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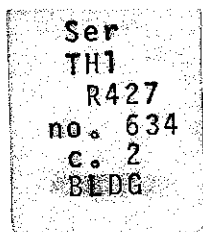
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***Inter-Laboratory Study for the  
Full Scale Room Fire Test:  
Results of Tests Conducted at  
the NFL/IRC***

Andrew Kim and Robert Onno

ANALYZED

Internal Report No. 634

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# **INTER-LABORATORY STUDY FOR THE FULL SCALE ROOM FIRE TEST: RESULTS OF TESTS CONDUCTED AT THE NFL/IRC**

by

Andrew Kim and Robert Onno

## **ABSTRACT**

This report summarizes the National Fire Laboratory's results from Room Burn Tests obtained over three years during which fourteen materials were tested. Most of were wood product lining materials with some insulation materials.

The test method and apparatus description are presented as well as observations and results of the tests. Heat flux values and ceiling temperatures in the room are tabulated as well as flashover time and smoke results. Room temperatures, duct flow rate, duct temperature, as well as O<sub>2</sub>, CO<sub>2</sub>, CO concentrations in the duct are also presented. Graphs of heat release rate, heat flux, smoke production and ceiling temperatures are included.

# **INTER-LABORATORY STUDY FOR THE FULL SCALE ROOM FIRE TEST: RESULTS OF TESTS CONDUCTED AT THE NFL/IRC**

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## **INTRODUCTION**

The National Fire Laboratory (NFL) of the Institute for Research in Construction (IRC), National Research Council of Canada (NRCC) has performed full-scale room burn fire tests for a period of three years. This proposed room burn test has generally been accepted as a realistic means of evaluating the fire hazard of room lining materials.

Some of the data has been submitted to an ASTM/ISO Round Robin that studied the repeatability and reproducibility of the test method. All of the room fire test results have been examined for comparison with the NFL's small-scale test results.

This report provides a brief description of the test method, instruments, calibration, as well as the detailed test results.

## **DESCRIPTION OF ROOM/CORNER TEST**

### **Test Method**

The objective of the full scale test is to evaluate the flammability of interior lining materials.

The ASTM room/corner test method uses a 2.4 m × 3.7 m × 2.4 m high room. Test materials cover three of the walls, excluding the wall containing the door. Ignition is carried out by a sand burner in a corner of the room.

The following parameters are obtained from the test: a visual observation of fire development, temperature measurements in the room, heat flux values on the floor, the rate of heat release (RHR), time until flashover and the smoke obscuration in the exhaust duct.

The detailed test method is described in Ref. 1.

### **Instruments**

A hood system is located above the door and collects the fire gases flowing from the doorway. Measurements of the gas velocity, gas temperature and concentrations of CO, CO<sub>2</sub> and O<sub>2</sub> in the exhaust duct provide the means for determining the heat release rate. The heat flux level from the fire is measured by two heat flux radiometers located on the floor. Thermocouples placed on the ceiling measure the temperature rise in the room. Smoke meters are positioned in the duct to measure the smoke obscuration of the fire gases in the duct. A video recorder is positioned outside the room to record the experiment.

### **Procedure**

The test commences prior to ignition of the sand burner to check and record baseline readings. Following the initial three minutes of non-fire conditions, the sand

burner is ignited. Propane gas flow is adjusted to produce 40 kW in the sand burner for the first five minutes. After five minutes, the propane gas flow to the sand burner is increased to produce a 160 kW fire. The test is recorded by a video camera and written observations made with corresponding times of important events, such as flashover time. The test is terminated upon flashover or fifteen minutes, whichever event occurs first.

## TEST MATERIALS

Fourteen materials were tested as shown in Table 1. These materials are generic products. Some materials were tested more than once in a given year, and some sample materials were from different batches as denoted by "Sample #2".

Table 1. Test Materials

Sample Material	Thickness (mm)	Sample #	Date Tested
Chipboard	6	1	June 12, 1990
Woodpanel	3	1	June 18, 1990
Plywood	6	1	June 21, 1990
Gypsumboard	13.4	1	June 26, 1990
Plywood	12.3	1	July 4, 1990
Fire Retarded Plywood	12.3	1	July 9, 1990
Expanded Polystyrene	26.1	1	July 12, 1990
Rigid Polyurethane	25.1	1	July 17, 1990
Plywood	12.3	1	July 20, 1990
Fire Retarded Plywood	12.3	1	July 26, 1990
Expanded Polystyrene	26.1	1	July 31, 1990
Woodpanel	6	1	November 1, 1990
Particle board	12.3	1	February 22, 1991
Plywood	6	2	March 25, 1991
Plywood	12.3	2	April 8, 1991
Polyurethane with Foil	40	1	April 30, 1991
Chipboard	6	2	May 7, 1991
Particle board	12.3	1	May 13, 1991
Woodpanel	5	1	May 16, 1991

## RESULTS AND DISCUSSION

### Results

The results are presented in separate appendices, each one devoted to a particular experiment.

The first item in each Appendix is a Summary Table, listing some key test results. The time at which the 2 radiometers, located on the floor, reached 20 kW/m<sup>2</sup> is shown. Paper bundles were also placed on the floor in the centre of the room. The time at which these ignited is tabulated, as well as the time that the flame travelled out the doorway. Thermocouples were located in the centre of the room and two inches above the doorway, as well as in other areas. The maximum temperature of these thermocouples as well as the times that they reach 600°C are noted. Each of these conditions represents flashover of the room. The maximum rates of smoke and heat production and the times of their peak occurrence are also tabulated.

One part of each Appendix contains information on visual observations of the tests, noting major changes in the fire growth in the room.

Each Appendix also contains a supplementary table which lists a number of other variables changing with time. The data from the thermocouples positioned at the door (DOOR TC) and above the sand burner (CORNER TC) are tabulated here. The duct temperature (DUCT TEMP) and duct flow rate (FLOW RATE) in the exhaust duct are noted. The CO, CO<sub>2</sub>, O<sub>2</sub> concentrations in the exhaust duct are also in this table.

In addition, Figures are located at the end of each Appendix presenting graphs of the following variables plotted versus time: rate of heat release, heat flux, smoke production and temperature at the centre of the ceiling.

### Discussion

The data was analyzed as per Ref. 1 and any deviation noted below:

There were some problems encountered with data analysis, primarily as a result of the response and delay time associated with the analyzers. For the CO<sub>2</sub> analyzer, a delay time of 5 s and a response time of 1 s was estimated from the calibration tests. For the O<sub>2</sub> analyzer, a delay time of 30 s and response time of 5 s was approximated. Since the O<sub>2</sub> and CO<sub>2</sub> delay times were different, a problem was created when a sudden heat release rate change occurred. To rectify this problem, the O<sub>2</sub> readings were adjusted so that the CO<sub>2</sub> and O<sub>2</sub> delay time would be approximately the same. The O<sub>2</sub> value adjustment included moving up the O<sub>2</sub> data in the data file so that the changes in O<sub>2</sub> readings and the changes in the CO<sub>2</sub> readings would correspond to the sand burner ignition. The difference was typically 18 to 24 s.

Another problem encountered was the effect of changing the fan speed near flashover time. The increase in fan speed was necessary during those tests involving a large amount of smoke. This increase in duct flow had a direct influence upon the calculation of the rate of heat release and smoke production values. Since the O<sub>2</sub> concentration measured at the time of the fan speed increase does not correspond correctly to the actual value, due to the delay time of the O<sub>2</sub> analyzer, an adjustment of 18 s was made by estimating the difference between the time of O<sub>2</sub> response and the fan speed change. This means that the first 18 s of increased fan speed values was replaced with the constant fan speed just prior to the increase, for the heat release rate calculation.

Three different smoke meters were used during the testing, a laser, a white light, and an in-house-developed smoke meter. A thorough examination showed that the white light was not providing consistent results, while the in-house-developed smoke meter appeared to be the most representative. The results presented in this report are those results from the in-house-developed smoke meter, unless otherwise specified.

During 1990, tests were terminated instantly upon flashover. Upon analyzing the data, some problems were encountered. The analyzer delay times brought forth the inability of estimating the HRR at the time of flashover, since the O<sub>2</sub> concentration levels measured at flashover would be the value 30 s prior. The 1990 results may be missing some of the data at the end of a test due to this delay time. The following modification to the test method was made to remedy this problem: a water spray system was assembled near the end of the exhaust to protect the fan system and the tests were run for a period of time after flashover to accommodate the analyzer delay time.

## SUMMARY

Fourteen materials have been tested in the National Fire Laboratory's full-scale room apparatus. The results of these experiments, as well as observations and test methods, have been presented.

## REFERENCES

1. "Proposed Method for Room Fire Test of Wall and Ceiling Materials and Assemblies", pp. 1618-1638, 1982 Annual Book of ASTM Standards.

## LIST OF APPENDICES

APPENDIX A:	6.0 mm Chipboard
APPENDIX B:	3.0 mm Woodpanel
APPENDIX C:	6.0 mm Plywood
APPENDIX D:	12.3 mm Plywood
APPENDIX E:	12.3 mm Fire Retarded Plywood
APPENDIX F:	26.1 mm Expanded Polystyrene
APPENDIX G:	25.1 mm Rigid Polyurethane
APPENDIX H:	12.3 mm Plywood
APPENDIX I:	12.3 mm Fire Retarded Plywood
APPENDIX J:	26.1 mm Expanded Polystyrene
APPENDIX K:	6.0 mm Woodpanel
APPENDIX L:	12.3 mm Particleboard
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APPENDIX P:	6.0 mm Chipboard
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APPENDIX R:	5.0 mm Woodpanel

## **APPENDIX A: 6 mm CHIPBOARD**





## SUMMARY TABLE OF RESULTS

Item	Results
Test material	6 mm chipboard
Test number	1
Date of test	June 12, 1990
Time to ignition of walls (left / right)	35 s / 25 s
Time at which 20 kW/m <sup>2</sup> reach at each radiometer	4 min / 4 min
Time at which paper targets ignite	4 min
Time of flame out of doorway	3 min 55 s
Maximum temperature at centre of room / time occurred	784°C / 4 min 20 s
Maximum temperature at the doorway / time occurred	634°C / 4 min 20 s
Time 600°C was obtained by TC at the centre of the room	3 min 55 s
Time 600°C was obtained by the TC at the doorway	4 min 5 s
Maximum instantaneous smoke produced / time occurred	0.41 OD / 4 min 10 s
Maximum instantaneous heat release / time occurred	943 kW / 4 min 10 s

## VISUAL OBSERVATIONS OF THE TEST

Material: 6 mm Chipboard

Date: June 12, 1990

Overall description of test and test material: Followed ASTM test procedures

### Observations of the test:

<u>Time (min:sec)</u>	<u>Observations</u>
0 : 00	Ignition of the sand burner (40 kW).
0 : 25	Flame tip reaching 2 ft. Average flame height is 1 ft.
0 : 35	Left panel ignites (it shows char marks).
0 : 40	Right panel ignites.
0 : 50	Flame tip is 4 ft.
1 : 05	Flame tip is reaching ceiling.
1 : 40	Flame is steadily reaching the ceiling. Flame tip is progressing along the ceiling-wall joint.
1 : 55	Flame front progressed to the ceiling.
2 : 10	Flame is progressing steadily along the ceiling-wall joint.
2 : 40	Steady flame on the ceiling-wall joint.
2 : 55	Smoke starts to come out of the room.
3 : 15	Distinct smoke layer in the room approximately 3 ft deep at the ceiling.
3 : 25	Steady smoke coming out of the room. Steady flame at the ceiling.
3 : 45	Ceiling is full of flame.
3 : 55	Flickering flame is starting to come out of the room.
4 : 00	Both papers on the floor ignite.
4 : 10	Steady flame is starting to come out of the room.
4 : 15	Test terminated.

# Supplementary Data of the Test

**MATERIAL:** Chipboard  
**DIMENSION (mm) :** 6  
**DATE TESTED:** June 12 1990

TIME (min)	CORNER TC (deg C)	DOOR TC (deg C)	DUCT TEMP (deg C)	FLOW RATE (m3/s)	CO CONC (%)	CO2 CONC (%)	O2 CONC (%)
0	31	26	26	1.17	0	0	21
0.5	97	53	28	1.15	0	0.03	20.97
1	172	84	32	1.11	0	0.14	20.84
1.5	302	130	40	1.1	0	0.29	20.67
2	493	184	51	1.08	0	0.55	20.41
2.5	693	289	68	0.99	0	1.05	19.91
3	816	350	98	0.94	0.01	1.94	18.95
3.5	829	401	119	0.9	0.09	2.56	18.49
4	965	560	222	0.73	0.29	3.87	15.87

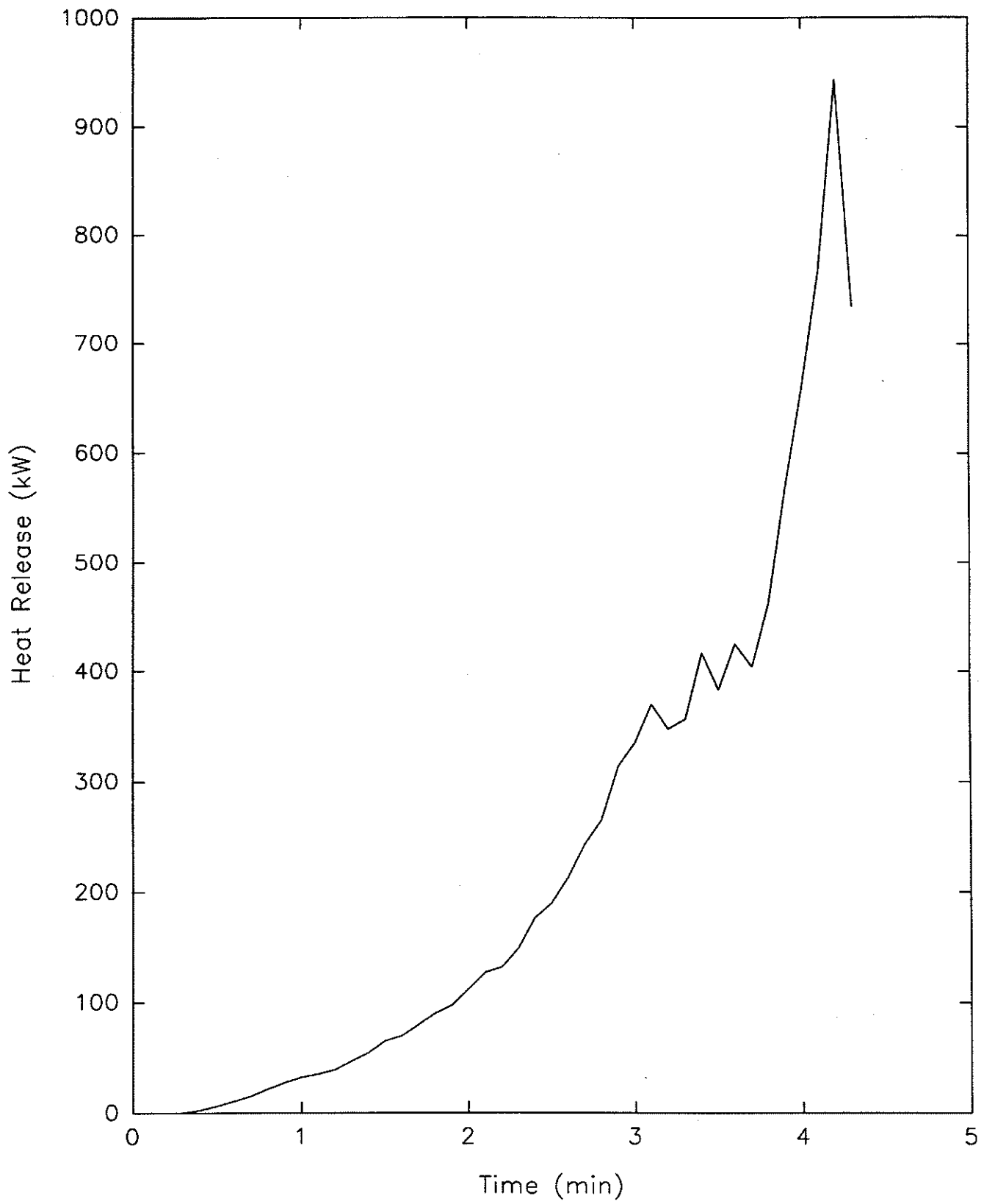


Figure A1 Heat Release Rate vs. Time

6mm Chipboard

June 12 1990

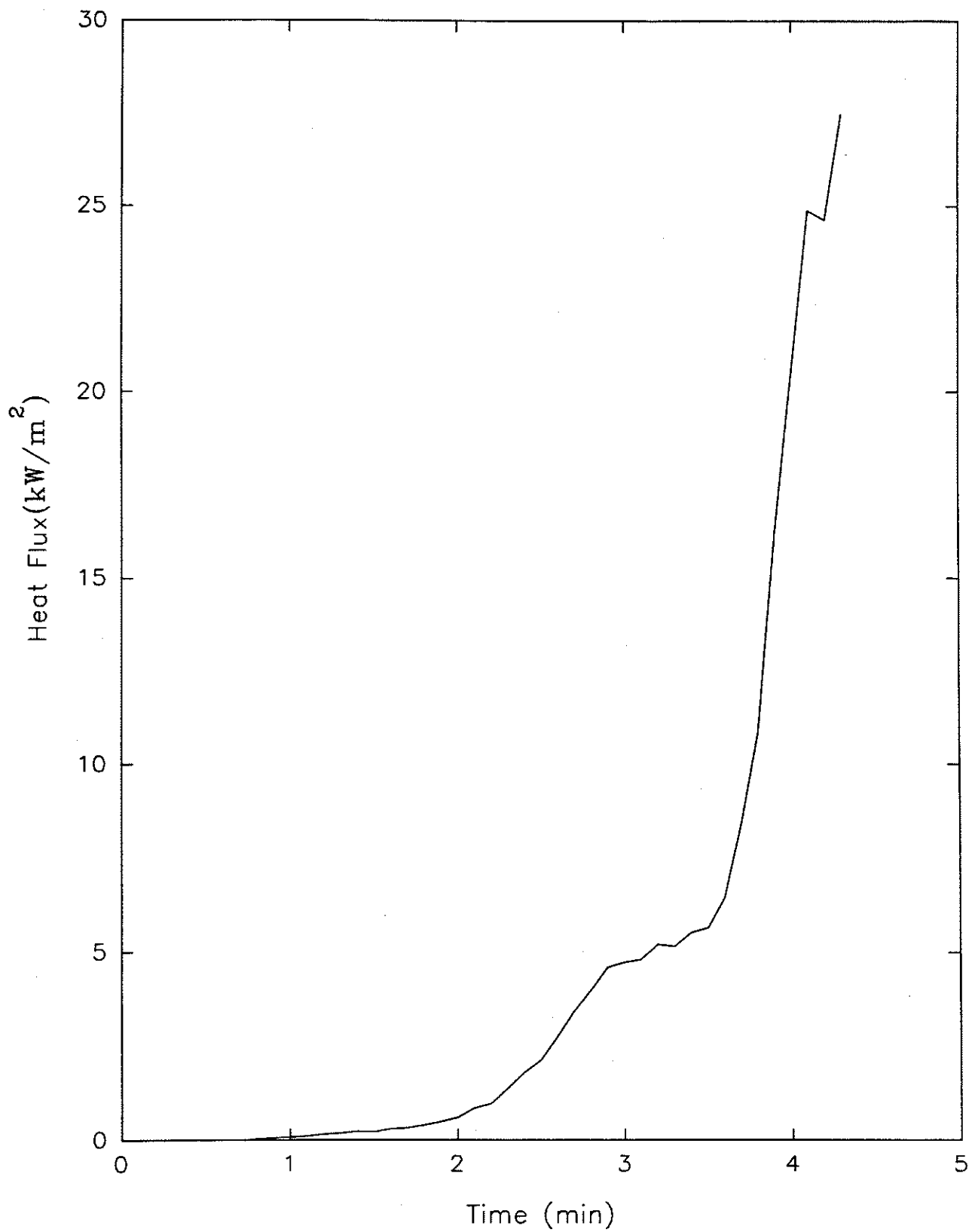


Figure A2 Heat Flux vs. Time  
6mm Chipboard

June 12 1990

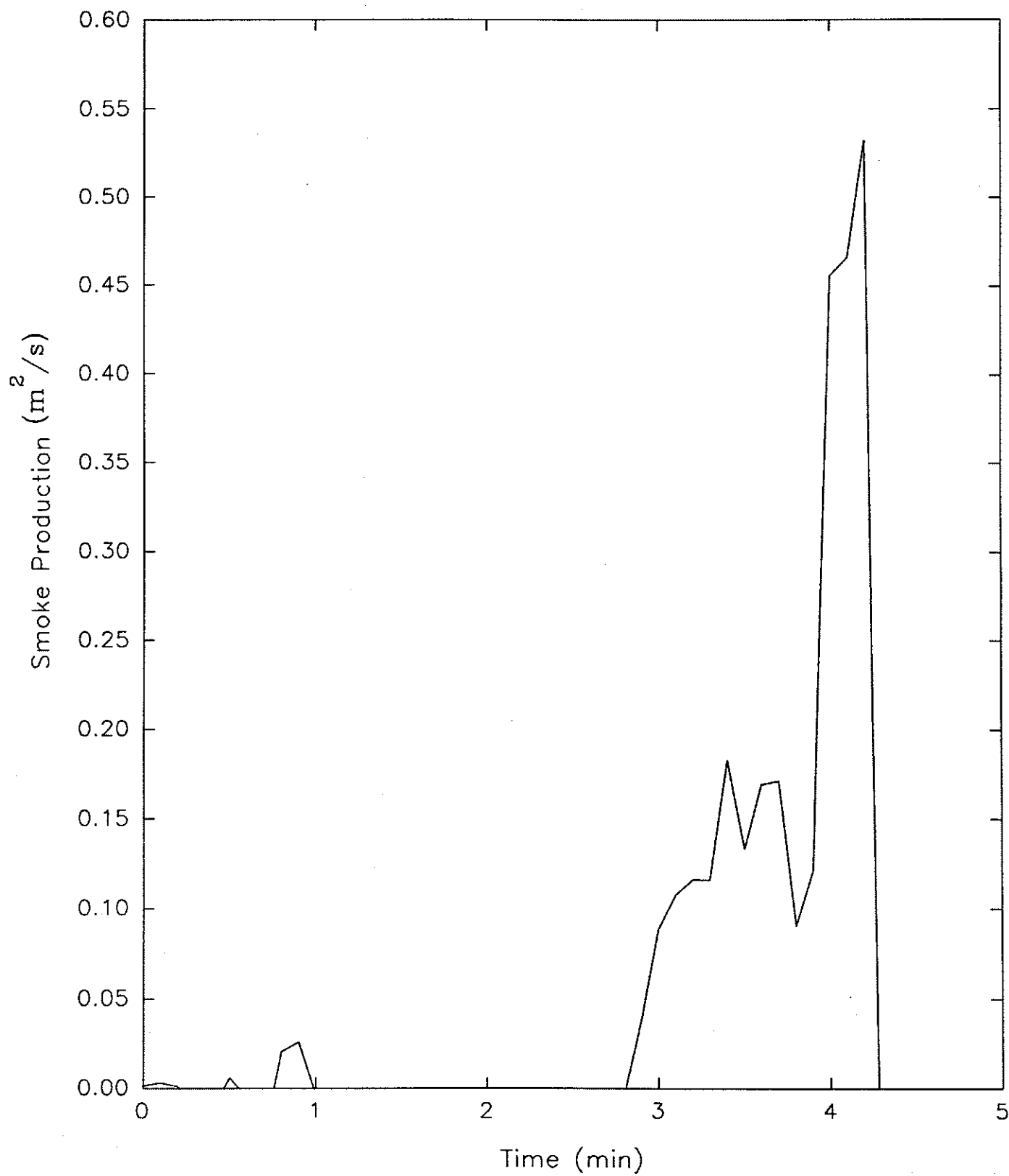


Figure A3 Rate of Smoke Production vs. Time  
6mm Chipboard

June 12 1990

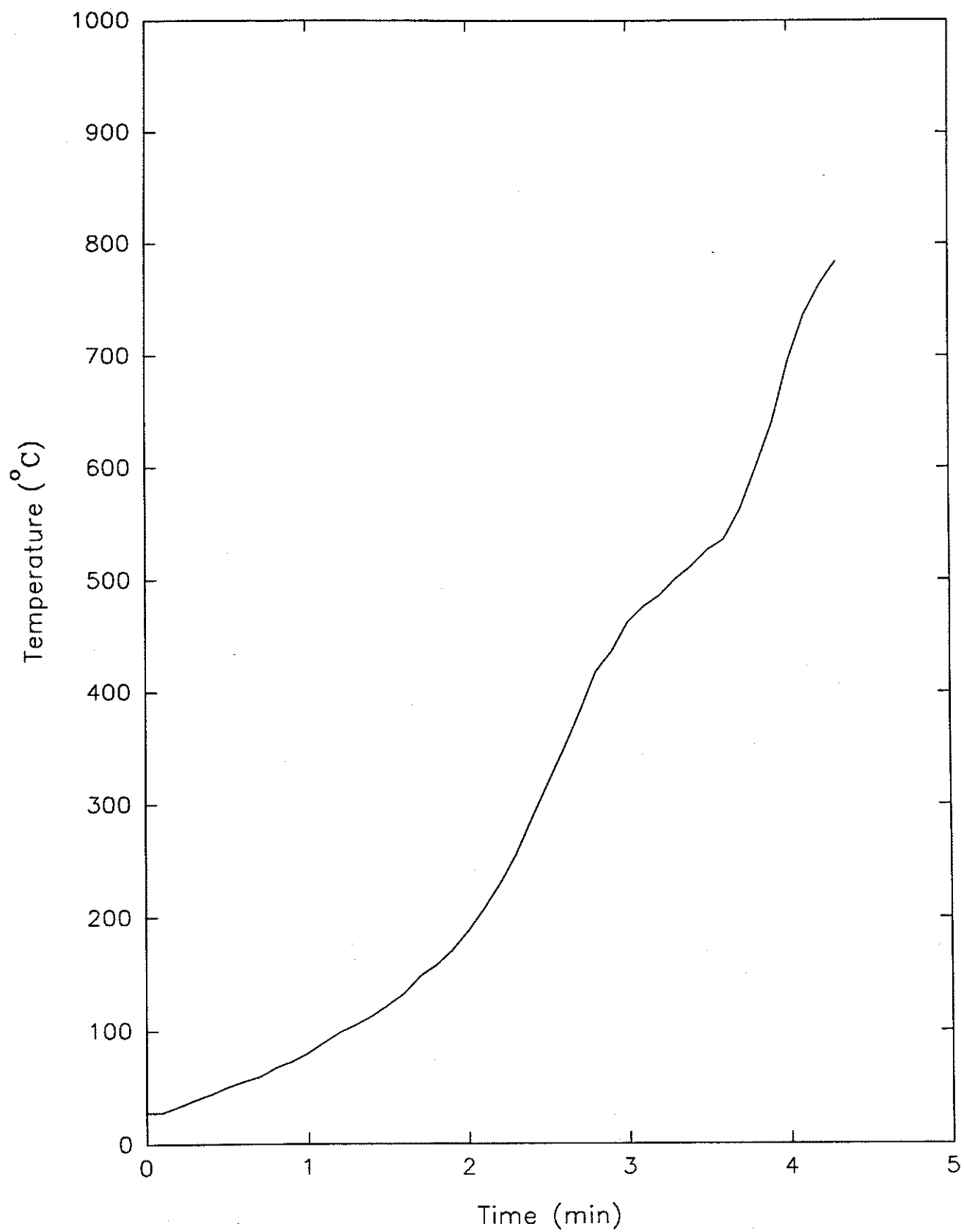


Figure A4 Temperature at the Centre of Ceiling vs. Time  
6mm Chipboard

June 12 1990





## **APPENDIX B: 3 mm WOODPANEL**



## SUMMARY TABLE OF RESULTS

Item	Results
Test material	3 mm woodpanel
Test number	1
Date of test	June 18, 1990
Time to ignition of walls (left / right)	40 s / 40 s
Time at which 20 kW/m <sup>2</sup> reach at each radiometer	DNO
Time at which paper targets ignite	DNO
Time of flame out of doorway	DNO
Maximum temperature at centre of room / time occurred	515°C / 3 min 55 s
Maximum temperature at the doorway / time occurred	389°C / 3 min 40 s
Time 600°C was obtained by TC at the centre of the room	DNO
Time 600°C was obtained by the TC at the doorway	DNO
Maximum instantaneous smoke produced / time occurred	0.04 OD / 3 min 50 s
Maximum instantaneous heat release / time occurred	303 kW / 4 min 5 s

DNO - Did not occur

## VISUAL OBSERVATIONS OF THE TEST

Material: 3 mm Panelboard

Date: June 18 1990

Overall description of test and test material: Followed ASTM test procedures  
Sand burner delayed by 7 s

### Observations of the test:

<u>Time (min:sec)</u>	<u>Observations</u>
0 : 00	Ignition of the sand burner (40 kW).
0 : 40	Flame tip reaching 3 ft. Both panels (left and right side of the sandburner) seem to ignite.
1 : 10	Flame tip nearly reaching the ceiling.
1 : 25	Flame steadily reaching the ceiling.
1 : 45	Flame is deflecting at the ceiling and flame tip starts to progress along the ceiling/wall joint.
2 : 00	Flame tip reaches 4 ft from the corner along the ceiling/wall joint.
3 : 00	Flame starts to spread along the ceiling. Definite smoke layer (3 ft) in the room.
4 : 00	Condition is steady. Wood panel in the corner on top of the burner is almost burned off revealing gypsum backboard.
4 : 30	Fire exposure in the room decreasing and flashover not likely because woodpanel in the corner is burned off and flame front is progressing weakly in the horizontal direction.
5 : 00	Propane flow increased to 112 L/min (160 kW).
5 : 10	Sandburner flame reaches ceiling. Woodpanel in the corner is all burned off so nothing is burning in the corner (except the sandburner). Some flame at the edge between the unburned panel and burned off panel (upper portion approximately 3-4 ft from the corner).
6 : 00	Condition steady.
10 : 00	Sandburner is off. Some flame at the edge of the unburned panel.
10 : 10	Burned off woodpanel in the corner is a cone shape. The width of the burned off region is approximately 1 ft in the lower portion (on top of the sand burner), 2 ft in the middle portion and 4 ft in the upper portion. Flame at the edge of the unburned woodpanel is in the middle portion, with 2-3 in. width and 1-2 ft high.
15 : 00	Very little flame left. Left side (back wall) flame is self-extinguished. Right side flame is approximately 2 in. wide and 1 ft high. Test terminated.

# Supplementary Data of the Test

**MATERIAL:** Woodpanel  
**DIMENSION (mm) :** 3  
**DATE TESTED:** June 18 1991

TIME (min)	CORNER TC (deg C)	DOOR TC (deg C)	DUCT TEMP (deg C)	FLOW RATE (m3/s)	CO CONC (%)	CO2 CONC (%)	O2 CONC (%)
0	31	28	27	1.12	0	0	21
0.5	128	57	29	1.1	0	0	21
1	206	97	35	1.05	0	0.11	20.89
1.5	347	133	41	1.08	0	0.24	20.78
2	626	213	53	1.04	0	0.52	20.58
2.5	711	296	64	0.97	0	0.96	20.2
3	867	318	69	0.98	0.01	1.23	19.87
3.5	829	360	78	0.99	0.03	1.47	19.54
4	593	366	82	0.93	0.05	1.87	19.15
4.5	445	334	83	0.93	0.05	1.73	19.28
5	449	278	75	0.97	0.04	1.41	19.6
5.5	623	294	90	0.94	0.04	1.52	19.46
6	640	279	90	0.94	0.03	1.47	19.44
6.5	654	282	92	0.91	0.02	1.41	19.53
7	614	282	91	0.95	0.02	1.25	19.59
7.5	626	256	94	0.93	0.02	1.24	19.63
8	597	271	91	0.94	0.02	1.29	19.61
8.5	607	251	89	0.95	0.03	1.15	19.69
9	600	236	89	0.93	0.03	1.17	19.71
9.5	610	234	90	0.9	0.03	1.1	19.74
10	588	239	88	0.91	0.04	1.12	19.7
10.5	601	242	90	0.92	0.04	1.11	19.75
11	592	240	90	0.95	0.03	1.05	19.72
11.5	601	218	89	0.95	0.04	1.05	19.79
12	617	250	90	0.97	0.03	1.08	19.8
12.5	617	237	93	0.92	0.03	1.12	19.72
13	610	232	94	0.86	0.03	1.06	19.65
13.5	627	245	92	0.9	0.03	1.08	19.69
14	602	246	89	0.91	0.03	1.06	19.68
14.5	609	215	94	0.88	0.03	1.11	19.75
15	615	225	94	0.92	0.02	1.09	19.71

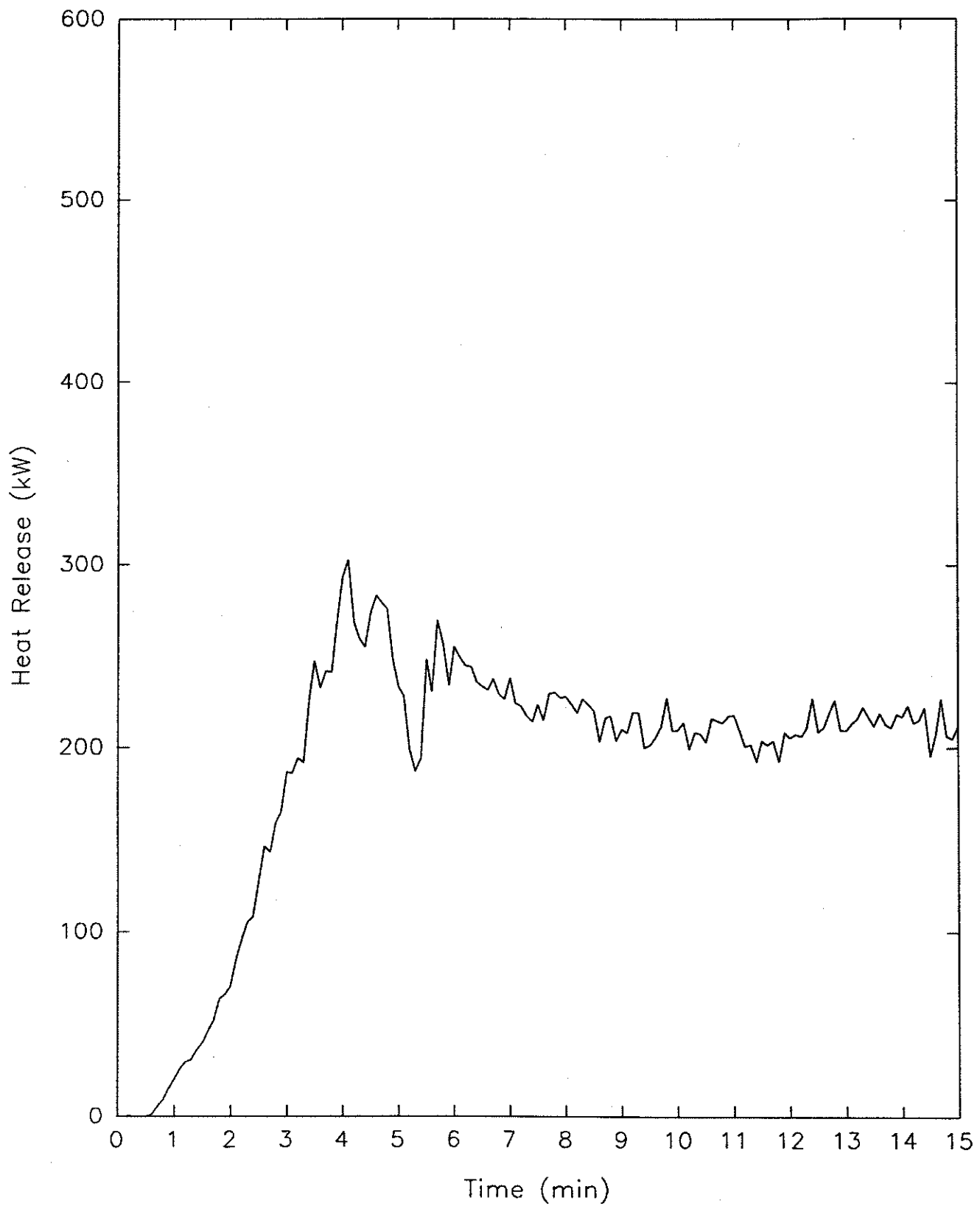


Figure B1 Heat Release Rate vs. Time

3mm Panelboard

June 18 1990

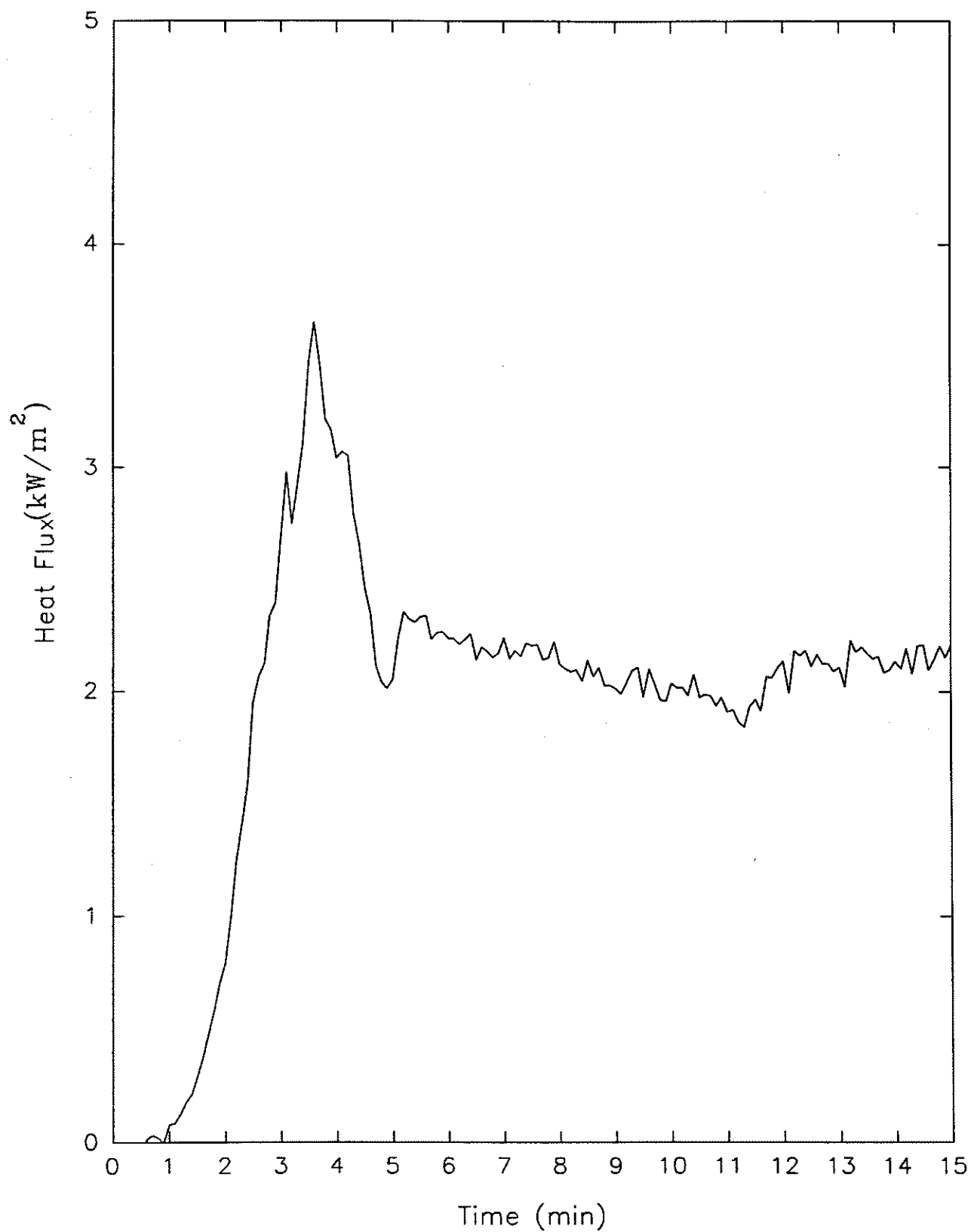


Figure B2 Heat Flux vs. Time  
3mm Panelboard

June 18 1990



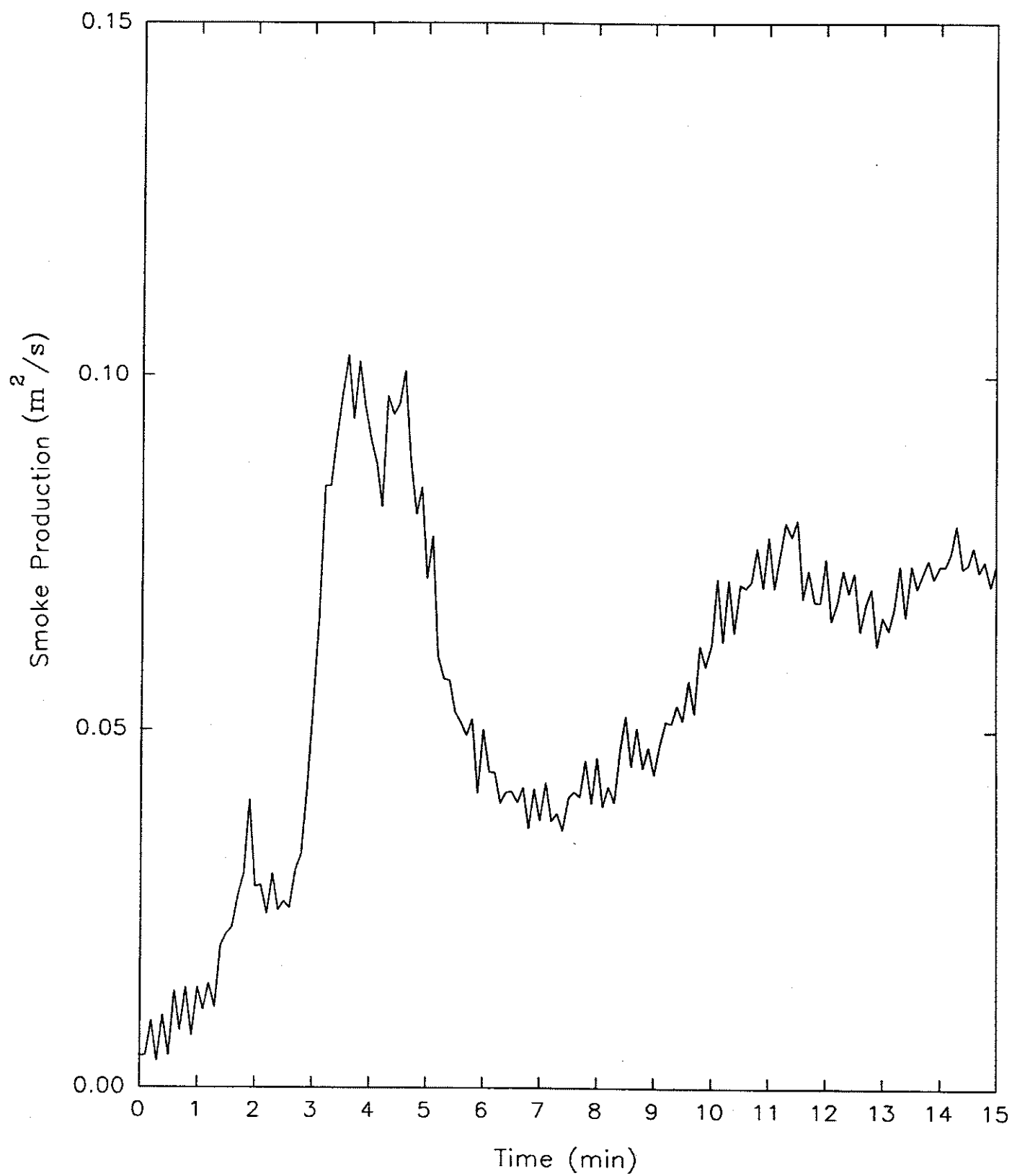


Figure B3 Rate of Smoke Production vs. Time  
3mm Panelboard

June 18 1990

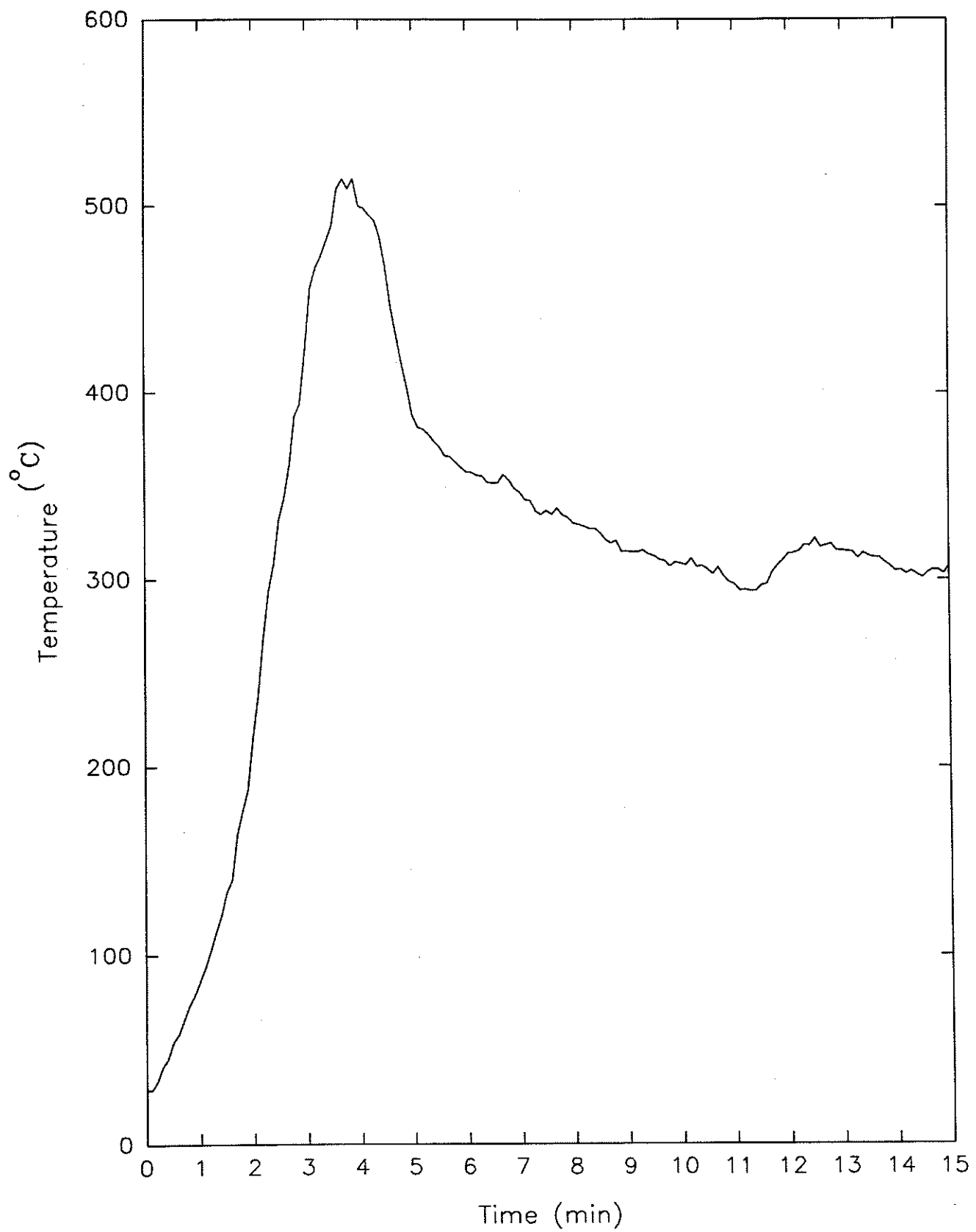


Figure B4 Temperature at the Centre of Ceiling vs. Time  
3mm Panelboard

June 18 1990



## **APPENDIX C: 6 mm PLYWOOD**



## SUMMARY TABLE OF RESULTS

Item	Results
Test material	6 mm plywood
Test number	1
Date of test	June 21, 1990
Time to ignition of walls (left / right)	35 s / 1 min 25 s
Time at which 20 kW/m <sup>2</sup> reach at each radiometer	5 min 55 s / 5 min 50 s
Time at which paper targets ignite	5 min 55 s
Time of flame out of doorway	5 min 55 s
Maximum temperature at centre of room / time occurred	769°C / 6 min
Maximum temperature at the doorway / time occurred	654°C / 5 min 55 s
Time 600°C was obtained by TC at the centre of the room	5 min 30 s
Time 600°C was obtained by the TC at the doorway	5 min 55 s
Maximum instantaneous smoke produced / time occurred	0.10 OD / 6 min 5 s
Maximum instantaneous heat release / time occurred	1165 kW / 6 min 5 s

## VISUAL OBSERVATIONS OF THE TEST

Material: 6 mm Plywood

Date: June 21, 1990

Overall description of test and test material: Followed ASTM test procedures  
Fan speed switched to height during the test

### Observations of the test:

<u>Time (min:sec)</u>	<u>Observations</u>
0 : 00	Ignition of the sand burner (40 kW).
0 : 35	Left wall ignited.
0 : 40	Flame tip reaching 3 ft above the top of the sand burner.
0 : 50	Flame tip reaching 4 ft.
1 : 05	Flame tip reaching 4 ft.
1 : 25	Right side wall ignited.
1 : 40	Flame tip reaching 6 ft.
1 : 45	Flame tip occasionally extends to ceiling (flickering).
1 : 55	Flame tip reaching ceiling steadily.
2 : 40	Flame tip deflects at the ceiling of the top corner and flame starts to spread along the ceiling/wall joint.
2 : 50	Flame front reached the ceiling. Flame is spreading along the ceiling/wall joint.
3 : 15	Flame tip reaches 3 ft from the corner along the ceiling/wall joint.
3 : 25	Flame tip reaches 4 ft along the joint.
3 : 45	Flame tip reaches 5 ft along the joint.
4 : 10	Flame is progressing steadily. No smoke layer visible and no smoke is coming out of the room.
5 : 05	Flame is progressing along the ceiling. Heavy smoke layer in the ceiling. Smoke starts to come out of the room.
5 : 15	Steady smoke coming out of the room.
5 : 30	Fan speed changed to high speed to prevent smoke spillover in the canopy (however, at this time, the amount of the smoke out of the room was not extremely heavy).
5 : 35	Ceiling is full of flame and smoke.
5 : 55	Flame starts to come out of the room very briefly. First paper bundle (closer to the backwall) ignites.
6 : 00	Steady flame is coming out of the room. Second paper bundle (closer to the door) ignites. Test terminated.

# Supplementary Data of the Test

**MATERIAL:** Plywood  
**DIMENSION (mm) :** 6  
**DATE TESTED:** June 21 1990

TIME (min)	CORNER TC (deg C)	DOOR TC (deg C)	DUCT TEMP (deg C)	FLOW RATE (m3/s)	CO CONC (%)	CO2 CONC (%)	O2 CONC (%)
0	57	20	18	0.9	-0.01	0	20.81
0.5	131	64	22	1.03	0	0.03	20.76
1	176	85	25	1.09	-0.01	0.13	20.67
1.5	233	103	28	1.02	-0.01	0.21	20.62
2	361	133	33	0.88	-0.01	0.3	20.53
2.5	489	163	38	1.07	0	0.46	20.42
3	573	197	43	1.09	0	0.59	20.31
3.5	620	234	50	1.03	0	0.77	20.17
4	710	284	61	1	0	1.06	19.94
4.5	777	313	73	0.97	0	1.26	19.74
5	801	323	81	0.98	0	1.6	19.49
5.5	947	522	149	0.77	0.08	3.14	17.36
6	908	639	230	1.41	0.26	3.51	17.01



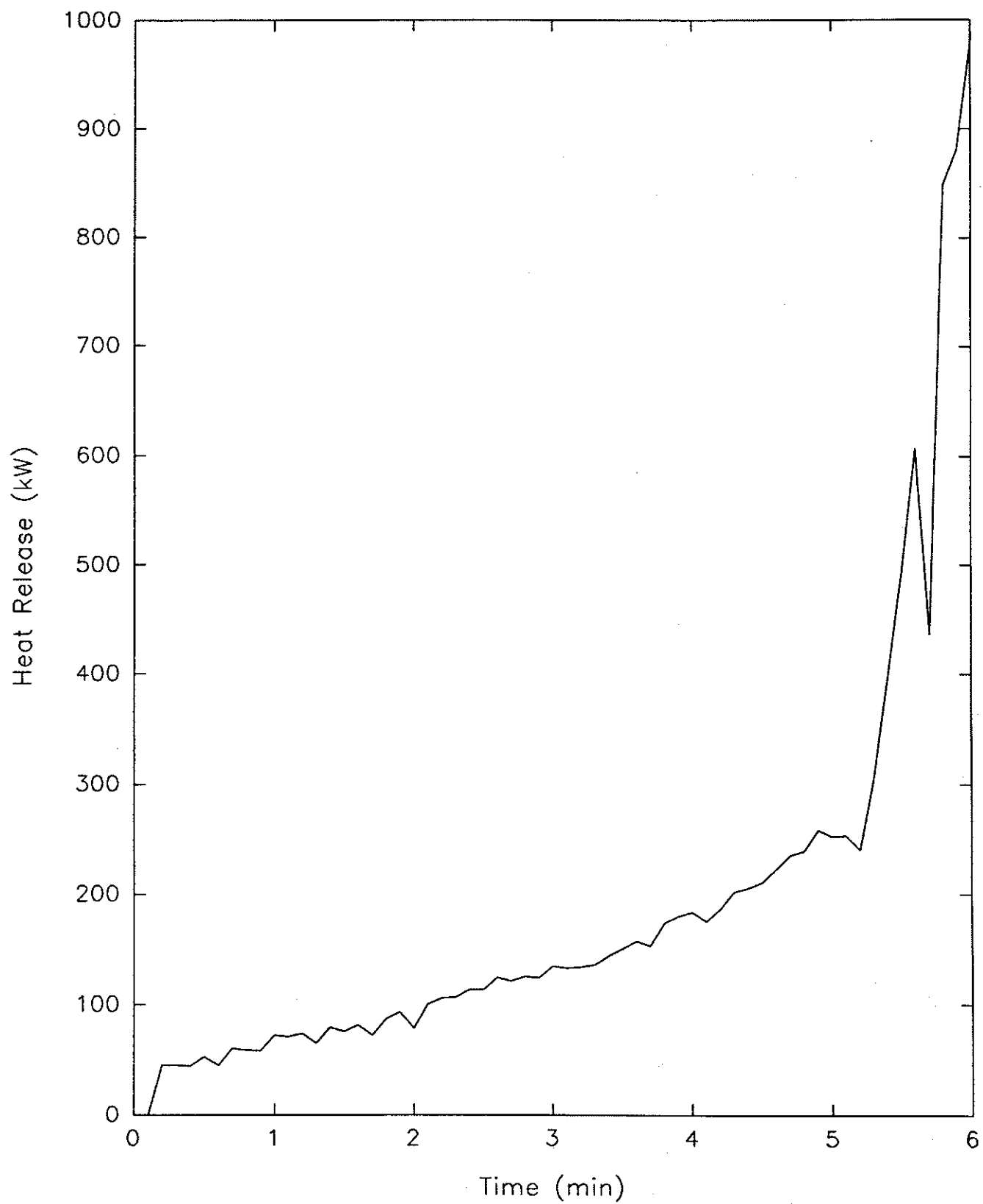


Figure C1 Heat Release Rate vs. Time  
6mm Plywood

June 21 1990

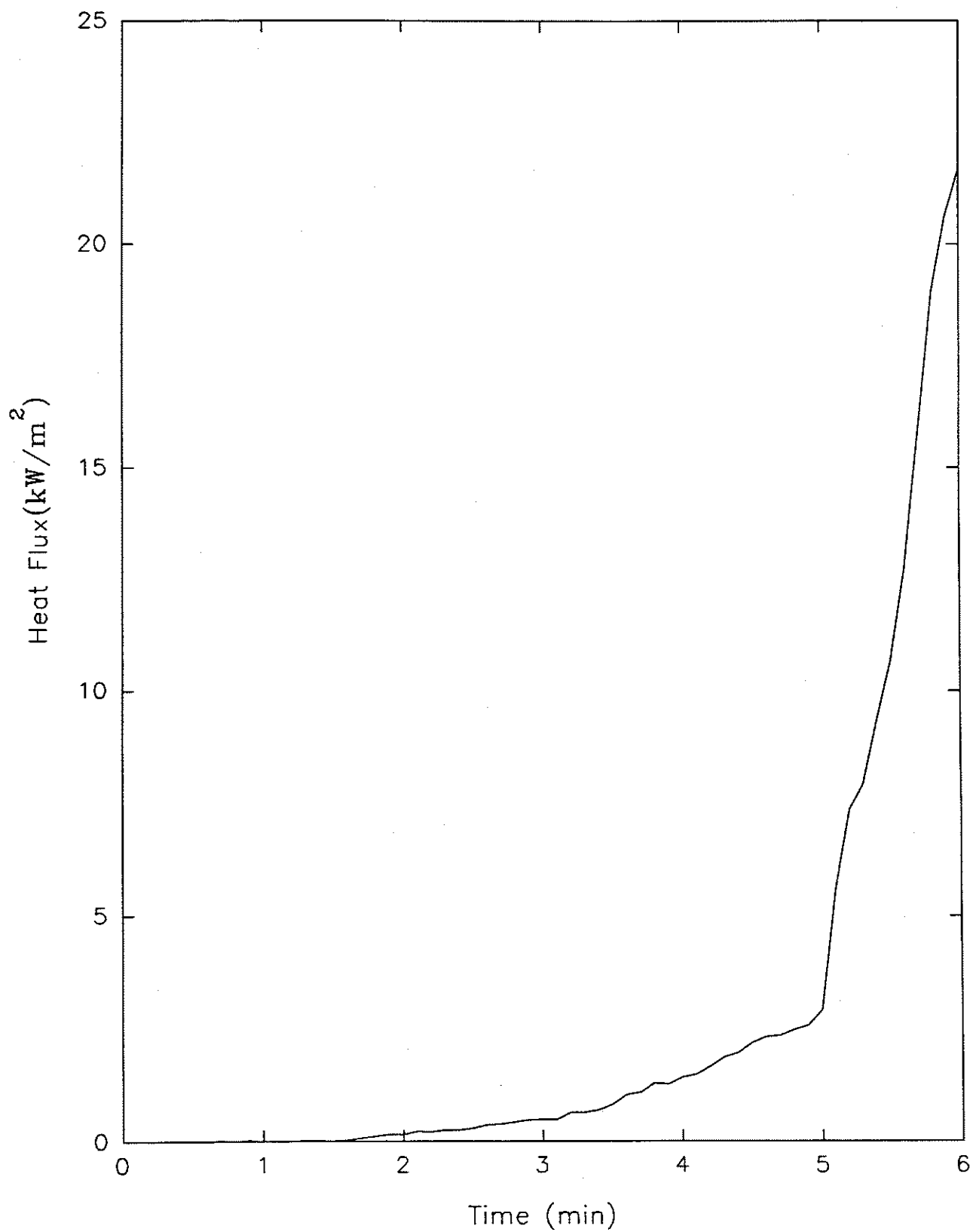


Figure C2 Heat Flux vs. Time  
6mm Plywood

June 21 1990

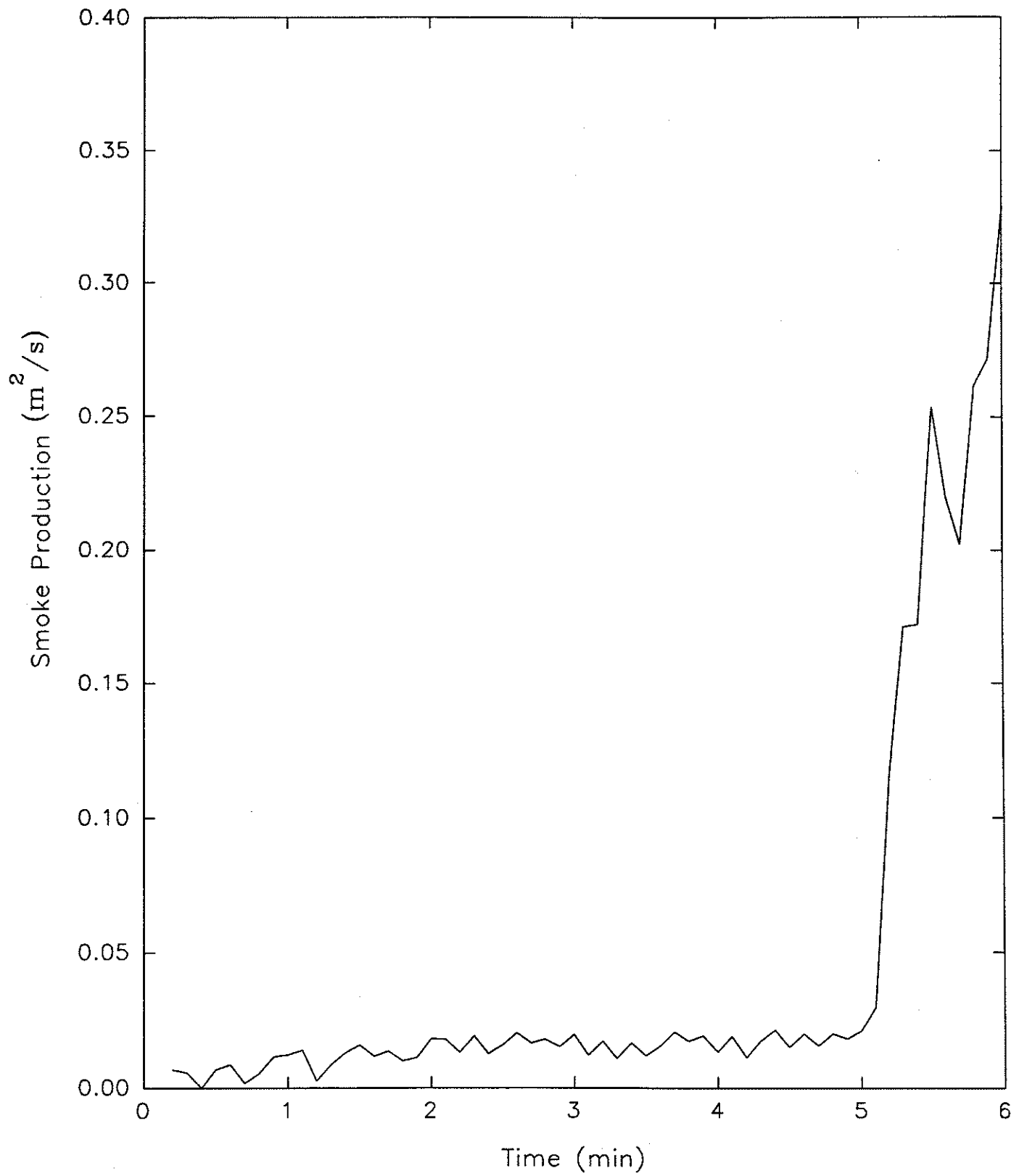


Figure C3 Rate of Smoke Production vs. Time  
6mm Plywood

June 21 1990

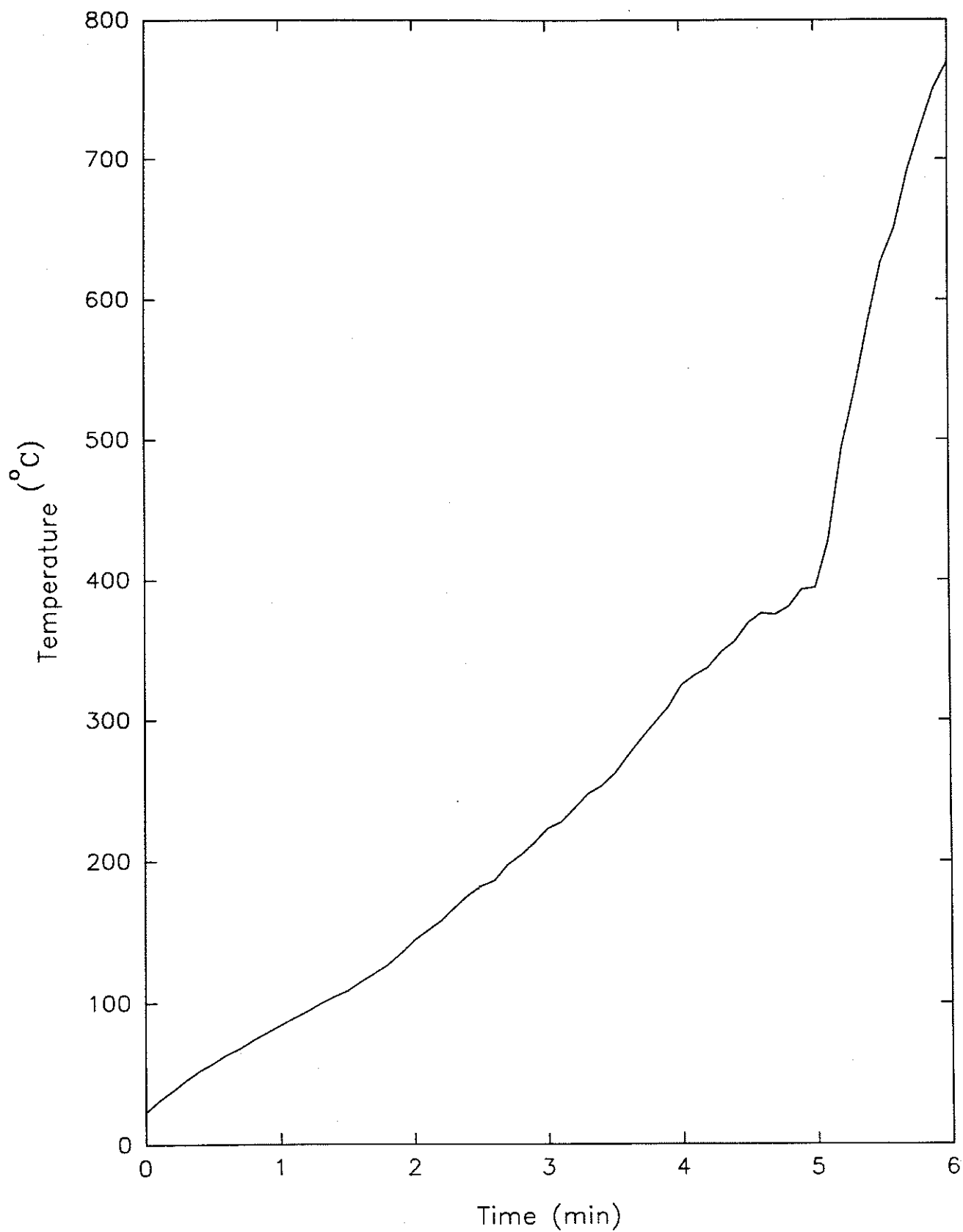


Figure C4 Temperature at the Centre of Ceiling vs. Time  
6mm Plywood

June 21 1990



## **APPENDIX D: 12.3 mm PLYWOOD**



## SUMMARY TABLE OF RESULTS

Item	Results
Test material	12.3 mm plywood
Test number	1
Date of test	July 14, 1990
Time to ignition of walls (left / right)	50 s / 50 s
Time at which 20 kW/m <sup>2</sup> reach at each radiometer	6 min 5 s / 5 min 55 s
Time at which paper targets ignite	6 min
Time of flame out of doorway	5 min 55 s
Maximum temperature at centre of room / time occurred	793°C / 6 min 20 s
Maximum temperature at the doorway / time occurred	639°C / 6 min 20 s
Time 600°C was obtained by TC at the centre of the room	5 min 35 s
Time 600°C was obtained by the TC at the doorway	6 min
Maximum instantaneous smoke produced / time occurred	0.77 OD / 10 s
Maximum instantaneous heat release / time occurred	1196 kW / 6 min 10 s



## VISUAL OBSERVATIONS OF THE TEST

Material: 12.3 mm Plywood  
Date: July 4 1990  
Room Temperature: 77°F  
Relative Humidity : 63%  
Barometric Pressure: 743.4 mm Hg

Overall description of test and test material: Followed ASTM test procedures  
Fan speed switched to high during the test

### Observations of the test:

<u>Time (min:sec)</u>	<u>Observations</u>
0 : 00	Ignition of the sand burner (40 kW).
0 : 15	Flame tip reaches 4 ft above the burner.
0 : 50	Plywood on both sides ignites. Flame tip reaches 5 ft.
1 : 00	Flame tip reaches ceiling. Flame front is 3 ft above the burner.
1 : 15	Flame front is 4 ft above the burner.
1 : 30	Flame tip reaches ceiling. Flame front is 5 ft above the burner.
1 : 45	Flame tip is deflecting at the ceiling and progresses along the ceiling/wall joint.
2 : 00	Flame tip reaches 2 ft from the corner along the ceiling/wall joint.
2 : 15	Flame front reaches ceiling. Flame tip reaches 3 ft from the corner along the ceiling/wall joint.
2 : 45	Flame is receding. Flame front reaches 4 ft above the burner. Flame tip reaches 2 ft from the corner along the ceiling/wall joint. Plywood sample is charred along the corner to the ceiling approximately 1 ft wide.
3 : 30	Flame is substantially receded. Flame tip reaches ceiling.
4 : 30	Flame tip reaches 6 ft.
4 : 45	Flame tip reaches 5 ft above the burner.
5 : 00	Propane flow increased to 160 kW.
5 : 10	Flame tip deflected at the ceiling and reaches 5 ft from the corner along the ceiling/wall joint.
5 : 15	Fire progresses rapidly. Flame is progressing along the ceiling.
5 : 25	Heavy smoke is coming out of the room through the doorway.
5 : 30	Ceiling is full of flame.
5 : 50	Exhaust fan speed switched to high from low speed.
5 : 55	Flame starts to come out through the doorway.
6 : 00	Steady flame coming out through the doorway. First paper bundle (near the backwall) ignites.
6 : 10	Second paper bundle ignites. Test terminated.

# Supplementary Data of the Test

**MATERIAL:** Plywood  
**DIMENSION (mm) :** 12.3  
**DATE TESTED:** July 4 1990

TIME (min)	CORNER TC (deg C)	DOOR TC (deg C)	DUCT TEMP (deg C)	FLOW RATE (m3/s)	CO CONC (%)	CO2 CONC (%)	O2 CONC (%)
0	24	24	25	0.82	0	0	21
0.5	137	57	28	1.12	0	0	20.97
1	284	106	33	1.12	0	0.14	20.82
1.5	395	143	42	1.09	0	0.33	20.65
2	516	176	46	1.09	0	0.5	20.52
2.5	573	210	52	0.97	0.01	0.69	20.37
3	554	214	55	1.02	0	0.74	20.29
3.5	495	212	55	1.08	0.01	0.83	20.26
4	521	205	53	1.02	0.01	0.84	20.33
4.5	467	188	50	1.04	0.01	0.69	20.41
5	414	176	50	1.07	0.01	0.58	20.49
5.5	934	486	142	0.8	0.01	0.96	19.07
6	939	605	210	0.76	0.62	4.86	14.54

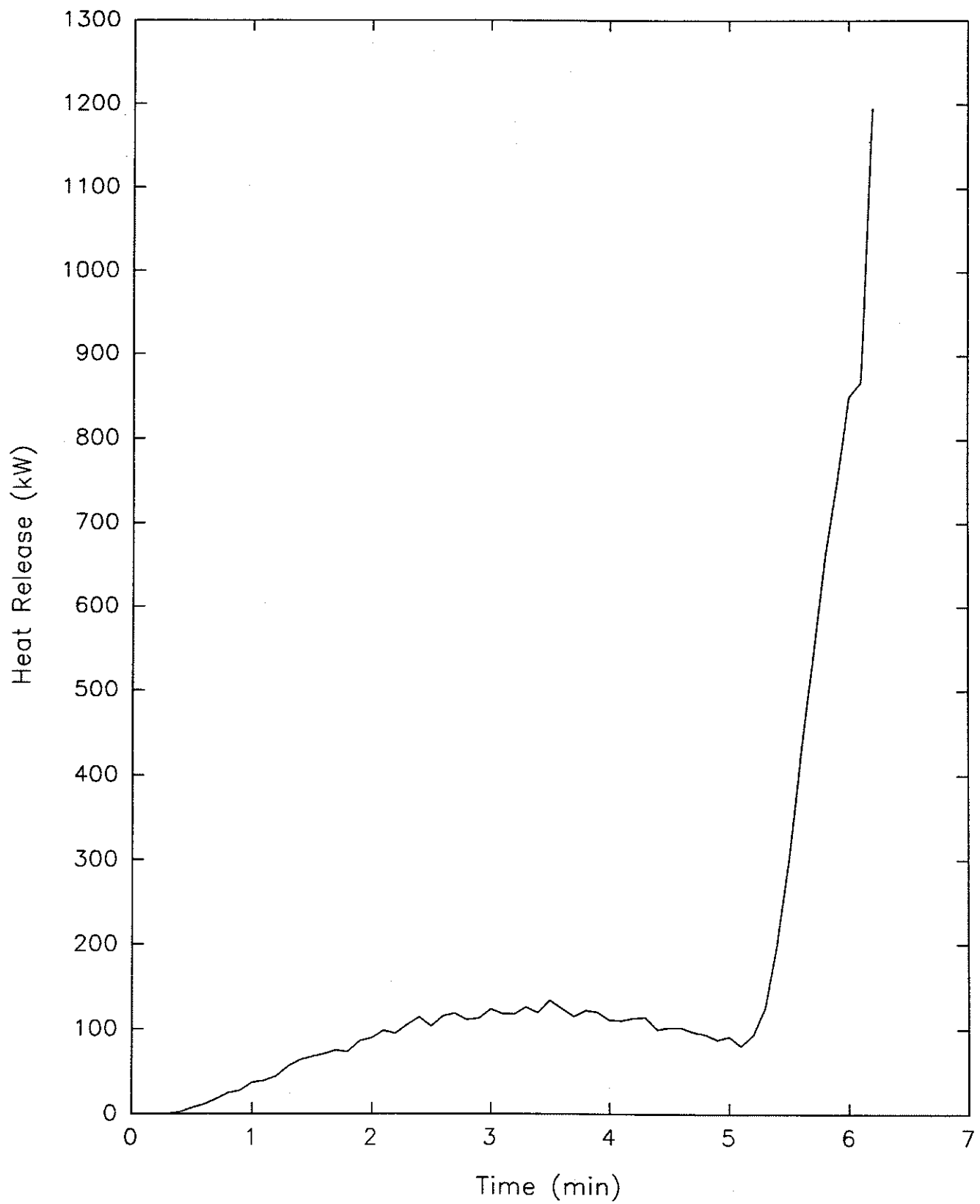


Figure D1 Heat Release Rate vs. Time

12.3mm Plywood

July 4 1990

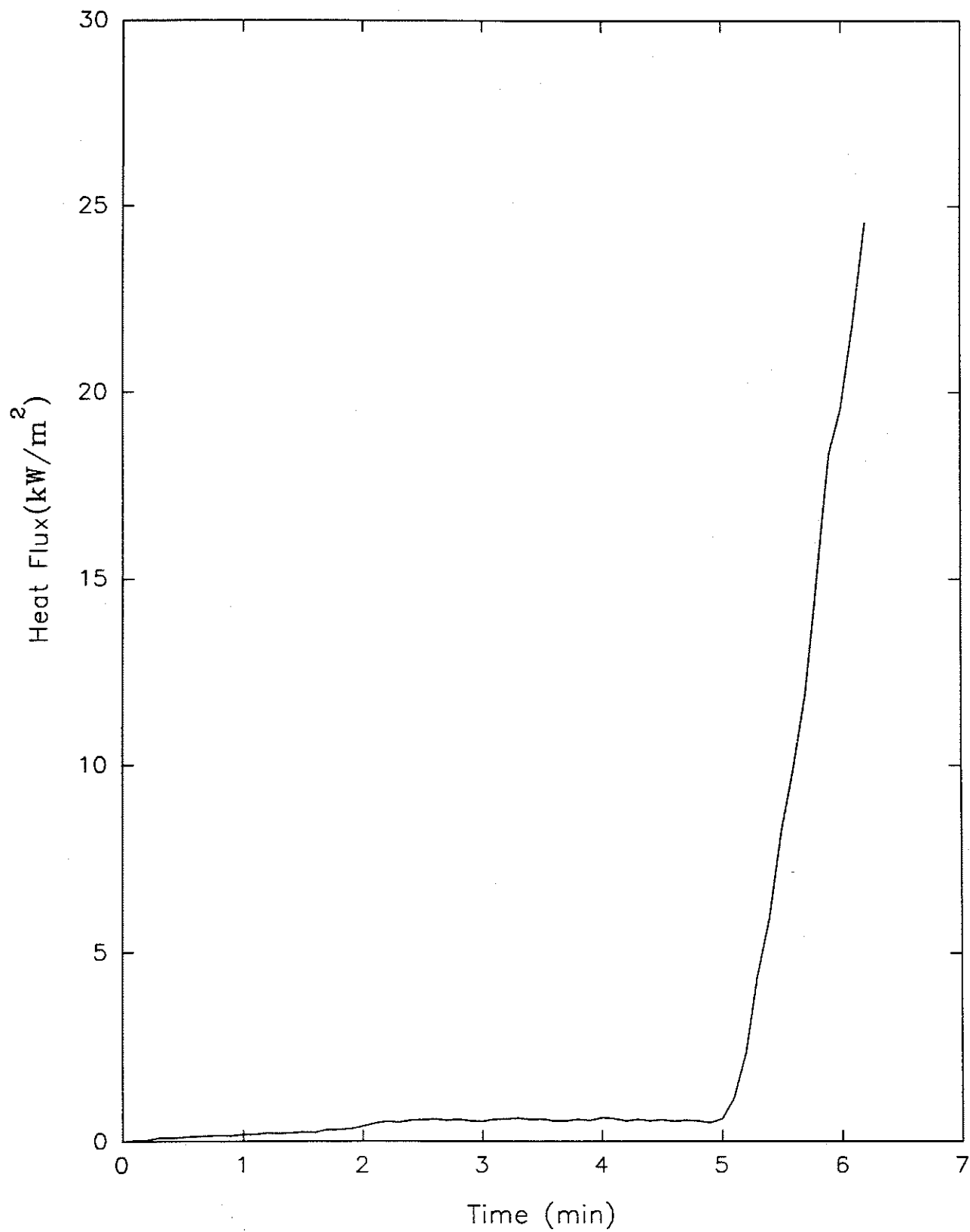


Figure D2 Heat Flux vs. Time  
12.3mm Plywood

July 4 1990

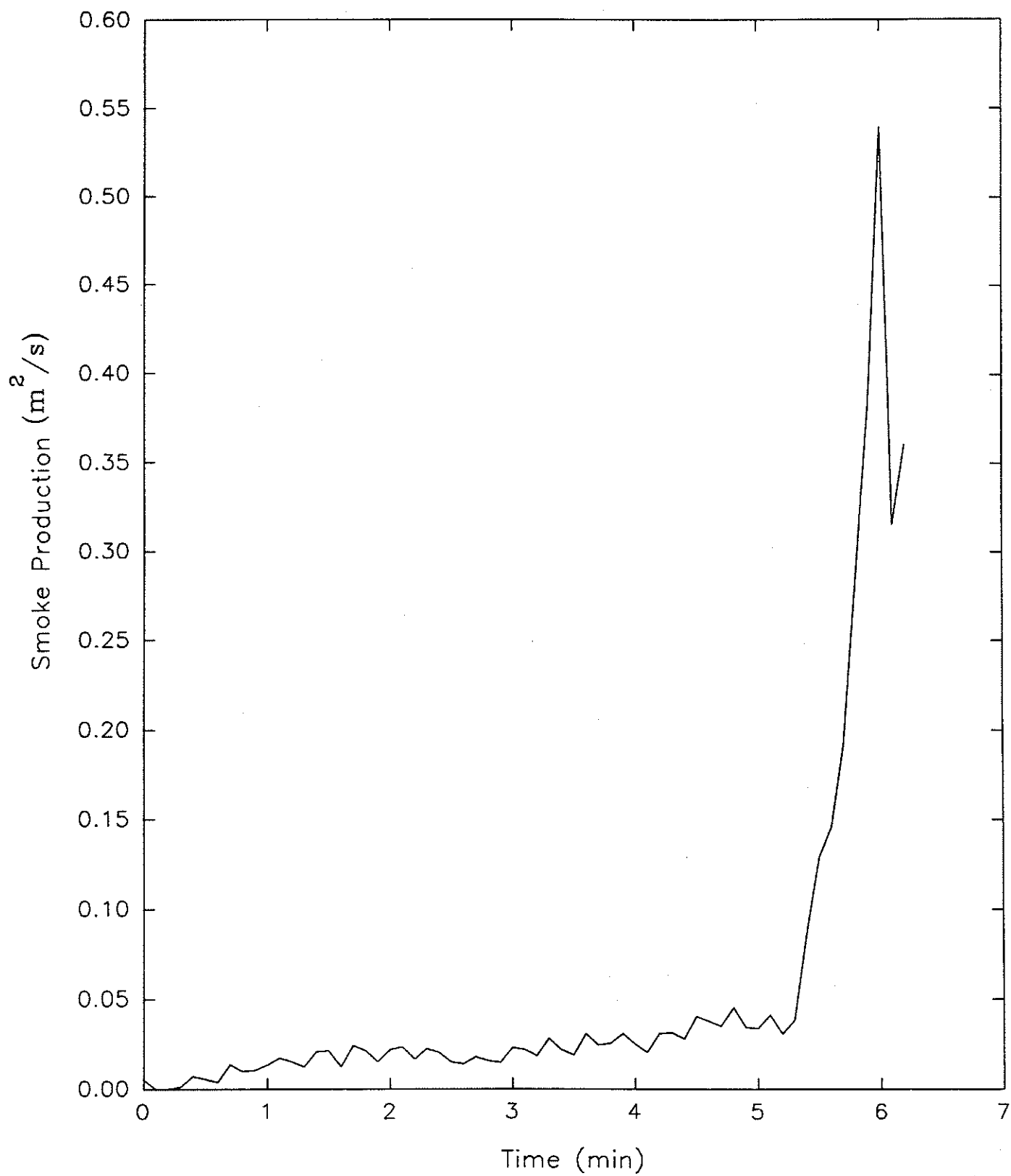


Figure D3 Rate of Smoke Production vs. Time  
12.3mm Plywood

July 4 1990

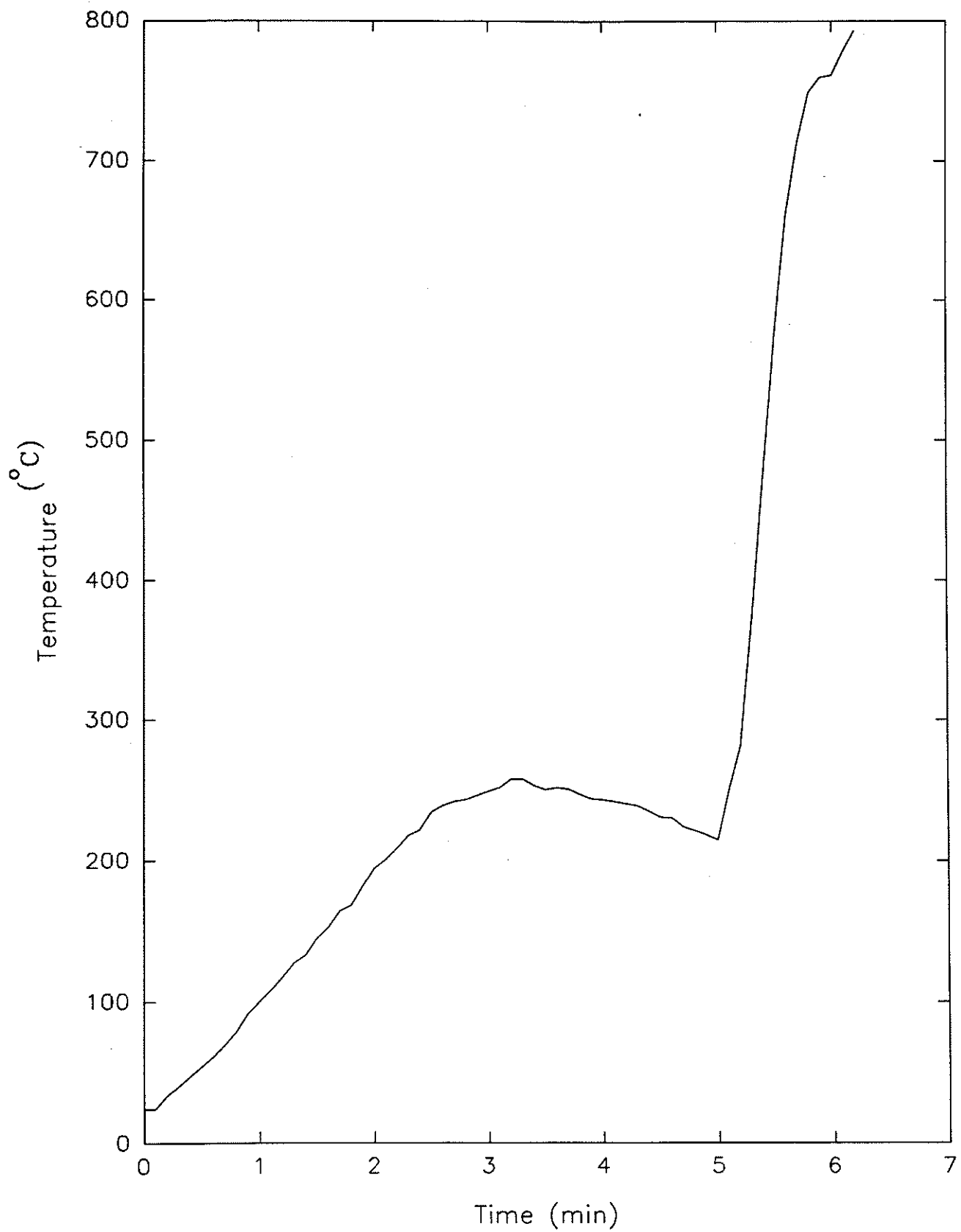


Figure D4 Temperature at the Centre of Ceiling vs. Time  
12.3mm Plywood .

July 4 1990



## **APPENDIX E: 12.3 mm FIRE RETARDED PLYWOOD**





## SUMMARY TABLE OF RESULTS

Item	Results
Test material	12.3 mm fire retarded plywood
Test number	1
Date of test	July 9, 1990
Time to ignition of walls (left / right)	DNO
Time at which 20 kW/m <sup>2</sup> reach at each radiometer	DNO
Time at which paper targets ignite	DNO
Time of flame out of doorway	DNO
Maximum temperature at centre of room / time occurred	496°C / 14 min 30 s
Maximum temperature at the doorway / time occurred	394°C / 13 min
Time 600°C was obtained by TC at the centre of the room	DNO
Time 600°C was obtained by the TC at the doorway	DNO
Maximum instantaneous smoke produced / time occurred	0.04 OD / 17 min
Maximum instantaneous heat release / time occurred	411 kW / 16 min

DNO - Did not occur

## VISUAL OBSERVATIONS OF THE TEST

Material : 12.3 mm Fire Retarded Plywood

Date: July 9, 1990  
Room Temperature: 79°F  
Relative Humidity : 54%  
Barometric Pressure: 749.0 mm Hg

Overall description of test and test material: Followed ASTM test procedures

Observations of the test:

<u>Time (min:sec)</u>	<u>Observations</u>
0 : 00	Ignition of the sand burner (40 kW).
0 : 15	Flame tip reaches 3 ft above the burner.
0 : 30	Flame tip reaches 4 ft above the burner. Plywood on both sides starts to char.
1 : 00	Flame tip reaches 5 ft above the burner.
1 : 45	Plywood on both sides of the corner heavily charred. Plywood ignition difficult to determine (no ignition, i.e., no flame from the plywood).
4 : 00	Condition steady. No ignition of plywood.
5 : 00	Propane flow increased to 160 kW.
5 : 15	Flame tip reaches ceiling. Light smoke layer in the room (approximately 3 ft deep)
5 : 30	Plywood on both sides of the corner heavily charred, but still no ignition. Flame tip reaches ceiling and deflected at the ceiling and runs along the ceiling/wall joint, flame tip flickers along the ceiling as far as 3-4 ft from the corner.
6 : 30	Light smoke coming out through the doorway.
7 : 00	Plywood at the top corner ignites.
7 : 15	Condition steady. Flame tip reaches ceiling and runs along the ceiling/wall joint reaching 3-4 ft from the corner.
11 : 00	Plywood at the corner is heavily charred. Char pattern is an inverted cone shape 1 ft wide at the bottom and 2 ft wide near the ceiling, also char patterns run along the ceiling/wall joint, 3-4 ft from the corner 1 ft wide.
11 : 30	Steady light smoke coming out through the top of the doorway.
12 : 00	Plywood burning near the corner at the top and just above the sand burner. Flame pattern is steady.
13 : 45	Pieces of charred plywood are falling off from the top corner.
14 : 30	Plywood at the corner is all burned off from above the sand burner to the ceiling, exposing gypsum backboard.
15 : 00	Propane flow to the sand burner is shut off.
15 : 05	Some flickering flame on the charred plywood above the burner and at the ceiling/wall joint near the corner.
15 : 30	Pieces of charred plywood are falling off from the top corner.
16 : 30	Very little flame remaining on the charred plywood.
19 : 00	Test terminated, no flame visible.

# Supplementary Data of the Test

**MATERIAL:** Fire Retarded Plywood  
**DIMENSION (mm) :** 12.3  
**DATE TESTED:** July 9 1990

TIME (min)	CORNER TC (deg C)	DOOR TC (deg C)	DUCT TEMP (deg C)	FLOW RATE (m3/s)	CO CONC (%)	CO2 CONC (%)	O2 CONC (%)
0	40	25	25	1.14	0.01	0	21
0.5	142	65	29	1.13	0.01	0	21
1	201	85	31	1.13	0.01	0.1	20.95
1.5	203	97	33	1.11	0.01	0.16	20.89
2	213	99	35	1.11	0.01	0.2	20.84
2.5	220	104	35	1.05	0.01	0.23	20.82
3	220	103	36	1.1	0.01	0.21	20.8
3.5	222	105	36	1.09	0.01	0.22	20.79
4	217	107	36	1.05	0.01	0.24	20.78
4.5	223	105	37	1.1	0.01	0.24	20.77
5	208	107	38	1.09	0.01	0.24	20.76
5.5	689	263	68	0.98	0.01	0.34	20.76
6	746	296	75	0.97	0.01	1.05	20.47
6.5	767	299	80	0.95	0.02	1.21	20.12
7	742	302	85	0.91	0.02	1.35	19.88
7.5	776	310	90	0.94	0.02	1.29	19.74
8	826	316	89	0.93	0.03	1.38	19.66
8.5	831	313	91	0.94	0.03	1.37	19.59
9	825	316	96	0.91	0.03	1.42	19.55
9.5	837	333	102	0.89	0.03	1.47	19.53
10	864	373	114	0.89	0.03	1.63	19.47
10.5	837	366	120	0.82	0.05	1.95	19.33
11	805	361	119	0.86	0.06	1.87	19.17
11.5	795	368	123	0.86	0.05	1.88	19.08
12	786	381	124	0.85	0.05	1.86	19.04
12.5	781	378	127	0.84	0.06	1.99	19.04
13	798	394	133	0.84	0.06	1.98	19.01
13.5	833	380	131	0.83	0.08	1.96	18.98
14	810	377	135	0.82	0.06	1.93	18.95
14.5	833	382	134	0.84	0.07	2	18.91
15	861	388	132	0.81	0.06	1.91	18.91
15.5	677	305	88	0.96	0.05	1.9	18.89
16	546	254	71	1	0.03	0.88	18.9
16.5	377	222	65	0.98	0.03	0.6	19.05
17	291	195	58	1.03	0.03	0.49	19.61
17.5	233	183	54	1.01	0.03	0.36	20
18	203	175	51	1.04	0.03	0.33	20.25
18.5	182	161	50	1.01	0.02	0.3	20.44
19	169	154	48	1	0.02	0.25	

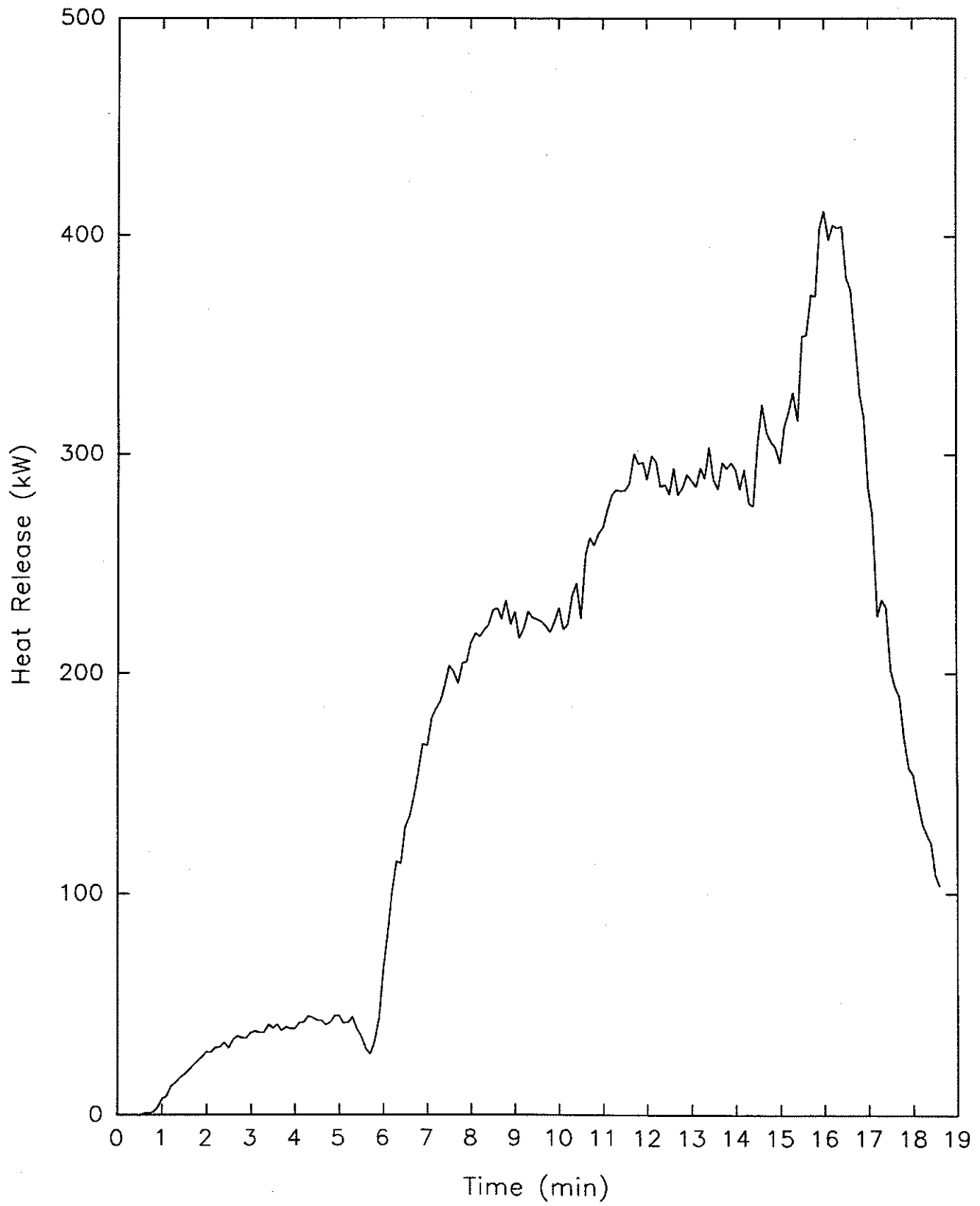


Figure E1 Heat Release Rate vs. Time

12.3mm Fire Retarded Plywood

July 9 1990

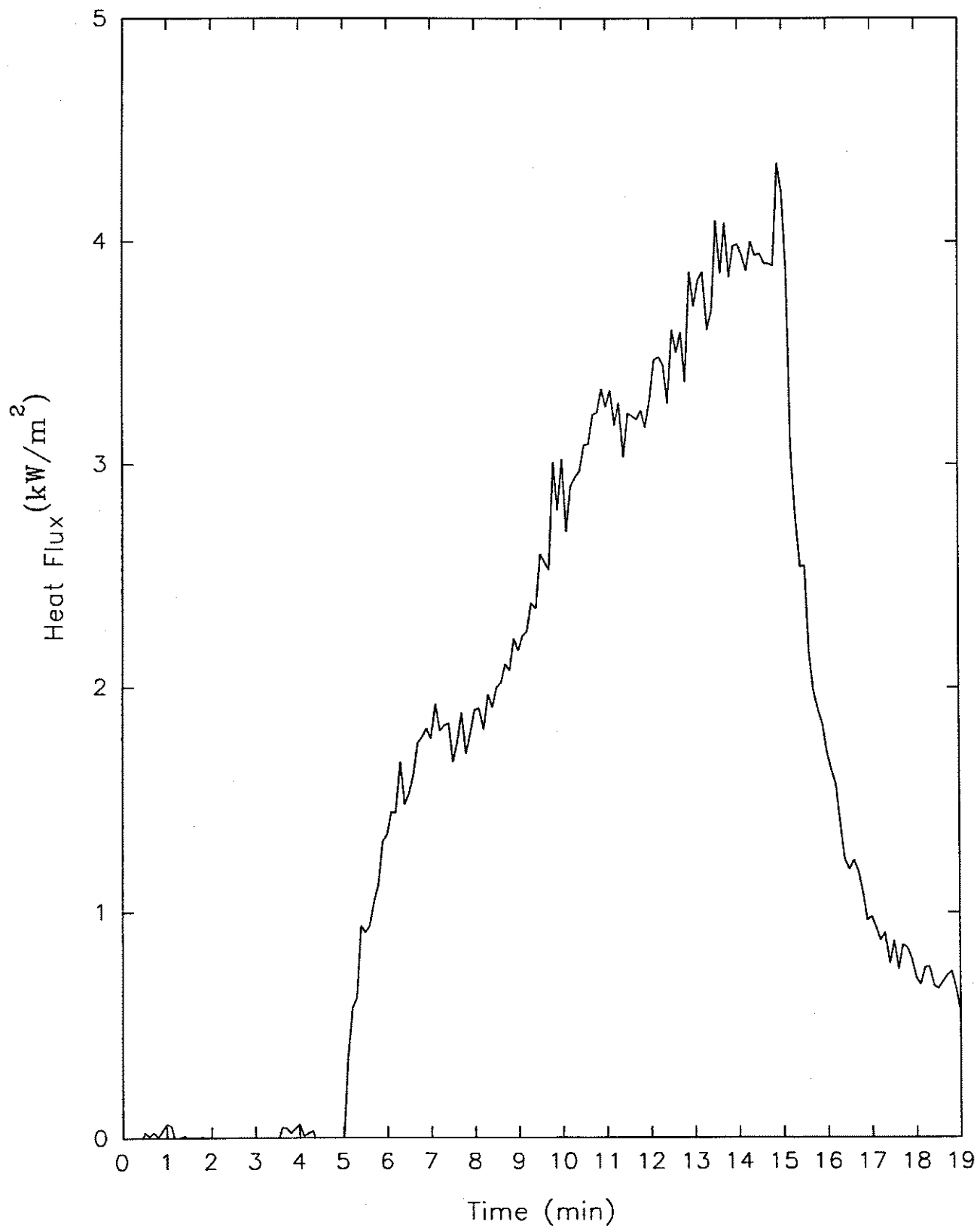


Figure E2 Heat Flux vs. Time  
12.3mm Fire Retarded Plywood

July 9 1990

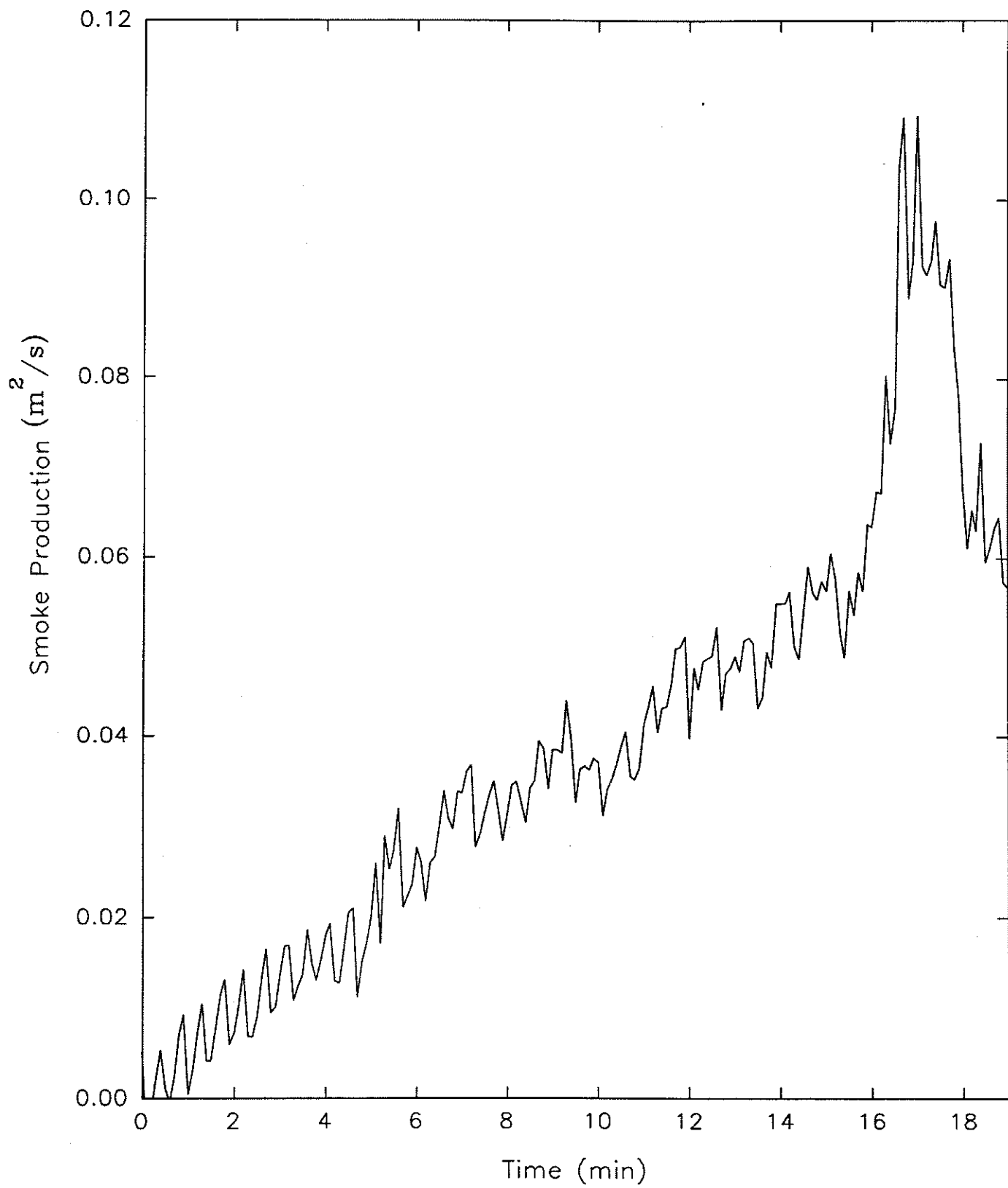


Figure E3 Rate of Smoke Production vs. Time  
12.3mm Fire Retarded Plywood

July 9 1990

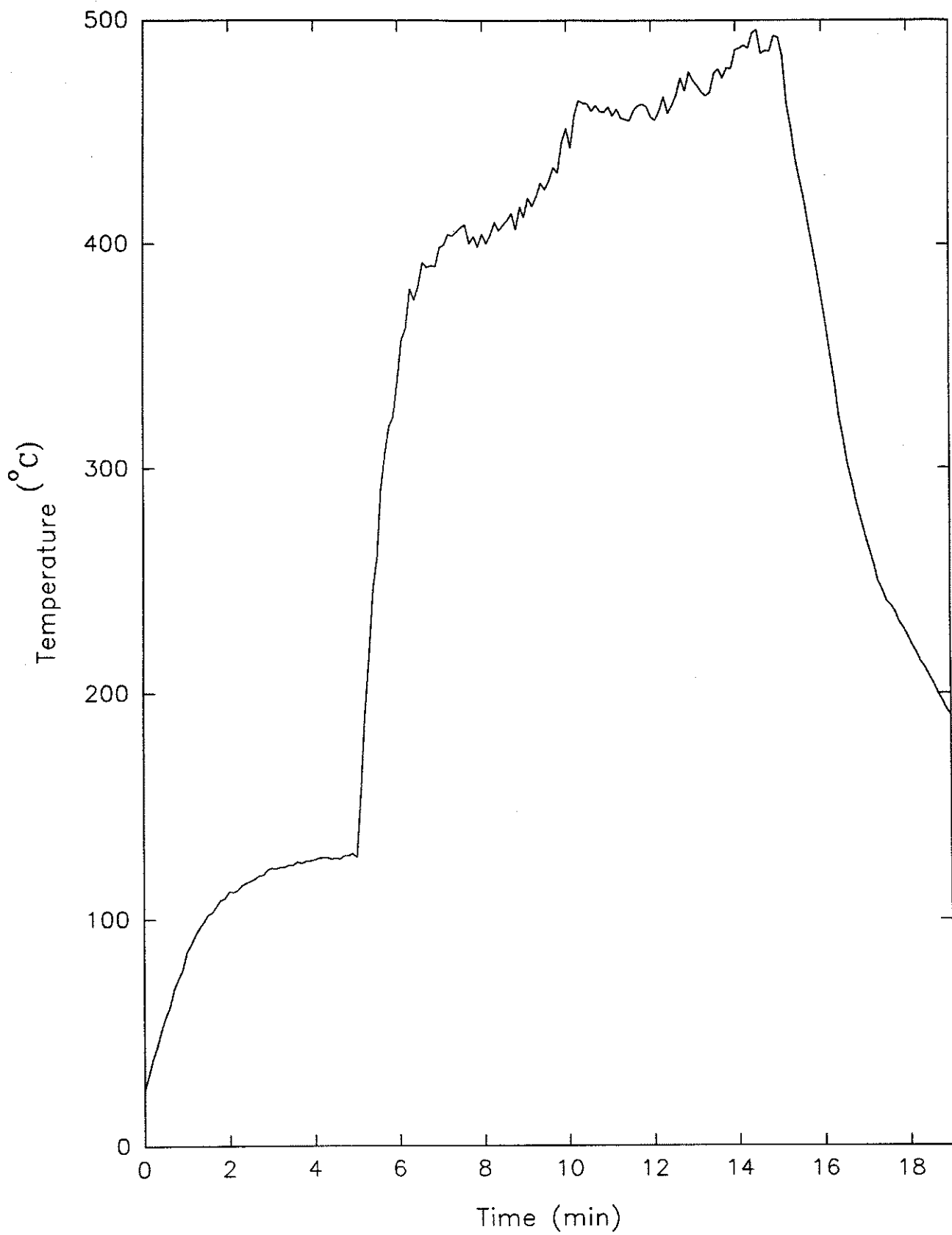


Figure E4 Temperature at the Centre of Ceiling vs. Time  
12.3mm Fire Retarded Plywood

July 9 1990





## **APPENDIX F: 26.1 mm EXPANDED POLYSTYRENE**



## SUMMARY TABLE OF RESULTS

Item	Results
Test material	26.1 mm polystyrene
Test number	1
Date of test	July 12, 1990
Time to ignition of walls (left / right)	15 s / 15 s
Time at which 20 kW/m <sup>2</sup> reach at each radiometer	DNO
Time at which paper targets ignite	DNO
Time of flame out of doorway	DNO
Maximum temperature at centre of room / time occurred	339°C / 6 min 30 s
Maximum temperature at the doorway / time occurred	262°C / 6 min 10 s
Time 600°C was obtained by TC at the centre of the room	DNO
Time 600°C was obtained by the TC at the doorway	DNO
Maximum instantaneous smoke produced / time occurred	0.15 OD / 1 min 30 s
Maximum instantaneous heat release / time occurred	235 kW / 7 min 20 s

DNO - Did not occur

## VISUAL OBSERVATIONS OF THE TEST

Material: 26.1 mm Polystyrene  
Date: July 12, 1990  
Room Temperature: 71°F  
Relative Humidity: 45%  
Barometric Pressure: 755.9 mm Hg

Overall description of test and test material: Followed ASTM test procedures

### Observations of the test:

<u>Time (min:sec)</u>	<u>Observations</u>
0 : 00	Ignition of the sand burner (40 kW).
0 : 10	Sample at the corner near the sand burner starts to melt.
0 : 15	Small area of the sample near the burner melted away exposing backboard.
0 : 25	Flame tip reaches 4 ft above the burner.
0 : 35	Flame tip reaches 5 ft above the burner. Sample is melting near the flame and drips as it burns. Black smoke layer in the room.
0 : 50	Flame tip reaches 6 ft above the burner.
1 : 00	Black smoke coming out of the doorway.
1 : 15	Black smoke layer approximately 4 ft deep in the ceiling of the room. Top portion of the flame hidden by the black smoke layer.
2 : 00	Sample near the corner melted away at 1.5 ft wide near the bottom and 3-4 ft wide near the top.
2 : 30	Flame is receding. Sample is melted away near the corner and little material is left to burn. Most of the sample near the corner is either melted away or consumed by the flame.
3 : 30	Ignition flame (sand burner) is the only flame in the room. No sample remaining near the ignition flame to burn.
5 : 00	Propane flow increased to 160 kW. Flame tip reaches the ceiling.
5 : 10	Edges of the sample starts to melt and burn again.
5 : 40	Black smoke again coming out of the doorway.
6 : 40	Sample is melting down and burning.
7 : 00	Black smoke layer in the room approximately 4 ft deep but black smoke coming out of the doorway is reduced.
7 : 40	All samples near the corner (ignition flame) have melted away and ignition flame is the only flame in the room.
12 : 00	Light smoke layer in the room approximately 3 ft deep. No flame other than ignition flame in the room.
15 : 00	Ignition flame off. Small amounts of melted sample on the wall are burning.
17 : 00	Test terminated.

**Supplementary Data of the Test**

**MATERIAL:** Polystyrene  
**DIMENSION (mm) :** 26.1  
**DATE TESTED:** July 12 1990

TIME (min)	CORNER TC (deg C)	DOOR TC (deg C)	DUCT TEMP (deg C)	FLOW RATE (m3/s)	CO CONC (%)	CO2 CONC (%)	O2 CONC (%)
0	23	23	22	0.8	0	0	21
0.5	154	69	27	1.11	0	0	21.01
1	260	108	33	1.14	0	0.12	20.93
1.5	410	151	45	1.1	0	0.27	20.79
2	431	172	49	1.06	0.01	0.57	20.55
2.5	335	153	46	1.05	0.01	0.58	20.45
3	275	136	42	1.09	0	0.42	20.54
3.5	239	122	41	1.04	0	0.32	20.63
4	218	116	42	1.06	0	0.28	20.69
4.5	205	119	41	1.1	0	0.27	20.71
5	217	117	40	1.1	0	0.26	20.73
5.5	553	224	70	0.97	0	0.24	20.75
6	698	260	81	0.97	0	0.89	20.29
6.5	694	255	93	0.94	0.01	1.22	19.85
7	615	245	88	0.97	0.01	1.3	19.65
7.5	588	236	83	0.92	0.01	1.11	19.72
8	597	236	84	0.96	0.01	0.98	19.85
8.5	549	238	84	0.94	0	0.92	19.9
9	561	231	84	0.98	0	0.89	19.94
9.5	606	238	87	0.98	0	0.9	19.96
10	548	233	90	0.93	0	0.95	19.97
10.5	544	230	88	0.95	0	0.89	19.98
11	550	228	92	0.93	0	0.93	19.98
11.5	524	235	91	0.91	0	0.9	19.97
12	541	227	89	0.97	0.01	0.88	19.99
12.5	517	236	92	0.91	0.01	0.93	19.96
13	521	224	92	0.96	0.01	0.9	19.97
13.5	573	236	92	0.91	0	0.93	19.96
14	542	236	96	0.91	0	0.88	20
14.5	547	234	94	0.92	0	0.9	19.96
15	502	233	95	0.92	0	0.94	19.95
15.5	308	215	73	1.01	0	0.9	19.95
16	213	141	50	1.11	0	0.26	20.4
16.5	167	120	44	1.11	0	0.12	20.72
17	142	107	40	1.13	0	0.08	N/A

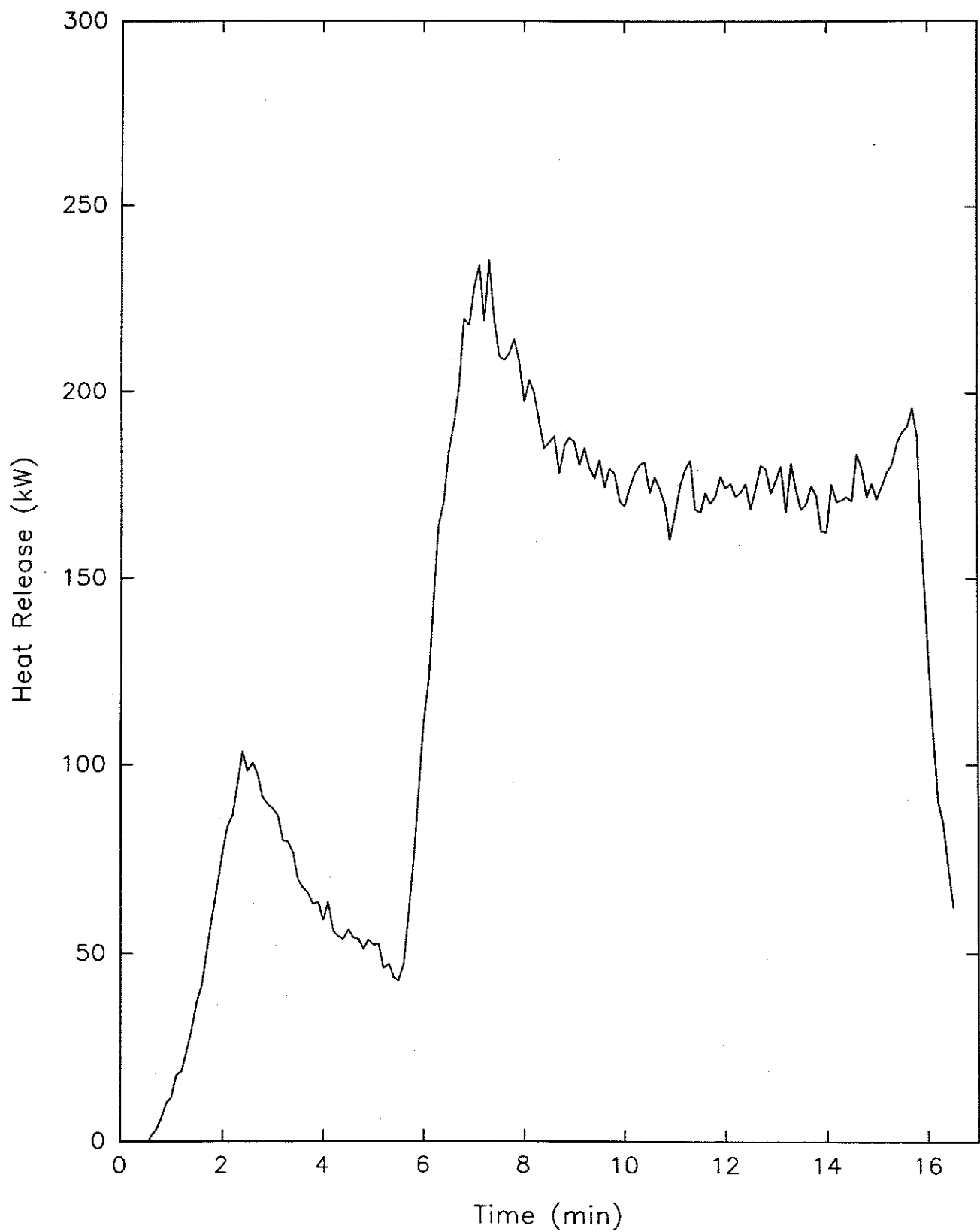


Figure F1 Heat Release Rate vs. Time

26.1mm Polystyrene

July 12 1990

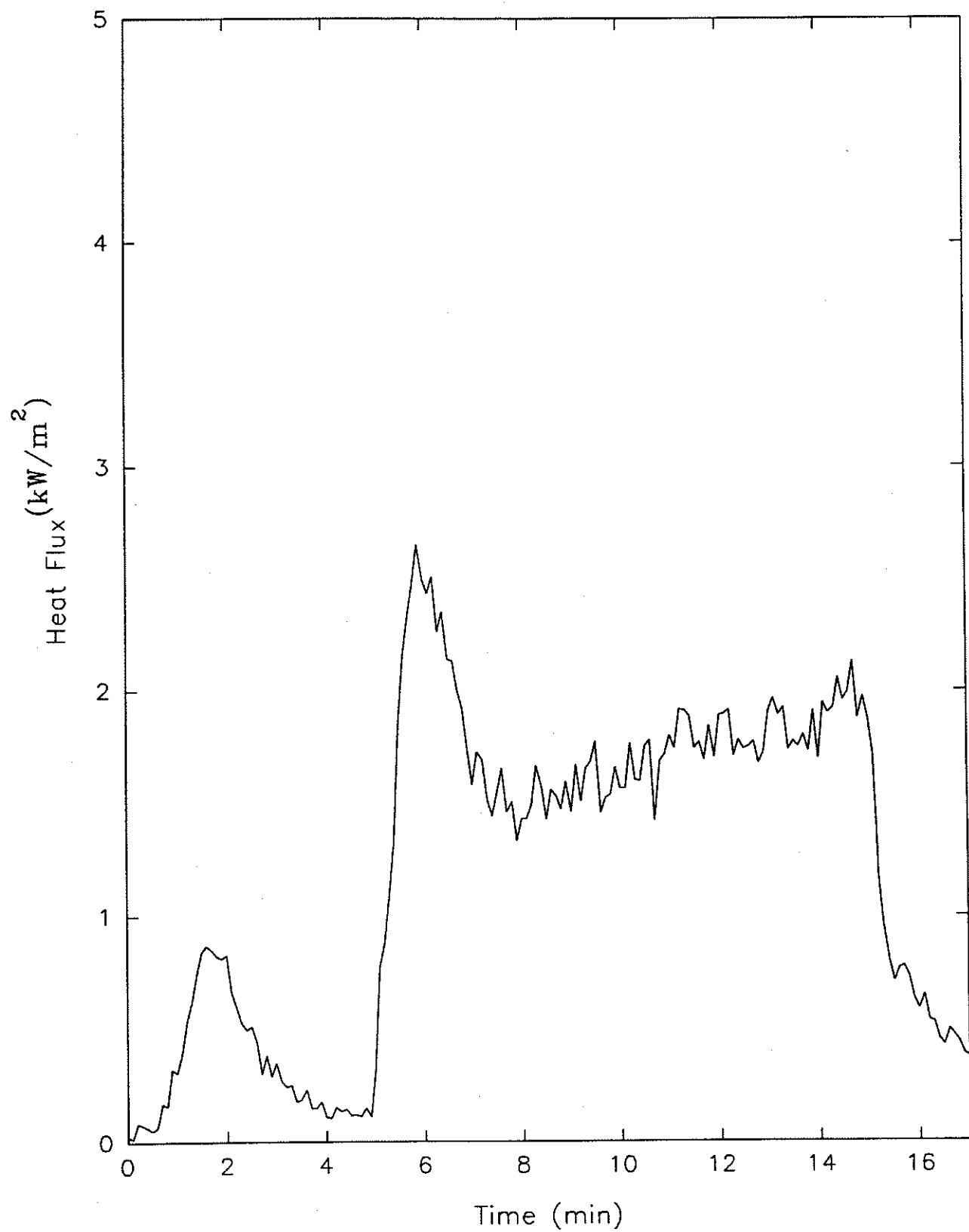


Figure F2 Heat Flux vs. Time  
26.1mm Polystyrene

July 12 1990



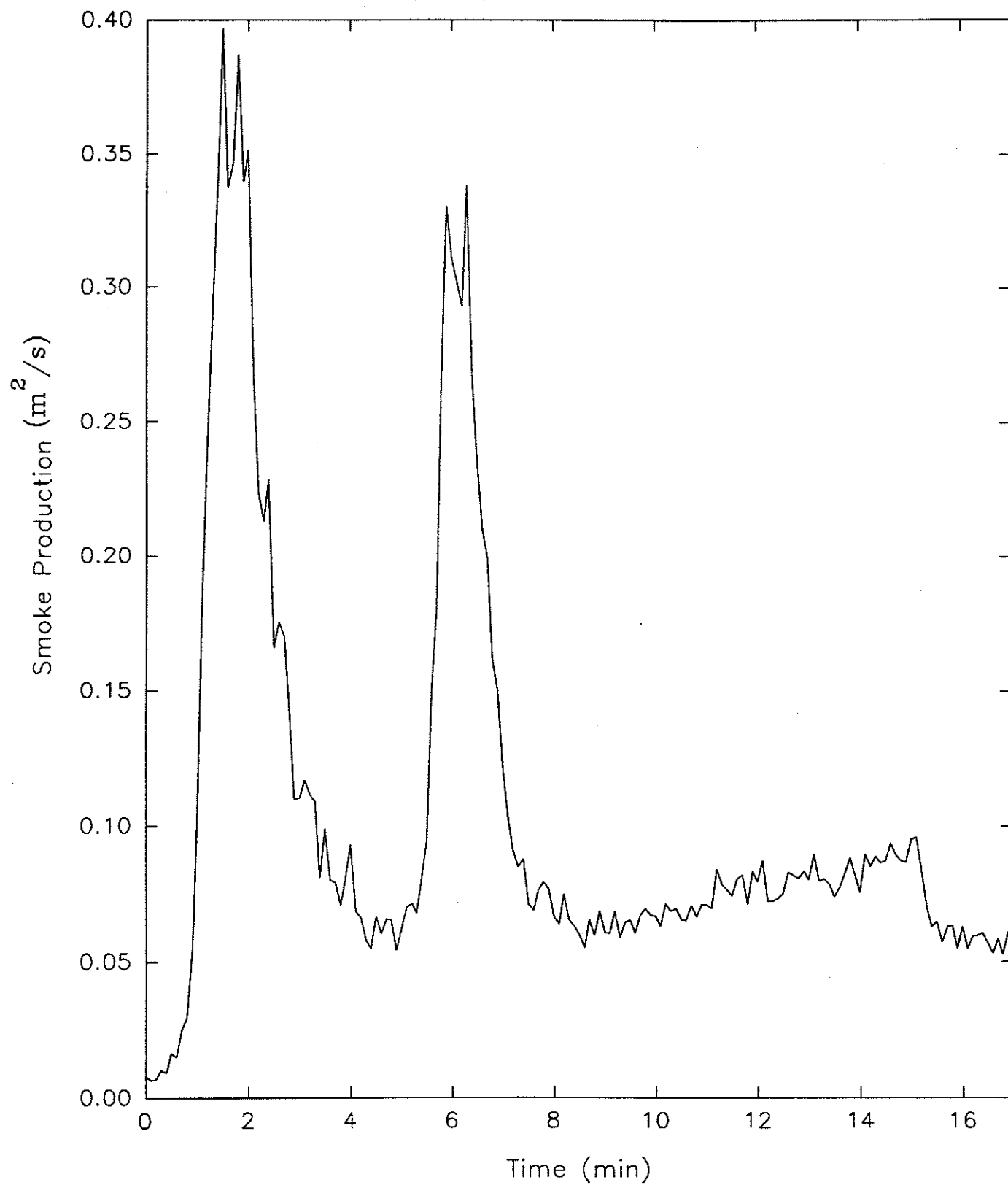


Figure F3 Rate of Smoke Production vs. Time  
26.1mm Polystyrene

July 12 1990

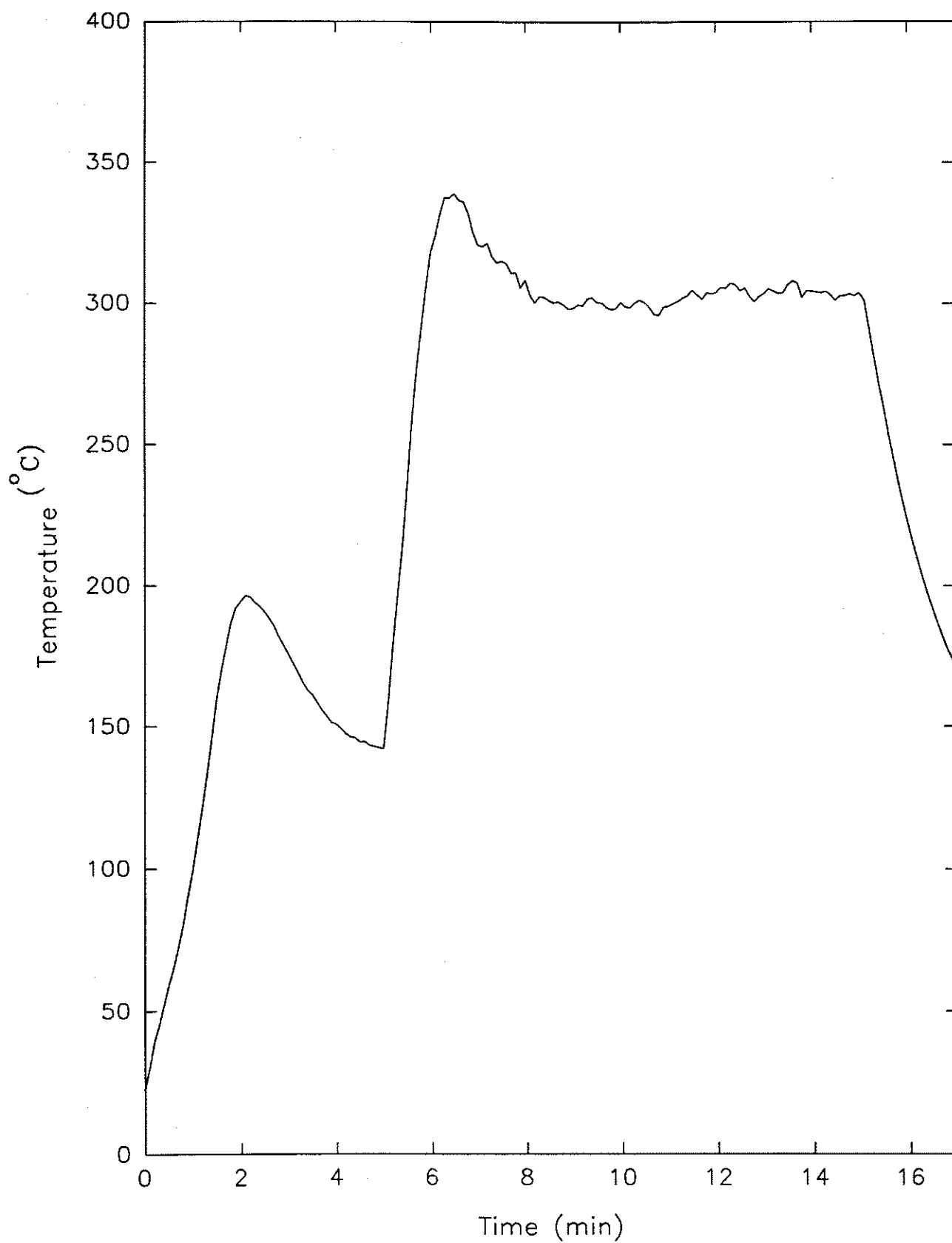


Figure F4 Temperature at the Centre of Ceiling vs. Time  
26.1mm Polystyrene

July 12 1990



**APPENDIX G: 25.1 mm RIGID POLYURETHANE**



## SUMMARY TABLE OF RESULTS

Item	Results
Test material	25.1 mm polyurethane
Test number	1
Date of test	July 17, 1990
Time to ignition of walls (left / right)	15 s / 15 s
Time at which 20 kW/m <sup>2</sup> reach at each radiometer	DNO
Time at which paper targets ignite	6 min 25 s
Time of flame out of doorway	6 min 20 s
Maximum temperature at centre of room / time occurred	519°C / 6 min 20 s
Maximum temperature at the doorway / time occurred	446°C / 6 min 20 s
Time 600°C was obtained by TC at the centre of the room	DNO
Time 600°C was obtained by the TC at the doorway	DNO
Maximum instantaneous smoke produced / time occurred	0.52 OD / 5 min 35 s
Maximum instantaneous heat release / time occurred	721 kW / 6 min 10 s

DNO - Did not occur

## VISUAL OBSERVATIONS OF THE TEST

Material: 25.1 mm Polyurethane

Date: July 17, 1990  
Room Temperature: 81°F  
Relative Humidity: 62%  
Barometric Pressure: 754.8 mm Hg

Overall description of test and test material: Followed ASTM test procedures  
Exhaust fan switched to high during the test

### Observations of the test:

<u>Time (min:sec)</u>	<u>Observations</u>
0 : 00	Ignition of the sand burner (40 kW).
0 : 10	Flame reaches the ceiling producing heavy dark smoke.
0 : 15	Samples on both sides of the corner ignite.
0 : 20	Smoke layer in the room 4 ft deep. Dark smoke coming out through the doorway.
0 : 40	Flame has receded a little. Flame tip reaches 5 ft above the burner. Samples near the corner burning but not as strong as before. Steady smoke coming out through the doorway.
1 : 15	Flame height (tip) is 4 ft.
1 : 30	Sample is charred and not burning. Flame height is 3 ft (sandburner flame only).
2 : 00	Char on the sample is cone shaped and 1 ft wide near the burner and 5 ft high above the burner. Flame is ignition (sandburner) flame only. Smoke layer in the room is lighter and little smoke coming out through the doorway.
4 : 00	Condition steady.
5 : 00	Propane flow increased to 160 kW. Flame reaches ceiling and deflected and progressing along the ceiling/wall joint reaching approximately 5 ft from the corner. Both walls (samples) at the corner ignite again and burn (steadily). Black smoke layer in the room is 4 ft deep. Black smoke coming out through the doorway.
5 : 35	Samples are burning very well. Black smoke layer in the room and flame is present in the ceiling among the smoke layer. Smoke coming out through the doorway is heavy.
5 : 45	Exhaust fan speed changed to high.
6 : 00	Both walls burn fiercely. Black smoke coming out of the room. Flame can be seen in the ceiling among the smoke layer.
6 : 20	Flame starts to come out of the room through the doorway.
6 : 25	Steady flame comes out of the room. Both paper bundles ignite. Test terminated.

# Supplementary Data of the Test

**MATERIAL:** Polyurethane  
**DIMENSION (mm) :** 25.1  
**DATE TESTED:** July 17 1990

TIME (min)	CORNER TC (deg C)	DOOR TC (deg C)	DUCT TEMP (deg C)	FLOW RATE (m3/s)	CO CONC (%)	CO2 CONC (%)	O2 CONC (%)
0	80	28	28	0.91	-0.01	0	21
0.5	260	110	37	1.09	0	0.13	20.98
1	250	120	42	1.08	0	0.31	20.75
1.5	222	119	41	1.13	0	0.25	20.73
2	212	116	42	1.07	0	0.23	20.75
2.5	205	114	42	1.08	0	0.24	20.76
3	200	113	43	1.05	0	0.23	20.78
3.5	197	115	43	1.12	0	0.24	20.77
4	201	117	43	1.04	0	0.23	20.77
4.5	201	115	44	1.08	0	0.25	20.77
5	218	117	44	1.04	0	0.24	20.77
5.5	831	309	105	0.94	0.03	1.04	20.75
6	807	353	79	0.94	0.16	1.96	19.28



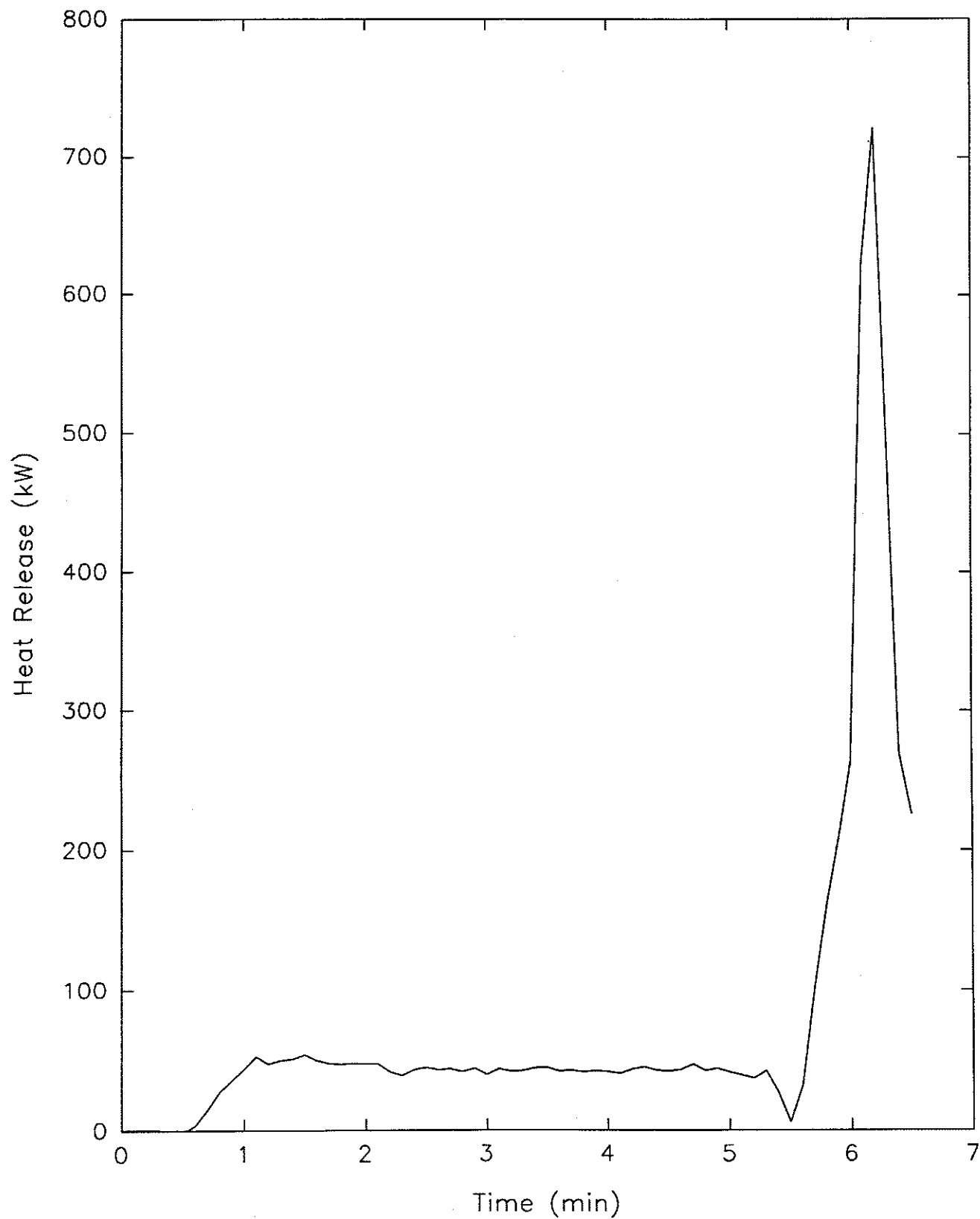


Figure G1 Heat Release Rate vs. Time

25.1mm Polyurethane

July 17 1990

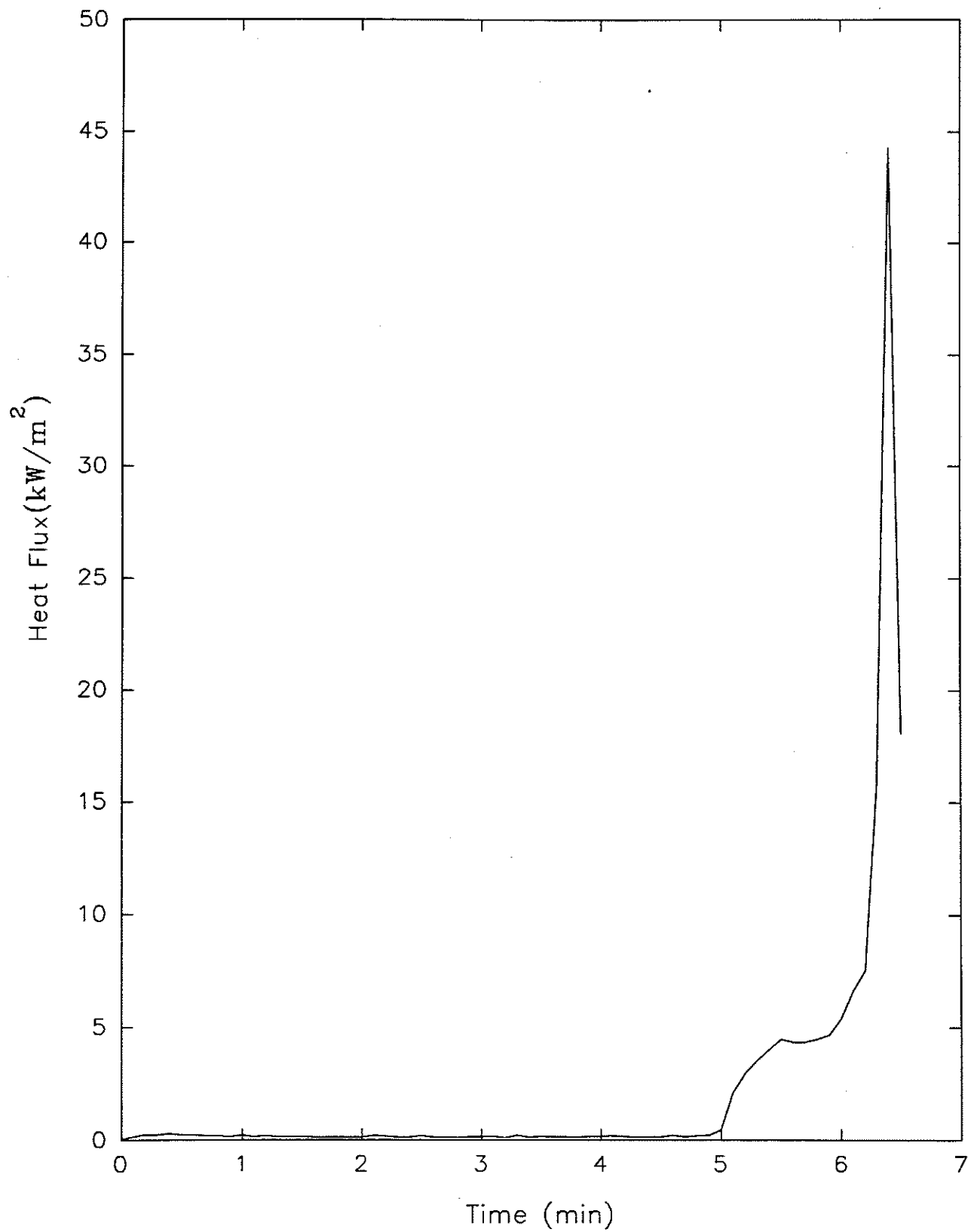


Figure G2 Heat Flux vs. Time  
25.1mm Polyurethane

July 17 1990

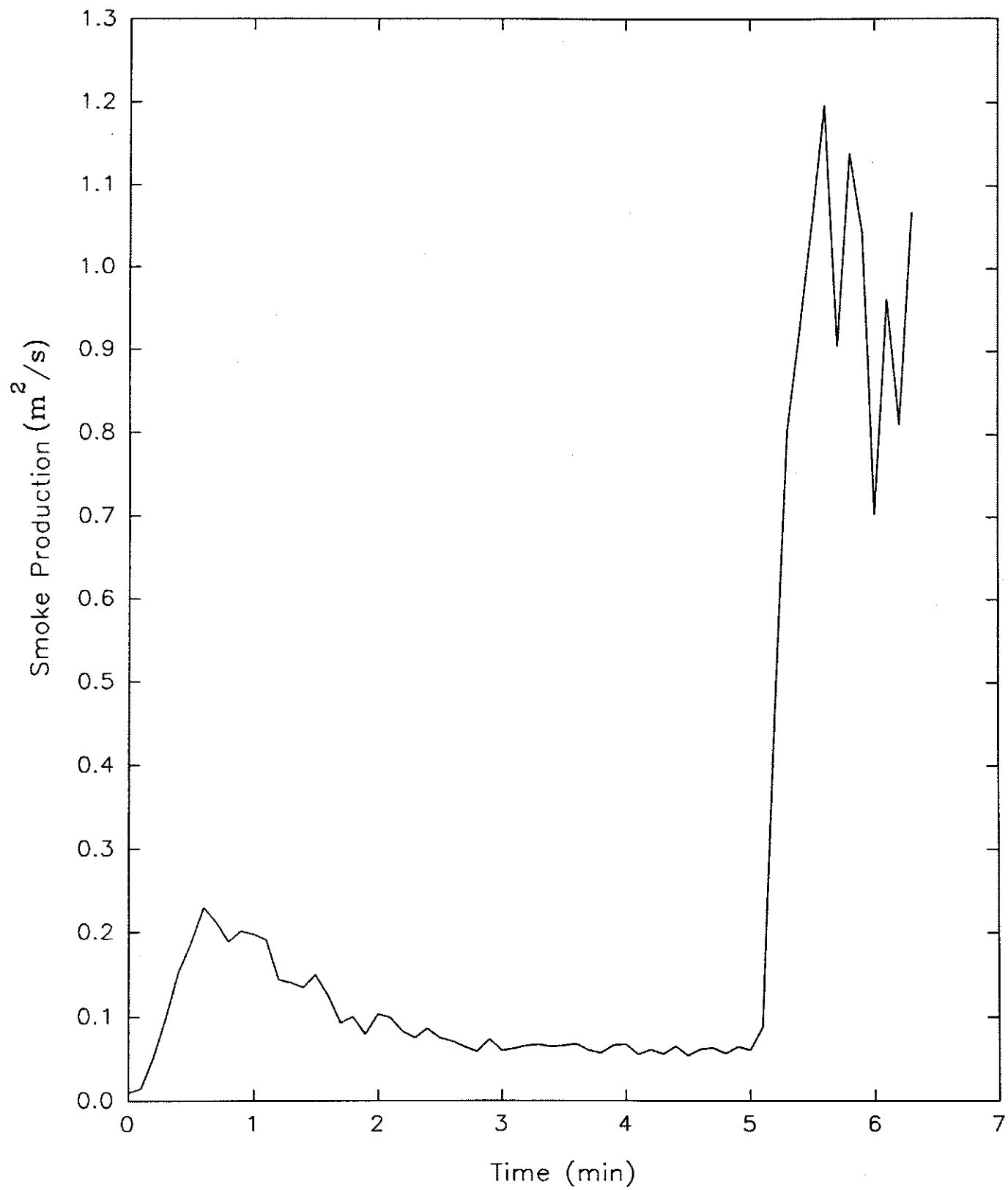


Figure G3 Rate of Smoke Production vs. Time  
25.1mm Polyurethane

July 17 1990

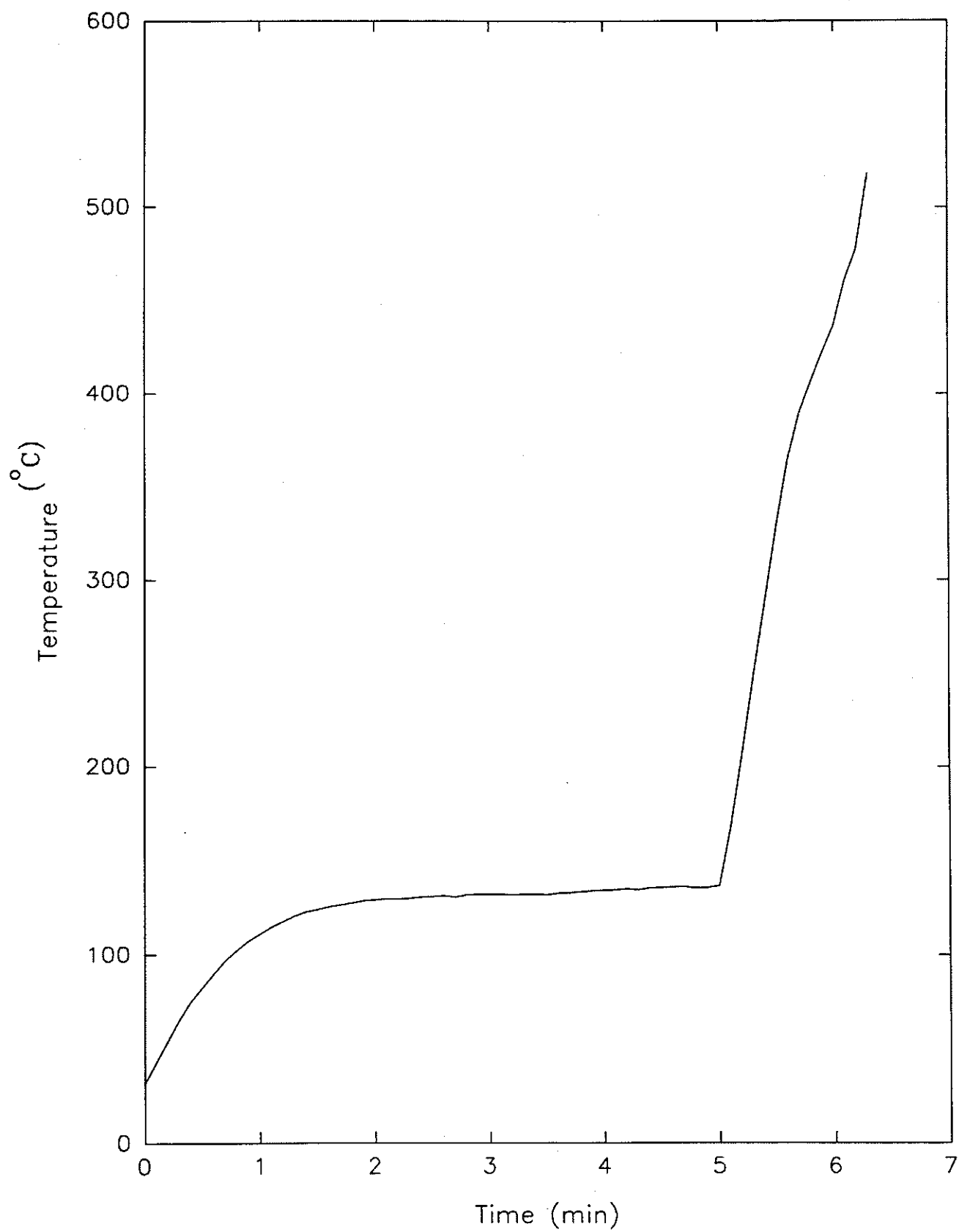


Figure G4 Temperature at the Centre of Ceiling vs. Time  
25.1mm Polyurethane

July 17 1990



## **APPENDIX H: 12.3 mm PLYWOOD**



## SUMMARY TABLE OF RESULTS

Item	Results
Test material	12.3 mm plywood
Test number	2
Date of test	July 20, 1990
Time to ignition of walls (left / right)	2 min 5 s / 2 min 5 s
Time at which 20 kW/m <sup>2</sup> reach at each radiometer	7 min / 7 min
Time at which paper targets ignite	7 min 7 s
Time of flame out of doorway	7 min
Maximum temperature at centre of room / time occurred	725°C / 7 min 5 s
Maximum temperature at the doorway / time occurred	673°C / 7 min 5 s
Time 600°C was obtained by TC at the centre of the room	6 min 50 s
Time 600°C was obtained by the TC at the doorway	6 min 55 s
Maximum instantaneous smoke produced / time occurred	0.07 OD / 7 min 5 s
Maximum instantaneous heat release / time occurred	710 kW / 6 min 50 s



## VISUAL OBSERVATIONS OF THE TEST

Material: 12.3 mm Plywood

Date: July 20, 1990

Room Temperature: 74°F

Relative Humidity: 73%

Barometric Pressure: 749.0 mm Hg

Overall description of test and test material: Followed ASTM test procedures  
Exhaust fan switched to high during the test

### Observations of the test:

<u>Time (min:sec)</u>	<u>Observations</u>
0 : 00	Ignition of the sand burner (40 kW).
0 : 10	Flame tip reaches 3 ft above the burner (i.e., flame height is 3 ft)
1 : 15	Samples on both sides of the corner start to char (or become black). Flame height is still 3 ft.
2 : 00	Flame height is still 3 ft. Light smoke layer at the ceiling.
2 : 05	Samples on both sides of the corner ignite.
2 : 15	Flame height is 4 ft. Both walls are burning at the corner.
2 : 25	Flame height is 5 ft.
2 : 30	Flame height is 6 ft.
2 : 40	Flame tip reaches ceiling.
3 : 00	Both walls are burning well. Flame tip reaches ceiling.
3 : 30	Flame reaches ceiling and reflected at the ceiling, however, does not progress along the ceiling/wall joint.
4 : 00	Condition is steady.
4 : 15	Flame is receding. Samples are heavily charred near the corner but have little flaming.
4 : 35	No flaming fire on the sample. Flame height is 5 ft.
4 : 45	Flame height is 4 ft.
4 : 55	Flame height is 3 ft (sandburner ignition flame only).
5 : 00	Propane flow increased to 160 kW. Flame reaches ceiling. Samples are burning again.
5 : 05	Flame is reflected at the ceiling and is progressing along the ceiling/wall joint to a distance of 4 ft from the corner. Samples are burning well. Light smoke is produced.
5 : 25	Light smoke is coming through the doorway.
5 : 40	Flame runs along the ceiling/wall joint to the other corner. Smoke layer at the ceiling. Flame is also progressing along the ceiling near the corner.
6 : 00	Samples are burning 2 ft wide at the corner and 1 ft down from the ceiling on the back wall and the side wall.
6 : 20	Samples are burning 3 ft wide at the corner.

7:00	Smoke coming out through the doorway. Flame starts to come out through the doorway. Exhaust fan speed changed to high.
7:07	Both paper bundles ignite.
7:08	Fire extinguished. Test terminated.

**MATERIAL:**

Plywood

**DIMENSION (mm) :**

12.3

**DATE TESTED:**

July 20 1990

TIME (min)	CORNER TC (deg C)	DOOR TC (deg C)	DUCT TEMP (deg C)	FLOW RATE (m3/s)	CO CONC (%)	CO2 CONC (%)	O2 CONC (%)
0	24.06	23.86	22.39	1.12	0	0	21
0.5	119.05	68.08	25.06	1.18	0	0.07	20.93
1	153.01	84.92	28.07	1.11	0	0.14	20.86
1.5	156.24	93.3	29.73	1.18	0	0.16	20.83
2	162.51	95.1	30.86	1.15	0	0.17	20.83
2.5	250.2	111.44	34.17	1.14	0	0.23	20.76
3	402.19	162.17	41.45	1.14	0	0.43	20.58
3.5	514.12	187.04	45.87	1.05	0.01	0.61	20.5
4	505.21	200.41	48.37	1.05	0.01	0.65	20.46
4.5	411.85	171.52	45.11	1.1	0.01	0.59	20.55
5	327.78	141.19	41.15	1.12	0.01	0.47	20.65
5.5	857.57	400.49	118.42	0.92	0.02	2.31	18.2
6	914.65	441.77	154.53	0.84	0.22	3.18	17.5
6.5	920.44	514.59	202.35	0.71	0.19	3.98	16.55
7	953.39	661.98	279.74	0.69	0.46	5.24	N / A

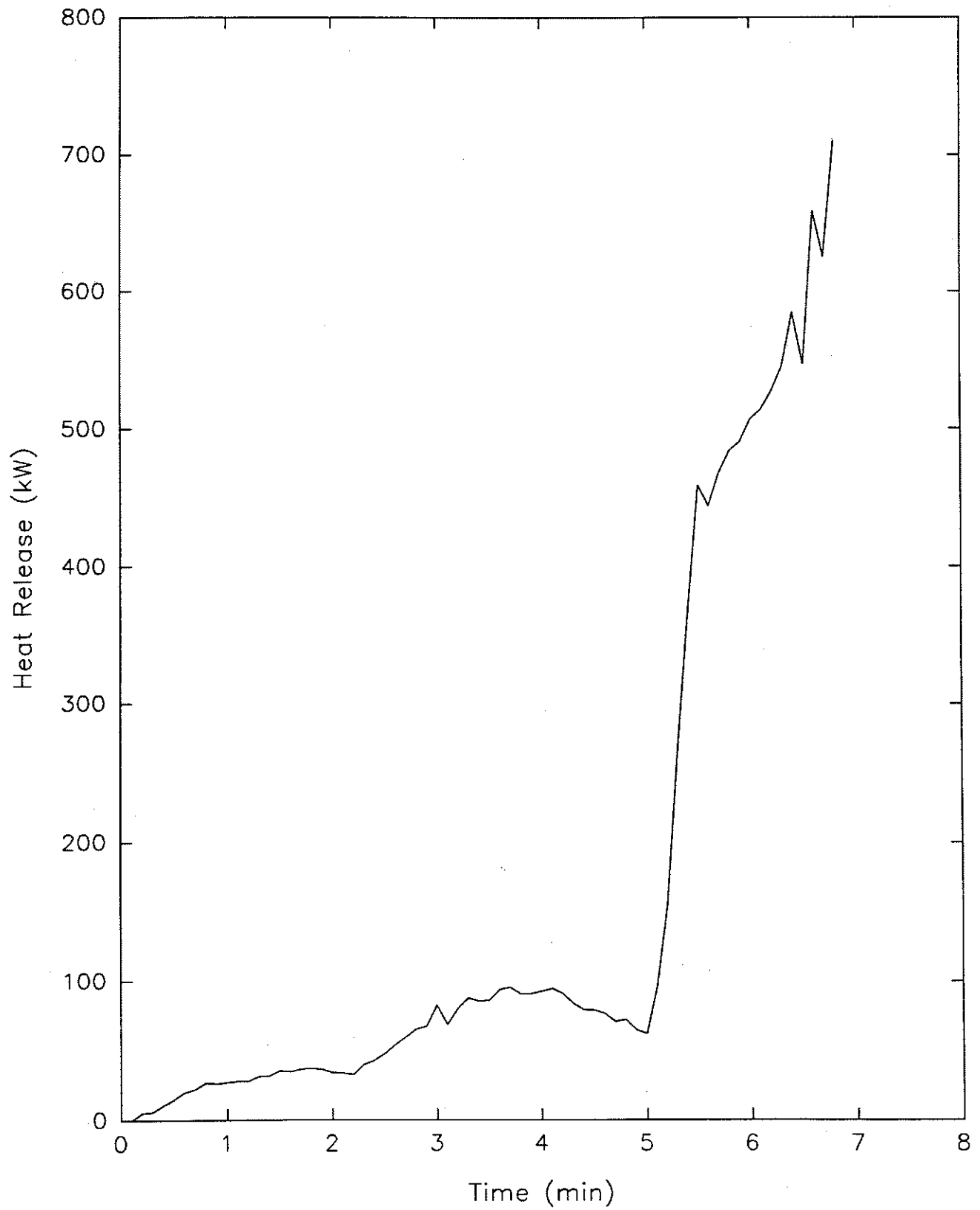


Figure H1 Heat Release Rate vs. Time

12.3mm Plywood

July 20 1990

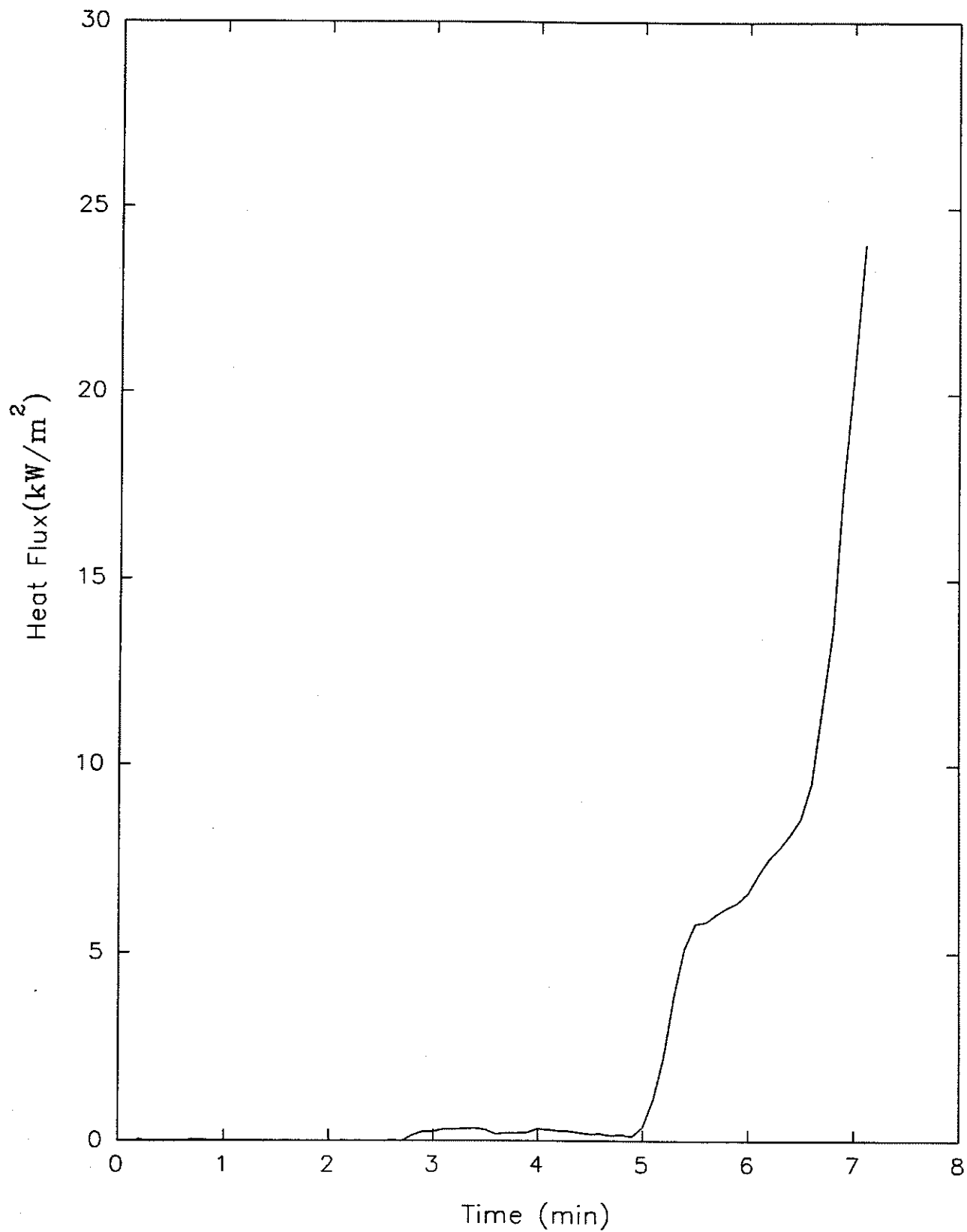


Figure H2 Heat Flux vs. Time  
12.3mm Plywood

July 20 1990

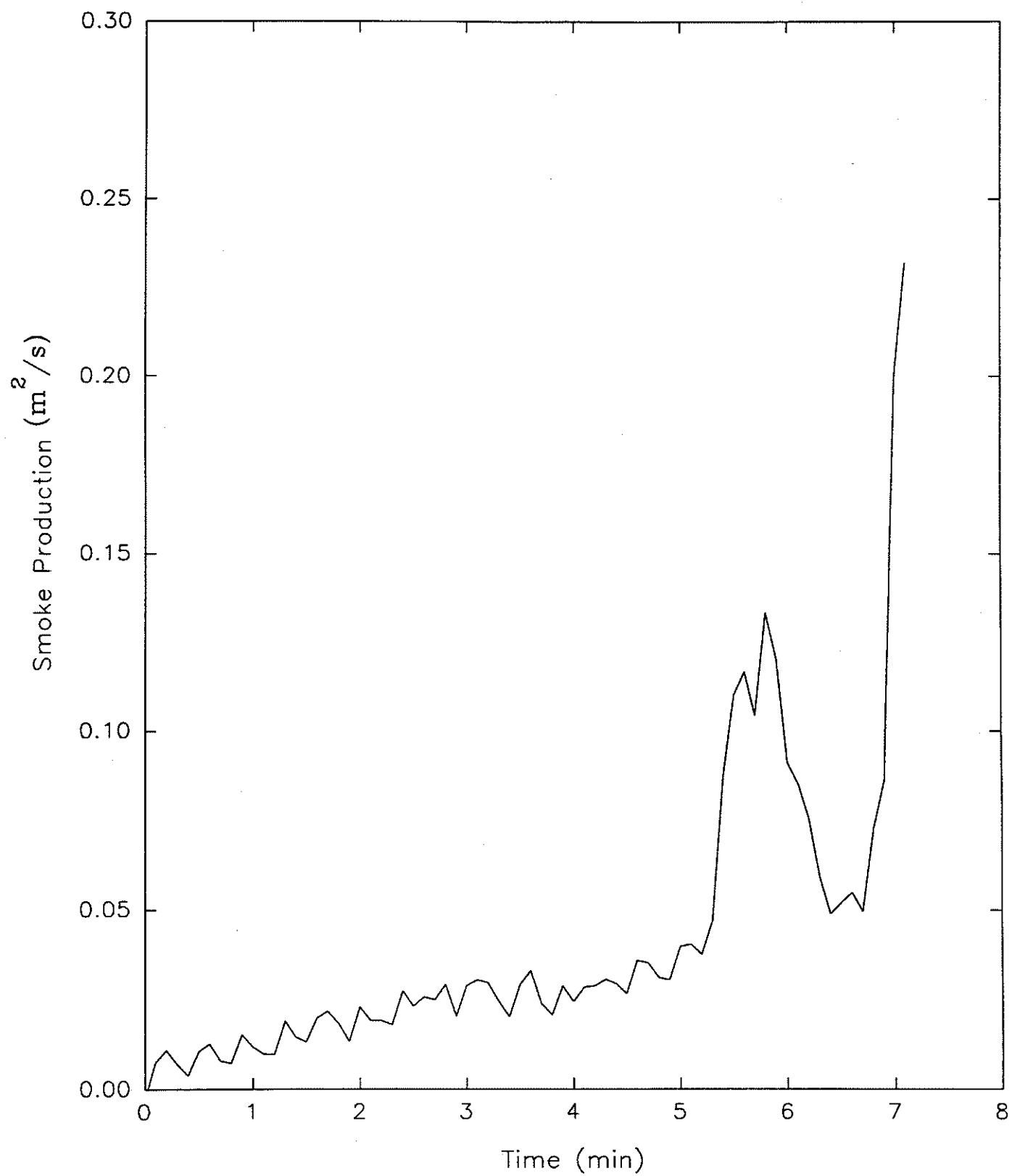


Figure H3 Rate of Smoke Production vs. Time  
12.3mm Plywood

July 20 1990

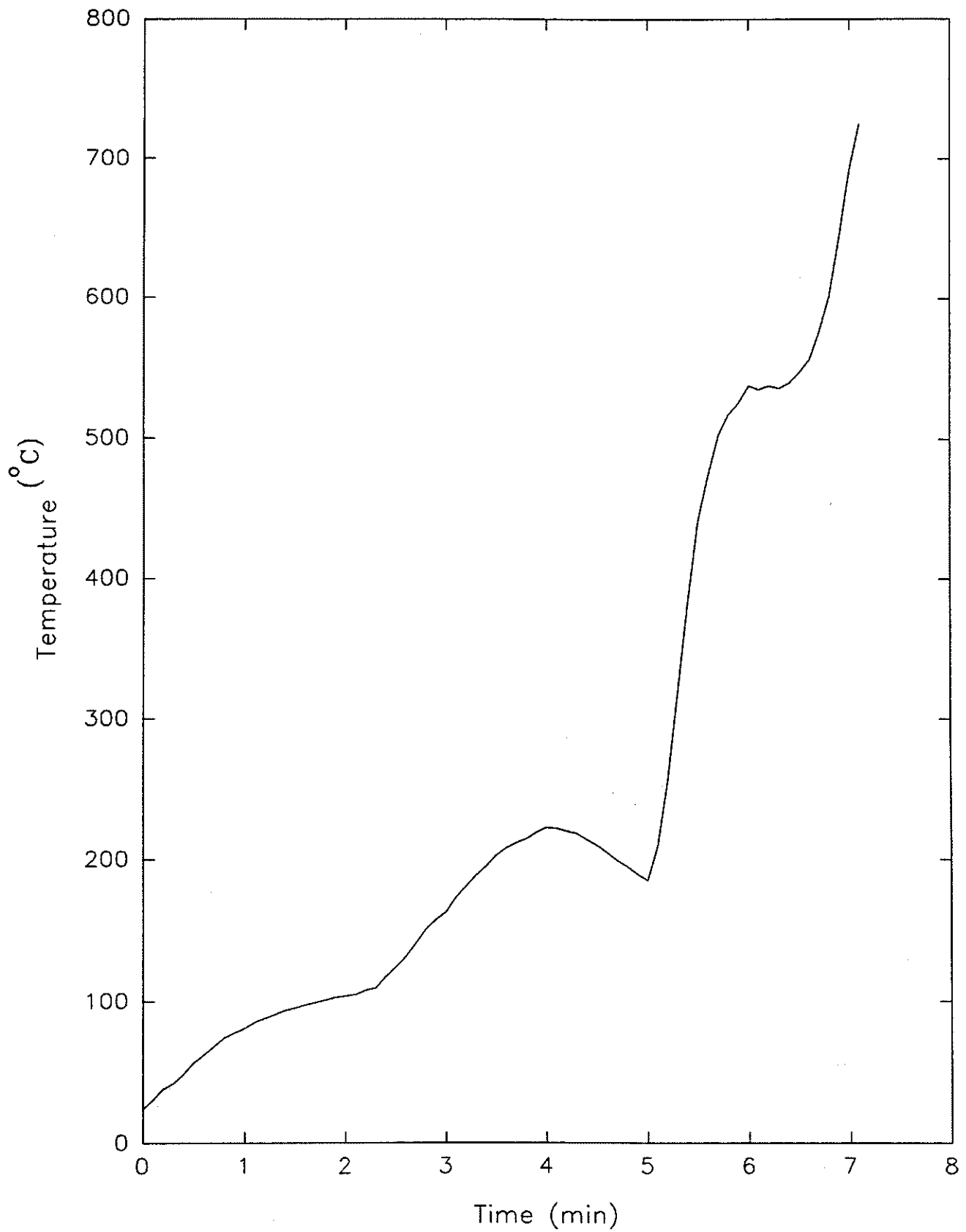


Figure H4 Temperature at the Centre of Ceiling vs. Time  
12.3mm Plywood

July 20 1990

**APPENDIX I: 12.3 mm FIRE RETARDED PLYWOOD**





## SUMMARY TABLE OF RESULTS

Item	Results
Test material	12.3 mm fire retarded plywood
Test number	2
Date of test	July 26, 1990
Time to ignition of walls (left / right)	DNO
Time at which 20 kW/m <sup>2</sup> reach at each radiometer	DNO
Time at which paper targets ignite	DNO
Time of flame out of doorway	DNO
Maximum temperature at centre of room / time occurred	710°C / 13 min 5 s
Maximum temperature at the doorway / time occurred	650°C / 13 min 20 s
Time 600°C was obtained by TC at the centre of the room	12.9 in
Time 600°C was obtained by the TC at the doorway	13.2 min
Maximum instantaneous smoke produced / time occurred	0.04 OD / 15 min 5 s
Maximum instantaneous heat release / time occurred	745 kW / 13 min 25 s

DNO - Did not occur

## VISUAL OBSERVATIONS OF THE TEST

Material: 12.3 mm Fire Retarded Plywood

Date: July 26, 1990  
Room Temperature: 81°F  
Relative Humidity: 48%  
Barometric Pressure: 760.0 mm Hg

Overall description of test and test material: Followed ASTM test procedures  
Switched fan speed to high during the test.

### Observations of the test:

<u>Time (min:sec)</u>	<u>Observations</u>
0 : 00	Ignition of the sand burner (40 kW).
0 : 10	Flame height is 3 ft (flame tip reaches 3 ft above the burner).
0 : 15	Flame height is 4 ft.
0 : 20	Samples on both side of the corner starts to char.
1 : 00	Flame height is 5 ft.
1 : 25	Light smoke layer in the room is 2 ft deep.
2 : 00	Flame height is 4 ft.
2 : 30	Flame height is 4 ft. Samples near the corner are charred, but there is no flame on the sample.
4 : 00	Flame height is 5 ft. Light smoke layer in the room 2 ft deep.
5 : 00	Propane flow increased to 160 kW. Flame reaches the ceiling and deflected along the ceiling/wall joint (flame tip extends 4 ft from the corner along the ceiling/wall joint). Sample is charred near the corner all the way to the ceiling.
7 : 00	Flame condition steady. Some flames visible on the charred surface of the sample at the top near the corner.
8 : 30	Condition is steady. Light smoke layer in the room, but no visible smoke coming out through the doorway. Burning of the charred surface of the sample at the top near the corner is increased.
12 : 30	Top portion of the sample on the two walls joining the corner are burning and the flame front extends all the way to the other corners along the ceiling/wall joint. Papers on the gypsumboard at the ceiling are burning.
13 : 00	Flames visible on the ceiling. Smoke is coming out through the doorway.
13 : 20	Exhaust fan speed changed to high.
13 : 45	No visible flame on the ceiling.
14 : 20	Flame is receding a little. Flame reaches ceiling, but does not extend along the ceiling/wall joint. Top portion of the samples on both walls heavily charred and some flames are visible on the charred surface.

Room is filled with light grey smoke.  
Steady light smoke coming out through the doorway.  
15 : 00 Propane flow shut off.  
Some flames on the charred surface of the sample.  
15 : 10 Some portion of the sample near the corner is burned off.  
Sample is charred at the top about 2 ft deep all the way around the room.  
Sample heavily charred near the corner and some portion of the sample is completely burned and charred pieces fall off exposing backing board (gypsumboard).  
Some flames at the top charred surface are visible.  
16 : 00 No flame is visible.  
Test terminated.

# Supplementary Data of the Test

**MATERIAL:** Fire Retarded Plywood  
**DIMENSION (mm) :** 12.3  
**DATE TESTED:** July 26 1990

TIME (min)	CORNER TC (deg C)	DOOR TC (deg C)	DUCT TEMP (deg C)	FLOW RATE (m3/s)	CO CONC (%)	CO2 CONC (%)	O2 CONC (%)
0	27	28	28	1.03	0	0	21
0.5	163	75	31	1.17	0	0.06	20.95
1	200	92	34	1.07	0	0.13	20.87
1.5	234	103	36	1.09	0.01	0.16	20.83
2	207	103	37	1.11	0.01	0.2	20.81
2.5	202	104	37	1.18	0.01	0.22	20.8
3	226	105	37	1.1	0	0.19	20.8
3.5	231	109	39	1.11	0.01	0.23	20.79
4	230	110	38	1.1	0.01	0.23	20.77
4.5	234	111	38	1.13	0.01	0.23	20.77
5	296	114	39	1.14	0.01	0.24	20.77
5.5	754	273	73	1.02	0.01	0.95	20.09
6	750	281	76	0.98	0.02	1.09	19.89
6.5	793	285	81	0.99	0.02	1.2	19.84
7	764	291	83	0.84	0.02	1.24	19.79
7.5	787	297	86	1	0.02	1.31	19.71
8	819	304	88	0.96	0.02	1.28	19.69
8.5	807	316	95	0.98	0.02	1.41	19.57
9	816	321	99	0.96	0.03	1.5	19.48
9.5	831	0	0	0.93	0.03	1.47	19.46
10	823	326	104	0.92	0.03	1.58	19.39
10.5	858	328	106	0.92	0.03	1.62	19.36
11	874	339	109	0.93	0.03	1.76	19.29
11.5	874	353	117	0.89	0.04	1.9	19.14
12	898	365	122	0.88	0.05	1.97	19.01
12.5	898	384	130	0.87	0.07	2.09	18.89
13	887	464	169	0.77	0.21	3.8	17.06
13.5	919	646	250	0.75	0.93	4.13	15.94
14	896	518	150	1.71	0.07	1.76	19.24
14.5	884	439	119	1.76	0.05	1.31	19.74
15	856	408	103	1.91	0.04	0.99	19.98
15.5	597	378	85	2.14	0.02	0.51	20.51
16	418	280	60	2.1	0.02	0.3	20.72

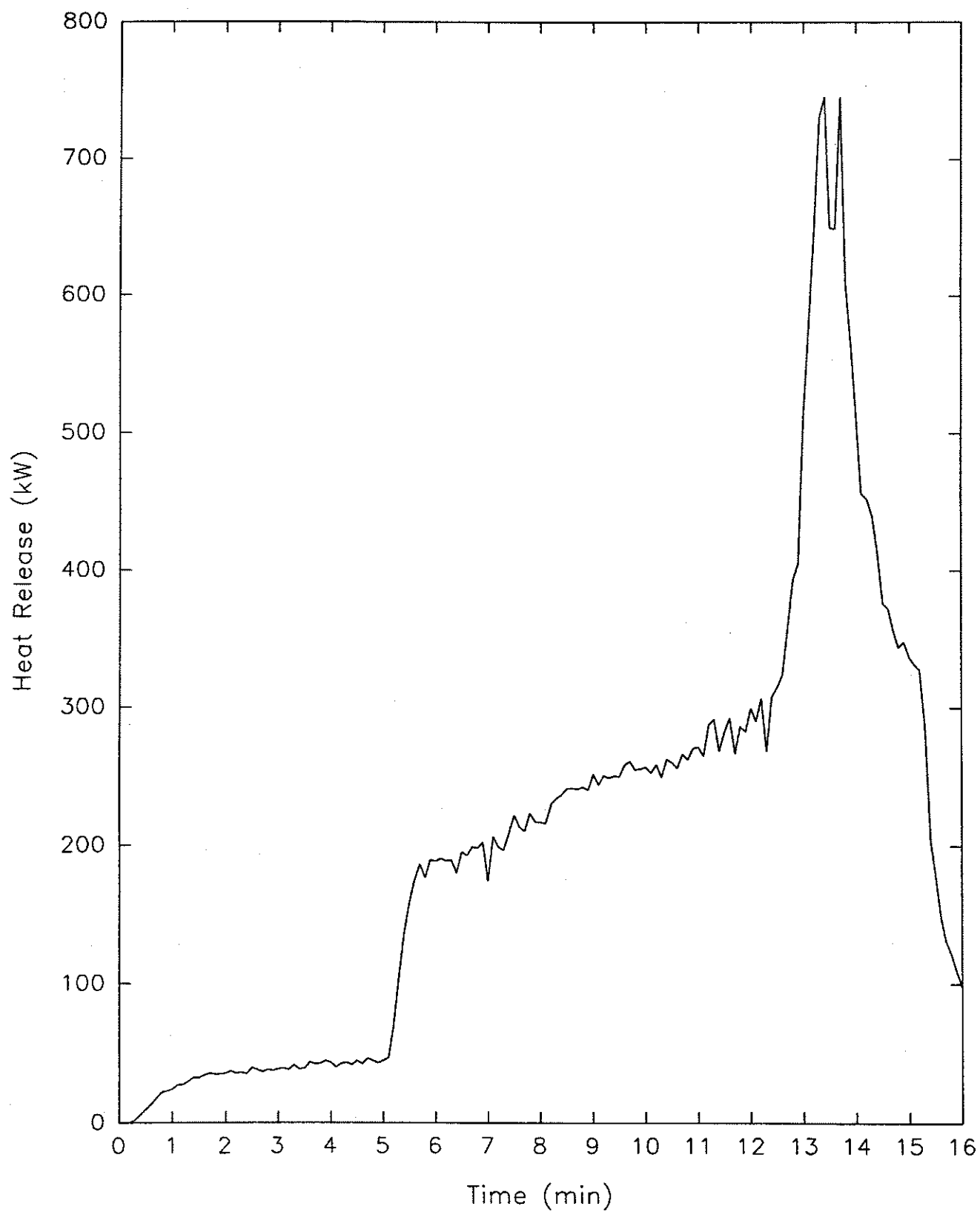


Figure I1 Heat Release Rate vs. Time

12.3mm Fire Retarded Plywood

July 26 1990

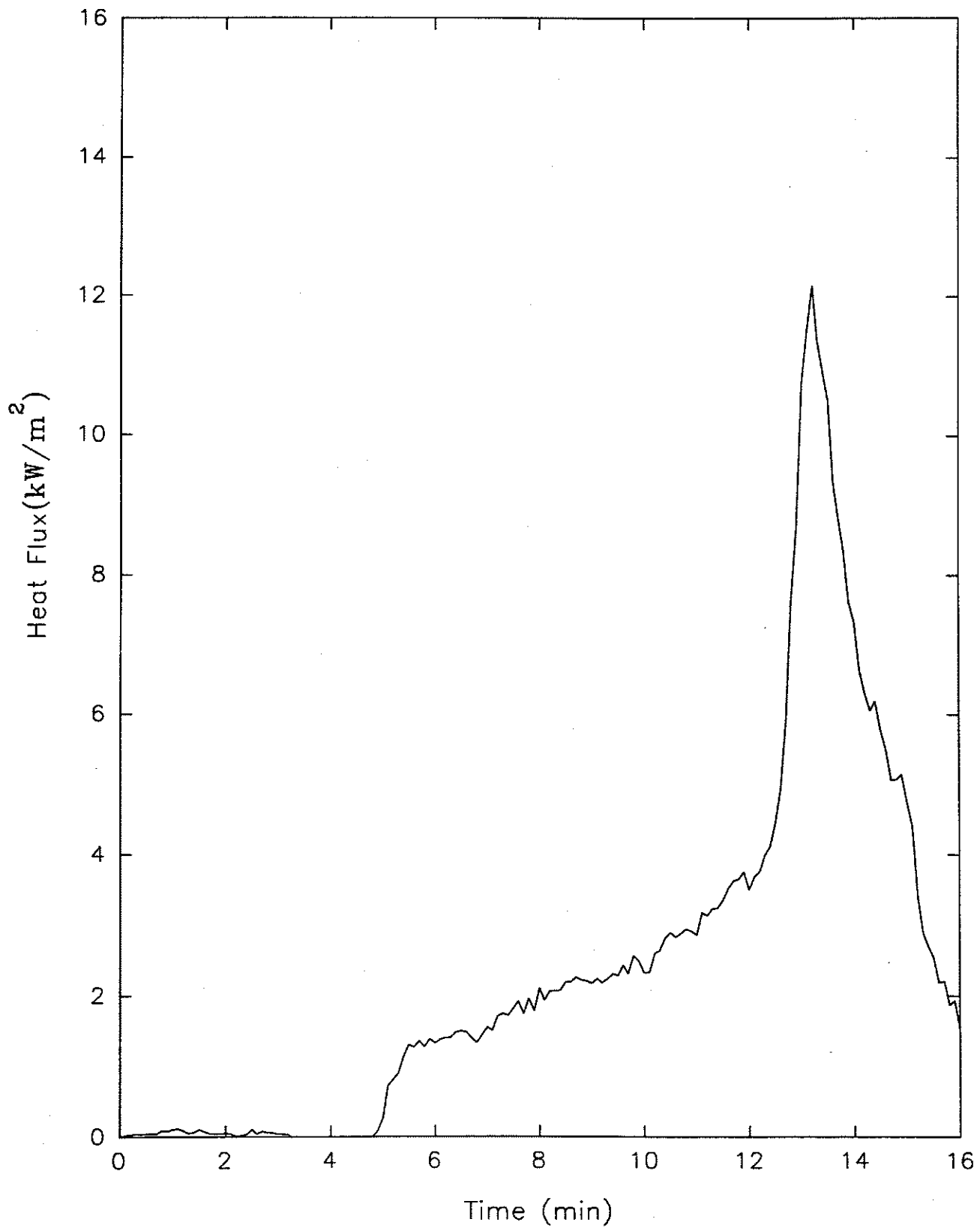


Figure I2 Heat Flux vs. Time  
12.3mm Fire Retarded Plywood

July 26 1990

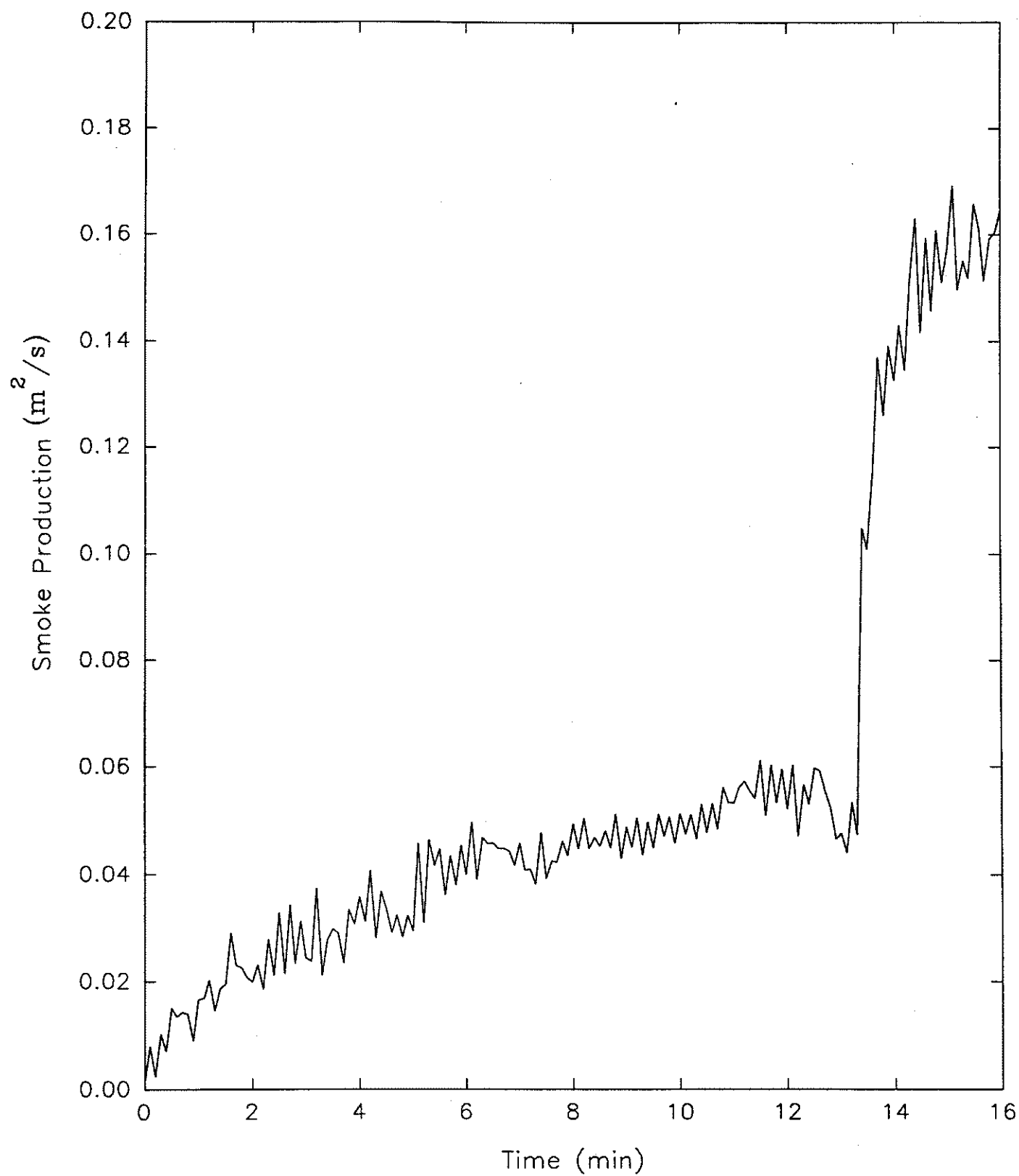


Figure 13 Rate of Smoke Production vs. Time  
12.3mm Fire Retarded Plywood

July 26 1990



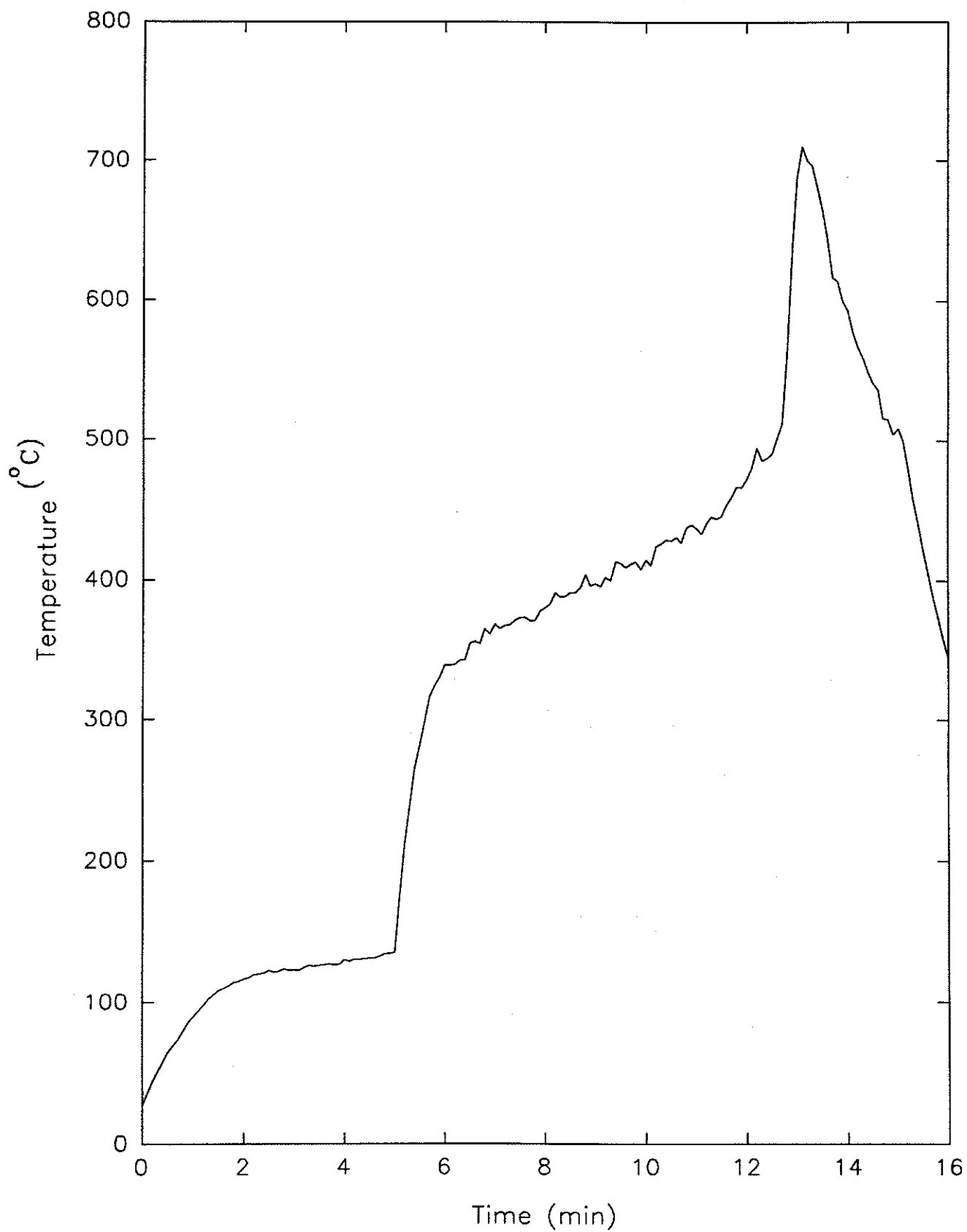


Figure I4 Temperature at the Centre of Ceiling vs. Time  
12.3mm Fire Retarded Plywood

July 26 1990

## **APPENDIX J: 26.1 mm EXPANDED POLYSTYRENE**



## SUMMARY TABLE OF RESULTS

Item	Results
Test material	26.1 mm polystyrene
Test number	2
Date of test	July 31, 1990
Time to ignition of walls (left / right)	DNO
Time at which 20 kW/m <sup>2</sup> reach at each radiometer	DNO
Time at which paper targets ignite	DNO
Time of flame out of doorway	DNO
Maximum temperature at centre of room / time occurred	308°C / 7 min 10 s
Maximum temperature at the doorway / time occurred	243°C / 7 min
Time 600°C was obtained by TC at the centre of the room	DNO
Time 600°C was obtained by the TC at the doorway	DNO
Maximum instantaneous smoke produced / time occurred	0.33 OD / 1 min 55 s
Maximum instantaneous heat release / time occurred	198 kW / 6 min 10 s

DNO - Did not occur

## VISUAL OBSERVATIONS OF THE TEST

Material: 26.1 mm Polystyrene

Date: July 31, 1990  
Room Temperature: 70°F  
Relative Humidity: 60%  
Barometric Pressure: 751.0 mm Hg

Overall description of test and test material: Followed ASTM test procedures  
Ignition 5 s too early

### Observations of the test:

<u>Time (min:sec)</u>	<u>Observations</u>
0 : 00	Ignition of the sand burner (40 kW).
0 : 05	Flame height is 3 ft (flame tip reaches 3 ft above the burner).
0 : 10	Sample starts to melt at the corner.
0 : 30	Samples at the corner melted away exposing the backboard (melted area is cone-shaped with a 1 ft base and reaching 3 ft above the burner).
0 : 40	Flame height is 4 ft.
0 : 50	Black smoke is produced at the corner.
1 : 10	Black smoke layer in the room is 3 ft deep.
1 : 10	Black smoke starts to exit through the doorway.
1 : 10	Samples near the burner start to burn as it melts.
2 : 00	Flame height reaches ceiling through the black smoke layer.
2 : 00	Flame at the corner is big, approximately 1 ft diameter column of flame reaching the ceiling through the black smoke layer.
2 : 30	Black smoke layer on the ceiling is 4 ft deep.
2 : 30	Flame is receding.
3 : 30	Some portion of sample near the burner is burning as it melts.
3 : 30	Smoke production in the corner is reduced.
3 : 30	Room is still filled with dark smoke, but the amount of smoke coming out through the doorway is reduced.
3 : 30	Flame at the corner is ignition flame only.
3 : 30	No sample remaining near the ignition flame to burn.
3 : 30	Room has light smoke layer in the ceiling, but no visible smoke coming out through the doorway.
5 : 00	Propane flow increased to 160 kW.
5 : 00	Flame tip reaches the ceiling.
5 : 30	Samples are melting again near the flame and start to burn as they melt.
5 : 50	Black smoke layer in the room is 4 ft deep.
5 : 50	Black smoke again comes out through the doorway.
6 : 00	Samples are melting down and burning.
6 : 50	Top portion of the samples on both walls of the corner are melting down.
7 : 00	Black smoke coming out of doorway is reduced.
7 : 30	Small portion of the sample is still burning as it is melting down, but the amount that is burning is very small.
10 : 00	Ignition flame is the only flame in the room.

11 : 00 No sample remaining near the ignition flame to burn.  
Light grey smoke layer in the room 3 ft deep.  
No visible smoke coming out through the doorway.

15 : 00 Propane flow to the sand burner shut off.

15 : 05 No flame in the room.

16 : 00 Test terminated.

Damage to the room is that samples near the corner, approximately 3 ft wide on each wall are all melted away exposing the backboard. This extends to the ceiling. Also, top portion of each wall (joining the sandburner corner) is melted away, approximately 3 ft from the ceiling and all the way around.

# Supplementary Data of the Test

**MATERIAL:** Polystyrene  
**DIMENSION (mm) :** 26.1  
**DATE TESTED:** July 31 1990

TIME (min)	CORNER TC (deg C)	DOOR TC (deg C)	DUCT TEMP (deg C)	FLOW RATE (m3/s)	CO CONC (%)	CO2 CONC (%)	O2 CONC (%)
0	59	22	19	0	0	-0.02	21
0.5	131	69	24	1.14	0	0.05	20.94
1	221	105	29	1.17	0	0.16	20.83
1.5	469	161	43	1.08	0.01	0.44	20.54
2	664	228	60	1.06	0.02	1.06	20.02
2.5	425	191	59	1.02	0.01	0.67	20.21
3	299	147	51	1.09	0.01	0.49	20.49
3.5	232	125	46	1.13	0	0.34	20.62
4	202	115	42	1.1	0	0.3	20.67
4.5	191	112	41	1.05	0	0.31	20.71
5	184	112	42	1.12	0	0.27	20.72
5.5	403	208	73	1.03	0.01	0.81	20.26
6	447	233	82	0.97	0.01	1.02	19.94
6.5	507	234	87	0.99	0.01	1.04	19.88
7	484	243	90	0.97	0.01	1.09	19.87
7.5	468	237	94	0.97	0.01	1.05	19.87
8	465	240	94	0.9	0.01	1.07	19.89
8.5	465	238	95	0.93	0.01	1.14	19.83
9	429	231	96	0.89	0.01	1.08	19.9
9.5	461	223	96	0.95	0.01	0.97	20.02
10	452	229	91	0.91	0.01	0.95	20.05
10.5	444	223	91	0.96	0.01	0.96	20.07
11	421	222	94	1.02	0	0.94	20.04
11.5	452	221	92	0.94	0	0.96	20.07
12	462	220	92	0.99	0	0.92	20.08
12.5	442	223	94	0.99	0	0.93	20.09
13	435	221	94	0.95	0.01	0.93	20.08
13.5	483	227	92	0.95	0	0.9	20.11
14	480	229	93	0.98	0	0.92	20.1
14.5	454	228	95	0.92	0	0.94	20.09
15	450	230	96	0.92	0	0.95	20.08
15.5	282	145	50	1.09	0	0.21	20.88
16	213	113	42	1.11	0	0.09	N/A

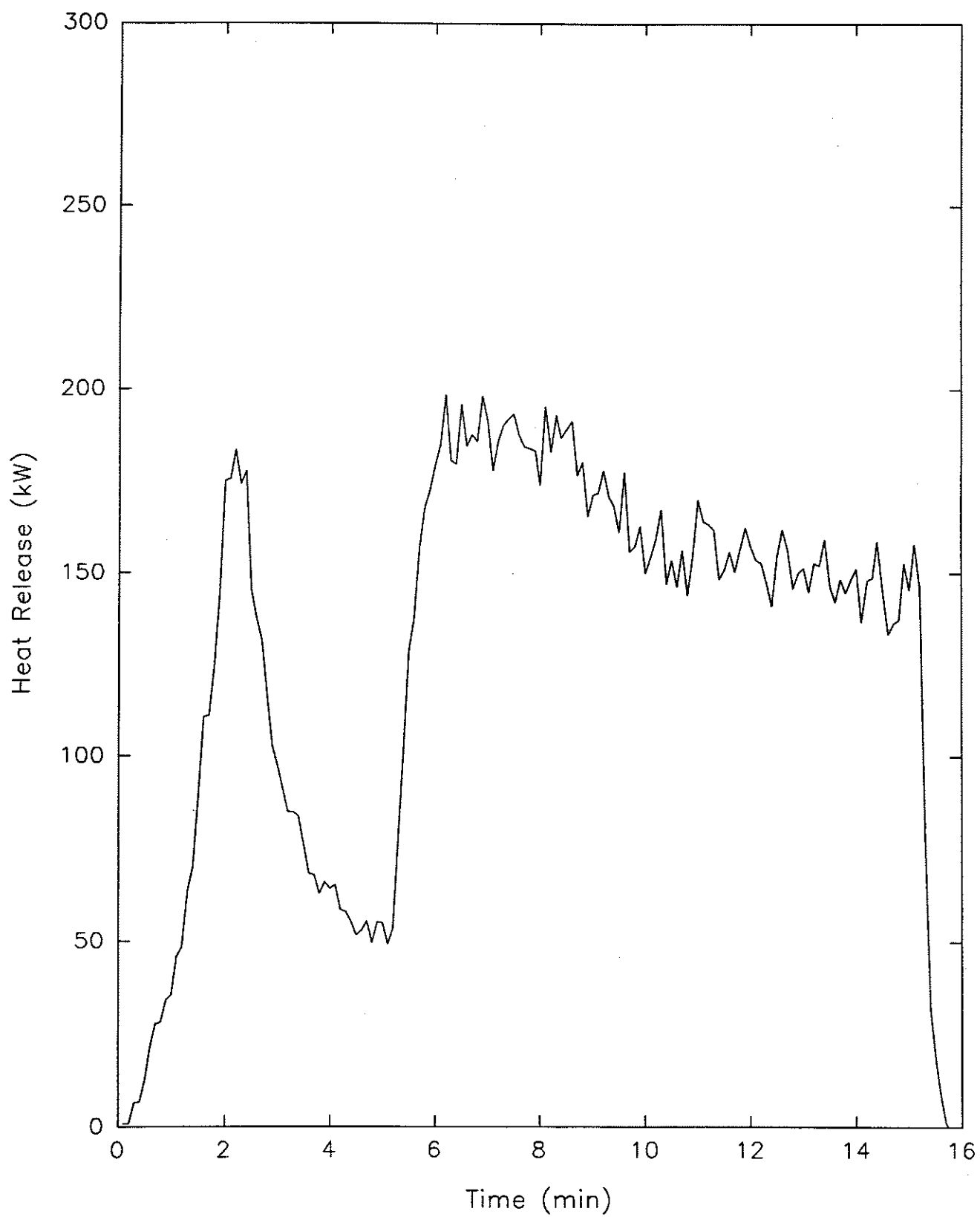


Figure J1 Heat Release Rate vs. Time

26.1mm Polystyrene

July 31 1990



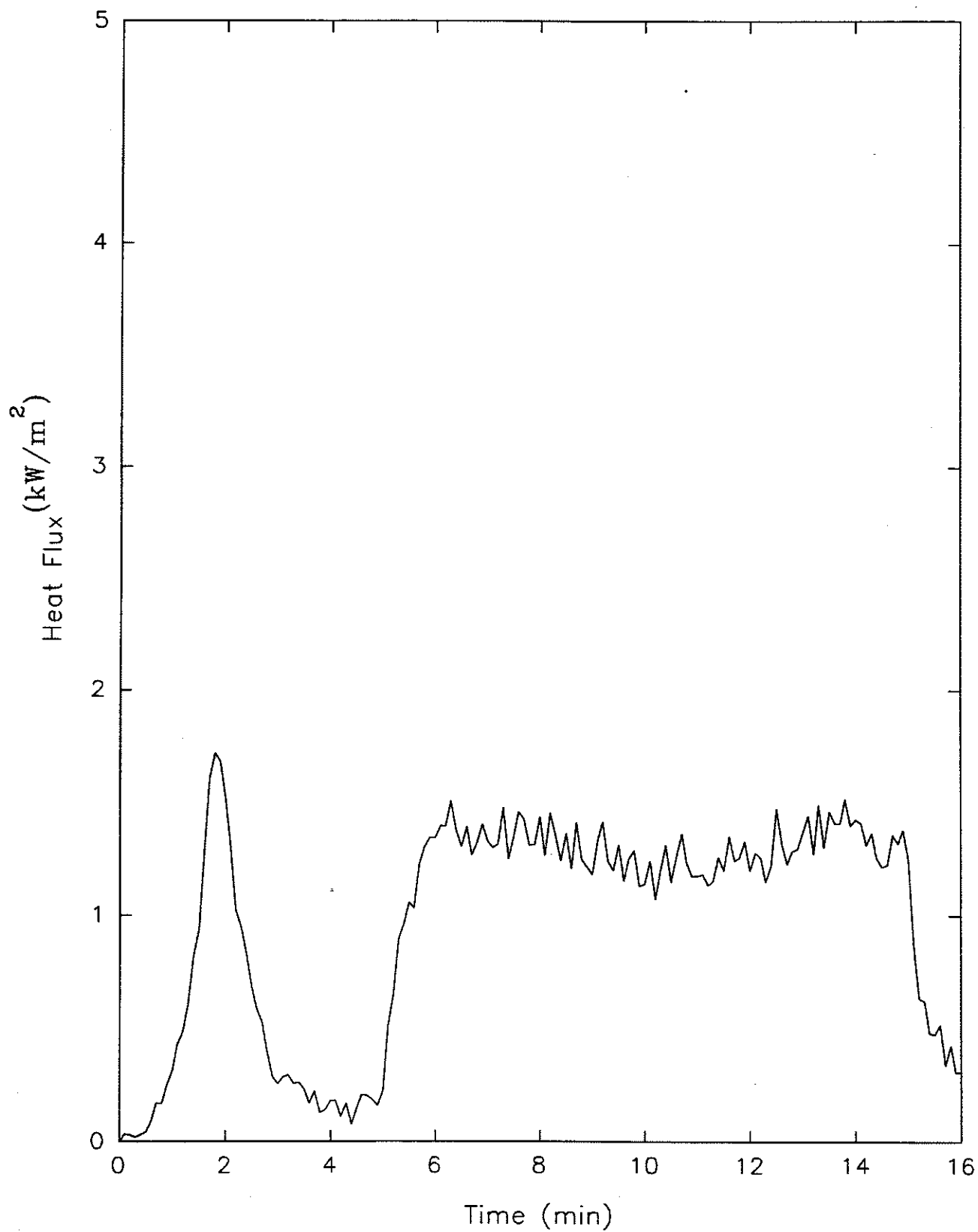


Figure J2 Heat Flux vs. Time  
26.1mm Polystyrene.

July 31 1990

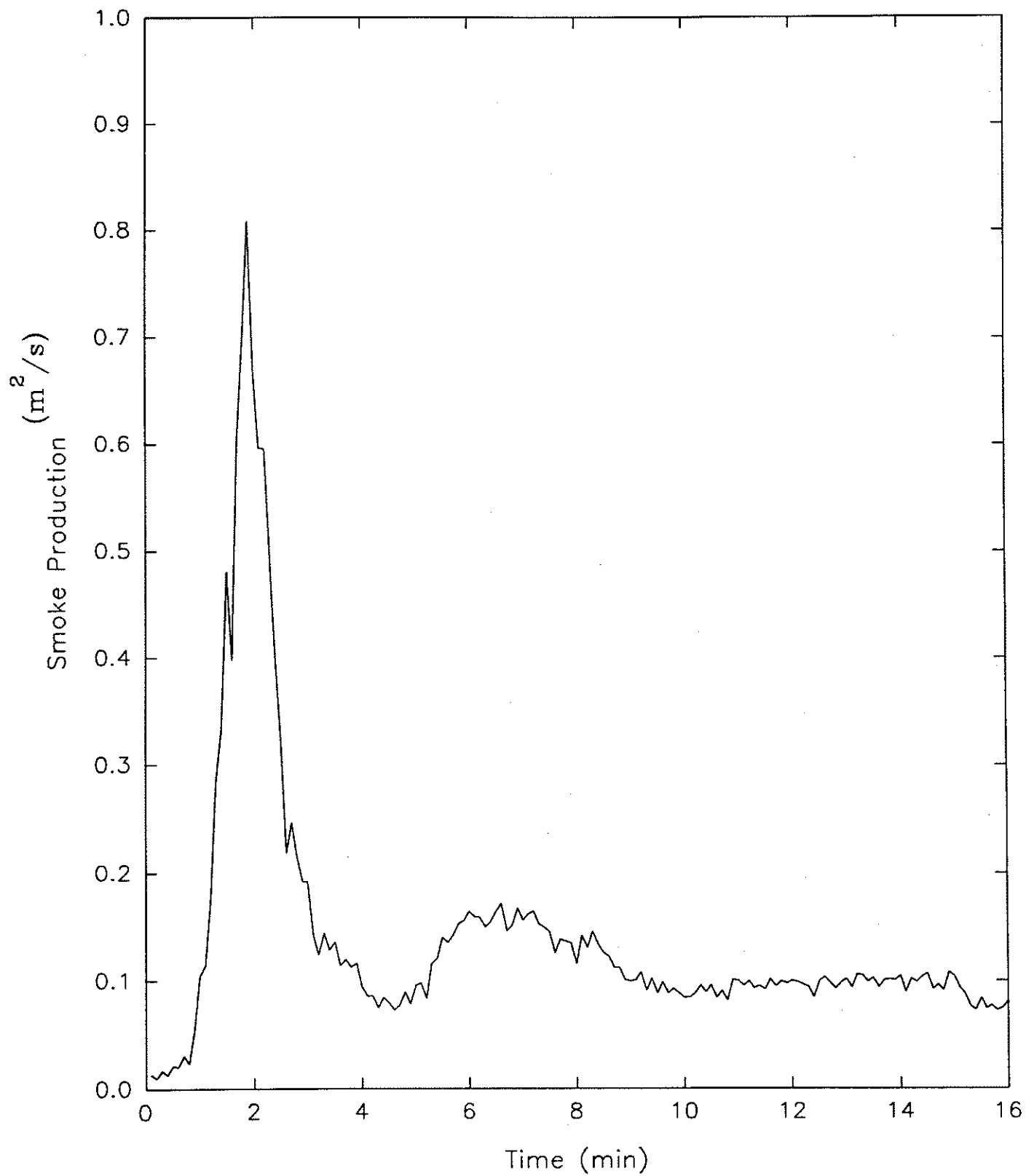


Figure J3 Rate of Smoke Production vs. Time  
26.1mm Polystyrene

July 31 1990

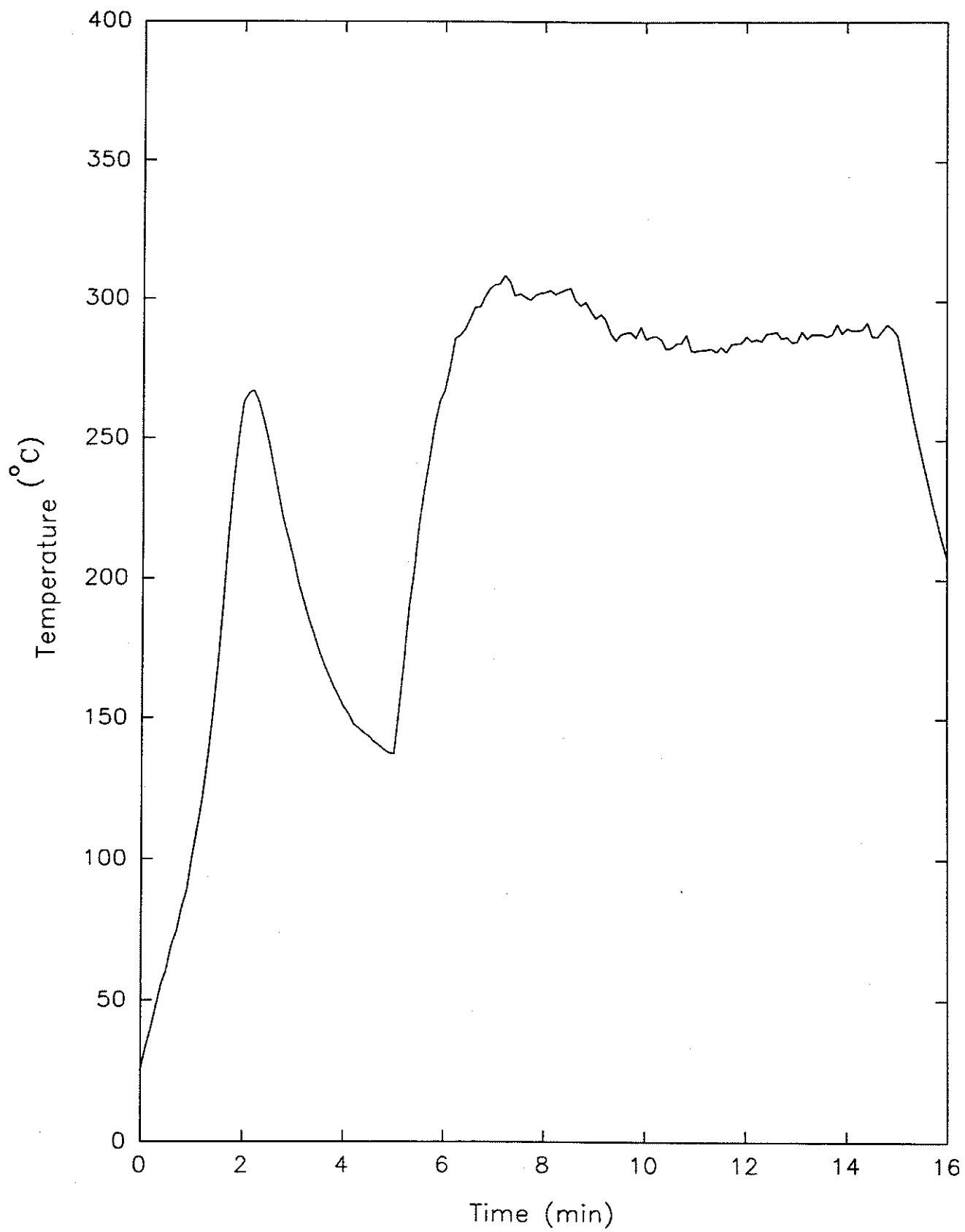


Figure J4 Temperature at the Centre of Ceiling vs. Time  
26.1mm Polystyrene

July 31 1990

## **APPENDIX K: 6 mm WOODPANEL**



## SUMMARY TABLE OF RESULTS

Item	Results
Test material	6 mm woodpanel
Test number	1
Date of test	November 1, 1990
Time to ignition of walls (left / right)	40 s / 40 s
Time at which 20 kW/m <sup>2</sup> reach at each radiometer	6 min 10 s / 6 min 10 s
Time at which paper targets ignite	6 min 10 s
Time of flame out of doorway	6 min 35 s
Maximum temperature at centre of room / time occurred	839°C / 6 min 30 s
Maximum temperature at the doorway / time occurred	607°C / 6 min 30 s
Time 600°C was obtained by TC at the centre of the room	5 min 35 s
Time 600°C was obtained by the TC at the doorway	6 min 30 s
Maximum instantaneous smoke produced / time occurred	0.36 OD / 6 min 30 s
Maximum instantaneous heat release / time occurred	966 kW / 6 min 5 s

## VISUAL OBSERVATIONS OF THE TEST

Material: 6 mm Woodpanel

Date: November 1, 1990

Overall description of test and test material: Followed ASTM test procedures  
Fan speed switched to high during the test

Observations of the test:

<u>Time (min:sec)</u>	<u>Observations</u>
0 : 00	Ignition of the sand burner (40 kW)
0 : 30	Flame height is 3 ft.
0 : 40	Both walls at the corner ignite. Flame height is 4 ft.
1 : 05	Flame height is 5 ft.
1 : 30	Flame height is 6 ft.
2 : 30	Flame reaches ceiling. Light smoke layer in the room.
3 : 30	Flame is reflected at the ceiling and flame tip runs along the ceiling/wall joint reaching 4 ft from the corner. Light smoke layer in the room approximately 4 ft deep.
4 : 00	Light smoke starting to come out through the doorway.
5 : 00	Propane flow increased to 160 kW. Flame is running along the ceiling/wall joint steadily. Dark smoke is coming out through the doorway.
5 : 10	Flame runs along the ceiling.
5 : 20	Upper portion at the room (near ceiling) is filled with dark smoke and flames. Steady dark smoke coming out.
6 : 05	Fan speed changed to high.
6 : 10	Flame starts to come out through the doorway. Both paper bundles ignite.
6 : 25	Steady flames coming out.
6 : 30	Test terminated.

# Supplementary Data of the Test

**MATERIAL:** Woodpanel  
**DIMENSION (mm) :** 6  
**DATE TESTED:** November 1 1990

TIME (min)	CORNER TC (deg C)	DOOR TC (deg C)	DUCT TEMP (deg C)	FLOW RATE (m3/s)	CO CONC (%)	CO2 CONC (%)	O2 CONC (%)
0	9	11	11	1.2	0	0	21.05
0.5	75	31	12	1.26	0	0.02	21.03
1	133	61	16	1.18	0	0.12	20.92
1.5	188	85	20	1.17	0	0.19	20.87
2	250	105	23	1.2	0	0.27	20.8
2.5	292	127	25	1.16	0	0.39	20.71
3	377	145	30	1.14	0	0.47	20.66
3.5	473	174	36	1.12	0	0.64	20.49
4	642	229	45	1.09	0	0.88	20.33
4.5	770	283	56	1.01	0	1.24	19.98
5	720	319	65	0.98	0	1.48	19.69
5.5	718	471	127	0.88	0.11	3.33	16.9
6	775	532	210	0.75	0.41	5.05	13.77
6.5	753	607	210	0.69	0.98	4.41	15.69



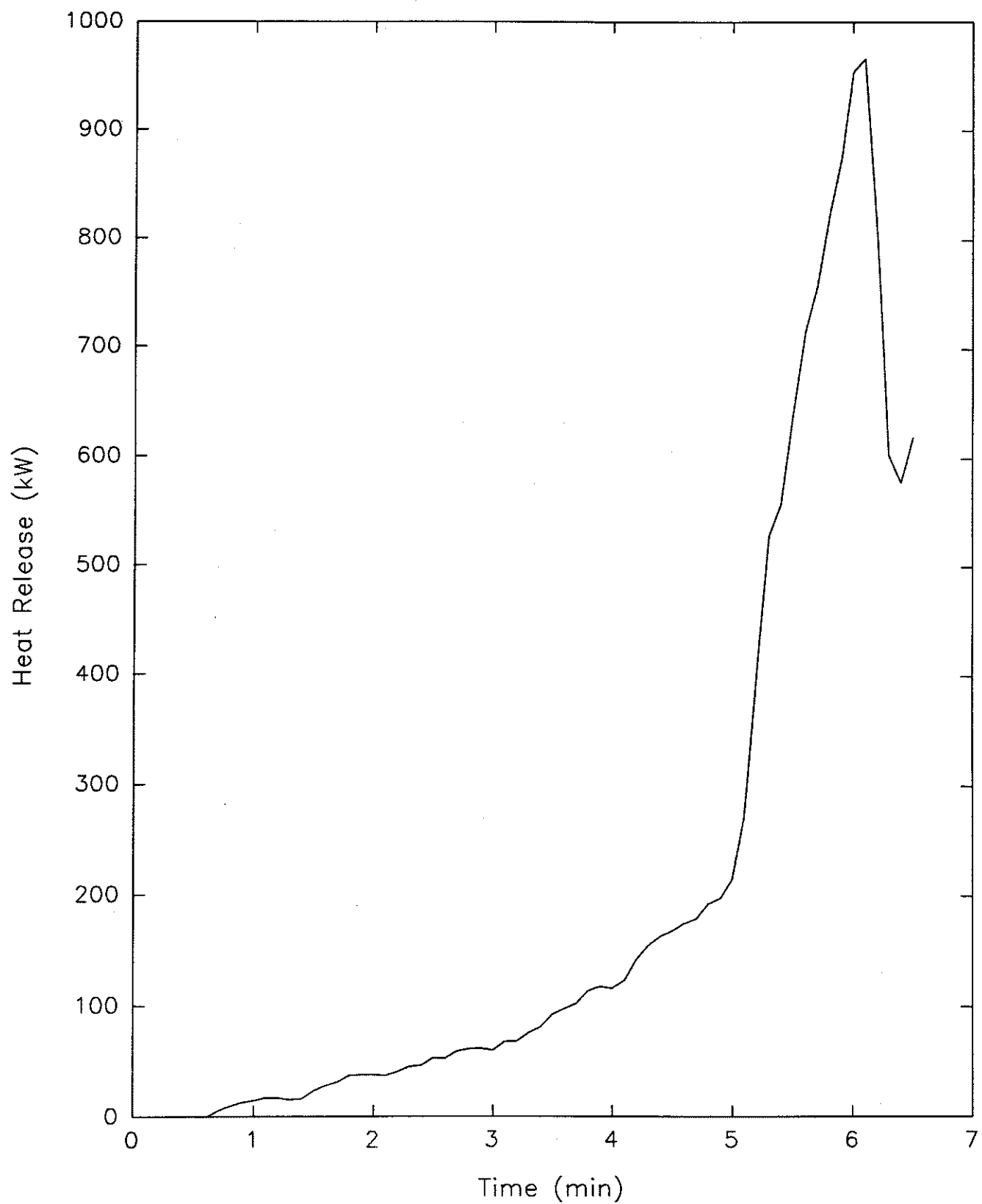


Figure K1 Heat Release Rate vs. Time  
6mm Woodpanel

Nov. 1 1990

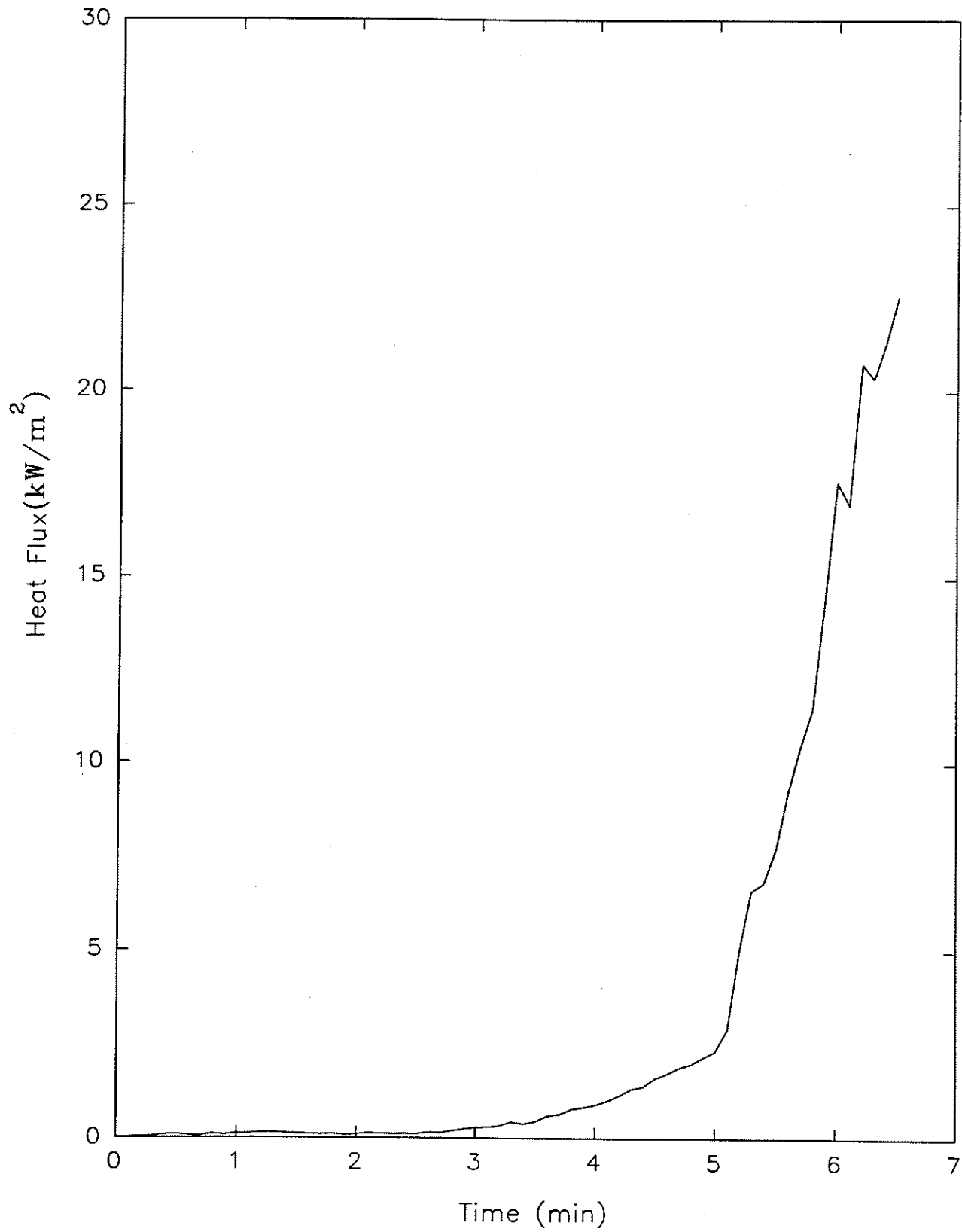


Figure K2 Heat Flux vs. Time  
6mm Woodpanel

Nov. 1 1990

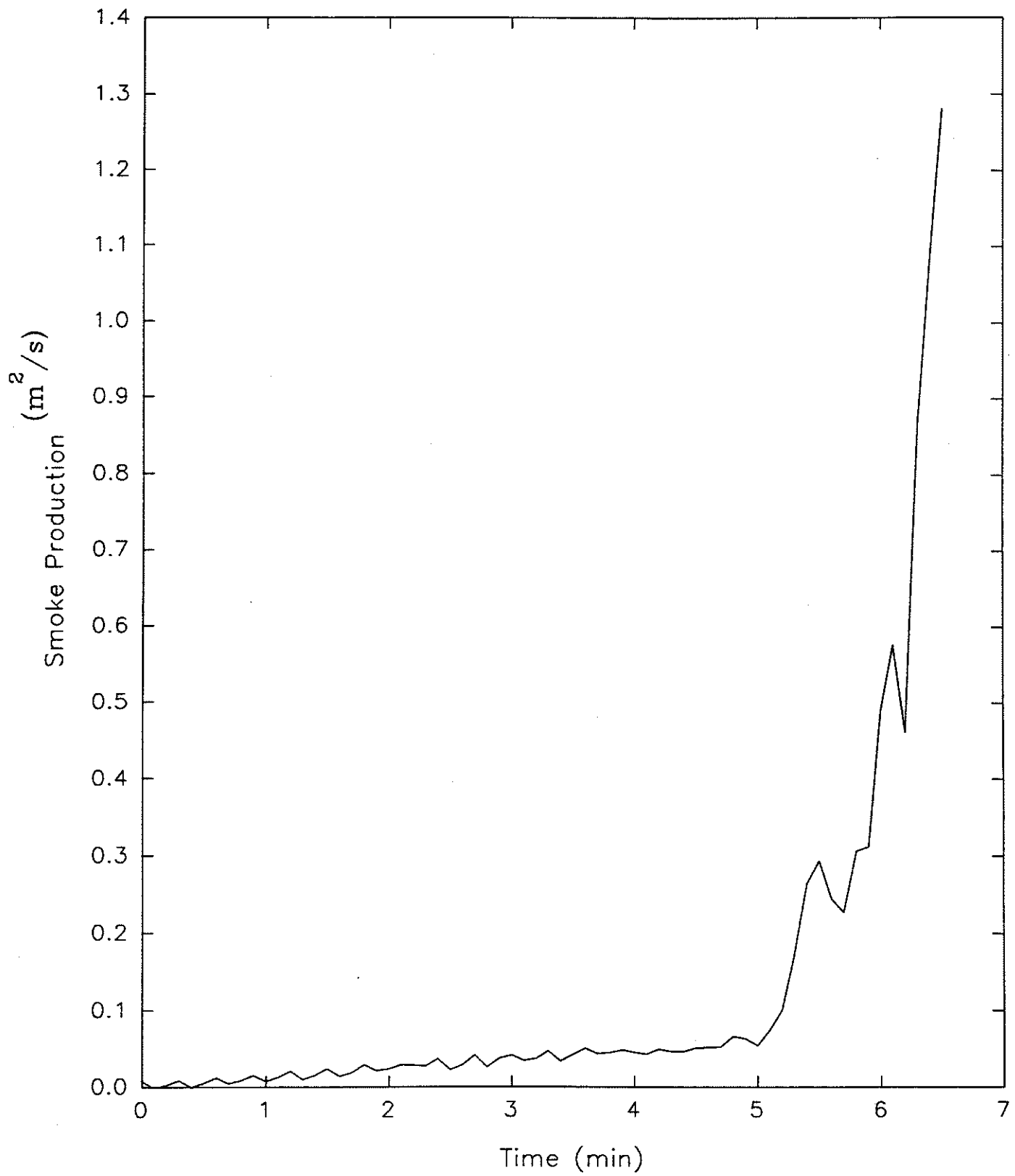


Figure K3 Rate of Smoke Production vs. Time  
6mm Woodpanel

Nov. 1 1990

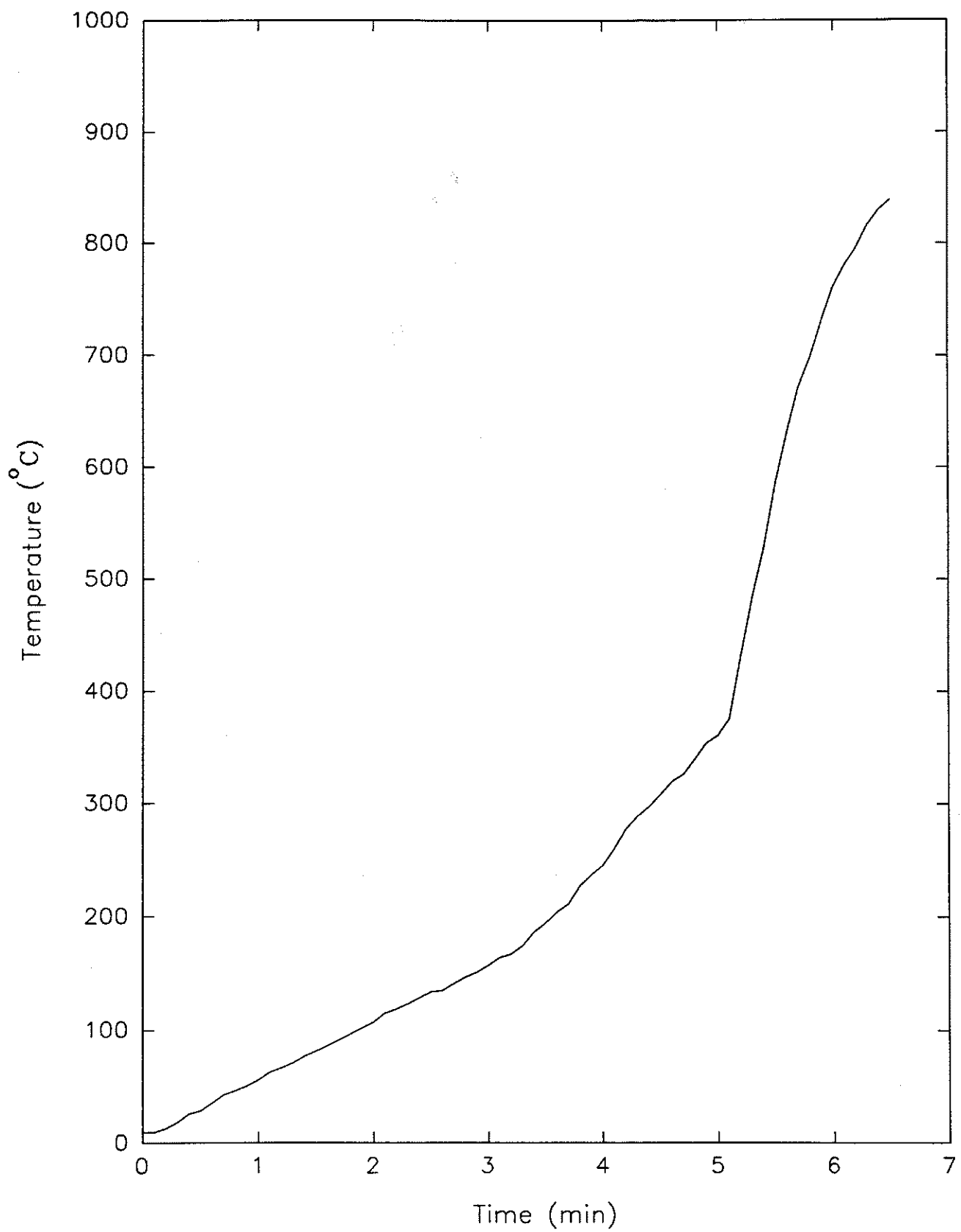


Figure K4 Temperature at the Centre of Ceiling vs. Time  
6mm Woodpanel

Nov. 1 1990



## **APPENDIX L: 12.3 mm PARTICLEBOARD**



## SUMMARY TABLE OF RESULTS

Item	Results
Test material	12.3 mm particleboard
Test number	1
Date of test	February 22, 1991
Time to ignition of walls (left / right)	20 s / 20 s
Time at which 20 kW/m <sup>2</sup> reach at each radiometer	5 min 40 s / 5 min 40 s
Time at which paper targets ignite	6 min
Time of flame out of doorway	5 min 45 s
Maximum temperature at centre of room / time occurred	865°C / 6 min 35 s
Maximum temperature at the doorway / time occurred	699°C / 6 min 30 s
Time 600°C was obtained by TC at the centre of the room	5 min 20 s
Time 600°C was obtained by the TC at the doorway	5 min 30 s
Maximum instantaneous smoke produced / time occurred	0.25 OD / 6 min
Maximum instantaneous heat release / time occurred	924 kW / 6 min 40 s



## VISUAL OBSERVATIONS OF THE TEST

Material: 12.3 mm Particleboard

Date: February 22, 1991

Overall description of test and test material: Followed ASTM test procedures  
Water spray applied at flashover time

### Observations of the test:

<u>Time (min:sec)</u>	<u>Observations</u>
0 : 00	Ignition of the sand burner (40 kW)
0 : 05	Flame height is 3 ft above the burner.
0 : 20	Both walls at the corner ignite. Flame height is 4 ft above the burner. Flame front is 2 ft above the burner.
1 : 30	Flame tip is intermittently reaching the ceiling. Flame front is 4 ft above the burner.
2 : 00	Flame steadily reaches ceiling. Flame front is 6 ft above the burner.
2 : 30	Flame front reaches ceiling. Flame is reflected at the ceiling and flame tip runs along the ceiling/wall joint.
3 : 00	Flame is steadily running along the ceiling/wall joint reaching 4 ft from the corner. No smoke visible in the room.
4 : 00	Flame is steady. Flame tip reaches 5 ft from the corner along the ceiling/wall joint. Light smoke is produced and some light smoke is coming out through the doorway.
4 : 30	Flame seems to be a little receded. Steady flame, but not as intense as before. Room is filled with light grey smoke in the upper area.
5 : 00	Propane flow increased to 160 kW.
5 : 10	Ceiling is covered with flame. Dark smoke is produced and some is coming out through the doorway.
5 : 15	Upper portion of the room is filled with flame and dark smoke.
5 : 20	A large amount of dark smoke is coming out through the doorway and smoke is spilling over the canopy area.
5 : 45	Flickering flames start to come out through the doorway. Water spray in the exhaust duct to protect the fan system from the flames has been turned on.
6 : 00	Steady flame is coming out of the room through the doorway. Dark smoke is also coming out through the doorway. Top half of the room is filled with flame and some dark smoke. Dark smoke spills over the canopy.
6 : 15	Steady flame comes out the doorway and goes into the canopy system.
6 : 20	Canopy is almost full of flame underneath.
6 : 30	Steady flame is going into the canopy in full strength.
6 : 40	Water sprayed into the room. Fire extinguished. Test terminated.

# Supplementary Data of the Test

**MATERIAL:** Particleboard  
**DIMENSION (mm) :** 12.3  
**DATE TESTED:** February 22 1991

TIME (min)	CORNER TC (deg C)	DOOR TC (deg C)	DUCT TEMP (deg C)	FLOW RATE (m3/s)	CO CONC (%)	CO2 CONC (%)	O2 CONC (%)
0	6	4	3	1.28	-0.01	0.01	21
0.5	104	50	7	1.23	0.01	0.05	20.92
1	162	71	11	1.15	-0.01	0.15	20.83
1.5	283	104	15	1.17	0.01	0.25	20.74
2	424	140	23	1.16	-0.01	0.47	20.61
2.5	523	185	32	1.11	0.01	0.61	20.45
3	637	236	40	1.08	-0.01	0.83	20.33
3.5	632	267	46	1.02	0.01	1.24	20.06
4	592	270	49	1.01	-0.01	1.24	20.05
4.5	588	273	51	1.13	0	1.29	19.98
5	755	286	61	0.98	0	1.35	19.91
5.5	973	602	216	0.74	0.03	3.68	16.73
6	985	640	262	0.66	1.55	6.08	13.21
6.5	965	699	637	0.45	1.71	6.32	12.59

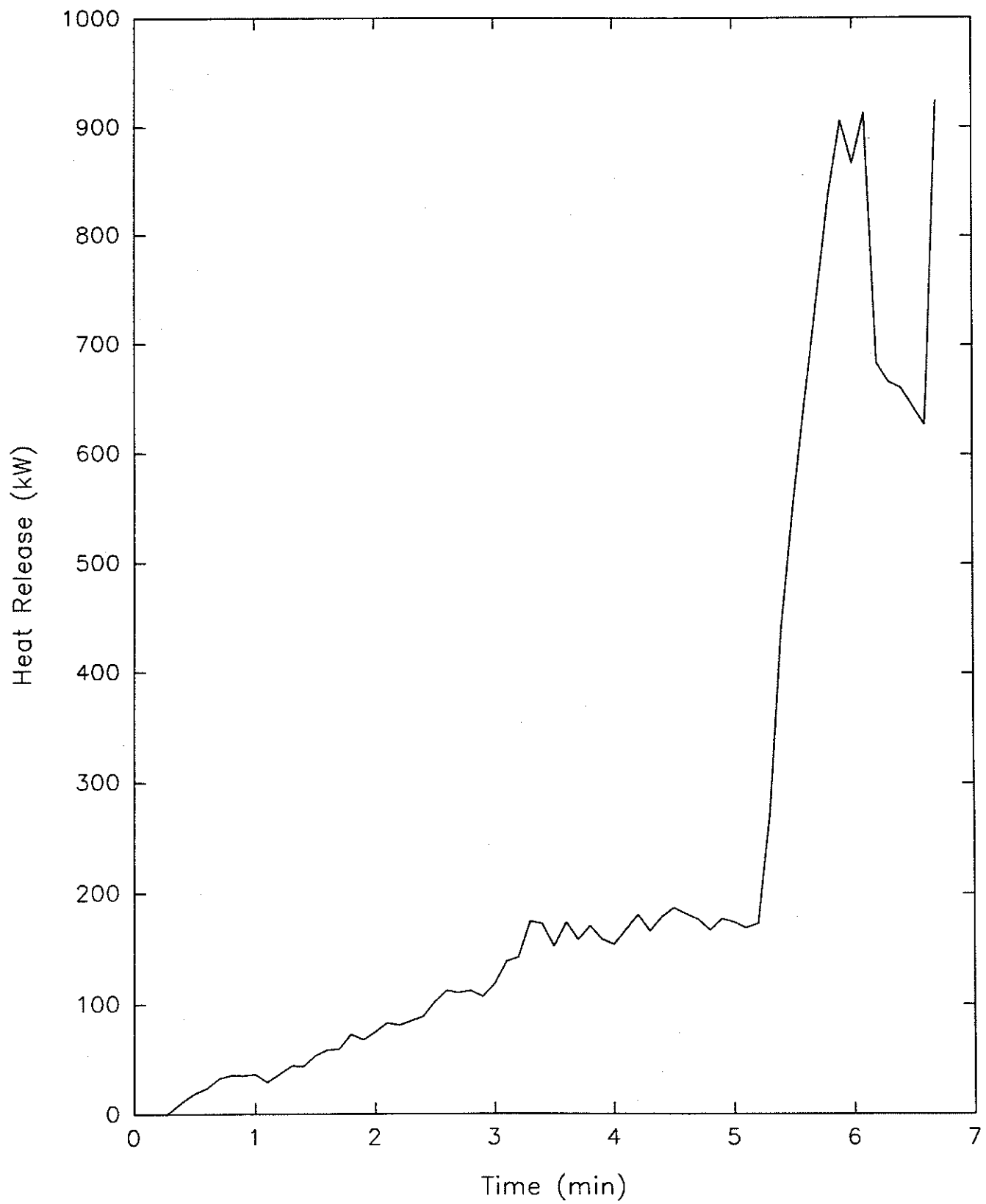


Figure L1 Heat Release Rate vs. Time  
12.3mm Particleboard

Feb. 22 1991

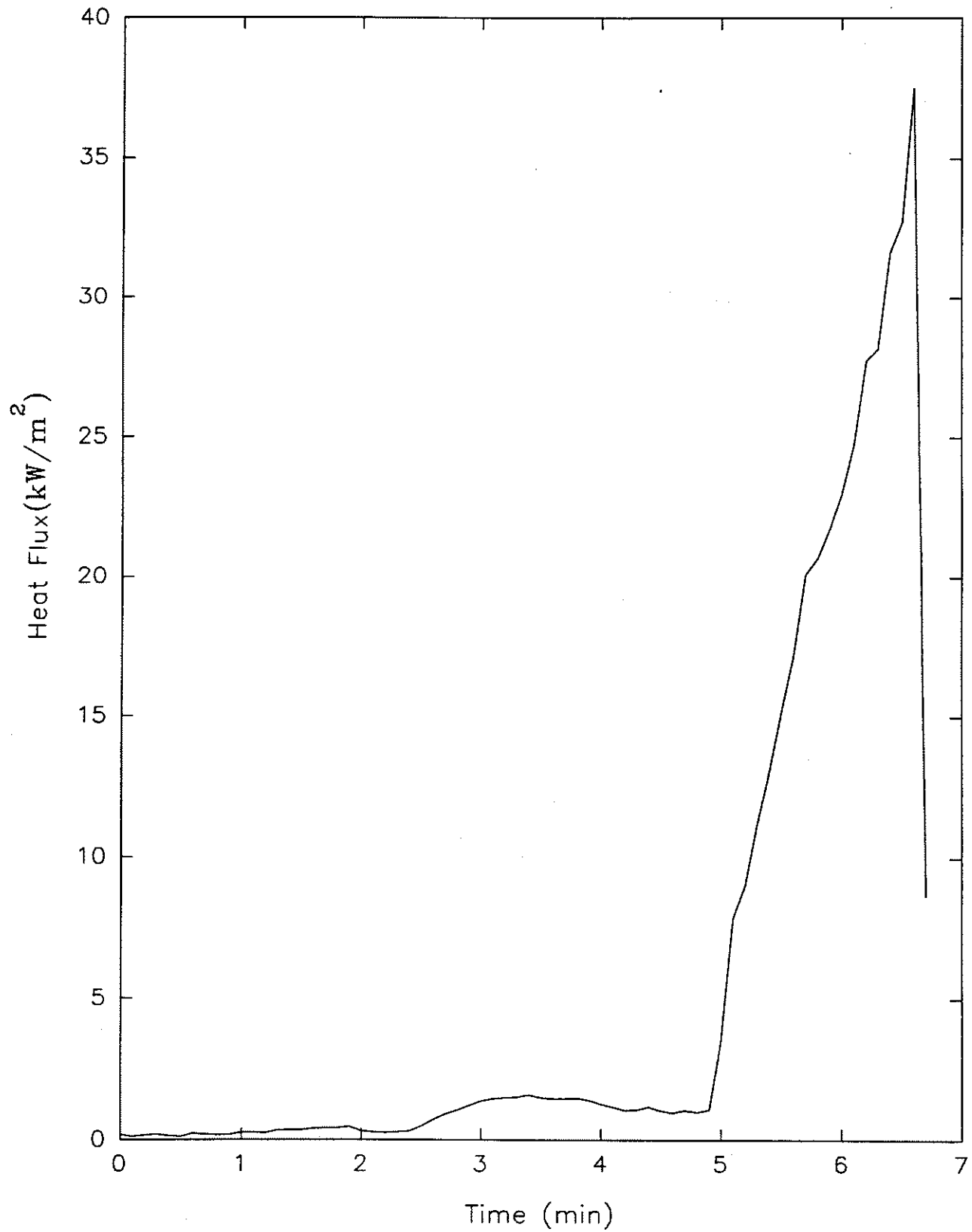


Figure L2 Heat Flux vs. Time  
12.3mm Particleboard

Feb. 22 1991

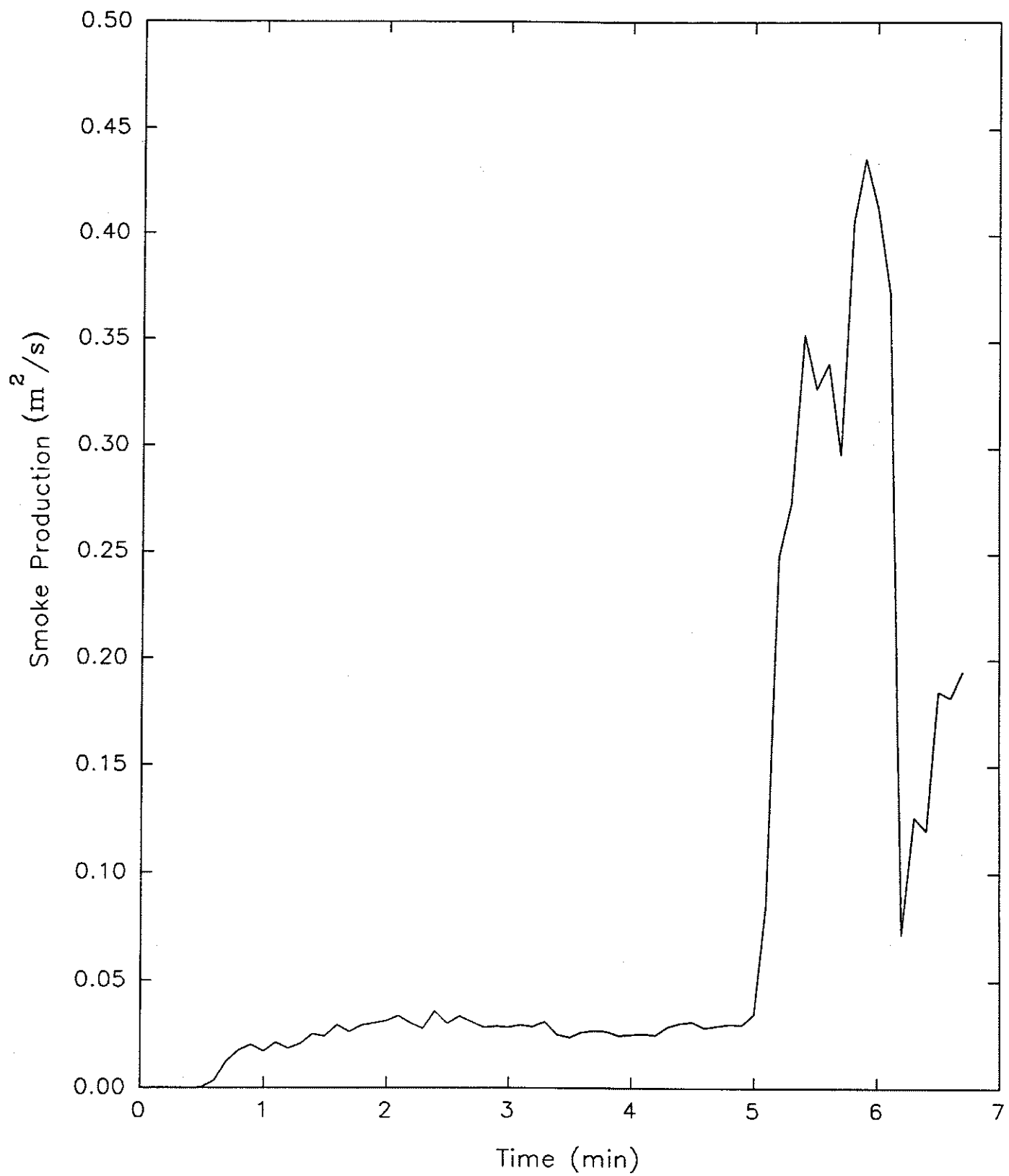


Figure L3 Rate of Smoke Production vs. Time  
12.3mm Particleboard

Feb. 22 1991

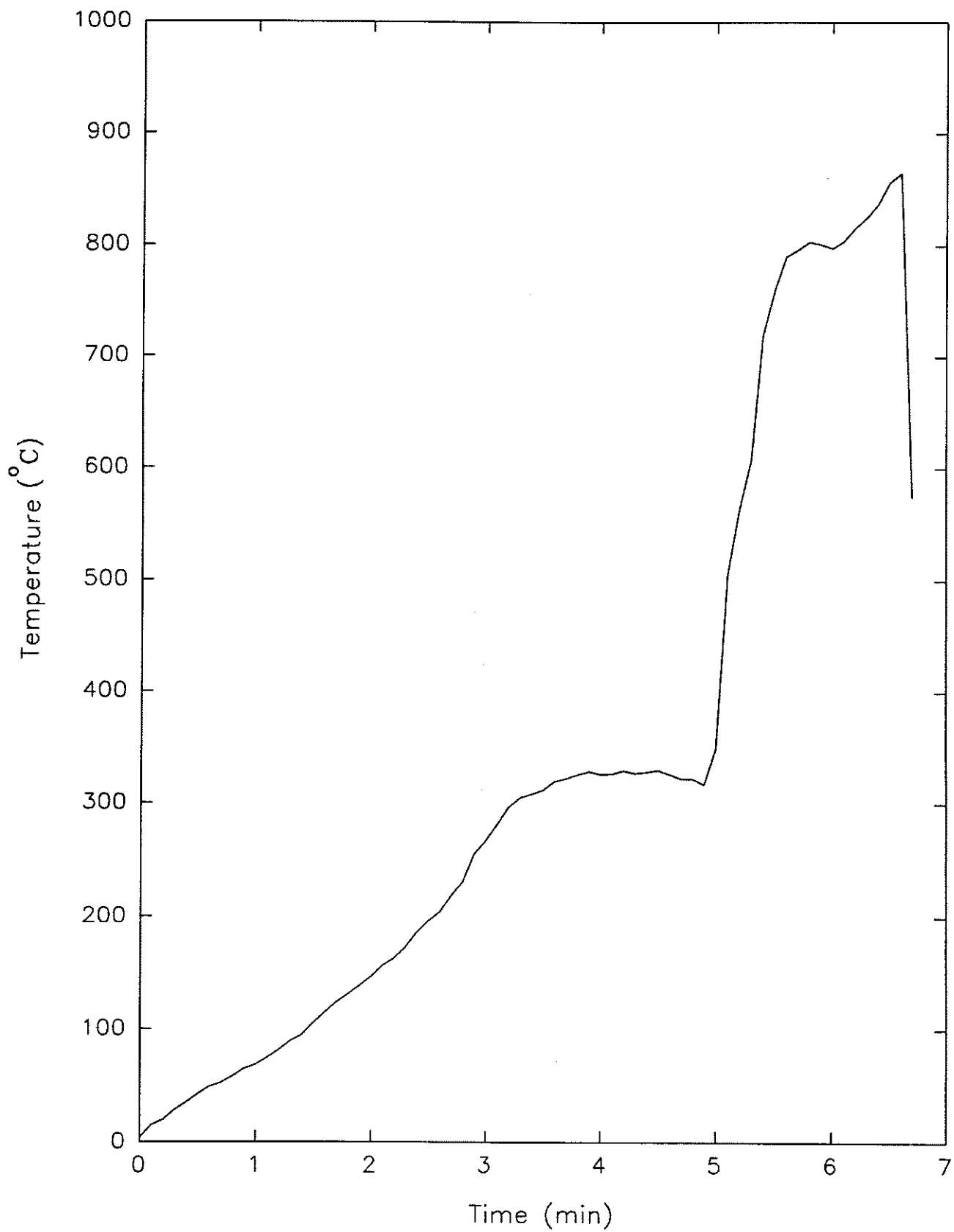


Figure L4 Temperature at the Centre of Ceiling vs. Time  
12.3mm Particleboard

Feb. 22 1991



## **APPENDIX M: 6 mm PLYWOOD**





## SUMMARY TABLE OF RESULTS

Item	Results
Test material	6 mm plywood
Test number	1
Date of test	March 25, 1991
Time to ignition of walls (left / right)	30 s / 30 s
Time at which 20 kW/m <sup>2</sup> reach at each radiometer	8 min 50 s / 8 min 50 s
Time at which paper targets ignite	9 min
Time of flame out of doorway	8 min 27 s
Maximum temperature at centre of room / time occurred	859°C / 9 min 50 s
Maximum temperature at the doorway / time occurred	661°C / 9 min 40 s
Time 600°C was obtained by TC at the centre of the room	8 min 5 s
Time 600°C was obtained by the TC at the doorway	9 min 20 s
Maximum instantaneous smoke produced / time occurred	0.18 OD / 9 min 10 s
Maximum instantaneous heat release / time occurred	1055 kW / 9 min 50 s

## VISUAL OBSERVATIONS OF THE TEST

Material: 6 mm Plywood

Date: March 25, 1991

Overall description of test and test material: Followed ASTM test procedures  
Fan speed started in high position  
Water spray applied at flashover time

### Observations of the test:

<u>Time (min:sec)</u>	<u>Observations</u>
0 : 00	Ignition of the sand burner (40 kW).
0 : 15	Flame height is 2 ft above the burner.
0 : 30	Both walls at the corner ignite.
0 : 45	Flame height is 4 ft above the burner. Flame front is 1 ft above the burner.
1 : 15	Flame height is 5 ft above the burner. Flame front is 2 ft above the burner.
1 : 30	Flame height is 6 ft above the burner. Flame front is 3 ft above the burner.
2 : 00	Flame tip reaches ceiling intermittently. Flame front is 5 ft above the burner.
2 : 30	Flame tip reaches ceiling steadily. Flame front is 6 ft above the burner.
3 : 00	Flame tip is reflected at the ceiling and runs along the ceiling/wall joint approximately 2 ft from the corner.
3 : 45	Flame tip reaches 3 ft along the ceiling/wall joint.
4 : 30	Flame tip reaches 4 ft along the joint.
5 : 00	Propane flow increased to 160 kW. Flame tip reaches 6 ft from the corner along the ceiling/wall joint.
5 : 30	Flame tip reaches the other side (8 ft from the corner in the backwall) along the ceiling/wall joint.
6 : 00	Light smoke is coming out through the doorway.
6 : 30	In the corner, the fire column is approximately 2 ft wide in diameter. Flame reaches the other side along the top of both walls. Room is filling with light smoke.
7 : 15	Room is filling with grey smoke. Grey smoke is coming out through the doorway. Top portion (approximately 1 ft wide from the ceiling) of both walls ignited.
7 : 30	Top portion of the backwall and side wall (near the burner side) is burning 3 ft wide from the ceiling down.
8 : 00	At the corner, plywood is charred and pieces of burning plywood are falling off to the floor.
8 : 30	Upper half of the backwall and sidewall are burning. Water spray in the exhaust duct was turned on.
8 : 45	Ceiling is full of black smoke and flame. Flame is coming out through the doorway intermittently. Black smoke is coming out steadily.
9 : 00	Both paper bundles on the floor ignite.

9 : 10      Steady flame is coming out the doorway.  
Canopy is filling with white smoke.  
Upper half of the room is filled with black smoke and flames.  
9 : 30      Smoke fills the canopy and spills over even with high fan speed.  
Steady flame is going into the canopy.  
9 : 45      Test terminated.

# Supplementary Data of the Test

**MATERIAL:** Plywood  
**DIMENSION (mm) :** 6  
**DATE TESTED:** March 25 1991

TIME (min)	CORNER TC (deg C)	DOOR TC (deg C)	DUCT TEMP (deg C)	FLOW RATE (m3/s)	CO CONC (%)	CO2 CONC (%)	O2 CONC (%)
0	N/A	7	5	2.4	0.01	0.01	21
0.5	N/A	41	7	2.39	0.01	0.03	20.99
1	N/A	72	9	2.46	0.01	0.1	20.93
1.5	N/A	100	12	2.44	0.01	0.16	20.9
2	N/A	132	14	2.48	0.01	0.27	20.84
2.5	N/A	153	16	2.3	0.01	0.36	20.8
3	N/A	176	18	2.4	0.01	0.39	20.76
3.5	N/A	209	20	2.43	0	0.5	20.7
4	N/A	240	23	2.15	0	0.62	20.64
4.5	N/A	255	26	2.31	0	0.7	20.58
5	N/A	272	26	2.3	0	0.75	20.58
5.5	N/A	348	44	2.04	0	1.35	20.16
6	N/A	366	50	2.12	0	1.42	20.08
6.5	N/A	385	53	2.06	-0.01	1.69	20.03
7	N/A	387	58	2.08	-0.01	1.6	19.97
7.5	N/A	415	55	2.08	-0.02	1.82	19.88
8	N/A	408	65	2.11	-0.02	1.72	19.8
8.5	N/A	483	90	1.88	-0.03	1.84	19.56
9	N/A	585	205	1.43	-0.09	4.44	17.2
9.5	N/A	651	378	1.13	-0.1	5.9	16.22

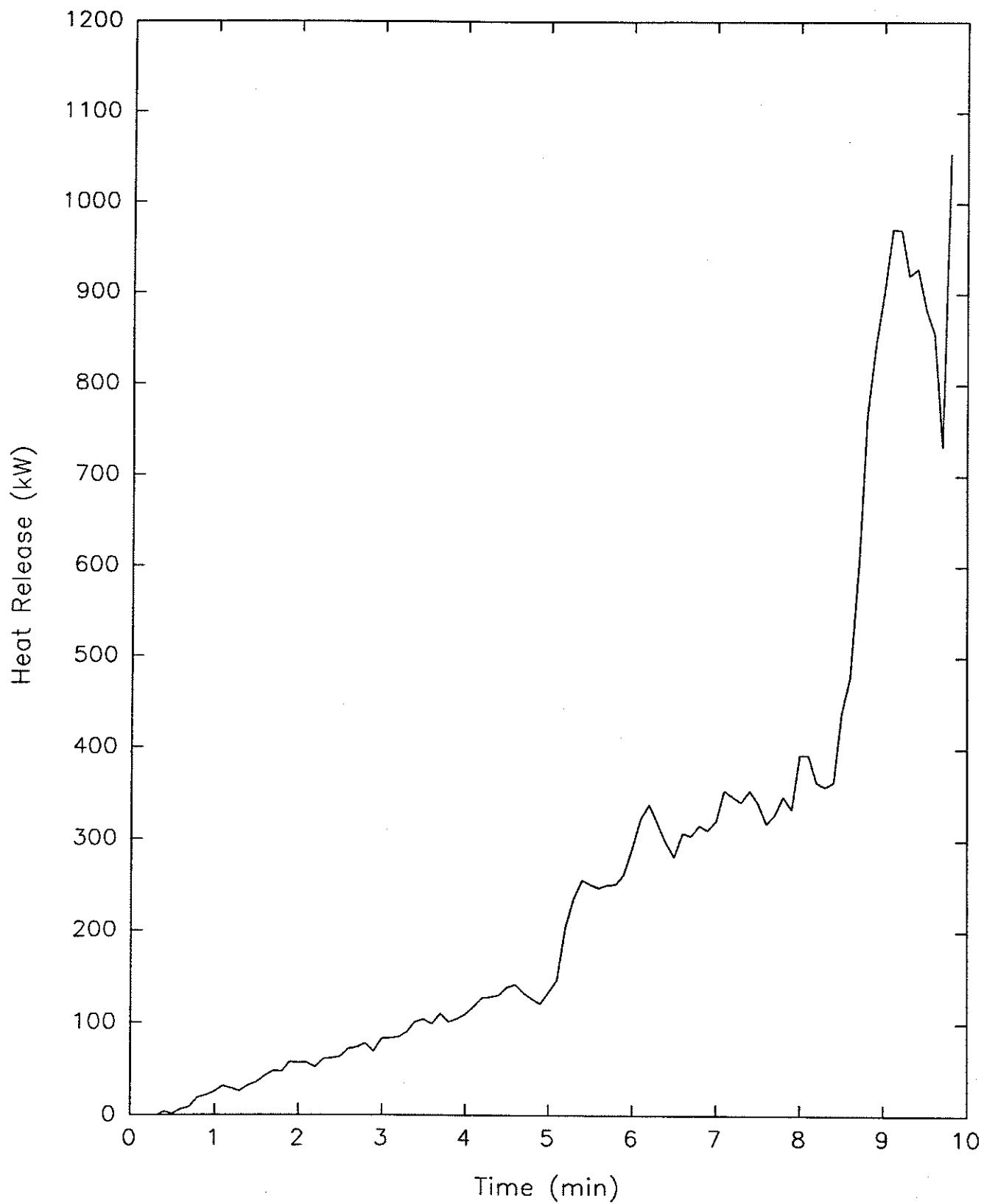


Figure M1 Heat Release Rate vs. Time

6mm Plywood

March 25 1991

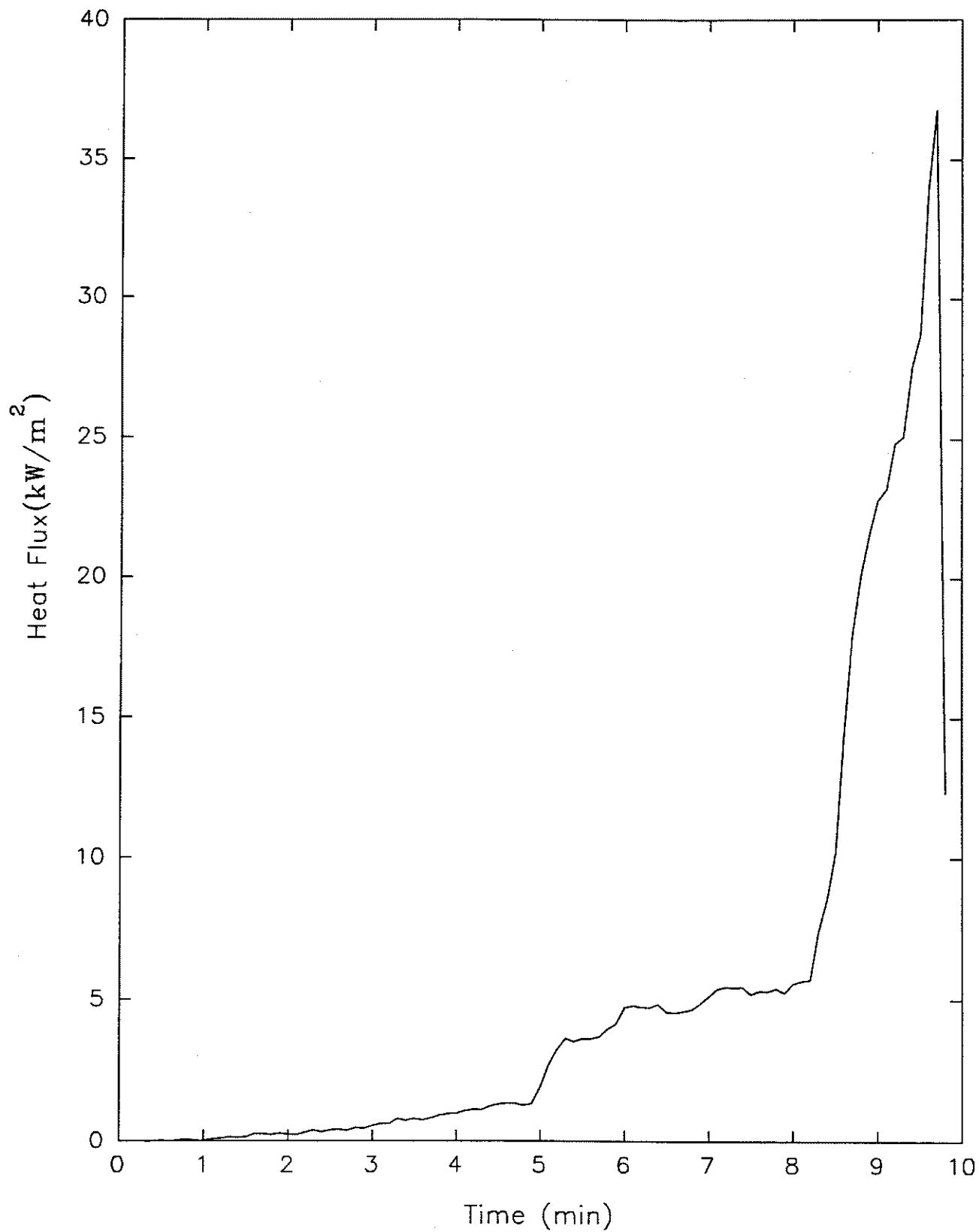


Figure M2 Heat Flux vs. Time  
6mm Plywood

March 25 1991

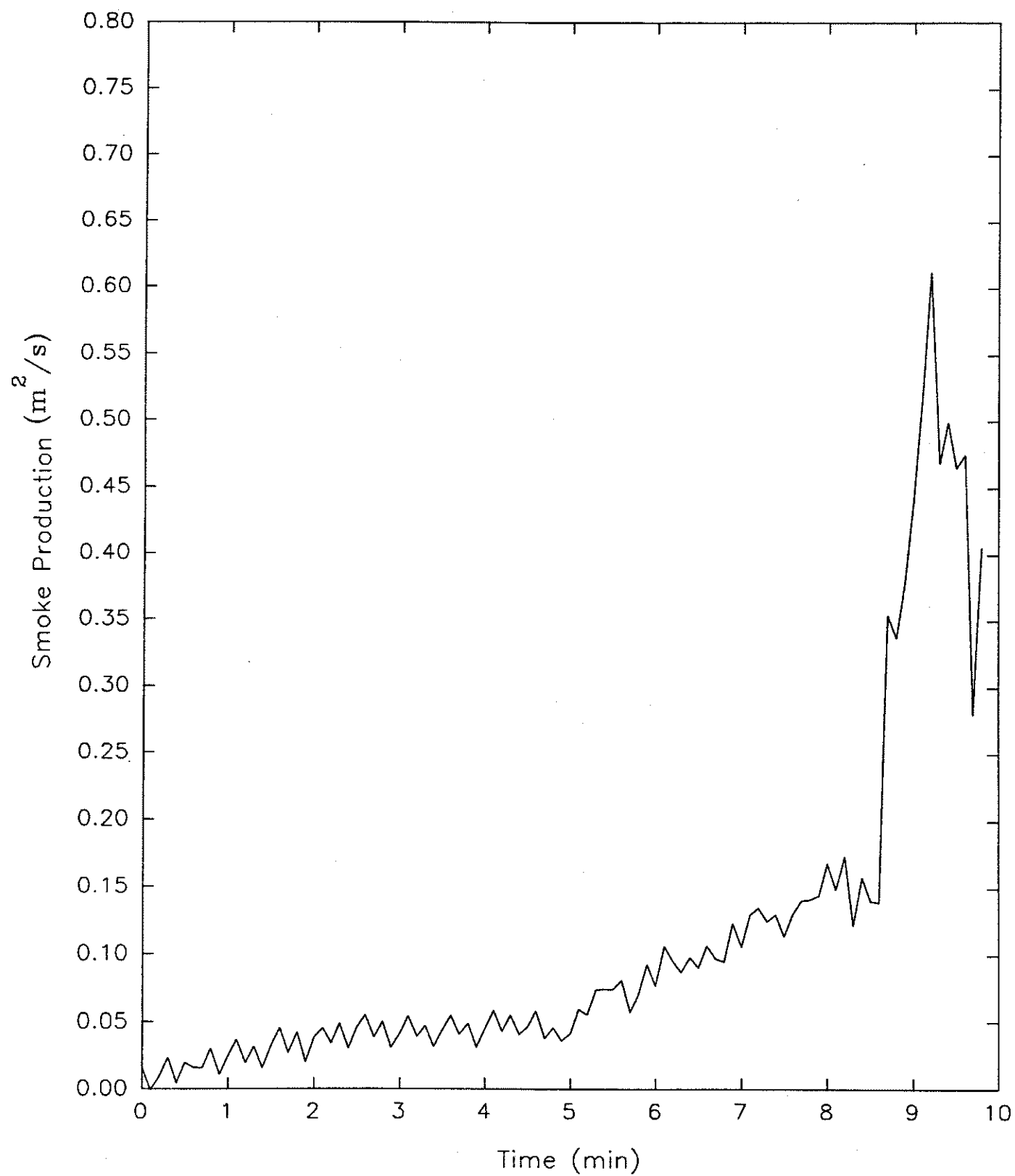


Figure M3 Rate of Smoke Production vs. Time  
6mm Plywood

March 25 1991



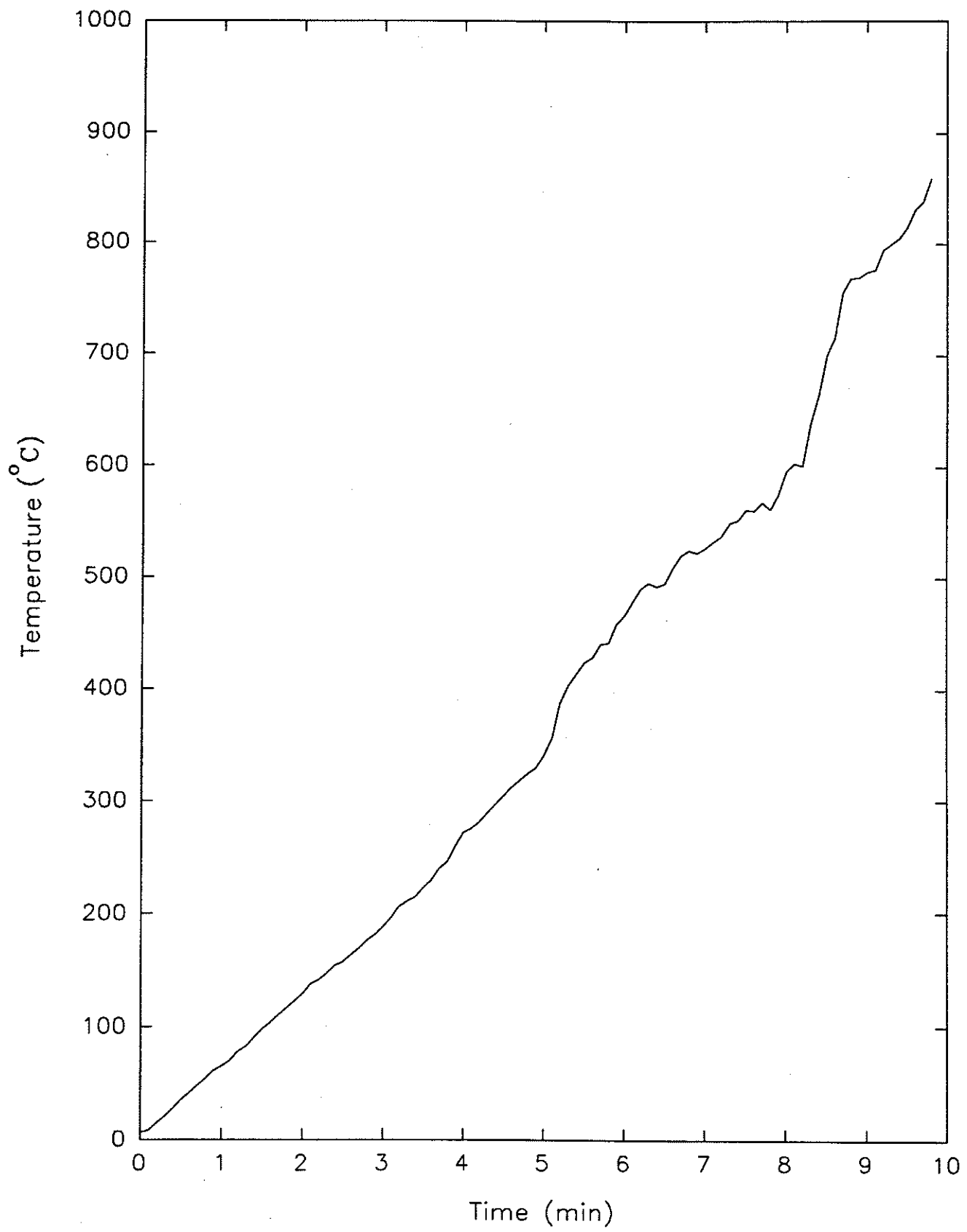


Figure M4 Temperature at the Centre of Ceiling vs. Time  
6mm Plywood

March 25 1991

**APPENDIX N: 12.3 mm PLYWOOD**



## SUMMARY TABLE OF RESULTS

Item	Results
Test material	12.3 mm plywood
Test number	1
Date of test	April 8, 1991
Time to ignition of walls (left / right)	30 s / 30 s
Time at which 20 kW/m <sup>2</sup> reach at each radiometer	9 min / 9 min
Time at which paper targets ignite	9 min
Time of flame out of doorway	8 min 27 s
Maximum temperature at centre of room / time occurred	835°C / 9 min 30 s
Maximum temperature at the doorway / time occurred	710°C / 9 min 30 s
Time 600°C was obtained by TC at the centre of the room	8 min 25 s
Time 600°C was obtained by the TC at the doorway	9 min 5 s
Maximum instantaneous smoke produced / time occurred	0.13 OD / 9 min 30 s
Maximum instantaneous heat release / time occurred	941 kW / 9 min 20 s

## VISUAL OBSERVATIONS OF THE TEST

Material: 12.3 mm Plywood

Date: April 8, 1991

Overall description of test and test material: Followed ASTM test procedures  
Fan speed started in high position  
Water spray applied at flashover time

### Observations of the test:

<u>Time (min:sec)</u>	<u>Observations</u>
0 : 00	Ignition of the sand burner (40 kW).
0 : 25	Both walls at the corner ignite.
1 : 00	Flame height is 6 ft above the burner. Flame front reaches 2 ft above the burner.
1 : 30	Flame tip reaches ceiling intermittently. Flame front is 4 ft above the burner.
2 : 10	Flame tip reaches ceiling steadily. Flame front is 6 ft above the burner.
2 : 30	Flame tip is reflected at the ceiling and runs along the ceiling/wall joint approximately 2 ft from the corner.
3 : 00	Flame tip runs along the ceiling/wall joint approximately 3 ft from the corner.
3 : 30	Flame front (charred surface) runs along the corner to the ceiling and runs along the ceiling/wall joint approximately 3 ft from the corner.
4 : 00	Flame is receding. Flame mostly along the corner and some flame present on the charred surface at the ceiling/wall joint.
4 : 30	Flame is further receding. Flame is confined to the corner barely reaching the ceiling.
5 : 00	Propane flow increased to 0.112 m <sup>2</sup> /min (160 kW). Flame is very strong and runs along the corner and reflected and runs along the ceiling/wall joint approximately 6 ft from the corner.
5 : 20	Flame runs along the ceiling/wall joint all the way to the other side (8 ft from the corner). Smoke is starting to come out through the doorway.
5 : 30	Smoke layer is 3 ft in the room.
7 : 30	Flame is progressing downward on the sidewall from the top approximately 2 ft down from the top.
8 : 50	Water spray in the exhaust duct was turned on. Flame is progressing along the ceiling.
8 : 55	Flame starts to come out through the doorway. Ceiling is filled with dark smoke and flame (4 ft deep)
9 : 10	Both paper bundles ignited. Steady flame is coming out through the doorway. Upper half of the room is filled with dark smoke and flame.
9 : 30	Some smoke is spilling over the canopy. Steady flame is going into the canopy. Test terminated.

# Supplementary Data of the Test

**MATERIAL:** Plwood  
**DIMENSION (mm) :** 12.3  
**DATE TESTED:** April 8 1991

TIME (min)	CORNER TC (deg C)	DOOR TC (deg C)	DUCT TEMP (deg C)	FLOW RATE (m3/s)	CO CONC (%)	CO2 CONC (%)	O2 CONC (%)
0	32	20	20	2.3	0	-0.01	20.98
0.5	128	61	22	2.32	0	0.01	20.95
1	203	88	25	2.34	0	0.07	20.89
1.5	292	117	27	2.22	0	0.15	20.84
2	415	150	29	2.21	0	0.22	20.8
2.5	504	190	30	2.21	0	0.31	20.74
3	625	223	35	2.26	0	0.41	20.66
3.5	600	242	37	2.08	0	0.48	20.64
4	547	227	35	2.21	0	0.51	20.66
4.5	479	202	33	2.19	0	0.4	20.71
5	573	179	35	2.19	0	0.33	20.65
5.5	897	373	68	1.98	0	1.11	19.88
6	921	408	76	1.95	0	1.46	19.65
6.5	927	436	77	1.86	0	1.56	19.7
7	933	424	84	1.93	0	1.47	19.65
7.5	926	438	86	1.87	0	1.53	19.64
8	945	423	82	1.9	0	1.42	19.67
8.5	947	439	89	1.83	0	1.49	19.54
9	997	578	188	1.48	0	2.01	17.9
9.5	970	710	681	0.81	0	6.05	N / A

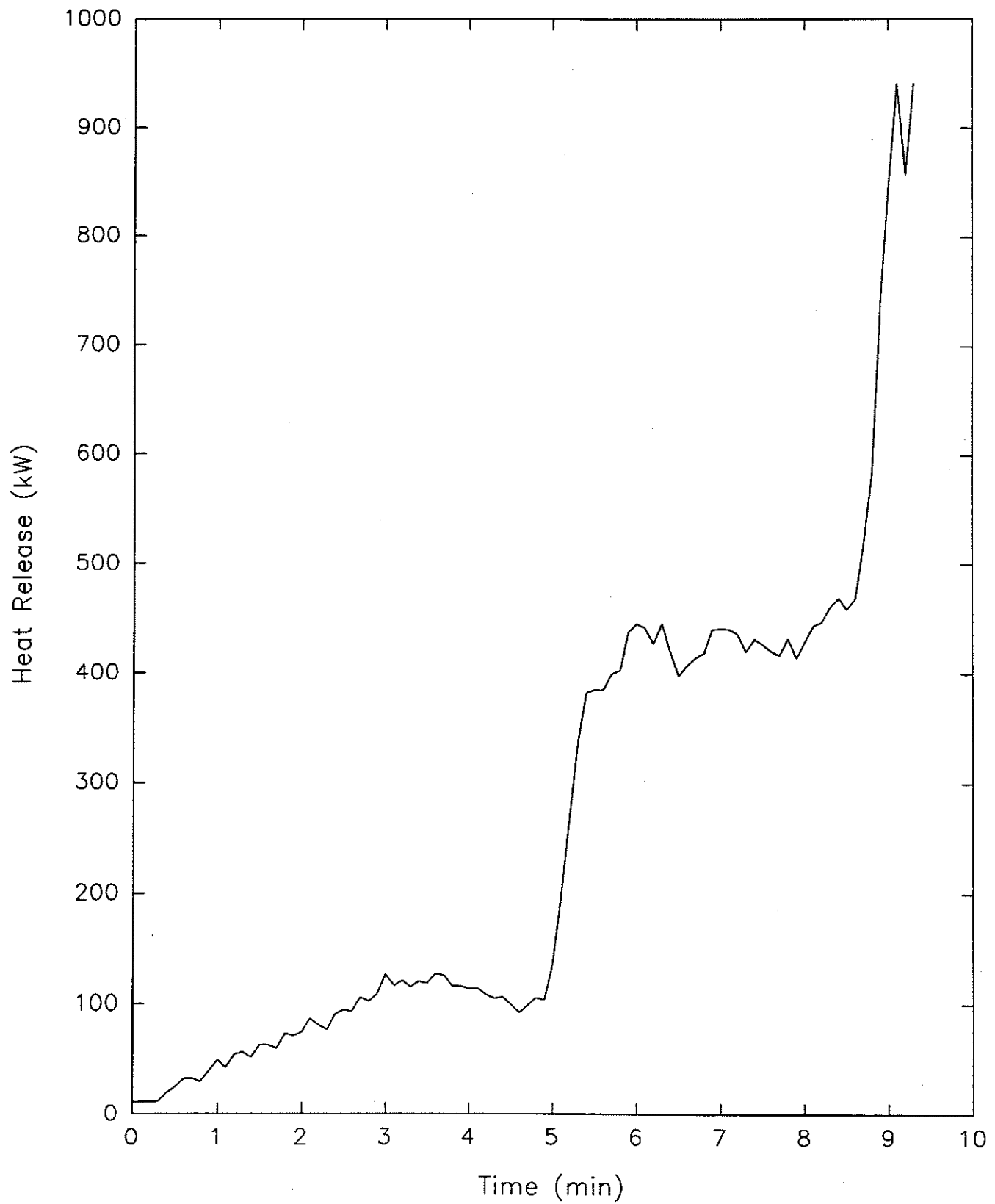


Figure N1 Heat Release Rate vs. Time

12.3mm Plywood

April 8 1991

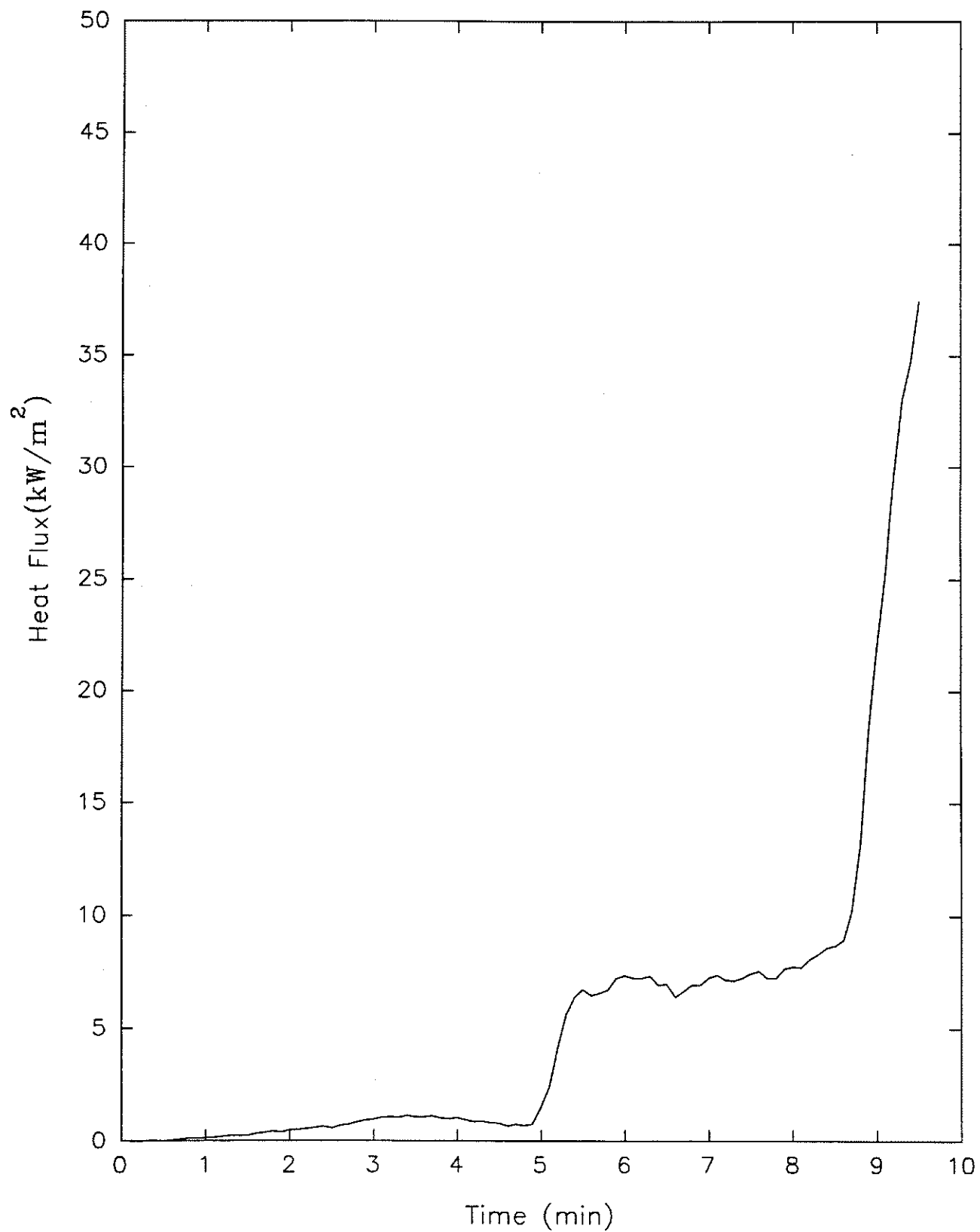


Figure N2 Heat Flux vs. Time  
12.3mm Plywood

April 8 1991



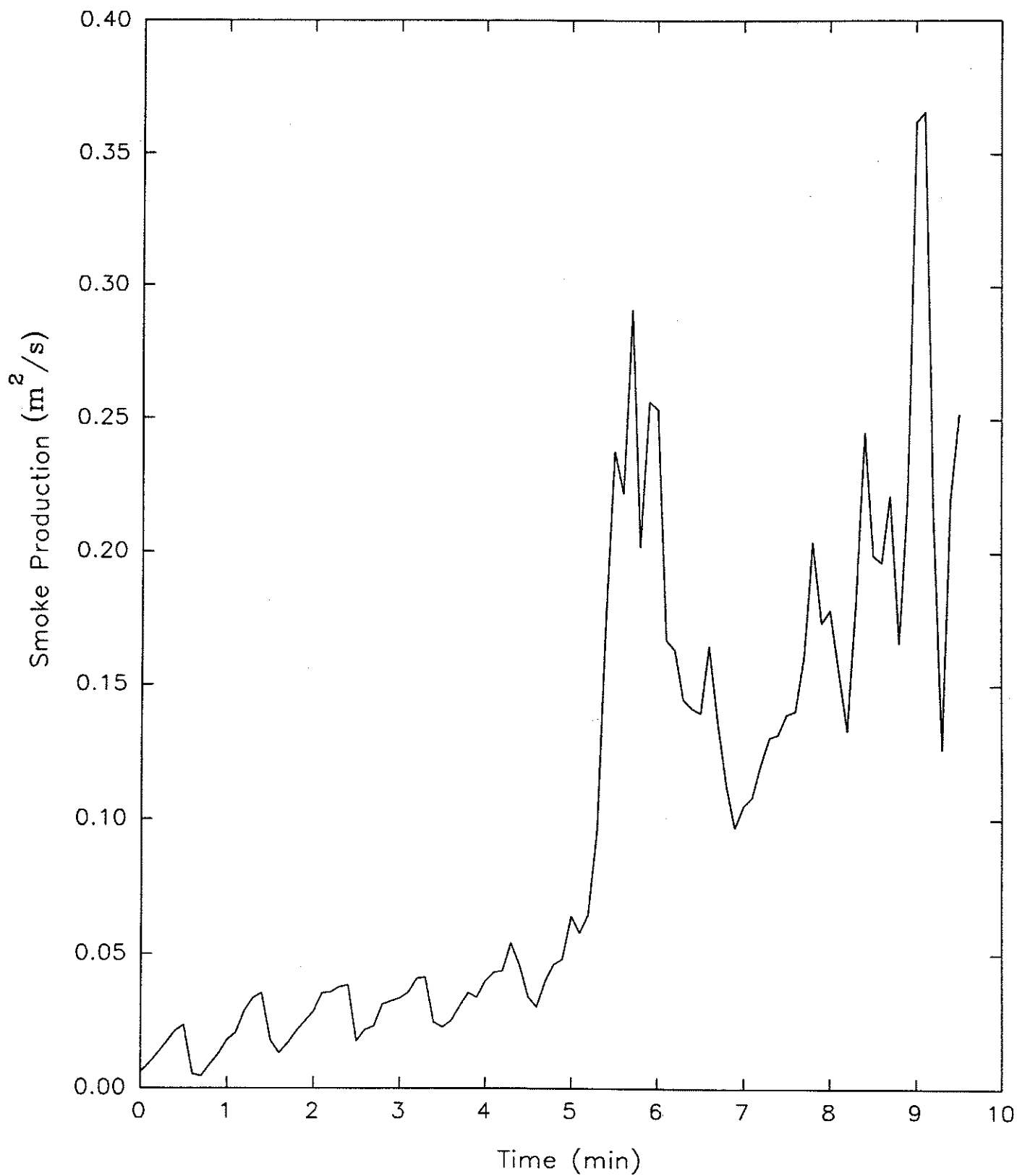


Figure N3 Rate of Smoke Production vs. Time  
12.3mm Plywood

April 8 1991

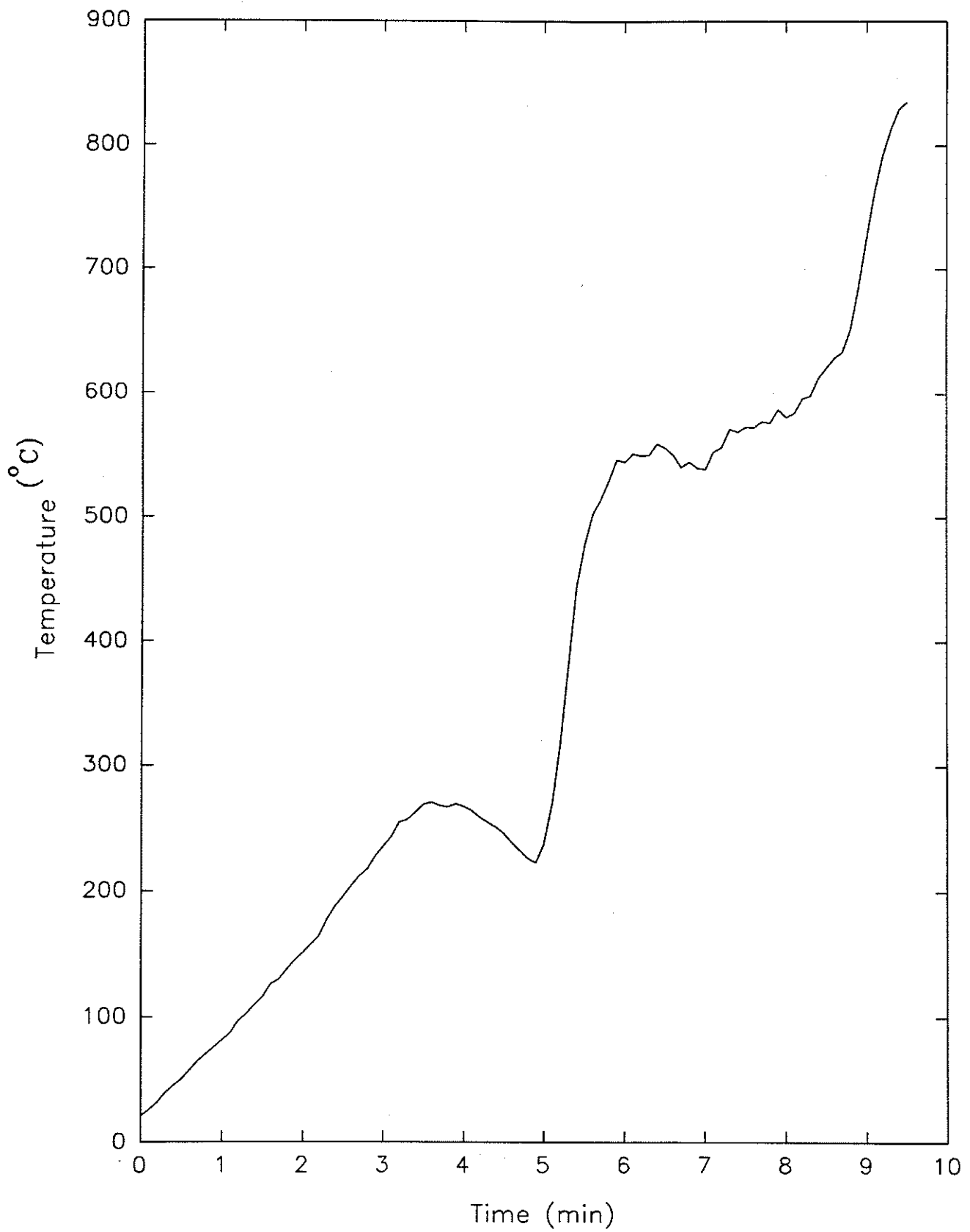


Figure N4 Temperature at the Centre of Ceiling vs. Time  
12.3mm Plywood

April 8 1991



## **APPENDIX O: 40 mm POLYURETHANE WITH FOIL**



## SUMMARY TABLE OF RESULTS

Item	Results
Test material	40 mm polyurethane with foil
Test number	1
Date of test	April 30, 1991
Time to ignition of walls (left / right)	15 s / 15 s
Time at which 20 kW/m <sup>2</sup> reach at each radiometer	DNO
Time at which paper targets ignite	DNO
Time of flame out of doorway	DNO
Maximum temperature at centre of room / time occurred	366°C / 12 min 5 s
Maximum temperature at the doorway / time occurred	310°C / 12 min 10 s
Time 600°C was obtained by TC at the centre of the room	DNO
Time 600°C was obtained by the TC at the doorway	DNO
Maximum instantaneous smoke produced / time occurred	0.11 OD / 5 min 25 s
Maximum instantaneous heat release / time occurred	219 kW / 5 min 35 s

DNO - Did not occur

## VISUAL OBSERVATIONS OF THE TEST

Material: 40 mm Polyurethane with foil covering

Date: April 30, 1991

Temperature: 59°F

Relative Humidity: 82%

Overall description of test and test material: Followed ASTM test procedures  
Fan speed started in high position

### Observations of the test:

<u>Time (min:sec)</u>	<u>Observations</u>
0 : 00	Ignition of the sand burner (40 kW).
0 : 15	Test sample ignited on both sides of the corner. Flame height is approximately 4 ft above the burner.
0 : 40	Ceiling is filled with grey smoke. Smoke layer is approximately 2 ft deep.
1 : 15	Flame height is 4 ft above the burner. Smoke layer is approximately 3 ft deep. Flame front is approximately 3 ft above the burner.
1 : 30	Light smoke is coming out through the doorway in small quantities.
3 : 00	Condition steady.
3 : 30	Flame front is approximately 4 ft above the burner. Flame height is approximately 5 ft above the burner.
5 : 00	Propane flow increased to 160 kW. Flame reaches ceiling and reflected at the ceiling and runs 2-3 ft along the ceiling/wall joint. Black smoke is produced. Ceiling filled with black smoke. Black smoke is coming out through the doorway. Smoke layer in the ceiling is 4 ft deep.
5 : 30	Flame reaches ceiling. Samples at the corner burning well.
6 : 00	Flame condition steady. Smoke layer changed from black smoke to dark grey smoke.
6 : 30	Flame condition steady. Room is filled with light smoke and no clear smoke layer exists.
8 : 00	Condition steady.
10 : 00	Flame condition steady. Room is clear of smoke. No smoke layer in the ceiling.
12 : 00	Condition steady. Sample is burning at the corner but not feeding the flame to spread.
15 : 00	Ignition is shut off. No flame visible in the room. Flashover not reached during the test period. Aluminum foil burned off at the corner approximately 1 ft wide all the way to the ceiling and polyurethane underneath is burned and charred. Other area (except in the corner) has aluminum foil in place and not damaged. Test terminated.

# Supplementary Data of the Test

**MATERIAL:** Polyurethane with foil  
**DIMENSION (mm) :** 40  
**DATE TESTED:** April 30 1991

TIME (min)	CORNER TC (deg C)	DOOR TC (deg C)	DUCT TEMP (deg C)	FLOW RATE (m3/s)	CO CONC (%)	CO2 CONC (%)	O2 CONC (%)
0	38	31	17	2.25	0	0.01	20.98
0.5	134	68	19	2.36	0	0.04	20.94
1	177	96	22	2.29	0.01	0.1	20.93
1.5	178	103	22	2.31	0.01	0.12	20.9
2	188	104	23	2.32	0.01	0.12	20.89
2.5	212	110	23	2.33	0.01	0.12	20.88
3	211	111	23	2.31	0.01	0.13	20.87
3.5	226	114	24	2.2	0.01	0.13	20.88
4	227	119	24	2.24	0.01	0.14	20.86
4.5	229	117	24	2.3	0.01	0.14	20.88
5	513	133	28	2.14	0.01	0.14	20.86
5.5	905	292	45	2.14	0.06	0.7	20.39
6	869	291	45	2.14	0.05	0.62	20.43
6.5	910	301	47	2.1	0.04	0.58	20.45
7	899	293	47	2.13	0.04	0.62	20.43
7.5	868	301	48	2.08	0.03	0.56	20.42
8	904	289	47	2.1	0.03	0.54	20.47
8.5	888	296	49	2.07	0.03	0.56	20.44
9	878	291	50	2.09	0.03	0.55	20.45
9.5	881	304	49	2.08	0.03	0.55	20.49
10	866	288	49	2.1	0.03	0.56	20.46
10.5	890	302	48	2.06	0.03	0.52	20.47
11	883	294	49	2.12	0.03	0.53	20.48
11.5	852	295	51	2.09	0.03	0.54	20.47
12	899	305	48	2.06	0.03	0.5	20.49
12.5	896	300	50	2.04	0.03	0.51	20.47
13	858	286	52	2.11	0.03	0.5	20.49
13.5	880	295	49	2.1	0.03	0.52	20.47
14	866	296	50	2.12	0.03	0.51	20.48
14.5	853	306	51	2.02	0.03	0.59	20.45
15	829	303	50	2.08	0.03	0.49	20.48



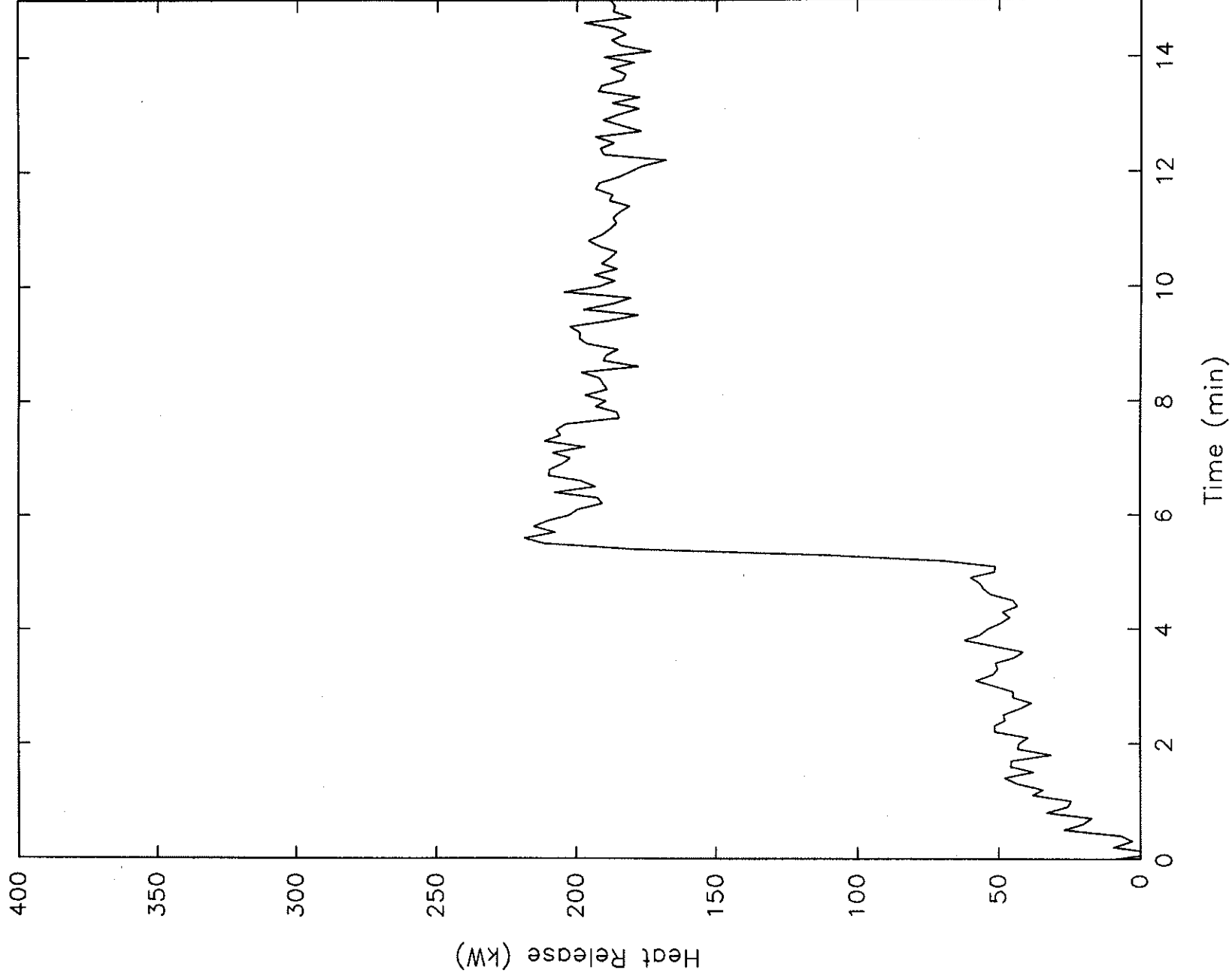


Figure 01 Heat Release Rate vs. Time

40mm Polyurethane with foil

April 30 1991

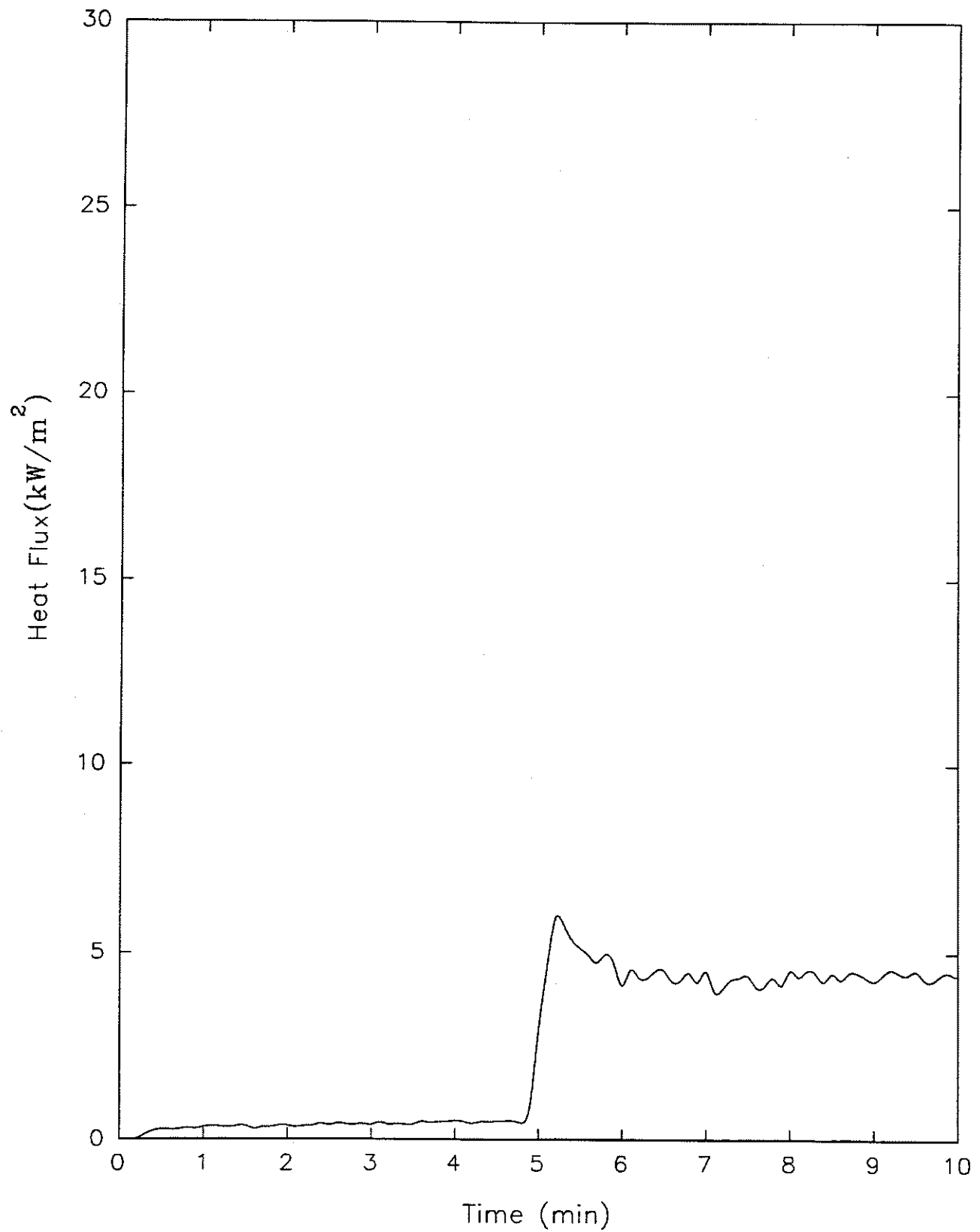


Figure 02 Heat Flux vs. Time  
40mm Polyurethane with foil

April 30 1991

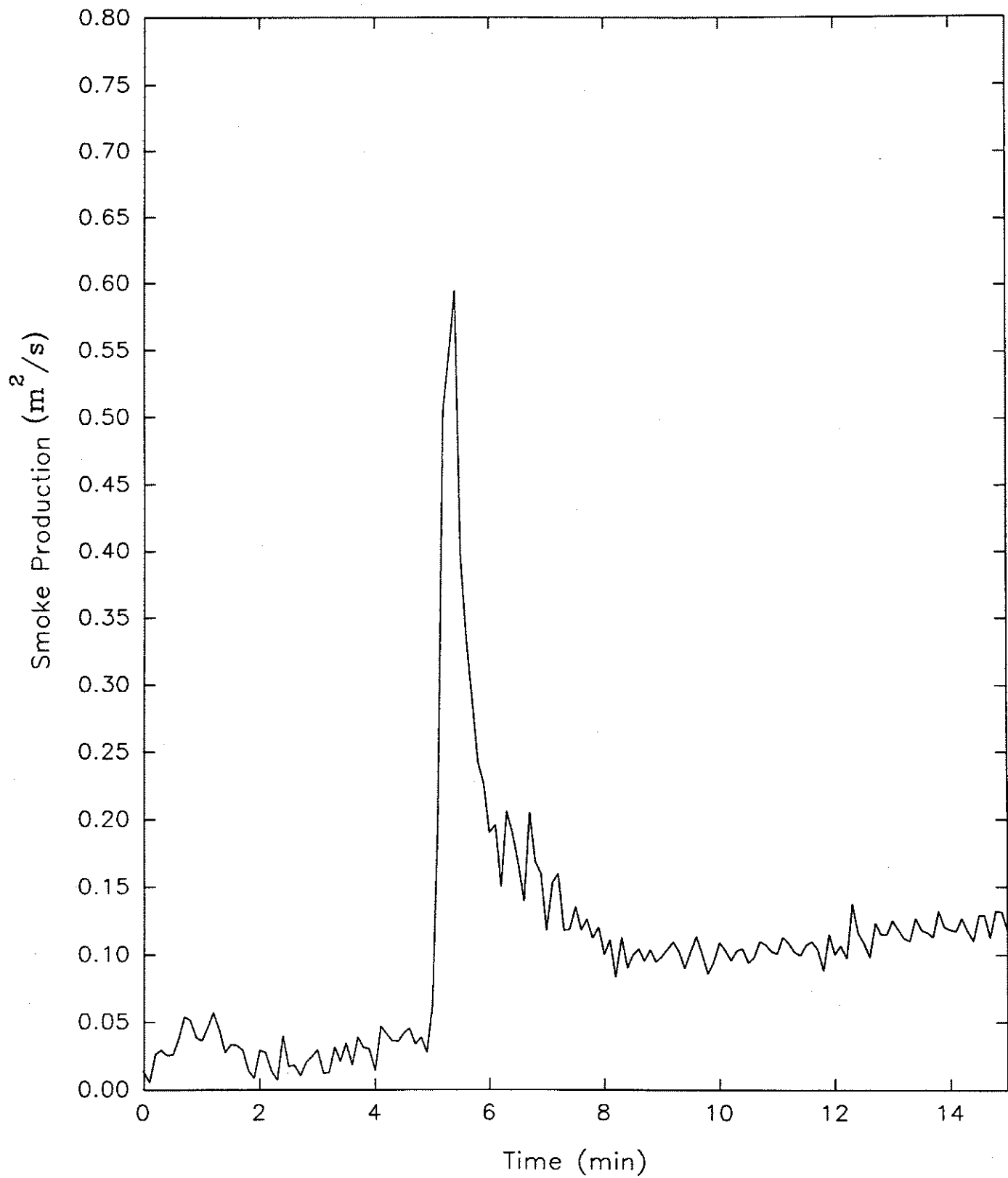


Figure 03 Rate of Smoke Production vs. Time  
40mm Polyurethane with foil

April 30 1991

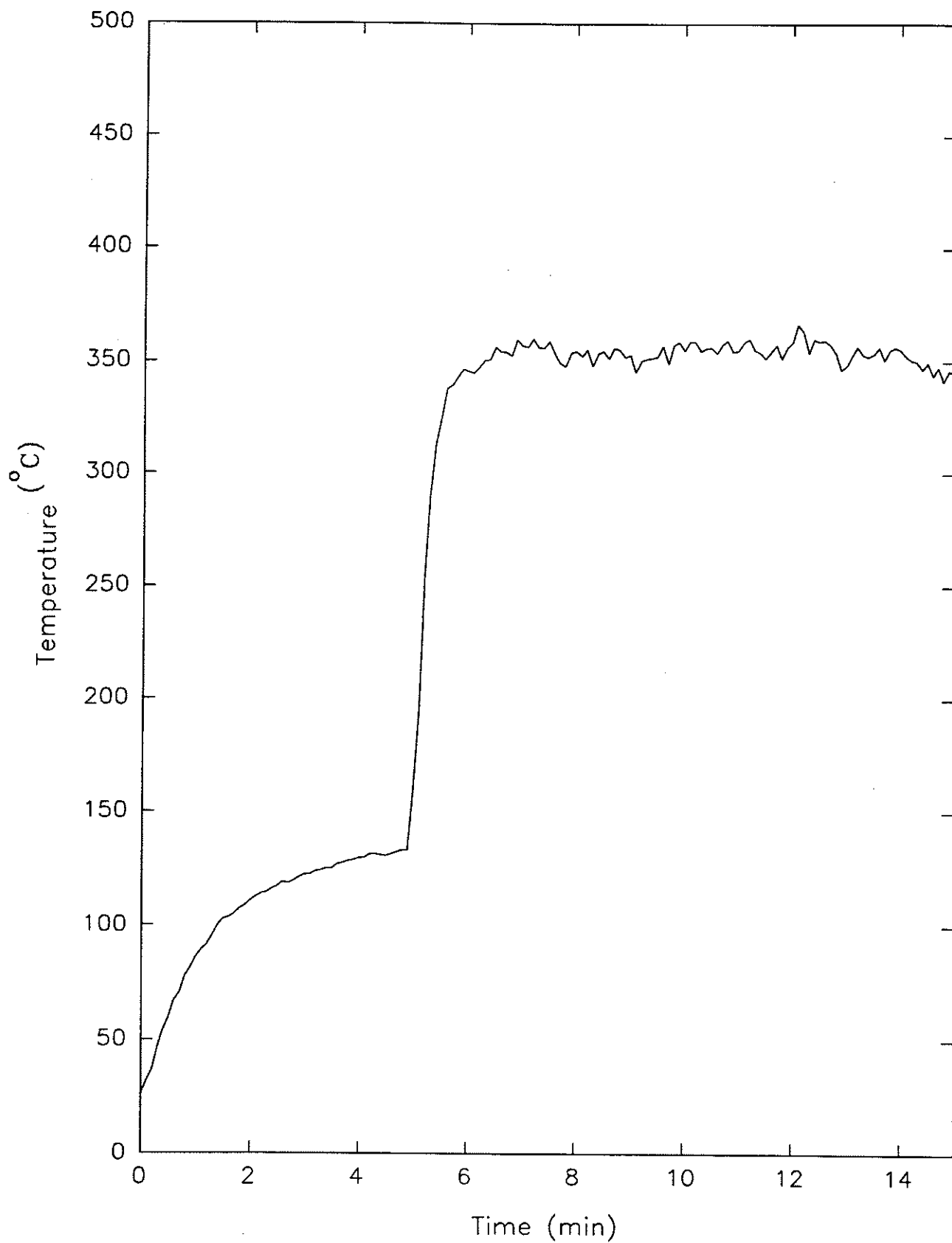


Figure 04 Temperature at the Centre of Ceiling vs. Time  
40mm Polyurethane with foil

April 30 1991



**APPENDIX P: 6 mm CHIPBOARD**



## SUMMARY TABLE OF RESULTS

Item	Results
Test material	6 mm chipboard
Test number	1
Date of test	May 7, 1991
Time to ignition of walls (left / right)	20 s / 40 s
Time at which 20 kW/m <sup>2</sup> reach at each radiometer	4 min 25 s / 4 min 25 s
Time at which paper targets ignite	4 min 35 s
Time of flame out of doorway	4 min 15 s
Maximum temperature at centre of room / time occurred	825°C / 5 min
Maximum temperature at the doorway / time occurred	686°C / 5 min 10 s
Time 600°C was obtained by TC at the centre of the room	4 min 10 s
Time 600°C was obtained by the TC at the doorway	4 min 10 s
Maximum instantaneous smoke produced / time occurred	0.26 OD / 4 min 40 s
Maximum instantaneous heat release / time occurred	1908 kW / 4 min 55 s



## VISUAL OBSERVATIONS OF THE TEST

Material: 6 mm Chipboard

Date: May 7, 1991

Temperature: 60°F

Relative Humidity: 49%

Overall description of test and test material: Followed ASTM test procedures

Observations of the test:

<u>Time (min:sec)</u>	<u>Observations</u>
0 : 00	Ignition of the sand burner (40 kW)
0 : 20	One side of the corner wall ignites.
0 : 40	Other side of the corner wall ignites.
0 : 45	Flame front reaches 2 ft above the burner. Flame tip reaches 5 ft above the burner.
1 : 15	Flame tip reaches ceiling.
2 : 00	Flame front reaches ceiling. Flame tip is reflected at the ceiling and runs along the ceiling/wall joint 4 ft from the corner.
2 : 45	Flame tip reaches other side of the wall running along the ceiling/wall joint (8 ft from the corner).
3 : 15	Flame front (charred portion) is 1.5 ft wide along the corner all the way to the ceiling and runs along the ceiling/wall joint approximately 1 ft down from the ceiling all the way to the other side.
3 : 45	Light smoke coming out through the doorway.
4 : 10	Flame starts to run along the ceiling. Dark smoke layer in the ceiling 3 ft deep.
4 : 20	Ceiling is filled with dark smoke and flame.
4 : 25	Flame starts to come out through the doorway. Dark smoke and flame mixture layer in the ceiling is 3 ft deep.
4 : 35	First paper bundle ignites.
4 : 45	Steady flame is coming out through the doorway. Dark smoke coming out the doorway. Upper half of the room (4 ft deep) is filled with black smoke and flames.
5 : 00	Second paper bundle ignites. Steady flames and black smoke coming out.
5 : 10	Steady flames coming out the doorway. Black smoke coming out the doorway and spills over the canopy hood.
5 : 15	Test terminated.

# Supplementary Data of the Test

**MATERIAL:** Chipboard  
**DIMENSION (mm) :** 6  
**DATE TESTED:** May 7 1991

TIME (min)	CORNER TC (deg C)	DOOR TC (deg C)	DUCT TEMP (deg C)	FLOW RATE (m3/s)	CO CONC (%)	CO2 CONC (%)	O2 CONC (%)
0	75	49	17	2.31	0	0.05	20.83
0.5	130	66	17	2.28	0	0.07	20.83
1	213	94	18	2.38	0	0.11	20.79
1.5	371	137	22	2.27	0.01	0.23	20.7
2	607	208	28	2.24	0.01	0.39	20.56
2.5	692	287	36	2.18	0.02	0.71	20.34
3	706	333	43	2.12	0.03	0.94	20.12
3.5	739	372	53	2.05	0.1	1.3	19.91
4	790	434	64	1.96	0.15	1.58	19.5
4.5	982	608	210	1.39	0.79	3.46	15.4
5	900	624	731	0.72	1.34	7.2	7.59

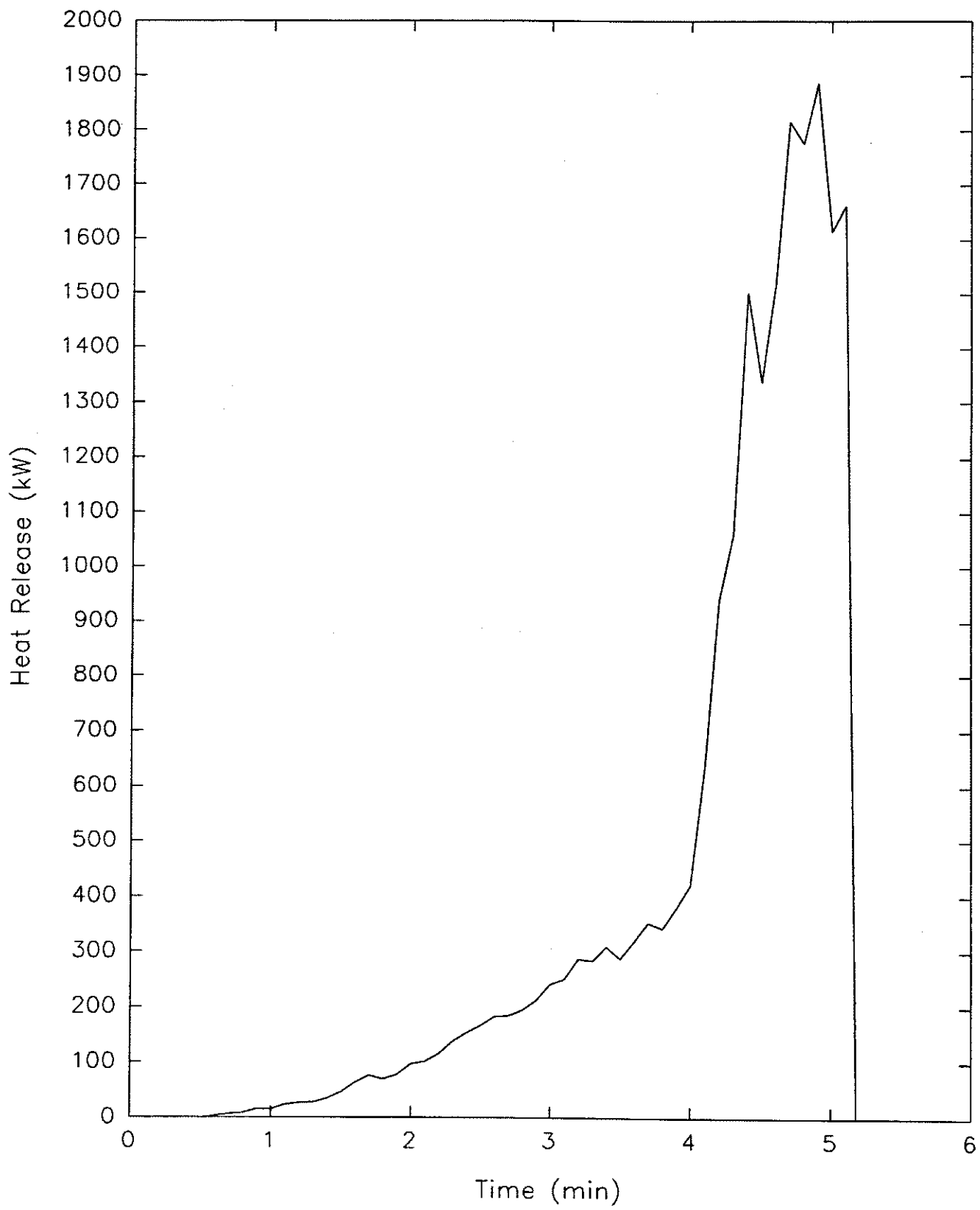


Figure P1 Heat Release Rate vs. Time

6mm Chipboard

May 7 1991

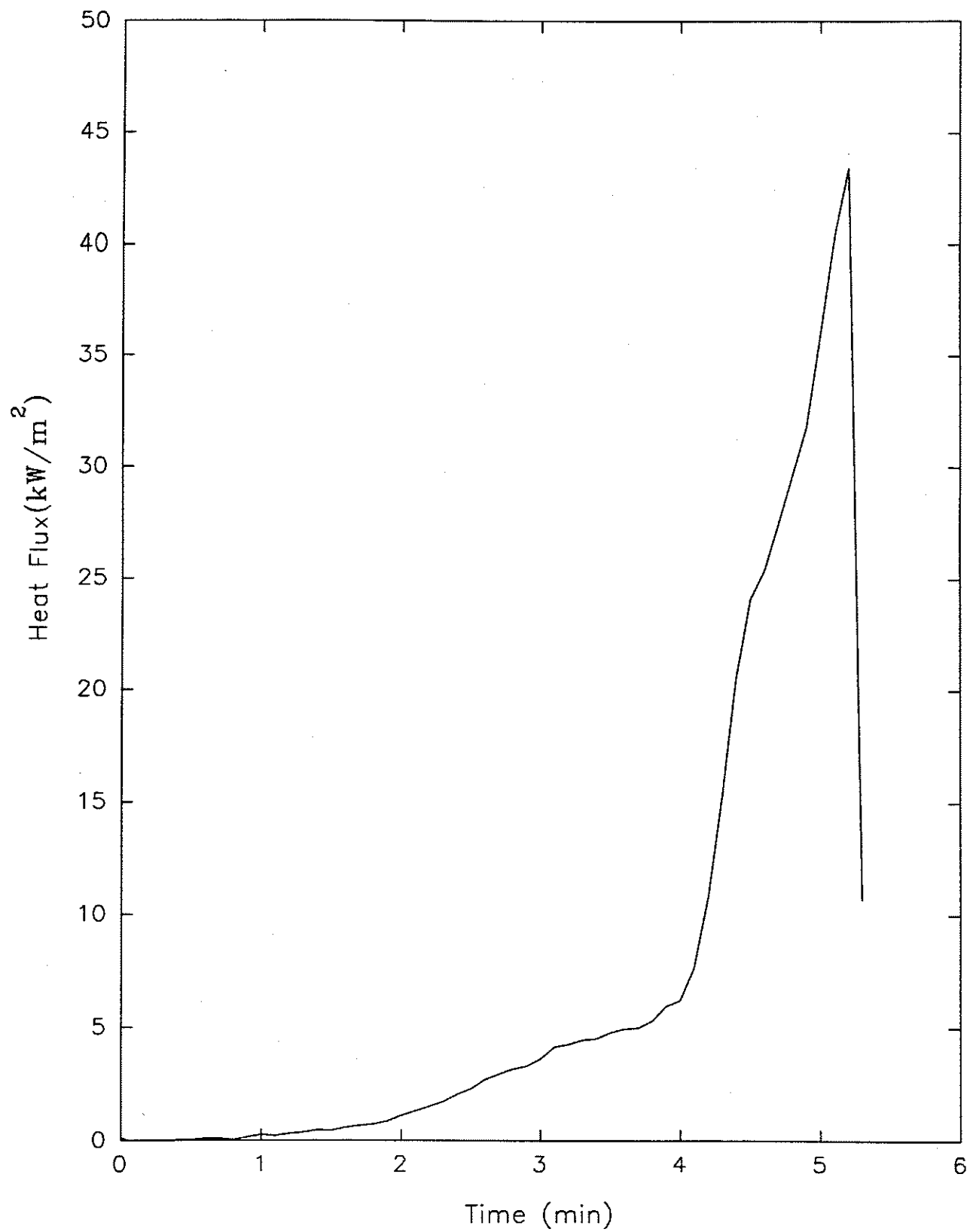


Figure P2 Heat Flux vs. Time  
6mm Chipboard

May 7 1991

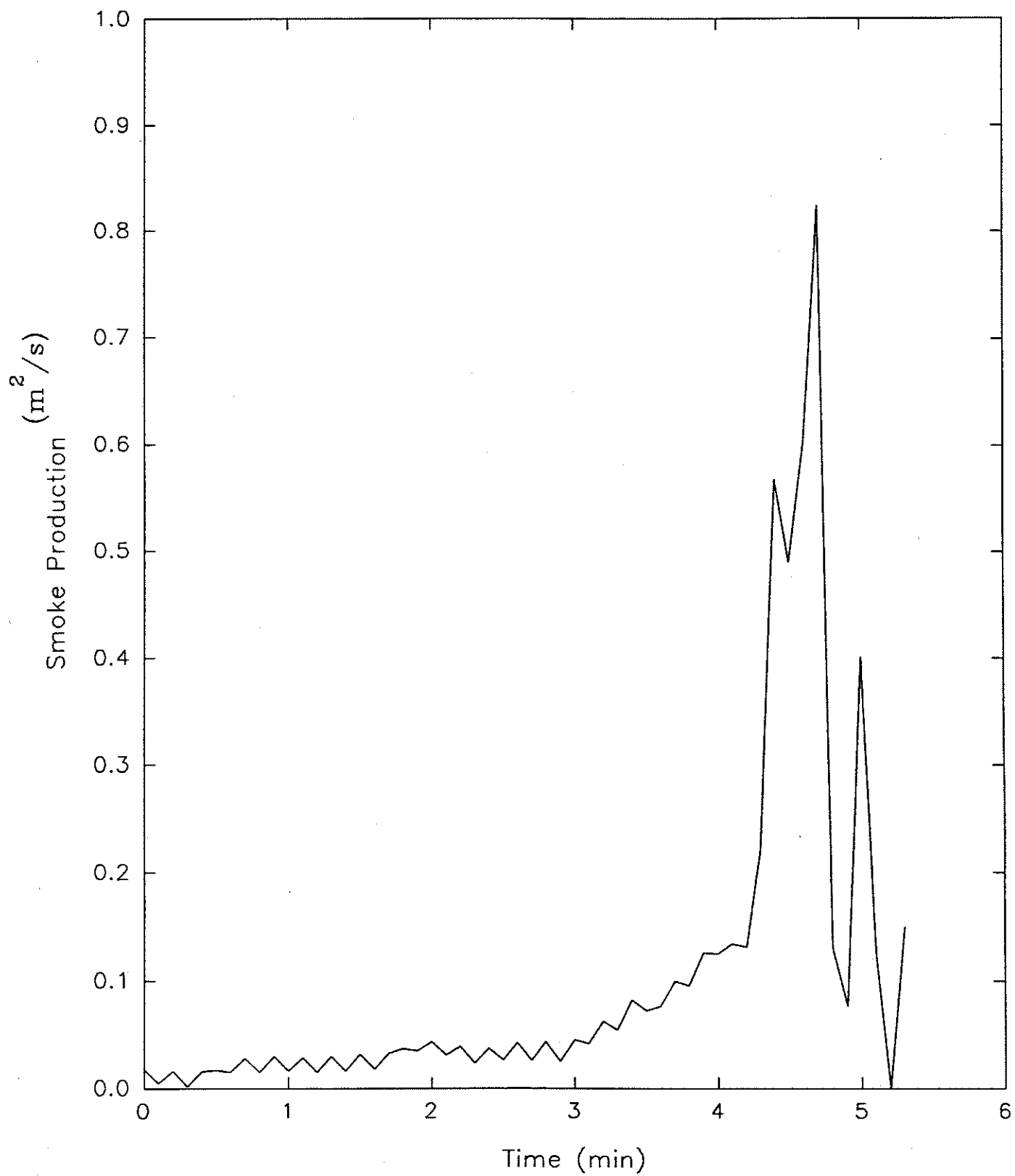


Figure P3 Rate of Smoke Production vs. Time  
6mm Chipboard

May 7 1991

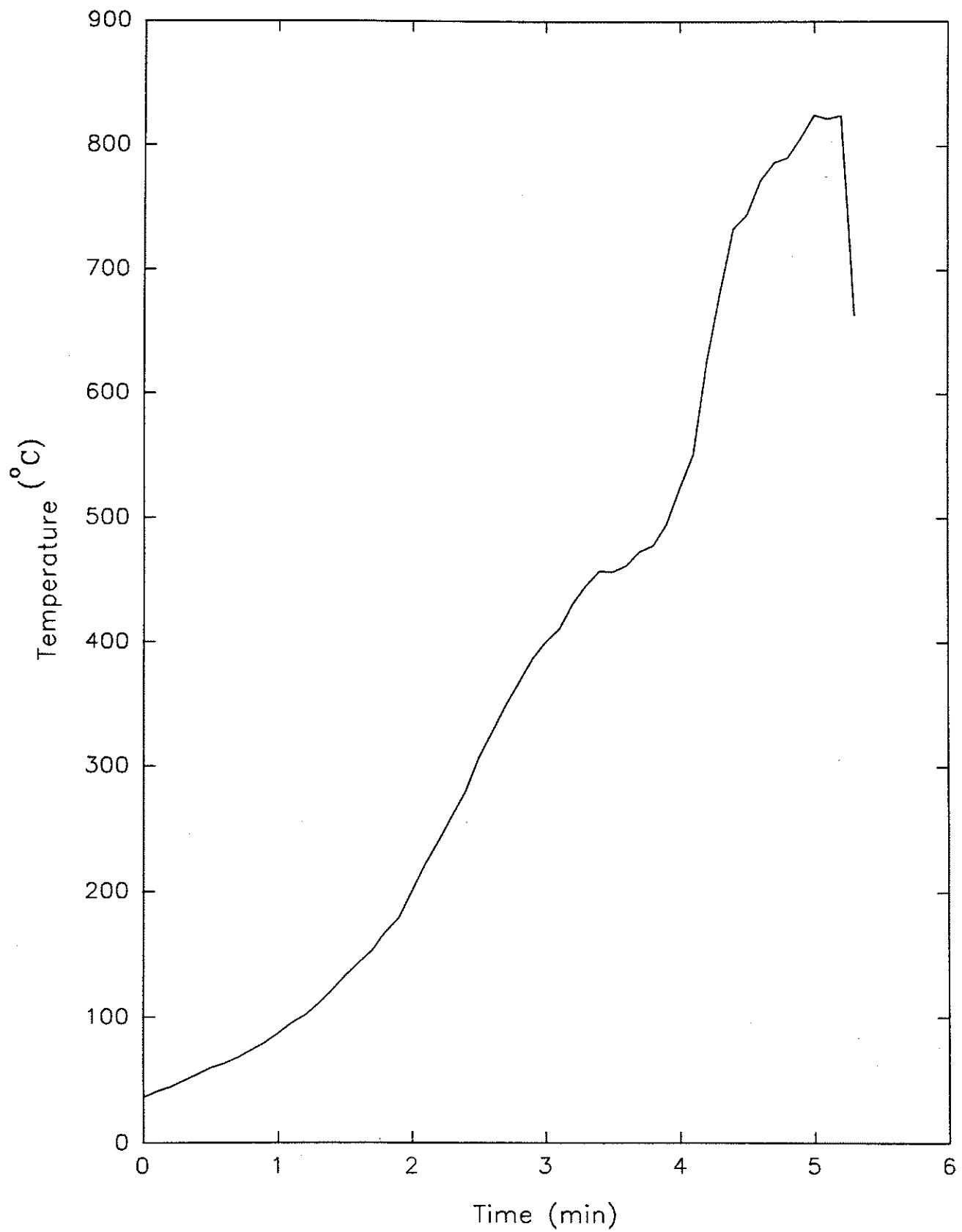


Figure P4 Temperature at the Centre of Ceiling vs. Time  
6mm Chipboard

May 7 1991



## **APPENDIX Q: 12.3 mm PARTICLEBOARD**





## SUMMARY TABLE OF RESULTS

Item	Results
Test material	12.3 particleboard
Test number	2
Date of test	May 13, 1991
Time to ignition of walls (left / right)	20 s / 20 s
Time at which 20 kW/m <sup>2</sup> reach at each radiometer	5 min 35 s / 5 min 35 s
Time at which paper targets ignite	5 min 55 s
Time of flame out of doorway	5 min 24 s
Maximum temperature at centre of room / time occurred	844°C / 6 min 25 s
Maximum temperature at the doorway / time occurred	654°C / 6 min 25 s
Time 600°C was obtained by TC at the centre of the room	5 min 30 s
Time 600°C was obtained by the TC at the doorway	5 min 50 s
Maximum instantaneous smoke produced / time occurred	0.36 OD / 5 min 5 s
Maximum instantaneous heat release / time occurred	1941 kW / 6 min 5 s

## VISUAL OBSERVATIONS OF THE TEST

Material: 12.3 mm Particleboard

Date: May 13, 1991

Temperature: 81°F

Relative Humidity: 30%

Overall description of test and test material: Followed ASTM test procedures  
Fan speed started in high position

### Observations of the test:

<u>Time (min:sec)</u>	<u>Observations</u>
0 : 00	Ignition of the sand burner (40 kW).
0 : 20	Both sides of the corner wall ignite.
0 : 45	Flame front is 2 ft above the sand burner. Flame tip is 4 ft above the sand burner.
1 : 20	Flame tip reaches ceiling.
2 : 00	Flame front is 6 ft above the burner. Flame tip is deflected at the ceiling and runs along the ceiling/wall joint to approximately 2 ft from the corner.
2 : 20	Flame front reaches ceiling. Flame tip reaches 4 ft from the corner along the ceiling/wall joint.
3 : 00	Flame tip reaches 8 ft (other end) from the corner along the ceiling/wall joint.
3 : 10	Light smoke is coming out through the doorway.
3 : 45	Flame is growing steadily.
4 : 15	Flame is receding. Materials at the corner are somewhat burned off.
5 : 00	Propane flow increased to 160 kW.
5 : 05	Flame is growing very strong.
5 : 15	Dark smoke is coming out through the doorway. Ceiling is filled with dark smoke and flames.
5 : 20	Upper half of the room (4 ft deep) is full of black smoke and flames.
5 : 40	Flame starts to come out of the doorway.
5 : 50	Flames come out the doorway intermittently.
5 : 55	Both paper bundles ignite.
6 : 00	Steady flames are coming out through the doorway. A lot of black smoke coming out through the doorway and spills over the canopy.
6 : 25	Test terminated.

# Supplementary Data of the Test

**MATERIAL:** Particleboard  
**DIMENSION (mm) :** 12.3  
**DATE TESTED:** May 13 1991

TIME (min)	CORNER TC (deg C)	DOOR TC (deg C)	DUCT TEMP (deg C)	FLOW RATE (m3/s)	CO CONC (%)	CO2 CONC (%)	O2 CONC (%)
0	65	43	27	2.35	0	0.01	20.97
0.5	126	64	28	2.25	0	0.03	20.94
1	190	90	30	2.22	0	0.09	20.88
1.5	373	131	33	2.24	0.01	0.17	20.8
2	550	180	36	2.1	0.01	0.26	20.72
2.5	707	253	44	2.13	0.02	0.44	20.54
3	802	330	53	2.05	0.02	0.75	20.24
3.5	782	352	57	1.97	0.05	1.08	20.17
4	747	361	61	1.94	0.07	1.1	20.19
4.5	706	346	58	1.95	0.07	1.06	20.22
5	691	332	58	2.01	0.06	0.94	19.79
5.5	965	558	128	1.71	0.18	2.16	16.48
6	969	619	299	1.19	0.99	4.38	11.79
6.5	910	521	547	0.96	1.22	8.2	20.99

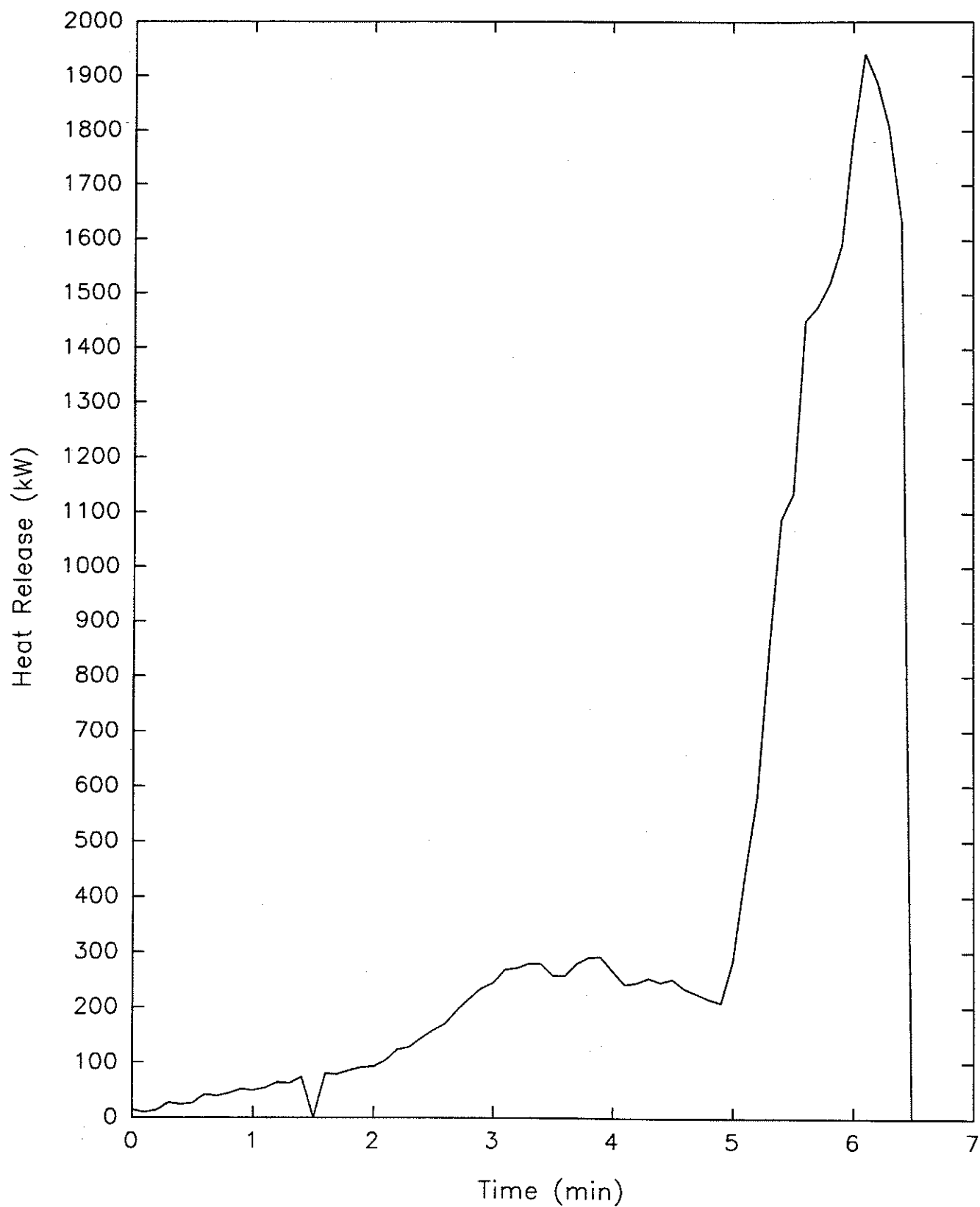


Figure Q1 Heat Release Rate vs. Time

12.3mm Particleboard

May 13 1991

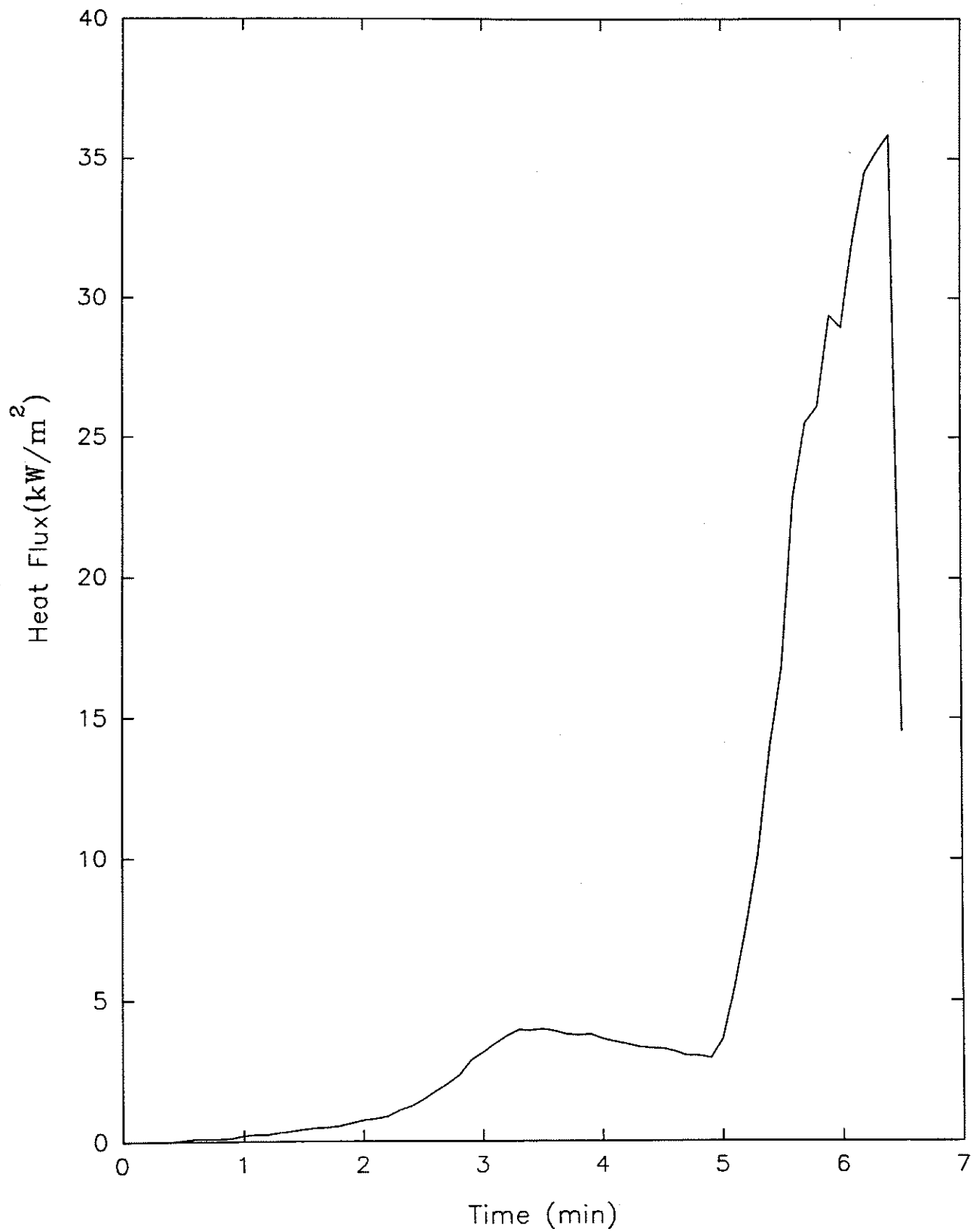


Figure Q2 Heat Flux vs. Time  
12.3mm Particleboard

May 13 1991

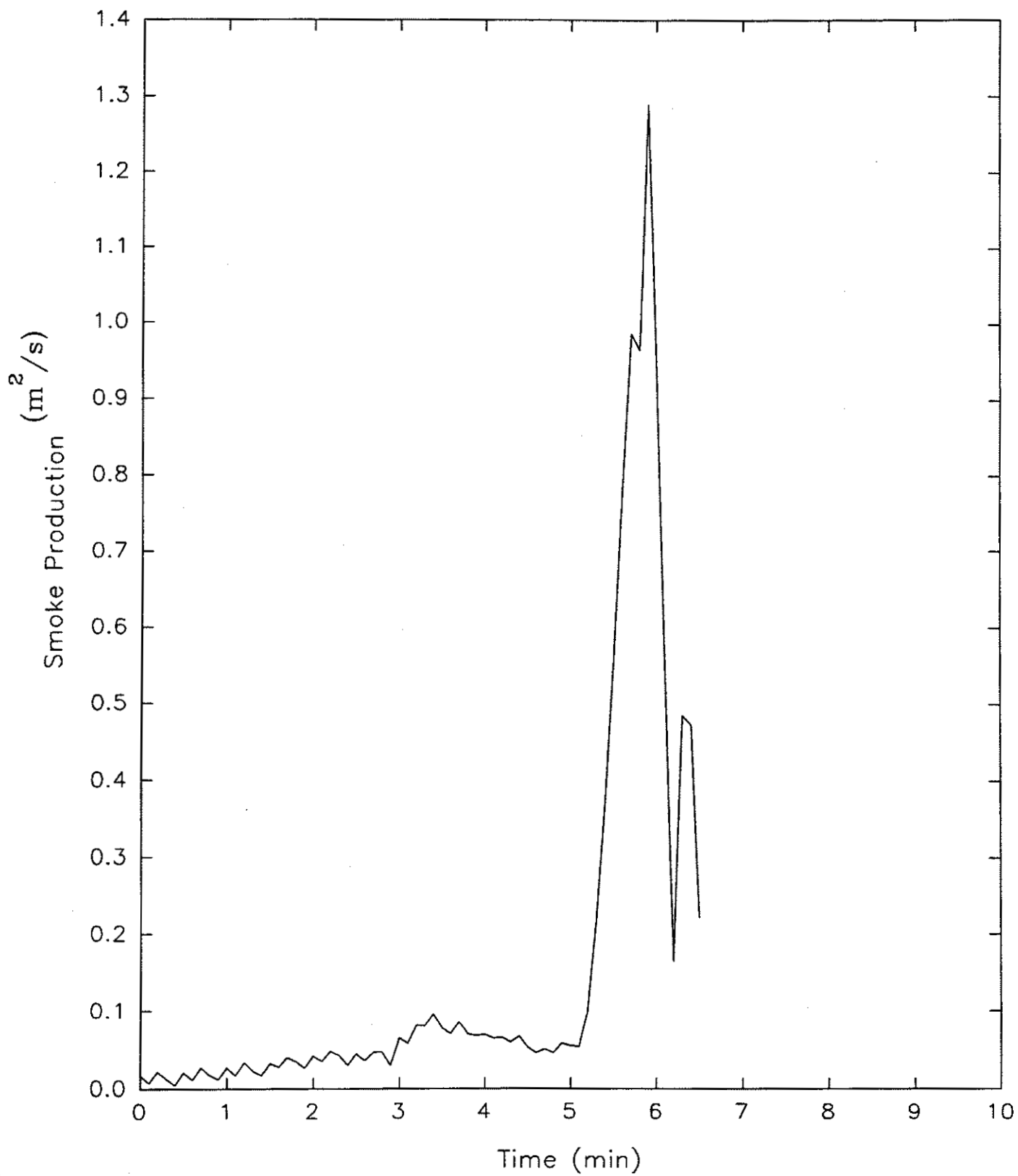


Figure Q3 Rate of Smoke Production vs. Time  
12.3mm Particleboard

May 13 1991

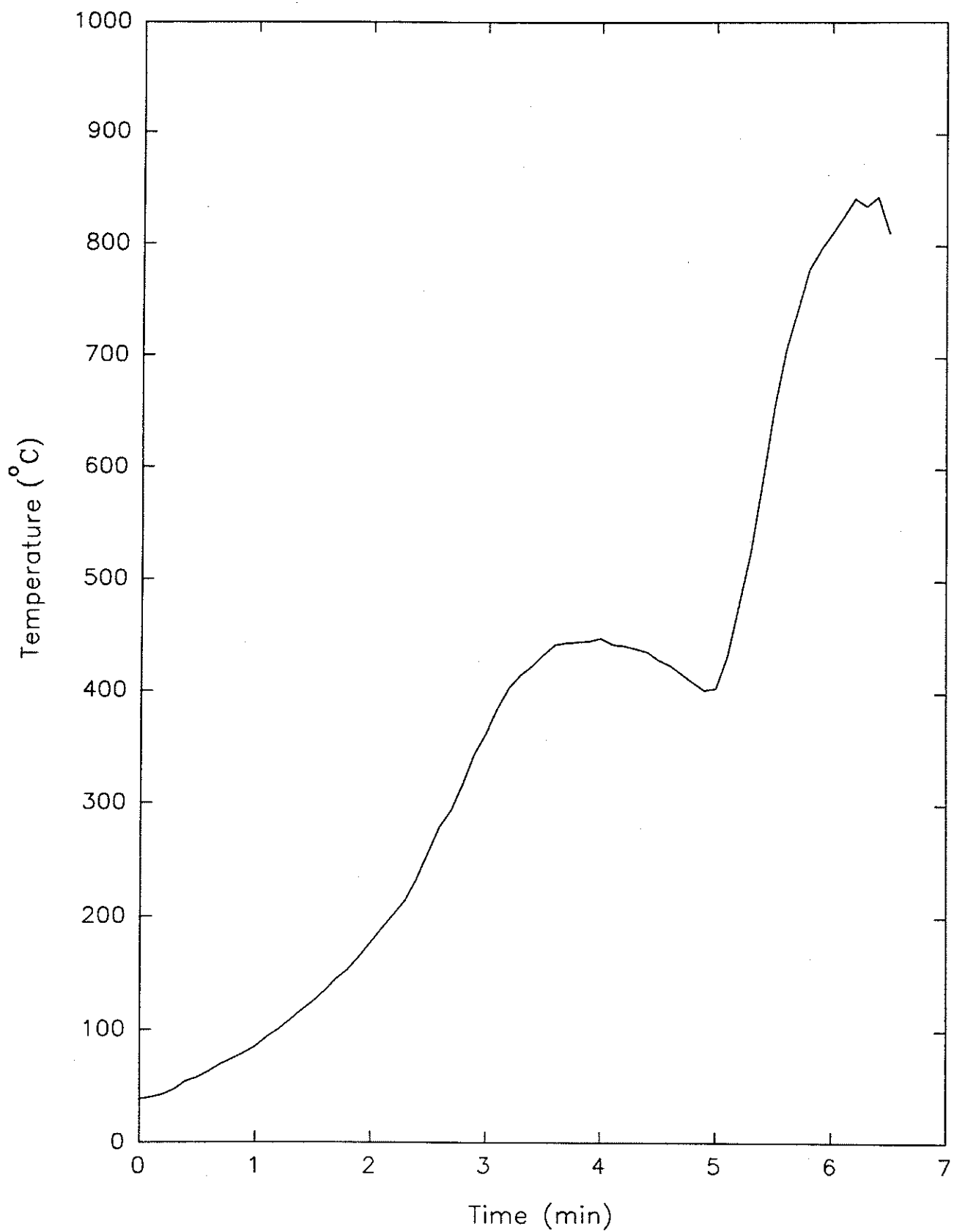


Figure Q4 Temperature at the Centre of Ceiling vs. Time  
12.3mm Particleboard

May 13 1991





**APPENDIX R: 5 mm WOODPANEL**



## SUMMARY TABLE OF RESULTS

Item	Results
Test material	5 mm woodpanel
Test number	1
Date of test	May 16, 1991
Time to ignition of walls (left / right)	1 min 40 s / 1 min 40 s
Time at which 20 kW/m <sup>2</sup> reach at each radiometer	6 min 25 s / 6 min 25 s
Time at which paper targets ignite	6 min 30 s
Time of flame out of doorway	6 min 12 s
Maximum temperature at centre of room / time occurred	866°C / 7 min 25 s
Maximum temperature at the doorway / time occurred	777°C / 7 min 20 s
Time 600°C was obtained by TC at the centre of the room	5 min 30 s
Time 600°C was obtained by the TC at the doorway	6 min 30 s
Maximum instantaneous smoke produced / time occurred	0.36 OD / 7 min 30 s
Maximum instantaneous heat release / time occurred	1736 kW / 7 min

## VISUAL OBSERVATIONS OF THE TEST

Material: 5 mm Woodpanel

Date: May 16, 1991

Temperature: 77°F

Relative Humidity: 43%

Overall description of test and test material: Followed ASTM test procedures  
Fan speed started in high position

### Observations of the test:

<u>Time (min:sec)</u>	<u>Observations</u>
0 : 00	Ignition of the sand burner (40 kW).
0 : 30	Flame tip is approximately 3 ft above the burner.
1 : 40	Both sides of the corner wall ignite.
2 : 15	Flame front is 2 ft above the burner. Flame tip is 5 ft above the burner.
3 : 00	Flame front is 3 ft above the burner.
4 : 00	Flame front is 5 ft above the burner. Flame tip reaches ceiling.
4 : 45	Flame front reaches ceiling. Flame is deflected at the ceiling and runs 4 ft from the corner along the ceiling/wall joint.
5 : 00	Propane flow increased to 160 kW.
5 : 05	Flame tip reaches the other side (8 ft from the corner) along the ceiling/wall joint.
5 : 10	Dark smoke is coming out of the room.
5 : 15	Flame runs along the ceiling surface.
5 : 25	Dark smoke layer in the room 4 ft deep.
5 : 40	Upper half of the room (4 ft deep) is filled with dark smoke and flames.
6 : 10	Ceiling is full of flames. Black smoke comes out through the doorway steadily.
6 : 20	First flame comes out through the doorway.
6 : 25	More flames and black smoke coming out through the doorway.
6 : 30	First paper bundle ignites.
6 : 40	Steady flames come out the doorway.
6 : 45	Second paper bundle ignites.
6 : 50	Steady flames come out. Black smoke coming out through the doorway spills over the canopy hood.
7 : 05	Steady flames come out. No smoke coming out.
7 : 10	Room is filled with flames and there is no smoke in the room. The flame depth in the room is 6 ft.
	Fierce flames come out the doorway.
7 : 30	Test terminated.

Supplementary Data of the Test

**MATERIAL:** Woodpanel  
**DIMENSION (mm) :** 5  
**DATE TESTED:** May 16 1991

TIME (min)	CORNER TC (deg C)	DOOR TC (deg C)	DUCT TEMP (deg C)	FLOW RATE (m3/s)	CO CONC (%)	CO2 CONC (%)	O2 CONC (%)
0	43	36	26	2.16	0	0.01	20.99
0.5	120	56	26	2.26	0	0.02	20.98
1	149	79	28	2.23	0	0.07	20.93
1.5	158	88	28	2.29	0	0.08	20.92
2	167	91	29	2.15	0	0.09	20.91
2.5	208	103	30	2.26	0	0.11	20.9
3	205	114	31	2.32	0	0.14	20.88
3.5	224	117	31	2.2	0	0.17	20.87
4	365	161	35	2.12	0.01	0.24	20.79
4.5	611	211	41	2.15	0.01	0.41	20.69
5	783	319	53	2.09	0.02	0.68	20.4
5.5	931	465	82	1.91	0.12	1.74	19.37
6	949	559	118	1.76	0.2	2.32	18.51
6.5	848	611	197	1.39	0.78	3.69	16.3
7	652	699	736	0.76	1.23	7.16	7.62
7.5	645	772	764	0.72	0.13	9.64	20.99

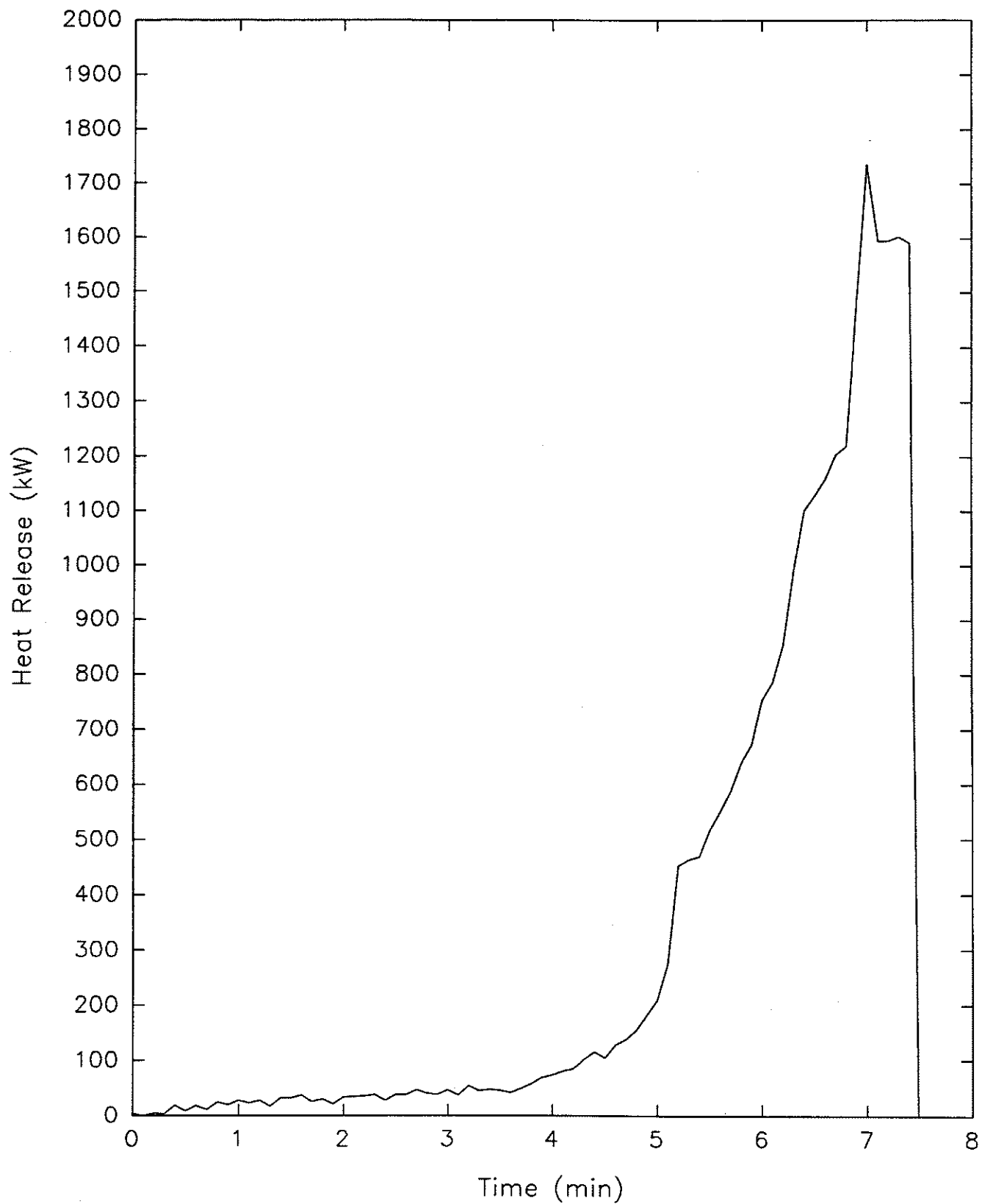


Figure R1 Heat Release Rate vs. Time

5mm Woodpanel

May 16 1991

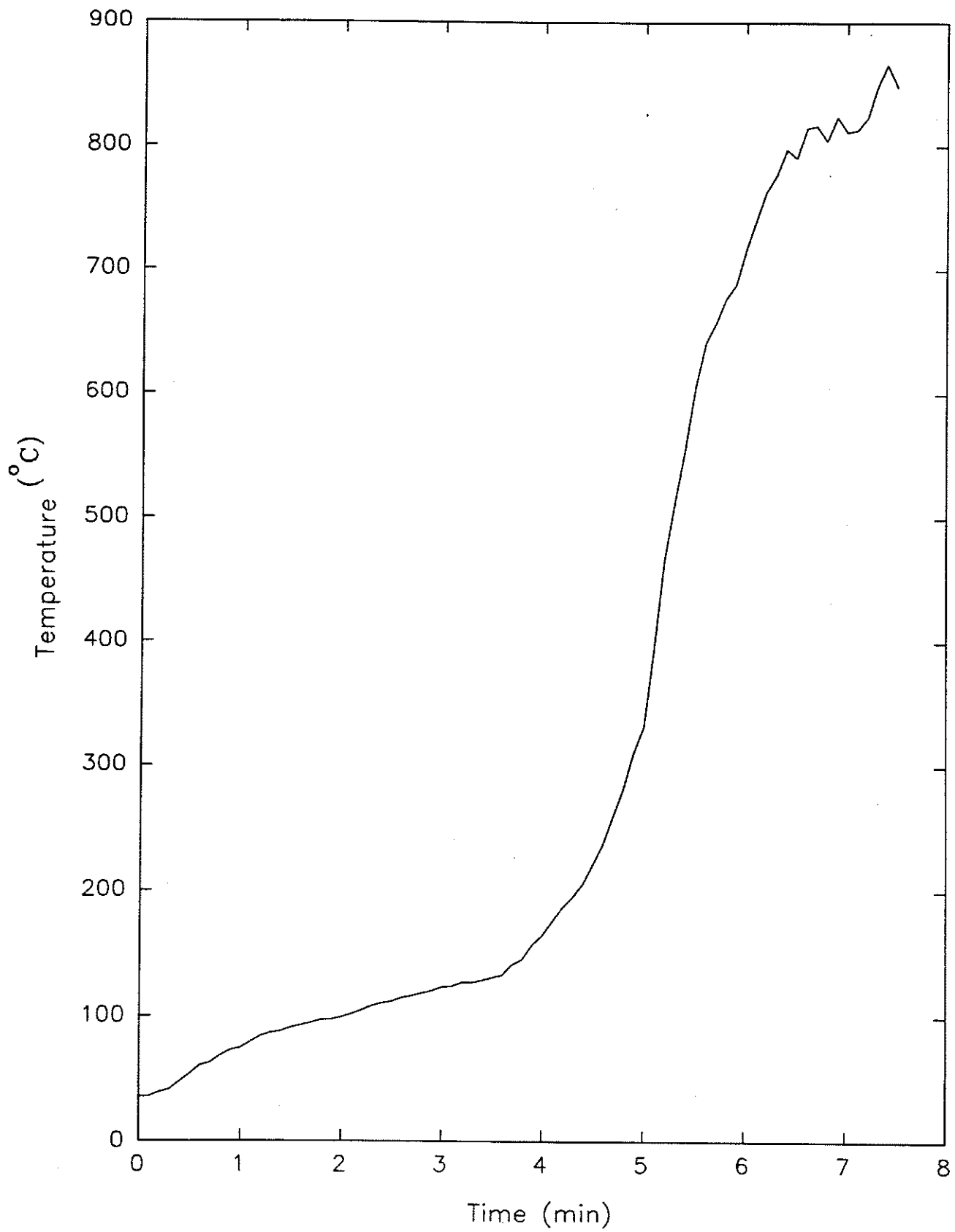


Figure R4 Temperature at the Centre of Ceiling vs. Time  
5mm Woodpanel

May 16 1991





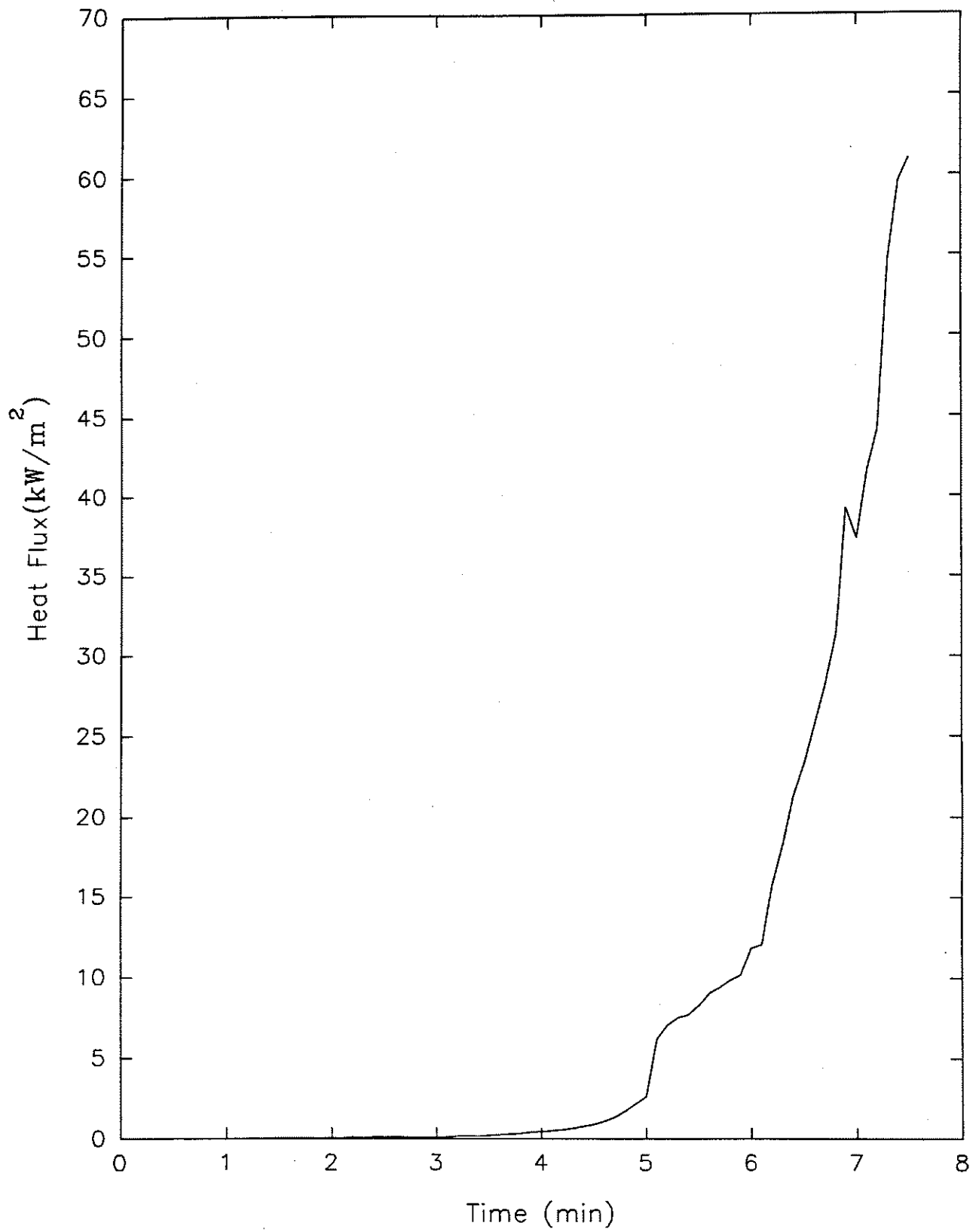


Figure R2 Heat Flux vs. Time  
5mm Woodpanel

May 16 1991

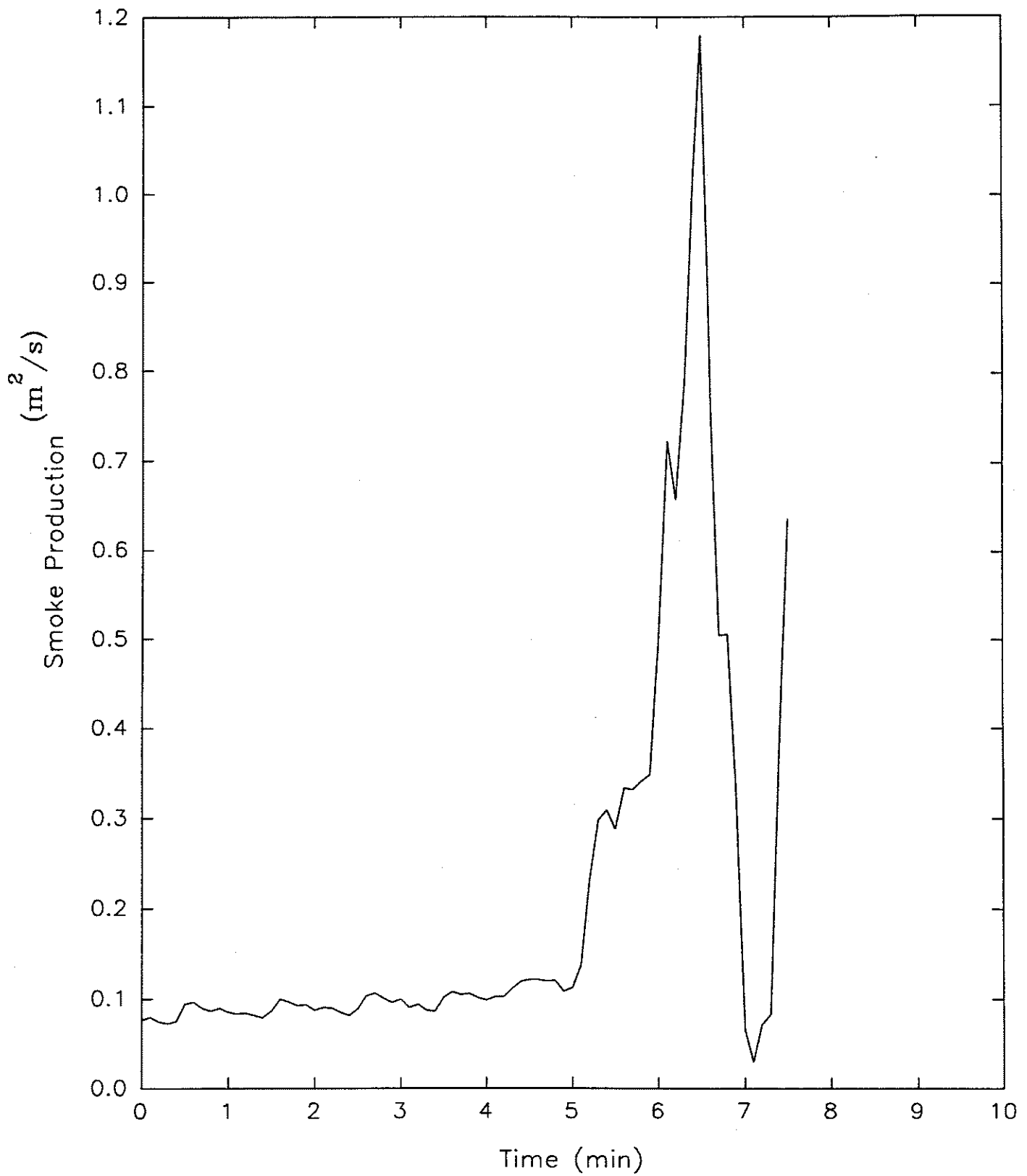


Figure R3 Rate of Smoke Production vs. Time  
5mm Woodpanel

May 16 1991