Designation: C 203 – 99

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

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

1.1.2 *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 method can be 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 may be 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:*

C 133 Test Methods for Cold Crushing Strength and Modulus of Rupture of Refractories[2]

C 168 Terminology Relating to Thermal Insulating Materials[3]

C 390 Criteria for Sampling and Acceptance of Preformed Thermal Insulation Lots[3]

C 870 Practice for Conditioning of Thermal Insulating Materials[3]

D 76 Specification for Tensile Testing Machines for Textiles[4]

E 4 Practice for Force Verification of Testing Machines[5]

3. Terminology

3.1 Terminology C 168 shall be considered as applying 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 *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 *Method II*—The bar rests on two supports and is loaded at the two quarter points (by means of two loading

[1] These test methods are under the jurisdiction of ASTM Committee C-16 on Thermal Insulation and are the direct responsibility of Subcommittee C16.32 on Mechanical Properties.

Current edition approved March 10, 1999. Published May 1999. Originally published as C 203 – 45 T. Replaced C 165 – 41 T and C 203 –55 T. Last previous edition C 203 – 92.

[2] *Annual Book of ASTM Standards*, Vol 15.01.
[3] *Annual Book of ASTM Standards*, Vol 04.06.
[4] *Annual Book of ASTM Standards*, Vol 07.01.
[5] *Annual Book of ASTM Standards*, Vol 03.01.

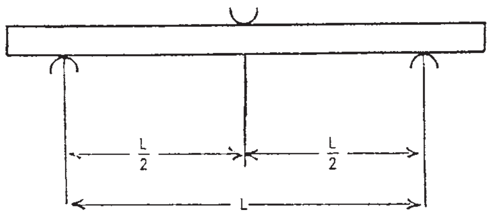

FIG. 1 Loading System for Method I

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 recommended 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 may 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 may provide acceptable results.

5.2 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 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 Method I and over the area between the loading fittings in Method II. Method I has a high shear stress component in the direction of loading, perpendicular to the axial fiber stress. The resolved shear stress may be sufficient to produce 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 Method II. Method II simulates a uniformly loaded beam in terms of equivalent stresses at the center of the specimen.

5.5 Flexural properties may vary 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 can be 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 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 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 C 133.

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

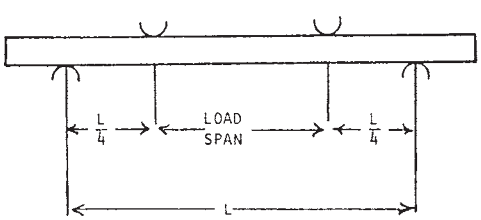

FIG. 2 Loading System for Method II

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 should be observed. Safety glasses should be worn when testing all brittle samples.

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

7.3 Respirators should 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 should be used when working with such materials or material that may be abrasive or a skin irritant.

8. Test Specimens

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

8.2 The specific materials specification should be consulted for recommendation regarding 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 should be 4 in. (100 mm), 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 recommended and minimum requirements for the test specimen geometry and test setup:

Recommended $L/d = 10$ — Require $20 \geq L/d \geq 2$
(Recommend that the support span be ten times the thickness.)

Recommended $L/b = 2.5$ — Require $L/b \geq 0.8$
(Recommend that support span be two and a half times the width.)

Recommended $b/d = 4$ — Require $b/d \geq 1$
(Recommend 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 recommended parameters. This incompatibility precludes a simple table of recommended and minimum dimensions.

8.4 The selection of the samples shall conform to Criteria 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 possible. Only one sample shall be cut from a single block or board. Multiple specimens may be 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 may be 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 recommended 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 may be used. The value obtained on specimens with machined surfaces may 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 recommended 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 may be made, but they shall be specifically listed in the test report.

10. Procedure

10.1 *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. It is desirable to measure each dimension 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, or as near as possible to it:

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

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%.

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 may be checked by means of a plate with parallel grooves into which the