INTERNATIONAL STANDARD

ISO 12131-3

First edition
2001-04-15

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

Reference number
ISO 12131-3:2001(E)

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Printed in Switzerland

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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.

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 part of ISO 12131 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 12131-3 was prepared by Technical Committee ISO/TC 123, *Plain bearings*, Subcommittee SC 4, *Methods of calculation of plain bearings*.

ISO 12131 consists of the following parts, under the general title *Plain bearings — Hydrodynamic plain thrust pad bearings under steady-state conditions*:

— *Part 1: Calculation of thrust pad bearings*

— *Part 2: Functions for the calculation of thrust pad bearings*

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

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 $\overline{p}$ 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 still give sufficient reliability in operation even when subjected to slight disturbing influences (see clause 4 of ISO 12131-1:2001).

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 part of ISO 12131 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

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 12131. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 12131 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 4381, *Plain bearings — Lead and tin casting alloys for multilayer plain bearings.*

ISO 4382-1, *Plain bearings — Copper alloys — Part 1: Cast copper alloys for solid and multilayer thick-walled plain bearings.*

ISO 4382-2, *Plain bearings — Copper alloys — Part 2: Wrought copper alloys for solid plain bearings.*

ISO 4383, *Plain bearings — Multilayer materials for thin-walled plain bearings.*

ISO 12131-1:2001, *Plain bearings — Hydrodynamic plain thrust bearings under steady-state conditions — Part 1: Calculation of thrust pad bearings.*

3 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 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 has to be filtered.

The minimum lubricant film thickness $h_{\text{lim,tr}}$ as a characteristic value for the transition into mixed lubrication (see 5.7 of ISO 12131-1:2001) can be determined in accordance with [1] using the following empirical equation:

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

This simple equation 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 $h_{\text{lim,tr}}$ 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, e.g. 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 follows:

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

with $C = 1{,}6 \times 10^{-5}$ up to $6{,}3 \times 10^{-5}$ and with F_{st}/F, ratio between the load carrying capacity under stationary conditions F_{st} and the bearing force F at nominal rotational frequency.

When equation (2) is used it is to be observed that

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

It is recommended that $h_{\text{lim}} \geqslant 1{,}25 \times h_{\text{lim,tr}}$

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

4 Guide values to avoid mechanical overloading

The maximum permissible specific bearing load 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, e.g. 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 has to be checked whether there is already full loading during starting. If the specific bearing load during starting $\overline{p} > 3$ 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 $\overline{p}_{\text{lim}}$.

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 D (thrust ring diameter) mm		Mean sliding velocity of thrust collar U m/s					
		$1 \leqslant U \leqslant 2{,}4$	$2{,}4 < U \leqslant 4$	$4 < U \leqslant 6{,}3$	$6{,}3 < U \leqslant 10$	$10 < U \leqslant 24$	$24 < U \leqslant 40$
		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 D (thrust ring diameter) mm		Mean sliding velocity of thrust collar U m/s					
		$1 \leqslant U \leqslant 2{,}4$	$2{,}4 < U \leqslant 4$	$4 < U \leqslant 6{,}3$	$6{,}3 < U \leqslant 10$	$10 < U \leqslant 24$	$24 < U \leqslant 40$
		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, e.g. for very low sliding velocities. 1 MPa = 1 N/mm^2.

5 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 International Standard 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 decisive for the useful life of the lubricant. In general, this ratio is more advantageous in the case of bearings with recirculating lubrication than in the case of self-lubricated bearings.

Table 4 — Guide values for the maximum permissible bearing temperature T_{lim}

Types of bearing lubrication	T_{lim} [a] °C Ratio of total lubricant volume to lubricant volume per minute (lubricant flow rate) $\leqslant 5$	> 5
Lubrication under pressure (recirculating lubrication)	100 (115)	110 (125)
Lubrication without pressure (self-lubrication)	90/110	

[a] The values in brackets may exceptionally be permitted for specific operating conditions.

Bibliography

[1] SPIEGEL, K. and FRICKE J., *Belastungsdiagramm zur Berechnung von Axialgleitlagern (Load diagram for the calculation of plain thrust bearings)*. Schmiertechnik + Tribologie **22** (1975) 3, pp. 59-64.

ICS 21.100.10

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