NATIONAL CLASS A FOAM RESEARCH PROJECT
TECHNICAL REPORT

KNOCKDOWN, EXPOSURE AND RETENTION TESTS

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Foreword

This report begins an extensive documentation of the effectiveness of Class A foams in firefighter hose streams used in structure fire suppression. Repeatable, comparative tests addressed questions of fire knockdown, exposure protection, rekindle resistance (foam retention) and foam quality. Water fire streams were also tested against the same fire challenges for comparison.

The fire service, manufacturers of foams and related equipment, and researchers sought data on foams for Class A fires following their extensive documentation in wildland fire suppression. Their questions led to the National Class A Foam Research Project. The results of the project's first phase of testing are reported here.

The Research Foundation expresses gratitude to the author, William M. Carey, P.E. The Foundation and the author thank the project's Technical Advisory Committee for their contributions in all respects: technical expertise, review, as well as financial resources to conduct this landmark initiative. Of course, participation does not necessarily constitute a participant's endorsement of every statement in the report.

National Class A Foam Research Project

Technical Advisory Committee

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Underwriters Laboratories Inc.

REPORT OF THE NATIONAL CLASS A FOAM RESEARCH PROJECT

PREPARED BY

UNDERWRITERS LABORATORIES INC.
PROJECT 93NK19730/NC987

FOR THE

NATIONAL FIRE PROTECTION
RESEARCH FOUNDATION

DECEMBER, 1993

N O T I C E

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EXECUTIVE SUMMARY

Class A foams have been used to fight forest and brush fires for many years. Recently, municipal fire departments have been using Class A foams to improve the operating efficiency of manual fire streams for structural fire fighting purposes.

To help quantify the improved fire fighting efficiency of Class A foam manual fire streams as compared to plain water, a series of wood crib fire, exposure protection and retention tests were conducted. Laboratory analyses and foam quality tests were also conducted under this project. All of the Class A fire tests were conducted using a single Class A foam concentrate which was approved by the United States Forest Service as a Wildland Fire Fighting Foam at concentrations between 0.1 and 1.0 percent.

The wood crib fire tests were conducted using Class 20-A wood cribs as referenced in the Standard for Rating and Fire Testing of Fire Extinguishers, ANDI/UL 711. These cribs were designed to be extinguished by a 33 gpm straight stream hoseline applying water only for one minute. For this series of tests, an adjustable nozzle set to a straight stream position and a flow rate of 15 gpm was used. Class A foam solutions of 0.1, 0.3 and 0.5 percent were used with a (1) standard, adjustable pattern nozzle (2) an air-aspirated nozzle and (3) by mixing the solution with compressed air to produce compressed air foam (CAF). The results of the wood crib fire tests demonstrated improved fire fighting effectiveness of using a Class A foam as compared to water. During baseline tests conducted with water only at 15 gpm, the crib was not extinguished at the end of discharge, even with the discharge duration increased from 60 to 90 seconds.

The exposure protection tests involved the application of water or Class A foam to wood cribs and then exposing them to heat fluxes of 25 and 50 Kw/m² until they ignited. The results of these tests demonstrated the enhanced ability of the Class A foam to retard the ignition of the wood test crib as compared to water at the 50 Kw/m² heat flux.

The retention tests measured the gain in weight of Class A foam applied to Class 1-A wood cribs for durations of 15 and 60 seconds. The results demonstrated that cribs exposed to a Class A foam had a 33 to 100 percent increase in retained weight as compared to cribs exposed to water.

It is recommended that additional research be conducted to measure the effectiveness of Class A foam as compared to water only using full scale room configurations. These tests should be conducted under a colorimeter so the rate of heat release, products of combustion, smoke obscuration and smoke density can be continuously monitored during each test.

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UL wishes to thank the members of the National Class A Foam Research Project for their support during the conduct of these tests.

Special acknowledgements are given to the following members of the Technical Advisory Committee (TAC): (1) Mr. Paul Blankenship, Chairman of the National Class A Foam Research Project (2) Mr. Richard Bielen, National Fire Protection Research Foundation (3) Mr. Jim Trapp, Elkhart Brass Manufacturing Company Inc. (4) Mr. Chuck George, U.S. Forest Service and (5) Mr. Dominic Colletti, Hale Products, for their assistance during the program.

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1.0 INTRODUCTION

BACKGROUND:

Class A foams are widely used to combat forest and brush fires where there is limited accessibility to water sources. Many fire departments, especially those serving rural areas, are also using Class A foam solutions with hand hose lines due to the lack of public water supplies.

An interest has developed among municipal fire departments regarding the use of Class A foams in conjunction with normal fire fighting operations. It is believed that Class A foam hose lines improve fire fighting efficiency and have the ability to reduce the potential for water damage.

A need has arisen to conduct research to investigate the effectiveness of Class A foam solutions as compared to water only under controlled test conditions. Under sponsorship of the National Fire Protection Research Foundation (NFPRF), Underwriters Laboratories Inc. (UL) investigated the effectiveness of Class A foams using a variety of discharge devices and solution concentrations. Under this research project, Class A foams were generated using (1) a standard spray nozzle, (2) an air-aspirated spray nozzle and (3) by injecting compressed air into the Class A foam solution.

OBJECTIVE:

The objectives of this research investigation, conducted by UL under guidance of the NFPRF Technical Advisory Committee (TAC), were (1) to develop test data related to the fire fighting effectiveness of Class A foam solutions as compared to water only and (2) to conduct laboratory analyses of the Class A foam concentrate used in the performance tests.

TEST PLAN:

A series of viscosity, specific gravity, surface tension, density, foam quality, wood crib fire, exposure protection and retention tests were conducted.

For the wood crib fire test, Class A foam was applied to a Class 20-A wood crib at a flow rate of 15 gpm and nominal Class A foam solution concentrations of 0.1, 0.3 and 0.5 percent. Nominal expansion ratios of the Class A foam were intended to be 5 using a standard nozzle and 7.5 using an air-aspirated nozzle and CAF.

For the exposure protection and retention tests, a flow rate of 1 gpm was used at solution concentrations of 0.3, 0.6 and 0.9 percent. Nominal expansion ratios of the Class A foam were intended to be 7.5 using an air aspirated nozzle and 7.5 and 15 using CAF. Deionized water was used in the preparation of the Class A foam solutions and for the water only tests.

2.0 SAMPLES AND FACILITIES

CLASS A FOAM CONCENTRATE:

A single Class A foam liquid concentrate was used for all of the tests. The Class A foam liquid concentrate utilized was a mixture of three batches of the same concentrate supplied by the United States Forest Service. The foam concentrate was approved by the United States Forest Service as a Wildland Fire Fighting Foam at concentrations between 0.1 and 1.0 percent. Neither the brand nor the manufacturer of the Class A foam concentrate were known to UL or to the other project participants.

DISCHARGE DEVICES:

Hand held discharge devices were used to apply the Class A foam for the wood crib fire, exposure protection and retention tests. The test nozzles used in this research project were designed to operate with water and/or Class B low expansion foam only.

For the wood crib fire tests, three different discharge devices were used. All of the devices discharged the Class A foam solution at a flow rate of 15 gpm. The first device was a conventional, adjustable pattern nozzle which was adjusted to provide a straight stream discharge pattern. It was intended to produce Class A foam at a nominal expansion ratio of 5.

The second device was the same conventional, adjustable pattern nozzle fitted with an air-aspirating attachment. It was also adjusted to provide a straight stream discharge pattern and was intended to produce Class A foam at a nominal expansion ratio of 7.5.

Compressed air foam was generated using a siamese fitting with 100 ft of 1 inch inside diameter rubber hose attached to the outlet. Class A foam solution flowed into one inlet of the siamese fitting at a rate of 15 gpm and compressed air flowed into the second inlet at a rate of 15 cfm. It was intended to produce Class A foam at a nominal expansion ratio of 7.5.

For the exposure protection and retention tests, two hand held discharge devices were used at a flow rate of 1 gpm. The first device was an air-aspirating, straight stream nozzle. This nozzle was intended to produce a Class A foam at a nominal expansion ratio of 7.5. The second device was of the CAF type and was operated at a Class A foam solution flow rate of 1 gpm and air flow rates of 1 and 2 cfm. This device was intended to produce Class A foam at nominal expansion ratios of 7.5 and 15.

FIRE TEST BUILDING:

The wood crib fire tests were conducted at UL's test facilities located in Northbrook, IL. The test building measured 40 by 40 by 50 ft in height and was equipped with a 30,000 cfm regenerative incinerator for smoke abatement purposes. The unit was operated at a rate of approximately 10,000 cfm for these tests. A 32 by 32 foot flat horizontal ceiling was suspended at a height of 30 ft above the floor. A clearance of approximately 4 ft was provided between the suspended ceiling and the walls.

3.0 LABORATORY ANALYSES AND PERFORMANCE TESTS

LABORATORY ANALYSES:

GENERAL

A series of viscosity, specific gravity, surface tension, and density tests were conducted on the Class A foam concentrate/foam solution used in the wood crib fire, exposure protection and retention tests. These tests were conducted in accordance with applicable American Society of Testing and Materials (ASTM) test standards.

METHODS

The viscosity and specific gravity of the Class A foam concentrate were determined in accordance with ASTM D-88, Test Methods for Saybolt Viscosity and ASTM D-1298, Test Method for Density, Relative Density (Specific Gravity) or API Gravity of Crude Petroleum and Liquid Petroleum Products by the Hydrometer Method, respectively.

The surface tension of the Class A foam concentrate, the Class A foam concentrate mixed with deionized water at solution concentrations of 0.1, 0.3, 0.5, 0.6 and 0.9 percent and deionized water were determined in accordance with ASTM D-1331, Test Method for Surface and Interfacial Tension of Surface-Active Agents.

The density (percentage of solids in suspension) was determined for the Class A foam concentrate in accordance with ASTM D-96, Test Method for water and sediment in Crude Oil by Centrifuge Method except that the solvent and emulsifier was not added and the test was conducted at 68 ± 2°F.

RESULTS

The following laboratory analyses test results were obtained:

Viscosity

The viscosity of the Class A foam concentrate was 35.57 centipoise at 77°F.

Specific Gravity

The specific gravity of the Class A foam concentrate was 1.0240 at 60°F.

Surface Tension

The surface tensions of the Class A foam concentrate, Class A foam solutions and deionized water were as follows:

Concentration, %	Surface Tension, dynes/cm
+	68.02
0.1	30.69
0.3	31.16
0.5	30.22
0.6	30.22
0.9	30.13
100	26.51

+ Deionized water.

Density

The density of the Class A foam concentrate F was 1.025 g/ml at 68 ± 2°F.

FOAM QUALITY TESTS:

METHOD

The expansion ratio and 25 percent drain time were determined for each nozzle and Class A foam solution concentration used in the wood crib fire, exposure protection and retention tests. These values were determined using a 1600 mL container in accordance with the Standard for Foam Chemical for Wildlands Fire Control, NFPA 298. Deionized water was used to prepare the Class A foam solutions.

In preparation for each test, a 1600 mL container was weighed and then filled with foam and a timer started. By knowing the weight of the empty container and the weight of the container filled with the Class A foam solution, the foam expansion ratio was calculated by dividing 1600 by the weight of the Class A foam solution sample in grams. Since one gram of Class A foam solution is approximately equivalent to 1 milliliter of Class A foam solution, the 25 percent drainage volume, in milliliters, was calculated by dividing the weight of the Class A foam sample by 4. When 25 percent of the Class A foam sample had drained, the timer was stopped and the time recorded as the 25 percent drain time.

RESULTS

The results of the Foam Quality Tests are contained in Table 1 and are shown in Ills. 1-4.

Table 1 - Foam Quality Test Results

Nozzle Type	Flowrate, GPM	Class A Foam Solution Concentration, Percent	Expansion Ratio	25 Percent Drain Time, Sec
AIR	1.0	0.3	5.69	100
AIR	1.0	0.6	5.10	88
AIR	1.0	0.9	6.80	129
CAF+	1.0	0.3	7.69	108
CAF+	1.0	0.6	7.44	121
CAF+	1.0	0.9	7.60	143
CAF++	1.0	0.3	13.80	226
CAF++	1.0	0.6	15.80	355
CAF++	1.0	0.9	15.20	263
STD	15.0	0.1	1.73	54
STD	15.0	0.3	3.03	52
STD	15.0	0.5	3.11	56
AIR	15.0	0.1	2.30	51
AIR	15.0	0.3	5.81	47
AIR	15.0	0.5	8.08	56
CAF+	15.0	0.1	7.30	171
CAF+	15.0	0.3	6.55	117
CAF+	15.0	0.5	7.60	128

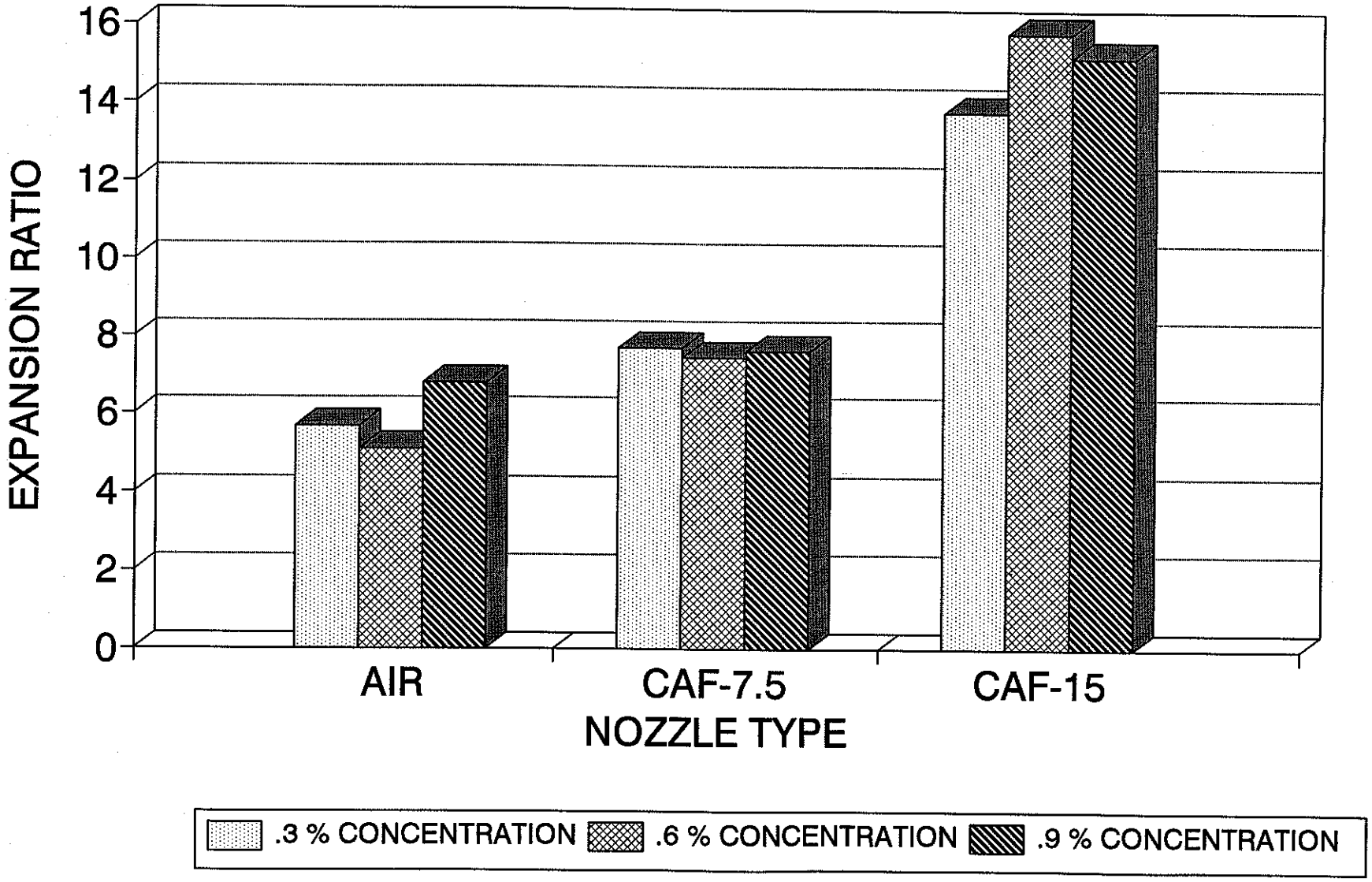
+ Class A foam produced at a ratio of 1 cfm air to 1 gpm Class A foam solution.

++ Class A foam produced at a ratio of 2 cfm air to 1 gpm Class A foam solution.

NFPRF CLASS A FOAM

FOAM QUALITY TEST RESULTS

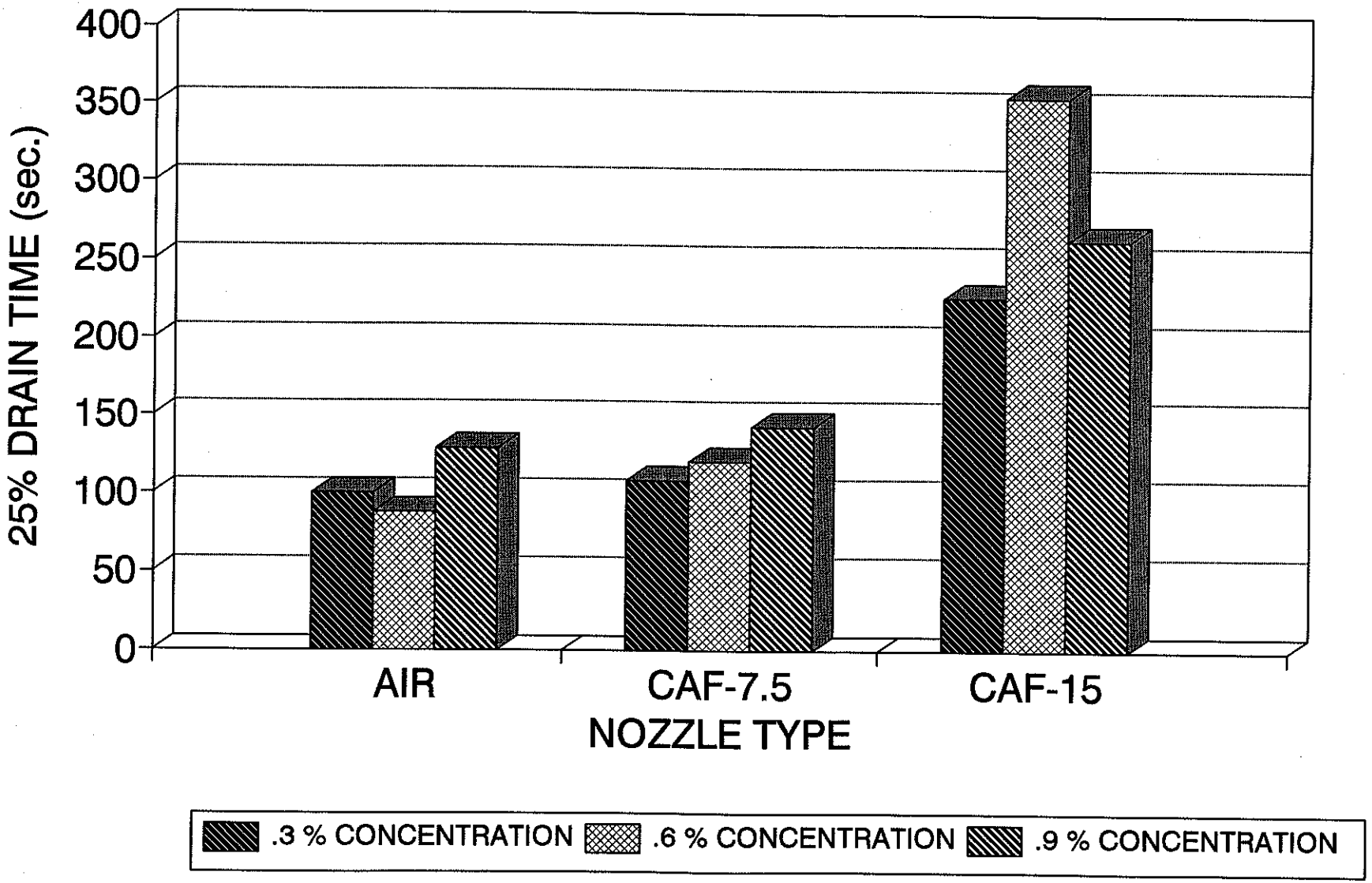
EXPOSURE AND RETENTION TESTS



NFPRF CLASS A FOAM

FOAM QUALITY TEST RESULTS

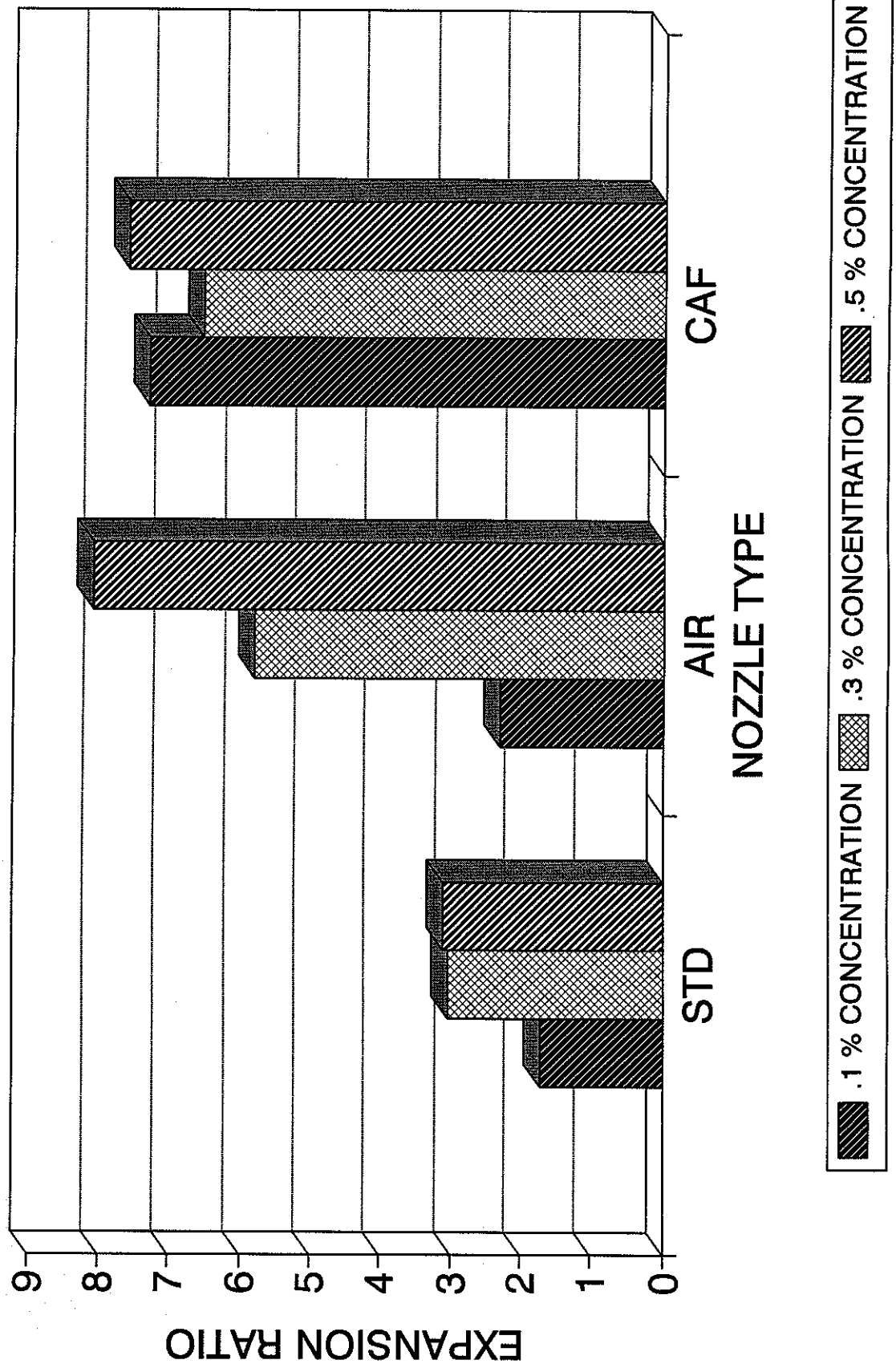
EXPOSURE AND RETENTION TESTS



NFPRF CLASS A FOAM

FOAM QUALITY TEST RESULTS

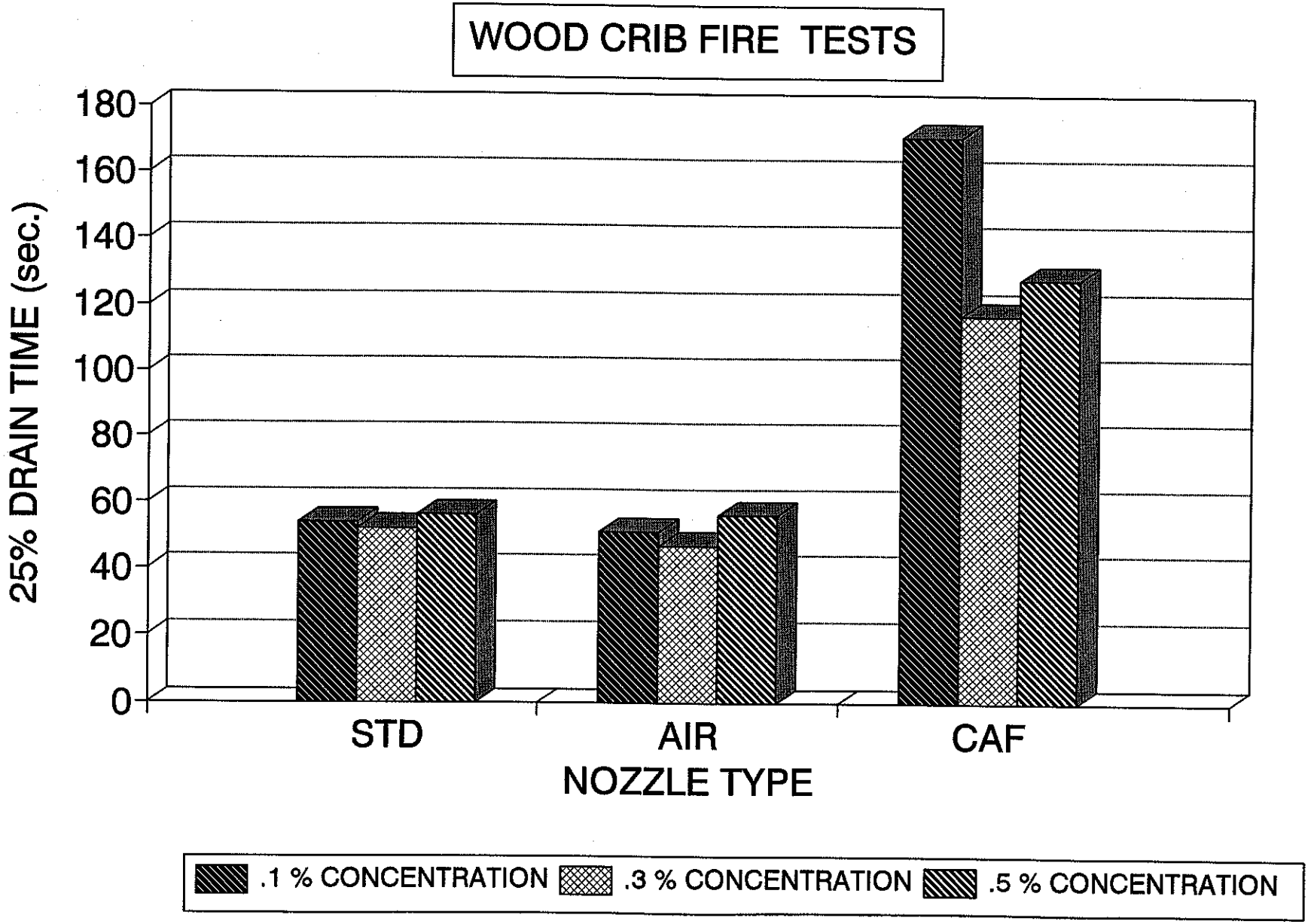
WOOD CRIB FIRE TESTS



ILL 3

NFPRF CLASS A FOAM

FOAM QUALITY TEST RESULTS



WOOD CRIB FIRE TESTS:

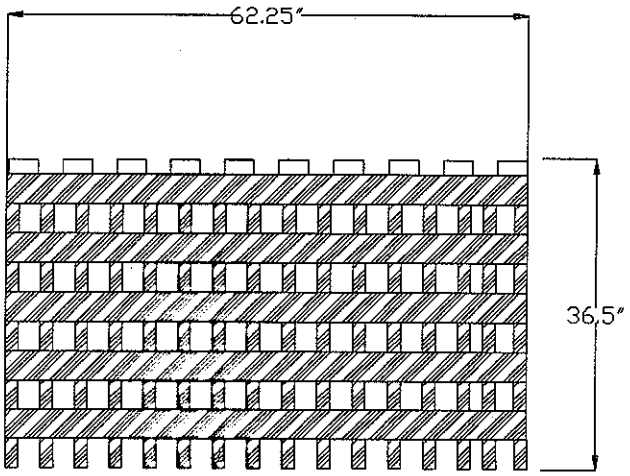
METHOD

The wood crib fire tests involved the use of Class 20-A cribs as described in the Standard for the Rating and Fire Testing of Fire Extinguishers, ANSI/UL 711. Each crib was constructed from 160 pieces of 2 by 4 by 62-1/4 in. long fir lumber and had a volume of approximately 85 ft^3. The crib consisted of 10 layers of 15 lumber pieces placed on their edge and evenly spaced. The top row consisted of 10 evenly spaced lumber pieces positioned on their side. See Ill. 5. The crib was positioned in the center of the test room at a height of 32 in. above the floor. See Ill. 6. To ignite the crib, 4-1/2 gallons of heptane was poured into a 20 ft^2 square steel test pan 12 in. high, having a 2 in. water base. The weight and moisture content of each crib was measured prior to each test.

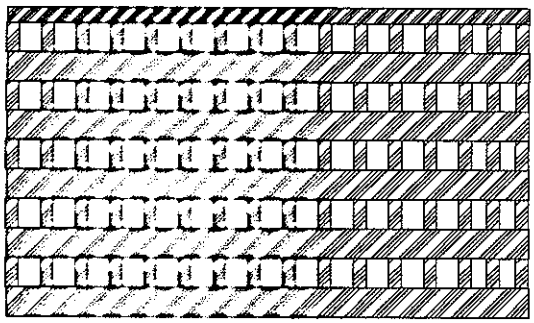
All fire tests were conducted using either (1) a standard (STD) nozzle or (2) an air aspirated (AIR) nozzle at a Class A foam solution flow rate of 15 gpm or (3) compressed air foam (CAF) at a Class A foam solution flow rate of 15 gpm and compressed air at a flow rate of 15 cfm. The STD nozzle was intended to produce Class A foam at a nominal expansion ratio of 5, the AIR nozzle at 7.5 and CAF at 7.5. Fire tests were also conducted using water only and the standard test nozzle. Deionized water was used for the water only tests and to prepare the Class A foam solutions at 0.1, 0.3 and 0.5 percent.

To record temperatures, thermocouples were positioned below the ceiling directly over the crib and at a 10 ft radius around the center of the crib. A thermocouple was also positioned in the center of the crib. To record smoke obscuration, a photoelectric device was positioned along the back wall of the test building at a height of 15 ft above the floor. See Ill. 7.

The heptane was ignited and the crib was permitted to burn freely for 7 minutes. Seven minutes into each test, an operator attacked the crib in a consistent manner from the top, bottom and three sides of the crib for a period of 60 seconds. The same operator was used for all fire tests. Observations were made for the degree of fire control or suppression achieved during the discharge. In addition, the
time for extinguishment of flames above the crib as well as the time of reignition of the crib, as evidenced by flaming at the top of the crib, were recorded.



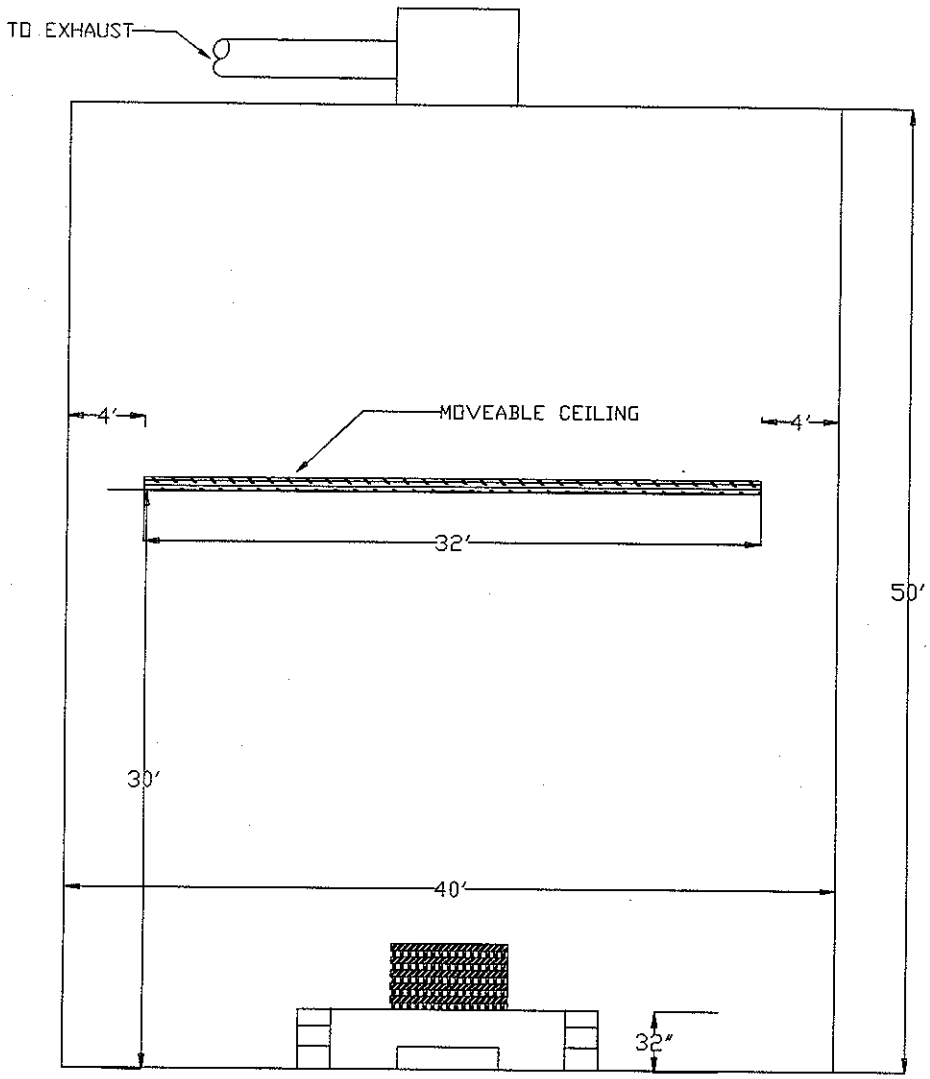
FRONT ELEVATION



SIDE

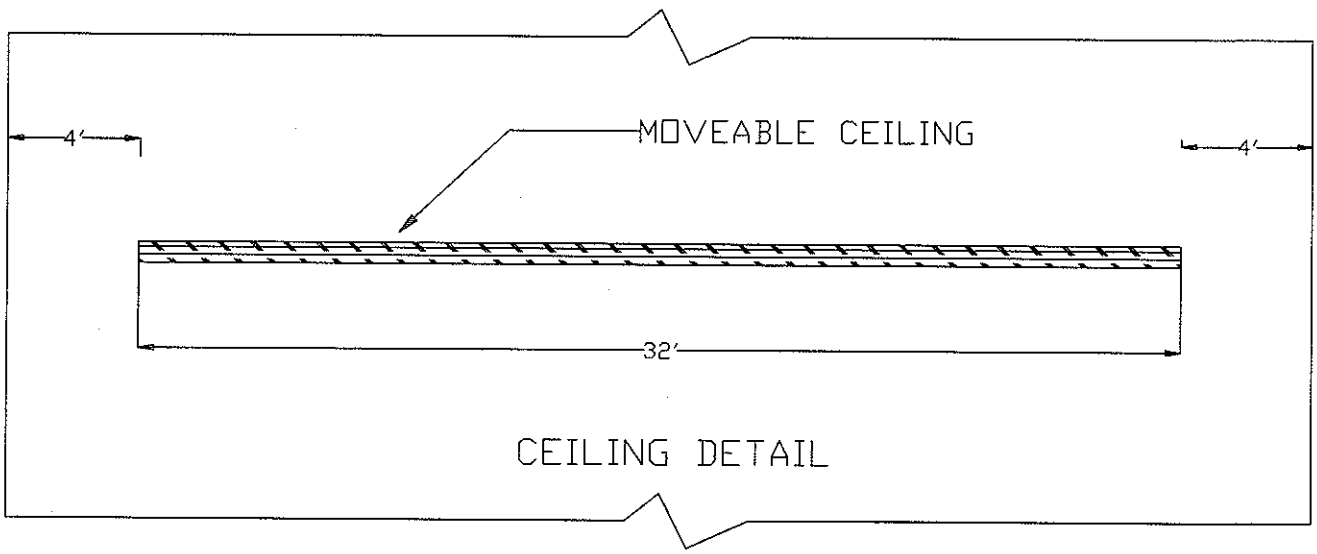
WOOD CRIB
FIRE TEST CRIB

ILL 5

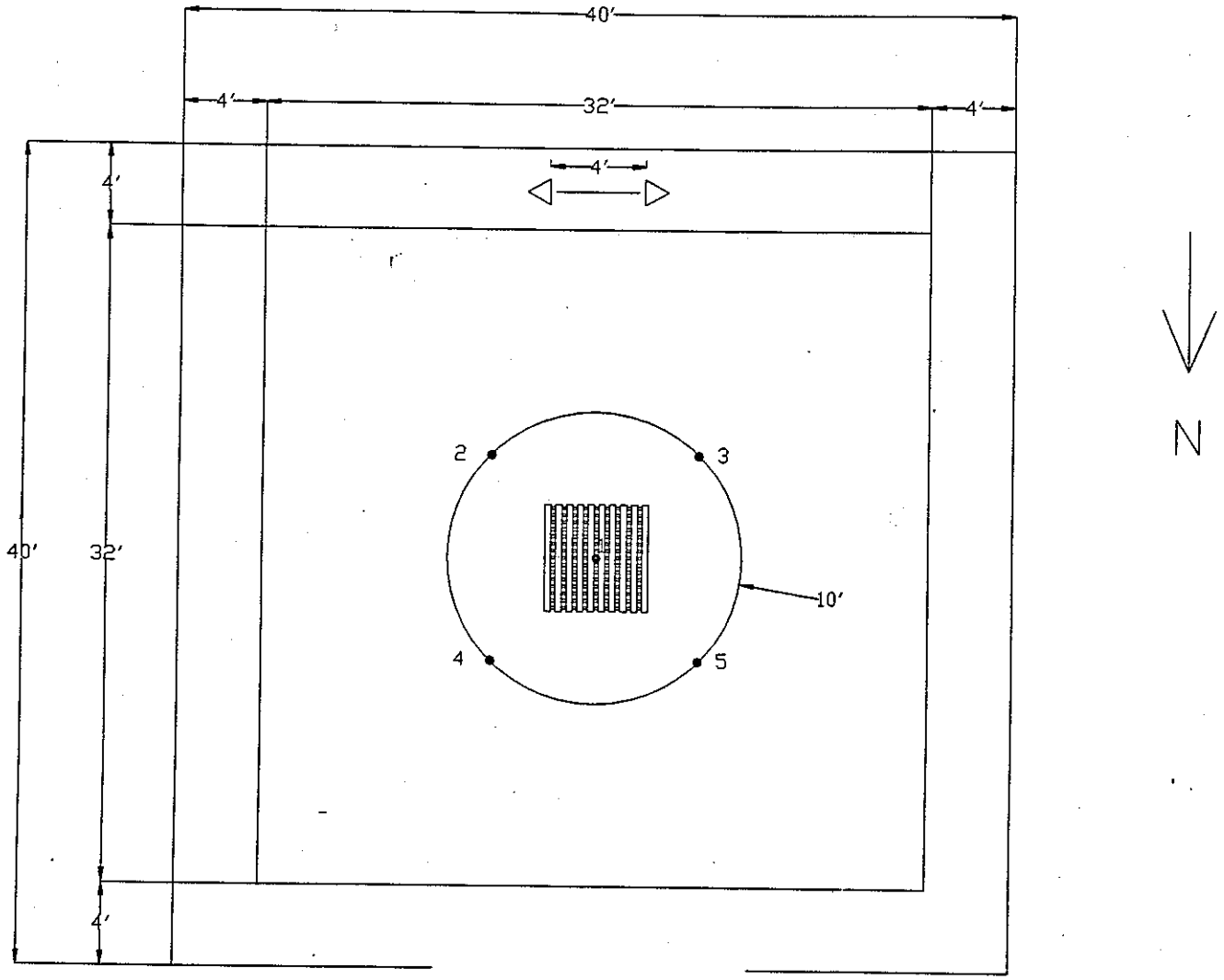


UL'S HIGHRISE TEST BUILDING

40' X 40' X 50' HIGH



CEILING DETAIL



● - THERMOCOUPLE POSITIONED 6" BELOW CEILING

- SIXTH THERMOCOUPLE POSITIONED WITHIN CENTER OF THE CRIB

◁ ▷ - SMOKE EYES POSITIONED 12' ABOVE FLOOR ON SOUTH WALL

CRIB AND THERMOCOUPLE LOCATIONS PLAN VIEW

Following each fire test, the crib was allowed to dry for approximately two weeks before being reweighed.

RESULTS

The results of the wood crib fire tests are presented in Table 2 and Ills. 8 and 9. Photographs of each fire test are shown on Figs. 1-10. Typical smoke obscuration data and temperature data recorded at the ceiling level directly over the crib and at a 10 ft radius are contained in Appendix A. Graphs of the temperature in the center of the crib versus time from 1 minute before the start of agent application until the end of the test are also presented in Appendix A.

The results of the fire tests conducted with the standard nozzle discharging water only indicated that the Class 20-A crib could not be extinguished at the 15 gpm flow rate when water was applied for 60 or 90 seconds. In accordance with ANSI/UL 711, the Class 20-A crib was designed to be extinguished using a straight stream nozzle discharging water at a flow rate of 33 gpm for 60 seconds.

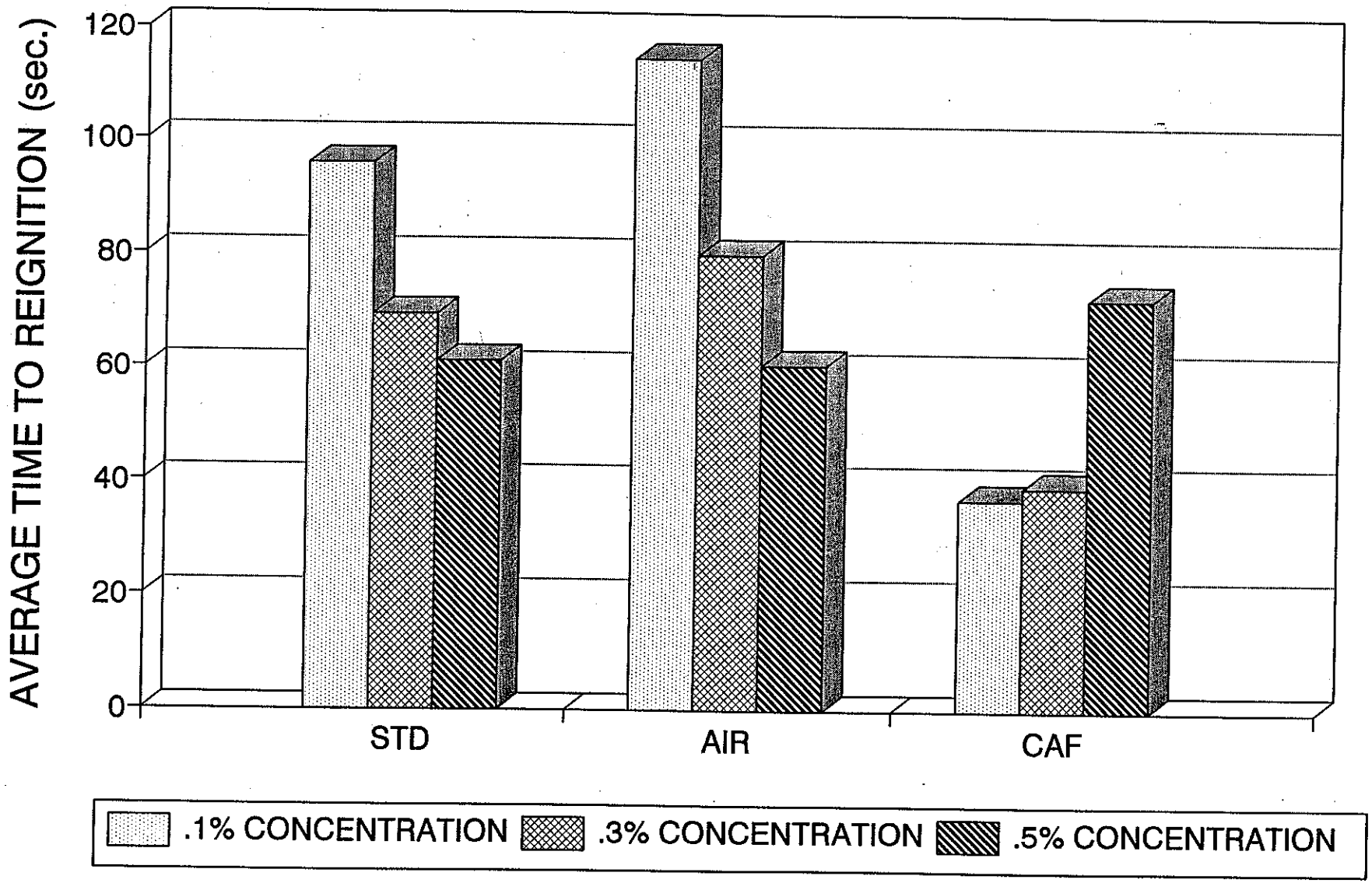
The results of the fire tests conducted with the standard nozzle discharging a Class A foam solution demonstrated an average time to reignition of 75 seconds. The air-aspirated nozzle fire tests demonstrated an average time to reignition of 85 seconds. The CAF nozzle fire tests demonstrated an average time to reignition of 49 seconds.

TABLE 2 - WOOD CRIB FIRE TEST RESULTS

Test No.	Nozzle Type	Class A Foam Solution Concentration, Percent	Foam Expansion Ratio	25 Percent Drain Time, Sec	Time To Flame Extinguishment, Sec	Time To Reignition, Sec	Crib Weight Loss, lbs	Crib Weight Loss, %
1	STD	Water only	-	-	+	++	347	42.2
2	STD	Water only	-	-	+	+++	400	47.0
3	STD	0.1	1.73	54	26	94	368	45.5
4	STD	0.1	1.73	54	25	98	355	45.1
5	STD	0.3	3.03	52	30	90	376	46.2
6	STD	0.3	3.03	52	46	46	319	40.3
7	STD	0.5	3.11	56	48	69	334	41.6
8	STD	0.5	3.11	56	47	53	297	36.6
9	AIR	0.1	2.30	51	27	93	318	39.9
10	AIR	0.1	2.30	51	25	136	321	38.9
11	AIR	0.3	5.81	47	47	86	315	38.3
12	AIR	0.3	5.81	47	28	74	269	33.4
13	AIR	0.5	8.08	56	42	63	277	33.9
14	AIR	0.5	8.08	56	43	58	265	32.3
15	CAF	0.1	7.30	171	40	38	259	32.3
16	CAF	0.1	7.30	171	40	36	278	32.7
17	CAF	0.3	6.55	117	40	40	344	43.9
18	CAF	0.3	6.55	117	30	38	302	36.8
19	CAF	0.5	7.60	128	26	82	258	31.4
20	CAF	0.5	7.60	128	29	63	339	41.0

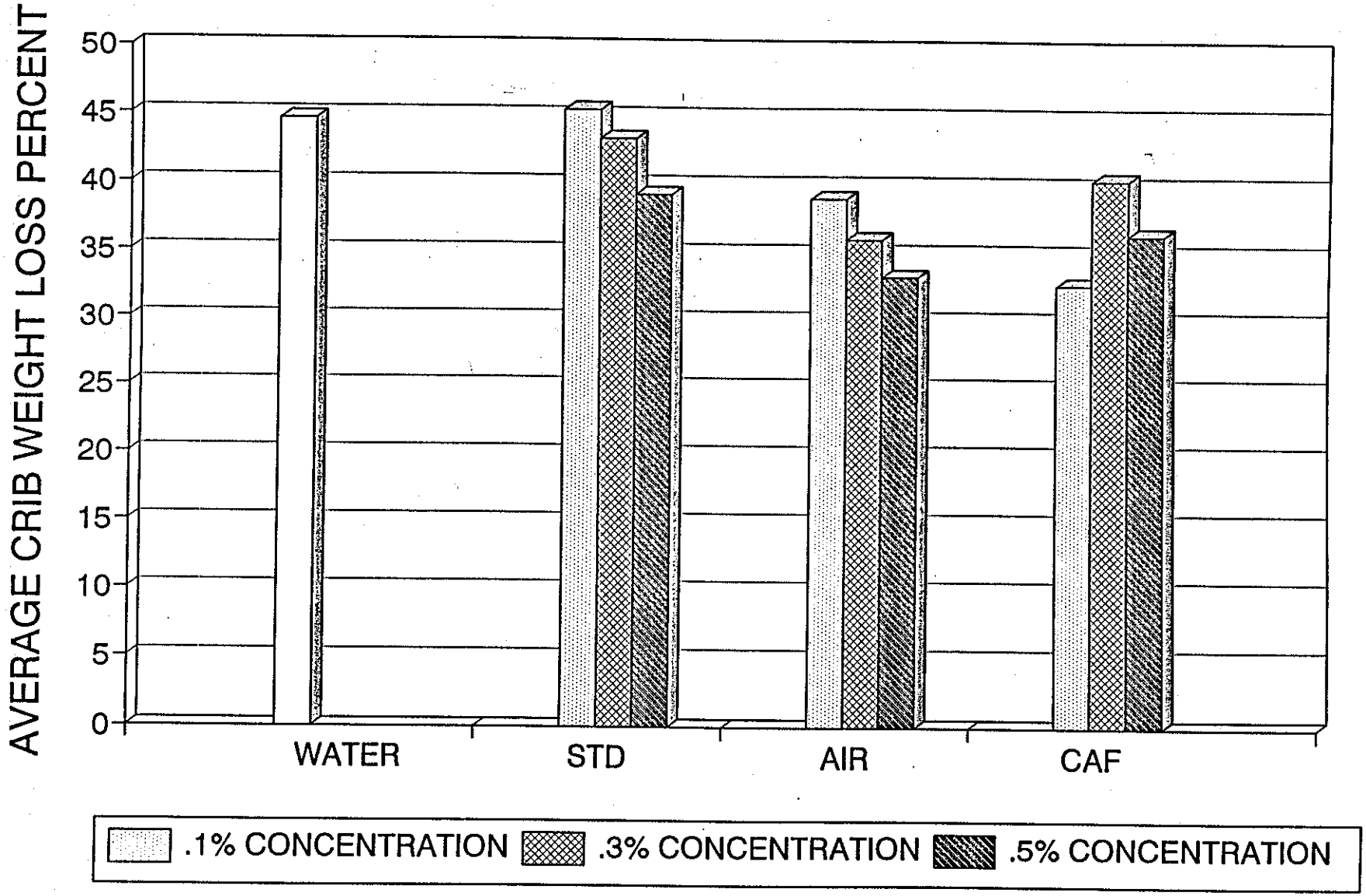
\+ - No extinguishment
++ - Water applied for 60 seconds.
+++ - Water applied for 90 seconds.

NFPRF CLASS A FOAM
WOOD CRIB FIRE TEST RESULTS



NFPRF CLASS A FOAM

WOOD CRIB FIRE TEST RESULTS



EXPOSURE PROTECTION TESTS:

METHOD

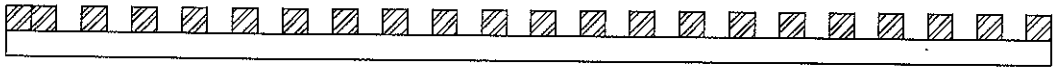
A series of exposure protection tests were conducted in accordance with ASTM E-1321, Test Method For Determining Material Ignition And Flame Spread Properties, at heat flux values of 25 and 50 kW/m². In preparation for each test, wood cribs, measuring 6.75 by 31.5 by 1.5 inches in thickness, consisting of two alternate layers of 3/4 by 3/4 in. fir lumber spaced 3/4 in. apart, were constructed. See Ill. 10. Each crib was then placed in a radiant panel test fixture in a vertical position. Using 1 gpm discharge devices, air-aspirated Class A foam at a nominal expansion ratio of 7.5 and CAF Class A foam solutions at nominal expansion ratios of 7.5 and 15 and foam solution concentrations of 0.3, 0.6 and 0.9 percent, or water only, were applied to the crib for 60 s. Deionized water was used for the water only tests and to prepare the Class A foam solutions. Following the 60 s application of foam or water, the crib and radiant panel test fixture were then placed in a horizontal position and carried to the radiant panel test apparatus. Ninety seconds after application of the agent, the test crib and radiant panel test fixture were returned to the vertical position and placed in the radiant panel test apparatus.

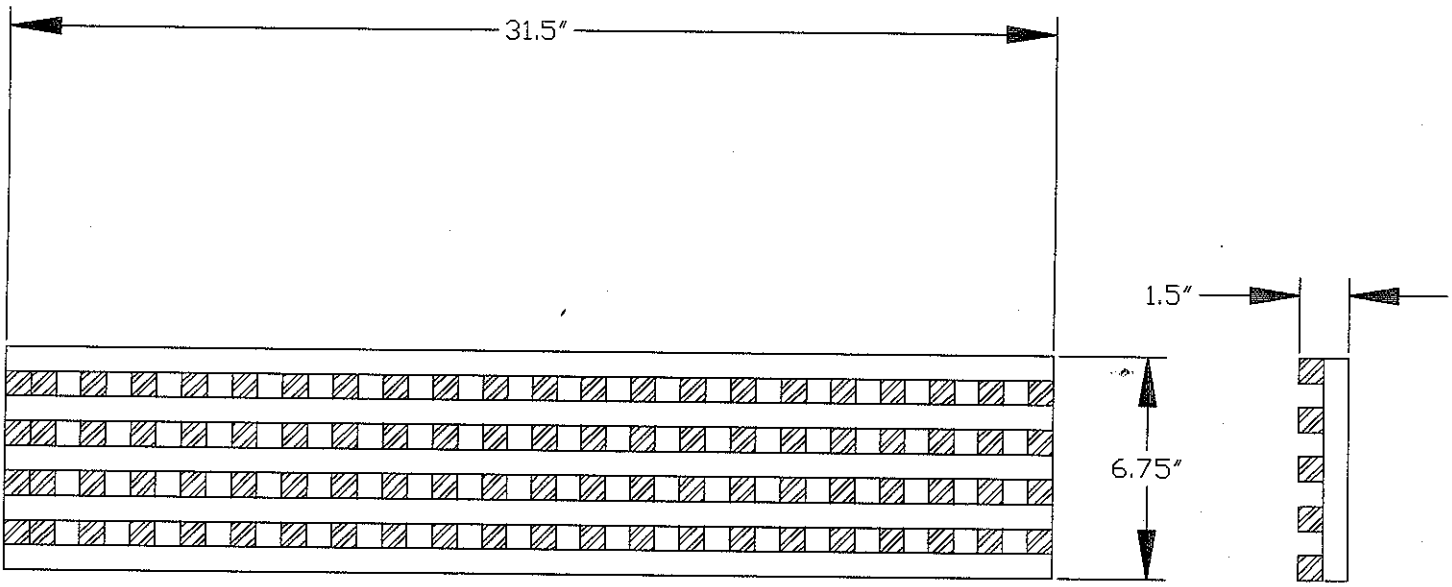
Observations were made for the ignition time of each crib. For comparison purposes, a series of tests were also conducted using untreated cribs. Two tests were conducted with each agent and nozzle combination for a total of 44 tests.

RESULTS

The results of the exposure protection test are contained in Tables 3 and 4 and are shown in Ills. 11 and 12.

PLAN





FRONT ELEVATION

SIDE

EXPOSURE PROTECTION TEST CRIB

TABLE 3 - EXPOSURE PROTECTION TEST RESULTS
25 kW/m² Heat Flux

Nozzle Type+	Class A Foam Solution Concentration, Percent	Foam Expansion, Ratio	25 Percent Drain Time, Sec.	Time To Ignition, Sec. Test 1	Test 2
#	-	-	-	386	387
AIR	Water Only	-	-	473	520
AIR	0.3	5.69	100	394	302
AIR	0.6	5.10	88	469	478
AIR	0.9	6.80	129	532	261
CAF 7.5	0.3	7.69	100	394	302
CAF 7.5	0.6	7.44	121	460	393
CAF 7.5	0.9	7.60	143	327	157
CAF 15	0.3	13.80	226	119	64
CAF 15	0.6	15.80	355	193	122
CAF 15	0.9	15.20	263	123	120

\# - Untreated crib.

AIR - Air -aspirated nozzle

CAF 7.5 - Class A foam produced at a ratio of 1 cfm air to 1 gpm Class A foam solution.

CAF 15 - Class A foam produced at a ratio of 2 cfm air to 1 gpm Class A foam solution.

TABLE 4 - EXPOSURE PROTECTION TEST RESULTS
50 kW/m² Heat Flux

Nozzle Type+	Class A Foam Solution Concentration, Percent	Foam Expansion, Ratio	25 Percent Drain Time, Sec.	Time To Ignition, Sec. Test 1	Test 2
#	-	-	-	28	26
AIR	Water Only	-	-	43	67
AIR	0.3	5.69	100	32	50
AIR	0.6	5.10	88	57	162
AIR	0.9	6.80	129	58	53
CAF 7.5	0.3	7.69	100	62	49
CAF 7.5	0.6	7.44	121	51	66
CAF 7.5	0.9	7.60	143	79	69
CAF 15	0.3	13.80	226	72	100
CAF 15	0.6	15.80	355	80	63
CAF 15	0.9	15.20	263	80	93

\# - Untreated crib.

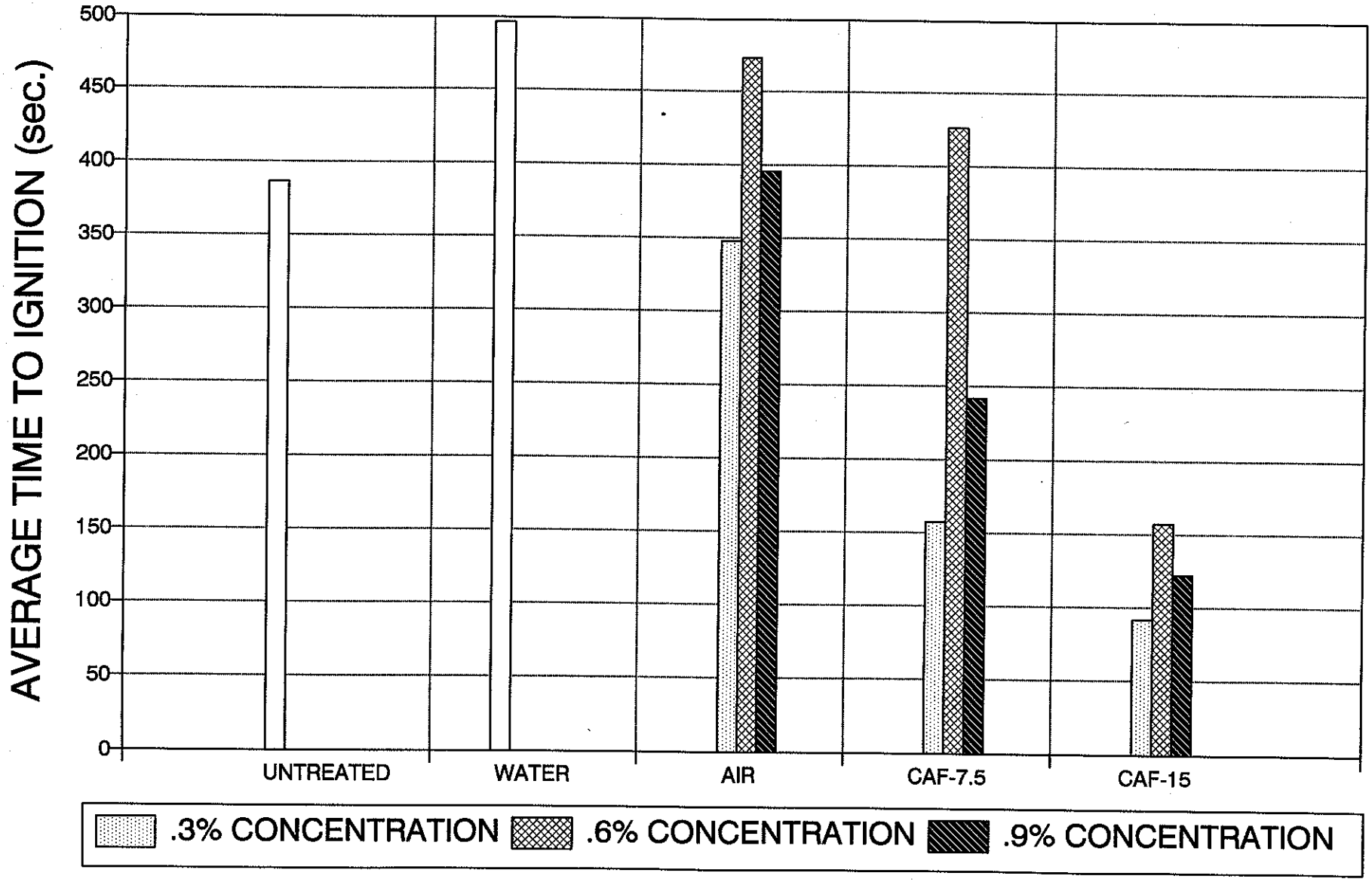
AIR - Air -aspirated nozzle

CAF 7.5 - Class A foam produced at a ratio of 1 cfm air to 1 gpm Class A foam solution.

CAF 15 - Class A foam produced at a ratio of 2 cfm air to 1 gpm Class A foam solution.

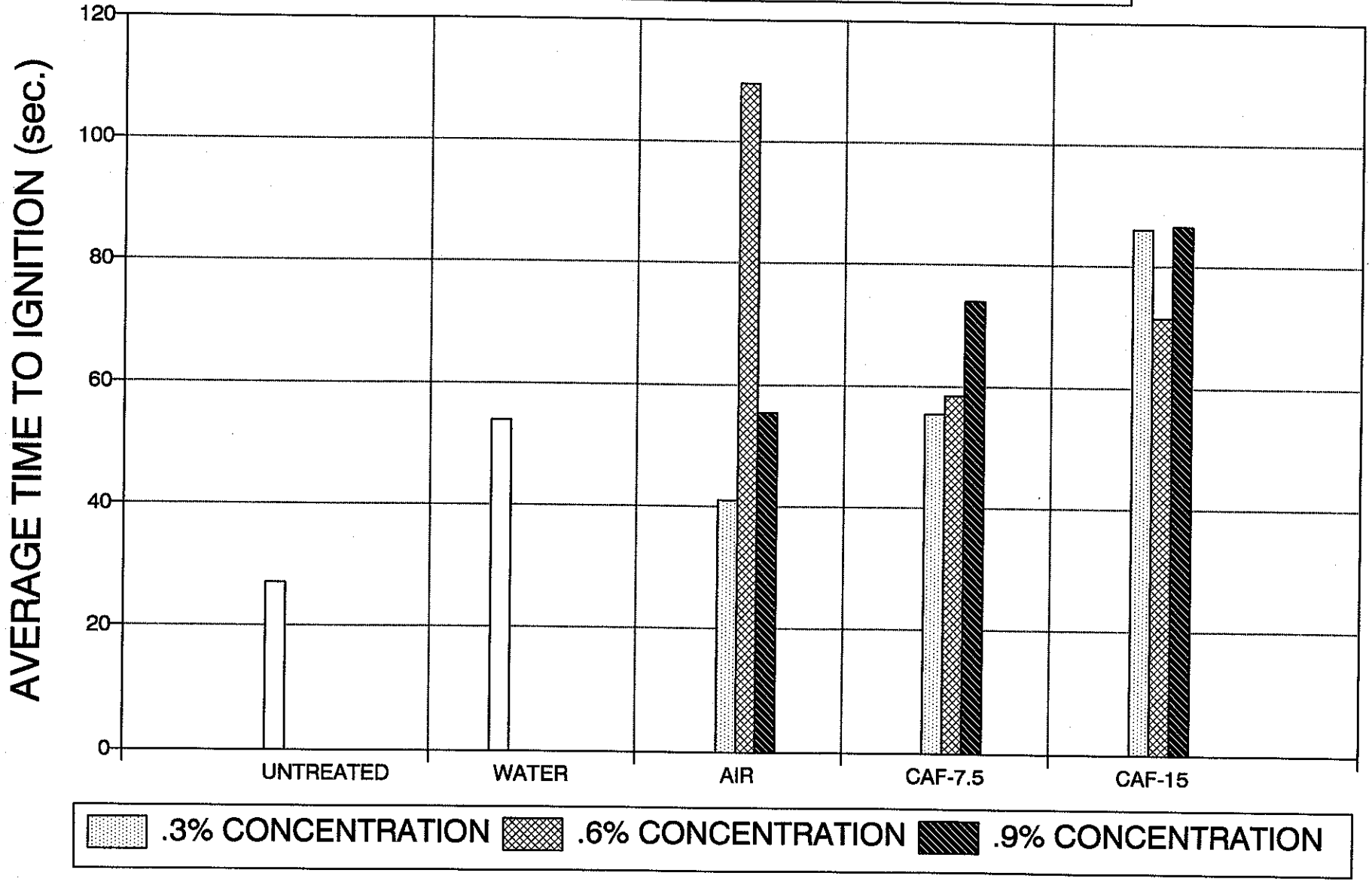
NFPRF CLASS A FOAM
EXPOSURE PROTECTION TEST RESULTS

EXPOSURE: 25 KW PER SQUARE METER



NFPRF CLASS A FOAM
EXPOSURE PROTECTION TEST RESULTS

EXPOSURE : 50 KW PER SQUARE METER



RETENTION TESTS:

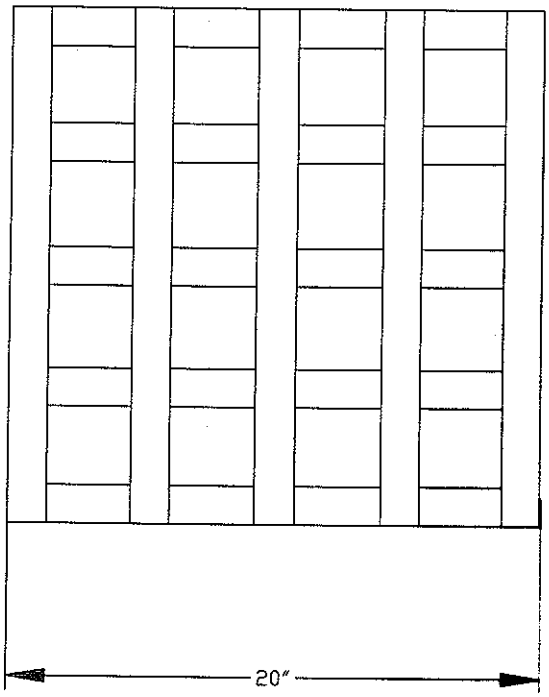
METHOD

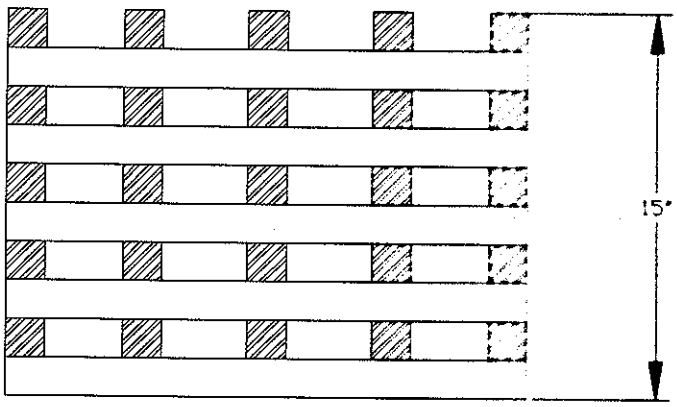
A series of retention tests were conducted to determine the amount of water or Class A foam solution retained in wood cribs. A Class 1-A crib as described in UL 711, which consisted of 50 pieces of 2 by 2 by 20 inch long fir lumber arranged in 10 evenly spaced rows of 5 boards, was positioned on a load cell. See Ill. 13. Using 1 gpm discharge devices, air aspirated Class A foam at a nominal expansion ratio of 7.5 and CAF Class A foam at expansion ratios of 7.5 and 15 and foam solution concentrations of 0.3, 0.6 and 0.9 percent, or water only, were applied to the crib for 15 or 60 s. Deionized water was used to mix the Class A foam solutions and for the water only tests. The increase in the weight of the crib at intervals of 15, 30, 45 and 60 s after the end of discharge were then recorded. Duplicate tests were conducted with each agent and discharge duration for a total of 40 tests.

RESULTS

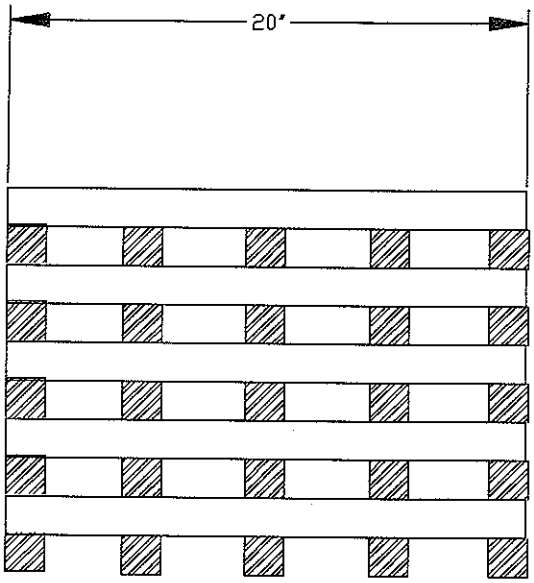
The results of the retention tests are contained in Tables 5 and 6 and are shown on Ills. 14 and 15.

PLAN





FRONT ELEVATION



SIDE

RETENTION TEST CRIB

TABLE 5 - RETENTION TEST RESULTS
15 Second Application

Nozzle Type +	Class A Foam Solution Concentration, Percent	Foam Expansion, Ratio	25 Percent Drainage Time, Sec.	Test No.	Weight Gain After Discharge, lb				Percent Increase in Weight Gain Compared To Water At 60 s
					15 s	30 s	45 s	60 s	
AIR	Water Only	-	-	1	1.0	0.9	0.9	0.9	-
				2	1.0	1.0	0.9	0.9	-
AIR	0.3	5.69	100	1	1.2	1.2	1.2	1.2	33
				2	1.2	1.2	1.2	1.2	33
AIR	0.6	5.10	88	1	1.3	1.3	1.2	1.2	33
				2	1.2	1.2	1.2	1.2	33
AIR	0.9	6.80	129	1	1.3	1.3	1.2	1.2	33
				2	1.3	1.2	1.2	1.2	33
CAF7.5	0.3	7.69	108	1	1.5	1.5	1.5	1.5	67
				2	1.5	1.4	1.4	1.4	56
CAF7.5	0.6	7.44	121	1	1.6	1.6	1.5	1.5	67
				2	1.6	1.5	1.5	1.5	67
CAF7.5	0.9	7.60	143	1	1.5	1.5	1.4	1.4	56
				2	1.5	1.4	1.4	1.4	56
CAF15	0.3	13.80	226	1	1.8	1.8	1.8	1.8	100
				2	1.7	1.6	1.6	1.5	67
CAF15	0.6	15.80	355	1	1.6	1.6	1.6	1.6	78
				2	1.8	1.7	1.7	1.6	78
CAF15	0.9	15.20	263	1	1.6	1.6	1.6	1.6	78
				2	1.8	1.7	1.7	1.6	78

AIR - Air-aspirated nozzle

CAF7.5 - Class A foam produced at a ratio of 1 cfm air to 1 gpm Class A foam solution.

CAF15 - Class A foam produced at a ratio of 2 cfm air to 1 gpm Class A foam solution.

TABLE 6 - RETENTION TEST RESULTS
60 Second Application

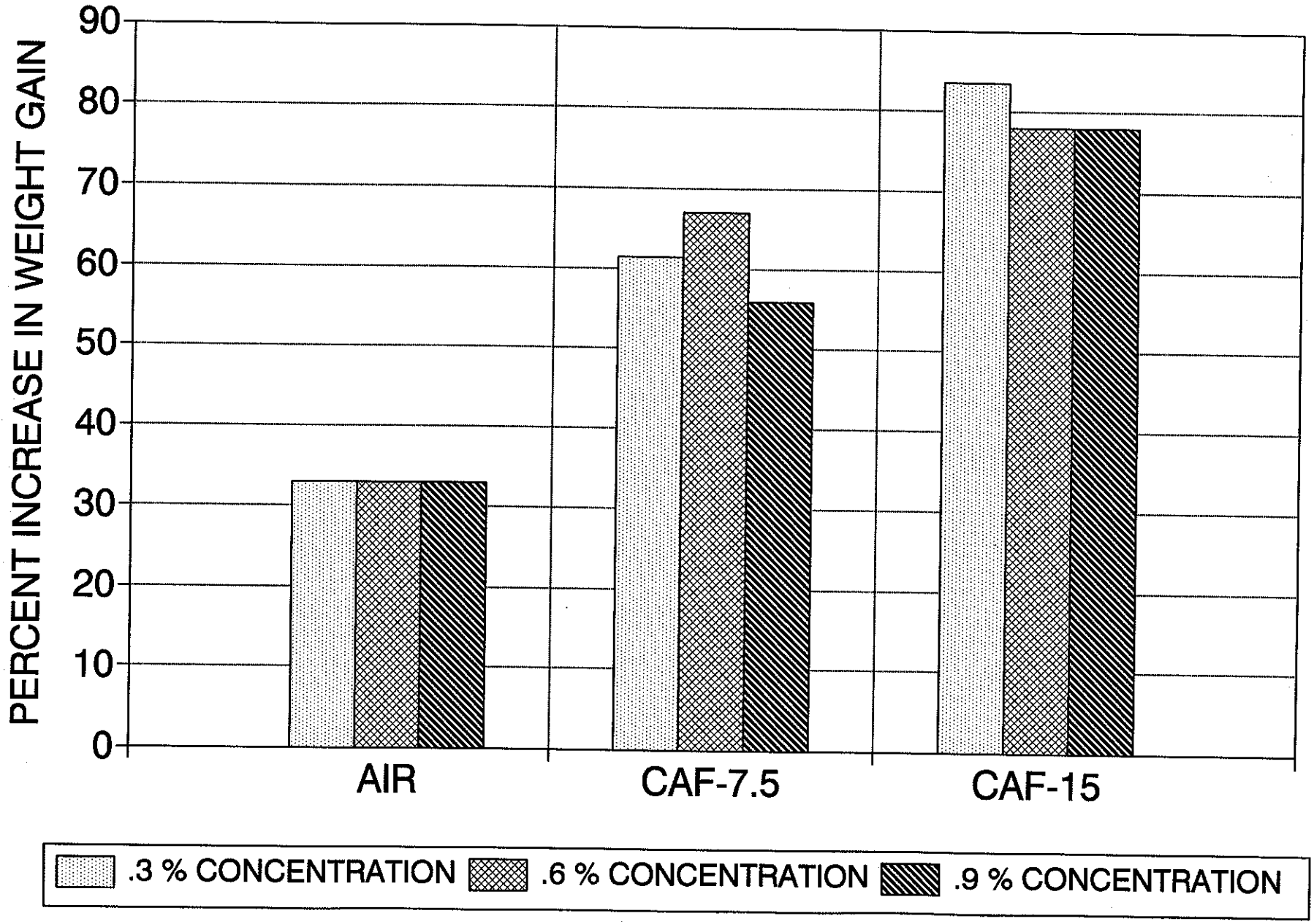
Nozzle Type +	Class A Foam Solution Concentration, Percent	Foam Expansion, Ratio	25 Percent Drainage Time, Sec.	Test No.	Weight Gain After Discharge, lb				Percent Increase in Weight Gain Compared To Water At 60 s
					15 s	30 s	45 s	60 s	
AIR	Water Only	-	-	1	1.9	1.6	1.3	1.3	-
				2	1.8	1.5	1.4	1.3	-
AIR	0.3	5.69	100	1	2.7	2.6	2.5	2.5	92
				2	2.8	2.7	2.6	2.5	92
AIR	0.6	5.10	88	1	2.9	2.8	2.7	2.6	100
				2	2.9	2.8	2.6	2.6	100
AIR	0.9	6.80	129	1	3.1	2.9	2.8	2.7	108
				2	2.9	2.8	2.8	2.7	108
CAF7.5	0.3	7.69	108	1	3.5	3.4	3.3	3.2	146
				2	3.7	3.5	3.5	3.4	162
CAF7.5	0.6	7.44	121	1	3.3	3.2	3.1	3.0	131
				2	3.3	3.1	3.0	3.0	131
CAF7.5	0.9	7.60	143	1	3.5	3.4	3.3	3.2	146
				2	3.2	3.1	3.0	2.9	123
CAF15	0.3	13.80	226	1	4.1	3.8	3.7	3.6	177
				2	4.4	4.1	4.0	3.9	200
CAF15	0.6	15.80	355	1	4.1	3.7	3.6	3.3	154
				2	4.5	3.9	3.7	3.5	169
CAF15	0.9	15.20	263	1	4.2	4.0	3.9	3.7	185
				2	4.3	4.2	3.8	3.6	177

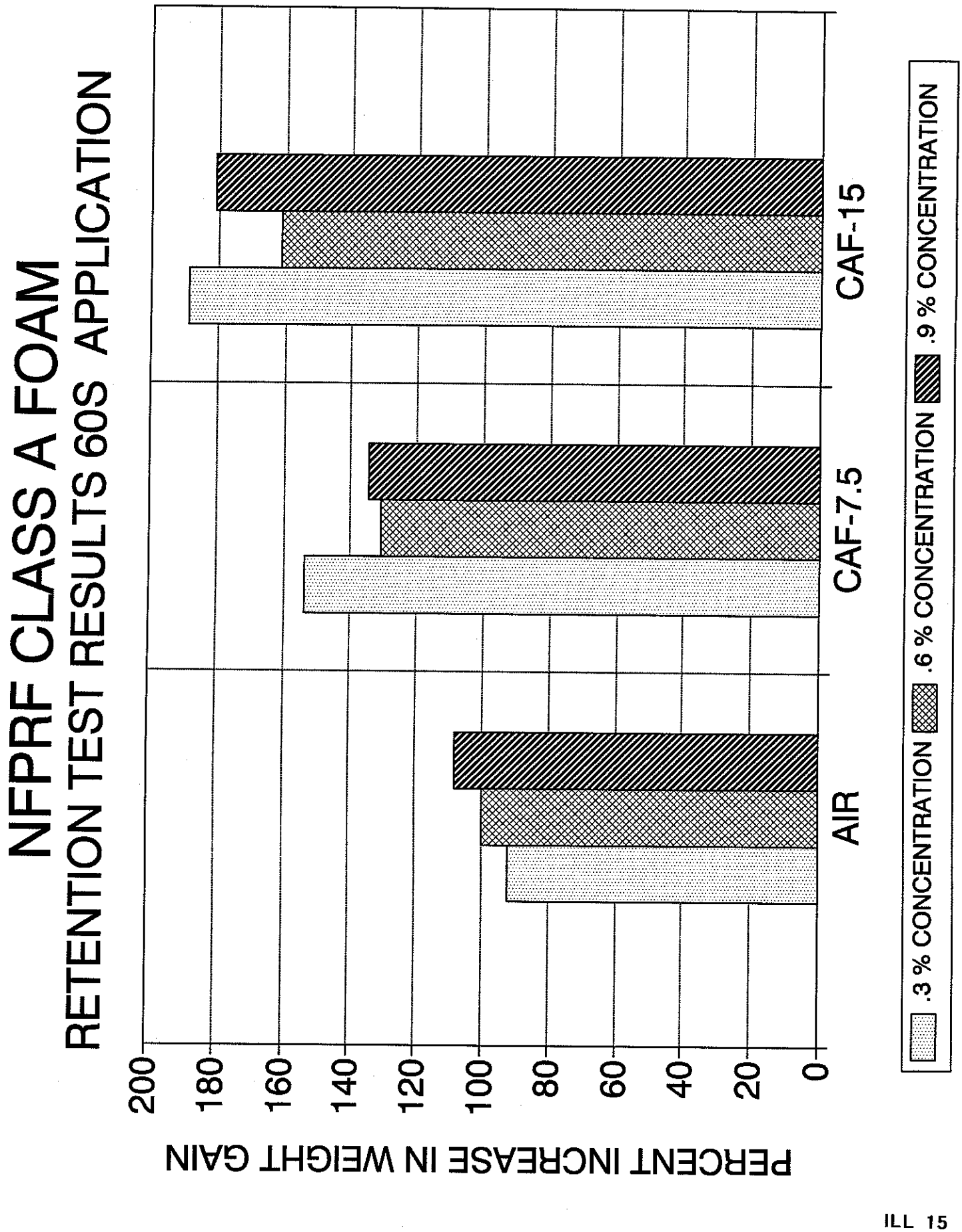
AIR - Air-aspirated nozzle

CAF7.5 - Class A foam produced at a ratio of 1 cfm air to 1 gpm Class A foam solution.

CAF15 - Class A foam produced at a ratio of 2 cfm air to 1 gpm Class A foam solution.

NFPRF CLASS A FOAM
RETENTION TEST RESULTS 15S APPLICATION




NFPRF CLASS A FOAM
RETENTION TEST RESULTS 60S APPLICATION
PERCENT INCREASE IN WEIGHT GAIN
200
180
160
140
120
100
80
60
40
20
0
AIR
CAF-7.5
CAF-15
.3 % CONCENTRATION
.6 % CONCENTRATION
.9 % CONCENTRATION

ILL 15

WEATHER CONDITIONS:

All fire tests were conducted inside the test building and weather conditions in the Northbrook area were recorded at 12:00 noon on each day a wood crib fire test was conducted. The wind velocity, temperature and barometric pressure were recorded. The readings were as follows:

Test Date	Wood Crib Fire Tests	Temperature, °F	Wind, Direction and Velocity (MPH)	Relative Humidity,%
8-23-93	1	85	S-15	75
8-24-93	5, 6,11 & 12	82	W-10	75
8-25-93	2, 7, 8, 13 & 14	86	S-8	57
8-26-93	17 & 18	88	SW-10	66
8-27-93	19 & 20	91	S-13	54
8-30-93	3, 4, 15 & 16	87	SW-14	65
8-31-93	9 & 10	70	N-13	61

4.0 DISCUSSION AND RECOMMENDATIONS

DISCUSSION:

GENERAL

Based upon an analysis by the TAC, the TAC believed that the data developed during this series of wood crib fire, exposure protection and retention tests demonstrated the ability of hand hoselines supplied with Class A foam solutions to provide enhanced fire fighting performance compared to hand hoselines supplied with water only. It should be noted that all tests were performed under laboratory conditions using specific, repeatable test methods and procedures.

FOAM QUALITY

The results of the foam quality tests conducted with the discharge devices used in the wood crib, retention and exposure protection tests indicated that the compressed air foam had the highest expansion ratios and longest 25 percent drainage times. It shall be recognized that the test nozzles used in this research project were designed to operate with water and/or Class B low expansion foams only.

WOOD CRIB FIRE TESTS

The results of the wood crib fire tests demonstrated the ability of the Class A foam solutions to reduce the time required to control the fire as compared to water only. During the fire tests conducted with water only, flames were initially extinguished above the wood crib but reappeared before the end of water application, even when the duration of water application was increased from 60 to 90 seconds. The fire tests conducted with the air-aspirated test nozzle had the longest reignition times and the tests conducted with the CAF foam had the lowest crib weight losses.

EXPOSURE PROTECTION

The results of the exposure protection tests demonstrated the ability of the Class A foam to lengthen the ignition time of a combustible surface as compared to an untreated crib. The ignition times of the wood cribs exposed to the Class A foam were up to six times longer than an untreated crib and, except for one test, all of the ignition times of the wood cribs were up to 50 percent longer as compared to those exposed to water at the 50 kW/m² heat flux value.

RETENTION

The results of the retention tests demonstrated the ability of wood cribs exposed to Class A foam to retain more weight than cribs treated with water. Following a 15 second application of Class A foam, the wood cribs had a 33 to 100 percent increase in weight gain as compared to wood cribs exposed to water. Following 60 seconds of Class A foam application, the weight increase was 92 to 200 percent greater than the cribs exposed to water. The CAF Class A foam exhibited the highest increase in weight gain.

RECOMMENDATIONS:

Additional tests should be undertaken to further quantify the fire fighting performance and overall improvement in operating efficiency when Class A foam solutions are used with hand held hoselines.

It is recommended that additional fire tests be conducted using a living room upholstered furniture fuel package. These tests should be conducted under a calorimeter so that the rate of heat release versus time can be measured during each test. It is also recommended that some of the tests be conducted using hand held hoselines and some using a fixed nozzle or sprinkler. Class A foam and/or water would be applied at known water flow rates until no visible flame exists. The time to reignition, if any, could then be recorded. Smoke obscuration, smoke density, rate of heat release, carbon monoxide, carbon dioxide, oxygen content and temperature measurements should be made during each test.

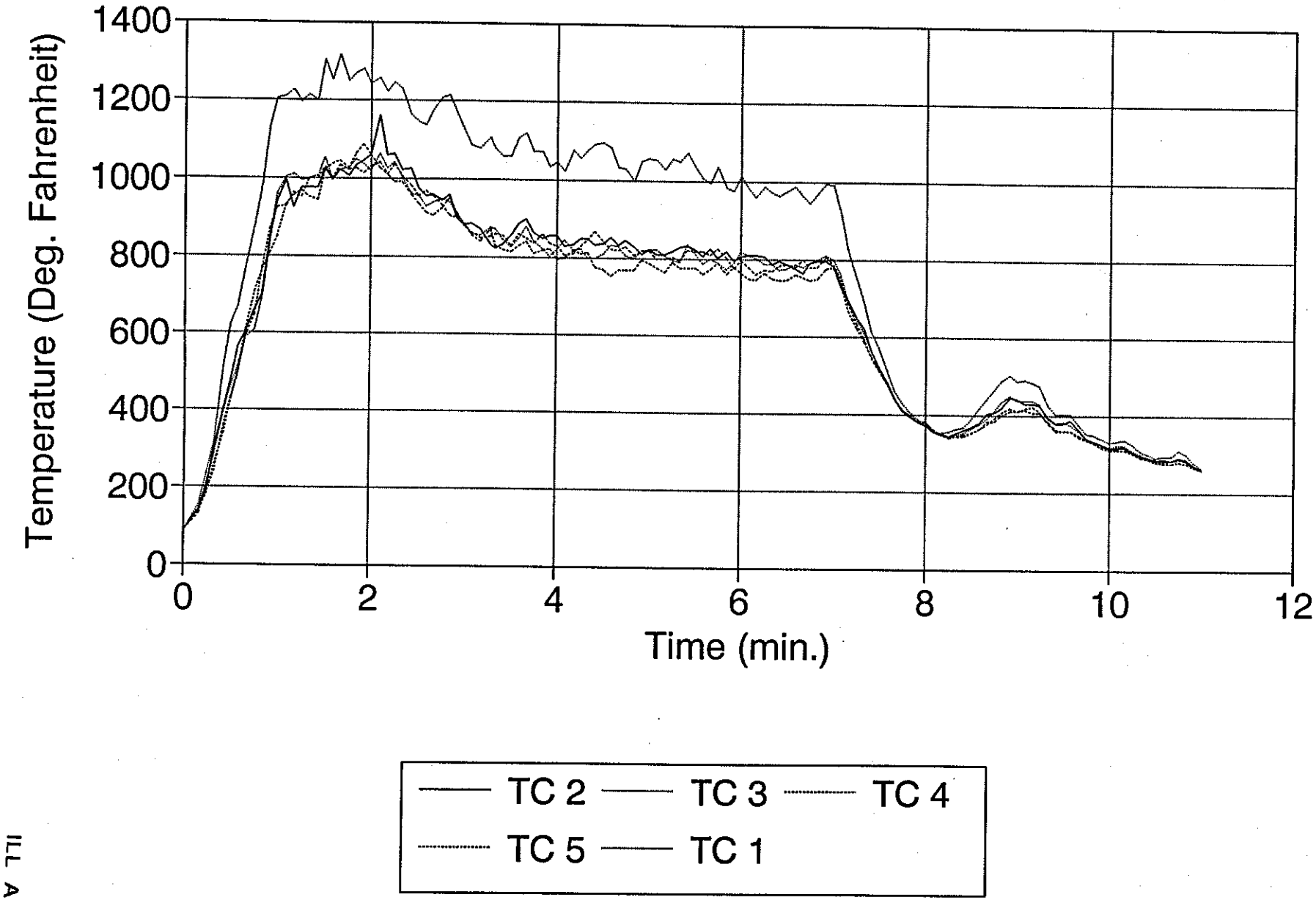
A P P E N D I X A

TEMPERATURE AND SMOKE OBSCURATION MEASUREMENTS

Test Number	Test Type	Illustration Number
Ceiling Temperatures (Typical)		
Fire Tests 1 and 2	Water	A1
Fire Tests 3 thru 8	STD	A2
Fire Tests 9 thru 14	AIR	A3
Fire Tests 15 thru 20	CAF	A4
Smoke Obscuration (Typical)		
Fire Tests 1 and 2	Water	A5
Fire Tests 3 thru 8	STD	A6
Fire Tests 9 thru 14	AIR	A7
Fire Tests 15 thru 20	CAF	A8
Wood Crib Temperature		
Fire Test 2	Water	A9
Fire Tests 3 and 4	STD, 0.1%	A10
Fire Tests 5 and 6	STD, 0.3%	A11
Fire Tests 7 and 8	STD, 0.5%	A12
Fire Tests 9 and 10	AIR, 0.1%	A13
Fire Tests 11 and 12	AIR, 0.3%	A14
Fire Tests 13 and 14	AIR, 0.5%	A15
Fire Tests 15 and 16	CAF, 0.1%	A16
Fire Test 17	CAF, 0.3%	A17
Fire Test 20	CAF, 0.5%	A18

NFPRF CLASS A FOAM

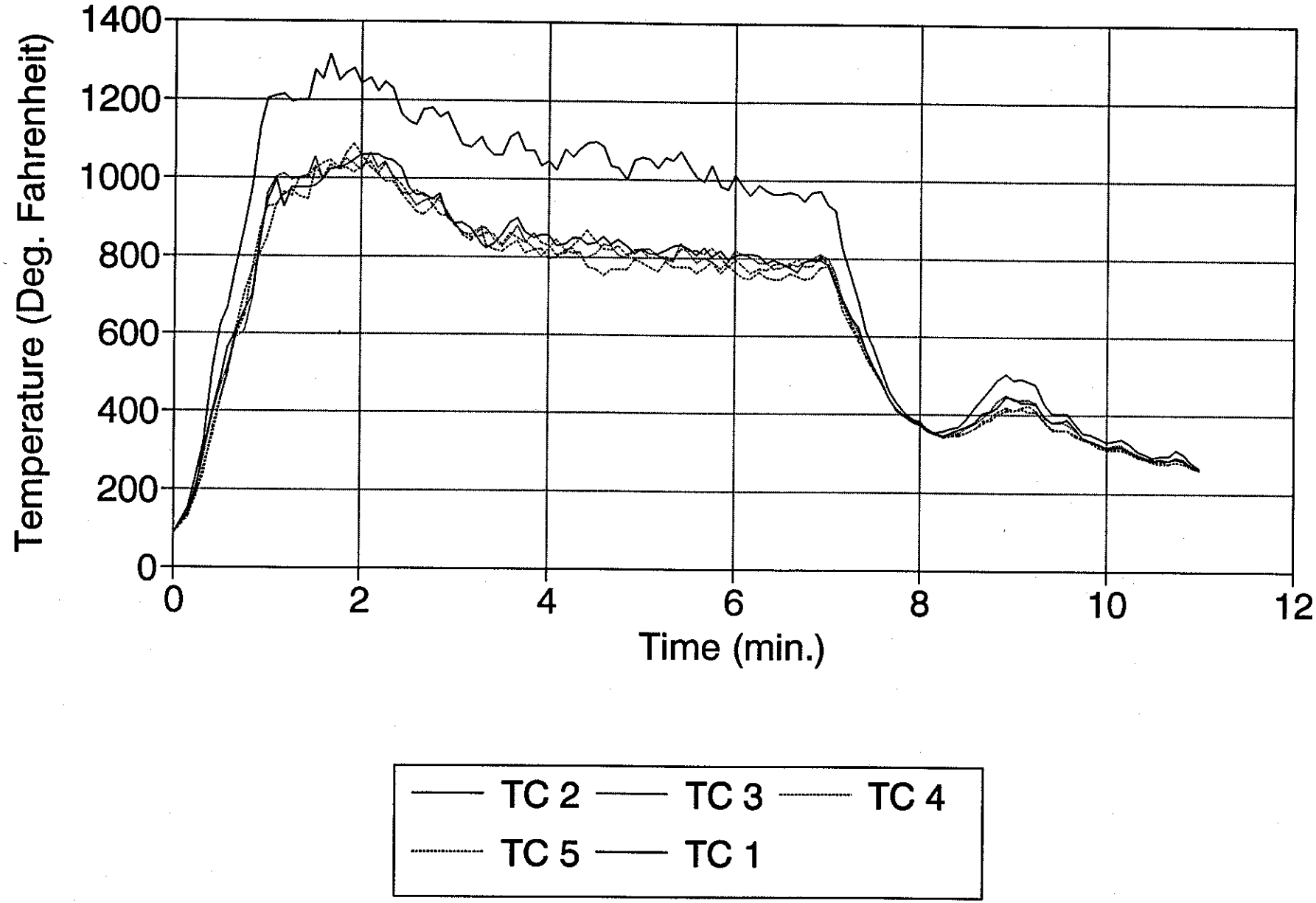
WATER CEILING TEMP (TYP)



ILL A1

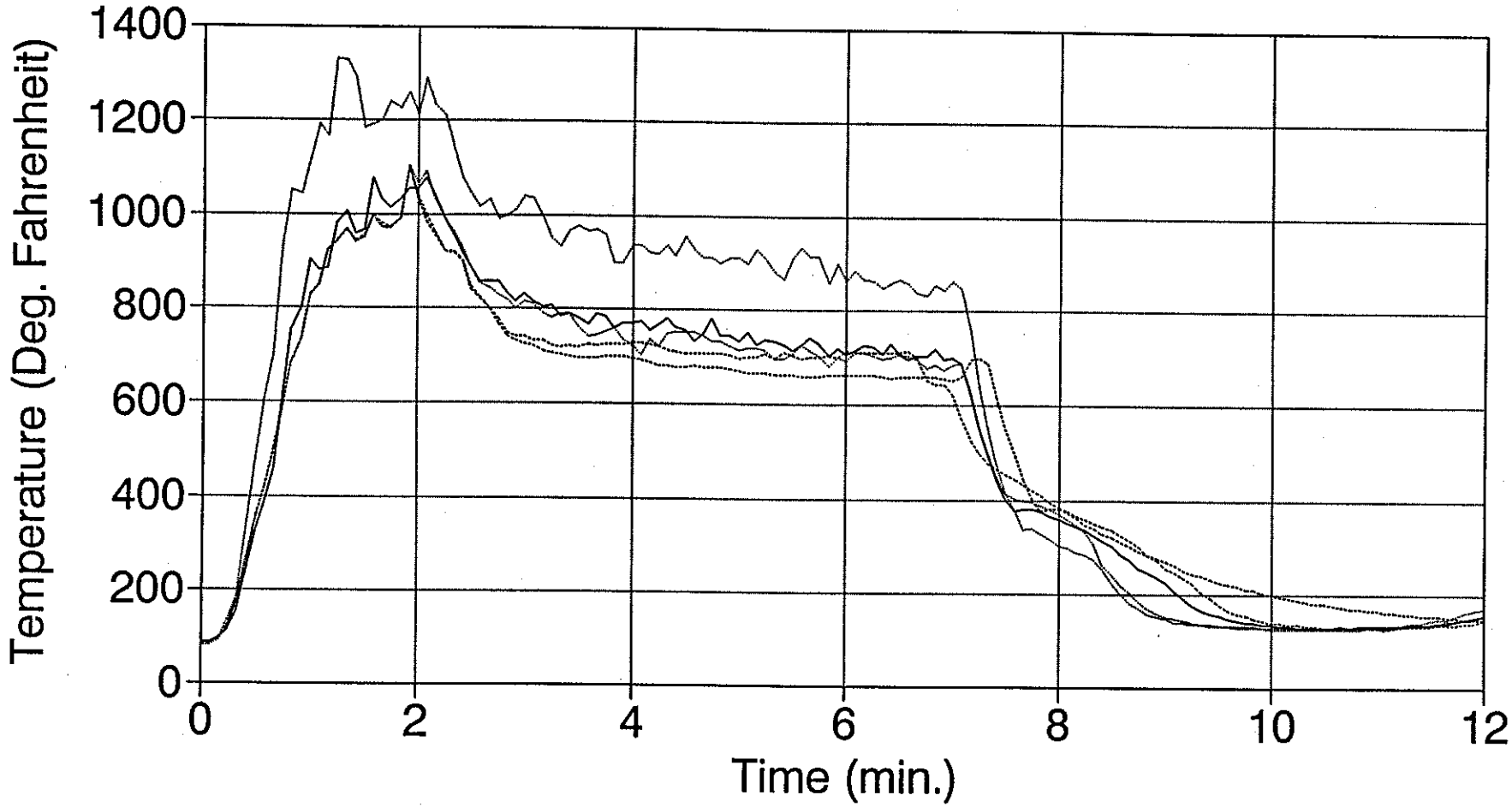
NFPRF CLASS A FOAM

STD NOZZLE CEILING TEMPERATURE (TYP)



ILL A2

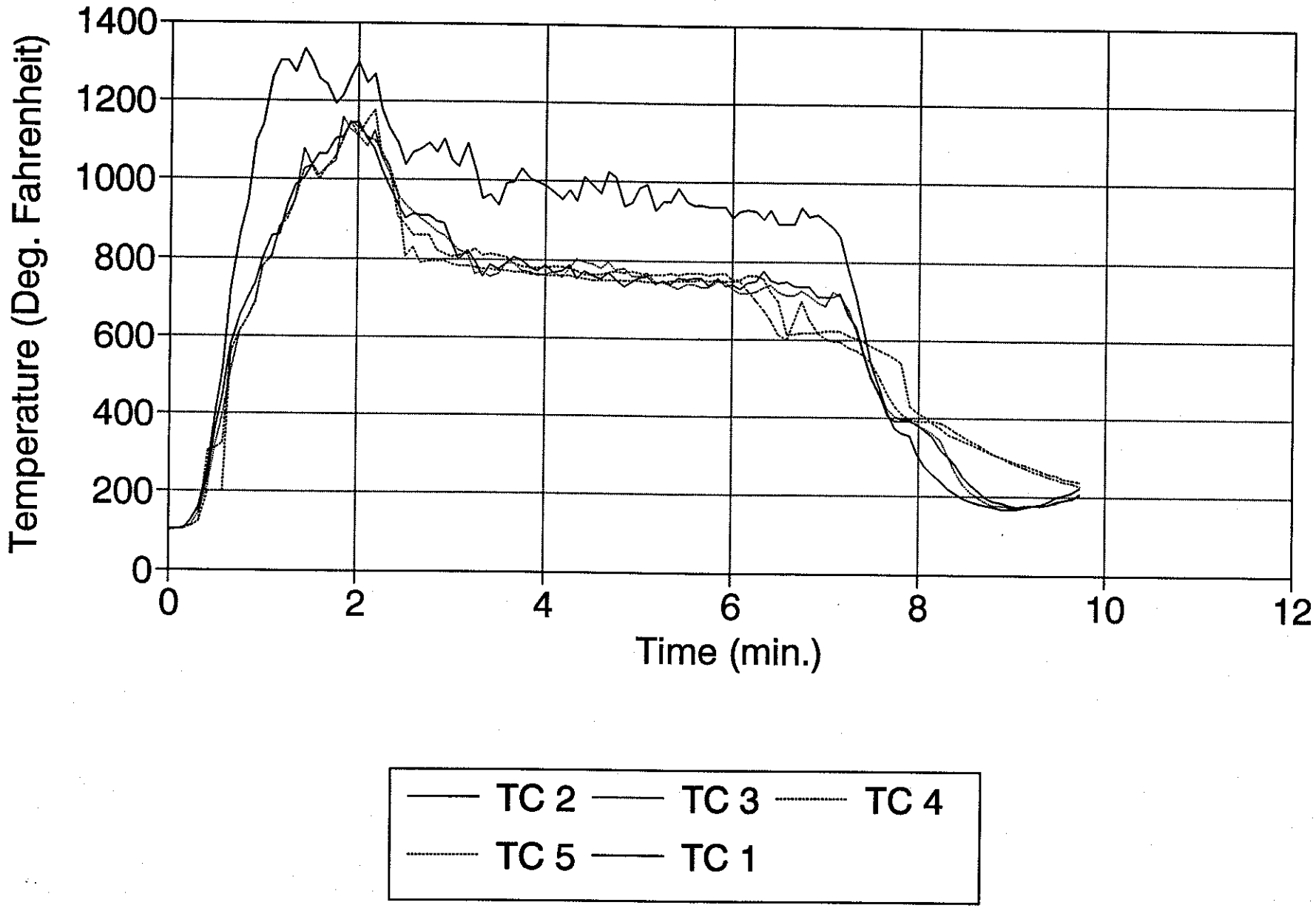
NFPRF CLASS A FOAM
AIR NOZZLE CEILING TEMPERATURE (TYP)



ILL A3

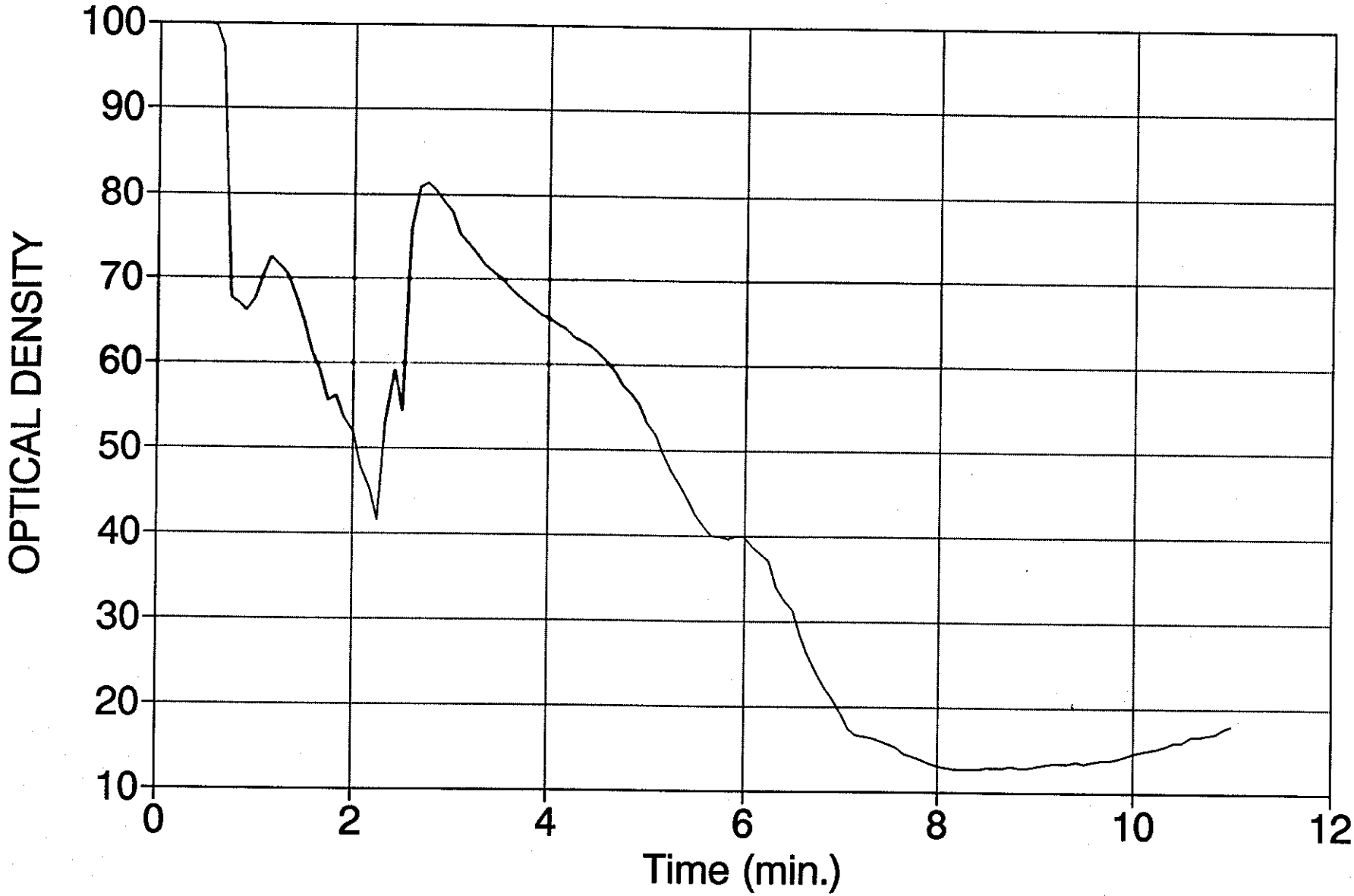
NFPRF CLASS A FOAM

CAF NOZZLE CEILING TEMPERATURE (TYP)



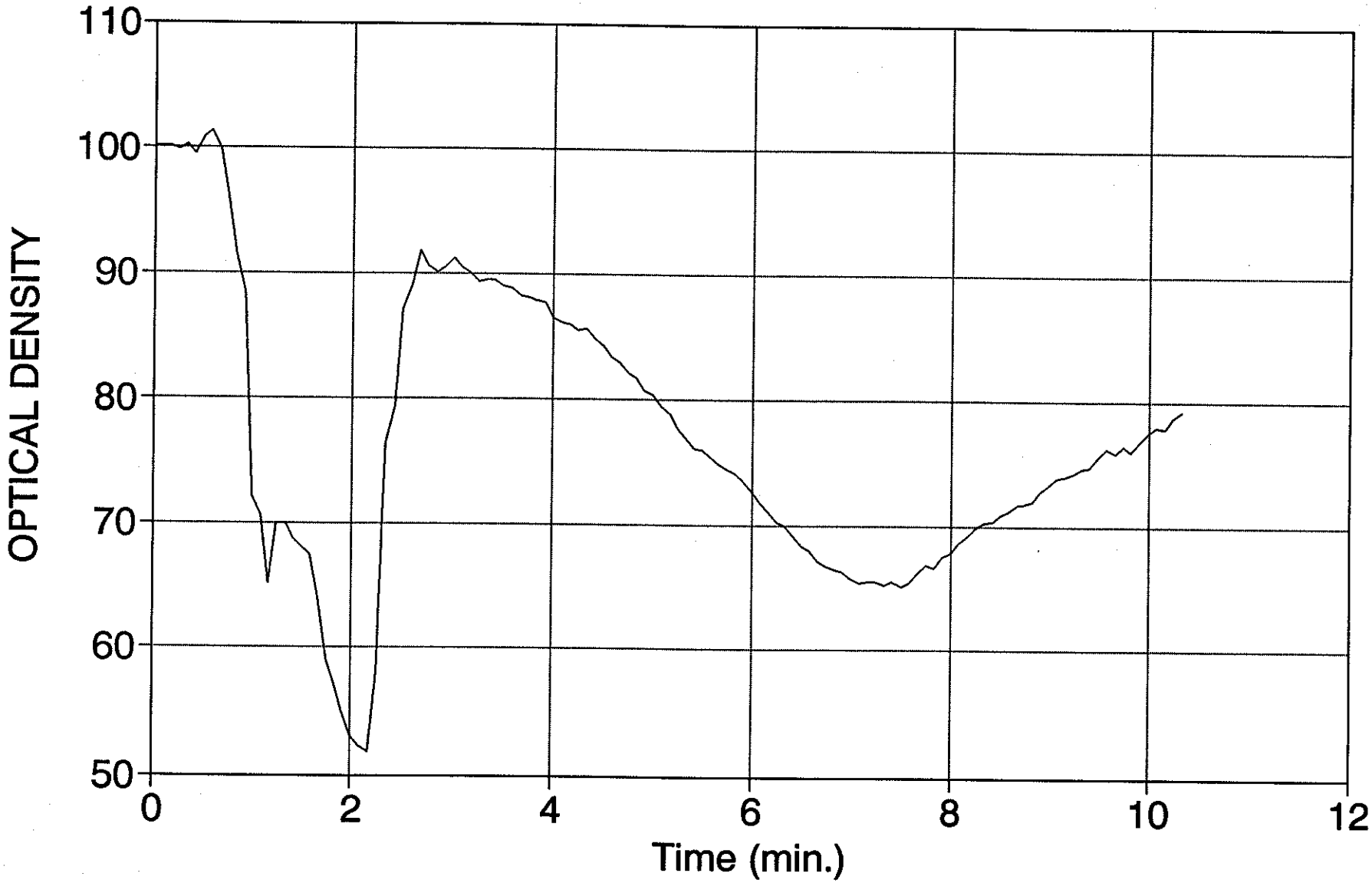
ILL A4

NFPRF CLASS A FOAM
WATER - SMOKE OBSCURATION (TYP)



NFPRF CLASS A FOAM

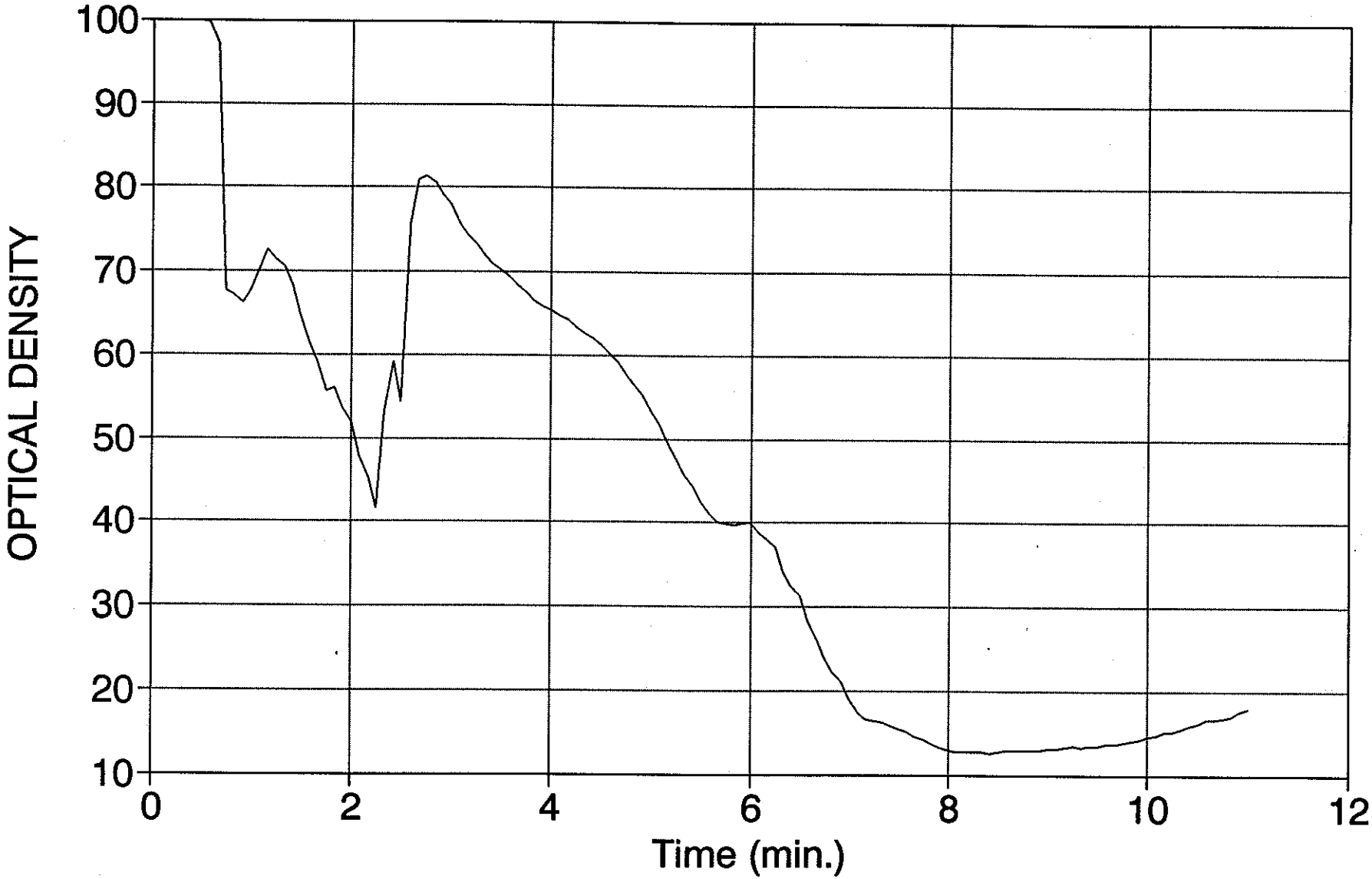
STD - SMOKE OBSCURATION (TYP)



ILL A6

NFPRF CLASS A FOAM

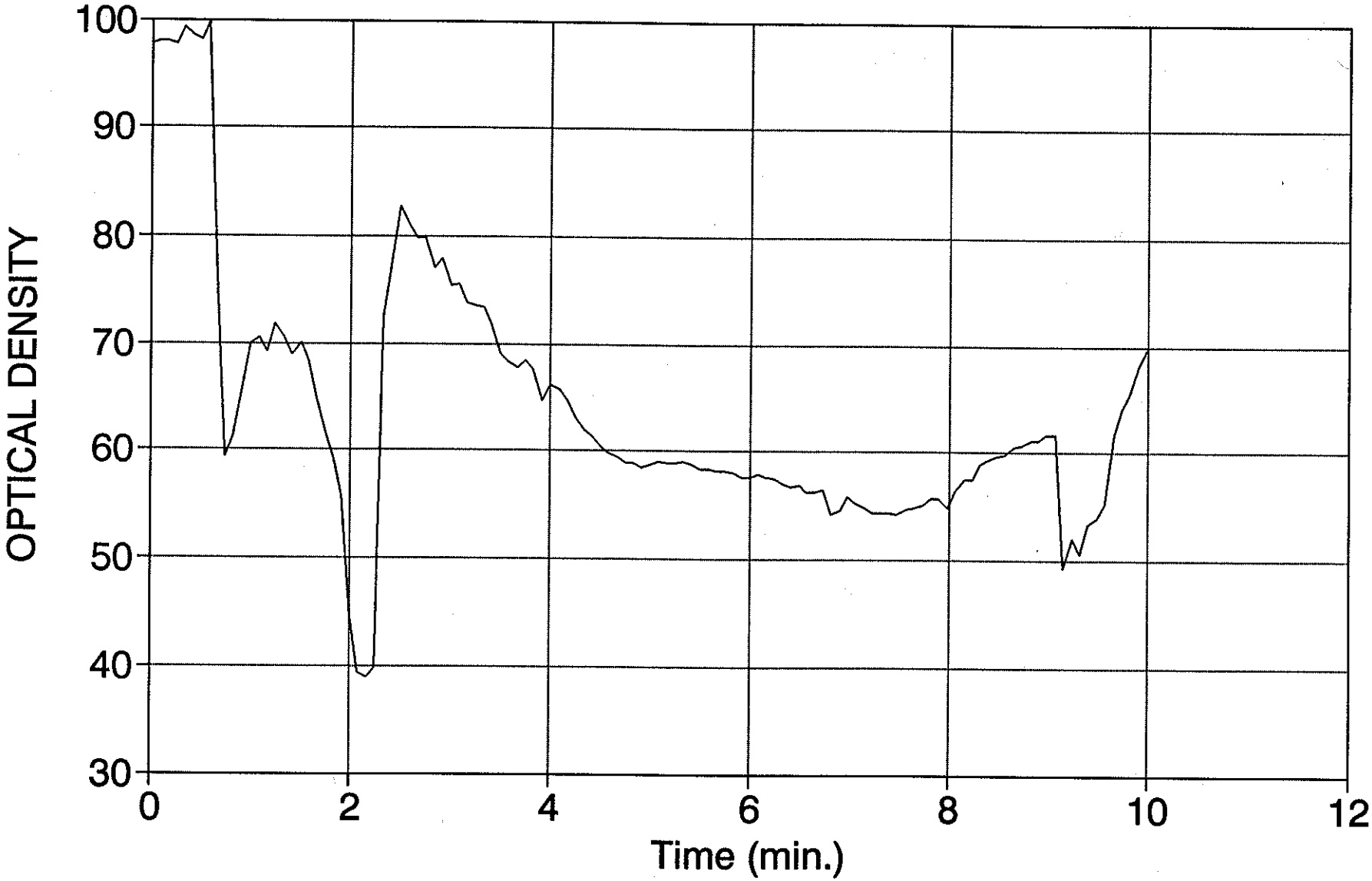
AIR - SMOKE OBSCURATION (TYP)



ILL A7

NFPRF CLASS A FOAM

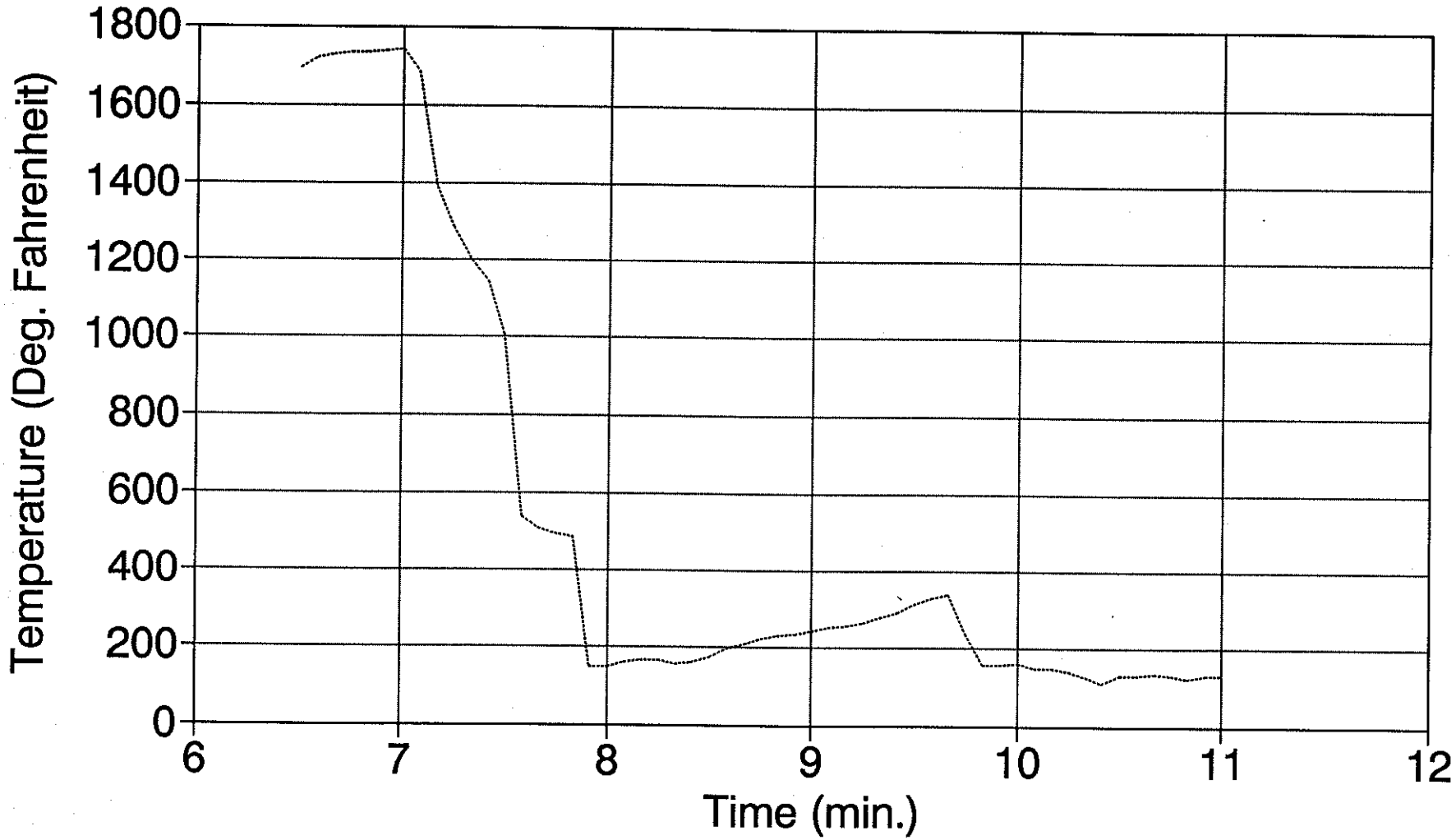
CAF - SMOKE OBSCURATION (TYP)



ILL A8

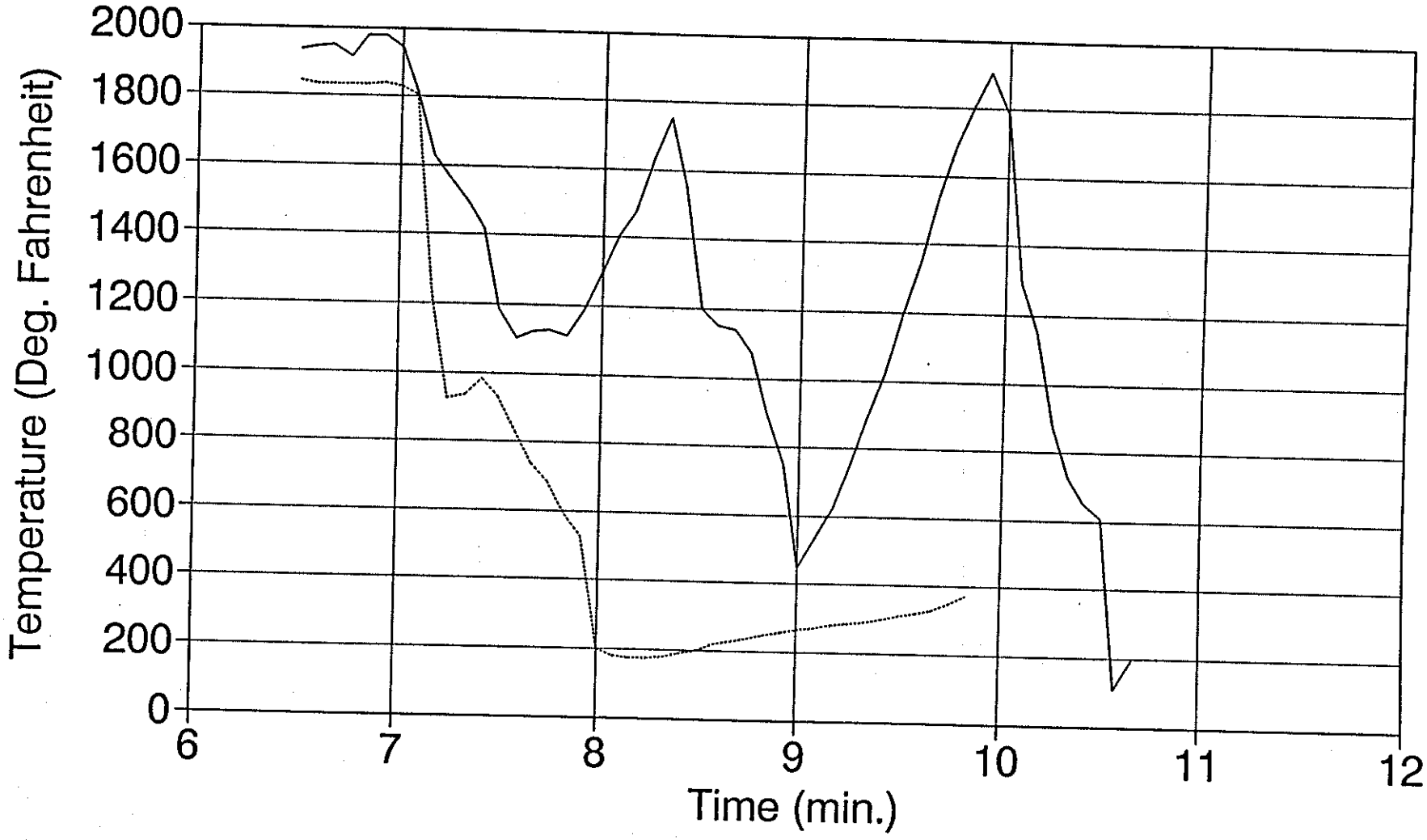
NFPRF CLASS A FOAM

CRIB TEMPS WATER APPLICATION



NFPRF CLASS A FOAM

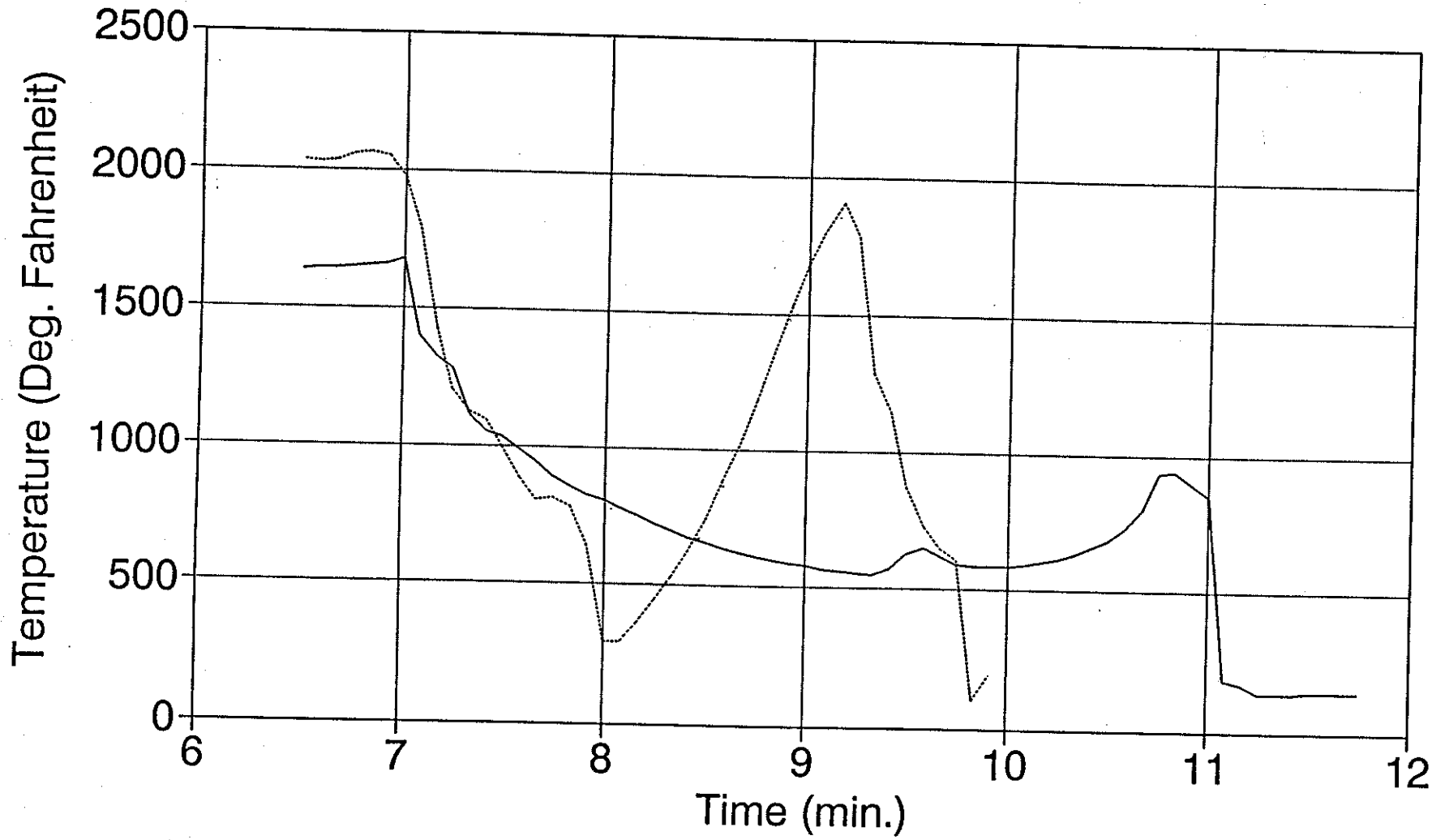
CRIB TEMPS STD NOZZLE .1% SOLUTION



ILL A10

NFPRF CLASS A FOAM

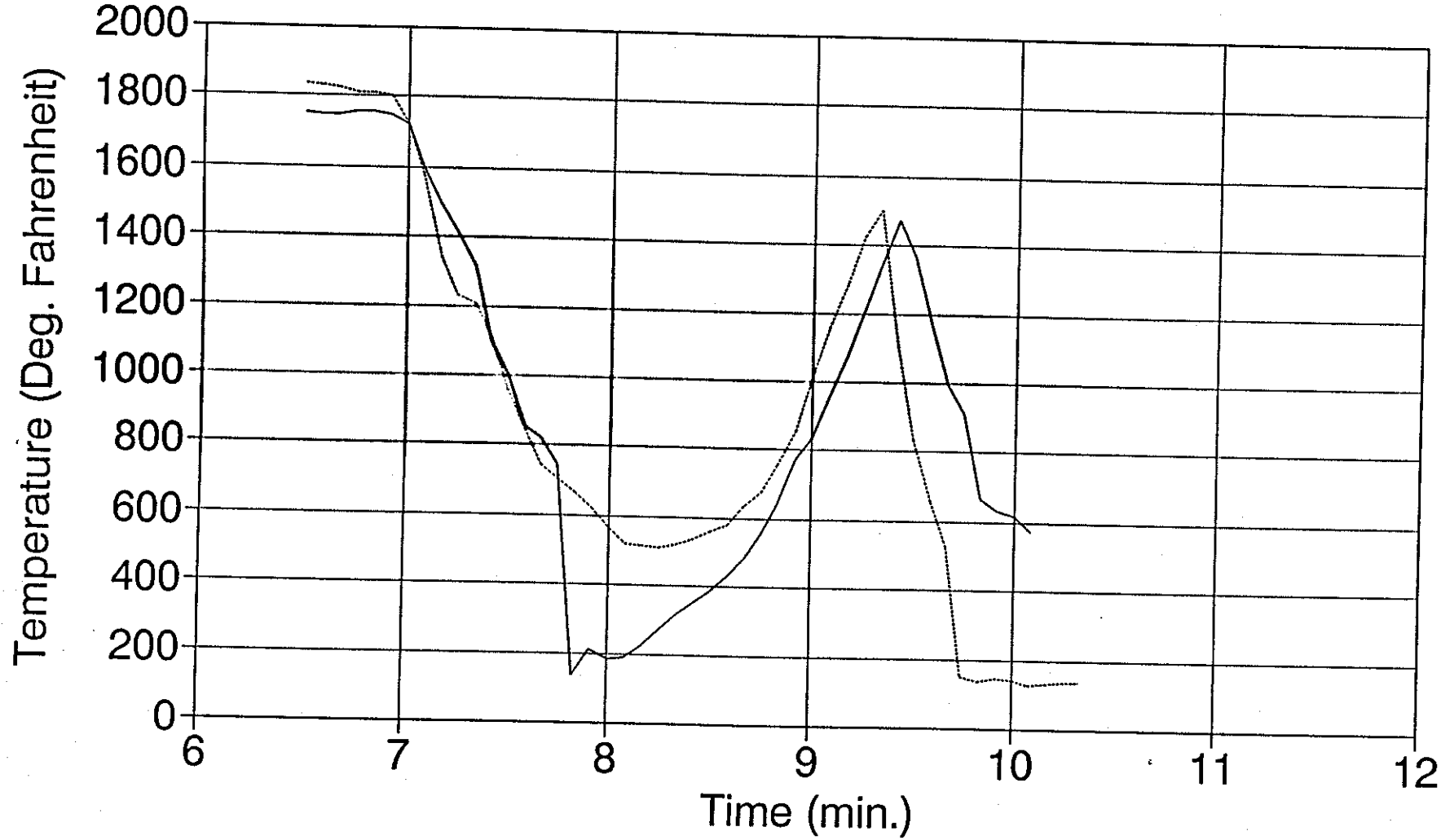
CRIB TEMPS STD NOZZLE .3% SOLUTION



ILL A11

NFPRF CLASS A FOAM

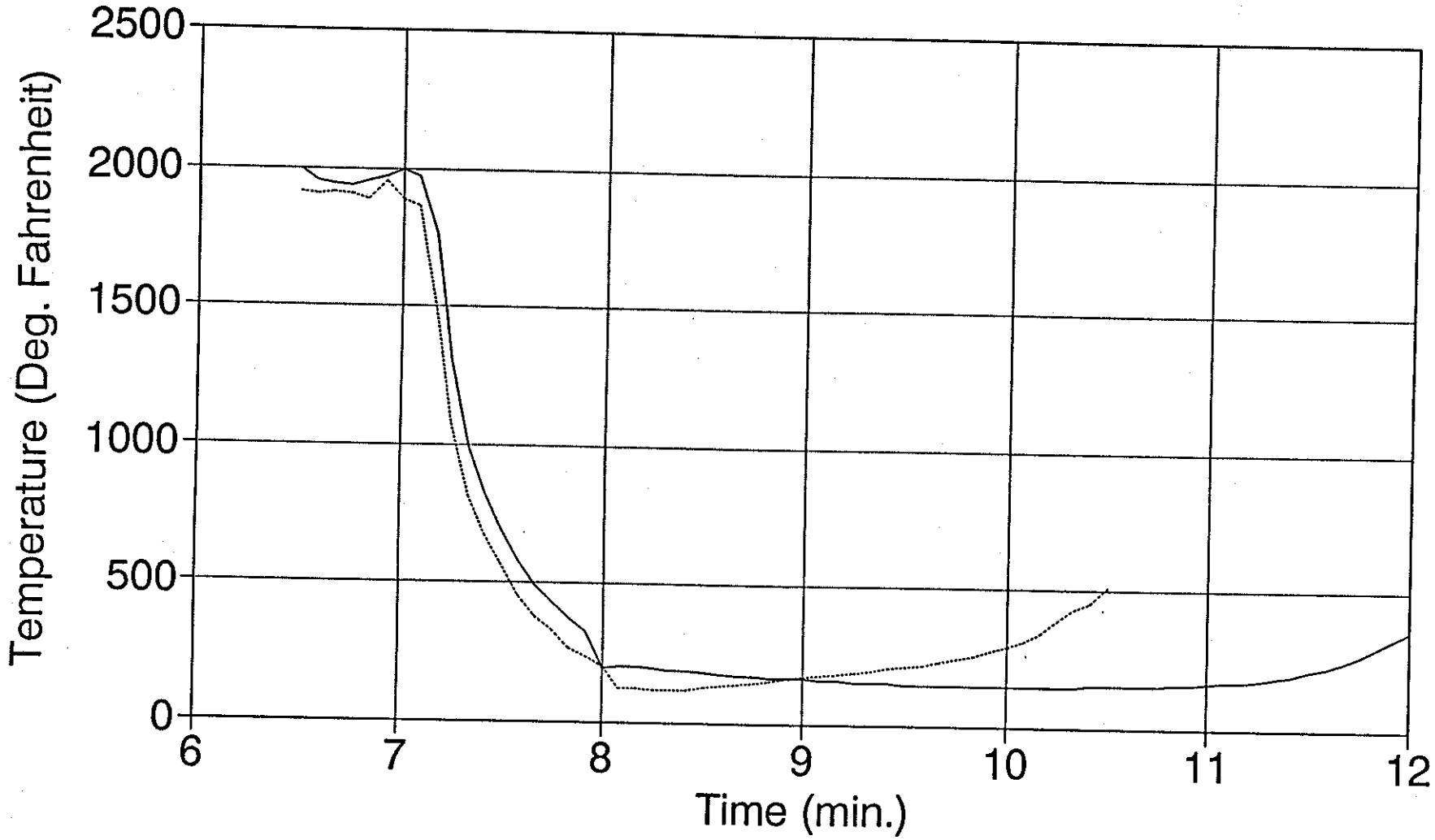
CRIB TEMPS STD NOZZLE .5% SOLUTION



ILL A12

NFPRF CLASS A FOAM

CRIB TEMPS AIR NOZZLE .1% SOLUTION



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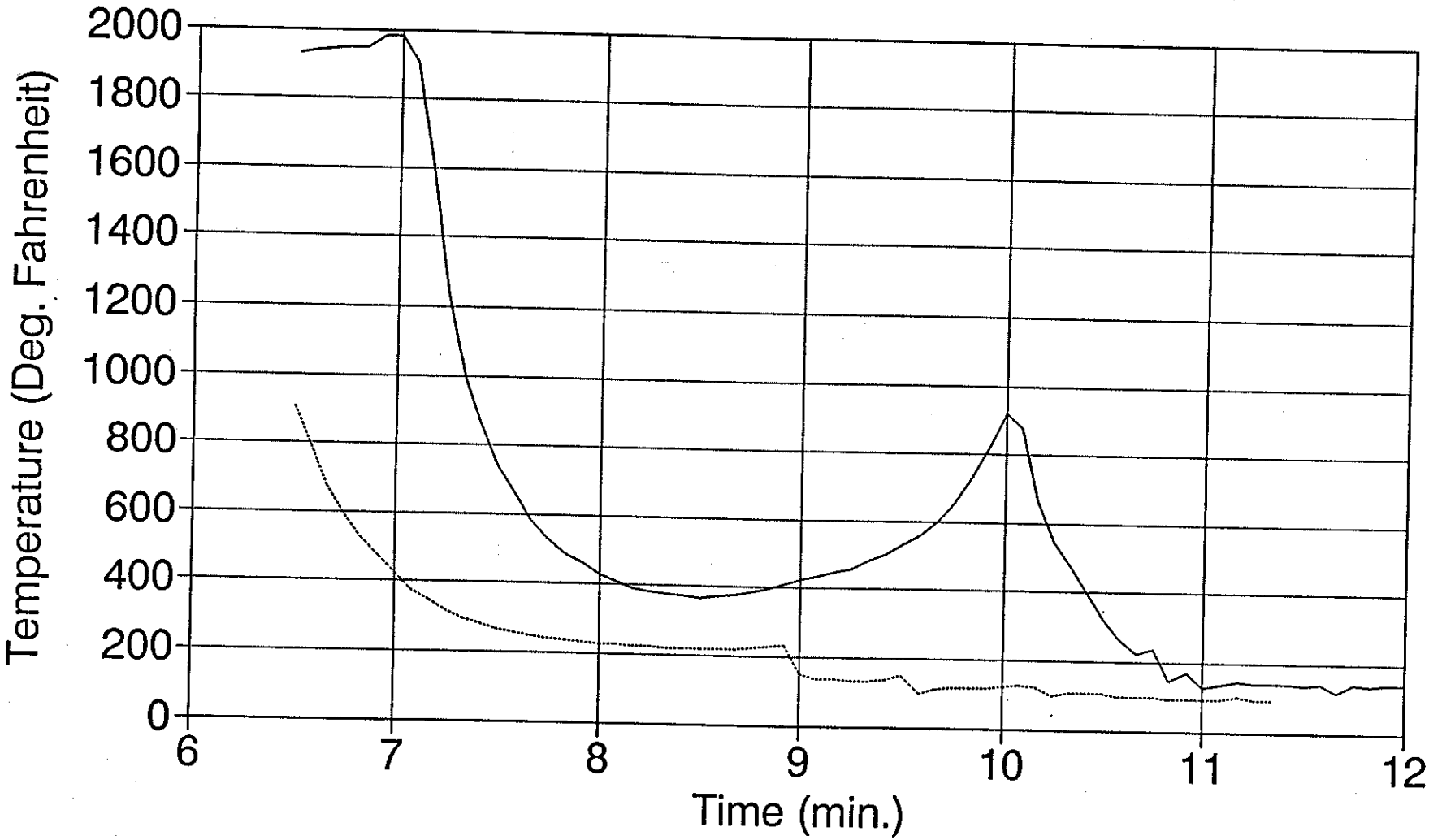
NFPRF CLASS A FOAM

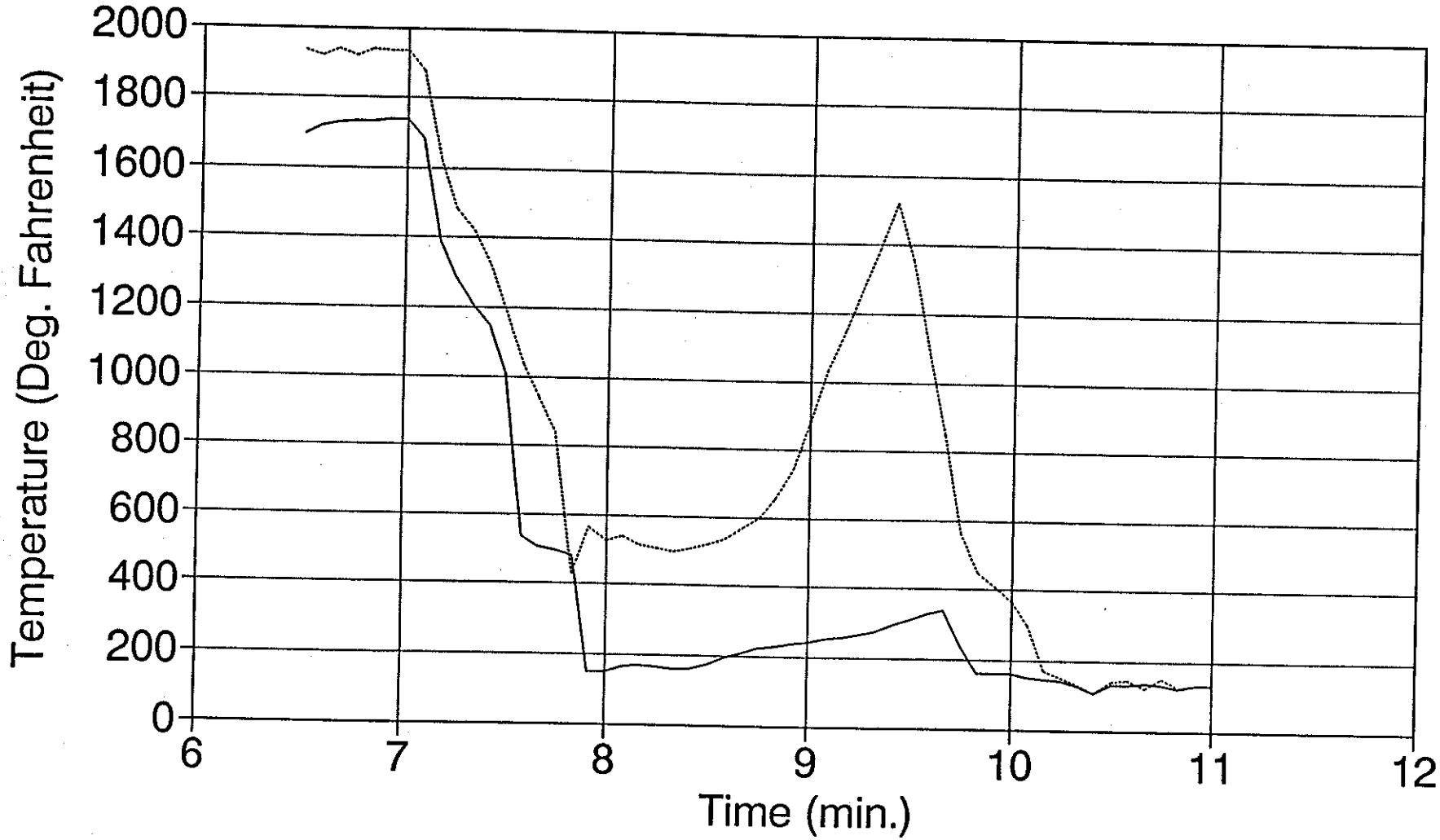
CRIB TEMPS AIR NOZZLE .3% SOLUTION



ILL A14

NFPRF CLASS A FOAM

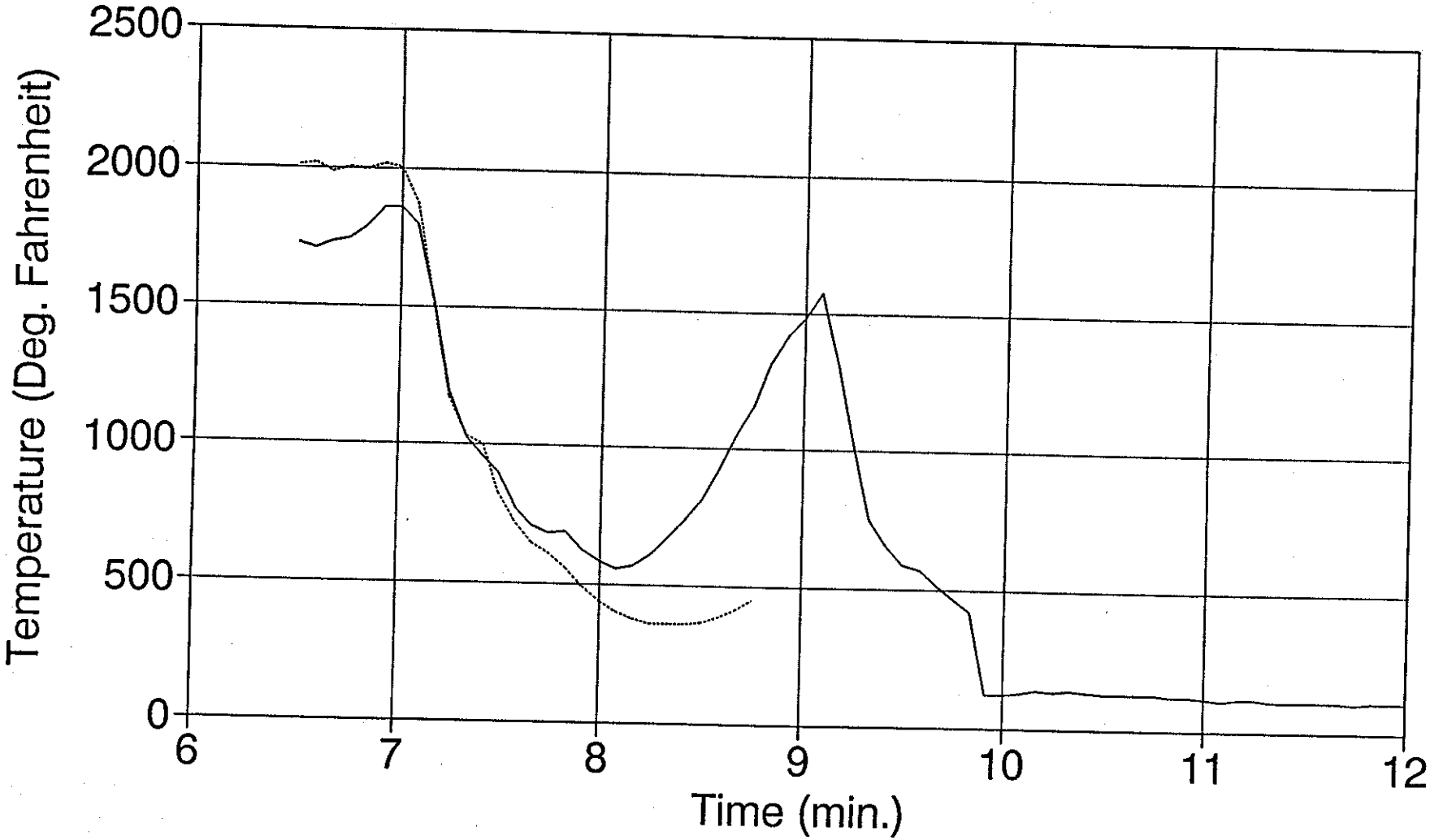
CRIB TEMPS AIR NOZZLE .5% SOLUTION



ILL A15

NFPRF CLASS A FOAM

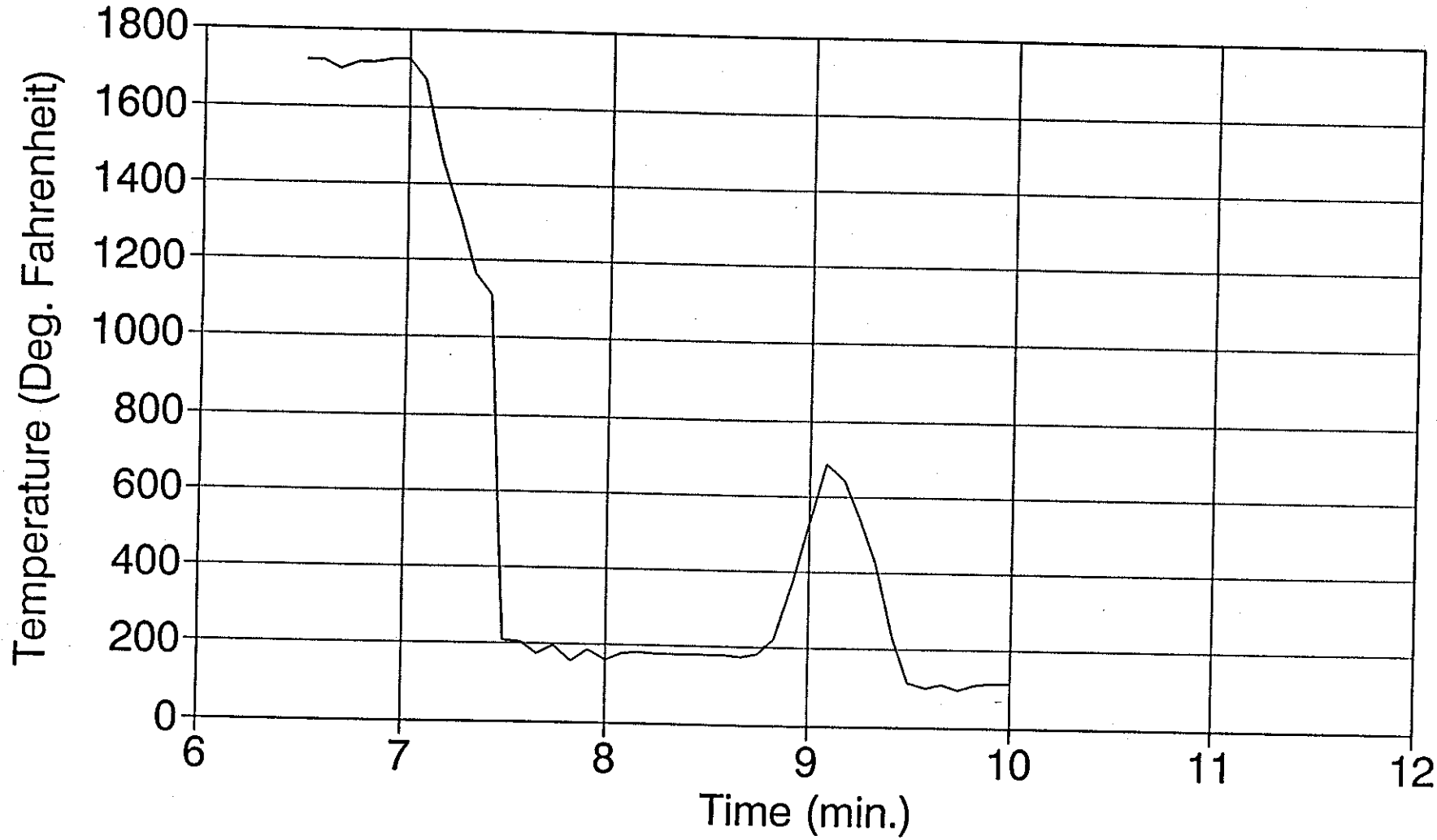
CRIB TEMPS CAF NOZZLE .1% SOLUTION



ILL A16

NFPRF CLASS A FOAM

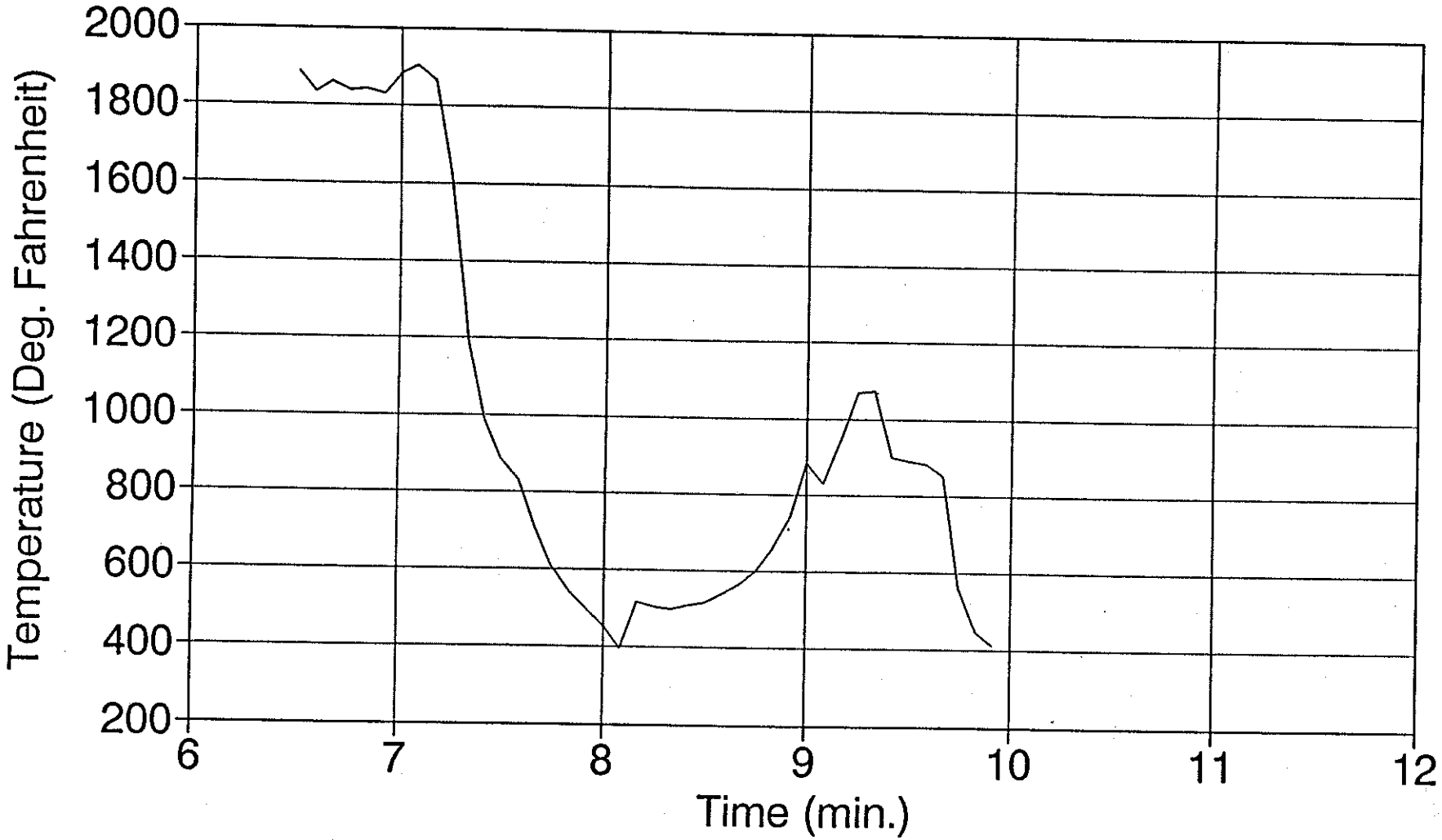
CRIB TEMPS CAF NOZZLE .3% SOLUTION



ILL A17

NFPRF CLASS A FOAM

CRIB TEMPS CAF NOZZLE .5% SOLUTION



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