Designation: D 1621 – 00

# Standard Test Method for Compressive Properties Of Rigid Cellular Plastics[1]

This standard is issued under the fixed designation D 1621; 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 Department of Defense.*

## 1. Scope *

1.1 This test method describes a procedure for determining the compressive properties of rigid cellular materials, particularly expanded plastics, based on test machine crosshead motion.

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

NOTE 1—This test method and ISO 844 are technically equivalent.

## 2. Referenced Documents

2.1 *ASTM Standards:*

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

E 4 Practices for Force Verification of Testing Machines[3]

E 691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method[4]

2.2 *ISO Standard:*

ISO 844 Cellular Plastics—Compression Test of Rigid Materials[5]

## 3. Terminology

3.1 *Definitions:*

3.1.1 *compressive deformation*—the decrease in length produced in the gage length of the test specimen by a compressive load expressed in units of length.

3.1.2 *compressive strain*—the dimensionless ratio of compressive deformation to the gage length of the test specimen or the change in length per unit of original length along the longitudinal axis.

3.1.3 *compressive strength*—the stress at the yield point if a yield point occurs before 10 % deformation (as in Fig. 1a) or, in the absence of such a yield point, the stress at 10 % deformation (as in Fig. 1b).

3.1.4 *compressive stress (nominal)*—the compressive load per unit area of minimum original cross section within the gage boundaries, carried by the test specimen at any given moment, expressed in force per unit area.

3.1.5 *compressive stress-strain diagram*—a diagram in which values of compressive stress are plotted as ordinates against corresponding values of compressive strain as abscissas.

3.1.6 *compressive yield point*—the first point on the stress-strain diagram at which an increase in strain occurs without an increase in stress.

3.1.7 *deflection*—crosshead movement after the loading plates contact the specimen, expressed in millimetres or inches.

3.1.8 *gage length*—the measured thickness of the test specimen expressed in units of length.

3.1.9 *modulus of elasticity*—the ratio of stress (nominal) to corresponding strain below the proportional limit of a material expressed in force per unit area based on the minimum initial cross-sectional area.

3.1.10 *proportional limit*—the greatest stress that a material is capable of sustaining without any deviation from proportionality of stress-to-strain (Hooke's law) expressed in force per unit area.

## 4. Significance and Use

4.1 This test method provides information regarding the behavior of cellular materials under compressive loads. Deformation data can be obtained, and from a complete load-deformation curve it is possible to compute the compressive stress at any load (such as compressive stress at proportional-limit load or compressive strength at maximum load) and to compute the effective modulus of elasticity.

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[1] This test method is under the jurisdiction of ASTM Committee D-20 on Plastics and is the direct responsibility of Subcommittee D20.22 on Cellular Plastics.

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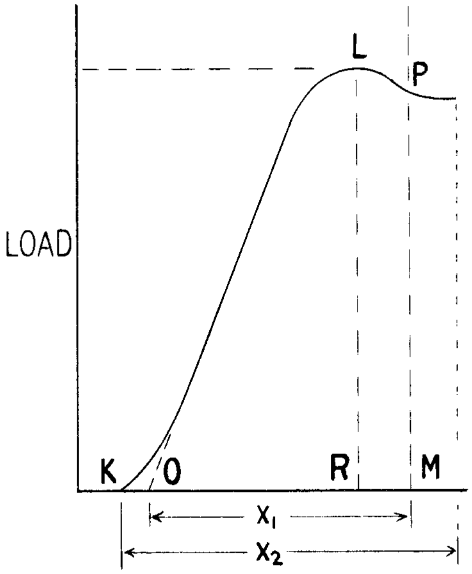
[2] *Annual Book of ASTM Standards*, Vol 08.01.

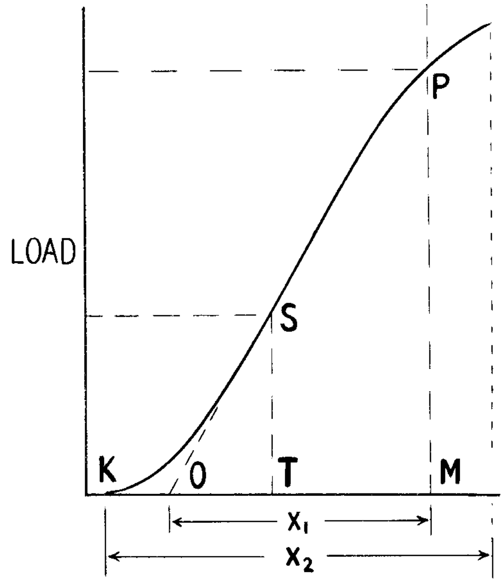
[3] *Annual Book of ASTM Standards*, Vol 03.01.

[4] *Annual Book of ASTM Standards*, Vol 14.02.

[5] 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.**




$X_1$ = 10 % CORE DEFORMATION
$X_2$ = DEFLECTION (APPROXIMATELY 13 %)

**FIG. 1 a Compressive Strength (See 3.1.3 and Section 9)**

**FIG. 1 b Compressive Strength (See 3.1.3 and Section 9)**

4.2 Compression tests provide a standard method of obtaining data for research and development, quality control, acceptance or rejection under specifications, and special purposes. The tests cannot be considered significant for engineering design in applications differing widely from the load - time scale of the standard test. Such applications require additional tests such as impact, creep, and fatigue.

4.3 Before proceeding with this test method, reference should be made to the specification of the material being tested. Any test specimen preparation, conditioning, dimensions, and/or testing parameters covered in the materials specification shall take precedence over those mentioned in this test method. If there are no material specifications, then the default conditions apply.

## 5. Apparatus

5.1 *Testing Machine*—Any suitable compression testing machine capable of operating at a constant rate of motion of the movable crosshead may be used. A spherical loading block of the suspended, self-aligning type is recommended for the upper loading platen.

5.2 *Load Indicator*—Use a load-indicating mechanism that will permit measurements to a precision of ±1 %. Verify the calibration of the test machine and lead indicator in accordance with Practices E 4.

5.3 *Deformation Indicator*—Use a deformation-indicating mechanism that will permit measurements to a precision of ±0.1 %.

5.4 *Micrometer Dial Gage*, caliper, or steel rule, suitable for measuring dimensions of the specimens to ±1 %.

NOTE 2—Although the use of dial gages or automatic recorders to measure crosshead movement and thus obtain deformation complies with this test method, it should be pointed out that this is not exactly comparable to the use of strain-measuring devices mounted on the specimen. The use of crosshead movement to obtain strain leads to values of moduli of elasticity having considerable variation, and to values perhaps only one tenth of those obtained by measuring strain directly on the specimen.

## 6. Test Specimen

6.1 The test specimen shall be square or circular in cross section with a minimum of 25.8 $cm^2$ (4 $in.^2$) and maximum of 232 $cm^2$ (36 $in.^2$) in area. The minimum height shall be 25.4 mm (1 in.) and the maximum height shall be no greater than the width or diameter of the specimen. Care should be taken so that the loaded ends of the specimen are parallel to each other and perpendicular to the sides.

NOTE 3—Cellular plastics are not ideal materials, and the compressive modulus may appear significantly different, depending on the test conditions, particularly the test thickness. All data that are to be compared should be obtained using common test conditions.

6.2 All surfaces of the specimen shall be free from large visible flaws or imperfections. If it is necessary to place gage marks on the specimen, this shall be done so as not to affect the surfaces of the specimen.

6.3 If the material is suspected to be anisotropic, the direction of the compressive loading must be specified relative to the suspected direction of anisotropy.

6.4 A minimum of five specimens shall be tested for each sample. Specimens that fail at some obvious flaw should be discarded and retests made, unless such flaws constitute a variable the effect of which it is desired to study.

## 7. Conditioning

7.1 *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 Practice D 618, unless otherwise specified in the contract or relevant material specification. In cases of disagreement, the tolerances shall be ±1°C (±1.8°F) and ±2 % relative humidity.

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

## 8. Procedure

8.1 Measure the dimensions of the specimen to a precision of ±1 % as follows:

8.1.1 Measure thicknesses up to and including 25.4 mm (1 in.) using a dial-type gage with a foot having a minimum area of 6.45 $cm^2$(1 $in.^2$). Hold the pressure of the dial foot to 0.17 ± 0.03 kPa (0.025 ± 0.005 psi).

8.1.2 Measure dimensions over 25.4 mm (1 in.) with a dial gage, a sliding-caliper gage, or a steel scale or tape. When a sliding-caliper gage is used, the proper setting shall be that point at which the measuring faces of the gage contact the surfaces of the specimen without compressing them.

8.1.3 Record each dimension as an average of three measurements.

8.2 Apply the load to the specimen in such a manner that it is distributed as uniformly as possible over the entire loading surface of the specimen. The rate of crosshead movement shall be 2.5 ± 0.25 mm (0.1 ± 0.01 in.)/min for each 25.4 mm (1 in.) of specimen thickness.

8.3 Use crosshead movement as a measure of deflection. If an automatic recorder is not used, measure the deflection in increments no greater than 0.5 % of the original thickness of the specimen. At each measurement, record the deformation and the corresponding load.

8.4 Continue until a yield point is reached or until the specimen has been compressed approximately 13 % of its original thickness, whichever occurs first.

8.4.1 When specified, a deformation other than 10 % may be used as the point at which stress shall be calculated. In such a case, compress the specimen approximately 3 % more than the deformation specified. Substitute the specified deformation wherever "10 % deformation" is cited in Sections 9 and 10.

## 9. Calculation

9.1 If an automatic recorder was not used, construct a load-deflection curve from the incremental values obtained in accordance with 8.3.

9.2 Using a straightedge, carefully extend to the zero load line the steepest straight portion of the load-deflection or load-strain curve. This establishes the "zero deformation" or "zero strain" point (Point *O* in Fig. 1a and Fig. 1b). Measure all distances for deformation or strain calculations from this point.

9.3 Measure from Point *O* along the zero-load line a distance representing 10 % deformation. At that point (Point *M* in Fig. 1a and Fig. 1b), draw a vertical line intersecting the load-deflection or load-strain curve at Point *P*.

9.3.1 If there is no yield point before Point *P* (as in Fig. 1b), read the load at Point *P*.

9.3.2 If there is a yield point before Point *P* (as Point *L* in Fig. 1), read the load and measure the percent core deformation or strain (Distance *O-R*) at the yield point.

9.3.3 Calculate the compressive strength by dividing the load (9.3.1 or 9.3.2) by the initial horizontal cross-sectional area of the specimen.

9.4 If compressive modulus is requested, choose any convenient point (such as Point *S* in Fig. 1b) along the straight portion of the load-deflection or load-strain curve. Read the load and measure the deformation or strain (Distance *O-T*) at that point.

9.4.1 Calculate the apparent modulus as follows:

$$E_c = WH/AD \quad (1)$$

where:
$E_c$ = modulus of elasticity in compression, Pa (psi),
$W$ = load, N (lbf),
$H$ = initial specimen height, m (in.),
$A$ = initial horizontal cross-sectional area, $m^2$ ($in.^2$),and
$D$ = deformation, m (in.).

9.4.2 Calculate the estimated standard deviation as follows:

$$s = \sqrt{(\Sigma x^2 - n\bar{X}^2)/(n-1)} \quad (2)$$

where:
$s$ = estimated standard deviation,
$x$ = value of a single observation,
$n$ = number of observations,and
$\bar{X}$ = arithmetic mean of the set of observations.

## 10. Report

10.1 Report the following information:

10.1.1 Complete identification of the material tested, including type, source, code numbers, form, principal dimensions, previous history, etc.

10.1.2 Number of specimens tested if different from that specified in 6.4.

10.1.3 Conditioning procedure used if different from that specified in Section 7.

10.1.4 Atmospheric conditions in test room if different from those specified in Section 7.

10.1.5 Values for each specimen, plus averages and standard deviations, of modulus (if requested) and compressive strength.

10.1.6 Deformation at maximum load to two significant figures.

10.1.7 Date of test.

## 11. Precision

11.1 Table 1 is based on a round robin[6] conducted in 1998 in accordance with Practice E 691, involving three materials tested by seven laboratories. For each material, all of the samples were prepared at one source, but the individual specimens were prepared at the laboratories that tested them. Each test result was the average of seven individual determinations. Each laboratory obtained six test results for each

[6] Supporting data are available from ASTM Headquarters. Request RR:D20–1201.

TABLE 1 Precision Data

| Materials | Average, psi | $S_r$ [A] | $S_R$ [B] | $r$ [C] | $R$ [D] |
|---|---|---|---|---|---|
| A | 13.6307 | 1.1491 | 1.6078 | 3.2174 | 4.5019 |
| B | 31.3183 | 1.0944 | 1.1213 | 3.0642 | 3.1398 |
| C | 10.3981 | 0.9796 | 1.0764 | 2.7430 | 3.0141 |

[A] $S_r$= within-laboratory standard deviation for the indicated material. It is obtained by pooling the within-laboratory standard deviations of the test results from all of the participating laboratories.

[B] $S_R$= between-laboratories reproducibility, expressed as standard deviation.

[C] $r$ = within-laboratory critical interval between two test results = 2.8 × $S_r$.

[D] $R$ = between-laboratories critical interval between two test results = 2.8 × $S_R$.

material. Precision, characterized by repeatability ($S_r$ and $r$) and reproducibility ($S_R$ and $R$) has been determined as shown in Table 1.

NOTE 4—Caution: The explanation of $r$ and $R$ are only intended to present a meaningful way of considering the approximate precision of this test method. The data in Table 1 should not be applied to acceptance or rejection of materials, as these data apply only to the materials tested in the round robin and are unlikely to be rigorously representative of other lots, formulations, conditions, materials, or laboratories. Users of this test method should apply the principles outlined in Practice E 691 to generate data specific to their materials and laboratory.

NOTE 5—The precision data presented in Table 1 was obtained using the test conditions defined in this test method. If a material specification defines other test conditions, this precision data shall not be assumed to apply.

## 12. Keywords

12.1 cellular plastics; compressive modulus; compressive strength

## SUMMARY OF CHANGES

This section identifies the location of selected changes to this test method. For the convenience of the user, Committee D–20 has highlighted those changes that may impact the use of this test method. This section may also include descriptions of the changes or reasons for the changes, or both.

*D 1621 – 00:*

(*1*) Section 3, Terminology —Changed definitions to meet the one sentence requirement.

(*2*) Added 4.3.

(*3*) Revised 7.1.

(*4*) Added 9.4.2.

(*5*) Added precision statement, Section 11, including Note 4 and Note 5.

(*2*) Included the Summary of Changes section.