FEDERAL TEST METHOD STANDARD

TEST FOR CRITICAL RADIANT FLUX OF CARPET FLOORING SYSTEMS (FLOORING RADIANT PANEL TEST)

This standard was approved by the Commissioner, Federal Supply Service, General Services Administration, for the use of all Federal agencies.

1. SCOPE

1.1 This method of test describes a procedure for measuring the critical radiant flux of horizontally mounted carpet 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 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 fire exposure behavior for floor covering systems. The imposed radiant flux simulates the thermal radiation levels likely to impinge on the floors of a building whose upper surfaces are heated by flames and/or hot gases from a fully-developed fire in an adjacent room or compartment. The method was developed to simulate an important fire exposure component of fires which may develop in corridors or exitways of buildings and is not intended for routine use in estimating flame spread behavior of floor covering in building areas other than corridors or exitways Caution should be used in applying this test in instances where fuel loading is anticipated to be over 5 lbs. per square feet and/or there are other combustibles in the corridor.

1.3 Critical radiant flux, while an important fire characteristic of carpet floor covering systems, is just one of a number of fire system variables which must be considered in predicting corridor floor covering fire behavior. Thus, while this measurement permits rank ordering of carpet floor covering systems on the basis of this important fire property, it should not be considered that compliance with a particular level of critical radiant flux will insure against all corridor fires

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 watt/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 fire exposure behavior of the 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 fundamental assumption inherent in the test is that "critical radiant flux" is one measure of the sensitivity to fire exposure of the carpet floor covering systems in a building corridor

3.3 The test is applicable to carpet floor covering systems mounted as the materials will be installed in the actual installation. Tests on the individual elements of the flooring system are of limited value and are 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 carpet floor covering system at the most distant flame out point. It is reported as watts/cm^2 (Btu/ft^2 sec)

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

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

4.4 Black Body Temperature is the temperature of a perfect radiator--a surface with an emissivity of unity and, therefore, a refectivity of zero.

4.5 Corridor is defined as an enclosed space connecting a room or compartment with an exit, the corridor may include normal extensions, such as lobbies or other enlarged spaces.

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, shall be as shown in Figures 3 and 4 The sides, ends, and top shall be of 1 3 cm (1/2 in) calcium silicate board, such as Marinite XL, 0.56 g/cm^3 (36 lbs/ft^3) nominal density with a thermal conductivity at 93°C (200°F) of 0 96 cal (gm)/hr cm^2 deg C per cm [0 77 Btu/(hr)(ft^2)(deg F per in)] One side shall be provided with an approximately 10 cm x 110 cm (4 in x 44 in) 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 A draft-tight fire-resistant observation window may be installed at the low flux end of the chamber

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 round the platform shall be in the range of 1950-3550 cm^2 (300-500 square inches)

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 as shown in Figures 3 and 4.

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 clear dry air supply capable of providing 28 3 NTP (Normal Temperature Pressure) 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 position on the specimen holder 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) The angle and dimensions given above are critical in order to obtain the required flux profile

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 black body temperature range of 490-510°C (914-950°F) 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) The pilot burner is positioned so that the flame generated will impinge on the center line 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.

1/ AISI Type 300 (UNA-N08330) or equivalent, thickness 0.198 cm (0.078 in)
2/ BERNZ-O-MATIC TX 101 or equivalent

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). The chamber thermocouple is located in the longitudinal central vertical plane of the chamber 2.5 cm (1 in) down from the top and 10 cm (4 in) back from the inside of the exhaust stack. The exhaust stack thermocouple is centrally located 15.2 cm (6 in) from the top of the stack.

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 larger than the plane area of the chamber with the specimen platform in the out position is used to remove combustion products from the chamber (With the panel turned on and the dummy specimen in place, there should be no difference in air flow through the chamber stack with the exhaust on or off, when measured with a suitable air velocity meter)

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 board, such as Marinite XL (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 sec), 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 <u>SAFETY PRECAUTIONS</u>

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

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 <u>TEST SPECIMENS</u>

7 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 accommodate the mounting frame bolts (see Figure 5) The description of mounting procedures is given in Appendix B

7 2 A minimum of three specimens per sample shall be tested

3/ Thermocouples should be kept clean to insure accuracy of readout
4/ Medtherm 64-2-20 will meet this requirement.

8. RADIANT HEAT ENERGY FLUX PROFILE STANDARDIZATION

8.1 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.

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

8.3 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 to a black body temperature as measured by the radiation pyrometer, of about 500°C (932°F), and the chamber temperature to about 180°C (356°F) When equilibrium has been established, move the specimen platform into the chamber

8.4 Allow 0.5 hours for the closed chamber to equilibrate

8.5 Measure the radiant heat energy flux level at the 20 cm, 40 cm, and 60 cm points 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 ± 10 seconds If the level is within the limits specified in 8.6 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

8.6 The test shall be run under chamber operating conditions which give a flux profile as shown in Figure 6 The radiant heat energy incident on the dummy specimen shall be between 0.87 and 0.95 watts/cm^2 (0.77 and 0.83 Btu/ft^2 sec) at the 20 cm point, between 0.48 and 0.52 watts/cm^2 (0.42 and 0.46 Btu/ft^2 sec) at the 40 cm point and between 0.22 and 0.26 watts/cm^2 (0.19 and 0.23 Btu/ft^2 sec) at the 60 cm point

8.7 Insert the flux meter in the 10 cm opening following the procedure given in 8.5 above Read the m.v output at 30 ± 10 seconds Proceed to the 20 cm point and repeat the 10 cm procedure The 30 - 90 cm flux levels are determined in the same manner Following the 90 cm measurement, made a check reading at 40 cm If this is within the limits set forth in 8.6 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

8.8 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

8.9 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 the radiation pyrometer output and record the 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 20 cm, 40 cm, and 60 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

9 CONDITIONING

9.1 Test specimens (including underlayment) are to be conditioned to equilibrium or a minimum of 48 hours, which ever is greater, at 21 ± 3°C (69.8 ± 5.4°F) and a relative humidity of 50 ± 5 percent immediately prior to testing

10 TEST PROCEDURE

10.1 With the sliding platform out of the chamber, ignite the radiant panel Allow the unit to heat for one hour[1/] 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 8.9 above, the chamber is ready for use

10.2 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

1/ It is recommended that a sheet of inorganic millboard be used to cover the opening when the hinged portion of the front panel is open and the specimen platform is moved out of the chamber The millboard is used to prevent heating of the specimen and to protect the operator

10.3 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 and leave burning until the test is terminated

10 4 If the specimen does not ignite within 10 minutes following the pilot burner flame application, the test is terminated by extinguishing the pilot burner flame 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 the flame to the substrate, etc

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

10 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/cm² critical radiant heat flux at flame out Read to two significant figures The suggested data log format is shown in Figure 8

10 7 Remove the specimen and its mounting frame from the moveable platform

10 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

11 CALCULATIONS

11 1 The standard deviation and coefficient of variation of the critical radiant flux data on the three specimens are calculated in accordance with ASTM standard practice as follows

$$S = \sqrt{\frac{\Sigma X^2 - n\bar{X}^2}{n-1}} \quad \text{and} \quad V = \frac{S}{\bar{X}} \times 100$$

Where S = estimated standard deviation
X = value of a single observation,
n = number of observations,
$\bar{X}$ = arithmetic mean of the set of observations, and
V = coefficient of variation

12 REPORT

12 1 The report shall include the following

12 1 1 Description of the flooring system tested including its elements

12 1 2 Description of the procedure used to assemble the carpet flooring system specimen

12.1.3 Number of specimens tested and individual test results

12.1 4 Average critical radiant flux and standard deviation

12 1 5 Observations of the burning characteristics of the specimen during the testing exposure such as delamination, melting, shrinking, etc

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 successively 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 The total flux meter shall be calibrated by the National Bureau of Standards[1/], or alternatively, its calibration shall be developed by transfer calibration methods with an NBS calibrated flux meter This latter calibration shall make use of the flooring radiant panel tester as the heat source Measurements shall be made at each of the nine dummy specimen positions and the mean value of these results shall constitute the final calibration

A2 2 It is recommended that each laboratory maintain a dedicated calibrated reference flux meter against which one or more working flux meters can be compared as needed In the absence of a reference flux meter, the working flux meters should be calibrated according to the procedure of A2 1 at least once per year

[1/] Direct requests for such calibration services to

Optical Radiation Section, 232 04
National Bureau of Standards
Washington D C 20234

APPENDIX B

Mounting Procedures

B1 Mounting Procedures

B1 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[1/] with the waffle side facing the carpet followed by a 0 64 cm (1/4 in) thick cement asbestos board[2/3/] and a 1.2 cm (1/2 in) 0.58 gms/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

B1 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 B2.1). Apply the adhesive to the smooth side of the cement asbestos board according to the directions provided by the adhesive manufacturer (see note B2.2) Mount the specimen in the testing frame as described in B1.1 and test according to the standard procedure

B2 NOTES

B2.1 Essex Chemical's Webtex No. 80 White Linoleum Adhesive or equivalent.

B2.2 In the absence of a manufacturer's recommendation, apply the adhesive with a 1 6 mm (1/16 in) notched trowel

1/ Standard is rubber coated jute and animal hair cushion conforming to Interim Federal Specification DDD-C-001023(GSA-FSS) and Amendment-1 of March 10, 1972, Type II, except that the finished weight of the cushion shall be not less than 50 ounces per square yard, and the thickness shall be not less than 3/8 inch

2/ Standard is flat asbestos-cement sheet 1/4" thick, ASTM C220 The cement asbestos board may spall during a test This can be avoided by heating the board for 12 hours at 160°C (320°F)

3/ The option of specifying that the actual subfloor to be used in the installation be tested is also acceptable

PREPARING ACTIVITY GSA-FSS

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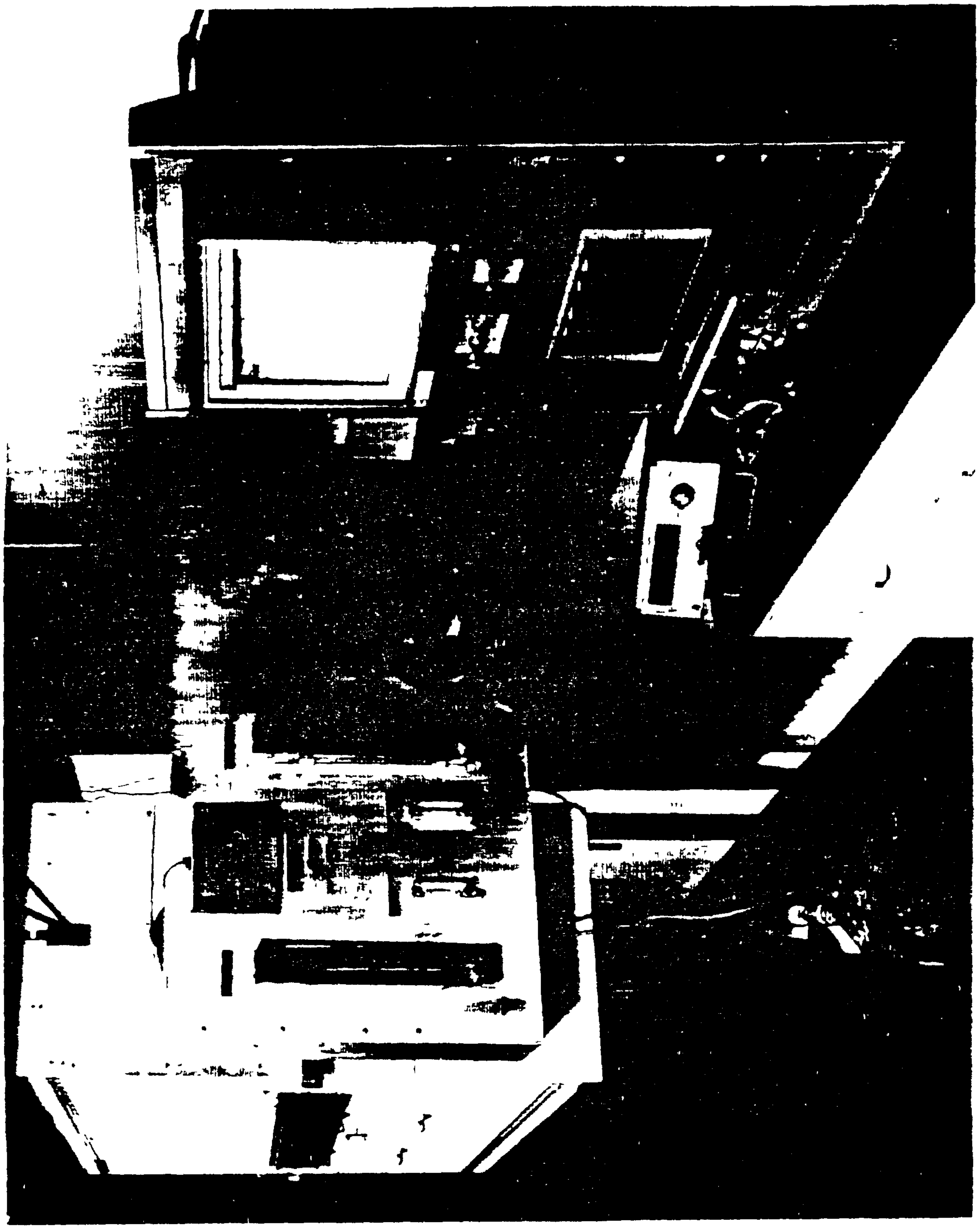

Figure 1. Flooring Radiant Panel Tester Apparatus (research model shown)

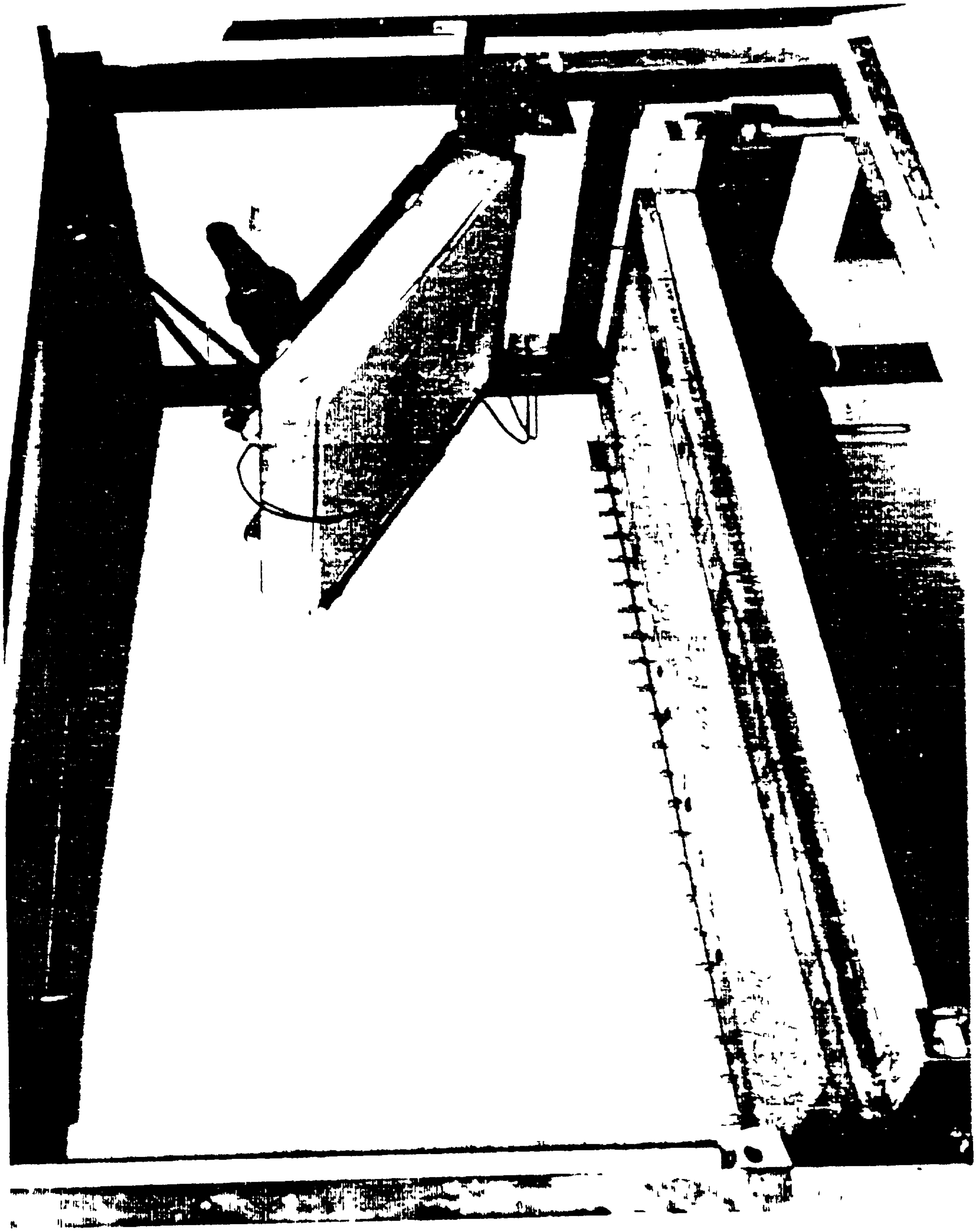

Figure 2 Floor Radiant Panel Tester Showing Carpet Specimen and Gas Fueled Panel (research model shown)

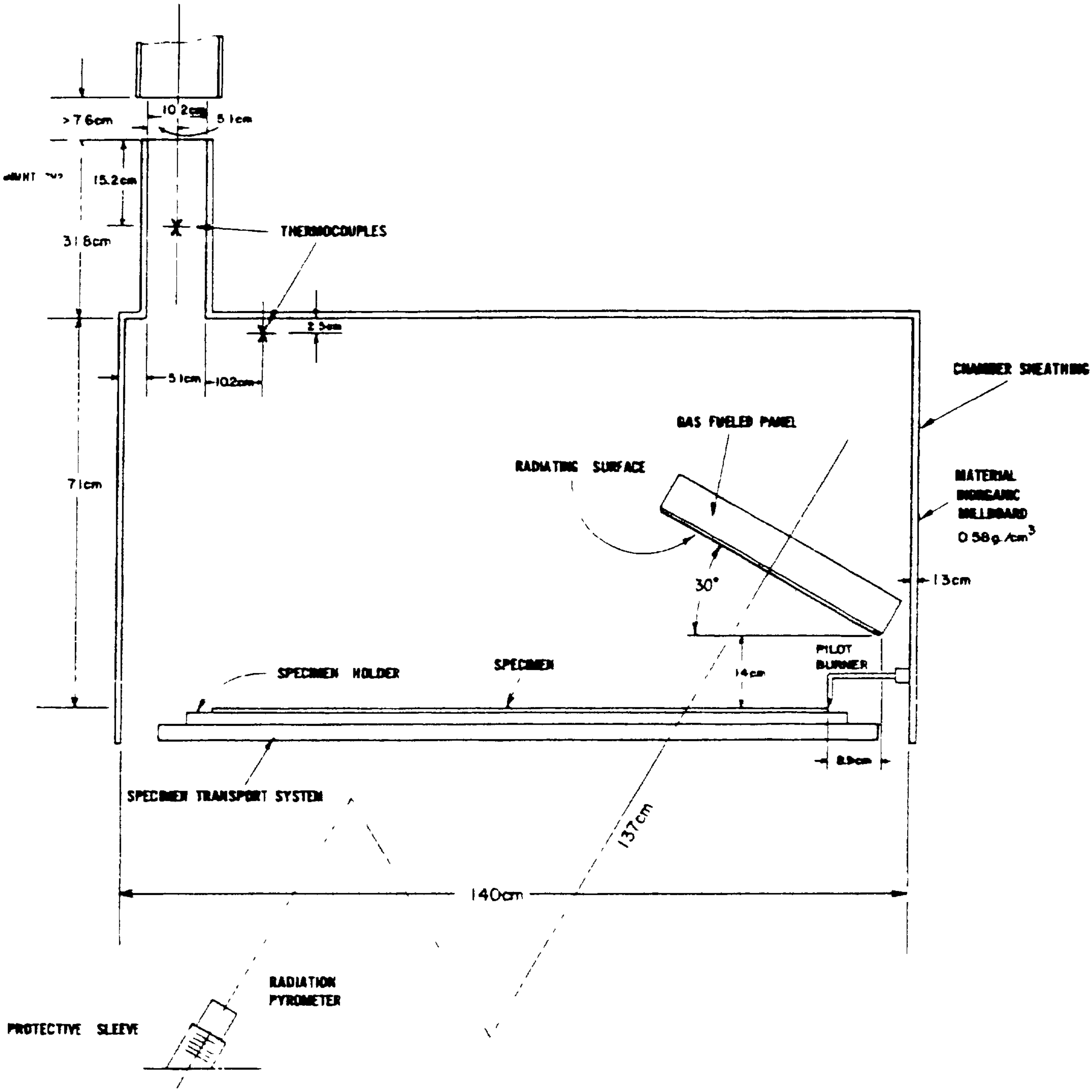

FIGURE 3 FLOORING RADIANT PANEL TESTER SCHEMATIC
SIDE ELEVATION

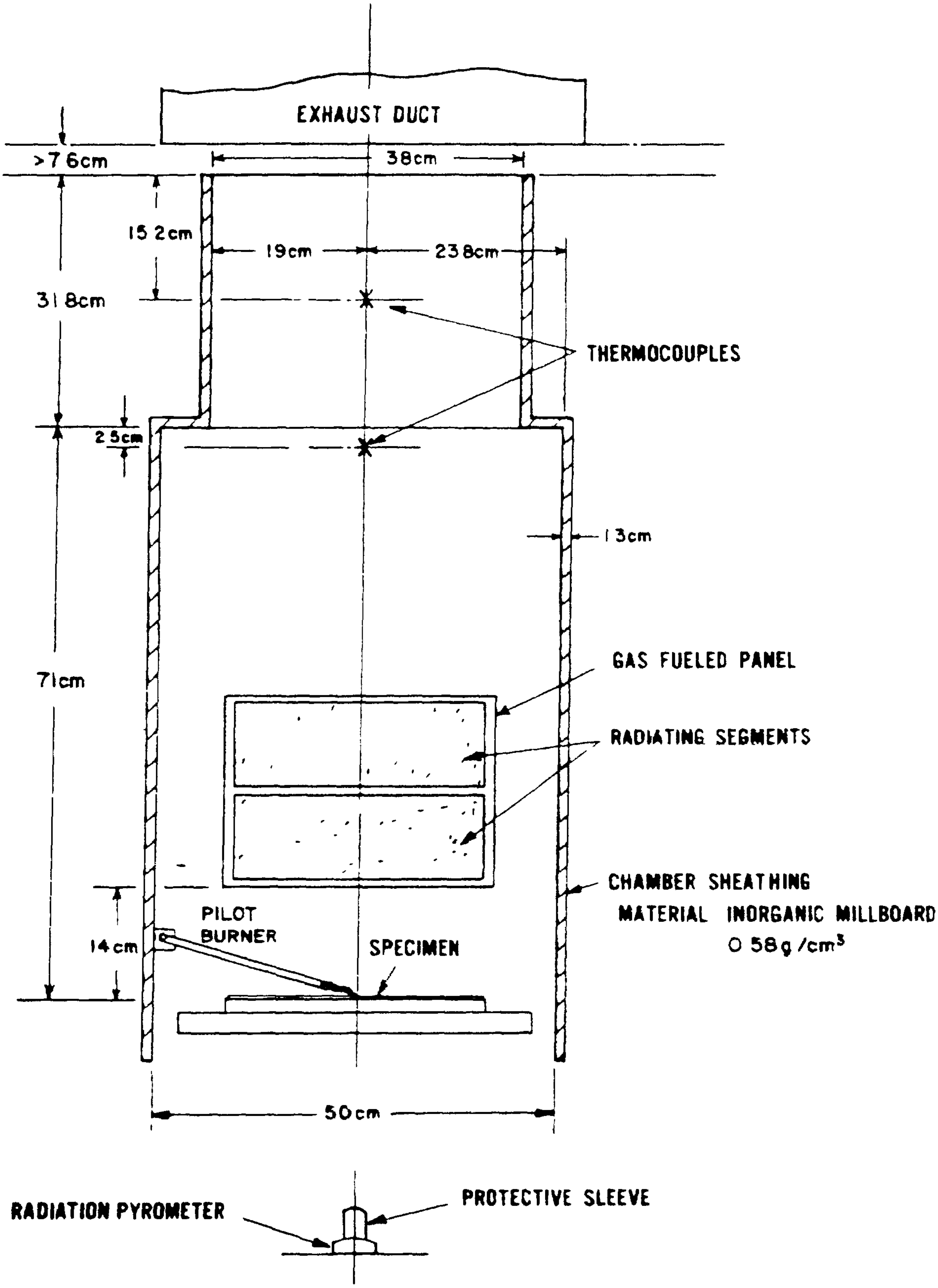

FIGURE 4 FLOORING RADIANT PANEL TESTER SCHEMATIC
LOW FLUX END, ELEVATION

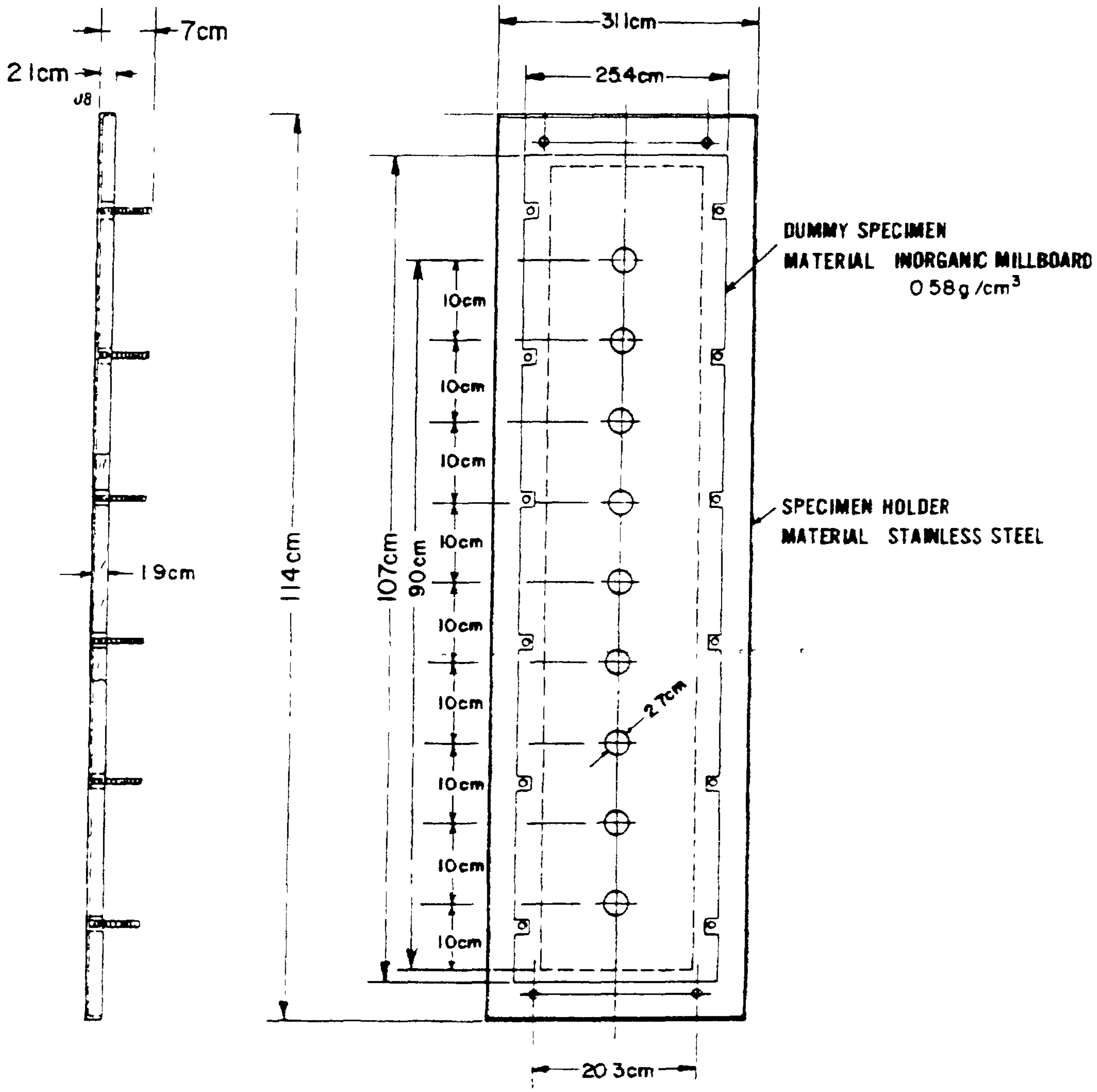

FIGURE 5 DUMMY SPECIMEN IN SPECIMEN HOLDER

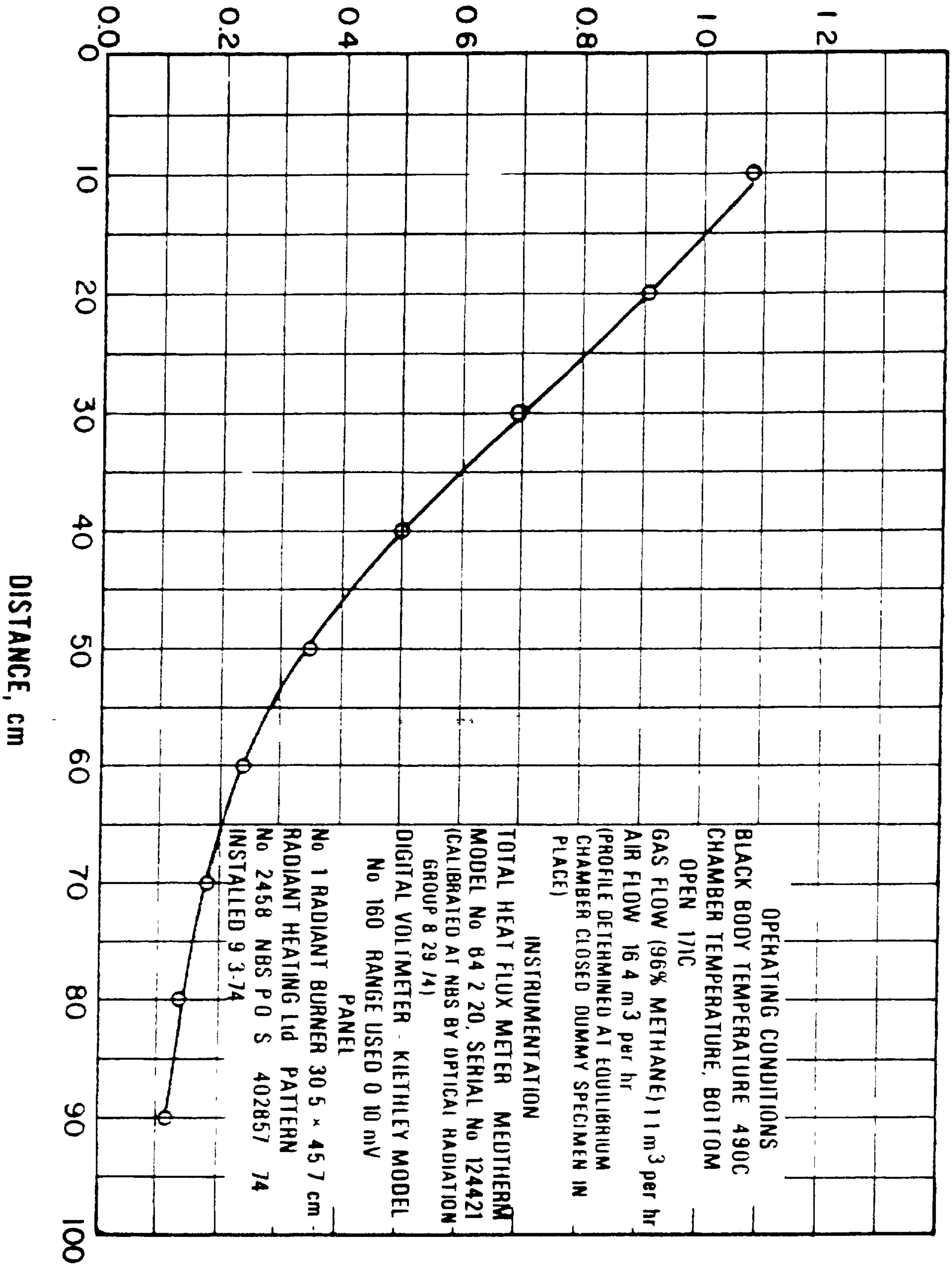

FIGURE 6 STANDARD RADIANT HEAT ENERGY FLUX PROFILE

RADIANT FLUX PROFILE

Date ______________

Black Body Temp. ______________ mv. ______________ °C

Gas Flow ______________ NTPm^{3}H   Air Flow ______________ NTPm^{3}H

Room Temp. ______________ °C

Air Press. ______________   Gas ______________ cm. of H^{2}O

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 Profice Reference_______________________________________

Observations:

Signed_______________________

FIGURE 8. Flooring Radiant Panel Test Data Log Format