NBSIR 75-950

Proposed Criteria for Use of the Critical Radiant Flux Test Method

Irwin A. Benjamin and C. Howard Adams

Center for Fire Research
Institute for Applied Technology
National Bureau of Standards
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Final Report

U. S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

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Abstract

The objective of this discussion is to present background and other technical data that will help in suggesting criteria to be used in conjunction with the Flooring Radiant Panel Test to determine the potential contribution to fire growth of floor covering systems for use in corridors and exitways.

Key words: Fire hazard; fire safety; flooring test; radiant panel.

1. INTRODUCTION

1.1. The Flooring Problem

"On December 18, 1969, there was published in the FEDERAL REGISTER (34 F.R. 19812) a notice of finding that a flammability standard was needed for carpets and rugs to protect the public against unreasonable risk of the occurrence of fire leading to death, injury or significant property damage arising from the hazards of rapid flash burning or continuous slow burning or smoldering..." This excerpt from the April 10, 1970, "Notice of Standard" states the need which led to the <u>first</u> U.S. National "Standard for the Surface Flammability of Carpets and Rugs," DOC FF 1-70, the pill test, designed to reduce the probability of carpet ignition. In January 1970, and thus before this standard went into effect, a serious corridor type fire in a Marietta, Ohio nursing home pointed to the need for a realistic flame spread test that could be used by the regulatory community to upgrade the fire safety of floor covering systems installed in building corridors and exitways.

1.2. Development of Flooring Tests

One of the early flame spread tests for carpets, that is still widely used, is the UL Steiner Tunnel Test (ASTM E-84), the test called for in the standards for the Hill-Burton program for federally subsidized hospital construction. The E-84 test was considered an interim measure when the directive regulating the "Use of carpeting in (Hill-Burton funded) hospitals" was issued in March 1965. For this reason, the Department of Health, Education and Welfare (HEW) in 1969 sponsored the development at Underwriters' Laboratories of a test specifically directed at evaluating flooring and floor covering materials. The UL 992 chamber was the product of this contract with the Health Services and Mental Health Administration.

The UL 992 chamber test is conducted with the specimen mounted on the floor whereas in the E-84 tunnel the specimen is on the ceiling. The chamber generates an index which has an as yet undetermined relevance to fire hazard. In the test chamber environment the draft supplying air to the flame is in the opposite direction to that observed in full-scale corridor fires. In recent months, under Man Made Fiber Producers Association/Carpet and Rug Institute (MMFPA/CRI) sponsorship, a new chamber has been built at Underwriters' Laboratories, Northbrook, Illinois. This new chamber is patterned after the NBS Model Corridor [1][1].

During the 1966-1974 period, another small-scale test, the Flooring Radiant Panel, was under development at the Research and Development Laboratories of Armstrong Cork Company. Concurrently in these years, full-scale corridor programs designed to gain a better understanding of the mechanisms controlling the spread of fire along a carpeted corridor were being carried out. The National Bureau of Standards and the Illinois Institute of Technology Research Institute built corridor test facilities which simulated a corridor with an adjoining fire source room. The results of these test programs shed some important light on the mechanism of corridor flame spread.

The development of the Flooring Radiant Panel Test has benefited from the work on the NBS Model Corridor and the full-scale corridor projects. The test has been proposed as a standard test for floor covering systems. It offers these advantages over ASTM E-84, UL 992 and the NBS Model Corridor:

1. It measures radiant exposure, which has been shown to be of great importance in full-scale corridor tests;
2. The total flooring system is tested, as used, in the horizontal plane;
3. Reproducibility and repeatability are good;
4. The apparatus is simple and compact and the test specimen is small;
5. The test procedure is simple; and
6. The test provides a continuous scale of floor covering performance in the range of 0.1 to 1.0 W/cm^2 radiant exposure.

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[1] Numbers in brackets refer to the literature references listed at the end of this paper.

2. DEVELOPMENT OF THE FLOORING RADIANT PANEL TEST

2.1. Historical

The Flooring Radiant Panel Test had its beginnings in the Research and Development Laboratories of the Armstrong Cork Company in 1966. Zabawsky originated the design and did the preliminary test development work. At this stage, the E-84 concept of a red oak standard was the basis for reporting results. Other approaches to data treatment and reporting were under study at Armstrong in 1970, e.g., 1) rate of burn and 2) distance burned to extinguishment of the flame. The latter is related to the measure of hazard that is used today, i.e., critical radiant flux.

Conceptualization in early 1972 of Critical Radiant Flux (W/cm^2 at extinguishment) as the measure of flame spread hazard is credited to work at NBS by Denyes[2] and Quintiere [1]. They determined in the course of work on a model corridor that the radiant energy level incident on the floor covering test specimen had considerable influence on whether flaming combustion would propagate or terminate. In the model the radiant energy level was a function of the energy input from a gas diffusion ignition burner. Several runs at different energy input levels were required to establish a Critical Radiant Flux for a given specimen - the minimum burner energy below which flames ceased to propagate. The concept of a governing radiant flux also reflected the energy approach to the full-scale corridor test, reported by Fung, Suchomel and Oglesby [2], where it was shown that the energy required to produce "flame over" in the corridor was a function of the given floor covering.

It was natural to apply the Denyes/Quintiere "Critical Radiant Flux" concept to the distance burned to extinguishment, and to then study a broad range of floor covering systems. This was the assignment given to Hartzell[3] then working at NBS in mid 1972. His report [3] covering the further development of the Flooring Radiant Panel Test during 1972-1973 has been, by and large, the basis for the current development program.

In 1973, one of the authors[4] was assigned the task of finalizing the test procedure and preparing a draft of the Flooring Radiant Panel Test, which would be suitable for use as a standard technique for measuring the critical radiant flux of floor covering systems. This report covers some of the highlights of this final phase of the test development.

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[2] Wells Denyes worked for Man Made Fiber Producers Association as a NBS Research Associate while the work was in progress.

[3] NBS Research Associate, Armstrong Cork Company.

[4] C. Howard Adams, NBS Research Associate, Society Plastics Industry.

2.2. The Test Procedure

The December 1975 draft of the proposed test procedure is entitled "Standard Method of Test for Critical Radiant Flux of Floor Covering Systems Using a Radiant Heat Energy Source." (see appendix) The reader is referred thereto for test specifics and apparatus details. This test procedure is the result of multiple comments and corrections suggested by the many individuals (approximately 20) who are currently operating the test apparatus.

The basic elements of the test hardware are shown in figure 1. The horizontally-mounted 100-cm floor covering test specimen receives radiant energy from an air-gas fueled radiant panel mounted above the specimen and inclined at an angle of 30°. A pilot burner is used to initiate the test by open flame ignition of the specimen. The gas panel generates a flux profile along the length of the specimen ranging from a maximum of 1.1 W/cm^2 to 0.1 W/cm^2 minimum.

As the first step in carrying out a test, the floor covering system specimen is mounted in the holding frame. With the chamber preheated to equilibrium conditions by the radiant panel, the specimen is moved into the test position and the chamber is closed. Following the two-minute preheat, the pilot burner (ignition) flame is applied. The test continues until the specimen flaming goes out (extinguishment). The distance burned to extinguishment is converted to W/cm^2 from the calibrated flux profile graph and the result is reported as a critical radiant flux, W/cm^2. This value is reported as the minimum flux necessary to sustain flame propagation on the flooring surface.

2.3. Interlaboratory Programs

2.3.1. ASTM E-5.04.08

A pilot interlaboratory program under the aegis of the ASTM E-5.04.08 Task Group involved NBS and Armstrong Cork Company. From this test program and previous data developed by Hartzell it was decided to standardize on a panel temperature of 490 °C. Although the Armstrong test equipment was smaller, exposed specimen length was approximately 80 centimeters compared to the now standard 100 centimeters; yet, the ranking of materials was consistent when the critical radiant flux levels were within the range of both the panels. The floor coverings included in this program were wool, acrylic, and nylon carpets, red oak and vinyl tile.

2.3.2. Phase I — NBS/Man Made Fiber Producers Association (MMFPA)

The Phase I — NBS/MMFPA Interlaboratory program was the first major study of the reproducibility and repeatability of the Flooring Radiant Panel Test. In this project, thirteen laboratories tested eight carpet systems in a classic factorial design with replication at the three level. The carpets in this program were primarily for residential use. The experimental results are given in table 1 and figure 2. The procedure used did not specify preheat of the sample. During this program, it was confirmed that total fluxmeters are the preferred instruments for the flux profile determination. All flux profile instrumentation was field calibrated by NBS to engineering standards.

The statistical analysis of the data was done by Mandel at NBS using the proposed ASTM E-11 procedure for interlaboratory evaluation studies [4]. This showed the test to be suitable for use as a standard. Defining a test result as the average of 3 replicate determinations, the repeatability (within laboratory variability) was about 20 percent of the measured value[5] and the reproducibility (among laboratory variability) was of the order of 35 percent of the measured value.[6]

This program pointed up a minor problem in the conduct of the test. Two laboratories had some trouble with inconsistent ignition of specimens. The difficulties were resolved by the use of a propane pencil flame torch, as the pilot burner.

2.3.3. Phase II — NBS/MMFPA/Carpet and Rug Institute (CRI)

The Phase II — NBS/MMFPA/CRI Interlaboratory program expanded on Phase I. The procedure used was modified to provide a two-minute preheat of the specimen prior to pilot application. The test included only carpets that are sold to what is identified as the contract market. Carpets in this category are used in regulated public occupancy buildings, e.g., hospitals, nursing homes, hotels, office buildings and apartment corridors. The Phase II program was divided into two parts. Part A was a classic 12-laboratory 10-carpet systems interlaboratory factorial design experiment with replication at the three level. The test data repeatability and reproducibility for this set of fabrics was comparable to that demonstrated in Phase I. The data are shown in table 2 and figure 2. The carpet system selection process was to have picked products that differed by uniform increments on the flux profile scale. Though this objective was not fully realized, the distribution of specimens did cover the range in reasonably good order.

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[5] "Repeatability" is a quantity that will be exceeded only about 5 percent of the time by the difference, taken in absolute value, of two randomly selected results obtained in the same laboratory on a given material. (See reference [4].)

[6] "Reproducibility" is a quantity that will be exceeded only about 5 percent of the time by the difference, taken in absolute value, of two single test results made on the same material in two different randomly selected laboratories [4].

2.3.3.1. Part B — Phase II, Economic Impact Studies

The purpose of Part B of Phase II was to determine the commercial impact on current contract carpet products for a given recommended critical flux threshold. This is part of a Carpet and Rug Institute economic impact assessment study. Part B included approximately 60 carpet systems selected to be representative of the 800+ carpet products that comprise the contract market. In this segment of the Phase II work, each carpet system was tested once in each of 6 laboratories. The laboratory selection process was done by reference to a random number table.

Figure 3 shows the distribution of this group of contract carpets as a function of Critical Flux level and provides some idea of the impact of various levels of regulation. The effect of the inclusion of a non-integral cushion pad in the system is clearly evident in figure 4. It may be appropriate at this point to emphasize that the Flooring Radiant Panel Test is intended to deal only with corridor and exitway floor coverings.

2.4. Other Laboratory Programs

In parallel with its participation in the interlaboratory programs cited, the Center for Fire Research has conducted cooperative projects with the Wool Bureau, the Resilient Tile Institute and several manufacturers of floor covering systems. The purpose of this work was to extend the applicability of the Flooring Radiant Panel Test and the knowledge base to include all commercially significant floor covering systems. The data obtained are plotted on the critical radiant flux map (see fig. 2).

3. CRITICAL RADIANT FLUX THRESHOLD CRITERIA

The rationale underlying the selection of recommended critical radiant flux threshold levels is built on a combination of:

1. the past record of fires involving floor coverings,
2. measurements of corridor radiant heat flux and other observations from full-scale burn tests,
3. judgement decisions to reflect occupancy characteristics and occupant levels, and
4. critical flux threshold levels for commercially used floor covering systems that are generally conceded to be of low hazard.

3.1. The Record of Past Fires

In 1973, Robertson reported on a study of fire incidents in which carpets were reported to have been significantly involved in the spread of flame along a corridor. From a total of 142 reports of carpet-related fire accidents, he concluded that there were seven instances in which the floor covering material seemed likely to pass the pill test and yet appeared to have been a factor in the spread of fire. Samples of carpet from three of these fire cases were obtained from the Flammable Fabrics Accident Case and Testing System (FFACTS)[7] file repository and run in the Flooring Radiant Panel Tester. Although only enough material was available to run one specimen, experience showed that the results are shown in figure 2. In each instance, the data show that critical radiant flux was very low. Therefore, from these data we concluded that a floor covering system with a critical radiant flux of less than 0.1 W/cm^2, as determined in the Flooring Radiant Panel Test, could present a flame spread hazard in a corridor or exitway. It is of interest to note that floors and stairs of wood construction are involved in the initial spread of fires as frequently as floor coverings such as carpet and tile [5].

3.2. Full-Scale Corridor Experiments

The full-scale corridor experiments are of value for their contribution to a better understanding of the mechanisms at work during a fire in this type of space. This research also provides some definition of the environment that floor covering systems may be exposed to in a real fire incident. Thus, the NBS and IITRI investigations [5] shed light on radiant flux levels incident on the floor covering system, temperature distributions in the corridor and air velocities. However, the results for corridor flame spread in the two test programs differed in the occurrence of flashover. The reasons for this lack of agreement are not completely understood, but it is surmised that in addition to corridor configuration, airflow patterns and fuel differences, certain key variables may have been uncontrolled, e.g., moisture, air temperature, carpet installation technique, air velocity, et al. In a special series of tests, subsequent to the earlier NBS work already discussed, Quintiere studied the effect of burn-room fire loadings on the corridor environment. The results are presented in figure 5 [6]. This shows incident radiant flux on the corridor floor as a function of distance from the burn-room door. Data for four levels of fuel loading are presented. These data are specific for the corridor and burn-room involved and were obtained in tests with the corridor free of organic combustibles, i.e., no carpet, no wall or ceiling covering, and no furnishings. The data in figure 5 are for a given ventilation and geometry and for the case of <u>no fuel</u> in the corridor. The effect of combustibles in the corridor is to

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[7] FFACTS is the accident case data system at the National Bureau of Standards, Washington, D.C.

raise the total incident flux on the floor. Thus, these data have been used as a rough approximation of the actual conditions and our choices of criteria have been tempered accordingly.

3.3. Occupancies

Two types of occupancies have been of prime concern in consideration of this type of fire hazard.

1. Institutional - Hospitals, nursing homes, and other health care facilities where the patients are generally non-ambulatory or only partially ambulatory.

2. Residential and Commercial Hotels, motels, offices, and apartments whose occupants are generally ambulatory.

As indicated previously, tests performed on the floor coverings known to have contributed to building fires show critical irradiance levels of less than 0.1 W/cm^2. This fire hazard level is thus assumed to be too low for acceptable flooring use in corridors and exitways of residential and commercial occupancies. Field experience with wood and resilient tile flooring suggests that such floors are seldom if ever major contributors to fire spread in corridors. The critical radiant flux of oak flooring has been determined as about 0.35 W/cm^2. Thus, the selection of 0.25 W/cm^2 for residential and commercial occupancies seems sufficiently severe to reduce substantially the number of incidents in which floor coverings serve as a prominent cause of fire spread.

Because of the special problems with nonambulatory patients a higher level of performance seems desirable for institutional occupancies. A level of 0.5 W/cm^2 is suggested for such applications.

Figure 5 gives an approximation of the total heat flux on the corridor floor, at various distances down the corridor, for a given fuel load in the fire room, assuming noncombustible floor, wall and ceiling linings. Assuming a fuel load of 9.8 Kg/m^2 (2 psf) in the fire room and no contribution from the corridor floor, wall or ceiling lining, the critical radiant fluxes of 0.25 and 0.50 W/cm^2 on the floor would be exceeded for distances down the corridor of approximately 7.5 m (25 ft) and 3.0 m (10 ft), respectively.

Application of critical irradiance level criteria of 0.25 and 0.50 W/cm^2 should significantly reduce the contribution of floor covering materials to fire spread in corridors during developing fires in rooms. They should not be regarded as insuring against spread when floor coverings are exposed to thermal radiation levels of higher intensity.

Errata Sheet

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$$S = \sqrt{\frac{(\Sigma X^2 - n \bar{X}^2)}{n - 1}}$$

The above values are suggested for use in corridors only and not for rooms or compartments. For this discussion a corridor is taken to be an enclosed public space linking a room or compartment to an exit. The values are suggested for buildings which do not have automatic extinguishment systems in the corridor. Where such systems are present, we suggest the above criteria are not necessary.

3.4. Performance of Available Commercial Floor Coverings

Using the above criteria, an evaluation was made of the critical radiant flux performance of floor covering materials in the commercial market place. Data on products selected by CRI are presented in figures 2, 3 and 4. Of particular importance are the data in figure 3. The carpets represent a total of 64 systems selected for this group of tests and are representative of the 800+ carpets currently identified with the contract market —— the institutional market.

About 80% of the carpets tested and two-thirds of the existing contract market production volume meet the 0.25 W/cm^2 criterion. Wood flooring and all sheet and tile flooring systems tested meet the criterion.

At the suggested health care facility criterion of 0.5 W/cm^{-2} the choice of products is limited to about the upper 50% of the current contract carpet market, including some carpets with integral foam backing. Also vinyl-asbestos tile and most resilient vinyl flooring materials meet the criterion.

4. CURRENT LIFE SAFETY CODE REQUIREMENTS

Reduced to its basics, the question of the fire safety of floor coverings involves:

1. the ease of ignition and fire spread in a "first-to-ignite" situation, i.e., under localized incident radiant energy flux; and
2. the degree to which the floor covering system presents a fire propagation link in a corridor and/or exitway given a fire in an adjoining room.

The test method described in the "Standard for the Surface Flammability of Carpets and Rugs" DOC FF 1-70 (the pill test) is believed to be an appropriate and valid measure of ignition ease and flame spread hazard under localized incident radiant energy conditions. Floor coverings which pass the pill test would be expected to provide adequate "first-to-ignite" protection in all occupancies.

The Flooring Radiant Panel Test is designed to deal with the fire propagation potential of floor covering systems in corridors and exitways before the corridor is otherwise involved in the fire. The test exposure spans the range of moderately high flux levels from a room fire source and therefore imposes a relatively high radiant energy load on the sample together with a flaming ignition input.

The criteria proposed in section 3.3. for institutional occupancies would also address the problem which has been posed by the interpretation of Section 10-1352 of the 1973 Life Safety Code. The code mandates the use of the E-84 tunnel test, and states that "floor finish materials shall be Class A or B throughout all hospitals, nursing homes, and residential —— custodial care facilities." We believe that an equivalent level of safety for such occupancies as that stipulated in Section 10-1352 can be achieved by:

1. limiting the critical radiant flux, as measured by the Critical Radiant Flux Method of Test, in the corridors and exitways; and

2. having all carpeting in the rooms and compartments meet the requirements of DOC FF 1-70.

This proposed change in requirements reflects a change in test evaluation technology and a re-evaluation of the hazard of carpeting.

5. SUMMARY

This discussion covers the background and history of the Flooring Radiant Panel Test Method: from hazard analysis, to full-scale test, to qualitative models, to the development of the test in its final form. For flooring in corridors and exitways an average acceptance criterion of 0.25 W/cm^2 for residential and commercial occupancies and an average acceptance criterion of 0.5 W/cm^2 critical radiant flux for institutional occupancies are suggested. These values are derived from experience with floor coverings above and below these values and analysis of measured flux values in the corridor experiments. These average values are subject to testing variance and should not be used without a rational sampling plan for testing.

6. ACKNOWLEDGEMENTS

The test development aspect of the program has, in effect, been a joint effort with the floor covering system industry. The laboratories of the Man Made Fiber Producer's Association and the Carpet and Rug Institute members have installed testers and participated in the Interlaboratory Programs discussed. Their people have contributed much time and effort to technical and procedural issues. Without this important help and motivation, the program could not have met its target dates.

7. REFERENCES

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Table 1. Phase I - NBS/MMFPA/CRI Interlaboratory Program Data (No Preheat)

Laboratories	Sample Identification							
	1. CT-4644-1 100% Acrylic-Level Loop (900 - 20)	1P. CT-4644-1 + Pad*	2. CT-4644-2 Nylon, Level Loop (900 - 11)	2P. CT-4644-2 + Pad*	3. CT-4644-3 Wool Plush (900 - 2)	5. CT-4644-5 Polyester (900 - 30)	6. CT-4644-6 Acrylic (900 - 21)	7. CT-4644-7 Nylon 6 Cut Pile Print
	Critical Radiant Flux, W/cm^{-2}							
1	0.48	0.25	0.96	0.31	0.56	0.38	0.16	0.56
	0.46	0.24	0.86	0.29	0.53	0.31	0.18	0.60
	0.44	0.29	0.76	0.34	0.55	0.32	0.17	0.51
2	0.60	0.32	0.64	0.43	0.78	0.36	0.20	0.64
	0.49	0.24	0.75	0.32	0.68	0.32	0.23	0.60
	0.46	0.32	0.71	0.36	0.58	0.52	0.25	0.70
3	0.51	0.36	0.71	0.36	0.67	0.34	0.26	0.64
	0.49	0.35	0.71	0.37	0.50	0.36	0.28	0.67
	0.48	0.32	0.70	0.42	0.80	0.40	0.26	0.68
4	0.49	0.24	0.71	0.27	0.55	0.38	0.19	0.45
	0.44	0.30	0.84	0.35	0.84	0.38	0.20	0.49
	0.44	0.21	0.63	0.33	0.63	0.38	0.17	0.55
5	0.38	0.31	0.66	0.32	0.66	0.43	0.30	0.76
	0.42	0.35	0.71	0.35	0.64	0.37	0.29	0.66
	0.45	0.34	0.84	0.37	0.66	0.47	0.29	0.66
6	0.43	0.22	0.60	0.32	0.64	0.42	0.21	0.52
	0.42	0.28	0.61	0.35	0.49	0.37	0.20	0.55
	0.40	0.36	0.63	0.38	0.59	0.30	0.19	0.55
7	0.40	0.28	0.58	0.31	0.58	0.52	0.24	0.60
	0.39	0.32	0.80	0.29	0.51	0.51	0.23	0.64
	0.43	0.30	0.84	0.27	0.69	0.54	0.23	0.69
8	0.47	0.40	0.76	0.40	0.73	0.33	0.35	0.59
	0.43	0.34	0.98	0.29	0.66	0.64	0.31	0.59
	0.64	0.39	0.74	0.29	0.73	0.24	0.30	0.58
9	0.50	0.27	0.80	0.26	0.60	0.60	0.25	0.50
	0.52	0.26	0.65	0.32	0.77	0.48	0.17	0.48
	0.42	0.26	1.23	0.28	0.82	0.33	0.19	0.60
10	0.49	0.30	0.74	0.43	0.58	0.49	0.22	0.62
	0.44	0.24	0.95	0.31	0.65	0.60	0.21	0.57
	0.53	0.31	0.90	0.42	0.53	0.54	0.21	0.63
11	0.39	0.30	0.74	0.25	0.53	0.20	0.19	0.67
	0.49	0.32	0.77	0.30	0.55	0.32	0.19	0.33
	0.57	0.22	0.76	0.32	0.47	0.34	0.21	0.58
12	0.48	0.34	0.66	0.39	0.60	0.39	0.18	0.53
	0.47	0.27	0.59	0.36	0.85	0.46	0.26	0.51
	0.42	0.37	0.71	0.34	0.62	0.38	0.22	0.52
13	0.50	0.28	0.78	0.31	0.62	0.34	0.21	0.78
	0.57	0.27	0.85	0.34	0.68	0.39	0.22	0.74
	0.42	0.31	0.85	0.33	0.74	0.25	0.21	0.52

*Type II Rubber Coated Jute DDD-C-001023 (GSA-FSS)

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Table 2. Phase II - Part A, NBS/MMFPA/CRI Interlaboratory Program Data (Two-Minute Preheat)

Laboratories	101 Wool, Level Loop, Velvet, Latex Backing 46 oz/yd^2	202† Nylon 6/6, Level Loop, Tufted, Jute Backing 28 oz/yd^2	202 + Pad*	207 Nylon 6, Level Loop, Tufted, 16 oz/yd^2 Integral Foam Backing	215 Nylon 6/6, Cut Loop, Woven, Latex Backing 34.7 oz/yd^2	301 Acrylic, Level Loop, Tufted, Jute Backing 42 oz/yd^2	301 + Pad*	402 Polyester, Level Loop, Tufted Jute Backing 42 oz/yd^2	507† Polypropylene, Level Loop Tufted, Jute Backing, 28 oz/yd^2 + Pad*	601 Acrylic/ Nylon, Level Loop Tufted, 37 oz/yd^2 Integral Foam - FR Backing
	Critical Radiant Flux, W/cm^2									
1	0.87	DNI	0.18	0.16	0.73	0.59	0.32	0.69	0.10	0.64
	0.80	DNI	0.23	0.24	0.65	0.59	0.30	0.69	0.10	0.77
	0.80	DNI	0.18	0.20	0.82	0.56	0.21	0.67	0.10	0.75
2	0.87	DNI	0.17	0.16	0.77	0.61	0.25	0.79	0.10	0.63
	0.82	DNI	0.23	0.22	0.78	0.64	0.21	0.81	0.10	0.52
	0.86	DNI	0.24	0.23	0.78	0.59	0.25	0.76	0.10	0.66
3	0.91	DNI	0.23	0.21	0.58	0.60	0.26	0.61	0.10	0.56
	0.87	DNI	0.20	0.29	0.72	0.56	0.26	0.66	0.10	0.55
	0.89	DNI	0.19	0.24	0.85	0.61	0.29	0.81	0.10	0.54
4	0.85	DNI	0.17	0.24	0.53	0.67	0.23	0.70	0.10	0.52
	0.86	DNI	0.17	0.12	0.63	0.59	0.20	0.79	0.10	0.42
	0.89	DNI	0.16	0.16	0.76	0.58	0.25	0.72	0.10	0.62
5	0.76	DNI	0.20	0.20	0.82	0.64	0.24	0.64	0.10	0.76
	0.90	DNI	0.21	0.17	0.85	0.77	0.26	0.68	0.10	0.73
	0.83	DNI	0.24	0.17	0.84	0.97	0.22	0.72	0.10	0.78
6	0.78	DNI	0.16	0.17	0.47	0.59	0.20	0.72	0.10	0.51
	0.67	DNI	0.20	0.26	0.56	0.60	0.19	0.54	0.10	0.52
	0.68	DNI	0.15	0.20	0.56	0.51	0.19	0.56	0.10	0.52
7	0.92	DNI	0.20	0.18	0.61	0.64	0.21	0.68	0.10	0.68
	0.72	DNI	0.22	0.22	0.57	0.55	0.24	0.63	0.10	0.64
	0.72	DNI	0.17	0.15	0.64	0.51	0.25	0.57	0.10	0.68
8	0.94	DNI	0.15	0.15	0.49	0.53	0.20	0.68	0.10	0.74
	0.87	DNI	0.16	0.14	0.51	0.57	0.21	0.63	0.10	0.83
	0.83	DNI	0.14	0.21	0.52	0.49	0.22	0.57	0.10	0.74
9	0.84	DNI	0.16	0.19	0.57	0.54	0.24	0.77	0.10	0.66
	0.75	DNI	0.10	0.17	0.65	0.60	0.17	0.59	0.10	0.67
	0.93	DNI	0.17	0.11	0.52	0.54	0.17	0.68	0.10	0.56
10	0.97	DNI	0.25	0.21	0.98	0.67	0.36	0.56	0.10	0.87
	0.88	DNI	0.23	0.27	0.68	0.60	0.32	0.55	0.10	0.88
	0.90	DNI	0.19	0.22	0.64	0.64	0.36	0.56	0.10	0.85
11	0.79	DNI	0.23	0.17	0.71	0.58	0.21	0.60	0.10	0.44
	0.85	DNI	0.17	0.18	0.87	0.60	0.27	0.65	0.10	0.60
	0.75	DNI	0.24	0.17	0.67	0.63	0.26	0.77	0.10	0.54
12	0.97	DNI	0.22	0.17	0.74	0.58	0.26	0.67	0.10	0.58
	0.88	DNI	0.23	0.17	0.78	0.57	0.27	0.58	0.10	0.67
	0.85	DNI	0.19	0.20	0.58	0.60	0.26	0.69	0.10	0.62
14	0.55	DNI	0.21	0.22	0.40	0.53	0.29	0.58	0.10	0.52
	0.78	DNI	0.18	0.23	0.85	0.55	0.30	0.60	0.10	0.66
	0.72	DNI	0.24	0.20	0.58	0.54	0.19	0.67	0.10	0.63

†Not included in statistical analysis

*Type II Rubber Coated Jute DDD-C-001023 (GSA-FSS)

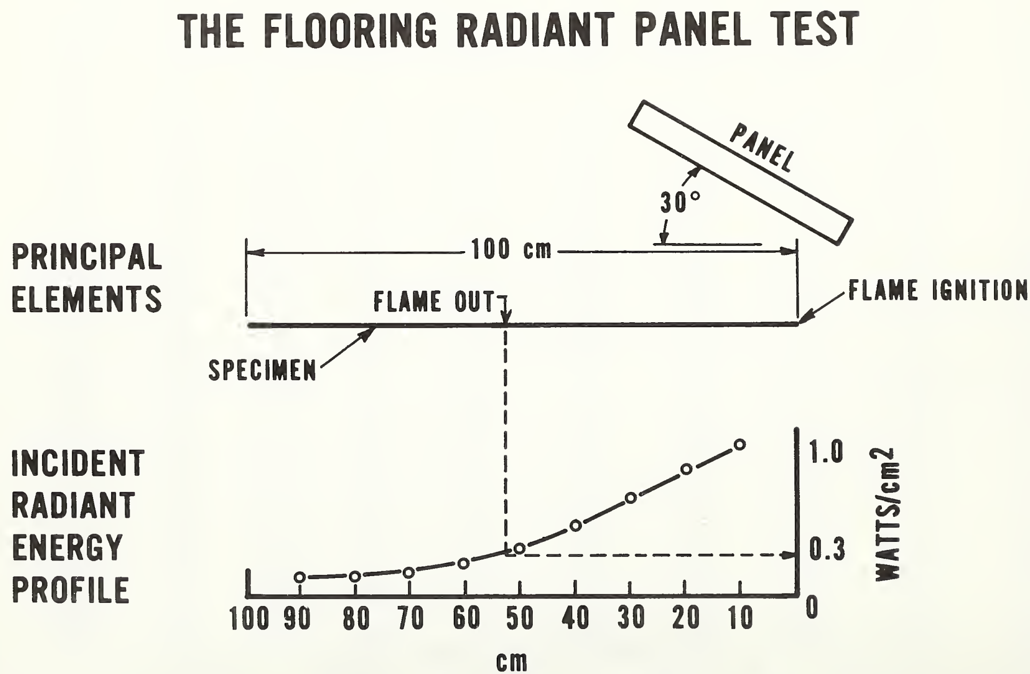

Figure 1. The Flooring Radiant Panel Test

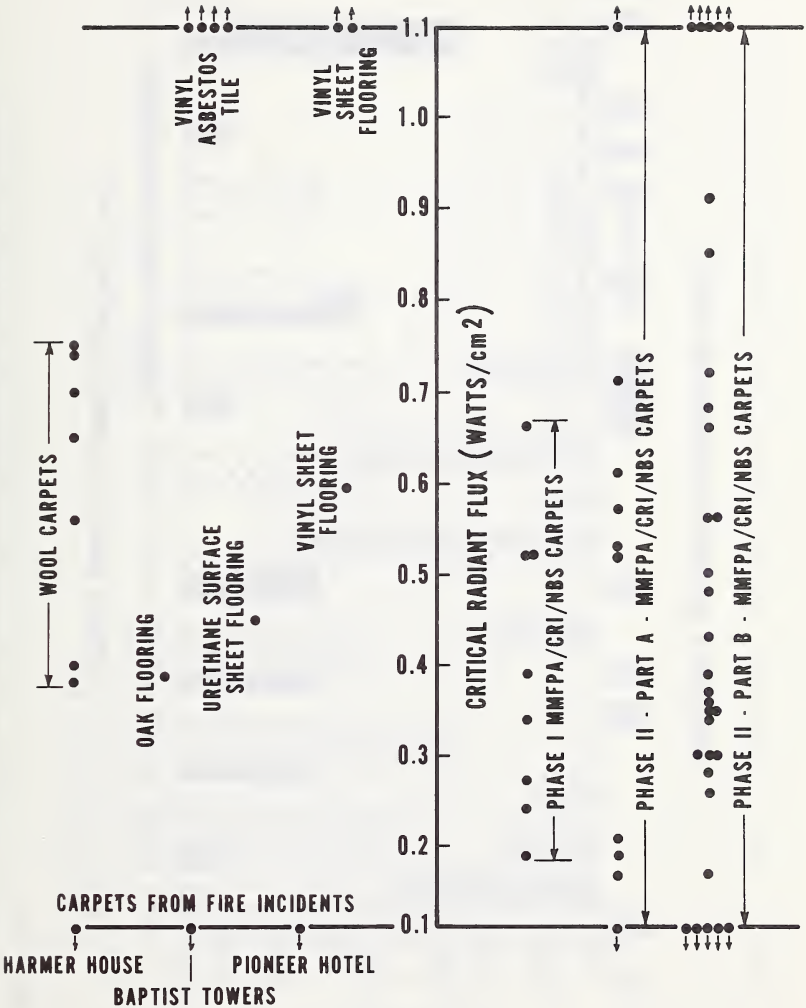

Figure 2. Critical Radiant Flux Map — Commercial Flooring Product Systems.

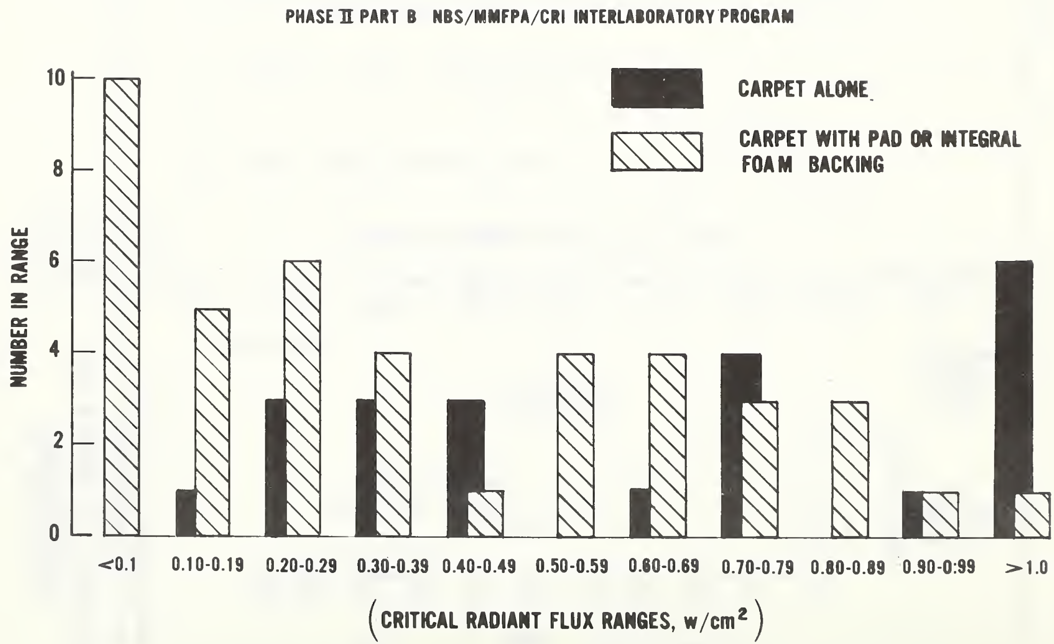

Figure 3. Distribution of Contract Carpet Products by Critical Flux Ranges

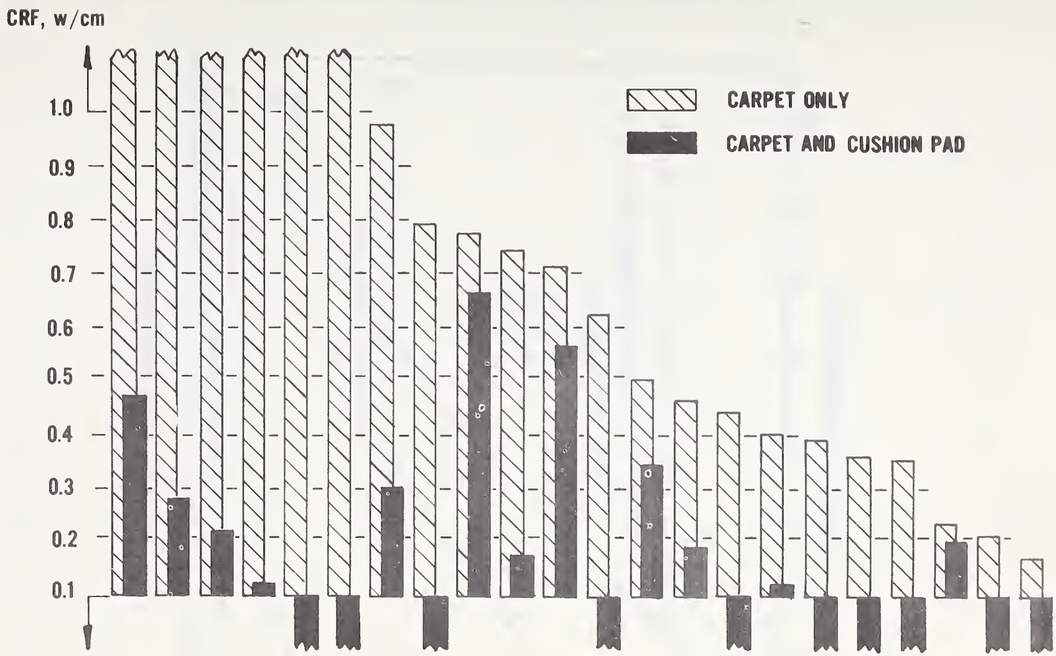

Figure 4. Effect of Cushion Pad on Critical Radiant Flux of Contract Carpet Products

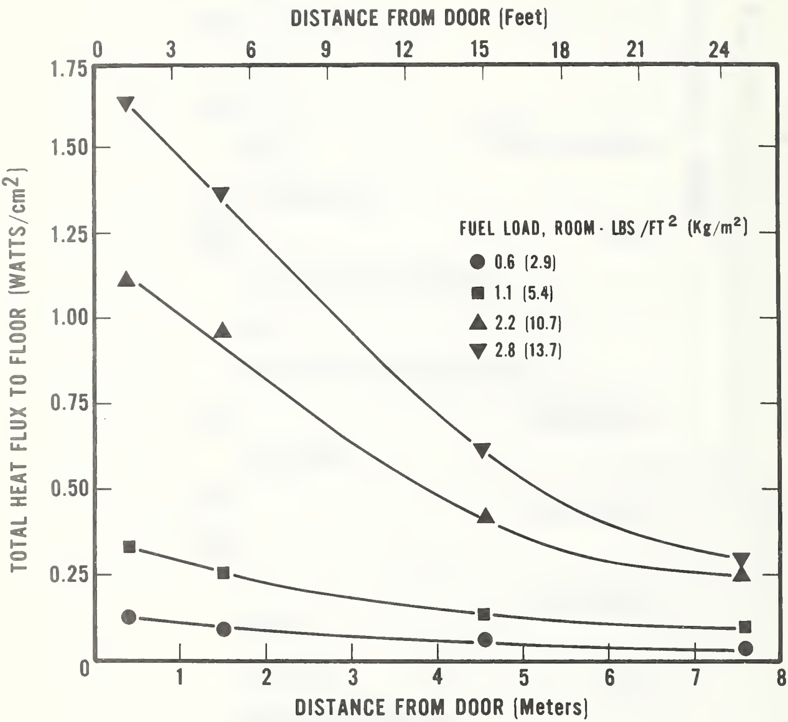

Figure 5. Maximum Total Incident Heat Flux to Corridor Floor (Assuming No Carpeting and Non-Combustible Surfaces in Corridor)

APPENDIX

STANDARD METHOD OF TEST FOR CRITICAL RADIANT FLUX
OF FLOOR COVERING SYSTEMS USING A
RADIANT HEAT ENERGY SOURCE

(The following Test Method is a Proposed Procedure
as drafted in December, 1975.)

APPENDIX

STANDARD METHOD OF TEST FOR CRITICAL RADIANT FLUX OF FLOOR COVERING SYSTEMS USING A RADIANT HEAT ENERGY SOURCE

- PROPOSED PROCEDURE -

December 1975

1. SCOPE

1.1. This method of test describes a procedure for measuring the critical radiant flux of horizontally-mounted floor covering systems exposed to a flaming ignition source in a graded radiant heat energy environment, in a test chamber. The specimen can be mounted over underlayment, a simulated concrete structural floor, bonded to a simulated structural floor, or otherwise mounted in a typical and representative way.

1.2. This method measures the critical radiant flux at flame-out. It provides a basis for estimating one aspect of flame spread behavior for floor covering systems in corridors or exitways of buildings. The imposed radiant flux simulates the thermal radiation levels likely to impinge on the floor of a corridor whose upper surfaces are heated by flames and/or hot gases from a fully-developed fire in an adjacent room or compartment.

2. SUMMARY OF METHOD

2.1. The basic elements of the test chamber, Figure 1, are: 1) an air-gas, fueled radiant heat energy panel inclined at 30° to and directed at 2) a horizontally-mounted floor covering system specimen, Figure 2. The radiant panel generates a radiant energy flux distribution ranging along the 100-cm length of the test specimen from a nominal maximum of 1.0 watts/cm^2 to a minimum of 0.1 watts/cm^2. The test is initiated by open flame ignition from a pilot burner. The distance burned to flame-out is converted to watts/cm^2 from the flux profile graph, Figure 6, and reported as critical radiant flux, watts/cm^2.

3. SIGNIFICANCE

3.1. This method of test is designed to provide a basis for estimating one aspect of the flame spread behavior of a floor covering system installed in a building corridor. The test environment is intended to simulate conditions that have been observed and defined in full-scale corridor experiments.

3.2. The test is intended to be suitable for regulatory statutes, specification acceptance, design purposes, or development and research.

3.3. The fundamental assumption inherent in the test is that "critical radiant flux" is one measure of the sensitivity to flame spread of floor covering systems in a building corridor.

3.4. The test is applicable to floor covering system specimens which follow or simulate accepted installation practice. Tests on the individual elements of a floor system are of limited value and not valid for evaluation of the flooring system.

4. DEFINITIONS OF TERMS

4.1. Critical Radiant Flux is the level of incident radiant heat energy on the floor covering system at the most distant flame-out point. It is reported as watts/cm^2 (Btu/ft^2 s).

4.2. Flux Profile is the curve relating incident radiant heat energy on the specimen plane to distance from the initiation of flaming ignition point, i.e. 0 cm.

4.3. Total Flux Meter is the instrument used to measure the level of radiant heat energy incident on the specimen plane at any point.

4.4. Black Body Temperature is the temperature of a perfect radiator — a surface with an absorptivity of unity and, therefore, a reflectivity of zero.

5. FLOORING RADIANT PANEL TEST CHAMBER — CONSTRUCTION AND INSTRUMENTATION

5.1. The flooring radiant panel test chamber employed for this test shall be located in a draft-protected laboratory.

5.1.1. The flooring radiant panel test chamber, Figures 3 and 4, shall consist of an enclosure 140 cm (55 in) long by 50 cm (19-1/2 in) deep by 71 cm (28 in) above the test specimen. The sides, ends, and top shall be of 1.3 cm (1/2 in) calcium silicate-asbestos fiber, 0.58 g/cm^3 (36 lbs/ft^3) nominal density, insulating material with a thermal conductivity @ 200 °F of 0.96 cal (g)/hr cm^2 deg C per cm [0.77 Btu/(hr) (ft^2) (deg F per in)]. One side shall be provided with a draft tight fire resistant glass window so that the entire length of the test specimen may be observed from outside the fire test chamber. On the same side and below the observation window is a door which, when open, allows the specimen platform to be moved out for mounting or removal of test specimens.

5.1.2. The bottom of the test chamber shall consist of a sliding steel platform which has provisions for rigidly securing the test specimen holder in a fixed and level position. The free, or air access, area around the platform shall be in the range of 1950-3550 cm^2 (300-500 sq in).

5.1.3. The top of the chamber shall have an exhaust stack with interior dimensions of 12.5 cm (5 in) wide by 38 cm (15 in) deep by 30 cm (12 in) high at the opposite end of the chamber from the radiant panel.

5.2. The radiant heat energy source shall be a panel of porous refractory material mounted in a cast iron frame, with a radiation surface of 30.5 x 45.7 cm (12 by 18 in). It shall be capable of operating at temperatures up to 816 °C (1500 °F). The panel fuel system shall consist of an aspirator for mixing gas and air at approximately atmospheric pressure, a clean dry air supply capable of providing 28.3 NTP m^3 per hr (1000 Standard Cubic Feet per Hour) at 7.6 cm (3.0 in) of water, and suitable instrumentation for monitoring and controlling the flow of fuel to the panel.

5.2.1. The radiant heat energy panel is mounted in the chamber at 30° to the horizontal specimen plane. The horizontal distance from the 0 mark on the specimen fixture to the bottom edge (projected) of the radiating surface of the panel is 8.9 cm (3-1/2 in). The panel to specimen vertical distance is 14 cm (5-1/2 in) (see Figure 3).

5.2.2. The radiation pyrometer for standardizing the thermal output of the panel shall be suitable for viewing a circular area 25.4 cm (10 in) in diameter at a range of about 1.37 m (54 in). It shall be calibrated over the 490-510 °C (914-950 °F) operating black body temperature range in accordance with the procedure described in Appendix A.

5.2.3. A high impedance potentiometer voltmeter with a suitable millivolt range shall be used to monitor the output of the radiation pyrometer described in 5.2.2.

5.3. The specimen holder (see Figure 5), is constructed from heat-resistant stainless steel[1] having overall dimensions of 115 cm (45 in) by 32 cm (12-3/4 in) with a specimen opening of 20 cm (7.9 in) x 100 cm (40 in). Six slots are cut in the flange on either side of the holder to reduce warping. The holder is fastened to the platform with two stud bolts at each end.

5.4. The pilot burner, used to ignite the specimen, is a commercial propane venturi torch[2] with an axially symmetric burner tip having a propane supply tube with an orifice diameter of 0.0076 cm (0.003 in). In operation, the propane flow is adjusted to give a pencil flame blue inner cone length of 1.3 cm (1/2 in). The pilot burner is positioned so that the flame generated will impinge on the centerline of the specimen at the 0 distance burned point at right angles to the specimen length (see Figures 3 and 4). The burner shall be capable of being swung out of the ignition position so that the flame is horizontal and at least 5 cm (2 in) above the specimen plane.

5.5. Two 0.32 cm (1/8 in) stainless steel sheathed grounded junction chromel alumel thermocouples[3] are located in the Flooring Radiant Panel Test Chamber (see Figures 3 and 4).

5.5.1. An indicating potentiometer with a range of 100-500 °C (212-932 °F) may be used to determine the chamber temperatures prior to a test.

5.6. An exhaust duct with a capacity of 28.3-85 NTP m^3 per minute (1000-3000 SCFM) decoupled from the chamber stack by at least 7.6 cm (3 in) on all sides and with an effective area of the canopy slightly

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[1]Thickness 0.198 cm (0.078 in)

[2]BERNZ-O-MATIC TX 101 or equivalent

[3]Thermocouples should be kept clean to insure accuracy of readout.

larger than plane area of the chamber with the specimen platform in the out position is used to remove combustion products from the chamber.

5.7. The dummy specimen which is used in the flux profile determination shall be made of 1.9 cm (3/4 in) inorganic 0.58 g/cm^3 (36 lbs/ft^3) nominal density calcium silicate asbestos fiber board (see Figure 5). It is 25 cm (10 in) wide by 107 cm (42 in) long with 2.7 cm (1-1/16 in) diameter holes centered on and along the centerline at the 10, 20, 30— 90 cm locations, measured from the maximum flux end of the specimen.

5.7.1. The total heat flux transducer used to determine the flux profile of the chamber in conjunction with the dummy specimen should be of the Schmidt-Boelter[4] type, have a range of 0-1.5 watts/cm^2 (0-1.32 Btu/ft^2 s), and shall be calibrated over the operating flux level range of 0.10 to 1.5 watts/cm^2 in accordance with the procedure outlined in Appendix A. A source of 15-25 °C cooling water shall be provided for this instrument.

5.7.2. A high impedance or potentiometric voltmeter with a range of 0-10 m.v. and reading to 0.01 m.v. shall be used to measure the output of the total heat flux transducer during the flux profile determination.

5.8. A timer shall be conveniently mounted on the chamber for measuring preheat and pilot contact time.

6. SAFETY PRECAUTIONS

6.1. The possibility of a gas-air fuel explosion in the test chamber should be recognized. Suitable safeguards consistent with sound engineering practice should be installed in the panel fuel supply system. These may include one or more of the following: 1) a gas feed cut-off activated when the air supply fails, 2) a fire sensor directed at the panel surface that stops fuel flow when the panel flame goes out, 3) a commercial gas water heater or gas-fired furnace pilot burner control thermostatic shut-off which is activated when the gas supply fails or other suitable and approved device. Manual reset is a requirement of any safeguard system used.

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[4] Medtherm 64-2-20 will meet this requirement.

6.2. In view of the potential hazard from products of combustion, the exhaust system must be so designed and operated that the laboratory environment is protected from smoke and gas. The operator should be instructed to minimize his exposure to combustion products by following sound safety practice, e.g., insure exhaust system is working properly, wear appropriate clothing including gloves, et al.

7. SAMPLING

7.1. The samples selected for testing shall be representative of the product.

7.2. Standard ASTM sampling practice shall be followed where applicable, see ASTM Method E-122.

8. WASHING OF TEXTILE FLOOR COVERINGS

8.1. If the carpet has had a treatment, or is made of fibers which have had a treatment as the term "treatment" is defined in 8.2,, the selected sample shall be washed as prescribed in Appendix C, unless this method can be proven to be unsuitable for the particular fabric involved. In this case, such other method as the manufacturer determines is likely to be used on the carpet in service and which is agreed to by the purchaser, may be used. Alternatively, the carpet may be washed and dried as many times under such other washing and drying procedures as shall have been demonstrated to be the equivalent of ten washings under the washing procedure described herein.

8.2. "Treatment" as that term is used in this standard shall mean any process, such as spraying, padding, dipping, brushing, or otherwise applying a material onto the pile or primary backing of a carpet at any stage of manufacture, which has the effect of reducing flammability.[5]

8.3. This washing requirement may be modified or waived by the purchaser if the manufacturer will certify that washing does not affect the permanence of the fire-retardance resulting from the treatment.

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[5] Use of fire retardant chemicals in latices or backing compounds are excluded from the definition of "treatment" since these materials are encapsulated in rubber or other polymeric material and cannot be leached out by ordinary carpet cleaning methods.

9. TEST SPECIMENS

9.1. The test specimen shall be a floor covering system sized to provide for adequate clamping in the mounting frame. Its minimum dimensions shall exceed the frame width [20 cm (7.9 in) nominal] and length [100 cm (39.4 in) nominal] by about 5 cm (2 in). It may be necessary to notch or punch holes in the specimen to accomodate the mounting frame bolts (see Figure 5).

9.2. Insofar as possible, the floor covering system specimen should simulate actual installation practice. Typical examples follow:

9.2.1. A carpet mounted over the standard[6] cushion or the standard simulated concrete subfloor[7] (see Appendix B2.1.).

9.2.2. A carpet with or without integral cushion pad bonded to a high density inorganic sheet simulating a concrete subfloor (see Appendix B2.2.).

9.2.3. A resilient floor bonded to a high density inorganic sheet simulating a concrete subfloor (see Appendix B3.1.).

9.2.4. A hardwood floor nailed to a plywood subfloor, then sanded and finished according to standard practice (see Appendix B4.1.).

9.3. A minimum of three specimens per sample shall be tested.

10. RADIANT HEAT ENERGY FLUX PROFILE STANDARDIZATION

10.1. In a continuing program of tests, the flux profile shall be determined not less than once a week. Where the time interval between tests is greater than one week, the flux profile shall be determined at the start of the test series.

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[6]Standard is: Type II - Rubber Coated Jute and Animal Hair or Fiber (3/8" thick, 50 oz/yd^2) DD-C-001023 (GSA-FSS) Amendment - 1 March 10, 1972. The option of specifying that the actual cushion pad to be used in the installation be tested is also acceptable.

[7]Standard is: Flat asbestos-cement sheet 1/4" thick, ASTM C220. The option of specifying that the actual subfloor to be used in the installation be tested is also acceptable.

10.2. Mount the dummy specimen in the mounting frame and attach the assembly to the sliding platform.

10.3. With the sliding platform out of the chamber, ignite the radiant panel. Allow the unit to heat for one hour. The pilot burner is off during this determination. Adjust the fuel mixture to give an air-rich flame. Make fuel flow settings to bring the panel black body temperature to about 500 °C (932 °F), and the chamber temperature to about 180 °C (356 °F). When equilibrium has been established, move the specimen platform in the chamber.

10.4. Allow 0.5 hours for the closed chamber to equilibrate.

10.5. Measure the radiant heat energy flux level at the 40 cm point with the total flux meter instrumentation. This is done by inserting the flux meter in the opening so that its detecting plane is 0.16-0.32 cm (1/16-1/8 in) above and parallel to the plane of the dummy specimen and reading its output after 30 $\pm$ 10 seconds. If the level is within the limits specified in 10.6 the flux profile determination is started. If it is not, make the necessary adjustments in panel fuel flow. A suggested flux profile data log format is shown in Figure 7.

10.6. The test shall be run under chamber operating conditions which give a flux profile of the form shown in Figure 6. The radiant heat energy incident on the dummy specimen at the 40 cm point shall be 0.5 $\pm$ 0.02 watts/cm^2 (0.44 $\pm$ 0.017 Btu/ft^2 s).

10.7. Insert the flux meter in the 10 cm opening following the procedure given in 10.5 above. Read the m.v. output at 30 $\pm$ 10 seconds and proceed to the 20 cm point. Repeat the 10 cm procedure. The 30 - 90 cm flux levels are determined in the same manner. Following the 90-cm measurement, make a check reading at 40 cm. If this is within the limits set forth in 10.6., the test chamber is in calibration and the profile determination is completed. If not, carefully adjust fuel flow, allow 0.5 hours for equilibrium and repeat the procedure.

10.8. Plot the radiant heat energy flux data as a function of distance along the specimen plane on rectangular coordinate graph paper. Carefully, draw the best smooth curve through the data points. This curve will hereafter be referred to as the flux profile curve.

10.9. Determine the open chamber black body and chamber temperatures that are identified with the standard flux profile by opening the door and moving the specimen platform out. Allow 0.5 hours for the chamber to equilibrate. Read optical pyrometer output and record black body temperature in °C. This is the temperature setting that can be used in subsequent test work in lieu of measuring the radiant flux at 40 cm using the dummy specimen. The chamber temperature also should be determined again after 0.5 hours and is an added check on operating conditions.

11. CONDITIONING

11.1. Specimens shall be conditioned according to standard practice for the floor covering being tested unless otherwise specified; see ASTM E-171-63.

12. TEST PROCEDURE

12.1. With the sliding platform out of the chamber, ignite the radiant panel. Allow the unit to heat for one hour. Read the panel black body temperature and the chamber temperature. If these temperatures are in agreement to within ± 5 °C with those determined in accordance with 10.9 above, the chamber is ready for use.

12.2. Invert the sample holder on a workbench and insert the flooring system. Place the steel bar clamps across the back of the assembly and tighten nuts firmly. Return the sample holder to its upright position, clean the test surface with a vacuum and mount on the specimen platform.

12.3. Ignite the pilot burner, move the specimen into the chamber and close the door. Start the timer. After 2 minutes preheat, with the pilot burner on and set so that the flame is horizontal and 5 cm above the specimen, bring the pilot burner flame into contact with the center of the specimen at the 0 cm mark. Leave the pilot burner flame in contact with the specimen for 10 minutes, then remove to a position 5 cm above the specimen. If the specimen does not ignite within 10 minutes following pilot burner flame application, the test is terminated by extinguishing the pilot burner flame.

12.4. For specimens that do ignite, the test is continued until the flame goes out. Observe and record significant phenomena such as melting, blistering, penetration of flame to the substrate, etc.

12.5. When the test is completed, the door is opened, the specimen platform is pulled out.

12.6. Measure the distance burned, i.e. the point of farthest advance of the flame front, to the nearest 0.1 cm. From the flux profile curve, convert the distance to watts/cm^2 critical radiant heat flux at flame out. Read to two significant figures. A suggested data log format is shown in Figure 8.

12.7. Remove the specimen and its mounting frame from the moveable platform.

12.8. The succeeding test can begin as soon as the panel black body temperature is verified (see 12.1.). The test assembly should be at room temperature prior to start up.

13. CALCULATIONS

13.1. The mean and standard deviation of the critical radiant flux test data on the three specimens are calculated in accordance with ASTM standard practice (ASTM Manual on Quality Control of Materials 1951 Edition STP 15C).

$$S = \sqrt{\frac{(\Sigma X^2 - n \bar{X}^2)}{n - 1}}$$

where S = estimated standard deviation

X = value of single observation

n = number of observations, and

$\bar{X}$ = arithmetic mean of the set of observations.

14. REPORT

14.1. The report shall include the following:

14.1.1. Description of the flooring system tested including its elements.

14.1.1.1. If a textile floor covering is tested, indicate whether it has been washed in accordance with 8.1.

14.1.2. Description of the procedure used to assemble the flooring system specimen.

14.1.3. Number of specimens tested.

14.1.4. Average critical radiant flux and standard deviation.

14.1.5. Observations of the burning characteristics of the specimen during the testing exposure, such as delamination, melting, sagging, shrinking, etc.

15. PRECISION[8]

Defining a test result as the average of 3 replicate determinations, the repeatability (within laboratory variability) is about 20 percent of the measured value[9] and the reproducibility (among laboratory variability) is of the order of 35 percent of the measured value.[10]

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[8] This statement is based on the results of two, 13-laboratory factorially designed experiments in which a total of 18 floor covering systems were tested.

[9] "Repeatability" is a quantity that will be exceeded only about 5 percent of the time by the difference, taken in absolute value, of two randomly selected results obtained in the same laboratory on a given material. Reference: Mandel, John, "Repeatability and Reproducibility" Materials Research and Standards, MTRSA, Vol. 11, No. 8, p. 8.

[10] "Reproducibility" is a quantity that will be exceeded only about 5 percent of the time by the difference, taken in absolute value, of two single test results made on the same material in two different randomly selected laboratories. Reference: see [9] above.

APPENDIX A

PROCEDURE FOR CALIBRATION OF RADIATION INSTRUMENTATION

A1. RADIATION PYROMETER

A1.1. Calibrate the radiation pyrometer by means of a conventional black body enclosure placed within a furnace and maintained at uniform temperatures of 490, 500, and 510 °C (914, 932, 950 °F). The black body enclosure may consist of a closed chromel metal cylinder with a small sight hole in one end. Sight the radiation pyrometer upon the opposite end of the cylinder where a thermocouple indicates the black body temperature. Place the thermocouple within a drilled hole and in good thermal contact with the black body. When the black body enclosure has reached the appropriate temperature equilibrium, read the output of the radiation pyrometer. Repeat for each temperature.

A2. TOTAL HEAT FLUX METER

A2.1. Calibrate the total flux meter against a standard quartz lamp source having a radiant energy output of approximately 0.15 watts/ cm^2 in accordance with the procedure (NBS Report of Calibration, Test No.: 221.12/1B/74 Interdivision Work Order No. 490-2220, dated 10/17/74) developed by the NBS optical radiation group. The precision (3 sigma limits) of the calibration based on 25 measurements at the above single point is of the order of $\pm$ 1 %. For a calibration across the operating range of the instrument, the manufacturer of the transducer should be contacted. This calibration can be good to $\pm$ 5%.

APPENDIX B

GUIDE TO MOUNTING METHODS

B1. INTRODUCTION

B1.1. This guide has been compiled as an aid in selecting a method for mounting various flooring materials in the fire test chamber. These mountings are suggested for test method uniformity and convenience.

B2. MOUNTING PROCEDURES

B2.1. Carpet and Cushion Pad Over Concrete, Simulated —— Carpet specimens should be cut in the machine direction. To mount a specimen, invert the holder on a clean, flat surface. Insert the test specimen in the holder. Then insert the cushion pad with the waffle side facing the carpet followed by a 0.64-cm (1/4 in) thick cement-asbestos board* and a 1.2-cm (1/2-in) 0.58 g/cm^2 (36 lbs/ft^3) inorganic millboard. Finally, place the steel bar clamps across the assembly and tighten firmly. Turn the specimen upright and vacuum to remove any foreign particles. Brush the surface to raise the pile to its normal position. Mount the test assembly on the specimen transport frame so that the pile lay faces the panel.

B2.2. Carpet with or without Integral Cushion Pad Bonded to Concrete, Simulated —— Carpet specimens should be cut in the machine direction. The adhesive shall be that recommended by the carpet manufacturer (see note B5.1.). Apply the adhesive to the smooth side of the cement-asbestos board according to the directions provided by the adhesive manufacturer. Mount the specimen in testing frame as described in B2.1., and test according to standard procedure.

B2.3. Carpet, Other —— The actual sub-floor may be substituted for the standard cement-asbestos board substrate.

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*The cement-asbestos board may spall during a test. This can be avoided by heating for 12 hours at 325 °F.

B3. RESILIENT FLOORING

B3.1. Follow and/or simulate commercial installation practice. This will, in most instances, mean bonding to the standard cement-asbestos substrate.

B4. HARDWOOD FLOORING

B4.1. Follow and/or simulate commercial installation practice. In a typical system, the substrate would be a 5/8" plywood sheet covered with building paper. The oak flooring strips would be nailed to the plywood then sanded, sealed, and waxed. The assembly should be treated with the moisture content of the oak at 7-8%.

B5. NOTES

B5.1. Taylor's Multi-purpose Latex Base #260 or equivalent.

APPENDIX C

METHOD FOR WASHING TEXTILE FLOOR COVERINGS

C1. PURPOSE AND SCOPE

C1.1. This laboratory procedure is designed to produce results comparable to the "Rotary Brush" and the "Roll-A-Jet" methods customarily used for textile floor coverings in service. The method is suitable whenever cleaning procedures, in which a textile floor covering is wetted-down, scrubbed, rinsed, and dried, are to be simulated.

C1.2. This method is applicable to either soiled or unsoiled textile floor coverings.

C1.3. This method is applicable for evaluating the permanence of fire-retardant treatments for textile floor coverings.

C2. PRINCIPLE

C2.1. The test is performed by wetting the textile floor covering with water, applying a solution of a sodium alkylsulfate surfactant, hand scrubbing with a nylon bristle brush, rinsing, extracting excess water, and then drying in a vented oven.

C3. APPARATUS AND MATERIALS

C3.1. Cleaning agent —— a 1% (by volume) solution of a sodium alkylsulfate (see note C5.1.).

C3.2. A brush having nylon bristles 0.056 to 0.066 cm (0.022 to 0.026 in) in diameter and a bristle height of 2.2 to 2.9 cm (0.88 to 1.13 in). Width of the brush should be approximately 5 cm (2 in). A desirable length of the brush should be approximately one dimensional width of the test specimen (see note C5.2.).

C3.3. A hydro extractor (see note C5.3).

C3.4. Laboratory oven, a vented, circulating air type, capable of removing the moisture from the specimens when maintained at 105 °C (221 °F) for 2 hours (see note C5.4.).

C4. PROCEDURE

C4.1. Cut three test specimens, 110 x 30 cm (41 x 11 in) in size from the sample free from defects or creases. The perimeter shall be stitched, if necessary, to prevent delamination, distortion, or other degradation.

C4.2. Immerse the test specimen to be washed in a container of water at 18 to 30 °C (65 to 85 °F) until it appears to be uniformly wet. Remove specimen, drain until excess water runs off, and then position on a flat working surface with traffic surface up.

C4.3. Apply 250 ml of the surfactant solution at a temperature of 18 to 30 °C (65 to 85 °F) distributed uniformly over the traffic surface of the test specimen. Hand scrub, with minimum pressure, the traffic surface with the nylon bristle brush for 10 strokes in the long direction, lifting the brush between strokes. Attempt to keep the brush centered on the specimen during each stroke. Rote the specimen a half-turn and repeat the brush strokes, doing this until the specimen has been stroked 10 times in each long direction for a total of 20 strokes.

C4.4. Thoroughly rinse the specimen on both sides by spraying forcibly with water at 46 to 52 °C (115 to 125 °F) until foaming ceases.

C4.5. Position the washed and rinsed test specimen in the hydro-extractor to extract excess water so there is no over-lapping, and spin-dry for approximately 3 minutes.

C4.6. Place the damp-dry specimen in the oven at 104 to 110 °C (220 to 230 °F) for 30 minutes and then remove for additional washing.

C4.7. Repeat steps C4.2. to C4.6. nine times until the specimen has been washed a total of 10 times.

C4.8. On the 10th and final cycle, keep the specimen in the oven until dry, or for not less than 2 hours. Remove the specimen from the oven and allow to stand at least 8 hours in order to come to equibibrium conditions with the laboratory environment.

C4.9. Cut the three specimens to 105 x 25 cm (40 x 10 in) in size, condition as prescribed in paragraph 11.1 of the test method, and test.

C5. NOTES

C5.1. Orvus WA Paste has been found to be suitable. Available from Procter and Gamble Company, Textile Specialities Section, P.O. Box 599, Cincinnati, Ohio 45201.

C5.2. A suitable brush may be obtained from the Atlanta Brush Company, 19 Hilliard Street, Atlanta, Georgia 30312 (stock number 1-4638).

C5.3 A satisfactory means of extracting excess water from specimens is the use of the spin-dry cycle only in a home laundry type of washing machine. Care must be used in setting the machine or closing the water valves so that no rinse water is admitted during this spin-dry cycle.

C5.4. Procedure 2 of ASTM D 2654-71, "Moisture Content and Moisture Regain of Textile Material," without the predrying feature for the incoming air describes a satisfactory oven.

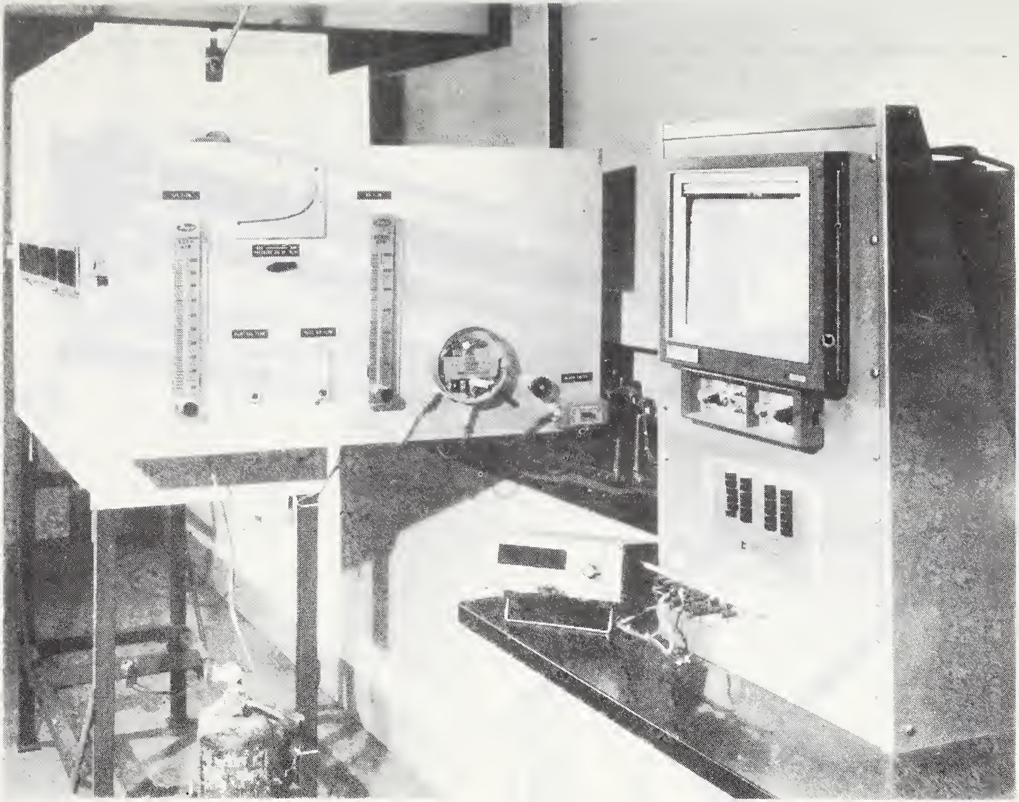

Figure 1. Flooring Radiant Panel Tester Apparatus

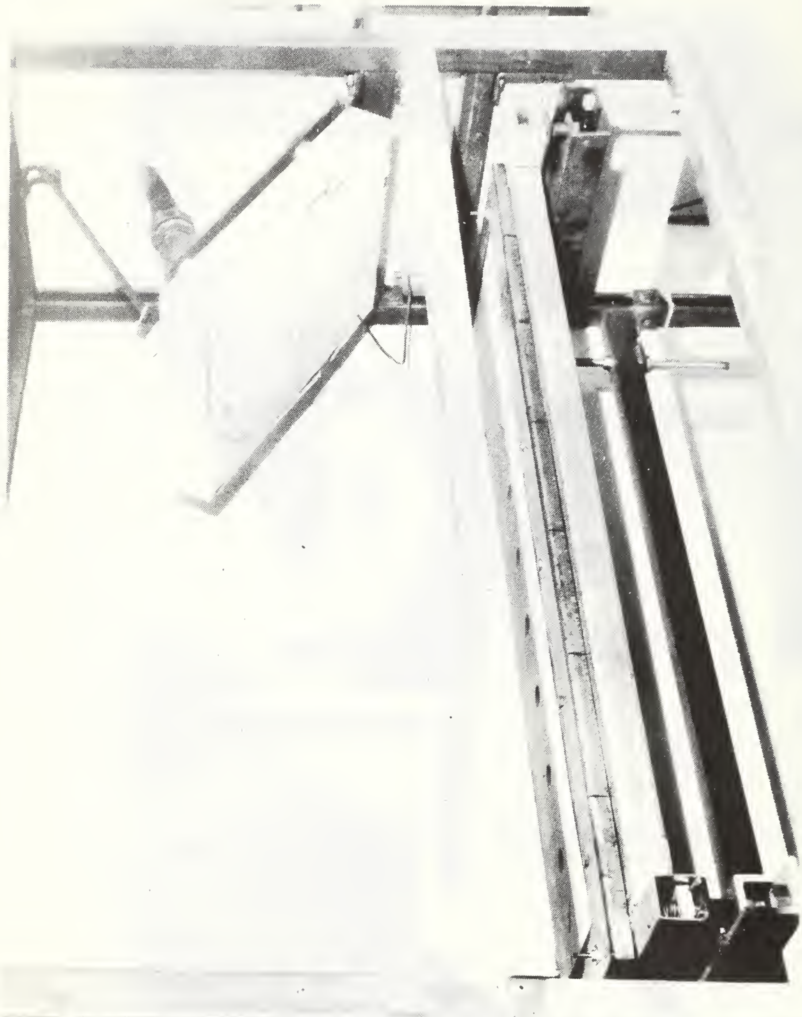

Figure 2. Flooring Radiant Panel Test Showing Carpet Specimen and Gas Fueled Panel

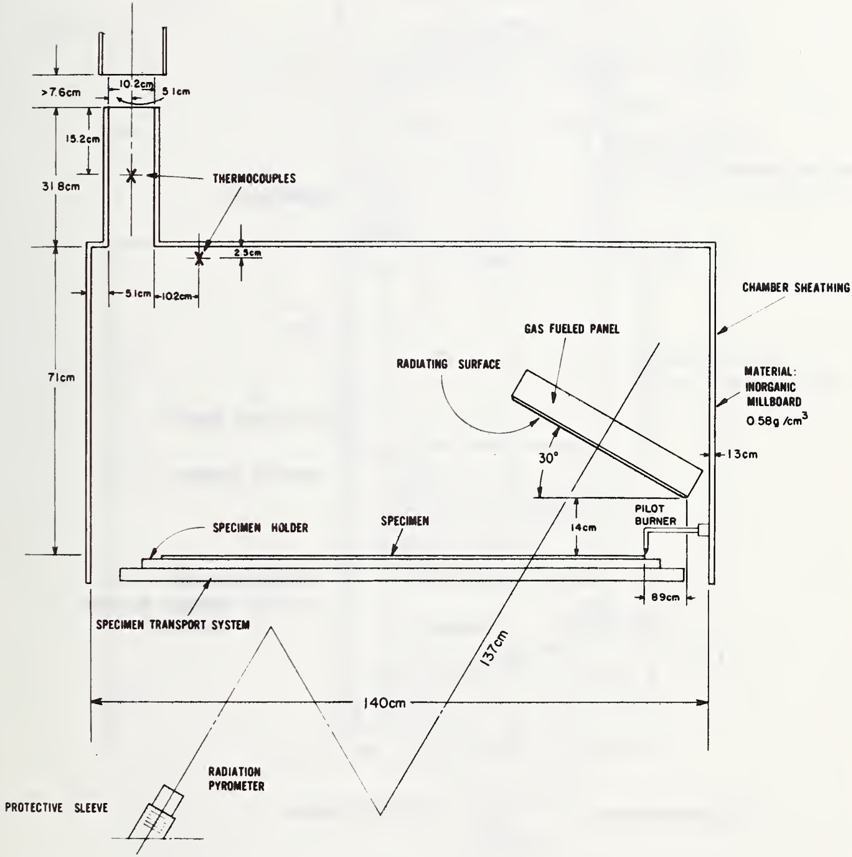

Figure 3. Flooring Radiant Panel Tester Schematic — Side Elevation

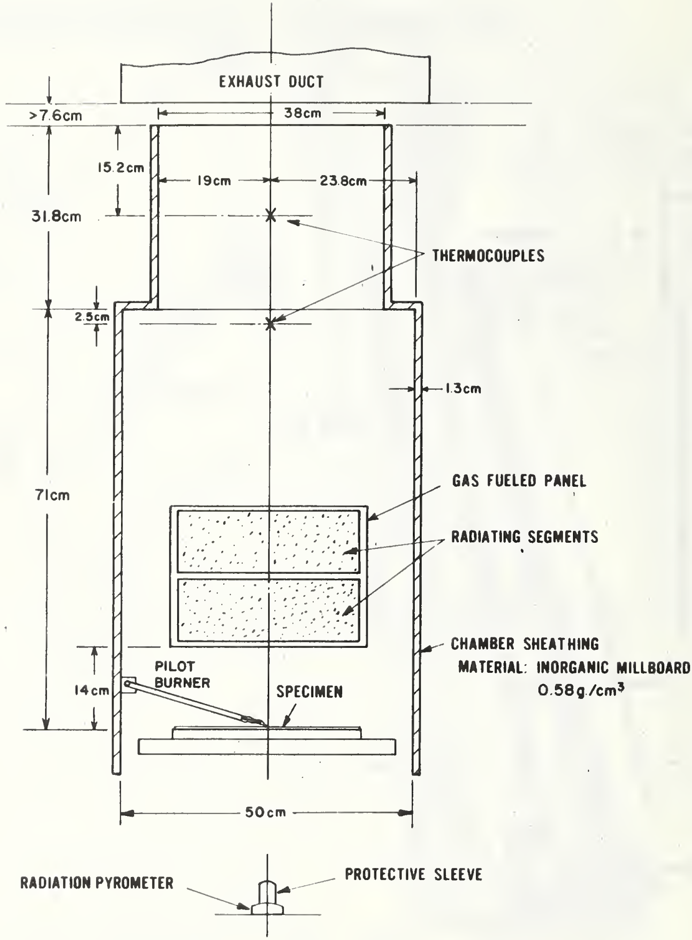

Figure 4. Flooring Radiant Panel Tester Schematic — Low Flux, Elevation

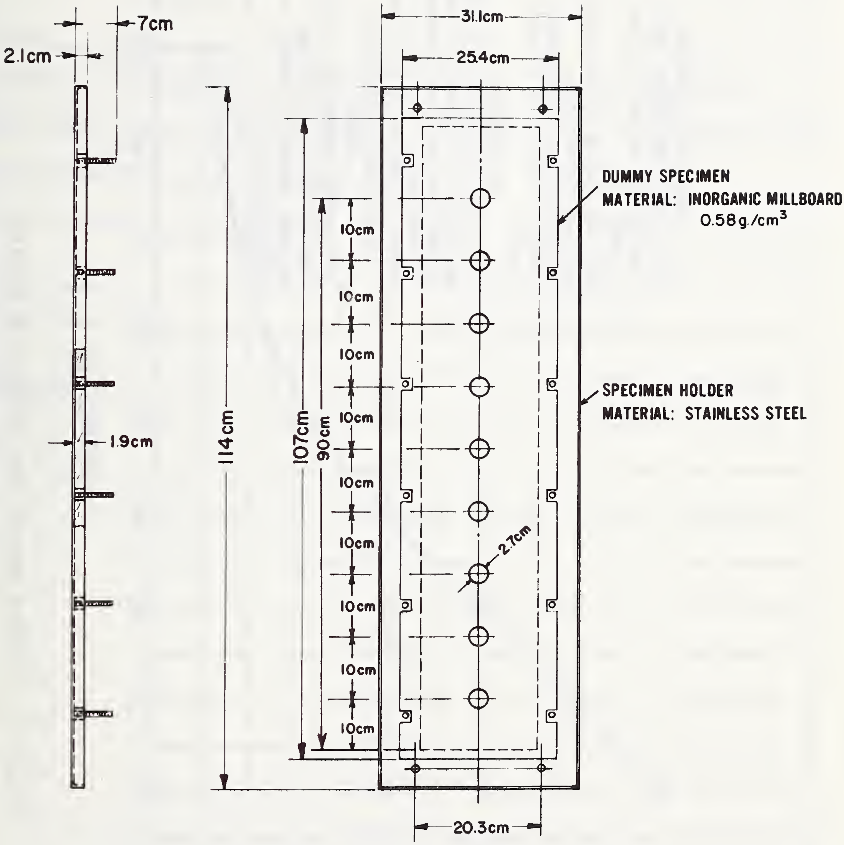

Figure 5. Dummy Specimen in Specimen Holder

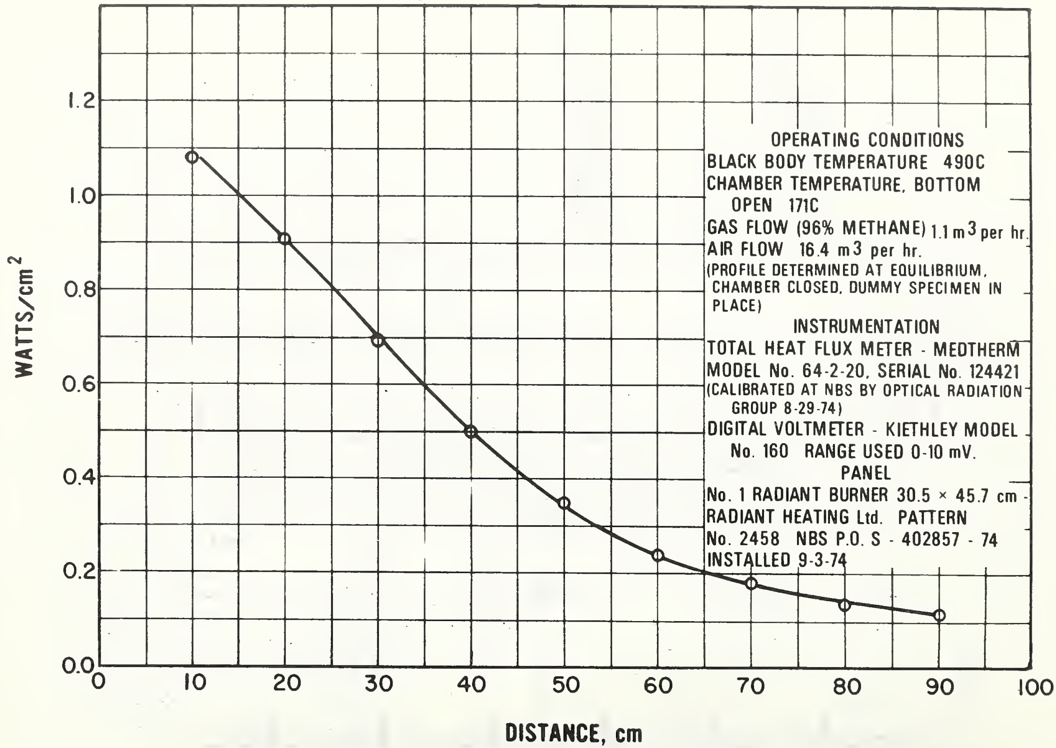

Figure 6. Standard Radiant Heat Energy Flux Profile

RADIANT FLUX PROFILE

Date________________

Black Body Temperature______________m.v. ______________°C (°F)

Gas Flow____________$NTPm^3H$ (SCFH) Air Flow_____________$NTPm^3H$ (SCFH)

Room Temperature_____________°C (°F)

Air Pressure ________________ Gas_____________cm (in) of H_2O

Flux Meter

Radiometer No.________________

Conversion Factor______________

from Calibration on_____________

Distance (cm)	MV	Watts/cm^2
10	________	________
20	________	________
30	________	________
40	________	________
50	________	________
60	________	________
70	________	________
80	________	________
90	________	________

Signed ______________________________

Figure 7. Flux Profile Data Log Format

Test Number __________ Date ____________ Time _________________

Laboratory ________________________________

Specimen Identification/Code No. ______________________________________

Test Assembly: ____

Panel: Angle ______________° Temperature ________________°C (°F)

Flow: Gas _______________NTPm^3H (SCFH) Air _______________NTPm^3H (SCFH)

Pressure, cm (in) H_2O: Initial, Air ______________ Gas _______________;

Chamber Temperature (Initial) __________________°C (°F)

Room: Temperature ___________°C (°F) Hood Draft _____________cm (in) water

Total Burn Length ___________________________________cm (in)

Critical Radiant Flux watts/cm^2____

Flux Profile Reference ____________________________________

Observations:

Signed _____________________

Figure 8. Flooring Radiant Panel Test Data Log Format

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15. SUPPLEMENTARY NOTES

16. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

The objective of this discussion is to present backgound and other technical data that will help in suggesting criteria to be used in conjunction with the Flooring Radiant Panel Test to determine the potential contribution to fire growth of floor covering systems for use in corridors and exitways.

17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)* Fire hazard; fire safety; flooring test; radiant panel.

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