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Rolling bearings — Static load ratings

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FOREWORD

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO member bodies). The work of developing International Standards is carried out through ISO technical committees. Every member body interested in a subject for which a technical committee has been set up 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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 76 was developed by Technical Committee ISO/TC 4, *Rolling bearings*, and was circulated to the member bodies in June 1977.

It has been approved by the member bodies of the following countries:

Australia	Hungary	South Africa, Rep. of
Austria	India	Spain
Belgium	Italy	Sweden
Brazil	Japan	Switzerland
Canada	Korea, Rep. of	Turkey
Czechoslovakia	Mexico	United Kingdom
Egypt, Arab Rep. of	Netherlands	U.S.A.
France	Poland	U.S.S.R.
Germany	Romania	Yugoslavia

No member body expressed disapproval of the document.

This International Standard cancels and replaces ISO Recommendation R 76-1958, of which it constitutes a technical revision.

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Rolling bearings — Static load ratings

0 INTRODUCTION

Permanent deformations appear in rolling elements and raceways of rolling bearings under static loads of moderate magnitude and increase gradually with increasing load.

It is often impractical to establish whether the deformations appearing in a bearing in a specific application are 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 most heavily stressed rolling element/raceway contact, can be tolerated in most bearing applications without impairment of subsequent bearing operation. In ball bearings, and in roller bearings with full line contact, this deformation occurs when the static equivalent load is equal to the basic static load rating.

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.

1 SCOPE AND FIELD OF APPLICATION

This International Standard specifies methods of calculating the basic static load rating and the static equivalent load for rolling bearings within the size ranges shown in the relevant ISO standards, manufactured from good quality hardened steel, in accordance with good manufacturing practice and basically of conventional design as regards the shape of rolling contact surfaces.

Calculations according to this International Standard do not yield satisfactory results for bearings in which, because of application conditions and/or because of internal design, there is a considerable truncation of the area of contact between the rolling elements and the ring raceways. The same limitation applies where application conditions cause deviations from a normal load distribution in the bearing, for example misalignment, preload or extra large clearance. Where there is reason to assume that such conditions prevail, the user should consult the bearing manufacturer for recommendations and evaluation of static equivalent load.

This International Standard is not applicable to designs where the rolling elements operate directly on a shaft or housing surface, unless that surface is equivalent in all respects to the bearing surface it replaces.

Double row radial bearings and double direction thrust bearings are, when referred to in this International Standard, presumed to be symmetrical.

2 DEFINITIONS

2.1 static load : The load acting on a bearing when the speed of rotation of its rings in relation to each other is zero.

2.2 basic static radial load rating :

2.2.1 for a ball bearing : That static radial load which corresponds to a total permanent deformation of ball and raceway at the most heavily stressed ball/raceway contact of 0,000 1 of the ball diameter. In the case of a single row angular contact bearing, the radial load rating refers to the radial component of that load which causes a purely radial displacement of the bearing rings in relation to each other.

2.2.2 for a roller bearing : That static radial load which corresponds to a total permanent deformation of roller and raceway at the most heavily stressed roller/raceway contact of 0,000 1 of the roller diameter if the rollers and raceway have, or are assumed to have, a common generatrix (full line contact) under zero load. In the case of a single row angular contact bearing, the radial load rating refers to the radial component of that load which causes a purely radial displacement of the bearing rings in relation to each other.

2.3 basic static axial load rating :

2.3.1 for a ball bearing : That static centric axial load which corresponds to a total permanent deformation of ball and raceway at the most heavily stressed ball/raceway contact of 0,000 1 of the ball diameter.

2.3.2 for a roller bearing : That static centric axial load which corresponds to a total permanent deformation of roller and raceway at the most heavily stressed roller/raceway contact of 0,000 1 of the roller diameter if the rollers and raceway have, or are assumed to have, a common generatrix (full line contact) under zero load.

2.4 static equivalent radial load : That static radial load which would cause the same total permanent deformation at the most heavily stressed rolling element/raceway contact as that which occurs under the actual load conditions.

2.5 static equivalent axial load : That static centric axial load which would cause the same total permanent deformation at the most heavily stressed rolling element/raceway contact as that which occurs under the actual load conditions.

2.6 roller diameter (applicable in the calculation of load ratings) : The diameter at the middle of the roller.

NOTE – For a tapered roller, this is equal to the mean value of the diameters at the theoretical sharp corners at the large end and the small end of the roller.

For an asymmetrical convex roller, this is an approximation for the diameter at the point of contact between the roller and the ribless raceway at zero load.

2.7 roller length (applicable in the calculation of load ratings) : The theoretical maximum length of contact between a roller and that raceway where the contact is shortest.

NOTE – This is normally taken to be either the distance between the theoretical sharp corners of the roller minus the roller chamfers or the raceway width excluding the grinding undercuts, whichever is the smaller.

2.8 nominal contact angle : The angle between a plane perpendicular to the bearing axis and the nominal line of the resultant of the forces transmitted by a bearing ring to a rolling element.

3 SYMBOLS

C_{or} = basic static radial load rating, in newtons

C_{oa} = basic static axial load rating, in newtons

D_w = ball diameter, in millimetres

D_{we} = roller diameter applicable in the calculation of load ratings, in millimetres

L_{we} = roller length applicable in the calculation of load ratings, in millimetres

F_r = bearing radial load = radial component of actual bearing load, in newtons

F_a = bearing axial load = axial component of actual bearing load, in newtons

P_{or} = static equivalent radial load, in newtons

P_{oa} = static equivalent axial load, in newtons

X_o = radial load factor

Y_o = axial load factor

Z = number of rolling elements in a single row bearing; number per row of a multi-row bearing with equal number of rolling elements per row

i = number of rows of rolling elements in a bearing

α = nominal contact angle of a bearing, in degrees

4 RADIAL BALL BEARINGS

4.1 Basic static radial load rating

The basic static radial load rating is given by the following formulae :

– for radial or angular contact groove ball bearings :

$$C_{or} = 12{,}3\, i\, Z\, D_w^2 \cos\alpha$$

– for self-aligning ball bearings :

$$C_{or} = 3{,}33\, i\, Z\, D_w^2 \cos\alpha$$

The formulae apply to bearings with a cross-sectional raceway groove radius not larger than $0{,}52\, D_w$ in radial and angular contact groove ball bearing inner rings and $0{,}53\, D_w$ in radial and angular contact groove ball bearing outer rings and self-aligning ball bearing inner rings.

The load-carrying ability of a bearing is not necessarily increased by the use of a smaller groove radius, but is reduced by the use of a radius larger than those indicated above.

4.1.1 *Bearing combinations*

a) The basic static radial load rating for two similar single row radial or angular contact ball bearings mounted side by side on the same shaft such that they operate as a unit (paired mounting) in "back-to-back" or "face-to-face" arrangement is twice the rating of one single row bearing.

b) The basic static radial load rating for two or more similar single row radial or angular contact ball bearings mounted side by side on the same shaft such that they operate as a unit (paired or stack mounting) in "tandem" arrangement, properly manufactured and mounted for equal load distribution, is the number of bearings times the rating of one single row bearing.

4.2 Static equivalent radial load

The static equivalent radial load for radial ball bearings is the greater of the two values given by the formulae :

$$P_{or} = X_o F_r + Y_o F_a$$

$$P_{or} = F_r$$

Values of factors X_o and Y_o are given in table 1.

Values of Y_o for intermediate contact angles are obtained by linear interpolation.

TABLE 1 – **Factors X_o and Y_o for radial ball bearings**

Bearing type		Single row bearings		Double row bearings	
		X_o	Y_o	X_o	Y_o
Radial contact groove ball bearings[1)]		0,6	0,5	0,6	0,5
Angular contact groove ball bearings	15°	0,5	0,46	1	0,92
	20°	0,5	0,42	1	0,84
	25°	0,5	0,38	1	0,76
	30°	0,5	0,33	1	0,66
	35°	0,5	0,29	1	0,58
	40°	0,5	0,26	1	0,52
	45°	0,5	0,22	1	0,44
Self-aligning ball bearings, $\alpha \neq 0°$		0,5	$0{,}22 \cot \alpha$	1	$0{,}44 \cot \alpha$

1) Permissible maximum value of F_a/C_{or} depends on bearing design (internal clearance and raceway groove depth).

4.2.1 *Bearing combinations*

a) When calculating the static equivalent radial load for two similar single row radial or angular contact ball bearings mounted side by side on the same shaft such that they operate as a unit (paired mounting) in "back-to-back" or "face-to-face" arrangement, use the X_o and Y_o values for a double row bearing and the F_r and F_a values for the total loads on the arrangement.

b) When calculating the static equivalent radial load for two or more similar single row radial or angular contact ball bearings mounted side by side on the same shaft such that they operate as a unit (paired or stack mounting) in "tandem" arrangement, use the X_o and Y_o values for a single row bearing and the F_r and F_a values for the total loads on the arrangement.

5 THRUST BALL BEARINGS

5.1 Basic static axial load rating

The basic static axial load rating for single or double direction thrust ball bearings is given by the formula :

$$C_{oa} = 49\, Z\, D_w^2 \sin \alpha$$

where Z is the number of balls carrying load in one direction.

The formula applies to bearings with a cross-sectional raceway radius not larger than $0{,}54\, D_w$.

The load-carrying ability of a bearing is not necessarily increased by the use of a smaller radius, but is reduced by the use of a larger radius.

5.2 Static equivalent axial load

The static equivalent axial load for the thrust ball bearings with $\alpha \neq 90°$ is given by the formula :

$$P_{oa} = 2{,}3\, F_r \tan \alpha + F_a$$

This formula is valid for all ratios of radial to axial load in the case of double direction bearings. For single direction bearings, it is valid where $F_r/F_a \leqslant 0{,}44 \cot \alpha$ and gives satisfactory but less conservative values of P_{oa} for F_r/F_a up to $0{,}67 \cot \alpha$.

Thrust ball bearings with $\alpha = 90°$ can support axial loads only. The static equivalent axial load for this type of bearing is given by the formula :

$$P_{oa} = F_a$$

6 RADIAL ROLLER BEARINGS

6.1 Basic static radial load rating

The basic static radial load rating for radial roller bearings is given by the formula :

$$C_{or} = 21{,}6\, Z\, L_{we}\, D_{we} \cos \alpha$$

NOTE – For roller bearings having such contact surface geometry that, under a heavy bearing load, the material stress is substantially uniform along the most heavily stressed roller/raceway contact, the permanent deformation caused by a radial load equal to C_{or} is generally smaller than that specified in 2.2.2. Consequently, a corresponding greater static equivalent load may be permitted for such bearings.

6.1.1 *Bearing combinations*

a) The basic static radial load rating for two similar single row roller bearings mounted side by side on the same shaft such that they operate as a unit (paired mounting) in "back-to-back" or "face-to-face" arrangement is twice the rating of one single row bearing.

b) The basic static radial load rating for two or more similar single row roller bearings mounted side by side on the same shaft such that they operate as a unit (paired or stack mounting) in "tandem" arrangement, properly manufactured and mounted for equal load distribution, is the number of bearings times the rating of one single row bearing.

6.2 Static equivalent radial load

The static equivalent radial load for roller bearings $\alpha \neq 0°$ is the greater of the values given by the formulae :

$$P_{or} = X_o\, F_r + Y_o\, F_a$$

$$P_{or} = F_r$$

Values of factors X_o and Y_o are given in table 2.

The static equivalent radial load for radial roller bearings

with $\alpha = 0°$, and subjected to radial load only, is given by the formula :

$$P_{or} = F_r$$

NOTE – The ability of radial roller bearings with $\alpha = 0°$ to support axial loads varies considerably with bearing design and execution. The bearing user should therefore consult the bearing manufacturer for recommendations regarding the evaluation of equivalent load in cases where bearings with $\alpha = 0°$ are subjected to axial load.

TABLE 2 – **Factors X_o and Y_o for radial roller bearings**

Bearing type	X_o	Y_o
Single row, $\alpha \neq 0$	0,5	0,22 cot α
Double row, $\alpha \neq 0$	1	0,44 cot α

6.2.1 *Bearing combinations*

a) When calculating the static equivalent radial load for two similar single row angular contact roller bearings mounted side by side on the same shaft such that they operate as a unit (paired mounting) in "back-to-back" or "face-to-face" arrangement, use the X_o and Y_o values for a double row bearing and the F_r and F_a values for the total loads on the arrangement.

b) When calculating the static equivalent radial load for two or more similar single row angular contact roller bearings mounted side by side on the same shaft such that they operate as a unit (paired or stack mounting) in "tandem" arrangement, use the X_o and Y_o values for a single row bearing and the F_r and F_a values for the total loads on the arrangement.

7 THRUST ROLLER BEARINGS

7.1 Basic static axial load rating

The basic static axial load rating for single and double direction thrust roller bearings is given by the formula

$$C_{oa} = 98{,}1\, Z\, L_{we}\, D_{we} \sin \alpha$$

where Z is the number of rollers carrying load in one direction.

In cases where rollers have different lengths, $Z\, L_{we}$ is taken as the sum of the lengths, defined in 2.7, of all the rollers carrying load in one direction.

NOTE – For roller bearings having such contact surface geometry that, under a heavy bearing load, the material stress is substantially uniform along the most heavily stressed roller/raceway contact, the permanent deformation caused by an axial load equal to C_{oa} is generally smaller than that specified in 2.3.2. Consequently, a correspondingly greater static equivalent load may be permitted for such bearings.

7.1.1 *Bearing combinations*

The basic static axial load rating for two or more similar single direction thrust roller bearings mounted side by side on the same shaft such that they operate as a unit (paired or stack mounting) in "tandem" arrangement, properly manufactured and mounted for equal load distribution, is the number of bearings times the rating of one single direction bearing.

7.2 Static equivalent axial load

The static equivalent axial load for thrust roller bearings with $\alpha \neq 90°$ is given by the formula

$$P_{oa} = 2{,}3\, F_r \tan \alpha + F_a$$

This formula is valid for all ratios of radial to axial load in the case of double direction bearings. For single direction bearings it is valid where $F_r/F_a \leqslant 0{,}44 \cot \alpha$ and gives satisfactory but less conservative values of P_{oa} for F_r/F_a up to $0{,}67 \cot \alpha$.

Thrust roller bearings with $\alpha = 90°$ can support axial loads only. The static equivalent load for this type of bearing is

$$P_{oa} = F_a$$

7.2.1 *Bearing combinations*

When calculating the static equivalent axial load for two or more thrust roller bearings mounted side by side on the same shaft such that they operate as a unit (paired or stack mounting) in "tandem" arrangement, use the F_r and F_a values for the total loads acting on the arrangement.