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ENGINEERING DATA TRANSMITTAL

Page 1 of 1
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		Design Authority				1	/	R. E. Jordan		1/26/00	S3-97
		Design Agent				6		P. J. McKenna		1/26/00	S3-96
1	/	Cog. Eng. R. A. Huckfeldt		1/18/00	S7-86	6		C. F. Myott			S7-86
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Fire Hazards Analysis for the Inactive Equipment Storage Sprung Structure

CH2M Hill Hanford Group, Inc.

P. O. Box 1500

Richland, WA 99352

U.S. Department of Energy Contract DE-AC06-99RL14047

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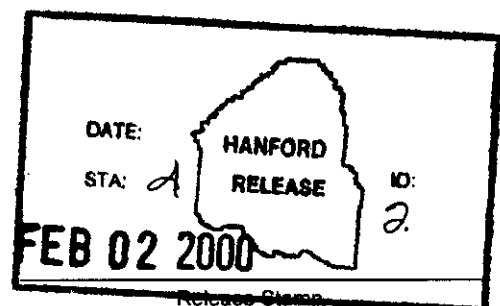
Key Words: Fire Hazards, DOE Order 5480.7A, Sprung Structure, Relocatable Structures, ignition sources

Abstract: The purpose of the analysis is to comprehensively assess the risk from fire within individual fire areas in relation to proposed fire protection so as to ascertain whether the fire protection objective of DOE Order 5480.7A are met. The order acknowledges a graded approach commensurate with the hazards involved.

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Approved For Public Release

FIRE HAZARDS ANALYSIS

FOR THE

INACTIVE EQUIPMENT STORAGE SPRUNG STRUCTURE

CH2M Hill Hanford Group, Inc.

December 1999

Prepared by

R. A. Huckfeldt

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FIRE HAZARDS ANALYSIS FOR THE INACTIVE EQUIPMENT SPRUNG STRUCTURE

1.0 INTRODUCTION

In accordance with Department of Energy (DOE) Order 5480.7A, a Fire Hazards Analysis must be performed for all new facilities. The purpose of the analysis is to comprehensively assess the risk from fire within individual fire areas in relation to proposed fire protection to ascertain whether the fire protection objectives of the Order are met. The Order acknowledges a graded approach commensurate with the hazards involved.

The requirements in DOE Standard 1088-95, Fire Protection for Relocatable Structures, are applicable to this facility. Relocatable structures are defined as manufactured structures, mobile homes, trailers, semi-trailers, modular type structures, factory assembled type structures, cargo containers, hazardous materials or flammable liquid storage containers, air supported/inflated structures, tent/membrane and cloth/rib structures.

2.0 SUMMARY AND CONCLUSIONS

The purpose of this document is to confirm that the location and use of the sprung structure is acceptable as proposed, and to confirm that all applicable objectives of DOE Order 5480.7A are met. All requirements within DOE Standard 1088-95 have been evaluated and are met. The standard states that all new structures over 5000 sq. ft. or having an MPFL over \$1M "should" be provided with automatic sprinkler protection. This analysis concludes that with the prescribed restraints on storage and ignition sources, automatic sprinkler protection is not warranted. Concurrence by the Office of the Fire Marshal is required to validate the conclusions of this report as an equivalency.

3.0 DESCRIPTION OF CONSTRUCTION

The Sprung Structure is an oblong dome shaped structure measuring 89 feet wide, 128 feet long, and 36 feet high and is 9650 sq. ft.. It has an aluminum frame and is covered by "Vernotex"® (Trade name of fabric made by Vernon Plastics, Shelly Rd. PO Box 8248, Haverhill, MA.) fabric. This fabric is qualified under NFPA 701 as fire retardant. The structure will have no utilities provided (Attachment 2). It is being used only for weather protection for multiple high valued pieces of mobile equipment.

4.0 FIRE PROTECTION FEATURES

This facility will be used solely for weather protection for housing some relatively valuable equipment which if left outside will deteriorate rapidly resulting in costly maintenance and repairs. Fire protection is provided in the form of prevention and control of combustibles. Minimizing sources of ignition is a necessity. Because the facility will normally be unoccupied, placement of fire extinguishers is not warranted. It is anticipated, however, that there may be activities conducted within the facility where fire watches will be established and fire extinguishers will be required.

5.0 DESCRIPTION OF FIRE HAZARDS

The Sprung Structure will have no permanent heating or electrical sources/systems. The structure is well isolated from any exposure fire hazards. The structure is constructed of an aluminum frame covered with a fire retardant fabric meeting the flame spread and smoke generation limitation requirements of NFPA 701. Ignition sources are minimized to the extent possible. No internal combustion engines will be operated while in the facility except for bringing the equipment in and removing the equipment. Batteries will be disconnected while in storage. No maintenance activities or other activities that may introduce ignition sources will be conducted within the facility except by procedures or permits approved by the CHG fire protection engineer. Storage will be limited to the equipment identified in this analysis. No transient combustibles will be stored within the facility.

The following is a list of equipment to be stored in this structure:

Long Length Contaminated Equipment Removal System (LLCERS)

1. LLCERS Receiver Trailer, Property No. 6404283 (18 gal. Diesel Tank)
2. LLCERS Transport Trailer, 6404280 (18 gal. Diesel Tank)
3. Miscellaneous parts

Cone Penetrometer (CPP)

1. Cone Penetrometer Platform (CPP), WC58860,
2. Lowboy trailer, 6405363
3. Generator, 7403470, on trailer, 6403833 (56 gal. Diesel Tank)
4. pallets, ballast and spacer blocks, and miscellaneous parts

Light Duty Utility Arm (LDUA)

1. Mobile Deployment System (MDS), (~60 gal. Gasoline Tank)
2. Tank Riser Interface Confinement System (TRIC)
3. Power Interface Module (PIM)
4. Power Distribution System (PDS), WC58557
5. At-Tank Instrument Enclosure (ATIE), WC58558

6. TRIC Grapple
7. Pallets of hoses and reels, and boxes containing LDUA parts
8. Decon Water System (DWSS) (Wood bed on trailer)

Range fires are a concern on the Hanford Site, however the physical location of this facility has adequate fire breaks which in conjunction with a qualified fire department provides adequate protection.

6.0 PROTECTION OF ESSENTIAL SAFETY CLASS SYSTEMS

There are no essential safety class systems associated with this facility or equipment.

7.0 LIFE SAFETY CONSIDERATIONS

This facility will normally be unoccupied. For life safety design purposes, NFPA 101, Life Safety Code, Storage classification is being applied. The facility meets all requirements with this classification.

8.0 CRITICAL PROCESS EQUIPMENT

There is no critical process equipment associated with this project.

9.0 HIGH VALUE PROPERTY

1. Long Length Contaminated Equipment Removal System (LLCERS)(~\$2M)
2. Cone Penetrometer (CPP)(~\$1.5M)
4. Light Duty Utility Arm (LDUA)
(Estimated replacement cost \$2.4M)

10.0 DAMAGE POTENTIAL

A Maximum Possible Fire Loss (MPFL) is the value of the property within a fire area, unless a fire hazard analysis demonstrates a lesser or greater loss potential. Due to the lack of an automatic fire suppression system, the Maximum Credible Fire Loss (MCFL) is equal to the (MPFL). The total replacement cost of the equipment stored is ~\$5.9M. The replacement cost of the structure is \$200,000. All equipment currently exists and is stored either outside or in unprotected facilities. Placing this equipment in the sprung structure does not create a new MCFL/MPFL except for the cost of the structure itself and the fact that the equipment is being stored all in one fire area. In November of 1994 Factory Mutual Research Corporation conducted a large scale corner fire test on this type of structure (Attachment 3). Seven hundred and fifty pounds of wood pallets were allowed to burn for 15 minutes. The test concluded that the fabric would not

propagate flame or sustain combustion when exposed to a severe fire. Only fabric immediately adjacent to the flaming fire source became involved in the fire. Due to the lack of ignition sources and the minimal combustible loading, a significant fire would not be expected unless the conditions in Section 5 were violated. (See Observation 99-01)

11.0 FIRE DEPARTMENT/BRIGADE RESPONSE

The Hanford Fire Department is located approximately one mile west of the 200 East area gate. The Hanford Fire Department provides an adequate response time of approximately five minutes to this area.

12.0 RECOVERY POTENTIAL

The anticipated recovery from the MCFL/MPFL would include cleanup and approximately six months to procure and construct another facility. Storage within the facility consists primarily of infrequently used prototype equipment. Should this equipment be damaged by fire, the equipment may not be replaced but if it is, replacement time may exceed a year. This equipment is not considered critical to existing tank farm operations because alternate methods of performing certain tasks can be utilized.

13.0 POTENTIAL FOR TOXICOLOGICAL, BIOLOGICAL, AND/OR RADIATION INCIDENT DUE TO FIRE

No impact is anticipated because there will be no toxicological, biological, and/or radiological sources stored in the facility.

14.0 EMERGENCY PLANNING

The RPP Administration Manual (HNF-IP-0842) provides a system of planned responses to minimize risks to personnel, equipment, buildings, and the environment in the event of emergencies including fire. The Hanford Fire Department will also review this facility and provide a pre-fire plan. (Observation 99-02)

15.0 SECURITY AND SAFEGUARD CONSIDERATIONS RELATED TO FIRE PROTECTION

The Sprung Structure is located northwest of the 2704HV Building next to the 200 East Area. There are no security barriers or special coordination requirements that would hinder the fire department's access. Previous fire department responses to the 2704HV Building have shown that the existing procedures are adequate.

16.0 NATURAL HAZARDS IMPACT ON FIRE SAFETY

16.1 FLOODS

The 200 Areas are situated on a plateau and the structure is not susceptible to flooding even by the "probable maximum flood" postulated by the U.S. Army Corps of Engineers (ERDA 1975) for the Columbia River Basin; therefore, flooding does not impact the fire safety features of the facility.

16.2 TORNADOES

As a pre-engineered facility, the structure is not designed to withstand tornadoes. The facility is designed to withstand wind loads of 70 miles/hour.

16.3 EARTHQUAKES

Eastern Washington is a region of low-to-moderate seismicity. Based on the seismic history since 1840, the U.S. Coast and Geodetic Survey has designated Eastern Washington as Zone 2B seismic probability, implying a potential for moderate damage from earthquakes. It is anticipated that the facility design should withstand an earthquake.

17.0 EXPOSURE FIRE POTENTIAL

This facility meets the exposure separation criteria established in NFPA 80A, Recommended Practice for Protection of Buildings from Exterior Fire Exposures. The facility placement exceeds the minimum exposure distances in all directions.

18.0 FINDINGS/OBSERVATIONS AND RECOMMENDATIONS

Observation 99-01: In accordance with DOE Standard 1088, all relocatable structures greater than 5000 sq. ft. in floor area or having an MPFL in excess of \$1M, should be provided with an automatic fire suppression system. This facility technically violates the verbatim recommendation. Restrictions on ignition sources and combustibles are in place as necessary controls mitigating the need for automatic suppression.

Recommendation: The controls identified in Section 5 of this document are necessary to comply with the spirit and intent of a DOE mandated standard. Some type of management system will be needed to assure the controls remain in place through the life of the facility. A suggestion might be to post the controls at an entrance and follow up with periodic inspections to verify conditions.

Observation 99-02: The position in Observation 99-01 deviates from a DOE recommendation in DOE-STD-1088-95, *Fire Protection of Relocatable Structures*.

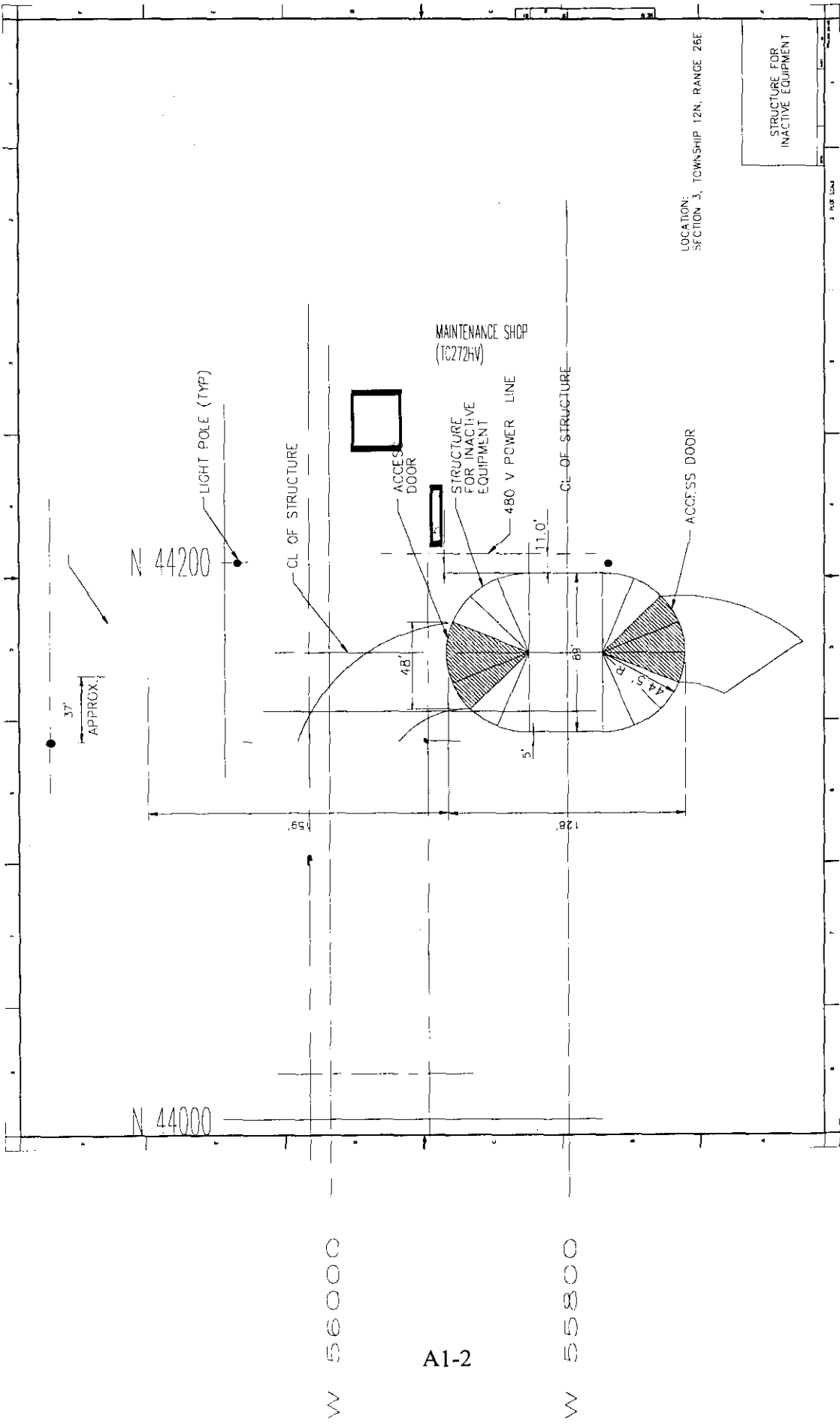
Recommendation: The document must be reviewed and concurred with by the Office of the Fire Marshal as an acceptable equivalency to a prescribed DOE standard. A pre-fire plan shall be prepared as part of the occupancy activities per LMH-PRO-372

19.0 REFERENCES

DOE Order 5480.7A, *Fire Protection*
DOE-STD-1088-95, *Fire Protection for Relocatable Structures*
HNF-IP-0842, RPP Administrative Manual
LMH-PRO-372, *Hanford Fire Department*
NFPA 101®, *Life Safety Code* ®
NFPA 701, *Standard Methods of Fire Tests for Flame Propagation of Textiles and Films*
NFPA 80A, *Recommended Practice for Protection of Buildings from Exterior Fire Exposures*

ATTACHMENT 1
(Total Number of Pages - 2)

STRUCTURE PLOT PLAN



ATTACHMENT 1
Not to Scale

ATTACHMENT 2
(Total Number of Pages - 22)

TENSION MEMBRANE MATERIAL DATA



**CALIFORNIA DEPARTMENT OF FORESTRY and FIRE PROTECTION
OFFICE OF THE STATE FIRE MARSHAL**

REGISTERED FLAME RESISTANT PRODUCT

Product:
VERNOTEX

Registration No.
FA-36501

Product Marketed By:
**VERNON PLASTICS
SHELLEY RD/P.O. BOX 8248
HAVERHILL MA 01835-0748**

This product meets the minimum requirements of flame resistance established by the California State Fire Marshal for products identified in Section 13115, California Health and Safety Code.

The scope of the approved use of this product is provided in the current edition of the CALIFORNIA APPROVED LIST OF FLAME RETARDANT CHEMICALS AND FABRICS, GENERAL AND LIMITED APPLICATIONS CONCERNS published by the California State Fire Marshal.


Deputy State Fire Marshal

Expires: 06/30/2000



The
Govmark
Organization, Inc.

P.O. BOX 807, BELLMORE, NY 11710
TEL: (516) 293-8944
FAX: (516) 293-8956

COMPANY SUBMITT

Name: Vernon Plastics Co
Address: Shelly Road - Ward Hill
Haverhill, MA 01830-0548
Telephone #: 508-373-1551
David Morse

CLIENT'S IDENTIFICATION: Sprung Structures, Inc.
18 oz/sq yd
Industrial Fabric

FAX: 508-373-6562

DATE SAMPLES RECEIVED: 9/20/91

TEST REPORT #: 96277-RV

TEST PERFORMED: NFPA 701 Small Scale Test for Flame Resistant Textiles & Films

GOVMARK TEST RESULTS

<u>Specimen #</u>	<u>After Flame Seconds</u>	<u>Flaming Drip Seconds</u>	<u>Char Length Inches</u>
1	<u>1</u>	<u>0</u>	<u>2.0</u>
2	<u>1</u>	<u>0</u>	<u>2.7</u>
3	<u>1</u>	<u>0</u>	<u>2.7</u>
4	<u>0</u>	<u>0</u>	<u>2.6</u>
5	<u>1</u>	<u>0</u>	<u>3.0</u>
6	<u>2</u>	<u>0</u>	<u>3.0</u>
7	<u>2</u>	<u>0</u>	<u>2.9</u>
8	<u>1</u>	<u>0</u>	<u>2.9</u>
9	<u>2</u>	<u>0</u>	<u>3.2</u>
10	<u>2</u>	<u>0</u>	<u>2.7</u>
Average:			<u>2.8</u>

REMARKS:

REQUIREMENTS:

<u>Fabric Weight</u> <u>oz./Sq. Yd.</u>	<u>After Flame Seconds</u> <u>Max. Ind. Specimen</u>	<u>Flaming Drip Seconds</u> <u>Max. Ind. Specimen</u>	<u>Char Length Inches</u> <u>Max. Avg. - Max. Ind.</u>
<u>xx] Over 10</u>	<u>2.0</u>	<u>0</u>	<u>3.5 4.5 [xx]</u>
<u>] Over 6</u>	<u>2.0</u>	<u>0</u>	<u>4.5 5.5 []</u>
<u>] 6 and under</u>	<u>2.0</u>	<u>0</u>	<u>5.5 6.5 []</u>

CONCLUSION: The above results indicate compliance with the stated requirements.

CERTIFICATION: I certify that the above results were obtained after testing specimens in
conformance with the procedures and equipment specified by NFPA 701 Small Scale Test for
Flame Resistant Textiles & Films 1989 Edition.

DATE TESTING COMPLETED 9/20/91

jd

Signature of Test Supervisor
THE GOVMARK ORGANIZATION, INC.

Certificate of Flame Resistance



REGISTERED FABRIC

or

CONCERN NUMBER

F-365-01

ISSUED BY

VERNON PLASTICS

DIVISION, BORDEN INC.

Date treated or manufactured

This is to certify that the materials described on the reverse side hereof have been flame-retardant treated (or are inherently nonflammable).

FOR SPRUNG INSTANT STRUCTURES

CITY CALGARY STATE ALBERTA, CANADA

Certification is hereby made that: (Check "a" or "b")

- (a) The articles described on the reverse side of this Certificate have been treated with a flame-retardant chemical approved and registered by the State Fire Marshal and that the application of said chemical was done in conformance with the laws of the State of California and the Rules and Regulations of the State Fire Marshal.

Name of chemical used _____ Chem. Reg. No. _____

Method of application

- (b) The articles described on the reverse side hereof are made from a flame-resistant fabric or material registered and approved by the State Fire Marshal for such use.

Trade name of flame-resistant fabric or material used VERNOTEX Reg. No. M-11614

The Flame Retardant Process Used will not Be Removed By Washing
(will or will not)

Name of Applicator or Production Superintendent

By

Name

TECHNICAL MANAGER

Ville

3
1
B
L



United States Testing Company, Inc.

701 FAIRFIELD AVENUE • FAIRFIELD, NEW JERSEY 07004 • 201-575-5252 • Fax: 201-573-8271

REPORT OF TEST

Engineering Services

CLIENT: Vernon Plastics Co.
Shelly Road - Ward Hill
Haverhill, Massachusetts
01835-0548

NUMBER: 023167
CR109384
November 2, 1993

SUBJECT: Flammability

REFERENCE:

Vernon Plastics Co., Purchase Order Number 32370 dated September 24, 1993.

Sample Rec'd.: 10/22/93

Test Date: 10/22/93
11/2/93

SAMPLE IDENTIFICATION:

One (1) sample was submitted and identified by the Client as:

Sprung Instant Structures 18 Oz. White
Lot #39346

TEST PERFORMED:

The submitted sample was tested for Flammability in accordance with the procedures outlined in Uniform Building Code Standard No. 55-1, 1991.

Testing Supervised by:

Steve Caldarola

Page 1 • Steve Caldarola
of 2 • Senior Supervisor
lv • Fire Technology

SIGNED FOR THE COMPANY

BY

John Thomas
John Thomas
Vice President



Member of the SGS Group (Société Générale de Surveillance)

• Biology • Chemistry • Environmental • Materials • Facilities in Principal Cities •

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NOV 02 1993 U.S.

United States Testing Company, Inc.

CLIENT: Vernon Plastics Co.

NUMBER: 023167
CR109384TEST RESULTS:

<u>Specimen</u>	<u>Direction</u>	<u>Dimensions, Inches</u>	<u>Char Length Inches</u>	<u>Afterburn Seconds</u>
1	Machine	5 x 84	0	0
2	Machine	5 x 84	0	0
3	Machine	5 x 84	0*	0*
4	Machine	5 x 84	0*	0*
5	Machine	5 x 84	0*	0*
6	Cross Machine	5 x 84	1	0
7	Cross Machine	5 x 84	2	0
8	Cross Machine	5 x 84	0*	0*
9	Cross Machine	5 x 84	0*	0*
10	Cross Machine	5 x 84	0*	0*

Observations: Charring, melting, shrinking.REQUIREMENTS:

A material tested in single sheets shall not continue flaming for more than two seconds after the test flame is removed. The vertical spread of burning shall not exceed 10 inches above the tip of the test flame. Portions of residues of textiles or films which break or drip from the test specimen shall not continue to flame after they reach the floor of the tester.

CONCLUSION:

The submitted sample (weathered and unweathered specimens) meets the requirements when tested per UBC 55-1 as indicated above.

*NOTES: Weathered specimens.



United States Testing Company, Inc.
Engineering Services Division

291 FAIRFIELD AVENUE • FAIRFIELD NEW JERSEY 07004-0000 • 201-575-5252

RPP-5486, Rev. 0
A2-7

REPORT OF TEST

CLIENT: Sprung Instant Structures Ltd.
1001 - 10th Avenue S.W.
Calgary, Alberta, T2R 0B7 Canada
NUMBER: 101586-2
July 10, 1991
SUBJECT: Flammability

REFERENCE:

Sprung Instant Structures Ltd., letter of authorization dated July 3, 1991 per R.E. Smith.

SAMPLE IDENTIFICATION:

Two (2) samples were submitted and identified by the Client as:

- 1) Vernon White Opaque White
- 2) Shelter-Rite White Opaque White

TEST PERFORMED:

The submitted samples were tested for Flammability in accordance with the procedures outlined in Underwriters Laboratories Inc., Tests for Flame Propagation of Fabrics & Films (Large Scale Flame Test, Single Sheets) UL-214.

Testing Supervised by:

Page 1
of 3
lv
Steve Caldarola
Senior Supervisor
Fire Technology Section

SIGNED FOR THE COMPANY

BY

John Lomash
Vice President

Laboratories in: New York • Chicago • Los Angeles • Richland • Tulsa • Modesto • Orlando

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CLIENT: Sprung Instant Structures Ltd.

NUMBER: 101586-2

TEST RESULTS:

Sample: Vernon

<u>Specimen</u>	<u>Direction</u>	<u>Dimensions, Inches</u>	<u>Char Length Inches</u>	<u>After Burn Seconds</u>
1	Machine	5 x 84	4-1/2	0
2	Machine	5 x 84	6	0
3	Machine	5 x 84	5	0
4	Machine	5 x 84	6	0
5	Machine	5 x 84	4-1/2	0
6	Cross Machine	5 x 84	4	0
7	Cross Machine	5 x 84	4	0
8	Cross Machine	5 x 84	5	0
9	Cross Machine	5 x 84	6	0
10	Cross Machine	5 x 84	7	0

Observations: Charring, melting, shrinking.

REQUIREMENTS:

A material tested in single sheets shall not continue flaming for more than two seconds after the test flame is removed. The vertical spread of burning shall not exceed 10 inches above the tip of the test flame. Portions of residues of textiles or films which break or drip from the test specimen shall not continue to flame after they reach the floor of the tester.

CONCLUSION:

The submitted sample meets the requirements when tested per UL-214 (Single Sheets) as indicated above.



United States Testing Company, Inc.
Engineering Services Division

291 FAIRFIELD AVENUE • FAIRFIELD NEW JERSEY 07004-0000 • 201-575-5252

RPP-5486, Rev. 0
A2-9

REPORT OF TEST

CLIENT: Sprung Instant Structures Ltd.
1001 - 10th Avenue S.W.
Calgary, Alberta T2R 0B7 Canada
NUMBER: 101490
July 2, 1991
SUBJECT: Surface Burning Characteristics of Building Materials

REFERENCE:

Sprung Instant Structures Ltd., Purchase Order Number
31196 dated June 24, 1991.

TEST PERFORMED:


The submitted sample was tested for Flammability in
accordance with the procedures outlined in
ASTM E-84-89a.

SAMPLE IDENTIFICATION:

One (1) sample of white flexible sheet material was
submitted and identified by the Client as:

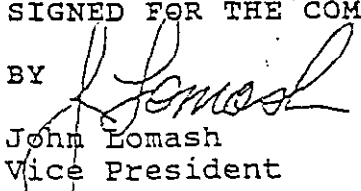
Vernon White Blackout Fabric
White Opaque White

Testing Supervised by:


Steve Caldarola
Senior Supervisor
Fire Technology Section

SIGNED FOR THE COMPANY

BY


John Lomash
Vice President

Page 1
of 6
lv

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CLIENT: Sprung Instant Structures Ltd.

NUMBER: 101490

INTRODUCTION:

This report presents test results of Flame Spread and Smoke Developed Values per ASTM E-84-89a. The report also includes Material Identification, Method of Preparation, Mounting and Conditioning of the specimens.

The tests were performed in accordance with the specifications set forth in ASTM E-84-89a, "Standard Test Method for Surface Burning Characteristics of Building Materials", both as to equipment and test procedure. This test procedure is similar to UL-723, ANSI No. 2.5, NFPA NO. 255 and UBC 42-1.

The test results cover two parameters: Flame Spread and Smoke Developed Values during a 10-minute fire exposure. Inorganic cement board and red oak flooring are used as comparative standards and their responses are assigned arbitrary values of 0 and 100, respectively.

PREPARATION AND CONDITIONING:

Two (2) 2' x 12' sections of material were placed end to end to form a 2' x 24' specimen. The material was laid on a 2-inch hexagonal wire mesh supported by steel rods spanning the width of the tunnel. The material was tested at a thickness of 0.021".

The sample was conditioned at $73^{\circ} \pm 5^{\circ}$ Fahrenheit and $50 \pm 5\%$ relative humidity.

TEST PROCEDURE:

The tunnel was thoroughly pre-heated by burning natural gas. When the brick temperature, sensed by a floor thermocouple, had reached the prescribed 105° Fahrenheit $\pm 5^{\circ}$ Fahrenheit level, the sample was inserted in the tunnel and test conducted in accordance with the standard ASTM E-84-89a procedures.

The operation of the tunnel was checked by performing a 10-minute test with inorganic board on the day of the test.

United States Testing Company, Inc.

RPP-5486, Rev. 0
A2-11

CLIENT: Sprung Instant Structures Ltd.

NUMBER: 101490

TEST RESULTS:

The test results, calculated in accordance with ASTM E-84-89a for Flame Spread and Smoke Developed Values are as follows:

Test Specimen: Vernon White Blackout Fabric

Flame Spread Index*: 10

Smoke Developed Value*: 240

*Graphs of the Flame Spread, Smoke Developed and Time-Temperature are shown in Figures 1, 2 and 3 at the end of this report.

OBSERVATIONS:

Ignition was noted at 14 seconds along with charring and melting of the specimen directly exposed to the flame. Also observed were shrinking, slight flaking and flaking embers as the flamefront advanced a maximum distance of 2 feet at 26 seconds. Afterglow was evident upon test completion.



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FLAME SPREAD

ATTACHMENT 2

Test No. 101490
Test Date July 2, 1991
I.C. Board

Sample Vernon White Blackout Fabric

Red Oak 0 0

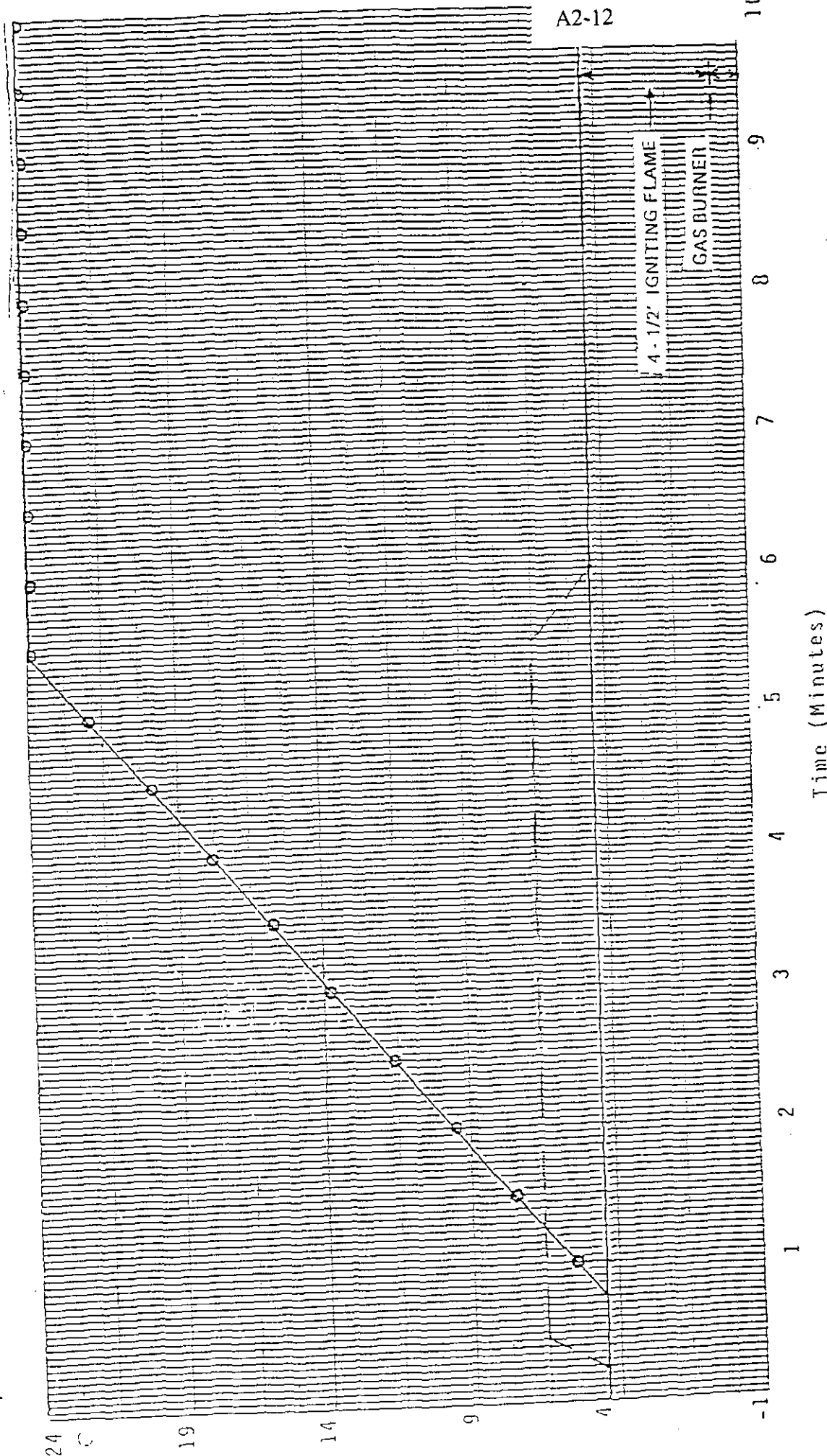


Figure 1

RPP-5486, Rev. 0
A2-12



UNITED STATES TESTING COMPANY, INC.

ATTACHMENT 2

TIME TEMPERATURE CURVE OF EXPOSED THERMOCOUPLE

SAMPLE Vernon White Blackout Fabric

TEST NO. 101490

RED OAK

+

TEST DATE July 2, 1991

I.C. BOARD

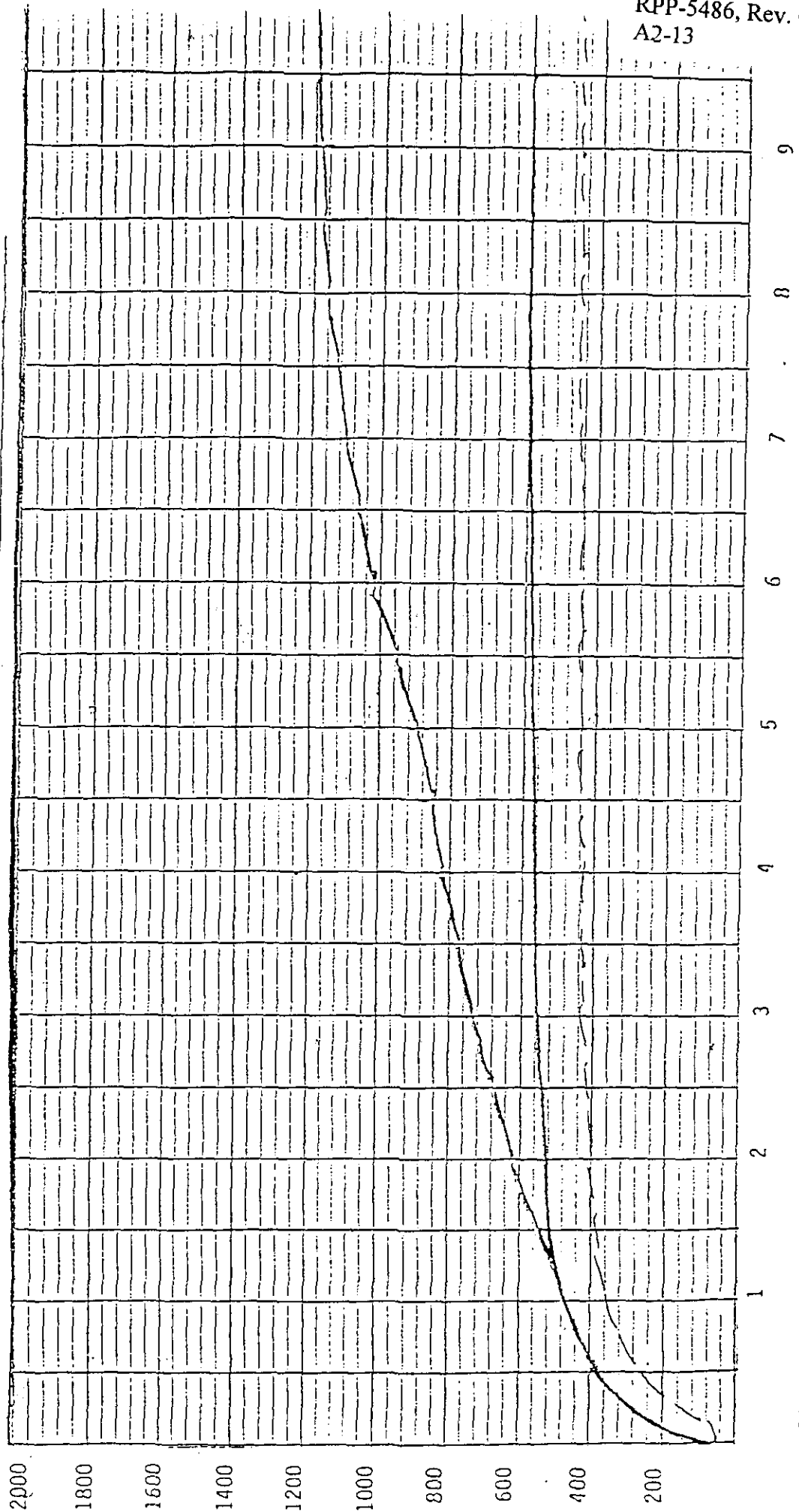


Figure 3

RPP-5486, Rev. 0
A2-13



UNITED STATES TESTING COMPANY, INC.

SMOKE DEVELOPED

SAMPLE Vernon White Blackout Fabric

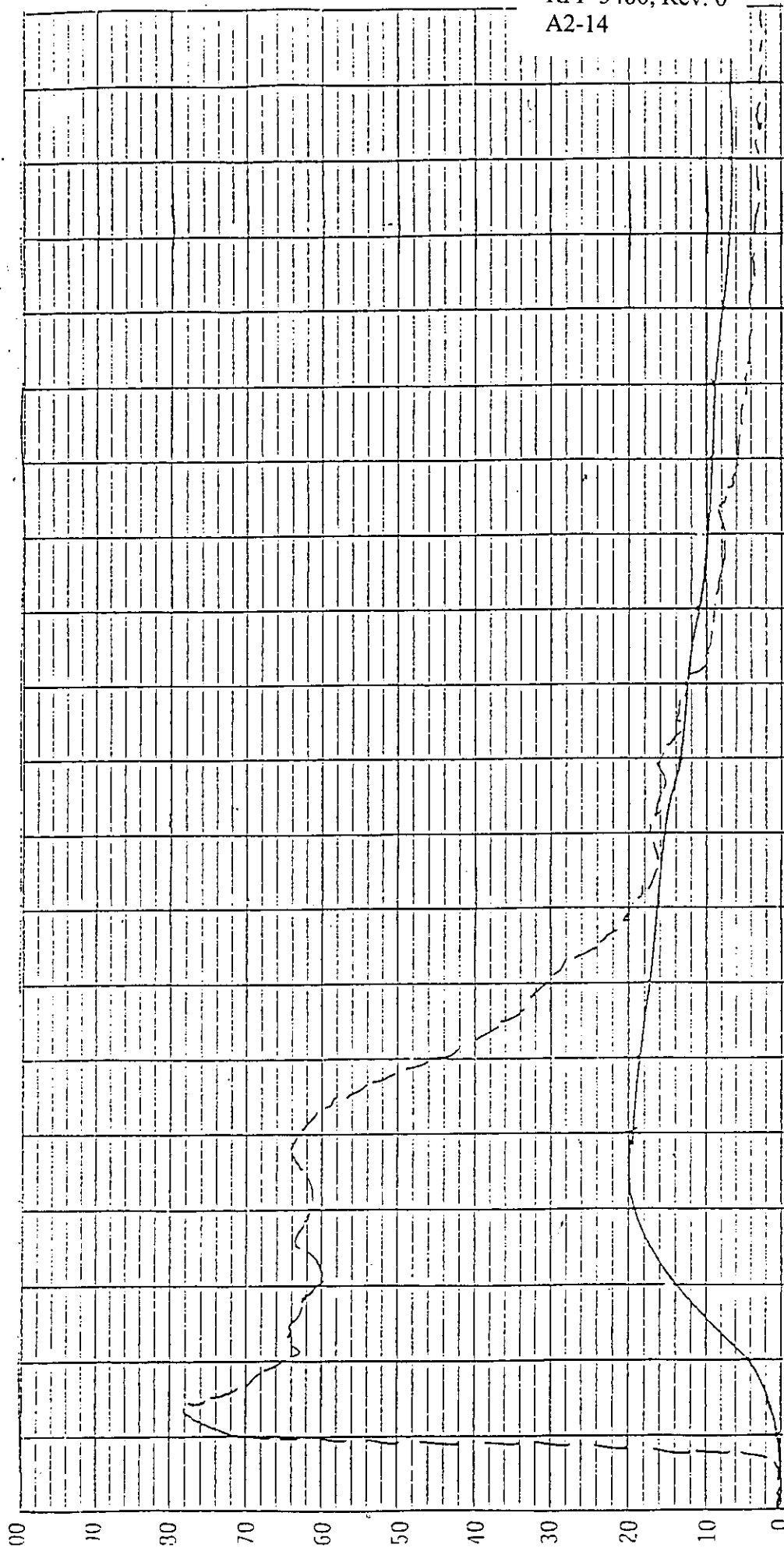
TEST NO. 101490

TEST DATE July 2, 1991

RED OAK

+

+



RPP-5486, Rev. 0
A2-14

Time (Min)

ATTACHMENT 2

**CAN/ULC-S109 Flame Resistance
of Vernon Vinyl Fabric**

A Report To: Sprung Instant Structures
1001 - 10th Avenue S.W.
Calgary, Alberta
T2R 0B7

Attention: Mr. Peter J. Bos

Submitted By: Fire & Flammability,
Materials Validation

Report No. 96-J52-95-58-340
2 pages + 1 page appendix

Date: June 13, 1996

**ORTECH**

ORTECH Corporation, 2395 Speakman Dr., Mississauga, Ontario, Canada L5K 1B3 Phone: (905) 822-4111 Fax: (905) 823-1446

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CAN/ULC-S109 Flame Resistance of Vernon Vinyl Fabric

Page 1 of 2

For: Sprung Instant Structures

Report No. 96-J52-95-58-340

ACCREDITATION

Standards Council of Canada, Registration #1B.

REGISTRATION

ISO 9002-1994, registered by QMI, Registration #001109.

SPECIFICATIONS OF ORDER

Determine flame resistance in accordance with the CAN/ULC-S109-M87 Small and Large Flame Tests, as per your authorization dated June 10, 1996.

IDENTIFICATION:

Fibre-reinforced vinyl fabric identified as Vernon Reinforced Vinyl Fabric, Lot #48403.

(ORTECH sample identification number 96-J52-S0340)

TEST RESULTS

CAN/ULC-S109 Small-Flame Test

Tested "as-received".

	<u>Damaged Length (mm)</u>	<u>Flaming Dripping (s)</u>	<u>Afterflame Time (s)</u>	
Machine 1:	160	0.0	11.3	
2:	160	0.0	22.6	
3:	125	0.0	6.5	
4:	115	0.0	2.5	
5:	135	0.0	3.6	
Cross 6:	115	0.0	2.3	
7:	90	0.0	2.2	
8:	120	0.0	4.6	
9:	105	0.0	0.0	
10:	<u>120</u>	0.0	7.7	
Average:	125			
Maxima Specified by				
ULC-S109 Small Flame Test:	165	-	-	(average)
	190	2.0	-	(individual)

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CAN/ULC-S109 Flame Resistance of Vernon Vinyl Fabric

Page 2 of 2

For: Sprung Instant Structures

Report No. 96-J52-95-58-340

TEST RESULTS (Cont..)

CAN/ULC-S109 Large Flame Test

Tested "as-received" and in single sheet configuration.


	<u>Damaged Length (mm)</u>	<u>Flaming Dripping (s)</u>	<u>Afterflame Time (s)</u>
Machine 1:	55	0.0	0.0
2:	65	0.0	0.0
3:	38	0.0	0.0
4:	50	0.0	0.0
5:	45	0.0	0.0
Cross 6:	25	0.0	0.0
7:	35	0.0	0.0
8:	55	0.0	0.0
9:	90	0.0	0.0
10:	<u>85</u>	0.0	0.0
Average:	54		

Maxima Specified by			
ULC-S109 Large Flame Test:	250	-	(average)
	-	2.0	(individual)

CONCLUSIONS

When tested in the as-received condition, the fibre-reinforced fabric identified in this report meets the flammability requirements of both the Small-Flame and Large-Flame Tests of CAN/ULC-S109.


R.A. Carleton,
Fire & Flammability,
Materials Validation.


H.J. Campbell Ph.D.,
Manager,
Fire & Flammability.

ORTECH

CAN/ULC-S109 Flame Resistance of Vernon Vinyl Fabric

For: Sprung Instant Structures

Report No. 96-J52-95-58-340

APPENDIX

(1 Page)

Summaries of Test Procedures

ORTECH

CAN/ULC-S109-M87

Standard Methods of Tests for Flame-Resistant Textiles and Films

Small-Flame Test

Ten specimens are cut, each 70 x 250 mm, with five in the warp direction and five in the weft direction, where applicable. The specimens are conditioned for 30 minutes at 105°C, or if they melt or distort at these temperatures, 18 - 22°C at 50% R.H. for at least 12 hours.

Each specimen is removed from the conditioning chamber individually, clamped in a U-shaped metal holder and suspended in a specified cabinet. The free edge of the specimen is positioned 20 mm above the tip of a gas burner which has been adjusted to yield a flame height of 40 mm. Flame exposure time is 12 seconds. Char length and afterflame time are measured.

Flame Resistance Requirements:

Maximum Average Length of
Char or Destroyed Material for
Ten Specimens
165 mm

Maximum Length of Char or
Destroyed Material for any
Specimens
190 mm

The specified maximum flaming time for residue on the floor of the tester from any specimen is 2.0 seconds.

Large-Flame Test

For conducting flame tests of fabrics in single sheets, the procedure specifies ten specimens, 125 mm by 750 mm to 2100 mm long. The specimens are conditioned at 105 ± 2°C for 30 minutes or, if distortion or melting occurs at these temperatures, 20 ± 2°C at 25 - 50% relative humidity for at least 12 hours.

Each specimen is removed from the conditioning chamber and cooled in a desiccator prior to being suspended in a steel stack 310 mm square and 2130 mm high, the said stack being open both top and bottom and supported 300 mm above the floor. The lower edge of the specimen is positioned 100 mm above the tip of a gas burner which is inclined at 25° to the vertical. The burner, which has been adjusted to yield a flame 280 mm in height is ignited and inserted directly beneath the specimen for 2 minutes. Char length is measured from the tip of the flame, upwards.

For conducting flame tests of fabrics hung in folds, at least four specimens 625 mm by 750 mm to 2100 mm are required. Each specimen is folded longitudinally to form four folds.

Flame Resistance Requirements - Specified Maxima:

<u>Specimen Configuration</u>	<u>Char Length or Damaged Material Length (mm)</u>	<u>Flaming Residue on Floor of Tester (s)</u>
Single sheets	250	2.0
Folded	635	2.0



BORDEN PACKAGING and INDUSTRIAL PRODUCTS
DOMESTIC AND INTERNATIONAL
DIVISION OF BORDEN, INC.

RPP-5486, Rev. 0
A2-20

October 30, 1990

Sprung Instant Structures
1001 10th Avenue Southwest
Calgary, Alberta, Canada
T2R 0B7

The following is a tabulation of physical properties relative to the fire safety characteristics of all Sprung Fabrics.

Physical and Environmental Properties		Test Results		Test Method
Fabric weight (Avg)		18.0 oz./yd ²		F.S. - 191 5041
		Warp	Fill	
Flame Resistance	Seconds after flame (Avg)	0	0	5903
	Inches Char Length (Avg)	3.0	3.0	5903
Breaking Strength - lbs./1" (Avg)		250	250	5100
Tear Resistance - lbs. (8 X 10)		85	90	5134
Hydrostatic Resistance - P.S.I. (Avg)		383		5512
Abrasion Resistance (Cycles to Zero Tensile)		30,000		5304
Adhesion - lbs. 2 inch		15		5970
Thickness - Mils (.001")		25		5030
Cold Crack °F		No cracking @ -30°F		5874
Resistance to Fungus and Microbial attack		Pass		ASTM-6-21-75
Resistance to UV and Weathering		Pass 1000 Hours		QUV
Other Flame Specifications				
California Fire Marshal Title 19		Small Scale - Pass		Registration
		Large Scale - Pass		#F-365.01
NFPA 701		Small Scale - Pass		
		Large Scale - Pass		
UL 214		Pass		
CPAI-84		Pass		
Acrylic Topcoat For UV Resistance and Cleanability				

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VERTICAL FLAMMABILITY TEST - DATA SHEET

RPP-5486, Rev. 0
A2-21

The
Govmark
Organization, Inc.
P.O. Box 807
Bellmore, New York 11710
Tel: 516/293-8944

COMPANY SUBMITTING SAMPLES

Name: Vernon Plastics Co
Address: Shelly Road - Ward Hill
Haverhill, MA 01830-0548
Telephone #: 508-373-1551
David Morse

CLIENT'S IDENTIFICATION:

Sample #1
Sprung Structures
18 oz. White
Lot #30443

PO # 84289

DATE SAMPLES RECEIVED: 8/29/91TEST REPORT #: 96101-1

TEST PERFORMED:

NFPA 701: Large Scale (Single Strip Specimens)

GOVMARK TEST RESULTS

SPECIMEN #	AFTER FLAME SECONDS	DRIP BURN SECONDS	CHAR LENGTH INCHES	SPECIMEN #	AFTER FLAME SECONDS	DRIP BURN SECONDS	CHAR LENGTH INCHES
1	0	0	1.0	6	0	0	1.5
2	0	0	2.0	7	0	0	3.0
3	0	0	0.5	8	0	0	3.0
4	0	0	2.0	9	0	0	1.0
5	0	0	2.5	10	0	0	4.5

REMARKS:

REQUIREMENTS:

For each specimen:

AFTER FLAME SECONDS: 2.0 Maximum
DRIP BURN SECONDS: 0.0 Maximum
CHAR LENGTH INCHES: 10.0 Maximum

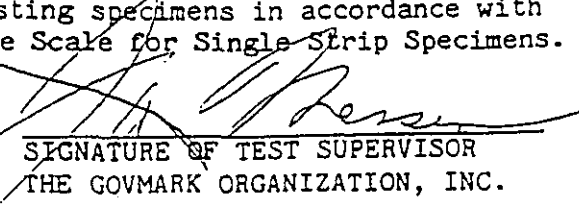
CONCLUSION:

The above results indicate compliance with the stated requirements.

Certify that the above results were obtained after testing specimens in accordance with
procedures and equipment specified by NFPA 701 Large Scale for Single Strip Specimens.

TESTING COMPLETED 9/6/91

jd


SIGNATURE OF TEST SUPERVISOR
THE GOVMARK ORGANIZATION, INC.

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ATTACHMENT 3
(Total Number of Pages - 26)

FULL-SCALE FIRE TEST
OF A
TENSION SUPPORTED MEMBRANE STRUCTURE

TECHNICAL REPORT

FULL-SCALE FIRE TEST OF A TENSION SUPPORTED MEMBRANE STRUCTURE

by
B.G. Vincent
M.M. Khan

Prepared for:
Westinghouse-Hanford Company
P.O. Box 1970
Richland, Washington 99353

November 1994



Factory Mutual Research

FACTORY MUTUAL RESEARCH CORPORATION

0Y3N9.CY

ABSTRACT

A full-scale fire test of a 40 ft wide x 50 ft long x 23.5 ft high tension supported membrane structure was conducted in the 60 ft ceiling site of the Factory Mutual Research Corporation (FMRC) Test Center located in West Glocester, Rhode Island.

The test structure consisted of a galvanized steel tube frame set on I-Beams anchored to the floor. The covering was 28 ounce per square yard polyvinyl chloride-coated polyester fabric tensioned over the framework.

For this test, instrumentation was used to measure fire signature data and to obtain information regarding fire detection response. Inside the structure, ceiling ionization and photoelectric smoke detector pairs were installed at two ceiling locations and fast-response and standard-response sprinkler pairs were installed at four sprinkler stations. The sprinklers were unconnected to a water supply and were used only to obtain information regarding sprinkler actuation times.

The fire was set in one corner of the test structure utilizing the fire source prescribed by the FMRC Approvals Division Building Corner Fire Test protocol. The first smoke detector (ionization type) actuated at 24 s after ignition and by 1 min. 7 s, all installed smoke detectors had actuated. First sprinkler actuations occurred at 4 min. 59 s and 5 min. 34 s for fast-response and standard-response sprinklers, respectively.

After severe exposure of the test structure to the fire source for a 15-minute duration, the fire test was concluded with no apparent self-sustained propagation of the fire by the fabric covering and no fire damage to structural support members.

Laboratory-scale flammability tests were also performed on the membrane fabric to measure heat release rate and ease of ignition properties. These data may be used to compare the fabric tested in the full-scale test with aged fabric or with other types of fabrics that may be introduced in the future.

FACTORY MUTUAL RESEARCH CORPORATION

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I

INTRODUCTION

Tension supported membrane structures (TSS) are prefabricated, disassemblable buildings consisting of a metal frame, usually steel or aluminum, covered with a coated fabric outer skin that forms the roof and walls. The outer skin is fastened in place under tension to provide a tight fitting exterior. Manufacturers' literature indicate that these structures are available with clear span widths of 10 ft to 200 ft and vertical sidewalls up to 50 ft high. Modular lengths of 10 ft to 16 ft can be used to construct buildings of any length desired.

Tension supported membrane structures are utilized for a wide variety of storage and operational applications. They provide a relatively inexpensive shelter alternative that can be set in place in a matter of days and, if desired, disassembled and reconstructed at a different site. These type structures are currently used at U.S. Department of Energy (DOE) facilities for storage of low-level radioactive waste. Typical units at DOE facilities cover a floor space of 100 ft x 300 ft.

With the increasing use of these structures, questions are raised regarding their behavior when exposed to fire. To address these issues, a full-scale fire test and a program of small-scale flammability testing were performed. The objective of the testing was to determine the following: a) whether the coated fabric used to cover a TSS will propagate flame to portions of the structure not directly exposed; b) the time of operation of the first automatic sprinkler installed inside such a structure; c) the time of operation of installed smoke detectors; and d) the flammability properties of the fabric covering.

The full-scale fire test was performed using an actual tension supported structure erected on site at the Factory Mutual Research Corporation (FMRC) Test Center. The test was designed to subject the wall and ceiling fabric covering to the same fire exposure prescribed by the FMRC Approvals Division Building Corner Fire Test¹. A series of small-scale laboratory tests was also conducted on the fabric used for the structure. The laboratory tests were performed at the FMRC Norwood, Massachusetts facility.

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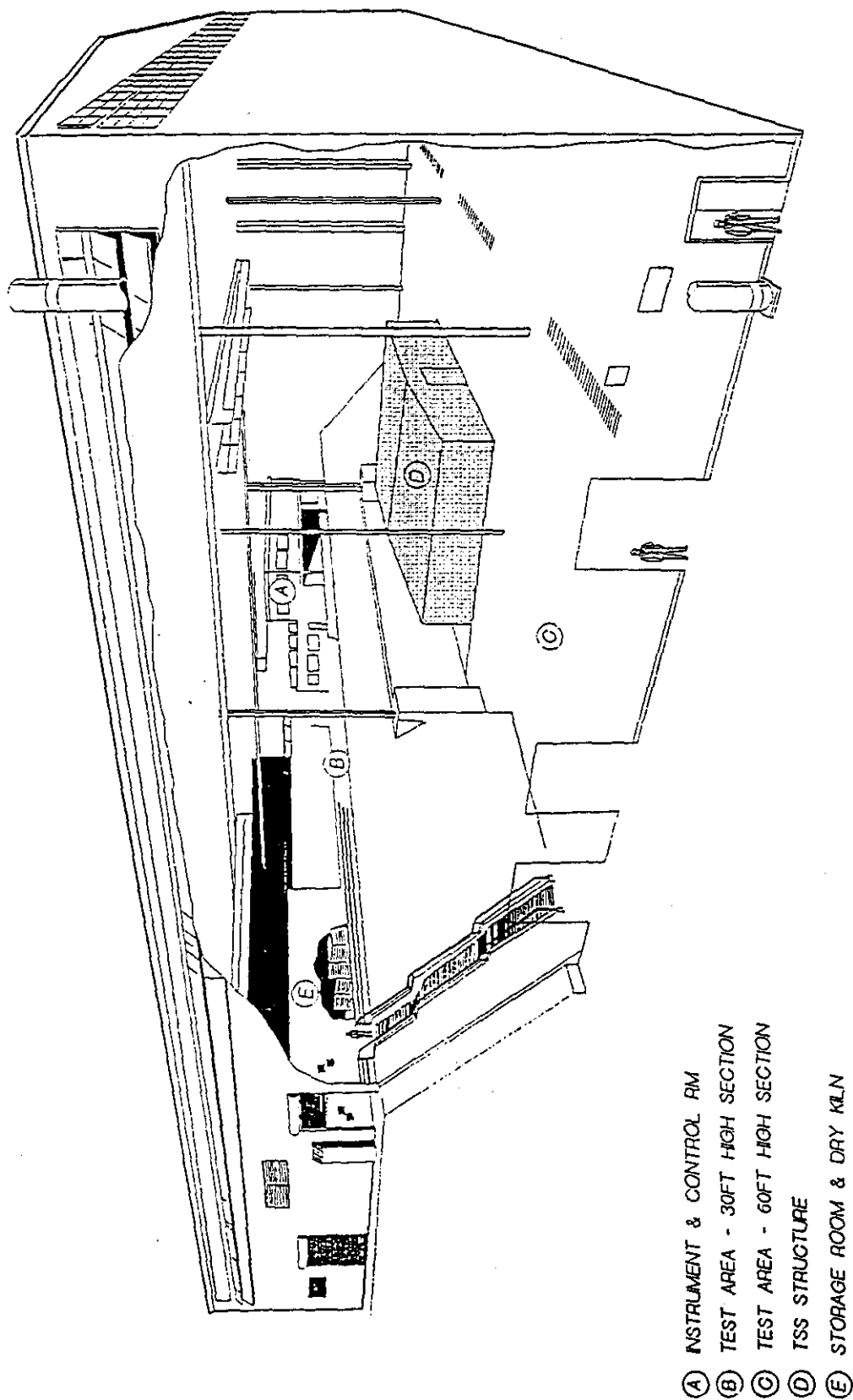
RPP-5486, Rev. 0
A3-6

Figure 1. Factory Mutual Research Corporation Test Center (Pictorial).

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0Y3N9.CY

A schematic drawing of the end cross section of the test structure is shown as Figure 3.

The inside framing members were made of hot-dipped galvanized steel tubes in a lattice joist arrangement. Structural steel tube framing members were 2-1/2 in. diameter, with 1-1/4 in. diameter tubes used as bracing. The entire framework of the test structure was anchored to a 6 in. high steel I-beam foundation fastened to the floor. The floor space of the structure had dimensions of 40 ft wide x 50 ft long. The height of the side walls was 16 ft 4 in. with the roof being 23 ft 6 in. at its apex.

The exterior shell of the structure was a heavy duty polyvinyl chloride (PVC)-coated polyester fabric designated as Shelter-Rite® Style 8028*. Manufacturer's data indicate that the weight of the polyester base fabric was a nominal 7.5 ounces per square yard. The finished fabric was nominally 28 ounces per square yard and contained antibacterial and antifungal agents as well as fire retardants.

The long dimension of the test structure, i.e., 50 ft, was aligned in the east-west direction within the 60 ft high ceiling site. The test structure contained a 10 ft wide, 12 ft high door opening positioned on the west wall. This remained open during the test. Although there were provisions made for four wall vents (two each on east and west walls), the necessary cuts were not made in the wall fabric at these locations; therefore, the vents were not operational. The sole source of ventilation was through the door opening located at the west end of the structure.

2.2 FIRE SOURCE

The fire source for this test was the same as that used in the FMRC Approvals Division Building Corner Fire Test protocol¹. This test protocol requires a 5 ft high, 750 lb pile of hardwood pallets (Figure 4) as an exposure fire for evaluation of wall and ceiling building materials. For this test, a total of 17 red oak hardwood pallets were used. Each pallet was 42 in. x 42 in. x 5 in. high. The fire source was positioned in the southeast corner of the test structure. It consisted of a stack of twelve pallets and, in order to complete the 750 lb requirement, an additional five pallets were stood on edge against the north side of the 5 ft high stack. As required by the test procedure, prior to the test all pallets used for the source fire had been stored

*Rubb Building Systems

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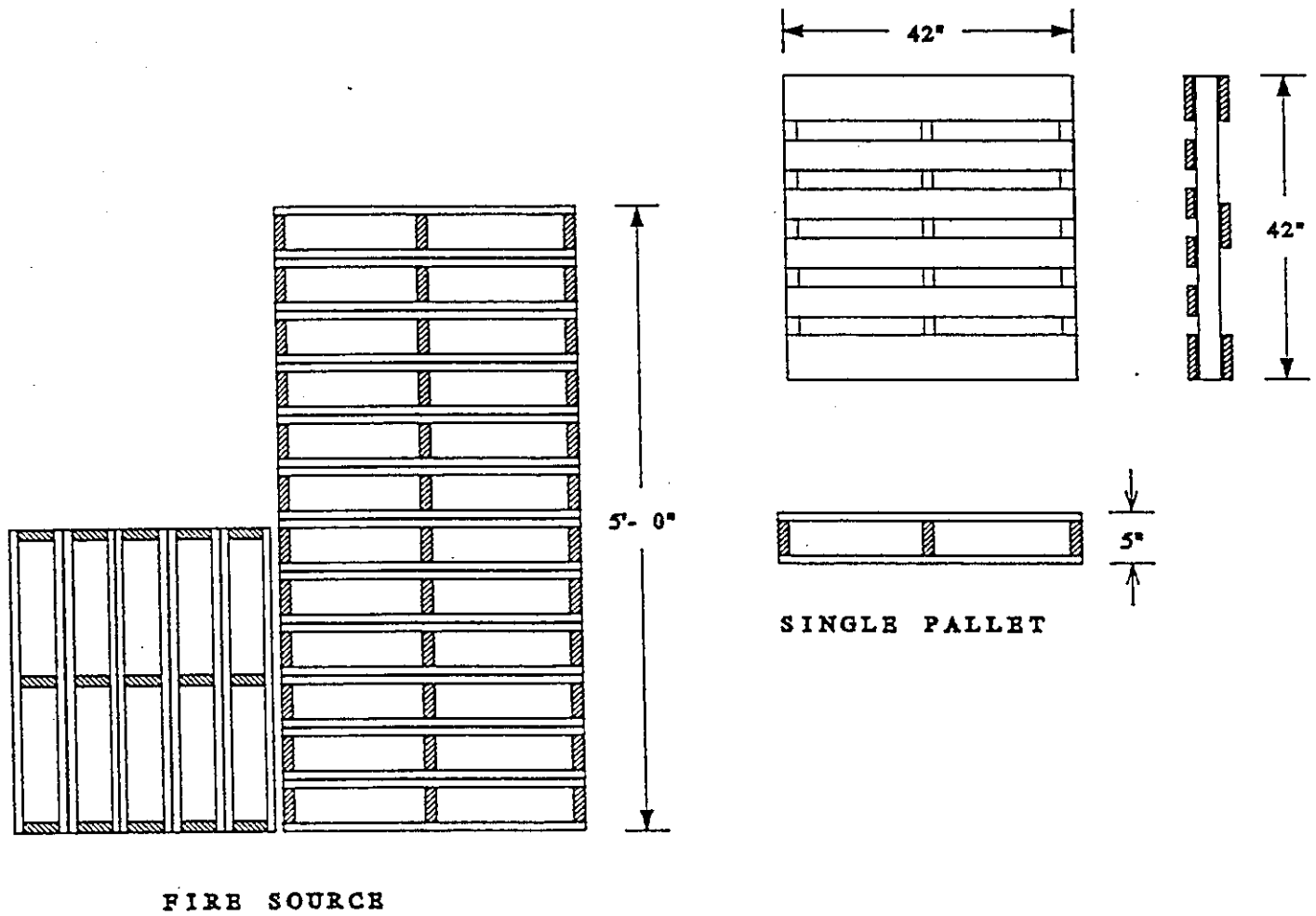


Figure 4. Fire Source for Full-Scale Fire Test.

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- Sprinkler Station
- Ⓢ Smoke Detector Station

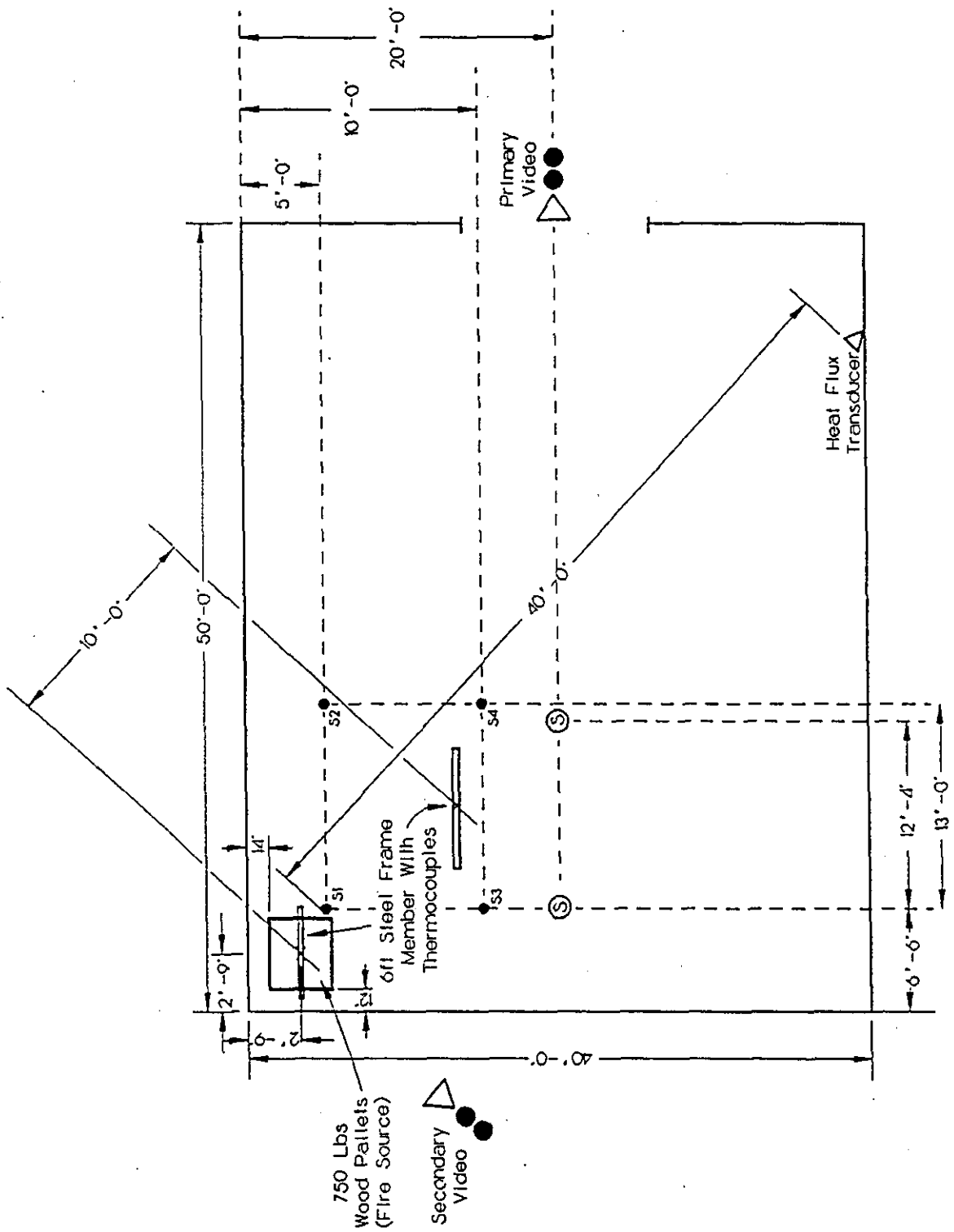


Figure 5. Plan View of Test Structure.

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● Sprinkler Station

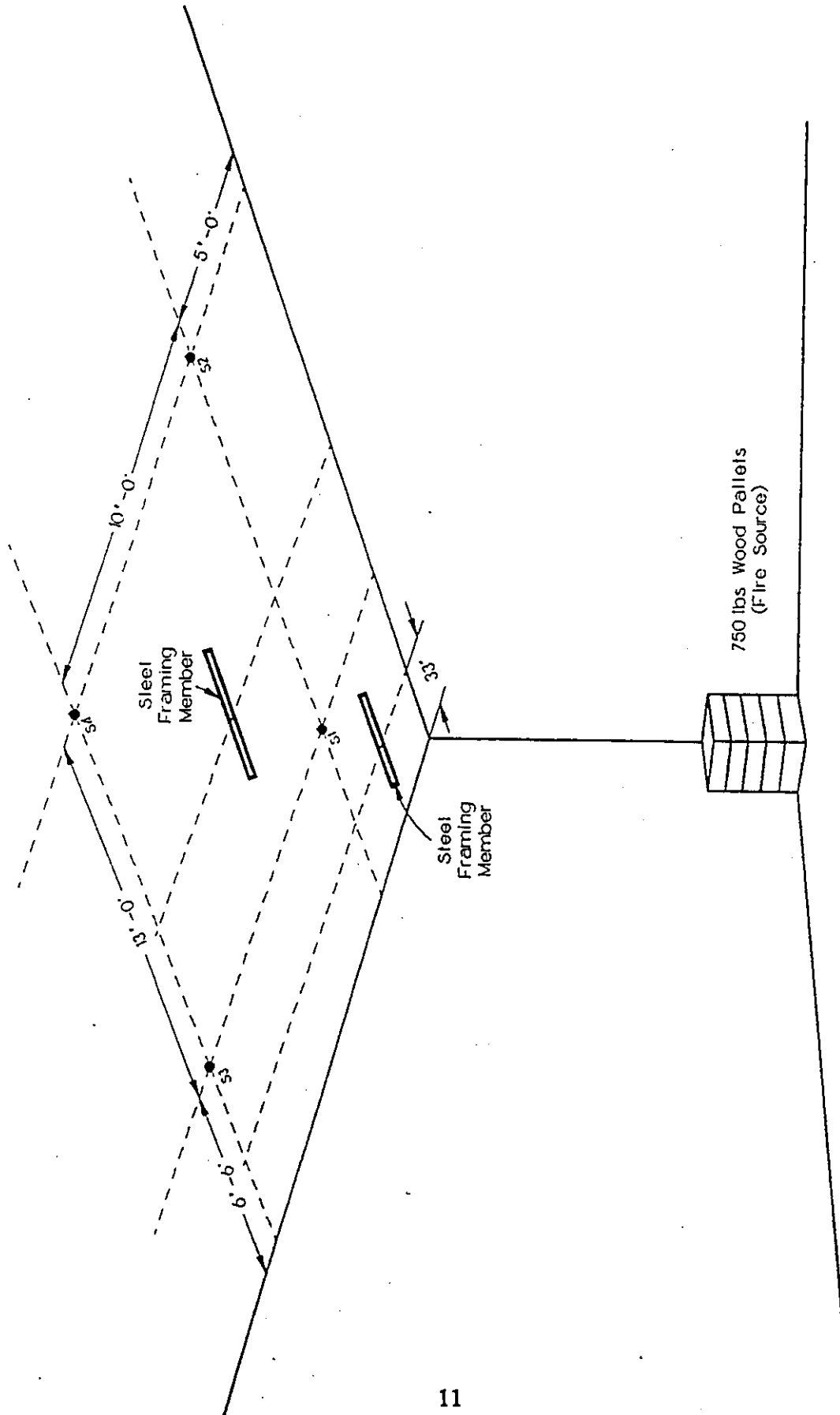


Figure 7. Sprinkler Station and Steel Temperature Monitoring Locations.

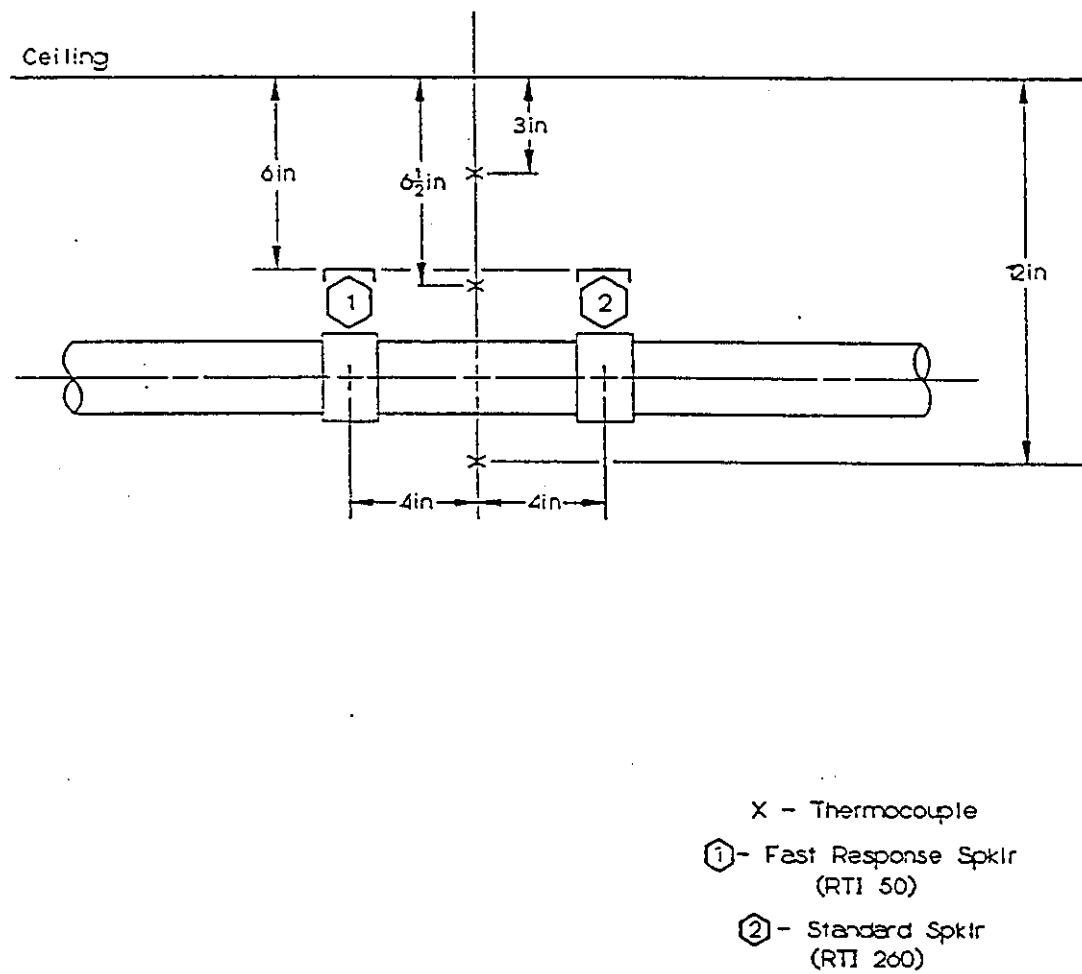


Figure 8. Sprinkler Station.

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steel section was installed at the ceiling 10 ft northwest from over the center of the fire source. The 6 ft sections of steel were fastened directly to the underside of the 2-1/2 main structural members which placed their upper surfaces 2-1/2 in. below the ceiling. The temperature of the steel sections was measured by inserting thermocouple beads into small cavities drilled into the metal. The 6 ft sections were oriented in the east-west direction and their ends were plugged with fiberglass to inhibit air flow.

A Medtherm Model 64 Series heat flux transducer was placed 40 ft northwest of the fire source to measure incident heat flux at this location and therefore verify the growth of fire intensity for the duration of the fire test. The transducer was 8 ft from the floor with its sensing window aimed toward the center of the central stack of wood pallets in the fire source arrangement.

2.4 TEST PROTOCOL

The test protocol for the full-scale fire test was similar to that used for the FMRC Approvals Division Building Corner Fire Test protocol with the following exceptions:

- 1) The FMRC Building Corner Test requires that the test frame behind the material under test, i.e., the PVC-coated polyester fabric, be sheathed with corrugated metal panels to prevent burn-through. One of the objectives of the test was to determine the effect of venting upon fire propagation. Consequently, the sheathing was not used in this test.

- 2) The Building Corner Test is conducted with a roof and two sides to simulate a corner of a full-scale structure. An actual TSS structure was evaluated in this full-scale test, not just the corner.

- 3) The Building Corner Test is not provided with smoke detectors, automatic sprinkler installations or thermocouples for exposed steel. These were provided for this test to determine fire detection and sprinkler operation times and to monitor exposed steel temperatures.

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Flames penetrated the south wall at 8:25. At 8:45 a large tear was noted in the fabric of the south wall extending from about the 4 ft elevation up to 8 ft.

Flames from the stack reached the ceiling at 10:00. Flames impinged directly on the lower structural steel members of the roof supports. At 11:00 flames from the fire source extended through an opening in the ceiling. Additional opening of the ceiling fabric over the fire source occurred at 12:05.

All wood pallets in the pile were involved at 13:00, including those on the side of the central 5 ft high stack.

TABLE 1. SMOKE DETECTOR ACTUATION TIMES

	IONIZATION	PHOTOELECTRIC
DETECTOR STATION	MIN:S	MIN:S
1	0:24	0:57
2	0:31	1:07

TABLE 2. SPRINKLER ACTUATION TIMES/TEMPERATURES*

	FAST-RESPONSE	STANDARD RESPONSE
SPRINKLER STATION	MIN:S (DEG F)	MIN:S (DEG F)
1	4:59 (225°F)*	5:34 (230°F)*
2	6:33 (225°F)	6:53 (260°F)
3	5:46 (190°F)	6:09 (230°F)
4	5:54 (225°F)	6:27 (250°F)

*Near-ceiling gas temperature adjacent (6.5 in. below ceiling) to sprinkler at time of actuation.

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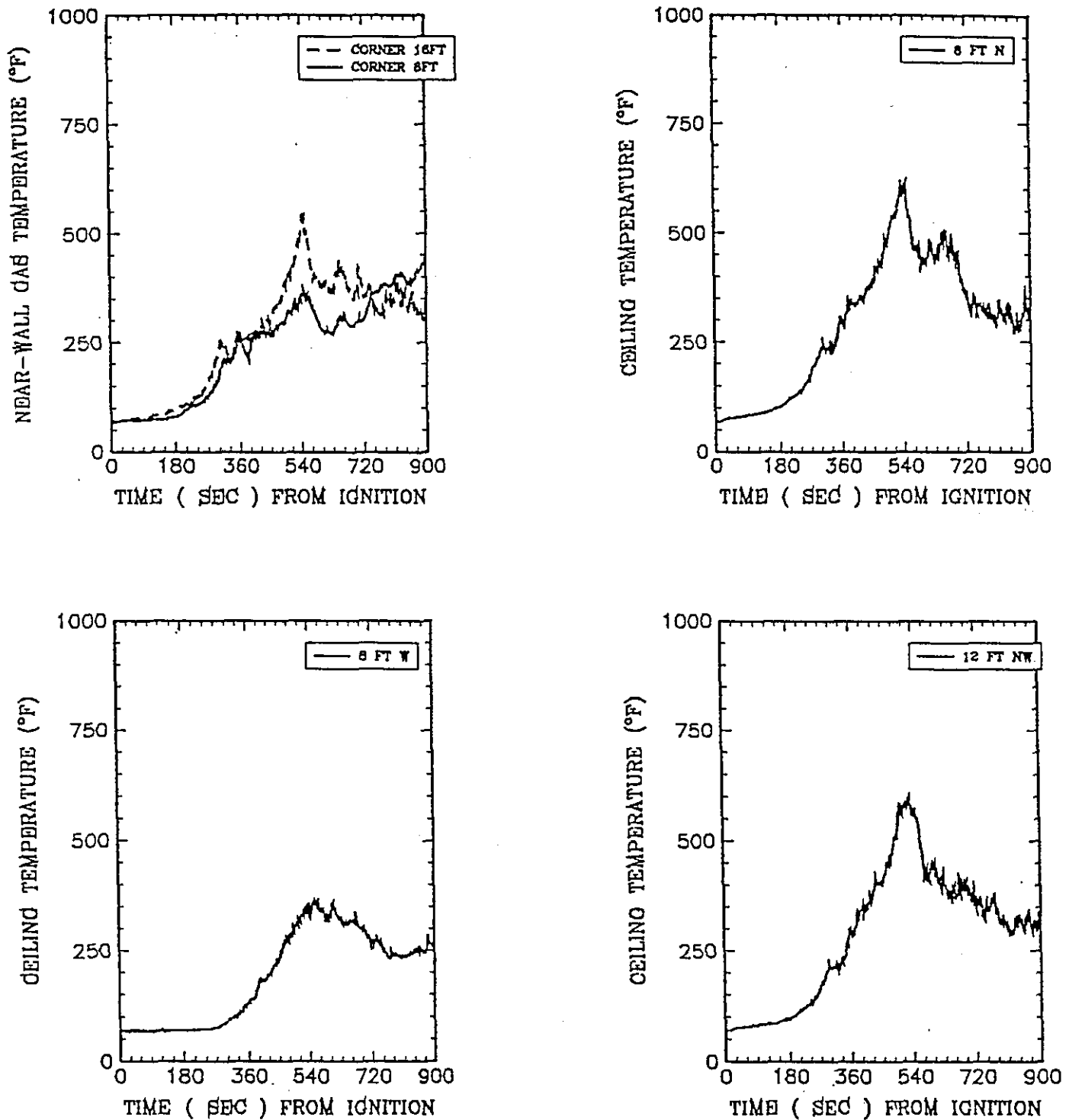


Figure 10. Wall and Ceiling Gas Temperatures.

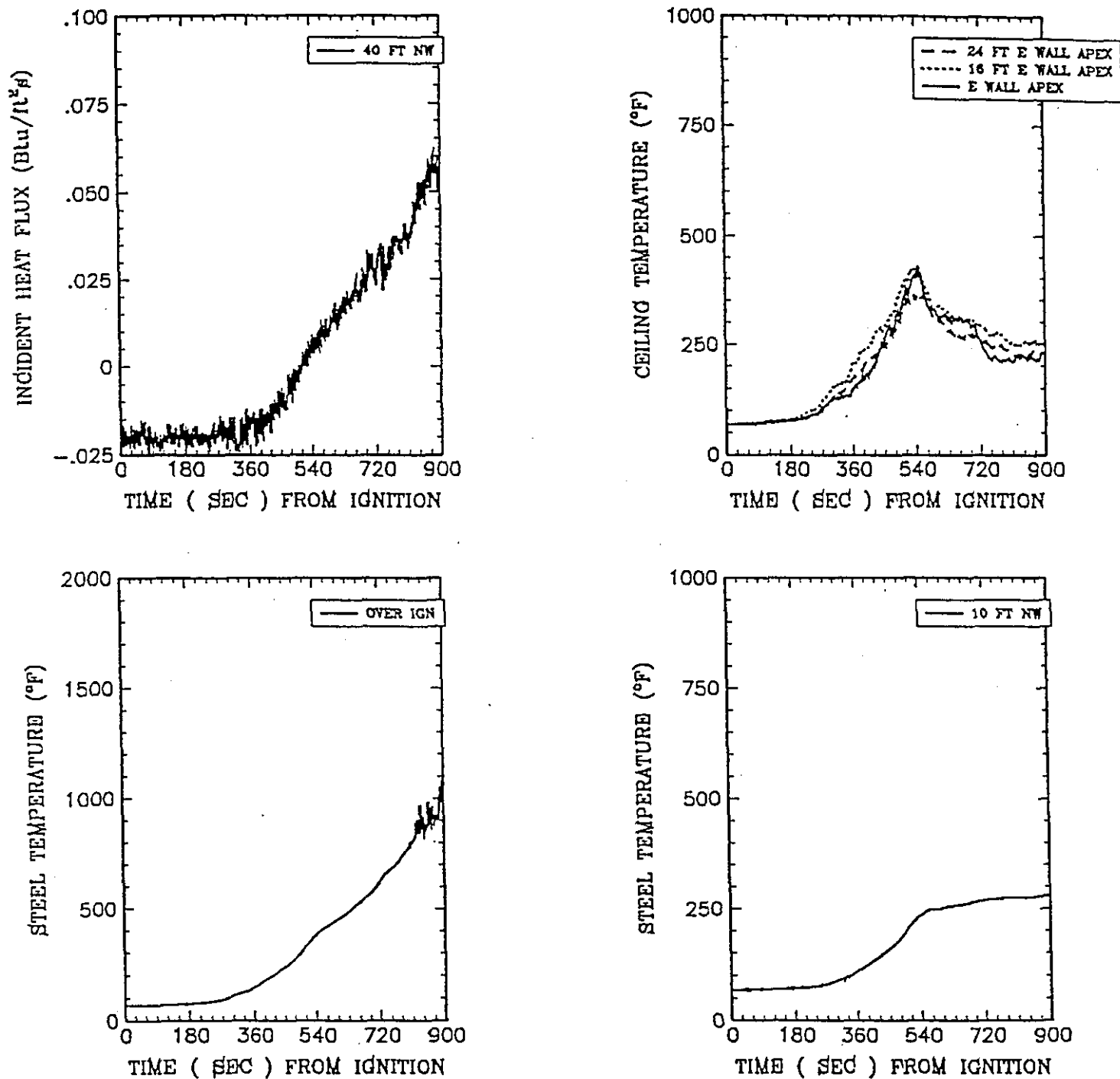


Figure 12. Heat Flux, Steel and Ceiling (Apex) Gas Temperatures.

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IV

LABORATORY FLAMMABILITY TEST

4.1 GENERAL

Properties of the fabric were determined using the Factory Mutual Research Corporation (FMRC) Flammability Apparatus, presented in Figure 13.

This apparatus is used to determine basic flammability properties of materials such as chemical heat release rate, time to ignition, and thermal response parameter. These properties could be used to compare the fabric tested in the large scale test with fabrics that may be introduced in the future and with aged fabrics. For a comparison of the FMRC Flammability Apparatus with other types of test apparatus, such as the Cone Calorimeter, see Reference 5.

4.2 IGNITION

The sample tested was placed in a 4 in. diameter aluminum dish. The sample was exposed to heat fluxes of 20, 30, 40, 50 and 60 kW/m² (simulating various fire exposures). The time to ignition was observed and recorded. The following ignition parameters were determined.

4.2.1 Critical Heat Flux

The Critical Heat Flux (CHF) is defined as the flux at or below which ignition is not possible. Figure 14 shows the inverse of the time to ignition plotted against heat flux. If the curve is extrapolated to the x-axis, a CHF of 17 kW/m² can be estimated.

4.2.2 Thermal Response Parameter

Thermal Response Parameter (TRP) is the thermal inertia of the material. It is an indicator of ignition resistance. The higher the TRP, the higher the resistance to ignition. TRP is obtained from the inverse slope of the curve shown in Figure 15, which plots the inverse of the square root of the time to ignition as a function of external heat flux.

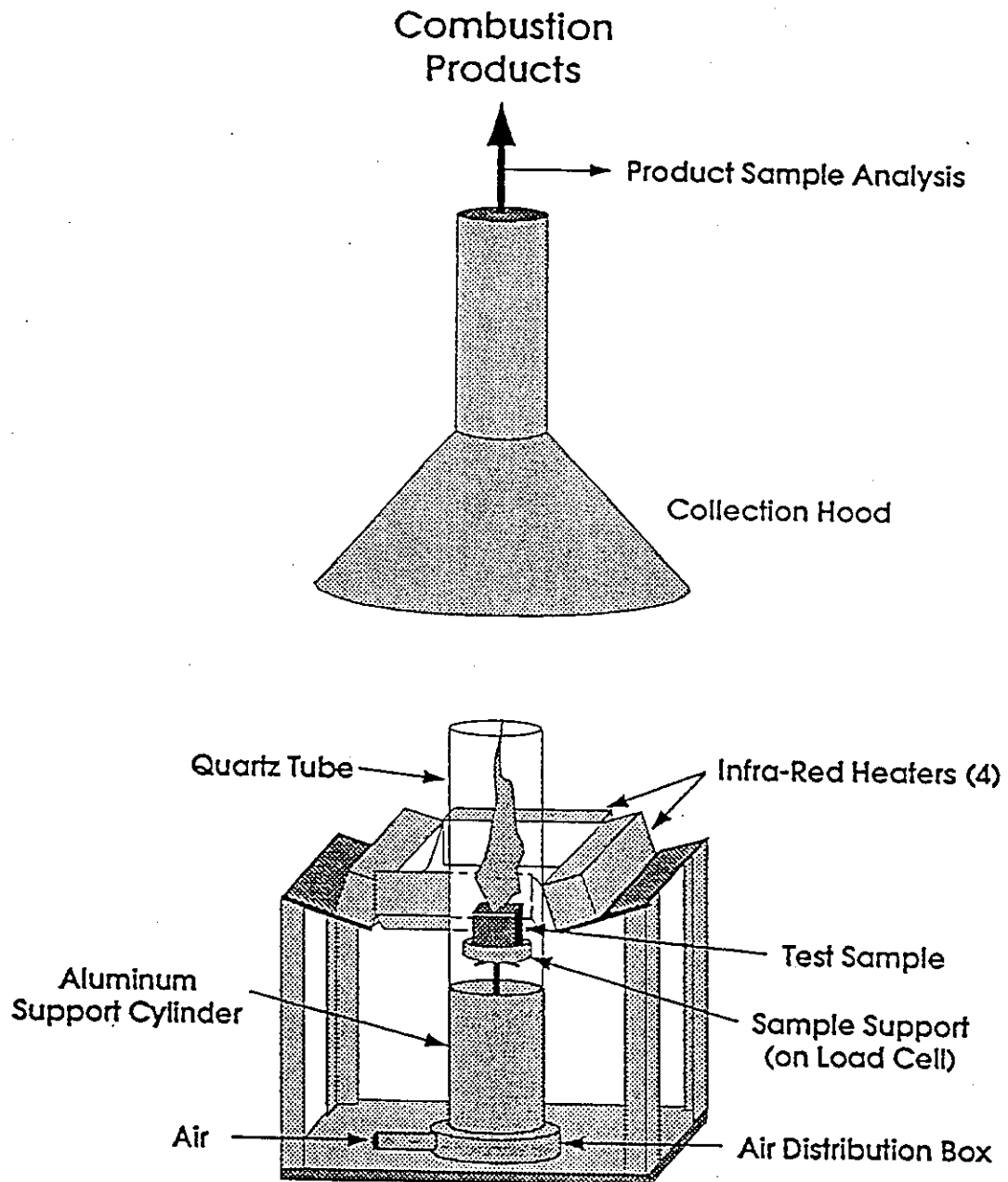


Figure 13. The Factory Mutual Research Corporation Flammability Apparatus.

SHELTER-RITE® 8028 FABRIC EVALUATION

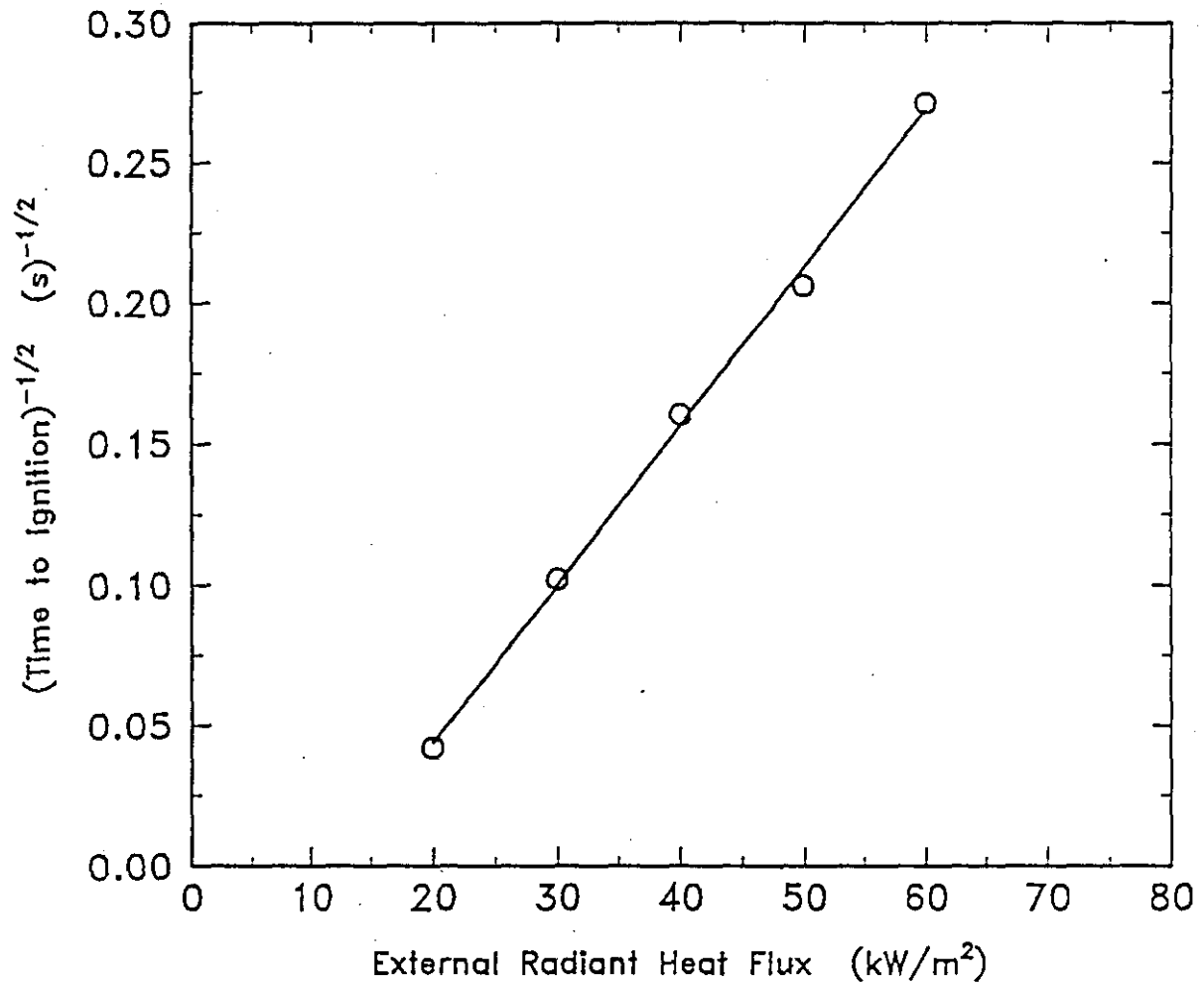


Figure 15. Inverse Square Root of Time to Ignition as a Function of External Radiant Heat Flux.

V

DISCUSSION

The fire source used for the full-scale fire test provided a severe exposure for the test structure. The fire burned away fabric sections from the south and east walls of the test structure out to at least 8 ft from the southeast corner in which the fire source was placed. This damage extended to 10 ft out at the top of the east wall. In addition, a 6 ft x 4 ft section of the ceiling directly over the fire source location was burned away. After 15 minutes the exposure fire was still burning at an intense rate, as indicated by the heat flux measurement made inside the structure. However, the fabric of the structure did not exhibit self-sustained fire involvement and only fabric immediately adjacent to the flaming fire source was affected.

Given the results of this test involving this intense source fire, if the fire were sufficiently far away from the walls, it is reasonable to expect that in the absence of early fire detection, a large undetected fire could develop before venting occurred.

Small-scale flammability tests performed on the fabric material indicate that the fabric would resist ignition and self-sustained flame propagation. The fabric required an externally applied heat flux of 17 kW/m^2 for ignition to occur. The thermal response parameter (TRP), which is an indicator of resistance to ignition, was $180 \text{ kW/m}^2\text{s}^{-1/2}$.

The actuation times of the installed smoke detectors were not significantly different from what would be expected in a noncombustible building having the same interior dimensions.

Although the fire penetrated the (east) wall closest to the fire source before first sprinkler actuation, all installed sprinklers actuated before flames burned through the south wall and the ceiling over the fire source location. Once burn-through occurred in the south wall at around 9 minutes after ignition, the building vented and interior temperatures were significantly reduced.

Four ceiling sprinkler stations were installed inside the test structure. These sprinklers were not connected to a water supply. The actuation of sprinklers not connected to a water supply provides only an indication of a first sprinkler actuation time and cannot assess the potential for other sprinkler actuations following the first. Had the first operating sprinkler, which was located closest to the fire source, actually discharged water, the fire may well have been sufficiently controlled to prevent subsequent sprinkler operations.

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VI

CONCLUSIONS

Fabric used for construction of the tension supported membrane structure evaluated during this program will not propagate flame or sustain combustion when exposed to a severe fire. Only the fabric immediately adjacent to the flaming fire source became involved in the fire.

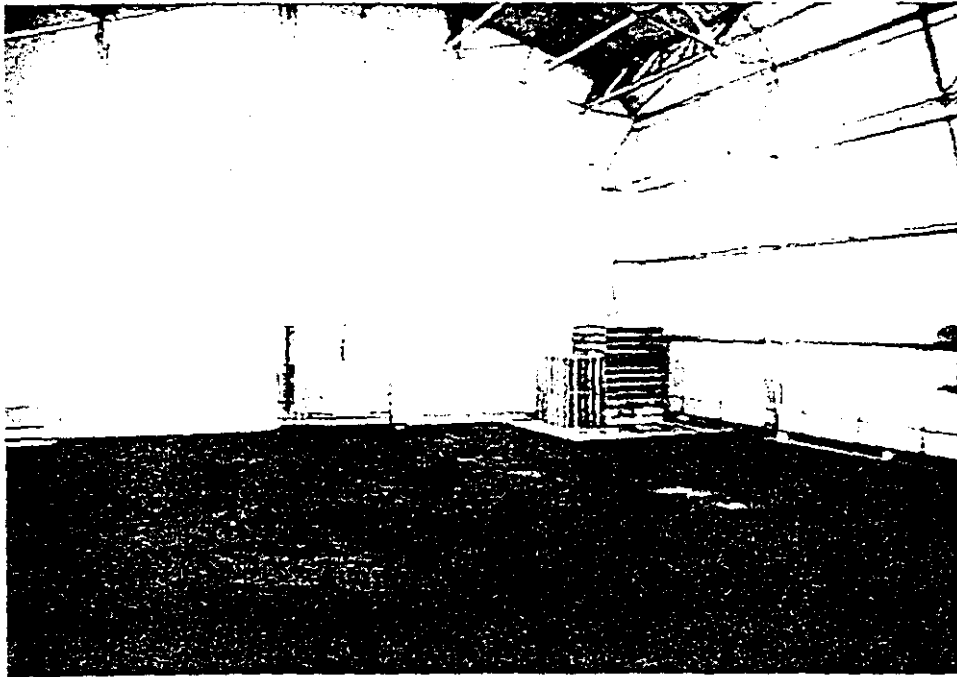
Smoke detectors will provide early warning against fire prior to burn-through or venting of the structure.

If a severe fire occurs in close proximity to walls, burn-through of the exposed walls is likely before a sprinkler can actuate. However, sprinklers would likely actuate prior to burn-through of the ceiling fabric.

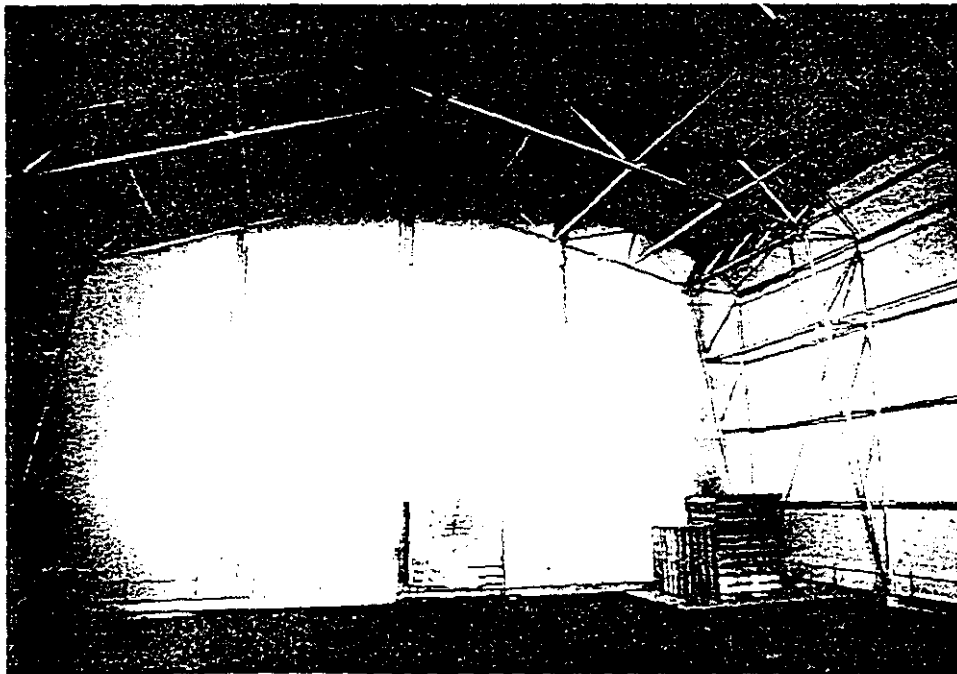
APPENDIX

Photographic Sequence of Fire Development

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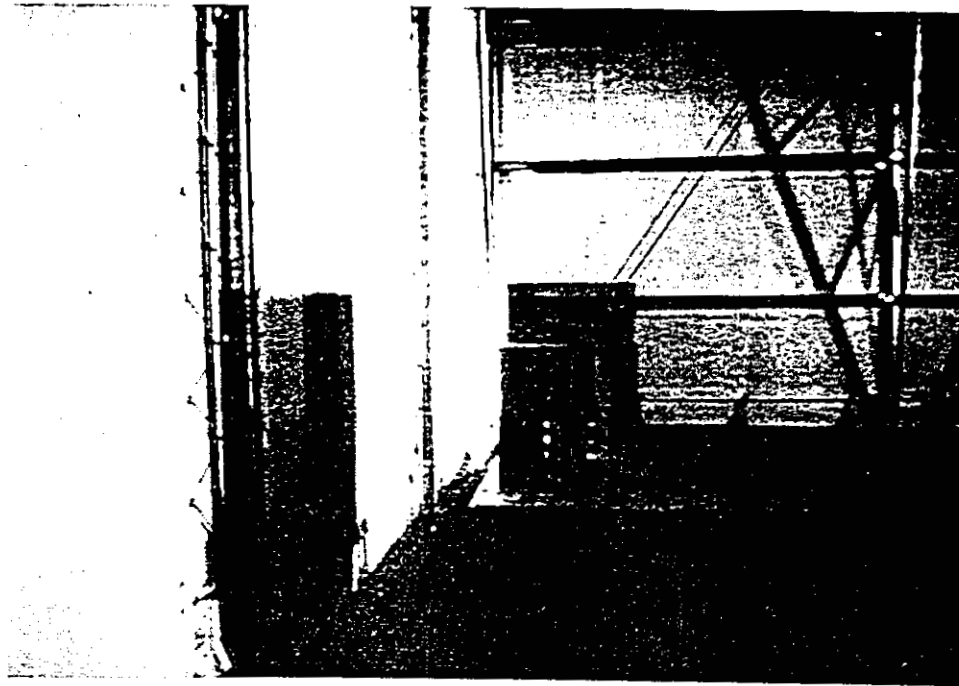


1:30 after ignition.

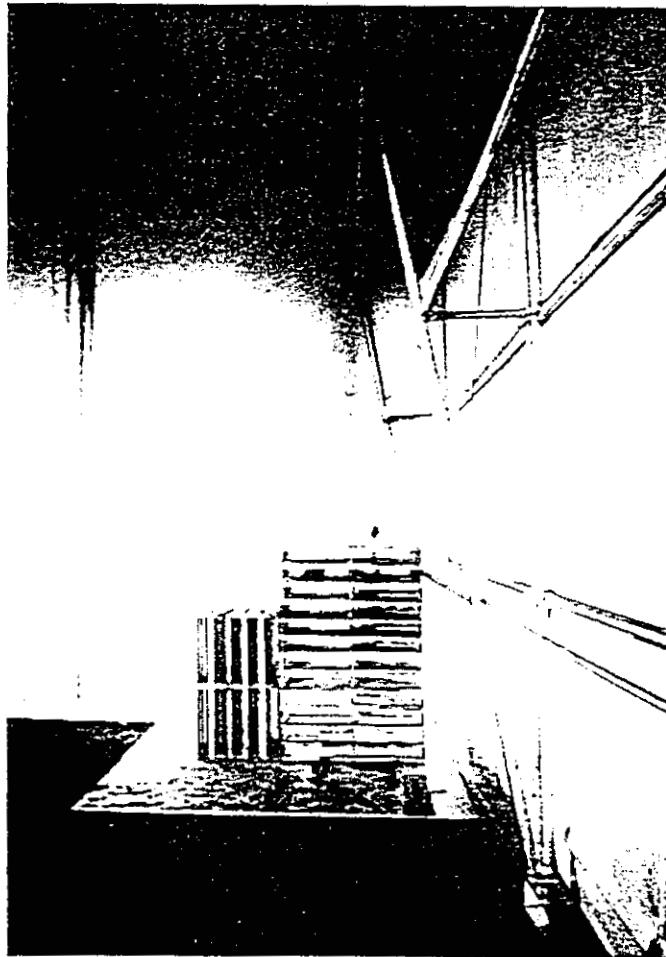


2:16 after ignition.

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4:50 after ignition.



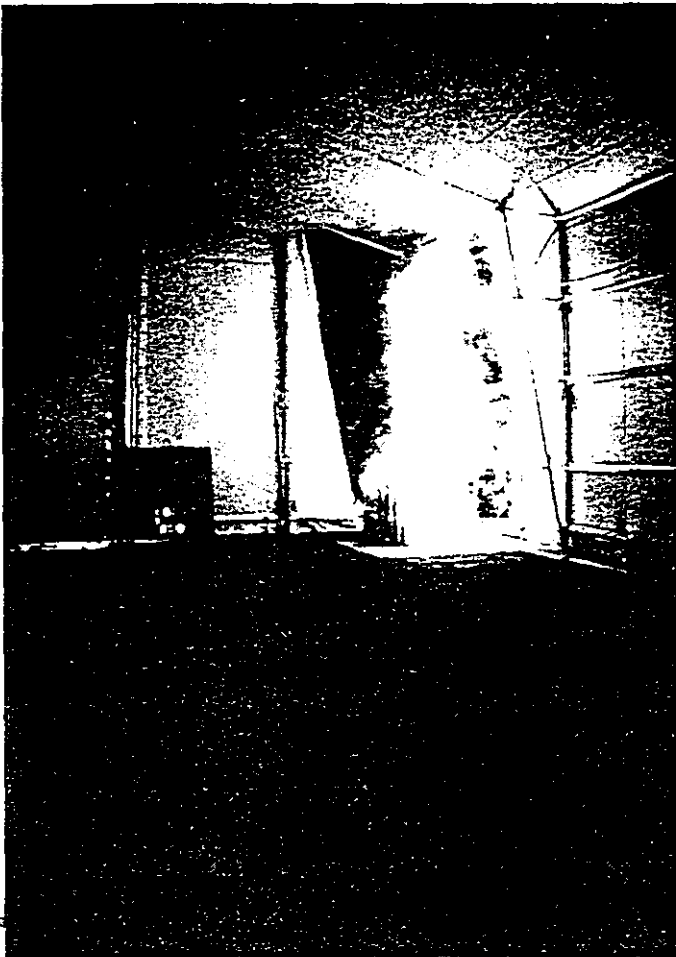
5:45 after ignition.



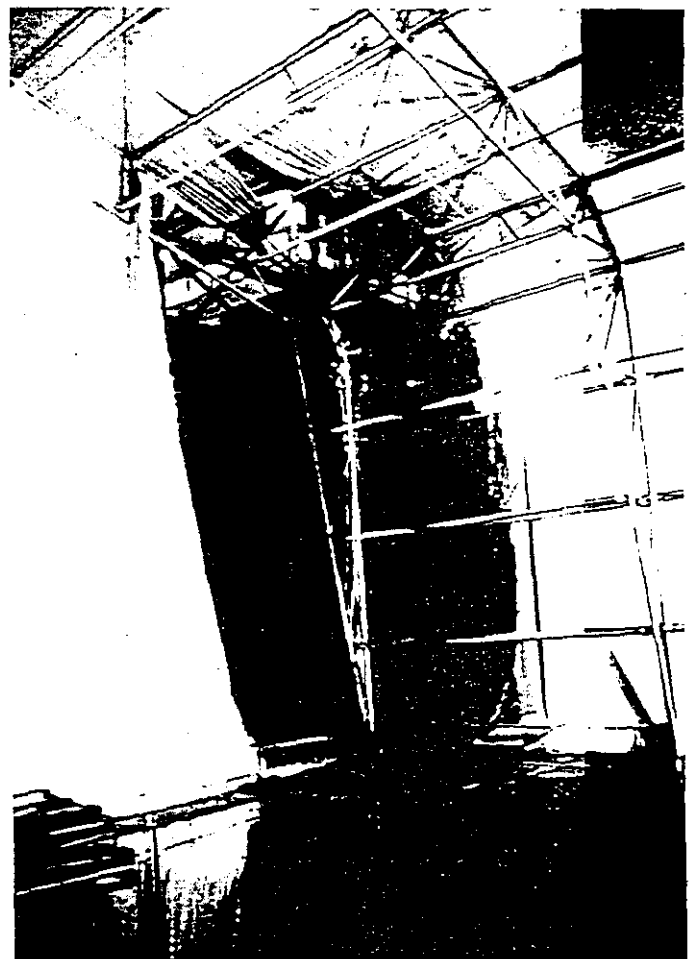
7:42 after ignition.
Exterior view
Southeast corner - east wall.



8:16 after ignition
Exterior view
Southeast corner - east wall.



14:30 after ignition



Post test - southeast corner.

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