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# NATIONAL BUREAU OF STANDARDS REPORT

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A FLAMMABILITY TEST FOR WALK-OFF MATS

by

Marjorie W. Sandholzer



U.S. DEPARTMENT OF COMMERCE  
NATIONAL BUREAU OF STANDARDS

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## ABSTRACT

A study of a timed-burning fuel pellet test for determining the flammability of walk-off mats is reported. The effects of varied test conditions and techniques, and the selection of appropriate performance criteria, were investigated. The resulting proposed test procedure is considered suitable for general laboratory use on a field basis.



## A Flammability Test for Walk-Off Mats

### 1. Introduction

As the use of walk-off mats at the entrances of public buildings increased, it was found that, unless a flame retardant treatment had been applied, the pile surface of the mat might be in a hazardously flammable condition. Although the backing of the mat would not easily become involved, the brush of a match or other flame might be sufficient to touch off flames which spread over the whole pile surface in a matter of seconds. Inasmuch as such mats were a regular procurement item of the General Services Administration, it was necessary for that agency to adopt a method of measuring the flammability and to establish performance requirements. After some preliminary trials of standard flame spread test methods, it appeared that a methenamine fuel pellet test suggested by a commercial concern might prove satisfactory for the particular purpose. The test had been presented in outline form, however, and the GSA requested a study of the method to determine its general usefulness and to provide a more completely defined procedure. It was desired that the test be kept sufficiently simple to permit its use on a field basis in various conveniently available laboratories.

### 2. Materials

Limited portions of treated mats, provided by the GSA for preliminary trials, were available, and in addition, several mats from the regular GSA procurement with unidentified dust control and flame retardant treatments were supplied. Untreated mats, mats treated with a dust control compound only, and mats treated with both a dust control compound and a flame retardant treatment were procured from a commercial manufacturer.

### 3. Experimental Work

Using the test procedure suggested by the commercial company as a basic outline, a schedule of experimental work was arranged to investigate the need for more specific definition of certain parts of the procedure.

#### A. Source of Ignition.

The suggested procedure specified methenamine timed-burning tablets (Eli Lilly No. 1588) as the source of ignition, the tablet being ignited by a match. No other type of ignition source was studied but different ways of placing the methenamine pellet on the pile of the mat were tried. The depth to which the pellet was embedded in the pile seemed of particular interest.

The burning of the pellet proved to be quite sensitive to any restriction in air supply. When it was pushed down into the pile of the mat it was not only difficult to ignite but would burn only briefly. If it occasionally sank slightly into the pile as it burned, it might go out with a small bead remaining unconsumed. It appeared best to place the pellet as lightly as possible on the pile.



The time required for a pellet to burn out, as used in this particular application, varied widely. It usually fell in the range of  $1\frac{1}{2}$  - 2 minutes, but instances outside that range in each direction were noted. Whether the pellet lay flat on the pile or was tipped up on edge did not appear to affect significantly the time or intensity of burning.

#### B. Sample Preparation.

The suggested procedure called for conditioning the 6-inch square test specimens at 65% RH and 70°F for 24 hours and testing them within 15 minutes after removal from the conditioning room. Each specimen was fluffed by giving it three shakes before testing.

In the experimental program conducted, the following variations of temperature and humidity were included in the conditioning procedures:

- (1) Ambient laboratory conditions where, with the artificial heating season in operation, the humidity was generally low (15 - 25%),
- (2) 65% RH and 70°F for 3 days or more, with testing immediately upon removal from the conditioning room,
- (3) 65% RH and 70°F for 3 days or more, followed by a 15-minute exposure to ambient laboratory conditions before test, and
- (4) one hour in an oven at 105°C followed by 5-10 minutes of cooling in a desiccator over silica gel before test.

For fluffing the pile, the suggested shaking was used and, in addition, a brushing procedure was tried. A plastic-bristle brush, of the type sold in brush-scraper combinations for removing snow from automobile windshields, was passed once (or twice on badly flattened pile) over the surface of the specimen.

#### C. Conduct of the Test.

In conducting the tests, a comparison was made between placing the specimen on a table in the open laboratory and placing it inside a ventilated cabinet, during exposure to the burning pellet. The pellet was placed at the center of the specimen.

The criteria used as a measure of flammability were basically the "rate of flame spread and char diameter" specified in the suggested procedure. Rate of flame spread has meaning only for materials which are relatively flammable and show continuing progress of flame travel over the surface. For such specimens, however, it appeared the most suitable criterion, and was noted in terms of the time required for the flame to spread over the entire surface of the specimen. For the most flammable mats this was an easily determined endpoint, but where the flame spread was highly erratic, it became unduly variable and its definition a little uncertain -- one or more small islands of pile might remain untouched



while the surface all around was completely involved. In later trials, the time at which the flame reached an edge of the specimen proved a more definite and dependable endpoint and was incorporated in the suggested test procedure. The additional endpoint of total involvement may often be of interest also, however, as a further indication of the speed and ease of flame spread.

For specimens on which the flame did not cover a major part of the specimen, the charred area offered the most convenient evidence of the extent of flame travel. The longest straight-line dimension across the charred area or areas was taken as an appropriate measure of the extent of flame spread. On the specimens tested, the char was clearly defined and easily measured after burning had ceased, and this would probably be the usual case, inasmuch as plain black would be an unlikely color for the mats. However, some thought was given to a simple means of gaging the flame travel in the possible situation where the char may not be clearly distinguishable. Twelve straight pins, three on each of the diagonal lines from the center to the four corners of the specimen, and set one inch apart starting one inch from the center, provided a pattern of known points from which the flame spread could be judged reasonably well as the burning progressed. As a guide in placing the pins, a triangle of cardboard, cut to fit inside two adjacent diagonals and suitably marked at one-inch intervals, was laid on the specimen with the hypotenuse first along one side and then along the opposite side of the specimen.

#### 4. Discussion of Results

The results of the tests made under varied conditions of procedure are shown in Table 1. Considering the effect of humidity, there was clearly the usual trend toward an increase in flammability with increased drying of the material. As might be expected, the effect was generally small with the more flame resistant mats, although it became significant with the more flammable types. The effect of heating at 105° C did not appear to be more than that of pronounced drying, without loss of the flame retardant (at least for the particular treatments applied). For the purpose of indicating the presence of an effective flame retardant rather than distinguishing between certain degrees of flammability, a convenient means of establishing fairly reproducible humidity conditions would appear more important than the precise conditions selected. Inasmuch as an oven is more commonly available than a conditioning room or cabinet maintained at higher humidities, we would suggest conditioning the specimens in an oven at 60° C (140° F). Although the humidity in the oven at that temperature will vary somewhat with seasonal variations, the moisture regain of cotton does not change greatly over the probable range of oven humidity.

The results indicated little difference between the shaking and brushing methods of fluffing the pile for mats in the usual clean or freshly treated condition. It was observed, however, that on heavily soiled or otherwise severely flattened mats, shaking was not sufficient to raise the pile to a normal condition. As it appeared that it might be easier to describe and procure a reasonably standard comb than a brush, the suitability



Table I. Effects of Variations in Test Procedure

Supplied by: GSA				Procured commercially											
				A		B		C		Untreated		Dust Control only		Dust Control + Flame Retardant	
Conditions Studied	No. of spec.	Avg. Char	No. of spec.	Avg. Char	No. of spec.	Avg. Char	No. of spec.	Avg. Time to flame cover spec.	No. of spec.	Avg. Time to flame cover spec.	No. of spec.	Avg. Time to flame cover spec.	No. of spec.	Avg. Char	
<u>Humidity</u>															
Oven, 105°C															
Room conditions	8	3.7	8	1.5	8	2.2	3	6	3	2	3	1.1			
65% RH, 70°F + 15 min. at room	8	1.6	8	1.3	8	1.1	3	53	3	15	3	0.8			
65% RH, 70°F	8	1.6	8	1.1	8	1.0	3	—*	2	30	3	0.8			
<u>Fluffing Procedure</u>															
Shaking	12	2.2	12	1.2	16	1.3									
Brushing	12	2.4	12	1.5	16	1.5									
<u>Draft Protection</u>															
Inside Cabinet	12	1.4	12	1.4	16	1.1									
Open Room	12	3.1	12	1.3	16	1.7									

\* Flame involved total surface on only one specimen at about 4 minutes after ignition. The average char for the other two specimens was 2.0 inches.



of a combing procedure rather than brushing was considered. Trials on various representative mats indicated that combing should be an effective and satisfactory procedure.

Testing inside the ventilated cabinet appeared to restrict the flame spread significantly in some cases. While testing in the open laboratory would therefore seem preferable, it should be noted that during this study the laboratory was quieter and more free from drafts than might usually be expected. For this reason some study of wire screening, as a possible draft deterrent which would not restrict the air supply, was made. The four-sided guard of 16-mesh galvanized window screen devised for the purpose proved reasonably effective in protecting the pellet flame from ordinary minor disturbances, such as those caused by the movement of personnel working near or walking by the test site. It should be feasible to avoid strong drafts, such as that from an electric fan, in selecting the test site.

To study the effect of soiling on the flammability of the mats, a composite mat was made up of the three types procured from a commercial manufacturer and was placed at the entrance of a building where, after about ten days, the soiling had become extremely heavy, amounting to about 1% on the untreated portion and 5 - 6% on the treated portions. In testing the segments of the soiled mat the specimens were room conditioned and the pile raised by brushing. Six specimens of each segment were tested. The portion which had been treated with both the dust control compound and the fire retardant showed an average char of 1.0 inch, practically the same as the 0.9 inch figure obtained before soiling. The average char values for the untreated segment and the segment treated with dust control compound only were 2.1 in. and 1.6 in., respectively, whereas before soiling, the flame spread over the whole surface of these two types in average times of 26 sec. and 7 sec., respectively (Table 1). Although the soiling in this trial was undoubtedly heavier than is usually allowed to accumulate, the results suggest that tests made on mats in service may not indicate the full hazard presented when they are clean and freshly treated.

## 5. Proposed Test Procedure

From the testing experience and a study of the results of the experimental work, the following description of a suggested flammability test for walk-off mats was developed.

Scope: This method is intended to determine the presence of hazardous flammability in walk-off mats. It is designed to use equipment that is easily portable or commonly available, to facilitate its use on a field basis.

### A. Test Equipment:

- (1) Methenamine timed-burning tablets (Eli Lilly No. 1588) as the ignition medium and matches to ignite the tablets,
- (2) An oven for conditioning specimens at 60°C,
- (3) A comb with 7 or 8 smooth rounded teeth per inch for raising the pile of the mat,



- (4) A four-sided draft guard, open at top and bottom and one foot square on a side, made of 16-mesh window-screen fastened to a rigid frame of rod or heavy wire, to protect the flame from minor drafts, and
- (5) A stop watch to time the flame spread.

B. Test Specimens:

The mats shall be tested in a clean or freshly treated condition. Three test specimens, each six inches square, shall be cut from each mat under test.

C. Specimen Preparation:

The specimens shall be laid or hung in a preheated oven in such a way that there is free access of air all around each one. They shall be conditioned at  $60 \pm 3^{\circ}\text{C}$  ( $140^{\circ}\text{F}$ ) for 1 -  $1\frac{1}{2}$  hours, then removed individually, fluffed, and tested immediately. The fluffing shall consist of drawing the comb once across the pile surface of the specimen with sufficient pressure to raise the pile to an upright position. (If the pile is severely flattened two or three passages of the comb may be used.) The specimen should be tested within 45 seconds after removal from the oven.

D. Test Procedure:

The test shall be conducted in the open laboratory but in a site removed from strong wind or drafts. The prepared specimen shall be laid, pile upward, on a flat flame-resistant surface, approximately centered inside the four-sided screen draft guard. A methenamine tablet shall be placed lightly on the pile surface at the center of the specimen and ignited with a match. Timing with the stopwatch shall be started at the moment of ignition of the tablet. If the flame spreads over the surface the time at which it reaches an edge shall be noted, but the timing shall be continued until the whole surface has become involved, if the flame spreads to that extent. If the flame does not reach an edge of the specimen, the test shall be stopped when all flame and glow have ceased. The extent of flame spread shall be determined as the longest straight-line dimension across the charred area or areas, measured to the nearest 0.1 inch. Figures 1 and 2 show a test in progress and some typical char patterns.

E. Report:

The results shall be reported as the average time for flame to reach an edge of the specimen and the average time for the flame to spread over the total surface of the specimen (if it continues to that extent), or the average char length, measured as the longest straight-line dimension across the charred area or areas.

6. Application of Proposed Procedure

To illustrate the type of data and possible problems of interpretation which might be developed, samples of the various mats available were tested by the procedure as described above, with the exception that the oven conditioning was omitted.



The 15 - 20% humidity in the winter-heated laboratory was within the seasonal humidity range of the oven at 60<sup>0</sup> C. The results of the tests are shown in Table 2.

Table 2

Results Obtained by Suggested Procedure  
(Room conditioned)

<u>Mat</u> <u>identification</u>	<u>No. of</u> <u>Specimens</u>	<u>Average time for flame to reach</u> <u>edge</u>	<u>total surface</u>	<u>Average</u> <u>char length</u>
		Seconds	Seconds	Inches
Procured commercially				
Untreated	10	13	30	> 6
Dust control	10	6	19	> 6
Dust control + flame retardant	5	NS		1.1
Supplied by GSA				
A	4	5	11*	2.1*
B	4	NS		1.1
D	5	NS		0.9
E	3	8	20	1.7*
F	6	11	48	2.5**

NS No significant spread of flame

\* One specimen only. On Mat A, flame failed to reach an edge on one specimen, and failed to cover total surface on two others. On Mat E, flame failed to reach an edge on one specimen.

\*\* Two specimens only (on which flame failed to reach an edge)

On the basis of such data there would clearly be no difficulty in distinguishing between mats which had no flame retardant treatment and those which were very well treated. Some treatments, however, would present problems of interpretation and definition. For three of the types of mats tested, some specimens showed flame spread over the whole surface while on others it was confined to a small area around the pellet. Although this situation would have to be recognized in establishing performance requirements, it would appear that an adequately clear and useful definition of acceptability should be possible. Perhaps the simplest definition might be that flame should not reach an edge of any specimen, but other definitions would be feasible depending on the degree of flame resistance desired.



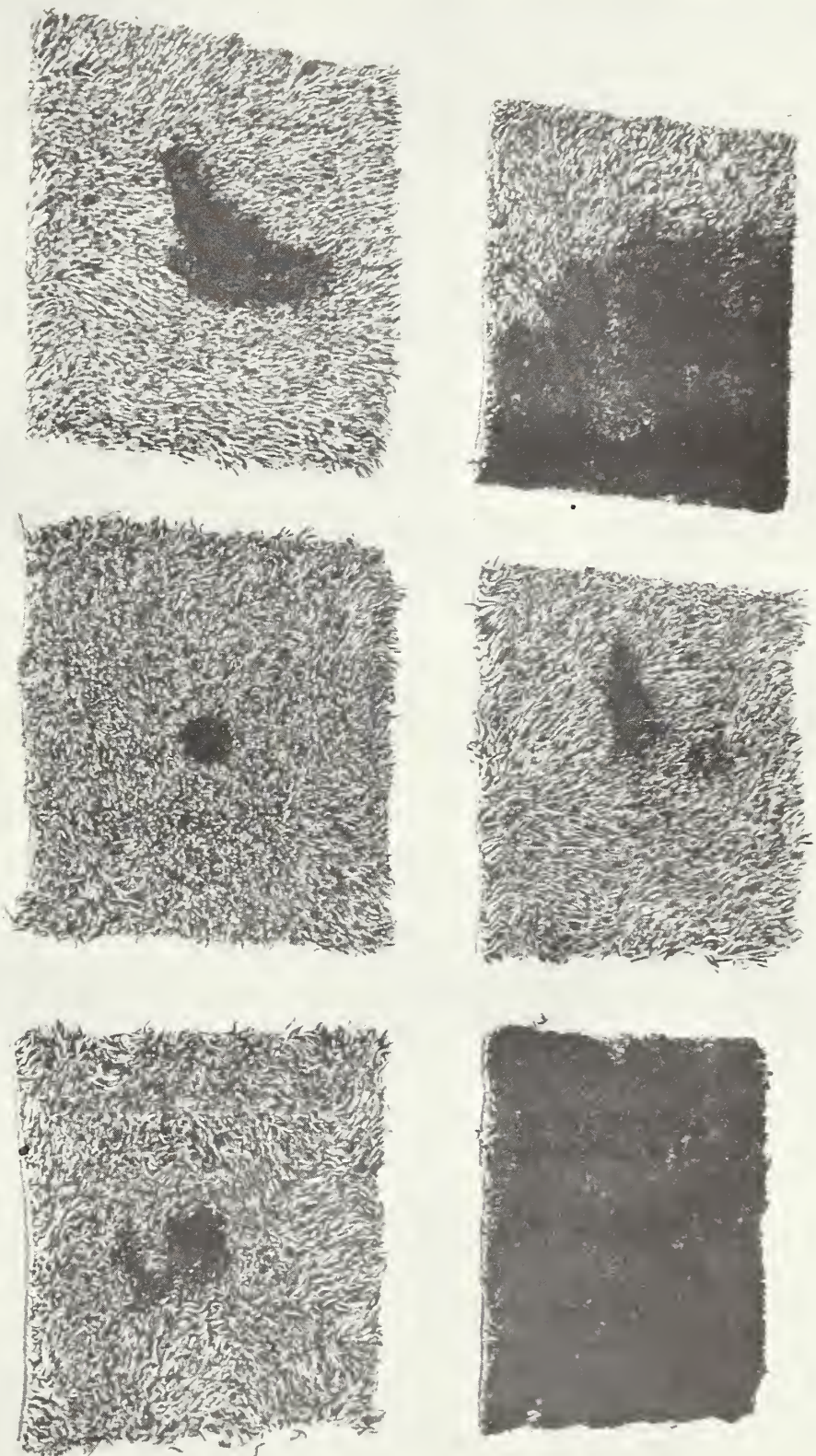


Figure 2. Specimens after test showing various patterns of char.

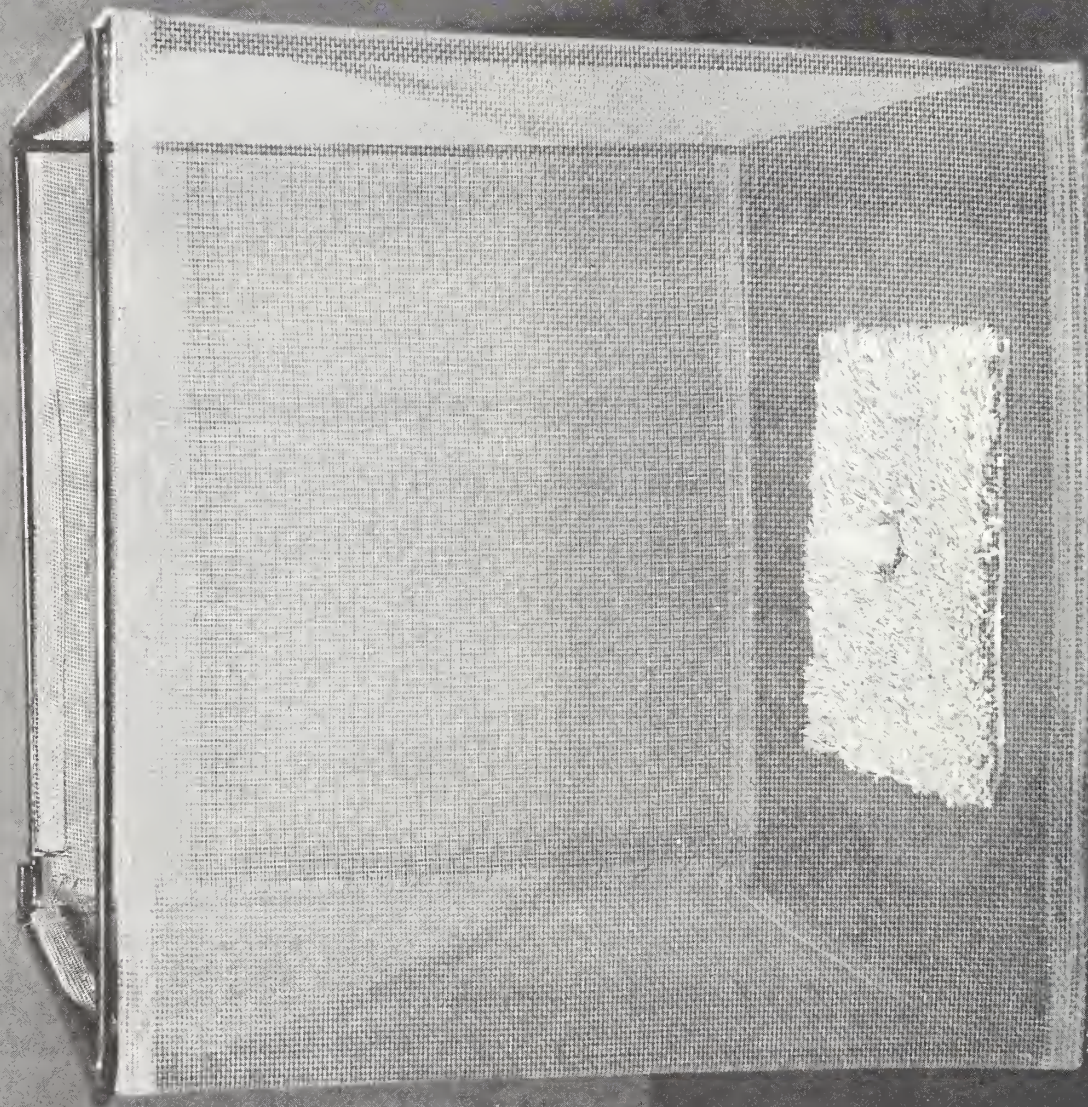


Figure 1. Methenamine pellet test in progress.



