



Standard Test Method for Inclined Plate Flow for Thermosetting Coating Powders¹

This standard is issued under the fixed designation D 4242; 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 specifies a method for determining the flow characteristics of a fused thermosetting coating powder down a plane inclined at a set angle to the horizontal. The test gives an indication of the degree of melt flow that may occur during the curing of the coating powder. This characteristic contributes to the coherence of the coating, to its surface appearance and to the degree of coverage over sharp edges (see Test Method D 2967), however, it should not be used as the sole factor for judgment. The test acts as a useful method for checking for batch to batch variation in the behavior of a given coating powder. Correlation between the results from coating powders of differing composition is not to be expected. This method is unlikely to yield meaningful results with coating powders which have gel times of less than one minute at the test temperature (see Test Method D 4217). Oven drafts, angle of inclination and pellet variations significantly affect results making inter-lab reproducibility somewhat difficult to correlate.

1.2 The values stated in SI units are to be regarded as the standard. The values given 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 to determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:

- D 792 Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement²
- D 2967 Test Method for Edge Coverage of Powder Coatings³
- D 4217 Test Method for Gel Time of Thermosetting Coating Powder³
- D 5965 Test Methods for Specific Gravity of Coating Powders³

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 D01.51 on Powder Coatings.

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² *Annual Book of ASTM Standards*, Vol 08.01.

³ *Annual Book of ASTM Standards*, Vol 06.02.

2.2 Other Documents:

- ISO 8130-2 Coating powders—Part 2: Determination of density by gas comparison pycnometer⁴
- ISO 8130-3 Coating powders—Part 3: Determination of density by liquid displacement pycnometer⁴
- ISO 8130–11:1997 Coating powders—Part 11: Inclined-plane flow test⁴

3. Terminology

3.1 Definitions:

3.1.1 *coating powder, n*—finely divided particles of resin, either thermoplastic or thermosetting, generally incorporating pigments, fillers, and additives and remaining finely divided during storage under suitable conditions, which after fusing and possibly curing, give a continuous film.

3.1.2 *powder coating, n*—coatings which are protective or decorative, or both, formed by the application of a coating powder to a substrate and fused in a continuous film by the application of heat or radiant energy.

3.1.3 *gel time of a coating powder*—the interval required at a given temperature for a coating powder to be transformed from a dry solid to a gel-like state.

3.1.4 *cure time of a coating powder*—the time required for a thermosetting coating powder to sufficiently chemically crosslink at a given temperature to provide the required coating properties.

3.1.5 *thermosetting, adj*—describing a material that, when heated per a minimum recommended cure condition, undergoes a chemical reaction and a permanent change to a more durable state capable of specific properties as designed for substrate protection or decoration, or both.

4. Summary of Test Method

4.1 The thermosetting coating powder is pressed into a pellet of standard size which is allowed to melt and flow down a heated inclined plate. The extent of flow is measured.

5. Significance and Use

5.1 This test method is useful for selecting coating powders of similar characteristics of melt flow under minimal shear. It is not recommended as an absolute measurement, but rather as a comparative measurement of samples on the same panel

⁴ Available from International Organization for Standards (ISO), 1 Rue de Varembe, Case Postale 56, CH-1211, Geneva 20, Switzerland.

*A Summary of Changes section appears at the end of this standard.

measured at the same time.

6. Apparatus

6.1 *Fan-assisted air circulation oven*, capable of maintaining the desired temperature to $\pm 2^{\circ}\text{C}$ ($\pm 4^{\circ}\text{F}$).

6.2 *Glass plates*, of suitable dimensions to undertake the test. As an alternative, metal plates may be used. However, these will need to be closely defined with respect to their composition and surface finish. The plates shall be sufficiently rigid so as not to flex during the test. The details of the glass or metal plates shall be included in the test report.

6.3 *Plate assembly*, of suitable metal and design that fits inside the oven. The assembly shall be capable of carrying one or more of the plates (6.2) in a horizontal position and at an angle of $65 \pm 1^{\circ}$ to the horizontal when moved by a lever projecting through the side of the oven. Alternatively a fixed plate holder, of suitable metal and design, capable of holding one or more of the plates at $65 \pm 1^{\circ}$ to the horizontal may be used. If otherwise agreed to, test angles other than 65° may be used and thus reported.

6.4 *Balance*, capable of measuring to ± 10 mg.

6.5 *Steel pellet-molding press*, together with a knockout rod, capable of making pellets of 12.5 ± 0.05 mm (0.5 ± 0.002 in.) in diameter and 6.5 ± 0.2 mm (0.25 ± 0.008 in.) thick.

6.6 *Steel rule*, graduated in millimeters.

7. Sampling

7.1 Obtain a representative sample of the coating powder.

7.2 Store the sample of coating powder in accordance with the manufacturer's recommendations, after sampling and prior to testing.

8. Procedure

8.1 Always include a sample of known flow in the test as a control. Carry out the determinations in duplicate.

8.2 Weigh on the balance to an accuracy of 10 mg a mass of the product under test equivalent in grams to half of the density of the coating powder in accordance with Test Methods D 792, D 5965, ISO 8130-2, or ISO 8130-3. By means of the pellet press, compact the coating powder into a pellet 12.5 ± 0.05 mm (0.5 ± 0.002 in.) in diameter and 6.5 ± 0.2 mm (0.25 ± 0.008 in.) thick and push the pellet out of the press with the knockout rod. Weigh the pellet to confirm that its mass is correct to 10 mg. If there is a delay between the commencement of the test and the preparation of the pellet, protect it against moisture absorption by storage in a desiccator or a sealed container.

8.3 Unless otherwise agreed, the temperature of the test shall be the recommended curing temperature. In the absence of this information, a temperature shall be used that provides an adequate pill flow for measurement.

8.4 If a plate assembly is to be used, place the plate(s) in the plate assembly in a horizontal position. Place the plate assembly and plate(s) into the oven set at the test temperature and allow the holder to attain the test temperature. Alternatively, it may be more convenient to maintain the plate assembly in the oven and carefully load the plate(s) in situ.

8.5 At the end of the preheat period turn off the circulation fan and open the door of the oven. Place the pellet(s) towards

the end of the plate(s) that will be uppermost when tilted. Close the door of the oven and restart the fan. This operation shall take no longer than 15 s to perform. After a further 15 s since closing the oven door, operate the plate assembly to bring the plate(s) to $65 \pm 1^{\circ}$ to the horizontal. Allow the plate(s) to remain in this position for 15 min. At the end of this period remove the plate(s) from the oven and allow to cool to room temperature in a horizontal position.

8.6 Using the steel rule, measure the total length of the flowed pellet in millimeters. This is most conveniently undertaken with glass plates by viewing from the reverse side and recording the total length of the flowed pellet. Record the measurements to the nearest 0.5 mm.

8.7 If a fixed plate holder is to be used, place the holder into the oven set at the test temperature and allow the holder to attain the test temperature. Metal panels are most commonly used with a fixed plate holder. Take the metal panel(s) at room temperature and place the prepared pellet(s) towards the end of the panel(s) that will be uppermost when positioned in the plate holder. Heat the underside of the end metal panel where the pellet(s) are located until the pellet(s) just stick to the metal. This is conveniently accomplished by resting the underside of the end of the panel on a hot plate and allowing the heat to conduct through the panel and cause the pellet(s) to adhere. This should take no longer than 5 s. Care should be taken to avoid excessive heat which will distort the shape of the pellet(s). Immediately (within 15 s) place the panel(s) onto the fixed plate holder already at test temperature in the oven. Allow the panel(s) to remain on the fixed plate holder at $65 \pm 1^{\circ}$ to the horizontal for 15 min. At the end of this period remove the panel(s) from the oven and allow to cool to room temperature in a horizontal position.

8.8 Using the steel rule, measure the total length of the flowed pellet in millimeters. Record the measurement to the nearest 0.5 mm.

9. Calculation

9.1 Whatever method of plate or panel support is used, if the duplicate results differ by less than 5 % of the lower figure, calculate and report the arithmetic mean to the nearest 0.5 mm. If the difference between the two results exceeds 5 %, repeat the procedure described in Section 8.

10. Report

10.1 The test report should contain at least the following information:

10.1.1 All details necessary to identify the product tested,

10.1.2 A reference to this standard,

10.1.3 The test temperature,

10.1.4 The weight of pellet,

10.1.5 The results of the test (individual values and mean value),

10.1.6 Plate composition and dimensions and if a metal panel was used, a description of its surface finish,

10.1.7 Method of plate support inside oven,

10.1.8 Any deviation from the test method specified, and

10.1.9 The date of the test.

11. Precision and Bias

11.1 *Precision*—It is not possible to specify the precision of

the procedure in Test Method D 4242 for measuring inclined plate flow because adequate data has not been established. No activity is planned to develop such data.

11.2 *Bias*—This test method has no bias because the value for plate flow is defined solely in terms of this test method.

12. Keywords

12.1 coating powder; pellet flow; pill flow; plate flow; powder coating; thermosetting

SUMMARY OF CHANGES

Committee D01 has identified the location of selected changes to this standard since the last issue (D 4242 - 01) that may impact the use of this standard.

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| (1) Scope clarified and expanded in Section 1. | (4) Apparatus details clarified and expanded in Section 6. |
| (2) References to ASTM and ISO standards added in Section 2. | (5) Procedure clarified and expanded in Section 8. |
| (3) Thermosetting definition added in Section 3. | (6) Precision statement revised. |

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