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Full-Scale Corridor Fire Experiment Using A Glass Fiber Carpet

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Center for Fire Research
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U.S. DEPARTMENT OF COMMERCE, Rogers C.B. Morton, *Secretary*
James A. Baker, III, *Under Secretary*
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NATIONAL BUREAU OF STANDARDS, Ernest Ambler, *Acting Director*

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SI CONVERSION UNITS

In view of present accepted practice in this technological area, U.S. customary units of measurement have been used throughout this report. It should be noted that the U.S. is a signatory to the General Conference on Weights and Measures which gave official status to the metric SI system of units in 1960. Readers interested in making use of the coherent system of SI units will find conversion factors in ASTM Standard Metric Practice Guide, ASTM Designation E 380-72 (available from American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103). Conversion factors for units used in this paper are:

Length

1 in = 0.0254* meter
1 ft = 0.3048* meter

Area

1 in^2 = 6.4516* x 10^{-4} $meter^2$
1 ft^2 = 9.2903 x 10^{-2} $meter^2$

Mass

1 lb = 0.4536 kg

Energy

1 Btu = 1054 J

Temperature

°C = 5/9 (Temperature °F - 32)*

Power

1 Btu/min = 17.57 W

Time

1 min = 60 s*

*Exact value

FULL-SCALE CORRIDOR FIRE EXPERIMENT USING A GLASS FIBER CARPET

Leslie H. Breden

A corridor fire experiment was carried out using a glass fiber carpet. It was observed that with a fuel loading of 2.7 pounds per square foot of wood in an adjacent fire room, no propagation of the fire occurred down the corridor. The glass fiber carpet in the burn-room became discolored and there was a significant weight loss of the carpet directly in contact with the fire. The carpet did not produce significant levels of smoke and did not spread the fire into the corridor.

Key words: Carpet; corridor test; fire testing; flammability; glass fiber.

1. INTRODUCTION

The current mandatory carpet flammability standard, DOC FF 1-70, uses the methenamine pill test to keep easily ignited carpets from the market. In some cases, however, such as in institutional buildings, multiple occupancy buildings, and other special occupancies, a more severe test of carpet performance is desirable. In the course of developing such a test, it has been found that an important parameter is the performance of the carpet in propagating fire down a corridor [1][1]. In addition, it is of interest to determine, where possible, the relative contributions of fiber, latex binder and backing to flame spread of the assembled carpet. This is most readily done when one or more components of the carpet is of a low order of combustibility. One potential candidate for this study is carpeting constructed of glass fiber.

The purpose of this paper is to report the effect of glass fiber carpet on the spread of fire on carpet in a corridor when the fire originates in a room adjacent to the corridor. The results are expected to be useful on two counts: 1) they provide at least one illustration of how a "high performance" material behaves in a full-scale fire test; and 2) they provide an indication of the contribution to flame spread of the backing and latex components of the assembled carpet. (The corridor investigation described below uses an experimental configuration to investigate fire spread over a flooring system and is not a test method to evaluate carpets.)

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

2. EXPERIMENTAL DESIGN

2.1. Description of the Corridor

Schematic drawings of the NBS corridor facility are shown in figures 1, 2 and 3. The corridor has been described extensively by other workers [1,2].

The corridor is 30 feet long, 3 feet wide, and 8 feet high. At one end of the corridor there is a doorway connecting to a burn-room where a crib fire is initiated. The walls and the ceiling are constructed of 1/2-inch low density cement-asbestos board on steel studs covered by 5/8-inch gypsum wall board. The subflooring consists of 1/4-inch high density cement-asbestos board on a brick base. An exit window, 70 x 41 inches, is located at the far end of the corridor. Part of the air needed for combustion of the cribs enters the burn-room through the vents in the outer walls while additional air enters the burn-room through the door from the corridor. Air enters the corridor along the floor and then into the burn-room. The hot combustion products from the burn-room flow out along the corridor ceiling and finally out the top of the exit window as shown in figure 4.

2.2. Description of the Burn-Room

A schematic drawing of the burn-room is shown in figure 1. The burn-room is of concrete block construction, approximately 7.8 x 8.3 x 9.2 ft high, with a door opening of 6.5 x 2.5 ft. Located one ft above the floor of the burn-room are two small vents, 7 x 14 inches. These vents are open to the atmosphere and are meant to simulate air ducts. The burn-room interior is sprayed with a one-inch thick protective coating of refractory material over the concrete block. This coating has the following properties:

Density	18.5 lb/ft^2
Thermal conductivity	0.057 Btu/hr °F
Specific heat	0.2 Btu/lb °F
Thermal diffusivity	0.015 ft^2/hr

2.3. Description of Wood Cribs

Full-scale experimental fires for room simulation suggest that wood cribs present a realistic fire severity [3]. Four hemlock wood cribs are used to simulate burning objects in a room. The cribs are made of sticks 1-1/2 inches wide with a cross stick spacing of 3 inches (see fig. 5). There are 4 sticks in each layer with 18 layers except for the top and bottom layer which has 2 sticks. The 4 cribs are oven dried to a moisture content of approximately 10%. They are placed in the burn-room on a load cell platform; each crib weights approximately 42.5 lbs with a total weight of 170 lbs. The four cribs yielded a fuel loading of 2.7 lbs per square foot of floor area and maximum burn rate of 2.5 lbs of wood per minute. To initiate the experiment they are ignited by 250 g of heptane placed in a pan under each crib. Assuming a value of 5,000 Btu/lb for 120 lbs of wood due to incomplete combustion, the heat release rate peaks out at 60,000 Btu/min and maintains this rate for 8 to 9 minutes reflected in the weight loss curve in figure 6.

2.4. Description of the Instrumentation

Table 1 outlines the measurements taken in the burn-room and the corridor. Chromel-alumel type thermocouples are used to measure temperature. Pitot-static tubes at the top of the burn-room and exit doors measured the combustion product velocities while the bottom pitot-static tubes measured the inlet airflow. Radiometers are mounted in the floor of the corridor to monitor the incident flux. In addition, there is a radiometer mounted on the wall monitoring radiation in the burn-room. Heat flux meters are also used to measure heat loss through the walls. Finally, the cribs are placed on a load cell platform so that the burning rate of the wood cribs can be measured. All measurements are recorded by a high speed digital data acquisition system. This system records all imputs at 20 second intervals with seven recording points per second.

2.5. Description of the Carpet

The carpet used in this experiment is composed of glass fiber with a total weight of 70 oz/yd^2. The face fiber has a weight of 50 oz/yd^2 and a back fabric weight of 7 oz/yd^2. There is also a latex binder of 13 oz/yd^2. The carpet was supplied by Carolina Narrow Fabrics of Winston-Salem, North Carolina.

3. PROCEDURE

A blank run (test No. 355), was made with four cribs in the burn-room, and a cement-asbestos board floor in the corridor. A metal can, filled with 250 g of heptane, was used to ignite each crib. Measurements were taken with these burning cribs alone. This procedure was then repeated with the glass fiber carpet in the corridor over the cement-asbestos board (test No. 366). The glass fiber carpet was laid down with no pad and consisted of two four-foot wide pieces spliced with the seam parallel to the length of the corridor. In addition, a piece of glass fiber carpet, two ft by four ft, was extended into the burn-room under the cribs. This piece provided for a continuous path for the flame to spread into the corridor.

4. OBSERVATIONS AND RESULTS

After ignition, the cribs burned vigorously and reached a maximum rate of weight loss after 3 minutes. This constant rate of weight loss was maintained for 8 to 9 minutes after which the crib fire began to decrease as illustrated in figure 7. A comparison of the burning rate of the cribs between the blank and the glass fiber carpet, indicated no significant differences. Fung, et al., have shown that with refractory material as the burn-room coating, it appears that the heat loss of the cribs to the burn-room surface by conduction is only significant during the early phase of burning [2]. For the rest of the test, the heat loss by conduction is about 15% of the total heat release. The radiant energy contribution to the energy supply to the corridor is about 10% of the total energy transport into the corridor. This is because the corridor is exposed only to the burn-room fire through the doorway. Thus, the bulk of energy released to the corridor from the cribs is in the form of convective energy by way of the burn-room doorway.

The ceiling temperature in the burn-room, as shown in figure 8, was not significantly different from the blank. A potential heat measurement made on the carpets yielded 1,165 Btu/lb. There was about a 16% weight loss of the carpet that was directly in contact with the burning cribs.

During the period of maximum burning, the fire plume extended from the burn-room and licked the corridor ceiling near the burn-room providing a temperature profile shown in figure 9. Figures 10 and 10A illustrate the gas concentrations, produced by the wood alone during the blank test, taken 20 feet down the corridor and 2 feet from the ceiling. A gas analysis was not carried out during the carpet test. Smoke and gaseous products passed into the corridor and generally filled the upper part of the corridor. The radiation at the burn-room door is shown in figure 11.

It should be noted that the radiation and heat flux level on the floor was high enough to cause flame propagation down the corridor had the carpet been made of an organic material (figure 12) [4]. Figures 13 through 20 summarize the temperature and air velocity measurements which were observed in the corridor and at the exit window. Differences that exist as shown in figure 14 can be attributed to the insulating effect of carpet. Figures 14 and 18 illustrate the measured temperature profile in the corridor due to the glass fiber carpet at the 5 feet and 25 feet positions.

5. CONCLUSIONS

The glass fiber carpet contributed to the fuel load in the burn-room and increased the temperature in the corridor. There was no propagation of the fire out of the burn-room with a 2.7 pound per square foot wood fuel loading. The carpet in contact with the burning cribs became discolored and showed a significant weight loss. While combustible materials were used in the carpet as binders and dyestuffs, there was no significant spread of the fire into the corridor.

6. REFERENCES

[1] Huggett, C., Carpet Flammability and the NBS Corridor Fire Program, ASTM Standardization News, Vol. 16, 1 (1973).

[2] Fung, T. C. W., Suchomel, M. R. and Oglesby, P. L., The NBS Program on Corridor Fires, Fire Journal, Vol. 67, 41 (1973).

[3] Christian, W. J. and Waterman, T. E., Fire Behavior of Interior Finish Material, Fire Technology, (Aug. 1970).

[4] Quintiere, J., Some Observations on Building Corridor Fire, Presented at the 15th International Symposium on Combustion in Tokyo, Japan. held August 25-31, 1974.

Table 1. Corridor Measurements

Channel No.	Description	Channel No.	Description
0	TC* Center of Burn-room Ceiling	34	Heat Flux Meter No. 2
1	TC Ceiling of Corridor 1 ft from CL** of Doorway	35	Heat Flux Meter No. 3
2	TC Corridor CL Ceiling 2 ft from W Wall	36	Heat Flux Meter No. 4
3	TC Corridor CL Ceiling 5 ft from W Wall	37	Pitot Tube No. 1 Burn-room Door
4	TC Corridor CL Ceiling 10 ft from W Wall	38	Pitot Tube No. 2 Burn-room Door
5	TC Corridor CL Ceiling 15 ft from W Wall	39	Pitot Tube No. 3 Burn-room Door
6	TC Corridor CL Ceiling 20 ft from W Wall	40	Pitot Tube No. 4 Burn-room Door
7	TC Corridor CL Ceiling 25 ft from W Wall	41	Pitot Tube No. 5 Burn-room Door Bottom
8	TC Pitot Tube No. 1		
9	TC Pitot Tube No. 2	42	Pitot Tube No. 6 East Window
10	TC Pitot Tube No. 3	43	Pitot Tube No. 7 East Window
11	TC Pitot Tube No. 4	44	Pitot Tube No. 8
12	TC 5 ft String 1 ft from Ceiling	45	Combustible Gas 20 ft
13	TC 5 ft String 2 ft from Ceiling	46	CO 20 ft
14	TC 5 ft String 3 ft from Ceiling	47	CO_2 20 ft
15	TC 5 ft String 5 ft from Ceiling	50	TC Door CL .5 ft
16	TC 5 ft String 6 in from Floor	51	TC Door CL 2 ft
17	TC 25 ft String 1 ft from Ceiling	52	TC Door CL 4 ft
18	TC 25 ft String 2 ft from Ceiling	53	TC Door CL 6.5 ft
19	TC 25 ft String 3 ft from Ceiling	54	CL Floor 5 ft from W Wall
20	TC 25 ft String 5 ft from Ceiling	55	CL Floor 9 ft from W Wall
21	TC 25 ft String 6 in from Floor	56	CL Floor 13 ft from W Wall
22	TC Pitot Tube No. 6	57	CL Floor 17 ft from W Wall
23	TC Pitot Tube No. 7	58	CL Floor 21 ft from W Wall
24	TC Pitot Tube No. 8	59	CL Floor 25 ft from W Wall
25	O_2 at 20 ft	61	TC Pitot Tube No. 5
26	O_2 Burn door	67	Seconds
27	O_2 2 ft Ceiling		
28	TC Ref†		
29	Load Cell		
30	Radiometer No. 2		
31	Radiometer No. 2		
33	Heat Flux Meter No. 1		

*Thermocouple

**Center line

†Reference

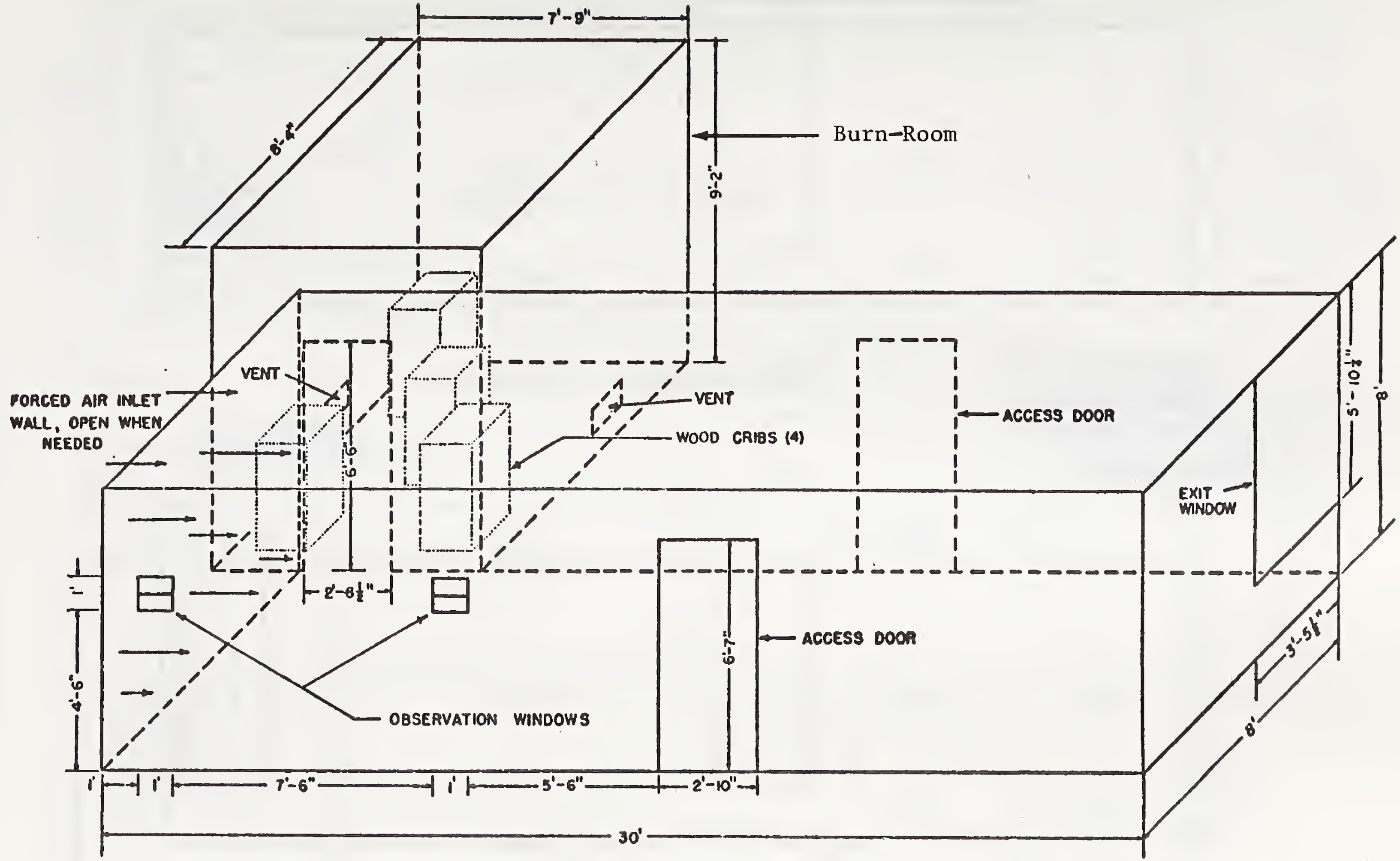

Figure 1. Corridor Facility

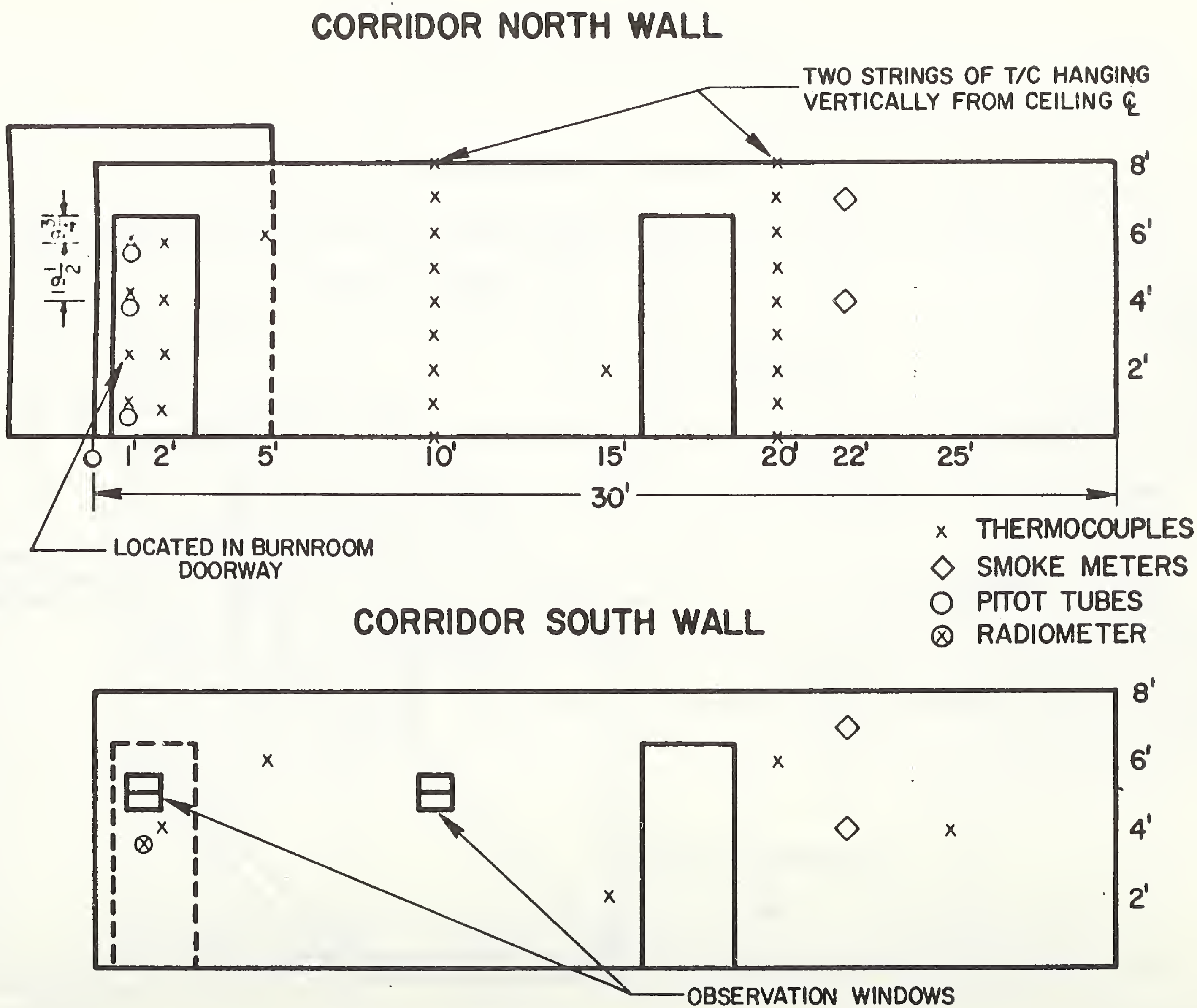

Figure 2. Corridor Wall Sensor Locations.

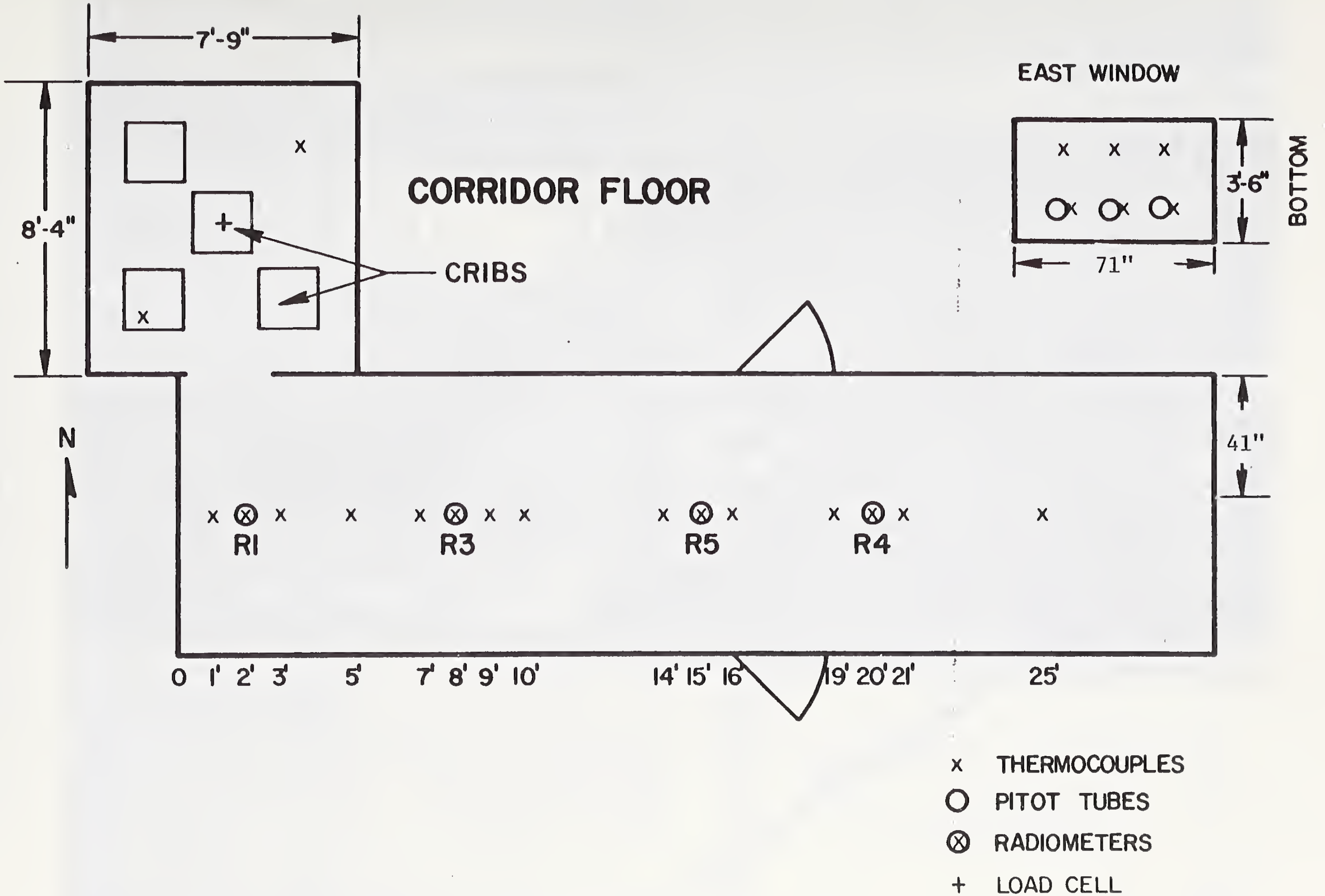

Figure 3. Corridor Floor Sensor Locations.

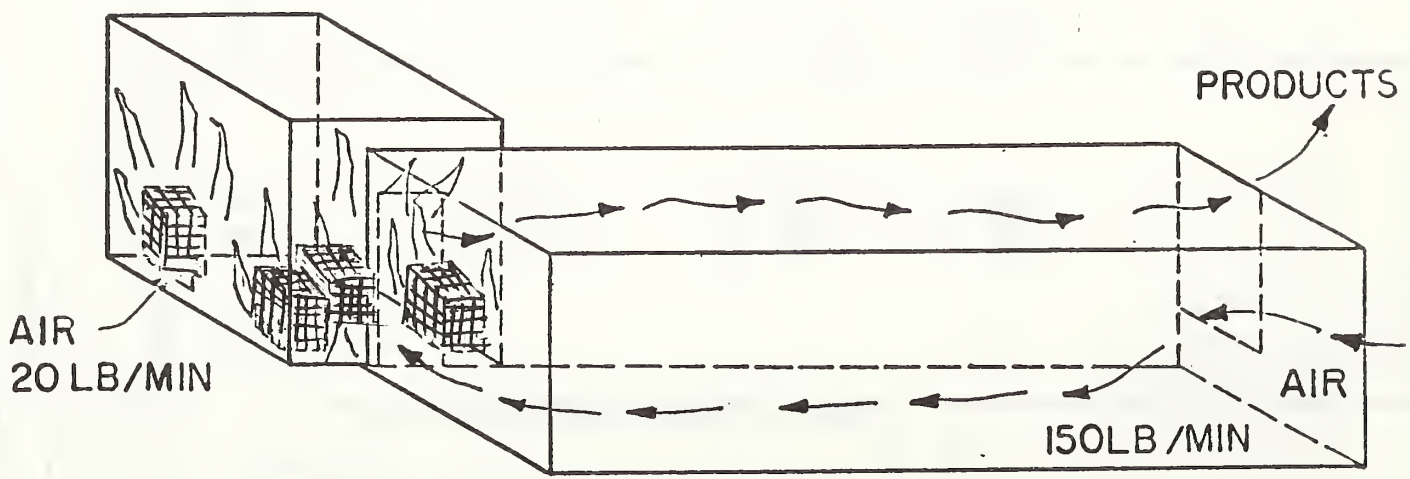

Figure 4. Burning Mode in Corridor.

Figure 5. View in Burn-Room Door Showing Wood Cribs. Center Crib on Load Cell. Thermocouples and Pitot Tubes in Doorway.

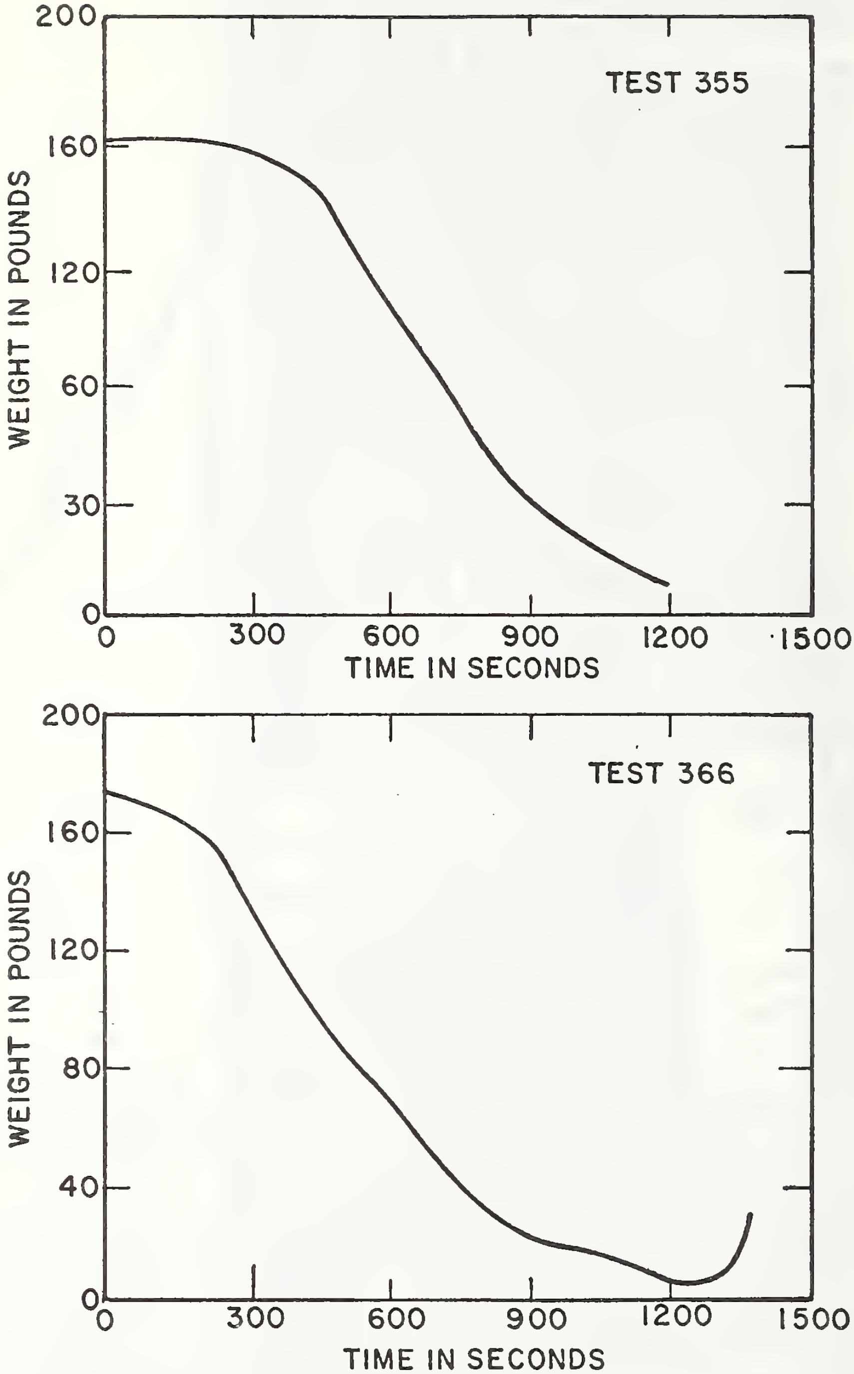

Figure 6. Weight Loss Versus Time

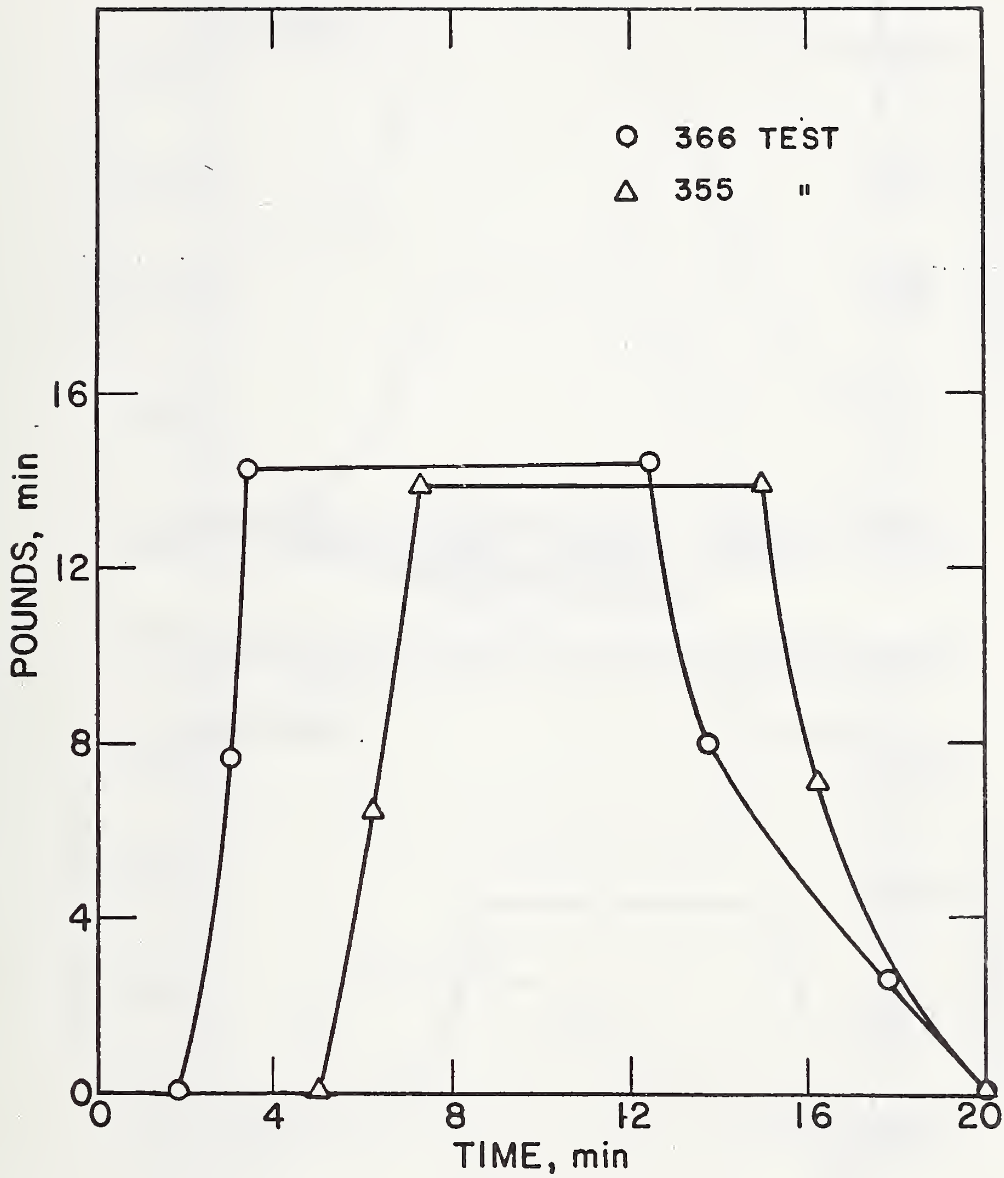

Figure 7. Rate of Weight Loss Derived From Load Cell Data.

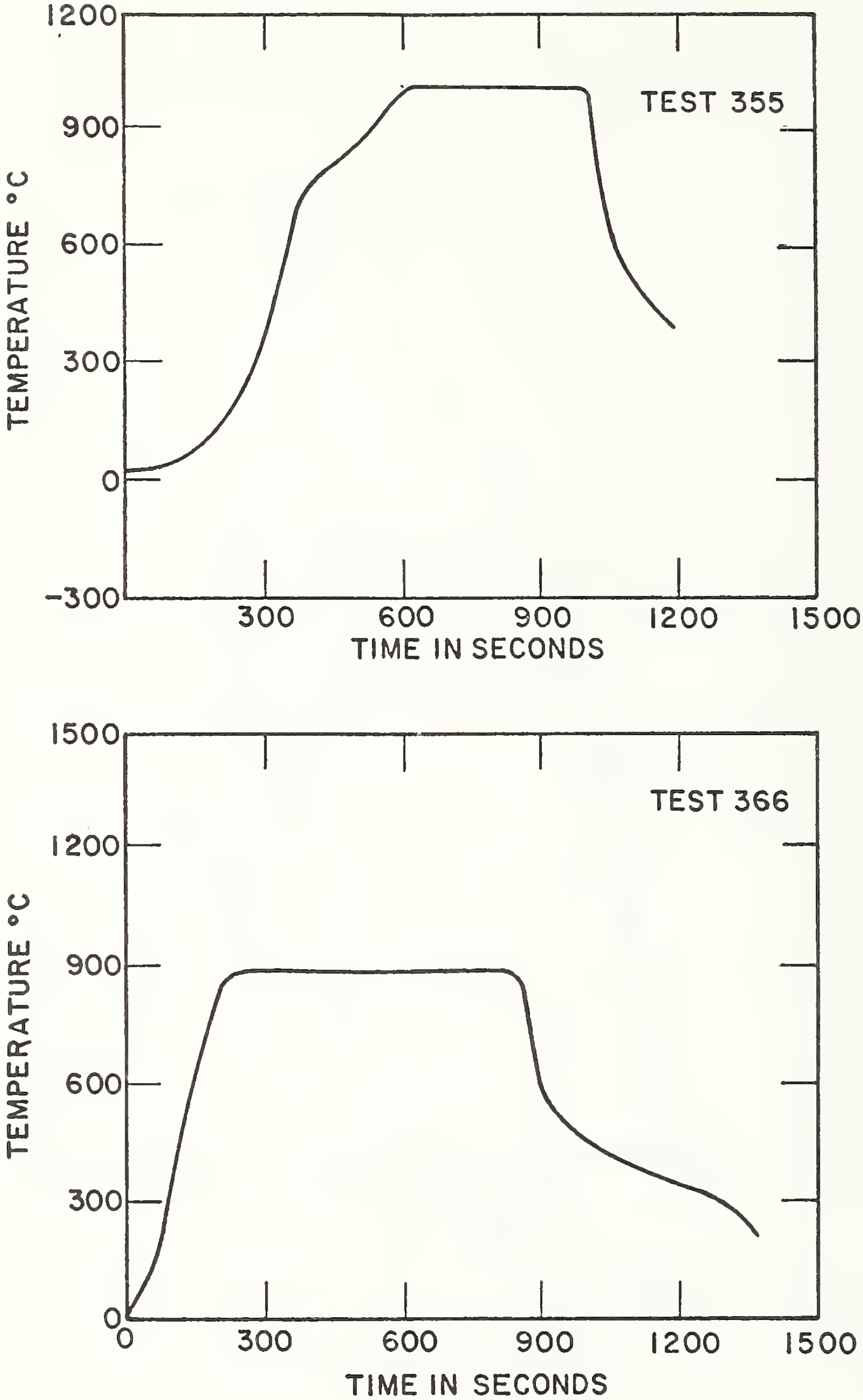

Figure 8. Ceiling Temperature of Burn-Room.

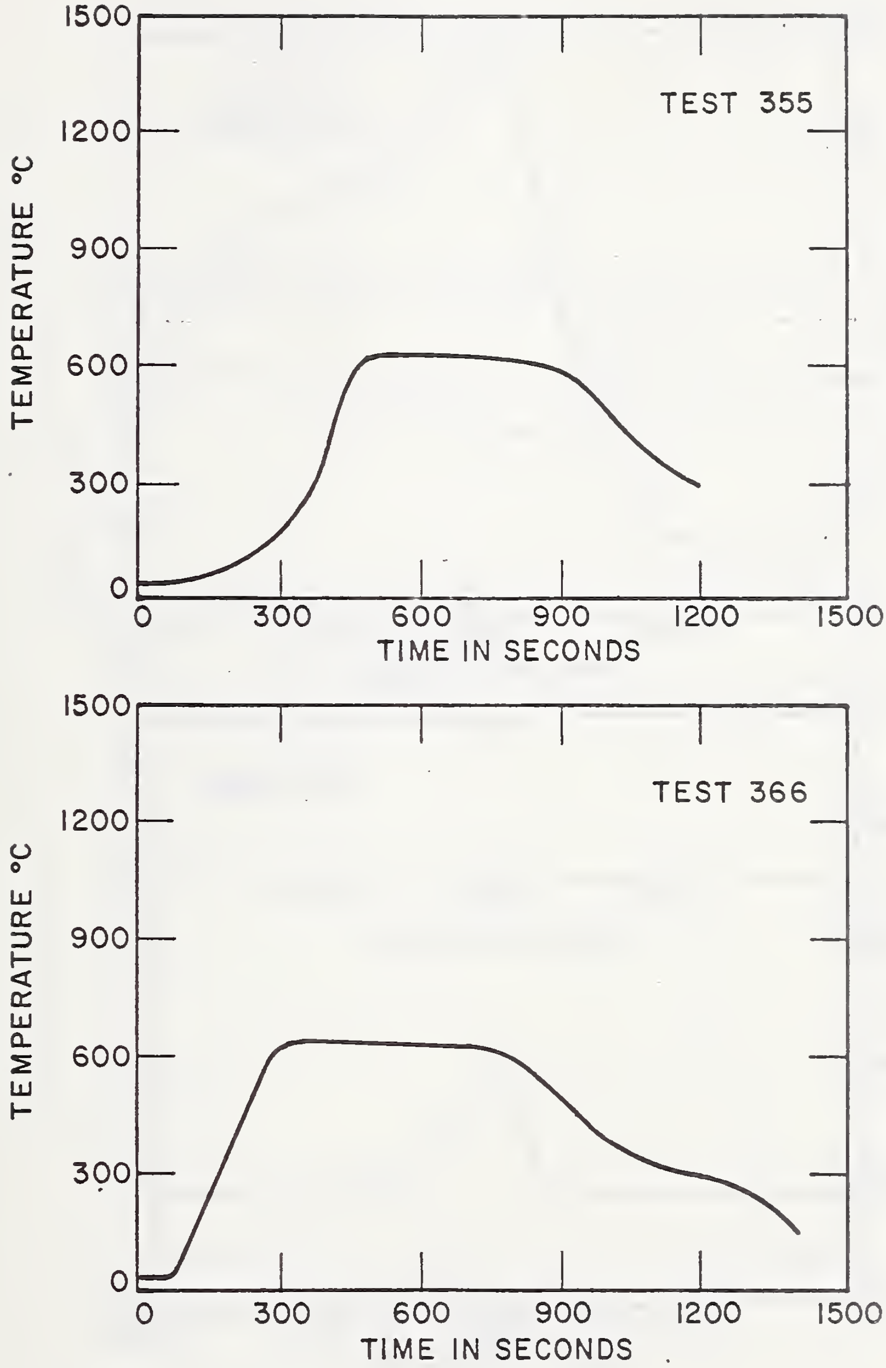

Figure 9. Ceiling Temperature 1 ft from Centerline of Doorway.

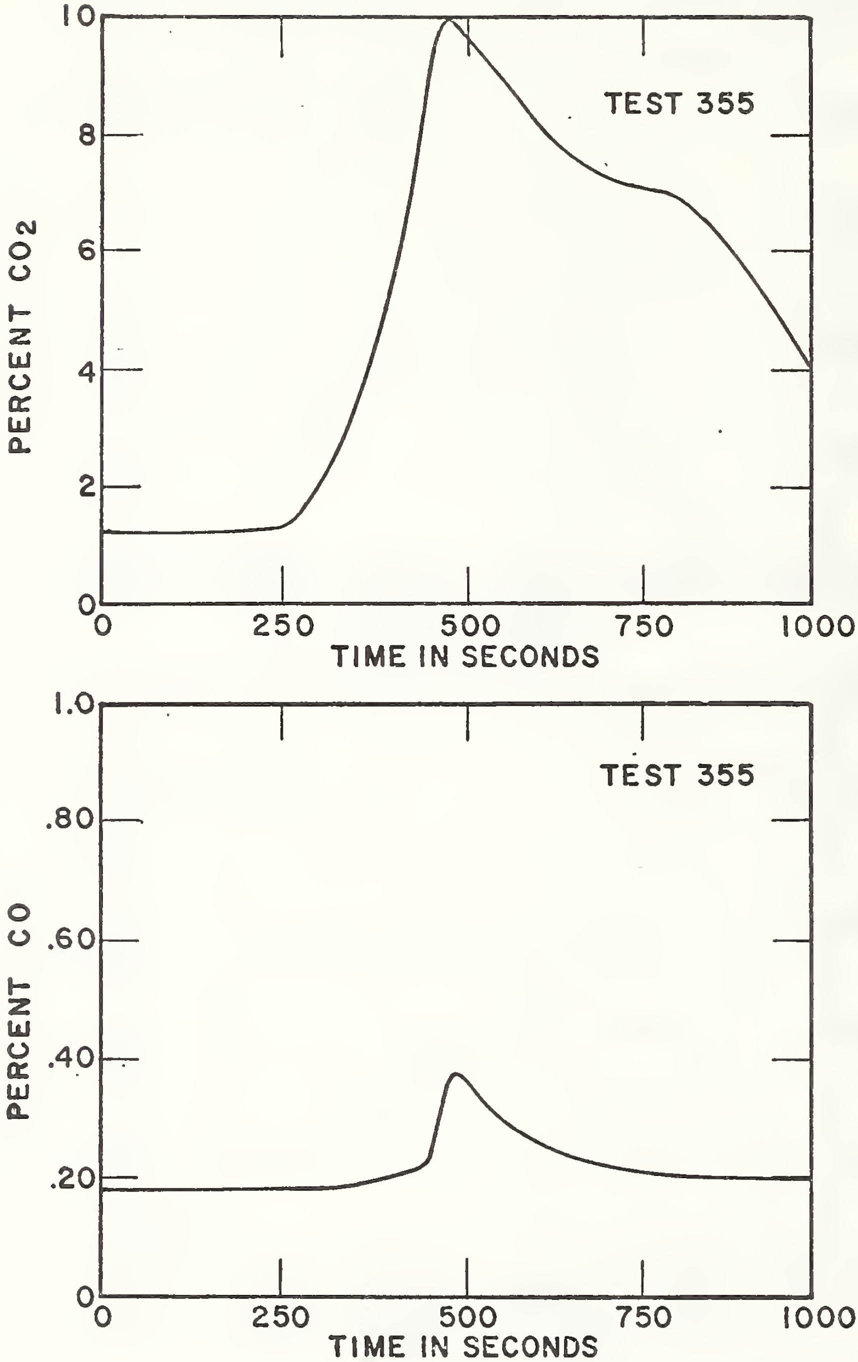

Figure 10. CO and CO_2 at 20 Feet and 6 Feet High Height.

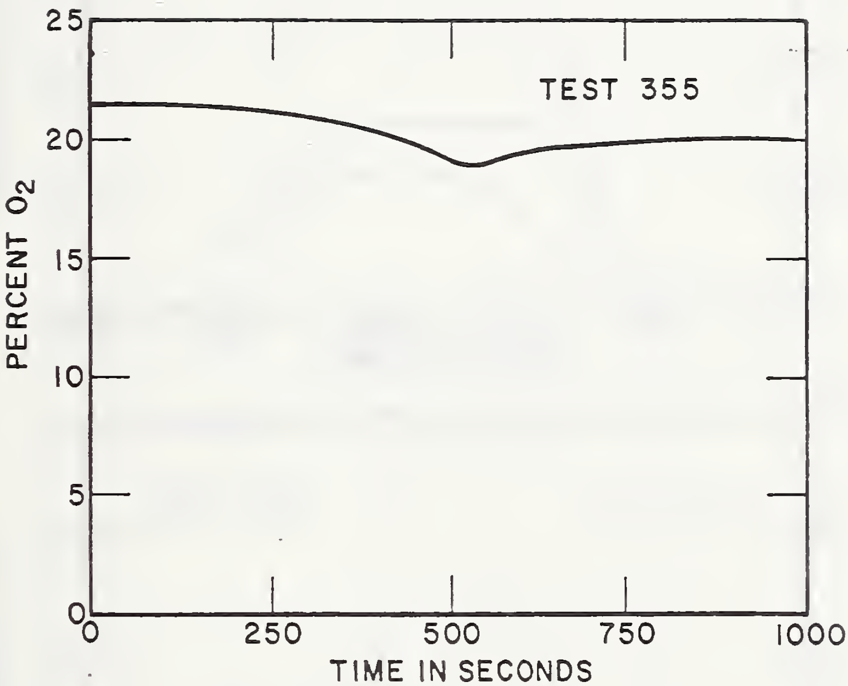

Figure 10A. O_2 at the Burn-Room Door

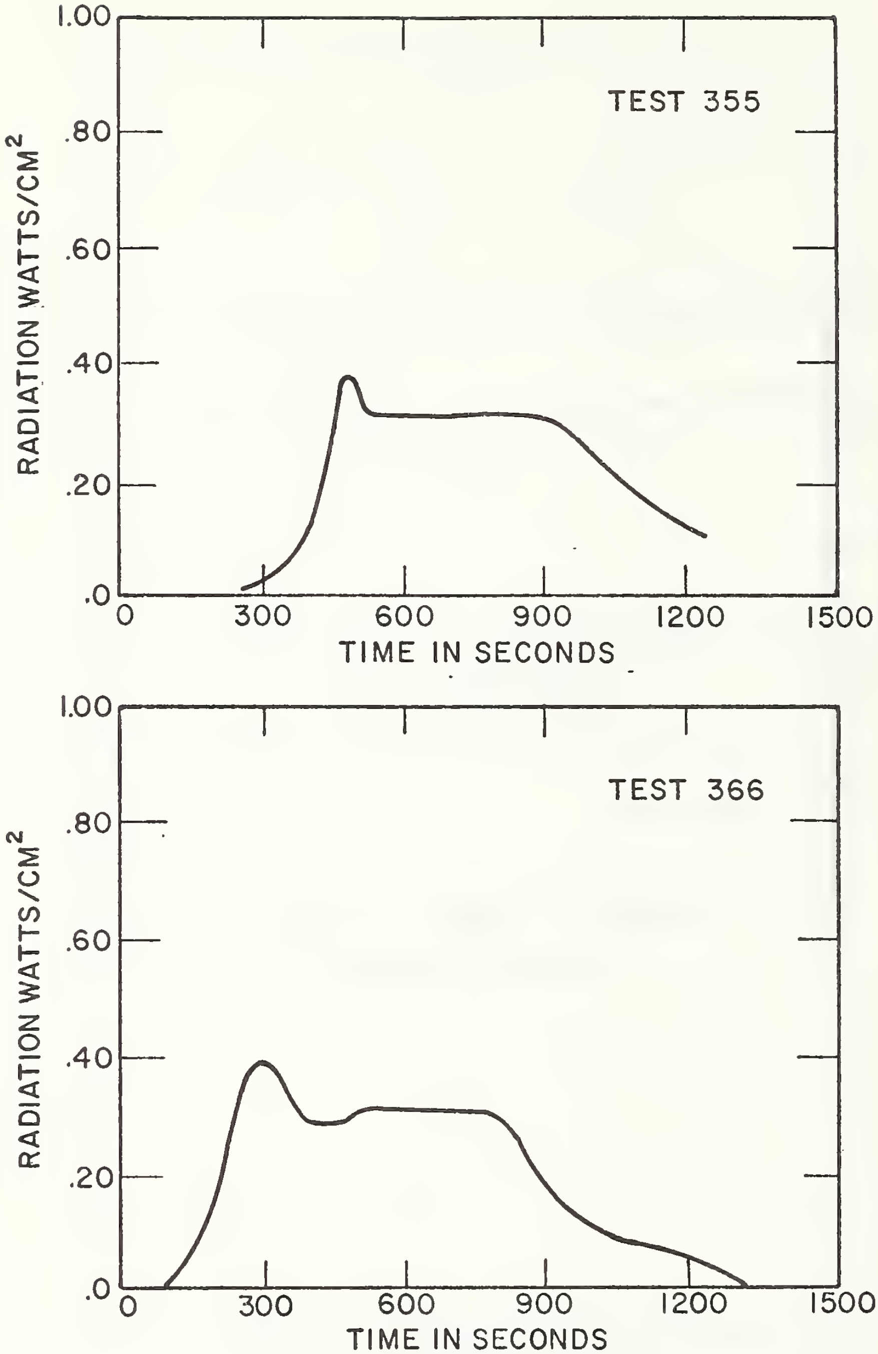

Figure 11. Heat Flux from Burn-Room.

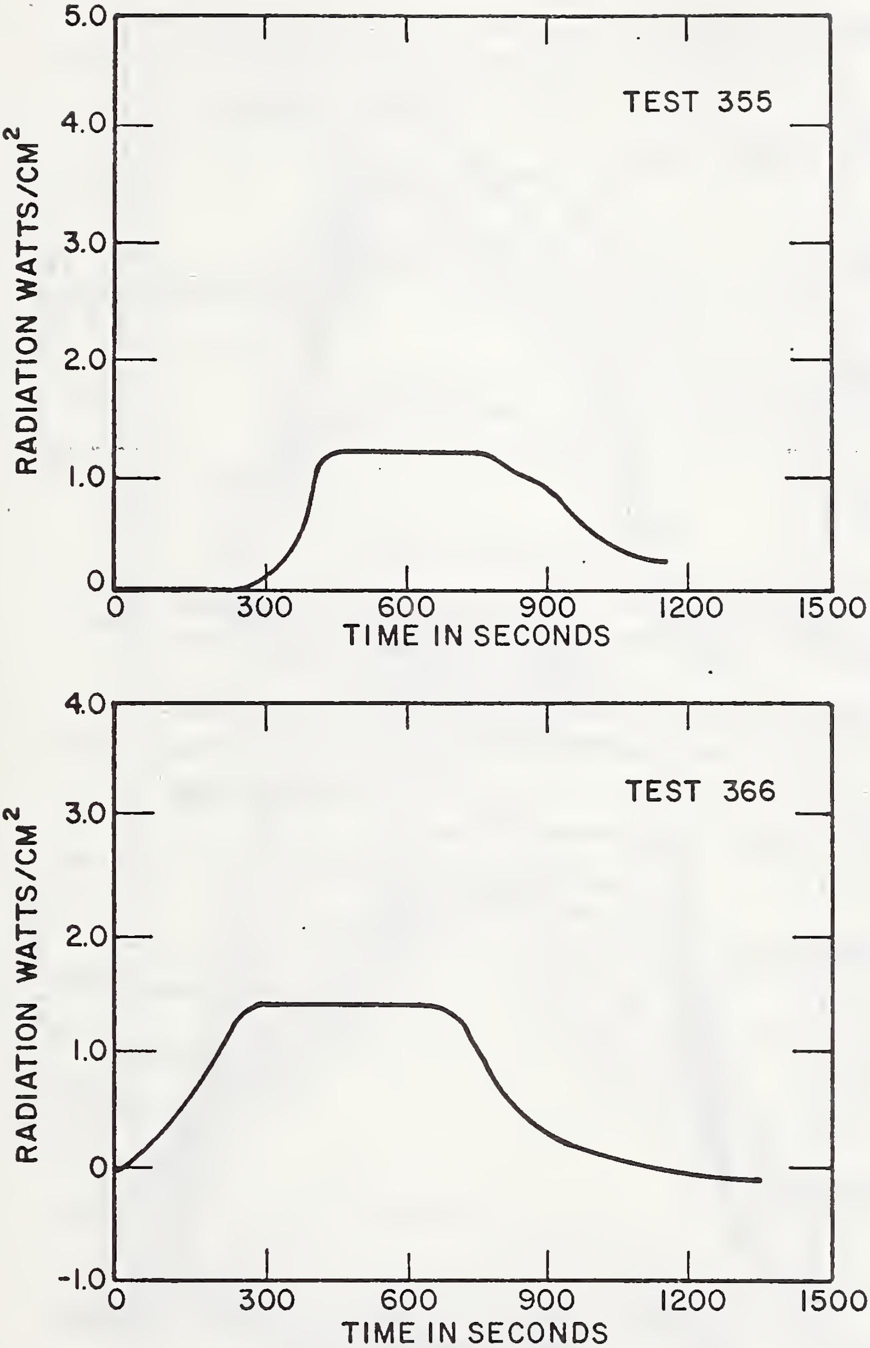

Figure 12. Radiation on the Floor 1-1/2 ft From West Wall.

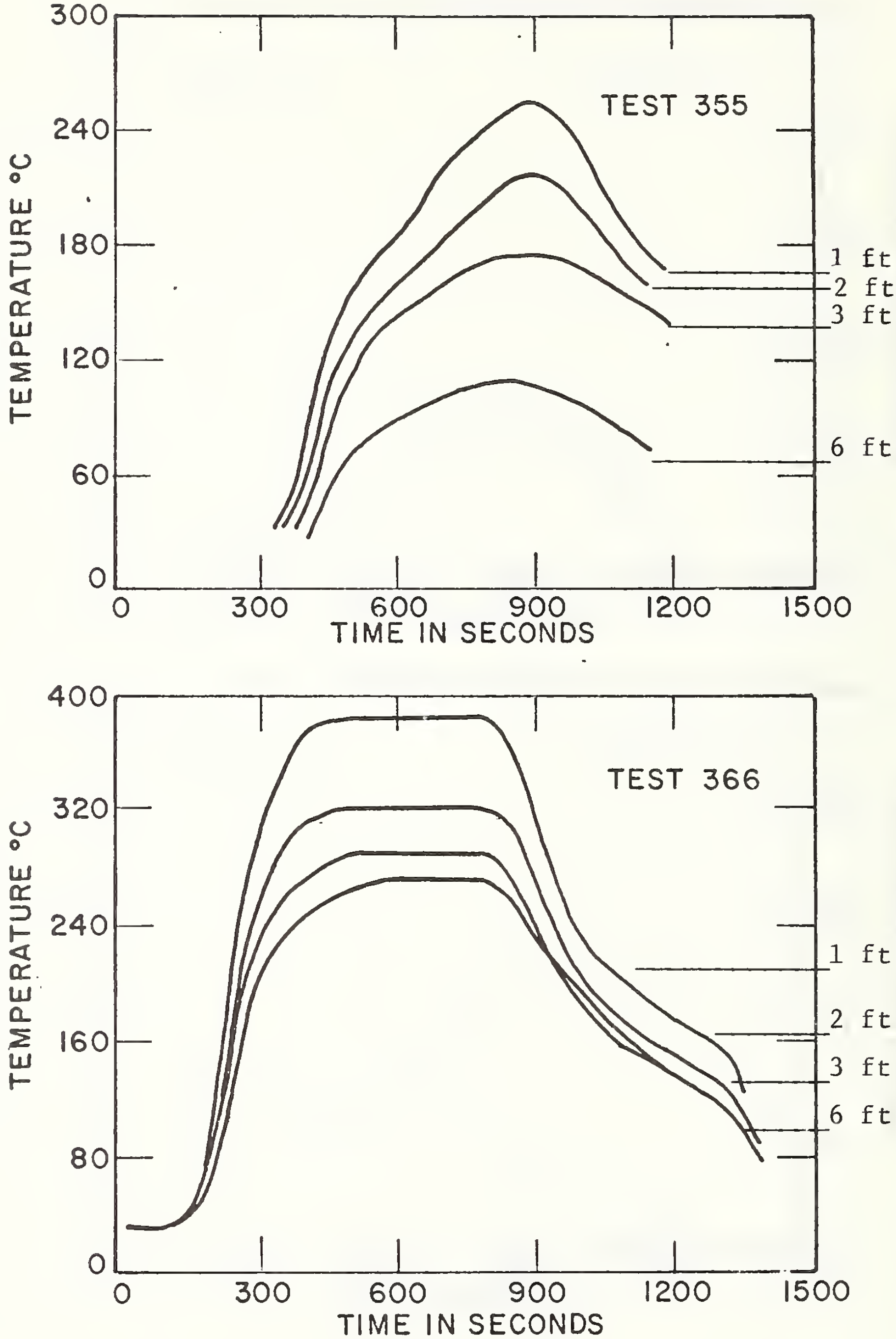

Figure 13. Temperature Across Floor at 6 ft.

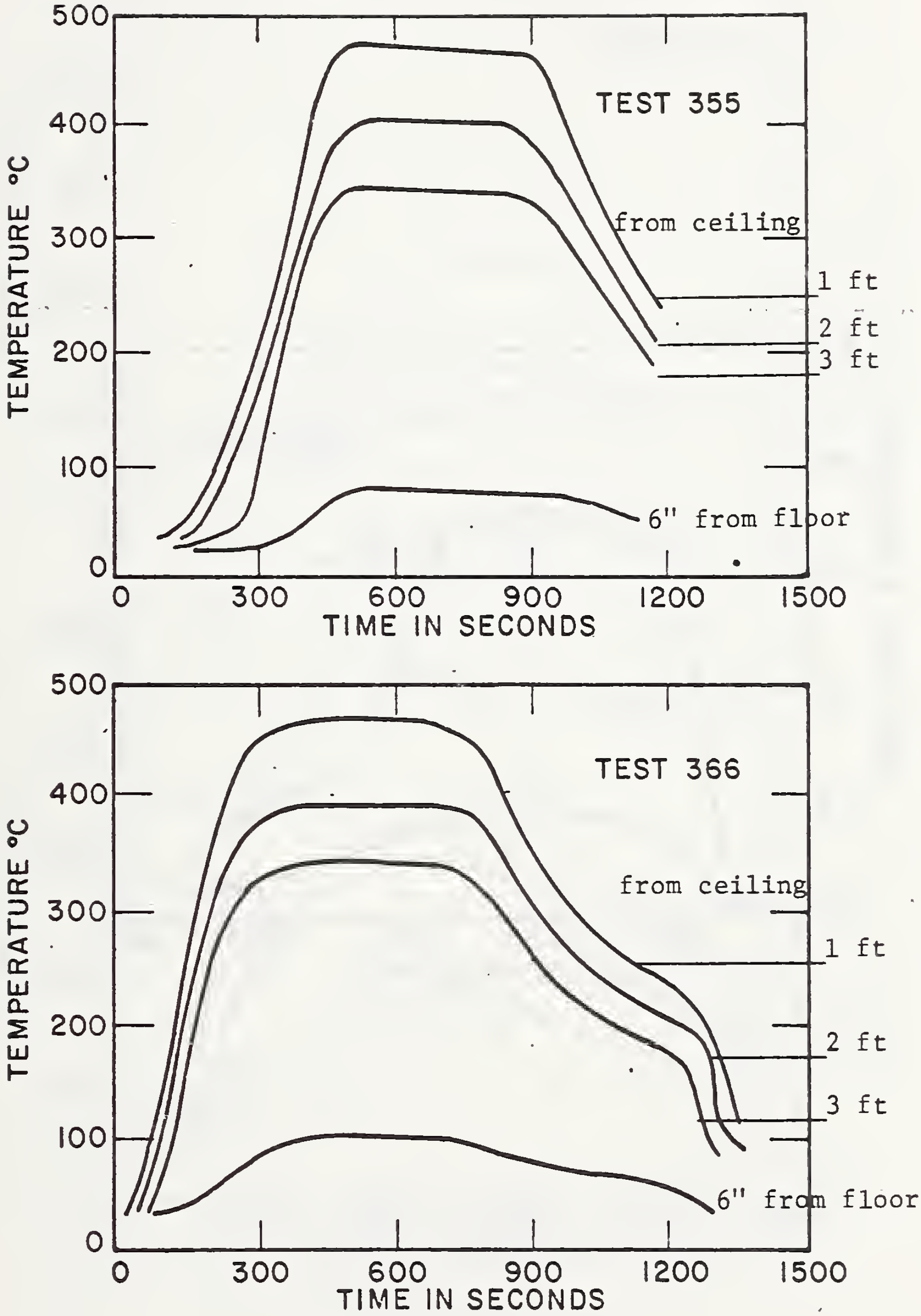

Figure 14. Temperature Profile at 5 ft.

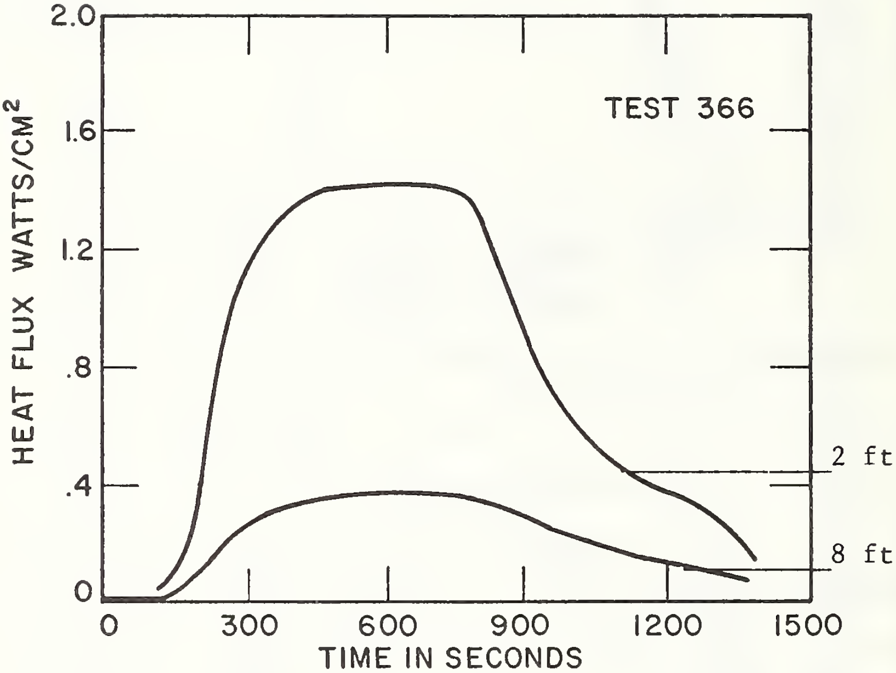

Figure 15. Heat Flux Meter

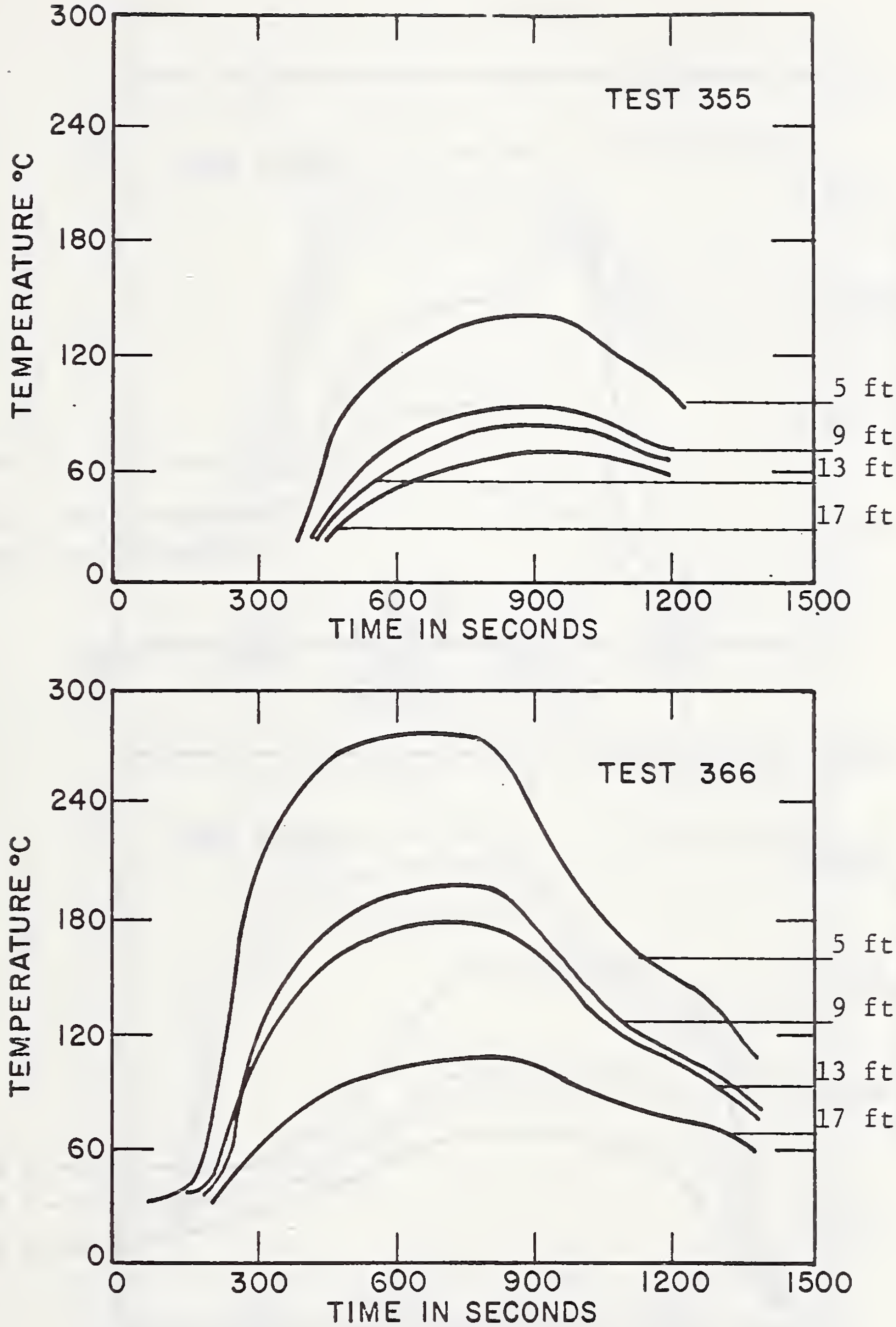

Figure 16. Temperature Down Corridor Floor.

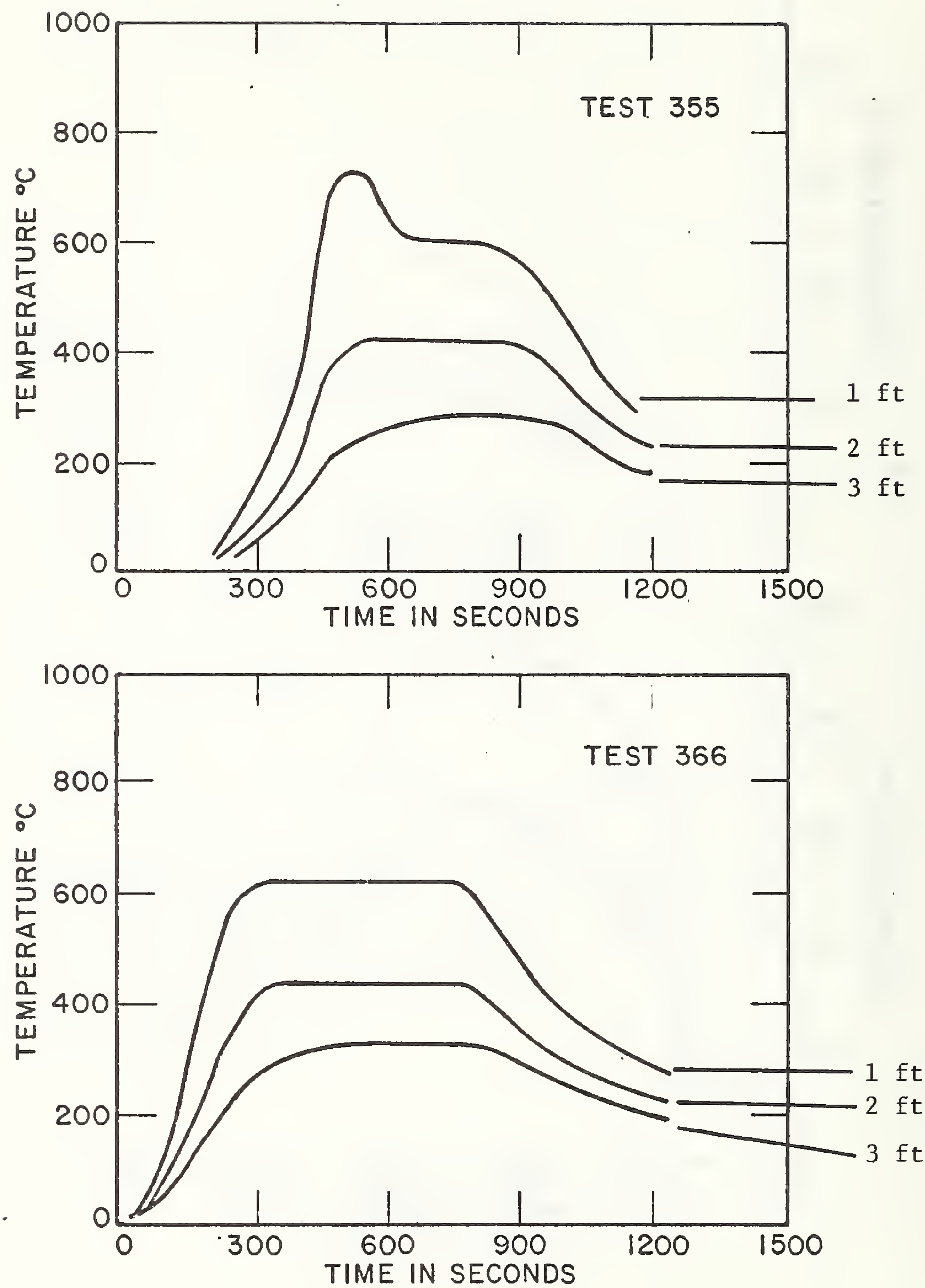

Figure 17. Ceiling Temperature Down Corridor.

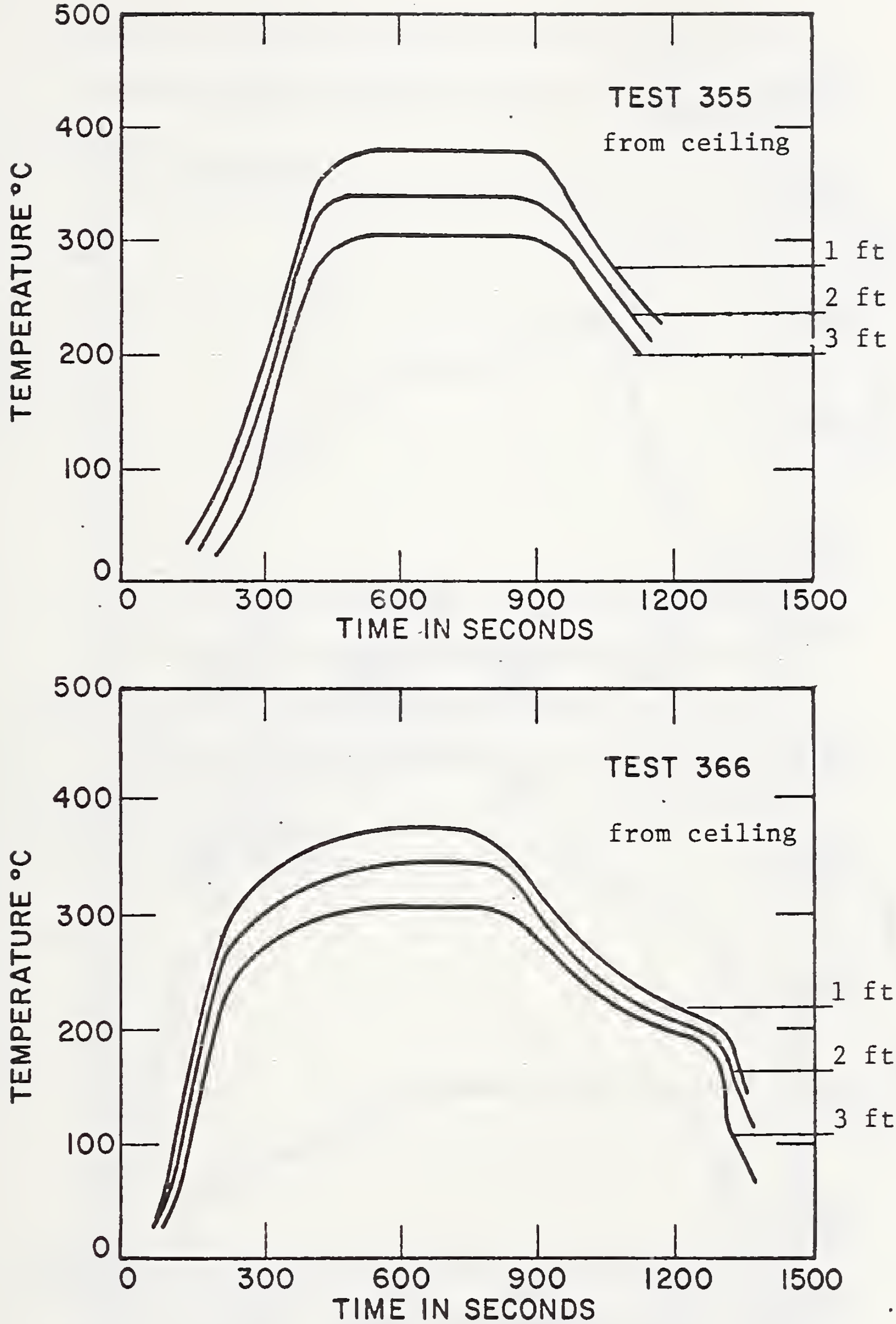

Figure 18. Temperature Profile at 25 ft.

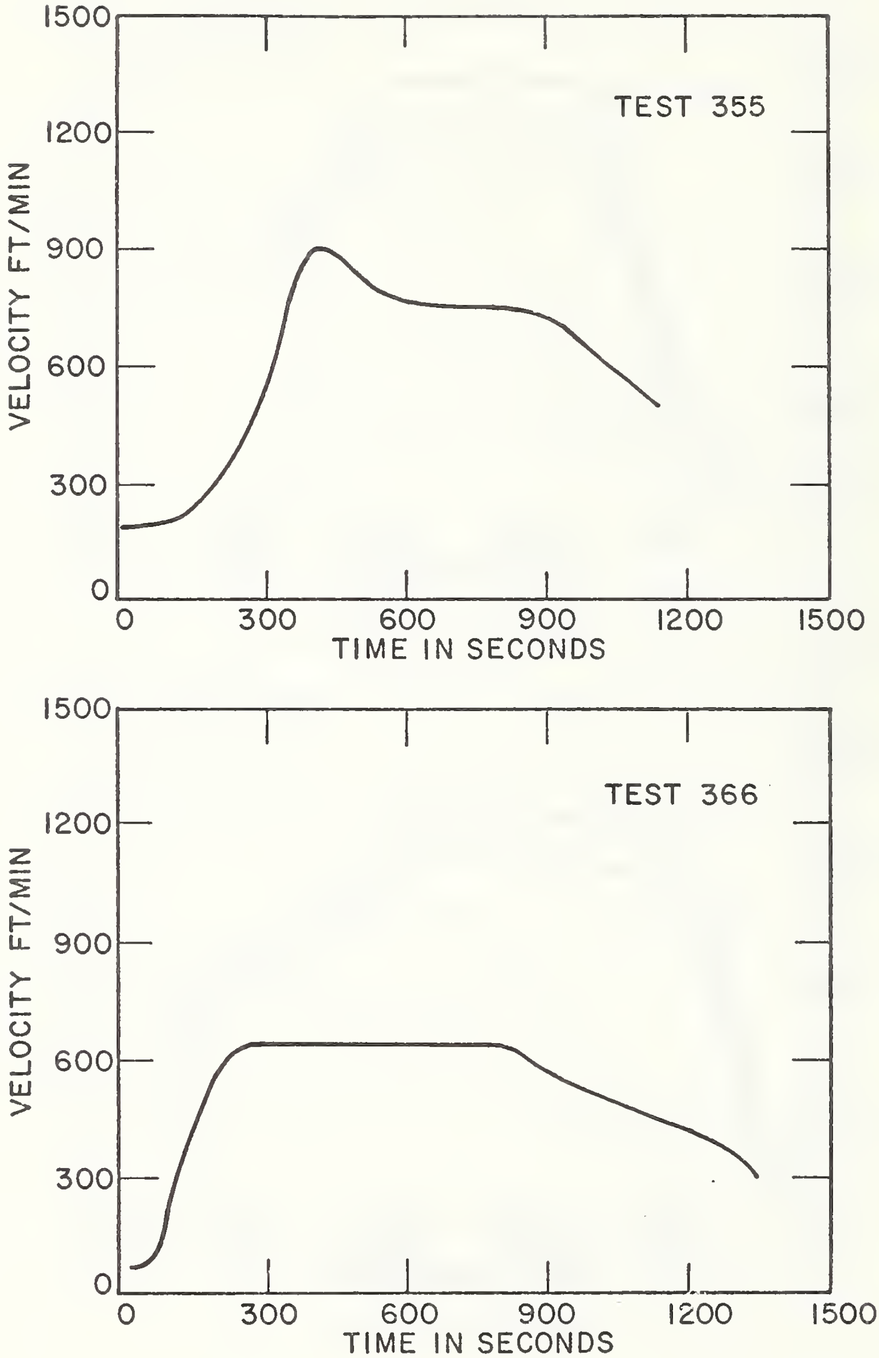

Figure 19. Velocity at Top Exit of Window 1 ft.

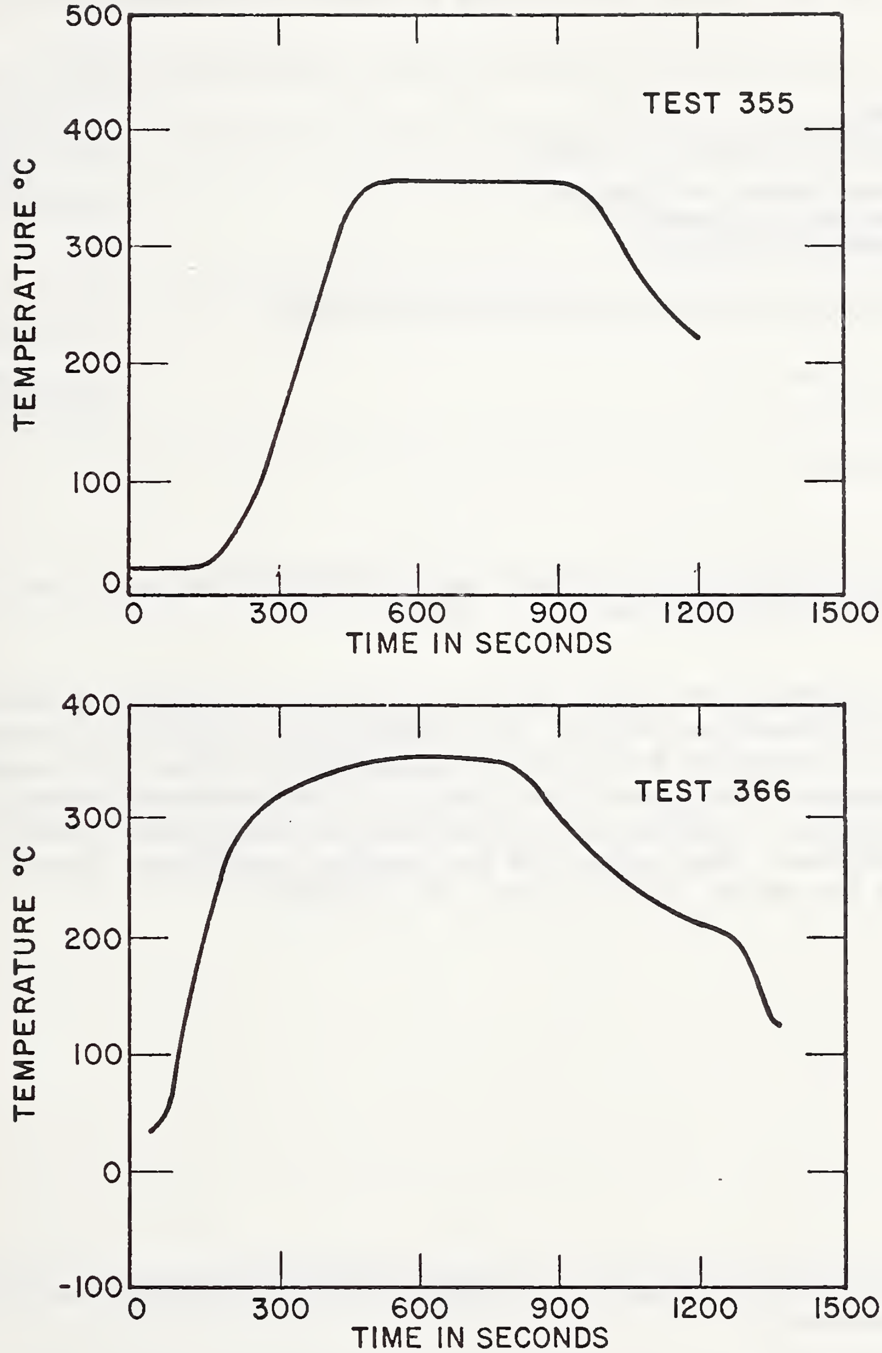

Figure 20. Temperature Profile at Exit Window

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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.)*

A corridor fire experiment was carried out using a glass fiber carpet. It was observed that with a fuel loading of 2.7 pounds per square foot of wood in an adjacent fire room, no propagation of the fire occurred down the corridor. The glass fiber carpet in the burn-room became discolored and there was a significant weight loss of the carpet directly in contact with the fire. The carpet did not produce significant levels of smoke and did not spread the fire into the corridor.

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)*

Carpet; corridor test; fire testing; flammability; glass fiber.

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