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Standard Specification for Silicon Nitride Bearing Balls[1]

This standard is issued under the fixed designation F2094/F2094M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This specification covers the establishment of the basic quality, physical/mechanical property, and test requirements for silicon nitride balls Classes I, II, and III to be used for ball bearings and specialty ball applications.

1.2 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.3 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *Order of Precedence:*

2.1.1 In the event of a conflict between the text of this document and the references herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.2 *ASTM Standards:*[2]

C1161 Test Method for Flexural Strength of Advanced Ceramics at Ambient Temperature

C1421 Test Methods for Determination of Fracture Toughness of Advanced Ceramics at Ambient Temperature

2.3 *ANSI Standard:*

ANSI/ASQC Z1.4 Sampling Procedures and Tables for Inspection by Attributes[3]

2.4 *ABMA Standards:*

STD 10 Metal Balls[4]

2.5 *ASME Standard:*

B 46.1 Surface Texture (Surface Roughness, Waviness, and Lay)[5]

2.6 *ISO Standards:*[6]

4505 Hardmetals—Metallographic Determination of Porosity and Uncombined Carbon

2.7 *JIS Standards:*

R 1601 Testing Method for Flexural Strength (Modulus of Rupture) of High Performance Ceramics[7]

R 1607 Testing Method for Fracture Toughness of High Performance Ceramics[7]

2.8 *CEN Standards:*

EN 843-1 Advanced Technical Ceramics—Monolithic Ceramics—Mechanical Properties at Room Temperature, Part 1. Determination of Flexural Strength[8]

ENV 843-5 Advanced Technical Ceramics—Monolithic Ceramics—Mechanical Properties at Room Temperature, Part 5, Statistical Analysis[8]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *ball diameter variation, Vdws, n*—ball diameter variation is the difference between the largest and smallest diameter measured on the same ball.

[1] This specification is under the jurisdiction of ASTM Committee F34 on Rolling Element Bearings and is the direct responsibility of Subcommittee F34.01 on Rolling Element.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Application for copies should be addressed to the American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

[4] Application for copies should be addressed to the American Bearing Manufacturer's Association, 1200 19th Street NW, Suite 300, Washington, DC 20036-2401.

[5] Application for copies should be addressed to the American Society of Mechanical Engineers (ASME), ASME International Headquarters, Three Park Ave., New York, NY 10016-5990, http://www.asme.org.

[6] Application for copies should be addressed to the Available from International Organization for Standardization (ISO), ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, http://www.iso.org.

[7] Application for copies should be addressed to the Japanese Standards Organization (JSA), 4-1-24 Akasaka Minato-Ku, Tokyo, 107-8440, Japan, http://www.jsa.or.jp.

[8] Application for copies should be addressed to the British Standards Institute (BSI), 389 Chiswick High Rd., London W4 4AL, U.K., http://www.bsi-global.com.

3.1.2 *ball gauge, S, n*—prescribed small amount by which the lot mean diameter should differ from nominal diameter, this amount being one of an established series of amounts. A ball gauge, in combination with the ball grade and nominal ball diameter, should be considered as the most exact ball size specification to be used by a customer for ordering purposes.

3.1.3 *ball gauge deviation, ΔS, n*—difference between the lot mean diameter and the sum of the nominal diameter and the ball gauge.

3.1.4 *ball grade, G, n*—specific combination of dimensional form and surface roughness tolerances. A ball grade is designated by a grade number followed by the letter "C" indicating Silicon Nitride Ceramic.

3.1.5 *blank lot, n*—single group of same-sized ball blanks processed together from one material lot through densification.

3.1.6 *ceramic second phase, n*—sintering additive based phases, for example, yttria and alumina, which appear darker or lighter than the silicon nitride matrix, but are not highly reflective in nature when viewed under reflected light microscopy and bright field illumination.

3.1.7 *color variation, n*—an area that appears lighter or darker than the surrounding area under reflected light microscopy but with no discernible physical discontinuity associated with it.

3.1.7.1 *Discussion*—Color variation is often not visible under scanning electron microscopy (SEM) examination.

3.1.8 *c-cracks, n*—curved, constant radius cracks, the result of ball-to-ball impact during finishing or subsequent handling. In extreme cases, the cracks can form a complete circle and multiple concentric cracks can form.

3.1.9 *cracks, n*—irregular, narrow breaks in the surface of the ball typically having a visible width of less than 0.002 mm [0.00008 in.]

3.1.9.1 *Discussion*—Most cracks are formed after densification but occasionally may be present as material faults. Some cracks may not be visible with normal white light microscopy and may only show up under ultraviolet light after processing with a suitable fluorescent penetrant.

3.1.10 *cuts, n*—Mechanically induced random, short, linear depressions in the surface.

3.1.11 *deviation from spherical form, ΔRw, n*—greatest radial distance in any radial plane between a sphere circumscribed around the ball surface and any point on the ball surface.

3.1.12 *finish lot, n*—single group of same-sized balls (which may be derived from multiple blank lots of the same material lot) processed together through finishing.

3.1.13 *inclusion, n*—any discrete imhomogeneity in the microstructure that is not intended to be included in the material.

3.1.13.1 *Discussion*—Inclusions typically consist of foreign material as a result of unintended external powder contamination and resulting reaction product after sintering.

3.1.14 *lot diameter variation, Vdwl, n*—difference between the mean diameter of the largest ball and that of the smallest ball in the lot.

3.1.15 *lot mean diameter, Dwml, n*—arithmetic mean of the mean diameter of the largest ball and that of the smallest ball in the lot.

3.1.16 *material lot, n*—single process lot of a blended powder (blended with additives), produced from a single lot of silicon nitride or silicon metal raw powder received from a material supplier.

3.1.16.1 *Discussion*—What constitutes a "single process lot" of blended powder can vary depending on the standard practices of the vendor and the requirements of the customer and application. For example, for many customers/applications, combining multiple mill charges from one raw material lot into a single material lot is acceptable while for others, each mill charge would be considered a separate material lot. It is difficult, if not impossible, for a single definition of material lot to apply to all applications. The material lot should be defined such that application-appropriate traceability is maintained and adequate testing appropriate for the intended application is performed to ensure that the chemistry and material properties of densified parts meet specifications. The material lot requirements should be discussed and agreed between the vendor and customer.

3.1.17 *mean diameter of a ball, Dwm, n*—arithmetic mean of the largest and the smallest actual single diameters of the ball.

3.1.18 *metallic phase, n*—material phase that is highly reflective when viewed by reflected light microscopy and bright field illumination.

3.1.19 *metallic smears, n*—metallic material from lapping or measuring equipment transferred onto the ball surface.

3.1.20 *nominal diameter, Dw, n*—size ordered that is the basis to which the nominal diameter tolerances apply. The nominal diameter is specified in inches or millimeters (decimal form).

3.1.21 *nominal diameter tolerance, n*—maximum allowable deviation from true specified nominal diameter for the indicated grade.

3.1.22 *pits, n*—voids or cavities in the ball surface.

3.1.22.1 *Discussion*—Pits can be formed by severe material pullout during ball finishing. Pits can also be a result of breakout of inclusions during finishing.

3.1.23 *porosity, n*—small, closely spaced voids permeating a region of the ball surface or the whole ball.

3.1.24 *pressing defects, n*—the result of cracks in the ball blanks prior to densification.

3.1.24.1 *Discussion*—Some pressing defects heal more or less completely on densification resulting in a region of material with slightly different composition and optical characteristics than the rest of the ball. These are known as healed or partially healed pressing defects. Unhealed or open pressing defects can have the appearance of cracks or fissures.

3.1.25 *raw material lot, n*—single process lot of raw silicon nitride or raw silicon metal powder received from a material supplier.