NFPA No.

259

STANDARD TEST METHOD FOR

POTENTIAL HEAT OF BUILDING MATERIALS 1976

NATIONAL FIRE PROTECTION ASSOCIATION
470 Atlantic Avenue, Boston, MA 02210

3M-7-76-HP-FP
Printed in U.S.A.

See Inside Back Cover for Official NFPA Definitions

Standard Test Method for

Potential Heat of Building Materials

NFPA No. 259–1976

Origin and Development of No. 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 this standard which was approved by the NFPA's Annual Meeting on May 19, 1976.

Committee on Fire Tests

Jack A. Bono, *Chairman*
Underwriters Laboratories Inc., 333 Pfingsten Rd., Northbrook, IL 60062

M. S. Abrams, Portland Cement Association

Irwin A. Benjamin, National Bureau of Standards

James R. Bercaw, duPont Company, Wilmington, DE (rep. Man-Made Fiber Producers Assoc.)

John A. Blair, E. I. duPont de Nemours & Co., Plastics Dept., Society of the Plastics Industry

Herbert B. Carlsen, Gypsum Assn.

Robert W. Dougherty, M & M Protection Consultants

Buell B. Dutton (rep. Building Officials & Code Administrators International, Inc.)

Richard G. Gewain, American Iron & Steel Institute

George B. Krumholz, Jr., U.S. Testing Co., Inc. (vote restricted to matters pertaining to textiles)

Gerald E. Lingenfelter, American Insurance Assn.

W. F. Maroni, Factory Mutual Research Corp.

William H. McLain, Southwest Research Institute

E. E. Miller, Industrial Risk Insurers

Norman S. Pearce, Underwriters' Laboratories of Canada

T. P. Pritsker, The Dallas Laboratories

Dr. A. F. Robertson, Institute of Applied Technology, National Bureau of Standards

John Ed Ryan, National Forest Products Assn.

Louis Segal, Office of State Fire Marshal, Los Angeles, CA (rep. Fire Marshals Assn. of North America)

Herman Spaeth, ISO

K. Sumi, National Research Council of Canada

Louis W. Vaughan, Canadian Sheet Steel Building Institute

Alternates

J. S. Barritt, Industrial Risk Insurers (Alternate to E. E. Miller)

David E. Brackett, Gypsum Assn. (Alternate to Herbert B. Carlsen)

R. Buchan, National Forest Products Assn. (Alternate to John Ed Ryan)

B. J. Callahan, Factory Mutual Engineering (Alternate to W. F. Maroni)

Peter McOrmand, ISO (Alternate to Herman Spaeth)

G. M. Watson, American Insurance Assn. (Alternate to Gerald E. Lingenfelter)

Nonvoting Member

A. J. Bartosic, Rohm & Haas Co.

This list represents the membership at the time the Committee was balloted on the text of this edition. Since that time, changes in the membership may have occurred.

Interpretation Procedure of the Committee on Fire Tests

Those desiring an interpretation shall supply the Chairman with five identical copies of a statement in which shall appear specific reference to a single problem, paragraph or section. Such a statement shall be on the business stationery of the inquirer and shall be duly signed.

When applications involve actual field situations they shall so state and all parties involved shall be named.

The Interpretations Committee will reserve the prerogative to refuse consideration of any application that refers specifically to proprietary items of equipment or devices. Generally inquiries should be confined to interpretation of the literal text or the intent thereof.

Requests for interpretations should be addressed to the National Fire Protection Association, 470 Atlantic Avenue, Boston, MA 02210.

Table of Contents

Chapter 1 General 259-5
1-1 Scope 259-5
1-2 Purpose 259-5
1-3 Definitions 259-5
1-4 General 259-5

Chapter 2 Test Apparatus and Materials 259-7
2-1 Oxygen Bomb Calorimeter 259-7
2-2 Electric Muffle Furnace 259-7
2-3 Mill 259-8
2-4 Pelleting Press 259-8
2-5 Microbalance 259-8
2-6 Oxygen Cylinder and Accessory Equipment 259-8
2-7 Compressed Air Supply 259-8
2-8 Standard Alkali Solution 259-8
2-9 Combustion Promoter 259-8

Chapter 3 Test Specimens 259-9
3-1 Specimens 259-9

Chapter 4 Direct Bomb Test 259-10
4-1 Specimen Preparation 259-10
4-2 Test Procedure 259-10

Chapter 5 Muffle Furnace and Bomb Test 259-13
5-1 Specimen Preparation 259-13
5-2 Muffle Furnace Procedure 259-13

Chapter 6 Calculating Potential Heat 259-15
6-1 Calculations with less than 5% residue 259-15
6-2 Calculations with more than 5% residue 259-15

Appendix 259-16

Standard Test Method for
Potential Heat of Building Materials

NFPA 259 — 1976

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. The information on application of potential heat data in the Appendix should be consulted prior to applying test results.

1-2 Purpose. 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).

1-3 Definitions. Potential heat of a material 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.

[1] The process is generally as described in ASTM D 3286-73, but with certain modifications or permissible exceptions, to be noted in the test procedure.

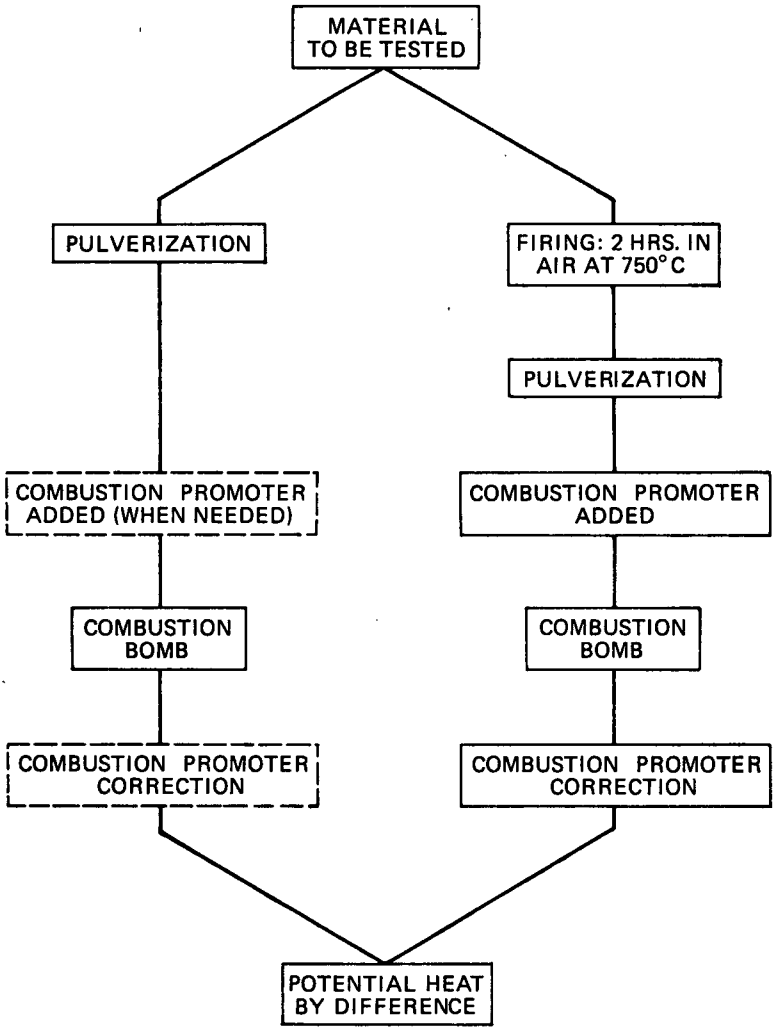

Figure 1-4.1. Schematic Diagram of Test Procedure for Potential Heat Measurements.

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 Fig. 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 similar material, shaped to hold the specimen container

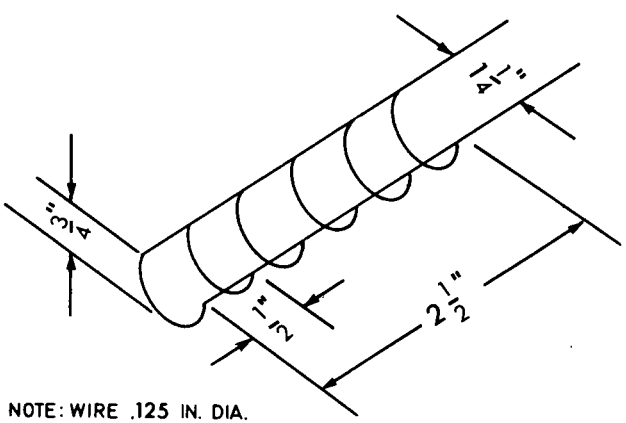

Figure 2-2(d) Wire Specimen Holder for Muffle Furnace Firing

(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 milligrams.

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 3286-73, paragraph 6.5.

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 grams 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 gram, 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 the *Standard Method of Test for Gross Calo-*

[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.

rific Value of Solid Fuel by the Isothermal-Jacket Bomb Calorimeter, ASTM D 3286-73 with the following exceptions:

Exception No. 1 (to par. 7.3.2): If fuse wire is provided for the bomb in use, a suitable correction factor for the wire shall be applied.

Exception No. 2 (to par. 9.1): In cases of incomplete burning, a combustion promoter shall be used.

Exception No. 3 (to par. 5.8): An ignition system supplied for the bomb may be substituted.

Exception No. 4 (to par. 7.2.7): 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 par. 10.3.1): 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 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-gram pellet shall be prepared using approximately ½-gram 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.

5-1.1 An air-dry specimen of the test material selected in accordance with Chapter 3 shall be cut in the form of a rectangular prism $\frac{1}{2} \pm \frac{1}{8}$ in. by $\frac{3}{4} \pm \frac{1}{8}$ in. by $2\frac{1}{2} \pm \frac{1}{2}$ 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 1382 ± 18°F (750 ± 10°C).

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.), referred 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 following subsections 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 pul-

verized into a homogeneous powder. A ½ gram sample of residue shall be mixed with an equal weight of benzoic acid and formed into a 1 gram 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 subsection 5-2.7 above by the ratio of residue weight, subsection 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.

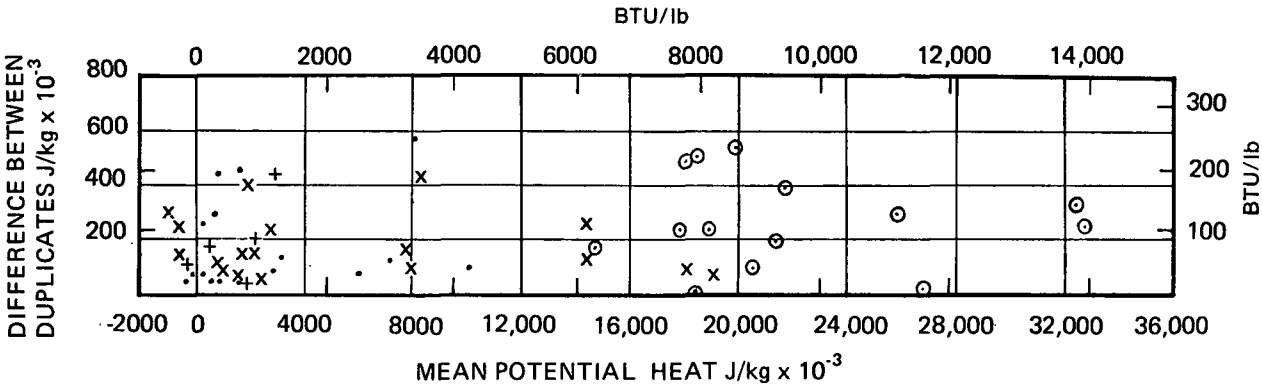

Figure A-1. NBS Data Difference Between Duplicate Potential Heat Measurements, as a Function of the Average.

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.