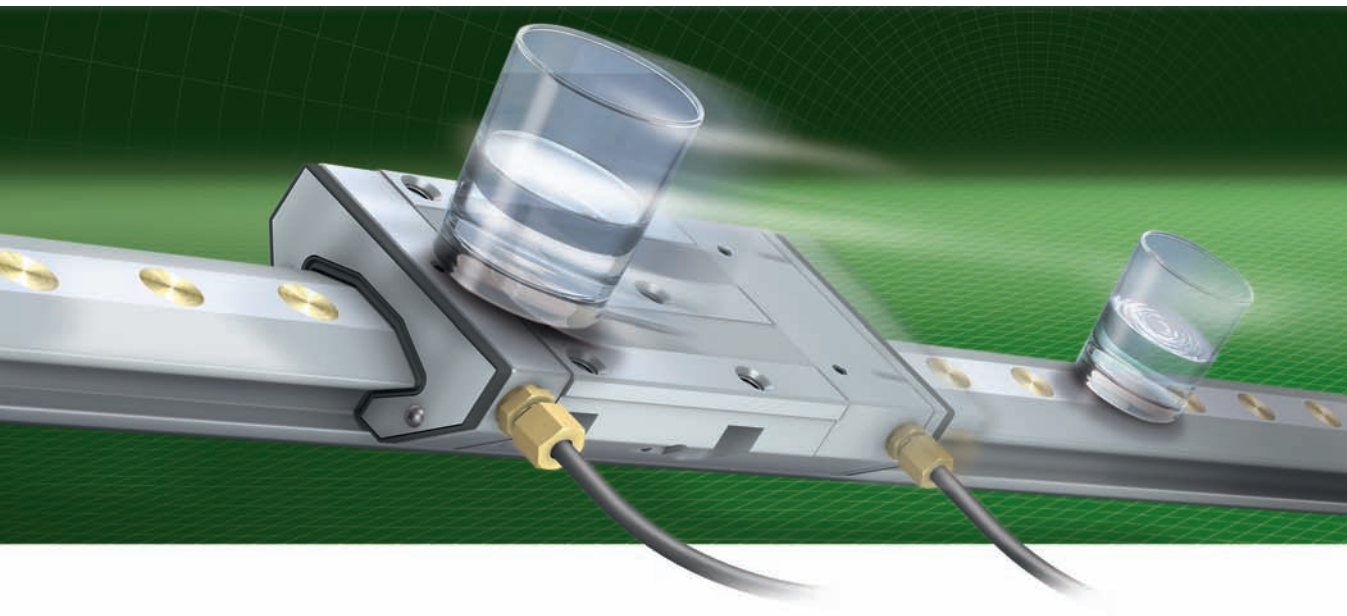

Hydrostatic Compact Guidance System

Matching the design envelope of a monorail guidance system

SCHAEFFLER GROUP
INDUSTRIAL

Hydrostatic compact guidance system

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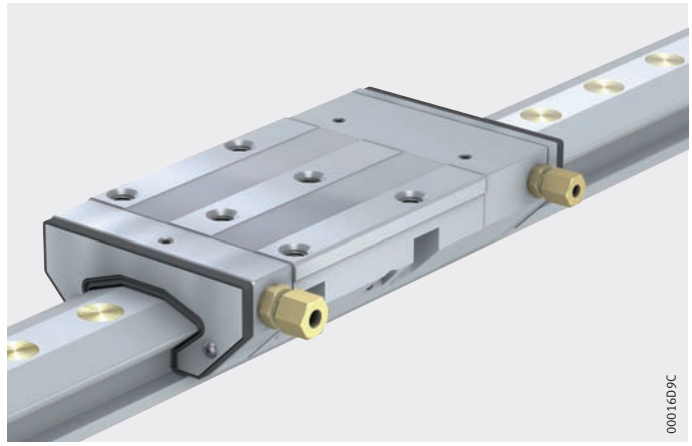
Matching the design envelope of a monorail guidance system

HLE45



Hydrostatic compact guidance system

Features

The carriages in monorail guidance systems cannot accommodate vibration damping. In order to allow appropriate damping of vibrations from the adjacent construction, additional elements such as the passive damping carriage RUDS-D for the linear recirculating roller bearing and guideway assemblies RUE-E are required, which is positioned between the carriages. In order to have the greatest effect when bending vibrations occur, however, the damping element must be positioned at the point of largest deflection. A good knowledge of the vibration patterns is therefore required.

Hydrostatic vibration damping by means of oil cushion

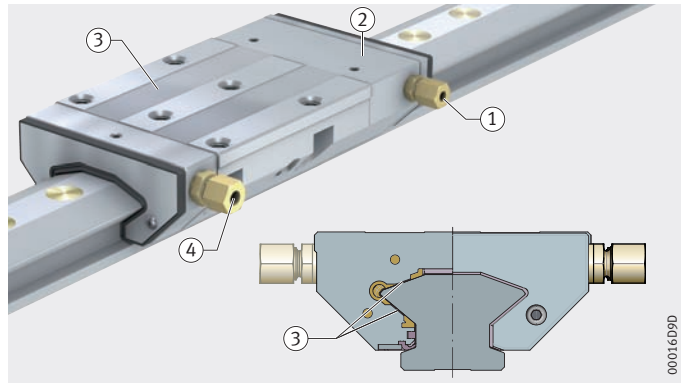
For applications with very high demands on damping, dynamic rigidity and load carrying capacity, there is now a hydrostatic compact guidance system based on our proven linear recirculating roller bearing and guideway assemblies RUE..-E for size 45.

This preloaded guidance system is a complete unit.
It has been designed specifically for damping and does not need to be retrofitted with special damping components.

Function

A chamber system in the carriage is charged with hydraulic oil. The oil is fed to the pressure side under continuous pressure, *Figure 1*. The integrated chokes are set so that the carriage is positioned optimally on the guideway and lifts off uniformly to a gap height of 0,025 mm when pressure is applied. Pressure pockets in the carriage ensure that the carriage is flushed with oil.

The unpressured oil is extracted from the compact guidance system on the suction side and fed back to the oil circuit.



① Pressure side
② Integrated choke
③ Pressure pockets
④ Suction side (unpressurised area)

Figure 1
Functional parts

Hydrostatic compact guidance system

Advantages of this solution

Due to an integral hydraulic controller, the hydrostatic guidance system is ready to fit and can be integrated into the standard design envelope of a linear recirculating roller bearing and guideway assembly.

Only one machine concept required

Due to compliance with the DIN design envelope and the DIN mounting dimensions for monorail guidance systems (identical geometrical mounting dimensions and identical outline profile), several performance classes are possible with a single machine concept. As a result, just one concept can be used to cover various requirements in relation to machining.

Depending on the key issue, for example, the following is possible:

- excellent surface quality and accuracy in normal machining
- increased cutting rate and cutting depth with high machining quality and accuracy in high performance machining.

Performance characteristics

There is approximately zero friction between the guideway and the carriage, see section Friction, page 5. The compressive rigidity corresponds to the normal linear recirculating roller bearing and guideway assembly RUE-E.

The operating load in machine tools is similar to the standard monorail guidance system. This guidance system can support loads from all directions, apart from the direction of motion, and moments about all axes.

It is suitable for accelerations of 100 m/s^2 and speeds up to 120 m/min.

Available designs

A hydrostatic system comprises at least two guideways TSH, two carriages HLW per guideway and brass closing plugs to seal off the fixing holes in the guideways.

The guideways are supplied as single pieces only up to a maximum length of 5 900 mm; guideways comprising joined sections are not permissible.

Operating precondition

For operation of a hydrostatic compact guidance system, a hydraulic oil HLP 46 in accordance with classification to DIN 51524-2 is required. The oil corresponds to the viscosity class ISO VG 46 and must be filtered to a particle size of 10 μm.

Sealing

Elastic seals on the end faces and sealing strips on the undersides of the carriages protect the system against contamination and retain the hydraulic oil in the carriage.

Anti-corrosion protection

A version with anti-corrosion protection is not available.

Operating temperature

The compact guidance system is designed for operation at room temperature (≈22 °C).

Design and safety guidelines

Interchangeability

The carriages and guideways are matched to each other and therefore cannot be freely combined with other guideways and carriages.

The chokes in the carriage are set to the specific gap.

A system with hydrostatic compact guidance systems always comprises at least two guideways each with two carriages. It is not possible to design a system with only one guideway or one carriage.

Preload

The guidance system HLE is preloaded hydraulically to a pressure of approx. 5 MPa. The preload is determined by the valve setting.

Influence of preload on the compact guidance system

Increasing the preload increases the rigidity. However, the preload has no influence on the displacement force or the operating life of the compact guidance system.

Friction

Friction is independent of load until the load limit is reached. Due to the all-round sealing, there is a constant displacement resistance of approx. 20 N per carriage.

Rigidity

The rigidity is as follows:

- compressive direction = 1 200 N/µm
- tensile direction = 900 N/µm
- lateral direction = 500 N/µm.

These values were determined on a system (HLE45), comprising two guideways (TSH45) and four carriages (HLW45) which were screw mounted on a plate, under an operating pressure of 10 MPa. They include the deformation of the hydrostatic guidance system HLE including the screw connections to the adjacent construction.

The rigidity curves are valid only for mounting using six screws and an appropriate oil supply, see section Hydraulic unit, page 7.

Mounting of the compact guidance system

Never slide the carriage onto the guideway without oil.

The guideways must be aligned, firmly screwed down and the holes must be closed off using brass plugs.

When using the hydrostatic guidance system, both guideways and one side of the carriages should have a fixed stop.

Fitting

Carry out fitting as described in the following steps:

- Slide the oiled carriage onto the guideway and move it to the mounting position without load.
- Make the hydraulic connection to the carriage (the positions of the pipe screw connectors for the oil connection lines and the closing plugs can be transposed to the other side if required).
- Apply the operating pressure to the system.
- Locate the mating part on the carriages.
- Screw in the carriage screw from the rear face of the carriage (from above).
- First tighten the four outer screws, then the central screws, observing the screw length.

The guidance system is thus ready for operation.

Hydraulic unit

An oil quantity of 1,3 l/min is required per carriage.

Example

In partnership with the company Hydac, the following examples of requirements for a hydraulic unit were developed. This is based on a guidance system comprising two guideways each with two carriages.

Requirements for the hydraulic unit:

- pressure circuit with electric motor V1, rating 1,5 kW, n = 1 500 min^{-1}, 400 V, external gear pump Q = 6 l/min at p ≈ 110 bar
- oil container NG63 with filling and venting filter, fill level control, electric temperature switch, drain ball valve
- filter circuit (suction pump) with electric motor V1, rating 0,37 kW, n = 1 500 min^{-1}, 400 V, external gear pump Q = 10 l/min at p ≈ 5 bar
- oil cooler with plate heat exchanger (HEX 615-30(C71,C71))
- compressor cooling device, cooling power corresponding at least to total of pump rating
- oil filter in the pressure line, particle size ≦ 10 µm.

Cooler design

The oil cooler must be dimensioned such that the oil outlet temperature from the hydraulic unit is 6 K below the required ambient temperature of the hydrostatic guidance system.

Inlet and outlet lines of hydraulic system

The largest possible pipe diameters must always be selected.

Inlet line

The inlet line should have an inside diameter of 16 mm and should be reduced as late as possible before the carriage to an inside diameter of 4 mm.

The pressure connector in the carriage is L6 (M10×1,0).

Outlet line

In the outlet line, the line resistance as far as the suction pump for all connected carriages must be identical and as low as possible.

The suction connector in the carriage is L8 (M12×1,5).

After exit from the carriage, the suction line should be expanded after a maximum of 300 mm to an inside diameter of 16 mm.

If the outlet line is longer than 3 m, a suction pump must be installed directly on the axis.

The banking-up pressure in the suction line must be less than 0,2 bar.

The line resistance for the suction and pressure lines must always be calculated.

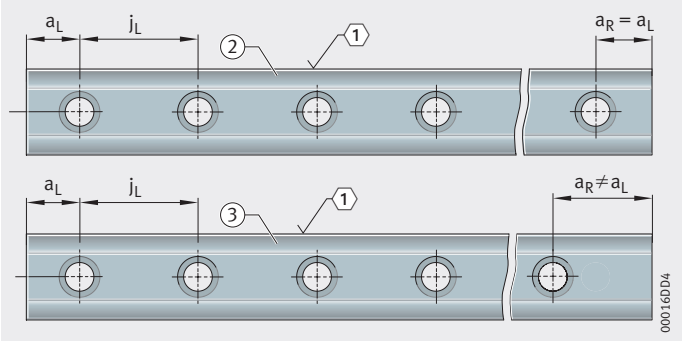
A pressure switch must be provided in the hydraulic unit that authorises motion of the hydrostatic axis in the controller only when sufficient pressure is present.

The guidance system should only be moved when the hydraulic system is active.

Hole pattern of guideway

Unless specified otherwise, the guideways have a symmetrical hole pattern, *Figure 2*.

An asymmetrical hole pattern may also be available at customer request. In this case, $a_L \geqq a_{L\,min}$ and $a_R \geqq a_{R\,min}$, *Figure 2*.



① Locating face
② Symmetrical hole pattern
③ Asymmetrical hole pattern

Figure 2
Hole patterns of guideways with one row of holes

Maximum number of pitches between holes

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

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

The distances a_L and a_R are generally determined as follows:

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

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

l mm
Guideway length

n –
Maximum possible number of pitches between holes

j_L mm
Distance between holes

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.

Multi-piece guideways

Multi-piece guideways are not possible.

Design of 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 the 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.

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.

Observe the tolerances according to *Figure 3*, page 10.

Surfaces should be ground or milled with the aim of achieving a mean roughness value Ra1,6.

Any deviations from the stated tolerances will impair the overall accuracy, alter the preload and can lead to malfunction.

Height difference ΔH

For ΔH, permissible values are in accordance with 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 3*, page 10

a –
Factor dependent on preload class, in this case: 0,075

b mm
Centre distance between guidance elements.

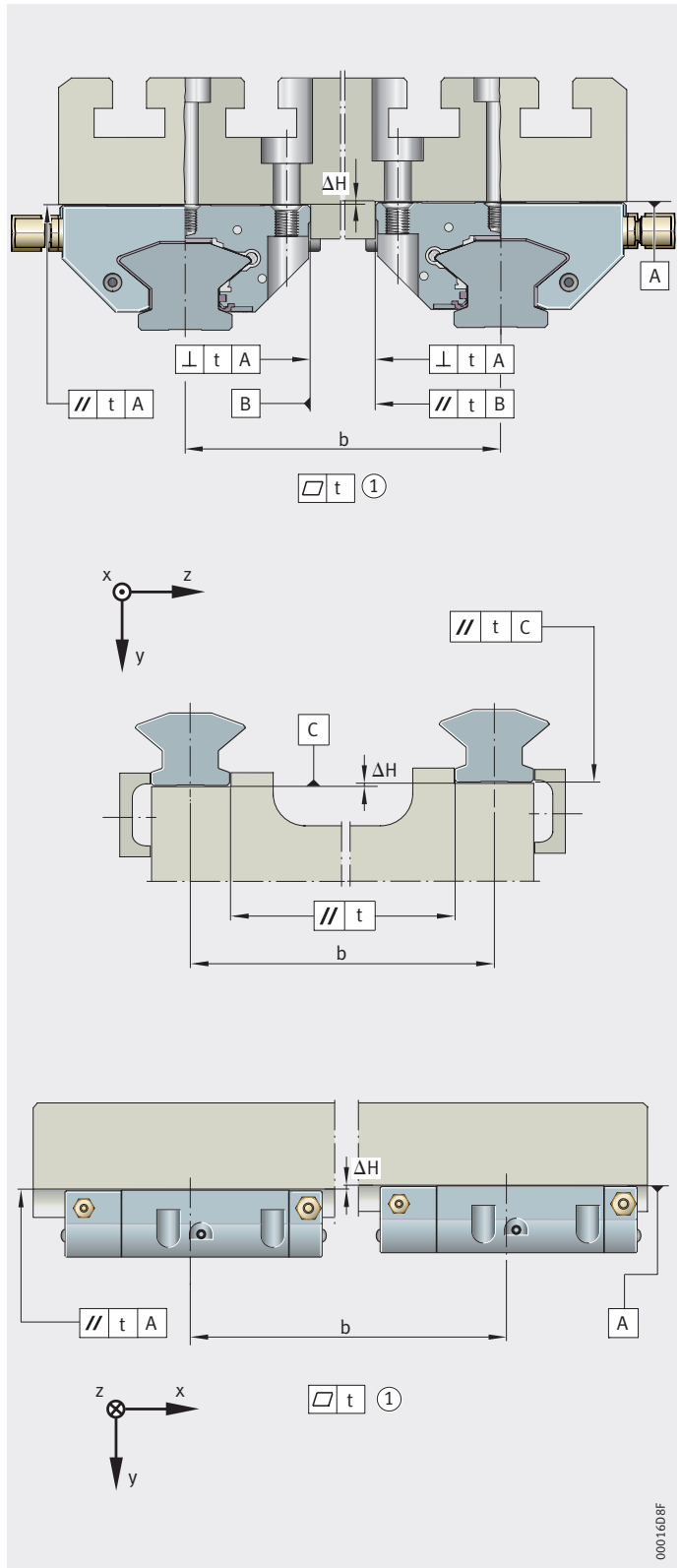
Parallelism of mounted guideways

For guideways arranged in parallel, the parallelism tolerance should be t, *Figure 3*, page 10, and table.

Parallelism tolerance t of guideways

Designation	Parallelism tolerance t μm
TSH45	< 10

If the maximum values are used, this may increase the displacement resistance.



b = distance between guideways
ΔH = height difference
t = parallelism tolerance
① Not convex
(for all machined surfaces)

Figure 3
Tolerances of mounting surfaces and parallelism of mounted guideways

Accuracy

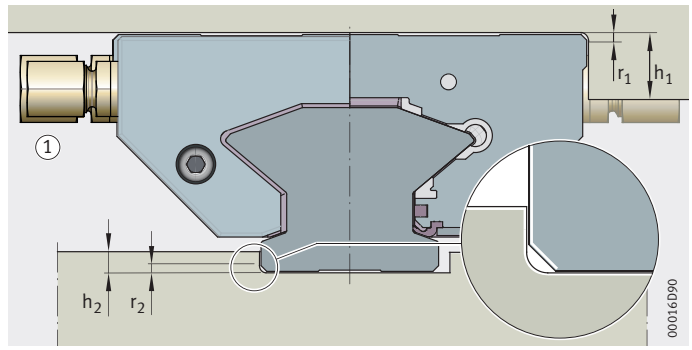
Locating heights and corner radii

The locating heights and corner radii must be matched to the compact guidance system, see table and *Figure 4*.

The adjacent construction must include a recess for the closing plugs and the pipe screw connectors, *Figure 4*.

Locating heights and corner radii

Designation	h_1 mm	h_2 max. mm	r_1 max. mm	r_2 max. mm
HLE45	10	8	1	0,8

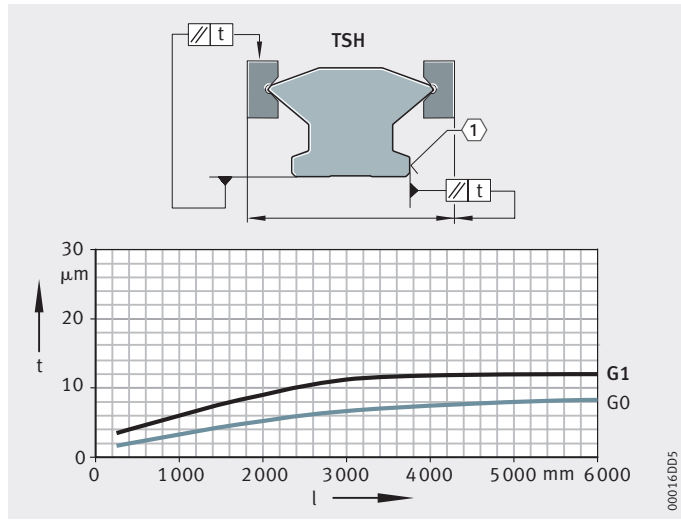


① Recess in the adjacent construction

Figure 4
Locating heights and corner radii

Accuracy classes

The compact guidance system HLE is available in the accuracy classes G0 to G1, *Figure 5*. The standard is class G1.



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

Figure 5
Accuracy classes and parallelism tolerances of guideways

Parallelism of raceways to locating faces

The parallelism of the guideways is dependent on the accuracy class, *Figure 5*, page 11.

Tolerances

The tolerances are arithmetic mean values. They relate to the centre point of the screw mounting 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, see table.

Datum dimensions H and A_1 see *Figure 6*.

Running accuracy

The running accuracy is influenced by the accuracy of the adjacent construction.

Accuracy class tolerances

Tolerance		Accuracy	
		G0 µm	G1[1] µm
Height tolerance	H[3]	±5	±10
Height difference[2]	ΔH	3	5
Spacing tolerance	A_1[3]	±5	±10
Spacing difference[2]	ΔA_1	3	7

[1] Standard accuracy class.

[2] Difference between several carriages on one guideway, measured at the same point on the guideway.

[3] Theoretical value used in production.

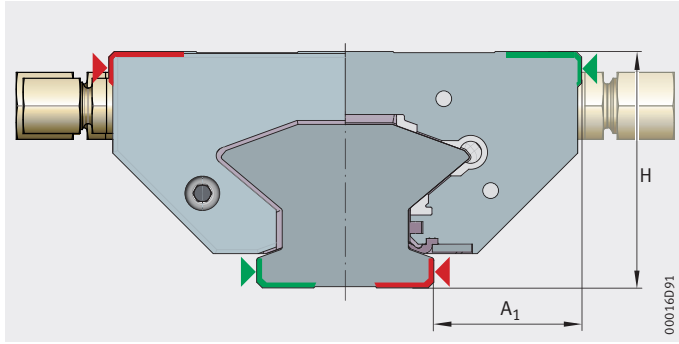


Figure 6
Datum dimensions for accuracy

Positional and length tolerances of guideways

Positional and length tolerances of guideways see *Figure 7* and table.

The hole pattern corresponds to DIN ISO 1101.

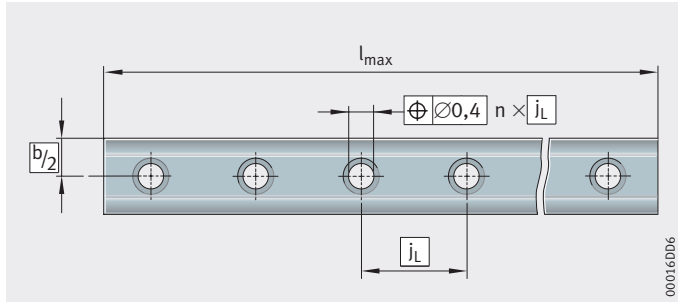


Figure 7
Positional and length tolerances of guideways

Length tolerances of guideways

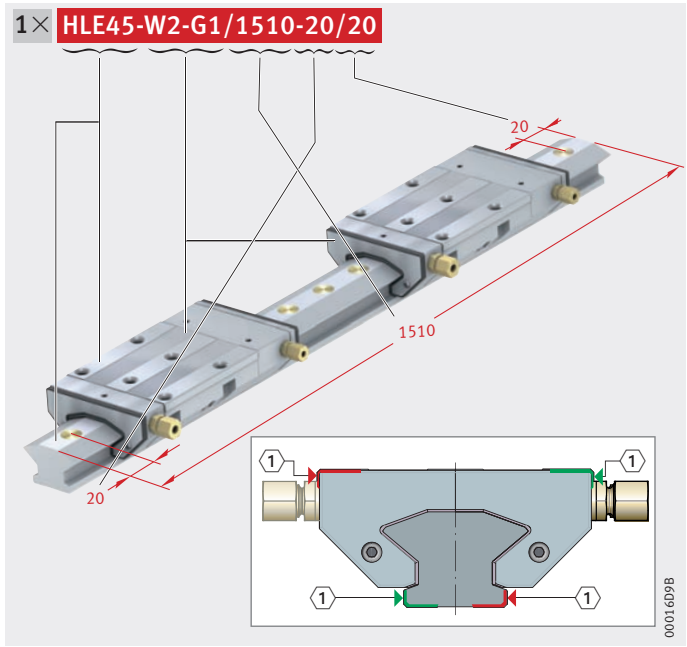
Designation	Tolerances of guideways, as a function of the length l_{max} [1]		
	≦1 000 mm	>1 000 mm <3 000 mm	>3 000 mm
TSH45	–1 mm	–1,5 mm	±0,1% of guideway length

[1] Length l_{max} see dimension table.

Ordering example, ordering designation Symmetrical hole pattern

Hydrostatic compact guidance system	HLE
Size	45
Number of carriages per unit	W2
Accuracy class	G1
Guideway length	1 510 mm
a_L	20 mm
a_R	20 mm

Ordering designation 1×**HLE45-W2-G1/1510-20/20**, *Figure 8*.



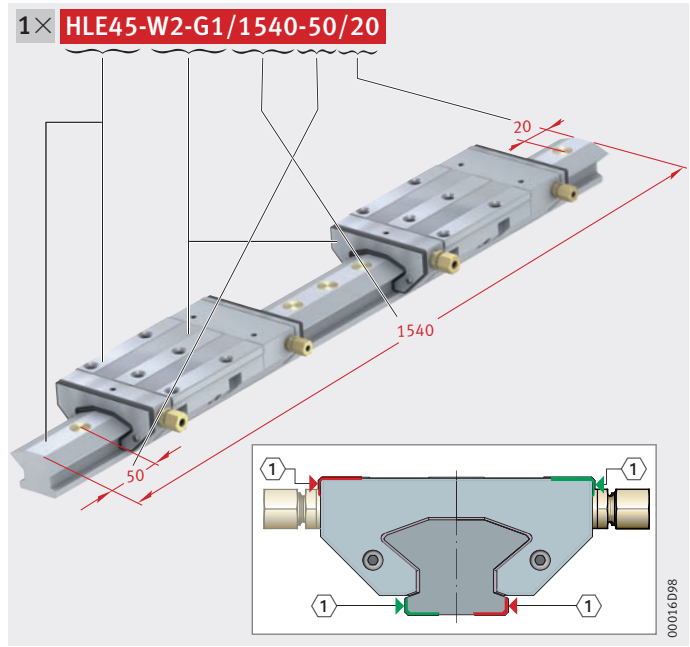
(1) Locating face

Figure 8
Ordering example, ordering designation

Asymmetrical hole pattern

Hydrostatic compact guidance system	HLE
Size	45
Number of carriages per unit	W2
Accuracy class	G1
Guideway length	1 540 mm
a_L	50 mm
a_R	20 mm

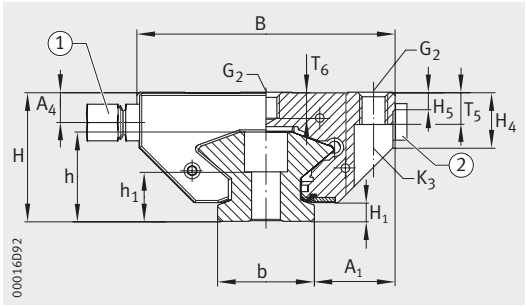
Ordering designation 1×**HLE45-W2-G1/1540-50/20**, *Figure 9*.



① Locating face

Figure 9
Ordering example, ordering designation

Hydrostatic compact guidance system



HLE45
①, ②[1)]

Dimension table · Dimensions in mm

Designation	Carriage		Guideway			Dimensions				Mounting dimensions				
	Designation	Mass m ≈kg	Designation	Mass m ≈kg	Closing plug	l_{max} [2)]	H	B	L	A_1	J_B	b −0,005 −0,035	L_1	L_S
HLE45	HLW45	6	TSH45	12,4	KA20-M	5 900	60	120	226,5	37,5	100	45	134,2	2,2

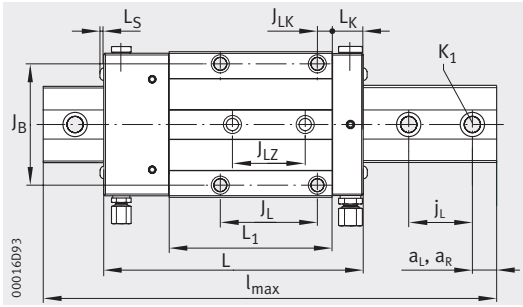
1) ① Pipe screw connector
② Closing plug
The positions of the pipe screw connectors and closing plugs can be transposed.

2) Available only as single piece up to a maximum length of 5 900 mm.
Guideway joints are not permissible.

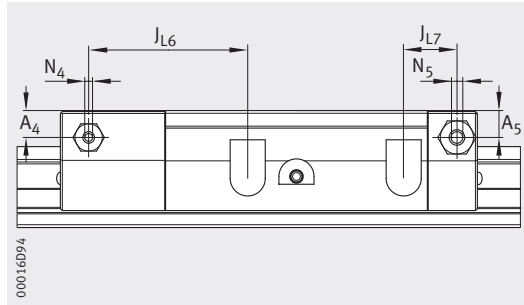
3) a_L and a_R are dependent on the guideway length.

Dimension table (continued) · Dimensions in mm

Designation	Fixing screws						Dimensioning of lubrication connectors					
	G_2 DIN ISO 4 762-12.9		K_1		K_3		A_4	N_4	J_{L6}	A_5	N_5	J_{L7}
		M_A Nm		M_A Nm		M_A Nm						
HLE45	M12	140	M12	140	M10	83	13,8	4	81,6	13,8	6	27,3

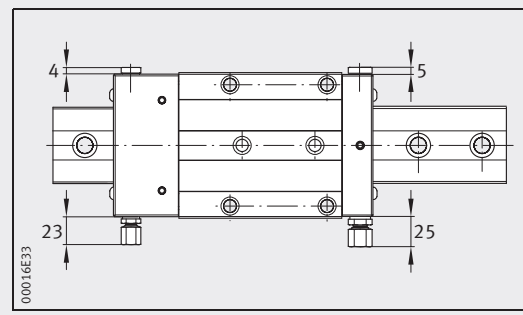


HLE45 · View rotated 90°



Lateral pressure oil connector

														Load carrying capacity at 10 MPa in		
L_K	J_L	J_{LK}	J_{LZ}	j_L	a_L, a_R [3]		H_1	H_5	H_4	T_5	T_6	h	h_1	compressive direction	tensile direction	lateral direction
					min.	max.							±0,5	N	N	N
31	80	12,1	60	52,5	20	41	8,7	8	25,8	15	10	41,5	23	22 000	17 400	7 500



Closing plugs and pipe screw connectors

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