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Plain bearings — Fluid film bearing materials for vehicular turbocharger

Paliers lisses — Matériaux antifriction à film fluide pour turbocompresseurs de véhicule

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Foreword

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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).

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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 7, *Special types of plain bearings*.

This second edition cancels and replaces the first edition (ISO 22507:2018), which has been technically revised.

The main changes compared to the previous edition are as follows:

— subclause 4.1 has been updated to include warnings regarding the application of lead or other restricted substances;

— Clause 5 has been updated to allow materials developed for specific operating conditions;

— the characteristic definitions of Table 1 have been updated;

— Figures A.2 and A.3 have been updated;

— a Bibliography has been added.

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.

Plain bearings — Fluid film bearing materials for vehicular turbocharger

1 Scope

This document specifies the material compositions and the required properties of fluid film bearings used for vehicular turbochargers.

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 4378-1, *Plain bearings — Terms, definitions, classification and symbols — Part 1: Design, bearing materials and their properties*

ISO 4378-2, *Plain bearings — Terms, definitions, classification and symbols — Part 2: Friction and wear*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 4378-1 and ISO 4378-2 apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

4 Requirements for bearing material

4.1 General

See Annex A for a general description of a vehicular turbocharger and bearings.

Distinctive conditions of turbochargers are:

— sliding speed is high,

— bearings are exposed to high temperature oil, and

— oil contains contaminants such as soot from the engine.

Therefore, fluid film bearing materials for vehicular turbochargers shall have special properties of seizure resistance, wear resistance and chemical corrosion resistance as described in the following subclauses. Manufacturers may use “in-house” test procedures to quantify material performance or refer to standard test procedures such as ISO 7148-1 and ISO 10129.

Materials of mating runner parts such as shaft and thrust collar shall be hard and smooth enough to use the maximum capability of the bearing materials.

Typical bearing material compositions are shown in Clause 5. Manufacturers also use lead-free aluminium-tin based alloys as alternatives with reduced hazardous material utilization. If the

purchaser's requirements necessitate limits for any element not specified, or limits different from those already specified, these should be agreed upon between the supplier and purchaser.

WARNING — Lead's (Pb) toxicity has been recognized and its use has since been phased out of many applications. However, many countries still allow the sale of products that expose humans to lead. Lead is a neurotoxin.

4.2 Seizure resistance

There are cases when the sliding speed of bearings exceeds 100 m/s. For such high-speed condition, seizure resistance against a possible metal contact is required for bearing materials.

4.3 Wear resistance

If a bearing comes into contact with the rotating shaft, or if soot is mixed into the lubricating oil, bearing wear can occur. In recent years, oil viscosity grade has also been decreasing from an environmental point of view. Excessively worn bearings bring vibration and decrease in machine efficiency. For such condition, wear resistance to ensure normal machine operation is required for bearing materials.

4.4 Chemical corrosion resistance

Bearing inlet oil temperature exceeds 100 °C, and the bearings are exposed to the oil at more than 200 °C just after the stop of the engine due to the heat flux from the turbine. For such condition, chemical corrosion resistance against high temperature oil is required for bearing materials.

5 Bearing material

This clause specifies the bearing materials. In accordance with operational environment, especially with the high temperature condition, copper alloys are mainly used for turbochargers due to their generally good tribological behaviour under elevated temperatures. Bearing and thrust bearings may be produced using solid copper alloys or multi-layered copper alloys with a steel backing. Alternatively, steel which has been surface-treated to improve wear resistance may be used. Bearing materials shall be accompanied with the requirements for bearing material described in Clause 4.

Annex A describes the form and function of the bearing and thrust bearing components within the turbocharger.

Table 1 shows the chemical compositions and characteristics of some example bearing materials that are currently in use. The characteristics in these tables are typical guidelines and are changeable in response to the operating conditions. Additionally, bearing material manufacturers may use compositions tailored to specific operating conditions.

Table 1 — Example of chemical composition and characteristics of bearing material

Chemical composition mass fraction %					
Chemical element	**CuPb15Sn8**[a]	**CuZn37Mn3Al2PbSi**[b]	**CuZn37Pb3**[a]	**CuSn10Pb10**[c]	**CuZn40**[d]
Cu	remainder	57 to 59	59 to 63	remainder	58 to 62
Zn	—	remainder	remainder	—	remainder
Sn	7 to 9	—	—	9 to 11	—
Al	—	1,3 to 2,3	—	—	—
Mn	—	1,5 to 3	—	—	—
Si	—	0,3 to 1,3	—	—	—
Pb	14 to 16	0,2 to 0,8	1,8 to 3,7	9 to 11	≤ 2
Total others	≤ 3	≤ 3	≤ 2	≤ 3	≤ 1
Characteristics					
Seizure resistance	good	very good	adequate	good	adequate
Wear resistance	good	very good	good	good	good
Corrosion resistance	adequate	very good	very good	adequate	very good

[a] Commonly used for journal bearing as solid metal.

[b] Commonly used for journal and thrust bearing as solid metal.

[c] Commonly used for thrust bearing as solid or multi-layered metal.

[d] Commonly used for thrust bearing as solid metal.

Annex A
(informative)

Vehicular turbocharger and bearings

A.1 Vehicular turbocharger

A turbocharger is a type of machine equipment that feeds compressed air to the engine combustion chamber. The turbocharger enhances the engine power, which contributes to low fuel consumption by engine downsizing and low emission of the exhaust gas.

Figure A.1 shows an example of a vehicular turbocharger. The main components of turbochargers include:

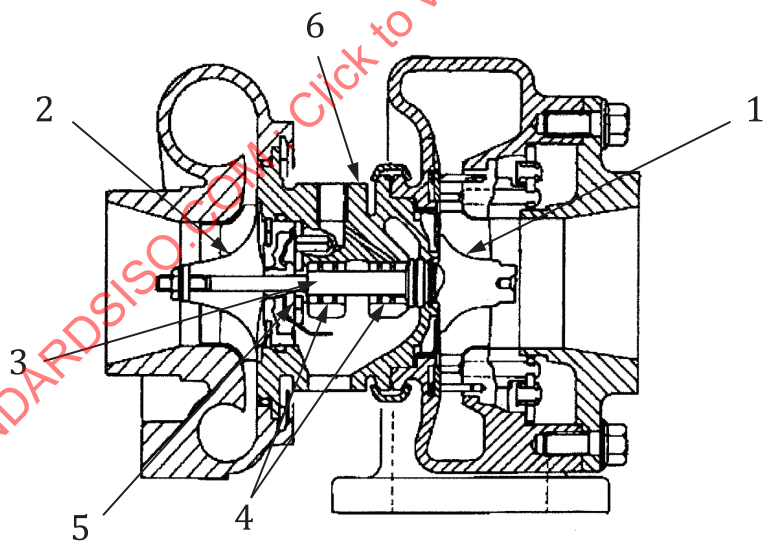
— a turbine that transforms the engine exhaust gas energy to the rotational energy of the shaft,

— a compressor that supplies compressed air to the engine to enhance the engine power,

— a shaft that connects the turbine and the compressor, and

— bearings that support the high-speed rotating shaft.

Regarding the bearings, both fluid film bearings and ball bearings are used. Fluid film bearings are, however, widely used because of their silence, better rotor dynamics and higher resistance to foreign particles in oil.



Key

1 turbine
2 compressor
3 shaft
4 journal bearings
5 thrust bearing
6 bearing housing

Figure A.1 — Example of a cross-sectional view of a turbocharger

A.2 Types of bearings for vehicular turbocharger

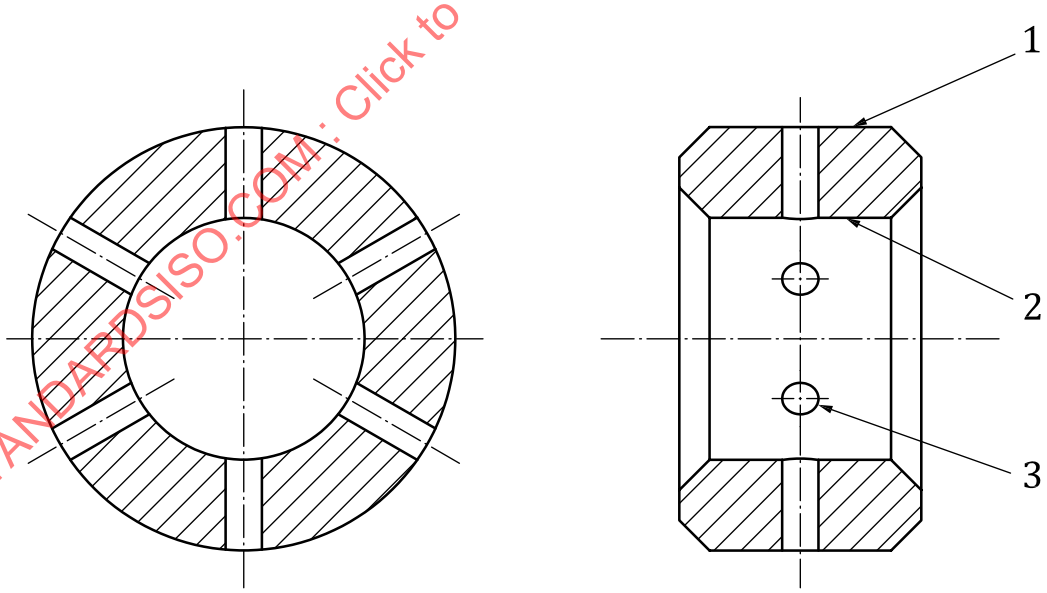
There are two types of fluid bearings used for turbochargers: journal bearings (see Figure A.2), which support the shaft in the radial direction, and thrust bearings (see Figure A.3), which support the shaft in the axial direction.

High vibration stability is required for the shaft system of turbochargers, because the shaft rotates at a high speed of several hundreds of thousands of rotations per minute and is also excited from the outside. For that reason, floating bush bearings or semi-floating bush bearings are used for journal bearings. Two journal bearings make a pair to support one rotating shaft.

The floating bush bearing has a floating bush that is installed between the shaft and the bearing housing. Thus, there are two fluid films for one bearing: the inner film is formed between the shaft and the bush, and the outer film is between the bush and the housing. This bush has a degree of freedom in the rotational direction so that it rotates at such speed that the friction torques of both oil films are balanced. Oil is supplied to the inner film via oil feeding holes drilled through the bush. If the bush rotates at high speed, it is possible that not enough oil is supplied due to the centrifugal force.

The rotational degree of freedom of the semi-floating bush, on the other hand, is constrained by a stop pin projected to the bush for example. Thus, the function of the outer film is only damping. Enough damping prevents from self-excited vibration (oil whirl). Because the bush does not rotate, there is another type of semi-floating bush bearing such that two bushes in two bearings are integrated.

The thrust bearing supports the axial fluid load that is generated by the turbine and the compressor. The type of bearing is not the tilting pad bearing but the fixed pad bearing due to size limitation. The typical shape of the sliding surface is that of a taper-land thrust bearing or step bearing. A pair of two bearings is arranged oppositely so that the axial position of the shaft (oil film thicknesses) is determined by the balance of the oil film pressures of two bearings. Since the thrust bearing loads generated by the compressor and the turbine are different, the designed load capacities of both bearings are different too.



Key

1 outer sliding surface
2 inner sliding surface
3 oil feed hole

Figure A.2 — Example of a journal bearing (floating bush)