
**Fine ceramics (advanced ceramics,
advanced technical ceramics) — Test
method for rolling contact fatigue
of silicon nitride ceramics at room
temperature by balls-on-flat method**

*Céramiques techniques — Méthode d'essai de fatigue de contact
de roulement des céramiques au nitrure de silicium à température
ambiante par la méthode des billes sur surface plane*

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Contents

Page

Foreword	iv
Introduction	v
1 Scope	1
2 Normative references	1
3 Terms and definitions	1
4 Principle	2
5 Testing machine	2
5.1 Structure of testing machine	2
5.2 Loading precision	4
6 Test specimens	4
6.1 Test specimen geometry	4
6.2 Fixation of test specimen	5
6.3 Specimen thickness	5
6.4 Surface finish	5
6.5 Number of test specimens	5
7 Test method	5
7.1 Balls	5
7.2 Loading method	5
7.3 Lubrication	6
7.4 Detection of surface failure	6
8 Treatment of test result	7
8.1 Mean effective load	7
8.2 Mean effective mechanical input	7
8.3 Flaking of ball surface	8
9 Test report	8
Annex A (informative) General information	10
Bibliography	12

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 14628 was prepared by Technical Committee ISO/TC 206, *Fine ceramics*.

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Introduction

Rolling contact fatigue (RCF) performance is essential for predicting the life of a rolling element. In general, RCF performance is evaluated from the life at a specific failure probability obtained by the Weibull analysis of test data under constant loading conditions. This International Standard specifies a fast and reliable method to compare RCF performance under stepwise loading as an alternative to accurate quantification by RCF tests under constant load. Ranking candidate materials, in other words comparison of performance among them, would be of value for choosing materials of required performance for bearings. In addition, material suppliers would receive feedback from the test results, allowing them to achieve a higher level of RCF performance.

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Fine ceramics (advanced ceramics, advanced technical ceramics) — Test method for rolling contact fatigue of silicon nitride ceramics at room temperature by balls-on-flat method

1 Scope

This International Standard specifies a test method for rolling contact fatigue of silicon nitride ceramics under stepwise loading that is carried out at room temperature. This test may be used as follows: relative comparison of the rolling contact fatigue performance, a pass/fail test for material qualification of rolling elements or choosing an appropriate load level for RCF testing under constant load.

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 3290-1:2008, *Rolling bearings — Balls — Part 1: Steel balls*

ISO 3290-2:2008, *Rolling bearings — Balls — Part 2: Ceramic balls*

ISO 3611:2010, *Geometrical product specifications (GPS) — Dimensional measuring equipment: Micrometers for external measurements — Design and metrological characteristics*

ISO 4287:1997, *Geometrical Product Specification (GPS) — Surface texture: Profile method — Terms, definitions and surface texture parameters*

ISO/IEC 17025:2005, *General requirements for the competence of testing and calibration laboratories*.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1

rolling contact

contact between rolling elements

NOTE Under pure rolling contact conditions, the relative velocity at the point of contact is zero. The relative velocity between real rolling elements is not, however, zero in most cases.

3.2

surface failure

flaking of test specimen surface

3.3

rolling contact fatigue

formation of surface failure due to cyclic rolling contact stress well below the stress when surface failure occurs under monotonic loading

3.4

rolling contact fatigue test

test where repeated rolling contact stress is applied to a test specimen, and the number of cycles to surface failure is measured

3.5
stepwise loading
loading method in which load is increased stepwise at regular intervals until the final failure of the test specimen

3.6
contact track
circular trail formed on a test specimen by repeated rolling contact of balls

3.7
mean effective load
constant load equivalent to stepwise loading

3.8
maximum Hertzian stress
maximum contact stress between two bodies using the elastic stress analyzing theory by Hertz

3.9
bearing-grade silicon nitride
silicon nitride ceramics specially designed for rolling elements

4 Principle

The life of flat plate under cyclic rolling contact stress, which is applied by balls rotating unidirectionally thereon, is determined by measuring the number of stress cycles to the final surface failure of the plate.

5 Testing machine

5.1 Structure of testing machine

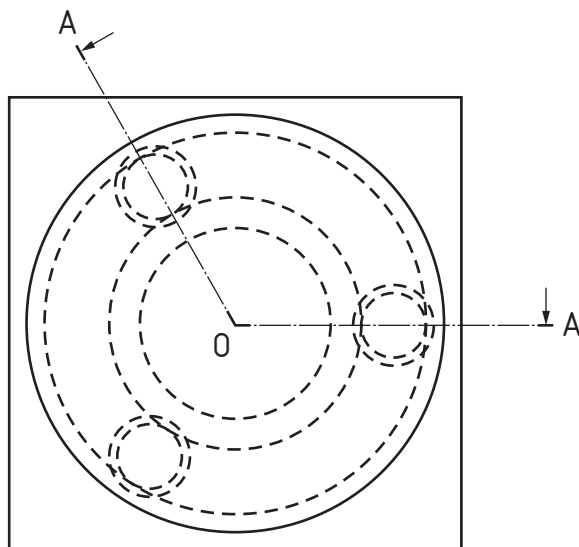
A testing machine shall be so constructed that rolling contact stress can be applied to the surface of a flat plate test specimen by balls thereon equally spaced with a retainer (see Figure 1). The balls shall be rolling in a circle with the rotation of the shaft washer of a 90° contact angle thrust ball bearing of a specified bore diameter. The shaft washer shall be rotated unidirectionally.

The testing machine is shown schematically in Figure 2. Load is applied by dead weights at the end of loading arm.

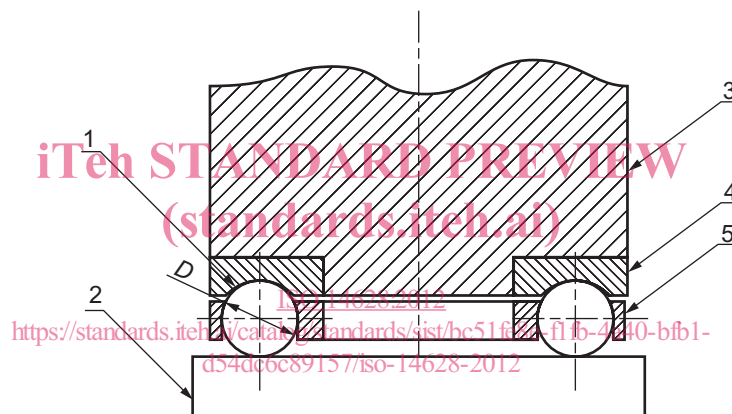
The testing machine shall be equipped with an automatic shutoff with a device detecting the surface failure, an apparatus capable of obtaining the number of rotations until the stop of testing, and a mechanism where its automatic reactivation is prevented when the testing machine is stopped for reasons of power failure or others.

NOTE 1 The shaft washer should be chosen on the basis of diameters of the ball and main shaft of the testing machine.

NOTE 2 The dimensions of the retainer depend on those of the shaft washer, ball diameter and number of balls.



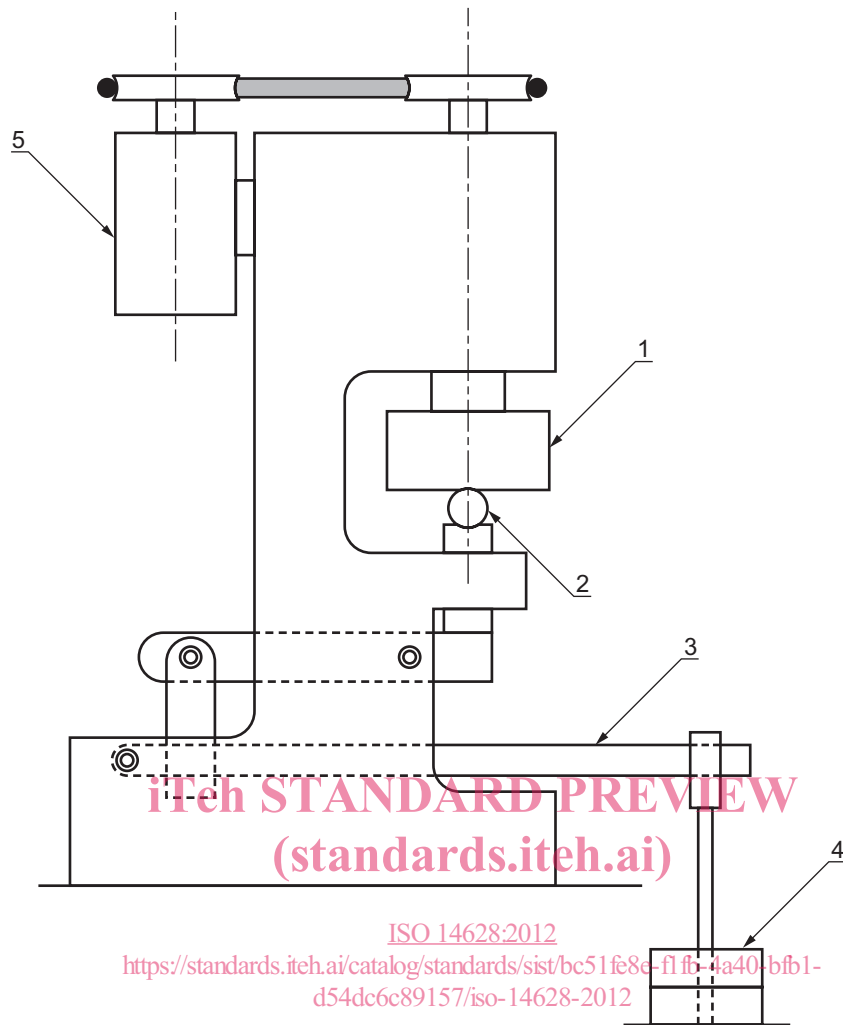
Section A-O-A



Key

- 1 ball of diameter D
- 2 test specimen
- 3 main shaft of a testing machine
- 4 shaft washer of a 90° contact angle thrust bearing
- 5 retainer

Figure 1 — Balls-on-flat configurations



Key

- 1 oil bath (balls-on-flat configurations are inside)
- 2 ball for pivot point to sustain oil bath
- 3 loading lever
- 4 dead weight
- 5 motor

Figure 2 — Schematic of testing machine

5.2 Loading precision

The fluctuation of the test load shall be within $\pm 1\%$ of the chosen value.

NOTE The test load can be applied with a dead weight with accuracy thereof. Usually the load by dead weight(s) is increased with a lever by a specific factor.

6 Test specimens

6.1 Test specimen geometry

The test specimen shall be a flat plate. The parallelism tolerance on opposite surfaces of the plate is 0,015 mm. The use of test specimens having twisting or warpage, which may lead to oscillation of the testing apparatus, is not permitted. The test specimen shall have enough margin outside a contact track to be fixed, as well as to

prevent the effect of the edge of the test specimen on the stress distribution around the point of contact, which may cause chipping of material.

6.2 Fixation of test specimen

The test specimen shall be fixed on the bottom of an oil bath to be immobilized and to prevent oscillation.

Special care should be paid to the surface finish and flatness of the bottom of the oil bath to fix the test specimen firmly thereon.

6.3 Specimen thickness

The specimen shall have enough thickness to prevent flexural oscillation of a plate. The thickness should be measured with a micrometer such as that described in ISO 3611 or alternative-dimension measuring instruments with a resolution of 0,002 mm or finer. If the specimen is measured before the test, measure the thickness at around the central part to avoid unnecessary contact to a prospective contact track.

6.4 Surface finish

The test specimen shall have a ground and polished surface. The roughness shall be 0,1 μm R_a or smaller, as defined in ISO 4287. Subsurface damage during grinding shall be removed by subsequent polishing to eliminate the effect thereof on the test result.

The skewness R_{sk} , as defined in ISO 4287, of the test specimen should also be measured.

NOTE When the R_{sk} exhibits a large positive value, it implies that the measured surface has more convex area than concave. The R_{sk} of a large positive value is not recommended for RCF testing because the test result may be affected by the surface integrity of a test specimen.

6.5 Number of test specimens

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The number of test specimens shall be based on the agreement between the tester and the requester. If a threshold value for a pass/fail test is set, at least five test specimens should be prepared.

7 Test method

7.1 Balls

Balls made of bearing-grade silicon nitride should be used for testing materials for bearing applications. The ball grade of balls should be G5 or G3, as defined in ISO 3290-2. If the purpose of the test is a pass/fail test for material qualification of rolling elements, bearing balls made of steel as defined in ISO 3290-1 may also be used.

Balls shall be in a retainer to keep a fixed spacing.

The ball diameter and number of balls should be agreed between a tester and a requester.

NOTE Three or six balls are commonly used in the balls-on-flat configuration.

7.2 Loading method

The test load shall be applied under the stepwise loading condition where the load is increased stepwise at regular intervals until a final failure as shown schematically in Figure 3. The starting load of the loading step and the loading interval should be agreed between a tester and a requester.

NOTE 1 Some sorts of silicon nitride ceramics may exhibit a sensitivity to loading history. An excessively low starting load may lead to overestimating of rolling contact fatigue performance.

NOTE 2 If the objective of the test is the relative comparison with existing data of tests under constant loading, the test may be conducted under constant load as an alternative.