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FIRE SUPPRESSION TESTING OF HYPERGOLIC VAPOR CONTROL FOAMS

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A recent Air Force study certified certain acrylic-modified foams as effective vapor suppression agents for hypergolic propellants, specifically hydrazine and nitrogen tetroxide. Large quantities of these materials are stored and used as rocket propellants in space and defense programs such as the Space Shuttle and Titan. Sizable quantities of these materials are subject to accidental spills and possible ignition during highway transport as well as during handling operations at the storage and use facilities. Thus, the natural follow-on for the vapor suppression certification was to test the effectiveness of these foams against propellant fires under a variety of scenarios. A series of 39 tests with anhydrous hydrazine (AH), monomethylhydrazine (MMH), unsymmetrical dimethylhydrazine (UDMH), Aerozine 50 (A-50), and nitrogen tetroxide (N_2O_4) was conducted at the Nevada Test Site in November 1985 and April 1986. This report describes the results of such testing, along with an analysis of products released into the environment when the acrylic-modified foams are →

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19. Abstract (Continued)

used to control hydrazine fires and when the foam-covered hydrazine is later disposed of by burning.

PREFACE

This final report was prepared by the New Mexico Engineering Research Insitute (NMERI), University of New Mexico, under Contract F29601-84-C-0080, with the Engineering and Services Laboratory, Headquarters Air Force Engineering and Services Center (AFESC), Tyndall Air Force Base, Florida.

This report summarizes the work done between 23 August 1985 and 30 September 1986. HQ/RDCF program manager was Mr. Joseph L. Walker. Task Officers were Mr. Bryce Mason, HQ AFESC/RDCF; Captian Jim Betschart, HQ SD/CFPE and Ms. Phyllis Cambell. NAVAIR.

This report has been reviewed by the Public Affairs Officer (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS it will be available to the general public, including foreign nationals.

This technical report has been reviewed and approved for publication.

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TABLE OF CONTENTS

TABLE OF CONTENTS
(CONCLUDED)

LIST OF FIGURES

LIST OF TABLES

SECTION I
INTRODUCTION

A. OBJECTIVES

The objectives of this research effort were (1) to develop documentation that may be used for Air Force certification of the presently developed hypergolic propellant vapor control foams for use as fire suppressants, and (2) to identify the chemicals released into the environment when foams are used to control hydrazine fires, or when foam-covered hydrazine is later disposed of by burning.

Appendices A through H contain additional data and information.

B. BACKGROUND

Large quantities of hypergolics, specifically hydrazine and nitrogen tetroxide (N_2O_4), are stored and used as rocket propellants in space and defense programs, such as the Space Shuttle and the Titan. Accidental spills of sizable quantities of these hazardous materials can occur during transport on the nation's highways, as well as during propellant handling operations at the storage and use facilities. Vapors in parts per million (ppm) (see Table 1 for conversion factors) concentrations constitute significant risks to human health (see Appendix A, Safety Data Sheets). Hydrazine fuels are also considered as suspect human carcinogens by the American Conference of Governmental Industrial Hygienists (ACGIH). Spills involving these substances pose the immediate threat of human exposure from propellant vapor and liquid, and the less immediate, but equally significant, threat of secondary contamination of water supplies and sewers from the escaping liquid propellant or from contaminated water used in spill response. An Air Force study to develop a foam system that could effectively reduce the volatilization of hydrazines and N_2O_4 spills has been completed recently (Reference 1). Foams with additives were developed and tested with positive results for hypergolic vapor suppression even under adverse weather and stream flowing conditions. Field demonstrations

TABLE 1. CONVERSION FACTORS FOR U.S. CUSTOMARY
TO METRIC (SI) UNITS OF MEASUREMENT.

To convert from	To	Multiply by
British thermal unit/second (Btu/s)	watt (W)	1.054 350 x E +03
degree Fahrenheit (°F)	degree Celsius (°C)	$t°_C = (t°_F - 32)/1.8$
foot (ft)	meter (m)	3.048 000 x E -01
ft^2	m^2	9.290 304 x E -02
ft^3/min	liter/min (L/min)	2.831 684 x E +01
$ft^3/min/ft^2$	$L/min/m^2$	3.047 999 x E +02
gal/min	L/min	3.785 412 x E 00
$gal/min/ft^2$	$L/min/m^2$	4.074 584 x E +01
inch (in.)	m	2.540 000 x E -02
miles/hour (mph)	km/h	1.609 344 x E 00
parts/million (ppm)	mg/l	1.000 000 x E 00
pound (lb)	kg	4.535 924 x E -01
$lb/in.^2$	atmospheres (atm)	4.725 000 x E -04
yard (yd)	m	9.144 000 x E -01

included scenarios of a propellant spill contained in a simulated diked enclosure, a running spill on a concrete surface, and a spill occurring inside a missile silo. The flame-extinguishing capabilities of both low- and high-expansion foams were demonstrated for propellant fuel fires. A major concern during a hydrazine spill is the spontaneous ignition of the fuel. An effective fire suppressant is needed for emergency response. Therefore, this program of fire suppression testing of hypergolic vapor control foams was conducted to provide the Air Force with valid and certified fire suppression agents for hypergolic propellants. Hydrazines are hygroscopic, water-soluble propellants which would be expected to remain toxic for a long time, be absorbed by the ground, and require environmentally acceptable processing. Four hydrazines (anhydrous, monomethyl, unsymmetrical dimethyl, and Aerozine 50) and possibly N_2O_4 fall in this category. If water is used to control the vapors or to control a fire, the volume of the resulting aqueous solution could be substantial. If contained as a pool, the solution would contaminate a greater quantity of soil than the hazardous materials themselves. When faced with a vast quantity of aqueous solution or contaminated ground which must be treated or disposed of, the effort to develop a foam was undertaken to reduce the quantity of water used and to reduce the containment volume. The spent foam and waste hydrazine must be disposed of once the spill has been controlled and contained. Rather than collect the material and bury it in a hazardous waste landfill, a controlled burning or incineration is proposed. Depending upon circumstances, it may be environmentally most practical to effect a controlled burn in place. The bulk of previous research has been directed toward the development of the foams as solutions to controlling the spill hazards. Very little research has been done to assess the reaction products formed when controlling a hydrazine fuel fire or when incineration of the used foam is a means for its disposal.

C. SCOPE

The scope of this effort encompassed a complete series of 38 fire tests conducted at the Nevada Test Site in November 1985 and April 1986. The tests were fully documented and the conditions and results completely described. The performance of the various foams and types of fires were recorded and conclusions were drawn from the variety of fire and foam interactions. Recommendations regarding types of foams and application rates for various propellants and spill conditions were drawn. Several of the fire tests were environmentally sampled through innovative and unique sampling techniques. Samples were analyzed for propellant and foam combustion products and a complete analytical compilation was derived.

SECTION II
HISTORY/PREVIOUS TESTS

Historically, propellant spills have been diluted with water for vapor suppression. This procedure creates an increased volume of material which must ultimately be disposed of, together with the attendant increases in cost and schedule. In the case of N_2O_4, the addition of water will cause a dramatic increase in the vapor evolution rate before reaching a more nonvolatile, diluted state. To perform more optimal vapor suppression, water-based foam formulations were developed through the efforts of the Chemical Systems Branch of the Plans and Project Directorate of Air Force Space Division (HQ-SD/CFPE) located at Los Angeles Air Force Station, California, and the Engineering/Reliability Branch of the Material Management Directorate of Ogden Air Logistics Center (OO-ALC/MMGRI) located at Hill Air Force Base, Utah. These efforts investigated the possibilities of vapor suppression and fire extinguishment while minimizing the volume of material which must be added to a propellant spill for hazard mitigation (Reference 2).

The results of this initial work indicated that aqueous foam systems could provide effective mitigation of the vapor hazard from spills of hypergolic propellants (Reference 3). The program was continued (Reference 1) with the subsequent development of acrylic-modified surfactant foam systems. Tests showed that these foams could significantly reduce vapor concentrations from hydrazine and N_2O_4 spills for extended time periods. This technology led to the development of a trailer-mounted foam response unit, a Portable Foam Vapor Suppression System (PFVSS) (Reference 4). Four of these units are actively deployed with the Titan Missile Wings of the Strategic Air Command while a fifth unit is in service at Vandenberg AFB.

Under a supplemental Air Force contract (Reference 5), field tests of the PFVSS were conducted to ascertain its capability in controlling large propellant spills. The technology was also used to design and install a demonstration fixed-foam system at the oxidizer storage area at the Vandenberg Air Force Base Titan Propellant Tank Farm. A foam system is also included in the new fuel storage facility at the Cape Canaveral Air Force Station.

The results of the investigations conducted in the Air Force-funded programs indicated conclusively that foam can be used to control the vapor hazard from spills of the hypergolic propellants, i.e., hydrazines and nitrogen tetroxide. The acrylic-modified foams tested were able to restrict hydrazine vapor levels to less than 1 ppm and N_2O_4 vapor levels to less than 100 ppm. In all cases, it was found that the foam blankets could be continuously or intermittently replenished to allow long-term spill control if necessary.

Best results were obtained with contained spills. A significant degree of control can be exercised in running spills if the foam can be applied to cover and follow the spill. Continuous liquid discharges were difficult but could be controlled if the discharge could be submerged in foam. Some limited tests were conducted which tentatively indicated that the acrylic-modified foams are effective in controlling and extinguishing hydrazine fires and nitrogen tetroxide supported fires involving nonpropellant flammable materials. Resulting foam technology has been successfully employed in both portable and fixed installations

The initial program to define vapor control procedures for spilled hypergolic propellants assessed the ability of the two techniques to mitigate the vapor hazard of hydrazine and N_2O_4. Each technique was pursued independently for both of the propellant materials. The program used a series of laboratory tests to evaluate the various methods and materials for vapor suppression. Vapor concentrations above the two propellant materials were measured using detector tubes. Tests in which the concentrations exceeded the maximum limit of detector tubes (about 35 ppm) were considered failures.

The evaluation of foam systems initially considered the commercially available foam agents as used by the fire services. When these did not prove effective, an experimental type of foam was also considered. This was an acrylic-modified agent.

Five basic foam agent types are currently in use for fire control. These are proteinaceous materials derived from natural protein, Aqueous Film-Forming Foams (AFFF) which employ a fluorocarbon surfactant, fluoroproteins which are combinations of AFFF and protein, synthetic materials which are hydrocarbon-surfactant base, and "alcohol" or "polar solvent" agents which are generally proprietary materials.

Two expansion ranges are used in foam technology. Expansion is the ratio of air to water in the foam mass. There are theoretical design limits, but in practice the limits are 5 to 20:1 for low-expansion and 250 to 750:1 for high-expansion foams. For fire control, the synthetic foaming materials are effective in both expansion ranges. The other foams are generally restricted to the low range, even though high-expansion foam can be generated with some of them.

AFFF materials perform quite poorly with water-reactive materials but were included because they are widely used by the Air Force. Each of the selected commercial agents was carried through screening tests to assess compatibility with both hydrazine and N_2O_4.

The tests with N_2O_4 were easy to evaluate; all foams collapsed rapidly with only minimal control of the vaporization rate. Of the five agents tested, the best results were obtained using MSA Type V, AFFF, and 3M ACT polar solvent agents (see Appendix H for definitions), but all control times were less than 5 minutes.

The tests conducted with hydrazine had more encouraging results. Except for AFFF and one alcohol foam type, the other foams survived between 30 and 60 minutes when generated at low-expansion. Vapor concentrations were reduced to 5 ppm or less.

Tests run with foams generated at high-expansion ratios were poor in all cases. The small laboratory tests provide data which are significantly better than those derived from the large-scale field tests conducted later in the program.

Prior work had indicated that polymer-modified foam agents might be effective against the propellant materials. Two acrylic polymer-modified foam agents were evaluated against hydrazine in the same fashion as the commercial agents. Both materials were compatible with hydrazine. The gelation provided a stable foam mass with little collapse. Each gel eventually broke down but the effective life of a 3-inch layer approach 4 hours. The carboxyvinyl polymer gave very viscous solutions. Although it could be handled in the dilute state, it did not appear to be practical in a concentrate form.

Both acrylic-gelling foams were tested with N_2O_4 for compatibility. Neither material could survive against the N_2O_4 for more than 15 minutes, but they were superior to all other agents tested. One of the acrylic polymers formed an intermediate skin between the foam and the N_2O_4, whereas the other foams reacted slowly with N_2O_4. In general, the latter behaved similarly but did not provide the same degree of control as evidenced by the formation of a discontinuous film.

The conclusion reached was that the acrylic polymer-modified foam systems possessed the best potential for evolving a successful vapor control system for the hypergolic propellants.

At the end of the initial laboratory studies of these foams, a short series of tests of a scaled-up size were run in a remote area of the Nevada Test Site (NTS) of the Department of Energy (DOE) in Mercury, Nevada. These tests were conducted to evaluate and verify laboratory results. The derived data provided the basis to decide on the continuation of the foam development program. It was not the principal purpose to develop absolute data but to evaluate the viability of the acrylic-modified foam approach for the control of hypergolic propellent spill vapor hazards. Tests were conducted with both hydrazine and N_2O_4. All tests used a 25 ft^2 pan, 12 inches deep, and a foam expansion of 20:1 generated with a foam pump. The acrylic modifier to the foam was Rohm & Haas AC33 in all tests. This acrylic was chosen because it had exhibited benefits in contact with both fuel and oxidizer. The foam composition was 10 percent surfactant, 10 percent acrylic, and 80 percent water. Variations were made in depth of the spilled propellant, between 1/4 inch and 6 inches. Foam depths were essentially constant for each propellant, 3 inches for hydrazine and 6 inches for N_2O_4.

Further extensive laboratory and field testing revealed that a volumetric foam formulation consisting of approximately 10 percent Rohm and Haas polyacrylic ASE-95 (fuel foam), 10 percent Mine Safety Appliance Research Corporation (MSAR) surfactant, and the remaining 80 percent water was most effective on hypergolic fuel spills. Best results on N_2O_4 oxidizer spills were obtained with a volumetric foam formulation consisting of approximately 10 percent Rohm & Haas polyacrylic ASE-60 (oxidizer foam), 10 percent MSAR surfactant containing a small amount of pectin, and 80 percent water. Best results for the fuel formulation were obtained when the foam was applied in a low-expansion ratio mode of 5 to 10:1. Oxidizer foam produced the best results when applied in a high-expansion mode of 150 to 300:1.

Under normal application conditions of light winds and no precipitation, reapplication is required approximately every 20 minutes for oxidizer spills and every hour for fuel spills. In higher wind conditions the foam collapses at a higher rate due to the increased amount of water draining through it, therefore requiring more frequent applications.

As the oxidizer high-expansion foam collapses, there is a tendency for gel-layer islands to form on the oxidizer surface. As successive applications of foam are made, the gel-layer tends to become continuous. At that point, if foam supplies are limited, it may be practical to allow the foam to collapse completely before the next layer is applied. Otherwise, with adequate foam supplies available, it is advisable from the hazard mitigation and safety points of view to apply foam in whatever manner will minimize vapor release, including spot patching when vapor breakthrough has taken place.

Low-expansion fuel foam exhibits a persistence time of from 1 to 2 hours as opposed to about 20 minutes for high-expansion foam. The low-expansion foam is the obvious choice for longevity of foam cover. Since the high-expansion foam allows a coverage rate about seven times faster than low-expansion foam using the same rate of commodity application, it may be desirable in circumstances requiring immediate vapor suppression to make an initial application of high-expansion foam followed by subsequent applications of low-expansion foam. It may also be desirable to apply high-expansion foam at transport spills where the ability to replenish the foam commodities may be limited. Although high-expansion foam must be replenished about three times more often, it consumes only about 60 percent of the foam commodities in the same length of time due to the much greater volume of foam generted per unit of foam concentrate and water used.

This testing program defined foam systems effective in controlling the vapor hazard of spilled hypergolic propellants. The technology has been translated from the laboratory to large-sized portable units and fixed-foam installations, with both types now in Air Force service.

The fire control testing also had positive results, but the data were not sufficient to fully define fire suppression capabilities or detailed application requirements. The use of the foams in either fire or spill control will leave an acrylic-resin residue. The handling and disposal of this material was not a part of this test series; however, it was this test series which dramatically illustrated the potential of the acrylic-modified foams and which led to the further work described in this report. Appendix C contains minutes of the more significant meetings leading to the development of this testing program, and Table 2 is the test matrix derived from those meetings.

TABLE 2. ORIGINAL TEST SCHEDULE MATRIX.

	Low expansion foam, Rate A, 1-minute preburn	Low expansion foam, Rate B, 1-minute preburn	Low expansion foam, Rate C, 1-minute preburn	Low expansion foam, Rate A, 10-minute preburn	Low expansion foam, Rate B, 10-minute preburn	Low expansion foam, Rate C, 10-minute preburn		High expansion foam, Rate A, 1-minute preburn	High expansion foam, Rate B, 1-minute preburn	High expansion foam, Rate C, 1-minute preburn	High expansion foam, Rate A, 10-minute preburn	High expansion foam, Rate B, 10-minute preburn	High expansion foam, Rate C, 10-minute preburn		Low expansion foam, Design Rate, 1-minute preburn[a]	High expansion foam, Design Rate, 1-minute preburn[b]		N_2O_4 pool, high expansion foam, Hydrazine spray			Hydrazine pool, low expansion foam, N_2O_4 drip[b]		AFFF-Foam	Polar solvent foam		High expansion foam, submergence time	High expansion foam, submergence time--N_2O_4 drip		Low expansion foam, 3 gal/min, UL 162	High expansion foam, 3 gal/min, UL 162	
[illegible]	X	X	X					X	X	X					X	X		X			X		X	X							A
[illegible]															X	X															B
Aerozine 50--ambient temperature															X	X															C
Anhydrous hydrazine															X	X															D
Hydrazine plus rusted metal															X	X															E
Hydrazine plus metal obstruction															X	X															F
																															G
Diesel fuel + N_2O_4, fresh mix								X	X	X						X															H
Diesel fuel + N_2O_4, 24-hour soak																X															I
																															J
Tires + N_2O_4, fresh mix																										X	X				K
Tires + N_2O_4, 24-hour soak																										X	X				L
																															M
Normal hydrocarbon--heptane																													X	X	N
Wood crib + N_2O_4--heptane																										X	X				O
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	

[a] A series of three tests were actually run on A-50 to develop a design rate. The previously calculated design rate for MMH was clearly inadequate. Thus, Tests C-15 and C-16 are actually three tests, each with the second two tests annotated A and B.

[b] Extensive problems in the reaction of Test A-18 led to the decision not to conduct Test A-21. Facilities, equipment, and procedures were not considered adequate.

SECTION III
TESTING

A. TEST AUTHORIZATION

Test authorization was requested via the HQ AFESC/RDCF letters and granted by the Department of Energy/Nevada Operations Office (DOE/NOO) letters contained in Appendix B. Because of the speed with which this program moved, test authorization requests did not always precede the requested test windows with sufficient lead time. However, DOE/NOO officials took exceptional expediting actions to permit approvals to be received in time for the testing to take place on schedule. The major drawback was that the Reynolds Electrical and Engineering Company (REECo) could not be authorized to perform work until the DOE/NOO approval was granted. This resulted in problems with the construction of the pans and excessive cost to set up the foam pen for the wood crib tests. A few additional comments on the NTS testing costs and conditions are appropriate here. DOE/NOO personnel typically estimate $15,000 to $20,000 per week for NTS testing support costs. This is fairly accurate in that NMERI testing periods spanned 4 1/2 weeks and cost about $72,000. The costs are applied toward REECo support, fire, security, weather, environmental, and photo (optional). Every aspect of NTS support was timely and effective. REECo was particularly supportive but extremely expensive. The estimate of $47,000 was exceeded by $14,000. The high cost of REECo is mainly due to Mercury support operations such as food, transportation, and billeting being heavily subsidized with the cost factored into the hourly rates charged for REECo support work.

From a test scheduling standpoint at NTS, there are several factors to consider. Where the need for light winds and stable wind direction is a major factor, as it was in this test series, testing should be conducted between April and October. This project's April series of tests had generally favorable winds while the tests of November were hampered by marginal winds. The period of April through October is also the time during which NTS conducts most of their underground tests. These tests can present major schedule disruptions because of their priority and the need to clear all of NTS prior to, during, and after such tests. Tests which are necessarily continuous for longer than a day and which cannot be segmented would be impacted by the underground testing. Other weather factors to be considered are the extremes in temperature. The nights during November subjected the equipment to freeze damage, while the heat (even as early as April) was extremely fatiguing and began to heat the fuel and apparatus to a hazardous level.

B. TEST SETUP

1. Site Preparation of Initial Test Series

The initial series of testing commenced at NTS on 13 November 1985. Prior to the initial test on this date, 5 working days were required to prepare the site. This involved (a) moving fuel, foam, dispensing apparatus and sampling apparatus to test site; (b) laying out test site; (c) assembling and testing all apparatus; (d) making contacts with appropriate NTS support officials; and (e) posting a safety board detailing safety procedures.

a. Movement of Materials

The movement of materials to the test site presented no problems. REECo was well-equipped and extremely cooperative in getting the materials moved in a safe and timely manner to the test site. The foam and apparatus and the N_2O_4 cylinder were stored near the Cave Spring Test Range and the hydrazines (21 drums) were stored in Mercury.

b. Test Site Layout

The test site was conveniently located about 15 miles north of Mercury. The surface at the site was a relatively clean, debris-free weathered asphalt. Since the prevailing winds were out of the south-southwest upon arrival, the four pans were set up in a square pattern, 75 feet apart, with the intention of burning in the sequence of northeast, northwest, southeast, southwest. This arrangement would permit four tests to be conducted in one day, with the foam and sampling equipment requiring only one move. The pan area was located approximately 200 yards east of the operations trailer.

c. Assembly and Testing of Apparatus

On 8 November, the MSA foam tanks were filled with water, pressurized and used to check out the 2-, 3-, and 6-gallon-per-minute (gal/min) nozzles. All systems ran well. The MSA system employed for all tests in this series was a field-adapted system consisting of two 70-gallon tanks pressurized to 110 lb/in.^{2} by a REECo-supplied air compressor. Pressures on the outlet side of the tanks were regulated to produce 90 lb/in.^{2} for low-expansion foam and 35 lb/in.^{2} for high-expansion foam at the nozzle. The acrylate was contained in one tank--mixed 1:4 with water; while the surfactant was in the second tank, also mixed 1:4 with water. The acrylate and surfactant solutions ran in separate lines of approximately 200 feet of 1-inch hose to a union where they were joined immediately prior to 10 feet of 1-inch piping leading to the nozzle. This system is shown in Figure 1. Between 9 and 11 November, the Thermal Gas Device (TGD) sampling apparatus (described in detail in Volume II) was assembled. Low temperatures, high winds, and snow made the setup lengthy and difficult. It was decided to orient the TGD on the SE side of the NE pan and run all tests to be sampled from that pan. The bulk of the TGD, number of connections, and number of support assemblies made this "permanent" setup necessary.

d. Contracts

All preliminary support arrangements were made with Mr. Lon Kilmer of the DOE Nevada Operation Office (702) 295-0968 in Las Vegas. At Mercury the primary support contracts were Mr. Wilson, DOE, (702) 295-4001; Mr. Dennis Finney, REECo, (702) 295-6540; Chief Ray Gudeman, Fire Protection (702) 295-6404; and Mr. Frank Tyner, PanAm Photo (702) 295-6771.

e. Safety Procedures

A safety board was assembled immediately inside the operation's trailer with the following information: copies of all pertinent material safety data sheets with instructions to all personnel to read and sign, emergency phone numbers, the safety portion of the test plan, and the test organizational chart (Appendix E).

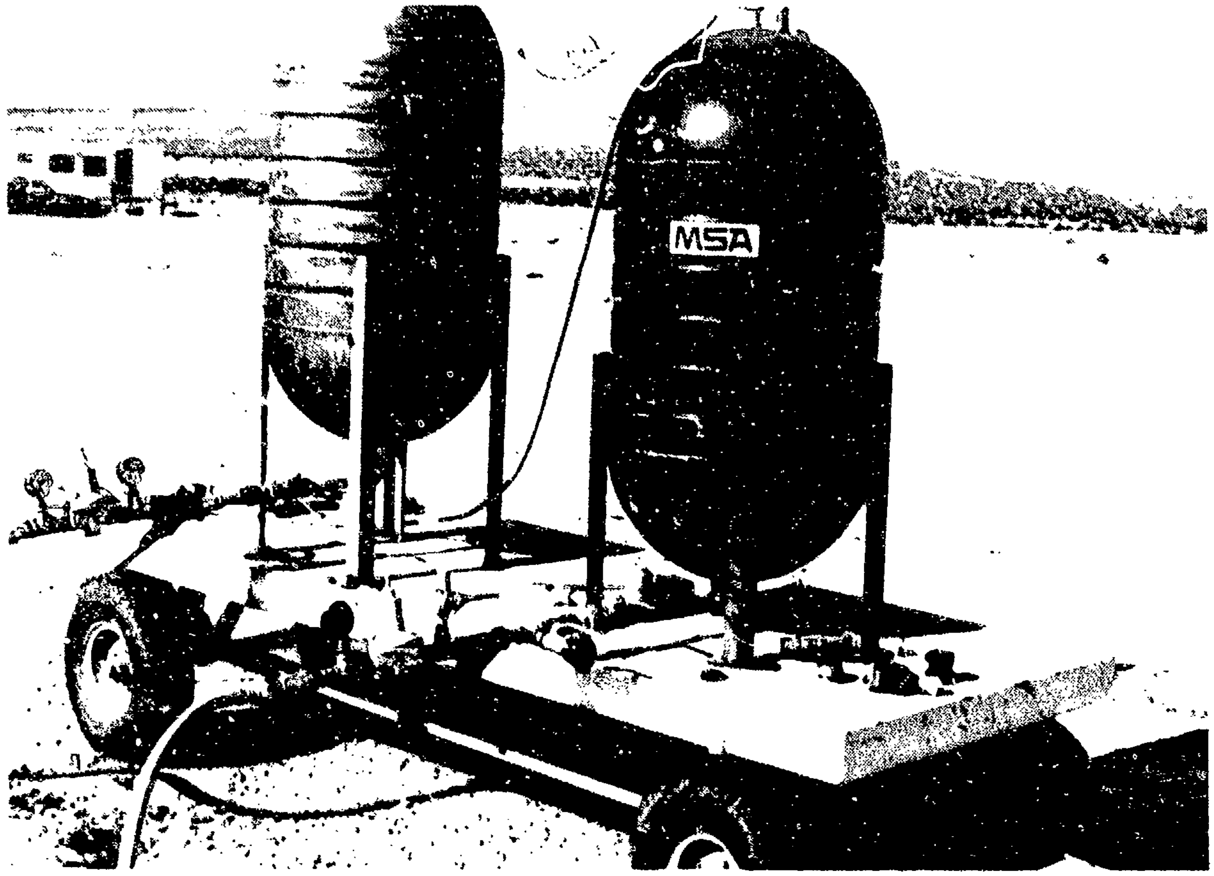

Figure 1. MSA-Dispensing Apparatus.

2. Site Preparation of Second Test Series

The second series of tests was begun at NTS on 15 April 1986. Prior to the initial tests on this date, two working days were required to prepare the site for testing. This involved (a) laying out test sites, and (b) assembling fuel/oxidizer dispensing apparatus.

a. Test Site Layout

The west side of the test site was selected as the most advantageous location for all tests in this series. This placed the support trailer 250 yards to the east and the fuel storage area 300 yards to the east. In the fuel storage area were the monomethylhydrazine (MMH), Aerozine 50 A-50), heptane, and diesel fuels. The two cylinders of N_2O_4 were kept immediately adjacent to the western edge of the test area. The foam pen for the wood crib tests was sited at the western edge of the test area.

b. Apparatus Assembly

REECo provided polyvinyl chloride (PVC) pipe and fittings to fit 20- and 10-foot extensions to the N_2O_4 cylinder and diesel drum. A nitrogen bottle and connections were obtained to further pressurize the N_2O_4 cylinder during pouring operations.

C. TEST CONDITIONS, EQUIPMENT, AND PROCEDURES

1. November 1985 Test Series

a. Weather

Before deciding to proceed with a test series during the month of November, it was understood that the weather would range between marginal and unacceptable, and that the test schedule would probably not be completed in its entirety. This was largely the case; and while the weather was more on the marginal side, it did not appear prudent to move into the N_2O_4 portion of the test series. Initial setup weather was deceptively good--60 to 70 °F with 6 to 12 mph winds. After 3 days, the temperature dropped, winds picked up, and snow fell for 3 days. When the precipitation stopped, the low temperatures and high winds continued for about another week and were followed by a warming trend with light and variable winds for the remainder of the test period. The high winds severely affected some tests, particularly on 18 November when they gusted to 46 mph and threatened to ignite the desert brush south of the test area. The high winds also increased the fatigue factor of the personnel handling the hydrazine and extinguishing apparatus while the extremely cold nights (15 to 20 °F) froze the foam apparatus, occasionally breaking valves and fittings. The light and variable winds presented a contrasting problem, the extent and direction of flow of the hazardous hydrazine vapors could not be ascertained. Perhaps the most crucial decision of the test series was made at this point, and that was to continue the tests with all personnel outside the operations trailer wearing either a pressure demand self-contained breathing apparatus (SCBA) or an industrial gas mask with the appropriate canister. From this point, the tests continued with no weather difficulties.

b. Equipment

In general, the equipment transported to the site by New Mexico Engineering Research Institute (NMERI) and MSA performed well. Minor malfunctions and shortcomings due to unavailability of parts were handled in the field and were more than amply supported by REECo in a timely manner. Dry ice for the cryogenic traps (see Appendix H) was not available on site as anticipated, and three trips to Las Vegas were made to procure an adequate amount for the tests. The diesel generators provided by REECo were marginal at best. Three generators were required, and a total of six generators were rotated through the site to provide minimal power. Generators had problems starting, maintaining the load requirements, and operating continuously on required phases and voltages. While REECo's response to these problems was usually timely, corrective actions were not lasting. The generator situation caused no delays in the testing schedule; however, it necessitated numerous last minute "work-arounds" and the extensive use of NMERI's 4-kilowatt (kW) portable generator, without which the test schedule definitely would have been impacted. Full portable power provided by NMERI was considered for future tests. Because of the late adjustments in the test dates and DOE/NOO permit processing lead times, the pans were not constructed in accordance with NMERI specifications. The four

50 ft^2 square pans were to be constructed of 3/16-inch steel with a ribbed, reinforced bottom. This steel could not be procured in time, nor was there lead time for reinforcing, so testing was begun with four pans of 3/32-inch steel, unreinforced. Furthermore, the pans were 52.5 ft^2 instead of the requested 50 ft^2. As expected, the pans warped badly and considerable hammering was applied between tests to achieve marginal releveling. Beginning with the AH low-expansion test on 19 November, two new pans were provided by REECo, with good bottom reinforcement; these two pans were 50 ft^2 and were used for the remainder of the tests. During the MMH pour for the low-expansion obstruction and rusty metal test on 22 November, one of the reinforced pans developed a leak along the seam on the middle of one side. The pan began to visibly drip, and heavy vapors were seen forming beneath the pan. No ignition outside the pan occurred, and the test was continued to a successful conclusion. If future pans are constructed as specified, no problems should occur.

c. Procedures

The NMERI and MSA teams worked very well together, and field procedures were easily resolved to the satisfaction of both parties. The schedule matrix of the test plan was followed fairly closely, and the test plan safety procedure proved adequate. Prior to the first MMH pour, it was decided to place an aluminum foil cap over the end of the TGD to prevent vapor accumulation and possible ignition. The foil was remotely removed at the start of the burn. During the first MMH pour, an air sample was taken approximately 1.6 miles downwind with no indication of hydrazine. All outside participants wore hydrazine indicator badges during the first day of testing; no badges indicated exposure to hydrazine at the 1 ppm level or greater. Essentially on all tests MSA personnel handled the fuels, foam, physical samples, and burnoff (Figures 2 through 5). NMERI personnel recorded test times and descriptions, operated the TGD sampling apparatus, and directed the PanAm photography. Site security and fire department support for all tests was excellent. Prior to each test, the fire department set up and charged a hand line, and remained on the test site until the final burnoff of the day was completed. Established areas for protective breathing apparatus were maintained until 20 November, from which time-pressure demand self-contained breathing apparatus (SCBA) or an industrial gas mask with appropriate canister were employed by all outside

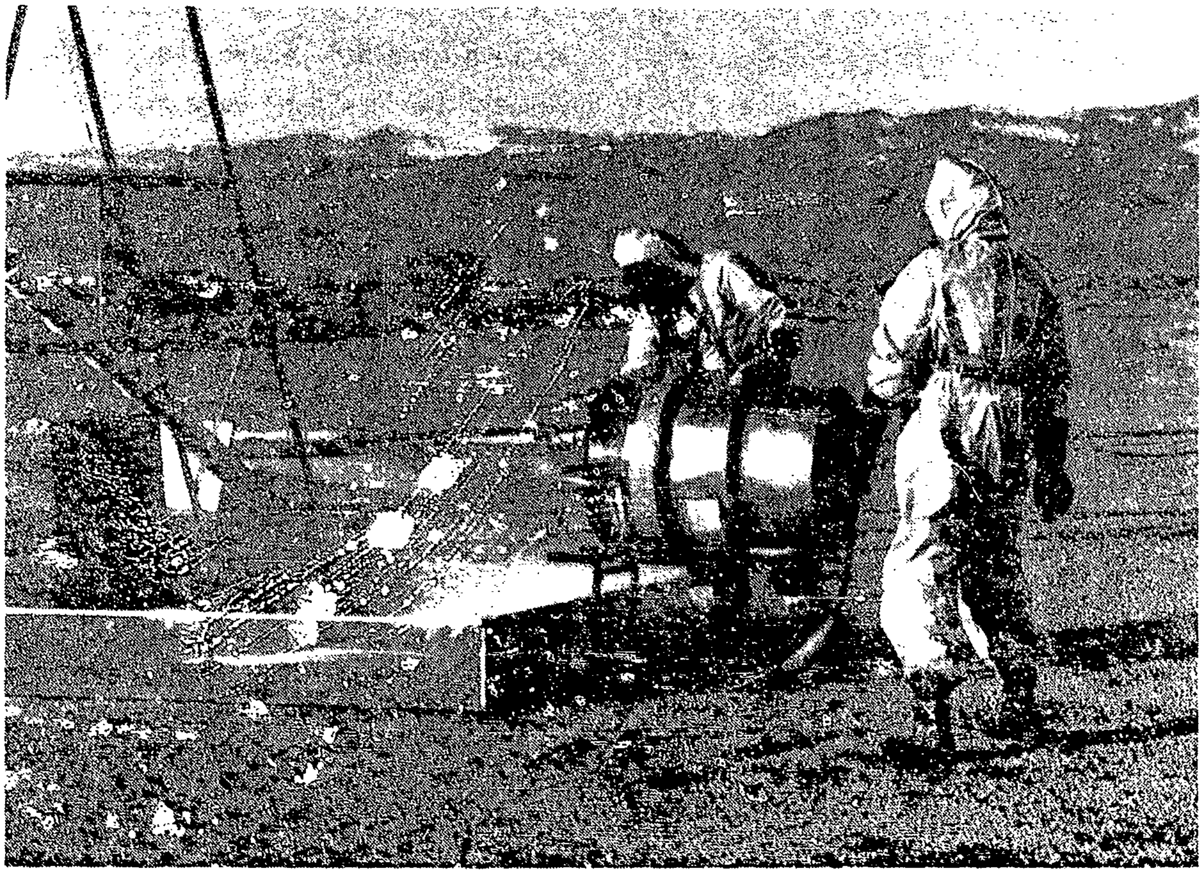

Figure 2. Manual Pour of MMH Directly into Burn Pan.

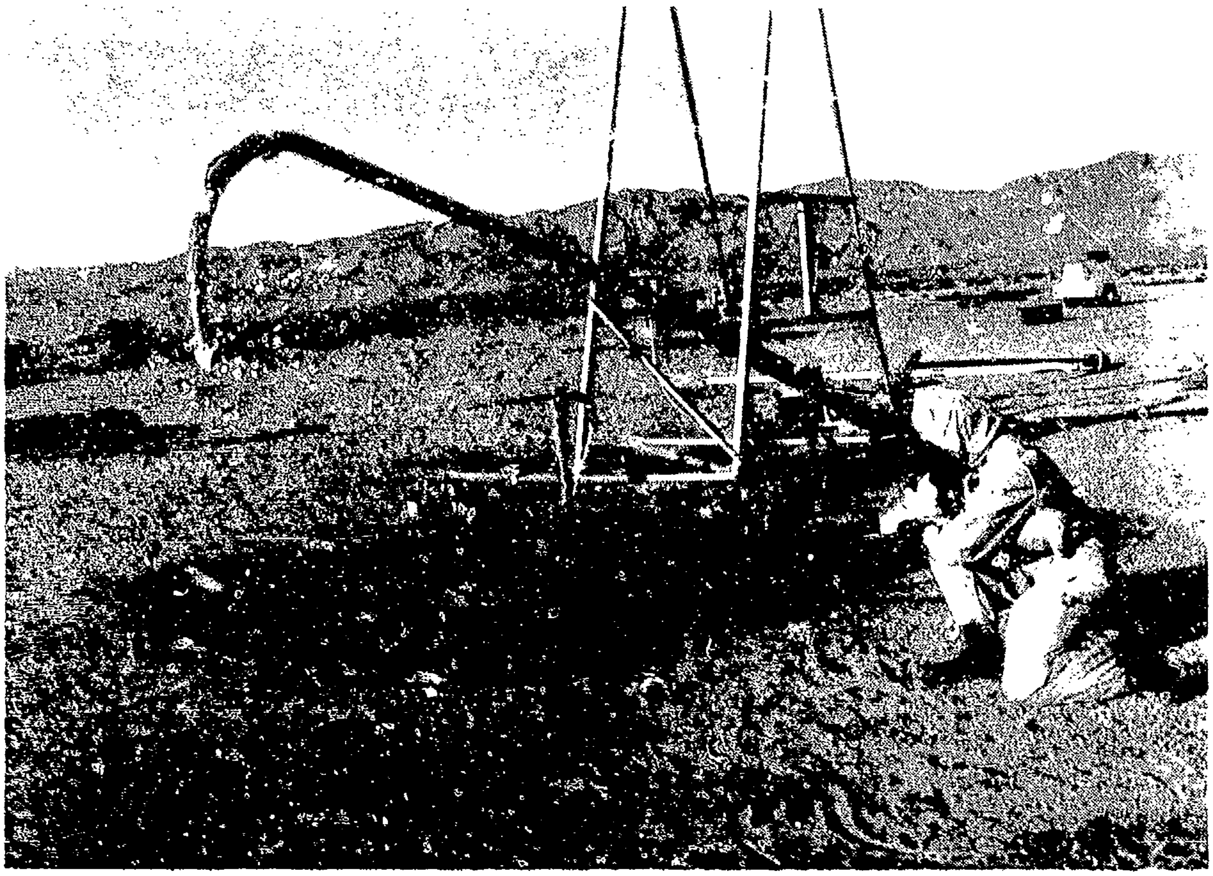

Figure 3. Manual Ignition of MMH.

Figure 4. Application of Low-Expansion Foam to Burning MMH.

Figure 5. Postextinguishment Removal of Foam from Burn Pan Before Final Burnoff.

personnel. All test start and completion times and safety matters were coordinated with the DOE onsite coordinators, Mr. Jim Baxter and Mr. Vince Iori, who also provided exceptional support. Fortunately, no schedule impacts resulted from conflicts with other ongoing tests at NTS. In addition to the weather constraints discussed above, a significant schedule factor was the fatigue on the part of the fuel and foam handlers. Particularly difficult was the movement and pouring of the 500-pound fuel drums while in full firefighting and protective breathing apparatus. It appeared that this amount of work levied on personnel under potentially explosive and toxic conditions would limit the number of tests to three tests per day. As expected, the efficiency of the testing team increased significantly as the test series progressed. This was clearly shown in the last 2 days of testing during which 6 tests were completed. As the comfort factor with the hazardous materials increased, it was extremely important to ensure that attention to safety details was maintained through the entire test series and that no safety incidents occurred.

2. April 1986 Test Series

a. Weather

Wind conditions and temperatures were generally as expected. Winds were usually from the south and southwest as predicted, averaging 6 to 12 mph on most days. However, winds as high as 21 mph with gusts to 37 mph were experienced. Testing under these conditions was minimized, but the wind was a factor in extending extinguishment times and adversely affecting the foam movement during the wood crib tests in the foam pen. The consistency of the wind direction greatly benefited the ease and safety of the N_2O_4 handling operations. Toward the end of the test period, higher temperatures produced earlier fatigue for personnel wearing protective suits and caused concern about the heat buildup of the fuel and in the metal pans. After a spontaneous ignition occurred on 28 April with Test C-15, (see Appendix F, Experimental Data, Test C-15) the pans were thoroughly cooled with water before and during the remaining tests with A-50. Overall, adverse weather only resulted in the loss of 1 day of testing over the 2 1/2-week period.

b. Equipment

Minor problems were encountered with the compressor and the forklift, but they caused no major impact on the test schedule. REECo's response to these problems was usually timely. It was determined to use the same pans as were used during the test series in November 1985. Generally the four unreinforced pans were used for the N_2O_4 tests while the two reinforced pans were used for the A-50 tests. The reinforced pans were repaired by REECo welders prior to use.

c. Procedures

The NMERI and MSA teams employed the same procedures as in the November 1985 test series. Fortunately, only minor schedule impacts resulted from conflicts with other ongoing tests at NTS.

D. FUEL AND OXIDIZER

The fuels used for this test series were anhydrous hydrazine (AH), monomethylhydrazine (MMH), unsymmetrical dimethylhydrazine (UDMH), and Aerozine 50 (A-50). The sole oxidizer used was N_2O_4. For most of the tests in this series, production fuels and oxidizers were used. Off-specification (off-spec) fuels, A-50, were used for the April 1986 fuel series. Off-spec fuels can be used for testing of this nature if fuel characteristics reasonably replicate production fuels. In no case, however, should the H_2O content be allowed to exceed 5 percent by weight.

Since this was a Government-sponsored program, NMERI was able to purchase the fuels from the San Antonio Air Logistics Center. The address is SA-ALC/SFRL, Kelly AFB, TX 78241. Contacts are Mr. Jack Paddie, Ms. Bea Hernandez, or Ms. Lucille Jordan at autovon 945-4877 or commercial (512) 925-4877. These people were extremely helpful in handling all fuel purchase and delivery actions. Under their program for production fuels, SA-ALC/SFRL either purchases the materials from a supplier or draws them from an existing Air Force stock pile and charges the customer a fixed price. Prices are revised quarterly. SA-ALC/SFRL also arranges for the shipping of the containers to and from the test site at no cost to the customer. This can be a very convenient arrangement for the customer, although production materials are expensive. A typical 55-gallon drum of fuel costs about $3000; whereas a 1-ton cylinder of N_2O_4 costs about $5,500. SA-ALC/SFRL personnel normally require that an order be placed 60 to 90 days before required delivery.

The use of off-spec materials presents problems of a different nature. SA-ALC/SFRL can normally locate a source of off-spec materials; but from that point forward, it is the customer's responsibility to negotiate and finance all arrangements. This entails a myriad of contacts, scheduling details and uncertainties. Attempts to obtain off-spec MMH for the November test series were not successful due to problems negotiating costs and liability issues within the tight time constraints placed on this first test series. Off-spec A-50 was obtained for the April test series. This was made possible largely because: (a) NMERI had acquired more knowledge of the fuel supplier community, (b) SA-ALC/SFRL personnel provided exceptionally good directions and guidance, and (c) the companies possessing the off-spec fuels were extremely cooperative. Thus, the fuels were obtained for the costs of handling and transportation only. This, by far, constitutes the best means of obtaining the material for test purposes if the necessary lead time is available.

SECTION IV
TEST RESULTS

A. NOVEMBER 1985 TEST SERIES

The series of fire tests conducted in November 1985 focused on the ability of acrylate-modified vapor suppression foam to extinguish burning hydrazine. Both high- and low-expansion foams were applied to 50.0 ft^2 and 52.5 ft^2 fires in square pans. The hydrazine fuels used were MMH, AH, and UDMH. Hydrazine fuels burn with very little visible flame. Flame visibility is lowest in AH fires, followed by MMH and UDMH, in that order. This generally made exact fire extinguishment times difficult to ascertain. Since the pan corners were the last portions of the flame to be extinguished, the continuity of the foam cover within the corners was normally a reliable measure of extinguishment. An IR camera, loaned to NMERI by the Naval Research Laboratory, was used during some tests, but it was difficult to distinguish the flame from the heated pan in the corner areas through the IR lens. The fire test procedures followed the Underwriters Laboratories (UL) Standard 162 (Reference 6) procedure for low-expansion foam and National Fire Protection Association (NFPA) 11A (Reference 7) for high-expansion foam. MSAR officials contributed to the test result data described below.

In addition to fire extinguishment timing tests using the low-expansion foam, wand and stovepipe tests were conducted. The wand test (Figure 6), as described in UL 162, Section 18.18-18.19, is performed after 5 minutes of foam application (provided extinguishment of the fire is achieved) by passing a lighted torch approximately 1 inch above the entire foam blanket for a specified amount of time. This specified time is 9 minutes for AFFF and 15 minutes for protein, fluoroprotein and synthetic concentrate foams. To pass the wand test, the fuel must not ignite within the time allotted unless it is able to self-extinguish in 30 seconds or less. The stovepipe test (Figure 7), which was performed directly following the wand test, is also outlined in UL 162, Section 18.20-18.21. This test involves placing a stovepipe of 12-inch diameter into the foam blanket. This pipe must be of sufficient height to protrude above the foam blanket by approximately 4 inches. The stovepipe must be placed about 2.5 feet from each of two adjacent sides of the test pan with as little disturbance to the foam blanket as possible. The portion of foam

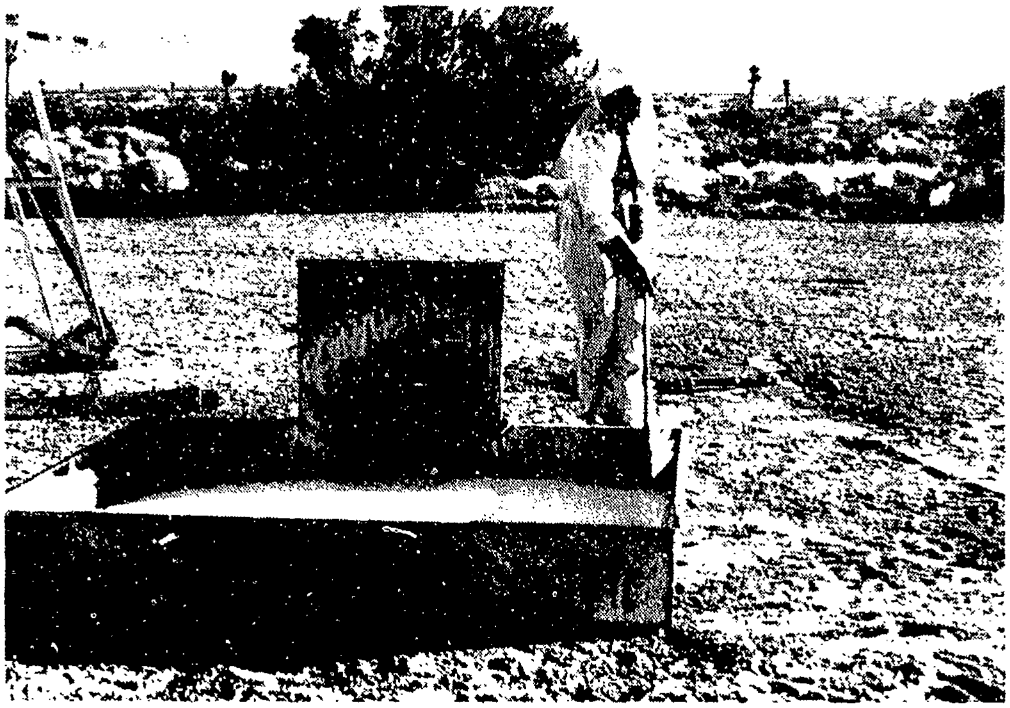

Figure 6. Wand Test.

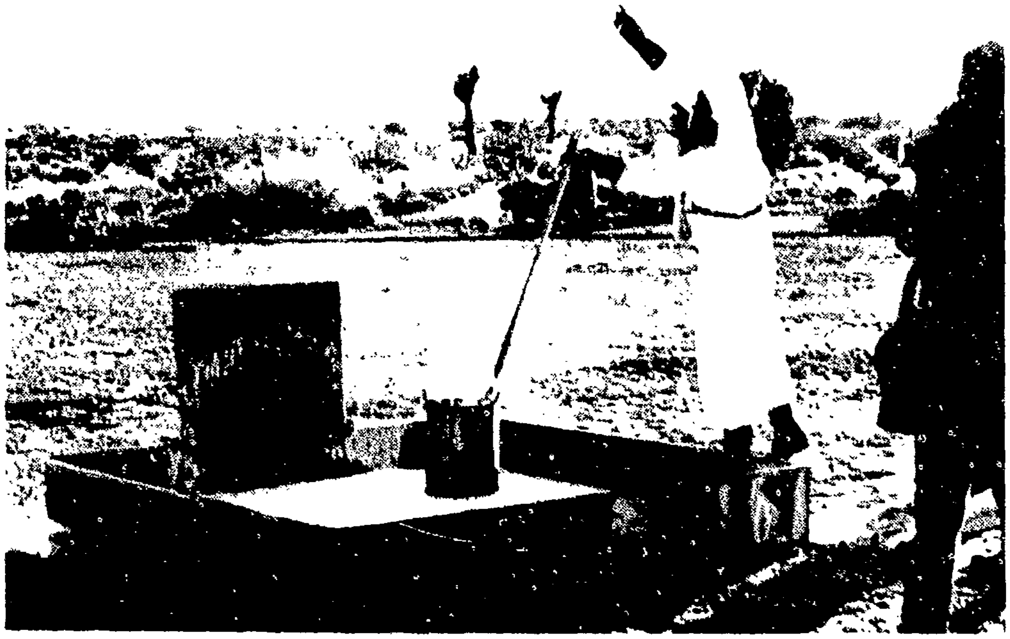

Figure 7. Stovepipe Test.

inside the stovepipe is removed, and the fuel within is ignited. The fuel is allowed to burn for 1 minute and the stovepipe is then slowly removed. The test is considered successful if (1) the foam blanket is able to restrict the spread of fire to an area of 10 ft^2 for 5 minutes, or (2) the foam is able to flow and cover the burning area. The wand and stovepipe tests are used for low-expansion foam only. Individual test descriptions and results are contained in Appendix F.

The basic fire sequences were conducted using MMH. The foam application used, described in UL 162, Section 18.12-18.13, involves positioning the nozzle so that the foam is directed across the pan, at an angle above the horizontal so as to strike a backboard on the opposite side of the pan (Figure 4). This method of application was used for all fire tests except the tests which used the AFFF flared nozzle, and foam application in accordance with MIL-F-24385C. Extinguishment times were obtained for different application rates. The data were plotted with foam application rate versus extinguishment time, and a typical curve for flammable liquid was fit to these points (Reference 2). Minimum application rate and design rate are defined using this curve (Figure 8). This is accomplished by drawing a tangent line to the vertical portion of the curve and extending this line to the abscissa. The point of intersection with the abscissa is defined as the minimum application rate. The design rate is then determined by drawing a second tangent to the horizontal portion of the curve, and extending a vertical line down to the abscissa from the tangent point. This point of intersection with the abscissa is the design rate. The calculated design rate of application for MMH was then used for AH and UDMH fires. These rates were also applied on MMH fires with obstructions and rusty metal present in the burn pan. Additional MMH fires were extinguished with commercial Aqueous Film-Forming Foam (AFFF) and Alcohol-Resistant Concentrate (ARC) foams. Finally, the acrylate-modified foam was tested using the calculated design rate with heptane and leaded gasoline fires.

1. Monomethylhydrazine

a. High-Expansion Foam

The high-expansion foam was generated at a nominal 160:1 expansion ratio. MMH Fire Tests A-9, A-10, and A-8 were conducted with

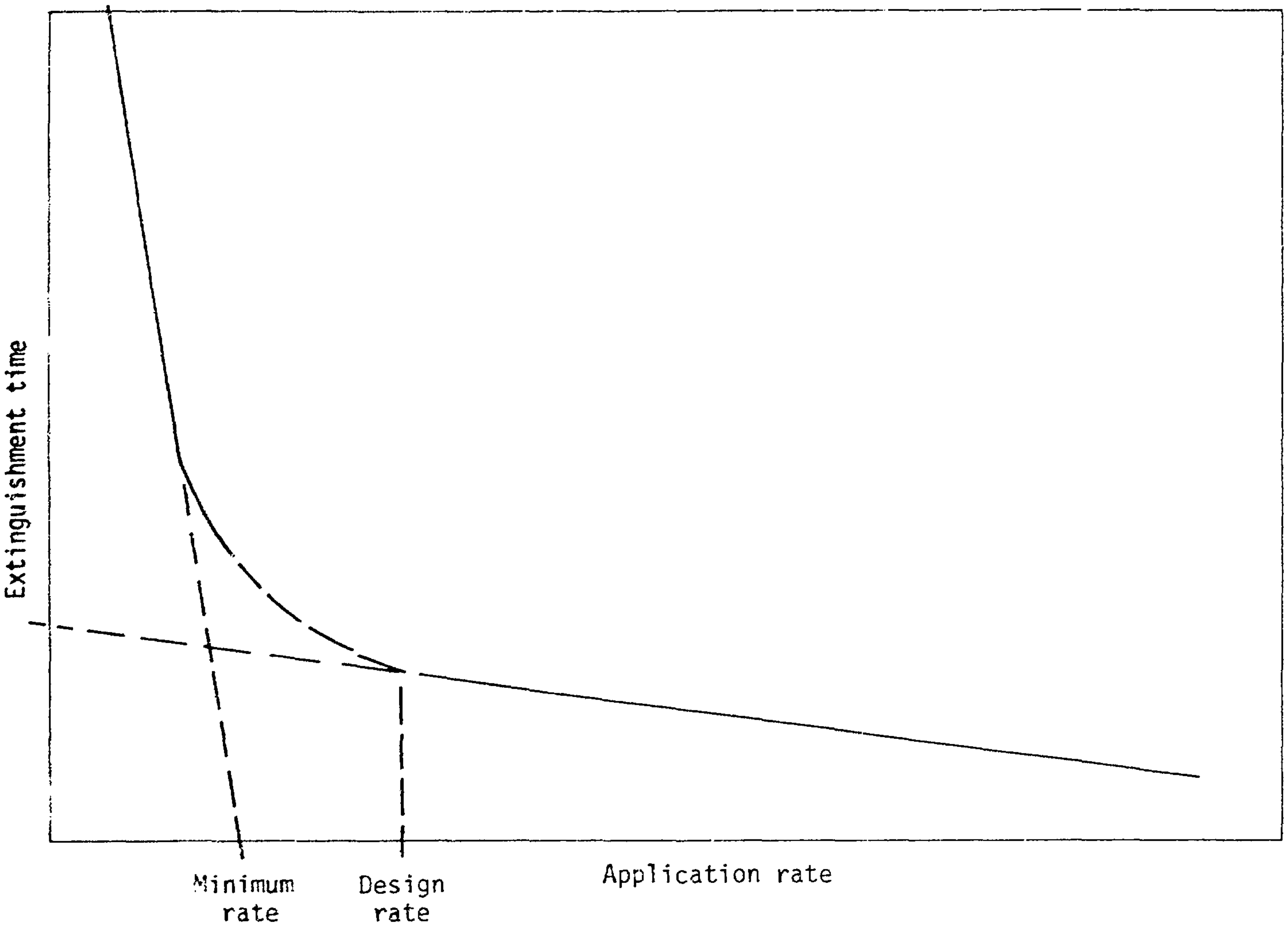

Figure 8. Typical Curve for Fire Extinguishment Versus Foam Application Rate.

application rates of 24 ft^3/min, 55 ft^3/min, and 118 ft^3/min, respectively. Tests A-9 and A-10 yielded no extinguishment, whereas Test A-8 produced extinguishment in 1 minute 1 second. The data was plotted in Figure 9 and a design rate of 79 ft^3/min for the 52.5 ft^2 fire, or 1.5 $ft^3/min/ft^2$ was established. A minimum application rate of 70 ft^3/min was also determined from the curve. At the design rate, the extinguishment time was 1 minute 15 seconds (Test A-16).

Test E-16/F-16 (Figure 10) was conducted to assess the ability of the foam to flow around obstacles and control fires where hot metal was present as a reignition source. The obstruction used was a 30-gallon rusted steel drum placed upright in the center of the fire pan. About 10 pounds of rusted scrap steel was wired together and placed beside the drum. This fire was extinguished in 39 seconds at the established design rate of 79 ft^3/min. When the reduced fire surface (caused by the presence of the drum) is considered, this time is consistent with data obtained for fires without obstacles. There was no evidence that the obstacles or hot metal interfered with the flow of the foam or the extinguishment of the fire. The data for the high-expansion fire tests are presented in Table 3. The obstruction test data are also plotted in Figure 9.

b. Low-Expansion Foam

Low-expansion foam had a nominal expansion of 8:1. The low-expansion tests on MMH fires employed initial application rates of 2 gal/min, 3 gal/min, and 6 gal/min. No extinguishment resulted in Test A-2 with an application rate of 2 gal/min. Test A-3, application rate of 3 gal/min, produced extinguishment in 2 minutes 13 seconds; and A-15, 6 gal/min application rate, extinguished the fire in 1 minute 12 seconds. The design rate for MMH fires using the low-expansion foam was estimated from the plotted curve in Figure 11 to be 4 gal/ min, or 0.076 $gal/min/ft^2$. Extinguishment time at this rate was 1 minute 18 seconds (Test A-1), slightly greater than the extinguishment time for the high-expansion foam using the calculated design rate.

The obstruction test, using MMH as the fuel (Test E-15/F-15), was conducted in the same manner as with the high-expansion foam obstruction test. The application rate used was 4 gal/min; at this rate the fire was

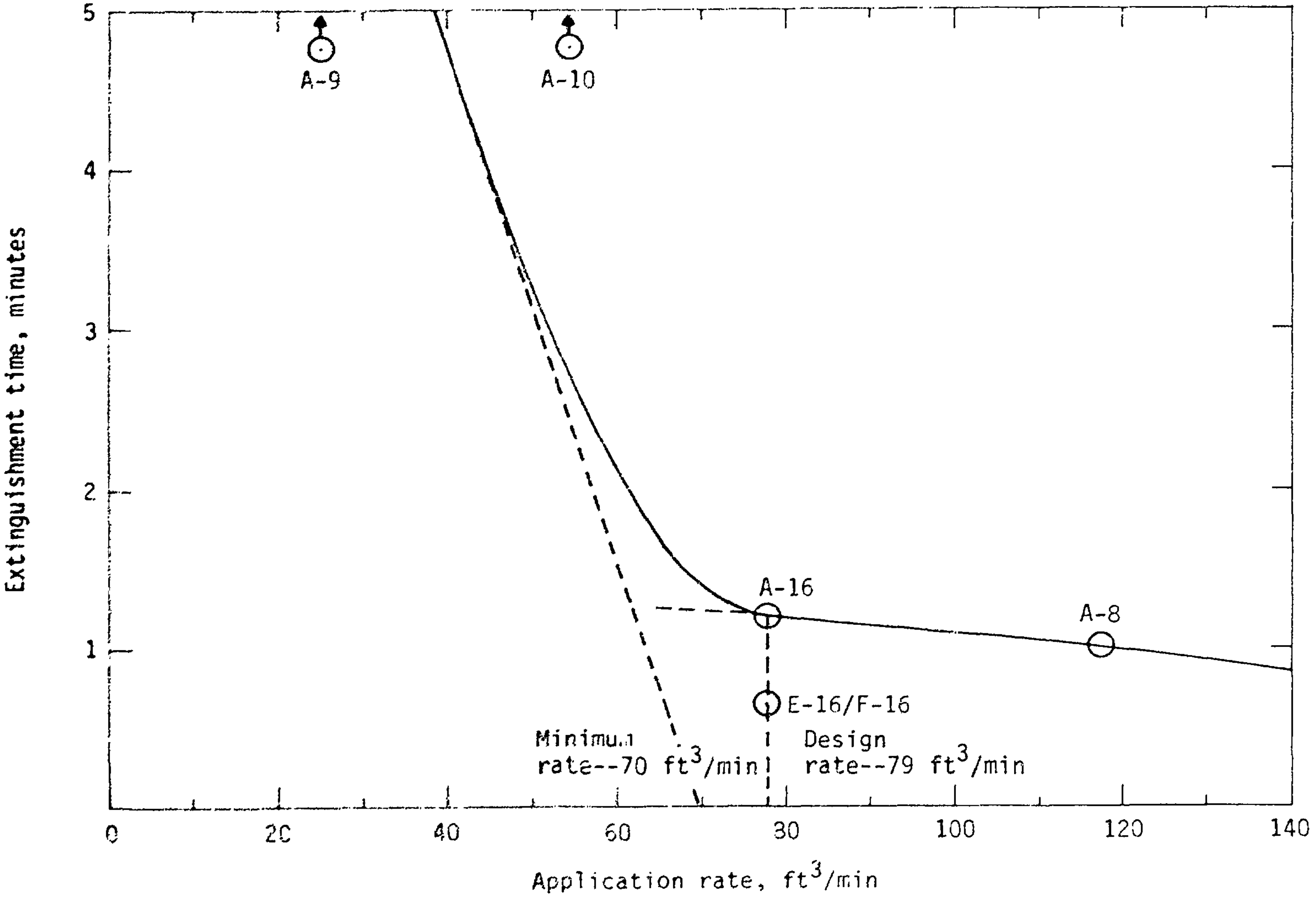

Figure 9. Application Rate Versus Extinguishment Time for Acrylic-Modified High-Expansion Foam--MMH Fuel.

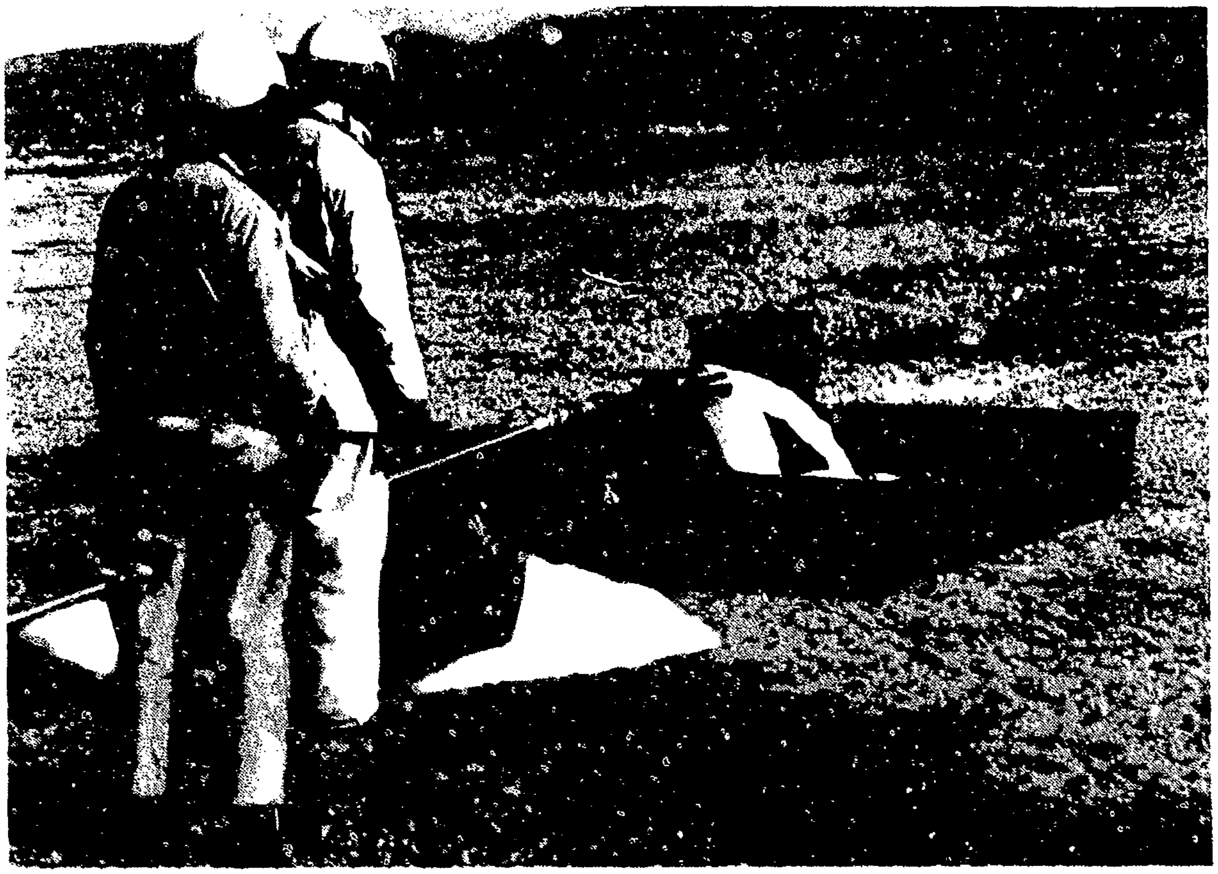

Figure 10. High-Expansion Foam with Obstruction and Rusty Metal.

TABLE 3. HIGH-EXPANSION ACRYLIC-MODIFIED FOAM TESTS.

Test no.	Date	Fuel		Fire size (ft^2)	Application rate (ft^3/min)	Extinguishment time (min-s)
		Type	Quantity (gal)			
A-8	11/17	MMH	55	52.5	118	1-01
A-9	11/18	MMH	30	52.5	24	Failed
A-10	11/18	MMH	55	52.5	55	Failed
A-16	11/19	MMH	55	52.5	79	1-15
D-16	11/20	AH	55	50.0	79	0-45
B-16	11/20	UDMH	55	50.0	79	6-30
E-16/F-16	11/22	MMH	55	50.0	79	0-39
N-30	11/24	Heptane	55	50.0	79	1-35

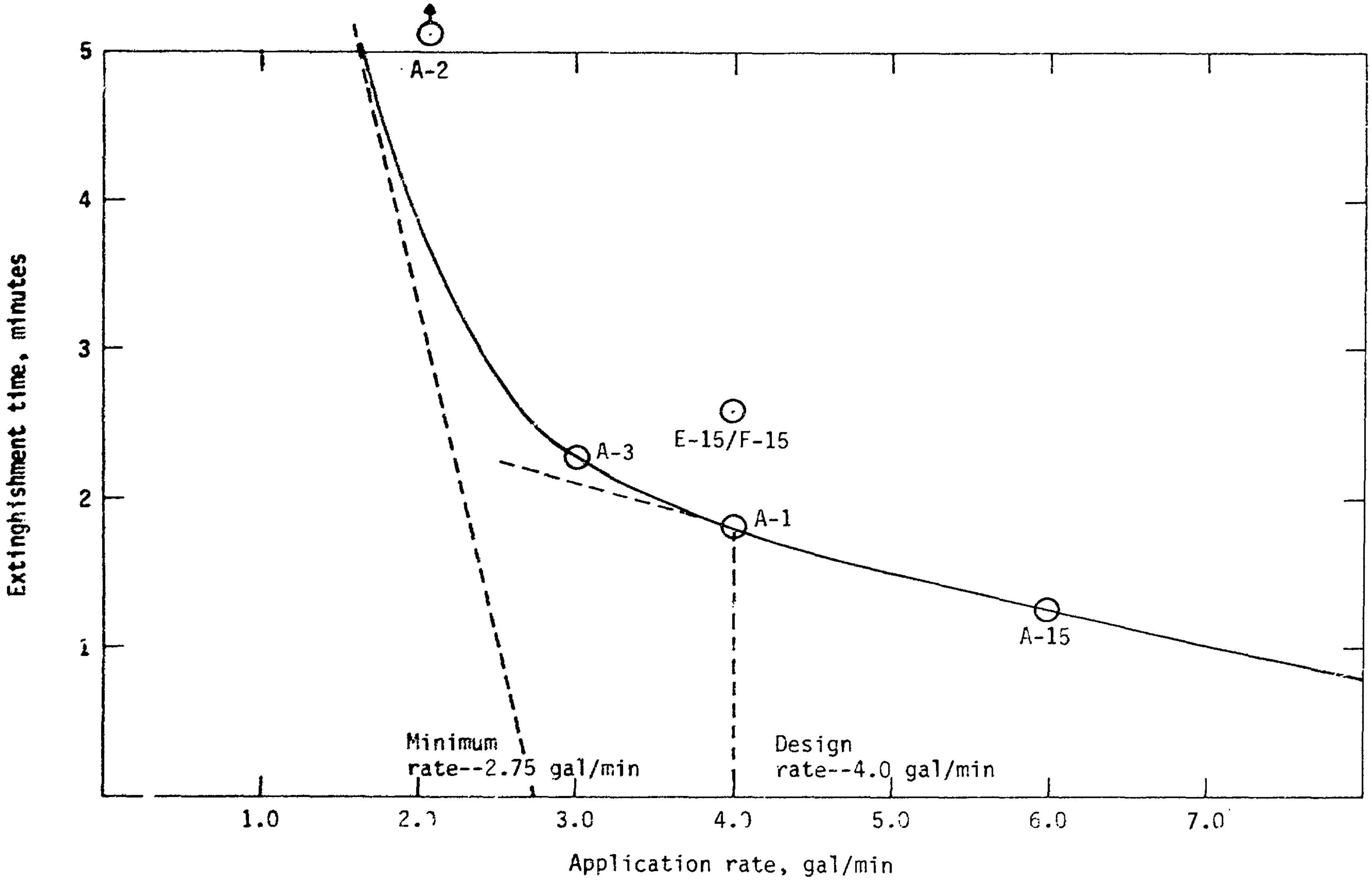

Figure 11. Application Rate Versus Extinguishment Time for Acrylic-Modified Low-Expansion Foam--MMH Fuel.

extinguished in 2 minutes 20 seconds. With low-expansion foam, the presence of the drum slows the extinguishment process because it is more difficult for the low-expansion foam to flow around the drum to reach the rear area of the pan. In all low-expansion tests the wand test was passed. The stovepipe tests were also passed, all in less than 10 seconds. The data for the low-expansion tests is given in Table 4. The obstruction test is plotted in Figure 11.

c. MIL-F-24385-C Tests

The low-expansion test utilized in certifying foams for Department of Defense (DOD) use, employs a round pan of 28 ft^2, a foam discharge of 2 gal/ min, a flared-foam pattern and a plunging-type application. The plunging-type application, described in UL standard 162, section 18.14, involves striking the fuel surface near the opposite side of the test pan with the nozzle at an angle slightly above horizontal. This test was conducted on a MMH fire (Test A-1A) using the acrylic-modified foam. Neither fire extinguishment nor control was achieved during the 5-minute time limit. This was expected since the plunging-type application is generally not suitable for water-miscible fuels. Data for this test are presented in Table 5.

d. Commercial Foam Agents, Low Expansion

Three fire tests were conducted using the commercial foam agents, Ansulite Alcohol-Resistant Concentrate (ARC), and Ansulite AFFF supplied by the Air Force. All tests were conducted in the 50 ft^2 pan using 55 gallons of MMH and a 1-minute preburn.

The ARC (6 percent) was tested at application rates of 4 gal/min for Test A-24-2 and 6 gal/min for Test A-24-1. These MMH fires were extinguished in 4 minutes 30 seconds and 1 minute 15 seconds, respectively. In both cases, the foam passed the wand tests and the stovepipe tests. For Test A-24-1, extinguishment was immediate once the stovepipe was removed. For Test A-24-2, the stovepipe test fire was not extinguished. The fire increased in size slowly but met the UL 162, Section 18.21, criteria of less than 10 ft^2 increase in 5 minutes. The ARC foams broke down more rapidly than the acrylic-modified foams once the fire was extinguished. These data are consistent with prior data for spill control where commercial ARC foams were able to control the vapor but exhibited much shorter control times.

TABLE 4. LOW-EXPANSION ACRYLIC-MODIFIED FOAM TESTS.

Test no.	Date	Fuel		Fire size (ft^2)	Application rate (gal/min)	Extinguishment time (min-s)	Comments
		Type	Quantity (gal)				
A-1	11/13	MMH	55	52.5	4	1-18	Design rate
A-2	11/14	MMH	55	52.5	2	Failed	
A-3	11/14	MMH	55	52.5	3	2-13	
A-15	11/17	MMH	55	52.5	6	1-12	
D-15	11/19	AH	55	50.0	4	1-12	
B-15	11/21	UMDH	55	50.0	4	Failed	
E-15/F-15	11/22	MMH	55	50.0	4	2.20	Obstructed test
N-19	11/24	Heptane	55	50.0	4	2-57	

TABLE 5. MIL-F-24385C AND COMMERCIAL LOW-EXPANSION FOAM TESTS.

Test no.	Date	Fuel		Fire size (ft^2)	Pan shape	Application rate (gal/min)	Foam type	Extinguishment time (min-s)	Comments
		Type	Quantity (gal)						
A-1A	11/20	MMH	25	28	Round	2	Acrylic	Failed	Plunging application
A-1B	11/24	Gasoline	25	28	Round	2	Acrylic	Failed	Plunging application
A-24-2	11/21	MMH	55	50	Square	4	ARC 6%	4-0	
A-24-1	11/21	MMH	55	50	Square	6	ARC 6%	1-15	
A-23	11/22	MMY	55	50	Square	6	AFFF 6%	2-51	

AFFF (6 percent) discharged at 6 gal/min, Test A-23, extinguished the MMH fire in 2 minutes 51 seconds and passed the wand test. In the stovepipe test, the fire increased in size but met the criteria of a maximum of 10 ft^2 increase in 5 minutes. This foam exhibited less stability over the MMH than the other agents tested. The data from the ARC and AFFF tests are also presented in Table 5.

2. Other Fuels--AH, UDMH, Heptane, and Gasoline

a. High-Expansion Foam

This series of tests was conducted in the same manner as tests using MMH fuel. The high-expansion foam was generated at a rate of 160:1. Using the design rate of 79 ft^2/min calculated for MMH, AH (Test D-16), and heptane (Test N-30), fires were extinguished at 45 seconds and 1 minute 35 seconds, respectively. UDMH (Test B-16) could not be extinguished in the 5-minute time limit established in UL 162, Section 17.19, using the calculated design rate. At the design rate, extinguishment required an application time of 6 minutes 30 seconds. The higher vapor pressure of UDMH is considered to be the reason for the more severe extinguishment requirements. This data is presented in Table 3. Figure 12 shows the MMH curve with extinguishment times for AH, heptane, and UDMH also shown on this curve.

b. Low-Expansion Foam

The expansion rate used for these tests was 8:1, as was used for the MMH fire tests. The calculated design rate of application for MMH, 4 gal/min, was employed for these tests. The AH fire (Test D-15) gave extinguishment in 1 minute 12 seconds, similar to the time for high-expansion foam. The heptane fire (Test N-29) was extinguished in 2 minutes 57 seconds. This extinguishment time was expected because the acrylic-modified foam does not produce an effective gel when placed in contact with heptane. Therefore, extinguishment of heptane fires takes longer than hydrazine fires where an effective gel is formed.

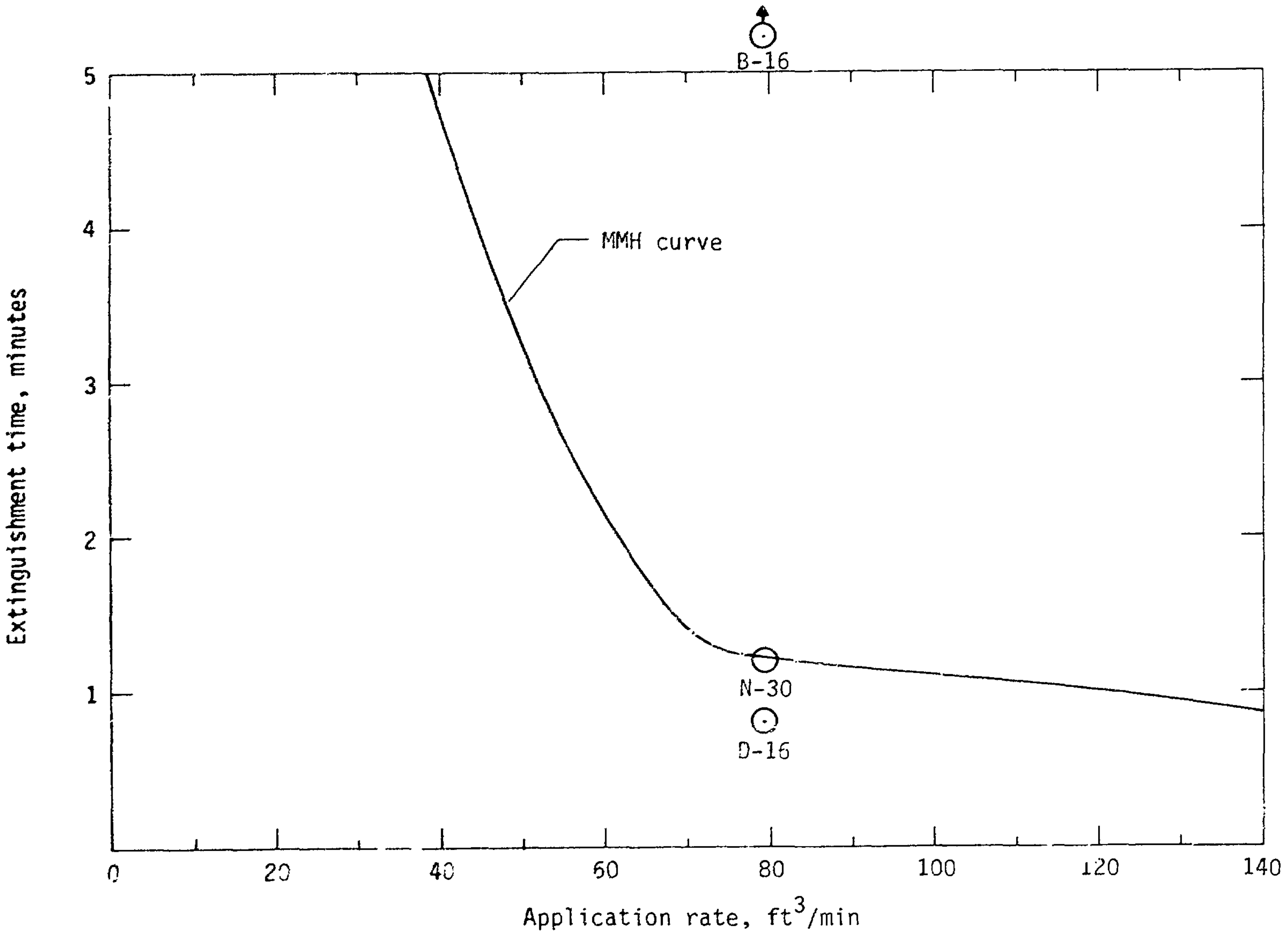

Figure 12. Additional High-Expansion Foam Tests Referenced to MMH Data.

The low-expansion foam failed to extinguish the UDMH fire (Test B-15) at the calculated design rate. After 5 minutes of discharge, less than half of the fire was covered with foam, and flame was visibly burning through the foam. This differed from the high-expansion foam application used with UDMH fires (Test B-16), where the only effect was the extension of the extinguishment time. Given the results of Tests B-15 and B-16, it was decided that a complete test series on A-50 should be run when testing resumes in April 1986. This will involve a three-test design set for both low- and high-expansion foams. These tests are deemed necessary because A-50 is 50 percent UDMH and is a widely used fuel. In all cases where the low-expansion foam produced extinguishment, the stovepipe and wand tests were passed. In all stovepipe tests, the fire was completely extinguished in 10 seconds or less once the stovepipe was removed. The test data with low-expansion foam are presented in Table 4. Figure 13 gives an overlay of the additional fire tests on the MMH curve.

c. MIL-F-24385C Tests

A second test (Test A-1B) of this type was conducted with the acrylic-modified foam using leaded gasoline as the fuel. The procedure used for this test was the same as was used for the previous MMH MIL-F-24385C tests. Control for this fire was achieved in 3 minutes, although there was no extinguishment. At the end of 5 minutes, significant flame was still present at the edge of the pan opposite the point of foam impact. Like the previous heptane tests, no gel formed with the gasoline; therefore, efficiency of the foam was impaired. The data from this test are presented in Table 5.

B. APRIL 1986 TEST SERIES

In April 1986, the program was resumed to complete the unfinished tests. Five test sequences were conducted. Two of the sequences involved A-50, a hydrazine-based propellant consisting of a 50-50 mixture of AH and UDMH. The other three sequences involved N_2O_4 supported fires. Individual test descriptions and results are contained in Appendix F. MSAR officials contributed to the following test result data.

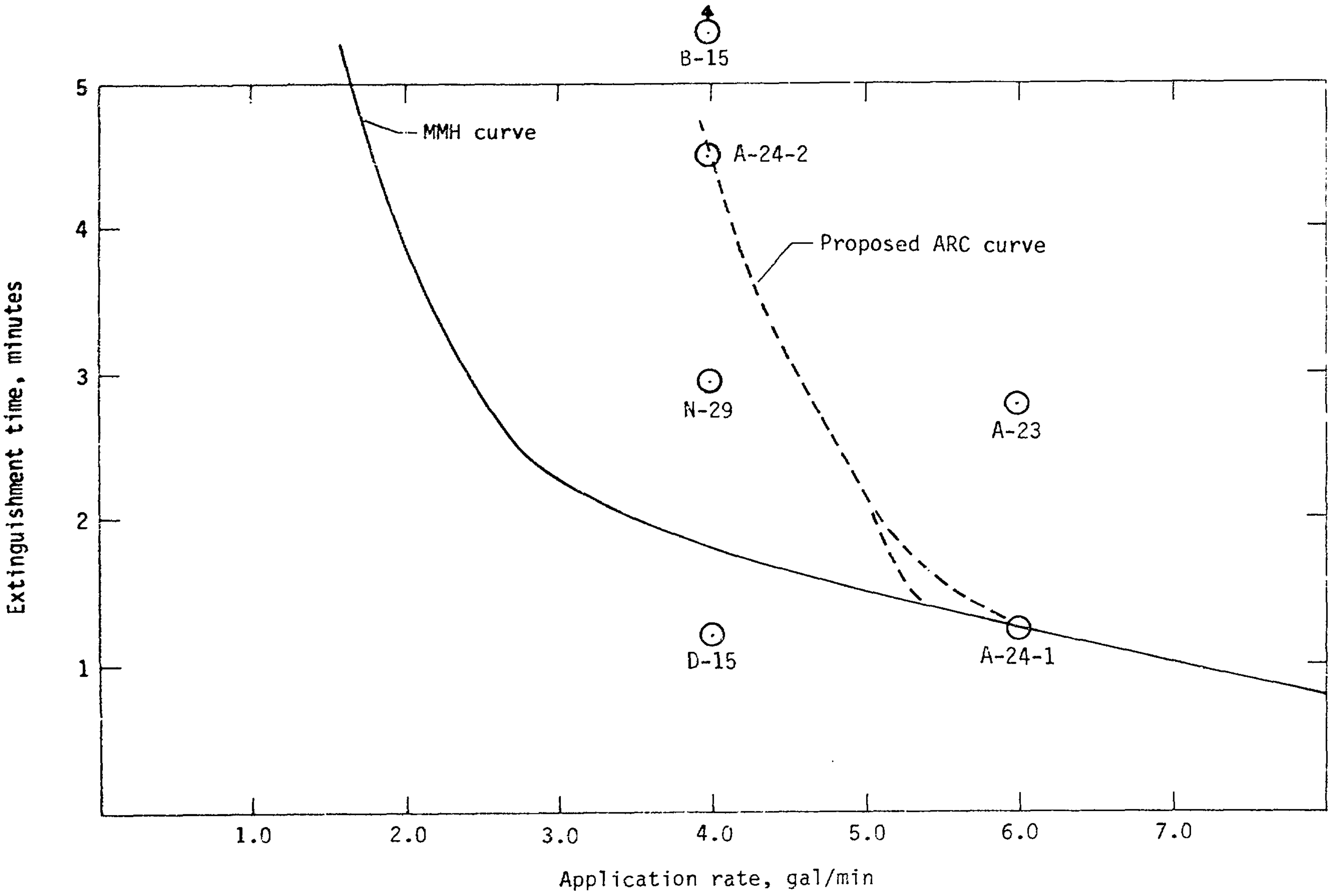

Figure 13. Additional Low-Expansion Foam Tests Referenced to MMH Data.

1. Aerozine 50 Fire Tests

The A-50 tests were conducted in the same manner as the previous hydrazine test fires. Before the tests, the question was raised as to whether the UDMH would burn off preferentially. The data obtained from the A-50 fires does not indicate any preferential burnoff of UDMH. It appears that because of UDMH, which increases volatility and reactivity, A-50 fires were more intense than those of AH or MMH, but less intense than those of UDMH.

a. High-Expansion Foam

A-50 was tested with high-expansion foam at 3 different application rates in a 50 ft^2 pan. Test A-18 with an application rate of 55 ft^3/min resulted in no extinguishment. Test C-16, using an application rate of 79 ft^3/min, and Test C-16A using 118 ft^3/min, resulted in extinguishment in 3 minutes 30 seconds and 2 minutes 15 seconds, respectively. One additional test was conducted at 173 ft^3/min, Test C-16B, which gave extinguishment in 1 minute. This high-expansion test data is plotted in Figure 14. Interpreting the high-expansion data gives a minimum foam application rate of 115 ft^3/min and a design rate of 150 ft^3/min or 3 ft^3/min/ft^2. Data from these tests are presented in Table 6.

b. Low-Expansion Foam

Results of low-expansion foam tests were obtained for application rates of 5, 6, and 9 gal/min in Tests C-15, C-15A, and C-15B, respectively. Test C-15 resulted in extinguishment in 3 minutes 55 seconds, whereas Test C-15A was extinguished in 3 minutes and 30 seconds. The shortest extinguishment time of 1 minute 8 seconds was obtained for Test C-15B. Plotting this data, control and extinguishment times yield the curve in Figure 15. The analysis of the low-expansion extinguishment data gives an estimated minimum application rate of 7.5 gal/min and an approximate design rate of 9.0 gal/min, or 0.18 gal/min/ft^2. The deviation of the UDMH data point (obtained from Test B-16) from the A-50 curve is not as pronounced for low-expansion foam as it is for the high-expansion foam. In the analysis of the

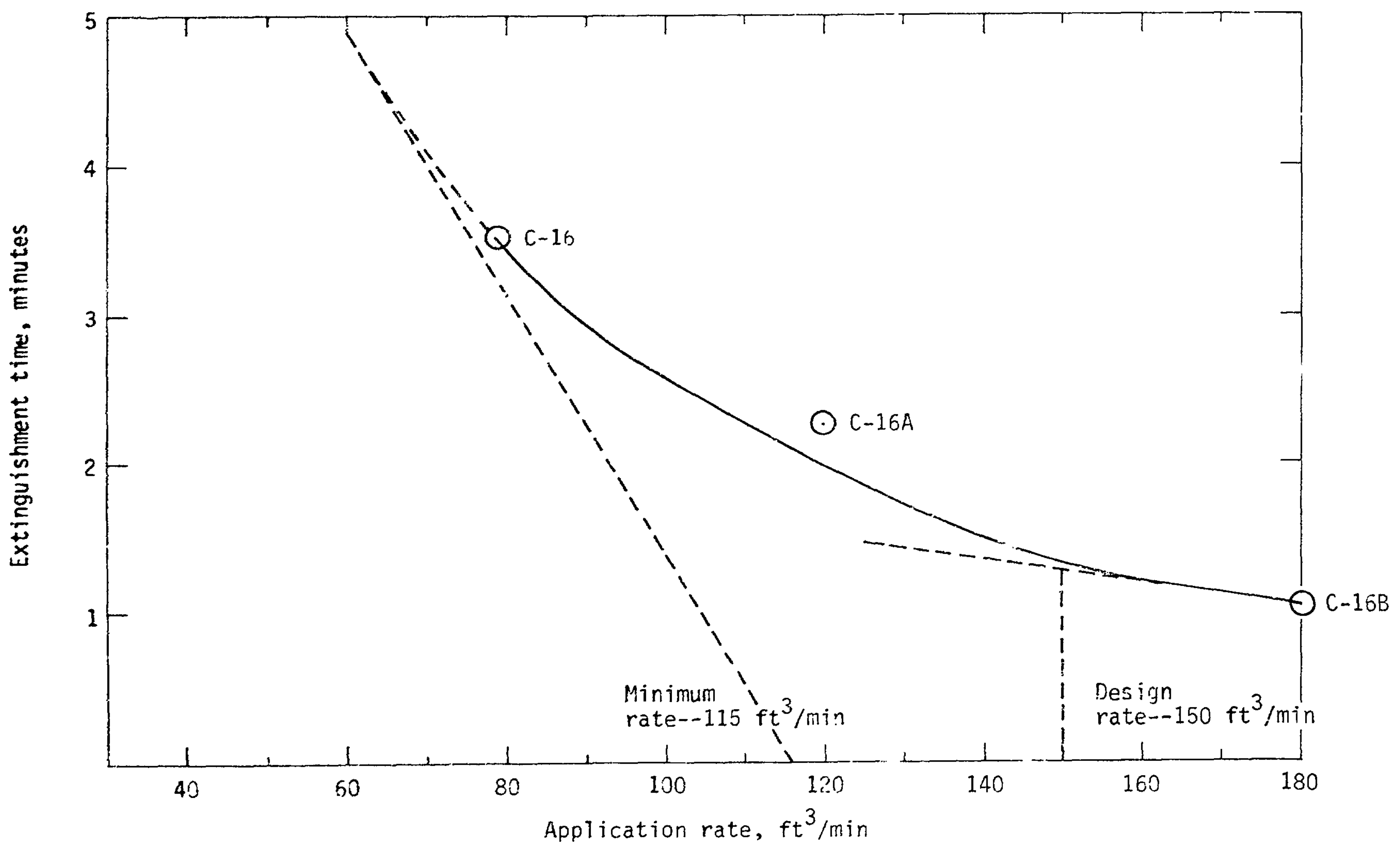

Figure 14. Application Rate Versus Extinguishment Time for Acrylic-Modified High-Expansion Foam--A-50 Fuel.

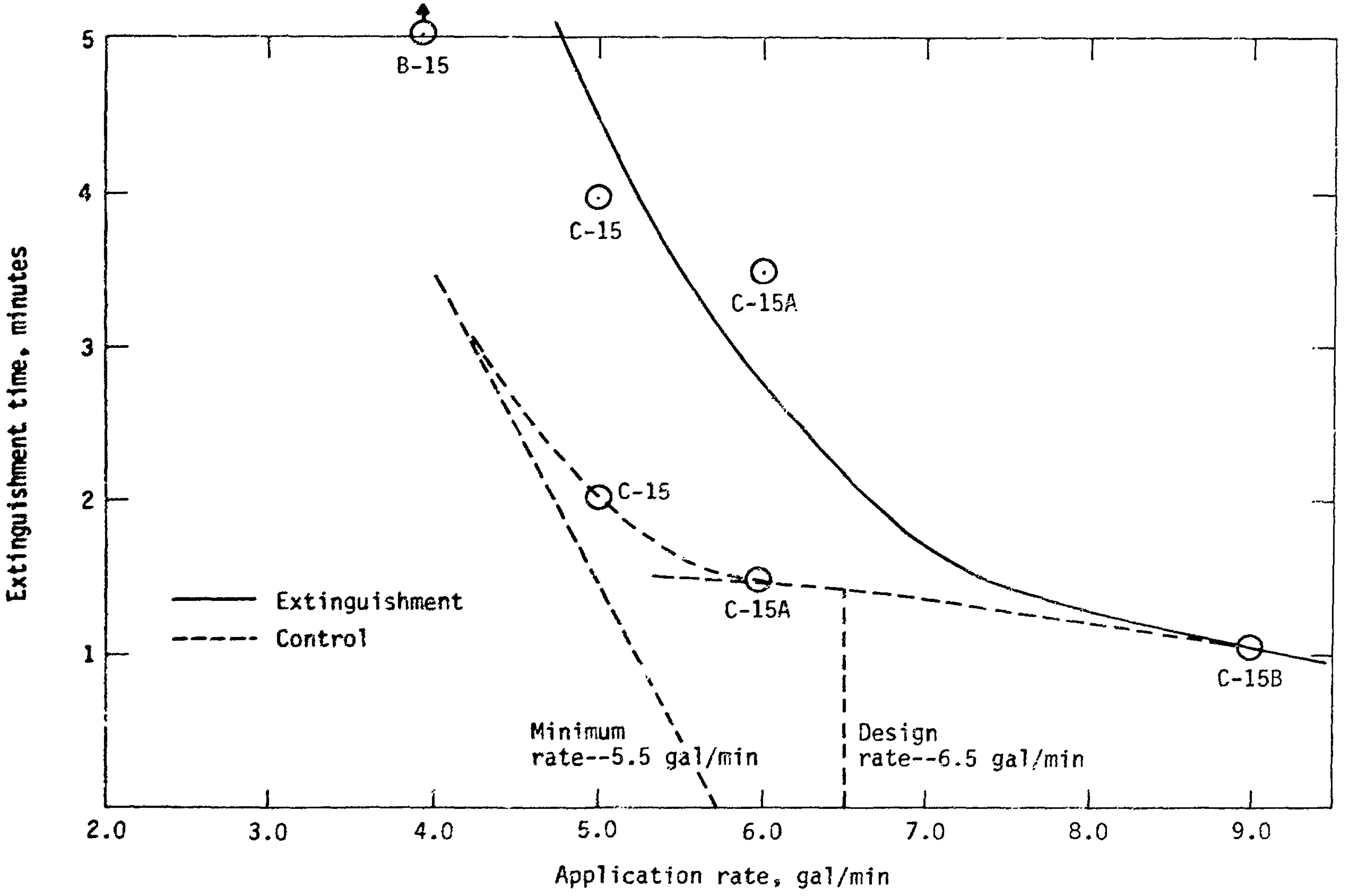

Figure 15. Application Rate Versus Extinguishment Time for Acrylic-Modified Low-Expansion Foam--A-50 Fuel.

TABLE 6. HIGH-EXPANSION FOAM TESTS--A-50 IN 50 FT^2 PAN.

Test no.	Date	Fuel quantity (gal)	Application rate (ft^3/min)	Extinguishment time (min-s)
C-16	4/17	55	79	3-30
C-16A	4/17	55	118	2-15
C-16B	4/28	55	173	1-0

low-expansion tests, at lower application rates there is a large difference between control and extinguishment times. This time difference is due to an abnormally long time to extinguish the final vestige of burning in the corners. If the UDMH data point is compared to this control time curve, knowing that no control was achieved in 5 minutes at 4 gal/min, UDMH is seen to be significantly more difficult to extinguish and control than A-50.

While additional data will define application rates more accurately than those derived above, it is felt that the curves for control time more nearly typify significant fire data in this case than do the curves defined by the extinguishment times. The same method can be used to define design rate and minimum rate for control time as is used with the extinguishment curve. Analysis of the control time curve gives minimum rate of 5.5 gal/min and a design rate of 6.5 gal/min or 0.13 gal/min/ft^2. The data for these tests is given in Table 7.

2. Nitrogen Tetroxide Supported Fire Tests

Nitrogen tetroxide (N_2O_4) is not flammable of itself; but being a strong oxidizer, it will intensify the burning of combustibles. The basic objective of this test series was to evaluate the ability of the acrylate-modified foams to control and extinguish fires involving N_2O_4. In the course of the tests, data were obtained on the effect of the high oxygen content of the nitrogen tetroxide on the burning rate and fire intensity.

TABLE 7. LOW-EXPANSION FOAM TESTS--A-50 IN 50 FT^2 PAN.

Test no.	Date	Fuel quantity (gal)	Application rate (ft^3/min)	Extinguishment time (min-s)	Comments
C-15	4/28	45	5	3-55	Fire out except for corners in 1 minute 57 seconds.
C-15A	4/26	55	6	3-30	Fire out except for corners in 1 minute 30 seconds.
C-15B	4/26	55	9	1-08	

In addition to the concern for the influences of N_2O_4 on the fire itself, questions also existed regarding the potential for spontaneous ignition. Such ignition could be due to contact of the oxidizer with combustibles, and long-term contact of organics with the oxidizer to form compounds such as nitrates which could increase flammability or other hazard potentials of the mixtures. A wide measure of these possibilities was inherently included in the test program. Individual test descriptions are contained in Appendix F.

a. Nitrogen Tetroxide and Flammable Liquids

Diesel fuel was selected as the flammable liquid to be used in these tests. Like all of the hydrazine tests, the basic fire tests were predicated on UL Standard 162. Prior testing has established that only high-expansion foam effectively controls N_2O_4 vapors. This is mainly because high-expansion foam has less water than low-expansion foam. The low-expansion foam contains 20 times as much water per volumetric measure as does the high-expansion foam. This amount of water makes the N_2O_4 increasingly more volatile and prohibits an effective gelling of the foam blanket. For this reason only high-expansion foam was tested for fire control of N_2O_4 supported combustibles.

Tests were run with 30 gallons of diesel fuel charged directly into the 50 ft^2 test pan. Normally hydrocarbons are floated on water for fire testing, but this is not acceptable with N_2O_4 because it reacts violently with water. An equal amount of N_2O_4 and diesel fuel was charged into the pan. Nitrogen tetroxide is heavier than diesel fuel and sinks to the bottom of the pan. As it boils through the fuel, it causes a bubbling and frothing which is the same color as the diesel and N_2O_4 mixture. The frothing was fairly vigorous early in the N_2O_4 discharge but slowed and localized with time. It was discovered during these tests that the fuel could not be ignited by applying flame to the froth areas. It appeared that the froth area was high in N_2O_4 but low in fuel vapor. Ignition was readily achieved in nonfrothing areas and the fire rapidly propagated over the total fuel surface, including the froth areas. Once fully developed, the diesel fuel/N_2O_4 mixture burned with an abnormally high intensity; flames were white rather than the normal yellow-orange. In all tests, the high-expansion foam consistently extinguished the diesel/N_2O_4 fires.

The diesel and N_2O_4 tests were run at three application rates, all of which were effective in extinguishing the fires. Test H-10, with a flow of 118 ft^3/min, achieved extinguishment in 1 minute 41 seconds. Tests H-8R and H-8 used an application rate of 142 ft^3/min which achieved extinguishment times of 1 minute 48 seconds and 3 minutes 50 seconds, respectively. The difference in these times directly relates to wind conditions. See Appendix F for detailed test conditions. At a flow rate of 236 ft^3/min, Test H-9 resulted in an extinguishment time of 1 minute 5 seconds.

No problems were experienced in mixing the diesel fuel with the N_2O_4. All ignitions were intentional. In I-16 the diesel fuel and N_2O_4 mixture was aged for 14 hours before the scheduled ignition. No spontaneous ignition occurred during the 14 hours. At the time of scheduled ignition, most of the N_2O_4 boiled off. A small portion remained dissolved in the diesel fuel as evidenced by a deep brown color. When this fire test was conducted, no abnormalities in the ignition or the burn were observed. The fire intensity did not appear to be as great as for those involving fresh fuel-nitrogen tetroxide mixtures. The extinguishment time, 2 minutes 4 seconds, was longer for the aged material. This was most likely due to the longer preburn time, 2 minutes versus 30 seconds for the unaged material. A 2-minute preburn was required to permit full development of the fire.

The only difficulty experienced in this test was in extinguishing the fire in the corners of the pan opposite the point of foam discharge. This difficulty resulted due to the formation of an acrylic layer where the foam contacted the N_2O_4. The acrylic layer, formed at the edge of the foam, was charred by the fire and formed floating islands of carbonized acrylic which were pushed into the corners by the advancing foam front. This carbonized acrylic absorbed the fuel and sustained the burning. The foam had to establish sufficient depth to cover this carbonized material before complete extinguishment was achieved. During the fire, intense N_2O_4 vapors evolved, as evidenced by a brownish-red cloud above the pan and a highly visible plume down range. Once the fire was extinguished, vapor control achieved by the foam was equivalent to a spill-only situation.

Analysis of this data plotted in Figure 16 gives a design application rate of 150 ft^3/min or 3 $ft^3/min/ft^2$. The flat portion of the curve is well-defined due to consistency of the data points. A minimum application of 110 ft^3/min is shown, but this can only be considered an approximation because the upper portion of the curve can only be estimates. Table 8 gives the data for this series as well as the N_2O_4/tire series.

TABLE 8. HIGH-EXPANSION FOAM TESTS--N_2O_4 SUPPORTED FIRES.

Test no.	Date	Fuel/ N_2O_4	Application rate (ft^3/min)	Extinguishment time (min-s)	Comments
H-10	4/16	Diesel	118	1-41	Frothing interfered with ignition
H-8R	4/16	Diesel	142	1-48	
H-9	4-15	Diesel	236	1-05	
I-16	4/23	Diesel	142	2-04	14-hour soak
K-26	4/16	Tire	142	2-30	
L-26	4/23	Tire	142	1-10	14-hour soak

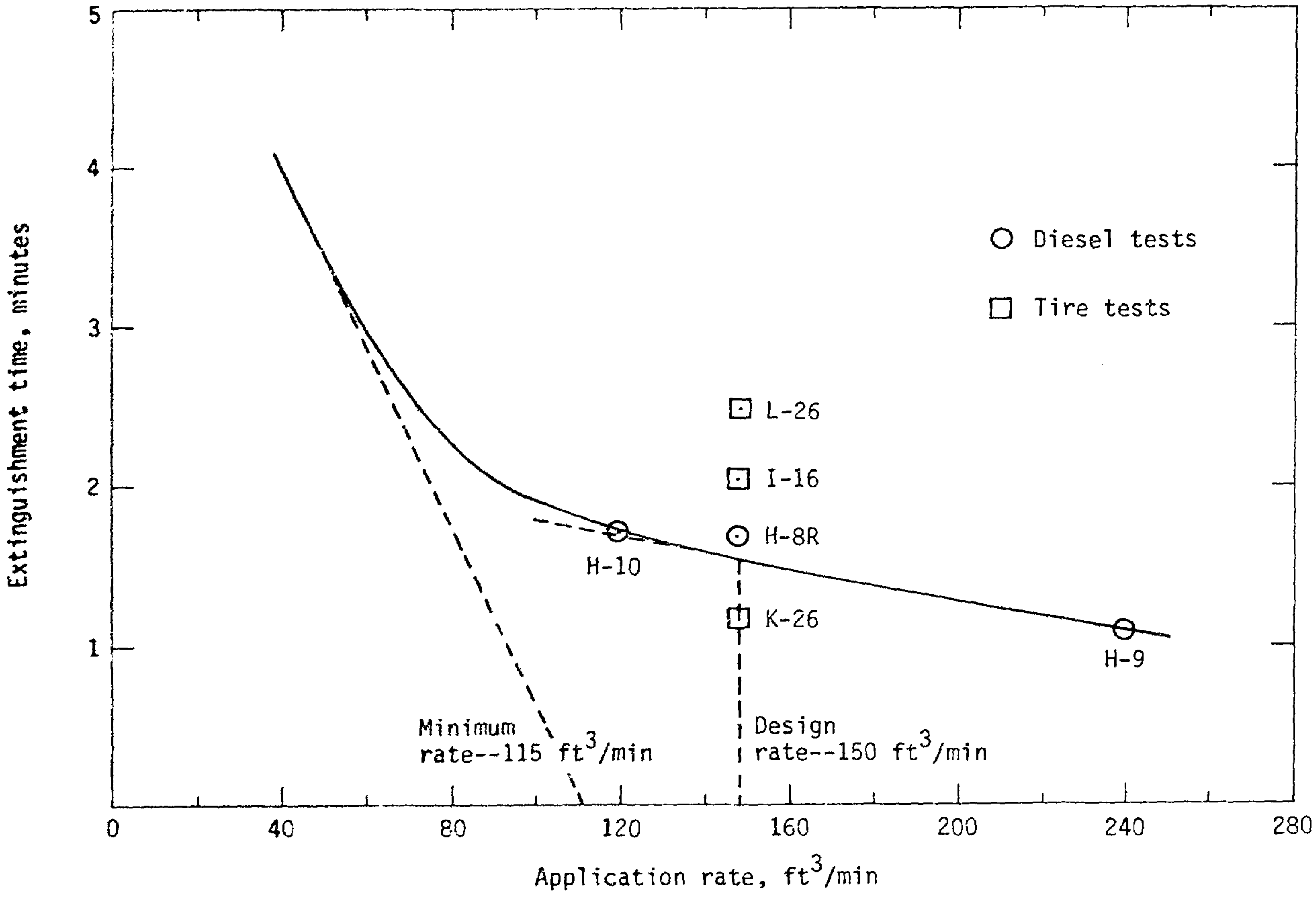

Figure 16. Application Rate Versus Extinguishment Time for Acrylic-Modified High-Expansion Foam--N_2O_4 Supported Diesel Fuel and Tire Fires.

b. Nitrogen Tetroxide and Tires

Two fire tests were conducted with tires exposed to N_2O_4. In each test, one-half of a commercial truck tire casing was placed in a 50 ft^2 pan and 30 gallons of N_2O_4 added. A small amount (2 gallons) of heptane was placed inside the casing to assist in ignition. The first fire, Test K-26, was ignited and allowed to burn long enough to consume the heptane and provide a well-developed fire in the casing. Foam was then discharged into the pan at a rate of 142 ft^3/min. It was difficult to determine if the presence of the N_2O_4 contributed significantly to the fire intensity. Extinguishment time was 2 minutes 30 seconds, which was the time necessary to build sufficient foam depth to cover the tire casing.

The second test, Test L-26, was identical to Test K-26, except that the tire casing was left in contact with the N_2O_4 overnight. In the 14-hour period, the free N_2O_4 boiled off. The tire and the N_2O_4 reacted to produce a gummy coating on the casing. This material produced wisps of red vapor from the N_2O_4 even after 14 hours of aging. When the tire was ignited, the gummy material burned much more intensely than the tire itself. This material was rapidly consumed, leaving the residual casing to burn in a typical manner. The extinguishment time, 1 minute 10 seconds, was shorter for this test than for Test K-26. This may be due to the absence of free N_2O_4 which normally contributes to foam collapse. As with the diesel fuel, no spontaneous ignitions occurred nor was there evidence of severe reactions in the fire sequences. The data from these tests are plotted in Figure 16 and presented in Table 8.

c. Nitrogen Tetroxide and Wood

For the fires involving wood, the fire test procedure for high-expansion foam using Class A combustibles given in paragraph A-1-10.5(a) of NFPA Standard 11A was chosen. In this test, the foam must flow for 12 minutes within an appropriately sized enclosure before reaching the specified wood pallet fire. A 1,500 ft^3/min foam generator was chosen to facilitate a large-scale realistic test. The pen size, as shown in Figure 17, was set at 15 feet wide, 120 feet long, and 10 feet high as dictated by NFPA 11A. The pen was constructed of a frame of two-by-fours covered on the sides and back with heavy clear plastic. The last 20 feet of the pen, where the fires took place, was constructed of sheet metal (sides, floor, and rear wall). This procedure was modified for two tests of this series by placing a pan charged with N_2O_4 beneath the stacked pallets (Figure 18).

Extreme difficulties were experienced in attempting to extinguish these fires. The foam appeared to flow adequately during the calibration test to determine flow and timing. In subsequent tests, however, difficulty was experienced when foam reached the mark which was calibrated on the pen at 9 minutes (usually between 80 and 90 feet from the foam maker). Either through gelling, drainage, or both, the foam lost its fluidity and stopped moving. In Test 0-27, even with a 10-foot head, the foam would not move beyond the 9-minute mark. Fire control was achieved in Test 0-26 in 22 minutes; this test was hampered by winds disrupting the foam continuity (Figure 19). In a third test (N-30), a following wind assisted in driving the foam the full length of the containment (Figure 20). In this test, the wood cribs were covered with foam and the visible evidence of the fire eliminated in 17 minutes. As is the usual case with the NFPA standard 11A test, the wood continues to smolder beneath the foam blanket and fire control rather than complete extinguishment is the measured result.

The presence of the N_2O_4 vapor appeared to accelerate the combustion of the wood. Visibility is restricted within the enclosure, particularly in the fire zone; whether or not the N_2O_4 affected the foam behavior could not be determined. Thermal currents and wind effects were the predominant influences in determining the movement of the foam within the pen, especially within the last 20 feet of the pen.

As with the diesel fuel and tires, one test (0-27) involved aging the combustible wood pallets in contact with N_2O_4. Only the pallets on the bottom of the stack were exposed directly to the N_2O_4. A small amount of heptane was used to assist in ignition. This test was one in which foam failed to flow properly. No attempt was made to extinguish the fire by other means, and the pallet fire burned to completion. An investigation of the fire residue

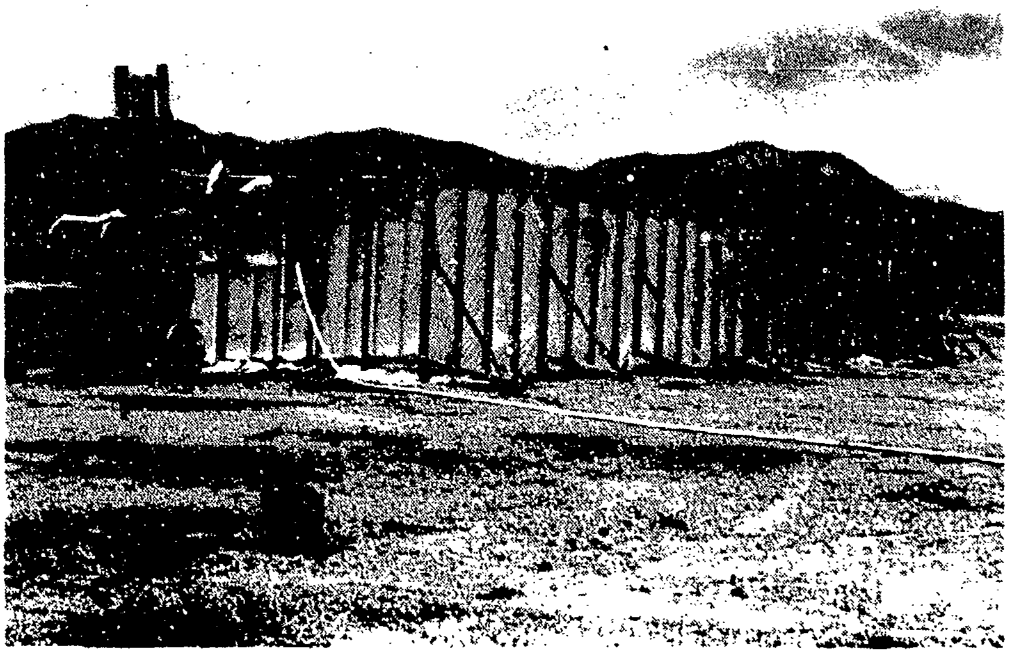

Figure 17. General Layout of Foam Pen.

Figure 18. Wood Crib Configuration and Placement Within Pen.

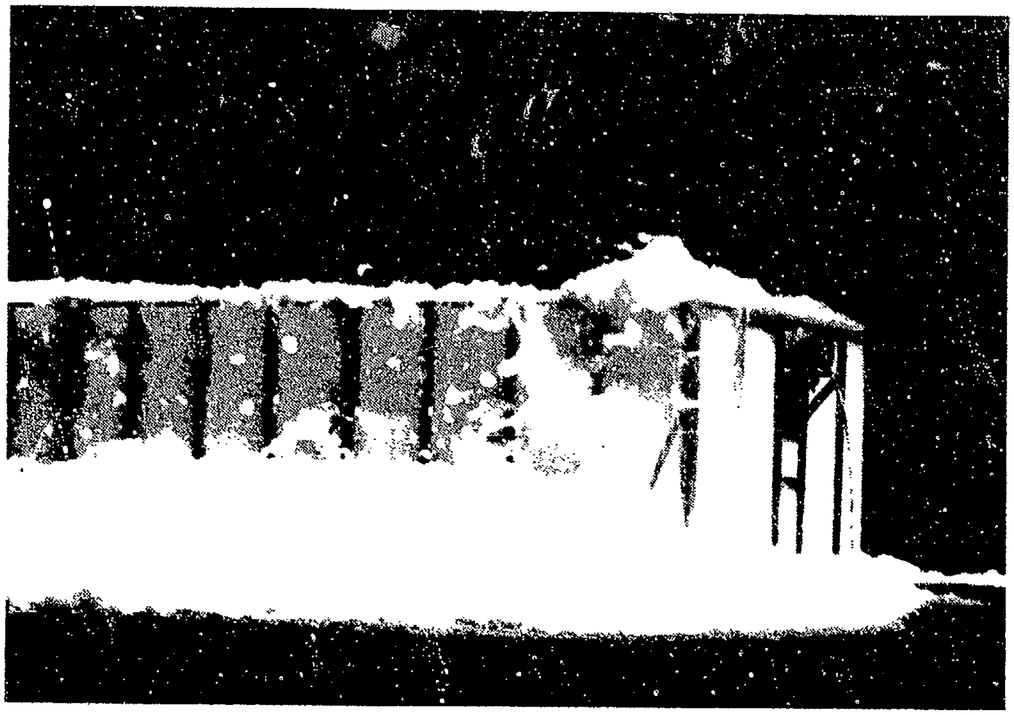

Figure 19. Effects of Wind on Foam Migration.

Figure 20. Movement of Foam Through Pen.

showed that the N_2O_4-exposed wood had, in fact, not burned to the same degree as the unexposed wood in the fire.

The data obtained in these tests show that the vapor suppression foam is effective in controlling Class A fires if the foam can be discharged to the fire. However, in these tests, the foam exhibited a stiffness and a tendency to dry along the forward edge of the foam mass, generally preventing it from reaching the fire. Wind, ambient temperature, and the roughness of the pen floor may have also had varying effects on the foam migration. Clearly, however, the foam characteristics are such that they are not consistent with the NFPA 11A-designed test requirements.

The last test conducted was Test A-18. A 50 ft^2 pan was charged with 30 gallons of N_2O_4. Six feet above the pan, a spray nozzle was suspended and attached via 1/4-inch stainless steel tubing to a 5-gallon pressurized container of A-50 10 feet from the pan. A solenoid was placed in this line next to the A-50 container and connected to a solenoid power box 80 feet away. Fifty feet further away was the generator powering the solenoid power box. The solenoid control box was 200 feet further from the power box at the trailer; thus, the closest personnel during this test were approximately 280 feet distant. Because of problems encountered with equipment and apparatus during preparation, the N_2O_4 was foamed four times in the hour before the A-50 release, the last time being 3 minutes before the first A-50 stream (spray discarded due to plugged nozzle). The first release of the A-50 produced immediate, violent ignition of the A-50 stream--a stream dropping into the N_2O_4 pan of the approximate size and velocity of a water pistol. A violent orange-white flame 1 foot in diameter and 5 feet high was produced. After 20 seconds, the A-50 stream was stopped and the fire immediately ceased. Ten seconds later, the stream was again activated with the same results. The procedure was then repeated several times with identical results. Ignition and combustion sounds were very loud, similar to those produced by a rocket engine.

Because of the violence of this reaction and the setup difficulty, it was determined not to proceed with Test A-21 (N_2O_4 drip into A-50 pan). This decision was based on safety factors and the violence of the hypergolic reaction as evidenced in this test. If the foam had any suppressive effect on the ignition and combustion resulting from this test, it appeared to be minimal.

SECTION V
CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

1. The acrylic-modified foams consistently extinguished 50 and 52.5 ft^2 fires of the complete hydrazine series and also fires of other combustibles supported by nitrogen tetroxide. The foams appeared to give repeatable and predictable results under a variety of different test parameters.

2. The performance of the AFFF and ARC foams was respectable. While extinguishment times were generally longer than with the acrylic-modified foams, burnback qualities were acceptable. Very visible vapor percolation occurred with these foams leading one to believe that the absence of a surfactant additive prevented these foams from being effective vapor control agents. The overall sealability of these foams was poor in comparison to the sealability of the acrylic-modified foams.

3. Sufficient extinguishment data was derived from several scenarios to establish desired foam performance parameters for the purpose of developing a Military Specification.

4. While visible evidence more than amply indicated that the acrylic-modified foams were effective against Class A combustibles, the foam did not migrate sufficiently within the foam pen, as described in NFPA 11A, to pass that particular test.

5. The hydrazines did not appear to be as difficult or hazardous to handle as previous data had indicated. Of 24 drums burned, 1 spontaneous ignition occurred. If additional or qualification testing of these or other foams are to be conducted in the future, the facilities at NTS can accommodate such testing. However, improvements in pan-filling procedures must be considered. The application of these foams against hydrazine/N_2O_4 mixtures should not be considered for testing at NTS, as adequate facilities for the explosive nature of this testing do not exist.

6. While the test series did not include comparisons of the acrylic-modified foam extinguishment performance and disposal potential with that of water, all visible notations would seem to indicate a vast superiority of the foam. A cost analysis can be performed comparing extinguishment of hydrazine and N_2O_4/ diesel fuel fires using the acrylic-modified foams with extinguishment of these materials using water. The scenario developed for the extinguishment of hydrazine assumes the following:

a. A 50 ft^2 fire in a contained pan with 55 gallons of MMH.

b. Water extinguishment occurs by the dilution of hydrazine below its flammable limit.

c. The amount of water necessary to extinguish a MMH fire is 3 gallons of water per gallon of MMH. This assumes that MMH requires a slightly greater amount of water to extinguish than does UDMH (2 gallons of water per gallon) (Reference 8).

The scenario developed for the extinguishment of a diesel fuel/N_2O_4 fire assumes the following:

a. A 50 ft^2 fire in a contained pan with 30 gallons of N_2O_4 and 30 gallons of diesel fuel.

b. Water extinguishment of N_2O_4 occurs through the dilution of the oxidizer to the extent that it no longer supports combustion. Then the remaining air-supported fire is extinguished with AFFF. The amount of water necessary to extinguish a N_2O_4/diesel fuel fire is 10 gallons per gallon of N_2O_4.

c. Before extinguishment is complete, 75 percent of the diesel fuel is burned.

In both scenarios, the amounts of foam necessary for extinguishment are based on actual test data contained in this report. Following extinguishment of hydrazine with foam, the foam is removed and disposed of as a hazardous waste and the remaining hydrazine burned off in a controlled burn, while the entire volume of hydrazine and water is disposed of as a hazardous waste.

Following extinguishment of N_2O_4 with foam, the entire volume of foam and N_2O_4/diesel is disposed of as a hazardous waste, as is the entire volume of the water-extinguished N_2O_4/diesel. For cost comparison purposes, disposal costs are estimated at $6 per gallon of contaminant. This figure was given by Captain Jim Betshart of the Chemical Systems Branch of the Air Force Space Division (HQ SD/CFPE). Based on the above conditions and assumptions, a cost analysis revealed the results contained in Table 9.

TABLE 9. RESULTS OF COST COMPARISON BETWEEN EXTINGUISHMENT OF HYPERGOLIC FUELS OR OXIDIZERS WITH ACRYLIC-MODIFIED FOAM AND WITH WATER.

Fuel	Method of extinguishment	Waste disposal costs ($)	Materials costs ($)	Manhour costs ($)[a]	Total costs ($)
MMH	Water	1320	---	Included	1320
MMH	Low-expansion foam	31	9	40	80
MMH	High-expansion foam	22	7	40	69
N_2O_4/Diesel	Water	1980	---	Included	1980
N_2O_4/Diesel	High-expansion foam	284	17	Included	301

[a] Two men for 2 hours at $10 per hour for conducting controlled burn.

B. RECOMMENDATIONS

1. This report should be made available to all users of the hypergolic propellants, hydrazine, and nitrogen tetroxide. The test results clearly indicate the superiority and effectiveness of the acrylic-modified foams which were tested, while the theoretical cost comparison developed in paragraph 6 of the conclusions evidences the significant cost advantages of the foams.

2. The proposed military specification (Appendix G) should be processed in an expeditious manner. The present need to field hypergolic vapor control and fire suppression foams is considered urgent.

3. For future fire testing of the hypergolic propellants, either singly or together, foremost consideration should be given to using the facilities at the Kennedy Space Center. If these facilities cannot be made available and NTS must be used, hydrazine testing should incorporate a safe, remote pan-filling procedure, and combination testing should not be attempted.

4. Candidate foams which are tested and judged to meet the Military Specification requirements should be further subjected to large-scale fires with the intent of studying hardware, large-scale application techniques, and logistical approaches.

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APPENDIX A

SAFETY DATA SHEETS

D.V. FORMAN
HO, POLY RES MON

ROHM AND HAAS COMPANY

CORPORATE PRODUCT INTEGRITY DEPARTMENT
INDEPENDENCE MALL WEST
PHILADELPHIA, PA 19105

EMERGENCY TELEPHONE
215-592-3000 (ROHM AND HAAS)
800-424-9300 (CHEMTREC)

HAZARD RATING
4=EXTREME
3=HIGH
2=MODERATE
1=SLIGHT
0=INSIGNIFICANT
**SEE SECTION IV

FIRE 0
REACTIVITY 0
TOXICITY 1
SPECIAL

MC107
LIST 8

MATERIAL SAFETY DATA SHEET

NOT OSHA HAZARDOUS

MATERIAL ACRYSOL® ASE-60 Thickening Agent	CODE 61611	KEY 904168-1	DOT HAZARD CLASS NONREGULATED
	DATE ISSUED 06/27/85		

FORMULA Not applicable	CHEMICAL NAME OR SYNONYMS Aqueous acrylic emulsion

I – COMPOSITIONAL INFORMATION

	CAS REG. NO.	APPROX WT %	TWA/TLV R&H	OSHA	ACGIH
Acrylic copolymer	NONHAZ	27-29	NE	NE	NE
Residual monomers (See Section X)	NOT REQ	0.1 max.	NR	NR	NR
Water	NONHAZ	71-73	NE	NE	NE

II – PHYSICAL PROPERTY INFORMATION

APPEARANCE · ODOR · pH Milky white liquid; mild acrylic odor; pH 2.1-4.0			VISCOSITY 5000 cps max.
MELTING OR FREEZING POINT 0C/32F water	BOILING POINT 100C/212F water	VAPOR PRESSURE (mm Hg) 17 20C/68F	VAPOR DENSITY (AIR=1) Less than 1, water
SOLUBILITY IN WATER Dilutable	PERCENT VOLATILE (BY WEIGHT) 71-73 water	SPECIFIC GRAVITY (WATER=1) 1.0-1.2	EVAPORATION RATE (BUTYL ACETATE=1) Less than 1, water

III – FIRE AND EXPLOSION HAZARD INFORMATION

FLASH POINT Non-combustible	AUTO IGNITION TEMPERATURE NA	LOWER EXPLOSION LIMIT (%) NA	UPPER EXPLOSION LIMIT (%) NA

EXTINGUISHING MEDIA
☐ FOAM ☐ "ALCOHOL" FOAM ☐ CO_2 ☐ DRY CHEMICAL ☐ WATER SPRAY ☐ OTHER

SPECIAL FIRE FIGHTING PROCEDURES

None

UNUSUAL FIRE AND EXPLOSION HAZARDS

Material can splatter above 100C/212F. Polymer film can burn.

IV – HEALTH HAZARD INFORMATION

ROHM AND HAAS RECOMMENDED WORK PLACE EXPOSURE LIMITS

EFFECTS OF OVEREXPOSURE

Inhalation: Vapor or mist can cause headache, nausea, and irritation of the nose, throat and lungs.
Skin Contact: Irritating to skin upon repeated or prolonged contact.
Eye Contact: Slightly irritating to eyes.

EMERGENCY AND FIRST AID PROCEDURES

Inhalation: Move subject to fresh air.

Eye and Skin Contact: Flush eyes with a large amount of water for at least 15 minutes. See physician if irritation persists. Wash affected skin areas with soap and water.

V – REACTIVITY INFORMATION

STABILITY ☒ STABLE ☐ UNSTABLE	CONDITIONS TO AVOID Temperatures over 177C/350F.
HAZARDOUS DECOMPOSITION PRODUCTS NA	
HAZARDOUS POLYMERIZATION ☐ MAY OCCUR ☒ WILL NOT OCCUR	CONDITIONS TO AVOID NA
INCOMPATIBILITY (MATERIALS TO AVOID) ☐ WATER ☐ OTHER	NA

VI – SPILL OR LEAK PROCEDURE INFORMATION

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED

Keep spectators away. Floor may be slippery; use care to avoid falling. Dike and contain spill with inert material (e.g., sand, earth). Transfer liquid to containers for recovery or disposal and solid diking material to separate containers for disposal. Keep spills and cleaning runoffs out of municipal sewers and open bodies of water.

Fish Toxicity: Product is non-toxic to fish. Fathead minnow, LC50 (96h): >1000 ppm; daphnia, LC50 (48h) >1000 ppm.

WASTE DISPOSAL METHODS

Coagulate the emulsion by the stepwise addition of ferric chloride and lime. Remove the clear supernatant liquid and flush to a chemical sewer. Landfill the solids and the contaminated diking material according to local, state, and federal regulations.

VII – SPECIAL PROTECTION INFORMATION

VENTILATION TYPE Mechanical local exhaust ventilation at point of contaminant release.	
RESPIRATORY PROTECTION None required if good ventilation is maintained. Otherwise, wear self-contained breathing apparatus (pressure-demand, MSHA/NIOSH-approved or equivalent).	
PROTECTIVE GLOVES Impervious	EYE PROTECTION Chemical splash goggles (ANSI Z-87.1 or approved equivalent)
OTHER PROTECTIVE EQUIPMENT	

VIII – STORAGE AND HANDLING INFORMATION

STORAGE TEMPERATURE	INDOOR	HEATED	REFRIGERATED	OUTDOOR
MAX. 49C/120F MIN. 1C/34F				

PRECAUTIONARY LABELING: KEEP FROM FREEZING--PRODUCT MAY COAGULATE.

IX – TOXICITY INFORMATION

Rat, oral LD50: >5.0 g/kg
Rabbit, dermal LD50: >5.0 g/kg
Rabbit, skin irritation: mildly irritating
Rabbit, eye irritation: inconsequentially irritating.

X – MISCELLANEOUS INFORMATION

NOTE: Monomer vapors can be evolved when product is heated during processing operations. In such a case, use local exhaust ventilation with a minimum capture velocity of 100 ft/min. (30 m/min.) at the point of monomer evolution. Refer to Industrial Ventilation: A Manual of Recommended Practice published by the American Conference of Governmental Industrial Hygienists.

FOOTNOTE TO SECTION I: NE=not established; NOT REQ or NR=not required.

ACRYSOL® IS A TRADEMARK OF ROHM AND HAAS COMPANY OR ONE OF ITS SUBSIDIARIES OR AFFILIATES.

NA = NOT APPLICABLE C = CEILING VALUE	KEY 904168-1	DATE OF ISSUE 06/27/85	SUPERSEDES 02/13/81

HO, POLY RES MON

ROHM AND HAAS COMPANY

CORPORATE PRODUCT INTEGRITY DEPARTMENT
INDEPENDENCE MALL WEST
PHILADELPHIA, PA 19105

EMERGENCY TELEPHONE
215-592-3000 (ROHM AND HAAS)
800-424-9300 (CHEMTREC)

HAZARD RATING
4=EXTREME
3=HIGH
2=MODERATE
1=SLIGHT
0=INSIGNIFICANT
**SEE SECTION IV

FIRE	TOXICITY	REACTIVITY	SPECIAL
0	1	0	

MC107
LIST 8

MATERIAL SAFETY DATA SHEET

NOT OSHA HAZARDOUS

MATERIAL	CODE	KEY	DOT HAZARD CLASS
ACRYSOL® ASE-95 Thickening Agent	65381	905357-9	NONREGULATED
	DATE ISSUED 06/27/85		

FORMULA	CHEMICAL NAME OR SYNONYMS
Not available	Aqueous acrylic emulsion

I – COMPOSITIONAL INFORMATION

	CAS REG. NO.	APPROX WT %	TWA/TLV R&H	OSHA	ACGIH
Acrylic copolymer	NONHAZ	19-21	NE	NE	NE
Residual monomers (See Section X)	NOT REQ	0.1 max.	NR	NR	NR
Water	NONHAZ	79-81	NE	NE	NE

II – PHYSICAL PROPERTY INFORMATION

APPEARANCE · ODOR · pH			VISCOSITY
Milky white liquid; mild acrylic odor; pH 2.1-4.0			6000 cps max.
MELTING OR FREEZING POINT	BOILING POINT	VAPOR PRESSURE (mm Hg)	VAPOR DENSITY (AIR=1)
0C/32F water	100C/212F water	17 20C/68F	Less than 1, water
SOLUBILITY IN WATER	PERCENT VOLATILE (BY WEIGHT)	SPECIFIC GRAVITY (WATER=1)	EVAPORATION RATE (BUTYL ACETATE=1)
Dilutable	79-81 water	1.0-1.2	Less than 1, water

III – FIRE AND EXPLOSION HAZARD INFORMATION

FLASH POINT	AUTO IGNITION TEMPERATURE	LOWER EXPLOSION LIMIT (%)	UPPER EXPLOSION LIMIT (%)
Non-combustible	NA	NA	NA

EXTINGUISHING MEDIA
☐ FOAM ☐ "ALCOHOL" FOAM ☐ CO_2 ☐ DRY CHEMICAL ☐ WATER SPRAY ☐ OTHER

SPECIAL FIRE FIGHTING PROCEDURES

None

UNUSUAL FIRE AND EXPLOSION HAZARDS

Material can splatter above 100C/212F. Polymer film can burn.

IV – HEALTH HAZARD INFORMATION

ROHM AND HAAS RECOMMENDED WORK PLACE EXPOSURE LIMITS

EFFECTS OF OVEREXPOSURE **

Inhalation: Vapor or mist can cause headache, nausea, and irritation of the nose, throat and lungs.

Skin Contact: Irritating to skin upon repeated or prolonged contact.

Eye Contact: Slightly irritating to eyes.

EMERGENCY AND FIRST AID PROCEDURES

Inhalation: Move subject to fresh air.

Eye and Skin Contact: Flush eyes with a large amount of water for at least 15 minutes. See physician if irritation persists. Wash affected skin areas with soap and water.

V – REACTIVITY INFORMATION

STABILITY ☒ STABLE ☐ UNSTABLE	CONDITIONS TO AVOID Temperatures over 177C/350F.
HAZARDOUS DECOMPOSITION PRODUCTS NA	
HAZARDOUS POLYMERIZATION ☐ MAY OCCUR ☒ WILL NOT OCCUR	CONDITIONS TO AVOID NA
INCOMPATIBILITY (MATERIALS TO AVOID) ☐ WATER ☐ OTHER	NA

VI – SPILL OR LEAK PROCEDURE INFORMATION

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED

Keep spectators away. Floor may be slippery; use care to avoid falling. Dike and contain spill with inert material (e.g., sand, earth). Transfer liquid to containers for recovery or disposal and solid diking material to separate containers for disposal. Keep spills and cleaning runoffs out of municipal sewers and open bodies of water.

WASTE DISPOSAL METHODS

Coagulate the emulsion by the stepwise addition of ferric chloride and lime. Remove the clear supernatant liquid and flush to a chemical sewer. Landfill the solids and the contaminated diking material according to local, state, and federal regulations.

VII – SPECIAL PROTECTION INFORMATION

VENTILATION TYPE

Mechanical local exhaust ventilation at point of contaminant release.

RESPIRATORY PROTECTION

None required if good ventilation is maintained. Otherwise, wear self-contained breathing apparatus (pressure-demand, MSHA/NIOSH-approved or equivalent).

PROTECTIVE GLOVES Impervious	EYE PROTECTION Chemical splash goggles (ANSI Z-87.1 or approved equivalent)

OTHER PROTECTIVE EQUIPMENT

VIII – STORAGE AND HANDLING INFORMATION

STORAGE TEMPERATURE	INDOOR	HEATED	REFRIGERATED	OUTDOOR
MAX. 60C/140F MIN. 0C/32F				

PRECAUTIONARY LABELING: KEEP FROM FREEZING--PRODUCT MAY COAGULATE.

IX – TOXICITY INFORMATION

Rat, oral LD50: >5.0 g/kg
Rabbit, dermal LD50: >5.0 g/kg
Rabbit, skin irritation: slightly irritating
Rabbit, eye irritation: inconsequentially irritating.

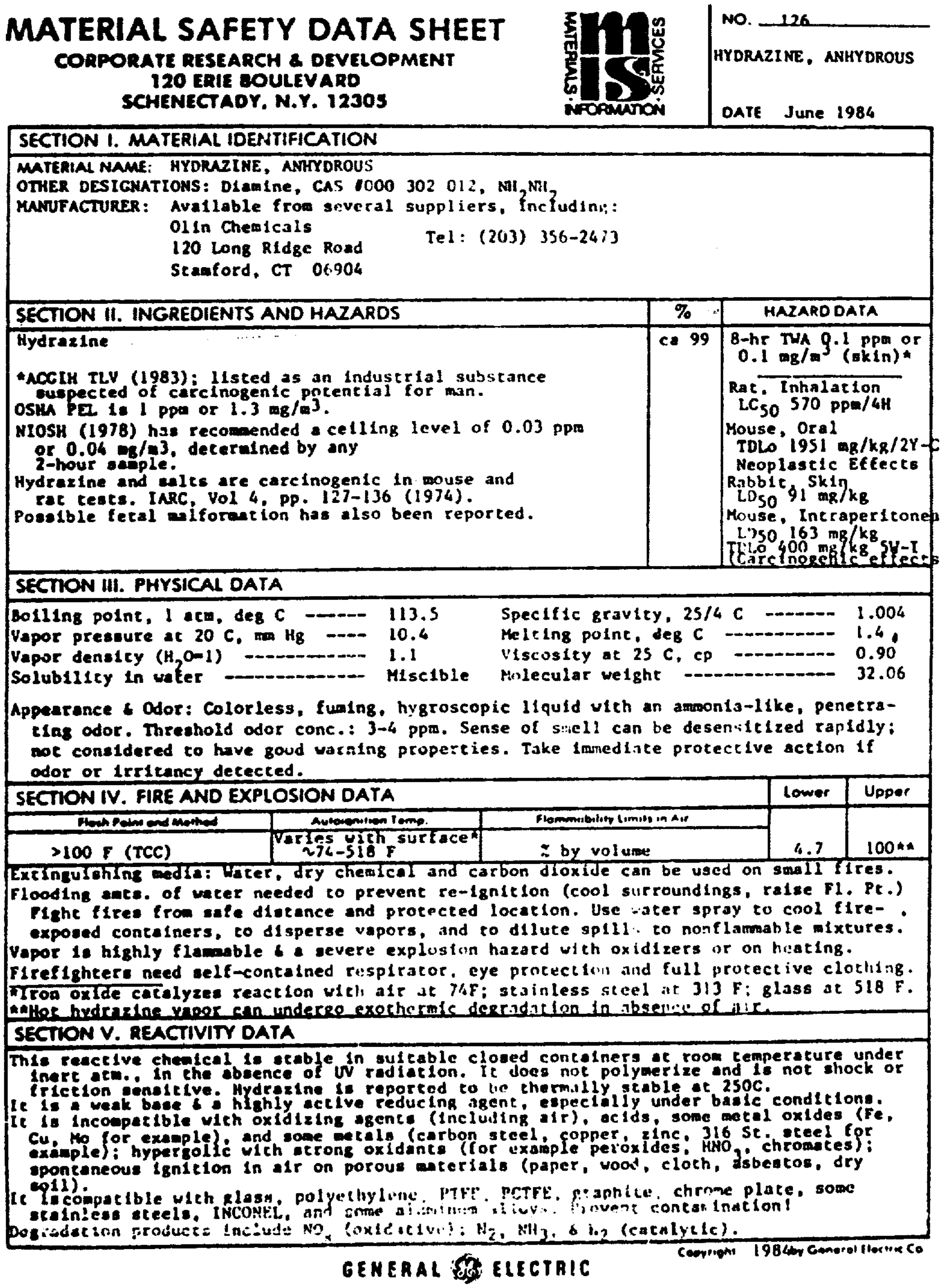
X – MISCELLANEOUS INFORMATION

NOTE: Monomer vapors can be evolved when product is heated during processing operations. In such a case, use local exhaust ventilation with a minimum capture velocity of 100 ft/min. (30 m/min.) at the point of monomer evolution. Refer to Industrial Ventilation: A Manual of Recommended Practice published by the American Conference of Governmental Industrial Hygienists.

FOOTNOTES TO SECTION I: NE=none established; NOT REQ or NR=not required.

ACRYSOL® IS A TRADEMARK OF ROHM AND HAAS COMPANY OR ONE OF ITS SUBSIDIARIES OR AFFILIATES.

NA = NOT APPLICABLE C = CEILING VALUE	KEY 905357-9	DATE OF ISSUE 06/27/83	SUPERSEDES 04/21/81



MATERIAL SAFETY DATA SHEET

CORPORATE RESEARCH & DEVELOPMENT
120 ERIE BOULEVARD
SCHENECTADY, N.Y. 12305

NO. 126

HYDRAZINE, ANHYDROUS

DATE June 1984

SECTION I. MATERIAL IDENTIFICATION

MATERIAL NAME: HYDRAZINE, ANHYDROUS
OTHER DESIGNATIONS: Diamine, CAS #000 302 012, NH_2NH_2
MANUFACTURER: Available from several suppliers, including:
Olin Chemicals
120 Long Ridge Road
Stamford, CT 06904
Tel: (203) 356-2473

SECTION II. INGREDIENTS AND HAZARDS	%	HAZARD DATA
Hydrazine *ACGIH TLV (1983); listed as an industrial substance suspected of carcinogenic potential for man. OSHA PEL is 1 ppm or 1.3 mg/m3. NIOSH (1978) has recommended a ceiling level of 0.03 ppm or 0.04 mg/m3, determined by any 2-hour sample. Hydrazine and salts are carcinogenic in mouse and rat tests. IARC, Vol 4, pp. 127-136 (1974). Possible fetal malformation has also been reported.	ca 99	8-hr TWA 0.1 ppm or 0.1 mg/m^3 (skin)* Rat, Inhalation LC_{50} 570 ppm/4H Mouse, Oral TDLo 1951 mg/kg/2Y-C Neoplastic Effects Rabbit, Skin LD_{50} 91 mg/kg Mouse, Intraperitoneal LD_{50} 163 mg/kg TDLo 400 mg/kg 5W-I (Carcinogenic effects)

SECTION III. PHYSICAL DATA

Boiling point, 1 atm, deg C	113.5	Specific gravity, 25/4 C	1.004
Vapor pressure at 20 C, mm Hg	10.4	Melting point, deg C	1.4
Vapor density (H_2O=1)	1.1	Viscosity at 25 C, cp	0.90
Solubility in water	Miscible	Molecular weight	32.06

Appearance & Odor: Colorless, fuming, hygroscopic liquid with an ammonia-like, penetrating odor. Threshold odor conc.: 3-4 ppm. Sense of smell can be desensitized rapidly; not considered to have good warning properties. Take immediate protective action if odor or irritancy detected.

SECTION IV. FIRE AND EXPLOSION DATA

Flash Point and Method	Autoignition Temp.	Flammability Limits in Air	Lower	Upper
>100 F (TCC)	Varies with surface* ~74-518 F	% by volume	4.7	100**

Extinguishing media: Water, dry chemical and carbon dioxide can be used on small fires.
Flooding amts. of water needed to prevent re-ignition (cool surroundings, raise Fl. Pt.) Fight fires from safe distance and protected location. Use water spray to cool fire-exposed containers, to disperse vapors, and to dilute spills to nonflammable mixtures.
Vapor is highly flammable & a severe explosion hazard with oxidizers or on heating.
Firefighters need self-contained respirator, eye protection and full protective clothing.
*Iron oxide catalyzes reaction with air at 74F; stainless steel at 313 F; glass at 518 F.
**Hot hydrazine vapor can undergo exothermic degradation in absence of air.

SECTION V. REACTIVITY DATA

This reactive chemical is stable in suitable closed containers at room temperature under inert atm., in the absence of UV radiation. It does not polymerize and is not shock or friction sensitive. Hydrazine is reported to be thermally stable at 250C.
It is a weak base & a highly active reducing agent, especially under basic conditions.
It is incompatible with oxidizing agents (including air), acids, some metal oxides (Fe, Cu, Mo for example), and some metals (carbon steel, copper, zinc, 316 St. steel for example); hypergolic with strong oxidants (for example peroxides, HNO_3, chromates); spontaneous ignition in air on porous materials (paper, wood, cloth, asbestos, dry soil).
It is compatible with glass, polyethylene, PTFE, PCTFE, graphite, chrome plate, some stainless steels, INCONEL, and some aluminum alloys. Prevent contamination!
Degradation products include NO_x (oxidative); N_2, NH_3, & H_2 (catalytic).

GENERAL ELECTRIC

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SECTION VI. HEALTH HAZARD INFORMATION	TLV 0.1 ppm (skin) (See Sect II)

Hydrazine is poisonous, very toxic by ingestion, inhalation and skin absorption (acute or chronic). Early systemic effects from chronic excessive exposure include anorexia, weight loss, weakness & tremors. Overexposure to vapors can immediately irritate nose & throat, followed by itching, burning & swelling of the eyes (possible temporary blindness if exposure severe), and possible dermatitis. 80 ppm IDLH* is reported. Systemic effects can include dizziness, nausea, convulsions and sensitization. Liquid contact can be corrosive to tissue, producing penetrating burns and possible permanent corneal opacity. Systemic toxicity: Liver, kidneys & blood forming system.

FIRST AID:

Eye or Skin Contact: Immediately flush with running water! Continue eye flushing for at least 15 min, including under eyelids. Remove contaminated clothing under safety shower Contact physician! Continue flushing with water. Skin burns to be treated like alkali or thermal burns.

Inhalation: Remove to fresh air. Restore and/or support breathing. Contact physician! Keep warm and at rest. Pulmonary edema may occur from severe exposure.

Ingestion: Promptly give 2-3 glasses of milk, water or citrus juice to drink and induce vomiting. Repeat. Contact physician!

*Concentration considered immediately dangerous to life and health.

SECTION VII. SPILL, LEAK, AND DISPOSAL PROCEDURES

Institute plan, prepared with supplier's guidance. Notify safety personnel of spills. Evacuate all except trained clean-up personnel who are protected against inhalation & contact. Use optimum explosion-proof ventilation. Remove sources of heat or ignition.

Promptly dilute spill with water spray to less than 40% hydrazine to control fire hazard; flush to provided containment or otherwise contain and collect liquid as may be feasible. Use sand (not combustible absorbent) to collect small spills and residues, & place in closed containers for disposal. Flush spill area with much water.

DISPOSAL: Follow Federal, State, and Local regulations. 2% solns can be decomposed with hypochlorite or 10% H_2O_2. The Air Force has used special mobile incinerators for hydrazine or its mixtures with water (NO_x evolution). Open pit burning of alcohol solutions has been reported. Dil. sulfuric acid has been used for neutralization of aq. hydrazine.

EPA (RCRA) HW No. is U133 (40 CFR 261).

SECTION VIII. SPECIAL PROTECTION INFORMATION

Use explosion-proof general and exhaust ventilation to meet TLV (exhaust scrubber may be needed). Use enclosed processes where feasible. Approved self-contained respirator with full facepiece can be used in a pressure-demand mode for non-routine conditions to 30 ppm or for emergency escape. Hoods should have 150 lfm face velocity.

NIOSH recommends using a regulated work area, excluding unauthorized personnel.

Use impervious* body-covering protection (rubber gloves, apron, boots, full suit, etc.) as conditions require to prevent skin contact. Use chemical safety goggles and faceshield to protect eyes. Contaminated impervious protection to be thoroughly washed off with water before & during removal. Contaminated clothing & equipment are fire & health hazard. Wear clean work clothing. Shower after work. Control laundering and cleaning procedure that is used for hydrazine contaminated items. Destruction of contaminated leather has been recommended.

Eyewash fountains, washing facilities and safety showers to be readily available where hydrazine is used or handled or stored. *Butyl rubber has been recommended.

SECTION IX. SPECIAL PRECAUTIONS AND COMMENTS

Store in tightly closed containers in a clean, cool, well-ventilated area with controlled drainage, away from oxidizing agents, acids, direct sunlight, & sources of heat or ignition. Water sprinkler-protected, sheltered, outside or detached storage preferred. Protect containers from physical damage; ground & bond for transfers to prevent static sparks; inert with nitrogen atmosphere. Prevent contamination of hydrazine. Concrete pads, dikes, drains and containment have been recommended for large tanks and drums.

Avoid breathing & contact with vapors! Prevent liquid contact with eyes, skin or clothing! Do not ingest! Practice good personal hygiene. Wash well after handling. Observe label precautions. Rigidly follow proper handling requirements. Obtain guidance from supplier. Use with proper ventilation.

DOT Classification: FLAMMABLE LIQUID I.D. No. UN2029 Label: FLAMMABLE LIQUID, POISON, CORROSIVE

IMO Class: 3.3

DATA SOURCE(S) CODE: 1-12,14,16,19, 20,23,25,26,31,37,38,42,47-49,52

APPROVALS: MIS/CRD	
INDUST. HYGIENE/SAFETY	6-8-84
MEDICAL REVIEW:	15 June 1984

GENERAL ELECTRIC

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                              CHEMTOX DATA
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 CHEMTOX RECORD 2209                     LAST UPDATE OF THIS RECORD:  02/19/86
 NAME:               1,1-DIMETHYLHYDRAZINE
 SYNONYMS            DIMAZINE; 1,1-DIMETHYLHYDRAZIN (German);
                     asymmetric DIMETHYLHYDRAZINE; N,N-DIMETHYLHYDRAZINE;
                     unsym-DIMETHYLHYDRAZINE; 1,1-DIMETHYLHYDRAZINE;
                     UNSYMMETRICAL (DOT : DMH; UDMH; UNSYMMETRICAL
                     HYDRAZINE, 1,1-DIMETHYL-; 1,1-DIMETHYL HYDRAZINE



 CAS:            57-14-7                 RTECS:          MV2450000
 FORMULA:        C2H8N2                  MOL WT:         60.12
 CHEMICAL CLASS:

 PHYSICAL DESCRIPTION: COLORLESS WATERY LIQUID WITH A FISHY OR
 BOILING POINT:  342.04 K  69.5 C    156 F
 MELTING POINT:  215.95 K  -57.2 C   -71 F
 FLASH POINT:    258 K     -15.2 C   4.[illegible] F
 VAPOR PRESSURE: 157 mm @25 C
 AUTO IGNITION:  255 K     -18.2 C   -.7 F
 UEL:    95 %      LEL:      2 %
 IONIZATION POTENTIAL  (eV):   7.46
 VAPOR DENSITY:  1.94 air=1
 SPECIFIC GRAVITY:  0.791 20C
 DENSITY:           0.782
 WATER SOLUBILITY:  MISCIBLE
 INCOMPATIBILITIES: OXIDIZERS, HALOGENS, METALLIC MERCURY, FUMING NITRIC
                    HYDROGEN PEROXIDE

 REACTIVITY WITH WATER:  PYROGENIC WHEN MIXED WITH H2O  Source: THIC
 REACTIVITY WITH COMMON MATERIALS: DISSOLVES, SWELLS, AND DISINTEGRATES
                       PLASTICS

 STABILITY DURING TRANSPORT:        No Data
 NEUTRALIZING AGENTS:               FLUSH WITH WATER.
 POLYMERIZATION POSSIBILITIES.      No data
 TOXIC FIRE GASES: NOX
 ODOR DETECTED AT (ppm):  6-14
 ODOR DESCRIPTION:        SHARP AMMONIACAL, FISHY  Source: CHRIS
 100 % ODOR DETECTION: No data

 DOT HAZARD CLASS:  Flammable liquid
 DOT GUIDE:         28
 DOT ID NUMBER:     UN1163
 DOT SHIPPING NAME: DIMETHYLHYDRAZINE, UNSYMMETRICAL
 STCC NUMBER:       4906210

 EPA WASTE NUMBER:  U098
 CERCLA REF:        Y
 RQ DESIGNATION:    X    1 pound (0.454 kg)
 CLEAN AIR ACT:     N
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NFPA CODES:
         HEALTH HAZARD (BLUE):  3
         FLAMMABILITY  (RED) :  3
         REACTIVITY    (YELLOW):1

TARGET ORGANS:      CNS, LIVER, GI, BLOOD, RESP SYS, EYES, SKIN
SYMPTOMS          :  BREATHING OF VAPOR CAUSES PULMONARY IRRITATION,
                     GASTROINTESTINAL IRRITATION, TREMORS & CONVULSIONS;
                     WITH SKIN OR MUCOUS MEMBRANES CAUSES CHEMICAL BURNS.
                     BE ABSORBED THROUGH SKIN TO CAUSE SYSTEMIC
                     & CONVULSIONS. IRRITATION OF EYES, DYSPNEA, NAUSEA,
                     CARDIOVASCULAR COLLAPSE. Source: TMIC


SYMPTOMS (CHRIS):
CONC IDLH:          50 PPM
PERMISSIBLE EXPOSURE (OSHA):  0.5 ppm SKIN
CARCINOGEN?:    Y   STATUS:   ANIMAL POSITIVE
        REFERENCES:
          ANIMAL POSITIVE IARC** 4,137,74


HUMAN TOXICITY DATA: (Source: NIOSH RTECS)


LD50  (mg/kg):   102; 2880 SPECIES:  IPR RAT: ORAL MOUSE (TDLO)

PROTECTION SUGGESTED:
CHRIS MANUAL:
RUBBER GLOVES, BOOTS, APRON; PLASTIC FACE SHIELD; GAS MASK WITH AMMONIA
CANISTER PROTECTS FOR 30 MIN. AGAINST 1% CONCENTRATION.FOR LONGER PERIODS
HIGHER CONCENTRATIONS, USE SELF-CONTAINED BREATHING APPARATUS.


NIOSH POCKET GUIDE TO CHEMICAL HAZARDS

** WEAR APPROPRIATE EQUIPMENT TO PREVENT:
      Any possibility of skin contact.

** WEAR EYE PROTECTION TO PREVENT:
     Any possibility of eye contact.

** EXPOSED PERSONNEL SHOULD WASH:
     Immediately when skin becomes contaminated.

** WORK CLOTHING SHOULD BE CHANGED DAILY:
     'ALL.OUT' LINE 350.  (R10) Variable has not been assigned a value. Zero used.
0

** REMOVE CLOTHING:
     Immediately remove any clothing that becomes wet to avoid any flammability hazard.
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** THE FOLLOWING EQUIPMENT SHOULD BE MADE AVAILABLE:
Eyewash,quick drench.

** REFERENCE: NIOSH

RECOMMENDED RESPIRATION PROTECTION Source: NIOSH POCKET GUIDE (85-114) LCT= 48
NIOSH (1,1-DIMETHYLHYDRAZINE)
Greater at any detectable concentration. : /Any self-contained breathing with full facepiece and operated in a pressure-demand or other positive mode./Any self-contained breathing apparatus with full facepiece and in a pressure-demand or other positive pressure mode./Any supplied-air with a full facepiece and operated in pressure-demand or other positive mode in combination with an auxiliary self-contained breathing apparatus in pressure-demand or other positive pressure mode./Any supplied-air with a full facepiece and operated in pressure-demand or other positive mode in combination with an auxiliary self-contained breathing apparatus in pressure-demand or other positive pressure mode.

ESCAPE: /Any air-purifying full facepiece respirator (gas mask) with a or front- or back-mounted canister providing protection against the of concern. /Any air-purifying full facepiece respirator (gas mask) with chin-style or front- or back-mounted canister providing protection the compound of concern. /Any appropriate escape-type self-contained apparatus./Any appropriate escape-type self-contained breathing

FIRST AID (NIOSH):
EYE:
FLOOD WITH WATER AND TREAT AS ALKALINE BURN.
SKIN:
FLOOD WITH WATER AND TREAT AS ALKALINE BURN.
INHALATION:
REMOVE VICTIM FROM CONTAMINATED AREA, GIVE ARTIFICIAL RESPIRATION & IF NEEDED; WATCH FOR SIGNS OF PULMONARY EDEMA; ENFORCE ABSOLUTE REST.

INGESTION:
DO NOT INDUCE VOMITING; HOSPITALIZE.

US Department of Transportation Guide to Hazardous Materials Transport Information - Publication DOT 5800.3
DOT SHIPPING NAME: DIMETHYLHYDRAZINE, UNSYMMETRICAL

POTENTIAL HAZARDS DOT GUIDE NUMBER 28

*HEALTH HAZARDS
Poison.
May be fatal if inhaled, swallowed or abasorbed through skin.
Contact may cause burns to skin and eyes.
Runoff from fire control or dilution water may cause pollution.

•FIRE OR EXPLOSION

Will burn. May be ignited by heat, sparks and flames.
Flammable vapor may spread away from spill.
Container may explode in heat of fire.
Vapor explosion and poison hazard indoors, outdoors, or in sewers.
Runoff to sewer may create fire or explosion hazard.

•EMERGENCY ACTION•

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Wear positive pressure breathing apparatus and special protective clothing.
Isolate for 1/2 mile in all directions if tank or tankcar is involved in fire.
FOR EMERGENCY ASSISTANCE CALL CHEMTREC (800) 424-9300.
Also, in case of water pollution, call local authorities.

•FIRE

Small Fires: Dry chemical, CO2, water spray or foam.
Large Fires: Water spray, fog or foam.
Move container from fire area if you can do it without risk.
Stay away from ends of tanks.
Cool containers that are exposed to flames with water from the side until well after fire is out.
Withdraw immediately in case of rising sound from venting safety device or discoloration of tank.

•SPILL OR LEAK

No flares, smoking or flames in hazard area.
Do not touch spilled material.
Stop leak if you can do it without risk.
Use water spray to reduce vapors.
Small Spills: Take up with sand, or other noncombustible absorbent material, then flush area with water.
Large Spills: Dike far ahead of spill for later disposal.

•FIRST AID

Move victim to fresh air; call emergency medical care.
If not breathing, give artificial respiration.
If breathing is difficult, give oxygen.
Remove and isolate contaminated clothing and shoes.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Keep victim quiet and maintain normal body temperature.
Effects may be delayed, keep victim under observation.

DISCLAMER: The data shown above on this chemical represents a best effort on the part of the compliers of the CHEMTOX database to obtain useful, accurate, and factual data. The use of these data shall be in accordance with the guidelines and limitations of the user's CHEMTOX license agreement. The COMPILERS of the CHEMTOX database shall not be held liable for inaccuracies or omissions within this database, or in any of its printed or displayed output forms.

MATERIAL SAFETY DATA SHEET

GENIUM PUBLISHING CORPORATION

1145 CATALYN ST., SCHENECTADY, NY 12303 USA (518) 377-8854

From Genium's MSDS Collection, to be used as a reference.

MSDS # G 552
METHYL HYDRAZINE

Issued: August, 1985
Revised:

SECTION 1. MATERIAL IDENTIFICATION

17

MATERIAL NAME: Methyl Hydrazine

OTHER DESIGNATIONS: Hydrazine, Methyl-; Hydrazomethane; 1-Methylhydrazine; Mono Methylhydrazine; MMH; CH_6N_2, CAS #60-34-4.

MANUFACTURER: Available from many suppliers, including:
Aldrich Chemical Company
P.O. Box 355
Milwaukee, WI 53201
(414) 273-3850

SECTION 2. INGREDIENTS AND HAZARDS

	%	HAZARD DATA
METHYL HYDRAZINE	98	8 HR TWA Ceiling: 0.2 ppm, 0.35 mg/m^3 (Skin)*
		Rat, oral: LD50: 33 mg/kg
* Current ACGIH TLV (1985-86) and OSHA PEL. Skin designation indicates that Methyl Hydrazine is absorbed through the skin.		Rat, Inhalation: LC50: 74 ppm/8Hr
		Rat, Skin: LD50: 183 mg/kg
		Rat, Ipr: LD50: 24 mg/kg

SECTION 3. PHYSICAL DATA

Boiling point, 1 atm	190.04°F (87.8°C)	Specific gravity, 20/4°C	0.874
Vapor pressure @ 25°C, mmHg	49.6	Volatiles, %	100
Vapor density (Air=1)	1.6	Evaporation rate	Not known
Solubility in water	Slightly soluble	Melting point	5.62°F (-20.9°C)
		Molecular weight	46.1

APPEARANCE & ODOR: Colorless, Hygroscopic liquid with an ammonia-like odor.

SECTION 4. FIRE AND EXPLOSION DATA

Flash Point and Method	Autoignition Temp	Flammability Limits in Air	Lower	Upper
70°F (21.1°C) C.O.C.	384.8°F (196°C)	% by Volume	2.5	92 ± 2

EXTINGUISHING MEDIA: Carbon dioxide, dry chemical, alcohol or polymer foam. Use water spray to cool tank. container. Do not use a solid stream of water since the stream will scatter and spread the fire.

This flammable liquid is a dangerous fire hazard when exposed to heat or flame. It is flammable over a wide range of vapor air concentration. Its vapors are heavier than air and may travel a considerable distance to the source of ignition and flashback. Methyl Hydrazine may ignite spontaneously in air when in contact with porous materials such as earth, asbestos, wood or cloth and with oxidants such as hydrogen peroxide or nitric acid. When containers of this material are exposed to heat or fire, the containers may violently rupture. Firefighters should wear self-contained breathing apparatus and full protective clothing.

SECTION 5. REACTIVITY DATA

Methyl Hydrazine is stable in closed containers at room temperature under normal storage and handling conditions. It does not undergo hazardous polymerization. This material is incompatible with oxidizing materials. Contact with dicyanofurazan, or its N-oxide (dicyan furoxan) is instantaneously explosive. It may explode in contact with metallic oxides. Exposure in air on a large surface may result in spontaneous ignition.

Thermal decomposition or burning may produce toxic fumes of nitrogen oxides.

MSDS # G 552 Issued 8/85 METHYL HYDRAZINE

SECTION 6. HEALTH HAZARD INFORMATION

TLV 0.2 ppm (See Section 2)

Methyl hydrazine is a poisonous compound which is readily absorbed from the lungs, gastrointestinal tract and skin. Systemic effects of exposure to methyl hydrazine incude convulsions and tremors, blood disorders and death. Vapors or mists of methyl hydrazine are irritating to the eyes, mucous membranes, and upper respiratory tract, and may cause respiratory distress and systemic effects. The liquid is irritating and corrosive to the skin and eyes and may be readily absorbed through the skin in toxic amounts. Chronic exposures to methyl hydrazine may cause kidney and liver damage. This material is a suspected carcinogen.

FIRST AID: EYE CONTACT: Promptly flush eyes, including under eyelids, with running water for at least 15 minutes. Get medical attention (Inplant, Paramedic, Community). SKIN CONTACT: Flush exposed area with water while removing contaminated clothing. Get medical attention (Inplant, paramedic, community). INHALATION: Remove to fresh air. Restore and/or support breathing as needed. Notify medical personnel. INGESTION: Give victim water or milk as quickly as possible. Call a physician or Poison Control Center. Do not induce vomiting! Transport to a medical facility. Never give anything by mouth to a person who is unconscious or is having convulsions.

SECTION 7. SPILL, LEAK AND DISPOSAL PROCEDURES

Notify safety personnel of spills or leaks. Evacuate all non-essential personnel from the area. Remove all ignition sources. Provide maximum explosion-proof ventilation. When performing clean-up, wear suitable protective clothing and equipment (see Section 8). Absorb small spills on sand or vermiculite and place in closed containers for disposal. Dike large spills and collect for reclamation or disposal. After bulk material is removed, wash the spill site and completely ventilate the area. Do not discharge to sewer, water sheds or waterways. Use non-sparking tools.

DISPOSAL: Place in suitable container for disposal by licensed contractors or burn in an approved incinerator equipped with an after burner and scrubber. Follow all Federal, State and local regulations.

EPA HAZARDOUS WASTE NO. P068 (EP Toxicity 140 CFR 261).

SECTION 8. SPECIAL PROTECTION INFORMATION

Provide general and local exhaust ventilation (explosion-proof) to meet TLV requirement. Handling in a chemical fume hood is preferred. For emergency or non-routine exposures where the TLV may be exceeded, wear a NIOSH-approved respirator. All electrical service in use or storage areas should have an explosion-proof design.

Avoid any contact with this material. Full protective clothing and equipment including splash goggles, face shield, impervious gloves, apron, boots, impervious shirt and trousers, hard hat with brim, and respirator should be available and worn as appropriate. Remove contaminated clothing immediately and do not wear until it has been properly laundered.

Eyewash stations and safety showers should be readily available where this material is handled or stored.

Contact lenses pose a special hazard; soft lenses may absorb and all lenses concentrate irritants.

SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS

Store in tightly closed containers in a cool, dry, well-ventilated area away from oxidants, metallic oxides dicyanofurazan, dicyanofuroxan, heat sources, sparks, and open flame. Protect containers from physical damage. Avoid storage on wooden floors. Methyl hydrazine is air-sensitive and hygroscopic; protect from moisture and handle and store under nitrogen.

Do not breathe vapors or mist. Avoid contact with skin, eyes, and clothing. Use only with adequate ventilation, preferably in a chemical fume hood. Wash thoroughly after handling and do not smoke in use or handling areas.

NOTE: Methyl hydrazine is poisonous, corrosive, and possibly carcinogenic; handle with extreme care!''

DOT CLASSIFICATION: Flammable liquid, poison, UN1244

DATA SOURCE(S) CODE (See Glossary) 1, 2, 4-9, 14, 25, 48, 49, 60, 63, 75, 78 R.

APPROVALS	11/85
INDUST. HYGIENE/SAFETY	11-85
MEDICAL REVIEW:	Dec 85

GENIUM PUBLISHING

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                              CHEMTOX DATA
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CHEMTOX RECORD 2256                        LAST UPDATE OF THIS RECORD:  02/19/86
NAME:           MONOMETHYL HYDRAZINE
SYNONYMS        HYDRAZINE, METHYL-; METHYL HYDRAZINE; METHYLHYDRAZINE;
                1-METHYLHYDRAZINE; METHYLHYDRAZINE (DOT); MMH


CAS:            60-34-4                RTECS:          MV5600000
FORMULA:        CH6N2                  MOL WT:         46.09
CHEMICAL CLASS:

PHYSICAL DESCRIPTION: COLORLESS LIQUID WITH AN AMMONIA LIKE ODOR
BOILING POINT:  350.95 K  87.8 C     190 F
MELTING POINT:  220.93 K  -52.2 C    -62 F
FLASH POINT:    343.15 K  70 C       158 F
VAPOR PRESSURE: 49.6 mm @ 25 C
AUTO IGNITION:  469.15 K  196 C      384.8 F
UEL:    98 %       LEL:      2.5 %
IONIZATION POTENTIAL  (eV):    7.67
VAPOR DENSITY:  1.59 air=1
SPECIFIC GRAVITY:  0.878 20C
DENSITY:              0.878 g/cc    or   9.1654 lb/gal
WATER SOLUBILITY:  SOLUBLE
INCOMPATIBILITIES: OXIDES OF IRON, COPPER, MANGANESE, LEAD, COPPER,
                   POROUS MATERIALS, EARTH, ASBESTOS, WOOD, CLOTH;
                   HYDROGEN PEROXIDE,NITRIC ACID

REACTIVITY WITH WATER:  No data on water reactivity
REACTIVITY WITH COMMON MATERIALS: REACTS SLOWLY WITH AIR, BUT HEAT MAY
                         IGNITION OF RAGS, RUST, OR OTHER


STABILITY DURING TRANSPORT:         No Data
NEUTRALIZING AGENTS:                FLUSH WITH WATER.
POLYMERIZATION POSSIBILITIES:       No data
TOXIC FIRE GASES:
ODOR DETECTED AT (ppm):  1-3
ODOR DESCRIPTION:          LIKE AMMONIA  Source: CHRIS
100 % ODOR DETECTION: No data

DOT HAZARD CLASS:  Flammable liquid
DOT GUIDE:            28
DOT ID NUMBER:        UN1244
DOT SHIPPING NAME: MONOMETHYL HYDRAZINE
STCC NUMBER:          4906230

EPA WASTE NUMBER:  P068
CERCLA REF:           Y
RQ DESIGNATION:       A     10 pounds (4.54 kg)
CLEAN AIR ACT:
```

NFPA CODES:
HEALTH HAZARD (BLUE): 3
FLAMMABILITY (RED) : 3
REACTIVITY (YELLOW): 1

TARGET ORGANS: CNS, RESPIRATORY SYSTEM, LIVER, BLOOD, CARDIOVASCULAR SYSTEM, EYES
SYMPTOMS : TREMORS AND CONVULSIONS FOLLOW ABSORPTION BY ANY
CONTACT OF LIQUID WITH EYES OR SKIN CAUSES IRRITATION,
AND SYSTEMIC EFFECTS. INHALATION CAUSES LOCAL
OF RESPIRATORY TRACT, RESPIRATORY DISTRESS, BURNS.
CAUSES HEMOLYTIC Source: CSDS

SYMPTOMS (CHRIS):
CONC IDLH: 5 PPM
PERMISSIBLE EXPOSURE (OSHA): 0.2 ppm SKIN - CEILING VALUE
CARCINOGEN?: Y STATUS: HUMAN POSITIVE
REFERENCES:

HUMAN TOXICITY DATA: (Source: NIOSH RTECS)

LD50 (mg/kg): 33 SPECIES: orl-rat

PROTECTION SUGGESTED:
CHRIS MANUAL:
ORGANIC CANSITER MASK OR SELF-CONTAINED BREATHING APPARATUS; GOGGLES OR
SHIELD; RUBBER GLOVES; PROTECTIVE CLOTHING

NIOSH POCKET GUIDE TO CHEMICAL HAZARDS

** WEAR APPROPRIATE EQUIPMENT TO PREVENT:
Any possibility of skin contact.

** WEAR EYE PROTECTION TO PREVENT:
Any possibility of eye contact.

** EXPOSED PERSONNEL SHOULD WASH:
Immediately when skin becomes contaminated.

** REMOVE CLOTHING:
Immediately remove any clothing that becomes wet to avoid any flammability hazard.

** THE FOLLOWING EQUIPMENT SHOULD BE MADE AVAILABLE:
Eyewash,quick drench.

** REFERENCE: NIOSH

RECOMMENDED RESPIRATION PROTECTION Source: NIOSH POCKET GUIDE (85-114) LCT= 41
NIOSH (MONOMETHYL HYDRAZINE)
Greater at any detectable concentration. : /Any self-contained breathing with full facepiece and operated in a pressure-demand or other positive mode./Any self-contained breathing apparatus with full facepiece and in a pressure-demand or other positive pressure mode./Any supplied-air with a full facepiece and operated in pressure-demand or other positive mode in combination with an auxiliary self-contained breathing apparatus in pressure-demand or other positive pressure mode./Any supplied-air with a full facepiece and operated in pressure-demand or other positive mode in combination with an auxiliary self-contained breathing apparatus in pressure-demand or other positive pressure mode.

ESCAPE: /Any appropriate escape-type self-contained breathing **appropriate** escape-type self-contained breathing apparatus.

FIRST AID (NIOSH):
EYE:
FLUSH FOR AT LEAST 15 MIN. WITH LARGE QUANTITIES OF WATER.

SKIN:
IMMEDIATELY WASH WITH LARGE QUANTITIES OF WATER AND TREAT AS FOR ALKALI

INHALATION:
MOVE VICTIM TO FRESH AIR AND KEEP QUIET; GIVE ARTIFICIAL RESPIRATION IF STOPS.

INGESTION:
GIVE EGG WHITES OR OTHER EMOLLIENT, FOLLOWED BY 5% SALT SOLUTION OR OTHER EMETIC. KEEP PATIENT AS QUIET AS POSSIBLE. TO CONTROL CONVULSIONS, BARBITUATES MAY BE ADMINISTERED PARENTERLLY BY PHYSICIAN WITH DUE REGARD DEPRESSION OF RESPIRATION.

US Department of Transportation Guide to Hazardous Materials Transport Information - Publication DOT 5800.3
DOT SHIPPING NAME: MONOMETHYL HYDRAZINE

POTENTIAL HAZARDS DOT GUIDE NUMBER 28

•HEALTH HAZARDS
Poison.
May be fatal if inhaled, swallowed or abasorbed through skin.
Contact may cause burns to skin and eyes.
Runoff from fire control or dilution water may cause pollution.

*FIRE OR EXPLOSION

Will burn. May be ignited by heat, sparks and flames.
Flammable vapor may spread away from spill.
Container may explode in heat of fire.
Vapor explosion and poison hazard indoors, outdoors, or in sewers.
Runoff to sewer may create fire or explosion hazard.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Wear positive pressure breathing apparatus and special protective clothing.
Isolate for 1/2 mile in all directions if tank or tankcar is involved in fire.
FOR EMERGENCY ASSISTANCE CALL CHEMTREC (800) 424-9300.
Also, in case of water pollution, call local authorities.

*FIRE

Small Fires: Dry chemical, CO2, water spray or foam.
Large Fires: Water spray, fog or foam.
Move container from fire area if you can do it without risk.
Stay away from ends of tanks.
Cool containers that are exposed to flames with water from the side until well after fire is out.
Withdraw immediately in case of rising sound from venting safety device or discoloration of tank.

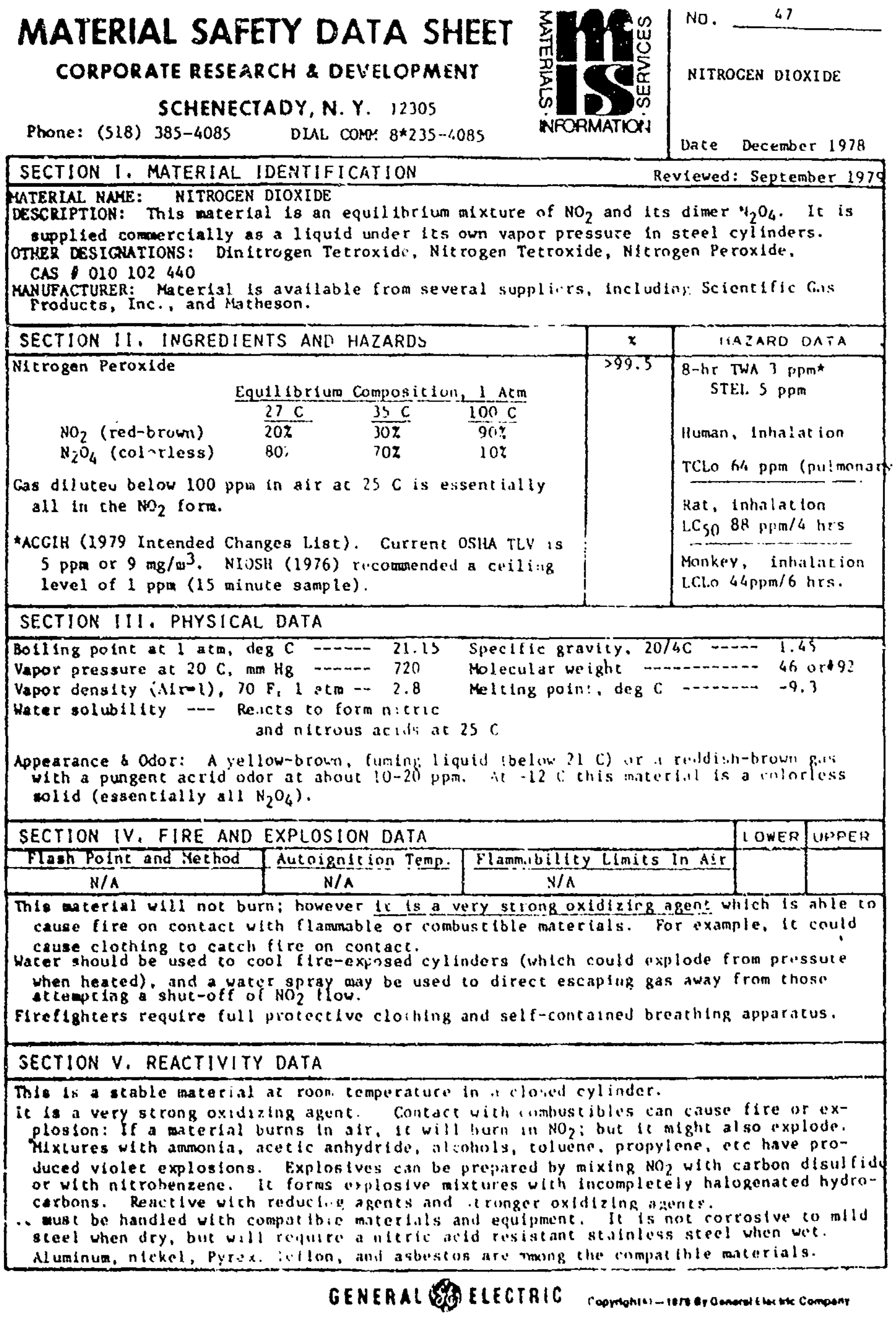
*SPILL OR LEAK

No flares, smoking or flames in hazard area.
Do not touch spilled material.
Use water spray to reduce vapors.
Small Spills: Take up with sand, or other noncombustible absorbent material, then flush area with water.
Large Spills: Dike far ahead of spill for later disposal.

*FIRST AID

Move victim to fresh air; call emergency medical care.
If not breathing, give artificial respiration.
If breathing is difficult, give oxygen.
Remove and isolate contaminated clothing and shoes.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Keep victim quiet and maintain normal body temperature.
Effects may be delayed, keep victim under observation.

DISCLAMER: The data shown above on this chemical represents a best effort on the part of the compliers of the CHEMTOX database to obtain useful, accurate, and factual data. The use of these data shall be in accordance with the guidelines and limitations of the user's CHEMTOX license agreement.
The COMPILERS of the CHEMTOX database shall not be held liable for inaccuracies or omissions within this database, or in any of its printed or displayed output forms.



MATERIAL SAFETY DATA SHEET

CORPORATE RESEARCH & DEVELOPMENT
SCHENECTADY, N. Y. 12305
Phone: (518) 385-4085   DIAL COMM 8*235-4085

MATERIALS · INFORMATION · SERVICES

NO. 47

NITROGEN DIOXIDE

Date December 1978

SECTION I. MATERIAL IDENTIFICATION

Reviewed: September 1979

MATERIAL NAME: NITROGEN DIOXIDE

DESCRIPTION: This material is an equilibrium mixture of NO_2 and its dimer N_2O_4. It is supplied commercially as a liquid under its own vapor pressure in steel cylinders.

OTHER DESIGNATIONS: Dinitrogen Tetroxide, Nitrogen Tetroxide, Nitrogen Peroxide, CAS # 010 102 440

MANUFACTURER: Material is available from several suppliers, including Scientific Gas Products, Inc., and Matheson.

SECTION II. INGREDIENTS AND HAZARDS

SECTION II. INGREDIENTS AND HAZARDS	%	HAZARD DATA
Nitrogen Peroxide	>99.5	8-hr TWA 3 ppm* STEL 5 ppm Human, inhalation TCLo 64 ppm (pulmonary) Rat, inhalation LC$_{50}$ 88 ppm/4 hrs Monkey, inhalation LCLo 44ppm/6 hrs.

Equilibrium Composition, 1 Atm

	27 C	35 C	100 C
NO_2 (red-brown)	20%	30%	90%
N_2O_4 (colorless)	80%	70%	10%

Gas diluted below 100 ppm in air at 25 C is essentially all in the NO_2 form.

*ACGIH (1979 Intended Changes List). Current OSHA TLV is 5 ppm or 9 mg/m^3. NIOSH (1976) recommended a ceiling level of 1 ppm (15 minute sample).

SECTION III. PHYSICAL DATA

Boiling point at 1 atm, deg C ------ 21.15
Vapor pressure at 20 C, mm Hg ------ 720
Vapor density (Air=1), 70 F, 1 atm -- 2.8
Water solubility --- Reacts to form nitric and nitrous acids at 25 C
Specific gravity, 20/4C ----- 1.45
Molecular weight ----------- 46 or 92
Melting point, deg C -------- -9.3

Appearance & Odor: A yellow-brown, fuming liquid (below 21 C) or a reddish-brown gas with a pungent acrid odor at about 10-20 ppm. At -12 C this material is a colorless solid (essentially all N_2O_4).

SECTION IV. FIRE AND EXPLOSION DATA

Flash Point and Method	Autoignition Temp.	Flammability Limits In Air	LOWER	UPPER
N/A	N/A	N/A		

This material will not burn; however it is a very strong oxidizing agent which is able to cause fire on contact with flammable or combustible materials. For example, it could cause clothing to catch fire on contact.

Water should be used to cool fire-exposed cylinders (which could explode from pressure when heated), and a water spray may be used to direct escaping gas away from those attempting a shut-off of NO_2 flow.

Firefighters require full protective clothing and self-contained breathing apparatus.

SECTION V. REACTIVITY DATA

This is a stable material at room temperature in a closed cylinder.

It is a very strong oxidizing agent. Contact with combustibles can cause fire or explosion: If a material burns in air, it will burn in NO_2; but it might also explode. Mixtures with ammonia, acetic anhydride, alcohols, toluene, propylene, etc have produced violet explosions. Explosives can be prepared by mixing NO_2 with carbon disulfide or with nitrobenzene. It forms explosive mixtures with incompletely halogenated hydrocarbons. Reactive with reducing agents and stronger oxidizing agents.

.. must be handled with compatible materials and equipment. It is not corrosive to mild steel when dry, but will require a nitric acid resistant stainless steel when wet. Aluminum, nickel, Pyrex, Teflon, and asbestos are among the compatible materials.

GENERAL ELECTRIC

NO. 47

SECTION VI. HEALTH HAZARD INFORMATION

TLV 3 ppm (See Sect. II)

Inhalation of NO_2 causes lung damage with severity dependent on the time and the level of exposure. Serious results may not be felt until hours or days after exposure, even though heavy damage has occurred. Exposure at 100 ppm for even a short time is dangerous and to over 200 ppm can be fatal even when treated. The discomfort or slight pain occurring at exposure may be ignored, but the cyanosis and pulmonary edema resulting from damaged lung tissue becomes disabling and can be fatal, especially if not promptly treated after exposure. Chronic exposure at 5-50 ppm can produce a slowly evolving pulmonary edema with respiratory tract irritation, cough, headache, weakness, and corrosion of the teeth. Contact with vapors is irritating to the eyes, nose, throat and wet skin; contact with liquid is corrosive.

FIRST AID:

Eye Contact: Immediately flush with plenty of running water, including under eyelids, for at least 15 minutes; then contact physician promptly. (Ophthalmologist if possible.)

Skin Contact: Remove contaminated clothing under the safety shower. Wash affected areas of skin with running water and soap and water for 15 minutes. Get medical help.

Inhalation: Remove exposed person to fresh air at once. Instruct to breathe rapidly and deeply for a few breaths to flush out lungs. Keep warm and at rest. Have qualified person administer oxygen. Contact physician immediately!

SECTION VII. SPILL, LEAK, AND DISPOSAL PROCEDURES

Notify safety personnel when leaks are detected or suspected. Provide maximum exhaust ventilation. Discontinue operations; exclude from site all except those involved in clean-up who are properly protected (see Sect. VIII). NO_2 measuring devices, moist blue litmus paper or starch-iodide paper can be used to locate small leaks. The red-brown color of NO_2 will make large leaks evident. Stop source of NO_2. Isolate and remove any leaking cylinder. Place in hood or in safe outdoor area. When slow release of gas to the air is unacceptable, attach needle valve and tube to run NO_2 into an excess of 5-10% aqueous sodium hydroxide solution (caution!) at a moderate rate, then neutralize for disposal. Cover liquid spill with an excess of $NaHCO_3$; mix; spray with water from atomizer, then flush to holding tank for disposal.

Disposal - Follow Federal, State and local regulations. Dilute neutral, low nitrite waste with much water and flush to drain with lots of water to meet dilution requirements for $NaNO_2$ discharge. (Waste high in nitrite requires oxidation to nitrate before discharge.)

SECTION VIII. SPECIAL PROTECTION INFORMATION

Use closed processing to prevent exposure whenever feasible. Consider use of continuous NO_2 monitoring devices. Use an exhaust hood with minimum 100 lfm face velocity to enclose. Provide general ventilation and local exhaust ventilation to meet TLV requirements. For emergency and nonroutine exposure provide an approved full facepiece respirator above the TLV; a cartridge or canister type can be used below 50 ppm; a self-contained or air-supplied respirator is required above 50 ppm or for unknown levels.

Prevent skin contact with liquid or vapors by use of gloves and protective clothing. Use safety goggles and a face shield for eye protection. Instant action eyewash stations and safety showers are needed in close proximity to use and handling area.

Those working with NO_2 must have special training in hazards and handling and close supervision.

SECTION IX. SPECIAL PRECAUTIONS AND COMMENTS

Observe basic precautions for handling and use of pressurized cylinders. Note! NO_2 cylinders do not have safety devices for pressure relief; store away from heat sources in low fire risk areas. Keep away from solvents, fuels, lubricants, combustibles, reducing agents. Use compatible materials and equipment for handling NO_2. Obtain detailed information from suppliers for handling and use under specific conditions.

O_2 and N_2 can react in an electric arc or other high temperature source to produce hazardous levels of NO_2; combustion of nitrogen-containing materials will produce NO_2.

Provide preplacement medical examination and at least an annual examination of exposed personnel with special attention to pulmonary function tests and dental care.

Preclude from exposure individuals with cardiac or pulmonary disease.

DATA SOURCE(S) CODE: 2,4-6,9,12,15-17,19,20

APPROVALS: MIS, CRD

Industrial Hygiene and Safety

Corporate Medical Staff

GENERAL ELECTRIC

(The reverse of this page is blank.)

APPENDIX B

TEST AUTHORIZATION DOCUMENTS

8-27 H McCormack T. Stepetic)
970-6256 246-0778

RDCF

Request Use of NTS Facilities

Mr. Thomas R. Clark
Manager, Nevada Operations Office
US DOE
P.O. Box 14100
Las Vegas NV 89114

1. Pursuant to the July 8, Headquarters Space Division letter, a copy of which was forwarded to your Ms Wendy Dixon, we wish to proceed with the fire suppression foam testing described therein and formally request the use of Nevada Test Site (NTS) facilities for these tests.

2. Request a 3-week window beginning on 21 Oct 85. Ideally, the tets can be completed in 1 1/2 to 2 weeks, but adverse weather conditions could stretch this period to 3 weeks. General construction support requirements will be minimal; however, we will require photographic support, both still and vidao. Funds are available for site rental and support.

3. The following agencies will have personnel on the site during the testing period:

HQ AFESC	2 persons	Full Test Period
Hill AFB	1 person	Full Test Period
NMERI	3 persons	Full Test Period
MSAR	4 persons	Full Test Period
Aerospace Corp	1 person	1st week

4. On-site billeting is requested for the individuals identified in paragraph three. Additional personnel from this office and the New Mexico Engineering Research Institute (NMERI) will view certain tests of the series, but will not require billeting. Security clearances and visit requests will be provided for all participants.

5. Point of contact at NMERI for further information/assistance is Mr Tim Stepetic, commercial telephone 505-247-3412.

JOSEPH L. WALKER
Chief, Fire Technology Branch

cc: MSAR(Mr. Hiltz)
HQ SD(Capt Betschart)
Aerospace(Mr. Lewis)
NMERI(Mr. Stepetic)

RD ________

RDC ________

RDCF 26 SEP 1985

Use of NTS Facilities (Our ltr, 27 Aug 85)

Mr. Thomas R. Clark
Manager, Nevada Operations Office
US DOE
P.O. Box 14100
Las Vegas NV 89114

1. In response to your request, enclosed is a draft copy of the test plan for use of the DOE Nevada Test facilities. The site will be used for validation testing of a newly developed hypergolic vapor/fire suppression foam and environmental sampling acquisition. Test facilities are requested for a 3-week period beginning 21 Oct 85.

2. Point of contact at the New Mexico Engineering Research Institute (NMERI) for further information/assistance is Mr. Tim Stepetic, commercial telephone (505)247-3412.

SIGNED

JOSEPH L. WALKER
Chief, Fire Technology Branch

1 Atch
Test Plan

cc: NMERI
AFSC/CFPE (Capt Betschart)

RDCF
COORD

RDC
RF

AFESC/CC
RF

RDCF, Joe Walker ________ 6451, 25 Sep 85, hsm

Department of Energy
Nevada Operations Office
P. O. Box 14100
Las Vegas, NV 89114-4100

November 8, 1985

Joseph L. Walker
Chief, Fire Technology Br.
HQAF Engineering & Services Center
Dept. of the Air Force
Tyndall Air Force Base, FL 32403

APPROVAL TO CONDUCT FIRE SUPPRESSION TESTING OF HYPERGOLIC VAPOR CONTROL FOAMS AT THE NEVADA TEST SITE (NTS)

A review of your proposal to conduct the subject tests has been completed. Approval of your request is hereby granted, subject to the enclosed conditions. Any significant deviation in the program or intended use of the facilities as set forth in your test plan must be approved by this office in advance of any NTS activity relating to those changes.

If you have any questions regarding the aforementioned conditions, please contact Lon Kilmer, Resource Management & Budget Division (702) 295-0968.

Thomas R. Clark
Manager

RMBD:LK-1051

Enclosure:
As stated

cc:
Ralph Hiltz, MSAR, Mine Safety
  Appliances Co., Evans City, PA
Tim Stepetic, NM Engrg. Res. Inst.
  Univ/NM, Albuquerque, NM
R. H. Ide, Resident Mgr., LLNL, Mercury, NV
R. H. Ide, Field Opns. Prog. Leader/Nuclear Test
  Group Director, LLNL, Livermore, CA
T. T. Scolman, Dep. Assoc. Dir., Test Opns., LANL, Los Alamos
J. D. Kennedy, Org. 7130, SNL, Albuquerque, NM
B. G. Edwards, Resident Mgr., SNL, Mercury, NV
H. D. Cunningham, Gen. Mgr., REECo, Las Vegas, NV
A. E. Gurrola, Vice Pres. & Genl. Mgr., H&N, Las Vegas, NV
R. W. Titus, Meteorologist-in-Charge, NOAA/WSNSO, Las Vegas, NV
Col. R. W. Smith, USAF/DOE-NV Liaison Officer, NV

cc: (continued)
R. M. Nelson, Jr., AMO
R. W. Taft, AME&S
V. F. Witherill, Director, NTSO
J. K. Magruder, Director, TOO
S. R. Elliott, Director, SHO
B. W. Church, Director, HPD
D. F. Miller, Director, OPA
E. W. Adams, Director, SSO
J. R. Rinaldi, QAO
F. E. Bingham, HPO

CONDITIONS FOR APPROVAL TO CONDUCT FIRE SUPPRESSION TESTING OF HYPERGOLIC VAPOR CONTROL FOAMS AT THE NEVADA TEST SITE (NTS)

1. General

This approval is subject to your compliance with the rules and regulations set forth for the NTS. All tests will be conducted on a noninterference basis with the Nuclear Weapons Program and other test site operations. Should a conflict develop between your test activity and ongoing NTS activities, access to specific areas may be delayed due to security or safety considerations.

Approval for use of the NTS must in no way affect the jurisdictions, responsibilities, and authorities of the DOE or the Air Force.

2. Environmental Aspects

The 1983 "Environmental Assessment for Spill Test of NH_3 and N_2O_4 at Frenchman Flat" will cover the activity. DOE/NV has prepared an environmental evaluation which satisfies the requirements of the National Environmental Policy at (NEPA).

3. Safety and Health

The MSAR Test Director will be responsible to the Manager, NV, for the safety of all Fire Suppression tests at the NTS and for assuring a safe and healthful work place.

The DOE safety, health and fire protection standards and the NTS Standard Operating Procedures (SOPs) will be applicable in addition to any other such standards which the Air Force might impose on the program.

A State of Nevada permit is required to conduct the specified tests. Application was filed by the Safety and Health Division, NV, on approximately September 15, 1985. Approval is anticipated, but has not yet been received.

4. Claims

The Air Force will be financially responsible for and will process claims that may arise as the result of the activities of its personnel or its contractor personnel. DOE will be financially responsible for and will process claims arising out of activities of its personnel or its contractor personnel.

5. Funding

NV will be reimbursed for all costs associated with the testing at the NTS. A funding document from the Air Force (MPR) will be provided to DOE/NV prior to the initiation of associated activities.

6. Construction Operations

All construction operations will be performed according to present SOPs (6001) by DOE contractors at the direction of NV/NTSO.

7. Weather Support

WSNSO will provide meteorological support as requested by the test organization and as required by the NV Operations Controller.

8. Security

Existing security rules for access to the NTS will be followed. Program personnel who require access to the NTS will follow normal visitor control rules concerning the submittal of visit requests through cognizant security offices which will result in the issuance of security badges.

Security personnel will be utilized to sweep, control, and aid in emergency evacuation support during periods of testing. Security details will be elaborated within the DOE/AMO Operations Plan.

9. Housing

Arrangements for housing must be coordinated with the REECo Housing Custodial and Food Services Department at (702) 986-9421. Housing requirements of personnel from other NTS programs will have precedence.

10. Medical

Paramedic and ambulance support will be provided by REECo from Mercury in the event of an emergency.

11. Concept of Operations

The test period has been revised to provide for commencement of tests on November 12, 1985, with arrival of personnel and test preparation activity during the prior week. Prior to the initiation of test activity, the Air Force will provide an organizational responsibility plan which clearly delineates the MSAR/NMERI responsibilities for conduct of the tests.

The DOE/NV Operations Controller will be represented by a DOE/NV Operations Coordinator who will serve as the on-site representative for the Operations Controller for any actions deemed necessary.

All test personnel will fully comply with NTS emergency evacuation policies and directions. Prior to commencing operations, an Operations Permit must be obtained from the Operations Coordination Center (OCC), NTS (702) 295-4015.

The concept of operations will be detailed within the DOE/AMO Operations Plan as established specifically for these tests.

12. Decommissioning

All trailers and other remaining equipment will be removed upon completion of the last test unless otherwise extended by permission from DOE/NV. Unusable equipment and debris will be properly disposed of in accordance with DOE/NV requirements.

13. Passes for Access and Egress of Equipment

To arrange for appropriate passes for entry on the NTS, a list of all equipment and vehicles and their contents must be submitted to the assigned NTS Project Engineer (Winfred Wilson) seven days in advance of delivery.

All property exiting the NTS must have a Radioactive Clearance sticker, available at the Radioactive Material Control (RAMATROL) Building, NTS (702) 295-7090, affixed to the Property Removal Authorization. A Property Removal Authorization can be obtained from the assigned NTS Project Engineer (702) 295-4001.

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR FORCE ENGINEERING AND SERVICES CENTER
TYNDALL AIR FORCE BASE, FL 32403

REPLY TO ATTN OF: RDCF (Mr Bryce Mason, 904 283-6194) 27 FEB 1986

SUBJECT: Use of NTS Facilities

TO: Mr Thomas R. Clark
Manager, Nevada Operations Office
USDOE
P.O. Box 14100
Las Vegas, NV 89114

1. References:

a. My letter, 27 August 1985, same subject, which formally requested the use of NTS facilities for fire suppression testing. .

b. My letter, 26 September 1985, same subject, which forwarded the test plan for the subject fire suppression tests.

c. Your latter, 8 November 1985, approving the use of NTS facilities for the testing.

2. While we were able to conduct a good series of 21 successful tests at NTS from 12 to 24 November 1985, we were not able to complete the test matrix due to weather constraints. I am enclosing a summary report of the November effort for your information. A total of 15 tests remain to be conducted and our proposed schedule for these tests is attached. These tests are all contained in the original test plan matrix.

3. Request a 2-week window beginning 4 April 1986 to complete this test series. General construction support requirements will be minimal and photographic support will not be required. Funds are available for support. Further request that on-site billeting be available for two NMERI and four MSAR personnel. Additional personnel from this office and NMERI may view certain tests, but will not require billeting. Security clearances and visit requests will be provided for all participants.

4. Please contact myself or Mr Tim Stepetic of NMERI (Commercial 505 247-3412) if we may be of any further assistance.

Joseph L. Walker
JOSEPH L. WALKER
Chief, Fire Technology Branch

2 Atch
1. Field Test Report
2. Test Schedule

cc: MSAR(Mr Hiltz)
HQ SD(Capt Betschart)
Aerospace(Mr Lewis)
NMERI(Mr Stepetic)

ATTACHMENT 1

Department of Energy
Nevada Operations Office
P. O. Box 14100
Las Vegas, NV 89114-4100

March 21, 1986

Joseph L. Walker
Chief, Fire Technology Br.
HQAF Engineering & Services Center
Dept. of the Air Force
Tyndall Air Force Base, FL 32403

USE OF NTS FACILITIES

Reference your letter dated February 27, 1986, subject as above, requesting approval to proceed with 15 previously described and planned tests which were not completed during your November 1985 test period.

Approval of your request is hereby granted, based upon the Test Plan documentation submitted for the November test period. This approval is subject to those same conditions which applied to our original approval letter of November 8, 1985, copy enclosed. A new state of Nevada permit will not be required, however, as the state has been advised of a resumption of testing to complete activities planned to occur under the original permit application.

Current NTS scheduling conflicts will require that your two-week test period commence on April 11, as opposed to your proposed date of April 4. You should also anticipate some conflict during the two-week period which could feasibly extend your test period by a couple of days.

If you have any question regarding these conditions, please contact Lon Kilmer, Resource Management and Budget Division, (702) 295-0968.

Thomas R. Clark
Manager

RMBD:LK-0352

Enclosure:
As stated

cc w/encl:
Ralph Hiltz, MSAR, Mine Safety
  Appliances Co., Evans City, PA
Tim Stepetic, NM Engrg. Res. Inst.
  Univ/NM, Albuquerque, NM
R. H. Ide, Resident Mgr., LLNL, Mercury, NV
R. H. Ide, Field Opns, Prog. Leader/Nuclear Test
  Group Director, LLNL, Livermore, CA
W. P. Wolff, Test Gp. Director, LANL, F-670, Los Alamos, NM

ATTACHMENT

cc w/encl: (continued)
W. P. Wolff, Test Gp. Director, LANL, Mercury, NV
J. D. Kennedy, Org. 7130, SNL, Albuquerque, NM
B. G. Edwards, Resident Mgr., SNL, Mercury, NV
H. D. Cunningham, Gen. Mgr., REECo, Las Vegas, NV
A. E. Gurrola, Vice Pres. & Genl. Mgr., H&N, Las Vegas, NV
R. W. Titus, Meteorologist-in-Charge, NOAA/WSNSO, Las Vegas, NV
Col. R. W. Smith, USAF/DOE-NV Liaison Office, NV
J. K. Magruder, Actg. AMO
R. W. Taft, AMES
V. F. Witherill, Director, NTSO
J. D. Stewart, Actg. Director, TOD
S. R. Elliott, Director, SHD
B. W. Church, Director, HPD
D. F. Miller, Director, OPA
E. W. Adams, Director, SSD
J. R. Rinaldi, Director, OAD
F. E. Bingham, HPD
W. A. Wilson, NTSO

FORM NV-50
(REV. 4/86)

US DOE
NV

OPERATIONS PERMIT

Permit No. 86-009

Date: 04/11/86

Sponsoring Agency: Mine Safety Appliances Research Effective Dates 04/11/86 - 05/02/86

Technical Agency in Field: MSAR

Project Designation: Fire Suppression Testing of Hypergolic Vapor Control Foams

ACTIVITY (Brief Description) 1) Develope documentation that may be used for A.F. Certification of the presently developed hypergolic propellant vapor control foams for use as fire suppressants, 2) To identify the chemicals released into the enviroment when foams are used to control hydrazine fires.

Field Operations will be under the direct supervision of: Thomas J. Stepetic

who may be reached at: (Telephone Number) 295-4373 (Radio Net) 14

Activity approved by: (Cite DOE letter or other authority) DOE/NV letter from Tom Clark to J. Walker, USAF dated 11/08/85, subject Use of NTS Facilities & NV letter same subject dated 11/26/85 signed by Bob Nelson

DOE On-site Representative/s Vince Iorii, TOD (5-1140), Bob Simms, OMB (5-4015)

The following guidelines apply to this work:

x (1) Provisions of NTSO-SOP except as may be described below.

x (2) Removal of classified materials from the Nevada Test Site (NTS) will be coordinated with Safeguards and NTS Security (5-0082).

X (3) All materials that are being transported off the NTS must be processed through REECo RAMATROL (5-7090).

X (4) Quality Assurance standards shall be maintained as relates to procedures, fabrication of materials, training of personnel and equipment.

X (5) All test locations will be restored to their original conditions.

X (6) Upon completion of activity, the Agency Representative will notify the OCC by calling 5-4015

x (7) All conditions as stated in the original letter of approval will be adhered to.

for ______ has been briefed by Robert T. Simms
AGENCY REPRESENTATIVE — DOE OPERATIONS COORDINATION REP
Eugene V. Polite — Robert T. Simms

cc Health Physics Division, NV
Test Operations Division, NV
Quality Assurance, NV
Director, NTSO, Mercury, M/S 701
SL, NTS, Security Branch, Mercury, M/S 701
SMO, NTSO, Mercury, M/S 701
REECo Environmental Sci., Attn: A. [illegible], Mercury, C. [illegible], CP-10, M/S 709
REECo Occupational Safety & Fire, Mercury, M/S 745
Agency Representative
CP-1 File

APPENDIX C

MINUTES OF SIGNIFICANT MEETINGS

Technical Interchange Meeting
Fire Suppression Testing of Hypergolic Vapor Control Foams

3 June 1985

A technical interchange meeting was held at MSA Research, Evans City, PA to provide NMERI (New Mexico Engineering Research Institute, contractor to HQ AFESC/RDCS Tyndall AFB) with information that will enable them to make the best selection of site and crew for the forthcoming tests. The meeting was held at the request of NMERI. In attendance at the meeting were: Messrs Ralph Hiltz, Stanley Hoover and Jack Greer of MSAR; Drs. Robert Tapscott and Harold Beeson of NMERI; Mr. Joseph Ranftl of The Aerospace Corporation. Dr. J. Wilson Mausteller, General Manager of MSAR was also introduced but did not participate in the technical discussion.

1.0 Discussion

The meeting began with a brief introduction by MSAR regarding their specialization in foams having properties of low drainage and high stability. NMERI posed a series of questions relating to the past experience of MSAR in dealing with tests on hypergolic propellants and also pertinent to the forthcoming tests. Responses are summarized in the following:

1.1 Regarding hazard data for the Nevada Test Site (NTS) MSAR has done an analysis for NTS and this information is incorporated in their Operational Plan for testing at NTS (copy of plan available to NMERI). MSAR stated further that whether tests are made at any particular time at NTS depends solely on the judgement of local site management which is not greatly influenced by users input.

1.2 MSAR plume calculations are based on an Air Force Manual (reference given to NMERI). N_2O_4 release is more critical than hydrazine.

1.3 MSAR expects that NTS could be made available within 6 weeks lead time - 8 weeks maximum. MSAR has been there 6 times already for tests and have stainless steel fire pans at NTS.

1.4 Use of the site costs $15,000 - 25,000 per week. MSAR, Tyndall and Space Division should be able to get it at the lower figure in negotiation with Al Dietz, D.O.E. Washington. Security guards are the biggest cost because of high overtime pay for all services, portal pay, etc. If area #11 could be fenced, costs could be lowered. Any already secure area that might be available would reduce costs, for example ETS-1 previously used but not available for the coming tests.

1.5 MSAR has extinguished some pure hydrazine fires with foam. 5 ft x 5 ft pans were used. High expansion foam was applied at a normal flow rate, however the low expansion foam was applied in excess.

1.6 For the tests planned, a 3 inch diameter hand held aerating nozzle will deliver 75 cfm of 350:1 foam. For low expansion a standard three to six gal/min. nozzle would be used at an 8:1 expansion ratio.

1.7 MSAR furnishes and uses their own protective clothing and breathing apparatus. No self contained breathing apparatus has been used nor is anticipated if MSAR performs the tests. There have been no accidents in past related testing.

1.8 MSAR would use 3 people to run the tests, 2 on equipment and 1 on data.

1.9 Spring is the best time of the year for tests at NTS, summer too hot, but September and October are satisfactory.

2.0 Foam Demonstration

Following the question-answer session, MSAR demonstrated foaming equipment and their foam test facility. The generation rate ranged from 75 cfm to 6000 cfm, depending on the equipment used.

3.0 Site Options

The remainder of the meeting centered on the necessity of an early decision on site and test personnel in order to assure certification of the foam by February 1986, assuming successful tests. Although many options are possible, it was decided to consider the following options:

3.1 NMERI mans all tests at Kirtland

3.2 NMERI mans fuel tests at Kirtland and MSAR mans oxidizer tests at NTS

3.3 MSAR mans all tests at NTS

3.4 MSAR mans fuel tests at Kirtland and also mans oxidizer tests at NTS

4.0 Selection Factors

Tyndall AFB has been suggested as an alternate site to Kirtland. Such a decision does not materially affect the issues associated with the above four selections nor the logic in making a choice. The most significant differences in the above options follow:

4.1 Under options 3.1 and 3.2 and to use Air Force fire crew the use of RFHCO clothing would be required. Associated with this is the cost of Air Force specialists and training on-site, as well as the supporting facilities pertinent to the use of RFHCO.

4.2 In options 3.2, 3.3 and 3.4 NMERI/Tyndall would bear the costs of use of NTS.

4.3 Options 3.3 avoids the necessary permitting at Kirtland to be performed by NMERI and estimated to require 2 to 3 months time. This would enable testing at an earlier date and also allows substantial cost avoidance.

5.0 Action Items

5.1 NMERI will decide by 14 June on which option they wish to pursue and so inform Space Division (in conversation with Dr. Dennis Zallen on 6 June this date was changed to no later than 21 June because of NMERI travel schedules and the necessity to confer with Tyndall).

5.2 Aerospace/Space Division will assist in locating surplus hydrazine to minimize fuel costs for the tests. This can be effectively accomplished only after the site is selected and receiving arrangements made.

5.3 If tests are to be performed at NTS, Space Division is to contact Wendy Dickson at DOE to give go-ahead on information already furnished her, by MSAR (this is because of Ralph Hiltz's travel out of the country until 16 July).

5.4 If tests are to be performed at Kirtland, MSAR will make a pretest visit for site and facilities review.

THE UNIVERSITY OF NEW MEXICO
NEW MEXICO ENGINEERING RESEARCH INSTITUTE

DATE : September 16, 1985
TO : See Distribution
FROM : Tim Stepetic, APT Division
SUBJECT: Meeting on Fire Testing of Hypergolic Vapor Control Foams, September 10, 1985, APT Conference Room, 2420 Alamo, Albuquerque, N.M.

1. The subject meeting commenced at 8:00 AM, with the following people in attendance:

Mr. Joe Walker	HQ AFESC/RDCF
Mr. Sherwin Lewis	Aerospace Corp.
Capt. Jim Betschart	Space Division
Mr. Ralph Hiltz	MSAR
Dr. Bob Tapscott	NMERI/APT
Mr. Tim Stepetic	NMERI/APT

2. The first subject discussed was the make-up and provision of propellants required for the tests. NMERI has placed a propellant order for the following propellants to be sole-sourced from the San Antonio Air Logistic's Center at Kelly AFB:

MMH	17 drums
Aerozine-50	3 drums
N_2O_4	1 one-ton cylinder

The order was placed with the request that "OFF-SPEC" propellants (with 5% H_2O limitation in MMH) be furnished to the maximum extent possible. The group decided that up to 15 drums of the MMH requirement could be filled by OFF-SPEC Aerozine-50, if it is available. It was also decided that two drums of anhydrous hydrazine and two drums of UDMH would be tested. NMERI will adjust the propellant request to reflect these changes.

3. It is understood that Mine Safety Appliances Research (MSAR) will provide all foam and delivery apparatus with the exception of 10 gallons of AFFF and 10 gallons of polar fuel foam to be furnished by Mr. Walker. MSAR will further furnish appropriate wearing apparel and breathing apparatus for their personnel and a reasonable number of other participants as determined by MSAR. Appropriate footwear is the responsibility of each participating/observing individual. MSAR will furnish NMERI with general data on safety apparatus and safety distances.

4. The testing plan as originally developed by MSAR along with a test matrix were discussed in considerable depth. A test sequence and schedule were agreed upon and are provided as attachments 1 and 2 to this memorandum. Test numbers are in accordance with the original MSAR matrix which is now expanded to include UDMH as Entry B, anhydrous hydrazine as Entry D and polar fuel foam as Entry 24.

5. Mr. Walker has sent the formal request for site use to the Nevada Operations Office, and Mr. Hiltz has provided the same office with an acceptable operation/safety plan. Dr. Tapscott will finalize the sampling plan (completed - Attachment 3) by the end of this week and send it through Mr. Walker to NTS no later than the middle of next week. NTS will require 2 to 3 weeks to process the complete request. Mr. Walker will also MIPR the site support funds to US DOE at NTS.

6. We will plan to have the NTS photo support contractor, Pan American, handle our photography requirements. In addition to a comprehensive series of still photos, we will require video with time overlay and some sort of IR or UV video, also with time overlay. NMERI will work closely with the photographer(s) to insure complete test coverage.

7. Captain Betschart will provide NMERI with an MDA sensor and tapes for use during the tests. He'll ship it to NMERI, who will take it to the test site and set it up.

8. NMERI will assemble a final test plan, drawing from MSAR's plans and matrix and Dr. Tapscott's sampling plan. The plans will be submitted to Mr. Walker for approval NLT 23 September 1985.

9. UL 162 procedures were discussed in considerable depth. The low expansion foam will be tested in accordance with UL 162 and the high expansion foam will be tested in accordance with NFPA 11 A.

10. If anyone desires corrections/additions to these minutes, please contact me.

Tim Stepetic
NMERI/APT
AUTOVON (244) 9462
Commercial (505) 247-3412

3 Enclosures

Distribution:

Mr. Joe Walker
AFESC/RDCF
Tyndall AFB, FL 32403

Mr. Sherwin Lewis
Aerospace Corporation
Director, Chemical Systems Office
2350 East El Segundo Blvd.
P. O. Box 92957
Los Angeles, CA 90009

Major Tom Lubozynski
AFESC/RDV
Tyndall AFB, FL 32403

Capt. James Betschart
SD/CFPE
LAAFS Box 929600
Los Angeles, CA 90009

Mr. Ralph Hiltz
MSA Research Corporation
Evans City, PA 16033

Mr. Surendra Joshi
AFESC/RDV
Tyndall AFB, FL 32403

October 7, 1985

MEMORANDUM OF MEETING

1. A meeting was held at the Mine Safety Appliances Research Corporation, Evans City, PA on October 1, 1985 to discuss testing protocol and MILSPEC requirements for Subtask Statement #3.20, Fire Suppression Testing of Hypergolic Vapor Control Foams. The following attended:

Mr. Ralph Hiltz	MSAR
Mr. Tom Hughes	Hughes and Assoc.
Mr. Ed Bolander	Hughes and Assoc.
Mr. Phil Di Nenno	Hughes and Assoc.
Dr. Bob Tapscott	NMERI/APT
Mr. Tim Stepetic	NMERI/APT

2. Mr. Hiltz opened the meeting by giving a general background on how this project came into being as a result of the increasing use of the hypergolics in the space programs and the Damascus, AK, Titan II incident. The resultant vapor control foams are essentially validated and now have official Technical Order procedures and National Stock Numbers; however, they have never been seen through the MILSPEC process. The storage facilities at the present launch sites are still upper and lower water deluge systems with the capability to turn off the upper system and use foam in the lower system.

3. Mr. Hughes stated his concern that the data anticipated from the tests presently planned would not be sufficient to produce a draft MILSPEC as required by the Subtask. He feels more effort must be made to reduce variables such as application Type II versus III, the effects of scale and the use of MIL-F-24385C versus UL162 as a criteria foundation. Mr. Hiltz stated that he felt that the MILSPEC is biased toward AFFF (Mr. Hughes agrees) and that UL162 better parallels the character of polar solvents. He further feels that Type III will probably not work with polar solvents and the extinguishment of a square fire presents a tougher challenge than a round fire. The N_2O_4 reactive fires with fuel, tires and wood are basically background tests and results will not necessarily be incorporated in the resultant specification document.

4. Mr. Bolander asked if we could reduce the number of N_2O_4 fires and increase the number of MMH tests, but we are too far into the project to make this significant a change at this date.

5. As regards scaling, previous vapor control testing at the Nevada Test Site (NTS) used 50 SF pans and for ease of late scheduling, the same was specified for fire suppression tests. Further investigation is required as to NTS allowable fire sizes for possible future tests. MSAR lab tests involved 9 SF fires with a low expansion rate of 6 gal/min and high expansion rate of 1.5 CFM/SF.

6. The following aspects of the test protocol were discussed in considerable detail:

a. Tests A1, 2 and 3 will be done with Type II application, imparting the rear of the pan approximately 2" above the fuel. A-15 and possibly others in the 15 series will be Type III application, hand-held with moving, lateral application if possible.

b. Standard nozzles will be used in all tests (National Foam 2, 3 and 6 GPM). Hughes Assoc. will loan MSAR an AFFF 2 GPM nozzle for the AFFF tests. NMERI will arrange for a back-up AFFF nozzle.

c. The standard pan (4 each) to be used will be 50 SF square (7.07' X 7.07'), 12 inches high. We will also do a second test for N-29 with a 28 SF round pan, four inches high. Mr. Hiltz will place the work order with RECO, through Mr. Win Wilson of NTS, to construct these 5 pans. On the square pans, we will exercise judgment on the degree of corner extinguishment required and attained.

d. The type of nozzles and nozzle variances are OK. The nozzle's pressure will be 100 PSI from a pumper with a 250 PSI capacity. The nozzles will have flow control readouts.

e. Pre-burn period for all tests will be 2 minutes.

7. Mr. Hughes advised of the need to closely monitor the effects of personal proximity to the fires. We all agreed that this will be handled as a major safety item and that it is a subject for future study with different ensembles and wearing apparel. We must also be alert to the possible contamination of apparel.

8. Mr. Bolander addressed the following physical and chemical characteristics of the foams.

a. Refractive Index is required for each solution to measure concentrations. MSAR uses refractive index as a quality control measurement for chemical deterioration and mechanical contamination. MSAR will furnish the index figures to Ed.

b. Viscosity must be closely tracked within a range. Again, MSAR will furnish figures. Viscosity is kept under 100 CPS, usually around 70. Pectin is heavily viscous in the surfactant and an in-line mixer is used.

c. PH for the mixed foams is about neutral with an acidic acrylic and basic surfactant. The ASE 95 used for the fuels gels on the basic side and can be readily pumped. The ASE 60 used for the oxidizer gels on the acid side and cannot be pumped due to high speed shear breakup of the emulsion. ASE 60 is fed through a proportioner and is buffered for storage. Containers are polyethylene lined.

d. Spreading Coefficient is not used because the foam is not film-forming. It has a surface tension of approximately 24.

e. Foamability is determined by MSAR through the quarter drainage of the graduated cylinder. This is the NFPA 4.12 test which works better with two materials.

f. Dry Chemical Compatability is not addressed because of Air Force phase-out plans for dry chemicals.

g. BOD and COD should be further analyzed later in the program. MSAR has BOD figures for a 2% solution, but they are presently using a 10% solution.

h. Environmental requirements will be determined by Hughes Assoc. and the requirements will be passed to MSAR. On proprietary materials MSAR will disclose contents but not proportions.

i. Stripability is presently being done by MSAR and data are available.

j. Sealability will be assessed via the wand test prescribed in UL 162.

k. Aging data are coming available through a Space Division contract with Fresno State University.

9. There is a range of product validation documents which can vary between a minimum of a proprietary product description through to a final specification. Hughes Assoc. will provide me with such a listing and the correspondent time, test programs and dollars required to produce each type of document. It is not generally felt that this test program and a limited amount of dollars can produce a draft military specification by April 1986. It was later learned from Captain Betschart of Space Division that the first west coast shuttle launch will take place in the April/May 1986 time frame and that he is looking for a milestone schedule which delineates managerial control and visibility of a program designed to produce a final MILSPEC.

10. Due to MSAR's three-week limitation on field activities, the test schedule will break after 1 November and testing (if necessary) will resume on 11 November.

11. The meeting closed with general agreement on all test aspects and optimism that the test schedule would be executed successfully with desired results.

Tim Stepetic

Tim Stepetic

February 14, 1986

MEMORANDUM OF MEETING

1. A meeting was held at NMERI on January 29, 1986 to discuss the continuation of the fire suppression testing of hypergolic vapor control foams. The meeting was attended by Captain James Betschart, Space Division; Mr. Ralph Hiltz, MSAR; Dr. Robert Tapscott, NMERI and Mr. Tim Stepetic, NMERI.

2. Mr. Hiltz had developed a proposed schedule for the continuation of testing at NTS in the 2 to 17 April 86 time frame. This was reworked and the agreed upon schedule is attached. The N_2O_4 will not be transported to the site until the A50 tests are complete. The A50 tests will be a design rate series for both high and low expansion - three tests in each series. There will be no A50 or MMH on site during the N_2O_4 testing except for the final two tests which incorporate both N_2O_4 and MMH. During the three overnight N_2O_4 soak tests, MSAR personnel will man the test site to avoid added security costs and to respond to (low probability) reactive combustion.

3. Because of the NTS processing time for site use and the newly added State of Nevada review requirement, it is imperative that the site request letter be moved as soon as possible. The draft site request letter with schedule was sent to AFESC/RDCF on 13 February for forwarding to NTS.

4. Captain Betschart had several good suggestions for use in developing the final report. The report should address the general effects of wind on extinguishment times. Also, the report should contain extensive background of all Air Force hypergolic studies to date.

   Additional report techniques on acronyms and content listings were discussed. Chemical data sheets on all associated propellants, foams, etc. will be included.

5. The continuation of this project was discussed in detail. $75K is required to complete the testing - such funds are not available at present. The alternative is to reduce the scope of the project to cover a MILSPEC for hydrazine fire suppression foams only. This would require returning the unused fuels through Kelly AFB to the suppliers and receiving a refund ($17.5K) and receiving a refund from NTS for site support costs paid but not incurred ($13K). The excessive costs incurred by this project were generated by the following:

   a. An extremely short period of time (7 weeks) between the project start date and the available NTS testing window generated horrendous logistical problems, the resolution of which required many more man-hours than planned.

   b. The test schedule slipped twice, necessitating the time and expense of altering all logistical arrangements. A new hazardous material transport ordnance passed by Clark County, Nevada further complicated fuel shipping schedules.

February 14, 1986

MEMORANDUM OF MEETING (continued)

c. The fuels cost of $69K significantly exceeded the budgeted cost of $50K.

d. The cost of purchasing and assembling the sampling apparatus exceeded planned cost because the device was the first of its kind to be built and required many refinements as construction proceeded and techniques were revised.

Funds required are as follows:

MILSPEC Preparation	$25K
NTS Use and Support	$19K
Purchase of A-50	$ 6K
TDY and Salaries	$25K

A determination on funds for the remainder of this project must be made as soon as possible.

Tim Stepetic

Tim Stepetic
NMERI/APT Principal Investigator

TEST SCHEDULE FOR N_2O_4 FIRE TESTS

NTS - April 1986

April 7	A50 Fire Tests - High Expansion Start with 118 cfm
April 8	A50 Fire Tests - Low Expansion
April 9	Conduct N_2O_4 Tests N30 and O26 Overnight O27
April 10	Conduct N_2O_4 Tests O27 and K26 Overnight L26
April 11	Conduct N_2O_4 Tests L26 and K27
April 14	Conduct N_2O_4 Tests H8 and H9
April 15	Conduct N_2O_4 Tests H10 and H15 Overnight I16
April 16	Conduct N_2O_4 Test I16 Move MMH to Site Overnight N_2O_4 Gel
April 17	N_2O_4-N_2H_4 Overspray A21 Overnight N_2H_4 Gel
April 18	N_2H_4-N_2O_4 Overspray A18

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APPENDIX D

TEST PLAN

CONTRACT NO. F29601-84-C-0080

SUBTASK STATEMENT NO. 3.20/00

FIRE SUPPRESSION TESTING OF HYPERGOLIC VAPOR CONTROL FOAMS

TEST PLAN

1. BACKGROUND

Large quantities of hypergolics are stored and used as rocket propellants in space programs, such as the Space Shuttle and the Titan. Accidental spills of sizeable quantities of these hazardous materials can occur during transport on the nation's highways as well as during propellant handling operations at the storage and use facilities. An Air Force study to develop a foam system that could effectively reduce the volatilization of hydrazines and nitrogen tetroxide spills has been completed recently. Foams with additives were developed and tested with positive results for hypergol vapor suppression even under adverse weather and stream flowing conditions. Field demonstrations included scenarios of a propellant spill contained in a simulated diked enclosure, a running spill on concrete surface, and a spill occurring inside a missile silo. The flame extinguishing capabilities of both low and high expansion foams were demonstrated for propellant fuel fires. A major concern during a hydrazine spill is the spontaneous ignition of the amine fuel and an effective fire suppressant is needed for emergency response. Therefore, fire suppression testing of hypergolic vapor control foams must be conducted to provide the Air Force certification of fire suppression agents for hydrazine. Hydrazines are hygroscopic, water-soluble propellants which would be expected to remain for a long time, be absorbed by the ground and require processing. The three hydrazines and possibly nitrogen tetroxide fall into this category. If water is used to control the vapors or control a fire, the volume of the resulting aqueous solution could be substantial and, if contained as a pool, would contaminate a substantially greater quantity of soil than the hazardous materials themselves would. When faced with a vast quantity of aqueous solution or contaminated ground which must be treated or disposed of, the effort to develop a foam was undertaken to reduce the quantity of water used and reduce the containment volume. The used foam and waste hydrazine must be disposed of once the spill has been controlled and contained. Rather than collect it and bury it in a hazardous waste landfill, a controlled burning or incineration is proposed. Depending upon circumstances, in some cases it may be most evironmentally effective to effect a controlled burn in place. The bulk of research has been directed toward development of the foams as a solution to controlling the spill hazards. Very little research has been done to assess the reaction products formed when controlling a hydrazine fuel fire or when incineration of the used foam is a means for its disposal.

2. OBJECTIVES

The objectives of this effort are twofold:

a. Develop documentation that may be used for Air Force certification of the presently developed hypergolic propellant vapor control foams for use as fire suppressants.

b. Identify the chemicals released into the environment when:

1). Foams are used to control hydrazine fires.

2). Foam covered hydrazine is later disposed of by burning.

3. OPERATIONS

In earlier phases of this Air Force sponsored program, a series of tests with the propellants were successfully conducted at Area 11 and at ETS 1 of the Nevada Test Site. Similar tests were conducted by the Mine Safety Applicances Research (MSAR) Corp. in Area 11 with chlorine and ethylene oxide in September 1978. To safely test hydrazine and nitrogen tetroxide an area is needed where the downwind vapor concentration of the spilled materials will not pose a hazard even under the worst conditions. In the prior chlorine tests, the risk area was set at 4.0 miles, with a maximum allowable downwind vapor concentration of 1 ppm. Testing using 3,000 lb quantities of chlorine was conducted with no downwind difficulties. This er series of tests used 500 lbs of each of the two propellants. A 1.0

mile exclusion area was calculated as adequate. This was a circular risk area radiating in all directions from the test site to compensate for diurnal wind changes which could carry the vapors in any direction. All tests were conducted without any downwind vapor hazard to adjacent areas. The Nellis Air Force Range and the U.S. Fish and Wildlife Service Desert National Wildlife Range are adjacent to the test area. Both areas were notified of the test programs. There was never any hazard to areas outside the NTS boundary.

a. Test Setup. Three people from MSAR will need five days to set up the test site. Each fire test setup will involve a surface area of 50 square feet, a rectangular area of 5 feet by 10 feet. All tests will use stainless steel pans. Three identical setups will be made to allow alternating tests.

b. Test Monitoring. The vapor concentration of each chemical will be detected using four portable battery operated continuous recording instruments. The detectors have a range of 0 to 100 ppm. The detectors will be arranged in an arc covering a 90 degree angle downwind of each test site. The detectors will be 30 degree apart and one foot above ground level. The wide coverage of the detectors will encompass the expected changes in the direction of the wind during the test. The detector array will be used in ensure that downwind vapor concentrations do not exceed allowable levels. Thermal sensors will be used to monitor fire intensity and the degree of fire control achieved. One ton N_2O_4 cylinder will be moved to the site along with 55-gallon drums of monomethyl hydrazine, two drums of anhydrous hydrazine, two drums of UDMH, and three drums of Aerozine 50. The cylinders and the 55 gallon drums will be covered with polyethylene to insure protection from any corrosive vapors. A water source up to 1,000 gallons will be needed in generating the foam. The fire truck which has been made available in past tests would be adequate. After the setup is complete, the foam generating equipment will be assembled and tested. Observers from the U.S. Air Force and Aerospace Corporation will be present to lend technical assistance. They are not expected to participate in the testing. The Fire Chiefs of the Eastern and Western Missile Ranges of the Air Force may also be present at the fire tests. A photographer will be present to document the program. A total of nine people should be present during the project. MSAR will be responsible for their safety at the site.

C. Spill Quantities. The N_2O_4 tests will require about 2,000 lbs of material. A maximum vapor loss of 20% is anticipated at the beginning of the filling of the test enclosure when the greatest quantity of N_2O_4 is released, detector tubes will be used to monitor the vapor concentration manually at the outer risk area. After the spill is completed, the monitoring at the perimeter of the risk area will no longer be necessary. Hydrazine will be tested in a similar manner. Due to its higher boiling point, less losses are expected during filling. Four-hundred-fifty pounds of hydrazine will be used per test with maximum filling losses in the range of 10%. It is expected that at least two, and up to four, tests will be run each day. At the end of each test, the liquid residue will be treated to destroy all hydrazine. The cleanup/disposal procedures will be those defined during the earlier programs and found acceptable. Upon completion of the experiments, two days will be needed for cleaning the test site and removing the equipment. The total project should be completed in 20 to 25 working days with about 15 days given to actual testing. The presence of NTS personnel during the testing will be at the discretion of DOE. The NTS botanist may wish to examine the test area before and after the tests to determine any influence on vegetation that may have occurred. Some acid fallout may occur close in to the test area during the N_2O_4 tests. NTSSO will provide area security. The manner of isolating the area shall be dictated by NTS. Other security measures deemed necessary are to be stated by NTS.

4. SAFETY

The chemical concentrations will be monitored by continuous recording instruments at all times during tests. They will also be manually tested with detector tubes on an intermittent but frequent basis when any personnel will be conducting or observing the test. Gas mask systems which are capable of absorbing nitrogen tetroxide or hydrazine to a 1,000 ppm level will be worn by those conducting the test. The mask systems will be available to all observers. Self-contained breathing apparatus will be available to all the personnel involved, both those conducting the tests and the observers, should the hazardous vapor concentration render the face mask useless. Oxygen resuscitation equipment will also be available. The respiratory protection will be supplied by MSAR for those conducting the tests and the predetermined Air Force and Aerospace Corporation personnel.

Gloves, protective suits, and face shields will be worn by those in the area during the filling, foam applications, and cleanup operations. Fire turnout and fire entry suits will be used by all personnel operating in the fire test area. All of the personnel actually involved in the test work have experience with the two chemicals. The access roads to the test site within the risk area will be closed as directed by NTS. The NTS hospital will be notified before actual testing is started to insure they are fully aware of our schedule and the hazardous materials to be tested.

a. Equipment and Facility Safety. All tests will be conducted in stainless steel pans which are inert to both the fuel and oxidizer. All tests will be conducted in the open and no contact between propellant and structures is expected. Test locations will be sufficiently far removed from structures and accumulations of combustible natural materials to insure that there can be no deleterious effects from radiant energy release. This is particularly true for a few tests which involve long term contact between nitrogen tetroxide and the Class A combustibles (wood and tires). Laboratory tests have shown that these fires can release sparks and burn with high intensity.

b. Personnel Safety. The test area will be divided into three zones: Zone 1 shall extend 20 feet in all directions from the test point, Zone 2 ll extend 40 feet in all directions from the test point, and the final zone will be that area upwind of the 40-foot exclusion area. All personnel in observer status shall remain in Zone 3 unless otherwise permitted by the test director. Those personnel working within Zone 1 during a spill or fire sequence shall wear total encapsulating clothing and self-contained breathing apparatus. When a spill or fire is effectively controlled by foam, breathing protection may be reduced to Rocket Fuel Handler Canister masks at the discretion of the test director. All personnel within the intermediate zone, more than 20 but less than 40 feet from the test point, shall wear Rocket Fuel Handler Canister masks during active spills or fires. This protection, at the discretion of the test director, may be reduced to respirators approved for organic vapors when the test is under effective foam control. Repirators approved for organic vapors must be carried by all personnel at all times when in Zone 3. This zone will be monitored routinely for propellant vapor during all active test operations. Levels exceeding the TLV for either propellant shall be assessed by the test director to determine a need for observer evacuations. Should such evacuation be ordered, the respirators shall be donned and utilized until directed otherwise by the test director or his designee. The mode, direction, and distance for evacuation shall be determined by the test director. No deviations from these procedures will be allowed on the test site unless all propellants are totally contained within approved vessels. Regardless of conditions, respirators approved for organic vapors shall be carried by all personnel at all times unless higher levels of breathing protection are mandated.

5. TECHNICAL REQUIREMENTS

a. The test plan shall be approved by the Subtask Officer before conducting any fire testing of the hypergolic propellants. Test configurations, operations and locations shall be approved by NMERI. All data concerning foam performance and the associated recording instrumentation shall be provided by NMERI. Site preparation, safety procedures, foam and required equipment to produce foam, protective clothing, test pits, waste disposal, test configuration materials, and the storage, handling and application of foams and propellants shall be provided from AF Contract F42600 83-C-0615. Equipment for plume and waste sample collection shall be provided by NMERI.

b. NMERI personnel shall direct the fire testing. Overriding direction shall be given by the subtask project officer to meet environmental and safety requirements. Personnel to handle fuels/oxidizers, the foam generation and application, and test configurations shall be provided from AF COntract F42600-83-C-0615. All data recording shall be provided by NMERI. All evaluations, analyses, and reporting shall be done by NMERI. Testing, recording, and analysis methods shall be approved by the Subtask Officer. A final report and video documentation shall be prepared. The performance of foams and equipment shall be presented. A draft military specifications shall be prepared. All methods, operations, results, conclusions and recommendations for fire suppression shall be reported.

c. Specification testing shall be accomplished to provide data similar to MIL-F 24385C for incorporation into a complete military specification. All evaluations and reporting shall be done by NMERI. Testing, recording and analysis methods shall be approved by the Subtask Officer. A final report and video documentation shall be prepared. A draft military specification shall be prepared. All methods, operations, results, conclusions, and recommendations for fire suppression shall be reported.

d. The test listing, schedule and matrix and the Environmental Sampling Plan are attachments 1 through 4 to this plan.

Prepared by: ____

Mr. Tim Stepetic, Principal Investigator Date

Reviewed by: ____

Dr. Dennis M. Zallen, APT Manager Date

Approved by: ____

Mr. Joe Walker, AF Task Officer Date

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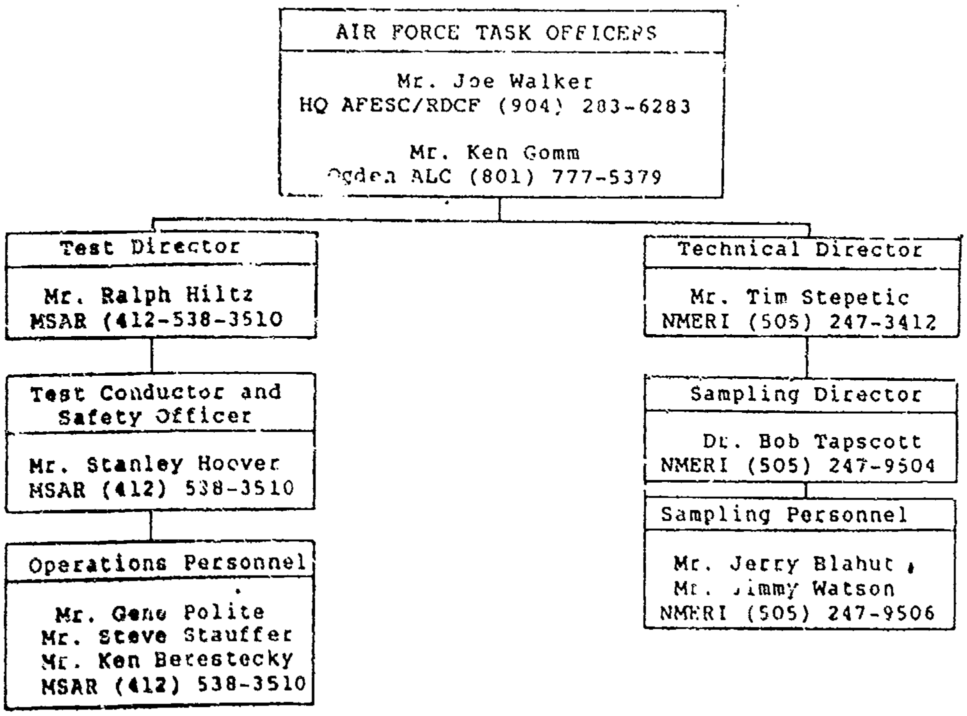
APPENDIX E

TEST ORGANIZATIONAL CHART

FIRE SUPPRESSION TESTING OF HYPERGOLIC VAPOR CONTROL FOAMS

ORGANIZATIONAL CHART



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Joseph L. Walker

JOSEPH L. WALKER
Chief, Fire Technology Branch

APPENDIX F

EXPERIMENTAL DATA

FIRE SUPPRESSION TESTING OF HYPERGOLIC VAPOR CONTROL FOAMS

Test # A-1 Date 11/13/85 Weather

Fuel MMH Amount 55 gallons Temp 36°F

Wind N 17 mi/h

Foam MSA ASE-95 Expansion Low

Nozzle 6 gal/min Configuration Single

Pan Size/Shape 52.5 ft^2 / square New X Used

Pour Start 1401 Complete 1409

Fuel Ignition 1412

Foam Application 1413

Extinguishment 1414 Total Extinguishment Time 1 minute 18 seconds

Burn-off Start 1500 Complete 1539

REMARKS

1. Nozzle become partially obstructed at beginning of foam flow -- either from foreign material or freezing. Estimated flow from nozzle is 4 gal/min.
2. Wand test caused slight flare-ups on three sides but they self-extinguished immediately.
3. Chimney test with 1 minute burn resulted in extinguishment in less than 5 seconds.
4. MMH is very difficult to reignite for burn-off.
5. Test was sampled.

FIRE SUPPRESSION TESTING OF HYPERGOLIC VAPOR CONTROL FOAMS

Test # A-2 Date 11/14/85 Weather

Fuel MMH Amount 55 gallons Temp 46°F

Wind NE 6 mi/h

Foam MSA ASE-95 Expansion Low

Nozzle 2 gal/min Configuration Single

Pan Size/Shape 52.5 ft^2 / square New X Used

Pour Start 1308 Complete 1320

Fuel Ignition 1322

Foam Application 1324

Extinguishment not achieved Total Extinguishment Time N/A

burn-off Start N/A Complete 1350

REMARKS

1. Preburn was 2 minutes.
2. Fire appeared to burn up foam at midpoint of pan, not allowing it to reach the backboard.
3. Foam allowed to flow for 5 minutes -- did not control or extinguish.

FIRE SUPPRESSION TESTING OF HYPERGOLIC VAPOR CONTROL FOAMS

Test # A-3 Date 11/14/85 Weather

Fuel MMH Amount 55 gallons Temp 45°F

Wind NE 6 mi/h

Foam MSA ASE-95 Expansion Low

Nozzle 3 gal/min Configuration Single

Pan Size/Shape 52.5 ft^2 / square New X Used

Pour Start 1458 Complete 1509

Fuel Ignition 1510

Foam Application 1511

Extinguishment 1513 Total Extinguishment Time 2 minutes 13 seconds

burn-off Start 1545 Complete 1645

REMARKS

1. Small flares along sides of pan during wand test, self-extinguished in less than 20 seconds.
2. Chimney test self-extinguished in 27 seconds.
3. Test was sampled.

FIRE SUPPRESSION TESTING OF HYPERGOLIC VAPOR CONTROL FOAMS

Test # A-8 Date 11/17/85 Weather

Fuel MMH Amount 55 gallons Temp 50°F

Wind NW 20 mi/h

Foam MSA ASE-95 Expansion High

Nozzle 118 ft^3/min Configuration Single

Pan Size/Shape 52.2 ft^2 / square New Used X

Pour Start 1510 Complete 1518

Fuel Ignition 1519

Foam Application 1520

Extinguishment 1521 Total Extinguishment Time 1 minute 1 second

burn-off Start 1530 Complete 1630

REMARKS

1. Foam tanks pressurized at 100 lb/in^2 -- pressure at nozzle was 30 lb/in^2.
2. Very orderly, clean test.
3. Test was sampled.

FIRE SUPPRESSION TESTING OF HYPERGOLIC VAPOR CONTROL FOAMS

Test # A-15 Date 11/17/85 Weather

Fuel MMH Amount 55 gallons Temp 52°F

Wind NW 17 mi/h

Foam MSA ASE-95 Expansion Low

Nozzle 6 gal/min Configuration Single

Pan Size/Shape 52.5 ft^2 / square New X Used

Pour Start 1353 Complete 1401

Fuel Ignition 1403

Foam Application 1404

Extinguishment 1405 Total Extinguishment Time 1 minute 12 seconds

burn-off Start 1415 Complete 1500

REMARKS

1. This test provided the fourth data point to establish a credible design rate curve -- design rate determined to be 4 gal/min.
2. No wand or chimney test performed.

FIRE SUPPRESSION TESTING OF HYPERGOLIC VAPOR CONTROL FOAMS

Test # A-9   Date 11/18/85   Weather

Fuel MMH   Amount 30 gallons   Temp 40°F

Wind NNE 28 mi/h gusts to 46 mi/h

Foam MSA ASE-95   Expansion High

Nozzle 24 ft^3/min   Configuration Single

Pan Size/Shape 52.5 ft^2 / square   New   Used X

Pour Start 1009   Complete 1012

Fuel Ignition 1014

Foam Application 1015

Extinguishment not achieved   Total Extinguishment Time N/A

burn-off Start N/A   Complete 1035

REMARKS

1. No extinguishment or control after 5 minutes of foam application.
2. Two dry spots appear in pan after preburn but have no effect on test results.
3. Winds threatened to ignite brush behind pan.
4. Test was sampled.

FIRE SUPPRESSION TESTING OF HYPERGOLIC VAPOR CONTROL FOAMS

Test # A-10 Date 11/18/85 Weather

Fuel MMH Amount 55 gallons Temp 42°F

Wind W 15 mi/h gusts to 29 mi/h

Foam MSA ASE-95 Expansion High

Nozzle 55 ft^3/min Configuration Single

Pan Size/Shape 52.5 ft^2 / square New ___ Used X

Pour Start 1450 Complete 1457

Fuel Ignition 1459

Foam Application 1500

Extinguishment not achieved Total Extinguishment Time N/A

burn-off Start N/A Complete 1550

REMARKS

1. No extinguishment or control after 5 minutes of foam although foam came close to achieving control.
2. In lesser wind, foam would have extinguished in 2 to 3 minutes.
3. Test was sampled.

FIRE SUPPRESSION TESTING OF HYPERGOLIC VAPOR CONTROL FOAMS

Test # A-16 Date 11/19/85 Weather

Fuel MMH Amount 55 gallons Temp 42°F

light and Wind variable

Foam MSA ASE-95 Expansion High

Nozzle 79 ft^3/min Configuration 24 ft^3/min + 55 ft^3/min

Pan Size/Shape 52.5 ft^2 / square New Used X

Pour Start 1420 Complete 1429

Fuel Ignition 1431

Foam Application 1432

Extinguishment 1433 Total Extinguishment Time 1 minute 15 seconds

burn-off Start 1450 Complete 1530

REMARKS

1. Good test with effective extinguishment.
2. Since burn-off set up very cleanly, 55 ft^3/min nozzle was used for "piggy-back" test. Foam extinguished fire in 1 minute 50 seconds, except for badly warped back corners where acrylate from original test continued to burn.

FIRE SUPPRESSION TESTING OF HYPERGOLIC VAPOR CONTROL FOAMS

Test # D-15
Date 11/19/85
Weather
Fuel AH
Amount 55 gallons
Temp 40°F
Wind light and variable
Foam MSA ASE-95
Expansion Low
Nozzle 4 gal/min
Configuration Two tandem 2 gal/min
Pan Size/Shape 50 ft^2 / square
New X
Used

Pour Start 1135
Complete 1146
Fuel Ignition 1150
Foam Application 1151
Extinguishment 1152
Total Extinguishment Time 1 minute 12 seconds
burn-off Start 1215
Complete 1300

REMARKS

1. The asbestos wrap for the nozzle began to burn and melt during preburn, therefore the preburn was shortened to 30 seconds. At this time, however, fire was considered to be fully developed.
2. No visible reignition during wand test.
3. Chimney test self-extinguished in less than 10 seconds.
4. Test was sampled.

FIRE SUPPRESSION TESTING OF HYPERGOLIC VAPOR CONTROL FOAMS

Test # A-1A Date 11/20/85 Weather

Fuel MMH Amount 25 gallons Temp 43°F

Wind SE 6 mi/h

Foam MSA ASE-95 Expansion Low

Nozzle 2 gal/min Flared AFFF Configuration Single

Pan Size/Shape 28 ft^2 / round New X Used

Pour Start 1227 Complete 1232

Fuel Ignition 1233

Foam Application 1234

Extinguishment not achieved Total Extinguishment Time N/A

burn-off Start N/A Complete 1305

REMARKS

1. Foam was plunged into middle of pan which produced turbulence and prohibited foam from setting up. When the foam was directed to the back of the pan (twice), the foam appeared to begin to set up and extinguish.
2. Foam application terminated after 3 minutes.

FIRE SUPPRESSION TESTING OF HYPERGOLIC VAPOR CONTROL FOAMS

Test # B-16 Date 11/20/85 Weather

Fuel UDMH Amount 55 gallons Temp 40°F

Wind S 3 mi/h

Foam MSA ASE-95 Expansion High

Nozzle 79 ft^3/min Configuration 24 ft^3/min + 55 ft^3/min

Pan Size/Shape 50 ft^2 / square New Used X

Pour Start 1441 Complete 1451

Fuel Ignition 1452

Foam Application 1455

Extinguishment 1501 Total Extinguishment Time 6 minutes 30 seconds

burn-off Start 1520 Complete 1610

REMARKS

1. Preburn was 2 minutes 30 seconds, due to opened disconnect in foam hose.
2. Fire was actually controlled in 3 minutes 30 seconds, but it took 3 more minutes to extinguish corners.
3. The heat and intensity of the fire broke the high-expansion down to low expansion, which effectively sealed. The newly applied high-expansion moved slowly over the low-expansion seal into the corners.
4. The UDMH produced no visible vapors during pour and looked relatively benign. Upon ignition, however, it produced a high (10 - 15 feet), turbulent and bright orange flame.
5. Test was sampled.

FIRE SUPPRESSION TESTING OF HYPERGOLIC VAPOR CONTROL FOAMS

Test # D-16   Date 11/20/85   Weather

Fuel AH   Amount 55 gallons   Temp 37°F

Wind light and variable

Foam MSA ASE-95   Expansion High

Nozzle 79 ft^3/min   Configuration 24 ft^3/min + 55 ft^3/min

Pan Size/Shape 50 ft^2 / square   New X   Used

Pour Start 1043   Complete 1051

Fuel Ignition 1053

Foam Application 1054

Extinguishment 1055   Total Extinguishment Time 45 seconds

burn-off Start 1115   Complete 1200

REMARKS

1. Preburn was 1 minute 25 seconds.
2. During foam application, quick disconnect opened and 5 seconds of application time was lost.
3. Test was sampled.

FIRE SUPPRESSION TESTING OF HYPERGOLIC VAPOR CONTROL FOAMS

Test # A-24-1 Date 11/21/85 Weather

Fuel MMH Amount 55 gallons Temp 46°F

Wind N 5 mi/h

Foam Ansulite ARC 6 percent Expansion Low

Nozzle 6 gal/min Configuration Single

Pan Size/Shape $50\ ft^2$ / square New Used X

Pour Start 1253 Complete 1300

Fuel Ignition 1301

Foam Application 1302

Extinguishment 1303 Total Extinguishment Time 1 minute 15 seconds

burn-off Start 1315 Complete 1335

REMARKS

1. Foam applied for full 5 minutes.
2. No reignitions on wand test.
3. Foam extinguished flame 5 seconds after chimney removal.
4. After initial extinguishment, foam percolated with appearance of releasing vapors.

FIRE SUPPRESSION TESTING OF HYPERGOLIC VAPOR CONTROL FOAMS

Test # A-24-2   Date 11/21/85   Weather

Fuel MMH   Amount 55 gallons   Temp 51°F

Wind S 3 mi/h

Foam Ansulite ARC 6 percent   Expansion Low

Nozzle 4 gal/min   Configuration Two tandem 2 gal/min

Pan Size/Shape 50 ft^2 / square   New ____   Used X

Pour Start 1424   Complete 1433

Fuel Ignition 1434

Foam Application 1435

Extinguishment 1439   Total Extinguishment Time 4 minutes

burn-off Start 1450   Complete 1520

REMARKS

1. Foam applied for full 5 minutes.
2. No reignition on wand test.
3. Upon removal of chimney, flame hole reduced to 3-inch diameter. After 5 minutes hole increased to 24-inch diameter.
4. Foam percolated similar to A-24-1.

FIRE SUPPRESSION TESTING OF HYPERGOLIC VAPOR CONTROL FOAMS

Test # B-15 Date 11/21/85 Weather

Fuel UDMH Amount 55 gallons Temp 42°F

Wind S 2 mi/h

Foam MSA ASE-95 Expansion Low

Nozzle 4 gal/min Configuration Two tandem 2 gal/min

Pan Size/Shape 50 ft^2 / square New Used X

Pour Start 1055 Complete 1103

Fuel Ignition 1104

Foam Application 1105

Extinguishment not achieved Total Extinguishment Time N/A

burn-off Start N/A Complete 1200

REMARKS

1. No control or extinguishment after 5 minutes of foam application.
2. A very hot and intense fire.
3. It appears that design rates based on MMH are insufficient for UDMH.
4. Test was sampled.

FIRE SUPPRESSION TESTING OF HYPERGOLIC VAPOR CONTROL FOAMS

Test # A-23 Date 11/22/85 Weather

Fuel MMH Amount 55 gallons Temp 31°F

Wind light and variable

Foam Ansulite AFFF 6 percent Expansion Low

Nozzle 6 gal/min Configuration Single

Pan Size/Shape 50 ft^2 / square New Used X

Pour Start 0946 Complete 0956

Fuel Ignition 0957

Foam Application 0958

Extinguishment 1001 Total Extinguishment Time 2 minutes 51 seconds

burn-off Start 1020 Complete 1045

REMARKS

1. Foam applied for full 5 minutes.
2. No reignitions on wand test.
3. On chimney test, hole enlarged very slightly after 5 minutes of burn.
4. Impressions were that 4 gal/min application rate would not have extinguished fire.

FIRE SUPPRESSION TESTING OF HYPERGOLIC VAPOR CONTROL FOAMS

Test # E-15/F-15 Date 11/22/85 Weather

Fuel MMH Amount 55 gallons Temp 53°F

Wind S 8 mi/h

Foam MSA ASE-95 Expansion Low

Nozzle 4 gal/min Configuration Two tandem 2 gal/min

Pan Size/Shape 50 ft^2 / square New Used X

Pour Start 1358 Complete 1407

Fuel Ignition 1408

Foam Application 1409

Extinguishment 1411 Total Extinguishment Time 2 minutes 20 seconds

burn-off Start 1435 Complete 1530

REMARKS

1. Fire was under control in 1 minute 5 seconds -- small but persistent fire remained in two corners behind obstruction -- obstruction and metal same as test number E-16/F-16.
2. Pan cracked at edge seam and began to leak part way through pour. Drip and heavy accumulation of vapors under pan -- neither drip nor vapors ignited upon fuel ignition.
3. Wand test caused no reignition with heavy emphasis around obstruction and metal.
4. Did not perform chimney test due to pan leak.

FIRE SUPPRESSION TESTING OF HYPERGOLIC VAPOR CONTROL FOAMS

Test # E-16/F-16 Date 11/22/85 Weather

Fuel MMH Amount 55 gallons Temp 48°F

Wind S 6 mi/h

Foam MSA ASE-95 Expansion High

Nozzle 79 ft^3/min Configuration 24 ft^3/min + 55 ft^3/min

Pan Size/Shape 50 ft^2 / square New Used X

Pour Start 1154 Complete 1203

Fuel Ignition 1205

Foam Application 1206

Extinguishment 1206 Total Extinguishment Time 39 seconds

burn-off Start 1225 Complete 1310

REMARKS

1. At 1204 a rusty barrel was placed in the middle of the pan and wired together assemblage of rusty metal pieces was placed 1 foot from the barrel. Upon placement there was no visible reaction between the metal and MMH.
2. Foam flowed around obstruction with no difficulty.

FIRE SUPPRESSION TESTING OF HYPERGOLIC VAPOR CONTROL FOAMS

Test # A-1B   Date 11/24/85   Weather

Fuel Leaded gasoline   Amount 25 gallons   Temp 52°F

Wind SE 5 mi/h

Foam MSA ASE-95   Expansion Low

Nozzle 2 gal/min   Configuration Single-flared AFFF type

Pan Size/Shape 28 ft^2 / round   New   Used X

Pour Start 1210   Complete 1212

Fuel Ignition 1214

Foam Application 1215

Extinguishment not achieved   Total Extinguishment Time N/A

burn-off Start N/A   Complete 1250

REMARKS

1. Foam controlled fire at approximately 3 minutes -- continuing edge fire and small center vapor fires.
2. During burn-off, foam showed good sealing characteristics.

FIRE SUPPRESSION TESTING OF HYPERGOLIC VAPOR CONTROL FOAMS

Test # N-29 Date 11/24/85 Weather

Fuel Heptane Amount 55 gallons Temp 52°F

Wind SW 5 mi/h

Foam MSA ASE-95 Expansion Low

Nozzle 4 gal/min Configuration Two tandem 2 gal/min

Pan Size/Shape 50 ft^2 / square New Used X

Pour Start 1114 Complete 1118

Fuel Ignition 1120

Foam Application 1121

Extinguishment 1124 Total Extinguishment Time 2 minutes 57 seconds

burn-off Start 1135 Complete 1205

REMARKS

1. Control achieved in 1 minute 15 seconds.
2. Wand test produced slight side flaring for 2 to 3 seconds.
3. Chimney test self-extinguished in 4 seconds.
4. One nozzle experienced partial block during application -- estimate 3 to 3.5 gal/min application rate.
5. Extremely hot fire -- warped pan badly.

FIRE SUPPRESSION TESTING OF HYPERCOLIC VAPOR CONTROL FOAMS

Test # N-30 Date 11/24/85 Weather

Fuel Heptane Amount 55 gallons Temp 53°F

Wind S 6 mi/h

Foam MSA ASE-95 Expansion High

Nozzle 79 ft^3/min Configuration 24 ft^3/min + 55 ft^3/min

Pan Size/Shape 50 ft^2 / square New Used X

Pour Start 1257 Complete 1302

Fuel Ignition 1303

Foam Application 1304

Extinguishment 1306 Total Extinguishment Time 1 minute 35 seconds

burn-off Start 1315 Complete 1400

REMARKS

FIRE SUPPRESSION TESTING OF HYPERGOLIC VAPOR CONTROL FOAMS

Test # H-8

Date 4/15/86

Weather

Fuel Diesel Fuel/N_2O_4

Amount 30 gallons ea

Temp 69°F

Wind SW 17 mi/h gusts to 26 mi/h

Foam MSA ASE-60

Expansion High

Nozzle 142 ft^3/min

Configuration 118 ft^3/min + 24 ft^3/min

Pan Size/Shape 50 ft^2 / square

New

Used X

Pour Start 1120

Complete 1133

Fuel Ignition 1134

Foam Application 1135

Extinguishment 1139

Total Extinguishment Time 3 minutes 30 seconds

burn-off Start 1155

Complete 1212

REMARKS

1. 30 gallons of N_2O_4 poured into pan via 20-foot PVC extension from one-ton cylinder.
2. Cylinder then moved 50 feet back and 30 gallons of diesel poured from 10-foot extension to 55 gallon drum of diesel.
3. One minute preburn.
4. Fire initially extinguished at 3 minutes 20 seconds -- self-reignited 5 seconds later -- continued foam achieved final extinguishment at 3 minutes 50 seconds.
5. Frequent gusts interfered with foam application -- estimate under normal wind conditions (6 to 12 mi/h) application rate would have extinguished in approximately 2 minutes.
6. Extremely intense fire -- we feel that in future diesel fires, a 30 second preburn will allow for a fully developed fire.

FIRE SUPPRESSION TESTING OF HYPERGOLIC VAPOR CONTROL FOAMS

Test # H-9   Date 4/15/86   Weather

Fuel Diesel Fuel/N_2O_4 Amount 30 gallons ea   Temp 71°F

SW 21 mi/h
Wind gusts to
37 mi/h

Foam MSA ASE-60   Expansion High

Nozzle 236 ft^3/min   Configuration Two tandem at 118 ft^3/min

Pan Size/Shape 50 ft^2 / square   New   Used X

Pour Start 1519   Complete 1536

Fuel Ignition 1537

Foam Application 1537

Extinguishment 1539   Total Extinguishment Time 1 minute 5 seconds

burn-off Start 1550   Complete 1615

REMARKS

1. Preburn reduced to 30 seconds.
2. A baffle was added to the foam apparatus to reduce the high wind effect.
3. Essentially the baffle was the top of a 55 gallon drum cut to thread onto the pipeline of 24 inches behind the front of the nozzles. In this the baffle led to better foam formation with less wind induced dispersion.
4. While the gust velocity was higher during this test, the dominant winds were steady at 17 to 23 mi/h and gusts were infrequent.

FIRE SUPPRESSION TESTING OF HYPERGOLIC VAPOR CONTROL FOAMS

Test # H-8R

Date 4/16/86

Weather

Fuel Diesel fuel/N_2O_4

Amount 30 gallons ea

Temp 53°F

Wind SW 9 mi/h gusts to 14 mi/h

Foam MSA ASE-60

Expansion High

Nozzle 142 ft^3/min

Configuration 118 ft^3/min + 24 ft^3/min

Pan Size/Shape 50 ft^2 / square

New

Used X

Pour Start 0943

Complete 0958

Fuel Ignition 1000

Foam Application 1001

Extinguishment 1003

Total Extinguishment Time 1 minute 48 seconds

burn-off Start 1016

Complete 1047

REMARKS

1. Test H-8 was repeated to see if better results were possible in nominal winds -- this proved to be the case. The in-place baffle was also continued to assess it's effect.
2. The test was carried out with no problems and the rate of 142 ft^3/min achieved total extinguishment at 1 minute 48 seconds.

FIRE SUPPRESSION TESTING OF HYPERGOLIC VAPOR CONTROL FOAMS

Test # H-10 Date 4/16/86 Weather

Fuel Diesel Fuel/N_2O_4 Amount 30 gallons ea Temp 56°F

SW 8 mi/h

Wind gust to 13 mi/h

Foam MSA ASE-60 Expansion High

Nozzle 118 ft^3/min Configuration Single

Pan Size/Shape 50 ft^2 / square New ____ Used X

Pour Start 1044 Complete 1102

Fuel Ignition 1103

Foam Application 1106

Extinguishment 1109 Total Extinguishment Time 1 minute 41 seconds

burn-off Start 1115 Complete 1135

REMARKS

1. Development of active froth between diesel and N_2O_4 made this mixture extremely difficult to ignite. Heptane igniter source was moved to nonfroth diesel area, this mixture ignited.
2. Development of intense fire occurred extremely fast.
3. During preburn middle of pan (25 percent) warped to high side and supported no liquid or flame.

FIRE SUPPRESSION TESTING OF HYPERGOLIC VAPOR CONTROL FOAMS

Test # K-26 Date 4/16/86 Weather

Fuel Tire/N_2O_4 Amount 20 gallons N_2O_4 Temp 59°F

Wind W 8 mi/h gusts to 17 mi/h

Foam MSA ASE-60 Expansion High

Nozzle 142 ft^3/min Configuration 118 ft^3/min + 24 ft^3/min

Pan Size/Shape 50 ft^2 / square New ___ Used X

Pour Start 1354 Complete 1401

Fuel Ignition 1402

Foam Application 1404

Extinguishment 1407 Total Extinguishment Time 2 minutes 30 seconds

burn-off Start 1420 Complete 1429

REMARKS

1. 2 gallons of heptane poured into inner tire casing for ignition.
2. 2 minute preburn.
3. Total fire extinguishment was straight-forward.

FIRE SUPPRESSION TESTING OF HYPERGOLIC VAPOR CONTROL FOAMS

Test # C-16 Date 4/17/86 Weather

Fuel A-50 Amount 55 gallons Temp 62°F

Wind SW 5 mi/h gusts to 13 mi/h

Foam MSA ASE-95 Expansion High

Nozzle 79 ft^3/min Configuration 24 ft^3/min + 55 ft^3/min

Pan Size/Shape 50 ft^2 / square New Used X

Pour Start 1220 Complete 1229

Fuel Ignition 1231

Foam Application 1232

Extinguishment 1236 Total Extinguishment Time 3 minutes 30 seconds

burn-off Start 1250 Complete 1317

REMARKS

1. Fire under control in 2 minutes, totally extinguished in 3 minutes 30 seconds.
2. 1 minute preburn.

FIRE SUPPRESSION TESTING OF HYPERGOLIC VAPOR CONTROL FOAMS

Test # C-16A

Date 4/17/86

Weather

Fuel A-50

Amount 55 gallons

Temp 57°F

Wind SE 7 mi/h gusts to 14 mi/h

Foam MSA ASE-95

Expansion High

Nozzle 118 ft^3/min

Configuration Single

Pan Size/Shape 50 ft^2 / square

New

Used X

Pour Start 1050

Complete 1059

Fuel Ignition 1100

Foam Application 1101

Extinguishment 1103

Total Extinguishment Time 2 minutes 15 seconds

burn-off Start 1120

Complete 1155

REMARKS

1. Fire under control in 1 minute 30 seconds, totally extinguished in 2 minutes 15 seconds.
2. 1 minute preburn.

FIRE SUPPRESSION TESTING OF HYPERGOLIC VAPOR CONTROL FOAMS

Test # I-16 Date 4/23/86 Weather

Fuel Diesel Fuel/N_2O_4 Amount 30 gallons ea Temp 62°F

Wind NE 7 mi/h

Foam MSA ASE-60 Expansion High

Nozzle 142 ft^3/min Configuration 118 ft^3/min + 24 ft^3/min

Pan Size/Shape 50 ft^2 / square New Used X

Pour Start Overnighnt (14 hours) Complete N/A

Fuel Ignition 0655

Foam Application 0657

Extinguishment 0659 Total Extinguishment Time 2 minutes 4 seconds

burn-off Start 0710 Complete 0735

REMARKS

1. 1 minute preburn.
2. Fire developed very slowly. Hot after initial development, but decreased quickly in intensity. Residual heat initially inhibited good foam development and consumed foam.
3. Overall fire not nearly as intense as with fresh N_2O_4.
4. Diesel/N_2O_4 mixture aged 14 hours.

FIRE SUPPRESSION TESTING OF HYPERGOLIC VAPOR CONTROL FOAMS

Test # L-26 Date 4/23/86 Weather

Fuel Tire/N_2O_4 Amount 20 gallons N_2O_4 Temp 59°F

Wind NE 5 mi/h

Foam MSA ASE-60 Expansion High

Nozzle 142 ft^3/min Configuration 118 ft^3/min + 24 ft^3/min

Pan Size/Shape 50 ft^2 / square New Used X

Pour Start Overnight (14 hours) Complete N/A

Fuel Ignition 0638

Foam Application 0640

Extinguishment 0641 Total Extinguishment Time 1 minute 10 seconds

burn-off Start N/A Complete N/A

REMARKS

1. Tire was ignited with 1/2 gallon heptane in center of tire.
2. Good initial fire but not lasting.
3. Fire extinguishment was fast (1 minute 10 seconds), but N_2O_4 vapor continued to percolate strongly through foam.
4. Tire was severly pitted and deteriorated where it was in contact with N_2O_4.
5. Tire/N_2O_4 was aged 14 hours.

FIRE SUPPRESSION TESTING OF HYPERGOLIC VAPOR CONTROL FOAMS

Test # 0-26

Date 4/23/86

Weather

Fuel Wood Crib/N_2O_4

Amount Crib-8 std. pallets
N_2O_4-30 gallons
Heptane-3 gallons

Temp 72°F

Wind SW 17 mi/h gusts to 29 mi/h

Foam MSA ASE-60

Expansion Low

Nozzle Mini-X 1500 ft^3/min

Configuration Single-elevated

Pan Size/Shape 50 ft^2 / square

New

Used X

Pour Start 1020

Complete 1026

Fuel Ignition 1029

Foam Application 1032 (Foam reaches pan)

Extinguishment 1042(control)

Total Extinguishment Time 22 minutes from foam start

burn-off Start N/A

Complete N/A

REMARKS

1. NFPA 11-A test with pen and crib to test foam against class A combustibles. Pen is 120 feet long by 15 feet wide and 10 feet high. No constructed bottom or top -- sides are 2 x 4 inch frame with heavy plastic lining. Last 20 feet of pen is galvanized sides and bottom. Orientation of pen is at 240° (foam generator) toward 060 (wood cribs). Mini-X mounted at 9-foot level, back of pen. Wood crib is composed of 8 standard pallets stacked on top of 3-foot by 3-foot by 12-inch deep pan containing heptane. The heptane pan is resting on concrete masonry blocks in the center of a 50 ft^2 square pan, centered on the 15-foot by 20-foot metal at the end of the pen.

2. The foam began to flow at 1020 at which time 30 gallons of N_2O_4 were poured into the 50 ft^2 pan through a hole in the pen wall. The foam moved fairly well down the pen but was broken up considerably by the wind which blew a lot of foam out of the pen. When the front end of the foam was judged to be three minutes from the fire, the heptane was lit (1029).
3. The foam reached the fire at 1032. The heat build-up on the metal wall surrounding the crib tended to break up the foam.
4. At 1040, the burning crib collapsed into the pan of N_2O_4, enabling the control of the fire at 1042. Control is defined as no visible flame, although N_2O_4 fumes were very prevalent.
5. The foam production was ceased at 1050 and the wood crib reignited at 1105.
6. The two major detrimental factors in this test were the wind and the metal enclosure portion at the end of the pen. The wind, in addition to breaking the foam, reflected from the metal rear wall of the pen, inhibiting foam build-up in the pan area. The hot metal enclosure around the pan contributed heavily to foam break-up in the pan area. Both of these problems could have been alleviated somewhat if the metal portion of the pen had been constructed with hardware screen.

FIRE SUPPRESSION TESTING OF HYPERGOLIC VAPOR CONTROL FOAMS

Test # N-30 Date 4/24/86 Weather

Fuel Wood Crib/Heptane Amount Crib-8 std. Pallets Heptane-3 gallons Temp 74°F

Wind SW 15 mi/h gusts to 23 mi/h

Foam MSA ASE-60 Expansion High

Nozzle Mini-X 1500 ft^3/min Configuration Single-elevated

Pan Size/Shape 50 ft^2 / square New ____ Used X

Pour Start N/A Complete N/A

Fuel Ignition 1341

Foam Application 1344 (foam reaches pan)

Extinguishment 1349(control) Total Extinguishment Time 17 minutes from foam start

burn-off Start N/A Complete N/A

REMARKS

1. Foam was started at 1332 and moved well down the pen.
2. Wind was only a minor factor in this test.
3. Crib configuration same as in 0-26 without N_2O_4.
4. Test ran well with control achieved in 17 minutes.
5. Foam was ceased at 1402 and crib reignited at 1412.

FIRE SUPPRESSION TESTING OF HYPERGOLIC VAPOR CONTROL FOAMS

Test # C-15A   Date 4/26/86   Weather

Fuel A-50   Amount 55 gallons   Temp 58°F

Wind NW 15 mi/h gusts to 37 mi/h

Foam MSA ASE-95   Expansion Low

Nozzle 6 gal/min   Configuration Single

Pan Size/Shape 50 ft^2 / square   New   Used X

Pour Start 1004   Complete 1013

Fuel Ignition 1015

Foam Application 1016

Extinguishment 1020   Total Extinguishment Time 3 minutes 30 seconds

burn-off Start 1030   Complete 1055

REMARKS

1. Fire was controlled in 25 seconds and 98 percent extinguished in 1 minute 30 seconds.
2. Frequent and lasting gusts of over 35 mi/h prevented foam from reaching the back corners of the pan in sufficient quantity to set up and extinguish.
3. Foam was continued for a full 5 minutes.
4. There were no reignitions during the wand test and the chimney test self-extinguishment was 6 seconds.
5. This test was sampled.

FIRE SUPPRESSION TESTING OF HYPERGOLIC VAPOR CONTROL FOAMS

Test # C-15B Date 4/26/86 Weather

Fuel A-50 Amount 55 gallons Temp 58°F

NE 20 mi/h
Wind gusts to
30 mi/h

Foam MSA ASE-95 Expansion Low

Nozzle 9 gal/min Configuration 6 gal/min +3 gal/min

Pan Size/Shape 50 ft^2 / square New Used X

Pour Start 1155 Complete 1203

Fuel Ignition 1205

Foam Application 1206

Extinguishment 1207 Total Extinguishment Time 1 minute 8 seconds

burn-off Start 1225 Complete 1250

REMARKS

1. Fire was controlled in 25 seconds.
2. Some strong wind gusts during the test but generally winds were significantly lighter than during previous test (C-15A).
3. Foam was continued for a full 5 minutes.
4. There were no reignitions during the wand test and the chimney test self-extinguished in less than 2 seconds.
5. Test was sampled.

FIRE SUPPRESSION TESTING OF HYPERGOLIC VAPOR CONTROL FOAMS

Test # C-15 Date 4/28/86 Weather

Fuel A-50 Amount 45 gallons Temp 68°F

Wind NW 3 mi/h

Foam MSA ASE-95 Expansion Low

Nozzle 5 gal/min Configuration 3 gal/min + 2 gal/min

Pan Size/Shape 50 ft^2 / square New Used X

Pour Start 1009 Complete 1016

Fuel Ignition 1018

Foam Application 1019

Extinguishment 1023 Total Extinguishment Time 3 minutes 55 seconds

burn-off Start 1040 Complete 1105

REMARKS

1. Fire under control after 1 minute 57 seconds.
2. During 1 minute preburn and prior to foam start pan bowed badly in middle -- about 20 percent of pan surface raised above the level of the fuel. This caused the foam to burn and coagulate around the pan center, preventing it from migrating to the forward corners for timely extinguishment.
3. Foam application rate performed better than extinguishment time would indicate. Foam continued for 5 minutes.
4. There were no reignitions during the wand test and chimney test self-extinguishment was 10 seconds.

5. During the first attempt at this test earlier in the day, the A-50 spontaneously ignited after about 10 gallons were poured into the pan. Extremely fast action on the part of the spill team prevented the flame from travelling into the drum with potentially tragic results. Gene Polite and Steve Stauffer of MSAR turned off the fuel flow and pulled the drum away from the intense fire in the pan while Jimmy Watson of NMERI, manning the high pressure hose, kept a steady stream of water between the drum and pan to prevent flame travel. While A-50 produces more flame than AH or MMH, the initial flame is not overly visible. The first signs of a spontaneous ignition are the noise and the immediate disappearance of the vapors directly above the fuel pool. Once the A-50 drum was removed from the pan area, the A-50 in the pan was allowed to burn-off. We can only speculate as to the cause of the spontaneous ignition. Most likely it was the high temperature of the pan from 3 hours of direct sun or rust in the pan or a combination of these. The particular A-50 was an off-spec material; however, it's characteristics were close to spec A-50, and 4 other drums from the same production batch were poured and ignited with no problems. For the remaining two A-50 burns, the pans were washed thoroughly immediately before the pours and during the pours a stream of water was run under and around the pan for cooling.
6. Test was sampled.

FIRE SUPPRESSION TESTING OF HYPERGOLIC VAPOR CONTROL FOAMS

Test # C-16B   Date 4/28/86   Weather

Fuel A-50   Amount 55 gallons   Temp 74°F

Wind SE 3 mi/h

Foam MSA ASE-95   Expansion High

Nozzle 173 ft^3/min   Configuration 118 ft^3/min + 55 ft^3/min

Pan Size/Shape 50 ft^2 / square   New   Used X

Pour Start 1138   Complete 1147

Fuel Ignition 1148

Foam Application 1149

Extinguishment 1150   Total Extinguishment Time 1 minute

burn-off Start 1205   Complete 1230

REMARKS

1. After a 1 minute preburn, the fire was controlled in 20 seconds and completely extinguished in 1 minute.
2. Very straight forward test.
3. Test was sampled.

FIRE SUPPRESSION TESTING OF HYPERGOLIC VAPOR CONTROL FOAMS

Test # 0-27

Date 4/29/86

Weather

Fuel Wood Crib/N_2O_4

Amount Crib-8 std. pallets N_2O_4-30 gallons

Temp 74°F

Wind SW 2 mi/h gusts to 13 mi/h

Foam MSA ASE-60

Expansion High

Nozzle Mini-X 1500 ft^3/min

Configuration Single-elevated

Pan Size/Shape 50 ft^2 / square

New

Used X

Pour Start Overnight (14 hours)

Complete N/A

Fuel Ignition X + 16 minutes (1103)

Foam Application X - foam start (1047)

Extinguishment none

Total Extinguishment Time N/A

burn-off Start N/A

Complete N/A

REMARKS

1. Pan test with wood crib soaked overnight in N_2O_4.
2. Foam started at 1047 and moved well to the 80-foot point in 6 minutes.
3. It took another 16 minutes to reach the 100-foot point (above 5 feet from the front of the pan). At this time (1103) the fire was lit.
4. The leading edge of the foam was very dry and did not move any further.
5. At 1115 the foam maker was moved to the midpoint of the pen on the east side.
6. The leading edge of the foam moved a little further but only small patches reached the fire with no effect.
7. The foam ran out at 1125 (38 minutes) with no extinguishment. Wood crib/N_2O_4 was aged for 14 hours.

FIRE SUPPRESSION TESTING OF HYPERGOLIC VAPOR CONTROL FOAMS

Test # A-18 Date 4/30/86 Weather

Fuel A-50/N_2O_4 Amount N_2O_4-30 gallons A-50 -spray Temp 73°F

Wind SW 6 mi/h

Foam MSA ASE-60 Expansion High

Nozzle 55 ft^3/min Configuration Single

Pan Size/Shape 50 ft^2 / square New Used X

Pour Start N/A Complete N/A

Fuel Ignition N/A

Foam Application N/A

Extinguishment N/A Total Extinguishment Time N/A

burn-off Start N/A Complete N/A

REMARKS

1. 6 feet above the pan of N_2O_4 a spray nozzle was suspended and attached via 1/4 inch stainless to 5 gallon pressurized container of A-50 10 feet from the pan. A solenoid was placed in this line adjacent to the A-50 container and connected to a solenoid power box 80 feet away. 50 feet further away was the generator powering the solenoid power box. The solenoid control box was 200 feet further from the power box at the trailer, thus the closest personnel during this test were approximately 280 feet distant. Because of problems encountered with equipment and apparatus during preparation, the N_2O_4 was foamed four times in the hour prior to the A-50 release, the last time being 3 minutes before the

first A-50 stream (spray discarded due to plugged nozzle). The first release of the A-50 produced immediate, violent ignition of the A-50 stream -- a stream dropping into the N_2O_4 pan of the approximate size and velocity of a water pistol. A violent orange-white flame 1 foot in diameter and 5 feet high was produced. After 20 seconds, the A-50 stream was stopped and the fire immediately ceased. 10 seconds later, the stream was again activated with the same results. The procedure was then repeated several times with identical results. Ignition and combustion sounds were very loud-similar to those produced by a rocket engine.

2. Because of the violence of this reaction and the set-up difficulty, it was determined not to proceed with test A-21 (N_2O_4 drip into A-50 pan). This decision was based on safety factors and the violence of the hypergolic reaction as evidenced in this test. If the foam had any suppressive effect on the ignition and combustion resulting from this test, it appeared to be a minimal effect at best.

APPENDIX G

PROPOSED MILITARY SPECIFICATION

This is a self-contained document with its own internal consistent style and numbering system.

MILITARY SPECIFICATION

VAPOR SUPPRESSING - FIRE EXTINGUISHING AGENT, FOAM CONCENTRATES FOR USE ON HYPERGOLIC PROPELLANTS

This specification is approved for use within the Department of the Air Force and is available for use by all Department and Agencies of the Department of Defense.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Headquarters Air Force Engineering and Services Center (HQ AFESC/RDCF), Tyndall Air Force Base, FL 32403-6001 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

AMSC NO. N/A FSC 6850

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

MIL-V-XXXX

CONTENTS

CONTENTS (Continued)

CONTENTS (Continued)

TABLES

FIGURES

MIL-V-XXXX

PROPOSED MILITARY SPECIFICATION

VAPOR SUPPRESSING-FIRE EXTINGUISHING AGENT, FOAM CONCENTRATES FOR USE ON HYPERGOLIC PROPELLANTS

1. SCOPE

1.1 Scope. This specification covers the requirements for gel forming foam liquid combination vapor suppression and fire extinguishing agents. The agents consist of appropriate acrylic gelling agents and alpha olefin sulfonate surfactants to conform to this specification. The surfactants and gelling agents are to be supplied as separate entities to be proportioned into water hose streams in a ratio of 1 part gelling agent, 1 part surfactant and 8 parts water by dispensing equipment at the time of application to liquid propellant spills.

1.2 Classification. Concentrates shall be of the following types:

Type F1 - gelling agent for use on spills of hydrazine fuels or hypergolic mixture of hydrazine fuel and dinitrogen tetroxide oxidant

Type F2 - foam forming surfactant for use on spills of hydrazine fuels or hypergolic mixtures of hydrazine fuel and dinitrogen tetroxide oxidant

Type 01 - gelling agent for use on spills of dinitrogen tetroxide oxidant

Type 02 - foam forming surfactant for use on spills of dinitrogen tetroxide oxidant

2. APPLICABLE DOCUMENTS

2.1 Issues of documents. The following documents, of the issue in effect on date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein.

SPECIFICATIONS

FEDERAL

TT-E-489	Enamel, Alkyd, Gloss (for Exterior and Interior Surfaces)
PPP-C-1337	Containers. Metal, with Polyethylene Inserts
VVF-800	Fuel oil, Diesel

MILITARY

MIL-P-2560	Propellant, Hydrazine-unsymmetrical dimethylhydrazine (50% N_2H_4 - 50% UDMH)
MIL-P-26539	Propellant, nitrogen tetroxide

STANDARDS

FEDERAL

FED-STD-595	Colors

FED-STD-313	Material safety data sheet, preparation and submission

MILITARY

MIL STD 105	Sampling Procedures and Tables for Inspection by Attributes
MIL STD 129	Marking for Shipment and Storage
MIL STD 130	Identification Marking of US Military Property

2.2 Other publications. The following documents form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of the documents which are DOD adopted shall be those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) specified in the solicitations. Unless otherwise specified the issues of documents not listed in the DODISS shall be the issue of the nongovernment documents which is current on the date of the solicitation.

UNDERWRITERS LABORATORIES, INC. (U.L.)

UL 162	Standard for Foam Equipment and Liquid Concentrates

(Application for copies should be addressed to the Underwriters Laboratories, Inc., 333 Pfingsten Road, Northbrook, IL 60062).

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 412	Standard for Evaluating Foam Fire Fighting Equipment on Aircraft Rescue and Fire Fighting Vehicles

(Application for copies should be addressed to the National Fire Protection Association, Batterymarch Park, Quincy, MA 02269).

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

D96	Test Method for Water and Sediment in Crude Oils
D1068	Test Methods for Iron in Water
D1218	Refractive Index and Refractive Dispersion of Hydrocarbon Liquids, Test for
D3673	Chemical Analysis of Alpha Olefin Sulfonates
D3716	Emulsion Polymers For Use in Floor Polishes
E70	pH of Aqueous Solutions With The Glass Electrode
E527	Numbering Metals and Alloys (UNS)
E729	Standard Practice for Conducting Acute Toxicity Tests with Fish, Macroinvertebrates and Amphibians

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.)

AMERICAN PUBLIC HEALTH ASSOCIATION (APHA)

Standard Methods for the Examination of Water and Waste Water.

(Application for copies should be addressed to the American Public Health Association, 1015 - 18th Street, N.W., Washington, DC 20036.)

(Nongovernment standards and other publications are normally available from the organizations which prepare or which distribute the documents. These documents also may be available in or through libraries or other informational services).

2.3 Order of Precedence. In the event of a conflict between the text of this specification and the references cited herein, the text of this specification shall take precedence. Nothing in this specification, however, shall supersede applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.0 Intended use. The foam concentrates defined in this specification are intended for use in controlling the vapor hazard from spills of hypergolic propellants, hydrazine and nitrogen tetroxide. The foams also have ancillary application for use as a fire extinguishing agent on fires fueled by hydrazine, or its methyl derivatives, alone or on Class A or B hydrocarbon fuel fires in which combustion is supported by nitrogen tetroxide. They are not effective in extinguishing fires involving hypergolic mixtures of hydrazines and nitrogen tetroxide but their use is recommended to control the release of toxic vapors and to mitigate combustion during those fires.

3.1 Qualification. Liquid concentrate fire extinguishing agent components furnished under this specification shall be products which are qualified for listing on the applicable Qualified Products List at the time set for opening of bids (see 4.3 and 6.3).

3.2 Materials. Concentrates shall consist of four materials, supplied in separate containers. The foam materials are: An acid-containing, acrylic emulsion copolymer for the fuel (Type F1), a surfactant for the fuel (Type F2), an acid-containing, crosslinked acrylic emulsion copolymer for the oxidizer (Type 01), and a surfactant for the oxidizer (Type 02) and other components as required to conform to performance requirements of this specification. Each component and the mixtures of individual components shall conform to the requirements specified. The materials shall have no adverse effects on the health of personnel when used as intended or handled as specified by Air Force directives.

3.3 Concentrate characteristics. Concentrates, or solutions made from these concentrates, shall conform to the chemical and physical requirements shown in Table I and Table II.

3.3.1 Stability. The concentrates (Types F1, F2, 01 and 02) shall conform to the following requirements after 10 days storage at 65°C + 2.0°C (see 4.7.11):

a. Stratification: No visible evidence following test (see 4.7.15).

b. Precipitation: Less than 0.05 percent by volume, (see 4.7.16).

3.3.2 Compatibility of concentrates. The concentrates of one manufacturer shall be compatible in all proportions with the corresponding concentrates furnished by other manufacturers listed on the qualified products list. Information regarding these materials may be obtained from the Air Force Engineering and Service Center, Tyndall Air Force Base, FL, 32403-6001. The concentrate mixtures shall conform to the following requirements after 10 days storage of the concentrates at 65°C ± 2.0°C (see 4.7.11):

a. Stratification: No visible evidence following test (see 4.7.15)

b. Precipitation: Less than 0.05 percent by volume, (see 4.7.16)

3.4 Foam mixture solutions characteristics. Mixtures of the two components for each of the two types of foams (Type F and Type O) shall conform to the chemical and physical requirements shown in Table II:

3.4.1 Stability. The 10-10-80 premix solution consisting of 10 parts each of Type F1 and F2 concentrates and 80 parts of fresh water, or Type 01 and 02 concentrates and 80 parts of fresh water, as applicable, shall conform to the following requirements after 10 days storage of the concentrates at 65°C + 2.0°C (see 4.7.11):

a. Foamability: (See Table II).

b. Fire performance: 50 ft^2 fire as specified in 3.5.

c. Vapor suppression: (See Table II).

3.4.2 Compatibility of foam mixture solution. The concentrates of one manufacturer shall be compatible in all proportions with concentrate furnished by other manufacturers listed on the qualified products list. Information regarding these materials may be obtained from the Air Force Engineering and Services Center, Tyndall Air Force Base, FL 32403-6001. The solutions shall conform to the following requirements after 10 days storage of the concentrates at 65°C + 2.0°C (see 4.7.11):

a. Foamability: (see Table II).

b. Fire performance 50 ft^2 fire as specified in 3.5.

c. Vapor suppression: (see Table II).

(3.3.2 applies to "concentrates" while 3.4.2 applies to "mixture solutions".)

3.5 Fire performance. The foam shall conform to the fire performance requirements shown in Table III.

3.6 Marking.

3.6.1 Identification marking shall be in accordance with MIL-STD-130. In addition, the marking on the containers (see 5.3) shall be in white characters against an orange background for Types 01 and 02, a red background for Types F1 and F2.

3.6.2 Two identical markings conforming to figures 1, 2, 3, and 4 shall be applied to containers, as appropriate, so that the markings are located diametrically opposite. The markings shall be applied on the containers in such a manner that water immersion contact with the contents of the containers, or normal handling will not impair the legibility of the marking. Paper labels shall not be used.

3.7 Material safety data sheet.

3.7.1 The contracting activity shall be provided a material safety data sheet (MSDS) at the time of contract award. The MSDS is form OSHA-20, found in and part of FED

TABLE I. Physical and chemical requirements for concentrates or solutions.

Requirement	Values				Applicable publication	Test paragraph
	Type F1 Fuel acrylate	Type F2 Fuel surfactant	Type 01 Oxidizer acrylate	Type 02 Oxidizer acrylate		
Refractive index, minimum maximum		1.3900 - 1.4100		1.3800 - 1.4200	ASTM 1218	4.7.1
Brookfield viscosity of concentrate centipoise minimum at 25°C	-	1640	-	2780	ASTM 3716	4.7.2.1
Brookfield viscosity of 1% neutralized solution centipoise range minimum maximum	4500 - 6000	-	3000 - 5000	-	-	4.7.2.1.1
Hydrogen ion concentration: (pH) 10% solution	2.1-4.0	8.7 - 9.3	2.1 - 4.0	8.7 - 9.3	ASTM E70	4.7.3
Density, g/cc @25%c	1.020 - 1.070	-	1.020 1.070	-		4.7.4
Corrosion rate: General, (mpy)	1.0	1.0	1.0	1.0	ASTM E527	4.7.5
Localized, pits	none	none	none	none		
% solids minimum	19.5	-	27.5	-		4.7.6
maximum	20.5		28.5			
Fraction gelled (gms/l)	0.2	-	0.1	-		4.7.7
Iron content (ppm) max	5	10	5	10	ASTM 1068	4.7.8
Environmental impact COD, mg/L, max	-	1,000,000	-	1,000,000	APHA Standard Methods	4.7.10.2
BOD_{20}/COD, min		0.75		0.75		4.7.10.3
Aquatic Toxicity LD50 for rainbow trout (ppm max)	1400	8	450	6	ASTM E729	4.7.10.1
Inorganic Sulfates maximum	-	1.6	-	1.6	ASTM D3673	4..7.9

Table II. Performance Requirements for Propellant Foams - Quality Control Laboratory Tests

	Foam System Evaluated	
Requirement	Types F1 + F2 over NH_4OH	Types 01 + 02 over HNO_3
Expansion ratio		
minimum	4.0	2.5
maximum	5.0	3.5
25% drainage time		
minimum	24 hours	10 minutes
Collapse % in 24 hours		
maximum	15	--
50% collapse time, minutes, minimum	--	50

1. Substitute propellant substrates are undiluted, reagent grade ammonium hydroxide and nitric acid over which foams are applied as specified in 4.7.1.4.

Table III. Fire performance.

	Hypergolic fuel foams			
	Type F low expansion	Type F high expansion	Type O high expansion	Test paragraphs
50 ft^2 fire (see 4.7.13)				
Foam application time to extinguish, seconds, max	240	150	75	4.7.14.1.5 4.7.14.2.5 4.7.14.3.5
Burnback time of resulting foam cover, minutes, min	5	N/A	N/A	4.7.14.1.6 4.7.14.2.6 4.7.14.3.6
Vapor securing ability, post-fire, concentration, ppm maximum	1 ppm N_2H_4	1 ppm N_2H_4	100 ppm NO_x	4.7.14.1.7 4.7.14.2.7 4.7.14.3.7
Foamability:				
Foam expansion, minimum	6	200	200	4.7.14.4
Foam 25% drainage time, minutes, minimum	12	5	4	4.7.14.4
Wand Test	Pass	Pass	Pass	4.7.14.1.6 4.7.14.2.6 4.7.14.3.6

STD 313. The MSDS shall be included with each shipment of the materials covered by this specification.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract, the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.2 Classification of inspections. The inspection requirements specified herein are classified as follows:

a. Qualification inspection (see 4.3).

b. Quality conformance inspection (see 4.5).

  1. Examination of filled containers.

  2. Quality conformance inspection.

4.3 Qualification inspection. Qualification inspection shall be conducted at a laboratory satisfactory to the Air Force Engineering Services Center, Tyndall Air Force Base. Qualification inspection shall consist of the tests shown in Table IV.

4.3.1 Samples for qualification inspection. One 55 gallon drum of each component is required for the qualification inspection.

4.4 Sampling for quality conformance inspection.

4.4.1 Inspection lot. A lot shall consist of each component manufactured as one batch and transferred from one mixing tank to the shipping container.

4.4.2 Sampling for examination of filled containers. A random sample of filled containers shall be inspected from each lot in accordance with MIL-STD-105 at inspection level I. The acceptable quality level (AQL) of 2.5 percent defective shall be used to verify compliance with all requirements regarding fill, closure, marking, and other requirements not requiring tests (see 4.6, 5.1.1.1, and 5.1.1.2).

4.4.3 Sampling for quality conformance inspection. Three filled 55-gallon containers of each concentrate shall be selected at random from each lot and used as one composite sample for the tests specified in 4.6. For purposes of the tests required by 4.5 one of the 55-gallon containers selected at random may be used or a 55 gallon sample of the product shall be withdrawn from an agitated mixing tank prior to packaging. The results of the tests required by 4.5 shall be submitted to the Air Force Systems Command, Space Division

(CFPE), Los Angeles, CA, 90009-2960 or the designated laboratory.

4.5 Quality conformance inspection. The samples selected in accordance with 4.4.3 shall be subjected to the quality conformance inspection of table IV. If the sample tested is found to be not in conformance with any of the quality conformance tests, the lot represented by the sample shall be rejected.

4.5.1 Quality conformance inspection report. The contractor shall prepare test reports in accordance with the data ordering document included in the contract (see 6.2.2).

4.6 Examination of filled containers. Each sample filled container shall be examined for defects of construction of the container, and the closure, for evidence of leakage, and for unsatisfactory markings. Each filled container shall also be weighed to determine the amount of contents. Any container in the sample having one or more defects or less than required fill, shall not be offered for delivery, and if the number of defective containers in any sample exceeds the acceptance number for the appropriate sampling plan of MIL-STD-105, this shall be cause for rejection of the lot represented by the sample.

4.7 Test procedures.

Note: Temperatures are recorded to the nearest degree, pH to the nearest 0.1 unit, density to the nearest 0.001

Table IV. Qualification and quality conformance inspections.

Examination or Test	Reference paragraph		Qualification	Quality Conformance
	Requirement	Test		
Refractive index	3.3	4.7.1	x	x
Viscosity	3.3	4.7.2	x	x
pH value	3.3	4.7.3	x	x
General Corrosion	3.3	4.7.5.1	x	
Localized corrosion	3.3	4.7.5.2	x	
Density	3.3	4.7.4	x	x
Percent solids	3.3	4.7.6	x	x
Fraction gelled	3.3	4.7.7	x	x
Inorganic sulfates	3.3	4.7.9	x	x
Iron content	3.3	4.7.8	x	x
Foamability	3.4	4.7.13	x	x
Performance with simulated propellants	3.4	4.7.17	x	x
Environmental impact	3.3	4.7.10	x	
50 ft^2 fire test	3.5	4.7.14	x	
Examination of filled containers	4.6	4.6		x
Stability	3.3.1 & 3.4.2	4.7.11	x	
Compatibility	3.3.2 & 3.4.2	4.7.12	x	
Stratification	3.3.1 & 3.4.1	4.7.15		x
Precipitation	3.3.2 & 3.4.2	4.7.16		x

g/cc, viscosity to the nearest 0.01 cp and refractive index to the nearest 0.0001 unit.

4.7.1 Refractive index. Measure the refractive index at a temperature of 20°C in accordance with ASTM 1218. Record refractive index and temperature.

4.7.2 Viscosity.

4.7.2.1 Viscosity of acrylate Emulsions and Surfactants. The viscosity shall be determined at a temperature of 25°C ± 0.2°C in accordance with ASTM D3716. Viscosity measurements of surfactants are determined on concentrated samples which have been thoroughly agitated assuring a uniform mixture before sampling and after temperature equilibration. The viscosity of acrylates is measured on a neutralized 1% copolymer solution after treating the original sample shown in 4.7.2.1.1. The viscosity shall be recorded in centipoise.

4.7.2.1.1 Thickened Viscosity of a 1% Copolymer Solution of Type F1 and Type 01. Using a platform balance, accurately weigh (X) g of sample into a 16-ounce, wide-mouth jar. Add (W) g of distilled water and (V) ml of IN NaOH, in that order. Use a buret calibrated to the nearest 0.1 ml to add the NaOH. Mix carefully with a spatula. Avoid aeration. Label this solution "A".

Using a platform balance, weigh specified amounts of solution "A" and distilled water (both from Table V under "Final Dilution") into a 16 ounce jar. Mix carefully with a spatula. Avoid aeration. Determine the pH of the solution in accordance with ASTM E70.

Use the following equations to calculate the weight of sample, volume of IN NaOH and weight of water required to prepare an initial neutralized copolymer solution.

$$X = \text{grams of sample} = \frac{R^*}{\%\ \text{gelled}^*}$$

$$V = \text{ml of NaOH} = \frac{(X) \times \text{Acid Number}^*}{56.1 \times N\ (\text{NaOH})} - B$$

$$W = \text{grams of water} = S^* - X - 1.04\ V$$

*R, B, and S are constants from Table V. Acid Number is considered a constant, unless otherwise indicated. % gelled is determined in accordance with 4.7.7. Determine the viscosity of the solution at 25°C ± 2°C. Use the Brookfield, Model LVF Viscometer and #3 spindle at 12 RPM.

4.7.3 pH value.

4.7.3.1 pH of acrylate emulsions. The pH value of the acrylate emulsions shall be determined on the neat material at 25°C ± 1.0°C in accordance with ASTM E70. Care must be taken to rinse electrodes thoroughly with distilled or deionized water immediately after determining the pH value.

4.7.3.2 pH of surfactants. The pH value of a 10% (by volume) solution of surfactant in distilled or deionized water shall be determined at 25°C ± 1.0°C in accordance with ASTM E70. The pH may change slowly with time; therefore, the

TABLE V. Constant Values and Ranges

				Final Dilution			
Type	R	B	S	g Solution "A"	g Water	Allowable pH Range	Acid Number
F1	689	2	400.0	125.0	125.0	7.5 - 9.0	89.0
O1	1842	3	400.0	50.0	200.0	7.5 - 8.5	72.3

relatively steady reading after several minutes of stirring is recorded.

4.7.4 Density. Weigh a clean, dry 10 cc volumetric flask. Fill to the mark with sample and reweigh. Adjust temperature to 25°C ± 2°C in a constant temperature bath. Record density in g/cc and actual sample temperature.

4.7.5 Corrosion. The liquid for immersion of the metal specimens for general corrosion and localized corrosion tests shall consist of the concentrate of each of Types F1, F2, 01 and 02.

4.7.5.1 General corrosion.

4.7.5.1.1 Test specimens. The test specimen shall consist of UNS 30400 in accordance with UNS designations (see ASTM E527). All specimens shall be milled to finished dimensions of approximately 1/16 inch thick, 1/2 inch wide, and 3 inches long. All specimens shall be degreased in acetone, rinsed with distilled water and air dried before exposure. (Prepared metal specimens may be obtained from the Metaspec Company, Box 6715, San Antonio, Texas 78209.)

4.7.5.1.2 Test procedures. Five weighed specimens shall be fully immersed in the test medium in a separate 600 mL beaker and held at 25°C ± 5°C for a period of 60 days. A watch-glass cover shall be used to retard evaporation. At the end of the exposure period, the weight-loss shall be determined and the corrosion rate calculated as required.

4.7.5.2 Localized corrosion.

4.7.5.2.1 Test specimens. The test specimens shall consist of UNS 30400 CRES milled to finished dimensions of approximately 1/16 inch thick, 1/2 inch wide, and 3 inches long. After degreasing with acetone, rinsing with distilled water, and air drying before exposure, the specimens shall be pretreated by immersion in a 1:9 concentrated nitric acid-water solution for a period of 5 minutes and then rinsed again with distilled water.

4.7.5.2.2 Procedure. Ten specimens shall be girdled lengthwise with a clean 1/16 to 1/8 inch wide band of a good grade of gum rubber of a size such that the band is taut during the test. Because of the poor quality of most commercial rubber bands, it is recommended that the bands for this test be cut from 1-3/4 inch flat width pure gum amber tubing. Gooch type (Preiser Scientific Rubber tubing, Pure Gum, Gooch type, 1/32-inch thin wall, pure gum amber tubing is very elastic, especially made for Gooch crucibles, Stock No. 139080, or equal). This tubing is most easily cut with sharp shears. The specimens girdled with the rubber bands shall be placed in a 60 mL beaker so that no contact is made between individual specimens. A 1/4-inch layer of glass beads shall be introduced into the beaker to aid in stabilizing specimen position. Enough liquid shall be added to completely immerse the specimens, and a watch-glass shall be placed over the beaker to retard evaporation (but allow air access) and act as a dust cover, and the assemblies allowed to stand at room temperature for 60 days.

4.7.5.2.3 Results. The specimens shall be monitored daily over the 60-day period to ascertain the presence or absence of pitting. These daily examinations shall be made without disturbing the test (other than removing the cover). Corrosion is customarily signaled by appearance of a dark spot which, if removed after sufficient exposure, discloses a corrosion pit. If the suspected area cannot be positively identified by the naked eye, it can be at a magnification of 10X. At the end of the test, each specimen shall be inspected carefully with particular attention being given to the edges of the specimens and those areas of the specimens under, or adjacent to the rubber bands. 10X magnification shall be used, if necessary.

4.7.6 Percent solids.

4.7.6.1 Test equipment. Tared aluminum dishes with a close-fitting cover having a diameter of approximately 60 mm and a height of 15 mm.

4.7.6.2 Test procedure. If the temperature of the emulsion is above room temperature, allow it to cool to room temperature. Then weigh two samples of approximately 1 g each to the nearest 1.0 mg in dried tared aluminum weighing dishes. Dry the samples for 20 min. in a forced-draft oven at a temperature of 150°C ± 2°C. Remove the samples from the oven, cool the container and contents to room temperature in a desiccator, and weigh them to the nearest 0.1 mg. Average the values if they are within 0.1%. If not, make additional duplicate determinations until a pair of duplicate determinations agree within 0.1%. Calculations of the percent solid content are to be conducted in accordance with ASTM D3716 paragraph 5.3.

4.7.7 Fraction gelled.

4.7.7.1 Test equipment. Sieves, Tyler or U.S.B.S. 20 and 100-mesh, diameter 8 inches, all stainless steel. Spray head with rubber hose connections. Tin can, 2-ounce, style #12, 2-3/8 X 13/16 inch, with bead and trim, body degreased, lid standard.

4.7.7.2 Test procedure. Transfer one liter of the sample into a 3.8 liter jar containing one liter of clean tap water (25-30°C) and swirl to obtain a uniform mixture. Thoroughly wet both sides of a 20-mesh and 100-mesh sieve with tap water. Connect the sieves with 20-mesh on top, and 100-mesh on bottom. Pour the diluted sample onto the 20-mesh and swirl until most of liquid has passed through. Using a shower head connected to a water outlet, rinse the sieves gently with clean tap water, being careful to avoid foam formation. Next, separate the sieves and gently rinse the 100 mesh sieve, again being careful to avoid foam formation.

(The purpose of the 20-mesh sieve is to assure the obtaining of true gel particles by removing any skins). Immediately, before the 100-mesh sieve can dry, treat the sieve as follows: Using the shower head, wash the gel particles on the sieve into as compact a mass as possible in one corner of the sieve. Place a dry paper towel on the underside of the sieve directly below the collected gel particles to dry the sieve and gel particles. Then, use a small spatula to scrape the gel particles off the screen and transfer them quantitatively into a weighed 2-ounce solids can. Place the can in a forced-draft oven at 150°C ± 2°C for 20 minutes. Remove the can from the oven, close the lid, and allow the can to cool in a desiccator to room temperature. Then, reweigh to determine the weight of dried residue. Report to the second decimal place, the weight of dried residue in grams per liter.

4.7.8 Iron content. Accurately weigh 10 grams of sample into a clean 30 ml ceramic crucible. Place the crucible in a clay triangle and carefully burn off all organics using a laboratory burner. Burn off the remaining carbon in a muffle furnace at 600°C. Cool the crucible to near room temperature, add 1 ml of concentrated hydrochloric acid and 1 ml of concentrated nitric acid and digest on a hot plate until light boiling occurs. Cool. Dilute sample to 10.0 ml and perform the atomic adsorption analysis in accordance with ASTM D1068. Use an air-acetylene flame (lean) and the longest burner possible.

4.7.9 Inorganic sulfates. The weight percent of inorganic sulfates as sodium sulfate shall be determined in accordance with ASTM D3673.

4.7.10 Environmental impact.

4.7.10.1 Toxicity. Toxicity test shall be performed on rainbow trout in accordance with ASTM E729, using dynamic procedures. The minimum acceptable dissolved oxygen content of water used in this procedure shall be 5 ppm.

4.7.10.2 Chemical oxygen demand. COD shall be determined in accordance with procedures in Standard Methods for the Examination of Water and Waste Water (latest applicable edition).

4.7.10.3 Biodegradability. Biodegradability shall be determined by dividing the value expressed in mg/L for the carbonaceous biochemical oxygen demand (CBOD) specified in Standard Methods for the Examination of Water and Waste Water (latest applicable edition) by the value expressed in mg/L for chemical oxygen demand (COD) determined as specified in 4.7.10.2.

4.7.11 Stability.

4.7.11.1 Sample preparation. Samples of each concentrate, and the two foam solutions, as appropriate, shall be prepared in sufficient quantity to perform the required tests. One liter (L) of each concentrate shall be placed in lightly stoppered glass cylinder. All concentrate samples shall then be stored being subjected to accelerated aging at 60°C ± 2.0°C for a period of 10 days. The concentrate samples, or solutions made from them, shall then be subjected to the following tests:

a.	Foamability	4.7.13
b.	Fire performance (50 ft^2)	4.7.14
c.	Stratification	4.7.15
d.	Precipitation	4.7.16
e.	Performance with simulated propellants	4.7.17

4.7.12 Compatibility.

4.7.12.1 Sample preparation. The Government will provide samples of appropriate qualified product to manufacturers officially authorized to submit candidate material for qualification (see 3.3.2). Mixtures of the concentrates to be tested shall be prepared in sufficient quantities to perform the required tests. (For qualification testing, the testing activity will determine the number of product mixtures to be evaluated and the ratio of products comprising these mixtures). One L of each shall be placed in lightly stoppered glass cylinders. The concentrate samples shall be stored at 65°C ± 2.0°C for a period of 10 days. The samples and solutions made from them shall then be subjected to the following tests:

a.	Foamability	4.7.13
b.	Fire performance (50 ft^2)	4.7.14
c.	Stratification	4.7.15
d.	Precipitation	4.7.16
e.	Performance with simulated propellants	4.7.17

4.7.13 Laboratory foamability.

4.7.13.1 Test equipment. Blender (Citation-Walther Corporation unit or equivalent), 1000 cc graduated cylinder, balance (1000 gram capacity) normal laboratory glassware.

4.7.13.2 Procedure. The expansion ratios and drainage rates of both Type F fuel foam and Type O oxidant foams are determined over simulated propellant substrates where hydrazine fuel is replaced with ammonium hydroxide (NH_4OH) and nitrogen tetroxide oxidant is replaced with nitric acid (HNO_3). Mix 1 volume of the acrylic concentrate (F1 for the fuel foam or 01 for the oxidizer foam) with 4 volumes of water and stir. Mix 1 volume of the surfactant concentrate (F2 for the fuel foam or 02 for the oxidizer foam) with 4 volumes of water and stir thoroughly, being careful to avoid foam formation. From each of the mixtures remove equal volume aliquots. Place the F2 or 02 aliquot in the foam generator (blender). Add the F1 or 01 (Make sure that F1 is combined with F2 for the fuel foam and 01 is combined with 02 for the oxidizer foam) aliquot and start agitation immediately using the #8 setting (18,500 rpm); continue for about 30 seconds. Add either 20 ml of concentrated reagent grade NH_4OH or HNO_3 as appropriate (see Table II) to the graduated cylinder. Weigh the cylinder and substrate to the nearest gram. Transfer 980 ml of the foam generated in the blender to the 1000 ml mark of the cylinder. Determine the 25% drainage time as specified in NFPA 412. In addition, the percent of foam collapse after 24 hours shall be determined for Type F foams only and the time, in minutes, required for 50% of the foam column to collapse shall be determined for Type O foams only.

4.7.14 Fire test. No fire test shall be conducted when the wind speed is above 10 miles per hour (mi/hr). The fire test shall be conducted in a square metal pan with a total area of 50 ft^2 in accordance with U.L. 162. NOTE: The materials used in this test are extremely hazardous and must be handled in accordance with approval safety procedures. Only a few test sites in this country are approved to conduct tests with these toxic materials. In addition to their toxicity, the fuel has been known to ignite spontaneously when certain conditions of heat and oxidation exist in the fire test pan.

4.7.14.1 Type F low expansion test.

4.7.14.1.1 Test equipment. The nozzle used for the low expansion test shall be the 4 gal/min nozzle manufactured by National Foam Systems, Inc., Lionville, PA, Part No. 1251-0896-8. The nozzle inlet pressure shall be a gage pressure of 100 lb/in^2. The discharge from the nozzle shall be directed against a backboard which is placed at one edge of the test plan in order to achieve the gentle application of foam described as Type II in the U.L. 162 procedure. Flame/extinguishment shall be viewed through an IR thermal imaging device (English Electric Valve Company Limited miniature thermal imaging camera Model P4428 or equal).

4.7.14.1.2 Foam component preparation. The two foam components, F1 and F2, shall be prepared at 20°C + 5°C. The premixed component solutions shall be 20 + 0.05 percent solutions made with fresh water. The two premixed component solutions shall be prepared no more than 24 hours before the initiation of the fire test. The premixed solutions shall be stored in stainless steel containers, to prevent polymerization by iron contamination of the components, see Figure 5.

4.7.14.1.3 Fuel. Fuel for the fire test shall be 55 gal of a 50-50 mixture of hydrazine and unsymmetric dimethyl hydrazine conforming to requirements of MIL-P-2560. NOTE: As stated in 4.7.14, this fuel is highly toxic and must be handled in accordance with proper safety procedures.

4.7.14.1.4 Foam generation. The two components shall not be mixed until immediately before being applied to the test pan. The two components shall be mixed in equal proportion at a total flow rate of 4 gal/min. No more than 20 ft of hose or piping shall be installed between the mixing point and the discharge nozzle. The recommended foam generation set-up is shown in Figure 5.

To make foam, each tank is loaded with the premix and sealed. Air pressure is applied to the tank top. When the pressure reaches 100 psi, each shutoff valve is opened individually and the pressure regulators adjusted to read 30 psi at the foam maker for high expansion foam, and 100 psi for low expansion foam. Both valves are then opened to insure that good foam is being produced, after which both valves are closed. The system is now ready for fire testing. It is advisable not to allow the mixed foam solutions to remain in the line between the balancing valve and the foamaker for more than 5 minutes without restarting flow.

When foam is to be generated for testing, both shutoff valves are opened simultaneously. Do not make any adjustments to the pressure regulators on either line. Foam generation is stopped by closing both shutoff valves simultaneously. Within 5 minutes after testing stops, all lines should be flushed with water and drained. In cold weather, care should be taken to prevent freezing of lines and components. The nozzle shall be directed at the same metal backboard over one edge of the pan to allow gentle application of foam to the fuel surface.

4.7.14.1.5 Test procedure. The fuel shall be dumped into the pan within 10 minutes and ignited within one minute of dumping. After allowing a preburn period of 60 seconds application of foam shall begin through the nozzle. The exact extinguishing time shall be recorded as viewed through the IR thermal imaging device, but foam application shall continue for a total of 5 minutes.

4.7.14.1.6 Burnback procedure. Conduct burnback and wand tests in accordance with UL162.

4.7.14.1.7 Post-fire vapor securing test. 60 seconds after successful completion of the burnback test, the atmosphere above the foam blanket shall be tested for the presence of fuel vapor. Samples shall be taken from 3 points above the foam surface, with two of the points being above the center and one of the edges of the pan, while the third point shall be above the area used for the burnback test. Note: Appropriate detector tubes and sampling devices are available from the Mine Safety Appliance Company (MSA) and other reliable manufacturers.

4.7.14.2 Type F high expansion test.

4.7.14.2.1 Test equipment. The foam shall be generated by means of the 5 inch Mark IV foam generator, as made by

Mine Safety Appliances Co., Inc., Evans City, Pennsylvania, (or equal) utilizing a Number 16 nozzle, adjusted to provide an expansion ratio of 230, when flowing a standard foam solution at 60 lb/in^2 inlet nozzle pressure. The inlet pressure shall be a gage pressure of 30 lb/in^2. The end of the foam generator shall be placed at the edge of the test pan at a height of 1 to 2 feet above the pan. Flame extinguishment shall be determined by viewing through the IR thermal imaging device described in 4.7.14.1.1.

4.7.14.2.2 Foam component preparation. As specified in 4.7.14.1.2.

4.7.14.2.3 Fuel. As specified in 4.7.14.1.3

4.7.14.2.4 Foam generation. The two components shall not be mixed until immediately before being applied to the test pan. The two components shall be mixed in equal proportion at a total flow rate of 2.6 gal/min. The recommended foam generation set-up and procedure is discussed in 4.7.14.1.4.

4.7.14.2.5 Test procedure. The fuel shall be dumped into the pan within 10 minutes and ignited within one minute of dumping. After allowing a preburn period of 60 seconds application of foam shall begin through the foam generator. The exact extinguishing time shall be recorded, as viewed through the IR thermal imaging device. Neither the wand test nor burnback test as specified in UL162 is applicable to high expansion foam.

4.7.14.2.6 Post-fire vapor securing test. As specified in 4.7.14.1.7 except that tests for the fuel vapor (N_2H_4) shall be conducted 60 seconds after completion of foam application.

4.7.14.3 Type O high expansion test.

4.7.14.3.1 Test equipment. As specified in 4.7.14.2.1

4.7.14.3.2 Foam component preparation. The O2 concentrate container shall be inverted at least twice, at 24 hour intervals (minimum), in the week immediately preceding the test. The O2 concentrate shall be mechanically mixed immediately before drawing off the material which will be used to prepare the premix component solutions. The two foam components, O1 and O2, shall be prepared at 20°C + 5°C. The premixed component solutions shall be 20 + 0.05 percent solutions made with fresh water. The two premixed component solutions shall be prepared no more than 24 hours before the initiation of the fire test. The premixed solutions shall be stored in stainless steel containers, see Figure 5.

4.7.14.3.3 Fuel. Fuel for the fire test shall be a mixture of 30 gal of dinitrogen tetroxide (N_2O_4) complying with MIL-P-26539, and 30 gal of diesel fuel complying with FED SPEC VV-F-800 (Grade DF-2). WARNING: The fumes from

N_2O_4 are extremely corrosive and toxic and extreme care must be utilized in handling this material.

4.7.14.3.4 Foam generation. As specified in 4.7.14.2.4.

4.7.14.3.5 Test procedure. As specified in 4.7.14.2.5, except preburn time is reduced to 30 seconds. Neither the wand test nor burnback test as specified in UL162 is applicable to these high expansion foams.

4.7.14.3.6 Post-fire vapor securing test. As specified in 4.7.14.1.7 except that tests for oxidant vapor (NOx) shall be conducted 60 seconds after completion of foam application.

4.7.14.4 Foamability. The foams shall be generated by means of the equipment described previously for the 50 ft^2 fire test. Foam samples shall be collected immediately after the cessation of foam application to the test pan. The nozzles shall be held at hip height and directed onto the backboard from the distances specified below. The method and procedure shall be in accordance with NFPA Standard No. 412. The expansion ratio and 25% drainage time shall be determined in accordance with this procedure.

4.7.14.4.1 Low expansion. The foam shall be generated by means of the 4 gallons per minute (gal/min) test nozzle described in 4.7.14.1.1. During sample collection the nozzle inlet pressure shall be maintained at a gage pressure of 100 pounds per square inch (lbs/in^2), and the solution directed onto the backboard from a distance of 4 to 6 feet.

4.7.14.4.2 High expansion. The nozzle used for the high expansion test shall be the foam generator specification 4.7.14.2.1. During sample collection the nozzle inlet pressure shall be maintained at a gage pressure of 30 lb/in^2 and the solution shall be directed onto the backboard from a distance of 2-3 feet.

4.7.15 Stratification. The presence of stratification shall be determined by visual examination of the samples contained in the glass cylinders.

4.7.16 Precipitation. The amount of precipitation shall be determined by centrifuging to a 100 mL sample withdrawn from the 1 L sample after thorough agitation in accordance with the primary method of ASTM D96-73.

4.7.17 Packaging inspection. Sample packages and packs and the inspection of preservation, packaging, packing, and marking for shipment and storage shall be in accordance with the requirements of 4.6, section 5 and the documents specified therein.

5. PACKAGING

(The packaging requirements specified herein apply only for direct Government acquisitions. For the extent of applicability of the packaging requirements of referenced documents listed in section 2, see 6.4.)

5.1 Preservation-packaging. Preservation-packaging for level A shall be as specified hereinafter.

5.1.1 The four liquid concentrate components shall be furnished in 55-gallon composite containers as specified (see 6.2.1).

5.1.1.1 Fifty-five gallon container. The 55-gallon container shall be a composite comprised of a plastic insert and a steel drum overpack. The composite container shall conform to the requirements of type II, class 4 of PPP-C-1337, and the following:

a. Insert. The insert shall contain two protruding openings in the top head - one 3/4-inch and one 2-inch. Openings shall be so designed that when positioned in the steel drum cover there will be no strain on the protruding openings. The protruding plastic openings shall be secured to the drum cover by means of lock or retaining rings and gaskets. Openings shall be closed by use of NPT threaded plastic plugs.

b. Covers. The steel drum cover shall be provided with two openings to accommodate the protruding insert openings. Covers shall be fully removable. Cover gaskets are not required. Covers shall be secured to the steel drum with minimum 16-gage bolt or lever lock type locking rings.

5.1.1.2 Exterior color and coatings. The red color (see 3.6) shall be an approximate match to color number 11105 of FED-STD-595. The orange color (see 3.6) shall be an approximate match to color number 12246 of FED-STD-595. Exterior coating for steel drum overpacks shall conform to TT-E-489.

5.2 Packing. For level A no further packing is required.

5.2.1 Method of shipment shall comply with Uniform Freight Classification Ratings, Rules, and Regulations or other carrier rules as applicable to the mode of transportation.

5.3 Marking. In addition to the marking specified in 3.6 and any special marking required (see 6.2.1), containers and palletized unit loads shall be marked in accordance with MIL-STD-129.

6. NOTES

6.1 Intended use. The concentrates as intended for use in mechanical foam generating equipment for suppressing toxic vapor release from accidental spills of liquid propellants as well as for extinguishing fires where the fuel is either hydrazine alone or a hydrocarbon fuel where combustion is supported by dinitrogen tetroxide as the oxidant.

6.2 Ordering data.

6.2.1 Acquisition requirements. Acquisition documents should specify the following:

a. Title, number, and date of this specification.

b. Type of concentrate(s) required (see 1.2).

c. Special marking, if required (see 5.3).

6.2.2 Data requirements. When this specification is used in a contract which invokes the provision of the "Requirements for Data" of the Defense Acquisition Regulation (DAR), the data identified below, which are required to be developed by the contractor, as specified on an approved Data Item Description (DD Form 1664), and which are required to be delivered to the Government, should be selected and specified on the approved Contract Data Requirement List (DD Form 1423) and incorporated in the contract. When the provisions of the "Requirements for Data" of the DAR are not invoked in a contract, the data required to be developed by the contractor and required to be delivered to the Government should be selected from the list below and specified in the contract.

Paragraph	Data requirement	Applicable DID
4.5.1	Test reports	DI-T-2072

(Copies of data item descriptions required by the contractors in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting officer. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply.)

6.2.2.1 The data requirements of 6.2.2 and any task in section 3, 4, or 5 of the specification required to be performed to meet a data requirement may be waived by the contracting/acquisition activity upon certification by the offeror that identical data were submitted by the offeror and accepted by the Government under a previous contract for identical item acquired to this specification. This does not apply to specific data which may be required for each contract regardless of whether an identical item has been supplied previously (for example, test reports).

6.3 With respect to products requiring qualification, awards will be made only for products which are at the time set for opening of bids, qualified for inclusion in the applicable Qualified Products List QPL XXXX whether or not such products have actually been so listed by that date. The attention of the contractors is called to these requirements, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or orders for the products covered by this specification. The activity responsible for the Qualified Products List is AFESC Tyndall AFB, Air Force Engineering Services Command, Fire Technology Branch, Tyndall Air Force

Base, FL, 32403, and information pertaining to qualification of products may be obtained from that activity. Application for Qualification tests shall be made in accordance with "Provisions Governing Qualification SD-6" (see 6.3.1).

6.3.1 Copies of "Provisions Government Qualification SD-6" may be obtained upon application to Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

6.4 Sub-contracted material and parts. The packaging requirements of referenced documents listed in section 2 do not apply when material is acquired by the contractor for incorporation into the concentrate and lose separate identity when the concentrate is shipped.

Custodians
Air Force - 19

Review Activities
Air Force - 68

Preparing Activities
Air Force - 50

(Project 6850-F828)

THIS END UP

U.S.

HYPERGOLIC PROPELLANT FOAMS LIQUID CONCENTRATE

In accordance with

MILITARY SPECIFICATION MIL-V

TYPE F1 - FUEL FOAM GELLING AGENT

THIS VAPOR SUPPRESSING/FIRE EXTINGUISHING CONCENTRATE IS FOR USE BY DILUTION WITH WATER IN FIXED OR MOBILE SYSTEMS. IT MUST BE USED IN COMBINATION WITH THE TYPE F2 SURFACTANT. THE CONCENTRATE MAY BE DILUTED FOR USE IN FLOW PROPORTIONING EQUIPMENT WITH FRESH WATER AT VOLUME PROPORTIONS OF ONE GALLON EACH OF THE F1 AND F2 CONCENTRATES TO 8 GALLONS WATER.

FOR READY USE DO NOT STORE BELOW 32°F. AVOID PROLONGED STORAGE ABOVE 120°F. DO NOT MIX WITH OTHER THAN TYPE F2 LIQUID CONCENTRATE IN ACCORDANCE WITH MIL-V- AND WATER.

MANUFACTURER'S NAME
ADDRESS
BATCH NO.
DATE OF MANUFACTURE

FIGURE 1. Type F1 container markings.

THIS END UP

U.S.

HYPERGOLIC PROPELLANT FOAMS LIQUID CONCENTRATE

In accordance with

MILITARY SPECIFICATION MIL-V-

TYPE F2 - FUEL FOAM SURFACTANT

THIS VAPOR SUPPRESSING/FIRE EXTINGUISHING CONCENTRATE IS FOR USE BY DILUTION WITH WATER IN FIXED OR MOBILE SYSTEMS. IT MUST BE USED IN COMBINATION WITH THE TYPE F1 GELLING AGENT. THE CONCENTRATE MAY BE DILUTED FOR USE IN FLOW PROPORTIONING EQUIPMENT WITH FRESH WATER AT VOLUME PROPORTIONS OF ONE GALLON EACH OF THE F1 AND F2 CONCENTRATES TO 8 GALLONS WATER.

FOR READY USE DO NOT STORE BELOW 32°F, AVOID PROLONGED STORAGE ABOVE 120°F. DO NOT MIX WITH OTHER THAN TYPE F1 LIQUID CONCENTRATE IN ACCORDANCE WITH MIL-V- AND WATER.

MANUFACTURER'S NAME
ADDRESS
BATCH NO.
DATE OF MANUFACTURE

FIGURE 2. Type F2 container markings.

THIS END UP

U.S.

HYPERGOLIC PROPELLANT FOAMS LIQUID CONCENTRATE

In accordance with

MILITARY SPECIFICATION MIL-V-

TYPE 01 - OXIDIZER FOAM GELLING AGENT

THIS VAPOR SUPPRESSING/FIRE EXTINGUISHING CONCENTRATE IS FOR USE BY DILUTION WITH WATER IN FIXED OR MOBILE SYSTEMS. IT MUST BE USED IN COMBINATION WITH THE TYPE 02 SURFACTANT. THE CONCENTRATE MAY BE DILUTED FOR USE IN FLOW PROPORTIONING EQUIPMENT WITH FRESH WATER AT VOLUME PROPORTIONS OF ONE GALLON EACH OF THE 01 AND 02 CONCENTRATES TO 8 GALLONS WATER.

FOR READY USE DO NOT STORE BELOW 32°F. AVOID PROLONGED STORAGE ABOVE 120°F. DO NOT MIX WITH OTHER THAN TYPE 02 LIQUID CONCENTRATE IN ACCORDANCE WITH MIL-V- AND WATER.

MANUFACTURER'S NAME
ADDRESS
BATCH NO.
DATE OF MANUFACTURE

FIGURE 3. Type 01 container markings.

THIS END UP

U.S.

HYPERGOLIC PROPELLANT FOAMS LIQUID CONCENTRATE

In accordance with

MILITARY SPECIFICATION MIL-V-

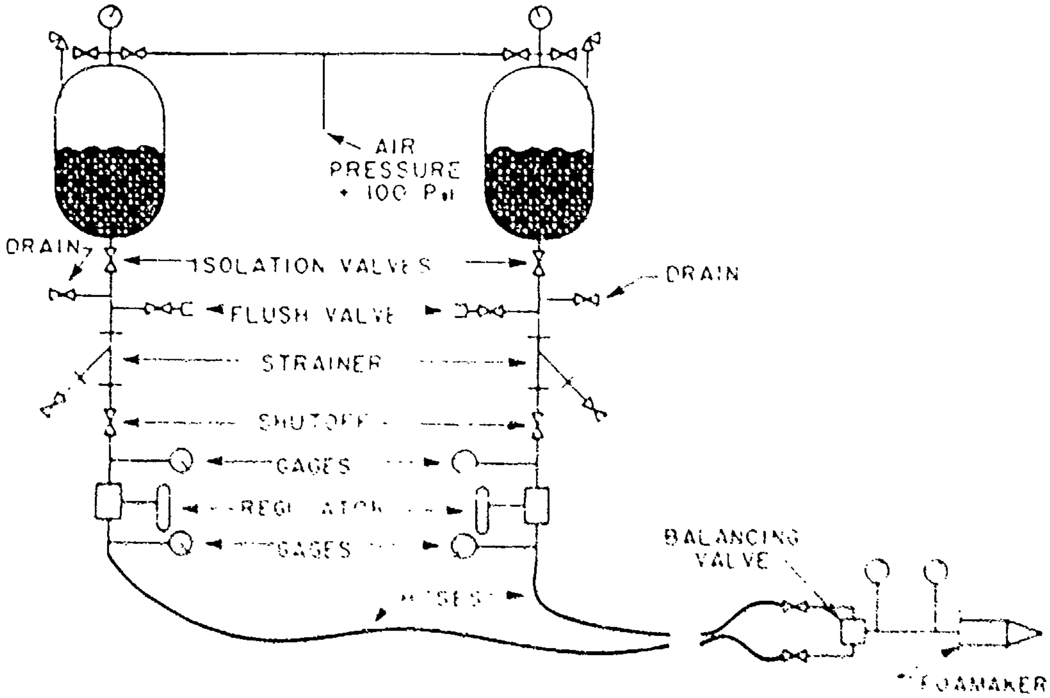
TYPE 02 - OXIDIZER FOAM SURFACTANT

THIS FIRE VAPOR SUPPRESSING/EXTINGUISHING CONCENTRATE IS FOR USE BY DILUTION WITH WATER IN FIXED OR MOBILE SYSTEMS. IT MUST BE USED IN COMBINATION WITH THE TYPE 01 GELLING AGENT. THE CONCENTRATE MAY BE DILUTED FOR USE IN FLOW PROPORTIONING EQUIPMENT WITH FRESH WATER AT VOLUME PROPORTIONS OF ONE GALLON EACH OF THE 01 AND 02 CONCENTRATES TO 8 GALLONS WATER.

FOR READY USE DO NOT STORE BELOW 32°F. AVOID PROLONGED STORAGE ABOVE 120°F. DO NOT MIX WITH OTHER THAN TYPE 01 LIQUID CONCENTRATE IN ACCORDANCE WITH MIL-V- AND WATER.

MANUFACTURER'S NAME
ADDRESS
BATCH NO.
DATE OF MANUFACTURE

FIGURE 4. Type 02 container markings



FIRE TEST FOAM SYSTEM

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

(See Instructions – Reverse Side)

1. DOCUMENT NUMBER	**2. DOCUMENT TITLE**
3a. NAME OF SUBMITTING ORGANIZATION	**4. TYPE OF ORGANIZATION** *(Mark one)* ☐ VENDOR ☐ USER ☐ MANUFACTURER ☐ OTHER *(Specify)*: ______
b. ADDRESS *(Street, City, State, ZIP Code)*	

5. PROBLEM AREAS

a. *Paragraph Number and Wording:*

b. *Recommended Wording:*

c. *Reason/Rationale for Recommendation:*

6. REMARKS

7a. NAME OF SUBMITTER *(Last, First, MI)* – Optional	**b. WORK TELEPHONE NUMBER** *(Include Area Code)* – Optional
c. MAILING ADDRESS *(Street, City, State, ZIP Code)* – Optional	**8. DATE OF SUBMISSION** *(YYMMDD)*

DD FORM 1426 87 MAR

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NOTE: This form may not be used to request copies of documents, nor to request waivers, deviations, or clarification of specification requirements on current contracts. Comments submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or to amend contractual requirements.

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APPENDIX H

GLOSSARY OF ACRONYMS AND TERMS

A-50 - Aerozine 50

A 50-50 blend by weight of unsymmetrical dimethylhydrazine and hydrazine.

Acidulation

Made acid or sour.

Acrylic-modified surfactant foam

Foam compound of appropriate acrylic gelling agents, alpha olefin sulfanate surfactants, and other appropriate additives developed for vapor suppression of hypergolic propellants.

AFFF

Aqueous Film-Forming Foam.

AH

Anhydrous hydrazine.

ARC - Alcohol-Resistant Concentrate

Foam concentrate for use on polar solvent fires.

Carboxyvinyl polymers

Organic-acid modified polymer used in foams.

Class A fires

Wood/paper products fires.

Cryogenic traps

Low temperature trapping apparatus.

Dry ice

Solid carbon dioxide, below -78.5 °C.

Foam Generator

A device which combines and aerates the foam constituents (water, surfactant, etc.) and delivers the expanded foam product.

Fuel

The hydrazine-based compound oxidized in the hypergolic mixture. The fuel may be hydrazine, MMH, UDMH, or A-50.

Heptane

Standard hydrocarbon fuel, C_7H_{16}.

High-expansion foam

Foam which occupies a volume greater than 100 times larger than commodities (water, surfactant, etc.) used to generate the foam.

High-volume generator

A foam generator which produces in excess of 2000 ft^3/min of high-expansion foam or greater than 75 gallons per minute of low-expansion foam.

Hydrazine

A colorless, corrosive, liquid base used as a jet and rocket fuel.

Hygroscopic

Attracting or absorbing moisture from the air, changed or altered by the absorption of moisture.

Hypergolics

Igniting spontaneously when mixed together, as rocket fuel and oxidizer combinations.

Low-expansion foam

Foam which occupies a volume less than 100 times that of the commodities (water, surfactant, etc.) from which it is generated.

Low-volume generator

A foam generator capable of generating less than 750 cubic feet per minute of high-expansion foam or less than 25 gallons per minute of low-expansion foam.

Medium-volume generator

A foam generator capable of generating between 750 and 2000 cubic feet per minute of high-expansion foam or between 25 to 75 gallons per minute of low-expansion foam.

MMH

Monomethylhydrazine.

MSA ASE-60

An acid-containing, crosslinked acrylic emulsion copolymer.

MSA ASE-95

An acid-containing, acrylic emulsion copolymer.

MSA Type V foam

A high water retention hydrocarbon surfactant base foam concentrate suitable for use in both low- and high-expansion foam appliances.

NFPA

National Fire Protection Association.

N_2O_4

Nitrogen Tetroxide.

Oxidizer

The nitrogen dioxide (NO_2) bearing component of the hypergolic mixture responsible for oxidizing the reaction. Oxidizers include nitrogen tetroxide (N_2O_4) and red fuming nitric acid (RFNA).

Oxidizer foam

A foam formulation developed for optimal vapor suppression and foam persistence over liquid nitrogen dioxide oxidizers.

Pen

A temporary test structure designed to test the flow of high-expansion foam over a significant distance.

Proteinaceous materials

Materials composed of protein (amino acid).

Rohm and Haas AC-33

A latex acrylic product.

SCBA

Self-contained breathing apparatus.

Silicic Acid Gels

Gels precipitated by acidifying sodium silicate solution.

Spill

An unplanned release of propellant liquid or vapor.

Surfactants

A surface-active agent.

TGD

Thermal Gas Device.

3M ACT polar solvent agent

Foam concentrate produced by 3M company for use on polar solvent fires.

Toxic Hazard Corridor

The area surrounding a spill in which the vapor concentration of propellant is at or exceeds the limits which have been determined as toxic.

UDMH

Unsymmetrical dimethylhydrazine.

UL

Underwriters Laboratories.

Wet ice

Solid water, 0° C.

Wind variability

An index of the lateral diffusion of a toxic chemical in the atmosphere.