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AMERICAN NATIONAL STANDARD

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Load Ratings and Fatigue Life for Roller Bearings ANSI/ABMA 11:1990

Secretariat

American Bearing
Manufacturers Association

ANSI/ABMA 11:1990

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Load Ratings and Fatigue Life for Roller Bearings

1. INTRODUCTION

1.1 Purpose of Standard

Roller bearing performance is a function of many variables. These include the bearing design, the characteristics of the material from which the bearings are made, the way in which they are manufactured, as well as many variables associated with their application. The only sure way to establish the satisfactory operation of a bearing selected for a specific application is by actual performance in the application. As this is often impractical, another basis is required to estimate the suitability of a particular bearing for a given application. This is the purpose of this standard.

This standard specifies the method of calculating the basic dynamic load rating of rolling bearings within the size ranges shown in the relevant ANSI/ABMA standards, manufactured from contemporary, commonly used, good quality hardened steel in accordance with good manufacturing practice and basically of conventional design as regards the shape of rolling contact surfaces.

This standard also specifies the method of calculating the basic rating life, which is the life associated with 90% reliability, with commonly used material and manufacturing quality, and with conventional operating conditions. In addition, it specifies the method of calculating adjusted rating life, in which various reliabilities, special bearing properties and specific operating conditions are taken into account by means of life adjustment factors.

Furthermore, this standard specifies the method of calculating the basic static load rating and the static equivalent load for roller bearings within the size ranges shown in the relevant ANSI/ABMA 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.

1.2 Life Criterion

Even if roller bearings are properly mounted, adequately lubricated, protected from foreign matter, and are not subjected to extreme operating conditions, they can ultimately fatigue. Under ideal conditions, the repeated stresses developed in the contact areas between the roller and the raceways eventually can result in fatigue of the material which

manifests itself as spalling of the load carrying surfaces. In most applications the fatigue life is the maximum useful life of a bearing. This fatigue is the criterion of life used as the basis for the first part of this standard.

Fatigue life calculated in accordance with this standard does not represent the maximum that can be attained by applying all known technology to roller bearing design and application. Neither does it represent the minimum that should be expected of a bearing made by a producer lacking skill and experience in the design and manufacture of roller bearings, even though the bearing meets the geometric parameters given below. The calculated fatigue life represents the performance normally expected from high quality bearings made by reputable manufacturers. Manufacturers can supply longer lived bearings by the application of advanced materials and manufacturing processes. The present standard has evolved as a means for bearing users to specify a reasonable standard of performance for the bearing they wish to purchase.

1.3 Static Load Criterion

A static load is a load acting on a non-rotating bearing. Permanent deformations appear in rollers and raceways under a static load 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 0.0001 of the rolling element diameter, at the center of the most heavily loaded roller/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 this deformation occurs when the static equivalent load is equal to the load rating.

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

— 4000 MPa (580,000 psi) for all roller bearings

at the center 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.

2. SYMBOLS

C_r = basic dynamic radial load rating, newtons (pounds)

C_{or} = basic static radial load rating, newtons (pounds)

C_a = basic dynamic axial load rating, newtons (pounds)

C_{oa} = basic static axial load rating, newtons (pounds)

D_{pw} = pitch diameter of roller set, millimetres (inches)

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

F_r = bearing radial load = radial component of the actual bearing load, newtons (pounds)

F_a = bearing axial load = axial component of the actual bearing load, newtons (pounds)

L_{10} = basic rating life, in million revolutions

L_{na} = adjusted rating life, in million revolutions

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

P_r = dynamic equivalent radial load, newtons (pounds)

P_{or} = static equivalent radial load, newtons (pounds)

P_a = dynamic equivalent axial load, newtons (pounds)

P_{oa} = static equivalent axial load, newtons (pounds)

X = dynamic radial load factor

X_o = static radial load factor

Y = dynamic axial load factor

Y_o = static 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

a_1 = life adjustment factor for reliability

a_2 = life adjustment factor for special bearing properties

a_3 = life adjustment factor for operating conditions

e = limit value of F_a/F_r for the applicability of different values of factors X and Y

f_{cm} = a factor which depends on the geometry of the bearing components, the accuracy to which the various components are made and contemporary, normally used material and its manufacturing quality

i = number of rows of rollers in a bearing

α = nominal contact angle of the bearing, degrees

3. DEFINITIONS

For the purposes of this Standard, the definitions given in ANSI/ABMA Standard 1 together with the following apply.

3.1 Life

For an individual rolling bearing, the 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 rolling elements.

3.2 Reliability (in the context of bearing life)

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.

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

3.3 Static Load

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

3.4 Pitch Diameter of a Roller Set, D_{pw}

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

3.5 Basic Rating Life, L_{10}

For an individual rolling bearing, or a group of apparently identical rolling bearings operating under the same conditions, the life associated with 90% reliability, with contemporary, commonly used material and manufacturing quality, and under conventional operating conditions.

3.6 Adjusted Rating Life, L_{na}

The rating life obtained by adjustment of the basic rating life for a desired reliability level, special bearing properties and specific operating conditions.

3.7 Basic Dynamic Radial Load Rating, C_r

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

3.8 Basic Static Radial Load Rating, C_{or}

Static radial load which corresponds to a calculated contact stress at the center of the most heavily loaded rolling element/raceway contact of

4000 MPa (580,000 psi).

NOTE: For this contact stress, a total permanent deformation of rolling element and raceway occurs which is approximately 0.0001 of the rolling element diameter.

3.9 Basic Dynamic Axial Load Rating, C_a

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

3.10 Basic Static Axial Load Rating, C_{0a}

Static centric axial load which corresponds to a calculated contact stress at the center of the most heavily loaded rolling element/raceway contact of

4000 MPa (580,000 psi) for thrust roller bearings.

NOTE: For this contact stress, a total permanent deformation of rolling element and raceway occurs which is approximately 0.0001 of the rolling element diameter.

3.11 Dynamic Equivalent Radial Load, P_r

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

3.12 Static Equivalent Radial Load, P_{0r}

Static radial load which would cause the same contact stress at the center of the most heavily loaded rolling element/raceway contact as that which occurs under the actual load conditions.

3.13 Dynamic Equivalent Axial Load, P_a

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

3.14 Static Equivalent Axial Load, P_{0a}

Static centric axial load which would cause the same contact stress at the center of the most heavily loaded rolling element/raceway contact as that which occurs under the actual load conditions.

3.15 Roller Diameter Applicable in the Calculation of Load Ratings, D_{we}

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 theoretically sharp corners at the large end and at the small end of the roller.

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

3.16 Roller Length Applicable in the Calculation of Load Ratings, L_{we}

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 theoretically sharp corners of the roller minus the roller chamfers or the raceway width excluding the grinding undercuts, whichever is the smaller.

3.17 Nominal Contact Angle, α

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

3.18 Line Contact

“Line contact” refers to rollers and raceways so formed that under no load and when in good alignment they contact along the full length of their basic form.

3.19 Point Contact

“Point contact” refers to rollers and raceways so formed that under no load and when in good alignment they contact at a point located approximately at the middle of the rollers.

3.20 Optimized Contact

“Optimized contact” refers to such design of the basic form of the rollers and/or ring raceways that under a bearing load somewhere in the range of 25% to 50% of the basic dynamic radial load rating C_r , the material stress is substantially uniform along the entire effective length of the contact at the most heavily loaded roller. Ideally, roller bearings are designed to approach optimized contact.

3.21 Conventional Operating Conditions

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

4. SCOPE

4.1 Bearing Types

4.1.1 General. Roller bearings covered by this standard are presumed to be within the size ranges shown in the ANSI/ABMA dimensional standards, manufactured of good quality hardened steel in accordance with good manufacturing practice and