Designation: E2786 – 10 (Reapproved 2015)

Standard Test Methods for Measuring Expansion of Intumescent Materials Used in Firestop and Joint Systems[1]

This standard is issued under the fixed designation E2786; 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 determine, by measurement, the expansion of intumescent materials used in firestop and joint systems under specified conditions.

1.2 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.3 The text of these test methods references notes and footnotes which provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the fire test response standard.

1.4 *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.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E176 Terminology of Fire Standards

E631 Terminology of Building Constructions

3. Terminology

3.1 *Definitions*—Definitions in the following standards will prevail for terms not defined in these test methods.

3.1.1 For definitions of general terms used in these test methods related to building construction, refer to Terminology E631.

3.1.2 For definitions of general terms used in these test methods related to fire standards, refer to Terminology E176.

3.2 *Definitions of Terms Specific to This Standard:*

3.3 *expansion, n*—an increase in the dimensions as the result of heating.

3.4 *expansion factor, n*—the ratio of the material height before and after heating, under test conditions that allow expansion only in the vertical direction.

3.5 *intumescent, adj*—characterized by swelling when exposed to high surface temperatures or flames.

4. Summary of Test Method

4.1 These test methods place a material of a specified thickness or volume into a specific device that is capable of heating the material.

4.2 After the material is heated, its dimensional or volumetric change is measured.

4.3 Two test methods are provided, one using a test specimen holder (Test Method A) and the other using a water displacement method (Test Method B).

4.4 Test Method A may be used for measuring expansion of any material.

4.5 Test Method B may be used for measuring expansion of any material, except for those materials that are granular, that are susceptible to absorbing paraffin in conditioned pre-expanded state or post-expanded state, or that are susceptible to damage or deformation in a post-expanded state.

4.6 The test method used must be reported, as use of different test methods will result in different expansion factors.

5. Significance and Use

5.1 These test methods are intended to measure the material's expansion after heating.

5.2 The test methods also provide a means to determine the expansion factor.

6. Apparatus

6.1 *Heating Device*—An enclosed furnace or oven or similar equipment capable of maintaining the temperature specified herein and large enough to contain the test specimen holder.

6.2 *Test Method A—Test Specimen Holder Method:*

[1] These test methods are under the jurisdiction of ASTM Committee E06 on Performance of Buildings and is the direct responsibility of Subcommittee E06.21 on Serviceability.

Current edition approved Jan. 1, 2015. Published January 2015. Originally approved in 2010. Last previous edition approved in 2010 as E2786–10. DOI: 10.1520/E2786-10R15.

[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.

6.2.1 *Test Specimen Holder*—A Series 300 stainless steel assembly consisting of at least two cylinders contained in a frame into which the material is placed. Each cylinder shall be nominally 5 in. (130 mm) high with a nominal 2 in. (50 mm) outside diameter. Fig. 1 is an example of a test specimen holder. Wall thickness shall be nominal 0.08 in. (2 mm).

6.2.2 *Restrictor Plate*—A Series 300 stainless steel disc with a diameter of 0.01 to 0.015 in. (0.25 to 0.38 mm) less than that of the cylinder in 6.2.1 and with a mass of 1.14 oz/in^2 (5 g/cm^2), ±0.023 oz/in^2 (0.1 g/cm^2).

NOTE 1—For a Series 300 stainless steel, a qualifying restrictor plate can be made from solid bar stock with an O.D. of 1.82 in. (46.2 mm) and a thickness of 0.25 in. (6.5 mm) (see Fig. 2).

6.2.3 *Steel rule die* with the same width as the diameter of the cylinder in 6.2.1, +0.0 – 0.015 in. (+0 – 0.38 mm).

6.2.4 The following are needed to prepare some test specimens:

6.2.4.1 A dial caliper with a smallest division of 0.001 in. (0.025 mm),

6.2.4.2 Drying oven capable of reaching and maintaining 212°F (100°C),

6.2.4.3 A balance accurate to ±0.00035 oz (±0.01 g),

6.2.4.4 A small hydraulic press with platens larger than 5 in. (130 mm) square,

6.2.4.5 Two nominal 0.25 in. (6.4 mm) thick metal shims at least 4 in. (100 mm) long to create the needed product thickness in the press,

6.2.4.6 Release liner paper, and

6.2.4.7 Steel ruler graduated to 0.0156 in. (0.39 mm).

6.3 *Test Method B—Water Displacement Method (See Fig. 3):*

6.3.1 *Base*, independent of the balance,

6.3.2 *Steel rule die*, 1 in. (25 mm) diameter,

6.3.3 *Glass beaker*, 400-mL smooth wall type,

6.3.4 Weight with hook attached,

6.3.5 *Aluminum tins*,

6.3.6 *Electric hot plate* for heating wax,

6.3.7 *Paraffin wax* with Melting Point of 132.8°F – 134.6°F (56°C – 57°C), or equivalent.

6.3.8 *Distilled Water*.

7. Hazards

7.1 This test method uses equipment, which alters a material's state that may create noxious gases that may be harmful. Care should be taken to provide adequate ventilation for all equipment capable of producing this effect.

8. Sampling, Test Specimens, and Test Units

8.1 Samples representative of the material shall be randomly selected. Record the name, address, manufacturer's designation, and lot number for the material that was used for the test sample.

NOTE 2—When samples are selected by the laboratory or its authorized representative as part of a quality assurance program, the samples shall be duly marked to ensure traceability.

NOTE 3—Samples may be selected from other sources other than the manufacturer's facility. The manufacturer of the samples may not be known.

8.2 The results of this test are only applicable to the specific nominal thickness and density of the material sampled and tested.

8.3 At least three test specimens shall be used.

8.4 Each test specimen shall be a single piece without any joints.

8.4.1 *Exception 1*—Granular materials.

8.4.2 *Exception 2*—Materials that have dimensions that are smaller than required to create a 2 in. (50 mm) method A or 1 in. (25 mm) method B, diameter round test sample shall be joined together to create the test specimen. The method of joining shall be acceptable to the test sponsor and to the testing laboratory.

NOTE 4—When joining is required, the method of joining should not have any significant anticipated effect on the results of the test. Prepare all test specimens using the same method for each material.

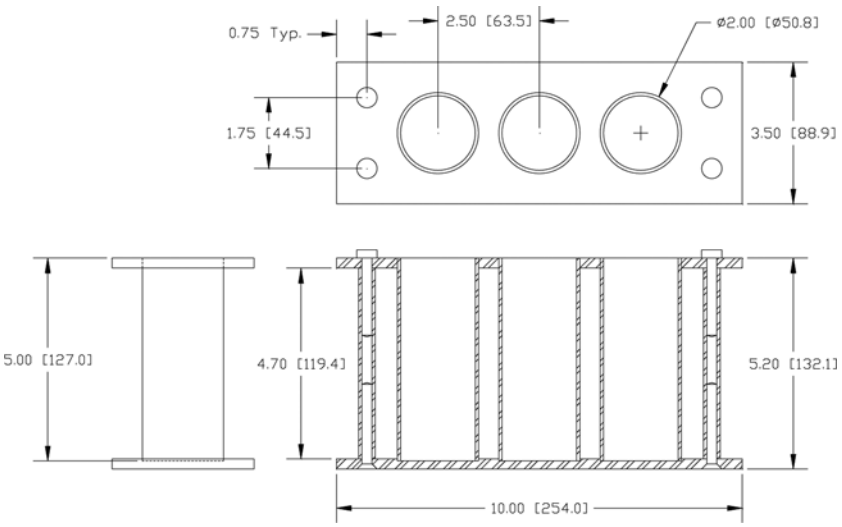

FIG. 1 Test Specimen Holder (Test Method A)

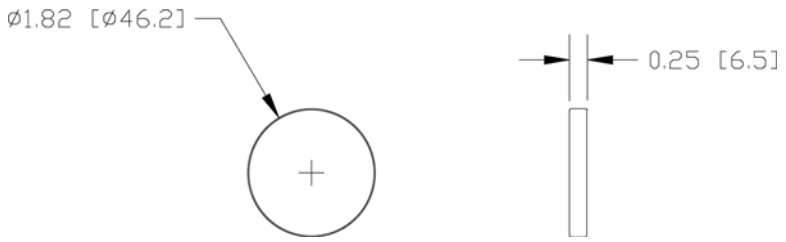

FIG. 2 Restrictor Plate

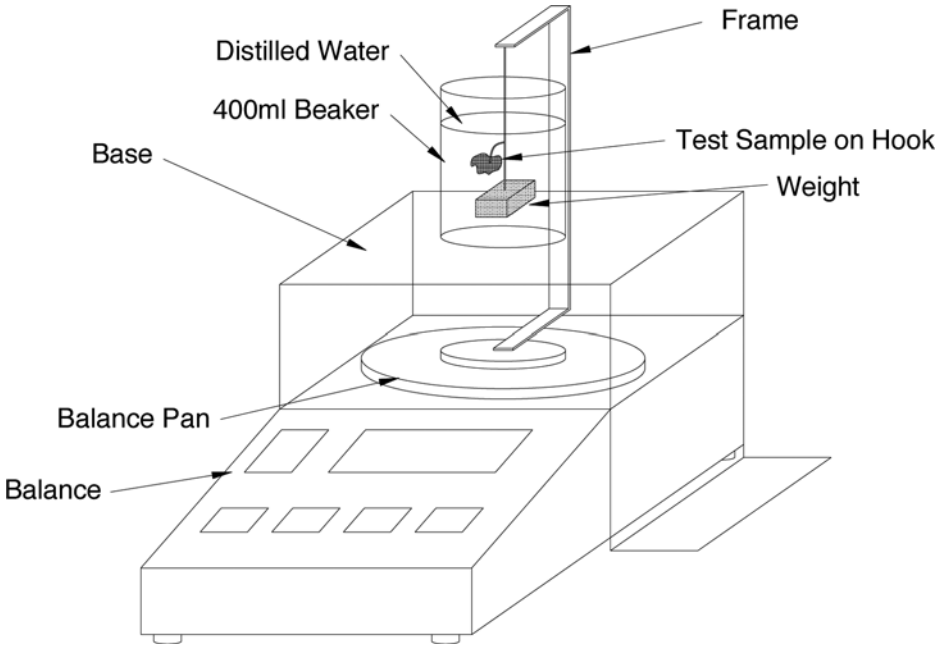

FIG. 3 Test Method B Apparatus

NOTE 5—When comparing results between laboratories or tests, it is critical that the same preparation and test method is used in all tests.

8.5 For preformed materials, cut the samples into disc-shaped test specimens using a die.

8.6 For caulk and putty materials:

8.6.1 Cut two pieces of release liner paper into nominal 5 in. (125 mm) squares for each test specimen. Place enough material in the center of one sheet so that when compressed it will create a nominal 4 in. (100 mm) square by 0.25 in. (6.4 mm) thick sample. Place the other sheet of release liner paper squarely over the top of the first, sandwiching the material between them.

8.6.2 Place the metal shims along the outer edges of the platen press.

8.6.3 Place the release liner paper and material sandwich between and in the center of the platen press.

8.6.4 Close the press so that it stops at the metal shims. Leave the release liner paper and material sandwich in the press for at least 30 s.

8.6.5 Remove sample from press.

8.6.6 Cure samples in accordance with manufacturer's published instructions.

8.6.7 Take the release liner with material out of the oven and let it cool to room temperature, then remove the top and bottom layers of the release liner paper and remove the cured material.

8.6.8 Cut the sample into at least three disc-shaped test specimens using a die.

8.7 For granular materials:

8.7.1 Pour granules into a 100 ml graduated cylinder.

8.7.2 Tap the graduated cylinder on hard surface 10 times.

8.7.3 Read and record the volume of granules in the graduated cylinder to the nearest millilitre (see 12.1.2.1).

8.7.4 Pour material into test specimen holder.

8.7.5 Repeat steps 8.7.1 – 8.7.4 until three test samples are prepared for heating.

8.8 Each test specimen shall have its own identification or designation. All information recorded shall reference that identification or designation.

9. Preparation of Apparatus

9.1 *Test Temperatures*—Prior to conducting the test, the heating device shall be brought to equilibrium at the required test temperature.

9.2 The test specimen holder, used for Test Method A, shall be cleaned prior to performing each test. Cleaning shall incorporate any process used at the discretion of the laboratory that will render the apparatus free from any debris or residue from previous testing. The apparatus shall also be fully dry prior to installing test specimens.

10. Calibration and Standardization

10.1 The temperature in the heating device shall be verified using a thermocouple or thermometer that is accurate to ±5°F (±3°C).

10.2 The measuring device used to determine expansion shall be accurate to ±0.01 in. ±(0.25 mm).

10.3 The measuring device used to determine the initial thickness of the samples shall be accurate to ±0.001 in. (±0.025 mm).

11. Conditioning

11.1 All test specimens shall be conditioned to equilibrium by weight in a room or chamber with a temperature of 72°F ± 5°F (23 ± 3°C) at 50 ± 5 % RH. Weigh and record the weight of each test specimen once a day until equilibrium is reached. Equilibrium is considered achieved when the weight change is less than 1 % per day. After the samples have reached equilibrium, they are to be retrieved and tested within 1 hour after removal from the conditioning environment.

12. Proceedure

TEST METHOD A – TEST SPECIMEN HOLDER METHOD

12.1 Measure the pre-test sample dimensions:

12.1.1 *Solid Samples:*

12.1.1.1 Measure and record each preformed test specimen thickness at five symmetrical points as shown in Fig. 4 for three test specimens. For granular materials, see 12.1.2.

12.1.1.2 Measure the thickness as shown in Fig. 4 within ±0.001 in. (±0.025 mm). Record this measurement as H_s (see 13.1.1).

12.1.2 *Granular Samples:*

12.1.2.1 Use the volume recorded in 8.7.3. Divide the volume by the cross-sectional area of the inside of the test specimen holder cylinder. Record this value as H_s.

NOTE 6—For the cylinder dimension discussed in 6.2.1, the inside diameter of commercially available stainless steel tubing is 1.834 in. (46.6 mm) and the correlating area is 2.64 in^2 (17 cm^2).

12.2 Place test specimens into the test specimen holder. Place one sample in the bottom of each cylinder. Each test specimen shall be laid flat in the bottom of the cylinder. Cover the test specimen with the Restrictor Plate as described in 6.2.2.

12.3 Measure the distance from the top edge of the test specimen holder to the top of Restrictor Plate. Record this distance as H_i.

12.4 The specimen holder containing test specimens, as described in 12.2, shall be exposed to a temperature of 1022 ± 5°F (550 ± 2.7°C).

12.5 Insert the test specimen holder into the pre-heated heating device as described in 6.1.

12.6 Leave the test specimen holder in the heating device for 30 ± 1 min.

12.7 Remove the test specimen holder from the heating device and place it in a room or chamber with a temperature of 72°F ± 5°F (23 ± 3°C) at 50 ± 5 % RH.

12.8 Allow the test specimen holder to cool to reach the temperature in the room or chamber.

12.9 *Measuring Expanded Samples:*

12.9.1 *Solid Samples:*

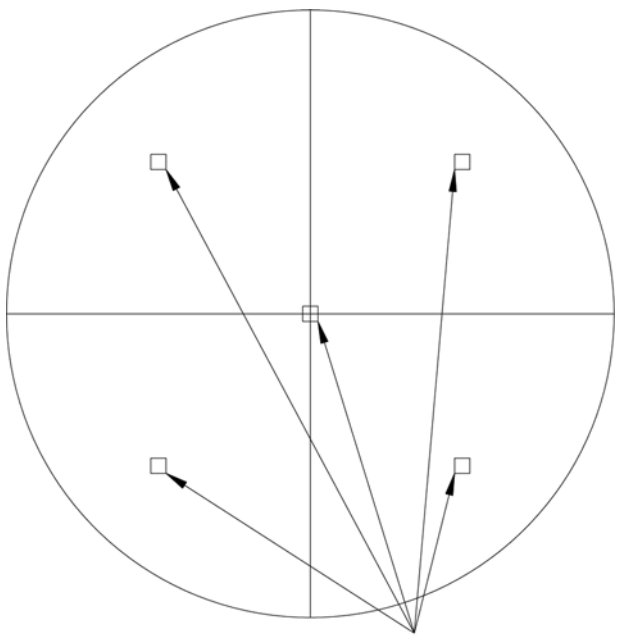

FIG. 4 Thickness Measuring Points

12.9.1.1 After cooling, measure and record the minimum and maximum expansion of intumescent materials for each test specimen to the nearest 1/16 in. (1.6 mm). Measure the distance from the top edge of the test specimen holder to the top of Restrictor Plate. Record this distance as H_f .

12.9.1.2 If the expanded sample height, as calculated by (H_f – H_i) + H_s, is less than 1.5 in. (38 mm), the test shall be discarded. Subsequent tests shall be conducted using the minimum number of multiple layers of material at the initial sample thickness, so that the expanded sample shall have a minimum height of 1.5 in. (38 mm) and a maximum height of 4 in. (102 mm).

NOTE 7—H_f is measured in 12.9.1.1, H_i is measured in 12.3, H_s is measured in 12.1.1.2 or 12.1.2.1.

NOTE 8—Discussion: A minimum expansion height is specified so the allowed measurement tolerance of 1/32 in. (0.8 mm) does not produce excessive errors in the final result.

12.9.1.3 Calculate the expansion factor using the procedure and formulas in 13.1.

12.9.2 *Granular Samples:*

12.9.2.1 Pour into a graduated cylinder large enough to hold the material.

12.9.2.2 Record the volume of material to the nearest millilitre.

12.9.2.3 Calculate the expansion factor using the procedure and formulas in Section 13, Test Method B.

TEST METHOD B – WATER DISPLACEMENT METHOD

NOTE 9—Some materials may not be appropriate to test using this method. For example, a product that loses structure after intumescing may be damaged with a paraffin soak, or a sample that the char cannot be handled without breaking.

NOTE 10—Procedure Test Method B uses Archimedes Principal to measure the volume displacement of the initial verses the expanded sample. Refer to Appendix X1 for a more in depth discussion on this principle and how it is applied in this method.

12.10 Die cut three 1 in. (25 mm) diameter samples from the material to be tested.

12.11 *Balance Set Up:*

12.11.1 Place the sample holder (metal frame) on top of the balance pan (Fig. 2).

12.11.2 Place the metal base over the balance. Make sure it is not touching the balance.

12.11.3 Place the beaker on the metal frame and fill with water to approximately 1 in. (25 mm) below the top rim.

12.11.4 Tare the balance.

12.12 *Unexpanded Volume Determination:*

12.12.1 Tare the balance with the hook and weight attached to the metal frame and suspended in water.

12.12.2 Place the unexpanded sample on top of the balance pan. Record the weight value from the balance as W_i, ±0.01 g. Tare the balance again, with the sample still on the balance pan.

12.12.3 Remove the sample from the pan and suspend it on the hook so that it is under water. The sample must be completely submerged and free from the sides of the beaker.

12.12.4 Record the balance reading after submerging each initial sample, Record this value as V_i, in grams ±0.01 g.

12.12.5 The V_i reading will be negative. Disregard the negative sign when recording the weight value.

12.13 Expanded volume determination.

12.13.1 Place the unexpanded samples in an aluminum tin and place it the kiln at 662 ± 9°F (350 ± 5°C) for 15 min.

12.13.2 Remove the sample form the kiln and allow it to cool to room temperature.

12.13.3 Melt paraffin wax in a heating vessel on the hot plate and keep the paraffin at 200 ± 5°F (93 ± 3°C).

12.13.4 Dip the expanded samples in paraffin wax for 10 s. Drain off excess wax and allow it to cool to room temperature.

12.13.5 Tare the balance with the hook and weight attached to the metal frame and suspended in water.

12.13.6 Place the expanded sample on top of the balance pan. Record the weight value from the balance as W_f, ±0.01 g. Tare the balance again, with the sample still on the balance

12.13.7 Remove the sample from the pan and suspend it on the hook so that it is under water. The sample must be completely submerged and free from the sides of the beaker.

12.13.8 Record the balance reading after submerging each expanded sample, Record this value as V_f, in grams ±0.01 g.

12.13.9 The V_f reading will be negative. Disregard the negative sign when recording the value.

12.13.10 Calculate the expansion factor using the procedure and formulas in Section 13, Test Method B.

13. Calculation or Interpretation of Results

TEST METHOD A – TEST SPECIMEN HOLDER

13.1 *Solid Materials:*

13.1.1 Prior to exposure, determine the average sample thickness by averaging the data (H_s) collected in 12.1.1.2. Record this value as T.

13.1.2 After each heat exposure, determine the average expansion height as follows:

13.1.2.1 Determine and record the maximum expansion height (H_{Max}) by subtracting the shortest distance recorded as H_f in 12.9.1.1 from the distance recorded as H_i in 12.3.

13.1.2.2 Determine and record the minimum expansion height (H_{Min}) by subtracting the longest distance recorded as H_f in 12.9.1.1 from the distance recorded as H_i in 12.3.

13.1.2.3 First calculate the expansion height (H_e) for each test specimen.

(1) H_e = expansion height in inches (millimetres), where $H_e = (H_{Min} + H_{Max})/2$,

(2) H_{Max} = Maximum Expansion Height, value from 13.1.2.1,

(3) H_{Min} = Minimum Expansion Height, value from 13.1.2.2.

13.1.2.4 The expansion factor (X) is the average value of all test specimens' results. Calculate expansion factor:

$$X = ((T1 + H_e1)/T1 + (T2 + H_e2)/T2 + \ldots (T_n + H_en)Tn)/n \quad (1)$$

where:

T = initial material thickness in inches (centimetres), value from 13.1.1, and

n = number of samples.

13.2 *Granular Materials:*

13.2.1 Prior to exposure, determine the average volume before exposure to heat or before expansion from 8.7.3. Record this value as V_i.

13.2.2 After each heat exposure, determine the average volume after exposure to heat or after expansion from 12.9.2. Record this value as V_f.

13.2.3 Record V_i and V_f for all samples and number them sequentially.

13.2.4 The expansion factor (X) is the average value of at least three test specimens' results. All specimen results shall be included in the calculated average. Calculate expansion factor:

$$X = ((V_f1/V_i1)+(V_f2/V_i2)+\ldots(V_fn/V_in))/n \quad (2)$$

where:

Vi = initial volume from 8.7.3, and
Vf = final volume from 12.9.2.

13.3 Record the expansion factor.

TEST METHOD B – WATER DISPLACEMENT METHOD

13.4 The expansion factor, X, is defined as the final (expanded) volume divided by the initial (unexpanded) volume, for a 1 in. (25 mm) diameter disc. Expansion factor (X) = V_f/V_i.

13.5 Repeat the calculation for all samples.

13.6 Calculate the average expansion factors and record the average values.

14. Report

14.1 Report the following information at a minimum:

14.1.1 Laboratory's name and address

14.1.2 Project or referenced number assigned to the test.

14.1.3 Test sponsor's name and address.

14.1.4 The name and address of the manufacturer who produced the test sample.

14.1.5 Name, date, and location where sample was acquired.

14.1.6 Manufacturer's or test sponsor's designation for the test sample.

14.1.7 Lot number of the test sample material selected.

14.1.8 Test method used, either Test Method A (expansion under pressure) or Test Method B (free expansion).

14.1.9 Thickness of test sample.

14.1.10 Type of test sample, that is, sealant, spray, sheet, foam, etc.

14.1.11 Color and texture of test sample.

14.1.12 Temperatures test conducted

14.1.13 Weight of each test specimen.

14.1.14 All measurement data.

14.1.15 All calculations.

14.1.16 The expansion factor (X).

14.1.17 For any items on this list that are not available to the test laboratory, those items shall be duly noted that they were not available in the test report.

15. Precision and Bias

15.1 No comprehensive test program has been conducted to develop data on which to derive statistical measures of repeatability (within-laboratory variability) or reproducibility (among laboratory variability). No information can be presented on the bias of the procedure in the test method for measuring the char height (intumescences) of materials because no material having an accepted reference value is available at this time.

16. Keywords

16.1 expansion; expansion factor; firestop; intumescent; joint system

APPENDIX

(Nonmandatory Information)

X1. ARCHIMEDES' PRINCIPLE

X1.1 Archimedes's Principle indicates that "A body wholly or partially immersed in a fluid will be buoyed up by a force equal to the weight of the fluid that it displaces".[3] Using this principle, the volume of an object having a non-uniform shape, like that of an article that has intumesced, can be determined by measuring the difference in weight between the object in air and the object fully submersed in water. 1 cubic centimeter of water weighs 1 gram. Since there is a 1 to 1 ratio between volume in cc's and, the weights recorded for the samples (V_i and V_f) can be recorded directly from the gram scale as volume measurements.

[3] Halliday and Resnick, *Fundamentals of Physics*, 3rd Edition extended, John Wiley & Sons, New York, 1988, p. 371.