# NATIONAL BUREAU OF STANDARDS REPORT

6301

## SURFACE FLAMMABILITY OF PROTECTED METALS

by
M. W. Sandholzer & E. W. Bender


U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

# THE NATIONAL BUREAU OF STANDARDS

## Functions and Activities

The functions of the National Bureau of Standards are set forth in the Act of Congress, March 3, 1901, as amended by Congress in Public Law 619, 1950. These include the development and maintenance of the national standards of measurement and the provision of means and methods for making measurements consistent with these standards; the determination of physical constants and properties of materials; the development of methods and instruments for testing materials, devices, and structures; advisory services to Government Agencies on scientific and technical problems; invention and development of devices to serve special needs of the Government; and the development of standard practices, codes, and specifications. The work includes basic and applied research, development, engineering, instrumentation, testing, evaluation, calibration services, and various consultation and information services. A major portion of the Bureau's work is performed for other Government Agencies, particularly the Department of Defense and the Atomic Energy Commission. The scope of activities is suggested by the listing of divisions and sections on the inside of the back cover.

## Reports and Publications

The results of the Bureau's work take the form of either actual equipment and devices or published papers and reports. Reports are issued to the sponsoring agency of a particular project or program. Published papers appear either in the Bureau's own series of publications or in the journals of professional and scientific societies. The Bureau itself publishes three monthly periodicals, available from the Government Printing Office: The Journal of Research, which presents complete papers reporting technical investigations; the Technical News Bulletin, which presents summary and preliminary reports on work in progress; and Basic Radio Propagation Predictions, which provides data for determining the best frequencies to use for radio communications throughout the world. There are also five series of nonperiodical publications: The Applied Mathematics Series, Circulars, Handbooks, Building Materials and Structures Reports, and Miscellaneous Publications.

Information on the Bureau's publications can be found in NBS Circular 460, Publications of the National Bureau of Standards ($1.25) and its Supplement ($0.75), available from the Superintendent of Documents, Government Printing Office, Washington 25, D. C.

Inquiries regarding the Bureau's reports should be addressed to the Office of Technical Information, National Bureau of Standards, Washington 25, D. C.

# NATIONAL BUREAU OF STANDARDS REPORT

| NBS PROJECT | | NBS REPORT |
|---|---|---|
| 1000-12-4801 | February 2, 1959 | 6301 |

## SURFACE FLAMMABILITY OF PROTECTED METALS

by
M. W. Sandholzer & E. W. Bender

for
Tri-Service Building Materials Investigation Committee




U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

# SURFACE FLAMMABILITY OF PROTECTED METALS


## ABSTRACT

A number of protected - metal siding and roofing materials, supplied from three different manufacturers, have been tested for flame-spread hazard by two different methods. An inclined tunnel test and a radiant panel test were used.

The results obtained by the two methods for the various products tested are presented in tabular form. Relative evaluation of the products by the two methods differed to some extent, presumably because of the difference in type of exposure employed.


## 1. INTRODUCTION

At the request of the U. S. Army Corps of Engineers and latterly of the Tri-Service Building Materials Investigation Committee, flame-spread tests have been made on various protected-metal siding and roofing materials at several different times during the past few years. Results of the tests have been presented in several reports, submitted in compliance with the individual requests. The present report gives the results obtained in the most recent series of these tests, and, to facilitate a comparison of the behavior of the various products under exposure to flame, such previously-reported data as are comparable have been included.

## 2. TEST MATERIALS

The materials tested have been supplied by inspectors from the Office of the Chief of Engineers. They were usually obtained directly from the factory, but were occasionally taken from stocks delivered at job sites. A description of the various products received, as compiled from visual inspection, from literature supplied by the manufacturer, and from statements of the manufacturer's representatives is given in Table 1, together with the approximate date at which test results for the respective products were reported.

## 3. TEST METHODS

The materials were tested by two different flame-spread methods, an inclined tunnel test and a radiant panel test.

The inclined tunnel test, which has been used in many previous tests of this type of product, involved placement of the specimen as the cover or upper enclosing surface of a tunnel 12 ft long, and about 40 in. wide and 9 in. deep. This tunnel was inclined at a slope of 5 in. vertical to 12 in. horizontal. The three fixed sides of the tunnel were of sheet metal lined with asbestos-millboard. The igniting flame was applied to the under surface of the specimen at the lower end.

All specimens for this test were so assembled as to have one joint running the 12-ft length, and they were placed with the surface intended for interior exposure facing downward and exposed to the igniting flame. The flame was applied for 35 minutes, and was produced by burning gas with a calorific value of approximately 1100 BTU/cu ft, at a rate of 3 cu ft/min for 30 minutes and at a rate of 5 cu ft/min for 5 minutes. The length of the igniting flame, measured with an unprotected sheet metal cover in place of the test specimen, was about $2\frac{1}{2}$ ft. Two specimens of each material were tested.

The radiant panel method has been described in the article, "A Method for Measuring Surface Flammability of Materials Using a Radiant Energy Source," Proc. ASTM, Vol. 56, 1956. It provides a means for exposing small specimens in a standard fashion to a radiant heat and ignition source. Measurements are made of the rates of flame spread and heat release. These factors are combined to produce a flame-spread index which provides a numerical means for classification of material flammability. Smoke production by the specimen is reported in terms of the weight of material deposited on a glass filter disk.

For some of the tests made by this radiant panel method, the corrugations in the materials were flattened out as much as feasible before the test specimens were cut. In other cases the test specimens were cut with the corrugations running lengthwise of the specimen, and on one product tests were also made with the corrugations running crosswise of the specimen. From two to four specimens of each material were tested.

## 4. TEST RESULTS

The results of the inclined tunnel tests are presented in Table 2. Only the corrugated materials were subjected to this test. All C1S materials were tested with the interior surface exposed to the igniting flame (the interior and exterior surfaces were the same on all C2S materials). When the two specimens tested in each case showed a difference in behavior, the two individual values obtained are given.

Table 3 shows the results obtained by the radiant panel method. The values given are averages of the results from the two to four determinations made in each case.

## 5. DISCUSSION OF TEST RESULTS

The results of the inclined tunnel tests indicate little difference in performance of the three C1S Galbestos materials, except that the grey colored product showed a somewhat greater final flame-spread than the others. Among the C2S Galbestos materials, the grey colored product appeared to give the best performance. Of the Steelbestos products tested, the grey Color Steelbestos gave somewhat the best results. In both the Galbestos and Steelbestos groups, the C2S materials generally showed a greater flame-spread than the C1S materials. Among the Plasteel products, the black Plasteel showed the least flame spread and little tendency toward dripping. Galvanizing of the sheet metal core had no significant effect on the behavior of the material.

The radiant panel method provides a different type of exposure from that of the inclined tunnel method, and consequently may indicate a different relative evaluation of products tested. In the tunnel test, the igniting gas flame sweeps over the surface of the specimen, combining with and rapidly burning off combustible gases evolved from the surface coating heated by the flame. Some types of coating break down under comparatively moderate heating but form a protective layer of char which tends to retard heating ahead of the flame and limit flame-spread. In the radiant panel test, however, flames do not sweep over the unburned portion of the specimen, which is heated independently by radiant energy and is unaffected by heat from the flames. Thus, flame-spread progresses as fast as combustible gases are produced by the radiant heating of new material, and coatings which break down under moderate heat will tend to show a rapid flame spread regardless of the type of char produced.

Referring to the radiant panel results in Table 3, the maroon colored products of the three groups (Galbestos, Steelbestos, and Plasteel) showed a fairly similar performance, and it appeared to be a decidedly better performance than that of the grey colored products in the respective groups. Data on the behavior of the black colored products in this test are not available. The tests on Plasteel showed a greater flame-spread index for the corrugated materials, tested lengthwise, than for the flat stock. As in the tunnel test, galvanizing of the sheet metal core had no significant effect on the flame-spread results.

Considering the relative evaluation of the products by the two test methods, the results of the tunnel tests generally indicated a slightly better performance for the grey colored products than for the maroon colored products in the respective groups. As tested by the radiant panel method, however, the grey products showed a poorer performance than the maroon products. The differences indicated by the radiant panel method were considerably more pronounced than those indicated by the tunnel method.

## 6. CONCLUSIONS

Several of the products tested showed a similar and reasonably satisfactory performance in the inclined tunnel test.

The results of the radiant panel test indicated a decidedly better performance for three of the products than for the others.

Relative evaluation of the products by the two methods differed to some extent, presumably because of the difference in the type of heat and flame exposure employed.

(FP Report No. 3484)

USCOMM-NBS-DC

TABLE 1. Description of Products Tested

| Date of Report | Product designation* | Color | Manufacturer | Core Material | Initial Coating (applied both surfaces) | Bonding Agent (initial coating) | Additional Coating (applied one or both surfaces) |
|---|---|---|---|---|---|---|---|
| 6/55 | Galbestos, C2S and C1S | black | H.H. Robertson Co. | corrugated steel sheet | asbestos felt impregnated with asphalt | zinc adhesive | filled bituminous material |
| 1/57 | Galbestos, C2S and C1S | maroon | " " | " | " " | " | pigmented bituminous material |
| " | Galbestos, C2S and C1S | grey | " " | " | " " | " | pigmented synthetic resin |
| 6/55 | Steelphalt | black | American Steel Band Co. | " | stabilized bituminous material surfaced with mica | -- | -- |
| " | Steelbestos, C1S | " | " " | " | asbestos felt impregnated with asphalt | thermoplastic resin | filled bituminous material |
| 1/57 | Steelbestos, C2S and C1S | maroon | " " | " | " " | " | pigmented bituminous material |
| 12/58 | Color Steelbestos, C1S | grey | " " | " | asbestos felt impregnated with asphalt, plus light application of plastic color | " | plastic color coating |
| 6/55 | Plasteel | black | Plasteel Products Corp. | " | stabilized bituminous material surfaced with mica | -- | -- |
| 1/57 | Plasteel | maroon | " " | " | " " | -- | -- |

* See footnote at end of Table 1

TABLE 1. (Continued)

| Date of Report | Product designation* | Color | Manufacturer | Core Material | Initial coating (applied both surfaces) | Bonding agent (initial coating) | Additional Coating (applied one or both surfaces) |
|---|---|---|---|---|---|---|---|
| 1/59 | Plasteel, C2S | grey | Plasteel Products Corp. | corrugated steel sheet | stabilized bituminous material surfaced with mica | -- | pigmented emulsified acrylic resin |
| " | Plasteel C2S | " | " " | flat steel sheet | " " | -- | " " |
| " | Plasteel CP-400, C2S | " | " " | corrugated galvanized steel sheet | " " | -- | " " |
| " | Plasteel, CP-400,C2S | " | " " | flat galvanized steel sheet | " " | -- | " " |
| " | Plasteel, C1S | " | " " | corrugated steel sheet | " " | -- | " " |
| " | Plasteel, C1S | " | " " | flat steel sheet | " " | -- | " " |
| " | Plasteel, CP-400, C1S | " | " " | corrugated galvanized steel sheet | " " | -- | " " |
| " | Plasteel, CP-400, C1S | " | " " | flat galvanized steel sheet | " " | -- | " " |

* C2S, C1S - coated 2 sides, coated 1 side, indicating whether the final coating described in the last column was applied to both or only one surface.

TABLE 2. Results of Inclined Tunnel Tests

| Date of Report | Product designation | Color | Time dripping first appeared | Maximum flame spread | |
|---|---|---|---|---|---|
| | | | | 0-30 min. | 30-35 min. |
| | | | min | ft | ft |
| 6/55 | Galbestos C2S | black | 4.0 | 1.0 | filled tunnel extending out top |
| 1/57 | Galbestos C2S | maroon | 6.0 and 7.0 | 3.5 | 12.0 |
| " | Galbestos C2S | grey | none | 2.5 and 4.5 | 4.5 and 9.5 |
| 6/55 | Galbestos C1S | black | 3.0 and none | 0.5 | 3.0 |
| 1/57 | Galbestos C1S | maroon | none | 1.5 | 3.5 |
| " | Galbestos C1S | grey | none | 1.5 | 4.5 and 7.5 |
| 6/55 | Steelphalt | black | 2.0 and 3.0 | 3.5 | filled tunnel extending out top |
| 1/57 | Steelbestos C2S | maroon | 5.0 and 7.0 | 2.5 and 5.5 | 12.0 |
| 6/55 | Steelbestos C1S | black | 3.0 and 4.0 | 2.0 and 4.0 | 7.0 |
| 1/57 | Steelbestos C1S | maroon | none | 1.5 | 6.5 |
| 12/58 | Color Steel-bestos C1S | grey | none | 2.0 | 2.5 |
| 6/55 | Plasteel | black | 8.0 and none | 0.5 | 4.5 |
| 1/57 | Plasteel | maroon | 1.5 and 2.0 | 1.5 | 12.0 |
| 1/59 | Plasteel C2S | grey | 2.5 and 4.0 | 6.0 and 4.0 | 7.5 |
| " | Plasteel CP-400, C2S | " | 4.0 and 1.8 | 4.5 and 5.0 | 8.0 and 7.0 |
| " | Plasteel C1S | " | 1.5 | 4.0 and 6.0 | 7.5 and 6.0 |
| " | Plasteel CP-400, C1S | " | 2.0 and 1.0 | 4.0 | 7.0 and 6.0 |

TABLE 3. Results of Radiant Panel Tests

| Date of Report | Product designation | Color | Direction, condition of corrugation | Flame spread, $I_s$ | | Smoke production | |
|---|---|---|---|---|---|---|---|
| | | | | interior surface | weather surface | interior surface | weather surface |
| | | | | | | mg | mg |
| 1/57 | Galbestos C2S | maroon | flattened | -- | 3.7 | -- | 2.3 |
| " | Galbestos C2S | grey | " | -- | 37.0 | -- | 3.3 |
| " | Galbestos C1S | maroon | " | 0.0 | 1.5 | 1.2 | 1.7 |
| " | Galbestos C1S | grey | " | 0.0 | 56.0 | 2.0 | 2.1 |
| " | Steelbestos C2S | maroon | " | -- | 7.2 | -- | 1.0 |
| " | Steelbestos C1S | " | " | 0.0 | 8.9 | 1.5 | 0.9 |
| 12/58 | Color Steel-bestos C1S | grey | " | -- | 54.0 | -- | 2.2 |
| " | Color Steel-bestos C1S | " | lengthwise | 23.0 | 98.0 | 0.5 | 2.2 |
| " | Color Steel-bestos C1S | " | crosswise | 9.5 | -- | 0.9 | -- |
| 1/57 | Plasteel | maroon | flattened | -- | 5.5 | -- | 0.5 |
| 1/59 | Plasteel C1S | grey | lengthwise | 14.0 | 84.0 | 0.9 | 1.2 |
| " | Plasteel C1S | " | no corrugations | 1.0 | 35.0 | 0.8 | 1.4 |
| " | Plasteel CP-400, C1S | " | lengthwise | 18.0 | 85.0 | 0.9 | 2.1 |
| " | Plasteel CP-400, C1S | " | no corrugations | 3.2 | 30.0 | 1.0 | 1.1 |

U. S. DEPARTMENT OF COMMERCE
Lewis L. Strauss, *Secretary*

NATIONAL BUREAU OF STANDARDS
A. V. Astin, *Director*

# THE NATIONAL BUREAU OF STANDARDS

The scope of activities of the National Bureau of Standards at its headquarters in Washington, D. C., and its major laboratories in Boulder, Colo., is suggested in the following listing of the divisions and sections engaged in technical work. In general, each section carries out specialized research, development, and engineering in the field indicated by its title. A brief description of the activities, and of the resultant publications, appears on the inside front cover.

## WASHINGTON, D. C.

**Electricity and Electronics.** Resistance and Reactance. Electron Devices. Electrical Instruments. Magnetic Measurements. Dielectrics. Engineering Electronics. Electronic Instrumentation. Electrochemistry.

**Optics and Metrology.** Photometry and Colorimetry. Optical Instruments. Photographic Technology. Length. Engineering Metrology.

**Heat.** Temperature Physics. Thermodynamics. Cryogenic Physics. Rheology. Engine Fuels. Free Radicals Research.

**Atomic and Radiation Physics.** Spectroscopy. Radiometry. Mass Spectrometry. Solid State Physics. Electron Physics. Atomic Physics. Neutron Physics. Radiation Theory. Radioactivity. X-rays. High Energy Radiation. Nucleonic Instrumentation. Radiological Equipment.

**Chemistry.** Organic Coatings. Surface Chemistry. Organic Chemistry. Analytical Chemistry. Inorganic Chemistry. Electrodeposition. Molecular Structure and Properties of Gases. Physical Chemistry. Thermochemistry. Spectrochemistry. Pure Substances.

**Mechanics.** Sound. Mechanical Instruments. Fluid Mechanics. Engineering Mechanics. Mass and Scale. Capacity, Density, and Fluid Meters. Combustion Controls.

**Organic and Fibrous Materials.** Rubber. Textiles. Paper. Leather. Testing and Specifications. Polymer Structure. Plastics. Dental Research.

**Metallurgy.** Thermal Metallurgy. Chemical Metallurgy. Mechanical Metallurgy. Corrosion. Metal Physics.

**Mineral Products.** Engineering Ceramics. Glass. Refractories. Enameled Metals. Concreting Materials. Constitution and Microstructure.

**Building Technology.** Structural Engineering. Fire Protection. Air Conditioning, Heating, and Refrigeration. Floor, Roof, and Wall Coverings. Codes and Safety Standards. Heat Transfer.

**Applied Mathematics.** Numerical Analysis. Computation. Statistical Engineering. Mathematical Physics.

**Data Processing Systems.** SEAC Engineering Group. Components and Techniques. Digital Circuitry. Digital Systems. Anolog Systems. Application Engineering.

• Office of Basic Instrumentation.

• Office of Weights and Measures.

## BOULDER, COLORADO

**Cryogenic Engineering.** Cryogenic Equipment. Cryogenic Processes. Properties of Materials. Gas Liquefaction.

**Radio Propagation Physics.** Upper Atmosphere Research. Ionospheric Research. Regular Propagation Services. Sun-Earth Relationships. VHF Research. Ionospheric Communication Systems.

**Radio Propagation Engineering.** Data Reduction Instrumentation. Modulation Systems. Navigation Systems. Radio Noise. Tropospheric Measurements. Tropospheric Analysis. Radio Systems Application Engineering. Radio-Meteorology.

**Radio Standards.** High Frequency Electrical Standards. Radio Broadcast Service. High Frequency Impedance Standards. Electronic Calibration Center. Microwave Physics. Microwave Circuit Standards.


NBS