BS ISO 14728-2:2017

BSI Standards Publication

Rolling bearings — Linear motion rolling bearings

Part 2: Static load ratings

bsi.

National foreword

This British Standard is the UK implementation of ISO 14728-2:2017. It supersedes BS ISO 14728-2:2004 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee MCE/7, Rolling bearings.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Date	Text affected

BS ISO 14728-2:2017

INTERNATIONAL STANDARD

ISO 14728-2

Second edition
2017-02

Rolling bearings — Linear motion rolling bearings —

Part 2: Static load ratings

Roulements — Roulements à mouvement linéaire —

Partie 2: Charges statiques de base

Reference number
ISO 14728-2:2017(E)

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 4, *Rolling bearings*, Subcommittee SC 8, *Load ratings and life*.

This second edition cancels and replaces the first edition (ISO 14728-2:2004), of which it constitutes a minor revision with the following changes:

— improvement of Figures 2, 4, 8 and 9;

— correction of formula for k_{0i} in Formula (1);

— alignment with the latest drafting rules.

A list of all parts in the ISO 14728 series can be found on the ISO website.

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Introduction

It is often impractical to establish the suitability of a linear motion rolling bearing selected for a specific application by testing. The following procedures have proved to be an appropriate and convenient substitute for testing:

— life calculation with dynamic load (ISO 14728-1);

— static load safety factor calculation with static load (ISO 14728-2).

Permanent deformation appears in rolling elements and raceways of rolling bearings under static loads of moderate magnitude and increases gradually with increasing load.

It is often impractical to establish whether the deformation appearing in a bearing in a specific application is permissible by testing the bearing in that application. Other methods are therefore required to establish the suitability of the bearing selected.

Experience shows that a total permanent deformation of 0,000 1 of the rolling element diameter, at the centre of the most heavily loaded rolling element/raceway contact, can be tolerated in most bearing applications without the subsequent bearing operation being impaired. The basic static load rating is, therefore, given a magnitude such that approximately that degree of deformation occurs when the static equivalent load is equal to the load rating.

Tests in different countries indicate that a load of the magnitude in question may be considered to correspond to a calculated contact stress of

— 5 300 MPa for recirculating linear ball bearings, sleeve type,

— 4 200 MPa to 4 600 MPa for recirculating linear ball bearings, linear guideway type (see 3.9 and Table 1),

— 4 200 MPa to 4 600 MPa for non-recirculating linear ball bearings (see 3.9 and Table 1), and

— 4 000 MPa for linear roller bearings,

at the centre of the most heavily loaded rolling element/raceway contact. The formulae and factors for the calculation of the basic static load ratings are based on these contact stresses.

The permissible static equivalent load may be smaller than, equal to or greater than the basic static load rating, depending on the requirements for smoothness of operation and friction, as well as on actual contact surface geometry. Bearing users without previous experience of these conditions should consult the bearing manufacturers.

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INTERNATIONAL STANDARD ISO 14728-2:2017(E)

Rolling bearings — Linear motion rolling bearings —

Part 2: Static load ratings

1 Scope

This document specifies methods of calculating the basic static load rating, static equivalent load and static safety factor for linear motion rolling bearings manufactured from contemporary, commonly used, high quality, hardened bearing steel in accordance with good manufacturing practice and basically of conventional design with regard to the shape of the rolling contact surfaces.

This document is not applicable to designs where the rolling elements operate directly on the slide surface of the machine equipment, unless that surface is equivalent in all respects to the raceway of the linear motion rolling bearing component it replaces.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 76 and ISO 5593, and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

3.1
recirculating linear ball bearing, sleeve type, with or without raceway grooves
basically cylindrical sleeve provided with a number of closed loops of recirculating balls designed to achieve linear rolling motion along a hardened cylindrical shaft

Note 1 to entry: See Figure 1.

Note 2 to entry: The raceways in the sleeve can be designed cylindrical as well as steel inserts with raceway grooves parallel to the axis.

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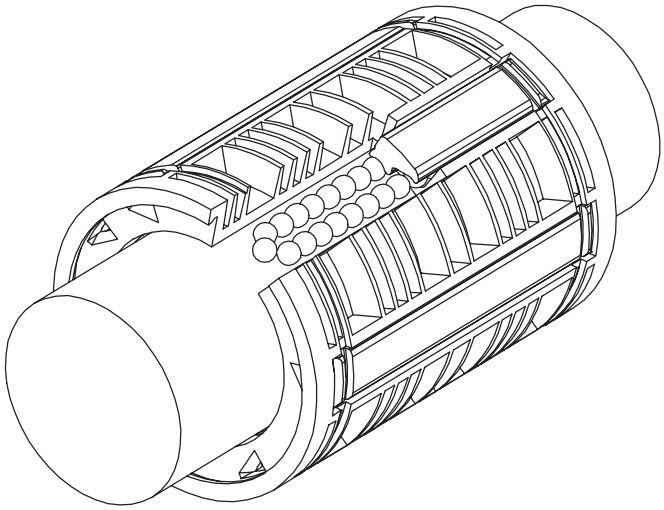

Figure 1 — Recirculating linear ball bearing, sleeve type

3.2
recirculating linear ball (or roller) bearing, linear guideway, carriage type
linear ball (or roller) bearing provided with a number of symmetrically arranged, closed loops of recirculating balls (or rollers) designed to achieve linear rolling motion along a hardened guideway furnished with adequate raceways

Note 1 to entry: See Figure 2.

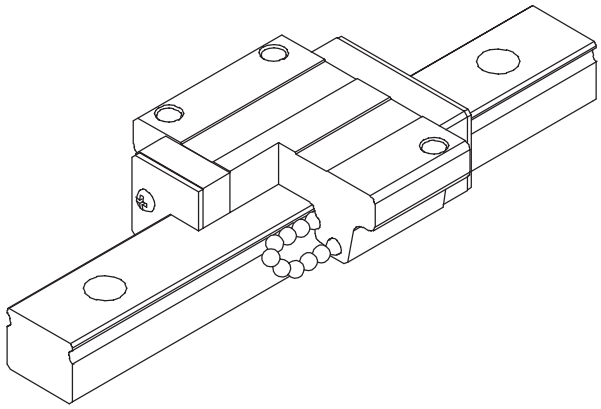

Figure 2 — Recirculating linear ball (or roller) bearing, linear guideway, carriage type

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3.3
non-recirculating linear ball bearing, linear guideway, deep groove type
linear bearing with balls as rolling elements, each ball having two points of contact

Note 1 to entry: See Figure 3.

Note 2 to entry: The cross-sectional radii of the raceway grooves in the two guideways are equal and may lie between 0,52 D_w and infinity.

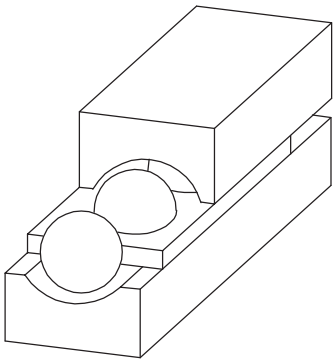

Figure 3 — Non-recirculating linear ball bearing, linear guideway, deep groove type

3.4
non-recirculating linear ball bearing, linear guideway, four-point-contact type
linear bearing with balls as rolling elements, each ball having four points of contact

Note 1 to entry: See Figure 4.

Note 2 to entry: The cross-sectional radii of the raceway grooves for the four points of contact in the two guideways are equal and may lie between 0,52 D_w and infinity.

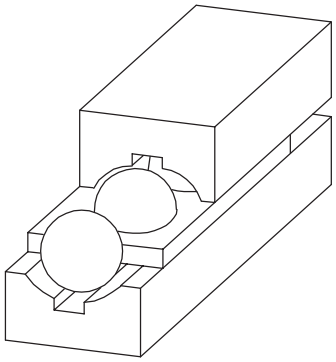

Figure 4 — Non-recirculating linear ball bearing, linear guideway, four-point-contact type

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3.5
non-recirculating linear roller bearing, linear guideway, flat type
linear bearing with needle rollers or cylindrical rollers as rolling elements

Note 1 to entry: See Figure 5.

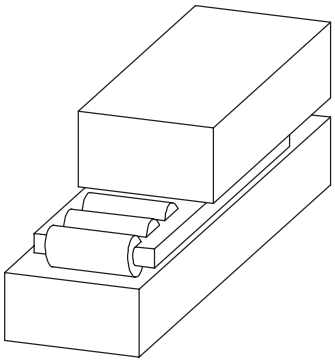

Figure 5 — Non-recirculating linear roller bearing, linear guideway, flat type

3.6
non-recirculating linear roller bearing, linear guideway, V-angle type
linear bearing with guideways designed as parts of a V with a 90° angle

Note 1 to entry: See Figure 6.

Note 2 to entry: Needle rollers or cylindrical rollers are used as rolling elements.

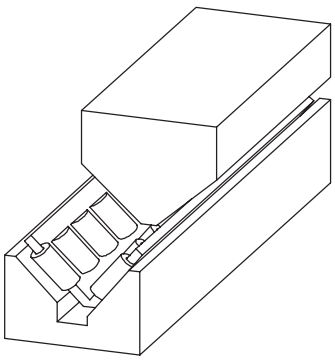

Figure 6 — Non-recirculating linear roller bearing, linear guideway, V-angle type

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3.7
non-recirculating linear roller bearing, linear guideway, crossed roller type
linear bearing with cylindrical rollers arranged in a crossed roller construction

Note 1 to entry: See Figure 7.

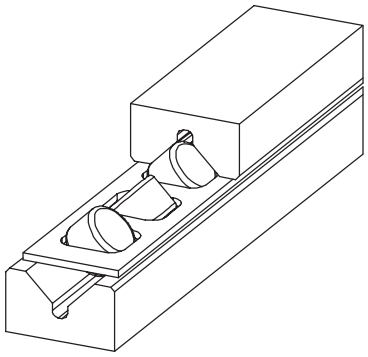

Figure 7 — Non-recirculating linear roller bearing, linear guideway, crossed roller type

3.8
static safety factor
ratio between the basic static load rating and the static equivalent load giving the margin of safety against inadmissible permanent deformation on rolling elements and raceways

3.9
basic static load rating of a linear motion rolling bearing
static load which corresponds to a calculated contact stress σ_{max} at the centre of the most heavily loaded rolling element or raceway contact

Note 1 to entry: For this contact stress, a total permanent deformation of rolling element and raceway occurs which is approximately 0,000 1 of the rolling element diameter.

— For a recirculating linear ball bearing, sleeve type: σ_{max} = 5 300 MPa;

— For a recirculating linear ball bearing, linear guideway type: see Table 1;

— For a non-recirculating linear ball bearing: see Table 1;

— For a linear roller bearing: σ_{max} = 4 000 MPa.

Table 1 — Contact stress, σ_{max}

r_g (mm)	≤0,52 D_w	0,53 D_w	0,54 D_w	0,55 D_w	0,56 D_w	0,57 D_w	0,58 D_w	0,59 D_w	≥0,6 D_w
σ_{max} (MPa)	4 200	4 250	4 300	4 350	4 400	4 450	4 500	4 550	4 600

3.10
static equivalent load
static load that causes the same contact stress at the centre of the most heavily loaded rolling element or raceway contact as the stress that occurs under the actual load conditions

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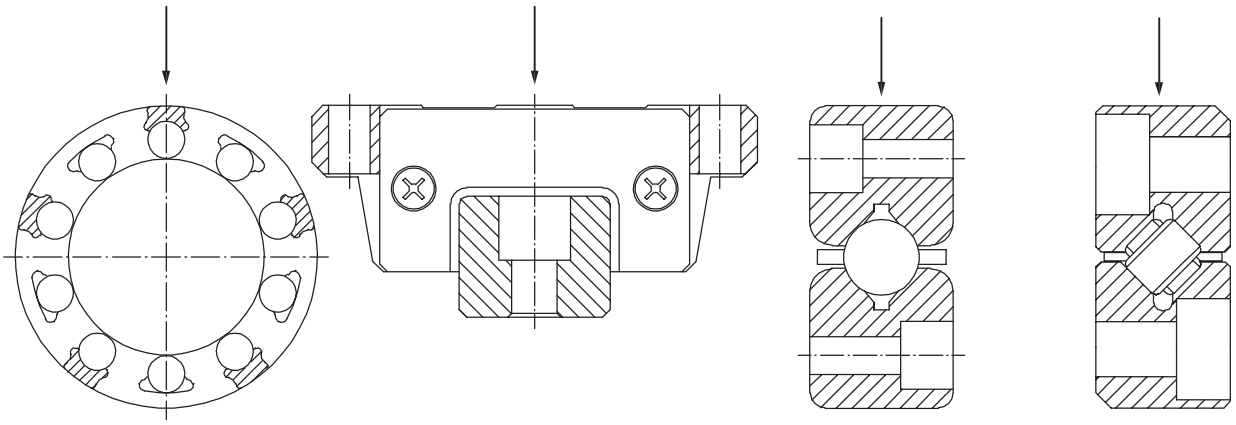
3.11
direction of load
direction of load applied for load rating calculation

Note 1 to entry: For calculation of basic static load ratings, the direction of the load is defined for all linear motion bearings as shown by the arrows in Figure 8.



Rolling bearing defined in			
3.1	3.2	3.4	3.7

Figure 8 — Direction of load

3.12
pitch diameter
<of recirculating linear ball bearing, sleeve type> diameter of the circle containing the centres of the balls in contact with the raceways, in a cross-sectional plane perpendicular to the bearing axis

3.13
nominal contact angle
angle between the direction of load on the linear bearing and the nominal line of action of the resultant of the forces transmitted by a bearing raceway member to a rolling element

Note 1 to entry: See Figure 9.

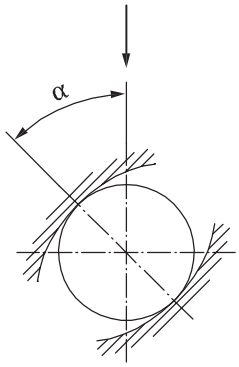


Figure 9 — Nominal contact angle

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4 Symbols

For the purposes of this document, the symbols given in ISO 76, ISO 15241 and Table 2 apply.

Table 2 — Symbols, terms and units

Symbol	Term	Unit
C_0	Basic static load rating	N
D_{pw}	Pitch diameter of ball rows	mm
D_w	Ball diameter	mm
D_{we}	Roller diameter applicable in the calculation of load ratings	mm
F	Load on bearing	N
f_0	Factor which depends on the geometry of the bearing components and on the applicable stress level	1
i	Number of rows of balls or rollers applicable in the calculation of load ratings NOTE In the case of recirculating linear bearings, sleeve type, it is the total number of rows of balls.	1
i_t	Number of load-carrying rows of balls in loaded zone $-90° < \varphi_j < +90°$ of recirculating linear ball bearings, sleeve type, with or without raceway grooves, applicable in the calculation of load ratings	1
k_{0F}	Static load factor	1
k_{0i}	Load factor that depends on number of rows of balls in a recirculating ball bearing, sleeve type	1
L_{we}	Roller length applicable in the calculation of load ratings	mm
P_0	Static equivalent load	N
r_g	Cross-sectional radius of the raceway groove on guideway	mm
S_0	Static load safety factor	1
Z	Number of balls or rollers in one row	1
Z_t	Number of load-carrying balls or rollers in one row applicable in the calculation of load ratings	1
α	Nominal contact angle	°
φ_j	Angle between the direction of load and the ball row j	°
σ_{max}	Contact stress at the centre of the most heavily loaded rolling element or raceway contact	MPa

5 Basic static load ratings

5.1 Linear ball bearings

5.1.1 Recirculating linear ball bearings, sleeve type, with or without raceway grooves

The basic static load rating for these bearings is given in Formula (1):

$$C_0 = f_0 \times k_{0i} \times Z_t \times D_w{}^2 \tag{1}$$

where

$$k_{0i} = \frac{\sum_{j=1}^{j=i_t} \left(\cos\varphi_j\right)^{2,5}}{\max\left\{\left(\cos\varphi_j\right)^{1,5}\right\}}$$

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In the number of load-carrying rows of balls in the loaded area, i_t, those rows which are arranged in an angular area of $-90° < \varphi_j < +90°$ to the direction of normal load (see Figure 8) are to be taken into account.

The values of k_{0i} of recirculating linear ball bearing, sleeve type, with equally spaced ball rows, are given in Table 3 and the values of f_0 in Table 4.

Table 3 — Values of k_{0i}

i	3	4	5	6	7	8	9	10
k_{0i}	1,000	1,000	1,106	1,354	1,614	1,841	2,052	2,284

Table 4 — Values of f_0

D_w/D_{pw}	f_0	D_w/D_{pw}	f_0	D_w/D_{pw}	f_0
0,005	14,801	0,105	13,297	0,205	11,770
0,010	14,726	0,110	13,221	0,210	11,693
0,015	14,651	0,115	13,146	0,215	11,616
0,020	14,577	0,120	13,070	0,220	11,539
0,025	14,502	0,125	12,994	0,225	11,462
0,030	14,427	0,130	12,918	0,230	11,384
0,035	14,352	0,135	12,842	0,235	11,307
0,040	14,277	0,140	12,765	0,240	11,230
0,045	14,202	0,145	12,689	0,245	11,152
0,050	14,127	0,150	12,613	0,250	11,075
0,055	14,052	0,155	12,537	0,255	10,997
0,060	13,977	0,160	12,460	0,260	10,920
0,065	13,902	0,165	12,384	0,265	10,842
0,070	13,826	0,170	12,307	0,270	10,765
0,075	13,751	0,175	12,231	0,275	10,687
0,080	13,675	0,180	12,154	0,280	10,609
0,085	13,600	0,185	12,077	0,285	10,531
0,090	13,524	0,190	12,000	0,290	10,454
0,095	13,449	0,195	11,924	0,295	10,376
0,100	13,373	0,200	11,847	0,300	10,298

5.1.2 Recirculating linear ball bearings, linear guideway, carriage type

The basic static load rating for this bearing is given in Formula (2):

$$C_0 = f_0 \times i \times Z_t \times {D_w}^2 \times \cos\alpha \tag{2}$$

The values of f_0 are given in Table 5 and are dependent on the cross-sectional radius of the raceway groove on the guideway and on the ball diameter.

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Table 5 — Values of f_0

r_g	f_0
0,52 D_w	94,64
0,53 D_w	76,33
0,54 D_w	66,07
0,55 D_w	59,48
0,56 D_w	54,89
0,57 D_w	51,55
0,58 D_w	49,03
0,59 D_w	47,08
0,60 D_w	45,57

The load-carrying ability of a bearing is not necessarily increased by the use of smaller raceway groove radii, but it is reduced by the use of larger raceway groove radii than those indicated in Table 5.

5.1.3 Non-recirculating linear ball bearings, linear guideway, deep groove and four-point-contact types

The basic static load rating for these bearings is given in Formula (3):

$$C_0 = f_0 \times i \times Z_t \times D_w{}^2 \times \cos\alpha \tag{3}$$

The values of i and Z_t are given in Table 6.

Table 6 — Values of i and Z_t

Bearing	i	Z_t
Deep groove type	1	Z
Four-point-contact type	2	Z

The values of f_0 are given in Table 7.

Table 7 — Values of f_0

r_g	f_0
0,52 D_w	94,64
0,53 D_w	76,33
0,54 D_w	66,07
0,55 D_w	59,48
0,56 D_w	54,89
0,57 D_w	51,55
0,58 D_w	49,03
0,59 D_w	47,08
0,60 D_w	45,57
∞	9,72

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5.2 Linear roller bearings

5.2.1 Recirculating linear roller bearings, linear guideway, carriage type

The basic static load rating for this bearing is given in Formula (4):

$$C_0 = f_0 \times i \times Z_t \times L_{we} \times D_{we} \times \cos\alpha \quad (4)$$

where

$f_0 = 221$

5.2.2 Non-recirculating linear roller bearings, linear guideway, flat, V-angle and crossed roller types

The basic static load rating for these bearings is given in Formula (5):

$$C_0 = f_0 \times i \times Z_t \times L_{we} \times D_{we} \times \cos\alpha \quad (5)$$

where

$f_0 = 221$

The values for i and Z_t are given in Table 8.

Table 8 — Values of i and Z_t

Bearing type	i	Z_t
Flat type	1	Z
V-angle type	2	Z
Crossed roller type	2	$Z/2$

6 Static equivalent load

The static equivalent load for a linear motion rolling bearing is given in Formula (6):

$$P_0 = k_{0F} \times F \quad (6)$$

The static load factor k_{0F} is taken to be 1 ($k_{0F} = 1$) when the direction of the bearing load, F, is normal (as shown in Figure 8) and the bearing clearance is in the normal range. When these conditions are not satisfied, the bearing manufacturer should be consulted for the applicable k_{0F} factor value.

7 Static load safety factor

The static load safety factor for a linear motion rolling bearing is given in Formula (7):

$$S_0 = \frac{C_0}{P_0} \quad (7)$$

The static load safety factor S_0 should be larger than 2 for conventional operating conditions. For a particular operating condition, the bearing manufacturer should be consulted for the applicable S_0 factor value.

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[1] ISO 76, *Rolling bearings — Static load ratings*

[2] ISO 5593, *Rolling bearings — Vocabulary*

[3] ISO 10285, *Rolling bearings — Sleeve type linear ball bearings — Boundary dimensions and tolerances*

[4] ISO 15241, *Rolling bearings — Symbols for physical quantities*

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