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ETA-06/0131 of 3 March 2026

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General Part

Technical Assessment Body issuing the European Technical Assessment:	Deutsches Institut für Bautechnik
Trade name of the construction product	MAURER MSM® Spherical and Cylindrical Bearing
Product family to which the construction product belongs	Spherical and cylindrical bearing with special sliding material made of UHMWPE (Ultra high molecular weight polyethylene)
Manufacturer	MAURER SE Frankfurter Ring 193 80807 München DEUTSCHLAND
Manufacturing plant	Werk 1 bis 5 Plant 1 to 5
This European Technical Assessment contains	35 pages including 27 annexes (annex A to J) which form an integral part of this assessment
This European Technical Assessment is issued in accordance with Article 95(4) of Regulation (EU) No 2024/3110, on the basis of	EAD 050004-01-0301
This version replaces	ETA-06/0131 issued on 3 April 2019

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Specific Part

1 Technical description of the product

1.1 General

The construction product "MAURER MSM® Spherical and Cylindrical Bearing" is a spherical or cylindrical bearing, which permits rotation and displacement movements by a flat and a curved sliding surface between bearing plates of steel (see Figures in Annex A). The subject of the ETA is the complete spherical or cylindrical bearing, including, if relevant, the necessary guides or restraints. As an alternative to the Figures in Annex A, the bearing may also be used upside down, i.e., with flat sliding surfaces lying below (meaningful, for example in the case of steel bridges).

The MAURER MSM® Spherical and Cylindrical Bearing is designed according to EN 1337-7 and may be combined with sliding elements according to EN 1337-2 as shown in EN 1337-1. Instead of PTFE according to EN 1337-2, MSM®, a special sliding material made of Ultra High Molecular Weight Polyethylene (UHMWPE), is used for the sliding surfaces of the bearing, which is suitable for low and high temperatures outside the scope of EN 1337-2 and has improved wear resistance and load-bearing capacity.

Sliding surfaces with a diameter of the circumscribing circle of sliding material sheets less than 75 mm or greater than 3000 mm, or working at long-term operating temperatures less than − 50 °C or greater than + 48 ºC, are outside the scope of this ETA (see Clause 2).

The ETA covers also sliding surfaces intended for working at short-term operating temperatures as due to daily temperature variations above + 48 ºC and up to + 80 ºC (see Clause 2). If composite materials in accordance with EN 1337-2, Clauses 5.2 and 5.3, are used in guides (see Table 1), the maximum short-term temperature is limited to + 48 °C.

Note: *The operating bearing temperature is considered to be the shade air temperature as given in EN 1991-1-5.*

Spherical and cylindrical bearings with an included angle 2 θ > 60° and 2 θ > 75°, respectively, are beyond the scope of this ETA (see EN 1337-7, Clause 1 and Figure 6).

Sliding material combinations

The sliding materials in the bearing are combined as shown in Table 1. Only one combination is used in a sliding surface.

Table 1: *Combination of materials for permanent applications as sliding surfaces for spherical and cylindrical bearings with UHMWPE sliding material MSM®*

Flat surface		Curved surface		Guides	
• Dimpled MSM®	• Austenitic steel • MSA®	• Dimpled MSM®	• Austenitic steel • Hard chromium • MSA®	• Undimpled MSM® • CM1 • CM2	• Austenitic steel

The flat sliding surface may be subdivided in two restrained parts above and below the rotation element permitting in total the design movement, see the example in Annex A, Fig. A.7.

MSM® sheets

The composition of the material is confidential. Relevant information is laid down in Table 2, further details are laid down in the technical documentation to this ETA, deposited with the Technical Assessment Body.

The required geometrical characteristics of MSM® sheets and their confinement are given in Annex F. The curved MSM® sheet may be attached to either the convex or the concave backing plate.

Composite material

Instead of the undimpled MSM® sheets, only where self-alignment between the mating parts of the bearing is possible, composite materials CM1 and CM2 in accordance with EN 1337-2, Clause 5.3, can be used in guides.

Austenitic steel

Austenitic steel sheets are in accordance with EN 1337-2, Clause 5.4 and Annex F, Clause F.5.

Hard chromium plated surfaces

Hard chromium plated surfaces are in accordance with EN 1337-2, Clause 5.5.

Sliding alloy MSA®

The sliding alloy MSA® with special surface treatment may be used as mating surface as an alternative to austenitic steel (Table 1) and as an alternative to steel for backing plates in accordance with Annex D. The material characteristics and surface treatments of MSA® are confidential and are laid down in the technical documentation to this ETA, deposited with the Technical Assessment Body.

Lubricant

Silicon grease in accordance with EN 1337-2, Clause 5.8, is used in the sliding surfaces, applied in accordance with EN 1337-2, Clause 7.4.

Ferrous materials for backing plates

Ferrous materials used for backing plates of the sliding surfaces are in accordance with EN 1337-2, Clause 5.6, or in accordance with EN 10250, parts 1 to 4, as relevant. This ETA covers only backing plates with a maximum deformation in accordance with Annex D.

Attachment of sliding materials

Attachment of sliding materials is in accordance with EN 1337-2, Clause 7.2 of and Annex F, Clause F.5.

2 Specification of the intended use in accordance with the applicable European Assessment Document

MAURER MSM® Spherical and Cylindrical Bearings are intended to be used for the support of bridges or building works in accordance with the scope of EN 1337-1, Clause 1, where the requirements on the individual bearing are critical. The bearings are also intended to be used in structures subjected to short-duration loads (e.g., due to accidental action or seismic action).

MAURER MSM® Spherical and Cylindrical Bearings are suitable for all types of structures but especially for non-rigid structures with relatively large and frequent displacements caused by working loads, next for superstructures that induce fast sliding displacements in bearings, e.g. in bridges for high-speed railways.

The range of operating bearing temperatures for MAURER MSM® Spherical and Cylindrical Bearings covered by this ETA is − 50°C and up to + 80°C, while temperatures above + 48°C are limited to short periods as due to the daily temperature cycle. If composite material is used in any sliding surfaces, the maximum operating bearing temperature is limited to + 48°C.

The provisions made in this European Technical Assessment are based on an assumed working life for the intended use of at least 125 years for MAURER MSM® Spherical and Cylindrical Bearings, depending on the accumulated total sliding paths assessed according to Table 2 and Annex E of this ETA, and provided that the bearings are subject to appropriate use and maintenance. These provisions are based upon the current state of the art and the available knowledge and experience. The assumed working life of the bearings is reduced to 10 years, if in the bearing's guides composite materials according to EN 1337-2 are used instead of MSM®.

The indications given on the working life cannot be interpreted as a guarantee given by the producer but are to be regarded only as a means for choosing the right products in relation to the expected economically reasonable working life of the works.

3 Performance of the product and references to the methods used for its assessment

Table 2: Essential characteristics and performance of MAURER MSM® Spherical and Cylindrical Bearings

<table>
<tr><th>Basic requi-rements for construction works</th><th>Essential characteristic</th><th>Method of assessment</th><th>Performance</th></tr>
<tr><td rowspan="11">BWR 1</td><td rowspan="5">Load-bearing capacity</td><td rowspan="5">EAD, Clause 2.2.1</td><td>Characteristic Compressive strength f_k for long-term loads:
See Annex C, Table C.1</td></tr>
<tr><td>Characteristic compressive strength $f_{k,s\text{-}t}$ for short-term loads:
See Annex C, Table C.2</td></tr>
<tr><td>Load-bearing capacity $N_{R,max}$ and $N_{R,max,s\text{-}t}$ for axial loads:
See Annex C, Clause C.3</td></tr>
<tr><td>Load-bearing capacity $V_{R,max}$ and $V_{R,max,s\text{-}t}$ for lateral loads:
See Annex C, Clause C.4</td></tr>
<tr><td>Load-deformation behaviour (further details see Annex D):
$k = \frac{\sigma_{MSM} - 11{,}7}{77{,}2} \quad with\ 0{,}43 \leq k < 1{,}02; \quad E_{tp} = 900\ MPa$</td></tr>
<tr><td>Rotation capability</td><td>EAD, Clause 2.2.2</td><td>See Annex E.1</td></tr>
<tr><td rowspan="4">Displacement capacity</td><td rowspan="4">EAD, Clause 2.2.3</td><td>Total slide path $S_{T,i}$ for different combination of materials in accordance with Table 1:</td></tr>
<tr><td>• Dimpled and lubricated MSM® with austenitic steel as mating partner for main sliding surfaces: 125 000 m
• Dimpled and lubricated MSM® with MSA® as mating partner for main sliding surfaces: 25 000 m</td></tr>
<tr><td>• Undimpled, initially lubricated MSM® with austenitic steel as mating partner for guides: 25 000 m</td></tr>
<tr><td>Further details of the displacement capacity: See Annex E.2</td></tr>
<tr><td>Coefficient of friction</td><td>EAD, Clause 2.2.4</td><td>See Annex B</td></tr>
<tr><td>BWR 2</td><td>Reaction to fire</td><td>EAD, Clause 2.2.5</td><td>Reaction to fire:
• Metal parts: Performance class A1 (Decision 96/603/EC)
• Sliding material MSM®: not assessed.
• Spherical and Cylindrical Bearing: not assessed.</td></tr>
<tr><td rowspan="4">Durability aspects</td><td>Protection against contamination of sliding surfaces</td><td>EAD, Clause 2.2.6.1</td><td>See Annex J, Clause J.1</td></tr>
<tr><td>Corrosion resistance</td><td>EAD, Clause 2.2.6.2</td><td>See Annex J, Clause J.2</td></tr>
<tr><td>Ageing resistance</td><td>EAD, Clause 2.2.6.3</td><td>See Annex J, Clause J.3</td></tr>
<tr><td>Resist. against chemical and environmental influences</td><td>EAD, Clause 2.2.6.4</td><td>See Annex J, Clause J.4</td></tr>
</table>

4 Assessment and verification of constancy of performance (AVCP) system applied, with reference to its legal base

In accordance with EAD 050004-01-0301 the applicable European legal act for the construction product MAURER MSM® Spherical and Cylindrical Bearings is Commission Decision 95/467/EC, as amended by 2001/596/EC, 2002/592/EC and 2010/679/EU.

The system of AVCP (see Annex V of Regulation (EU) No 305/2011) is 1.

5 Technical details necessary for the implementation of the AVCP system, as provided for in the applicable European Assessment Document

Technical details necessary for the implementation of the AVCP system are laid down in the control plan deposited at the Technical Assessment Body Deutsches Institut für Bautechnik.

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Head of Section

beglaubigt:
Hoppe

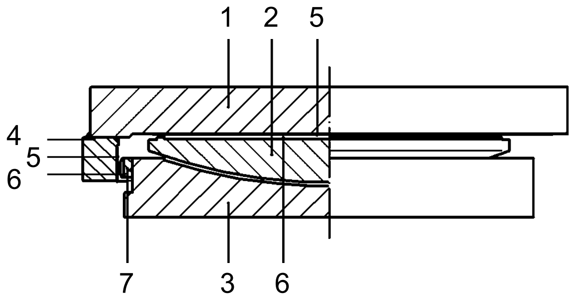
Annex A

Description of the product and its intended use

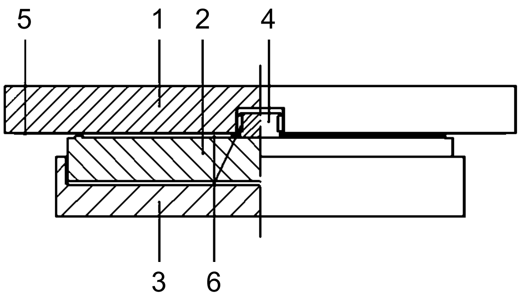
MAURER MSM® Spherical and Cylindrical Bearing (example)

Guided spherical bearing (moveable unidirectional)

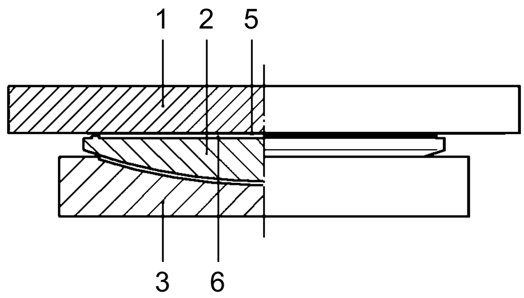
Free spherical bearing (moveable multidirectional)



Guided cylindrical bearing (moveable unidirectional)



Free cylindrical bearing (moveable multidirectional)



Key:

1	Sliding plate
2	Rotational element (convex plate)
3	Bottom plate (concave backing plate)
4	Guiding key
5	Austenitic steel sheet
6	MSM® sheet or strip
7	Rocker strip

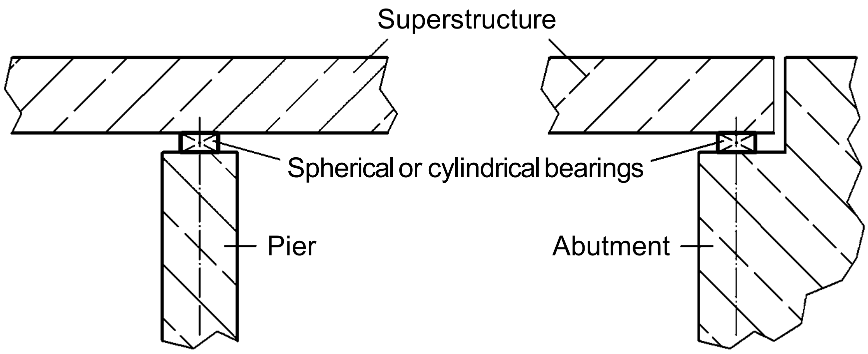
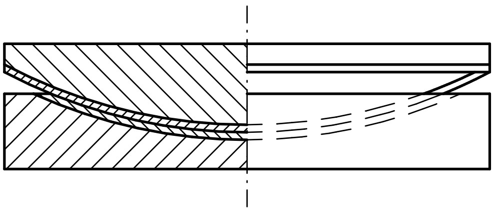


Figure A.1: Assembly of a guided and free movable MAURER MSM® Spherical and Cylindrical Bearings and its intended use (example)

MAURER MSM® Spherical and Cylindrical Bearings consist of a backing plate with a convex spherical or cylindrical surface (rotational element) and a backing plate with a concave spherical or cylindrical surface between which a MSM® sheet and the mating material form a curved sliding surface (see Figure A.2 and Figure A.4).

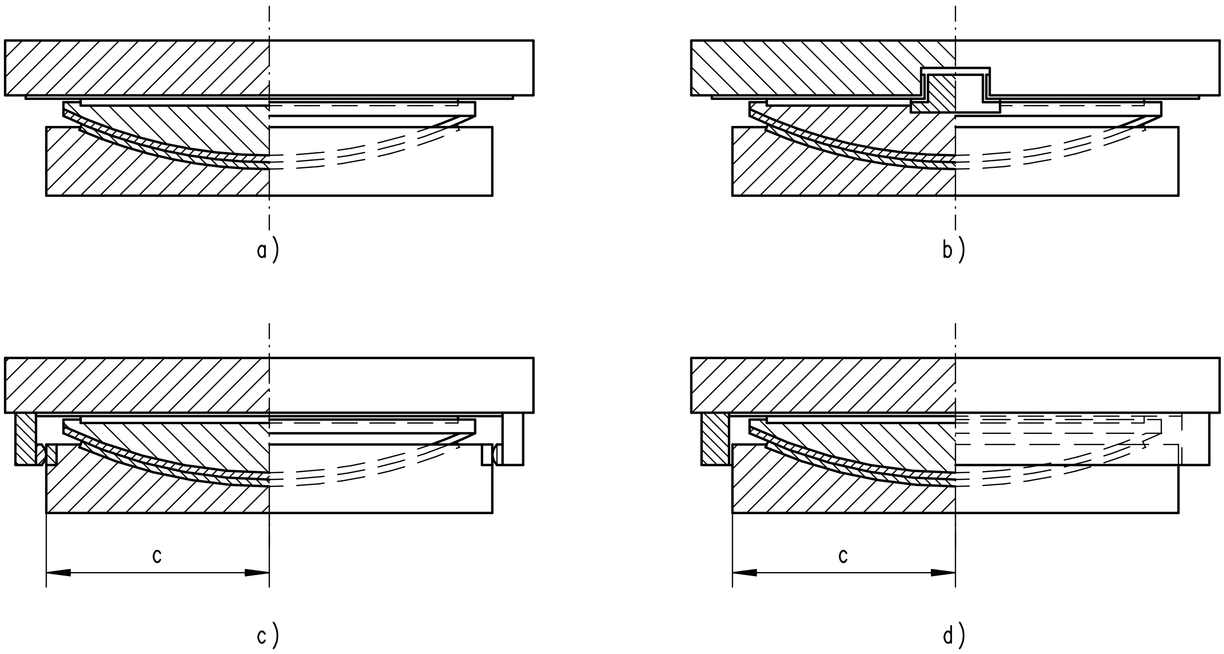
MAURER MSM® Spherical and Cylindrical Bearings are also used in combination with flat sliding elements and guides to form free and guided bearings (see Figure A.3 a) to d) and A.5 a) to c)). MAURER MSM® Spherical Bearings combined with a flat sliding element can be used together with a restraining ring to form fixed bearings (see Figure A.3 d)).

Note: Numbers in brackets in Figures A.2 to A.5 refer to the examples shown in Figure 1 of EN 1337-1.



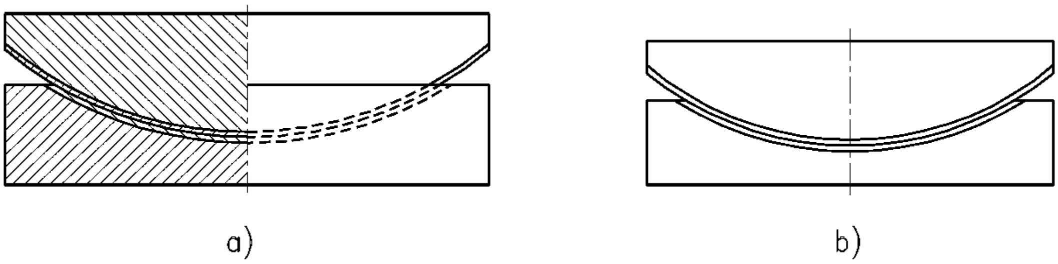
Fixed by sliding surface (3.2)

Figure A.2: MAURER MSM® Spherical Bearing



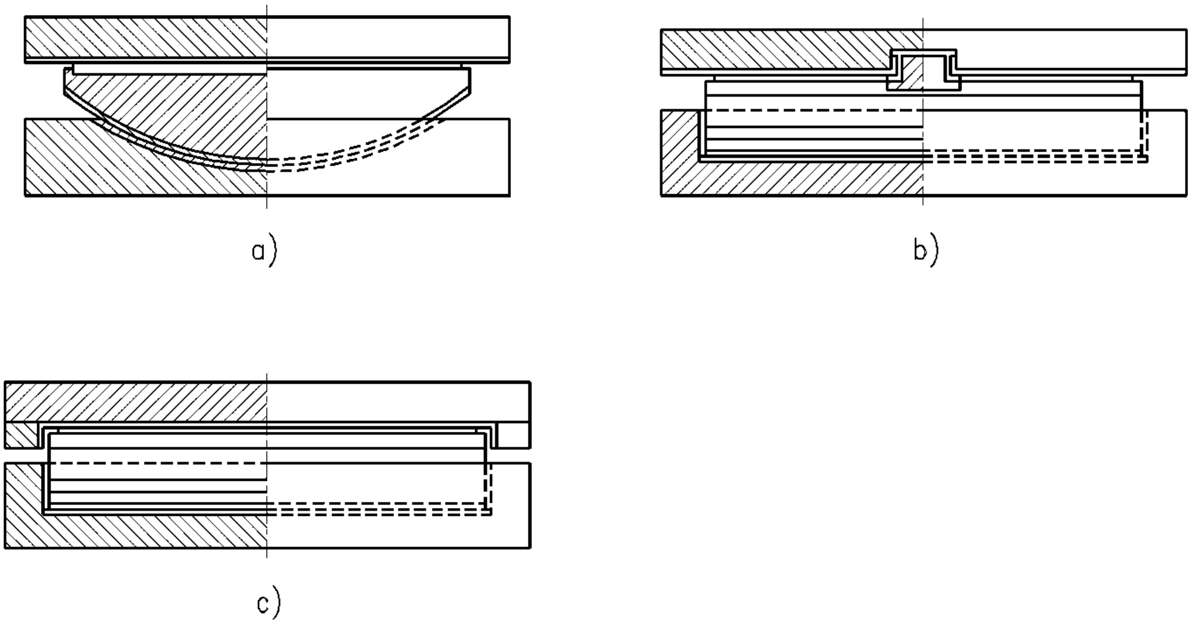
Key:
a) Free for displacements in any direction (3.5)
b) Guided by an internal guide for displacements in one direction (3.4)
c) Guided by external guides in one direction (3.3)
d) Fixed by a restraining ring (3.1)

Figure A.3: MAURER MSM® Spherical Bearings combined with flat sliding elements



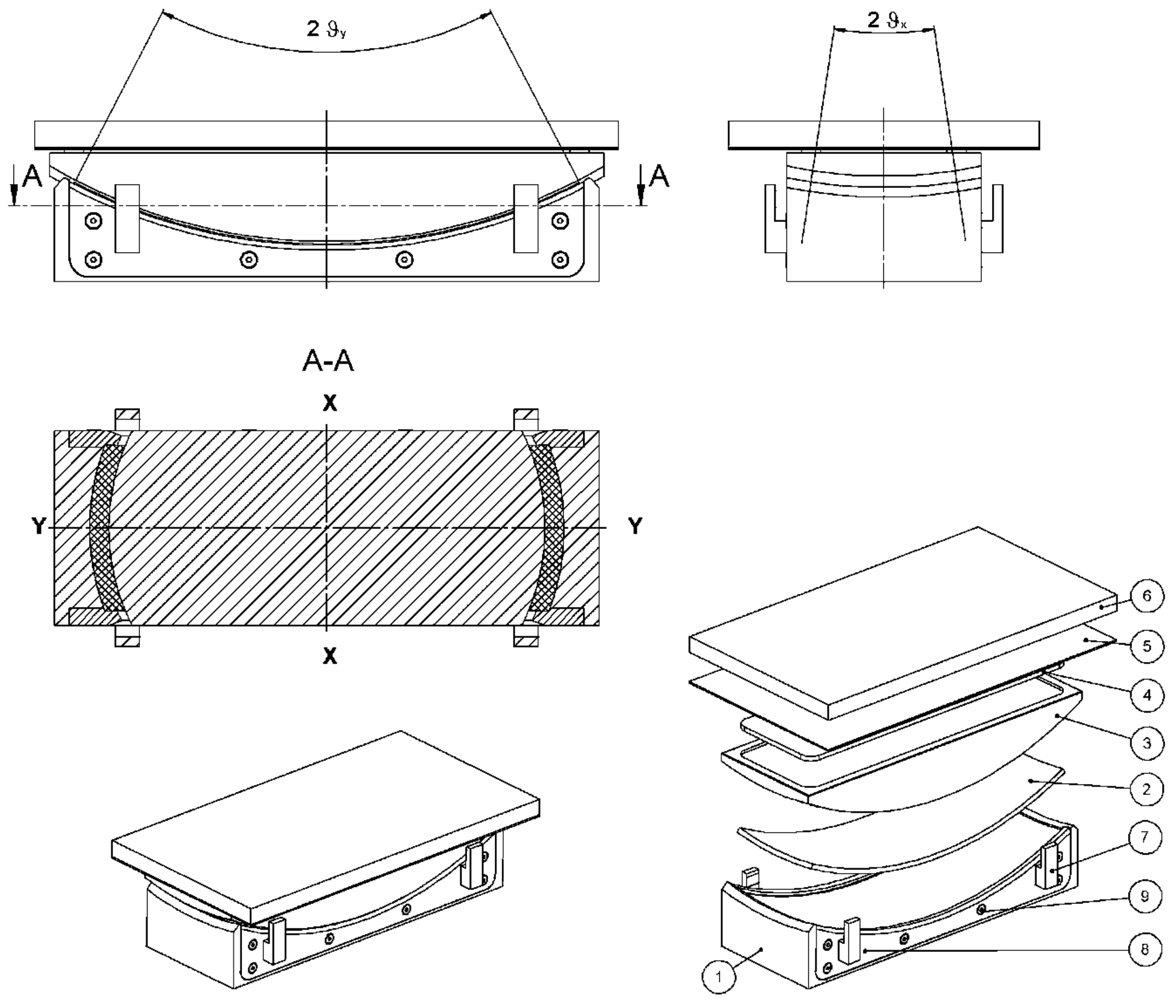
Key:
a) Fixed by end stops and sliding surface (7.1)
b) Without end stops for displacements in y-direction (7.2)

Figure A.4: MAURER MSM® Cylindrical Bearings



Key:
a) Free for displacements in any direction (7.4)
b) Guided by an internal guide for displacements in x-direction (7.3)
c) Guided by external guides for displacements in x-direction

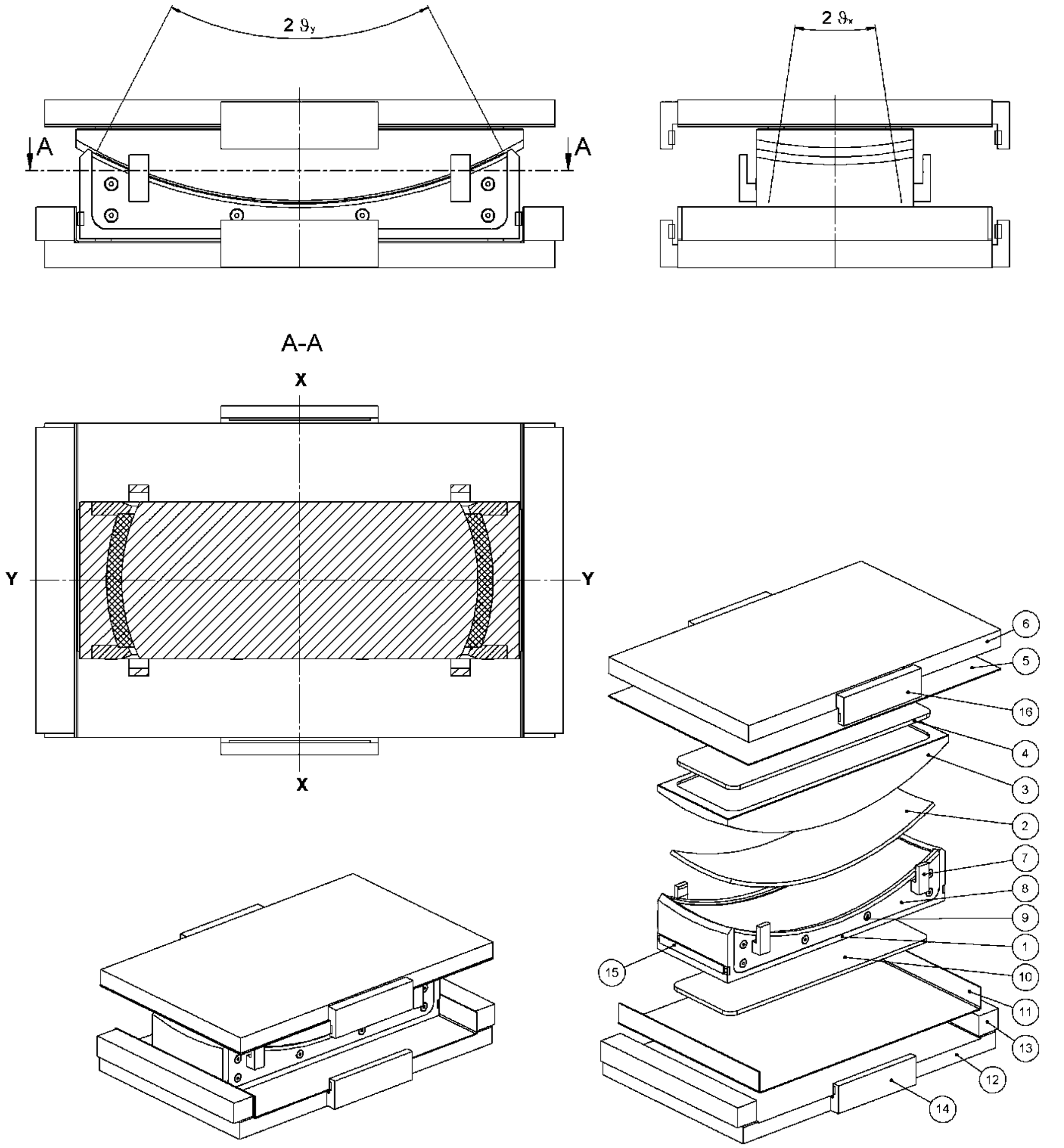
Figure A.5: MAURER MSM® Cylindrical Bearings combined with flat sliding elements



Key:

1 Lower backing plate
2 Curved MSM® sheet
3 Segmental spherical part
4 Flat MSM® sheet
5 Mating surface
6 Upper backing plate
7 Locking device
8 Lateral recess plate
9 Screw

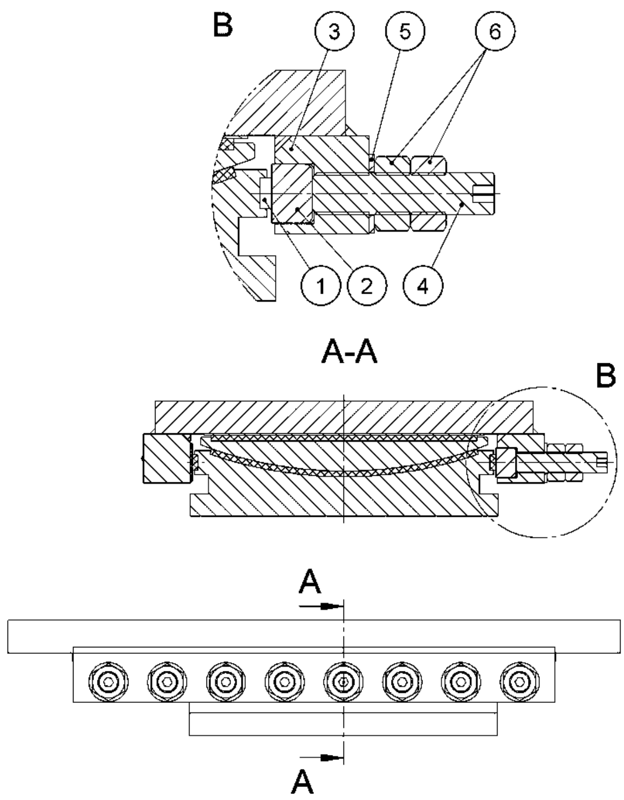
Figure A.6: MAURER MSM® Spherical Segment Bearing (example)



Key:

1 Lower backing plate
2 Curved MSM® sheet
3 Segmental spherical part
4 Upper flat MSM® sheet
5 Upper mating surface
6 Upper sliding plate
7 Locking device
8 Lateral recess plate
9 Screw
10 Lower flat MSM® sheet
11 Lower mating surface
12 Lower Sliding plate
13 Guiding key
14 Lower restraint
15 MSM® strip
16 Upper restraint

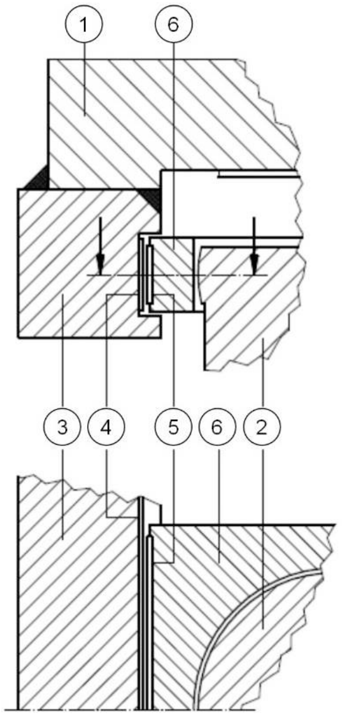
Figure A.7: MAURER MSM® Spherical Segment Bearing with two sliding surfaces (example)



Key:

1 MSM® strip in guides
2 Austenitic steel bar
3 Guiding key
4 Threaded bolts
5 Washer
6 nut, lock nut

Figure A.8: MAURER MSM® Bearings with adjustable guides (example)



Key:

1 Sliding plate
2 Backing plate
3 Guiding key
4 Mating surface
5 MSM® or CM
6 Guide ring

Figure A.9: MAURER MSM® Spherical Bearings with guided rotation ring (example)

Annex B

Coefficient of friction

The following coefficients of friction μ_{max} shall be used for the design evaluation of the bearing. These values shall not be applied in the presence of high dynamic actions which may occur for instance in seismic zones. The effects of friction shall not be used to relieve the effects of externally applied horizontal loads.

The coefficient of friction μ_{max} for dimpled and lubricated MSM® sheets in main sliding surfaces is determined for different minimum operating temperatures T_{min} and as a function of the average pressure σ_{MSM} [MPa] [1)] as given in Table B.1 for sliding elements with austenitic steel or hard chromium plating and in Table B.2 for sliding elements with MSA® as mating partner, respectively. For guides incorporating undimpled and initially lubricated MSM® sheets, the coefficient of friction shall be considered to be independent of contact pressure and is given in Table B.3 for different minimum operating temperatures T_{min}.

For guides incorporating composite materials CM1 or CM2, μ_{max} is given in EN 1337-2, Clause 6.7.

Table B.1: Coefficient of friction for sliding elements incorporating dimpled and lubricated MSM® sheets with austenitic steel or hard chromium plating as mating partner for total slide paths up to 125 000 m

Operating temperatures	Coefficient of friction in main sliding surfaces
Moderate low temperatures (T_{min} = − 5 °C)	$0{,}010 \leq \mu_{max} = \dfrac{0{,}60}{12 + (\sigma_{MSM})^{0{,}91}} \leq 0{,}06$
Low temperatures (T_{min} = − 35 °C)	$0{,}013 \leq \mu_{max} = \dfrac{0{,}65}{10 + (\sigma_{MSM})^{0{,}87}} \leq 0{,}08$
Very low temperatures (T_{min} = − 50 °C)	$0{,}018 \leq \mu_{max} = \dfrac{0{,}55}{8 + (\sigma_{MSM})^{0{,}74}} \leq 0{,}08$

Table B.2: Coefficient of friction for sliding elements incorporating dimpled and lubricated MSM® sheets with MSA® as mating partner for total slide paths up to 25 000 m

Operating temperatures	Coefficient of friction in main sliding surfaces
Moderate low temperatures (T_{min} = − 5 °C)	$0{,}012 \leq \mu_{max} = \dfrac{0{,}79}{19 + (\sigma_{MSM})^{0{,}93}} \leq 0{,}06$
Low temperatures (T_{min} = − 35 °C)	$0{,}018 \leq \mu_{max} = \dfrac{1{,}1}{19 + (\sigma_{MSM})^{0{,}89}} \leq 0{,}08$
Very low temperatures (T_{min} = − 50 °C)	$0{,}025 \leq \mu_{max} = \dfrac{1{,}2}{19 + (\sigma_{MSM})^{0{,}80}} \leq 0{,}08$

Table B.3: Coefficient of friction for guides incorporating undimpled and initially lubricated MSM® sheets with austenitic steel as mating partner for total slide paths up to 25 000 m

Operating temperatures	Coefficient of friction in guides
Moderate low temperatures (T_{min} = − 5 °C)	$\mu_{max} = 0{,}031$
Low temperatures (T_{min} = − 35 °C)	$\mu_{max} = 0{,}038$
Very low temperatures (T_{min} = − 50 °C)	$\mu_{max} = 0{,}048$

[1)] In the formulas for the calculation of μ_{max}, the average contact pressure σ_{MSM} [MPa] shall be used as dimensionless value.

Annex C

Load-bearing capacity

C.1 General

Sliding surfaces of MAURER MSM® Spherical and Cylindrical Bearings are dimensioned in accordance with Clause 6.2.1 and 6.2.2 of EN 1337-7 and Clause 6.8.1 to Clause 6.8.3 of EN 1337-2 with the following adaptations accounting for the essential characteristics of the MSM® sliding material:

- Possible material combinations are given in Table 1.
- The characteristic temperature-dependent compressive strength of MSM® is used in the determination as given in Clause C.2
- When calculating the total eccentricity e_t of the axial force N_S, the frictional resistance of the sliding surfaces shall be determined using the coefficients of friction of MSM® in accordance with Annex B.
- Backing plates are assessed in accordance with Annex D.

The following conditions shall be verified for sliding surfaces:

$N_{Sd} \leq N_R / \gamma_m$ and $N_{Sd,s-t} \leq N_{R,s-t} / \gamma_{m,s-t}$ for axial long- and short-term loads, respectively, as well as

$V_{Sd} \leq V_R / \gamma_m$ and $V_{Sd,s-t} \leq V_{R,s-t} / \gamma_{m,s-t}$ for lateral long- and short-term loads, respectively.

where is:

N_{Sd}, V_{Sd}: Design value of axial and lateral long-term load, respectively, under the fundamental combination of actions.

$N_{Sd,s-t}$, $V_{Sd,s-t}$: Design value of axial and lateral short-term load, respectively, under the seismic combination of actions.

N_R, V_R: Load bearing capacity of sliding surfaces for long-term axial loads (see Clause C.3) and long-term lateral loads (see Clause C.4), respectively.

$N_{R,s-t}$, $V_{R,s-t}$: Load bearing capacity of sliding surfaces for short-term axial loads (see Clause C.3) and short-term lateral loads (see Clause C.4), respectively.

γ_m, $\gamma_{m,s-t}$: Partial safety factor for materials in accordance with EN 1990.[2)]

Deformation of sliding materials shall not be used to accommodate rotations except as permitted in Annex F, Clause F.3.

C.2 Compressive strength of MSM®

The characteristic temperature-dependent compressive strength of MSM® for long-term loads is given in Table C.1. For bearings exposed to a maximum operating bearing temperature in excess of + 35 °C and up to + 80° C the characteristic compressive strength shall be estimated by linear interpolation of the values given in Table C.1.

The characteristic compressive strength of MSM® for short-term loads is given in Table C.2 and is valid for operating bearing temperatures up to $T_{max,\,seismic}$ = 48 °C.

If composite material CM1 or CM2 in accordance with EN 1337-2, Clause 5.3, is used as sliding material in guides, the value of the characteristic compressive strength shall be taken from Table 10 in Clause 6.6 of EN 1337-2.

2) The value for γ_m (long-term loads) and $\gamma_{m,s-t}$ (short-term loads) should be given as NDP (national determined parameter). In absence of relevant NDPs the recommended value is γ_m = 1,4 and $\gamma_{m,s-t}$ = 1,2

Table C.1: Characteristic compressive strength $f_k(T)$ of MSM® for long-term loads

Operating bearing temperature		≤ 35 °C	48 °C	60 °C	70 °C	80 °C
Sliding surface		**Characteristic compressive strength for long-term loads $f_k(T)$**				
Main sliding surface Dead loads and variable loads		180 MPa	135 MPa	105 MPa	90 MPa	75 MPa
Guides	Variable loads					
	Dead loads; Effects of temperature, shrinkage and creep	60 MPa	45 MPa	35 MPa	30 MPa	25 MPa

Table C.2: Characteristic compressive strength $f_{k,s-t}(T)$ of MSM® for short-term loads

Maximum bearing temperature $T_{max,\,seismic}$	48 °C
Sliding surface	**Characteristic compressive strength for short-term loads $f_{k,s-t}$**
Main sliding surface Short-term loads due to seismic events	240 MPa
Guides Short-term loads due to seismic events	

C.3 Load-bearing capacity for axial loads

The load-bearing capacities for long-term axial loads N_R and short-term axial loads $N_{R,s-t}$, respectively, of a sliding surface are defined as follows:

Load-bearing capacity for long-term axial loads:

$$N_R = f_k(T) \cdot A_r = f_k(T) \cdot \lambda \cdot A$$

Load-bearing capacity for short-term axial loads:

$$N_{R,s-t} = f_{k,s-t}(T) \cdot A_r = f_{k,s-t}(T) \cdot \lambda \cdot A$$

where is:

$f_k(T)$: Characteristic temperature-dependent compressive strength for long-term loads in accordance with Table C.1

$f_{k,s-t}(T)$: Characteristic temperature-dependent compressive strength for short-term loads in accordance with Table C.2

A_r: Reduced contact area of the sliding surface

A: Contact area of the flat sliding surface or the projection of curved surfaces

λ: Coefficient given in Annex G

For the purpose of compressive stress evaluation the curved sliding surface shall be replaced by its projection on a flat surface as shown in EN 1337-7, Figure 6.

The centroid of the reduced contact area of the sliding surface A_r is the point through which the axial force N_S acts with the total eccentricity e_t, which is caused by both mechanical and geometrical effects. A_r shall be calculated on the basis of the theory of plasticity assuming a rectangular stress block (see Annex G).

Internal forces and moments acting on the curved sliding surface due to frictional resistance, externally applied horizontal loads and the rotated condition of the bearing shall be taken into account when determining the resulting total eccentricity e_t. Secondary effects due to the action of the restraints shall also be considered. In Annex H formulae are given for the evaluation of the eccentricities in the most common cases.

For MSM® sheets with smallest dimension *L, a or b* in accordance with Annex F.1 larger or equal to 100 mm, contact areas A and A_r shall be taken as the gross area without deduction for the area of the dimples. For sheets with *L, a or b* smaller than 100 mm the area of the dimples shall be deducted from the gross area.

Exemplary characteristic axial load-bearing capacities of MAURER MSM® Spherical Bearings at relevant operating temperatures including the maximum values $N_{R,max}$ and $N_{R,s-t,max}$ at L = 3000 mm are given in Table C.3.

Separation of sliding surfaces may lead to wear due to contamination and increased deformation due to lack of confinement of the MSM® sheet. As this could endanger long term fitness for use, the edge pressure condition $\sigma_{MSM} = 0$ is considered as serviceability limit state. With the exception of guides, it shall be verified that $\sigma_{MSM} \geq 0$ under the characteristic combination of actions. In doing so the sliding material shall be assumed to be linear elastic and the backing plates shall be deemed to be rigid. The condition $\sigma_{MSM} \geq 0$ is satisfied when the total eccentricity e_t falls within the kernel of the projected area. For circular sheets this condition is satisfied when:

$$e_t \leq \frac{L}{8},$$ where L is the diameter in accordance with Annex F.

Table C.3: Exemplary characteristic axial load-bearing capacity of MAURER MSM® Spherical Bearings

		Diameter L of the projected area of MSM® sheet								
		250 mm			1000 mm			3000 mm		
		Eccentricity e/L								
Maximum operating temperature	**Character. compressive strength**	0,25	0,125	0,05	0,25	0,125	0,05	0,25	0,125	0,05
		Coefficient $\lambda = A_r/A$								
		0,4110	0,7055	0,8822	0,4110	0,7055	0,8822	0,4110	0,7055	0,8822
T_{max}	$f_k(T)$	**Load-bearing capacity N_R for long-term axial loads [MN]** a) b)								
35 °C	180 MPa	3,6	6,2	7,8	58,1	99,7	124,7	523	898	1122
48 °C	135 MPa	2,7	4,7	5,8	43,6	74,8	93,5	392	673	842
60 °C	105 MPa	2,1	3,6	4,5	33,9	58,2	72,8	305	524	655
70 °C	90 MPa	1,8	3,1	3,9	29,0	49,9	62,4	261	449	561
80 °C	75 MPa	1,5	2,6	3,2	24,2	41,6	52,0	218	374	468
$T_{max,seismic}$	$f_{k,s-t}(T)$	**Load-bearing capacity $N_{R,s-t}$ for short-term axial loads [MN]** a) b)								
≤ 48°C	240 MPa	4,8	8,3	10,4	77,5	133,0	166,3	697	1197	1497

a) For bearings with internal guides (bearing example (b) in Figure A.3), the reduced load-bearing area has to be considered
b) Different values of L, T_{max} or e/L shall be considered by using the formulas in accordance with Clause C.3

C.4 Load-bearing capacity for lateral loads

Guides may be used for resisting lateral forces due to variable and permanent actions. The load-bearing capacities for long-term lateral loads V_R and short-term lateral loads $V_{R,s-t}$, respectively, of the sliding surface of guides are defined as follows:

Load-bearing capacity for long-term lateral loads: $V_R = f_k(T) \cdot A$

Load-bearing capacity for short-term lateral loads: $V_{R,s-t} = f_{k,s-t}(T) \cdot A$

where is:

$f_k(T)$: Characteristic temperature-dependent compressive strength of MSM® for long-term loads in accordance with Table C.1

$f_{k,s-t}(T)$: Characteristic temperature-dependent compressive strength of MSM® for short-term loads in accordance with Table C.2

A: Area of the sliding surface (in accordance with EN 1337-2, Clause 6.8.3, eccentricity can be neglected for guides)

Exemplary characteristic lateral load-bearing capacities of the guides of MAURER MSM® Spherical and Cylindrical Bearings at relevant operating temperatures are given in Table C.4.

Further requirements for guides in MAURER MSM® Spherical and Cylindrical Bearings are given in Annex F, Clause F.3.

Table C.4: Exemplary characteristic lateral load-bearing capacity of MAURER MSM® Spherical Bearings

Maximum operating temperature	**Charact. compressive strength**	**Length L of MSM® sheet in guide; width a = 50 mm a)**		
		250 mm	1000 mm	3000 mm
T_{max}	$f_k(T)$ b)	**Load-bearing capacity V_R for long-term lateral loads [kN] b) c)**		
35 °C	180 MPa	2250	9000	27000
48 °C	135 MPa	1688	6750	20250
60 °C	105 MPa	1313	5250	15750
70 °C	90 MPa	1125	4500	13500
80 °C	75 MPa	938	3750	11250
$T_{max,seismic}$	$f_{k,s-t}(T)$	**Load-bearing capacity $V_{R,s-t}$ for short-term lateral loads [kN] c)**		
≤ 48°C	240 MPa	3000	12000	36000

a) For the definition of variables *L* and *a* see Figure F.3; If the effective load-bearing area in guides is reduced, e.g. by subdivision of the MSM® sheet, the load-bearing capacity decreases by the same proportion.

b) Valid for variable loads in guides. For dead loads and effects of temperature, shrinkage and creep, the load-bearing capacity values listed in this table for long-term loads shall be multiplied by 0,33 in accordance with Table C.1

c) Different values of L, a or T_{max} shall be considered by using the formulas in accordance with Clause C.4

Annex D

Load - deformation behaviour

The indication of product performance is based on assessments conducted under the following conditions.:

- The MSM® sheets and the mating materials shall be supported by metallic plates (backing plates) with flat or curved surfaces.
- The geometrical conditions are as given in Annex I.

The design of the backing plates shall take into account the following:

- verification for the fundamental combination of actions when internal forces and moments from lateral actions are to be considered in addition to the effects from deformation as per hereafter,
- any cross-section reduction (for example due to keyway and the attachment bolts),
- deformations as per hereafter,
- the required stiffness for transport and installation as per hereafter,
- distribution of forces to the adjacent structural members as per hereafter.

Note: If the deformations (see Figure D.1) exceed the values given below, unacceptably small clearance between the adjacent backing plates and higher wear will occur. As this could endanger the long term fitness for use of the sliding element, this condition is considered serviceability limit state.

The deformation Δw (see Figure D.1) shall not exceed the value Δw_{lim} as given in following equation in accordance with EAD 050004-01-0301, Annex B:

$$\Delta w_{\text{lim}} = \frac{3}{2}\left[0{,}9 \cdot h_0 - \left(2\,k\sqrt{\frac{(0{,}9 \cdot h_0)^3}{L}}\right) - \left(h_{r,basis} + h_{r,flatTol}\right)\right]$$

where is:

h_0	Initial height of protrusion of the MSM® sheet in unloaded condition [mm] (see Annex F)
k	Pressure-dependent compliance coefficient of MSM®
L	Diameter of the circumscribing circle of the MSM® sheet [mm] (see Annex F)
$h_{r,basis}$	Basic limit value of the sliding gap; $h_{r,basis}$ = 1,0 mm in accordance with EN 1337-2, Clause 10.
$h_{r,flatTol}$	Term considering the unevenness of the backing plates. In accordance with the tolerance given in EN 1337-2, Clause 7.1.2, this calculates to: $h_{r,flatTol}$ = 0,0003 mm × L or 0,2 mm, whichever value is higher.

The compliance coefficient k shall be calculated as a function of the average pressure σ_{MSM} as follows:

$$k = \frac{\sigma_{MSM} - 11{,}7}{77{,}2} \qquad with \quad 0{,}43 \leq k < 1{,}02$$

where is:

σ_{MSM}	Average pressure in the sliding surface under the characteristic combination of action. In the calculation of k, the pressure σ_{MSM} [MPa] shall be used as dimensionless value.

The stress in the backing plate induced by the respective deformation shall not exceed the yield stress in order to avoid permanent deformations. The theoretical model for evaluation of the above requirements (deformation Δw_{lim} and yield strength) shall include the effects of all the bearing components which have a significant influence on these deformations including the adjacent structural members and their short and long-term properties. For steel and concrete, the design values of material properties in accordance with EN 1993-1-1 and EN 1992-1-1, respectively, apply.

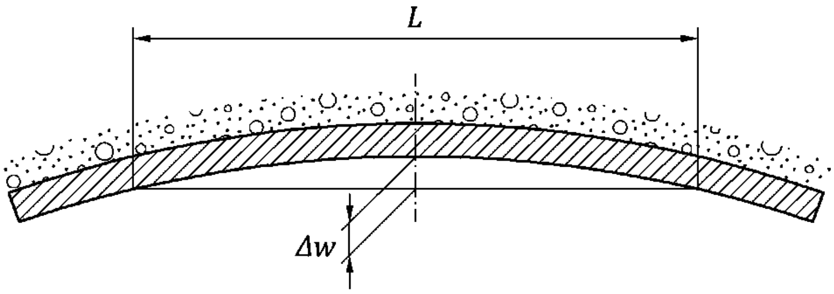


Figure D.1: Deformations of backing plates.

In this model the following assumptions shall be made:

a) central load;
b) notional design modulus of elasticity of MSM® = 900 MPa;
c) the total thickness t_{MSM} of MSM® sheet;
d) notional design Poisson' s ratio of MSM® = 0,44;
e) in the case of adjacent structural members of solid construction: linear reduction of the elastic modulus of concrete or mortar from the edge to the centre of the backing plate from 100 % to 80 %.

A suitable method for calculating deformation Δw for common materials is given by Annex I, Clause I.5. When using the method given in Annex I, yield stress evaluation of the backing plate is not required if:

- the condition for the deformation Δw is met;
- the concrete strength class is at least C25/30 in accordance with EN 206-1;
- and the steel grade is at least S355 in accordance with EN 10025.

The above also applies when using lower concrete strength classes and/or steel grades, provided the deformation limit values calculated as above are reduced by a factor of:

0,90 when using concrete strength class C20/25
0,67 when using steel S235
0,60 when using both concrete C20/25 with steel S235.

Note: The above is not the only criterion to be considered in determining the relative deformation Δw. Particular attention shall be paid to loadings during construction (e.g. when large backing plates are not propped during concrete casting).

The calculation of the relative deformation of the backing plate with convex surface shall be omitted.

Square or rectangular plates shall be idealised to circular plates of diameter

$$d_b = 1{,}13 \cdot a_b$$

where a_b is the side of the square plate or the minor side of the rectangular plate.

The thickness of the backing plate shall be:

$$t_b \geq 0{,}04 \cdot \sqrt{a_b^2 + b_b^2}$$

or 10 mm, whichever is greater, where:

a_b is the minor side of backing plate and
b_b is the major side of backing plate.

Annex E

Rotation capability and displacement capacity

E.1 Rotation capability

The rotation capability of the MAURER MSM® Spherical and Cylindrical Bearing is determined geometrically on the basis of the construction data taking into account the most unfavourable displacement of the flat sliding surface. Under the fundamental combination of actions, the maximum geometrical rotation angle $\alpha_{max,geom.}$ is the lowest value of the following:

- Maximum rotation angle for which there is no contact between the upper and lower plate or any other metallic component, in accordance with EN 1337-7, Clause 6.2.4, thus the tilting gap is > 0;
- Maximum rotation angle for which the MSM® sheet in the curved sliding surface is still covered by the mating material, in accordance with EN 1337-7, Clause 6.2.4;
- In case of guided bearings without rotational element for guides in accordance with EN 1337-2, Clause 6.4: Maximum rotation angle at which the differential deformation of the sliding material sheet in guides across its smallest dimension is < 0,2 mm (see Annex F, Clause F.3);
- In case of guided bearings with rotational elements for guides in accordance with EN 1337-2, Clause 6.4: Maximum rotation angle at which the rotational element for guides in accordance with EN 1337-2, Clause 6.4, reaches the limit of its rotational capacity.

The maximum rotation angle α_{max} is calculated by subtracting the increased rotation in accordance with EN 1337-1, Clause 5.4 from the determined angle $\alpha_{max,geom.}$. Exemplary values for α_{max} of MAURER MSM® Spherical and Cylindrical Bearings at eccentricity ratios e/L of 0,125 and 0,250 depending on the minimum operating temperature T_{min} and the minimum average contact pressure σ_{MSM} are given in Table E.1.

Table E.1: Maximum rotation angle α_{max} of MAURER MSM® Spherical and Cylindrical Bearings at the eccentricity ratios e/L of 0,125 and 0,250 under the assumption that guides or contact between upper and lower plates do not result in a reduction in rotation capability under consideration of the increased rotation in accordance with EN 1337-1, Clause 5.4.

		σ_{MSM} ≥ 30 MPa a)			**σ_{MSM} ≥ 60 MPa** a)		
Minimum operating temperature T_{min}		-5 °C	-35 °C	-50 °C	-5 °C	-35 °C	-50 °C
Coefficient of friction μ_{max}		0,0185	0,0278	0,0351	0,0123	0,0192	0,0264
Eccentricity e/L b)	**Opening angle θ**	**Maximum rotation angle α_{max} [rad]** c)					
0,125	10°	0,020	0,011	0,003	0,026	0,019	0,012
	20°	0,060	0,051	0,044	0,066	0,059	0,052
	25°	0,079	0,069	0,062	0,085	0,078	0,071
	30°	0,096	0,087	0,080	0,103	0,096	0,089
	37,5° d)	0,121	0,112	0,105	0,128	0,121	0,114
0,250	10°	0,063	0,054	0,047	0,069	0,063	0,055
	20°	0,146	0,136	0,129	0,152	0,145	0,138
	25°	0,184	0,175	0,168	0,191	0,184	0,176
	30°	0,221	0,212	0,205	0,228	0,221	0,214
	37,5° d)	0,274	0,264	0,257	0,280	0,273	0,266

a) Friction values used for the calculation are valid for the given minimum average contact pressures σ_{MSM}
b) Eccentricities assumed for the calculation in accordance with Annex H as follows: $e_1 = \mu_{max} \cdot r$; $e_3 = \alpha \cdot r$; $e_2 = e_4 = 0$
c) The requirement for increased rotational capacity in accordance with EN 1337-1, Clause 5.4 has been taken into account
d) In accordance with the scope of this ETA, opening angles of 30° < θ < 37,5° are only valid for cylindrical bearings

If composite material CM1 or CM2 in accordance with EN 1337-2, Clause 5.3, is used as sliding material in guides, see EN 1337-2, Clause 6.3.

For MAURER MSM® Spherical Bearings with external guides the rotation capability around the vertical axis may be increased using a guide ring, see Annex A, Figure A.9. The contact surfaces of this guide ring are designed in accordance with the requirements given in Annex F, Clause F.4.

E.2 Displacement capacity

The single, maximum displacement capacity of the MAURER MSM® Spherical and Cylindrical Bearing is given by the project specific geometrical design of the sliding elements. By taking into account the increased movements according to EN 1337-1, Clause 5.4, it shall be verified under the fundamental combination of actions that with maximum displacement of the sliding element the mating sliding partner completely covers the MSM® or CM sheets, respectively.

The assessed displacement capacity of sliding surfaces incorporating MSM® sheets in terms of the maximum total slide path $S_{T,i}$ for different combination of materials in accordance with Table 1 is as follows:

- Dimpled and lubricated MSM® with austenitic steel as mating partner for main sliding surfaces: 125 000 m
- Dimpled and lubricated MSM® with MSA® as mating partner for main sliding surfaces: 25 000 m
- Undimpled, initially lubricated MSM® with austenitic steel as mating partner for guides: 25 000 m

In accordance with EAD, Annex E, these displacement capacities of sliding surfaces correspond to an assumed working life for the intended use of MAURER MSM® Spherical and Cylindrical Bearings of 125 years.

If sliding materials CM1 and CM2 in accordance with EN 1337-2, Clause 5.3, are used in guides, the total slide path for this combination is in accordance with EN 1337 2, Table 4. Accordingly, the working life is reduced to 10 years.

Annex F
Characteristics of sliding elements

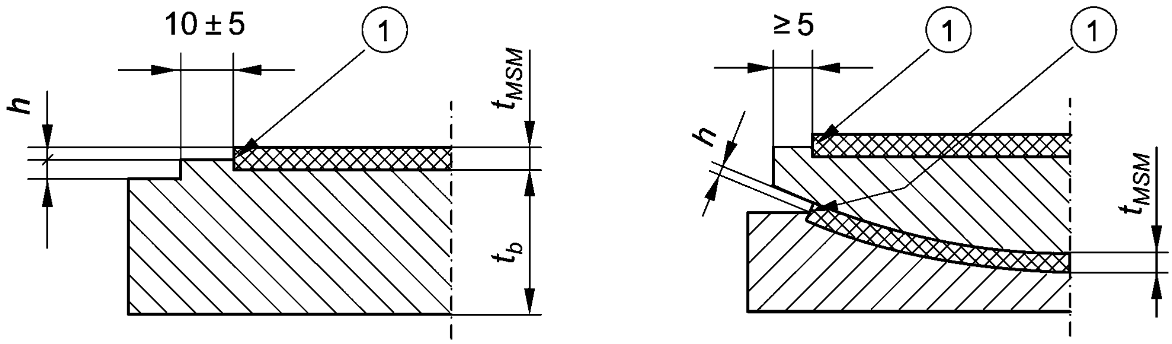
F.1 Geometrical characteristics of MSM® sheets

The performance characteristics of MAURER MSM® Spherical and Cylindrical Bearings given in this ETA are valid only for the geometrical conditions given in this Annex.

For MAURER MSM® spherical bearings the absence of two symmetrical circular segments for not subdivided sheets is permissible, if the limitation for the included angle given in Clause 1 and the proof of non-separation of the sliding surfaces given in Annex C, Clause C.3 is fulfilled for both the main axes. The main principle of MAURER MSM® spherical segment bearings is shown in Fig. A.6 and A.7 of Annex A.

F.1.1 Recessed MSM® sheets

The MSM® sheets shall be recessed into a backing plate as shown in Figure F.1.



Key for Figure F.1:

(1) sharp edge

Figure F.1: Details of MSM® recess and relief; dimensions given in millimetres

Note: A fixed value for the depth of the relief can be given to facilitate the measurement of the MSM® protrusion h after installation. For section X-X, see EN 1337-2, Figure 3.

The thickness t_{MSM} and protrusion h_0 of the MSM® sheet in the unloaded condition with corrosion protection shall meet the conditions given in Table F.1

Table F.1: Thickness t_{MSM} and protrusion h_0 of MSM® sheets

Design values	**Flat and curved sliding surfaces**	**Guides**
Thickness t_{MSM}	$2{,}65 \cdot h_0 \leq t_{MSM} \leq 8{,}1\ mm$	$8{,}0\ mm \leq t_{MSM} \leq 10{,}0\ mm$
Protrusion h_0	$h_0 = 2{,}50\ mm + \frac{L}{3000\ mm} \leq 3{,}1\ mm\ ^{a)}$	$h_0 = 3{,}0\ mm \pm 0{,}2\ mm$
a) L is the diameter of the projected area of circumscribing circle of single or multiple MSM® sheet in mm		

The tolerance on the protrusion h_0 is ± 0,2 mm for L ≤ 1200 mm and ± 0,3 mm for L > 1200 mm. The protrusion h_0 shall be verified at marked measuring points, where the corrosion protection coating shall not exceed 300 µm. There shall be at least two measuring points, suitably located.

The admissible tolerance on thickness t_{MSM} of single MSM® sheets or associated multiple sheets is:

- $^{+0,3}_{-0,0}$ mm for sheets with a diameter $L \leq 1200$ mm and
- $^{+0,4}_{-0,0}$ mm for sheets with a diameter $L > 1200$ mm.

F.1.2 Flat MSM® sheets

Flat MSM® sheets for the main sliding surface shall be circular or rectangular and may be sub-divided into a maximum of four identical parts as shown in EN 1337-2, Figure 3. The smallest dimension "*a*" of any of these subdivided MSM® sheets shall not be less than 50 mm. The distance between individual MSM® sheets shall not be greater than twice the thickness of the backing plate of the MSM® or the mating material, whichever is least.

F.1.3 Curved MSM® sheets

Curved MSM® sheets for cylindrical sliding surfaces shall be rectangular and may be subdivided into a maximum of two identical parts as shown in EN 1337-2, Figure 4.

Curved MSM® sheets for spherical sliding surfaces shall be circular and may be subdivided into a disc and an annulus. If the curved sliding sheet is subdivided, the diameter *d* shall not be less than 1000 mm or 2/3 · *L*, whichever is greater, and the width of the annulus shall not be less than 50 mm. The annulus may be divided into equal segments. Both the disc and the annulus may be retained in recesses. The separating ring of the backing plate shall not be more than 10 mm wide. The configuration of curved MSM® sheets for spherical sliding surfaces is shown in EN 1337-2, Figure 5.

F.1.4 MSM® sheets for MAURER Multisurface Spherical Bearings

As an alternative to the geometrical rules given in Clause F.1.2 and F.1.3, flat and curved surfaces of spherical bearings made of MSM® may consist of one centric circular sheet with diameter *a* and one or more concentric annuli with a constant width *b*. The dimensions a and b shall not be smaller than 50 mm. The radial distance *f* between the individual sheets shall not be less than 10 mm and not greater than twice the thickness of the backing plate of the MSM® sheet or the backing plate of the mating material, whichever is least. The annuli may be subdivided into segments. Both the disc and the annulus may be retained in recesses. Figure F.2 shows the configurations of flat and curved MSM® sheets for MAURER MSM® Multisurface Spherical Bearings.

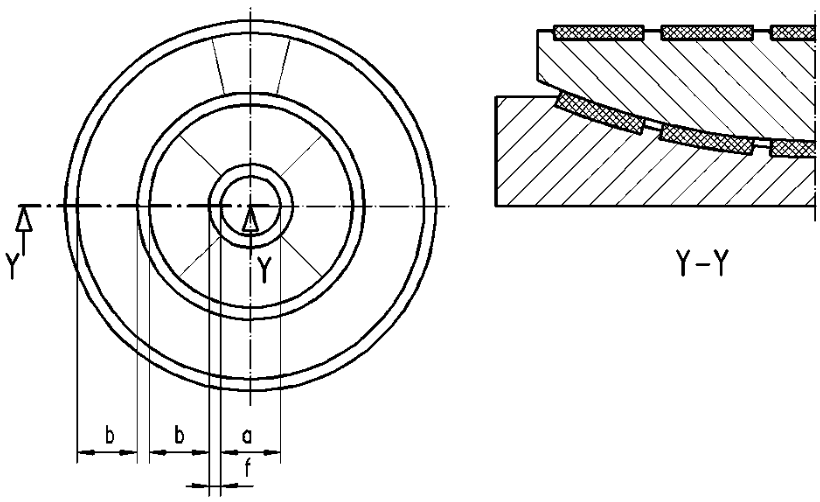


Figure F.2: Subdivision of recessed MSM® sheets for MAURER MSM® Multisurface Spherical Bearings (Example)

F.1.5 MSM® sheets for guides

Dimension *a* shall be not less than 15 mm and the modified shape factor

$$S = \frac{A_{MSM}}{u \cdot h} \cdot \frac{t_{MSM} - h}{h}$$

shall be greater than 4 (see Figure F.3). A_{MSM} is the compressed (undeformed) surface and *u* the perimeter of the MSM® sheet.

Dimensions in millimetres

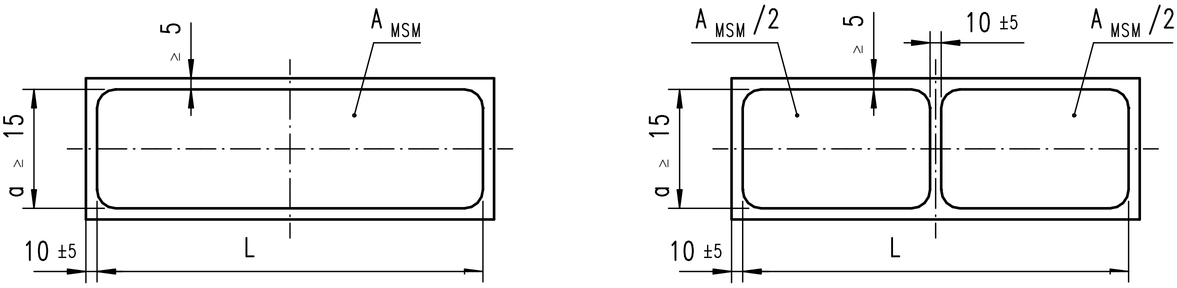
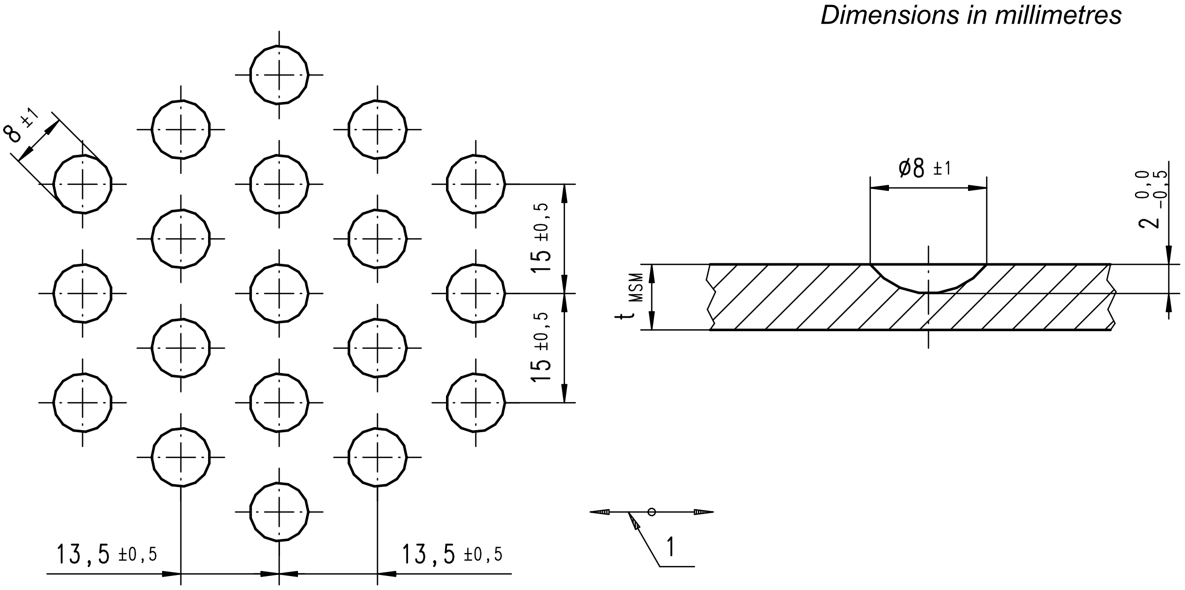


Figure F.3: Examples of recessed MSM® sheets for guides

F.2 Dimple pattern for sliding elements with MSM®

For pressures due to characteristic permanent actions G_k exceeding 5 MPa a uniform pattern of dimples shall be provided to retain the lubricant. The shape and arrangement of the dimples in the unloaded and unused condition and the alignment with the main direction of sliding is shown in Figure F.4.

Dimensions in millimetres



Key:
1 Main direction of sliding

Figure F.4: Pattern of dimples in recessed MSM® sheets

F.3 Guides

Guides may be used for resisting lateral forces due to variable and permanent actions. Depending on the bearing construction, the guides may be arranged externally or centrally. The sliding materials shall be fixed on keys and keyways in the backing plates.

The clearance c between sliding components in unused condition shall meet the following condition:

$$c \leq 1{,}0\ mm + \frac{L\ [mm]}{1000}$$

A typical example of the attachment of guides is shown in Figure A.1 of Annex A. In the design of the connection at ultimate limit state in accordance with EN 1993-1-1, the effects of the horizontal force, its induced moment and the friction forces shall be considered.

The maximum clearance in guides may be reduced due to adjustable guides. For this purpose, high tensile screws in accordance with EN 1993 shall be used. The main principle of adjustable guides is shown in Figure A.8 of Annex A

Where, under the design rotation about transverse axis, under the characteristic combination of actions the differential deformation of the MSM® sheet across its smallest dimension "*a*" would exceed 0,2 mm, a rotation element shall be included in the backing plate (see EN 1337-1, Figure 1, No. 3.3). The rotation element shall be designed in accordance with the requirements of the mating surfaces of guides given in this ETA and pot-to-piston contact surfaces given in EN 1337-5.

F.4 Restraining rings

The free MAURER MSM® Spherical Bearing may be fixed by a steel restraining ring as shown in EN 1337-7, Figure 4 (d). For the dimensioning, a friction coefficient μ_{max} of 0,2 shall be used for the steel-to-steel contact, in accordance with the design rules for pot and piston of pot bearings given in EN 1337-5, Clause 6.1.3.2 and 6.2.2 to 6.2.4.

F.5 Austenitic steel sheets

The minimum thickness of austenitic steel sheet shall be in accordance with Table F.2.

The indication of products performance is based on the assessment under the following conditions:

- The austenitic steel sheet is fully in contact with the backing plate over the area which will be in contact with the MSM® sheet.
- When attaching the austenitic steel sheet by screwing, counterpunched screwing and riveting, corrosion resistant fasteners compatible with the austenitic steel sheet shall be used for securing its edges. They shall be provided at all corners and along the edges outside the area of contact with the MSM® sheet with the maximum spacing listed in Table F.3.

Table F.2: Thickness and methods of attachment of austenitic steel sheets.

Type of surface	Method of attachment	Thickness [mm]
flat	full surface bonding	1,5
	continuous fillet weld	≥ 1,5
	counterpunched screwing	≥ 1,5
	screwing, riveting	≥ 2,5
spherical	full surface bonding	≥ 2,5
	continuous fillet weld	≥ 2,5
	recessed in concave surfaces	≥ 2,5
cylindrical	full surface bonding	≥ 1,5
	continuous fillet weld	≥ 1,5
	recessed in concave surfaces	≥ 2,5

Table F.3: Maximum fastener spacing for attachment of austenitic steel sheets by screwing, counterpunched screwing and riveting.

Austenitic steel sheet thickness [mm]	Maximum fasteners spacing [mm]
1,5	150
2,0	300
2,5	450
3,0	600

Annex G

Reduced area for sliding elements

This annex gives the values of the coefficient λ used in Annex C for the calculation of the reduced area A_r of flat and curved sliding surfaces. The values of the coefficient λ have been calculated by means of a mathematical model made with the following assumptions:

1) only compressive stresses are transmitted;
2) the stresses in the compressed area are constant and equal to the design value f_d of compressive resistance of MSM® sheets (i.e. the stress block theory is adopted);
3) stresses are always normal to the contact surface: a conservative hypothesis justified by the low coefficient of friction of MSM® in contact with polished metal surfaces;
4) the adjacent backing plates are perfectly rigid.

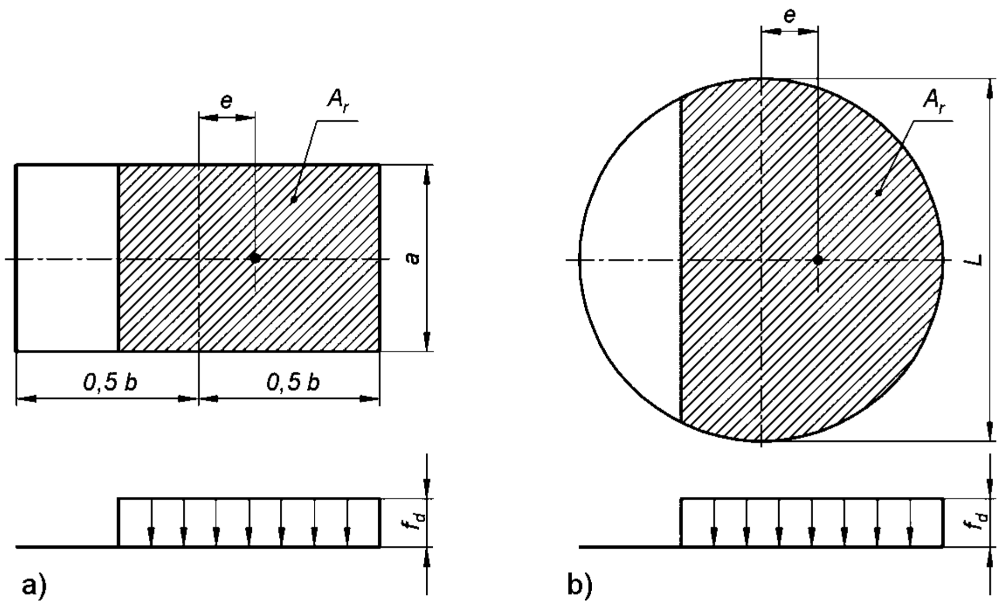


Figure G.1: Reduced contact area A_r for a) rectangular and b) circular sliding surfaces.

The reduced contact area is given by the formula:

$A_r = \lambda \cdot A$

<u>where is:</u>

λ : Geometrical Coefficient;

- For circular sliding sheets given in Table G.1; For flat sliding surfaces, the approximate formula $\lambda = 1 - 0{,}75\,\pi \cdot {}^{e_t}/_{L}$ can alternatively be used, where e_t is the total eccentricity.
- For rectangular sliding sheets $\lambda = 1 - {}^{2e}/_{b}$ or given in Table G.1, where e is the eccentricity in the considered direction. If several eccentricities occur in a cross-section under consideration, they need to be added. If a bearing cannot rotate about one axis (as for cylindrical bearings), in accordance with EN 1337-1, Clause 5.5, the minimum eccentricity to be considered is 1/10 of the side's length perpendicular to that axis.
- For guides, the eccentricity can be neglected ($\lambda = 1$).

A: Contact area for flat sliding surfaces or projection area of the curved sliding surface

Table G.1: Coefficient $\lambda = A_r/A$

e/L	Sliding surface								
	Spherical					Cylindrical			
		Θ							
	flat	**30°**	**25°**	**20°**	**10°**	**37,5°**	**25°**	**20°**	**10°**
0,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
0,005	0,990	0,991	0,991	0,990	0,990	0,992	0,992	0,991	0,990
0,010	0,979	0,982	0,981	0,980	0,979	0,984	0,983	0,981	0,980
0,020	0,957	0,962	0,961	0,960	0,958	0,968	0,965	0,962	0,961
0,030	0,934	0,942	0,940	0,938	0,936	0,951	0,947	0,943	0,941
0,040	0,912	0,922	0,919	0,916	0,913	0,934	0,929	0,924	0,921
0,050	0,888	0,901	0,898	0,894	0,890	0,917	0,911	0,905	0,901
0,060	0,865	0,880	0,876	0,872	0,867	0,900	0,893	0,886	0,881
0,070	0,841	0,858	0,853	0,849	0,844	0,882	0,874	0,866	0,862
0,080	0,818	0,836	0,831	0,826	0,820	0,864	0,855	0,847	0,842
0,090	0,793	0,814	0,808	0,803	0,796	0,846	0,837	0,827	0,822
0,100	0,769	0,792	0,786	0,780	0,773	0,828	0,818	0,808	0,802
0,110	0,745	0,770	0,763	0,757	0,749	0,809	0,799	0,788	0,782
0,120	0,722	0,747	0,740	0,733	0,724	0,790	0,779	0,768	0,762
0,125	0,709	0,736	0,729	0,722	0,712	0,780	0,769	0,758	0,752
0,130	0,697	0,725	0,717	0,710	0,700	0,771	0,760	0,749	0,742
0,140	0,673	0,702	0,693	0,686	0,676	0,752	0,740	0,729	0,722
0,150	0,649	0,680	0,670	0,663	0,653	0,733	0,721	0,709	0,702
0,160	0,625	0,657	0,647	0,639	0,628	0,713	0,701	0,689	0,682
0,170	0,601	0,635	0,624	0,616	0,604	0,693	0,681	0,669	0,662
0,180	0,577	0,612	0,601	0,592	0,581	0,673	0,661	0,649	0,642
0,190	0,552	0,590	0,578	0,569	0,557	0,653	0,641	0,629	0,622
0,200	0,529	0,567	0,556	0,546	0,533	0,633	0,621	0,609	0,602
0,210	0,506	0,545	0,533	0,523	0,510	0,612	0,600	0,589	0,582
0,220	0,482	0,523	0,511	0,500		0,592	0,580	0,569	0,562
0,230	0,458	0,501				0,571	0,559	0,548	0,542
0,240	0,435					0,550	0,539	0,528	0,522
0,250	0,412					0,529	0,518	0,508	0,502
Note: Intermediate values may be obtained by linear interpolation									

Annex H

Method for calculation the eccentricities in MAURER MSM® Spherical and Cylindrical Bearings

H.1 General

Frictional forces, forces from applied horizontal loads and the rotated condition of the bearing produce eccentricity of the axial force N_S, which is used in the verification of MSM® sheets, the adjacent structural members and the anchoring devices. This annex gives methods for calculating the significant eccentricities. Depending on the design features of a particular bearing, additional eccentricities may exist. When several eccentricities occur in a cross-section under consideration, they need to be added.

H.2 Friction resistance

H.2.1 Curved sliding surfaces

In the presence of rotational movements an internal moment occurs due to the frictional resistance. Regardless of whether the bearing has one or two surfaces, the associated eccentricity e_1 is:

$$e_1 = \mu_{max} \cdot r$$

The coefficient of friction μ_{max} is given in Annex B.

H.2.2 Sliding surfaces with external guides and restraining rings

For spherical bearings of the type shown by Figures A.3 c) and d) in Annex A rotational movements produce an eccentricity e_2 which affects only the adjacent structural members (i.e. plinth, beam etc.) and the anchoring devices, where:

$$e_2 = \frac{V_S}{N_S} \cdot \mu_{max} \cdot c$$

For bearings with sliding elements in guides as per Table 1, the coefficient of friction μ_{max} is given in Annex B. For restraining rings with steel-to-steel contact μ_{max} should be assumed to be 0,2.

H.3 Rotation

In all the types of bearings with two sliding surfaces a rotation angle α produces an eccentricity e_3 of the vertical load on the curved surface equal to:

$$e_3 = \alpha \cdot (r + b)$$

where *b* represents the distance between the cross-section under consideration and the sliding surface (see EN 1337-7, Figure 6). At any rate, this eccentricity acts nonetheless in the opposite direction to that given under Clause H.2.2. The occurrence of e_3 depends on whether the curved MSM® sheet is either attached to the convex or concave backing plate and whether the value α is greater or lesser than μ as well as on whether the bearing clearance is performing its function effectively in the case of guided bearings. In the type of bearings equipped with only one sliding surface e_3 occurs only in the curved MSM® sheet and, furthermore, only when said sheet is attached to the convex backing plate.

H.4 Lateral forces

Lateral forces result from horizontal actions and the friction resistance of the other bearings in the structure. In bearings where lateral forces are transmitted by external guides or restraining rings, the eccentricity in the curved sliding surface is equal to zero. In bearings of the fixed type with only one sliding surface or with internal guides the horizontal load V_S produces an eccentricity given by (see EN 1337-7, Figure 6):

$$e_4 = \frac{V_S}{N_S} \cdot (r + b)$$

In all cases where the lines of application of lateral action and reaction are not coincident the resulting couple causes an eccentricity that shall be additionally taken into account.

Annex I

Backing plates

I.1 General

Dimensional limitations of backing plates with concave surfaces are shown in Figure I.1.

Dimensions in millimetres

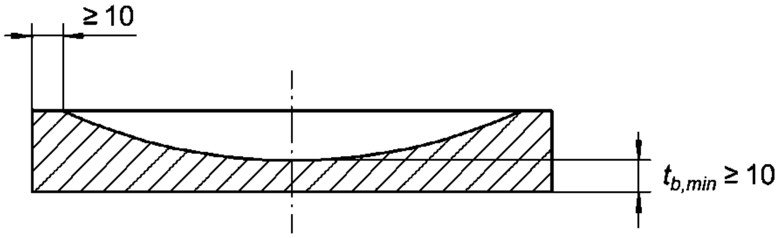


Figure I.1: Dimensional limitations of a backing plate with a concave surface

I.2 MSM® confinement

The shoulders of the recess shall be sharp and square to restrict the flow of MSM® (see Figure F.1 in Annex F). The radius at the root of the recess shall not exceed 1 mm. The depth of the confining recess shall be related to the dimensions of the MSM® sheet in accordance with Annex F. In principle the MSM® sheet shall fit the recess without clearance. Intermittent gaps between the edge of the MSM® sheet and the recess shall not exceed the values given in Table I.1 at room temperature.

Table I.1 - Fit of confined MSM® sheets.

Dimension *L* [mm]	Gap [mm]
$75 \leq L \leq 600$	0,6
$600 < L \leq 1200$	0,9
$1200 < L \leq 1500$	1,2

<u>where is</u>

L Diameter according to Annex F

For diameters L > 1500 mm the gaps are limited to $L\,[\mathrm{mm}]/1250$

I.3 Flatness

Surfaces of backing plates in contact with sliding materials or anchor and shimming plates shall be treated in such a way that the maximum deviation Δz from theoretical flat surface shall not exceed $0{,}0003 \times d$ or 0,2 mm, whichever is greater.

I.4 Fit of sliding surfaces

The maximum deviation Δz from theoretical flat or curved surface within the area of the mating MSM® sheet shall not exceed $0{,}0003 \times L$ or 0,2 mm, whichever is greater.

I.5 Method for calculating the deformation of backing plates attached to concrete

For circular metallic plates attached to concrete structural members of concrete strength class C20/25 according to EN 206-1 or greater and mortar layers of equivalent strength, the maximum relative deformation Δw over the diameter L is given by the equation below:

$$\Delta w = \frac{0{,}55}{L} \cdot k_c \cdot \alpha_c \cdot k_b \cdot \alpha_b$$

with

$k_c = 1{,}1 + (1{,}7 - 0{,}85 \cdot d_b/L) \cdot (2 - d_b/L_0)$ if $L_0 \leq d_b \leq 2 \cdot L_0$

$k_c = 1{,}1$ if $d_b > 2 \cdot L_0$

$$\alpha_c = \frac{N_{Qd}}{E_{cd}} + \frac{N_{Gd}}{E_{crd}}$$

$$k_b = 0{,}30 + (0{,}55 \cdot d_b/L)$$

$$\alpha_b = \left(\frac{L}{L + 2 \cdot t_b}\right)^2 \cdot \left(\frac{3 \cdot L_0}{d_b}\right)^{0{,}4}$$

<u>where is</u>

d_b diameter of the backing plate

t_b thickness of the backing plate; for backing plates with a concave surface the calculation may be based on the equivalent constant thickness
$t'_b = t_{b,min} + 0{,}6\,(t_{b,max} - t_{b,min})$

L diameter of MSM® sheet

L_0 reference diameter = 300 mm

N_{Qd} design axial force due to variable actions

N_{Gd} design axial force due to permanent actions

E_{cd} design secant modulus of elasticity of concrete

E_{crd} design reduced modulus of elasticity of concrete, for the determination of creep when acted upon by permanent design actions N_{Gd} ($E_{crd} \cong 1/3\ E_{cd}$)

The above approximate procedure may also be applied to square plates and rectangular plates if they are idealised to circular plates of diameter

$$d_b = 1{,}13 \cdot a_b$$

where a_b is the side of the square plate or the minor side of the rectangular plate.

Annex J

Durability aspects

J.1 Protection against contamination of sliding surfaces

The sliding surfaces of MSM® spherical and cylindrical bearings are protected from contamination in accordance with EN 1337-2, Clause 7.3, by suitable devices like brushes or rubber skirts which are easily removable for the purpose of inspection.

J.2 Corrosion resistance

The protective measures for MSM® spherical and cylindrical bearings against environmental and other external factors that could reduce its service life comply with EN 1337-9, Clause 4. Furthermore, the provisions of EN 1337-2, Clause 7.3 for the corrosion protection regarding sliding surfaces apply.

The components of MAURER MSM® spherical and cylindrical bearings made of structural steel are furnished with a protective coating system based on project specifications for corrosivity categories C4 or C5 in accordance with EN ISO 12944-2, Clause 5.1, and a durability range of "high" or "very high" in accordance with EN ISO 12944-1, Clause 5.5.

The durability rating of the sliding alloy MSA® is "B" in accordance with EN 1999-1-1, Table 3.1a.

J.3 Ageing resistance

The resistance of MSM® against ageing has been assessed in accordance with EAD, Clause 2.2.6.3 by exposure of virgin MSM® specimens to the temperature T_{max} = 80°C in air for a duration of 168 hours. The average deviations (%) of the material properties of the aged specimens from the properties of virgin specimens are given in Table J.1.

Table J.1: Average deviation (%) of MSM® specimen properties during aging in air at T_{max} = 80°C in air for a duration of 168 hours

Material property	Average deviation [%]
Tensile modulus	-7,4
Stress at yield,	+1,5
Stress at break	-1,6
Strain at break	-4,9
Ball indentation hardness	+2,4

J.4 Resistance against chemical and environmental influences

The resistance of sliding elements incorporating MSM® sheets against chemical and environmental influences has been assessed by separate exposure of test specimens of MSM® to different chemical substances in accordance with the EAD, Clause 2.2.6.4. The average deviations (%) of the material properties of the exposed specimens from the properties of virgin specimens are given in Table J.2.

Table J.2: Average deviation (%) of MSM® specimen properties in the tests of resistance against chemical and environmental influences

Medium	**Exposure time and temperature**	**Change of volume [%]**	**Change of mass [%]**	**Change of strain at break [%]**
Silicone grease	(60 days at ambient temperature)	+0,04	+0,00	+3,9
Distilled water		-0,10	-0,01	+8,5
Sodium chloride [1)]		+1,17	-0,02	+9,1
Chromium chloride [1)]		0,00	+0,01	+2,1
Ferric chloride [1)]		+0,05	+0,01	+4,7
Zinc chloride [1)]		+0,01	0,00	-16,3
Silicone grease	(90 days at + 80 °C)	+0,22	+0,43	-5,1
Silicone grease	(21 days at + 90 °C)	+0,45	+0,44	-7,36
1) saturated aqueous solution				

The values of strain at break of the exposed specimens shown in Table J.2 are well within the tolerance range of MSM® properties in accordance with EAD, Clause 3.4.1 and as laid down in the control plan deposited with the Technical Assessment Body Deutsches Institut für Bautechnik.