

## Corrosion-resistant miniature linear recirculating ball bearing and guideway assemblies

in sizes 05 to 15

Technical Product Information



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# 1 Technical principles

## 1.1 Miniature linear recirculating ball bearing and guideway assemblies in 2 variants

Miniature linear recirculating ball bearing and guideway assemblies in sizes 05 to 15 are full complement, linear locating bearings of various preload classes for unlimited stroke lengths. They are of a two-row design and comprise a guideway and a carriage. The two-row units have 2 rows of rolling elements in four point contact with the raceways and are preloaded.

### 1.1.1 Miniature linear recirculating ball bearing and guideway assemblies KUEM05

Miniature linear recirculating ball bearing and guideway assemblies are available in 2 different designs with carriages KWEM05 and KWEM05-W. The matching guideways TKDM05 (in 6 preferred lengths) and TKDM05-W (in 7 preferred lengths) are available in any lengths up to the maximum section length.

1 Miniature linear recirculating ball bearing and guideway assemblies

1	TKDM05	2	TKDM05-W
3	KWEM05	4	KWEM05-W
5	Dummy guideway		

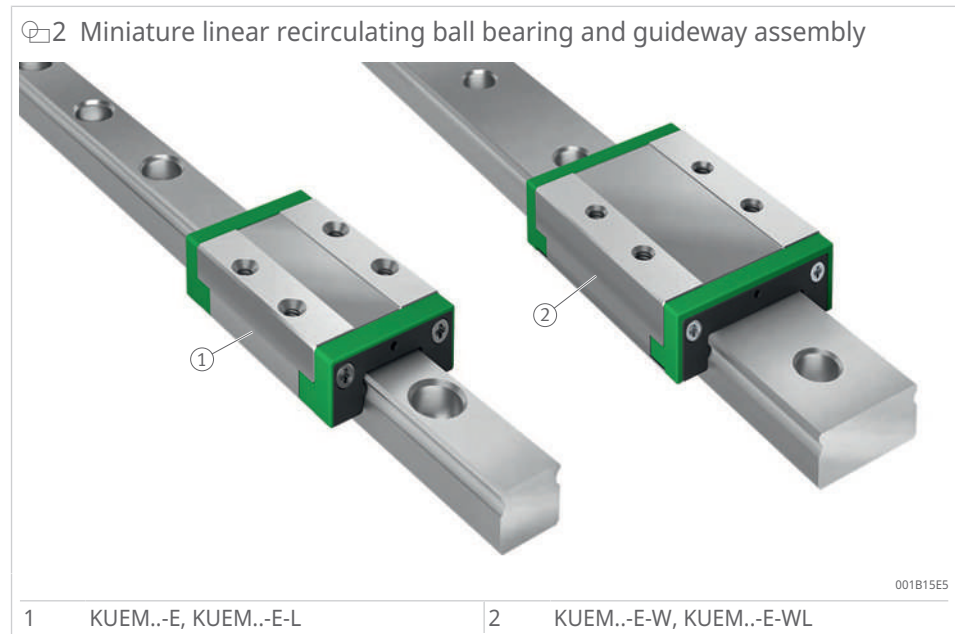
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#### 1 Available designs

Design	Description
-	Standard
W	Wide design

### 1.1.2 Miniature linear recirculating ball bearing and guideway assemblies KUEM..-E

Miniature linear recirculating ball bearing and guideway systems are available in 4 sizes (07, 09, 12 and 15) and 4 different designs with carriages KWEM..-E, KWEM..-E-L, KWEM..-E-W and KWEM..-E-WL. The matching guideways TKDM..-E and TKDM..-E-W for the systems are available in freely selectable lengths, taking into account the maximum length available.



#### 2 Available designs

Design	Description
-	Standard
W	Wide design
L	Long design
WL	Wide, long design

### 1.1.3 Corrosion-resistant design

The miniature linear recirculating ball bearing and guideway assemblies are corrosion-resistant under normal conditions due to the use of high-alloy premium steel for the carriages and guideways.

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

### 1.1.4 Applications

The miniature linear recirculating ball bearing and guideway assemblies are particularly suitable for applications:

- in the microelectronics industry and similar sectors
- in optical equipment
- in medical equipment
- in textile machinery
- that require high speeds and very uniform running behaviour
- where particularly economical miniature guidance systems are needed for moderate to high loads and moderate to high rigidity requirements
- requiring high performance in a minimal design envelope

## 1.2 Load carrying capacity and rating life

### 1.2.1 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  $C$  and the basic static load rating  $C_0$ .

#### Calculation of the basic load rating according to DIN ISO

The calculation of the basic dynamic and static load ratings in the product tables is based on DIN ISO 14728-1 und -2.

#### Differences between DIN ISO and suppliers from the Far East

Suppliers from the Far East frequently calculate basic load ratings using a basic rating life based on a displacement distance of only 50 km in contrast to 100 km according to DIN ISO. This results in comparatively higher basic load ratings.

#### Conversion of basic load ratings

For miniature linear recirculating ball bearing and guideway assemblies, the basic load ratings to DIN can be converted to basic load ratings as used in the Far East and vice versa:

$f_1$

$$C_{50} = 1,26 \cdot C_{100}$$

$f_2$

$$C_{100} = 0,79 \cdot C_{50}$$

$C_{50}$	N	Basic dynamic load rating according to DIN ISO 14728-1, based on 50 km
$C_{100}$	N	Basic dynamic load rating according to DIN ISO 14728-1, based on 100 km

### 1.2.2 Basic rating life

The basic rating life  $L$  and  $L_h$  is achieved or exceeded by 90 % of a sufficiently large group of identical bearings before the first evidence of material fatigue occurs.

f13

$$L = \left( \frac{C_{100}}{P} \right)^p \cdot 100$$

f14

$$L_h = \frac{833}{H \cdot n_{osc}} \cdot \left( \frac{C_{100}}{P} \right)^p$$

f15

$$L_h = \frac{1666}{v_m} \cdot \left( \frac{C_{100}}{P} \right)^p$$

$C_{100}$	N	Basic dynamic load rating according to DIN ISO 14728-1, based on 100 km
H	m	Single stroke length for oscillating motion
L	km	Basic rating life as a distance
$L_h$	h	Basic rating life in operating hours
$n_{osc}$	min <sup>-1</sup>	Number of return strokes per minute
P	N	Equivalent dynamic bearing load
p	-	Life exponent for ball bearings: p = 3
$v_m$	m/min	Mean velocity

**!** According to DIN ISO 14728-1, the equivalent dynamic load P should not exceed the value  $0,5 \cdot C$ . If lateral forces are present, the frictional locking of the fixing screws should be checked. Ideally, locating edges should be provided.

#### Mean velocity

Where the velocity varies in steps, the mean velocity is calculated as follows:

f16

$$v_m = v_1 \cdot \frac{q_1}{100} + v_2 \cdot \frac{q_2}{100} + \dots + v_z \cdot \frac{q_z}{100}$$

$q_z$	%	Time proportion of the period of action
$v_m$	m/min	Mean velocity
$v_z$	m/min	Variable speed

### 1.2.3 Static load safety factor

The static load safety factor  $S_0$  is the security against permanent deformation at the rolling contact:

f17

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



f18

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

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

f19

$$P_0 = F_{\max}$$

f110

$$M = M_{\max}$$

$C_0$	N	Basic static load rating in the load direction
$M$	Nm	Equivalent static moment in the load direction
$M_0$	Nm	Static moment rating in the load direction ( $M_{0x}$ , $M_{0y}$ , $M_{0z}$ )
$P_0$	N	Equivalent static bearing load in the 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 not be less than  $S_0 = 3$ . For high loads, the load carrying capacity of the fixing screws must be checked, see VDI Guideline 2230.

### 1.3 Preload

Increasing the preload increases the rigidity of the guidance system. The preload influences not only the rigidity but also the displacement force of the guidance system. The higher the preload, the larger the displacement force. Furthermore, the preload also influences the operating life of the guidance system.

The approximate calculation of the equivalent static and dynamic load is based on the standard preload.

Under low load and high preload, the values for rating life and static load safety factor may be lower than those calculated using the approximation formulae for the equivalent static and dynamic load.

Miniature linear recirculating ball bearing and guideway assemblies are available in different preload classes.

The preload class affects the characteristics of a carriage.

#### 3 Preload classes

Preload class	Preload setting
V0 <sup>1)</sup>	Slight clearance
V1 <sup>2)</sup>	Slight preload
V2 <sup>3)</sup>	Moderate preload, higher rigidity

1) Standard for size 05

2) Standard for sizes 07 to 15

3) Not available for size 05, as unit available in sizes 07 to 15

## 1.4 Load carrying capacity

The units can support forces from all directions, apart from the direction of motion, and moments about all axes. They have moderate load carrying capacity and moderate to high moment load carrying capacity.

## 1.5 Temperature range

End wipers reduce the maximum permissible operating temperature by +20 °C.

4 Influence of end wipers on operating temperature

Carriage	Operating temperature	
	°C	
	min.	max.
With end wipers	-10	+80
Without end wipers	-10	+100

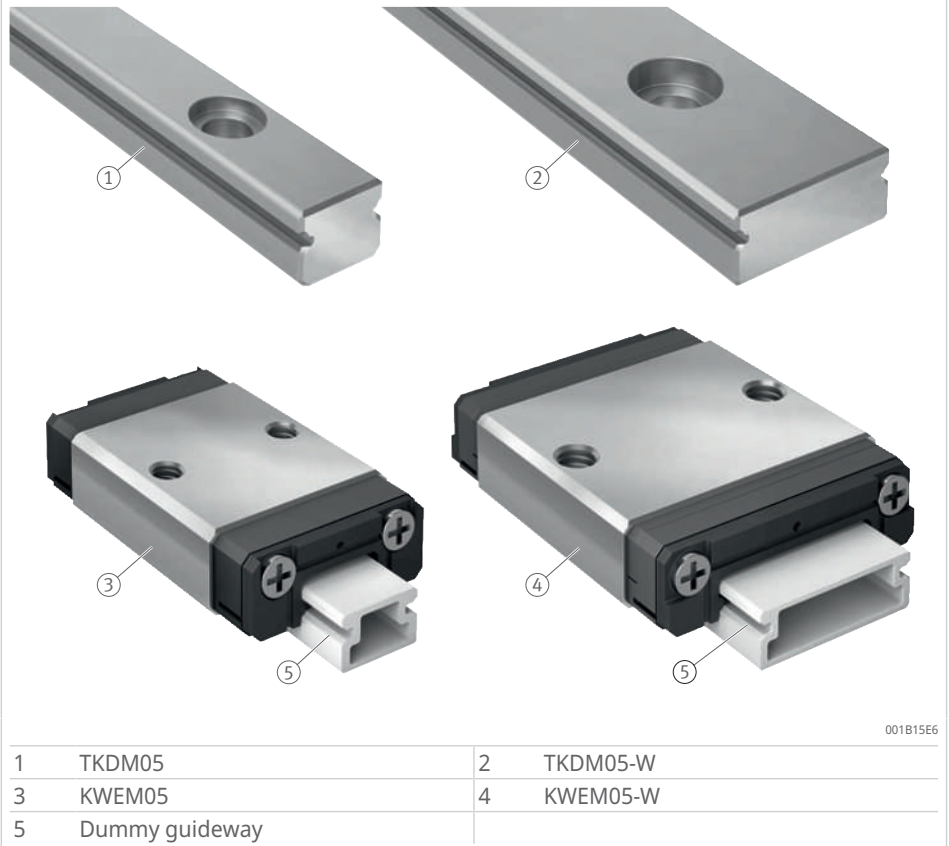
## 2 Miniature linear recirculating ball bearing and guideway assemblies, carriage KWEM05 and guideway TKDM05

### 2.1 Product design

#### 2.1.1 Carriage

Carriages KWEM05 have end wipers and are supplied greased. Carriages KWEM05 and guideways TKDM05 are always ordered and supplied separately.

3 Product overview, guideways and carriages with optional long term lubrication unit on dummy guideway



**!** Carriages are always pushed directly from the guideway onto the dummy guideway and must remain there until they are remounted. The plastic dummy guideway prevents damage to the rolling element set and prevents the rolling elements from falling out if the carriage is removed from the guideway. It must be ensured that the dummy guideway remains in contact with the guideway at all times during mounting and dismounting to prevent the loss of rolling elements.

### 2.1.2 Guideways

Guideways TKDM05 and TKDM05-W have a locating edge, are made from corrosion-resistant high-grade steel, are hardened and are ground on all faces. The raceways for the rolling elements are ground to very high precision. For fixing to the adjacent construction, they have threaded holes with counterbores for the screw heads. The guideways are fixed from above and are available in preferred lengths up to the maximum length.

5 Preferred lengths of guideways

Designation	Preferred lengths	Maximum length
Guideway	mm	mm
TKDM05, TKDM05-W	60, 90, 105, 120, 150, 210	210

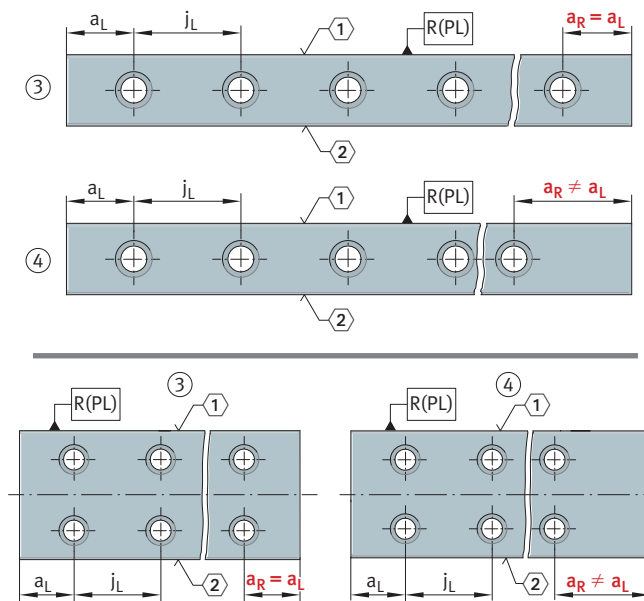
#### 2.1.2.1 Hole patterns for guideways

An asymmetrical hole pattern may also be available upon request. In this case,  $a_L \geq a_{L\ min}$  and  $a_R \geq a_{R\ min}$ .

Unless specified otherwise, the guideways have a symmetrical hole pattern where  $a_L = a_R$ .

**!** Irrespective of the orientation of the locating face,  $a_L$  is on the left and  $a_R$  is on the right. When ordering, the required orientation of the locating face must be indicated as top or bottom.

4 Hole patterns of guideways with 1 or 2 rows of holes



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1	Locating face	2	Marking
3	Symmetrical hole pattern	4	Asymmetrical hole pattern
R(PL)	Reference face of the guideway		

### 2.1.2.2 Maximum number of pitches between holes

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

$$f11 \quad n = \frac{l - 2 \cdot a_{L \min}}{j_L}$$

The distances  $a_L$  and  $a_R$  are generally determined as follows:


$$f12 \quad a_L + a_R = l - n \cdot j_L$$

For guideways with a symmetrical hole pattern:

$$f13 \quad a_L = a_R = \frac{1}{2} \cdot (l - n \cdot j_L)$$

Number of holes:

f14		
$x = n + 1$		
$a_L, a_R$	mm	Distance between start or end of guideway and nearest hole
$a_{L \min}, a_{R \min}$	mm	Minimum values for $a_L, a_R$
$j_L$	mm	Distance between holes
$l$	mm	Guideway length
$n$	-	Max. possible number of hole pitches
$x$	-	Number of holes

 If the minimum values for  $a_L$  and  $a_R$  are not observed, the counterbores of the holes may be intersected. Risk of injury.

### 2.1.3 Interchangeability

Carriages KWEM05 and guideways TKDM05 of the same size can be combined or replaced. If the guideways and carriages are combined or replaced within a single accuracy class, the accuracy class is also maintained for the system.

 6 Interchangeability of carriages and guideways

Accuracy class			Comment
Carriage KWEM05	Guideway TKDM05	Unit	
G1	G1	G1	Recommended combination
G1	G2	G2	-
G2	G1	G2	-
G2	G2	G2	Recommended combination

## 2.2 Acceleration and speed

Carriages KWEM05 permit accelerations up to 50 m/s<sup>2</sup> and speeds up to 3 m/s.

## 2.3 Lubrication

Carriages KWEM05 are supplied in greased form. The carriages can be lubricated through lubrication holes in the end pieces using the relubrication kit.

**!** Protect the carriages against solid and liquid contaminants.

### 2.3.1 Relubrication kit

The relubrication kit consists of a syringe and needle. The syringe is filled with grease with a lithium soap base in accordance with the classification to DIN 51825 KEHC2K-50.



#### 7 Available relubrication kit

Type	Ordering designation
Relubrication kit for carriage KWEM05 (-W)	SPRI.KWEM07

### 2.3.2 Clean room applications

For clean room applications, carriages with clean room grease are available. Please contact us for information about the clean room grease.

## 2.4 Sealing

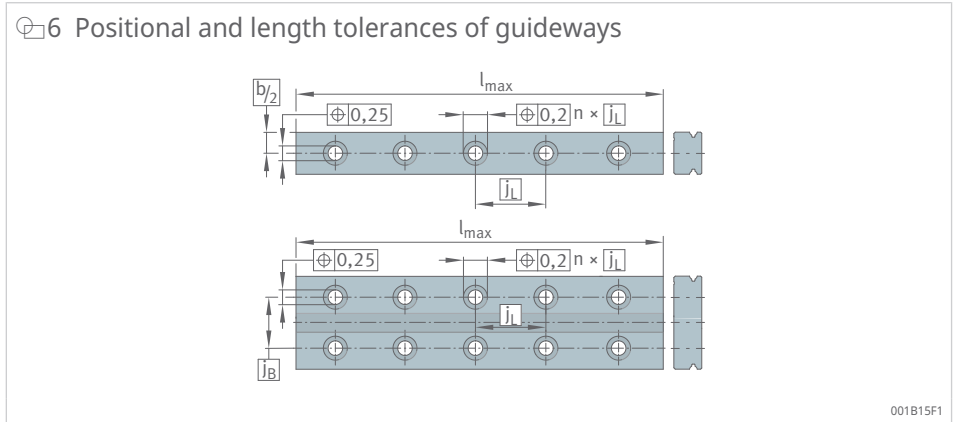
In the standard version of carriage KWEM05, end wipers on the end faces protect the rolling element system against contamination.

**!** In order to prevent damage to the guidance systems, the raceways must be kept clean at all times. If the wipers used as standard are not adequate for this purpose, additional seals must be provided in the adjacent construction.

## 2.5 Tolerances of guideways

### 2.5.1 Positional and length tolerances of guideways

The hole pattern corresponds to DIN EN ISO 1101.

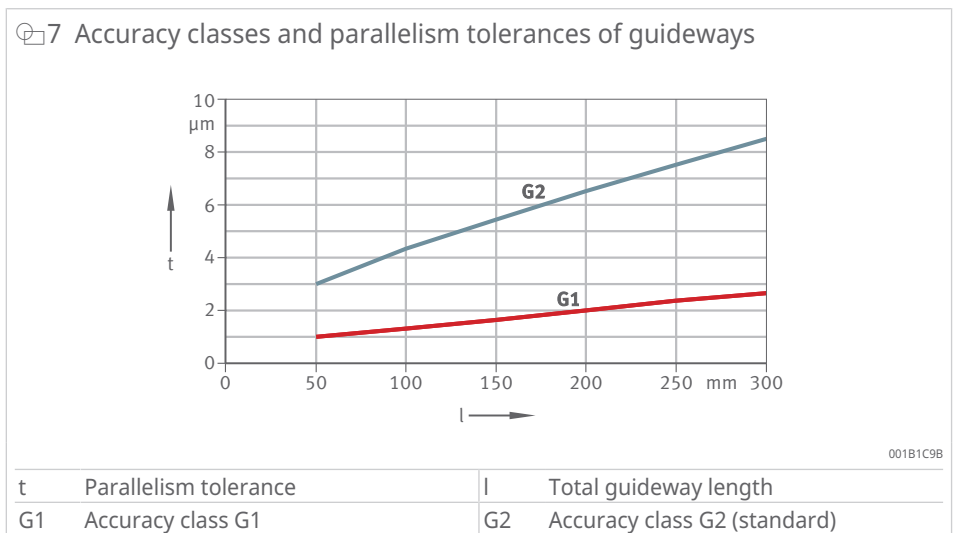


### 8 Length tolerances of guideways

Designation Guideway	Tolerances	
	U mm	L mm
TKDM05, TKDM05-W	+0,2	-2,2
L	mm	Lower limit deviation
U	mm	Upper limit deviation

### 2.5.2 Accuracy classes

Miniature linear recirculating ball bearing and guideway assemblies KWEM05 are available in accuracy classes G1 and G2. The standard accuracy class is G2.



### 2.5.3 Tolerances

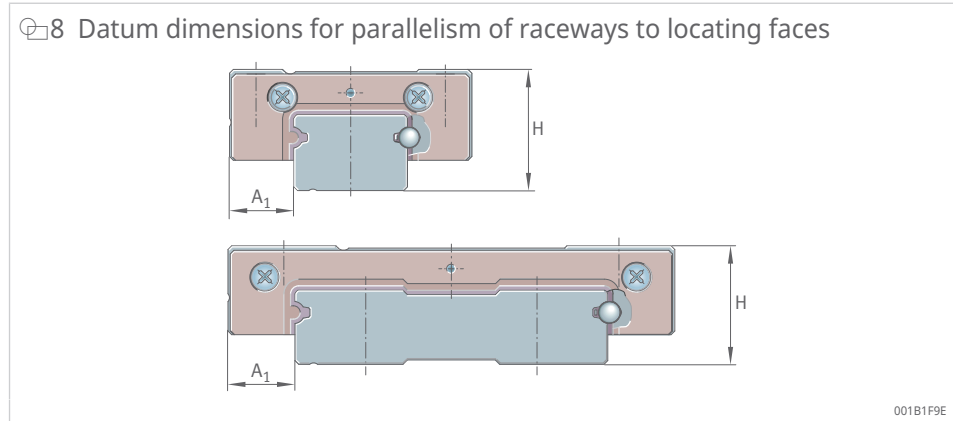
The tolerances are arithmetic mean values. They relate to the centre point of the screw mounting surfaces or locating surfaces of the carriage.

The dimensions H and  $A_1$  should always remain within the tolerance irrespective of the position of the carriage on the guideway.

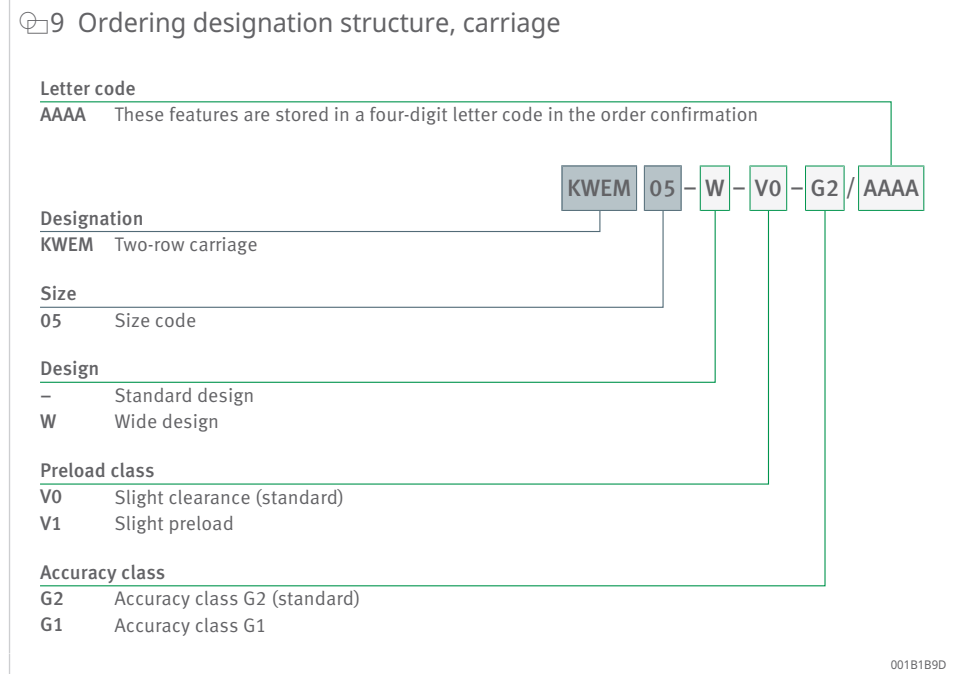
9 Tolerances for height and spacing  $A_1$

Tolerance		Accuracy	
		G1	G2 <sup>1)</sup>
		$\mu\text{m}$	$\mu\text{m}$
Tolerance for height	H	$\pm 10$	$\pm 20$
Difference in height <sup>2)</sup>	$\Delta H$	7	15
Tolerance for spacing	$A_1$	$\pm 15$	$\pm 25$
Difference in spacing <sup>2)</sup>	$\Delta A_1$	10	20

- 1) Standard
- 2) Dimensional difference between several carriages on one guideway, measured at the same point on the guideway

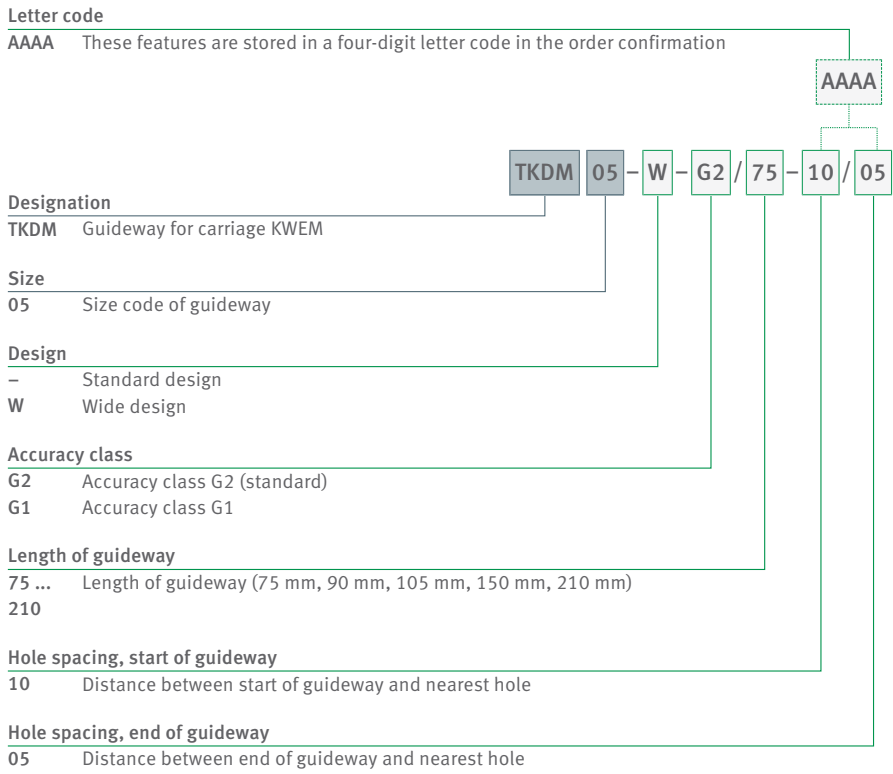


## 2.6 Structure of the ordering designation





10 Ordering designation structure, guideway



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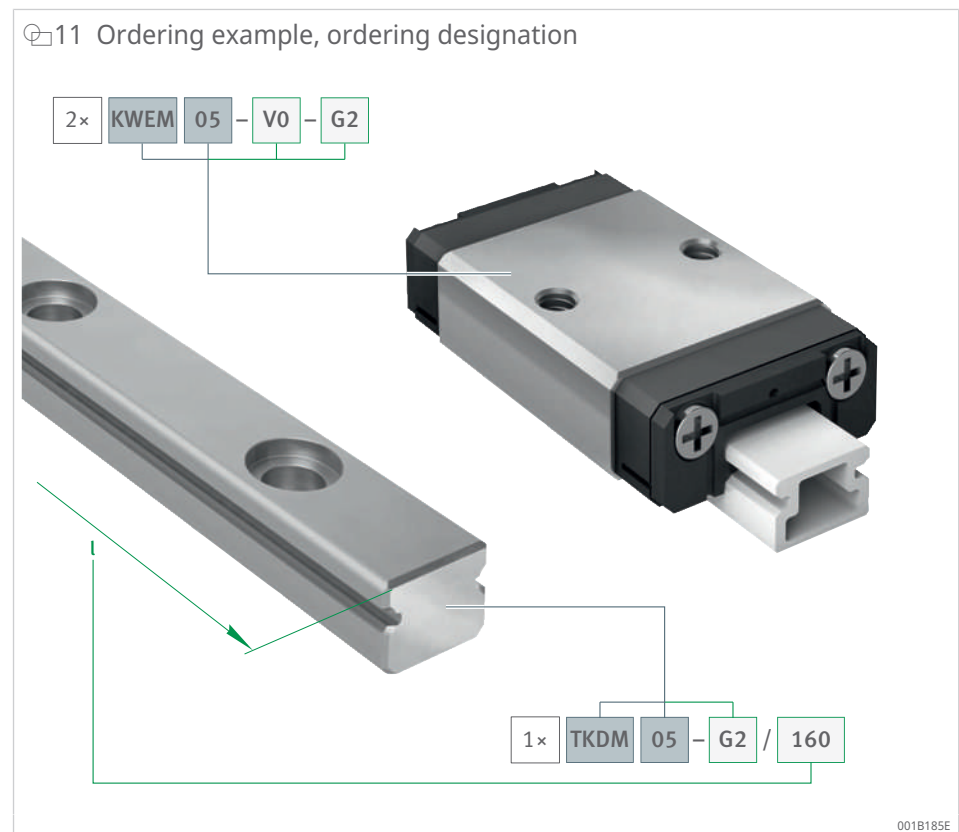
## 2 carriages and matching guideway

An order is to be placed for 2 identical carriages and 1 matching guideway with a symmetrical hole pattern:

- 2 carriages: KWEM05
- size: 05
- preload: V0
- accuracy class: G2
- with end wipers
- matching guideway: TKDM05
- size: 05
- accuracy class: G2
- length: 160 mm

Ordering designation provided by the customer and in the order confirmation (with sample letter code):

- 2×KWEM05-V0-G2
- 1×TKDM05-G2/160



### Carriage

Single carriages can be ordered as follows:

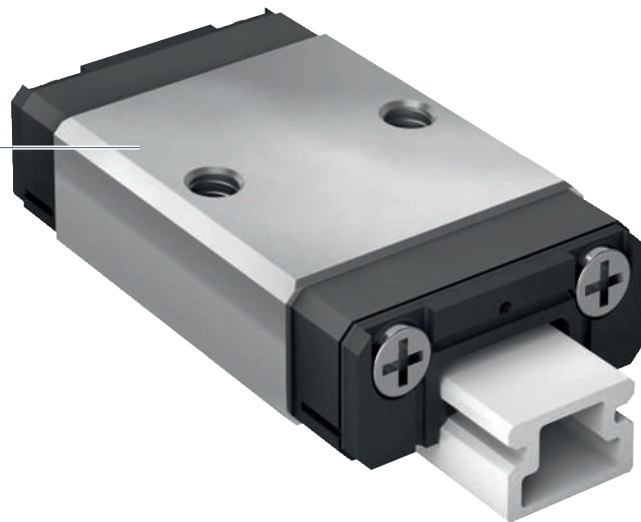
- carriage: KWEM05
- size: 05
- preload: V0
- accuracy class: G2
- with end wipers

Ordering designation provided by the customer and in the order confirmation (with sample letter code):

- 1×KWEM05-V0-G2

12 Ordering example, ordering designation

KWEM 05 - V0 - G2



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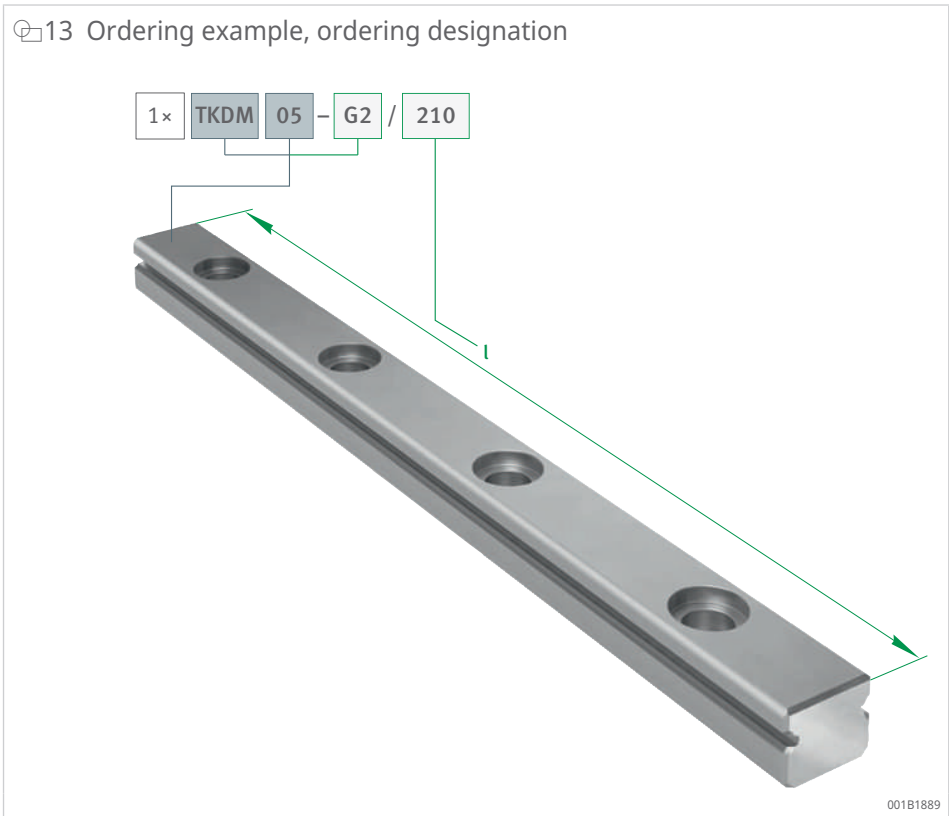
### Guideway

Single guideways can be ordered as follows:

- guideway that can be combined with the existing carriage of identical width and belonging to accuracy class G2:  
TKDM05
- size: 05
- accuracy class: G2
- length: 210 mm

Ordering designation provided by the customer and in the order confirmation (with sample letter code):

- 1×TKDM05-G2/210



## 2.7 Design of the bearing arrangement

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

The straightness of the system is most readily achieved by pressing the guideway against a locating face.

If high demands are to be made on the running accuracy and/or if soft sub-structures and/or movable guideways are used, please contact Schaeffler.

### 2.7.1 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.



Tolerances of mounting surfaces and parallelism of mounted guideways must be observed.

Surfaces should be ground or precision milled: aim to achieve a mean roughness value  $R_{max}$  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.

### 2.7.2 Height difference $\Delta H$

For  $\Delta H$ , permissible values are in accordance with the following formula. If larger deviations are present, please consult Schaeffler.

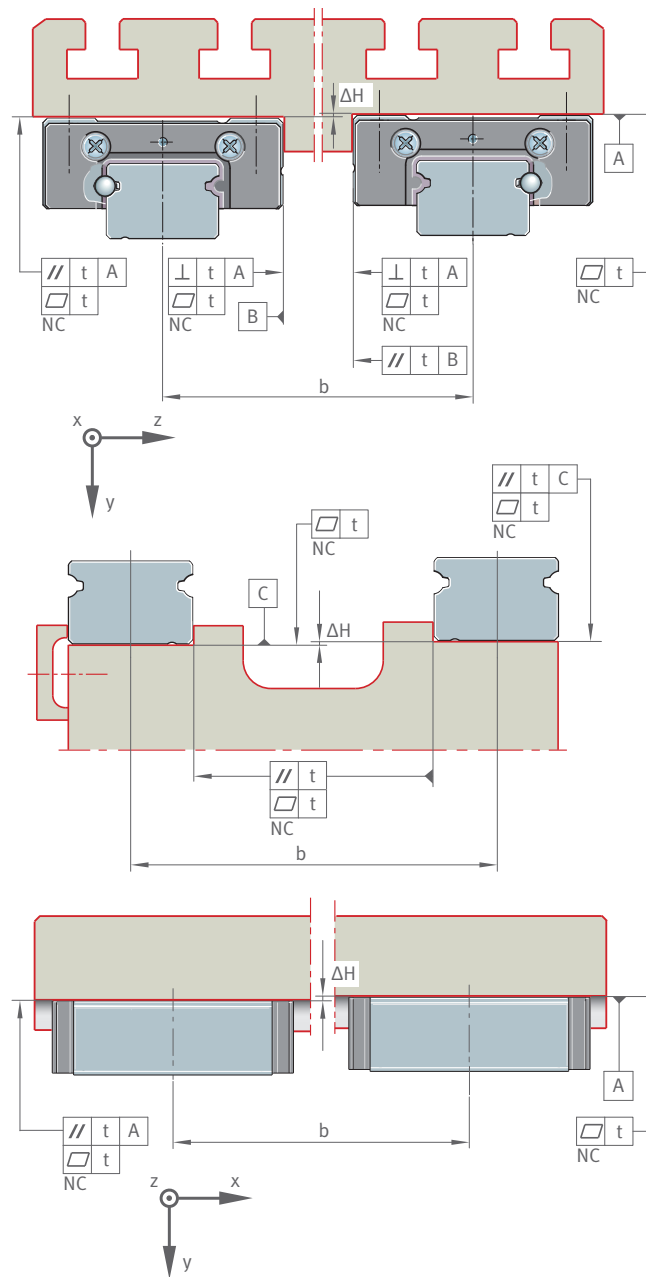
$f_{15}$		
$\Delta H = a \cdot b$		
a	-	Factor, as a function of the preload class
b	mm	Centre distances between guidance elements
$\Delta H$	$\mu m$	Maximum permissible deviation from the theoretically precise position

#### 10 Factor a

Designation Carriage	Factor a	
	Preload classes	
	V0 <sup>1)</sup>	V1
KWEM05, KWEM05-W	0,1	0,01

<sup>1)</sup> Standard

14 Tolerances of mounting surfaces and parallelism of mounted guideways and carriages



001B167E

NC	Not convex	b	Spacing between guidance elements
$\Delta H$	Height difference	t	Parallelism, flatness and perpendicularity tolerance

### 2.7.3 Parallelism of mounted guideways

For guideways arranged in parallel, a parallelism  $t$  is required. If the maximum values are used, this may increase the displacement resistance. If larger tolerances are present, please contact Schaeffler.

11 Values for the parallelism tolerances of two-row units

Designation Guideway	Parallelism tolerance $t$	
	Accuracy class	
	G1	G2 1)
	$\mu\text{m}$	
TKDM05, TKDM05-W	20	30

1) Standard

### 2.7.4 Locating heights and corner radii

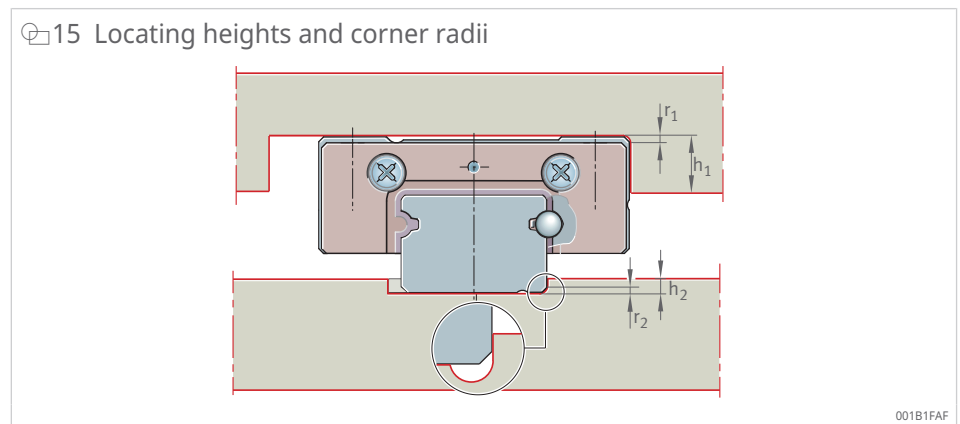
The following data can be used to design the locating heights and corner radii.

12 Locating heights, corner radii

Designation		Locating heights		Corner radii	
Carriage	Guideway	$h_1$	$h_2$	$r_1$	$r_2$ 1)
		mm	mm	mm	mm
		max.	max.	max.	max.
KWEM05	TKDM05	2	0,8	0,3	0,2
KWEM05-W	TKDM05-W	2	1,2	0,3	0,2

1) Preferably with undercut

15 Locating heights and corner radii



## 2.8 Product tables

2

### 2.8.1 Explanations

(1)	-	Locating face
$A_1$	mm	Distance from locating edge on carriage to locating edge on guideway
$A_2$	mm	Distance from locating edge to hole
$A_3$	mm	Position of lubrication connector
$a_L$	mm	Distance between start of guideway and nearest hole
$a_R$	mm	Distance between end of guideway and nearest hole
$b$	mm	Width of guideway
$B$	mm	Width
$C_{0I+II}$	N	Basic static load rating in load directions I and II: tensile load and compressive load
$C_{0III}$	N	Basic static load rating in load direction III: lateral load
$C_{I+II}$	N	Basic dynamic load rating in load directions I and II: tensile load and compressive load
$C_{III}$	N	Basic dynamic load rating in load direction III: lateral load
$G_2$	-	Thread size, DIN ISO 4762-12.9
$h$	mm	Height of guideway
$H$	mm	Height
$h_1$	mm	Length
$H_1$	mm	Free space, system dimension
$J_B$	mm	Hole spacing
$J_L$	mm	Distance between holes
$J_L$	mm	Hole spacing
$K_1$	-	Thread size, DIN ISO 4762-12.9
$L$	mm	Length of carriage
$L_1$	mm	Effective saddle plate length
$l_{max}$	mm	Maximum length of guideway
$M_{0x}$	Nm	Static moment rating about x axis
$M_{0y}$	Nm	Static moment rating about y axis
$M_{0z}$	Nm	Static moment rating about z axis
$M_A$	Nm	Tightening torque
$m_c$	kg	Mass of carriage
$m_r$	kg/m	Mass of guideway
$T_5$	mm	Thread depth

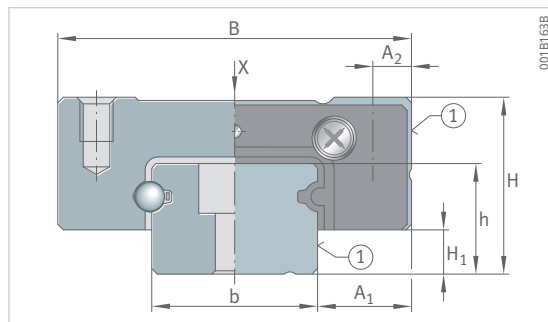




2.8.2 KWEM05, TKDM05

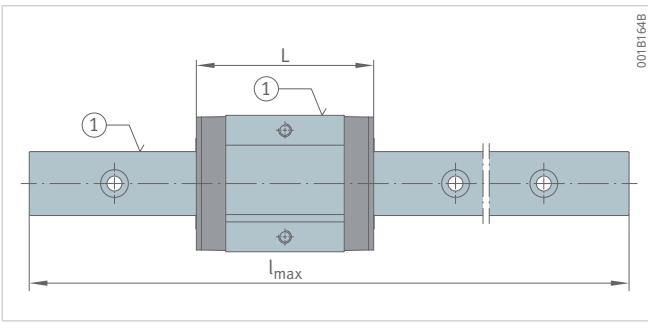
Double row

2

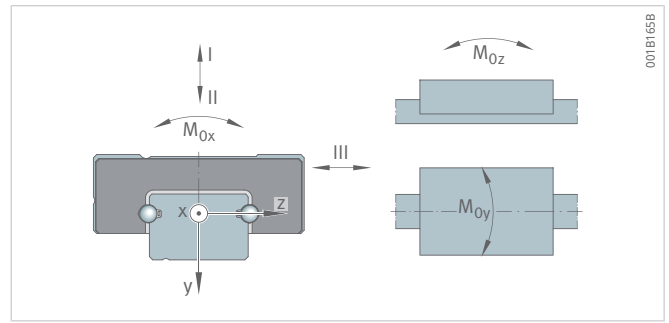


KWEM05 with TKDM05

Carriage		Guideway		$l_{max}$	H	B	L	h	b
Designation	$m_c$	Designation	$m_r$						
-	kg	-	kg/m	mm	mm	mm	mm	mm	mm
KWEM05	0,12	TKDM05	0,004	210	6	12	19	3,7	5
KWEM05-W	0,28	TKDM05-W	0,008	300	6,5	17	24,5	4	10



KWEM05 with TKDM05, view rotated 90°

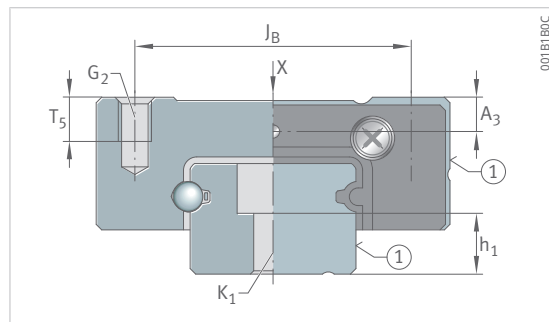


Moments and load direction

$A_1$	$A_2$	$H_1$	$C_{I+II}$	$C_{0I+II}$	$C_{III}$	$C_{0III}$	$M_{0x}$	$M_{0y}$	$M_{0z}$
mm	mm	mm	N	N	N	N	Nm	Nm	Nm
3,5	2	1	534	1090	470	916	2,9	1,9	2,3
3,5	2	1,5	671	1510	590	1268	7,8	3,5	4,2

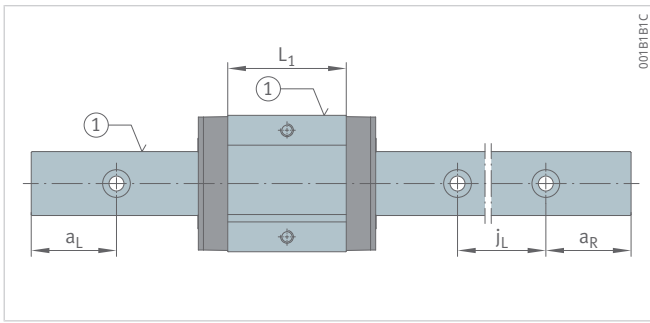
KWEM05, TKDM05

Double row



KWEM05 with TKDM05

Carriage Designation	Guideway Designation	$J_B$	$L_1$	$T_5$	$A_3$
-	-	mm	mm	mm	mm
KWEM05	TKDM05	8	12,6	1,5	1,2
KWEM05-W	TKDM05-W	13	17,6	1,5	1,3



KWEM05 with TKDM05, view rotated 90°

$G_2$		$h_1$	$j_L$	$a_L$		$a_R$		$K_1$	
-	$M_A$			min	max	min	max	-	$M_A$
-	Nm	mm	mm	mm	mm	mm	mm	-	Nm
M2	0,6	2,9	15	4	11,5	4	11,5	M2	0,6
M2	0,6	2,9	15	4	11,5	4	11,5	M2	0,6

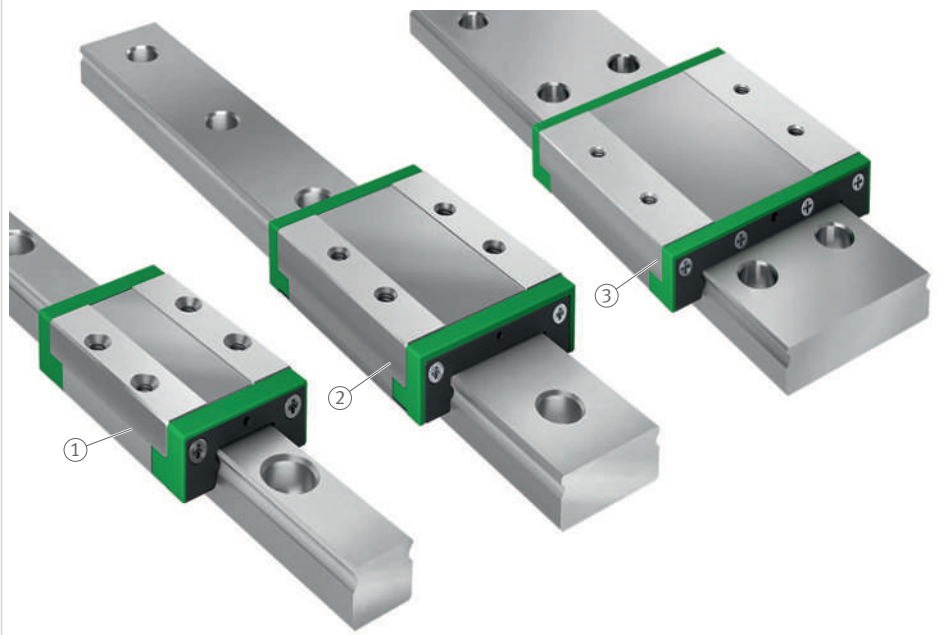
### 3 Miniature linear recirculating ball bearing and guideway assemblies KUEM..-E

#### 3.1 Product design

##### 3.1.1 Linear recirculating ball bearing and guideway assemblies, carriages and guideways

The miniature linear recirculating ball bearing and guideway assemblies designated KUEM..-E are available in 4 sizes (07, 09, 12, 15) and in 4 different designs (KUEM..-E, KUEM..-E-L, KUEM..-E-W and KUEM..-E-WL). Guideway and carriage are matched to each other within accuracy class G1 and must be ordered together as KUEM..-E. Carriages KWEM..-E, KWEM..-E-L, KWEM..-E-W and KWEM..-E-WL and guideways TKDM..-E and TKDM..-E-W can also be ordered separately. The matching guideways are available in freely selectable lengths, taking into account the maximum length available. A dummy guideway is not required.

16 Product overview, linear recirculating ball bearing and guideway system consisting of carriage and guideway



001B15E5

1	KUEM07-E, KUEM09-E, KUEM12-E, KUEM15-E	2	KUEM07-E-W, KUEM09-E-W, KUEM12-E-W
3	KUEM15-E-W		

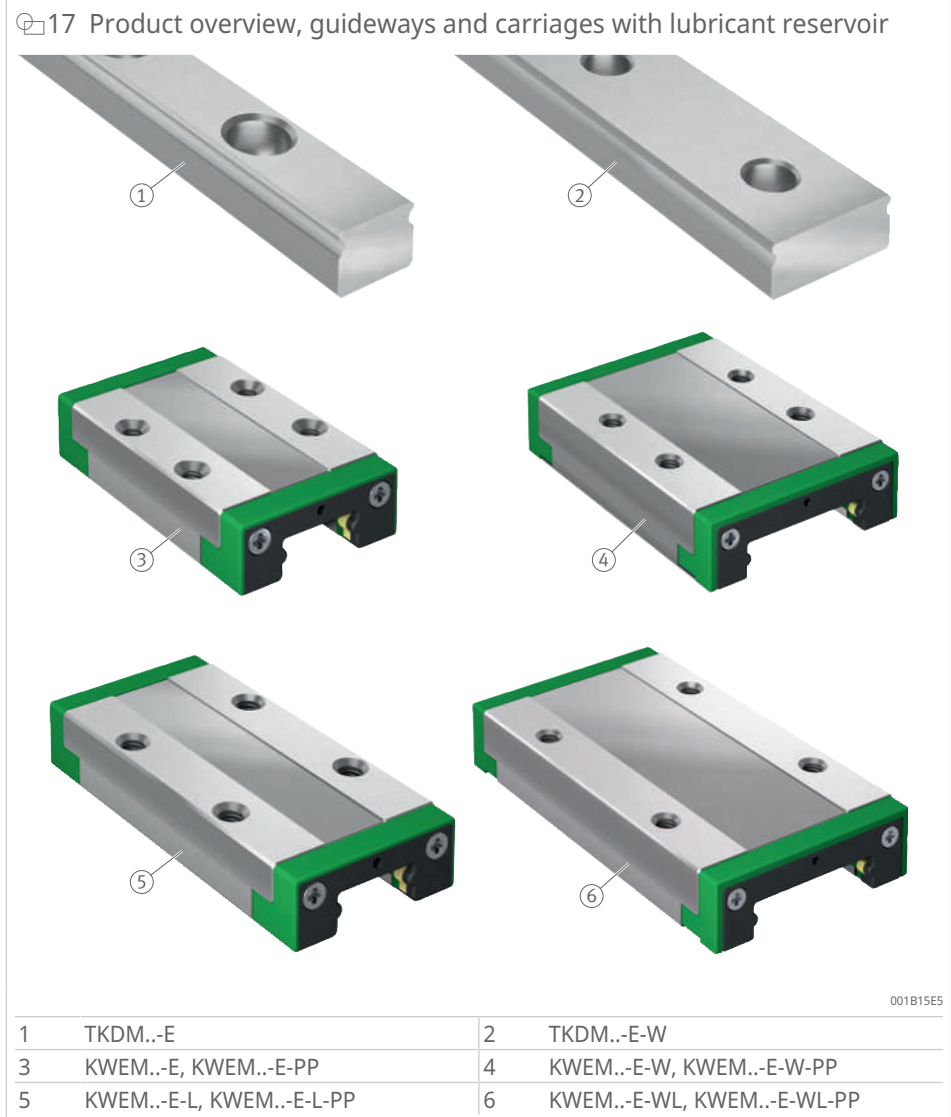
Carriages are available to order as an option. Carriages KWEM..-E have a lubricant reservoir filled with oil and are available with or without end wipers (PP).

Carriages KWEM..-E-L are variants. With the long version, a higher basic load rating is achieved.

Carriages KWEM..-E-W are variants. With the wide version, higher moment loads can be supported.

Carriages KWEM..-E-WL are variants. With the wide, long version, higher moment loads can be supported and a higher basic load rating is achieved.

Carriage and guideway can be ordered separately within accuracy class G2.



### 3.1.2 Guideways

Guideways can be ordered individually. Guideways TKDM...-E and TKDM...-E-W have 2 locating edges. The guideways are made from corrosion-resistant high-grade steel and are hardened and ground, the rolling element raceways are precision ground. For fixing to the adjacent construction, the guideways have fixing holes with counterbores for the screw heads. The guideways are fixed from above. The maximum length of a guideway is dependent on the size.

13 Maximum lengths of guideways

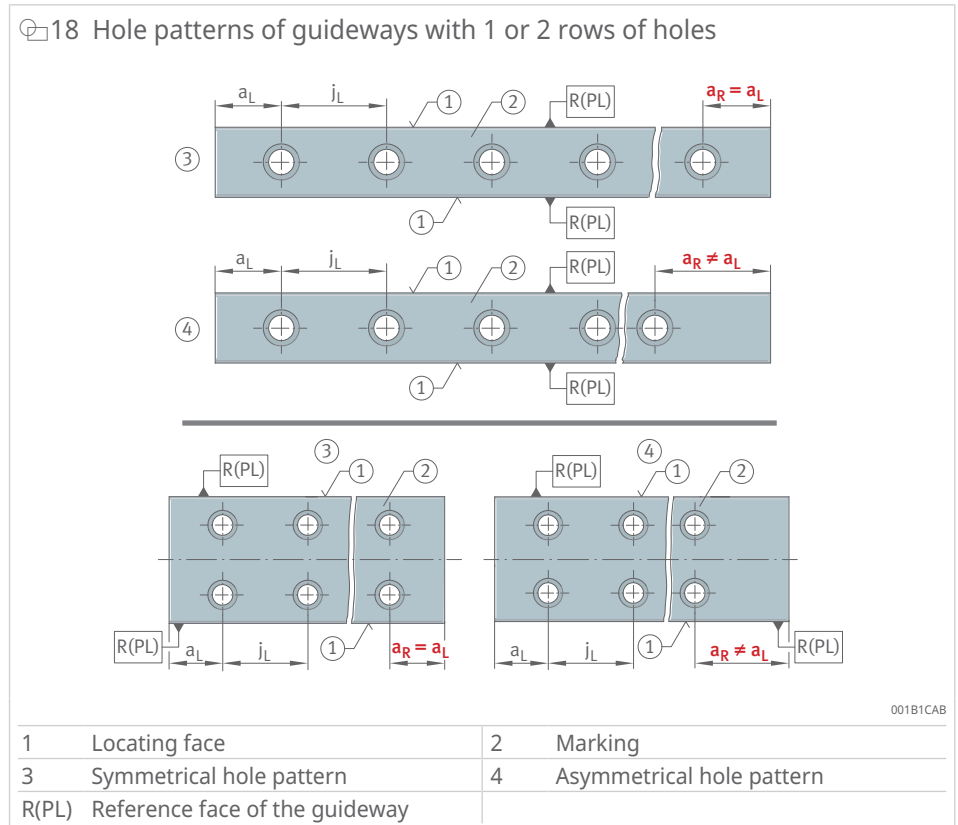
Designation	Maximum length
Guideway	mm
TKDM07-E	1000
TKDM07-E-W	2000
TKDM09-E, TKDM09-E-W	2000
TKDM12-E, TKDM12-E-W	2000
TKDM15-E, TKDM15-E-W	2000

3.1.2.1 Hole patterns for guideways

Unless specified otherwise, guideways TKDM..-E and TKDM..-E-W have a symmetrical hole pattern.

An asymmetrical hole pattern may also be available upon request. In this case,  $a_L \geq a_{L\ min}$  and  $a_R \geq a_{R\ min}$ .

**!** Irrespective of the orientation of the locating face,  $a_L$  is on the left and  $a_R$  is on the right. When ordering, the required orientation of the locating face must be indicated as top or bottom.



3.1.2.2 Maximum number of pitches between holes

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

$$f16 \quad n = \frac{l - 2 \cdot a_{L\ min}}{j_L}$$

The distances  $a_L$  and  $a_R$  are generally determined as follows:

$$f17 \quad a_L + a_R = l - n \cdot j_L$$

For guideways with a symmetrical hole pattern:

$$f18 \quad a_L = a_R = \frac{1}{2} \cdot (l - n \cdot j_L)$$



Number of holes:

$f_{19}$		
$x = n + 1$		
$a_L, a_R$	mm	Distance between start or end of guideway and nearest hole
$a_{Lmin}, a_{Rmin}$	mm	Minimum values for $a_L, a_R$
$j_L$	mm	Distance between holes
$l$	mm	Guideway length
$n$	-	Max. possible number of hole pitches
$x$	-	Number of holes

**!** If the minimum values for  $a_L$  and  $a_R$  are not observed, the counterbores of the holes may be intersected. Risk of injury.

### 3.1.3 Interchangeability

Carriages KWEM..-E and guideways TKDM..-E of the same size can be combined or replaced in accuracy class G2. Accuracy class G1 is only possible with miniature linear recirculating ball bearing and guideway system KUEM..-E.

14 Interchangeability of carriages and guideways

Accuracy class			Comment
Carriages KWEM..-E, KWEM..-E-W	Guideway TKDM..-E, TKDM..-E-W	Unit	
G1	G1	G1	As complete system only
G2	G2	G2	Recommended combination

## 3.2 Acceleration and speed

Carriages KWEM..-E permit accelerations up to 140 m/s<sup>2</sup> and speeds up to 5 m/s.

## 3.3 Lubrication

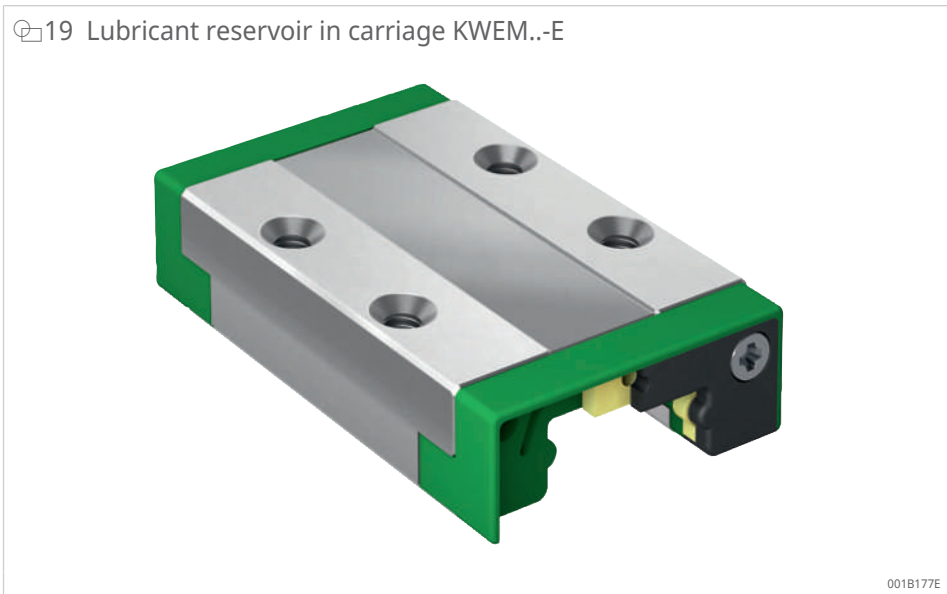
Carriages KWEM..-E are supplied lubricated with a food grade lubricant (NSF H1 and ISO VG grade). The carriages can be lubricated through lubrication holes in the end pieces using the SPRI.KWEM09 relubrication kit.

**!** Protect the carriages against solid and liquid contaminants.

### 3.3.1 Lubricant reservoir

The miniature linear recirculating ball bearing and guideway assemblies are supplied as standard with a lubricant reservoir, which is located in the end piece. The lubricant reservoir ensures long-term and uniform distribution of the lubricant, allowing the assemblies to operate over particularly long distances without the need for relubrication.

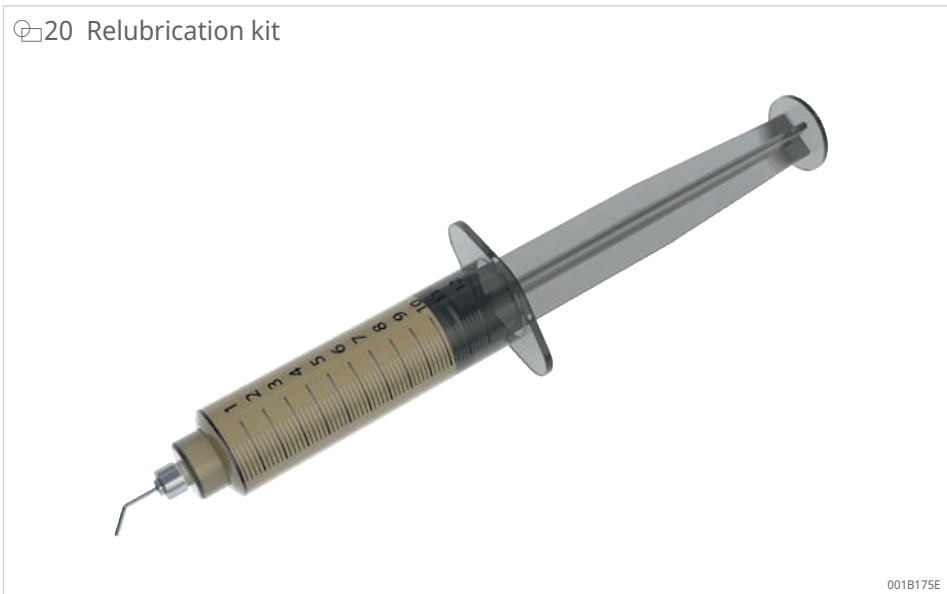
19 Lubricant reservoir in carriage KWEM..-E



### 3.3.2 Relubrication kits

The relubrication kit consists of a syringe and needle. The syringe is filled with grease with a lithium soap base in accordance with the classification to DIN 51825 KEHC2K-50.

20 Relubrication kit



15 Available relubrication kits

Type	Ordering designation
Relubrication kit for carriages KWEM07-E (-L, -W, -WL), KWEM09-E (-L, -W, -WL), KWEM12-E (-L, -W, -WL), KWEM15-E (-L, -W, -WL)	SPRI.KWEM09

### 3.3.3 Clean room applications

For clean room applications, carriages with clean room grease are available. Please contact us for information about the clean room grease.

### 3.4 Sealing

In the standard version, carriages KWEM..-E are fitted with gap seals on the end faces. If high demands are placed on protecting the rolling element system against contamination, the end faces of carriages KWEM..-E can optionally be ordered with end wipers made of highly abrasion-resistant material. Carriages with end wipers have the suffix PP.

2 ball retaining plates are attached to the underside of the carriage. The narrow gap seals between the guideway and ball retaining plates protect against contaminants from the underside of the carriage.

**!** In order to prevent damage to the guidance systems, the raceways must be kept clean at all times. If the wipers used as standard are not adequate for this purpose, additional seals must be provided in the adjacent construction.

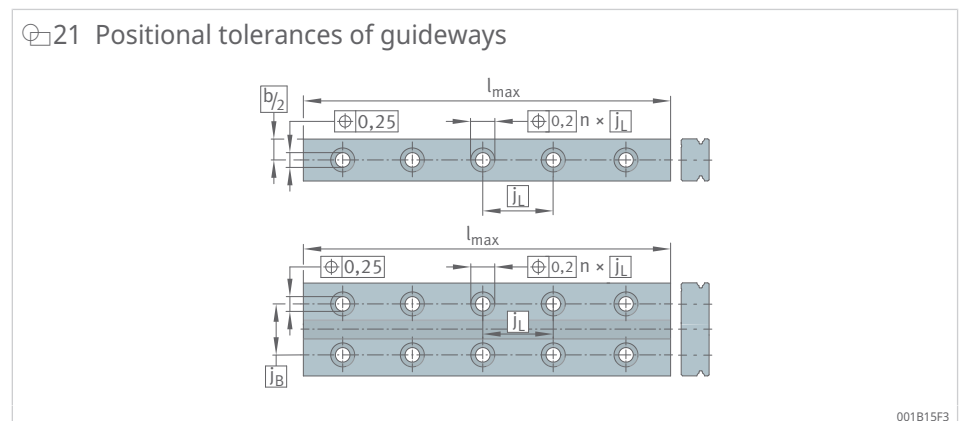
#### 3.4.1 End wipers

The special version of carriage KWEM..-E with contact type end wipers has the suffix PP.

### 3.5 Tolerances of guideways

#### 3.5.1 Positional and length tolerances of guideways

The hole pattern corresponds to DIN EN ISO 1101.



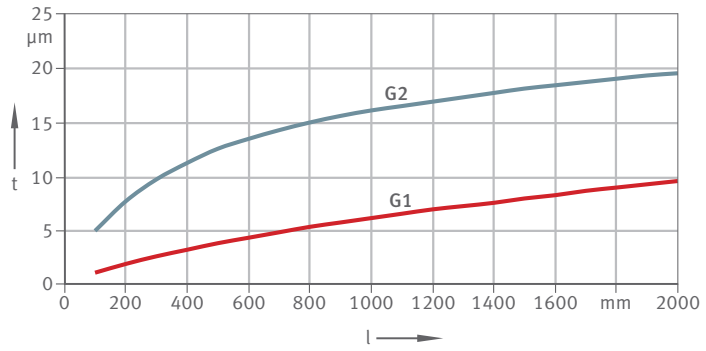
#### 16 Length tolerances of guideways

Designation	Tolerances	
	U	L
Guideway	mm	mm
TKDM07-E, TKDM07-E-W, TKDM09-E, TKDM09-E-W, TKDM12-E, TKDM12-E-W, TKDM15-E, TKDM15-E-W	+1,5	-1,5
L	mm	Lower limit deviation
U	mm	Upper limit deviation

#### 3.5.2 Accuracy classes

Miniature linear recirculating ball bearing and guideway assemblies KWEM..-E are available in accuracy classes G1 and G2. The standard accuracy class is G2.

22 Accuracy classes and parallelism tolerances of guideways



001B162A

t	Parallelism tolerance	l	Total guideway length
G1	Accuracy class G1	G2	Accuracy class G2 (standard)

### 3.5.3 Tolerances

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

The dimensions H and A<sub>1</sub> should always remain within the tolerance irrespective of the position of the carriage on the guideway.

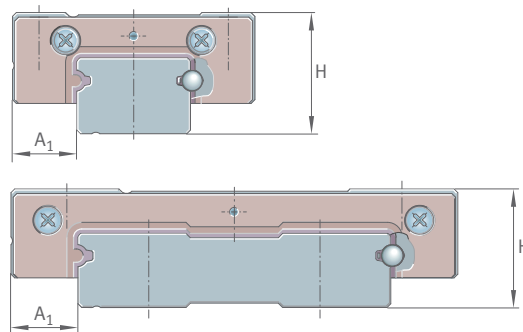
17 Tolerances for height and spacing A<sub>1</sub>

Tolerance		Accuracy	
		G1	G2 1)
		μm	μm
Tolerance for height	H	±10	±20
Difference in height 2)	ΔH	7	15
Tolerance for spacing	A <sub>1</sub>	±15	±25
Difference in spacing 2)	ΔA <sub>1</sub>	10	20

1) Standard

2) Dimensional difference between several carriages on one guideway, measured at the same point on the guideway

23 Datum dimensions for parallelism of raceways to locating faces



001B1F9E

### 3.6 Structure of the ordering designation

#### 24 Ordering designation structure, guidance unit

**Letter code**

AAAA These features are stored in a four-digit letter code in the order confirmation

AAAA

**Designation**

KUEM Guidance unit consisting of carriage and guideway



**Size**

07 ... Size code of guidance unit  
15 (07, 09, 12, 15)

**Version**

E Version

**Design**

- Standard design
- L Long design
- W Wide design
- WL Wide, long design

**Number of carriages**

W1 ... Number of carriages per guideway  
W6 Maximum of 6 carriages per guideway line

**Length of guideway**

... Length of the guideway in mm in 1 mm increments,  
2000 exception TKDM07 with a maximum length of 1000 mm

**Seal**

- With gap seal
- PP With end wipers in the end pieces

**Number of guideways**

R2 ... Number of guideways  
Rn

**Preload class**

- V1 Slight preload (standard)
- V0 Slight clearance
- V2 Moderate preload, higher rigidity

**Accuracy class**

- G2 Accuracy class G2 (standard)
- G1 Accuracy class G1

**Hole spacing, start of guideway**

10 Distance between start of guideway and nearest hole

**Hole spacing, end of guideway**

15 Distance between end of guideway and nearest hole

001B1BBD

25 Ordering designation structure, carriage

**Letter code**

**AAAA** These features are stored in a four-digit letter code in the order confirmation

**Designation**

**KWEM** Two-row carriage

**Size**

**07 ...** Size code of carriage

**15** (07, 09, 12, 15)

**Version**

**E** Version

**Design**

**-** Standard design

**L** Long design

**W** Wide design

**WL** Wide, long design

**Seal**

**-** With gap seal

**PP** With end wipers in the end pieces

**Preload class**

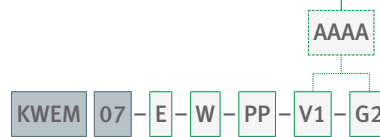
**V1** Slight preload (standard)

**V0** Slight clearance

**Accuracy class**

**G2** Accuracy class G2 (standard)

**G1** Accuracy class G1



001B1BCD

26 Ordering designation structure, guideway

**Letter code**

**AAAA** These features are stored in a four-digit letter code in the order confirmation

**Designation**

**TKDM** Guideway for carriage KWEM

**Size**

**07 ...** Size code of guideway  
**15** (07, 09, 12, 15)

**Version**

**E** Version

**Design**

**-** Standard design  
**W** Wide design

**Accuracy class**

**G2** Accuracy class G2 (standard)

**Length of guideway**

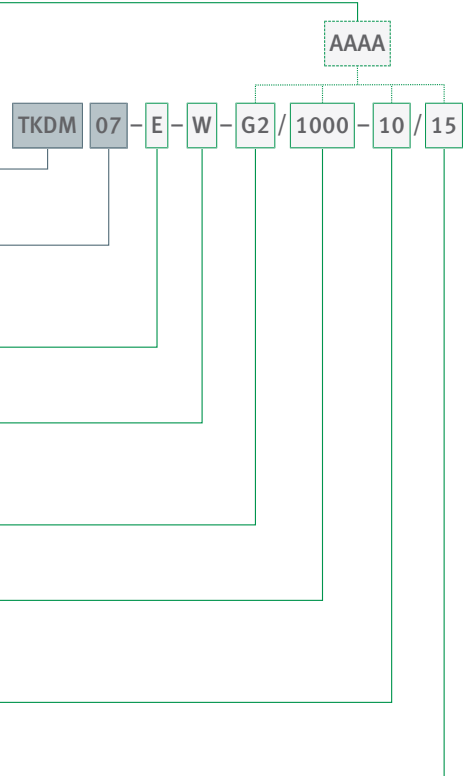
**...** Length of the guideway in mm in 1 mm increments,  
**2000** exception TKDM07 with a maximum length of 1000 mm

**Hole spacing, start of guideway**

**10** Distance between start of guideway and nearest hole

**Hole spacing, end of guideway**

**15** Distance between end of guideway and nearest hole



001B1BDD

### Linear recirculating ball bearing and guideway assemblies KUEM..-E with carriage and guideway in accuracy class G1 as complete unit

If carriage and guideway are to have accuracy class G1, a KUEM..-E system must be ordered. Carriage and guideway are then ordered under a joint order number.

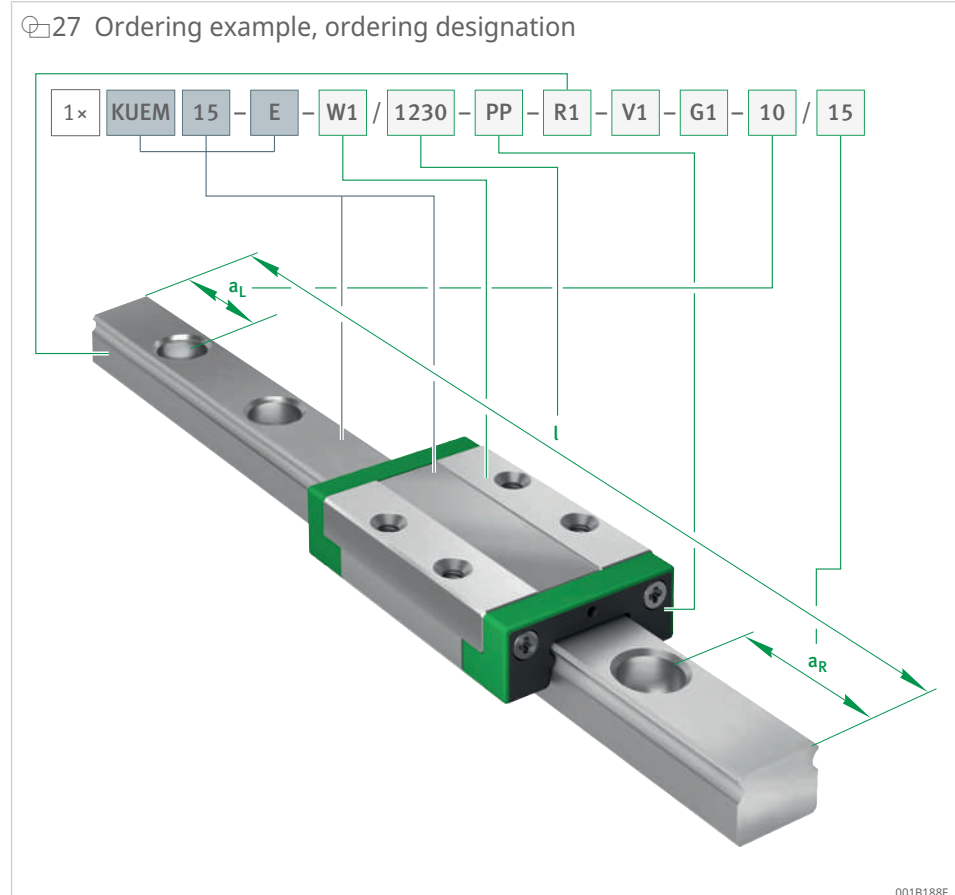
An order is to be placed for one KWEM..-E carriage with accuracy class G1 and a matching guideway. As accuracy class G1 is required, carriage KWEM..-E and guideway TKDM..-E must be ordered together.

An order is placed for one linear recirculating ball bearing and guideway assembly KUEM..-E:

- 1 carriage: KWEM..-E
- size: 15
- preload: V1
- accuracy class: G1
- with end wipers
- with lubricant reservoir
- matching guideway: TKDM..-E
- size: 15
- accuracy class G1
- length: 1230 mm
- $a_L$ : 15 mm
- $a_R$ : 15 mm

Ordering designation provided by the customer and in the order confirmation (with sample letter code):

- 1×KUEM15-E-W1/1230-PP-R1-V1-G1-10/15





### Guideway with carriage ordered separately

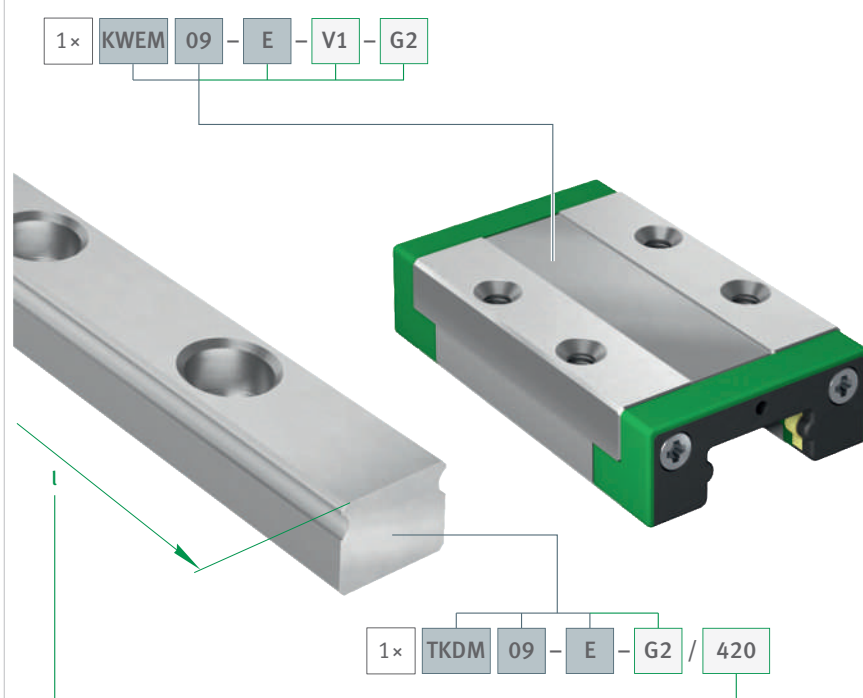
An order is placed for a carriage and a matching guideway with a symmetrical hole pattern:

- carriage: KWEM..-E
- size: 09
- preload: V1
- accuracy class: G2
- with lubricant reservoir
- matching guideway: TKDM..-E
- size: 09
- accuracy class G2
- length: 420 mm

Ordering designation provided by the customer and in the order confirmation (with sample letter code):

- 1×KWEM09-E-V1-G2
- 1×TKDM09-E-G2/420

28 Ordering example, ordering designation



001B188B

### Carriage

Single carriages can be ordered as follows:

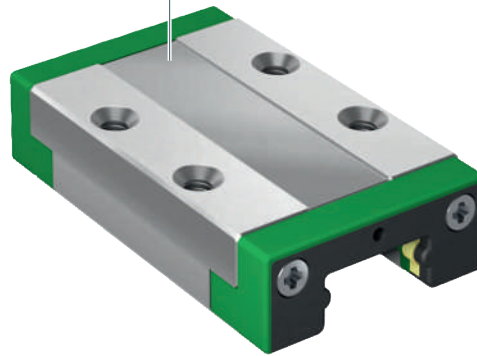
- carriage: KWEM..-E
- size: 09
- preload: V1
- accuracy class: G2
- with end wipers
- with lubricant reservoir

Ordering designation provided by the customer and in the order confirmation (with sample letter code):

- KWEM09-E-V1-G2-PP

29 Ordering example, ordering designation

KWEM 09 - E - V1 - G2



001B188C

### Guideway

The displacement distance needs to be extended. As a result, a longer guideway is required.

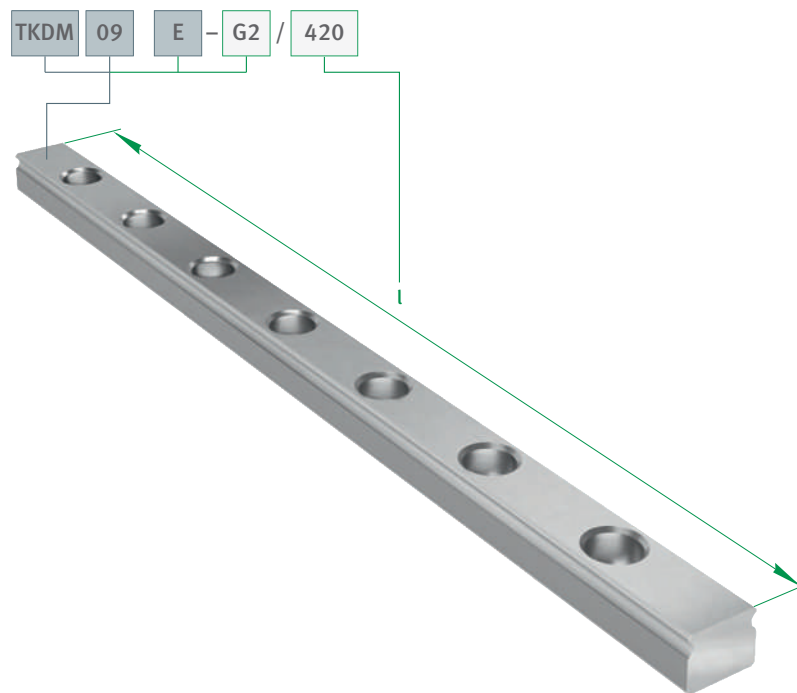
The guideway can be ordered as follows:

- guideway that can be combined with the existing carriage of identical size and belonging to accuracy class G2: TKDM..-E
- size: 09
- accuracy class: G2
- length: 420 mm

Ordering designation provided by the customer and in the order confirmation (with sample letter code):

- TKDM09-E-G2/420

30 Ordering example, ordering designation



001B188D

### 3.7 Design of the bearing arrangement


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

The straightness of the system is most readily achieved by pressing the guideway against a locating face.

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

#### 3.7.1 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.

 Tolerances of mounting surfaces and parallelism of mounted guideways must be observed.

Surfaces should be ground or precision milled: aim to achieve a mean roughness value  $R_{max}$  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.

#### 3.7.2 Height difference S1 and S2

The height deviation in transverse direction S1 is dependent on the preload class and the guideway spacing d and is permissible in accordance with the following formulae.

$$f_{120}$$

$$S1 = b \cdot Y$$


$$f_{121}$$

$$S1 < 2 \cdot H$$

$$f_{122}$$

$$S1 < \Delta H$$

a	-	Factor, as a function of the preload class
b	mm	Centre distances between guidance elements
H	µm	System height tolerance
S1	µm	Maximum permissible deviation from the theoretically precise position
Y	-	Side factor
ΔH	µm	Height deviation

 18 System height tolerance H as a function of the accuracy class

Accuracy class	H
	µm
G2	+20 / -20
G1	+10 / -10

### 19 Height deviation $\Delta H$ as a function of the accuracy class

Accuracy class	$\Delta H$
	$\mu\text{m}$
G2	15
G1	7

### 20 Side factor Y as a function of the preload class

Side factor	Preload class		
	V0	V1	V2
Y	0,0003	0,00015	0,0001

### 21 Factor a

Designation Carriage	Factor a		
	Preload classes		
	V0	V1	V2
KWEM07-E, KWEM07-E-L, KWEM07-E-W, KWEM07-E-WL	0,125	0,02	0,01
KWEM09-E, KWEM09-E-L, KWEM09-E-W, KWEM09-E-WL	0,175	0,03	0,01
KWEM12-E, KWEM12-E-L, KWEM12-E-W, KWEM12-E-WL	0,25	0,06	0,01
KWEM15-E, KWEM15-E-L, KWEM15-E-W, KWEM15-E-WL	0,3	0,15	0,01

The height deviation in longitudinal direction S2 with more than one carriage on the same guideway is permissible in accordance with the following formulae.

f123

$$S2 = c \cdot X$$

f124

$$S2 < 2 \cdot \Delta H$$

c	mm	Centre distances between guidance elements
S2	$\mu\text{m}$	Maximum permissible deviation from the theoretically precise position
X	-	Longitudinal factor
$\Delta H$	$\mu\text{m}$	Height deviation

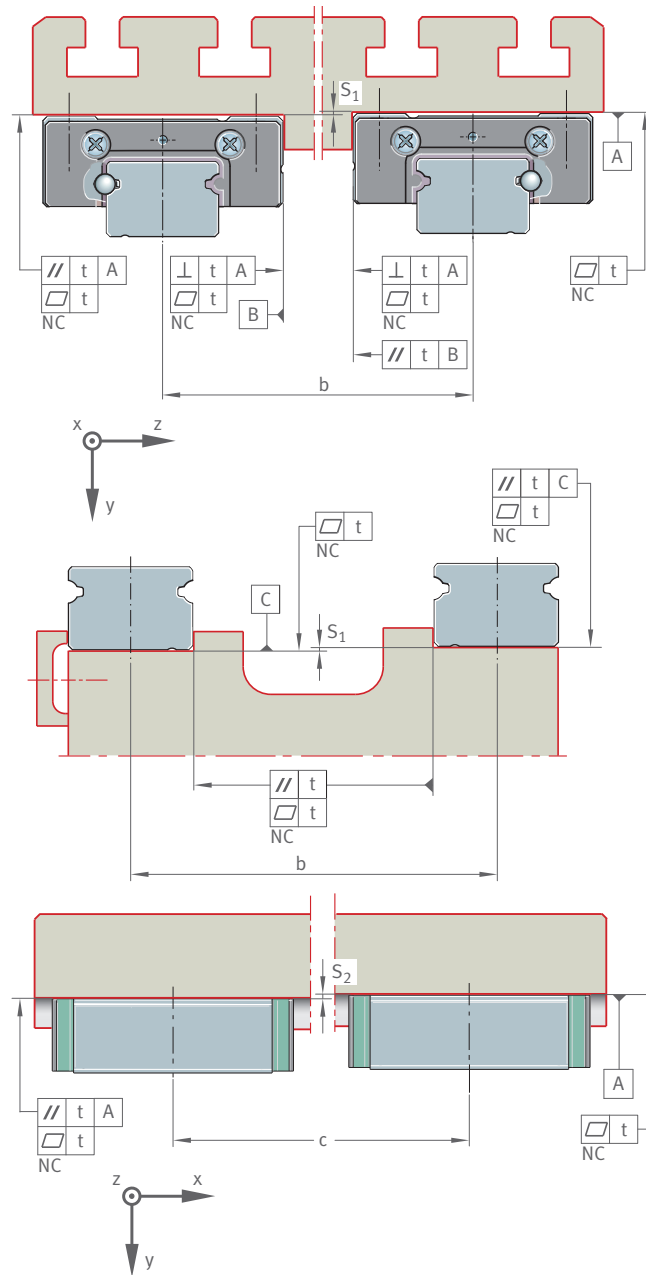
### 22 Height deviation $\Delta H$ as a function of the accuracy class

Accuracy class	$\Delta H$
	$\mu\text{m}$
G2	15
G1	7

### 23 Longitudinal factor X

Longitudinal factor	
X	0,00007

31 Tolerances of mounting surfaces and parallelism of mounted guideways and carriages



001B169E

NC	Not convex	b	Spacing between guidance elements
S1	Height deviation in transverse direction	S2	Height deviation in longitudinal direction
t	Parallelism, flatness and perpendicularity tolerance		

### 3.7.3 Parallelism of mounted guideways

For guideways arranged in parallel, a parallelism  $t$  is required. If the maximum values are used, this may increase the displacement resistance. If larger tolerances are present, please contact Schaeffler.

24 Values for the parallelism tolerances of two-row units

Designation Guideway	Parallelism tolerance t				
	Accuracy class		Preload class		
	G1	G2	V0	V1	V2
	$\mu\text{m}$	$\mu\text{m}$	$\mu\text{m}$	$\mu\text{m}$	$\mu\text{m}$
TKDM07-E, TKDM07-E-W	20	30	5	2	1
TKDM09-E, TKDM09-E-W	20	30	6	3	2
TKDM12-E, TKDM12-E-W	20	30	7	4	2
TKDM15-E, TKDM15-E-W	20	30	10	7	4

### 3.7.4 Locating heights and corner radii

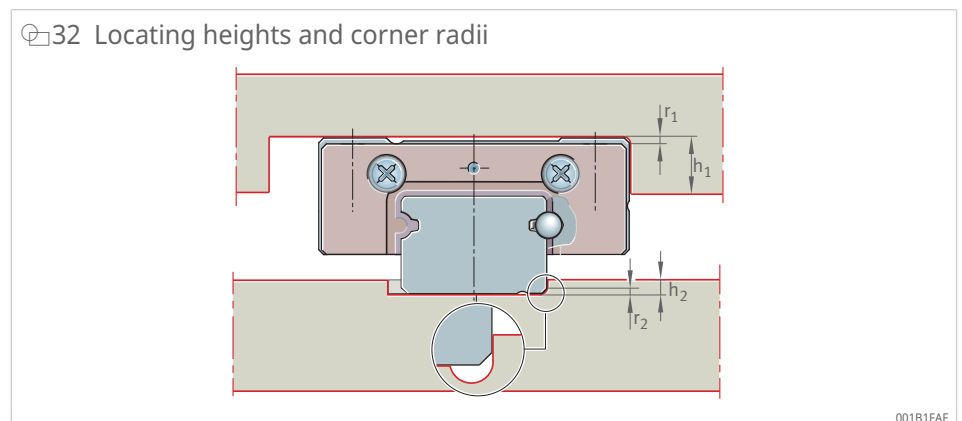
The following data can be used to design the locating heights and corner radii.

25 Locating heights, corner radii

Designation		Locating heights		Corner radii	
Carriage	Guideway	$h_1$	$h_2$	$r_1$	$r_2$ <sup>1)</sup>
		mm	mm	mm	mm
		max.	max.	max.	max.
KWEM07-E, KWEM07-E-L	TKDM07-E	2,2	1,1	0,2	0,3
	TKDM07-E-W	2,2	1,1	0,2	0,3
KWEM09-E, KWEM09-E-L	TKDM09-E	2,5	1,3	0,2	0,3
	TKDM09-E-W	2,5	1,3	0,2	0,3
KWEM12-E, KWEM12-E-L	TKDM12-E	3,5	2	0,2	0,4
	TKDM12-E-W	3,5	2	0,2	0,4
KWEM15-E, KWEM15-E-L	TKDM15-E	4,5	3,0	0,4	0,4
	TKDM15-E-W	4,5	3,0	0,4	0,4

1) Preferably with undercut

32 Locating heights and corner radii



001B1FAF

## 3.8 Product tables

### 3.8.1 Explanations

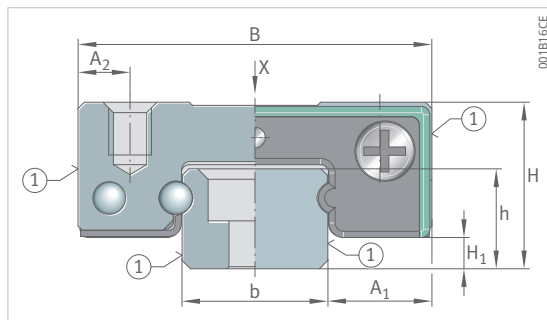
(1)	-	Locating face
$A_1$	mm	Distance from locating edge on carriage to locating edge on guideway
$A_2$	mm	Distance from locating edge to hole
$A_3$	mm	Position of lubrication connector
$a_L$	mm	Distance between start of guideway and nearest hole
$a_R$	mm	Distance between end of guideway and nearest hole
$b$	mm	Width of guideway
$B$	mm	Width
$C$	N	Basic dynamic load rating
$C_0$	N	Basic static load rating
$G_2$	-	Thread size, DIN ISO 4762-12.9
$h$	mm	Height of guideway
$H$	mm	Height
$h_1$	mm	Length
$H_1$	mm	Free space, system dimension
$j_B$	mm	Distance between holes
$J_B$	mm	Hole spacing
$j_L$	mm	Distance between holes
$J_L$	mm	Hole spacing
$K_1$	-	Thread size, DIN ISO 4762-12.9
$L$	mm	Length of carriage
$L_1$	mm	Effective saddle plate length
$l_{max}$	mm	Maximum length of guideway
$M_{0x}$	Nm	Static moment rating about x axis
$M_{0y}$	Nm	Static moment rating about y axis
$M_{0z}$	Nm	Static moment rating about z axis
$M_A$	Nm	Tightening torque
$m_c$	kg	Mass of carriage
$m_r$	kg/m	Mass of guideway
$T_5$	mm	Thread depth





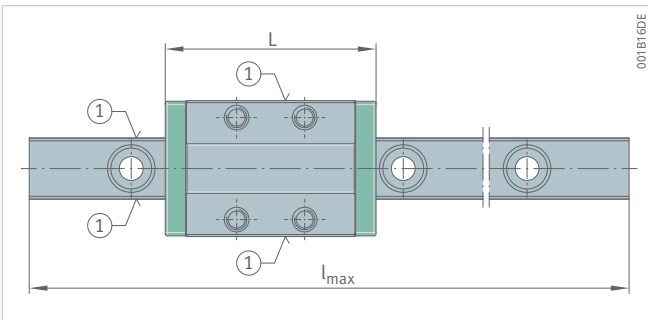
### 3.8.2 KUEM..-E

Double row

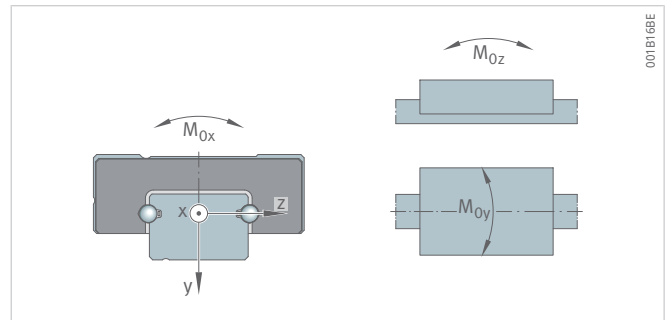


KUEM..-E

System	Carriage		Guideway		$l_{max}$	H	B	L	h	b
Designation	Designation	$m_c$	Designation	$m_r$						
-	-	kg	-	kg/m	mm	mm	mm	mm	mm	mm
KUEM07-E	KWEM07-E	0,012	TKDM07-E	0,230	1000	8	17	23,5	4,8	7
KUEM07-E-L	KWEM07-E-L	0,017	TKDM07-E	0,230	1000	8	17	31,5	4,8	7
KUEM09-E	KWEM09-E	0,021	TKDM09-E	0,395	2000	10	20	31	6,5	9
KUEM09-E-L	KWEM09-E-L	0,280	TKDM09-E	0,395	2000	10	20	40,5	6,5	9
KUEM12-E	KWEM12-E	0,041	TKDM12-E	0,745	2000	13	27	35	8,8	12
KUEM12-E-L	KWEM12-E-L	0,057	TKDM12-E	0,745	2000	13	27	46,5	8,8	12
KUEM15-E	KWEM15-E	0,080	TKDM15-E	1,035	2000	16	32	44	9,5	15
KUEM15-E-L	KWEM15-E-L	0,119	TKDM15-E	1,053	2000	16	32	62	9,5	15



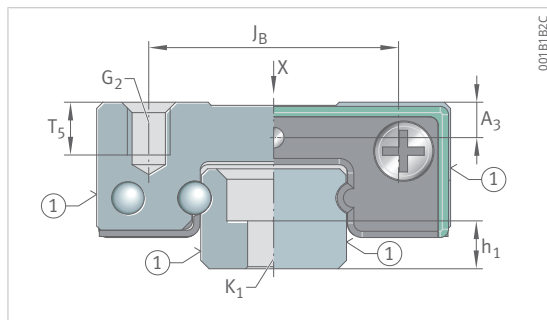
KUEM...-E, view rotated 90°



Moments and load direction

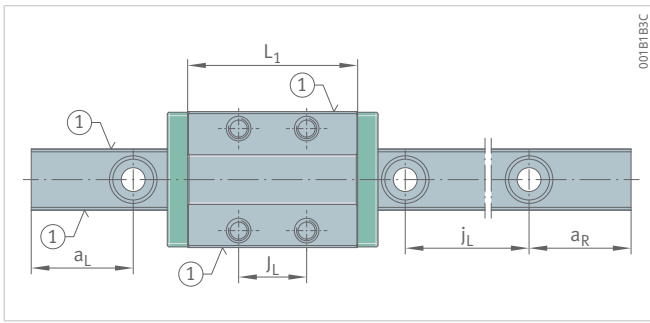
A <sub>1</sub>	A <sub>2</sub>	H <sub>1</sub>	C	C <sub>0</sub>	M <sub>0x</sub>	M <sub>0y</sub>	M <sub>0z</sub>
mm	mm	mm	N	N	Nm	Nm	Nm
5	2,5	1,5	915	1460	4,6	2,6	2,6
5	2,5	1,5	1270	2400	7,9	8,7	8,7
5,5	2,5	2,35	1700	2800	11,5	7,5	7,5
5,5	2,5	2,35	2280	4300	18,5	20	20
7,5	3,5	3,35	2500	3900	21,5	11,7	11,7
7,5	3,5	3,35	3550	6300	35,9	33,4	33,4
8,5	3,5	4	3900	5850	38,9	23,9	23,9
8,5	3,5	4	5500	9800	64,1	63,3	63,3

KUEM..-E  
Double row



KUEM..-E

System	Carriage	Guideway	J <sub>B</sub>	L <sub>1</sub>	J <sub>L</sub>	T <sub>5</sub>	A <sub>3</sub>
Designation	Designation	Designation	mm	mm	mm	mm	mm
-	-	-	mm	mm	mm	mm	mm
KUEM07-E	KWEM07-E	TKDM07-E	12	18	8	2,5	1,7
KUEM07-E-L	KWEM07-E-L	TKDM07-E	12	26	13	2,5	1,7
KUEM09-E	KWEM09-E	TKDM09-E	15	25	10	3	1,65
KUEM09-E-L	KWEM09-E-L	TKDM09-E	15	34,5	16	3	1,65
KUEM12-E	KWEM12-E	TKDM12-E	20	29	15	3,5	2,65
KUEM12-E-L	KWEM12-E-L	TKDM12-E	20	40,5	20	3,5	2,65
KUEM15-E	KWEM15-E	TKDM15-E	25	37	20	4	2,3
KUEM15-E-L	KWEM15-E-L	TKDM15-E	25	55	25	4	2,3



KUEM..-E, view rotated 90°

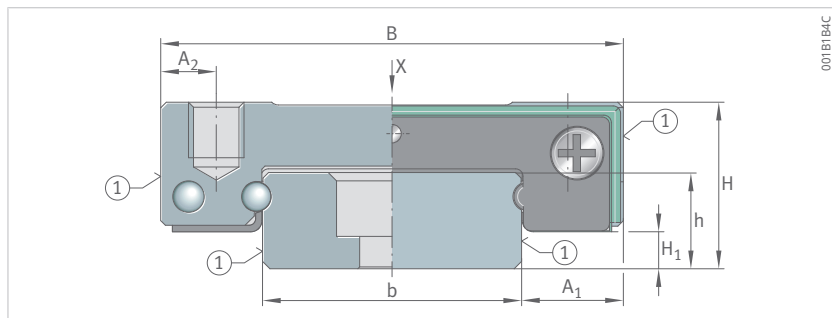
G <sub>2</sub>	M <sub>A</sub>	h <sub>1</sub>	j <sub>L</sub>	a <sub>L</sub>		a <sub>R</sub>		K <sub>1</sub>	
				min	max	min	max	-	M <sub>A</sub>
-	Nm	mm	mm	mm	mm	mm	mm	-	Nm
M2	0,32	2,3	15	4	11	4	11	M2	0,32
M2	0,32	2,3	15	4	11	4	11	M2	0,32
M3	1,1	3	20	5	15	5	15	M3	1,1
M3	1,1	3	20	5	15	5	15	M3	1,1
M3	1,1	4,3	25	5	20	5	20	M3	1,1
M3	1,1	4,3	25	5	20	5	20	M3	1,1
M3	1,1	5	40	5	35	5	35	M3	1,1
M3	1,1	5	40	5	35	5	35	M3	1,1

### 3.8.3 KUEM..-E-W

Double row

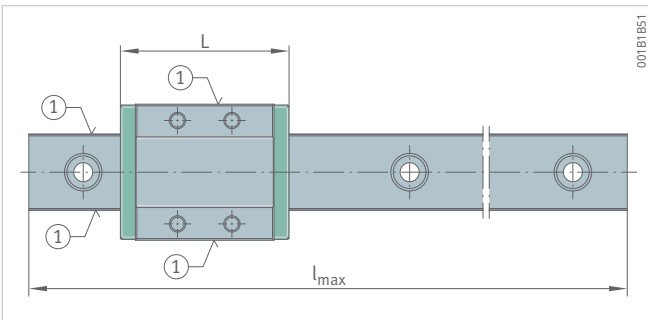
Wide design

3

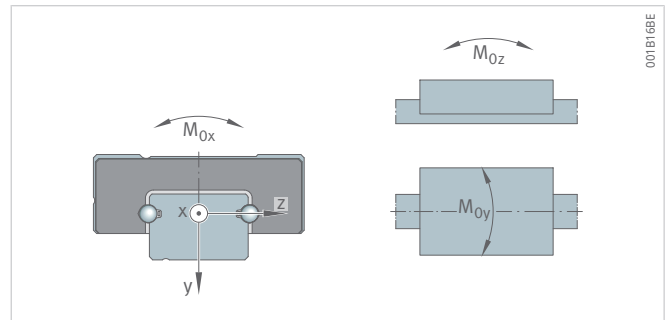


KUEM..-E-W

System	Carriage		Guideway		$l_{max}$	H	B	L	h	b
Designation	Designation	$m_c$	Designation	$m_r$						
-	-	kg	-	kg/m	mm	mm	mm	mm	mm	mm
KUEM07-E-W	KWEM07-E-W	0,540	TKDM07-E-W	0,024	2000	9	25	31	5,2	14
KUEM07-E-WL	KWEM07-E-WL	0,540	TKDM07-E-W	0,034	2000	9	25	41,5	5,2	14
KUEM09-E-W	KWEM09-E-W	0,940	TKDM09-E-W	0,051	2000	12	30	39	7	18
KUEM09-E-WL	KWEM09-E-WL	0,940	TKDM09-E-W	0,068	2000	12	30	50,5	7	18
KUEM12-E-W	KWEM12-E-W	1,525	TKDM12-E-W	0,085	2000	14	40	43,5	8,5	24
KUEM12-E-WL	KWEM12-E-WL	1,525	TKDM12-E-W	0,118	2000	14	40	58	8,5	24
KUEM15-E-W	KWEM15-E-W	2,960	TKDM15-E-W	0,169	2000	16	60	55,5	9,5	42
KUEM15-E-WL	KWEM15-E-WL	2,960	TKDM15-E-W	0,236	2000	16	60	74,5	9,5	42



KUEM...-E-W, view rotated 90°



Moments and load direction

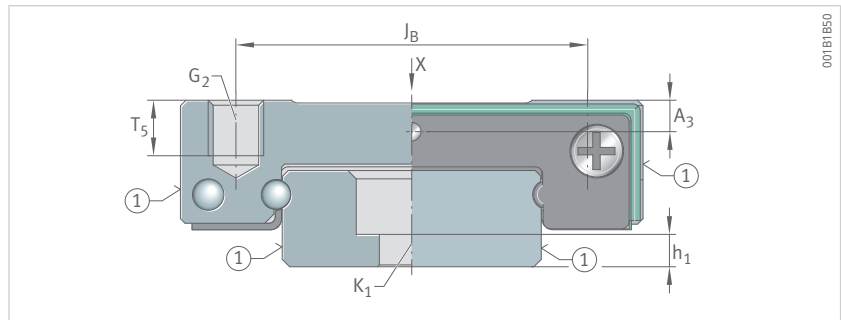
3

A <sub>1</sub>	A <sub>2</sub>	H <sub>1</sub>	C	C <sub>0</sub>	M <sub>0x</sub>	M <sub>0y</sub>	M <sub>0z</sub>
mm	mm	mm	N	N	Nm	Nm	Nm
5,5	3	2	1220	2200	14,7	6,4	6,4
5,5	3	2	1660	3450	23	15,8	15,8
6	4,5	2,5	2160	4050	36,2	17,3	17,3
6	4,5	2,5	2850	5850	51,7	36,1	36,1
8	6	3	3100	5300	69,1	28,5	28,5
8	6	3	4250	8300	96,8	57,9	57,9
9	7,5	4	5000	8500	178,8	54,3	54,3
9	7,5	4	6550	12500	241,8	105,5	105,5

KUEM..-E-W

Double row

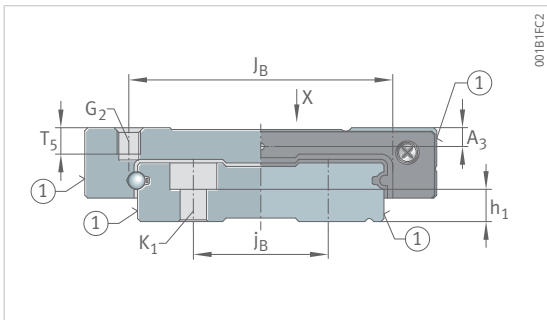
Wide design



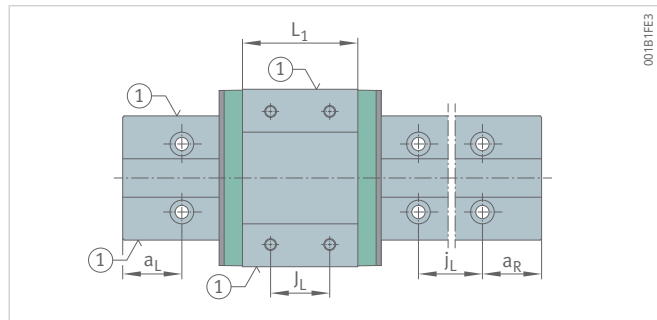
KUEM..-E-W (size 07, 09, 12)

System	Carriage	Guideway	$J_B$	$L_1$	$J_L$	$T_5$	$A_3$
Designation	Designation	Designation	mm	mm	mm	mm	mm
-	-	-	mm	mm	mm	mm	mm
KUEM07-E-W	KWEM07-E-W	TKDM07-E-W	19	25,5	10	3	1,7
KUEM07-E-WL	KWEM07-E-WL	TKDM07-E-W	19	36	19	3	1,7
KUEM09-E-W	KWEM09-E-W	TKDM09-E-W	21	33	12	3	2,35
KUEM09-E-WL	KWEM09-E-WL	TKDM09-E-W	23	44,5	24	3	2,35
KUEM12-E-W	KWEM12-E-W	TKDM12-E-W	28	37,5	15	3,5	2,7
KUEM12-E-WL	KWEM12-E-WL	TKDM12-E-W	28	52	28	3,5	2,7
KUEM15-E-W	KWEM15-E-W	TKDM15-E-W	45	48,5	20	4,5	2,7
KUEM15-E-WL	KWEM15-E-WL	TKDM15-E-W	45	67,5	35	4,5	2,7





KUEM..-E-W



KUEM15-E-W, view rotated 90°

G <sub>2</sub>	M <sub>A</sub>	h <sub>1</sub>	j <sub>L</sub>	j <sub>B</sub>	a <sub>L</sub>		a <sub>R</sub>		K <sub>1</sub>	M <sub>A</sub>
					mm	max	min	max		
M3	1,1	1,7	30	-	5	25	5	25	M3	1,1
M3	1,1	1,7	30	-	5	25	5	25	M3	1,1
M3	1,1	2,5	30	-	5	25	5	25	M3	1,1
M3	1,1	2,5	30	-	5	25	5	25	M3	1,1
M3	1,1	4	40	-	6	34	6	34	M4	1,1
M3	1,1	4	40	-	6	34	6	34	M4	1,1
M4	2,6	5	40	23	6	34	6	34	M4	2,6
M4	2,6	5	40	23	6	34	6	34	M4	2,6

**Schaeffler Technologies AG & Co. KG**

Industrial Automation

Berliner Straße 134

66424 Homburg (Saar)

Germany

[www.schaeffler.de/en](http://www.schaeffler.de/en)

[info.industrialautomation@schaeffler.com](mailto:info.industrialautomation@schaeffler.com)

In Germany:

Phone 0180 5003872

From other countries:

Phone +49 9721 91-0

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