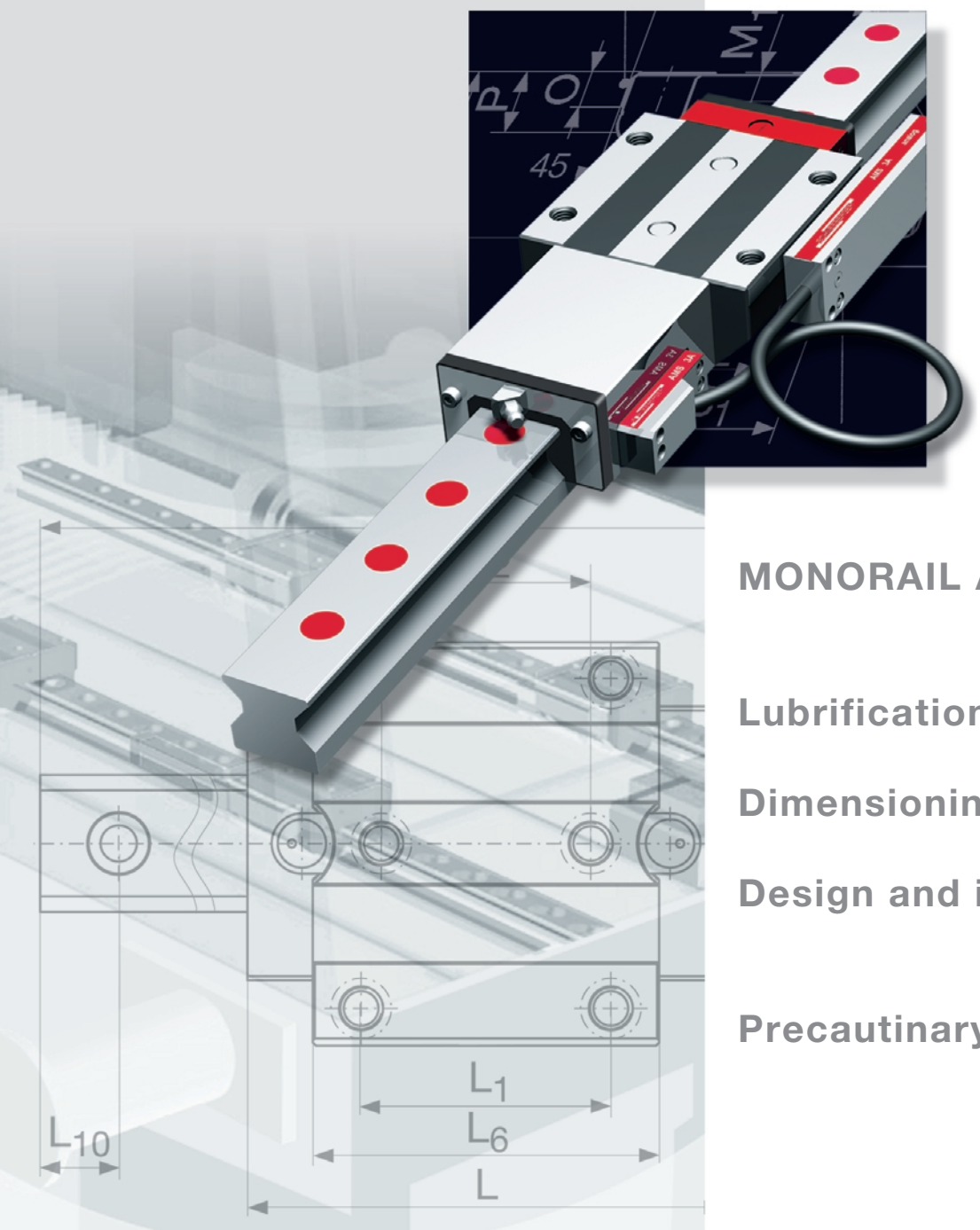
SCHNEEBERGER
LINEAR TECHNOLOGY



MONORAIL AND AMS

3.7 Lubrication

An adequate lubrication is required to maintain the function of linear guideways, because lubricant protects against wear and corrosion and in addition reduces the friction. This also calls for a regular subsequent lubrication. Possible lubricants are both grease as well as liquid grease or oil.

As delivered condition

At delivery the carriages are preserved with mineral oil. This is sufficient as a protection for the assembly of the guideway. Before taking into operation it must be guaranteed that enough lubricant is in the carriages and on the beforehand cleaned rails.
Quantities of lubricant for the initial lubrication, refer to the tables on page 26 and 27.

Lubrication connections

The front plates are fitted with several prepared lubrication connections with threads. These are located at the front and on the side (please refer to the table below). Here either a grease nipple can be attached or a central lubrication system connected. In doing so, both sides of the carriages (i. e., all four tracks) are provided with lubricant.

The front plates furthermore are equipped with an O-ring seat on top for direct connection to a central lubrication system through the connection construction. Here too, both sides of the carriages are provided with lubricant.

In the standard version, the thread M 6 (M 3 in the case of BM 15) at the center of the front plate (-SM) is foreseen for the connection of the lubrication system. From the factory, these lubrication bores in the front plate are closed on both sides with a cap plug. The corresponding cap plug for the required bore has to be removed by the customer.
The other connections are closed.

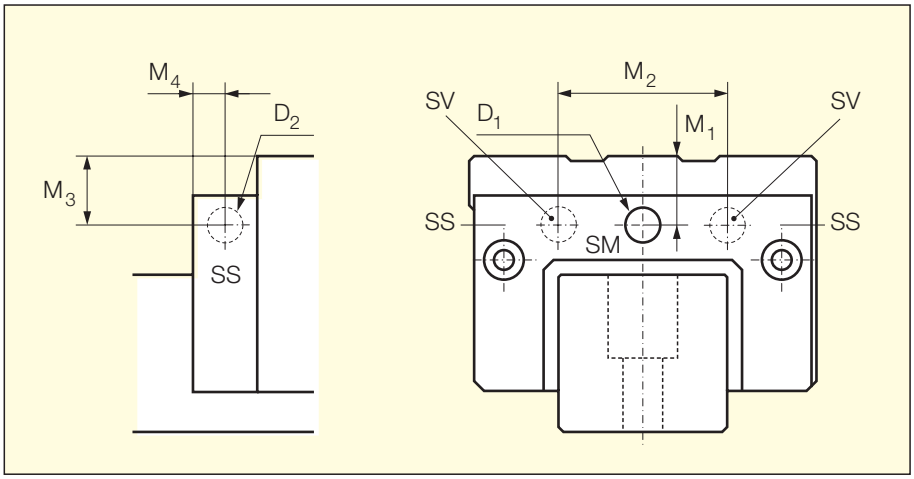
If a lateral connection is required, then this has to be indicated on the order sheet. The lubrication connection selected is opened by SCHNEEBERGER and the one at the center closed.

Ordering information:	Front laterally:	– SV (not for MR 25, MONORAIL BM)
	Lateral:	– SS (not for MR 25)

The lateral connections of the sizes BM 15 and BM 20 are prepared so that an M 3 nipple can be attached.

For a lateral lubrication connection in the case of size MR 25, the intermediate plate ZPL 25 has to be used (please refer to chapter 4.6).

Connection thread in the front plate in front and on the side



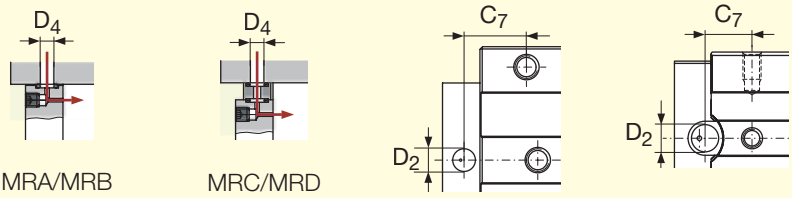
Type		Dimensions (mm) M_1	M_2	M_3	M_4	D_1	D_2
MRA/B	**25**	5.5	–	–	–	M6	–
MRC/D/E	**25**	9.5					
MRA/B	**35**	7	32	7	6.5	M6	M6
MRC/D/E	**35**	14		14			
MRA/B	**45**	8	40	8	7.5	M6	M6
MRC/D	**45**	18		18			
MRA/B	**55**	9	50	9	8.5	M6	M6
MRC/D	**55**	19		19			
MRB/D	**65**	13	64	13	12.5	M6	M6

Type		Dimensions (mm) M_1	M_2	M_3	M_4	D_1	D_2
BMA/F	**15**	4	–	4	4	M3	M3
BMC	**15**	8		8			
BMA/B	**20**						
BMC/D	**20**	5.2	–	5.2	5	M6	M3
BMF/G	**20**						
BMA/B	**25**	5.5		5.5			
BMC/D/E	**25**	9.5	–	9.5	6	M6	M6
BMF/G	**25**	5.5		5.5			
BMA/B	**30**	7		7			
BMC/D/E	**30**	10	–	10	6	M6	M6
BMF/G	**30**	7		7			
BMA/B	**35**	7		7			
BMC/D/E	**35**	14	–	14	6.5	M6	M6
BMF/G	**35**	7		7			
BMA/B	**45**	8	–	8	7.5	M6	M6
BMC/D	**45**	18		18			

Lubrication connection from above

If lubrication is required from above, the required location has to be indicated with the order. The necessary retrofitting work is carried out by SCHNEEBERGER.

Ordering information: From above: – SO



MRA/MRB
BMA/BMB
BMC/BMD
BME
BMF/BMG

MRC/MRD
MRE

D_1 = O-ring internal diameter
D_2 = Counterbore diameter
D_3 = O-ring thickness
D_4 = Max. diameter of lubrification bores

C_7 (mm)	MR 25	MR 35	MR 45	MR 55	MR 65
MRA	12	14	17	21.5	–
MRB	23.2	27.5	34.5	42.5	54
MRC	17	20	27	31.5	–
MRD	20.7	22.5	34.5	42.5	49
MRE	17	20	–	–	–
D_4	6	6	6	6	6
D_2	10	10	10	10	10

C_7 (mm)	BM 15	BM 20	BM 25	BM 30	BM 35	BM 45
BMA	8	10.5	13.2	14.5	14.5	17
BMB	–	18.5	22.7	25.5	27.25	32.75
BMC	10	12.5	18.2	20.5	20.5	27
BMD	–	13.5	20.2	21.5	22.25	32.75
BME	–	–	18.2	20.5	20.5	–
BMF	10	12.5	18.2	20.5	20.5	–
BMG	–	13.5	20.2	21.5	22.25	–
D_4	4	6	8	8	8	8
D_2	8	10	12	12	12	12

Typ	D_1	×	D_3
BM 15	4.48	×	1.78
BM 20, MR 25–55	6.75	×	1.78
BM 25–45	8.73	×	1.78
MR 65	6.5	×	2

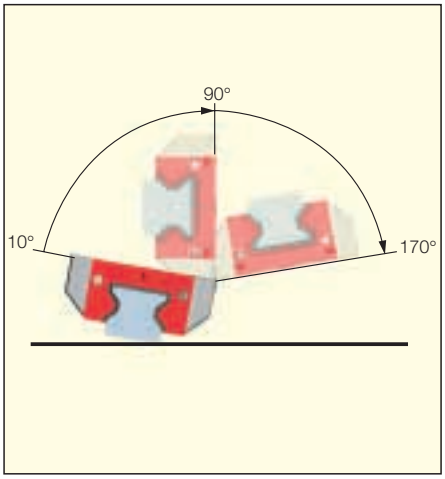
General information

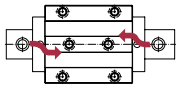
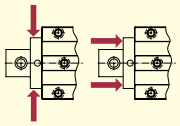
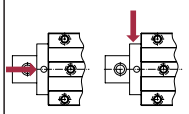
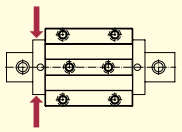
- The lubrication connections are plastic threads. Therefore care must be taken when installing fittings.
- Any retrofitting work on the end plates for changing the lubrication connection should be carried out by SCHNEEBERGER. In case of rework by the customer, it is necessary to contact SCHNEEBERGER beforehand.
- Grease nipples as well as lubrication adapter pieces are not included on the carriages and have to be ordered separately.

Special installation orientations

In the case of oil lubrication and a horizontal or vertical installation, also no particular precautions have to be taken. Because of the small lubrication channel cross sectional areas in the front plates, this is also applicable for an installation with the guideways rotated by 180 ° around the longitudinal axis of the rails.
In the case of a vertical installation, the lubrication connection has to be provided in the upper front plate.

If , however, lubrication with oil and a different installation position (e.g., inclined by 10° to 170° around the longitudinal axis of the rail) are foreseen, then special measures are necessary, because oil on the basis of its lower viscosity has the tendency to flow downwards due to the force of gravity and therefore to flow towards one running track side.
It has to be assured, that all 4 running tracks of the carriages are supplied with sufficient lubricant. Depending on the type of guideway, this takes place in a different manner.



Type	Measure	Ordering information	Lubrication connections number per carriage and installation positions*	
MR 25	Speciel front plate STP-SE	Special: –ST	2 × fronte –SM	
MR 35 – MR 65	Modified standard front plate	Special: –ST Drawing required	2 × laterally –SS or fronte laterally –SV	
BM 15 – BM 20	Supply the quantity of lubricant in a single pulse or in several pulses in close succession	–SM or –SS	1 × front –SM or laterally –SS	
BM 25 – BM 45	Special front plate	Special: –ST Drawing required	2 × laterally -SS	

Installation position*: When ordering, the required connections have to be indicated on the order sheet.

Quantities of lubricant, refer to the chapter Lubrication with oil.

In the case of special installation orientations, the customer should include an installation drawing with the inquiry, to obtain a recommendation from SCHNEEBERGER regarding lubrication! In the case of a single lubrication connection per carriage, grease, or liquid grease, is preferred over oil.

Short stroke – general lubrication remark

In the case of a stroke smaller than 2 × the carriage length, two lubrication connections are recommended, i. e., a lubrication from both ends.
If in the case of a **short stroke** the number of connections is doubled, then the total quantity of lubricant for subsequent lubrication nonetheless remains the same per carriage, i. e., the quantity per end is halved.

Lubrication with oil

For the lubrication using oil, SCHNEEBERGER recommends mineral oil CLP (DIN 51517) or HLP (DIN 51524) in the viscosity range of ISO VG32 to ISO VG100 in accordance with DIN 51519. Bed track oils CGLP up to ISO VG220 can also be used.

Initial lubrication prior to operation
Prior to operation, the carriages have to be filled with the indicated quantities for the first lubrication. In doing so, the total oil quantity should be injected in a single impulse or in several impulses in short succession while the carriage is being moved. The indicated quantities are applicable per carriage with one connection. If two connections per carriage are used, then the values have to be correspondingly halved.
In case of a special installation orientation or a short stroke, the lubrication guidelines in the corresponding chapters have to be followed.

Initial lubrication oil quantity per carriage in cm^3	**MR 25**	**MR 35**	**MR 45**	**MR 55**	**MR 65**
Any installation orientation	0.95	0.55	0.7	0.9	1.2

Initial lubrication oil quantity per carriage in cm^3	**BM 15**	**BM 20**	**BM 25**	**BM 30**	**BM 35**	**BM 45**
Any installation orientation	0.2	0.5	0.6	0.9	1.1	1.2

Subsequent lubrication intervals and quantities
The subsequent lubrication intervals depend on the load on the carriages and on external factors. As an indicative value, with a speed of $v \leqslant 1$ m / sec and a load ratio $C/P \geqslant 2$, the following interval for subsequent lubrication can be assumed:

Subsequent lubrication interval = 30 km

The lubrication quantity to be provided in accordance with this lubrication interval can be taken from the following table.

Applicable in case of a normal installation orientation is:

Table value:
pulse lubrication quantity × number of pulses per lubrication interval

Example: With v = 0.2 m / sec and 100 % operating time, the lubrication interval of 30 000 m corresponds to approximately 40 operating hours. With a lubrication quantity requirement of 0.50 cm^3 in accordance with the table, a pulse oil quantity of 0.1 cm^3 every 8 hours follows.

In the case of a special installation orientation or short stroke, the lubrication information in the corresponding chapter has to be observed.

Subsequent lubrication oil quantity per carriage in cm³	**MR 25**	**MR 35**	**MR 45**	**MR 55**	**MR 65**
Normal installation orientation	0.15	0.25	0.35	0.5	0.7
Special installation orientation	0.95	0.55	0.7	0.9	1.2

Subsequent lubrication oil quantity per carriage in cm³	**BM 15**	**BM 20**	**BM 25**	**BM 30**	**BM 35**	**BM 45**
Normal installation orientation	0.07	0.17	0.2	0.3	0.35	0.4
Special installation orientation	0.14	0.34	0.4	0.6	0.7	0.8

Remarks

The values indicated above are only guideline values. An accurate determination of the quantities and intervals can only be done under real operating conditions.
It is recommended to lubricate at least 1× per month and after a longer machine shut-down prior to putting it into operation again.
In the case of unfavorable conditions, loads, climate, ambient conditions, a more frequent lubrication is necessary.

Lubrication with grease

SCHNEEBERGER recommends KP2K grease in accordance with DIN 51825 or liquid grease GPOON and GPOOON accordance with DIN 51826.

Attention:
During greasing the carriage should be moved several times over a distance corresponding to at least 3 times its length.

Initial greasing prior to operation
After the installation of the MONORAIL guideway, an initial greasing of the carriages has to take place. This also applies if the mounting of lubrication plates is additionnally foreseen. The quantities indicated are applicable per carriage.

Initial greasing grease quantity per carriage in cm³	**MR 25**	**MR 35**	**MR 45**	**MR 55**	**MR 65**
MRA / MRC / MRE	1.9	2.9	5.3	8.4	–
MRB / MRD	2.2	3.7	6.6	10.6	18.9

Initial greasing grease quantity per carriage in cm³	**BM 15**	**BM 20**	**BM 25**	**BM 30**	**BM 35**	**BM 45**
BMA/BMC/BME/BMF	0.9	1.7	2.8	4.7	6.6	12.6
BMB/BMD/BMG	–	2.1	3.5	5.8	8.1	15.6

Subsequent lubrication intervals and quantities
The subsequent lubrication intervals depend on the load on the carriages and on external factors. As an indicative value, with a speed of $v \leqslant 1$ m/sec and a load ratio $C/P \geqslant 2$, the following interval for subsequent lubrication can be assumed:

Subsequent lubrication interval = C/P · 100 km

The quantity of grease to be provided in accordance with this interval can be taken from the following table.

Subsequent lubrication grease quantity per carriage in cm³	**MR 25**	**MR 35**	**MR 45**	**MR 55**	**MR 65**
MRA/MRC/BME/BMF	0.4	1.1	2.1	3.2	–
MRB/MRD/BMG	0.5	1.3	2.4	4	7.4

Subsequent lubrication grease quantity per carriage in cm³	**BM 15**	**BM 20**	**BM 25**	**BM 30**	**BM 35**	**BM 45**
BMA/BMC/BME/BMF	0.3	0.6	1.1	1.7	2.5	5
BMB/BMD/BMG	–	0.8	1.4	2.1	3.2	6.1

Remarks

The values indicated above are only guideline values. An accurate determination of the quantities and intervals can only be done under real operating conditions.
It is recommended to lubricate at least every 3 months.
In the case of unfavorable conditions, loads, climate, ambient conditions, a more frequent lubrication is necessary.

Lubrication plate SPL

The lubrication plate is utilized in such applications, where long lubrication intervals are demanded. It enables an automatic and uniform supplying of the roller elements with lubricating oil over a long period of time. In order to achieve maximum travelling distances without any re-lubrication, the lubrication plates are always installed in pairs – i. e., one lubrication plate per carriage end and respectively installed in front of the front plates.

Installation positions

The SPL guarantees an assured supply of lubricant in all installation positions.

Delivered condition

General
The SPL is on principle delivered ready for installation, i.e., filled with oil. The lubrication connections for re-lubrication at the front in the centre (–SM) as well as on the narrow sides (–SS) are respectively closed off with a set screw pin, respectively a screw.

Delivery installed on the carriage
In the case of delivery together with a MONORAIL system or individual carriages, respectively two lubrication plates are installed on the carriage at the works. The carriages are in addition filled with a roller bearing grease (lithium based saponified grease on a mineral oil basis).

Delivery as accessory / Individual component
In case of delivery of the SPL for retro-fitting, these are supplied in pairs ready for installation, i. e., filled with oil.

First oil fill

The SPL ex works SCHNEEBERGER Höfen / Enz is filled with oil type KLÜBER Lamora D 220 and therefore immediately ready for use.

First oil fill SPL-MR oil quantity per 1 × SPL in cm³	**MR 25**	**MR 35**	**MR 45**	**MR 55**	**MR 65**
	3.1	8.4	15.6	26.8	61

First oil fill SPL-BM oil quantity per 1 × SPL in cm³	**BM 15**	**BM 20**	**BM 25**	**BM 30**	**BM 35**	**BM 45**
	0.7	2	3.4	4.1	8.3	15.6

Refilling interval and quantity

The refilling of the lubrication plates should take place in dependence of the load as well as of the other application conditions of the guideways. As a guideline value, the following refilling intervals can be assumed:

Refilling interval						
		MR 25		**MR 35**	**MR 45**	**MR 55**	**MR 65**
BM 15	**BM 20**	**BM 25**	**BM 30**	**BM 35**	**BM 45**		
		2500 km			5000 km		

Remarks

The values indicated above are only guideline values. An accurate determination of the time intervals can only be established under actual operating conditions. In case of unfavourable conditions, loads, climate, environment, a more frequent refilling is necessary. Independent of the distance travelled, a refilling is necessary after a maximum of **12 months** of operation.

For the refilling of the lubrication plates, oil type **KLÜBER Lamora D 220** has to be utilized. In case of refilling with other lubricants, the SCHNEEBERGER will assume no liability whatsoever.

The oil quantity for the indicated refilling intervals can be taken from the following table.

Refilling SPL-MR qty oil per 1 × SPL in cm³	**MR 25**	**MR 35**	**MR 45**	**MR 55**	**MR 65**
	2.2	6	11	19	43

Refilling SPL-BM qty oil per 1 × SPL in cm³	**BM 15**	**BM 20**	**BM 25**	**BM 30**	**BM 35**	**BM 45**
	0.5	1.4	2.4	2.9	5.8	10.9

The SPL is refilled through one of the three lubricating bores described above at the front in the middle or on the side refilled with the help of a lubrication nipple.

General remarks

- When lubrication plates are retro-fitted, on principle the carriages in addition have to be filled with grease. For the recommended lubricant quantities, please refer to the section on lubrication with grease
- In case of applications, in which coolant can come into contact with the MONORAIL guideways, additional wipers ZCN/ZCV respectively ZBN/ZBV have to be installed in front of every lubrication plate, refer to installation instructions SPL.

Service lifetime lubrication

The lubricant forms a protective film between the roller element and the track and prevents metallic contact. Therefore the lubrication protects against wear and corrosion.

Grease lubrication or grease lubrication in combination with the lubrication plate SPL, frequently also referred to as lifetime lubrication.

During the operation of MONORAIL guideways loss of lubricant takes place. In addition, the grease changes his consistence because of the diffusion of oil out of the carrier substance. These circumstances call for subsequent lubrication. This is also applicable with the utilisation of the lubrication plate SPL, in the case of which by means of the additional oil reservoir the available quantity of lubricant is increased and with this the relubrication intervals are significantly prolonged.

Depending on the application, i. e., corresponding to the loading ratio C/P, the stroke of the carriage and ambient influences, the useful service lifetime of the grease can amount to between some hundreds of hours and several years. As a rule, the maximum storage – and usage period of the lubricants amounts to three to four years, because they are subject to an aging process and after this time period they become unusable as a result of chemical changes. It is recommended that the indications of the lubricant manufacturers are observed!

SCHNEEBERGER cannot guarantee, that with a single lubrication, the calculated service lifetime of the MONORAIL guideways will be achieved!

Without any subsequent lubrication, the service lifetime of the MONORAIL guideway will depend on the useful service lifetime of the grease!

8.2 Operational life calculation

The operational life is calculated in the following example. Due to undeterminable factors, there is no standard wear-life calculation procedure.

Determination of external forces and moments
The external forces acting on the guideway system are determined by the force components $\mathbf{F_{ax}}$, $\mathbf{F_{ay}}$, $\mathbf{F_{az}}$ with the force application coordinates $\mathbf{X_a}$, $\mathbf{Y_a}$, $\mathbf{Z_a}$. A mass **m** with the acceleration components $\mathbf{a_x}$, $\mathbf{a_y}$, $\mathbf{a_z}$ causes the guideway system to be loaded by the inertia forces $\mathbf{F_{mx}}$, $\mathbf{F_{my}}$, $\mathbf{F_{mz}}$, which act at the center of gravity coordinates $\mathbf{X_m}$, $\mathbf{Y_m}$, $\mathbf{Z_m}$.

$$\mathbf{F_{mx} = m \cdot -a_x}$$
$$\mathbf{F_{my} = m \cdot -a_y}$$
$$\mathbf{F_{mz} = m \cdot -a_z}$$

The forces $\mathbf{\Sigma F_y}$, $\mathbf{\Sigma F_z}$ acting at 90° to the longitudinal axis of the table are to be taken up directly by the guideway sytem:
The longitudinal forces $\mathbf{\Sigma F_x}$ are transmitted by the longitudinal drive:
External moments $\mathbf{M_{ax}}$, $\mathbf{M_{ay}}$ **and** $\mathbf{M_{az}}$ can also act:
The external forces $\mathbf{F_{ax}}$, $\mathbf{F_{ay}}$, $\mathbf{F_{az}}$ and inertia forces $\mathbf{F_{mx}}$, $\mathbf{F_{my}}$, $\mathbf{F_{mz}}$ in combination with their respective points of actions X_a, Y_a, Z_a or X_m, Y_m, Z_m, also result in moments:
The point of action of the force of the longitudinal drive $\mathbf{Y_{sp}}$, $\mathbf{Z_{sp}}$ affects the moments acting on the guideway system.

Distribution of forces and moment loads on the individual MONORAIL carriages
The longitudinal carriage spacing **K** and lateral spacing **Q** are required to calculate the side forces $\mathbf{F_{jy}}$ and compression-tension forces $\mathbf{F_{jz}}$ on each MONORAIL carriages (j = 1…n).
The arrangement of carriage and guiderail in the axes must be taken into account.

Determination of preload and deformation
The MONORAIL preload is determined by the service conditions as well as the demands made on the rigidity of the machine guideway.
Preloads V1, V2 or V3 increase not only the rigidity, they also additionally load the rolling-contact surfaces as long as the preload is effective.
The forces acting on the MONORAIL cause displacements which can be obtained from the deformation diagrams in chapter 4.4 for MONORAIL MR, resp. 7.4 for MONORAIL BM.

Operational life calculation
The factors affecting the operational life are the forces acting on MONORAIL carriages, selected preload, dynamic loading capacity C and event probability.
If constant forces act over the entire translation distance, the operational life is calculated with the equivalent force $\mathbf{P_j}$. However, if varying forces are expected, the dynamic equivalent loading must be used.

Equivalent force P

The equivalent force $\mathbf{P_j}$ for each MONORAIL (j = 1…n) is required for the operational life calculation. The values of the force components $\mathbf{F_{jy}}$ and $\mathbf{F_{jz}}$ acting on each MONORAIL carriage are added algebraically to obtain the effective $\mathbf{F_j}$:

$$\mathbf{F_j = |F_{jy}| + |F_{jz}|}$$

In the case of applications, in which the MONORAIL-carriages are subject to loads comprising both forces and torques, e.g., in the case of single carriages or systems with only one rail, the dynamic equivalent force Fj is determined in accordance with the following formula:

$$\mathbf{F_j = |F_{jy}| + |F_{jz}| + C \cdot \left|\frac{Mj}{M_{QL}}\right|}$$

C = dynamic loading capacity (N)
M_{QL} = admissible dynamic longitudinal-, resp., transverse torque (Nm)
Mj = dynamic torque loading (Nm)

The following formula can be used to calculate the approximate value of the equivalent force $\mathbf{P_j}$ which actually acts on the rolling-contact surfaces:

$$\mathbf{P_j = F_{Vorsp} + 2/3 \cdot F_j} \quad \text{for } \mathbf{F_j \leqslant 3 \cdot F_{Vorsp}}$$

$$\mathbf{P_j = F_j} \quad \text{for } \mathbf{F_j > 3 \cdot F_{Vorsp}}$$

Dynamic equivalent loading

If force P is not constant, the equivalent force **P** in the step-loading mode can be calculated for each MONORAIL with the following formula (the respective force $\mathbf{P_{jk}}$ is constant for each partial translation distance $\mathbf{l_k}$):

$$\mathbf{P_j} = \sqrt[10/3]{\frac{\sum_{k=1}^{n} (P_{j,k}^{10/3} \cdot l_k)}{\sum_{k=1}^{n} l_k}}$$

Dynamic loading capacity C

The loading capacity figures for anti-friction guideways are based on the principles specified by the ISO for calculation of rolling-contact bearings (DIN ISO 281).
Dynamic loading capacity is the loading which results in a nominal operational life corresponding to a translation distance of 10 000 m provided that the loading due to mass and direction is unchanged and the line of influence acts vertically on the rolling-contact bearing unit.

Comparison of loading capacities

Other suppliers often indicate their loading capacities for a translation distance of 50 000 m. These values according to JIS Standard are above the values according to DIN ISO. The recalculation of the loading capacities is done as follows:

$$\mathbf{C_{50} = 1.23 \cdot C_{100}} \quad \text{for roller guideways}$$

$$\mathbf{C_{50} = 1.26 \cdot C_{100}} \quad \text{for roller guideways}$$

Event probability
According to DIN ISO, the loading capacities for rolling-contact bearings are specified such that a value results from the operational life formula which will be exceeded with a probability of 90 %. If this probability is insufficient, the operational life values must be reduced by a factor a_1 according to the adjacent table:

Event probability %	90	95	96	97	98	99
a_1	1.00	0.62	0.53	0.44	0.33	0.21

Operational life calculation
The nominal calculated operational life L for the equivalent force P and a dynamic loading capacity C is

$$L = a_1 \, (C/P)^q \cdot 10^5 \, m$$

L = nominal life (m)
a_1 = event probability
q = 10/3 for roller guideways
q = 3 for ball guideways

$$L_h = \frac{L}{2 \cdot s \cdot n \cdot 60} = \frac{L}{60 \cdot v_m}$$

L_h = nominal life (h)
s = stroke length (m)
n = stroke frequency (min^{-1})
v_m = medium traversing speed (m/min)

8.3 Calculation of static reliability factor

The static reliability factor S_0 is the reliability with respect to permanent deformations on rolling elements and tracks and is defined as the ratio of the static loading capacity C_0 to the static equivalent loading P_0.

$$S_0 = C_0/P_0$$

$$P_o = |F_{0y}| + |F_{0z}| + C_0 \cdot \left|\frac{M_0}{M_{0QL}}\right|$$

F_{0y}, F_{0z} = external static forces (N)
M_{OQL} = admissible static longitudinal-, resp., transverse torque (Nm)
M_0 = static moment capacity (Nm)

The actual force acting on the rolling-contact surfaces must be taken into account for P_0. The governing factor for a deformation of the rolling-contact surfaces is the highest amplitude which can also occur for a very short period of time.

Operating conditions	S_0
Highest rigidity, high shock loads and vibrations	≥ 6
High rigidity, medium, varying loads and vibrations	≥ 4
Uniform load, small vibrations	≥ 3

8.4 Calculation Program for the dimensioning of MONORAILs

The manual calculation of the service lifetime, of the load bearing safety and of the displacement under a combined load is very complicated and can only be carried out for simple applications. For this reason, SCHNEEBERGER as a service offers to carry out these calculations with the help of a computer program.

Objective and Purpose of the Calculation Program

The computer-assisted calculation program for the design of MONORAILs serves for the determination of:

- the required MONORAIL size
- the optimum preload
- the static reliability factor
- the nominal service lifetime
- the elastic displacements of the working point under the effect of a load for a given MONORAIL system.

Taken into consideration to do this are the real, non-linear rigidities of the individual MONORAIL carriages and the interaction of the carriages amongst one another, which are produced by the differing rigidities under tensile, compressive and lateral loads.
Additional deformations as a result of thermal expansion and elastic deformation of the machine construction are not taken into consideration.

Required Data

For the calculation, all information is required, as represented on the following machine drawing with data sheet:

- Guideway geometries with the number of carriages and rails, carriage spacings longitudinally and laterally
- Position of the axes in space and distances between them (distances between the reference points of neighboring axes)
- Masses of all machine axes and workpieces to be calculated
- Location of the mass centers of gravity
- Location of the drive elements versus the corresponding of the axis reference point
- Location of the load point (point of attack of force and moment)
- Maximum travel distances (stroke) of the axes to be calculated
- Maximum speed and acceleration of the axes

Additionally, in the case of differing load cases:

- Collective load with speed, acceleration, travel distance and percentage proportion of time as well as magnitude and direction of the forces and moments applied at the point of work in function of the corresponding load case.

All geometrical dimensions are referred to the corresponding axis center (refer to drawing). The designation of the axes in the cartesian coordinates' system can be selected as required.

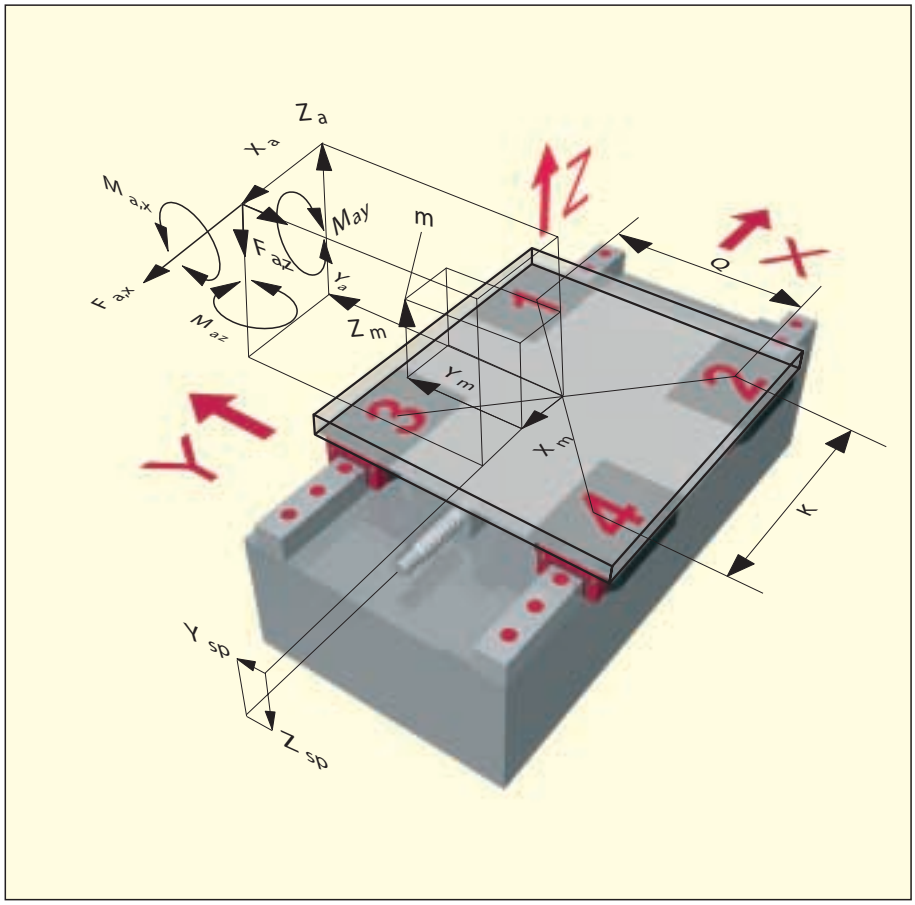
For a large number of typical machines and designs, SCHNEEBERGER can provide machine sketches and data sheets. For further information, please contact a SCHNEEBERGER representative.

8.1 Basics

The demands for accuracy, surface quality and short machining times are becoming increasingly stringent. This is why the anti-friction guideways in modern machine construction are selected according to permissible elastic deformation.
The following steps are therefore necessary for the dimensioning of anti-friction guideways.

- **Determination of the external forces and moment loads**
- **Distribution of forces and moment loads acting on individual MONORAIL carriages**
- **Preload and deformation determination**
- **Calculation of operational life**
- **Calculation of static reliability factor**

The operational life is limited by material fatigue as well as by heavy wear of the rolling-contact surfaces caused by environmental influences.
The rolling contact of the surfaces causes material fatigue and therefore results in damage to the track and rolling element (spalling). If the force acting on the rolling-contact surfaces is known, the operational life can be calculated according to DIN ISO 281 or DIN 636.
The wear of the running surfaces is determined above all by the lubrication, by contamination with dirt, by the surface pressure and by the value of the relative movements of the surfaces under load.



Sample data sheet for an x-/y-table

Masses

m_x = _____ kg m_y = _____ kg m_w = _____ kg

Dimensions

S_1 = _____ mm S_2 = _____ mm S_3 = _____ mm
S_4 = _____ mm S_5 = _____ mm S_6 = _____ mm
S_7 = _____ mm S_8 = _____ mm S_9 = _____ mm

K_1 = _____ mm K_5 = _____ mm
Q_2 = _____ mm Q_4 = _____ mm

A_2 = _____ mm A_3 = _____ mm
A_4 = _____ mm A_6 = _____ mm

L_4 = _____ mm L_5 = _____ mm L_6 = _____ mm

B_1 = _____ mm B_2 = _____ mm B_3 = _____ mm

Stroke (max.)

s_x = _____ mm s_y = _____ mm

Acceleration (max.)

a_x = _____ m/s² a_y = _____ m/s²

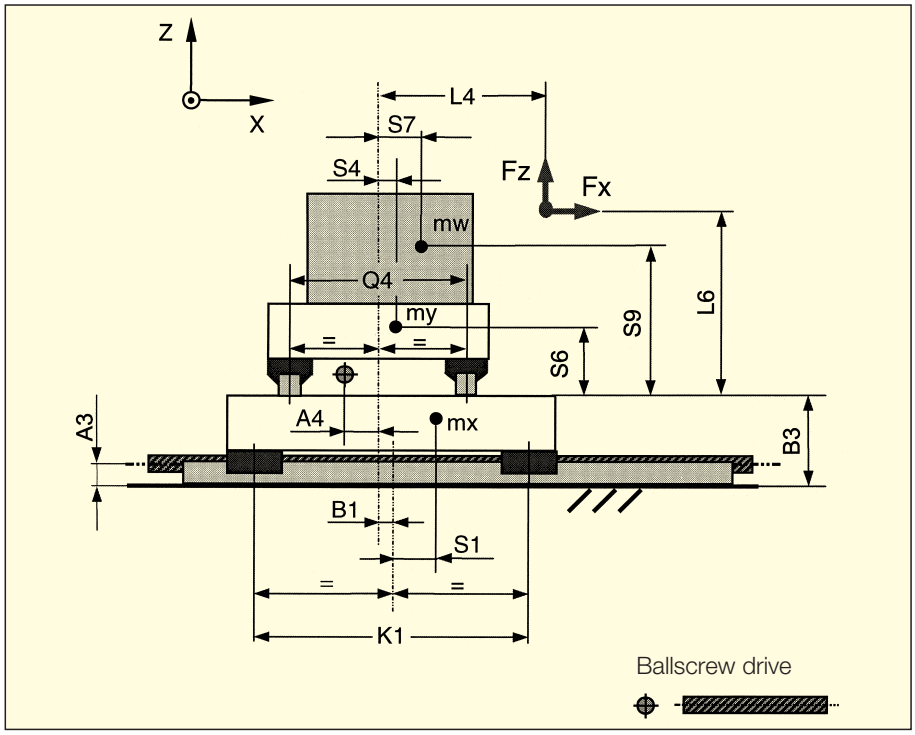
Collective load: Forces / Moments

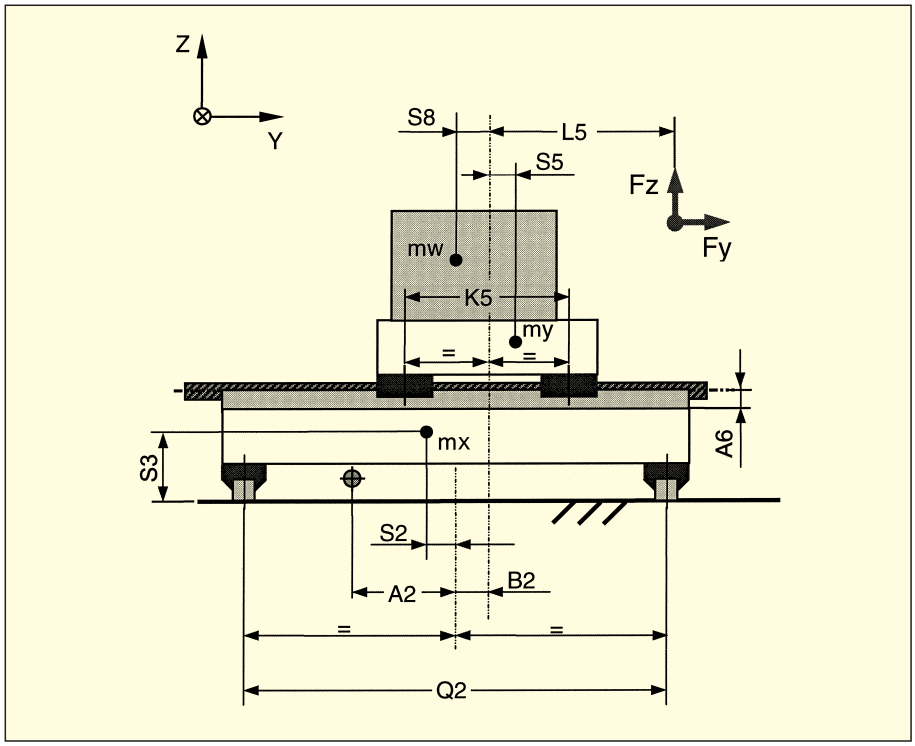
No.	**Cycle**	**F_x** N	**F_y** N	**F_z** N	**M_x** Nm	**M_y** Nm	**M_z** Nm
1							
2							
3							
4							
5							

Collective load: Travel distance / Proportion of time

No.	**x-axis speed** v (m/min)	**Proportion of time** t (%)	**Travel distance** s (mm)	**y-axis speed** v (m/min)	**Proportion of time** t (%)	**Travel distance** s (mm)
1						
2						
3						
4						
5						

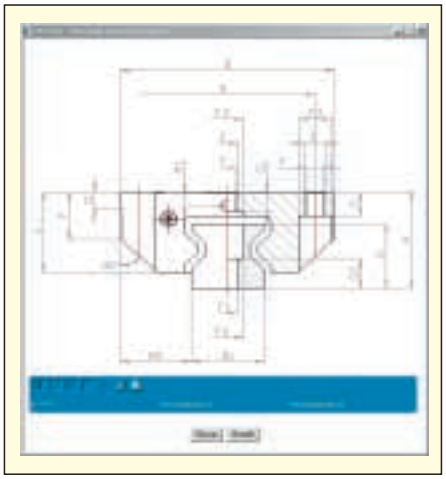
Sample machine drawing for an x-/y-table





8.5 CAD Data base MONORAIL

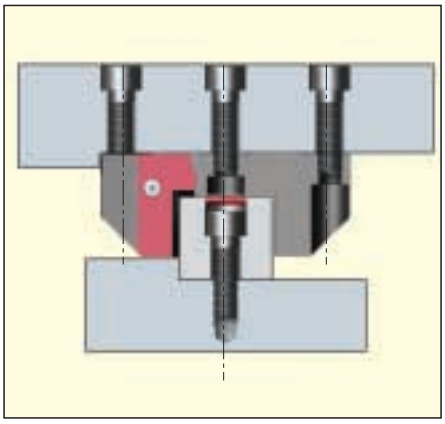
In order to assist the development and design in the CAD-environment, all MONORAIL-components are available for down-loading as 2-D or 3-D volume models in all common data formats under www.schneeberger.com. This gives the customer the possibility to configure his individual system with all accessories as well as with the suitable rail lengths and carriage shapes and to insert them into his ambient structure as a complete assembly.



9.1 Installation methods

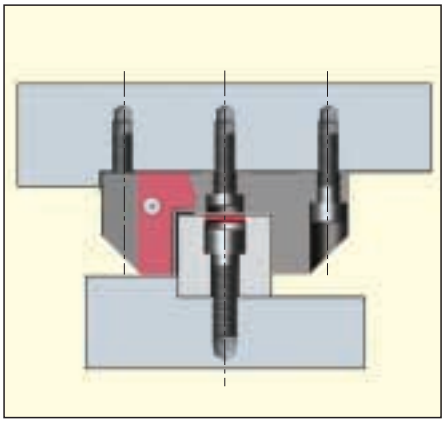
MONORAILs can be installed horizontally or vertically. To achieve maximum carriage rigidity, use of all six mounting bolts is necessary.

The MRA/MRB and BMA/BMB carriage types can be fastened to the structure in two ways. They therefore are fitted with so called combination holes.

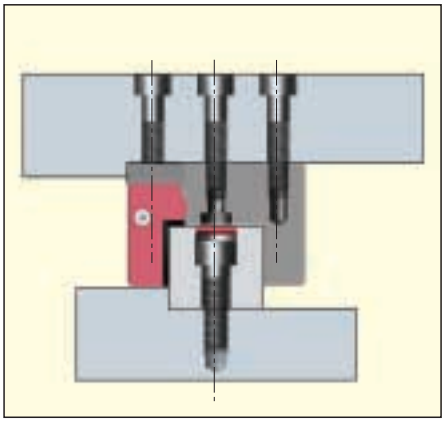


a) Using the tapped holes
This is the preferred method. It results in a stronger joint because the thread permits the use of a larger diameter screw.

b) Using the through-holes
In this case screws with low screw heads DIN 6912 have to be used in the two middle attaching holes.
Remove the protective plugs if both middle attaching holes in the carriage are also needed.



The MRC / MRD / MRE and BMC / BMD / BME / BMF / BMG carriage types can be fastened only by using the tapped holes. Remove the protective plugs if the middle attaching holes in the carriage are needed.

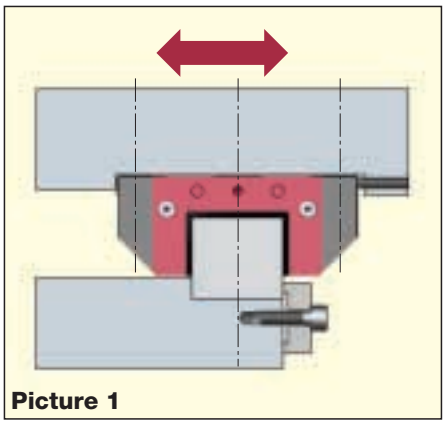


9.2 Configuration of the locating surfaces

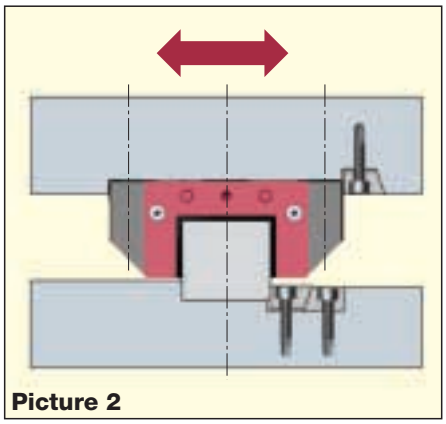
Methods of lateral fixation

MONORAILs can be fastened with or without lateral locating surfaces.
Lateral stop surfaces, however are recommended, because with these the effort for aligning the rails straight is significantly minimised and greater lateral forces are capable of being transmitted, refer to section 9.5 Admissible lateral forces without stop surfaces. For the lateral fixing, various elements for pressing against can be utilized:

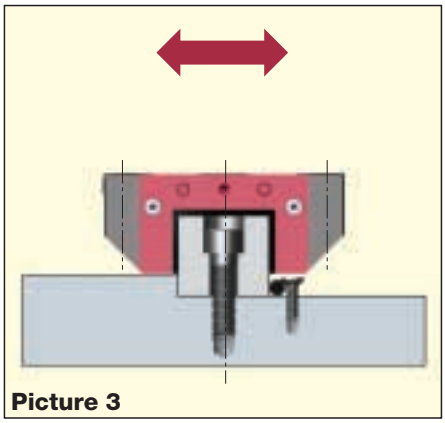
- Adjusting screws and clamping strips (picture 1)
- Single or double wedge strips (picture 2)
- Shaft with countersunk head screw (picture 3)
- Eccentric screw (picture 4)
- Clamping piece with conical chamfer (picture 5)



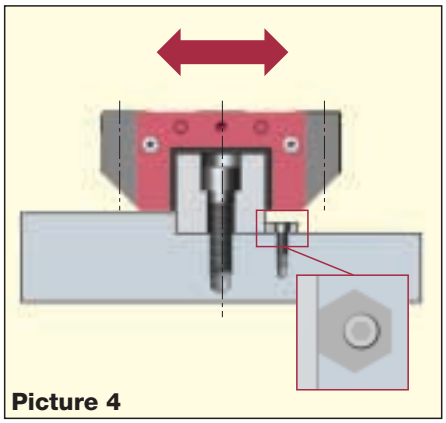
Picture 1



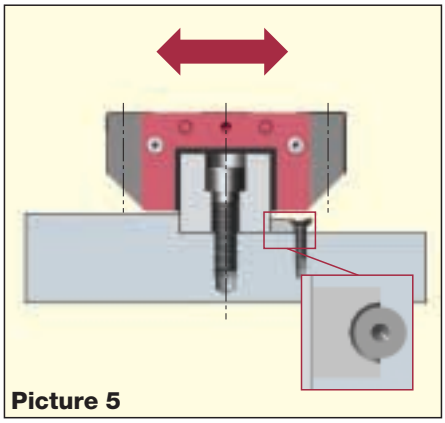
Picture 2



Picture 3



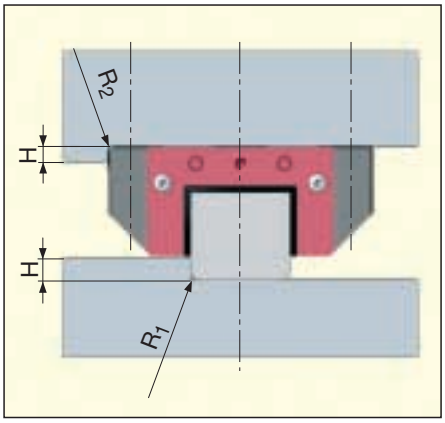
Picture 4



Picture 5

Configuration of the lateral locating sides

The corners between the support and locating surfaces of the surrounding structure are normally provided with a relief groove. However, if no relief groove is provided, then the dimensions tabulated below must be maintained.



Type	Size	H	$R_{1\ max}$	$R_{2\ max}$
MR	25	5	0.8	0.8
	35	6	0.8	0.8
	45	8	0.8	0.8
	55	10	1.2	1.2
	65	10	1.5	1.5
BM	15	3.5	0.8	0.6
	20	4	0.9	0.9
	25	5	1.1	1.1
	30	5.5	1.3	1.3
	35	6	1.3	1.3
	45	8	1.3	1.3

9.3 Configuration of assembly surfaces

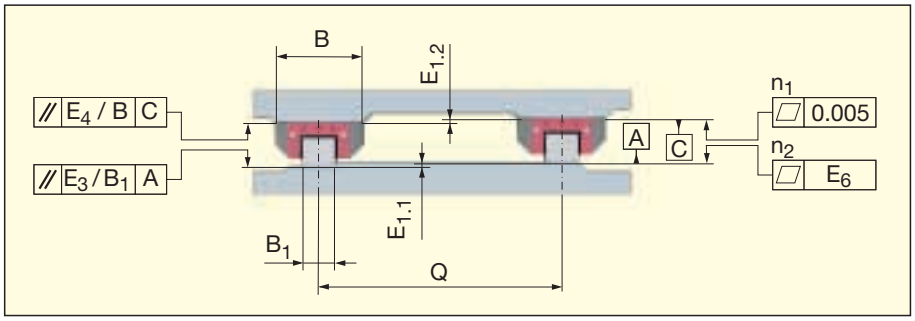
MONORAIL advantages can only be achieved when mounted to a rigid, accurately machined structure.
The surface quality of the supporting surfaces has no direct influence on the operational and run-out behavior. A roughness average ratio of R_a 0.4 to 1.6 µm is recommended for support and locating surfaces to enable the specified flatness tolerances to be maintained.

Inaccuracies of the attachment surfaces are partially compensated by the elastic deformation of the MONORAIL. However, they may affect overall accuracy, running behavior and operational life.

Geometrical and position accuracy of the support surfaces

Use values in mm for the calculation

Admissible deviations in transverse direction



Height deviation transverse
E1=$E_{1.1}$ + $E_{1.2}$.
This also includes the tolerance for the dimension A = MONORAIL-height

$$E_1 = v \cdot Q \cdot 10^{-4}$$

Q = Rail distance

Preload class			
	V1	V2	V3
v	3.0	2.0	1.0

Parallelism rail support transverse E_3

$$E_3 = v \cdot B1 \cdot 10^{-4}$$

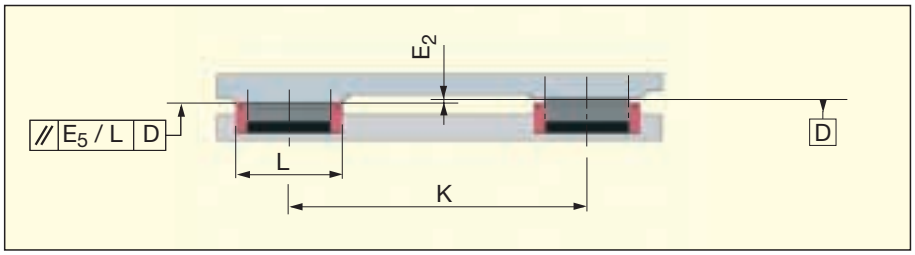
B_1 = Rail width

Parallelism carriage support transverse E_4

$$E_4 = v \cdot B \cdot 10^{-4}$$

B = Carriage width

Admissible deviations in longitudinal direction



The height deviation longitudinal E_2 also includes the tolerance delta A

$$E_2 = t \cdot K \cdot 10^{-5}$$

K = Carriage distance longitudinal
t = 5 for MRA/C and BMA/C/F
t = 4 for MRB/D and BMB/D/G

Parallelism carriage support longitudinal E_5

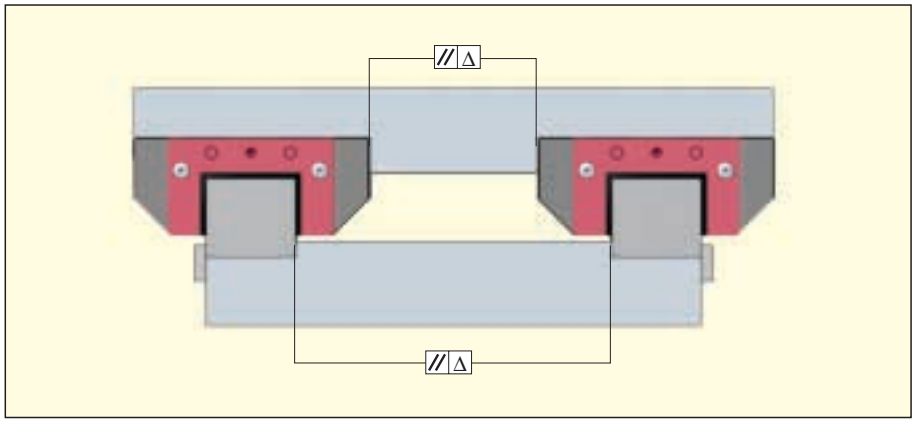
$$E_5 = 4 \cdot L \cdot 10^{-5}$$

L = Carriage length

Evenness of the supporting surfaces

The evenness of the carriage support should not exceed values of 5 µm.
For the evenness E_6 of the rail support over the whole length, it is recommended to orient oneself by the values for the running accuracy in dependence of the accuracy class in accordance with the diagram chapter 3.3.

Parallelism tolerances of the locating surfaces



Tolerances Δ for preload class (mm) **Size**	**V1**	**V2**	**V3**
15	0.01	0.007	0.003
20	0.012	0.008	0.004
25	0.016	0.01	0.005
30	0.016	0.01	0.005
35	0.021	0.014	0.008
45	0.024	0.016	0.009
55	0.026	0.017	0.01
65	0.028	0.018	0.011

The specified values are also valid when locating surfaces are provided for the carriages only.
Because of parts and mounting tolerances the preload can be increased. Together with the during the operation arising uneven deformations of the rail surroundings an increased stress of the rolling partners may occur.

9.4 Attaching the rails

MONORAIL MR and BM

See the table for the max. tightening torques for attaching screws DIN 912 / ISO 4762. Values are based on a coefficient of friction of μ = 0.125.

Attention:

- The recommendations of the screw suppliers have to be followed.
- Screws with low head DIN 6912 are installed according to strength grade 8.8
- For rails with measuring system **AMS,** screws of strength grade 8.8 have to be used.

Tightening torques for DIN 912 / ISO 4762 attaching screws, μ = 0.125

Strength grade	**max. tightening torque** (Nm)							
	M 4	**M 5**	**M 6**	**M 8**	**M 10**	**M 12**	**M 14**	**M 16**
8.8	3	6	10	24	48	83	132	200
12.9	5	10	16	40	81	95	166	265

A more uniform preload force is obtained when grease containing MoS_2 (Molybdenum disulfide) is applied to the rail attaching screws which are then tightened with a torque wrench. This results in a marked improvement of running accuracy.

Attention:

By using greases, especially greases containing MoS_2, the coefficient of friction μ can drop to half. The torques must be reduced accordingly. It may be necessary to execute field tests to evaluate the exact coefficient of friction.

Secure the screws in case of expected decreasing of the internal tension.

9.5 Permissible side force with no locating surfaces

The guide values for the maximum permissible side forces can be obtained from the table below for cases where **no locating surfaces** are provided. The F_{max} values depend on dynamic load carrying capacity C, the method of fastening the MONORAIL and the strength grade of screws.

Max. side force F_{max} (N) per carriage without locating surfaces
Depending on size and number of attaching screws DIN 912 / ISO 4762

Strength grade	F_{max} (N) M 4		M 5		M 6		M 8	
	4 scr.	6 scr.	4 scr.	6 scr.	4 scr.	6 scr.	4 scr.	6 scr.
8.8	1 250	1 900	2 100	3 150	2 950	4 450	5 400	8 100
12.9	2 150	3 250	3 550	5 300	5 000	7 500	9 200	13 800

Strength grade	F_{max} (N) M 10		M 12		M 14		M 16	
	4 scr.	6 scr.	4 scr.	6 scr.	4 scr.	6 scr.	4 scr.	6 scr.
8.8	8 600	13 000	12 600	19 000	17 300	26 000	23 900	35 800
12.9	14 600	21 900	21 300	32 000	29 300	44 000	40 300	60 400

Max. side force F_{max} (N) on the rail without locating surfaces
Depending on the size of the attaching screws DIN 912. The values in the chart indicate the max. allowed side force of one carriage on the rail and are valid for a standard hole pitch L_4. The values increase accordingly by the use of two or more carriages.

MR Strength grade	F_{max} (N) M 6	M 8	M 12	M 14	M 16
8.8	3 400	6 200	13 900	20 000	29 800
12.9	5 700	10 600	23 500	33 700	50 400

BM Strength grade	F_{max} (N) M 4	M 5	M 6	M 8	M 12
8.8	450	1 100	1 750	2 850	7 200
12.9	800	1 850	3 000	4 800	12 200

9.6 Installation guidelines MONORAIL

Installation instructions

The installation of the MONORAIL guideways, distance measuring system and accessories is described in detail in the

- **Installation Instructions MONORAIL** (Content: MR, BM) and
- **Installation Instructions MONORAIL AMS** (Content: MR, AMS).

As delivered condition standard

The SCHNEEBERGER guideways **MONORAIL MR, MONORAIL BM** and **MONORAIL AMS** are delivered in a suitable packaging and are protected with a corrosion protection coating for transportation:

- Carriages on the rails ready for installation.
- Additional wipers and lubrication plates installed on the carriage.
- Other accessories included in a separate package.
- 2-part steel plugs included in a separate package.
- Cover strip enclosed separate from the rail or mounted onto the rail.
- Standard lubrication connection at the front center in the front plate, or optional lubrication connections prepared in accordance with the order and closed off with plastic plugs to prevent the ingress of dirt.
- Lubrication connections not required for use are closed.
- O-rings for the «lubrication connection top» separately packed.
- AMS measuring systems are assembled ready to plug-in.
- Electrical accessories and cables are packed with the mechanics.
- Product related mounting notes and operating instructions are delivered with the products.

Transportation and intermediate storage

The MONORAIL guideways and the measuring system are highly precise components, which have to be treated with care. As a protection against damage, the following instructions should be followed:

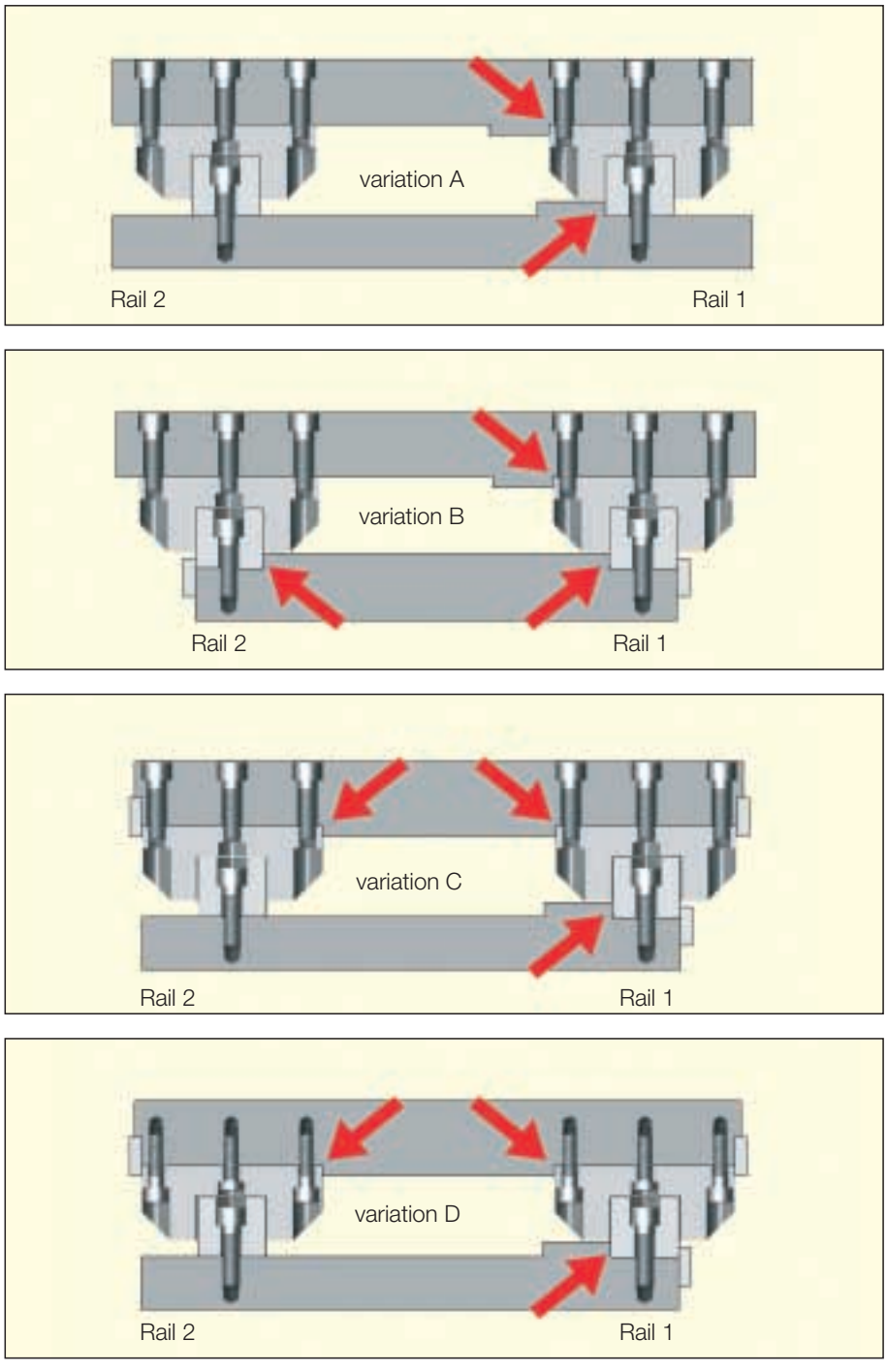
- Always store and transport MONORAIL guideways in their original packaging.
- Protect the guideways against impacts and dampness / humidity.
- Suspend long rails at several points with a crane during transportation.
- Protect MONORAIL rails with distance measuring systems from magnetic fields and from mechanical damage. Magnetic fields can destroy the magnetization of the measuring ruler.

Preparation for the installation

- Check the scope of supply of the components for completeness and with respect to their condition.
- Check the locating sides of the machine bed and mounting plate with regard to correct shape and locating accuracy in accordance with the guidelines in chapter 9.2 / 9.3 and if necessary rework them.
- Clean all locating sides thoroughly, remove any burrs and unevennesses with an oil stone (oil rubber).
- Take care, that the guideways and the mounting base have the same ambient temperature before and during the installation.
- Remove the corrosion protection from carriages and rails.
- Lightly oil the locating sides of the carriages and rails.

Installation alternatives

Described in the following are four typical installation alternatives (picture 1). These differ with respect to the location of the locating sides on the machine side and therefore to the lateral guide. They are described in detail in the separate **Mounting Instructions MONORAIL.**



Picture 1: Installation alternative (A, B, C, D)

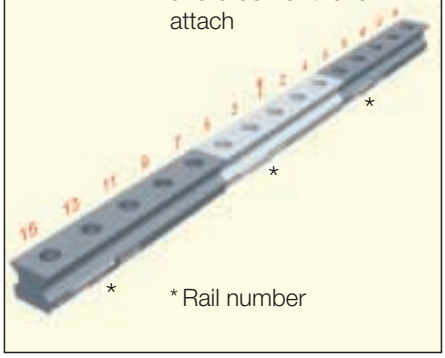
Handling the rails

When handling the rails, the following has to be observed:

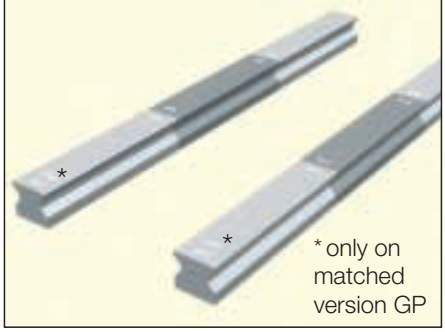
- Always place the rails with their locating side on to the locating side of the mounting base. The locating side of the rail is that side of the rail opposite the one with the SCHNEEBERGER lettering and the type number.
- Always tighten the fixing screws alternately starting from the center of the rail, or multi-section rails (picture 2).
- Multi-part rails are identified with a number at the butt joints and in the case of matched version in addition with a set number at the start of the rail (picture 3). Install the rails in such a manner, that the butt joint numbers are matching. The rail with the set number index 1, respectively, with the butt joint number 1 is designated as the reference rail.
- During the installation of multi-part rail tracks without any stop in the machine bed, align the rail butt joints by means of a fixing bridge. (picture 4). During the installation with stop surfaces on the machine side, always lay the rails against the stop surface with their stop side. In both cases pay attention, that the rails are joined together without any gaps.

- In the case of MONORAIL AMS, install the rail with the magnetic ruler as the rail 1. You can identify guideways of the type MONORAIL AMS by the designation on the rail and by the carriage with the scanning head. Note included instructions.

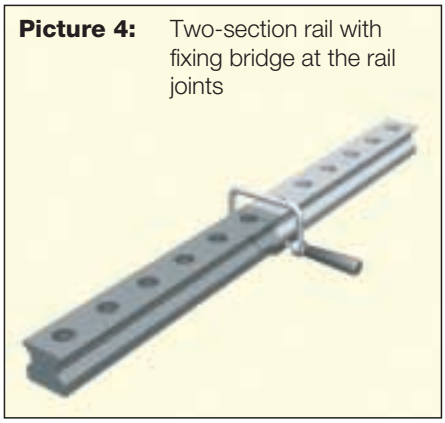
Picture 2: Numbering of the rail and order for the rail attach



Picture 3: Numbering of the rail joints and set numbers



Picture 4: Two-section rail with fixing bridge at the rail joints

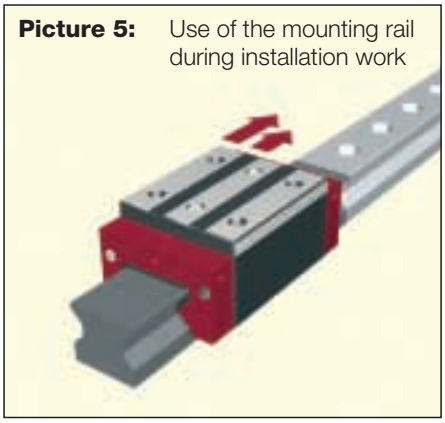


Handling the carriages

For handling the carriages, the following rules apply:

- Carriages and rails form a unit. Do **not** exchange carriages belonging to different rails.This is especially applicable to matched versions.
- If at all possible, always leave the carriages on the rail. For removing a carriage from the rail and when sliding it on again, always use a mounting rail MRM in the case of MONORAIL MR (picture 5). For MONORAIL BM a mounting rail MBM is recommended to facilitate the installation.
- Protect individual carriages against dirt. During transportation and storage always leave the carriages on a mounting rail.
- In the case of carriages with a scanning head, always remove the scanning head before sliding the carriage on to a mounting rail MRM.
- Always place the locating side of the carriages against the locating side on the slide. The locating side of the carriage is the side with a ground finish.
- Any retrofitting work on the front plates for the purpose of changing lubrication connections should be carried out by SCHNEEBERGER.

Picture 5: Use of the mounting rail during installation work



MONORAIL installation

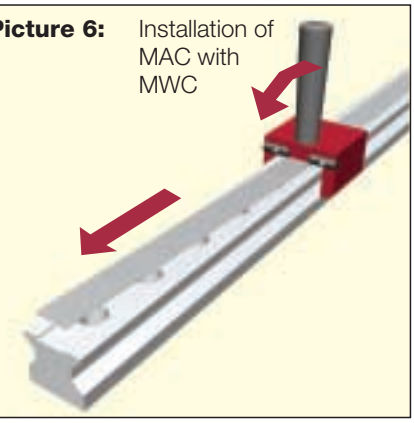
- Prepare the mounting base and the guideways for installation in accordance with the preceding section.
- Install the MONORAIL guideways depending on the installation alternative in accordance with the **Installation Instructions MONORAIL**.
- Close the fixing bores of the rails with plugs or steel cover strip, refer to section «Installation Accessories».
- In the case of guideways with a distance measuring system, install the AMS scanning head, measuring electronics and extension cable in accordance with the **Installation Instructions MONORAIL AMS**.
- Slightly rub the rail surface with lubricant.
- If applicable, install the bellows.
- Carry out the initial lubrication of the carriage – for this refer to chapter 3.6.

Installation accessories

The installation of the accessories is described in detail in the **Installation Instructions MONORAIL.** The following has to be observed:

- MONORAIL MR carriages with **additional wipers ZCN/ZCV** on rails with through holes and without a rail cover strip are supplied with an installation protection strip. This strip serves to protect the sealing lips during the installation and it must only be removed after the rail bores have been closed off.
- In the case of single carriages with **sheet metal wipers ASM** or **ABM,** release the wiper slightly before running it on to a rail. After running on, adjust the wipers so that there is a uniform gap in the running surface area. Then tighten the fixing screws again.
- Install **covering strips MAC** in accordance with the installation instructions for covering strips MAC for MONORAIL MR. To do this, utilize the installation tool MWC (picture 6). Prior to the installation make sure, that the ends of the strip protrude beyond the ends of the rail uniformly distributed. In the case of multi-part rails, install the covering strips in such a manner, that the butt joints of the covering strip and the butt joints of the rails are not located above one another. The individual parts are identified the same way as in the case of the rails, in order to make the correct assignment easier.
- Install the **cover strip BAB** (picture 7) in accordance with the installation instructions. In the case of cover strips in several parts, the individual parts are marked the same way as the rails. Install the cover strips so that the rail joints and cover strip joints are not above one another (do not coincide).
- Support the **cover strips** during transportation and storage along their whole length and never let them buckle.

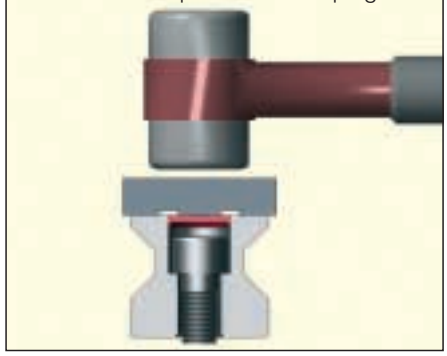
Picture 6: Installation of MAC with MWC



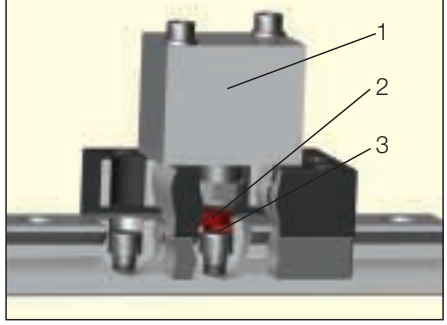
Picture 7: Installation of the cover strip BAB

- For the installation of **plastic**, resp., **brass** plugs, use a hammer with an intermediate plate (see picture 8). First place the plug on the rail bore. In doing so, pay attention to the parallel seating of the plug with respect to the rail surface. First tap the plug in lightly, check the seating again and remove any chips produced. Thereafter hammer the plug in until it is flush with the rail surface.
- Steel plugs **MRZ** are supplied in two pieces. First place the bushing onto the screw head, then insert the plug into the bushing. In doing so, pay attention to the parallel seating of the plug with respect to the rail surface. For pressing the plug in, use the hydraulic installation tool **MWH** (see picture 9).
- Install the **bellows FBM** resp. **FBB** in accordance with the Installation Instructions MONORAIL.

Pictures 8: Installation of the plastic-/ brass plugs



Picture 9: Installation too MWH for 2-part steel plugs



1 Hydraulic installation tool
2 Tapered steel plug
3 Seal ring

AMS installation

The installation of the MONORAIL rails with integrated measuring system is described in the **Installation Instructions MONORAIL AMS.**

10 Precautionary Measures

In order to maintain the operability of the MONORAIL guideways during the demanded service lifetime, the following points must imperatively be noted:

- The MONORAIL linear guideways and the distance measuring system AMS are precision components. Therefore the guideways during transportation and storage have to be protected against shocks and humidity and the distance measuring system additionally against strong magnetic fields.
- The installation of the guideways has to be carried out properly and expertly in accordance with the instructions of the manufacturer; in particular, the rail bores have to be closed off flush with the rail surface.
- The profile rail guideways have to be adequately supplied with a lubricant, which is suitable for the movement and the load profile as well as adapted to the environmental conditions. For the selection of the lubricant, if so required a lubricant producer should be directly consulted.
- The compatibility of coolants and lubricants has to be checked and verified by the user, in order to preclude any detrimental influences on the linear guideway.
- The guideways should be protected against contamination with dirt, hot metal chips and any direct contact with coolants by means of covers or corresponding installation positions.
- Depending on the material to be machined, resp., the dirt produced and in cases, where coolant comes into contact with the linear guideways, it is indispensable, that additional wipers are installed in front of the front plates. In addition, shorter inspection intervals are also called for.
- In such case, where the linear guideways come into contact with hot metal chips, in addition the utilization of metal wipers is recommended.
- The wipers on the ends of the MONORAIL carriages have to be examined for wear at regular time intervals and if necessary replaced. This is also applicable for additional wipers.

10.1055/-01/807/e/4.1/SRO/EG/Printed in Switzerland. Subject to technical change