INTERNATIONAL STANDARD

ISO 281

First edition
1990-12-01

AMENDMENT 2
2000-02-15

Rolling bearings — Dynamic load ratings and rating life

AMENDMENT 2: Life modification factor a_{XYZ}

Roulements — Charges dynamiques de base et durée nominale

AMENDEMENT 2: Facteur a_{XYZ} de modification de la durée

Reference number
ISO 281:1990/Amd.2:2000(E)

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 734 10 79
E-mail copyright@iso.ch
Web www.iso.ch

Printed in Switzerland

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 3.

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 Amendment may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

Amendment 2 to International Standard ISO 281:1990 was prepared by Technical Committee ISO/TC 4, *Rolling bearings*, Subcommittee SC 8, *Load ratings and life* and constitutes a replacement of clause 9 **Adjusted rating life**.

Annex A of this Amendment is for information only.

Introduction

Since International Standard ISO 281 was published in 1990 more knowledge has been gained regarding the influence on bearing life of contamination, lubrication, internal stresses from mounting, stresses from heat treatment, fatigue load limit of the material etc. It is therefore now possible to take into consideration factors influencing the life calculations in a more complete way. In this amendment is specified how new, additional knowledge can be put into practice in a consistent way in the life formula. The life calculated with this extended life formula is called modified rating life and replaces the adjusted rating life, $L_{n\mathrm{a}}$, in ISO 281:1990. The modified rating life has received a new designation, $L_{n\mathrm{m}}$, to avoid confusion with $L_{n\mathrm{a}}$.

Rolling bearings — Dynamic load ratings and rating life

AMENDMENT 2: Life modification factor a_{XYZ}

1 Symbols

a_{XYZ} is the ife modification factor, based on a systems approach in accordance with 2.4;

a_1 is the life adjustment factor for reliability;

a_2, a_3, a_4, a_5, a_m are the interdependent life adjustment factors for various influences in accordance with 2.3 and 2.4.2;

e is the Weibull exponent;

$L_{n\mathrm{a}}$ is the adjusted rating life, in millions of revolutions;

$L_{n\mathrm{m}}$ is the modified rating life, in millions of revolutions;

L_{10} is the basic rating life, in millions of revolutions;

n is the probability of failure, in %;

S is the reliability (probability of survival) in %, within the range 100 to 0;

κ is the ratio of viscosity = ν/ν_1;

Λ is the film parameter, ratio of film thickness to composite surface roughness;

ν is the actual lubricant viscosity at the operating temperature, in square millimetres per second;

ν_1 is the required viscosity at the operating temperature to obtain adequate lubrication, in square millimetres per second;

σ is the real stress used in fatigue criterion, in megapascals;

σ_u is the endurance stress limit used in fatigue criterion, in megapascals.

2 Modified rating life

2.1 General

It is often sufficient to use the basic rating life, L_{10}, as a criterion of bearing performance. This life is associated with 90 % reliability.

However, for some applications it may be of interest to calculate the life for a higher reliability, and for many applications it is desirable to take into account the influence of the bearing quality and operating conditions in a more accurate and complete way. The modified rating life, $L_{n\mathrm{m}}$, meets this demand. [The index n represents probability of failure in % and (100 – n) the probability of survival (also expressed as the reliability).]

The life $L_{n\mathrm{m}}$, i.e. the basic rating life modified for a reliability of (100 – n) %, for special bearing properties and for specific operating conditions, can be calculated with the formula

$$L_{n\mathrm{m}} = a_1 \, a_{\mathrm{XYZ}} \, L_{10} \tag{1}$$

Values of the life adjustment factor a_1 are given in Table 1.

2.2 Life adjustment factor for reliability, a_1

Table 1 — Life adjustment factor for reliability, a_1

Reliability S	$L_{n\mathrm{m}}$	a_1
90	$L_{10\mathrm{m}}$	1
95	$L_{5\mathrm{m}}$	0,62
96	$L_{4\mathrm{m}}$	0,53
97	$L_{3\mathrm{m}}$	0,44
98	$L_{2\mathrm{m}}$	0,33
99	$L_{1\mathrm{m}}$	0,21

Table 1 is based on a Weibull exponent of e = 1,5. It is possible to calculate a_1 for other exponent values (see annex A).

2.3 Life modification factor, a_{XYZ}

In ISO 281-1:1977 the factors a_2 and a_3 were introduced to consider the influence of material and lubrication conditions on bearing life. However, it has been recognised that a_2 and a_3 are interdependent, and this has led many bearing manufacturers to use a combined a_{23} factor. The scope of this combined factor a_{23} has been extended with the introduction of the a_{XYZ} factor to cover additional interdependent influences.

These interdependencies imply that

$$a_{\mathrm{XYZ}} = f\,(a_2, a_3, a_{\mathrm{m}}) \tag{2}$$

Modern technology makes it possible to determine a_{XYZ} by combining computer supported theory with empirical tests and practical experience. Besides bearing type, the factor a_{XYZ} can include the influence of:

— material (e.g. cleanliness, hardness, surface structure, fatigue limit, response to temperature);

— lubrication (e.g. viscosity, bearing speed, bearing size, type of lubricant, additives);

— environment (e.g. contamination level, humidity);

— contaminant particles (e.g. hardness, size, form, material);

— internal stresses in the rings (e.g. from the manufacturing process, from inner ring interference after mounting);

— mounting (e.g. handling damages, misalignment);

— bearing load.

2.4 Systems approach to life calculations

2.4.1 Modified life calculation by means of systems approach

Below a certain load a modern high quality bearing can attain an infinite life if the lubrication conditions, the cleanliness and other operating conditions are favourable. The real contact stress when the fatigue load limit is reached is of the order of 1 500 MPa for normal bearing steels.

In many applications however, contact stresses are larger than this value and, in addition, the operating conditions can further reduce the bearing life.

It is possible to relate all influences to the applied stresses and to the strength of the material, e.g.:

— indentations give rise to edge stresses;

— a thin oil film increases the shear stresses in the contact region between raceway and rolling element;

— an increased temperature reduces the fatigue limit of the material, i.e. its strength;

— a tight inner ring fit gives rise to hoop stresses.

The different influences on bearing life are dependent on each other. A systems approach to the fatigue life calculation is therefore appropriate in which the influence on the life of the system due to variation and interaction of interdependent factors will be considered.

Diagrams or equations can be made up expressing a_{XYZ} as a function of σ_u/σ, the endurance stress limit divided by the real stress, with as many influencing factors as possible considered (see Figure 1).

In Figure 1, the diagram for a given lubrication condition also illustrates how a_{XYZ} asymptotically approaches infinity, if the real stress, σ, is decreased down to the endurance stress limit, σ_u, when a fatigue criterion applies. Traditionally, the orthogonal shear stress has been used as a fatigue criterion in bearing life calculations (see reference [1] in the Bibliography). The diagram in Figure 1 can therefore also be based on endurance strength in shear.

Manufacturers are expected to be responsible for the advice given about the calculation of a_{XYZ} as a function of real stresses, endurance stress limit and operating conditions. The letters XYZ in the designation a_{XYZ} indicate that a manufacturer or organization can select any combination and number of letters.

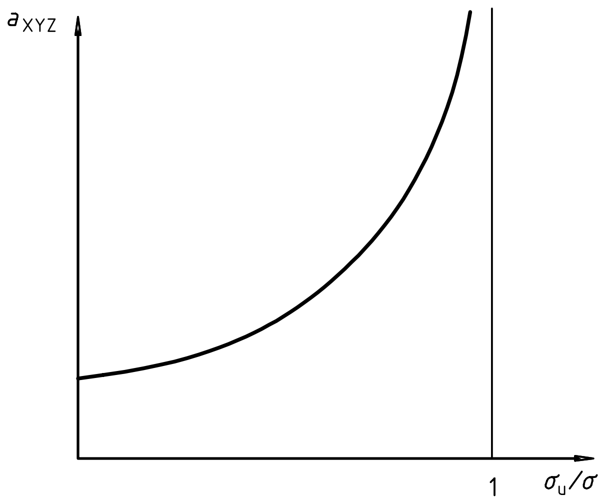

Figure 1 — Life modification factor a_{XYZ}

The lubrication conditions can be expressed either by

— the viscosity ratio $\kappa = \nu/\nu_1$, which is defined as the real, actual oil viscosity ν at the operating temperature divided by the oil viscosity ν_1, required for adequate lubrication,

or by

— the film parameter Λ, which is defined as the ratio of the oil film thickness to the root mean square of the surface irregularities of the contacting surfaces.

The factors κ and Λ are both measures of the risk of intermetallic contact through the lubricant film. Manufacturers are expected to supply recommendations regarding the calculation of the factors.

2.4.2 Modified life calculation by means of multiplication factors

As a special case of the systems approach, it is possible to calculate a_{XYZ} with the aid of multiplication factors, e.g.

$$a_{\mathrm{XYZ}} = a_2\, a_3\, a_4\, a_5 .... \qquad (3)$$

In this way the fatigue life can be calculated with the equation in ISO 281:1990

$$L_{n\mathrm{a}} = a_1\, a_2\, a_3\, L_{10} \qquad (4)$$

or more generally, with the factor a_{XYZ} expressed as

$$a_{\mathrm{XYZ}} = a_2\, a_3\, a_{\mathrm{m}} \qquad (5)$$

The a_{m} factor includes environmental variables that are not accounted for in ISO 281:1990. To fulfil the demand on a systems approach, it is however, important to understand the fact that life-influencing factors are interdependent, and a change in operating conditions can influence all factors in equations (3) to (5).

Annex A
(informative)

Equation for calculating the life adjustment factor a_1 for reliability

The life adjustment factors, a_1, in Table 1 of this Amendment are calculated with the aid of equation (A.1)

$$a_1 = \left(\frac{\ln \frac{100}{S}}{\ln \frac{100}{90}} \right)^{\frac{1}{e}} \tag{A.1}$$

Table 1 is calculated for different reliabilities (probabilities of survival) S in % and a constant value 1,5 of the Weibull exponent e.

The equation (A.1) also makes it possible to calculate the factor a_1 for other Weibull exponents.

Bibliography

[1] LUNDBERG, G. and PALMGREN, A., *Dynamic Capacity of Rolling Bearings*, Acta Polytechnica, **7** (1947), Mechanical engineering Series, Vol. 1, No. 3.

ICS 21.100.20

Price based on 6 pages