Hydrostatic Compact Guidance System

Matching the design envelope of a monorail guidance system
# Hydrostatic compact guidance system

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Product overview  Hydrostatic compact guidance system

Matching the design envelope of a monorail guidance system

HLE45-A-XL
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.

**X-life**

Hydrostatic compact guidance systems HLE45-A-XL are supplied in X-life quality.

The guidance systems combine damping values of more than 470,000 kg/s with levels of tensile/compressive rigidity that are almost as high as the rigidity of the corresponding rolling element guidance systems. When used in machine tools, this gives higher cutting output, better surface quality and longer tool life.

A special bronze coating in the pressure pockets of the saddle plate gives excellent emergency running characteristics, which means that the guidance system is not damaged even when overloaded or during operation without hydraulic pressure.
Hydrostatic compact guidance system

Function

A chamber system in the carriage is charged with hydraulic oil. The oil is fed to the pressure side under continuous pressure, thus filling the pressure pockets, Figure 1. The integrated chokes are set such that the pressure pockets in the carriage are subjected uniformly to pressure.

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

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 6. 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. The 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/s² and speeds up to 120 m/min.
| **Available designs** | A hydrostatic system comprises at least two guideways TSH45-XL, each with two carriages (1×HLW45-A-SR-XL and 1×HLW45-A-SL-XL) and brass closing plugs KA20-M to seal off the fixing holes in the guideways. Where there are increased requirements relating to leakage, Schaeffler offers a conical special closing plug KA20-M-FA512.7 made from brass; please consult us in such cases. The guideways are supplied as single pieces only up to a maximum length of 2 940 mm; guideways comprising joined sections are not permissible. If longer guideway lengths are required, please consult us. |
| **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 use with a hydraulic oil HLP 46 at +40 °C. This temperature must be maintained, for example by means of a cooling system. |
Hydrostatic compact guidance system

Design and safety guidelines

Interchangeability

The carriages and guideways are interchangeable and can therefore 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, Figure 2. It is not possible to design a system with only one guideway or one carriage.

Preload

The guidance unit HLE45-A-XL is preloaded by hydraulic means to a pressure of approx. 5 MPa per raceway (pressure pocket). 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 simply a constant displacement resistance of approx. 20 N per carriage.
Rigidity

The rigidity per carriage (at approx. +40 °C) is as follows:
- in a compressive direction = 1200 N/μm
- in a tensile direction = 900 N/μm
- in a lateral direction = 500 N/μm.

The values were determined on a system (HLE45-A-XL), comprising two guideways (TSH45-XL) and four carriages (HLW45-A..-XL) 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 8.

Mounting of the compact guidance system

Never slide the carriage onto the guideway without oil. Otherwise, the seals may be damaged.

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.

Before mounting the guideways and carriages, the mounting steps and warning messages in the mounting manual MON 50 must always be observed.

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 then ready for operation.
Hydrostatic compact guidance system

Hydraulic unit

Each carriage must have a volume flow of 1.3 l/min.

Inlet and outlet pipes for the hydraulic system

Inlet line

In order to minimise the pressure losses due to pipe resistance, the pipe cross-section should only be reduced to an inside diameter of 4 mm immediately before the connector to the carriage. The pressure connector in the carriage is L6 M12×1,5 (screw thread in carriage M10×1).

A shut-off valve should be fitted in the inlet pipe that will stop pressure being applied to the carriage if the pressure in the extraction pipe is too high (2 bar).

Outlet line

In the outlet pipe, the pipe resistance as far as the extraction pump for all connected carriages must be identical and as low as possible, in order to ensure uniform extraction from all carriages. The extraction connector in the carriage is L8 M12×1,5 (screw thread in carriage M12×1,5).

After exit from the carriage, the extraction pipe should be expanded after a maximum of 300 mm to an inside diameter of 16 mm, in order to minimise the pipe resistance.

When using longer outlet pipes (>2 m), the oil should be extracted by the extraction module directly on the guidance axis. Through the use of the extraction module, the pipe cross-sections towards the unit can be reduced.

The dynamic pressure on the extraction side of the carriage must be less than 0.2 bar, in order to minimise leakage and friction of the guidance system. Where there are higher requirements relating to leakage and friction, there should be an underpressure on the extraction side of the carriage (to −0.5 bar).

The pipe resistances of the extraction and pressure pipe must always be calculated; please consult us as necessary.

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.

Movement and operation of the guidance system (despite the excellent emergency running characteristics) is only recommended when the hydraulic system is active.
Example:
Hydraulic unit from Hydac for guidance systems HLE45-A-XL

In partnership with the company Hydac, the example configuration of a hydraulic unit was developed. The hydraulic unit was designed with 3 power levels for guidance systems with 4, 8 and 12 carriages. In order to provide the necessary cooling performance for the guidance system, the unit can be combined with a suitable compressor chiller, Figure 3.

Features

The hydraulic unit configured with the company Hydac has the following features:

- power level matched to 4, 8 or 12 carriages
- electronic monitoring of:
  - contamination indicator on pressure side
  - contamination indicator on extraction side
  - oil level
  - oil temperature
  - pressure on pressure side
  - pressure on extraction side
  - pressure in the cooling loop
- filtration of oil on pressure side and return side
- in the case of ambient temperatures deviating from the specified range, see table, page 10, special tempering carried out as necessary.

Where there are long return distances to the hydraulic unit or when using energy chains, an additional extraction module is recommended in order to assist the return movement of oil.
The technical data for the hydraulic unit are indicated for guidance systems with different numbers of carriages, see table.

<table>
<thead>
<tr>
<th>Features</th>
<th>Design</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of carriages</td>
</tr>
<tr>
<td></td>
<td>4</td>
</tr>
<tr>
<td><strong>Motor</strong></td>
<td></td>
</tr>
<tr>
<td>Rated frequency Hz</td>
<td>50</td>
</tr>
<tr>
<td>Rated speed min⁻¹</td>
<td>1420</td>
</tr>
<tr>
<td>Connection voltage (threephase current) V</td>
<td>400</td>
</tr>
<tr>
<td>Rated power kW</td>
<td>2,2</td>
</tr>
<tr>
<td><strong>Pump</strong></td>
<td></td>
</tr>
<tr>
<td>Volume flow l/min</td>
<td>5,2</td>
</tr>
<tr>
<td>Volume flow with extraction module l/min</td>
<td>6,7</td>
</tr>
<tr>
<td><strong>Controller</strong></td>
<td></td>
</tr>
<tr>
<td>Pressure setting bar</td>
<td>115</td>
</tr>
<tr>
<td><strong>Duty cycle</strong></td>
<td></td>
</tr>
<tr>
<td>Continuous operation bar</td>
<td>Suitable</td>
</tr>
<tr>
<td><strong>Tank</strong></td>
<td></td>
</tr>
<tr>
<td>Fill volume l</td>
<td>80</td>
</tr>
<tr>
<td>Mounting position –</td>
<td>Horizontal</td>
</tr>
<tr>
<td><strong>Ambient temperature</strong></td>
<td></td>
</tr>
<tr>
<td>– min. °C</td>
<td>–10</td>
</tr>
<tr>
<td>– max. °C</td>
<td>+30</td>
</tr>
<tr>
<td><strong>Cooling system</strong></td>
<td></td>
</tr>
<tr>
<td>Power of compressor chiller kW</td>
<td>1,5</td>
</tr>
<tr>
<td>Heat exchanger –</td>
<td>HYDAC HEX S610</td>
</tr>
<tr>
<td><strong>Hydraulic fluid</strong></td>
<td></td>
</tr>
<tr>
<td>Mineral oil HL/HLP to</td>
<td>HLP 46, DIN 51524-2</td>
</tr>
<tr>
<td>Oil temperature min. °C</td>
<td>+20</td>
</tr>
<tr>
<td>Oil temperature max. °C</td>
<td>+40</td>
</tr>
</tbody>
</table>
Dimensions

The external dimensions of the hydraulic units with and without a compressor chiller differ only in the height, Figure 4 and Figure 5.

**Figure 4**

Hydraulic unit for HLE45-A-XL without compressor chiller

**Figure 5**

Hydraulic unit for HLE45-A-XL with compressor chiller

The dimensioning of the hydraulic pipe connectors is dependent on the number of carriages for which the unit is designed, see table.

<table>
<thead>
<tr>
<th>Number of carriages</th>
<th>Hydraulic pipe connector</th>
</tr>
</thead>
<tbody>
<tr>
<td>HLW45-A</td>
<td></td>
</tr>
<tr>
<td>Outlet</td>
<td>Inlet</td>
</tr>
<tr>
<td>4</td>
<td>10L</td>
</tr>
<tr>
<td>8</td>
<td>12L</td>
</tr>
<tr>
<td>12</td>
<td>15L</td>
</tr>
</tbody>
</table>
Hydrostatic compact guidance system

Extraction module

The use of an extraction module gives significant advantages in oil extraction:

- Dynamic pressures in the outlet pipe can lead to increased oil consumption in the carriages. With the aid of extraction, this can be compensated up to a level of 2.5 bar.
- The use of an extraction module allows the use of significantly smaller hose diameters. This means that less space is required in the energy chain.
- Through the use of an extraction module, the hydraulic system is less sensitive to pressure fluctuations and air in the pipes.

One extraction module can be used to operate up to 4 carriages HLW45-A. Each extraction module requires an additional volume flow of 1.5 l/min.

Dimensions of the extraction module, Figure 6.

Figure 6
Extraction module
Hole pattern of guideway

Unless specified otherwise, the guideways have a symmetrical hole pattern, Figure 7.

An asymmetrical hole pattern may also be available at customer request. In this case, \( a_L \geq a_{L, \text{min}} \) and \( a_R \geq a_{R, \text{min}} \), Figure 7.

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

\[
n = \lfloor \frac{l - 2 \cdot a_{L, \text{min}}}{i_L} \rfloor
\]

The distances \( a_L \) and \( a_R \) are generally determined as follows:

\[
a_L = a_R = \left( 1 + n \right) i_L
\]

For guideways with a symmetrical hole pattern:

\[
a_L = a_R = \frac{1}{2} \left( 1 + n \right) i_L
\]

Number of holes:

\[
x = n + 1
\]

- \( n \): Maximum possible number of pitches between holes
- \( l \): Guideway length (mm)
- \( a_{L, \text{min}}, a_{R, \text{min}} \): Minimum values for \( a_L, a_R \), see dimension table
- \( i_L \): Distance between holes (mm)
- \( x \): Distance between start or end of guideway and nearest hole

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.
Hydrostatic compact guidance system

Design of the adjacent construction
The running accuracy is essentially dependent on the straightness, accuracy and rigidity of the fit and mounting surfaces. The running accuracy of the system is only achieved when the guideway is pressed against the datum surface.

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 8, page 15. Surfaces should be ground or milled with the aim of achieving a mean roughness value Ra 1.6. 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.

\[ \Delta H = a \cdot t \]

ΔH \( \text{μm} \)
Maximum permissible deviation from the theoretically precise position, Figure 8, page 15
a
Factor dependent on preload class, in this case: 0.075
b \( \text{mm} \)
Centre distance between guidance elements.

Parallelism of mounted guideways
For guideways arranged in parallel, observe the parallelism tolerance t, Figure 8, page 15 and table.

Parallelism tolerance t of guideways

<table>
<thead>
<tr>
<th>Designation</th>
<th>Parallelism tolerance t ( \mu m )</th>
</tr>
</thead>
<tbody>
<tr>
<td>TSH45-XL</td>
<td>&lt; 10</td>
</tr>
</tbody>
</table>

If the maximum values are used, this may increase the displacement resistance.
b = distance between guideways
\( \Delta H \) = height difference
t = parallelism tolerance

Figure 8
Tolerances of mounting surfaces and parallelism of mounted guideways
Hydrostatic compact guidance system

Accuracy
Locating heights and corner radii

The locating heights and corner radii must be matched to the compact guidance system, see table and Figure 9.

The adjacent construction must include a recess for the closing plugs and the pipe screw connectors, Figure 9.

<table>
<thead>
<tr>
<th>Designation</th>
<th>h₁ max.</th>
<th>h₂ max.</th>
<th>r₁ max.</th>
<th>r₂ max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>HLE45-A-XL</td>
<td>10</td>
<td>8</td>
<td>1</td>
<td>0,8</td>
</tr>
</tbody>
</table>

Figure 9
Locating heights and corner radii

Accuracy classes

The hydrostatic compact guidance system HLE45-A-XL is available in the accuracy class G1, Figure 10.

Figure 10
Parallelism tolerances of guideways
The parallelism tolerance of the guideways is indicated for the accuracy class G1, Figure 10, page 16.

**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 A₁ should always remain within the tolerance irrespective of the position of the carriage on the guideway, see table.

For datum dimensions H and A₁, Figure 11.

**Running accuracy**

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

### Tolerances of accuracy class

<table>
<thead>
<tr>
<th>Tolerance</th>
<th>Accuracy class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tolerance for height H₁)</td>
<td>± 10</td>
</tr>
<tr>
<td>Height difference ΔH</td>
<td>5</td>
</tr>
<tr>
<td>Tolerance for spacing A₁₁)</td>
<td>15</td>
</tr>
<tr>
<td>Spacing difference ΔA₁</td>
<td>5</td>
</tr>
</tbody>
</table>

1) Theoretical value used in production.
2) Difference between several carriages on one guideway, measured at the same point on the guideway.

---

**Figure 11**

Datum dimensions for accuracy
Hydrostatic compact guidance system

Positional and length tolerances of guideways

For the positional and length tolerances of guideways, see Figure 12 and table.
The hole pattern corresponds to DIN ISO 1101.

Figure 12
Positional and length tolerances of guideways

Length tolerances of guideways

<table>
<thead>
<tr>
<th>Designation</th>
<th>Tolerances of guideways, as a function of length $l_{\text{max}}$ ¹</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>≤1 000 mm</td>
</tr>
<tr>
<td>TSH45-XL</td>
<td>−1 mm</td>
</tr>
</tbody>
</table>

¹ Length $l_{\text{max}}$ see dimension table.
**Ordering example, ordering designation**

**Symmetrical hole pattern**

Standard system design:
- Hydrostatic compact guidance system: HLE-.A-XL
- Size code: 45
- Number of carriages per unit: W2
- Accuracy class: G1
- Length of guideway: 1510 mm
  - \( a_L \): 20 mm
  - \( a_R \): 20 mm

**Ordering designation**

2×HLE45-A-XL-W2-G1, *Figure 13*

Composition:
- 2×TSH45-XL-G1/1510-20/20
- 2×HLW45-A-SR-XL
- 2×HLW45-A-SL-XL.

*Figure 13*  
Ordering example, ordering designation   
① Locating face
Hydrostatic compact guidance system

X-life

Dimension table • Dimensions in mm

<table>
<thead>
<tr>
<th>Designation</th>
<th>Carriage</th>
<th>Guideway</th>
<th>Dimensions</th>
<th>Mounting dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Designation</td>
<td>Mass kg</td>
<td>Designation</td>
<td>Mass kg</td>
</tr>
<tr>
<td>HLE45-A-XL</td>
<td>HLW45-A-SR-XL$^3$</td>
<td>6</td>
<td>TSH45-XL</td>
<td>12,4</td>
</tr>
</tbody>
</table>

1) Pipe screw connector; 2) Closing plug
The positions of the pipe screw connectors (as standard on the opposing side to the locating face) and closing plugs can be transposed if necessary.

1) Locating face

1) Available only as single piece up to a maximum length of 2 940 mm.
   For longer guideway lengths, please consult us.
2) $a_L$ and $a_R$ are dependent on the guideway length.
3) Position of locating face on right.
4) Position of locating face on left.

Dimension table (continued) • Dimensions in mm

<table>
<thead>
<tr>
<th>Designation</th>
<th>Fixing screws</th>
<th>Dimensioning of lubrication connectors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$G_2$</td>
<td>$G_3$</td>
</tr>
<tr>
<td></td>
<td>$M_A$ Nm</td>
<td>$M_A$ Nm</td>
</tr>
<tr>
<td>HLE45-A-XL</td>
<td>M12</td>
<td>83</td>
</tr>
</tbody>
</table>
### Load carrying capacity at 10 MPa in N

<table>
<thead>
<tr>
<th>l_K</th>
<th>l_L</th>
<th>l_K</th>
<th>l_L</th>
<th>a_L, a_K²</th>
<th>H_1</th>
<th>H_5</th>
<th>H_6</th>
<th>T_5</th>
<th>T_6</th>
<th>h</th>
<th>h₁</th>
<th>Compressive direction</th>
<th>Tensile direction</th>
<th>Lateral direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>31</td>
<td>80</td>
<td>12,1</td>
<td>60</td>
<td>52,5</td>
<td>20</td>
<td>41</td>
<td>8,7</td>
<td>8</td>
<td>25,8</td>
<td>15</td>
<td>41,5</td>
<td>±0,5</td>
<td>22 000</td>
<td>17 400</td>
</tr>
</tbody>
</table>

**HLE45-A-XL** · View rotated 90°

**Pressure oil connector on side**

**HLW45-A-SR-XL (SL-XL)**