INTERNATIONAL STANDARD

ISO 14728-2

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Rolling bearings — Linear motion rolling bearings —

Part 2: Static load ratings

Roulements — Roulements à mouvement linéaire —

Partie 2: Charges statiques de base

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 14728-2 was prepared by Technical Committee ISO/TC 4, *Rolling bearings*, Subcommittee SC 8, *Load ratings and life*.

ISO 14728 consists of the following parts, under the general title *Rolling bearings — Linear motion rolling bearings*:

— *Part 1: Dynamic load ratings and rating life*

— *Part 2: Static load ratings*

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

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

— 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.

Rolling bearings — Linear motion rolling bearings —

Part 2:
Static load ratings

1 Scope

This part of ISO 14728 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 as regards the shape of the rolling contact surfaces.

This part of ISO 14728 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

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

ISO 76:1987, *Rolling bearings — Static load ratings*

ISO 5593:1997, *Rolling bearings — Vocabulary*

ISO 15241:2001, *Rolling bearings — Symbols for quantities*

3 Terms and definitions

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

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

See Figure 1.

NOTE The raceways in the sleeve can be cylindrical in design as well as the steel inserts with raceway grooves parallel to the axis.

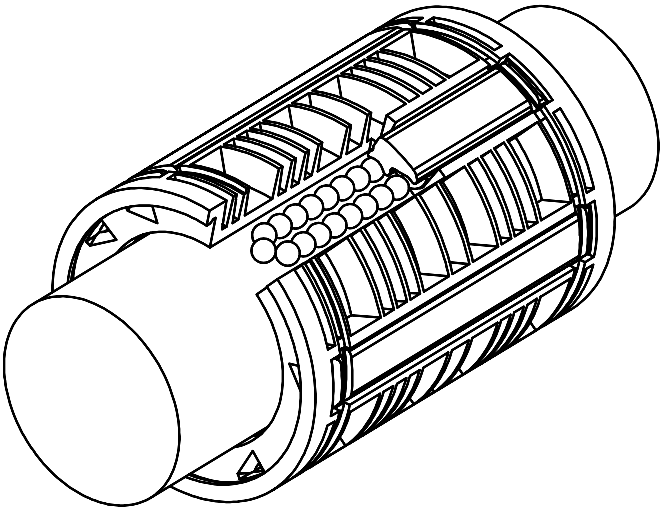


Figure 1 — Recirculating linear ball bearing, sleeve type

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

See Figure 2.

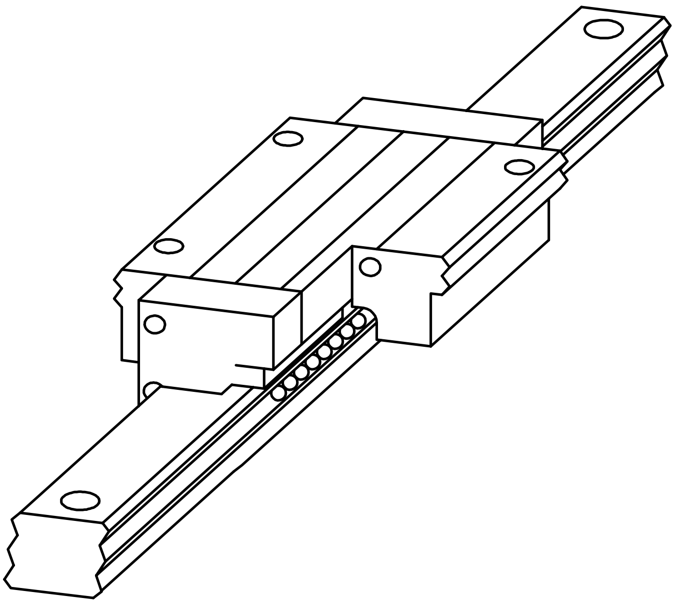


Figure 2 — Recirculating linear ball [roller] bearing, linear guideway type

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

See Figure 3.

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

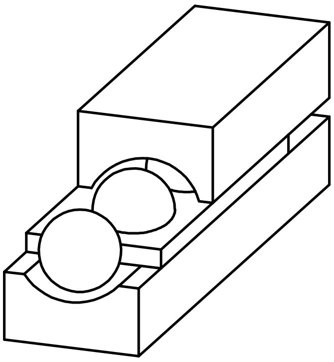


Figure 3 — Non-recirculating linear ball bearing, linear guideway, deep groove type

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

See Figure 4.

NOTE 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.

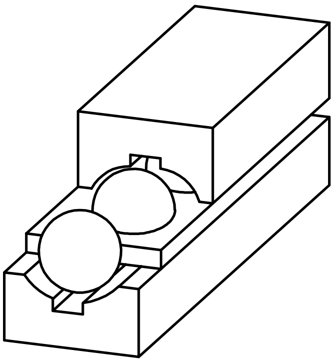


Figure 4 — Non-recirculating linear ball bearing, linear guideway, four-point-contact type

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

See Figure 5.

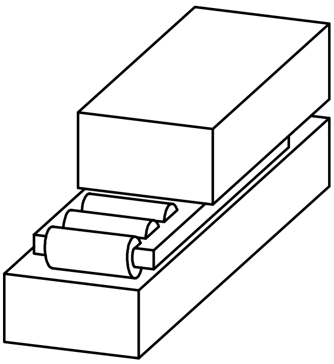


Figure 5 — Non-recirculating linear roller bearing, linear guideway, flat type

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

See Figure 6.

NOTE Needle rollers or cylindrical rollers are used as rolling elements.

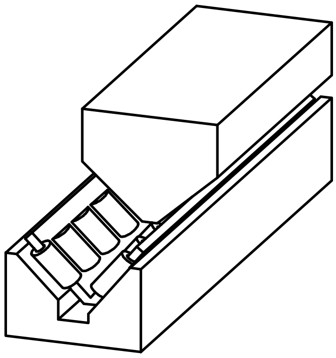


Figure 6 — Non-recirculating linear roller bearing, linear guideway, V-angle type

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

See Figure 7.

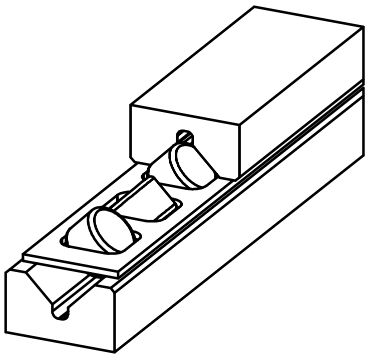


Figure 7 — Non-recirculating linear roller bearing, linear guideway, crossed roller type

3.8
static load 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/raceway contact

NOTE 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.

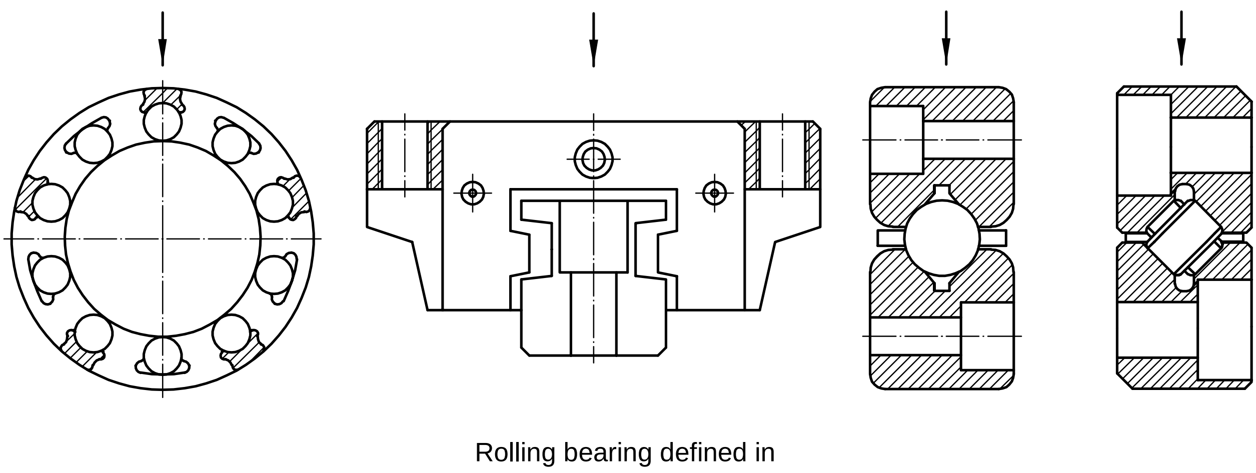
Table 1 — Contact stress, σ_{max}

r_g	⩽ 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}	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/raceway contact as the stress that occurs under the actual load conditions

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

NOTE 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 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

See Figure 9.

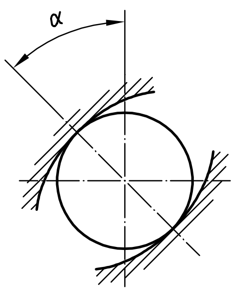


Figure 9 — Nominal contact angle

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 $-90° < \phi_j < +90°$	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	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/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 by the following equations:

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

where

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

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	11,77
0,01	14,726	0,11	13,221	0,21	11,693
0,015	14,651	0,115	13,146	0,215	11,616
0,02	14,577	0,12	13,07	0,22	11,539
0,025	14,502	0,125	12,994	0,225	11,462
0,03	14,427	0,13	12,918	0,23	11,384
0,035	14,352	0,135	12,842	0,235	11,307
0,04	14,277	0,14	12,765	0,24	11,23
0,045	14,202	0,145	12,689	0,245	11,152
0,05	14,127	0,15	12,613	0,25	11,075
0,055	14,052	0,155	12,537	0,255	10,997
0,06	13,977	0,16	12,46	0,26	10,92
0,065	13,902	0,165	12,384	0,265	10,842
0,07	13,826	0,17	12,307	0,27	10,765
0,075	13,751	0,175	12,231	0,275	10,687
0,08	13,675	0,18	12,154	0,28	10,609
0,085	13,6	0,185	12,077	0,285	10,531
0,09	13,524	0,19	12	0,29	10,454
0,095	13,449	0,195	11,924	0,295	10,376
0,1	13,373	0,2	11,847	0,3	10,298

5.1.2 Recirculating linear ball bearings, linear guideway, carriage type

The basic static load rating for this bearing type is given by the following equation:

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

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.

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
0,6 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 by the following equation:

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

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
0,6 D_w	45,57
∞	9,72

5.2 Linear roller bearings

5.2.1 Recirculating linear roller bearings, linear guideway type

The basic static load rating for this bearing is given by the following equation:

$$C_0 = f_0 \times i \times Z_t \times L_{we} \times D_{we} \times \cos\alpha$$

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 by the following equation:

$$C_0 = f_0 \times i \times Z_t \times L_{we} \times D_{we} \times \cos\alpha$$

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 bearing is given by the following equation:

$$P_0 = k_{0F} \times F$$

The static load factor k_{0F} is taken to be 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 bearing is given by the following equation:

$$S_0 = \frac{C_0}{P_0}$$

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.

Bibliography

[1] ISO 10285:1992, *Rolling bearings, linear motion, recirculating ball, sleeve type — Metric series*

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