Designation: C 1185 – 99

Standard Test Methods for Sampling and Testing Non-Asbestos Fiber-Cement Flat Sheet, Roofing and Siding Shingles, and Clapboards[1]

This standard is issued under the fixed designation C 1185; 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.

1. Scope

1.1 These test methods cover sampling and testing of non-asbestos fiber-cement flat sheets, roofing shingles, siding shingles, and clapboards. These products may be smooth or surface textured. These test methods are utilized in evaluating products cited in Specifications C 1186, C 1225, C 1288, and C 1325.

1.2 *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.*

1.3 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

2. Referenced Documents

2.1 *ASTM Standards:*

C 20 Test Methods for Apparent Porosity, Water Absorption, Apparent Specific Gravity, and Bulk Density of Burned Refractory Brick and Shapes by Boiling Water[2]

C 1154 Terminology for Non-Asbestos Fiber-Reinforced Cement Products[3]

C 1186 Specification for Flat Non-Asbestos Fiber-Cement Sheets[3]

C 1225 Specification for Non-Asbestos Fiber-Cement Roofing Shingles, Shakes, and Slates[3]

C 1288 Specification for Discrete Non-Abestos Fiber-Cement Interior Substrate Sheets[3]

C 1325 Specification for Fiber-Mat Reinforced Non-Abestos Cement Interior Substrate Sheets[3]

2.2 *ISO Standard:*

ISO 390 Product in Fiber Reinforced Cement Sampling and Inspection[4]

2.3 *Military Standards:*

MIL-STD-105 Sampling Procedures and Tables for Inspection by Attributes[5]

MIL-STD-414 Sampling Procedures and Tables for Inspection by Variables for Percent Defective[5]

3. Terminology

3.1 *Definitions:* Refer to Terminology C 1154.

3.1.1 *density*—the mass per unit volume expressed in pounds per cubic foot (lb/ft^3) or kilograms per cubic metre (kg/m^3).

3.1.2 *flexural strength*—the average flexural strength is the average of two perpendicular breaks expressed in pound-force per square inch (megapascals) as calculated from the average breaking load of wet or equilibrium test specimens, loaded as simple beams, with the load applied at the center.

3.1.3 *heat-rain sheets*—fixed to a building frame in accordance with the manufacturer's recommended installation practices. The sheeted frame is then subjected to alternate wetting and heating cycles and any structural alteration of the sheet caused by the test is reported.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *dimensions*—for the purpose of these test methods, the length, width and thickness of fiber-cement flat sheets, roofing shingles, siding shingles, and clapboard are measured under specified conditions.

3.2.2 *moisture content*—for the purpose of these test methods, the percentage of moisture content of the fiber-cement product when conditioned at 50 ± 5 % relative humidity and a temperature of 73 ± 4°F (23 ± 2°C).

3.2.3 *moisture movement*—in these test methods, the linear variation in length and width of test specimen, with change in moisture content.

3.2.4 *water absorption*—for the purpose of these test methods, the increase in mass of the test specimen expressed as a percentage of its dry mass after immersion in water for a specified period of time as prescribed.

4. Sampling

4.1 Employ sampling procedures providing an acceptable

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[2] *Annual Book of ASTM Standards*, Vol 15.01.

[3] *Annual Book of ASTM Standards*, Vol 04.05.

[4] Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

[5] Available from Standardization Documents, Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094. ATTN: NPODS.

quality level (AQL) of 4 % at a 90 % confidence level, except where specific sampling is required by particular test procedures.

4.2 *Acceptable Quality Level (AQL)*—The acceptable quality level (AQL) may be defined as follows:

4.2.1 The maximum percent nonconforming that, for purposes of sampling inspection, can be considered satisfactory as a process or long-term average, and

4.2.2 A quality level which corresponds to relatively high probability (commonly 90 %) of acceptance.

NOTE 1—When a manufacturer's process satisfies a sampling scheme with an AQL of 4 % then this indicates that better than 96 % of the inspected production exceeds the specifications. Under this type of specification the consumer is provided the protection and confidence of a clearly defined lower boundary. This would not be true if acceptance were based solely on the average value of the measured property. Examples of sampling schemes which may be used can be found in documents such as MIL-STD-105, MIL-STD-414, or ISO 390. Other sampling schemes may be used. Inspection by attributes is a method which consists of determining, for every item of a sample, the presence or absence of a certain qualitative characteristic (attribute) with respect to the applicable specification. It is, in essence, a pass-fail inspection which determines the number of items in a sample that do conform to the specification and the number of those that do not conform. An attribute could be a dimensional measurement, or a flexural strength value, or others that are described in these test methods. Inspection by variable is a method which consists of measuring a quantitative characteristic for each item in a sample. Conformance with the applicable specification is determined from the mean values of the measured properties and the statistical variations of these values above and below the mean. These procedures detail sampling plans to suit all common sampling situations. The sampling plans specify the number of specimens to be taken from each batch and the acceptance/rejection criteria. The specified inspection levels have been selected to suit fiber-cement products, to balance the cost of assessment against confidence in results commensurate with this industry.

5. Flexural Strength (Modulus of Rupture)

5.1 *Significance and Use*—This is a routine test measuring a primary product characteristic used for product grading.

5.2 *Procedure*:

5.2.1 *Preparation of Test Specimens, (Flat Sheets)*—Cut a pair of specimens, each 6 ± 1⁄16 in. (152 ± 1.6 mm) in width and 12 ± 1⁄16 in. (305 ± 1.6 mm) in length, from the interior area of each sample sheet in such a manner that no edge of specimen is less that 3 in. (76 mm) from the original edges of the sheet. The longer dimension of one of the specimens of each pair shall be parallel to the length of the sheet (that is, parallel with the fiber lay), and the other shall be at right angles to it.

5.2.2 *Preparation of Test Specimens, (Roofing Shingles, Siding Shingles, and Clapboards)*—Cut a single specimen 6 ± 1⁄16 in. (152± 1.6 mm) in width and 12 ± 1⁄16in. (305 ± 1.6 mm) in length from each unit. Cut one half of the specimens in such a manner that the 12-in. (305-mm) dimension of each specimen is parallel to one edge of the shingle or clapboard unit; cut one half of the specimens at right angles thereto.

NOTE 2—Alternate test specimen dimensions and span may be used provided that the ratio of the test span to specimen thickness is not less than 18, and that the actual span used be reported.

5.2.3 *Conditioning*:

5.2.3.1 *Equilibrium Conditioning*—Place the test specimens, for at least four days [thickness< ½ in. (12 mm)] or at least seven days [thickness ≥ ½ in. (12 mm)] in a controlled atmosphere of 73 ± 4°F (23 ± 2°C) and 50 ± 5 % relative humidity and in such a manner that all faces are adequately ventilated.

5.2.3.2 *Wet Conditioning*— Immerse specimens to be tested in wet condition in water at a temperature of 73 ± 7°F (23 ± 4°C) for a period of 48 h minimum. Test the specimens immediately upon removal from the water.

5.2.4 *Test Procedure*— Determine the flexural strength of each specimen by placing the underside of the specimen on supports that cannot exert longitudinal constraints [rocker-type bearing edges, rollers, etc. with a 1⁄8-in. (3.2-mm) minimum radius and a ½-in. (12.7-mm) maximum radius] and apply the load at mid-span through a similar edge bearing against the finished surface of the specimen. The test span shall be 10 ± 1⁄16 in. (254 ± 1.6 mm) and the load line and support shall be parallel. Mount a dial micrometer reading to 0.01 in. (0.25 mm) or an equally sensitive apparatus, to bear on the loading member or on the specimen at mid-span to determine the deflection of the specimen at the center of the test span. Measure and record the deflection when the maximum load is reached. Increase the load at a uniform deflection rate, such as will result in failure of the specimen between five and thirty seconds. The error in the load reading shall not exceed 1 % of the maximum load.

NOTE 3—Alternate test specimen dimensions and span may be used provided that the ratio of the test span to specimen thickness is not less than 18, and that the actual span used be reported.

5.2.4.1 Measure the specimen thickness, for the flexural test, at four points along the line of break for an average result. This measurement may be completed either before or after load testing. The thickness gage shall have flat parallel anvils of between 0.4-in. (10-mm) and 0.6-in. (15-mm) diameter with an accuracy of ±0.002-in. (±0.05-mm). Determine face-textured product thickness from volume measurement by water displacement using the formula:

$$t = \frac{V}{L \times W} \tag{1}$$

where:

t = specimen thickness, in.,
V = volume, determined by water displacement, in.^{3},
L = length, in., and
W = width, in.

NOTE 4—Alternative methods for determination of average thickness of textured product may be used provided that they can be proven, on average, to yield a thickness measurement within ±2 % of that determined from volume measurement by water displacement.

5.3 *Calculation and Report*:

5.3.1 Calculate the flexural strength for each specimen by the following equation:

$$R = \frac{3\,PL}{2\,bd^2} \tag{2}$$

where:

R = flexural strength, psi (MPa),

P = maximum load, lb (N),
L = length of span, in. (mm),
b = width of specimen, in. (mm), and
d = average thickness, in. (mm).

The average flexural strength of the specimen pair shall be the arithmetic mean value obtained in the two directions. Report the arithmetic mean value of each pair.

5.3.2 It shall be the option of the manufacturer to report the handleability index of his product. Handleability index values are relative and are used to determine the capability of the material to be handled without breaking. An increase in handleability index means increased ease of handling. For each sheet direction, calculate handleability index using the formula:

$$U = \frac{0.5\,P\Delta}{t} \tag{3}$$

where:
U = handleability index, in., lb/in. (mm, N/mm),
P = breaking load, lb (N), in each direction at a span of 10 in. (254 mm),
Δ = ultimate deflection, in. (mm), under center loading at a span of 10 in. (254 mm), and
t = thickness of the test specimen, in. (mm).

5.3.3 Calculate the breaking moment (roofing products only) for each sample specimen by the following equation:

$$M = \frac{P\,L}{4\,b} \tag{4}$$

where:
M = breaking moment, ft, lbf/ft (Nm/m),
P = maximum load, lbf (N),
L = length of span, ft (m), and
b = width of specimen, ft (m).

Report the arithmetic mean value for the sample specimen group.

5.4 Calculate the modulus of elasticity (interior substrate sheets only) for each sample specimen by the following equation:

$$E = (P_2 - P_1) \times L^3/4bd^3\,(y_2 - y_1) \tag{5}$$

where:
E = modulus of elasticity, psi (kg/mm^2),
P_2 and P_1 = loads, lb (kg), taken from two points within the linear section of the plot,
y_2 and y_1 = deflections, in. (mm) corresponding to the loads selected,
b = width of specimen, in. (mm),
d = thickness of specimen, in. (mm), and
L = length of span, in. (mm).

5.5 *Precision and Bias*:

5.5.1 *Precision*—The precision of the procedure in Test Methods C 1185 for measuring flexural strength is being determined.

5.5.2 *Bias*—Since there is no accepted reference material suitable for determining the bias for the procedure in Test Methods C 1185 for measuring flexural strength, no statement on bias is being made.

6. Density

6.1 *Significance and Use*—The uniformity of density results are used for quality control assurance.

6.2 *Procedure*:

6.2.1 *Preparation of Test Specimen*—Use a test specimen from the flexural test or a specimen of equivalent dimension.

6.2.2 *Testing Procedure*—Determine the volume of the specimen by any method capable of giving a result accurate to within 2 % of the results obtained by the water displacement method. Determine the mass by drying out the test specimen in an oven at 194 ± 4°F (90 ± 2°C) until the difference between two consecutive weighings, at intervals not less than two hours, is less than 0.1 % by mass.

NOTE 5—Water displacement can be obtained per Test Methods C 20, in which volume (V) of the test specimen is obtained in cubic centimetres by subtracting the suspended weight (W) from the saturated weight (S), both in grams as follows:

$$V = W - S \tag{6}$$

where:
V = volume, cm^3,
W = saturated weight, g, and
S = suspended weight, g.

This assumes that 1 cm^3 of water weighs 1 g. This is true within about three parts in 1000 for water at room temperature. Suspended weight (S) is obtained for each test specimen by suspending the specimen in a loop or halter of AWG gage No. 22 (0.644 mm) copper wire hung from one arm of the balance. The balance shall be previously counter balanced with the wire in place and immersed in water to the same depth as is determining the suspended weight, blot each specimen lightly with a moistened smooth linen or cotton cloth to remove all drops of water from the surface, and determine the saturated weight (W) in grams by weighing in air to the nearest 0.1 g.

6.3 *Calculation and Report*—Calculate and report the density of the specimen in pounds per cubic foot (lb/ft^3) using the equations:

$$\text{density} = \frac{W}{V} \times \frac{1}{454} \times \frac{1728}{1} \tag{7}$$

where:
W = dry mass of specimen, g, and
V = volume, in.^{3},

or in kilograms per cubic metre (kg/m^3) using the equation:

$$\text{Density} = \frac{W}{V} \times 1\,000\,000 \tag{8}$$

where:
W = dry mass of specimen, g, and
V = volume, mm^3.

6.4 *Precision and Bias*:

6.4.1 *Precision*—The precision of the procedure in Test Methods C 1185 for measuring density is being determined.

6.4.2 *Bias*—Since there is no accepted reference material suitable for determining the bias for the procedure in Test Methods C 1185 for measuring density, no statement on bias is being made.

7. Dimensional Measurements

7.1 *Significance and Use*:

7.1.1 These are routine measurements for determining whether the length and width of the individual units are as ordered, to ensure that they fit together properly in application, and to determine the uniformity of the specified thickness.

7.1.2 In determining the thickness of a sheet having a textured or granulated surface, a metal plate is placed adjacent to the textured surface, and the micrometer readings are taken on the combined thickness of the sheet and the metal plate. The purpose is to obtain a more accurate overall thickness measurement of the textured or granulated sheet. This would be rather difficult to do, in many cases, because of surface irregularities when the plate is not used.

7.2 *Conditioning*— Condition the specimens to be tested in an environment of 73 ± 4°F (23 ± 2°C) temperature and 50 ± 5 % relative humidity for 48 h. Condition specimens for all dimensional measurement tests.

7.3 *Measurement or Thickness*:

7.3.1 *Flat Sheets Measurement of Thickness*—Take thickness measurements at the midpoint along each edge dimension with a gage capable of reading to an accuracy of 0.002 in. (0.05 mm).

7.3.2 *Textured or Granulated Sheets*—Measure the thickness of each test specimen by placing a smooth metal plate of uniform thickness with dimensions approximately 1⁄64 by 4 by 4 in. (0.4 by 102 by 102 mm) against the finished, textured, or weather-exposed surface of the specimen. Using a gage capable of reading to 0.002 in. (0.05 mm), measure the overall thickness of the metal plate and specimen at the approximate midpoint of each edge of the specimen and at least ½in. (12.7 mm) from the edge of the specimen.

7.3.2.1 *Flat Sheets*— Average the four measurements and record as the specimen thickness.

7.3.2.2 *Textured or Granulated Sheets*—Subtract the measured thickness of the metal plate from each measurement and average four measurements to give the specimen thickness. This method shall not be used for calculation of flexural strength and density.

7.4 *Flat Sheets Measurement of Squareness*—Measure the length of the diagonals, as well as the edge lengths of the sheets, with a steel tape capable of reading to an accuracy of 1⁄32 in. (0.7 mm).

7.5 *Flat Sheets Measurement of Edge Straightness*—Measure the greatest distance between the edge of the sheet and a string or wire stretched from one corner of the panel to the adjacent corner with a steel rule capable of reading to an accuracy of 1⁄32 in. (0.7 mm).

7.6 *Flat Sheets Measurement of Length and Width*—Take three measurements of each dimension with a steel tape capable of reading to an accuracy of 1⁄32 in. (0.7 mm).

7.7 *Precision and Bias*:

7.7.1 *Precision*—The precision of the procedure in Test Methods C 1185 for dimensional measurements is being determined.

7.7.2 *Bias*—Since there is no accepted reference material suitable for determining the bias for the procedure in Test Methods C 1185 for dimensional measurements, no statement on bias is being made.

8. Moisture Movement

8.1 *Significance and Use: Moisture Movement*—This test is used to determine the serviceability of product in areas of high humidity and exposure to moisture.

8.2 *Test Specimen*— The test specimens shall be 3 in. (76 mm) in width and at least 12 in. (305 mm) in length. Provide two specimens, one cut parallel with the long dimension of each sheet and one from the same sheet cut at right angles to the long dimension.

8.3 *Conditioning*— Condition each specimen to practical equilibrium at a relative humidity of 30 ± 2 % and a temperature of 73 ± 4°F (23 ± 2°C). Practical equilibrium is defined as the state of time change in weight where, for practical purposes, the specimen is neither gaining nor losing moisture content more than 0.1 wt. % in a 24-h period.

8.4 *Procedure*—Measure the length of each specimen in a dial gage comparator using a standard bar of the same nominal length as the specimen for reference, or any other method capable of measuring each specimen to the nearest 0.001 in. (0.02 mm). Then condition the specimens to practical equilibrium at a relative humidity of 90 ± 5 % and a temperature of 73 ± 6°F (23 ± 3°C). Measure the length of each specimen in a dial gage comparator or any other method capable of measuring each specimen to the nearest 0.001 in. (0.02 mm). If bowing is evident, choose a method that will record measurements on both sides of the test specimen and average the results.

8.5 *Calculation and Report*—Report the linear change in moisture content as the percentage change in length based on the length at relative humidity change of 30 to 90:

$$\text{linear change, \%} = \frac{(L) \text{ at } 90\ \% - (L) \text{ at } 30\ \% \times 100}{(L) \text{ at } 30\ \%} \qquad (9)$$

8.6 *Precision and Bias*:

8.6.1 *Precision*—The precision of the procedure in Test Methods C 1185 for moisture movement is being determined.

8.6.2 *Bias*—Since there is no accepted reference material suitable for determining the bias for the procedure in Test Methods C 1185 for moisture movement, no statement on bias is being made.

9. Water Absorption

9.1 *Significance and Use*—This is a routine test. The values are relative. The test is made to determine the tendency of a product to absorb water and sometimes determine uniformity of the product.

9.2 *Procedure*:

9.2.1 Dry each specimen of minimum size of 4 by 4 in. (100 by 100 mm) to constant weight in a ventilated oven at a temperature of 194 ± 4°F (90 ± 2°C) and cool to room temperature in a desiccator or desiccator-type cabinet. Weigh each cooled specimen separately on a scale of an accuracy of 0.5 % of specimen mass. Record the dry weight of each cooled specimen. Submerge the specimen for 48 ± 8 h in clean water at 73 ± 7°F (23 ± 4°C).

9.2.2 Remove each specimen from the water, wipe with a damp cloth, and weigh each specimen separately on a scale of an accuracy of 0.5 % of specimen mass.

9.3 *Calculation and Report*:

9.3.1 Calculate the water absorption value for each specimen as follows:

$$\text{water absorption, mass } \% = [(W_s - W_d)/W_d] \times 100 \quad (10)$$

where:
W_s = saturated mass, lb (g) of specimen, and
W_d = dry mass, lb (g) of specimen.

9.3.2 Report the water absorption as the average value for all specimens tested.

9.4 *Precision and Bias*:

9.4.1 *Precision*—The precision of the procedure in Test Methods C 1185 for water absorption is being determined.

9.4.2 *Bias*—Since there is no accepted reference material suitable for determining the bias for the procedure in Test Methods C 1185 for water absorption, no statement on bias is being made.

10. Moisture Content

10.1 *Significance and Use*—This is a routine test. Nominal values and tolerances for moisture content shall be declared by the manufacturer for his products.

10.2 *Procedure*:

10.2.1 *Preparation of Test Specimen*—Use a test specimen from the flexural test. When for any reason additional determination of moisture content are required, prepare separate samples. These moisture content specimens shall be the full thickness of the material and 3 in. (76 mm) wide and 6 in. (152 mm) long.

10.2.2 *Conditioning*— Condition as stated in 5.2.3.1.

10.2.3 *Testing Procedure*—After equilibrium conditioning, weigh each sample separately on a scale to an accuracy of 0.5 %. Note this mass as initial mass (*w*). Dry each specimen to constant mass in a circulated oven at a temperature of 194 ± 4°F (90 ± 2°C) and cool to room temperature in a desiccator-type cabinet. Record the dry mass of each cooled specimen and note as final mass when oven-dry (*F*).

10.3 *Calculation and Report*—Calculate the moisture content as follows:

$$M = 100\,[(W - F)/F] \quad (11)$$

where:
M = moisture content, %,
W = initial mass, lb (kg), and
F = final mass when oven-dry, lb (kg).

10.4 *Precision and Bias*:

10.4.1 *Precision*—The precision of the procedure in Test Methods C 1185 for moisture content is being determined.

10.4.2 *Bias*—Since there is no accepted reference material suitable for determining the bias for the procedure in Test Methods C 1185 for moisture content, no statement on bias is being made.

11. Water Tightness

11.1 *Significance and Use*—This test is used to determine the serviceability (water tightness) of product when subjected to a determined water head for a protracted period.

11.2 *Test Specimens*— Cut the test specimens to 24 by 20 in. (610 by 508 mm) minimum, from at least three sampled sheets. Cut one specimen from each sheet with a total of three specimens for each test. Where product size is less than 24 by 20 in. (610 by 508 mm) use the largest size product as the test specimen.

11.3 *Procedure*—Keep the 24 by 20-in. (610 by 508-mm) test specimens in a controlled environment for at least five days at an ambient temperature [exceeding 41°F (5°C)]. Place and seal a suitable frame 22 by 18 in. (559 by 457 mm) minimum on top of the face of the specimen and fill with water to a height of 2 in. (50 mm) above the face of the sheet. Place the specimen in a controlled environment at 73 ± 4°F (23 ± 2°C) and 50 ± 5 % relative humidity for a period of 24 h.

11.4 *Calculation and Report*—Examine the specimen with the unaided eye and report any formation of drops of water on the underside of the sheet. Report the thickness of the product tested.

11.5 *Precision and Bias*—No statement is made about either the precision or bias of Test Methods C 1185 for measuring water tightness since the result merely states whether there is conformance to the criteria for success specified in the procedure.

12. Freeze/Thaw—Cladding Products

12.1 *Significance and Use*—This test investigates the possible degradation of the product due to exposure to repeated freeze or thaw cycles, or both. This test is a comparative one and is only significant for as-received products.

12.2 *Test Specimens*— The test specimens shall be 6 by 12 in. (152 by 305 mm) cut from at least five sampled sheets as delivered by the manufacturer. Cut two pairs of two specimens from each sheet with a total of ten pairs of specimens for this test.

12.3 *Procedure*:

12.3.1 Divide the paired specimens to form two sets of paired specimens each.

12.3.2 Submit the first set of ten specimens to the saturated flexural strength test according to Section 5.

12.3.3 Saturate the remaining set of ten specimens by immersing in water of a temperature greater than 41°F (5°C) for a minimum of 48 h. Then seal each specimen separately in a plastic bag. The plastic bag shall have a thickness between 8 mils (0.2 mm) and 12 mils (0.3 mm). The length and width of the plastic bag shall not exceed the length and width of the sample by more than 20 %, respectively. Subject the specimens to freeze/thaw cycles consisting of:

12.3.3.1 Cool to − 4 ± 4°F (−20 ± 2°C) over a period of not less than one hour nor more than two hours. Hold the specimens at − 4± 4°F (−20 ± 2°C) for one hour.

12.3.3.2 Thaw to 68 ± 4°F (20 ± 2°C) over a period of not less than one hour and a maximum of two hours. After thawing, maintain the specimens at 68 ± 4°F (20 ± 2°C) for one hour before proceeding with freezing.

(*1*) Each freeze/thaw cycle shall have a minimum cycle time of four hours and a maximum of six hours.

(*2*) The freezer unit shall have a forced-air circulation capable of being regulated to the prescribed freezing condition with a full load of test specimens.

(*3*) The total number of freeze/thaw cycles shall be as

specified in the applicable standard specification.

(*4*) Freeze/thaw cycles may be controlled automatically or manually.

(*5*) An interval between cycles, maximum 48 h, is permissible. During this interval, store specimens in warm condition at 68 ± 4°F (20 ± 2°C).

(*6*) During both freezing and thawing, position the specimens to enable free circulation of the conducting medium (air or water) around each bag.

12.4 *Calculation and Report*:

12.4.1 Examine the specimens with the unaided eye in order to detect possible cracks, delamination, and other defects, and record any observations.

12.4.2 Saturate the specimens and test the flexural strength (*Ff*) according to Section 5.

12.4.3 Calculate and report the ratio (*R*) of the strength averaged for the set undergoing freeze/thaw cycles (*Ff*) to the strength averaged for the control of reference set (*Fr*).

$$R = F_f/F_r \tag{12}$$

12.5 *Precision and Bias*:

12.5.1 *Precision*—The precision of the procedure in Test Methods C 1185 for freeze/thaw is being determined.

12.5.2 *Bias*—Since there is no accepted reference material suitable for determining the bias for the procedure in Test Methods C 1185 for freeze/thaw, no statement on bias is being made.

13. Warm Water

13.1 *Significance and Use*—This test investigates the long-term chemical interaction of constituent materials. Wet and elevated temperature conditions are used to accelerate the results. This test is a comparative one and is only significant for products as delivered.

13.2 *Sampling*:

13.2.1 Sample five or more sheets as delivered by the producer. Cut ten sets of paired specimens to suit the flexural strength test, in accordance with 5.2.1.

13.2.2 Cut each specimen pair from the same sheet and uniquely number for later comparison of results. Two pairs of specimens may be cut from the sheet.

13.3 *Procedure*:

13.3.1 Divide the paired specimens to form two sets of ten specimens each.

13.3.2 Submit the first lot of ten specimens to the saturated flexural strength test, as specified in Section 5, and at the same time immerse the ten specimens of the second lot in water saturated with an excess of lime and maintained at 140 ± 4°F (60 ± 2°C) for 56 ± 2 days. At the end of this period, place the specimens in a conditioning chamber at 73 ± 4°F (23 ± 2°C) and 50± 5 % relative humidity for 48 ± 2 h.

13.3.3 Examine the specimens with the unaided eye in order to detect possible cracks, delamination, or other defects, and record any observations.

13.3.4 Carry out the flexural strength test as specified in Section 5, after preliminary conditioning for wet strength.

13.4 *Calculation, Interpretation of Results, and Report*:

13.4.1 For each pair of specimens ($i = 1$ to 10), calculate the individual ratio (*ri*) as follows:

$$r_i = t_i/c_i \tag{13}$$

where:

t = flexural strength after warm water immersion, and
c = control flexural strength.

13.4.2 Calculate and report the average ($\bar{x}$) and the standard deviation (*S*) of the individual ratios (*ri*). The standard deviation (estimated) shall be calculated as follows:

$$s = \sqrt{\frac{n\Sigma(x)^2 - (\Sigma x)^2}{n(n-1)}} = \sqrt{\frac{\Sigma x^2 - (\Sigma x)^2/n}{(n-1)}} \tag{14}$$

where:

s = estimated standard deviation,
x = value of single observation, and
n = number of observations.

13.4.3 Calculate and report the 95 % lower confidence estimate of the ratio as follows:

$$L_{95} = \bar{x} - 0.58\,s \tag{15}$$

where:

$\bar{x}$ = arithmetic mean of the set of observations, and
s = estimated standard deviation.

13.5 *Precision and Bias*:

13.5.1 *Precision*—The precision of the procedure in Test Methods C 1185 for warm water is being determined.

13.5.2 *Bias*—Since there is no accepted reference material suitable for determining the bias for the procedure in Test Methods C 1185 for warm water, no statement on bias is being made.

14. Heat/Rain—Wall Structures

14.1 *Significance and Use*—This test is used to assess the installed performance of the produce under cyclic changes in moisture content.

14.2 *Test Specimens*— Sheet specimens used for the test shall be drawn at random from stock of finished products. The number of sheets required will depend upon the manufacturer's installation recommendations and on the size of the sheets to be tested.

14.3 *Procedure*:

14.3.1 Assemble a test frame, according to the manufacturer's recommendations, that simulates the rigidity of the field installation. The frame construction should include provisions for at least one sheet joint in its central region. The perimeter of the frame should allow for standard sheet edge finishing. The construction of the frame should meet the following requirements:

14.3.1.1 A minimum of 37.7 ft^2(3.5 m^2),

14.3.1.2 Allow sheets to be installed with normal orientation,

14.3.1.3 Allow installation of at least two sheets as follows, and

14.3.1.4 Avoid any significant external air flow during test period.

(*1*) Area per sheet >19.4 ft^2(1.8 m^2) for 2 specimens,

(*2*) Area per sheet <19.4 ft^2 (1.8 m^2) or a sufficient number

of specimens to cover an area of 37.7 ft^2(3.5 m^2), and

(*3*) If the combined area of the sheets exceeds 37.7 ft^2(3.5 m^2) the sheet lengths may be reduced to provide a test area not less than 37.5 ft^2(3.5 m^2).

14.3.1.5 Avoid any significant external air flow during the test period.

14.3.2 Fix the sample sheets to the test frame, observing all manufacturer's recommendations. The edge fixing distance shall be the minimum allowed. The center distance between fixing shall be the maximum allowed. Include all weatherproofing and other attachments normally specified in the assembly. Where sheets are recommended to have overlapping joints, assemble the test frame accordingly. Set the sheeted test frame in a vertical position. Provide a water spray station to wet one surface, along with a heating station, to provide uniform radiant heat. Subject the sheeted test frame to the number of cycles specified in the applicable standard specification meeting the following requirements.

14.3.3 Water spray at a rate of 1 gal/min for a period of 2 h, 55 min, water temperature not to exceed 86°F (30°C),

14.3.4 Pause for a period of 5 min,

14.3.5 Radiant heat to give a measurement plate (1) temperature across the complete test frame surface of 140 ± 9°F (60 ± 5°C) for a period of 2 h, 55 min, and

14.3.6 Pause for a period of 5 min.

NOTE 6—A measurement plate is defined as an aluminum plate 2 by 2 in. (50 by 50 mm) of 0.040-in. (1-mm) thickness having a black matte finish. A suggested method for obtaining a black matte finish is to completely blacken the measurement plate with soot from a burning candle. The measurement plate shall have a thermal couple or similar device attached to the surface of the plate.

14.4 *Report*—On completion of the final test cycle, inspect the sheets with the unaided eye and report any damage or structural alteration caused by the test.

14.5 *Precision and Bias*—No statement is made about either the precision or bias of Test Methods C 1185 for heat/rain—wall structures, since the result merely states whether there is conformance to the criteria for success specified in the procedure.

15. Heat/Rain—Roof Structures

15.1 *Significance and Use*—This test is used to assess the installed performance of fiber cement roofing products under cyclic changes in moisture content.

15.2 Fiber cement roofing materials are fastened to a roofing frame in accordance with the manufacturer's recommended installation practices. The assembled frame is then subjected to alternate wetting and heating cycles, and any structural alteration of the roofing materials caused by the test is reported.

15.3 *Test Specimens*— Fiber cement roofing product specimens used for the test shall be drawn at random from the stock of finished products. The number of specimens required will depend upon the manufacturer's installation recommendations and the size of the assembly to be tested.

15.4 *Procedure*:

15.4.1 Assemble a roof test frame according to the manufacturer's recommendations that simulates the rigidity of the field installation. The construction of the frame should be a minimum of 47.7 ft^2(4.5 m^2).

15.4.1.1 Avoid any significant external air flow during the test period.

15.4.2 Fix the roofing materials to the test frame, observing all manufacturer's recommendations. The head lapping distance shall be the minimum allowed. All weatherproofing and other attachments normally specified shall be included in the assembly. The assembled test frame may be set in a plane down to a minimum slope of one in four, or alternatively may be set in a vertical position. A water spray station is provided to wet the top weather surface, along with a heating station to provide uniform radiant heat. The sheeted test frame should be subjected to the number of cycles specified in the applicable standard specification meeting the following requirements.

15.4.2.1 Water spray at a rate of 1 gal/min (4 L/min) for a period of 2 h, 55 min, with a water temperature not to exceed 86°F (40°C).

15.4.2.2 Pause for a period of 5 min.

15.4.2.3 Radiant heat to give a measurement plate (1) temperature across the complete test frame surface of 140 ± 9°F (60 ± 5°C) for a period of 2 h and 55 min.

15.4.2.4 Pause for a period of 5 min.

NOTE 7—A measurement plate is defined as an aluminum plate 2 by 2 in. (50 by 50 mm) of 0.040-in. (1-mm) thickness having a black matte finish. A suggested method for obtaining a black matte finish is to completely blacken the measurement plate with soot from a burning candle. The measurement plate shall have a thermal couple or similar device attached to the surface of the plate.

15.5 *Report*—On completion of the final test cycle, inspect the roofing products with the unaided eye and report any damage or structural alteration caused by the test.

15.6 *Precision and Bias*—No statement is made about either the precision or bias of Test Methods C 1185 for heat/rain—roof structures, since the result merely states whether there is conformance to the criteria for success specified in the procedure.

16. Freeze/Thaw—Roofing Products

16.1 *Significance and Use*—This test investigates the degradation of the product due to exposure to repeated freeze-thaw cycles. This test is a comparative one based on the percentage of strength reduction after a specified number of cycles.

16.2 *Test Specimens*—Twenty test specimens shall be cut from ten separate pieces of product. Product to be tested shall be conditioned for 28 days at 73 ± 4°F (23 ± 2°C) and a relative humidity of 50 ± 5 %. The specimens shall be 12 in. (305 mm) long and 6 in. (152 mm) wide or one-half the width of an individual piece, if the piece is less than 12 in. wide. Cut two specimens from each piece of product, so that at least 50 % of the top surface area will come form the area of the piece that would normally be exposed, as specified in the manufacturer's installation instructions. There shall be at least one cut edge of 12 in. that exposes the substrate on each specimen. Label each piece to identify which two pieces were cut from a specific sample.

16.3 *Procedure*:

16.3.1 Divide the test specimens from each piece to form two sets of ten specimens each. One set is for control and one is for freeze/thaw testing. Control specimens shall be retained in a freezer at -10 ± 10°F (-23 ± 6°C) to retard hydration.

16.3.2 Saturate one set of ten test specimens by immersing them in water at a temperature of 60 ± 18°F (16 ± 10°C) for a minimum of 48 h.

16.3.3 The specimens shall be sealed individually into plastic bags surrounded on all sides by a minimum of 250 mL and a maximum of 500 mL of water; air shall be evacuated from the bag. The plastic bag shall have a thickness of between 8 mils (0.2 mm) and 12 mils (0.3 mm). The length and width of the bags shall not exceed the length and width of the specimen by more than 20 %, respectively.

16.3.3.1 Specimens shall be horizontal during freezing and thawing. It is permitted to test individual specimens or to stack specimens on top of each other, provided that spaces of at least ¼ in. (6 mm) thick are used between adjacent specimens, or individual perforated shelves are provided for each specimen to allow circulation of air and water between specimens.

16.3.3.2 When specimens are stacked, one of the specimens in the middle of the stack shall have a thermocouple embedded in a small hole 1⁄16 in. (1.5 mm) maximum diameter drilled in the center of the top surface to a depth of the mid-plane of the specimen, to determine when the specimens have reached the prescribed temperature.

16.3.4 Subject the specimens to the number of freeze/thaw cycles required in the applicable product specification to achieve the desired grade classification.

16.3.5 Freeze in a freezer where the specimen with the thermocouple shall reach at temperature of -10 ± 10°F (-23 ± 6°C) within 24 h and be held for a minimum of 1 h.

16.3.6 Thaw in air or water, where the specimen with the thermocouple shall reach a temperature of 60 ± 18°F (16 ± 10°C) within 24 h and be held for a minimum of 1 h before proceeding with freezing.

16.3.7 Each freeze/thaw cycle shall have a minimum cycle time of 4 h and a maximum of 48 h, but an interval of 72 h maximum can be taken between cycles.

16.3.8 The freezer unit shall be capable of being controlled to the prescribed freezing condition with a full load of test specimens.

16.3.9 During both the freezing and thawing cycles, the specimens shall be positioned to allow the free circulation of air/water around the individual bags. Care shall be taken to ensure that the proper quantity of water remains in the bag. Bags can be replaced or repaired during the test program.

16.3.10 Saturate the control specimens and the cycled specimens (removed from the bags) by immersing them in water at a temperature greater than 60°F (15°C) for a minimum of 48 h. On the same day, submit both sets of specimens to the saturated flexural test according to Section 5. Specimens with a uniform thickness shall have the strength recorded as MOR. Specimens with an uneven thickness shall have the strength recorded as the breaking load.

16.4 *Calculation and Report*—Calculate and report the ratio R of the strength averaged for the set undergoing freeze/thaw cycles (F_f) to the strength averaged for the control of reference set (F_r).

$$R = \frac{F_f}{F_r} \tag{16}$$

16.5 *Precision and Bias*:

16.5.1 *Precision*—The precision of the procedure in Test Methods C 1185 for freeze/thaw-roofing products is being determined.

16.5.2 *Bias*—Since there is no accepted reference material suitable for determining the bias for the procedures in Test Methods C 1185 for freeze/thaw-roofing products, no statement on bias is being made.

17. Keywords

17.1 accelerated aging; acceptable quality limit (AQL); cellulose fiber; clapboards; cracking; delamination; density; dimensional measurements; edge straightness measurement; equilibrium conditioning; flat sheet; flexural; freeze/thaw; granulated surface; heat/rain; inspection by attributes; inspection by variables; length measurement; linear change; long-term chemical interaction; modulus of rupture; moisture content; moisture movement; non-asbestos fiber cement; polyethylene fiber; polyvinyl alcohol fiber; radiant heat; roofing; sample conditioning; sample testing; sampling; sampling by attributes; sampling by variables; sampling schemes; saturated conditioning; serviceability; shakes; shingles; siding; slates; smooth surface; squareness measurement; strength; textured surface; thickness measurement; warm water; water absorption; water displacement method; water tightness; weather degradation; weathering exposure; weatherproofing; wet conditioning; width measurement