

Structural bearings —

Part 3: Elastomeric bearings

The European Standard EN 1337-3:2005 has the status of a British Standard

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National foreword

This British Standard was published by BSI. It is the UK implementation of EN 1337-3:2005. It partially supersedes BS 5400-9-1:1983 and BS 5400-9-2:1983 which will remain current until the remaining parts of the BS EN 1337 series have been published, the last part being Part 8.

The UK participation in its preparation was entrusted to Technical Committee B/522, Structural bearings.

A list of organizations represented on B/522 can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Foreword

This document (EN 1337-3:2005) has been prepared by Technical Committee CEN/TC 167 “Structural bearings”, the secretariat of which is held by UNI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by September 2005, and conflicting national standards shall be withdrawn at the latest by December 2006.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

For relationship with EU Directive(s), see informative Annex ZA, which is an integral part of this document.

This European Standard EN 1337: “Structural bearings” consists of the following 11 parts:

Part 1	General design rules
Part 2	Sliding elements
Part 3	Elastomeric bearings
Part 4	Roller bearings
Part 5	Pot bearings
Part 6	Rocker bearings
Part 7	Spherical and cylindrical PTFE bearings
Part 8	Guide bearings and restrain bearings
Part 9	Protection
Part 10	Inspection and maintenance
Part 11	Transport, storage, and installation

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

1 Scope

This part of EN 1337 applies to elastomeric bearings with or without complementary bearing devices to extend their field of use such as flat sliding elements covered by EN 1337-2 or sliding surface described in 4.4.4, as used in bridge structures or any other structure with comparable support conditions.

This part of EN 1337 applies to elastomeric bearings with dimensions in plan up to (1200 x 1200) mm and does not cover elastomeric bearings made with other elastomers materials than those specified in 4.4.1. It applies to laminated bearings types A, B, C, laminated sliding bearings types E and D, plain pad and strip bearings type F.

This part deals with bearings for use in operating temperatures ranging from – 25 °C to + 50 °C and for short periods up to + 70 °C.

It is recognised that the air temperature in some regions of Northern Europe is lower than –25 °C.

In this case of very low operating temperature (down to – 40 °C), it is essential that bearing characteristics comply also with the shear modulus at very low temperature (see 4.3.1.3. and annex F)

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 1337-1:2000, *Structural bearings - Part 1: General design rules.*

EN 1337-2:2004, *Structural bearings - Part 2: Sliding elements.*

prEN 1337-8, *Structural bearings - Part 8: Guide bearings and restrain bearings.*

EN 1337-9:1997, *Structural bearings - Part 9: Protection.*

EN 1337-10; *Structural Bearings - Part 10: Inspection and maintenance.*

EN 1337-11; *Structural bearings - Part 11: Transport, storage and installation.*

EN 10025-1, *Hot rolled products of structural steels - Part 1: General technical delivery conditions.*

EN 10025-2, *Hot rolled products of structural steels - Part 2: Technical delivery conditions for non-alloy structural steels*

ISO 34-1, *Rubber, vulcanized or thermoplastic - Determination of tear strength - Part 1: Trouser, angle and crescent test pieces.*

ISO 37, *Rubber, vulcanized or thermoplastic - Determination of tensile stress-strain properties.*

ISO 48, *Rubber, vulcanized or thermoplastic - Determination of hardness (hardness between 10 IRHD and 100 IRHD).*

ISO 188, *Rubber, vulcanized or thermoplastic - Accelerated ageing and heat resistance tests.*

ISO 815, *Rubber, vulcanized or thermoplastic - Determination of compression set at ambient, elevated or low temperatures.*

ISO 1431-1, *Rubber, vulcanized or thermoplastic - Resistance to ozone cracking - Part 1: Static strain testing.*

3 Terms, definitions, symbols and abbreviations

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 1337-1:2000 and the following apply.

3.1.1

batch

individual mix or blend of mixes of elastomer, when used for bearing production or a number of identical components produced at the same machine setting

3.1.2

elastomer

macromolecular material, which returns to approximately its initial dimensions and shape after substantial deformation by a weak stress and release of stress. In this part of the standard it defines the compound that will be used for the production of a rubber part or parts.

3.1.3

elastomeric bearing

bearing comprising a block of vulcanised elastomer that may be reinforced with one or more steel plates

3.1.4

laminated bearing

elastomeric bearing reinforced internally with one or more steel plates, chemically bonded during vulcanisation

3.1.5

plain pad bearing

elastomeric bearing consisting of a solid block of vulcanised elastomer without internal cavities

3.1.6

sliding elastomeric bearing

laminated bearing with a PTFE sheet, at top surface, which may be vulcanised directly onto the outer layer of elastomer or fixed to a steel plate, in contact with a sliding plate

3.1.7

sliding plate

component which bears on and is immediately adjacent to the top sliding surface of a bearing. It can be:

- a) a single piece of austenitic steel,
- b) a thin plate of austenitic steel fixed to a mild steel supporting plate,
- c) a thin plate of austenitic steel bonded to an elastomeric interlayer which is vulcanised to a mild steel supporting plate.

3.1.8

strip bearing

plain pad bearing for which the length is at least ten times the width

3.1.9

top sliding surface

polytetrafluoroethylene surface vulcanised on to an elastomeric bearing, in contact with the sliding plate which allows relative translatory displacement

3.2 Symbols

For the purposes of this document, the following symbols apply.

3.2.1 Latin upper case letters

A	Overall plan area of elastomeric bearing	 Documents Document Sharing Hub
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A'	Effective plan area of laminated bearing (area of the steel reinforcing plates) mm ²
A_r	Reduced effective plan area of elastomeric bearing mm ²
C_c	Compressive stiffness of a bearing N/mm
D	Overall diameter of circular bearing mm
D'	Effective diameter of circular laminated bearing mm
E	Modulus of elasticity MPa
E_b	Bulk modulus MPa
E_{cs}	Intersecting compression modulus MPa
E_d	Design load effects
F_{xd}, V_{yd}	Horizontal design forces N: kN
F_{xy}	Maximum resultant horizontal force obtained by vectorial addition of v_x and v_y N: kN
F_{zd}	Vertical design force N: kN
G	Nominal value of conventional shear modulus of elastomeric bearing MPa
G_{dyn}	Conventional shear modulus of elastomeric bearing under dynamic actions MPa
G_e	Shear modulus of elastomer MPa
G_g	Conventional shear modulus of elastomeric bearing determined by testing MPa
K_{ce}	Factor for strain due to compressive load for elliptical bearing
K_{de}	Factor for vertical deflection for load for elliptical bearing
K_{se}	Factor for restoring moment for elliptical bearing
K_f	Friction factor
K_h	Factor for induced tensile stresses in reinforcing plate
K_L	Type loading factor
K_m	Moment factor
K_p	Stress correction factor for the steel reinforcing plates
K_r	Rotation factor
K_s	Factor for restoring moment
M_e	Experimental value of restoring moment N x mm: kN x m
M_d	Design value of restoring moment N x mm: kN x m
R_d	Design value of resistance

R_{xy}	Resultant of the forces resisting to translatory movement
S	Shape factor
S_1	Shape factor for the thickest layers
S_d	Design value of an internal force or moment of a respective vector of several internal forces or moments
T_o	Average total initial thickness of bearing ignoring top and bottom covers mm
T_b	Total nominal thickness of bearing mm
T_{bo}	Mean total initial thickness of bearing mm
T_e	Total nominal thickness of elastomer mm
T_q	The average total initial thickness of elastomer in shear, including the top and bottom covers when these are not restrained for shearing. mm

3.2.2 Latin lower case letters

a	Overall width of bearing (shorter dimension of rectangular bearing) mm
a_e	Minor axis of elliptic bearing
a'	Effective width of laminated bearing (width of the steel reinforcing plates) mm
b	Overall length of a bearing (longer dimension of a rectangular bearing) mm
b_e	Major axis of elliptical bearing
b'	Effective length of a laminated bearing (length of the steel reinforcing plates) mm
c	compression stiffness N/mm
f_y	Yield stress of steel N/mm ²
l_p	Force free perimeter of elastomeric bearing
n	Number of elastomer layers
t	Thickness of plain pad or strip bearing mm
t_e	Effective thickness of elastomer in compression mm
t_i	Thickness of an individual elastomer layer in a laminated bearing mm
t_p	Thickness of PTFE sheet mm
t_s	Thickness of steel reinforcing plate mm
t_{so}	Thickness of outer steel reinforcing plate mm
v_{cd}	Total vertical deflection mm
v_x	Maximum horizontal relative displacement in direction of dimension a mm
v_y	Maximum horizontal relative displacement in direction of dimension b mm
v_z	Vertical movement/deflection mm
v_{xy}	Maximum resultant horizontal relative displacement obtained by vectorial addition of v_x and v_y mm

3.2.3 Greek letters

α	Angular rotation of a bearing rad
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α_a	Angular rotation across width a of a rectangular bearing rad
α_b	Angular rotation across length b of a rectangular bearing rad
α_{ab}	Resultant angular rotation across width a and length b of a rectangular bearing rad
α_d	Angular rotation across the diameter D of a circular bearing rad
γ_m	Partial safety factor for the resistance
δ	Vertical deflection of individual elastomer layer mm
Σ	Sum of values
$\epsilon_{\alpha,d}$	Design strain in elastomer slab due to angular rotation
$\epsilon_{c,d}$	Design strain in elastomer slab due to compressive loads
$\epsilon_{q,d}$	Design shear strain in elastomer slab due to translatory movements
$\epsilon_{t,d}$	Total nominal design strain in elastomer slab
ϵ_z	Compressive strain of a bearing
μ_d	Design friction coefficient
μ_e	Friction coefficient for elastomer
σ_c	Compressive stress MPa
σ_m	Average of the compressive stress MPa
σ_s	Tensile stress in steel MPa
τ	Shear stress MPa

3.2.4 Subscripts

d	Design
dyn	Dynamic
k	Characteristic
max	Maximum
min	Minimum
t	Total
u	At ultimate limit state

3.3 Abbreviations

For the purposes of this document, the following abbreviations apply.

CR	Polychloroprene Rubber
NR	Natural Rubber
pphm	Parts per hundred million by volume
PTFE	Polytetrafluoroethylene
SLS	Serviceability Limit State
ULS	Ultimate Limit State

4 Requirements

4.1 General

The level of quality required for an Elastomeric Bearing is mainly defined in terms of product performance through the limiting values and quantifiable characteristics by reference to complete bearings.

The specifications for materials from which the product shall be manufactured complement the essential requirements.

To ensure appropriate levels of performance, it is also necessary to refer to the following parts of EN 1337:

- part 1 General design rules
- part 2 Sliding elements
- part 8 Guide bearings and restrain bearings
- part 9 Protection
- part 10 Inspection and maintenance
- part 11 Transport, storage, and installation

4.2 Functional requirements

Elastomeric bearings shall be designed and manufactured to accommodate translational movements in any direction and rotational movements about any axis by elastic deformation, in order to transmit in a correct manner, from one structural component to another, the design forces and accommodate the design movements derived from the structural analysis.

They can be combined with complementary bearing devices to extend their field of use, such as a sliding system, either temporary or permanent, or a constraining system in any direction.

Elastomeric bearings shall function correctly when they are subject to normal environmental conditions and maintenance, during an economically reasonable designed working life. Where exceptional environmental and application conditions are encountered additional precautions shall be taken (see EN 1337-9). The conditions shall then be precisely defined.

Although elastomeric bearings are designed to accommodate shear movements, they shall not be used to provide permanent resistance to a constantly applied external shear force.

4.3 Performance requirements for complete bearings

This section defines all quantifiable characteristics of complete bearings. It specifies also the type of test either type test or routine test, their frequency and the type of the samples (see clause 8).

NOTE The laboratory temperature range for testing has been enlarged from that normally specified, taking into account that the properties of elastomers suitable for bearings do not change significantly between 15 °C and 30 °C. In the event of a conflict between test results from two different laboratories the range 23 °C ± 2 °C should take precedence.

4.3.1 Shear modulus

The shear modulus (G_g) is the apparent "conventional shear modulus" of elastomeric bearings determined by testing at different temperatures or after ageing in accordance with the method specified in annex F (normative).

NOTE See informative annex D.

4.3.1.1 Shear modulus at nominal temperature

At a nominal temperature of $23\text{ °C} \pm 2\text{ °C}$ the value G_g of the conventional shear modulus shall comply with one of the values given hereafter:

$$G_g^* = 0,7\text{ MPa} \quad G_g = 0,9\text{ MPa} \quad G_g^* = 1,15\text{ MPa}$$

*Only if specified by the structure designer.

The test shall be performed for type tests at a temperature of $23\text{ °C} \pm 2\text{ °C}$, and for routine test at a temperature of $23\text{ °C} \pm 5\text{ °C}$.

- Requirements: The value of shear modulus G_g obtained by test shall comply with the following tolerances:

$$G_g = 0,9\text{ MPa} \pm 0,15\text{ MPa}$$

$$G_g^* = 0,7\text{ MPa} \pm 0,10\text{ MPa}$$

$$G_g^* = 1,15\text{ MPa} \pm 0,20\text{ MPa}$$

*Only if specified by the structure designer.

The sample surfaces shall be free from voids, cracks or faults for example arising from moulding or bonding defects.

- Testing conditions: The tests shall be performed not earlier than one day after vulcanisation.

4.3.1.2 Shear modulus at low temperature

At low temperature the conventional shear modulus shall comply with the following requirement:

$$G_{g \text{ low temperature}} \leq 3 G_g$$

The test shall be performed as a type test.

- Samples conditioning: The uncompressed bearing shall be air-cooled in a chamber at

$-25\text{ °C} \pm 2\text{ °C}$ for 7 days.

- It shall be supported in such a way as to allow free circulation of air around it.

- Testing conditions: - In a chamber at $-25\text{ °C} \pm 2\text{ °C}$ or

- At a maximum temperature of 25 °C provided that, during the test, the edge surface temperature shall not be higher than -18 °C .

- Mean pressure: 6 MPa.

4.3.1.3 Shear modulus at very low temperature

At very low temperature the conventional shear modulus shall comply with the following requirement:

$$G_{g \text{ very low temperature}} \leq 3 G_g$$

The test shall be performed as a type test.

- Samples conditioning: The uncompressed bearing shall be air-cooled in a chamber at $-40\text{ °C} \pm 3\text{ °C}$ for 7 days.
 - It shall be supported in such a way as to allow free circulation of air around it.
- Testing conditions:
 - In a chamber at $-40\text{ °C} \pm 3\text{ °C}$ or
 - At a maximum temperature of 25 °C provided that, during the test, the edge surface temperature shall not be higher than -18 °C .
 - Mean pressure : 6 MPa.

4.3.1.4 Shear modulus after ageing (3 days at 70 °C)

This test determines the variation of conventional shear modulus after accelerated ageing and shall be performed as a type test.

$$G_g \text{ after ageing} \leq G_g \text{ before ageing} + 0,15 \text{ MPa}$$

- Conditioning of the samples : the uncompressed bearing shall be stored in a heated chamber at :
 - $70\text{ °C} \pm 2\text{ °C}$ for 3 days
 - It shall be supported in such a way as to allow free circulation of air around it.
- Testing conditions: The test shall be performed at laboratory temperature ($23\text{ °C} \pm 5\text{ °C}$), not earlier than 2 days after the end of the ageing procedure.

4.3.2 Shear bond strength

The shear bond strength of elastomeric bearings shall determined in accordance with the method specified in annex G.

4.3.2.1 Shear bond strength at ambient temperature

At a temperature of $23\text{ °C} \pm 5\text{ °C}$ the shear bond test shall be performed as a type and a routine test.

- Requirements : The slope of the force-deflection curve shall not show a maximum or a minimum value up to the maximum shear strain of 2. At maximum strain the edge of the bearing shall be free from splitting within the rubber due to moulding or bonding defects.
- Testing conditions : Mean pressure : 12 MPa

4.3.2.2 Shear bond strength after ageing (3 days at 70 °C)

After ageing the shear bond test shall be performed as a type test.

- Requirements: as in 4.3.2.1.
- Conditioning of the samples and testing conditions: as in 4.3.1.4.

4.3.3 Compression stiffness

The compression stiffness of elastomeric bearings shall be determined in accordance with the method specified in annex H.

For the type test, level 1 of the compressive test method is applicable.

For the routine test, level 2 of the compressive test method is applicable.

For a particular project when specified by the structure designer, level 3 of the compressive test method is applicable.

4.3.3.1 Type test (level 1 of testing method)

- Requirements:
 - The slope of the force-deflection curve shall not show a maximum or a minimum value of up to the maximum design load ($5 \cdot G \cdot A' \cdot S / 1,5$)
 - At the maximum load the edge of the bearing shall be free from splits within the rubber for example due to moulding or bonding defects.
 - No misplaced reinforcing plates.
 - The conventional intersecting modulus (E_{cs}) shall be recorded.
- Testing conditions : At ambient temperature: Conventional intersecting modulus (E_{cs}) shall be determined at $23 \text{ }^{\circ}\text{C} \pm 5 \text{ }^{\circ}\text{C}$ between 30 % and 100 % of the maximum load ($5 \cdot G \cdot A' \cdot S / 1,5$).

4.3.3.2 Routine test : Quick compressive test (level 2 of the testing method)

This test is normally made on bearings by the manufacturer, to check for misplaced reinforcing plates, bond failures at the steel/elastomer interface, surface defects and out of tolerance stiffness under the maximum load for the application.

- Requirements: There shall be no visual evidence of bond failure, misaligned reinforcing plates, or splits in the surface of the elastomer. The corrugations due to the restraining effects of the plates shall be uniform.
- Testing conditions: The serviceability limit state load specified, at ambient temperature ($23 \text{ }^{\circ}\text{C} \pm 5 \text{ }^{\circ}\text{C}$) is applied to the bearing and held constant during a visual examination for the above defects. Where defects are suspected they shall be proved by other appropriate tests.

During this test, the deflection between 30 % and 100 % of the maximum load for the application shall be recorded and used to check the consistency of the stiffness values.

4.3.3.3 Inspection under compressive load (level 3 of the testing method)

When specified, this test is carried out on every bearing as part of the normal production process. Its main objective is to eliminate by visual inspection poorly made bearings in a quick and efficient way.

- Requirements: There shall be no visual evidence of bond failure, misaligned reinforcing plates, or defects developing during testing in the surface of the elastomer under the maximum load for the application. The corrugations due to the restraining effects of the plates shall be uniform.
- Testing conditions: The serviceability limit state load is applied. The temperature of the room in which the bearings are tested shall not vary more than $10 \text{ }^{\circ}\text{C}$ throughout the test.

4.3.4 Resistance to repeated loading in compression

The resistance to repeated loading in compression of elastomeric bearings shall be determined in accordance with the method specified in annex I.

- Requirements: The intersecting compression modulus after dynamic fatigue shall be less than or equal to the intersecting modulus prior to dynamic fatigue + 12 %.

No faults accepted: bonding defects, cracks, etc.

- Testing conditions: At laboratory temperature $23\text{ °C} \pm 2\text{ °C}$. The temperature rise in the bearing during the test should not exceed: 42 °C and the frequency may be adjusted to achieve this requirement.

Numbers of cycles: 2 000 000

Frequency: < 3 Hz

During the test, the variation of stress shall be between the two following values:

Minimum mean pressure: 7,5 MPa

Maximum mean pressure: 25 MPa

NOTE It is essential to carry out the test at higher stresses than those which occur in practice, because the number of cycles is much less than expected during the life of bearing.

4.3.5 Static rotation capability

4.3.5.1 General

The static rotation capability of elastomeric bearings shall be determined on the base of the eccentric loading test and/or restoring moment, in accordance with test methods indicated in the following clauses.

The purpose of these tests is to determine the performance of elastomeric bearings under static rotation conditions. For most purposes the static rotation behaviour calculated from the equation in 5.3.3.6 and 5.3.3.7 is adequate, but if rotational performance is critical and the main reason for using the bearing is to provide rotation for elastomeric bearing type E and D a type test shall be carried out. Two aspects of rotational performance may be assessed, the maximum angle of rotation and the restoring moment exerted by the bearing on the structure. These two aspects can be determined respectively by the eccentric loading test or restoring moment test.

NOTE For a given bearing construction the manufacturer can only change the value of the shear modulus of the rubber to influence the rotational performance so it may be necessary to waive the requirements of 4.3.1 to achieve the desired performance. The consequence of such a change is that the vertical deflection (5.3.3.7.) will be affected.

4.3.5.2 Eccentric loading test

This test shall be performed to verify the maximum angle of rotation by determination of the area and mean pressure at the contact surface under imposed eccentricity or by determination of the maximum eccentricity to produce a specified contact area.

It shall be determined in accordance with the method specified in annex J.

- Requirements: Neither the uplift contact area, nor the mean contact pressure, shall exceed the values specified.

When no value has been specified the following requirement shall be satisfied:

No faults accepted (bonding defects, cracks, etc) under an angle of rotation of 0,025 rad and an eccentricity of 1/6th of the smaller plan dimension of the test piece.

- Testing conditions: At laboratory temperature ($23\text{ °C} \pm 2\text{ °C}$), the test is carried out with an experimental arrangement with known and low friction which permits rotation of the top surface relative to the bottom surface and loading bearing to the design value with a determined eccentricity or at different degrees of eccentricity.

4.3.5.3 Restoring moment test

The purpose of this test is to determine the experimental value of the restoring moment of a bearing.

It shall be determined in accordance with the method specified in annex K.

- Requirements: The experimental values of the restoring moment (M_e) shall not exceed the value agreed between the purchaser and the supplier
- Testing conditions: At laboratory temperature ($23\text{ °C} \pm 5\text{ °C}$), the test is carried out under a mean pressure of 7 MPa. A moment is applied repeatedly for 10 cycles at a frequency $\leq 0,03\text{ Hz}$ to produce the required rotation.

4.3.6 Ozone resistance

The ozone resistance of elastomeric bearings shall be determined in accordance with the method specified in annex L.

The purpose of this test is to determine the ozone resistance of a complete bearing under compression and shear deformation.

- Requirements: No cracks in rubber.
No cracks or bonding failure on the edge surface of the bearing.
- Testing conditions:

Mean pressure:	1,3 G·S
Shear deformation:	$v_x = 0,7 \cdot T_q$
Testing temperature:	$40\text{ °C} \pm 2\text{ °C}$
Ozone concentration:	NR : 25 pphm CR : 50 pphm
Testing time:	72 h

4.3.7 PTFE / elastomer shear bond strength

The PTFE/elastomer shear bond strength of elastomeric bearings shall be determined in accordance with the method specified in annex M.

The purpose of this test is to verify the correct bonding of the PTFE sheet of the sliding surface onto the external elastomer layer.

- Requirements: The slope of the force-deflection curve shall not show a maximum or a minimum value up to the maximum shear strain of 2. At maximum strain the PTFE / elastomer interfaces shall be free from bonding defects.
- Testing conditions: This test shall be performed at a temperature of $23\text{ °C} \pm 5\text{ °C}$.

Mean pressure: 6 MPa

4.4 Material properties

4.4.1 General

The elastomer used in the manufacture of Elastomeric Bearings should be specified in the project documentation as either natural rubber (NR) or chloroprene rubber (CR) as the raw polymer. Blending with up to 5 % of another polymer, which may be added to aid processing, is permitted. No reclaimed or ground vulcanised rubber shall be used.

NOTE Natural rubber bearings can be protected by a cover of polychloroprene, both parts being vulcanised simultaneously.

4.4.2 Physical and mechanical properties of elastomer

The physical and mechanical properties of the elastomer shall comply with the requirements given in Table 1, depending upon the raw polymer used. In case of a natural rubber bearing having a polychloroprene cover, the natural rubber does not have to be tested for ozone resistance.

The polychloroprene compound for the cover shall meet the requirements for polychloroprene and the core shall meet the requirements for NR, except for ozone resistance.

The frequency of the tests is given in clause 8.

The specifications are given for moulded test pieces or samples taken from complete finished bearings. In this case they shall be taken from the top and bottom surfaces or first internal layer, and from the internal layer at the centre of the bearing.

Table 1 — Physical and mechanical properties of elastomer

Characteristics	Requirements			Test methods
G Modulus (MPa)	0,7	0,9^a	1,15	
Tensile strength (MPa) Moulded Test Piece Test Piece from Bearing	≥ 16 ≥ 14	≥ 16 ≥ 14	≥ 16 ≥ 14	ISO 37 type 2
Minimum Elongation at break (%) Moulded Test Piece Test Piece from Bearing	450 400	425 375	300 250	
Minimum Tear Resistance (kN/m) CR NR	≥ 7 ≥ 5	≥ 10 ≥ 8	≥ 12 ≥ 10	
Compression Set (%) 24 h ; 70 °C	CR ≤ 15 NR ≤ 30			ISO 815 φ 29 x 12,5 mm Spacer : 9,38 - 25 %
Accelerated Ageing (Maximum change from unaged value) - <u>Hardness</u> (IRHD) NR 7 d, 70 °C CR 3 d, 100 °C - <u>Tensile strength</u> (%) NR 7 d, 70 °C CR 3 d, 100 °C - <u>Elongation at break</u> (%) NR 7 d, 70 °C CR 3 d, 100 °C	- 5 +10 ± 5 ± 15 ± 15 ± 25 ± 25			ISO 48 ISO 188
Ozone Resistance <u>Elongation</u> : 30 % - 96 h 40 °C ± 2 °C NR 25 pphm CR 100 pphm)	No cracks			ISO 1431-1
^a See 4.3.1.1.				

4.4.3 Steel reinforcing plates

4.4.3.1 Inner plates

The inner reinforcing plates shall be of steel grade S 235 according to EN 10025 or steel with a minimum equivalent elongation at break. Their minimum thickness shall be 2 mm.

The provisions of 5.3.3.5 shall apply.

4.4.3.2 Outer plates for type C (see Table 2)

The outer reinforcing plates shall be of steel grade S 235 according to EN 10025 or steel with a minimum equivalent elongation at break.

For elastomeric bearings type C with internal layers less than or equal to 8 mm thick, the minimum thickness of the outer plates shall be 15 mm.

For thicker layers, the minimum thickness of the outer plates shall be 18 mm.

4.4.4 Sliding surfaces

This section deals with sliding materials vulcanised onto the elastomer or recessed into a backing plate as shown in Table 2, Bearings type D and E respectively.

The sliding surface of bearings type D shall only be used to accommodate irreversible movements (creep, shrinkage, etc.).

For all considerations which are not stipulated hereafter for bearings type D and E, EN 1337-2 applies.

4.4.4.1 Bonding of austenitic steel for bearings type D and type E (see Table 2)

For sliding elastomeric bearings, austenitic steel sheets can be bonded to the backing plate by means of an elastomeric layer.

The following requirements shall be satisfied:

- Thickness of the backing plate: see 6.9 of EN 1337-2:2004.
- Thickness of the elastomer, if present between the backing plate and the austenitic steel sheet:
2,5 mm $\pm$ 0,5 mm
- Minimum thickness of the austenitic steel sheet : 2 mm

4.4.4.2 Top sliding surface of bearings type D (see Figure 1 and Table 2)

The following requirements shall be satisfied:

- Minimum thickness of PTFE sheet: $t_p > 1,5 \text{ mm}$
- Maximum thickness of PTFE sheet: $t_p < 2,5 \text{ mm}$
- Thickness of elastomer under the PTFE: Max: 3 mm
Min: 0,5 mm (at any point)
- Depth of the dimples if any: Min: 1 mm
Max: 2,5 mm

4.4.4.3 Lubrication dimples of bearing type D (see Figure 1 and Table 2)

Lubricant retention dimples in PTFE shall comply with the following requirements.

Where dimples are produced by hot pressing, the temperature of the vulcanising process shall not exceed 200 °C.

The plan area of the cavities shall be between 20 % and 30 % of the total PTFE bearing surface including the area of the dimples.

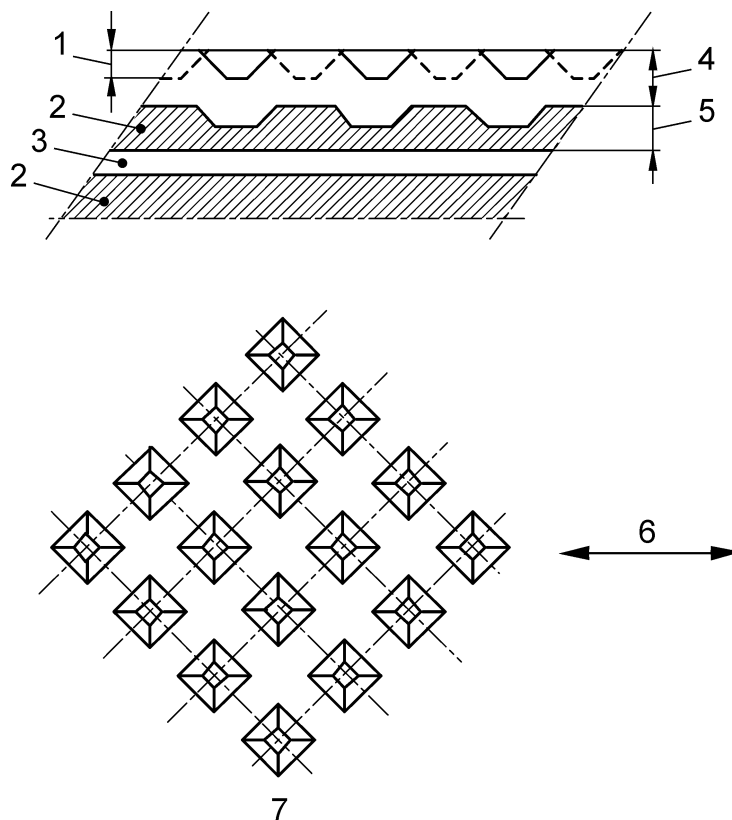
The volume of the cavities shall not be less than 10 % nor more than 20 % of the volume of PTFE, including the volume of cavities.

Undimpled PTFE sheets as sliding material for bearings of type D shall only be used if so specified by the structure designer.

4.4.4.4 Friction coefficient

For sliding elastomeric bearings the friction coefficient shall be determined in the same way and shall satisfy the same requirements as other sliding elements (see 6.9 of EN 1337-2:2004).

Partial cross section example of elastomeric bearing external layers type D



Key

- 1 1 mm < dimple depth < 2,5 mm
- 2 Elastomeric layers
- 3 Reinforcing steel plate
- 4 1,5 mm < t_p < 2,5 mm
- 5 0,5 mm < thickness of elastomer < 3 mm
- 6 Main direction of sliding
- 7 Plan view

Figure 1 — Lubrication dimples of bearing type D

5 Design rules

5.1 General

Elastomeric bearings shall be designed to meet the relevant provisions of this section at ultimate limit state.

At the ultimate limit state the strength and stability of bearings shall be adequate to withstand the ultimate design loads and movements of the structure.

Performance and durability of bearings designed according to this standard are based on the assumption that tolerances given in clause 6 are complied with.

5.2 Design values of actions

Elastomeric bearings shall be designed in such a way that design value of actions S_d (see form in Table E.1) does not exceed the design value of resistance R_d , taking into account all the principal and secondary action effects and the relative movements as defined in 5.5 of EN 1337-1:2000.

When installation inaccuracies exceed the specified tolerance limits given in 7.1, the consequences of this deviation on the structures shall be determined.

5.3 Laminated bearings

5.3.1 Types of laminated bearings

Bearing design shall be in accordance with one of the types or a combination of the types classified as in Table 2.

5.3.2 Sizes and shapes of laminated bearings

Bearing types are rectangular or circular but, for particular applications elliptical or octagonal (approximating to elliptical) shapes are acceptable. Specific design rules for elliptical bearings are given in annex A (normative). Octagonal bearings may be regarded as elliptical for all calculations, other than shape factor and pressure, with the major and minor axes equal to the length and width dimensions.

A particular bearing shall be designed with internal rubber layers of the same thickness between 5 mm and 25 mm each.

Recommended standard sizes for bearings type B are given in Table 3.

For laminated bearings it is permissible to reduce the loaded area, without changing the plan dimensions, by including holes of uniform section in the loaded area.

The symbols used in design rules are shown in Figure 2.

Dimensions in millimetres

Edge cover

Top and bottom cover

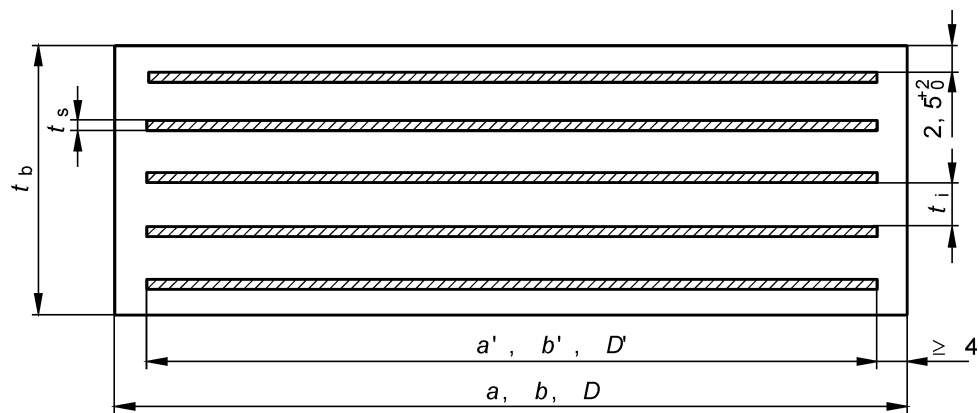
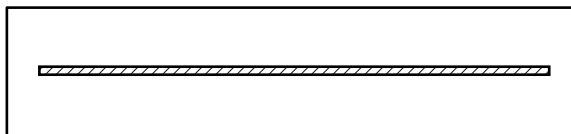


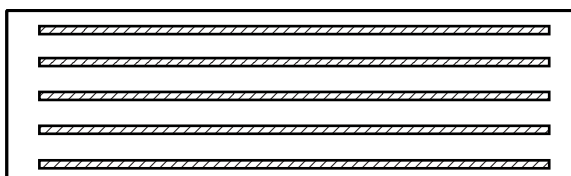
Figure 2 — Typical cross section of an elastomeric bearing type B

Table 2 — Different types of bearing cross sections

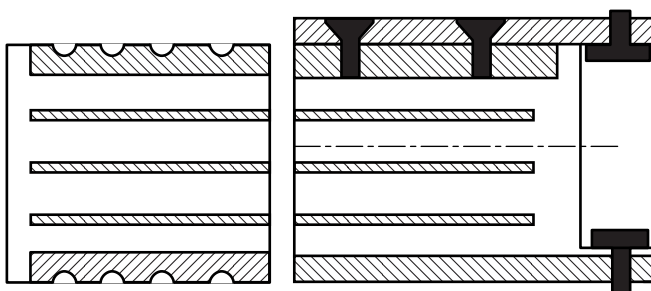
- Type A: Laminated bearing fully covered with elastomer comprising only one steel reinforcing plate.



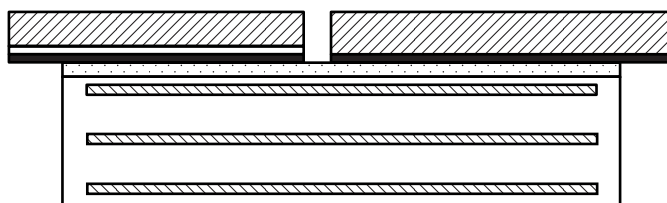
- Type B: Laminated bearing fully covered with elastomer comprising at least two steel reinforcing plates.



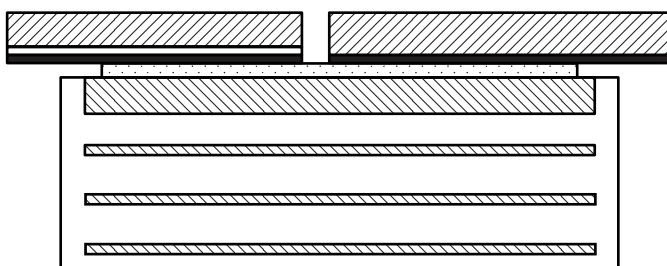
- Type C: Laminated bearing with outer steel plates (profiled or allowing fixing).
NOTE The sketch shows examples of a few fixing methods; other methods can be used by agreement.



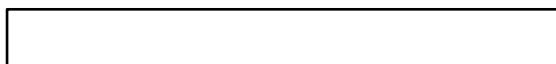
- Type D: Type B with PTFE sheet bonded to the elastomer.



- Type E: Type C with one outer plate bonded to the elastomer and PTFE sheet recessed in the steel.



- Type F: Plain pad bearings and strip bearings



NOTE Features of the above types can be combined.

Table 3 — Standard sizes for bearings type B

Dimensions a x b (mm) or D	THICKNESS in mm						Number of layers n	
	Unloaded bearing		Elastomer (total ^a)		Elastomer layers	Reinforcing plates	min.	max.
	min.	max.	min.	max.				
100 x 150	30	41	16	24	8	3	2	3
100 x 200	30	41	16	24	8	3	2	3
150 x 200	30	52	16	32	8	3	2	4
φ 200	30	52	16	32	8	3	2	4
150 x 250	30	52	16	32	8	3	2	4
150 x 300	30	52	16	32	8	3	2	4
φ 250	30	52	16	32	8	3	2	4
200 x 250	41	74	24	48	8	3	3	6
200 x 300	41	74	24	48	8	3	3	6
200 x 350	41	74	24	48	8	3	3	6
φ 300	41	74	24	48	8	3	3	6
200 x 400	41	74	24	48	8	3	3	6
250 x 300	41	85	24	56	8	3	3	7
φ 350	41	85	24	56	8	3	3	7
250 x 400	41	85	24	56	8	3	3	7
300 x 400	57	105	36	72	12	4	3	6
φ 400	57	105	36	72	12	4	3	6
300 x 500	57	105	36	72	12	4	3	6
φ 450	57	105	36	72	12	4	3	6
300 x 600	57	105	36	72	12	4	3	6
350 x 450	57	121	36	84	12	4	3	7
φ 500	57	121	36	84	12	4	3	7
400 x 500	73	137	48	96	12	4	4	8
φ 550	73	137	48	96	12	4	4	8
400 x 600	73	137	48	96	12	4	4	8
450 x 600	73	153	48	108	12	4	4	9
φ 600	73	153	48	108	12	4	4	9
500 x 600	73	169	48	120	12	4	4	10
φ 650	73	169	48	120	12	4	4	10
600 x 600	94	199	64	144	16	5	4	9
φ 700	94	199	64	144	16	5	4	9
600 x 700	94	199	64	144	16	5	4	9
φ 750	94	199	64	144	16	5	4	9
700 x 700	94	220	64	160	16	5	4	10
φ 800	94	220	64	160	16	5	4	10
700 x 800	94	220	64	160	16	5	4	10
φ 850	94	220	64	160	16	5	4	10
800 x 800	110	285	80	220	20	5	4	10
φ 900	110	285	80	220	20	5	4	10
900 x 900	110	285	80	220	20	5	4	11

^a Total thickness without 2,5 mm top and bottom cover

5.3.3 Basis of design

The design rules are based on the assumption that the elastomer is an viscoelastic material, the deflection of which under a compressive load is influenced by its shape. Reinforcing plates in the bearing shall be chemically bonded to the elastomer to prevent any relative movement at the steel / elastomer interface.

Design calculation shall not be applied to the external top and bottom layer when their thickness is less or equal to 2,5 mm.

All designed bearings including standard sizes shown in Table 3 shall meet the requirements given hereafter:

a) Maximum design strain

At any point in the bearing the sum of the strains ($\varepsilon_{t,d}$) due to the design load effects (E_d) is given by the expression:

$$\varepsilon_{t,d} = K_L (\varepsilon_{c,d} + \varepsilon_{q,d} + \varepsilon_{\alpha,d}) \quad (1)$$

where:

$\varepsilon_{c,d}$ is the design strain due to compressive design loads as defined in 5.3.3.2.

$\varepsilon_{q,d}$ is the design shear strain due to design translatory movements as defined in 5.3.3.3.

$\varepsilon_{\alpha,d}$ is the design strain due to the design angular rotation as defined in 5.3.3.4.

K_L is a type-loading factor; see annex C (normative) to determine value.

$\varepsilon_{t,d}$ shall not exceed the maximum value $\varepsilon_{u,d}$ given by the expression:

$$\varepsilon_{u,d} = \frac{\varepsilon_{u,k}}{\gamma_m} \quad (2)$$

where:

$\varepsilon_{u,k}$ is the maximum permissible value of 7 for ULS (See note 1)

γ_m is a partial safety factor which value may be chosen in the National Annex.
The recommended value is $\gamma_m = 1.00$

b) Maximum tensile stresses in reinforcing plates

Reinforcing plates shall be designed for ULS as defined in 5.3.3.5.

c) Stability criteria (see 5.3.3.6)

Stability criteria shall be evaluated taking into account the following:

- Stability regarding rotation
- Stability regarding buckling
- Stability regarding sliding

d) Forces, moments, and deformations exerted on the structure (see 5.3.3.7)

Forces, moments and deformations shall be evaluated taking into account the following:

- The pressure at the contact surfaces between the bearing and the structure
- The force exerted on the structure by the bearing resisting translatory movement
- The restoring moment due to the bearing resisting rotational movement
- Vertical deflection due to the vertical load

NOTE The nominal shear modulus can be modified for dynamic load effects (railway structures, earthquake), depending on the exciting frequencies (generally frequencies > 6Hz) and movement amplitudes: the factor, which may vary for different compounds, can be obtained experimentally.

5.3.3.1 Shape factor

The shape factor S is a means of taking account of the shape of the elastomer in strength and deflection calculations. It is the ratio of the effective plan area of an elastomeric slab to its force-free surface area, including holes.

For laminated bearings the shape factor S for each individual elastomer layer is given by the expression:

$$S = \frac{A_1}{l_p \cdot t_e} \quad (3)$$

For plain pad bearings the shape factor S is given by the expression:

$$S = \frac{A}{l_p \cdot t_e} \quad (4)$$

For strip bearings the shape factor S is given by the expression:

$$S = \frac{a}{2t_e} \quad (5)$$

where:

A_1 : is the effective plan area of the bearing, i.e. the plan area common to elastomer and steel plate, excluding the area of any holes if these are not later effectively plugged.

A : is the overall plan area of the elastomeric bearing.

a : is the overall width of the strip bearing.

l_p : is the force-free perimeter of the bearing including that of any holes if these are not later effectively plugged.

t_e : is the effective thickness of an individual elastomer layer in compression; in laminated bearings it is taken as the actual thickness, t_i , for inner layers, and $1,4 t_i$ for outer layers with a thickness ≥ 3 mm ; in plain pad and strip bearings it is taken as $1,8 t_i$ (t_i is the thickness of an individual elastomer layer).

NOTE For a rectangular bearing without holes:

$$A_1 = a' \cdot b' \text{ and} \quad (6)$$

$$l_p = 2 (a' + b') \quad (7)$$

where

a' : is the effective width of the bearing (i.e. the width of reinforcing plates).

b' : is the effective length of the bearing (i.e. the length of reinforcing plates).

5.3.3.2 Design strain due to compressive load

For calculation purpose G shall be one of the values defined in Table 1.

$\varepsilon_{c,d}$ is the design strain due to compressive loads, and is given by the expression:

$$\varepsilon_{c,d} = \frac{1,5 \cdot F_{z,d}}{G \cdot A_r \cdot S} \quad (8)$$

A_r : is the reduced effective plan area due to the loading effects, where A_r is given by the expression:

$$A_r = A_1 \left(1 - \frac{v_{x,d}}{a} - \frac{v_{y,d}}{b} \right) \quad (9)$$

where

$v_{x,d}$: is the maximum horizontal relative displacement of parts of the bearing in the direction of dimension a of the bearing due to all design load effects ;

$v_{y,d}$: is the maximum horizontal relative displacement of parts of the bearing in the direction of dimension b of the bearing due to all design load effects.

5.3.3.3 Shear strain

The shear strain $\varepsilon_{q,d}$ of the elastomer due to translatory movement shall not exceed 1,00, and is given by the expression.

$$\varepsilon_{q,d} = \frac{v_{xy,d}}{T_q} \quad (10)$$

where

$v_{xy,d}$: is the maximum resultant horizontal relative displacement of parts of the bearing obtained by vectorial addition of $v_{x,d}$ and $v_{y,d}$;

($v_{x,d}$ and $v_{y,d}$ are defined in 5.3.3.2)

T_q : is the total thickness of the elastomer in shear including the top and bottom cover, unless relative movement between the outer plates of the bearing and the structure is restrained by dowelling or other means.

NOTE The maximum permissible value for $\varepsilon_{q,d}$ defined as 1,00 for ULS has been derived from $\varepsilon_{g,k}$ by multiplying with $\gamma_f = 1,40$

5.3.3.4 Design strain due to angular rotation

The nominal strain due to angular rotation is given by the expression:

$$\varepsilon_{\alpha,d} = \frac{(a^2 \cdot \alpha_{a,d} + b^2 \cdot \alpha_{b,d}) t_i}{2 \sum (t_i^3)} \quad (11)$$

$\alpha_{a,d}$: is the angle of rotation across the width, a , of the bearing;

$\alpha_{b,d}$: the angle of rotation (if any) across the length, b , of the bearing;

t_i : is the thickness of an individual layer of elastomer.

5.3.3.5 Reinforcing plate thickness

To resist induced tensile stresses under load, the minimum thickness of the steel plates in a laminated bearing is given by the expression:

$$t_s = \frac{K_p \cdot F_{z,d} \cdot (t_1 + t_2) \cdot K_h \cdot \gamma_m}{A_r \cdot f_y} \quad \text{and} \quad t_s \geq 2 \text{ mm} \quad (12)$$

where

$F_{z,d}$ and A_r are as defined in 3.2

t_1 and t_2 are the thickness of elastomer on either side of the plate;

f_y is the yield stress of the steel;

K_h is a factor for induced tensile stresses in reinforcing plate which value is given hereafter:

without holes : $K_h = 1$

with holes : $K_h = 2$

γ_m is the partial safety factor which value may be chosen in the National Annex.

The recommended value is given hereafter: $\gamma_m = 1,00$

K_p is a stress correction factor which value is given hereafter:

$K_p = 1,3$

5.3.3.6 Limiting conditions

- Rotational limitation condition

For laminated bearings, the rotational limitation shall be satisfied when the total vertical deflection $\Sigma v_{z,d}$ (see 5.3.3.7.) complies with:

$$\text{For rectangular bearings } \Sigma v_{z,d} - \frac{(a' \cdot \alpha_{a,d} + b' \cdot \alpha_{b,d})}{K_{r,d}} \geq 0 \quad (13)$$

$$\text{For circular bearings } \Sigma v_{z,d} - \frac{(D' \cdot \alpha_d)}{K_{r,d}} \geq 0 \quad (14)$$

where

D' is the effective diameter of the bearing

$K_{r,d}$ is a rotation factor, which is defined in annex B (normative)

$\Sigma v_{z,d}$ is the total vertical deflection producing α_a and α_b

- Buckling stability