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Plain bearings — Hydrodynamic plain tilting pad thrust bearings under steady-state conditions —

Part 3: Guide values for the calculation of tilting pad thrust bearings

Paliers lisses — Butées hydrodynamiques à patins oscillants fonctionnant en régime stationnaire —

Partie 3: Paramètres opérationnels admissibles pour le calcul des butées à patins oscillants

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

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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.

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).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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 12130-3:2001), 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 12130 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 for tilting pad thrust bearings calculated in accordance with ISO 12130-1 to be sufficiently reliable in operation, it is necessary that the calculated operational parameters h_{min}, T_B or T_2 and $\overline{p}$ do not fall below or exceed the guide values h_{lim}, T_{lim} and $\overline{p}_{lim}$.

For limiting cases at high specific loads and/or high rotational frequencies, more accurate calculations are necessary taking into consideration thermal, elastic, hydrodynamic and/or turbulence effects.

The guide values represent limiting values in the tribological system plain bearing unit which are dependent on geometry and technology. These are empirical values which give still sufficient reliability in operation even when subjected to slight disturbing influence as shown in ISO 12130-1:2001, Clause 4.

Plain bearings — Hydrodynamic plain tilting pad thrust bearings under steady-state conditions —

Part 3:
Guide values for the calculation of tilting pad thrust bearings

1 Scope

This document specifies guide values for the calculation of tilting pad thrust bearings as described in ISO 12130-1.

The empirical values given can be modified for specific fields of application.

This document is not applicable to heavily loaded tilting pad thrust bearings.

2 Normative references

There are no normative references in this document.

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 Guide values to avoid damage caused by wear

Explanation of the symbols and examples of calculation can be found in ISO 12130-1.

To achieve minimum wear and low susceptance to failure, ensure full lubrication of the plain bearing unit by taking into account the minimum permissible lubricant film thickness h_{lim}. The lubricant should be free from dirt as this may result in increasing wear, scoring and local overheating which would impair the correct functioning of the plain bearing. If necessary, the lubricant shall be filtered.

The minimum lubricant film thickness $h_{\mathrm{lim,tr}}$ as a characteristic value for the transition into mixed lubrication (see ISO 12130-1) can be determined according to Reference [6] using empirical Formula (1):

$$h_{\mathrm{lim,tr}} = \sqrt{\frac{D \times Rz}{12\,000}} \tag{1}$$

where

D is the mean sliding diameter;

Rz is the average peak to valley height of thrust collar.

This simple formula takes into account that, in general, machining tolerances increase with increasing size of the work piece.

However, as in this case the machining method and the actual conditions of the machine tools have a great influence, the value $h_{\text{lim,tr}}$ calculated on this basis is of limited information only.

Faulty manufacturing of shafts, flanges or thrust collars and the exceeding of permissible tolerances very quickly results in failure of the plain thrust bearings. Further, it is of importance how long a machine is operated under mixed lubrication during starting and stopping.

For higher sliding velocities, it is suitable to also increase the minimum permissible lubricant film thicknesses for standard operation so that, for example, during stopping, the mixed lubrication range is not reached too quickly.

Guide values for the minimum permissible lubricant film thickness h_{lim} may be calculated as follows:

$$h_{\text{lim}} = C\sqrt{U \times D \times \frac{F_{\text{st}}}{F}} \tag{2}$$

where

C	is equal to $0{,}4 \times 10^{-5}$ up to $2{,}9 \times 10^{-5}$;
U	is the mean sliding velocity of thrust collar;
F_{st}/F	is the ratio between the load-carrying capacity under conditions of standstill, F_{st}, and the bearing force, F, at the nominal rotational frequency.

When Formula (2) is used, $h_{\text{lim}} > h_{\text{lim,tr}}$.

It is recommended that $h_{\text{lim}} \geq 1{,}25\ h_{\text{lim,tr}}$.

Empirical values for h_{lim} are given in Tables 1 and 2.

For $F_{\text{st}}/F = 0$, the values of the first column in Tables 1 and 2 are valid independent of the sliding velocity.

Table 1 — Guide values for the minimum permissible lubricant film thickness h_{lim} in µm for $F_{\text{st}}/F = 1$ calculated where $C = 1 \times 10^{-5}$

Mean sliding diameter (thrust ring diameter) D mm	Mean sliding velocity of thrust collar U m/s					
	$1 \leq U \leq 2{,}4$	$2{,}4 < U \leq 4$	$4 < U \leq 6{,}3$	$6{,}3 < U \leq 10$	$10 < U \leq 24$	$24 < U \leq 40$
	Minimum permissible lubricant film thickness h_{lim} µm					
$24 \leq D \leq 63$	4	4	4,8	6	8,5	12
$63 < D \leq 160$	6,5	6,5	7,5	8,5	14	19
$160 < D \leq 400$	10	10	12	15	22	30
$400 < D \leq 1\,000$	16	16	19	24	35	48
$1\,000 < D \leq 2\,500$	26	26	30	38	55	75

Table 2 — Guide values for the minimum permissible lubricant film thickness h_{lim} in µm for F_{st}/F = 0,25 calculated where $C = 1 \times 10^{-5}$

Mean sliding diameter (thrust ring diameter) D mm	Mean sliding velocity of thrust collar U m/s					
	$1 \le U \le 2,4$	$2,4 < U \le 4$	$4 < U \le 6,3$	$6,3 < U \le 10$	$10 < U \le 24$	$24 < U \le 40$
	Minimum permissible lubricant film thickness h_{lim} µm					
$24 \le D \le 63$	4	4	4	4	4,3	6
$63 < D \le 160$	6,5	6,5	6,5	6,5	7	8,5
$160 < D \le 400$	10	10	10	10	11	15
$400 < D \le 1\,000$	16	16	16	16	17	24
$1\,000 < D \le 2\,500$	26	26	26	26	27	37

5 Guide values to avoid mechanical overloading

The maximum permissible specific bearing load $\bar{p}_{lim}$ results from the requirement that deformation of the sliding surfaces shall neither lead to an impairment of the correct functioning nor to cracks. Besides the composition of the bearing material, there is still a great number of other decisive influencing factors, for example, the manufacturing process, the material structure, the thickness of the bearing material as well as the shape and type of the bearing backing. Irrespective of this, it shall be checked whether there is already full loading during starting. If the specific bearing load during starting $\bar{p}$ > 2,5 N/mm^2 but ≤3 N/mm^2, a hydrostatic arrangement shall be provided, if appropriate, otherwise wear on the sliding surfaces may occur. The data given in Table 3 are general empirical values for $\bar{p}_{lim}$.

Table 3 — Guide values for the maximum permissible specific bearing load $\bar{p}_{lim}$

Bearing material group[a]	$\bar{p}_{lim}$ N/mm^2 (MPa)[b]
Pb and Sn alloys	5 (15)
Cu-Pb alloys	7 (20)
Cu-Sn alloys	7 (25)
Al-Sn alloys	7 (18)
Al-Zn alloys	7 (20)

[a] For materials, see ISO 4381, ISO 4382-1, ISO 4382-2 and ISO 4383.

[b] So far, the values in parentheses have been used in particular cases only. They may be permitted in exceptional cases for specific operating conditions, e.g. for very slow sliding velocities. 1 MPa = 1 N/mm^2.

6 Guide values to avoid thermal overloading

See Table 4.

The maximum permissible bearing temperature, T_{lim}, is a function of the bearing material and the lubricant.

Hardness and strength of the bearing materials decrease with increasing temperature. This becomes especially apparent in the case of Pb and Sn alloys on account of their lower melting temperatures.

Further, the viscosity of the lubricant decreases with increasing temperature. The load-carrying capacity of the plain bearing unit is then reduced and this may lead to mixed lubrication with wear.