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Plain bearings — Fluid film bearing materials for vehicular turbocharger

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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*.

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 required properties of fluid film bearings used for vehicular turbochargers.

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 Requirements for bearing material

4.1 General

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.

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.

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

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 to 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 assure 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. There are two types of bearing materials. One is solid copper alloy, and another is multi layered copper alloy. The solid alloy is made of copper alloy only, and the multi layered alloy has a steel backing. Bearing materials shall be accompanied with the requirements for bearing material described in Clause 4.

As described in Annex A, the cylindrical shaped bush is installed between the shaft and the housing so that two oil films are formed. Taking account of the productivity, the bush is usually machined down from cast round bar material.

There are two types of thrust bearings whose shapes are flat plate. One has two bearing alloy surfaces on both sliding plate surfaces, and another has one bearing alloy surface. The material of the bearing is cast solid alloy or sintered solid alloy. Multi layered sintered alloys with a steel backing are also used for thrust bearings to increase the strength of the bearing. From the viewpoint of the strength, a steel bearing that is surface treated in order to improve the wear resistance, such as soft nitriding, is used as well.

From the viewpoint of seizure resistance and wear resistance, bronze (CuSn alloy) is appropriate for bearing material. If higher chemical corrosion resistance is required, brass (Cu-Zn alloy) is selected.

Bronze is used with the addition of Pb to improve the seizure resistance. The strength of bronze matrix is enhanced to improve the seizure resistance and the wear resistance.

Brass is used with the addition of Pb to improve the seizure resistance too. Brass is also used with the addition of hard particles such as MnSi, and accordingly the strength of brass matrix is enhanced to improve the seizure resistance and the wear resistance. To improve the chemical corrosion resistance, it is applicable with increased Zn.

In place of environmentally hazardous Pb, new materials including Bi or materials excluding both Pb and Bi are expanding.

As an example, Table 1 shows the chemical compositions and characteristics of major bearing materials that are currently in use. The characteristics in these tables are typical guidelines and are changeable in response to the operating conditions.

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

Chemical composition (mass fraction, in %)					
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	superior	poor	good	poor
Wear resistance	good	superior	good	good	good
Corrosion resistance	poor	superior	superior	poor	superior

[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:

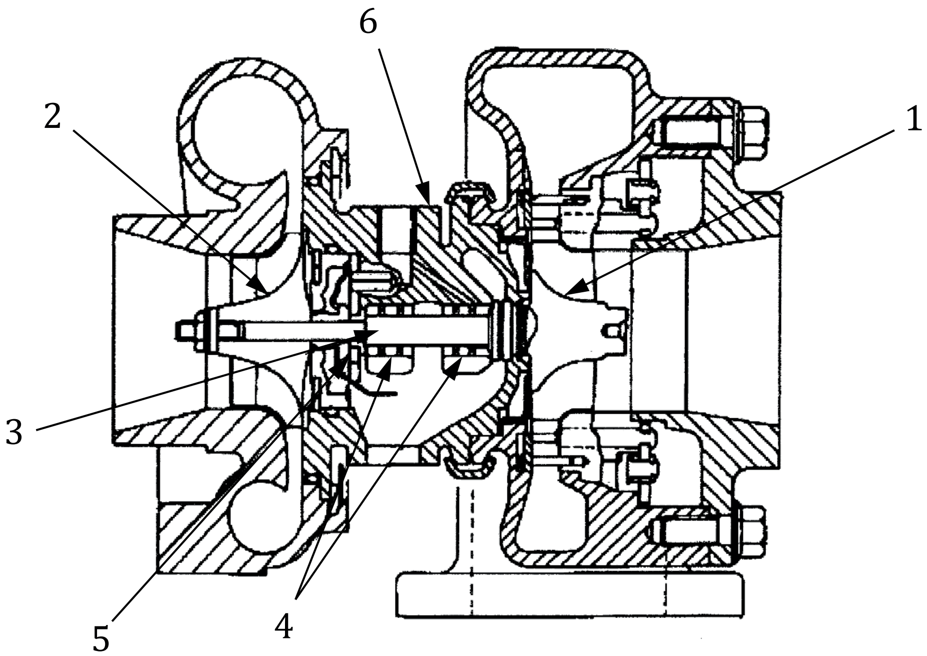
— a turbine that transforms the engine exhaust gas energy to the rotational energy of the shaft,

— 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 (Figure A.2), which support the shaft in the radial direction, and thrust bearings (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

