Designation: D7971 – 15

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 and health practices and determine the applicability of regulatory limitations prior to use.*

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:*

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.

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

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[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.

Current edition approved April 1, 2015. Published April 2015. DOI: 10.1520/D7971-15.

[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.

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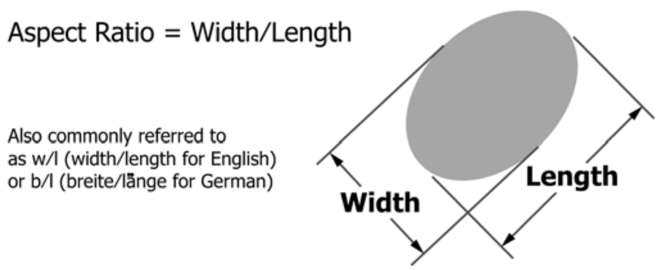

FIG. 1 Aspect Ratio

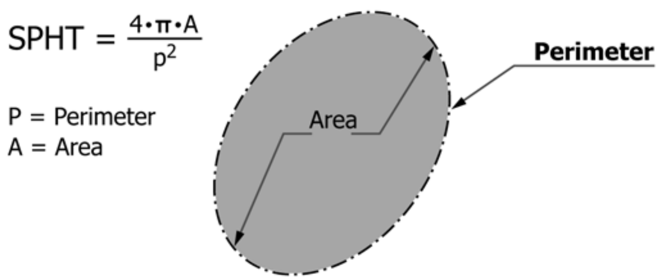

FIG. 2 Sphericity

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.

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.

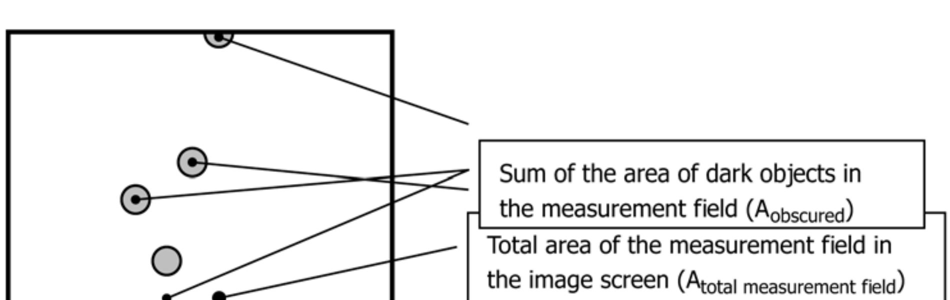

FIG. 3 Nominal Covered Area