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Characteristics of Incidental Fires in the Living Room of A Mobile Home

David P. Klein

Center for Fire Research
National Engineering Laboratory
National Bureau of Standards
Washington, D.C. 20234

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CHARACTERISTICS OF INCIDENTAL FIRES IN THE LIVING ROOM OF A MOBILE HOME[1]

David P. Klein

Abstract

A series of fire tests was conducted in the corner of a mobile home living room. The corner was lined with interior finish materials which did not contribute to the fires. The test series was designed to examine the fire characteristics of typical incidental (low intensity) fires which may be used as the ignition source for tests to evaluate the effects of interior finish materials.

This test series involved three types of source fires: standardized wood cribs ranging in weight from 2.3 kg to 13.6 kg (5 lb to 30 lb), identically constructed upholstered chairs, and polyethylene waste containers filled with crumpled newsprint. Experimental measurements were made of burn rate, temperature, heat flux, flame height, smoke density, and concentrations of oxygen, carbon monoxide, and carbon dioxide.

Under the test conditions employed, it was found that the fire severities for the several sizes of standardized wood cribs fell between those for the polyethylene waste containers filled with crumpled newsprint and the more severe incidental fires produced by the 16 kg (35 lb) upholstered chairs in terms of characteristics such as maximum temperature and heat flux levels, flame height, and changes in oxygen, carbon monoxide and carbon dioxide concentrations. Of the fires with wood cribs, it was found that the fires with 13.6 kg (30 lb) standardized wood cribs were most similar to the fires with 16 kg (35 lb) upholstered chairs, although the peak burning rate was generally higher for fires with upholstered chairs than for fires with wood cribs. It was also found that the time to reach the period of active burning was more reproducible for fires with wood cribs than fires with upholstered chairs.

Key words: Chairs; compartment fires; crib fires; fire tests; incidental fires; ignition source; mobile homes; repeatability; source fires; upholstered furniture.

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[1]This work was principally supported by funds provided by the Division of Energy, Building Technology and Standards, Office of Policy Development and Research of the U.S. Department of Housing and Urban Development with supplemental funding by the Center for Fire Research at the National Bureau of Standards.

1. INTRODUCTION

The work reported here is based on completion of a segment of a broad ongoing research program at the National Bureau of Standards to investigate some of the characteristics which may affect the growth and spread of fire in a single-wide mobile home. As part of the program, full-scale fire tests were conducted in typical mobile homes to characterize fire growth potential as a function of the interior finish materials used on the walls and ceiling in different areas throughout the mobile home. These tests were designed based on a scenario in which an incidental (i.e., low intensity) fire starts in the corner of a room and becomes more severe by involving the interior finish materials on the walls and ceiling. This scenario was based on examination of current residential fire loss data. These data indicate that a large percentage of fires occurring in residential occupancies are initially incidental in nature, and that in many fires, especially those in mobile homes, the spread of flame from the initial burning item appears to result from involvement of the wall and ceiling materials [1-6].[2]

Incidental fires, such as might occur in a wastebasket or upholstered chair, have been defined by Gross and Fang [7] as being of limited size, duration, and energy content. For this study an incidental fire is considered to be one that by itself does not cause flashover[3] in the room in which it is burning. While an incidental fire does not cause flashover in a room, the ignition of nearby combustibles, including interior finish materials, may result in a more severe situation, including the possiblity of flashover. For this reason incidental fires are frequently used when evaluating the effects of interior finish materials used on wall and ceiling systems. Fang [10] has reported that the essential characteristics of typical incidental fires, e.g. burning time, temperature and heat flux levels, and the size and shape of the flame, can be duplicated with reproducible fires from a standardized wood crib (cross-piled pieces of wood). Other researchers have noted similar findings. Theobald and Heselden [11] concluded that fires from wood cribs constructed of 40 mm (1.6 in) thick sticks are reasonably representative of fires from various types of upholstered chairs and other wood furniture which they tested. And it has been reported by researchers at Underwriters Laboratories [12] that 1500 g (3.3 lb) wood cribs constructed of 25 mm (1 in) thick sticks provided consistent, reproducible ignitions of urethane-foam-padded upholstered chairs weighing approximately 15 kg (33 lb) and provided ignition of wall finish materials in a corner configuration without prior flame impingement on the ceiling.

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

[3]Flashover is defined here as a fire phenomenon in which the heated upper surfaces of a room transmit sufficient radiation into the lower part of the room to cause ignition of all combustible materials [8]. The term is synonomous with the phrase "total room involvement" [9].

In light of the complex and frequently unreproducible nature of real-world fire situations, the maximum possible reproducibility in initial fire build-up is desirable when conducting comparative full-scale fire testing. Experiments have demonstrated that the initial fire development in a typical item of furniture such as an upholstered chair may be considerably different from test to test, even when tested under similar fire conditions [13]. This is primarily due to the variation in sequential involvement of portions of the burning item. The use of reproducible incidental fires such as those afforded by standardized wood cribs minimizes variation in initial fire build-up and thereby allows a more precise evaluation to be obtained.

When using crib fires and other incidental fires to provide the ignition source for evaluating the effects of interior finish materials, it is of value to know the effects of the incidental fires themselves. This report addresses the results of a series of tests which was designed to examine the fire characteristics of some typical incidental fires in the living room of a mobile home.

Several different types of incidental fires were tested in a corner configuration. The corner was chosen because the confinement of the hot combustion gases and the reflected radiation from the walls cause an increased fire severity in that configuration. Since the intent of the tests was to develop data on the incidental fires themselves, the room was designed not to contribute heat, flames or smoke to the fires. In addition, no other combustible items were included in the living room during the tests.

The objectives of this test series were:

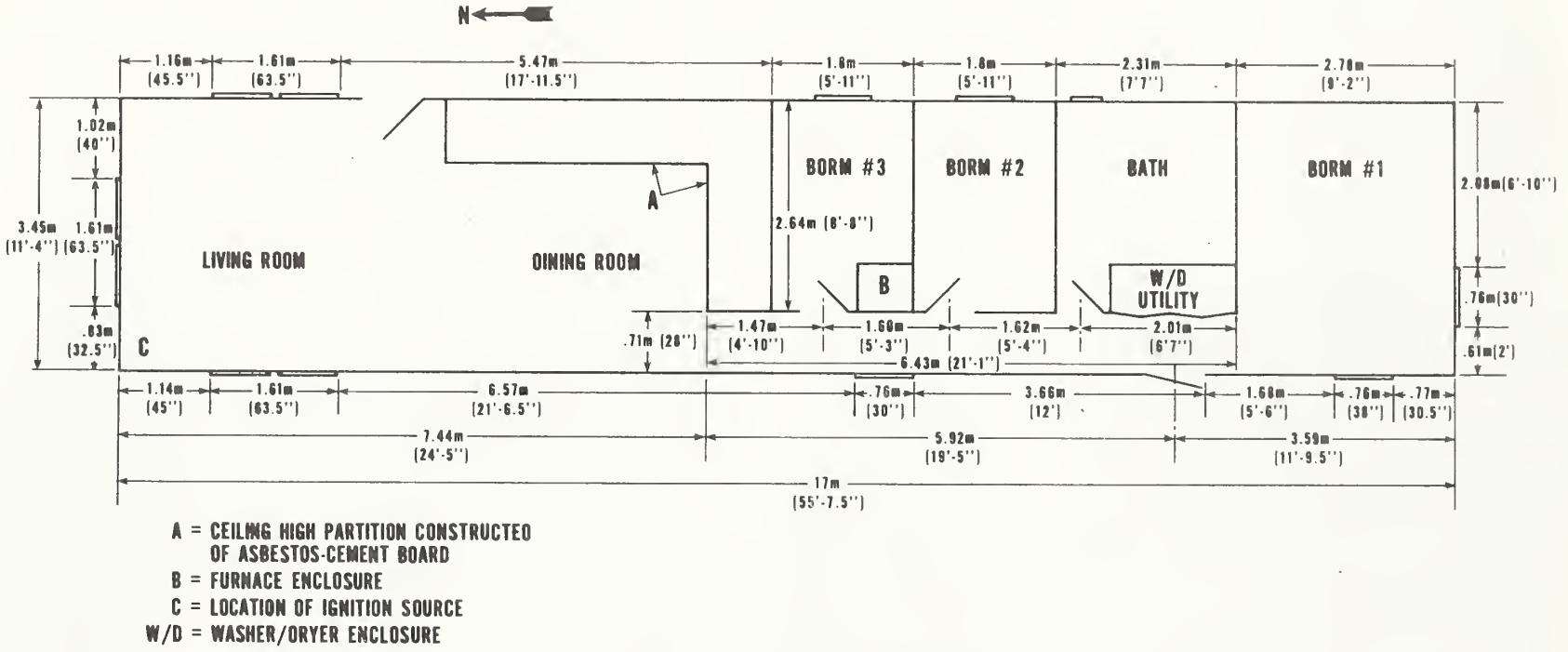
1. To provide a comparison of the characteristics, such as burn rate, temperature and heat flux levels, flame height, smoke densities, and concentrations of oxygen, carbon monoxide, and carbon dioxide, of fires with medium size upholstered chairs, small waste containers filled with newsprint, and several sizes of standardized wood cribs.

2. To obtain data on incidental fires resulting from the burning of the upholstered chairs, waste containers, and wood cribs in a compartment designed not to contribute to the fires, in order to provide information for comparison with data on similar incidental fires in the same compartment lined with combustible interior finish materials on the walls and ceilings (see reference [14]).

2. EXPERIMENTAL DETAILS

2.1 Test Facility

The tests were conducted in a typical single-wide mobile home whose exterior dimensions were approximately 3.6 x 18.3 m (12 x 60 ft). The mobile home included a living room and dining area, kitchen, bathroom,



A = CEILING HIGH PARTITION CONSTRUCTED OF ASBESTOS-CEMENT BOARD
B = FURNACE ENCLOSURE
C = LOCATION OF IGNITION SOURCE
W/D = WASHER/DRYER ENCLOSURE

Figure 1. Plan view of the mobile home test unit illustrating dimensions.

and three bedrooms (see figure 1). The dimensions of the living/dining room were approximately 7.5 m (24 ft 5 in) long and 3.5 m (11 ft 4 in) wide with a net usable floor area of 23.6 m^2 (254 ft^2). The ceiling height in this room and throughout the mobile home was 2.1 m (7 ft). A ceiling-high partition constructed of cement asbestos board and covered with 13 mm (0.5 in) thick Type X gypsum wallboard was built in front of the kitchen area to protect it from the effects of the test fires. The other three walls and the ceiling of the room were also lined with 13 mm (0.5 in) thick Type X gypsum wallboard mechanically fastened to the wall studs and ceiling truss system. Additional protection in the northwest corner where the ignitions occurred was provided by 13 mm (0.5 in) thick sheets of calcium silicate ($CaSiO_3$) marine board[4] which were installed over the gypsum. The calcium silicate board extended from floor to ceiling and outward 1.2 m (4 ft) from the corner on both the north and east walls, and covered a 3.0 m^2 (32 ft^2) area of the ceiling in the corner. Calcium silicate board is an inorganic board that contributed no heat, flames, or smoke to the fires. Since none of the fires left the corner area the effect was a noncontributing compartment.

The exterior wall system of the mobile home consisted of nominal 51 x 76 mm (2 x 3 in) hemlock studs, 406 mm (16 in) on center, with 64 mm (2.5 in) of single thickness paper-faced glass fiber insulation in the wall, and painted aluminum siding mechanically fastened on the exterior. The roof was constructed of painted aluminum sheeting mechanically fastened to a system of wood bow-string trusses, 406 mm (16 in) on center and insulated by 76 mm (3 in) of glass fiber above a polyethylene vapor barrier. The floor covering in the room was 3.1 mm (0.13 in) thick vinyl asbestos taken from a continuous 3.6 m (12 ft) wide roll and stapled to the 19 mm (0.75 in) thick particle board subfloor. The room contained six windows, each 660 x 762 mm (26 x 30 in) in size. Two each were located in the west, north, and east walls. The room contained no furnishings.

2.2 Instrumentation

Figure 2 is a diagram showing the locations where test parameters were measured. Table 1 lists each sampling location and its type of measurement. Table 2 lists the range and sensitivity of the instrumentation.

Temperature measurements were taken with 47 thermocouples located throughout the mobile home. The thermocouple trees located in the center of the living room and bedroom #1 and the set of three thermocouples located 0.9 m (3 ft) above the floor of the living room at horizontal

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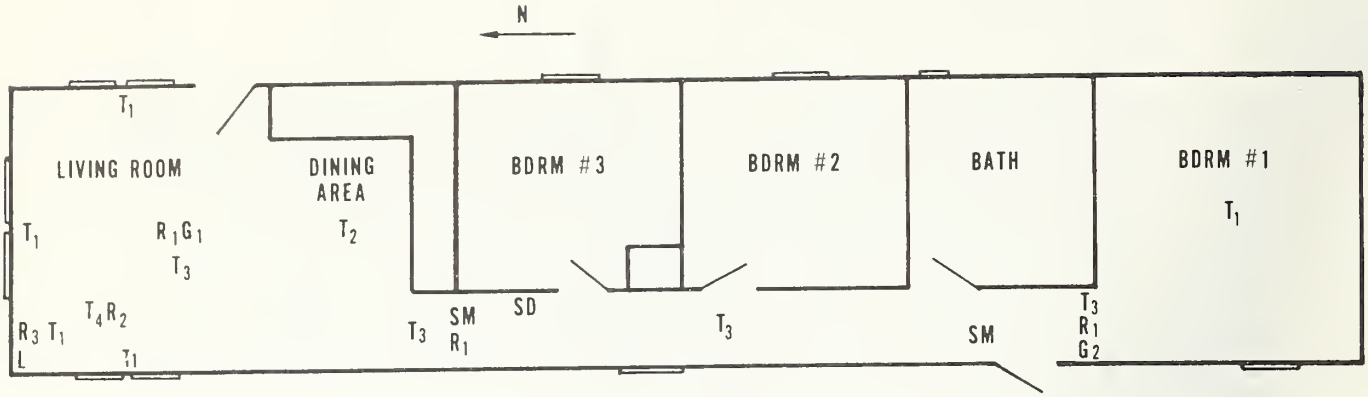
[4]Manufacturer's specifications for the calcium silicate board are:
density = 46 lb/ft^3
specific heat = 0.34 Btu/°F/lb at 800°F
thermal conductivity = 0.93 Btu $in/ft^2/°F/hr$ at 800°F



TEMPERATURE

T_1 = Thermocouples 211, 188, 132 cm above floor
T_2 = Thermocouples 211, 188, 132, 91 cm above floor
T_3 = Thermocouples 211, 188, 132, 91, 46, 2.5 cm above floor
T_4 = Thermocouples 92 cm above floor; 61, 122, 183 cm from specimen

INCIDENT HEAT FLUX

R_1 = Transducer at floor level
R_2 = Transducers 92 cm above floor; 61, 122, 183 cm from specimen
R_3 = Transducers at wall surface 92 cm and 183 cm above floor, transducer at ceiling level centered over specimen

WEIGHT LOSS OF SPECIMEN

L = Strain gage load cell

GAS CONCENTRATIONS

G_1 = CO, CO_2, O_2 sampled 1.5 m above floor
G_2 = CO, O_2 sampled 1.5 m above floor

SMOKE CONCENTRATION

SM = Horizontal smoke meter at 0.6, 1.2, 1.8 m above floor with path length of 0.8 m, and vertical smoke meter at ceiling with path length of 0.46 m

SMOKE DETECTOR

SD = Commerical ionization type smoke detector positioned 18 cm below ceiling on inside corridor wall

Figure 2. Plan view of the mobile home test unit illustrating sampling locations for experimental measurements.

distances of 0.6, 1.2, and 1.8 m (2, 4, and 6 ft) from the specimen were 0.61 mm diameter (24 gage) Chromel and Alumel wires enclosed in glass fiber insulation with bare beaded ends. The remaining thermocouples were 0.91 mm diameter (20 gage) Chromel and Alumel wires packed in mineral insulation and enclosed in a 3.150 mm (0.124 in) diameter Inconel 702 sheath with a grounded junction.

Measurements of incident heat flux were taken with nine water-cooled Gardon-type total incident heat flux transducers. Two were installed in the north wall flush with the wall surface immediately adjacent to the test specimen, one was installed in the ceiling, again flush with the surface, directly above and with a downward view in the direction of the flame plume, and three were located 0.9 m (3 ft) above the floor in the living room, with a horizontal view of the flame plume, at 0.6, 1.2, and 1.8 m (2, 4 and 6 ft) away from the specimen. The remaining three were located in the floor at the north and south ends of the corridor and the center of the living room, each with an upward view.

Levels of smoke density were measured at two locations, one at the south end of the corridor and one at the north end next to the entrance to the living room. All the smoke meters operated by continuously measuring the attenuation of a collimated beam of light from a tungsten lamp impinging on a photo tube. At each location three horizontally aligned smoke meters were positioned at 0.6, 1.2, and 1.8 m (2, 4, and 6 ft) above the floor. These meters were designed to measure the smoke stratification in the upper part of the corridor. The path length of each of these meters was approximately 0.8 m (30 in). In addition, at each location, one vertically aligned smoke meter was positioned midway between the corridor walls to measure smoke obscuration along a path from 610 mm (24 in) below the ceiling to 152 mm (6 in) below the ceiling.

In order to determine the rate of weight loss of the specimen during a test, each specimen was positioned on a water-cooled, strain gage load cell located in the northwest corner of the living room.

Continuous sampling of gas concentrations was made at 1.5 m (5 ft) above the floor in the center of the living room and at the south end of the corridor at the entrance to bedroom #1. These gases were filtered through glass fiber to remove soot and particulate matter, chilled in an ice bath to condense water vapor, and passed through an infrared gas analyzer to measure concentrations of CO and CO_2. Measurements of O_2 concentrations were made with chemical oxygen cells.

Indicator specimens of crumpled newsprint were placed on the floor of the living room at distances of 0.6, 1.2, and 1.8 m (2, 4, and 6 ft) from the specimen. Based on previous work [15], the crumpled newsprint was used to provide information on the time of involvement of combustible items in the room as a result of the incidental fire.

A commercially available, A.C. powered, ionization-type residential smoke detector was placed at the north end of the corridor. The detector was located on an inside wall, approximately 229 mm (9 in) below the ceiling and 381 mm (15 in) from the entrance to the living room.

Graphic documentation for the tests was provided by 35 mm color slides and black and white video tape. In addition, visual observations were recorded on a tape recorder and transcribed after each test.

Signals from all the instruments were collected every 10 seconds on a multiple-channel data acquisition system and were recorded on magnetic tape in order to be processed by computer. In addition, data from 24 thermocouples, the heat flux transducers, the gas analyzers, and the load cell were simultaneously recorded either on strip chart or multi-point recorders.

2.3 Test Specimens

The specimens tested were upholstered chairs, all weighing approximately 16 kg (35 lbs), 0.3 kg (12 oz) polyethylene waste containers (9 liter (9.5 quart) capacity) filled with approximately 227 g (0.5 lb) of crumpled newsprint, and 2.3 kg (5 lb), 6.4 kg (14 lb), 9.1 kg (20 lb), and 13.6 kg (30 lb) standardized wood cribs. The upholstered chairs were of the same design and were produced by the same manufacturer. Each was constructed of a wood frame with polyurethane foam and cotton batting, and covered with rayon fabric. The seat cushion was also polyurethane foam covered with rayon fabric. The chairs were stored in a test building until their weight stabilized. Temperature and relative humidity in the test building were maintained at 75 $\pm$ 5°F and 35 $\pm$ 10%, respectively. The wood cribs consisted of pieces of hemlock arranged in layers, with each layer placed at a right angle to the previous one. In addition, two bottom layers of two sticks each were included to support the crib above a pan of heptane. All the cribs were conditioned at 21 °C (70 °F) and 50% relative humidity until the moisture content and the resulting change in weight had stabilized. Because the tests were conducted in a mobile home located outdoors, the moisture content, when measured at test time with an electric resistance moisture meter, varied slightly, ranging from 6.3 to 9.5%. The cribs were designed so that after conditioning their final weight would be at least as great as the weight specified. Weight adjustments could then be made by removing one or more sticks from the top. Design specifications for the cribs are summarized in table 3.

In addition to the above specimens, tests were conducted using pans of 54 mL and 150 mL of heptane, the amounts used to ignite the wood cribs. These tests were for calibration purposes only and were of short duration due to the limited amount of fuel used.

3. TEST PROCEDURE

Prior to the start of a test, the temperature and relative humidity inside and outside the mobile home were recorded. Table 4 summarizes

this information. The interior environment of the mobile home was maintained at as constant a level as possible using the central heating system and a dehumidifier as required. However, due to the wide range of exterior conditions during the testing period, some variation in the interior conditions was experienced.

In tests using an upholstered chair, the chair was positioned diagonally in the northwest corner of the living room on the weighing platform so that the back of the chair was approximately 25 mm (1 in) from both the north and west walls. A 0.3 kg (12 oz) polyethylene waste container (9 liter (9.5 quart) capacity) filled with approximately 227 g (0.5 lb) of crumpled newsprint was placed on the floor adjacent to the left arm of the chair, and the newsprint was ignited by remote electrical activation of a wooden match.

In tests using only the waste container and newsprint, the waste container was placed in a five-sided wire mesh enclosure. The dimensions of the enclosure base were approximately 305 x 356 mm (12 x 14 in) and the four sides were each approximately 127 mm (5 in) tall. The enclosure was designed to prevent any newsprint from falling from the weighing platform, which was approximately 254 mm (10 in) above the floor. Dripping of molten polyethylene from the weighing platform was prevented through the use of a 13 mm (0.5 in) thick sheet of marine board, approximately 1.2 m (2 ft) square, which was placed between the mesh enclosure and the top of the weighing platform. The newsprint was again remotely ignited with a wooden match.

In tests using a wood crib, the crib was positioned on the weighing platform so that two of its sides were approximately 25 mm (1 in) from both the north and west walls. The base of the crib was approximately 254 mm (10 in) above the floor. A metal pan, either 203 x 203 x 25 mm (8 x 8 x 1 in) containing 150 ml of heptane, or 127 x 127 x 25 mm (5 x 5 x 1 in) containing 54 ml of heptane, depending on the crib size, was placed under the crib and was again remotely ignited. Figure 3 shows an upholstered chair and a 6.4 kg wood crib, both in their position in the corner configuration.

Prior to ignition, all exterior doors and windows were closed to provide an initially static atmosphere. The doors leading into bedrooms #2 and #3 and the bathroom were also closed. The door to bedroom #1 was left open.

4. TEST RESULTS

4.1 Fire Development

Fire development during the tests of upholstered chairs was characterized by an initial period of build-up, a period of active burning, and a decay period when the majority of the fuel had been consumed and the flame plume had degenerated into flamelets no greater than 100-150 mm (4-6 in) high above the fuel surface.

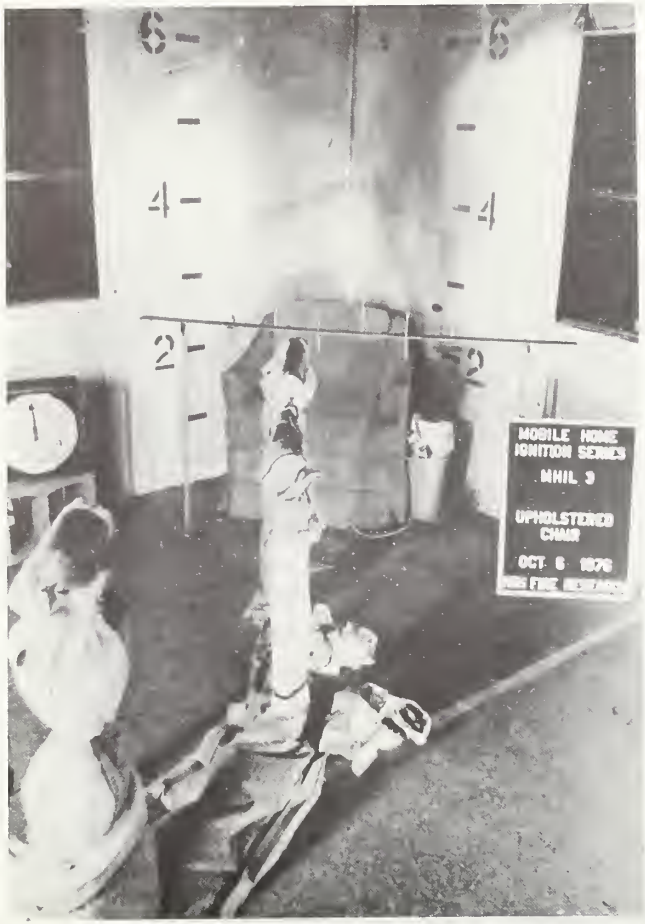


Figure 3. Photographs of a 16 kg (35 lb) upholstered chair and a 6.4 kg (14 lb) wood crib on the load platform prior to ignition.

Typically, ignition of the newsprint in the waste container resulted in a flame 0.3-0.6 m (1-2 ft) above the top of the waste container. This flame impinged on the exterior fabric of the left arm of the chair igniting it within 45 sec - 2 min. At the same time, the polyethylene waste container began deforming and melting away (at approximately one minute into the test) and by four to seven minutes into the test no longer significantly affected the development of the chair fire.

Although the general tendency was for the fires to burn from left to right across the chairs, there was some variation in the sequential involvement of the various surface areas of each chair. The period of active burning gnerally began at approximately the time the polyurethane foam inside the left arm of the chair became involved. This burning continued to increase until the flame reached maximum height and intensity. The decay period began at approximately the time the seat cushion and back cushion were almost completely consumed with the right arm being the only major source of fuel remaining in the chair.

The fire development of the 6.4, 9.1, and 13.6 kg wood cribs was characterized by similar periods of build-up, active burning, and decay. However, the build-up period for the cribs was relatively shorter than for the chairs. Typically, ignition of the heptane in the pan under the crib resulted in combustion throughout the interior of the crib and a flame which extended 0.3-1.5 m (1-5 ft) above the top surface of the crib. Complete consumption of the heptane ranged from 1 min 35 sec to 2 min, and in most cases, the flame then receded somewhat in height. Combustion continued, characterized by an increase in the intensity of the fire as well as the height of the flame above the crib, until a maximum fire intensity and flame height were reached. At this point the crib exhibited relatively steady burning over a period of at least 15 minutes before most of the fuel was consumed and the intensity of the burning began to decrease.

Fire development was somewhat different with the 2.3 kg cribs, which were contructed of smaller and more densely packed elements and which used a lesser volume of heptane with less exposed surface area. In these tests, the flame produced by the burning heptane was confined in the interior of the crib for 1 min 35 sec (Test 11) and 1 min 45 sec (Test 12) before appearing above the top surface. The heptane was completely consumed in 3 min (Test 11) and 3 min 15 sec (Test 12), at which time the burning of the crib itself was not sufficient to produce a flame above the top surface. When a flame did become evident above the top surface, at 6 min 10 sec and 6 min 20 sec, respectively, the flame was unattached to the crib and was burning in the gas plume above the crib. The flame became attached to the top surface at 7 min 10 sec in both tests as the burning spread throughout the interior of the crib and increased in intensity. The flame height then temporarily stabilized until approximately 12 and 13 min, respectively, when the flame increased to a maximum height and remained steady for a period of approximately 5 min in both tests until the fuel was nearly exhausted.

Summary information on maximum flame heights; test duration; and

time to smoke detector alarm, exhaustion of the heptane, and flame impingement on the ceiling is presented in table 5. This information was compiled from visual observations recorded by test personnel. Determination of flame heights during the fires with upholstered chairs was at times difficult due to the dense, black smoke produced during these tests. Detailed chronological documentation of events for representative tests is provided in Appendix A.

Results from Test 4, involving a 6.4 kg wood crib, are not included since that test was aborted immediately after the exhaustion of the heptane due to failure of the heptane to fully ignite the crib. Apparently a delay between the pouring of the heptane and its ignition resulted in excessive evaporation. The crib design was used again in Tests 10 and 15.

4.2 Rate of Burning

The rate of burning was calculated as the measured weight loss of the specimen over an interval of time and is expressed in g/sec. Maximum rates of burning are presented in table 6. These burn rates are measured over 30-second and 1-minute intervals with each interval beginning every 10 seconds throughout the test.

The maximum 30-second burn rate ranged from 2.4 to 12.3 g/sec for the wood cribs, with the larger cribs experiencing the greater burn rates; from 15.1 to 53.7 g/sec for the upholstered chairs; and from 1.1 to 1.4 g/sec for the waste containers. The maximum 1-minute rate ranged from 2.2 to 12.2 g/sec for the cribs, from 13.2 to 39.2 g/sec for the upholstered chairs, and from 0.9 to 1.1 g/sec for the waste containers.

For each of the wood cribs tested, the difference between the maximum 30-second burn rate and the maximum 1-minute burn rate in each test ranged from 0 to 9 percent of the 1-minute rate. For the upholstered chairs, that difference ranged from 14 to 37 percent. And for the waste containers the differences were 22 and 27 percent. The smaller difference for the cribs indicates that these fires did not experience as marked a peak in rate of burning as did the fires with upholstered chairs or waste containers.

During the initial period of fire development the rate of burning of the chairs was rather low. During the period of active burning, it rapidly accelerated to a maximum rate, remained at that rate for a short time, and then gradually decreased. The period of rapid rise occurred approximately 5 min later in Test 3 than in Test 1 and approximately 1 min earlier in Test 3 than in Test 2. The variation in rate of burning of wood cribs of the same weight was considerably less, as noted above. Changes in the burn rate of the cribs occurred gradually, indicating a more stable burning. As might be expected, the maximum burn rate of the wood cribs increased with crib size, with the larger (heavier) cribs, containing more fuel and more exposed fuel surface, experiencing the

greater rates. Time histories of the rate of burning for the three upholstered chairs and four 6.4 kg wood cribs are shown in figure 4a and the histories of four cribs of different weights are shown in figure 4b. These burn rates are measured over 30-second intervals. Time histories of the burn rate, along with time histories of ceiling temperature and total incident heat flux at three locations for each upholstered chair, wood crib, and waste container are included in Appendix B.

4.3 Temperature

Summary data on maximum temperatures reached at various locations in the mobile home are presented in table 7.

During peak fire conditions, the temperature measured at a location 25 mm below the ceiling in the center of the living room ranged from 90 to 260 °C for the tests with wood cribs (with the higher temperatures being produced by the larger cribs), from 236 to 335 °C for the upholstered chairs, and from 57 to 107 °C for the heptane alone. The maximum temperature measured during the tests with waste containers filled with newsprint was 37 °C.

The average upper room gas temperatures at 25, 250, and 810 mm (1, 10, and 32 in) below the ceiling were calculated by averaging the gas temperatures at four locations throughout the living room at each of these heights. During peak fire conditions the average temperature 25 mm (1 in) below the ceiling ranged from 84 to 262 °C for the wood cribs (again with the higher temperatures being produced by the larger cribs), from 215 to 312 °C for the upholstered chairs, and from 47 to 83 °C for the heptane alone. The maximum temperature measured during the tests with waste containers was approximately 32 °C. Thus the differences between the temperature below the ceiling in the center of the room and the average temperature at the same height were small.

The newsprint indicator specimens placed on the floor of the living room did not ignite during any of the tests. Fang [15] has reported, based on tests conducted in a 22 m^3 (788 ft^3) compartment, that, for the purpose of estimating the conditions leading to room flashover (the involvement of all combustible contents), the average upper room gas temperature necessary for spontaneous ignition of newsprint is 540 $\pm$ 40°C. (It should be noted that this average included low temperatures at the mid-height of the room and that temperatures 25 mm (1 in) below the ceiling in his tests almost always exceeded 600 °C.)

Time histories of the temperature measured 25 mm (1 in) below the ceiling at the center of the living room are shown in figure 5a for the three upholstered chairs and four 6.4 kg wood cribs, and in figure 5b for four wood cribs of different sizes. The ASTM E-119 standard time-temperature curve [16] is also included to show the magnitude of these incidental fires as compared to the expected exposure from a fully involved room. The temperature produced by the fully involved room is considerably more severe.

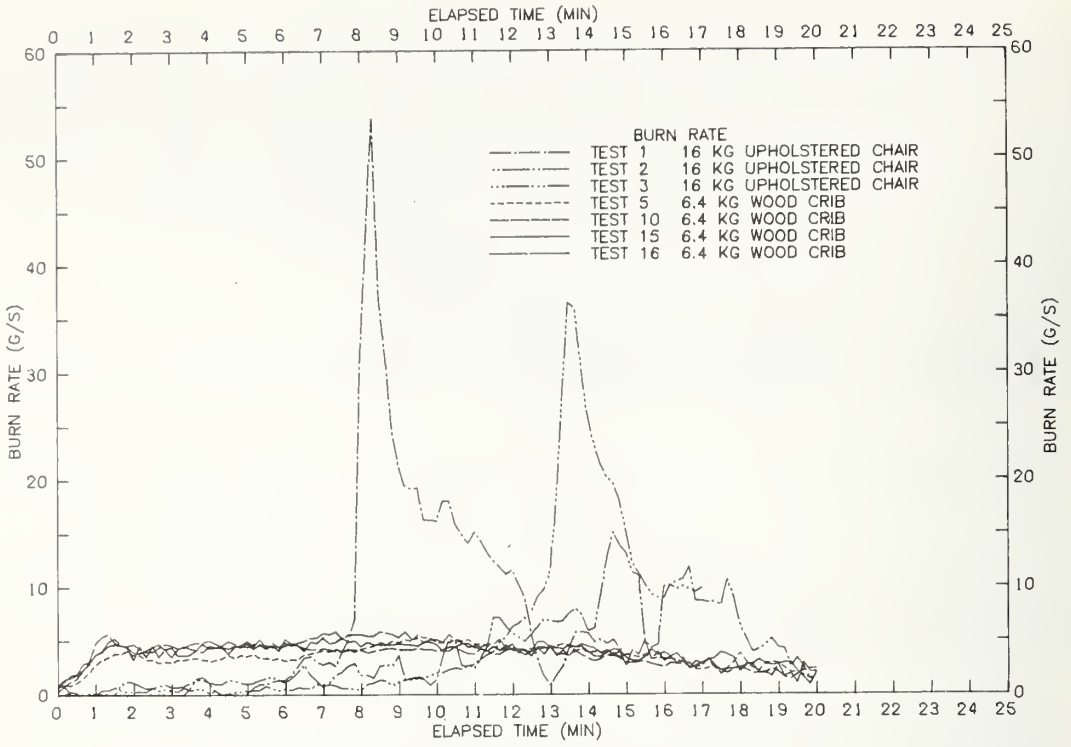


Figure 4a. Burn rates of 16 kg (35 lb) upholstered chairs and 6.4 kg (14 lb) wood cribs (Ignition Characterization Series).

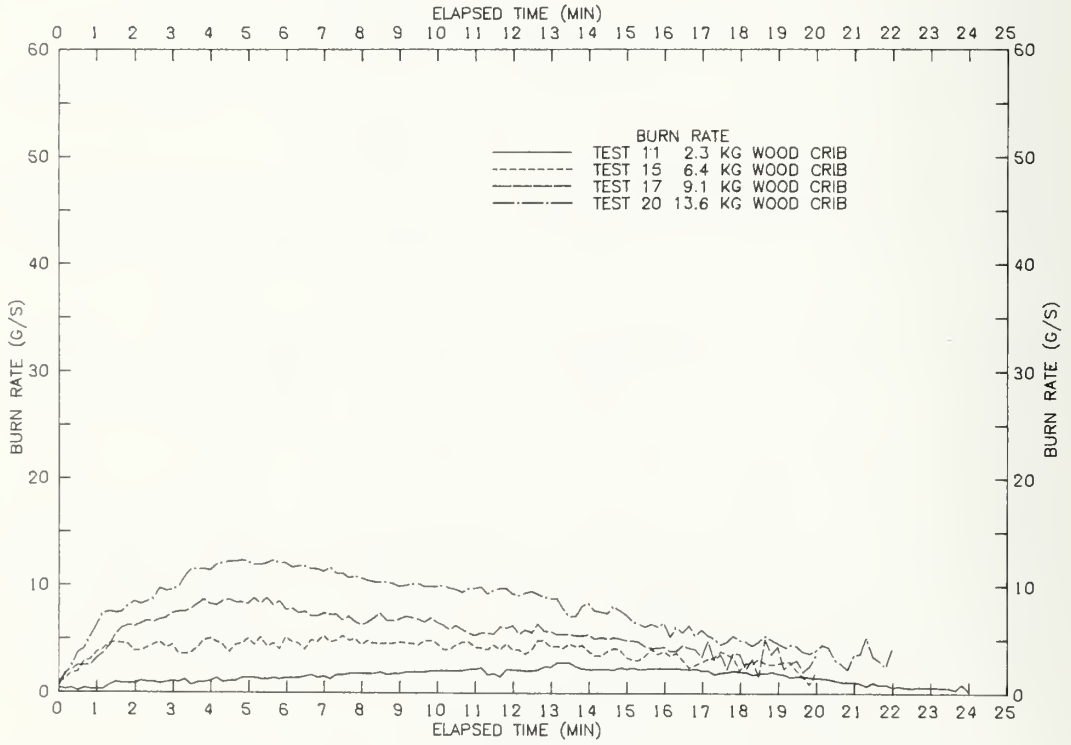


Figure 4b. Burn rates of various size wood cribs (Ignition Characterization Series).

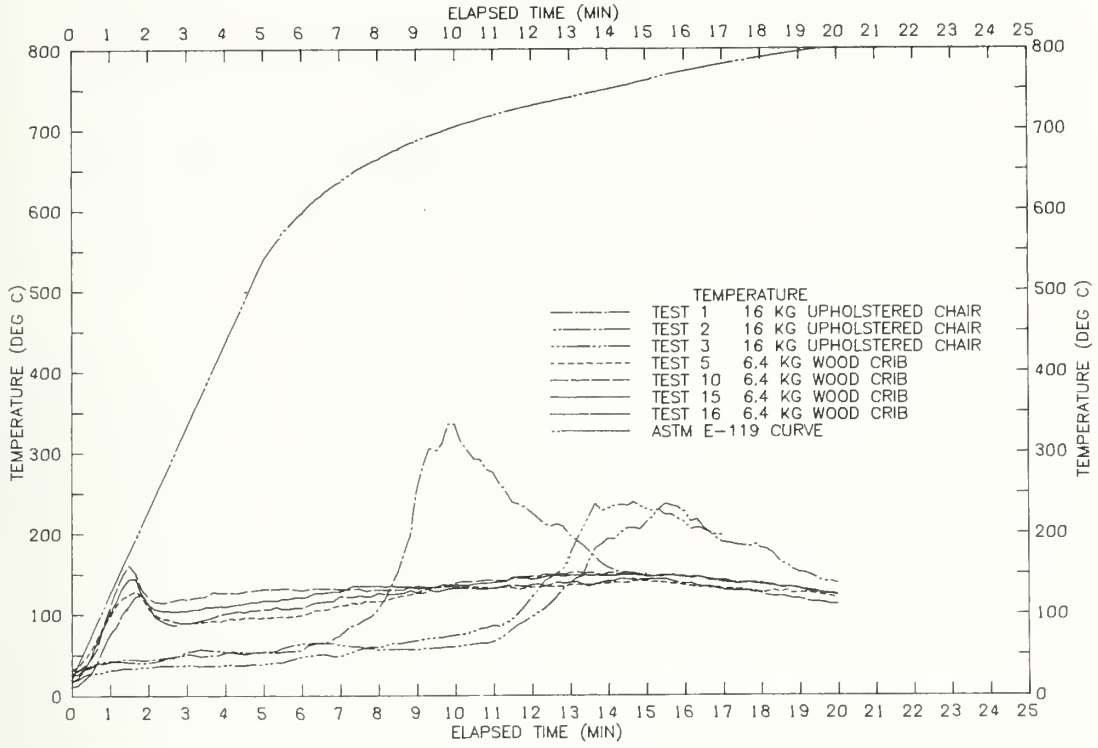


Figure 5a. Time-Temperature curves for the thermocouple 25 mm (1 in) below the ceiling in the center of the living room for 16 kg (35 lb) upholstered chairs and 6.4 kg (14 lb) wood cribs (Ignition Characterization Series).

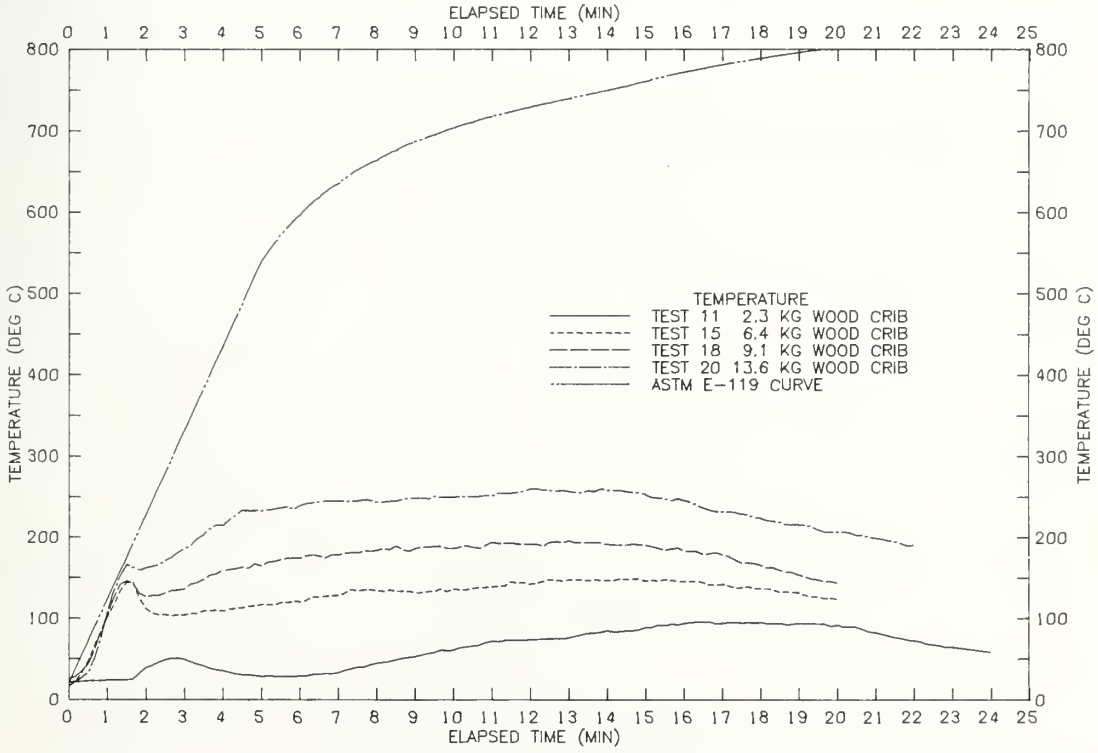


Figure 5b. Time-Temperature curves for the thermocouple 25 mm (1 in) below the ceiling in the center of the living room for various size wood cribs (Ignition Characterization Series).

As with the burn rate, temperatures measured 25 mm (1 in) below the ceiling in the center of the living room during the tests of upholstered chairs remained low during the initial period of fire development, but increased rapidly to a peak temperature, remained at that peak for a short period of time, and then began decreasing as the fire entered the period of decay. With the exception of the period just after the heptane ignitor was completely consumed, the temperature produced by the various size wood cribs did not experience sharp peaks. Rather, there was a gradual increase in temperature over the course of about 15 minutes followed by a gradual decrease.

Figure 6 shows typical vertical gas temperature profiles which occurred in the center of the burn room for tests of all three upholstered chairs, one of each type crib, and one waste container. These profiles occurred at the time of maximum temperature 25 mm (1 in) below the ceiling and illustrate the presence of vertical temperature stratification in the living room as a result of heat released by the incidental fire and cooling air supplied from outside the room.

4.4 Incident Heat Flux

Data on total incident heat flux measured at various locations in the living room are summarized in table 8. These levels are the result of combined radiative and convective heating.

Maximum incident heat flux levels measured 0.6 m (2 ft) from the edge of the specimen and 0.9 m (3 ft) above the floor looking horizontally at the specimen ranged from 0.24 to 1.32 W/cm^2 (0.21 to 1.16 Btu/ft^2 sec) for the different wood cribs, from 1.15 to 1.75 W/cm^2 (1.01 to 1.54 Btu/ft^2 sec) for the upholstered chairs, and from 0.25 to 0.72 W/cm^2 (0.22 to 0.63 Btu/ft^2 sec) for the heptane alone. The maximum levels measured during the tests of waste containers were 0.10 to 0.12 W/cm^2 (0.09 and 0.11 Btu/ft^2 sec). None of these incident heat flux levels is sufficient to cause spontaneous ignition of ordinary combustible materials as a level of approximately 2 W/cm^2 (1.76 Btu/ft^2 sec) is required.

Maximum incident heat flux measured on the exposed wall at approximately 25 mm (1 in) from the specimen, again at 0.9 m (3 ft) above the floor and looking horizontally at the specimen, during tests of the 9.1 and 13.6 kg cribs, upholstered chairs, and 150 ml of heptane, were of sufficient levels to cause ignition of combustible materials located at that distance. These heat flux levels ranged from 3.46 to 4.48 W/cm^2 (3.05 to 3.94 Btu/ft^2 sec) for the two types of cribs, from 2.51 to 4.80 W/cm^2 (2.21 to 4.23 Btu/ft^2 sec) for the chairs, and from 2.97 to 4.06 W/cm^2 (2.61 to 3.57 Btu/ft^2 sec) for the heptane.

Maximum incident heat flux levels measured at the ceiling looking vertically down on the flame plume ranged from 0.64 to 4.32 W/cm^2 (0.56 to 3.80 Btu/ft^2 sec) for the different cribs, from 1.66 to 4.20 W/cm^2 (1.46 to 3.70 Btu/ft^2 sec) for the upholstered chairs, and from 0.29 to 1.41 W/cm^2 (0.26 to 1.24 Btu/ft^2 sec) for the heptane alone. Measured

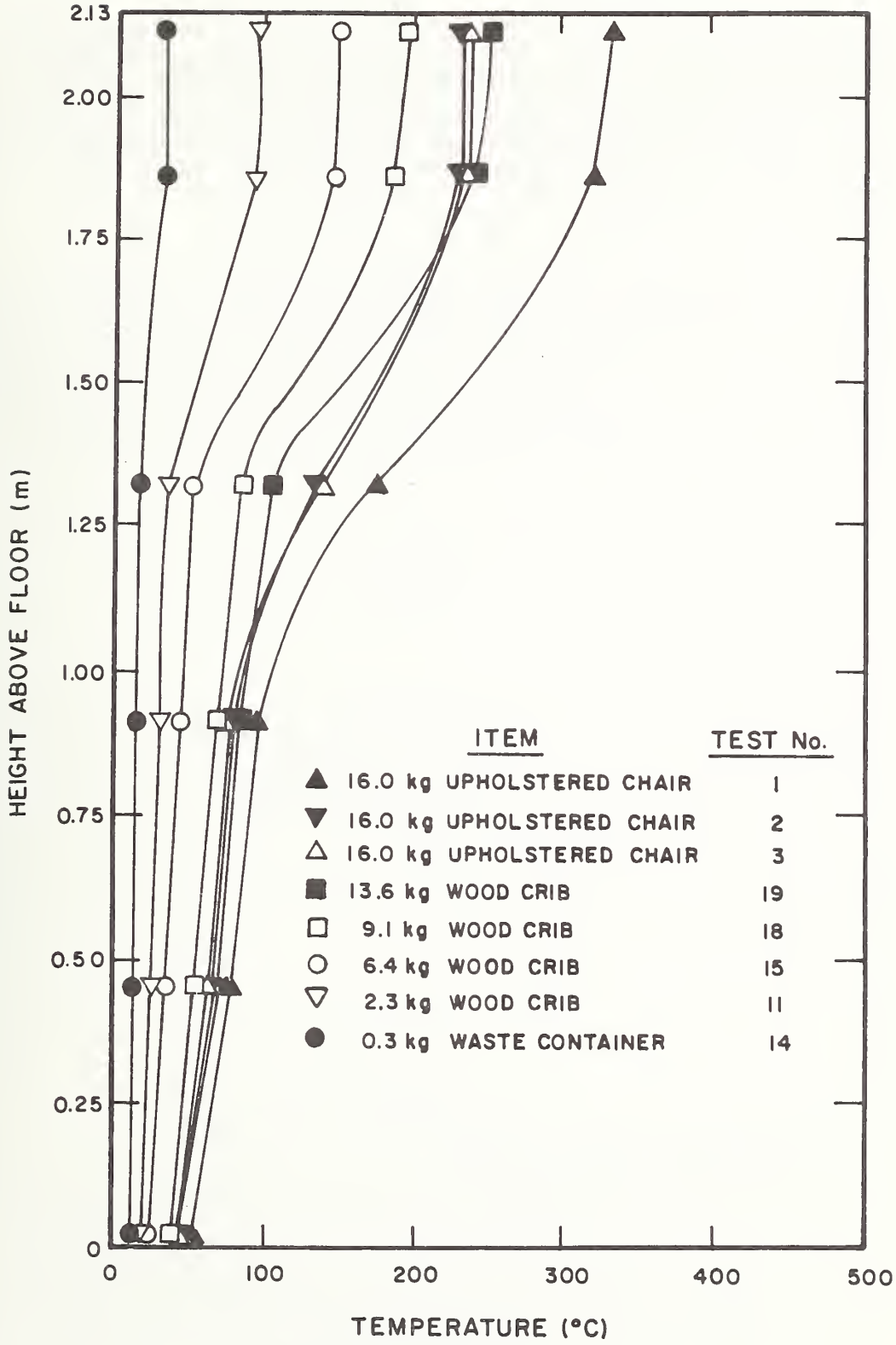


Figure 6. Vertical temperature profiles in the center of the living room for selected ignition sources (Ignition Characterization Series).

levels were 0.19 and 0.28 W/cm^2 (0.17 and 0.25 Btu/ft^2 sec) for the waste containers.

Maximum incident heat flux levels measured at the floor in the center of the living room were negligible during the heptane and waste container tests, and measured levels were never greater than 0.20 and 0.28 W/cm^2 (0.18 and 0.25 Btu/ft^2 sec) for any of the tests with cribs or chairs, respectively.

Plots of incident heat flux levels measured 0.6 m (2 ft) from the edge of the specimen at 0.9 m (3 ft) above the floor (horizontal view) versus elapsed time are shown in figure 7a for the three upholstered chairs and four 6.4 kg wood cribs, and in figure 7b for four wood cribs of different size. As would be expected, the general trends of the heat flux levels resulting from the burning item were similar to the trends shown in the time histories of temperature (figures 5a and 5b).

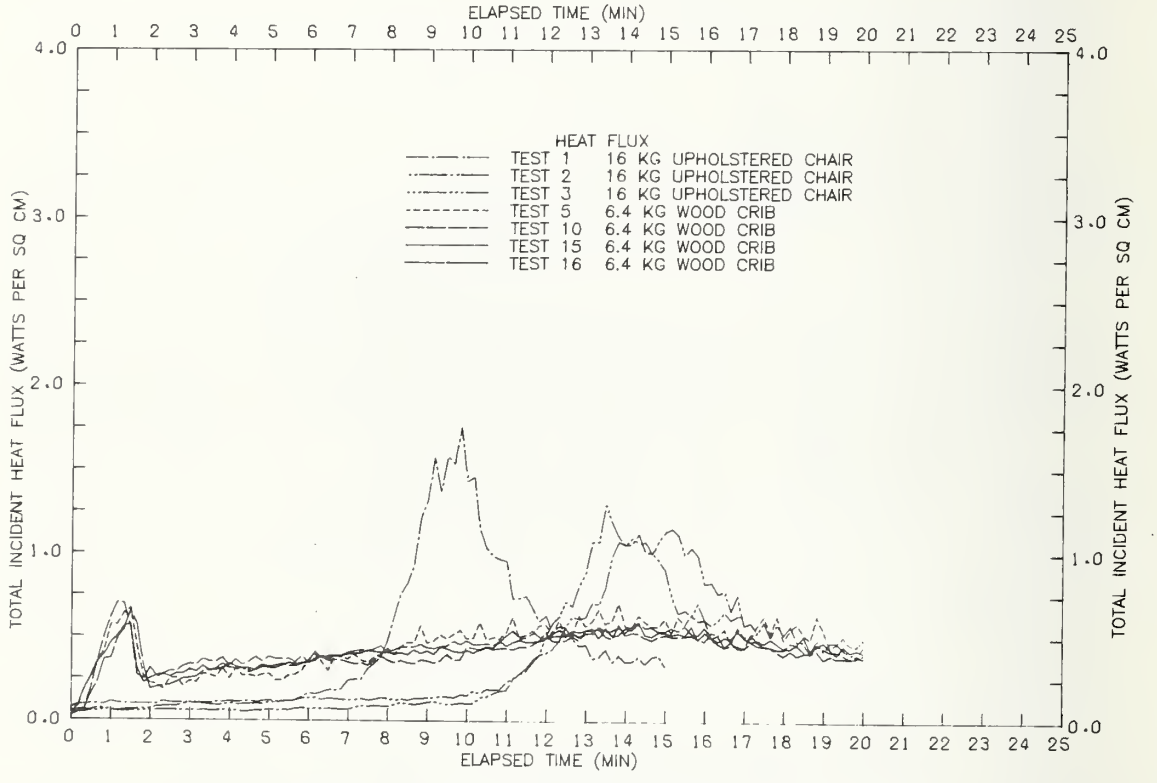


Figure 7a. Total incident heat flux, horizontal orientation, 0.6 m (2 ft) from the edge of the specimen, 0.9 m (3 ft) above the floor for 16 kg (35 lb) upholstered chairs and 6.4 kg (14 lb) wood cribs (Ignition Characterization Series).

Figure 8 shows a plot of incident heat flux measured 0.9 m (3 ft) above the floor (horizontal view) versus distance from the flame plume. Data from tests of all three upholstered chairs, one of each type crib, and one waste container are included. These profiles occurred at the time of maximum incident heat flux 25 mm (1 in) from the flame.

4.5 Smoke and Gas Concentrations

Summary data on minimum concentrations of oxygen, and maximum concentrations of carbon monoxide and carbon dioxide measured in the living room and in the corridor; and maximum concentrations of smoke measured at the living room doorway and in the corridor are presented in table 9.

The rate of smoke production during the tests varied appreciably. Production tended, though, to be greater for the upholstered chairs than for any of the other items tested. The smoke concentration measured at the living room doorway 1.2 m (4 ft) above the floor varied from 2.0 to 2.1 OD/m for the chairs and from 0.1 to 1.5 OD/m for the wood cribs. For the waste container it was less than 0.1 OD/m and for the pans of

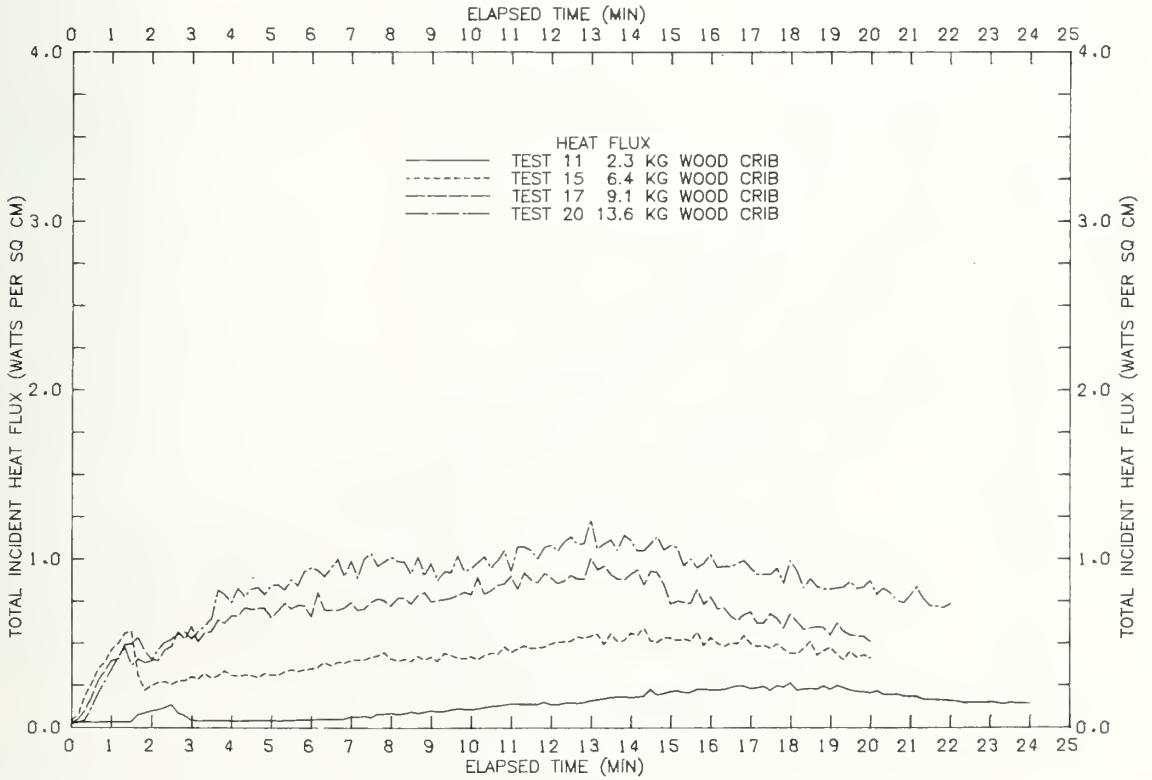


Figure 7b. Total incident heat flux, horizontal orientation, 0.6 m (2 ft) from the edge of the specimen, 0.9 m (3 ft) above the floor for various size wood cribs (Ignition Characterization Series).

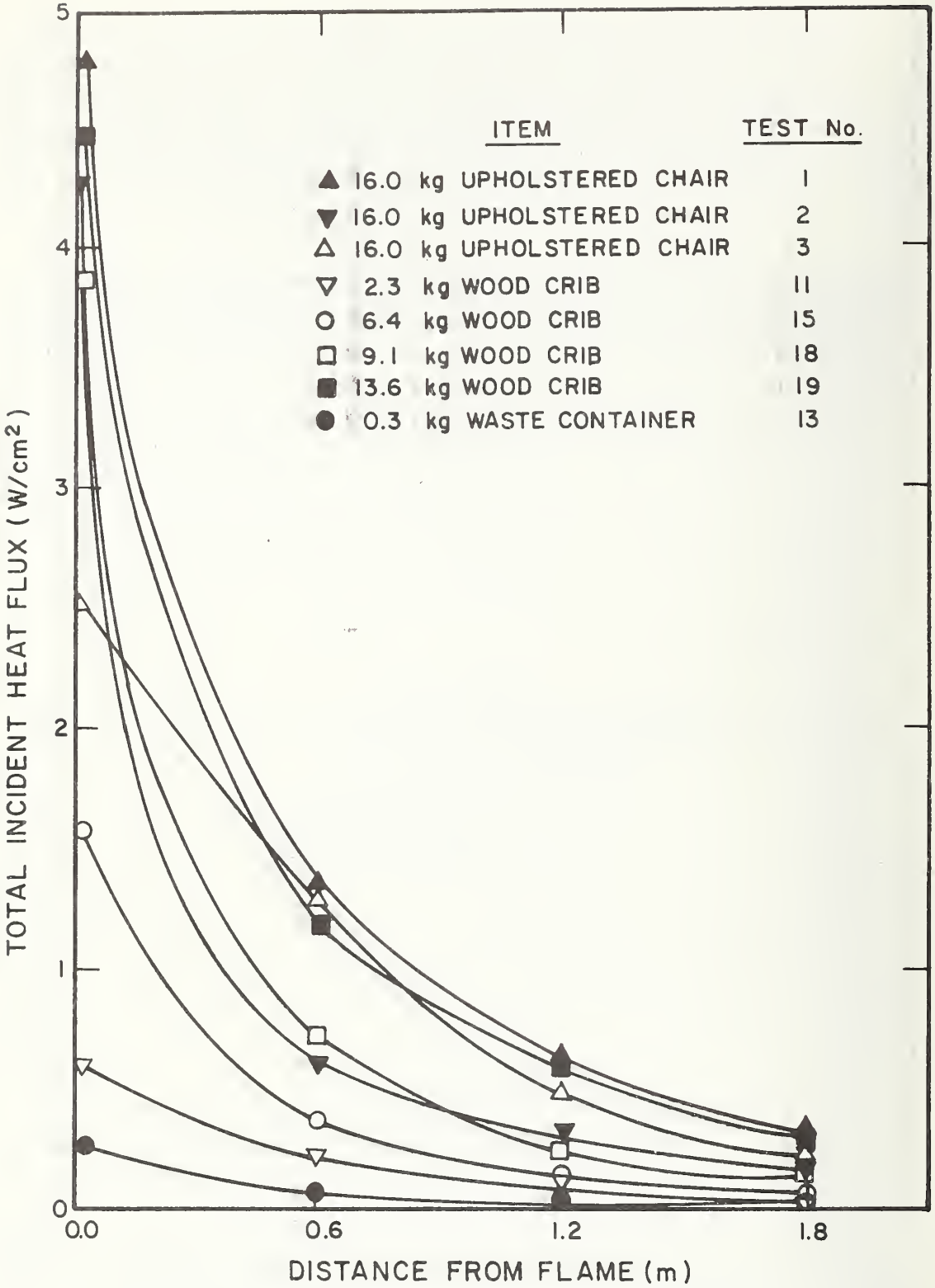


Figure 8. Total incident heat flux distributions, horizontal orientation, at 0.9 m (3 ft) above the floor for selected ignition sources (Ignition Characterization Series).

150 ml and 54 ml of heptane it was approximately 0.1 OD/m. Comparison of data from the tests of wood cribs indicates that there did not appear to be a simple relationship between peak smoke production and the size of the crib.

Time histories of the average smoke concentration at the door to the living room, calculated by averaging the output from the horizontal smoke meters located 0.6, 1.2, and 1.8 m (2, 4, and 6 ft) above the floor, are shown in figure 9a for the three upholstered chairs and four 6.4 kg wood cribs, and in figure 9b for four cribs of different size and a waste container. The smoke produced by the chairs during their peak burning period was black in color and the smoke produced by the cribs was gray. Average smoke concentrations, rather than the smoke concentration at any one of the three smoke meters, was plotted since it was found to be less prone to variation over the course of time, even though there was a general tendency for smoke concentration to be higher at the upper measuring location.

Minimum concentrations of oxygen measured in the living room ranged from 19.3 to 18.1 percent for tests with the upholstered chairs and from 20.4 to 18.5 percent during tests with the wood cribs. Minimum O_2 levels measured at the south end of the corridor ranged from 20.1 to 17.0 percent for tests with the upholstered chairs and from 19.9 to 15.1 percent for tests with the wood cribs. All O_2 samples were taken 1.5 m (5 ft) above the floor. During every crib test and in two of the three chair tests (Tests 2 and 3), the minimum O_2 concentration measured at the south end of the corridor was less than the minimum concentration measured in the center of the living room. It is believed that gas circulation patterns in the mobile home are the reason for this.

Time histories of O_2 concentrations sampled in the center of the living room are shown in figure 10a for the three chairs and four 6.4 kg cribs, and in figure 10b for four cribs of different sizes.

Maximum carbon monoxide concentrations sampled in the living room never exceeded 0.2 and 0.1 percent for tests with the chairs and cribs respectively. CO concentrations sampled in the south end of the corridor never exceeded 0.1 percent. In all three chair tests and in all but one of the crib tests, the maximum CO concentration in the living room was higher than that in the corridor. Maximum concentrations of carbon dioxide never exceeded 4.2 and 5.0 percent for tests with the chairs and cribs, respectively.

5. DISCUSSION

Much of the behavior of fires from the wood cribs and upholstered chairs studied in this test series were comparable when analyzed in relation to what might be expected during a fully developed room fire under similar conditions. As is consistent with the concept of an incidental fire, full room involvement was not reached during any of the tests.

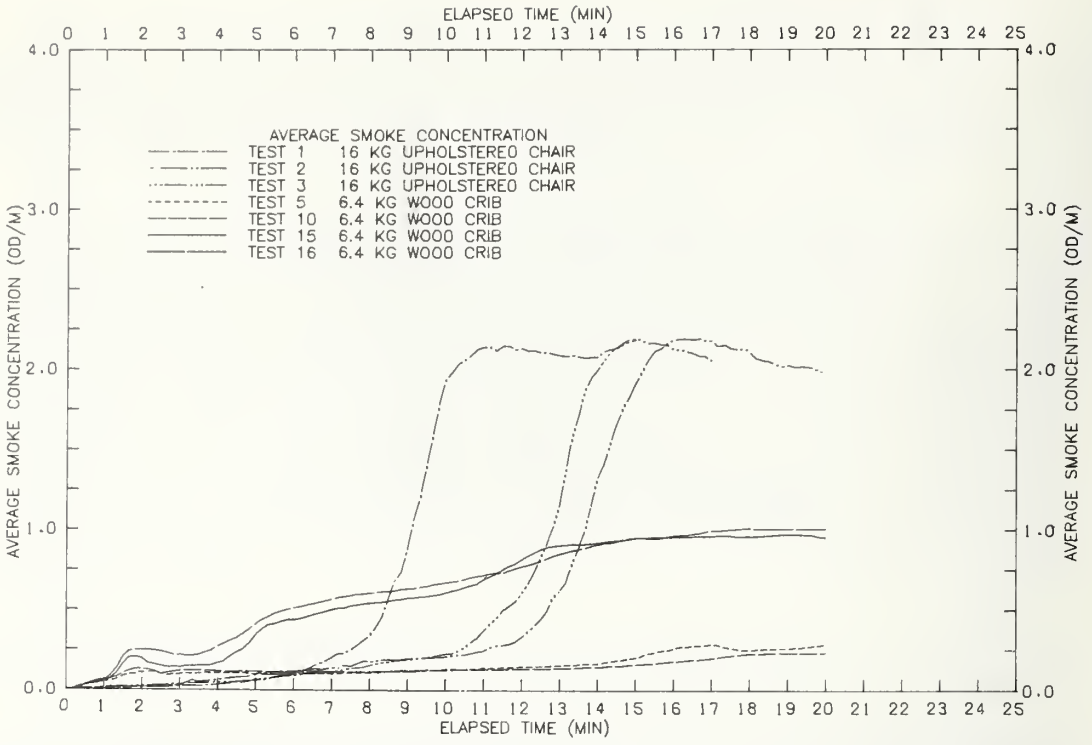


Figure 9a. Average smoke concentrations at the door to the living room for 16 kg (35 lb) upholstered chairs and 6.4 kg (14 lb) wood cribs (Ignition Characterization Series).

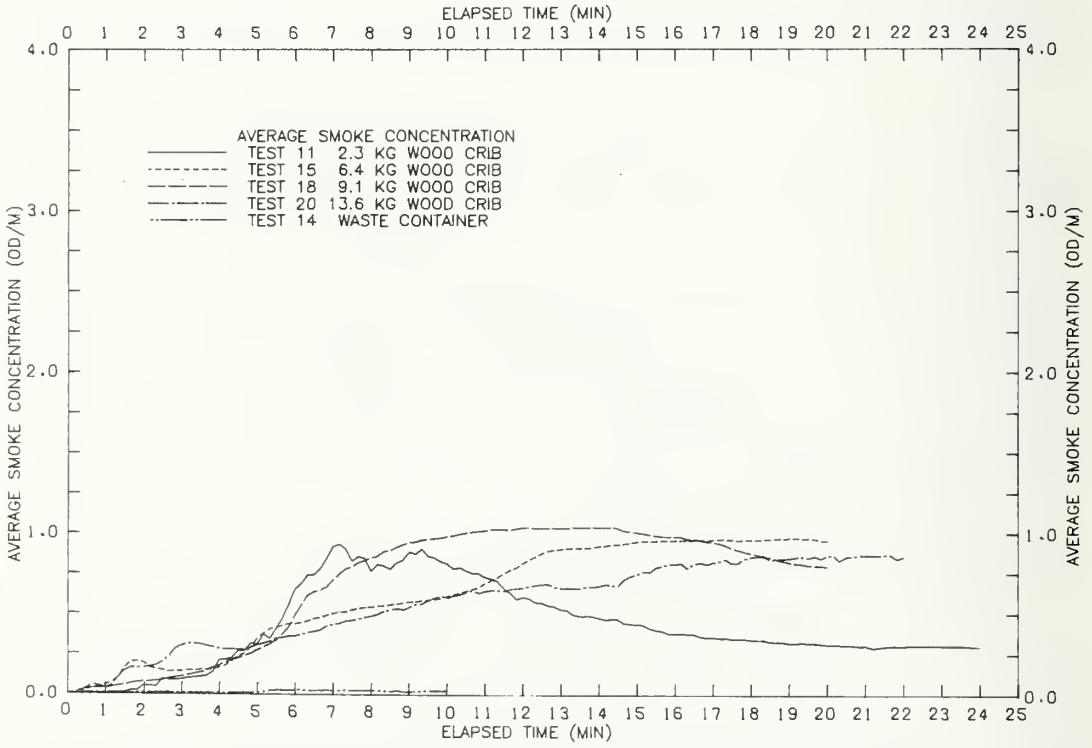


Figure 9b. Average smoke concentrations at the door to the living room for various size wood cribs and a waste container (Ignition Characterization Series).

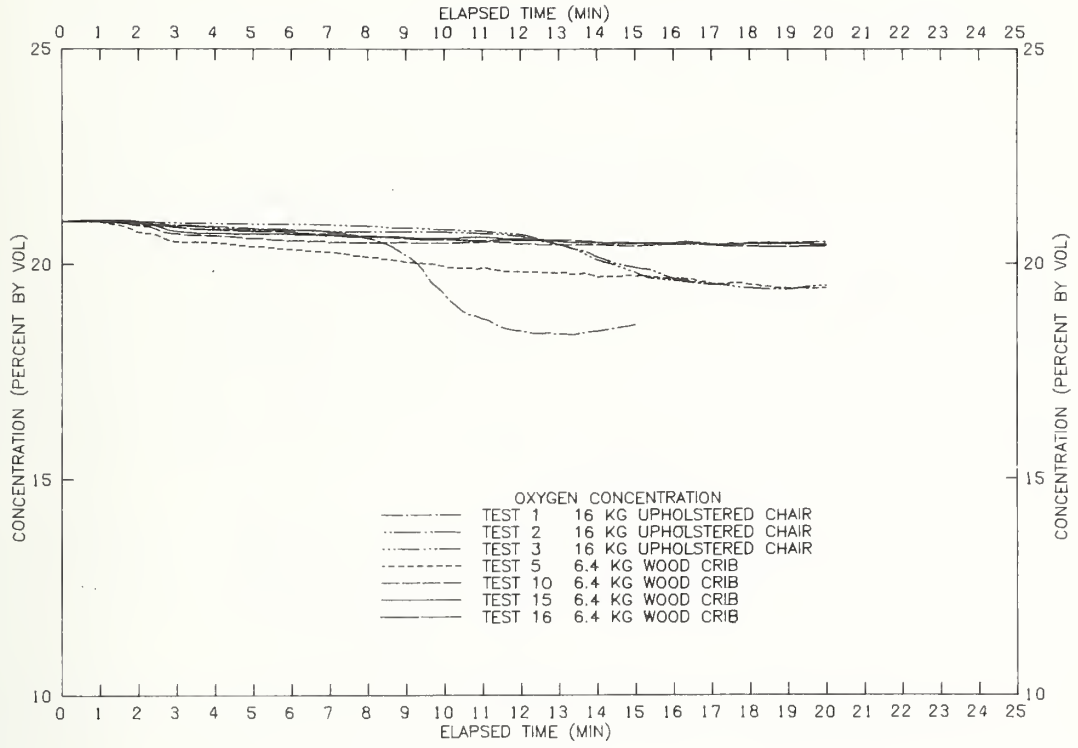


Figure 10a. Oxygen concentrations in the center of the living room for 16 kg (35 lb) upholstered chairs and 6.4 kg (14 lb) wood cribs (Ignition Characterization Series).

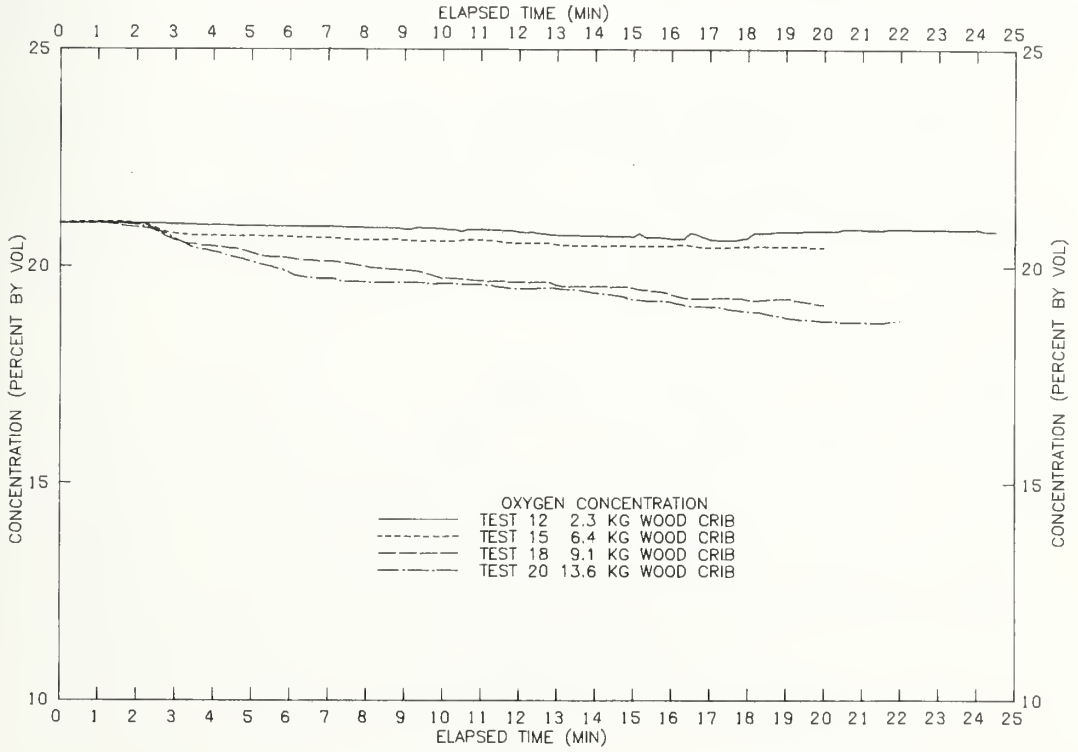


Figure 10b. Oxygen concentrations in the center of the living room for various size wood cribs (Ignition Characterization Series).

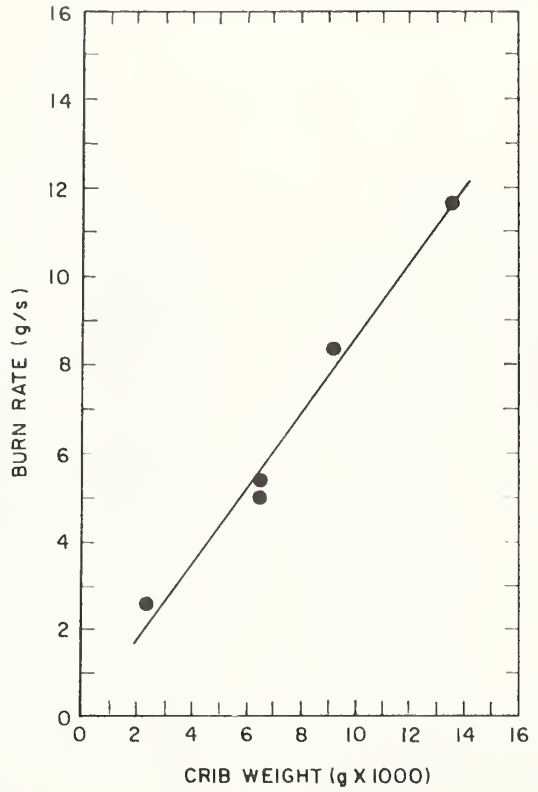


Figure 11. Maximum 1-minute burn rate versus crib weight for each size wood crib (Ignition Characterization Series).

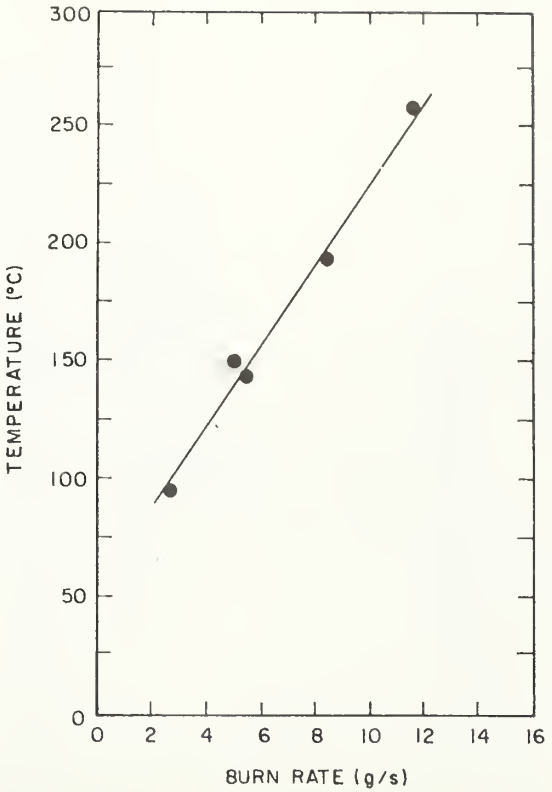


Figure 12. Maximum temperature 25 mm (1 in) below the ceiling in the center of the living room versus maximum 1-minute burn rate for each size wood crib (Ignition Characterization Series).

Characteristics such as maximum temperature in the flame plume and in the upper part of the living room, maximum incident heat flux, steady burning flame height, decrease in O_2 concentration, and increase in CO and CO_2 concentrations for fires with the wood cribs fell within a range defined by the severities of the fires produced by the waste containers filled with newsprint and the fires produced by the upholstered chairs. The most severe crib fires occurred with the largest (13.6 kg) cribs. These fires were similar to fires with the upholstered chairs. The 2.3 kg cribs produced fires which were more severe than fires with the waste containers and newsprint but generally less severe than fires with the 6.4 kg and 9.1 kg cribs. Fires with the 6.4 kg cribs generally fell well within the spectrum of the fires examined and it therefore seems appropriate to use the 6.4 kg crib to represent a broad range of incidental fire sizes and severities similar to those used in this test series. Table 10 presents a summary of averaged results for the waste containers, 6.4 kg and 13.6 kg wood cribs, and 16 kg upholstered chairs.

It was found from replicate tests that the fires from wood cribs, especially the 6.4 kg wood cribs, were fairly repeatable. The active burning period of the wood cribs of all sizes tended to be at least as great as the active burning period of the upholstered chairs and, due to the variation in fire development across the exterior fabric of the chairs, their active burning period began at different times in each test. Therefore, exposure of the nearby walls and ceiling to the intense flame began at correspondingly different times during tests of similar chairs but began at about the same time for tests of similar cribs. For this reason, when using incidental fires as the ignition source for tests designed to evaluate the effects of interior finish materials used on the walls and ceiling, the more reproducible fires from wood cribs would seem to be preferable to the fires from upholstered chairs.

Figure 11 shows the highest 1-minute burn rate plotted against the crib weight for all tests of wood cribs. As indicated in the figure, there is a direct relationship between crib weight and maximum burn rate. Using linear regression analysis by the method of least squares and assuming a curve that passes through (0,0), the following equation was derived for the data points:

$$R = 0.00086\ W \qquad (1)$$

where R is the maximum burn rate (in grams) measured over a 1-minute interval and W is the initial weight (in grams) of the wood crib. The coefficient of correlation for equation 1 is 0.99, indicating a close approximation to the data points.

In figure 12, the maximum gas temperature 25 mm (1 in) below the ceiling in the center of the living room was plotted against the maximum 1-minute burn rate for all tests of wood cribs. Again a proportional relationship was indicated over the range of burn rates and temperatures involved. The equation derived for the data points is:

$$T = 17.41\ R - 52.44 \qquad (2)$$

where T is the maximum gas temperature (in °C) 25 mm (1 in) below the ceiling in the center of the living room and R is the maximum burn rate (in g/s) measured over a 1-minute interval. The coefficient of correlation for equation 2 is 0.99, again indicating a close approximation to the data points. It is obvious that in this case temperature could also be shown to be a function of initial crib weight.

Table 11 summarizes the measurements of the maximum total incident heat flux H (in W/cm^2) at the center of the floor and the maximum average air temperature T (in °C) 25 mm (1 in) below the ceiling in the living room for all tests of wood cribs and upholstered chairs. Based on this data, the following relationship can be formulated:

$$H = (0.45 \pm 0.08)\ \sigma T^4 \qquad (3)$$

where σ is the Stefan-Boltzmann constant (in $W/cm^2\ K^4$). It should be noted that this relationship is not general but applies only to the particular room geometry and test conditions studied. From a number of tests conducted in the same living room, Budnick [14] found that, for tests in which flashover occurred, the minimum total incident heat flux at the center of the floor was 1.5 W/cm^2 (1.3 Btu/ft^2 sec) and the minimum average air temperature 25 mm (1 in) below the ceiling was 600°C. That is,

$$H \geq 1.5\ W/cm^2 \quad \text{and} \quad T \geq 600\ °C \quad .$$

When T = 600 °C, then $\sigma T^4 = 3.3\ W/cm^2$. If this value of σT^4 is used in equation 3, then

$$H = 0.45 \times 3.3 = 1.5\ W/cm^2 \quad .$$

This establishes a correlation between data obtained during flashover and non-flashover conditions.

6. SUMMARY AND CONCLUSIONS

The following conclusions are based on the results of a limited number of fire tests conducted in the corner of a mobile home living room which was designed not to contribute to the fires. The objectives of this test series were (1) to provide a comparison of the characteristics, such as burn rate, temperature and heat flux levels, flame height, smoke densities, and concentrations of oxygen, carbon monoxide, and carbon dioxide, of fires with medium size upholstered chairs, small waste containers filled with newsprint, and several sizes of standardized wood cribs, and (2) to obtain data on incidental fires resulting from the burning of the upholstered chairs, waste containers, and wood cribs in a compartment designed not to contribute to the fires in order to provide information for comparison with data on similar incidental fires in the same compartment lined with combustible interior finish materials on the walls and ceiling. In addition, information was obtained on

incidental fires resulting from the burning of two different volumes of heptane.

Based on the results of the tests reported here, the following conclusions are drawn:

1. Under the experimental conditions of this test series, an incidental fire resulting from the burning of a wood crib up to 13.6 kg (30 lb) or a medium size upholstered chair by itself did not result in conditions conducive for full room involvement.

2. Characteristics of incidental fires such as maximum temperature and heat flux levels, flame height, and change in carbon monoxide, cardon dioxide, and oxygen concentrations were similar for a 13.6 kg (30 lb) wood crib and a typical 16 kg (35 lb) upholstered chair.

3. The period of active burning was more stable for fires with wood cribs than for fires with upholstered chairs.

4. The peak burn rate was generally higher for fires with upholstered chairs than for fires with wood cribs of approximately the same weight.

5. The time to reach the period of active burning was more reproducible for fires with wood cribs than fires with upholstered chairs. For this reason, wood cribs may be preferable to upholstered chairs for use as the ignition source in tests designed to evaluate the effects of interior finish materials used on the walls and ceiling.

6. Based on data from the tests of wood cribs, linear relationships were determined between crib weight and maximum burn rate, and between maximum burn rate and maximum upper-air burn room temperature.

7. ACKNOWLEDGMENTS

The author would like to express his thanks to Mr. E. Budnick, with whom the concept and planning of the test series was developed; and Mr. W. Bailey, Mr. J. Lawson, Mr. T. Maher, Mr. T. Prather, Mr. B. Ramey, Mr. S. Steel, Mr. C. Veirtz and Mr. M. Womble for their assistance in the experimental work. This work was sponsored in part by the United States Department of Housing and Urban Development.

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Table 1. Instrumentation Locations (Ignition Characterization Series)

TC 1	TC - Living room, north	211 cm above floor
TC 2	TC - Living room, north	188 cm above floor
TC 3	TC - Living room, north	132 cm above floor
TC 4	TC - Living room, over specimen	211 cm above floor
TC 5	TC - Living room, over specimen	188 cm above floor
TC 6	TC - Living room, over specimen	132 cm above floor
TC 7	TC - Living room, west	211 cm above floor
TC 8	TC - Living room, west	188 cm above floor
TC 9	TC - Living room, west	132 cm above floor
TC 10	TC - Living room, east	211 cm above floor
TC 11	TC - Living room, east	188 cm above floor
TC 12	TC - Living room, east	132 cm above floor
TC 13	TC - Living room, center	211 cm above floor
TC 14	TC - Living room, center	188 cm above floor
TC 15	TC - Living room, center	132 cm above floor
TC 16	TC - Living room, center	91 cm above floor
TC 17	TC - Living room, center	46 cm above floor
TC 18	TC - Living room, center	2.5 cm above floor
TC 19	TC - Living room, south	211 cm above floor
TC 20	TC - Living room, south	188 cm above floor
TC 21	TC - Living room, south	132 cm above floor
TC 22	TC - Living room, south	91 cm above floor
TC 23	TC - Living room, doorway	211 cm above floor
TC 24	TC - Living room, doorway	188 cm above floor
TC 25	TC - Living room, doorway	132 cm above floor
TC 26	TC - Living room, doorway	91 cm above floor
TC 27	TC - Living room, doorway	46 cm above floor
TC 28	TC - Living room, doorway	2.5 cm above floor
TC 29	TC - Corridor, center	211 cm above floor
TC 30	TC - Corridor, center	188 cm above floor
TC 31	TC - Corridor, center	132 cm above floor
TC 32	TC - Corridor, center	91 cm above floor
TC 33	TC - Corridor, center	46 cm above floor
TC 34	TC - Corridor, center	2.5 cm above floor
TC 35	TC - Corridor, south	211 cm above floor
TC 36	TC - Corridor, south	188 cm above floor
TC 37	TC - Corridor, south	132 cm above floor
TC 38	TC - Corridor, south	91 cm above floor
TC 39	TC - Corridor, south	46 cm above floor
TC 40	TC - Corridor, south	2.5 cm above floor
TC 41	TC - Living room 0.9 m above floor, 0.6 m from specimen	
TC 42	TC - Living room 0.9 m above floor, 1.2 m from specimen	
TC 43	TC - Living room 0.9 m above floor, 1.8 m from specimen	
TC 45	TC - Bedroom 1, center	211 cm above floor
TC 46	TC - Bedroom 1, center	188 cm above floor
TC 47	TC - Bedroom 1, center	132 cm above floor
HF 1	Incident heat flux - Living room, center, floor level	
HF 2	Incident heat flux - Corridor, north, floor level	
HF 3	Incident heat flux - Corridor, south, floor level	
HF 18	Incident heat flux - North wall, 0.2 m from corner, 0.9 m above floor	
HF 19	Incident heat flux - North wall, 0.2 m from corner, 1.8 m above floor	
HF 20	Incident heat flux - Living room, ceiling level, centered over specimen	
HF 21	Incident heat flux - Living room, 0.9 m above floor, 0.6 m from specimen	
HF 22	Incident heat flux - Living room, 0.9 m above floor, 1.2 m from specimen	
HF 23	Incident heat flux - Living room, 0.9 m above floor, 1.8 m from specimen	
HSM 4	Horizontal smoke meter - Corridor, north, 0.6 m above floor	
HSM 5	Horizontal smoke meter - Corridor, north, 1.2 m above floor	
HSM 6	Horizontal smoke meter - Corridor, north, 1.8 m above floor	
VSM 7	Vertical smoke meter - Corridor, north, upper 0.46 m	
HSM 8	Horizontal smoke meter - Corridor, south, 0.6 m above floor	
HSM 9	Horizontal smoke meter - Corridor, south, 1.2 m above floor	
HSM 10	Horizontal smoke meter - Corridor, south, 1.8 m above floor	
VSM 11	Vertical smoke meter - Corridor, south, upper 0.46 m	
CO 13	CO - Center of living room at 1.5 m above floor	
CO2 14	CO2 - Center of living room at 1.5 m above floor	
O2 15	O2 - Center of living room at 1.5 m above floor	
CO 16	CO - South corridor at 1.5 m above floor	
O2 17	O2 - South corridor at 1.5 m above floor	
L CELL	Load cell	

Table 2. Range and Limits of Error for Instrumentation
(Ignition Characterization Series)

Instrument	Range			Limits of Error	
Thermcouples					
all	0 to	277	°C	± 2.2	°C
	277 to	1260	°C	± 3/4	% of reading
Heat Flux Transducers					
HF 1 - 3	0 to	5.7	W/cm^2	± 10	% of reading
HF 18 - 22	0 to	22.3	W/cm^2	± 10	% of reading
HF 23	0 to	1.1	W/cm^2	± 10	% of reading
Gas Analyzers					
CO 13	0 to	10	%	± 2	% of range
CO_2 14	0 to	20	%	± 2	% of range
CO 16	0 to	2	%	± 5	% of range
O_2 15, 17	0 to	21	%	± 1	% of reading
Smoke Meters					
HSM 4-6, 8-10	0 to	5	mv	± 4	% of reading
VSM 7, 11	0 to	5	mv	± 10	% of reading
Load Cell	-225 to	+225	kg	± 0.1	% of reading

Table 3. Design Specifications for the Standardized Wood Cribs (Ignition Characterization Series)

Crib Weight		Width and Depth of Square Cross Section of Each Stick		Separation Distance Between Sticks		Length of Each Stick		Number of Sticks Per Layer	Number of Layers	Amount of Heptane Ignitor	Comments
(kg)	(lbs)	(mm)	(in)	(mm)	(in)	(mm)	(in)			(ml)	
2.3	5	19	0.75	10	0.4	191	7.5	7	10	54	
6.4	14	38	1.5	69	2.7	356	14	4	6	150	Type A
6.4	14	38	1.5	48	1.9	381	15	5	5	150	Type B
9.1	20	38	1.5	48	1.9	381	15	5	6	150	
13.6	30	38	1.5	48	1.9	381	15	5	10	150	

Table 4. Test Conditions (Ignition Characterization Series)

Item	Test No.	Interior Conditions			Exterior Conditions		
		Temperature		Relative Humidity	Temperature		Relative Humidity
		(°C)	(°F)	(%)	(°C)	(°F)	(%)
16 kg Upholstered Chair	1	24	76	51	23	74	58
	2	20	68	42	23	73	52
	3	22	72	50	17	63	93
0.3 kg Waste Container	13	14	58	48	12	53	51
	14	14	58	47	14	58	42
2.3 kg Crib	11	16	60	46	15	59	78
	12	20	68	44	18	65	68
6.4 kg Crib Type A	10	16	61	35	17	63	51
	15	18	64	45	14	57	42
6.4 kg Crib Type B	5	24	76	55	23	74	79
	16	16	60	44	9	48	58
9.1 kg Crib	17	10	50	46	7	45	42
	18	21	69	37	16	60	26
13.6 kg Crib	19	21	70	34	8	46	60
	20	21	70	33	11	52	33
54 ml Heptane	8	16	61	35	17	63	51
	9	16	61	35	17	63	51
150 ml Heptane	6	16	61	35	17	63	43
	7	16	61	35	17	63	43

Table 5. Summary of Selected Test Results (Ignition Characterization Series)

Item	Test No.	Time to Smoke Detector Alarm (min:sec)	Time to Exhaustion of Heptane Igritor (min:sec)	Height of Maximum Steady-Burning Flame* (m)	Time to Flame Impingement or Ceiling (min:sec)	Test Duration (min:sec)
16 kg Upholstered Chair	1	0:45	NA**	2.1	8:35	15:00
	2	0:42	NA	2.1	13:00	20:05
	3	0:34	NA	1.8	-	17:00
0.3 kg Waste Container	13	0:36	NA	0.5	-	10:00
	14	0:34	NA	0.5	-	10:00
2.3 kg Crib	11	2:00	3:00	1.5	-	24:00
	12	2:10	3:15	1.5	-	24:30
6.4 kg Crib Type A	10	0:31	1:49	1.2	-	20:00
	15	0:29	1:48	1.2	-	20:00
6.4 kg Crib Type B	5	0:33	1:51	1.2	-	20:00
	10	0:32	1:55	1.5	-	20:00
9.1 kg Crib	17	0:31	1:57	1.8	-	20:00
	18	0:37	1:35	2.1	3:15	20:00
13.6 kg Crib	19	NR***	1:37	2.1	2:38	22:00
	20	0:38	1:40	2.1	1:45	22:00
54 ml Heptane	8	0:58	2:24	NA	-	2:24
	9	0:54	2:32	NA	-	2:32
150 ml Heptane	6	0:30	1:30	NA	1:00	1:37
	7	0:30	1:35	NA	0:59	1:35

*For tests involving cribs, the height of the flame due to burning heptane was not considered
**NA designates Not Applicable
***NR designates Not Recorded

Table 6. Summary of Maximum Fuel Burning Rates
(Ignition Characterization Series)

Item	Test No.	Maximum Fuel Burning Rate (g/s)	
		Measured Over a 30-Second Interval	Measured Over a 1-Minute Interval
16 kg Upholstered Chair	1	53.7	39.2
	2	15.1	13.2
	3	36.4	31.2
0.3 kg Waste Container	13	1.1	0.9
	14	1.4	1.1
2.3 kg Crib	11	2.9	2.7
	12	2.4	2.2
6.4 kg Crib Type A	10	5.0	4.7
	15	5.3	5.3
6.4 kg Crib Type B	5	5.5	5.2
	16	5.9	5.8
9.1 kg Crib	17	8.8	8.6
	18	8.7	8.1
13.6 kg Crib	19	11.5	11.0
	20	12.3	12.2

Table 7. Summary of Maximum Temperatures Attained at Selected Locations (Ignition Characterization Series)

Item	Test No.	Maximum Temperature (°C)									
		In Flame Plume	25 mm (1 in) Below Ceiling		250 mm (10 in) Below Ceiling		1.3 m (52 in) Above Floor				
			Center of Living Room	Living Room Average	Center of Living Room	Living Room Average	Center of Living Room	Door of Living Room	Center of Corridor	South End of Corridor	Bedroom No. 1
16 kg Upholstered Chair	1	647	335	312	321	268	178	156	112	111	96
	2	575	236	215	243	171	139	126	87	85	76
	3	592	238	234	237	195	146	133	94	93	82
0.3 kg Waste Container	13	123	37	32	38	28	17	16	15	14	13
	14	146	37	31	36	27	19	17	17	16	15
2.3 kg Crib	11	396	96	87	95	63	42	39	40	41	37
	12	325	90	84	88	61	44	43	42	43	40
6.4 kg Crib Type A	10	286	152	146	153	107	69	63	63	64	58
	15	311	149	142	148	116	59	57	54	56	49
6.4 kg Crib Type B	5	286	141	143	154	112	73	68	67	67	62
	16	285	143	139	146	110	53	50	47	50	43
9.1 kg Crib	17	572	190	178	192	150	84	82	73	73	65
	18	437	196	191	191	151	94	86	80	81	76
13.6 kg Crib	19	718	253	262	244	187	115	98	90	92	83
	20	585	260	251	232	172	108	99	89	93	84
54 ml Heptane	8	116	57	48	56	36	26	22	23	22	22
	9	100	57	47	56	36	26	21	22	22	21
150 ml Heptane	6	188	107	83	96	54	26	19	21	21	20
	7	184	102	80	95	51	26	20	21	22	21

Table 8. Summary of Maximum Total Incident Heat Flux Levels Attained (Ignition Characterization Series)

Item	Test No.	Maximum Total Incident Heat Flux (W/cm^2)						
		Horizontal View					Vertical View	
		1.8m (6 ft) Above Floor, 25mm (1 in) From Item	0.9 m (3 ft) Above Floor, Distance From Item				Ceiling, Centered over Item Downward View	Center of Burn Room Floor, Upward View
			25mm (1 in)	0.6m (2 ft)	1.2m (4 ft)	1.8m (6 ft)		
16 kg Upholstered Chair	1	3.43	4.80	1.75	0.72	0.41	4.20	0.28
	2	1.33	4.27	1.15	0.46	0.25	1.66	0.15
	3	1.56	2.51	1.29	0.49	0.26	2.16	0.16
0.3 kg Waste Container	13	0.16*	0.27*	0.10	0.05	0.01	0.28	0.01
	14	0.19*	0.32*	0.12	0.06	0.01	0.19	0.01
2.3 kg Crib	11	0.47	0.61	0.27	0.14	0.05	0.67	0.04
	12	0.36	0.60	0.24	0.14	0.05	0.64	0.04
6.4 kg Crib Type A	10	0.87	1.67	0.58	0.23	0.12	1.25	0.08
	15	0.96	1.58	0.59	0.24	0.12	1.40	0.09
6.4 kg Crib Type B	5	0.95	1.32	0.71	0.23	0.12	1.17	0.08
	16	1.01	1.91	0.59	0.23	0.10	1.47	0.07
9.1 kg Crib	17	1.23	3.46	1.01	0.35	0.17	2.10	0.11
	18	1.68	3.87	0.96	0.41	0.20	2.43	0.12
13.6 kg Crib	19	2.51	4.48	1.32	0.66	0.49	4.32	0.20
	20	2.04	4.24	1.24	0.60	0.30	2.81	0.18
54 ml Heptane	8	0.29	0.92	0.32	0.13	0.04	0.29	0.03
	9	0.34	0.81	0.25	0.11	0.04	0.44	0.03
150 ml Heptane	6	0.97	4.06	0.72	0.28	0.10	1.41	0.03
	7	0.93	2.97	0.70	0.27	0.11	1.35	0.03

*Actual distance approximately 0.3 m (1 ft)

Table 9. Summary of Selected Smoke and Gas Concentrations (Ignition Characterization Series)

Item	Test No.	Maximum Smoke Concentration (OD/m)						Gas Concentrations (% by vol) 1.5m (5 ft) Above Floor				
		Door to Living Room			South End of Corridor			Minimum O_2*		Maximum CO		Maximum CO_2
		Distance Above Floor			Distance Above Floor							
		0.6 m (2 ft)	1.2m (4 ft)	1.8m (6 ft)	0.6m (2 ft)	1.2m (4 ft)	1.8m (6 ft)	Living Room	South Corridor	Living Room	South Corridor	Living Room
16 kg Upholstered Chair	1	2.2	2.0	2.5	1.8	2.5	2.4	18.1	20.1	0.2	NC***	4.2
	2	2.3	2.1	2.3	1.4	2.2	1.9	19.2	18.2	0.1	0.1	3.1
	3	2.3	2.1	2.5	2.0	2.2	2.0	19.3	17.0	0.1	0.1	3.7
0.3 kg Waste Container	13	NC	NC	0.1	NC	NC	NC	20.7	20.6	**	NC	NC
	14	NC	NC	0.1	NC	NC	0.1	NC	20.6	**	NC	NC
2.3 kg Crib	11	0.9	1.2	1.7	0.9	1.3	1.6	20.4	19.9	0.1	0.1	1.2
	12	0.3	0.7	1.7	0.6	0.8	1.5	20.4	19.4	0.1	0.1	1.2
6.4 kg Crib Type A	10	0.3	0.2	0.3	0.3	0.2	0.2	20.2	18.1	**	NC	2.1
	15	0.8	1.5	0.7	0.6	0.6	0.5	20.2	18.3	NC	NC	2.1
6.4 kg Crib Type B	5	0.5	0.1	0.3	0.6	0.2	0.2	19.2	18.1	0.1	NC	2.4
	16	0.9	1.4	0.9	1.0	1.9	1.1	20.2	19.3	NC	NC	2.6
9.1 kg Crib	17	1.1	1.2	1.1	1.2	1.6	0.5	19.5	16.8	0.1	NC	3.7
	18	1.3	1.2	1.0	0.9	1.4	0.9	18.9	16.4	0.1	NC	3.6
13.6 kg Crib	19	1.0	1.2	0.5	0.5	0.7	0.5	19.3	15.4	NC	0.1	3.7
	20	0.9	1.3	0.8	0.9	0.7	0.5	18.5	15.1	0.1	0.1	5.0
54 ml Heptane	8	NC	0.1	0.3	NC	0.1	0.2	NC	20.7	**	NC	NC
	9	NC	0.1	0.3	NC	NC	0.2	20.7	20.7	**	NC	NC
150 ml Heptane	6	NC	0.1	0.7	NC	0.2	0.5	NC	20.5	**	NC	NC
	7	NC	0.1	0.6	NC	0.1	0.5	20.7	20.4	**	NC	NC

*Based on initial O_2 concentration of 20.8%

**Data could not be reliably obtained

***Essentially unchanged from initial condition

Table 10. Summary of Averaged Readings for Selected Types of Incidental Fires (Ignition Characterization Series)

Item	Maximum Temperature		Maximum Total Incident Heat Flux		Maximum Steady Burning Flame Height	Gas Concentrations in the Living Room		
	In Flame Plume	Center of Room, 25 mm (1 in) From Ceiling	25 mm (1 in) From Item, 0.9 m (3 ft) Above Floor	Center of Living Room Floor Level		Minimum O_2	Maximum CO	Maximum CO_2
	(°C)	(°C)	(W/cm^2)	(W/cm^2)	(m)	(%)	(%)	(%)
0.3 kg Waste Container	135	37	0.30	0.01	0.5	20.7	*	NC**
6.4 kg Crib	295	146	1.62	0.08	1.3	20.0	NC	2.3
13.6 kg Crib	652	257	4.36	0.19	2.1	18.9	0.1	4.4
16 kg Upholstered Chair	605	270	3.86	0.20	2.0	18.9	0.1	3.7

* Data could not be reliably obtained.
** Essentially unchanged from initial condition.

Table 11. Relationship Between Maximum Total Incident Heat Flux on the Floor in the Center of the Living Room and Maximum Average Temperature 25 mm (1 in) Below the Ceiling in the Living Room for all Tests of Wood Cribs and Upholstered Chairs (Ignition Characterization Series)

Test No.	T Maximum Average Living Room Temperature 25 mm (1 in) Below Ceiling	σT^4	H Maximum Total Incident Heat Flux at Floor of Living Room	$\frac{H}{\sigma T^4}$
	(°C)	(W/cm^2)	(W/cm^2)	
1	312	0.66	0.28	0.42
2	215	0.32	0.15	0.47
3	234	0.38	0.16	0.42
5	145	0.17	0.08	0.47
10	146	0.17	0.08	0.47
11	87	0.10	0.04	0.40
12	84	0.09	0.04	0.44
15	142	0.17	0.09	0.53
16	133	0.15	0.07	0.47
17	178	0.23	0.11	0.48
18	191	0.26	0.12	0.46
19	262	0.47	0.20	0.43
20	251	0.43	0.18	0.42
				Average = 0.45

Note: σ is Stefan-Boltzmann constant

APPENDIX A

CHRONOLOGICAL SUMMARY OF OBSERVATIONS

FOR

SELECTED TESTS

MOBILE HOME IGNITION CHARACTERIZATION SERIES
TEST 3
16 kg (35 lb) Upholstered Chair

Time (Min:Sec)	Observation/Event
0:00	Ignition of newsprint in polyethylene waste container
0:14	Flame from newsprint impinging on left arm of chair
0:25	Charring of left arm of chair
0:30	Flame height approximately 0.8 m (2.5 ft) above floor
0:34	Smoke detector alarm
0:45	Ignition of left arm of chair
0:55	Height of flame from newsprint and left arm of chair is approximately 0.9 m (3.0 ft) above floor
1:12	Waste container beginning to melt away
1:35	Slight spread of flame on left arm, scorch area approximately 0.3 m (1.0 ft) wide
2:45	Involvement of polyurethane foam inside left arm
3:05	Waste container approximately 50% melted
4:25	Smoke visible from underneath chair
5:10	Flame height approximately 0.9 m (3.0 ft) above floor
5:40	Flame intensity increasing
5:45	Left rear of chair has become involved
6:10	Material dripping from chair
6:50	Waste container completely melted down
6:55	Increase in flame intensity as polyurethane foam in left arm becomes more involved.
7:00	Charring of front left area of seat cushion
7:15	Flame height approximately 1.1 m (3.5 ft) above floor
7:40	Flame height approximately 1.2 m (4.0 ft) above floor
7:55	Entire left side of chair is involved or charred
8:35	Bottom of smoke layer approximately 0.9 m (3.0 ft) above floor
10:10	Burn-through of left arm of chair
10:15	Flames from left arm are impinging on rear cushion of chair
10:45	Involvement of left portion of rear cushion
10:55	Flame height approximately 1.2 m (4.0 ft) above floor
11:15	Flame height approximately 1.4 m (4.5 ft) above floor
11:25	Involvement of left portion of seat cushion
11:30	Flame height approximately 1.5 m (5.0 ft) above floor
11:35	Increase in flame intensity and smoke obscuration in the living room
11:55	Flame height approximately 1.7 m (5.5 ft) above floor
12:00	Flame height approximately 1.8 m (6.0 ft) above floor
12:10	Left portion of rear cushion and left portion of seat cushion fully involved - left portion of front of chair becoming involved
12:25	Black smoke being produced
12:50	Involvement of right arm of chair
13:15	Involvement of entire rear portion of chair

14:30	Burn-through of the rear cushion and seat cushion
14:40	Bottom of smoke layer approximately 0.3 m (1.0 ft) above floor
15:30	Flame intensity decreasing
16:00	Rear of chair, left arm, and seat cushion almost completely consumed
17:00	Termination of test

MOBILE HOME IGNITION CHARACTERIZATION SERIES
TEST 12
2.3 kg (5 lb) Wood Crib

Time (Min:Sec)	Observation/Event
0:00	Ignition of heptane in pan under crib
0:20	Dark gray smoke, but no flames, being emitted from top of crib
1:45	Flames visible above crib
1:50	Flame height 1.1 - 1.2 m (3.5 - 4.0 ft) above floor
2:10	Smoke detector alarm
3:15	Heptane completely consumed --- flames no longer visible above crib, however, burning is present in interior of crib
4:10	Bottom of smoke layer is approximately 1.5 m (5 ft) above floor
6:20	Detached flame burning in gas plume above crib
6:55	Flame height approximately 0.9 m (3.0 ft) above floor
7:10	Flame now attached to top of crib --- flame height approximately 1.1 m (3.5 ft) above floor
7:50	Bottom of smoke layer approximately 1.2 m (4.0 ft) above floor
9:00	Flame height 1.2 - 1.4 m (4.0 - 4.5 ft) above floor
10:40	Bottom 1/4 of crib is glowing, rest is flaming
13:35	Lower 1/3 of crib is glowing, many sticks have collapsed in interior of crib --- flame height 1.4 - 1.5 m (4.5 - 5.0 ft) above floor
16:45	Lower 1/2 of crib is glowing, rest is flaming --- flame height still 1.4 - 1.5 m (4.5 - 5.0 ft) above floor
19:30	Flame height approximately 1.2 m (4.0 ft) above floor
20:50	Most of interior of crib has collapsed --- flame height 1.1 - 1.2 m (3.5 - 4.0 ft) above floor
23:40	Flame height 0.8 - 0.9 m (2.5 - 3.0 ft) above floor
23:45	Crib has completely collapsed
24:30	Termination of test

MOBILE HOME IGNITION CHARACTERIZATION SERIES
TEST 15
6.4 kg (14 lb) Wood Crib

Time Min:Sec	Observation/Event
0:00	Ignition of heptane in pan under crib
0:15	Flame height approximately 1.2 m (4.0 ft) above floor
0:29	Smoke detector alarm
0:30	Flame height 1.2 - 1.4 m (4.0 - 4.5 ft) above floor
0:40	Flame height approximately 1.5 m (5.0 ft) above floor
0:55	Flame height approximately 1.8 m (6.0 ft) above floor
1:15	Flame impingement on ceiling (flame height 2.1 m (7.0 ft) above floor)
1:35	Flames receding from ceiling
1:45	Flame height 1.2 - 1.4 (4.0 - 4.5 ft) above floor
1:48	Heptane completely consumed
2:00	Flame height 1.1 - 1.2 m (3.5 - 4.0 ft) above floor
2:17	Flame height approximately 1.2 m (4.0 ft) above floor
2:17-8:00	No appreciable change in conditions or size of fire
8:00	Flame height approximately 1.1 - 1.2 m (3.5 - 4.0 ft) above floor --- no significant change in visibility in room
9:00	Flame height approximately 1.2 m (4.0 ft) above floor
9:00-13:30	No appreciable change in conditions or size of fire
13:30	Flame height approximately 1.2 m (4.0 ft) above floor
13:50	Interior of crib beginning to collapse
14:00	Flame height approximately 1.2 m (4.0 ft) above floor
14:30	Flame height approximately 1.1 m (3.5 ft) above floor
15:30	Flame height approximately 1.1 m (3.5 ft) above floor
15:40	Flame more yellow, not as intense --- flame height approximately 1.1 m (3.5 ft) above floor
16:45	Flame height approximately 1.1 m (3.5 ft) above floor
17:20	Flame height approximately 0.9 m (3.0 ft) above floor
17:55	Flame height approximately 0.9 m (3.0 ft) above floor
19:05	Flame height 150 - 200 mm (6.0 - 8.0 in) above top of crib (approximately 0.6 m (2.0 ft) above floor)
19:25	Crib has collapsed throughout the center
20:00	Termination of test

MOBILE HOME IGNITION CHARACTERIZATION SERIES
TEST 18
9.1 kg (20 lb) Wood Crib

Time (Min:Sec)	Observation/Event
0:00	Ignition of heptane in pan under crib
0:25	Flame height approximately 1.2 m (4.0 ft) above floor

0:35	Flame height approximately 1.5 m (5.0 ft) above floor
0:37	Smoke detector alarm
0:55	Flame impingement on ceiling (flame height 2.1 m (7.0 ft) above floor)
1:35	Heptane completely consumed, reduction in flame height to approximately 1.5 m (5.0 ft) above floor
2:50	Flame height 1.7 - 1.8 m (5.5 - 6.0 ft) above floor
3:10	Flame height 1.8 - 2.0 m (6.0 - 6.5 ft) above floor
3:15	Intermittent flame impingement on ceiling
3:40	Flame impingement on ceiling
4:15	Intermittent flame impingement on ceiling
4:15-10:15	No appreciable change in conditions or size of fire
10:15	Intermittent flame impingement on ceiling
10:50	Flame is more yellow, less intense
11:25	Collapse of a stick near bottom of crib
11:50	Bottom of smoke layer is approximately 0.6 m (2.0 ft) above floor
12:20	Flames continuing to lose intensity
13:25	Bottom of smoke layer at floor level
14:20	Flame height 1.7 - 1.8 m (5.5 - 6.0 ft) above floor
15:15	Flame height 1.7 - 1.8 m (5.5 - 6.0 ft) above floor
15:20	Sticks at bottom of crib continuing to collapse
15:50	Smoke meters at door to living room are obscured from view by smoke
17:05	Flame height 1.4 - 1.5 m (4.5 - 5.0 ft) above floor
17:40	Flame height 1.1 - 1.2 m (3.5 - 4.0 ft) above floor
18:30	Flame height approximately 0.3 m (1.0 ft) above top of crib (approximately 0.8 m (2.5 ft) above floor)
19:35	Flame height 150-200 (6.0 - 8.0 in) above top of crib
20:00	Termination of test

MOBILE HOME IGNITION CHARACTERIZATION SERIES
TEST 20
13.6 kg (30 lb) Wood Crib

Time (Min:Sec)	Observation/Event
0:00	Ignition of heptane in pan under crib
0:24	Flame height approximately 0.9 m (3.0 ft) above floor
0:28	Flame height approximately 1.2 m (4.0 ft) above floor
0:32	Flame height 1.4 - 1.5 m (4.5 - 5.0 ft) above floor
0:38	Smoke detector alarm
0:53	Flame impingement on ceiling (flame height 2.1 m (7.0 ft) above floor)
1:40	Heptane completely consumed, no decrease in flame height
1:45	Flame impingement on ceiling

3:30	Steady flame impingement on ceiling, flames are extending out from corner approximately 0.9 m (3.0 ft) into living room at ceiling level
3:30-11:25	No appreciable change in conditions or size of fire
11:25	Collapse of some sticks in interior of crib
12:20	Steady flame impingement on ceiling, flames are extending out from corner 1.1 - 1.2 m (3.5 - 4.0 ft) into living room at ceiling level
12:40	Bottom of smoke layer is at floor level
15:35	Continuing steady flame impingement on ceiling, flames are extending approximately 0.9 m (3.0 ft) into living room at ceiling level
15:45	Flames are becoming less intense
16:20	Intermittent flame impingement on ceiling
16:35	Flames are more yellow, less intense
17:12	Intermittent flame impingement on ceiling
17:30	Flame height approximately 2.0 m (6.5 ft) above floor --- no impingement on ceiling
18:30	Flame height 1.7 - 1.8 m (5.5 - 6.0 ft) above floor
19:05	Flame height 1.4 - 1.5 m (4.5 - 5.0 ft) above floor
19:40	Flame height 1.4 - 1.5 m (4.5 - 5.0 ft) above floor
20:35	Flame height 1.1 - 1.2 m (3.5 - 4.0 ft) above floor
20:45	Sticks in interior of crib continuing to collapse
21:30	Flame height 1.1 - 1.2 m (3.5 - 4.0 ft) above floor
22:00	Termination of test

APPENDIX B

PLOTTED TEST DATA ILLUSTRATING CHANGES IN VARIOUS MEASURED CONDITIONS

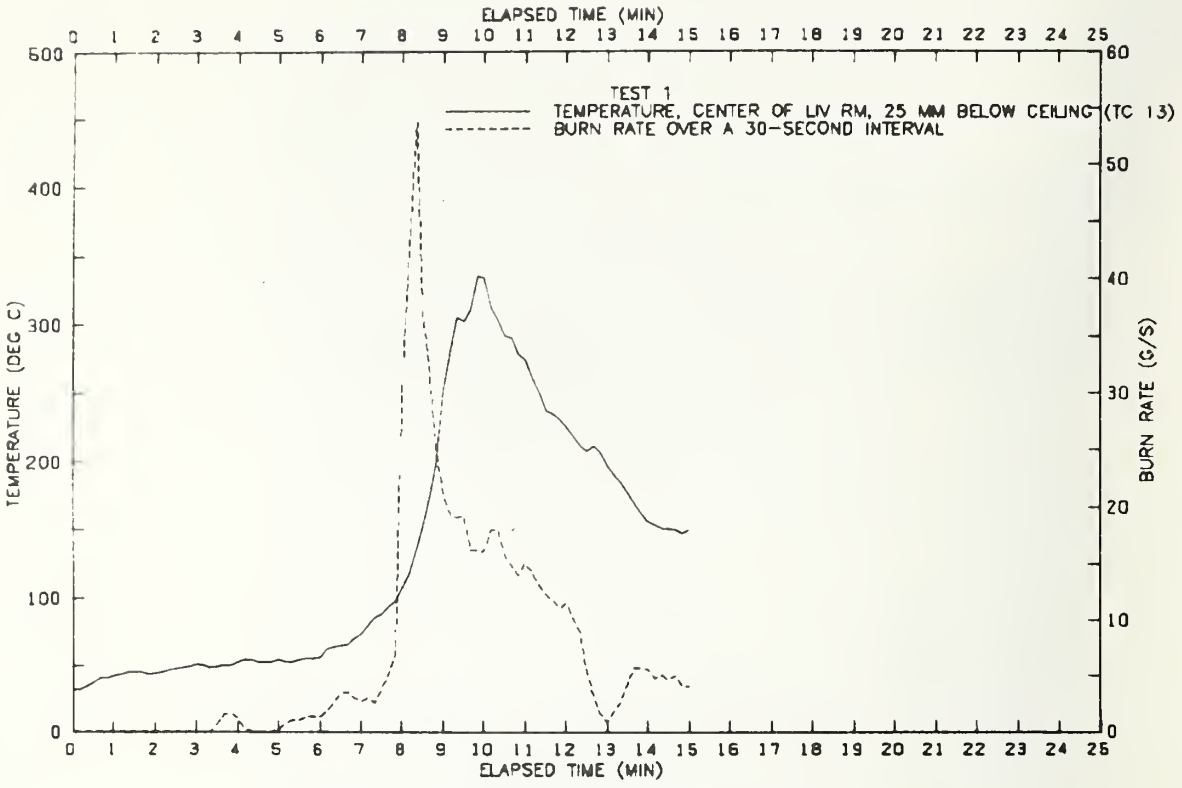

FIGURE B1. GAS TEMPERATURE MEASURED IN THE LIVING ROOM, AND THE BURN RATE OF THE UPHOLSTERED CHAIR.

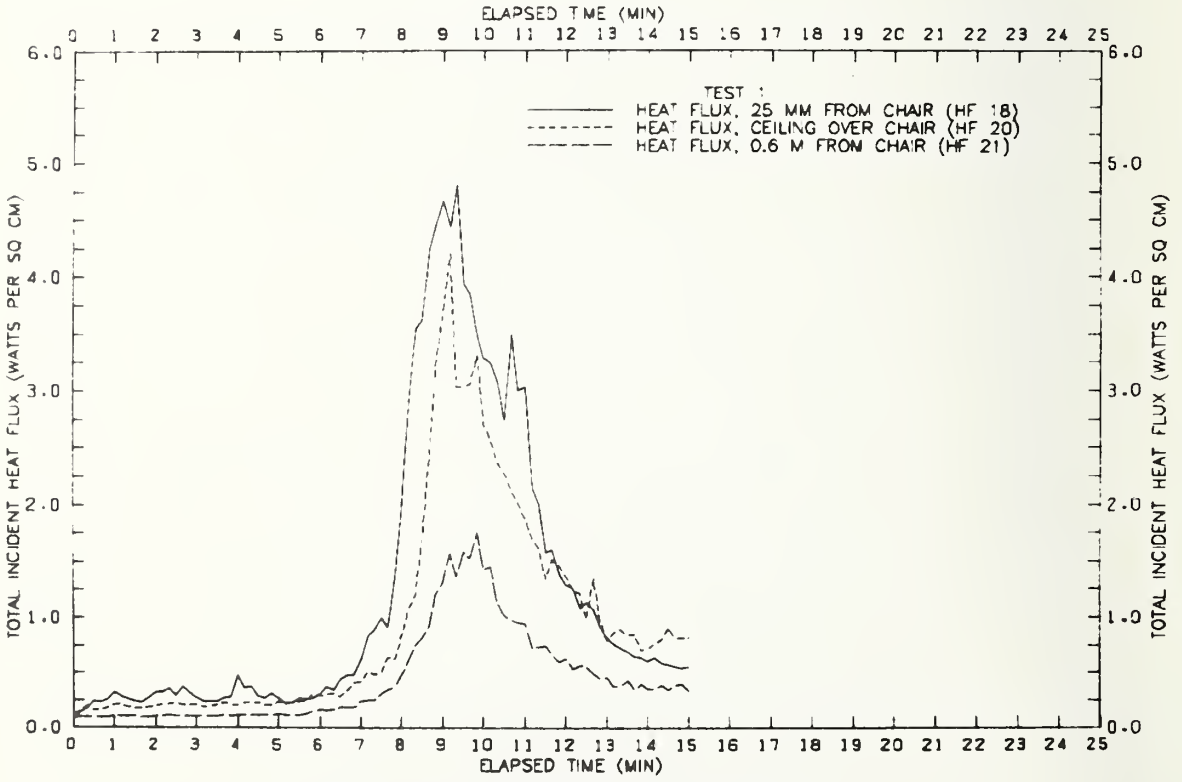

FIGURE B2. TOTAL INCIDENT HEAT FLUX MEASURED AT DIFFERENT LOCATIONS AROUND THE UPHOLSTERED CHAIR.

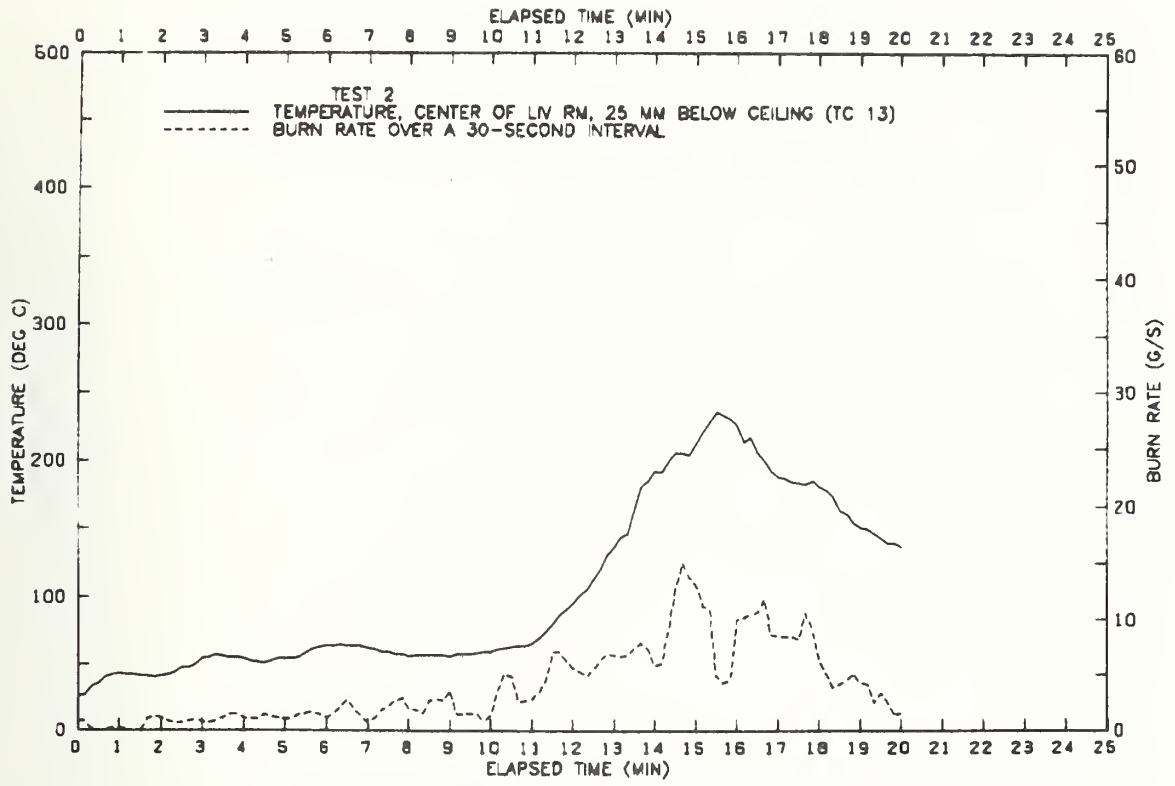

FIGURE B3. GAS TEMPERATURE MEASURED IN THE LIVING ROOM, AND THE BURN RATE OF THE UPHOLSTERED CHAIR.

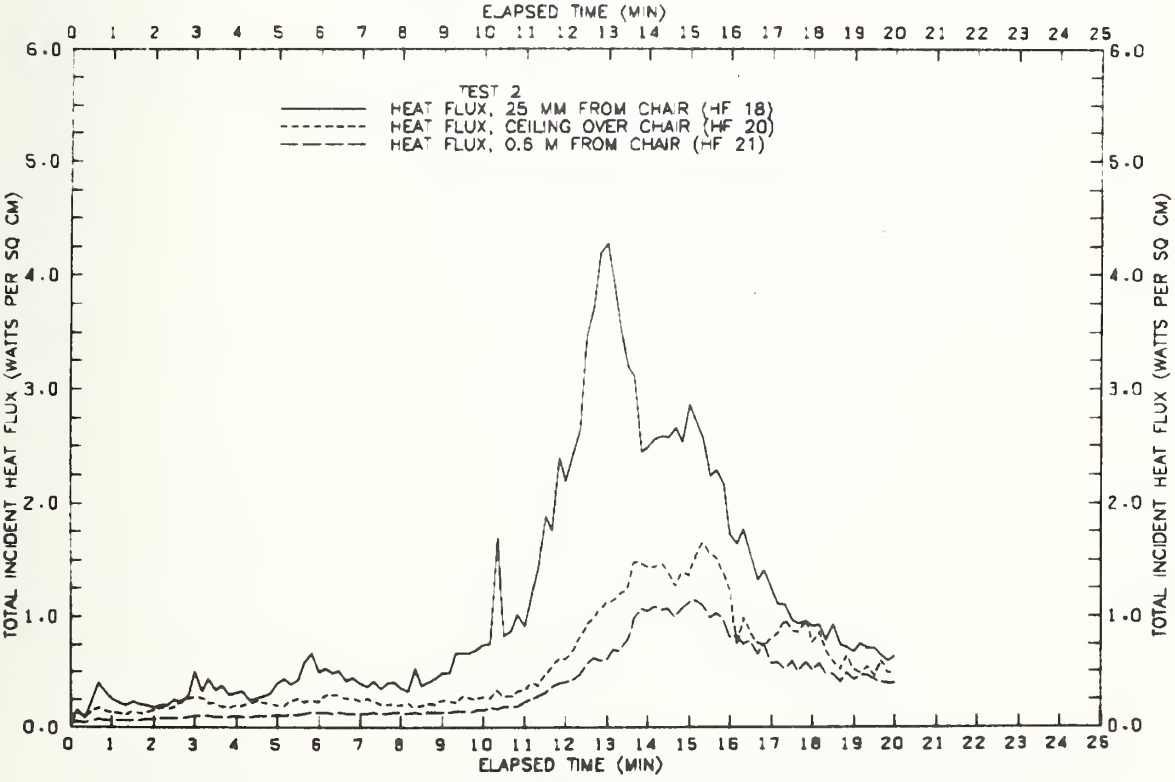

FIGURE B4. TOTAL INCIDENT HEAT FLUX MEASURED AT DIFFERENT LOCATIONS AROUND THE UPHOLSTERED CHAIR.

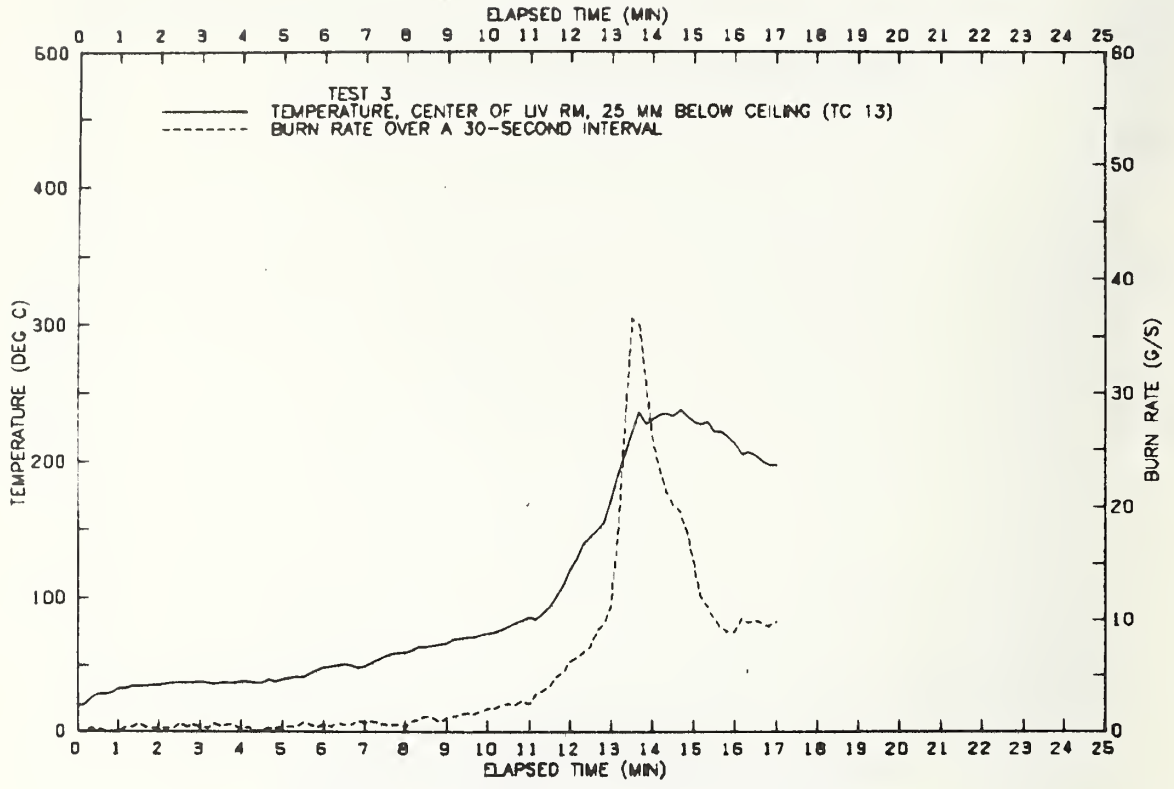

FIGURE B5. GAS TEMPERATURE MEASURED IN THE LIVING ROOM, AND THE BURN RATE OF THE UPHOLSTERED CHAIR.

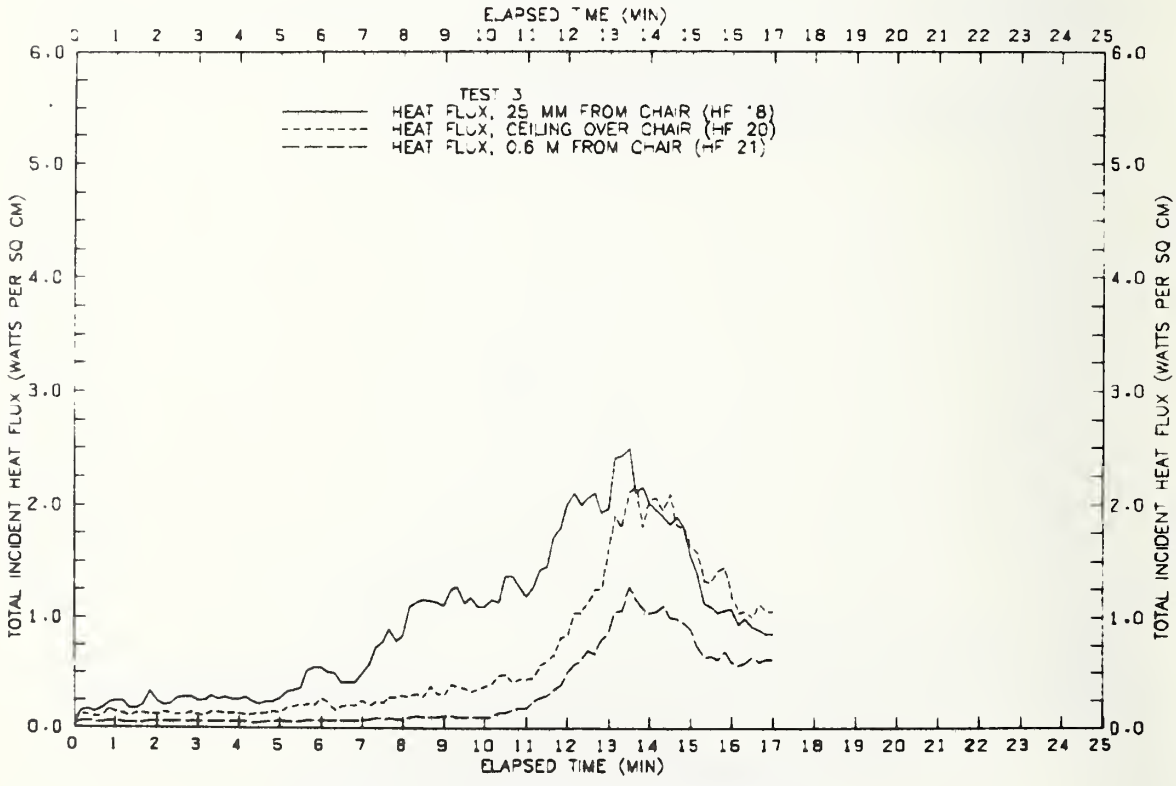

FIGURE B6. TOTAL INCIDENT HEAT FLUX MEASURED AT DIFFERENT LOCATIONS AROUND THE UPHOLSTERED CHAIR.

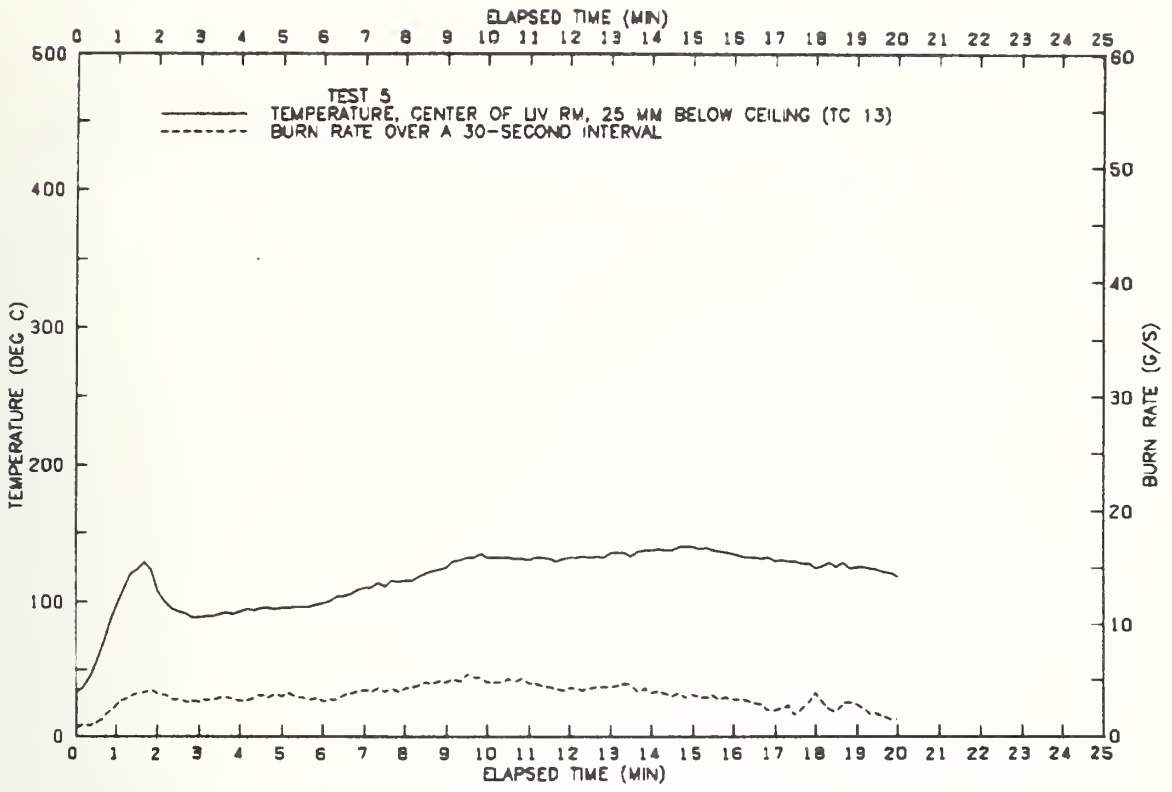

FIGURE B7. GAS TEMPERATURE MEASURED IN THE LIVING ROOM, AND THE BURN RATE OF THE WOOD CRIB.

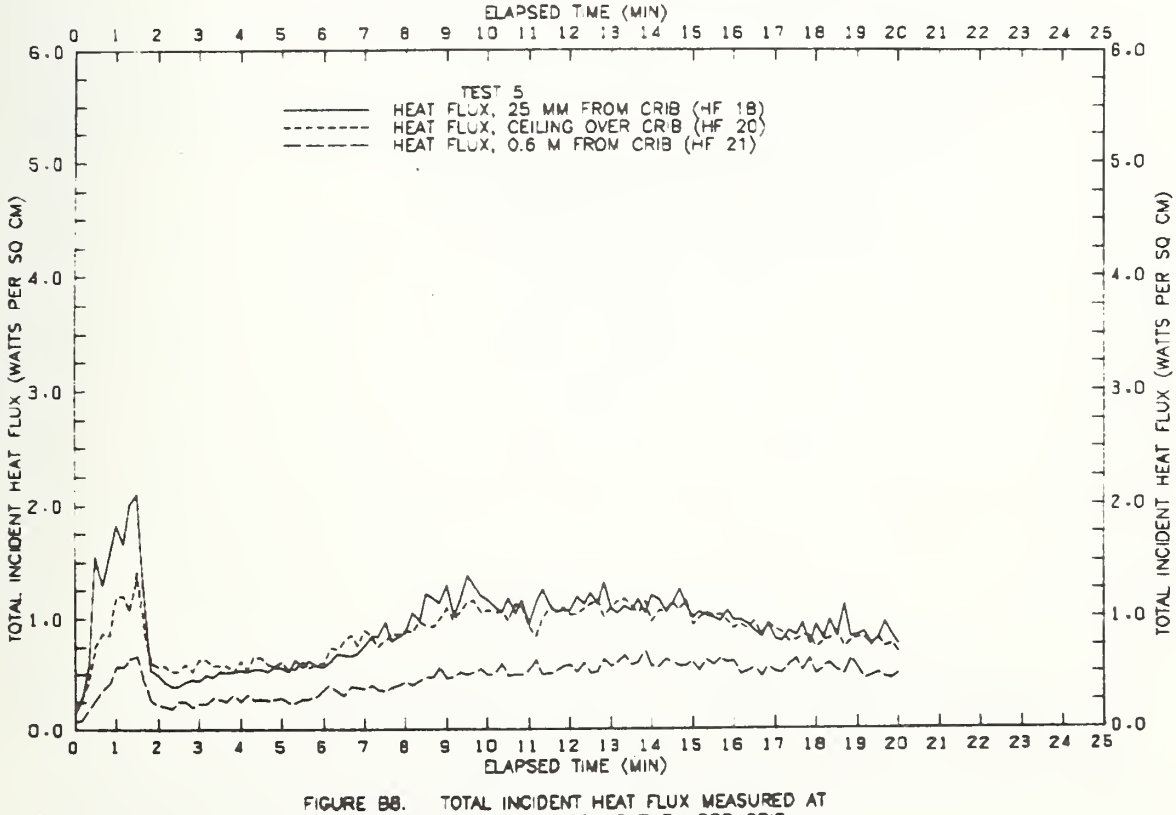

FIGURE B8. TOTAL INCIDENT HEAT FLUX MEASURED AT DIFFERENT LOCATIONS AROUND THE WOOD CRIB.

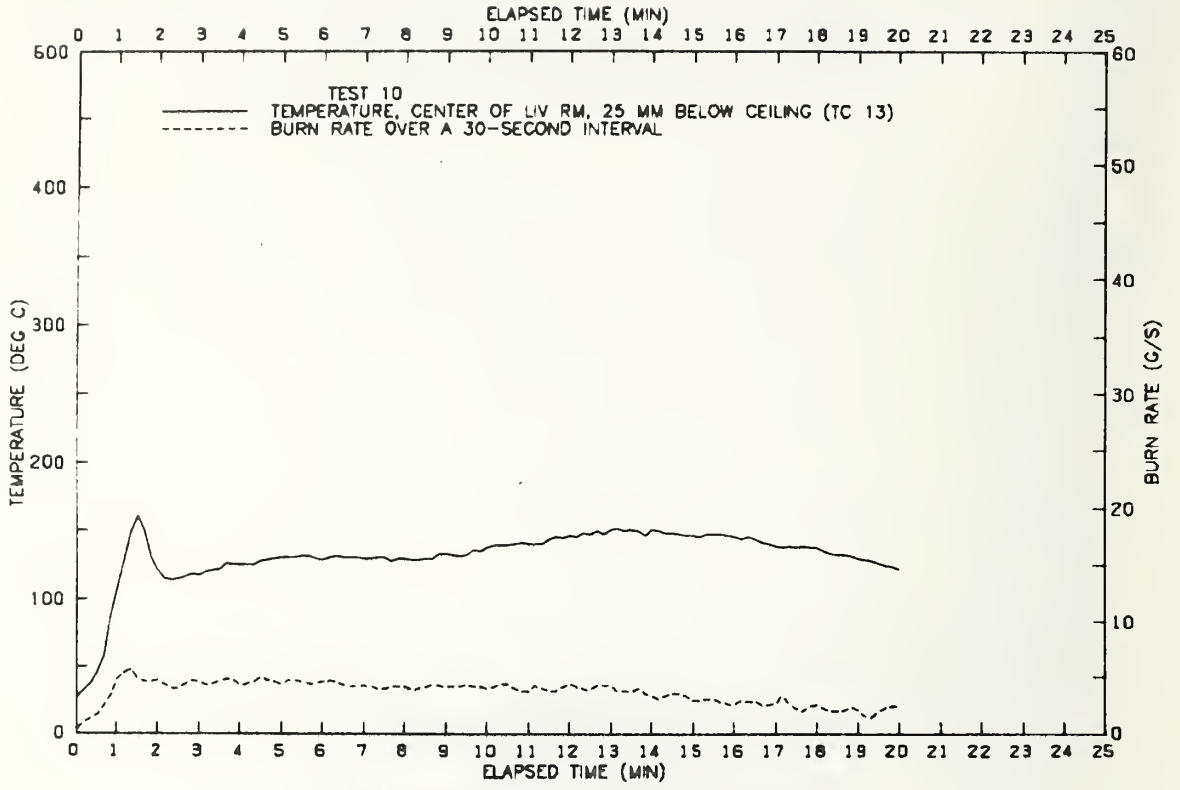

FIGURE B9. GAS TEMPERATURE MEASURED IN THE LIVING ROOM, AND THE BURN RATE OF THE WOOD CRIB.

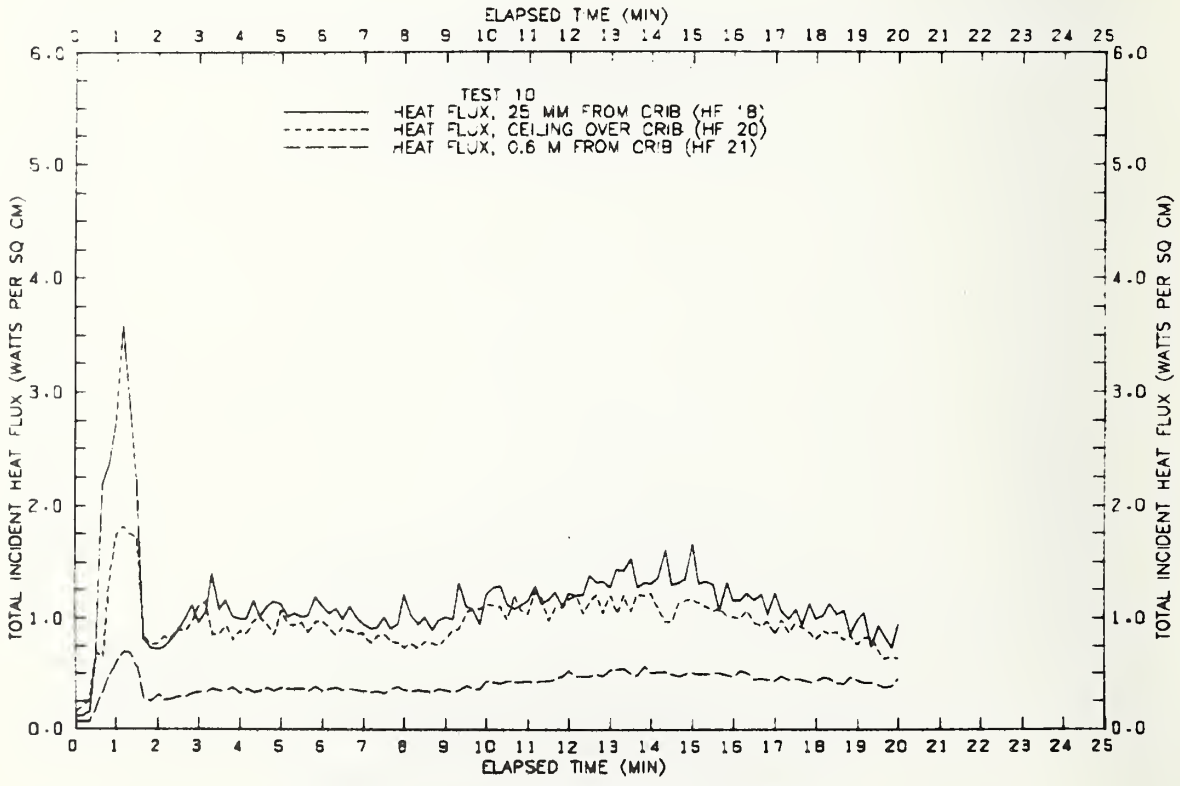

FIGURE B10. TOTAL INCIDENT HEAT FLUX MEASURED AT DIFFERENT LOCATIONS AROUND THE WOOD CRIB.

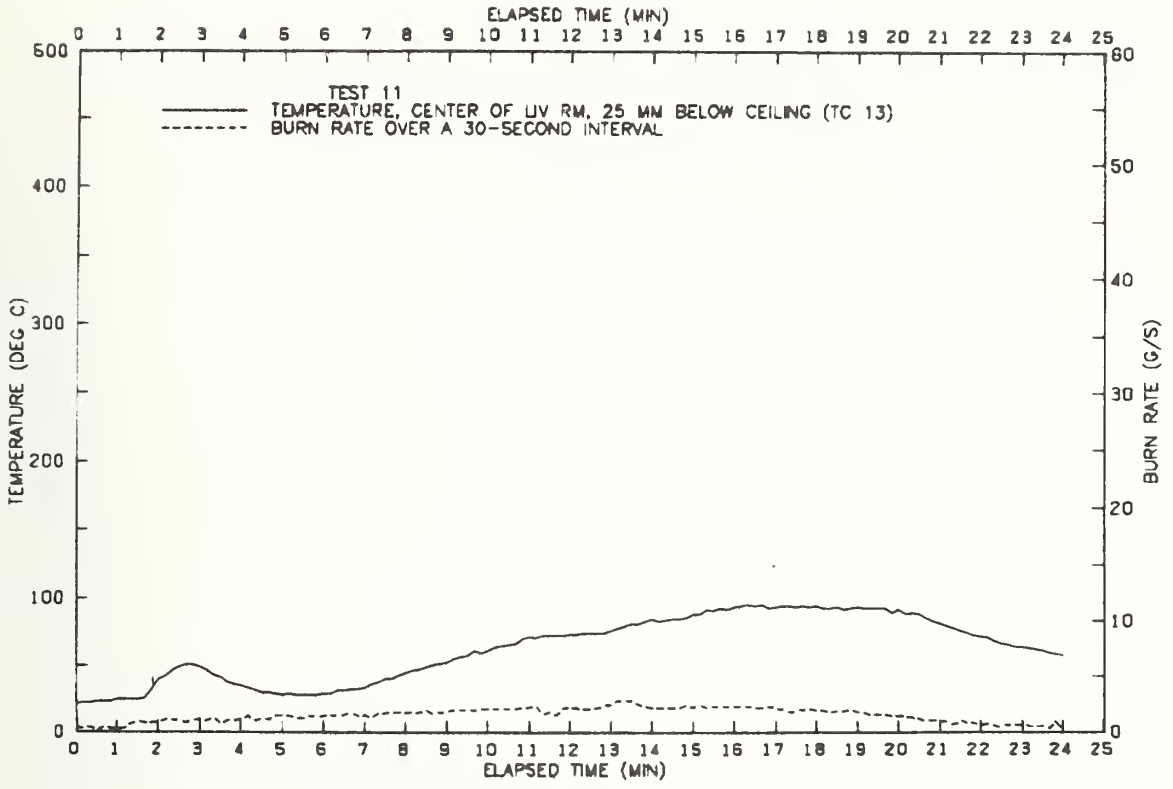

FIGURE B11. GAS TEMPERATURE MEASURED IN THE LIVING ROOM, AND THE BURN RATE OF THE WOOD CRIB.

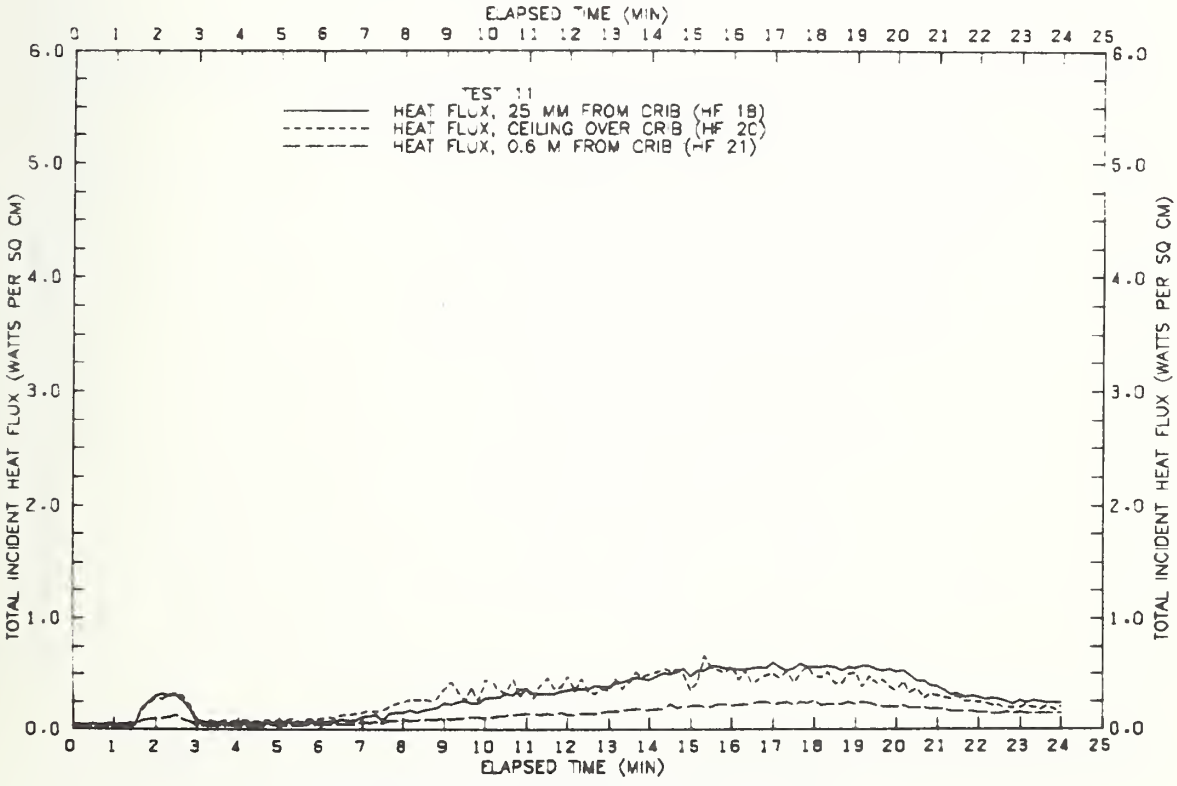

FIGURE B12. TOTAL INCIDENT HEAT FLUX MEASURED AT DIFFERENT LOCATIONS AROUND THE WOOD CRIB.

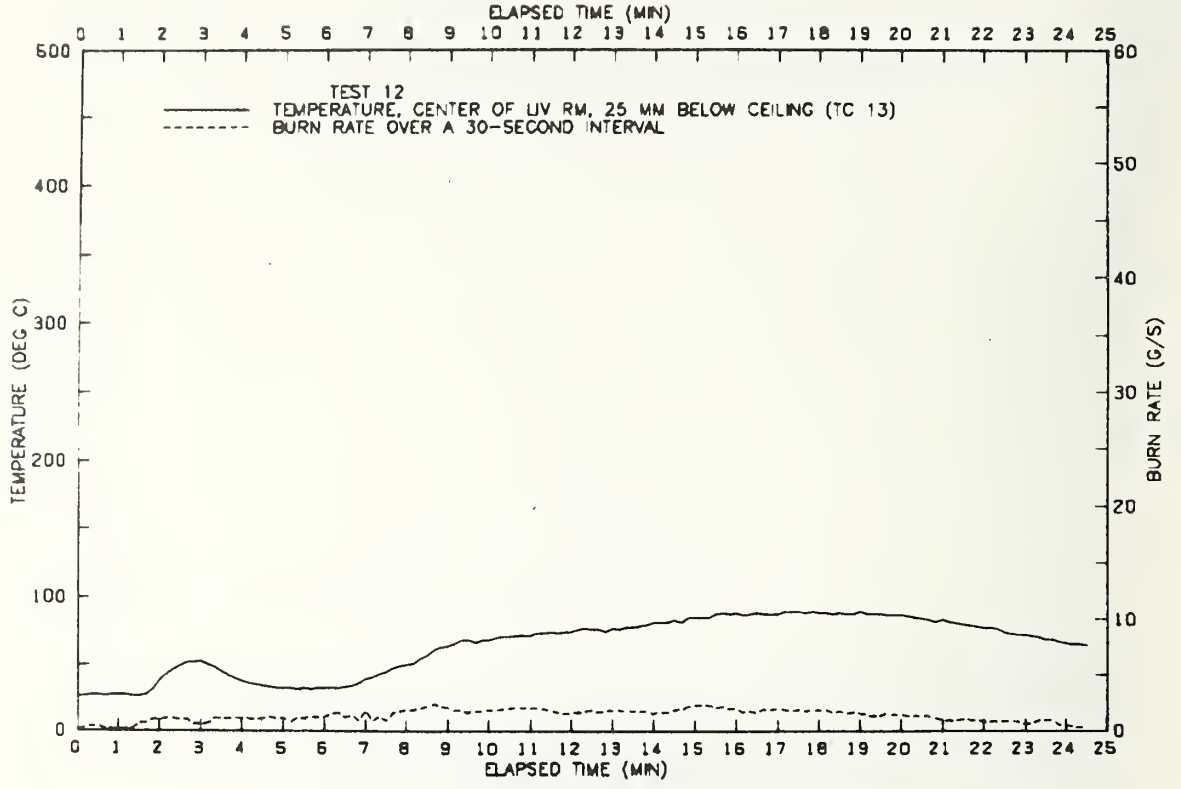

FIGURE B13. GAS TEMPERATURE MEASURED IN THE LIVING ROOM, AND THE BURN RATE OF THE WOOD CRIB.

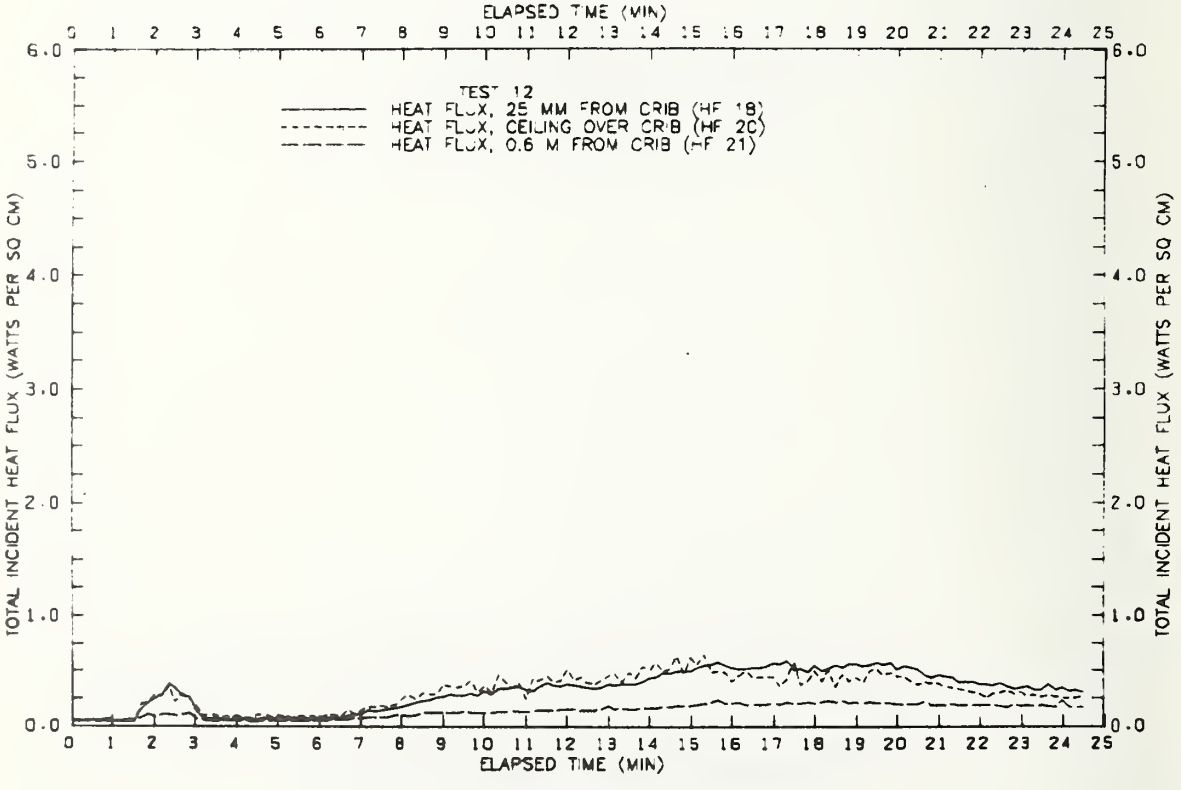

FIGURE B14. TOTAL INCIDENT HEAT FLUX MEASURED AT DIFFERENT LOCATIONS AROUND THE WOOD CRIB.

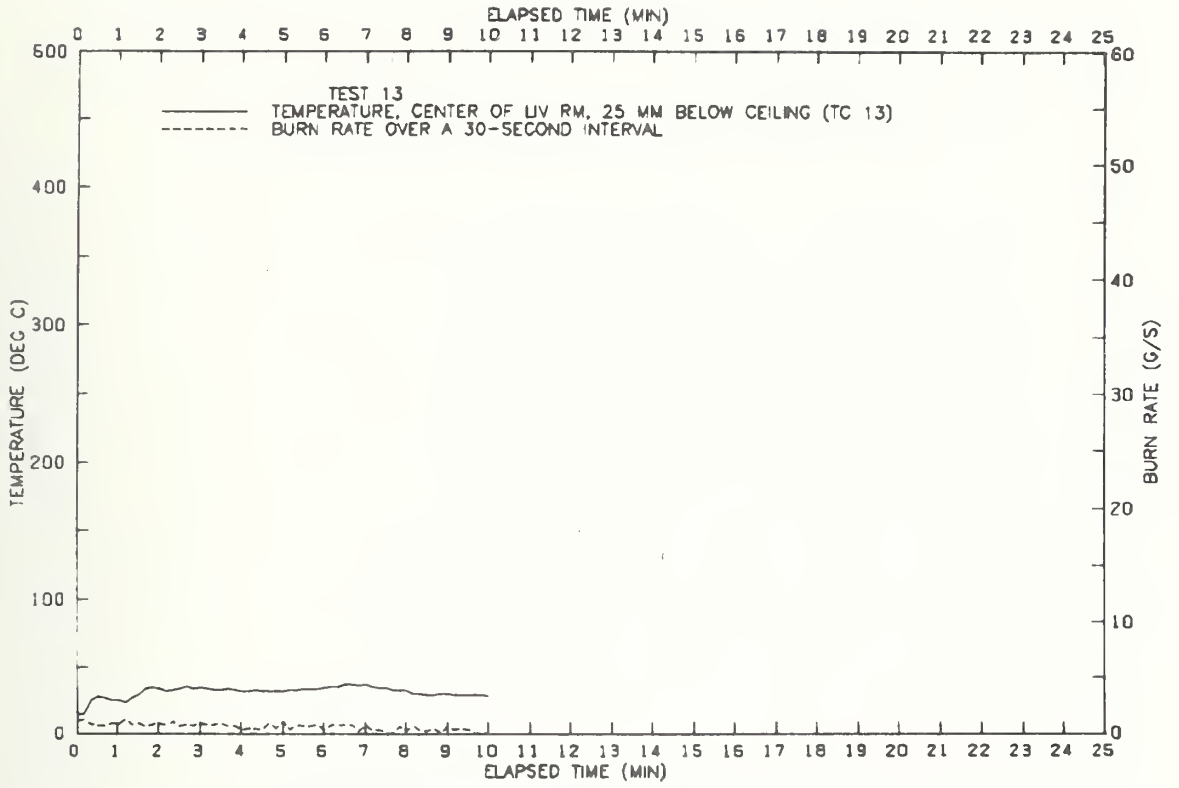

FIGURE B15. GAS TEMPERATURE MEASURED IN THE LIVING ROOM, AND THE BURN RATE OF THE WASTE CONTAINER AND NEWSPAPER.

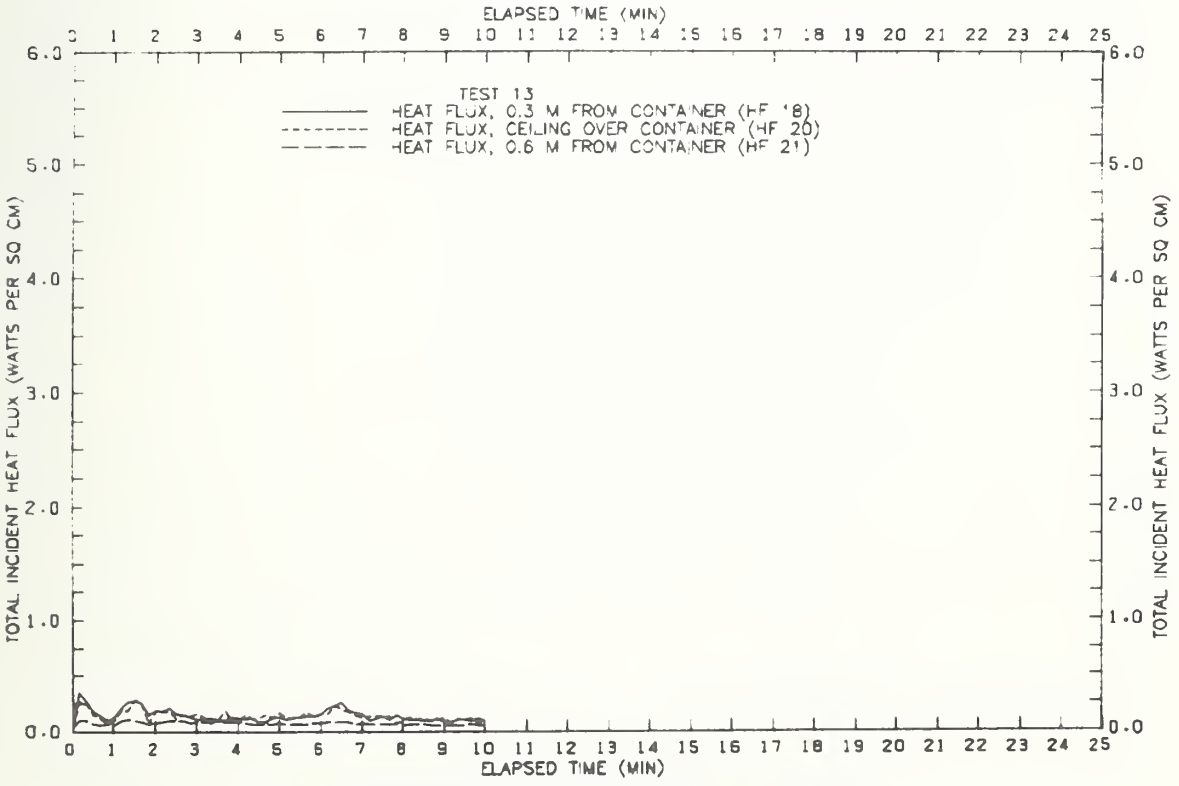

FIGURE B16. TOTAL INCIDENT HEAT FLUX MEASURED AT DIFFERENT LOCATIONS AROUND THE WASTE CONTAINER.

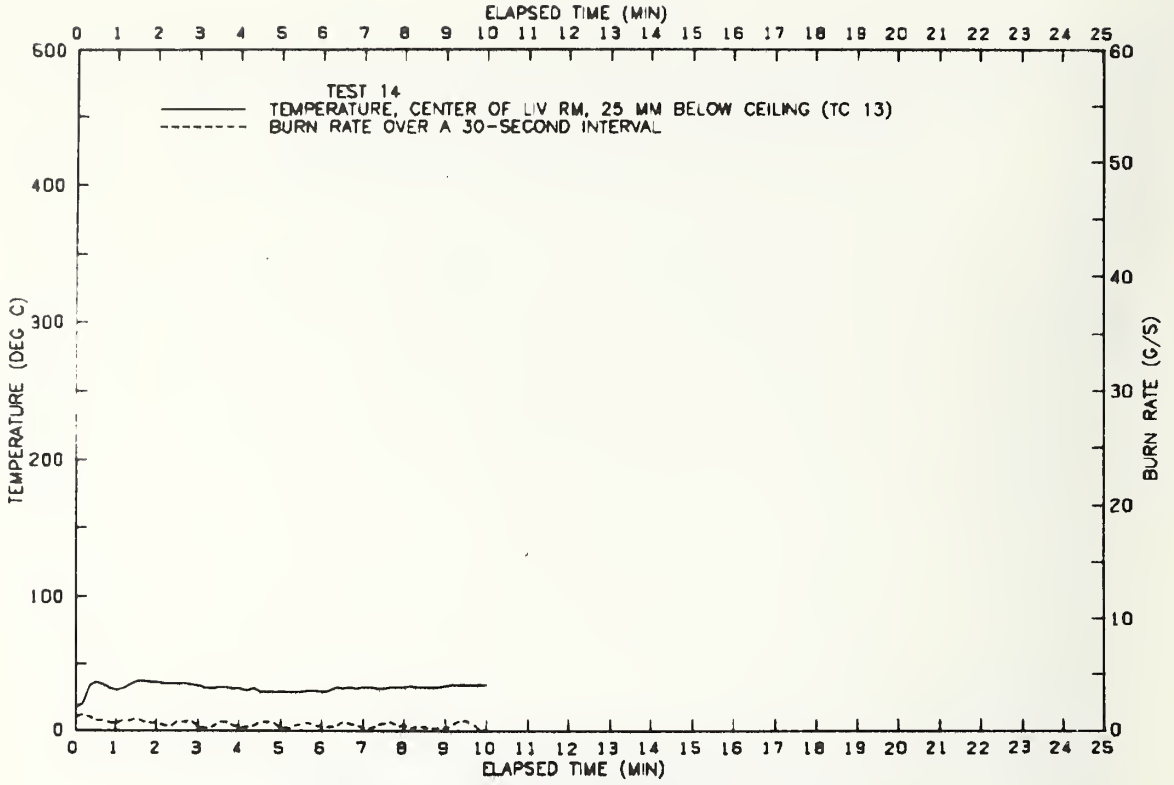

FIGURE B17. GAS TEMPERATURE MEASURED IN THE LIVING ROOM, AND THE BURN RATE OF THE WASTE CONTAINER AND NEWSPAPER.

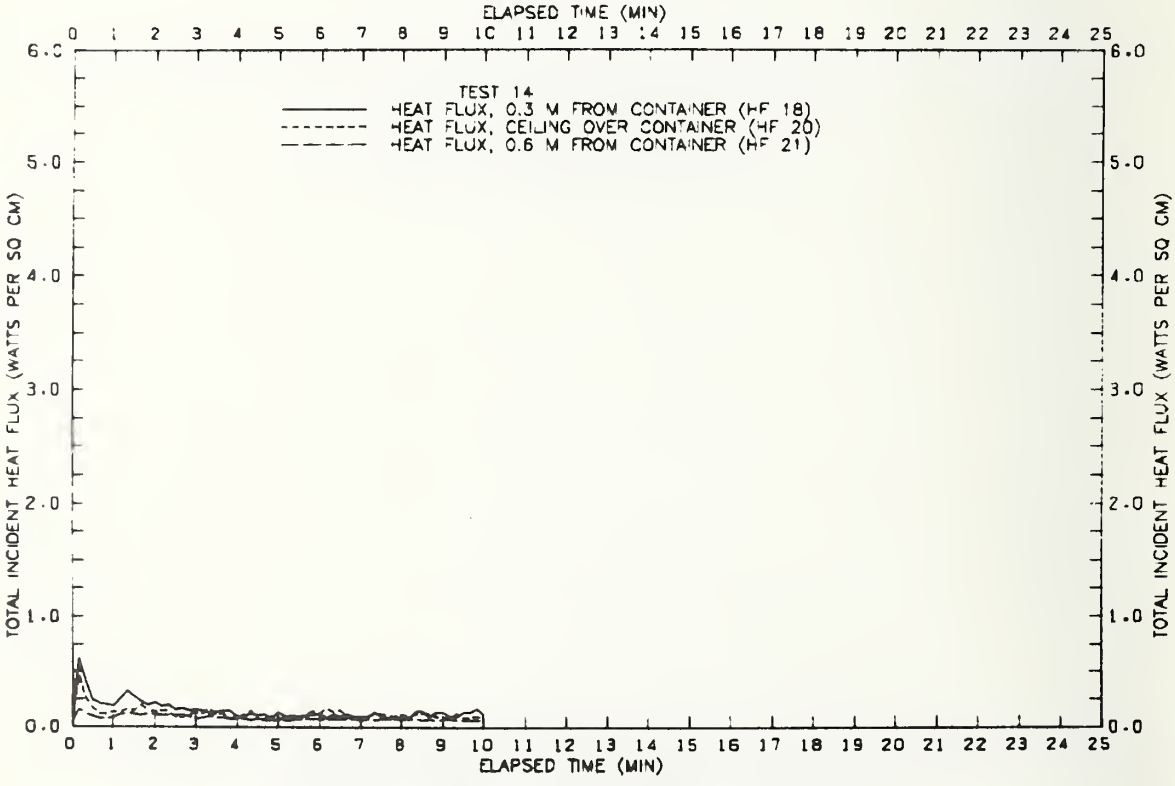

FIGURE B18. TOTAL INCIDENT HEAT FLUX MEASURED AT DIFFERENT LOCATIONS AROUND THE WASTE CONTAINER.

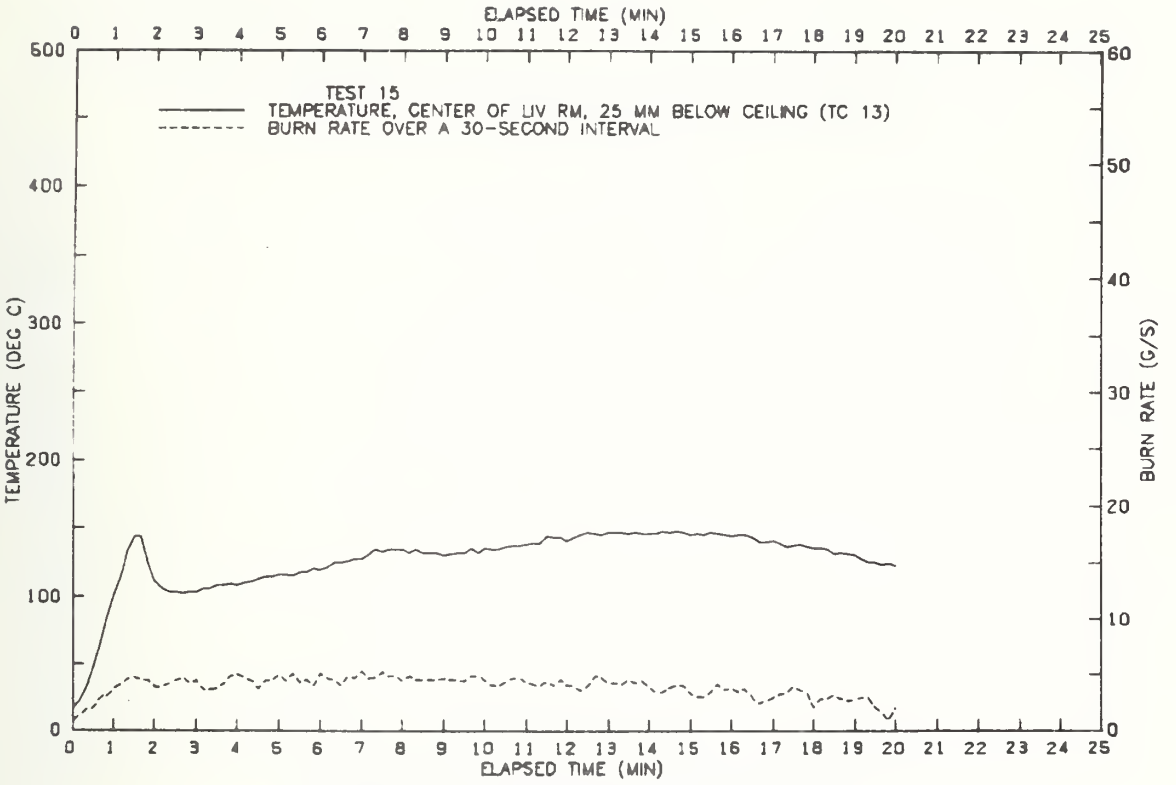

FIGURE B19. GAS TEMPERATURE MEASURED IN THE LIVING ROOM, AND THE BURN RATE OF THE WOOD CRIB.

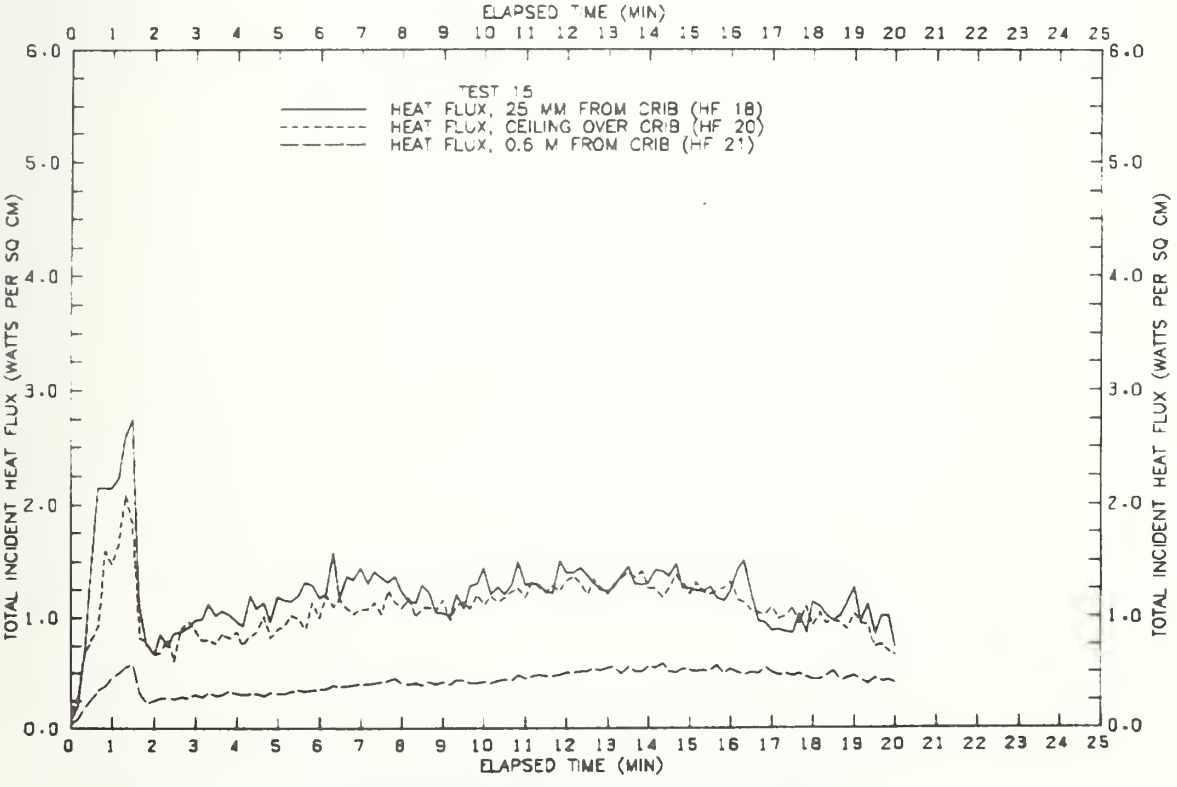

FIGURE B20. TOTAL INCIDENT HEAT FLUX MEASURED AT DIFFERENT LOCATIONS AROUND THE WOOD CRIB.

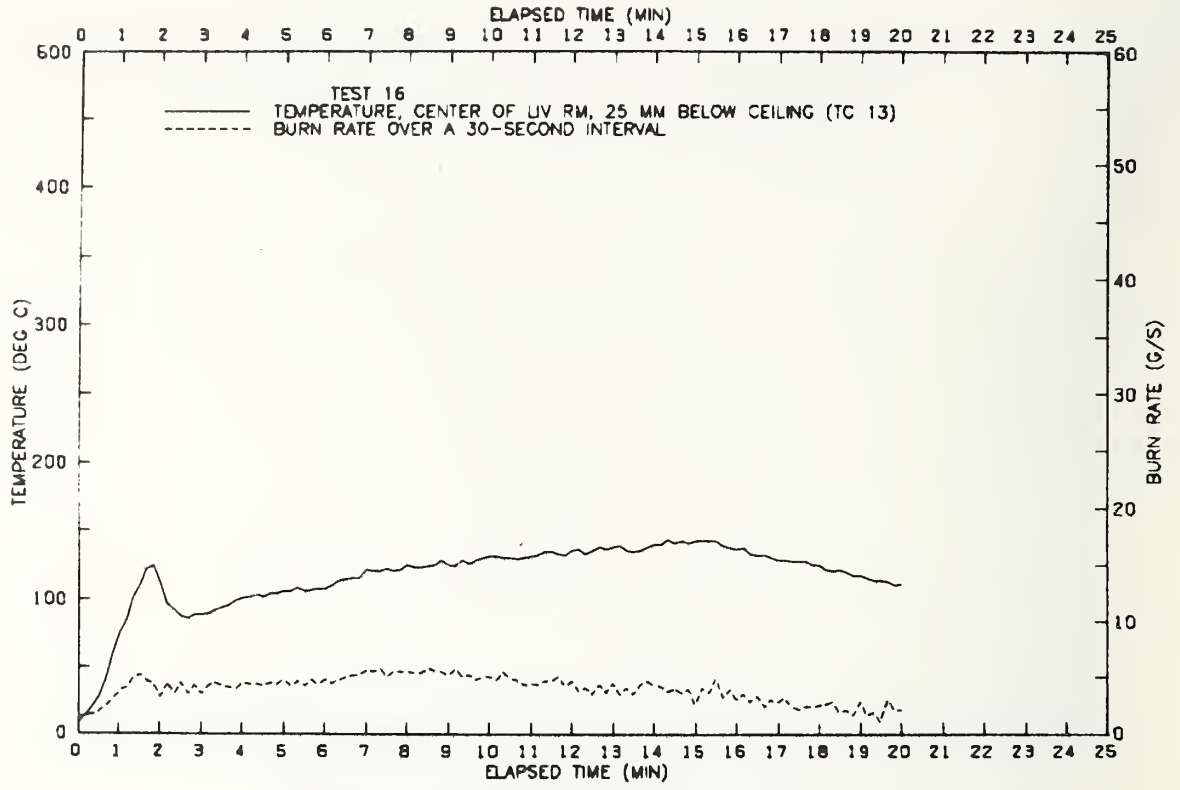

FIGURE B21. GAS TEMPERATURE MEASURED IN THE LIVING ROOM, AND THE BURN RATE OF THE WOOD CRIB.

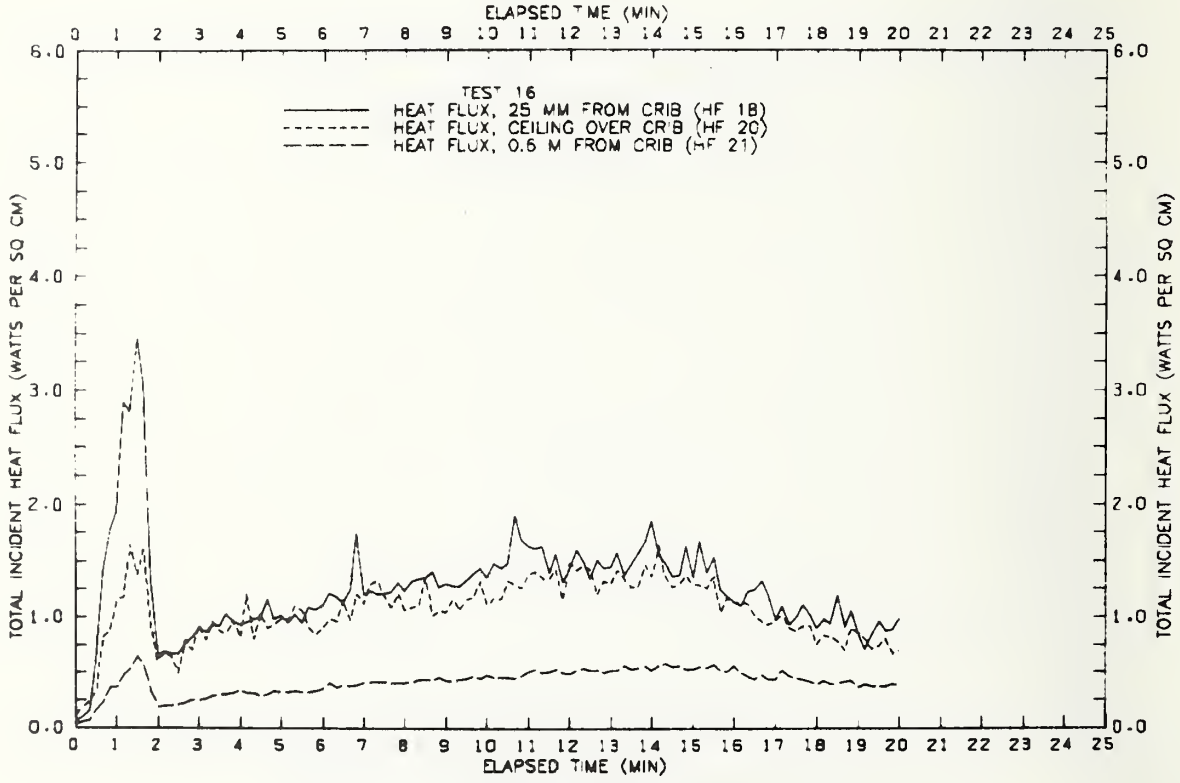

FIGURE B22. TOTAL INCIDENT HEAT FLUX MEASURED AT DIFFERENT LOCATIONS AROUND THE WOOD CRIB.

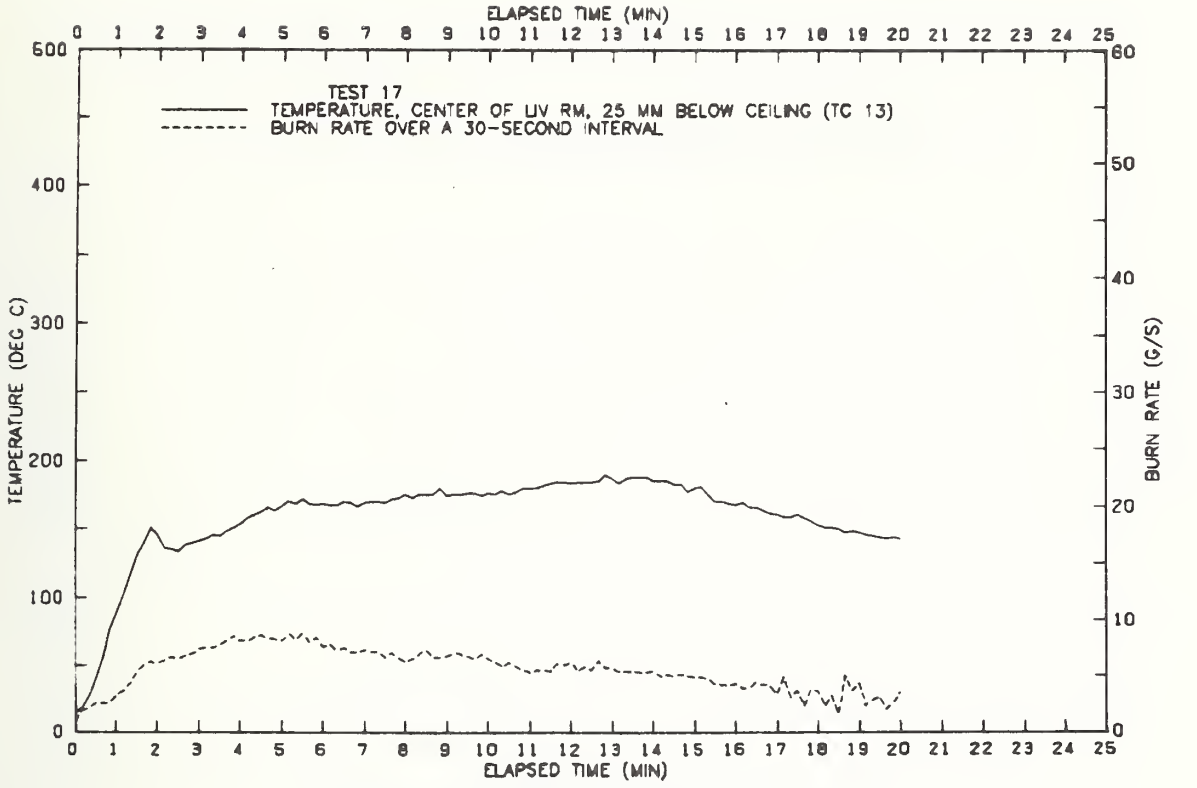

FIGURE B23. GAS TEMPERATURE MEASURED IN THE LIVING ROOM, AND THE BURN RATE OF THE WOOD CRIB.

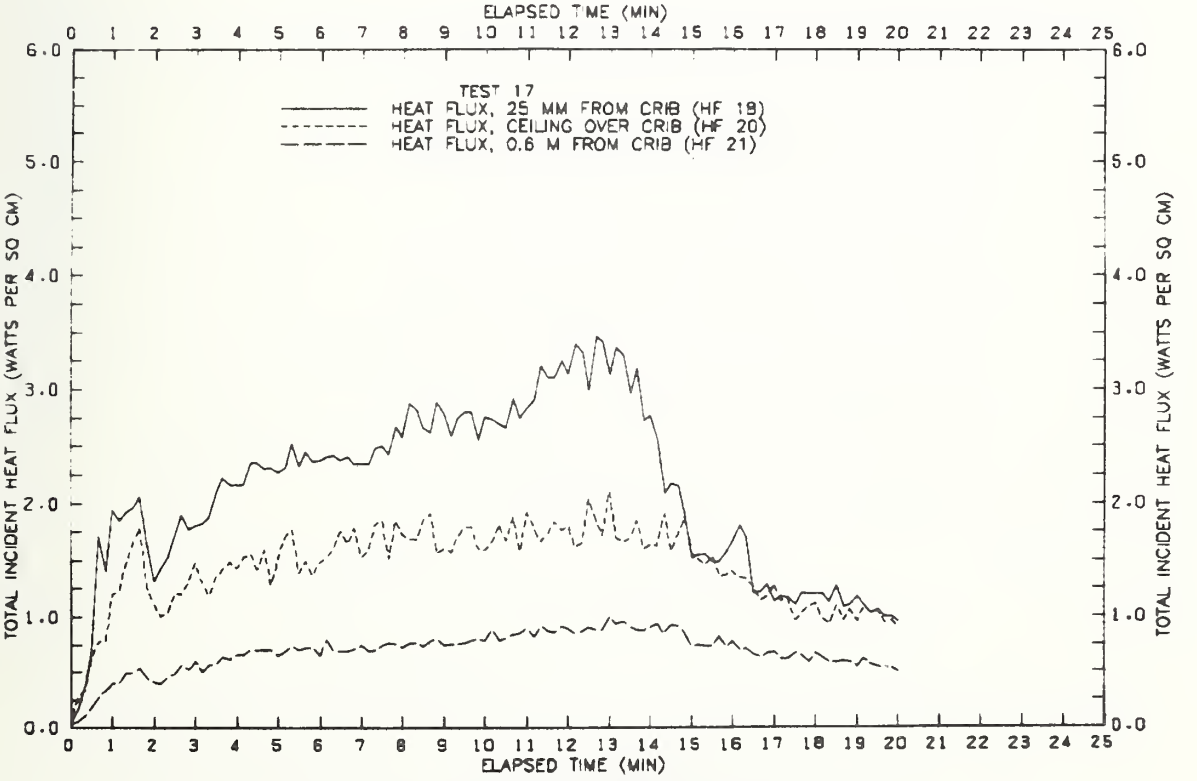

FIGURE B24. TOTAL INCIDENT HEAT FLUX MEASURED AT DIFFERENT LOCATIONS AROUND THE WOOD CRIB.

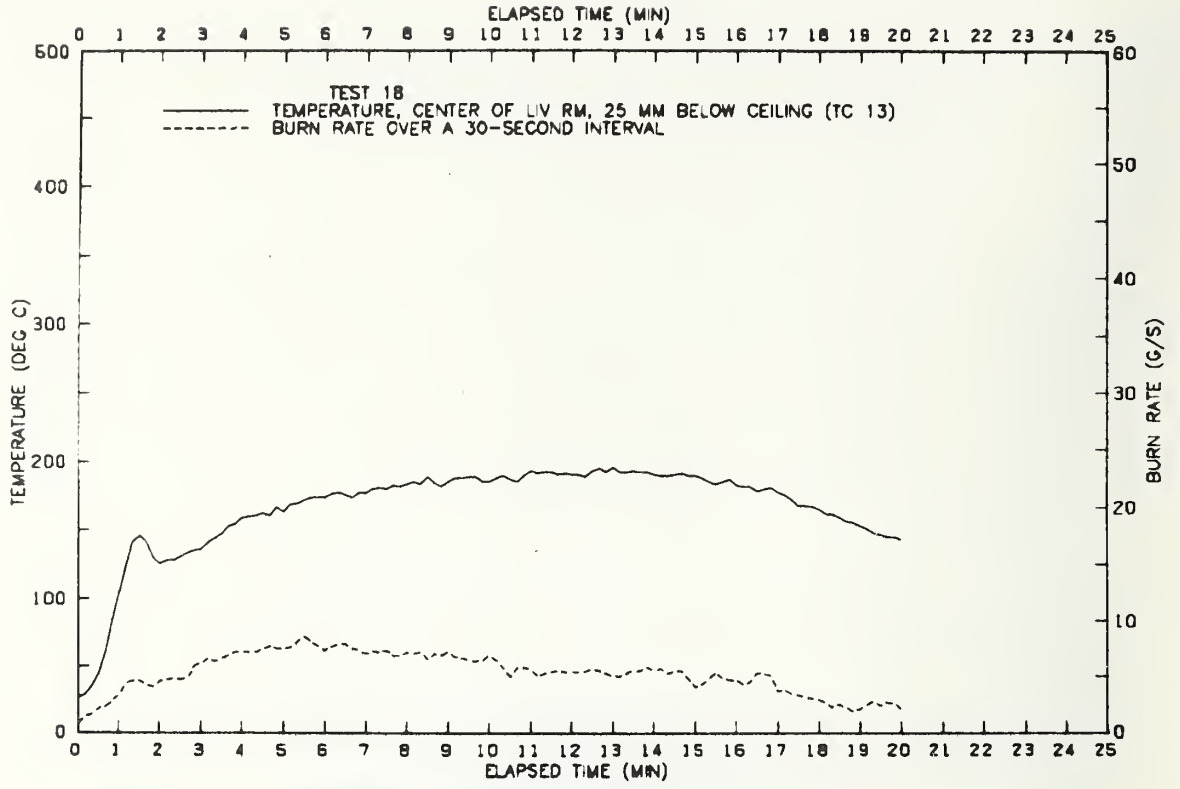

FIGURE B25. GAS TEMPERATURE MEASURED IN THE LIVING ROOM, AND THE BURN RATE OF THE WOOD CRIB.

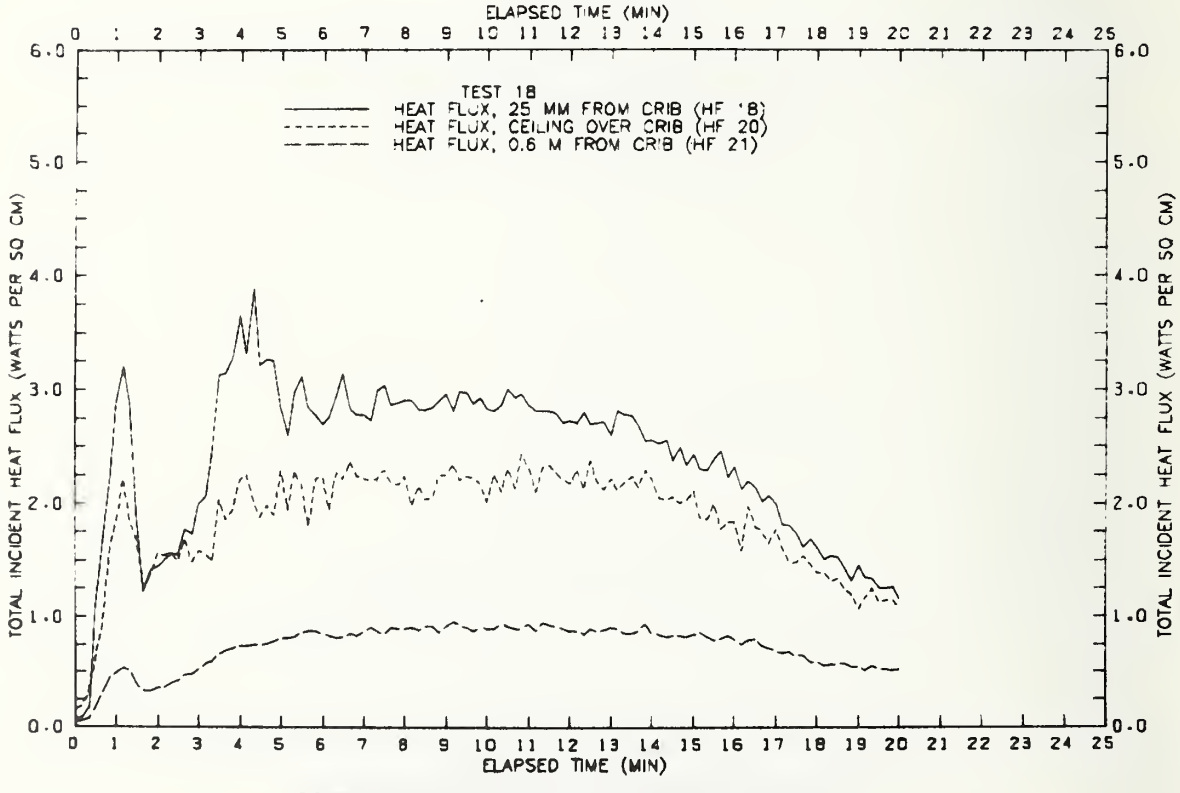

FIGURE B26. TOTAL INCIDENT HEAT FLUX MEASURED AT DIFFERENT LOCATIONS AROUND THE WOOD CRIB.

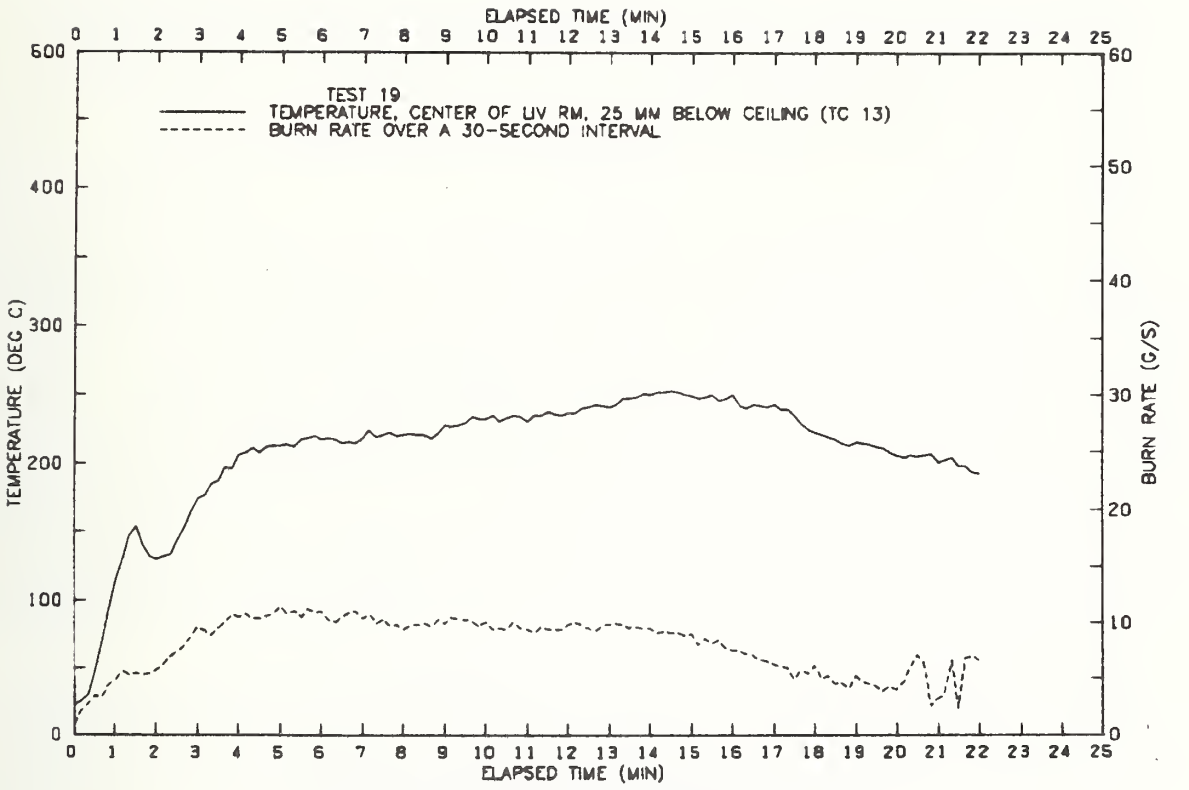

FIGURE B27. GAS TEMPERATURE MEASURED IN THE LIVING ROOM, AND THE BURN RATE OF THE WOOD CRIB.

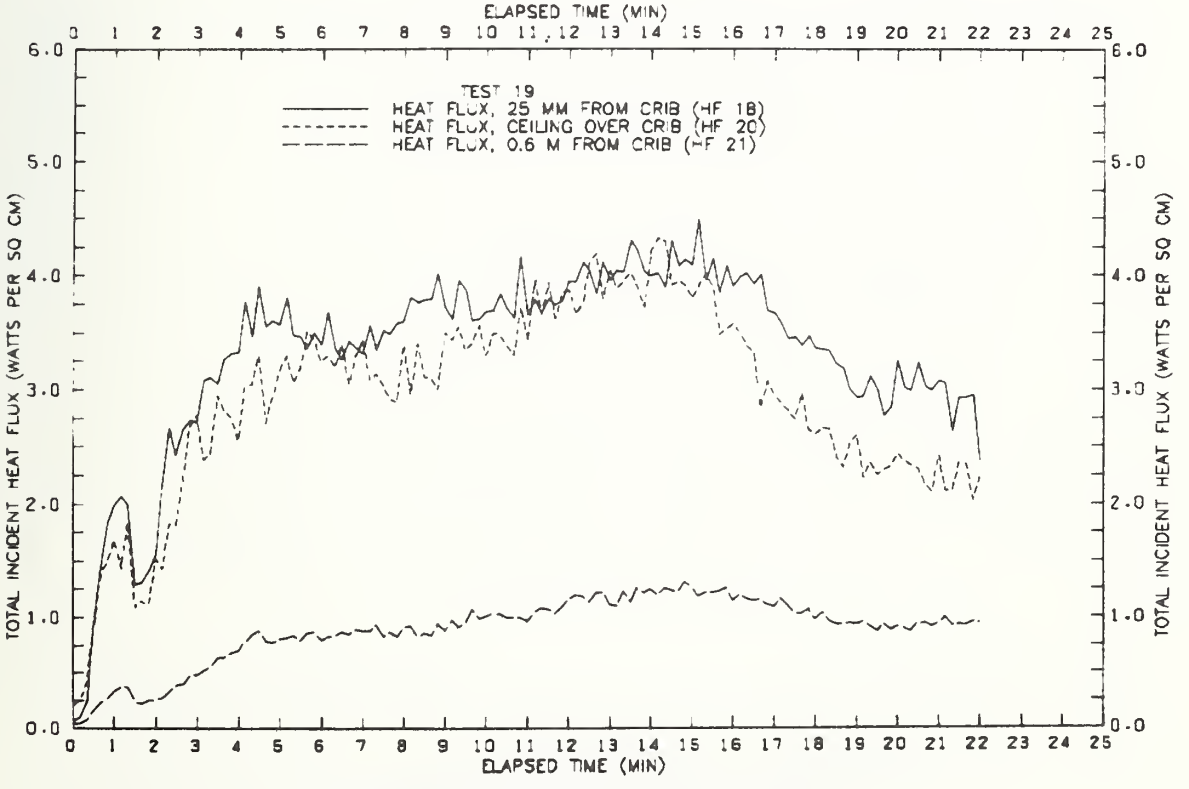

FIGURE B28. TOTAL INCIDENT HEAT FLUX MEASURED AT DIFFERENT LOCATIONS AROUND THE WOOD CRIB.

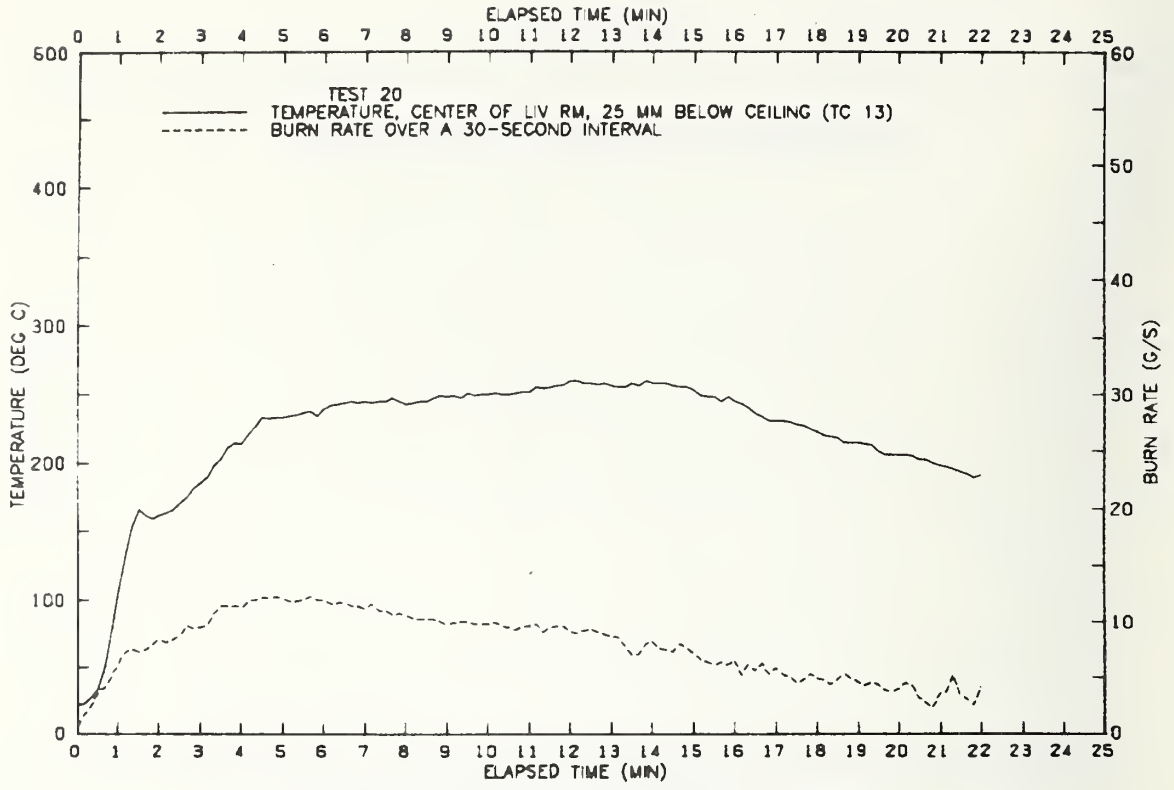

FIGURE B29. GAS TEMPERATURE MEASURED IN THE LIVING ROOM, AND THE BURN RATE OF THE WOOD CRIB.

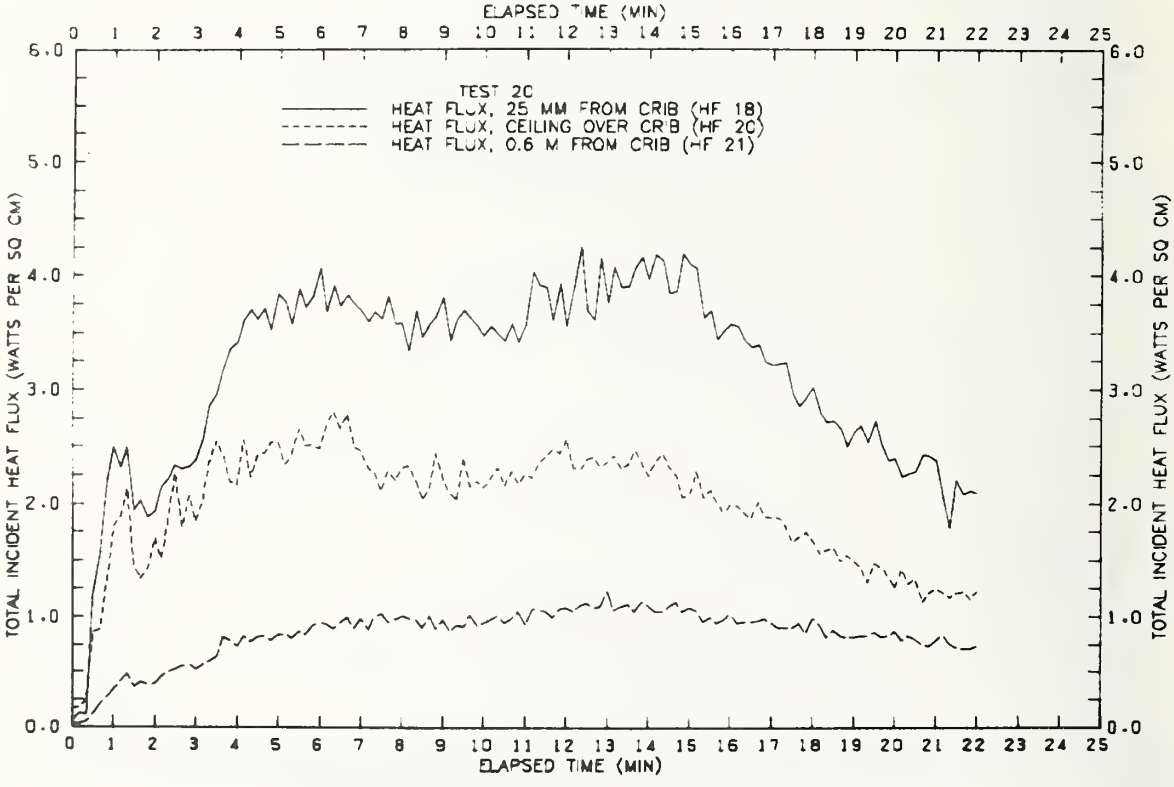

FIGURE B30. TOTAL INCIDENT HEAT FLUX MEASURED AT DIFFERENT LOCATIONS AROUND THE WOOD CRIB.

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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.)* A series of fire tests was conducted in the corner of a mobile home living room. The corner was lined with interior finish materials which did not contribute to the fires. The test series was designed to examine the fire characteristics of typical incidental (low intensity) fires which may be used as the ignition source for tests to evaluate the effects of interior finish materials.

This test series involved three types of source fires: standardized wood cribs ranging in weight from 2.3 kg to 13.6 kg (5 lb to 30 lb), identically constructed upholstered chairs and polyethylene waste containers filled with crumpled newsprint. Experimental measurements were made of burn rate, temperature, heat flux, flame height, smoke density, and concentrations of oxygen, carbon monoxide, and carbon dioxide.

Under the test conditions employed, it was found that the fire severities for the several sizes of standardized wood cribs fell between those for the polyethylene waste containers filled with crumpled newsprint and the more severe incidental fires produced by the 16 kg (35 lb) upholstered chairs in terms of characteristics such as maximum temperature and heat flux levels, flame height, and changes in oxygen, carbon monoxide and carbon dioxide concentrations. Of the fires with wood cribs, it was found that the fires with 13.6 kg (30 lb) standardized wood cribs were most similar to the fires with 16 kg (35 lb) upholstered chairs, although the peak burning rate was generally higher for fires with upholstered chairs than for fires with wood cribs. It was also found that the time to reach the period of active burning was more reproducible for fires with wood cribs than fires with upholstered chairs.

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)* Chairs; compartment fires; crib fires; fire tests; incidental fires; ignition source; mobile homes; repeatability; source fires; upholstered furniture.

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