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**Rolling bearings—Dynamic load
ratings and rating life**

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Foreword

This translation has been made based on the original Japanese Industrial Standard revised by the Minister of Economy, Trade and Industry, through deliberations at the Japanese Industrial Standards Committee as the result of proposal for revision of Japanese Industrial Standard submitted by The Japan Bearing Industrial Association (JBIA) with the draft being attached, based on the provision of Article 12 Clause 1 of the Industrial Standardization Law applicable to the case of revision by the provision of Article 14.

Consequently **JIS B 1518**:1992 is replaced with this Standard.

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Rolling bearings—Dynamic load ratings and rating life

Introduction

This Japanese Industrial Standard has been prepared based on the second edition of **ISO 281** published in 2007 with some modifications of technical contents, such as addition of terms and definitions.

The portions with continuous sidelines or dotted underlines are the matters not given in the corresponding International Standard. A list of modifications with explanations is given in Annex JA.

1 Scope

This Standard specifies methods of calculating the basic dynamic load rating and rating life of rolling bearings designed in accordance with bearings-related standards specified in **JIS B 1511**, and manufactured by quenching the steel material specified in **JIS G 4805** or alloy steel equivalent thereto in quality to an appropriate hardness.

In addition to the methods of calculating the basic rating life, which is the life associated with 90 % reliability with conventional operating conditions, this Standard also specifies methods of calculating the modified rating life, in which various reliabilities, lubrication condition, contaminated lubricant and fatigue load of the bearing are taken into account.

The following should be noted in using this Standard.

- This Standard does not cover the influence of wear, corrosion and electrical erosion on bearing life.
- This 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 ring (or washer) raceway it replaces.
- Double-row radial bearings and double-direction thrust bearings are, when referred to in this Standard, presumed to be symmetrical.

NOTE : The International Standard corresponding to this Standard and the symbol of degree of correspondence are as follows.

ISO 281:2007 *Rolling bearings—Dynamic load ratings and rating life* (MOD)

The symbols which denote the degree of correspondence in the contents between the relevant International Standard and **JIS** are IDT (identical), MOD (modified), and NEQ (not equivalent) according to **ISO/IEC Guide 21-1**.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. For standards with the year indication, only the editions of the indicated year shall be applied and the revisions (including amendments) made thereafter shall not be applied. For those without the indication of the year, the most recent edition (including amendments) shall be applied.

JIS B 0104 *Rolling bearings—Vocabulary*

NOTE : Corresponding International Standard: ISO 5593:1997 *Rolling bearings—Vocabulary* (MOD)

JIS B 0124 *Rolling bearings—Symbols for quantities*

NOTE : Corresponding International Standard: ISO 15241:2001 *Rolling bearings—Symbols for quantities* (MOD)

JIS B 1511 *Rolling bearings—General code*

JIS B 1519 *Rolling bearings—Static load ratings*

NOTE : Corresponding International Standard: ISO 76:2006 *Rolling bearings—Static load ratings* (IDT)

JIS G 4805 *High carbon chromium bearing steels*

ISO/TR 1281-1:2008 *Rolling bearings—Explanatory notes on ISO 281—Part 1: Basic dynamic load rating and basic rating life*

3 Terms and definitions

For the purposes of this Standard, the terms and definitions given in **JIS B 0104** and the following apply.

3.1 life

number of revolutions which one of the bearing rings or washers makes in relation to the other ring or washer before the first evidence of fatigue develops in the material of one of the rings or washers or one of the rolling elements

NOTE : Life may also be expressed in number of hours of operation at a given constant speed of rotation.

3.2 reliability

for a group of apparently identical rolling bearings, operating under the same conditions, the percentage of the group that is expected to attain or exceed a specified life

NOTE : The reliability of an individual rolling bearing is the probability that the bearing will attain or exceed a specified life.

3.3 rating life

predicted value of life based on a basic dynamic radial load rating or a basic dynamic axial load rating

3.4 basic rating life

rating life associated with 90 % reliability for bearings operating under conventional operating conditions

3.5 modified rating life

rating life modified for 90 % or other reliability, bearing fatigue load, and/or contaminated lubricant, and/or other non-conventional operating conditions

3.6 basic dynamic radial load rating

constant stationary radial load which a rolling bearing can theoretically endure for a basic rating life of one million revolutions

NOTE : 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.

3.7 basic dynamic axial load rating

constant centric axial load which a rolling bearing can theoretically endure for a basic rating life of one million revolutions

3.8 dynamic equivalent radial load

constant stationary radial load under the influence of which a rolling bearing would have the same life as it would attain under the actual load conditions

3.9 dynamic equivalent axial load

constant centric axial load under the influence of which a rolling bearing would have the same life as it would attain under the actual load conditions

3.10 fatigue load limit

bearing load under which the fatigue stress limit, σ_u , is just reached in the most heavily loaded raceway contact

3.11 roller diameter

theoretical diameter in a radial plane, applicable in the calculation of load ratings

NOTE 1 For a tapered roller, the applicable diameter is equal to the mean value of the diameters at the imaginary sharp corners at the large end and at the small end of the roller.

NOTE 2 For a symmetrical roller, the applicable diameter is a diameter in a radial plane through the middle of the roller length.

NOTE 3 For an asymmetrical convex roller, the applicable diameter is an approximation of the diameter at the point of contact between the roller and the ribless raceway at zero load.

3.12 effective roller length

theoretical maximum length of contact between a roller and that raceway where the contact is shortest, applicable in the calculation of load ratings

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

3.13 nominal contact angle

angle between a plane perpendicular to a bearing axis (a radial plane) and the nominal line of action of the resultant of the forces transmitted by a bearing ring or washer to a rolling element

NOTE : For bearings with asymmetrical rollers, the nominal contact angle is determined by the contact with the non-ribbed raceway (usually, raceway of outer ring).

3.14 pitch diameter of ball set

diameter of the circle containing the centres of the balls in one row in a bearing

3.15 pitch diameter of roller set

diameter of the circle intersecting the roller axes at the middle of the rollers in one row in a bearing

3.16 conventional operating conditions

conditions which may be assumed to prevail for a bearing which is properly mounted and protected from foreign matter, adequately lubricated, conventionally loaded, not exposed to extreme temperature and not run at exceptionally low or high speed

3.17 viscosity ratio

actual kinematic oil viscosity at operating temperature divided by the reference kinematic viscosity for adequate lubrication

3.18 film parameter

ratio of lubricant film thickness to composite r.m.s. (root mean square) surface roughness, used to estimate the influence of lubrication on bearing life

3.19 pressure-viscosity coefficient

parameter characterizing the influence of oil pressure on the oil viscosity in the rolling element contact

3.20 viscosity index

index characterizing the degree of influence of temperature on the viscosity of lubricating oils

3.21 fatigue stress limit

maximum stress that does not generate fatigue in a bearing material

3.22 reference kinematic viscosity

kinematic viscosity necessary for adequate lubrication in operating

3.23 dynamic radial load factor

factor by which a radial load is multiplied when a dynamic equivalent load is calculated

3.24 dynamic axial load factor

factor by which an axial load is multiplied when a dynamic equivalent load is calculated

4 Symbols

For the purposes of this Standard, the symbols given in **JIS B 0124** and the following apply.

- a_{ISO} : life modification factor, based on a systems approach (system in which various conditions are taken into consideration to basic rating life) of life calculation
- a_1 : life modification factor for reliability
- b_m : rating factor for commonly used material and product quality (which varies with bearing type and design)
- C_a : basic dynamic axial load rating (N)
- C_r : basic dynamic radial load rating (N)
- C_u : fatigue load limit (N)
- C_{0a} : basic static axial load rating¹⁾ (N)
- C_{0r} : basic static radial load rating¹⁾ (N)
- D : bearing outside diameter (mm)
- D_{pw} : pitch diameter of ball or roller set (mm)
- D_w : nominal ball diameter (mm)
- D_{we} : roller diameter (mm)
- d : bearing bore diameter (mm)
- e : limiting value of F_a/F_r for the applicability of different values of factors X and Y
- e_C : contamination factor
- F_a : bearing axial load (axial component of actual bearing load) (N)
- F_r : bearing radial load (radial component of actual bearing load) (N)
- f_c : factor, applicable in the calculation of the basic dynamic load ratings
- f_0 : factor, applicable in the calculation of the basic static load ratings¹⁾
- i : number of rows of rolling elements
- L_{nm} : modified rating life, of failure probability $n\%$ ($\times 10^6$ revolutions)
- L_{we} : effective roller length (mm)
- L_{10} : basic rating life ($\times 10^6$ revolutions)
- n : speed of rotation (min^{-1})
- P : dynamic equivalent load (N)
- P_a : dynamic equivalent axial load (N)
- P_r : dynamic equivalent radial load (N)
- S : reliability (probability of survival) (%)
- X : dynamic radial load factor
- Y : dynamic axial load factor
- Z : number of rolling elements in a single-row bearing; number of rolling elements per row of a multi-row bearing with the same number of rolling elements per row

- α : nominal contact angle (°)
 κ : viscosity ratio ($= \nu/\nu_1$)
 Λ : film parameter
 ν : actual kinematic viscosity at the operating temperature (mm²/s)
 ν_1 : reference kinematic viscosity (mm²/s)
 σ : (real) stress (N/mm²)
 σ_u : fatigue stress limit of raceway material (N/mm²)

Note ¹⁾ For definitions, calculation methods and values of C_{0a} , C_{0r} and f_0 , see **JIS B 1519**.

5 Radial ball bearings

5.1 Basic dynamic radial load rating

5.1.1 Basic dynamic radial load rating for single bearings

The basic dynamic radial load rating for radial ball bearings is given by equation (1) or (2):

$$C_r = b_m f_c (i \cos \alpha)^{0.7} Z^{2/3} D_w^{1.8} \dots\dots\dots (1)$$

for $D_w \leq 25.4$ mm

$$C_r = 3.647 b_m f_c (i \cos \alpha)^{0.7} Z^{2/3} D_w^{1.4} \dots\dots\dots (2)$$

for $D_w > 25.4$ mm

where the values of b_m and f_c are given in tables 1 and 2 respectively.

They apply to bearings with a cross-sectional raceway groove radius (hereafter referred to as “groove radius”) not larger than $0.52 D_w$ in deep groove and angular contact ball bearing inner rings and not larger than $0.53 D_w$ in deep groove and angular contact 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 it is reduced by the use of a groove radius larger than those indicated in the previous paragraph. In the latter case, a correspondingly reduced value of f_c shall be used.

Calculation of this reduced value of f_c can be carried out by means of equation (15) given in **ISO/TR 1281-1**.

Table 1 Values of b_m for radial ball bearings

Bearing type	b_m
Deep groove ball bearings and angular contact ball bearings (except filling slot bearings), insert bearings, self-aligning ball bearings and <u>magneto ball bearings</u>	1.3
Filling slot bearings	1.1

5.1.2 Basic dynamic radial load rating for bearing combinations

5.1.2.1 Two single-row deep groove ball bearings operating as a unit

When calculating the basic dynamic radial load rating for two single-row deep groove ball bearings with similar internal specifications²⁾ mounted side by side on the same shaft, such that they operate as a unit (paired mounting), the pair is considered as one double-row deep groove ball bearing.

Note ²⁾ "Internal specifications" here refers to a combination of nominal ball diameter, number of balls, pitch diameter of ball set, raceway groove radius, nominal contact angle, etc. that are necessary for the calculation of the load rating.

5.1.2.2 Back-to-back and face-to-face arrangements of single-row angular contact ball bearings

When calculating the basic dynamic radial load rating for two single-row angular contact ball bearings with similar internal specifications²⁾ mounted side by side on the same shaft, such that they operate as a unit (paired mounting) in a back-to-back or a face-to-face arrangement, the pair is considered as one double-row angular contact ball bearing.

5.1.2.3 Tandem arrangement

The basic dynamic radial load rating, for two or more single-row deep groove ball bearings or two or more angular contact ball bearings with similar internal specifications²⁾ mounted side by side on the same shaft, such that they operate as a unit (paired or stack mounting) in a tandem arrangement, is the number of bearings to the power of 0.7 times the rating of one single-row bearing. The bearings need to be properly manufactured and mounted for equal load distribution between them.

5.1.2.4 Independently replaceable bearings

If, for some technical reason, the bearing arrangement is regarded as a number of single-row specially manufactured bearings which are replaceable independently of each other, then **5.1.2.3** does not apply.

5.2 Dynamic equivalent radial load

5.2.1 Dynamic equivalent radial load for single bearings

The dynamic equivalent radial load for radial and angular contact ball bearings, under constant radial and axial loads, is given by the following formula (3):

$$P_r = XF_r + YF_a \dots\dots\dots (3)$$

where the values of factors X and Y are given in table 3. These factors apply to bearings with cross-sectional groove radii according to **5.1.1**. For other groove radii, calculation of X and Y can be carried out by means of **5.2** in **ISO/TR 1281-1**.

Table 2 Values of factor f_c for radial ball bearings

$\frac{D_w \cos \alpha^{a)}}{D_{pw}}$	f_c			
	Single-row deep groove ball bearings and single-row and double-row angular contact ball bearings	Double-row deep groove ball bearings	Single-row and double-row self-aligning ball bearings	Magneto ball bearings
0.01	29.1	27.5	9.9	9.4
0.02	35.8	33.9	12.4	11.7
0.03	40.3	38.2	14.3	13.4
0.04	43.8	41.5	15.9	14.9
0.05	46.7	44.2	17.3	16.2
0.06	49.1	46.5	18.6	17.4
0.07	51.1	48.4	19.9	18.5
0.08	52.8	50	21.1	19.5
0.09	54.3	51.4	22.3	20.6
0.1	55.5	52.6	23.4	21.5
0.11	56.6	53.6	24.5	22.5
0.12	57.5	54.5	25.6	23.4
0.13	58.2	55.2	26.6	24.4
0.14	58.8	55.7	27.7	25.3
0.15	59.3	56.1	28.7	26.2
0.16	59.6	56.5	29.7	27.1
0.17	59.8	56.7	30.7	27.9
0.18	59.9	56.8	31.7	28.8
0.19	60	56.8	32.6	29.7
0.2	59.9	56.8	33.5	30.5
0.21	59.8	56.6	34.4	31.3
0.22	59.6	56.5	35.2	32.1
0.23	59.3	56.2	36.1	32.9
0.24	59	55.9	36.8	33.7
0.25	58.6	55.5	37.5	34.5
0.26	58.2	55.1	38.2	35.2
0.27	57.7	54.6	38.8	35.9
0.28	57.1	54.1	39.4	36.6
0.29	56.6	53.6	39.9	37.2
0.3	56	53	40.3	37.8
0.31	55.3	52.4	40.6	38.4
0.32	54.6	51.8	40.9	38.9
0.33	53.9	51.1	41.1	39.4
0.34	53.2	50.4	41.2	39.8
0.35	52.4	49.7	41.3	40.1
0.36	51.7	48.9	41.3	40.4
0.37	50.9	48.2	41.2	40.7
0.38	50	47.4	41	40.8
0.39	49.2	46.6	40.7	40.9
0.4	48.4	45.8	40.4	40.9

Note ^{a)} Values of f_c for intermediate values of $\frac{D_w \cos \alpha}{D_{pw}}$ not shown in the table are obtained by linear interpolation.

Table 3 Values of X and Y for radial ball bearings

Bearing type	Relative axial load ^{a), b)}		Single-row bearing				Double-row bearing				e		
			$\frac{F_a}{F_r} \leq e$		$\frac{F_a}{F_r} > e$		$\frac{F_a}{F_r} \leq e$		$\frac{F_a}{F_r} > e$				
			X	Y	X	Y	X	Y	X	Y			
Deep groove ball bearings	$\frac{f_0 F_a^{c)}}{C_{0r}}$	$\frac{F_a}{i Z D_w^2}$	1	0	0.56	2.3 1.99 1.71 1.55 1.45 1.31 1.15 1.04 1	1	0	0.56	2.3 1.99 1.71 1.55 1.45 1.31 1.15 1.04 1	0.19 0.22 0.26 0.28 0.3 0.34 0.38 0.42 0.44		
	0.172	0.172											
	0.345	0.345											
	0.689	0.689											
	1.03	1.03											
	1.38	1.38											
	2.07	2.07											
	3.45	3.45											
	5.17	5.17											
	6.89	6.89											
Angular contact ball bearings	$\frac{f_0 i F_a^{c)}}{C_{0r}}$	$\frac{F_a}{Z D_w^2}$	1	0	0.56	2.3 1.99 1.71 1.55 1.45 1.31 1.15 1.04 1	1	2.78 2.4 2.07 1.87 1.75 1.58 1.39 1.26 1.21	0.78	3.74 3.23 2.78 2.52 2.36 2.13 1.87 1.69 1.63	Single-row bearing	Double-row bearing	
	$\alpha = 5^\circ$	0.173									0.172	0.19	0.23
		0.346									0.345	0.22	0.26
		0.692									0.689	0.26	0.3
		1.04									1.03	0.28	0.34
		1.38									1.38	0.3	0.36
		2.08									2.07	0.34	0.4
		3.46									3.45	0.38	0.45
		5.19									5.17	0.42	0.5
		6.92									6.89	0.44	0.52
	$\alpha = 10^\circ$	0.175	0.172	0.29									
		0.35	0.345	0.32									
		0.7	0.689	0.36									
		1.05	1.03	0.38									
		1.4	1.38	0.4									
		2.1	2.07	0.44									
		3.5	3.45	0.49									
		5.25	5.17	0.54									
		7	6.89	0.54									
	$\alpha = 15^\circ$	0.178	0.172	0.38									
		0.357	0.345	0.4									
		0.714	0.689	0.43									
		1.07	1.03	0.46									
		1.43	1.38	0.47									
		2.14	2.07	0.5									
		3.57	3.45	0.55									
		5.35	5.17	0.56									
		7.14	6.89	0.56									
	$\alpha = 20^\circ$	—	—			0.57							
	$\alpha = 25^\circ$	—	—			0.68							
	$\alpha = 30^\circ$	—	—	1	0	0.39	0.76	1	0.78	0.63	1.24	0.8	
	$\alpha = 35^\circ$	—	—			0.37	0.66		0.66	0.6	1.07	0.95	
	$\alpha = 40^\circ$	—	—			0.35	0.57		0.55	0.57	0.93	1.14	
	$\alpha = 45^\circ$	—	—			0.33	0.5		0.47	0.54	0.81	1.34	
Self-aligning ball bearings			1	0	0.4	$0.4 \cot \alpha$	1	$0.42 \cot \alpha$	0.65	$0.65 \cot \alpha$	$1.5 \tan \alpha$		
Magneto ball bearings			1	0	0.5	2.5	—	—	—	—	0.2		

Table 3 (concluded)

Notes	^{a)} Permissible maximum value depends on the bearing design (internal clearance and raceway groove depth). Use the first or second column depending on available information.
	^{b)} Values of X , Y and e , for intermediate values of $\frac{f_0 F_a}{C_{0r}}$, $\frac{f_0 i F_a}{C_{0r}}$, $\frac{F_a}{i Z D_w^2}$, $\frac{F_a}{Z D_w^2}$ or α not shown in the table are obtained by linear interpolation.
	^{c)} For values of f_0 , see JIS B 1519 .

5.2.2 Dynamic equivalent radial load for bearing combinations

5.2.2.1 Back-to-back and face-to-face arrangements of single-row angular contact ball bearings

When calculating the equivalent radial load for two single-row angular contact ball bearings with similar internal specifications²⁾ mounted side by side on the same shaft, such that they operate as a unit (paired mounting) in a back-to-back or a face-to-face arrangement, the pair is considered as one double-row angular contact ball bearing.

NOTE : If two single-row deep groove ball bearings with similar specifications²⁾ are operating in back-to-back or face-to-face arrangement, the user should consult the bearing manufacturer about calculation of equivalent radial load.

5.2.2.2 Tandem arrangement

When calculating the equivalent radial load for two or more single-row deep groove ball bearings or two or more single-row angular contact ball bearings with similar internal specifications²⁾ mounted side by side on the same shaft, such that they operate as a unit (paired or stack mounting) in a tandem arrangement, the values of X and Y for a single-row bearing shall be used.

The values of relative axial load $\frac{f_0 F_a}{C_{0r}}$, $\frac{f_0 i F_a}{C_{0r}}$ or $\frac{F_a}{i Z D_w^2}$, $\frac{F_a}{Z D_w^2}$ shown in table 3, are established by using $i = 1$, and the axial load F_a and the basic static radial load rating C_{0r} which both refer to one of the bearings only (even though the radial load F_r and the axial load F_a values referring to the total loads are used for the calculation of the equivalent load for the complete arrangement).

5.3 Basic rating life

5.3.1 Life equation

The basic rating life for a radial ball bearing is given by the following equation (4):

$$L_{10} = \left(\frac{C_r}{P_r} \right)^3 \dots \dots \dots (4)$$

The values of the basic dynamic radial load rating C_r and the dynamic equivalent radial load P_r are calculated in accordance with **5.1** and **5.2**.

The life equation is also used for the evaluation of the life of two or more single-row bearings operating as a unit (paired or stack mounting). In this case, the basic

dynamic radial load rating C_r is calculated in accordance with **5.1.2**. The dynamic equivalent radial load P_r is calculated for the total loads acting on the arrangement, using the values of X and Y indicated in **5.2.2**.

5.3.2 Loading restriction on the life equation

The life equation gives satisfactory results for a broad range of bearing loads. However, extra-heavy loads may cause detrimental plastic deformations at the ball/raceway contacts. The user should therefore consult the bearing manufacturer to establish the applicability of the life equation in cases where the dynamic equivalent radial load P_r exceeds C_{0r} or $0.5 C_r$, whichever is smaller.

Very light loads may cause different failure modes to occur. These failure modes are not covered by this Standard.

6 Thrust ball bearings

6.1 Basic dynamic axial load rating

6.1.1 Basic dynamic axial load rating for single-row thrust ball bearings

The basic dynamic axial load rating for single-row, single-direction or double-direction thrust ball bearings is given by the following equations (5) to (8):

$$C_a = b_m f_c Z^{2/3} D_w^{1.8} \dots\dots\dots (5)$$

$$\text{for } D_w \leq 25.4 \text{ mm and } \alpha = 90^\circ$$

$$C_a = b_m f_c (\cos \alpha)^{0.7} \tan \alpha Z^{2/3} D_w^{1.8} \dots\dots\dots (6)$$

$$\text{for } D_w \leq 25.4 \text{ mm and } \alpha \neq 90^\circ$$

$$C_a = 3.647 b_m f_c Z^{2/3} D_w^{1.4} \dots\dots\dots (7)$$

$$\text{for } D_w > 25.4 \text{ mm and } \alpha = 90^\circ$$

$$C_a = 3.647 b_m f_c (\cos \alpha)^{0.7} \tan \alpha Z^{2/3} D_w^{1.4} \dots\dots\dots (8)$$

$$\text{for } D_w > 25.4 \text{ mm and } \alpha \neq 90^\circ$$

where Z is the number of balls carrying load (number of balls for single-direction bearings, and number of balls of one side for double-direction bearings) in one direction and $b_m = 1.3$. Values of f_c are given in table 4 and apply to bearings with cross-sectional raceway groove radii not larger than $0.54 D_w$.

The load-carrying ability of a basic dynamic axial load bearing is not necessarily increased by the use of a smaller groove radius, but is reduced by the use of a larger groove radius than that indicated above. In the latter case, a correspondingly reduced value of f_c shall be used.

Calculation of this reduced value of f_c can be carried out by means of equation (20) in **ISO/TR 1281-1** for bearings with $\alpha \neq 90^\circ$ and equation (25) in **ISO/TR 1281-1** for bearings with $\alpha = 90^\circ$.

6.1.2 Basic dynamic axial load rating for bearings with two or more rows of balls

The basic dynamic axial load rating for thrust ball bearings, with two or more rows of similar balls carrying load in the same direction, is given by the following formula (9):

$$C_a = (Z_1 + Z_2 + \dots + Z_n) \times \left[\left(\frac{Z_1}{C_{a1}} \right)^{10/3} + \left(\frac{Z_2}{C_{a2}} \right)^{10/3} + \dots + \left(\frac{Z_n}{C_{an}} \right)^{10/3} \right]^{-3/10} \dots\dots\dots (9)$$

The load ratings C_{a1} , C_{a2} , ..., C_{an} for the rows with Z_1 , Z_2 , ..., Z_n balls are calculated from the appropriate single-row bearing equation given in 6.1.1.

6.1.3 Basic dynamic axial load rating for bearing combinations

6.1.3.1 Tandem arrangement

The basic dynamic axial load rating, for two or more single-direction thrust ball bearings with similar internal specifications³⁾ mounted side by side on the same shaft, such that they operate as a unit (paired or stack mounting) in a tandem arrangement, is the number of bearings to the power of 0.7 times the rating of one bearing. The bearings need to be properly manufactured and mounted for equal load distribution between them.

Note ³⁾ “Internal specifications” here refers to a combination of nominal ball diameter, number of balls, pitch diameter of ball set, raceway groove radius, nominal contact angle, etc. that are necessary for the calculation of the load rating.

6.1.3.2 Independently replaceable bearings

If, for some technical reason, the bearing arrangement is regarded as a number of single-direction specially manufactured bearings which are replaceable independently of each other, then 6.1.3.1 does not apply.

Table 4 Values of f_c for thrust ball bearings

$\frac{D_w^{a)}}{D_{pw}}$	f_c	$\frac{D_w \cos \alpha^{a)}}{D_{pw}}$	f_c		
	$\alpha = 90^\circ$		$\alpha = 45^\circ \text{ b)}$	$\alpha = 60^\circ$	$\alpha = 75^\circ$
0.01	36.7	0.01	42.1	39.2	37.3
0.02	45.2	0.02	51.7	48.1	45.9
0.03	51.1	0.03	58.2	54.2	51.7
0.04	55.7	0.04	63.3	58.9	56.1
0.05	59.5	0.05	67.3	62.6	59.7
0.06	62.9	0.06	70.7	65.8	62.7
0.07	65.8	0.07	73.5	68.4	65.2
0.08	68.5	0.08	75.9	70.7	67.3
0.09	71	0.09	78	72.6	69.2
0.1	73.3	0.1	79.7	74.2	70.7
0.11	75.4	0.11	81.1	75.5	—
0.12	77.4	0.12	82.3	76.6	—
0.13	79.3	0.13	83.3	77.5	—
0.14	81.1	0.14	84.1	78.3	—
0.15	82.7	0.15	84.7	78.8	—
0.16	84.4	0.16	85.1	79.2	—
0.17	85.9	0.17	85.4	79.5	—
0.18	87.4	0.18	85.5	79.6	—
0.19	88.8	0.19	85.5	79.6	—
0.2	90.2	0.2	85.4	79.5	—
0.21	91.5	0.21	85.2	—	—
0.22	92.8	0.22	84.9	—	—
0.23	94.1	0.23	84.5	—	—
0.24	95.3	0.24	84	—	—
0.25	96.4	0.25	83.4	—	—
0.26	97.6	0.26	82.8	—	—
0.27	98.7	0.27	82	—	—
0.28	99.8	0.28	81.3	—	—
0.29	100.8	0.29	80.4	—	—
0.3	101.9	0.3	79.6	—	—
0.31	102.9	—	—	—	—
0.32	103.9	—	—	—	—
0.33	104.8	—	—	—	—
0.34	105.8	—	—	—	—
0.35	106.7	—	—	—	—

Notes ^{a)} The values of f_c for intermediate values of $\frac{D_w}{D_{pw}}$, $\frac{D_w \cos \alpha}{D_{pw}}$ or α not shown in the table are obtained by linear interpolation.

^{b)} For thrust bearings $\alpha > 45^\circ$. Values for $\alpha = 45^\circ$ are given to permit interpolation of values for α between 45° and 60° .

6.2 Dynamic equivalent axial load

The dynamic equivalent axial load for thrust ball bearings with $\alpha \neq 90^\circ$, under constant radial and axial loads, is given by the following formula (10):

$$P_a = XF_r + YF_a \dots\dots\dots (10)$$

where the values of X and Y are given in table 5. These factors apply to bearings with cross-sectional groove radii not exceeding $0.54 D_w$.

For other groove radii, calculation of X and Y can be carried out by means of **5.2** in **ISO/TR 1281-1**.

Thrust ball bearings with $\alpha = 90^\circ$ can support axial loads only. The dynamic equivalent axial load for this type of bearing is given by the following formula (11):

$$P_a = F_a \dots\dots\dots (11)$$

Table 5 Values of X and Y for thrust ball bearings

$\alpha^{\text{a)}}$	Single-direction bearings ^{b)}		Double-direction bearings				e
	$\frac{F_a}{F_r} > e$		$\frac{F_a}{F_r} \leq e$		$\frac{F_a}{F_r} > e$		
	X	Y	X	Y	X	Y	
45° ^{c)}	0.66	1	1.18	0.59	0.66	1	1.25
50°	0.73		1.37	0.57	0.73		1.49
55°	0.81		1.6	0.56	0.81		1.79
60°	0.92		1.9	0.55	0.92		2.17
65°	1.06		2.3	0.54	1.06		2.68
70°	1.28		2.9	0.53	1.28		3.43
75°	1.66		3.89	0.52	1.66		4.67
80°	2.43		5.86	0.52	2.43		7.09
85°	4.8	11.75	0.51	4.8	14.29		
$\alpha \neq 90^\circ$	$1.25 \tan \alpha \left(1 - \frac{2}{3} \sin \alpha\right)$	1	$\frac{20}{13} \tan \alpha \left(1 - \frac{1}{3} \sin \alpha\right)$	$\frac{10}{13} \left(1 - \frac{1}{3} \sin \alpha\right)$	$1.25 \tan \alpha \left(1 - \frac{2}{3} \sin \alpha\right)$	1	$12 \tan \alpha$
Notes ^{a)} Values of X, Y and e for intermediate values of α not shown in the table are obtained by linear interpolation. ^{b)} $\frac{F_a}{F_r} \leq e$ is unsuitable for single-direction bearings. ^{c)} For thrust bearings, $\alpha > 45^\circ$. Values for $\alpha = 45^\circ$ are given to permit interpolation of values for α between 45° and 50°.							

6.3 Basic rating life

6.3.1 Life equation

The basic rating life for a thrust ball bearing is give by the following equation (12):

$$L_{10} = \left(\frac{C_a}{P_a}\right)^3 \dots\dots\dots (12)$$

The values of the basic dynamic axial load rating C_a and the dynamic equivalent axial load P_a are calculated in accordance with **6.1** and **6.2**.

6.3.2 Loading restriction on the life equation

The life equation gives satisfactory results for a broad range of bearing loads. However, extra-heavy loads may cause detrimental plastic deformations at the ball/raceway contacts. The user should therefore consult the bearing manufacturer to establish the applicability of the life equation in case where the dynamic equivalent axial load P_a exceeds $0.5 C_a$.

Very light loads may cause different failure modes to occur. These failure modes are not covered by this Standard.

7 Radial roller bearings

7.1 Basic dynamic radial load rating

7.1.1 Basic dynamic radial load rating for single radial roller bearings

The basic dynamic radial load rating for a radial roller bearing is given by the following formula (13):

$$C_r = b_m f_c (i L_{we} \cos \alpha)^{7/9} Z^{3/4} D_{we}^{29/27} \dots\dots\dots (13)$$

Where the values of b_m and f_c are given in tables 6 and 7 respectively. The values of f_c given in table 7 are maximum values applicable only to roller bearings in which, under a bearing load, the contact stress is substantially uniform along the most heavily loaded roller/raceway contact.

Smaller values of f_c than those given in table 7 should be used if, under load, an accentuated stress concentration is present in some part of the roller/raceway contact. Such stress concentrations are to be expected, at the centre of the nominal contact points and at the extremities of the line contacts, in bearings where the rollers are not accurately guided and in bearings having rollers longer than 2.5 times their diameter.

Table 6 Values of b_m for radial roller bearings

Bearing type	b_m
Cylindrical roller bearings, tapered roller bearings, needle roller bearings with machined rings, <u>long cylindrical roller bearings</u>	1.1
Drawn cup needle roller bearings	1
Spherical roller bearings	1.15