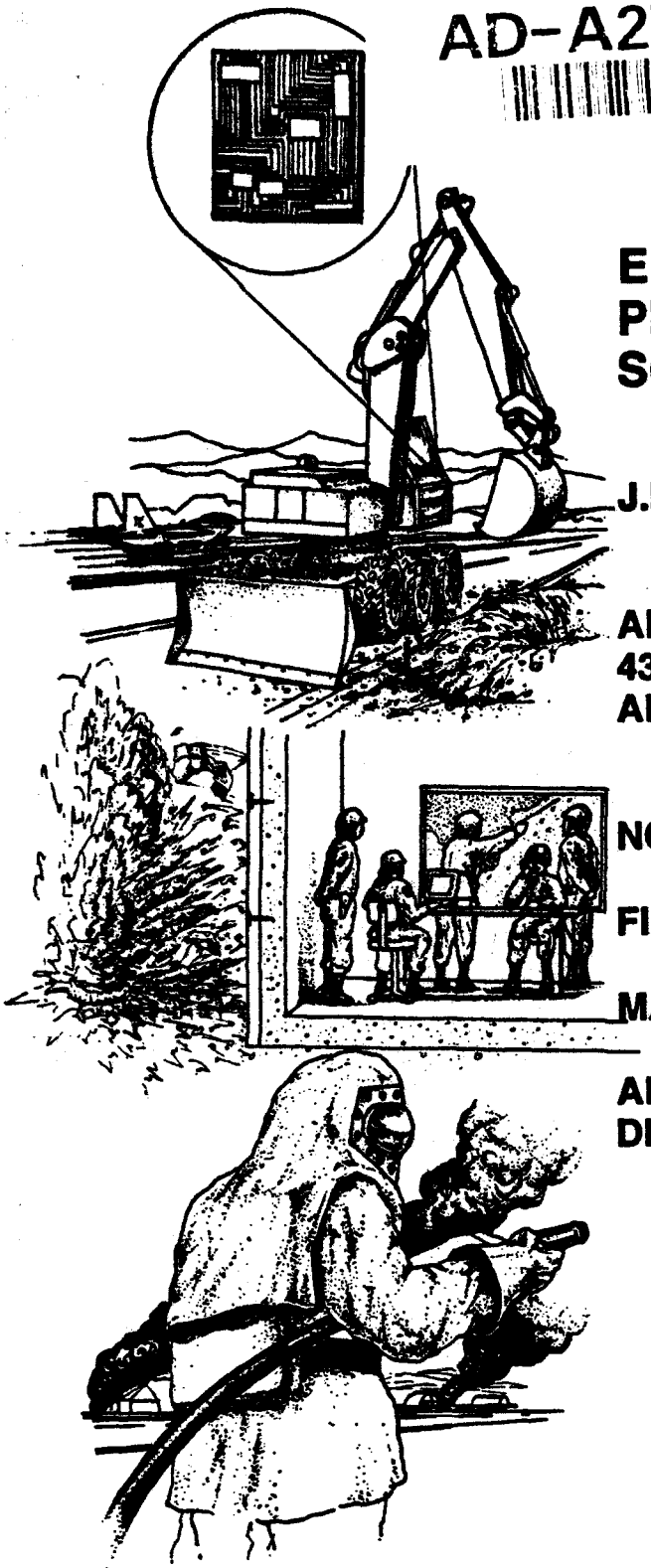

ESL-TR-92-53

EXPANDED POLYSTYRENE PROTECTIVE BARRICADE FULL-SCALE FIRE EXPOSURE TEST

J.H. STORM, B.R. DEES, M.J. WILSON

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NOVEMBER 1992

FINAL REPORT

MAY 1992

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ENGINEERING RESEARCH DIVISION
Air Force Civil Engineering Support Agency
Civil Engineering Laboratory
Tyndall Air Force Base, Florida 32403

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This test program evaluated the burning characteristics of expanded polystyrene foam used as a munitions barricade in underground storage facilities. In accordance with nationally-accepted standards, a crib fire burning 30 pounds of wood was used as the ignition source. Standard sheet rock was evaluated as a protective material for the polystyrene barricades. Additionally, the two potential ignition sources present within munitions storage bays, an electrically overloaded light fixture and a 4 ounce paint spill, were evaluated for their ability to ignite the test polystyrene cell.

While the sheet rock did protect the polystyrene from the fire and extend the time to failure, test results show that a large fire will melt the polystyrene material releasing the sand and extinguishing fire before a dangerous temperature is reached at the weapons location or serious damage is done. Therefore, a polystyrene barricade retrofit with a protective covering does not appear to be warranted.

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EXECUTIVE SUMMARY

A. OBJECTIVE

The major objectives of this test series were to evaluate the burning characteristics of polystyrene foam barricades when exposed to a fully developed Class A fire, evaluate the degree of protection afforded by covering the foam material with sheet rock, and evaluate the ignition potential of a burned out light fixture and a 4-ounce paint spill.

B. BACKGROUND

During a technical assistance visit to the Kirtland Underground Munitions Storage Complex (KUMSC), the AFMC fire protection engineer (FPE) determined that an exposed expanded polystyrene foam material was to be used as a barricade material between munitions in the two weapons storage bays. Generic polystyrene is a highly combustible material which could be expected to contribute to an extensive spread of fire throughout this facility.

Continued investigation of this issue by the AFMC FPE determined that, although the use of the polystyrene was approved in TO 11N-20-7, no quantitative combustibility tests had been conducted on this material.

AFCESA/DF, with AFMC/CECS support, in conjunction with AFCESA/RACF, establish a short timeframe program to evaluate both the burning characteristics and the ignition susceptibility of the expanded polystyrene foam being used at the munitions storage facilities.

C. SCOPE

This test program evaluated the burning characteristics of expanded polystyrene foam used as a munitions barricade in underground storage facilities. In accordance with nationally-accepted standards, a crib fire burning 30 pounds of wood was used as the ignition source. Standard sheet rock was evaluated as a protective material for the polystyrene barricades. Additionally, the two potential ignition sources present within munitions storage bays, a burned up light fixture and a 4 ounce paint spill, were evaluated for their ability to ignite the test polystyrene cell.

D. CONCLUSION

The peak temperature encountered during the 30-pound wood fires located in the corner of the test storage cell was 425°F immediately adjacent to the fire. A thermocouple located at the weapons storage location showed peak temperatures of 82°F for the unprotected cell fire test and 162°F during the sheet rock protected fire test. This higher temperature was due to the longer burning time, and consequently larger, more developed fire, during this test as compared to the unprotected fire. Reflected radiant heat from the sheet rock may also have contributed to this higher temperature at the weapon location. During the fire test with the unprotected walls, the current storage facility configuration, the polystyrene melted releasing sand and extinguishing the fire after five minutes. While the polystyrene material did melt during the wood crib and paint spill fires, it did not burn or contribute to the fire.

B. RECOMMENDATIONS

While the sheet rock does protect the polystyrene from the fire and extend the time to failure, test results show that a large fire will melt the polystyrene material releasing the sand and extinguishing fire before a dangerous temperature is reached at the weapons location or serious damage is done. Therefore, a retrofit of the polystyrene barricades with a protective covering does not appear to be warranted.

PREFACE

This report was prepared by the Air Force Civil Engineering Laboratory, Air Force Civil Engineering Support Agency, Tyndall Air Force Base, Florida 32403.

Mr. Fred Walker, AFCESA/DF, was the Project Officer. This test program was completed in support of the USAF Chief of Fire Protection, AFCESA/DF. This report presents the results of the Expanded Polystyrene Protective Barricade Full-scale Fire Exposure Test conducted on 5 and 6 May 1992 at Tyndall AFB, Florida.

This report has been reviewed and is approved.

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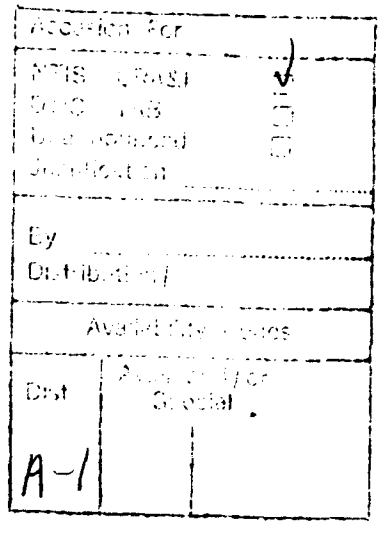

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LIST OF FIGURES

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SECTION I

INTRODUCTION

A. OBJECTIVES

The major objectives of this test series were to evaluate the burning characteristics of polystyrene foam barricades when exposed to fully developed Class A fires, evaluate the degree of protection afforded by covering the foam material with sheet rock, and evaluate the ignition potential of a burned out light fixture and a 4-ounce paint spill.

Specific objectives were as follows:

1. Evaluate the effects on the polystyrene foam cell from a burning light fixture of the type used in munitions storage facilities.

2. Evaluate the effects on the polystyrene foam cell from a burning paint or solvent spill of the type used for munitions touch-up within the storage facilities.

3. Measure and compare the ignition time and temperatures and flame spread rate of unprotected expanded polystyrene, in a munitions barricade configuration, subjected to standard fire test UBC 17-5.

4. Measure and compare the ignition time and temperature and flame spread rate of expanded polystyrene covered with various fire protection coverings when configured as a munition barricade and subjected to standard fire test UBC 17-5.

B. BACKGROUND

During a technical assistance visit to the Kirtland Underground Munitions Storage Complex (KUMSC), the AFMC fire protection engineer (FPE) determined that an exposed expanded polystyrene foam material was to be used as a barricade material between munitions in the two weapons storage bays. Generic polystyrene is a highly combustible material which could be expected to contribute to an extensive spread of fire throughout this facility.

Continued investigation of this issue by the AFMC FPE determined that, although the use of the polystyrene was approved in TO 11N-20-7, the DNA test program (DNA Report 2892F) for that TO had not considered the polystyrene combustibility issue. Telephone conversations between AFMC staff and the Field Command Defense Nuclear Agency (FC-DNA) determined that no quantitative test had been conducted on this material, such as the standard test for exposed foam plastics, Uniform Building Code 17-5, Room Fire Test Standard for Interior of Foam Plastic Systems.

AFCESA/DF, with AFMC/CECS support, in conjunction with AFCESA/RACF, establish a short timeframe program to evaluate both the burning characteristics and the ignition susceptibility of the expanded polystyrene foam being used at the munitions storage facilities. The polystyrene foam was supplied by the munitions storage facility at Nellis AFB.

C. MEASURES OF MERIT

1. Acceptable performance of the polystyrene material during the evaluation of Objectives 1, 2, and 4 was as follows:

a. No loss of structural integrity; no walls collapse.

b. Sufficient sand remains in place to ensure effective barrier performance.

c. Temperatures do not exceed the condition damage threshold.

2. A suitable fire protective covering should protect the expanded polystyrene foam blocks from structural failure (including collapse or release of sand fill) and ignition from the standard wood crib fire for up to 15 minutes. Time to ignition, temperature, and flame spread rate are the parameters to be measured during this test program.

D. SCOPE

This test program evaluated the burning characteristics of expanded polystyrene foam used as a barricade between adjacent munitions in underground storage facilities. In accordance with nationally-accepted Underwriters' Laboratories and Uniform Building Code (UBC) standards for determining the burning characteristics of exposed foam plastics, a crib fire burning 30 pounds of wood was used as the ignition source fire for this test. Protective materials, which might be used to reduce the ignition probabilities of the foam, were evaluated during laboratory-scale tests. The most promising of these covering materials, sheet rock, was tested in this test program using the full-scale test polystyrene storage cell. This test also used the wood crib fire as the source. Additionally, the two potential ignition sources present within munitions storage bays, a burned up light fixture and a 4 ounce paint spill, were evaluated for their ability to ignite the test polystyrene cell.

E. AUTHORITY

HQ USAF Program Management Directive (PMD) Number 2132(15)/63723F (2104), 15 March 1991, Civil Engineering Technology, was the authority for this test. This test program was conducted in accordance with the PMD and AFR 80-14.

SECTION II

TEST DESCRIPTION

A. INTRODUCTION

This test program was conducted by constructing a U-shaped munitions storage cell of polystyrene and sand inside the NATO Semi-hardened structure fire test facility at Tyndall AFB, Florida. The cell was exposed to three different ignition sources, an electrically overloaded overhead electric light fixture, an ignited 4-ounce paint spill, and a standard wood crib fire used as the standard fire test for exposed plastics. The cell was constructed of the polystyrene foam material in the same configuration as used at KUMSC. The cell was filled with a local sand type that closely duplicates the sand used at KUMSC. Details of the test procedure are contained in the paragraphs below. The test site layout is depicted in Figure 1.

The NATO semi-hardened structure, at Sky X, Tyndall AFB, Florida, was used for all fire tests. A full-size barricade, of the same dimensions as the barricades used at the KUMSC facility, was constructed for this test. Test data included temperature and event time measurements recorded both electronically and manually. Video cameras recorded all test events.

B. LIGHT FIXTURE FAILURE BURN SUSCEPTIBILITY TEST

This test evaluated the susceptibility of the polystyrene munitions storage cell to ignition from an electrically overloaded overhead electric light fixture. The test was conducted by installing a fluorescent light fixture, of the same type as used in Air Force munitions storage facilities, directly over the center of the back wall of the test polystyrene cell. The fixture was a series M106N, Model 1-40W F40 LPF, manufactured by the Mercury Light Products Company, Inc. The light fixture was deliberately burned up by applying excess voltage until the unit burned and the circuit opened. In theory, any burned material from the light fixture could fall directly onto the polystyrene cell, resulting in ignition of the polystyrene. The test sequence was video taped and evaluated. This test evaluated the potential results of a burned up light fixture, not the probability of the event occurring.

C. PAINT SPILL BURN SUSCEPTIBILITY TEST

This test evaluated the susceptibility of the polystyrene munitions storage cell to ignition from an ignited 4 ounce spill of lacquer touch-up paint, (NSN 8010-00-257-5377), the type authorized for in-cell munitions touch-up painting. The test was conducted by spilling 4 ounces of paint on the floor in the corner of the test storage cell, as shown in Figure 1, allowing the spill to spread for 10 seconds, and igniting the paint with a butane lighter. The resultant fire was permitted to burn to self extinguishment. The results of this paint fire was video taped and evaluated. This test evaluated the potential results of a paint spill fire, not the probability of the event occurring.

NATO SEMI-HARDENED STRUCTURE FIRE TEST FACILITY

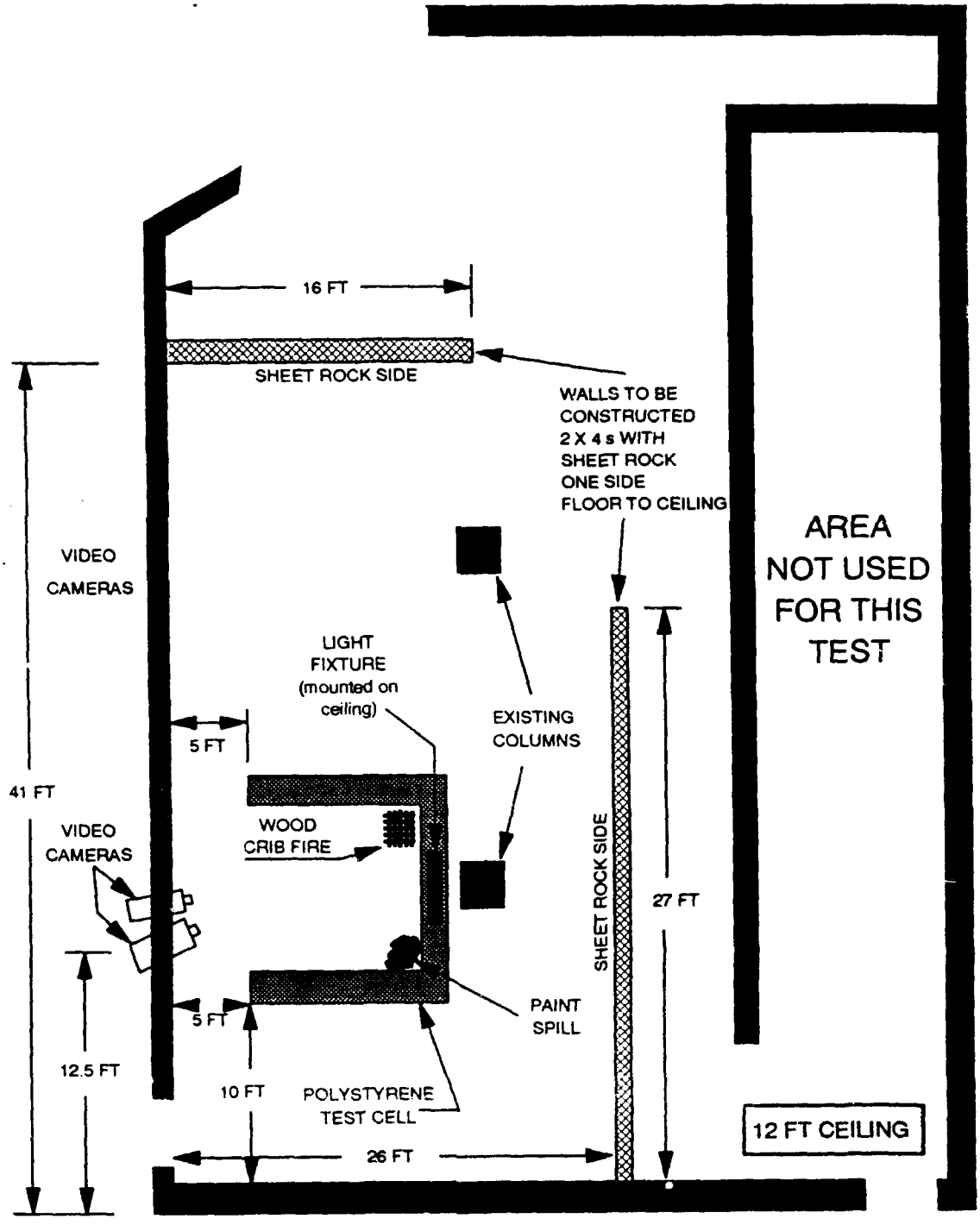

Figure 1. NATO Semi-Hardened Structure Fire Test Facility

D. UNPROTECTED BARRICADE FIRE IGNITION TEST

This test measured the fire performance, time to ignition, burning temperature, and burning characteristics of the unprotected polystyrene block material, configured as a full-scale munitions storage cell. The polystyrene and sand U-shaped barricade was constructed as shown in Figures 1 and 2. The inside dimensions of the cell were 84 inches by 84 inches and 80 inches high. Thermocouples were placed at six locations within the test cell, as shown in Figure 2, to provide temperature histories throughout the fire test. This test was completed by subjecting the polystyrene test cell to the standard expanded foam plastic fire exposure test, in accordance with UBC 17-5. The ignition source for this test consisted of a 30-pound wood crib, placed in the corner of the cell as shown in Figure 2. Wood crib details are shown in Figure 3. The alcohol-soaked wood excelsior, located under the wood crib, was ignited with a butane lighter. The fire was permitted to burn to self extinguishment. The test was video recorded by two video cameras, placed as shown in Figure 1.

E. COVERED BARRICADE FIRE IGNITION TEST

The Covered Barricade fire tests was completed in the same manner as the unprotected barricade test, described in paragraph D, above. In this test the inside walls of the barricade cell were covered with 1/2 inch thick sheet rock to evaluate the degree of fire protection afforded by this covering material. Previously conducted laboratory scale tests showed sheet rock to provide a reasonable level of protection from an open flame. The ignition source was the same wood crib fire, as used in the unprotected wood crib fire test. The test was video recorded by two video cameras, placed as shown in Figure 1.

F. INSTRUMENTATION AND DATA COLLECTION

Temperature measurements were made at six locations on the polystyrene barricade. Thermocouple locations and numbers are shown in Figure 2. All data were recorded on the data collection sheets contained in Annex 4 of the test plan. Two video cameras recorded all test activities. Still photographs were taken of selected events.

NATO SEMI-HARDENED STRUCTURE POLYSTYRENE TEST CELL DETAIL AND INSTRUMENTATION LOCATIONS

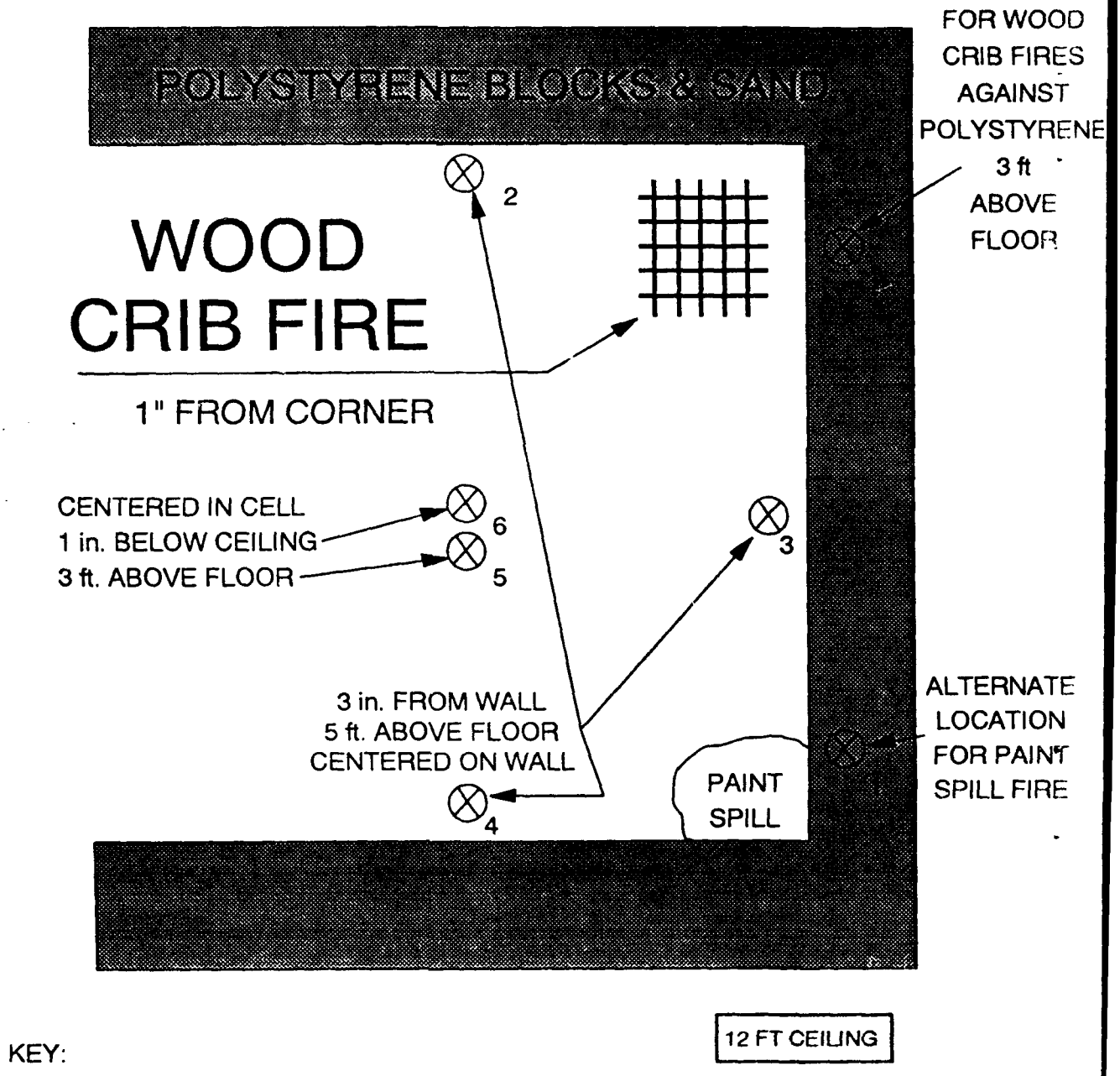

Figure 2. Polystyrene Test Cell Detail and Instrumentation Locations

WOOD FIRE CRIB DETAIL

(IAW UBC 17-5)

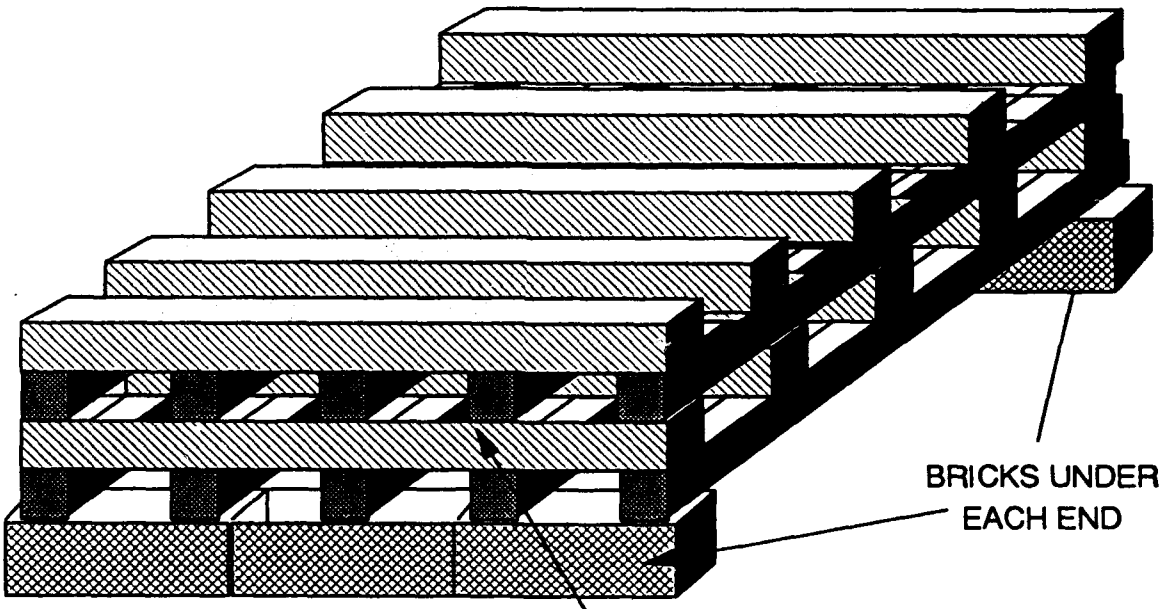

Figure 3. Wood Fire Crib Detail

polystyr3

SECTION III

TEST RESULTS

A. GENERAL

This test program was conducted on 5 and 6 May 1992, as described in Section II, Test Description. The results of each test are presented in the following paragraphs.

B. LIGHT FIXTURE FAILURE BURN SUSCEPTIBILITY TEST

Two separate light tests were conducted. The first test was conducted with the light fixture disassembled so that the failure mode could be determined. Standard operating voltage for this light fixture is 120 volts. The fixture was wired to 240 volts to deliberately burn it up. When the voltage was applied the light initially operated normally. Within 15 seconds the ballast began overheating. At 90 seconds the light failed. The ballast was quite hot, but there was no other indication of failure. An electrical check of the fixture with an ohmmeter showed the ballast to be open circuited. The test was repeated with the light fixture fully assembled, mounted on the ceiling 12 feet over the cell, as shown in Figure 1. The results were the same; the ballast burned out with an open circuit in the ballast in approximately 90 seconds. There was no loss of ballast fluid or any other indication of failure that could result in ignition of the polystyrene.

C. PAINT SPILL BURN SUSCEPTIBILITY TEST

Ignition tests were conducted on 4 May 1992, on three of the paint types identified as used in munitions storage areas, with the following results:

PAINT TYPE	IGNITED WITH SPARK IGNITION	IGNITED WITH FLAME IGNITION
Epoxy, 2-part	No	Yes, burned very slowly
Enamalized Alkyd	No	No
Lacquer, Cellulose	Yes, burned rapidly	Yes

The purpose of these ignition tests was to determine the most flammable paint and its susceptibility to spark only ignition. As a result, the lacquer was used for the paint spill test.

The paint spill test was conducted as described in Section II. Four ounces of lacquer touch-up paint was poured on the floor in the corner of the polystyrene cell, as shown in Figures 1 and 2. After a 10-second period to permit the paint to spread, the paint was ignited with a butane lighter. This lacquer paint ignited readily from the gas lighter but would not light from a spark ignition source alone. During paint ignition tests, conducted previously, this type lacquer did ignite readily from a spark ignition source alone (no flame). The paint burned for 3 minutes and 30 seconds and self extinguished. Damage the polystyrene walls was minimal. The surface of the polystyrene was melted and scorched, but did not melt through or release any sand. The polystyrene material itself did not burn or contribute to the fire.

Thermocouples were located and numbered as shown in Figure 2. As can be seen by the temperature measurements shown in Figures 4 through 9, ignition occurred at approximately 1354. Thermocouple number 1 was located on the back wall of the polystyrene cell just behind the paint fire. Peak temperature at this location was 425°F. The peak temperature at location 5, the position where a weapon might be located, was 83°F.

D. UNPROTECTED BARRICADE FIRE IGNITION TEST

The fire was ignited at 1323 with a butane lighter. The intensity of the fire built slowly at first and later into a fully developed wood fire. The polystyrene began melting from the walls in the area of the fire approximately 80 seconds after ignition. In 4 minutes the polystyrene wall broke releasing sand onto the fire, partially extinguishing it. Approximately 5 minutes after ignition, a large quantity of sand flowed from the wall, extinguishing the fire. At no time did the melted polystyrene burn or contribute to the fire.

The volume of sand released from the failed polystyrene wall structure was approximately 2.9 feet^3. Depleted areas of the wall were limited to 24 inches from the inside corner in the top half of the wall sections.

Temperature profiles are shown in Figures 10 through 15. Thermocouple numbers and locations are shown in Figure 2. Thermocouple number 1, located on the polystyrene wall adjacent to the fire recorded the highest temperature at 350°F. The peak temperature at location 5, the position where a weapon might be located, was 92°F.

E. COVERED BARRICADE FIRE IGNITION TESTS

The fire was ignited at 0921 with a butane lighter. The paper on the dry wall began to burn at approximately 0924. At approximately 0936, 15 minutes after the fire was ignited, the dry wall broke out at the lower section of the wall adjacent to the fire, releasing some sand on the edge of the burning wood crib. A post fire examination showed that some of the nylon straps that hold the polystyrene walls together had melted. The loss of internal structural integrity resulted in the weight of the sand breaking through the polystyrene and now deteriorated dry wall. The wood crib fire continued to burn for an additional 4 minutes before it was extinguished using C_6 fire extinguishing agent. Some polystyrene melted during the fire but did not burn or contribute to the fire.

Temperature profiles are shown in Figures 16 through 21. Thermocouple numbers and locations are shown in Figure 2. Thermocouple number 1 was located on the polystyrene wall behind the sheet rock protective covering. As a result, the temperature at this location rose slowly until the sheet rock broke, exposing the sensor directly to the fire. Peak temperature at this location was approximately 425°F. The peak temperature at location 5, the position where a weapon might be located, was 162°F. This temperature was somewhat higher than in the unprotected crib fire test. This higher temperature was due to the longer burning time, and consequently larger, more developed fire, during this test as compared to the unprotected fire. Reflected radiant heat from the sheet rock may also have contributed to this higher temperature at the weapon location. The high temperatures indicated by thermocouples 3 and 4, Figures 18 and 19, appear to be instrumentation anomalies.

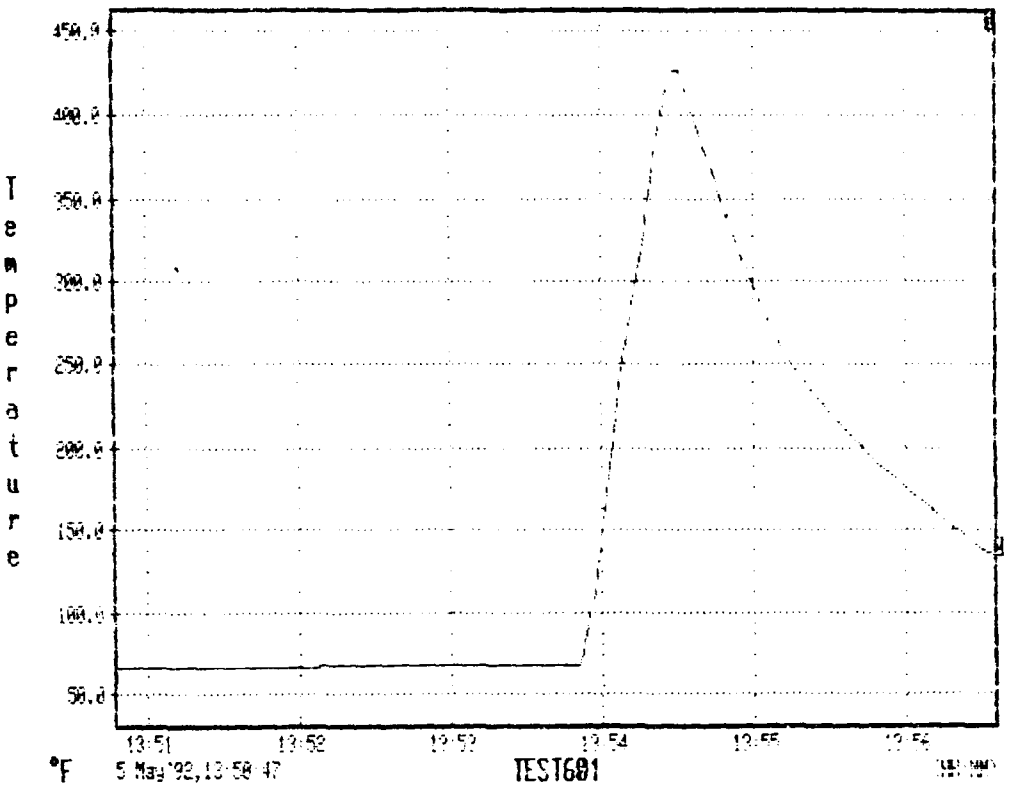

Figure 4. Paint Spill Test - Thermocouple #1, Adjacent to Fire

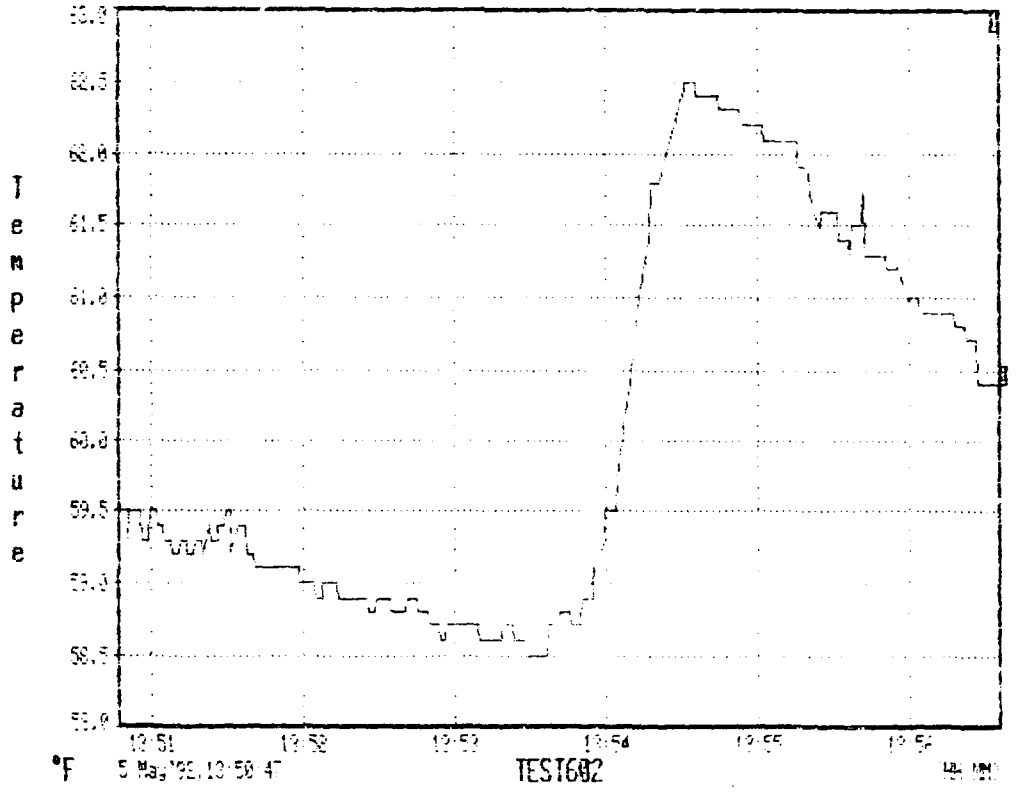

Figure 5. Paint Spill Test - Thermocouple #2, Cell Left Wall

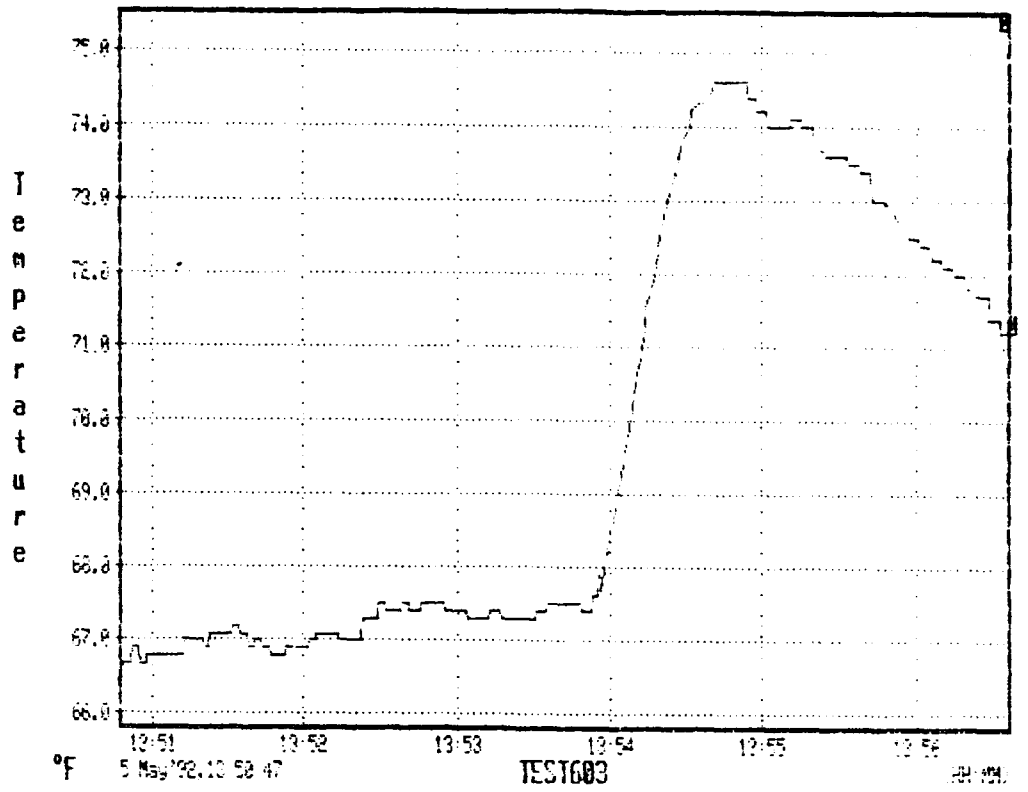

Figure 6. Paint Spill Test - Thermocouple #3, Cell Back Wall

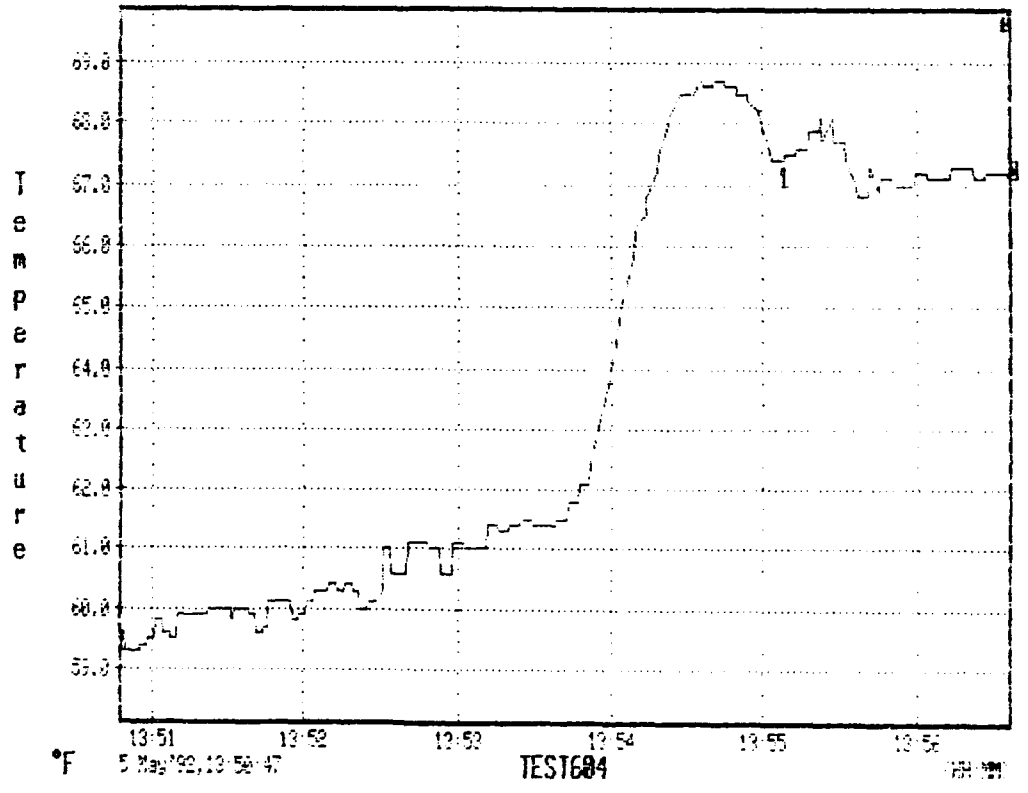

Figure 7. Paint Spill Test - Thermocouple #4, Cell Right Wall

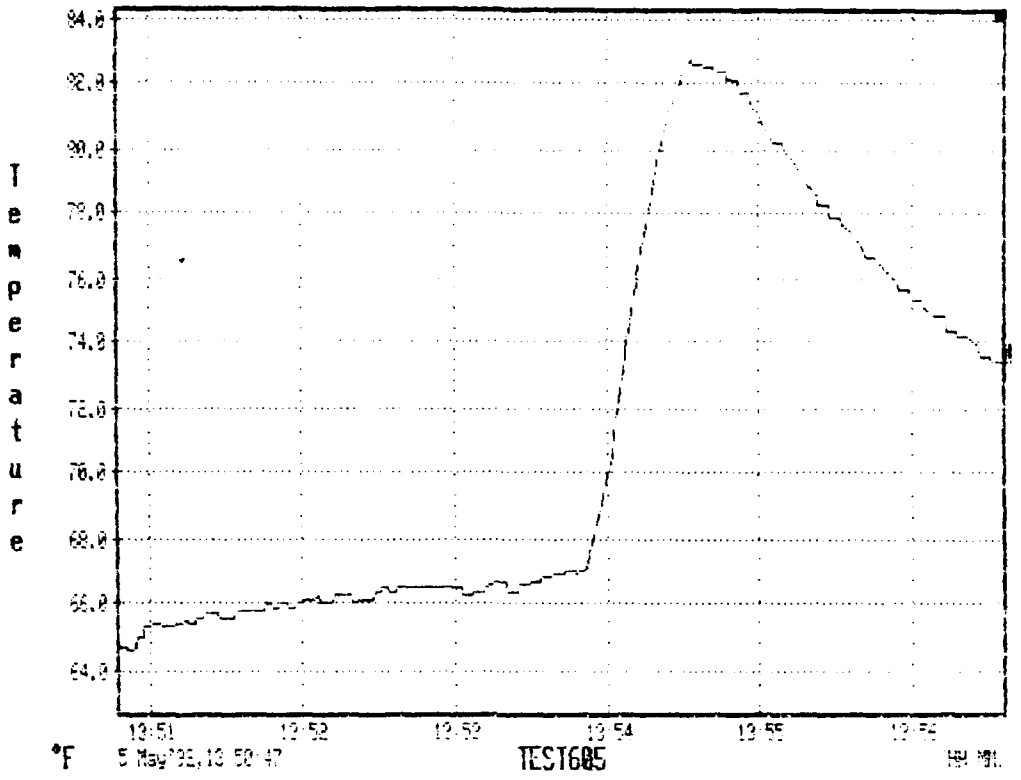

Figure 8. Paint Spill Test - Thermocouple #5, Center of Cell, 3 Ft

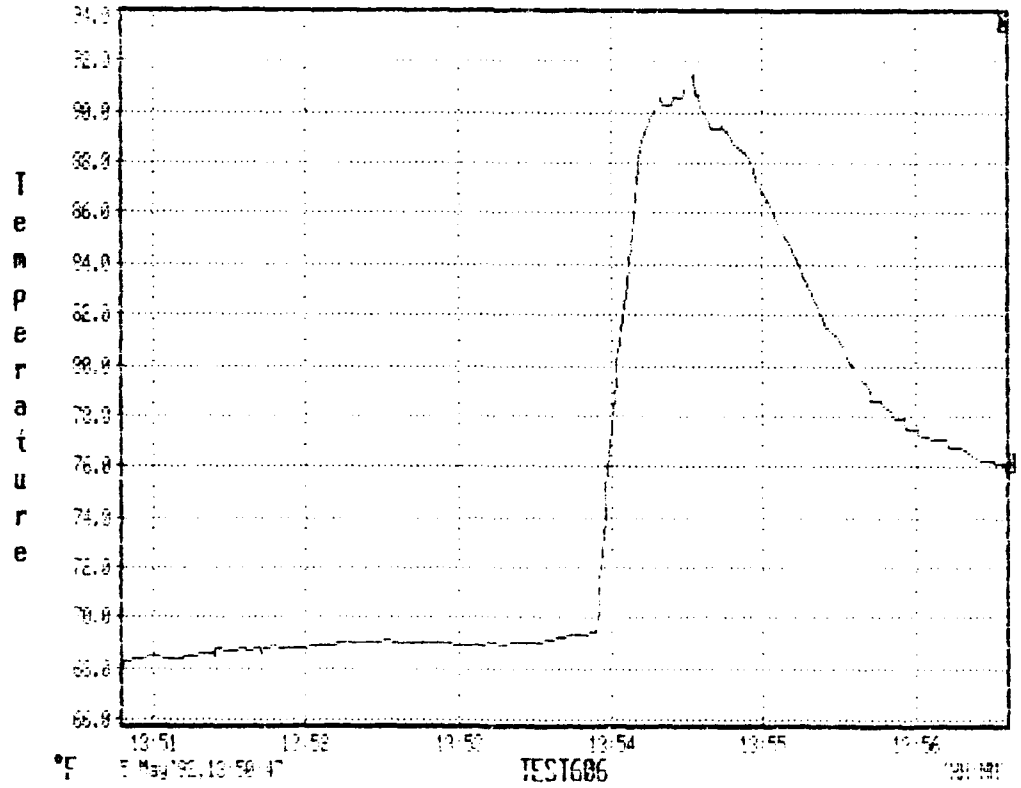

Figure 9. Paint Spill Test - Thermocouple #6, Center of Cell - Ceiling

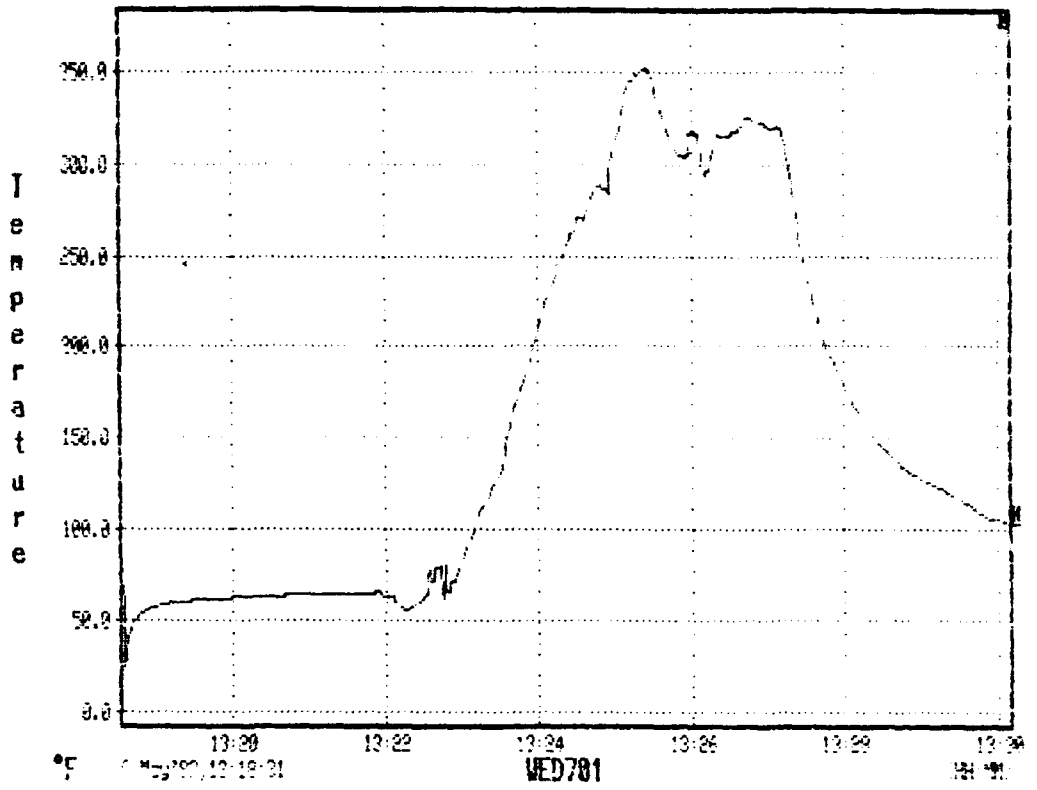

Figure 10. Unprotected Barricade Test - Thermocouple #1, Adjacent to Fire

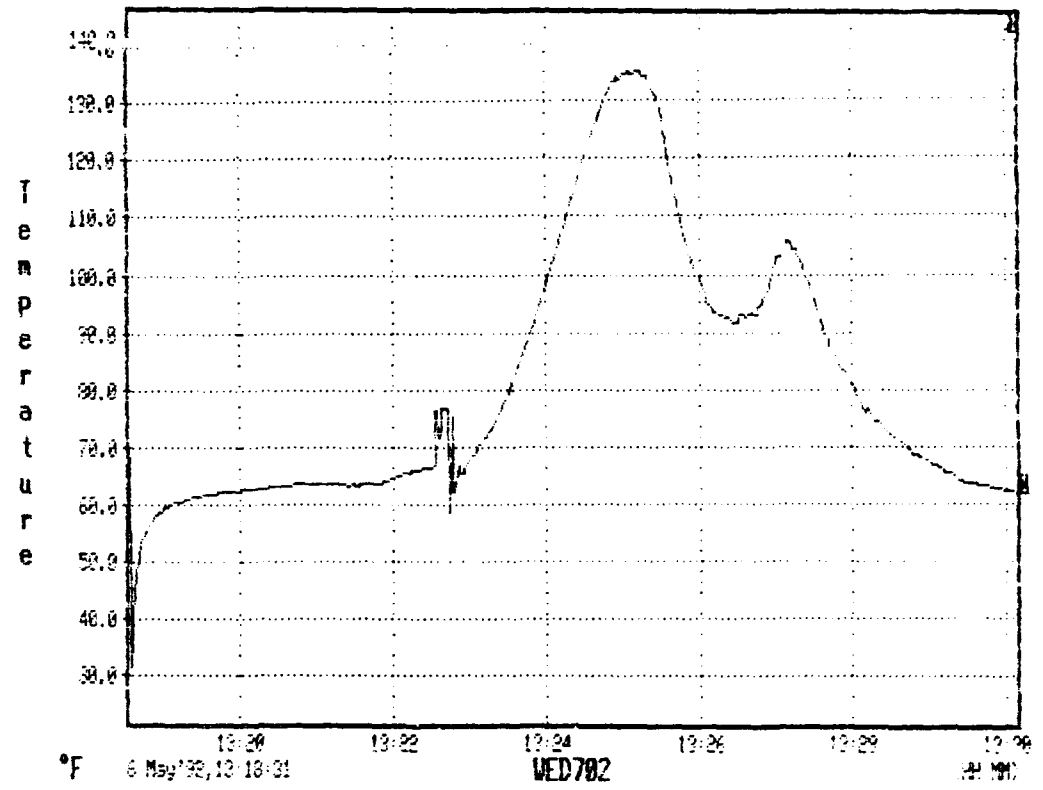

Figure 11. Unprotected Barricade Test - Thermocouple #2, Cell Left Wall

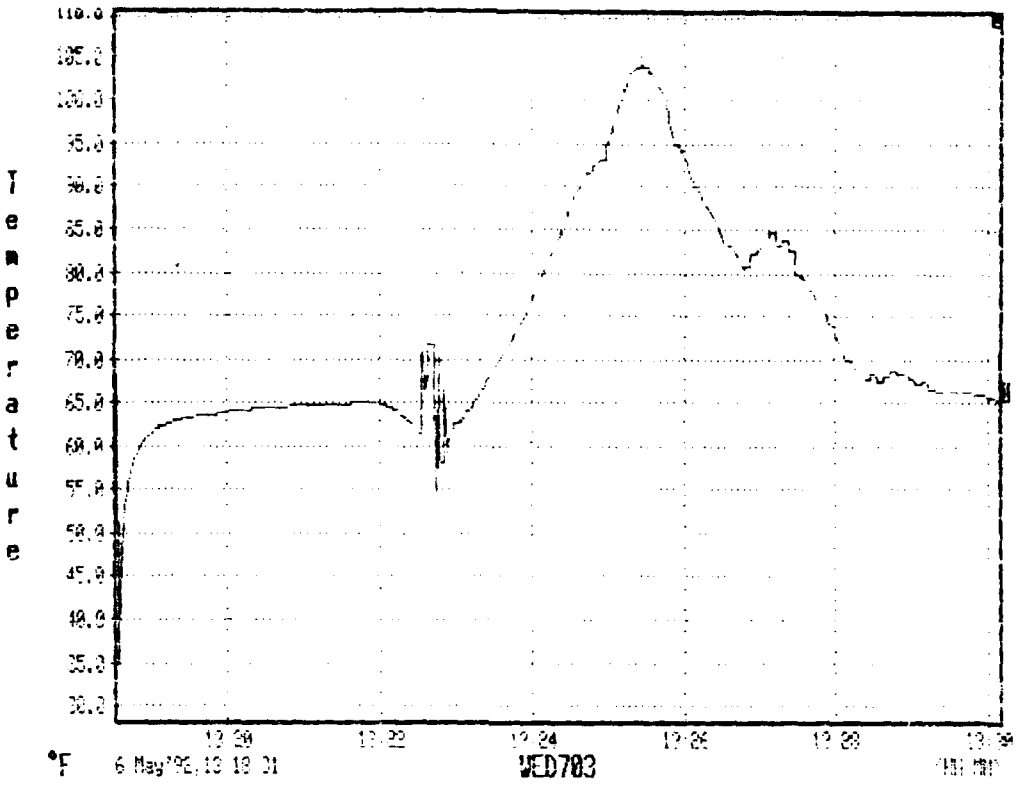

Figure 12. Unprotected Barricade Test - Thermocouple #3, Cell Back Wall

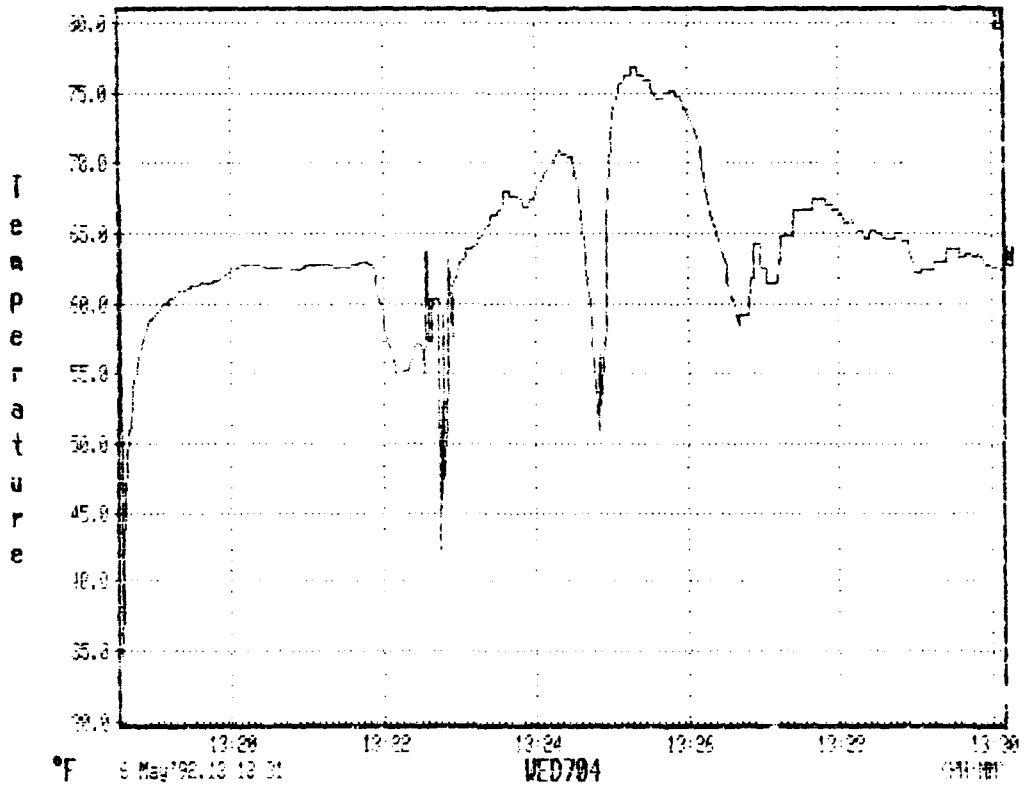

Figure 13. Unprotected Barricade Test - Thermocouple #4, Cell Right Wall

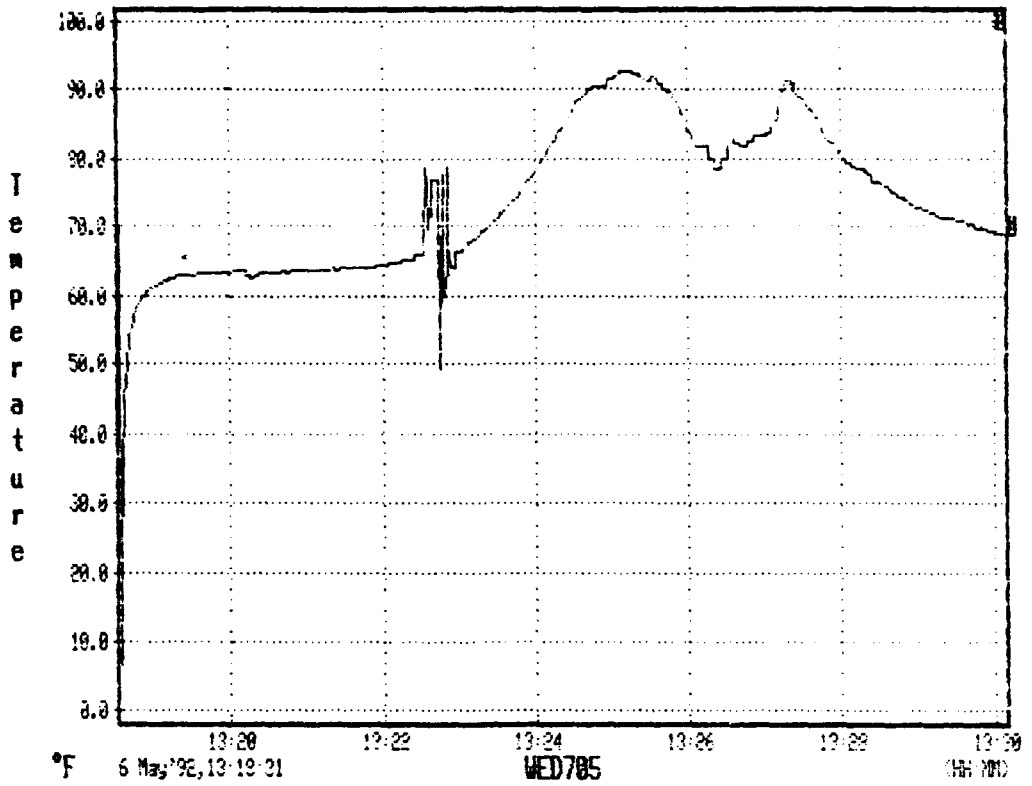

Figure 14. Unprotected Barricade Test - Thermocouple #5, Center of Cell, 3 Ft

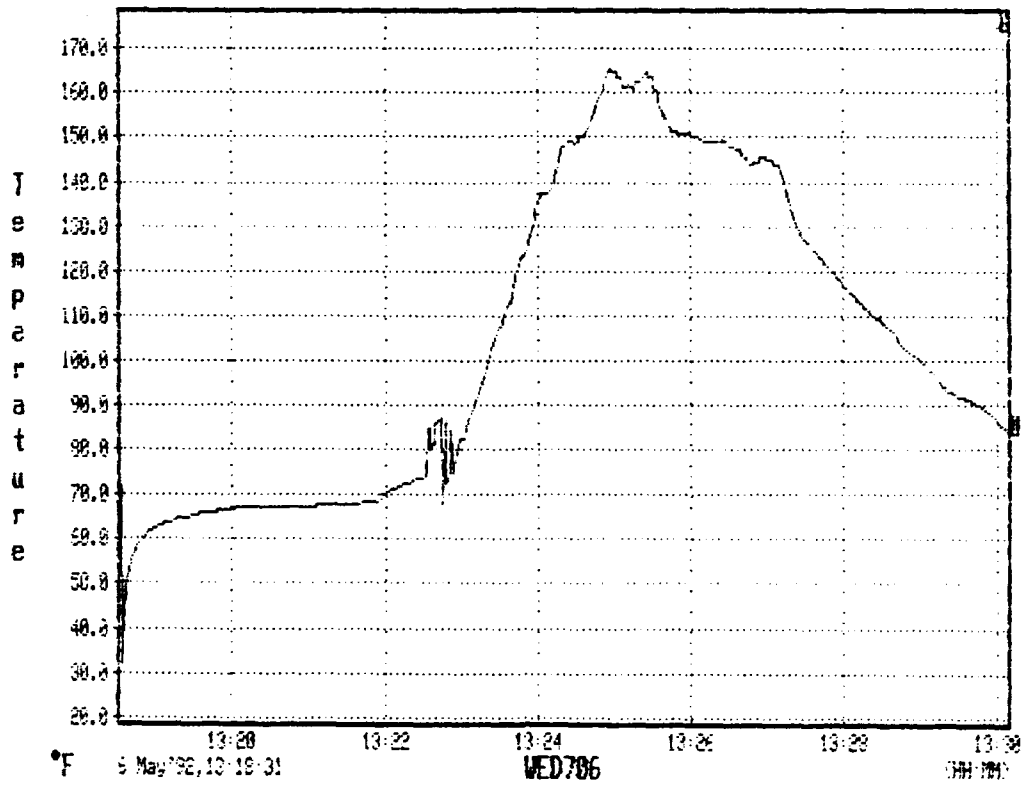

Figure 15. Unprotected Barricade Test - Thermocouple #6, Center of Cell - Ceiling

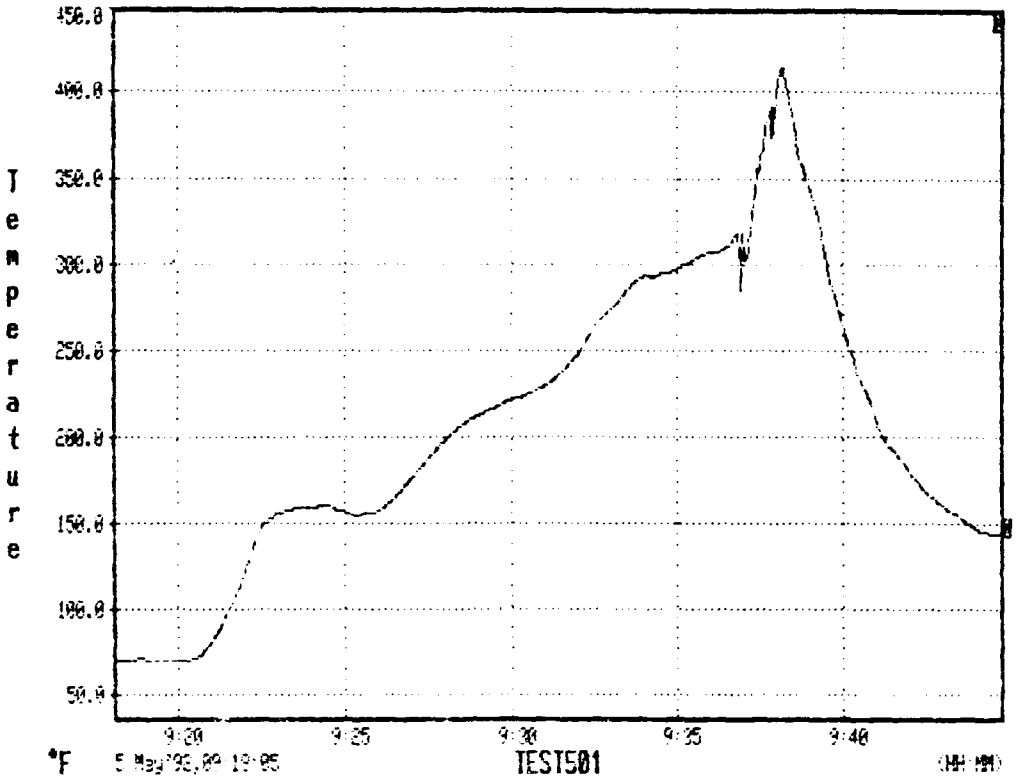

Figure 16. Covered Barricade Test - Thermocouple #1, Adjacent to Fire

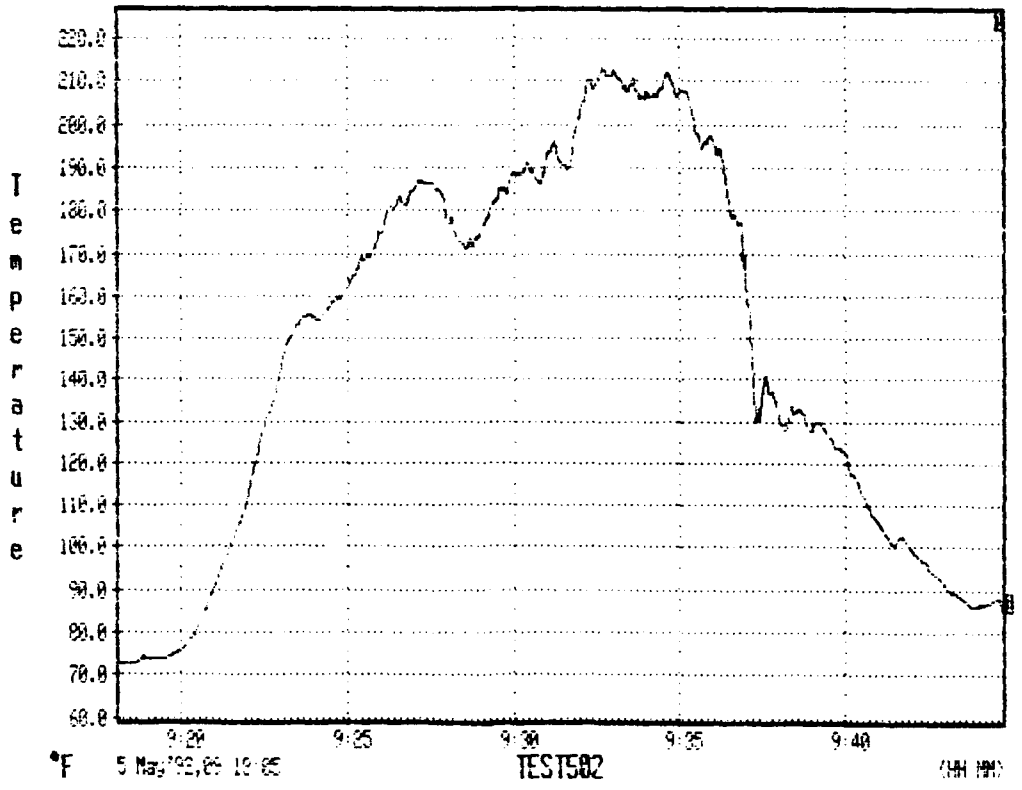

Figure 17. Covered Barricade Test - Thermocouple #2, Cell Left Wall

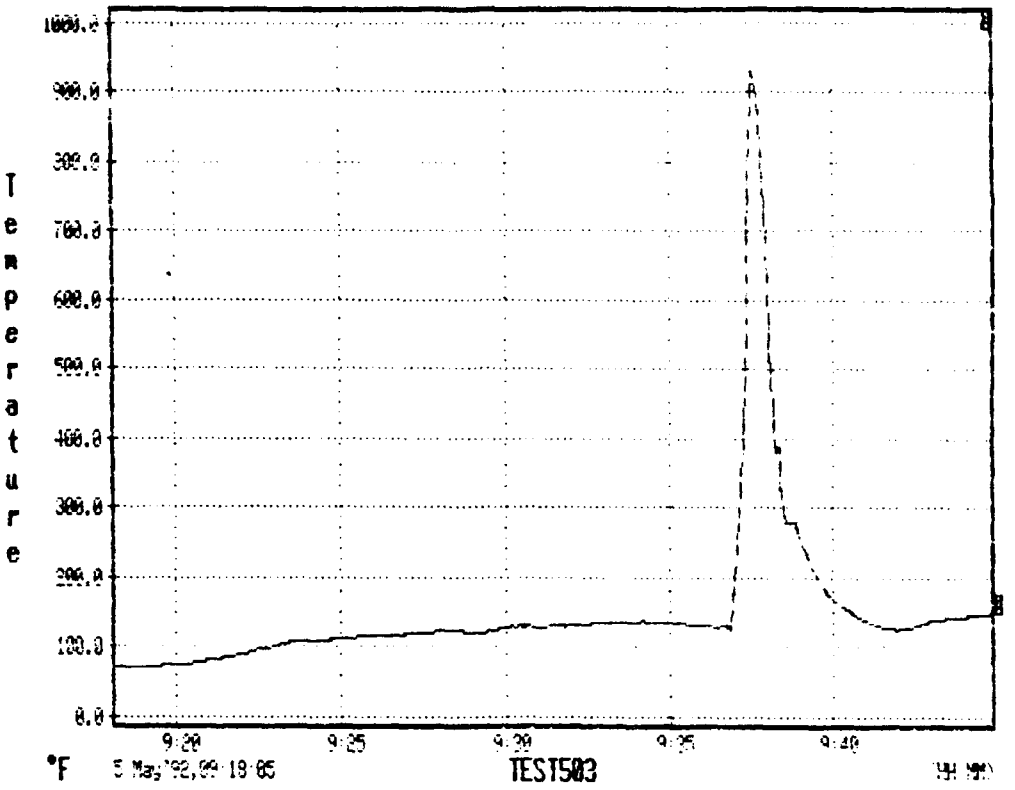

Figure 18. Covered Barricade Test - Thermocouple #3, Cell Back Wall

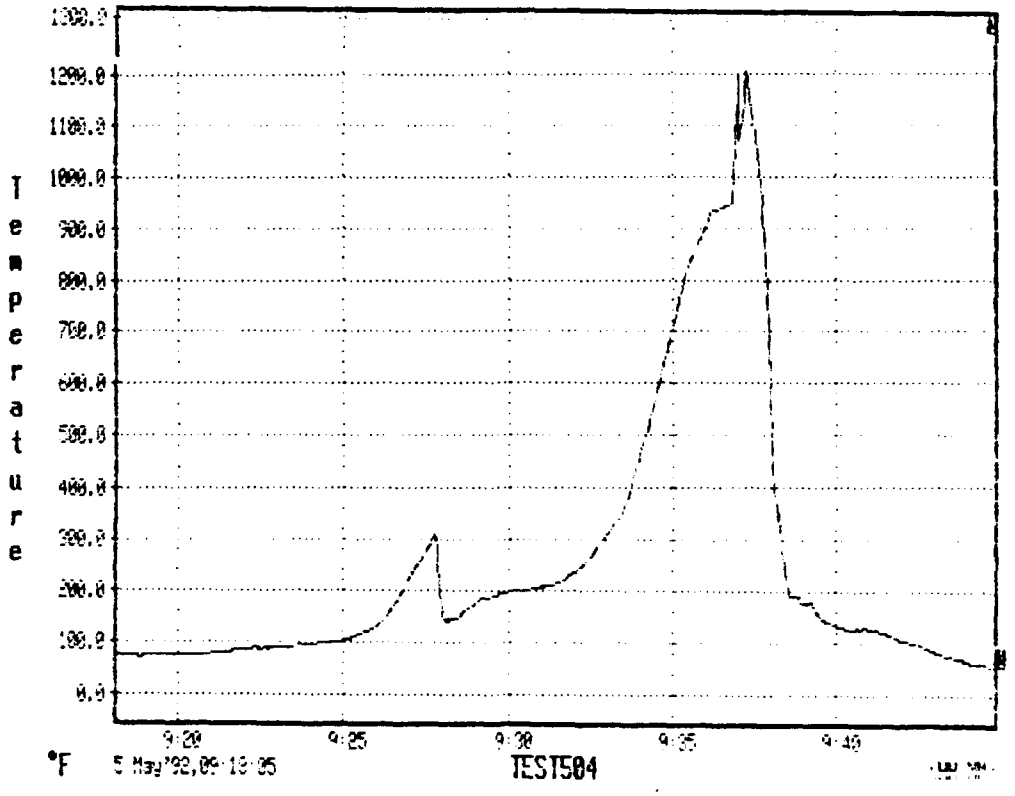

Figure 19. Covered Barricade Test - Thermocouple #4, Cell Right Wall

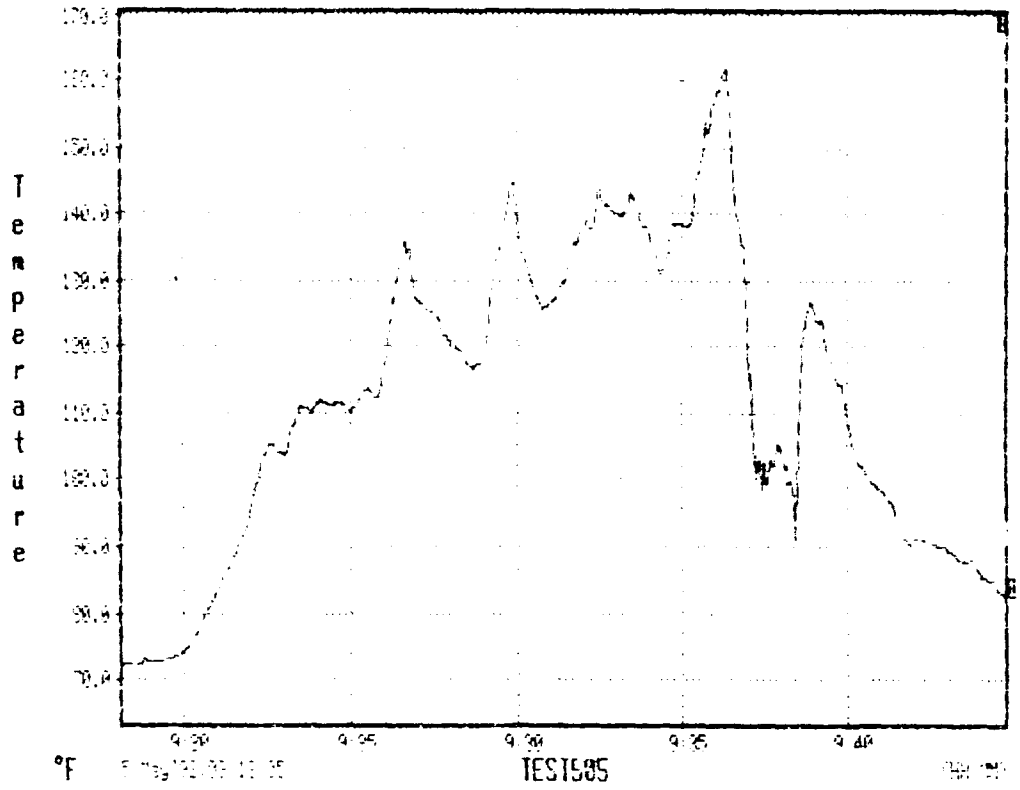

Figure 20. Covered Barricade Test - Thermocouple #5, Center of Cell, 3 Ft

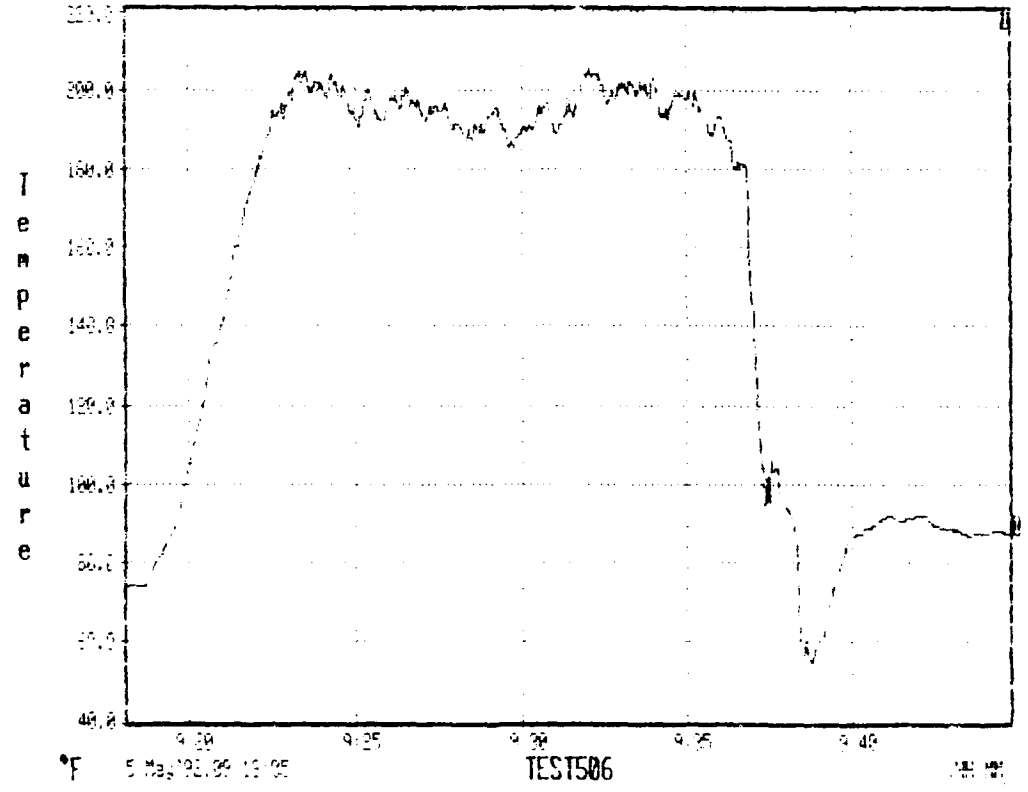

Figure 21. Covered Barricade Test - Thermocouple #6, Center of Cell - Ceiling

SECTION IV

CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

The peak temperature encountered during the 30-pound wood fires located in the corner of the test storage cell was 425°F immediately adjacent to the fire. A thermocouple was located at the center of the test cell, 3 feet above the floor, and approximately 2 feet from the crib fire to measure the temperature at the weapons storage location. During the fire test with the sheet rock protected walls, the maximum temperature attained at the weapons location was 162°F during a 19 minute fire. During the fire test with the unprotected walls, the current storage facility configuration, the peak temperature at the weapons location was 82°F in a 5 minute fire (released sand extinguished the fire after five minutes). This lower temperature was due to the shorter burning time, and consequently smaller, less developed fire, during the this test as compared to the sheet rock protected fire. Reflected radiant heat from the sheet rock may also have contributed to the higher temperature during this fire test. The current configuration of the polystyrene cells results in a lower weapons location temperature during a large wood crib fire.

While the polystyrene material did melt during the wood crib and paint spill fires, it did not burn or contribute to the fire.

The wood crib fire conducted in the unprotected polystyrene cell resulted in a sufficient quantity of polystyrene melting to release sand in a quantity sufficient to smoother and extinguish the crib fire.

B. RECOMMENDATIONS

While the sheet rock does protect the polystyrene from the fire and extend the time to failure, test results show that a large fire will melt the polystyrene material releasing the sand and extinguishing fire before a dangerous temperature is reached at the weapons location or serious damage is done. Therefore, a retrofit of the polystyrene barricades with a protective covering does not appear to be warranted.

APPENDIX A

EXPANDED POLYSTYRENE PROTECTIVE BARRICADE

FULL-SCALE FIRE EXPOSURE

TEST PLAN

AIR FORCE CIVIL ENGINEERING SUPPORT AGENCY
Tyndall Air Force Base, Florida 32403

EXPANDED POLYSTYRENE PROTECTIVE BARRICADE

FULL-SCALE FIRE EXPOSURE TEST

22 April 1992

TEST PLAN

This test plan has been reviewed and approved by:

FRED WALKER
Using Organization
Project Officer, AFCESA/DF

RICHARD REID, Capt, USAF
Safety Officer, AFCESA/RACS

RICHARD N. VICKERS
and Crash Rescue Systems Branch
Chief, Air Base Fire Protection

NEIL H. FRAVEL, Lt Col, USAF
Chief, Engineering Research Division

FRANK P. GALLAGHER III, Colonel USAF
Director, Civil Engineering Laboratory

TABLE OF CONTENTS

SECTION I

INTRODUCTION

A. SCOPE

This test program will evaluate the burning characteristics of expanded polystyrene foam used as a barricade between adjacent munitions in underground storage facilities. In accordance with nationally-accepted Underwriters' Laboratories and Uniform Building Code (UBC) standards for determining the burning characteristics of exposed foam plastics, a crib fire burning 30 pounds of wood will be used as the ignition source fire for this single burning characteristics test. This is the only fire test that will result in the burning of a significant quantity (approximately 240 pounds) of polystyrene foam. Protective materials, which might be used to reduce the ignition probabilities of the foam, have been evaluated during laboratory-scale tests. The most promising of these covering materials, sheet rock, will be tested in a second full-scale scenario using the test storage cell constructed from the polystyrene material and sand. This test will also use the wood crib fire as the source, but ignition of the polystyrene is not anticipated. Additionally, the two potential ignition sources present within munitions storage bays, a burned up light fixture and a 4 ounce paint spill, will be applied to the actual storage configuration to evaluate their potential to ignite the polystyrene foam. The actual burning of the polystyrene foam during these tests is not anticipated. The results of this test program will be evaluated and recommendations developed relative to the use and possible protective covering for expanded polystyrene barricade materials for munitions storage facilities.

B. BACKGROUND

During a technical assistance visit to the Kirtland Underground Munitions Storage Complex (KUMSC), the AFMC fire protection engineer (FPE) determined that an exposed expanded polystyrene foam material was to be used as a barricade material between munitions in the two weapons storage bays. Generic polystyrene is a highly combustible material which could be expected to contribute to an extensive spread of fire throughout this facility.

Continued investigation of this issue by the AFMC FPE determine that, although the use of the polystyrene was approved in TO 11N-20-7, the DNA test program (DNA Report 2892F) for that TO had not considered the polystyrene combustibility issue. Telephone conversations between AFMC staff and the Field Command Defense Nuclear Agency (FC-DNA) determined that no quantitative test had been conducted on this material, such as the standard test for exposed foam plastics, Uniform Building Code 17-5, Room Fire Test Standard for Interior of Foam Plastic Systems.

AFCESA/DF, with AFMC/CECS support, and in conjunction with AFCESA/RACF, establish a very short timeframe program to evaluate both the burning characteristics and the ignition susceptibility of the expanded polystyrene foam being used at the munitions storage facilities. The actual foam was to have been supplied by KUMSC, but availability problems made it necessary to ship the test foam from Nellis AFB. The test program will include evaluation of possible thermal protective barriers which could be used to reduce the burning and the ignition characteristics of the polystyrene foam.

C. AUTHORITY

HQ USAF Program Management Directive (PMD) Number 2132(15)/63723F (2104), 15 March 1991, Civil Engineering Technology, is the authority for this test. This test program will be conducted as directed in the PMD and AFR 80-14.

D. PURPOSE

The purpose of this test program is to evaluate the ignition potential and burning characteristics of expanded polystyrene foam and find a suitable fire protection material for use in munitions storage facilities.

SECTION II

TEST OBJECTIVES AND MEASURES OF MERIT

A. TEST OBJECTIVES

1. Evaluate the effects on the polystyrene foam cell from a burning light fixture of the type used in munitions storage facilities.

2. Evaluate the effects on the polystyrene foam cell from a burning paint or solvent spill of the type used for munitions touch-up within the storage facilities.

3. Measure and compare the ignition time and temperatures and flame spread rate of unprotected expanded polystyrene, in a munitions barricade configuration, subjected to standard fire test UBC 17-5.

4. Measure and compare the ignition time and temperature and flame spread rate of expanded polystyrene covered with various fire protection coverings when configured as a munition barricade and subjected to standard fire test UBC 17-5.

B. MEASURES OF MERIT

1. Acceptable performance of the polystyrene material during the evaluation of Objectives 1, 2, and 4 is as follows:

a. No loss of structural integrity; no walls collapse.

b. Sufficient sand remains in place to ensure effective barrier performance. The sand quantities and areas lost during each fire will be detailed in the final report.

c. Temperatures do not exceed the condition damage threshold. The temperature time histories will be reported in the final report.

2. A suitable fire protective covering should protect the expanded polystyrene foam blocks from structural failure (including collapse or release of sand fill) and ignition from the standard wood crib fire for up to 15 minutes. Time to ignition, temperature, and flame spread rate are the parameters to be measured during this test program.

SECTION III

MANAGEMENT AND ORGANIZATIONAL RESPONSIBILITIES

A. MANAGEMENT

Overall test responsibility rests with the AFCESA/RACF Test Director. The Test Director will delegate authority, as necessary. Specific responsibilities for safety, instrumentation, photography, and engineering support are listed in the following paragraphs.

B. ORGANIZATIONAL RESPONSIBILITIES

1. HQ AFCESA - The Air Force Civil Engineering Support Agency is responsible for overall test management.

2. AFCESA/RACF will:

a. Develop, coordinate, and publish a test plan.

b. Provide the Test Director and Range Safety Officer.

c. Provide the necessary fire test facilities, fire fighting agents, and data collection and instrumentation systems.

d. Prepare a test report describing the method of test and test results.

3. AFCESA/DF will:

a. Coordinate on the test plan.

b. Review the test data and assist with its interpretation.

4. KUMSC will:

a. Provide an on-site technician to assist with the construction of the polystyrene cells.

SECTION IV

TEST EXECUTION

A. GENERAL

This test program will be conducted by constructing a U-shaped munitions storage cell of polystyrene and sand and exposing the cell to three different ignition sources, a failed overhead electric light fixture, an ignited 4-ounce paint spill, and a standard wood crib fire used as the standard fire test for exposed plastics. The cells will be constructed of the polystyrene foam material in the same configuration and filled with sand that most closely duplicates the those used at KUMSC. Details of the test procedure are contained in the paragraphs below. The test site layout is depicted in Figure 1.

The NATO semi-hardened structure, at Sky X, Tyndall AFB, Florida, will be used for all fire tests. A full-size barricade, of the same dimensions as the barricades used at the KUMSC facility, will be constructed for this test. Test data will include temperature and event time measurements recorded both electronically and manually. Video cameras will record all test events.

Pretest briefings will be conducted to evaluate weather conditions, discuss the results of the previous test, verify that all systems are functional. Individual protective equipment will be worn by all actively involved personnel and will be verified as fully operational before each fire test. Observers will be located a minimum of fifty feet away from the test facility during all fire tests. No unprotected personnel will enter the test area after a fire test until cleared by the test director or safety officer. Additional functions to include: safety, weather, test and data collection readiness will be completed before each individual test. When all functions are ready, the fire will be ignited. The order to ignite the fire will be given by the AFCESA Test Director. A P-19 firefighting vehicle will be readily available to extinguish the fire if it becomes necessary or desirable.

B. LIGHT FIXTURE FAILURE BURN SUSCEPTIBILITY TEST

This test will evaluate the susceptibility of the polystyrene munitions storage cell to ignition from a failed overhead electric light fixture. The test will be conducted by installing a fluorescent light fixture, of the same type as used in Air Force munitions storage facilities, directly over the center of the back wall of the test polystyrene cell. The light fixture will be deliberately burned up by applying excess voltage until the unit burns and the circuit opens. Any burned material from the light fixture will fall directly on the polystyrene cell. The results of this contact will be video taped and evaluated. This test will evaluate the potential results of a totally burned up light fixture, not the probability of this event occurring.

NATO SEMI-HARDENED STRUCTURE FIRE TEST FACILITY

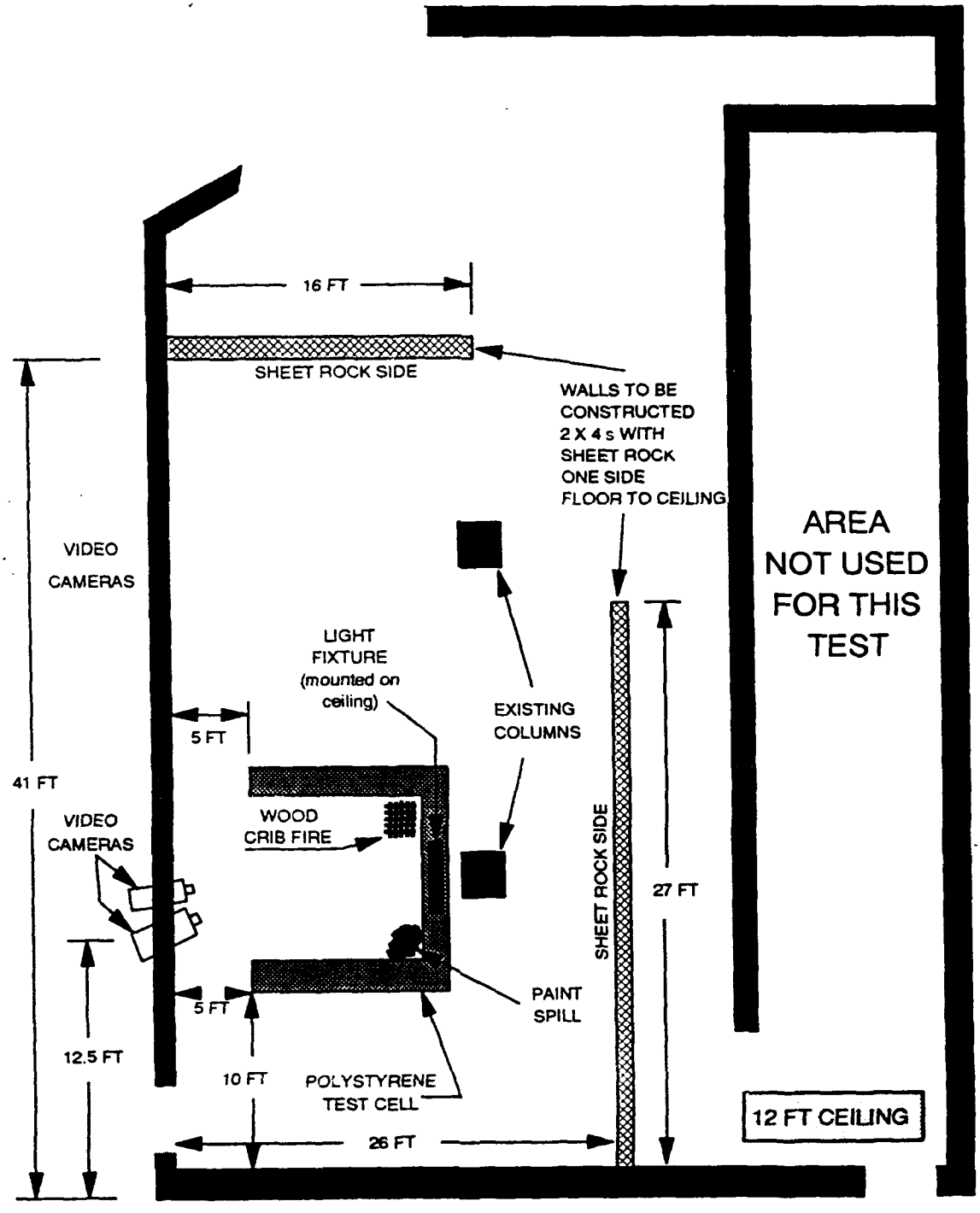

Figure 1. NATO Semi-Hardened Structure Fire Test Facility

NATO SEMI-HARDENED STRUCTURE POLYSTYRENE TEST CELL DETAIL AND INSTRUMENTATION LOCATIONS

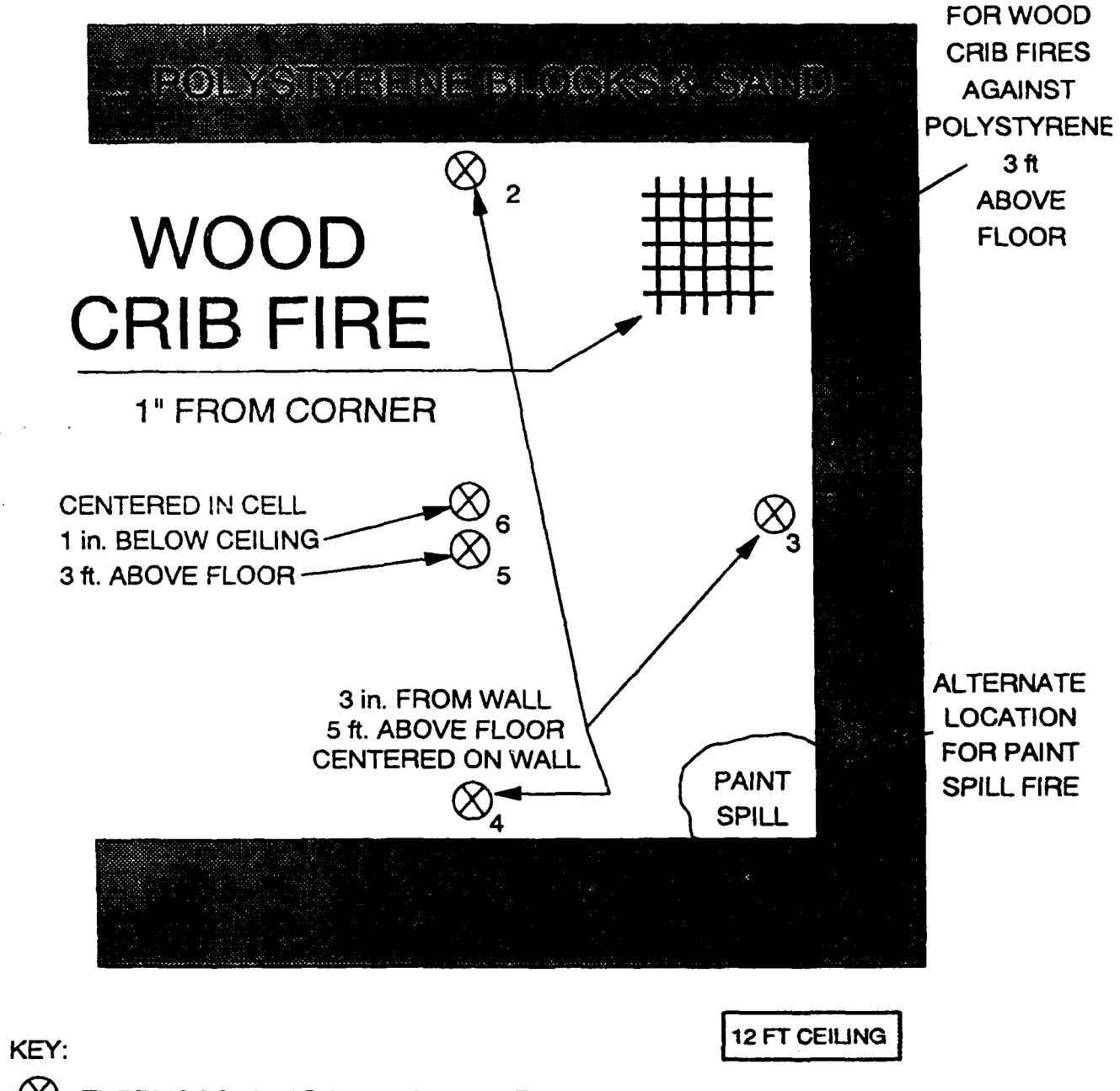

Figure 2. Polystyrene Test Cell Detail and Instrumentation Locations

WOOD FIRE CRIB DETAIL

(IAW UBC 17-5)

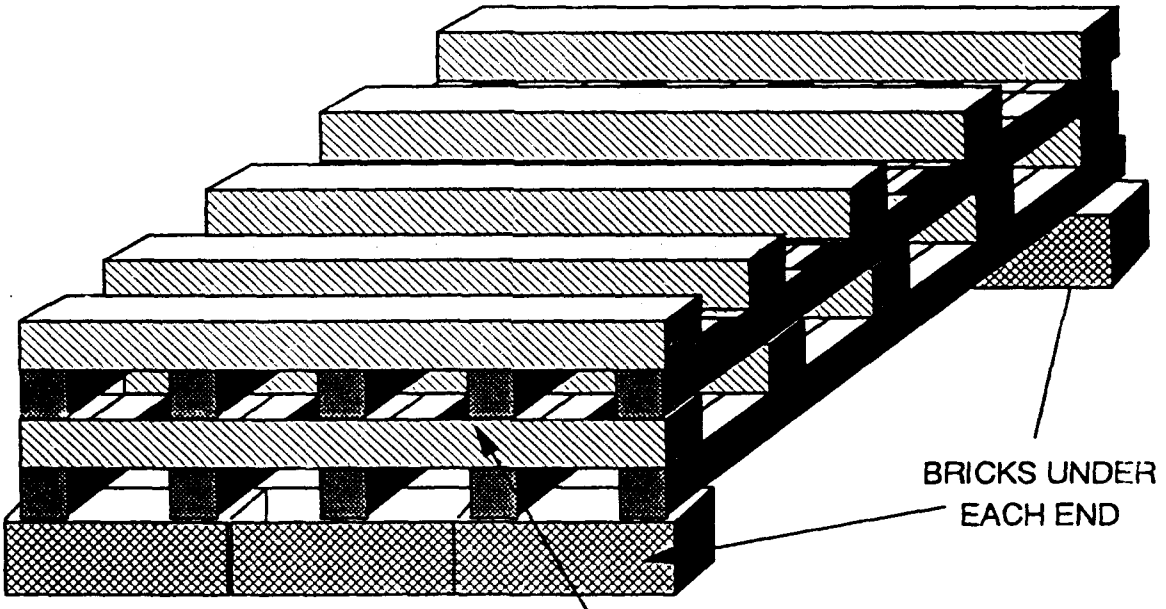

Figure 3. Wood Fire Crib Detail

C. PAINT SPILL BURN SUSCEPTIBILITY TEST

This test will evaluate the susceptibility of the polystyrene munitions storage cell to ignition from an ignited 4 ounce spill of touch-up paint, of the type authorized for in-cell touch-up painting of munitions. The test will be conducted by spilling 4 ounces of touch-up paint or solvent on the floor in the corner of the test storage cell, allowing the spill to spread for 10 seconds, and igniting the paint with an electric spark. Any resultant fire will be permitted to burn to self extinguishment. The results of this paint fire and subsequent ignition of the polystyrene cell, if it occurs, will be video taped and evaluated. This test will evaluate the potential results of a paint spill fire, not the probability of this event occurring.

D. UNPROTECTED BARRICADE FIRE IGNITION TEST

This test will measure the fire performance, time to ignition, ignition temperature, as well as temperature histories at several locations within the test apparatus and evaluate the burning characteristics of the unprotected polystyrene block material, configured as a full-scale munitions storage cell. The cell will be located in the NATO fire test facility as shown in Figure 1. The polystyrene and sand U-shaped barricade will be constructed as shown in Figures 1 and 2. The inside dimensions of the cell will be 84 inches by 84 inches and 80 inches high. Thermocouples will be placed at six locations within the test apparatus to provide temperature histories throughout all fire tests. This test will be completed by subjecting the polystyrene test cell to the standard expanded foam plastic fire exposure test, UBC 17-5. The ignition source for this test consists of a 30-pound wood crib. It will be constructed in the corner of the cell as shown in Figure 2. Wood crib details are shown in Figure 3. All tests will be video recorded by two video cameras, placed as shown in Figure 1. When the test apparatus is prepared in accordance with this test plan, as determined by the AFCESA Test Director, he will give the command to ignite the crib fire. It is anticipated that in this unprotected polystyrene test, the polystyrene will ignite and burn to destruction. The fire will be permitted to burn for 15 minutes, after which it may be extinguished, at the discretion of the test director.

E. COVERED BARRICADE FIRE IGNITION TESTS

The Covered Barricade fire tests will be completed in the same manner as the unprotected barricade test, described in paragraph B, above. In these tests the inside walls of the barricade cell will be covered with 1/2 inch thick sheet rock or other fire retardant materials, in an attempt to protect the polystyrene material from ignition by the wood crib fire source. The crib fire will be permitted to burn to extinction or 15 minutes, which ever occurs first.

F. INSTRUMENTATION AND DATA COLLECTION

Temperature measurements will be made in six locations on the polystyrene barricade in accordance with the diagram in Figure 2. All data will be recorded on the data collection sheet contained in Annex 4. Two video cameras will record all test activities. Still photographs will be taken of selected events. Standard weather data, wind direction and velocity, temperature, and relative humidity, will be recorded for each fire test. Data will not be distributed without direction of the Air Force Civil Engineering Laboratory.

SECTION V

SAFETY

A. GENERAL

Safety is an integral part of the test. The Test Director is responsible for accident prevention. Personnel and equipment safety will take precedence over test execution at all times. Special emphasis will be placed on providing thorough supervision and guidance throughout all test phases. Premission briefings will be conducted daily by the test director detailing the test procedures for the day and emphasizing safety in all test phases.

The AFCESA Test Director is ultimately responsible for safety. The Safety Officer is responsible for range safety and the conduct of the fire test. However, the test may be suspended at any time by anyone if a safety hazard is observed. Identification of a potential safety hazard will result in test suspension until the hazard can be evaluated and corrected to the satisfaction of the Test Director and the Safety Officer.

B. IDENTIFIED HAZARD

An open class-A fire, by its very nature, is hazardous. The largest source fire planned for this test series will be a 30-pound wood crib fire located in the center of the 7- by 7-foot barricade constructed for the test. The largest fire resulting from this test could include the 7- by 7-foot polystyrene test cell. The approved test plan has been examined for safety distance from surrounding objects and is well within safe distance limits.

The combustion products generated when polystyrene is burned have minimal toxicity. However, to be completely on the safe side, all non-protected participants and observers shall be located a minimum of 50 feet on the upwind side of the fire test facility during the actual fire tests. The test director shall ensure that all personnel are located in a safe position before igniting fires.

C. SAFETY REPORTING

Accidents, incidents, and serious hazards will be reported in accordance with AFR 127-4 through AFCESA/SEG and HQ 325 FW/SEG. The Safety Officer is responsible for accident/incident reporting.

The Test Director will ensure that all appropriate safety procedures are followed throughout all testing. Testing will be suspended if an event occurs contrary to this checklist. During the actual fire testing, observers will be located a minimum of 50 feet from the fire test facility.

Individual protective equipment will be worn by test personnel during all fire tests.

SECTION VI

ENVIRONMENTAL IMPACT

A. GENERAL

It is anticipated that all evidence of visible smoke will be dispersed within one hour. Any unplanned event that may affect the environment will immediately be reported to the AFCESA and Tyndall AFB environmental offices.

B. DISPOSAL PROCEDURES

At the conclusion of each individual fire test that produces any polystyrene residue, the residue will be collected and disposed of in hazardous waste barrels in accordance with established procedures. All residue material will be contained within the NATO structure on the concrete floor. Entrances will be bermed to prevent any possible runoff from the concrete floor.

ANNEX 1

TEST SCHEDULE

TEST PREPARATION AND SET-UP	17 MAR - 30 APR 92
BARRICADE FIRE TESTS	6 - 15 MAY 92
REPORT PREPARATION	15 - 31 MAY 92

NOTE: *Dates are tentative.*

ANNEX 2

LOGISTICS SUPPORT

A. FACILITY REQUIREMENTS

The test facility for this test is the NATO Semi-Hardened Research structure, located at Sky X, Tyndall AFB, Florida. This test facility will be used for all fires conducted in this series.

B. PERSONNEL REQUIREMENTS

Personnel to support this test will be provided by AFCESA/RACF.

Agency/Organization	Personnel Required
AFCESA/RACF	Test Director Safety Officer Fire Test Conductors (2 ea) Data collector (1 ea) Video Operator (1 ea)
USAF HOSPITAL - TYNDALL AFB	Emergency Medical Care

C. MATERIAL REQUIREMENTS

Material requirements are as follows:

ITEM	QUANTITY	SOURCE
Polystyrene blocks	For 3 barricades	AFCESA/RACF
Sand	18 yds	AFCESA/RACF
White fir sticks 1.5 x 1.5 x 15"	200 ea.	AFCESA/RACF
Wood excelsior	5 pounds	AFCESA/RACF
Denatured Alcohol	1 gallon	AFCESA/RACF
Touch-up paint	1 can	AFCESA/RACF
Munitions light fixture	1 ea	AFCESA/RACF
Video tape	4 cassettes	AFCESA/RACF
35 mm film	2 rolls	AFCESA/RACF

D. EQUIPMENT REQUIREMENTS

ITEM	QUANTITY
Portable Fire Extinguishers	4
Protective Clothing (sets)	3
SCBA units	2
First Aid Kit .	1
Hand Held Radios	2
35mm Still Frame Cameras	2
VHS 1/2" Video Cameras	2
Stopwatches	2
Tape measure	1
Weather station -	1
Wind direction & velocity	
Ambient temperature	
Relative humidity	
Barometric pressure	
P-19 Firefighting Vehicle	1
Temperature measuring inst.	1
Thermocouples	6

ANNEX 3

MEDIUM-SCALE FIRE TEST OPERATIONAL PROCEDURES

The following are general procedures to be used during fire test operations at the NATO Sky X facility.

1. Insure all agencies are notified of test events.
2. Conduct Safety Briefing.
3. Verify all data collection equipment in place and operational.
4. Insure downrange area clear.
5. Verify ignition source ready for fire test.
6. Start data collection.
7. Ignite fire.
8. Conduct fire event/test.
9. Secure fire burn area/downrange.
10. Check test results.
11. Conduct post-test and facility shutdown procedures.
12. Notify all agencies that test complete & facility secure.
13. Conduct critique.
14. Document test results.

PRETEST CHECK LIST

DATE:_____ TIME:_____

VERIFIED	PROCEDURES
___	Brief all personnel on proper safety procedures.
___	All personnel at the test site are required for the test or are an approved visitor?
___	Brief all personnel on accident and fire reporting procedures.
___	Radio or telephone communications available?
___	Post telephone numbers for the ambulance and fire department by the telephone or radio.
___	Ensure that adequate first aid kit is available.
___	Ensure that an emergency eye wash apparatus is available.
___	Ensure Individual Protective Equipment is fully charged and operational.
___	Secure area prior to igniting fire.

ANNEX 4

EXPANDED POLYSTYRENE PROTECTIVE BARRICADE

FULL-SCALE FIRE EXPOSURE TEST

DATA COLLECTION SHEET

DATE:_____ TIME:_____ TEST CONDUCTORS: Dees / Lewis / McKenzie

TEST NO:_____ TEST TYPE: UNPROTECTED ____ COVERED ____ MATERIAL _____

SOURCE FIRE: WOOD CRIB _____ BURNING LIGHT FIXTURE _____ PAINT SPILL _____

METEOROLOGICAL DATA:

WIND DIR:_____ WIND VELOCITY:_____ TEMPERATURE:_____°F REL HUMIDITY:_____

BAROMETRIC PRESSURE:_____"Hg

TEST READINESS:

_____ Weather within limits _____ Communications check

_____ Fire vehicles ready _____ Ignition system ready

_____ Video cameras ready _____ Source fire ready

_____ Emer. Medical notified _____ Test Facility Secure

CLEARANCE FOR IGNITION:

_____ Safety Officer _____ Fire Department

SOURCE IGNITION TIME: _____ INITIAL POLYSTYRENE MELT TIME: _____

POLYSTYRENE IGNITION TIME: _____ SAND RELEASED TIME: _____

STRUCTURAL FAILURE: _____ SELF EXTINGUISH TIME: _____

AGENT APPLICATION: START: _____ END: _____ EXTINGUISH TIME: _____

GENERAL COMMENTS:

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