NFPA
259

STANDARD TEST METHOD FOR

POTENTIAL HEAT OF BUILDING MATERIALS

1982

NATIONAL FIRE PROTECTION ASSOCIATION, INC.
Batterymarch Park, Quincy, MA 02269

.75M-1-82-FP
Printed in U.S.A.

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Standard Test Method for
Potential Heat of Building Materials

NFPA 259-1982

1982 Edition of NFPA 259

This edition of NFPA 259, *Standard Test Method For Potential Heat of Building Materials*, was prepared by the Technical Committee on Fire Tests and acted on by the National Fire Protection Association, Inc. on November 18, 1981, at its Fall Meeting in Toronto, Ontario, Canada. It was issued by the Standards Council on December 9, 1981, with an effective date of December 29, 1981, and supersedes all previous editions.

Changes other than editorial are indicated by a vertical rule in the margin of the pages on which they appear. These lines are included as an aid to the user in identifying changes from the previous edition.

Origin and Development of NFPA 259

This standard is based on a test method developed at the National Bureau of Standards in 1961. Consideration of the test method by the NFPA was begun in 1973 culminating in the standard which was adopted in 1976, and reconfirmed at the 1981 Fall Meeting.

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Chapter 1 General

1-1 Scope. This method of test provides a means of determining, under controlled laboratory conditions, the total potential release of heat of materials under defined fire exposure conditions. Determinations may be made on individual homogeneous or individual composite materials, from which a representative sample can be taken. It is essential that the information on application of potential heat data in the Appendix be consulted prior to applying test results.

1-2 Significance. The potential heat test method yields a property type measurement of the total heat release possible from building materials when exposed to oxidizing conditions at 750°C (1382°F).

Except for very low heat materials such as steel, results are reported in terms of heat release per unit mass (BTU/lb).

1-3 Definition. Potential heat of a material as determined by this method is the difference between the heat of combustion of a representative specimen of the material and the heat of combustion of any residue remaining after exposure to a defined fire condition, using combustion calorimetric techniques.

1-4 General. One of two specimens removed from the material to be tested is pulverized, pelleted, and burned in a high-pressure oxygen atmosphere.[1] This determines the gross heat of combustion of the material. The second specimen is heated in air for two hours at a temperature of 750°C (1382°F). A portion of the resulting residue of this specimen, if any, corresponding to a predetermined weight of original material, is ground or pulverized, mixed with a combustion promoter, and pelleted for burning as was the first specimen. After correcting for the heat produced by the combustion promoter, the difference in heating values of the two specimens is the potential heat as defined in Section 1-3. The test procedure is illustrated schematically in Figure 1-4.1.

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[1] The process is generally as described in ASTM D 3286-77, *Standard Test Method for Gross Calorific Value of Solid Fuel by the Isothermal-Jacket Bomb Calorimeter,* but with certain modifications or permissible exceptions, to be noted in the test procedure.

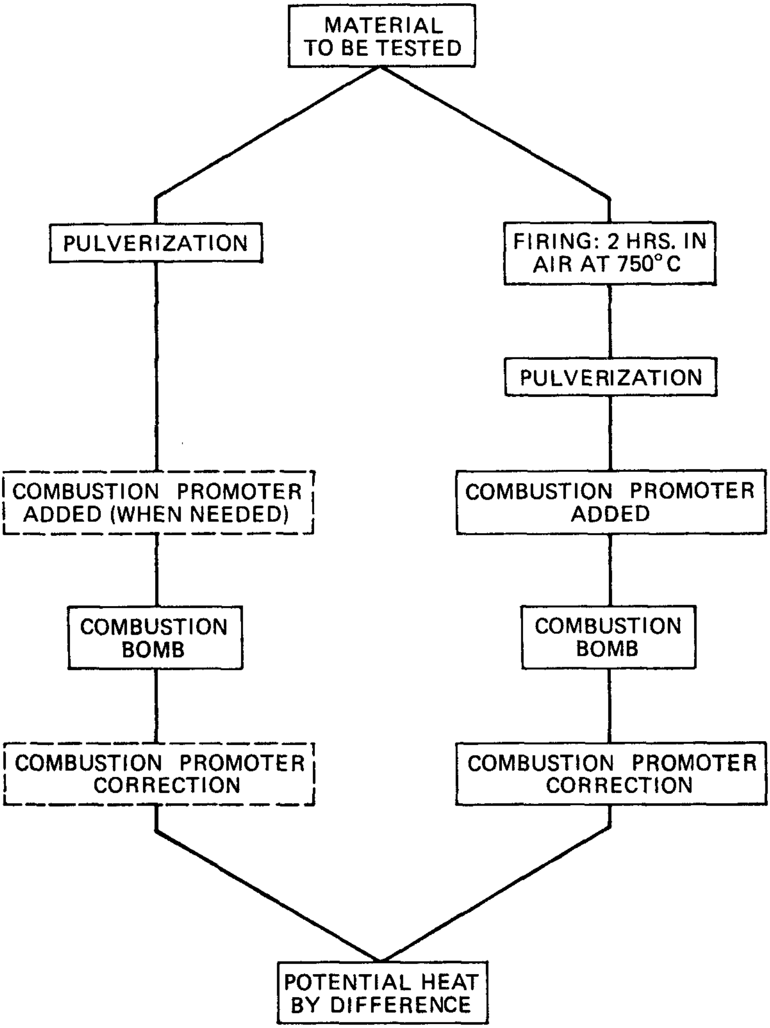


Figure 1-4.1 Schematic Diagram of Test Procedure for Potential Heat Measurements

Chapter 2 Test Apparatus and Materials

2-1 Oxygen Bomb Calorimeter. This device shall be used to determine the gross heat of combustion of the test specimen. The apparatus shall include the firing circuit and fuse wire.

2-2 Electric Muffle Furnace. This apparatus shall be used to fire the test specimen. A small opening or port shall be provided for passage of an air-supply tube. Auxiliary apparatus includes:

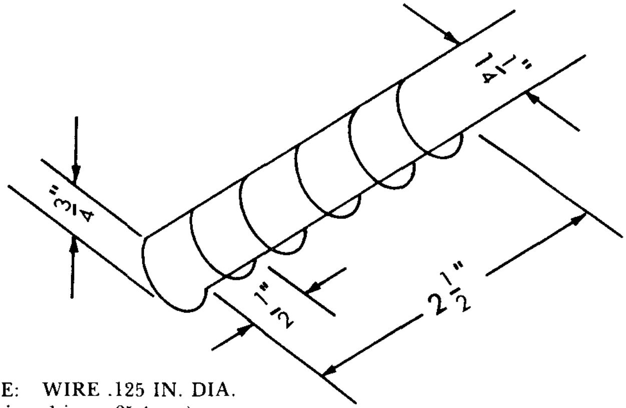
(a) *Specimen Container.* This shall be a fused silica or ceramic container, 1¼ in. (31.8 mm) inside diameter by 4 in. (101.6 mm) long.

(b) *Container Cap.* This shall be of material similar to the specimen container (a) and shall be snug fitting. An opening shall be provided for insertion of the air tube (c), sized to allow a loose fit.

(c) *Air Supply Tube.* This tube shall be of porcelain, fused silica, or corrosion-resistant metal. Inside diameter shall be $^3/_{16}$ in. (4.8 mm) minimum; length shall be sufficient to extend beyond the opening in the container cap (b).

(d) *Wire Specimen Holder* [*see Figure 2-2 (d)*]. This shall be formed to hold the test specimen away from the walls of the specimen container (a), thus allowing free air flow around the specimen. Corrosion-resistant wire shall be used.

(e) *Specimen Container Support.* This shall be of fire brick or



NOTE: WIRE .125 IN. DIA.
(For SI Units: 1 in. = 25.4 mm)

Figure 2-2(d) Wire Specimen Holder for Muffle Furnace Firing similar material, shaped to hold the specimen container (a) and cap (b) in alignment with the port of the muffle furnace, thus allowing the air supply tube (c) to be inserted through the port and into the specimen container (a).

2-3 Mill. This shall be either the hand mill or the ball mill type. It shall be used to pulverize test specimens.

2-4 Pelleting Press. This press shall be used for compressing the pulverized test specimen into a pellet shape suitable for the bomb calorimetry procedure. The press shall be a type normally used for bomb calorimetry.

2-5 Microbalance. This balance shall be a type normally used for chemical analysis, weighting to 0.1 mg.

2-6 Oxygen Cylinder and Accessory Equipment. This cylinder and its accessories shall be suitable for use with the bomb calorimeter.

2-7 Compressed Air Supply. This shall be a suitable laboratory air supply for use with the muffle furnace.

2-8 Standard Alkali Solution. This shall be the standard alkali titrating solution, as specified in ASTM D 3286-77, *Standard Test Method for Gross Calorific Value of Solid Fuel by the Isothermal-Jacket Bomb Calorimeter*, paragraph 7-5.

2-9 Combustion Promoter. This shall be the National Bureau of Standards standard material for calorimetric determinations, benzoic acid.

Chapter 3 Test Specimens

3-1 Specimens. Two air-dry representative specimens shall be required for each determination, one for each test procedure.

3-1.1 A specimen shall be considered air dry when it has reached constant weight in an environment maintained at 73 ± 2 °F (23 ± 1 °C) and 50 ± 5 percent relative humidity.

3-1.2 If the test subject is a composite or heterogeneous material, the various elements of the subject shall be contained in the test specimen in the same proportions as in the material.

Chapter 4 Direct Bomb Test

4-1 Specimen Preparation.

4-1.1 One test specimen shall be pulverized in the hand or ball mill so as to pass through a 60 mesh screen.[1] Enough of the specimen shall be pulverized so as to provide no less than 10 g of powder.

4-1.1.1 The specimen which is pulverized shall not be smaller than ½ in. × 3 in. (12.7 mm × 76.2 mm) in the thickness supplied.

4-1.1.2 Particular care shall be taken to avoid segregation or separation of components. For grossly heterogeneous materials, a representative specimen shall be obtained by combining samples of material from different units (or sheets) and from different locations on each unit.

4-1.2 A pellet, weighing approximately 1 g, shall be prepared from an intimate mixture of the powder.

4-1.2.1 All weight measurements shall be to the nearest 0.1 mg.

4-1.2.2 Pellets shall be made in accordance with the method for the particular pelleting press in use and of a size convenient for the specimen cup. The pellets shall be no harder than is necessary to prevent their disintegration during preparation for firing. Excessively hard pellets may fracture and result in incomplete combustion when fired.

4-2 Test Procedure.

4-2.1 The pellet, prepared per Section 4-1, shall be tested in accordance with ASTM D 3286-77, *Standard Test Method for Gross Calorific Value of Solid Fuel by the Isothermal-Jacket Bomb Calorimeter*, with the following exceptions:

Exception No. 1 (to paragraph 8.3.2): If fuse wire is provided for the bomb in use, a suitable correction factor for the wire shall be applied.

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[1] While many materials may be suitably reduced using a clean carbide double bastard file or mortar and pestle or both, it may sometimes be useful to (dry-ice) freeze materials containing asphaltic, mastic, or plastic components prior to filing, or to use mechanical blenders, ball or hammer mills, grinders, milling or lathe cutters, etc. For laminated materials, it may be preferable to separate into component layers and to grind, file, or pulverize each component separately. The powdered components then may be mixed intimately in proportion to their original weight fractions and the mixture tested, or, alternately, each component may be tested separately and the contributions of heat combined in proportion to their original weight fraction.

Exception No. 2 (to paragraph 10.1): In cases of incomplete burning, a combustion promoter shall be used.

Exception No. 3 (to paragraph 6.8): An ignition system supplied for the bomb may be substituted.

Exception No. 4 (to paragraph 8.2.7): Where materials leave a residue, the cup containing the residue shall be removed and the bomb rinsed out and titrated (as described in this paragraph).

Exception No. 5 (to paragraph 11.3.1): The method of this test for potential heat release of materials gives the gross heat of combustion of a material in an air-dry condition; net calorific value (net heat of combustion) calculations, as described in paragraph 11.3.2, are not normally a part of this procedure.

Exception No. 6: For tests on specimens which are predominantly metallic, the use of a silica combustion capsule is recommended. The water equivalent of the calorimeter using the silica capsule should be measured and used.

4-2.2 If, after being fired in the oxygen bomb, the pellet is found to have burned completely, or to have left residue or ash which weighs less than 1 percent of the original pellet weight, the heat of combustion shall be computed on an air-dry basis. In this case, procedures set forth in 4-2.3 shall be ignored.

4-2.3 If the pellet does not burn, or a residue or ash which weighs 1 percent or more of the original pellet weight remains after the firing, another 1-g pellet shall be prepared using approximately ½-g portions of the powdered specimen and a standard specimen of benzoic acid combustion promoter. (*See Section 4-1.*)

4-2.3.1 Each portion shall be weighed accurately to 0.1 mg prior to pelletizing.

4-2.3.2 The pellet shall be weighed accurately to 0.1 mg.

4-2.3.3 Any loss in weight after mixing and pelletizing shall be subtracted from the specimen and the combustion promoter in proportion to their original weight fractions, and the corrected weights shall be used in the heat of combustion calculations.

4-2.3.4 The pellet prepared with the benzoic acid shall be tested in accordance with 4-2.1.

4-2.4 In calculating the heat of combustion, as determined in 4-2.3, a correction for the heat of combustion of the benzoic acid present in the pellet shall be applied to the measured heat released by the specimen. The heat of combustion of the specimen material, on an air-dry basis, shall then be computed.

Chapter 5 Muffle Furnace and Bomb Test

5-1 Specimen Preparation. An air-dry specimen of the test material selected in accordance with Chapter 3 shall be cut in the form of a rectangular prism ½ ± ⅛ in. by ¾ ± ⅛ in. by 2 ½ ± ½ in. (12.7 ± 3.2 mm by 190 ± 3.2 mm by 63.5 ± 12.7 mm). Sheet materials shall be layered to these dimensions.

5-2 Muffle Furnace Procedure.

5-2.1 The muffle furnace shall be preheated to 750 ± 10 °C (1382 ± 18 °F).

5-2.2 The specimen shall be weighed and placed on the wire support in the specimen container. The container shall be closed with its cap, and placed in the fire-brick base.

5-2.3 When the furnace has been preheated, the fire-brick base, with the specimen and its container, shall be placed in the muffle furnace so as to align the muffle furnace port and the opening in the specimen container cap. The external air supply tube shall be passed through the port into the container in proximity to the specimen.

5-2.4 The test specimen shall be fired for two hours with a regulated air flow supplied to the specimen of 0.1 cfm (47.2 cm^3/sec), referenced to 60 °F (15.6 °C) and 30 in. Hg (101,000 N/m^2).

5-2.4.1 If ignition should occur immediately upon placing the specimen in the furnace, application of air shall be delayed until the initial flaming has stopped.

5-2.5 Upon completion of the two-hour firing cycle, the container with the specimen shall be cooled in a desiccator, and the weight of the residue shall be determined.

5-2.6 If the residue from the muffle firing procedure is less than 5 percent of the initial weight of the specimen, the provisions of 5-2.7 and 5-2.8 shall be omitted, and the heat of combustion previously determined under the direct bomb test, Chapter 4, shall be reported as the potential heat of the material.

5-2.7 If the residue after muffle firing is in excess of 5 percent of the original specimen weight, the residue shall be pulverized into a homogeneous powder. A ½-g sample of residue shall be mixed with an equal weight of benzoic acid and formed into a 1-g pellet. The pellet is then treated as specified in the procedure for direct bomb test, Chapter 4, to determine the heat of combustion of the residue.

5-2.8 The heat of combustion of the residue per unit weight of original specimen shall be computed by multiplying the heat of combustion determined in 5-2.7 above by the ratio of residue weight, in 5-2.5, to the original specimen weight.

Chapter 6 Calculating Potential Heat

6-1 The potential heat for test specimens yielding a residue from the muffle test procedure of less than 5 percent of the specimen's initial weight shall be equivalent to the specimen's heat of combustion, as determined by the direct bomb test, Chapter 4.

6-2 For test specimens which yield a residue from the muffle test procedure of 5 percent or more of initial specimen weight and, therefore, require direct bomb calorimetry of the residue, the potential heat shall be determined as follows:

6-2.1 The heat of combustion of the residue shall be subtracted from the heat of combustion determined via the direct bomb test, Chapter 4. The potential heat shall thus be a measure of the heat released by a material in the muffle furnace firing.

6-2.2 Potential heat shall be reported as quantity of heat per unit weight.

Exception: Where appropriate, potential heat shall be reported as quantity of heat per unit volume or surface area. For material such as metals where the combustion process is relatively slow, and is a function of surface area, potential heat shall be reported appropriately on a surface area basis only.

6-2.3 One determination of the potential heat of a material is normally adequate, provided there is not significant variability to the material and the testing laboratory has established good confidence in its procedures.

Appendix Application of Potential Heat Data

This Appendix is not a part of the requirements of this NFPA document. . .but is included for information purposes only.

Application of Potential Heat Data.

The potential heat test provides an assessment of one property of a material — the total heat release possible with muffle exposure of the specimen, under oxidizing conditions, at 750°C (1382°F). The appropriate use of this procedure must recognize its nature as a property type-test.[1] In many applications, additional supporting test data by other fire test methods may be required for qualifying materials for various fire safe applications. As an example, it should be recognized that under actual fire conditions some materials release all or most of their heat very rapidly. Other materials release heat very slowly and depending upon thicknesss and fire conditions may never release all the heat possible. The use of the material and additional supporting data are usually required for classifying the materials.

The Test Method.

The potential heat test method[2] makes use of oxygen bomb calorimetric measurement methods. It measures the difference between the heat of combustion of a product sample and that of the residue remaining after exposure of another specimen to a standardized intense thermal exposure. Results of the test are usually reported in terms of heat release per unit mass of the specimen involved.

The test procedure is based on as complete combustion of the specimen as is possible within a two-hour exposure period in a muffle furnace at 750°C (1382°F).

The bomb calorimetry techniques used involve very small specimens of about one g mass. Because of this, the sampling and specimen preparation procedures used become of considerable importance, especially with heterogeneous or composite materials. Two procedures are available to the investigator: one involves measurement of the potential heat of the individual components of the material and then on the basis of computations deriving an overall value of the composite. Another possibility involves the pulverization of a representative section of the composite and then the test of the resulting mixture in the form of a small pellet. The selection of a specimen for thermal exposure in the muffle furnace will, of course, depend on which of the preparation procedures is to be used.

The fact that the muffle exposure is a severe one, involving combustion of most of the oxidizable fuel at 750°C (1382°F), is essential for its consideration as a property type-test method. This must be carefully considered when applying potential heat data as a basis of code or regulatory procedures for building or other fire safety purposes. This is especially true when life safety is of prime concern. Thus the potential heat of two wall components may be identical, and yet in one wall the combustible component may be placed on the exposed wall surface while in the other it may be deeply buried, for example, beneath an exposed masonry construction. Obviously, these walls represent two possible extremes in the hazard presented by the wall to building occupants in the event of a fire. Thus, simple consideration of the potential heat of the wall materials yields little information on the relative fire participation hazard of the two walls. This problem is characteristic of property type fire tests. It emphasizes the need for discretion in the use of the test methods and in the application of resulting test data.

Auxiliary Tests.

As indicated above, property type fire tests are seldom comprehensive enough to form the sole basis of acceptance of materials or products. Additional tests are usually required. Examples of other types of tests that might be of value in evaluating materials as to their fire hazard include the adiabatic furnace,[6] a smoldering test, heat release rate calorimeter, [4,5] and flame spread tests.[7,8] Only the flame spread tests have received recognition by national standards organizations. The smoldering test has not yet received sufficient recognition to have been developed, although numerous ad hoc tests of this type have been conducted as the need for them became obvious.

Precision of the Potential Heat Test.

The original paper on this test method[2] discussed the precision level possible within a single laboratory. It was concluded that with technicians skilled in the procedure involved, the standard deviation of differences between duplicate determinations of potential heat would be equal to about 94 BTU/lb. This prediction, based on early work at NBS, was later confirmed for three of the five materials tested in the interlaboratory study.[3] In this reference a figure of 92 BTU/lb was reported. These values correspond to expected repeatability between duplicates of 200 BTU/lb with a 95 percent confidence level.

In the original paper it was stated that this order of repeatability was independent of the potential heat measured. Figure A-1 provides a graphical indication of the basis of this claim. This figure presents

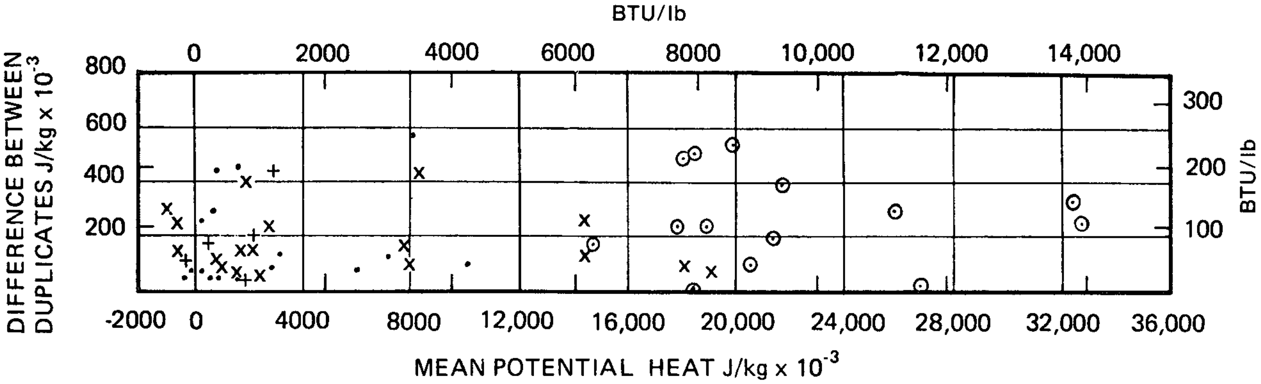

Figure A-1 NBS Data Difference Between Duplicate Potential Heat Measurements, as a Function of the Average

Deviation between duplicates as a function of average potential heat for a wide range of materials. Data points represent: × specified procedure, two determinations on both material and muffled specimen, + specified procedure NBS data from round robin study[3], · specified procedure but only one test of muffled specimen and ⊙ specified procedure for materials of low ash content no test on muffled specimen.