NBSIR 76-1013

Flame Spread of Carpet Systems Involved in Room Fires

King-Mon Tu and Sanford Davis

Center for Fire Research
Institute for Applied Technology
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Final Report

U. S. DEPARTMENT OF COMMERCE

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U.S. DEPARTMENT OF COMMERCE, Elliot L. Richardson, ***Secretary***
Edward O. Vetter, ***Under Secretary***
Dr. Betsy Ancker-Johnson, ***Assistant Secretary for Science and Technology***
NATIONAL BUREAU OF STANDARDS, Ernest Ambler, ***Acting Director***

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FLAME SPREAD OF CARPET SYSTEMS INVOLVED IN ROOM FIRES

King-Mon Tu and Sanford Davis

Abstract

This study was designed to test the hypothesis that given a situation where a chair or other item of furniture becomes the first item to burn in a room (providing the ceiling and walls are noncombustible), there is little reason to expect involvement of the carpet in the fire beyond the immediate vicinity of the burning object. Four small sized carpet fire tests and eight full-scale burn room fire experiments were conducted. Experimental data for temperature distribution and incident heat flux to the floor covering were measured in the rooms. General analysis of the experimental results obtained shows this to be the case. It also is evident that the critical radiant flux of the floor covering system is predictive of the extent of burning. From this study, carpet systems used in rooms will not normally spread fire provided they meet the requirements of DOC FF 1-70 (the pill test).

Key words: Carpets; carpet systems; fire safety; flame spread; flooring radiant panel test; floor coverings; ignition sources; pill test; room fires.

1. INTRODUCTION

The question of fire safety of floor coverings within a room involves the ease of ignition in a "first-to-ignite" situation, and the degree to which the floor covering system presents a fire propagation link in the room of fire origin.

The test method described in the "Carpets and Rugs (Pill Test), Standard for the Surface Flammability of Carpets and Rugs" [1][1], is believed to be an appropriate and valid measure of ignition ease under localized conditions from small ignition sources. Floor coverings which pass the pill test would be expected to provide adequate "first-to-ignite" protection in rooms in all occupancies.

This report addresses the question of the extent to which the floor covering will act as a means of fire propagation. A number of carpet systems were examined; all carpets passed the pill test. The carpets having various levels of critical radiant flux (CRF) [2] (defined as the

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

incident radiant flux level below which a flame will no longer propagate under test conditions), were exposed in a room fire situation to ignition sources of varying sizes. The extent of fire propagation was measured for the various sources and correlated to the size of fire source and the CRF level of the carpet.

2. EXPERIMENTAL DETAILS

2.1. Small Carpet Tests

A preliminary series of experiments was carried out utilizing four different small carpet system samples in the corner of the burn room opposite the door. The carpets, measuring 0.9 by 0.9 m (3 by 3 ft), had CRF values of 0.26, 0.23, 0.12, and $\sim$ 0.04 W/cm^2 and were bonded to cement-asbestos board of the same size. The ignition source was a polyethylene wastepaper basket (capacity 6.0 ℓ) lined with a disposable polyethylene trash bag and filled with 32 pages of folded newspaper, three sheets of 22 by 28 cm (8-1/2 by 11 in) writing paper, one 0.71 ℓ (1/2 pt) milk carton, two empty cigarette packages, three paper tissues, and three 89 cm^3 (3 oz) paper cups; the total weight of the ignition source was 0.5 kg (1.1 lb). The basket was placed in the corner 7.6 cm (3 in) from each wall, on top of the carpet.

Color movies (16 mm) and color video-tapes were taken to document the fire event.

A match was used to ignite the paper; the fire in the wastebasket ignited the carpet. The burned area of the carpet extended about 15 to 30 cm (6 to 12 in) from the wastepaper basket edge, and 43-56 cm from the corner. The burned areas are shown in figure 1 for the different tests.

2.2. Large Carpet Tests

2.2.1. Instrumentation

Based on the results of the small tests, it was decided to carry out some tests in a fully carpeted room, in which different carpet systems were exposed to fire sources of larger size. In addition to visual documentation of each test, data were taken from thermocouples measuring gas and floor surface temperatures and from three pairs of total heat flux meters and radiometers measuring incident heat flux to the floor covering. The data were recorded on a paper tape data acquisition system at a rate of one full scan every 20 seconds.

The dimensions of the floor covering test room are:

Burn room width and length - 3.4 by 2.7 m (11 by 9 ft)
Burn room ceiling height - 2.4 m (8 ft)
Open doorway width and height - 0.9 by 2.1 m (3 by 7 ft)

The walls and ceilings were constructed of 1.6 cm (5/8 in) thick type X fire proof gypsum wallboard on steel studs covered by 1.3 cm (1/2 in) thick low density (928 kg/m^3 or 58 lb/ft^3) cement-asbestos board. The cement-asbestos boards were off-set slightly to the seams of the gypsum wallboard beneath in order to insure an air-tight room. All joints, both gypsum and cement-asbestos were spackled. The sub-flooring of the room consisted of 13 cm (5 in) concrete and is 74 cm (29 in) above the laboratory ground floor. Inside the test burn room, there were 1.3 cm (1/2 in) thick cement-asbestos boards resting directly on the concrete sub-flooring. Pyrex glass windows were built on the side walls for photographic and viewing purposes.

Figure 2 is the schematic diagram of the burn room showing a standardized wood crib in the room corner and the arrangement of the instrumentation. The walls, ceiling, and floor were constructed of non-combustible materials.

2.2.2. Test Specimens and Ignition Sources

The floor covering tests were carried out using either wood cribs or chairs as ignition sources; carpet systems had CRF values ranging from ∿ 0.04 to 0.33 W/cm^2. Four carpet systems were used to cover this range.

	CRF, W/cm^2
Acrylic carpet w/o pad	0.33
Acrylic carpet w/hair jute pad	0.23
Polypropylene carpet w/hair jute pad	0.14
Polyester carpet w/hair jute pad	∿ 0.04

Two types of standardized wood crib were used. A small sized wood crib, measuring 30 by 30 by 27 cm (12 by 12 by 10-1/2 in) high and weighing approximately 6.4 kg (14 lb), consisted of 26 pieces of 3.8 by 3.8 by 30.5 cm (1-1/2 by 1-1/2 by 12 in) long hemlock sticks. A larger sized wood crib, 56 by 56 by 55 cm (22 by 22 by 21-1/2 in) high, weighing about 29 kg (64 lb), was constructed by piling 34 pieces of 3.8 by 8.9 by 56 cm (1-1/2 by 3-1/2 by 22 in) long hemlock sticks. The detailed arrangement of the hemlock sticks is shown in figure 3. The moisture content of the wood cribs was measured with an electrical resistance moisture meter and the values ranged between 8 and 10 percent.

Two chairs, weighing 14.5 kg (32 lb) and 19 kg (42 lb), were burned on carpets having critical radiant flux values of 0.23 W/cm^2 and 0.14 W/cm^2, respectively. The 14.5-kg chair had a wool/nylon (88/12) cover over cotton and polyurethane foam padding; the seat cushion was all urethane. The 19-kg chair had a 100 percent nylon cover over cotton padding with a polyurethane foam seat cushion.

2.2.3. Test Procedure

Eight experiments were carried out in this series of large floor covering tests. The wood crib (or chair) was situated close to the southeast corner of the burn room and was 15 cm (6 in) from each wall. The test was started by application of an open flame to ignite 80 ml of ethanol in a 20 by 20 by 2.5 cm (8 by 8 by 1 in) deep steel pan placed underneath the smaller wood crib. In the case of the larger wood crib and the chairs, 120 ml of ethanol was used.

Test 1 was a control, in which the 6.4 kg crib was the only combustible in the room. In the subsequent tests, the carpet or carpet and pad was placed in the room without the use of adhesives or nailing strips along the room perimeter.

3. EXPERIMENTAL RESULTS

3.1. Large Tests

3.1.1. Crib Burning Time

In all of the tests, the wood crib (or chair) was placed directly on the carpet in order to provide a direct flaming ignition; a load cell platform was not used to measure the burning rate of the crib. The elapsed time between ignition of the crib and the time the wood crib completely collapsed is given in table 1. The time to collapse appears to be a rough indication of an effect of feedback of the different carpet systems on the burning rate of the wood crib, with the carpet having the lowest CRF showing the shortest time to collapse.

Carpets with lower CRF values appear to cause the wood crib (the original fire fuel) to burn faster than carpets with higher CRF values.

3.1.2. Flame Spread and Burn Area

After ignition of the exposure (crib or chair), there was a several minute delay before the fire built up to where a significant amount of radiation was impinging on the floor. Direct contact between the igniting item and the carpet caused the carpet to ignite. It was not possible to determine at what time the carpet actually became involved, particularly with the crib exposure, since ignition sometimes occurred beneath or behind the crib near the wall. It could be seen that in most cases the carpet began to burn behind the crib in a region which was not directly visible from the observation points. In all cases, the fire spread slowly across the surface of the carpet within the region of the exposure and then self-extinguished. Schematic drawings for Test Nos. 2 to 8, indicating the areas burned, are shown in figures 4 to 10. In no case of fire propagation on the carpet was the area burned out more than 20 percent of the total room area. The distances burned varied with the

Table 1. Time from Ignition to Collapse of Wood Crib

Test No.	Carpet System	CRF, (W/cm^2)	Elapsed Time, (min:s)
1	none	—	26:08
3	Acrylic, no pad	0.33	25.36
2	Acrylic, w/pad	0.23	23:39
4	Polypropylene, w/pad	0.14	23:47
8	Polyester, w/pad	~0.04	22:23

size of the exposure and its position relative to the corner. In some of the tests, e.g., Tests 4 and 5, the distance the carpet burned along the edge is farther than that in the diagonal direction since the carpet was not secured to the floor and curled up along the edge during the test.

The results are summarized in table 2. The data show that for a given size fire exposure the area burned and the distance burned are increased with decreasing CRF of the carpet system. There may be a value of carpet CRF below which a fire on the carpet would be expected to self-propagate. However, at the lowest value of carpet CRF tested ($\sim$.04 W/cm^2) the fire did not self-propagate. This CRF value is considered to be about the minimum value for a carpet that will pass the pill test. (A discussion of the pill test is given in section 3.2.) Conversely, at higher CRF values used in this test, the extent of fire propagation did not go much beyond the immediate vicinity of the exposure.

Data for the four tests using a 6.4-kg crib are shown in figure 11, which shows the relationship between the carpet CRF and the distance burned. With a larger ignition crib source, the burn pattern for the same CRF carpet is larger (cf. Test No. 3, figure 4 and Test No. 6, figure 10); but the pattern is similar. Likewise, the same general pattern of burning was noted for the 14.5-kg chair on the 0.23 carpet (Test No. 7, figure 8) as for the larger chair (19 kg) on the 0.14 carpet (Test No. 5, figure 9); in the latter test, however, more burning occurred along the walls because the carpet was not fastened to the floor along the walls and was able to burn on both sides.

Another observation of the burning of a floor covering system is the effect on the maximum height of the flames over the fire exposure. Once a carpet begins to burn, it will contribute additional energy into the room in an amount directly related to the area burning and indirectly related to the CRF value of the carpet system. As the CRF values of the carpet systems decrease, the measured flame height on the carpet increases for a given fire exposure (table 3, Test Nos. 1-4, 8). This phenomenon, in turn, results in increased flame height over the original fire fuel. As was noted earlier, the carpets with lower CRF values appear to cause the wood crib to burn faster than carpets with higher CRF values. However, when the radiant energy impinging on the floor as measured by the instrumentation falls below the CRF value of the carpet system, the carpet ceases to burn.

3.1.3. Incident Heat Flux to the Floor

The rate of heating of the floor covering system during a fire event is dependent on the radiant heat flux originating from the flames from the burning wood crib (or chair), from the heating of the walls and ceiling, and from hot gases in the burn room. For regions near the room corner, the east side and south side of the wood crib in these tests, the heating rates are higher and ignition of the carpet on these two sides occurred first. The carpet on the west side of the crib was the second part to ignite and burn.

Table 2. Flame Spread and Burned Area of Carpet Systems

Test No.	Exposure	CRF (W/cm^2)	Burned Out Area (%)	Distance Burned					
				Along E Wall (m)	(in)	Along S Wall (m)	(in)	From Corner (m)	(in)
3	6.4-kg crib	0.33	4.6	0.74	29	0.69	27	0.76	30
2	6.4-kg crib	0.23	7.1	0.81	32	0.86	34	0.91	36
4	6.4-kg crib	0.14	7.9	0.91	36	1.17	46	0.91	36
8	6.4-kg crib	~0.04	13.1	1.22	48	1.12	44	1.24	49
7	14.5-kg chair	0.23	17.8	1.57	62	1.12	44	1.60	63
5	19-kg chair	0.14	17.3	1.88	74	1.68	66	1.24	49
6	29-kg crib	0.33	19.6	1.42	56	1.47	58	1.52	60

Table 3. Maximum Flame Heights

Test No.	Maximum Flame Height Over Exposure		Maximum Flame Height Over Carpet	
	(m)	(ft)	(cm)	(in)
1	0.9 – 1.2	3-4	—	—
3	1.2 – 1.5	4-5	13 – 15	5-6
2	1.5	5	15	6
4	1.5 – 1.7	5 – 5-1/2	25	10
8	1.8	6	30	12
7	2.4	8*	30	12
5	2.4	8*	30	12
6	2.4	8*	30	12

*Flames spread along ceiling

The history of incident heat flux and temperature variation on the floor surface at locations A, B, and C are plotted in figures 12 to 19 for each of the tests. Three sets of total heat flux meters and radiometers were placed on the floor with the sensing surfaces facing upwards and flush with the carpet surface. The total heat flux meter to monitor the incident heat flux has a viewing angle of 180 degrees; the radiometer has a viewing angle of 150 degrees. Air entering the room along the floor through the open door keeps the gas temperature near the floor low; conductive and convective heat transfer to the floor is small compared to the incident radiant heat flux. Therefore, the total heat flux meter can be used as a radiometer with little error.

Figures 13, 14, 16 and 18 show a second peak rise of incident heat flux. This occurred at the time the carpet on the north side of the crib started to burn and contribute more radiant energy to the floor covering surface. The north side is closest to all the heat flux meters. Comparing these data to figure 12 (blank with no carpet), it is obvious that carpets contribute additional thermal energy to the burn room and result in a higher level of fire hazard. Similarly, a plot of temperature versus time measured at point D, 7.6 cm (3 in) below the ceiling, shows that the presence of a carpet raised the gas temperature, due to the additional fuel load in the room (figure 20), from about 140 to 280 °C. Also, for a given size fire, the rise in gas temperatue relates inversely to the CRF value.

The burning of the crib and the carpet together is a thermal interaction phenomenon. Thus, the thermal energy generated by the burning of a carpet can cause a significant modification of the burning behavior of the crib. The modification is particularly important if the rate of thermal energy released by the burning interaction is sufficiently large to lead to flashover in the burn room. In these circumstances, the thermal field in the burn room could depart significantly from conditions of the control case. A cursory study of the flux and temperature curves for the control (figure 12) with respect to those for tests in which carpets were in place (figures 13-19) shows that the thermal energy generated by the burning of the carpet raised the thermal energy in the burn room and, in turn, caused a faster burning of the wood crib (or chair). In this manner, the burning behavior for both the crib (or chair) and carpet are mutually reinforced by each other as the fire event proceeds.

3.1.4. Incident Radiant Flux: Theoretical Versus Experimental

Theoretical calculations were performed to predict the incident radiant flux on the floor surface as a function of the distance from the face of a burning wood crib, for the case of a 6.4 kg crib on a noncombustible floor (figure 21). Three sources of radiation were assumed: the first is the radiation from the crib (fuel bed), the second is the flame above the crib, and the third is the radiation from the hot ceiling gas. The overhead flame was assumed to be triangular in shape for calculation purpose. Other assumptions were (1) a fuel bed temperature of

800 °C and total emissivity of 0.90 for the bed, (2) a flame temperature of 750 °C and total emissivity of 0.25 for the flame, and (3) ceiling gas temperature of 140 °C and an average shape factor of 0.35. The theoretical curve shown in figure 21 was based on a crib width of 31 cm (12 in) and height of 27 cm (10-1/2 in) with triangular flame shape and a predicted flame height of 61 cm (2 ft). Basically, these measurements apply to the fire phenomenon of Test No. 1. At a time of 6 to 8 minutes after ignition of the crib, one obtained the maximum flame height of 90 to 120 cm (3 to 4 ft) above the floor and the fuel bed was not fully involved. During this time period there was not much burning inside the crib and figure 12 shows that the incident radiant flux to the floor was still increasing at this time. About 16 to 18 minutes after ignition, figure 12 shows that the incident radiant flux curves are at the maximum values. During this time interval, the fuel bed is fully involved in burning, the overhead flame height has receded to about 61 cm (2 ft) above the floor. Also, the ceiling, side walls, and hot gases in the burn room which are heated emit radiant energy to the floor.

The maximum values for incident heat flux on the floor at points A, B and C, recorded during Test No. 1 are shown in figure 21. Good agreement between the theoretical calculations and the experimental results were obtained.

3.1.5. Distance Burned Versus Critical Radiant Flux

The Flooring Radiant Panel Test is designed to measure the CRF of floor covering systems; CRF is defined as the incident radiant flux level below which a flame will no longer propagate. If the test is valid, then burning on the floor should not proceed beyond the point where the CRF value of the carpet system exceeds the flux to the floor. This can be tested by comparing the measured CRF values for the carpet systems to the incident radiant flux measured on the floor surface at three discrete points. Table 4 shows the test results.

In Test No. 2 (figure 5), the distance burned was just past flux meter A (flux meters B and C were not reached by the fire). The experimental measurements for incident heat flux at point A over the major time period of this test were higher than 0.23 W/cm^2, the CRF for this particular carpet system as measured by the flooring radiant panel test; for points B and C, the maximum incident heat flux values were less than 0.23 W/cm^2.

In Test No. 3 (figure 4), most data for incident heat flux were more than 0.33 W/cm^2 and the burned edge never reached point A.

Results of Test No. 4 (figure 6) were similar to those of Test No. 2.

In Test No. 6 (figure 10), the incident heat flux values at point B were a little higher than 0.33 W/cm^2 and the fire burned just barely past point B.

Table 4. Distance Burned Versus Critical Radiant Flux

Test No.	Figure No.	Measured CRF Value (W/cm^2)	Measured Incident Flux (W/cm^2)	Distance Burned
2	5 and 14	0.23	>0.23 at position A	Just past position A
3	4 and 13	0.33	>0.33 at position A	Not reached position A
4	6 and 15	0.14	>0.14 at position A	Just past position A
6	10 and 19	0.33	>0.33 at position B	Just reached position B
8	7 and 16	~0.04	>0.04 at position B	Between positions A and B

In Test No. 8 (figure 7), the data for points A, B, and C were all higher than 0.04 W/cm^2 but the fire stopped between points A and B. This can be explained as follows: by the time the flame front on the carpet had proceeded to the point of extinguishment, the incident flux on the floor was below 0.04 W/cm^2. Since this carpet system passed the "pill" test, the energy output of the burning carpet under low incident radiant flux is not sufficient to sustain burning.

In general, these experimental results were in good agreement with the data provided by the flooring radiant panel test.

3.2. Measurement of the Pill Heat Flux

In light of the foregoing results obtained with the carpet system which has a CRF of $\sim$0.04 W/cm^2, an effort was made to determine the incident radiant flux onto a horizontal surface from a methenamine pill used in the carpet standard test procedure. A simple experiment to determine the heat output of a burning pill was carried out [3].

The heat output was measured for the special case of the carpet exposed to a burning pill. A technique developed by Mehta and Wong of MIT in their fabric fire injury experiments was used [4]. This technique employs thermocouples placed on the surface of a material rather than a heat flux meter. By using a mathematical computation scheme known as Duhamel's Integral Method, the measured surface temperature history is converted to a surface flux density as a function of time.

A pill was placed on the center of a 15 by 15 by 0.16 cm (6 by 6 by 1/16 in) thick asbestos paper square. The asbestos paper was painted with a velvet black coating which has a surface emissivity between 0.90 and 0.98. The asbestos paper, in turn, was placed on a 5-cm (2-in) thick glass fiber block. A wire screen was placed around the entire assembly to decrease the effects of air movement in the laboratory without hampering the air supply to the pill. Since it was assumed that the heat flux onto a substrate below the pill was symmetrical around the pill, three thermocouples were located on a line originating at the center of the pill. The thermocouples were placed on top of the asbestos paper 9.5 mm (3/8 in), 15.9 mm (5/8 in), and 28.6 mm (1-1/8 in) from the center of the pill.

Figure 22 shows the calculated heat flux, as a function of time, that would impinge on a carpet surface at the three distances from the ignition source. This does not include any additional energy that a burning carpet would introduce as part of its feedback energy. Figure 23 shows the approximate radial energy distribution on the plane surface at two given times.

From figure 22 it can be seen that the energy falling on the carpet within a radius of 16 mm exceeds the minimum radiant flux level (0.1 W/cm^2) from the flooring radiant panel test for a large portion of the pill's burning time — 90 seconds. On the other hand, figure 23 shows that at a distance of 20 mm, the flux is well below 0.1 W/cm^2. This means that while one part of the carpet is experiencing high heat flux levels, it is of short duration and limited to a small area around the pill. Also, it is worth noting that at 25.4 mm (1 in) from the center of the pill the flux is below 0.04 W/cm^2, the lowest CRF of the carpet systems used in this series.

4. SUMMARY AND CONCLUSIONS

Four small sized carpet fire tests and eight full-scale burn room fire experiments were conducted. Experimental data for temperature distribution and incident heat flux to the floor covering were obtained in the room. The test data and analysis indicate that given a situation where a chair or other comparable size furniture becomes the first and the only item to burn in a room, providing the ceiling and walls are non-combustible, there is little reason to expect involvement of the carpet in the fire beyond the immediate vicinity of the burning object. It also is evident that the critical radiant flux of the floor covering system is predictive of the extent of burning under these conditions. From this study, carpet systems used in rooms will not normally spread fire provided they meet the requirements of DOC FF 1-70 (the pill test).

5. REFERENCES

[1] Carpet and Rugs (Pill Test) Standard for the Surface Flammability of Carpets and Rugs, DOC FF 1-70, Federal Register, Vol. 35, No. 74, 6211 (Apr. 16, 1970).

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[3] Braun, E., National Bureau of Standards, Private Communication.

[4] Mehta, A. K. and Wong, F., Measurement of Flammability and Burn Potential of Fabrics, Fuels Research Laboratory, Massachusetts Institute of Technology, Project DSR 73884 (Feb. 1973).

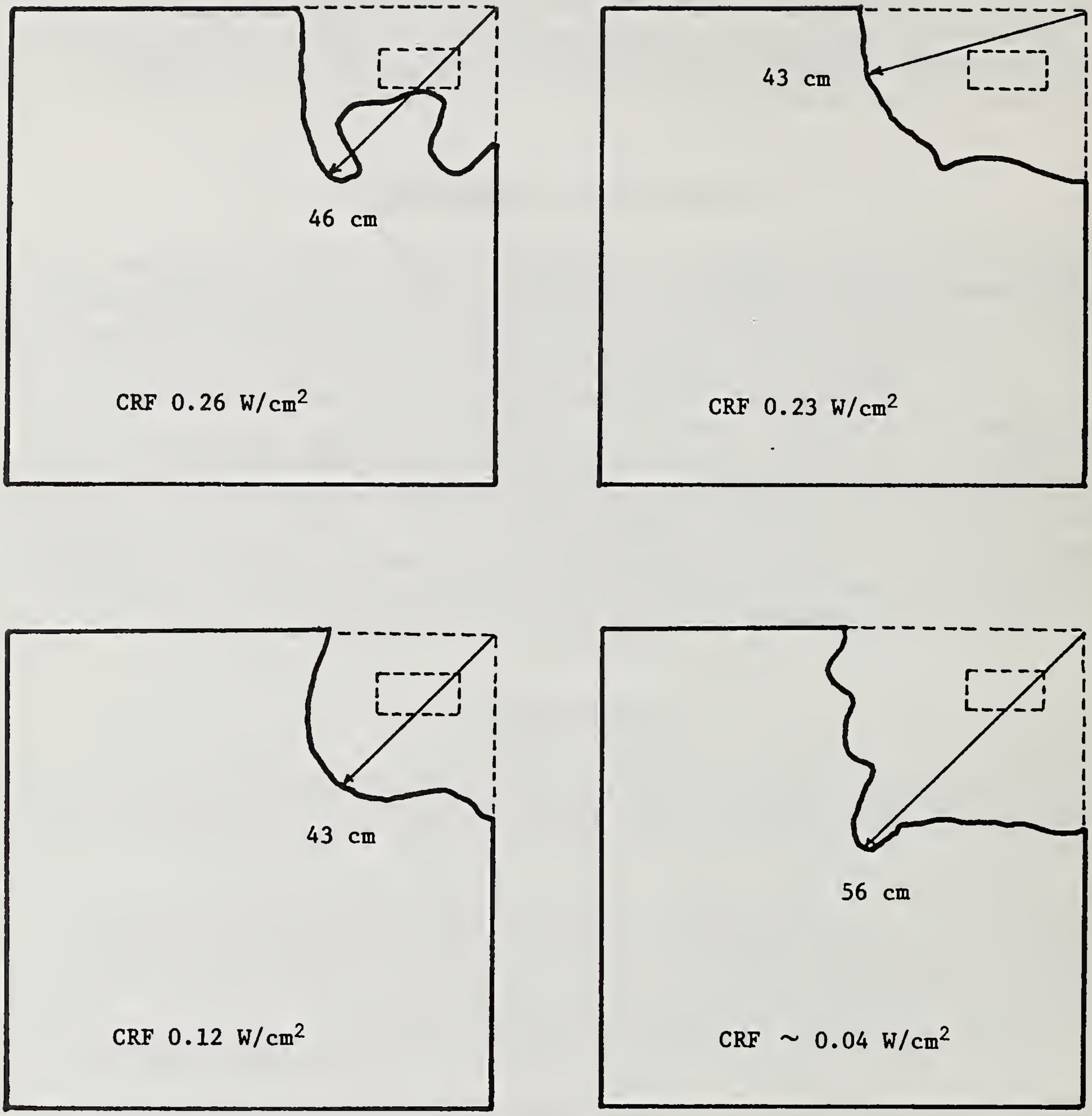
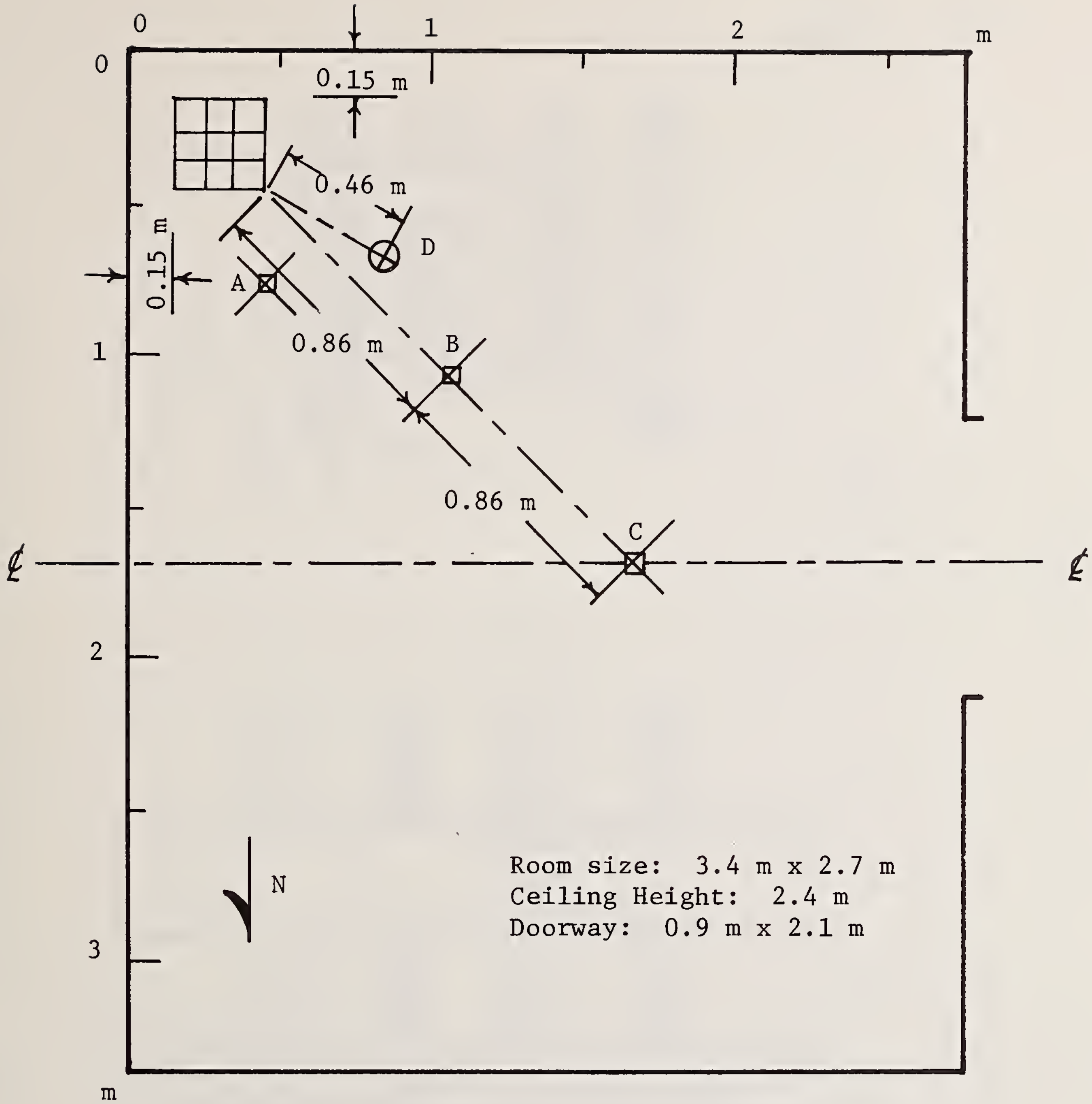


Figure 1. Carpet Burn Area

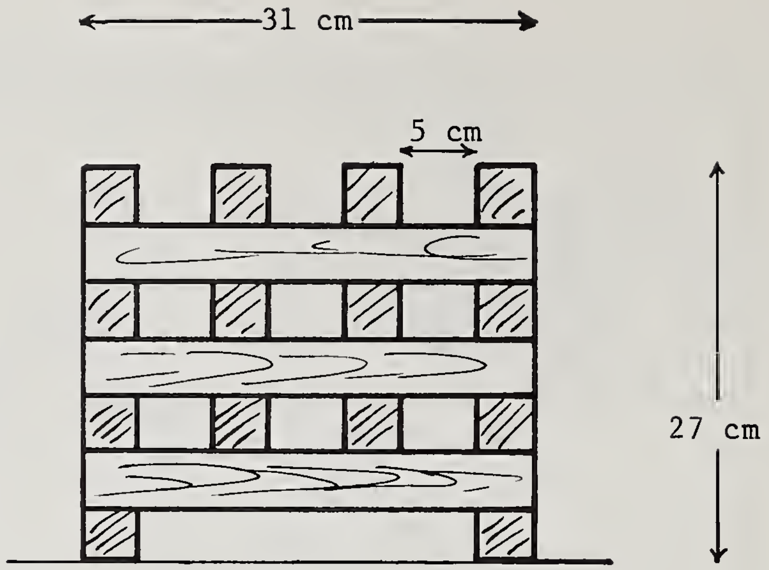


Instrumentation:

Total heat flux meter, radiometer,
and thermocouple located at A, B, and C on the floor
Thermocouple tree located at D

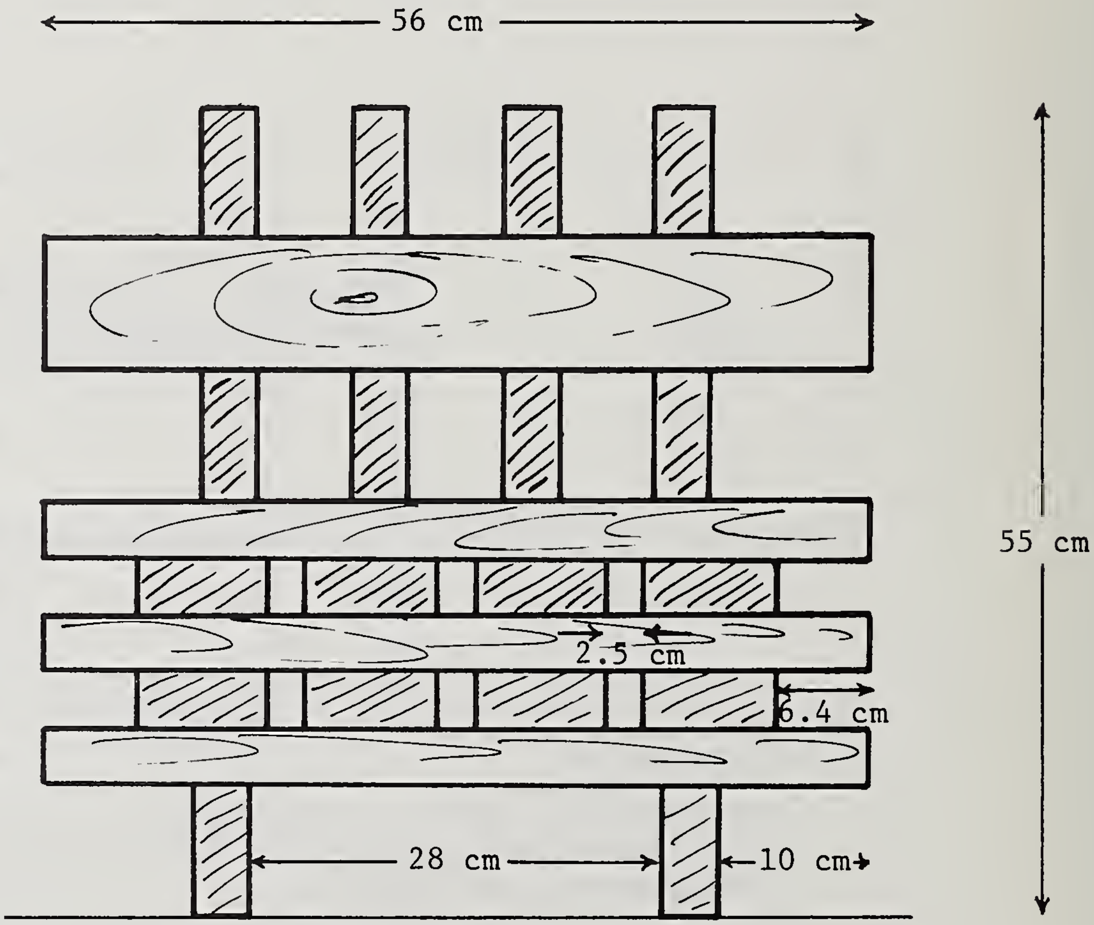
Figure 2. Diagram of the Burn-Room Showing Location of Wood Crib and Arrangement of Instrumentation

Layer No.	No. of Sticks
1	4
2	4
3	4
4	4
5	4
6	4
7	2



6.4 kg

Layer No.	No. of Sticks
1	4
2	4
3	4
4	4
5	4
6	4
7	4
8	4
9	4



29 kg

Figure 3. Wood Cribs (Elevation)

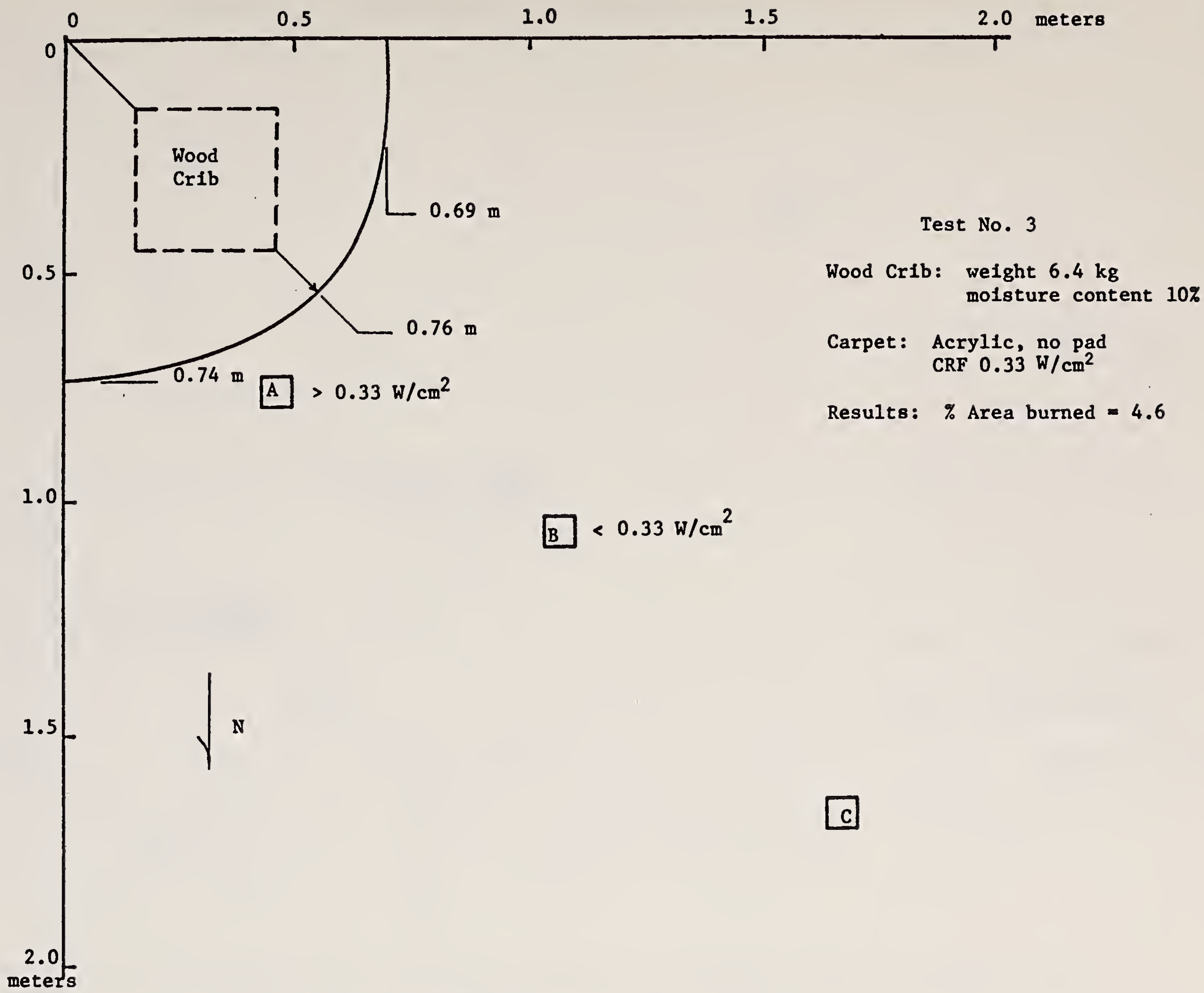


Figure 4. Carpet Burn Area - Test No. 3

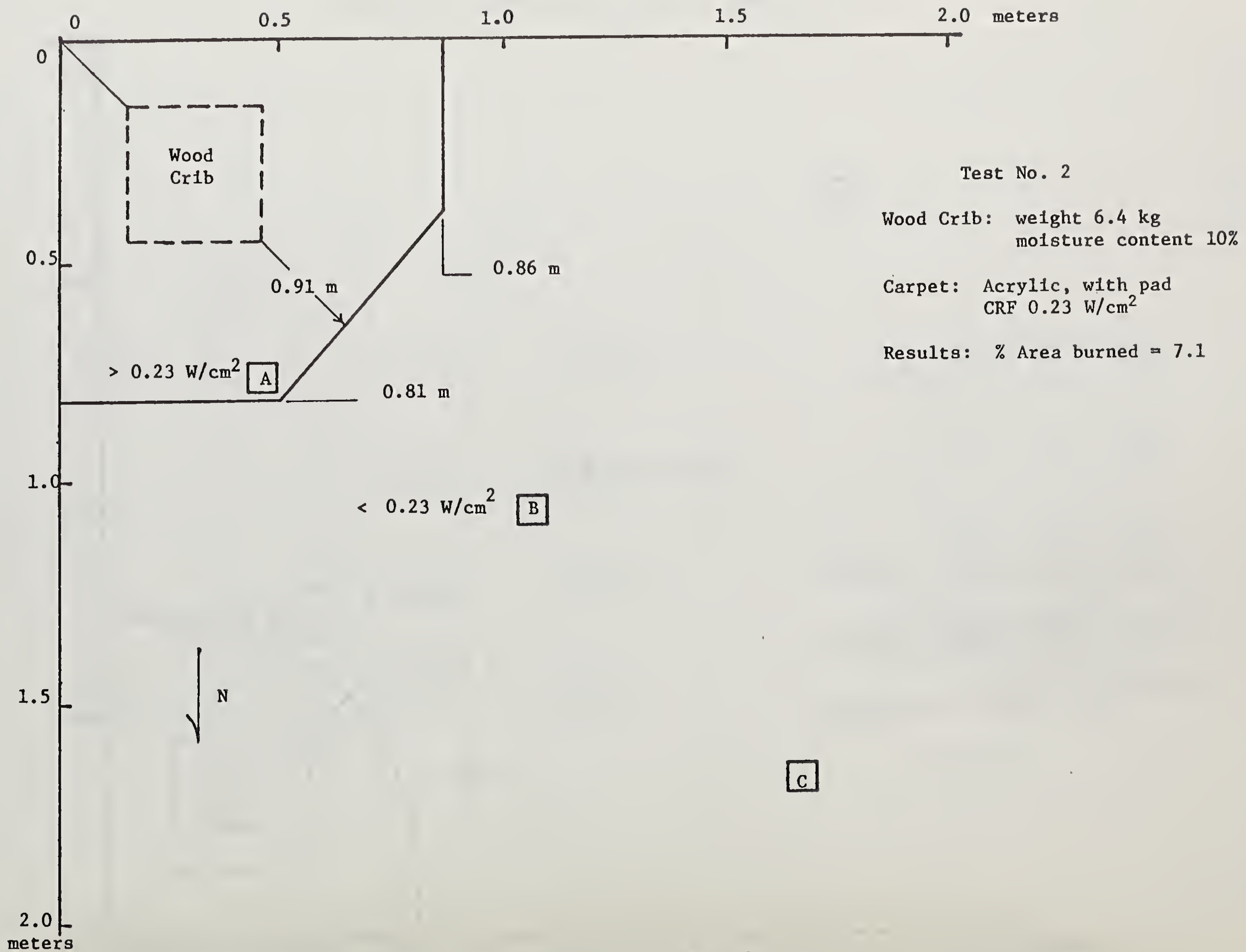


Figure 5. Carpet Burn Area - Test No. 2

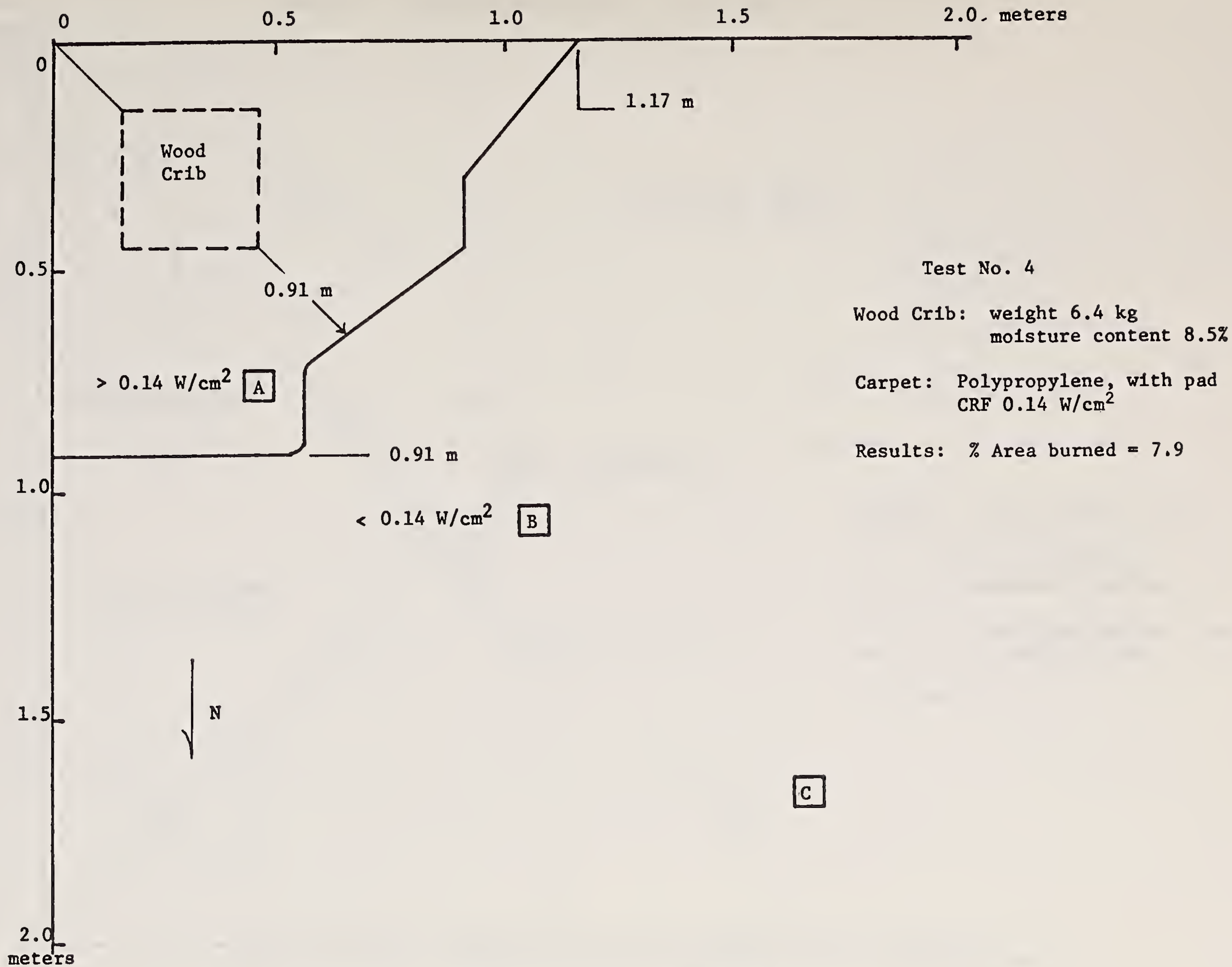
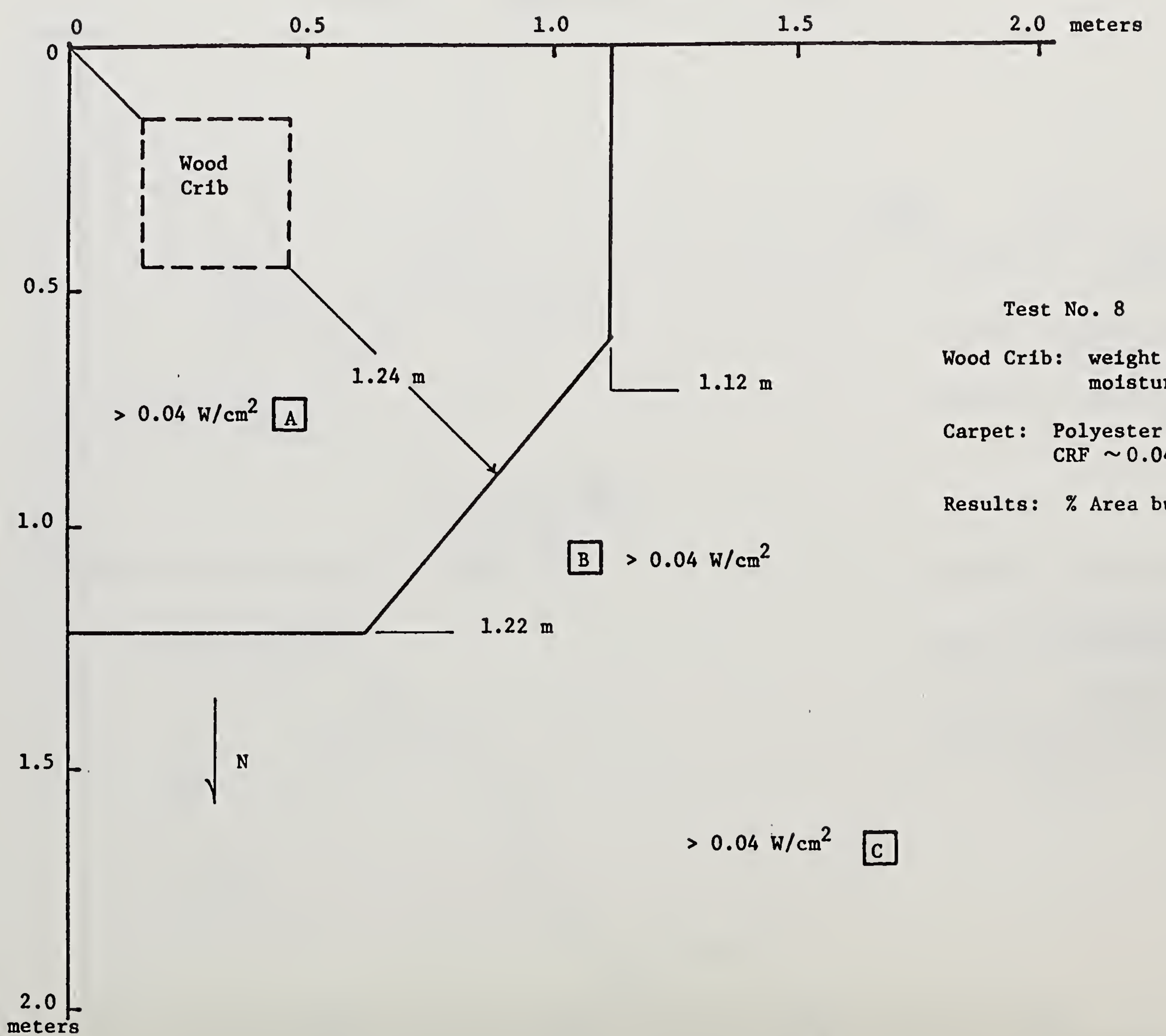


Figure 6. Carpet Burn Area - Test No. 4



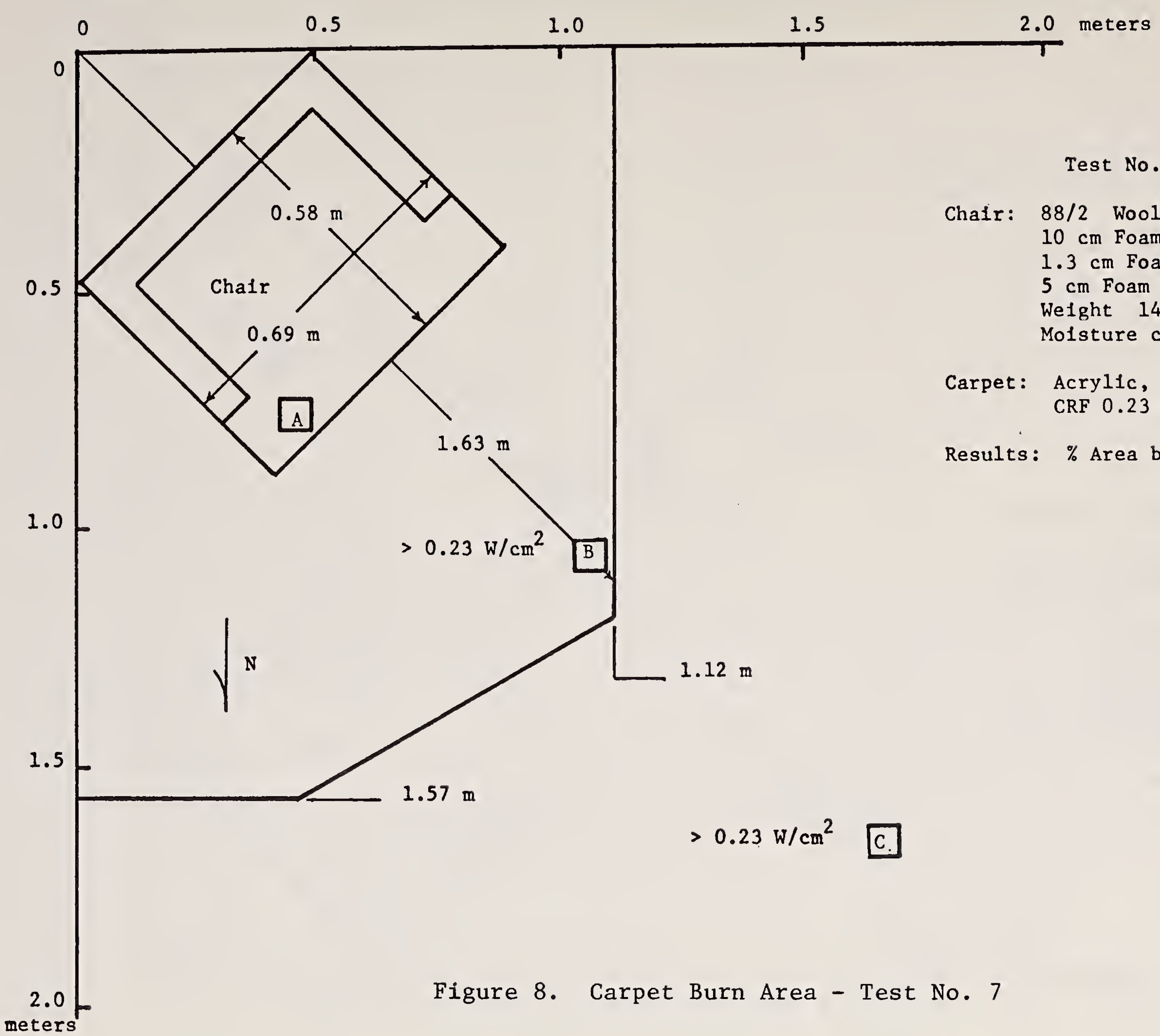
Test No. 8

Wood Crib: weight 6.4 kg
moisture content 7-8%

Carpet: Polyester, with pad
CRF ~ 0.04 W/cm^2

Results: % Area burned = 13.1

Figure 7. Carpet Burn Area - Test No. 8



Test No. 7

Chair: 88/2 Wool/Nylon Cover
10 cm Foam seat
1.3 cm Foam over 5 cm cotton sides
5 cm Foam back
Weight 14.5 kg
Moisture content 7-8%

Carpet: Acrylic, with pad
CRF 0.23 W/cm^2

Results: % Area burned = 17.8

Figure 8. Carpet Burn Area - Test No. 7

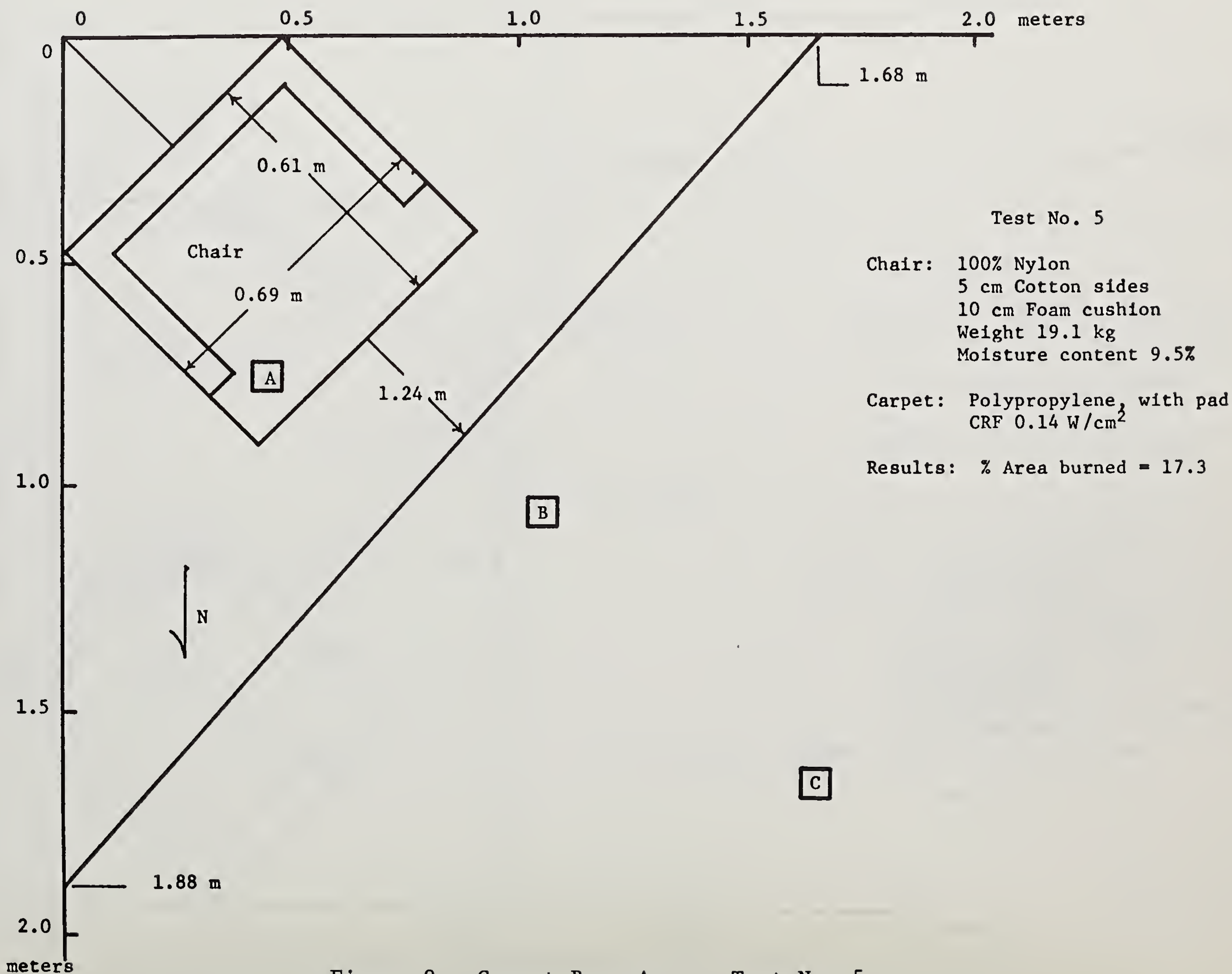


Figure 9. Carpet Burn Area - Test No. 5

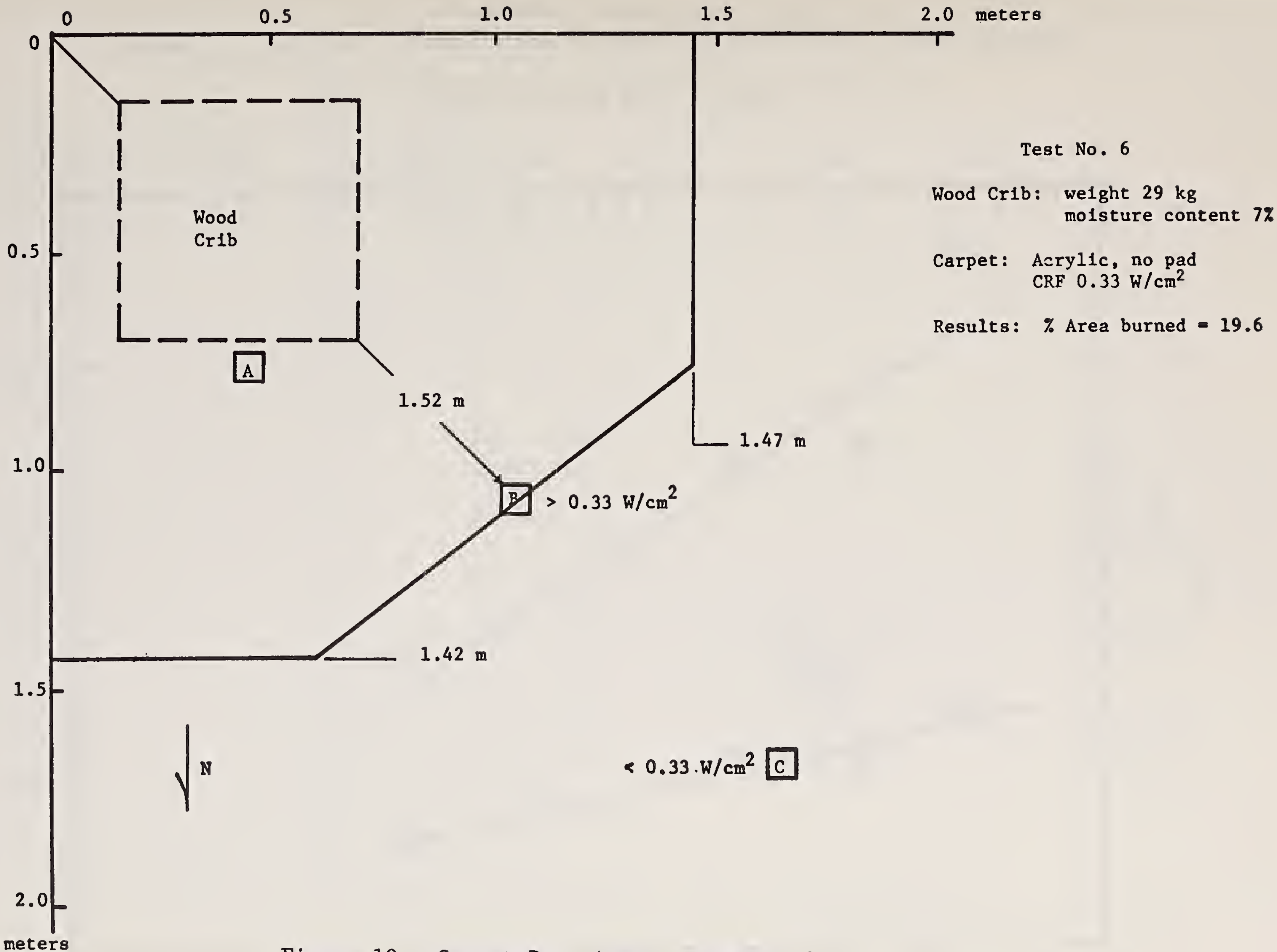


Figure 10. Carpet Burn Area - Test No. 6

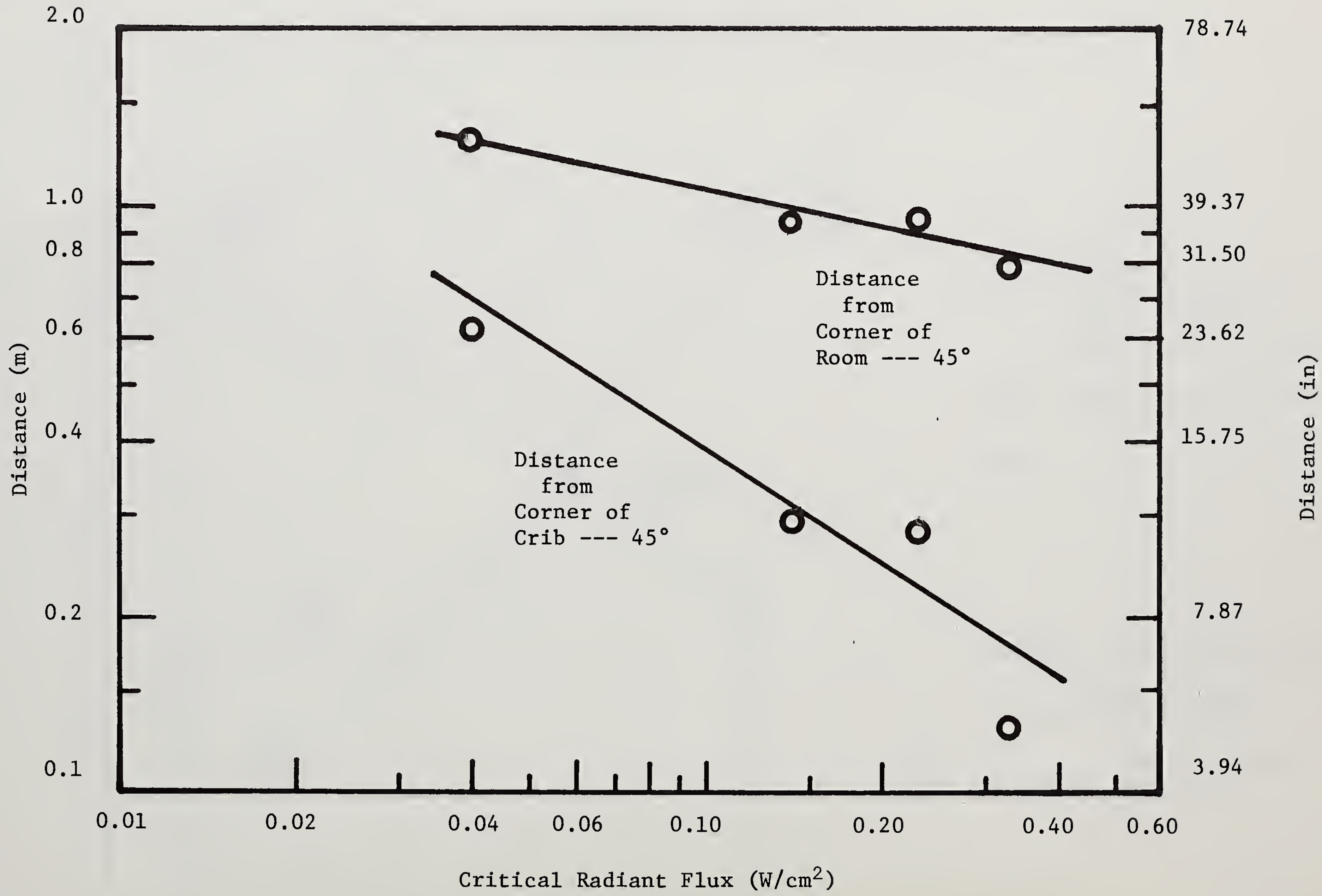


Figure 11. Distance Burned Versus Critical Radiant Flux of Carpet Systems

Test No. 1 (Blank)

Wood Crib 6.4 kg

No Carpet

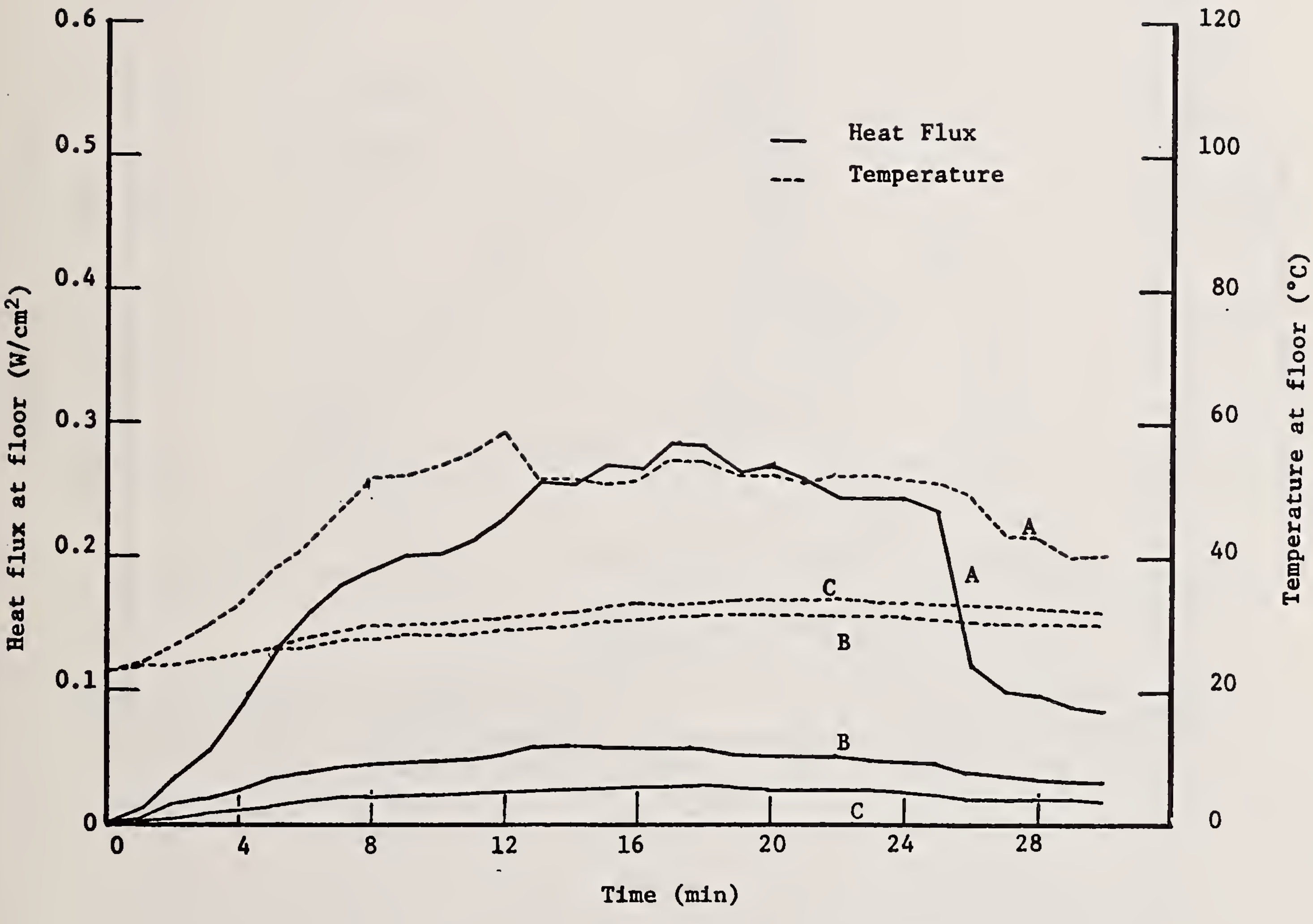


Figure 12. Total Heat Flux and Temperature - Test No. 1

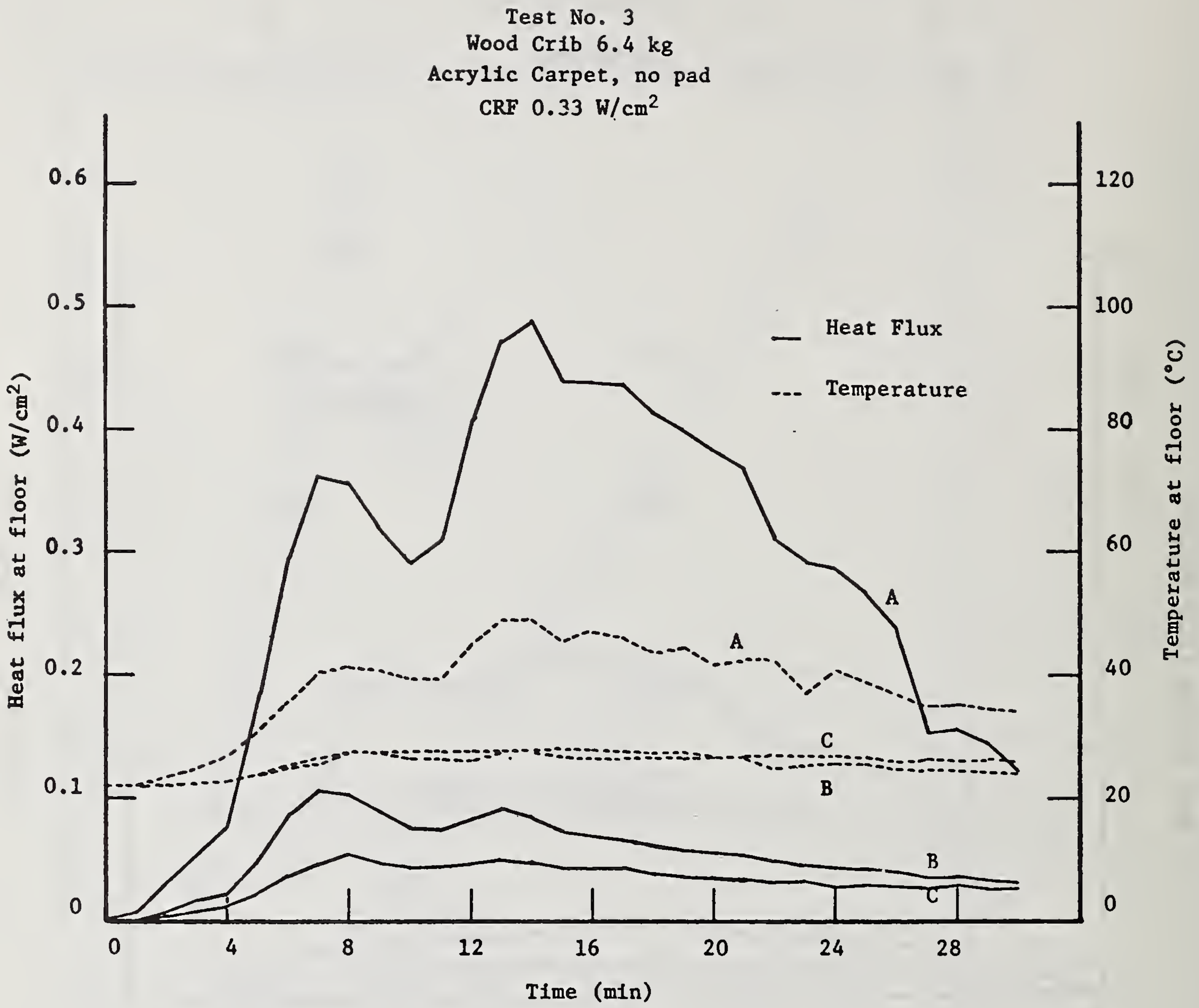


Figure 13. Total Heat Flux and Temperature - Test No. 3

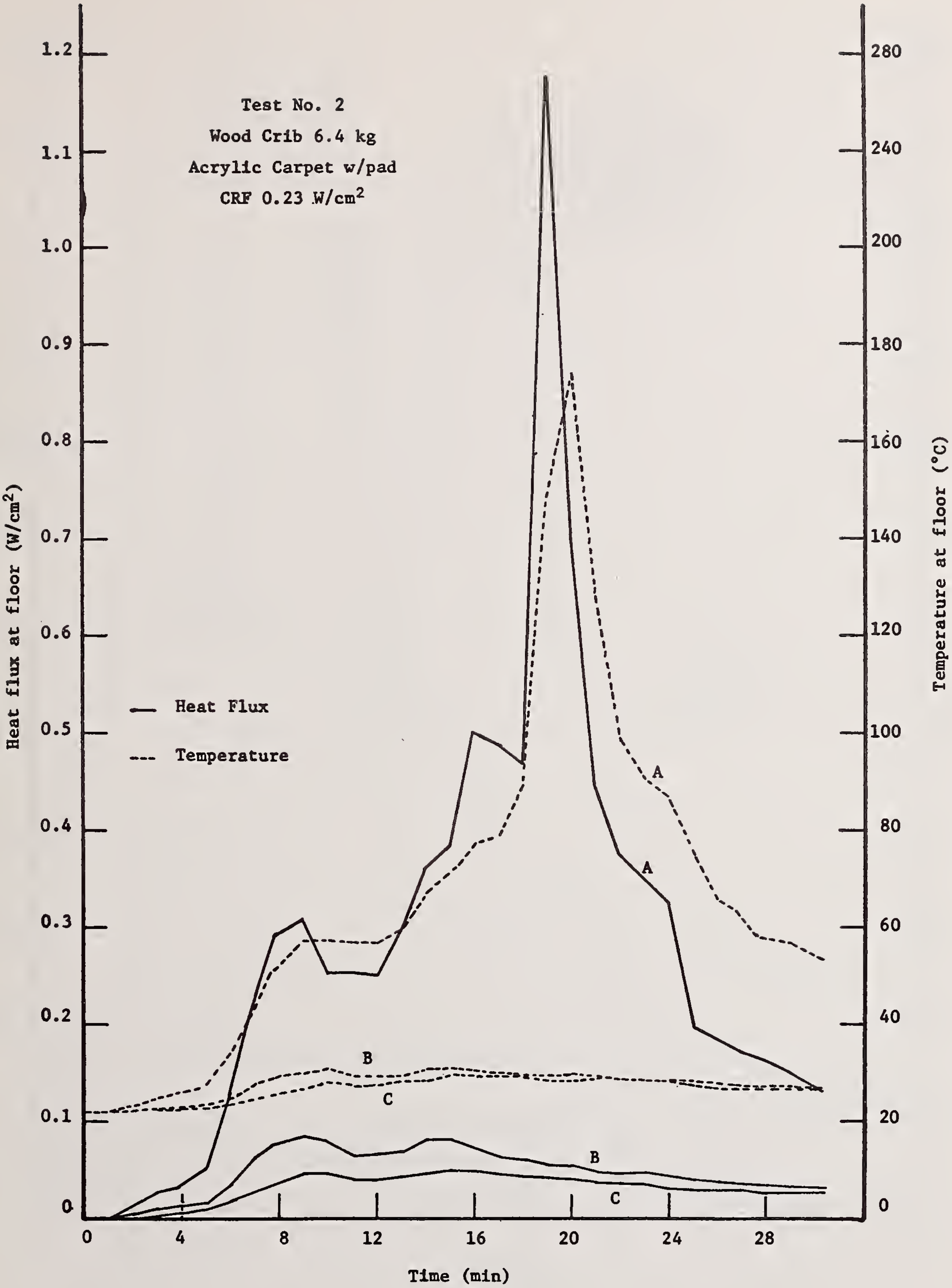


Figure 14. Total Heat Flux and Temperature - Test No. 2

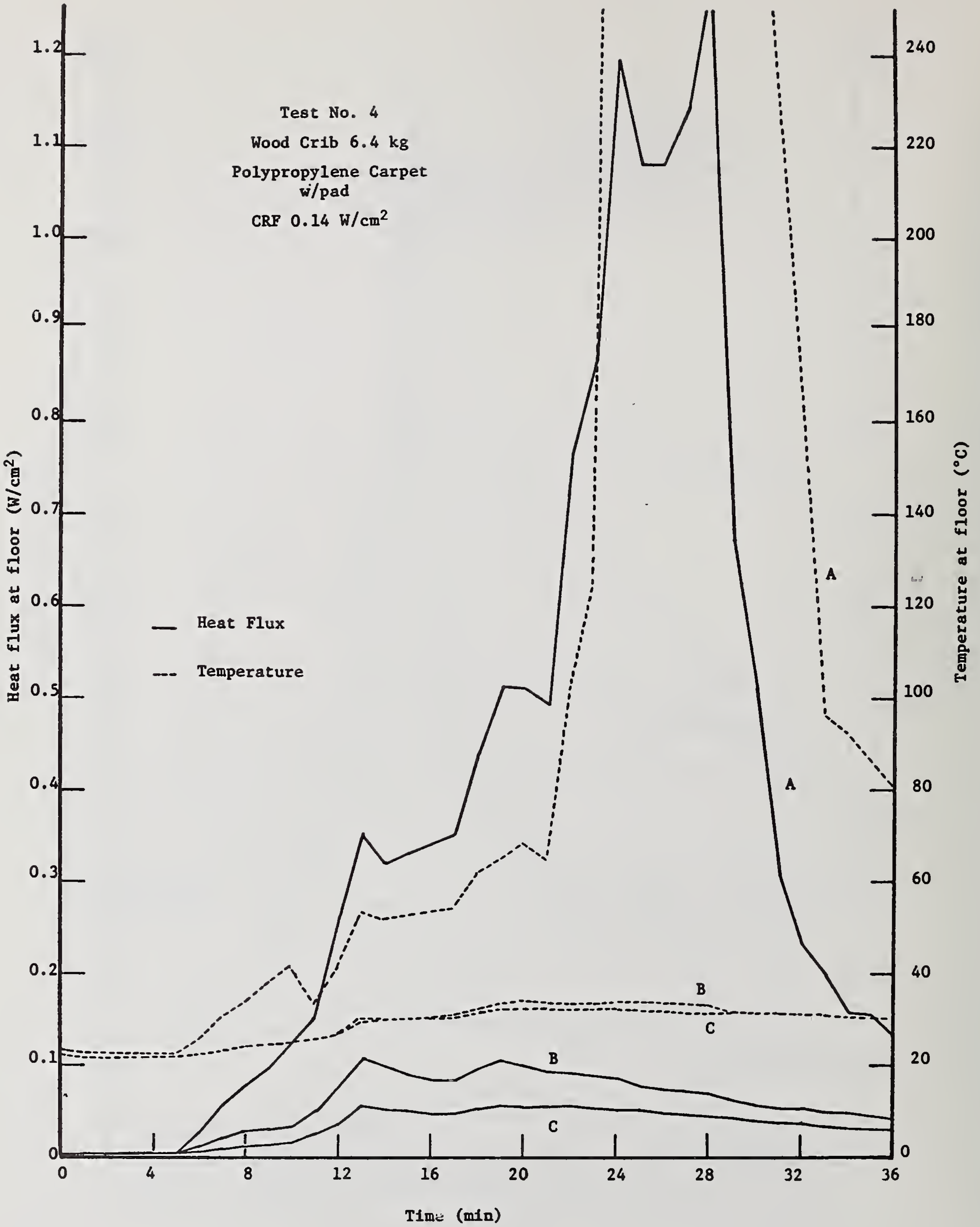


Figure 15. Total Heat Flux and Temperature - Test No. 4

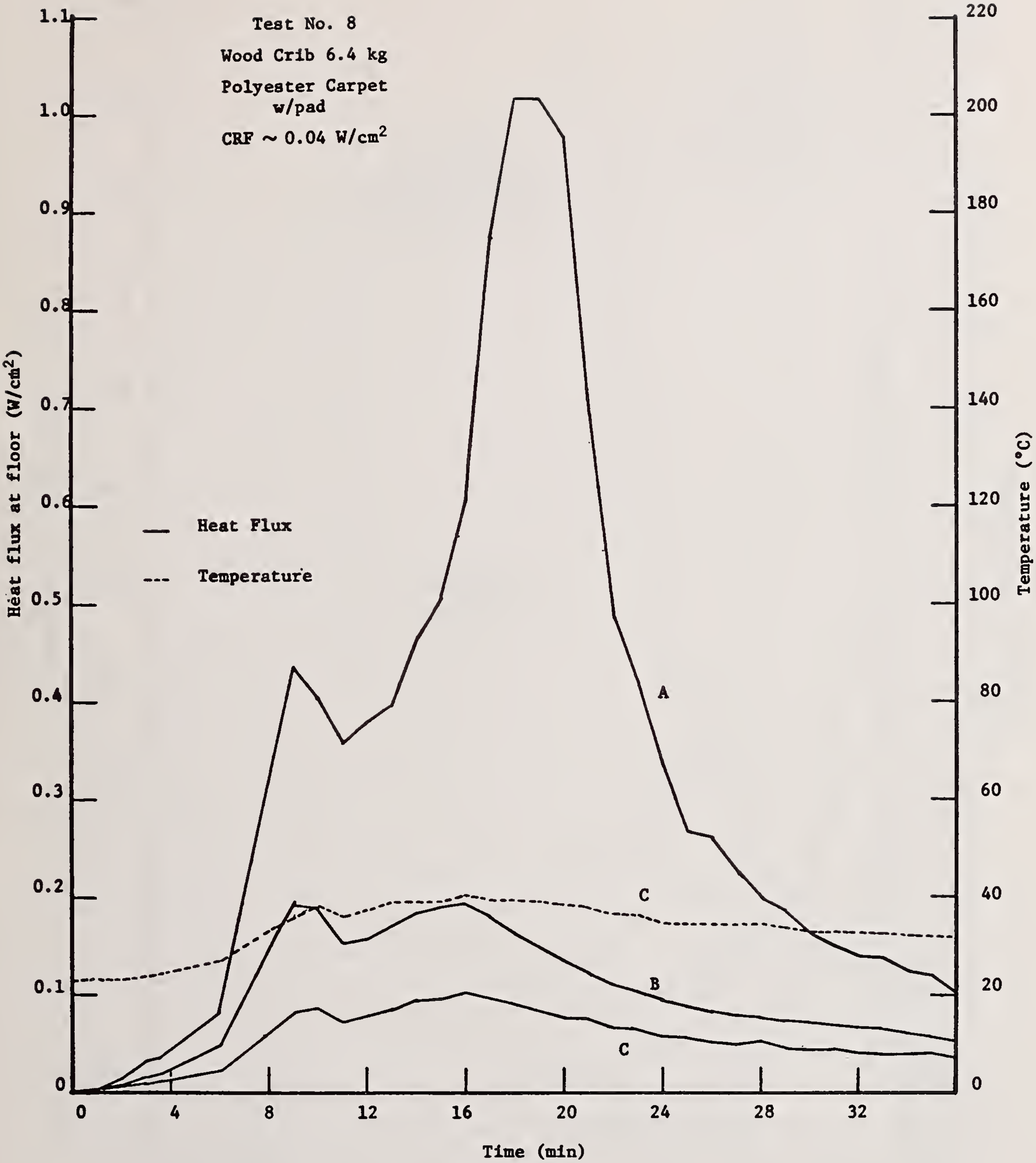


Figure 16. Total Heat Flux and Temperature - Test No. 8

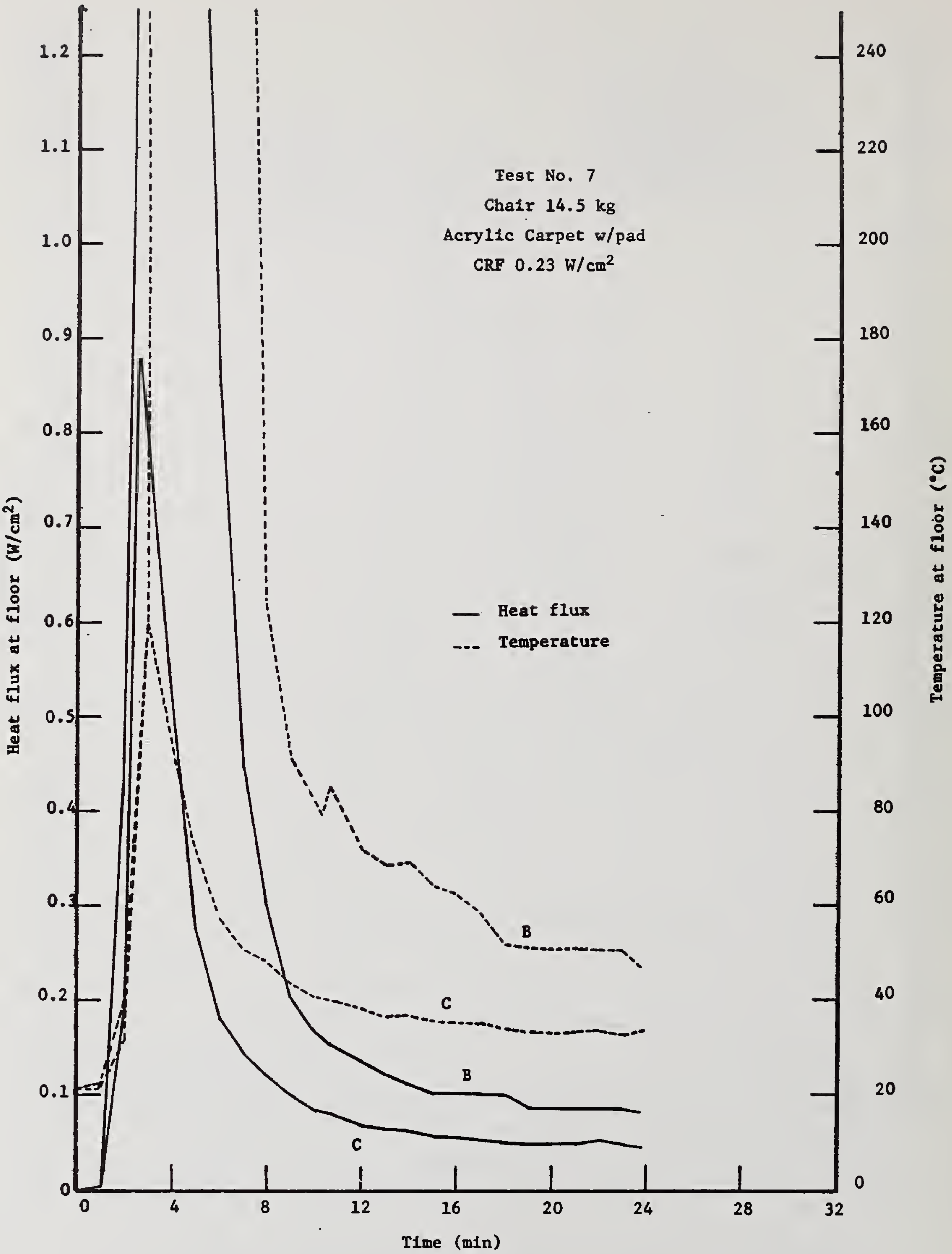


Figure 17. Total Heat Flux and Temperature - Test No. 7

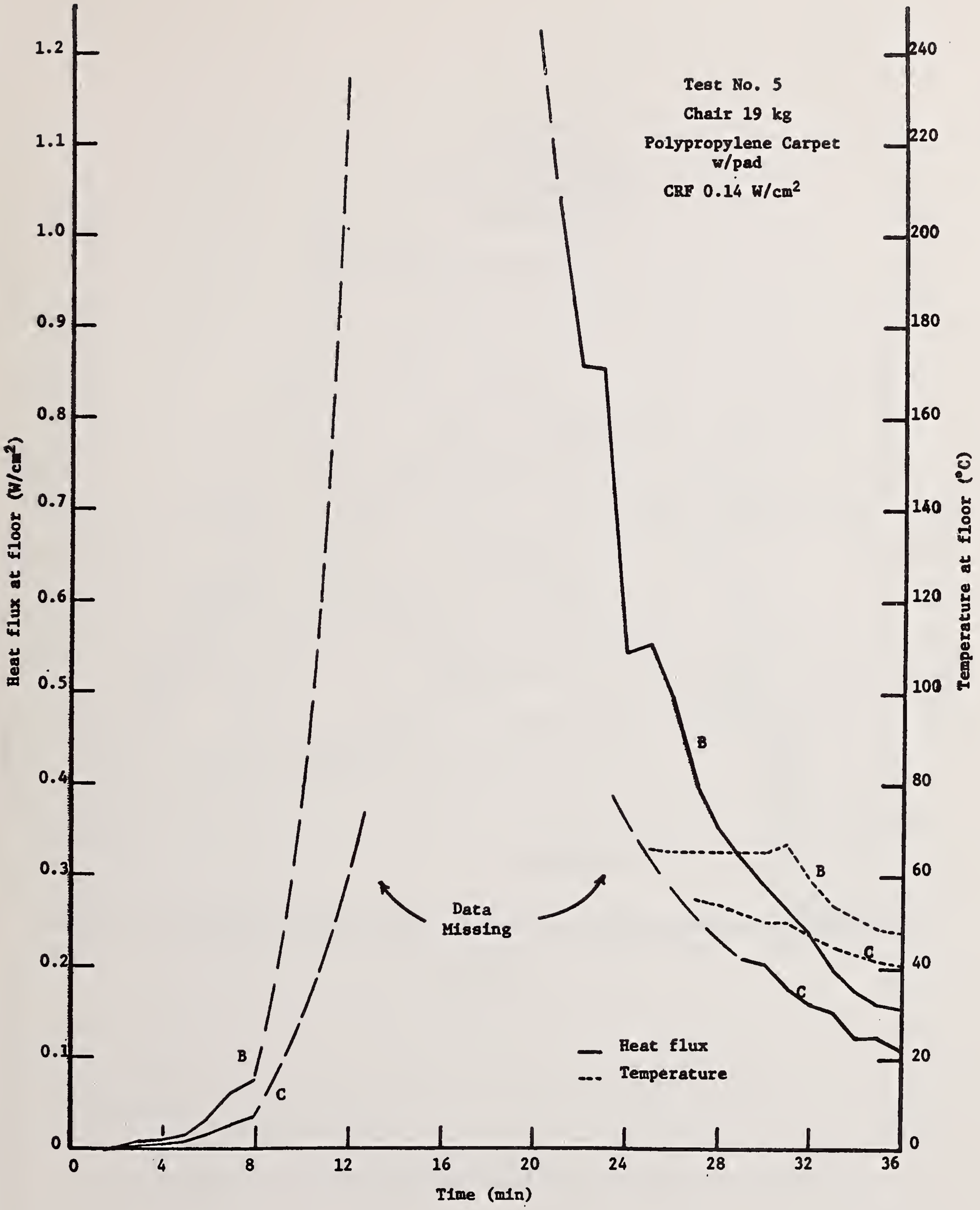


Figure 18. Total Heat Flux and Temperatures - Test No. 5

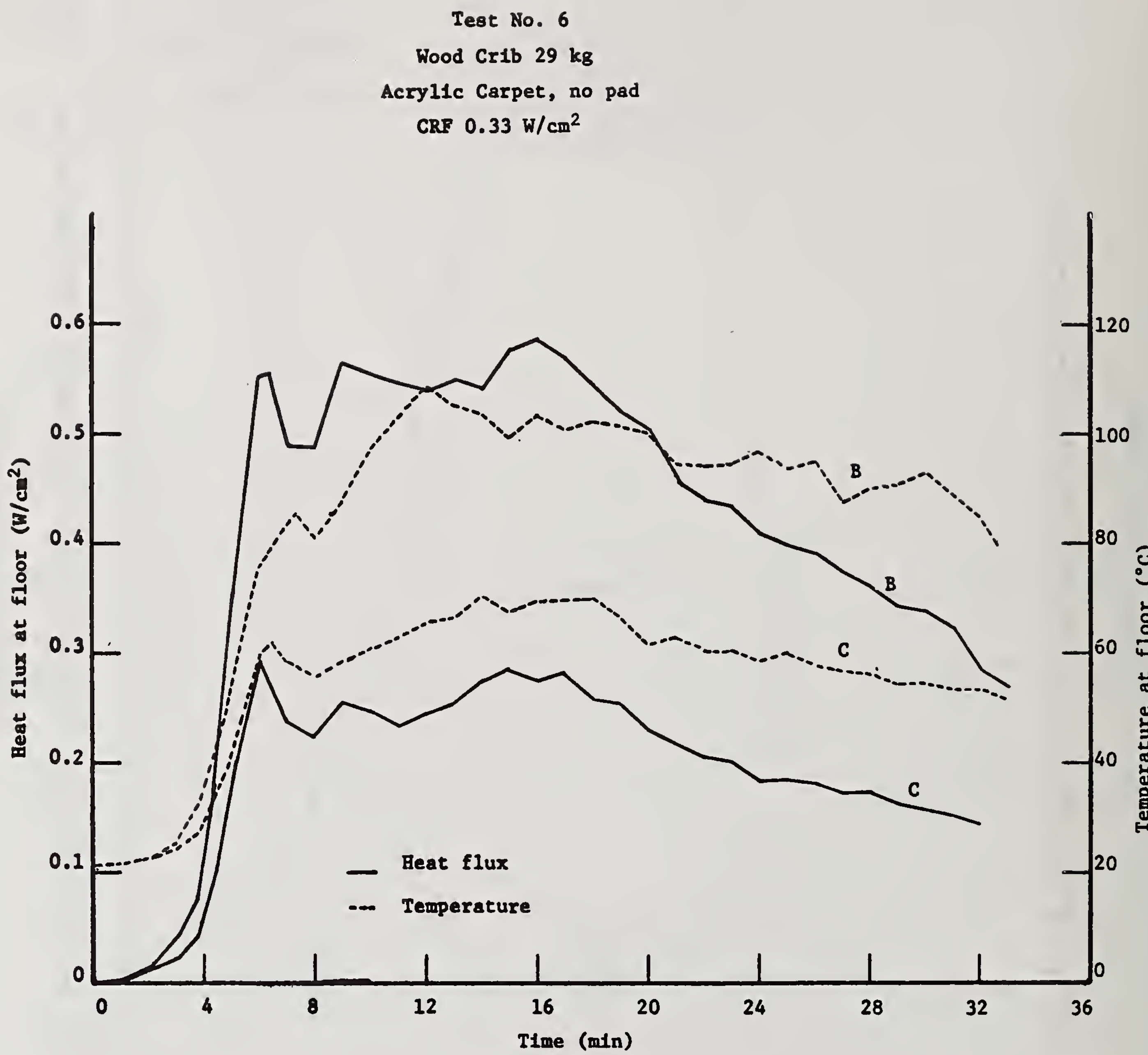


Figure 19. Total Heat Flux and Temperature - Test No. 6

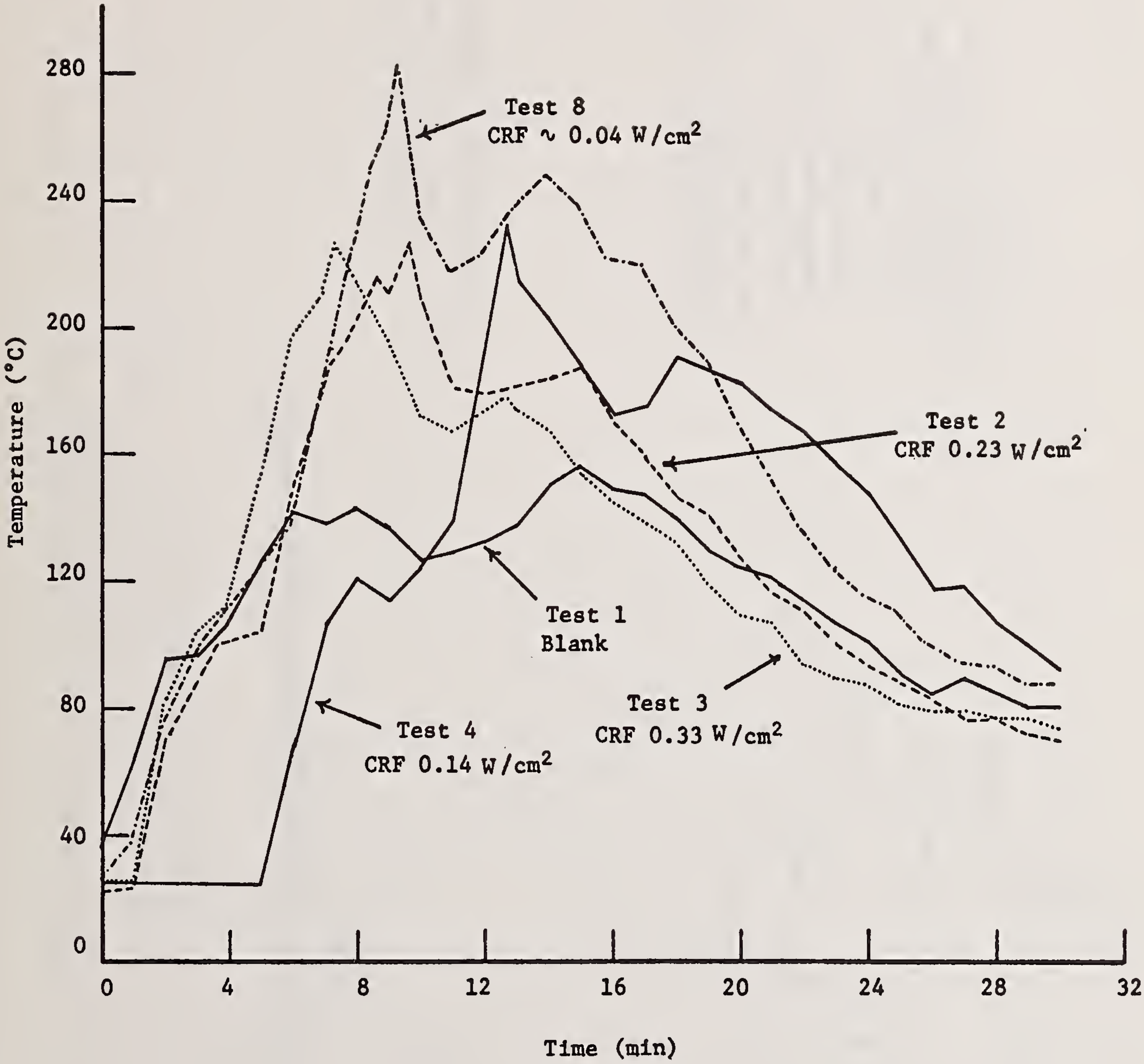


Figure 20. Gas Temperatures 7.6 cm Below Ceiling (Wood Cribs 6.4 kg)

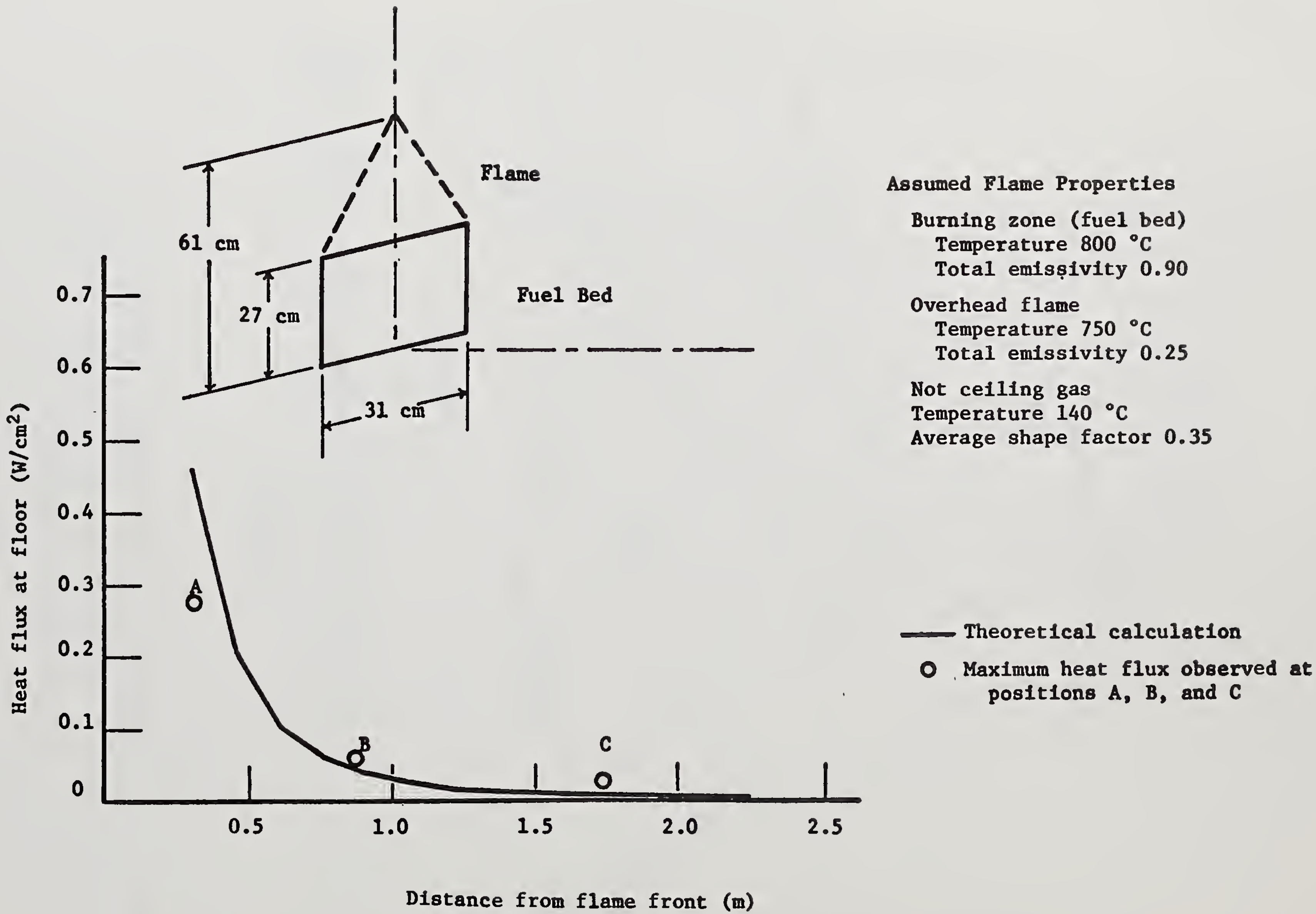


Figure 21. Distribution of Incident Radiant Heat Flux on the Floor Due to a Fire from a 6.4-kg Wood Crib

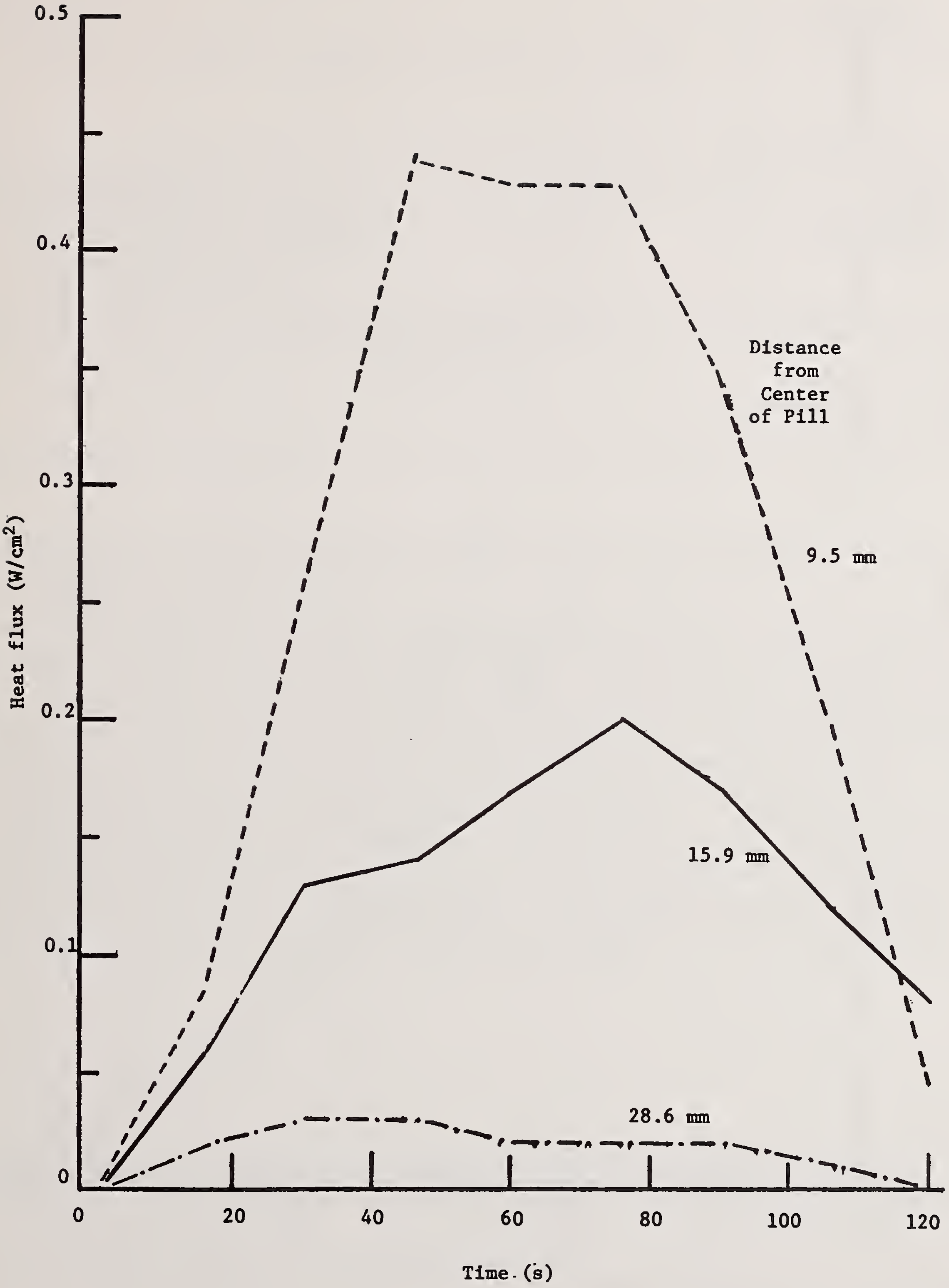


Figure 22. Heat Flux to Substrate for a Methenamine Pill

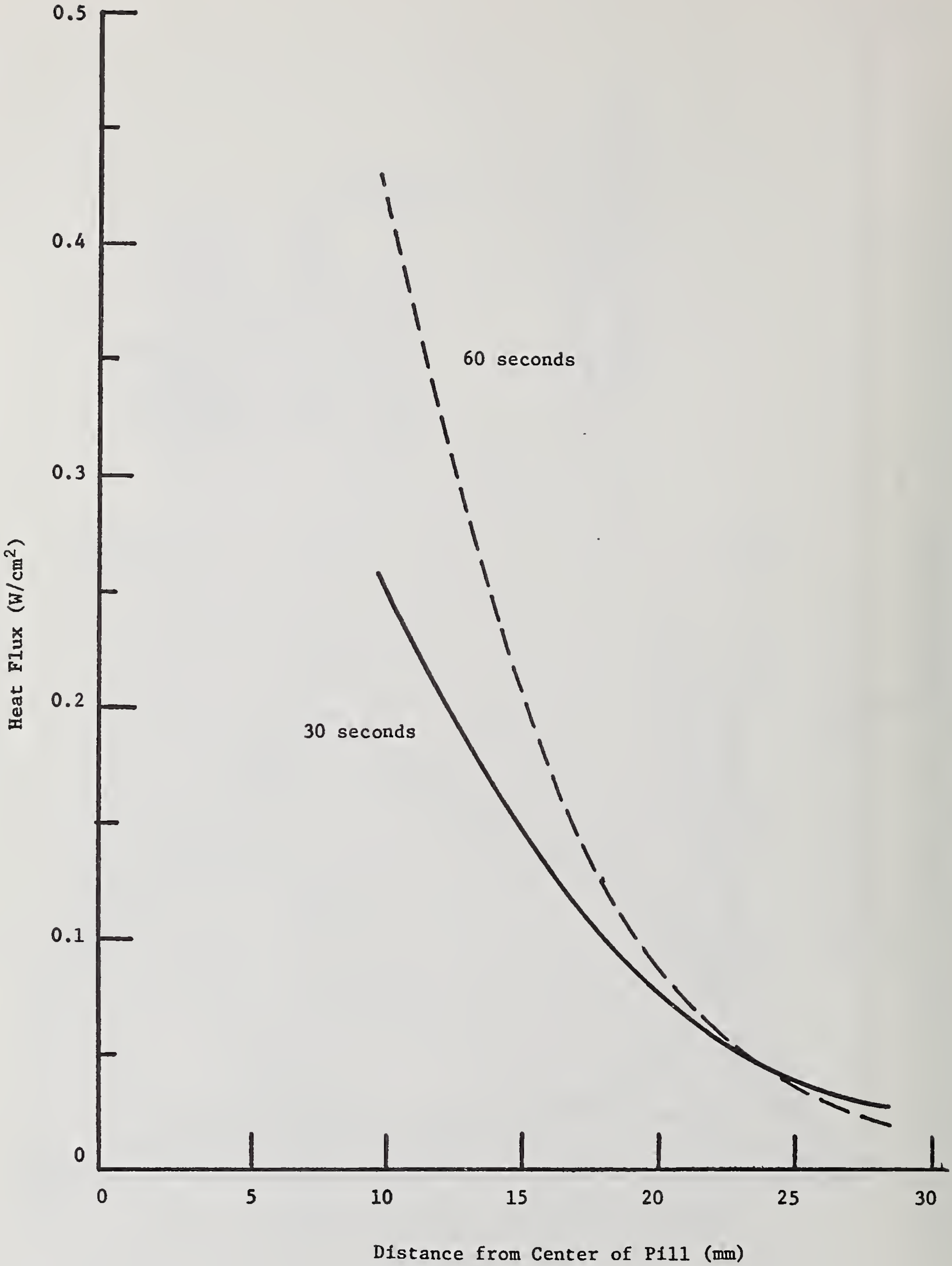


Figure 23. Methenamine Pill Heat Flux to Substrate for a Methenamine Pill

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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.)*

This study was designed to test the hypothesis that given a situation where a chair or other item of furniture becomes the first item to burn in a room (providing the ceiling and walls are non-combustible), there is little reason to expect involvement of the carpet in the fire beyond the immediate vicinity of the burning object. Four small-sized carpet fire tests and eight full-scale burn room fire experiments were conducted. Experimental data for temperature distribution and incident heat flux to the floor covering were measured in the rooms. General analysis of the experimental results obtained shows this to be the case. It also is evident that the critical radiant flux of the floor covering system is predictive of the extent of burning. From this study, carpet systems used in rooms will not normally spread fire provided they meet the requirements of DOC FF 1-70 (the pill test).

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)* Carpets; carpet systems; fire safety; flame spread; flooring radiant panel test; floor coverings; ignition sources; pill test; room fires.

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