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भारतीय मानक मसौदा

रोलिंग बियरिंग्स – भाग 2 सिरेमिक बॉल्स (ISO 3290-2 : 2014, संशोधित)

[IS 2898 (भाग 2) *का पहला पुनरीक्षण*]

Draft Indian Standard

Rolling Bearings – Part 2 Ceramic Balls (ISO 3290-2 : 2014, MOD)

[*First revision of* IS 2898 (Part 2)]

ICS 21.100.20

Bearings Sectional Committee, PGD 13	Last date for Comment: **24 October 2025**

NATIONAL FOREWORD

This Indian Standard (Part 2) (First Revision) which is a modified adoption of ISO 3290-2 : 2014 'Rolling bearings — Balls Part 1: Ceramic balls' issued by the International Organization for Standardization (ISO) will be adopted by the Bureau of Indian Standards on the recommendation of the Bearings Sectional Committee and approval of the Production and General Engineering Division Council.

This Indian Standard (Part 2) was published in 2019 and is identical with ISO 3290-2 : 2014 'Rolling bearings — Balls — Part 2 : Ceramic balls' issued by the International Organization for Standardization (ISO). This first revision has been brought out to align the standard with the latest technological developments and international practices.

The major changes in this revision are as follows:

a) The hardness testing clause has been added;
b) Definition of Crushing Strength has been added;
c) Crushing Strength Test has been added; and
d) A new figure (Fig. 1) has been added.

This standard has been published in two parts. The other part in this series is "Rolling bearings — Part 1 Steel balls".

This standard also makes a reference of technical deviation to ISO 3290-1 : 2014. Details of which are as given below:

Clause	*Modifications*
2	All references to ISO standards have been substituted with equivalent Indian Standards.

3.16	Clause 3.16, providing the definition of 'Crushing Strength', has been newly introduced.
5.4	Hardness requirements have been modified in accordance with Indian environmental and operational conditions.
5.5	A new Clause 5.5, regarding 'Crushing Strength Test' has been added to ensure that balls can withstand high compressive forces during operations.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 2022 ‘Rules for rounding off numerical values (*second revision*).’ The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Draft Indian Standard

ROLLING BEARINGS – PART 2 CERAMIC BALLS (ISO 3290-2 : 2014, MOD)

(*First Revision*)

1 SCOPE

This standard specifies requirements for finished silicon nitride balls for rolling bearings.

2 NORMATIVE REFERENCES

The standards listed in Annex D contain provisions which through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards listed in Annex D.

3 TERMS AND DEFINITIONS

For the purposes of this standard, the terms and definitions given in IS 11027 (Part 1), IS 2399, IS 17936 and the following apply.

3.1 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.

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

3.2 Ball Gauge Interval

Absolute difference of two consecutive ball gauges.

3.3 Ball Grade

Specific combination of dimensional, form, surface roughness, and sorting tolerances for balls.

NOTE — Ball grade is identified by the letter G and a number, for example, G 20.

3.4 Ball Lot

Definite quantity of balls manufactured under conditions presumed uniform and which is considered as an entity.

3.5 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 in question.

NOTES

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

3.6 Ball Subgauge Interval

Absolute difference of two consecutive ball subgauges.

3.7 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 to are:

a) Deviation from spherical form;
b) Surface defect;
c) Surface roughness; and
d) Waviness.

3.7.1 *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.

3.7.2 *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.

NOTES
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.
2. The limits for surface defects are not specified in this part of IS 2898.

3.7.3 *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, for example, within the limits of the sampling length.

3.7.4 *Waviness*

Surface irregularities of random or periodical deviation from the ideal spherical form.

NOTES
1. Waviness shall be evaluated by default as velocity amplitude.
2. In practice, the waviness components are separated from the real surface by a waviness analyser (filters).

3.8 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.

3.9 Hardness

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.

3.10 Mean Ball Diameter

Arithmetical mean of the largest and the smallest of the single diameters of a ball.

3.11 Mean Diameter of Ball Lot

Arithmetical mean of the mean diameters of the largest ball and the smallest ball in a ball lot.

3.12 Nominal Ball Diameter

Diameter value which is used for the general identification of a ball size.

3.13 Single Ball Diameter

Distance between two parallel planes tangential to the actual surface of a ball.

3.14 Variation of Ball Diameter

Difference between the largest and the smallest of the single diameters of a ball.

3.15 Variation of Ball Lot Diameter

Difference between the mean diameters of the largest ball and the smallest ball in a ball lot.

3.16 Crushing Strength

(Rolling bearings) Measure of resistance to compressive forces or crushing, till failure.

4 SYMBOLS

For the purposes of this standard, the symbols given in IS 18761 and the following apply.

The symbols (except those for tolerances) and the values given in Table 1, Table 2 and Table 3 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
R_a	-	Arithmetical mean deviation of surface texture [*see* IS 18432 (Part 2)]
S	-	Ball gauge
V_{DwL}	-	Variation of ball lot diameter
V_{Dws}	-	Variation of ball diameter

Δ_{RSw} - Deviation from spherical form
Δ_S - Deviation of a ball lot from a ball gauge

NOTE — $\Delta_S = D_{wmL} - (D_w + S)$

5 REQUIREMENTS

5.1 Ball Size

The preferred nominal ball diameters shall be as 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:

a) Variation of ball diameter shall be as given in Table 2;
b) Deviation from spherical form shall be as given Table 2 and shall be measured in accordance with Annex A;
c) Limits and measuring methods for waviness shall be as agreed between the manufacturer and the customer;
d) Surface roughness shall be as given in Table 2;
e) Local inhomogeneities in colour, densification, pressing defects, snowflakes, etc. and cracks inherent to the material and its processing shall be as agreed between the manufacturer and customer; and
f) Local defects originating from machining and handling shall be as agreed between the manufacturer and customer.

5.3 Sorting Accuracy and Ball Gauges

Illustration of ball gauges and sorting principles is given in Annex B. The applicable values for the following shall be as given in Table 3:

a) Variation of ball lot diameter;
b) Gauge interval;
c) Preferred gauges;
d) Subgauge interval; and
e) Subgauges.

5.4 Hardness

The hardness of the balls shall be as agreed between the manufacturer and customer when measured in accordance with IS 17991.

5.5 Crushing Strength Test for Bearing Rolling Elements

5.5.1 The crushing strength test shall be conducted as specified in **5.5.2** or an equivalent method, if requested by the customer or specified by the manufacturer. The minimum crushing load value shall be declared by the manufacturer.

5.5.2 The static load-carrying capacity of individual rolling elements is determined through this test. A typical test setup consists of three vertically arranged rolling elements, with one ball positioned directly above another, as illustrated in Fig. 1. A gradual load is applied to the top ball, and the loading process is monitored.

To maintain alignment during the loading process, a load cell is positioned horizontally at the center of the middle ball, as shown in Fig. 1. Initially, the central ball is placed slightly offset toward the load cell. As the load is gradually applied, a portion of the force is measured by the horizontal load cell. The test setup allows for adjustments to the central ball's position until it is aligned along the centerline of the arrangement, ensuring that the load measured by the horizontal load cell is negligible. This process is repeated until the central ball is securely positioned between the top and bottom balls. The load is then gradually increased at a specific loading rate between 1960 N/sec to 5880 N/sec until fracture occurs in any of the three balls.

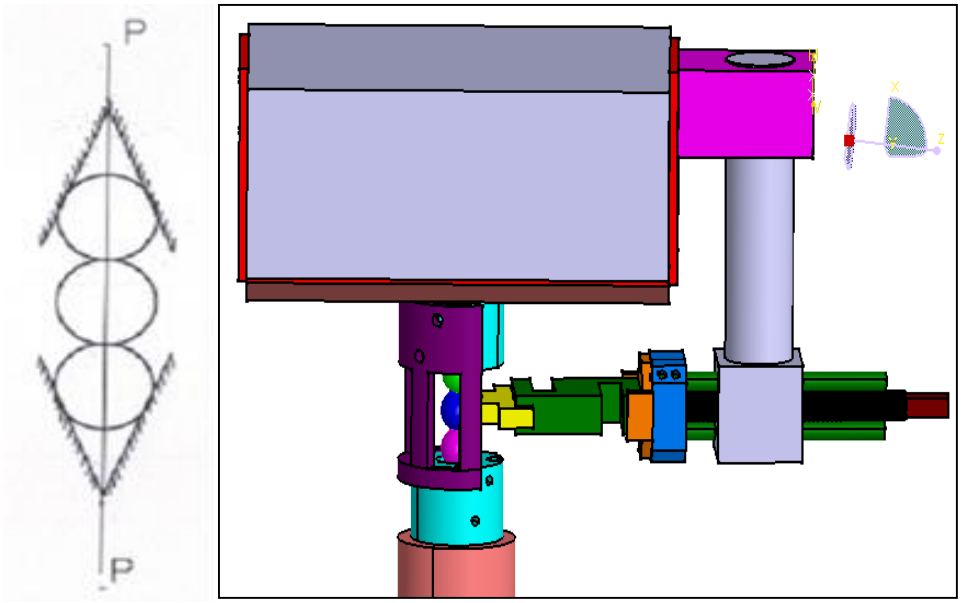


FIG. 1 SCHEMATIC DIAGRAM OF THE LOADING ARRANGEMENT BEFORE TESTING

6 MATERIAL

The balls shall be manufactured from silicon nitride material in accordance with IS 17985.

7 DIMENSIONS AND TOLERANCES

7.1 General

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

7.2 Shortened Formats for Nominal Diameter Identification

7.2.1 *Metric Option*

For purchasing and other general administrative purposes, some users optionally identify nominal metric ball diameters with only three digits following the decimal comma.

This option does not identify the diameter with adequate precision for manufacturing purposes and the full long diameter values given in Table 1 with four or five digits following the decimal comma to precisely identify the size shall always be used for gauge and subgauge sorting purposes to avoid any possibility of ambiguity.

7.2.2 *Imperial Option*

For purchasing and other general administrative purposes, some users optionally continue to identify nominal ball diameters with imperial exact fraction or decimal sizes which carry no risk of ambiguity. Metric equivalents are sometimes also shown but not used as the primary administrative identifier.

If this option is applied, gauge and subgauge diameter tolerances in micrometres shall be added to the imperial nominal reference size or its exact metric equivalent with four or five digits following the decimal comma according to Table 1, for sorting purposes during manufacturingprocedures.

Table 1 Preferred Nominal Ball Diameters

(*Clauses* 4, 5.1, 7.1, 7.2.1 and 7.2.2)

Nominal ball diameter D_w mm	**Corresponding inch size** (reference) in
0.3	—
0.396 88	1/64
0.4	—
0.5	—
0.508	1/50
0.6	—
0.635	1/40
0.68	—
0.7	—
0.793 75	1/32
0.8	—
1	—
1.190 62	3/64
1.2	—
1.5	—
1.587 5	1/16

Table 1 (*Continued*)

Nominal ball diameter D_w mm	**Corresponding inch size** (reference) in
1.984 38	5/64
2	—
2.381 25	3/32
2.5	—
2.778 12	7/64
3	—
3.175	1/8
3.5	—
3.571 88	9/64
3.968 75	5/32
4	—
4.365 62	11/64
4.5	—
4.762 5	3/16
5	—
5.159 38	13/64
5.5	—
5.556 25	7/32
5.953 12	15/64
6	—
6.35	1/4
6.5	—
6.746 88	17/64
7	—
7.143 75	9/32
7.5	—
7.540 62	19/64
7.937 5	5/16
8	—
8.334 38	21/64
8.5	—
8.731 25	11/32
9	—
9.128 12	23/64
9.5	—
9.525	3/8

Table 1 (*Continued*)

Nominal ball diameter D_w mm	**Corresponding inch size** (reference) in
9.921 88	25/64
10	—
10.318 75	13/32
10.5	—
11	—
11.112 5	7/16
11.5	—
11.509 38	29/64
11.906 25	15/32
12	—
12.303 12	31/64
12.5	—
12.7	1/2
13	—
13.493 75	17/32
14	—
14.287 5	9/16
15	—
15.081 25	19/32
15.875	5/8
16	—
16.668 75	21/32
17	—
17.462 5	11/16
18	—
18.256 25	23/32
19	—
19.05	3/4
19.843 75	25/32
20	—
20.5	—
20.637 5	13/16
21	—
21.431 25	27/32
22	—
22.225	7/8

Table 1 (*Continued*)

Nominal ball diameter D_w mm	**Corresponding inch size** (reference) in
22.5	—
23	—
23.018 75	29/32
23.812 5	15/16
24	—
24.606 25	31/32
25	—
25.4	1
26	—
26.193 75	1 1/32
26.987 5	1 1/16
28	—
28.575	1 1/8
30	—
30.162 5	1 3/16
31.75	1 1/4
32	—
33	—
33.337 5	1 5/16
34	—
34.925	1 3/8
35	—
36	—
36.512 5	1 7/16
38	—
38.1	1 1/2
39.687 5	1 9/16
40	—
41.275	1 5/8
42.862 5	1 11/16
44.45	1 3/4
45	—
46.037 5	1 13/16
47.625	1 7/8
49.212 5	1 15/16
50	—

Table 1 (*Concluded*)

Nominal ball diameter D_w mm	**Corresponding inch size** (reference) in
50.8	2
53.975	2 1/8
55	—
57.15	2 1/4

Table 2 Form and Surface Roughness Tolerances
(*Clauses* 4, 5.2 and 7.1)
Tolerance values are in Micrometres

Ball grade	**Variation of ball diameter**[1)] V_{Dws} max.	**Deviation from spherical form**[1)] Δ_{RSw} max.	**Surface roughness**[1)] R_a 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

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

Table 3 Sorting Tolerances and Ball Gauges
(*Clauses* 4 and 7.1)
Tolerance values are in Micrometres

Ball grade	**Variation of ball lot diameter** V_{DwL} max.	**Ball gauge interval**	**Preferred ball gauges**	**Ball sub-gauge inter-val**	**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

Table 3 (*Concluded*)

Ball grade	Variation of ball lot diameter V_{DwL} max.	Ball gauge interval	Preferred ball gauges	Ball sub-gauge inter-val	Ball subgauges
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
(*Clause* 5.2)
METHOD FOR ASSESSMENT OF DEVIATION FROM SPHERICAL FORM

The measurement of deviation from spherical form of a ball shall be carried out by the 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 the calculation from the least squares reference circle in accordance with IS 16226 (Part 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* IS 15373.

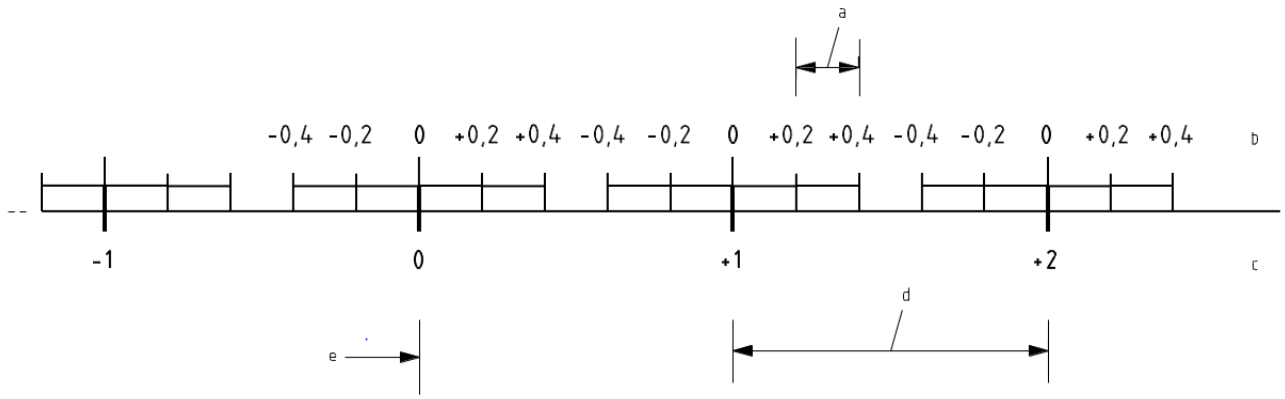
If a different evaluation method is used, it should be agreed between the manufacturer and customer.

Annex B
(*Clause* 5.3)
ILLUSTRATION OF BALL GAUGES AND SORTING PRINCIPLES

B-1 BALL GAUGE AND BALL SUBGAUGE

Fig. 2 shows an example of ball gauge and ball subgauge for Grade G 5 balls.

Values are in Micrometres



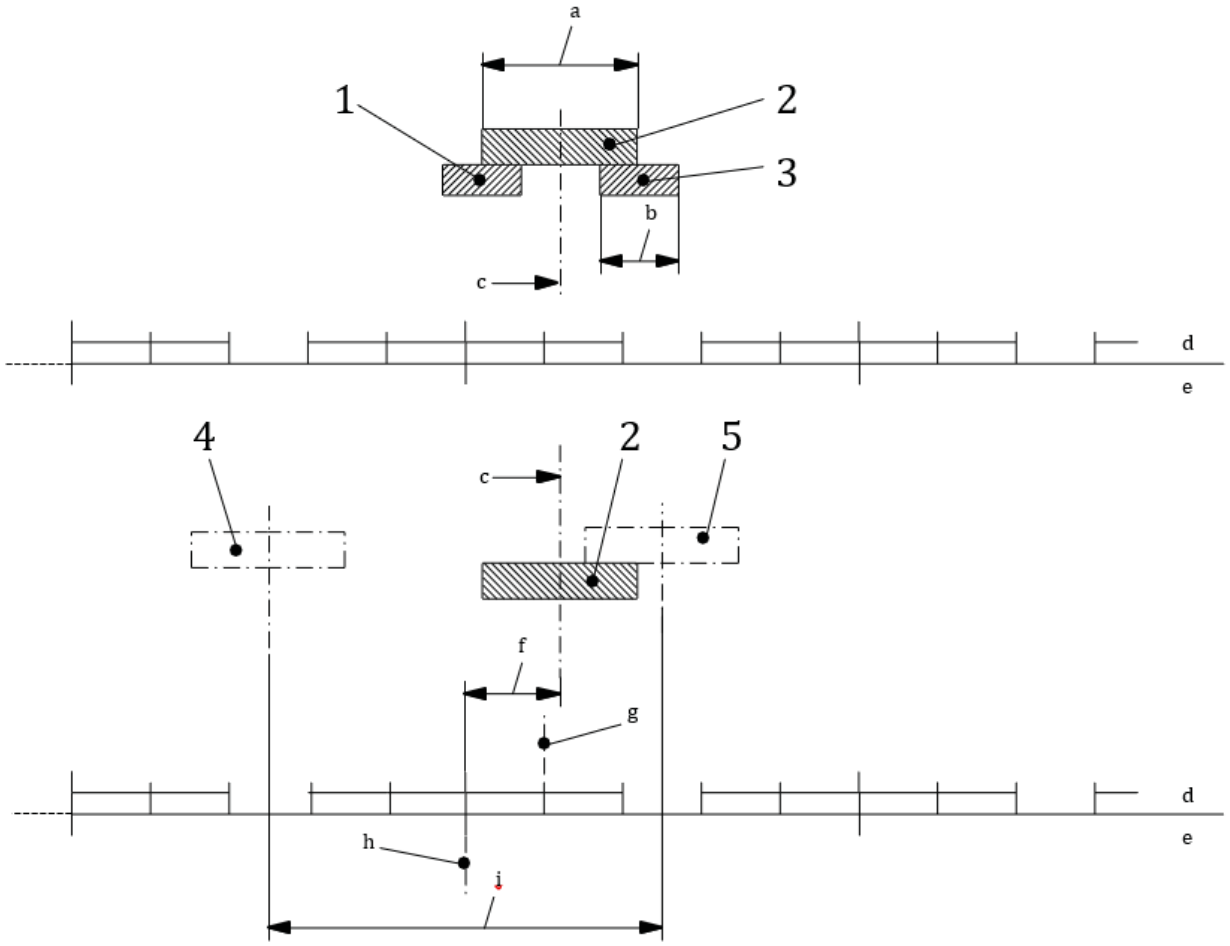
Key

a - Ball subgauge interval
b - Ball subgauge scale
c - Ball subgauge scale
d - Ball subgauge interval
e - Nominal Ball diameter, D_w

FIG. 2 EXAMPLE OF BALL GAUGE AND BALL SUBGAUGE GRADE G5 BALLS

B-2 BALL LOT AND BALL GAUGE DEVIATION

Fig. 3 shows the relationship between a ball lot and its ball gauge.



Key

1 - Smallest ball in ball lot
2 - Ball lot
3 - Largest ball in ball lot
4 - Ball lot with smallest D_{wmL} to be referred to ball gauge
5 - Ball lot with largest D_{wmL} to be referred to ball gauge *S*

a - Variation of ball lot diameter, V_{DwL}
b - Variation of ball diameter, V_{Dws}
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*

FIG. 3 RELATIONSHIP BETWEEN A BALL LOT AND ITS BALL GAUGE

Annex C
(*Informative*)
EXAMPLES OF DEFECT TYPES AND METHODS OF INSPECTION

C-1 GENERAL

Due to the material structure and manufacturing methods of silicon nitride balls, the defects listed in **C-2.1** can occur. Methods for inspection/detections of these defects are listed in **C-2.2**.

C-2 DEFECTS

C-2.1 Types of Defects

The types of defects are

a) Inclusions;
b) Porosity;
c) Pits;
d) Scratches;
e) Nicks;
f) Scuffs;
g) Cracks; and
h) Colour variations.

C-2.2 Methods of Inspection

The following are methods of inspection:

a) Visual white light (with or without artificial magnification);
b) Fluorescent penetrant inspection (FPI) (with or without artificial magnification); and
c) 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.

ANNEX D
(*Clause* 2**)**
REFERENCES

IS No./ Other publication	*Title*
IS 2399 : 2024 / ISO 5593 : 2023	Rolling bearings — Vocabulary (*third revision*)
IS 11027 (Part 1) : 2019 / ISO 1132-1 : 2000	Rolling bearing — Tolerances Part 1 Terms and definitions (*first revision*)
IS 15373 : 2003 / ISO 4291 : 1985	Method for the assessment of departure from roundness — Measurement of variations in radius
IS 16226 (Part 1) : 2014 / ISO 12181-1 : 2011	Geometrical product Specifications (GPS) — Roundness Part 1 Vocabulary and parameters of roundness
IS 17936:2022 / ISO 20507 : 2014	Fine ceramics (advanced ceramics, advanced technical ceramics) — Vocabulary
IS 17985: 2022/ ISO 26602 : 2017	Fine ceramics (advanced ceramics, advanced technical ceramics) — Silicon nitride materials for rolling bearing balls and rollers
IS 17991:2022 / ISO 14705 : 2016	Fine Ceramics (Advanced Ceramics, Advanced Technical Ceramics) — Test Method for Hardness of Monolithic Ceramics at Room Temperature
IS 18432 (Part 2) : 2023 / ISO 21920-2 : 2021	Geometrical product specifications (GPS) — Surface texture — Profile Part 2 Terms, definitions and surface texture parameters
IS 18761 : 2024 / ISO 15241 : 2012	Rolling bearings — Symbols for physical quantities