



Standard Test Methods for Breaking Load and Flexural Properties of Block-Type Thermal Insulation¹

This standard is issued under the fixed designation C 203; 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 These test methods cover the determination of the breaking load and calculated flexural strength of a rectangular cross section of a preformed block-type thermal insulation tested as a simple beam. It is also applicable to cellular plastics. Two test methods are described as follows:

1.1.1 *Test Method I*—A loading system utilizing center loading on a simply supported beam, supported at both ends.

1.1.2 *Test Method II*—A loading system utilizing two symmetric load points equally spaced from their adjacent support points at each end with a distance between load points of one half of the support span.

1.2 Either test method is capable of being used with the four procedures that follow:

1.2.1 *Procedure A*—Designed principally for materials that break at comparatively small deflections.

1.2.2 *Procedure B*—Designed particularly for those materials that undergo large deflections during testing.

1.2.3 *Procedure C*—Designed for measuring at a constant stress rate, using a CRL (constant rate of loading) machine. Used for breaking load measurements only.

1.2.4 *Procedure D*—Designed for measurements at a constant crosshead speed, using either a CRT (constant rate of traverse) or CRE (constant rate of extension) machine. Used for breaking load measurements using a fixed crosshead speed machine.

1.3 Comparative tests are capable of being run according to either method or procedure, provided that the method or procedure is found satisfactory for the material being tested.

1.4 These test methods are purposely general in order to accommodate the widely varying industry practices. It is important that the user consult the appropriate materials specification for any specific detailed requirements regarding these test methods.

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

1.6 *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.* For specific precautionary statements, see Section 11.

2. Referenced Documents

2.1 *ASTM Standards:*²

C 133 Test Methods for Cold Crushing Strength and Modulus of Rupture of Refractories

C 168 Terminology Relating to Thermal Insulation

C 390 Practice for Sampling and Acceptance of Preformed Thermal Insulation Lots

C 870 Practice for Conditioning of Thermal Insulating Materials

D 76 Specification for Tensile Testing Machines for Textiles

E 4 Practice for Force Verification of Testing Machines

3. Terminology

3.1 Terminology **C 168** shall be considered applied to the terms used in this method.

4. Summary of Test Methods

4.1 A bar of rectangular cross section is tested in flexure as a beam as follows:

4.1.1 *Test Method I*—The bar rests on two supports and is loaded by means of a loading fitting or piece midway between the supports (see **Fig. 1**).

4.1.2 *Test Method II*—The bar rests on two supports and is loaded at the two quarter points (by means of two loading fittings), each an equal distance from the adjacent support

¹ These test methods are under the jurisdiction of ASTM Committee C16 on Thermal Insulation and are the direct responsibility of Subcommittee C16.32 on Mechanical Properties.

Current edition approved Nov. 1, 2005. Published December 2005. Originally approved in 1945. Last previous edition approved 2005 as C 203 – 05.

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.

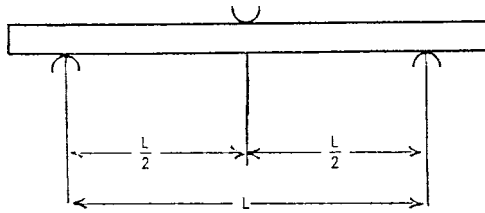


FIG. 1 Loading System for Test Method I

point. The distance between the loading fittings is one half of the support span (see Fig. 2).

4.2 The specimen is deflected until rupture occurs, unless the materials specification indicates termination at a particular maximum strain level.

NOTE 1—One criteria used is to limit the strain to 5 %. If failure does not occur at 5 % strain, the strain rate is increased and the test repeated on a new specimen.

4.3 Procedures A and B allow for testing at two different strain rates. Procedure C specifies a stress rate. Procedure D specifies a rate of extension or traverse.

4.3.1 Procedure A specifies a strain rate of 0.01 in./in. (mm/mm) that is useful for testing insulations that are very stiff or break at quite low deflections.

4.3.2 Procedure B specifies a strain rate of 0.1 in./in. (mm/mm) which is useful for testing insulations that are relatively flexible or break at higher deflections.

4.3.3 Procedure C specifies a stress rate of 550 psi (3.79 MPa)/min except as applicable in the materials specification.

4.3.4 Procedure D specifies a CRE machine with a fixed crosshead speed, or a CRT machine with a movable load clamp, such as the Scott tester. Because the strain rate is a function of specimen geometry, this procedure does not give a constant strain rate for specimens of different thicknesses tested on the same loading fixture.

5. Significance and Use

5.1 These test methods are to be used to determine the resistance of some types of preformed block insulation when transverse loads are normally applied to the surface. Values are measured at the maximum load or breaking point under specified conditions or specimen size, span between supports, and rate of load application. The equations used are based on the assumption that the materials are uniform and presume that the stress-strain characteristics below the elastic limit are linearly elastic. These assumptions are not strictly applicable to thermal insulations of certain types in which crushing occurs before failure is obtained in transverse bending; however,

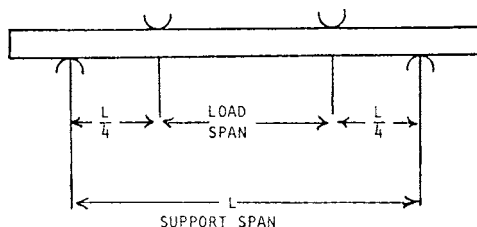


FIG. 2 Loading System for Test Method II

depending upon the accuracy required, these procedures are capable of providing acceptable results.

5.2 Test Method I is especially useful when testing only for the modulus of rupture or the breaking load. This information is useful for quality control inspection and qualification for specification purposes.

5.3 Test Method II is useful in determining the elastic modulus in bending as well as the flexural strength. Flexural properties determined by these test methods are also useful for quality control and specification purposes.

5.4 The basic differences between the two test methods is in the location of the maximum bending moment, maximum axial fiber (flexural or tensile) stresses, and the resolved stress state in terms of shear stress and tensile/compression stress. The maximum axial fiber stresses occur on a line under the loading fitting in Test Method I and over the area between the loading fittings in Test Method II. Test Method I has a high shear stress component in the direction of loading, perpendicular to the axial fiber stress. Sufficient resolved shear stress is capable of producing failure by a shear mode rather than a simple tension/flexural failure. There is no comparable shear component in the central region between the loading fittings in Test Method II. Test Method II simulates a uniformly loaded beam in terms of equivalent stresses at the center of the specimen.

5.5 Flexural properties are capable of varying with specimen span-to-thickness ratio, temperature, atmospheric conditions, and the difference in rate of straining specified in Procedures A and B. In comparing results it is important that all parameters be equivalent. Increases in the strain rate typically result in increased strengths and in the elastic modulus.

6. Apparatus

6.1 *Testing Machine*— A properly calibrated testing machine that is capable of being operated at either constant load rates or constant rates of crosshead motion over the range indicated, and in which the error in the load-measuring system shall not exceed $\pm 1\%$ of maximum load expected to be measured. The load-indicating mechanism shall be essentially free of inertial lag. The accuracy and calibration of the testing machine shall be verified in accordance with Practice E 4. If stiffness or deflection measurements are to be made, then the machine shall be equipped with a deflection-type measuring device. The stiffness of the testing machine shall be such that the total elastic deformation of the system does not exceed 1 % of the total deflection of the test specimen during test, or appropriate corrections shall be made.

6.2 *Bearing Edges*— The loading fittings and supports shall have cylindrical surfaces. In order to avoid excessive indentation, or failure due to stress concentration directly under the loading fitting or fittings, the diameter of these bearing edges shall be $1\frac{1}{4} \pm \frac{1}{4}$ in. (32 ± 6 mm). The bearing cylinders shall be straight and parallel to each other, and they shall be self-aligning to maintain full contact with the specimen throughout the test. They shall have a length at least equal to the width of the specimen.

6.3 Bearing cylindrical supports are described in Test Methods C 133.

6.4 See Fig. 1 for Test Method I; Fig. 2 for Test Method II.

6.4.1 CRL machines are described in Specification D 76.

6.4.2 CRE and CRT machines are described in Specification **D 76**.

7. Safety Precautions

7.1 Safety precautions consistent with the normal usage of any universal testing machine shall be observed. Safety glasses should be worn when testing all brittle samples.

7.2 Smoking and open flames shall be avoided when working with flammable or combustible specimens.

7.3 Respirators shall be worn during preparation of specimens that are friable or composed of compacted powder when dust levels are above permissible limits. Laboratory clothes and gloves shall be used when working with such materials or material that is abrasive or a skin irritant.

8. Test Specimens

8.1 The number of specimens to be tested shall be given in the materials specification. In the absence of such specification, test at least four samples.

8.2 The specific materials specification shall be consulted for the test specimen geometry and specific directions concerning selection or cutting of specimens. In the absence of such guidance, the preferred test specimen shall be 1 in. thick by 4 in. wide by 12 in. long (25 by 100 by 300 mm) tested on a 10 in. (250 mm) support span. The test specimens shall be 4 in. (100 mm) unless otherwise specified, but in no case less than 3 in. (75 mm) in width, and 1 in. (25 mm) thick. The test specimens shall be long enough to accommodate a support span of 10 in. (25 mm) in length. The width and thickness of test specimens shall be recorded to the nearest 0.01 in. (0.3 mm).

NOTE 2—When comparing test results, such data must be obtained using a common specimen size and the same procedure.

8.3 The following are commonly used and minimum requirements for the test specimen geometry and test setup:

Common $L/d = 10$ (Common requirement that the support span be ten times the thickness.)	Require $20 \geq L/d \geq 2$
Common $L/b = 2.5$ (Common requirement that support span be two and a half times the width.)	Require $L/b \geq 0.8$
Common $b/d = 4$ (Common requirement that the width be four times the thickness.)	Require $b/d \geq 1$

where:

L = support span, in. (or mm),
 d = thickness of specimen, in. (or mm), and
 b = width of specimen, in. (or mm).

NOTE 3—Examination of the minimum test requirements shows they are not compatible. They represent a compromise of industrial practices with the emphasis toward the commonly used parameters. This incompatibility precludes a simple table of commonly used and minimum dimensions.

8.4 The selection of the samples shall conform to Practice **C 390**. The specimens shall be cut from larger blocks or irregular shapes in such a manner to preserve as many of the original surfaces as acceptable. Only one sample shall be cut from a single block or board. Multiple specimens are capable of being cut from a sample such as a large bun of insulation material. If the test specimen is cut to obtain a narrower width than as received, the cut shall be made lengthwise of the block.

For anisotropic materials, flexural tests are capable of being run in other than the length direction, such as the cross direction of the sample. When comparative tests are to be made on preformed materials, all specimens shall be of the same thickness, except as applicable in the materials specification. The bearing faces of the test specimens shall be approximately parallel planes. In preparing specimens from pieces of irregular shape, any means such as a band saw, or any method involving the use of abrasives such as high-speed abrasion wheel or rubbing bed, that will produce a specimen with approximately plane and parallel faces (parallel within 1°) without weakening the structure of the specimen is capable of being used. The value obtained on specimens with machined surfaces will differ from those obtained on specimens with original surfaces. Consequently, the report must state if original surfaces were retained and when only one original surface was retained, whether it was on the tension or compression side of the beam.

9. Conditioning

9.1 Dry and condition specimens prior to test, following applicable specifications for the material. In the absence of definitive drying specifications, follow accepted practices for conditioning in Practice **C 870**. Where circumstances or requirements preclude compliance with these conditioning procedures, exceptions agreed upon between the manufacturer and the purchaser shall be made, and will be specifically listed in the test report.

10. Procedure

10.1 Test Method I, Procedure A:

10.1.1 Use an untested specimen for each measurement. Measure the width and depth of the specimen to the nearest 0.01 in. (0.3 mm) at the center of the support span. Each dimension is to be measured at three points along the center line of the span and to use the average value of these measurements in order to get a better value in case the sides are not truly parallel.

10.1.2 Determine the support span to be used and set up the support span to within 1 % of the determined value. Measure this support span to the nearest 0.1 in. (3.0 mm) at three points and record this measurement.

10.1.3 Calculate the rate of crosshead motion as follows and set the machine for the calculated rate:

$$R = ZL^2/6d \quad (1)$$

where:

R = rate of crosshead motion, in./min. (or mm/min.),
 L = support span, in. (or mm),
 d = depth of beam, in. (or mm), and
 Z = rate of straining of the outer fiber, in./in·min (or mm/mm·min). Z shall equal 0.01.

In no case shall the actual crosshead rate differ from that calculated from Eq 1, by more than $\pm 50\%$.

10.1.4 Align the loading fitting and supports so that the axes of the cylindrical surfaces are parallel and the loading fitting is midway between the supports. The parallelism is capable of being checked by means of a plate with parallel grooves into which the loading fitting and supports will fit when properly

aligned. Center the specimen on the supports, with the long axis of the specimen perpendicular to the loading fitting and supports.

10.1.5 Apply the load to the specimen at the specified crosshead rate, and take simultaneous load-deflection data. Measure deflection either by a gage under the specimen in contact with it at the center of the support span, the gage being mounted stationary relative to the specimen supports, or by measurement of the motion of the loading fitting relative to the supports. In either case, make appropriate corrections for indentation in the specimens and deflections in the weighing system of the machine. Crushing or indentation, or both, of the specimen at the support fixtures results in a downward translation in position of the specimen that will appear as a bending of the specimen if appropriate correction is not taken if and when necessary. Similar indentation is capable of occurring at the loading fixture(s); thus crosshead movement of the machine will not provide a true measure of the deflection due to bending alone in the specimen. A gage measuring the resultant specimen thickness at the supports is capable of being used as an indication of the amount of indentation. The importance of this correction depends upon the degree of accuracy required of the results. It is not required in screening or comparative testing or where only the failure load is the parameter of interest. Load-deflection curves are to be plotted to determine the flexural yield strength, secant or tangent modulus of elasticity, and the total work measured by the area under the load-deflection curve.

10.1.6 Normally, terminate the test if the maximum strain in the outer fibers has reached 0.05 in./in. (mm/mm). See **Note 1**. Beyond 5 % strain, these test methods and equations are not applicable. An exception to the above is where the failure load is the only parameter of interest. The deflection at which this strain occurs is calculated by letting ϵ equal 0.05 in./in. (mm/mm) as follows:

$$D = \epsilon L^2/6d \quad (2)$$

where:

D = deflection at center of sample, in. (or mm),
 ϵ = strain, in./in. (or mm/mm),
 L = support span, in. (or mm), and
 d = depth of beam, in. (or mm).

10.2 Test Method II, Procedure A:

10.2.1 See 10.1.1.

10.2.2 See 10.1.2.

10.2.3 Calculate the rate of crosshead motion as follows, and set the machine to that calculated rate:

$$R = ZL^2/6d \quad (3)$$

where:

R = rate of crosshead motion, in./min. (or mm/min),
 L = support span, in. (or mm),
 d = depth of beam, in. (or mm), and
 Z = rate of straining of the outer fibers, in./in.·min (mm/mm·min). Z shall equal 0.01.

In no case shall the actual crosshead rate differ from that calculated from Eq 3 by more than $\pm 50\%$.

10.2.4 Align the loading fitting and supports so that the axes of the cylindrical surfaces are parallel and the distance between the loading fitting (that is, load span) is one half of the support span. This parallelism is capable of being checked by means of a plate containing parallel grooves into which the loading fittings and supports will fit when properly aligned. Center the specimen on the supports, with the long axis of the specimen perpendicular to the loading fittings and supports. The loading fitting assembly shall be of the type that will not rotate.

10.2.5 Apply the load to the specimen at the specified crosshead rate, and take simultaneous load-deflection data. The deflection is capable of being measured by a gage under the specimen in contact with it at the common center of the span, the gage being mounted stationary relative to the specimen supports. Make appropriate corrections for indentation in the specimens and deflections in the weighing system of the machine. The importance of this indentation has been discussed previously in 10.1.5. Load-deflection curves are to be plotted to determine the flexural yield strength, secant or tangent modulus of elasticity, and the total work measured by the area under the load-deflection curve.

10.2.6 If no break has occurred in a specimen by the time the maximum strain in the outer fibers has reached 0.05 in./in. (mm/mm), discontinue the test for the reasons discussed in 10.1.6. The deflection at which this strain occurs is calculated by letting ϵ equal 0.05 in./in. (mm/mm) as follows:

$$F = \epsilon L^2/6d \quad (4)$$

or

$$D = \epsilon L^2/4.363d \quad (5)$$

where:

D = deflection, in. (or mm),
 F = deflection, in. (or mm) at load fixture at position $L/4$ or $3L/4$ in Test Method II,
 ϵ = strain, in./in. (or mm/mm),
 L = support span, in. (or mm), and
 d = depth of beam, in. (or mm).

10.3 Methods I and II, Procedure B:

10.3.1 Use an untested specimen for each measurement.

10.3.2 Test conditions shall be identical to those described in 10.1 or 10.2 except that the rate of straining of the outer fibers shall be 0.10 in./in.·min (mm/mm·min).

10.4 Methods I and II, Procedure C:

10.4.1 Use an untested specimen for each measurement.

10.4.2 Test conditions shall be identical to those described in 10.1 or 10.2 except that the basis of testing shall be based on a stress rate rather than a strain rate. The stress rate shall be 550 psi (3.79 MPa)/min, except as specified in the appropriate materials specification.

10.5 Methods I and II, Procedure D:

10.5.1 Use an untested specimen for each measurement.

10.5.2 Test conditions shall be identical to those described in 10.1 or 10.2 except that the basis of testing shall be based on a constant crosshead speed of 10 to 12 in. (250 to 305 mm)/min except as applicable in the materials specification.

11. Calculations

11.1 *Maximum Fiber Stress, Test Method I*—When a beam of homogeneous, elastic material is tested in flexure as a simple beam supported at two points and loaded at the midpoint, the maximum stress in the outer fibers occurs at mid-span. This stress is capable of being calculated for any point on the load-deflection curve by the following equation:

$$S = 3PL/2bd^2 \quad (6)$$

The stress at any position, such as a non-central break between the supporting bearing edges, is as follows:

$$S = 3PX/bd^2 \quad (7)$$

where:

- S = stress in the outer fibers, psi (or MPa),
- P = load at a given point on the load-deflection curve, lbf (or N),
- L = support span, in. (or mm),
- b = width of beam tested, in. (or mm),
- d = depth of beam tested, in. (or mm), and
- X = minimum distance from non-central break to support bearing edge, in. (or mm).

Eq 6 applies strictly to materials for which the stress is linearly proportional to strain up to the point of rupture, and for which the strains are small. Use of the equations for simple beams cited in these methods assumes small deflection, linear beam theory which is applicable where $L/d \leq 16$, $D/d \leq 1.0$, $D/L \leq 0.2$.

11.2 *Maximum Fiber Stress, Test Method II*—When a beam is loaded in flexure at two central points and supported at two outer points, the maximum stress in the outer fibers occurs between the two central loading points that define the load span (Fig. 2). This stress is capable of being calculated for any point on the load-deflection curve for relatively small deflections by the following equation:

$$S = 3PL/4bd^2 \quad (8)$$

where:

- S = stress in the outer fiber throughout central load span between the two load fittings ($L/4 \leq X \leq 3L/4$), psi (or MPa),
- P = load at a given point on the load deflection curve, lbf (or N), and
- L = support span, in. (or mm).

11.3 *Flexural Strength (Modulus of Rupture)*—The flexural strength is equal to the maximum stress in the outer fibers at the moment of break. It is calculated in accordance with Eq 6, Eq 7, or Eq 8, by letting P equal the load at the moment of break. If the material does not break, this part of the test is not applicable. In this case, the yield strength, if applicable, shall be calculated and the corresponding strain be reported also (see 11.4, 11.5, and 11.6).

11.4 *Flexural Yield Strength*—Some materials that do not break at outer fiber strains up to 5 % are capable of providing load-deflection curves that show a point, Y , at which the load does not increase with an increase in deflection. In such cases,

the flexural yield strength is calculated in accordance with Eq 6, Eq 7, or Eq 8, by letting P equal the load at point Y .

11.5 *Stress at a Given Strain*—The maximum fiber stress at any given strain is calculated in accordance with Eq 6, Eq 7, or Eq 8, by letting P equal the load read from the load-deflection curve at the deflection corresponding to the applicable strain.

11.6 *Maximum Strain, Test Method I*—The maximum strain in the outer fibers also occurs at midspan, and is calculated as follows:

$$\epsilon = 6Dd/L^2 \quad (9)$$

where:

- ϵ = maximum strain in the outer fibers, in./in. (or mm/mm),
- D = maximum deflection of the center of the beam, in. (or mm),
- L = support span, in. (or mm), and
- d = depth, in. (or mm).

11.7 *Maximum Strain, Test Method II*—The maximum strain in the outer fibers also occurs at midspan and is calculated as follows:

$$\epsilon = 6Fd/L^2 \quad (10)$$

where D , d , L , and ϵ are the same as in Eq 4. Only for linear elastic materials is the strain uniform in the central region between the load fittings. In this case the strain is calculated as follows:

$$\epsilon = 6Fd/L^2 \quad (11)$$

where F = deflection at load fixture at position $L/4$ or $3L/4$, in. (or mm).

NOTE 4—If the midspan deflection exceeds the depth of the test beam, the assumption of a small deflection, linear beam theory is of questionable validity. Corrections or a cautionary note, or both, must be included in the report for the large deflection case where either $D/d > 1$ or $D/L > 0.2$.

11.8 Elastic Modulus:

11.8.1 *Moment of Inertia*—The moment of inertia is calculated as follows:

$$I = bd^3/12 \quad (12)$$

where:

- I = moment of inertia, in.⁴ (mm⁴),
- b = specimen width, in. (mm), and
- d = specimen thickness, in. (mm)

11.8.2 *Elastic Modulus, Test Method I*—The elastic modulus in bending is calculated by the following equation:

$$E = PL^3/48ID \quad (13)$$

where:

- E = elastic modulus, psi (MPa),
- D = corrected deflection at center of sample, in. (mm),
- I = moment of inertia, in.⁴ (mm⁴),
- L = support span, in. (mm), and
- P = load at a given deformation within the proportional limit of the specimen, lbf (N).

11.8.3 *Elastic Modulus, Test Method II*—The elastic modulus in bending is calculated by the following equations:

$$E = 5PL^3/384ID \quad \text{or} \quad E = PL^3/96I\delta \quad (14)$$

where:

D = corrected deflection at center of sample, in. (mm), and
 δ = corrected deflection at load fixture, in. (mm) and the rest of the parameters are as previously defined.

As discussed in 10.1.5, correct the apparent deflection of the specimen to minimize errors due to any indentation of the specimen at the support fixture and at the loading fixture(s).

NOTE 5—Modulus of Elasticity (Young’s Modulus) is defined as the rate of change of unit stress with respect to unit strain within the proportional limit of a material. The load, P , must be selected within the proportional limit.

11.9 *Arithmetic Mean*— For each series of tests, calculate the arithmetic mean of all values obtained to three significant figures and report as the “average value” for the particular property in question.

11.10 *Standard Deviation (Normal, Gaussian)*—Calculate the standard deviation (estimated) as follows and report to two significant figures:

$$s = \sqrt{\frac{\sum X^2 - n\bar{X}^2}{n-1}} \quad (15)$$

or

$$s = \sqrt{\frac{\sum (X - \bar{X})^2}{n-1}} \quad (16)$$

where:

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

NOTE 6—The Gaussian distribution is not always followed. other distributions, such as the Weibull distribution are acceptable.

12. Report

12.1 Report the following information:

12.1.1 Complete identification of the material tested, including type, source, manufacturer’s code number, form, principal dimensions, and previous history,

12.1.2 Direction of cutting and loading specimens,

12.1.3 Conditioning procedure,

12.1.4 Depth and width of specimen,

12.1.5 Method used,

12.1.6 Procedure used,

12.1.7 Support span length,

12.1.8 Support span-to-depth ratio (L/d ratio); support span-to-width ratio (L/b ratio); width-to-depth ratio (b/d ratio),

12.1.9 Radius of supports and loading fittings,

12.1.10 Rate of crosshead speed,

12.1.11 Maximum strain in the outer fibers of the specimens,

12.1.12 Breaking load, average value, and standard deviation,

12.1.13 Flexural strength (if applicable), average value, and standard deviation. Average deflection to depth ratio and deflection to support span ratio at given flexural strength,

12.1.14 Flexural yield strength, average value, and standard deviation, and

12.1.15 Stress at any given strain up to and including 5 % , with strain used, average value, and standard deviation.

13. Precision and Bias

13.1 An interlaboratory study (ILS) on the breaking load and flexural properties of block-type thermal insulation was conducted in 2005. The eight laboratories participating in the ILS measured the breaking load/flexural property of five randomly selected samples of four different block-type EPS/XPS thermal insulations at two different cross-head speeds. The ILS was conducted in accordance to Test Method C 203-99, Method 1, Procedures A and B and Practice E691. ³

13.2 *Test Results*—The precision information given below is for the average breaking load/flexural property reported at yield, break or 5% deflection, whichever occurs first, in the units of measurement (psi) at a cross-head speed of 0.2in./min:

	Material A	Material B	Material C	Material D
Average Test Value, psi	91.17	30.52	40.81	45.40
95% repeatability limit (within laboratory)	7.066	3.594	2.641	4.073
95% reproducibility limit (between laboratories)	9.409	5.263	4.125	6.738

The precision information given below is for the average breaking load/flexural property reported at yield, break or 5% deflection, whichever occurs first, in the units of measurement (psi) at a cross-head speed of 2.0in. /min:

	Material A	Material B	Material C	Material D
Average Test Value, psi	90.52	31.37	40.94	48.52
95% repeatability limit (within laboratory)	7.385	4.215	3.314	3.509
95% reproducibility limit (between laboratories)	11.624	4.877	3.723	7.040

13.3 *Bias*—Since there is no accepted reference material suitable for the bias for this flexural property test method, no statement on bias is being made.

13.4 Due to the nature of the equations involved, the accuracy of the resultant flexural stress depends on the accuracy of the measured variables such as load, span, specimen width, and thickness. For example, a variance or uncertainty of 2 % in each of these measured variables will lead to a variance of 4.5 % in the apparent flexural strength. If increased accuracy

³ Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR: C16-1032.

is necessary, then the accuracy of the dimensional measurements of the specimen given in 10.1.1 shall be increased.

14. Keywords

14.1 breaking load; breaking strength; flexural strength; modulus of elasticity; modulus of rupture

ASTM International takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.

This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, at the address shown below.

This standard is copyrighted by ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, United States. Individual reprints (single or multiple copies) of this standard may be obtained by contacting ASTM at the above address or at 610-832-9585 (phone), 610-832-9555 (fax), or service@astm.org (e-mail); or through the ASTM website (www.astm.org).