INTERNATIONAL STANDARD

ISO 19843

First edition
2018-10

Rolling bearings — Ceramic bearing balls — Determination of strength by notched ball test

Roulements — Billes en céramique — Détermination de la résistance par test sur bille rainurée

Reference number
ISO 19843:2018(E)

Contents

Page

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 on 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 the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 4, *Rolling bearings*, Subcommittee SC 12, *Ball 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

To determine the strength of components, specially prepared test pieces are usually produced and then tested in flexure.

The transfer of the values measured on standard ceramic bending test pieces to the original components is possible only in some limited cases.

Since the surface finish of the ceramic balls should not be modified, the notched ball test may be successfully applied as a component test for quality control. Moreover, influences of the manufacturing process and service can be quantified.

This testing method is applicable to process and material development, quality assurance, materials characterization and selection, and the determination of design parameters. The measured strength is determined under the following conditions:

a) linear-elastic material behaviour (stress-strain relation);

b) homogeneous and isotropic material behaviour.

This testing method is intended to be conducted at a laboratory using precise processing equipment, measurement device and testing machine. It is intended to be applied by experienced operators paying considerable attention to notch processing and measurement on notch parameters to perform mechanical testing.

Rolling bearings — Ceramic bearing balls — Determination of strength by notched ball test

1 Scope

This document specifies a method for the determination of the strength of finished ceramic balls for ball bearings, preferably made of silicon nitride (Si_3N_4), with ball diameters from 3 mm to 50 mm.

NOTE 1 ISO 26602 specifies the requirements for preprocessed silicon nitride materials for rolling bearing balls. ISO 3290-2 specifies requirements for finished silicon nitride balls for rolling bearings.

NOTE 2 Other test methods to determine ceramic ball strength can be found in Reference [7].

The results of the strength tests slightly depend on the Poisson's ratio. For this reason, all calculations are restricted to a Poisson's ratio ranging from 0,15 to 0,35. This includes the Poisson's ratio of a typical silicon nitride ceramic used as rolling element in ball bearings.

The method can also be used for rolling bearing balls made of other ceramic materials, but the reported prefactors may not be valid.

NOTE 3 Poisson's ratio of isotropic materials can be determined by one of the methods given in ISO 17561.

Because of the (defect controlled) brittle fracture behaviour of ceramic materials, a significant scatter of individual results in the characterization of a series of nominally identical samples can occur.

NOTE 4 A further statistical analysis according to ISO 20501 can be carried out.

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 463, *Geometrical Product Specifications (GPS) — Dimensional measuring equipment — Design and metrological characteristics of mechanical dial gauges*

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

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

ISO 6106, *Abrasive products — Checking the grain size of superabrasives*

ISO 7500-1:2018, *Metallic materials — Calibration and verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Calibration and verification of the force-measuring system*

ISO 20501, *Fine ceramics (advanced ceramics, advanced technical ceramics) — Weibull statistics for strength data*

3 Terms and definitions

For the purposes of this document, the following terms and definitions 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/

3.1
equatorial plane
plane of symmetry of the ball perpendicular to the loading direction

3.2
fracture force
F
applied force at fracture

3.3
ligament cross section
remaining segment of a circle in the equatorial plane of the notched ball

3.4
ligament thickness
h
maximum thickness of the ligament cross section in the *equatorial plane* (3.1) between the *notch root* (3.13) and the ball surface

Note 1 to entry: See Figure 1 and Figure 2.

3.5
mean notch root radius
R_m
arithmetic average of the *notch root radii* (3.10) R_1 and R_2

3.6
nominal width of the cutting wheel
w_{nom}
width of the cutting tool as declared by the producer

3.7
notch centricity
z
quantifiable value of departure from perfect notch midplane, related to the equatorial plane

Note 1 to entry: Practically, the asymmetry of the notch is determined as the notch centricity *z*; see Figure 2.

3.8
notch depth
l
theoretical depth of the notch

Note 1 to entry: $l = D_w - h$.

Note 2 to entry: See Figure 2.

3.9
notch midplane
imaginary plane through the centre of the real notch perpendicular to the loading direction

Note 1 to entry: See Figure 1 and Figure 2.

3.10
notch root radii
R_1, R_2
radii of the fillet of the *notch root* (3.13)

Note 1 to entry: See Figure 2.

3.11
notched ball
ball with a positioned notch, which is used as the test piece for the notched ball test

Note 1 to entry: See Figure 1.

3.12
notched ball strength
σ_f
theoretical maximum endured fibre stress at the point of the maximum nominal stress at the apex of the *ligament cross section* (3.3) at the time of fracture

Note 1 to entry: See Figure 1. The calculation is performed according to Formula (6).

3.13
notch root
region at the deepest point of the notch

Note 1 to entry: See Figure 1.

3.14
notch width
w
width of the notch, measured at a distance $w_{nom}/2$ away from the *notch root* (3.13)

Note 1 to entry: See Figure 5 and 8.1.

3.15
pole
discrete point of the ball surface where the load is applied

Note 1 to entry: See points B and B´ in Figure 1. The line connecting points B and B' goes through the ball centre and is perpendicular to the notch midplane.

3.16
preload
F_0
force which is applied before the test, in order to fix the test piece in the designated position

3.17
relative notch centricity
ζ
notch centricity (3.7) related to the ball diameter

Note 1 to entry: $\zeta = z/D_w$.

3.18
relative notch depth
λ
notch depth (3.8) related to the ball diameter

Note 1 to entry: $\lambda = l/D_w$.

3.19
relative notch root radius
ρ
mean notch root radius (3.5), related to the *notch width* (3.14)

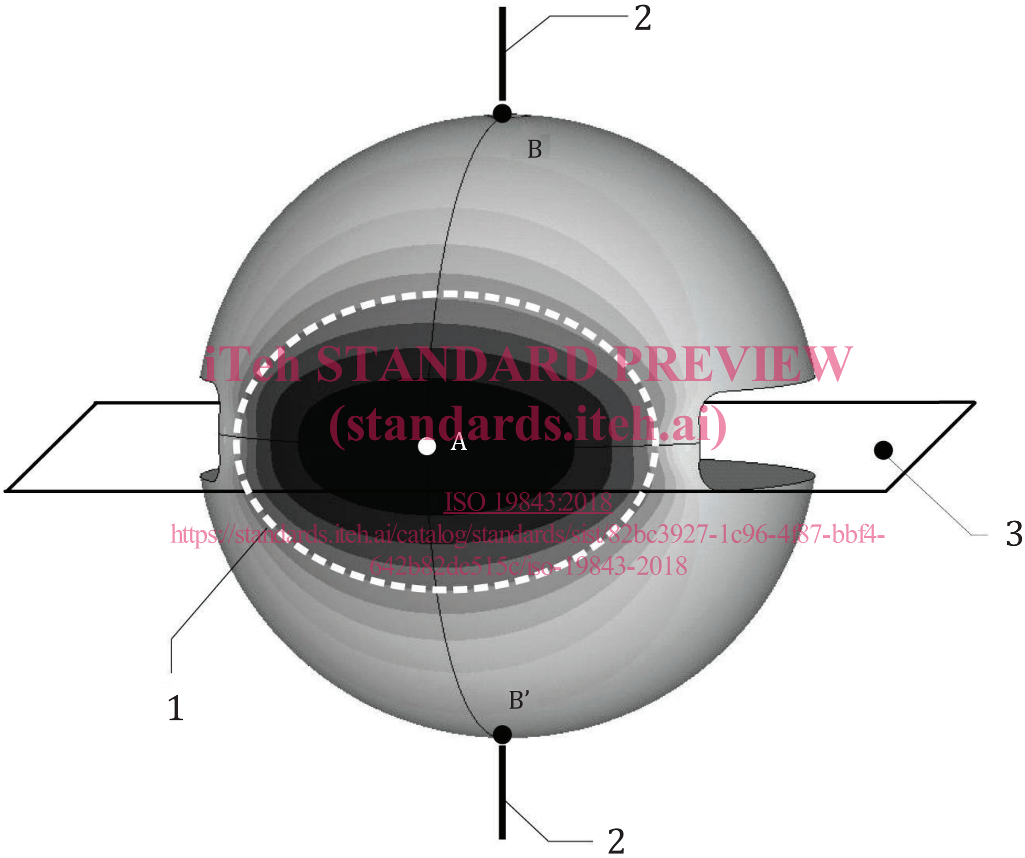
Note 1 to entry: $\rho = R_m/w$.

3.20
relative notch width
ω
notch width (3.14) related to the ball diameter

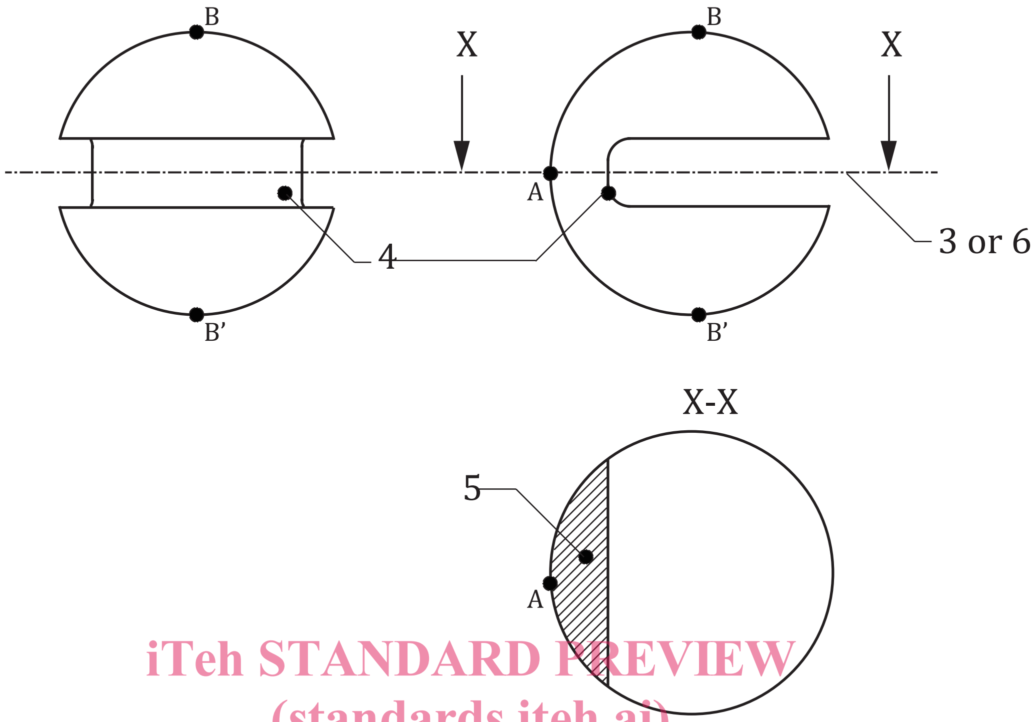
Note 1 to entry: $\omega = w/D_w$.

3.21
test surface
surface area of the *notched ball* (3.11) opposite to the *notch root* (3.13), where the maximum tensile stresses occur during loading

Note 1 to entry: See Figure 1.



a) Volume model illustrated with the stress amplitude



b) Front view, side view and section view (cut)

Key

A point of maximum nominal stress at the apex of the ligament cross section

B, B' points where the load is introduced

t_z tolerance value associated with z

1 test surface

2 loading direction

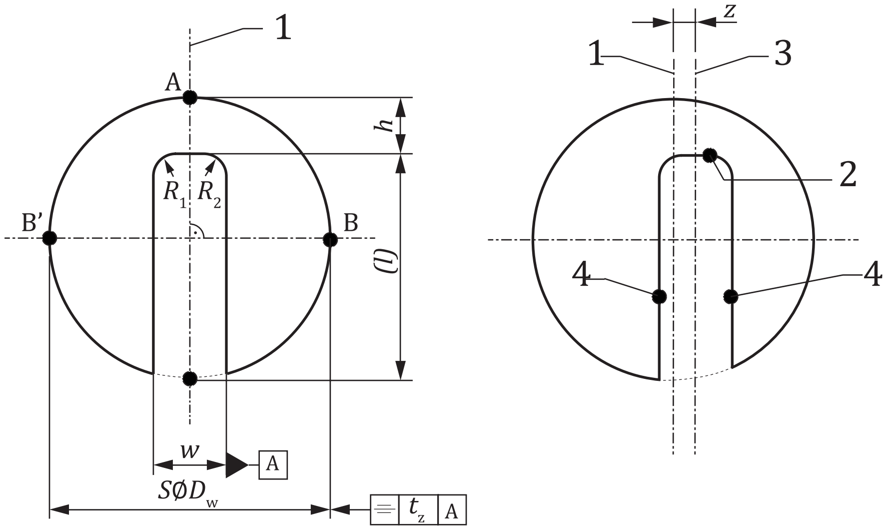
3 equatorial plane

4 notch root

5 ligament cross section

6 notch midplane

Figure 1 — Notched ball test piece



Key

1 equatorial plane

2 notch root

3 notch midplane

4 notch side faces

NOTE See also Figure 1.

Figure 2 — Notch parameter of the notched ball

4 Symbols

See Table 1.

Table 1 — Symbols

Symbol	Unit	Nomenclature
D_w	mm	ball diameter
F	N	fracture force
F_0	N	preload
f	—	prefactor
f_λ	—	correction factor of the notch depth to calculate the reference strength
f_ω	—	correction factor of the notch width to calculate the reference strength
h	mm	ligament thickness
l	mm	notch depth
m	—	Weibull modulus of a batch
n	—	number of test pieces
p_1, p_2	mm	auxiliary distances for the determination of the notch centricity
R_m	mm	mean notch root radius
R_S	mm	radius of the tip of the measuring gauge
R_1, R_2	mm	notch root radii
r_1, r_2	mm	auxiliary distances for the determination of the notch root radii
S_{eff}	mm^2	effective surface
V_{eff}	mm^3	effective volume

Table 1 *(continued)*

Symbol	Unit	Nomenclature
w	mm	notch width
w_{nom}	mm	nominal width of the cutting wheel
w_S	mm	width of the measuring blade
z	mm	notch centricity
ζ	—	relative notch centricity
λ	—	relative notch depth
ν	—	Poisson's ratio
ρ	—	relative notch root radius
σ_f	MPa	notched ball strength
σ_0	MPa	characteristic strength of a batch
σ_{Ref}	MPa	reference strength
ω	—	relative notch width

5 Test description

During test piece preparation, a notch is centrally ground in the equatorial plane of the ball. In the subsequent strength test, a load is applied at the poles of the notched ball via two parallel anvils. The notch faces are squeezed together, whereby tensile stresses are generated on the surface opposite to the notch root. The load is increased uniformly until fracture. From the fracture force, the notched ball strength is calculated.

NOTE 1 The maximum stress is the first principal stress, the direction of which is parallel to the loading direction.

NOTE 2 Further details can be found in References [8], [9] and [11].

NOTE 3 A similar principle using a C-shaped notch is described in Reference [10], which was derived from Reference [5].

6 Equipment and testing devices

6.1 Loading device

The loading device consists of two parallel plates (testing anvils) and shall meet the following requirements.

The contact areas of the testing anvils shall be made of hard metal or of silicon nitride plates with a thickness of at least 10 mm. The material shall be chosen so that no plastic indentations remain on the anvil faces. The anvil surfaces shall be aligned perpendicular to the loading direction [see item 2 in Figure 1 a)]. The loading direction shall be the same as the moving direction of the crosshead of the testing machine. The anvil surfaces shall be smooth and their parallelism shall be designed in order that the anvil surfaces show a difference in the loading direction of less than 0,05 mm related to a transverse length of 50 mm. While loading, the stiffness shall be sufficient to avoid tilting.

The design of the test anvils shall be selected so that the positioning of the test piece is not hindered. An example is shown in Annex D. The points of the load application B and B' shall be axial in line with the anvil, i.e. they shall lie in the centre of the anvil faces. The dimensions of the anvil-surfaces shall be at least the ball diameter.

It shall be ensured that frictional constraints and maladjustments of the test piece are minimized.