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DEUTSCHE NORM September 1984

Structural bearings

General design rules

DIN 4141 Part 1

Lager im Bauwesen; allgemeine Regelungen

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 Section *Einheitliche Technische Baubestimmungen*. It has been recommended to the *Laender* building inspectorates by the *Institut für Bautechnik* (Institute for Building Technology), Berlin, for inclusion in the *Laender* building regulations.

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,

Further Parts of this standard are in course of preparation.

Contents

1 Field of application

This standard applies to bearings and to bearing support surfaces as employed in the construction of bridges (or in that of structures requiring comparable bearing systems), as well as in building and industrial construction.

This standard is not applicable to bearings which also transmit moments M_z as principal stress resultants, nor to bearings for which F_z may be a tensile force (see table 1).

This standard may be applied analogously to auxiliary structures.

2 Concept

A bearing is a structural component designed to transmit the stress resultants which have been selected to be the principal stress resultants of the bearing concerned from the six possible stress resultants ($F_x, F_y, F_z, M_x, M_y, M_z$) acting at the joints between two structural components, and to do so either without relative movement, or with restricted relative movement of those structural components. It is also designed to afford the structural components degrees of freedom ($v_x, v_y, v_z, \vartheta_x, \vartheta_y, \vartheta_z$) in the direction of action of the remaining stress resultants, i.e. to permit translation and rotation. Bearing resistances (secondary stress resultants) counteract these relative movements.

Depending on the nature of the resistance, a distinction is to be drawn between

resistances of moving parts to rolling or sliding

and

resistances of resilient parts to deformation.

Most common types of bearing are listed in table 1 according to the nature and number of the degrees of freedom and the principal stress resultants to be transmitted, each bearing type being identified by its static and kinetic function. In this respect, F_z is the force which the bearing transmits at right angles to the bed joint of the supported structural component. The coordinate directions x and y are interchangeable.

*) At present at the stage of draft.

Continued on pages 2 to 12

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For the purposes of this standard, the following shall not be classed as bearings:

a) installation (mounting) aids which are subsequently removed or become inoperative prior to the scheduled date of utilization of the building or structure (cf. subclause 8.3 of DIN 4141 Part 3, September 1984 edition);

b) joint fillers which are intended to prevent or restrict the transmission of forces between adjoining structural components (cf. subclause 4.2 of DIN 4141 Part 3, September 1984 edition);

c) impervious layers which are intended to prevent the ingress of water, unset concrete, dirt and other unwanted materials into certain parts of the structure;

d) separation layers between ceilings and walls, such as double layers of roofing felt or unlaminated "slide foils" (cf. relevant parts of subclause 4.2 of DIN 18 530, December 1974 edition).

3 Bearing resistances

3.1 Classification according to load type

Stress resultants derived from the resistance of bearings to rolling or sliding are classified as transient loads. For design purposes, however, the following shall apply.

a) In the case of sliding bearings, the minimum value for load case 1[1]) shall be taken as half the values of resistance to sliding derived from load case 1, plus half the values of resistance to sliding due to probable settlement of the foundations.

b) In the case of roller bearings, the minimum value for the main load shall be taken as half the values of the resistance to rolling derived from permanent load, prestressing, shrinkage, creep, temperature effects, and probable settlement of the foundations.

c) In the case of all other components for which a distinction is drawn between the main load and other load cases, the main load shall be at least half the values of the sliding and rolling resistances of the other bearings for the load cases listed under items a) and b) above.

Stress resultants derived from the resistance of bearings to deformation shall be classified as

- main loads, if they transmit loads derived from main loads,
- transient loads, if they transmit loads derived from transient loads, and
- constraint loads, if they are produced by constraining stresses.

3.2 General specifications

The coefficients to be taken for calculating the resistances to movement and deformation (secondary stress resultants) for the different types of bearing are specified in the other Parts of this standard. They shall be used to calculate both the theoretical ultimate load and the normal working load of the structure. Besides allowing for the variations due to the physical properties of the bearing material and for the specific factors of safety imposed by the standards, these coefficients also take into account the effects of inaccuracies in the installation of bearings which are virtually unavoidable in practice and which are equivalent in their effect to changes in the resistance of the bearings to movement and deformation. The magnitude of the presumed inaccuracies in installation is specified in conjunction with the relevant coefficients of resistance. The less favourable value of the coefficients of resistance specified for resistance to movement (max. f, min f)[2]) shall always be used when designing other structural components that are affected by the secondary stress resultants.

The coefficients specified for the different types of bearing for purposes of calculating the resistances to movement and deformation are normally valid within the range of the following standard conditions.

a) Temperatures in the bearing shall not exceed the limits previously established by suitability testing (see Explanatory notes).

b) Inaccuracies in installation (e.g. alignment errors) relating to the static system of the structure in its free state or to its state prior to commissioning shall not exceed the limits specified for the different types of bearing in the other Parts of this standard.

   If such inaccuracies exceed the given limits, the structural implications of this error shall be demonstrated by calculation. That involves calculating the difference between the inaccuracy as measured and the inaccuracy in the installation of the particular type of bearing already allowed for. Otherwise, the installation error shall be corrected.

c) The velocities of translation and rotation shall not exceed those occurring under loading as specified in DIN 1072, DS 804[3]) or DIN 1055 Parts 1 to 6 (see Explanatory notes).

d) The bearings shall not be exposed to certain substances which may damage them. The other Parts of this standard list the substances which most commonly cause damage to the different types of bearing.

e) It shall be ensured, by selecting the correct type and design of bearing and by subsequently maintaining it in the manner best suited to local (environmental etc.) conditions, that no undue contamination of the bearing occurs, and that any damage may be readily recongnized and promptly remedied.

f) It shall be possible to remove and replace wearing parts (see subclause 7.5).

3.3 Resistance to rolling and sliding of a number of bearings

If, in bearings and their support surfaces, stress resultants originate in the resistance to movement generated by a number of bearings, then the coefficients of friction, f, for the bearings concerned shall be entered in the calculation of the stress resultants as a function of the

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[1]) Load case 1 is a load classification only applying to sliding bearings; it comprises dead load, prestressing, shrinkage, creep and temperature effects (see Explanatory notes).

[2]) Symbols comply with DIN 50 281.

[3]) Obtainable from the *Drucksachenverwaltung der Bundesbahndirektion Hannover* (Publicity department of the German Federal Railways), Schwarzer Weg 8, D-4950 Minden.

Table 1.

Bearing No.	Symbol	Code	Type and function of bearing	Translation: General	Translation: In direction x	Translation: In direction y	Translation: In direction z	Principal stress resultants / Relative movements	Types of bearing (examples)	Bearing No.
1	□	V2	Resilient bearings	Horizontal movement in 2 directions	Resilient	Resilient	Almost none	F_x / V_x, F_y / V_y	Elastomeric bearing (EL)	1
2		V1		Horizontal movement in 1 direction		None		F_x / V_x, F_y	EL with restraining device for 1 axis	2
3		V		None	None			F_x, F_y	EL with restraining device for 2 axes	3
4		VG1	Resilient sliding bearing	Horizontal movement in 1 direction	Sliding and resilient			$V_x^{2)}$, F_y, ϑ_x	EL with sliding device for 1 axis and restraining device for the other axis	4
5		VG2		Horizontal movement in 2 directions		Sliding and resilient		$V_x^{2)}$, $V_y^{2)}$, ϑ_x	EL with sliding device for movement in 2 axes	5
6		VGE2				Resilient		$V_x^{2)}$, F_y / V_y, ϑ_x	EL with sliding device for movement in 1 axis	6
7	∘	P	Point rocker bearing	None	None	None	None	F_x, F_y, $F_z^{4)}$	a) Steel point rocker bearing b) Spherical bearing c) Pot bearing d) EL with restraining device for 2 axes	7
8		P1		Horizontal movement in 1 direction	Sliding or rolling			V_x, F_y, ϑ_y, ϑ_z 1)	Bearings free to move in 1 axis, such as bearings No. 7, items a) to d)	8
9		P2		Horizontal movement in 2 directions		Sliding or rolling		V_x, V_y	Bearings free to move in 2 axes, such as bearings No. 7, items a) to d)	9
10		L	Linear rocker bearing	None	None	None		F_x, F_y, M_x	a) Steel linear rocker bearing b) Concrete hinge (not a bearing as defined in this standard)	10
11		L1 3)		Horizontal movement in 1 direction	Sliding or rolling			V_x, F_y, M_x	a) Single roller bearing b) Rocker sliding bearing for movement in 1 direction (at right angles to axis of tilt)	11
12		L1q 3)			None	Sliding or rolling		F_x, V_y, M_x	Sliding bearing with tilting device transverse to the direction of movement	12
13		L2 3)		Horizontal movement in 2 directions	Sliding or rolling			V_x, V_y, M_x	Rocker sliding or roller bearing free to move in 2 directions	13
14		H1	Side thrust bearing	Horizontal movement in 1 direction	Sliding	None	Sliding	V_x, F_y, V_z, ϑ_x	Fixed guide bearing for movement in 1 direction (not capable of absorbing vertical loads or moments)	14
15	⊙	H		None	None			F_x, F_y, V_z, ϑ_x	Fixed point or side thrust bearing, restrained in 2 directions (not capable of absorbing vertical loads or moments)	15

For 1) to 4), see page 4.

Forces F_x, F_y, F_z — Moments M_x, M_y, M_z — Stress resultants

Translations v_x, v_y, v_z — Rotations ϑ_x, ϑ_y, ϑ_z — Movements

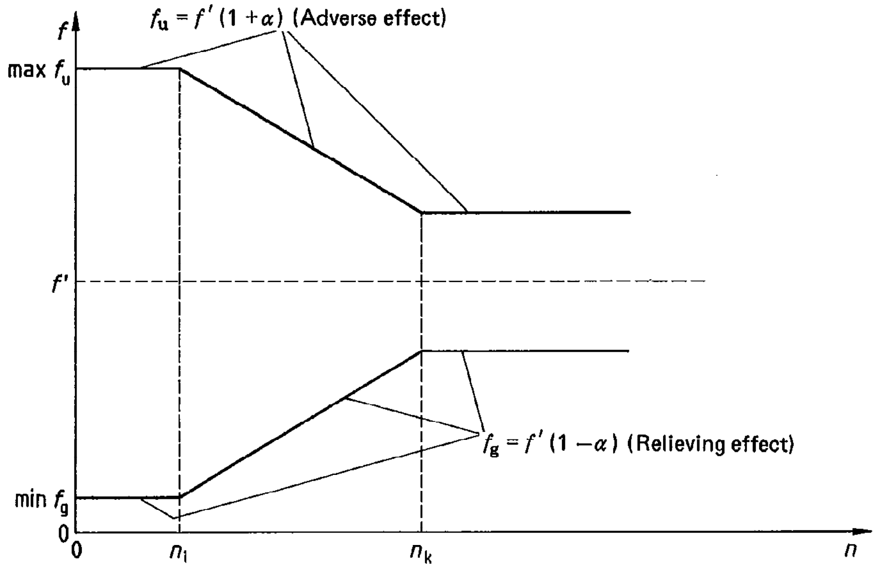


Figure 1. Relative values, f, of sliding and rolling coefficients of friction for bearings exerting a relieving or adverse effect on another bearing, as a function of the total number n of bearings exerting a relieving or adverse effect.

adverse or relieving effect of the friction and of the total number of bearings exerting an adverse or relieving effect, in accordance with the equation given below, provided that the inaccuracies in installation (e.g. twist), the contamination and the wear are not one-sided, and that a more detailed investigation is not carried out, in which allowance is made for the probability of the superposition of frictional forces:

$$f_u = f'(1+\alpha) \quad (1)$$

$$f_g = f'(1-\alpha) \quad (2)$$

where

u signifies adverse;

g signifies relieving;

f' is a value to be specified in the other Parts of this standard; until such a specification is available, f' shall be taken as $0{,}5 \cdot \max. f$;

α is a value to be specified in the other Parts of this standard. Below a given total n_i and above another given total n_k of the bearings which are exerting a relieving or adverse effect in any one instance, this value is a constant, while between these two given totals, it is a variable.

The numbers n_k and n_i are to be specified in the other Parts of this standard; until such a specification is available, the following values may be adopted:

n	α
≤ 4	1
$4 < n < 10$	$\frac{16-n}{12}$
≥ 10	0,5

i.e. $n_i = 4$ and $n_k = 10$.

Plotting the coefficients of friction in accordance with the above relationship gives the graph shown in figure 1.

4 Effects on bearings requiring structural analysis (loads and movements)

4.1 General

Design loads such as are specified in DIN 1072, DS 804[3]), DIN 1055 Parts 1 to 6, or in other codes of practice covering special applications, shall apply for the calculation of the effects on bearings. If no such design load specifications are available, then they shall be derived analogously on the basis of the available data and physical laws. Allowance shall be made for these effects in structural analysis to the extent stipulated in the relevant regulations (codes of practice, building inspectorate approvals etc.).

For [3]), see page 2.

Footnotes to table 1

[1]) In some types of bearing, ϑ_z may be closely toleranced.

[2]) Sliding and resilient.

[3]) If a distinction is to be made between translation by sliding and that by rolling, the letters g and r respectively shall be added, together with an indication of the direction of movement, e.g. L2, g_y, r_x.

[4]) Whether v_z is significant or not shall be checked in cases where it occurs.

4.2 Increased values for movements (translation, rotation)

If the movements of bearings have not been calculated on the basis of data specified for that purpose in codes of practice, then the values of the movements which are to be determined and allowed for as specified in subclause 4.1 shall be increased. If a derivable, realistic limiting value for such an increase is not known, then a factor $k = 1{,}3$ may be assumed. Movements which are designed to be absorbed by deformation of the bearing components need not be increased.

4.3 Allowance to be made for the conditions of installation

If the exact conditions (e.g. temperature) under which the connection between superstructure and fixed bearing will be made, or which will prevail once the structure is completed, are not known at the time when the bearing is being assembled, and if no provision is made for corresponding adjustments on site, then the effects to be determined and allowed for as specified in subclause 4.2 (as a general rule only the movements, but exceptionally the loads, as well) shall be increased by a factor at least corresponding to the possible difference between results obtained from calculations based on the assumed conditions and those based on the possible conditions. Relevant specifications given in other codes of practice (e.g. DIN 1072) remain unaffected.

4.4 Assumed minimum movements for structural analysis purposes

Unless the other Parts of this standard or other codes of practice, e.g. those referred to in subclause 4.1, require closer tolerances, the structural analysis shall assume a minimum rotational movement of not less than ± 0,003 radians and a minimum translational movement of not less than ± 2 cm. These minimum values do not apply to bearing components designed to accommodate movement by deformation.

5 Minimum values for movement capacity of bearings

Unless the other Parts of this standard or the building inspectorate approvals specify more stringent requirements, the structural design of the bearing shall increase its movement capacity as compared with the values for movements obtained as specified in subclause 4.2 by the minimum values given below. These increases may be ignored in the overall structural analysis, and only apply provided that such movements are not designed to be accommodated by deformation of bearing components and that movement capacity is in fact a design consideration.

a) Rotation

The values calculated on the basis of subclauses 4.1 to 4.3 shall be increased by:

$$\Delta\vartheta = \pm 0{,}005 \text{ radians, but by not less than}$$

$$\Delta\vartheta = \pm \frac{1}{a}$$

(where a is the radius in cm required for the calculation of rotation).

b) Translation

The values calculated on the basis of subclauses 4.1 to 4.3 shall be increased by ± 2 cm. In the case of sliding and rolling bearings for bridges and comparable structures, however, the movement capacity shall at least total

± 5 cm in the main direction of translation movement of the structure

and

± 2 cm at right angles to the main direction.

6 Verification of safety against sliding

Safety against sliding in joints formed by elastomeric bearings without positive means of location shall be deemed adequately verified if proof of the minimum compression is provided (a standard dealing with plain elastomeric bearings is in course of preparation).

In other cases, the following equation shall be used to verify the safety against sliding of bearing components relative to each other and in their joints with other structural components:

$$\nu \cdot F_{xy} \leq f \cdot F_z + D \qquad (3)$$

where

ν is the factor of safety for which a value of 1,5 shall be assumed;

F_z is the sum of all loads acting normal to the plane of the bearing;

F_{xy} is the resultant in the plane of the bearing; In the calculation of F_z and F_{xy}, the relative movement of the bearings under normal working load shall be increased by a factor of 1,35.[4]) (F_z and F_{xy} apply for the same associated load combination).

D is the shear force obtaining when the fixing devices are under a working load;

f is the coefficient of friction; it shall be taken as 0,2 for steel on steel, and as 0,5 for concrete on concrete and steel on concrete.

These coefficients of friction are based on the following assumptions in respect of the surface of the steel, namely that:

- for steel on steel, the contact surfaces are either non-coated and free from grease, or galvanized, or zinc silicate coated;
- for steel on concrete, the same applies as for steel on steel, or that the steel surface is unprotected;
- and as a general rule that any coating has completely hardened prior to installation or assembly of the components.

In the case of dynamically stressed structures where extreme load fluctuations can occur, e.g. railway bridges, the horizontal loads shall not be absorbed by friction, i.e. f shall here be taken as zero.

7 Basic design features

7.1 Bearing clearance

If the theoretical clearance calculated for a bearing is zero, the permissible clearance (movement capacity

[4]) Exceptionally, in the case of bearings in a highly variable load system, it may be necessary to calculate F_z and F_{xy} using a realistic model of the bearing system with the load increased by a factor of 1,35.

between two extreme positions) shall be kept as small as possible.

As a guideline value for the clearance 2Δ the following limit shall apply:

$$2\Delta \leq 2 \text{ mm}.$$

If the clearance is larger, a check shall be made whether the action of the bearing clearance on the distribution of forces in the structure requires analysis.

The bearing clearance shall not be employed to absorb design bearing movements, nor as a movement capacity reserve, unless measures have been taken to ensure that the clearance in question will remain available for the desired direction until the structure is commissioned.

As a result of the bearing clearance, a horizontal bearing pressure will generally only be absorbed by one of the fixed bearings in designs where several fixed bearings are located on one support axis. It is, however, possible to distribute such bearing pressure onto several bearings by modifying the design of the bearing or of its support surface. Such measures shall be verified by structural analysis.

7.2 Safeguarding against loss of bearing components

If gradual slackening of a bearing assembly, e.g. as a result of dynamic effects, cannot be ruled out, then suitable precautions shall be taken to prevent any components dropping or rolling out of the bearing.

7.3 Identification and fittings of bearings

Bearings shall be marked by the manufacturer with the

manufacturer's name;

type;

year of manufacture;

works serial number;

item number;

site of installation;

direction of installation;

maximum normal and tangential design loads;

maximum design displacement.

These markings shall be in a durable and clearly intelligible form and, if likely to be required for future reference, so positioned on the bearing as to remain legible subsequent to its installation.

Bearings assembled from several components not bonded or otherwise rigidly attached to each other shall comply with the following requirements.

For their protection during transport and installation the bearing components shall be held in place by temporary clamping devices to be supplied by the manufacturer which both allow for the required presetting and ensure that the bearing components are in their correct design location when the bearing becomes operative. Such clamps shall be mounted without play and designed to withstand deformation due to stresses occurring during transport or in the course of installation. The clamps shall be fixed by bolts, or be so designed as to detach automatically without damaging the bearing when the latter is put under load. As a general rule, however, temporary clamping devices should be removed as far as possible before the bearings become operative.

Unless they are so light as to be easily moved manually, bearings shall be fitted with handling attachments (eye bolts on bearing components) for slinging and placing purposes.

With the general exception of resilient bearings Nos. 1 to 3 in table 1, bearings for bridges and comparable structures shall be provided with a measuring surface for alignment purposes and for subsequent inspections of the state of rotation. The location of such surfaces shall be indicated in the drawings. The deviation from parallelism of the measuring surface with respect to the datum surface shall not exceed 1 ‰.

Unless otherwise specified in the other Parts of this standard, each roller bearing and sliding bearing (including guides) installed in a bridge or in a comparable structure shall be provided with clearly visible and permanent movement indicators, on which at least the positions of permissible maximum displacement of the bearing are marked.

If dimensional changes such as creep and shrinkage cannot be ruled out (e.g. in the case of the height of the gap in PTFE sliding bearings), provision shall be made for measuring such changes with the degree of accuracy necessary for their proper evaluation.

7.4 Protection against corrosion

Steel surfaces of bearings shall be protected against corrosion by means of metallic cladding and/or coatings as specified in DIN 55 928 Parts 1 to 9 enabling them to withstand the atmospheric conditions and any other special environmental effects to which they are exposed in service. Excepted from the above specification are rolling or sliding surfaces manufactured from special stainless steels, as well as non-corroding metal or plastic surfaces, measuring surfaces and surfaces covered by a layer of concrete not less than 4 cm thick without deeply incised joints. The effect of anti-corrosive measures on the coefficient of friction for the surface concerned shall be taken into consideration (see clause 6).

7.5 Provision for resetting and replacement

To facilitate proper maintenance, provision shall be made that functionally indispensible bearings and bearing components which may be subject to a deterioration incompatible with their correct functioning are easily accessible and replaceable. The design of bearings and of their support surfaces shall therefore allow for the removal and replacement of the complete bearing or of parts thereof once the two adjoining structural components have been separated by not more than 10 mm (jacking-up).

The other Parts of this standard specify which parts of the different types of bearings are to be replaceable.

When bearings or bearing components are replaced, care shall be taken to ensure that their replacements comply with the original specifications with regard to the accuracy of contact surfaces and, where applicable, to tolerances on height.

If in exceptional cases bearings are inaccessible and thus cannot be replaced, they shall be designed to be corrosion-proof and maintenance-free during their intended life. Otherwise, the additional forces occurring in the event of bearing failure shall be calculated and verification provided that the structure is able to absorb such additional forces without suffering damage. As regards the suitability of steel plates, refer to subclause 7.6.

7.6 Height correction

Should height correction prove necessary, it shall be effected by grouting or packing with fine-grained mortar or similar materials.

Height correction with the aid of additional metal plates is only permitted if it can be ensured that they remain plane-parallel until their installation is completed.

8 Fire protection

It is not generally possible to specify fire resistance classes in accordance with DIN 4102 Part 2.

The other Parts of this standard specify the requirements to be met by bearings in case of exposure to fire. These requirements deal with the transmission of stress resultants (principal stress resultants) of the bearing, with the resistance to movement and deformation, and with bearing friction.

If the behaviour of a bearing in fire cannot be accurately assessed beforehand, then it shall either be protected against the effects of fire in cases where fire protection is a requirement, or the loss of the functional properties of the bearing in respect of stability shall be allowed for in the overall structural design.

Standards referred to and other documents

DIN 1055 Part 1 Design loads for buildings; stored materials, building materials and structural members, self weights and angle of friction

DIN 1055 Part 2 Design loads for buildings; soil characteristics, specific weight, angle of friction, cohesion, angle of wall friction

DIN 1055 Part 3 Design loads for buildings; imposed loads

DIN 1055 Part 4 Design loads for buildings; imposed loads, wind loads of structures unsusceptible to vibration

DIN 1055 Part 5 Design loads for buildings; imposed loads, snow load and ice load

DIN 1055 Part 6 Design loads for buildings; loads in silo bins

DIN 1072 Road bridges and footbridges; design loads

DIN 4102 Part 2 Fire behaviour of building materials and building components; building components, terminology, requirements and testing

DIN 4141 Part 3 Structural bearings; bearing systems for buildings

DIN 18 530 Solid ceiling structures for roofs; code of practice for design and construction

DIN 50 281 Friction in bearings; terminology, types, conditions, physical quantities

DIN 55 928 Part 1 Corrosion protection of steel structures by organic, inorganic and metallic coatings; general

DIN 55 928 Part 2 Corrosion protection of steel structures by organic, inorganic and metallic coatings; appropriate design features to achieve corrosion protection

DIN 55 928 Part 3 Corrosion protection of steel structures by organic, inorganic and metallic coatings; planning of corrosion protection

DIN 55 928 Part 4 Corrosion protection of steel structures by organic, inorganic and metallic coatings; preparation and testing of surfaces

DIN 55 928 Part 5 Corrosion protection of steel structures by organic, inorganic and metallic coatings; coating materials and protective systems

DIN 55 928 Part 6 Corrosion protection of steel structures by organic, inorganic and metallic coatings; execution and inspection of corrosion protection work

DIN 55 928 Part 7 Corrosion protection of steel structures by organic, inorganic and metallic coatings; control areas

DIN 55 928 Part 8 Corrosion protection of steel structures by organic, inorganic and metallic coatings; corrosion protection of loadbearing, thin-walled structural components (light gauge steel construction)

DIN 55 928 Part 9 Corrosion protection of steel structures by organic, inorganic and metallic coatings; binders and pigments for coating materials

DS 804 *Vorschrift für Eisenbahnbrücken und sonstige Ingenieurbauwerke* (Specification for railway bridges and other civil engineering structures)

Other relevant standards and documents

DIN 1045 Concrete and reinforced concrete; design and construction

DIN 1073 Steel road bridges; design and principles

DIN 1075 Concrete bridges; design and construction

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

DIN 4141 Part 4 Structural bearings; transport, intermediate storage and installation

[1] Rahlwes, K. *Lagerung und Lager von Bauwerken* (Bearing systems and bearings for structures), *Beton-Kalender* Part 2, e.g. 1981, pp. 473 ff.

[2] *Grundlagen für die Sicherheit von Bauwerken* (Basic principles relating to the safety of structures), *Beuth Verlag.*

[3] Eggert, Grote, Kauschke. *Lager im Bauwesen* (Bearings in building and civil engineering), *Verlag Wilhelm Ernst und Sohn*, Berlin.

Explanatory notes

Re clause 1 Field of application

The explicit restriction of the field of application to "bearings and bearing support surfaces" is intended to make it quite clear that this standard does not make any specifications with respect to the structure as a whole. Such a restriction is necessary in order to avoid specifications being duplicated. Yet it is naturally not to be interpreted as signifying that implementation of this standard will have no effect whatsoever on the structure, but rather that any effect which it does have is indirect.

Besides the bearing applications referred to in the opening sentence of clause 1 there are numerous other possible applications for bearings in the field of civil engineering and building construction, e.g. in hydraulic engineering or in nuclear power engineering, but these involve design considerations not covered by the present standard.

That also applies to bearings which are designed to transmit moments, M_z, about a vertical axis, a design consideration conceivable in the case elastomeric bearings having a relatively large base area. Bearings designed to transmit tensile stresses present a number of structural problems and it is generally recommended that such bearing applications be avoided. Although there are known examples of the use of these bearings in the past, the committee did not feel competent to specify in this standard the design considerations which must be complied with in order to obviate the need for repeated repairs.

It is commonly accepted today that the same standard of safety shall apply during erection procedures as applies to the final structure. That does not, however, prevent those effects being evaluated more favourably for which the time of their occurrence is the decisive factor. If, for example, sliding bearings are only employed to accommodate translational movements during the erection procedures in the frost-free half of the year, then significantly lower coefficients of friction may be adopted for calculation purposes than those specified for permanent service, since the effects of "abrasive wear" and "cold weather" need not be taken into account, This consideration prompted the insertion of the qualifying expression "analogously" in the last paragraph of clause 1. The specific conditions of such applications shall be subject to agreement.

For most common types of bearing and bearing applications it is sufficient to allow for rotation and translation by introducing a factor of safety and then to dimension the bearing accordingly. Whether split factors are used in the bearing design (as proposed in the January 1981 edition of the draft standard) or whether it is based on allowable stresses (as is current practice) is of negligible significance. The present standard does not provide detailed design recommendations. Where there is a need for such specification, it will be found in the other Parts of this standard which deal with the different types of bearing.

As regards the design of bearing plates, a recommendation based on extensive tests carried out in Karlsruhe is to be published shortly.

Re clause 2 Concept

A support that is restrained in all directions cannot strictly be classed as a bearing and thus does not fall within the scope of this standard. This type of support, e.g. the rigid connection between pier and superstructure, is a common design feature and doubtless suits the purpose which it is designed to serve.

The roller and linear rocker bearings (Nos. 10 to 13) are now obsolescent and are hardly ever used in modern construction. They owe their inclusion in the present standard to their occurrence in older structures now in need of modernization.

As far as the support which they provide is concerned, bearings V1 and V, i.e. laminated elastomeric bearings with restraining devices, are simply a combination of a V2 bearing (bearing No. 1) with a side thrust bearing (H1 or H). The user should be aware of this fact. In some cases, it may even be advisable to separate the two functions physically by installing the bearings at different points.

The movement capacity of resilient bearings is also indicated by the figure given in the corresponding code in table 1.

Types of bearing that are seldom used have been omitted from the list of examples.

Owing to their resistance to deformation, certain resilient components of individual bearings are even capable of transmitting in the direction of their degrees of freedom principal stress resultants with defined and limited relative movements of the structural components. Such cases have been identified in table 1 by a diagonal line in the corresponding field.

With regard to the problem of "secondary stress resultants M_z" and to footnote 1 of table 1, the following should be noted.

Where bearings designed for linear tilting are installed without sliding surfaces, allowance shall always be made for M_z moments as secondary stress resultants. The most adverse loading conditions are given by the assumption that rotational movement is made possible by the friction in the tilting joint having been overcome. In the case of roller bearings, this results in off-track running, while in that of linear rocker bearings, damage to the shearing protection is a possible consequence. The above consideration also demonstrates the limits to the application of bearings designed for linear tilting.

In the case of point tilting (bearing Nos. 1 to 8), as well as in that of guides and fixed point bearings, the occurrence of M_z as a secondary stress resultant is design-dependent. As far as their effect on the overall structure is concerned, such secondary stress resultants may invariably be considered negligible. However, the same does not necessarily apply to their effect on bearings, and in cases of doubt a rough calculation should be made as a check. The following three cases are to be distinguished.

a) The secondary stress resultant M_z is negligible in the case of resilient bearing constructions free from play (e.g. laminated elastomeric bearings).

b) In the case of non-resilient bearing constructions with clearance against rotation about the z axis (e.g. spherical bearings with DU metal guide, free to move in one direction), the secondary stress resultant M_z may be a cause of increased wear in the guides, so that here at least a comparison calculation should be carried out. The risk of such damage may to some extent be reduced by the provision of a suitable intermediate plate to serve as a turntable.

c) Bearing constructions without play and designed to resist rotation about the z axis are generally unsuitable as bearings because they are not able to absorb the restraint stress resultant M_z derived by calculation without risk of failure.

The list of structural components which by definition cannot be classed as bearings has been taken from DIN 4141 Part 3 and included in the present standard because, even though the components listed are mainly used in building construction, such definitions essentially fall within the scope of indroductory standards providing general specifcations, as is the case with DIN 4141 Part 1.

Re subclause 3.1 Classifcation according to load type

Whereas DIN 1072 classifies the loads acting on a structure into main loads, transient loads and exceptional loads, depending on the probability of their occurrence and on their superposition, official approvals currently distinguish, as regards the design of sliding planes, between load case 1 and load case 2, the distinction being based on the duration of the action. Common to both cases is the element of continuously acting loads, and a decision had thus to be made as to what proportion of the rolling and sliding resistances are to be considered continuously acting loads. Total "stress relief", i.e. the total absence in a structure of forces resulting from rolling or sliding, is inconceivable; measurements providing actual average values are not available. In view of the given margin of safety and of other probabilities, the ruling specified in this standard, whereby half the values are to be treated as permanent loads, may be regarded as a safe assumption.

The above considerations do not apply to deformation resistances, because these are essentiallly indistinguishable from the constraining forces of other elastic components of the loadbearing structure.

Re subclause 3.2 General specifications

Bearing resistances are not just variables in the way that other effects are. Rather, they are specifically defined for a given field of application in respect of stressing and service conditions.

At present, the temperature limitation is only of practical relevance for bearings containing elastomers or PTFE.

The coefficients of friction given for PTFE are based on an assumed temperature range from above −35 °C to no significantly above +21 °C, so that such bearings are suitable for outdoor use in Germany.

Elastomers are suitable for use within a temperature range from −30 °C to +70 °C, and their shear modulus at −30 °C is already twice as high as at normal temperature. The restoring moments of pot bearings require a temperature of not less than −20 °C to be maintained over a period of several days.

The influence of ambient temperature can thus be disregarded for the installations covered by the present standard, except in the case of such special applications as, for example, the installation of bearings in structures on high mountains or in cold stores.

It is primarily roller and sliding bearings that are affected by inaccuracies in installation. Obviously, any increase in the resistance of the bearing to movement resulting from an inaccuracy in its installation may only amount to a fraction of the theoretical resistance to movement if an adequate degree of freedom for the action of the remaining effects is to be retained.

At rapid rates of loading there is a significant increase in the shear modulus of elastomeric bearings and in the restoring moment of pot bearings. As a rule, this is a relieving effect, because rapid rates of load are invariably the result of external forces, and the consequent stiffening reduces the movement of the structure which is in most cases considered undesirable. This effect is , however, adverse in the case of sliding surfaces. Moreover, the rate of wear of PTFE when under constant pressure is roughly proportional to the sliding velocity (cf. [3], page 301 ff).

The replaceability of wearing parts, which is taken for granted in mechanical engineering, should become an accepted design feature in building and civil engineering, too.

Noxious substances cause irreparable damage to bearings in the form of corrosion or disintegration of the elastomer. That should not be confused with contamination, which can seriously impair the performance of roller bearings. To what extent the performance of sliding bearings is adversely affected by contamination has not yet been clarified.

Re subclause 3.3 Resistance to rolling and sliding of a number of bearings

Due consideration is to be given to the following significant effects on the friction behaviour of bearings:

a) divergence between the results of laboratory tests and the behaviour of the bearings when incorporated in the structure;
b) effects resulting from inaccurate installation;
c) effects caused by contamination;
d) effects resulting from abrasive wear;
e) effects resulting from temperature.

Whereas effects a) and b) can be random variables for each of the bearings installed in a structure, it may be assumed that effects d) and e) exert an influence common to all the bearings of a structure. Effect c), contamination, may be a common or a variable tendency. If a part of the structure is affected by the resistance to movement of a single bearing only, then the most adverse combination (max. f) of all effects shall be allowed for when calculating the resistance to movement, if the resistance to movement is adverse, and the most favourable combination (min. f) of all effects, if it is relieving. If, on the other hand, a part of the structure is affected by the resistance to movement of a number of bearings, then the variable effects a) and b), and possibly effect c), as well, will tend towards common average values representing the average for all the bearings involved. In theory, therefore, the same coefficients of friction f should occur both for relieving and for adverse resistances to movement, provided due allowance is made for their load dependency. For reasons of safety, however, a certain interval has been retained in this standard between the coefficients of friction exerting a relieving effect and those exerting an adverse effect, even in cases involving large numbers of bearings. The minimum value of adverse coefficients of friction and the maximum value of relieving coefficients of friction is obtained when, in each case, the number of bearings participating is 10. The number of bearings participating refers to the number of bearings which in each case exert an adverse or a relieving effect.

The November 1967 edition of DIN 1072 permitted relieving resistances of roller and sliding bearings to be taken at half their value for calculation purposes. When applied to a single bearing, that is a highly questionable specification, because the actual coefficients of friction, as distinct from the allowable coefficients of friction, may easily approach the installation tolerances during the early period of its service life (i.e. while still free from contamination and abrasive wear) and then, when these effects act in the opposite direction, the resultant force will be zero. Consequently, allowances for the relieving effect are not permitted for approved bearings.

It is highly improbable, in the case of a large number of bearings, that any inaccuracy in installation will operate in the same direction for all of them. Nor is it likely that the bearings will all be inaccurately installed at any one time to the fulll extent currently permitted for such inaccuracies.

There is, then, adequate justification, in the case of a large number of bearings, for reducing the adverse resistances while making allowance for the relieving resistances.

It was agreed to specify that the existing "conditions of approval" should remain valid for systems with relatively few bearings, whereas for systems with a very large number of bearings subject to equal loading and having their locating point at the centre of the bearing the instruction specified in the November 1967 edition of DIN 1072 should take effect (instead of 1,0 × adverse minus 0,5 × relieving, in future 0,75 × adverse minus 0,25 relieving will apply).

As a general rule, this should not present any complications. The "participating bearings" are always those exerting either an adverse or a relieving effect, so that generally different values are to be taken for n in accordance with figure 1. For large area bearing systems, such as extremely wide and short bridges, the conditions are rather more complex, and in such cases it may be that the specifications of subclause 3.3 can only be applied analogously.

Re clause 4 Effects on bearings requiring structural analysis (loads and movements)

The specifications given here, and other simplified specifications given elsewhere in this standard, shall not be deemed applicable to special, non-standard applications; for such applications, [2] shall be consulted.

Re subclause 4.1 General

DIN 1072 and DS 804 deal exhaustively with the specifications applying to bridge construction, but there is not the same degree of coverage for other fields of building and civil engineering. Thus, for example, the variations in temperature to be considered when calculating the constraints and deformations in conventional buildings have as yet not been specified. The wording of clause 4 is intended to ensure that in the case of applications other than bridge construction an initial check is always made as to whether the available codes of practice provide all the design principles required for the particular application. If certain specifications are found to be lacking, the gaps shall be made good at the discretion and on the responsibility of the engineer concerned in collaboration with the inspecting body or the building inspectorate.

Re subclause 4.2 Increased values for movements (translation, rotation)

and

Re subclause 4.3 Allowance to be made for the conditions of installation

Specifications relating to the phenomenon of discontinuity at the bearing application points were already made a few years ago in the supplementary regulations to DIN 1072. These specifications involved either increasing the effects by a factor of 1,3 (to allow for shrinkage and creep), or increasing the temperature range which, besides allowing for the unknown temperature at the time of installation, also amounts to an increase by a factor of 1,3.

This specification was retained in draft Standard 1072.

In view of the factors of safety already incorporated in the allowable values for angles of rotation and for shear deformation, such an increase is not required for resilient bearings which resemble in their mode of action other resilient structural components. That naturally does not apply to the rotational movements of pot bearings, because in their case the rotational movements are not absorbed by a corresponding deformation; on the contrary, the deformation of the elastomer is a geometrically unavoidable additional phenomenon and the sliding of the elastomer against the steel wall also has a significant effect.

Since bearings are highly sensitive to improper handling, it is generally prohibited for adjustments to be made to them once they have left the manufacturer's works. Thus, for example, a bearing should not, except in exceptional circumstances, be preset to the mean value between extremes of temperature and subsequently adjusted to the prevailing temperature conditions after the release of the superstructure. As a general rule, therefore, the conditions likely to prevail at the time of commissioning of the bearing shall be estimated and provision made for an additional safety margin. The temperature assumptions given in DIN 1072 already include a margin that is normally adequate for bridge conditions, so that for this, the main field of bearing application, calculation problems are not likely to occur.

One problem which has not been dealt with in this subclause is the consideration to be given to those displacements derived from statical calculations which, for reasons of structural safety, assume very high values that are not only unacceptably high for the bearing design, but also unrealistically so. This refers in particular to the effect of bridge pier head displacements calculated in connection with the verification of pier stability. Where slender piers are concerned, such values can, given the assumptions prescribed in DIN 1045 for imperfection and materials, amount to a multiple of the value obtained for deformation due to temperature, which is normally the decisive factor. An acceptable method of making due allowance for this effect remains to be found. In the meantime, as far as the bearing standard was concerned, there was no alternative but to allow for it by requiring it to be increased. A suitable reduction of the undesirable initial deflection of the pier and the assumption of a realistic mean stress-strain curve for the concrete would be a conceivable and acceptable solution to this problem. The final sentence of subclause 7.2.1 in the April 1981 edition of DIN 1075 contains a recommendation which could be adapted and applied here as a temporary expedient.

It is consistent with the assumption of deformation movements that the rotation of pot bearings should be treated in the same way as sliding or rolling movements, despite the fact that in the case of pot bearings some deformation (of the elastomer) also occurs.

Re subclause 4.4 Assumed minimum movements for structural analysis purposes

A consistent application of the safety considerations expounded in [2] would require the proportions exhibiting a different (plus or minus) sign to be weighted differently in calculations of rotation, in order to counteract the "difference of large number" effect in the case of prestressed concrete, for example.

This consideration has in fact been anticipated in the present standard by the specification of a minimum value derived from calculations of extreme cases of application in conventional bridge construction. An imperfection increment of 1 ‰ is also included in this minimum value. That a portion of the minimum value ought to be allowed for as an increment in the case of appreciably larger rotations, as well, has been ignored here both for the sake of simplification and because of its negligible influence.

In addition to allowing for inaccurate installation, the minimum value also incorporates an unquantifiable increment for imponderables.

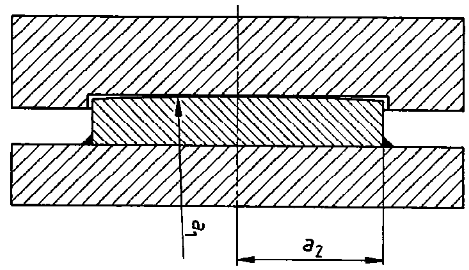
See Explanatory notes to subclause 4.2 for the classification of pot bearings.

Re clause 5 Minimum values for movement capacity of bearings

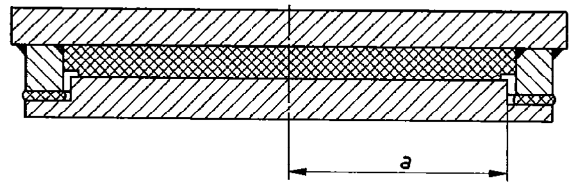
The retention of an adequate safety margin even at the extremes of bearing movement has always been considered an essential specification. Such safety margins take the form, for example, of an overhang at the edge of the pot at maximum rotation of the pot lid, or a "clearance reserve" from the edge of the sliding surface in the case of sliding bearings. The relevant specifications, which in the past were generally included in the separate approval documents, have now been put on a general footing. The special regulation of the minimum translations of bridge bearings, which in the longitudinal direction exceed those specified in subclause 4.4, is intended to prevent any "fine tuning", as inappropriate to such applications.

A number of examples of the limiting radius a are given below.

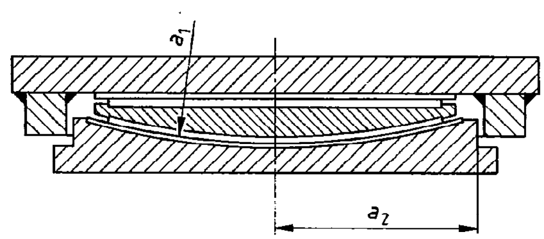
a) For dimensioning the rocker of rocker bearings, the significant dimension is the radius of curvature, a_1; for dimensioning the limit stop of the outer bearing plate of rocker bearings, the significant dimension is the radius of recess, a_2.



b) For pot bearings, the significant dimension is the radius of pot or lid, a.



c) For dimensioning the sliding surface of spherical bearings, the significant dimension is the radius of curvature of the sphere, a_1, while for dimensioning the limit stop, the significant dimension is one half of the inside diameter of the guide edges, a_2.



Re clause 6 Verification of safety against sliding

Whereas the other verifications of stability (safety against uplift and overturning) are detailed in the standards covering specific applications, it was deemed appropriate, after consultations with the technical committee responsible for DIN 1072, to specify in the present standard the verification of safety against sliding in the different joints of a bearing, one reason for this decision being the fact that the design of fixing devices depends on such verification and, as they are integral components of the bearing, their design is essentially a matter of bearing design.

The restriction of the coefficient of friction 0,5 to combinations of steel on concrete and concrete on concrete, and the reduction of the coefficient of friction for steel on steel from the previous value of 0,3 or 0,5 to 0,2 (corresponding to lower values obtained in tests) justified in the opinion of the technical committee the limitation of the verification to compliance with equation (3). Since subclause 3.3 in this standard and the future wind load assumptions in DIN 1072 may both be expected to facilitate calculation of F_{xy} on the left-hand side of the equation, the reduction of the coefficient of friction to 0,2 should not yet produce any marked effect, the less so since it still represents a doubling of the required holding forces $f \cdot F_z + D$ as specified in the July 1974 edition of DIN 1073.

The "working load of the fixing devices" is not always clearly defined, as is the case for example with fastenings by means of high-strength bolts. In such cases, the calculation should be adapted to suit, i.e. the product of the allowable shear force and the associated factor of safety should be taken as a substitute for D. When dealing with prestressed friction grip bolt joints, the product of the allowable transmissible force and the sliding resistance coefficient shall be taken in place of D if prevention of sliding in the joint by the amount of the bolt hole clearance is desired. Otherwise, 1,7 times the allowable transmissible force of the SL joint for load case H shall be taken.

Re subclause 7.1 Bearing clearance

Consideration shall be given to bearing clearance in the following cases:

1) for roller bearings, the clearance in the guides;
2) for point rocker bearings, the clearance
   a) between rocker and the upper outer plate of steel point bearings;
   b) between the lid and the pot of pot bearings;
   c) between the upper and lower plate of fixed spherical bearings;

   and the clearance in fixing devices;
3) the clearance in the guiding edge of sliding and guide bearings free to move in one direction;
4) the clearance in side thrust bearings.

The above list makes it clear that a single general specification in respect of bearing clearances is not a practical proposition. Thus, for example, a far larger clearance can be tolerated in the case of steel point rocker bearings when they are subjected to sufficiently small horizontal forces, which can safely be absorbed by the friction of steel on steel, than can be tolerated in the case of pot bearings where the effectiveness of the seal is only ensured under conditions of very close clearances.

Since the side against which, given a clearance, the components concerned will butt, is not predetermined, clearances are not generally suitable for absorbing design movements. In the past, however, stops made of plastic have been found useful to counteract the clearance temporarily. These are only designed to absorb the relatively small forces occurring during transport and installation, and they disintegrate once the bearing is released. Such measures require a great deal of care and attention, and should therefore remain the exception rather than the rule.

Detailed and precise allowance for bearing claearance in structural analysis should also remain the exception, since normally the bearing clearance triggers additional constraining forces in the structure, while the loadbearing capacity remains unaffected. It is, however, necessary to make at least a rough estimate of this effect.

The last paragraph of subclause 7.1 refers to cases such as several bridge bearings arranged on a common support. The problems associated with a common loadbearing action for horizontal forces are outlined in *Lager im Bauwesen* (Bearings in building construction and civil engineering), *Verlag Ernst & Sohn*, 1974, pp. 14 and 90.

When assessing the bearing clearance, the possible clearance between the rollers or similar elements and the associated contact apertures shall, of course, also be considered, in function of the verification of resistance to sliding as specified in clause 6.

It shall also be borne in mind that the achievement of closer bearing clearances considered necessary for design reasons will result in higher manufacturing costs for the bearing.

Re subclause 7.2 Safeguarding against loss of bearing components

This subclause explicitly refers to supplementary measures to be taken to ensure that bearing components cannot drop or roll out of the bearing in order to emphasize that it is not permissible to contravene the specifications of other standards in attempting to achieve the same effect.

Re subclause 7.3 Identification and fittings of bearings

The skeletal information given on the rating plate is naturally not sufficient to exempt the engineer from drawing up (where reconstruction work is planned, for example) a detailed schedule of the bearings on the basis of the construction documents (drawings, structural analysis).

Re subclause 7.4 Protection against corrosion

The requirement that unprotected steel parts be covered by concrete to a thickness of not less than 4 cm is a new specification.

Re subclause 7.5 Provision for resetting and replacement

The specification corresponding to the requirement that it shall be possible to raise the structure by 10 mm at one half the imposed load will be incorporated in the revised edition of DIN 1072, which was published in August 1983 as a draft Standard.

Re subclause 7.6 Height correction

When correcting the effects of any differential settlement, it shall generally be assumed that it is not the bearing which requires replacement but that only the height of the support point needs to be corrected. In the past, the use of additonal steel plates was considered suitable for this purpose, and it was regarded as an advantage if such plates were already provided at the time of installation of the bearing so that they could then be inserted or removed as and when required. The damage which has occurred in connection with these plates has, however, shown that they cannot safely be used unless they are manufactured, at an exorbitant cost, with a plane-parallel top and bottom face. If they are not plane-parallel, then a stack of such plates will act in the same way as a spring, and that is, especially in the case of sliding bearings, unacceptable. It is thus better to correct the height in other ways. The committee considerd it necessary to include a specification in respect of such plates because of the general ignorance of the problems involved in their use.

Re clause 8 Fire protection

Detailed instruction on the subject of fireproofing and fire protection will be included in the standard dealing with plain elastomeric bearings which is currently in the course of preparation.

International Patent Classification

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