UDC 624.078.5-036.074:69 DEUTSCHE NORM September 1985

Structural bearings

Laminated elastomeric bearings
Design and construction

DIN 4141 Part 14

Lager im Bauwesen; bewehrte Elastomerlager; bauliche Durchbildung und Bemessung

In keeping with current practice in standards published by the International Organization for Standardization (ISO), a comma has been used throughout as the decimal marker.

This standard has been prepared by *NABau* Section *Einheitliche Technische Baubestimmungen.*

The following standards form part of the DIN 4141 series:

DIN 4141 Part 1	Structural bearings; general design rules
DIN 4141 Part 2	Structural bearings; bearing systems for civil engineering structures forming part of traffic routes (bridges)
DIN 4141 Part 3	Structural bearings; bearing systems for buildings
DIN 4141 Part 4*)	Structural bearings; transport, intermediate storage and installation
DIN 4141 Part 14	Structural bearings; laminated elastomeric bearings; design and construction

Further Parts of this standard are in the course of preparation.

Contents

1 Field of application

This standard applies to laminated elastomeric bearings in bridges and building structures within a temperature range from −25 °C to +50 °C, and for short periods, up to 70 °C.

This standard only applies in conjunction with DIN 4141 Part 1, Part 2 and Part 3.

2 Concept, quantities and symbols

Elastomeric bearings are building components capable of elastic deformation (resilient bearings). Every external force which, besides axial compression strain, causes relative movement (translation, rotation) of the structural components connected by the bearing, results in deflection of the bearing.

The symbols used in this standard are as follows.

A	plan area of the bearing
a, b	dimensions of the sides of rectangular bearings, a being the shorter side or (when calculating the restoring moment, M) the side vertical to the axis of rotation
D	diameter of bearings of circular plan
d	force-free thickness (= installation height) of bearing
F	vertical load
G	shear modulus (factor for the calculation of restoring forces)
n	number of elastomer layers between reinforcing plates
r	thickness of lateral elastomer cover
s	thickness of individual steel reinforcing plate
T	effective thickness of elastomer = sum total of all individual layers of elastomer
t	thickness of elastomer layer between two reinforcing plates
x	thickness of individual outer reinforcing plates (cover plates) (in the case of restrained bearings)
α	angle of rotation per elastomer layer
γ	shear angle of the bearing
σ_m	mean design pressure
$\min \sigma$	mean design pressure at the smallest calculated vertical load

3 Design

Laminated elastomeric bearings may be rectangular, square or circular in plan. Their reinforcement consists in flat steel plates which are located in the bearing equidistant to each other and symmetrical to the plane of the mean bearing height (bearing plane). The steel plates are bonded to the elastomer in a hot-vulcanization process.

*) At present at the stage of draft.

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Unrestrained bearings are only reinforced internally with steel plates, whereas restrained bearings are also provided with external reinforcement in the form of cover plates.

Elastomeric bearings with a plan area exceeding 350 mm X 450 mm, or with a diameter exceeding 400 mm, shall be made up of not less than 3 layers of elastomer.

Edges of the reinforcing plates shall be carefully machined to avoid nicking.

Holes may be drilled at right angles to the bearing plane through the elastomer and steel plates of laminated elastomeric bearings (cf. subclause 5.1).

Bearings may be installed either with or without the provision of restraints, restraints here referring to devices serving to restrict movements in the contact joint between bearing and the adjoining structural component.

Bearings installed without restraints are replaceable. In the case of restrained bearings, the replaceability of the bearing, or of individual bearing components, is, as specified in subclause 7.5 of the September 1984 edition of DIN 4141 Part 1, a possible design feature.

The design of unrestrained bearings is shown in figure 1.

Examples of restrained bearings are shown in figure 2.

The identification of elastomeric bearings shall comply with DIN 4141 Part 1 (see clause 8).

Exposed steel parts shall be adequately protected against corrosion in accordance with the relevant specifications.

4 Materials

4.1 Elastomer

A chloroprene rubber based elastomer shall be used; the elastomer shall be resistant to weather, ozone and ageing.[1])

4.2 Steel

Reinforcing plates (steel plates) shall be made of St 50-2, St 52-3 or St 60-2 steel in accordance with DIN 17 100.

5 Permissible loading; verification of stability

5.1 Effective plan area

Holes in the bearing which are at right angles to the bearing plane need not be allowed for in the overall design if the following requirements are met:

the total cross-sectional area of holes does not exceed 5 % of the bearing surface;

the hole diameter does not exceed 80 mm;

the axis of the hole is within the core cross section of the bearing area;

the hole is protected against the effects of weather.

5.2 Load application at right angles to the bearing plane

Application of a vertical load F gives a mean bearing pressure of

$$\sigma_m = \frac{F}{A} \quad (1)$$

$$A = a \cdot b \text{ or} \quad (2)$$

$$A = \frac{\pi \cdot D^2}{4} \quad (3)$$

The mean bearing pressure σ_m shall not, as a rule, exceed the values listed in table 5.

An increase of up to 50 % in the pressure is permitted if a sliding device is interposed which practically eliminates stressing in the form described in subclause 5.3. Special proof, such as a building inspectorate approval, is required in such instances. The tensile splitting stresses in the bearing support surfaces shall be calculated. This involves accounting for the distribution of the compressive stress in the joint on the basis of a quadratic parabola.

5.3 Load application parallel to the bearing plane

A parallel movement v between the superstructure and substructure causes a shear strain of

$$\tan \gamma = \frac{v}{T} \quad (4)$$

with the corresponding force in the bearing plane of

$$F_{xy} = A \cdot G \cdot \tan \gamma \quad (5)$$

where $G = 1$ N/mm^2.

For bearings with an effective elastomer thickness $T \leqq a/5$ or $D/5$, the permitted value of $\tan \gamma$ shall be

$$\text{zul} \tan \gamma = 0{,}7 \quad (6)$$

For thicker bearings with T not exceeding $\frac{a}{3}$ or $\frac{D}{3}$, the permitted value of $\tan \gamma$ shall be

$$\text{zul} \tan \gamma = 0{,}7 - \left(\frac{T}{a} - 0{,}2\right) \text{ or} \quad (7)$$

$$= 0{,}7 - \left(\frac{T}{D} - 0{,}2\right) \quad (8)$$

[1]) A standard specifying the composition of the elastomer and quality control procedures is in the course of preparation. Until this standard is issued, the rules for factory control and third party inspection of laminated elastomeric bearings such as are given, for example, in Eggert/Grote/Kauschke. *Lager im Bauwesen, Verlag W. Ernst & Sohn*, Berlin, shall apply.

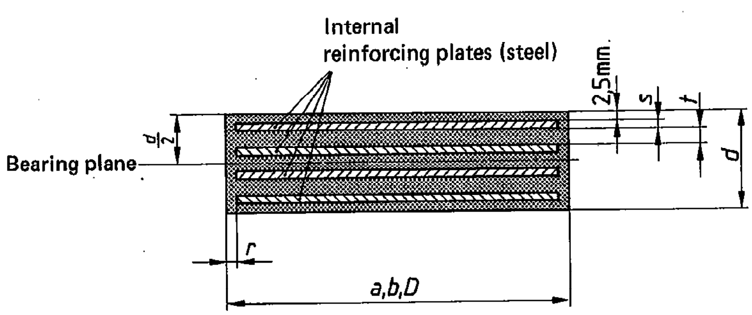
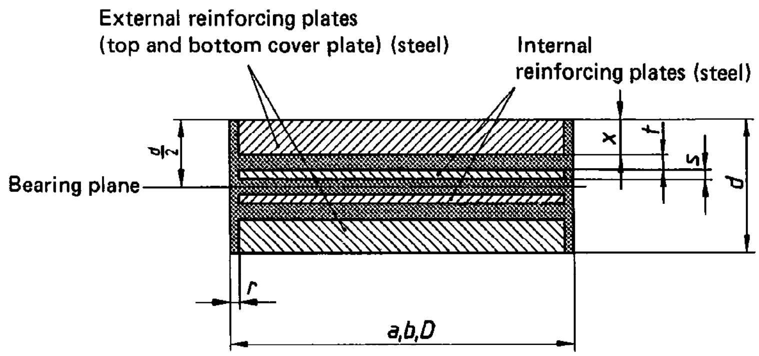
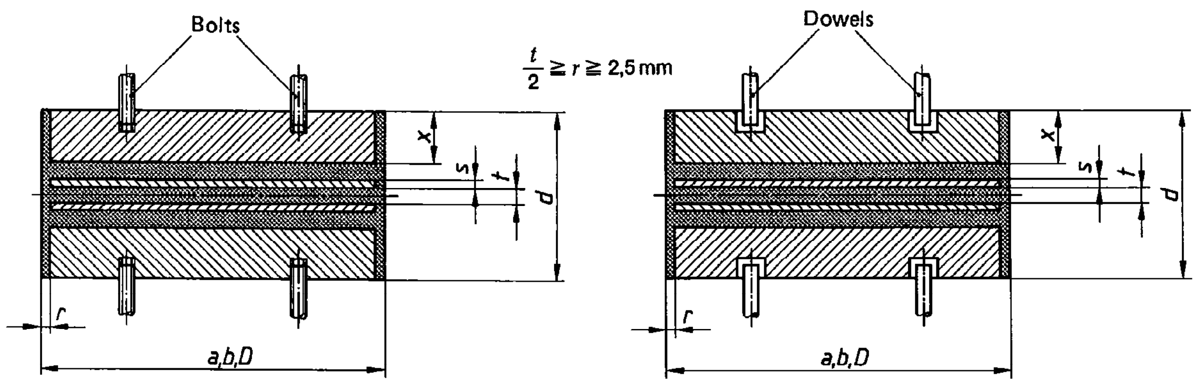


Figure 1. Unrestrained laminated elastomeric bearing



$x \geqq 10$ mm

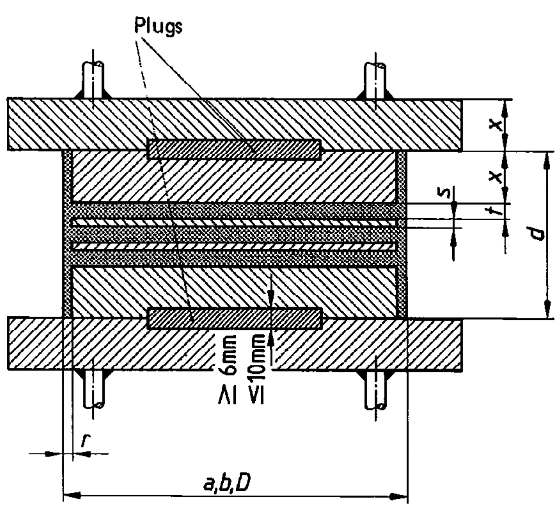
a) Laminated elastomeric bearing with full surface restraints



$x \geqq 15$ mm for bearings as per table 2
$x \geqq 20$ mm for bearings as per table 4

$x \geqq 15$ mm for bearings as per table 2
$x \geqq 20$ mm for bearings as per table 4

b) Laminated elastomeric bearing restrained by bolts or dowels



$x \geqq 15$ mm for bearings as per table 2
$x \geqq 20$ mm for bearings as per table 4

c) Laminated elastomeric bearing restrained by round plugs

Figure 2. Laminated elastomeric bearings with examples of restraints

Where shear strain occurs in more than one direction, the total resultant relative displacement of parts of the bearing shall be obtained by vectorial addition.

Movements of the structure, v, parallel to the bearing plane shall be calculated on the basis of the building regulations which apply to the structural components to be supported. The safety margins prescribed for movable bearings (roller bearings, sliding bearings etc.) need not be allowed for in such calculations.

Design stressing parallel to the bearing plane due to permanent external forces, including that of active earth pressure, is not permitted. Stressing parallel to the bearing plane due to constraint or short-term external forces is, however, permitted as long as the movements which then occur are permissible with regard to the overall design of the structure.

5.4 Rotation

A rotational difference ϑ between the superstructure and the substructure gives an angle of rotation, α, for each elastomer layer of:

$$\alpha = \frac{\vartheta}{n} \qquad (9)$$

The angles of rotation shall not exceed the values listed in table 5. If the permissible increase in pressure specified in subclause 5.2 is utilized, then

$$\vartheta = n \cdot \alpha \leqq 0{,}005$$

shall be maintained.

Any permanent deviation from parallelism between the bearing support surfaces occurring in the finished structure as a result of imperfections shall not, together with the design angle of rotation, exceed the permitted angle of rotation listed in table 5 by more than a factor of 1,3; furthermore, the proportion of the imposed load effect shall not exceed the values listed in table 5 by more than a factor of 0,5.

The theoretical value of the restoring moment due to rotation of the bearings shall be

for rectangular bearings, $$M = \frac{a^5 \cdot b \cdot G}{50 \cdot t^3} \cdot \alpha \qquad (10)$$

for circular bearings with G at the value specified in subclause 5.3, $$M = \frac{D^6 \cdot G}{100 \cdot t^3} \cdot \alpha \qquad (11)$$

5.5 Verification of safety against sliding

The following conditions shall be met to prevent unrestrained bearings slipping:

a) for elastomeric bearings with a maximum plan area of 300 mm X 400 mm, or a maximum diameter of 350 mm,

$\sigma_m \geqq 3{,}0$ N/mm^2;

b) for elastomeric bearings with a larger plan area

$\sigma_m \geqq 5{,}0$ N/mm^2.

Structures subject to high dynamic loadings as specified in DS 804, e.g. railway bridges, may require higher values.

In the case of smaller mean pressures, bearings shall be provided with positive means of location and their safety against sliding verified as specified in clause 6 of the September 1984 edition of DIN 4141 Part 1.

5.6 Compressive strain

In addition to a deflection of the bearing of approximately 1 mm due to settlement in the initial bedding down phase, a further deflection of roughly 2 % of the elastomer thickness T may occur under the permissible design load as a result of compressive strain.

As the stress-strain characteristics are not linear, the compressive strain proportion of imposed loads is smaller than their proportion of the total load.

Where necessary, the effect of compressive strain in the bearing on the adjacent structural component shall be verified.

5.7 Distribution of load onto a number of bearings

(Cf. subclause 3.6 in the September 1984 edition of DIN 4141 Part 2.)

If more than 2 bearings are used to mount a structural component in one line of support with a ratio of

$$\frac{\max\ (A/T)}{\min\ (A/T)} \leqq 1{,}2,$$

the effect of compressive strain may be disregarded in the calculation of the load distribution. In other cases, special verification is required, which is not covered by this standard (see also subclauses 7.4 and 7.5).

6 Standard bearings

The design data for standard bearings are listed in tables 1 to 5. Verification for these bearings is only required to give details of pressure, shear deformation and rotation.

Intermediate sizes may be manufactured to this standard provided that t and s correspond to the dimensions for the next smaller size bearing of equal area.

7 Transport and installation

7.1 Relevant requirements of DIN 4141 Part 4 shall be observed.

7.2 To prevent stressing of the bearings beyond the design assumptions, all bearing support surfaces shall be level and parallel with each other.

If the surfaces of these structural components no longer permit plastic deformation at the time the bearings are installed (no mortar bed or cast-in-situ concrete), their maximum deviation u from a plane relating to the bearing dimensions shall not exceed

$u \leqq 0{,}003 \cdot a$ or $0{,}003 \cdot D$

and $u \leqq 1{,}0$ mm.

Deviations from parallelism are dealt with in subclause 5.4.

7.3 All bearing support surfaces shall be designed to prevent shear strain in the bearing occurring in the assumed undeformed state of the structure under permanent load effects, including that of active earth pressure (cf. also subclause 5.3, last paragraph).

7.4 The arrangement at a calculated support point of two or more bearings in tandem in the longitudinal direction (direction of principal loadbearing system) of the structural component to be supported is permitted in exceptional cases, but only if the compressive strain characteristics of the bearings are known for the intended range of application (e.g. established by testing), and if proof can be provided on the basis of such data that the permissible design load of the individual bearings will not be exceeded even at the worst combination of load effects.

7.5 When the support of a precast structural component is shown in the layout to be statically indeterminate, a layer of mortar shall generally be laid between the redundant bearings and the subjacent part of the structure. While this mortar layer is setting, auxiliary supports shall be used to take up superstructure mass. The mortar seating may be dispensed with, if the design load transfer through all bearings can be ensured by other means.

7.6 The design deformation (shear, rotation) of the side walls of the bearings shall not be impeded.

7.7 When bearings are to be bedded by grouting, care shall be taken to use only good quality mortar as the bedding material. The mass of the superstructure shall not, even for short periods, be transmitted to the bearings through wedges only, unless a steel plate of adequate thickness (minimum 20 mm) is interposed. Wedges shall be removed when the grout has set.

7.8 No welding shall be carried out on the cover plates of restrained bearings.

7.9 Suitable precautions shall be taken to prevent contamination of the bearings by grease, solvents and similar materials, and particularly by formwork oil.

8 Inspection, identification, delivery note

8.1 General

The proper manufacture of laminated elastomeric bearings requires expertise, experience, special processing equipment and continual production and quality control.

Confirmation that a vulcanizing plant meets these requirements is given, on successful completion of prototype testing, in the form of a works identification mark. Fulfilment of the requirements for the manufacture of thicker bearings (see formulae (7) and (8) in subclause 5.3) shall be confirmed by the issue of a separate works identification mark.[2)]

8.2 Identification

Bearings shall be supplied under the name of the vulcanizing plant, with details of the plan area, loadbearing capacity, thickness d, effective elastomer thickness T, and the number of elastomer layers, n.

The bearings shall carry the works identification mark of the vulcanizing plant together with a serial number. The manufacturer confirms with his identification mark that the bearings conform to the requirements of this standard. If the building regulations demand an inspection, then the bearing shall carry the standard inspection mark as proof of inspection.[3)]

Identification shall in other respects be in compliance with the relevant specifications given in subclause 7.3 of the September 1984 edition of DIN 4141 Part 1.

8.3 Delivery note

The bearing supplier shall confirm with every batch supplied that the bearings conform to this standard and have thus been subject to production control during their manufacture.

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2) The register of works identification marks (bearing marking) is kept and published by the *Institut für Bautechnik* in Berlin.

3) See, for example, the *Runderlaß des Ministers für Landes- und Stadtentwicklung Nordrhein-Westfalen: Überwachung der Herstellung von Baustoffen und Bauteilen; Einheitliche Überwachungszeichen*, in: *Ministerialblatt des Landes Nordrhein-Westfalen*, 31.07.1980, p. 1901.

Table 1. **Standard bearing sizes for unrestrained bearings (for $\sigma_m \geqq 3{,}0$ N/mm^2) 4)**

1	2	3	4	5	6
Dimensions of *A* and *D*	Thickness of unloaded bearing *d*	Thickness of elastomer *T*	Number of elastomer layers *n*	Thickness of elastomer layer *t*	Thickness of reinforcing plates *s*
mm	mm	mm	–	mm	mm
100 × 100 100 × 150	14 21 28 (35) (42)	10 15 20 (25) (30)	1 2 3 (4) (5)	5	2
150 × 200	21 28 35 42 (49) (56) (63)	15 20 25 30 (35) (40) (45)	2 3 4 5 (6) (7) (8)	5	2
200 × 250 200 × 300 200 × 400 ø 200	30 41 52 (63) (74) (85)	21 29 37 (45) (53) (61)	2 3 4 (5) (6) (7)	8	3
250 × 400 ø 250	41 52 63 (74) (85) (96)	29 37 45 (53) (61) (69)	3 4 5 (6) (7) (8)	8	3
300 × 400 ø 300	41 52 63 74 85 (96) (107) (118)	29 37 45 53 61 (69) (77) (85)	3 4 5 6 7 (8) (9) (10)	8	3
ø 350	54 69 84 99 (114) (129) (144)	38 49 60 71 (82) (93) (104)	3 4 5 6 (7) (8) (9)	11	4

4) The values given in brackets apply to bearings which are subject to the limiting conditions listed in subclause 5.3, formulae (7) and (8).

Table 2. **Standard bearing sizes for restrained bearings (for $\sigma_m < 3{,}0$ N/mm²)[4])**

1	2	3	4	5	6
Dimensions of *A* and *D*	Thickness of unloaded bearing *d*	Thickness of elastomer *T*	Number of elastomer layers *n*	Thickness of elastomer layer *t*	Thickness of reinforcing plates *s*
mm	mm	mm	–	mm	mm
100 × 100 100 × 150	42 49 56 (63) (70)	10 15 20 (25) (30)	2 3 4 (5) (6)	5	2
150 × 200	49 56 63 70 (77) (84) (91)	15 20 25 30 (35) (40) (45)	3 4 5 6 (7) (8) (9)	5	2
200 × 250 200 × 300 200 × 400 ∅ 200	60 71 82 (93) (104)	24 32 40 (48) (56)	3 4 5 (6) (7)	8	3
250 × 400 ∅ 250	60 71 82 93 (104) (115) (126)	24 32 40 48 (56) (64) (72)	3 4 5 6 (7) (8) (9)	8	3
300 × 400 ∅ 300	71 82 93 104 (115) (126) (137) (148)	32 40 48 56 (64) (72) (80) (88)	4 5 6 7 (8) (9) (10) (11)	8	3
∅ 350	71 86 101 116 (131) (146) (161)	33 44 55 66 (77) (88) (99)	3 4 5 6 (7) (8) (9)	11	4

For [4]), see table 1.

Table 3. **Standard bearing sizes for unrestrained bearings (for $\sigma_m \geqq 5{,}0$ N/mm²)⁴)**

1	2	3	4	5	6
Dimensions of A and D	Thickness of unloaded bearing d	Thickness of elastomer T	Number of elastomer layers n	Thickness of elastomer layer t	Thickness of reinforcing plates s
mm	mm	mm	–	mm	mm
350 × 450	54 69 84 99 (114) (129) (144)	38 49 60 71 (82) (93) (104)	3 4 5 6 (7) (8) (9)	11	4
400 × 500 ø 400	54 69 84 99 114 (129) (144) (159)	38 49 60 71 82 (93) (104) (115)	3 4 5 6 7 (8) (9) (10)	11	4
450 × 600 ø 450	54 69 84 99 114 129 (144) (159) (174)	38 49 60 71 82 93 (104) (115) (126)	3 4 5 6 7 8 (9) (10) (11)	11	4
500 × 600 ø 500	54 69 84 99 114 129 144 (159) (174) (189) (204)	38 49 60 71 82 93 104 (115) (126) (137) (148)	3 4 5 6 7 8 9 (10) (11) (12) (13)	11	4
600 × 700 ø 600	70 90 110 130 150 170 (190) (210) (230)	50 65 80 95 110 125 (140) (155) (170)	3 4 5 6 7 8 (9) (10) (11)	15	5
700 × 800 ø 700	70 90 110 130 150 170 190 (210) (230) (250) (270)	50 65 80 95 110 125 140 (155) (170) (185) (200)	3 4 5 6 7 8 9 (10) (11) (12) (13)	15	5
For ⁴), see table 1.					

Table 3. (continuation)

1	2	3	4	5	6
Dimensions of *A* and *D*	Thickness of unloaded bearing *d*	Thickness of elastomer *T*	Number of elastomer layers *n*	Thickness of elastomer layer *t*	Thickness of reinforcing plates *s*
mm	mm	mm	–	mm	mm
800 × 800 ∅ 800	79 102 125 148 171 194 (217) (240) (263) (286) (309)	59 77 95 113 131 149 (167) (185) (203) (221) (239)	3 4 5 6 7 8 (9) (10) (11) (12) (13)	18	5
900 × 900 ∅ 900	79 102 125 148 171 194 217 (240) (263) (286) (309) (332)	59 77 95 113 131 149 167 (185) (203) (221) (239) (257)	3 4 5 6 7 8 9 (10) (11) (12) (13) (14)	18	5

Table 4. **Standard bearing sizes for restrained bearings (for $\sigma_m < 5{,}0$ N/mm^2)4)**

1	2	3	4	5	6
Dimensions of *A* and *D*	Thickness of unloaded bearing *d*	Thickness of elastomer *T*	Number of elastomer layers *n*	Thickness of elastomer layer *t*	Thickness of reinforcing plates *s*
mm	mm	mm	–	mm	mm
350 × 450	81 96 111 126 (141) (156) (171)	33 44 55 66 (77) (88) (99)	3 4 5 6 (7) (8) (9)	11	4
400 × 500 ∅ 400	81 96 111 126 141 (156) (171) (186) (201)	33 44 55 66 77 (88) (99) (110) (121)	3 4 5 6 7 (8) (9) (10) (11)	11	4
450 × 600 ∅ 450	81 96 111 126 141 156 (171) (186) (201) (216)	33 44 55 66 77 88 (99) (110) (121) (132)	3 4 5 6 7 8 (9) (10) (11) (12)	11	4
For 4), see table 1.					

Table 4. (continuation)

1	2	3	4	5	6
Dimensions of *A* and *D*	Thickness of unloaded bearing *d*	Thickness of elastomer *T*	Number of elastomer layers *n*	Thickness of elastomer layer *t*	Thickness of reinforcing plates *s*
mm	mm	mm	–	mm	mm
500 × 600 ø 500	81 96 111 126 141 156 171 (186) (201) (216) (231)	33 44 55 66 77 88 99 (110) (121) (132) (143)	3 4 5 6 7 8 9 (10) (11) (12) (13)	11	4
600 × 700 ø 600	95 115 135 155 175 195 (215) (235) (255) (275)	45 60 75 90 105 120 (135) (150) (165) (180)	3 4 5 6 7 8 (9) (10) (11) (12)	15	5
700 × 800 ø 700	95 115 135 155 175 195 215 (235) (255) (275) (295) (315)	45 60 75 90 105 120 135 (150) (165) (180) (195) (210)	3 4 5 6 7 8 9 (10) (11) (12) (13) (14)	15	5
800 × 800 ø 800	104 127 150 173 196 219 242 (265) (288) (311) (334)	54 72 90 108 125 144 162 (180) (198) (216) (234)	3 4 5 6 7 8 9 (10) (11) (12) (13)	18	5
900 × 900 ø 900	104 127 150 173 196 219 242 265 (288) (311) (334) (357) (380)	54 72 90 108 126 144 162 180 (198) (216) (234) (252) (270)	3 4 5 6 7 8 9 10 (11) (12) (13) (14) (15)	18	5

Table 5. **Permissible pressures and angles of rotation**

1	2	3	4	5
Dimensions of *A* and *D*	Thickness of elastomer layer t	Mean bearing pressure σ_m	Permissible angle of rotation α per elastomer layer for the axis of rotation	
			parallel to the longer side in plan	parallel to the shorter side in plan
mm	mm	N/mm²	radians	radians
100 × 100	5	10,0	0,0040	0,0040
100 × 150	5	10,0	0,0040	0,0030
150 × 200	5	10,0	0,0030	0,0030
200 × 250	8	12,5	0,0030	0,0025
200 × 300	8	12,5	0,0030	0,0020
200 × 400	8	12,5	0,0030	0,0012
250 × 400	8	12,5	0,0025	0,0012
300 × 400	8	15,0	0,0020	0,0012
350 × 450	11	15,0	0,0025	0,0020
400 × 500	11	15,0	0,0020	0,0015
450 × 600	11	15,0	0,0020	0,0012
500 × 600	11	15,0	0,0020	0,0012
600 × 700	15	15,0	0,0020	0,0015
700 × 800	15	15,0	0,0020	0,0012
800 × 800	18	15,0	0,0020	0,0020
900 × 900	18	15,0	0,0015	0,0015
ø 200	8	10,0		0,0040
ø 250	8	12,5		0,0040
ø 300	8	12,5		0,0030
ø 350	11	12,5		0,0040
ø 400	11	15,0		0,0030
ø 450	11	15,0		0,0030
ø 500	11	15,0		0,0020
ø 600	15	15,0		0,0020
ø 700	15	15,0		0,0020
ø 800	18	15,0		0,0020
ø 900	18	15,0		0,0015

Standards and other documents referred to

DIN 4141 Part 1 Structural bearings; general design rules

DIN 4141 Part 2 Structural bearings; bearing systems for civil engineering structures forming part of traffic routes (bridges)

DIN 4141 Part 3 Structural bearings; bearing systems for buildings

DIN 4141 Part 4 (at the stage of draft) Structural bearings; transport, intermediate storage and installation

DIN 17 100 Structural steel; quality standards

DIN 18 200 Inspection of building materials, structural components and systems; general principles

DS 804 Regulations relating to railway bridges and other engineering structures (VEI)[5]

Richtlinien für die Güteüberwachung von bewehrten Elastomerlagern im Rahmen der Eigenüberwachung und der Fremdüberwachung

Runderlaß des Ministers für Landes- und Stadtentwicklung Nordrhein-Westfalen: Überwachung der Herstellung von Baustoffen und Bauteilen; Einheitliche Überwachungszeichen

[5]) Obtainable from the *Drucksachenverwaltung der Deutschen Bundesbahn*, Hinterm Hauptbahnhof 2a, D-7500 Karlsruhe.

Explanatory notes

In the same way as the "Special Regulations" which have previously formed part of the general approval documents issued by the building inspectorates, the present standard is primarily intended for the use of those practically engaged in design and construction work. Specifications relating to quality control will thus be dealt with in a separate standard within the DIN 4141 series. As detailed quality control specifications are of immediate interest only for inspection bodies and manufacturers of bearings, it seemed sensible, in line with previous practice in the standards of this series, not to encumber the present standard with them.

Re clause 1 Field of application

Although elastomeric bearings do not generally suffer damage from the extremes of temperature occasionally occurring in bridge constructions, they do become progressively stiffer at low temperatures, so that at temperatures below −30 °C it may not be assumed that they are capable of accommodating movements unless this has been specifically verified.

As a function of falling temperature, the relevant factor, the shear modulus, exhibits a virtually constant curve for unsteady deflection until a temperature of −30 °C is reached, and then, on further cooling, an almost discontinuous increase, so that at −40 °C, its original value has increased by as much as six times (transition to crystallized state, cf. *Lager im Bauwesen; Verlag Ernst & Sohn,* 1974, p. 138, fig. 4.129).

Re clause 2 Concept, quantities and symbols

The concepts, quantities and symbols customarily used in official approvals have been retained in all cases where they correspond to normal usage in DIN Standards and are in line with those already employed in DIN 4141 Parts 1 to 3.

Re clause 3 Design

The explicit reference in this clause to the acceptability of drilled holes is a new specification not found in official approvals issued to date (cf. subclause 5.1).

Re figures 1 and 2 Thickness of covering *r*

The given inequation $\frac{t}{2} \geqq r \geqq 2{,}5$ mm is a bandwidth specification within which the thickness of covering may be selected. Taking the minimum value of t as 5 mm results in a design covering layer r of 2,5 mm; the standard currently being prepared on quality control takes this latter value as the basis for its tolerance specifications.

Re subclause 4.1 Elastomer

The validity of clause 1 depends in part on the exclusive use of elastomer containing chloroprene rubber.

Re clause 5 Permissible loading; verification of stability

The extreme variability of the material properties of rubber virtually rules out an accurate calculation being made of "rubber bearings" as interposed structural components. Clause 5 thus provides simple design rules which are on the safe side and which have been common engineering practice for many years. Even given the worst combination of all design effects (compression, translation, rotation), the available margin of safety is still comparable to that expected of other loadbearing structural components. Though in special applications more detailed verification is required, this safety margin may well justify the occasional use of higher design load effects in parts of a structure, on the basis, perhaps, of test results, "more accurate" non-linear theories, or the ORE formulae.[6]) The same applies to bearing sizes which differ from those specified in this standard.

Re subclause 5.2 Load application at right angles to the bearing plane

An increase in the permissible pressure normal to resilient sliding bearings is justified by the fact that the introduction of a sliding device practically eliminates the translational effect, so that the bearing may be expected to accommodate higher stresses of the other component, pressure, without detriment to overall stability.

In the case of resilient sliding bearings guided in one direction, this only applies if the shear deflection at right angles to the sliding movement is minimal. All further specification in this respect is given in the official approvals.

The assumption of a distribution of the compressive stress parabolic in section, a second order parabola, is safer than higher grade curves. Calculations and measurements have so far indicated a stress distribution over a larger area of the circular cross section.

Resilient sliding bearings still require a building inspectorate approval; a standard covering such bearings is in course of preparation.

Re subclause 5.3 Load application parallel to the bearing plane

Bearings can accommodate load effects both normal and parallel to the bearing plane, as well as rotation and translation of their seating surface. Experience gained with existing applications shows that it is not worth attempting to achieve what may conceivably be more accurate results by including the effect of elastomer creep in calculations. Instead, the design assumption of a permanent load in the direction of the bearing plane has been excluded, which is always technically feasible (see subclause 5.3). These specifications are on the safe side. Small load effects which may occur parallel to the bearing plane as a result of permanent deviation of the bearing plane as a result of permanent deviation of the bearing plane from the design location caused by inaccuracies in installation or structural tolerances are, however, permitted (see subclause 5.4). The consequence for statically indeterminate systems is that calculations must be made on the basis of a variable disposition of permanent and transient loads.

The identification check carried out as an integral part of quality control also indirectly serves to check that the creep behaviour of a bearing has not changed to a significant extent.

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[6]) Eggert, H. *Vorlesungen über Lager im Bauwesen, Verlag Wilhelm Ernst & Sohn,* Berlin/München.

No specifications are given in respect of bearings with $T > \frac{a}{3}$ or $\frac{D}{3}$, since such bearings have not yet been investigated and are thus not included among the standard bearings listed in tables 1 to 5.

If such bearings are required in special applications, they shall be treated as any other new building system requiring individual approval or general approval issued by a building inspectorate.

Re subclause 5.3, formula (5) and subclause 5.4, formulae (10) and (11)

Shear modulus is a factor which is significantly shape-dependent. It has here been defined in such a way that it may be used in place of actual material parameters for standard bearings within the limits of their range of application. The permissible deviation for the results of experimental checks carried out in connection with quality control is ± 20 %, which clearly demonstrates that calculations of deformation on the basis of the shear modulus can only be approximative.

Shear movements that are large in relation to the overall installation height can, in cases where the bearing conditions are critical to the stability of the structure (e.g. in the case of socket stanchions), exert an unexpected effect, and it is not initially clear whether it would be safe or unsafe to disregard it (cf. W. Kanning. *Elastomerlager für Pendelstützen; Der Bauingenieur* **55**, 1980; pp. 455–60).

Throughout this standard, the treatment given to resilient bearings compares in all respects with that given to other resilient structural components. Whereas the official approvals issued to date did not permit consideration of restoring forces and moments derived from constrained deformation, even when these exerted a relieving effect, this, or a comparable restriction will no longer apply, nor will it be reintroduced by DIN 1072, at present at the stage of draft, because, in view of the other relevant specifications of a conservative nature, a safety risk, such as inadequately dimensioned foundations, may be deemed improbable. The spread in the material properties of the elastomer, which was the reason for the original specification of this restriction, is matched by comparable conditions in other loadbearing materials.

Re subclause 5.6 Compressive strain

Experiments to quantify the compressive strain of a layer of elastomer under pressure have been carried out by several test houses (cf. *Lager im Bauwesen*, 1974, p. 205f).

The results of more recent systematic investigations have been published in the Research report *Auflagerausbildung bei Fertigteilen (Technische Universität Braunschweig,* 1983) commissioned by the *Bundesministerium für Raumordnung, Bauwesen und Städtebau* (reference number: B 15-80 01 80-22). The empirical formula given in that report indicates the complexity of the problem, which for most practical purposes has little significance:

$$f = t \cdot \frac{\sigma_m}{10 \cdot G \cdot S + 2 \cdot \sigma_m} \cdot \frac{1}{K_e} \cdot K_T \cdot K_Z \cdot K_u + \Delta t_0$$

where

S is the shape factor = $\frac{\text{area in compression}}{\text{force-free area}}$;

K is a correction factor with indices for the effect of surface (e), temperature (T), time (Z) and load fluctuation (u).

Re subclause 7.3

The bearings shall be so located that they only act as compression bearings, when the effects of a higher order and the effects of imposed loads, including snow and wind, are disregarded. This is to be observed both in the design of bearings (subclause 5.3) and in the construction of the seating surfaces, as specified in subclause 7.3. Tolerances of the condition of the first order (inaccuracies in manufacture) as well as the effects of the theoretical conditions of the second order (rotation due to the loading of the structure) are hereby ignored, and in any case limited, e.g. in accordance with DIN 4141 Part 4 and with subclause 5.4.

Re subclause 7.5

The permissible pressure in the mortar joint is specified in subclause 17.3.4 of the December 1978 edition of DIN 1045.

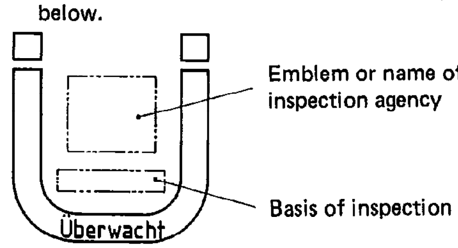
Re subclause 8.2 Identification

The identification of a bearing is required to perform three distinct functions:

a) It must permit identification of the supplier, because bearings from different manufacturers, but of the same type, all look alike. This is the function of the works identification mark referred to in subclause 8.1. Such marks are designed by the bearing manufacturer and will not be changed on any of the currently available bearings. The issue of the mark through the inspection agency signifies an agreement between third party inspectors and factory inspectors on the terms and results of prototype testing. An identification mark on a bearing which is not found in the register kept by the *Institut für Bautechnik* shall be deemed not to have been issued on the conditions of the above-mentioned agreement, and the bearing concerned thus cannot be deemed to be compliant with this standard. Improper use of the works identification mark may naturally lead to its withdrawal.

b) Information recorded on the outer face of the bearing must indicate to the expert the load effect for which the bearing has been designed. Subclause 7.3 of the September 1984 edition of DIN 4141 Part 1 specifies the most important data to be indicated on the bearing (cf. also footnote 4).

c) Regulations issued by the competent authorities require documentation of continual production control by means of the inspection mark, illustrated below.



The identification of the functions required under a), b) and c) may be combined in a single mark, detailed specification of which is not necessary here.

International Patent Classification

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