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Rolling bearings — Damage and failures — Terms, characteristics and causes

Roulements — Détérioration et défaillance — Termes, caractéristiques et causes

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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 15243 was prepared by Technical Committee ISO/TC 4, *Rolling bearings*.

Introduction

In practice, damage or failure of a bearing can often be the result of several mechanisms operating simultaneously. The failure can result from improper assembly or maintenance or from faulty manufacture of the bearing or its adjacent parts. In some instances, failure is due to a design compromise made in the interests of economy or from unforeseen operating conditions. It is the complex combination of design, manufacture, assembly, operation and maintenance that often causes difficulty in establishing the primary cause of failure.

In the event of extensive damage to or catastrophic failure of the bearing, the evidence is likely to be lost and it will then be impossible to identify the primary cause of failure. 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 failure established in this International Standard is based primarily upon the features visible on rolling element contact surfaces and other functional surfaces. Consideration of each feature is required for reliable determination of the cause of bearing failure. Since more than one process may cause similar effects to these surfaces, a description of appearance alone is occasionally inadequate for determining the reason for the failure. In such cases, the operating conditions must be considered.

Rolling bearings — Damage and failures — Terms, characteristics and causes

1 Scope

This International Standard defines, describes and classifies the characteristics, changes in appearance and possible causes of failure of rolling bearings occurring in service. It will assist in the understanding of the various forms of change in appearance and the failure that has occurred.

For the purposes of this International Standard the term “failure of rolling bearings” means the result of a defect or damage that prevents the bearing meeting the intended design performance.

Consideration is restricted to characteristic forms of change in appearance and failure, which have a well-defined appearance and which can be attributed to particular causes with a high degree of certainty. The features of particular interest for explaining changes and failures are described. The various forms are illustrated with photographs and diagrams, and the most frequent causes are indicated.

The failure mode designations shown in the subclause titles are recommended for general use, but similar expressions or synonyms are given within parentheses below the titles.

Examples of rolling bearing failures are given in Annex A, together with a description of the causes of failure and proposed corrective actions.

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 5593:1997, *Rolling bearings — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 5593 and the following apply.

3.1
characteristics
visual appearance resulting from service performance

NOTE Surface defects and types of geometrical change that occur during wear (appearance of wear) are partly defined in ISO 6601 and ISO 8785.

4 Classification of failure modes occurring in rolling bearings

Rolling bearing failures are classified strictly according to their primary causes. However, it is not always easy to distinguish between causes and characteristics (symptoms) or, in other words, between failure mechanisms and failure modes. The large number of articles and books written on the subject confirms this (see Bibliography).

The evolution of tribological research during recent decades has led to a remarkable increase of new knowledge describing failure mechanisms and failure modes. In this International Standard, failure modes are classified in six main groups and various sub-groups (see Figure 1).

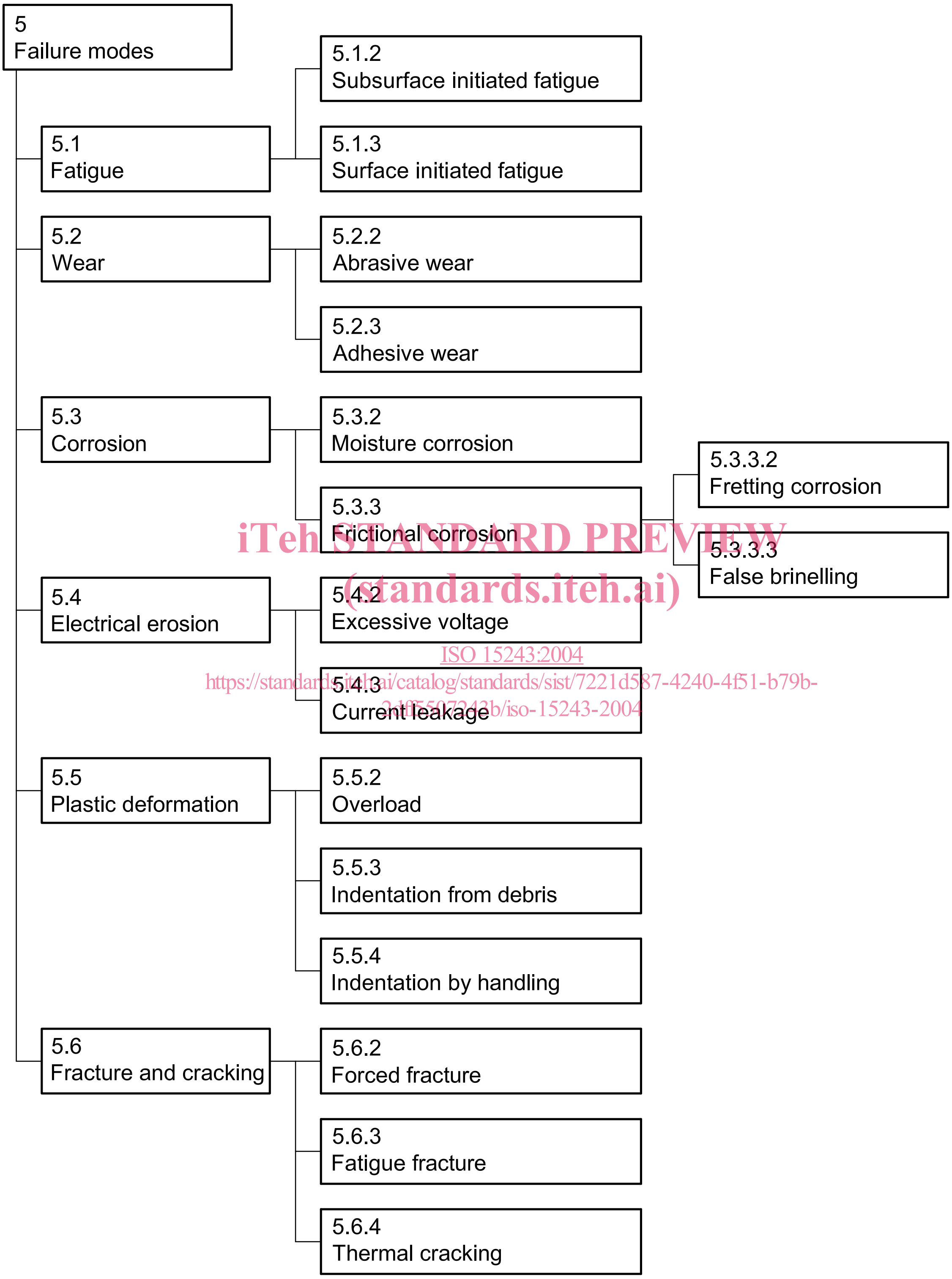

Figure 1 — Classification of failure modes

5 Failure modes

5.1 Fatigue

5.1.1 General definition

The change in the structure, which is caused by the repeated stresses developed in the contacts between the rolling elements and the raceways, is described as fatigue. Fatigue is manifested visibly as a flaking of particles from the surface.

5.1.2 Subsurface initiated fatigue

Under the influence of loads in rolling contacts, described by the Hertzian Theory, structural changes will occur and microcracks will be initiated at a certain depth under the surface, i.e. subsurface. The initiation of the microcracks is often caused by inclusions in the bearing steel (see Figure 2). The microcracks, which are observed at the edge of the white etched areas (butterflies), will normally propagate to the rolling contact surface producing flaking, spalling (pitting) and then peeling (see Figure 3).

NOTE The bearing life calculation in accordance with ISO 281 and ISO 281/Amd. 2 is based on subsurface initiated fatigue.

5.1.3 Surface initiated fatigue

Fatigue initiated from the surface is, among other things, caused by surface distress.

Surface distress is the damage to the rolling contact metal surface asperities under a reduced lubrication regime and a certain percentage of sliding motion, causing the formation of

— asperity microcracks, see Figure 4;

— asperity microspalls, see Figure 5;

— microspalled areas (grey stained), see Figure 6.

Indentations in the raceways caused either by contaminant particles or by handling can also lead to surface initiated fatigue (see 5.5.3 and 5.5.4). Surface initiated fatigue caused by indentation arising from plastic deformation is shown in A.2.6.1 and A.2.6.3.

NOTE ISO 281/Amd. 2 includes surface related calculation parameters that are known to have an influence on the bearing life, such as material, lubrication, environment, contaminant particles and bearing load.

Figure 2 — Subsurface microcrack with the “butterfly phenomenon” (white etched area) (Scale 500:1)

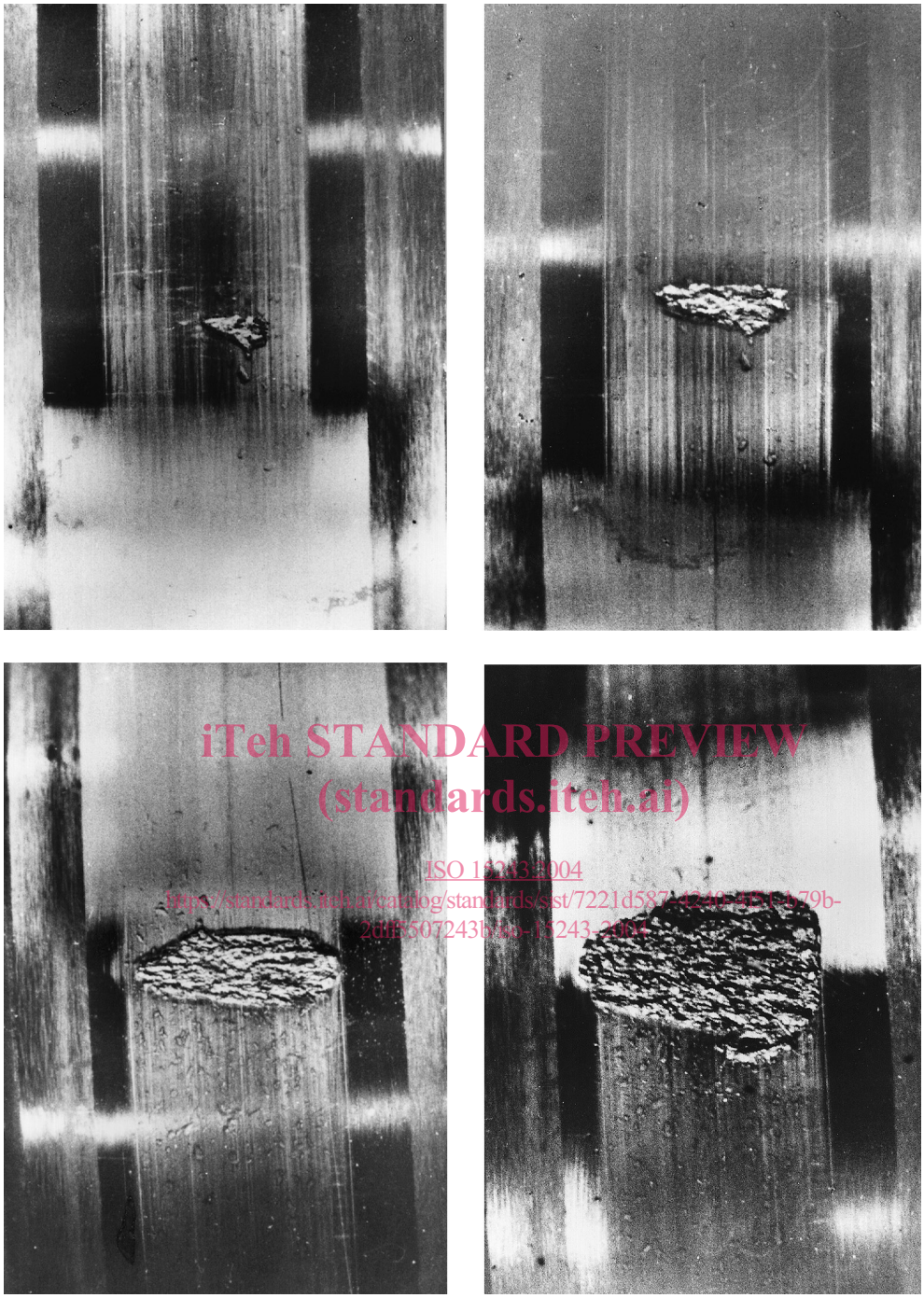

Figure 3 — Progression of subsurface fatigue

5.2 Wear

5.2.1 General definition

Wear is the progressive removal of material resulting from the interaction of the asperities of two sliding or rolling/sliding contacting surfaces during service.

5.2.2 Abrasive wear
(particle wear; three body wear)

Abrasive wear is the result of inadequate lubrication or the ingress of foreign particles. The surfaces become dull to a degree, which varies according to the coarseness and nature of the abrasive particles (see Figure 7). These particles gradually increase in number as material is worn away from the running surfaces and cage. Finally, the wear becomes an accelerating process that results in a failed bearing.

NOTE The "running-in" of a rolling bearing is a natural short process after which the running behaviour, e.g. noise or operating temperature, stabilizes or even improves.

5.2.3 Adhesive wear
(smearing; skidding; galling)

Adhesive wear is a transfer of material from one surface to another with frictional heating and, sometimes, tempering or rehardening of the surface. This produces localized stress concentrations with the potential for cracking or flaking of the contact areas.

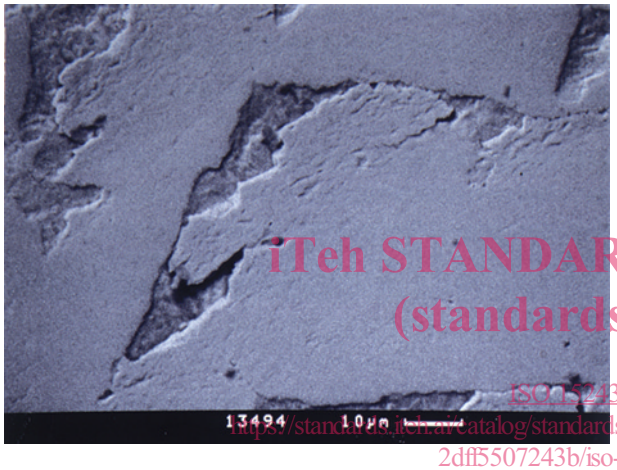

Figure 4 — Microcracks forming a "fish-scale" appearance

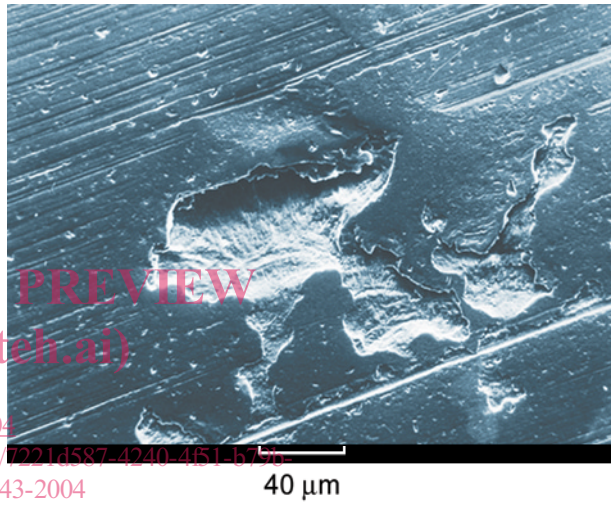

Figure 5 — Microspalls

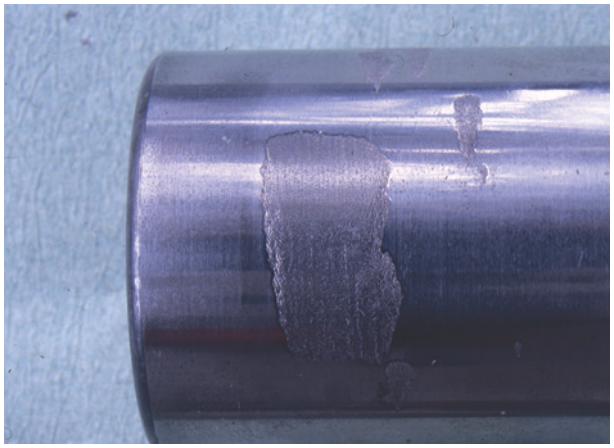

Figure 6 — Heavy grey stained areas
(Scale 1,25:1)

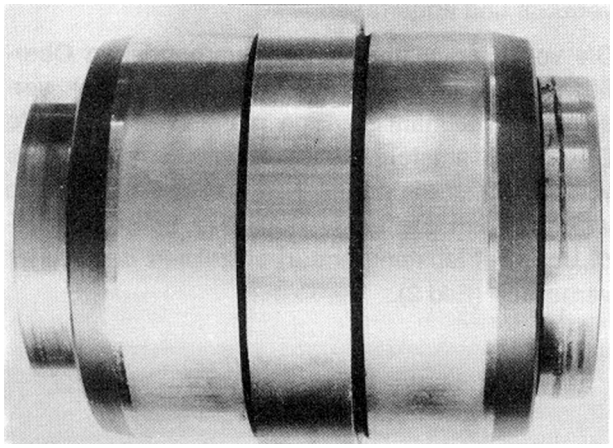

Figure 7 — Abrasive wear on the inner ring raceways of a double-row cylindrical roller bearing with central rib