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Rolling bearings — Balls —

Part 2: Ceramic balls

Roulements — Billes —

Partie 2: Billes de roulement en céramique

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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 3290-2 was prepared by Technical Committee ISO/TC 4, *Rolling bearings*.

ISO 3290 consists of the following parts, under the general title *Rolling bearings — Balls*:

— *Part 1: Steel balls*

— *Part 2: Ceramic balls*

Rolling bearings — Balls —

Part 2: Ceramic balls

1 Scope

This part of ISO 3290 specifies requirements for finished silicon nitride balls for rolling bearings.

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 1132-1, *Rolling bearings — Tolerances — Part 1: Terms and definitions*

ISO 4288, *Geometrical Product Specifications (GPS) — Surface texture: Profile method — Rules and procedures for the assessment of surface texture*

ISO 5593, *Rolling bearings — Vocabulary*

ISO/TS 12181-1, *Geometrical Product Specifications (GPS) — Roundness — Part 1: Vocabulary and parameters of roundness*

ISO 15241, *Rolling bearings — Symbols for quantities*

ISO 26602:—[1)] *Fine ceramics (advanced ceramics, advanced technical ceramics) — Silicon nitride materials for rolling bearing balls*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 1132-1, ISO 5593 and the following apply.

3.1
nominal ball diameter
diameter value which is used for the general identification of a ball size

[ISO 5593:1997, 05.04.01]

1) To be published.

3.2
single ball diameter
distance between two parallel planes tangential to the actual surface of a ball

[ISO 5593:1997, 05.04.02]

3.3
mean ball diameter
arithmetical mean of the largest and the smallest of the single diameters of a ball

[ISO 5593:1997, 05.04.03]

3.4
variation of ball diameter
difference between the largest and the smallest of the single diameters of a ball

[ISO 5593:1997, 05.04.04]

3.5
deviation from spherical ball surface
various types of deviation from the perfect spherical ball surface, uniformly or non-uniformly distributed and repeated around the ball surface

NOTE The deviations to which limits can be attributed are:

— deviation from spherical form;

— waviness;

— surface roughness;

— surface defect.

3.5.1
deviation from spherical form
radial distance between the smallest circumscribed sphere and the greatest inscribed sphere, with their centres common to the least squares sphere centre

NOTE This definition supersedes ISO 5593:1997, 05.06.03.

3.5.2
waviness
surface irregularities of random or periodical deviation from the ideal spherical form

NOTE 1 Waviness can be evaluated as velocity amplitude by default.

NOTE 2 In practice, the waviness components are separated from the real surface by a waviness analyser (filters).

3.5.3
surface roughness
surface irregularities with relatively small spacings, which usually include irregularities resulting from the method of manufacture being used and/or other influences

NOTE These irregularities are considered within the limits that are conventionally defined, e.g., within the limits of the sampling length.

3.5.4
surface defect
element, irregularity or group of elements and irregularities of the real surface, unintentionally or accidentally caused during manufacture, storage, handling or use of the surface

NOTE 1 These types of element or irregularity differ considerably from those constituting the surface roughness and are not considered during the measurement of the surface roughness.

NOTE 2 The limits for surface defects are not specified in this part of ISO 3290.

3.6
ball lot
definite quantity of balls manufactured under conditions presumed uniform and which is considered as an entity

[ISO 5593:1997, 05.04.05]

3.7
mean diameter of ball lot
arithmetical mean of the mean diameters of the largest ball and the smallest ball in a ball lot

[ISO 5593:1997, 05.04.06]

3.8
variation of ball lot diameter
difference between the mean diameters of the largest ball and the smallest ball in a ball lot

[ISO 5593:1997, 05.04.07]

3.9
ball grade
specific combination of dimensional, form, surface roughness and sorting tolerances for balls

[ISO 5593:1997, 05.04.08]

NOTE Ball grade is identified by the letter G and a number, e.g. G 20.

3.10
ball gauge
amount by which the mean diameter of ball lot should differ from the nominal ball diameter, this amount being one of an established series

[ISO 5593:1997, 05.04.09]

NOTE 1 Each ball gauge is a whole multiple of the ball gauge interval established for the ball grade in question.

NOTE 2 A ball gauge, in combination with the ball grade and nominal diameter, is considered as the most exact ball size specification to be used by a customer for ordering purposes.

3.11
deviation of a ball lot from ball gauge
difference between the mean diameter of a ball lot and the sum of the nominal ball diameter and the ball gauge

[ISO 5593:1997, 05.04.10]

3.12
ball subgauge
amount, of an established series of amounts, which is the nearest to the actual deviation from the ball gauge of a ball lot

[ISO 5593:1997, 05.04.11]

NOTE 1 Each ball subgauge is a whole multiple of the ball subgauge interval established for the ball grade in question.

NOTE 2 The ball subgauge, in combination with the nominal ball diameter and the ball gauge, is used by ball manufacturers to denote the mean diameter of a ball lot and is not generally used by customers for ordering purposes.

3.13
hardness
⟨rolling bearings⟩ measure of resistance to penetration as determined by a specific test method

NOTE For ceramics balls, such a test method is the Vickers hardness test.

4 Symbols

For the purposes of this document, the symbols given in ISO 15241 and the following apply.

The symbols (except those for tolerances) and the values given in Tables 1 to 3 denote nominal dimensions unless specified otherwise.

D_{w} nominal ball diameter

D_{wm} mean ball diameter

D_{wmL} mean diameter of ball lot

D_{ws} single ball diameter

G ball grade

S ball gauge

$V_{D\mathrm{wL}}$ variation of ball lot diameter

$V_{D\mathrm{ws}}$ variation of ball diameter

$\Delta_{R\mathrm{Sw}}$ deviation from spherical form

Δ_S deviation of a ball lot from ball gauge

NOTE $\Delta_S = D_{\mathrm{wmL}} - (D_{\mathrm{w}} + S)$

5 Requirements

5.1 Ball size

The preferred nominal ball diameters are given in Table 1 and, where applicable, the corresponding inch sizes are given for reference purposes only.

5.2 Quality of geometry and surface

Requirements for:

— variation of ball diameter, see Table 2;

— deviation from spherical form, see Table 2;

— waviness, see Note 1;

— surface roughness, see Table 2;

— surface appearance, see Notes 2 and 3.

Measurement of surface roughness shall be carried out in accordance with ISO 4288.

NOTE 1 Limits and measuring methods for waviness are subject to agreement between customer and supplier.

NOTE 2 Local inhomogeneities in colour, densification, pressing defects, snowflakes, etc. and cracks inherent to the material and its processing are subject to agreement between customer and supplier.

NOTE 3 Local defects originating from machining and handling are subject to agreement between customer and supplier.

5.3 Sorting accuracy and ball gauges

Table 3 comprises the applicable values for:

— variation of ball lot diameter;

— gauge interval;

— preferred gauges;

— subgauge interval;

— subgauges.

6 Material

The balls shall be manufactured from silicon nitride material in accordance with ISO 26602:—.

7 Dimensions and tolerances

The preferred nominal ball diameters are given in Table 1. Tolerances for form and surface roughness are given in Table 2. Sorting tolerances and ball gauges are given in Table 3.

Table 1 — Preferred nominal ball diameters

Nominal ball diameter D_w mm	Corresponding inch size (reference) in	Nominal ball diameter D_w mm	Corresponding inch size (reference) in	Nominal ball diameter D_w mm	Corresponding inch size (reference) in
0,3		9,525	3/8	30,162 5	1 3/16
0,396 88	1/64	9,921 88	25/64	31,75	1 1/4
0,4		10		32	
0,5		10,318 75	13/32	33	
0,508	0,02	10,5		33,337 5	1 5/16
0,6		11		34	
0,635	0,025	11,112 5	7/16	34,925	1 3/8
0,68		11,5		35	
0,7		11,509 38	29/64	36	
0,793 75	1/32	11,906 25	15/32	36,512 5	1 7/16
0,8		12		38	
1		12,303 12	31/64	38,1	1 1/2
1,190 62	3/64	12,5		39,687 5	1 9/16
1,2		12,7	1/2	40	
1,5		13		41,275	1 5/8
1,587 5	1/16	13,493 75	17/32	42,862 5	1 11/16
1,984 38	5/64	14		44,45	1 3/4
2		14,287 5	9/16	45	
2,381 25	3/32	15		46,037 5	1 13/16
2,5		15,081 25	19/32	47,625	1 7/8
2,778 12	7/64	15,875	5/8	49,212 5	1 15/16
3		16		50	
3,175	1/8	16,668 75	21/32	50,8	2
3,5		17		53,975	2 1/8
3,571 88	9/64	17,462 5	11/16	55	
3,968 75	5/32	18		57,15	2 1/4
4		18,256 25	23/32		
4,365 62	11/64	19			
4,5		19,05	3/4		
4,762 5	3/16	19,843 75	25/32		
5		20			
5,159 38	13/64	20,5			
5,5		20,637 5	13/16		
5,556 25	7/32	21			
5,953 12	15/64	21,431 25	27/32		
6		22			
6,35	1/4	22,225	7/8		
6,5		22,5			
6,746 88	17/64	23			
7		23,018 75	29/32		
7,143 75	9/32	23,812 5	15/16		
7,5		24			
7,540 62	19/64	24,606 25	31/32		
7,937 5	5/16	25			
8		25,4	1		
8,334 38	21/64	26			
8,5		26,193 75	1 1/32		
8,731 25	11/32	26,987 5	1 1/16		
9		28			
9,128 12	23/64	28,575	1 1/8		
9,5		30			

Table 2 — Form and surface roughness tolerances

Tolerance values in micrometres

Ball grade	Variation of ball diameter [a] V_{Dws} max.	Deviation from spherical form [a] Δ_{RSw} max.	Surface roughness [a] Ra max.
G 3	0,08	0,08	0,01
G 5	0,13	0,13	0,014
G 10	0,25	0,25	0,02
G 16	0,4	0,4	0,025
G 20	0,5	0,5	0,032
G 24	0,6	0,6	0,04
G 28	0,7	0,7	0,05
G 40	1	1	0,06
G 60	1,5	1,5	0,08
G 100	2,5	2,5	0,1

[a] The values do not take into account surface defects; hence measurement shall be taken outside such defects.

Table 3 — Sorting tolerances and ball gauges

Tolerance values in micrometres

Ball grade	Variation of ball lot diameter V_{DwL} max.	Ball gauge interval	Preferred ball gauges	Ball subgauge interval	Ball subgauges
G 3	0,13	0,5	− 5, … − 0,5, 0, + 0,5, .. + 5	0,1	− 0,2, − 0,1, 0, + 0,1, + 0,2
G 5	0,25	1	− 5, … − 1, 0, + 1, …. + 5	0,2	− 0,4, − 0,2, 0, + 0,2, + 0,4
G 10	0,5	1	− 9, … − 1, 0, + 1, ... + 9	0,2	− 0,4, − 0,2, 0, + 0,2, + 0,4
G 16	0,8	2	− 10, .. − 2, 0, + 2, …. + 10	0,4	− 0,8, − 0,4, 0, + 0,4, + 0,8
G 20	1	2	− 10, .. − 2, 0, + 2, …. + 10	0,4	− 0,8, − 0,4, 0, + 0,4, + 0,8
G 24	1,2	2	− 12, .. − 2, 0, + 2, …. + 12	0,4	− 0,8, − 0,4, 0, + 0,4, + 0,8
G 28	1,4	2	− 12, .. − 2, 0, + 2, …. + 12	0,4	− 0,8, − 0,4, 0, + 0,4, + 0,8
G 40	2	4	− 16, .. − 4, 0, + 4, …. + 16	0,8	− 1,6, − 0,8, 0, + 0,8, + 1,6
G 60	3	6	− 18, .. − 6, 0, + 6, …. + 18	1,2	− 2,4, − 1,2, 0, + 1,2, + 2,4
G 100	5	10	− 40, .. − 10, 0, + 10, ... + 40	2	− 4, − 2, 0, + 2, + 4

Annex A
(normative)

Method for assessment of deviation from spherical form

The measurement of deviation from spherical form of a ball shall be carried out by measurement of roundness deviation in three single equatorial planes at about 90° to each other.

The default evaluation method of roundness deviation in a single equatorial plane shall be carried out by calculation from the least squares reference circle in accordance with ISO/TS 12181-1.

The greatest roundness deviation in any of these single equatorial planes is assumed to be the deviation from spherical form.

For a detailed description of methods for the assessment of deviation from roundness, see ISO 4291[1].

If a different evaluation method is used it should be agreed between customer and supplier.

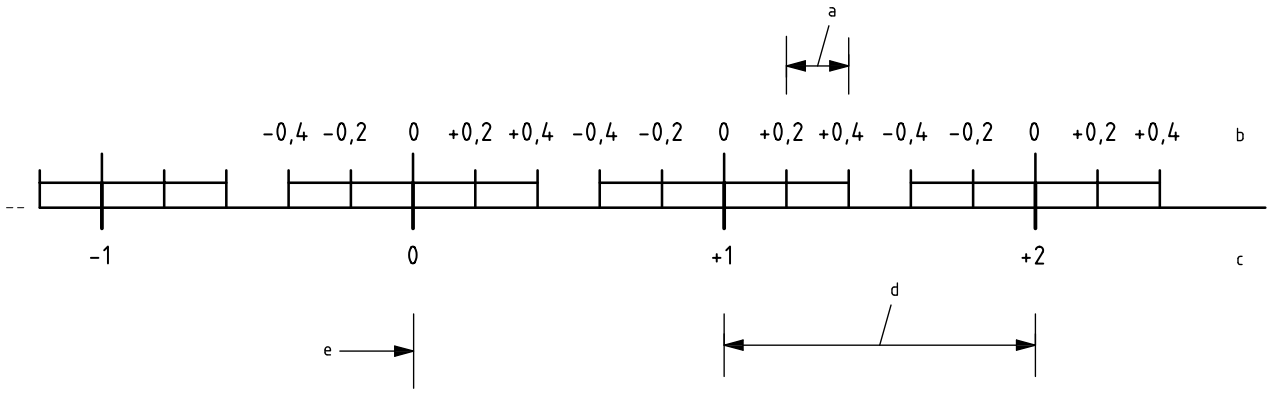
Annex B
(normative)

Illustration of ball gauges and sorting principles

B.1 Ball gauge and ball subgauge

Figure B.1 shows an example of ball gauge and ball subgauge for Grade G 5 balls.

Values in micrometres



Key

a Ball subgauge interval.

b Ball subgauge scale.

c Ball gauge scale.

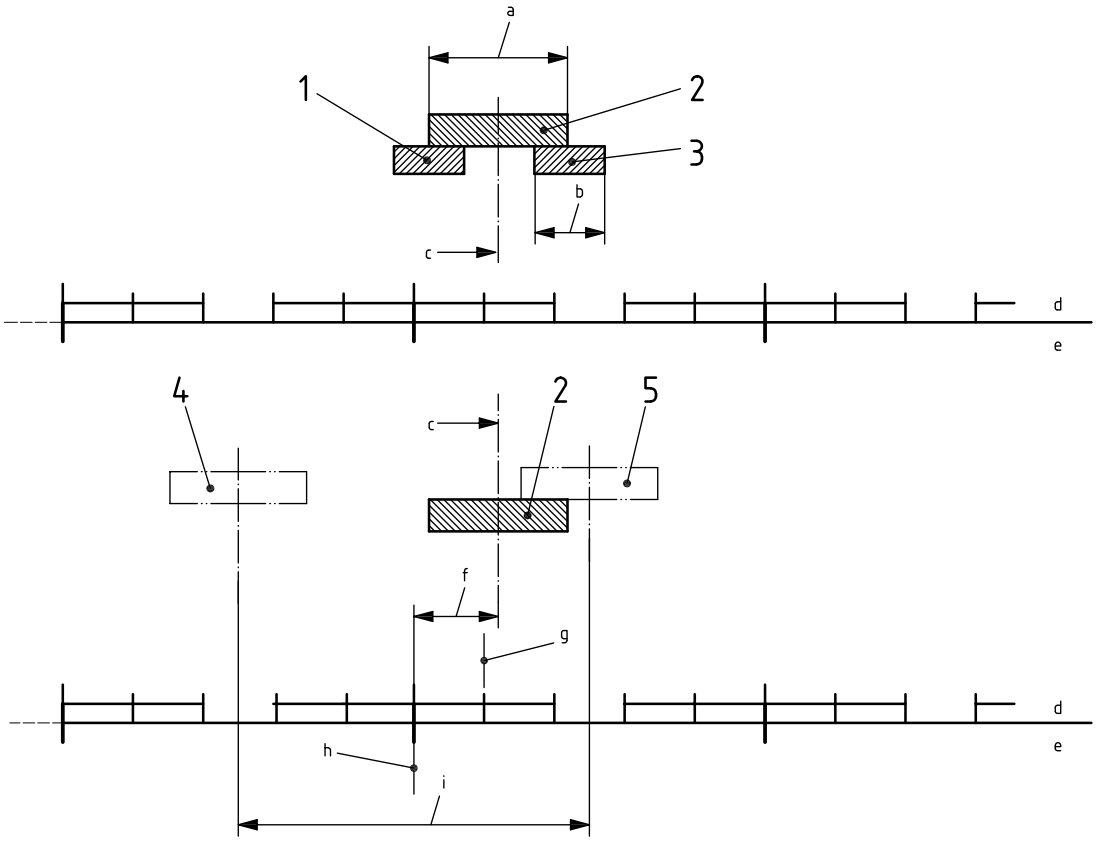
d Ball gauge interval.

e Nominal ball diameter, D_w.

Figure B.1

B.2 Ball lot and ball gauge deviation

Figure B.2 shows the relation between a ball lot and its ball gauge.



Key

1 smallest ball in the ball lot
2 ball lot
3 largest ball in the ball lot
4 ball lot with smallest D_{wmL} to be referred to ball gauge S
5 ball lot with largest D_{wmL} to be referred to ball gauge S

a Variation of ball lot diameter, $V_{D\mathrm{wL}}$.
b Variation of ball diameter, $V_{D\mathrm{ws}}$.
c Mean diameter of ball lot, D_{wmL}.
d Ball subgauge scale.
e Ball gauge scale.
f Deviation of a ball lot from ball gauge, Δ_S.
g Ball subgauge to which the ball lot is assigned.
h Ball gauge, S.
i Range of mean diameter of ball lot for ball gauge, S.

Figure B.2

Annex C
(informative)

Examples of defect types and methods of inspection

C.1 Defects

The defects listed in C.1.1 may exist in silicon nitride bearing balls. Methods for their inspection/detection are listed in C.1.2.

C.1.1 Types of defects

The types of defect are:

— inclusions;

— porosity;

— pits;

— scratches;

— nicks;

— scuffs;

— cracks;

— colour variations.

C.1.2 Methods of inspection

The methods of inspection are:

— visual white light (with or without artificial magnification);

— fluorescent penetrant inspection (FPI) (with or without artificial magnification);

— ultrasonic inspection.

NOTE The following methods are currently being developed, but still require extensive evaluation to be applicable:

a) resonance inspection (resonant ultrasound spectroscopy);

b) Raleigh wave;

c) acoustic microscopy.

Bibliography

[1] ISO 4291, *Methods for the assessment of departure from roundness — Measurement of variations in radius*

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