
Standard Practice for

**Determination of Size and Shape of
Glass Beads Used in Traffic
Markings by Means of
Computerized Optical Method**

AASHTO Designation: R 98-20 (2024)¹

Adopted: 2020

Reviewed but Not Updated: 2024

Editorially Revised: 2024

Technical Subcommittee: 4c, Markings and Coatings



American Association of State Highway and Transportation Officials
555 12th Street NW, Suite 1000
Washington, DC 20004

Determination of Size and Shape of
Glass Beads Used in Traffic Markings by
Means of Computerized Optical Method

AASHTO Designation: R 98-20 (2024)¹



Adopted: 2020 Reviewed but Not Updated: 2024 Editorially Revised: 2024

Technical Subcommittee: 4c, Markings and Coatings

1.	SCOPE
1.1.	This practice describes measuring size and shape of translucent glass beads used in traffic markings with computerized optical equipment. This practice is intended for glass beads from 0.15 mm to 2.35 mm in diameter.
1.2.	<i>This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this procedure to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to its use.</i>
2.	REFERENCED DOCUMENTS
2.1.	<i>AASHTO Standards:</i> ■ M 247, Glass Beads Used in Pavement Markings ■ R 76, Reducing Samples of Aggregate to Testing Size
2.2.	<i>ASTM Standards:</i> ■ B215, Standard Practices for Sampling Metal Powders ■ C670, Standard Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials ■ D1155, Standard Test Method for Roundness of Glass Spheres ■ D1214, Standard Test Method for Sieve Analysis of Glass Spheres
2.3.	<i>ISO Standards:</i> ■ ISO 14488, Particulate Materials—Sampling and Sample Splitting for the Determination of Particulate Properties ■ ISO 3252, Powder Metallurgy—Vocabulary
2.4.	<i>Other Reports:</i> ■ NCHRP Web-Only Document 156, <i>Optical Sizing and Roundness Determination of Glass Beads Used in Traffic Markings</i>, http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_w156.pdf

- NCHRP 20-07 (364) Final Report, Revision of AASHTO PP-74 Test Method for Optical Sizing and Roundness Determination of Glass Beads Utilized in Traffic Markings. Available from [http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP20-07\(364\)_FR.pdf](http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP20-07(364)_FR.pdf)

3. TERMINOLOGY

3.1. General Definitions:

- 3.1.1. *funnel (hopper)*—for feeding the glass beads to the device.
- 3.1.2. *guide plate*—particles fall through an adjustable-width set of guide plates to keep particles focused but randomly oriented to show all possible projections to the camera. This provides a two-dimensional (2D) measurement of at least one orientation of each particle measured. Size (width and length) and shape (aspect ratio and form factor) are measured from the images taken.
- 3.1.3. *measurement shaft*—volume through which particles fall and their images are captured.
Note 1—Two methods can be employed to capture optimum orientation of particles as they tumble through the sensing zone. One is to use a guide plate and the other is to use three-dimensional (3D) measurement of all particles.
- 3.1.4. *image capturing device*—digital cameras with lenses to capture free-falling particles.
Note 2—Two methods of image focus and capture can be employed. The images from the two methods are used for 2D or 3D (multiple 2D images) analysis of the particles. The 2D method requires one or more fixed-position cameras and the 3D analysis requires one adjustable-position camera.
- 3.1.5. *one adjustable position camera (3D = multiple 2D)*—one high-resolution, high-speed digital camera mounted, along with the lens, on a rail can be adjusted at variable distances from the particle stream to capture the complete particle stream and all particles in the sample in their different orientations. Any out-of-focus particles are automatically removed from the image file and data.
- 3.1.6. *one or two fixed-position cameras (2D)*—the high-resolution digital cameras provide two different levels of magnification: the higher magnification to measure the smaller particles in a smaller frame area and the lower resolution to measure larger particles in a larger frame area. This method uses a normalization algorithm to put together two distributions of sizes and shapes of particles captured at two different magnifications. Because of this algorithm, the higher-magnification camera does not need to capture all of the small particles. Because of the guide plate, there are no out-of-focus particles.
- 3.1.7. *particle illumination unit*—light source for strong and homogeneous illumination when camera(s) capture images.
- 3.1.8. *photo-optical particle size analyzer*—general term for computerized optical equipment to measure the size distribution, count, and shape of particles.
- 3.1.9. *sample collection container*—for collecting the glass beads during the test.
- 3.1.10. *three-dimensional (3D) measurement*—multiple images of single particles falling through the sensing zone will be captured. In the case where the particles are tumbling and turning in an optimum way, the largest (length, L) and smaller (width, W) dimensions can be estimated from the largest projected area captured. In addition, the third major dimension of the particle (thickness, T , reported as the smallest dimension) is measured and reported from the smallest projected area image. SPHT (see Section 3.2.6) is calculated from the largest projected area image. Figure 1

shows a row of images from different views of the same particle captured multiple times as it tumbles (optimum case). This allows views of both the largest and smallest projected areas to be measured.

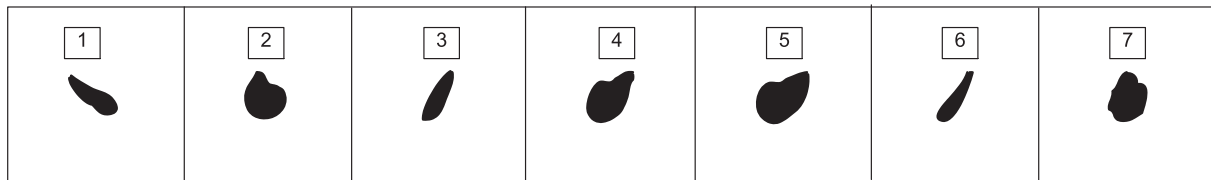


Figure 1—Schematic Diagram of Particle as It Falls through the Measurement Zone of the 3D Digital Particle Analyzer. The camera recognizes and follows every particle by taking multiple pictures when particles fall through the imaging zone. The 3D software uses the particle marked “3” for the measurement of thickness and the particle marked “5” for the measurement of length and width.

- 3.1.11. *vibrating feeder*—vibration unit for control of particle delivery and for dispersing particles.
- 3.2. *Measurement Terms:*
 - 3.2.1. *aspect ratio*—a shape parameter, which can be determined in both 2D and 3D.
 - 3.2.2. *L (l)*—length of the particles (3D and 2D).
 - 3.2.3. *percent circular*—equivalent to the term “percent round” by either “aspect ratio” or “SPHT.”
 - 3.2.4. *percent round*—property of “roundness” expressed in ASTM D1155 and M 247.
 - 3.2.5. *shape*—equivalent to the term “roundness” in ASTM D1155 and M 247.
 - 3.2.6. *SPHT*—a shape parameter also referred to as Form Factor (*FF*). $SPHT = 4\pi A/P^2$, where *A* is the measured area, and *P* is the measured perimeter. For an ideal circle, *SPHT* is 1; otherwise, it is smaller than 1. The threshold value for deciding if a particle is close to a circle or not is approximately 0.93.
 - 3.2.7. *T*—thickness of the particles (3D). In an optimum case $X_{c \min}$ of the smallest particle projection is *T*.
 - 3.2.8. *T/L ratio (3D aspect ratio)*—thickness-to-length ratio is a shape measure. For an ideal sphere, *T/L* is 1; otherwise, it is smaller than 1. The threshold value used for measuring percentage of spherical particles using *T/L* is 0.83.
Note 3—Based on analysis of x-ray tomography images of various glass bead types reported in NCHRP Document 156, it was found that the threshold value of the aspect ratio parameter is not the same for different types of glass beads. Therefore, there are uncertainties associated with using a single cutoff threshold for all glass bead types. The proposed threshold values for the shape parameters have been computed as the median over each range of threshold values corresponding to Types 1, 3, and 5 glass beads.
 - 3.2.9. *W* ($X_{F \min}$, $X_{c \min}$, *w*, or *b*)—width (breadth) of the particles. In an optimum case $X_{c \min}$ of the largest particle projection is *W*.
 - 3.2.10. $X_{c \min}$ —shortest of all maximum chords from all directions.