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FULL-SCALE ROOM FIRE EXPERIMENTS CONDUCTED AT THE UNIVERSITY OF MARYLAND

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ADDENDUM

TO

"FULL-SCALE ROOM FIRE EXPERIMENTS

CONDUCTED AT THE UNIVERSITY OF MARYLAND"

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III ADD TO ACKNOWLEDGEMENTS

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Notice

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Full-Scale Room Fire Experiments

Conducted at the University of Maryland

Test Report

to

National Institute of Standards and Technology

by

James A. Milke and Stephen M. Hill

Department of Fire Protection Engineering

University of Maryland at College Park

June 25, 1996

I. Burn #1, June 5, 1996
Burn Tower, Training Academy, Maryland Fire & Rescue Institute
University of Maryland

1.1 Description of Test Facility

1.1.1 Room Description

The room was located on the first floor of the burn tower. Dimensions of the room were 3,660 mm x 3,660 mm, with a height of 2,440 mm. There was a single door opening to the room centered on the East wall, with a width of 910 mm and height 2,090 mm. A single, double-hung window was centered on the North wall of the room, with the bottom of the frame located 901 mm from the floor. The window had 2 panes of glass, each 690 mm wide and 380 mm in height. The outside dimensions of the window frame were 1,070 mm wide and 930 mm in height.

1.1.2 Furniture Plan

The furniture in the room included the items listed in Table 1.1. The relative locations of the furniture are indicated in Figure 1.1. The mass of the furnishings is indicated in Table 1.2.

1.2. Instrumentation

Temperature, heat flux and gas sampling measurements were obtained. Locations of the instrumentation are described in the following sections and are depicted in Figure 1.1.

1.2.1 Thermocouples

Thermocouples were placed at the locations noted in Table 1.2.

Table 1.1

Furniture Item	Description
Single Bed	1,820 mm x 910 mm x 560 mm box springs, mattress raised on metal frame, fully made with sheets, bedspread (polymer composition, probably polyurethane), blanket, comforter, and pillow located in NW corner of room
Armchair	970 mm wide x 910 mm deep (410 mm high at seat, 610 mm high at back) located flush against West wall, 410 mm from bed
Dresser	1,320 mm x 460 mm x 760 mm located in SW corner, 25 mm off S wall and 30 mm off W wall Lamp w/ bulb plugged in (not energized) centered on dresser Lamp: 660 mm high, base diameter: variable - 250 mm at largest, 150 mm at smallest
Wastebasket	plastic wastebasket 380 mm high 300 mm x 180 mm footprint
End Table	530 mm x 220 mm x 550 mm located 440 mm off E wall, 51 mm off N wall Same size lamp with bulb plugged into wall (energized)
Carpet	Full-sized carpet (nylon) and padding (polyurethane pad) (with baseboards around room)

1.2.2 Heat Flux Meters

Two heat flux meters were provided in the room, pointed in the upward vertical direction. One was located in the center of the room and one in the doorway, 150 mm from the ground. The heat flux meters are water-cooled and are located within a protective wooden bridge 150 mm (width) x 150 mm (height) on the floor of the room to protect the cooling tubes.

Table 1.2

Item		Mass (kg)
Bed	Box spring	50.0
	Frame, metal (12.5 kg)	
	Headboard	
	Mattress	
Bedding	Bedspread	4.5
	Blanket	
	Pillow	
	Pillow Case	
	Sheet, Bottom	
	Sheet, Top	
Carpet and Pad		21.0
Chair		32.0
Dresser		42.0
Lamp, Porcelain with 60 W Bulb		2.5
Lamp, Metal with 60 W Bulb		3.0
Night Table		15.0
Picture Frame		3.0
Curtains		0.4
Waste Basket, Plastic with Trash		0.6
Total		174.0

Table 1.3

Trees	Location	Thermocouple Heights (from floor)
A	Doorway	2,440 mm, top of door opening (2,080 mm), 305 mm increments downward from top of door (excluding one at the floor, or datum, height)
B	Center of Room	top at 2,440 mm with 305 mm increments
C	Window	305 mm off N wall, 305 mm from left of window frame (as viewed from the inside) Note: the bed location interferes with the tree location, so the tree leans at a slight angle and hangs over the foot of the bed top at 2,440 mm with 305 mm increments
D	Hallway	Tree: outside room, 1,220 mm North and 150 mm West of the NE corner top at 2,440 mm with 305 mm increments

1.2.3 Gas Sampling Probes

Gas sampling probes to monitor O_2, CO, CO_2 concentrations were included at the following locations in the room:

(1) Center of room 460 mm from the floor, slightly angled away from the doorway, measuring only O_2.

(1) SW corner above dresser, 305 mm from the ceiling, 610 mm from the west wall, 610 mm from the south wall measures O_2, CO, CO_2 (provided by NIST).

(1) Doorway, 305 mm above the floor, 305 mm from the east side of the door opening, measuring O_2 (separate instrument not recorded in data file).

1.2.4 Video Cameras

Videotape records were made of the tests from the following locations:

- Ground level, in doorway, facing the chair and the bed.
- 4 ft above the floor, from the instrument room, facing the outside of the window.

1.3 Procedure

The fire was initiated using a book of ignited paper matches, placed under four sheets of newpaper on the chair. When the ignited book of matches was placed on the chair, a switch was closed to indicate ignition on the data acquisition system.

1.4 Data

Data collected during the test is included in Figures 1.2 to 1.9. Table 1.4 summarizes the presentation of the data in the seven figures. A tabulation of the data is presented in the appendix. Visual observations were noted on the audio track on the videotape records.

Table 1.4

Measurement	Figure
Thermocouple tree, room center	1.2
Thermocouple tree, doorway	1.3
Thermocouple tree, window	1.4
Thermocouple tree, outside	1.5
Thermocouple at window	1.6
Heat flux	1.7
CO and CO_2 concentration	1.8
O_2 concentration	1.9

Oxygen concentrations from the University analyzer appears to indicate a low reading, for an extended duration. Upon review of the instrumentation, it is believed that the calibration process for the analyzer was incorrect.

II. Burn #2, June 6, 1996
Burn Tower, Training Academy, Maryland Fire & Rescue Institute
University of Maryland

2.1 Description of Test Facility

2.1.1 Room Description

The room was located on the first floor of the burn tower. Dimensions of the room were 3,660 mm x 3,660 mm, with a height of 2,440 mm. There was a single door opening to the room centered on the North wall, with a width of 910 mm and height 2,090 mm. A single, double-hung window was centered on the West wall of the room, with the bottom of the frame located 910 mm from the floor. The window had 2 panes of glass, each 690 mm wide and 380 mm in height. The outside dimensions of the window frame were 1,070 mm wide and 930 mm in height.

2.1.2 Furniture Plan

The furniture in the room included the items listed in Table 2.1. The relative locations of the furniture are indicated in Figure 2.1.

2.2 Instrumentation

Temperature, heat flux and gas sampling measurements were obtained. Locations of the instrumentation are described in the following sections and are depicted in Figure 2.1.

2.2.1 Thermocouples

Thermocouples were placed at the locations noted in Table 2.2.

Table 2.1

Furniture Item	Description
Single Bed	1,820 mm x 910 mm x 560 mm box springs, mattress raised on metal frame, fully made with sheets, bedspread (polymer composition, probably polyurethane), blanket, comforter, and pillow located in SW corner of room
Armchair	970 mm wide x 910 mm deep (410 mm high at seat, 610 mm high at back) located flush against South wall, 410 mm from bed
Dresser	1,320 mm x 460 mm x 760 mm located in SE corner, 25 mm off E wall and 305 mm off S wall Lamp w/ bulb plugged in (not energized) centered on dresser Lamp: 660 mm high, base diameter: variable - 250 mm at largest, 150 mm at smallest
Wastebasket	plastic wastebasket 380 mm high 305 mm x 180 mm footprint
End Table	530 mm x 220 mm x 550 mm located 440 mm off N wall, 51 mm off W wall Same size lamp with bulb plugged into wall (energized)
Carpet	Full-sized carpet (nylon) and padding (polyurethane pad) (with baseboards around room)

Note: The second room is constructed as a duplicate of the first burn room, except the lamps are not energized and the orientation of the room in plan view is rotated 90° due to the characteristics of the burn tower enclosure. The mass of the furnishings is indicated in Table 1.2)

The largest difference is the volume outside of openings in the rooms. Outside the window, fresh air was available through a large window in the burn tower where a camera viewed the window during the test. The volume near the door was more restricted than in the first test.

2.2.2 Heat Flux Meters

Two heat flux meters were provided in the room, pointed in the upward vertical direction. One was located in the center of the room and one in the doorway, 150 mm from the ground. The heat flux meters are water-cooled and are located within a protective

wooden bridge 150 mm (width) x 150 mm (height) on the floor of the room to protect the cooling tubes.

Table 2.2

Trees	Location	Thermocouple Heights (from floor)
A	Doorway	2,440 mm, top of door opening (2,080 mm), 305 mm increments downward from top of door (excluding one at the floor, or datum, height)
B	Center of Room	top at 2,440 mm with 305 mm increments
C	Window	305 mm off E wall, 305 mm from left of window frame (as viewed from the inside) Note: the bed location interferes with the tree location, so the tree leans at a slight angle and hangs over the foot of the bed top at 2,440 mm with 305 mm increments
D	Hallway	Tree: outside room, 990 mm East 1840 mm North of the NW corner top at 2,440 mm with 305 mm increments

2.2.3 Gas Sampling Probes

Gas sampling probes to monitor O_2, CO, CO_2 concentrations were included at the following locations in the room:

(1) Center of room 460 mm from the floor, slightly angled away from the doorway, measuring only O_2.

(1) SW corner above dresser, 305 mm from the ceiling, 610 mm from the west wall, 610 mm from the south wall measures O_2, CO, CO_2 (provided by NIST).

(1) Doorway, 305 mm above the floor, 305 mm from the east side of the door opening, measuring O_2 (separate instrument not recorded in data file).

2.2.4 Video Cameras

Videotape records were made of the tests from the following locations:

- Ground level, in doorway, facing the chair and the bed.
- view of the outside of the window from outside of burn tower.
- floor of instrument room, facing the outside of the doorway (provided by ATF).

2.3 Procedure

The fire was initiated using a book of ignited paper matches, placed under four sheets of newpaper on the chair. When the ignited book of matches was placed on the chair, a switch was closed to indicate ignition on the data acquisition system.

2.4 Data

Data collected during the test is included in Figures 2.2 to 2.9. Table 2.3 summarizes the presentation of the data in the seven figures. A tabulation of the data is presented in the appendix. Visual observations were noted on the audio track on the videotape records.

Table 2.3

Measurement	Figure
Thermocouple tree, room center	2.2
Thermocouple tree, doorway	2.3
Thermocouple tree, window	2.4
Thermocouple tree, outside	2.5
Thermocouple at window	2.6
Heat flux	2.7
CO and CO_2 concentration	2.8
O_2 concentration	2.9

Oxygen concentrations from the University analyzer appears to indicate a low reading, for an extended duration. Upon review of the instrumentation, it is believed that the calibration process for the analyzer was incorrect.

III. Acknowledgements

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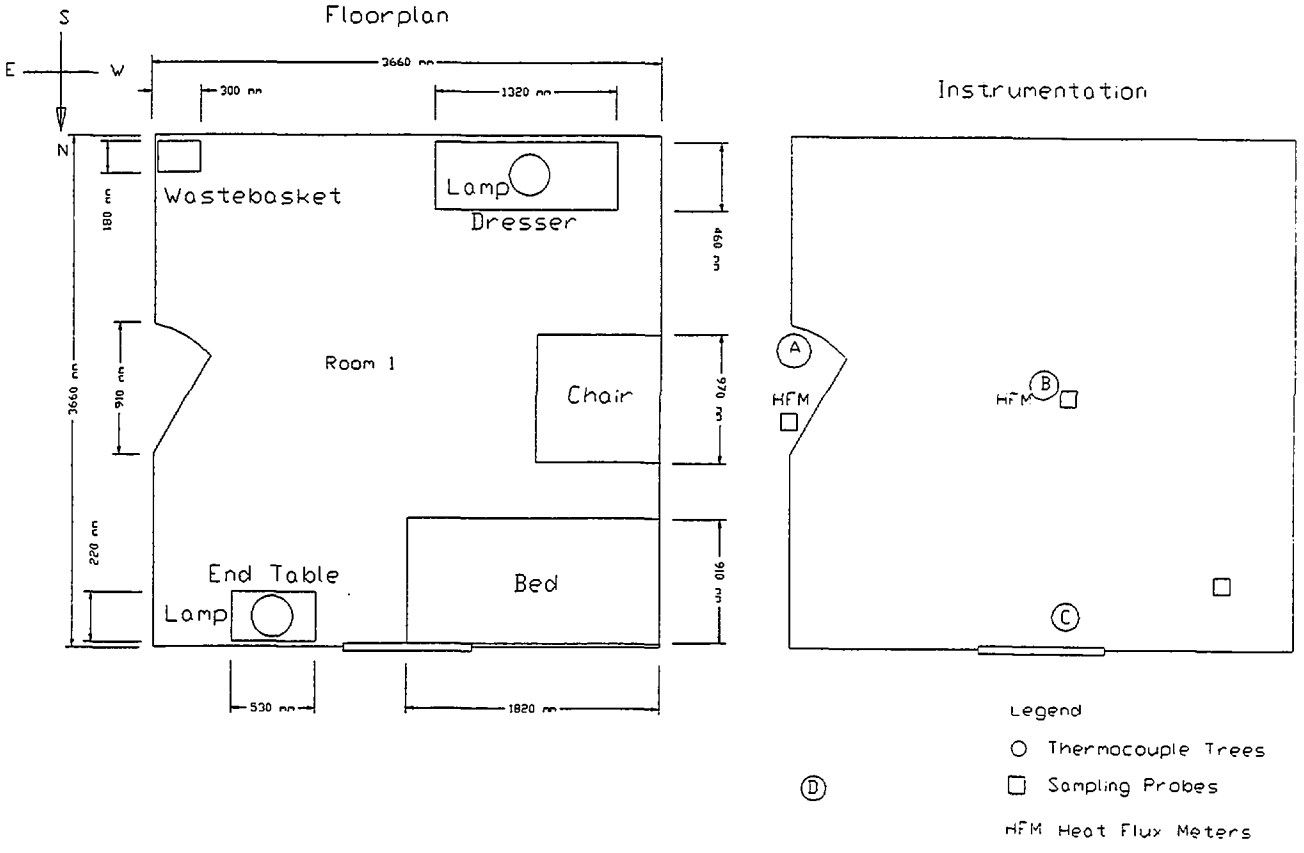
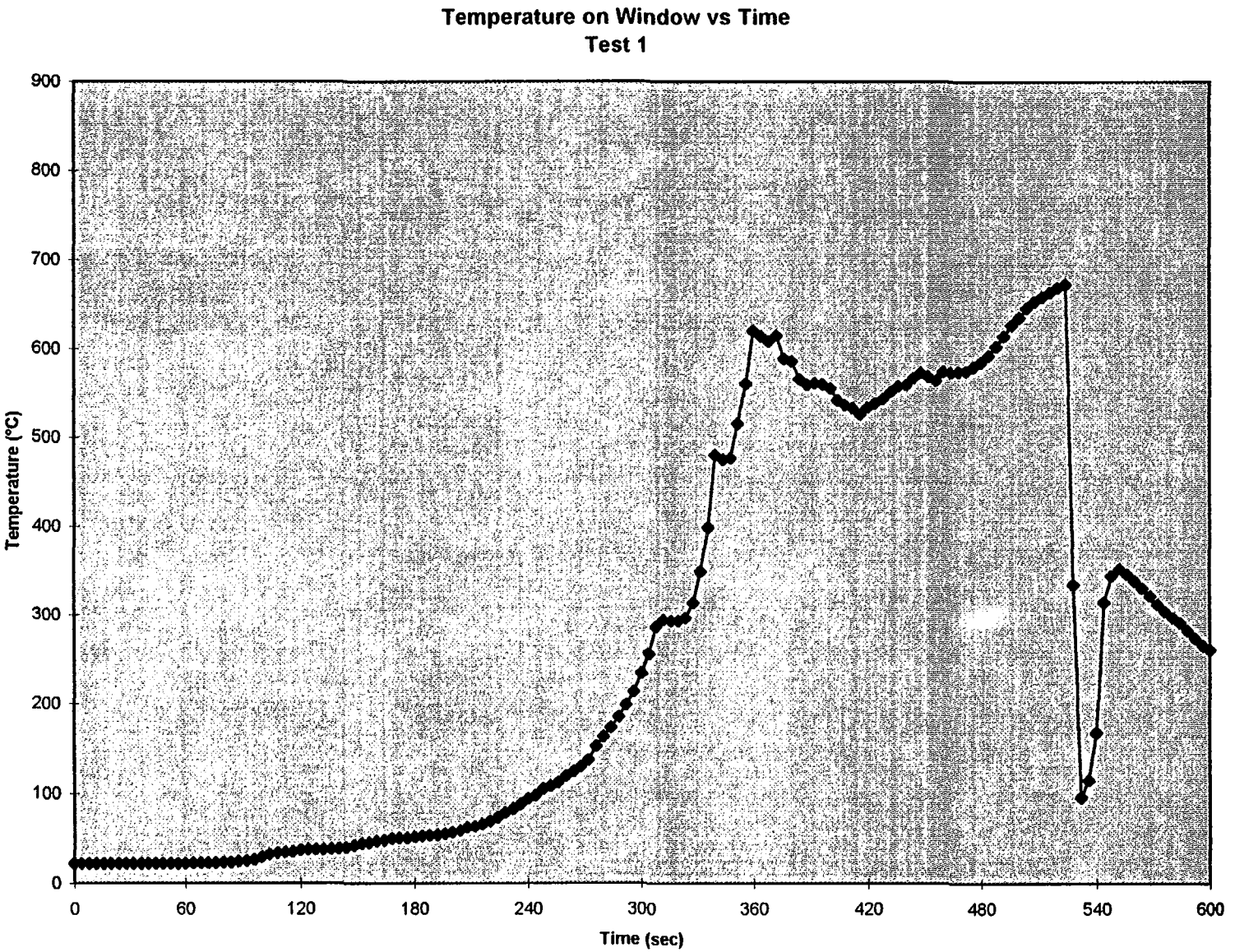
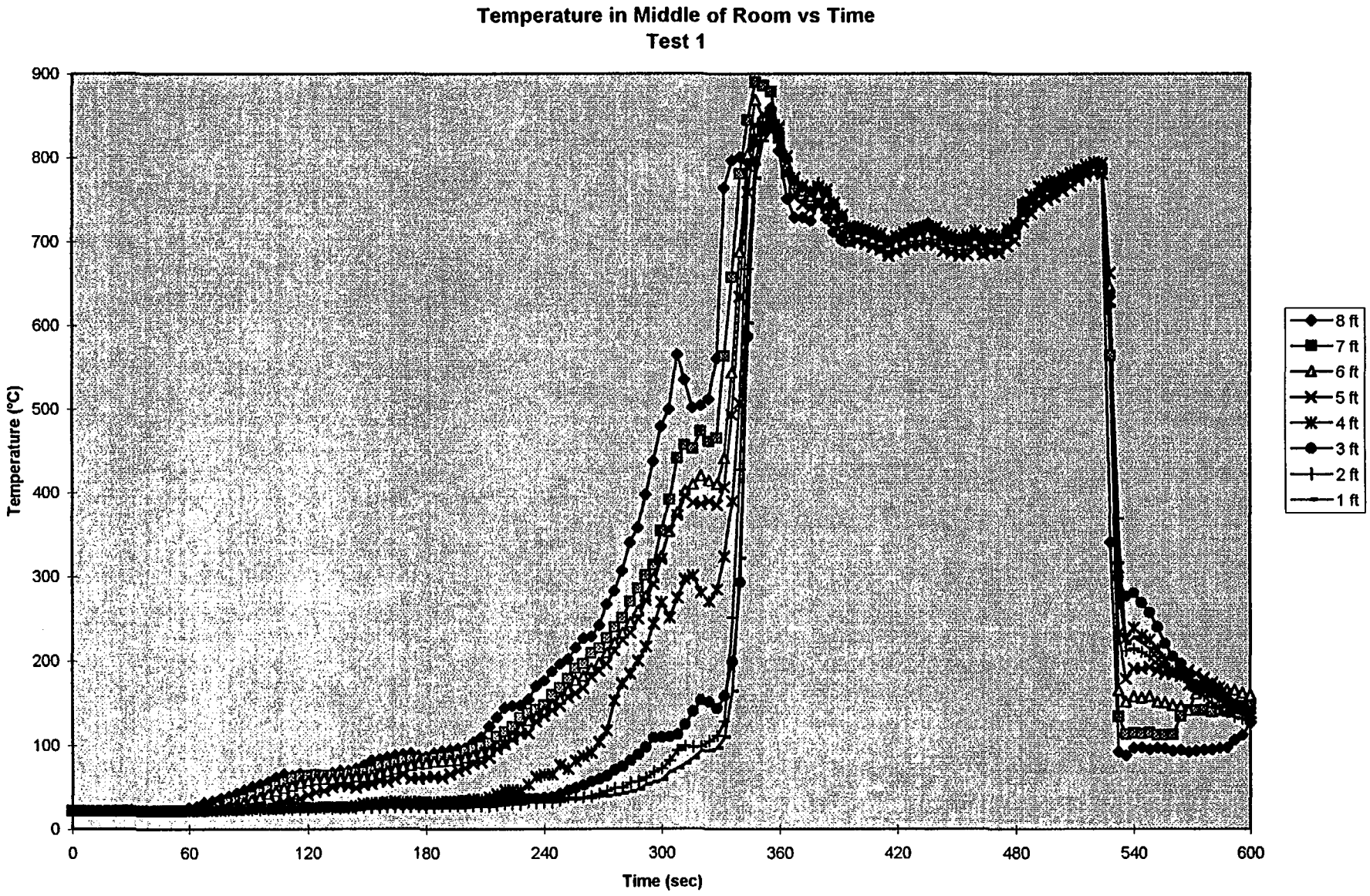
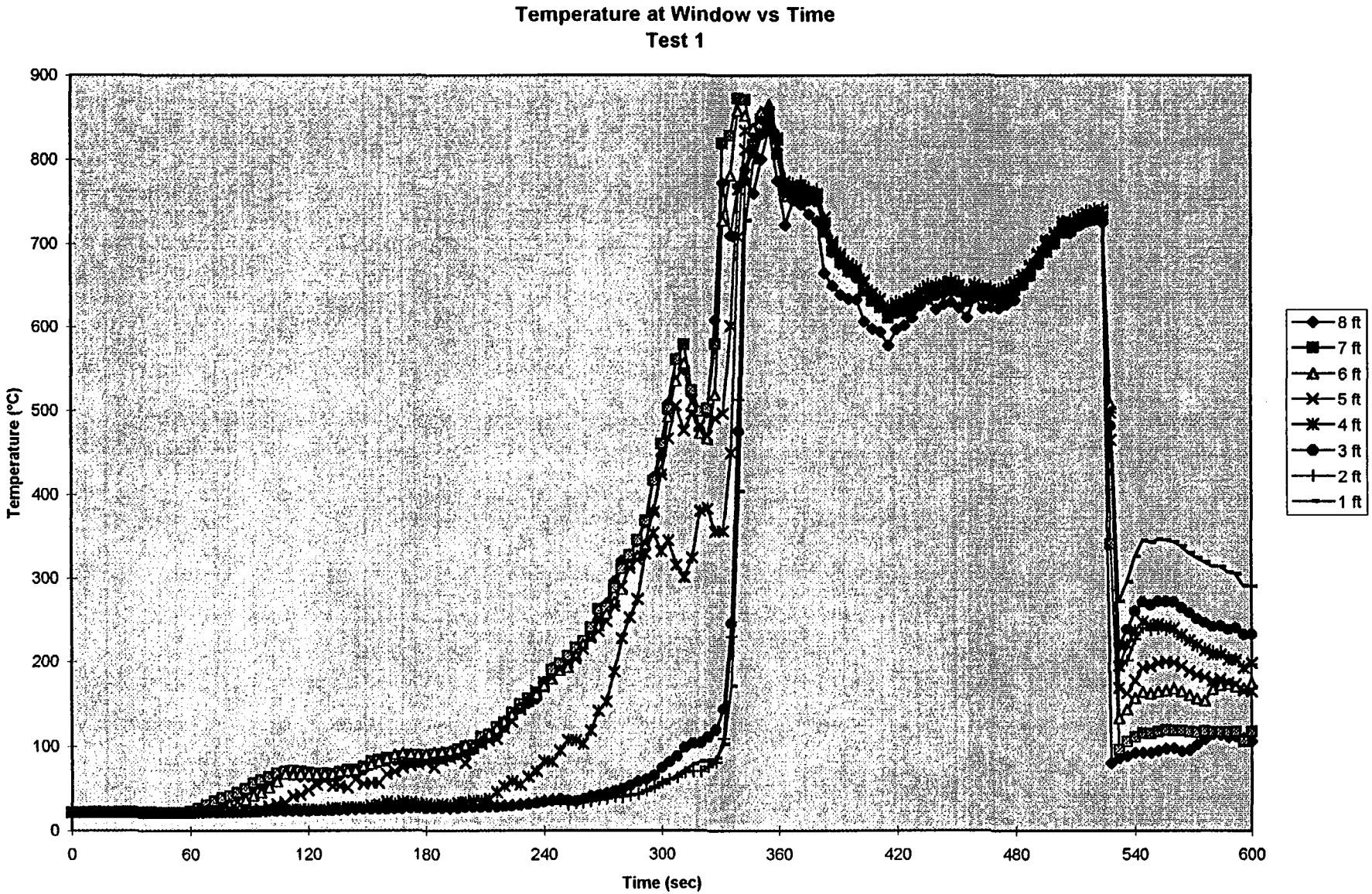
Test 1

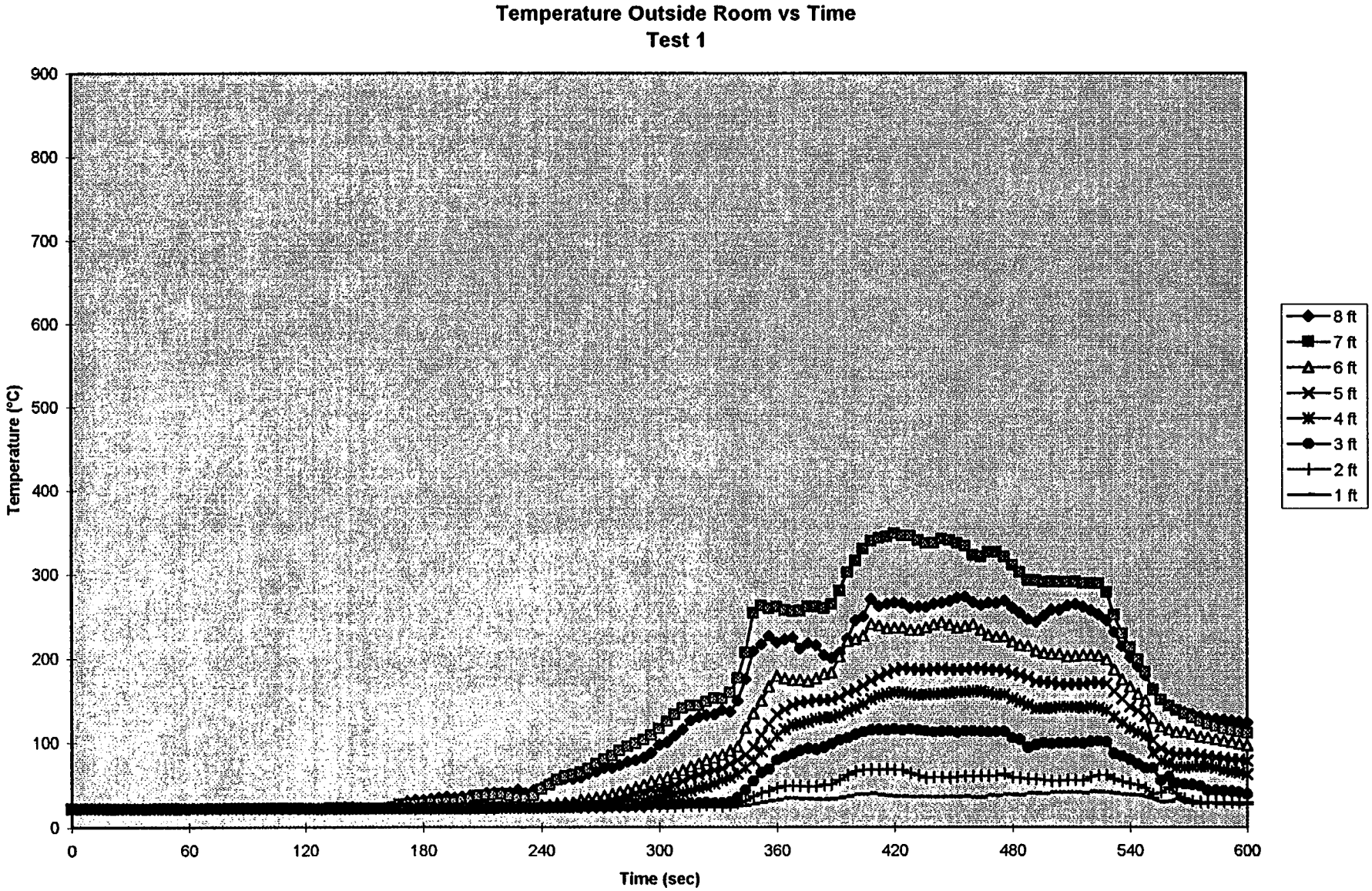
Figure 1.1 Diagram of Furnishings and Instrumentation for Test 1, June 5, 1996

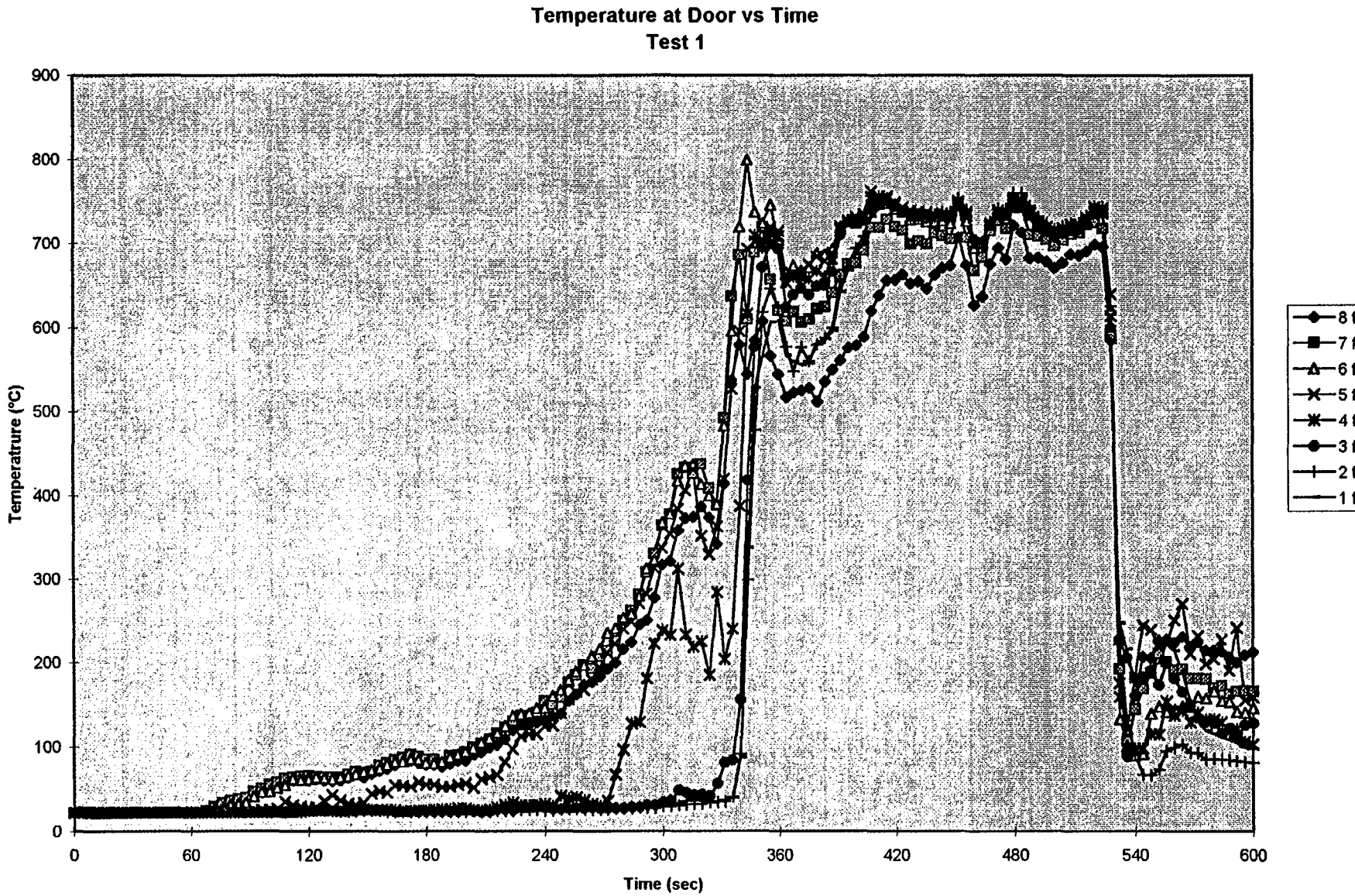


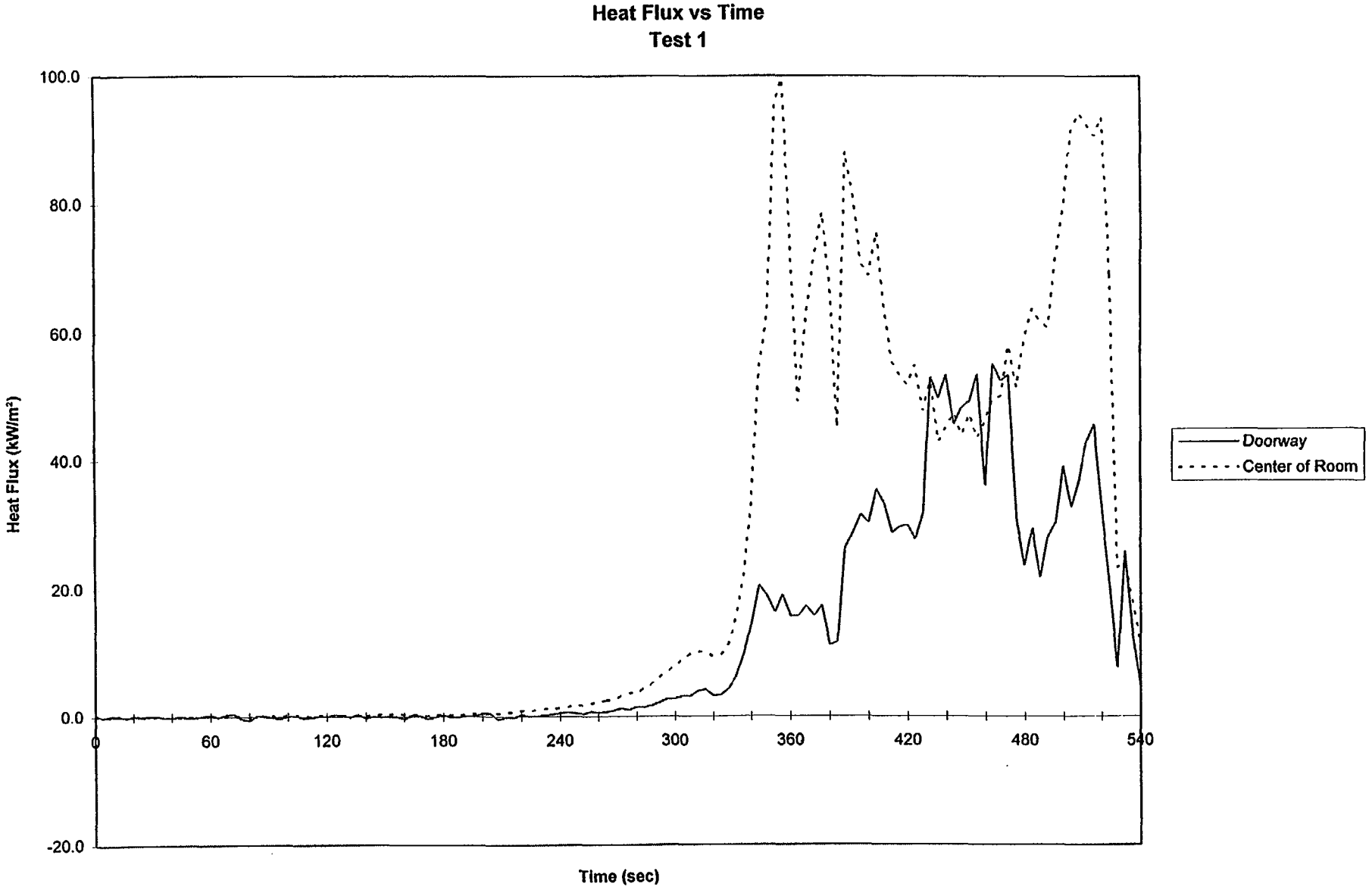

Temperature on Window vs Time
Test 1
Temperature (°C)
900
800
700
600
500
400
300
200
100
0
0
60
120
180
240
300
360
420
480
540
600
Time (sec)

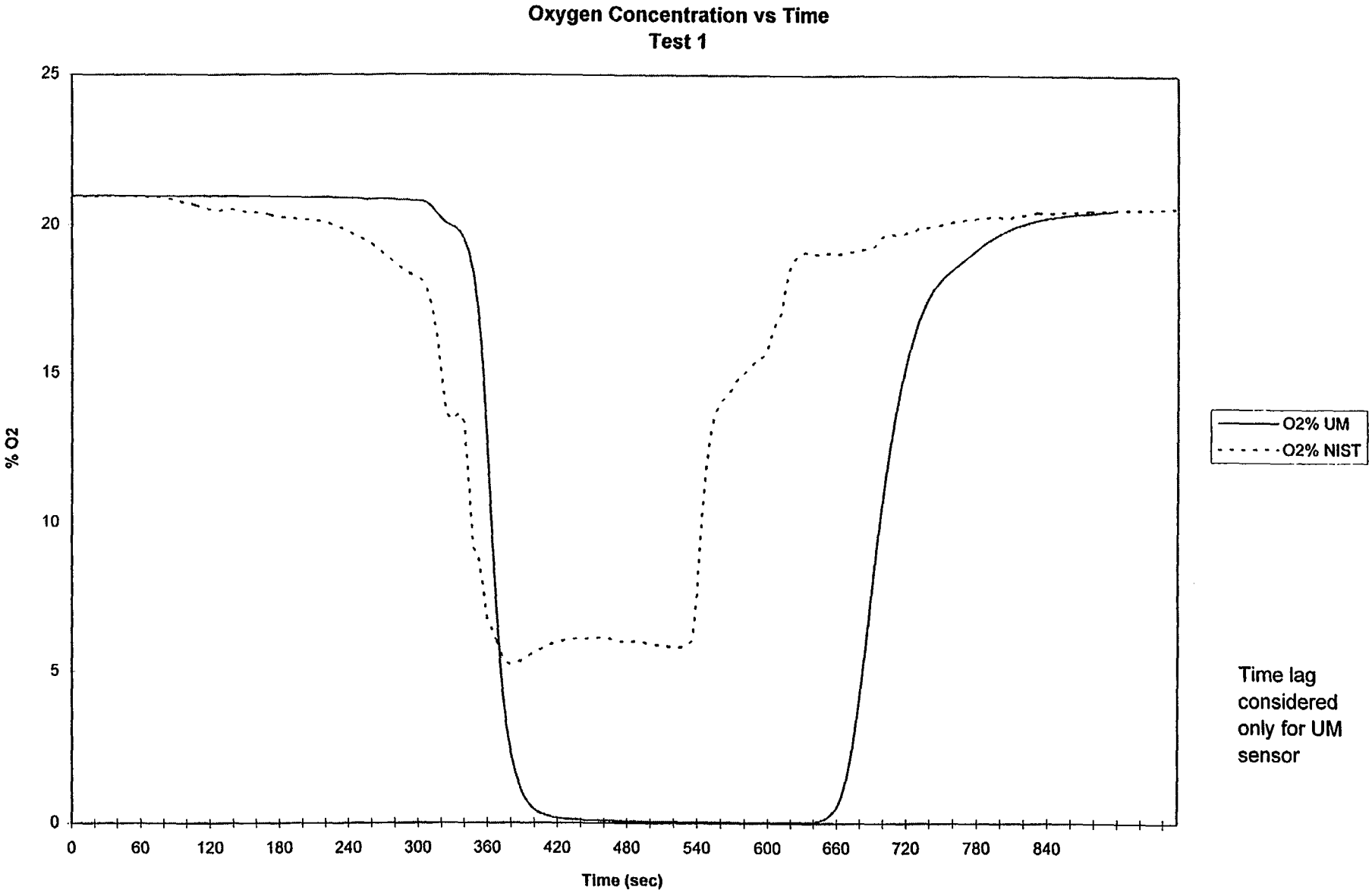

Temperature in Middle of Room vs Time
Test 1
Temperature (°C)
900
800
700
600
500
400
300
200
100
0
0
60
120
180
240
300
360
420
480
540
600
Time (sec)
8 ft
7 ft
6 ft
5 ft
4 ft
3 ft
2 ft
1 ft


Temperature at Window vs Time
Test 1
Temperature (°C)
Time (sec)
0
100
200
300
400
500
600
700
800
900
0
60
120
180
240
300
360
420
480
540
600
8 ft
7 ft
6 ft
5 ft
4 ft
3 ft
2 ft
1 ft


Temperature Outside Room vs Time
Test 1
Temperature (°C)
900
800
700
600
500
400
300
200
100
0
0
60
120
180
240
300
360
420
480
540
600
Time (sec)
8 ft
7 ft
6 ft
5 ft
4 ft
3 ft
2 ft
1 ft

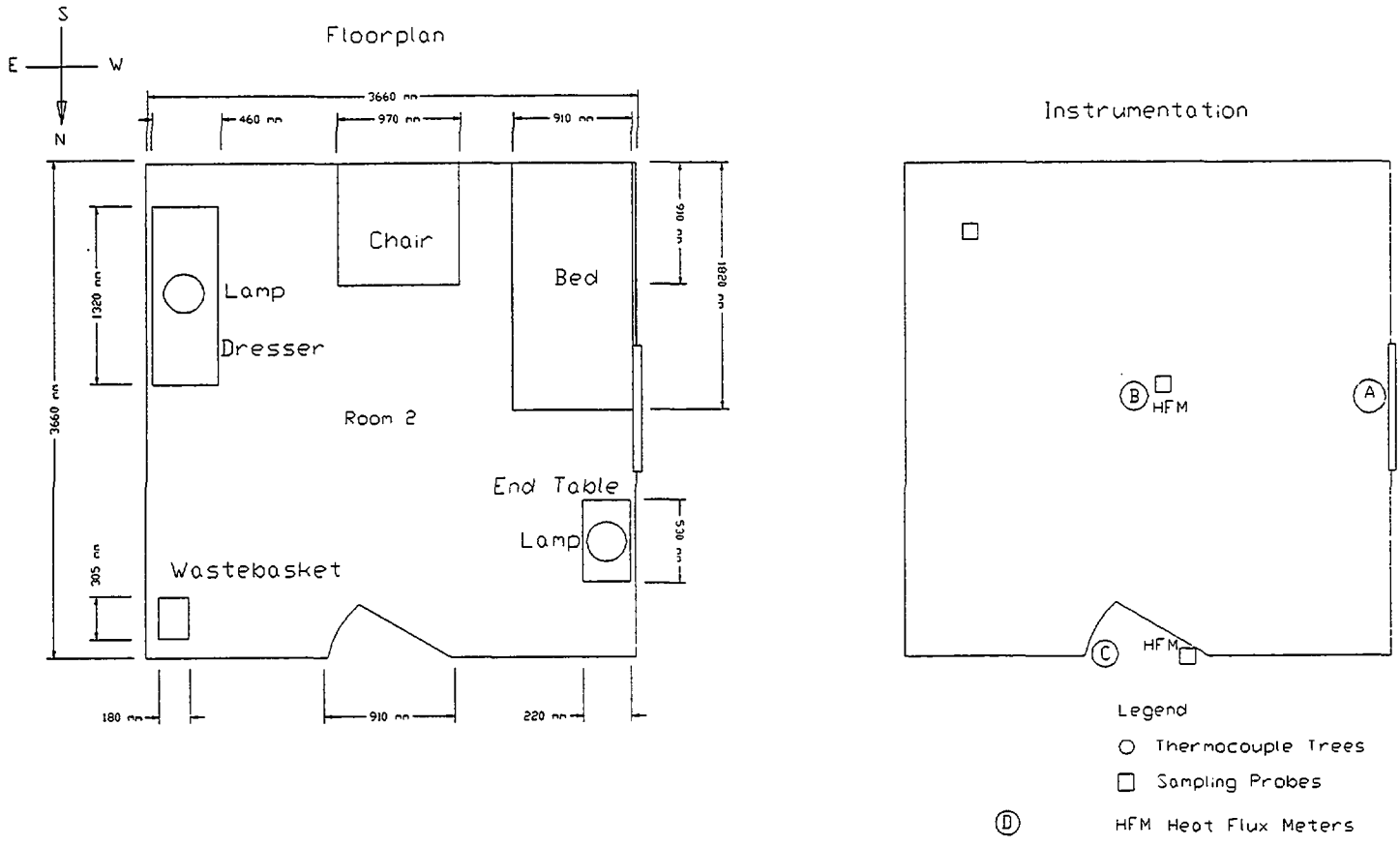

Temperature at Door vs Time
Test 1
Temperatrure (°C)
900
800
700
600
500
400
300
200
100
0
0
60
120
180
240
300
360
420
480
540
600
Time (sec)
8 ft
7 ft
6 ft
5 ft
4 ft
3 ft
2 ft
1 ft

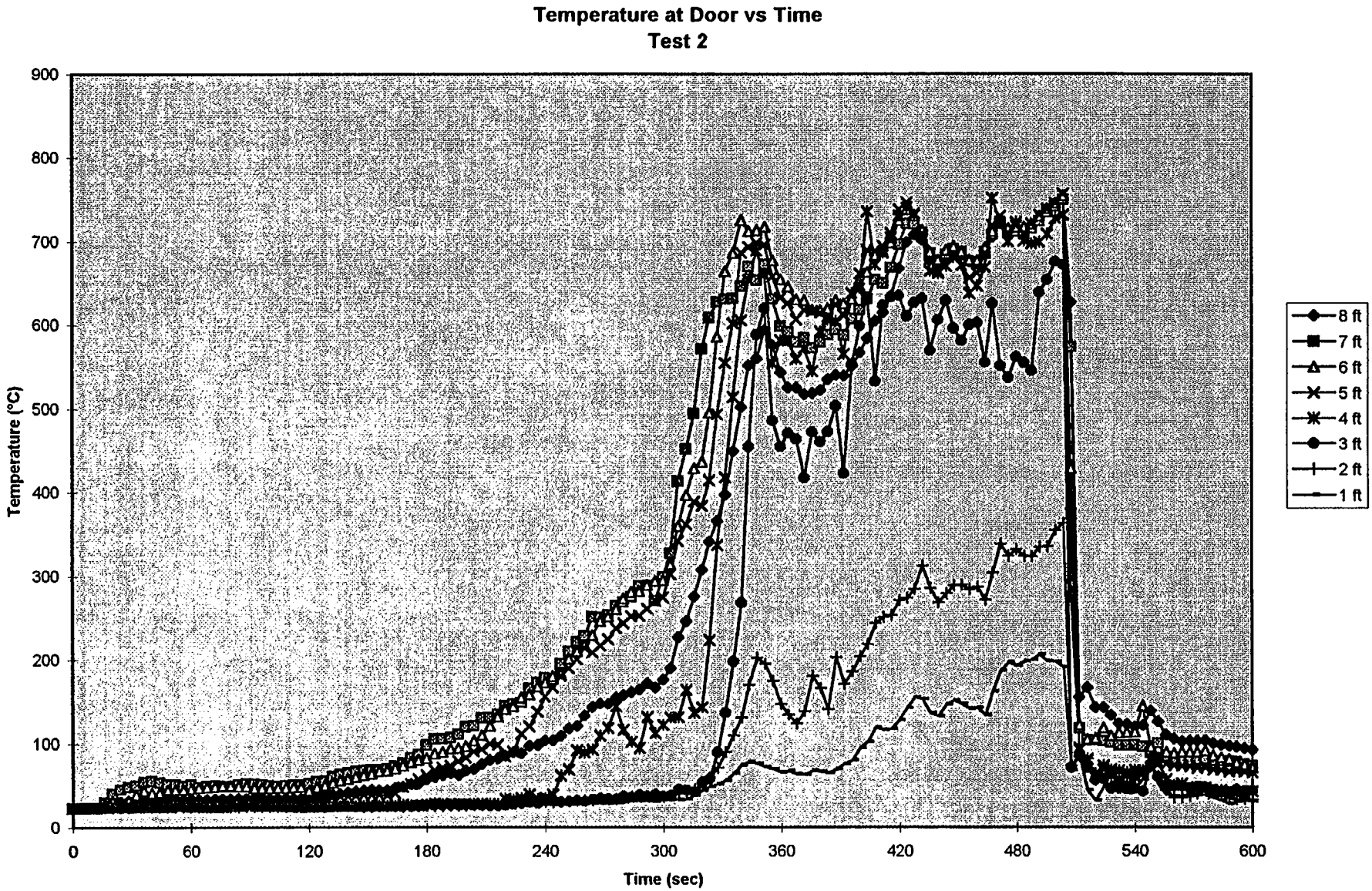

Heat Flux vs Time
Test 1
100.0
80.0
60.0
40.0
20.0
0.0
-20.0
Heat Flux (kW/m²)
0
60
120
180
240
300
360
420
480
540
Time (sec)
Doorway
Center of Room

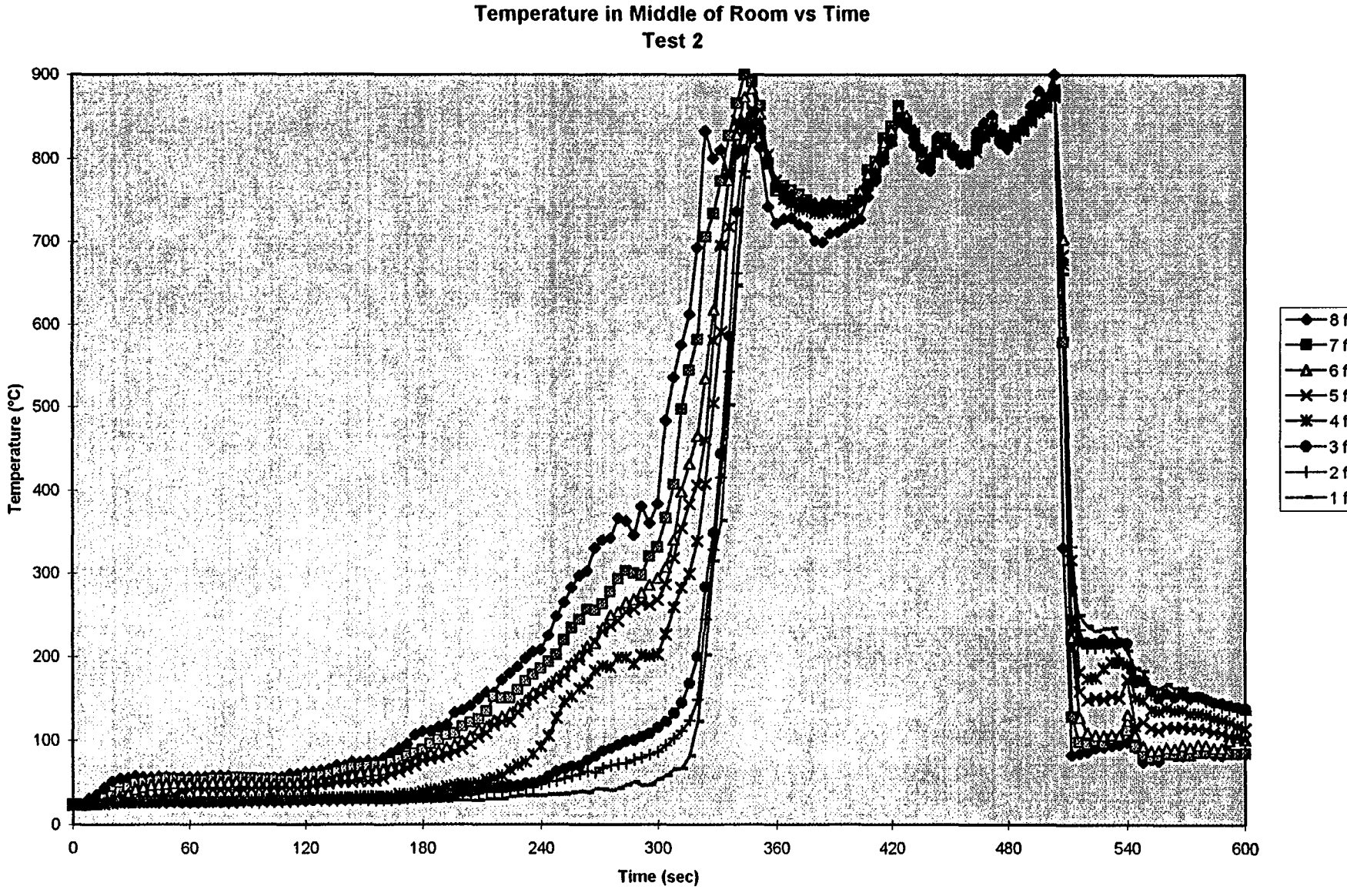

Oxygen Concentration vs Time
Test 1
25
20
15
10
5
0
% O2
0
60
120
180
240
300
360
420
480
540
600
660
720
780
840
Time (sec)
O2% UM
O2% NIST
Time lag considered only for UM sensor

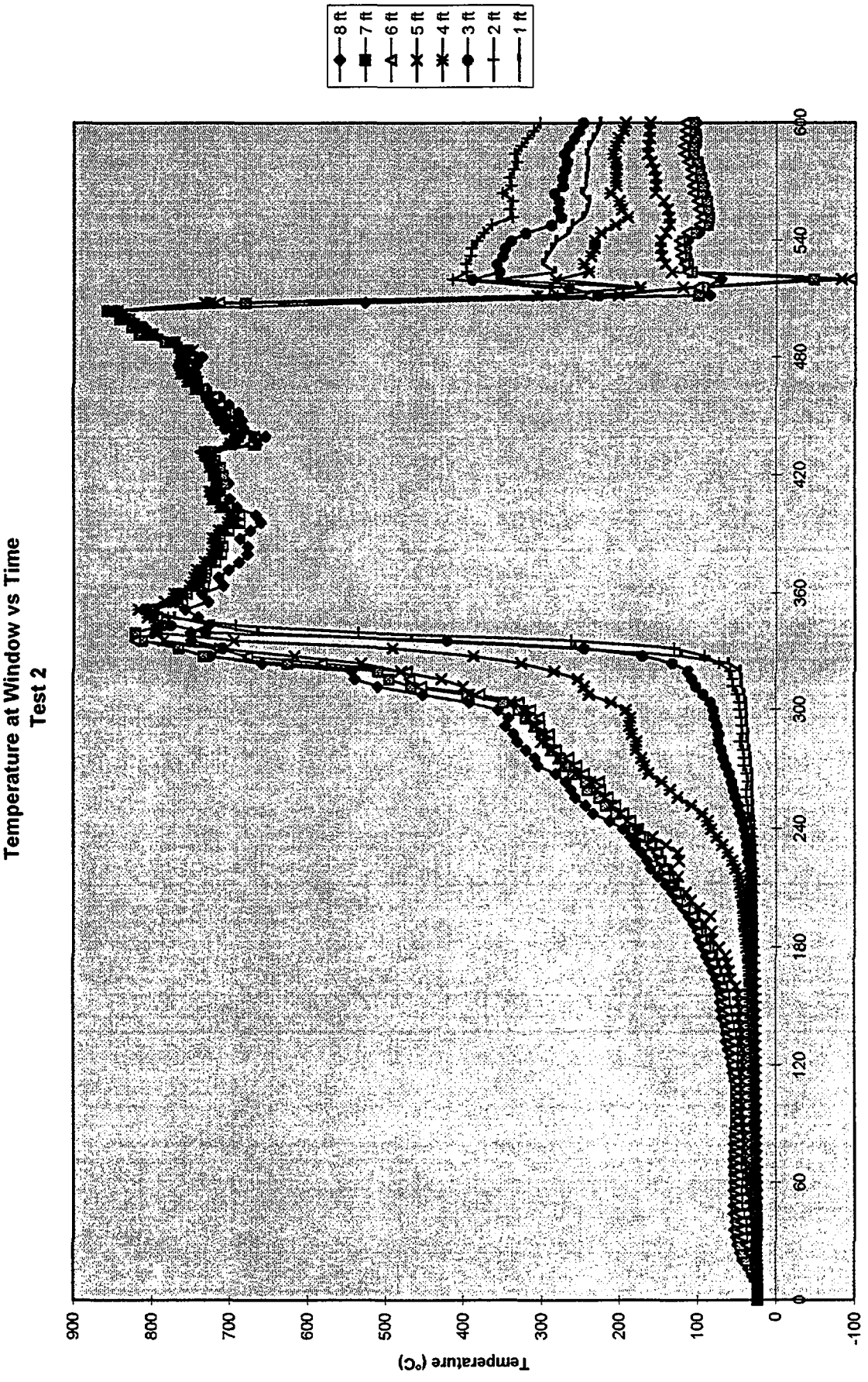
Test 2

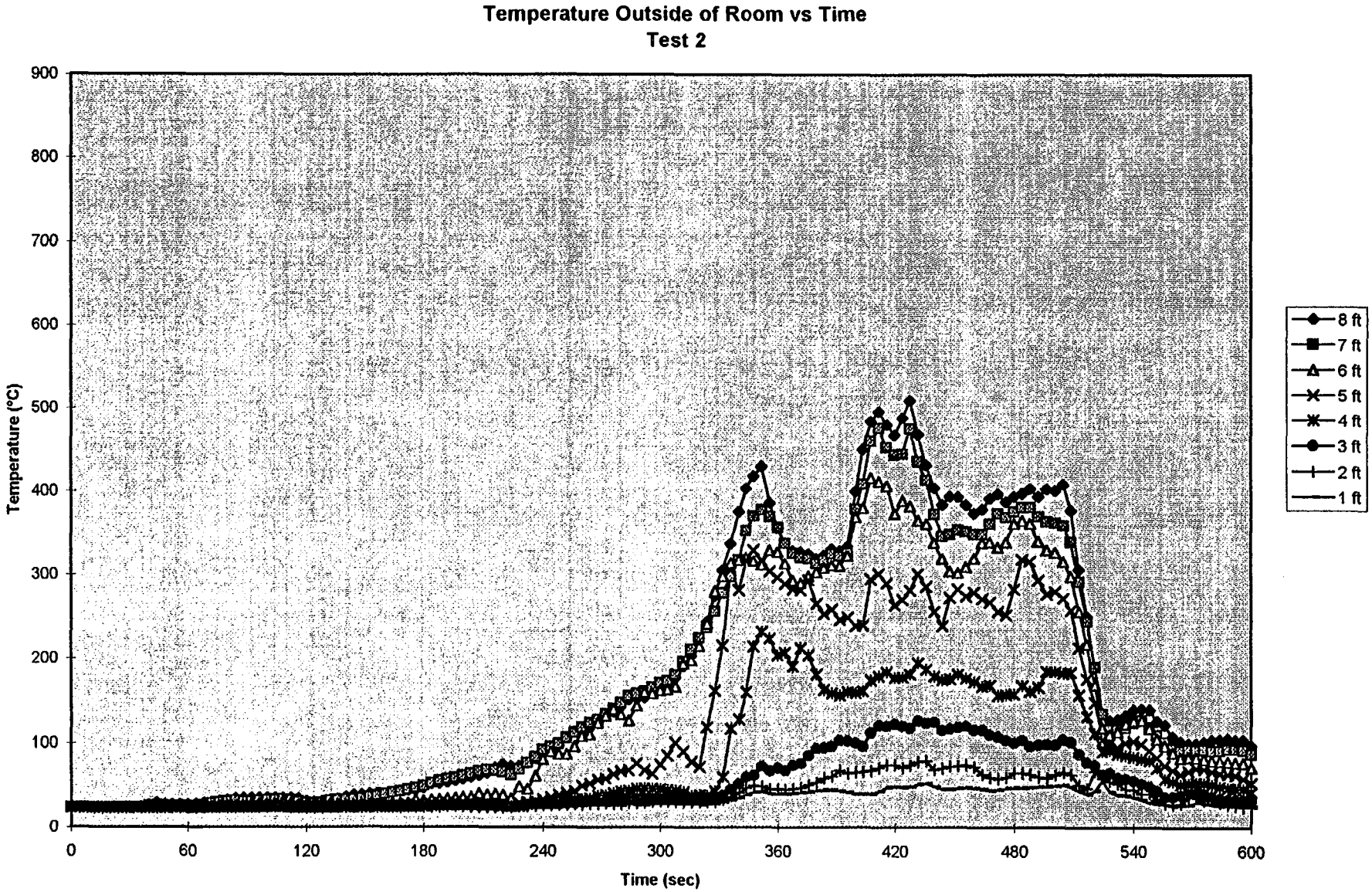
Figure 2.1 Diagram of Furnishings and Instrumentation for Test 2, June 6, 1996

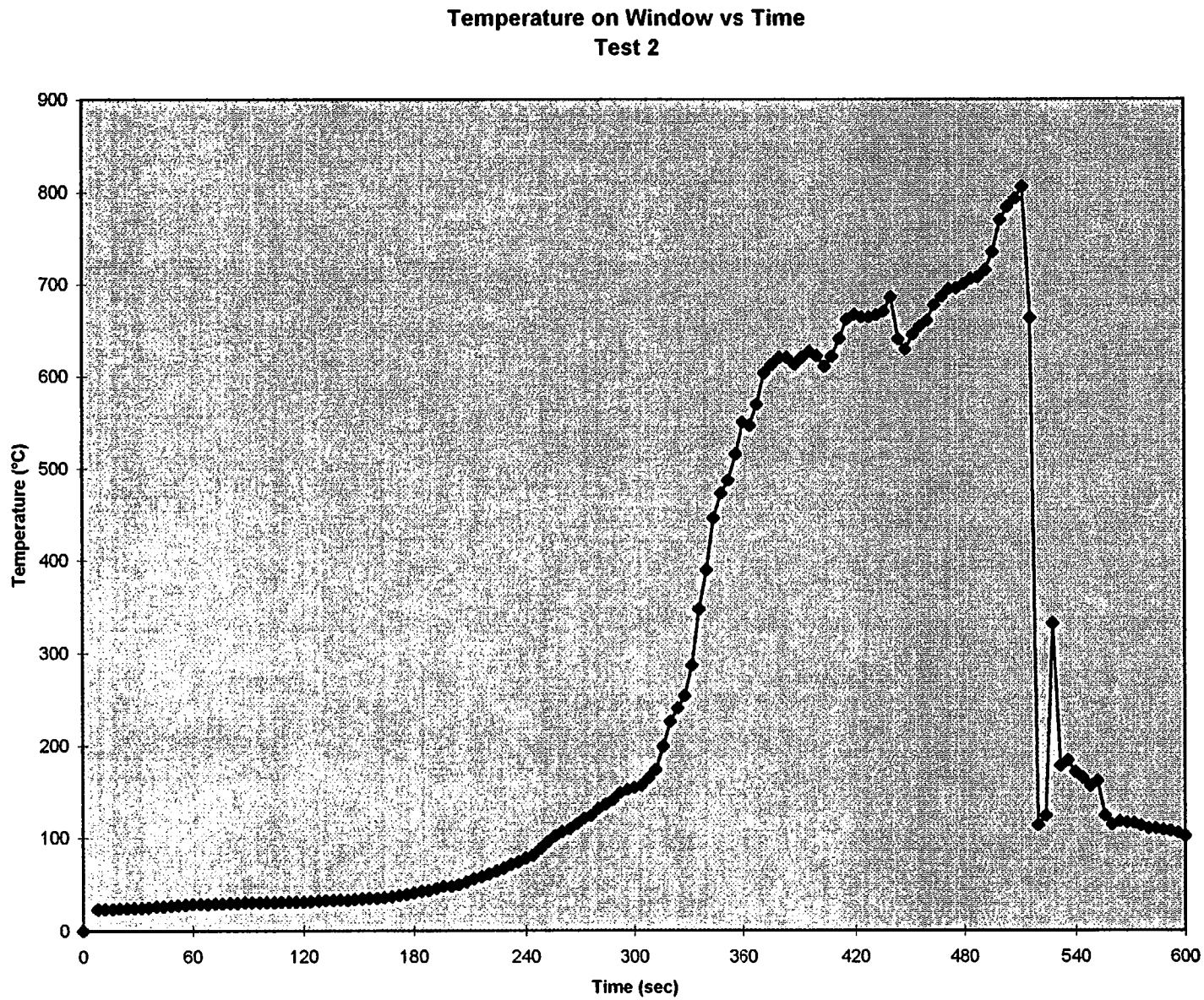


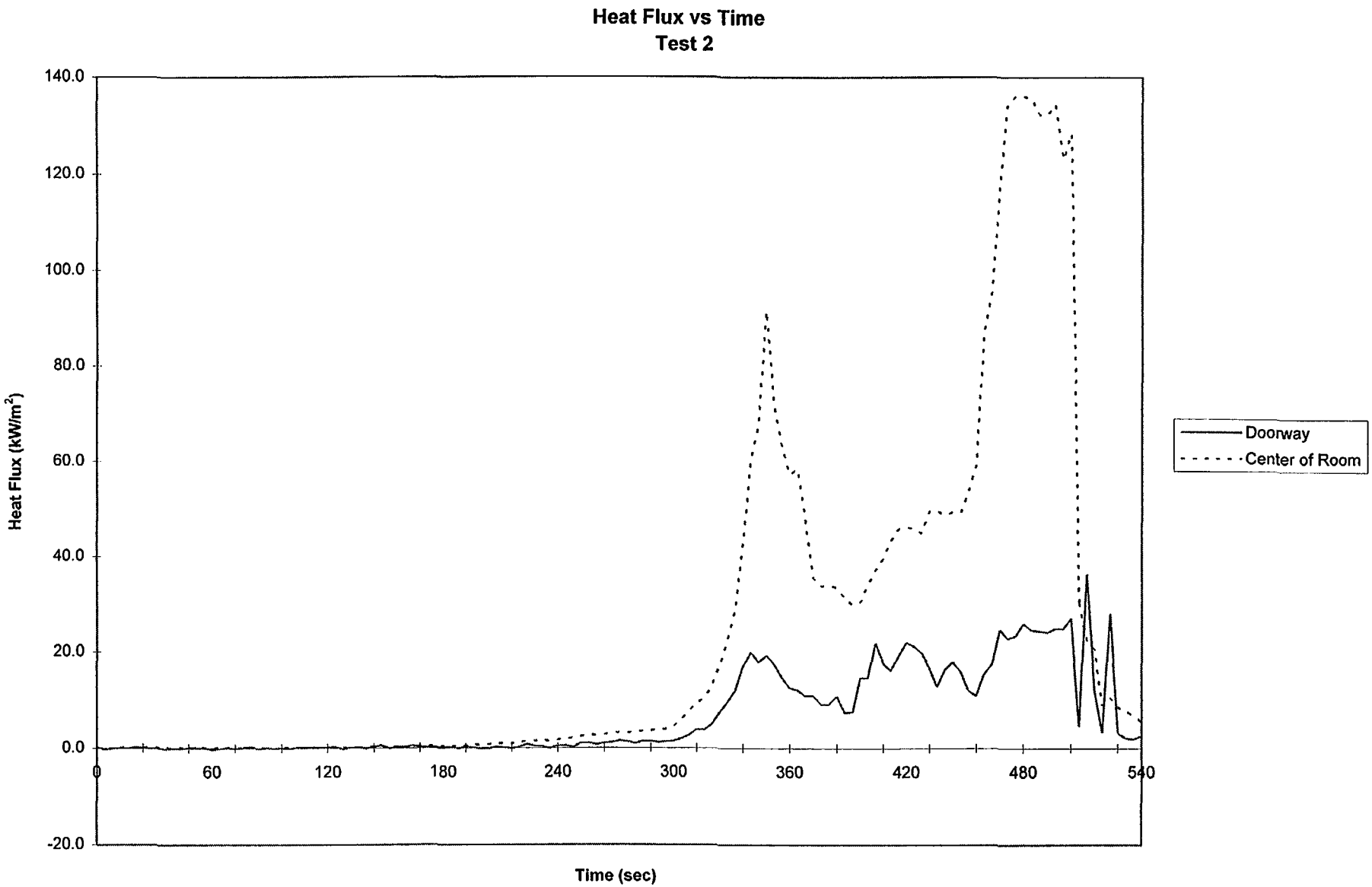

Temperature at Door vs Time
Test 2
Temperature (°C)
900
800
700
600
500
400
300
200
100
0
0
60
120
180
240
300
360
420
480
540
600
Time (sec)
8 ft
7 ft
6 ft
5 ft
4 ft
3 ft
2 ft
1 ft

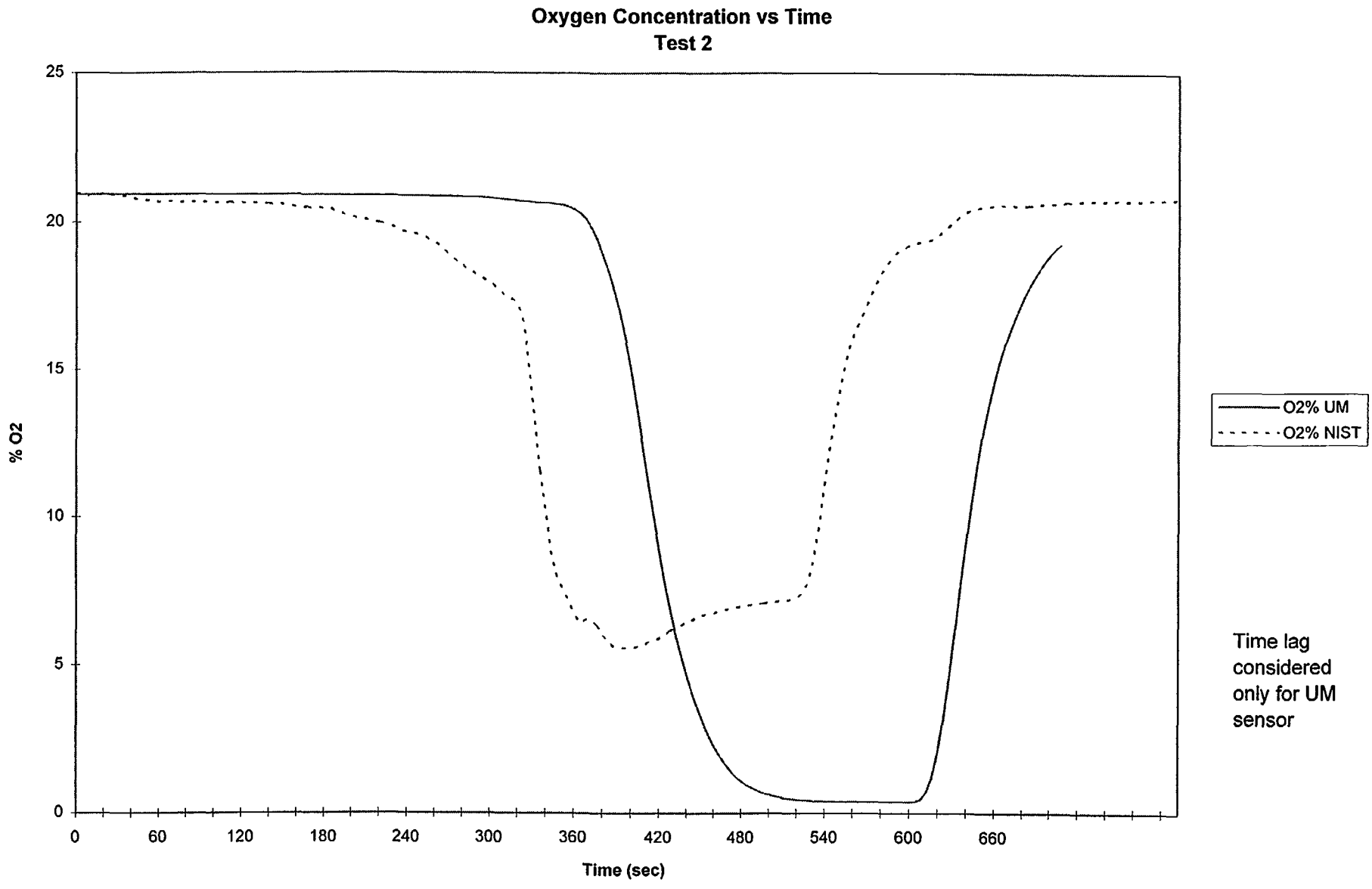

Temperature in Middle of Room vs Time
Test 2
Temperature (°C)
900
800
700
600
500
400
300
200
100
0
0
60
120
180
240
300
360
420
480
540
600
Time (sec)
8 ft
7 ft
6 ft
5 ft
4 ft
3 ft
2 ft
1 ft


Temperature at Window vs Time
Test 2
8 ft
7 ft
6 ft
5 ft
4 ft
3 ft
2 ft
1 ft
Temperature (°C)
900
800
700
600
500
400
300
200
100
0
-100
Time (sec)
0
60
120
180
240
300
360
420
480
540
600


Temperature Outside of Room vs Time
Test 2
Temperature (°C)
900
800
700
600
500
400
300
200
100
0
0
60
120
180
240
300
360
420
480
540
600
Time (sec)
8 ft
7 ft
6 ft
5 ft
4 ft
3 ft
2 ft
1 ft


Temperature on Window vs Time
Test 2
Temperature (°C)
900
800
700
600
500
400
300
200
100
0
0
60
120
180
240
300
360
420
480
540
600
Time (sec)


Heat Flux vs Time
Test 2
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
-20.0
Heat Flux (kW/m²)
0
60
120
180
240
300
360
420
480
540
Time (sec)
Doorway
Center of Room


Oxygen Concentration vs Time
Test 2
% O2
Time (sec)
0
5
10
15
20
25
0
60
120
180
240
300
360
420
480
540
600
660
O2% UM
O2% NIST
Time lag considered only for UM sensor

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Two full size furnished bedrooms were burned, June 5 and June 6, at the University of Maryland Fire and Rescue Institute Facilities. These burns were performed for two cooperating agencies; The Alcohol, Tobacco and Firearms Agency of the Treasury Department, who used them as part of their Certified Fire Investigator training, and the Building and Fire Research Laboratory of NIST, who used them for forensic research. It was intended that these two burns be identical, to see if close analysis of the results would find differences. There were differences, possibly due to small differences in the inflow of ventilation air. In both cases, ignition was caused by burning newspaper on an upholstered chair. This report describes the test arrangement and instrumented results.

KEY WORDS (MAXIMUM OF 9; 28 CHARACTERS AND SPACES EACH; SEPARATE WITH SEMICOLONS; ALPHABETIC ORDER; CAPITALIZE ONLY PROPER NAMES)
fire markings; fire research; flashover; full scale burn; ignition

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