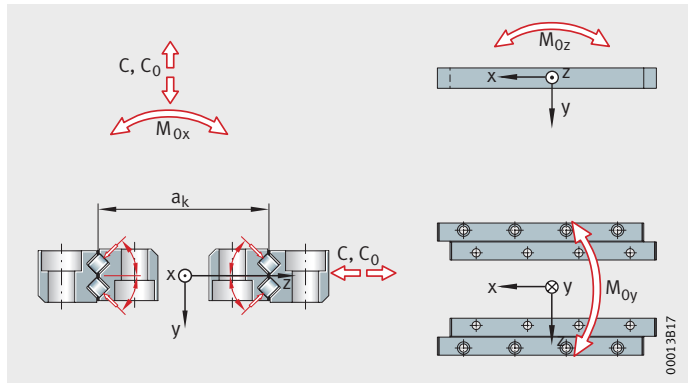
Figure 4
Load carrying capacity and load directions

Load carrying capacity of fixing screws

! For high loads, the load carrying capacity of the fixing screws must always be checked.

Miniature linear guidance sets

Basic rating life

The basic rating life is calculated as follows:

$$L = k_{KHV} \cdot \left(\frac{C}{P}\right)^p$$

$$L_h = \frac{8,33 \cdot 10^5}{H \cdot n_{osc}} \cdot k_{KHV} \cdot \left(\frac{C}{P}\right)^p$$

C	N

Basic dynamic load rating, see dimension tables from page 29

H	mm

Distance between ends of stroke

k_{KHV}	−

Short stroke factor according to DIN 636-3, *Figure 5*

L	m

Basic rating life in 100 000 m

L_h	h

Basic rating life in operating hours

n_{osc}	min^{-1}

Number of return strokes per minute

p	−

Life exponent, for guideways supported by rollers = 10/3

P	N

Equivalent dynamic load.

① Stroke length, cage length

Figure 5
Short stroke factor k_{KHV},
as a function of stroke length
and cage length

151 254
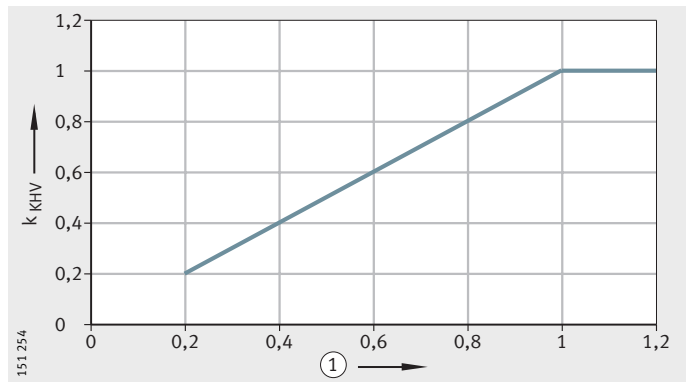
Static load safety factor   The static load safety factor S_0 is the security against permanent deformation at the rolling contact.

It can be determined using the following formula:

$$S_0 = \frac{C_0}{P_0}$$

$$S_0 = \frac{M_0}{M}$$

The equivalent static bearing load P_0 is determined in approximate terms from the maximum loads:

$$P_0 = F_{max}$$

$$M_0 = M_{max}$$

C_0 N
Basic static load rating, see dimension tables from page 29
M Nm
Equivalent static moment in load direction
M_0 Nm
Static moment rating in load direction
(M_{0x}, M_{0y}, M_{0z}, see dimension tables from page 29)
P_0 N
Equivalent static bearing load in load direction
S_0 –
Static load safety factor.

⚠️   If high demands are placed on accuracy and smoothness of running, the static load safety factor should be $S_0 \geqq 3$.

Miniature linear guidance sets

Static moment rating M_{0x}

The static moment ratings are the loads under which a permanent overall deformation of the raceways and rolling elements occurs which corresponds to 1/10 000 of the rolling element diameter.

The moment ratings for rolling elements in an O arrangement can be determined using the following formulae:

$$a_k = a_i + B$$

$$M_{0x} = k_M + a_k \cdot W_{M0x}$$

a_k mm
Cage spacing, *Figure 6*

a_i mm
Minimum internal width, *Figure 6*

B mm
Total height of guidance system, *Figure 6* and dimension tables from page 29

M_{0x} Nm
Static moment rating about X axis, *Figure 6*

k_M Nm
Moment constant, see dimension tables from page 29

W_{M0x} Nm
Static moment factor about X axis, see dimension tables from page 29.
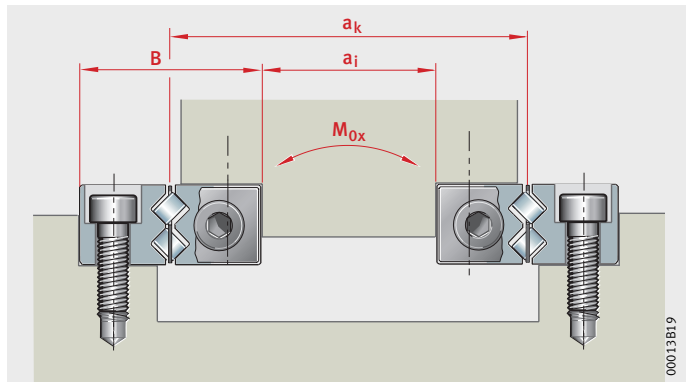
Figure 6
Static moment rating M_{0x}
about X axis

| | Preload | Miniature linear guidance sets are available in the preload class V1, see table. |

Preload class

Preload class	Preload setting	Suitable for
V1	$0{,}005 \cdot C$ to $0{,}02 \cdot C$	☐ Light to moderate loads ☐ Moderate to high rigidity ☐ Moment load

Influence of preload on the cage guidance system

Increasing the preload increases the rigidity, the moment load carrying capacity and the guidance accuracy. It also affects the displacement resistance and operating life of the cage guidance system.

Location of guideways through the adjacent construction

If the guideways are to be located using the threaded holes in the guideways, the diameters D_1 and d_1 of the through holes in the adjacent construction must be larger.

Setting the preload
① Insert nut ESM

Figure 7
Location through
the adjacent construction
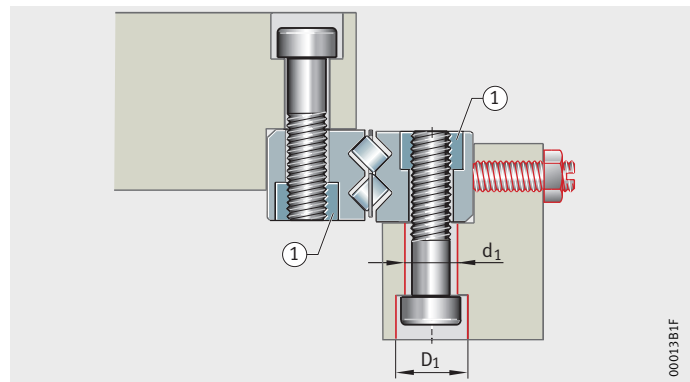
Location of guideways through the guideway

If the guideways are to be located using the through holes in the guideways, thinner screws for setting preload can be used.

Setting the preload
① Special screw

Figure 8
Location using special screws
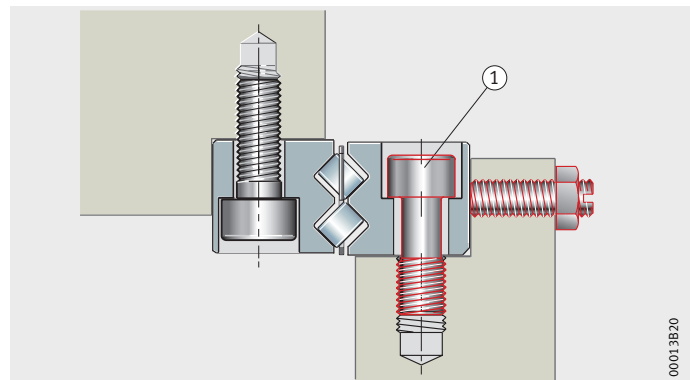
Miniature linear guidance sets

Hole patterns of guideways

The hole pattern of the guideways corresponds to DIN 645-2.

The guideways have a symmetrical hole pattern in accordance with ISO 1101, *Figure 9*.

Maximum number of pitches between holes

The number of pitches between holes is the rounded down whole number equivalent to:

$$n = \frac{l - 2 \cdot a_{L\,min}}{j_L}$$

The distances a_L and a_R are generally determined by:

$$a_L + a_R = l - n \cdot j_L$$

For guideways with a symmetrical hole pattern:

$$a_L = a_R = \frac{1}{2} \cdot (l - n \cdot j_L)$$

Number of holes:

$$x = n + 1$$

a_L, a_R mm
Distance between start or end of guideway and nearest hole
$a_{L\,min}$, $a_{R\,min}$ mm
Minimum values for a_L, a_R, see dimension table, page 28
l mm
Guideway length
n –
Maximum possible number of pitches between holes
j_L mm
Distance between holes
x –
Number of holes.

Caution!

If the minimum values for a_L and a_R are not observed, the counterbores of the holes may be intersected.
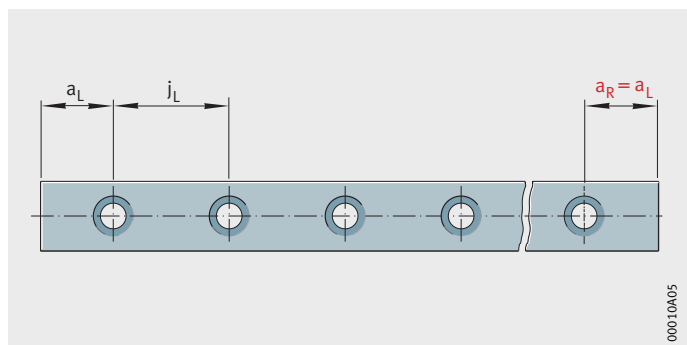
Figure 9
Hole pattern

| Demands on the adjacent construction | The running accuracy is essentially dependent on the straightness, accuracy and rigidity of the fit and mounting surfaces. |

Demands on the adjacent construction

The running accuracy is essentially dependent on the straightness, accuracy and rigidity of the fit and mounting surfaces.

The straightness of the system is only achieved when a guideway is pressed against the datum surface.

If high demands are to be made on the running accuracy and/or if soft substructures and/or movable guideways are used, please contact us.

⚠ The strength of the adjacent construction must be sufficiently high in accordance with VDI Guideline 2 230.

Geometrical and positional accuracy of the mounting surfaces

The higher the requirements for accuracy and smooth running of the guidance system, the more attention must be paid to the geometrical and positional accuracy of the mounting surfaces.

⚠ The tolerances for the mounting surfaces and parallelism of the mounted guideways must be observed, *Figure 10*, page 16 and table Values for parallelism tolerances t, page 17.

Surfaces should be ground or milled with the aim of achieving a mean roughness value $R_a 1,6$.

Any deviations from the stated tolerances will impair the overall accuracy, alter the preload and reduce the operating life of the guidance system.

Height difference ΔH

The permissible values for ΔH are given by the following formula. If larger deviations are present, please contact us.

$$\Delta H = a \cdot b$$

ΔH μm
Maximum permissible deviation from the theoretically precise position, *Figure 10*, page 16
a –
Factor as a function of size, see table
b mm
Centre distance between guidance elements.

Factor a

Designation	Factor a
RWS1808	0,08

Miniature linear guidance sets

① Not convex
(for all machined surfaces)

Figure 10
Tolerances of mounting surfaces
and parallelism
of mounted guideways
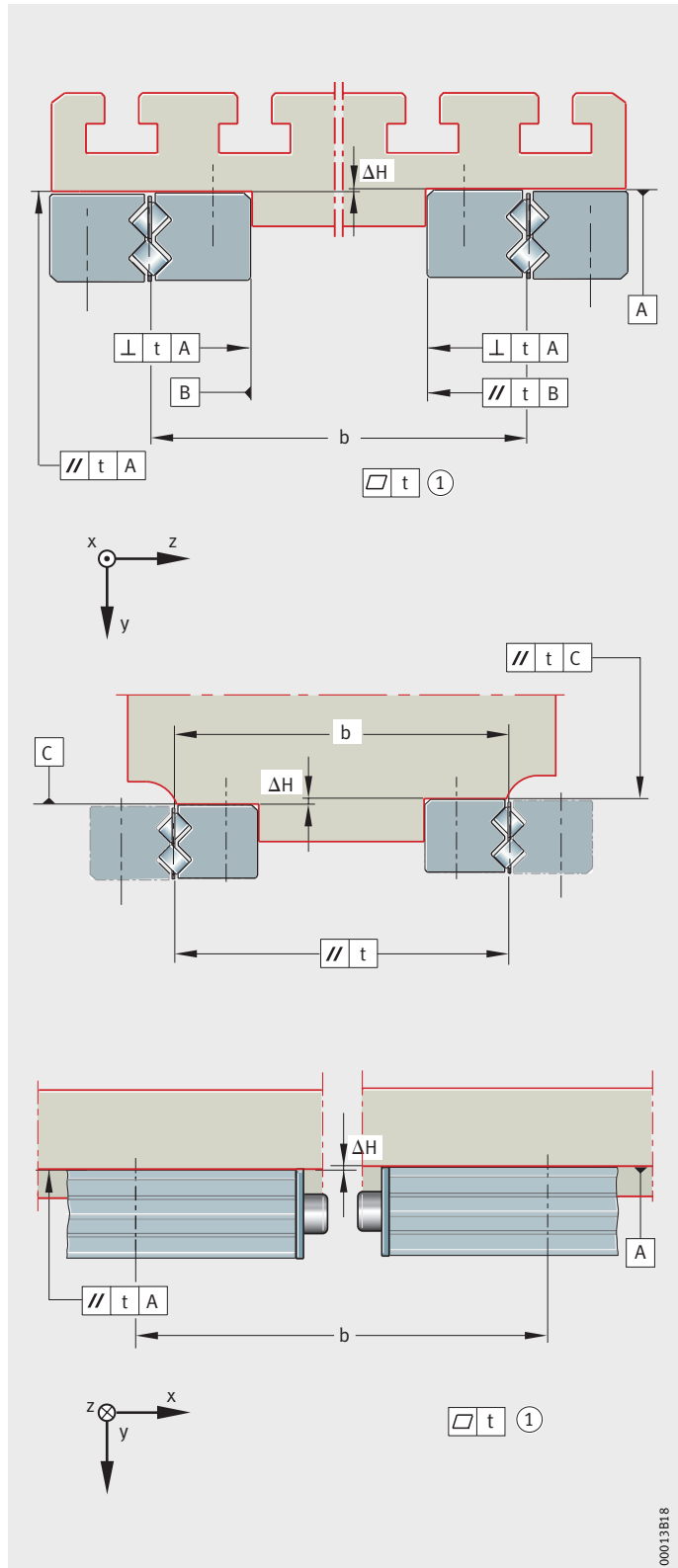
Parallelism of mounted guideways

For guideways arranged in parallel, the parallelism t should be in accordance with *Figure 10*, page 16 and the table. If the maximum values are used, this may increase the displacement resistance. If larger tolerances are present, please contact us.

Values for parallelism tolerances t

Designation		Parallelism tolerance $t^{1)}$
Miniature linear guidance system	Guideway	μm
RWS1808	RW	5

$^{1)}$ Value for guidance system set free from clearance.

Locating heights and corner radii

The locating heights and corner radii should be in accordance with the table and *Figure 11*.

Locating heights and corner radii

Designation Miniature linear guidance system	Locating heights		Corner radii	
	h_1 mm	h_2 mm	r_1 mm	r_2 mm
		max.	max.	max.
RWS1808	7,5	7,5	0,4	0,4
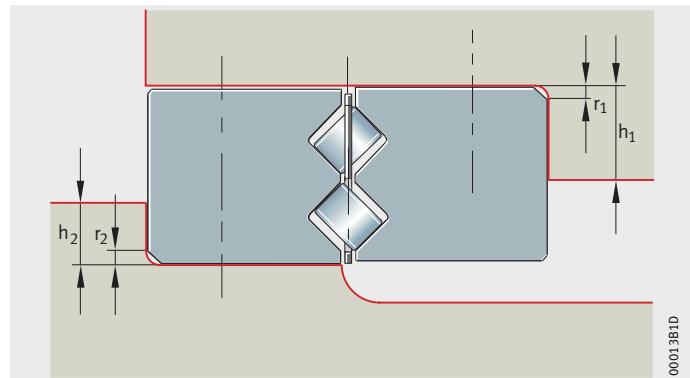
Figure 11
Locating heights and corner radii

Miniature linear guidance sets

Location of guideways

In order to avoid location defects, the holes in the adjacent construction must be deburred.

⚠ The counterbores of the guideway fixing holes have sharp edges. Risk of injury!

The guideways have a defined locating face.
This should be used in the design of the adjacent construction.
The locating face is the side with the large chamfer on the guideway.
When correctly fitted, the large guideway chamfers must be diagonally opposite each other. The chamfer on the end piece and the chamfer on the guideway must match in position.

Location of guideways with Insert nuts ESM

The guideways have counterbored fixing holes as standard.
This hole type can be used in combination with insert nuts ESM, *Figure 12*.

① Standard fixing hole
② With ESM
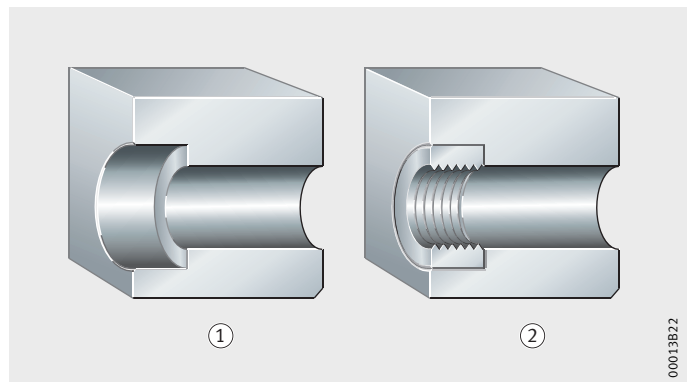
Figure 12
Hole types for guideways

①   ②

00013B22

Guideways with the standard fixing hole are screw mounted to the adjacent construction, *Figure 13*.
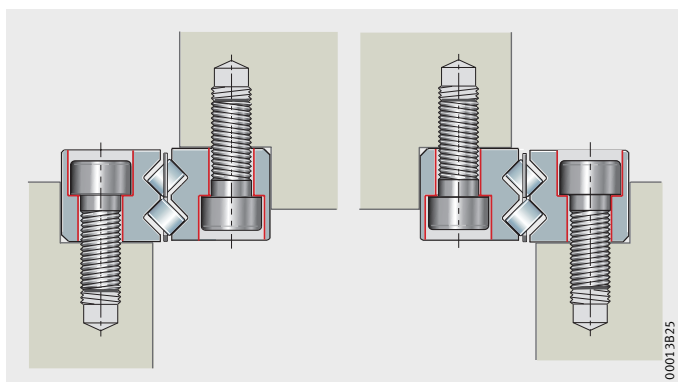
In combination with the insert nuts ESM, the standard fixing hole can be used as a threaded hole, *Figure 14*.
For fitting of insert nuts, see section Fitting of insert nuts ESM, page 23.
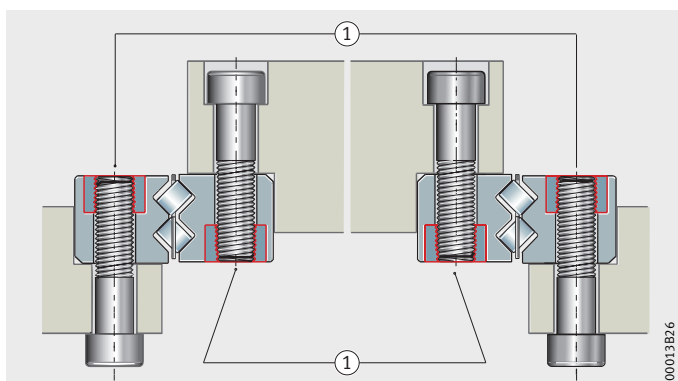
① With ESM

Fixing screws

For high loads, the load carrying capacity of the fixing screws must always be checked.

If corrosion-resistant fixing screws are used, their lower tensile strength and lower tightening torques must be taken into consideration.

Miniature linear guidance sets

Accuracy

Accuracy classes

Miniature linear guidance sets are available in the accuracy class G1, *Figure 15*.

Parallelism of raceways to locating faces

The parallelism tolerances of guideways are shown in *Figure 15*.

① Locating face
t = parallelism tolerances with differential measurement
l = total guideway length

Figure 15
Accuracy class and parallelism tolerances of guideways
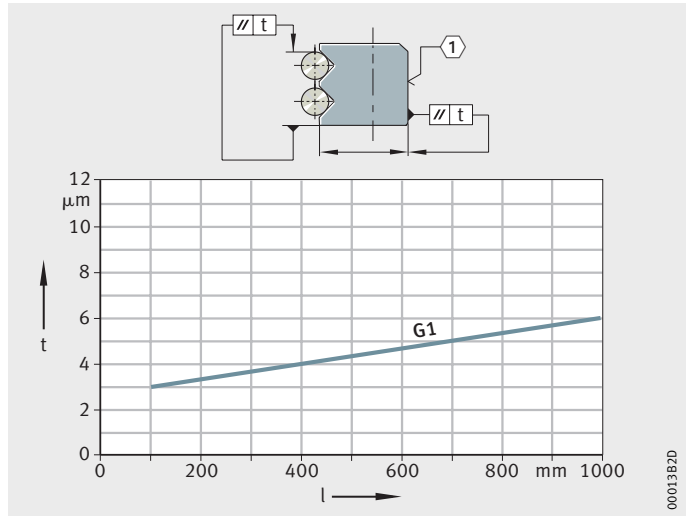
Tolerances Tolerances: see table and *Figure 16*, Datum dimensions B and H for accuracy.

The tolerances are arithmetic mean values. They relate to the centre point of the screw mounting or locating surfaces of the guideways.

The dimensions H and B should always remain within their tolerance irrespective of the position of the guideways, see table.

Tolerances of accuracy classes

Tolerance		Accuracy G1 μm
Tolerance for height	H	±10
Distance difference	B	0 to −200

RWS

Figure 16
Datum dimensions B and H
for accuracy

00013B2E
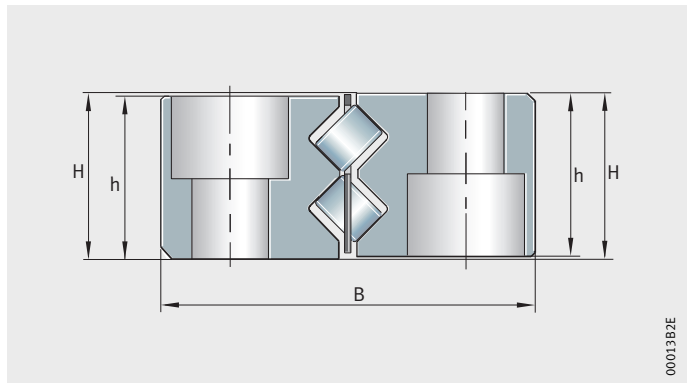
Miniature linear guidance sets

Positional and length tolerances of guideways

The positional and length tolerances are shown in *Figure 17* and the table.
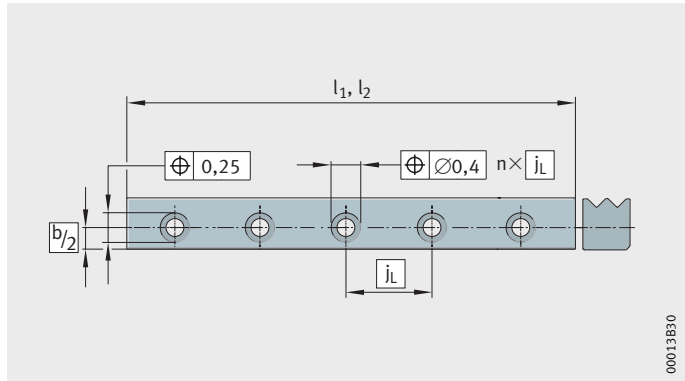
Figure 17
Positional and length tolerances of guideways

Length tolerances of guideways

Tolerances of guideways, as a function of length l
Guideway length l mm
$\leqq 350$
+0,6 mm to −1,1 mm

[1] Lengths l_1, l_2, see dimension tables from page 29.

Accessories

Insert nuts ESM

Insert nuts ESM are accessories for the location of guideways. With the aid of these nuts, the fixing holes can be used as threaded holes.

The nuts must be ordered separately and are included loose with the delivery.

The suffix for insert nuts is +ESM.

⚠️ The nuts must be fixed by adhesive in the counterbores of the fixing screw holes.

Fitting of insert nuts ESM

The counterbores in the guideway and insert nuts ESM must be degreased using conventional cleaning agents and dried, *Figure 18*.

⚠️ Legal specifications relating to the use of cleaning agents (manufacturer's instructions, regulations covering health and safety at work and environmental protection etc.) must be observed.

Cleaning agents must be disposed of correctly after use.

① Degreasing the counterbore
② Drying the counterbore

Figure 18
Degreasing
and drying the counterbore
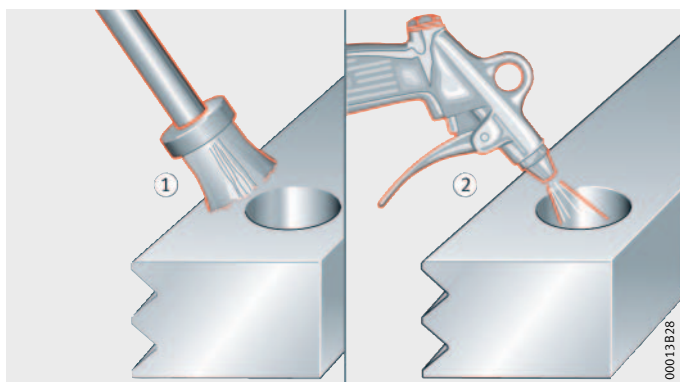
Apply adhesive to the outside surface and one end face of the nuts, *Figure 19* and table.

The manufacturer's guidelines must be observed.

① Apply adhesive
② Insert the nut in the counterbore

Figure 19
Applying adhesive
and inserting the nuts
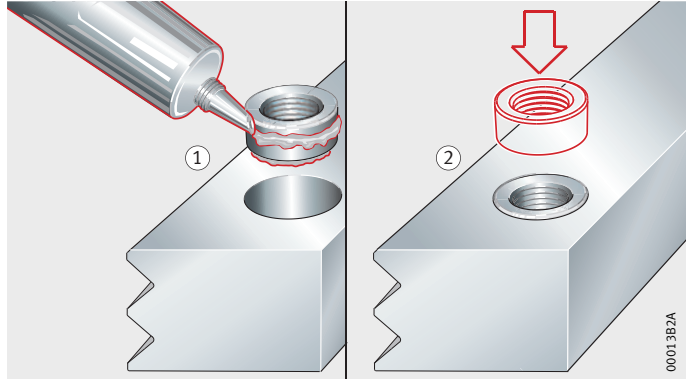
Fixing adhesive

Fixing adhesive	Example	Hardening time
Loctite 0641	Parts to be joined	30 min to 60 min
Loctite 0242	Securing of screws	30 min to 60 min
Loctite cyanoacrylate adhesive	–	30 s to 50 s

Fixing adhesive for parts to be joined or securing screws with a gap filling capacity of at least 0,2 mm.

Allow the adhesive to harden with a weight on top of the nut or while under tension using a screw inserted through the bottom of the counterbore, *Figure 20*.

Figure 20
Allow the adhesive to harden
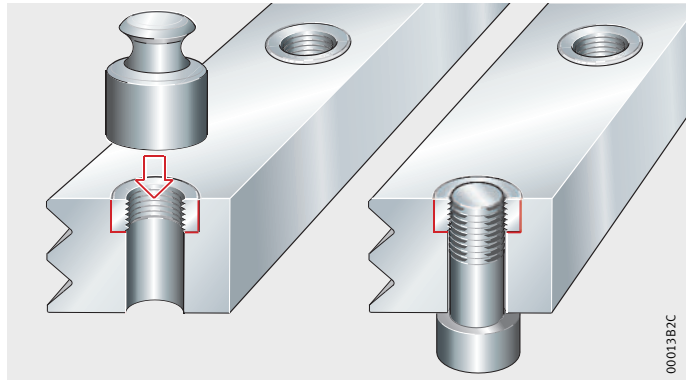
Ordering example

The ordering designation for the insert nuts ESM for a miniature linear guidance set is:

n×**ESM for RWS1808**, *Figure 22*, page 27

Ordering example, ordering designation

Calculation of guideway lengths

The lengths of the guideway pairs are calculated using the following formula:

$$l_1 = l_2 + h + z$$

l_2 mm
Length of the inner guideway pair, see dimension tables from page 29

l_1 mm
Length of the outer guideway pair, see dimension tables from page 29

h mm
Stroke length

z mm
Safety range ($4 \leqq z \leqq 10$).

Calculation example

Given

Length of the inner guideway pair l_2	150 mm
Stroke length h	20 mm
Safety allowance z ($4 \leqq z \leqq 10$)	5 mm

Calculation

$$l_1 = 150 + 20 + 5$$

$$l_1 = 175 \, \text{mm}$$

The next longest guideway, see dimension tables from page 29	175 mm

Miniature linear guidance sets

Set, guideways of unequal length ($l_2 \leqq l_1$)

Miniature linear guidance set
with cylindrical roller flat cage RWS
Size 1808
Length of
inner guideway pair l_2 ① 150 mm
outer guideway pair l_1 ② 175 mm
Stroke length h 20 mm

Ordering designation

1×**RWS1808-150/175×20,** *Figure 21*

⚠ The cylindrical roller flat cages must not be shorter than the inner guideway pair.
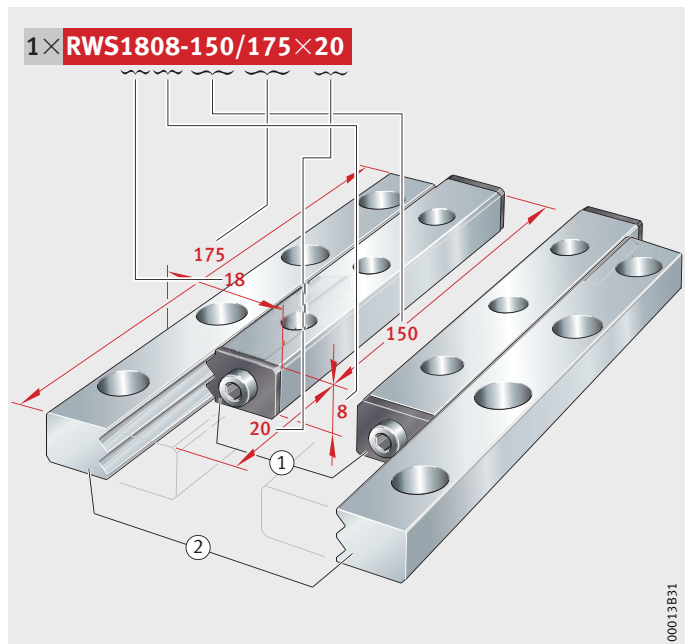
Figure 21
Ordering example,
ordering designation

Set, guideways of equal length ($l_2 = l_1$)

Miniature linear guidance set
with cylindrical roller flat cage   RWS
Size   1808
Length of
   inner guideway pair l_2 ①   150 mm
   outer guideway pair l_1 ②   150 mm
Location using insert nut   +ESM
Stroke length h   20 mm

Ordering designation

1×**RWS 1808-150/150+ESM×20**, *Figure 22*

20×**ESM for RWS 1808**, *Figure 22*
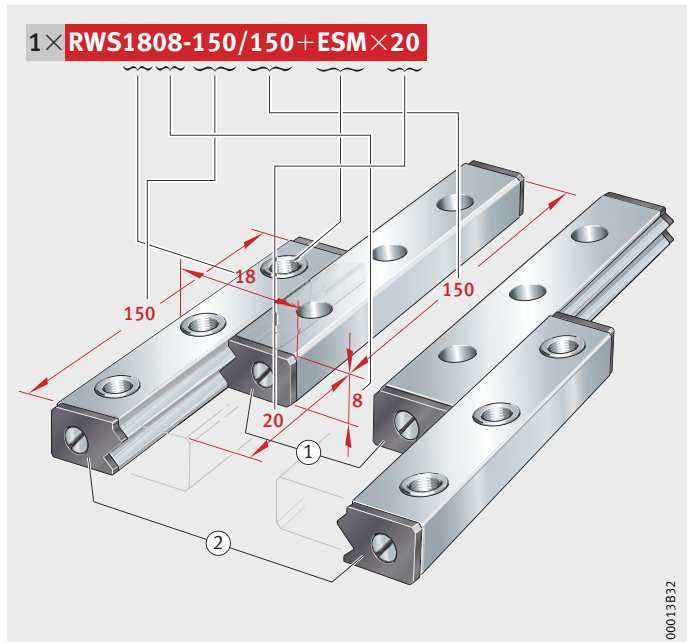
Figure 22
Ordering example,
ordering designation

Miniature linear guidance set

With cylindrical roller flat cages
Guideways of equal and unequal length
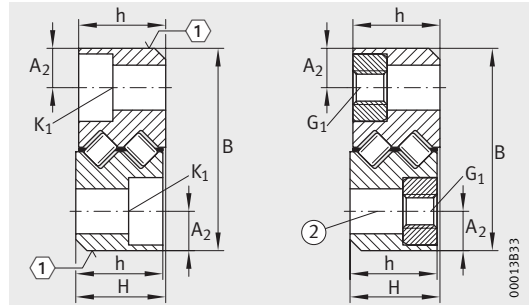
RWS1808
①, ② [2]

Dimension table · Dimensions in mm													
Designation		Dimensions			Mounting dimensions						Fixing screws		
Unit	Guideway pair 1 or 2	l_1, l_2 [1]	H	B	A_2	h	j_L	a_L	a_R	A_{L1}	G_1, K_1 DIN ISO 4 762-12.9		
												Maximum drive torque M_A	
		max.										Nm	
RWS1808	RWT	350	8	18	3,5	7,9	25	12,5	12,5	3	M3	2,2	

[1] Maximum production length of guideway.
Special lengths available by agreement.

[2] ① Locating face
② With ESM
③ Standard
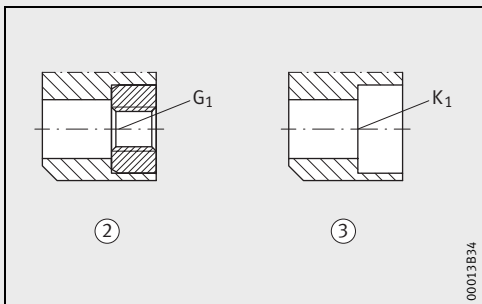
Hole types
②, ③ [2]
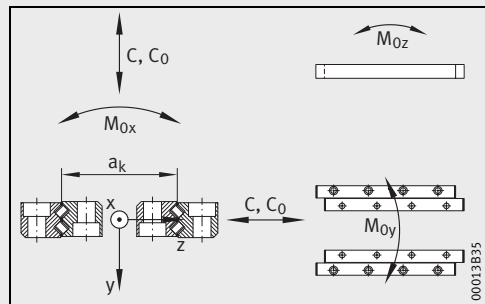
Load directions
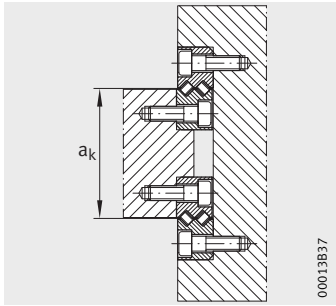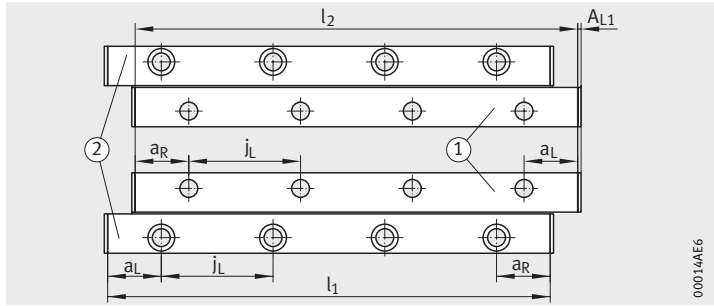
Distance between cages a_k, determined by the adjacent construction

RWS1808, guideway pair of equal length 1 and 2 (miniature linear guidance set)
①, ② [1]

Dimension table · Carriage length, stroke length, basic load ratings, moment ratings

Guideway					Load carrying capacity				
Designation	Mass	Stroke length	Dimensions		Basic load ratings		Moment ratings		
	m	h	l_1	l_2	dyn. C	stat. C_0	$M_{0x} = k_M + a_j \cdot W_{M0x}$	M_{0y}	M_{0z}
	$\approx$ g	mm	mm	mm	N	N	Nm	Nm	Nm
RWT	44	40	50	50	5 100	9 400	$10 + a_k \cdot 4{,}5$	60	60
		32			5 600	10 500	$10 + a_k \cdot 5$	60	60
		26			6 100	11 700	$10 + a_k \cdot 5{,}5$	73	73
		18			6 500	12 900	$10 + a_k \cdot 6$	88	88
		12			7 000	14 100	$10 + a_k \cdot 7$	104	104
		4			7 500	15 200	$10 + a_k \cdot 7{,}5$	121	121
	68	62	75	75	7 000	14 100	$10 + a_k \cdot 7$	104	104
		54			7 500	15 200	$10 + a_k \cdot 7{,}5$	121	121
		48			7 900	16 400	$10 + a_k \cdot 8$	139	139
		40			8 300	17 600	$10 + a_k \cdot 8{,}5$	159	159
		34			8 800	18 700	$15 + a_k \cdot 9$	180	180
		26			9 200	19 900	$15 + a_k \cdot 9{,}5$	203	203
		20			9 600	21 100	$15 + a_k \cdot 10{,}5$	227	227
		12			10 000	22 300	$20 + a_k \cdot 11$	252	252
		6			10 400	23 400	$20 + a_k \cdot 11{,}5$	279	279
	90	84	100	100	8 800	18 700	$15 + a_k \cdot 9$	180	180
		76			9 200	19 900	$15 + a_k \cdot 9{,}5$	203	203
		70			9 600	21 100	$15 + a_k \cdot 10{,}5$	227	227
		62			10 000	22 300	$20 + a_k \cdot 11$	252	252
		56			10 400	23 400	$20 + a_k \cdot 11{,}5$	279	279
		48			10 800	24 600	$20 + a_k \cdot 12$	306	306
		42			11 200	26 000	$20 + a_k \cdot 12{,}5$	336	336
		34			11 600	27 000	$20 + a_k \cdot 14$	366	366
		28			12 000	28 000	$25 + a_k \cdot 14$	398	398
		20			12 400	29 500	$25 + a_k \cdot 14{,}5$	431	431
		14			12 800	30 500	$25 + a_k \cdot 15$	465	465
		6			13 200	31 500	$25 + a_k \cdot 15{,}5$	501	501

[1] ① Guideway pair 1
② Guideway pair 2

Miniature linear guidance set

With cylindrical roller flat cages
Guideways of equal and unequal length

Distance between cages a_k, determined by the adjacent construction

Dimension table · Carriage length, stroke length, basic load ratings, moment ratings (continued)									
Guideway						Load carrying capacity			
Designation	Mass	Stroke length	Dimensions		Basic load ratings		Moment ratings		
	m	h	l_1	l_2	dyn. C	stat. C_0	$M_{0x} = k_M + a_j \cdot W_{M0x}$	M_{0y}	M_{0z}
	$\approx$ g	mm	mm	mm	N	N	Nm	Nm	Nm
RWT	114	112	125	125	10 000	22 300	$20 + a_k \cdot 11$	252	252
		106			10 400	23 400	$20 + a_k \cdot 11,5$	279	279
		98			10 800	24 600	$20 + a_k \cdot 12$	306	306
		92			11 200	26 000	$20 + a_k \cdot 12,5$	336	336
		84			11 600	27 000	$20 + a_k \cdot 14$	366	366
		78			12 000	28 000	$25 + a_k \cdot 14$	398	398
		70			12 400	29 500	$25 + a_k \cdot 14,5$	431	431
		64			12 800	30 500	$25 + a_k \cdot 15$	465	465
		56			13 200	31 500	$25 + a_k \cdot 15,5$	501	501
		50			13 500	33 000	$25 + a_k \cdot 16$	538	538
		42			13 900	34 000	$25 + a_k \cdot 16,5$	577	577
		36			14 300	35 000	$25 + a_k \cdot 17$	616	616
		28			14 600	36 500	$30 + a_k \cdot 18$	657	657
		22			15 000	37 500	$30 + a_k \cdot 18,5$	700	700
		14			15 400	38 500	$30 + a_k \cdot 19$	743	743
		8			15 700	40 000	$30 + a_k \cdot 19,5$	788	788

RWS1808, guideway pair of equal length 1 and 2 (miniature linear guidance set)
①, ② [1]

RWS1808, guideway pair of unequal length 1 and 2 (miniature linear guidance set)
①, ② [1]

Dimension table · Carriage length, stroke length, basic load ratings, moment ratings (continued)

Guideway					Load carrying capacity				
Designation	Mass	Stroke length	Dimensions		Basic load ratings		Moment ratings		
	m	h	l_1	l_2	dyn. C	stat. C_0	$M_{0x} = k_M + a_j \cdot W_{M0x}$	M_{0y}	M_{0z}
	$\approx$ g	mm	mm	mm	N	N	Nm	Nm	Nm
RWT	136	134	150	150	11 600	27 000	$20 + a_k \cdot 14$	366	366
		128			12 000	28 000	$25 + a_k \cdot 14$	398	398
		120			12 400	29 500	$25 + a_k \cdot 14,5$	431	431
		114			12 800	30 500	$25 + a_k \cdot 15$	465	465
		106			13 200	31 500	$25 + a_k \cdot 15,5$	501	501
		100			13 500	33 000	$25 + a_k \cdot 16$	538	538
		92			13 900	34 000	$25 + a_k \cdot 16,5$	577	577
		86			14 300	35 000	$25 + a_k \cdot 17$	616	616
		78			14 600	36 500	$30 + a_k \cdot 18$	657	657
		72			15 000	37 500	$30 + a_k \cdot 18,5$	700	700
		64			15 400	38 500	$30 + a_k \cdot 19$	743	743
		58			15 700	40 000	$30 + a_k \cdot 19,5$	788	788
		50			16 100	41 000	$30 + a_k \cdot 20$	835	835
		44			16 500	42 000	$30 + a_k \cdot 21$	882	882
		36			16 800	43 500	$35 + a_k \cdot 21,5$	931	931
		30			17 200	44 500	$35 + a_k \cdot 21,5$	982	982
		22			17 500	45 500	$35 + a_k \cdot 22$	1 030	1 030
		16			17 900	47 000	$35 + a_k \cdot 23$	1 080	1 080
		8			18 200	48 000	$35 + a_k \cdot 24$	1 140	1 140
		2			18 600	49 000	$35 + a_k \cdot 24,5$	1 190	1 190

[1] ① Guideway pair 1
② Guideway pair 2

Miniature linear guidance set

With cylindrical roller flat cages
Guideways of equal and unequal length

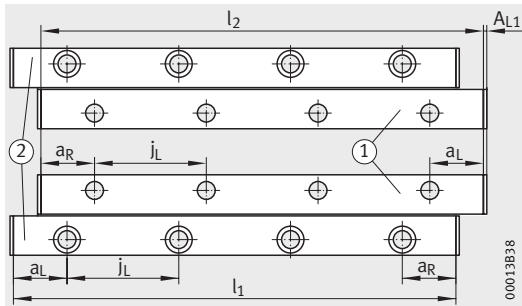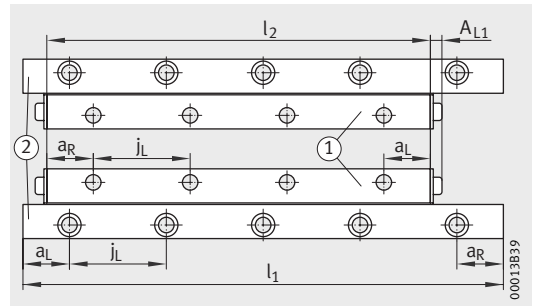Distance between cages a_k, determined by the adjacent construction

Dimension table · Carriage length, stroke length, basic load ratings, moment ratings (continued)									
Guideway					Load carrying capacity				
Designation	Mass	Stroke length	Dimensions		Basic load ratings		Moment ratings		
	m	h	l_1	l_2	dyn. C	stat. C_0	$M_{0x} = k_M + a_j \cdot W_{M0x}$	M_{0y}	M_{0z}
	$\approx$g	mm	mm	mm	N	N	Nm	Nm	Nm
RWT	160	156	175	175	13 200	31 500	$25 + a_k \cdot 15,5$	501	501
		150			13 500	33 000	$25 + a_k \cdot 16$	538	538
		142			13 900	34 000	$25 + a_k \cdot 16,5$	577	577
		136			14 300	35 000	$25 + a_k \cdot 17$	616	616
		128			14 600	36 500	$30 + a_k \cdot 18$	657	657
		122			15 000	37 500	$30 + a_k \cdot 18,5$	700	700
		114			15 400	38 500	$30 + a_k \cdot 19$	743	743
		108			15 700	40 000	$30 + a_k \cdot 19,5$	788	788
		100			16 100	41 000	$30 + a_k \cdot 20$	835	835
		94			16 500	42 000	$30 + a_k \cdot 21$	882	882
		86			16 800	43 500	$35 + a_k \cdot 21,5$	931	931
		80			17 200	44 500	$35 + a_k \cdot 21,5$	982	982
		72			17 500	45 500	$35 + a_k \cdot 22$	1 030	1 030
		66			17 900	47 000	$35 + a_k \cdot 23$	1 080	1 080
		58			18 200	48 000	$35 + a_k \cdot 24$	1 140	1 140
		52			18 600	49 000	$35 + a_k \cdot 24,5$	1 190	1 190
		44			18 900	50 500	$35 + a_k \cdot 25$	1 250	1 250
		38			19 200	51 500	$35 + a_k \cdot 25,5$	1 310	1 310
		30			19 600	52 500	$40 + a_k \cdot 26$	1 370	1 370
		24			19 900	54 000	$40 + a_k \cdot 26,5$	1 430	1 430
		16			20 200	55 000	$40 + a_k \cdot 27,5$	1 490	1 490
		10			20 600	56 000	$40 + a_k \cdot 28$	1 550	1 550
		2			20 900	57 500	$40 + a_k \cdot 28,5$	1 620	1 620

RWS1808, guideway pair of equal length 1 and 2 (miniature linear guidance set)
①, ② [1]

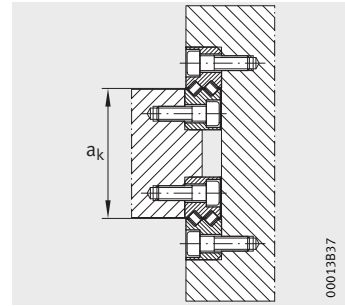RWS1808, guideway pair of unequal length 1 and 2 (miniature linear guidance set)
①, ② [1]

Dimension table · Carriage length, stroke length, basic load ratings, moment ratings (continued)

Guideway						Load carrying capacity				
Designation	Mass	Stroke length	Dimensions			Basic load ratings		Moment ratings		
	m	h	l_1	l_2		dyn. C	stat. C_0	$M_{0x} = k_M + a_j \cdot W_{M0x}$	M_{0y}	M_{0z}
	$\approx$g	mm	mm	mm		N	N	Nm	Nm	Nm
RWT	182	186	200	200		14 300	35 000	$25 + a_k \cdot 17$	616	616
		178				14 600	36 500	$30 + a_k \cdot 18$	657	657
		172				15 000	37 500	$30 + a_k \cdot 18,5$	700	700
		164				15 400	38 500	$30 + a_k \cdot 19$	743	743
		158				15 700	40 000	$30 + a_k \cdot 19,5$	788	788
		150				16 100	41 000	$30 + a_k \cdot 20$	835	835
		144				16 500	42 000	$30 + a_k \cdot 21$	882	882
		136				16 800	43 500	$35 + a_k \cdot 21,5$	931	931
		130				17 200	44 500	$35 + a_k \cdot 21,5$	982	982
		122				17 500	45 500	$35 + a_k \cdot 22$	1 030	1 030
		116				17 900	47 000	$35 + a_k \cdot 23$	1 080	1 080
		108				18 200	48 000	$35 + a_k \cdot 24$	1 140	1 140
		102				18 600	49 000	$35 + a_k \cdot 24,5$	1 190	1 190
		94				18 900	50 500	$35 + a_k \cdot 25$	1 250	1 250
		88				19 200	51 500	$35 + a_k \cdot 25,5$	1 310	1 310
		80				19 600	52 500	$40 + a_k \cdot 26$	1 370	1 370
		74				19 900	54 000	$40 + a_k \cdot 26,5$	1 430	1 430
		66				20 200	55 000	$40 + a_k \cdot 27,5$	1 490	1 490
		60				20 600	56 000	$40 + a_k \cdot 28$	1 550	1 550
		52				20 900	57 500	$40 + a_k \cdot 28,5$	1 620	1 620
		46				21 200	58 500	$40 + a_k \cdot 29$	1 680	1 680
		38				21 600	60 000	$40 + a_k \cdot 29,5$	1 750	1 750
		32				21 900	61 000	$45 + a_k \cdot 30,5$	1 820	1 820
		24				22 200	62 000	$45 + a_k \cdot 31$	1 890	1 890
		18				22 600	63 500	$45 + a_k \cdot 31,5$	1 960	1 960
		10				22 900	64 500	$45 + a_k \cdot 32$	2 030	2 030
		4				23 200	65 500	$45 + a_k \cdot 32,5$	2 110	2 110

[1]   ① Guideway pair 1
      ② Guideway pair 2

Miniature linear guidance set

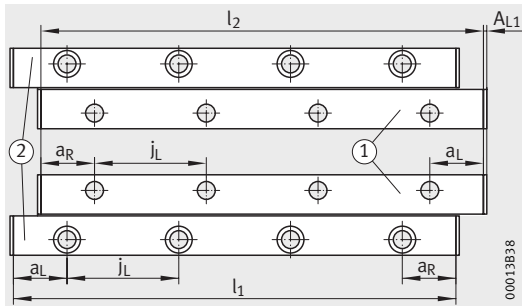With cylindrical roller flat cages
Guideways of equal and unequal length

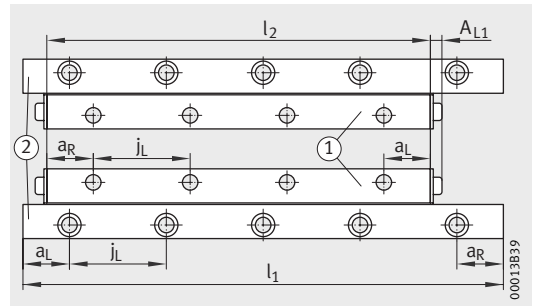Distance between cages a_k, determined by the adjacent construction

Dimension table · Carriage length, stroke length, basic load ratings, moment ratings (continued)									
Guideway						**Load carrying capacity**			
Designation	Mass	Stroke length	Dimensions		Basic load ratings		Moment ratings		
	m	h	l_1	l_2	dyn. C	stat. C_0	$M_{0x} = k_M + a_j \cdot W_{M0x}$	M_{0y}	M_{0z}
	$\approx$ g	mm	mm	mm	N	N	Nm	Nm	Nm
RWT	206	208	225	225	15 700	40 000	$30 + a_k \cdot 19{,}5$	788	788
		200			16 100	41 000	$30 + a_k \cdot 20$	835	835
		194			16 500	42 000	$30 + a_k \cdot 21$	882	882
		186			16 800	43 500	$35 + a_k \cdot 21{,}5$	931	931
		180			17 200	44 500	$35 + a_k \cdot 21{,}5$	982	982
		172			17 500	45 500	$35 + a_k \cdot 22$	1 030	1 030
		166			17 900	47 000	$35 + a_k \cdot 23$	1 080	1 080
		158			18 200	48 000	$35 + a_k \cdot 24$	1 140	1 140
		152			18 600	49 000	$35 + a_k \cdot 24{,}5$	1 190	1 190
		144			18 900	50 500	$35 + a_k \cdot 25$	1 250	1 250
		138			19 200	51 500	$35 + a_k \cdot 25{,}5$	1 310	1 310
		130			19 600	52 500	$40 + a_k \cdot 26$	1 370	1 370
		124			19 900	54 000	$40 + a_k \cdot 26{,}5$	1 430	1 430
		116			20 200	55 000	$40 + a_k \cdot 27{,}5$	1 490	1 490
		110			20 600	56 000	$40 + a_k \cdot 28$	1 550	1 550
		102			20 900	57 500	$40 + a_k \cdot 28{,}5$	1 620	1 620
		96			21 200	58 500	$40 + a_k \cdot 29$	1 680	1 680
		88			21 600	60 000	$40 + a_k \cdot 29{,}5$	1 750	1 750
		82			21 900	61 000	$45 + a_k \cdot 30{,}5$	1 820	1 820
		74			22 200	62 000	$45 + a_k \cdot 31$	1 890	1 890
		68			22 600	63 500	$45 + a_k \cdot 31{,}5$	1 960	1 960
		60			22 900	64 500	$45 + a_k \cdot 32$	2 030	2 030
		54			23 200	65 500	$45 + a_k \cdot 32{,}5$	2 110	2 110
		46			23 500	67 000	$45 + a_k \cdot 33$	2 180	2 180
		40			23 800	68 000	$50 + a_k \cdot 34$	2 260	2 260
		32			24 200	69 000	$50 + a_k \cdot 34{,}5$	2 340	2 340
		26			24 500	70 500	$50 + a_k \cdot 35$	2 420	2 420
		18			24 800	71 500	$50 + a_k \cdot 35{,}5$	2 500	2 500
		12			25 000	72 500	$50 + a_k \cdot 36$	2 580	2 580
		4			25 500	74 000	$50 + a_k \cdot 37$	2 660	2 660

RWS1808, guideway pair of equal length 1 and 2
(miniature linear guidance set)
① , ② [1]

RWS1808, guideway pair of unequal length 1 and 2
(miniature linear guidance set)
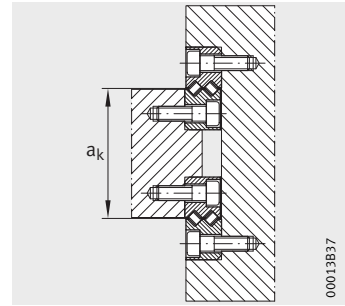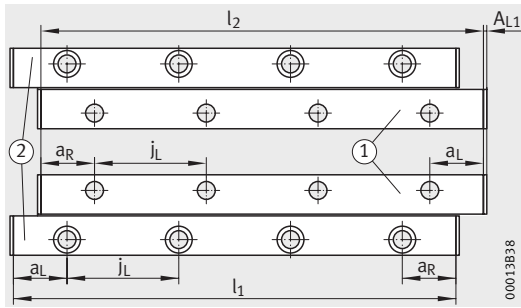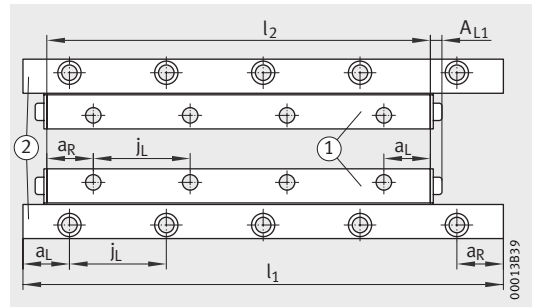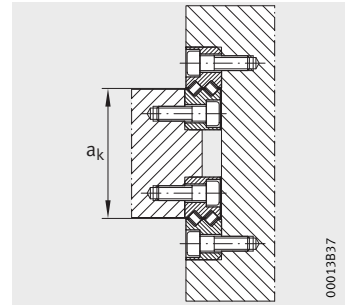① , ② [1]

Dimension table · Carriage length, stroke length, basic load ratings, moment ratings (continued)

Guideway						Load carrying capacity				
Designation	Mass	Stroke length	Dimensions			Basic load ratings		Moment ratings		
	m	h	l_1	l_2		dyn. C	stat. C_0	$M_{0x} = k_M + a_j \cdot W_{M0x}$	M_{0y}	M_{0z}
	$\approx$ g	mm	mm	mm		N	N	Nm	Nm	Nm
RWT	228	236	250	250		16 800	43 500	$35 + a_k \cdot 21{,}5$	931	931
		230				17 200	44 500	$35 + a_k \cdot 21{,}5$	982	982
		222				17 500	45 500	$35 + a_k \cdot 22$	1 030	1 030
		216				17 900	47 000	$35 + a_k \cdot 23$	1 080	1 080
		208				18 200	48 000	$35 + a_k \cdot 24$	1 140	1 140
		202				18 600	49 000	$35 + a_k \cdot 24{,}5$	1 190	1 190
		194				18 900	50 500	$35 + a_k \cdot 25$	1 250	1 250
		188				19 200	51 500	$35 + a_k \cdot 25{,}5$	1 310	1 310
		180				19 600	52 500	$40 + a_k \cdot 26$	1 370	1 370
		174				19 900	54 000	$40 + a_k \cdot 26{,}5$	1 430	1 430
		166				20 200	55 000	$40 + a_k \cdot 27{,}5$	1 490	1 490
		160				20 600	56 000	$40 + a_k \cdot 28$	1 550	1 550
		152				20 900	57 500	$40 + a_k \cdot 28{,}5$	1 620	1 620
		146				21 200	58 500	$40 + a_k \cdot 29$	1 680	1 680
		138				21 600	60 000	$40 + a_k \cdot 29{,}5$	1 750	1 750
		132				21 900	61 000	$45 + a_k \cdot 30{,}5$	1 820	1 820
		124				22 200	62 000	$45 + a_k \cdot 31$	1 890	1 890
		118				22 600	63 500	$45 + a_k \cdot 31{,}5$	1 960	1 960
		110				22 900	64 500	$45 + a_k \cdot 32$	2 030	2 030
		104				23 200	65 500	$45 + a_k \cdot 32{,}5$	2 110	2 110
		96				23 500	67 000	$45 + a_k \cdot 33$	2 180	2 180
		90				23 800	68 000	$50 + a_k \cdot 34$	2 260	2 260
		82				24 200	69 000	$50 + a_k \cdot 34{,}5$	2 340	2 340
		76				24 500	70 500	$50 + a_k \cdot 35$	2 420	2 420
		68				24 800	71 500	$50 + a_k \cdot 35{,}5$	2 500	2 500
		62				25 000	72 500	$50 + a_k \cdot 36$	2 580	2 580
		54				25 500	74 000	$50 + a_k \cdot 37$	2 660	2 660
		48				25 500	75 000	$50 + a_k \cdot 37{,}5$	2 750	2 750
		40				26 000	76 000	$50 + a_k \cdot 38$	2 840	2 840
		34				26 500	77 500	$50 + a_k \cdot 38{,}5$	2 920	2 920
		26				26 500	78 500	$55 + a_k \cdot 39$	3 010	3 010
		20				27 000	79 500	$55 + a_k \cdot 40$	3 100	3 100
		12				27 500	81 000	$55 + a_k \cdot 40{,}5$	3 190	3 190
		6				27 500	82 000	$55 + a_k \cdot 41$	3 280	3 280

[1] ① Guideway pair 1
② Guideway pair 2

Miniature linear guidance set

With cylindrical roller flat cages
Guideways of equal and unequal length
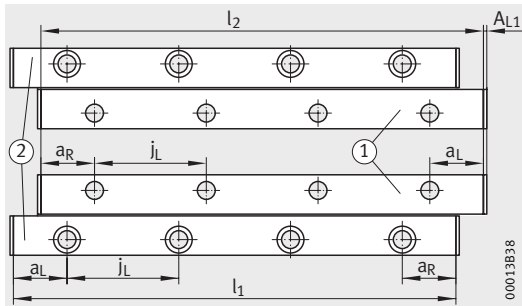

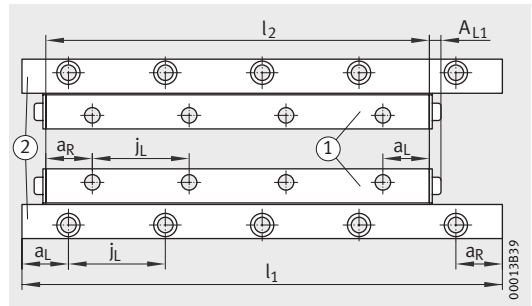Distance between cages a_k, determined by the adjacent construction

Dimension table · Carriage length, stroke length, basic load ratings, moment ratings (continued)										
Guideway					**Load carrying capacity**					
Designation	Mass	Stroke length	Dimensions		Basic load ratings		Moment ratings			
	m	h	l_1	l_2	dyn. C	stat. C_0	$M_{0x} = k_M + a_j \cdot W_{M0x}$	M_{0y}	M_{0z}	
	$\approx$g	mm	mm	mm	N	N	Nm	Nm	Nm	
RWT	275	280	300	300	19 600	52 500	$40 + a_k \cdot 26$	1 370	1 370	
		274			19 900	54 000	$40 + a_k \cdot 26{,}5$	1 430	1 430	
		266			20 200	55 000	$40 + a_k \cdot 27{,}5$	1 490	1 490	
		260			20 600	56 000	$40 + a_k \cdot 28$	1 550	1 550	
		252			20 900	57 500	$40 + a_k \cdot 28{,}5$	1 620	1 620	
		246			21 200	58 500	$40 + a_k \cdot 29$	1 680	1 680	
		238			21 600	60 000	$40 + a_k \cdot 29{,}5$	1 750	1 750	
		232			21 900	61 000	$45 + a_k \cdot 30{,}5$	1 820	1 820	
		224			22 200	62 000	$45 + a_k \cdot 31$	1 890	1 890	
		218			22 600	63 500	$45 + a_k \cdot 31{,}5$	1 960	1 960	
		210			22 900	64 500	$45 + a_k \cdot 32$	2 030	2 030	
		204			23 200	65 500	$45 + a_k \cdot 32{,}5$	2 110	2 110	
		196			23 500	67 000	$45 + a_k \cdot 33$	2 180	2 180	
		190			23 800	68 000	$50 + a_k \cdot 34$	2 260	2 260	
		182			24 200	69 000	$50 + a_k \cdot 34{,}5$	2 340	2 340	
		176			24 500	70 500	$50 + a_k \cdot 35$	2 420	2 420	
		168			24 800	71 500	$50 + a_k \cdot 35{,}5$	2 500	2 500	
		162			25 000	72 500	$50 + a_k \cdot 36$	2 580	2 580	
		154			25 500	74 000	$50 + a_k \cdot 37$	2 660	2 660	
		148			25 500	75 000	$50 + a_k \cdot 37{,}5$	2 750	2 750	

RWS1808, guideway pair of equal length 1 and 2 (miniature linear guidance set)
①, ② [1]

RWS1808, guideway pair of unequal length 1 and 2 (miniature linear guidance set)
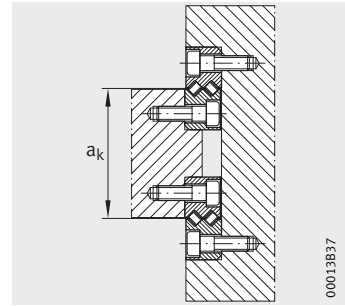①, ② [1]

Dimension table · Carriage length, stroke length, basic load ratings, moment ratings (continued)

Guideway					Load carrying capacity				
Designation	Mass	Stroke length	Dimensions		Basic load ratings		Moment ratings		
	m	h	l_1	l_2	dyn. C	stat. C_0	$M_{0x} = k_M + a_j \cdot W_{M0x}$	M_{0y}	M_{0z}
	$\approx$g	mm	mm	mm	N	N	Nm	Nm	Nm
RWT	275	140	300	300	26 000	76 000	$50 + a_k \cdot 38$	2 840	2 840
		134			26 500	77 500	$50 + a_k \cdot 38{,}5$	2 920	2 920
		126			26 500	78 500	$55 + a_k \cdot 39$	3 010	3 010
		120			27 000	79 500	$55 + a_k \cdot 40$	3 100	3 100
		112			27 500	81 000	$55 + a_k \cdot 40{,}5$	3 190	3 190
		106			27 500	82 000	$55 + a_k \cdot 41$	3 280	3 280
		98			28 000	83 000	$55 + a_k \cdot 41{,}5$	3 380	3 380
		92			28 000	84 500	$60 + a_k \cdot 42$	3 470	3 470
		84			28 500	85 500	$60 + a_k \cdot 42{,}5$	3 570	3 570
		78			29 000	86 500	$60 + a_k \cdot 43{,}5$	3 670	3 670
		70			29 000	88 000	$60 + a_k \cdot 44$	3 770	3 770
		64			29 500	89 000	$60 + a_k \cdot 44{,}5$	3 870	3 870
		56			29 500	90 000	$60 + a_k \cdot 45$	3 970	3 970
		50			30 000	91 500	$60 + a_k \cdot 45{,}5$	4 070	4 070
		42			30 500	92 500	$65 + a_k \cdot 46{,}5$	4 180	4 180
		36			30 500	93 500	$65 + a_k \cdot 47$	4 280	4 280
		28			31 000	95 000	$65 + a_k \cdot 47{,}5$	4 390	4 390
		22			31 000	96 000	$65 + a_k \cdot 48$	4 500	4 500
		14			31 500	97 500	$65 + a_k \cdot 48{,}5$	4 610	4 610
		8			32 000	98 500	$65 + a_k \cdot 49$	4 720	4 720

[1]
① Guideway pair 1
② Guideway pair 2

Miniature linear guidance set

With cylindrical roller flat cages
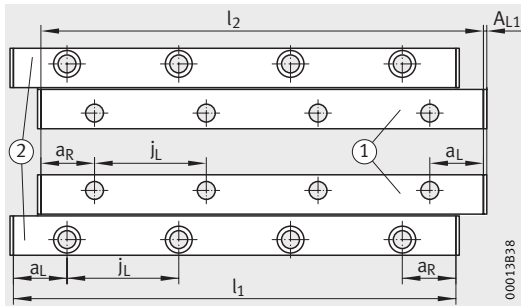Guideways of equal and unequal length

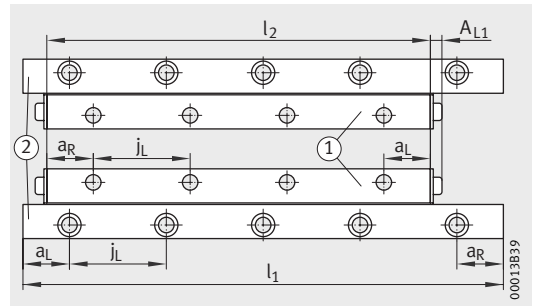Distance between cages a_k, determined by the adjacent construction

Dimension table · Carriage length, stroke length, basic load ratings, moment ratings (continued)

Guideway					Load carrying capacity				
Designation	Mass	Stroke length	Dimensions		Basic load ratings		Moment ratings		
	m	h	l_1	l_2	dyn. C	stat. C_0	$M_{0x} = k_M + a_j \cdot W_{M0x}$	M_{0y}	M_{0z}
	≈g	mm	mm	mm	N	N	Nm	Nm	Nm
RWT	320	332	350	350	21 900	61 000	$45 + a_k \cdot 30{,}5$	1 820	1 820
		324			22 200	62 000	$45 + a_k \cdot 31$	1 890	1 890
		318			22 600	63 500	$45 + a_k \cdot 31{,}5$	1 960	1 960
		310			22 900	64 500	$45 + a_k \cdot 32$	2 030	2 030
		304			23 200	65 500	$45 + a_k \cdot 32{,}5$	2 110	2 110
		296			23 500	67 000	$45 + a_k \cdot 33$	2 180	2 180
		290			23 800	68 000	$50 + a_k \cdot 34$	2 260	2 260
		282			24 200	69 000	$50 + a_k \cdot 34{,}5$	2 340	2 340
		276			24 500	70 500	$50 + a_k \cdot 35$	2 420	2 420
		268			24 800	71 500	$50 + a_k \cdot 35{,}5$	2 500	2 500
		262			25 000	72 500	$50 + a_k \cdot 36$	2 580	2 580
		254			25 500	74 000	$50 + a_k \cdot 37$	2 660	2 660
		248			25 500	75 000	$50 + a_k \cdot 37{,}5$	2 750	2 750
		240			26 000	76 000	$50 + a_k \cdot 38$	2 840	2 840
		234			26 500	77 500	$50 + a_k \cdot 38{,}5$	2 920	2 920
		226			26 500	78 500	$55 + a_k \cdot 39$	3 010	3 010
		220			27 000	79 500	$55 + a_k \cdot 40$	3 100	3 100
		212			27 500	81 000	$55 + a_k \cdot 40{,}5$	3 190	3 190
		206			27 500	82 000	$55 + a_k \cdot 41$	3 280	3 280
		198			28 000	83 000	$55 + a_k \cdot 41{,}5$	3 380	3 380
		192			28 000	84 500	$60 + a_k \cdot 42$	3 470	3 470
		184			28 500	85 500	$60 + a_k \cdot 42{,}5$	3 570	3 570
		178			29 000	86 500	$60 + a_k \cdot 43{,}5$	3 670	3 670
		170			29 000	88 000	$60 + a_k \cdot 44$	3 770	3 770
		164			29 500	89 000	$60 + a_k \cdot 44{,}5$	3 870	3 870

RWS1808, guideway pair of equal length 1 and 2 (miniature linear guidance set)
①, ② [1]

RWS1808, guideway pair of unequal length 1 and 2 (miniature linear guidance set)
①, ② [1]

Dimension table · Carriage length, stroke length, basic load ratings, moment ratings (continued)

Guideway					Load carrying capacity				
Designation	Mass	Stroke length	Dimensions		Basic load ratings		Moment ratings		
	m	h	l_1	l_2	dyn. C	stat. C_0	$M_{0x} = k_M + a_j \cdot W_{M0x}$	M_{0y}	M_{0z}
	$\approx$ g	mm	mm	mm	N	N	Nm	Nm	Nm
RWT	320	156	350	350	29 500	90 000	$60 + a_k \cdot 45$	3 970	3 970
		150			30 000	91 500	$60 + a_k \cdot 45,5$	4 070	4 070
		142			30 500	92 500	$65 + a_k \cdot 46,5$	4 180	4 180
		136			30 500	93 500	$65 + a_k \cdot 47$	4 280	4 280
		128			31 000	95 000	$65 + a_k \cdot 47,5$	4 390	4 390
		122			31 000	96 000	$65 + a_k \cdot 48$	4 500	4 500
		114			31 500	97 500	$65 + a_k \cdot 48,5$	4 610	4 610
		108			32 000	98 500	$65 + a_k \cdot 49$	4 720	4 720
		100			32 000	99 500	$70 + a_k \cdot 50$	4 830	4 830
		94			32 500	101 000	$70 + a_k \cdot 50,5$	4 950	4 950
		86			32 500	102 000	$70 + a_k \cdot 51$	5 060	5 060
		80			33 000	103 000	$70 + a_k \cdot 51,5$	5 180	5 180
		72			33 500	104 500	$70 + a_k \cdot 52$	5 300	5 300
		66			33 500	105 500	$70 + a_k \cdot 53$	5 410	5 410
		58			34 000	106 500	$70 + a_k \cdot 53,5$	5 530	5 530
		52			34 000	108 000	$70 + a_k \cdot 54$	5 660	5 660
		44			34 500	109 000	$75 + a_k \cdot 54,5$	5 780	5 780
		38			34 500	110 000	$70 + a_k \cdot 55$	5 900	5 900
		30			35 000	111 500	$70 + a_k \cdot 56$	6 030	6 030
		24			35 500	112 500	$75 + a_k \cdot 56,5$	6 160	6 160
		16			35 500	113 500	$75 + a_k \cdot 57$	6 290	6 290
		10			36 000	115 000	$75 + a_k \cdot 57,5$	6 410	6 410
		2			36 000	116 000	$80 + a_k \cdot 58$	6 540	6 540

[1] ① Guideway pair 1
② Guideway pair 2

Notes