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An American National Standard

AMERICAN SOCIETY FOR TESTING AND MATERIALS
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Standard Practice for Compression Molding Thermoplastic Materials into Test Specimens, Plaques, or Sheets[1]

This standard is issued under the fixed designation D 4703; 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 compression molding of thermoplastic granules and milled stock for the preparation of test specimens.[2]

1.2 Certain ASTM standards require the use of Test Method D 1928 for compression molding of polyethylene test specimens. Determine whether such requirements exist before using this practice.

1.3 While conditions for certain materials are given, the primary source of specific conditions shall be the material specification standards for each type of material.

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

1.5 *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.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 1928 Test Method for Preparation of Compression-Molded Polyethylene Test Sheets and Test Specimens[3]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *average cooling rate (°C/min), n*—the cooling rate calculated by dividing the difference between the molding and demolding temperatures by the time required to cool the mold to the demolding temperature.

3.1.2 *cooling rate (°C/h), n*—the rate of cooling obtained by controlling the flow of the cooling fluid in such a way that during each 10-min interval, the deviation from this specified cooling rate shall not exceed the specified tolerance.

3.1.3 *demolding temperature*, *n*—the temperature of the mold or the press platens at the end of the cooling time, measured in the nearest vicinity to the molded material.

3.1.3.1 *Discussion*—For positive molds, holes are normally drilled in the mold for measuring the temperatures defined in 3.1.3 and 3.1.4.

3.1.4 *molding temperature*, *n*—the temperature of the mold or the press platens during the preheating and molding time, measured in the nearest vicinity to the molded material.

3.1.5 *molding time*, *n*—the time during which full pressure is applied while maintaining the molding temperature.

3.1.6 *preheating time*, *n*—the time required to heat the material in the mold up to the molding temperature while maintaining the contact pressure.

4. Significance and Use

4.1 The methods by which sample materials are prepared and molded influence the mechanical properties of the specimen. Unlike injection molding, the objective of compression molding is to produce test specimens or sheets that are both homogeneous and isotropic. Molded specimens may be made either from pellets such as are received directly from a material manufacturer, particles produced in a recycle recovery operation, or from a milled preform or sheet prepared on a two-roll mill. The pellets, particles, preform, or sheet are melted and molded in a mold designed to produce a finished specimen of a given geometry, size, and thickness, or melted and molded in the form of a smooth plaque or sheet of uniform thickness from which desired specimens are cut, punched, or machined. Working a compound on a two-roll mill prior to molding will disperse and distribute the compound additives in a manner that will affect the physical properties of the compound. The need for milling a sample prior to compression molding may be determined by reference to the relevant material specification or the material manufacturer. It is important to treat different samples of the same type of material in the same way: if milling was done prior to molding on a material which is to be used as a standard for comparison, all new materials to be tested against this practice should be prepared and molded in a similar manner.

4.2 The apparatus and exact conditions required to prepare adequate specimens may vary for each plastic material. Apparatus and procedures which should be satisfactory for molding many different plastic materials are given in this practice in Sections 5 and 6. The apparatus and procedures which have been found satisfactory for molding certain specific materials

[1] This practice is under the jurisdiction of ASTM Committee D-20 on Plastics and is the direct responsibility of Subcommittee D20.09 on Specimen Preparation.

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[2] This practice was created as a coalescence of and replacement for Practices D 2292, D 3010, and D 3463.

[3] *Annual Book of ASTM Standards*, Vol 08.02.

are given in the Appendix. In any case, the apparatus and procedures to be used in producing compression-molded specimens of a given material may be obtained by reference to the relevant material specification and should be agreed upon between the purchaser and the supplier.

TABLE 1 Cooling Methods

Cooling Method	Average Cooling Rate (See 3.1.1), °C/min	Cooling Rate (See 3.1.2), °C/min	Remarks
A	10 + 5		
B	15 + 5		
C	60 + 30		Quench cooling
D		5 + 0.5	Slow cooling

5. Apparatus

5.1 *Mill*—Any size two-roll mill having chrome-plated rolls, capable of maintaining a constant temperature within ± 2°C (±3.6°F) of the temperature needed for the particular material involved, and being adjustable in speed as needed for the material to be worked, is adequate. Some recommendations for mills to be used for specific types of materials are given in the Appendix.

5.2 *Molds*:

5.2.1 *Mold Types*—Several different types of molds may be used for the compression molding of test specimens of thermoplastics. In general, however, the molds used will fall into one of two categories: a *flash-type* mold (see Figs. 1 and 2) or a *positive-type* mold (see Fig. 3). The characteristics of the test specimens prepared by using different types of molds are not the same. In particular, the mechanical properties depend on the pressure applied to the material during cooling.

5.2.2 *Flash-Type Mold*—The flash-type mold may be of the *picture-frame* type, where a steel chase (the picture frame) is sandwiched between two thin steel ferrotype plates (see Fig. 1), or it may be of the machined-cavity type (see Fig. 2), where the mold consists of a cavity machined in a steel plate, with a single steel ferrotype plate used as a top or cover. The cavity, or cavities, in the flash-type mold may be constructed to mold a single plaque from which test specimens may be stamped or machined, or the mold may be built to mold one or more specimens to finished dimensions. Flash molds permit excess molding material to be squeezed out and do not exert molding pressure on the material during cooling. Nevertheless, this type of mold is useful for preparing test specimens or panels of similar thickness or comparable levels of low internal stress.

5.2.3 *Positive-Type Mold*—The positive-type mold consists of a cavity machined in a plate or block of steel and a force or plunger which closely mates with the sidewalls of the cavity (see Fig. 3). Like the flash-type mold, the cavity may be built to produce a plaque from which test specimens may be stamped or machined, or to mold a test specimen to finished dimensions. Because of the manner in which the positive mold operates, it is recommended that this mold type, either for a plaque or a finished specimen, be limited to a single cavity. In the positive-type mold, the full molding pressure, neglected friction, is exerted on the material during cooling. The thickness, stress and density of the resulting moldings depend on the mold construction, the size of the material charge, and the molding conditions. This type of mold produces test specimens with high density, and it is particularly suitable for obtaining flat surfaces and for suppressing the formation of voids within test specimens.

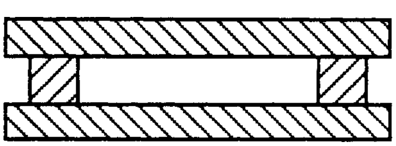

FIG. 1 Flash Picture-Frame Mold

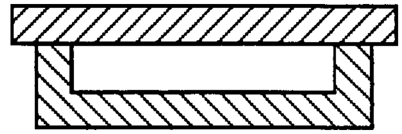

FIG. 2 Flash Mold with Machined Cavity

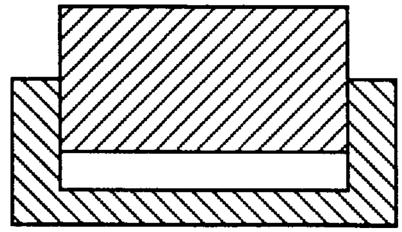

FIG. 3 Positive-Type Mold

5.2.4 *Mold Surfaces*—The surfaces of either type of mold that form the flat faces of the specimen should be finished to the degree required by the test for which the specimen is intended. For most tests, a surface quality of SPI-SPE #2 is adequate.[4] The edges of the mold cavity should be visually free of nicks and scratches which could cause premature failure of the specimen during testing.

5.3 *Press*:

5.3.1 The press shall have a clamping force capable of applying a pressure (conventionally given as the ratio of the clamping force to the area of the mold cavity) of at least 10 MPa (1450 psi), and shall be capable of maintaining pressure within 10 % of the specified pressure during the molding cycle.

5.3.2 The platens of the press shall be capable of being heated to at least 240°C, and being cooled at a rate consistent with the cooling method selected from Table 1.

5.3.3 The platens or mold shall be heated either by high-pressure steam, by a heat-conducting fluid in an appropriate channel system, or by using electric-heating elements. The platens or mold are cooled by a heat-conducting fluid (usually cold water) in a channel system.

5.3.4 The heating and cooling systems in the mold platens shall be such that, when used with a particular mold, they shall be capable of maintaining a temperature difference between points on the mold surfaces of no more than ±5°C during heating or cooling.

5.3.5 For quench cooling (Method C in Table 1), two presses shall be used, one for heating during molding and the

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

other for cooling unless it can be demonstrated that the press used for heating can cool at the specified rate.

NOTE 1—For a specified cooling method, the flow rate of the heat-conducting fluid should be predetermined in a test without any material in the mold.

6. Procedure

6.1 *Preparation of Molding Material*:

6.1.1 *Drying of Granular Material*—Dry the granular material as specified in the relevant material specification, or in accordance with the material supplier's instructions. If no instructions are given, dry for 24 ± 1 h at 70 ± 2°C in an oven.

6.1.2 *Preparation of Preforms*—Direct molding of test specimens, plaques, and sheets from granules shall be the standard procedure, provided that a sufficiently homogeneous sheet is obtained. Normally this means that the molded specimen, plaque, or sheet is free from surface irregularities and internal imperfections. Poly(vinyl chloride) (PVC) compounds and chlorinated poly(vinyl chloride) (CPVC) compounds will generally require milling to obtain a preform for the final molding procedure.

6.1.3 *Milling*—Direct molding from powder or granules may sometimes require melt homogenization using a hot-melt milling or mixing procedure to achieve a satisfactory final sheet. Where such is required, a two-roll mill will usually perform satisfactorily. Take the milled material from the mill and cut or shape it to become a preform for the compression mold in which it ultimately will be molded. Use milling conditions that do not degrade the polymer. Recommended conditions for milling the material, particularly the stock temperature and time on the rolls, may be obtained from the relevant material specification or the material manufacturer. The preform prepared by milling should normally be thicker than the specimen, plaque, or sheet to be molded to enable the molding to be done properly.

6.2 *Molding*:

6.2.1 Adjust the mold temperature to within ±5°C of the molding temperature indicated in the relevant material specification.

6.2.2 Place a weighed quantity of the material (granules or preforms) in the preheated mold. If granular material is used, make sure that it is evenly spread over the mold surface. The mass of the material shall be sufficient to fill the cavity volume when it is melted and allow about a 10 % loss for a flash mold and about a 3 % loss for a positive mold. With flash molds, cover the mold with the top ferrotype plate (see Figs. 1 and 2) and then place the mold in the preheated press. With picture-frame (Fig. 1) molds or large, heavy molds it may not be necessary or desirable to preheat the mold itself. This will then require slight increases in the preheat time of the cycle and the temperature stability of the material must be considered.

6.2.3 Close the press and preheat the material charge by applying a contact pressure for a minimum of 5 min. Then apply full pressure for a minimum of 2 min (molding time, see 3.1.5) and then cool down (see 6.3).

NOTE 2—A preheating time of 5 min is the standardized time for evenly spread material charges sufficient for sheets up to 2 mm in thickness. For thicker moldings, adjust the time accordingly.

NOTE 3—At contact pressure the press is just closed with a pressure low enough to avoid flow of the material. Full pressure means a pressure sufficient to shape the material and squeeze out the excess material.

6.3 *Cooling*:

6.3.1 *General*—With some thermoplastics, the cooling rate affects the ultimate physical properties. For this reason, the cooling methods are specified in Table 1. The method of cooling shall always be stated together with the final physical properties. The appropriate cooling method is normally given in the relevant material specification. If no method is indicated, Method B shall be used.

6.3.2 *Cooling Methods*—The appropriate cooling method shall be selected from Table 1.

6.3.2.1 In the case of quench cooling (see Method C in Table 1), transfer the mold assembly from the heating press to the cooling press as quickly as possible. If the heating press has the capability to cool at the specified rate, it may be used for the cooling step.

6.3.3 The demolding temperature shall be <40°C if no other instructions are given.

NOTE 4—Method D is recommended for producing test specimens free of any internal stress, or for slow cooling after annealing of previously prepared sheets.

7. Inspection of the Molded Specimens, Plaques, or Sheets

7.1 After cooling, check the molded specimens, plaques, or sheets for appearance (such as sink marks, shrink holes, discolorations) and for conformance to specified dimensions. Discard any test specimens or sheets having molding defects.

7.2 Make sure there is no degradation or unwanted crosslinking, using the method specified in the relevant material specification, or as agreed upon between the interested parties.

8. Report

8.1 Provide the following information in the processing report:

8.1.1 Reference to this practice and the relevant material specification,

8.1.2 Dimensions of the specimen and its intended use,

8.1.3 Complete identification of molding material (type, designation, etc.),

8.1.4 Preparation of molding material:

8.1.4.1 Drying conditions for granules and powder, and

8.1.4.2 Processing conditions used in the preparation of preforms and their average thickness,

8.1.5 Type of mold and plates used,

8.1.6 Molding conditions:

8.1.6.1 Preheating time,

8.1.6.2 Molding temperature, pressure, and time,

8.1.6.3 Cooling method used, and

8.1.6.4 Demolding temperature,

8.1.7 State of specimen, if applicable, and

8.1.8 Any other observations.

9. Precision and Bias

9.1 No statement is made about either the precision or the bias of this practice for preparation of compression-molded test specimens since there is no numerical result.