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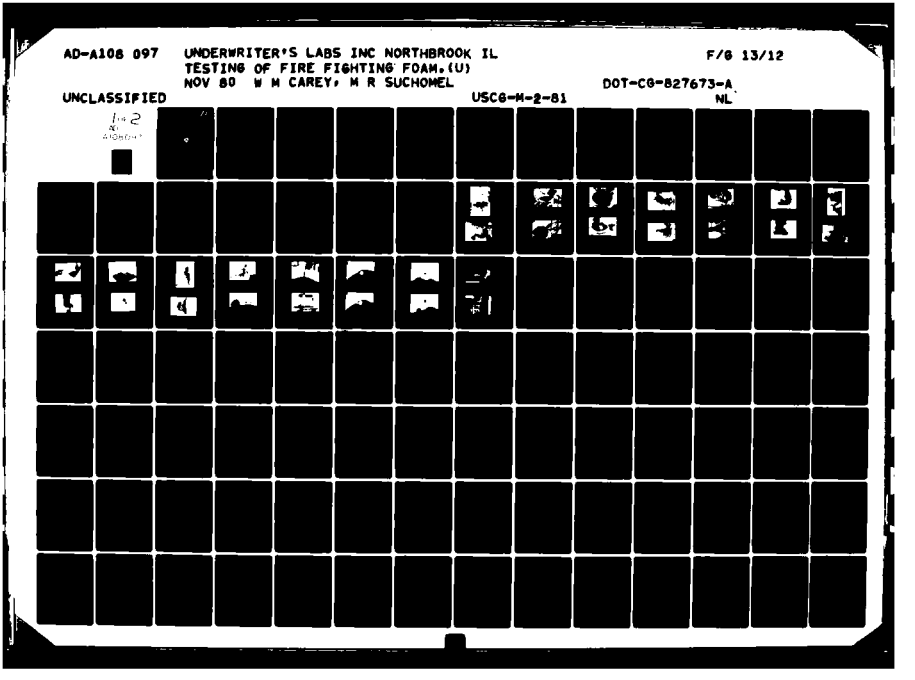

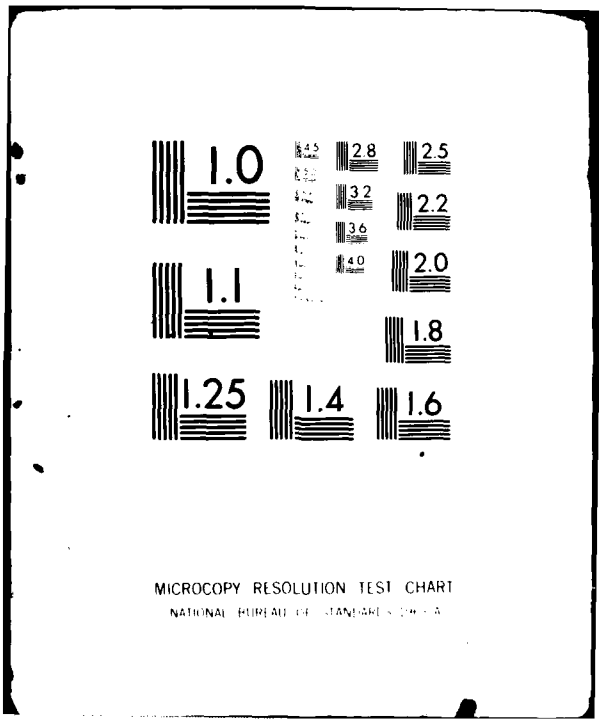
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NATIONAL BUREAU OF STANDARDS-1963-A

Report No. CG-M-2-81

TESTING OF FIRE FIGHTING FOAM

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NOVEMBER 1980

FINAL REPORT

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16. Abstract

The effectiveness of commercially available, non alcohol, fire fighting foams is determined by using four published test methods. These methods are compared to evaluate the required foam characteristics, which include (1) resistance to breakdown when in contact with hot surfaces, (2) ability to control and extinguish fuel fires, (3) sealability of the foam blanket, (4) burnback resistance to contain reignited openings, and (5) compatability with fresh and salt water. The influence of gasoline and n-heptane as test fuels was studied. The test methods used are: (A) Fire Research Note No. 1007 (FRN1007), by S.P. Benson, P. R. Bevan and J.G. Lorrie; (B) Military Specification for Six-Percent Aqueous Film-Forming Foam (AFFF) Fire Extinguishing Agent for Fresh and Sea Water (MIL-F-24385); (C) Underwriters Laboratories Inc. Standard for Air Foam Equipment and Liquid Concentrates (UL162); (D) Federal Specification for Mechanical Fire Extinguishing Foam Liquid (O-F-555C). To minimize the effects of ambient conditions, all tests are indoor-tests.

In general AFFF foams had the best control and extinguishment times. Protein and fluoroprotein foam had the best burnback resistance.

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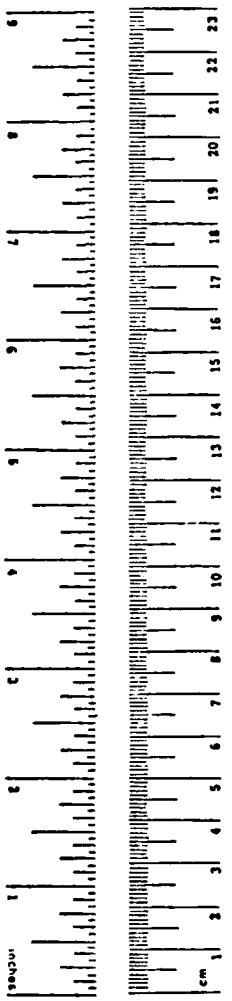
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

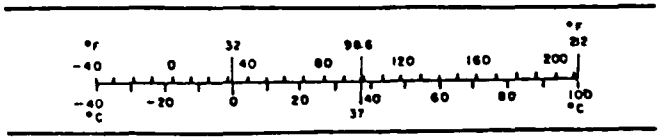
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°f	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°c

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°c	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°f



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LIST OF ABBREVIATIONS AND SYMBOLS

A, AFFF	Aqueous Film Forming Foam
Avg	Arithmetic mean
Cyl	Foam quality test method described in NFPA 11B[8]
D.T.	Drain Time
$\triangle$ %	Difference expressed as a percentage of base number
Exp	Expansion
F	Fresh water
FP	Fluoroprotein Foam
FRN	FRN1007 Test Method
FT	Feet (304.8 mm = 1 ft)
G	Gasoline
gpm	gallons per minute (3.785 liters per minutes - 1 gpm)
H	N-heptane
in.	inch (25.4 mm = 1 in.)
lpm	liters per minute
M	Motor Octane Rating
MIL	MIL-F-24385 Test Method
NFPA	National Fire Protection Association
OF	O-F-555C Test Method
P	Protein Foam
Pan	Foam quality test method described in NFPA 11[9]
psi	pound force per square inch gauge (1 psi = 6.895 kilopascals)
R	Research octane rating
S	Sea water, or simulated sea water
SD	Unbiased standard deviation
Syn	Snythetic foam
UL	Underwriters Laboratories Inc.
UL 162	UL 162 Test Method

I. INTRODUCTION

Title 46 Code of Federal Regulations 34.05 requires that approved foam systems be installed aboard tankers. The foam liquid concentrates used in these systems are required to demonstrate compliance with the fire test requirements of Federal Specification O-F-555C - "Federal Specifications for Mechanical Foam Liquid"(1). Claims have been made that data from one or more of three other test methods should be used for the approval, but the relationship of the results of these test methods to one another and to those of the O-F-555C requirements is not known. In addition, not all currently available foams have been subjected to the Federal Specification O-F-555C.

The objective of this program was to: (1) determine the relative fire-fighting effectiveness of commercially available fire-fighting foams on fires approximating the severity of the early stages of tanker fires, and (2) determine whether or not the four prominently accepted national and international fire-test methods provide comparable and interchangeable measures of fire-fighting effectiveness.

To fulfill the objectives, 26 commercially available, nonalcohol, ordinary temperature foam liquid concentrates were subjected to each of four different evaluation methods. The foams include protein, fluoroprotein, aqueous film forming foam (AFFF) and synthetic foams of various concentrations. Foam performance characteristics which were evaluated include:

1. Resistance-to-breakdown when in contact with hot surfaces.

2. Fire-fighting effectiveness in the control and extinguishment of liquid fuel fires.

3. Sealability of the foam blanket for a measured period of time.

4. Containment of reignited openings in the blanket (i.e., burnback resistance).

5. Compatibility with fresh and sea waters.

In addition to Federal Specification O-F-555C, the procedures of British Fire Research Note 1007(2), MIL-F-24384(3), and Underwriters Laboratories Standard 162(4) were employed. Tests included foams generated with both fresh and sea waters. Test fires were fueled with both gasoline and n-heptane fuels. Foam-quality and physical-property tests were conducted on each foam as specified in each method. Properties of the test fuels were also determined.

II. CONDUCT OF TESTS

A. Test Descriptions

This section describes each of the four test methods and apparatus in general terms. Complete details of each method are contained in references 1 through 4 listed at the end of this report. However, Table 1 summarizes the essential features of the tests.

FRN 1007 - The FRN 1007 test method[2] is a laboratory-scale test designed primarily to compare the relative effectiveness of a foam liquid concentrate when tested with a specific nozzle on different types of fuel. While this test method requires a small amount of equipment and is easy and economical to perform, it is intended primarily to determine the relative effects of varying fuels with a given test nozzle and foam combination. A given foam may produce different foam qualities within the test nozzle than those produced using full-scale foam equipment. The FRN 1007 method does not contain requirements except that the fire must be extinguished within 3 min of foam application. Figures 1 through 8 depict various stages of this test.

A brass 5 lpm standard branch pipe[6], fitted with the diverter specified in FRN 1007, was used. The diverter was adjusted to provide a straight stream discharge into the pan at a flow rate of 0.75 lpm and the remainder discharged to waste as shown in Figures 1, 2, and 3. During calibration, 5.167 lpm flowed through this nozzle at 100 psig (3.3 percent high).

A round brass test pan 15 cm high and 56.5 cm in diameter (2.7 sq ft) was used. The brass burnback pot employed was 11 cm high and had an inside diameter of 12 cm.

MIL-F-34385 - This method, as revised by Amendment 8[3], requires that the foam be applied for 65 sec with a specified test nozzle which produces a fan-shaped, angular discharge pattern. Foam quality and identification tests are specified. This method is intended primarily for evaluating 6 percent aqueous film forming foams (AFFF). The preburn time of 15 sec is shorter than that used in the other test methods studied. Gasoline is the specified test fuel, but both gasoline and heptane were used in the present tests. Figures 9 through 12 show several stages of this test method.

A brass nozzle with a nominal capacity of 2 gpm at 100 psig was used. The outlet was modified by adding a "wing tip" spreader to provide a fan-shaped discharge. During calibration, 1.947 gpm flowed through this nozzle at 100 psig (2.7 percent low). See Figure 10.

The round steel test pan was 5 in. high and 6 ft in diameter (28 sq ft). The steel burnback pan measured was 2 in. high and 12 in. in diameter.

UL 162 - The UL Standard for Air-Foam Equipment and Liquid Concentrates, UL 162, Fourth Edition, is a performance-orientated standard intended to evaluate the suitability of the foam liquid concentrate when used in combination with specific foam equipment. This standard does not specify a standard test nozzle. Rather, it specifies that the foam quality and 25 percent drainage values obtained with a test nozzle be equivalent to those produced with the full-scale foam making equipment. For purposes of uniformity and to maximize the value of comparative data in the tests carried out under this project, the same nozzle was used on all foam tests for this method. Heptane is the specified test fuel, but for this series of tests, both heptane and gasoline were used. The standard contains performance criteria for foam properties, concentration, fire extinguishment, sealability, and resistance to burnback. It has had wide acceptance and use for evaluating both protein, fluoroprotein and synthetic type foam liquid concentrates for use on both alcohol and hydrocarbon type flammable liquids. Although it does not contain specifications for aqueous film forming foams all foams were tested in accordance with the test methods fourth edition. These requirements for aqueous film forming foams have been added to proposed new Fifth Edition of the Standard. See Figures 13 through 18.

Underwriters Laboratories recognizes three types of foam discharge outlets. They are as follows:

Type I - Discharge devices that conduct and deliver foam gently onto the liquid surface without submergence of the foam or agitation of the surface. Examples include porous asbestos tubes, foam troughs along the inside of a tank wall, foam chutes, or foam ladders.

Type II - Discharge devices that do not deliver foam gently onto the liquid surface but are designed to lessen submergence of the foam or agitation of the surface. Examples include foam chambers, subsurface injection equipment, or applying the foam off a blackboard or the wall of a tank.

Type III - Discharge devices that deliver foam directly onto the liquid surface at an angle above the horizontal. Examples include hand held nozzles or monitors.

Type III application was used exclusively for the UL 162 portion. All references to the UL 162 method in the report employ the use of the Type III application only.

The brass nozzle used was the same as that specified for the MIL-F-24385 tests, but fitted with an orifice having a nominal capacity of 3 gpm at 100 psi. The wing tip spreader was not used for these tests. This nozzle was used for all UL 162 tests. Ordinarily, a foam manufacturer is permitted to provide his own nozzle for this test, so long as the foams produced are shown to have the same expansion and 25 percent drain time foams produced by the full size nozzle. Accordingly, this is a modification of standard procedures for this test method and must be considered when reviewing the results. During calibration, 2.96 gpm flowed through this nozzle at 100 psig (1.3 percent low). See Figure 13.

The square steel test pan was 12 in. high and 84.8 in. square (50 sq ft). The square steel burnback container was 12 in. high and 6 in. square, with open top and bottom.

Federal Specification O-F-555C - This method was originally developed for the evaluation of 6 percent protein base foams. This test method requires the use of a specific test nozzle and is generally associated with outdoor fire testing. The large fire size and the gasoline fuel make outdoor tests desirable. However, variations in weather and wind conditions can have a significant and unpredictable effect on the outcome of test conduct outdoors. This test method is depicted by Figures 19 through 28. N-heptane was used in addition to the specified gasoline. The specified test nozzle may not always produce foams having properties and performance equivalent to foam produced from equipment designed specifically for that foam.

A brass nozzle with a nominal capacity of 6 gpm at 100 psi was used. During calibration, 5.99 gpm flowed through the nozzle at 100 psi (0.167 percent low).

A square steel pan 36 in. high and 10 ft square (100 sq ft) was used. The burnback container was the same as that used for the UL 162 tests.

B. Test Materials

1. Foams - Twenty-six foams were selected for the tests and they included protein, fluoroprotein, AFFF, and synthetic foam types. All were nonalcohol, regular temperature foams. A letter symbol has been arbitrarily assigned to each foam concentrate for identification. Foams B, E, G, K, L, O, P, Q, W and Y were produced under the Listing and Follow-Up Service of Underwriters Laboratories Inc. Table 4 shows the generic types and concentrations of the foams.

A sufficient quantity of foam was obtained through a distributor for each foam A through Z to perform all of the tests shown in Table 5. Each foam was from a single manufacturing lot or batch to avoid possible production variations.

The physical properties were determined for the 26 foam concentrates using the test methods given in Table 6. The measured properties are given in Table 7.

In addition, infrared analyses were conducted on all synthetic and AFFF type foams. The results provide comparisons of the basic moecular structures of successive samples, rather than absolute analyses of product composition. Infrared analyses are useful for monitoring factory production changes which might affect foam properties, since the molecular structure of a given synthetic material and its infrared absorption spectrum are well-defined. Copies of the spectra are contained in the Appendix. It should be noted that experience has shown a variation of the infrared absorption spectrum among successive production samples of protein-based foaming agent from a given manufacturer. This is expected and is largely the result of variations in the molecular composition of the natural protein sources used.

Each foam solution was prepared by premixing one batch and using the same solution for one O-F-555C, one UL 162, one or two MIL-F-24385 and up to two FRN 1007 tests. The solution was pumped from a mixing tank into a pressure tank from which it was applied to each of the test fires via hose line and the appropriate foam test nozzle. Foam quality determinations were only made once for each foam solution-nozzle combination. These values are repeated in Tables 9 through 34 for convenience.

2. Fuels - Two different fuels were specified for this test program; n-heptane and regular gasoline, having an average octane rating ((R + M)/2) of 83 to 92. Because it is possible that the effectiveness of a foam may be influenced by the fuel, both fuels were included in the project.

Bulk quantities of n-haptane and gasoline were purchased and stored in tanks to provide uniform fuels for all fire tests. The properties of the fuels were determined and are presented in Tables 2 and 3.

3. Fresh and Sea Water - Since foams will be used with either sea or fresh water, their ability to produce acceptable fire-fighting, sealability and burnback resistance characteristics was measured when mixed with both fresh or sea (salt) water.

The preparation of the substitute sea water followed the methods of ASTM D1141-75, Formula A, Table 1, Sec. 4[7]. Fresh water for the tests was supplied from a spring fed pond.

C. Test Facilities

It appears that O-F-555C and MIL-F-24385 were developed and used for outdoor fire tests; whereas UL 162 and FRN 1007 are primarily indoor fire test procedures. Experience has indicated that outdoor fires are more quickly controlled and extinguished than the same size fire in an indoor situation. Also, outdoor tests involve variable draft conditions which adversely affect the repeatability of test results even when the same foam, water, and fuel combinations are used[5]. In order to achieve repeatability and to address the more severe fire situation, all of the present tests were performed indoors.

All fire tests and foam quality measurements were conducted in two interconnected fire test buildings at the Northbrook, IL testing facilities of UL.

One building, approximately 37 ft by 66-1/2 ft and 22-1/2 ft high, was used in conducting the FRN, MIL and UL 162 tests. This building is connected to a second by a door that is 12 ft wide and 14 ft high. The second building is 40 ft by 40 ft and 50 ft high. It was used in conducting the O-F-555C tests.

The connecting door was open for all tests, and exterior doors were closed at least until fire control was achieved. With the doors closed air for the combustion process was induced through a floor trench system to the outside. Exhaust gases from the fires were collected and passed through gas-fired afterburners for smoke abatement. During the O-F-555C tests, water sprays were employed within the test building to assist in smoke removal and to cool the walls of the test building.

D. Test Procedures

The following test sequences were used for each of the four test methods. In all cases, times required for control and extinguishment to be achieved were recorded. Also recorded were, water temperature, maximum and minimum air temperatures, and maximum and minimum relative humidities. The latter data are given in Table 8.

1. FRN-1007 - The premixed foam solution storage tank was pressurized with air at 100 psi. The foam discharge hose was then connected to the 5 lpm test nozzle and foam was discharged for several minutes to insure that both the line and the test nozzle were fully purged. The diverter on the test nozzle was adjusted to provide a foam solution flow rate of 0.75 lpm. This was accomplished by adjusting the diverter until a 75 g sample was collected in 6 sec. As soon as the nozzle flow rate was adjusted, a foam sample was taken for expansion and drainage time measurements. Both expansion and 25 percent drain time were measured using the pan, and/or cylinder methods, as described by NFPA 11[8] and NFPA 11B[9]. See Figures 29 and 30. In some cases, the foam was too thick to flow into the collection cylinder and foam properties could only be determined using the pan method.

A test nozzle was positioned 25 cm in front of, and 15 cm above, the test pan. Nine liters of test fuel were poured into the test pan, ignited and allowed to burn for 1 min. During this time, the foam discharge was initiated and directed outside the pan. After the 1 min preburn, foam was applied to the test pan by a direct plunge method for a period of 3 min. See Figures 1 through 4.

Whenever a fire was successfully extinguished, the burnback pot, containing 1 liter of test fuel, was positioned in the center of the test pan. One minute after the foam discharge had ceased, the fuel in the burnback pot was ignited and allowed to burn until the entire pan was reinvolved in flame. (Note Figure 5.) Observations were made of the time required for reinvolvement of the entire test pan. See Figures 6, 7, and 8.

2. MIL-F-24385 - The foam discharge hose was connected to the 2 gpm test nozzle. Foam solution was permitted to flow for a period of 1 to 2 min to insure that the test nozzle was purged. A foam sample was then collected for determination of expansion and 25 percent drain time. In some cases using the pan method, the 25 percent drain time was less than 1 min and was not recorded.

Ten gallons of test fuel were placed in the 6 ft diameter test pan, ignited, and permitted to burn freely for 15 sec. See Figure 9. The discharge nozzle was located 3-1/2 ft above the floor and aimed as shown in Figure 10 to permit the maximum amount of the foam discharge to be applied into the test pan. Foam solution was discharged for 65 sec. Other tests, which are indicated with the letter A after the test number, were conducted with the discharge nozzle hand-held rather than fixed for the duration of the test. In these tests, the operator was permitted to move along the perimeter of the test pan and move the nozzle in a side to side motion.

Following extinguishment of the test fire, a 1 ft diameter burnback pan containing 1 qt of fuel was carefully placed in the center of the test pan. The fuel in the burnback pan was ignited 30 sec after the foam discharge ceased and observations were made of the time required for 25 percent of the pan area to be reinvolved. The minimum acceptable burnback time is 4 min.

3. UL 162 - The foam discharge hose was connected to the 3 gpm test nozzle. Foam was discharged for 1 to 2 min before a foam sample was collected for measurement of expansion and 25 percent drain time. In some cases using the pan method, the drain time could not be recorded.

The test nozzle was mounted on a test stand (see Figure 13) approximately 3-1/2 ft above the floor and 6 ft in front of the test pan and aimed so that the foam would strike the fuel surface approximately 1 ft in front of the rear edge of the test pan. Sixty-five gallons of fuel were placed in the test pan, ignited and allowed to burn freely for 1 min. Foam was applied to the test pan for a duration of 5 min. For subsequent tests, fresh fuel was added to maintain a 2 in. layer of n-heptane. See Figures 14, 15, and 16.

Following the foam application, the foam blanket was left undisturbed for 15 min. During this time, a lighted torch was passed over the foam blanket to determine its ability to seal vapors from the fuel and prevent reignition. See Figures 17 and 18.

Following the 15 min torch test, a 6 by 6 in. steel container was placed into the foam blanket approximately 2-1/2 ft from two adjacent sides of the test pan. The exposed fuel surface was ignited and allowed to burn freely for 1 min before the container was removed. Observations were made to determine that the reinvolved area did not exceed 4 sq ft within 5 min.

4. O-F-555C - The foam discharge hose was connected to a 6 gpm test nozzle. Foam was allowed to flow through the nozzle for 1 to 2 min before a foam sample was collected for determination of expansion and 25 percent drain time.

Seventy-five gallons of test fuel were placed in the 100 sq ft test pan for the first test of each day. Twenty-five gallons were added for each subsequent test. The fuel in the test pan was ignited and allowed to burn freely for 1 min. See Figure 19.

The foam nozzle was positioned directly over the front edge of the test pan and aimed so as to strike the back side of the test pan approximately 12 in. above the fuel surface, as shown in Figure 22. Foam was applied to the test pan for a duration of 5 min. See Figures 20 and 21.

Following the 5 min of foam application, the foam surface was left undisturbed for 10 min. As shown by Figure 23, a lighted torch was passed around the test pan for the period 10 to 14 min without touching or penetrating the foam. From 14 to 15 min after completion of the foam application, the lighted torch was permitted to touch the foam blanket but not penetrate more than 1/2 in. During this time, no sustained reignition shall occur. See Figure 24.

Following completion of the torch test, a 6 by 6 in. steel container was placed into the blanket approximately 2 ft from the front and right side of the pan and the foam removed. See Figure 25. The exposed fuel was ignited and allowed to burn freely for 1 min before the container was removed. See Figures 26 and 27. It is required that the reinvolved area should not exceed a 20 by 20 in. square for 5 min.

Fig. 1
FRN Nozzle Being Positioned

Fig. 2
Foam Beginning to Control
FRN Pan

C80-15742

Fig. 3
Control of FRN Test Pan

Fig. 4
Near Extinguishment Fire
Burning on Back Edge

C80-15743

Fig. 5
Ignition of Burnback Pot

Fig. 6
Fire Spreading Over Foam Surface

C80-15744

Fig. 7
Pan Approximately 90% Reinvolved

Fig. 8
Pan Completely Reinvolved

Fig. 9
Fuel Being Placed In MIL Test Plan

Fig. 10
Nozzle And Fan Tip Being Positioned
For MIL Fire Test

C80-15746

Fig. 11
Foam Being Applied Into MIL Test Pan

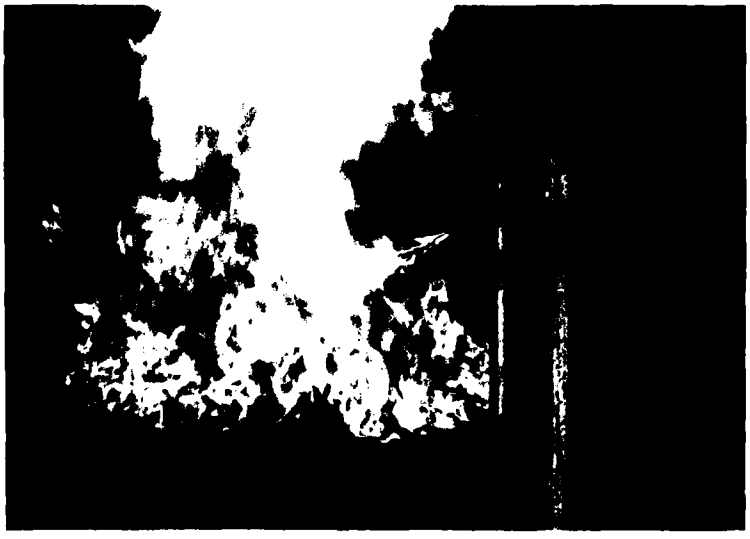


Fig. 12
Foam Being Applied Into Test Pan

Fig. 13
Positioning Of UL162 Test Nozzle

Fig. 14
Foam Beginning To Cover Test Pan

Fig. 15
Control Of Test Fire

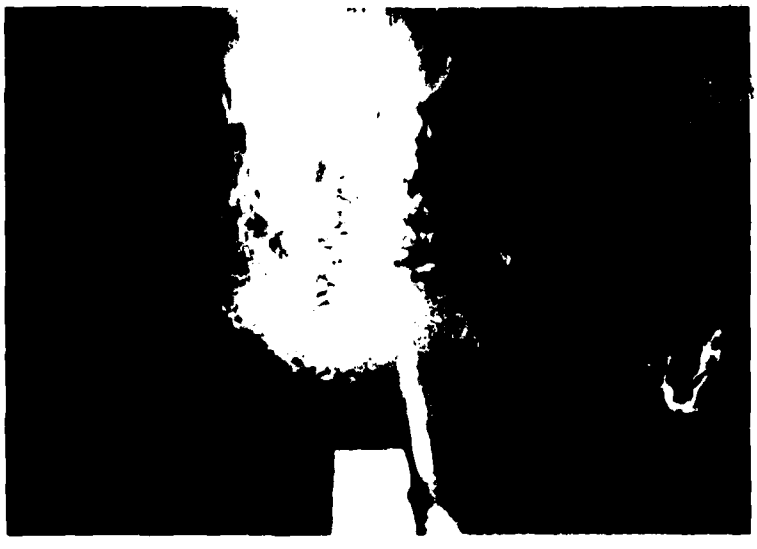


Fig. 16
Fuel Burning In Front Corners
And Foam Plunge Area

C80-15749

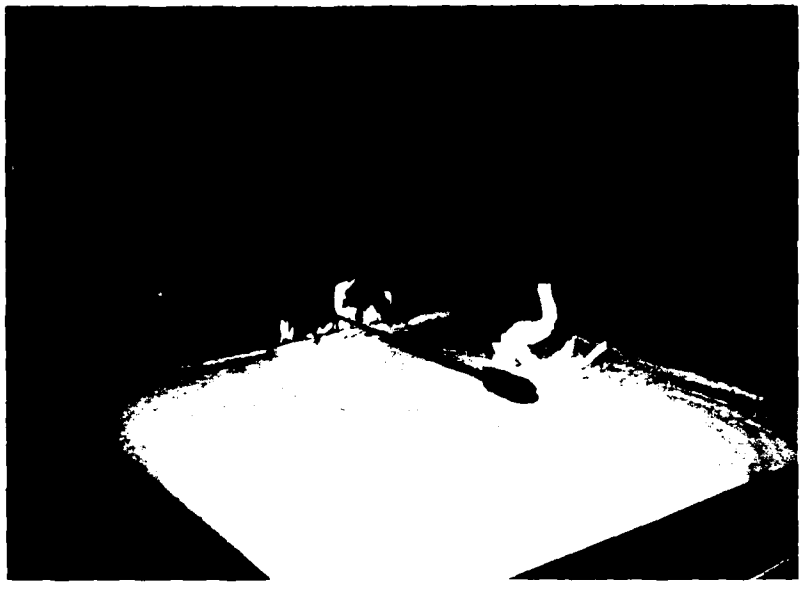


Fig. 17
Passing Of Torch Accross Center
With Fire Burning Along Edge Of UL Pan

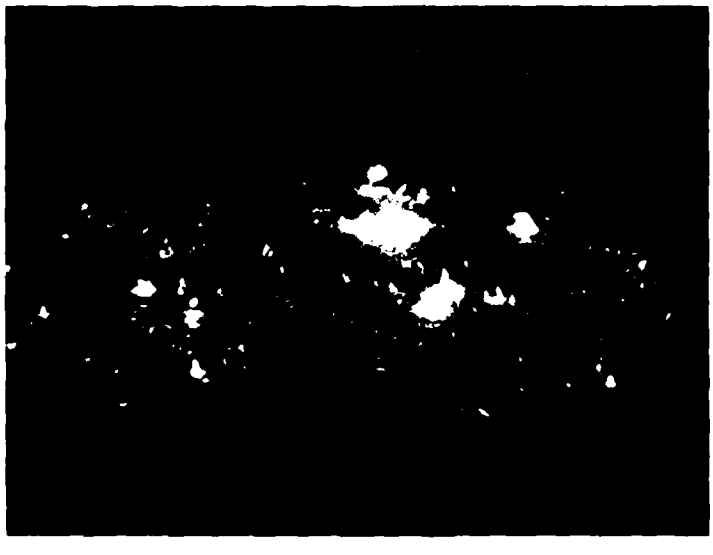


Fig. 18
Ghosting Of Flames Accross Pan

C80-15750

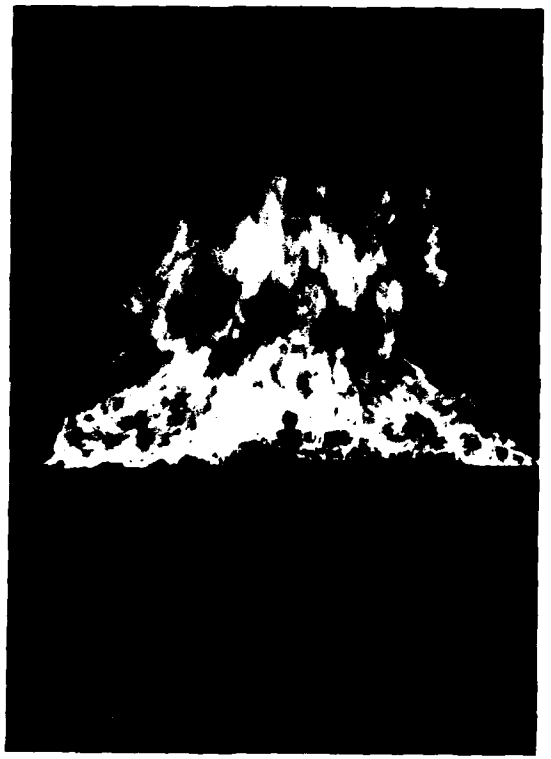


Fig. 19
Preburn Of 100 Sq. Ft. OF Test Pan

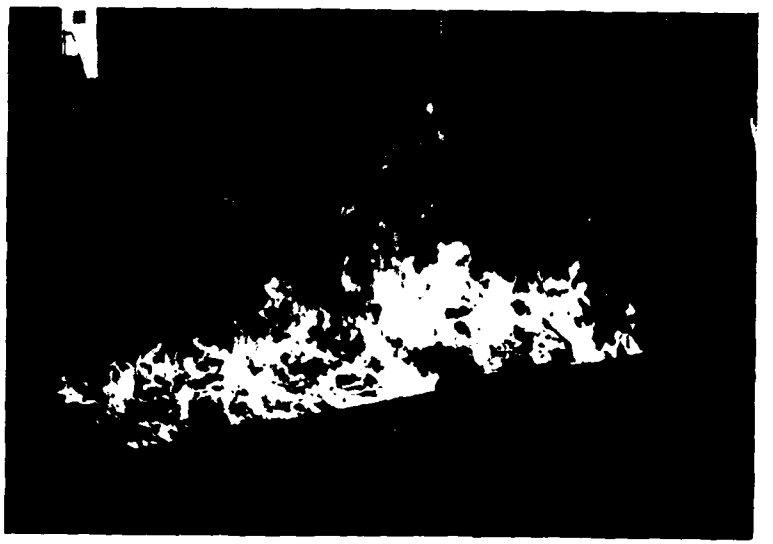


Fig. 20
Foam Beginning to Cover
OF Test Pan

C80-15751

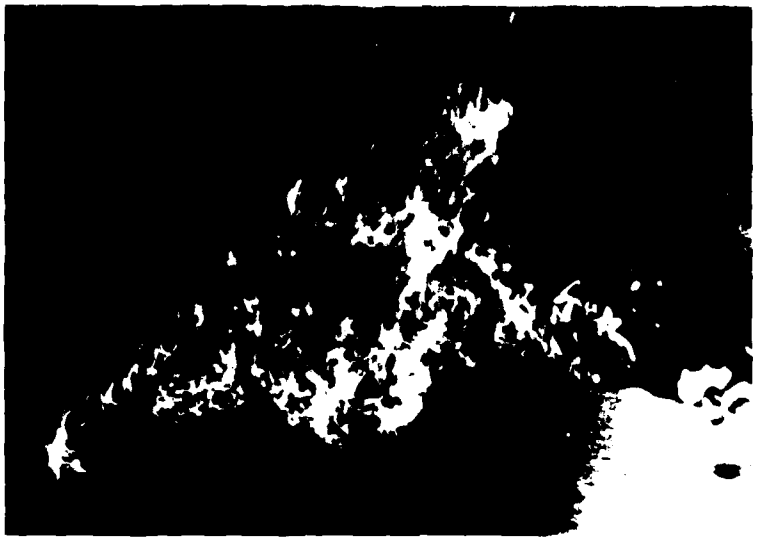


Fig. 21
Fire Burning In Front Corner

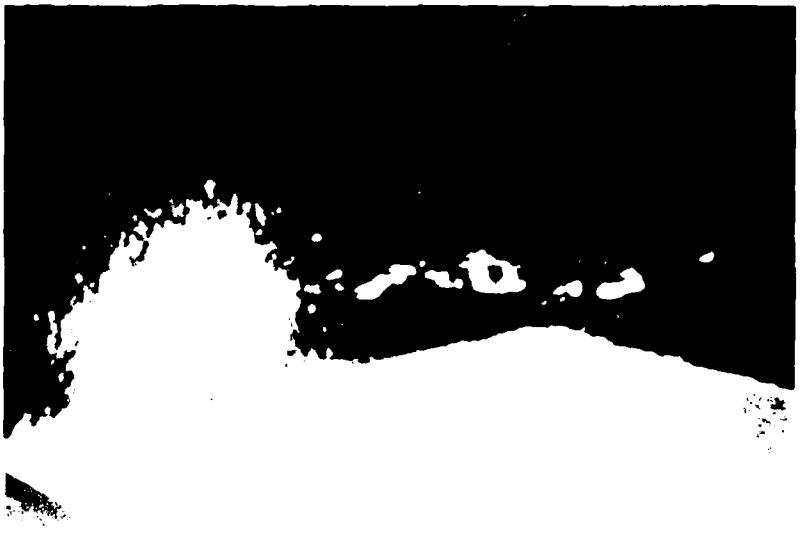


Fig. 22
Extinguishment - Foam Striking Back
Edge Of Of Test Pan

Fig. 23
Passing Torch Around OF Test Pan

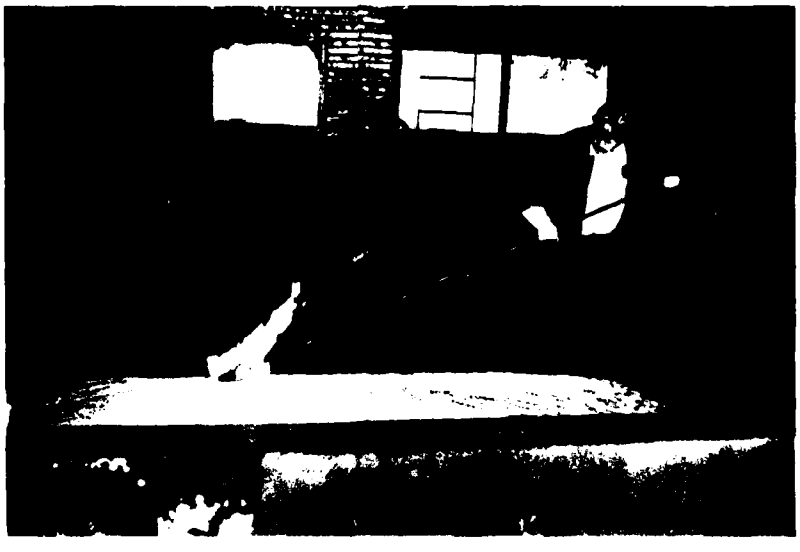


Fig. 24
Torch Point Placed 1/2 Inch In
Foam Blanket

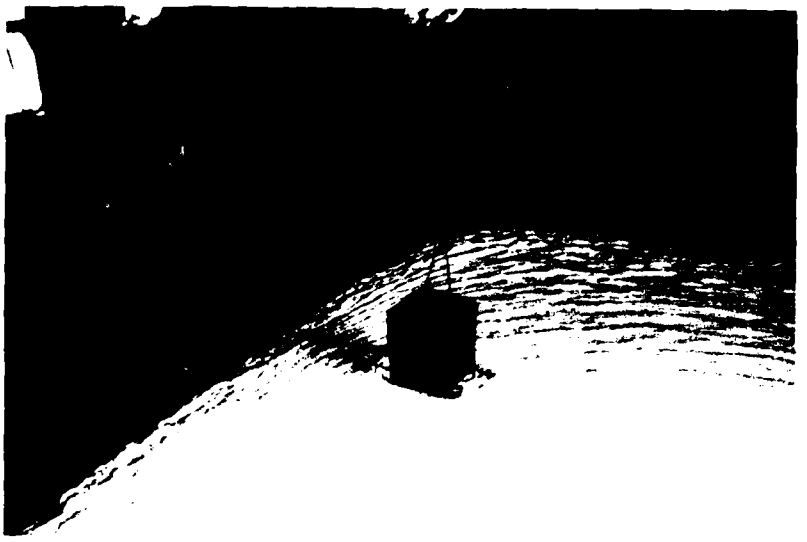


Fig. 25
Burnback Container Being Placed
In Foam Blanket

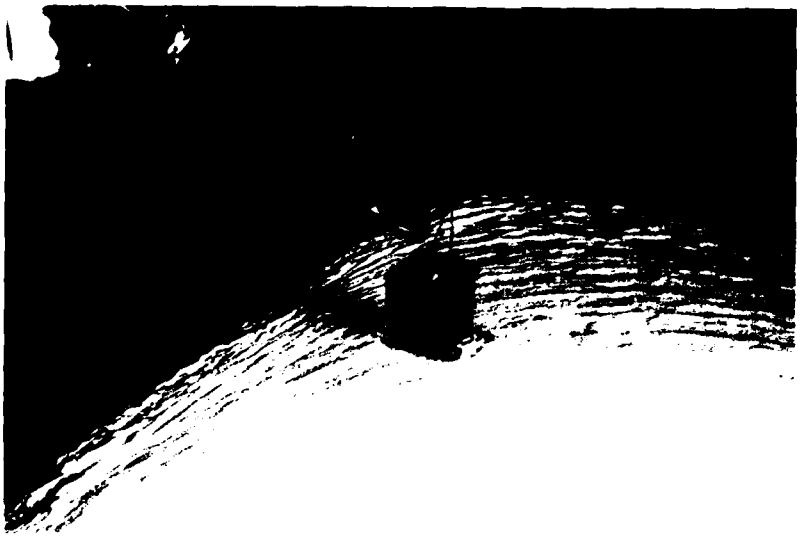


Fig. 26
Ignition Of Exposed Fuel - OF Test
Method

C80-15754

Fig. 27
Burnback Container Being Removed
From OF Pan

Fig. 28
6 By 6 In. Opening Burning In
Foam Blanket

C80-15755

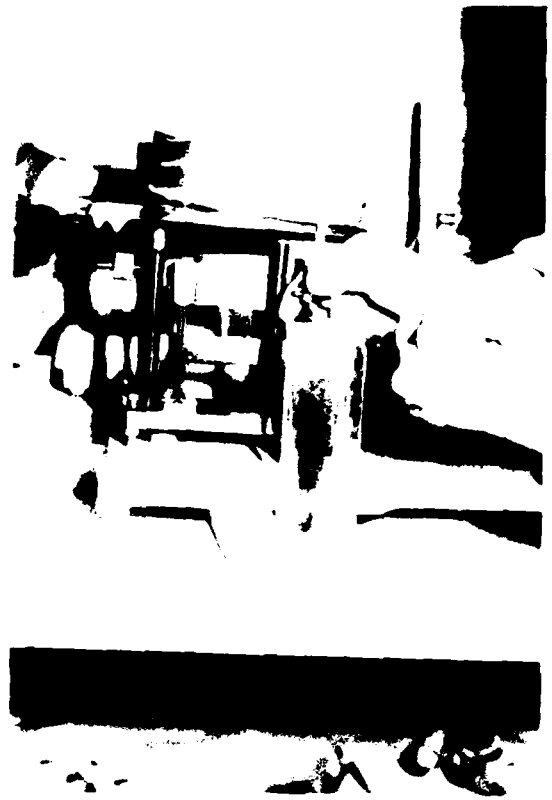


Fig. 29
Foam Quality Apparatus Pan Method

Fig. 30
Foam Quality Apparatus Cylinder Method

TABLE 1

COMPARISON OF FIRE TEST METHODS

Test Parameter	TEST METHOD			
	FRN-1007	MIL-F-24385	UL162	O-F-555C
Test Pan Shape	Round	Round	Square	Square
Area, Sq Ft	2.7	28	50	100
Height of Pan, In.	5.9	5	12	36
Fuel Type	Not specified	Gasoline	n-Heptane	Gasoline
Fuel Depth, In.	1.0	0.7	2.0	1.2
Freeboard, In.	4.9	4.4	6.0	24.0
Preburn, Sec	60	15	60	60
Application Method	Plunging	Fan Shaped Discharge	Plunging	Off Backboard
Application Rate, GPM Per Sq Ft	0.07	0.07	0.06	0.06
Application Duration, Sec	180	65	300	300
Extinguishing Time, Sec	180	65	300	300
Control Time, Sec	Not specified	Not specified	Not specified	240
Coverage Time, Sec	Not specified	Not specified	Not specified	120
Torch Period, Min	None	None	15	15
Burnback Area, Sq In.	17.5	37.7	36	36
Maximum Burnback Area, Sq In.	Entire Pan	1008	576	400
Burnback Duration, Sec	Not specified End of test	240	300	300

TABLE 2

PHYSICAL PROPERTIES OF TEST FUELS

Property	Gasoline	Heptane
Specific Gravity, 60 F/60 F	0.737	0.719
Reid Vapor Pressure, PSI	8.1	2.0
Research Octane Rating	92.5	60.0
Motor Octane Rating	84.3	50.6
Barometric Pressure	752.7 mm of Hg at 24 C	749.7 mm of Hg at 24 C

TABLE 3

DISTILLATION TEST RESULTS

Recovery, ML	Temperature C Gasoline	Heptane
Initial Boiling Point	30.0	89.5
10	53.0	91.5
20	64.5	92.0
30	76.0	92.5
40	88.5	92.5
50	100.5	93.0
60	112.0	93.5
70	126.0	94.0
80	148.5	94.5
90	178.0	95.5
95	199.0	96.5
End Point	224.5	125.0
Recovery, ML	98.0	99.0
Residue, ML	1.0	0.5

TABLE 4

COMMERCIALLY AVAILABLE FOAM LIQUID CONCENTRATES

Letter Identification	Type	Percent Concentration
A	Protein	3
B	Protein	6
C	Synthetic	3
D	Synthetic	6
E	Protein	3
F	Protein	6
G	Fluoroprotein	3
H	Fluoroprotein	6
I	AFFF	3
J	AFFF	6
K	AFFF	3
L	AFFF	6
M	AFFF	3
N	AFFF	6
O	AFFF	3
P	AFFF	6
Q	AFFF	3
R	AFFF	6
S	Protein	3
T	Protein	6
U	Fluoroprotein	3
V	Fluoroprotein	6
W	Protein	3
X	Protein	6
Y	Fluoroprotein	3
Z	Fluoroprotein	6

TABLE 5

SUMMARY OF TEST METHOD VS. FUEL-WATER COMBINATION

	Test Method			
Fuel-Water	FRN1007	MIL-F-24385	UL162	O-F-22351
Fresh Water-Gasoline	All Foams	All Foams	Selected Foams	All Foams
Fresh Water-Heptane	All Foams	Selected Foams	All Foams	Selected Foams
Sea Water-Gasoline	Selected Foams	All Foams	Selected Foams	All Foams
Sea Water-Heptane	Selected Foams	Selected Foams	All Foams	Selected Foams

TABLE 6

TEST METHODS FOR DETERMINING PHYSICAL PROPERTIES

Property	Test Method
Flash point	ASTM D56
Specific gravity	ASMT D1298
Viscosity	ASTM D88
pH	Electrometric means
Pour point	ASTM D97
Sedimentation	ASTM D96
Precipitation	ASTM D96

TABLE 7

PHYSICAL PROPERTIES OF FOAM CONCENTRATES

Foam	Concentrates	Type	Specific Gravity at 60 F/60 F	Pour Point, F	pH	Flash Point,[a] F	Viscosity, Centistokes at 68 F	Viscosity, Centistokes at 32 F	Sedimentation, Percent by Volume[b]	Precipitation Percent by Volume
A	3 percent	Protein	1.180	-31	7.3	No flash to 150	26.6	80.2	less than 0.04	less than 0.02
B	6 percent	Protein	1.163	6	7.1	No flash to 145	20.3	51.0	less than 0.02	less than 0.02
C	3 percent	Synthetic	0.990	28	6.2	Flashed at 110	7.96	c	less than 0.02	0.10[d]
D	6 percent	Synthetic	0.990	42	3.6	Flashed at 108	9.43	c	less than 0.02	less than 0.02
E	3 percent	Protein	1.165	14	7.0	No flash to 130	14.6	36.8	0.40	less than 0.02
F	6 per cent	Protein	1.107	25	7.2	No flash to 130	3.85	7.89	0.90	less than 0.02
G	3 per cent	Fluoroprotein	1.181	-2	7.2	No flash to 140	31.5	91.5	less than 0.02	less than 0.02
H	6 percent	Fluoroprotein	1.070	30	7.2	No flash to 140	2.18	4.42	0.15	less than 0.02
I	3 percent	AFFF	1.007	30	6.7	No flash to 155	2.65	6.02	none	less than 0.02
J	6 percent	AFFF	1.007	32	6.9	No flash to 170	1.85	3.72	none	less than 0.02
K	3 percent	AFFF	1.026	32	8.1	No flash to 150	3.22	7.10	less than 0.04	less than 0.02
L	6 percent	AFFF	1.015	27	8.2	No flash to 150	2.78	6.96	less than 0.04	less than 0.02
M	3 percent	AFFF	1.026	32	8.2	No flash to 140	3.21	6.66	less than 0.02	less than 0.02
N	6 percent	AFFF	1.015	27	8.3	No flash to 140	2.57	5.70	less than 0.02	less than 0.02

Table Continued On Next Page.....

TABLE 7

PHYSICAL PROPERTIES OF FOAM CONCENTRATES

Foam	Concentrates	Type	Specific Gravity at 60 F/60 F	Pour Point, F	pH	Flash Point,[a] F	Viscosity, Centistokes at 68 F	Viscosity, Centistokes at 32 F	Sedimentation, Percent by Volume[b]	Precipitation Percent by Volume
O	3 percent	AFFF	1.055	-29	8.0	No flash to 140	9.51	23.5	less than 0.02	less than 0.02
P	6 percent	AFFF	1.020	30	7.7	No flash to 185	2.59	5.54	less than 0.02	less than 0.02
Q	3 percent	AFFF	1.066	19	8.2	No flash to 125	22.2	48.3	less than 0.04	0.20[d]
R	6 percent	AFFF	1.044	32	7.8	No flash to 135	2.38	4.78	less than 0.04	less than 0.02
S	3 percent	Protein	1.142	13	6.8	No flash to 145	35.7	111	none	none
T	6 percent	Protein	1.154	5	6.8	No flash to 135	19.5	51.6	none	none
U	3 percent	Fluoroprotein	1.145	14	6.7	No flash to 135	40.3	130	0.15	less than 0.02
V	6 percent	Fluoroprotein	1.152	8	6.7	No flash to 135	26.9	75.5	0.25	less than 0.02
W	3 percent	Protein	1.163	9	7.3	No flash to 125	57.0	200	less than 0.02	less than 0.02
X	6 percent	Protein	1.152	12	7.4	No flash to 125	56.7	199	less than 0.02	less than 0.02
Y	3 percent	Fluoroprotein	1.169	6	7.4	No flash to 140	66.6	240	less than 0.02	none
Z	6 percent	Fluoroprotein	1.153	8	7.3	No flash to 135	56.3	211	less than 0.02	none

a - In tests where no flash was obtained, the testing was discontinued when the test flame was extinguished by the foam vapors.

b - In all of these tests, any sedimentation formed passed through an 80 mesh sieve and was completely dispersible on mild shaking.

c - Sample was solidified at 32 F.

d - These liquids were readily miscible with the synthetic sea water, but a white cloudy precipitate formed on mixing.

TABLE 8

ATMOSPHERIC CONDITIONS

Tests	Water Temp, °F		Air Temp, °F		Relative Humidity, %	
	Morn.	Afternoon	Min.	Max.	Min.	Max.
1-[illegible]	75	-	64	70	80	[illegible]
[illegible]-13	75	75	70	76	[illegible]	86
1[illegible]-22	75	76	60	73	50	[illegible]
23-31	76	77	70	79	[illegible]	[illegible]
32-40	76	76	65	79	[illegible]	[illegible]
41-49	76	76	68	[illegible]	[illegible]	[illegible]
50-55	77	76	66	[illegible]	60	[illegible]
56-64	75	76	[illegible]	[illegible]	[illegible]	80
65-70	75	76	70	[illegible]	[illegible]	[illegible]
71-79	74	74	62	[illegible]	[illegible]	[illegible]
80-88	70	72	60	[illegible]	60	[illegible]
89-97	64	58	-7	[illegible]	[illegible]	[illegible]
98-106	58	56	54	[illegible]	[illegible]	
107-115	73	72	56	[illegible]	[illegible]	[illegible]
116-124	65	65	58	[illegible]	[illegible]	1
125-130	65	70	[illegible]	74	[illegible]	[illegible]
131-136	68	72	[illegible]	[illegible]	[illegible]	[illegible]
137-142	72	74	56	[illegible]	[illegible]	[illegible]
143-151	70	72	60	[illegible]	30	[illegible]
152-157	[illegible]	70	56	[illegible]	[illegible]	[illegible]
158-166	60	60	[illegible]	74	[illegible]	[illegible]
167-173	[illegible]	61	[illegible]	61	[illegible]	[illegible]
176-183	[illegible]	61	[illegible]	61	68	[illegible]
184-192	65	[illegible]	[illegible]	[illegible]	60	[illegible]
193-199	[illegible]	[illegible]	45	[illegible]	[illegible]	[illegible]

TABLE 8

cont'd

Tests	Water Temp, °F		Air Temp, °F		Relative Humidity, %	
	Morn.	Afternoon	Min.	Max.	Min.	Max.
200-205	68	68	69	75	[illegible]	[illegible]
206-212	[illegible]	62	52	[illegible]	[illegible]	100
213-223	60	60	38	-2	60	65
224-234	50	58	34	50	34	80
233-241	60	N/A	36	[illegible]	40	7[illegible]
242-247	60	58	30	48	40	80
248-256	58	60	30	58	40	100
257-265	57	60	37	41	60	[illegible]
266-274	56	60	30	38	50	68
275-283	50	52	36	-2	30	7[illegible]
284-289	52	58	32	-3	75	[illegible]
291-296	56	56	25	32	4[illegible]	80
303-311	56	56	30	38	60	72
297-302	52	52	30	40	[illegible]8	80
312-314	52	52	40	45	62	8[illegible]

III. RESULTS OF TESTS

At least three trials were conducted with each method on each of the 26 foams. Since each trial contained fire performance and foam quality determinations, the data is extensive. The results are shown for foams A through Z in Tables 9 through 34. The differences in foam quality results for similar test conditions may be attributed to normal test variations. The tables arrange the data to illustrate the way each foam reacted to the four test methods. Atmospheric conditions for each test are provided in Table 8.

To show the way in which the foams reacted to each test method, the data is regrouped per test method and tabulated again in Tables 35 through 51. The following summarizations may help further illustrate the very extensive data.

A. FRN-1007

PROTEIN FOAMS - TABLE 35

Twenty-five tests on eight protein foams were conducted. Control was achieved in 23 of these tests and the average control was 1.82 min. Twenty-one of the fires were extinguished with an average extinguishment time of 2.38 min. The protein foams had an average burnback time in 21 of the tests of 18.99 min.

SYNTHETIC FOAMS - TABLE 36

Six tests were conducted using synthetic foams. Control was achieved in five of these tests with an average control time of 1.29 min. Two of the six fires were extinguished with extinguishment times of 1.19 and 2.87 min. The average burnback time was the least of all foams used with an average of 6.13 min.

FLUOROPROTEIN - TABLE 37

Eighteen tests were conducted with fluoroprotein foams, and extinguishment was achieved in 17 of these tests. The average control time was 1.11 min and average extinguishment time was 1.76 min. The average burnback time for these 17 tests was 18.84 min.

AFF - TABLE 38

Control was achieved in all 32 tests with an average control time of 0.682 min. Twenty-seven of these fires were extinguished with an average time of 0.86 min. The average burnback time was 8.90 min.

Table 39 and Figures 31 and 32 provides a further summarization of the test results on this method. The table contains average performance values for each foam type and overall averages grouped to show the effects of fuels, water, and concentratations. This was the only test method with sufficient data to develop such a summarization.

B. MIL-F-24385

The results of the tests according to MIL-F-24385 can be summarized as follows:

PROTEIN FOAMS - TABLE 40

Control was achieved in one of the 24 tests conducted with protein foams. The control time was 1.05 min. None of the fires was extinguished.

SYNTHETIC FOAM - TABLE 41

No control or extinguishment was achieved in the six tests conducted.

FLUOROPROTEIN - TABLE 42

Control was achieved in two of the 18 tests conducted. Control times were 0.83 and 1.08 min. None of the fires were extinguished.

AFFF - TABLE 43

Control was achieved in 51 of the 59 tests conducted with an average control time of 0.78 min. Twelve test fires were extinguished with an average extinguishment time of 0.91 min. Acceptable burnback results were obtained in ten tests.

C. UL 162

The results of the UL 162 tests can be summarized as follows:

PROTEIN FOAMS - TABLE 44

Control was achieved in 14 of the 24 tests conducted with an average control time of 3.59 min. None of the fires was extinguished.

SYNTHETIC FOAM - TABLE 45

Control was achieved in two of the six tests conducted with a control time of 1.58 and 0.92 min. Extinguishment was not obtained in any of the tests.

FLUOROPROTEIN - TABLE 46

Control was obtained in 15 of the 18 tests conducted with average control time of 2.99 min. Four of the test fires were extinguished and the average extinguishment time was 4.23 min. Three foams passed the torch test and one foam passed the burnback resistance test.

AFFF - TABLE 47

Control was achieved in all of the 30 tests conducted with an average control time of 1.66 min. Eighteen of the foams extinguished the test fire with an average extinguishment time of 2.73 min. None of the foams passed the torch or burnback tests.

D. O-F-555C

The following results were obtained in the O-F-555C tests.

PROTEIN - TABLE 48

Control was obtained in 22 of the 24 tests conducted with an average control time of 2.41 min. The fire was extinguished in 20 of the tests with an average extinguishment time of 3.60 min. Six foams met the torch and burnback resistance requirements.

SYNTHETIC FOAM - TABLE 49

Control was obtained in all of the five tests conducted with an average control time of 1.45 min. Three of the five fires were extinguished with an average extinguishment time of 3.36 min. None of the foams passed the torch or burnback resistance test.

FLUOROPROTEIN - TABLE 50

Control was achieved in all 18 tests conducted with an average control time of 1.71 min. Seventeen of the test fires were extinguished with an average extinguishment time of 2.94 min. Successful torch tests results were obtained in 16 of the tests and acceptable burnback resistance results were obtained in 12 tests.

AFFF - TABLE 51

Control was achieved in all 30 tests conducted with an average control time of 1 min. Twenty-five of the fires were extinguished with an average extinguishment time of 2.08 min. Six passed the torch test and four passed the burnback resistance test.

E. Foam Quality

The foam quality tests, as specified by the pan method (NFPA 11[2]) and cylinder method (NFPA 11B[2]), are summarized by Tables 52, 53, and 54 and by Figures 33 through 42.

The purpose of Tables 52 through 54 is not to provide a ranking of foams based upon foam quality, but merely to provide tabular representations of this data.

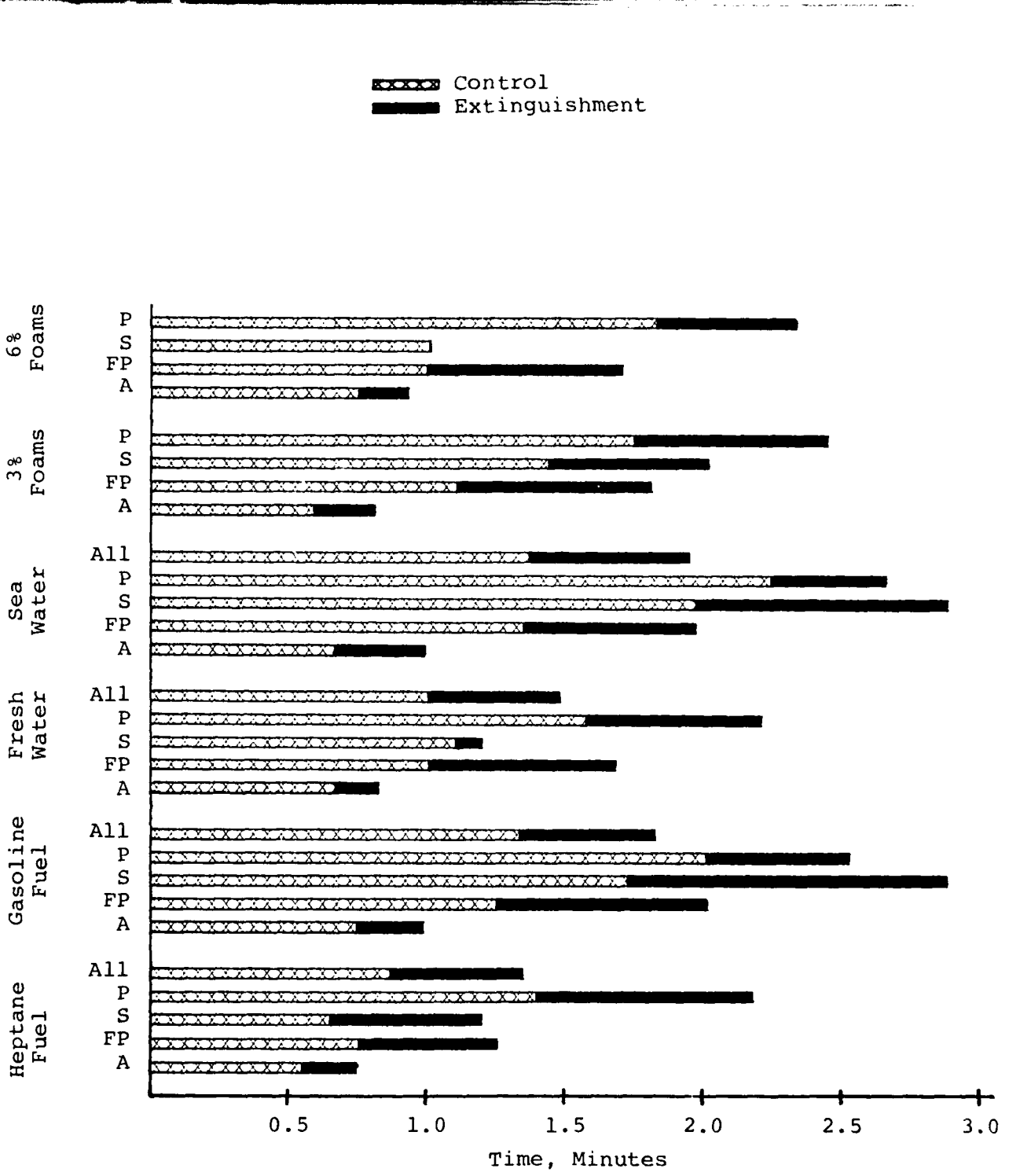


Fig. 31 Comparison Of Average FRN Fire Control And Extinguishment Time With Foams, Waters, And Concentrations

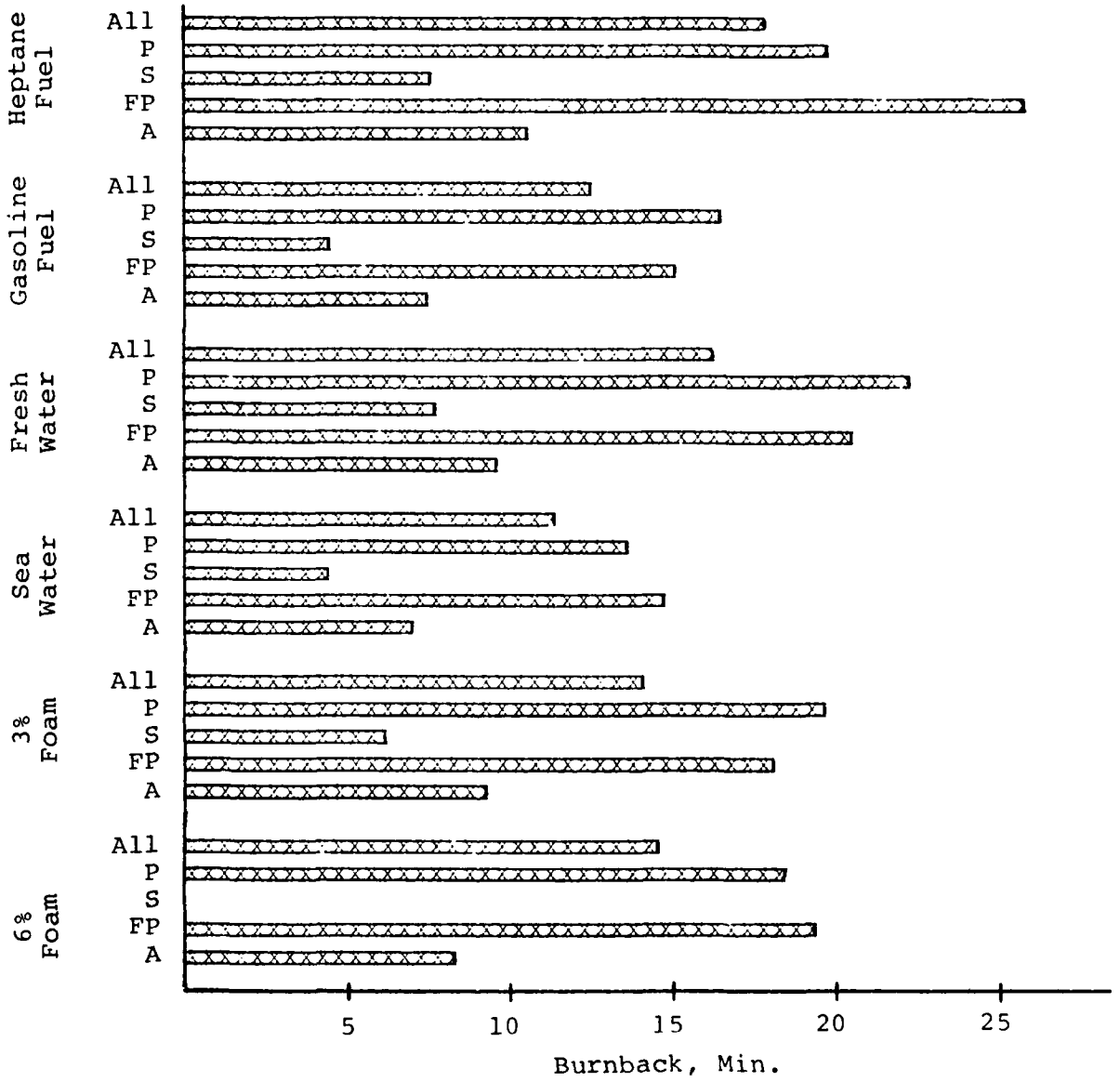


Fig. 32 Comparison Of Average FRN Burnback Resistance With Foams, Fuels, Waters, And Concentrations.

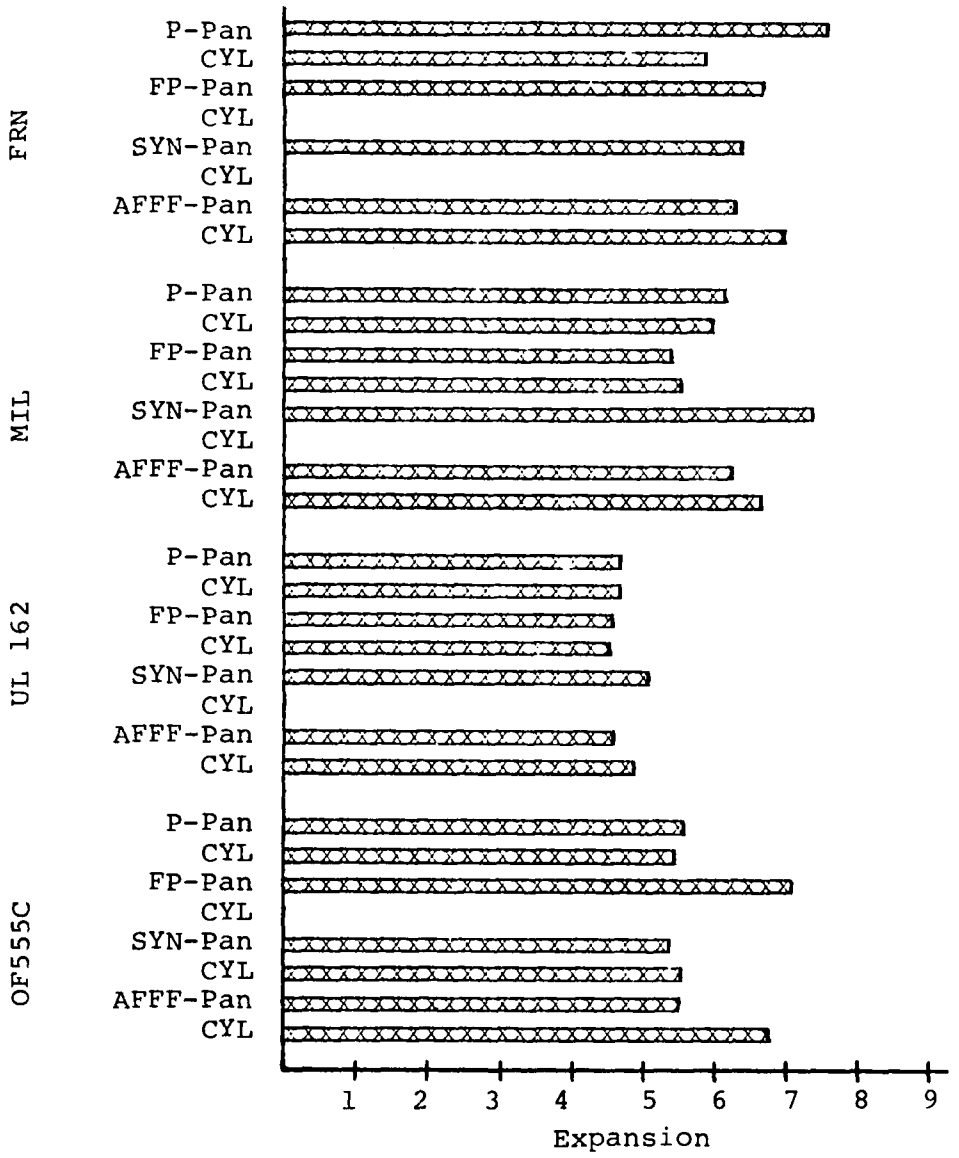


Fig. 33. Comparison Of Average Expansion Values For Test Methods And Foams

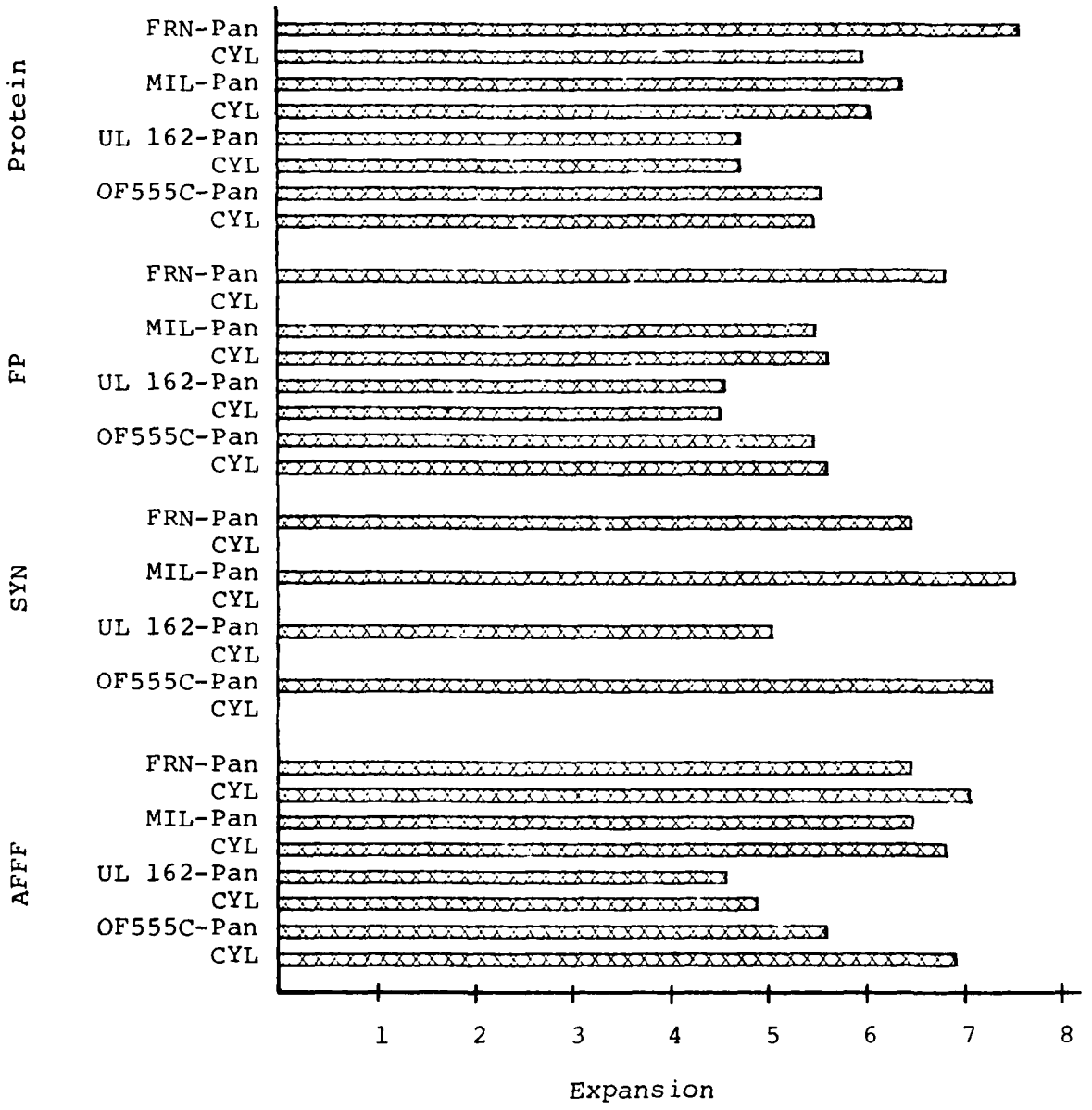


Fig. 34 Comparison Of Average Expansion Values For Foams And Test Methods

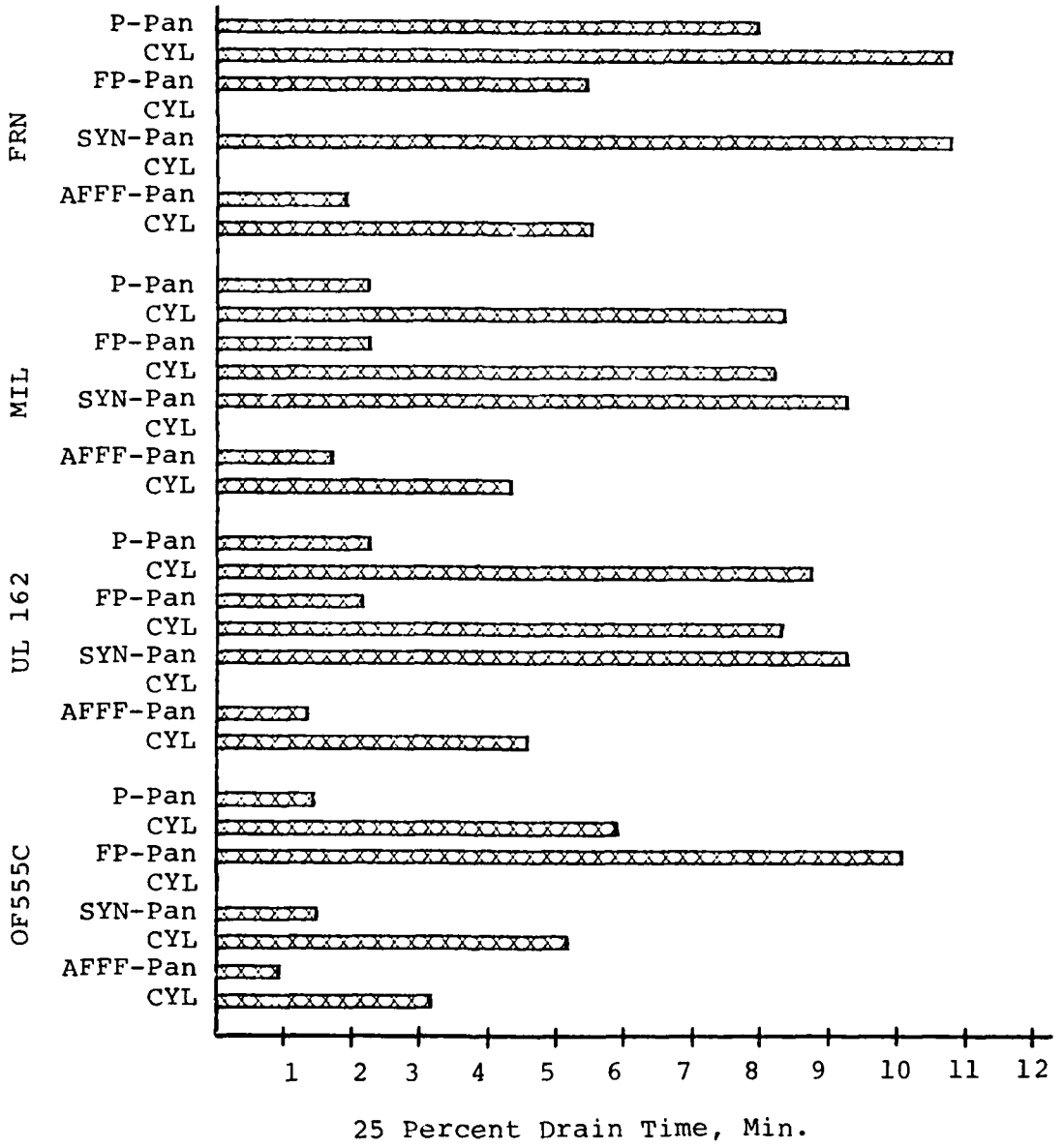


Fig. 35. Comparison Of Average 25 Percent Drain Time For Test Methods And Foams.

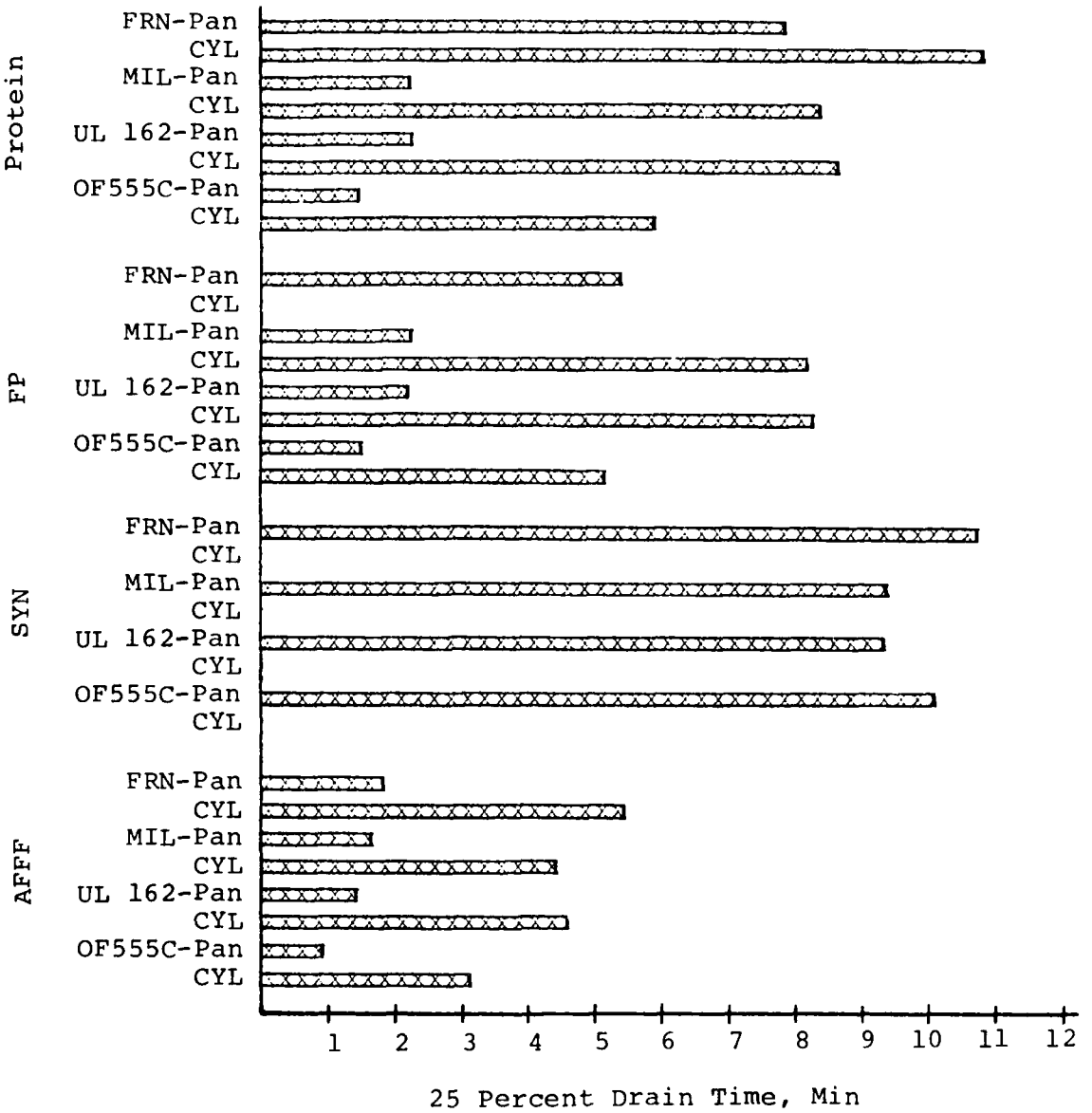


Fig. 36 Comparison Of Average 25 Percent Drain Time For Foams And Test Methods

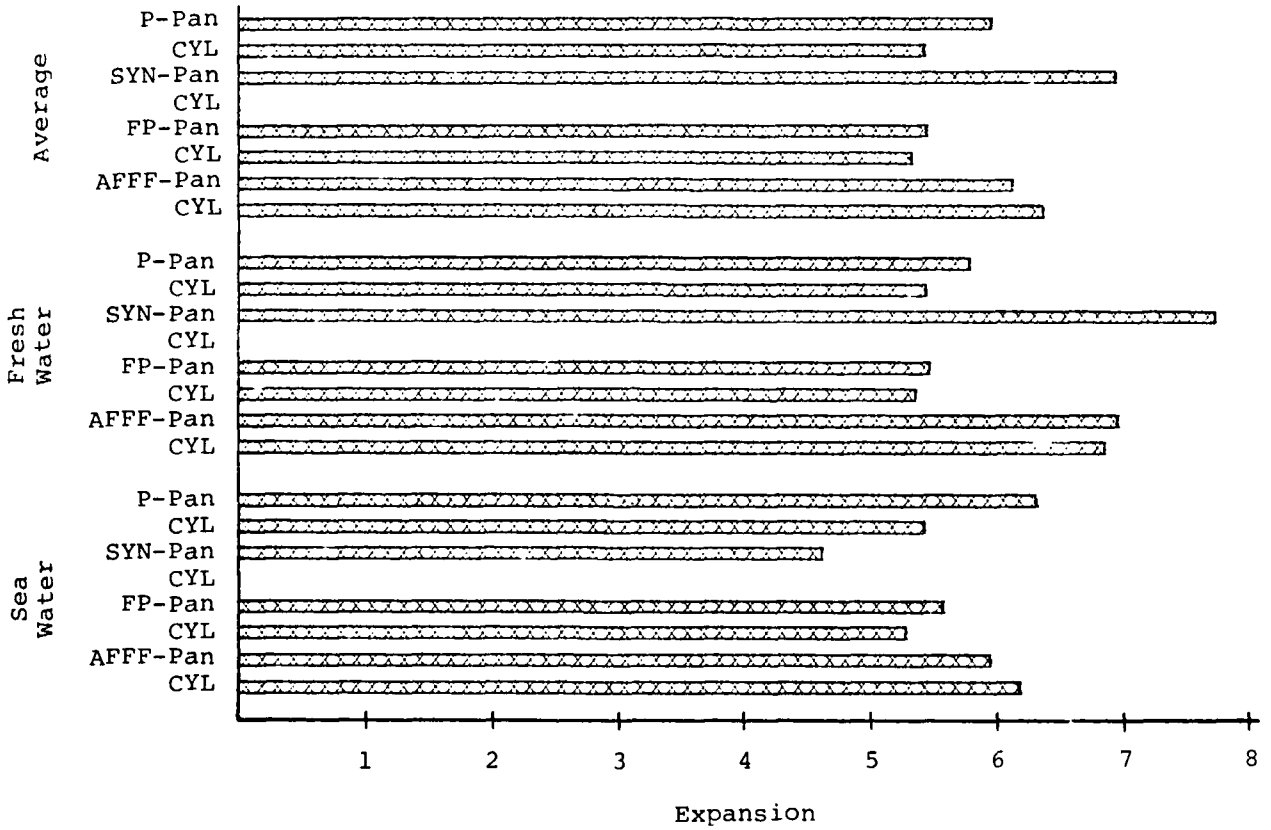


Fig. 37 Comparison Of Average Expansion Values By Type Of Foam And Water

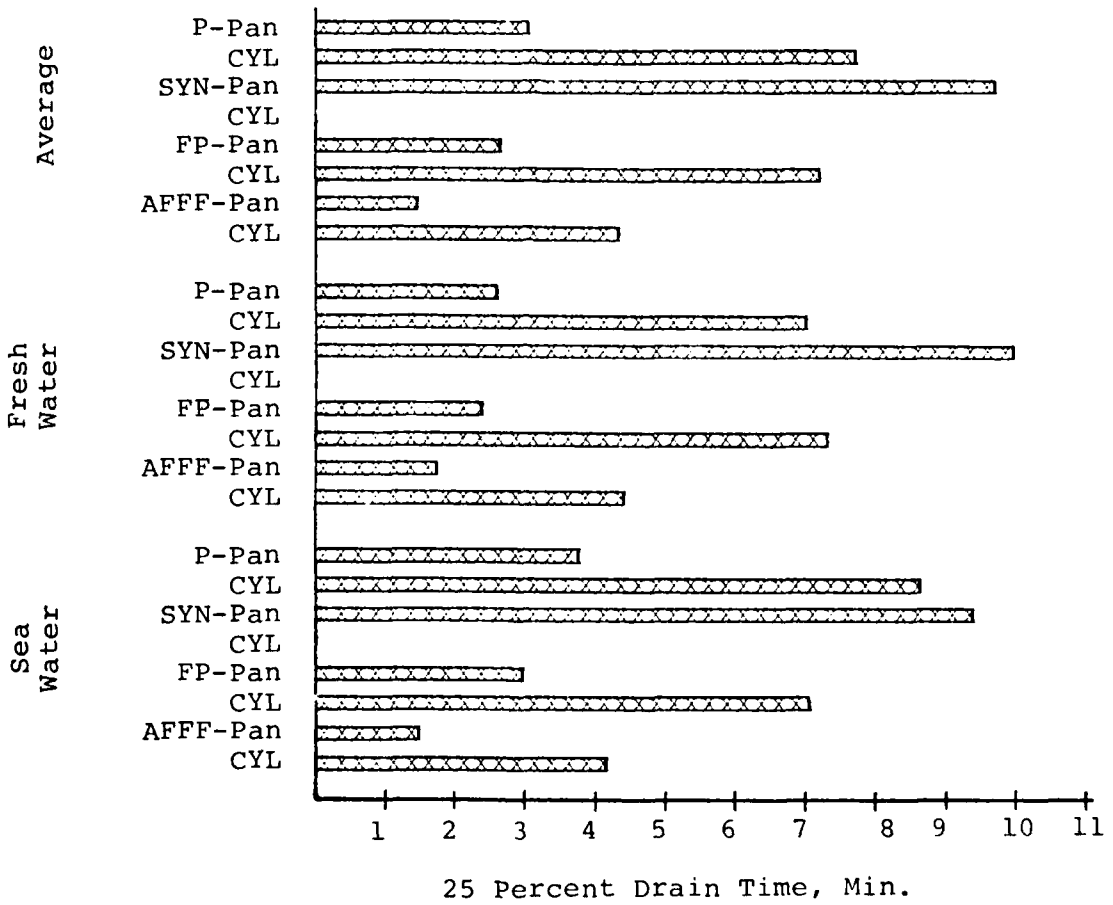


Fig. 38 Comparison Of Average 25 Percent Drain Time By Type Of Foam And Water

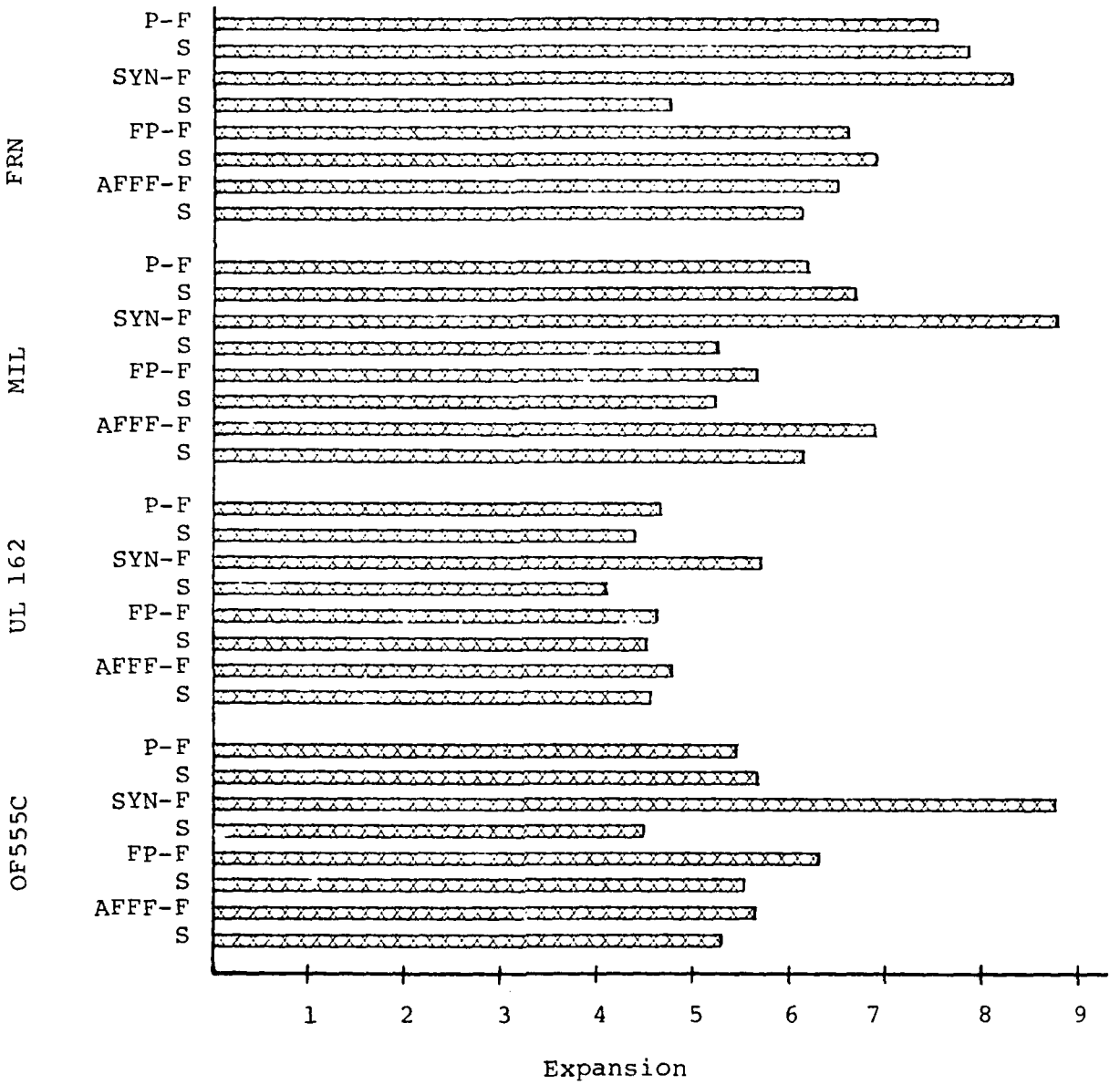


Fig. 39 Comparison Of Expansion Values Using The Pan Method For All Test Methods And Waters

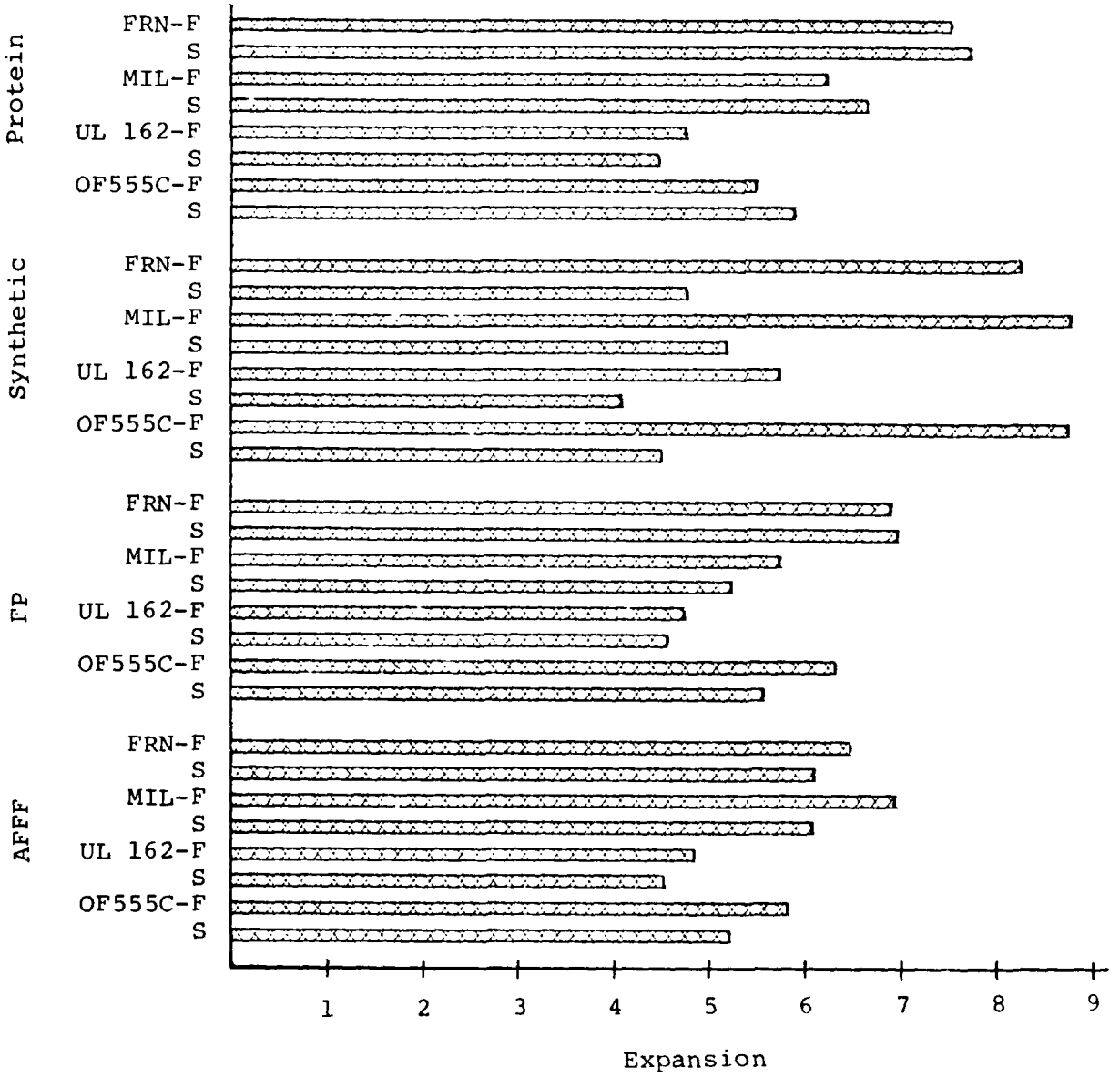


Fig. 40 Comparison Of Expansion Values Using The Pan Method For All Foams And Waters.

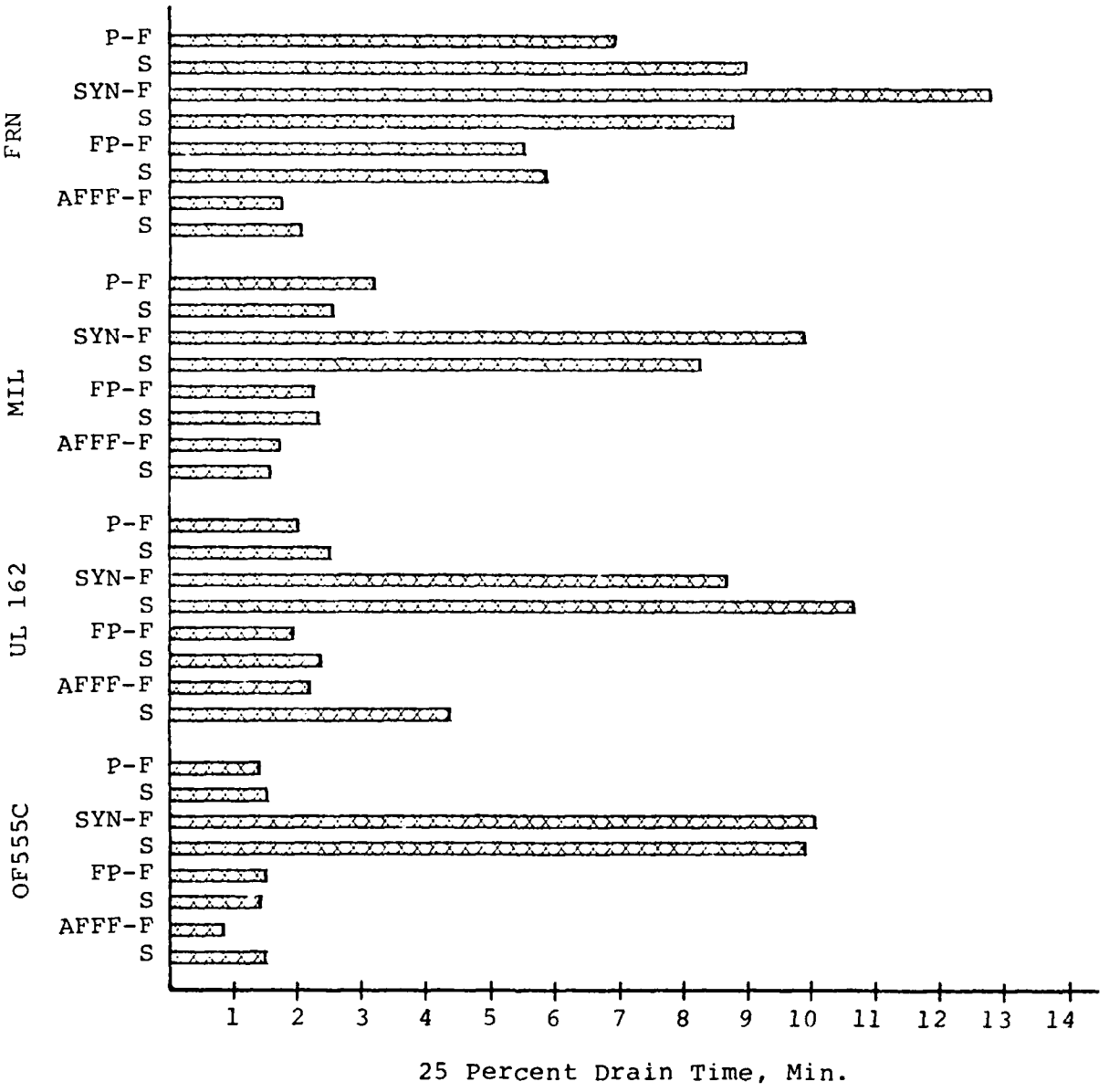


Fig. 41 Comparison Of 25 Percent Drain Time Using The Pan Method For All Test Methods And Waters

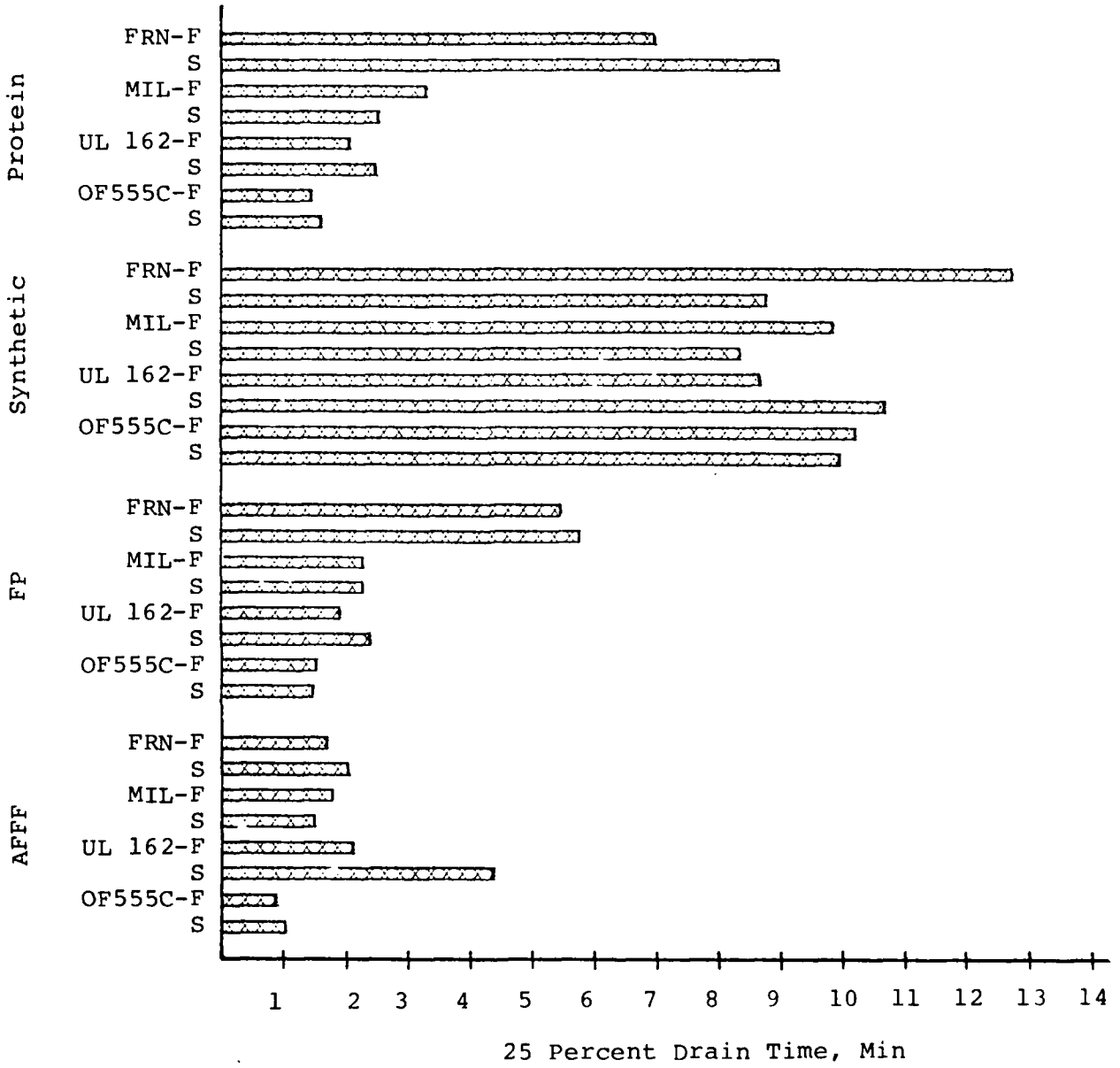


Fig. 42 Comparison Of 25 Percent Drain Time Using The Pan Method For All Foams And Waters

TABLE 9

FOAM: A TYPE: PROTEIN CONCENTRATION: 3 PERCENT

METHOD	TEST	WATER	FUEL	CONTROL MIN.	EXT. MIN.	TORCH	BURNBACK MIN.	EXPANSION PAN	EXPANSION CYLINDER	DRAIN TIME, MIN. PAN	DRAIN TIME, MIN. CYLINDER
FRN	248	F	H	1.00	1.75	-	23.85	6.6	-	6.78	-
FRN	249	F	G	1.89	2.67	-	19.15	6.6	-	6.78	-
FRN	253	S	G	1.50	1.95	-	18.30	7.5	-	8.73	-
MIL	250	F	G	None	-	-	-	5.6	5.8	1.43	7.03
MIL	254	S	G	None	-	-	-	5.6	5.6	1.75	7.55
MIL	291	F	H	None	-	-	-	5.4	5.2	1.18	7.35
UL 162	251	F	H	4.13	None	-	-	4.4	4.5	2.78	8.58
UL 162	255	S	H	4.13	None	-	-	4.9	4.7	2.23	9.53
UL 162	292	F	G	None	-	-	-	4.1	4.5	1.30	7.35
OF555C	252	F	G	3.55	4.25	Failed	-	3.6	4.2	1.00	3.47
OF555C	256	S	G	1.88	4.17	Failed	-	5.8	6.3	1.03	8.82
OF555C	293	F	H	2.67	3.83	Failed	-	6.10	6.15	<1.00	-
							AVG	5.41	5.27	2.66	7.41
							S.D.	1.12	0.85	2.62	1.84

TABLE 10

FOAM: B TYPE: PROTEIN CONCENTRATION: 6 PERCENT

METHOD	TEST	WATER	FUEL	CONTROL MIN.	EXT. MIN.	TORCH	BURNBACK +	EXPANSION PAN	EXPANSION CYLINDER	DRAIN TIME, MIN. PAN	DRAIN TIME, MIN. CYLINDER
FRN	206	F	H	1.70	2.20	-	12.30	8.6	-	7.67	-
FRN	208	F	G	1.87	2.02	-	13.04	8.6	-	7.67	-
FRN	211	S	G	2.58	3.00	-	11.00	8.6	-	12.13	-
MIL	207	F	G	None	-	-	-	6.2	6.6	2.32	6.50
MIL	212	S	G	None	-	-	-	6.7	6.9	3.63	11.65
MIL	242	F	H	None	-	-	-	5.9	6.2	2.33	9.08
UL 162	209	F	H	3.25	None	-	-	5.2	4.9	2.42	9.32
UL 162	213	S	H	4.83	None	-	-	4.9	5.3	2.97	8.45
UL 162	243	F	G	None	-	-	-	4.6	4.9	2.37	8.73
OF555C	210	F	G	3.00	4.42	Failed	-	4.4	5.1	1.67	4.58
OF555C	214	S	G	2.50	3.67	Failed	-	5.1	5.4	<1.00	7.92
OF555C	244	F	H	1.50	2.67	Passed	10 by 10	3.7	4.4	<1.00	2.57
							AVG	5.81	5.52	3.59	7.64
							S.D.	1.62	0.85	3.36	2.72

+ - Burnback in min for FRN test method and in. for OF555C test method.

TABLE 11

FOAM: C TYPE: SYNTHETIC CONCENTRATION: 3 PERCENT

METHOD	TEST	WATER	FUEL	CONTROL MIN.	EXT. MIN.	TORCH	BURNBACK MIN.	EXPANSION PAN	EXPANSION CYLINDER	DRAIN TIME, MIN. PAN	DRAIN TIME, MIN. CYLINDER
FRN	56	F	G	1.88	None	-	-	8.7	-	13.10	-
FRN	59	F	H	0.78	1.19	-	7.75	8.7	-	13.10	-
FRN	61	S	G	1.97	2.87	-	4.50	6.4	-	3.93	-
MIL	57	F	G	None	-	-	-	8.0	-	7.50	-
MIL	62	S	G	None	-	-	-	5.6	-	4.18	-
MIL	140	F	H	None	-	-	-	9.3	-	10.62	-
UL 162	58	F	H	1.58	None	-	-	5.7	-	7.42	-
UL 162	63	S	H	None	-	-	-	4.8	-	3.58	-
UL 162	141	F	G	None	-	-	-	5.8	-	8.77	-
OF555C	60	F	G	1.25	None	-	-	9.6	-	5.98	-
OF555C	64	S	G	1.75	2.00	Failed	-	4.2	-	2.70	-
OF555C	142	F	H	1.33	None	-	-	8.1	-	9.63	-
							AVG	6.93		7.04	
							S.D.	1.88		3.31	

TABLE 12

FOAM: D TYPE: SYNTHETIC CONCENTRATION: 6 PERCENT

METHOD	TEST	WATER	FUEL	CONTROL MIN.	EXT. MIN.	TORCH	BURNBACK MIN.	EXPANSION PAN	EXPANSION CYLINDER	DRAIN TIME, MIN. PAN	DRAIN TIME, MIN. CYLINDER
FRN	23	F	G	1.65	None	-	-	7.8	-	12.38	-
FRN	25	F	H	1.50	None	-	-	7.8	-	12.38	-
FRN	28	S	G	None	-	-	-	3.1	-	13.62	-
MIL	24	F	G	None	-	-	-	8.3	-	10.75	-
MIL	29	S	G	None	-	-	-	4.8	-	12.47	-
MIL	65	F	H	None	-	-	-	9.5	-	10.58	-
UL 162	26	F	H	0.92	None	-	-	5.2	-	9.45	-
UL 162	30	S	H	None	-	-	-	3.4	-	17.75	-
UL 162	66	F	G	None	-	-	-	6.1	-	9.00	-
OF555C	27	F	G	1.00	4.67	Failed	-	9.5	-	19.43	-
OF555C	31	S	G	*	*	*	*	4.7	-	17.17	-
OF555C	67	F	H	1.92	3.42	Failed	-	7.7	-	5.50	-
							AVG	6.37		12.55	
							S.D.	2.31		4.20	

* - Test not conducted

TABLE 13

FOAM: E TYPE: PROTEIN CONCENTRATION: 3 PERCENT

METHOD	TEST	WATER	FUEL	CONTROL MIN.	EXT. MIN.	TORCH	BURNBACK MIN.	EXPANSION PAN	EXPANSION CYLINDER	DRAIN TIME, MIN. PAN	DRAIN TIME, MIN. CYLINDER
FRN	176	F	H	1.08	2.70	-	13.68	6.6	6.0	3.63	10.83
FRN	176X	F	G	None	-	-	-	6.6	6.0	3.63	10.83
FRN	193	S	H	2.21	2.67	-	9.00	7.0	-	5.03	-
FRN	195	S	G	None	-	-	-	7.0	-	5.03	-
MIL	177	F	H	None	-	-	-	4.5	5.5	1.18	5.55
MIL	177B	F	G	None	-	-	-	4.5	5.5	1.18	5.55
MIL	194	S	G	None	-	-	-	6.1	6.7	1.83	7.05
UL 162	178	F	G	None	-	-	-	4.3	4.1	0.97	5.05
UL 162	196	S	H	None	-	-	-	4.4	4.3	1.58	7.48
UL 162	198	F	H	None	-	-	-	4.4	4.3	1.20	5.63
OF555C	179	F	H	None	-	-	-	3.5	3.2	-	2.08
OF555C	197	S	G	2.83	4.00	Failed	-	5.5	5.1	1.42	4.55
OF555C	199	F	G	None	-	-	-	5.5	5.1	0.88	4.60
							AVG	5.17	4.93	1.95	5.86
							S.D.	1.15	1.06	1.52	2.42

FOAM: F TYPE: PROTEIN

TABLE 14
CONCENTRATION: 6 PERCENT

METHOD	TEST	WATER	FUEL	CONTROL MIN.	EXT. MIN.	TORCH	BURNBACK +	EXPANSION PAN	EXPANSION CYLINDER	DRAIN TIME, MIN. PAN	DRAIN TIME, MIN. CYLINDER
FRN	143	F	H	0.87	2.18	-	12.11	8.0	-	5.55	-
FRN	145	F	G	2.67	None	-	-	8.0	-	5.55	-
FRN	148	S	G	2.59	2.77	-	4.19	8.5	-	8.42	-
MIL	144	F	G	None	-	-	-	6.2	-	1.08	-
MIL	149	S	G	None	-	-	-	6.2	-	1.50	-
MIL	152	S	H	None	-	-	-	6.3	-	1.78	-
UL 162	146	F	H	3.33	None	-	-	4.4	-	1.20	-
UL 162	150	S	H	None	-	-	-	4.0	-	1.53	-
UL 162	153	S	G	None	-	-	-	4.8	-	1.85	-
OF555C	147	F	G	4.00	None	-	-	4.9	-	0.95	-
OF555C	151	S	G	2.00	2.50	Passed	++	5.7	-	1.00	-
OF555C	154	S	H	1.42	4.55	Failed	-	5.2	-	1.70	-
							AVG	5.84		2.38	
							S.D.	1.42		2.38	

\+ - Burnback in min for FRN test method and in. for OF555C test method.

++ - Self extinguished

TABLE 15

FOAM: G TYPE: FLUOROPROTEIN CONCENTRATION: 3 PERCENT

METHOD	TEST	WATER	FUEL	CONTROL MIN.	EXT. MIN.	TORCH	BURNBACK +	EXPANSION PAN	EXPANSION CYLINDER	DRAIN TIME, MIN. PAN	DRAIN TIME, MIN. CYLINDER
FRN	184	F	H	0.85	1.09	-	19.09	6.7	-	3.73	-
FRN	186	F	G	1.97	3.85	-	9.85	6.7	-	3.73	-
FRN	189	S	G	None	-	-	-	7.3	-	5.67	-
MIL	185	F	G	None	-	-	-	4.5	4.5	1.00	5.43
MIL	190	S	G	None	-	-	-	5.7	5.8	1.58	7.45
MIL	200	F	H	None	-	-	-	6.4	6.6	1.97	8.35
UL 162	187	F	H	3.83	None	-	-	4.3	4.9	1.25	5.68
UL 162	191	S	H	2.83	None	-	-	4.9	4.5	1.92	7.68
UL 162	201	F	G	2.83	None	-	-	4.5	4.5	1.45	6.87
OF555C	188	F	G	-	4.58	Passed	36 by 36	3.3	4.6	<1.00	2.55
OF555C	192	S	G	-	2.25	Passed	36 by 36+++	3.8	4.6	<1.00	2.15
OF555C	202	F	H	-	2.42	Passed	8 by 8	4.9	5.5	<1.00	5.55
							AVG	5.11	5.06	1.96	5.54
							S.D.	1.26	0.75	1.47	2.27

\+ - Burnback in min for FRN test method and in. for OF555C test method.

++ - Test discontinued after 1 min of burnback.

+++ - Test discontinued after 3 min of burnback

TABLE 16

FOAM: H TYPE: FLUOROPROTEIN CONCENTRATION: 6 PERCENT

METHOD	TEST	WATER	FUEL	CONTROL MIN.	EXT. MIN.	TORCH	BURNBACK +	EXPANSION PAN	EXPANSION CYLINDER	DRAIN TIME, MIN. PAN	DRAIN TIME, MIN. CYLINDER
FRN	303	F	H	0.77	1.40	-	23.45	8.0	-	6.18	-
FRN	304	F	G	0.77	1.57	-	17.65	8.0	-	6.18	-
FRN	308	S	G	1.58	2.03	-	21.42	8.0	-	7.08	-
MIL	305	F	G	None	-	-	-	6.0	6.0	2.35	11.62
MIL	309	S	G	None	-	-	-	5.3	6.1	2.30	11.07
MIL	312	F	H	None	-	-	-	5.6	6.3	2.17	10.08
UL 162	306	F	H	2.35	None	-	-	4.5	4.8	2.20	9.20
UL 162	310	S	H	2.33	None	-	-	4.6	4.8	2.47	9.42
UL 162	313	F	G	2.67	None	-	-	4.6	4.8	2.00	7.68
OF555C	307	F	G	1.42	2.67	Passed	4 by 4	5.7	6.4	1.00	6.47
OF555C	311	S	G	1.00	2.07	Passed	5 by 5	5.7	6.2	1.43	6.75
OF555C	314	F	H	1.50	2.17	Passed	5 by 5	4.9	6.7	1.33	8.18
							AVG	5.73	5.79	2.77	8.94
							S.D.	1.23	0.77	1.97	1.82

+ - Burnback in min for FRN test method and in. for OF555C test method.

TABLE 17

FOAM: I TYPE: AFFF CONCENTRATION: 3 PERCENT

METHOD	TEST	WATER	FUEL	CONTROL MIN.	EXT. MIN.	TORCH	BURNBACK MIN.	EXPANSION PAN	EXPANSION CYLINDER	DRAIN TIME, MIN. PAN	DRAIN TIME, MIN. CYLINDER
FRN	167	F	H	0.80	0.95	-	9.28	-	6.3	-	5.27
FRN	168	F	G	0.80	0.99	-	6.92	-	6.3	-	5.27
FRN	172	S	G	0.60	None	-	-	-	5.6	-	5.33
FRN	180	S	G	0.81	1.11	-	7.84	5.5	5.3	1.23	5.33
MIL	169	F	G	1.00	None	-	-	-	5.6	-	3.97
MIL	169A+	F	G	0.97	None	-	-	-	5.6	-	3.97
MIL	173	S	G	0.83	None	-	-	-	5.9	-	4.17
MIL	181	S	H	None	-	-	-	5.2	5.7	1.00	3.33
MIL	181A	S	H	0.88	None	-	-	5.2	5.7	1.00	3.33
UL 162	170	F	H	1.60	2.78	Failed	-	-	4.6	-	4.17
UL 162	174	S	H	1.97	None	-	-	-	4.9	-	4.35
UL 162	182	S	G	1.08	None	-	-	4.3	4.5	1.08	4.93
OF555C	171	F	G	0.88	1.43	Failed	-	-	4.4	-	2.08
OF555C	175	S	G	0.88	1.70	Failed	-	-	5.5	-	2.32
OF555C	183	S	H	2.33	None	-	-	4.9	5.1	0.75	2.50
							AVG	4.98	5.28	1.02	4.00
							S.D.	*0.51*	*0.59*	*0.20*	1.16

+ - Suffix A indicates nozzle moved by operator during foam application.

TABLE 18

FOAM: J TYPE: AFFF CONCENTRATION: 6 PERCENT

METHOD	TEST	WATER	FUEL	CONTROL MIN.	EXT. MIN.	TORCH	BURNBACK MIN.	EXPANSION PAN	EXPANSION CYLINDER	DRAIN TIME, MIN. PAN	DRAIN TIME, MIN. CYLINDER
FRN	158	F	G	0.68	0.79	-	7.02	-	6.4	-	5.37
FRN	159	F	H	0.60	0.80	-	11.24	-	6.4	-	5.37
FRN	163	S	G	0.95	1.35	-	8.25	-	4.7	-	5.30
MIL	160	F	G	0.78	None	-	-	-	6.1	-	3.12
MIL	160A+	F	G	0.88	None	-	-	-	6.1	-	3.12
MIL	164	S	G	1.00	None	-	-	-	4.7	-	3.73
MIL	164A	S	G	0.92	None	-	-	-	4.7	-	3.73
MIL	203	S	H	0.88	None	-	-	5.2	5.5	0.87	3.58
MIL	203A	S	H	0.78	None	-	-	5.2	5.5	0.87	3.58
UL 162	161	F	H	3.38	None	-	-	-	4.8	-	4.70
UL 162	165	S	H	2.83	None	-	-	-	4.0	-	4.25
UL 162	204	S	G	2.38	None	-	-	4.2	4.3	0.92	3.70
OF555C	162	F	G	1.17	2.00	Failed	-	-	6.6	-	3.07
OF555C	166	S	G	1.17	2.72	Failed	-	-	4.9	-	2.55
OF555C	205	S	H	1.80	2.25	Failed	-	4.8	4.8	0.75	2.17
							AVG	4.73	5.16	0.85	3.78
							S.D.	0.50	0.86	0.09	1.05

+ - Suffix A indicates nozzle moved by operator during foam application.

TABLE 19

FOAM: K TYPE: AFFF CONCENTRATION: 3 PERCENT

METHOD	TEST	WATER	FUEL	CONTROL MIN.	EXT. MIN.	TORCH	BURNBACK +	EXPANSION PAN	EXPANSION CYLINDER	DRAIN TIME, MIN. PAN	DRAIN TIME, MIN. CYLINDER
FRN	32	F	G	0.45	0.55	-	7.10	-	7.7	-	5.33
FRN	34	F	H	0.45	0.65	-	9.67	-	7.7	-	5.33
FRN	37	S	G	0.50	0.56	-	5.10	-	7.3	-	4.70
MIL	33	F	G	1.00	None	-	-	-	7.2	-	3.77
MIL	33A+	F	G	0.58	0.88	-	5.83	6.5	6.4	1.27	3.80
MIL	38	S	G	None	-	-	-	-	7.6	-	3.17
MIL	38A	S	G	0.62	0.92	-	5.83	5.4	6.4	1.30	4.55
MIL	50	S	H	0.75	None	-	-	-	7.1	-	3.13
MIL	50A	S	H	0.72	0.97	-	5.83	6.3	6.1	1.27	4.33
UL 162	35	F	H	1.08	1.75	Failed	-	-	5.0	-	5.97
UL 162	39	S	H	1.33	2.08	Failed	-	-	5.4	-	3.25
UL 162	51	S	G	1.50	3.08	Failed	-	-	5.0	-	3.68
OF555C	36	F	G	0.75	None	-	-	-	7.0	-	2.67
OF555C	40	S	G	0.67	2.00	Passed	++	-	7.8	-	2.42
OF555C	52	S	H	0.75	1.75	Failed	-	-	6.9	-	2.83
							AVG	6.08	6.64	1.28	3.83
							S.D.	0.59	0.96	0.02	1.04

\+ - Suffix A indicates nozzle moved by operator during foam application.

++ - Entire pan became reinvolved when burnback container was removed.

TABLE 20

FOAM: L TYPE: AFFF CONCENTRATION 6 PERCENT

METHOD	TEST	WATER	FUEL	CONTROL MIN.	EXT. MIN.	TORCH	BURNBACK ++	EXPANSION PAN	EXPANSION CYLINDER	DRAIN TIME, MIN. PAN	DRAIN TIME, MIN. CYLINDER
FRN	1	S	H	0.40	0.72	-	10.10	-	7.3	-	4.97
FRN	5	S	G	0.30	0.75	-	5.95	-	7.5	-	5.23
FRN	9	F	H	0.50	0.62	-	9.50	-	8.0	-	5.50
FRN	11	F	G	0.50	3.50	-	5.03	-	8.0	-	5.50
MIL	2	S	H	0.67	1.00	-	8.25	-	6.7	-	2.75
MIL	2A+	S	H	1.07	None	-	-	6.1	6.1	1.77	5.32
MIL	6	S	G	0.25	1.08	-	4.50	-	7.2	-	3.23
MIL	6A	S	G	0.70	None	-	-	5.8	5.6	1.00	3.13
MIL	10	F	G	0.50	None	-	-	-	9.6	-	3.70
MIL	10A	F	G	0.58	0.80	-	6.25	7.0	6.6	1.55	5.56
UL 162	3	S	H	1.08	1.75	Failed	-	-	4.8	-	4.42
UL 162	7	S	G	0.75	1.50	Failed	-	-	4.6	-	4.22
UL 162	12	F	H	0.67	2.58	Failed	-	-	5.1	-	4.25
OF555C	4	S	H	1.25	3.17	Failed	-	-	6.8	-	2.37
OF555C	8	S	G	1.00	1.75	Passed	+++	-	8.0	-	3.08
OF555C	13	F	G	1.50	3.00	Passed	+++	-	7.3	-	2.78
							AVG	6.30	6.68	1.44	4.06
							S.D.	0.62	1.22	0.40	1.15

+ - Suffix A indicates nozzle moved by operator during foam application.

++ - Burnback in min for FRN and MIL test methods and in. for MIL and OF555C test methods.

+++ - Self extinguished.

TABLE 21

FOAM: M TYPE: AFFF CONCENTRATION: 3 PERCENT

METHOD	TEST	WATER	FUEL	CONTROL MIN.	EXT. MIN.	TORCH	BURNBACK MIN.	EXPANSION PAN	EXPANSION CYLINDER	DRAIN TIME, MIN. PAN	DRAIN TIME, MIN. CYLINDER
FRN	107	F	G	0.40	0.55	-	7.27	-	8.1	-	5.90
FRN	109	F	H	0.40	0.69	-	8.97	-	8.1	-	5.90
FRN	112	S	G	0.50	0.62	-	5.77	-	6.9	-	5.42
MIL	108	F	G	0.55	None	-	-	-	8.9	-	3.38
MIL	108A+	F	G	0.63	0.78	-	5.83	6.7	6.9	2.22	7.02
MIL	113	S	G	0.75	None	-	-	-	7.2	-	3.17
MIL	113A	S	G	0.77	0.97	-	6.50	7.6	6.5	1.63	-
MIL	137	F	H	0.98	None	-	-	-	7.9	-	3.33
MIL	137A	F	H	0.83	None	-	-	-	7.9	-	3.33
UL 162	110	F	H	1.53	2.18	Failed	-	-	4.8	-	4.20
UL 162	114	S	H	1.50	4.53	Failed	-	-	4.6	-	4.30
UL 162	138	F	G	2.03	None	-	-	-	5.4	-	3.25
OF555C	111	F	G	0.83	None	-	-	7.8	8.6	0.50	2.33
OF555C	115	S	G	0.83	2.58	Failed	-	-	7.2	-	2.63
OF555C	139	F	H	1.08	1.82	Failed	-	-	7.6	-	2.68
							AVG	7.37	6.89	1.45	3.97
							S.D.	0.59	1.39	0.87	1.46

+ - Suffix A indicates nozzle moved by operator during foam application.

TABLE 22

FOAM: N TYPE: AFFF CONCENTRATION: 6 PERCENT

METHOD	TEST	WATER	FUEL	CONTROL MIN.	EXT. MIN.	TORCH	BURNBACK ++	EXPANSION PAN	EXPANSION CYLINDER	DRAIN TIME, MIN. PAN	DRAIN TIME, MIN. CYLINDER
FRN	116	F	G	2.17	None	-	-	-	8.3	-	6.00
FRN	118	F	H	0.62	0.72	-	13.82	-	8.3	-	6.00
FRN	121	S	G	0.95	None	-	-	-	7.7	-	5.30
MIL	117	F	G	None	-	-	-	-	7.7	-	4.30
MIL	117A+	F	G	1.00	None	-	-	-	7.7	-	4.30
MIL	122	S	G	None	-	-	-	-	7.7	-	3.77
MIL	122A	S	G	None	-	-	-	-	7.7	-	3.77
MIL	155	F	H	0.95	None	-	-	-	7.4	-	4.17
MIL	155A	F	H	0.78	None	-	-	-	7.4	-	4.17
UL 162	119	F	H	1.25	None	-	-	-	5.6	-	4.88
UL 162	123	S	H	2.08	None	-	-	-	5.0	-	4.33
UL 162	156	F	H	2.93	None	-	-	-	5.4	-	4.68
OF555C	120	F	G	1.17	1.83	Passed	30 by 30	-	8.2	-	3.25
OF555C	124	S	G	0.83	1.33	Passed	6 by 6	-	6.7	-	2.50
OF555C	157	F	H	1.00	1.50	Failed	-	-	8.2	-	3.77
							AVG	-	7.08	-	4.18
							S.D.	-	1.21	-	0.82

+ - Suffix A indicates nozzle moved by operator during foam application.

++ - Burnback in min for FRN test method and in. for OF555C test method.

TABLE 23

FOAM: O TYPE: AFFF CONCENTRATION: 3 PERCENT

METHOD	TEST	WATER	FUEL	CONTROL MIN.	EXT. MIN.	TORCH	BURNBACK MIN.	EXPANSION PAN	EXPANSION CYLINDER	DRAIN TIME, MIN. PAN	DRAIN TIME, MIN. CYLINDER
FRN	L$	S	G	0.47	1.63	-	7.80	-	7.7	-	6.30
FRN	18	F	H	0.59	0.65	-	18.00	-	8.9	-	5.68
FRN	20	F	G	0.90	1.25	-	7.20	-	8.9	-	5.68
MIL	15	S	G	0.83	None	-	-	-	8.3	-	5.28
MIL	15A	S	G	0.58	None	-	-	7.8	7.4	3.03	7.28
MIL	19	F	G	0.67	None	-	-	-	8.2	-	4.80
MIL	19A+	F	G	0.58	None	-	-	8.2	7.9	3.37	4.75
MIL	53	S	H	0.80	None	-	-	-	7.9	-	4.45
MIL	53A	S	H	0.50	0.83	-	7.20	6.5	6.3	1.37	6.77
UL 162	16	S	H	1.17	2.75	Failed	-	-	5.1	-	5.75
UL 162	21	F	H	0.75	1.87	Failed	-	-	5.6	-	5.58
UL 162	54	S	G	0.87	4.08	Failed	-	-	5.4	-	5.17
OF555C	17	S	G	1.33	4.08	Failed	-	-	8.1	-	3.92
OF555C	22	F	G	0.75	1.75	Failed	-	-	9.8	-	3.58
OF555C	55	S	H	0.83	1.83	Failed	-	-	8.0	-	4.13
							AVG	7.50	7.47	2.76	5.36
							S.D.	0.89	1.38	0.79	1.18

+ - Suffix A indicates nozzle moved by operator during foam application.

TABLE 24

FOAM: P TYPE: AFFF CONCENTRATION: 6 PERCENT

METHOD	TEST	WATER	FUEL	CONTROL MIN.	EXT. MIN.	TORCH	BURNBACK MIN.	EXPANSION PAN	EXPANSION CYLINDER	DRAIN TIME, MIN. PAN	DRAIN TIME, MIN. CYLINDER
FRN	41	S	G	1.85	None	-	-	-	7.1	-	3.12
FRN	45	F	H	0.30	0.40	-	7.34	-	8.3	-	5.17
FRN	47	F	G	0.75	1.70	-	7.17	-	8.3	-	5.17
MIL	42	S	G	0.66	None	-	-	-	6.6	-	3.75
MIL	42A+	S	G	0.65	None	-	-	6.0	7.0	2.35	8.62
MIL	46	F	G	None	-	-	-	-	7.6	-	3.72
MIL	46A	F	G	None	-	-	-	7.5	6.9	1.28	5.47
MIL	68	S	H	0.83	None	-	-	-	7.1	-	3.70
MIL	68A	S	H	0.58	0.82	-	6.92	7.1	7.0	1.82	7.25
UL 162	43	S	H	0.90	2.10	Failed	-	-	5.4	-	4.83
UL 162	48	F	H	1.07	2.60	Failed	-	-	4.9	-	3.95
UL 162	69	S	G	2.33	3.57	Failed	-	-	5.3	-	4.48
OF555C	44	S	G	0.70	None	-	-	-	5.9	-	3.67
OF555C	49	F	G	0.83	3.17	Failed	-	-	8.1	-	3.58
OF555C	70	S	H	0.92	1.92	Failed	-	-	7.2	-	3.52
							AVG	6.87	6.74	1.82	4.63
							S.D.	0.78	1.02	0.54	1.58

+ - Suffix A indicates nozzle moved by operator during foam application.

TABLE 25

FOAM: Q TYPE: AFFF CONCENTRATION: 3 PERCENT

METHOD	TEST	WATER	FUEL	CONTROL MIN.	EXT. MIN.	TORCH	BURNBACK +	EXPANSION PAN	EXPANSION CYLINDER	DRAIN TIME, MIN. PAN	DRAIN TIME, MIN. CYLINDER
FRN	275	F	H	0.58	0.75	-	14.35	8.2	8.2	1.75	7.82
FRN	276	F	G	0.56	0.60	-	14.56	8.2	8.2	1.75	7.82
FRN	280	S	G	1.08	None	-	-	6.4	7.0	2.17	6.15
MIL	277	F	G	0.75	1.08	-	3.33	7.2	6.9	1.78	5.53
MIL	277A++	F	G	0.58	0.80	-	6.50	7.2	6.9	1.78	5.53
MIL	281	S	G	0.72	None	-	-	6.3	6.6	1.13	4.55
MIL	281A	S	G	0.62	None	-	-	6.3	6.6	1.13	4.55
MIL	300	S	H	1.00	None	-	-	6.2	6.9	1.15	4.29
MIL	300A	S	H	0.75	None	-	-	6.2	6.9	1.25	4.48
UL 162	278	F	H	1.13	3.30	Failed	-	5.4	5.4	3.22	6.43
UL 162	282	S	H	1.92	3.33	Failed	-	5.2	5.2	1.10	4.75
UL 162	301	S	G	2.75	3.33	Failed	-	4.9	4.7	1.25	4.47
OF555C	279	F	G	0.22	0.83	Passed	2 by 2	5.3	8.5	0.78	5.42
OF555C	283	S	G	0.33	0.83	Failed	-	6.4	9.3	1.30	4.32
OF555C	302	S	H	1.17	2.08	Failed	-	4.7	4.3	1.47	5.30
							AVG	6.02	6.64	1.56	5.38
							S.D.	1.05	1.62	0.67	1.07

\+ - Burnback in min for FRN and MIL test methods and in. for OF55C test method.

++ - Suffix A indicates nozzle moved by operator during foam application.

TABLE 26

FOAM: R TYPE: AFFF CONCENTRATION: 6 PERCENT

METHOD	TEST	WATER	FUEL	CONTROL MIN.	EXT. MIN.	TORCH	BURNBACK MIN.	EXPANSION PAN	EXPANSION CYLINDER	DRAIN TIME, MIN. PAN	DRAIN TIME, MIN. CYLINDER
FRN	233	F	H	0.83	0.99	-	9.93	5.7	6.0	1.67	5.85
FRN	234	F	G	0.85	0.99	-	8.77	5.7	6.0	1.67	5.85
FRN	238	S	G	0.64	1.21	-	6.44	6.5	5.5	2.63	5.28
MIL	235	F	G	0.98	None	-	-	5.2	5.1	0.90	3.17
MIL	235A+	F	G	1.05	None	-	-	5.2	5.1	0.90	3.17
MIL	239	S	G	None	-	-	-	5.5	5.7	1.05	2.78
MIL	239A	S	G	0.80	None	-	-	5.5	5.7	1.05	2.78
MIL	287	S	H	0.72	None	-	-	5.5	5.4	1.43	3.30
MIL	287A	S	H	0.67	None	-	-	5.5	5.4	1.43	3.30
UL 162	236	F	H	1.87	None	-	-	4.3	4.5	1.07	4.80
UL 162	240	S	H	2.58	None	-	-	4.4	4.3	1.00	3.20
UL 162	288	S	G	1.42	None	-	-	4.4	4.5	1.33	4.07
OF555C	237	F	G	1.15	None	-	-	6.4	6.2	1.17	3.02
OF555C	241	S	G	1.08	2.92	Failed	-	5.6	6.1	0.83	2.73
OF555C	289	S	H	1.00	1.67	Failed	-	4.9	5.3	0.90	2.62
							AVG	5.31	5.33	1.27	3.76
							S.D.	0.76	0.67	0.52	1.11

+ - Suffix A indicates nozzle moved by operator during foam application.

TABLE 27

FOAM: S TYPE: PROTEIN CONCENTRATION: 3 PERCENT

METHOD	TEST	WATER	FUEL	CONTROL MIN.	EXT. MIN.	TORCH	BURNBACK MIN.	EXPANSION PAN	EXPANSION CYLINDER	DRAIN TIME, MIN. PAN	DRAIN TIME, MIN. CYLINDER
FRN	89	F	G	2.20	2.59	-	12.25	6.4	-	5.52	-
FRN	91	F	H	1.64	2.59	-	28.25	6.4	-	5.52	-
FRN	94	S	G	2.60	3.00	-	17.10	7.3	-	7.77	-
MIL	90	F	G	None	-	-	-	6.2	-	1.70	-
MIL	95	S	G	None	-	-	-	6.2	-	1.87	-
MIL	125	F	H	None	-	-	-	6.6	-	1.50	-
UL 162	92	F	H	2.83	None	-	-	4.5	-	1.75	-
UL 162	96	S	H	3.47	None	-	-	4.9	-	2.70	-
UL 162	125	F	G	None	-	-	-	4.8	-	1.88	-
OF555C	93	F	G	2.75	4.75	Failed	-	6.0	-	0.87	-
OF555C	97	S	G	2.67	3.08	Failed	-	6.9	-	1.67	-
OF555C	127	F	H	2.58	4.17	Failed	-	6.1	-	1.37	
							AVG	5.99	-	2.60	-
							S.D.	0.80	-	2.11	-

TABLE 28

FOAM: T TYPE: PROTEIN CONCENTRATION: 6 PERCENT

METHOD	TEST	WATER	FUEL	CONTROL MIN.	EXT. MIN.	TORCH	BURNBACK MIN.	EXPANSION PAN	EXPANSION CYLINDER	DRAIN TIME, MIN. PAN	DRAIN TIME, MIN. CYLINDER
FRN	98	F	G	2.00	2.32	-	20.00	8.9	-	10.25	-
FRN	100	F	H	1.65	1.89	-	26.45	8.9	-	10.25	-
FRN	103	S	G	2.71	3.00	-	12.05	8.7	-	11.67	-
MIL	99	F	G	None	-	-	-	8.5	-	3.20	-
MIL	104	S	G	None	-	-	-	9.4	-	4.67	-
MIL	104A+	S	H	None	-	-	-	9.4	-	4.67	-
MIL	128	F	H	None	-	-	-	7.8	-	3.38	-
UL 162	101	F	H	2.75	None	-	-	5.5	-	2.48	-
UL 162	105	S	H	3.33	None	-	-	5.8	-	3.23	-
UL 162	129	F	G	3.63	None	-	-	5.7	-	2.90	-
OF555C	102	F	G	-	1.00	Failed	-	9.1	-	4.12	-
OF555C	106	S	G	1.00	4.77	Failed	-	7.9	-	3.60	-
OF555C	130	F	H	1.17	3.08	Failed	-	6.2	-	2.13	-
							AVG	7.59	-	4.69	-
							S.D.	1.50	-	3.19	-

+ Suffix A indicates nozzle moved by operator during foam application.

TABLE 29

FOAM: U TYPE: FLUOROPROTEIN CONCENTRATION: 3 PERCENT

METHOD	TEST	WATER	FUEL	CONTROL MIN.	EXT. MIN.	TORCH	BURNBACK +	EXPANSION PAN	EXPANSION CYLINDER	DRAIN TIME, MIN. PAN	DRAIN TIME, MIN. CYLINDER
FRN	80	F	H	0.80	0.96	-	27.45	5.2	-	3.08	-
FRN	82	F	G	1.08	1.41	-	16.97	5.2	-	3.08	-
FRN	85	S	G	1.08	1.90	-	11.75	5.7	-	4.08	-
MIL	81	F	G	None	-	-	-	4.4	-	0.97	-
MIL	86	S	G	None	-	-	-	4.8	-	1.28	-
MIL	131	F	H	None	-	-	-	5.5	-	2.00	-
UL 162	83	F	H	1.92	4.83	Passed	++	4.2	-	1.75	-
UL 162	87	S	H	4.00	None	-	-	4.3	-	1.58	-
UL 162	132	F	G	None	-	-	-	4.8	-	1.62	-
OF555C	84	F	G	1.92	2.75	Passed	3 by 3	4.6	-	0.70	-
OF555C	88	S	G	2.00	2.50	Passed	30 by 30	5.0	-	1.00	-
OF555C	133	F	H	1.67	None	-	-	5.4	-	1.92	-
							AVG	4.90	-	1.82	-
							S.D.	0.51	-	0.99	-

\+ - Burnback in min for FRN test method and in. for UL 162 and OF555C test methods.

++ - Entire pan reignited. About 75 percent self-extinguished. Remaining 25 percent continued to burn.

TABLE 30

FOAM: V TYPE: FLOUROPROTEIN CONCENTRATION: 6 PERCENT

METHOD	TEST	WATER	FUEL	CONTROL MIN.	EXT. MIN.	TORCH	BURNBACK +	EXPANSION PAN	EXPANSION CYLINDER	DRAIN TIME, MIN. PAN	DRAIN TIME, MIN. CYLINDER
FRN	71	F	H	0.87	1.37	-	24.10	8.7	-	7.10	-
FRN	73	F	G	1.50	1.98	-	15.91	8.7	-	7.10	-
FRN	76	S	G	1.80	2.11	-	12.46	7.4	-	9.25	-
MIL	72	F	G	0.83	None	-	-	7.0	-	3.75	-
MIL	77	S	G	None	-	-	-	6.0	-	3.50	-
MIL	134	F	H	None	-	-	-	7.3	-	2.75	-
UL 162	74	F	H	1.83	3.00	Failed	-	5.6	-	2.95	-
UL 162	78	S	H	2.33	5.00	Passed	++	4.7	-	3.22	-
UL 162	135	F	G	4.25	None	-	-	5.6	-	2.53	-
OF555C	75	F	G	1.00	2.75	Passed	5 by 5	7.1	-	2.75	-
OF555C	79	S	G	2.00	3.33	Failed	-	7.3	-	2.28	-
OF555C	136	F	H	1.33	4.75	Passed	8 by 8	7.1	-	2.03	-
							AVG	6.66	-	3.83	-
							S.D.	1.19	-	2.26	-

\+ - Burnback in min for FRN test method and in. for UL 162 and OF555C test methods.

++ - Entire pan reignited.

TABLE 31

FOAM: W TYPE: PROTEIN CONCENTRATION: 3 PERCENT

METHOD	TEST	WATER	FUEL	CONTROL MIN.	EXT. MIN.	TORCH	BURNBACK +	EXPANSION PAN	EXPANSION CYLINDER	DRAIN TIME, MIN. PAN	DRAIN TIME, MIN. CYLINDER
FRN	257	F	H	1.42	1.97	-	36.55	8.4	-	10.50	-
FRN	258	F	G	1.93	None	-	-	8.4	-	10.50	-
FRN	262	S	G	2.00	2.75	-	18.14	8.1	-	9.75	-
MIL	259	F	G	None	-	-	-	6.1	6.9	2.13	10.25
MIL	263	S	G	None	-	-	-	6.8	6.3	2.22	9.33
MIL	294	F	H	None	-	-	-	5.6	5.8	2.57	10.97
UL 162	260	F	H	2.83	None	-	-	4.6	4.7	2.22	8.58
UL 162	264	S	H	3.87	None	-	-	4.6	4.8	2.62	10.93
UL 162	295	F	G	None	-	-	-	4.4	5.0	2.17	11.20
OF555C	261	F	G	1.75	3.33	Passed	10 by 10	6.3	7.8	1.30	8.95
OF555C	265	S	G	1.67	2.92	Passed	8 by 8	6.8	7.1	1.65	8.17
OF555C	296	F	H	1.92	2.98	Passed	4 by 4	6.6	7.0	1.42	8.32
							AVG	6.21	6.06	3.50	9.56
							S.D.	1.34	1.18	3.31	1.28

+ - Burnback in min for FRN test method and in. for OF555C test method.

TABLE 32

FOAM: X TYPE: PROTEIN CONCENTRATION: 6 PERCENT

METHOD	TEST	WATER	FUEL	CONTROL MIN.	EXT. MIN.	TORCH	BURNBACK +	EXPANSION PAN	EXPANSION CYLINDER	DRAIN TIME, MIN. PAN	DRAIN TIME, MIN. CYLINDER
FRN	215	F	H	1.17	1.79	-	34.07	6.9	-	5.97	-
FRN	216	F	G	0.95	2.18	-	32.20	6.9	-	5.97	-
FRN	220	S	G	1.85	2.31	-	14.79	7.0	-	4.47	-
MIL	217	F	G	None	-	-	-	5.1	5.2	1.77	8.67
MIL	221	S	G	None	-	-	-	5.8	4.5	2.97	8.45
MIL	245	F	H	1.05	None	-	-	7.2	8.1	2.05	8.25
UL 162	218	F	H	3.45	None	-	-	4.7	4.8	2.83	8.53
UL 162	222	S	H	4.37	None	-	-	4.9	4.7	3.13	11.27
UL 162	246	F	G	None	-	-	-	5.3	6.0	2.07	8.85
OF555C	219	F	G	3.92	None	-	-	4.3	5.7	0.92	5.33
OF555C	223	S	G	1.58	2.77	Failed	-	3.9	4.2	0.82	7.97
OF555C	247	F	H	4.33	5.08	Passed	12 by 12	6.9	6.5	1.17	5.13
							AVG	5.64	5.52	2.83	8.05
							S.D.	1.19	1.22	2.10	1.86

+ - Burnback in min for FRN test method and in. for OF555C test method.

TABLE 33

FOAM: Y TYPE: FLUOROPROTEIN CONCENTRATION: 3 PERCENT

METHOD	TEST	WATER	FUEL	CONTROL MIN.	EXT. MIN.	TORCH	BURNBACK +	EXPANSION PAN	EXPANSION CYLINDER	DRAIN TIME, MIN. PAN	DRAIN TIME, MIN. CYLINDER
FRN	266	F	H	0.66	1.50	-	26.95	5.3	-	3.70	-
FRN	267	F	H	1.60	2.72	-	15.66	5.3	-	3.70	-
FRN	271	S	G	1.67	2.25	-	16.30	5.7	-	1.83	-
MIL	268	F	G	None	-	-	-	5.1	5.0	1.55	5.58
MIL	272	S	G	None	-	-	-	4.4	5.1	2.67	3.42
MIL	297	F	H	None	-	-	-	5.2	5.1	1.97	9.52
UL 162	269	F	H	4.08	None	-	-	4.2	4.2	1.08	9.43
UL 162	273	S	H	2.25	4.08	Passed	3 by 3	4.3	4.3	2.08	8.40
UL 162	298	F	G	None	-	-	-	4.2	4.3	2.03	8.40
OF555C	270	F	G	3.13	4.58	Passed	7 by 7	5.9	5.7	1.28	5.40
OF555C	274	S	G	2.37	3.13	Passed	8 by 8	5.8	5.8	1.80	6.92
OF555C	299	F	H	2.00	3.03	Passed	5 by 5	4.8	4.6	1.08	4.83
							AVG	4.96	4.90	1.91	6.89
							S.D.	0.61	0.60	0.76	2.19

+ - Burnback in min for FRN test method
and in. for UL 162 and OF555C test methods.

TABLE 34

FOAM: Z TYPE: FLUOROPROTEIN CONCENTRATION: 6 PERCENT

METHOD	TEST	WATER	FUEL	CONTROL MIN.	EXT. MIN.	TORCH	BURNBACK +	EXPANSION PAN	EXPANSION CYLINDER	DRAIN TIME, MIN. PAN	DRAIN TIME, MIN. CYLINDER
FRN	224	F	H	0.60	1.14	-	33.00	7.3	-	6.50	-
FRN	225	F	G	1.05	2.11	-	14.63	7.3	-	6.50	-
FRN	299	S	G	1.11	1.69	-	12.51	7.4	-	6.88	-
MIL	226	F	G	None	-	-	-	5.7	6.4	2.22	8.18
MIL	230	S	G	None	-	-	-	5.2	5.6	2.30	7.12
MIL	284	F	H	1.08	None	-	-	5.2	5.8	3.73	10.05
UL 162	227	F	H	3.92	None	-	-	4.6	4.7	2.77	9.37
UL 162	231	S	H	3.40	None	-	-	4.5	4.5	2.92	9.55
UL 162	285	F	G	None	-	-	-	4.5	4.8	2.00	8.83
OF555C	228	F	G	1.10	2.10	Passed	8 by 8	5.3	5.5	0.97	4.48
OF555C	232	S	G	2.02	2.77	Passed	36 by 36	5.7	5.8	1.05	4.25
OF555C	286	F	H	1.25	2.17	Passed	5 by 5	6.5	6.8	2.95	6.02
							AVG	5.63	5.54	3.12	7.54
							S.D.	1.04	0.78	1.94	2.19

+ - Burnback in min for FRN test method and in. for OF555C test method.

TABLE 35

TEST METHOD: FRN TYPE OF FOAM: PROTEIN

FOAM	TEST	WATER	FUEL	CONTROL MIN.	EXT. MIN.	BURNBACK MIN.	EXPANSION PAN	EXPANSION CYLINDER	DRAIN TIME, MIN. PAN	DRAIN TIME, MIN. CYLINDER
A	248	F	H	1.00	1.75	23.85	6.6	-	6.78	-
A	249	F	G	1.89	2.67	19.15	6.6	-	6.78	-
A	253	S	H	1.50	1.95	18.30	7.5	-	8.73	-
B	206	F	H	1.70	2.20	12.30	8.6	-	7.67	-
B	208	F	H	1.87	2.02	13.04	8.6	-	7.67	-
B	211	S	G	2.58	3.00	11.00	8.6	-	12.13	-
E	186	F	H	1.08	2.70	13.68	6.6	6.0	3.63	10.83
E	176X	F	G	None	-	-	6.6	6.0	3.63	10.83
E	193	S	H	2.21	2.67	9.00	7.0	-	5.03	-
E	195	S	G	None	-	-	7.0	-	5.03	-
F	143	F	H	0.87	2.18	12.11	8.0	-	5.55	-
F	145	F	G	2.67	None	-	8.0	-	5.55	-
F	148	S	G	2.59	2.77	4.19	8.5	-	8.42	-
S	89	F	G	2.20	2.59	12.25	6.4	-	5.52	-
S	91	F	H	1.64	2.59	28.25	6.4	-	5.52	-
S	94	S	G	2.60	3.00	17.10	7.3	-	7.77	-
T	98	F	G	2.00	2.32	20.00	8.9	-	10.25	-
T	100	F	H	1.65	1.89	26.45	8.9	-	10.25	-
T	103	S	G	2.71	3.00	12.05	8.7	-	11.67	-
W	257	F	H	1.42	1.97	36.55	8.4	-	10.50	-
W	285	F	G	1.93	None	-	8.4	-	10.50	-
W	262	S	G	2.00	2.75	18.14	8.1	-	9.75	-
X	215	F	H	1.17	1.79	34.07	6.9	-	5.97	-
X	216	F	G	0.95	2.18	32.20	6.9	-	5.97	-
X	220	S	G	1.85	2.31	14.79	7.0	-	7.47	-

TABLE 36

TEST METHOD: FRN TYPE OF FOAM: SYNTHETIC

FOAM	TEST	WATER	FUEL	CONTROL MIN.	EXT. MIN.	BURNBACK MIN.	EXPANSION PAN	EXPANSION CYLINDER	DRAIN TIME, MIN. PAN	DRAIN TIME, MIN. CYLINDER
C	56	F	G	1.88	None	-	8.7	-	13.10	-
C	59	F	H	0.78	1.19	7.75	8.7	-	13.10	-
C	61	S	G	1.97	2.87	4.50	6.4	-	3.93	-
D	23	F	G	1.65	None	-	7.8	-	12.38	-
D	25	F	H	1.50	None	-	7.8	-	12.38	-
D	28	S	G	None	-	-	3.1	-	13.62	-

TABLE 37

TEST METHOD: FRN TYPE OF FOAM: FLUOROPROTEIN

FOAM	TEST	WATER	FUEL	CONTROL MIN.	EXT. MIN.	BURNBACK MIN.	EXPANSION PAN	EXPANSION CYLINDER	DRAIN TIME, MIN. PAN	DRAIN TIME, MIN. CYLINDER
G	184	F	H	0.85	1.09	19.09	6.7	-	3.73	-
G	186	F	G	1.97	3.85	9.85	6.7	-	3.73	-
G	189	S	G	None	-	-	7.3	-	5.67	-
H	303	F	H	0.77	1.40	23.45	8.0	-	6.18	-
H	304	F	G	0.77	1.57	17.65	8.0	-	6.18	-
H	308	S	G	1.58	2.03	21.42	8.0	-	7.08	-
U	80	F	H	0.80	0.96	27.45	5.2	-	3.08	-
U	82	F	G	1.08	1.41	16.97	5.2	-	3.08	
U	85	S	G	1.08	1.90	11.75	5.7	-	4.08	-
V	71	F	H	0.87	1.37	24.10	8.7	-	7.10	-
V	73	F	G	1.50	1.98	15.91	8.7	-	7.10	-
V	76	S	G	1.80	2.11	12.46	7.4	-	9.25	-
Y	266	F	H	0.66	1.50	26.95	5.3	-	3.70	-
Y	267	F	G	1.60	2.72	15.66	5.3	-	3.70	-
Y	271	S	G	1.67	2.25	16.30	5.7	-	1.83	-
Z	224	F	H	0.60	1.14	33.00	7.3	-	6.50	-
Z	225	F	G	1.05	2.11	14.63	7.3	-	6.50	-
Z	229	S	G	1.11	1.69	12.51	7.4	-	6.88	-

TABLE 38
TEST METHOD: FRN TYPE OF FOAM: AFFF

FOAM	TEST	WATER	FUEL	CONTROL MIN.	EXT. MIN.	BURNBACK MIN.	EXPANSION PAN	EXPANSION CYLINDER	DRAIN TIME, MIN. PAN	DRAIN TIME, MIN. CYLINDER
I	167	F	H	0.80	0.95	9.28	-	6.3	-	5.27
I	168	F	G	0.80	0.99	6.92	-	6.3	-	5.27
I	172	S	G	0.60	None	-	-	5.6	-	5.33
I	180	S	G	0.81	1.11	7.84	5.5	5.3	1.23	5.33
J	158	F	G	0.68	0.79	7.02	-	6.4	-	5.37
J	159	F	H	0.60	0.80	11.24	-	6.4	-	5.37
J	163	S	G	0.95	1.35	8.25	-	4.7	-	5.30
K	32	F	H	0.45	0.55	7.10	-	7.7	-	5.33
K	34	F	H	0.45	0.65	9.67	-	7.7	-	5.33
K	37	S	G	0.50	0.56	5.10	-	7.3	-	4.70
L	1	S	H	0.40	0.72	10.10	-	7.3	-	4.97
L	5	S	G	0.30	0.75	5.95	-	7.5	-	5.23
L	9	F	H	0.50	0.62	9.50	-	8.0	-	5.50
L	11	F	G	0.50	3.50	5.03	-	8.0	-	5.50
M	107	F	G	0.40	0.55	7.27	-	8.1	-	5.90
M	109	F	H	0.40	0.69	8.97	-	8.1	-	5.90
M	112	S	G	0.50	0.62	5.77	-	6.9	-	5.42
N	116	F	G	2.17	None	-	-	8.3	-	6.00
N	118	F	H	0.62	0.72	13.82	-	8.3	-	6.00
N	121	S	G	0.95	None	-	-	7.7	-	5.30
O	14	S	G	0.47	1.63	7.80	-	7.7	-	6.30
O	18	F	H	0.59	0.65	18.00	-	8.9	-	5.68
O	20	F	G	0.90	1.25	7.20	-	8.9	-	5.68

TABLE 38 (Con't)

TEST METHOD: FRN TYPE OF FOAM: AFFF

FOAM	TEST	WATER	FUEL	CONTROL MIN.	EXT. MIN.	BURNBACK MIN.	EXPANSION PAN	EXPANSION CYLINDER	DRAIN TIME, MIN. PAN	DRAIN TIME, MIN. CYLINDER
P	41	S	G	1.85	None	-	-	7.1	-	3.12
P	45	F	H	0.30	0.40	7.34	-	8.3	-	5.17
P	47	F	G	0.75	1.70	7.17	-	8.3	-	5.17
Q	275	F	H	0.58	0.75	14.35	8.2	8.2	1.75	7.82
Q	276	F	G	0.56	0.60	14.56	8.2	8.2	1.75	7.82
Q	280	S	G	1.08	None	-	6.4	7.0	2.17	6.15
R	233	F	H	0.83	0.99	9.93	5.7	6.0	1.67	5.85
R	234	F	G	0.85	0.99	8.77	5.7	6.0	1.67	5.85
R	238	S	G	0.64	1.21	6.44	6.5	5.5	2.63	5.28

TABLE 39

COMPARISON OF FRN CONTROL, EXTINGUISHMENT AND BURNBACK RESISTANCE RESULTS WITH VARYING FUELS AND WATERS

Foam Type	Control Min		Extinguishment, Min		Burnback Resistance, Min	
	Average	S.D.	Average	S.D.	Average	S.D.
ALL TEST						
All	1.16	0.65	1.62	0.78	14.67	7.86
ALL TESTS WITH HEPTANE						
All	0.88	0.46	1.35	0.69	17.79	9.19
Protein	1.42	0.43	2.19	0.38	19.81	12.13
Synthetic	0.64	0.20	1.19	+	7.75	+
Fluoroprotein	0.76	0.11	1.24	0.21	25.67	4.67
AFFF	0.55	0.17	0.73	0.16	10.65	3.00
ALL TESTS WITH GASOLINE						
All	1.33	0.69	1.82	0.80	12.46	5.96
Protein	2.08	0.49	2.52	0.40	16.46	6.53
Synthetic	1.72	0.23	2.87	+	4.50	+
Fluoroprotein	1.27	0.30	2.05	0.44	15.11	3.27
AFFF	0.75	0.42	0.97	0.40	7.52	2.24
ALL TESTS WITH FRESH WATER						
All	1.06	0.55	1.47	0.72	16.27	8.46
Protein	1.59	0.48	2.21	0.33	22.24	8.63
Synthetic	1.12	0.56	1.19	+	7.75	+
Fluoroprotein	1.01	0.36	1.68	0.62	20.48	6.57
AFFF	0.68	0.37	0.82	0.30	9.61	3.09
ALL TESTS WITH SEA WATER						
All	1.37	0.79	1.94	0.83	11.33	5.17
Protein	2.26	0.44	2.66	0.40	13.70	4.90
Synthetic	1.79	+	2.87	+	4.50	+
Fluoroprotein	1.35	0.29	1.97	0.19	14.90	4.06
AFFF	0.68	0.35	0.97	0.41	7.06	1.75
ALL TESTS WITH 3 PERCENT CONCENTRATES						
All	1.15	0.63	1.64	0.92	14.19	7.68
Protein	1.77	0.49	2.43	0.40	19.63	8.52
Synthetic	1.43	0.60	2.03	1.19	6.13	2.30
Fluoroprotein	1.13	0.36	1.82	0.71	18.13	6.34
AFFF	0.60	0.20	0.81	0.32	9.38	3.88

Table Cont'd On Next Page.....

TABLE 39 (Con't)

Foam Type	Control Min Average	Control Min S.C.	Extinguishment, Min Average	Extinguishment, Min S.D.	Burnback Resistance, Min Average	Burnback Resistance, Min S.D.
	ALL TESTS WITH 6 PERCENT CONCENTRATES					
All	1.22	0.72	1.68	0.77	14.48	8.15
Protein	1.86	0.64	2.33	0.44	18.41	8.73
Synthetic	1.08	0.81	+	+	+	+
Fluoroprotein	1.09	0.39	1.71	0.36	19.47	6.71
AFFF	0.76	0.46	0.92	0.35	8.38	1.63

+ - Insufficient Data

TABLE 40

TEST METHOD: MIL TYPE OF FOAM: PROTEIN

FOAM	TEST	WATER	FUEL	CONTROL MIN.	EXT. MIN.	BURNBACK MIN.	EXPANSION PAN	EXPANSION CYLINDER	DRAIN TIME, MIN. PAN	DRAIN TIME, MIN. CYLINDER
A	250	F	G	None	-	-	5.6	5.8	1.43	7.03
A	254	S	G	None	-	-	5.6	5.6	1.75	7.55
A	291	F	H	None	-	-	5.4	5.2	1.18	7.35
B	207	F	G	None	-	-	6.2	6.6	2.32	6.50
B	212	S	G	None	-	-	6.7	6.9	3.63	11.65
B	242	F	H	None	-	-	5.9	6.2	2.33	9.08
E	177	F	H	None	-	-	4.5	5.5	1.18	5.55
E	177X	F	G	None	-	-	4.5	5.5	1.18	5.55
E	194	S	G	None	-	-	6.1	6.7	1.83	7.05
F	144	F	G	None	-	-	6.2	-	1.08	-
F	149	S	G	None	-	-	6.2	-	1.50	-
F	152	S	H	None	-	-	6.3	-	1.78	-
S	90	F	G	none	-	-	6.2	-	1.70	-
S	95	S	G	None	-	-	6.2	-	1.87	-
S	125	F	H	None	-	-	6.6	-	1.50	-
T	99	F	G	None	-	-	8.5	-	3.20	-
T	104	S	G	None	-	-	9.4	-	4.67	-
T	104A	S	H	None	-	-	9.4	-	4.67	-
T	128	F	H	None	-	-	7.8	-	3.38	-
W	259	F	G	None	-	-	6.1	6.9	2.13	10.25
W	263	S	G	None	-	-	6.8	6.3	2.22	9.33
W	294	F	H	None	-	-	5.6	5.8	2.57	10.97
X	217	F	G	None	-	-	5.1	5.2	1.77	8.67
X	221	S	G	None	-	-	5.8	4.5	2.97	8.45
X	245	F	H	1.05	None	-	7.2	8.1	2.05	8.25

TABLE 41

TEST METHOD: MIL TYPE OF FOAM: SYNTHETIC

FOAM	TEST	WATER	FUEL	CONTROL MIN.	EXT. MIN.	BURNBACK MIN.	EXPANSION PAN	EXPANSION CYLINDER	DRAIN TIME, MIN. PAN	DRAIN TIME, MIN. CYLINDER
C	57	F	G	None	-	-	8.0	-	7.50	-
C	62	S	G	None	-	-	5.6	-	4.18	-
C	140	F	H	None	-	-	9.3	-	10.62	-
D	24	F	G	None	None	-	8.3	-	10.75	-
D	29	S	G	None	-	-	4.8	-	12.47	-
D	65	F	H	None	-	-	9.5	-	10.58	-

TABLE 42

TEST METHOD: MIL TYPE OF FOAM: FLUOROPROTEIN

FOAM	TEST	WATER	FUEL	CONTROL MIN.	EXT. MIN.	BURNBACK MIN.	EXPANSION PAN	EXPANSION CYLINDER	DRAIN TIME, MIN. PAN	DRAIN TIME, MIN. CYLINDER
G	185	F	G	None	-	-	4.5	4.5	1.00	5.43
G	190	S	G	None	-	-	5.7	5.8	1.58	7.45
G	200	F	H	None	-	-	6.4	6.6	1.97	8.35
H	305	F	G	None	-	-	6.0	6.0	2.35	11.62
H	309	S	G	None	-	-	5.3	6.1	2.30	11.07
H	312	F	H	None	-	-	5.6	6.3	2.17	10.08
U	81	F	G	None	-	-	4.4	-	0.97	-
U	86	S	G	None	-	-	4.8	-	1.28	-
U	131	F	H	None	-	-	5.5	-	2.00	-
V	72	F	G	0.83	None	-	7.0	-	3.75	-
V	77	S	G	None	-	-	6.0	-	3.50	-
V	134	F	H	None	-	-	7.3	-	2.75	-
Y	268	F	G	None	-	-	5.1	5.0	1.55	5.58
Y	272	S	G	None	-	-	4.4	5.1	2.67	3.42
Y	297	F	H	None	-	-	5.2	5.1	1.97	9.52
Z	226	F	G	None	-	-	5.7	6.4	2.22	8.18
Z	230	S	G	None	-	-	5.2	5.6	2.30	7.12
Z	284	F	H	1.08	None	-	5.2	5.8	2.73	10.05

TABLE 43

TEST METHOD: MIL TYPE OF FOAM: AFFF

FOAM	TEST	WATER	FUEL	CONTROL MIN.	EXT. MIN.	BURNBACK MIN.	EXPANSION PAN	EXPANSION CYLINDER	DRAIN TIME, MIN. PAN	DRAIN TIME, MIN. CYLINDER
I	169	F	G	1.00	None	-	-	5.6	-	3.97
I	169A	F	G	0.97	None	-	-	5.6	-	3.97
I	173	S	G	0.83	None	-	-	5.9	-	4.17
I	181	S	H	None	-	-	5.2	5.7	1.00	3.33
I	181A	S	H	0.88	None	-	5.2	5.7	1.00	3.33
J	160	F	G	0.78	None	-	-	6.1	-	3.12
J	160A	F	G	0.88	None	-	-	6.1	-	3.12
J	164	S	G	1.00	None	-	-	4.7	-	3.73
J	164A	S	G	0.92	None	-	-	4.7	-	3.73
J	203	S	H	0.88	None	-	5.2	5.5	0.87	3.58
J	203A	S	H	0.78	None	-	5.2	5.5	0.87	3.58
K	33	F	G	1.00	None	-	-	7.2	-	3.77
K	33A	F	G	0.58	0.88	5.83	6.5	6.4	1.27	3.80
K	38	S	G	None	-	-	-	7.6	-	3.17
K	38A	S	G	0.62	0.92	5.83	5.4	6.4	1.30	4.55
K	50	S	H	0.75	None	-	-	7.1	-	3.13
K	50A	S	H	0.72	0.97	5.83	6.3	6.1	1.27	4.33
L	2	S	H	0.67	1.00	8.25	-	6.7	-	2.75
L	2A	S	H	1.07	None	-	6.1	6.1	1.77	5.32
L	6	S	G	0.25	1.08	4.50	-	7.2	-	3.23
L	6A	S	G	0.70	None	-	5.8	5.6	1.00	3.13
L	10	F	G	0.50	None	-	-	8.6	-	3.70
L	10A	F	G	0.58	0.80	6.25	7.0	6.6	1.55	5.56
M	108	F	G	0.55	None	-	-	8.9	-	3.38
M	108A	F	G	0.63	0.78	5.83	6.7	6.9	2.22	7.02
M	113	S	G	0.75	None	-	-	7.2	-	3.17
M	113A	S	G	0.77	0.97	6.50	7.6	6.5	1.63	-
M	137	F	H	0.98	None	-	-	7.9	-	3.33
M	137A	F	H	0.83	None	-	-	7.9	-	3.33

TABLE 43 (Con't)

TEST METHOD: MIL TYPE OF FOAM: AFFF

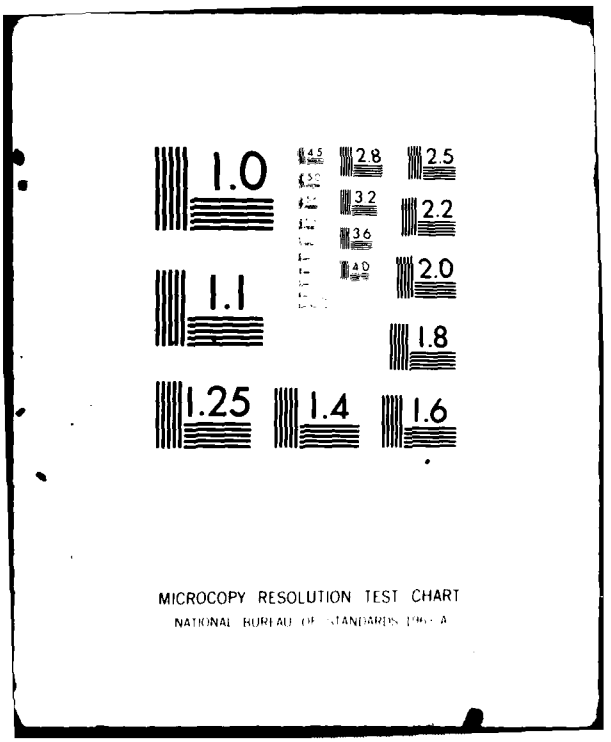
FOAM	TEST	WATER	FUEL	CONTROL MIN.	EXT. MIN.	BURNBACK MIN.	EXPANSION PAN	EXPANSION CYLINDER	DRAIN TIME, MIN. PAN	DRAIN TIME, MIN. CYLINDER
N	117	F	G	None	-	-	-	7.7	-	4.30
N	117A	F	G	1.00	None	-	-	7.7	-	4.30
N	122	S	G	None	-	-	-	7.7	-	3.77
N	122A	S	G	None	-	-	-	7.7	-	3.77
N	155	F	H	0.95	None	-	-	7.4	-	4.17
N	155A	F	H	0.78	None	-	-	7.4	-	4.17
O	15	S	G	0.83	None	-	-	8.3	-	5.28
O	15A	S	G	0.58	None	-	7.8	7.4	3.03	7.28
O	19	F	G	0.67	None	-	-	8.2	-	4.80
O	19A	F	G	0.58	None	-	8.2	7.9	3.37	4.75
O	53	S	H	0.80	None	-	-	7.9	-	4.45
O	53A	S	H	0.50	0.83	7.20	6.5	6.3	1.87	6.77
P	42	S	G	0.66	None	-	-	6.6	-	3.75
P	42A	S	G	0.65	None	-	6.0	7.0	2.35	8.62
P	46	F	G	None	-	-	-	7.6	-	3.72
P	46A	F	G	None	-	-	7.5	6.9	1.28	5.47
P	68	S	H	0.83	None	-	-	6.9	-	3.70
P	68A	S	H	0.58	0.82	6.92	7.1	7.0	1.82	7.25
Q	277	F	G	0.75	1.08	3.33	7.2	6.9	1.78	5.53
Q	277A	F	G	0.58	0.80	6.50	7.2	6.9	1.78	5.53
Q	281	S	G	0.72	None	-	6.3	6.6	1.13	4.55
Q	281A	S	G	0.62	None	-	6.3	6.6	1.13	4.55
Q	300	S	H	1.00	None	-	6.2	6.9	1.15	4.29
Q	300A	S	H	0.75	None	-	6.2	6.9	1.25	4.48
R	235	F	G	0.98	None	-	5.2	5.1	0.90	3.17
R	235A	F	G	1.05	None	-	5.2	5.1	0.90	3.17
R	239	S	G	None	-	-	5.5	5.7	1.05	2.78
R	239A	S	G	0.80	None	-	5.5	5.7	1.05	2.78
R	287	S	H	0.72	None	-	5.5	5.4	1.43	3.30
R	287A	S	H	0.67	None	-	5.5	5.4	1.43	3.30

TABLE 44

TEST METHOD: UL 162 TYPE OF FOAM: PROTEIN

FOAM	TEST	WATER	FUEL	CONTROL MIN.	EXT. MIN.	TORCH	BURNBACK INS.	EXPANSION PAN	EXPANSION CYLINDER	DRAIN TIME, MIN. PAN	DRAIN TIME, MIN. CYLINDER
A	251	F	H	4.13	None	-	-	4.4	4.5	2.78	8.58
A	255	S	H	4.13	None	-	-	4.9	4.7	2.23	9.53
A	292	F	G	None	-	-	-	4.1	4.5	1.30	7.35
B	209	F	H	3.25	None	-	-	5.2	4.9	2.42	9.32
B	213	S	H	4.83	None	-	-	4.9	5.3	2.97	8.45
B	243	F	G	None	-	-	-	4.6	4.9	2.37	8.73
E	178	F	G	None	-	-	-	4.3	4.1	0.97	5.05
E	196	S	H	None	-	-	-	4.4	4.3	1.58	7.48
E	198	F	H	None	-	-	-	4.4	4.3	1.20	5.63
F	146	F	H	3.33	None	-	-	4.4	-	1.20	-
F	150	S	H	None	-	-	-	4.0	-	1.53	-
F	153	S	G	None	-	-	-	4.8	-	1.85	-
S	92	F	H	2.83	None	-	-	4.5	-	1.75	-
S	96	S	H	3.47	None	-	-	4.9	-	2.70	-
S	126	F	G	None	-	-	-	4.8	-	1.88	-
T	101	F	H	2.75	None	-	-	5.5	-	2.48	-
T	105	S	H	3.33	None	-	-	5.8	-	3.23	-
T	129	F	G	3.63	None	-	-	5.7	-	2.90	-
W	260	F	H	2.83	None	-	-	4.6	4.7	2.22	8.58
W	264	S	H	3.87	None	-	-	4.6	4.8	2.62	10.93
W	295	F	G	None	-	-	-	4.4	5.0	2.17	11.20
X	218	F	H	3.45	None	-	-	4.7	4.8	2.83	8.53
X	222	S	H	4.37	None	-	-	4.9	4.7	3.13	11.27
X	246	F	G	None	-	-	-	5.3	6.0	2.07	8.85

AD-A108 097 UNDERWRITER'S LABS INC NORTHBROOK IL F/G 13/12
TESTING OF FIRE FIGHTING FOAM.(U)
NOV 80 W M CAREY, M R SUCHOMEL DOT-CG-827673-A
UNCLASSIFIED USCG-M-2-81 NL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MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

TABLE 45

TEST METHOD: UL 162 TYPE OF FOAM: SYNTHETIC

FOAM	TEST	WATER	FUEL	CONTROL MIN.	EXT. MIN.	TORCH	BURNBACK INS.	EXPANSION PAN	EXPANSION CYLINDER	DRAIN TIME, MIN. PAN	DRAIN TIME, MIN. CYLINDER
C	58	F	H	1.58	None	-	-	5.7	-	7.42	-
C	63	S	H	None	-	-	-	4.8	-	3.58	-
C	141	F	G	None	-	-	-	5.8	-	8.77	-
D	26	F	H	0.92	None	-	-	5.2	-	9.45	-
D	30	S	G	None	-	-	-	3.4	-	17.75	-
D	66	F	G	None	-	-	-	6.1	-	9.00	-

TABLE 46

TEST METHOD: UL 162 TYPE OF FOAM: FLUOROPROTEIN

FOAM	TEST	WATER	FUEL	CONTROL MIN.	EXT. MIN.	TORCH	BURNBACK INS.	EXPANSION PAN	EXPANSION CYLINDER	DRAIN TIME, MIN. PAN	DRAIN TIME, MIN. CYLINDER
G	187	F	H	3.83	None	-	-	4.3	4.9	1.25	5.68
G	191	S	H	2.83	None	-	-	4.9	4.5	1.92	7.68
G	201	F	G	2.83	None	-	-	4.5	4.5	1.45	6.87
H	306	F	H	2.35	None	-	-	4.6	4.8	2.20	9.20
H	310	S	H	2.33	None	-	-	4.6	4.8	2.47	9.42
H	3.3	F	G	2.67	None	-	-	4.6	4.8	2.00	7.68
U	83	F	H	1.92	4.83	Passed	+	4.2	-	1.75	-
U	87	S	H	4.00	None	-	-	4.3	-	1.58	-
U	132	F	G	None	-	-	-	4.8	-	1.62	-
V	74	F	H	1.83	3.00	Failed	-	5.6	-	2.95	-
V	78	S	H	2.33	5.00	Passed	++	4.7	-	3.22	-
V	135	F	G	4.25	None	-	-	5.6	-	2.53	-
Y	269	F	H	4.08	None	-	-	4.2	4.2	1.08	9.43
Y	273	S	H	225	4.08	Passed	3 by 3	4.3	4.3	2.08	8.40
Y	298	F	G	None	-	-	-	4.2	4.3	2.03	8.40
Z	227	F	H	3.92	None	-	-	4.6	4.7	2.77	9.37
Z	231	S	H	3.40	None	-	-	4.5	4.5	2.92	9.55
Z	285	F	G	None	-	-	-	4.5	4.8	2.00	8.83

\+ - Entire pan reignited. About 27 percent self extinguished remaining 25 percent continued to burn.

++ - Entire pan reignited.

TABLE 47

TEST METHOD: UL 162 TYPE OF FOAM: AFFF

FOAM	TEST	WATER	FUEL	CONTROL MIN.	EXT. MIN.	TORCH	BURNBACK INS.	EXPANSION PAN	EXPANSION CYLINDER	DRAIN TIME, MIN. PAN	DRAIN TIME, MIN. CYLINDER
I	170	F	H	1.60	2.78	Failed	-	-	4.6	-	4.17
I	174	S	H	1.97	None	-	-	-	4.9	-	4.35
I	182	S	G	1.08	None	-	-	4.3	4.5	1.08	4.93
J	161	F	H	3.38	None	-	-	-	4.8	-	4.7-
J	165	S	H	2.83	None	-	-	-	4.0	-	4.25
J	204	S	G	2.38	None	-	-	4.2	4.3	0.92	3.70
K	35	F	H	1.08	1.75	Failed	-	-	5.0	-	5.97
K	39	S	H	1.33	2.08	Failed	-	-	5.4	-	3.25
K	51	S	G	1.50	3.08	Failed	-	-	5.0	-	3.68
L	3	S	H	1.08	1.75	Failed	-	-	4.8	-	4.42
L	7	S	G	0.75	1.50	Failed	-	-	4.6	-	4.22
L	12	F	H	0.67	2.58	Failed	-	-	5.1	-	4.25
M	110	F	H	1.53	2.18	Failed	-	-	4.8	-	4.20
M	114	S	H	1.50	4.53	Failed	-	-	4.6	-	4.30
M	138	F	G	2.03	None	-	-	-	5.4	-	3.25
N	119	F	H	1.25	None	-	-	-	5.6	-	4.88
N	123	S	H	2.08	None	-	-	-	5.0	-	4.33
N	156	F	G	2.93	None	-	-	-	5.4	-	4.68
O	16	S	H	1.17	2.75	Failed	-	-	5.1	-	5.75
O	21	F	H	-.75	1.87	Failed	-	-	5.6	-	5.58
O	54	S	G	0.87	4.08	Failed	-	-	5.4	-	5.17

TABLE 47 (Con't)

TEST METHOD: UL 162 TYPE OF FOAM: AFFF

FOAM	TEST	WATER	FUEL	CONTROL MIN.	EXT. MIN.	TORCH	BURNBACK INS.	EXPANSION PAN	EXPANSION CYLINDER	DRAIN TIME, MIN. PAN	DRAIN TIME, MIN. CYLINDER
P	43	S	H	0.90	2.10	Failed	-	-	5.4	-	4.83
P	48	F	H	1.07	2.60	Failed	-	-	4.9	-	3.95
P	69	S	G	2.33	3.57	Failed	-	-	5.3	-	4.48
Q	278	F	H	1.13	3.30	Failed	-	5.4	5.4	3.22	6.43
Q	282	S	H	1.92	3.33	Failed	-	5.2	5.2	1.10	4.75
Q	301	S	G	2.75	3.33	Failed	-	4.9	4.7	1.25	4.47
R	236	F	H	1.87	None	-	-	4.3	4.5	1.07	4.80
R	240	S	H	2.58	None	-	-	4.4	4.3	1.00	3.20
R	288	S	G	1.42	None	-	-	4.4	4.5	1.33	4.07

TABLE 48

TEST METHOD: OF555C TYPE OF FOAM: PROTEIN

FOAM	TEST	WATER	FUEL	CONTROL MIN.	EXT. MIN.	TORCH	BURNBACK INS.	EXPANSION PAN	EXPANSION CYLINDER	DRAIN TIME, MIN. PAN	DRAIN TIME, MIN. CYLINDER
A	252	F	G	3.55	4.25	Failed	-	3.6	4.2	1.00	3.47
A	265	S	G	1.88	4.17	Failed	-	5.8	6.3	1.03	8.82
A	293	F	H	2.67	3.83	Failed	-	6.0	6.5	<1.00	-
B	210	F	G	3.00	4.42	Failed	-	4.4	5.1	1.67	4.58
B	214	S	G	2.50	3.67	Failed	-	5.1	5.4	<1.00	7.92
B	244	F	H	1.50	2.67	Passed	10 by 10	3.7	4.4	<1.00	2.57
E	179	F	H	None	-	-	-	3.5	3.2	-	2.08
E	197	S	G	2.83	4.00	Failed	-	5.5	5.1	1.42	4.55
E	199	F	G	None	-	-	-	5.5	5.1	0.88	4.60
F	147	F	G	4.00	None	-	-	4.9	-	0.95	-
F	151	S	H	2.00	2.50	Passed	o+	5.7	-	1.00	-
F	154	S	H	1.42	4.55	Failed	-	5.2	-	1.70	-
S	93	F	G	2.75	4.75	Failed	-	6.0	-	0.87	-
S	97	S	G	2.67	3.08	Failed	-	6.9	-	1.67	-
S	127	F	H	2.58	4.17	Failed	-	6.1	-	1.37	-
T	102	F	G	-	1.00	Failed	-	9.1	-	4.12	-
T	106	S	G	1.00	4.77	Failed	-	7.9	-	3.60	-
T	130	F	H	1.17	3.08	Failed	-	6.2	-	2.13	-
W	261	F	G	1.75	3.33	Passed	10 by 10	6.3	7.8	1.30	8.95
W	265	S	G	1.67	2.92	Passed	8 by 8	6.8	7.1	1.65	8.17
W	296	F	H	1.92	2.98	Passed	4 by 4	6.6	7.0	1.42	8.32
X	219	F	G	3.92	None	-	-	4.3	5.7	0.92	5.33
X	223	S	G	1.58	2.77	Failed	-	3.9	4.2	0.82	7.97
X	247	F	H	4.33	5.08	Passed	12 by 12	6.9	6.5	1.17	5.13

+ - Self extinguished.

TABLE 49

TEST METHOD: OF555C TYPE OF FOAM: SYNTHETIC

FOAM	TEST	WATER	FUEL	CONTROL MIN.	EXT. MIN.	TORCH	BURNBACK INS.	EXPANSION PAN	EXPANSION CYLINDER	DRAIN TIME, MIN. PAN	DRAIN TIME, MIN. CYLINDER
C	60	F	G	1.25	None	-	-	9.6	-	5.98	-
C	64	S	G	1.75	2.00	Failed	-	4.2	-	2.70	-
C	142	F	H	1.33	None	-	-	8.1	-	9.63	-
D	27	F	G	1.00	4.67	Failed	-	9.5	-	19.43	-
D	31	S	G	+	+	+	+	4.7	-	17.17	-
D	67	F	H	1.92	3.42	Failed	-	7.7	-	5.50	-

+ test not conducted

TABLE 50

TEST METHOD: OF555C TYPE OF FOAM FLUOROPROTEIN

FOAM	TEST	WATER	FUEL	CONTROL MIN.	EXT. MIN.	TORCH	BURNBACK INS.	EXPANSION PAN	EXPANSION CYLINDER	DRAIN TIME, MIN. PAN	DRAIN TIME, MIN. CYLINDER
G	188	F	G	-	4.58	Passed	36 by 36+	3.3	4.6	<1.00	2.55
G	192	S	G	-	2.25	Passed	36 by 36H	3.8	4.6	<1.00	2.15
G	202	F	H	-	2.42	Passed	8 by 8	4.9	5.5	<1.00	5.55
H	307	F	G	1.42	2.67	Passed	4 by 4	5.7	6.4	1.00	6.47
H	311	S	G	1.00	2.07	Passed	5 by 5	5.7	6.2	1.43	6.75
H	314	F	H	1.50	2.17	Passed	5 by 5	4.9	6.7	1.33	8.18
U	84	F	G	1.92	2.75	Passed	3 by 3	4.6	-	0.70	-
U	88	S	G	2.00	2.50	Passed	30 by 30	5.0	-	1.00	-
U	133	F	H	1.67	None	-	-	5.4	-	1.92	-
V	75	F	G	1.00	2.75	Passed	5 by 5	7.1	-	2.75	-
V	79	S	G	2.00	3.33	Failed	-	7.3	-	2.28	-
V	136	F	H	1.33	4.75	Passed	8 by 8	7.1	-	2.03	-
Y	270	F	G	3.13	4.58	Passed	7 by 7	5.9	5.7	1.28	5.40
Y	274	S	G	2.37	3.13	Passed	8 by 8	5.8	5.8	1.80	6.92
Y	299	F	H	2.00	3.03	Passed	5 by 5	4.8	4.6	1.08	4.83
Z	228	F	G	1.10	2.10	Passed	8 by 8	5.3	5.5	0.97	4.48
Z	232	S	G	2.02	2.77	Passed	36 by 36	5.7	5.8	1.05	4.25
Z	286	F	H	1.25	2.17	Passed	5 by 5	6.5	6.8	2.95	6.02

\+ - Test discontinued at 23 min.

++ - Test discontinued at 25 min.

TABLE 51

TEST METHOD: OF555C TYPE OF FOAM: AFFF

FOAM	TEST	WATER	FUEL	CONTROL MIN.	EXT. MIN.	TORCH	BURNBACK INS.	EXPANSION PAN	EXPANSION CYLINDER	DRAIN TIME, MIN. PAN	DRAIN TIME, MIN. CYLINDER
I	171	F	G	0.88	1.43	Failed	-	-	4.4	-	2.08
I	175	S	G	0.88	1.70	Failed	-	-	5.5	-	2.32
I	183	S	H	2.33	None	-	-	4.9	5.1	0.75	2.50
J	162	F	G	1.17	2.00	Failed	-	-	6.6	-	3.07
J	166	S	G	1.17	2.72	Failed	-	-	4.9	-	2.55
J	205	S	H	1.80	2.25	Failed	-	4.8	4.8	0.75	2.17
K	36	F	G	0.75	None	-	-	-	7.0	-	2.67
K	40	S	G	0.67	2.00	Passed	+	-	7.8	-	2.42
K	52	S	H	0.75	1.75	Failed	-	-	6.9	-	2.83
L	4	S	H	1.25	3.17	Failed	-	-	6.8	-	2.37
L	8	S	G	1.00	1.75	Passed	o++	-	8.0	-	3.08
L	13	F	G	1.50	3.00	Passed	o++	-	7.3	-	2.78
M	111	F	G	0.83	None	-	-	7.8	8.6	0.50	2.33
M	115	S	G	0.83	2.58	Failed	-	-	7.2	-	2.63
M	139	F	H	1.08	1.82	Failed	-	-	7.6	-	2.68
N	120	F	G	1.17	1.83	Passed	30 by 30	-	8.2	-	3.25
N	124	S	G	0.83	1.33	Passed	6 by 6	-	6.7	-	2.50
N	157	F	H	1.00	1.50	Failed	-	-	8.2	-	3.77
O	17	S	G	1.33	4.08	Failed	-	-	8.1	-	3.92
O	22	F	G	0.75	1.75	Failed	-	-	9.8	-	3.58
O	55	S	H	0.83	1.83	Failed	-	-	8.0	-	4.13
P	44	S	G	0.70	None	-	-	-	5.9	-	3.67
P	49	F	G	0.83	3.17	Failed	-	-	8.1	-	3.58
P	70	S	H	0.92	1.92	Failed	-	-	7.2	-	3.52

+ - Entire pan became reinvolved.

++ - Self extinguished.

TABLE 51 (Con't)
TEST METHOD: OF555C TYPE OF FOAM: AFFF

FOAM	TEST	WATER	FUEL	CONTROL MIN.	EXT. MIN.	TORCH	BURNBACK INS.	EXPANSION PAN	EXPANSION CYLINDER	DRAIN TIME, MIN. PAN	DRAIN TIME, MIN. CYLINDER
Q	279	F	G	0.22	0.83	Passed	2 by 2	5.3	8.5	0.78	5.42
Q	283	S	G	0.33	0.83	Failed	-	6.4	9.3	1.30	4.32
Q	302	S	H	1.17	2.08	Failed	-	4.7	4.3	1.47	5.30
R	237	F	G	1.15	None	-	-	6.4	6.2	1.17	3.02
R	241	S	G	1.08	2.92	Failed	-	5.6	6.1	0.83	2.73
R	289	S	H	1.00	1.67	Failed	-	4.9	5.3	0.90	2.62

TABLE 52

FOAM QUALITY PROPERTIES BY TEST METHOD

Foam	Test Method FRN		MIL		UL		OF555C	
Protein		Δ%		Δ%		Δ%		Δ%
Expansion - Pan	7.69		6.35		4.75		5.66	
Expansion - Cylinder	6.00	-21.9	6.09	-4.1	4.77	0.4	5.58	-1.4
Drain Time - Pan	7.94		2.18		2.17		1.45	
Drain Time - Cylinder	10.83	36.4	8.38	284.4	8.63	297.7	5.89	301.2
Synthetic								
Expansion - Pan	6.50		7.58		5.17		7.30	
Expansion - Cylinder	-	-	-	-	-	-	-	-
Drain Time - Pan	10.76		9.35		9.33		10.07	
Drain Time - Cylinder	-	-	-	-	-	-	-	-
Fluoroprotein								
Expansion - Pan	6.89		5.52		4.61		5.49	
Expansion - Cylinder	-	-	5.69	3.1	4.59	-0.4	5.68	3.5
Drain Time - Pan	5.42		2.22		2.10		1.48	
Drain Time - Cylinder	-	-	8.16	267.6	8.38	299.0	5.14	247.3
AFFF								
Expansion - Pan	6.46		6.4		4.64		5.64	
Expansion - Cylinder	7.08	9.6	6.82	6.6	4.94	6.5	6.95	23.2
Drain Time - Pan	1.89		1.60		1.37		0.94	
Drain Time - Cylinder	5.47	189.4	4.36	172.5	4.52	229.9	3.13	233.0

TABLE 53

FOAM QUALITY PROPERTIES BY TYPE OF FOAM

Expansion	Protein	Synthetic	Fluoro-protein	AFFF
Avg Pan	5.956	6.927	5.496	6.127
Avg Cylinder	5.461	-	5.322	6.391
Fresh/Pan	5.779	7.729	5.468	6.911
Fresh/Cylinder	5.462	-	5.354	6.862
Sea/Pan	6.261	4.625	5.563	5.977
Sea/Cylinder	5.457	-	5.259	6.198
Drain				
Avg Pan	3.027	9.793	2.628	1.493
Avg Cylinder	7.703	-	7.227	4.293
Fresh/Pan	2.566	10.008	2.341	1.701
Fresh/Cylinder	7.023	-	7.326	4.464
Sea/Pan	3.780	9.425	2.966	1.488
Sea/Cylinder	8.603	-	7.029	4.141
Avg Tests Both Pan and Cylinder				
Pan - Expansion	5.255	-	5.011	6.127
- Drain	1.789	-	1.828	1.493
Cylinder - Expansion	5.280	-	5.322	6.209
- Drain	7.719	-	7.227	4.821
△Percent Pan/ Cylinder				
Expansion	0.48	-	6.21	1.33
Drain	331.47	-	295.35	222.91

Avg 283.2

TABLE [illegible]

Effects of Fresh and Sea Waters on [illegible] Quality

	PROTEIN		[illegible]YN		[illegible]		[illegible]	
	FRESH	SEA	FRESH	SEA	FRESH	SEA	FRESH	SEA
[illegible]								
[illegible]-PAN	[illegible]	[illegible]	8.25	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	--	--	--	--	--	--	[illegible]	[illegible]
[illegible]-PAN	[illegible]	[illegible]	[illegible]	[illegible]	5.30	[illegible]	[illegible]	[illegible]
[illegible]	--	--	--	--	--	--	[illegible]	[illegible]
[illegible]								
[illegible]-PAN	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	--	--	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]P-[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	--	--	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]162								
[illegible]-PAN	[illegible]	[illegible]	5.7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	.78	[illegible]	--	--	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]-PAN	2.00	2.50	8.66	10.67	[illegible]	[illegible]	2.15	[illegible]
[illegible]	[illegible]	[illegible]	--	--	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]								
[illegible]-PAN	[illegible]	[illegible]	[illegible]	4.45	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	--	--	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]-PAN	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	5.00	[illegible]	--	--	[illegible]	[illegible]	[illegible]	[illegible]

S U M M A R Y

A. Test Nozzle

A different test nozzle was specified for each test procedure. This is the standard procedure for the tests according to FRN 1007, MIL-F-24385 and OF-555-C, but it is not in accordance with UL's usual evaluations under UL 162. For evaluating the performance of foams according to UL 162, it is required that the nozzle used in the test produces foam of the same quality as that produced by the full-scale equipment with which the foam is to be used.

The use of the same nozzle for all the tests using a given procedure was agreed upon with the Coast Guard Technical Representative in order to compare the foams performances without introducing variables associated with the nozzle itself. This procedure is not without drawbacks, however. With any given test method, the test results provide evaluations of the foam/nozzle combinations, and not evaluations of inherent characteristics of the foams themselves. The actual performance of a given foam produced in a field installation with full-scale hardware, may be different than the performance which the test results might suggest. Also, the relative performance and foam characteristics of various foams produced in the field may differ from the corresponding relationships obtained in the present test.

For this reason, the results of the tests must be interpretted with caution, as with any assignment of relative merits or rankings.

B. Foam Quality

The average expansions of the foams in the four test methods are shown in Figures 33 and 34. It is seen that the highest values were achieved by the FRN-1007 method and the lowest by the UL 162 method (with special nozzle) in most cases. Figure 34 does not suggest any trend toward higher or lower expansions among the four foam types. With two exceptions (FRN/protein and OFF-555-C/AFFF), there is no significant difference in expansion between results of the pan and cylinder methods.

Average drain times are shown in Figures 35 and 36. The charts indicate significant differences between results of the pan and cylinder methods. In every instance, the drain time obtained by the cylinder method was greater (36 to 301 percent) then that by the pan method. Except for the FRN-1007 test method using protein foam, all cylinder drain times were at least 2.7 times the pan values. Overall, the synthetic foams appear to have the largest 25 percent drain time.

Figures 37 through 42 show the average expansion values and 25 percent drain times in a number of different formats which display the effects of the water used. Except for the synthetic foams, there appears to be little difference between the expansion values when using fresh or sea water. The average expansion of synthetic foams prepared with sea water were 41.2 percent less than those for foams prepared with fresh water.

C. Test Methods

With the FRN-1007 method, extinguishment was obtained in 92 percent of the tests. This test method provides both an economical and reproducible laboratory-scale test procedure for conducting fire tests with foam liquid concentrates using a fixed nozzle. The control, extinguishment and burnback resistance times can be used to identify one batch or group of foam liquid concentrates with previously obtained data. The method may also be used as a laboratory-scale test procedure to compare the relative control, extinguishment and burnback resistance characteristics of foams. The method can be used to establish the relative effectiveness on different types of fuel. A drawback of this test method is that the foam produced by the laboratory-scale nozzle may not have the same foam properties produced with full-scale equipment.

The results of test using the MIL-F-24385 method indicate that only AFFF type agents can comply with the established requirements. The results of these tests improved when the test nozzle was hand-held and moved to various positions rather than held at a fixed position. This may place considerable reliance on the experience of the operator, which could mask the performance characteristics of the foam being tested. The fan-shaped discharge pattern produced by the test nozzle does not represent typical nozzles used in the field. Because most foams did not extinguish the test fire, specific findings could not be established regarding the burnback requirements. This method requires a foam to have rapid extinguishment characteristics (65 sec) and is quite severe from that standpoint. However, the preburn time is quite short (15 sec), and thus the test does not simulate the effects of hot metal surfaces that are associated with most large fires.

With the UL 162 method, extinguishment was obtained in 60 percent of the tests with AFFF and in 22 percent of the tests with fluoroprotein foams. None of the protein or synthetic foams produced extinguishment. These results should not be used to judge acceptability form UL Listing because:

1. Only Type III foam application was used. Some foams would fail under Type III application yet be eligible for use with Type I or II foam equipment.

2. A special test nozzle was used which may not have produced foam equivalent in quality to the full scale equipment. This is required under the UL 162 test method but was not included as part of this testing program to permit the testing of all foams with the same test nozzle.

The UL 162 test method used in this program was more severe than the MIL-F-24385 method on a number of counts: 1.) the pan was larger, 2.) the preburn time was longer, 3.) the nozzle was fixed in one location throughout the test, and 4.) the foam discharge was directly plunged onto the fuel surface.

The O-F-555C test method produced acceptable extinguishment results in 72 of the 77 tests, largely because the foam was applied against the side of the test pan. This relatively gentle application of the foam onto the fuel surface avoided fuel pick-up and agitation. A standard test nozzle is specified; foams discharged through this nozzle may or may not have the same foam properties when discharged through full-scale equipment.

Previous experience with this test involved out-of-doors exposures under varying wind conditions. The prospect of conducting these tests indoors is appealing since reproducibility would certainly be enhanced. The results of these tests indicate that it is possible to conduct test fires of this magnitude indoors under controlled conditions.

One objective of the investigation was to determine whether or not the four prominently accepted fire test methods provide comparible and interchangeable measures of fire performances. For this purpose, comparisons of results of the various tests could be made for a number of performance measures as well as for quality of foam produced. Here, the results are compared for two groups of experiments on the basis of whether or not extinguishment was achieved and the time to extinguishment. Tables 55 and 56 and Figures 43 and 44 show results for all experiments using fresh water foams with both heptane and gasoline fuels. For convenience, the tests are arranged in order of increasing time to extinguishment in the FRN-1007 tests. These tables are not intended to represent rankings of the foam performance capabilities, but only vehicles for comparing results from the foam test methods.

Inspection of the results for the FRN-1007 and OF-555C tests in both tables shows a very weak correlation at best, which would not justify using results interchangeably. A similar observation may be made from Table 56 with respect to the relationship of UL 162 results to those from the FRN-1007 and OF-555C tests. Because only two successful extinguishments recorded with the MIL-F-24385 tests, no correlation between the FRN and MIL test methods could be determined.

Because of the foregoing results with respect to extinguishment by fresh water foams, further comparisons are not considered useful.

D. Waters and Fuels

In general, the average control and extinguishment times were greater with sea water than fresh. As shown by Figure 31, the use of either water alone cannot be considered a test of relative extinguishing and control characteristics because a change in water produces different results with each type of foam.

There were no significant differences in either expansion or drain times using either water, except with synthetic type foams. These foams had lower expansion and shorter drain times with sea water.

In all cases, the use of gasoline as a test fuel resulted in longer control and extinguishment times, and in shorter burnback resistance times. Although n-heptane was shown to be a somewhat less severe fire exposure, it continues to offer the advantage of consistency and long-term repeatability of the fuel properties.

E. Overall Performance of Foams

Detailed comparisons of foam performances based on the data presented here are unwarranted for several reasons. Perhaps the most cogent reason is that a single nozzle was used for all experiments with a given test method, and the foam produced would not be expected to duplicate the foam produced by full-scale equipment. It is conceivable that a full-scale application might produce better results for some foams and worse results for others. Another reason is that the intended field application technique should dictate the appropriate foam application method in the test procedure,as well as the performance measures that are most important. If rapid control and extinguishment were of greatest importance, the present results suggest that AFFF type foams would be most effective. On the other hand, if resistance to burnback were of primary interest, protein and fluoroprotein foams would be most effective, based on the present results.

Conceivably, a rating system could be developed to provide an overall performance measure for a given foam. Forming such a system would require judgements to be made concerning the relative values of various performance features on the basis of the intended field application. One system of many that might be used is shown below the purposes of illustrations, but no recommendation is intended.

Point values from 1 to 5 for example, may be assigned to the test results as follows:

1 = failed to control
2 = controlled but did not extinguish
3 = extinguished but failed torch exposure
4 = passed torch exposure, but failed burnback
5 = passed all test exposure stages.

This has been done for the eight required tests with each foam, so that there is correspondence between test methods, fuels and waters used with the various foams. MIL tests having the suffix "A" during which the nozzle was moved by the operator were excluded from the ranking. In order to display the results, the point values have been summed for each foam. Figure 45 and Table 57 shows the results of this procedure along with the average point values for each foam type.

This point system has several drawbacks. Some of these can be summarized as follows:

1. Greater importance has been placed on successful extinguishment. No credit was given for torch or burnback unless extinguishment was achieved. These foams which failed to extinguish received no credit for any torch or burnback resistance they might have.

2. Perhaps control should not have been given any credit. On the other hand, control, which is defined as approximately 90 percent extinguishment, is better than no control of the fire at all.

3. The least severe test method tends to dominate the resulting point values. For example, the FRN test results account for about 40 percent of the total points in the ranking, yet this test method defines only two failure conditions.

This is only an example of one ranking method. Development of a universally acceptable ranking method might be possible, but extensive data analysis would be necessary. Such analysis is outside the scope of this work.

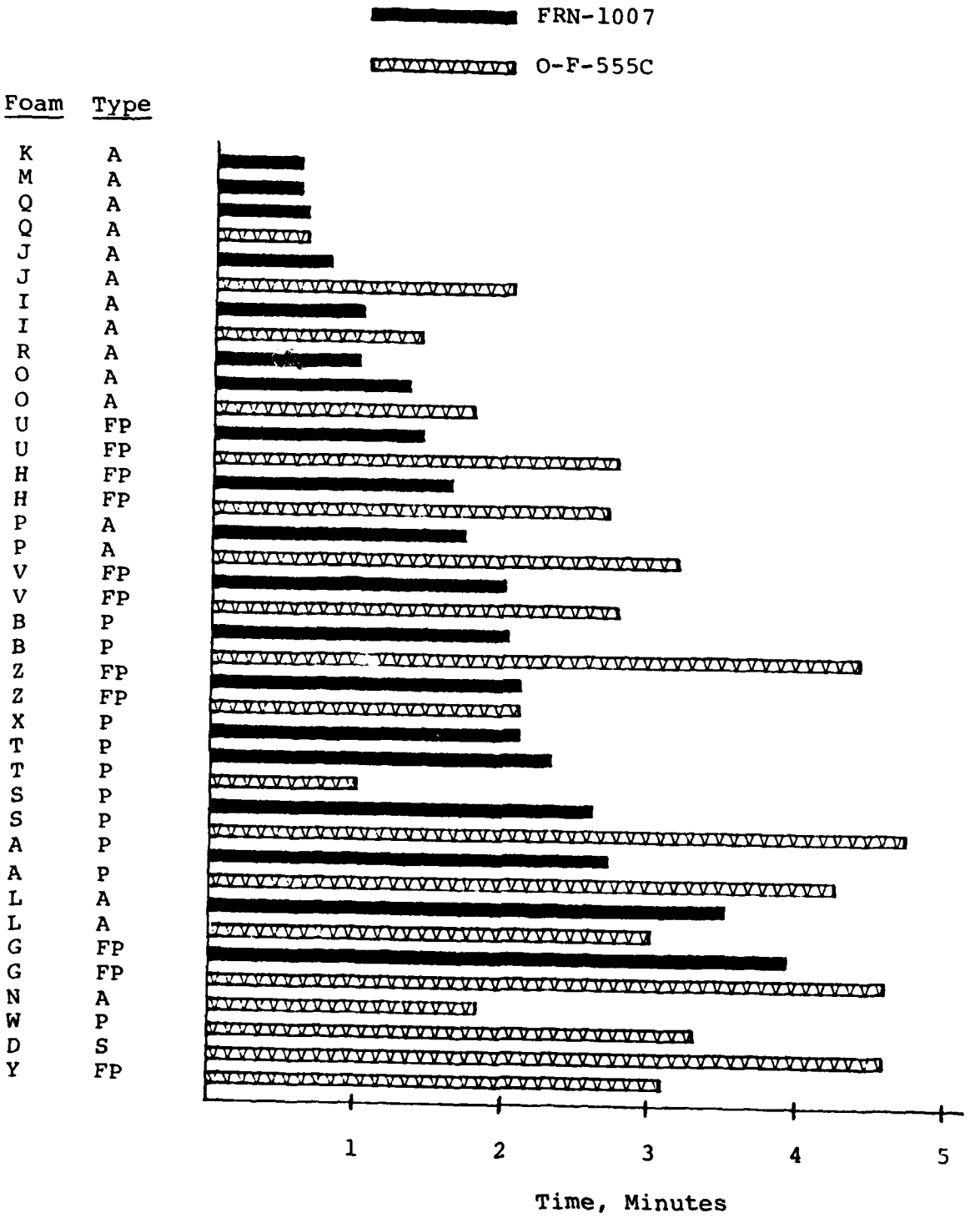
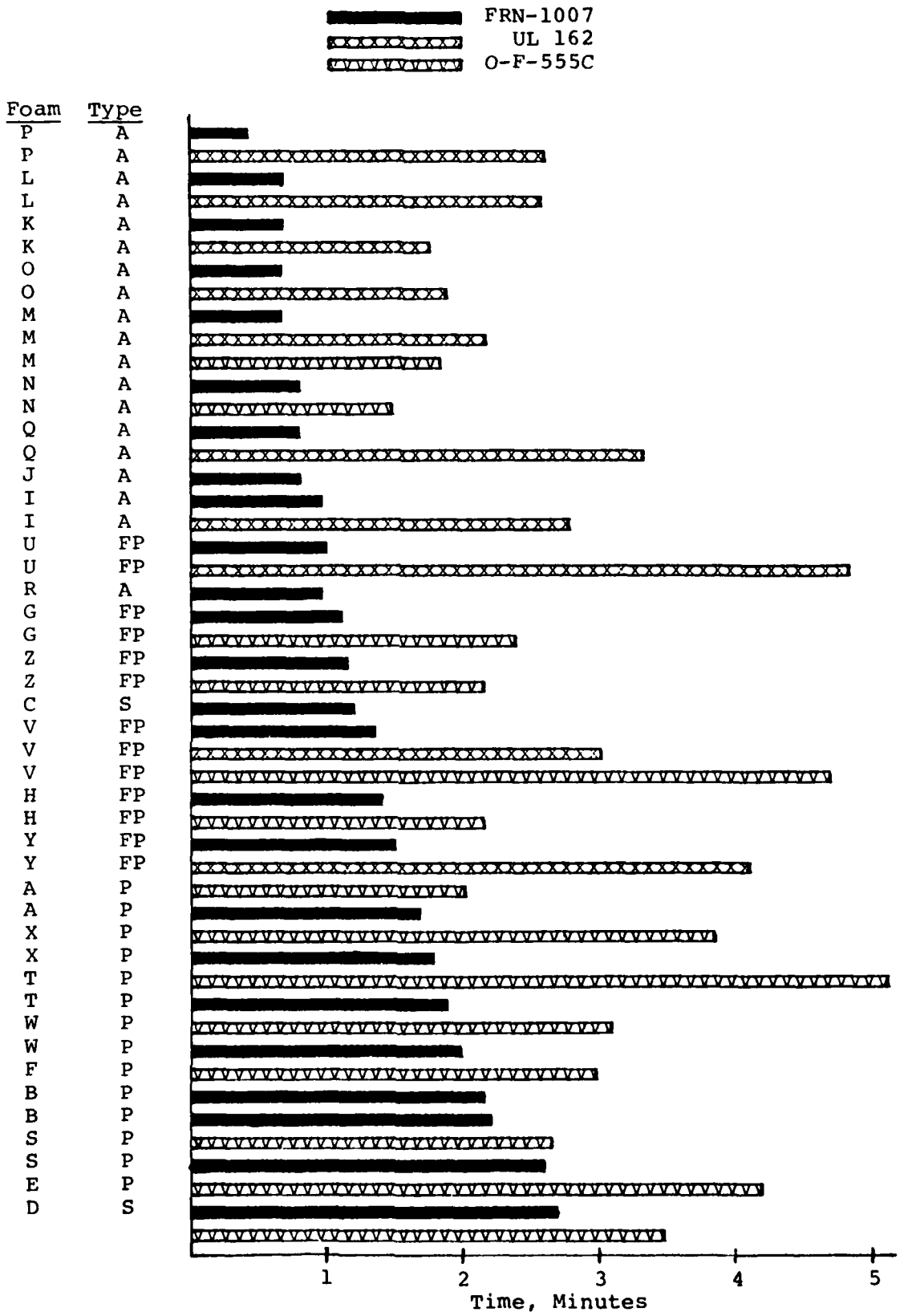


Fig. 43 Comparison Of Extinguishment Times For Gasoline Fires And Fresh Water Foams



Fir. 44 Comparison of Extinguishment Time For N-Heptane Fires and Fresh Water Foams

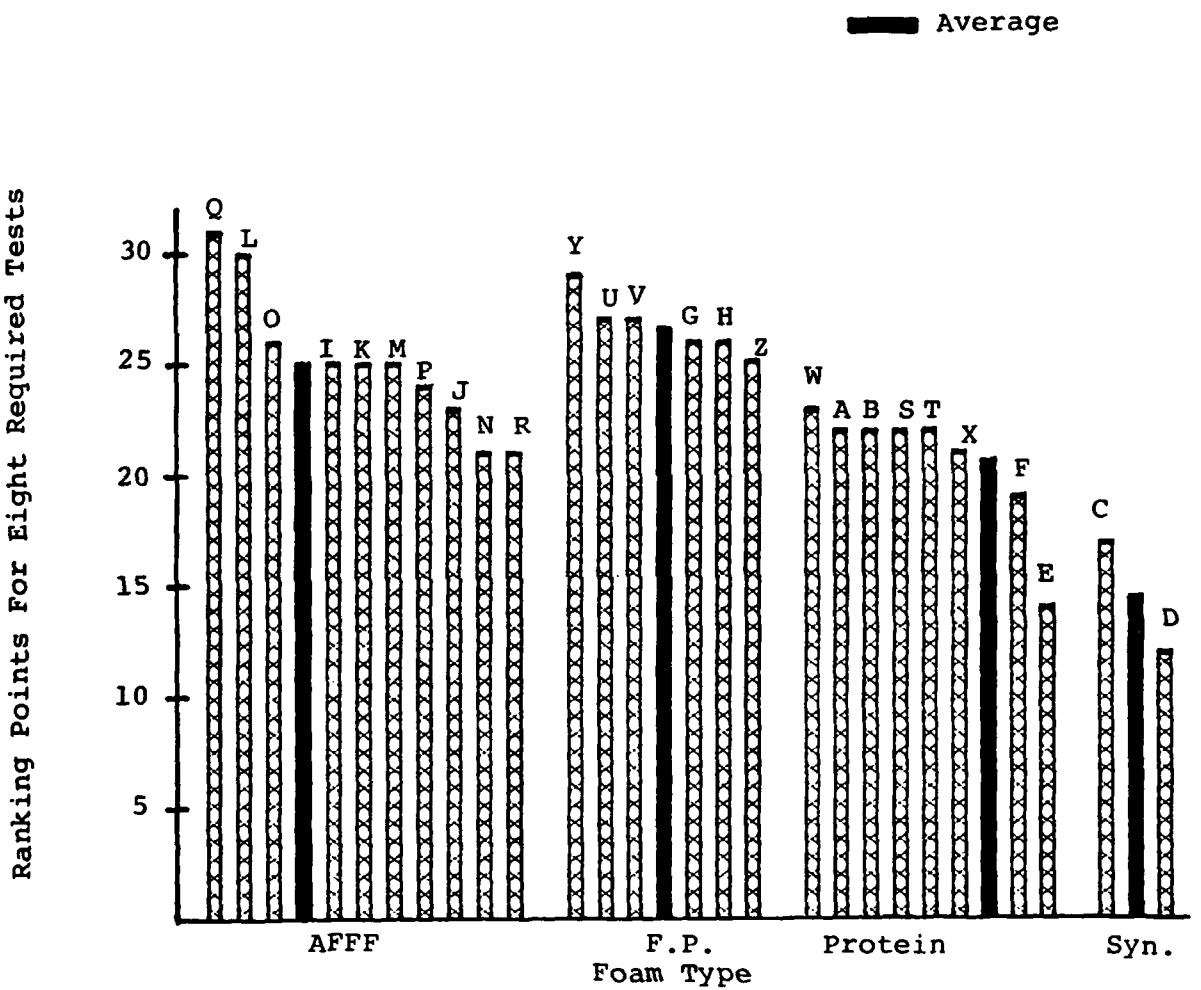


Fig. 45 Point Values For All Fire Test Methods

TABLE 55
EXTINGUISHMENT TIMES FOR GASOLINE
FIRES AND FRESH WATER FOAMS

FOAM	TYPE	FRN-1007	MIL-F-24385	UL162	OF-555C
K	A	0.55	NONE	†	NONE
M	A	0.55	NONE	NONE	NONE
Q	A	0.60	0.80	†	0.83
J	A	0.79	NONE	†	2.00
I	A	0.99	NONE	†	1.43
R	A	0.99	NONE	†	NONE
O	A	1.25	NONE	†	1.75
U	FP	1.41	NONE	NONE	2.75
H	FP	1.57	NONE	NONE	2.67
P	A	1.70	NONE	†	3.17
U	FP	1.98	NONE	NONE	2.75
B	P	2.02	NONE	NONE	4.42
Z	FP	2.11	NONE	NONE	2.10
X	P	2.14	NONE	NONE	NONE
T	P	2.32	NONE	NONE	1.00
S	P	2.59	NONE	NONE	4.75
A	P	2.67	NONE	NONE	4.25
L	A	3.50	0.80	†	3.00
G	FP	3.85	NONE	†	4.58
N	A	NONE	NONE	†	1.83
W	P	NONE	NONE	NONE	3.33
D	S	NONE	NONE	NONE	4.62
C	S	NONE	NONE	NONE	NONE
E	P	NONE	NONE	NONE	NONE
F	P	NONE	NONE	NONE	NONE
Y	FP	†	NONE	NONE	3.13

†-Experiment not conducted

TABLE 56
EXTINGUISHMENT TIMES FOR N-HEPTANE
FIRES AND FRESH WATER FOAMS

FOAM	TYPE	FRN-1007	MIL-F-24385	UL162	OF-555C
P	A	0.40	†	2.60	†
L	A	0.62	†	2.58	†
K	A	0.65	†	1.75	†
O	A	0.65	†	1.87	†
M	A	0.69	NONE	2.18	1.82
N	A	0.72	NONE	NONE	1.50
Q	A	0.75	†	3.30	†
J	A	0.80	†	NONE	†
I	A	0.95	†	2.78	†
U	FP	0.96	NONE	4.83	NONE
R	A	0.99	†	NONE	†
G	FP	1.09	NONE	NONE	2.42
Z	FP	1.14	NONE	NONE	2.17
C	S	1.19	NONE	NONE	NONE
V	FP	1.37	NONE	3.00	4.75
H	FP	1.40	NONE	NONE	2.17
Y	FP	1.50	NONE	4.08	2.00
A	P	1.75	NONE	NONE	3.83
X	P	1.79	NONE	NONE	5.08
T	P	1.89	NONE	NONE	3.08
W	P	1.97	NONE	NONE	2.98
F	P	2.18	†	NONE	†
B	P	2.20	NONE	NONE	2.67
S	P	2.59	NONE	NONE	4.17
E	P	2.70	NONE	NONE	NONE
D	S	NONE	NONE	NONE	3.42

†-Experiment not conducted

TABLE 57

RANKING OF FOAM BY TEST METHOD

Foam	Percent	Type	FRN		MIL		UL 162		OF555C		Overall	
			Pts	Ranking	Pts	Ranking	Pts	Ranking	Pts	Ranking	Pts	Ranking
A	3	Protein	10	1	2	10	4	11	6	12	22	16
B	6	Protein	10	1	2	10	4	11	6	12	22	16
C	3	Synthetic	7	21	2	10	3	23	5	20	17	24
D	6	Synthetic	4	26	2	10	3	23	3	26	12	26
E	3	Protein	6	25	2	10	2	26	4	25	14	25
F	6	Protein	7	21	2	10	3	23	7	11	19	23
G	3	Fluoroprotein	10	1	2	10	4	11	10	1	26	6
H	6	Fluoroprotein	10	1	2	10	4	11	10	1	26	6
I	3	AFFF	10	1	4	2	5	10	6	12	25	9
J	6	AFFF	10	1	3	6	4	11	6	12	23	14
K	3	AFFF	10	1	3	6	6	2	6	12	25	9
L	6	AFFF	10	1	4	2	6	2	10	1	30	2
M	3	AFFF	10	1	4	2	6	2	5	20	25	9
N	6	AFFF	7	21	2	10	4	11	8	8	21	20
O	3	AFFF	10	1	4	2	6	2	6	12	26	6
P	6	AFFF	10	1	3	6	6	2	5	20	24	9
Q	3	AFFF	10	1	7	1	6	2	8	8	31	1
R	6	AFFF	10	1	2	10	4	11	5	20	21	20
S	3	Protein	10	1	2	10	4	11	6	12	22	16
T	6	Protein	10	1	2	10	4	11	6	12	22	16
U	3	Fluoroprotein	10	1	2	10	6	2	9	2	27	4
V	6	Fluoroprotein	10	1	3	6	6	2	8	8	27	4
W	3	Protein	7	21	2	10	4	11	10	1	23	14
X	6	Protein	10	1	2	10	4	11	5	20	21	20
Y	3	Fluoroprotein	10	1	2	10	7	1	10	1	29	3
Z	6	Fluoroprotein	10	1	2	10	4	11	9	2	25	9

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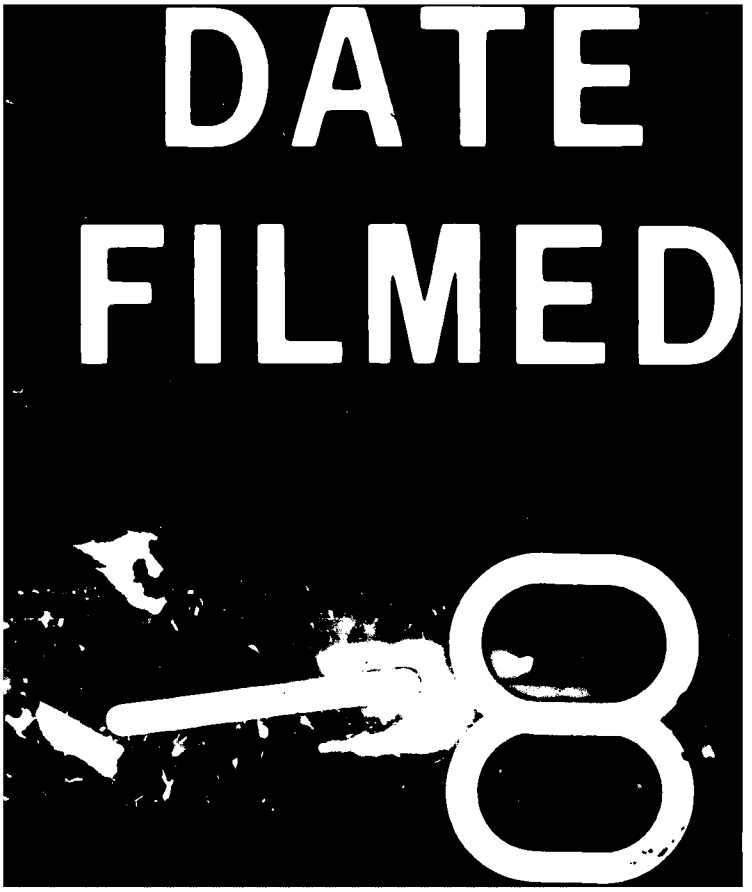
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