Designation: D 3419 – 00

Standard Practice for In-Line Screw-Injection Molding Test Specimens From Thermosetting Compounds[1]

This standard is issued under the fixed designation D 3419; 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 practice covers the general principles to be followed when injection molding test specimens of thermosetting materials. It is to be used to obtain uniformity in methods of describing the various steps of the injection molding process and in the reporting of those conditions. The exact molding conditions will vary from material to material, and should become part of the material specification or be agreed upon between the purchaser and the supplier.

NOTE 1—The utility of this practice has been demonstrated for the molding of thermosetting molding compounds exhibiting lower-viscosity non-Newtonian flow.

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 problems, 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.*

1.4 This practice assumes the use of reciprocating screw injection molding machines.

NOTE 2—This standard is similar in content (but not technically equivalent) to ISO 10724: 1994(E).

2. Referenced Documents

2.1 *ASTM Standards:*

D 883 Terminology Relating to Plastics[2]

D 958 Practice for Determining Temperatures of Standard ASTM Molds for Test Specimens of Plastics[3]

2.2 *ISO Standards:*

ISO 10724: 1994(E)—Plastics—Thermosetting Moulding Materials—Injection Moulding of Multipurpose Test Specimens[4]

ISO 3167: 1993, Plastics—Multipurpose Test Specimens[4]

3. Terminology

3.1 *Definitions:*

3.1.1 *General*—Definitions of terms applying to this practice appear in Terminology D 883.

3.1.2 *injection molding*—the process of forming a material by forcing it, in a fluid state and under pressure, through a runner system (sprue, runner, and gate(s)) into the cavity of a closed mold.

3.1.3 *Discussion*—Screw-injection molding and reaction-injection molding are types of injection molding.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *breathing, v*—the operation of opening a mold or press for a very short period of time at an early stage in the process of cure.

3.2.2 *Discussion*—Breathing allows the escape of gas or vapor from the molding material and reduces the tendency of thick moldings to blister.

3.2.3 *cavity (of a mold), n*—the space within a mold to be filled to form the molded product.

3.2.4 *landing (of a cavity), v*—the practice of relieving the mold around the cavity (cavities), thus reducing the surface area of the flat mating surfaces of the mold halves. Typical lands are 4.5 mm (3⁄16 in.) to 6 mm (1⁄4 in.) in width. Landing pads should be incorporated to hold the mold open 0.0125 mm (0.0005 in.) to prevent damage to the lands.

4. Significance and Use

4.1 This practice is subject to the definition of injection molding given in 3.1.2 with the further provision that with in-line screw injection the plastic compound, heated in a chamber by conduction and friction, is fluxed by the action of a reciprocating screw and then is forced into a hot mold where it solidifies. Hereafter, in-line screw-injection molding will be referred to simply as injection molding.

4.2 The mold referenced in this section (Fig. 1) is generally useful, and describes what have been the most common specimens required for the testing of thermosets. ISO specimens and testing are gaining favor, however. ISO 10724 describes the layout and practice for injection molding the multi-purpose specimens per ISO 3167.

[1] This practice is under the jurisdiction of ASTM Committee D20 on Plastics and is the direct responsibility of Subcommittee D20.09 on Specimen Preparation.

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

[3] Discontinued 1995. See *1994 Annual Book of ASTM Standards*, Vol 08.01.

[4] Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

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

4.3 Typically, injection-molded test specimens are made with shorter cycles than those used for similar moldings made by compression, and the cycle is equal to or faster than that for transfer molding.

4.4 Breathing of the mold is not usually required to release trapped volatile material as the gas is free to flow from the vent end of the mold. This is particularly advantageous for heat-resistant compounds and reduces the tendency for molded specimens to blister at high exposure temperatures.

4.5 Injection molding is intended for low-viscosity compounds. One set of processing parameters cannot be specified for all types of thermosetting materials, nor for samples of the same material having different plasticities.

4.6 Materials containing fibrous fillers such as glass roving, chopped cloth, or cellulosic fibers can be injection molded, but their properties will be affected depending upon how much fiber breakdown occurs as the compound is worked by the screw and as it passes through the system of runners and gates. The orientation of the fibers in the molded specimen will also affect injection-molded properties.

4.7 Flow and knit lines in a molded piece are often sites of mechanical or electrical weakness. The fluxed material passing through the gate wrinkles and folds as it proceeds into the mold cavity. Knit lines may be found to some degree throughout the molded piece; these knit lines affect end-test results. Fibers and other reinforcements in the molding compound align with the flow pattern and, consequently, may be perpendicular to the axis of the bar at its center and parallel at its surface.

4.7.1 Placement and size of gates and vents can be used to minimize flow and knit lines, for example, side gating of bars will minimize the tendency of the material to fold onto itself as the material front proceeds through the length of the mold.

4.8 The izod impact strength of injection-molded specimens containing short fibers will generally be lower than the values obtained using compression molding methods. The impact strength may also vary along the axis of the bar due to molding parameters, flow patterns, and fiber orientation.

4.9 The flexural and tensile strength of injection-molded specimens of molding compounds containing short fibers will generally be higher than the values obtained using compression-molding methods. Flexural tests are particularly sensitive to injection molding due to the thin resin skin formed at the surface of the bar during final filling of the cavity and pressure buildup.

4.10 At constant mold temperature the following parameters may cause an underfilled condition at the vented end of the cavity: incorrect plasticity, too low an injection pressure, insufficient material, too long an injection time, blocked vents, high stock temperature, or incorrect die temperature.

5. Apparatus

5.1 *In-Line, Screw-Injection Machine*— A device incorporating a hydraulically or electrically driven screw which, working against a predetermined back pressure, draws material from the feed hopper and by frictional and conducted heat works a charge of material into a hot plastic state. Following the plasticating step, the screw stops rotating, moves forward and forces the hot material through the nozzle, sprue, runner, and gate into the cavity. The machine should be capable of accurately delivering and maintaining suitable injection and clamp pressures within the range from 70 to 140 MPa (10 000 to 20 000 psi). Measurement of actual molding pressures can be made with pressure transducers placed strategically in the cavities.

5.1.1 The clamp force of the machine shall be sufficient to prevent excessive flashing under all operating conditions (see 5.2.5).

5.2 *Mold*—The mold cavities and layout will depend on the specimens required by the tests in question. Fig. 1 has been found satisfactory, although molds with fewer cavities and/or different configurations may be used. Molds with multiple-identical-cavity layouts with symmetrical gates and runners are normally recommended. Single cavity molds are not recommended. In either case, it is important to describe the mold in the report on the specimen preparation.

5.2.1 Family molds like the one shown in Fig. 1 require proper precautions to ensure that constant and uniform filling is achieved in all cavities.

5.2.2 Gate dimensions equal to two-thirds of the width and height of end-gated specimens are recommended for specimens not greater than 4-mm (0.16-in.) thickness. For specimens over 4-mm (0.16-in.) thickness, or for other than end-gated specimens, gate dimensions of 8 mm (0.31 in.) width by 3 mm (0.12 in.) thickness are recommended. The gates should be as short as possible, not exceeding 3 mm (0.12 in.) in length.

5.2.3 Suitable venting must be provided from each cavity. Dimensions of 4 to 6 mm (0.16 to 0.24 in.) width by 0.05 to 1 mm (0.002 to 0.004 in.) depth are recommended.

5.2.4 It is recommended that cavities be landed, so that if flashing does occur, the mold will re-close after the injection stroke. Typical lands are 4.5 mm (3/16 in.) to 6 mm (1/4 in.) in width. Landing pads should be incorporated to hold the mold open 0.0125 mm (0.0005 in.) to prevent damage to the lands.

5.2.5 Full round runners, at least 6 mm (0.24 in.) diameter, are recommended as they offer less resistance to flow.

5.2.6 Sharp corners in gates and runners are to be avoided as they can cause hot spots and premature curing.

5.2.7 On larger specimens, such as discs or plaques, multiple gates can produce knit lines where the material flows together. One larger gate is generally better than several smaller gates.

5.2.8 Mold surfaces should be finished to a roughness of 0.4 um to 0.8 um (SPI-SPE #2 or equivalent[5]), unless it is known that the particular test is not affected by a coarser surface finish. Chrome plating is recommended but not necessary. All cavity surfaces should be draw polished to facilitate specimen removal.

5.2.9 Hydraulic or mechanical knockout systems outside of the specimen test area may be used.

5.2.10 For specimens no greater than 4 mm (0.16 in.) thickness, a maximum cavity draft angle of 1° should be used. For thicker specimens a maximum cavity draft angle of 2° may be used.

[5] Mold comparison kits are available from the D-M-E Co., 29111 Stephenson Highway, Madison Heights, MI 48071.