Deutsches Institut für Bautechnik
DIBt

Approval body for construction products and types of construction

Bautechnisches Prüfamt

An institution established by the Federal and Laender Governments

European Technical Assessment

ETA-08/0115 of 14 April 2021

English translation prepared by DIBt - Original version in German language

General Part

Technical Assessment Body issuing the European Technical Assessment:	Deutsches Institut für Bautechnik
Trade name of the construction product	mageba RESTON®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) ROBO®SLIDE L2
Manufacturer	mageba SA Solistraße 68 8180 Bülach SCHWEIZ
Manufacturing plant	mageba, Plants 1 - 6
This European Technical Assessment contains	26 pages including 20 annexes which form an integral part of this assessment
This European Technical Assessment is issued in accordance with Regulation (EU) No 305/2011, on the basis of	EAD 050004-00-0301
This version replaces	ETA-08/0115 issued on 7 November 2017

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Specific part

1 Technical description of the product

mageba RESTON®Spherical and Cylindrical Bearing is a spherical or cylindrical bearing, which permits rotation and displacement movements by a plane and a curved sliding surface between bearing plates of steel (see Figures Annex A). The subject of the European Technical Assessment is the complete 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 positioned at the bottom side (meaningful, for example in the case of steel bridges).

mageba RESTON®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. A special sliding material made of UHMWPE (Ultra high molecular weight polyethylene) with melting temperature of at least 50 °C higher than the maximum operating temperature described below, suitable for low temperatures outside the scope of EN 1337-2 with improved wear resistance and load-bearing capacity, is used for the sliding surfaces of the bearing.

Sliding surfaces with a diameter of the circumscribing circle of special sliding material sheets made of UHMWPE less than 75 mm or greater than 3000 mm, or with effective bearing temperatures less than -50 °C or greater than +80 °C, are outside the scope of this European Technical Assessment. Operating bearing temperatures above 48 °C are limited to short periods as due to climate temperatures changes. If composite material is used in guides the maximum operating bearing 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.

Bearings with an included angle $2\,\theta > 60°$ for spherical and $2\,\theta > 75°$ respectively for cylindrical bearings are beyond the scope of this European Technical Assessment.

The combination of materials used are given in Table 1 of this ETA.

Table 1: Combination of materials for permanent applications as sliding surfaces for spherical and cylindrical bearings with special sliding material made of UHMWPE ROBO®SLIDE L2

Plane surface		Curved surface		Guides	
dimpled ROBO®SLIDE L2	austenitic steel	dimpled ROBO®SLIDE L2	austenitic steel	undimpled ROBO®SLIDE L2	austenitic steel
			hard chromium	CM1	
				CM2	

The mating surfaces are made of either austenitic steel in accordance with clause 5.4 of EN 1337-2, or hard chromium plating in accordance with clause 5.5 of EN 1337-2.

The ferrous materials used for backing plates of the sliding surfaces are in accordance with EN 1337-2, clause 5.6.

Attachment of sliding materials in accordance with clause 7.2 of EN 1337-2.

Instead of PTFE according to EN 1337-2, referred to in EN 1337-7, the specified ROBO®SLIDE L2 is used as sliding material.

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

mageba RESTON®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.

mageba RESTON®Spherical and Cylindrical Bearings with special sliding material made of UHMWPE ROBO®SLIDE L2 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 in-duce fast sliding displacements in bearings, e.g. in bridges for high speed railways, as well as for regions with permanently low temperatures.

mageba RESTON®Spherical and Cylindrical Bearing is mainly used in concrete, steel and composite structures.

It is the responsibility of the manufacturer to ensure that each delivery contains proper information for the use of mageba RESTON®Spherical and Cylindrical Bearings including general guidance on the basis of the European Technical Assessment.

The verifications and assessment methods on which this European Technical Assessment is based lead to the assumption of a working life of the mageba RESTON®Spherical and Cylindrical Bearings of 50 years, depending on the accumulated total sliding path assessed according to clause 3.1.1 of this ETA, and provided that mageba RESTON®Spherical and Cylindrical Bearings are subject to appropriate use and maintenance. The working life of the bearing is reduced to 10 years, if in bearing's guides the composite materials according to EN 1337-2 are used instead of the special sliding material made of UHMWPE ROBO®SLIDE L2.

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

3.1 Mechanical resistance and stability (BWR 1)

3.1.1 mageba RESTON®Spherical and Cylindrical Bearings with special sliding material made of UHMWPE ROBO®SLIDE L2

Essential characteristic	Method of assessment	Performance
Load bearing capacity	EAD, Clause 2.2.1	Characteristic compressive strengths f_k for all mating partners according to Table 1: See Annex D, Table D.1
Rotation capability	EAD, Clause 2.2.2	Total rotation capability (see Annex F): 10.000 m of accumulated slide path in curved sliding surfaces for all mating partner according to Table 1
Displacement capacity	EAD, Clause 2.2.3	Total displacement capacity 50.000 m of accumulated slide path in flat sliding surfaces for mating partner austenitic steel 10.000 m of accumulated slide path in guides for mating partner austenitic steel
Durability aspects	EAD, Clause 2.2.4	Durable Protective coating systems of ferrous materials: Durability class “high” in accordance with EN ISO 12944-5, 4 Corrosivity category C5 C4 for locations protected from environmental factors (interior)
Load bearing capacity (of the sliding element)	EAD, Clause 2.2.5	Material combinations according to Table 1 of this ETA: See Annex D
Coefficient of friction (of the sliding element)	EAD, Clause 2.2.6	Sliding elements combined with dimpled and lubricated special sliding material-sheets: According Annex B Guides: According Annex B
Durability aspects (of the sliding element)	EAD, Clause 2.2.7	Durable

3.1.2 sliding material material made of UHMWPE ROBO®SLIDE L2

Essential characteristic	Method of assessment	Performance
Material properties according to Table C.1, Annex C of this of this ETA	EAD, Clause 2.2.8	see Annex D
Compressive strength of special sliding material	EAD, Clause 2.2.9	see Annex D
Load – deformation behaviour of special sliding material: Stiffness coefficient, modulus of elasticity	EAD, Clause 2.2.10	Stiffness coefficient $k = (\sigma \text{ [MPa]} - 45)/78.5$ Modulus of elasticity E_{tp} = 900 [MPa]
Load – deformation behaviour of special sliding material: Protrusion after loading [mm]	EAD, Clause 2.2.10	Laid down in the technical documentation deposited with the Technical Assessment Body
Load – deformation behaviour of special sliding material: Ratio tensile strength/yield strength		
Load – deformation behaviour of special sliding material: Ratio elongation at break/yield deformation		
Resistance to high temperatures	EAD, Clause 2.2.11	Resistant
Resistance of the special sliding material against chemical and environmental influences	EAD, Clause 2.2.12	Resistant

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

In accordance with EAD No. EAD 050004-00-0301 the applicable European legal act is: Decision 95/467/EC of the European Commission, amended by the Commission Decision 2001/596/EC and 2002/592/EC /EC(EU)].

The system to be applied is: 1

5 Technical details necessary for the implementation of the AVCP system, as provided for in the applicable EAD

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

Issued in Berlin on 14 April 2021 by Deutsches Institut für Bautechnik

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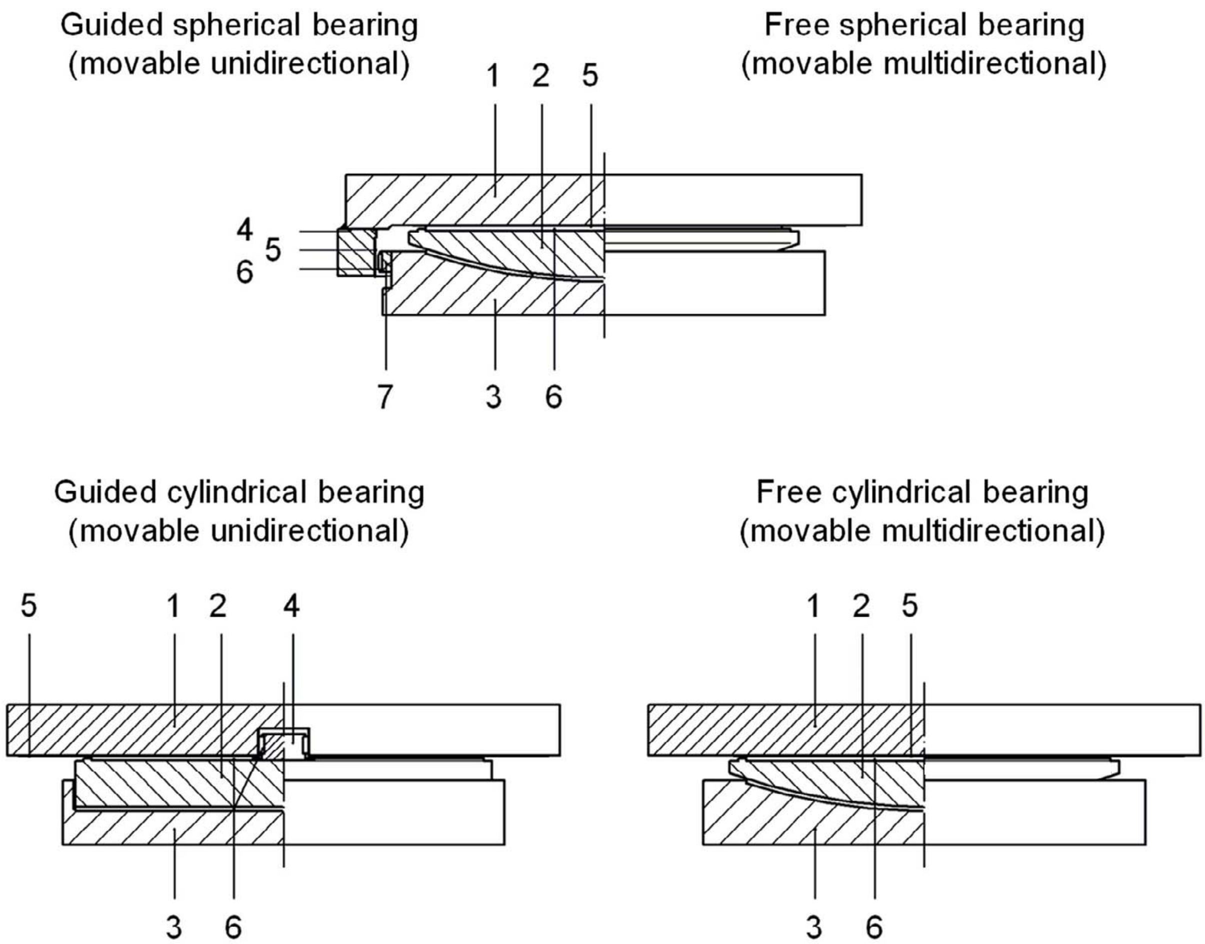
Head of Section

beglaubigt:
Hoppe

Deutsches Institut für Bautechnik DIBt

Annex A
Description of the product and its intended use

mageba RESTON® Spherical and Cylindrical Bearing



Key:

1 Sliding plate
2 Rotational element (convex plate)
3 Bottom plate (concave backing plate)
4 Guiding key
5 Austenitic steel sheet
6 ROBO®SLIDE L2 – sheet or strip
7 Rocker strip

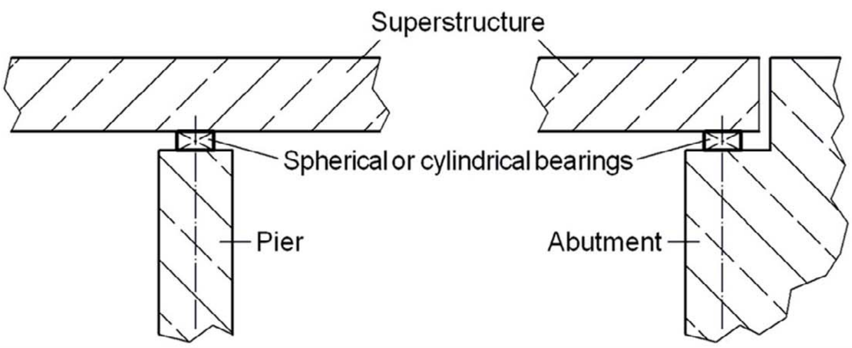
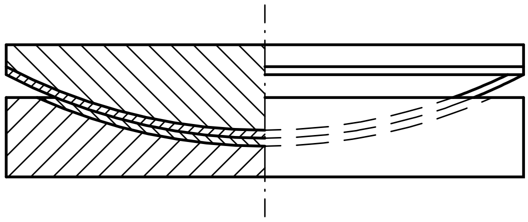


Figure A.1 - Assembly of guided and free movable mageba RESTON® Spherical and Cylindrical Bearings and its intended use (example) mageba RESTON® Spherical and Cylindrical Bearings consist of a backing plate with a convex spherical or cylindrical surface (rotational element) and a backing plate with a concave spherical or cylindrical surface between which a ROBO®SLIDE L2 sheet and the mating material form a curved sliding surface (see Figure A.2 and A.4). mageba RESTON® Spherical and Cylindrical Bearings are also used in combination with flat sliding elements and guides to form free sliding and guided bearings (see Figure A.3 a) to c) and A.5 a) to c)).

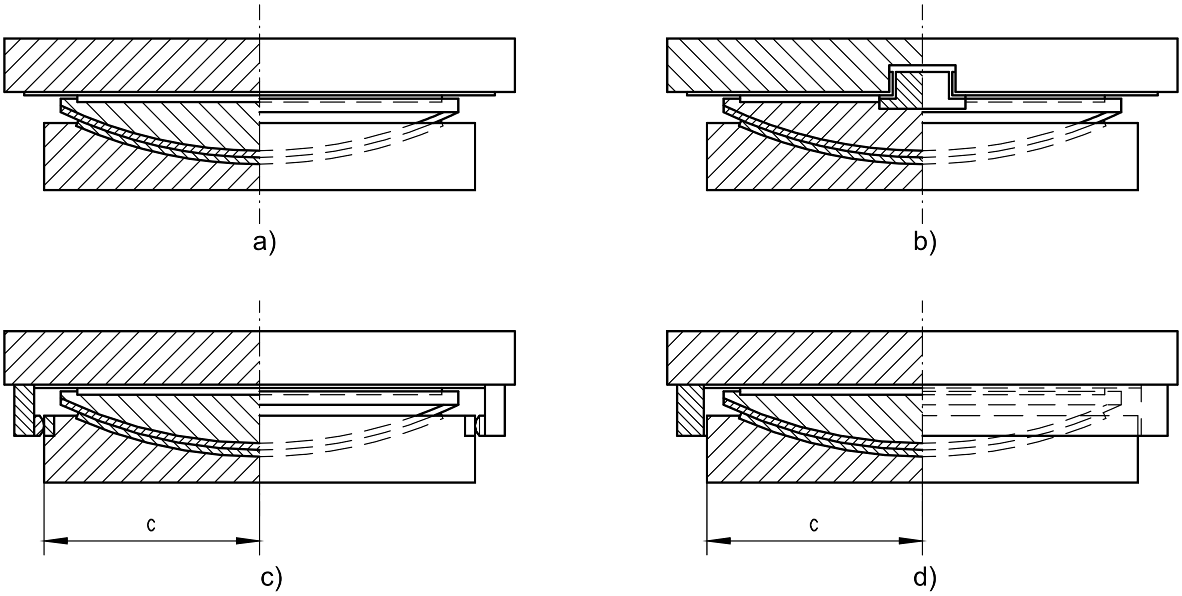
mageba RESTON® Spherical and Cylindrical Bearings combined with a flat sliding element can be used together with a restraining ring or keys to form fixed bearings (see Figure A.3 d)).

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 - mageba RESTON® Spherical Bearing



Key:

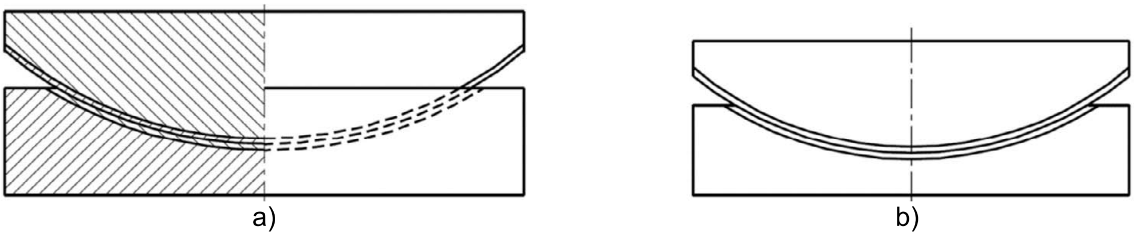
a) Free, for displacements in any direction (3.5)

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) or keys

Figure A.3 - mageba RESTON® Spherical Bearing combined with flat sliding elements

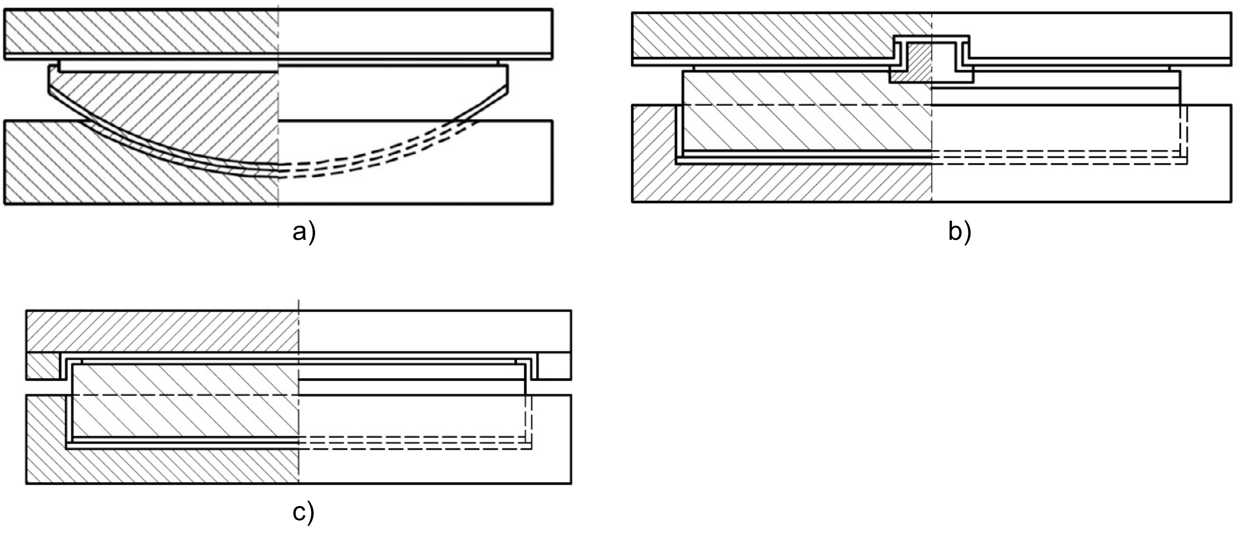


Key:

a) Fixed by end stops and sliding surface (7.1)

b) Without end stops for displacements in y-direction (7.2)

Figure A.4 - mageba RESTON® Cylindrical Bearing



Key:

a) Free for displacements in any direction (7.4)

b) Guided by an internal guide for displacements in one direction (7.3)

c) Guided by external guides for displacements in one direction

Figure A.5 - mageba RESTON® Cylindrical Bearing combined with flat sliding elements

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Annex B
Sliding friction coefficient

The following coefficients of friction μ_{max} shall be used for the design evaluation of the bearing and the structure in which it is incorporated. 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.

(a) Coefficient of friction at low temperatures

For sliding elements combined with dimpled and lubricated ROBO®SLIDE L2 sheets used in zones where the minimum effective bearing temperature doesn't fall below -35 °C, the coefficient of friction μ_{max} is determined as a function of the average pressure σ_{RSL} [MPa], as follows:

$$0.020 \leq \mu_{max} = \frac{1.6}{15+\sigma_{RSL}} \leq 0.08$$

For guides, the coefficient of friction shall be considered to be independent of contact pressure. The coefficient of friction μ_{max} = 0.10 shall be used.

(b) Coefficient of friction at very low temperatures

For sliding elements combined with dimpled and lubricated ROBO®SLIDE L2 sheets used in zones where the minimum effective bearing temperature does fall below -35 °C (down to -50 °C), the coefficient of friction μ_{max} is determined as a function of the average pressure σ_{RSL} [MPa], as follows:

$$0.027 \leq \mu_{max} = \frac{2.8}{30+\sigma_{RSL}} \leq 0.08$$

For guides, the coefficient of friction shall be considered to be independent of contact pressure. The coefficient of friction μ_{max} = 0.12 shall be used.

(c) Coefficient of friction at moderately low temperatures

For sliding elements combined with dimpled and lubricated ROBO®SLIDE L2 sheets used in zones where the minimum effective bearing temperature doesn't fall below -5 °C, the coefficient of friction μ_{max} is determined as a function of the average pressure σ_{RSL} [MPa], as follows:

$$0.015 \leq \mu_{max} = \frac{1.2}{15+\sigma_{RSL}} \leq 0.06$$

For guides the coefficient of friction shall be considered to be independent of contact pressure. The coefficient of friction μ_{max} = 0.07 shall be used.

For composite materials see 6.7 of EN 1337-2.

Annex C
Material properties

C.1 Special sliding material material made of UHMWPE ROBO®SLIDE L2

Table C.1: Material properties of special sliding material made of UHMWPE ROBO®SLIDE L2.

Property	Testing Standard
Young modulus	EN ISO 527-1 and -3
Yield strength	
Tensile strength	
Elongation at break	
Ball hardness	EN ISO 2039-1
Mass density	EN ISO 1183
Melting temperature and enthalpy	EN ISO 11357-5

Annex D

Load bearing capacity (Design verification for sliding surfaces)

D.1 General

The indication of product performance is based on the assessment under the conditions as given in clause 2.2.1 of the EAD.

The characteristic compressive strengths of ROBO®SLIDE L2 are given in Table D.1 and are valid for operating bearing temperatures up 80 °C. 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 the table D.1.

Table D.1: Characteristic compressive strengths f_k, $f_k(T_i)$ of ROBO®SLIDE L2

Max. operating bearing temperature T_{max}	≤ 35 °C	48 °C	60 °C	70 °C	80 °C
	f_k	$f_k(T_{48})$	$f_k(T_{60})$	$f_k(T_{70})$	$f_k(T_{80})$
		[MPa]			
Main sliding surfaces Dead loads and variable loads **Guides** Variable loads	180	135	110	90	70
Guides Dead loads; Effects of temperature, shrinkage and creep	60	45	37	30	23

For guides with composite material see EN 1337-2, sections 6.3 and 6.6.

D.2 Main sliding surfaces

When dimensioning main sliding surfaces, all the internal forces and moments due to actions and frictional resistance shall be considered. The design values of the action to be taken into account shall be determined in accordance with the basic design criteria given in EN 1337-1. Deformation of sliding materials shall not be used to accommodate rotations.

The following conditions shall be verified under a fundamental combination of actions:

$$N_{Sd} \leq f_d \cdot A_r = \frac{f_k}{\gamma_m} \cdot \lambda \cdot A$$

where

- N_{Sd} design axial force at ultimate limit state
- f_k characteristic value of compressive strength acc. Table D.1
- γ_m partial safety factor for materials in accordance with EN 1337-2
- A contact area of the flat sliding surface or the projection of curved surfaces
- λ coefficient acc. to Annex H
- A_r reduced contact area of the sliding surface whose centroid is the point through which N_{Sd} 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 uniform stress block (see Annex H). For guides, the eccentricity can be neglected.

NOTE: The γ_m value should be given in NDP (national determined parameter). In absence of NDP the recommended value is γ_m = 1.4.

For ROBO®SLIDE L2 sheets with smallest dimension L or a ≥ 100 mm (acc. to Fig. G.2) 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 or a smaller than 100 mm the area of the dimples shall be deducted from the gross area.

For the purpose of compressive stress evaluation the curved sliding surface shall be replaced by its projection on a plane surface as shown in Figure D.1.

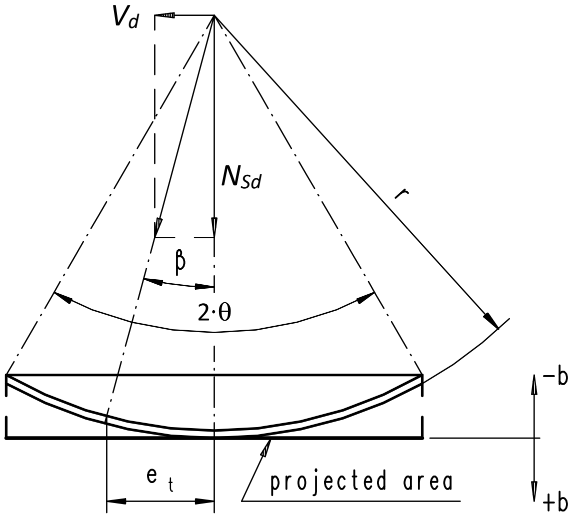


Figure D.1 -Evaluation scheme for the curved sliding surface (example)

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 of the axial force N_{Sd}.

Secondary effects due to the action of the restraints shall be also be considered.

Note: In Annex I, formulae are given for the evaluation of the eccentricities in the most common cases. Separation of sliding surfaces may lead to wear due to contamination and increased deformation due to lack of confinement of the ROBO®SLIDE L2 sheet. As this could endanger long term fitness for use, the achievement of the edge pressure $\sigma_{RSL} = 0$ is considered as serviceability limit state.

It shall be verified that $\sigma_{RSL} \geq 0$ 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 $\sigma_{RSL} \geq 0$ is satisfied when the total eccentricity falls within the kernel of the projected area.

For circular sheets this condition is satisfied when:

$$e_t \leq \frac{L}{8}$$

For rectangular sheets this condition is satisfied when:

$$e_a \leq \frac{a}{6} \cdot \left(1 - 6 \cdot \frac{e_b}{b}\right) \text{ and } e_b \leq \frac{b}{6} \cdot \left(1 - 6 \cdot \frac{e_a}{a}\right)$$

where is

L diameter

$a; b$ side lengths

$e_a; e_b$ eccentricity in respective direction

D.3 Guides

Guides may be used for resisting horizontal forces V_d due to variable and permanent actions. For the sliding strip, it shall be verified that

$$V_d \leq f_d \cdot A = \frac{f_k}{\gamma_m} \cdot A$$

The used parameters are defined in section D.2.

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:

$$c \leq 1.0\ mm + \frac{L[mm]}{1000}$$

where is

L length acc. to Fig. G.4

A typical example of the attachment of guides is shown in Figure A.1. In the design of the connection of the guide to the backing plate at ultimate limit state in accordance with EN 1993-1-1 resp. EN 1993-1-8, the effects of the horizontal force V_d, its induced moment and the friction forces shall be considered.

Where, under the design rotation about transverse axis, the differential deformation of the ROBO®SLIDE L2 sheet across its smallest dimension "a" would exceed 0.2 mm, a rotation element shall be included in the backing plate (see Figure 1, 3.3 of EN 1337-1). This condition shall be verified under the characteristic combination of actions.

D.4 Restraining rings

The indication of products performance is based on the assessment under the following conditions:
The free mageba RESTON® Spherical and Cylindrical Bearing may be fixed by a steel restraining ring. For the design and verifications, the rules for pot and piston of EN 1337-5 shall be applied.

D.5 Austenitic steel sheets

The minimum thickness of austenitic steel sheet shall be in accordance with Table D.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 ROBO®SLIDE L2 sheet.
- When attaching the austenitic steel sheet by screwing, counterpunched screwing or riveting, corrosion resistant fasteners compatible with the austenitic steel sheet shall be used for securing its edges. They shall be provided outside the area of contact with the ROBO®SLIDE L2 at all corners and along all edges sheet with the maximum spacing listed in Table D.3.

Table D.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
curved	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 D.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 E
Load - deformation behaviour

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

- The ROBO®SLIDE L2 and the mating sliding materials shall be supported by backing plates with plane or curved surfaces.
- The geometrical conditions are given in Annex J.

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

- the strength verification at the ultimate limit state 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 E.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 E.1) shall meet the following condition:

$$\Delta w \leq h\left(0.45 - 1.708k\sqrt{h/L}\right) \quad with \quad 0 \leq 1.708k \leq 1.0 \quad and \quad k = \frac{\sigma_{RSL}[MPa] - 45}{78.5}$$

where is

L, h see Annex G

σ_{RSL} average pressure in the sliding surface under the characteristic combination of actions

k stiffness coefficient (sliding material dependent)

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 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.

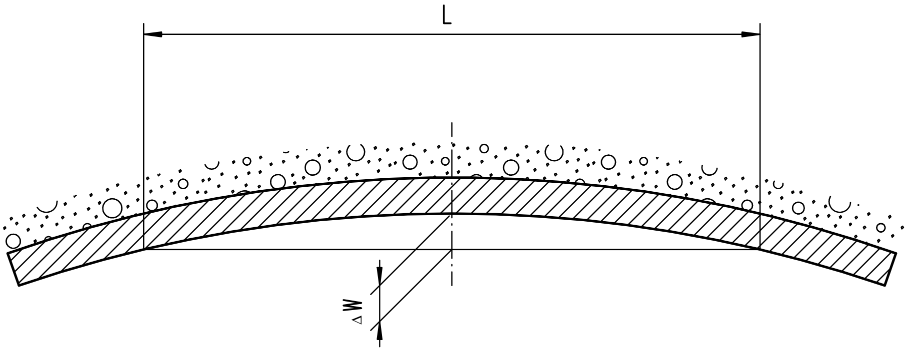


Figure E.1 - Deformation of backing plates

For steel and concrete, the design values of material properties in accordance with EN 1993-1-1 and EN 1992-1-1, respectively, apply.

In this model the following assumptions shall be made:

a) centric load;

b) notional design modulus of elasticity of recessed ROBO®SLIDE L2 E_{tp} = 900 MPa;

c) the total thickness t_{RSL} of ROBO®SLIDE L2 sheet;

d) notional design Poisson' s ratio of ROBO®SLIDE L2 = 0.44;

e) in the case of adjacent structural concrete members: 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 in clause J.5.

When using the method given in Annex J, a 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 C 25/30 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 C 20/25

0.67 when using steel S 235

0.60 when using both concrete C 20/25 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 neglected.

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

$$d_b = 1.13\ a_b$$

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 F
Rotation capability

The indication of product performance regarding the sliding surfaces is based on the assessment under conditions given in this European Technical Assessment.

Under the fundamental combination of actions it shall be shown that:

- the metallic surfacing mating with the ROBO®SLIDE L2 material shall completely cover the ROBO®SLIDE L2 sheet,
- there is no contact between the upper and the lower part of the bearing or any other metallic component (see EN 1337-1, Annex A).

Concerning the above conditions the increase of rotations, specified in EN 1337-1, clause 5.4, shall be taken into account.

For rotations about the movable axis of guided bearings see clause D.3.

For guides with composite material see EN 1337-2 section 6.3.

Annex G
Geometrical characteristics of ROBO®SLIDE L2 sheets

G.1 Details of recess and relief for sliding elements with ROBO®SLIDE L2

The performance characteristics of mageba RESTON® Spherical and Cylindrical Bearings given in this European Technical Assessment are valid only for the following geometrical conditions.

G.1.1 Recessed ROBO®SLIDE L2 sheets

The ROBO®SLIDE L2 sheets shall be recessed into a backing plate as shown in Figure G.1.

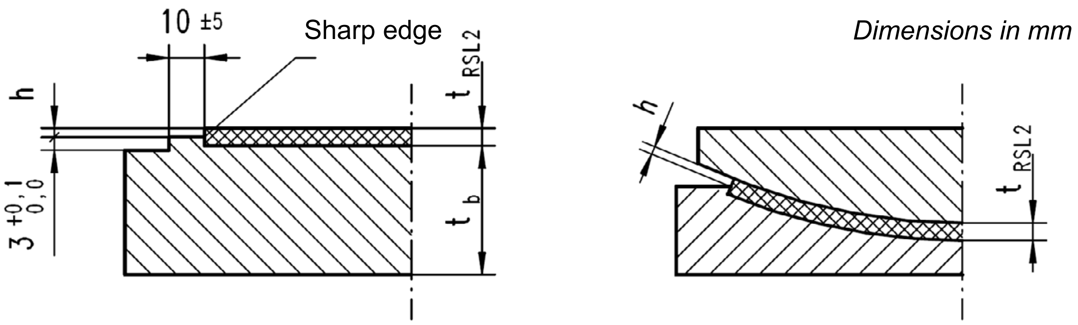


Figure G.1 – ROBO®SLIDE L2 Details (sections X-X as per Figure G.2)

Note: A fixed value for the depth of the recess is defined to facilitate the measurement of the protrusion h after installation.

The thickness t_{RSL} and protrusion h of the ROBO®SLIDE L2 sheet in the unloaded condition with corrosion protection shall meet the conditions given in Table G.1

Table G.1- Thickness t_{RSL} and protrusion h of the ROBO®SLIDE L2 sheet

Design values	Flat and curved sliding surfaces	Guides
Thickness t_{RSL} in mm	$2.65 \cdot h \leq t_{RSL} \leq 10.0$ with h in mm	$8.0 \leq t_{RSL} \leq 10.0$
Protrusion h in mm	$h = 2.50 + \frac{L}{3000}$ L diameter of the projected area of the ROBO®SLIDE L2 sheet in mm	$h = 3.0 \pm 0.2$

The tolerance on the protrusion h is $\pm$ 0.2 mm for $L \leq 1200$ mm and $\pm$ 0.3 mm for $L > 1200$ mm. The protrusion h 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_{RSL} of single ROBO®SLIDE L2 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.

G.1.2 Flat ROBO®SLIDE L2 sheets

Flat ROBO®SLIDE L2 sheets for the main sliding surface shall be circular for spherical bearings and rectangular for cylindrical bearings and may anyhow be subdivided into a maximum of four identical parts. Further sub-divisions are beyond the scope of this European Technical Assessment. The smallest dimension a shall not be less than 50 mm. The distance between individual ROBO®SLIDE L2 sheets shall not be greater than twice the thickness of the backing plate, of the ROBO®SLIDE L2 or the mating material, whichever is least. Figure G.2 shows examples of flat ROBO®SLIDE L2 sheets.

Dimensions in mm

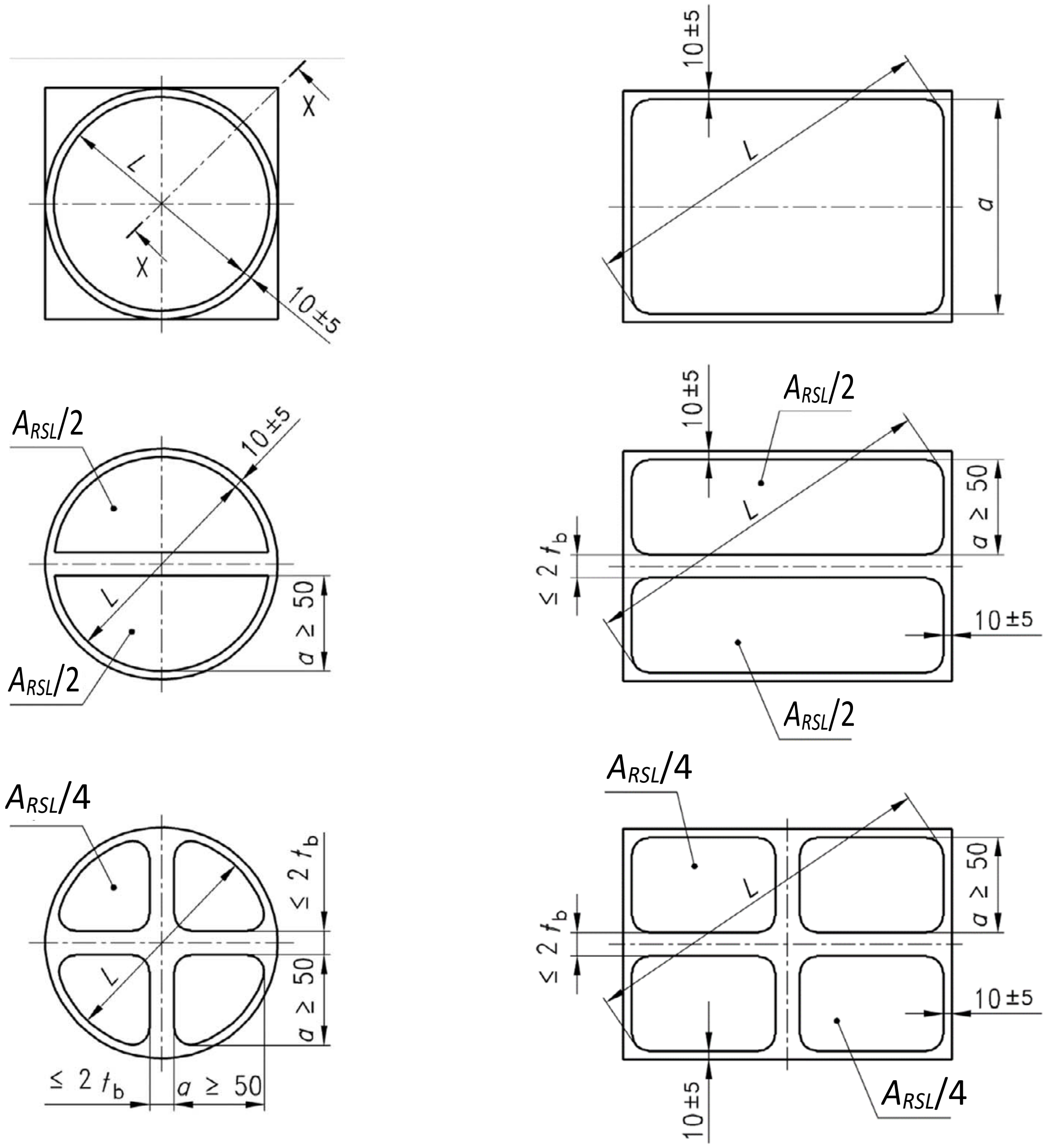


Figure G.2 - Examples of recessed flat ROBO®SLIDE L2 configurations

G.1.3 Curved ROBO®SLIDE L2 sheets

Curved ROBO®SLIDE L2 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 disc 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. Figure G.3 shows the configurations of curved ROBO®SLIDE L2 sheets for spherical sliding surfaces.

Dimensions in millimetres

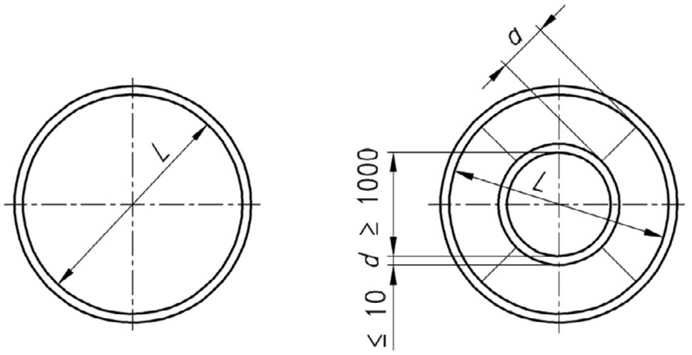


Figure G.3 - Subdivision of recessed ROBO®SLIDE L2 sheets for spherical sliding surfaces

Curved ROBO®SLIDE L2 sheets for cylindrical sliding surfaces shall be rectangular and may be subdivided into a maximum of two identical parts. EN 1337-2 Figure 4 shows the configurations of curved ROBO®SLIDE L2 sheets for cylindrical sliding surfaces.

G.1.4 ROBO®SLIDE L2 sheets for guides

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

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

shall be greater than 4 (see figure G.4). A_{RSL} is the compressed (undeformed) surface and u the perimeter of the ROBO®SLIDE L2 sheet.

Dimensions in millimetres

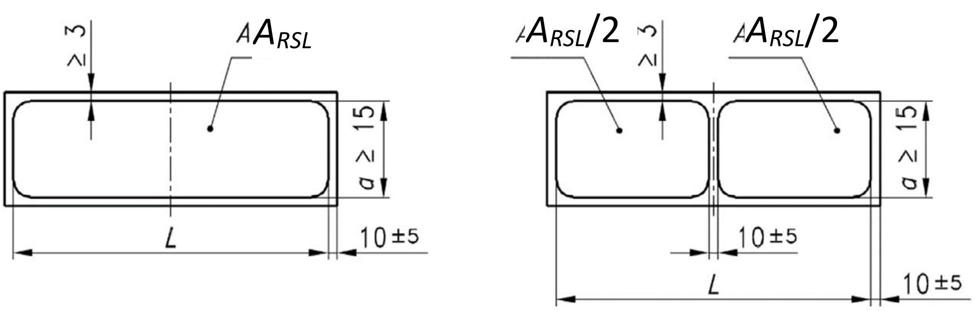
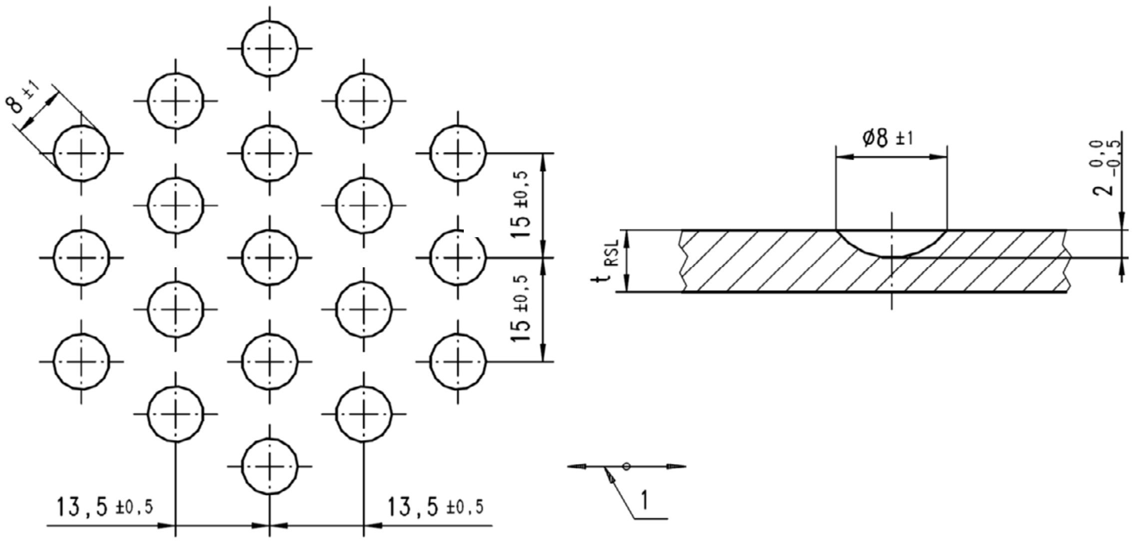


Figure G.4 - Examples of recessed ROBO®SLIDE L2 sheets for guides

G.2 Dimple pattern for sliding elements with ROBO®SLIDE L2

For pressures due to characteristic permanent actions exceeding G_k = 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 G.5.

Dimensions in millimetres



Key

1 main direction of sliding

Figure G.5 - Pattern of dimples in recessed ROBO®SLIDE L2 sheets

Annex H
Reduced area for sliding elements

H.1 General

This annex gives the values of the coefficient λ used in Annex D for the calculation of the reduced area A_r of curved and flat sliding surfaces. The reduced area A_r of sliding surfaces is defined as:

$$A_r = \lambda \cdot A$$

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 not larger than the design value of compressive resistance of ROBO®SLIDE L2 sheets $f_d = f_k / \gamma_m$ acc. to Annex D (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 ROBO®SLIDE L2 in contact with polished metal surfaces;
4) the adjacent backing plates are perfectly rigid.

H.2 Circular sliding elements

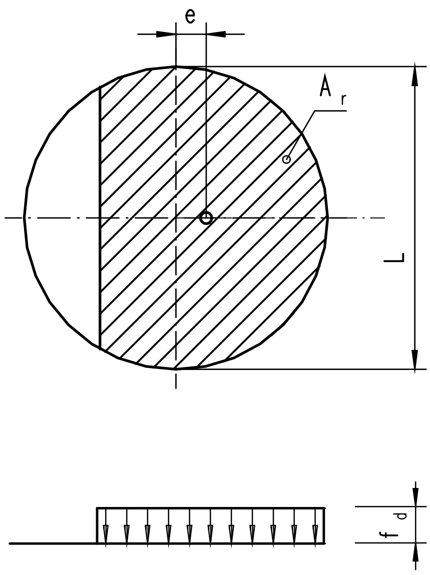


Figure H.1 - Reduced contact area A_r for circular sliding elements

where is

λ Coefficient given in Table G.1.

e the resultant load eccentricity

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

$$A = \pi \cdot L^2 / 4$$

As an alternative to the exact values given in Table H.1, the following approximate formula can be used for flat sliding surfaces of spherical bearings:

$$\lambda = 1 - 0.75\,\pi \cdot e / L$$

Table H.1 - Coefficient $\lambda = A_r / A$

e / *L*	flat	sliding surface							
		spherical				cylindrical			
		Θ							
		30°	25°	20°	10°	30°	25°	20°	10°
0.0000									
0.0500	0.990	0.991	0.991	0.990	0.990				
0.0100	0.979	0.982	0.981	0.980	0.979	0.984	0.983	0.981	0.980
0.0200	0.957	0.962	0.961	0.960	0.958	0.968	0.965	0.962	0.961
0.0300	0.934	0.942	0.940	0.938	0.936	0.951	0.947	0.943	0.941
0.0400	0.912	0.922	0.919	0.916	0.913	0.934	0.929	0.924	0.921
0.0500	0.888	0.901	0.898	0.894	0.890	0.917	0.911	0.905	0.901
0.0600	0.865	0.880	0.876	0.872	0.867	0.900	0.893	0.886	0.881
0.0700	0.841	0.858	0.853	0.849	0.844	0.882	0.874	0.866	0.862
0.0800	0.818	0.836	0.831	0.826	0.820	0.864	0.855	0.847	0.842
0.0900	0.793	0.814	0.808	0.803	0.796	0.846	0.837	0.827	0.822
0.1000	0.769	0.792	0.786	0.780	0.773	0.828	0.818	0.808	0.802
0.1100	0.745	0.770	0.763	0.757	0.749	0.809	0.799	0.788	0.782
0.1200	0.722	0.747	0.740	0.733	0.724	0.790	0.779	0.768	0.762
0.1255	0.709	0.736	0.729	0.722	0.712	0.780	0.769	0.758	0.752
0.1300	0.697	0.725	0.717	0.710	0.700	0.771	0.760	0.749	0.742
0.1400	0.673	0.702	0.693	0.686	0.676	0.752	0.740	0.729	0.722
0.1500	0.649	0.680	0.670	0.663	0.653	0.733	0.721	0.709	0.702
0.1600	0.625	0.657	0.647	0.639	0.628	0.713	0.701	0.689	0.682
0.1700	0.601	0.635	0.624	0.616	0.604	0.693	0.681	0.669	0.662
0.1800	0.577	0.612	0.601	0.592	0.581	0.673	0.661	0.649	0.642
0.1900	0.552	0.590	0.578	0.569	0.557	0.653	0.641	0.629	0.622
0.2000	0.529	0.567	0.556	0.546	0.533	0.633	0.621	0.609	0.602
0.2100	0.506	0.545	0.533	0.523	0.510	0.612	0.600	0.589	0.582
0.2155	0.500	0.541	0.529	0.518		0.602	0.590	0.579	0.572
0.2200	0.482	0.523	0.511	0.500		0.592	0.580	0.569	0.562
0.2300	0.458	0.501				0.571	0.559	0.548	0.542
0.2400	0.435					0.550	0.539	0.528	0.522
0.2500	0.412					0.529	0.518	0.508	0.502
NOTE: Intermediate values may be obtained by linear interpolation									

Annex I

Method for calculation the eccentricities in mageba RESTON® Spherical and Cylindrical Bearings

I.1 General

Frictional forces, forces from applied horizontal loads and the rotated condition of the bearing produce eccentricity of the axial force N_{Sd}, which is used in the verification of ROBO®SLIDE L2 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.

I.2 Friction resistance

I.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 more surfaces, the associated eccentricity e_1 is:

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

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

I.2.2 Sliding surfaces with external guides and restraining rings

For the spherical and cylindrical bearings of the type shown by Figures A.3 c) and d) and A.5 c), rotational movements produce an eccentricity which affects only the adjacent structural members (i.e. plinth, beam etc.) and the anchoring devices, where:

$$e_2 = \frac{V_d}{N_{sd}} \cdot \mu_{max} \cdot c$$

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.

I.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. At any rate, this eccentricity acts nonetheless in the opposite direction to that given in Annex D. The occurrence of e_3 depends on whether the curved ROBO®SLIDE L2 sheet is either attached to the convex or concave backing plate and whether the value α is greater or less than μ_{max} as well as on whether the bearing clearance performs its function effectively in the case of guided bearings. For the type of bearings equipped with only one sliding surface, e_3 occurs only in the curved ROBO®SLIDE L2 sheet and, furthermore, only when said sheet is attached to the convex backing plate.

I.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:

$$e_4 = \frac{V_d}{N_{sd}} \cdot (r + b)$$

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 J
Backing plates

J.1 General

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

Dimensions in mm

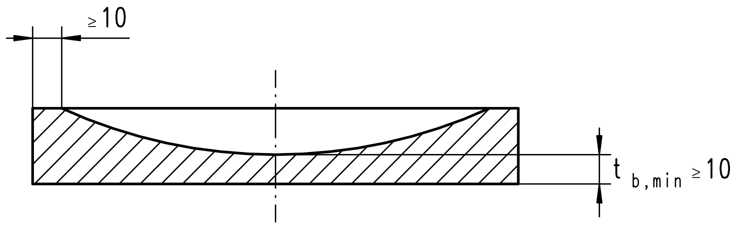


Figure J.1 – Dimensional limitations of a backing plate with a concave surface

J.2 ROBO®SLIDE L2 confinement

The shoulders of the recess shall be sharp and rectangular to restrict the flow of ROBO®SLIDE L2 (see Figure G.1). 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 ROBO®SLIDE L2 sheet in accordance with Annex G. In principle the ROBO®SLIDE L2 sheet shall fit the recess without clearance. Intermittent gaps between the edge of the ROBO®SLIDE L2 sheet and the recess shall not exceed the values given in Table J.1 at room temperature.

Table J.1 - Fit of confined ROBO®SLIDE L2 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

where is

L Diameter of the circumscribing circle [mm] according to Annex G

For $L > 1500$ [mm] the gaps are limited to L [mm] / 1250.

J.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 $0.0003 \cdot L$ or 0.2 [mm], whichever is greater.

J.4 Fit of sliding surfaces

The maximum deviation Δz from theoretical plane or curved surface within the area of the mating ROBO®SLIDE L2 sheet shall not exceed $0.0003 \cdot L$ or 0.2 [mm], whichever is greater.

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

For circular steel plates attached to structural concrete members of strength class C 20/25 according to EN 206-1, 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

$$k_c = 1.1 + (1.7 - 0.85 \cdot d_b / L) \cdot (2 - d_b / L_0) \qquad \text{if } L_0 \le d_b \le 2 \cdot L_0$$

$$k_c = 1.1 \qquad \text{if } d_b > 2 \cdot L_0$$

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

$$k_b = 0.30 + 0.55 \cdot d_b / L$$

$$\alpha_b = \left(\frac{L}{L + 2 \cdot t_b}\right)^2 \cdot \left(\frac{3 \cdot L_0}{d_b}\right)^{0.4}$$

where is

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 ROBO®SLIDE L2 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 and rectangular plates if they are idealised to circular plates of diameter

$d_b = 1.13\, a_b$

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