Designation: D7971 – 20

Standard Guide for Measuring Roundness of Glass Spheres Using a Flowing Stream Digital Image Analyzer[1]

This standard is issued under the fixed designation D7971; 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 guide covers the determination of the roundness of glass spheres used in pavement marking systems using a flowing stream digital analyzer. Typical gradations for pavement marking systems are defined in ranges from Type 0 through 5 in AASHTO M247.

1.2 This guide provides for the presentation of roundness data in a variety of formats to the requirement of the agency pavement marking material specification. For most specifications the standard format is to present the roundness data as Percent True Spheres relative to a series of standard ASTM sieve sizes.

1.3 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *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 *ASTM Standards:*[2]

B215 Practices for Sampling Metal Powders

2.2 *AASHTO Standard:*[3]

AASHTO M247 Standard Glass Beads Used in Traffic Markings

2.3 *ISO Standards:*[4]

ISO 9276–6 Representation of results of particle size analysis — Part 6: Descriptive and quantitative representation of particle shape and morphology

ISO 13322–1 Particle size analysis — Image analysis methods — Part 1: Static image analysis methods

3. Terminology

3.1 *Flowing Stream Digital Analyzer:*

3.1.1 A computer controlled particle analyzer employing a high resolution digital imaging device and computer image processing software to do photo optical single particle counting and particle size analysis.

3.2 *Roundness of Glass Beads:*

3.2.1 Roundness, in the context of this guide, refers to the percentage of true spheres in a sample as a ratio of the total number of particles measured.

3.2.2 *Methods:*

3.2.2.1 These are specific observations and calculations of the streaming particles that combine to form a protocol for measuring the percentage of true spheres within the sample.

3.3 *Aspect Ratio:*

3.3.1 Aspect ratio, often referred to as b/l or w/l, is one of the several methods of determining roundness and is illustrated in Fig. 1.

3.3.2 Aspect ratio will be the recommended method for the majority of roundness measurements, especially when there exists a reasonable expectation that all of the particles being measured have rounded surfaces and mostly resemble the shape of a sphere.

3.4 *Sphericity (also referred to as circularity):*

3.4.1 Sphericity is one of a number of methods of determining roundness and is illustrated in Fig. 2.

[1] This guide is under the jurisdiction of ASTM Committee D01 on Paint and Related Coatings, Materials, and Applications and is the direct responsibility of Subcommittee D01.44 on Traffic Coatings.

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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] Available from American Association of State Highway and Transportation Officials (AASHTO), 444 N. Capitol St., NW, Suite 249, Washington, DC 20001, http://www.transportation.org.

[4] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

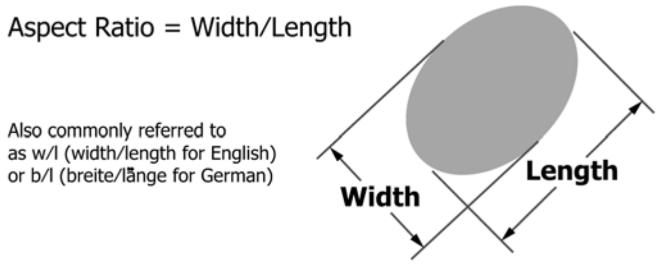

FIG. 1 Aspect Ratio

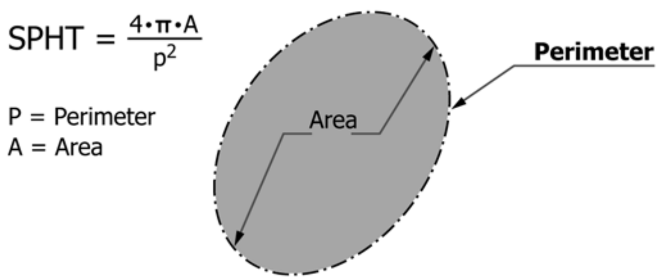

FIG. 2 Sphericity

3.4.2 SPHT-value or sphericity is calculated from the measurements of

1. the area* A* of the particle projection (particle image),
2. multiplied by four · Pi (4π) and
3. divided by the perimeter P of the particle projection squared (P^2).

3.4.3 SPHT result values are between 0 and 1 (including 1) and following ISO 9276–6.

NOTE 1—A high percentage of the volume of glass beads are produced from crushed and sized recycled glass. The most common method of production involves passing the particles in a reverse free fall through a gas-rich, highly luminous, natural gas flame wherein they reach their melting point. Due to nature's insistence that all liquids exhibit tension at their surface, the particles are then forced to reconfigure into a shape which maintains the smallest ratio of surface area to volume. This shape is a sphere. One of the main quality control concerns of this production method is ensuring that all the particles pass through the flame and become spheres. If not, the particles will remain in the state in which they are introduced and will consist of irregular shapes with sharp edges. A large variance between sphericity and aspect ratio could reveal that sphericity is the better method in this particular case.

3.5 *Nominal Covered Area:*

3.5.1 Nominal covered area (Fig. 3) (set value of obscuration percentage) = $A_{obscured} / A_{total\ measurement\ field}$.

3.5.2 Nominal covered area (set value of obscuration) is calculated using the obscured area by particles divided by the total measurement area.

3.5.3 The higher the nominal covered area, the more coincidental particles that are captured. With more coincidental particles measured, the more non-round particles detected.

3.5.4 The task file setting for nominal covered area should not exceed a certain percentage. Values of nominal covered area (fld = field density) of 0.8 % for smaller grades (20 to 100 mesh, Type 0 and Type 1 outlined in AASHTO M247) and 1 % for larger grades (10 to 25 mesh, Type 2, Type 3, Type 4 and Type 5) should not be exceeded. Lower values are possible. Values of 0.3 % to 0.5 % will lead to more accurate results. For example, a measurement with 0.7 % nominal covered area leads to 18 % non-round particles, a measurement with 0.3 % nominal covered area would show 17 % non-round particles.

4. Significance and Use

4.1 The roundness of glass beads has a significant influence on the retroreflective efficiency of a pavement marking system.

4.2 The guide is for the characterization of the roundness of glass beads for the purpose of compliance testing against standard specification for glass beads in pavement marking applications.

4.3 While there are potential industrial applications for this guide beyond the measurement of roundness of glass beads for pavement markings, those are beyond the scope of this standard.

5. Summary of Guide

5.1 The glass particles are run through a flowing stream digital image analyzer, a measuring system for determining the roundness of dry, free flowing and harmless bulk products. The total recommended measuring range of sizes is between 110 µm and 2.36 mm. The method uses photo optical single particle counting technology for the image processing. The measurement time depends on the quantity of material to be measured, the width of the metering feeder and the mean grain size. The quantity of material to be measured depends on the grain size and width of the metering feeder. Typical measuring times are approximately 2 to 10 min.

6. Apparatus

6.1 *Typical Apparatus*—See Fig. 4.

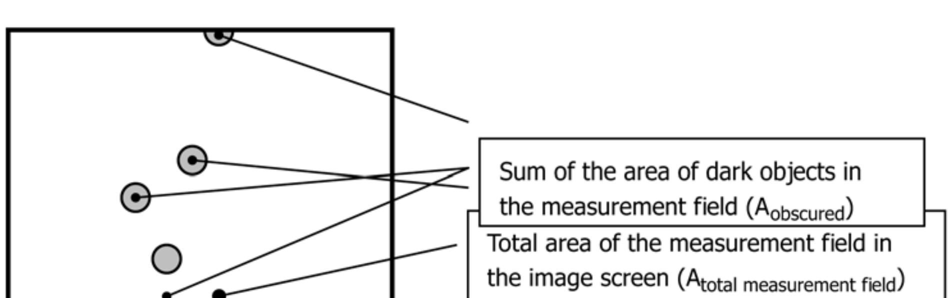

FIG. 3 Nominal Covered Area

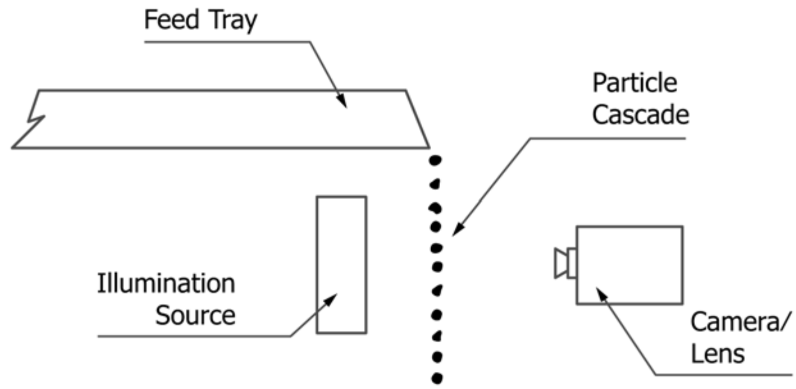

FIG. 4 Typical Apparatus

TABLE 1 Sample Size by Type — AASHTO M247

Type 0	50 g
Type 1	50 g
Type 2	70 g
Type 3	100 g
Type 4	150 g
Type 5	200 g

7. Operating Conditions

7.1 *Environmental Temperature*—between 10 and 40°C.

7.2 *Air Humidity*—80 % maximum relative humidity at temperatures up to 30°C, linear decrease to 50 % maximum relative humidity at a temperature of 40°C.

7.3 *Height of Installation and Operation*—maximum 3000 m above sea level.

7.4 *Installation Location*—Place the particle analyzer on a firm, horizontal, vibration free surface.

7.5 *Light Conditions*—Avoid strong direct external light on the particle measurement shaft or on the cameras.

7.6 This method is designed for indoor or outdoor use as prescribed by the manufacturer's design and instructions.

8. Hazards

8.1 *General Safety Information*—Operate the instrument in accordance with the manufacturer's recommendations following all required safety precautions.

9. Sampling, Test Specimens, and Test Units

9.1 In order to obtain representative samples when sampling from packaged containers, blenders or storage tanks, methods outlined in Practices B215 shall be followed.

9.2 The approximate number of particles in a test sample measured by weight varies greatly between Type 0 and Type 5 as outlined in AASHTO M247. Table 1 represents the minimum recommended sample size for each glass bead type.

9.3 Compared to sieve analysis for gradation and Round-O-Meter analysis for roundness, dynamic image analyzers have no upper limits for the amount of sample required. As should be expected, the larger the sample size of an individual type, the higher the degree of accuracy and reliability. Larger sample sizes lengthen the duration of the test. The end user should therefore balance the tolerance of test time duration against the desire for accuracy. ISO 13322–1 can be referenced for a sufficient number of particles for a certain precision and correct representation of the size distribution. Since the segregation of particle shape in a bulk material is lower than the segregation for particle size, users are on the safe side when they follow the sampling recommendations for particle size.

10. Preparation of Apparatus

10.1 Follow the manufacturer's instructions for the particle analyzer being used.

11. Calibration and Standardization

11.1 The particle analyzer, in most cases, will be calibrated by the manufacturer prior to shipping. Re-calibration might become necessary occasionally, for example, after the transportation of the instrument or if required by quality management regulations. In this case, follow the calibration procedures as outlined in the manufacturer's instruction manual.

12. Conditioning

12.1 *Sample Preparation:*

12.1.1 Use a sample splitter, if necessary, to reduce the amount of sample to the appropriate size.

12.1.2 Pour entire glass bead sample into the glass beaker or suitable container.

12.1.3 Assure glass beads are moisture free and free flowing.

NOTE 2—Check with the instrument manufacturer for suggestions on how best to set up any software that comes with their instrument. Setting up the instrument software properly will speed up any glass sphere roundness measurements and allow for meaningful reports.

13. Procedure

13.1 Load the sample into the feeder of the flowing stream digital image analyzer. The analyzer software will allow the user to carry out his measurements quickly and without error. All measuring and analysis parameters are determined initially and set into the computer program. Different task files are created for different specifications.

13.1.1 When assigning sieve ranges to be used in a task file, the user must use the ASTM mesh sieve choice, not the W. S. Tyler mesh. The quantity of the material to be measured has to be placed into the funnel of the metering feeder. The material