Designation: D1238 – 23

Standard Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer[1]

This standard is issued under the fixed designation D1238; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope*

1.1 This test method covers the determination of the rate of extrusion of molten thermoplastic resins using an extrusion plastometer.

1.2 The values stated in SI units are to be regarded as standard.

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

NOTE 1—This standard and ISO 1133 address the same subject matter, but differ in technical content.

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D618 Practice for Conditioning Plastics for Testing

D883 Terminology Relating to Plastics

D3364 Test Method for Flow Rates for Poly(Vinyl Chloride) with Molecular Structural Implications

D4000 Classification System for Specifying Plastic Materials

D5947 Test Methods for Physical Dimensions of Solid Plastics Specimens

E4 Practices for Force Calibration and Verification of Testing Machines

E456 Terminology Relating to Quality and Statistics

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

2.2 *ANSI Standard:*

B46.1 on Surface Texture[3]

2.3 *ISO Standard:*

ISO 1133 Determination of the Melt-Mass Flow Rate (MFR) and the Melt Volume-Flow Rate (MVR) of Thermoplastics[3]

3. Terminology

3.1 Terms used in this standard are defined in accordance with Terminology D883, unless otherwise specified. For terms relating to precision and bias and associated issues, the terms used in this standard are defined in accordance with Terminology E456.

4. Summary of Test Method

4.1 After a specified preheating time, resin is extruded through a die with a specified length and orifice diameter under prescribed conditions of temperature, load, and piston position in the barrel. Four procedures are described. Comparable results have been obtained by these procedures in interlaboratory round-robin measurements of several materials and are described in Section 16.

4.2 Procedure A is used to determine the melt flow rate (MFR) of a thermoplastic material. The units of measure are grams of material/10 min (g/10 min). It is based on the measurement of the mass of material that extrudes from the die over a given period of time. It is generally used for materials having melt flow rates that fall between 0.15 and 50 g/10 min (see Note 2).

4.3 Procedure B is an automatically timed measurement used to determine the melt flow rate (MFR) as well as the melt

[1] This test method is under the jurisdiction of ASTM Committee D20 on Plastics and is the direct responsibility of Subcommittee D20.30 on Thermal Properties (Section D20.30.08).

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[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 National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

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

volume rate (MVR) of thermoplastic materials. MFR measurements made with Procedure B are reported in g/10 min. MVR measurements are reported in cubic centimeters/10 min (cm^3/10 min). Procedure B measurements are based on the determination of the volume of material extruded from the die over a given period of time. The volume is converted to a mass measurement by multiplying the result by the melt density value for the material (see Note 3). Procedure B is generally used with materials having melt flow rates from 0.50 to 1500 g/10 min.

4.4 Procedure C is an automatically timed measurement used to determine the melt flow rate (MFR) of polyolefin materials. It is generally used as an alternative to Procedure B on samples having melt flow rates greater than 75 g/10 min. Procedure C involves the use of a modified die, commonly referred to as a "half-die," which has half the height and half the internal diameter of the standard die specified for use in Procedures A and B thus maintaining the same length to diameter ratio. The test procedure is similar to Procedure B, but the results obtained with Procedure C shall not be assumed to be half of those results produced with Procedure B.

4.5 Procedure D is a multi-weight test commonly referred to as a "Flow Rate Ratio" (FRR) test. Procedure D is designed to allow MFR determinations to be made using two or three different test loads (either increasing or decreasing the load during the test) on one charge of material. The FRR is a dimensionless number derived by dividing the MFR at the higher test load by the MFR at the lower test load. Results generated from multi-weight tests shall not be directly compared with results derived from Procedure A or Procedure B.

NOTE 2—Polymers having melt flow rates less than 0.15 or greater than 900 g/10 min may be tested by the procedures in this test method; however, precision data have not been developed.

NOTE 3—Melt density is the density of the material in it molten state. It is not to be confused with the standard density value of the material. See Table 4.

5. Significance and Use

5.1 This test method is particularly useful for quality control tests on thermoplastics.

5.2 The data produced by this test method serves to indicate the uniformity of the flow rate of the polymer as made by an individual process. It is not to be used as an indication of uniformity of other properties without valid correlation with data from other tests.

5.3 The flow rate obtained with the extrusion plastometer is not a fundamental polymer property. It is an empirically defined parameter critically influenced by the physical properties and molecular structure of the polymer and the conditions of measurement. The rheological characteristics of polymer melts depend on a number of variables. It is possible that the values of these variables occurring in this test will differ substantially from those in large-scale processes, which would result in data that does not correlate directly with processing behavior.

5.4 Measure the flow rate of a material using any of the conditions listed for the material in X4.1. For many materials, there are specifications that require the use of this test method, but with some procedural modifications that take precedence when adhering to the specification. Therefore, it is advisable to refer to that material specification before using this test method. Table 1 in Classification D4000 lists the ASTM materials standards that currently exist. An alternative test method for poly (vinyl chloride) (PVC) compounds is found in Test Method D3364.

5.5 Additional characterization of a material can be obtained if more than one condition is used. In the case that two or more conditions are employed, a Flow Rate Ratio (FRR) is obtained by dividing the flow rate at one condition by the flow rate at another condition. Procedure D provides one method to measure more than one condition in a single charge.

5.6 Frequently, variations in test technique, apparatus geometry, or test conditions, which defy all but the most careful scrutiny, exist, causing discrepancies in flow rate determinations. A troubleshooting guide is found in Appendix X2 and it is a resource to be used to identify sources of test error.

6. Apparatus

6.1 *Extrusion Plastometer (Alternative Names—Melt Indexer, Melt Flow Indexer):*

NOTE 4—Older plastometers that were manufactured in accordance with "design specifications" detailed in previous revisions of this test method (pre D1238 - 04c) are deemed to be acceptable, as long as they meet the dimensional and performance specifications stated in this section.

NOTE 5—Relatively minor changes in the design and arrangement of the component parts have been shown to cause differences in results among laboratories. For the best interlaboratory agreement, it is important that the design adhere closely to the description herein; otherwise, it should be determined that modifications do not influence the results. Refer to Fig. 1.

6.1.1 The apparatus is a dead-weight piston plastometer consisting of a thermostatically controlled heated steel cylinder with a bore that contains a die at the lower end, and a weighted piston operating within the cylinder. The essential features of the plastometer, illustrated in Figs. 1 and 2, are described in 6.2-6.12. The bore of the extrusion plastometer shall be properly aligned in the vertical direction (see Appendix X1). All dimensional measurements shall be made when the article being measured is at 23 ± 5°C. As an acceptable alternative, the test force can be applied via a drive system working with a load cell. In case of dispute between two cooperating laboratories, the dead weight plastometer shall be considered correct.

6.2 *Cylinder*—The cylinder shall be 50 mm ± 10 mm in diameter, 115 to 180 mm in length with a smooth, straight bore 9.5504 ± 0.0076 mm in diameter. The cylinder bore shall be manufactured in a way that produces a finish approximately 12 rms or better in accordance with ANSI B46.1. Means shall be provided to monitor the temperature inside the bore.

6.3 *Die (Orifice):*

6.3.1 *Standard Die*—The outside diameter of the die shall be such that it will fall freely to the bottom of the hole in the cylinder. The orifice of the die shall have a smooth straight bore 2.095 ± 0.005 mm in diameter and shall be 8.000 ± 0.025 mm in length (see Fig. 2). The bore of the orifice and its finish are

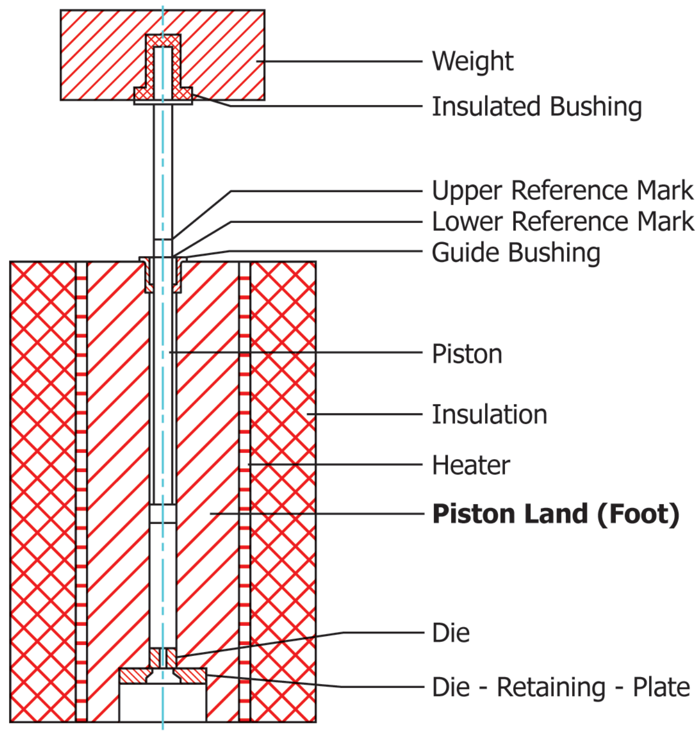

FIG. 1 General Arrangement of Extrusion Plastometer (See Section 6.)

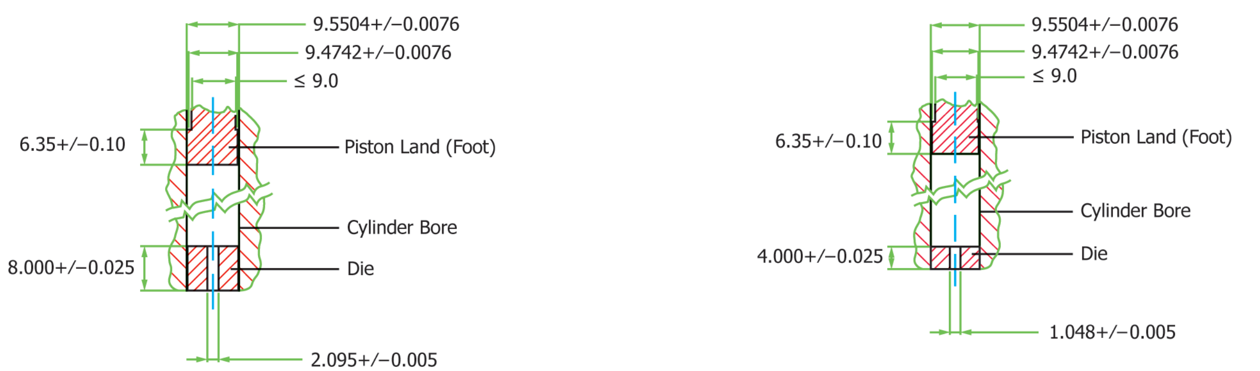

Figure #2 - Dimensions of the cylinder bore, piston foot & standard die

All measurements in "mm"

Figure #2a - Dimensions of the cylinder bore, piston foot & "half" die

FIG. 2 Details of Extrusion Plastometer

critical. It shall have no visible drill or other tool marks and no detectable eccentricity. The bore of the orifice shall be manufactured by techniques known to produce finishes approximately 12 rms or better in accordance with ANSI B46.1.

6.3.2 *"Half" Die—Used for Procedure C.* When testing polyolefins with a MFR of 75 or greater (using the standard die), an alternate die has shown to improve the reproducibility of results by reducing the flow rate of these materials. The outside diameter of the die shall be such that it will fall freely to the bottom of the hole in the cylinder. The orifice shall have a smooth straight bore 1.048 ± 0.005 mm in diameter and shall be 4.000 ± 0.025 mm in length (see Fig. 2A). The bore of the orifice and its finish are critical. It shall have no visible drill or other tool marks and no detectable eccentricity. The bore of the orifice shall be manufactured by techniques known to produce finishes approximately 12 rms or better in accordance with ANSI B46.1 (Note Note 6). No spacer shall be used with this die.

NOTE 6—Recommended die material is tungsten carbide. Also satisfactory are steel, synthetic sapphire, and cobalt-chromium-tungsten alloy. When softer materials are used, it will be necessary to conduct critical dimensional checks and visual inspections on the die more often.

6.4 *Piston:*

6.4.1 The piston shall be made of steel. There shall be insulation at the top as a barrier to heat transfer from the piston to the weight. The piston shall be prevented from rubbing on the bore. Most commercially available instruments use a loose fitting metal guide sleeve, but other methods are acceptable. The weight of the sleeve shall not be considered as part of the test load. The land (foot) of the piston shall be