RDTN NO. 96
4 MARCH 1970

INITIAL STUDY OF PHENOLIC FOAM FOR THERMAL PROTECTION

PREPARED BY

RESEARCH AND DEVELOPMENT DEPARTMENT
NAVAL AMMUNITION DEPOT, CRANE, INDIANA

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Crane, Indiana 47522

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Initial Study of Phenolic Foam for Thermal Protection

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Prepared by Richard E. Hannah
Chemist

Clifford Muessig
Research Chemist

RESEARCH AND DEVELOPMENT DEPARTMENT

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1. Acknowledgement. The authors wish to acknowledge the assistance of Mr. A. J. Mallet and S. J. Wheatley of Union Carbide Corporation, Nuclear Division, Oak Ridge, Tennessee. Through their cooperation information on the basic formulation of the phenolic foam, fiberfoam, and problems involved in mixing, processing, and curing was obtained.

ABSTRACT

At the present time there is a need for protecting various types of ammunition, pyrotechnics, etc., against the hazard of fire.

In the work described in this report a fire resistant phenolic foam has been briefly evaluated and found to offer quite favorable promise as a possible solution to this problem. Further study in this area is recommended.

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Introduction and Background.

The Navy has experienced the problem of pyrotechnic items functioning by a fuel fire environment aboard ship. This problem is mainly the result of the inadequate protection provided by thin metal walls and, in some cases, by plastics which are flame retardant but not non-burning. With such an environment there is usually insufficient time to allow the fire to be brought under control, thus increasing the possibility of a larger uncontrollable fire. A possible solution to this problem would be a fire resistant, non-burning coating of sufficient thickness to allow the fire to be controlled (5 to 10 minutes).

Recently, a phenolic fire resistant foam, "Fiberfoam" was developed by Union Carbide Nuclear Division at Oak Ridge, Tennessee. This foam was used to protect cylinders of uranium hexafluoride in shipment. In addition to its non-burning properties the foam was found to be non-corrosive, antistatic, and non-toxic. A comprehensive background in this material was obtained by visiting Union Carbide at Oak Ridge. Samples of the foam were brought back for additional tests. The necessary chemicals and resins needed to make the foam were purchased and some preliminary coatings were prepared for evaluation.

Testing and Evaluation.

Testing Procedure: The fiberfoam was tested by utilizing it as a coating and packaging material for standard pyrotechnic items and subjecting the unit package to a high temperature fire until the pyrotechnic items functioned. Since nominal cook-off time (i.e. time from the start of the fire until the item functions) was known for the pyrotechnic items used, the increase in cook-off time was a measure of the effectiveness of the fiberfoam as a thermal barrier.

The fire was constructed by filling a concrete pit 20' x 20' x 1' deep with 1000 gallons of JP-4 jet engine fuel. A fire of this size will give a temperature range of 1800 to 2000°F. However, the advantage of this type of test was not particularly the high temperature, but rather the vast amount of available thermal energy and thermal convection forces.

Evaluation.

(1) For a preliminary check of the material, three unsealed aluminum tanks I, II, III, were coated with 5/8", 1 3/4", and 2 5/8", respectively (Figure 1). The tanks were then half-filled with JP-4 jet engine fuel and subjected to a fire of 1000 gallons of JP-4 fuel. Visual examination after the 15 minute, 2000°F, fire showed that the steel support cables on tanks I and III had burned through and the tanks fell into the fire (Figure 2). Tank II remained hanging over the burning fuel. After the fire had burned out, Tank II was removed from its support cables and found to be still half filled with JP-4. The fiberfoam had charred to a depth of approximately 1".

(2) A second evaluation was then conducted with the Mk 112 Photoflash Cartridge. Two cartridges were coated with 3/4 inch of the phenolic material, leaving the detonators exposed. Cook-off times over a 1000 gallon JP-4 fire were 7 minutes for Cartridge I and 8 minutes for Cartridge II. Both cartridges ejected but did not detonate. Nominal cook-off time for the unprotected cartridges is approximately 30 seconds.

(3) A third test was conducted where a MK 45 Aircraft Parachute Flare Container was molded in the same configuration as the present polystyrene box. The phenolic container was loaded with two MK 45 flares and subsequently subjected to the burn test (Figure 3). The package was heavily charred after the 17 minute and 52 second fire had burned out (Figure 4). However, the contained flares had not ignited and were still intact. The flares were removed from the container and ignited at a later date (Figure 5).

(4) The fiberfoam has undergone 14 day Temperature and Humidity Cycling (-65°F to +165°F) without apparent change in physical size or scope. The bare foam has absorbed as much as 55% of its weight of water. This water is slowly lost in drying at ambient conditions. Indications are that the material loses some of its fire resistance properties after exposure to moisture.

(5) A metal corrosion test was conducted by taping pieces of fiberfoam to steel and aluminum plates and placing the samples along with standards in 100% Relative Humidity at 150°F for 72 hours. Visual examination of test samples and the standards indicated no

increase in corrosion to steel. A slight increase in the amount of corrosion on the aluminum was observed.

(6) Static tests were also run on samples of the material using a Model 600A Kiethly Electrometer and a cat fur. Samples were shown to be inherently antistatic with a total buildup of less than 1 KV.

(7) Shear adhesion tests were conducted using steel, aluminum, and wood as adherents. The test was conducted by foaming the phenolic material between two adherent plates and after the foam had cured the plates were pulled in tension tangent to the surface area of the foam. This method is the same as ASTM D1002 except the adhesive thickness was 1 inch and the plate thicknesses were .125 inch for steel and aluminum and .25 inches for the wood.

TABLE I

RESULTS OF THE TEST

Material	Foam Density g/in^3	lbs/2" sq. area
plywood	10.5	54
steel	10.5	0
aluminum	10.5	0

TABLE II

(8) Cook-off times of protected and unprotected items.

Item	Thickness of Foam	Time Protected	Time Unprotected	Foam Density
MK 112 Photoflash	3/4"	7-8	< 30 sec	23 pcf
MK 45 Aircraft Flare	3/4"	17 Min. 52 Sec.	< 1 Min	12 pcf

TABLE III
PHENOLIC FORMULATION

MATERIAL	% BY WEIGHT
Phenolic Resin UCC BRL 2760	65.8 ± 0.2
Surfactant UCC Silicone L-530	2.0 ± 0.1
Refrigerant DuPont Freon 113	6.6 ± 0.1
Boric Anhydride Reagent Grade Varlacoid Chemical Co. No. 1136 -100 + 200 Mesh	4.1 ± 0.1
Boric Anhydride Reagent Grade No. 1137 -200 Mest	4.1 ± 0.1
Oxalic Acid Anhydrous Reagent Grade Baker and Adamson	8.2 ± 0.1
Fiberglass Rovings 1/4" Chopped Lengths Owens-Corning Fiberglass No. 805	9.2 ± 0.1

CONCLUSIONS

1. The fiberfoam at the densities shown add significantly to the cook-time of the pyrotechnic items tested.

2. The material adheres well to wood but not to clean steel or aluminum.

3. The material is inherently antistatic.

4. The foam is susceptible to water penetration.

5. As a result of the high viscosity of the resole and the utilization of glass fibers, large product mixing problems will be encountered.

6. The material molds to complex shapes.

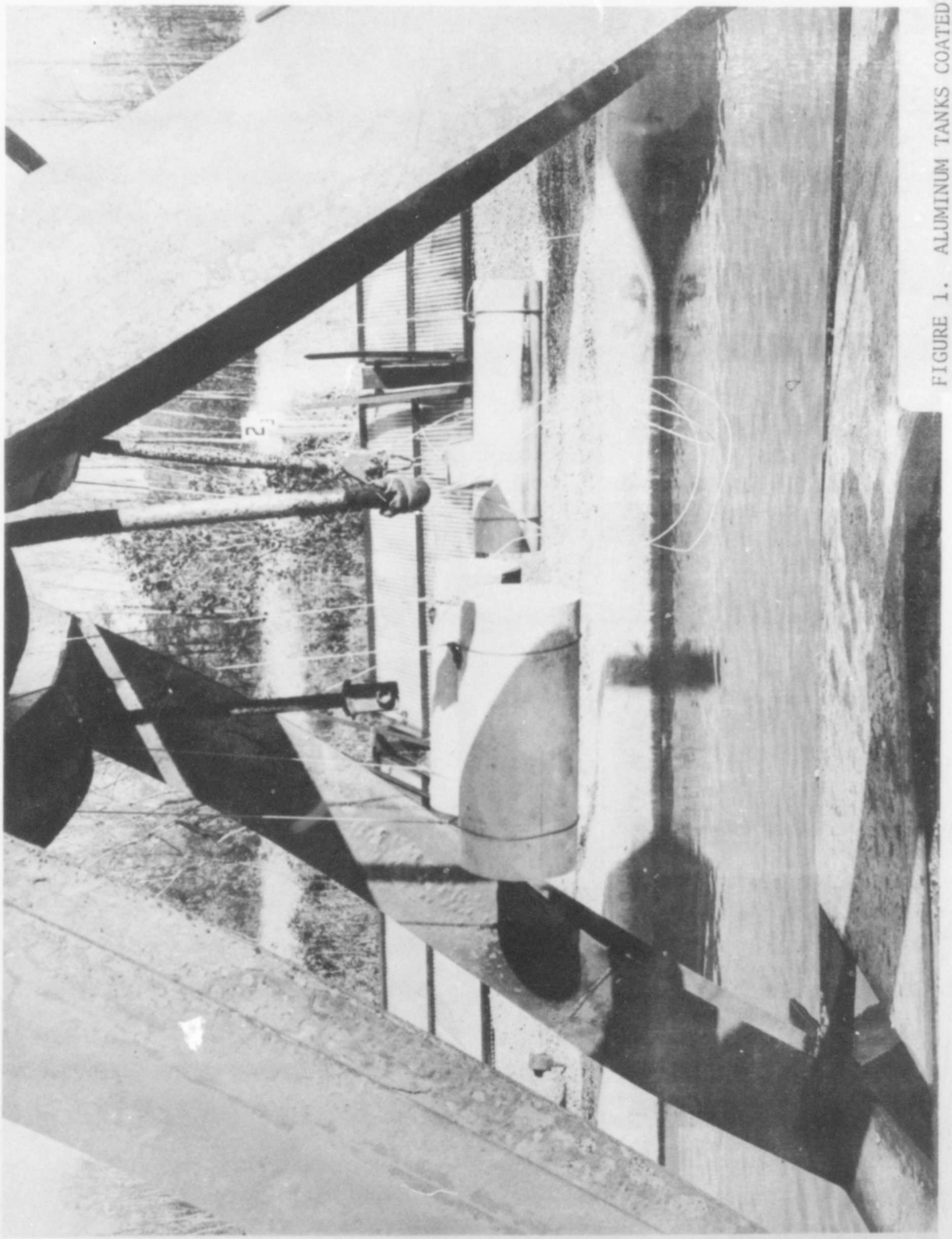

FIGURE 1. ALUMINUM TANKS COATED WITH PHENOLIC FOAM

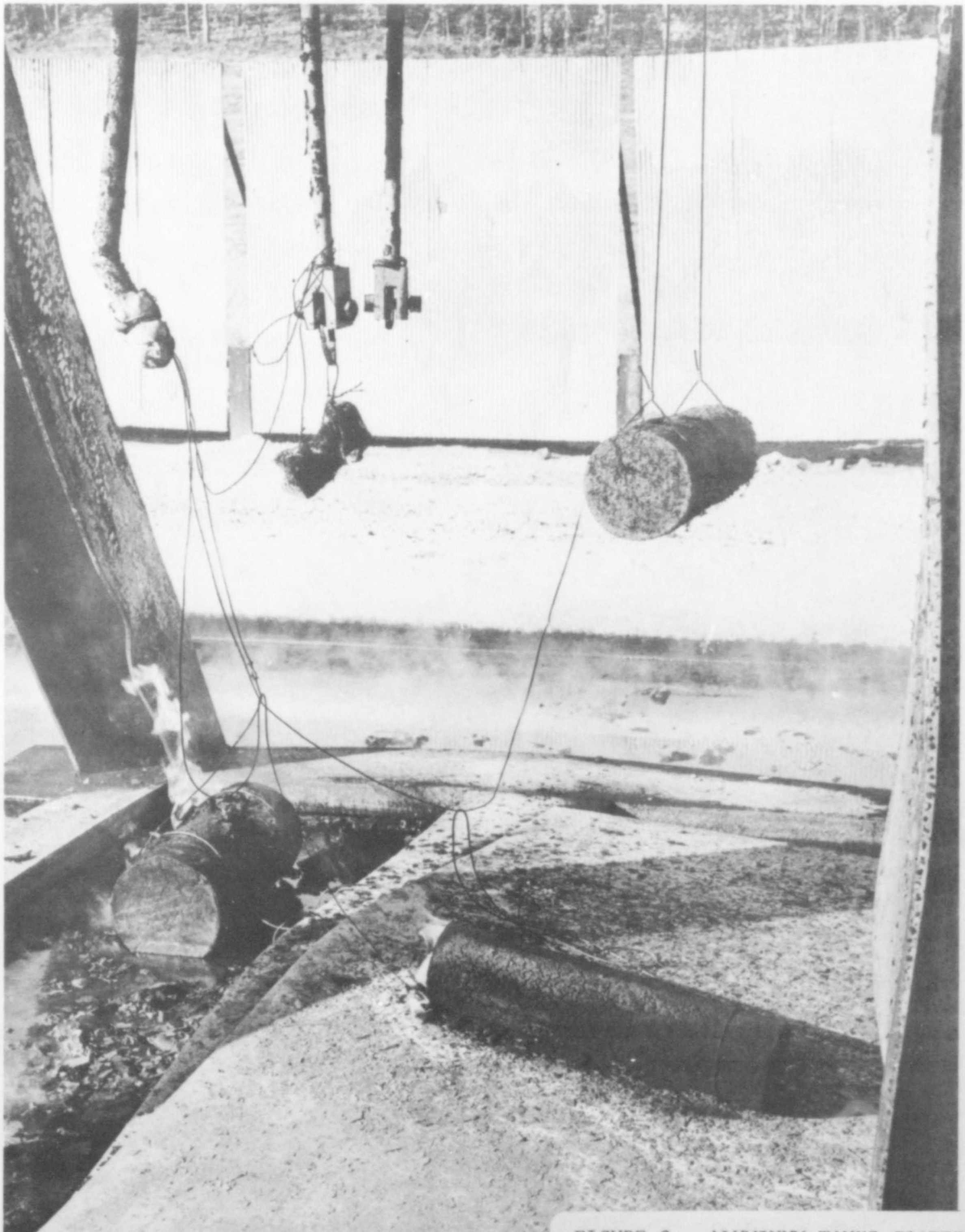

FIGURE 2. ALUMINUM TANKS COATED WITH PHENOLIC FOAM AFTER 15 MINUTE 2000°F FIRE

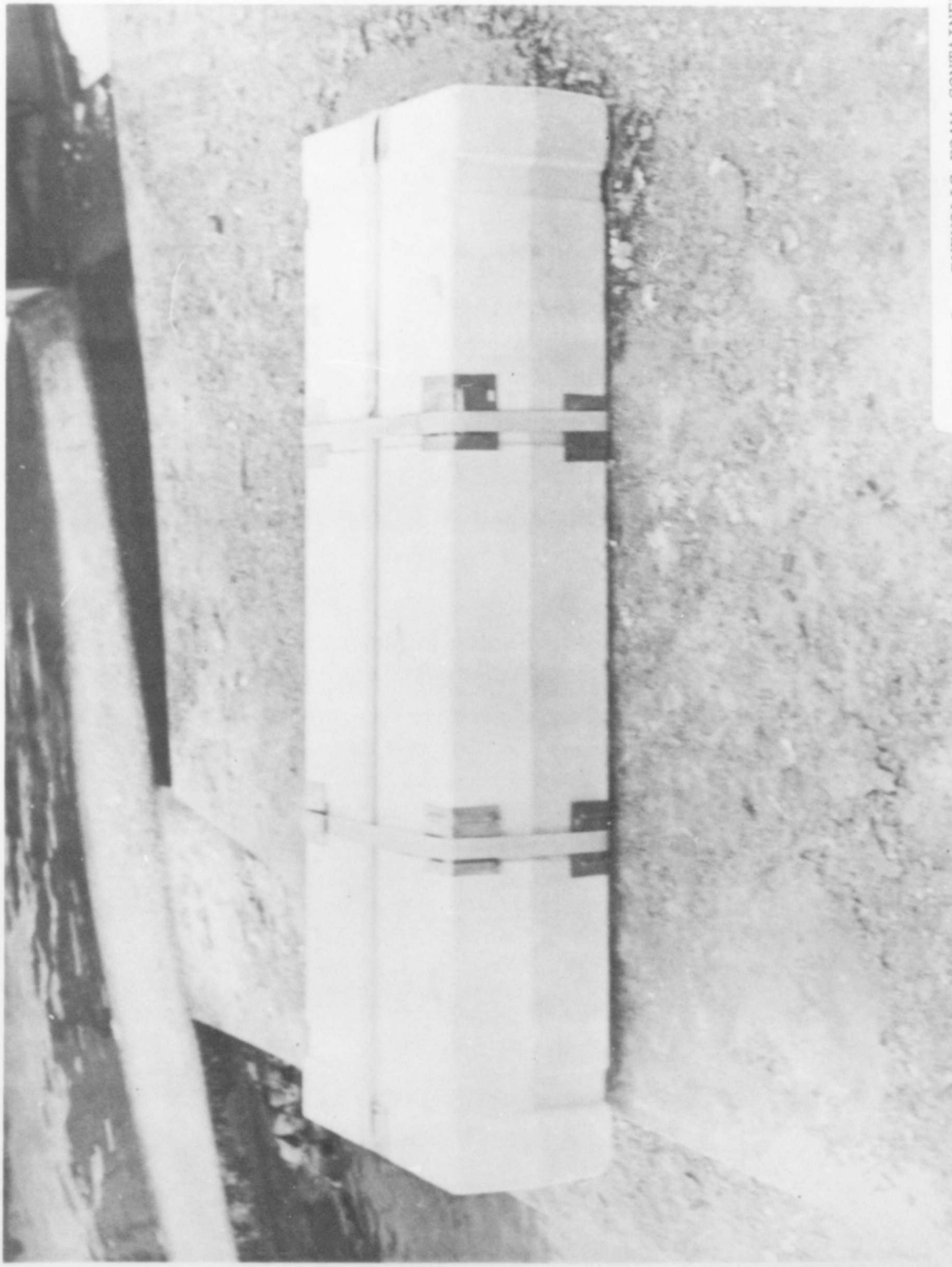

FIGURE 3. PHENOLIC FOAM CONTAINER FOR 2 MK 45 FLARES BEFORE BURNING

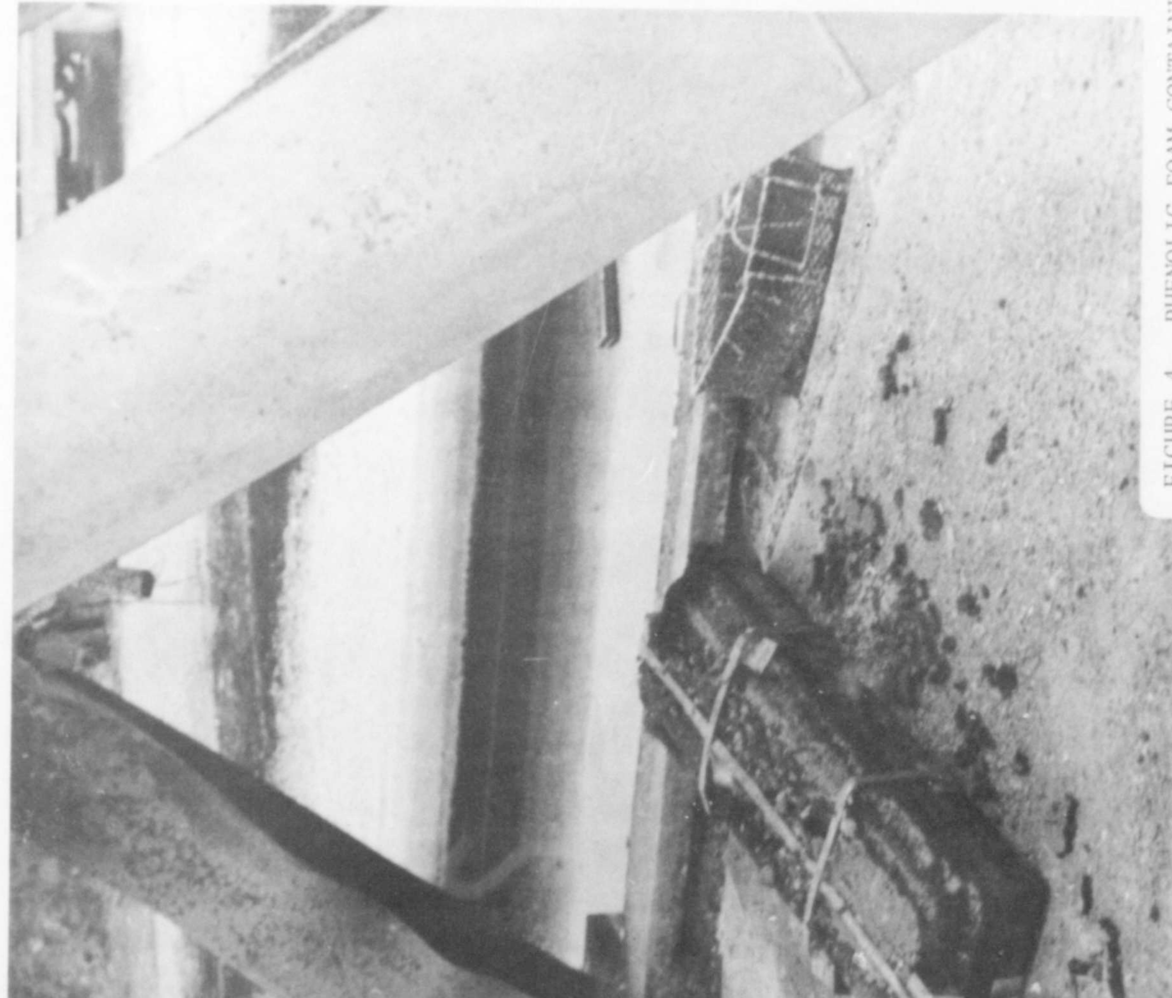

FIGURE 4. PHENOLIC FOAM CONTAINER CONTAINING 2 MK 45 FLARES AFTER 17 MINUTE 52 SECOND FIRE

FIGURE 5. TEST BURNING OF MK 45 FLARE TAKEN FROM CHARRED PHENOLIC FOAM CONTAINER

UNCLASSIFIED

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) Naval Ammunition Depot Crane, Indiana	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP
3. REPORT TITLE Initial Study of Phenolic Foam for Thermal Protection	
4. DESCRIPTIVE NOTES (Type of report and inclusive dates)	
5. AUTHOR(S) (First name, middle initial, last name) Richard E. Hannah and Clifford W. Muessig	

6. REPORT DATE 4 March 1970	7a. TOTAL NO. OF PAGES 11	7b. NO. OF REFS
8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S) RDTN No. 96	
b. PROJECT NO.		
c.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)	
d.		

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY

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14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Phenolic Foam						
Fire Resistant Materials						
Thermal Protection						