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Hydrodynamic plain journal bearings under steady-state conditions — Circular cylindrical bearings —

Part 3: Permissible operational parameters

Paliers lisses hydrodynamiques radiaux fonctionnant en régime stabilisé — Paliers circulaires cylindriques —

Partie 3: Paramètres opérationnels admissibles

Reference number
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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 123, *Plain bearings*, Subcommittee SC 8, *Calculation methods for plain bearings and their applications*.

This second edition cancels and replaces the first edition (ISO 7902-3:1998), of which it constitutes a minor revision. The changes compared to the previous edition are as follows:

— adjustment to ISO/IEC Directives, Part 2:2018;

— correction of typographical errors.

A list of all parts in the ISO 7902 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

In order to attain sufficient operational reliability of circular cylindrical plain journal bearings when calculated in accordance with ISO 7902-1, it is essential that the calculated operational parameters h_{min}, T_B or T_{ex} and $\bar{p}$ do not lie above or below the permissible operational parameters h_{lim}, T_{lim} and $\bar{p}_{lim}$. The permissible parameters represent geometrically and technologically dependent operational limits within the plain bearing tribological system. They are empirical values which still enable sufficient operational reliability even for minor influences (see ISO 7902-1).

Hydrodynamic plain journal bearings under steady-state conditions — Circular cylindrical bearings —

Part 3: Permissible operational parameters

1 Scope

This document specifies empirical permissible values for h_{lim}, T_{lim} and $\bar{p}_{\mathrm{lim}}$.

The empirical values stated can be modified for certain applications, for example if information supplied by the manufacturer is to be taken into account. The descriptions of the symbols and calculation examples are given in ISO 7902-1.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 7902-1, *Hydrodynamic plain journal bearings under steady-state conditions Circular cylindrical bearings — Part 1: Calculation procedure*

3 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

4 Symbols and units

Symbols and units are defined in Table 1. ISO 7902-1:2020, Table 1 shall be referenced to identify the meaning of symbols not listed in Table 1.

Table 1 — Symbols and their designations

B	Nominal bearing width	m
C	Nominal bearing clearance	m
D	Nominal bearing diameter (inside diameter)	m
E	Dimensionless modulus of elasticity	1
G	Dimensionless shear modulus	1
h_{wav}	Waviness of sliding surface (from Figure 3)	m
$h_{\mathrm{wav,eff}}$	Effective waviness of sliding surface	m
$h_{\mathrm{wav,eff,lim}}$	Maximum permissible effective waviness	m
$h_{\mathrm{wav,lim}}$	Maximum permissible waviness	m

Table 1 *(continued)*

i	Number of waviness	1
l_G	Length of lubrication groove	m
l_P	Length of lubricant pocket	m
L_H	Length of bearing housing	m
N_F	Rotational frequency of the bearing force	s^{-1}
Q_1	Lubricant flow rate at the inlet to clearance gap	m^3/s
Q_2	Lubricant flow rate at the outlet to clearance gap	m^3/s
Rz_B	Average peak-to-valley height of bearing sliding surface	m
Rz_J	Average peak-to-valley height of shaft mating surface	m
y	Amount of deflection	m
γ	Angle of misalignment of the shaft	rad
φ_{wav}	Period of waviness	°

5 Operational parameters to avoid wear

5.1 Minimum permissible lubrication film thickness

The aim of keeping above the minimum permissible lubrication film thickness h_{lim} is to retain complete lubrication of the plain bearing in order to attain least possible wear and low susceptibility to faults. The lubricant should be free of contaminating particles, otherwise increased wear, scoring and local overheating can result, thus impairing correct functioning of the plain bearing. If necessary, appropriate filtering of the lubricant should be provided for.

The minimum permissible lubrication film thickness h_{lim}, as a characteristic parameter for the transition to mixed friction (see ISO 7902-1:2020, 7.6), can be determined from the following formula as shown in Figure 1.

$$h_{lim} = Rz_B + Rz_J + \frac{1}{2} B \cdot y + \frac{1}{2} y + h_{wav,eff} \tag{1}$$

Formula (1) takes into account

— the sum of the mean peak-to-valley heights of bearing and shaft at the ideal location (line X-X) [$Rz_B + Rz_J$],

— the misalignment (line Y-Y) within the bearing length [1/2 $B{\cdot}y$], and

— the mean deflection (line Z-Z) [1/2 y].

5.2 Effective waviness and maximum permissible effective waviness

If wavy geometrical deviations occur in the sliding surfaces (bearing or shaft) in the circumferential direction, they are taken into account during the determination of h_{lim} by the effective waviness $h_{wav,eff}$ for the most unfavourable shaft position. In this case, $h_{wav,eff}$ is the effective waviness of the bearing under static loading or the effective waviness of the shaft under rotating loading, respectively.

The effective waviness $h_{wav,eff}$ and the maximum permissible effective waviness $h_{wav,eff,lim}$ at a given operating point (ε or h_{lim}) can be determined using Figure 2 if roughnesses, deformations and tilt positions are known.

In accordance with Formula (1), the following applies:

$$h_{\mathrm{lim}}=m+h_{\mathrm{wav,eff}}$$

where

$$m=Rz_{\mathrm{B}}+Rz_{\mathrm{J}}+\frac{1}{2}B\cdot y+\frac{1}{2}y$$

$$h_{\mathrm{wav,eff}}=\frac{E}{G}a$$

With a given minimum lubricant film thickness h_{min} the maximum permissible effective waviness amplitude is determined from

$$h_{\mathrm{wav,eff,lim}}=h_{\mathrm{min}}-m$$

The maximum permissible absolute waviness, $h_{\mathrm{wav,eff,lim}}$, is determined from

$$h_{\mathrm{wav,lim}}=\frac{G}{E}h_{\mathrm{wav,eff,lim}}$$

An example of the determination of $h_{\mathrm{wav,eff}}$, h_{lim}, $h_{\mathrm{wav,eff,lim}}$ and $h_{\mathrm{wav,lim}}$ (from Figure 2) is as follows.

Given quantities:

$$B/D=0{,}5$$

$$C/2=85\times10^{-6}\ \mathrm{m}$$

$$m=6\times10^{-6}\ \mathrm{m}$$

$$h_{\mathrm{wav}}=5\times10^{-6}\ \mathrm{m}$$

$$i=6$$

$$h_{\mathrm{min}}=8{,}5\times10^{-6}\ \mathrm{m}$$

$$\varepsilon=1-\frac{h_{\mathrm{min}}}{\frac{C}{2}}=0{,}9$$

With $B/D=0{,}5$, Figure 2 gives E = 0,86.

With i = 6 and ε = 0,9, Figure 2 gives G = 1,85.

Hence

$$h_{\text{wav, eff}} = \frac{0{,}86}{1{,}85} \times 5 \times 10^{-6} = 2{,}32 \times 10^{-6}\ \text{m}$$

and

$$h_{\text{lim}} = 6 \times 10^{-6} + 2{,}32 \times 10^{-6} = 8{,}32 \times 10^{-6}\ \text{m}$$

Since $h_{\text{min}} > h_{\text{lim}}$, $h_{\text{min}} = 8{,}5 \times 10^{-6}\ \text{m}$ is permissible.

$$h_{\text{wav, eff, lim}} = 8{,}5 \times 10^{-6} - 6 \times 10^{-6} = 2{,}5 \times 10^{-6}\ \text{m}$$

$$h_{\text{wav, lim}} = \frac{1{,}85}{0{,}86} \times 2{,}5 \times 10^{-6} = 5{,}38 \times 10^{-6}\ \text{m}$$

In general, deviations of form are irregular. For the determination of $h_{\text{wav, eff}}$, the waves in the sliding surface area under load are significant.

For running-in processes under low load and sliding velocity, it is possible to allow a lower minimum film thickness owing to the smoothing and adjusting of the sliding surfaces. If necessary, a bearing material having a good running-in ability shall be used.

Table 2 gives empirical permissible values for h_{lim}, in which a mean peak-to-valley height of $Rz_{\text{J}} < 4\ \mu\text{m}$ for the shaft, minor geometrical errors of the sliding surfaces, careful assembly and adequate filtering of the lubricant are assumed.

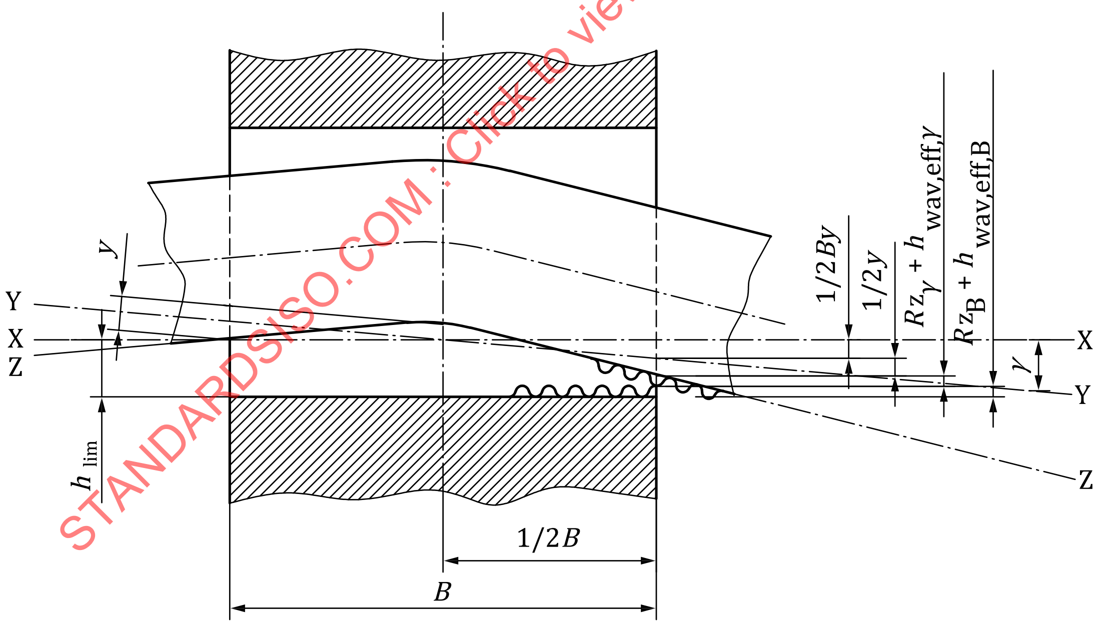
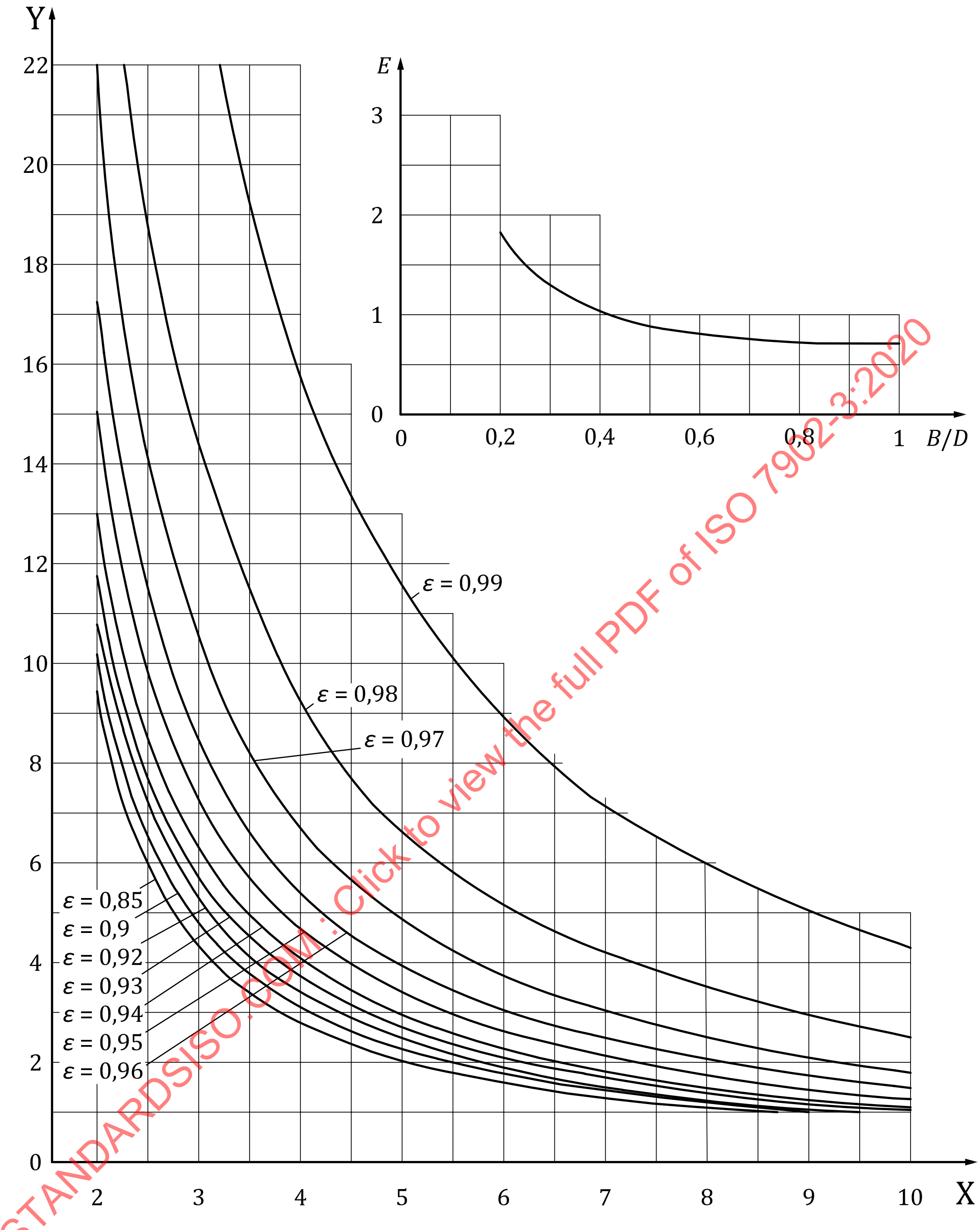


Figure 1 — Minimum permissible lubrication film thickness when no running-in process is allowed



Key

X number of waves i at the periphery of the sliding surface of the bearing or the shaft

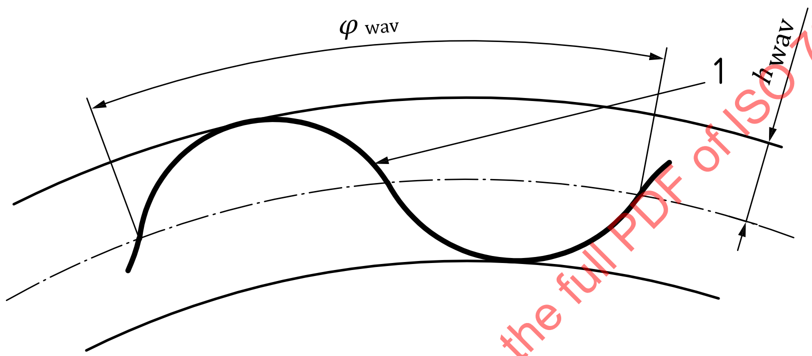
Y Shear modulus, G

Figure 2 — Determination of the effective waviness $h_{wav,eff}$ and the maximum permissible effective waviness $h_{wav,eff,lim}$

Table 2 — Empirical permissible values for the minimum permissible least lubricant film thickness, h_{lim}

Minimum permissible thicknesses in micrometres

Shaft diameter, D_J mm	Minimum permissible least lubricant film thickness, h_{lim}				
	$U_J \le 1$ m/s	$1 < U_J \le 3$ m/s	$3 < U_J \le 10$ m/s	$10 < U_J \le 30$ m/s	$30 < U_J$ m/s
$24 < D_J \le 63$	3	4	5	7	10
$63 < D_J \le 160$	4	5	7	9	12
$160 < D_J \le 400$	6	7	9	11	14
$400 < D_J \le 1\,000$	8	9	11	13	16
$1\,000 < D_J \le 2\,500$	10	12	14	16	18



Key

1 sliding surface of the bearing or of the shaft

NOTE Number of waves $i = \dfrac{360°}{\varphi_{wav}} Z$

Figure 3 — Absolute waviness amplitude, h_{wav}, period of waviness, φ_{wav} and number of waves, i, of the sliding surface

6 Operational parameters to avoid excessive mechanical loading

The maximum permissible specific bearing load, p_{lim}, is the result of the requirement that a deformation of the sliding surfaces may not result in impairment of correct functioning and the formation of cracks. In addition to the composition of the bearing material, there are many other decisive influencing factors, such as the method of manufacture, the material structure, the thickness of bearing material and the geometry and type of bearing liner backing. Independently of these, a check shall be made as to whether the bearing is subjected to the full load when starting. If the specific bearing load during starting, p, is greater than 2,5 N/mm^2 to 3 N/mm^2, it may be necessary to provide relief by pressurized oil (auxiliary hydrostatic device). Otherwise wear can occur on the sliding surfaces.

Table 3 gives empirical values for $\bar{p}_{lim}$.