INTERNATIONAL STANDARD

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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

Reference number
ISO 12130-3:2001(E)

Introduction

In order to achieve that tilting pad thrust bearings calculated in accordance with ISO 12130-1 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 give still sufficient reliability in operation even when subjected to slight disturbing influence as shown in clause 4 of ISO 12130-1:2001.

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 part of ISO 12130 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 part of ISO 12130 is not applicable to heavily loaded tilting pad thrust bearings.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 12130. 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 12130 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 12130-1:2001, *Plain bearings — Hydrodynamic plain tilting pad thrust bearings under steady-state conditions — Part 1: Calculation of tilting pad thrust bearings*

3 Guide values to avoid damage caused by wear

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

To achieve minimum wear and low susceptance to failure it is aimed at 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 $h_{lim,tr}$ as a characteristic value for the transition into mixed lubrication (see ISO 12130-1) can be determined according to [1] using the following empirical equation:

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

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

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

where

$C = 0{,}4 \times 10^{-5}$ up to $2{,}9 \times 10^{-5}$ and the F_{st}/F, ratio between the load-carrying capacity under conditions of standstill F_{st} and the bearing force F at nominal rotational frequency.

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

$$h_{lim} > h_{lim,tr} \tag{3}$$

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

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

For $F_{st}/F = 0$, 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_{st}/F = 1 calculated where $C = 1 \times 10^{-5}$

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} µ					
$24 \leqslant D \leqslant 63$	4	4	4,8	6	8,5	12
$63 < D \leqslant 160$	6,5	6,5	7,5	8,5	14	19
$160 < D \leqslant 400$	10	10	12	15	22	30
$400 < D \leqslant 1\,000$	16	16	19	24	35	48
$1\,000 < D \leqslant 2\,500$	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 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} µ					
$24 \leqslant D \leqslant 63$	4	4	4	4	4,3	6
$63 < D \leqslant 160$	6,5	6,5	6,5	6,5	7	8,5
$160 < D \leqslant 400$	10	10	10	10	11	15
$400 < D \leqslant 1\,000$	16	16	16	16	17	24
$1\,000 < D \leqslant 2\,500$	26	26	26	26	27	37

4 Guide values to avoid mechanical overloading

The maximum permissible specific bearing load $\overline{p}_{lim}$ 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 such as, e.g., 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 $\overline{p} > 2{,}5$ N/mm² but $\leqslant 3$ N/mm², 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 $\overline{p}_{lim}$.

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

Bearing material group [a]	$\overline{p}_{lim}$ N/mm² (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/mm²

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 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. 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 according to ISO 12130 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 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}

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

[a] The values in parentheses may be permitted in exceptional cases 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) No. 3, pp. 59-64