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

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

Paliers lisses — Butées hydrodynamiques à patins géométrie fixe fonctionnant en régime stationnaire —

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

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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 12131-3:2001), of which it constitutes a minor revision. The changes compared to the previous edition are as follows:

— adjustments have been made to ISO/IEC Directives, Part 2:2018;

— typographical errors have been corrected.

A list of all parts in the ISO 12131 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 achieve that pad thrust, bearings calculated in accordance with ISO 12131-1 are sufficiently reliable in operation, it is necessary that the calculated operational parameters h_{min}, T_B or T_2 and $\bar{p}$ do not fall below or exceed the guide values h_{lim}, T_{lim} and $\bar{p}_{lim}$.

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 still give sufficient reliability in operation even when subjected to slight disturbing influences (see ISO 12131-1:2020, Clause 5).

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

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

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

1 Scope

This document specifies guide values for avoiding damage to thrust-pad bearings in service.

The explanation of the symbols as well as examples for calculation are given in ISO 12131-1.

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 for avoiding damage caused by wear

To achieve minimum wear and low susceptibility to failure, full lubrication of the plain bearing unit is aimed at 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, $h_{lim,tr}$, as a characteristic value for the transition into mixed lubrication (see ISO 12131-1:2020, 6.7) can be determined in accordance with Reference [6] using Formula (1).

$$h_{lim,tr} = \sqrt{\frac{D \times Rz}{3\,000}} \quad (1)$$

where

D is the mean sliding diameter, in mm;

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

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

As in this case, however, the machining method and the actual condition of the machine tools have a great influence, the value $h_{lim,tr}$ calculated on this basis is of only limited information value.

Faulty manufacturing of shafts, flanges or thrust collars and the exceeding of permissible tolerances rapidly 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 range of mixed lubrication is not reached too quickly.

Guide values for the minimum permissible lubricant film thickness, h_{lim}, may be calculated as given in Formula (2).

$$h_{lim} = C \times \sqrt{U \times D \times \frac{F_{st}}{F}} \quad (2)$$

where

C is equal to $1,6 \times 10^{-5}$ up to $6,3 \times 10^{-5}$

F_{st}/F is the ratio between the load carrying capacity under stationary conditions F_{st} and the bearing force F at nominal rotational frequency;

U is the mean sliding velocity of thrust collar, in m/s.

When Formula (2) is used it is to be observed that Formula (3) is satisfied.

$$h_{lim} > h_{lim,tr} \quad (3)$$

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

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

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 lead neither 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 such as, the manufacturing process, the material structure, the thickness of 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 is $\bar{p} > 3\ \text{N/mm}^2$, 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 1 — Guide values for the minimum permissible lubricant film thickness, h_{lim}, for $F_{st}/F = 1$, calculated with $C = 2 \times 10^{-5}$

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	63	8	8	9,5	12	17	24
63	160	13	13	15	19	28	38
160	400	20	20	24	30	44	60
400	1 000	32	32	38	48	69	95

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

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	63	8	8	8	8	8,6	12
63	160	13	13	13	13	14	19
160	400	20	20	20	20	22	30
400	1 000	32	32	32	34	34	47

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

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

Bearing material group[a]	$\bar{p}_{lim}$ MPa[b]
Pb and Sn alloys	5 (15)
CuPb alloys	7 (20)
CuSn alloys	7 (25)
AlSn alloys	7 (18)
AlZn 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. Exceptionally they may be permitted for specific operating conditions, for example, for very low 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 points.

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. Moreover, at temperatures exceeding 80 °C, ageing of mineral oil-based lubricants becomes increasingly evident.

A constant temperature field is given for plain bearings under steady-state conditions. For the calculation of plain bearings in accordance with this document, it is sufficient to describe the thermal bearing load by the bearing temperature, T_B, and the lubricant outlet temperature, T_2, and to ensure that they do not exceed T_{lim}.

Only a small part of the total amount of lubricant provided for the lubrication of the bearing is temporarily in the lubrication clearance gap and consequently at an increased temperature level. This means that not only T_B and T_2 but also the ratio of total amount of lubricant to lubricant flow rate are

