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SIS-ISO/TR 1281-2:2008

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Rullningslager – Förklaringar till ISO 281 – Del 2: Beräkning av modifierad livslängd baserat på utmattningsspänningar

Rolling bearings – Explanatory notes on ISO 281 – Part 2: Modified rating life calculation, based on a systems approach to fatigue stresses

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This Technical Report is not a Swedish Standard. This document contains the English version of ISO/TR 1281-2:2008

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Contents

Page

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.

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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/TR 1281-2 was prepared by Technical Committee ISO/TC 4, *Rolling bearings*, Subcommittee SC 8, *Load ratings and life*.

This first edition of ISO/TR 1281-2, together with the first edition of ISO/TR 1281-1, cancels and replaces the first edition of ISO/TR 8646:1985, which has been technically revised.

ISO/TR 1281 consists of the following parts, under the general title *Rolling bearings — Explanatory notes on ISO 281*:

— *Part 1: Basic dynamic load rating and basic rating life*

— *Part 2: Modified rating life calculation, based on a systems approach of fatigue stresses*

Introduction

Since the publication of ISO 281:1990 [25], more knowledge has been gained regarding the influence on bearing life of contamination, lubrication, fatigue load limit of the material, internal stresses from mounting, stresses from hardening, etc. It is therefore now possible to take into consideration factors influencing the fatigue load in a more complete way.

Practical implementation of this was first presented in ISO 281:1990/Amd.2:2000, which specified how new additional knowledge could be put into practice in a consistent way in the life equation. The disadvantage was, however, that the influence of contamination and lubrication was presented only in a general fashion. ISO 281:2007 incorporates this amendment, and specifies a practical method of considering the influence on bearing life of lubrication condition, contaminated lubricant and fatigue load of bearing material.

In this part of ISO/TR 1281, background information used in the preparation of ISO 281:2007 is assembled for the information of its users, and to ensure its availability when ISO 281 is revised.

For many years the use of basic rating life, L_{10}, as a criterion of bearing performance has proved satisfactory. This life is associated with 90 % reliability, with commonly used high quality material, good manufacturing quality, and with conventional operating conditions.

However, for many applications, it has become desirable to calculate the life for a different level of reliability and/or for a more accurate life calculation under specified lubrication and contamination conditions. With modern high quality bearing steel, it has been found that, under favourable operating conditions and below a certain Hertzian rolling element contact stress, very long bearing lives, compared with the L_{10} life, can be obtained if the fatigue limit of the bearing steel is not exceeded. On the other hand, bearing lives shorter than the L_{10} life can be obtained under unfavourable operating conditions.

A systems approach to fatigue life calculation has been used in ISO 281:2007. With such a method, the influence on the life of the system due to variation and interaction of interdependent factors is considered by referring all influences to the additional stress they give rise to in the rolling element contacts and under the contact regions.

Rolling bearings — Explanatory notes on ISO 281 —

Part 2:
Modified rating life calculation, based on a systems approach to fatigue stresses

1 Scope

ISO 281:2007 introduced a life modification factor, a_{ISO}, based on a systems approach to life calculation, in addition to the life modification factor for reliability, a_1.These factors are applied in the modified rating life equation

$$L_{nm} = a_1 a_{ISO} L_{10} \quad (1)$$

For a range of reliability values, a_1 is given in ISO 281:2007 as well as the method for evaluating the modification factor for systems approach, a_{ISO}. L_{10} is the basic rating life.

This part of ISO/TR 1281 gives supplementary background information regarding the derivation of a_1 and a_{ISO}.

NOTE The derivation of a_{ISO} is primarily based on theory presented in Reference [5], which also deals with the fairly complicated theoretical background of the contamination factor, e_C, and other factors considered when calculating a_{ISO} .

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 281:2007, *Rolling bearings — Dynamic load ratings and rating life*

ISO 11171, *Hydraulic fluid power — Calibration of automatic particle counters for liquids*

3 Symbols

Certain other symbols are defined on an *ad hoc* basis in the clause or subclause in which they are used.

A	scaling constant in the derivation of the life equation
a_{ISO}	life modification factor, based on a systems approach to life calculation
a_{SLF}	stress-life factor in Reference [5], based on a systems approach to life calculation (same as the life modification factor a_{ISO} in ISO 281)
a_1	life modification factor for reliability
C	basic dynamic load rating, in newtons
C_u	fatigue load limit, in newtons

C_0 basic static load rating, in newtons

c exponent in the stress-life equation (in Reference [5] and ISO 281, $c = 31/3$ is used)

D_{pw} pitch diameter, in millimetres, of ball or roller set

dV elementary integration volume, in cubic millimetres

e Weibull's exponent (10/9 for ball bearings and 9/8 for roller bearings)

e_C contamination factor

F_r bearing radial load (radial component of actual bearing load), in newtons

L_n life, corresponding to n percent probability of failure, in million revolutions

L_{nm} modified rating life, in million revolutions

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

L_{10} basic rating life, in million revolutions

N number of load cycles

n probability of failure, expressed as a percentage

P dynamic equivalent load, in newtons

P_u fatigue load limit, in newtons (same as C_u)

Q_{max} maximum load, in newtons, of a single contact

Q_u fatigue load, in newtons, of a single contact

Q_0 maximum load, in newtons, of a single contact when bearing load is C_0

S reliability (probability of survival), expressed as a percentage

s uncertainty factor

w exponent in the load-stress relationship (1/3 for ball bearings and 1/2,5 for roller bearings)

x contamination particle size, in micrometres, with ISO 11171 calibration

Z number of rolling elements per row

α nominal contact angle, in degrees

β_{cc} lubricant cleanliness degree (in Reference [5] and Clause 5)

$\beta_{x(c)}$ filtration ratio at contamination particle size x (see symbol x above)

NOTE The designation (c) signifies that the particle counters — of particles of size x µm — shall be an APC (automatic optical single-particle counter) calibrated in accordance with ISO 11171.

η_b lubrication factor

η_c contamination factor (same as the contamination factor e_C in ISO 281)

κ viscosity ratio, ν / ν_1

Λ ratio of oil film thickness to composite surface roughness

ν actual kinematic viscosity, in square millimetres per second, at the operating temperature

ν_1 reference kinematic viscosity, in square millimetres per second, required to obtain adequate lubrication

τ_i fatigue stress criterion of an elementary volume, dV, in megapascals

τ_u fatigue stress limit in shear, in megapascals

4 Life modification factor for reliability, a_1

4.1 General

In the context of bearing life for a group of apparently identical rolling bearings, operating under the same conditions, reliability is defined as 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. Reliability can thus be expressed as the probability of survival. If this probability is expressed as S %, then the probability of failure is (100 – S) %.

The bearing life can be calculated for different probability of failure levels with the aid of the life modification factor for reliability, a_1.

4.2 Derivation of the life modification factor for reliability

4.2.1 Two parameter Weibull relationship

Endurance tests, which normally involve batches of 10 to 30 bearings with a sufficient number of failed bearings, can be satisfactorily summarized and described using a two parameter Weibull distribution, which can be expressed

$$L_n = \eta \left[\ln\left(\frac{100}{S}\right) \right]^{1/e} \tag{2}$$

$$n = 100 - S \tag{3}$$

where

S is the probability, expressed as a percentage, of survival;

n is the probability, expressed as a percentage, of failure;

e is the Weibull exponent (set at 1,5 when $n < 10$);

η characteristic life.

With the life L_{10} (corresponding to 10 % probability of failure or 90 % probability of survival) used as the reference, L_n / L_{10} can be written, with the aid of Equation (2), as

$$L_n = L_{10} \left[\frac{\ln(100/S)}{\ln(100/90)} \right]^{1/e} \tag{4}$$

By including the life modification factor for reliability, a_1, Equation (4) can be written

$$L_n = a_1 L_{10} \tag{5}$$

The life modification factor for reliability, a_1, is then given by

$$a_1 = \left[\frac{\ln(100/S)}{\ln(100/90)} \right]^{1/e} \tag{6}$$