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# NATIONAL BUREAU OF STANDARDS REPORT

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## NAVAL SHIPBOARD FIRE RISK CRITERIA

Progress Report on Evaluation of Fire Test Requirements

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NBS

U.S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

# NATIONAL BUREAU OF STANDARDS

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[3] Located at 5285 Port Royal Road, Springfield, Virginia 22151.

# NATIONAL BUREAU OF STANDARDS REPORT

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## NAVAL SHIPBOARD FIRE RISK CRITERIA

Progress Report on Evaluation of Fire Test Requirements

by

Fire Research Section

Prepared For

Naval Ship Systems Command
Department of the Navy
Order No. N 00024-69-F-5177: Contract 6101C-NN531



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U.S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards
Washington, D.C. 20234

October 1, 1969

MEMORANDUM FOR NAVSEC, 6101C

From: Fire Research Section
National Bureau of Standards

Subject: Order No. N 00024-69-F-5177:Contract 6101C-NN531

This report covers work accomplished since the previous Quarterly Progress Report dated May 20, 1969. It does not include the evaluation of composite materials for submarine hull insulation which was prepared as a special report dated July 14, 1969.

Covered in this report are:

A discussion of test results on a variety of deck covering materials by the fire-resistance test method (NASL burner) and by the radiant panel flame spread test method (ASTM E162).

Test data and a discussion of the candle test in MIL-P-15280E for cellular plastic insulation.

A status report on a proposed method for measuring rate of heat release of materials.

Tests are currently in progress to measure the following fire exposure properties of materials:

a. Smoke and gaseous products

b. Potential heat

c. Noncombustibility

d. Horizontal panel flame exposure test

Parts of this report were prepared in a form suitable for inclusion (with necessary additions and modifications) in a future final report.

NAVAL SHIPBOARD FIRE RISK CRITERIA
Progress Report on Evaluation of Fire Test Requirements

by

Fire Research Section

## 1.0 FIRE-RESISTANCE TEST APPARATUS

This apparatus was developed at the Naval Applied Science Laboratory (NASL), Brooklyn, approximately 25 years ago. The apparatus is not available commercially, and the NASL setup is one of only two or three in use in the country.

The apparatus consists of a communicating horizontal and vertical flue constructed of 1/16 inch steel sheeting lined with 1/8 inch asbestos [-cement] board with the exception of the horizontal bottom plate which is all steel. The deck covering to be tested is applied to a specimen holder made of 1/8 inch mild steel plate 31-1/2 inches long by 7 inches wide. The holder is mounted in the horizontal flue so that hot gases can pass beneath the holder and be vented through the vertical flue. Flames and hot gases can also travel above the holder and be vented through the vertical flue. Exposure is by means of four open blast burners mounted side by side at one end of the horizontal flue, and the flames impinge both at the lower (steel) and upper (specimen) edges of the holder. The total rate of heat supply by the burners is approximately 400 Btu/minute providing a moderately severe exposure.

The test is used to measure a variety of specimen properties: Ignitibility, Flame Spread, Charring, Glowing and Smoke Production. The apparatus is used in many test specifications with variations in test observations and performance requirements. These include:

MIL-C-7176D - Carpet, Aircraft

MIL-D-3134F - Deck Covering Materials

MIL-D-3135D - Deck Covering Underlay Materials

MIL-D-23003 - Deck Covering Compound, Nonslip, Lightweight

MIL-M-15562C - Matting, Floor, Rubber

MIL-T-18830A - Tile, Plastic, Fire-Retardant

The test method is also described in Method 6411 (Fire Resistance) of Federal Test Method Standard No. 501a "Floor Coverings, Resilient, Non-Textile: Sampling and Testing." This description is slightly more detailed than the Military Specifications in terms of measurement tolerances and could serve as a common reference to the method, with any exceptions noted in the individual specification.

Although the test is prescribed and performed in a nominally identical manner in these test methods, the terminology and evaluations vary. For example:

1. The duration of flaming may be prescribed in terms of "combustion plus ignition time" (also "ignition plus combustion time") or "flaming time after shutoff of burners."

2. The specimen damage after test may be defined as "average char length" or "linear damage", that is the length of specimen permanently damaged by burning, charring, blistering or imbrittlement.

3. Materials may be rated "fire retardant", "fire resistant", or "slow burning" based on different criteria.

In addition, interpretation of specifications may vary. For example, an alternate interpretation of combustion plus ignition time would be the duration of flaming from the time at which the specimen ignites (as evidenced by flashing, yellow or longer flames) rather than the time of "initial application of burner flames" at the start of the test.

Table 1 summarizes the performance requirements of these test methods.

Test observations on a variety of deck covering materials, including those currently used by the Navy, are summarized in Table 2. Data and observations were taken in a uniform manner--even when not called for by the applicable specification. Typical curves of flame travel versus time for several materials are shown in Figure 1. It may be noted from Table 2 that all materials tested ignited within 1 minute and burned for periods ranging from at least 1 minute 10 seconds to over 15 minutes. Observation of the maximum flame length was somewhat difficult due to unsteady flaming and to limited visibility through the sight windows, which were occasionally smoked-up. For thick materials, particularly the carpets, the burner flames were almost entirely below the plate, resulting in slower and more variable flaming. The extent of specimen damage after test (average char length) was also difficult to measure particularly when soot deposits remained after test. Glowing persisted on the vinyl asbestos tile for periods ranging up to 1-1/2 minutes, on the rubber matting up to about 3 minutes and on carpeting for considerably longer periods. Glowing was generally very localized and its presence could be noted only with extreme care, e.g., darkening of the room for better visibility.

Visual estimation of smoke production depends entirely upon the individual operator and is unreliable.

Photographs of specimens before and after test are shown in Figures 2 and 3.

Based upon the test requirements in Table 1 and the test observations in Table 2, the following conclusions may be reached:

1. On materials purchased to Navy specifications:

   a. Vinyl asbestos tile (AD) fails the requirements of MIL-T-18830; combustion plus ignition time 4:05 versus 4:00 minutes; maximum flame length 24 inches versus 13 inches; barely passes on average char length (9 inches versus 10 inches).

   b. Flight deck compound (N) passes the requirements of MIL-D-23003, but char length was within 1/2 inch of the 6-inch limit.

   c. Deck covering underlay (Q), in 1/16-inch thickness, passes the requirements of MIL-D-3135. The underlay was not tested at the required 1/4-inch thickness.

   d. Rubber matting (R) fails the requirements of MIL-M-15562C; maximum flame length 18 inches versus 10 inches; "flaming time after burner shutdown" extended beyond 60 seconds in one specimen (if occasional local reignition of glowing material is considered flaming); also average char length of 9 inches was within 1 inch of the 10-inch limit of linear damage.

2. On other materials:

   a. Of the carpeting materials tested--wool, nylon, acrylic, acrylic/modacrylic and polypropylene--all carpets flamed for a minimum of 6-1/2 minutes (i.e., 2-1/2 minutes after burner flames were turned off). All the carpets except the two wool specimens spread flame the full length of the holder. The average char length on the wool carpets was 12 and 13 inches compared to 22 inches and over for the others. Glowing in both the carpet and the hair pad (or integral foam cushion for material H) was noted on all materials after flames died out.

b. The MIL-T-18830 vinyl asbestos tile was noticeably better than a commercial vinyl asbestos tile and a commercial vinyl tile. When the MIL-T-18830 tile was applied with a commercial adhesive (AE-2), flame travel was considerably more rapid compared to an assembly using MIL-A-21016E adhesive (AD-2), although the maximum flame travel was very similar. The presence of a longitudinal joint did not have a very marked effect on the results (AE-3 versus AE-2). Commercial linoleum (LE) and battleship linoleum (S) spread flames to a considerably greater degree than the other resilient deck coverings tested.

## 2.0 RADIANT PANEL TEST APPARATUS

Measurements were made using the radiant panel flame-spread test apparatus. The detailed test procedure is outlined in ASTM Designation E162. In brief, the test requires a 6 by 18 inch specimen, facing and inclined 30 degrees to a vertically-mounted, gas-fired radiant panel. The energy output of the panel is controlled to be the same as that from a blackbody of the same dimensions operating at a temperature of 670 °C (1238 °F). Ignition is initiated at the upper edge of the test specimen and observations made of the progress of the flame front down the specimen surface, as well as the temperature rise of the thermocouples in a stack supported above the test specimen. The test duration is 15 minutes, or until sustained flame propagates down the entire 18-inch length of specimen, whichever time is less. The flame-spread index, $I_s$, is computed as the product of the flame-spread factor, $F_s$, and the heat evolution, Q, or $I_s = F_sQ$, where

$$F_s = 1 + \frac{1}{t_3} + \frac{1}{t_6 - t_3} + \frac{1}{t_9 - t_6} + \frac{1}{t_{12} - t_9} + \frac{1}{t_{15} - t_{12}}$$

The symbols $t_3$ to $t_{15}$ correspond to times in minutes from specimen exposure until arrival of the flame front at a position 3 to 15 inches, respectively, along the length of the specimen. The heat evolution Q is proportional to the observed maximum temperature rise of the stack thermocouples.

The same deck covering materials were tested by the radiant panel method, and the results are summarized in Table 3. A flame-spread factor of 1.0 (materials N and Q) indicates that no flames propagated along the specimen down to the 3-inch position. On vinyl asbestos tile (AD) flames traveled beyond 3 inches, but this occurred after a considerable time delay. Thus, this flaming contributes only slightly to the flame-spread factor. On the other hand, material P, which ignited earlier and spread flames faster and farther than the other materials tested, had a flame-spread factor of 18.8. The flame-spread index values ranged from 0 for materials N and Q to 440 for material P. Photographs of specimens after test are shown in Figure 4.

It is informative to plot the flame travel versus time data on semilograthmic coordinates as in Figure 5. A material which has a regular pattern of surface flaming will usually plot as a straight line or nearly so.

Also included in Table 3 is data on material T (chlorinated alkyd resin enamel). The MIL-E-17970C specification states that this enamel provides a degree of flame resistance ("nonflaming"), but includes no performance test. There was no flame propagation on a 6-mil coating on steel, but a similar coating applied to a combustible substrate, permitted appreciable flame propagation ($I_s$ = 73). In a previous study, it was found that the flame-spread index increased with increasing thickness of a paint coating applied on steel sheet. For oil-base paint coatings of 5, 10, 15 and 20 mils, the flame-spread index of a No. 18 gage red-lead primed steel sheet was 1, 7, 69 and 110, respectively.

## 3.0 CANDLE TEST

The "Fire Resistance" test in MIL-P-15280E (as amended 21 March 1969) for elastomeric plastic foam insulation, requires that a candle flame be applied to the lower end of a 1 by 1/2 by 6 inch specimen mounted at 45 degrees. The candle is moved so as to keep the specimen continuously in the flame as the specimen warps or bends. The candle flame is applied for 15 seconds after which the candle is removed. Measurements are made of the burning time after removal of flame and the loss in weight on ten specimens. A flammability index is calculated using the following expression:

$$I = w + b + t$$

where I = flammability index
w = average weight loss, calculated to the nearest 0.1 percent
b = number of specimens which burned after removal of flame
and t = average burning time (seconds) = $\frac{\text{sum of burning times}}{b}$ .

This test method has been used to evaluate several plastic foam insulation materials most of which were purchased locally. The group includes at least one material which is currently approved by the NAVY. The results are shown in Table 4, which also includes results from the Radiant Panel Test on the same materials (see Figure 6). The "Fire Resistance" test in MIL-P-40619 for cellular expanded polystyrene is somewhat similar and test results for this material are also included in Table 4.

## 4.0 HEAT RELEASE RATE CALORIMETER

It has been recognized for a long time that the rate of heat release is of the same order of importance as the total heat released by a particular combustible component in a fire. The design of a standard test for the heat release rate of materials and components, however, has a number of problems associated with it. The rate depends heavily on the size, shape, and orientation of the component as well as the nature of the fire environment to which it is exposed. Ideally, we should be able to measure some fundamental properties of the materials used in the component and then calculate the performance of the component as a function of the above parameters. Unfortunately, our understanding of fires has not progressed to a stage which will permit us to do this. We thus have two responsibilities. One is to increase our understanding of fires and the other is to develop a practical heat release rate test which reflects the state of the art and can be used at the present time. The second responsibility has the highest priority, but the first one must not be neglected.

The heat release rate test must simulate the exposure conditions in a real fire insofar as possible. Since these conditions vary considerably with time, location, particular fire, etc., there is some flexibility in choosing the conditions to be used for the test. Three guidelines should be employed in the selection:

1. The conditions should be typical of a severe fire so that the component gets an adequate test.

2. The conditions must be reproducible so that other operators can obtain the same results in other copies of the test apparatus.

3. Simple well defined conditions should be chosen so that the results and their application can be as predictable as possible.

During the early 1960's, NBS built an experimental model of a heat release calorimeter which was to be developed into an instrument which could perform a standard heat release rate test on building materials. The test specimen formed one wall of a chamber in which the two adjacent walls were gas-fired panels. The high intensity radiant exposure caused the combustible portion of the test specimen to burn and its rate of heat release was determined from the increase in the temperature of the hot gases passing up the flue at the top of the chamber. The results of the early work were encouraging and at the same time revealed several problems with the original apparatus. The thermal inertia of the walls and the system of baffles used for mixing has an appreciable effect on the time response of the system. The mounting of the test specimen as one wall of the chamber presented problems of sealing that were never completely solved, and the loss of heat to the walls of the chamber was too high to be acceptable. Before this device could be perfected, work had to be halted due to a reduction in personnel.

The background from this project is being used to design a modified chamber. In order to overcome the thermal inertia of the earlier system, the flue gases are to be held at a constant temperature by the use of an auxillary burner, and the heat release rate of the specimen will be determined by the decrease in gas flow required by the auxillary burner to keep the flue temperature constant. The sealing problem will be eliminated by locating the specimen in the center of the chamber instead of making it part of the wall. The boundary condition which allows heat losses from the rear surface of the specimen will be preserved by locating a water-cooled copper heat sink close to, but not in contact with, the back surface. The heat losses to the walls will be reduced by the new location of the specimen and by changing the path of the flue gases so that mixing is complete, and the temperature is measured before the gases come in contact with an external wall of the chamber.

The specimen is oriented vertically and will have a higher and more uniform irradiance in the new system. The intensity and wavelength distribution of the radiation are typical of a fire environment. Pilot ignition is provided at the base of the specimen so that some of the heat generated by the specimen flame will be fed back to the surface to increase the rate of pyrolysis. Provisions are made for completing the combustion of the pyrolysis products before they pass up the flue. This will ensure that the full heat producing potential of the pyrolysis products is included in the measurements. Tests should be run as a function of sample size and exposure level in order to determine the effect of these parameters. The new chamber is now being designed.

It is anticipated that this calorimeter will not only serve as a prototype from which to design a larger apparatus capable of measuring the heat release rate from specimens up to 18 by 24 inches, but will also supply data of the type needed for burning rate studies of materials. The eventual rationalization and prediction of the rate of heat release from specimens in such a chamber would be a useful early step in the prediction of the response of combustible components in a real fire environment. Studies on idealized compartment fires must ultimately set the most desirable exposure level for the test and the acceptable values of the heat release rate of components subjected to the test.

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TABLE 1

PERFORMANCE REQUIREMENTS FOR FIRE-RESISTANCE TEST

| | TEST REQUIREMENTS | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | MIL-C-7176D* | | | | MIL-D-23003 | MIL-D-3134F | | | MIL-D-3135D | MIL-M-15562C | MIL-T-18830A |
| | Incomb | Fire-Resist | Slow-Burn | Combustible | | Incomb | Fire-Ret'd | Slow-Burn | | | |
| Combustion + Ignition Time, min | | | | | ≤4-1/4 | | ** | | ≤4-1/2 | | ≤4 |
| Flaming Time After Shut-Off of Burners, sec | | | | | | | | | | ≤60 | |
| Glow Time | | | | | | | ** | | | | |
| Flash or Flame, in | None | Slight | | | | None | Slight | | | ≤10 | ≤13 |
| Average Char Length, in | | | | | ≤6 | | | | ≤8 | | ≤10 |
| Linear Damage, in | | | | | | | ** | | | ≤10 | |
| Material Damage Beyond Exposed Area | None | Not Burned Beyond 6" | Burned 6<D<10 | D>31-1/2 | | None | Not Burned Beyond 7" | Burned 7<D<31-1/2 | | | |
| Smoke | | | | | | | | | | | Light |

* Use of 2 instead of 4 burners, and other test method variations.

** Items to be noted, but may not form part of acceptance criteria.

TABLE 2

BURNER TEST OBSERVATIONS

| Material Code Designation | Material Description | Color | Thickness | Weight | Ignition Time[a] | Combustion Plus Ignition Time[b] | Maximum Flash or Flame Length | Average Char Length (Material Damage) | Glow Time (Beyond 4 min) | Smoke |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | in | psf | min:sec | min:sec | in | in | min:sec | |
| AD-2 | Vinyl Asbestos Tile (MIL-T-18830)<br>Adhesive (MIL-A-21016E) | Brown | .075 | .87 | 0:25 | 4:05 | 24 | 12 (9)[c] | 0:30 | Light |
| AE-2 | Vinyl Asbestos Tile (MIL-T-18830)<br>Adhesive ("Commercial") | Brown | .075 | .87 | 0:15 | 4:00 | 25 | 15 (11)[c] | ~ 1:00<br>(Faint) | Light |
| AE-3 | Same as AE-2 with Longitudinal Joint | Brown | .075 | .87 | 0:07 | 4:00 | 30 | 14 (10)[c] | 1:30<br>(Faint) | Light |
| BD-2 | Vinyl Asbestos Tile (L-T-00345)<br>Adhesive (MIL-A-21016E) | White-Grey | .120 | 1.32 | 0:05 | 5:45 | >31-1/2 | 21 (15)[c] | ------- | Light |
| CE-2 | Vinyl Tile (L-F-00450b)<br>Adhesive ("Commercial") | White/Black | .120 | 1.10 | 0:03 | 6:45 | >31-1/2 | 21 | ------- | Moderate |
| GM-1 | Wool Carpet (DDD-C-95)<br>Hair Pad | Brown/Black | .3<br>.3 | .52<br>.35 | 0:15 | 9:00 | 24 | 13 | > 5:00 | Very Light |
| H-1 | Acrylic/Modacrylic Carpet (DDD-C-95)<br>Integral Foam Cushion | Olive/Brown | .45 | .52 | 0:00 | 6:30 | >31-1/2 | 22 | > 2:30 | Light/Moderate |
| IM-1 | Acrylic Carpet (DDD-C-95)<br>Hair Pad | Gold | .3<br>.3 | .57<br>.35 | 0:10 | 10:30 | >31-1/2 | 26 | >11:00 | Heavy |
| JM-1 | Wool Carpet (DDD-C-95)<br>Hair Pad | Gold | .3<br>.3 | .54<br>.35 | 0:15 | 7:00 | 15 | 12 | 8:15 | Light |
| KM-1 | Nylon Carpet (DDD-C-95)<br>Hair Pad | Gold | .3<br>.3 | .37<br>.35 | 0:05 | >15:00 | >31-1/2 | >31-1/2 | ------- | Light/Moderate |
| LE-1 | Linoleum (LLL-F-1238)<br>Adhesive ("Commercial") | Grey | .120 | .92 | 0:07 | > 4:00 | >31-1/2 | >31-1/2 | Not Measured | (Heavy) |
| N-1 | Flight Deck Compound (MIL-D-23003) | Red | 1/8 | .4 | 0:30 | 2:15 | 6 | 5-1/2 | ------ | None |
| P-1 | Polypropylene Carpet<br>Hair Pad | Red | .4<br>.3 | .52<br>.35 | 0:10 | > 4:00 | >31-1/2 | >31-1/2 | Not Measured | Light (Increasing after 4 min) |
| P-2 | Polypropylene Carpet<br>Hair Pad | Red | .4<br>.3 | .52<br>.35 | 0:10 | > 4:00 | >31-1/2 | >31-1/2 | Not Measured | Moderate |
| Q-1 | Deck Covering Underlay (MIL-D-3135) | Grey | 1/16 | .4 | 0:50 | > 2:00<br>< 4:00 | 5 | 0 | 0 | Negligible |
| Q-2 | Deck Covering Underlay (MIL-D-3135) | Grey | 1/16 | .4 | 0:45 | < 4:00 | 5 | 0 | 0 | Negligible |
| R-1 | Rubber Matting (MIL-M-15562) | Grey | .18 | 1.15 | 0:02 | > 6:00 | 18 | 9 | > 2:00 | Light |
| R-2 | Rubber Matting (MIL-M-15562) | Grey | .18 | 1.15 | 0:02 | 4:45 | 18 | 9 | ~ 3:00 | Moderate |
| S-1 | Battleship Linoleum (LLL-F-1238)<br>Adhesive (MIL-A-21016E) | Green | .120 | .87 | 0:00 | > 4:00 | >31-1/2 | >31-1/2 | Not Measured | Light/Moderate |
| S-2 | Battleship Linoleum (LLL-F-1238)<br>Adhesive (MIL-A-21016E) | Green | .120 | .87 | 0:00 | > 4:00 | >31-1/2 | >31-1/2 | Not Measured | Moderate |

[a] Ignition time = time at which specimen ignited as evidenced by flashing, by yellow flames or by longer flames.

[b] Combustion + Ignition Time measured from initial application of the burner flames.

[c] Initial value based on visual observation of blackened area immediately after test. Value in parentheses based on area of actual material damage (not softening, blistering, or discoloration) after cleaning with solvent to remove soot.

TABLE 3
RADIANT PANEL TEST RESULTS

| Material Code Designation | Material Description | $F_s$ | $I_s$ |
|---|---|---|---|
| | DECK COVERINGS | | |
| AD | Vinyl Asbestos Tile (MIL-T-18830)<br>Adhesive (MIL-A-21016E) | 1.30 | 5 |
| AE | Vinyl Asbestos Tile (MIL-T-18830)<br>Adhesive ("Commercial") | 4.08 | 27 |
| AE | Same, but with Longitudinal Joint | 4.82 | 28 |
| BD | Vinyl Asbestos Tile (L-T-00345)<br>Adhesive (MIL-A-21016E) | 3.69 | 23 |
| CE | Vinyl Tile (L-F-00450b)<br>Adhesive ("Commercial") | 4.97 | 56 |
| FM | Nylon Carpet (DDD-C-95)<br>Hair Pad | 13.2 | 312 |
| GM | Wool Carpet (DDD-C-95)<br>Hair Pad | 6.36 | 46 |
| H | Acrylic/Modacrylic Carpet (DDD-C-95)<br>Integral Foam Cushion | 6.76 | 52 |
| IM | Acrylic Carpet (DDD-C-95)<br>Hair Pad | 12.78 | 95 |
| JM | Wool Carpet (DDD-C-95)<br>Hair Pad | 11.6 | 87 |
| KM | Nylon Carpet (DDD-C-95)<br>Hair Pad | 9.97 | 206 |
| LE | Linoleum (LLL-F-1238)<br>Adhesive ("Commercial") | 6.27 | 103 |
| N | Flight Deck Compound (MIL-D-23003) | 1.0 | 0 |
| P | Polypropylene Carpet<br>Hair Pad | 18.8 | 440 |
| Q | Deck Covering Underlay (MIL-D-3135) | 1.0 | 0 |
| R | Rubber Matting (MIL-M-15562) | 2.64 | 7 |
| S | Battleship Linoleum (LLL-F-1238)<br>Adhesive (MIL-A-21016E) | 3.72 | 68 |
| | COATINGS | | |
| T | Semigloss Chlorinated Alkyd Resin Enamel (MIL-E-17970C), 6 mil thickness on 1/8 inch steel | 1.0 | 0 |
| T | Same, but on 3/16 inch tempered hardboard | 3.14 | 73 |

TABLE 4

TEST RESULTS ON PLASTIC FOAM INSULATION

| Material | Thickness | Density | Fire Resistance Test MIL-P-15280E | | | | Radiant Panel Test ASTM E-162 | |
|---|---|---|---|---|---|---|---|---|
| | in. | $lb/ft^3$ | w | b | t | I | $F_s$ | $I_s$ |
| 1. Armstrong | 1/2 | 6.0 | 4.4 | 7 | 1.2 | 12.6 | 7.1 | 64 |
| 2. B. F. Goodrich | 1/2 | 5.1 | 4.7 | 10 | 1.5 | 16.2 | 14.8 | 60 |
| 3. Griswald | 1/2 | 33.2 | Not Tested | | | | 11.3 | 426 |
| 4. Rubatex | 1/2 | 7.7 | Not Tested | | | | 1.0 | 4 |
| 5. Uniroyal (Ensolite) | 1/2 | 6.2 | 2.6 | 0 | 0 | 2.6 | 1.0 | 0.8 |
| 6. Shields | 1/2 | 7.4 | 3.3 | 10 | 1.2 | 14.5 | 7.9 | 64 |
| 7. Polystyrene (MIL-P-40619)* | 1/4 | 2.0 | --- | -- | --- | ---- | 31.4 | 191 |

* Flames extended over entire length of 24 in. long specimen. Flammability index of MIL-P-15280E not applicable.

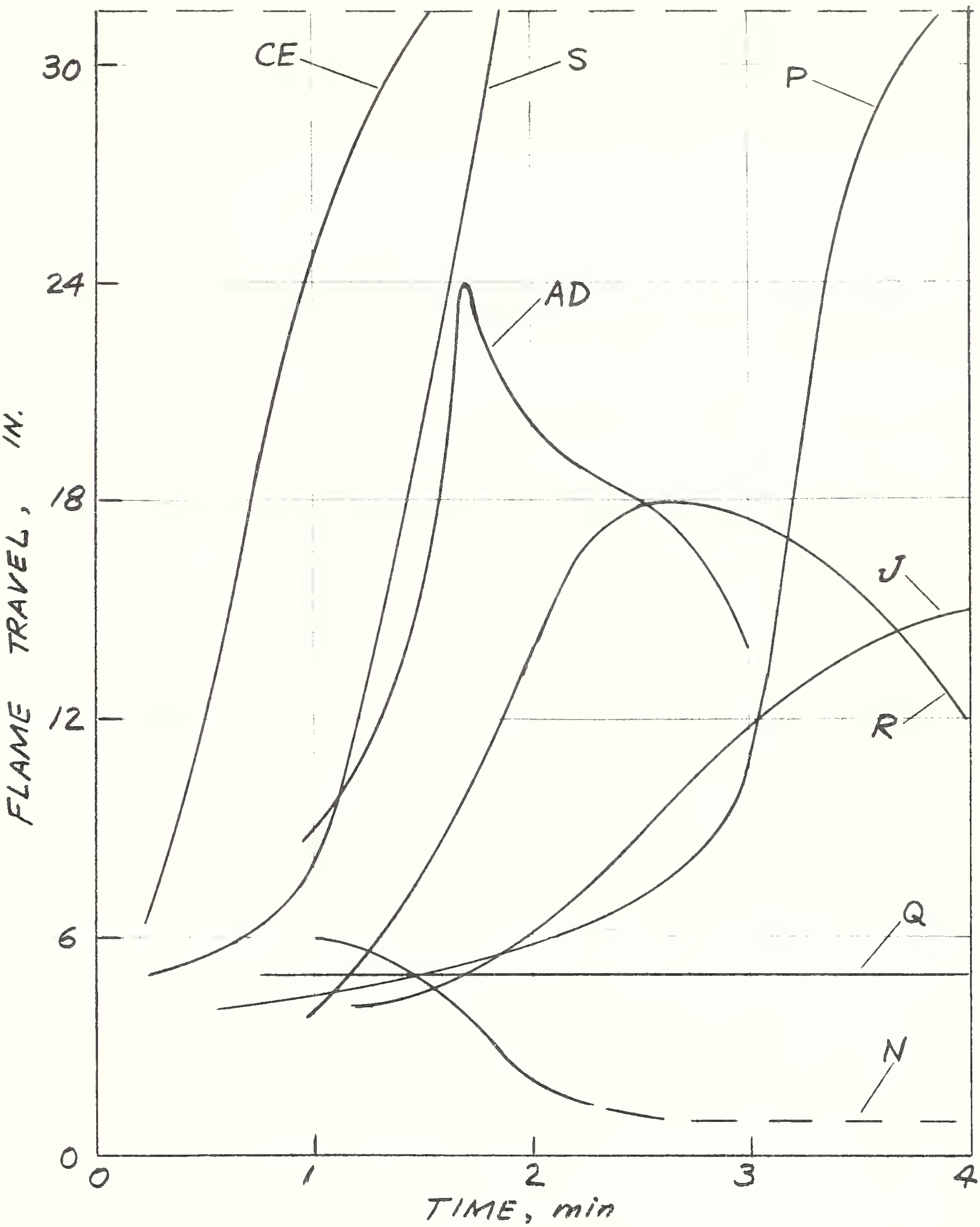


Fig. 1 - Flame Travel Data in Burner Test

AD = Vinyl Asbestos Tile (MIL-T-18830)
CE = Vinyl Tile
J = Wool Carpet
N = Flight Deck Compound (MIL-D-23003)
P = Polypropylene Carpet
Q = Deck Covering Underlay (MIL-D-3135)
R = Rubber Matting (MIL-M-15562)
S = Battleship Linoleum

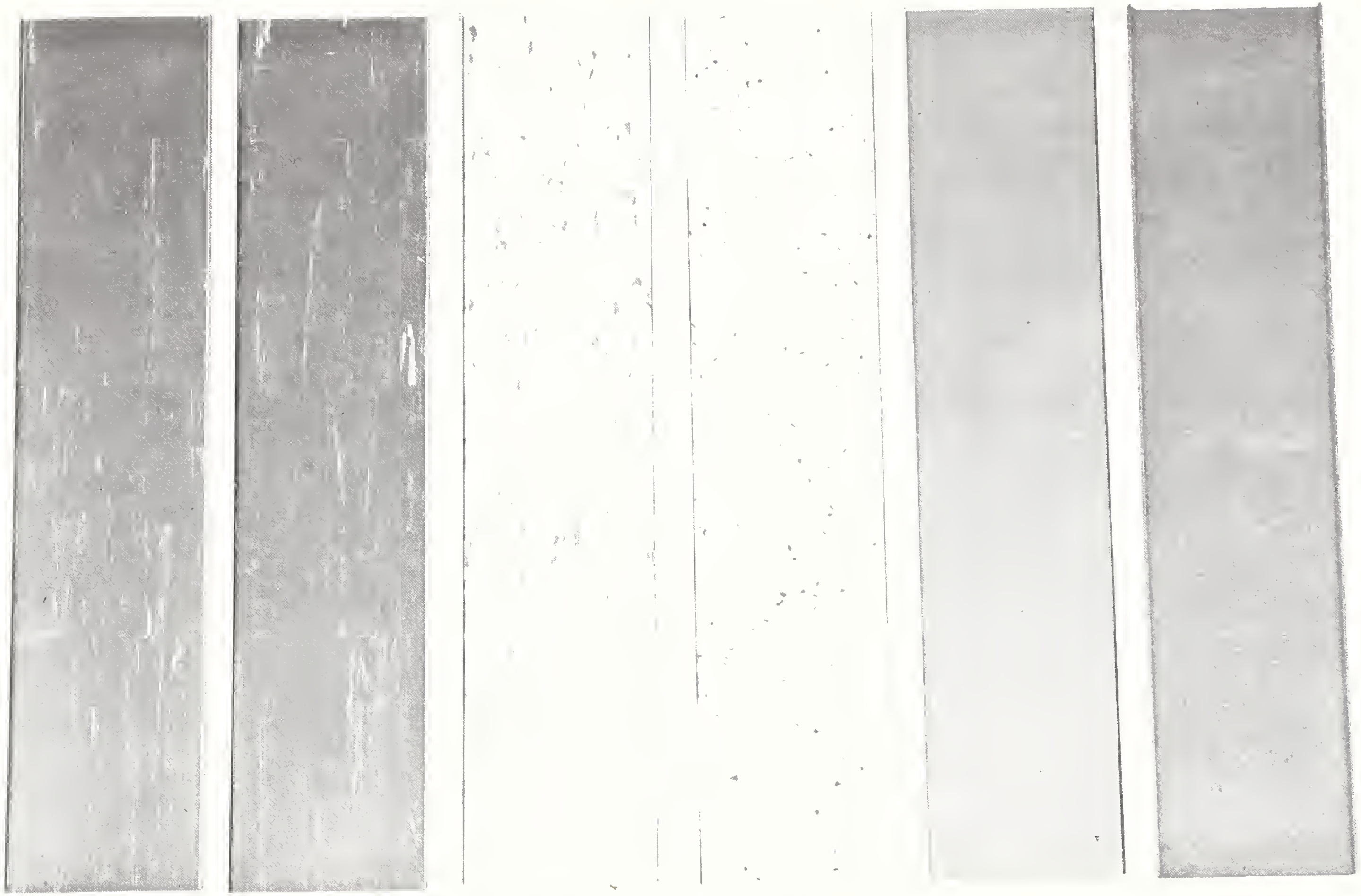

Fig. 2a - Deck Covering Specimens Prior to Burner Test

AD = Vinyl Asbestos Tile (MIL-T-18830) Adhesive (MIL-A-21016E)
AE = Vinyl Asbestos Tile (MIL-T-18830) Adhesive (Commercial)
BD = Vinyl Asbestos Tile (Commercial) Adhesive (MIL-A-21016E)
CE = Vinyl Tile
LE = Linoleum
N = Flight Deck Compound (MIL-D-23003)

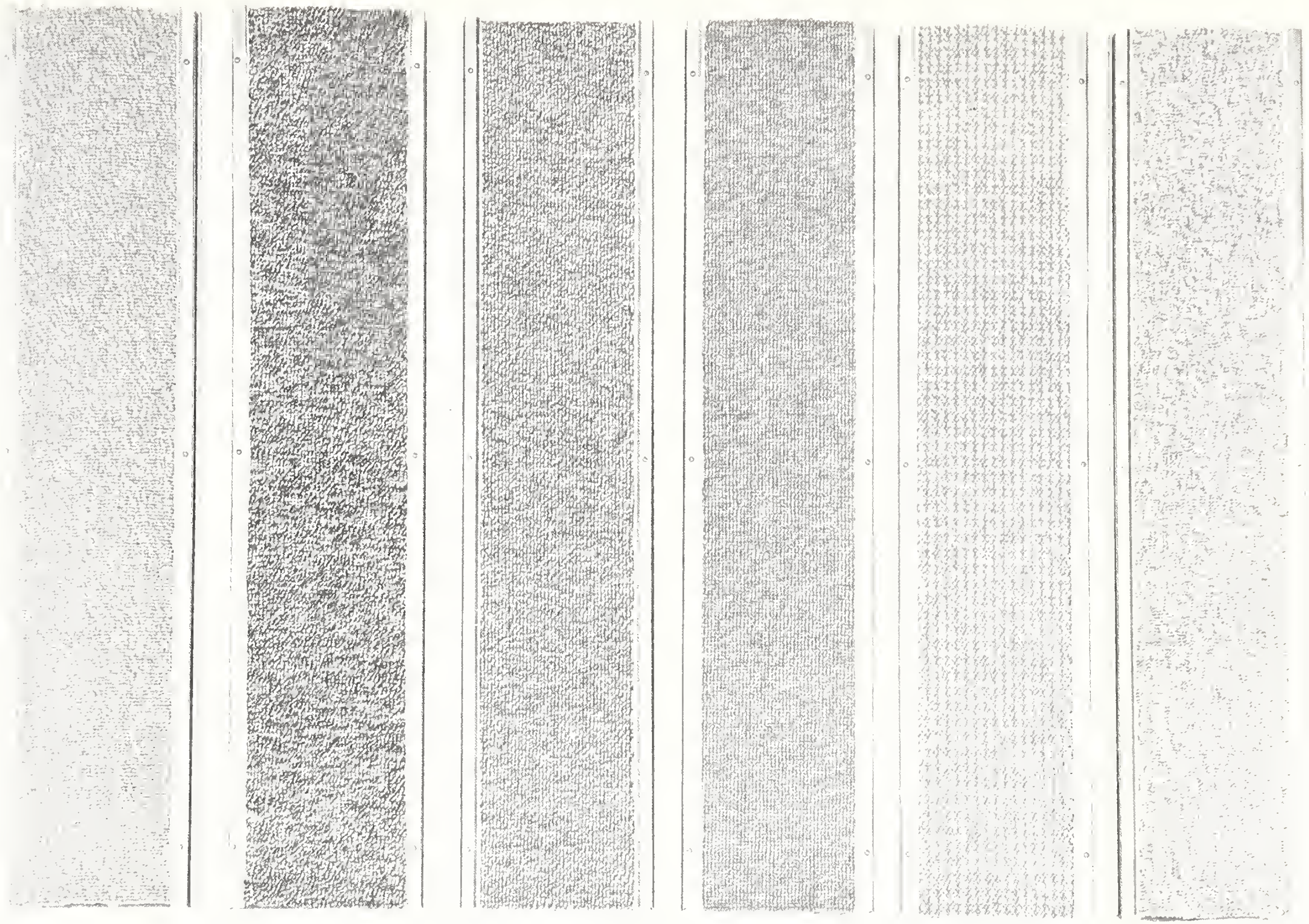

Fig. 2b - Deck Covering Specimens Prior to Burner Test

FM = Nylon Carpet, Hair Pad
GM = Wool Carpet, Hair Pad
H = Acrylic/Modacrylic Carpet, Integral Foam Cushion
IM = Acrylic Carpet, Hair Pad
JM = Wool Carpet, Hair Pad
KM = Nylon Carpet, Hair Pad

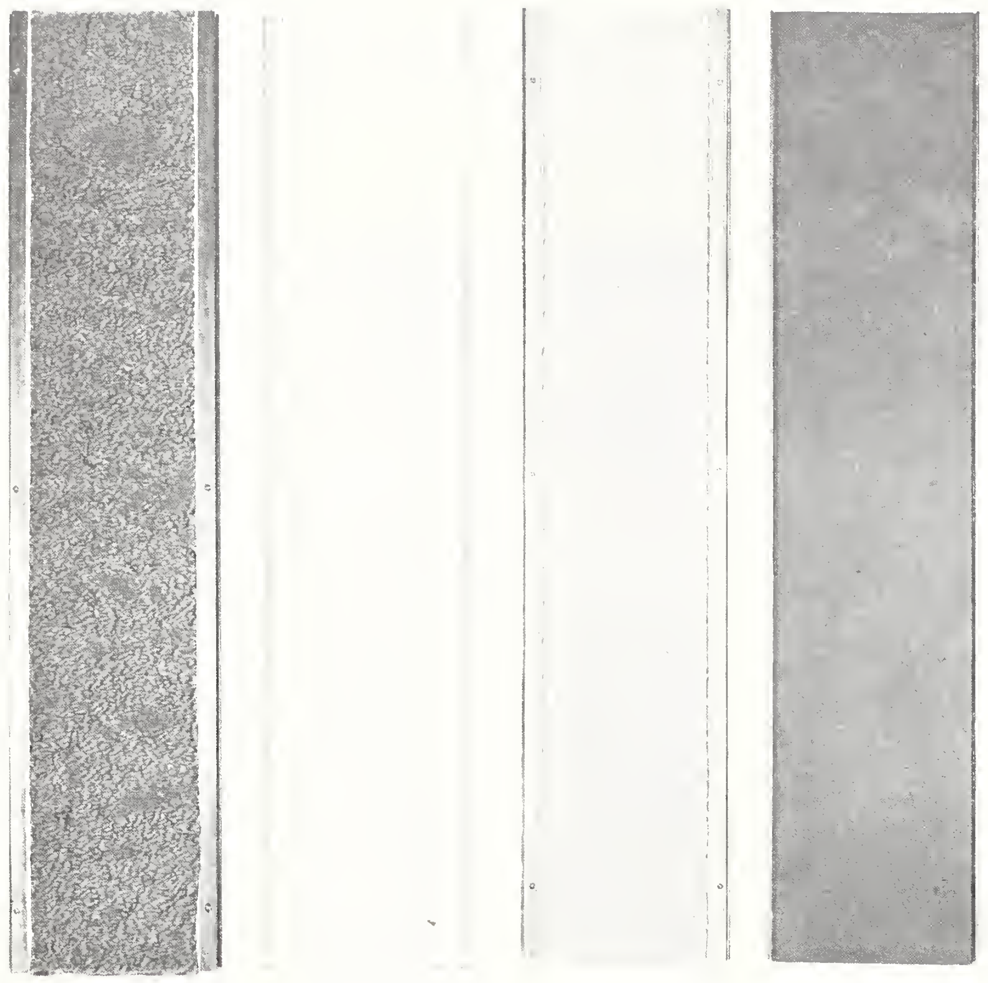

Fig. 2c - Deck Covering Specimens Prior to Burner Test

PM = Polypropylene Carpet, Hair Pad
Q = Deck Covering Underlay (MIL-D-3135)
R = Rubber Matting (MIL-M-15562)
S = Battleship Linoleum

Fig. 3a - Deck Covering Specimens After Burner Test

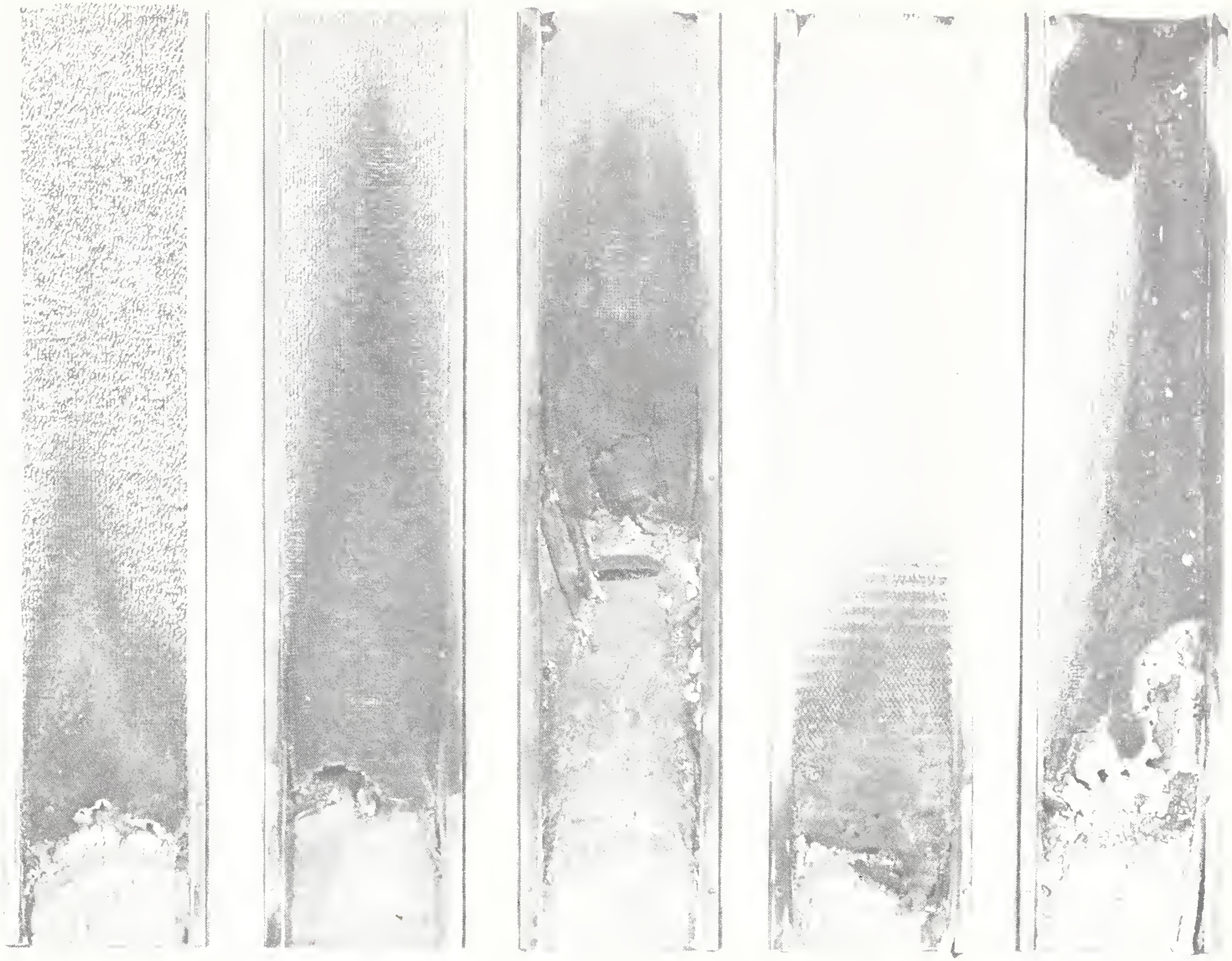

Fig. 3b - Deck Covering Specimens After Burner Test

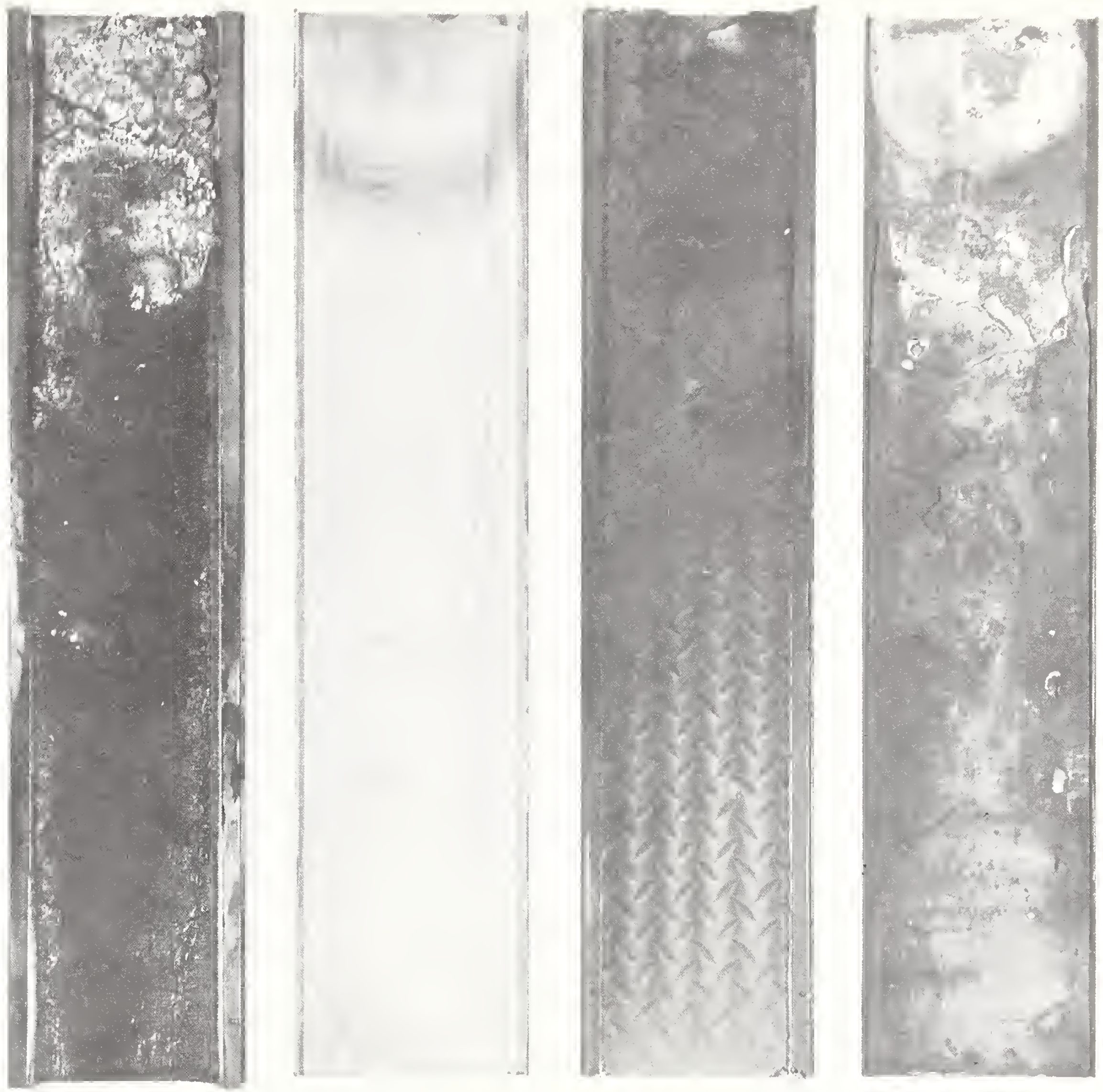

Fig. 3c - Deck Covering Specimens After Burner Test

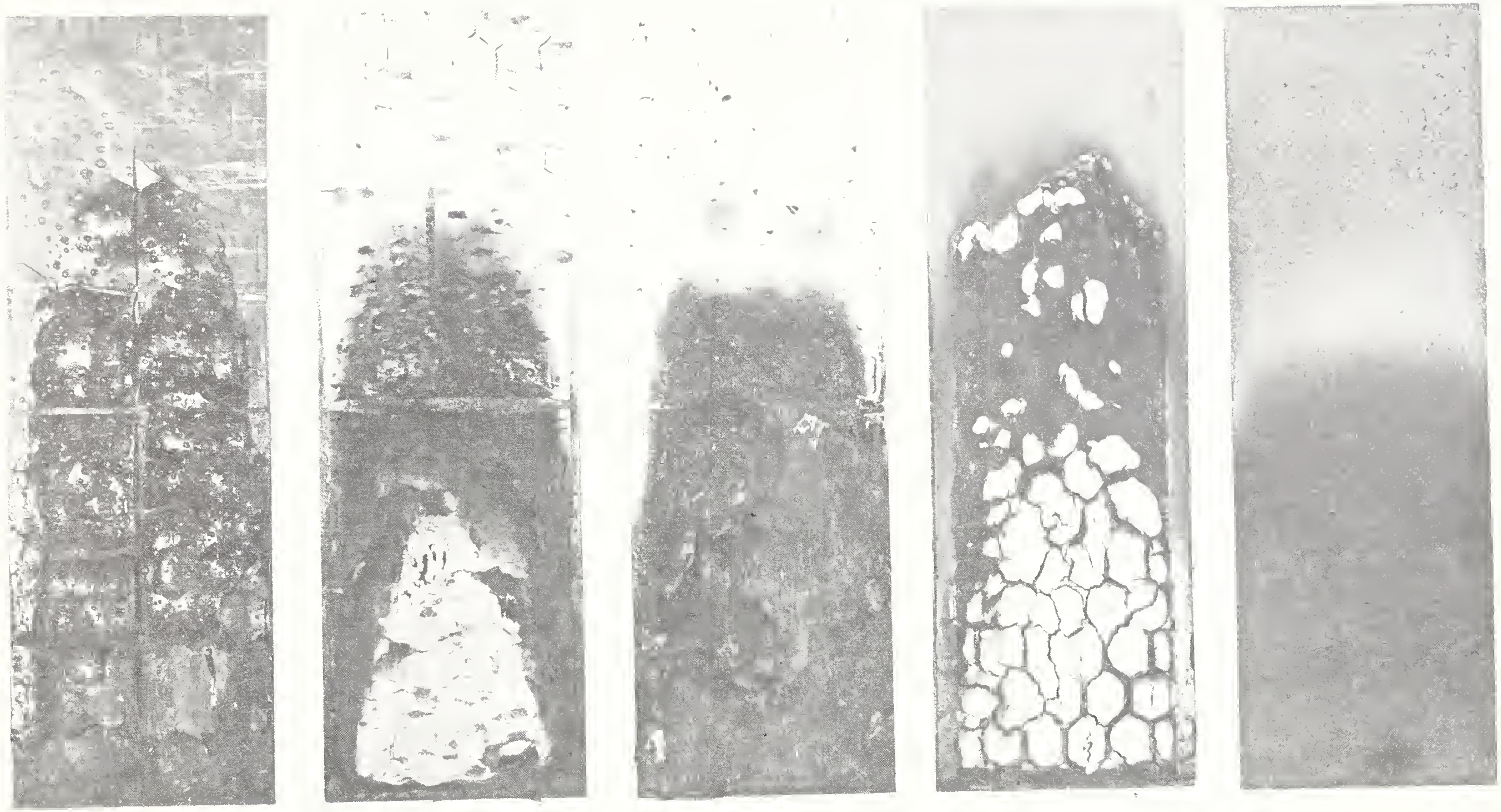

Fig. 4a - Deck Covering Specimens After Radiant Panel Test

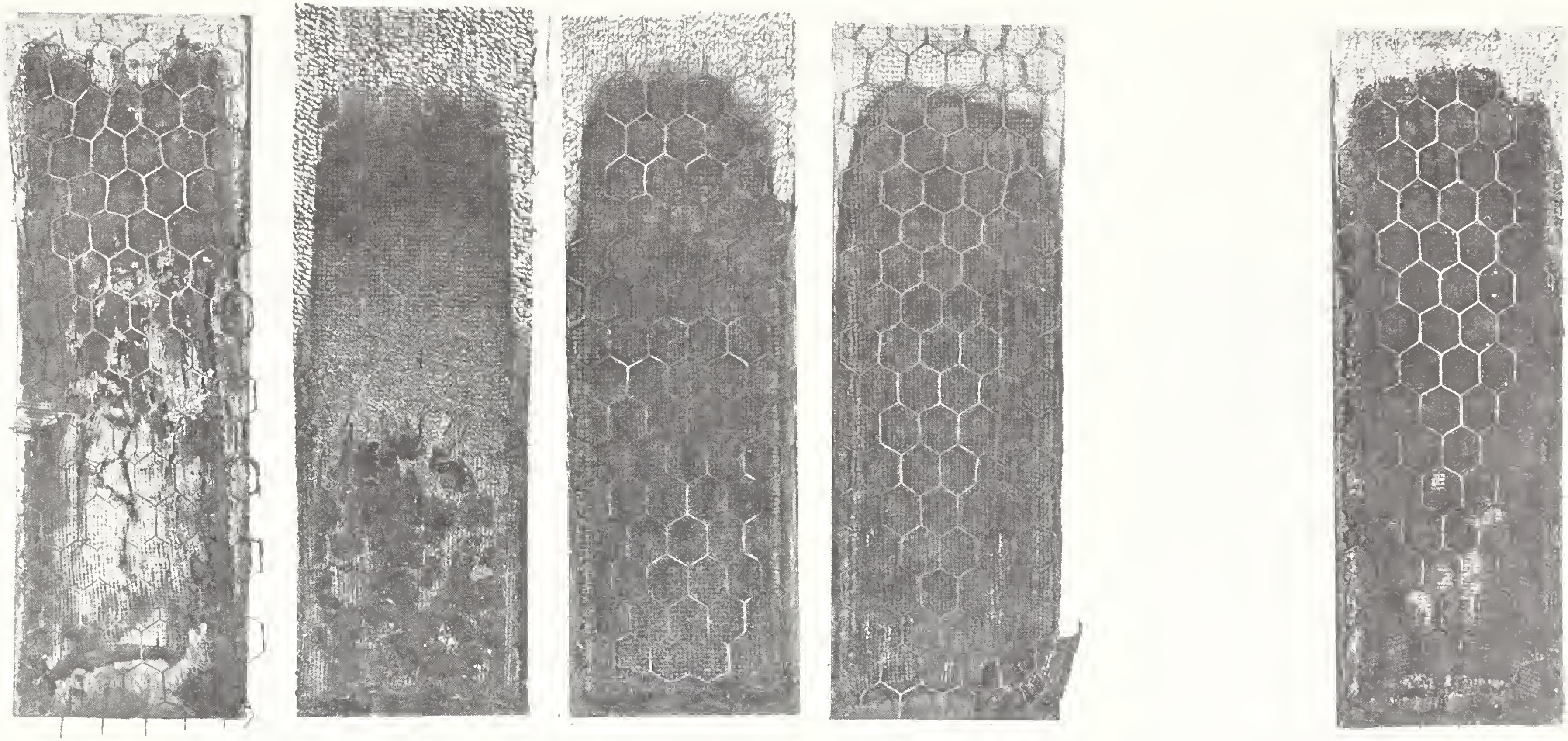

Fig. 4b - Deck Covering Specimens After Radiant Panel Test

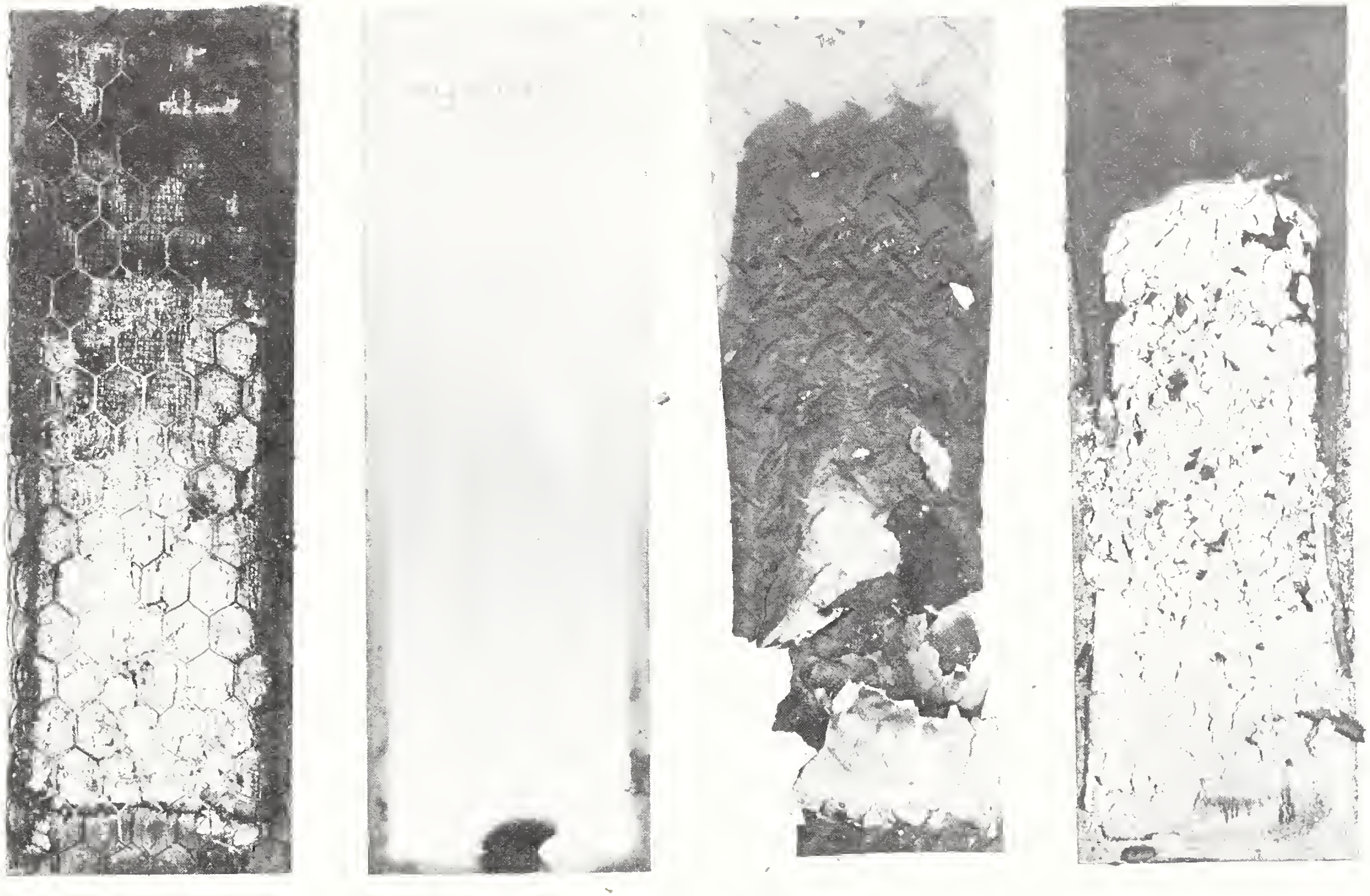

Fig. 4c - Deck Covering Specimens After Radiant Panel Test

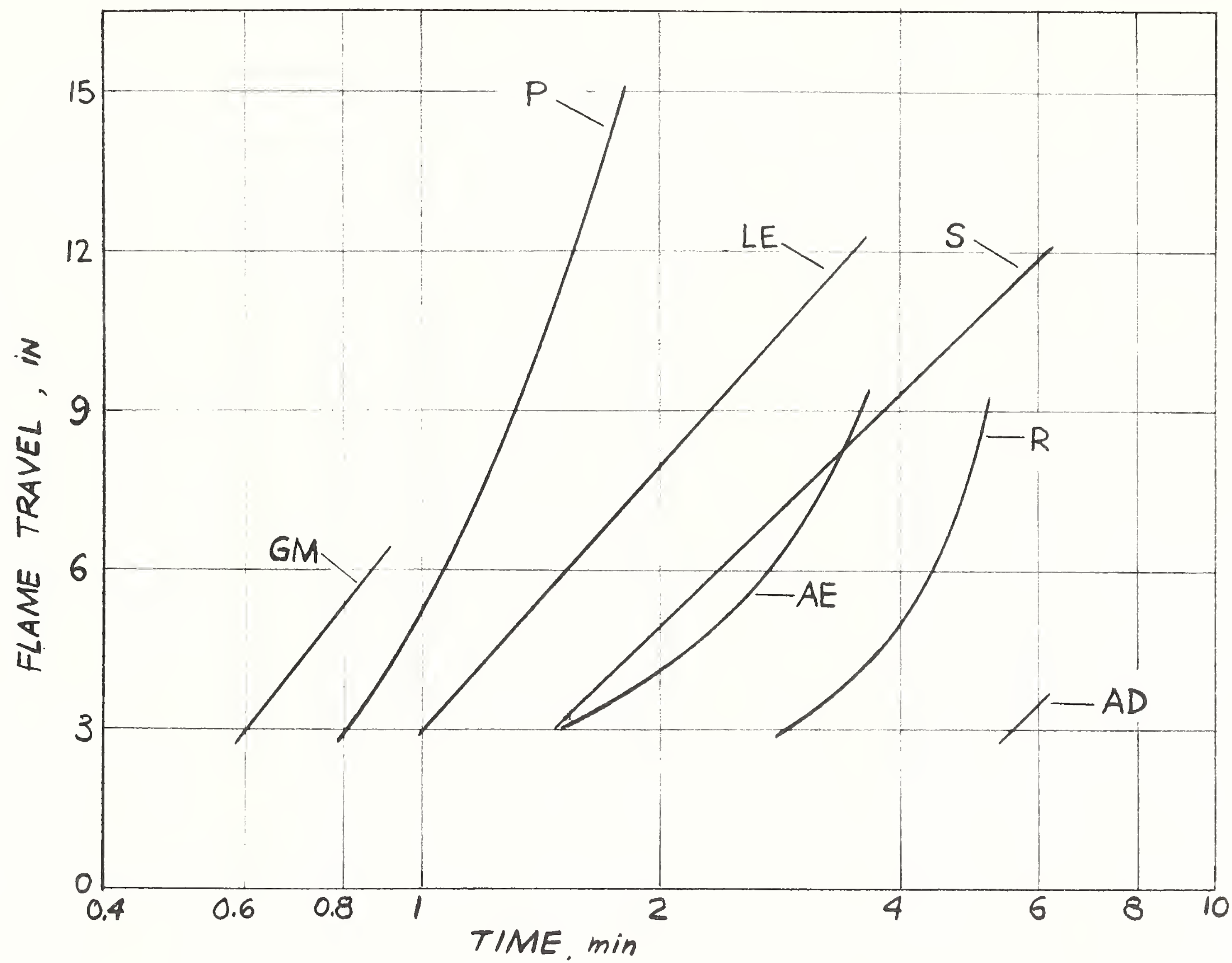


Fig. 5 - Flame Travel Data in Radiant Panel Test

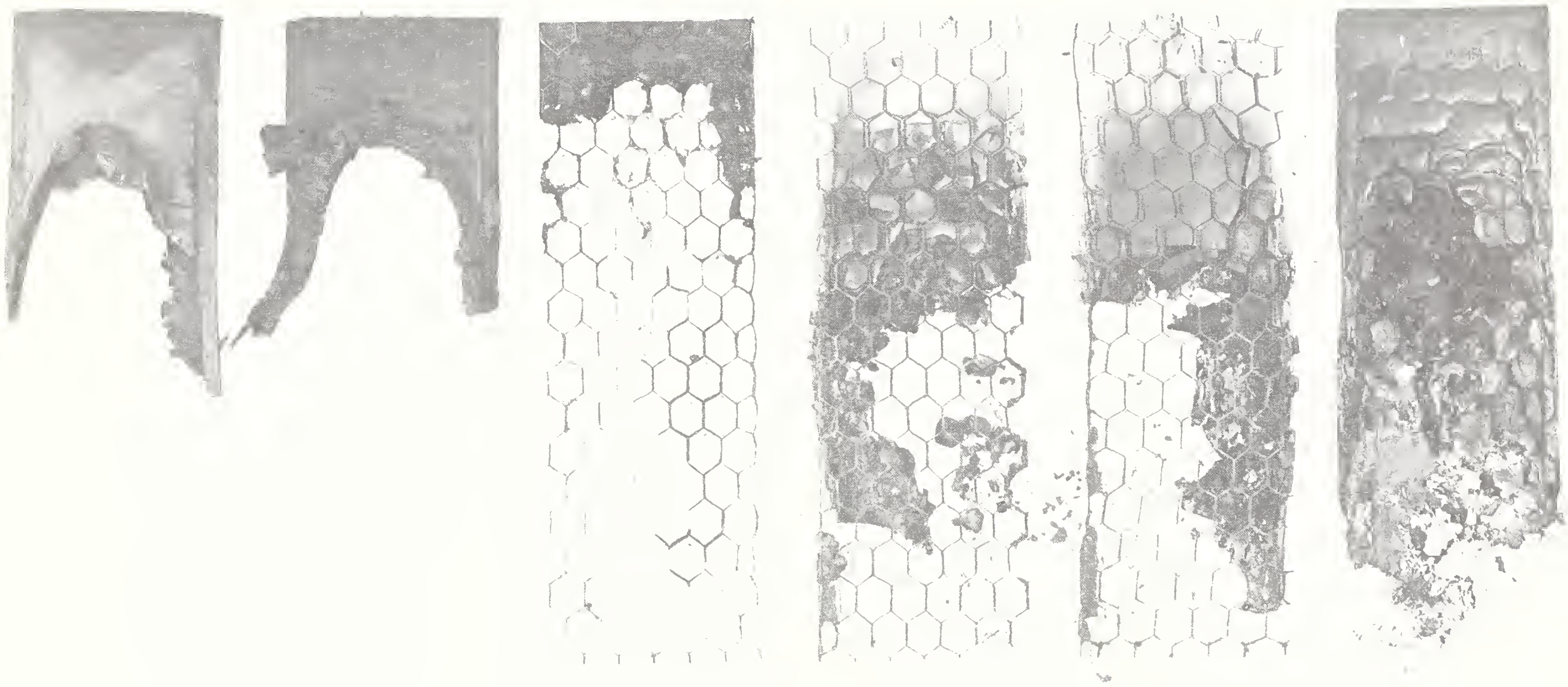

Fig. 6 - Plastic Foam Insulation Specimens After Radiant Panel Test

1 = "Armstrong"
2 = "B. F. Goodrich"
3 = "Griswald"
4 = "Rubatex"
5 = "Uniroyal (Ensolite)"
6 = "Shields"