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Plain bearings — Pad materials for tilting pad bearings

Paliers lisses — Matériaux des patins pour paliers à patins oscillants

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Foreword

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This document was prepared by Technical Committee ISO/TC 123, *Plain bearings*, Subcommittee SC 7, *Special types of plain bearings*.

This second edition cancels and replaces the first edition (ISO 14287:2012), which has been technically revised. The main changes compared to the previous edition are as follows:

— The content of the Scope has been changed to a concise expression.

— Descriptions on processing and sheet dimensions have been deleted.

— Table 1, Figure A.1 and Figure A.2 have been reviewed.

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.

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Introduction

Tilting pad bearings are divided in circumferential direction and are pivoted at the supporting points on their back surfaces. This configuration allows the pads to tilt freely, enabling an optimum position and oil film to be realized for the applied duty condition (i.e. speed, pressure and oil viscosity), and improves load-carrying capabilities.

Such bearings are normally used as thrust and journal bearings for rotating machineries; tilting pad bearings are classified to the category of static load conditions with lubricating oil applied. They have been used for many years and have a long history. As a result of developments in high-speed, high-performance rotating machineries, many various types of pad materials have been put into practical use.

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Plain bearings — Pad materials for tilting pad bearings

1 Scope

This document specifies requirements for tilting pad bearing lining materials (metals and polymers), backing metals and pivots.

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 4381, *Plain bearings — Tin casting alloys for multilayer plain bearings*

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

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 Requirements

4.1 General

The sliding surface of a pad may be a metal or a polymer, which is typically bonded to a backing metal, depending on the operating conditions of the bearing. Alloys shall be in accordance with ISO 4381; materials shall be in accordance with ISO 4383. Guidance for the selection of pad surface layer materials is given in Annex A.

4.2 Metallic materials

4.2.1 Typical materials

The chemical composition of some typical materials based on metal is given in Table 1.

4.2.2 Tin-based white metals

Tin-based white metals are used as general-purpose metallic lining materials. They are generally provided with linings by casting.

White metals are characterized by good castability. However, attention should be paid to quality problems, such as bonding strength with the back metal, segregation and blow holes.

To ensure appropriate strength/softness of a white metal alloy, the combination of Sb and Cu described in Table 1 is used in many applications.

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Lead-based white metals are rarely used due to their generally inferior performance and concerns over their impact on the environment.

4.2.3 Aluminium bearing alloys

Aluminium-based bearing alloys are used for high-speed operation under high-load and high-temperature conditions. Al-Sn alloys, i.e. alloys which are made by adding tin to aluminium, are the most commonly used aluminium bearing alloys. To improve sliding characteristics at high speed, 40 % Sn-Al alloy is typically used.

The pad of a bearing manufactured from such an alloy is formed from a bimetal strip consisting of an aluminium alloy, which is roll-bonded to carbon steel.

4.2.4 Lead-bronze bearing alloys

Lead-bronze bearing alloys are used under operating conditions equivalent to those for aluminium-bearing alloys or under higher load and higher temperature conditions. However, lead-bronze bearing alloys have limited uses. Lead-bronze bearing alloys are high in hardness; they normally require surface hardening (quench hardening, etc.) on the sliding surfaces of mating parts.

The pad of a bearing manufactured from such an alloy, as in the case of an aluminium bearing alloy, is typically formed from a bimetal strip. It can take the form of a copper alloy with a steel backing, although it is a rare case.

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Table 1 — Chemical composition of metal materials

Chemical element	Chemical composition (mass fraction, %)			
	Tin-based white metals		Aluminium bearing alloys	Lead-bronze bearing alloys
	SnSb8Cu4	SnSb12Cu6Zn		
Sn	Remainder	Remainder	35 to 42	8 to 12
Al	0,01	0,01	Remainder	—
Cu	3 to 5	5,5 to 6,5	0,7 to 1,3	Remainder
Sb	8 to 10	11 to 13	—	0,5
Pb	0,5	0,06	—	7 to 13
Zn	0,01	0,3 to 0,7	—	0,75
Ni	—	0,06	0,15	0,5
Si	—	—	0,3	—
Fe	0,08	0,03	0,7	0,35
Bi	0,08	0,06	—	—
As	0,01	—	—	—
Ag		0,05 to 0,15	—	—

4.3 Polymer materials

Bearings with pads having polymer layers on their sliding surfaces, which are characterized by polymer-specific tribological characteristics, are in use.

Polyether-etherketone (PEEK) and polytetrafluoro-ethylene (PTFE) polymer materials are available. Bearings composed of such materials are provided with special measures to allow for bonding to the back metal. A porous metal layer is used as the bonding interface layer and its voids are impregnated with a polymer layer material to form a sliding surface layer. Thus, the metal interface layer is joined with the back metal. PEEK polymer materials contain some PTFE in order to improve sliding characteristics.

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The chemical composition of some typical polymer materials is given in Table 2.

Two types of electrical conductivities are provided: conductive and non-conductive, which are determined depending on the elements added. Non-conductive polymer materials have the advantage of preventing electro-erosion without an additional insulator.

Table 2 — Chemical composition of polymer materials

Chemical element	Chemical composition (mass fraction, %)		
	PEEK material		PTFE material
PEEK	Remainder	Remainder	—
PTFE	1 to 3	8 to 12	Remainder
CF	27 to 33	—	10 to 20
MoS_2	—	—	4 to 6

Key

CF: carbon fibre

MoS_2: molybdenum disulfide

4.4 Back metal materials

Low-carbon steels containing approximately 0,10 % to 0,35 % mass fraction carbon are often used as back metal materials. The carbon content of a back metal material is typically determined using a combination of a surface layer bearing material and a bonding process.

In the case of bearings operating under high-speed and high-temperature conditions, a copper alloy may be used as a back metal, although it is a rare case. Back metals of the copper alloy are usually Cu-Cr (copper chromium) alloys, which are expected to decrease pad temperature by approximately 10 °C to 20 °C because of their excellent thermal conductivity.

4.5 Pivot materials

Pivots are subjected to concentrated loads and can be integral to the pad. Pivot materials are very hard and are fixed to pads. A typical example of a pivot surface is a flat, cylindrical and spherical one. It is press-fitted on to the back surface of a pad and is then secured by caulking. High-carbon chromium bearing steels containing approximately 0,95 % to 1,10 % mass fraction carbon are commonly used for tilt pad pivots and in general heat-treated.

The shape of a pivot is designed to have different curvatures with respect to the circumferential and lateral directions to allow the pad to tilt freely in the circumferential and lateral directions.

Pivots may be fastened to the bearing casing instead of to the back of the pads.

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Annex A
(informative)

Guidance on properties and selection of materials

A.1 Additional information on metal materials

A.1.1 White metals

White metals have excellent castability and provide good conformability, seizure resistance and embeddability in operation. Therefore, they are often used in thrust and journal bearings.

Gravity casting and centrifugal casting are used to produce thrust pads and journal pads, respectively. Centrifugal casting produces fine structures with high bonding strength.

White metals are limited in strength and high-temperature characteristics; the maximum permissible sliding surface temperature of white metals is approximately 120 °C to 130 °C.

Bearings can be subjected to high temperatures due to the development of high-speed and high-performance rotating machinery. Some of them employ aluminium alloy. Aluminium alloy-lined bearings can be used at temperatures about 25 °C to 30 °C higher than white metal-lined bearings.

A.1.2 Aluminium alloys

Aluminium alloy-lined bearings are formed by machining bimetal strip materials. The size of a bearing is limited by the size of the bimetal strip and the size capacity of the machinery through which the bearing is processed. In general, small or medium size bearings are produced.

A.1.3 Leaded-bronze alloys

Lead bronze alloy-lined bearings can be used at temperatures about 30 °C to 40 °C higher than white metal-lined bearings. However, they are high in hardness and sensitive to seizure. Their uses are thought to be limited to special applications utilizing the high-temperature characteristics of copper materials.

A.2 Additional information on polymer materials

In general, PEEK and PTFE polymer materials are excellent in low-friction coefficient and seizure resistance. In recent years, PEEK and PTFE polymer materials utilizing those characteristics have been developed. Such materials are used to produce pads for both thrust and journal bearings.

The low thermal conductivity of polymer materials is beneficial to reduce thermal distortion of the bearing surface. PEEK materials have excellent load-carrying capabilities and little wear/creep deformation under high surface pressure conditions. In addition, PEEK-lined bearings can be used at temperatures approximately 75 °C higher than white metal-lined bearings. Owing to the excellent load durability and low friction, the size of bearings can be reduced and the overall size of equipment can accordingly be reduced.

Experimental results for the start-up friction coefficient under vertical static load conditions are shown in Figure A.1. In some cases, the use of jacking oil for large-size vertical thrust bearings can be eliminated by specifying PTFE or PEEK thrust pads. The size of PEEK sheet materials which can be produced vary according to the capability of the equipment used.

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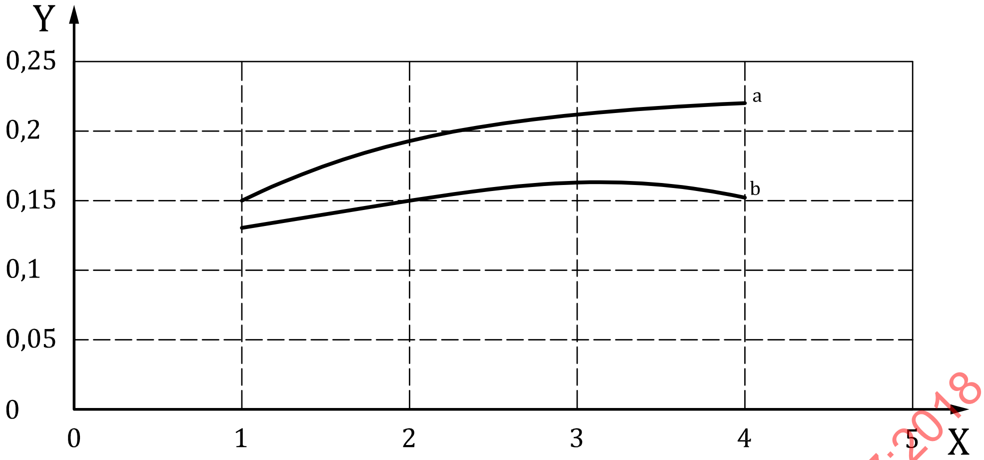

Key

X specific bearing load (MPa)

Y friction coefficient at start-up

a White metal.

b PEEK.

NOTE These results are based on a test carried out about a tilting pad thrust bearing with eight pads having an outside diameter of 457 mm and an inside diameter of 246 mm.

Figure A.1 — Example of start-up coefficient of friction on a vertical static load test machine

A.3 Operation range

A general chart, giving the operation range for metallic materials and polymer materials, is shown in Figure A.2.

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