INTERNATIONAL STANDARD

ISO 7146-2

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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

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 7146-2 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 first edition of ISO 7146-2, together with ISO 7146-1, cancels and replaces ISO 7146:1993 the technical content of which has been technically revised and augmented.

ISO 7146 consists of the following parts, under the general title *Plain bearings — Appearance and characterization of damage to metallic hydrodynamic bearings*:

— *Part 1: General*

— *Part 2: Cavitation erosion and its countermeasures*

Introduction

In practice, damage to a bearing may often be the result of several mechanisms operating simultaneously. The damage may 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 may 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, and it will then be 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 International Standard is based primarily upon the features visible on the running surfaces and elsewhere, and consideration of each aspect is required for reliable determination of the cause of bearing damage.

Since more than one process may 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 have to be considered.

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

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

Part 2: Cavitation erosion and its countermeasures

1 Scope

This part of ISO 7146 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 may 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 referenced documents are indispensable for the application 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.

4 Cavitation erosion

4.1 Mechanism of cavitation erosion

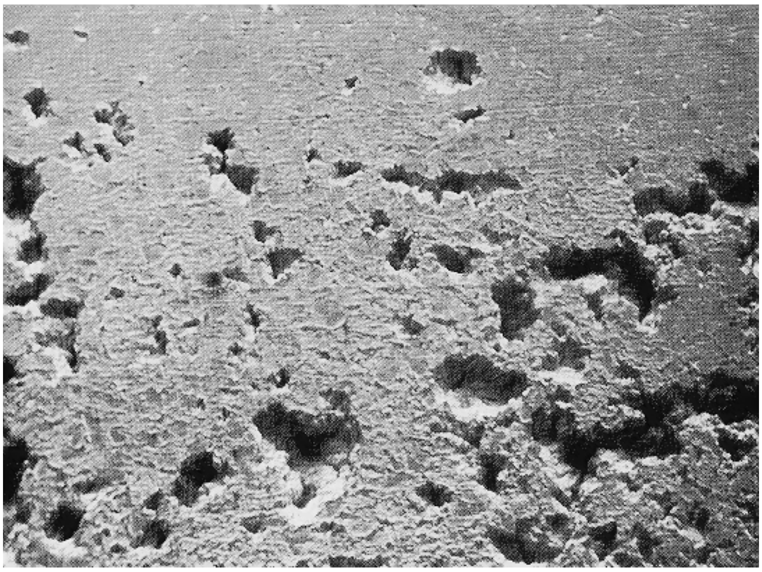
Cavitation erosion is a form of damage to the surface of a solid body in liquid caused by implosion (violent inward collapse) of cavities or vapour bubbles. When the static pressure in the liquid is decreased under the vapour pressure of the liquid at a given temperature, evaporation occurs and bubbles 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, chemical reaction “cavitation corrosion” can take place. The damage may also occur together with “fluid erosion” and “cavitation corrosion”. A phenomenon known as the “micro-Diesel-effect”, where the imploding cavities release electrical charge, is also detected in plain bearing oil.

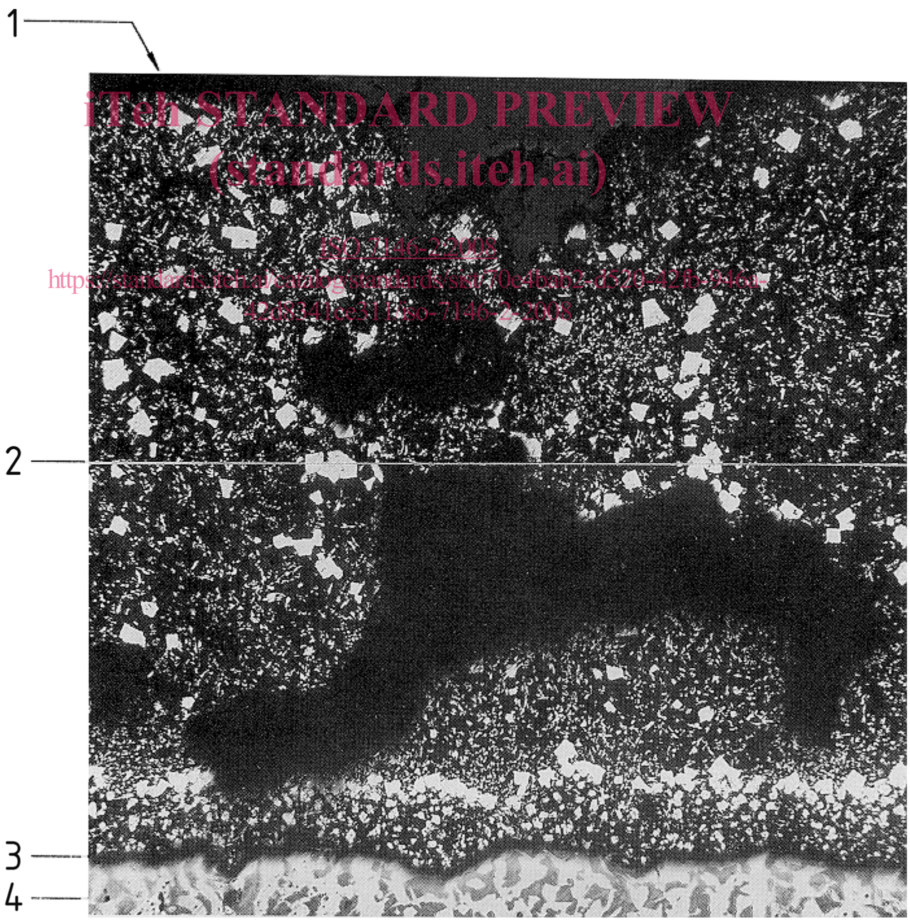
When a bearing surface is eroded by cavitation, first the colour of the surface changes slightly due to roughening. Then small pores form, and cracks initiate on the surface, especially at grain boundaries. These cracks with sharp edges are spread first on the surface and then deepen according to the 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 given in the following: 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

Key

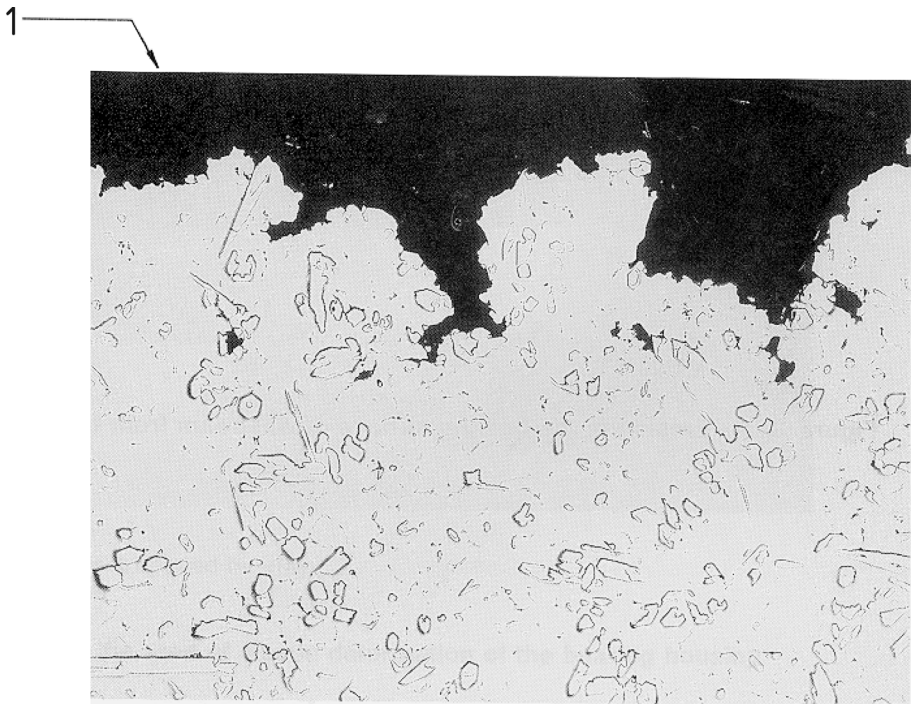
1 sliding surface

2 bearing metal (tin-based)

3 bonding area

4 steel backing

Figure 1 (*continued*)



c) cross-section under higher magnification

Key

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

Figure 1 — Sliding surface with cavitation erosion

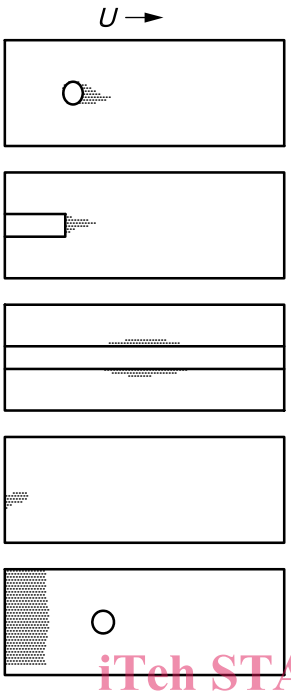
4.2 Classification of cavitation erosion

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 may not always be easy to identify. These are classified as type 5, miscellaneous. (See Table 1.)

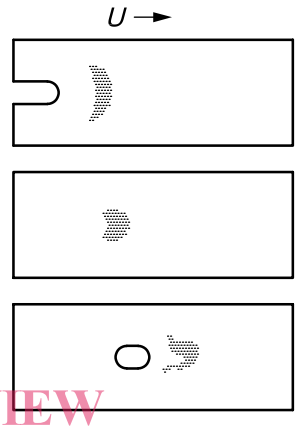
Table 1 — Cavitation erosion classification

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

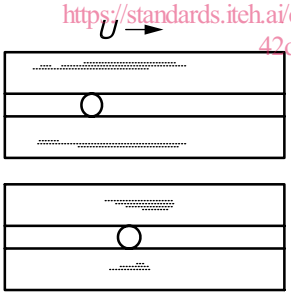
Types 1 and 2 take place both under static and dynamic bearing load, whereas types 3 and 4 only under dynamic bearing load.



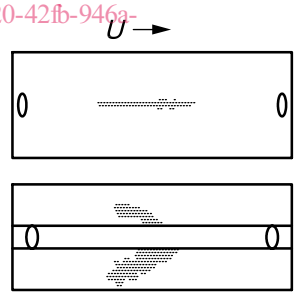
a) cavitation erosion type 1: flow



b) cavitation erosion type 2: impact



c) cavitation erosion type 3: suction



d) cavitation erosion type 4: discharge

Key

U direction of journal rotation

Figure 2 — Examples of the characteristic appearance of four types of cavitation erosion in journal bearings