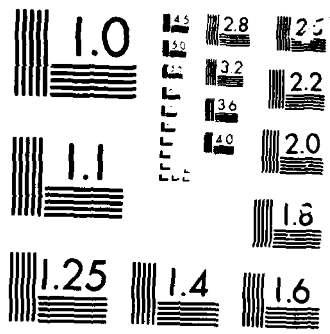
AD-A168 927 ALTERNATIVE AFFF (AQUEOUS FILM FORMING FOAM) 1/1
PROPORTIONING SYSTEMS FOR THE SSN 21 DESIGN - T&E(U)
NAVAL RESEARCH LAB WASHINGTON DC F W WILLIAMS ET AL.
UNCLASSIFIED 02 JUN 86 NRL-MR-5778 F/G 13/12 NL



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Naval Research Laboratory

Washington, DC 20375-5000   NRL Memorandum Report 5778   June 2, 1986

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Alternative AFFF Proportioning Systems for the SSN 21 Design—T&E

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SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution unlimited.
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S) NRL Memorandum Report 5778	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION Naval Research Laboratory 6b. OFFICE SYMBOL (If applicable) Code 6180	7a. NAME OF MONITORING ORGANIZATION
6c. ADDRESS (City, State, and ZIP Code) Washington, DC 20375-5000	7b. ADDRESS (City, State, and ZIP Code)
8a. NAME OF FUNDING/SPONSORING ORGANIZATION Naval Sea Systems Command 8b. OFFICE SYMBOL (If applicable) 05R26	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (City, State, and ZIP Code) Washington, DC 20360	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO: 63561 PROJECT NO: S0364-SL TASK NO: 204A000 WORK UNIT ACCESSION NO: DN880-171

11. TITLE (Include Security Classification)
Alternative AFFF Proportioning Systems for the SSN 21 Design — T&E

12. PERSONAL AUTHOR(S)
Williams, F. W., Beller, R. C.,* Burns, R. E.* and Scheffey, J. L.*

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Interim	FROM 10/85 TO 1/86	1986 June 2	21

16. SUPPLEMENTARY NOTATION
*Hughes Associates, Inc., Wheaton, MD 20902

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	Fire fighting; Fixed systems; AFFF

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

The Aqueous Film Forming Foam (AFFF) fire suppression systems proposed for flammable liquid fuel hazards on the SSN 21 require proportioning systems to inject 3% AFFF concentrate into seawater systems to create AFFF solution. Alternative proportioning systems each of which utilizes an air-pressurized concentrate storage tank are being evaluated by the Naval Research Laboratory (NRL). One candidate system uses multiple single-user injection points (e.g., orifice metering plates) to proportion AFFF at each hose station or sprinkler system. The other system, which uses an in-line balanced pressure proportioner and ratio controller, is designed as a central system which can proportion over a range of demands.

Proportioning using the orifice plate system is pressure sensitive and not flow sensitive. As pressure differential between the injected concentrate and seawater increases, flow rate increases. If the pressure differential can vary considerably during operation, AFFF flow and storage requirements must be overdesigned to meet the lowest design point, i.e., 3% at the smallest pressure differential. The size of the orifice in the orifice plate design may be so small (e.g., 0.1 in. dia.) that clogging of the orifice could be a problem.

(Continues)

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION UNCLASSIFIED	
22a. NAME OF RESPONSIBLE INDIVIDUAL F. W. Williams	22b. TELEPHONE (Include Area Code) (202) 767-2476	22c. OFFICE SYMBOL Code 6180

DD FORM 1473, 84 MAR — 83 APR edition may be used until exhausted. All other editions are obsolete.

SECURITY CLASSIFICATION OF THIS PAGE

19. ABSTRACT (Continued)

Proportioning using the balancing valve system is flow sensitive. A steady level of % concentrate is maintained over a range of flows. The use of a central proportioning system creates, in effect, a separate AFFF firemain system. The central proportioning system allows more effective use of AFFF concentrate, but significant design and operational problems result from the requirement to have seawater only capability at AFFF hose stations.

Future R&D work will focus on the single-user injection point system. Two additional single-user injection point systems may be available for testing in the near future.

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ALTERNATIVE AFFF
PROPORTIONING SYSTEMS FOR THE SSN 21 DESIGN - T&E

I. INTRODUCTION

The Aqueous Film Forming Foam (AFFF) fire suppression systems proposed for flammable liquid fuel hazards on the SSN 21 (including the diesel auxiliary generator space, lube oil bay bilge and aft hydraulic plant) require proportioning systems to inject 3% AFFF concentrate into seawater systems to create AFFF solution at sprinkler systems and hose stations. Alternative proportioning systems which utilize an air-pressurized concentrate storage tank are being evaluated. One candidate proportioning system uses orifice metering plates to proportion AFFF at each seawater injection point (i.e., sprinkler system or hose station.) An alternative system uses an in-line balanced pressure proportioner and ratio controller to proportion AFFF over a range of system demands.

The objective of this report is to provide an interim analysis of the alternative proportioning systems, based on a review of the proposed designs and results of conceptual testing of the systems.

II. TECHNICAL DESCRIPTION

A. General

As now envisioned, the AFFF firefighting systems will be supplied from the on-board seawater flushing system. This is a new concept compared to the SSN 688 class design, where seawater fire hose stations are supplied directly from the trim discharge header. AFFF concentrate storage tanks, located forward and aft of the reactor compartment, will be pressurized from available service air systems to inject AFFF concentrate into branch lines serving AFFF sprinklers and hose stations. It is anticipated that each concentrate tank will be pressurized at 8.79 kg/cm^2 (125 psi), which will eliminate the need for concentrate pumps typically found in surface ship AFFF designs. A schematic of the proposed system, developed by NAVSEA 56Y52, is shown in Fig. 1. Conceptual schematics of the two candidate proportioning systems are shown in Fig. 2.

Manuscript approved February 26, 1986.

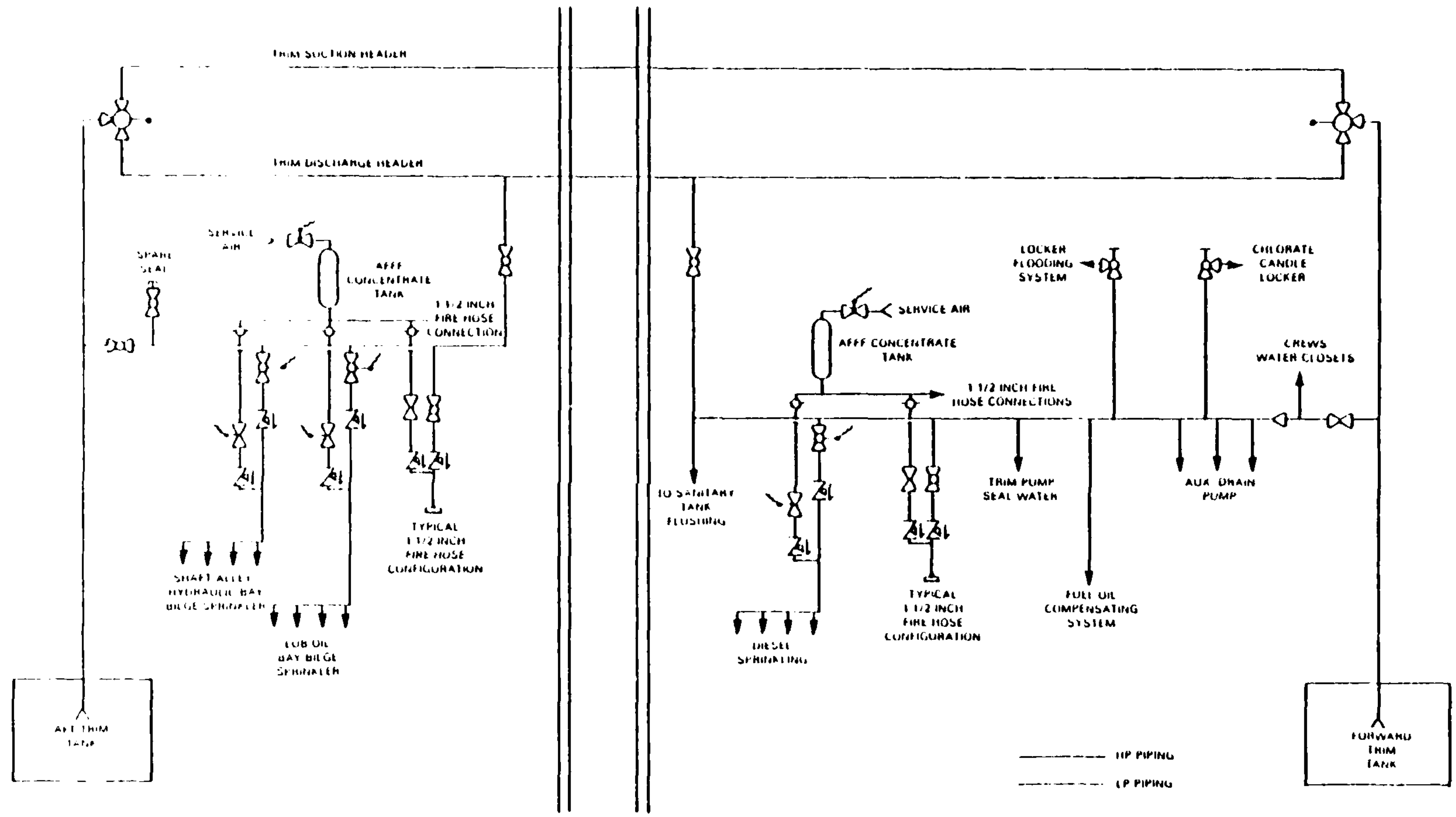

Fig. 1 — SSN 21 AFFF distribution system

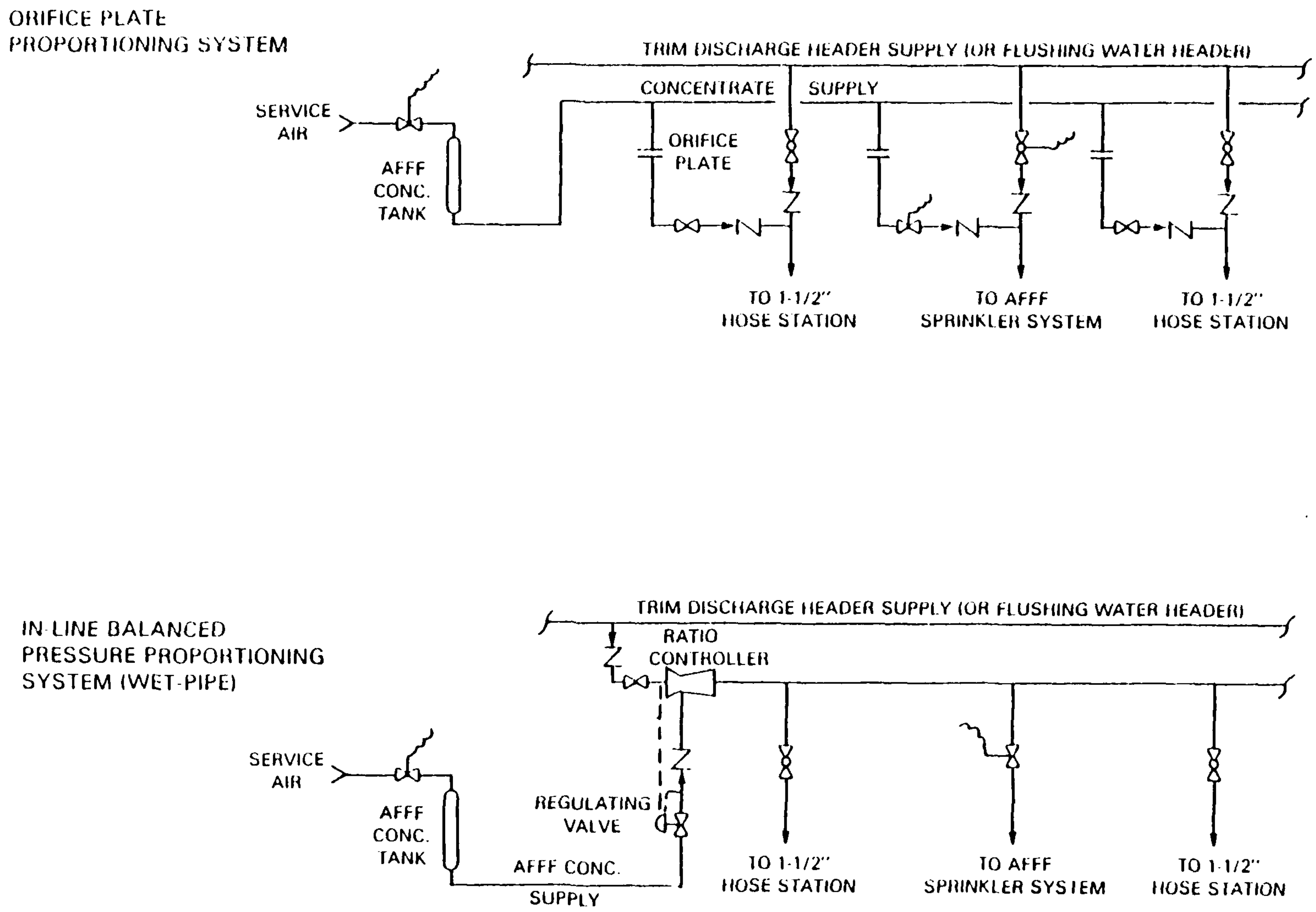

Fig. 2 — Conceptual schematics of alternative proportioning systems

It is currently estimated that each concentrate tank will be sized for 5 minutes of agent application when the largest sprinkler system and two 3.81 cm (1-1/2 in.) handlines are operating simultaneously. Tentative criteria have been established to provide AFFF hose stations so that any point can be reached from at least two hose stations with 15.24 m (50 ft.) of hose.

The seawater service pressure, supplied from either the flushing water or trim discharge header, has not been finalized, and it is not known whether this pressure will be relatively constant (e.g., 3.52 kg/cm^2 (50 psi) from the flushing water system) or variable as is the case in the SSN 688 design where trim discharge pressure is increased (through air pressurization or pump activation) in the event of a fire. Testing has assumed a variable seawater service pressure at the AFFF injection point of 2.11-7.03 kg/cm^2 (30-100 psi), and a concentrate injection of 8.79 kg/cm^2 (125 psi).

NAVSEA has established two criteria which are important in the overall conceptual development of the proportioning system: AFFF hose stations must have seawater-only capability at any given time; and, AFFF may not be introduced into the primary trim discharge or flushing water lines.

B. Orifice Plate System

The orifice metering plate system uses a single-user injection point method of proportioning AFFF. An AFFF concentrate line from the concentrate tank would supply AFFF to an orifice plate at each hose station or sprinkler system. The orifice diameter of each plate would be sized for 3% AFFF proportioning, based on the pressure differential between the concentrate line pressure and seawater firemain pressure at the injection points, and flow demand of the nozzle or sprinklers.

C. In-line Balanced Pressure Proportioner

The in-line balanced pressure proportioner system is a central proportioning system with a single concentrate injection point, based on the same concepts which apply to the balanced pressure proportioner currently specified for surface ships. A regulating valve is located in the concentrate supply line. Pilot lines connected to the upstream side of the seawater supply and downstream side of the concentrate supply throttle (open or close) the regulating diaphragm to create equal inlet pressures at the injection point. A ratio controller with an internal orifice plate sized for 3% AFFF proportioning is installed at the injection point and proportions the AFFF at 3% over a range of flows. Unlike the surface ship balanced pressure proportioner, the in-line balanced pressure proportioner does not have a concentrate return line back to the tank. The throttling valve opens as demand increases and closes as demand decreases; the opposite is true in the surface ship balanced pressure proportioning system where the regulating valve is located in the concentrate return line.

A pressure regulating valve and ratio controllers manufactured by Feecon Corp. are being used in these tests. Similar commercial units are available from other vendors.

III. TEST RESULTS

A. Orifice Plate System

A series of tests were conducted to confirm the feasibility of the orifice metering plate injection system. Straight-edged orifice plates were fabricated to proportion AFFF based on flow rates being used in concurrent testing of sprinkler nozzles. Tables 1 and 2 show proportioning and orifice coefficient of discharge C_d data for 4 orifice diameters tested using fresh water. The data confirm that the pressure differential between the concentrate injection line and the firemain is the governing factor on concentrate flow for a given orifice. Concentrate flow is not sensitive to seawater flow. Average C_d for all tests was 0.74.

In order for an orifice plate system to be efficient, the concentrate/firemain pressure differential must remain relatively constant. An example of the change in AFFF concentrate resulting from varying pressure differentials for a given orifice plate is shown in Figure 3. In these tests, flow was held constant as pressure differential was varied. In an actual submarine situation, flow will also change as firemain pressure changes, which in turn will effect % AFFF concentration. The impact of this is shown in Table 3, which is a calculation for determining the orifice plate and AFFF concentrate storage requirements for a 3.81 cm (1 1/2 in.) diameter hose line at various pressures. This example shows the inefficiency of the orifice plate design (i.e., overdesign requirements) when there is a large firemain pressure variation.

Tests of orifice plates were also conducted to determine the accuracy in calculating the orifice plate diameter for 3% proportioning. For a given orifice plate diameter and solution flow rate, required pressure differential for 3% concentrate flow was calculated, and then tested using water to determine the accuracy of the calculation. Data in Table 4 shows good agreement between actual and calculated results.

Table 1 · Orifice plate proportioning tests

Nominal Flow, lpm (gpm)	Orifice Dia., mm (in.)	% Concentrate at Varying Injection Pressures, kg/cm² (psi) 2.11 (30)	3.52 (50)	5.27 (75)	7.03 (100)	7.73 (110)
136 (36)	2.1 (0.0825)	4.2	4.2	3.9	2.3	2.3
136 (36)	3.25 (0.128)	9.2	10.6*	9.3	5.8	4.1
136 (36)	3.76 (0.148)	12.6	12	9.9	7.0	4.1
136 (36)	4.50 (0.177)	14.3	13	12	8.3	7.3
189 (50)	2.1 (0.0825)	2.5	2.4	2.2	1.7	1.5
189 (50)	3.25 (0.128)	5.6	6.3*	5.0	3.7	0.16**
189 (50)	3.76 (0.148)	7.9	6.6	5.5	4.4	3.6
189 (50)	4.50 (0.177)	11.0	10.2	8.4	6.2	5.0
284 (75)	2.1 (0.0825)	1.7	1.8	1.6	1.2	1.0
284 (75)	3.25 (0.128)	4.4	4.2	3.5	1.6	2.0*
284 (75)	3.76 (0.148)	5.1	5.7*	4.0	2.9	2.3
284 (75)	4.50 (0.177)	7.5	7.4	5.9	4.2	3.4

Tests conducted with nominal AFFF concentrate injection pressure of 8.79 kg/cm² (125psi)

* Data does not fit expected pattern of results

** Bad data point

Table 2   Orifice plate discharge coefficients

Orifice Dia. mm (in.)	Nominal Flow lpm (gpm)	2.1 kg/cm² (30psi) FM Conc.Flow lpm (gpm)	C_d	3.5 kg/cm² (50psi) FM Conc.Flow lpm (gpm)	C_d	5.3 kg/cm² (75psi) FM Conc.Flow lpm (gpm)	C_d	7.03kg/cm² (100psi) FM Conc.Flow lpm (gpm)	C_d	7.73kg/cm² (110psi) FM Conc.Flow lpm (gpm)	C_d	Average C_d
2.10 (0.0825)	136 (36)	5.26 (1.39)	0.69	5.00 (1.32)	0.74	4.73 (1.25)	0.85	2.80 (0.74)	0.69	2.73 (0.72)	0.84	0.76
	189 (50)	4.81 (1.27)	0.63	4.73 (1.25)	0.70	4.35 (1.15)	0.79	3.26 (0.86)	0.80	2.80 (0.74)	0.86	0.76
	284 (75)	5.07 (1.34)	0.67	5.26 (1.39)	0.76	4.50 (1.19)	0.81	3.44 (0.91)	0.85	3.33 (0.88)*	0.99	0.77
3.25 (0.128)	136 (36)	12.5 (3.30)	0.72	12.2 (3.23)	0.75	11.3 (2.99)	0.84	6.81 (1.80)	0.79	5.79 (1.53)	0.81	0.78
	189 (50)	12.2 (3.23)	0.70	12.1 (3.19)	0.78	9.61 (2.54)	0.76	7.42 (1.96)	0.80	3.07 (0.81)*	0.44	0.76
	284 (75)	12.7 (3.35)	0.72	11.9 (3.14)	0.77	9.80 (2.59)	0.77	7.23 (1.91)	0.80	5.64 (1.49)	0.81	0.77
3.76 (0.148)	136 (36)	16.3 (4.30)	0.68	15.9 (4.20)	0.76	12.1 (3.20)	0.72	7.95 (2.10)	0.66	5.79 (1.53)	0.74	0.71
	189 (50)	15.9 (4.20)	0.68	15.9 (4.20)	0.74	12.1 (3.20)	0.69	8.52 (2.25)	0.73	6.70 (1.77)	0.78	0.72
	284 (75)	15.5 (4.10)	0.67	16.5 (4.35)	0.80	11.7 (3.10)	0.71	8.33 (2.20)	0.72	6.51 (1.72)	0.70	0.72
4.50 (0.177)	136 (36)	22.7 (6.00)	0.70	20.4 (5.40)	0.71	15.1 (4.00)	0.69	12.1 (3.20)	0.75	9.84 (2.60)	0.80	0.73
	189 (50)	22.0 (5.80)	0.68	19.7 (5.20)	0.69	16.3 (4.30)	0.69	11.6 (3.06)	0.67	9.24 (2.44)	0.75	0.70
	284 (75)	22.0 (5.80)	0.69	21.6 (5.70)	0.74	16.8 (4.43)	0.71	11.7 (3.10)	0.68	9.77 (2.58)	0.74	0.71
		Avg.	0.69	Avg.	0.76	Avg.	0.75	Avg.	0.75	Avg	0.78	0.74

*Data not included in averages

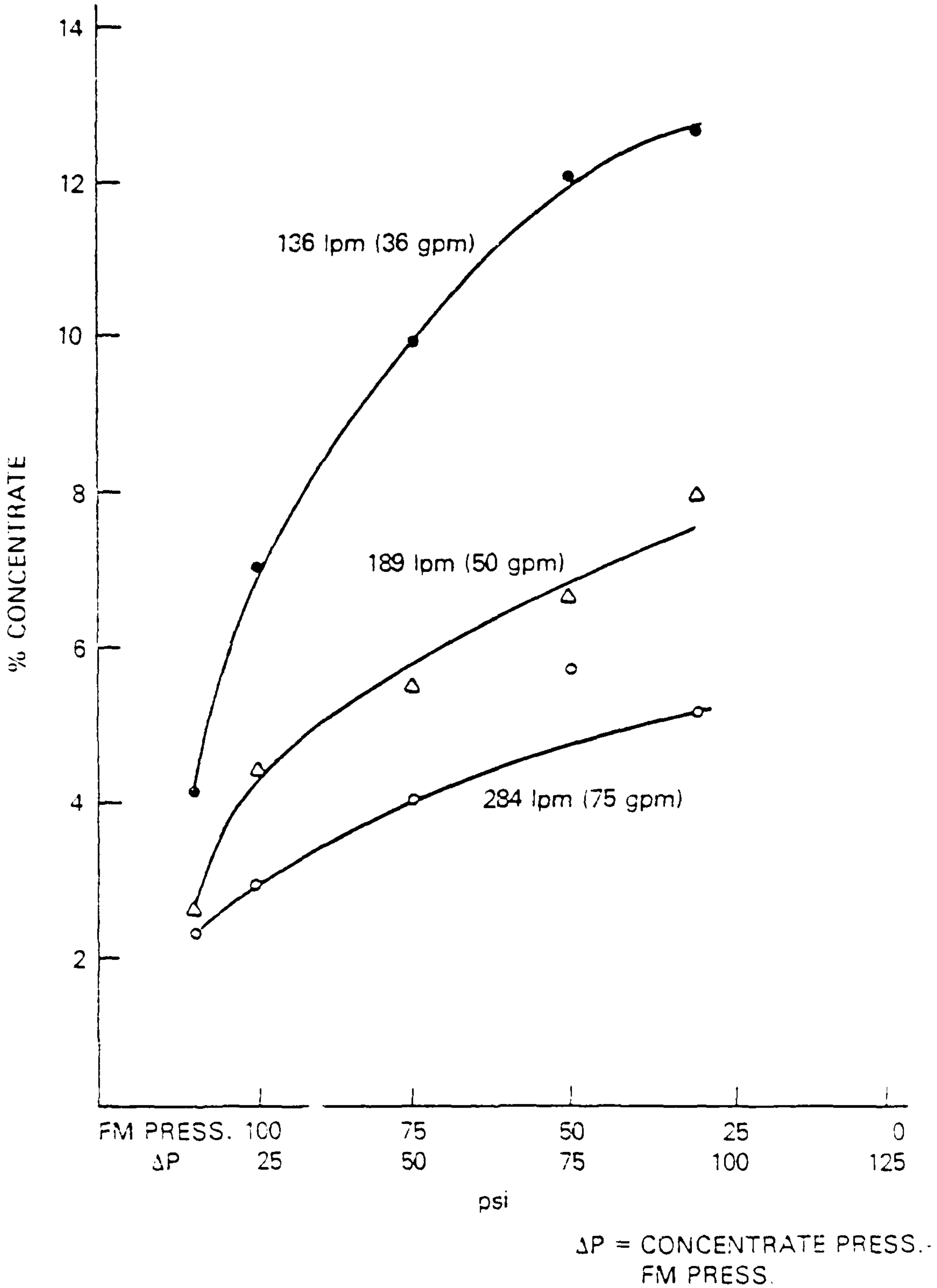

Fig. 3 — Proportioning tests using 3.76mm (0.148 in.) orifice

Table 3 — Orifice plate metering efficiency

Assumptions

The SSN 21 "firemain" pressure is normally 2.46 kg/cm^2 (35 psi), but in an emergency can be increased.

Calculation is for one 3.81 cm (1-1/2 in.) AFFF handline with 15.24 cm (50 ft.) of rubber lined hose and a Type I 360 lpm (95 gpm) nozzle

Orifice coefficient - 0.74

Minimum AFFF concentrate - 3%

Concentrate injection pressure (assume 0.35 kg/cm^2 (5psi) drop to injection point) - 8.4 kg/cm^2 (120psi)

1. Pressure increase from nominal 2.46 kg/cm^2 (35 psi) to 7.03 kg/cm^2 (100 psi)

At 7.03 kg/cm^2 (100 psi)	Nozzle flow = 356 lpm (95 gpm) Concentrate flow 10.6 = lpm (2.8 gpm) % concentrate = 3% Storage requirement (5 minutes) = 53 l (14 gal.)
At 2.46 kg/cm^2 (35 psi)	Nozzle flow = 202 lpm (53.4 gpm) Concentrate flow = 22 lpm (5.9 gpm) % Concentrate = 11% Orifice diameter = 4.3 mm (0.17 in.) Storage requirement = 112 l (29.5 gal.)

2. Pressure increase from nominal 2.46 kg/cm^2 (35 psi) to 3.52 kg/cm^2 (50 psi)

At 3.52 kg/cm^2 (50 psi)	Nozzle flow = 241 lpm (63.7 gpm) Concentrate flow = 702 lpm (1.91 gpm) % Concentrate = 3% Orifice diameter = 2.6 mm (0.102 in.) Storage requirement = 36 l (9.5 gal.)
At 2.46 kg/cm^2 (35 psi)	Nozzle flow = 202 lpm (53.4 gpm) Concentrate flow = 7.9 lpm (2.1 gpm) % Concentrate = 4% Storage requirement = 39.7 l (10.5 gal.)

Table 4 — Orifice plate tests for 3% proportioning

Orifice Dia. cm (dia)	Nominal FM Pressure/ Total Flow for 3% kg/cm²/lpm (psi/gpm)	P_{FM} kg/cm² (psi)	P_C kg/cm² (psi)	Q_{FM} lpm (gpm)	Q_C lpm (gpm)	Q_T lpm (gpm)	Concentration (%)	Calc. % Conc. Based On Actual Press./Flow
3.25 (0.128)	4.3/363 (61.5/96)	4.5 (64)	8.8 (125)	363 (96)	11 (3.0)	375 (99.0)	3.0	2.9
3.25 (0.128)	6.0/288 (85/76)	6.1 (86.5)	8.8 (125)	284 (75)	9.1 (2.4)	293 (77.4)	3.1	2.9
3.25 (0.128)	4.7/349 (66.3/92.3)	4.7 (67.5)	8.8 (125)	344 (91)	11 (2.9)	355 (93.9)	3.1	2.9
3.76 (0.148)	4.9/454 (69.5/120)	4.9 (69.5)	8.8 (125)	435 (115)	14 (3.7)	449 (118.7)	3.1	3.0
3.76 (0.148)	5.6/409 (80/108)	5.6 (80)	8.8 (126)	390 (103)	12.1 (3.3)	402 (106.3)	3.1	3.1
1.32 (0.052)	4.2/61 (60/16.1)	4.2 (60)	8.8 (125)	57 (15.1)	1.9 (0.5)	59 (15.6)	3.2	3.1
2.10 (0.0825)	5.9/122 (83.7/32.2)	5.8 (83)	8.8 (125)	112 (29.7)	3.8 (1.0)	116 (30.7)	3.3	3.2
2.10 (0.0825)	2.2/182 (32/48)	2.3 (33)	8.8 (125)	174 (46)	5.3 (1.4)	179 (47.4)	3.0	3.0

B. In-line Balanced Pressure Proportioner

A series of tests was conducted to confirm the conceptual feasibility of an in-line balanced pressure proportioning system. Tests using water have been completed for 5.8 cm (2 in.) and 7.62 cm (3 in.) diameter ratio controllers designed to proportion at 3%. The data in Tables 5 and 6 indicate that:

1. Proportioning is constant over a range of demands;

2. Constant proportioning is independent of pressure differential; and

3. Friction loss across the unit increases as flow increases, but is within acceptable limits for application to the SSN 21 design.

It was noted in some of the 7.62 cm (3 in.) ratio controller tests that there was a slight pressure gain across the unit, probably due to the high injection pressure. When water only is flowing through the ratio controller (i.e., no concentrate injection), the pressure drop is higher. A complete set of water-only data would be required if the unit is used on submarines, since this is a possible scenario.

C. Evaluation of Proportioning Systems

Table 7 is an evaluation of the two proportioning systems with respect to simplicity, proportioning efficiency, design/operational efficiency, reliability, general space, weight and cost factors. The orifice plate system is the more simple system, but suffers in proportioning efficiency if the potential for a wide range of flows and pressure differentials exist. Both systems can be considered reliable, but have specific design details which reduce overall reliability. Additional check and isolation valves are required in the orifice plate system, while supply piping is larger in the balanced pressure proportioning system.

From a design and operational standpoint, the balanced pressure proportioner has design features which significantly reduce its efficiency if the requirement to have combination seawater and AFFF stations is maintained.

Table 5 — 2 in. Ratio controller — 3% orifice plate

Nominal Flow/Press. lpm/kg/cm² (gpm/psi)	Inlet Water Flow lpm (gpm)	Conc. Flow lpm (gpm)	Total Flow lpm (gpm)	Concentration (%)	Pi kg/cm² (psi)	Po kg/cm² (psi)	Pressure Drop Across Ratio Controller kg/cm² (psi)
114/2.1 (30/30)	132 (35)	6.9 (1.82)	139 (36.8)	4.9	2.3 (33)	2.0 (29)	0.28 (4.0)
189/2.1 (50/30)	204 (54)	8.9 (2.35)	213 (56.4)	4.2	2.2 (31)	1.8 (26)	0.35 (5.0)
114/3.5 (30/50)	131 (34.5)	6.0 (1.58)	137 (36.1)	4.0	3.6 (51)	3.3 (47)	0.28 (4.0)
189/3.5 (50/50)	214 (56.5)	9.0 (2.37)	223 (58.9)	4.0	3.7 (52)	3.3 (47)	0.35 (5.0)
284/3.5 (75/50)	273 (72)	11.2 (2.95)	284 (75)	3.9	3.7 (53)	3.0 (43)	0.80 (10.0*)
378/3.5 (100/50)	360 (95)	14.4 (3.8)	375 (99)	3.8	3.7 (52)	3.2 (45.5)	0.46 (6.5)
473/3.5 (125/50)	477 (126)	19.6 (5.19)	496 (131)	4.0	3.7 (52)	3.0 (42)	0.70 (10.0)
189/5.3 (50/75)	216 (57)	9.2 (2.44)	225 (59.4)	4.1	5.5 (78)	5.2 (74)	0.28 (4.0)
284/5.3 (75/75)	273 (72)	11.3 (2.99)	284 (75)	4.0	5.3 (76)	5.0 (71)	0.35 (5.0)
378/5.3 (100/75)	360 (95)	15.0 (3.95)	375 (99)	4.0	5.3 (75)	4.9 (69.5)	0.37 (5.5)
473/5.3 (125/75)	460 (121.6)	17.4 (4.6)	429 (126.6)	3.7	5.3 (75)	5.1 (72)	0.21 (3*)
568/5.3 (150/75)	625 (165)	24.8 (6.56)	651 (172)	4.0	5.5 (78)	4.5 (64)	0.98 (14.0)
284/7.0 (75/100)	287 (75.8)	10.6 (2.8)	298 (78.6)	3.5	7.1 (101)	6.9 (98)	0.21 (3)
378/7.0 (100/100)	370 (97.7)	14.2 (3.76)	384 (101.5)	3.7	7.2 (102)	6.8 (97)	0.35 (5)
473/7.0 (125/100)	471 (124.5)	17.7 (4.69)	489 (129.2)	3.6	7.2 (103)	6.7 (96)	0.49 (7)
568/7.0 (150/100)	552 (145.8)	21.1 (5.58)	573 (151.4)	3.7	7.2 (103)	6.6 (94)	0.63 (9)
662/7.0 (175/100)	658 (173.7)	24.6 (6.51)	682 (180.2)	3.6	7.1 (101)	6.5 (92)	0.63 (9)
757/7.0 (200/100)	734 (194)	29.3 (7.74)	765 (202)	3.9	7.6 (108)	6.0 (86)	1.5 (22)

Inlet pressure to balancing valve - nominal 8.79 kg/cm² (125psi)
* Repeat data required

Table 6 — 3 in. Ratio controller — 3% orifice plate

Nominal Flow/ Press, lpm/kg/cm² (gpm/psi)	Inlet Water Flow, lpm (gpm)	Conc. Flow, lpm (gpm)	Total Flow, lpm (gpm)	Concen -tration (%)	PI, kg/cm² (psi)	PO, kg/cm² (psi)	Pressure Drop Across Ratio Contoller, kg/cm² (psi)
284/3.5 (75/50)	280 (74)	9.5 (2.5)	290 (76.5)	3.3	3.8 (53.5)	3.9 (55)	-0.11 (-1.5)
378/3.5 (100/50)	371 (98)	11.7 (3.1)	383 (101.1)	3.0	3.7 (52)	3.7 (52)	0 (0)
757/3.5 (200/50)	734 (194)	23.1 (6.1)	757 (200.1)	3.0	3.5 (50)	3.5 (50)	0 (0)
1136/3.5 (300/50)	1132 (299)	37.1 (9.8)	1169 (308.8)	3.2	3.7 (52)	3.6 (51)	007 (1)
378/5.3 (100/75)	367 (97)	12.1 (3.2)	379 (100.2)	3.2	5.1 (73)	5.3 (76)	-0.21 (-3)
757/5.3 (200/75)	742 (196)	23.8 (6.3)	766 (202.3)	3.1	5.4 (77)	5.3 (75)	0.14 (2)
1136/5.3 (300/75)	1136 (300)	37.9 (10)	1173 (310)	3.2	5.5 (78)	5.3 (75)	0.21 (3)
1514/5.3 (400/75)	1495 (395)	49.2 (13)	1544 (408)	3.2	5.6 (79)	5.1 (73)	0.42 (6)
378/7.0 (100/100)	375 (99)	12.5 (3.3)	287 (102.3)	3.2	7.1 (101)	7.2 (102)	-0.07 (-1)
757/7.0 (200/100)	746 (197)	22.3 (5.9)	768 (202.9)	2.9	7.1 (101)	7.1 (101)	0 (0)
1136/7.0 (300/100)	1132 (299)	36.3 (9.6)	1168 (308.6)	3.1	7.2 (102)	7.0 (99)	0.21 (3)
1514/7.0 (400/100)	1476 (390)	48.1 (12.7)	1524 (402.7)	3.2	7.2 (102)	6.9 (97.5)	0.32 (4.5)
1893/7.0 (500/100)	1749 (462)	57.2 (15.1)	1806 (477.1)	3.2	7.6 (108)	7.0 (100)	0.56 (8)

Inlet pressure to Balancing valve - nominal 8.79 kg/cm² (125 psi)

Table 7 — Evaluation of orifice plate and balanced pressure porportioning systems

FACTOR	ORIFICE PLATE SYSTEM	BALANCED PRESSURE PROPORTIONER
1. Simplicity	Very simple	Simple
2. Proportioning Efficiency		
a. Variable flow/ pressure differential	Inefficient at large flow and pressure differentials	Excellent efficiency
b. Relatively constant flow/ pressure differential	Improved efficiency	Excellent efficiency
3. Design/Operational efficiency	Hose stations can easily flow seawater only with a minimum impact on design	Significant design implications for combined seawater only and AFFF capability o Wet pipe system - slug of seawater in the line which must be discharged prior to AFFF flow at the appliance - highly undesirable o Dry pipe system (considered undesirable by NAVSEA) -less reliable -slight delay in agent flow o Once AFFF is introduced to system, seawater only capability is lost -the alternative is to create, in effect, separate AFFF and seawater branchlines to each dual agent station
4. Reliability	Small orifice diameters for individual injection points may be easily clogged o Fine mesh strainers may be required-impact on concentrate pressure due to friction loss across strainer Impact of friction loss characteristics over time, i.e., as pipes deteriorate with age, friction loss characteristics may change, which may result in inefficient proportioning	Dead end system - single valve failure at the connection to the seawater supply results in the loss of the entire AFFF system
5. General Space, Weight, Cost	Additional check/backflow prevention & gate valves required because each discharge station is connected to the seawater supply Possible agent storage increase if potential for large concentrate/ seawater pressure differential exists	Larger supply pipe size required from central injection point to individual discharge outlets-this line is an AFFF solution line instead of a concentrate line Balancing valve and ratio controller instead of orifice plates

IV. ALTERNATIVE SYSTEMS

Two additional alternatives to orifice metering plates have been identified for distributed single-user injection points. An automatic flow control valve has been ordered for evaluation. This diaphragm operated valve may be able to maintain a constant flow of AFFF concentrate over a range of differential pressures. This may reduce overdesign requirements as shown in Table 3 (i.e., flow rate will not increase as pressure differential increases). The effective free area of the orifice opening may also be larger than the opening in an orifice plate for the same design point, which could reduce the possibility of clogging and increase reliability.

Akron Brass Co. is working on a modified eductor proportioning concept. Their goal is to create an eductor which will proportion concentrate (injected under pressure) within a relatively narrow range (e.g., 3-5%) over a range of pressures and flows, while maintaining relatively low pressure drop across the unit. NRL will maintain contact with Akron to keep abreast of this developmental work.

V. SUMMARY

The AFFF fire suppression systems proposed for flammable liquid fuel hazards on the SSN 21 require proportioning systems to inject 3% AFFF concentrate into seawater systems to create AFFF solution. Alternative proportioning systems each of which utilizes an air-pressurized concentrate storage tank are being evaluated by the Naval Research Laboratory (NRL). One candidate system uses multiple single-user injection points (e.g., orifice metering plates) to proportion AFFF at each hose station or sprinkler system. The other system, which uses an in-line balanced pressure proportioner and ratio controller, is designed as a central system which can proportion over a range of demands.

Proportioning using the orifice plate system is pressure sensitive and not flow sensitive. As pressure differential between the injected concentrate and seawater increases, flow rate increases. If pressure differential can vary considerably during operation, AFFF flow and storage requirements must be overdesigned to meet the lowest design point, i.e., 3% at the smallest pressure differential. The size of the orifice in the orifice plate design may be so small (e.g., 2.5 cm (0.1 in.) dia.) that clogging of the orifice could be a problem.

Proportioning using the balancing valve system is flow sensitive. A steady level of % concentrate is maintained over a range of flows. The use of a central proportioning system creates, in effect, a separate AFFF firemain system. The central proportioning system allows more effective use of AFFF concentrate, but significant design and operational problems result from the requirement to have seawater only capability at AFFF hose stations.

Future R&D work will focus on the single-user injection point system. Two additional single-user injection point systems may be available for testing in the near future.

END

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