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An American National Standard

AMERICAN SOCIETY FOR TESTING AND MATERIALS
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Standard Test Methods for Deformation of Plastics Under Load[1]

This standard is issued under the fixed designation D 621; 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.

These test methods have been approved for use by agencies of the Department of Defense to replace Method 1101 of Federal Test Method Standard 406, and for Listing in the DoD Index of Specifications and Standards.

$^{\epsilon 1}$ NOTE—The safety hazards caveat and the Precision and Bias section were added editorially in March 1988. The Referenced Documents section was also added, causing the renumbering of subsequent sections.

1. Scope

1.1 These test methods cover the determination of the deformation under compression of nonmetallic sheet and molded plastic materials, of all classes and all commercial thicknesses, intended for structural and insulating purposes. Two test methods are included, as follows:

Test Method A—For rigid plastics.

Test Method B—For nonrigid plastics.

1.2 The word deformation is used herein in the broad sense to cover (*1*) dimensional change due almost entirely to flow, and (*2*) dimensional change due to a combination of flow and shrinkage caused by loss of water or other volatile matter. The word flow as used in these test methods may describe either plastic or elastic deformation or combinations thereof.

NOTE 1—The values stated in SI units are to be regarded as the standard.

NOTE 2—Methyl methacrylate and polystyrene are examples of materials that deform almost entirely by flow. Cellulose acetate, cellulose acetate butyrate, phenolic laminated fiber, and vulcanized fiber are examples of materials that deform by a combination of flow and shrinkage.

1.3 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems 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 374 Test Methods for Thickness of Solid Electrical Insulation[2]

D 575 Test Methods for Rubber Properties in Compression[3]

D 618 Methods of Conditioning Plastics and Electrical Insulating Materials for Testing[2]

3. Significance and Use

3.1 Data obtained by Test Method A give a measure of the ability of a rigid plastic in assemblies of conductors and insulators that are held together by bolts, rivets, or similar fastening devices, to withstand compression without yielding and loosening the assembly with time. Test Method A also gives a measure of the rigidity of plastics at service temperatures and consequently can be used as an identification test for procurement purposes.

3.2 Data obtained by Test Method B give a measure of the ability of a nonrigid plastic to return to its original dimensions with time after having been deformed. Test Method B determines the extent to which the plastic will follow associated parts in applications requiring elastic properties.

TEST METHOD A—RIGID PLASTICS

4. Nature of Test

4.1 The principle of Test Method A is essentially that of the parallel plate plastometer, namely, a constant-force system whereby a test specimen is conditioned, if necessary, and is then placed between the parallel plates of a constant-force device and the thickness observed over a required period at the stipulated temperature or temperatures.

5. Apparatus

5.1 *Testing Machine*—A machine capable of exerting a constant force of 113 kg (250 lb), 227 kg (500 lb), and 454 kg (1000 lb) ±1 % between the parallel anvils of the machine, which shall be arranged so that they can be brought into contact with the test specimen before the load is applied. A machine suitable for this test is shown in Fig. 1. A recommended method for calibrating such a device is given in the Appendix. One of the anvils of the machine shall preferably be self-aligning and shall, in order that the load may be applied evenly over the face of the specimen, be arranged so that the specimen is accurately centered and the resultant of the load is through its center. The machine shall also be equipped with a dial gage or the equivalent capable of measuring the relative movement of the faces to 0.025 mm (0.001 in.) or less. A thermometer of the total immersion type shall be suspended in such a manner that the bulb is

[1] These test methods are under the jurisdiction of ASTM Committee D-20 on Plastics and are the direct responsibility of Subcommittee D20.30 on Thermal Properties (Section D20.30.07).

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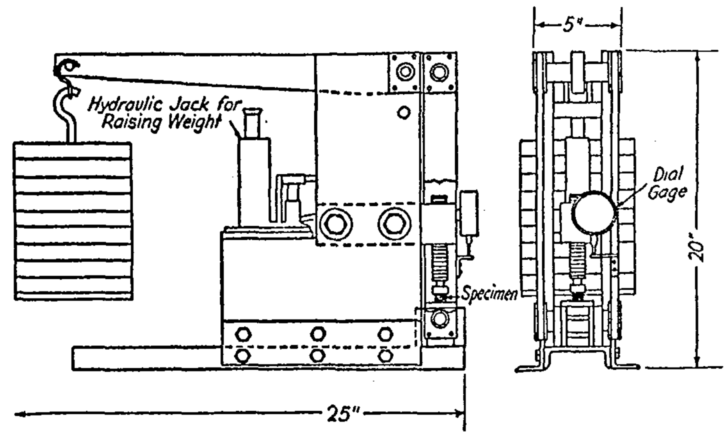
[2] *Annual Book of ASTM Standards*, Vol 08.01.

[3] *Annual Book of ASTM Standards*, Vol 09.01.



Metric Equivalents

in.	5	20	25
mm	127	508	635

FIG. 1 Deformation Testing Machine

approximately level with the specimen and not more than 76 mm (3 in.) therefrom.

5.2 *Test Chamber*—A test chamber of suitable size and construction to enclose the testing machine and maintain it during the test within ±1°C (2°F) of the specified test temperature, except for the short period at the beginning when opening the door may cause a drop in temperature.

6. Test Specimens

6.1 The test specimen shall be a 12.7-mm (½-in.) cube, either solid or composite. Materials over 12.7 mm (½ in.) in thickness shall be reduced to 12.7 mm (½ in.), and thinner materials shall be piled up with the total height as near to 12.7 mm (½ in.) as possible. The squares of the composite specimen shall be accurately aligned in all cases. Surfaces of the test specimens shall be plane and parallel.

6.2 The specimens for materials made in large sheets, such as phenolic laminated fiber, where moisture absorption characteristics may vary over the entire surface, shall be prepared, unless otherwise specified, in accordance with the sampling method described in 6.3, which averages the effect over the sheet by selecting squares comprising the specimen in such a manner that each square represents the same proportional part of the entire area of the sheet.

6.3 *Specimen from Sheet Materials*—The specimen shall be selected from the whole sheet by cutting a strip 12.7 mm (½ in.) in width from the sheet, parallel to the two long edges if the sheet is not square or parallel to any two if it is square, midway between them, and extending from the edge to the center of the sheet. If quarter sheets are used, the strip shall be taken from the edge corresponding to the center-to-edge section of the original whole sheet. The strip shall be divided into eight equal parts numbered from 1 to 8, beginning with the piece corresponding to the edge of the sheet. The squares used to form the composite test specimen shall be taken from these pieces. If the whole piece is not used, the squares cut from it shall be taken from the end which was originally nearest the edge of the sheet. If any piece is insufficient for the number of squares required to be cut from a piece bearing that number, a second strip shall be cut adjacent to the first one, cut into pieces, and the required number of squares taken from the appropriate pieces. The number of squares to be cut from each piece is prescribed in Table 1.

NOTE 3—Substantial variations in test values may occur, particularly with composite specimens, if the opposite faces of the specimens are not plane and parallel or if sink marks or other similar imperfections are present. To minimize such variations, the squares used to form the composite specimens, if necessary, shall be rendered plane and parallel and their adjoining surfaces shall be freed of sink marks and other imperfections by milling, grinding, or other appropriate means. If solid cubes are used, their opposite faces in contact with the anvils of the testing machine, if necessary, shall be milled plane and parallel and shall be smooth and free of imperfections.

7. Conditioning

7.1 Where deformation under average room conditions is required, condition and test specimens in accordance with 7.1.1 and 7.1.2.

7.1.1 *Conditioning*—Condition the test specimens at 23 ± 2°C (73.4 ± 3.6°F) and 50 ± 5 % relative humidity for not less than 40 h prior to test in accordance with Procedure A of Methods D 618 for those tests where conditioning is re-

TABLE 1 Number of Squares to be Cut from Each Piece

NOTE—In case of material of thicknesses not included in the table, the squares used in the composite test specimen shall be selected in accordance with the method for nearest thickness given in the table. In case the thickness is midway between two adjacent values in the table, the squares used in the composite test specimen shall be selected in accordance with the instructions for the thinner material.

Thickness of Material, mm (in.)	Total Number of Squares Required	Number of Piece							
		1	2	3	4	5	6	7	8
0.40 (1/64)	32	8	6	6	4	3	3	2	...
0.79 (1/32)	16	4	3	3	2	2	1	1	...
1.19 (3/64)	11	2	2	2	2	1	1	1	...
1.59 (1/16)	8	2	1	1	1	1	1	1	...
2.38 (3/32)	5	1	1	1	1	...	1	...	...
3.2 (1/8)	4	1	1	1	...	1	...	...	...
4.8 (3/16)	3	1	...	1	...	1	...	...	...
9.5 (3/8)	1	...	...	1	...	...	...	...	...
12.7 (1/2)	1	...	...	1	...	...	...	...	...

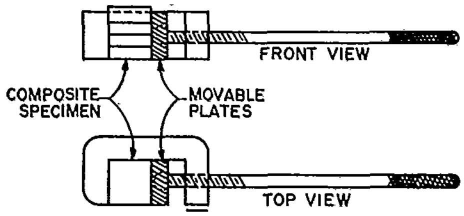


FIG. 2 Jig for Composite Specimen

quired. In cases of disagreement, the tolerances shall be ±1°C (±1.8°F) and ±2 % relative humidity.

7.1.2 *Test Conditions*—Conduct tests in the Standard Laboratory Atmosphere of 23 ± 2°C (73.4 ± 3.6°F) and 50 ± 5 % relative humidity, unless otherwise specified in the test methods or in these test methods. In cases of disagreement, the tolerances shall be ±1°C (±1.8°F) and ±2 % relative humidity.

7.2 In those materials where shrinkage is a large part of total deformation, the specimens shall be preconditioned for 4 h at 65 ± 3°C (150 ± 5°F) and then conditioned for 68 h at a temperature of 35 ± 1°C (95 ± 1.8°F) and a relative humidity of 90 ± 2 %, unless otherwise specified. The specimens shall be supported during conditioning upon a ⅛-in. mesh wire screen or the equivalent in order to permit free access of the atmosphere to all surfaces.

7.3 Where a quick measurement of total deformation is desired, such as for procurement of materials wherein the flow is relatively great compared to shrinkage, the specimens shall be exposed for 16 to 18 h in a circulation air oven at 50°C (122°F). The specimens shall be removed from the oven and cooled to the Standard Room Temperature (Methods D 618) in a desiccator over anhydrous calcium chloride for a period of at least 3 h.

7.4 Where it is definitely known that the material is not moisture-responsive, conditioning of any kind may be omitted.

8. Test Temperatures

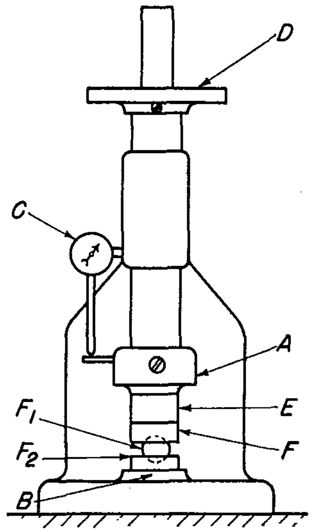
8.1 The test temperature, that is, the temperature of the chamber containing the testing apparatus shall be one or more of the following: 23°C (73.4°F), 50°C (122°F), and 70°C (158°F), each temperature being maintained within ±1°C (1.8°F).

9. Recommended Limiting Value of Deformation

9.1 It is recommended that, whenever practicable, deformation values should not exceed 25 % since the engineering significance of substantially higher values is doubtful. In the event that the combination of force and temperature originally chosen as best representing probable service applications results in deformation in excess of 25 %, it is suggested that the factor that is of lesser importance from a service standpoint be lowered to the next specified condition.

10. Procedure

10.1 Place the conditioned test specimens between the anvils of the testing machine immediately upon removal from the conditioning atmosphere. The specimens tested without conditioning shall be at room temperature when placed in the testing machine. Where composite specimens



A—Movable anvil.
B—Stationary plate.
C—Thickness indicator.
D—Weight platform.
E—Test specimen.
F—Lower anvil mounted on ball support (F_1) and loose plate (F_2).

FIG. 3 Low-Pressure Deformation Tester

are used, take care to ensure that the squares are well aligned.

10.2 Apply the load to the specimen without shock and take the initial reading 10 s after the full load is on the specimen. At the end of 24 h, take a second reading and record the total change in height in mils. Determine the original height in mils of the specimen by measuring the specimen after it is removed from the testing machine and adding to this the total change in height as read on the dial of the testing machine.

NOTE 4—*Composite Specimen Procedure:* The height of a composite specimen is difficult to determine accurately without disturbing the position of each square in the stack. Therefore it is recommended that the stack be removed as a unit by the use of a jig such as a small toolmaker's clamp (Fig. 2) and the height measured by a machinist micrometer to 0.0025 mm (0.0001 in.) by Method A of Test Methods D 374. In no case shall sufficient clamping pressure be used to mushroom the edges of the composite specimen. The initial and final height of the composite specimen in the test machine may also be measured by use of a long-range dial micrometer and calibrated slug.

11. Calculation

11.1 Calculate the deformation as the percentage change in height of the test specimens after 24 h, as follows:

$$\text{Deformation, \%} = (A/B) \times 100$$

where:
A = change in height in mm (mils) in 24 h, and
B = original height in mm (mils).

12. Report

12.1 The report shall include the following:

12.1.1 Original height of test specimen in mils,

12.1.2 Thickness of components in mils where a composite test specimen is used,

12.1.3 Conditioning procedure,

12.1.4 Temperature of test and force applied, 12.1.5 Change in height of the test specimen in 24 h in mils, and

12.1.6 Deformation (flow or combined flow and shrinkage) expressed as the percentage change in height of the test specimen calculated on the basis of its original height.

TEST METHOD B—NONRIGID PLASTICS

13. Nature of Test

13.1 Test Method B is essentially the same as Test Method A except that the pressure is 0.69 MN/m^2 (100 psi), and the period of test used for deformation is 3 h. The recovery is based on removing the specimen from compression and allowing it to remain at the stated temperatures for a period of 1 h and at room temperature for ½ h, after which the amount of recovery is measured.

14. Apparatus

14.1 *Testing Machine*—A testing machine similar in principle and operation to the one described in Test Method A (5.1), except that it shall be capable of exerting a constant force of 45 kg (100 lb) ±1 %. A machine suitable for this test is illustrated in Fig. 3. The machine shown in Fig. 1 may be used provided it is equipped with a locking device for the upper anvil so as to obtain a zero point. A lock nut added to the upper portion of the movable anvil has been found suitable for this purpose.

NOTE 5—In making tests in accordance with Test Method B, care should be taken to reduce machine friction to a minimum. This is particularly desirable when using the high-pressure machine shown in Fig. 1.

14.2 *Test Chamber*—A test chamber similar to that prescribed in Test Method A (5.2).

14.3 *Conditioning Chamber*—A chamber for drying, consisting of a desiccator provided with anhydrous calcium chloride.

15. Test Specimens

15.1 The test specimens shall be 28.67 mm (1.129 in.) in diameter by 12.7 mm (½ in.) in thickness, this size being suitable for the high-pressure testing machine shown in Fig. 1, whose arm without weights but including pan provides a load of 45 kg (100 lb) (Note 6). A single specimen shall be used. The specimen shall be molded or cut (Note 7) from a 12.7-mm (½-in.) sheet at least 25.4 mm (1 in.) from the edges and so selected as to be of uniform thickness, homogeneous, and free from bubbles.

NOTE 6—Unavoidable variations in diameter of the specimen may require slight adjustment of load to obtain 0.69 MN/m^2 (100 psi).

NOTE 7—A tool suitable for this purpose is described in Test Methods D 575.

16. Conditioning

16.1 The specimen shall be conditioned by placing it in the desiccator for 24 h, unless it is definitely established that the material is not affected by moisture. The specimen shall be so supported and desiccated as to permit free access of the atmosphere to all faces and edges.

16.2 The test temperatures, that is, the temperatures of the chamber containing the testing apparatus, shall be one or more of the following: 23°C (73.4°F), 50°C (122°F), and 70°C (158°F), each temperature being maintained within ±1°C (1.8°F).

17. Procedure

17.1 The procedure for Test Method B shall be the same as that of Test Method A, as described in the procedure section, except that the duration of the deformation test shall be 3 h. Also, obtain the zero point or initial reading for the beginning of the test by determining the dial reading with the anvils together under full load and calculating the zero point from the thickness of the specimen measured with a micrometer having a low-pressure ratchet attachment and capable of measuring to the nearest 0.2 mil. After determining the thickness of the specimen at the end of 3 h, remove the specimen from the machine and leave for 1 h in the chamber at the temperature at which it is being tested. Then remove it from the chamber and keep at room temperature for ½ h, after which again determine the thickness with a micrometer.

18. Calculation

18.1 Calculate the deformation and recovery as follows:

$$\text{Deformation, } \% = [(H_0 - H_1)/H_0] \times 100$$

$$\text{Recovery, } \% = [(H_2 - H_1)/(H_0 - H_1)] \times 100$$

where:

H_0 = original specimen height or thickness,
H_1 = specimen thickness after 3 h under load of 0.69 MN/m^2 (100 psi), and
H_2 = specimen thickness 1½ h after load removal.

19. Report

19.1 The report shall include the following:

19.1.1 Temperature of test,

19.1.2 Original thickness of test specimens in mils,

19.1.3 Total deformation in 3 h expressed as a percentage change in thickness calculated on the basis of its original thickness, and

19.1.4 Recovery, the total increase in specimen height which occurs during the 1½-h period following load removal, expressed as a percentage of the original deformation.

20. Precision and Bias

20.1 Attempts to develop precision and bias for this test method have not been successful.[4]

[4] To participate in the development of precision and bias data, contact the staff manager for Committee D-20 on Plastics at ASTM Headquarters.

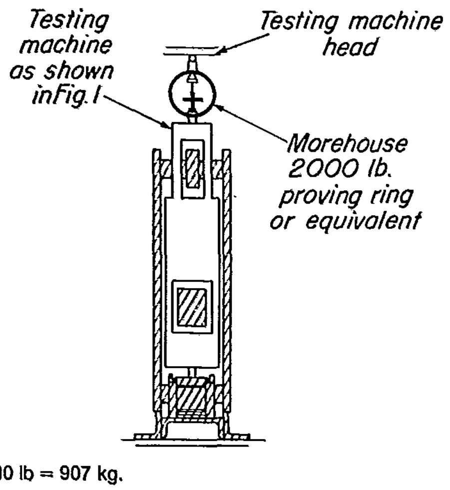
APPENDIX

(Nonmandatory Information)

X1. CALIBRATION OF DEFORMATION-UNDER-LOAD TESTING MACHINE IN ACCORDANCE WITH METHOD A

X1.1 The deformation-under-load testing machine may be calibrated by means of a calibrating bar and a proving ring, as shown in Fig. X1.1. Figure X1.2 shows a calibrating bar with dimensions suitable for use in the testing machine illustrated in Fig. 1.

X1.2 The dial gage, is actuating detail, the upper anvil and screw, and the jack control handles should be removed to make room for the calibrating bar which, when properly in place, will be in contact with only the lower anvil of the load deformation machine. The weight of the calibrating bar and the proving ring should be determined and added to the load indicated by the proving ring. The testing machine with the calibrating bar and the proving ring should be set up in a compression testing machine or other suitable machine which has sufficient opening and is controllable to move the upper contact of the proving ring up or down or hold it stationary, as required. To calibrate the machine for any load the weights to be used for giving that load should be placed on the machine. Readings of the proving ring may be made with the compression machine held stationary or with the proving ring and test bar moving either up or down. Movement at a rate of a few mils per second is easy to attain and provides sufficient time for measurement. For a complete calibration it is desirable to measure the loads with the machine both moving and stationary in the upper, middle, and lower positions.



NOTE—2000 lb = 907 kg.

FIG. X1.1 Arrangement of Bar and Proving Ring in Calibration of Testing Machine

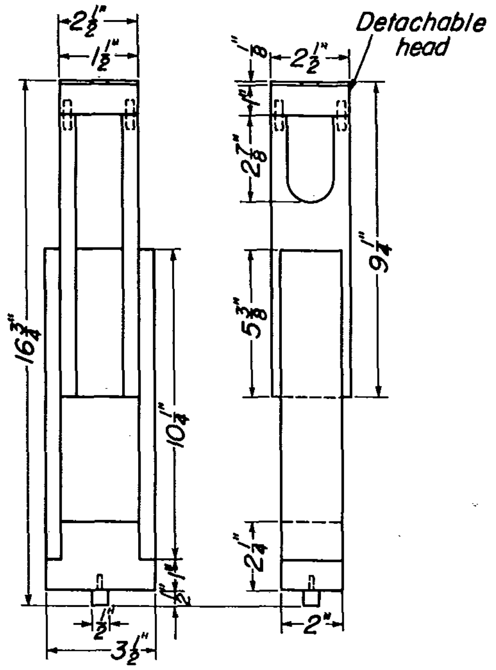


Table of Metric Equivalents

in.	mm
⅛	3.2
½	12.7
1	25.4
2	50.8
2¼	57
2½	63
2⅞	73
3½	89
5⅜	136
9¼	235
10¼	260
16¾	425

FIG. X1.2 Bar for Calibrating Deformation-Under-Load Testing Machine