Designation: D1155 – 10 (Reapproved 2015)

Standard Test Method for Roundness of Glass Spheres[1]

This standard is issued under the fixed designation D1155; 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 test method[2] covers the determination of the percent of true spheres in glass spheres used for retroreflective marking purposes and industrial uses.

1.2 This test method includes two procedures as follows:

1.2.1 *Procedure A,* in which the selected specimen is split into two size ranges or groups prior to separation into true spheres and irregular particles, and

1.2.2 *Procedure B,* in which the selected specimen is split into five size ranges or groups prior to separation.

1.2.3 In determining compliance with specification requirements, either Procedure A or Procedure B may be used. Where tests indicate failure to meet the specified percent of true spheres and irregular particles, the referee test shall be made in accordance with Procedure B.

1.3 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

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:*[3]

E11 Specification for Woven Wire Test Sieve Cloth and Test Sieves

E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

2.2 *Other Document:*

ASTM MNL32 Manual on Test Sieving Methods

3. Summary of Test Method

3.1 The glass particles are mechanically separated into true spheres and irregular particles by controlled vibration on a glass plate fixed at a predetermined slope.

4. Significance and Use

4.1 The roundness of glass spheres is one measurable aspect relating to their performance as a retroreflective media. The function of this test method is to measure the percent of true spheres as related to compliance with applicable specifications.

NOTE 1—This method has been used in other industrial areas outside the intended scope of this test method.

5. Apparatus (Fig. 1)

5.1 *Electrical Feeder-Vibrator,* upon which is mounted a smooth glass panel, 152.4 mm (6 in.) wide and 381 mm (15 in.) long.

5.2 *Hinged Base,* supporting the vibrator and panel in such a manner that the angle of slope of the glass panel with the horizontal may be varied and fixed in any predetermined position.

5.3 *Vibrator*—Means of varying the amplitude or strength of the vibrations transmitted to the glass panel, at a fixed frequency of 60 impulses per second.

5.4 *Feeding Device or Pan (Optional),* affixed to the glass panel in such a manner that the selected sample of glass may be evenly dropped at a uniform rate upon the glass panel, from various heights above the panel and at various points on the slope.

5.5 *Collecting Pans or Containers,* at either end of the sloping panel, in which to collect the spheres and irregular particles.

5.6 *Digital Level,* approximately 30 to 60 cm (12 to 24 in.) in length (not shown).

[1] This test method 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 information on the development of this test method, reference may be made to the paper by Keeley, A. E., "Roundness Testing of Glass Spheres," *ASTM Bulletin*, No. 174, May 1951, p. 72.

[3] 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.

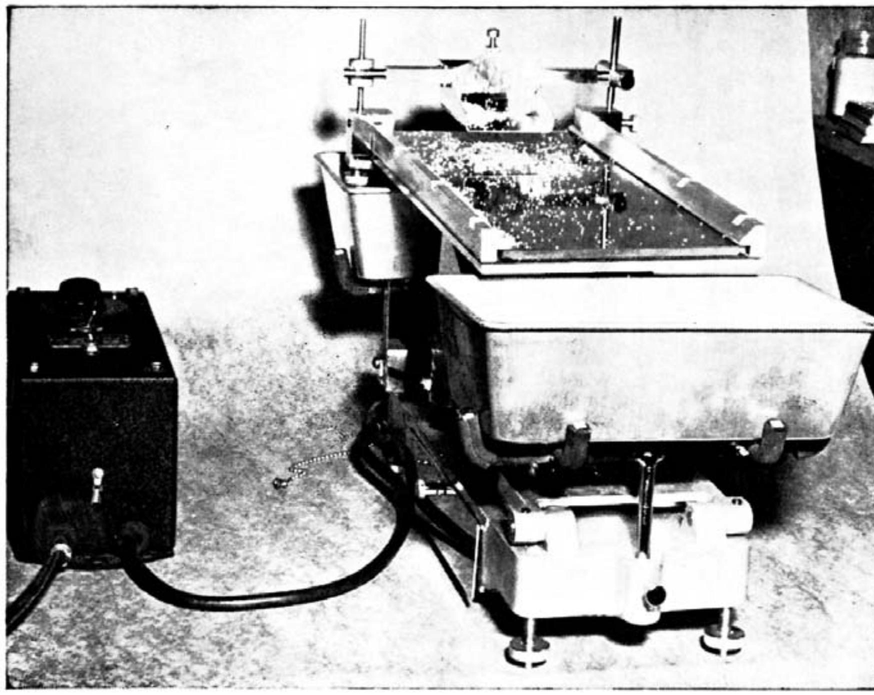


FIG. 1 Apparatus for Roundness Test of Glass Spheres

6. Selection of Specimen

6.1 Select a specimen of approximately 10 to 50 g of the glass spheres to be tested for roundness in one of the following ways:

6.1.1 By mechanically splitting a bag or other container of glass spheres, selected at random from the shipment to be tested, or

6.1.2 By grain or seed-rod selection from the container.

6.1.3 The final sample for testing must be obtained using the appropriate sample splitters or reducers. Arrive as near as possible to the desired sample quantity for testing by only using this equipment.

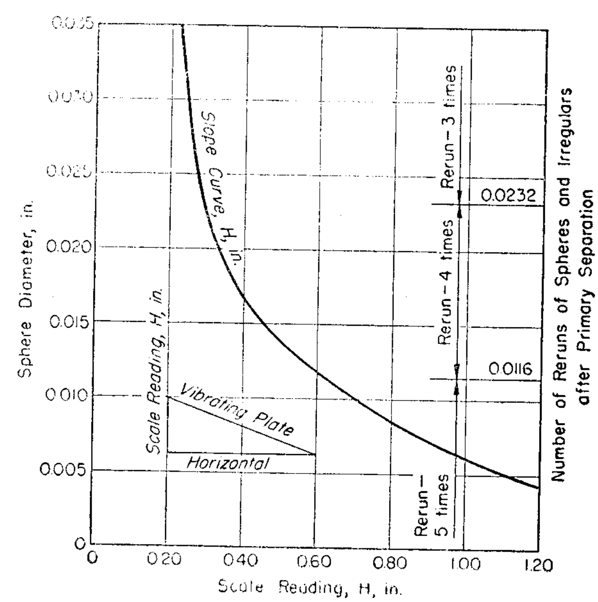
6.1.4 When there is a need to obtain the highest degree of accuracy possible the operator should use a sample size that is closest to the 50 g size limit. In cases where there are disputes between the results obtained by two or more testing parties the maximum sample size should be used in order to settle the dispute.

7. Procedure A

7.1 Sieve the selected specimen through a 300-µm (No. 50) sieve (Note 2). Run the spheres retained on the sieve as one group, and run the spheres passing the sieve as a second group.

NOTE 2—Detailed requirements for ASTM sieves are given in Specification E11. The purchaser or specifying agency may require alternative sieve sizes to be used in lieu of the above reference sizes.

7.2 Level the glass panel; then set the angle of the roundometer plate to the 300-µm (50 U.S. Sieve) setting of 2.3 degrees (from the table in Fig. 2) using a digital level. Affix the feed hopper to the side of the panel at the upper one-third point of the slope, so that the spheres may be dropped in a uniform monolayer onto the glass panel from a height of approximately 13 mm (½ in.). Alternatively, the material may be manually fed



U.S. Mesh	Decimal Angle
20	1.0
30	1.1
40	1.5
50	2.3
60	2.7
70	3.1
80	3.6
100	3.9

FIG. 2 Angle Chart for Setting the Roundometer Inclination with a Digital Level

by slowly pouring from a height of 13 mm (½ in.) to a point in the center of the plate one-third down from the uphill end.

7.3 Place the size group to be tested in the feed pan unless manual feeding is being used, and start the vibrator. Set the vibrator amplitude control at such a position that irregular particles on the upper half of the panel will move slowly up the slope, while the true spheres roll down. Feed slowly, at such a rate that no "bunching up" or flooding of spheres on the panel occurs.

7.4 When the glass panel is well covered with spheres, stop feeding until separation of true spheres has occurred. Stop the vibrator and, after all true spheres have rolled down the slope into the sphere pan, brush or scrape all particles remaining on the panel into the upper pan containing the irregular particles. For purpose of test, all particles not rolling freely down the slope are considered as irregular.

7.5 Repeat the procedure described in 7.3 and 7.4 until the selected size group has been completely separated, removing the true spheres and irregular particles from the collecting pans into appropriate containers.

7.6 Using the true spheres collected in the primary separation, repeat the procedure described in 7.3 and 7.4. Next, feed using the irregular particles collected in the primary separation, and again repeat the procedure described in 7.3 and 7.4. Examine the separated spheres and irregular particles under a 20-diameter magnifying glass and repeat the reruns until satisfactory separation is obtained.

7.7 Determine the total weights of the true spheres and of the irregular particles obtained by the above separations, and record.

7.8 Using the second size group obtained in accordance with 7.1, repeat the procedure described in 7.2 – 7.7 setting the angle of the roundometer plate to the 100 U. S. Sieve setting of 3.9 degrees (from the table in Fig. 2) using a digital level.

7.9 From the total weight of true spheres obtained from both size groups, calculate the percent of true spheres in the total specimen, using as 100 % the total weight of true spheres plus irregular particles collected in the test—thereby eliminating from the calculation any loss of spheres that may have occurred during handling and testing.

8. Procedure B

8.1 Divide the specimen into five size ranges or groups, as follows:

Passing Sieve	Retained on Sieve
600-µm (No. 30)	425-µm
425-µm (No. 40)	300-µm
300-µm (No. 50)	212-µm
212-µm (No. 70)	...

NOTE 3—The purchaser or specifying agency may require alternative sieve sizes to be used in lieu of the above reference sizes in the determination of roundness.

8.2 Level the glass panel; then set the angle of the roundometer plate to the value indicated in Table 1 for the sieve fraction being tested. For example, the sieve fraction passing the 600 µm Sieve (No. 30) and retained on the 425 µm Sieve (No. 40), the 425 µm (No. 40) Sieve setting should be used (1.5 degrees). Affix the feed hopper over the center line of the panel, at the upper one-third point of the slope, with the feed end up-slope and approximately 13 mm (½ in.) from the glass panel. Alternatively, the material may be manually fed by slowly pouring from a height of 13 mm (½ in.) to a point in the center of the plate one-third down from the uphill end.

8.3 Place the size group to be tested in the feed pan, unless manual feeding is being used, and start the vibrator. Set the vibrator amplitude control at such a position that irregular particles on the upper half of the panel will move slowly up the slope, while the true spheres roll down. Feed slowly, at such a rate that no "bunching up" or flooding of spheres on the panel occurs.

8.4 When the glass panel is well covered with spheres, stop feeding until separation of true spheres has occurred. Stop the vibrator and, after all true spheres have rolled down the slope into the sphere pan, brush or scrape all particles remaining on the panel into the upper pan containing the irregular particles. For purposes of this test, all particles not rolling freely down the slope are considered as irregular.

8.5 Repeat the procedure described in 8.3 and 8.4 until the selected size group has been completely separated, removing the true spheres and irregular particles from the collecting pans into appropriate containers.

8.6 Using the true spheres collected in the primary separation, repeat the procedure described in 8.3 and 8.4. Next, feed using the irregular particles collected in the primary separation and again repeat the procedure described in 8.3 and 8.4. Examine the separated spheres and irregular particles under a 20-diameter magnifying glass and repeat the reruns until satisfactory separation is obtained.

TABLE 1 Percent True Spheres (Rounds)

				Repeatability Standard Deviation	Reproducibility Standard Deviation	Repeatability Limit	Reproducibility Limit
Sieve Size	% True Spheres	Average[A] Sample Size (g)	$s\bar{x}$	s_r	s_R	r	R
30	23.187	1.600	1.342	2.076	2.162	5.813	6.053
40	45.669	10.667	2.719	2.130	3.228	5.963	9.037
50	72.202	14.655	1.553	.982	1.748	2.751	4.894
70	84.669	7.283	1.758	1.528	2.156	4.280	6.037
Pan	80.355	2.437	6.771	2.919	7.178	8.174	20.099

[A] Average of laboratories calculated averages.

Note: The average sample size used to conduct this testing was 36.642 grams.

8.7 The procedure described in 8.3, 8.4, and 8.5 comprises the primary separation and that in 8.6 is one complete rerun. Make a primary separation for each of the five size groups listed in 8.1 and then make the appropriate number of reruns for each size group, as follows:

Spheres Retained on Sieve	Reruns
425-μm (No. 40)	4
300-μm (No. 50)	4
212-μm (No. 70)	5
Spheres Passing Sieve	
212-μm (No. 70)	5

NOTE 4—In lieu of performing the mandated number of reruns, when applicable the operator can evaluate the repeatability of two reruns with the information provided in Section 10 to determine the precision of the results.

8.8 From the total weight of true spheres obtained from separations from all five size groups, calculate the percent of true spheres in the total specimen, using as 100 % the total weight of true spheres plus irregular particles collected in the complete test—thereby eliminating from the calculation any loss of spheres that may have occurred during handling and testing.

9. Report

9.1 Report the following information:

9.1.1 The weight percent of true spheres in the total specimen and

9.1.2 Whether Procedure A or Procedure B was used.

10. Precision and Bias[4]

10.1 The precision of this test method is based on an interlaboratory study of Test Method D1155, Test Method for Roundness of Glass Spheres, conducted in 2008. Five laboratories participated in this study. Each of the labs reported triplicate test results for a single material. Every "test result" reported represents an individual determination. Except for the use of data from only five laboratories and a single material, Practice E691 was followed for the design and analysis of the data; the details are given in the appropriate Research Report.

10.1.1 *Repeatability Limit (r)*—Two test results obtained within one laboratory shall be judged not equivalent if they differ by more than the "*r*" value for that material, "*r*" is the interval representing the critical difference between two test results for the same material, obtained by the same operator using the same equipment on the same day in the same laboratory.

10.1.2 *Reproducibility Limit (R)*—Two test results shall be judged not equivalent if they differ by more than the "*R*" value for that material; "*R*" is the interval representing the critical difference between two test results for the same material, obtained by different operators using different equipment in different laboratories.

10.1.2.1 Reproducibility limits are listed in Table 1.

10.1.3 The above terms (repeatability limit and reproducibility limit) are used as specified in Practice E177.

10.1.4 Any judgment in accordance with statement 10.1.2 would normally have an approximate 95 % probability of being correct, however the precision statistics obtained in this ILS must not be treated as exact mathematical quantities which are applicable to all circumstances and uses. The limited number of laboratories reporting results guarantees that there will be times when differences greater than predicted by the ILS results will arise, sometimes with considerably greater or smaller frequency than the 95 % probability limit would imply. The reproducibility limit should be considered as a general guide, and the associated probability of 95 % as only a rough indicator of what can be expected.

10.2 *Bias*—At the time of the study, there was no accepted reference material suitable for determining the bias for this test method, therefore no statement on bias is being made.

10.3 The precision statement was determined through statistical examination of 75 results, from five laboratories, on a single material.

11. Keywords

11.1 roundness; glass spheres

[4] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D01-1153. Contact ASTM Customer Service at service@astm.org.