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INVESTIGATION OF THE INTERNAL ROOM FIRE CHARACTERISTICS OF A 5-MIL THICK REINFORCED PVC MEMBRANE CEILING TESTED IN GENERAL ACCORDANCE WITH UBC STANDARD 26-3, "ROOM FIRE TEST STANDARD FOR INTERIOR OF FOAM PLASTIC SYSTEMS"

FINAL REPORT
SwRI Project No. 01.03050.01.211a[1]
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Consisting of 33 Pages

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ABSTRACT

On December 5, 2000, Southwest Research Institute conducted a fire performance evaluation on a 5-mil thick reinforced PVC membrane ceiling fabric identified as "TRM 15," and evaluated for Newmat USA of Huntington, New York and Newmat SA of Haubourdin, France. The test was performed in general accordance with Uniform Building Code (UBC) 26-3, "Room Fire Test Standard for Interior of Foam Plastic Systems," 1997.

Additional measurements consisted of smoke release rate, total smoke released, percent light transmission, and CO/CO_2 in a stainless steel duct and exhaust hood system in accordance to ISO 9705, "Fire Tests - Full Scale Room Test for Surface Products: 1996-06-01."

Additional instrumentation placed in the room interior was composed of ceiling mount and wall mount pendant sprinklers.

As this test was performed for Newmat USA and Newmat S.A. to comply with a request from ICBO as a Modified Room Corner Test to establish only the performance of the membrane under exposure to fire regardless of the flame spread and smoke rating (previously tested with ASTM E 84), and since the UBC 26-3 Room Corner Test was modified to add sprinkler heads, the pass/fail of the standard UBC 26-3 Room Corner test does not apply.

I. INTRODUCTION

This report presents the results of an investigation of the interior room fire characteristics of a 5-mil thick reinforced PVC membrane identified as "TRM15," and evaluated for Newmat USA of Huntington, New York, and Newmat SA of Haubourdin, France. This program was conducted on December 5, 2000, by Southwest Research Institute's (SwRI) Department of Fire Technology located in San Antonio, Texas. This report contains a description of the material evaluated, procedures used, and the results. Note that the results apply only to the specimens tested, in the manner tested, and not to the entire production of this or similar materials, nor to the performance of this material when used in combination with other materials.

The evaluation was conducted in general accordance with the provisions of Uniform Building Code (UBC) Standard No. 26-3 (formerly 17-5), "Room Fire Test Standard for Interior of Foam Plastic Systems," 1997. Exceptions to this standard are noted in Section V.B.1 of the Research Committee Acceptance Criteria for Foam Plastics under Section 1713 of the 1994 Edition to Uniform Building Code, International Conference of Building Officials (ICBO).

Additional measurements consisted of smoke release rate, total smoke released, percent light transmission, and CO/CO_2 in a stainless steel duct and exhaust hood system in accordance to International Standardization Organization (ISO) 9705, "Fire Tests - Full Scale Room Test for Surface Products: 1996-06-01."

Additional instrumentation installed in the test room interior was composed of two wall mount and two ceiling mount sprinkler heads.

As this test was performed for Newmat USA and Newmat S.A. to comply with a request from ICBO as a Modified Room Corner Test to establish only the performance of the membrane under exposure to fire regardless of the flame spread and smoke rating (previously tested with ASTM E 84), and since the UBC 26-3 Room Corner Test was modified to add sprinkler heads, the pass/fail of the standard UBC 26-3 Room Corner test does not apply.

II. TEST MATERIAL

The reinforced PVC membrane was received on December 4, 2000, and installed into the completed test room.

Material I.D.:	TRM15
Trade name:	Reinforced PVC Membrane
Thickness:	5-mil (nominal)
Color:	White
Composition:	PVC
Dimensions:	8 x 12-ft sheet (prefabricated and reinforced)
Aluminum rail:	1 x 1 in. (angle) x 19 gauge (nominal)

III. TEST FACILITY

The test structure consisted of a fully enclosed 8 x 12 x 9-ft room, which had one 30-in. x 7-ft doorway in the center of an 8-ft wide x 9-ft high wall (Figure 1[1]). This test structure was located in a fully enclosed air-conditioned 40 x 90 x 24-ft high building at SwRI's fire test facility.

The walls and ceiling of the test structure were constructed using nominal 2 x 4-in. wood studs spaced 24 in. on center. The walls and ceiling were lined with one layer of ½-in. Type X gypsum wallboard using standard drywall screws every 12 in. on center.

IV. TEST SETUP

Installation of the reinforced PVC membrane began on December 5, 2000. Mr. Pascal Gicquel representing Newmat USA and Newmat SA installed the aluminum rail wall mount trim and the reinforced PVC membrane in the test structure. The aluminum rail interlocking wall mount angle molding, 19 gauge (as measured with a U.S. Standard No. 283 gauge), was installed 8 ft from the floor and secured horizontally (around the inside perimeter) over the ½-in. thick gypsum wallboard substrate with a No. 6 x 1-5/8-in. long drywall screw. The screws were randomly attached every 6 in. apart, through the 1-in. wide leg using a drywall screw gun with the 1-in. wide interlocking leg of the wall mount angle at a right angle away from the wall. Additional 2 x 4-in. wood blocking was secured horizontally, 8 ft from the floor, on the exterior walls of the test module to secure the aluminum angle trim to the gypsum wallboard without the screws "pulling-out."

The prefabricated reinforced PVC membrane was then placed in the room interior and interlocked around the perimeter of the room. A small circular incision was performed around the perimeter of the

[1]All figures are located at the end of Section XI, Conclusions, see pages 7-8.

suspended sprinkler head, which was installed in the center of the room interior (at the PVC stretch membrane), and the decorative cover plate for the sprinkler head was installed completing the installation. Mounting details and sprinkler head layout are shown in Figure 2.

V. CONDITIONS OF ACCEPTANCE

A foam plastic wall or ceiling assembly shall be considered as meeting the requirements for acceptable performance within the following conditions:

1. Charring of the foam plastic shall not extend to the outer extremities of the test area within a 15-min period after ignition of the excelsior. Discoloration extending not more than ¼ in. (6 mm) into the foam plastic shall not be considered as charring.
2. Smoke levels generated during the test period shall not be excessive.
3. Structural panels shall sustain the applied load during the test period.

VI. IGNITION SOURCE

The wood crib fuel source was constructed using 1½ x 1½ -in. sticks of Douglas fir wood cut into 15-in. lengths. The crib had a dry wood weight of 30 lb and was 15 in. square in plan. One 8-penny nail was driven at each intersection of two sticks. The crib was assembled in tiers of five sticks each with each tier oriented 90 degrees to the sticks in the adjacent tiers.

Prior to placement of the crib in the test room, its moisture content was measured to verify that it was below 8 percent. The crib was then placed on four brick pieces, one under each corner of the crib, to provide a 4-in. space between the floor and the lower surface of the crib. Ignition of the crib was accomplished by evenly distributing 1 lb of shredded and fluffed wood excelsior beneath the crib over a 21 x 21-in. area and soaking with 4 oz of absolute ethyl alcohol.

VII. INSTRUMENTATION AND DOCUMENTATION

Eight 20-gauge Type "K" Chromel-Alumel thermocouples were used for temperature measurement in the test room at the reinforced PVC membrane ceiling, which was installed 8 ft from the floor. The placement of these thermocouples is shown in Figure 1.

An additional five thermocouples were installed 9 ft from the floor at the gypsum wallboard ceiling in alignment with the thermocouples installed at the 8-ft level. The placement of these thermocouples is also shown in Figure 1.

In addition to the thermocouples installed at the reinforced PVC ceiling and the gypsum wallboard ceiling, four thermocouples were placed into the room interior at the location of the four sprinkler heads installed in the test room interior.

Photographic documentation of the test consisted of 35-mm color prints and color videotape. Videotaping was conducted as specified in ICBO Subject No. Misc. #2-R2-0794, "Test Protocol for Video Recording of Tests Conducted Under UBC Standards Nos. 17-5 and 42-2," July 1994.

Additional measurements consisted of smoke release rate, total smoke released, percent light transmission, and CO/CO_2 in a stainless steel duct and exhaust hood system in accordance to ISO 9705, "Test Tests - Full Scale Room Test for Surface Products: 1996-06-01."

VIII. SPRINKLER HEADS

Each sprinkler was installed with a trip wire on the fusible link to determine "trip time" and a thermocouple placed ½ in. away from the fusible link to measure temperature of the air at the sprinkler head. Each sprinkler head was individually pressurized to 25 psi with compressed air to help drive the activation links and determine trip time. The pressurized air was immediately turned off upon activation of each head.

Two sprinkler heads were installed in the center of the room interior to register activation and temperature "trip times." One flush mount sprinkler head was installed in the center of the room interior directly on the gypsum wallboard. The second sprinkler was mounted directly on the reinforced PVC membrane ceiling in the center of the room (12 in. below the sprinkler installed on the gypsum ceiling).

A second set of sprinkler heads was installed on the vertical wall containing the doorway and located midway between the side wall and the leading edge of the open doorway. One wall mount sprinkler head was installed (in the center of the air cavity) 6 in. down from the gypsum ceiling and 15 in. away from the right wall. The second wall mount sprinkler head was mounted 6 in. down from the reinforced PVC membrane ceiling and 15 in. away from the right wall.

The side wall mount sprinkler heads were identified as Rasco Reliable Top HDW-I with a rated activation temperature of 165°F (74°C). The suspended ceiling mount sprinkler heads were identified as Rasco, with a rated activation temperature of 165°F (74°C). (All sprinkler heads were provided by Newmat USA.)

IX. TEST RESULTS

Observations made during the test are provided in Appendix A. Photographic documentation is included in Appendix B. Prior to the test, the heat release rate measuring system was calibrated with a 100-300 kW propane burner as specified in ISO 9705. The resulting calibration data are shown in Appendix C. Room temperatures, smoke release rate, total smoke released, percent light transmission, and CO/CO_2 generation data are represented in graphical form in Appendix D. Sprinkler head activation time and temperature at time of activation are provided in Appendix E.

The test was terminated normally at 15 min.

X. SUMMARY

On December 5, 2000, SwRI conducted a fire performance evaluation on a nominal 5-mil thick reinforced PVC membrane ceiling identified as "TRM-15" and evaluated for Newmat USA of Huntington, New York, and Newmat S.A. of Haubourdin, France. Present to witness the test was Mr. Pascal Gicquel of Newmat USA. The test was performed in general accordance with UBC 26-3, "Room Fire Test Standard for Interior of Foam Plastic Systems," supplemented with instrumentation as specified in ISO 9705, "Fire Tests - Full Scale Room Test for Surface Products: 1996-06-01."

Ambient temperature at the start of the test was 68°F (20°C) with a relative humidity of 64%. Following a 2-min baseline, the 15-min fire exposure was initiated with ignition of the excelsior under the crib. A light white smoke formed in the room interior due to the burning excelsior. After ignition of the excelsior under the wood crib, the reinforced PVC membrane that was initially stretched taut across the ceiling began to slightly sag throughout the ceiling. A small hole melted on the membrane in the direct vicinity of the crib at the ceiling.

The hole gradually increased causing the membrane to tear at the crib corner and "flap down" diagonally and in a triangular pattern away from the crib corner. The weight of the membrane and the increasing heat from the burning crib softened the reinforced PVC membrane, causing it to further tear and

drape towards the floor. During the course of the fire exposure, the reinforced PVC membrane fabric did not ignite, but draped diagonally away from the burning crib towards the floor. In the area where the reinforced PVC membrane opened up, the membrane draped downward approximately 5½ ft above the floor. All four sprinkler heads mounted in the room interior activated between 2 min 34 sec and 5 min 39 sec into the 15-min fire exposure. A light white layer of smoke stratified in the room interior approximately 5½ ft above the floor. Sprinkler head activation and temperature can be found in Appendix D, Sprinkler Head Activation.

The test was terminated normally at 15 min and the crib extinguished.

XI. CONCLUSIONS

On December 5, 2000, Southwest Research Institute conducted a product performance evaluation on a 5-mil thick reinforced PVC membrane identified as "TRM-15" and evaluated for Newmat USA of Huntington, New York, and Newmat S.A. of Harbourdin, France. The test was performed in general accordance with Uniform Building Code (UBC) 26-3, "Room Fire Test Standard for Interior of Foam Plastic Systems," 1997.

During the initial course of the15-min fire exposure, flames and heat from the burning crib softened and melted the reinforced PVC membrane initially forming a small hole to develop in the ceiling corner. All four sprinkler heads installed in the room interior activated. By the end of the 15-min fire exposure, the reinforced PVC membrane melted/tore away in the crib corner approximately 8-ft along both walls which formed the crib corner, and hung down 5½ ft above the floor.

As this test was performed for Newmat USA and Newmat S.A. to comply with a request from ICBO as a Modified Room Corner Test to establish only the performance of the membrane under exposure to fire regardless of the flame spread and smoke rating (previously tested with ASTM E 84), and since the UBC 26-3 Room Corner Test was modified to add sprinkler heads, the pass/fail of the standard UBC 26-3 Room Corner test does not apply.

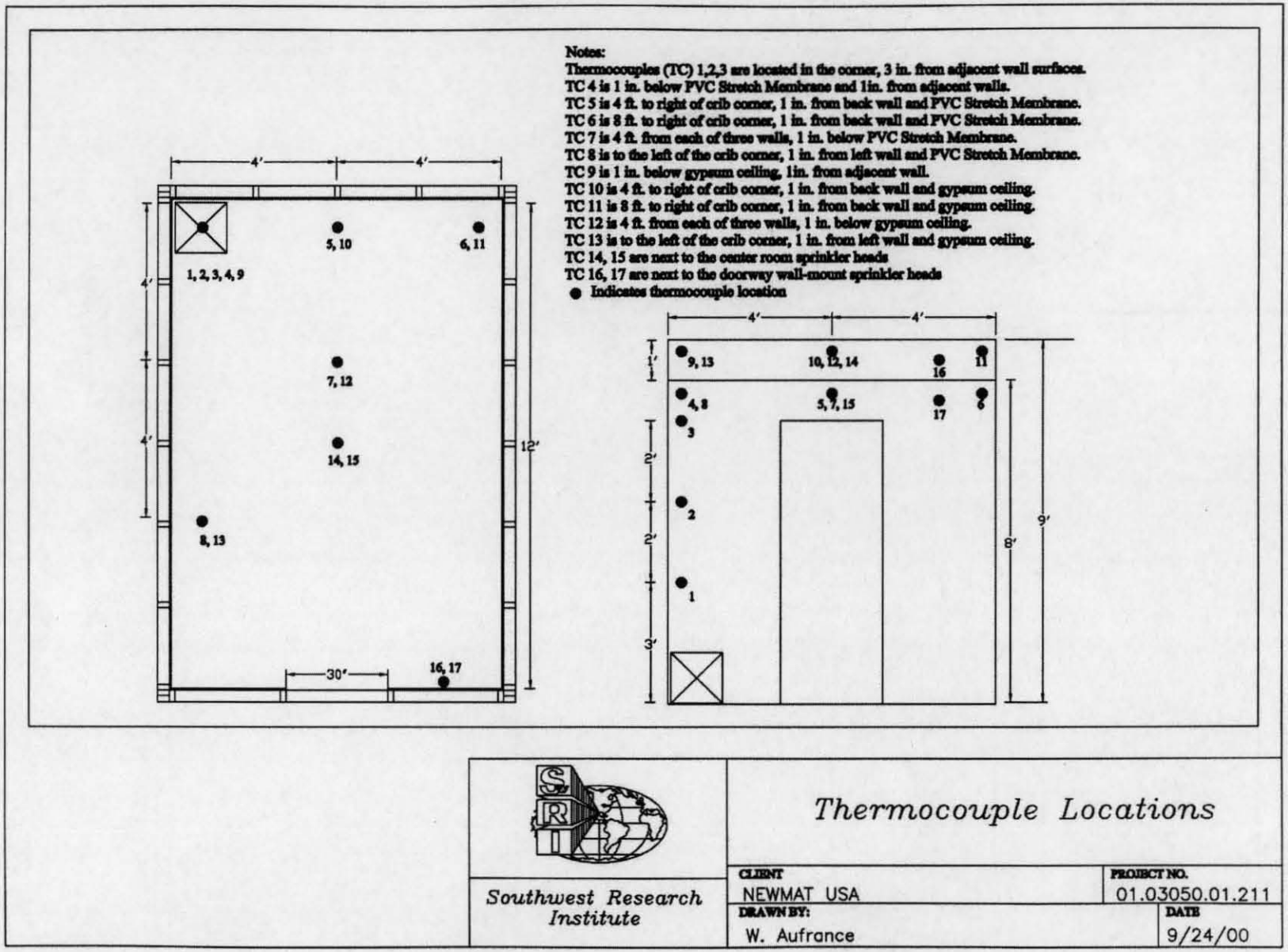


Figure 1. Layout of Test Room.

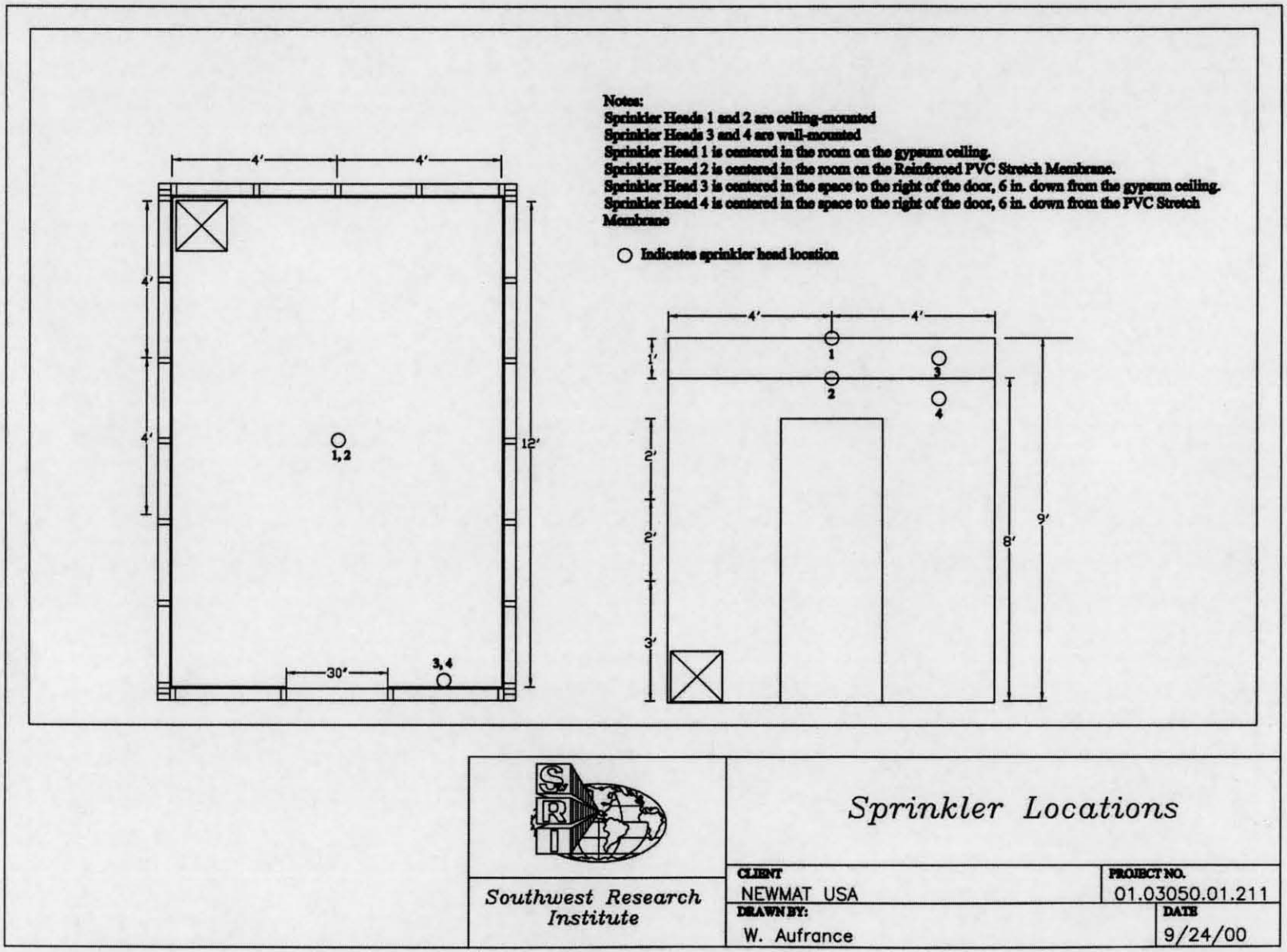


Figure 2. Sprinkler Locations.

APPENDIX A

Visual Observations
(Consisting of 2 Pages)

Date of Test: December 5, 2000
SwRI Project No. 01.03050.01.211a[1]
UBC 26-3 Room Corner Test
Newmat USA and Newmat S.A.
Material ID: TRM-15

TIME MIN:SEC	TEST OBSERVATIONS
00:00	Start of Test, flames from excelsior under crib.
00:15	Flames from the burning excelsior up to 3½ ft above the floor.
00:30	Light white smoke in the room interior due to the burning excelsior.
01:00	Flames from the burning crib are up to 4½ ft above the floor. Light white smoke in the room interior down to 5½ ft above the floor.
01:15	Slight discoloration on the gypsum wallboard paper in the burner corner, with flames from the burning crib up to 5½ ft above the floor.
01:22	The light white smoke is beginning to dissipate in the room interior.
01:26	Discoloration on the gypsum wallboard in the crib corner up to 3 ft from the floor.
01:42	Slight discoloration on the reinforced ceiling membrane in the crib corner.
02:00	Melt-thru of the reinforced PVC membrane directly in the crib corner.
02:16	The hole, which has developed in the crib corner on the reinforced PVC membrane, is now approximately12 in. in diameter. A white smoke is beginning to develop in the room interior.
02:28	Flames from the burning crib are intermittently touching the ceiling. A white smoke is coming out from the hole that has developed on the reinforced PVC membrane on the ceiling.
02:34	Sprinkler head No. 2 has tripped (center of room 8 ft from floor).
02:50	Sprinkler head No. 3 has tripped (doorway wall – 6 in. below gypsum ceiling - air cavity).
03:10	The reinforced PVC membrane is beginning to sag and is touching the thermocouple positioned in the 4 x 4 quad section 1 in. below the reinforced PVC ceiling.
03:25	The reinforced PVC membrane is now open approximately 24-in. in a triangular pattern directly above the burning crib.
03:28	Sprinkler head No. 1 has tripped (center of room 9 ft from floor).
04:00	The reinforced PVC membrane is sagging downward approximately 4 to 6-in., the reinforced PVC membrane has opened up approximately 4 to 4½ ft in a triangular pattern away from the crib corner. The reinforced cable that is supporting the PVC membrane is preventing the PVC from opening up further along the left wall in the test room.
04:27	In the crib corner flames from the crib are 7 ft above the floor. Charring and discoloration of the paper on the gypsum wallboard is up to 5½ ft above the floor. The reinforced PVC membrane is now sagging approximately 12 in. down from the original 8-ft high ceiling.
04:45	The reinforced PVC ceiling is hanging downward to the floor approximately 14 to 16 in.
05:00	Smoke in the room interior is down to 5 ft above the floor and white in color.
05:39	Sprinkler No. 4 has tripped (doorway wall – 6 in. below reinforced PVC membrane).
06:00	Flames from the crib are 8 ft from the floor.
09:00	The thermocouple that is installed 4 ft from each test wall (on a support rod mounted on the concrete floor) and 1 in. down from the original reinforced PVC membrane is in contact with the drooping reinforced PVC membrane ceiling. Flames from the crib are now at the 7-ft level.
11:00	The reinforced PVC membrane has pulled away from the aluminum angle trim 6 ft from each wall away from the crib corner.

TIME MIN:SEC	TEST OBSERVATIONS
14:00	The reinforced PVC membrane has pulled away from the aluminum angle trim 7 ft from each wall away from the crib corner. Flames from the crib are 6 to 6½ ft above the floor.
14:55	The reinforced PVC membrane has pulled away from the aluminum angle trim 8 ft from each wall away from the crib corner, and is hanging downwards 5½ ft above the floor. Flames from the crib are 5½ ft above the floor.
15:00	End of 15 min fire exposure, crib extinguished.

APPENDIX B

Photographic Documentation
(Consisting of 8 Pages)

Figure B-1. View of Crib Corner at the Wall/Ceiling Intersection. Aluminum Angle is Mounted 12 in. Below Gypsum Ceiling Around Interior of Room.

Figure B-2. Room Interior Ceiling with Sprinkler Heads Installed Before Installation of Reinforced PVC Membrane.

Figure B-3. View of Reinforced PVC Membrane with Flush Mount Sprinkler Head Installed at Center of Room.

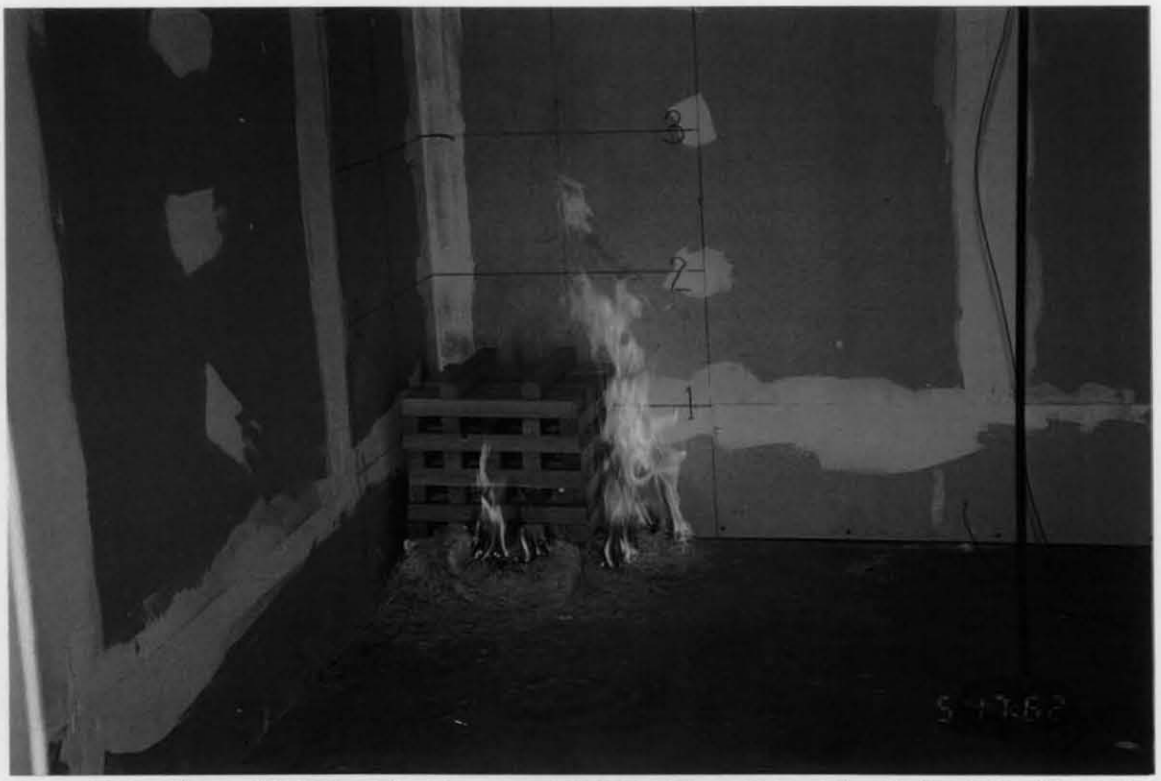


Figure B-4. Start of 15-Min. Fire Exposure With Ignition of Excelsior Under 30 lb Wood Crib.

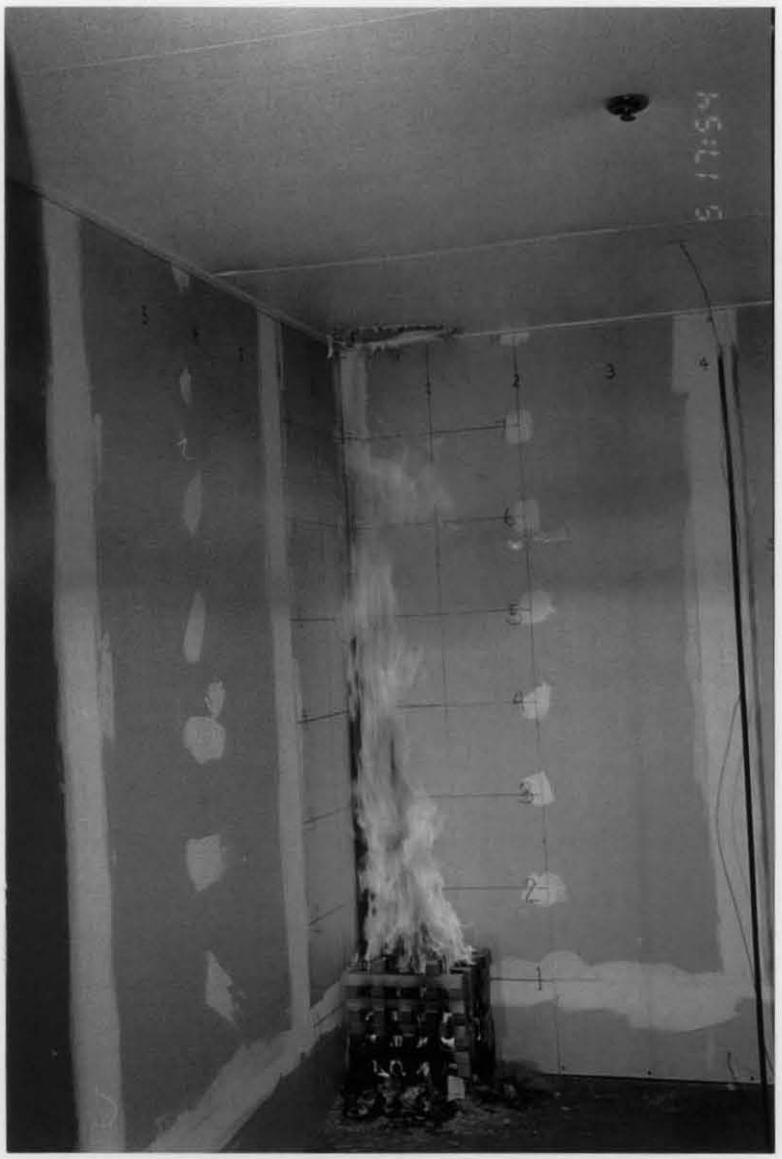


Figure B-5. **View of Crib Corner with Melt-Through of Reinforced PVC Membrane at the Crib Corner. Note: Layer of Smoke in Room Interior. Test Time Is Approximately 2 Min.**

Figure B-6 View of Test Corner and Ceiling. Reinforced PVC Membrane Is Beginning to Sag at Crib Corner and Around Sprinkler Head.

Figure B-7. Room Interior at Approximately 6 Min into Fire Exposure. Reinforced PVC Membrane Is "Hanging Down" Approximately 18 In. (6½ Ft from Floor).

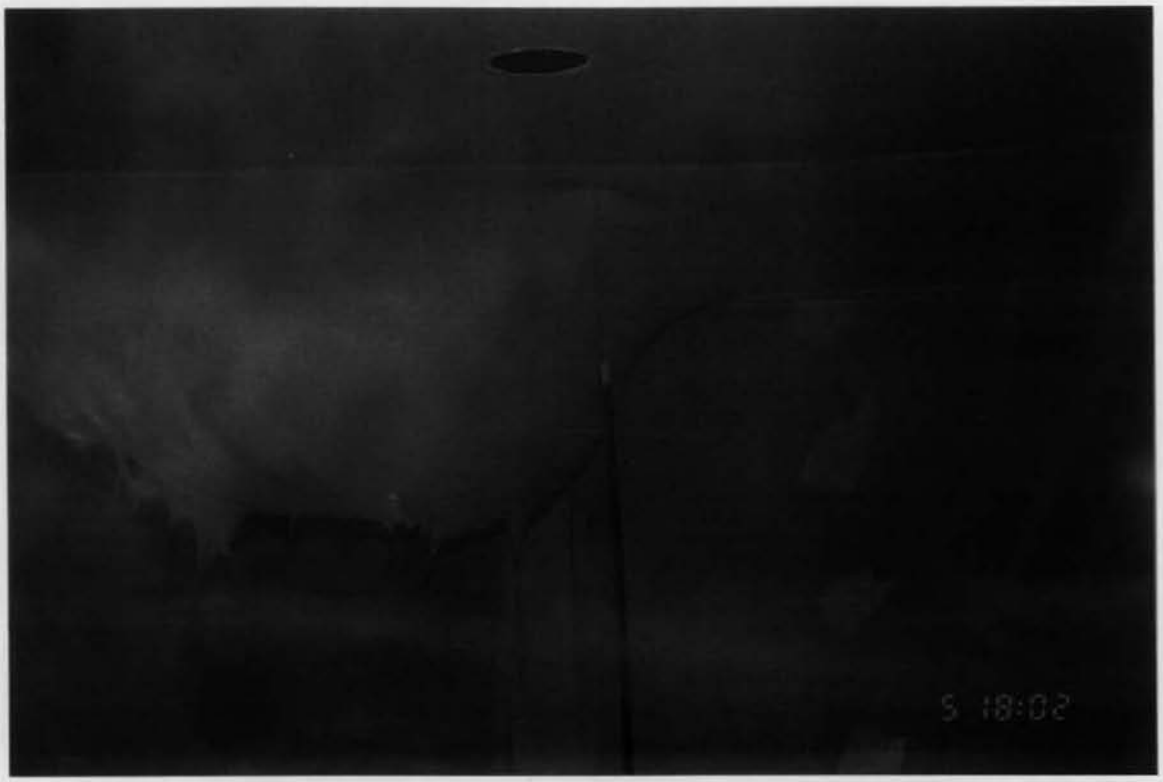


Figure B-8. Close-up View of Reinforced PVC Membrane "Hanging Down" Approximately 18 In. from 8-Ft Ceiling (6½ Ft Above Floor). Center of Membrane Has Softened and Stretched, Detaching and Falling Away from Sprinkler Head Installed at Center of Room.

Figure B-9. Room Interior at Approximately 14 Min into 15-Min Fire Exposure. Reinforced PVC Membrane Is "Hanging Down" Approximately 2½ Ft Down from 8-Ft Ceiling (5½ Ft Above the Floor).

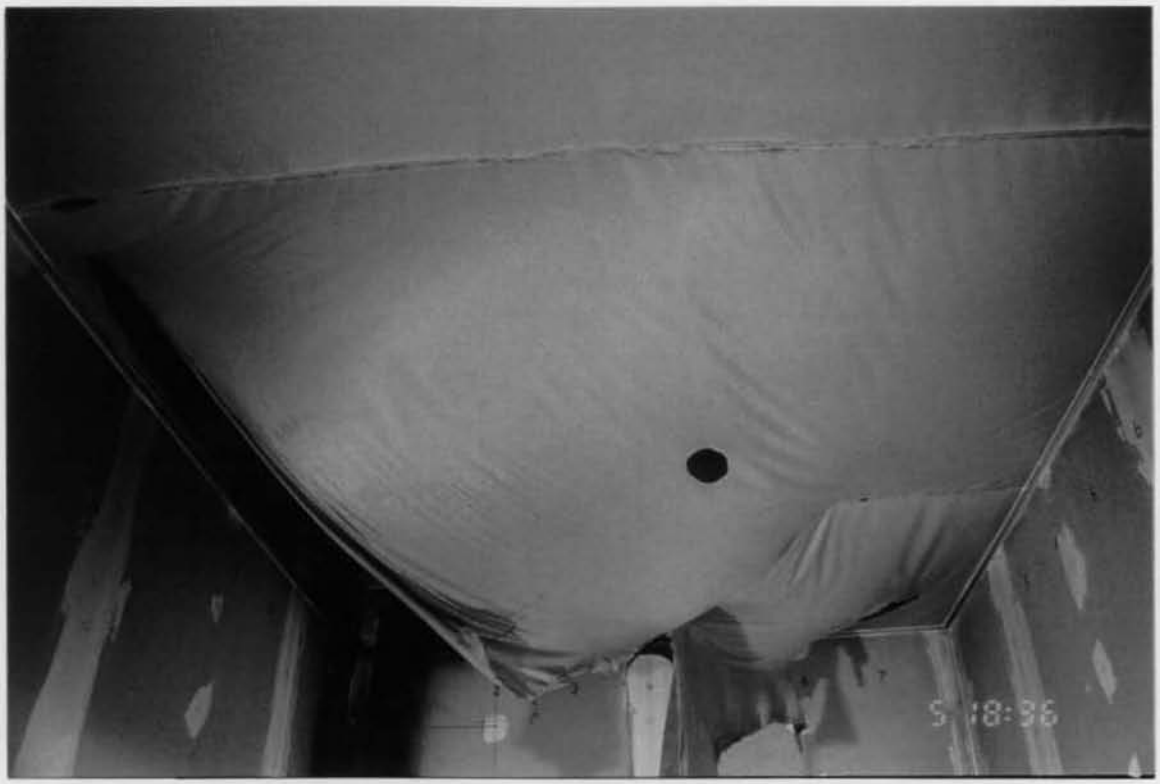


Figure B-10. Reinforced PVC Membrane Ceiling at End of 15-Min Fire Exposure. Membrane Has Torn from Angle Trim 8 Ft Along both Walls.

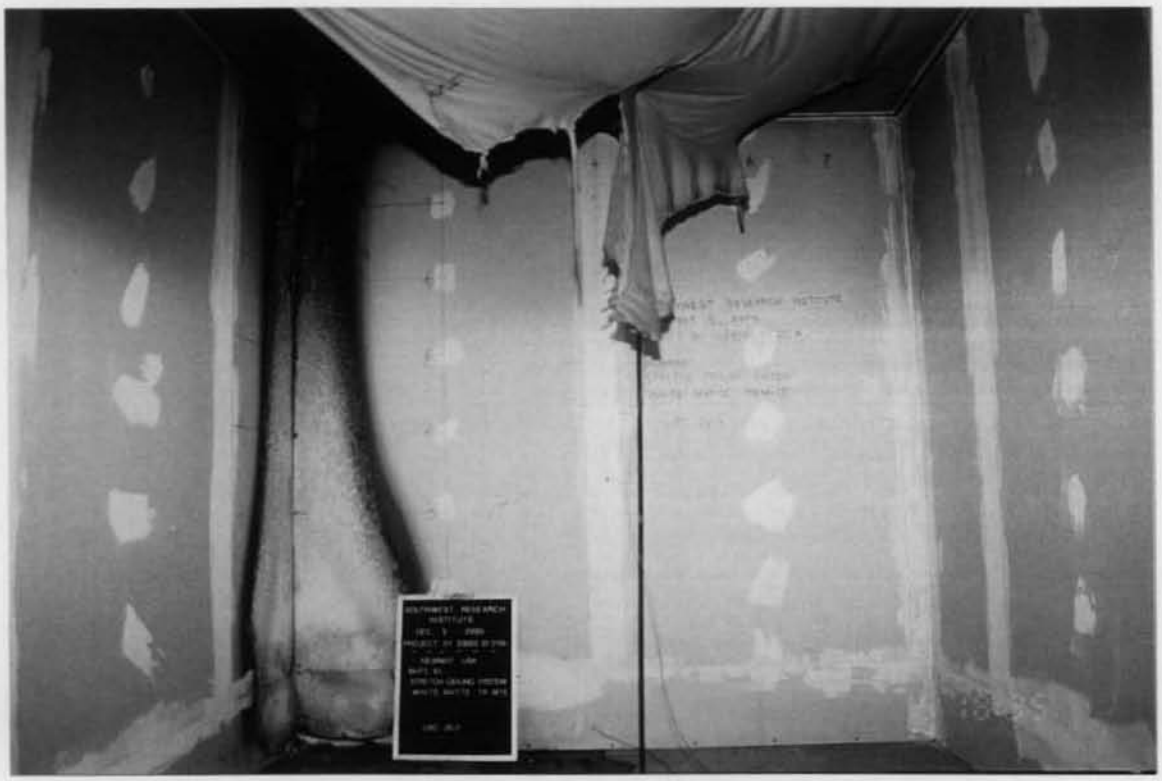


Figure B-11. Room Interior with Crib Removed.

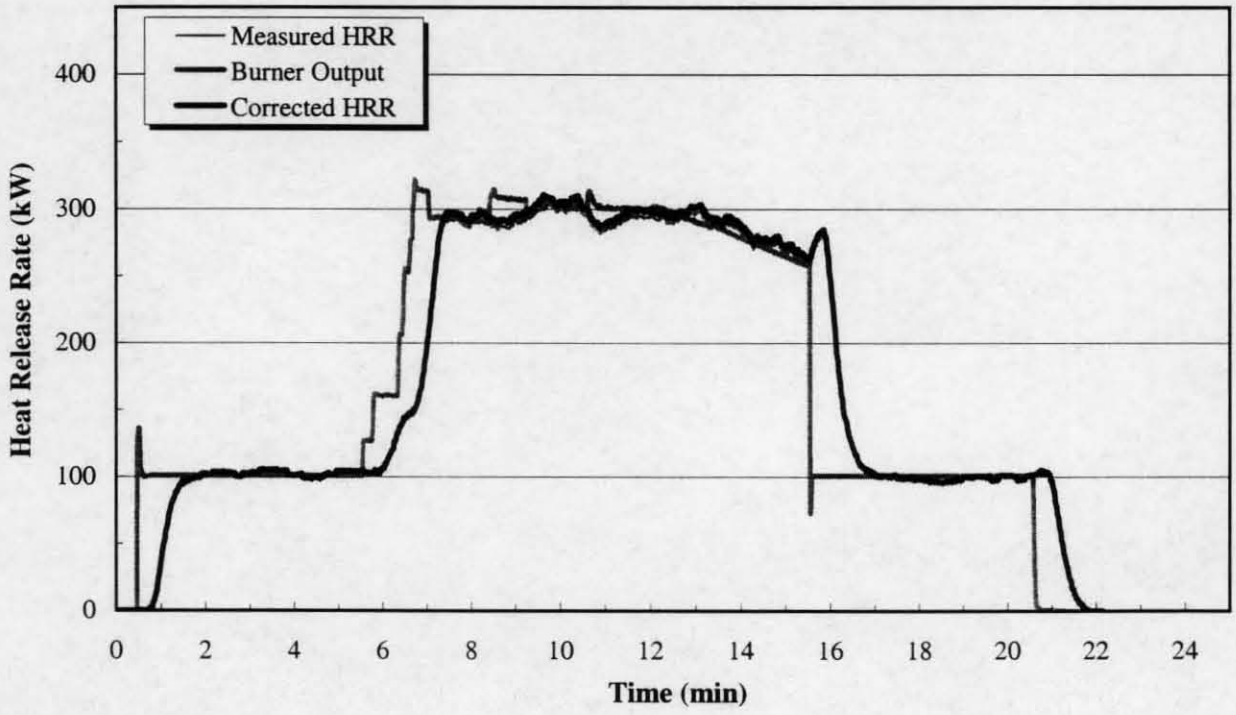
APPENDIX C

Calibration Results
(Consisting of 1 Page)

HEAT RELEASE RATE CALIBRATION RESULTS

Total Heat Released from Burner	229.36 MJ
Total Heat Release Measured	225.74 MJ
Percent Difference	-1.58%
Initial C Factor	2.9560
Correction Factor	1.0160
Calibrated C Factor	**3.0033**

HEAT RELEASE RATE & BURNER OUTPUT



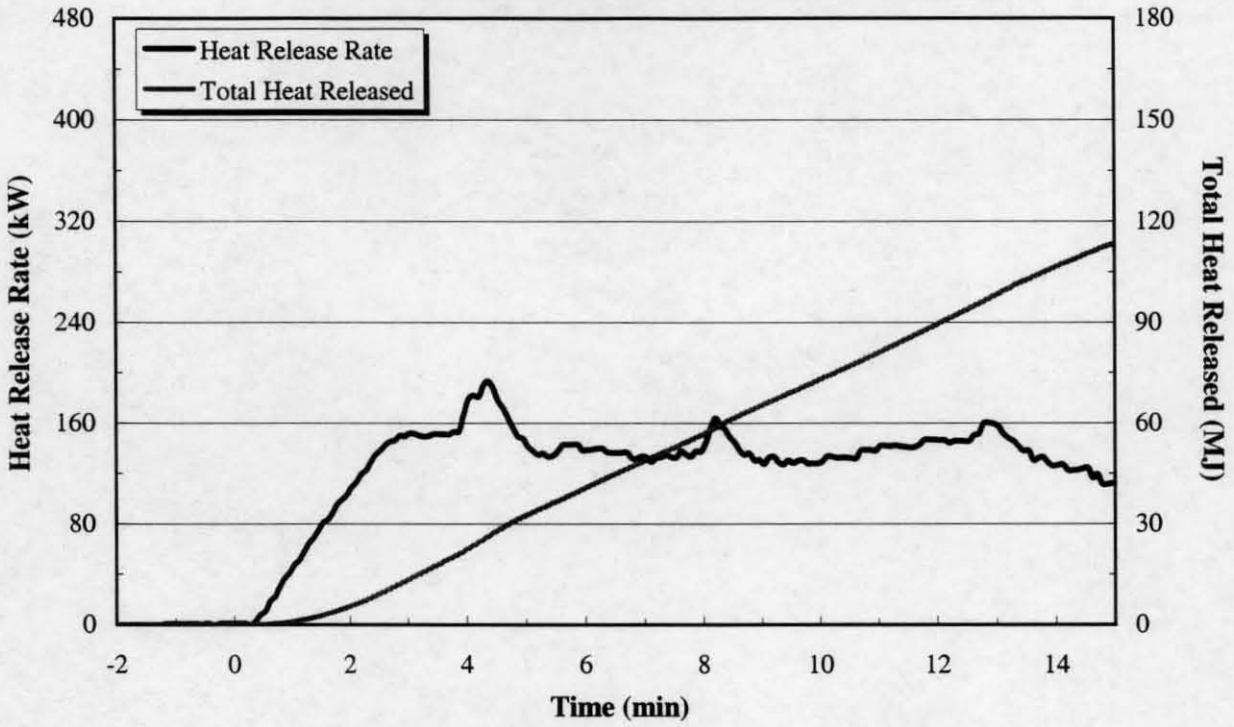
APPENDIX D

Temperature and Light Transmission Data
(Consisting of 6 Pages)

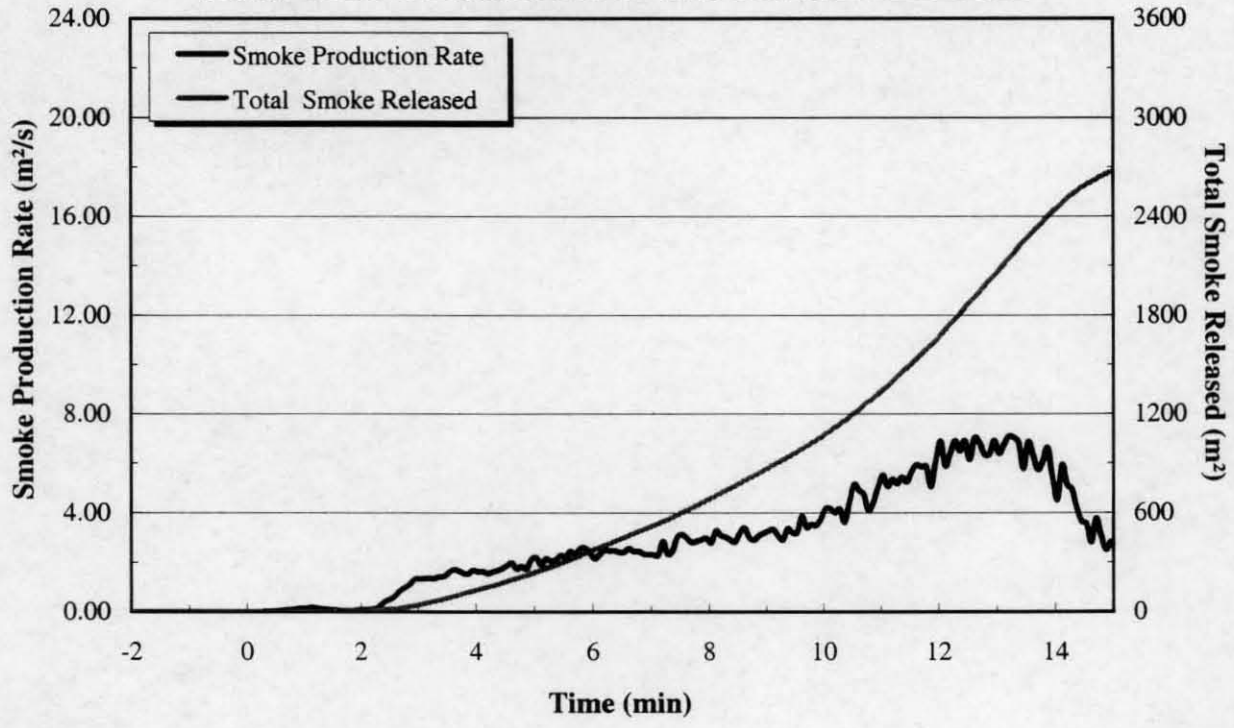
SUMMARY OF
UBC 26-3 ROOM-CORNER TEST RESULTS

Peak HRR_{total}	194 kW	at	4 min	22 sec
Average HRR_{total}	126 kW			
Total Heat Released	113 MJ			
Peak Smoke Production Rate	7.10 m^2/s	at	13 min	12 sec
Average Smoke Production Rate	2.97 m^2/s			
Total Smoke Released	2670 m^2			
Peak Optical Density	1.34 1/m	at	12 min	37 sec
Exhaust Duct Flow at Peak O.D.	2.28 m^3/s			
Average Optical Density	0.449 1/m			
Average Volumetric Exhaust Flow	1.57 m^3/s			
Peak Temperature - 8 Ft Above Floor (4 ft. from the walls)	289°C 553°F	at	13 min	22 sec
Peak Temperature - 9 Ft Above Floor (4 ft. from the walls)	337°C 639°F	at	12 min	22 sec
Sprinkler #1 Activation	3 min 28 sec	at	178 °C or	352°F
Sprinkler #2 Activation	2 min 34 sec	at	171 °C or	340°F
Sprinkler #3 Activation	2 min 50 sec	at	153 °C or	307°F
Sprinkler #4 Activation	5 min 39 sec	at	134 °C or	272°F
Peak CO Production Rate	0.2×10^{-6} m^3/s	at	1 min	27 sec
Peak CO Release Rate	0.2×10^{-3} g/s			
Peak CO_2 Production Rate	0.012 m^3/s	at	4 min	27 sec
Peak CO_2 Release Rate	22 g/s			

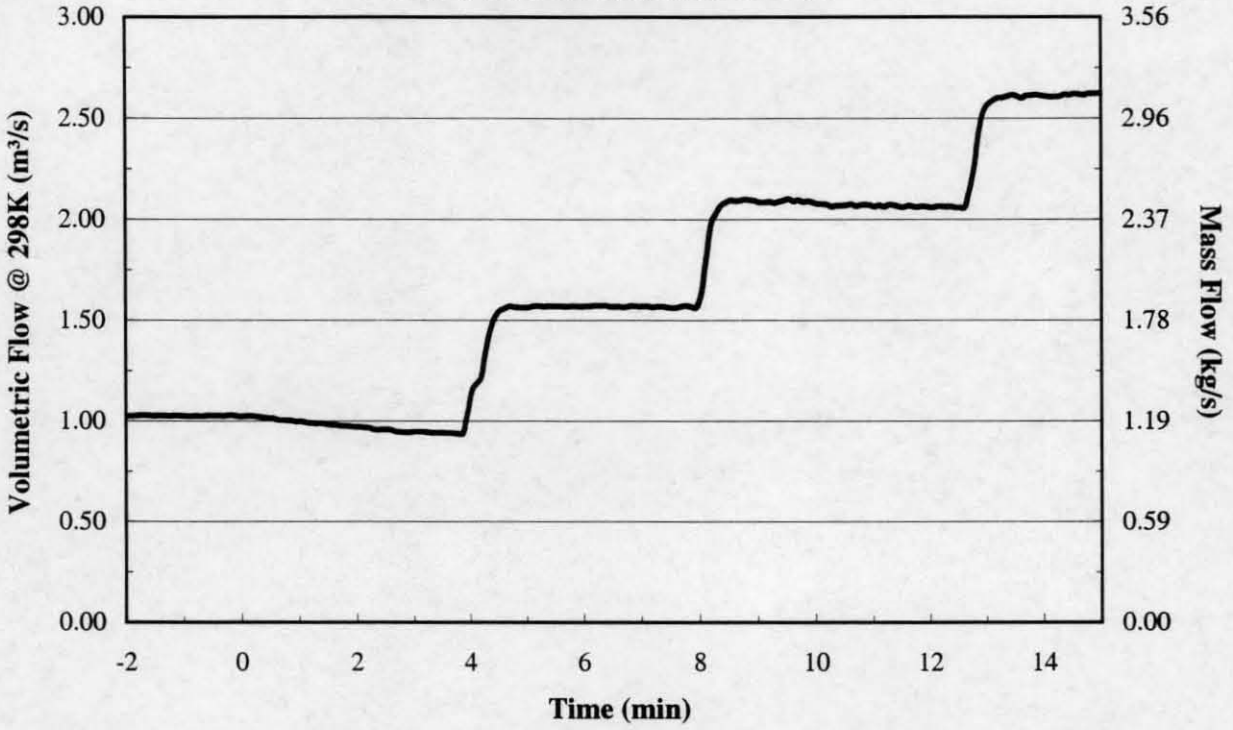
HEAT RELEASE RATE & TOTAL HEAT RELEASED



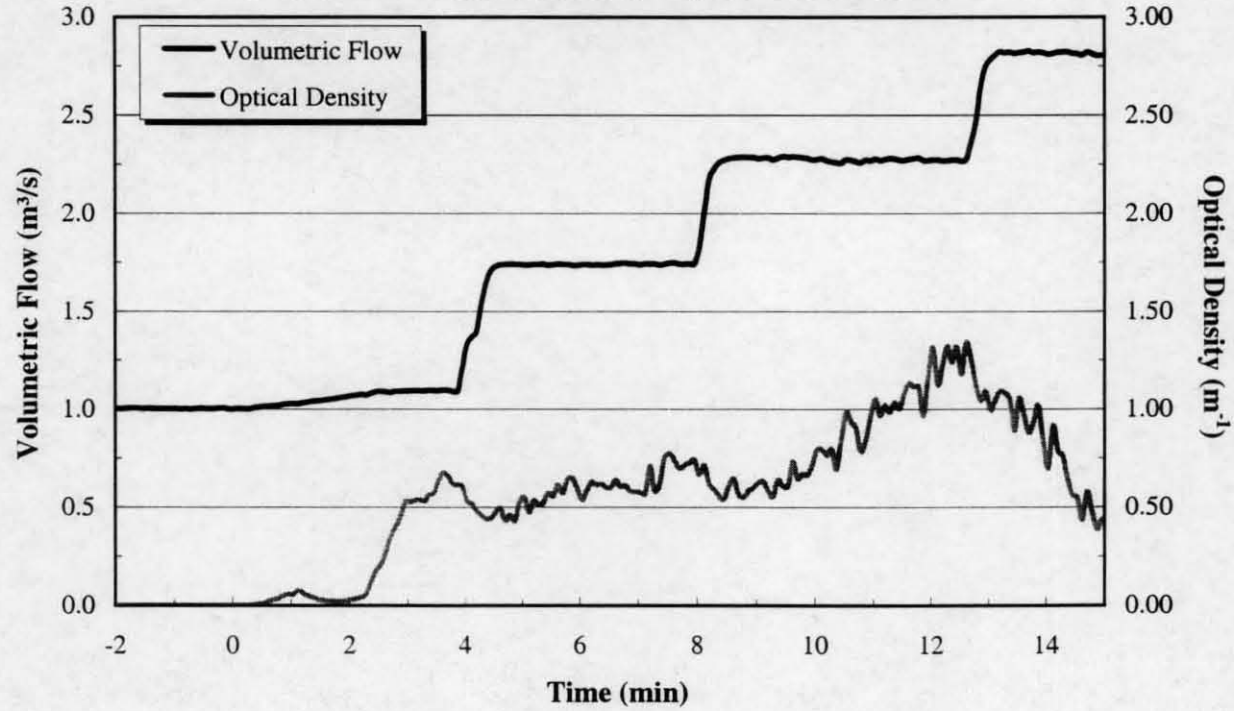
SMOKE PRODUCTION RATE & TOTAL SMOKE RELEASED



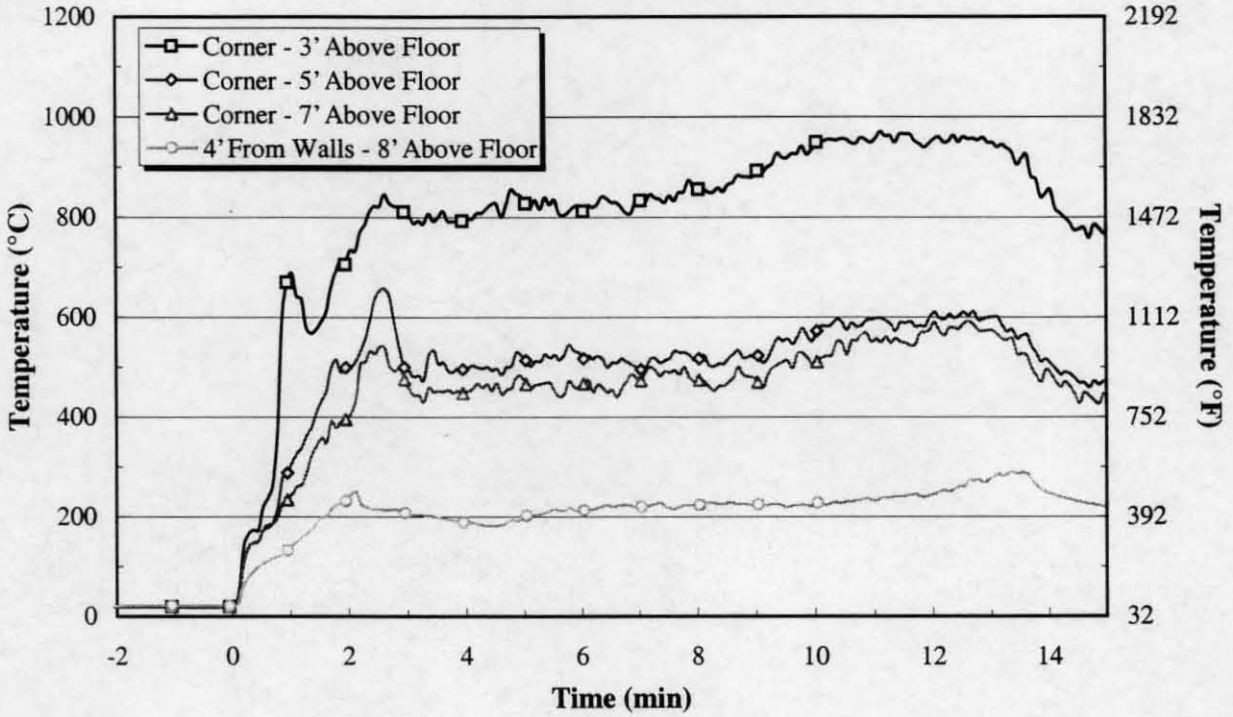
FLOW IN THE EXHAUST DUCT



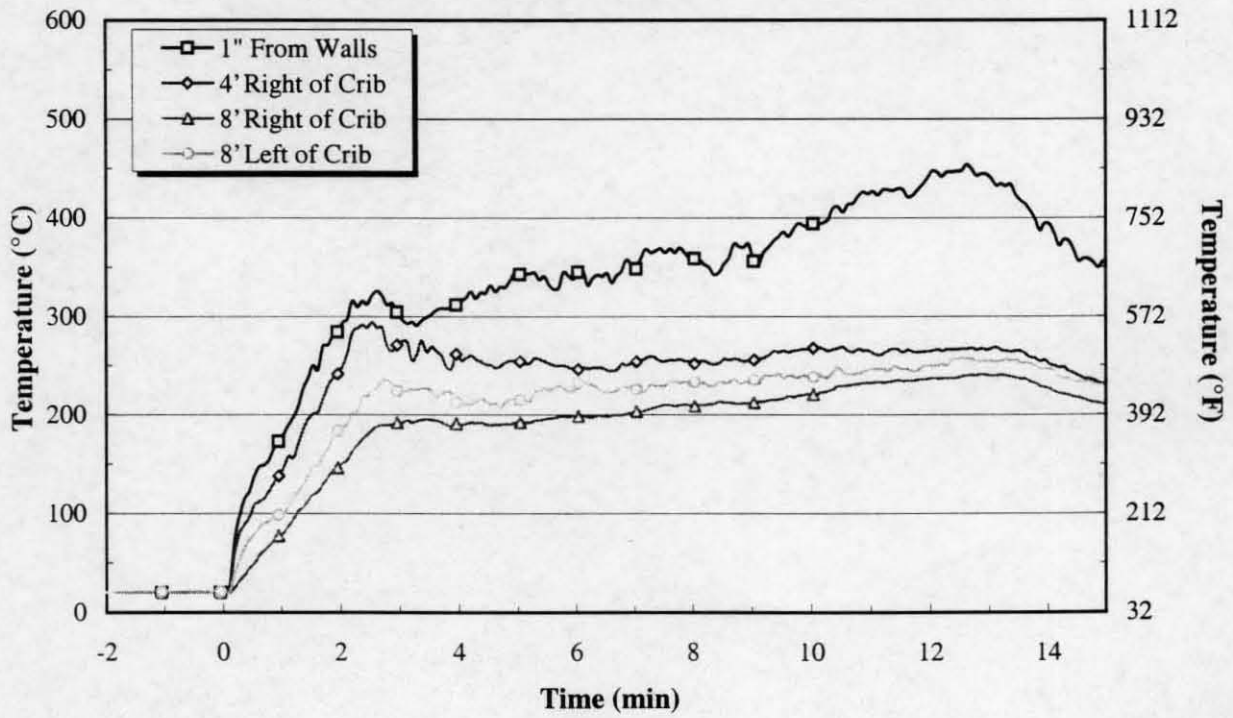
ACTUAL VOLUMETRIC FLOW IN THE EXHAUST DUCT & OPTICAL DENSITY PER UNIT LIGHT PATH LENGTH



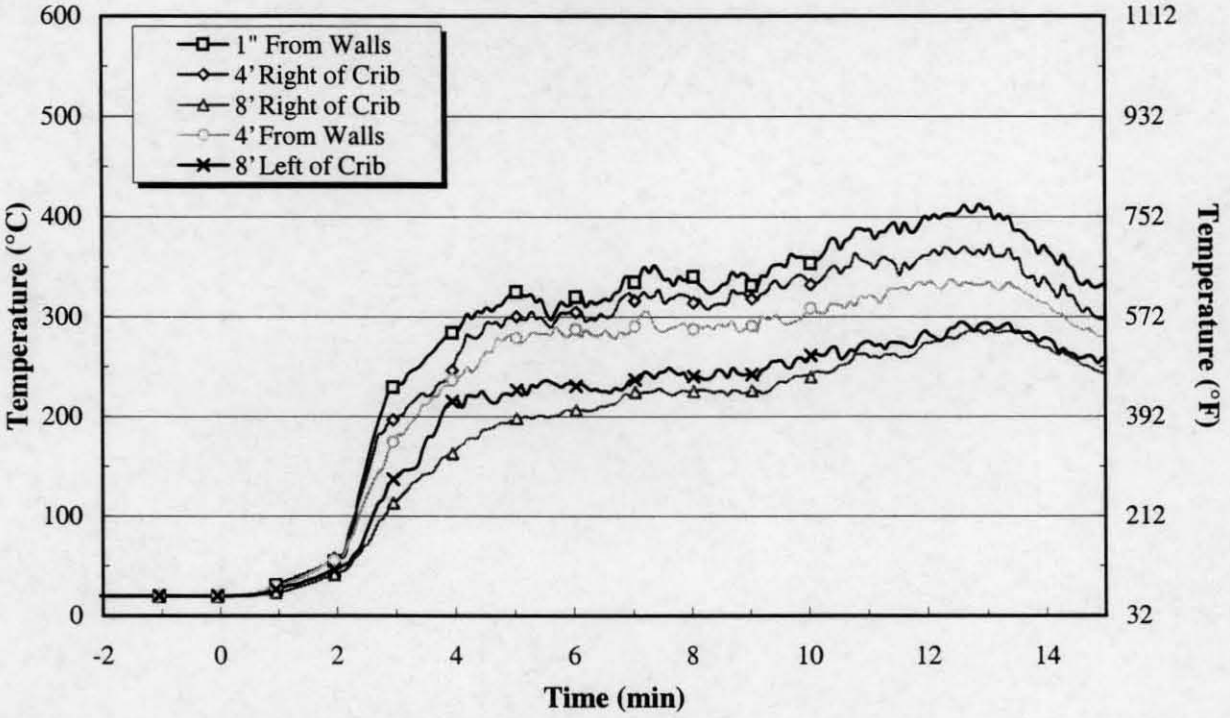
UBC 26-3 TEMPERATURES



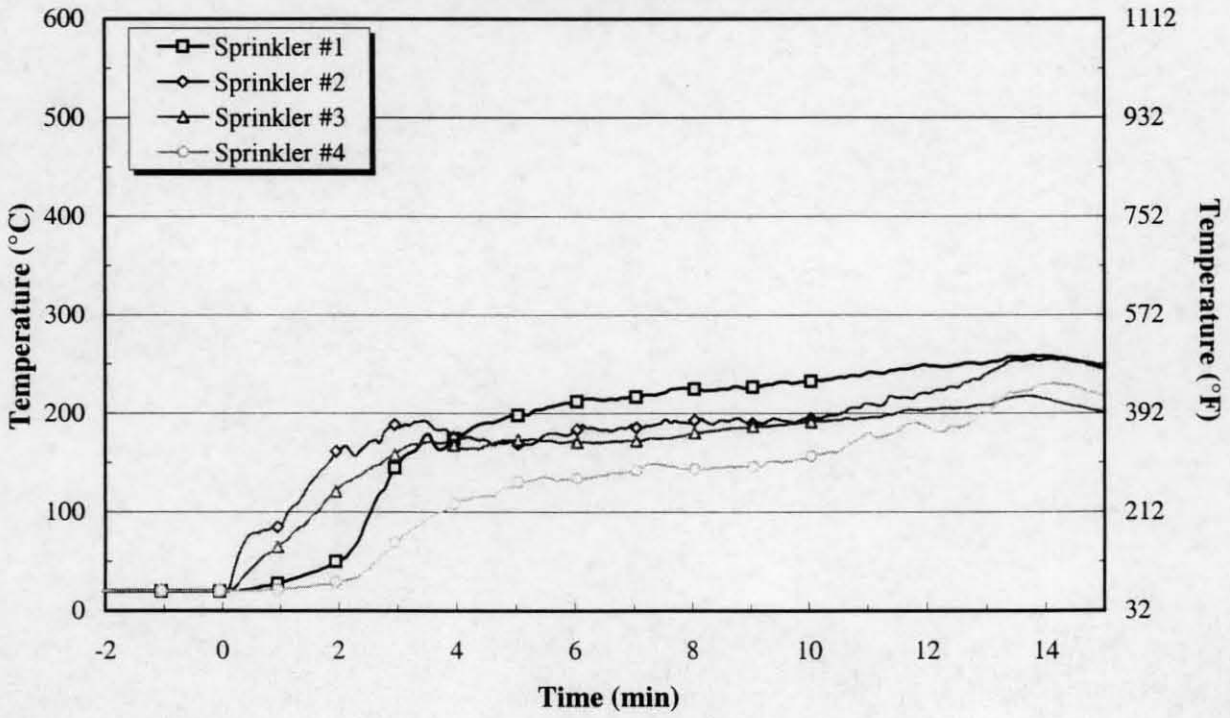
SUPPLEMENTAL TEMPERATURES - 8 FT ABOVE FLOOR



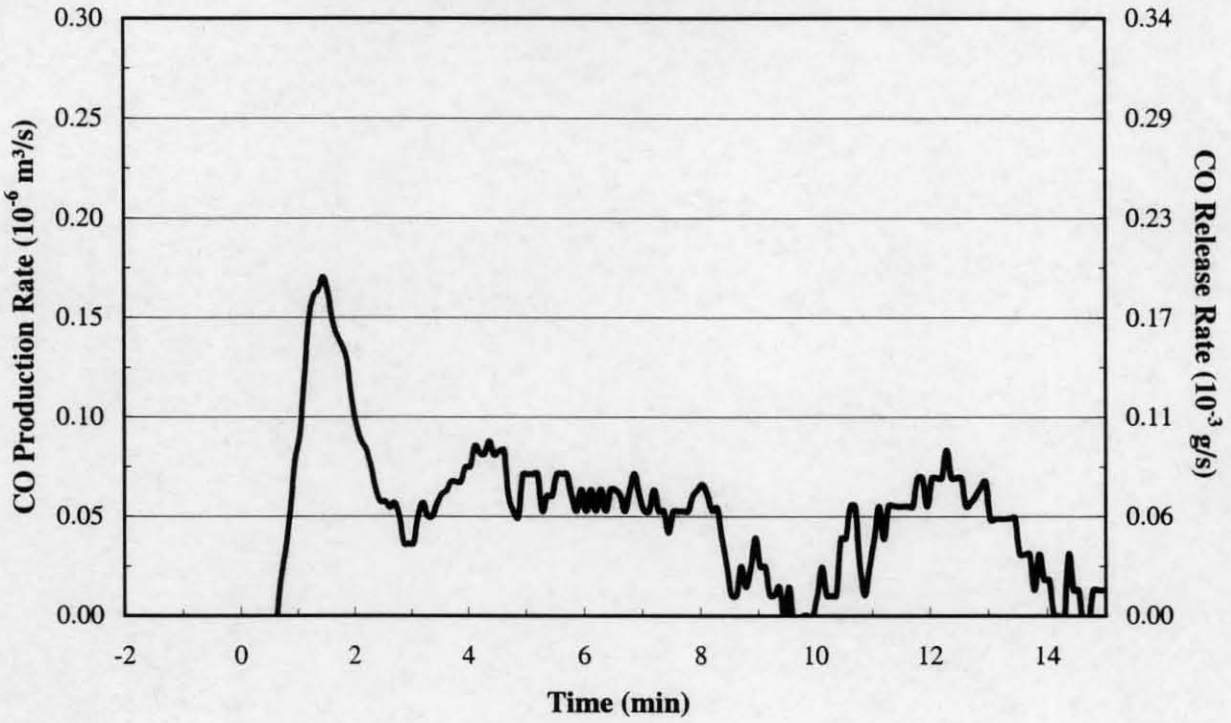
SUPPLEMENTAL TEMPERATURES - 9 FT ABOVE FLOOR



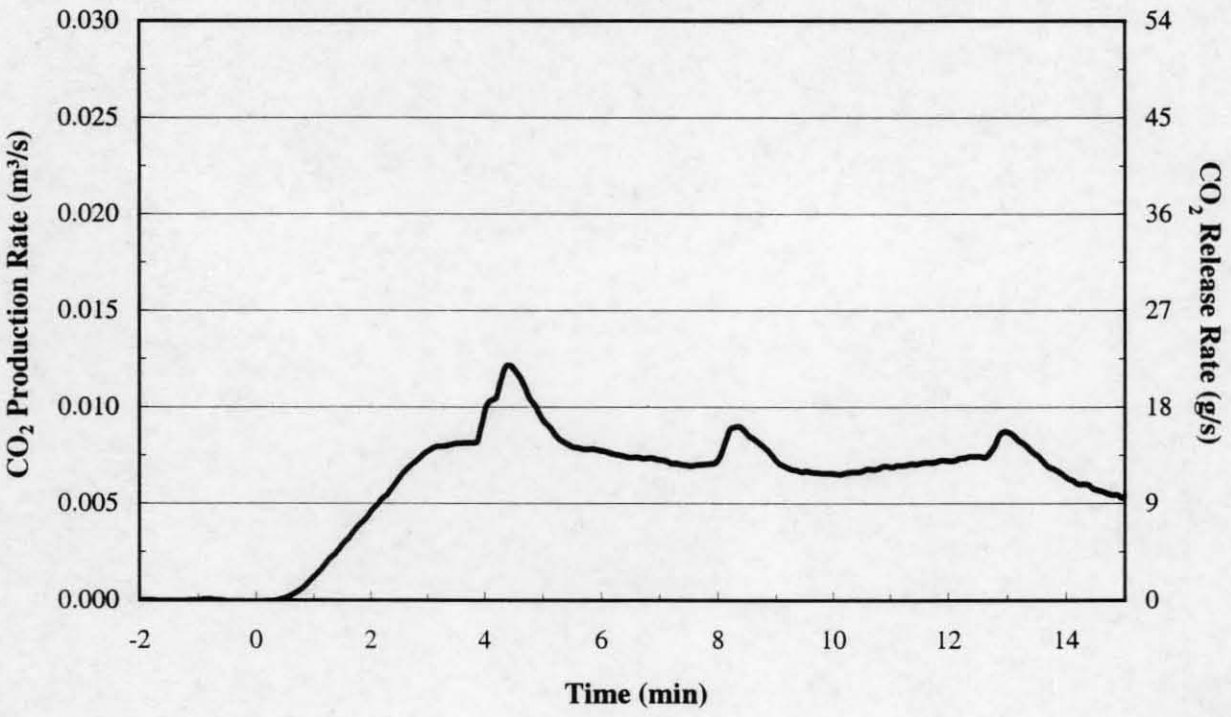
SPRINKLER TEMPERATURES



CARBON MONOXIDE (CO) PRODUCTION RATE



CARBON DIOXIDE (CO_2) PRODUCTION RATE



APPENDIX E

Sprinkler Activation and Temperature
(Consisting of 1 Page)

Table E-1. Sprinkler Activation Time and Temperature.

Sprinkler head	Activation Time	Temperature
Sprinkler Head No. 1	3 min 28 sec	178°C / 352°F
Sprinkler Head No. 2	2 min 34 sec	171°C / 340°F
Sprinkler Head No. 3	2 min 50 sec	153°C / 307°F
Sprinkler Head No. 4	5 min 39 sec	134°C / 272°F

Sprinkler head No. 1 was located in the center of the room on the gypsum wallboard ceiling; the thermocouple was installed ½-in. away from the fusible activation link on the head (ceiling head-space).

Sprinkler head No. 2 was located in the center of the room on the reinforced PVC membrane ceiling (12 in. below the gypsum wallboard ceiling); the thermocouple was installed ½-in. away from the fusible activation link on the head.

Sprinkler head No. 3 was located on the wall near the doorway, 6 in. down from the gypsum wallboard ceiling and 15 in. away from the right wall (in the center of the air cavity). The thermocouple was installed ½-in. away from the fusible link on the head.

Sprinkler head No. 4 was located on the wall near the doorway, 6 in. down from the reinforced PVC membrane ceiling and 15 in. away from the right wall; the thermocouple was installed ½-in. away from the fusible link on the head.

See Appendix B, Photographic Documentation for sprinkler and thermocouple placement.