



Standard Test Method for Measuring the Angle of Repose of Free-Flowing Mold Powders¹

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1. Scope

1.1 Particle size, shape, and bulk density will affect the flowability of powder material. This test method is used for the determination of the angle of repose of free-flowing mold powders. At angles greater than this value this material will flow.

1.2 The values stated in inch-pound units and degrees are to be regarded as standard. The values stated in parentheses are for information only.

1.3 *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:

E 691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method²

E 1169 Guide for Conducting Ruggedness Tests²

3. Significance and Use

3.1 This test method indicates the ability of a mold powder to flow freely.

3.2 The property of powder flow is an important property for the correct functioning of a mold powder. Good powder flow properties help to ensure complete coverage of the molten steel in the mold by the mold powder providing, in addition to other benefits, insulation of the molten steel.

4. Apparatus

4.1 *Funnel*, with a discharge spout opening between 0.25 in. (0.64 cm) and 0.38 in. (0.97 cm) with a capacity to hold approximately 0.25 lb (113.5 g) to 0.50 lb (227.2 g) of mold powder.

4.2 *Ring Stand*, with one ring, sized to hold the funnel.

4.3 *Stopper*, sized to fit the funnel discharge spout opening.

4.4 *Base Plate*, flat, rigid, wooden or metal, at least 12 in. (30.5 cm) by 12 in. (30.5 cm).

4.5 *Glazed Paper*,

4.6 *Calculator*, with trigonometric functions.

4.7 *Calipers*, with measuring range up to 12 in. (30.5 cm) to ± 0.01 in. (0.025 cm).

4.8 *Block*, with height of 1.5 in. (3.81 cm).

5. Procedure

5.1 Obtain approximately a 1-lb (454 g) sample of the mold powder. The sample should be homogeneous and representative of the bulk material. Place in a jar container 30 to 50 % larger than the sample to allow for remixing.

5.2 Measure the internal diameter of the funnel discharge spout in inches to the nearest 0.01 in. (0.025 cm).

5.3 Place the ring stand with funnel on a sheet of glazed paper on the base plate. Level the base plate along two perpendicular horizontal axes.

5.4 Place the height block in position under the funnel, adjust the funnel until the nozzle contacts the height block, lock the funnel in position, and remove the height block.

5.5 Insert the stopper into the funnel nozzle.

5.6 Feed the mold powder into the funnel until nearly full.

5.7 Remove the stopper from the funnel and continue adding the mold powder into the funnel at a rate similar to its discharge rate. When the tip of the mold powder cone forming on the base plate enters the funnel nozzle, stop feeding the mold powder into the funnel.

5.8 Using the calipers, measure the diameter of the cone in four places to the nearest 0.05 in. (0.13 cm). Average these four test observations and record this test determination to the nearest 0.05 in. (0.13 cm).

5.9 Return the tested specimen to the jar container and remix to homogenize. Repeat 5.2-5.8 two more times and record the three test determinations as D_1 , D_2 , and D_3 .

6. Calculation

6.1 Calculate the test result as follows:

$$\text{Angle of repose} = \tan^{-1} [2H/(D_A - d)] \quad (1)$$

where:

¹ This test method is under the jurisdiction of ASTM Committee C08 on Refractories and is the direct responsibility of Subcommittee C08.03 on Physical Properties.

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² *Annual Book of ASTM Standards*, Vol 14.02.

- H = height of the cone 1.5 in. (3.81 cm),
 D_A = average, to the nearest 0.10 in. (0.254 cm) of the three test determinations, D_1 , D_2 , and D_3 from 5.9, and
 d = internal diameter of the funnel nozzle, in.

7. Report

- 7.1 Report the following information:
 7.1.1 Designation of the mold powder, source, and date.
 7.1.2 Angle of repose to the nearest 0.1°.
 7.1.3 Date of the test and name of the operator.

8. Precision and Bias

8.1 Ruggedness Data—Ruggedness tests were conducted in 1997, following the procedures outlined in Guide E 1169, on an angle of repose procedure in which the funnel height above a fixed diameter circular disk was continuously increased until the maximum mold powder cone height was reached. Ruggedness variables studied included the height of the bottom of the funnel above the disk, the funnel discharge spout diameter, the funnel composition, the disk diameter, the centering of the funnel over the disk, and the method of feeding material into the funnel. Variables which were found to be non-rugged included the height of the funnel above the disk, the funnel discharge spout diameter, the centering of the funnel over the disk, and the method of feeding the material into the funnel. The funnel feed variable was eliminated by placing a stopper into the bottom of the funnel discharge spout during filling of the funnel. Even after specifying limits for the height of the funnel above the disk, the diameter of the funnel discharge spout and the centering of the funnel over the disk, round-robin tests showed this procedure to be non-rugged. This was due to the formation of a variable concave depression in the cone tip, resulting in an unacceptable variation in the calculated angle of repose. The current procedure negates the effect of the concave depression in the cone tip.³ Use of an uncovered base plate without the specified glazed paper affects the results.

³ Supporting data have been filed at ASTM Headquarters and may be obtained by requesting Research Report C08-1017.

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8.2 Interlaboratory Data—An interlaboratory round robin was conducted in 2000 using the current procedure, in which five laboratories determined the angle of repose of a free-flowing mold powder. Each laboratory used two different operators. Each operator calculated the test result for angle of repose three times. The precision statistics from this study are given in Table 1.³ Refer to Practice E 691 for calculation and explanation of the various components.

8.3 Precision:

8.3.1 Repeatability—The maximum permissible difference due to test error between two test results, obtained by one operator on the same material using the same test equipment, is given by the repeatability interval. The 95 % repeatability interval is given in Table 1. Two test results that do not differ by more than the repeatability interval will be considered to be from the same population, and, conversely, two test results that do differ by more than the repeatability interval will be considered to be from different populations.

8.3.2 Reproducibility—The maximum permissible difference due to test error between two test results, obtained by two operators in different laboratories on the same material using the specified test equipment, is given by the reproducibility interval. The 95 % reproducibility interval is given in Table 1. Two test results from different laboratories or different operators, or both, that do not differ by more than the reproducibility interval will be considered to be from the same population. Conversely, two test results from different laboratories or different operators, or both, that do differ by more than the reproducibility interval will be considered to be from different populations.

8.4 Bias—No justifiable statement of bias can be made since the true value for mold powder angle of repose cannot be established by an acceptable reference standard.

9. Keywords

- 9.1 angle of repose; flow; mold powder; refractories

TABLE 1 Precision Statistics

Average Angle of Repose	Standard Deviation Within	Standard Deviation Between	95 % Repeatability Interval	95 % Reproducibility Interval
33.4	0.5	0.8	1.4	2.4