INTERNATIONAL STANDARD

ISO 7146-2

Second edition
2019-05

Plain bearings — Appearance and characterization of damage to metallic hydrodynamic bearings —

Part 2: Cavitation erosion and its countermeasures

Paliers lisses — Aspect et caractérisation de l'endommagement des paliers métalliques à couche lubrifiante fluide —

Partie 2: Érosion de cavitation et sa contre-mesure

Reference number
ISO 7146-2:2019(E)

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Published 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.

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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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 2, *Materials and lubricants, their properties, characteristics, test methods and testing conditions*.

This second edition cancels and replaces the first edition (ISO 7146-2:2008), of which it constitutes a minor revision. The changes compared to the previous edition are as follows:

— Adjustment to the ISO Directives, including the replacement of "may" with "can" throughout.

A list of all parts in the ISO 7146 series can be found on the ISO website.

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.

Introduction

In practice, damage to a bearing can often be the result of several mechanisms operating simultaneously. The damage can result from improper assembly or maintenance or from faulty manufacture of the bearing, its housing or the counterface against which it operates. In some instances, damage can be caused by a design compromise made in the interests of economy or from unforeseen operating conditions. It is the complex combination of design, manufacture, assembly, operation, maintenance and possible reconditioning which often causes difficulty in establishing the primary cause of damage.

In the event of extensive damage or destruction of the bearing, the evidence is likely to be lost, in which case it is impossible to identify how the damage came about.

In all cases, knowledge of the actual operating conditions of the assembly and the maintenance history is of the utmost importance.

The classification of bearing damage established in this document is based primarily upon the features visible on the running surfaces and elsewhere, and consideration of each aspect is needed for reliable determination of the cause of bearing damage.

Since more than one process can cause similar effects on the running surface, a description of appearance alone is occasionally inadequate in determining the cause of damage. In such cases, the operating conditions need to be considered.

Cavitation erosion dealt with in ISO 7146-1 is treated in this document in more detail.

Plain bearings — Appearance and characterization of damage to metallic hydrodynamic bearings —

Part 2: Cavitation erosion and its countermeasures

1 Scope

This document defines, describes and classifies the characteristics of damage occurring in service in hydrodynamically lubricated metallic plain bearings due to cavitation erosion, together with possible countermeasures. It assists in understanding the various characteristic forms of damage which can occur.

Consideration is restricted to damage which has a well-defined appearance and which can be attributed to particular causes with a high degree of certainty. Various appearances are illustrated with photographs and diagrams.

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*

ISO 4378-3, *Plain bearings — Terms, definitions, classification and symbols — Part 3: Lubrication*

ISO 7146-1, *Plain bearings — Appearance and characterization of damage to metallic hydrodynamic bearings — Part 1: General*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 4378-1, ISO 4378-2, ISO 4378-3, and ISO 7146-1 apply.

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 Cavitation erosion

4.1 Mechanism of cavitation erosion

Cavitation erosion is a form of damage to the surface of a solid body in liquid caused by implosion (violent inward collapse) of cavities or vapour bubbles. When the static pressure in the liquid is decreased under the vapour pressure of the liquid at a given temperature, evaporation occurs and bubbles of vapour are generated in the liquid. This phenomenon is called “cavitation”. When these cavities encounter higher pressure, because they have flowed to a place of higher pressure or the pressure at the place of

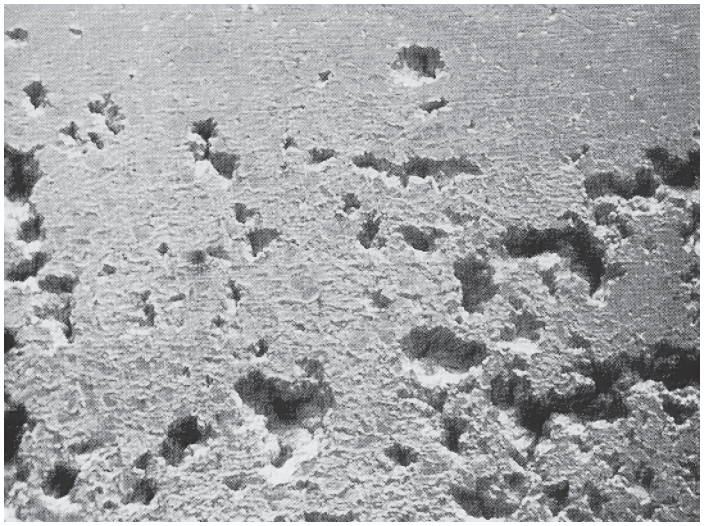
cavitation has increased in the meantime, they condense instantaneously and implode, causing a very high and local pressure and high temperature in the liquid. It can lead, after repeated implosion, to "cavitation erosion" of the surface of the solid body near the place of implosion.

Because of the high intensity of cavity implosion, a chemical reaction called "cavitation corrosion" can take place. The damage can also occur together with "fluid erosion" and "cavitation erosion". A phenomenon known as the "micro-Diesel effect", where the imploding cavities release electrical charge, is also detected in plain bearing oil.

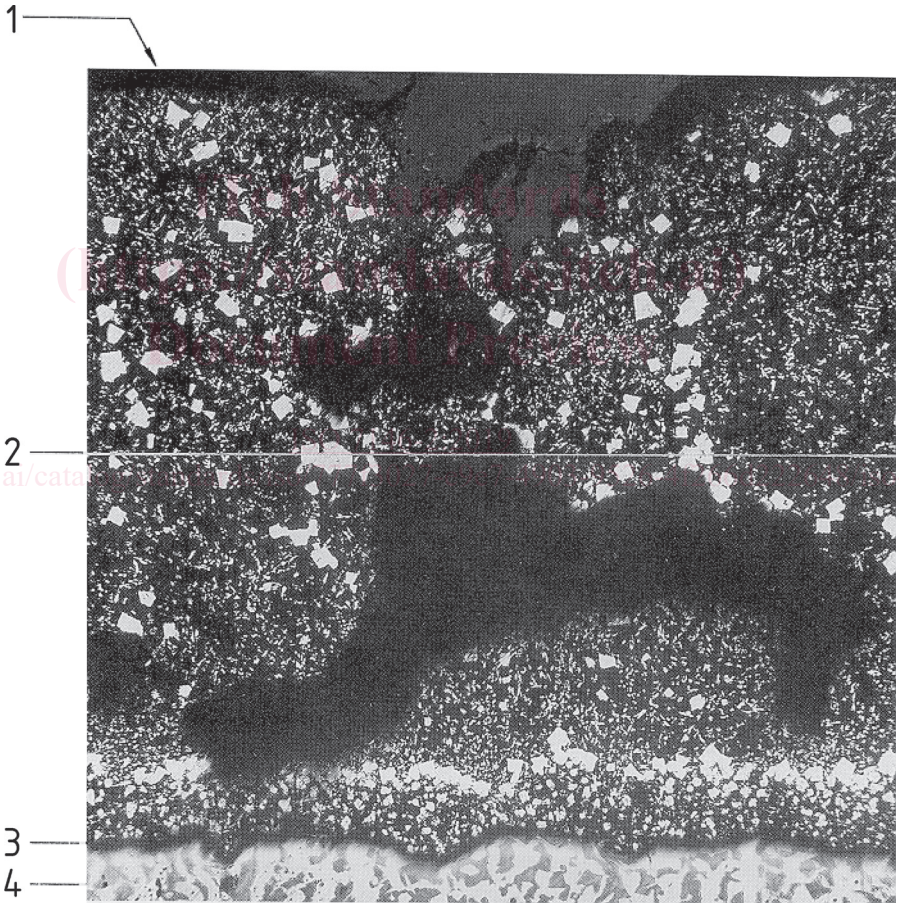
When a bearing surface is eroded by cavitation, the colour of the surface changes slightly due to roughening. Then small pores form, and cracks initiate on the surface, especially at grain boundaries. These cracks with sharp edges are spread first on the surface and then deepen according to the properties of the underlying material (see Figure 1). The cracks are joined together leading to break-out and wash-away of small particles of bearing materials.

When the damage is caused solely by collapsing cavities, the attacked areas show a rough texture. Metallurgical section often shows signs of local work-hardening and fatigue cracking due to hammer blows caused by cavity collapse. But if particles are trapped in the damage pockets, the surface can be eroded and exhibits a smooth and polished appearance. The place of cavitation erosion is usually limited locally and spreads seldom to a broader region. The cavitation erosion usually appears in the unloaded areas of the bearing.

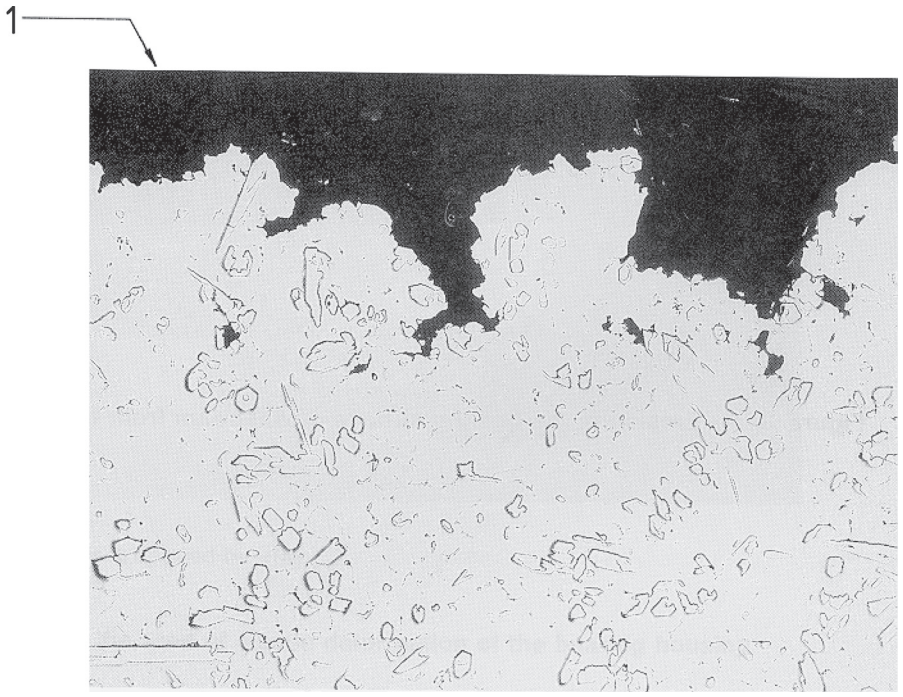
The occurrence of cavitation erosion depends on many factors as follows: journal speed, specific bearing load, dynamic load pattern (especially time rate of load variation), motion of journal center, bearing vibration, bearing clearance, size and geometry of bearing clearance space, edge form and location of oil hole, groove and pocket, existence and position of the drilling in journal, bearing material, especially its hardness, elastic modulus, toughness, fatigue strength and corrosion resistance, oil supply pressure, oil constituent and its vapor pressure, oil viscosity, oil temperature, air and water content and contamination of oil, etc.



a) View under magnification



b) Cross-section under magnification



c) Cross-section under higher magnification

Key

1	sliding surface	3	bonding area
2	bearing metal (tin-based)	4	steel backing

Figure 1 — Sliding surface with cavitation erosion

4.2 Classification of cavitation erosion

Though cavitation erosion occurs in plain bearings of various machines, that in bearings of internal combustion engines has been studied most intensively and has attracted increasing attention as engine performance has increased. For engine bearings, cavitation erosion has been classified into types 1 to 4 by the mechanism of cavity creation. However, this classification may also be applied to other kinds of machines, provided that the characteristic flow conditions are similar. Examples of characteristic appearances and mechanisms of four types of cavitation erosion in journal bearings are given in Figures 2 and 3. Besides these four types, there are some kinds of cavitation erosion which are not always easy to identify. These are classified as type 5, miscellaneous. (See Table 1.)

Table 1 — Cavitation erosion classification

Type number	Cavitation erosion classification
1	Flow
2	Impact
3	Suction
4	Discharge
5	Miscellaneous

Types 1 and 2 take place under both static and dynamic bearing loads, whereas types 3 and 4 only under dynamic bearing load.