International Standard

ISO 3643

Rolling bearings — Ceramic rolling elements — Terms and characteristics of surface imperfections

Roulements — Éléments roulants en céramique — Termes et caractéristiques des imperfections de surface

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Foreword

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This document was prepared by Technical Committee ISO/TC 4, *Rolling 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.

Introduction

Surface appearance provides the first impression of quality and gives confidence in product performance and function to the user and customer. The presence of a surface imperfection can have an impact on the actual performance and function.

Ceramic rolling elements are produced in different main steps, which can be realized by the same company or by different companies. Industrial production of ceramic rolling elements, as all manufacturing processes, is subject to a variability coming from materials, process parameters and/or manufacturing steps, which can lead to imperfections on the surface. In addition, handling of parts can also induce some imperfections on the finished surface.

So far, no common vocabulary exists and in industry different words are used to describe surface imperfections of finished ceramic rolling elements for bearing applications. This leads to different interpretations and makes objective comparison difficult.

This document aims to describe imperfections of ceramic finished rolling elements before use. However, some of these imperfections can also be detected on blanks (before machining) or after use.

Imperfections can correspond to:

— material imperfection, which can constitute a defect or not, depending on the morphology of the imperfection (shape, size), on the position on the rolling element and on the requirements of the application; the acceptance limits of the imperfections are defined by customers and/or suppliers, depending on the application;

— local surface imperfection, which corresponds to irregularity on a part of the surface; as for material imperfection, it can correspond or not to a defect depending on characteristics of this imperfection and requirements of the application;

— surface appearance deviation, which is a deviation from the optical appearance of the usual surface pattern or colour.

At the time this document is prepared, visual inspection is the method of choice to identify surface imperfections, in combination or not with dye penetrant inspection (see Annex A and Annex B). Other NDT (non-destructive testing) methods can also be used as a complement, such as acoustic or thermal microscopy, resonant ultrasound spectroscopy or laser spectroscopy to give a few examples.

Inspection of ceramic rolling elements is performed with naked eyes or under small magnification for mass production control. Scanning electron microscope (SEM – see Annex C) is only used to specify the pattern identified by NDT but is not a method suitable with mass production control.

The inspection methods and parameters used for rolling element inspection are subject to agreement between customer and supplier and are not the topic of this document.

Concerning these controls: steel rolling elements are more widespread than ceramic rolling elements. They have some characteristics in common, but methods and parameters of inspection are different.

Rolling bearings — Ceramic rolling elements — Terms and characteristics of surface imperfections

1 Scope

This document establishes terms, descriptions and characteristics and provides typical photos of specified surface imperfections which can be found on finished silicon nitride rolling elements.

Rolling elements refer to balls and rollers. Imperfections defined in this document correspond to patterns found on finished rolling elements before use.

Deviations for the geometric product specifications (GPS) are not addressed in this document.

This document does not give criteria for the acceptance limits of these imperfections. The identification of an imperfection is done between the different actors involved in the manufacturing, assembly or final use of the silicon nitride parts, depending on the technical specifications and the criticality of the application.

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 5593, *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.

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/

3.1
surface imperfection
DEPRECATED: surface defect
element, irregularity or group of elements and irregularities of the real surface unintentionally or accidentally caused during manufacture, storage or use of the surface

Note 1 to entry: See definition of "defect" in ISO 9000.

Note 2 to entry: Such types of elements or irregularities differ considerably from those constituting a rough surface.

Note 3 to entry: The presence of imperfection on the real surface does not necessarily mean that the given surface is unsuitable for use. The acceptability of an imperfection is dependent on the application or function of the surface and is specified in appropriate terms, e.g. length, depth, width, height, number per unit area, etc.

Note 4 to entry: The term "indication" can also be used, as a synonym of imperfection, in the frame of visual inspections. The term "indication" is classically used in non-destructive testing field.

Note 5 to entry: The term "real surface" corresponds to the homogeneous, free from irregularities, finished surface of the component.

[SOURCE: ISO 8785:1998, 2.4, modified — The deprecated term has been added; Note 1 to entry has been modified; Notes 4 and 5 to entry have been added.]

3.2
blank
ceramic rolling element after sintering and/or after hot isostatic pressing (HIP) but before grinding

3.3
characteristic
description of the imperfections in terms of size, shape and aspect by the way it appears by visual inspection under naked eyes or small magnification (<100×)

Note 1 to entry: Information related to the origin of the imperfections can be given.

Note 2 to entry: If the term used to describe the same imperfection is already defined in another standard, it is specified, and comments related to the observation of this imperfection can be added.

Note 3 to entry: If other terms can also be used to describe the same imperfection, they are also named for information.

4 Classification of surface imperfections

Several classifications are possible for ceramic rolling element imperfections, depending on the intended goal. In this document, imperfections are classified in four families based on their optical appearance. The terms and descriptions of these four families are given in Figure 1.

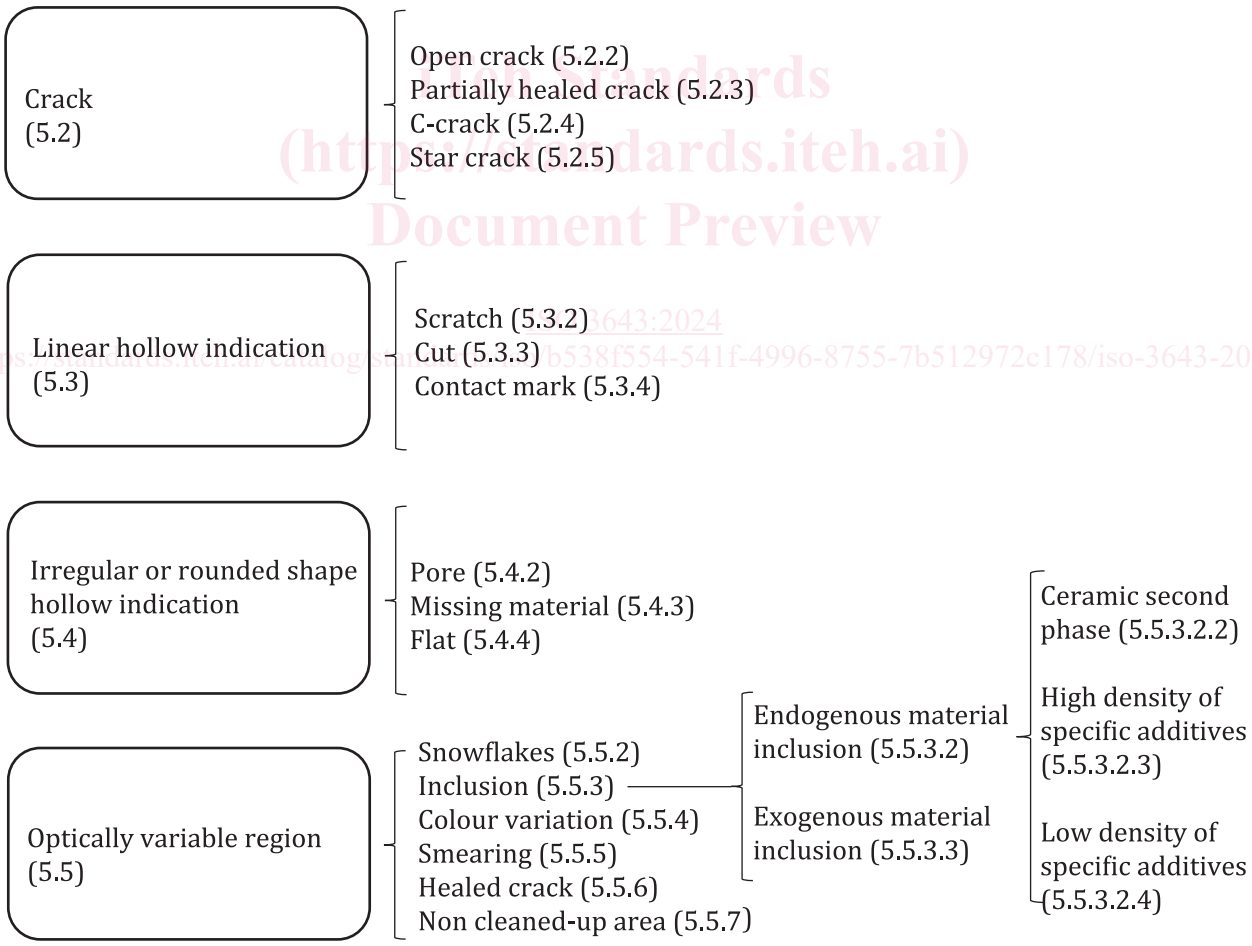


Figure 1 — Families of imperfections

5 Surface imperfections

5.1 General

The following paragraphs give the name, a description of its characteristics and representative pictures of the imperfection at different magnifications. The pictures are obtained by:

— stereo microscope (also known as binocular) and reflected light microscope in bright field [BF] or dark field [DF]; these pictures are named “optical view [BF]” and “optical view [DF]”;

— scanning electronic microscope (SEM) in secondary electrons [SE] or back-scattered electrons [BSE]; these are the pictures named “electronic view [SE]” or “electronic view [BSE]”.

Descriptions of these imaging and illumination methods are described in Annex A and Annex C.

For each imperfection, several pictures of the same type of imperfection are provided to illustrate the different cases which can occur. The pictures are displayed in three types as follows:

a) Type 1 shows a picture taken under optical view BF;

b) Type 2 shows a picture taken under optical view DF;

c) Type 3 shows a picture taken under electronic microscope.

For some terms, there are synonyms used in the field. With the goal of clarifying and homogenising to enable better communication between the different actors of the market, deprecated terms are mentioned in NOTES.

5.2 Crack

5.2.1 General

A crack corresponds to a thin discontinuity in the surface. Its shape is variable and depends on the type of the crack. The bottom of the imperfection is not visible by optical inspection. See Figure 2 to Figure 9.

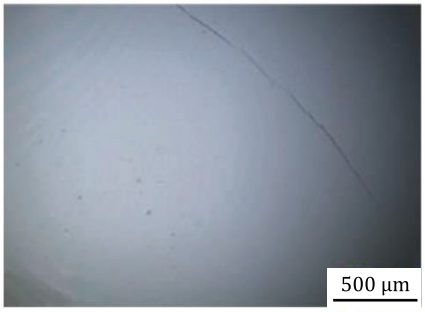
NOTE There are several types of cracks depending on the morphology and the origin of the indication (crack generated during blank manufacturing, during machining or handling).

5.2.2 Open crack

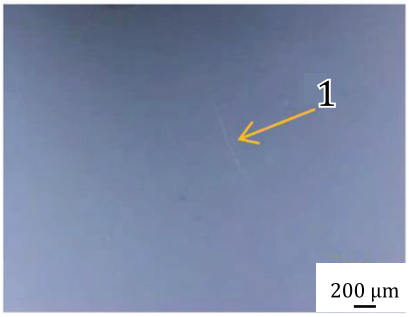
An open crack is an irregular, narrow, opened break in the surface of the element, with straight or jagged edges. A crack can be linear or non-linear.

NOTE 1 Under SEM, Si_3N_4 grains can be visible inside the crack.

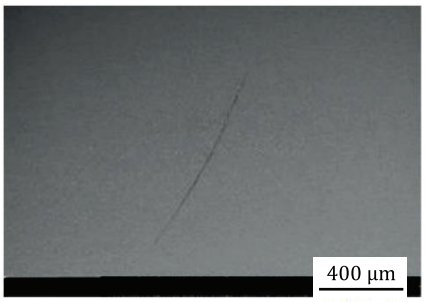
NOTE 2 The deprecated terms for "open crack" are “pressing defects” and “green crack”.



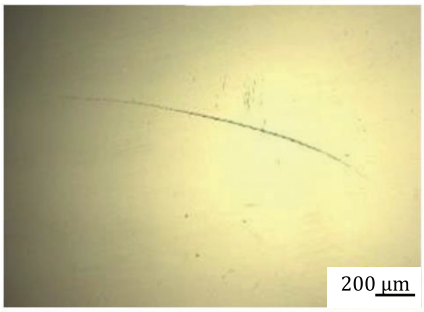
a) Sample 1: surface of a ball – Optical view – [BF]



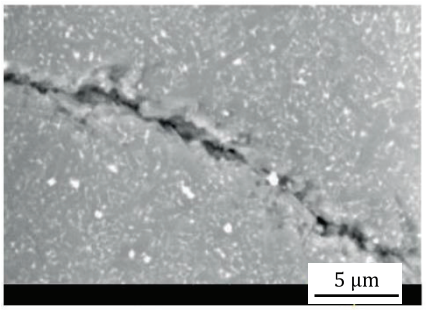
b) Sample 2: surface of a ball – Optical view – [DF]



c) Sample 3: surface of a ball – Electronic view – [BSE]



d) Sample 4: surface of a ball – Optical view – [BF]

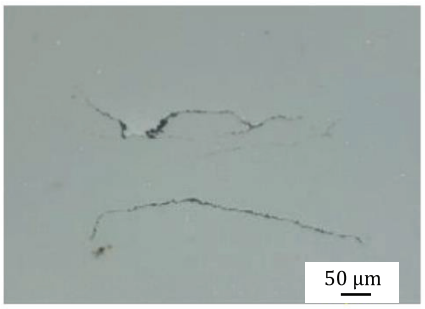


e) Sample 5: surface of a ball (zoom in an open crack) – Electronic view – [BSE]

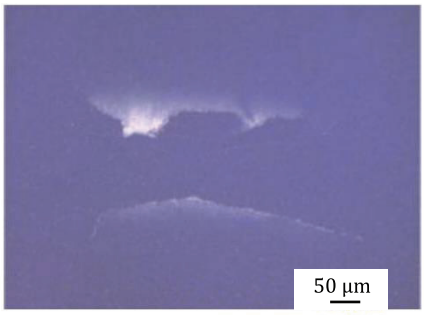
Key

1 open crack without Si_3N_4 grains

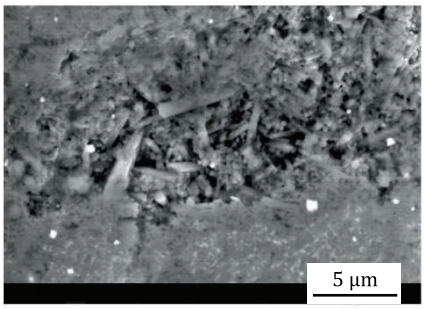
Figure 2 — Examples of open crack without Si_3N_4 grains visible inside the crack



a) Sample 1: surface of a ball – Optical view – [BF]



b) Sample 1: surface of a ball, same as a) – Optical view – [DF]



c) Sample 2: surface of a ball (zoom in an open crack) – Electronic view – [BSE]

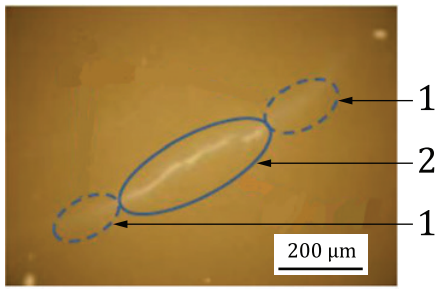
Figure 3 — Examples of open crack with Si_3N_4 grains visible inside the crack

5.2.3 Partially healed crack

A partially healed crack is a mix between open crack (5.2.2) and healed crack (5.5.6). This type of crack can be linear or branched.

NOTE 1 In partially healed crack, sintering additives [oxides of Al (aluminium), Y (yttrium), Mg (magnesium), Ti (titanium)...] can be identified inside the crack with SEM under back-scattered electrons (BSE) detector. In this case, sintering additives appear darker or lighter than the matrix and chemical analysis confirms the nature of the area.

NOTE 2 The deprecated terms for "partially healed crack" are “pressing defects” and “green crack”.



Key

1 healed crack

2 open crack

Figure 4 — Example of partially healed crack (surface of a ball – Optical view – [DF])

5.2.4 C-crack

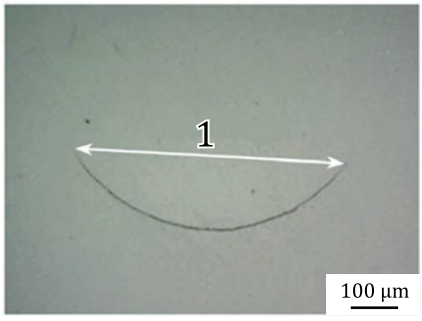
A C-crack is a curved crack, which can be C-shaped or O-shaped when the crack propagation is total. C-cracks can also be stacked. In this case, several concentric C-cracks or O-cracks can be observed.

NOTE 1 Opening of this type of crack is very thin, usually less than 1 µm, which makes them difficult to detect (diffraction on the lips of the crack is needed).

NOTE 2 C-cracks are characterized by the angle of the chord if it is less than 180° or by the diameter for larger chord lengths, as illustrated by Figure 5 a) and Figure 7 a) respectively. For stacked C-crack, the largest is characterized.

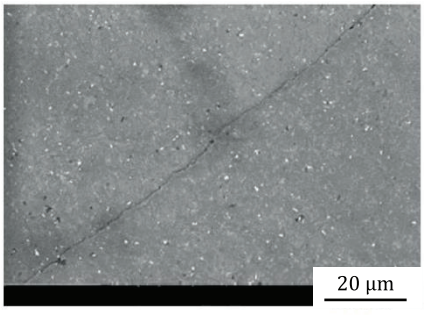
NOTE 3 Under SEM observation, no Si_3N_4 grains are observed inside the crack. Crack propagation occurs in a transgranular and intergranular way.

NOTE 4 Missing material (5.4.3) can be observed with C-crack.



a) Sample 1: surface of a ball – Optical view – [BF]

b) Sample 1: surface of a ball, same as a) – Optical view – [DF]

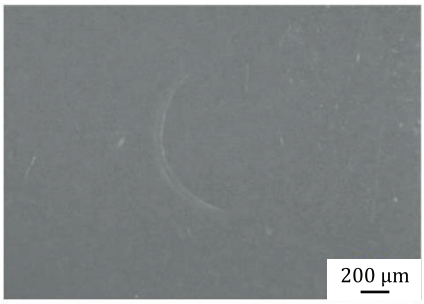


c) Sample 2: surface of a ball (zoom on a C-crack) - Electronic view – [BSE]

Key

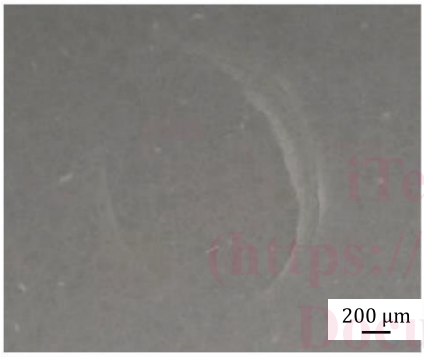
1 chord length

Figure 5 — Examples of C-crack with chordal angle < 180°

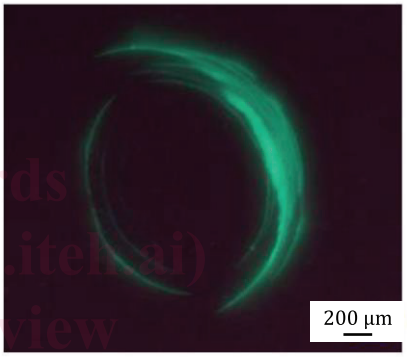


a) Sample 1: surface of a ball – Optical view – [DF] white light

b) Sample 1: surface of a ball, same as a) – Optical view – [DF] UV light

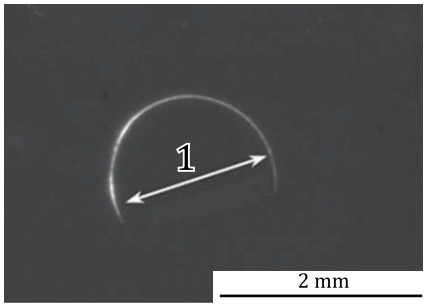


c) Sample 2: surface of a ball (several stacked C-cracks) – Optical view – [DF] white light

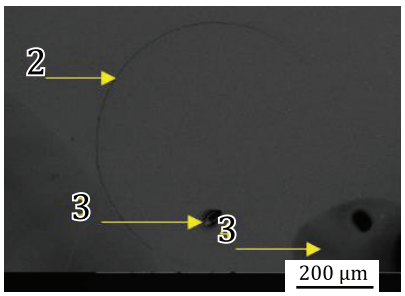


d) Sample 2: surface of a ball, same as c) – Optical view – [DF] UV light

Figure 6 — Examples of stacked C-crack



a) Sample 1: surface of a ball – Optical view – [DF]



b) Sample 2: surface of a ball – Electronic view – [BSE]