Designation: C203 – 22

Standard Test Methods for Breaking Load and Flexural Properties of Block-Type Thermal Insulation[1]

This standard is issued under the fixed designation C203; 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 U.S. 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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.* For specific precautionary statements, see Section 10

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C133 Test Methods for Cold Crushing Strength and Modulus of Rupture of Refractories
C168 Terminology Relating to Thermal Insulation
C390 Practice for Sampling and Acceptance of Thermal Insulation Lots
C870 Practice for Conditioning of Thermal Insulating Materials
D76 Specification for Tensile Testing Machines for Textiles
E4 Practices for Force Calibration and Verification of Testing Machines

3. Terminology

3.1 Terminology C168 applies 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:

[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.

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[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.

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 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, 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.

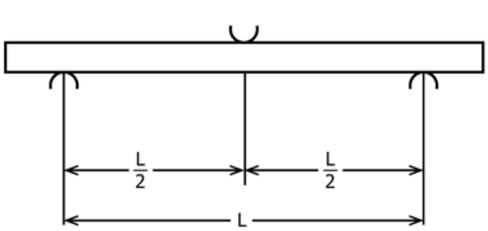

FIG. 1 Loading System for Test Method I

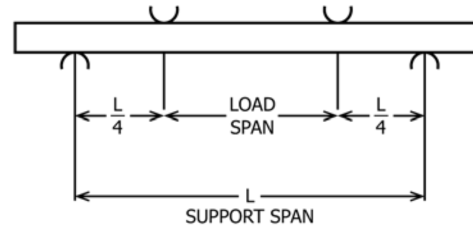

FIG. 2 Loading System for Test Method II

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 ±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 E4. 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 1¼ ± ¼ 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 C133.

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

6.4.1 CRL machines are described in Specification D76.

6.4.2 CRE and CRT machines are described in Specification D76.

7. Test Specimens

7.1 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.

7.2 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. (250 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.

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

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

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.

7.4 The selection of the samples shall conform to Practice C390. 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.

8. Conditioning

8.1 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 C870. 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.

9. Procedure

9.1 *Test Method I, Procedure A:*

9.1.1 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.

9.1.2 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.

9.1.3 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 ± 50%.

9.1.4 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.

9.1.5 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.

9.1.6 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:

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

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).

9.2 *Test Method II, Procedure A:*

9.2.1 See 9.1.1.

9.2.2 See 9.1.2.

9.2.3 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 ±50 %.

9.2.4 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.

9.2.5 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 9.1.5. Load-deflection curves are to 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.

9.2.6 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 9.1.6. The deflection at which this strain occurs is calculated by letting ε equal 0.05 in./in. (mm/mm) as follows:

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

or

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

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).

9.3 *Methods I and II, Procedure B:*

9.3.1 Use an untested specimen for each measurement.

9.3.2 Test conditions shall be identical to those described in 9.1 or 9.2 except that the rate of straining of the outer fibers shall be 0.10 in./in.·min (mm/mm·min).

9.4 *Methods I and II, Procedure C:*

9.4.1 Use an untested specimen for each measurement.

9.4.2 Test conditions shall be identical to those described in 9.1 or 9.2 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.

9.5 *Methods I and II, Procedure D:*

9.5.1 Use an untested specimen for each measurement.

9.5.2 Test conditions shall be identical to those described in 9.1 or 9.2 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.

10. Calculations

10.1 *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