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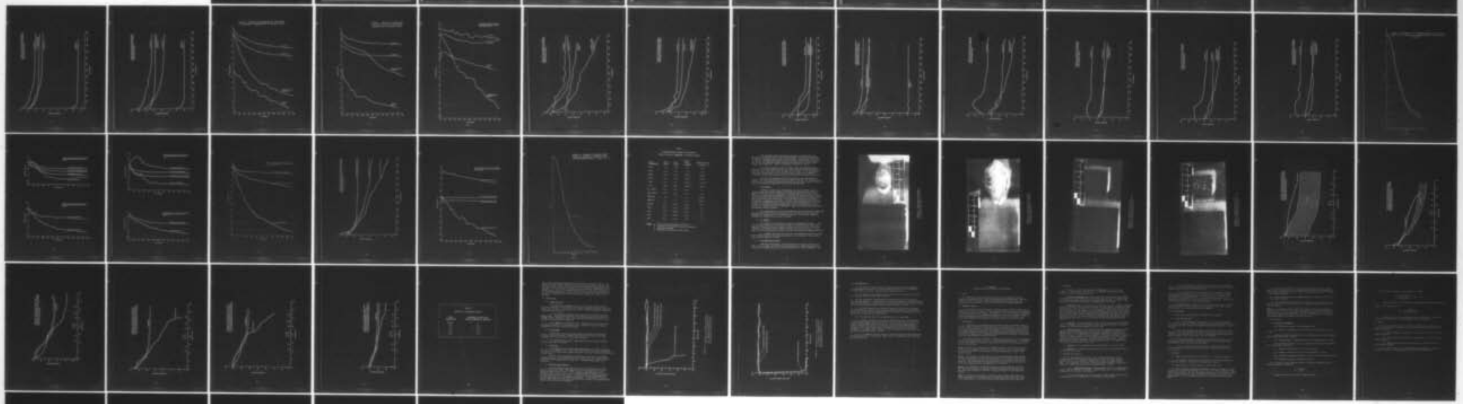

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EVALUATION OF FLOTATION MATERIALS USED IN RECREATIONAL BOATS

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October 1976

Final Report

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16. Abstract

The effects of immersion, friability, freeze-thaw cycling and gasoline vapor on various plastic flotation materials is examined. Fresh water, salt water, bilge cleaner in water, and gasoline were used as immersion liquids. The materials tested included polyvinyl chloride, polyethylene, polystyrene, and polyurethane foams in a 1 to 4 pound per cubic foot density range. Test procedures for evaluating the immersion and gasoline vapor resistance of buoyancy materials are reported.

17. Key Words

flotation materials, polystyrene foam, polyurethane foam, polyethylene foam, PVC foam, immersion

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METRIC CONVERSION FACTORS

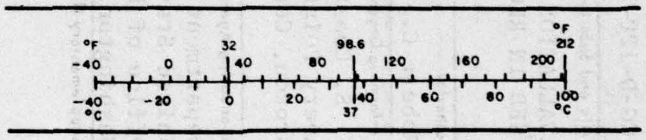
Approximate Conversions to Metric Measures

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

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

Approximate Conversions from Metric Measures

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



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1.0 INTRODUCTION

1.1 Background

Regulations for flotation materials require that such materials be capable of withstanding the combined effects of contact with oil, oil products, or other liquids or compounds with which the material may be expected to come in contact during normal use including fuel oil, gasoline, grease, lubricating oil, common bilge solvents and salt and fresh water. They must also be capable of withstanding exposure to sunlight, vibration, shock and temperature changes which may be expected during normal uses. These standards do not make clear what makes one material acceptable and another one unacceptable, nor how the boat manufacturer should make this determination.

1.2 Objective

The objective of this test program was to develop the required test procedures and acceptance/rejection criteria. Test methods which have already been developed are also being examined with regard to their suitability for application to flotation material evaluation.

1.3 Scope

The program was concerned primarily with investigating the effects of the environment on the buoyancy of flotation materials. Immersion tests were performed with fresh water, salt water, a mixture of fresh water and common bilge cleaner, and gasoline; all of which can be expected to be present in boat bilges and affect the flotation materials. It was also considered important to examine the effects of freeze-thaw cycling on selected materials, since large stresses can be introduced in freezing and may result in physical breakdown with attendant buoyancy decline.

As a preliminary step in the vibration testing, a standard ASTM friability test was conducted on the test materials. Resistance to friability can be of importance because some materials may do well in the immersion tests but be so friable that they would not withstand the vibrational stresses encountered during normal boat operations.

1.4 Limitations

The tests performed in this program were limited in number due to time and funding limitations. For immersion, testing was limited to three specimens of each test material in each fluid. In the freeze-thaw test only one sample of each material was used.

In spite of the small number of samples tested, it is believed that the results are representative of those that would be obtained had a larger sampling been possible.

2.0 TEST PROCEDURES

2.1 Immersion

The immersion test was based on the ASTM standard test method D2842-69, Test for Water Absorption of Rigid Cellular Plastics. It was modified slightly to yield direct values of buoyant force rather than liquid absorption and for safety reasons in the gasoline immersion tests. Appendix A contains a copy of the test method used in all the immersion tests.

Immersion liquids included fresh water, salt water, a mixture of fresh water and bilge cleaner, and gasoline. These liquids were characterized as follows:

Fresh water - Deionized, distilled water having a density of 0.998 gms/cm^3 at 22°C and a Ph of 6.751.

Salt water - A solution of synthetic sea salts with the fresh water described above. This mixture yielded a salt water with a density of 1.021 gms/cm^3 at 22°C, a Ph of 8.3, and the ion content listed in Table 1.

Bilge cleaner in water - A solution of 2.2% Sudbury Bilge Cleaner (Fuller Brush Company, Marine Division) in the fresh water characterized above. The ingredients of Fuller's #9FM-1017-F1 Sudbury Bilge Cleaner are surfactant DN-65, Ortho-dichlorobenzene, Light Soda Ash, FC-128, and water. It weighs 8.6 pounds per gallon and the solution's density was 0.996 gms/cm^3.

Gasoline - ASTM Reference Fuel B as listed in ASTM Specification D471 entitled "Test for Change in Properties of Elastomeric Vulcanizates Resulting from Immersion in Liquids." This reference fuel contains 70 volume percent Iso-octane and 30 volume percent Toluene and has a density of 0.741 gm/cm^3.

2.2 Friability

ASTM Standard Test Method *C421-71, Mechanical Stability of Preformed* Thermal Insulation by Tumbling, was used for the friability testing. Refer to Appendix B for a detailed test method description. This test method was modified for those materials in which no change in weight could be measured after 10 minutes of tumbling. These materials were tumbled for up to 50 minutes to attempt to get some measurable results.

2.3 Freeze-Thaw

A simple freeze-thaw test method was devised. One specimen of each material to be tested was placed in a large pan with all the others (due to space limitations only six specimens were tested). The specimens were not treated in any way prior to testing, and were the same as when originally received. The specimens were restrained so they would not float, and water was poured into the pan until all specimens were covered with 1-4 ± 1/16 inch of water. The pan was then placed in a freezer until the water was solidly frozen. The temperature of the ice was not allowed to drop more than a few degrees below freezing. The frozen pan was then thawed by placing it in an oven. The temperature of the water was brought to within a few degrees of room temperature. This freeze-thaw cycle was repeated a total of 40 times during the test. At night and during weekends the samples were left submerged.

Measurements of buoyant force were made before and during the test in fresh water. The procedure followed was the same as that used in the immersion testing. Test samples were examined for physical changes also.

TABLE 1

SALT AND TRACE ION CONTENT OF THE SALT WATER IMMERSION LIQUID

ION	CONTENT PPM	ION	CONTENT PPM
Cℓ	18400	F	1.0
Na	10220	M_oO_4	.6
SO_4	2518	S_2O_3	.3
Mg	1238	Li	.2
Ca	390	Rb	.1
K	370	I	.07
HCO_3	142	EDTA	.06
Br	60	Aℓ	.04
(BO_3 of H_3BO_3)	25	Zn	.02
Sr	6	V	.02
SiO_3	3	Co	.01
PO_4	1.3	Fe	.01
Mn	1.2	Cu	.003

2.4 Gasoline Vapor Exposure

These tests were designed to determine the effects of a gasoline saturated atmosphere on the buoyancy of flotation materials. They were conducted in saturated atmospheres of ASTM Reference Fuel B at 100°F and 140°F. Appendix C contains a copy of the test method used. Ten measurements were performed on each type of material. They encompassed a period of twenty to ninety days. The sampling interval was varied within this period in order to provide the best definition for the material being tested. The four types of materials indicated in Table 2, Note d. were tested.

3.0 TEST RESULTS AND DISCUSSION

3.1 Immersion

Table 2 lists the materials which have undergone immersion testing to date. Figures 1 through 14 are graphs of buoyant force plotted against time for all materials and test fluids. These graphs are arranged by material so that the results in the different test fluids may be readily compared. In addition, curves for several materials in a given test fluid are plotted on the same axes in Figures 15 through 18 so that the results of the different materials may be readily compared to one another.

Table 3 contains values for the percent change in buoyancy calculated at Day 30 relative to the buoyancy at the beginning of the test. This may be expressed as:

$$\Delta\% = \frac{BF30 - BF0}{BF_0} \times 100\%$$

A negative value implies a decrease in buoyancy, whereas a positive value implies that the material experienced swelling during immersion.

From the curves in Figures 1 through 18 it is evident that all materials exhibited the same general behavior during immersion. This behavior is characterized by a rapid initial decrease in buoyant force followed by a slower decrease which is often quite linear. Depending on the material and the immersion fluid the slope of this linear portion varies widely. In addition, the trend is almost always toward a decrease in buoyancy, although in some cases swelling results in an increase. For those materials which exhibited a leveling of the curve, that condition usually occurred within 15 to 20 days after immersion.

When the log of the buoyant force is plotted versus time it becomes evident that the change is actually due to two mechanisms which vary exponentially. One component rapidly becomes negligible and most probably reflects surface absorption which quickly saturates. The second component falls off slowly and is seen as a linear portion. This represents absorption into the body of the foam and as such proceeds slowly. In the gasoline test, dissolution of the specimen can also occur. Of course this speeds the decrease in buoyancy.

TABLE 2

FLOTATION MATERIALS EVALUATED

FOAM TYPE	FOAM DESIGNATION	TRADE NAME/MFG.	DENSITY LBS/FT^3	NOTES
PVC Crosslinked	R-200	Rigicell/B.F.Goodrich	2.1	
PVC Crosslinked	R-400	Rigicell/B.F.Goodrich	3.8	
PVC Plasticized	H-200	Koroseal/B.F.Goodrich	2.4	
PVC Plasticized	H-335	Koroseal/B.F.Goodrich	3.9	
Polyethylene	L-200	Minicell/Havgel Ind.	1.5	
Polyethylene	573-A	Ethafoam/Dow Chemical	2.3	
Polystyrene	White Styrofoam	Styrofoam/Dow Chemical	0.8	d.
Polystyrene	Orange Styrofoam	Styrofoam/Dow Chemical	1.7	
Solvent Resistant Polystyrene	FPK524-H	--/Sinclair-Koppers Co.	4	a.
Solvent Resistant Polystyrene	FPK424-L	--/Sinclair-Koppers Co.	2	a.,d.
Polyurethane	Thuran	Thuran/Dow Chemical	1.8	b.,d.
Polyurethane	7359	Autofroth/Olin Chemical	2	c.,d.
Polyurethane	7343	Autofroth/Olin Chemical	2	c.
Polyurethane	7438	Autofroth/Olin Chemical	2	c.
Polyurethane	7405	Autofroth/Olin Chemical	2	c.

NOTES:
a. Tested only in ASTM Reference Fuel B
b. Controlled pour board stock
c. Free rise foam - not tested in ASTM Reference Fuel B
d. Also tested in 100 + 140°F gasoline vapor tests

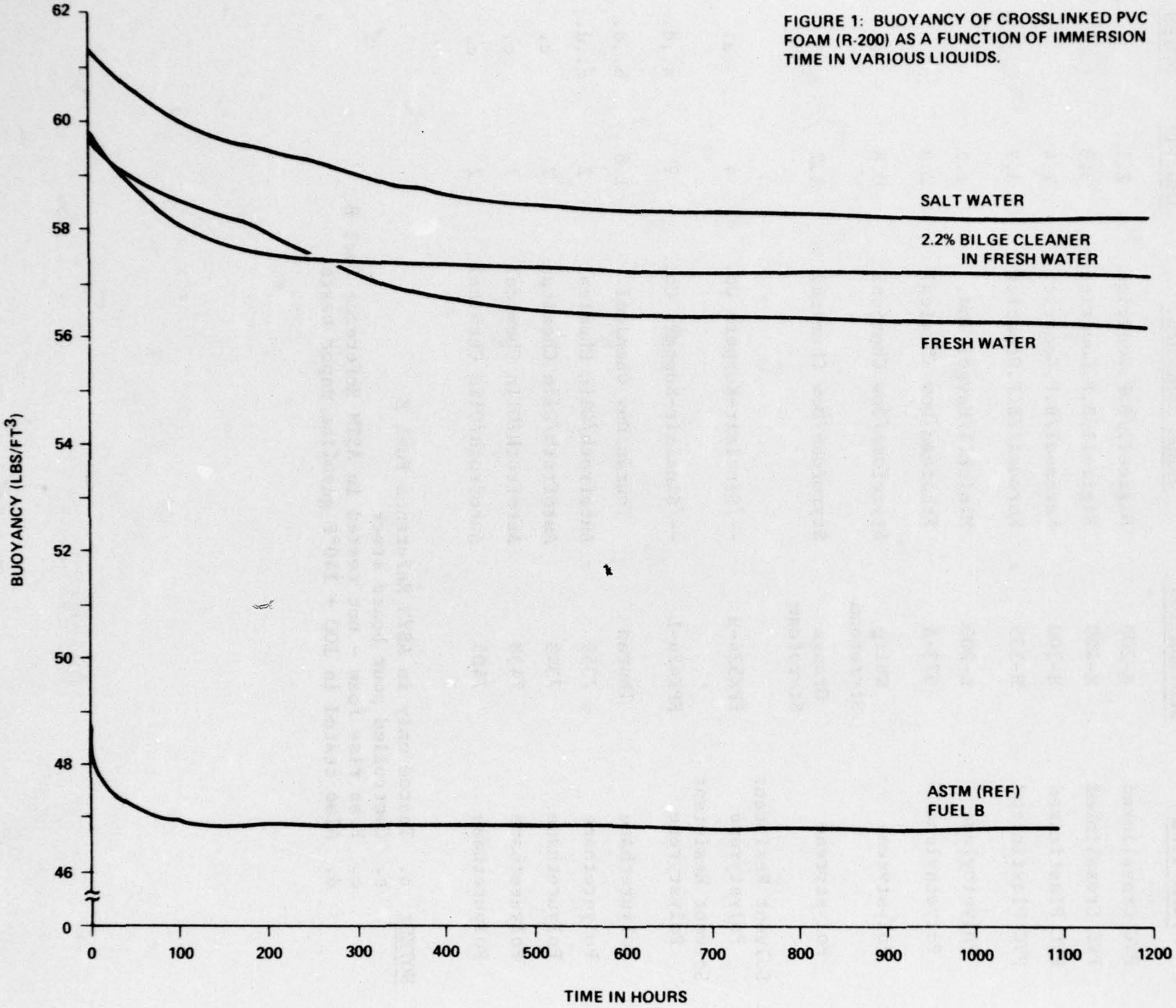


FIGURE 1: BUOYANCY OF CROSSLINKED PVC FOAM (R-200) AS A FUNCTION OF IMMERSION TIME IN VARIOUS LIQUIDS.

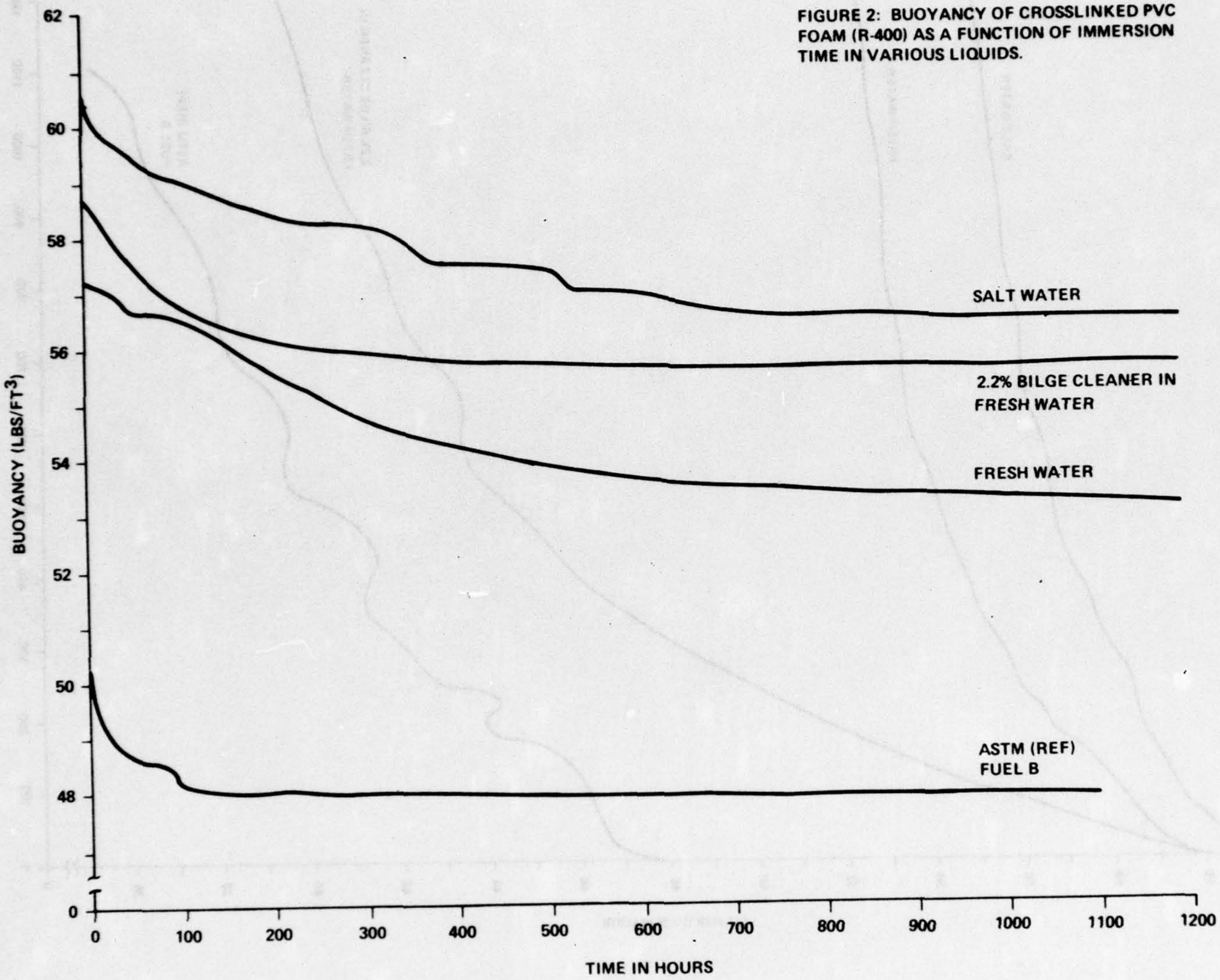


FIGURE 2: BUOYANCY OF CROSSLINKED PVC FOAM (R-400) AS A FUNCTION OF IMMERSION TIME IN VARIOUS LIQUIDS.

FIGURE 3: BUOYANCY OF PLASTICIZED PVC FOAM (H-200) AS A FUNCTION OF IMMERSION TIME IN VARIOUS LIQUIDS.

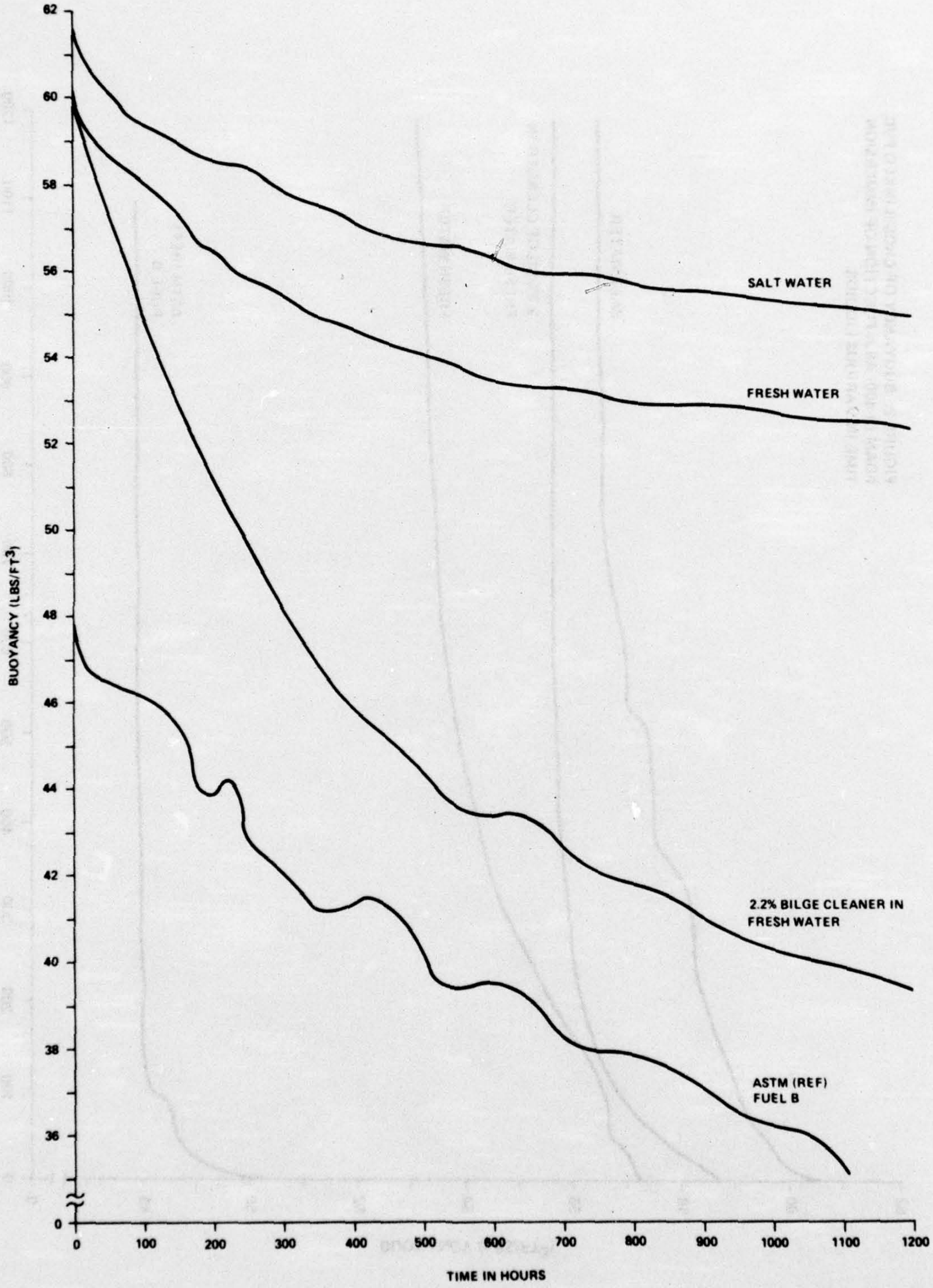


FIGURE 4: BUOYANCY OF PLASTICIZED PVC FOAM (H-335) AS A FUNCTION OF IMMERSION TIME IN VARIOUS LIQUIDS.

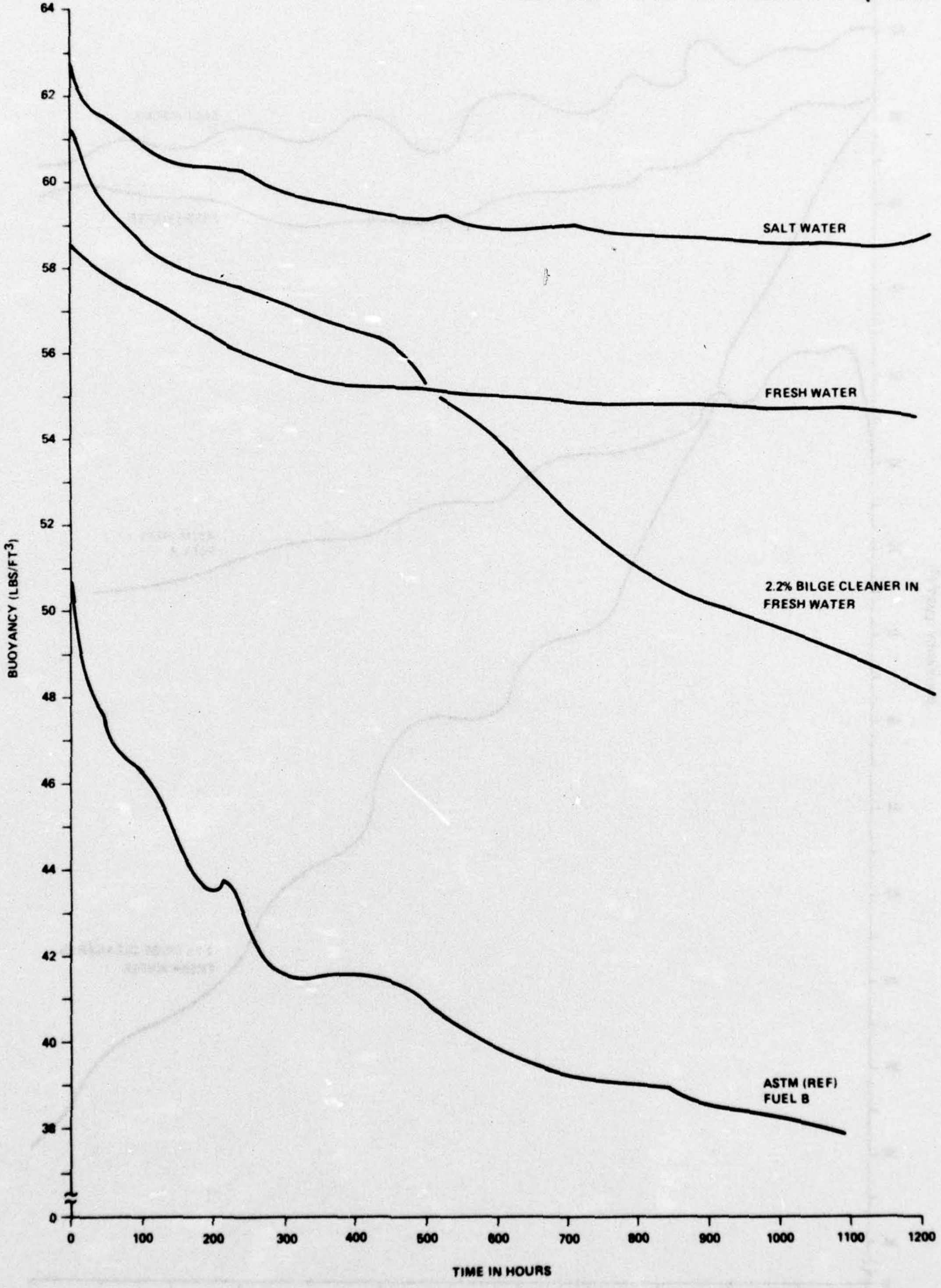
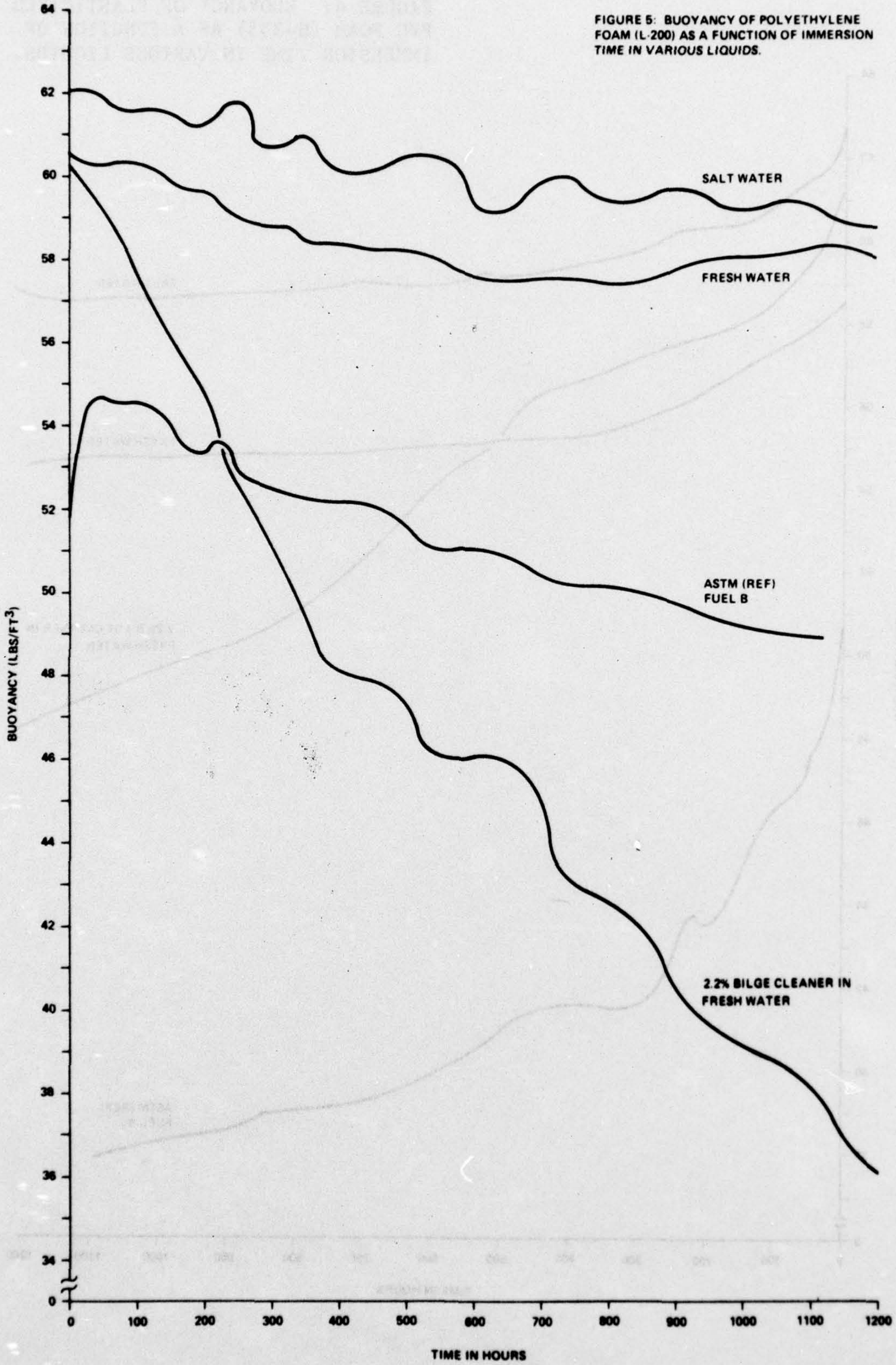


FIGURE 5: BUOYANCY OF POLYETHYLENE FOAM (L-200) AS A FUNCTION OF IMMERSION TIME IN VARIOUS LIQUIDS.



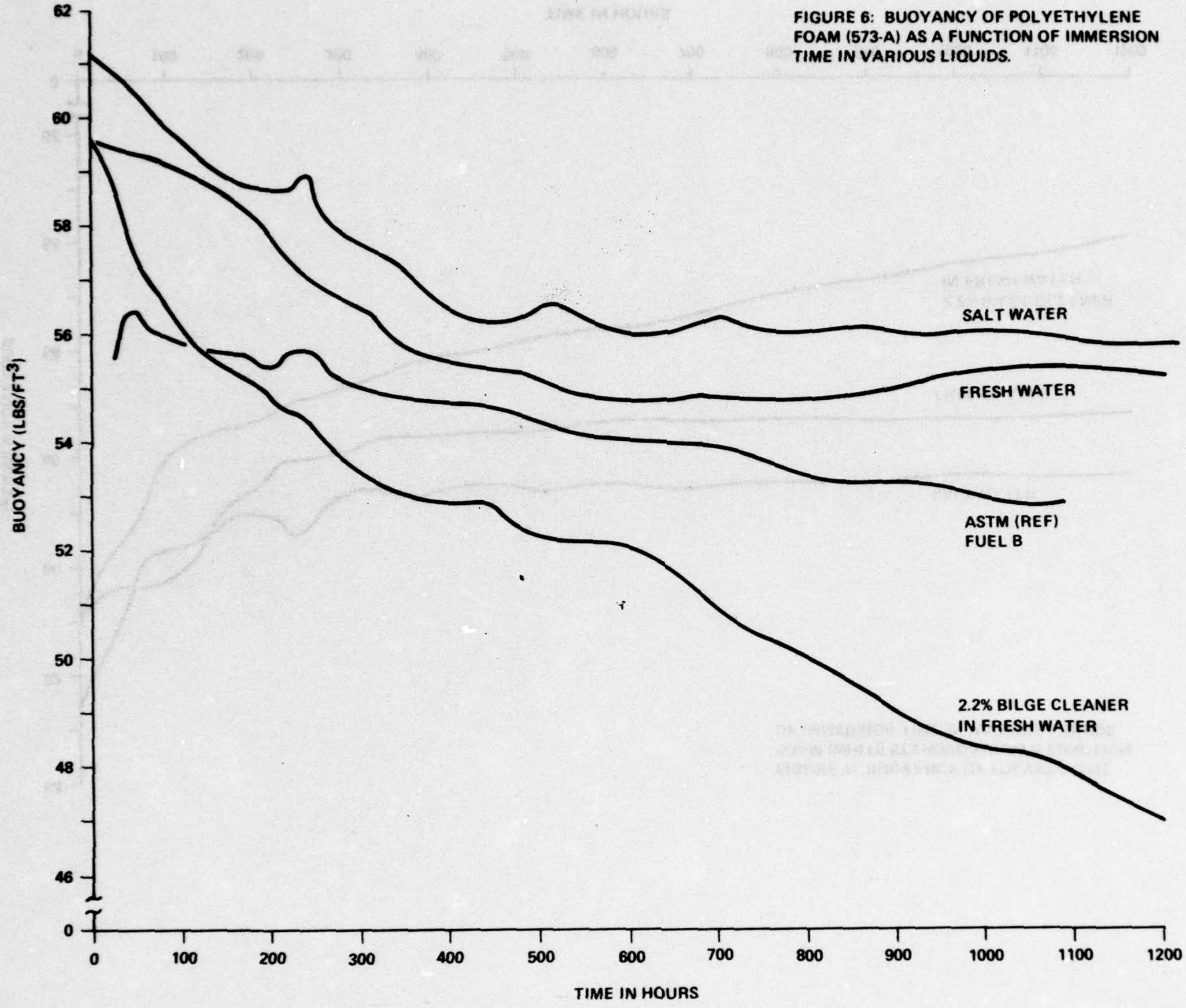


FIGURE 6: BUOYANCY OF POLYETHYLENE FOAM (573-A) AS A FUNCTION OF IMMERSION TIME IN VARIOUS LIQUIDS.

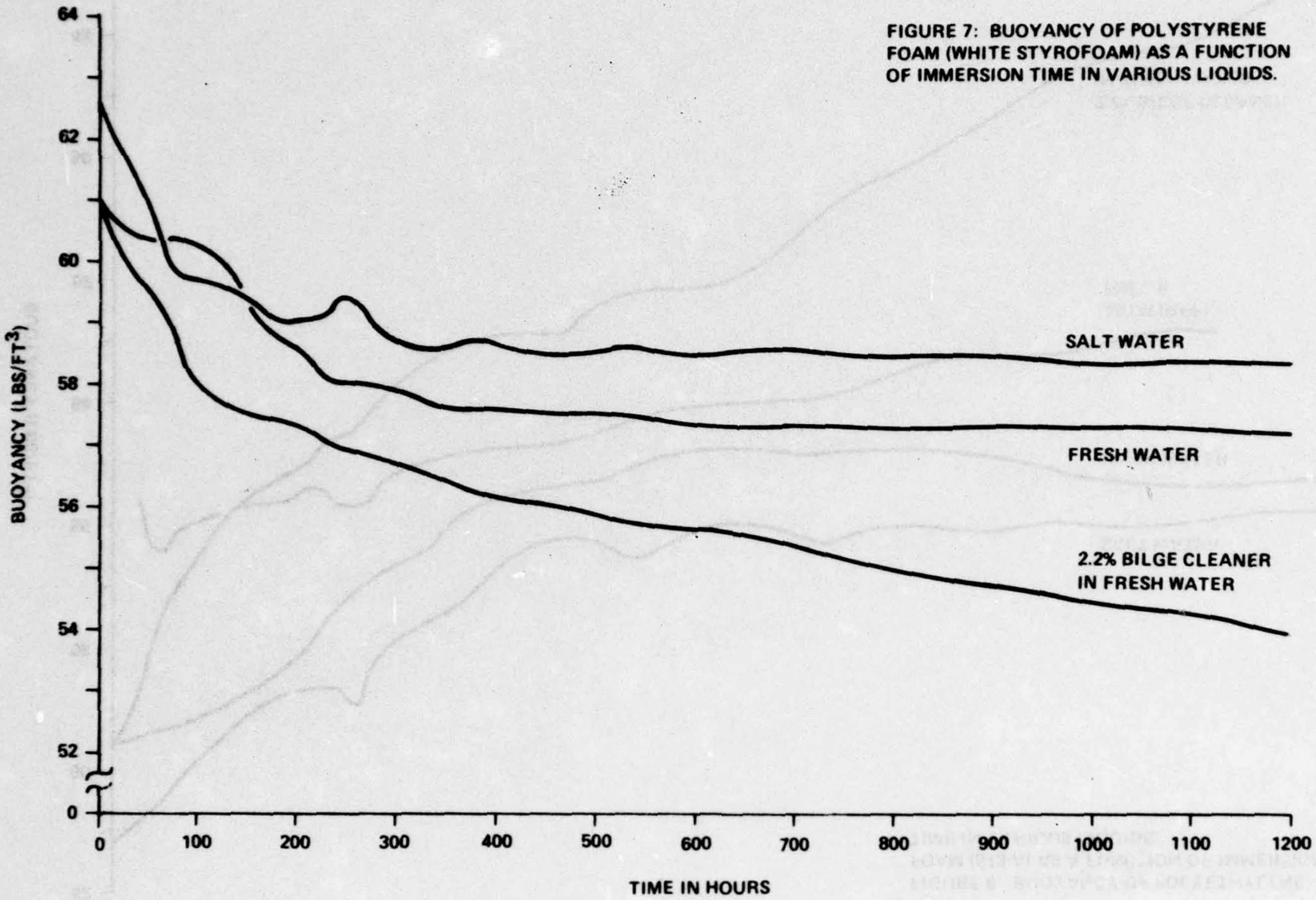


FIGURE 7: BUOYANCY OF POLYSTYRENE FOAM (WHITE STYROFOAM) AS A FUNCTION OF IMMERSION TIME IN VARIOUS LIQUIDS.

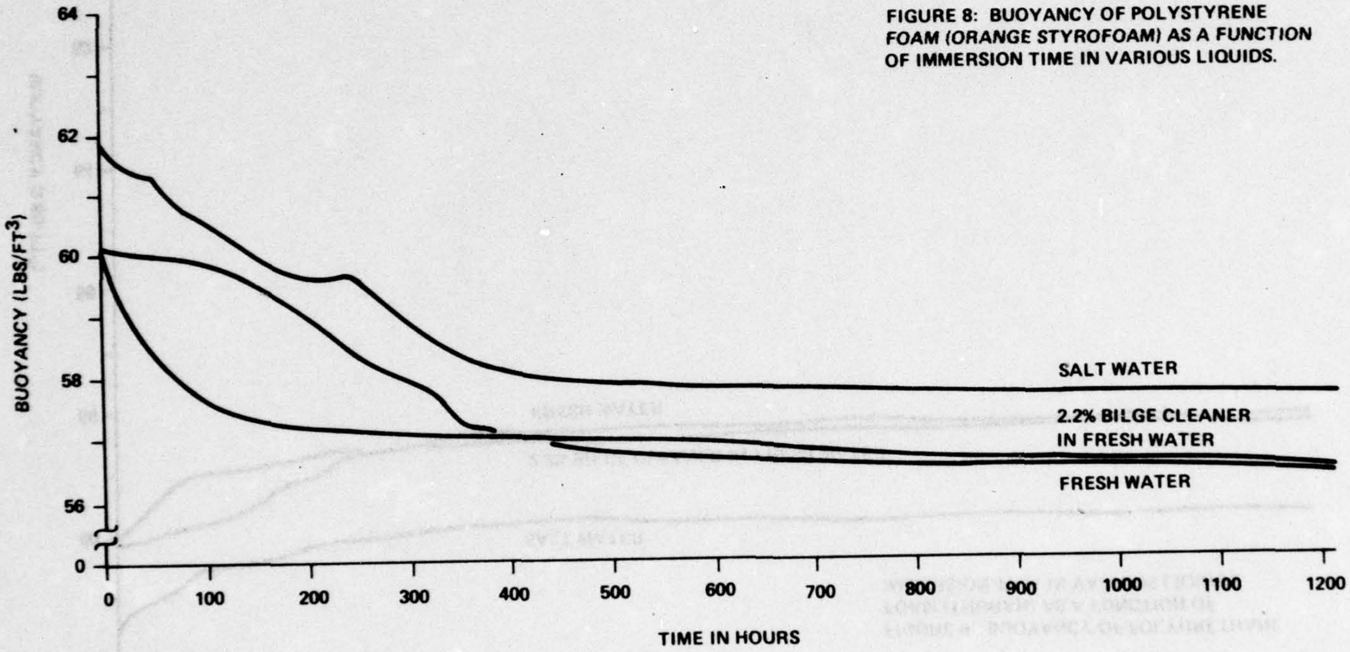


FIGURE 8: BUOYANCY OF POLYSTYRENE FOAM (ORANGE STYROFOAM) AS A FUNCTION OF IMMERSION TIME IN VARIOUS LIQUIDS.

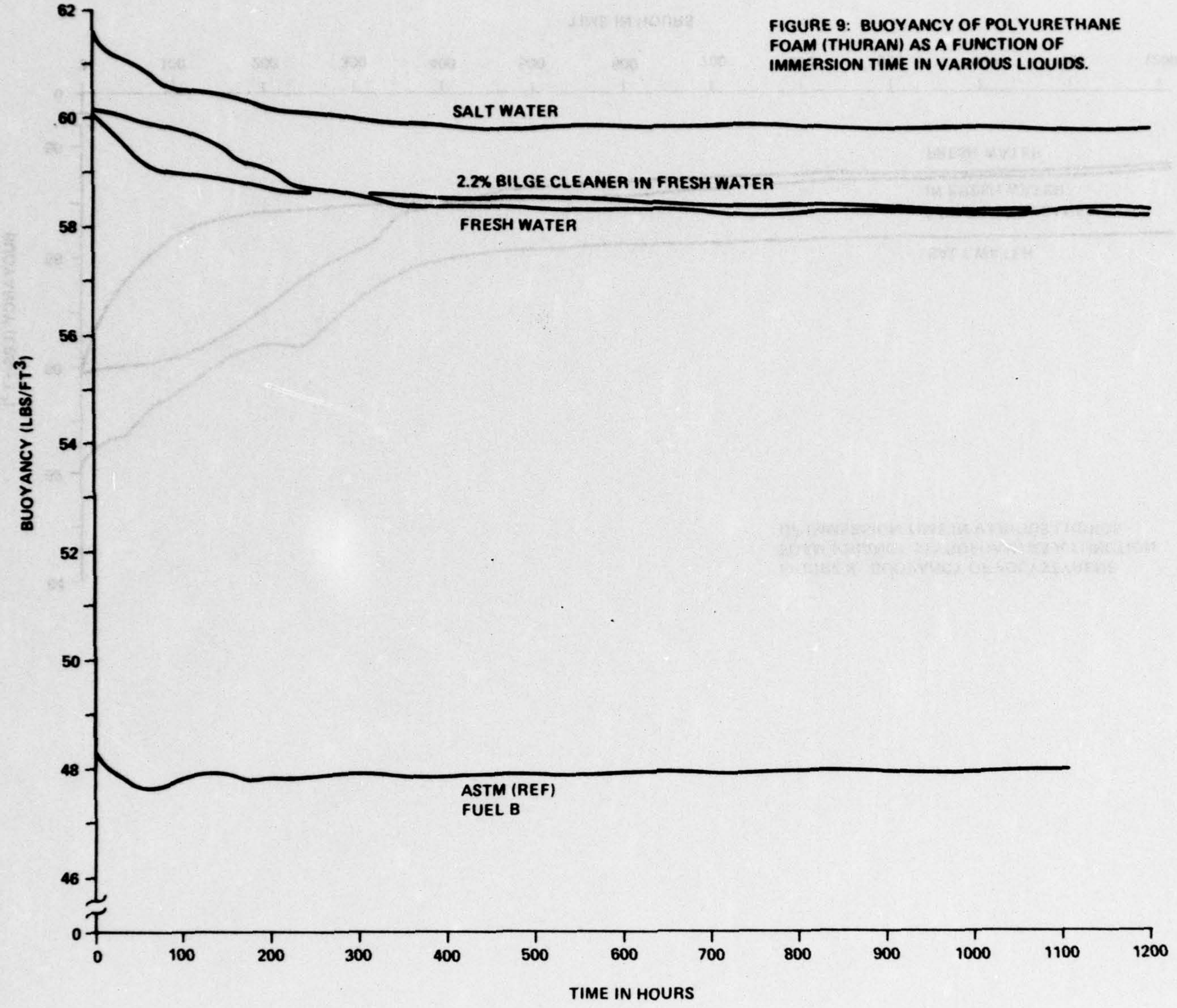
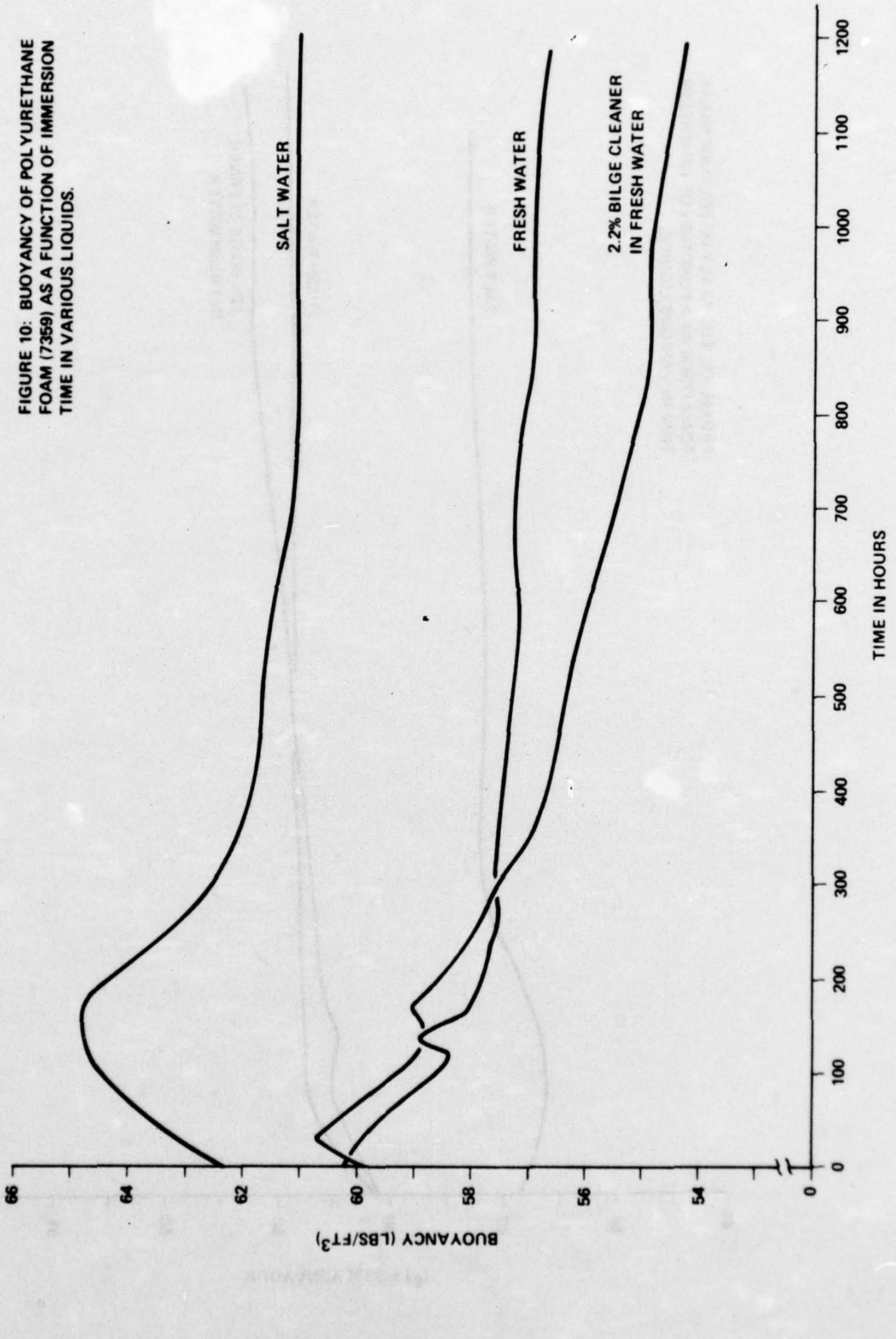


FIGURE 9: BUOYANCY OF POLYURETHANE FOAM (THURAN) AS A FUNCTION OF IMMERSION TIME IN VARIOUS LIQUIDS.

FIGURE 10: BUOYANCY OF POLYURETHANE FOAM (7359) AS A FUNCTION OF IMMERSION TIME IN VARIOUS LIQUIDS.



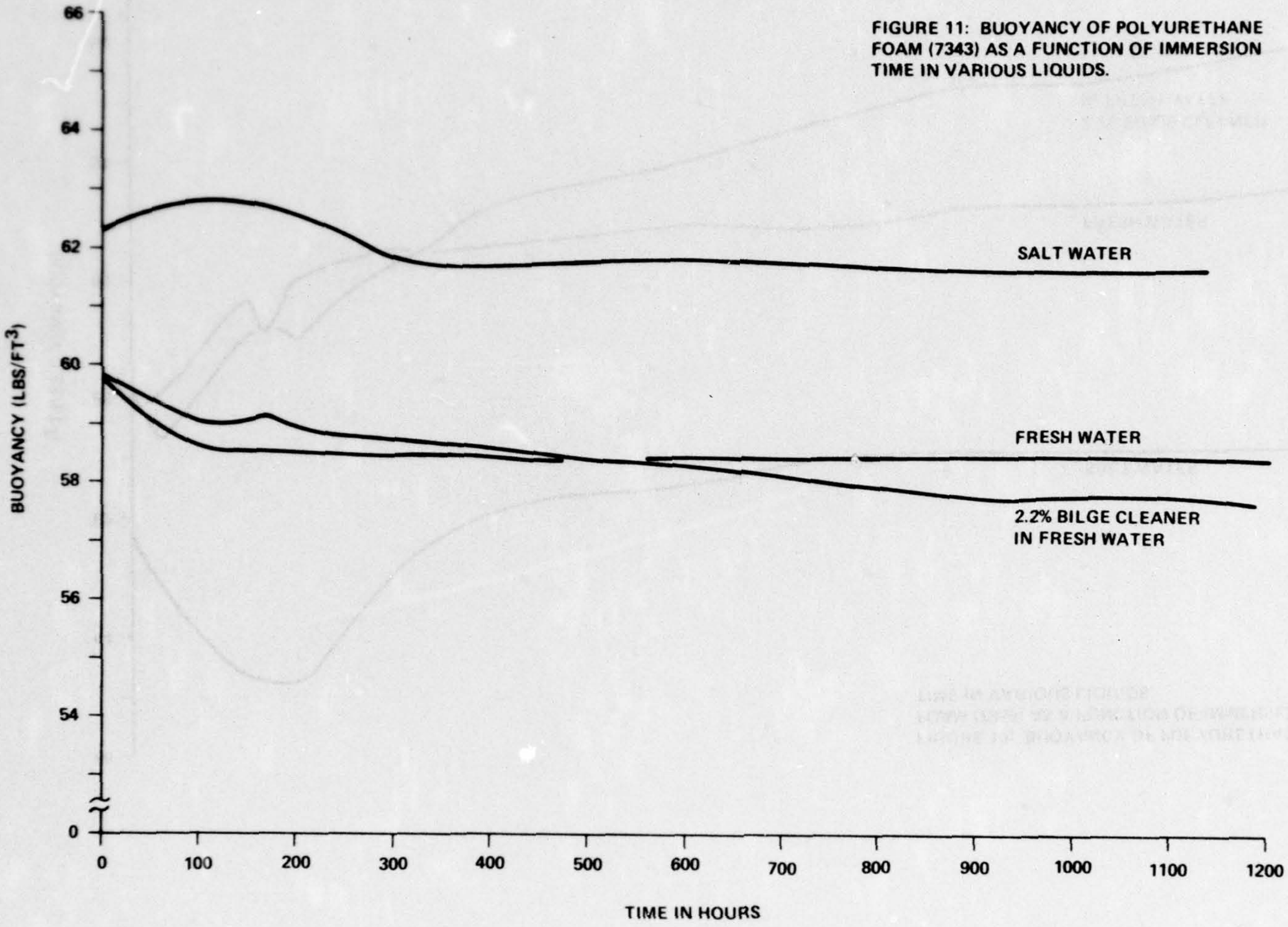


FIGURE 11: BUOYANCY OF POLYURETHANE FOAM (7343) AS A FUNCTION OF IMMERSION TIME IN VARIOUS LIQUIDS.

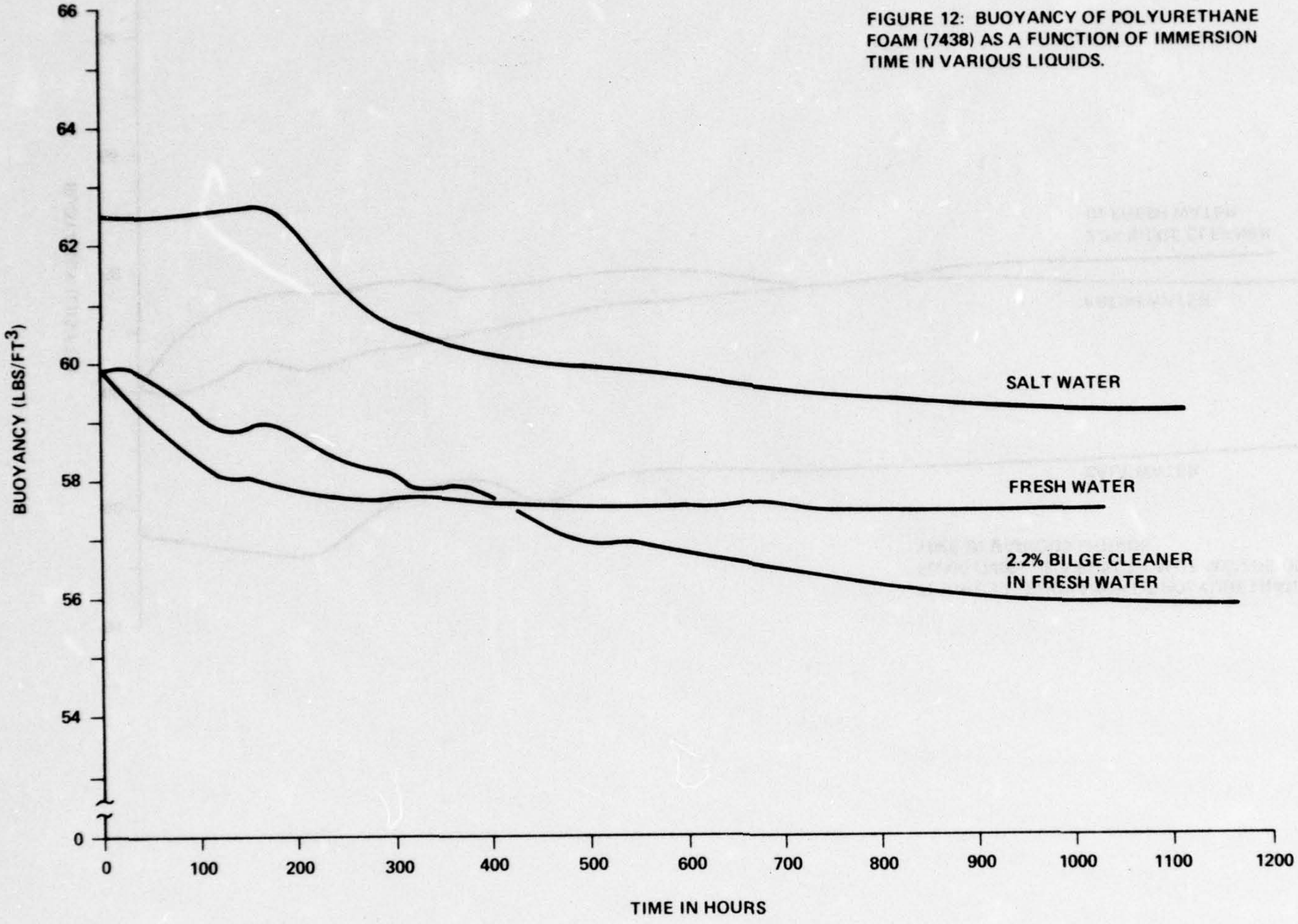


FIGURE 12: BUOYANCY OF POLYURETHANE FOAM (7438) AS A FUNCTION OF IMMERSION TIME IN VARIOUS LIQUIDS.

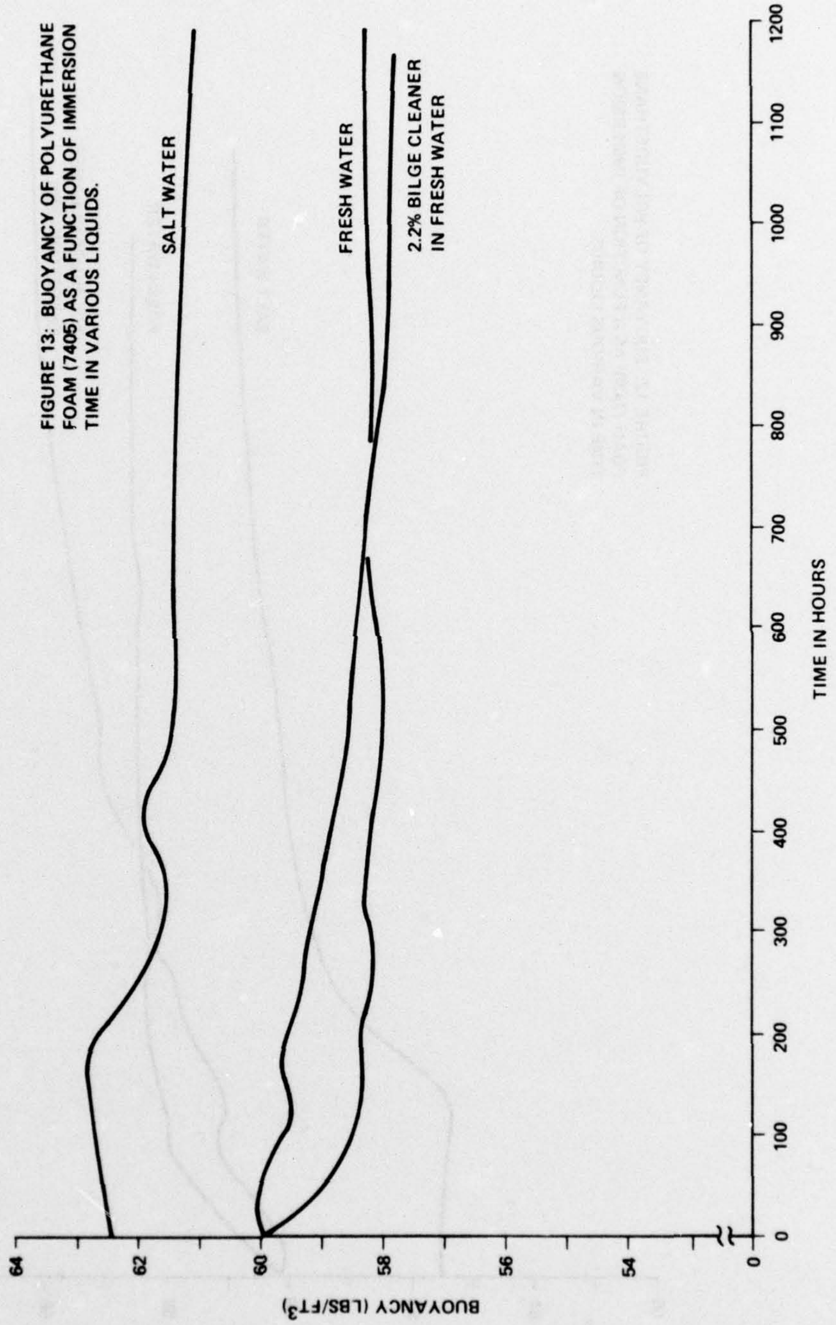
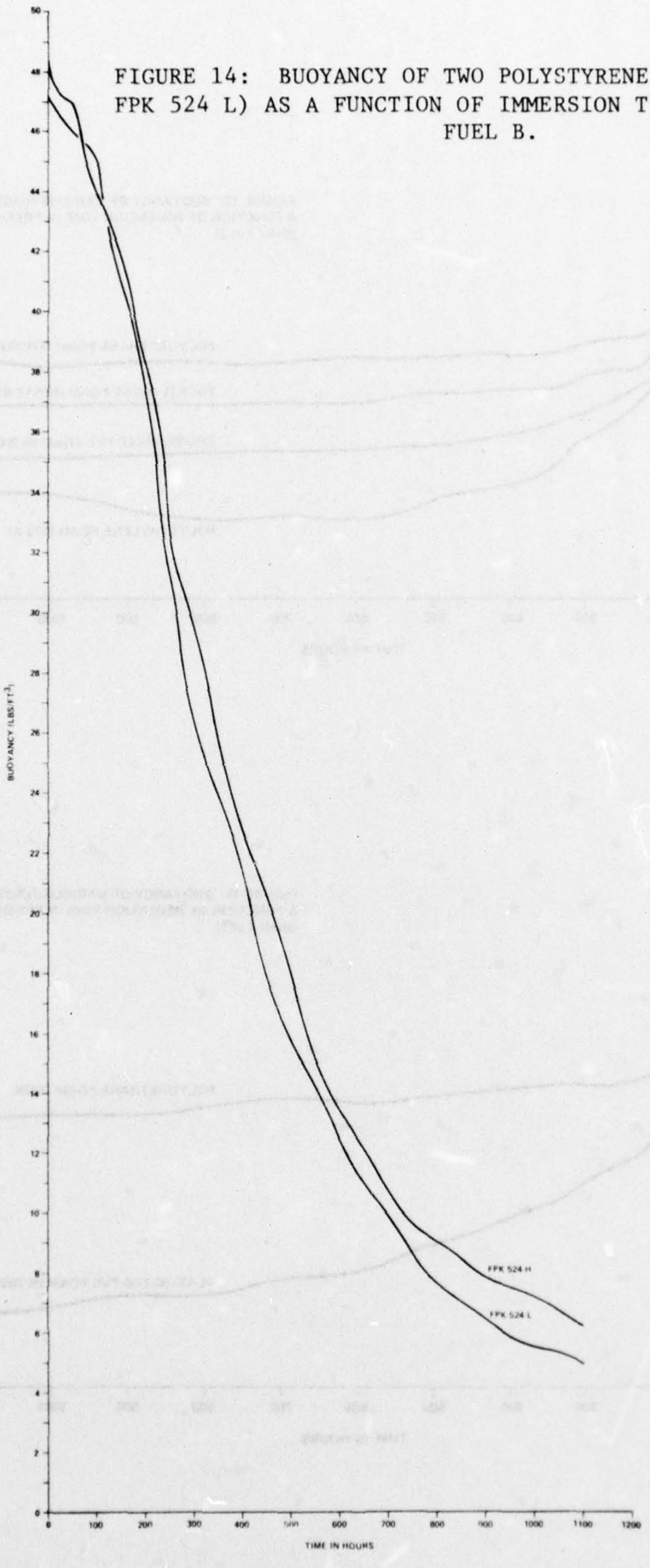


FIGURE 13: BUOYANCY OF POLYURETHANE FOAM (7405) AS A FUNCTION OF IMMERSION TIME IN VARIOUS LIQUIDS.

FIGURE 14: BUOYANCY OF TWO POLYSTYRENE FOAMS (FPK 524 H AND FPK 524 L) AS A FUNCTION OF IMMERSION TIME IN ASTM REFERENCE FUEL B.



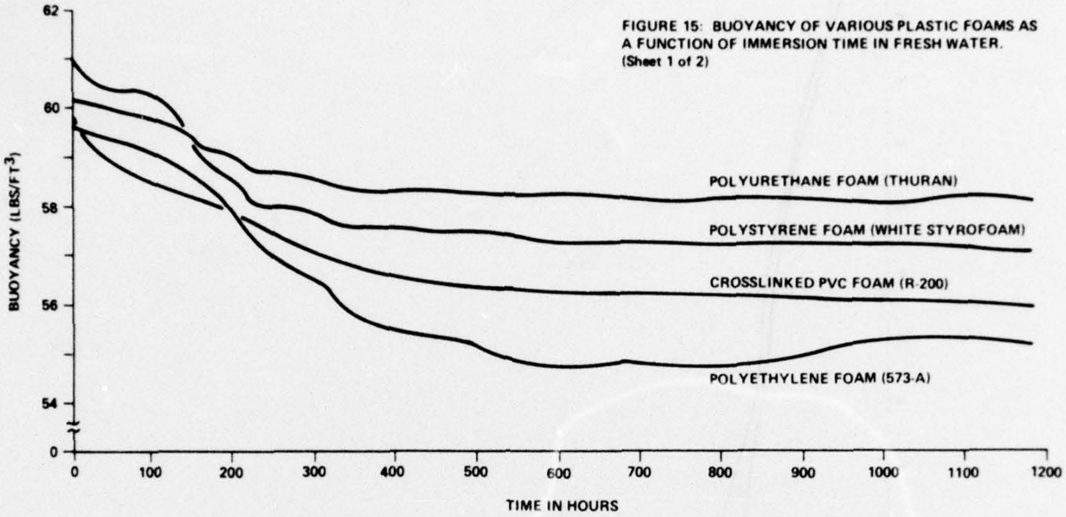


FIGURE 15: BUOYANCY OF VARIOUS PLASTIC FOAMS AS A FUNCTION OF IMMERSION TIME IN FRESH WATER. (Sheet 1 of 2)

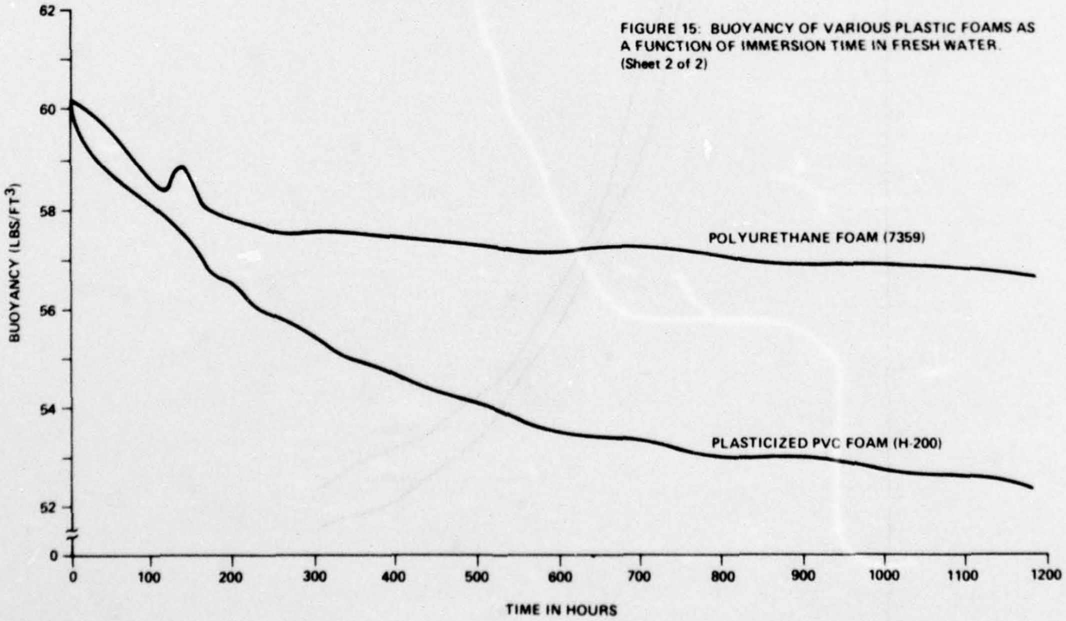


FIGURE 15: BUOYANCY OF VARIOUS PLASTIC FOAMS AS A FUNCTION OF IMMERSION TIME IN FRESH WATER. (Sheet 2 of 2)

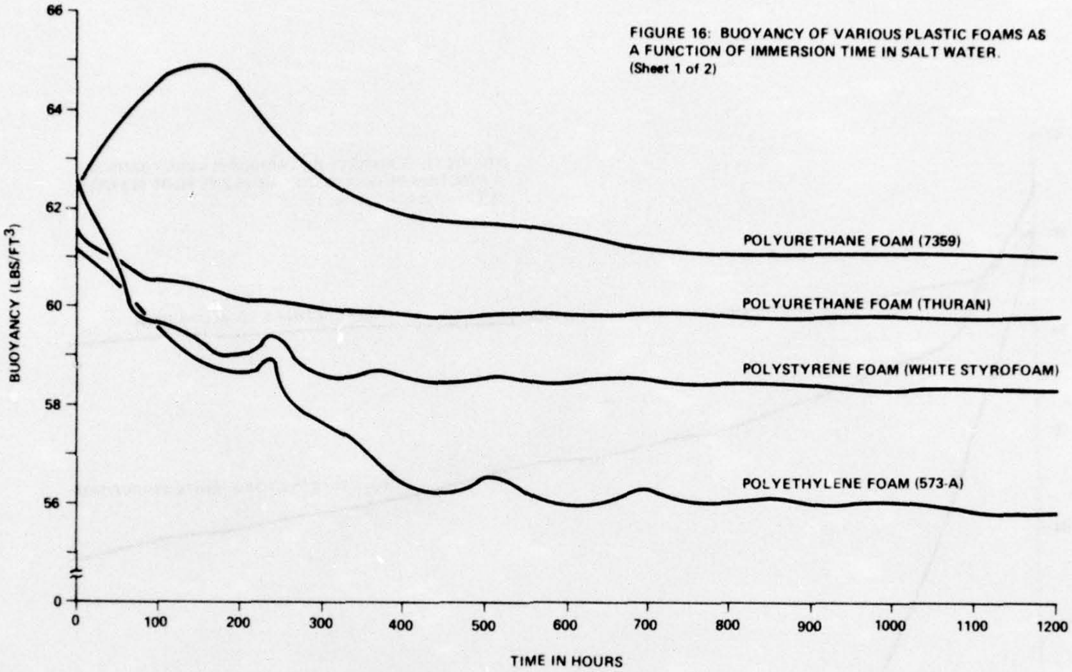


FIGURE 16: BUOYANCY OF VARIOUS PLASTIC FOAMS AS A FUNCTION OF IMMERSION TIME IN SALT WATER. (Sheet 1 of 2)

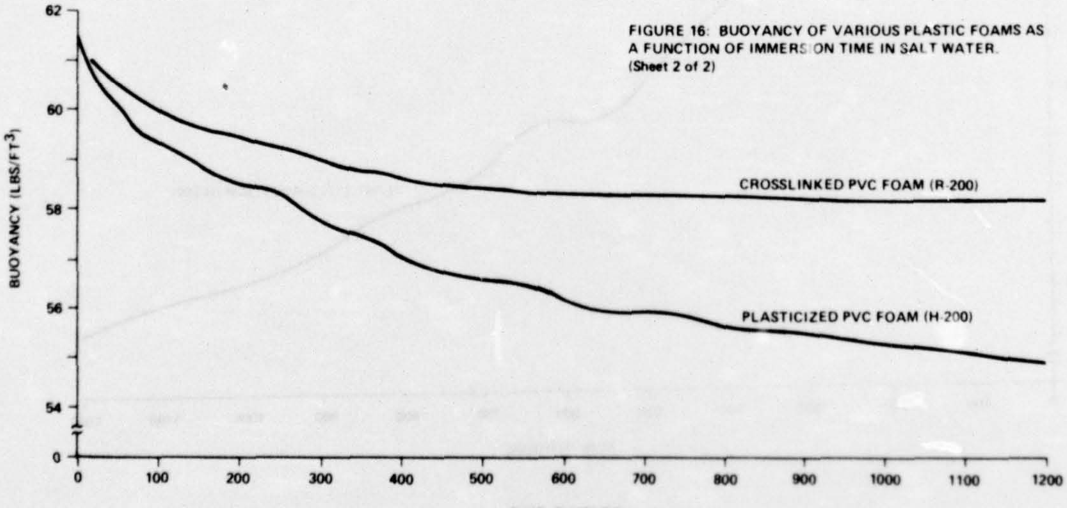


FIGURE 16: BUOYANCY OF VARIOUS PLASTIC FOAMS AS A FUNCTION OF IMMERSION TIME IN SALT WATER. (Sheet 2 of 2)

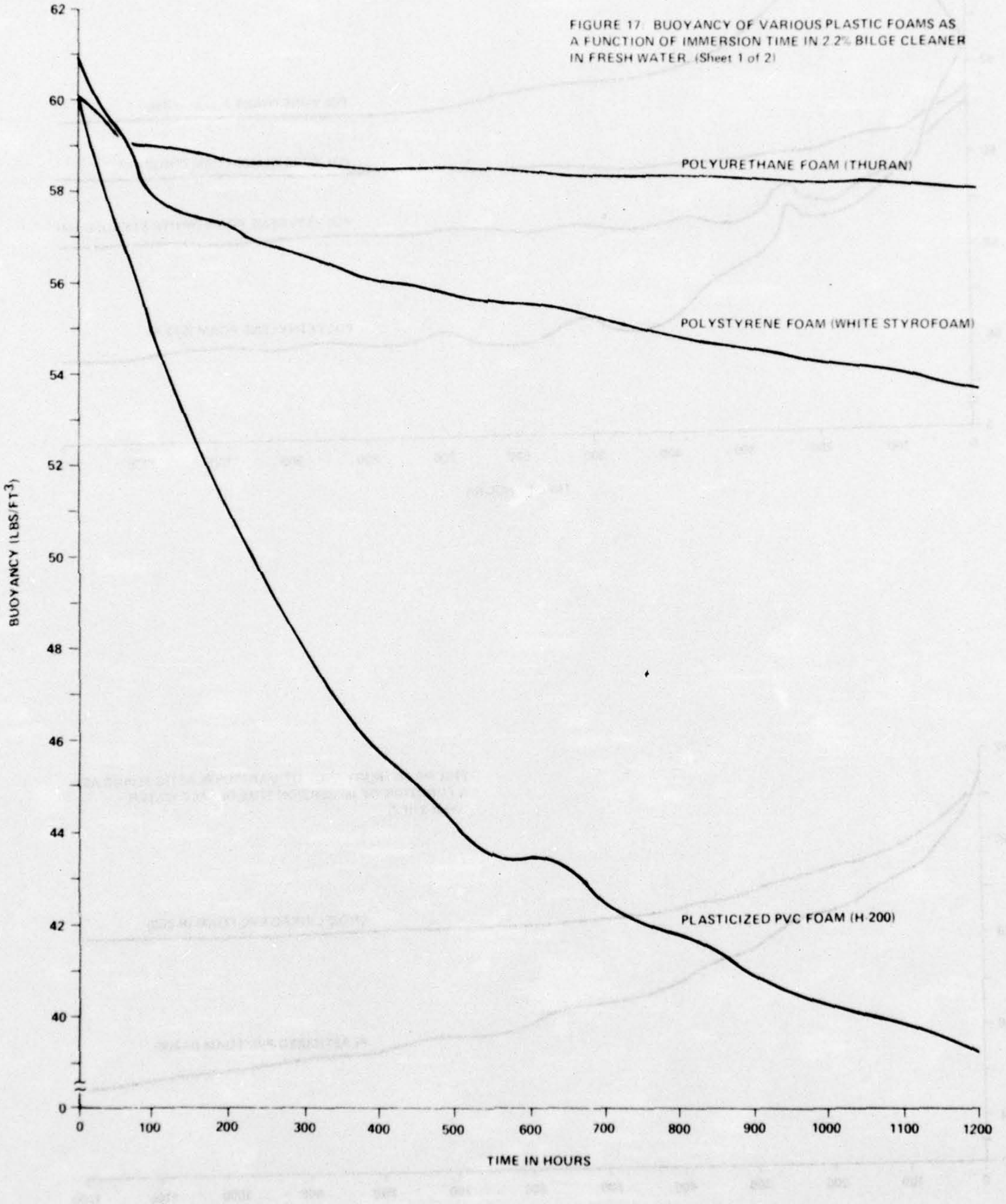


FIGURE 17 BUOYANCY OF VARIOUS PLASTIC FOAMS AS A FUNCTION OF IMMERSION TIME IN 2.2% BILGE CLEANER IN FRESH WATER. (Sheet 1 of 2)

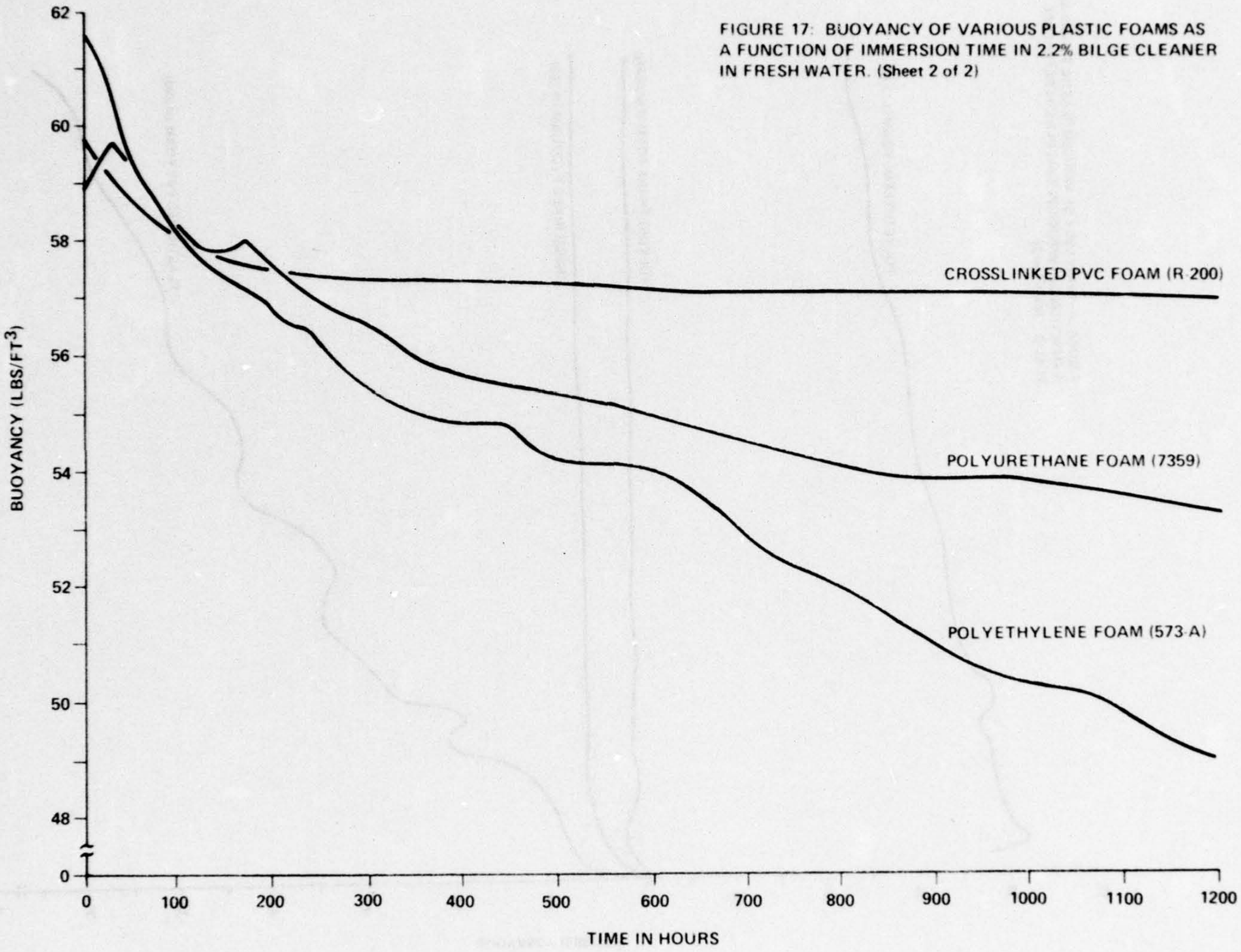


FIGURE 17: BUOYANCY OF VARIOUS PLASTIC FOAMS AS A FUNCTION OF IMMERSION TIME IN 2.2% BILGE CLEANER IN FRESH WATER. (Sheet 2 of 2)

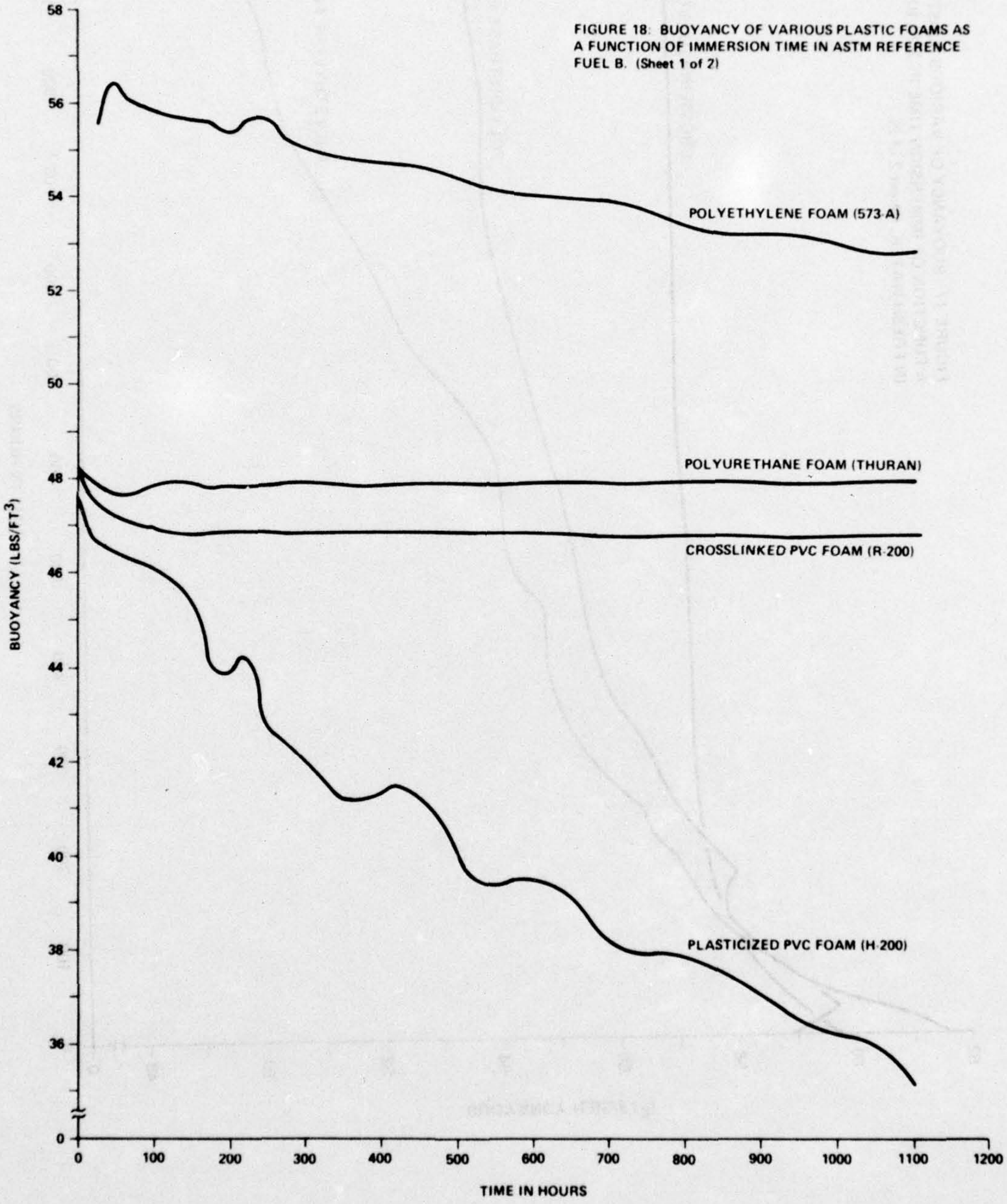


FIGURE 18: BUOYANCY OF VARIOUS PLASTIC FOAMS AS A FUNCTION OF IMMERSION TIME IN ASTM REFERENCE FUEL B. (Sheet 1 of 2)

FIGURE 18: BUOYANCY OF VARIOUS PLASTIC FOAMS AS A FUNCTION OF IMMERSION TIME IN ASTM REFERENCE FUEL B. (Sheet 2 of 2)

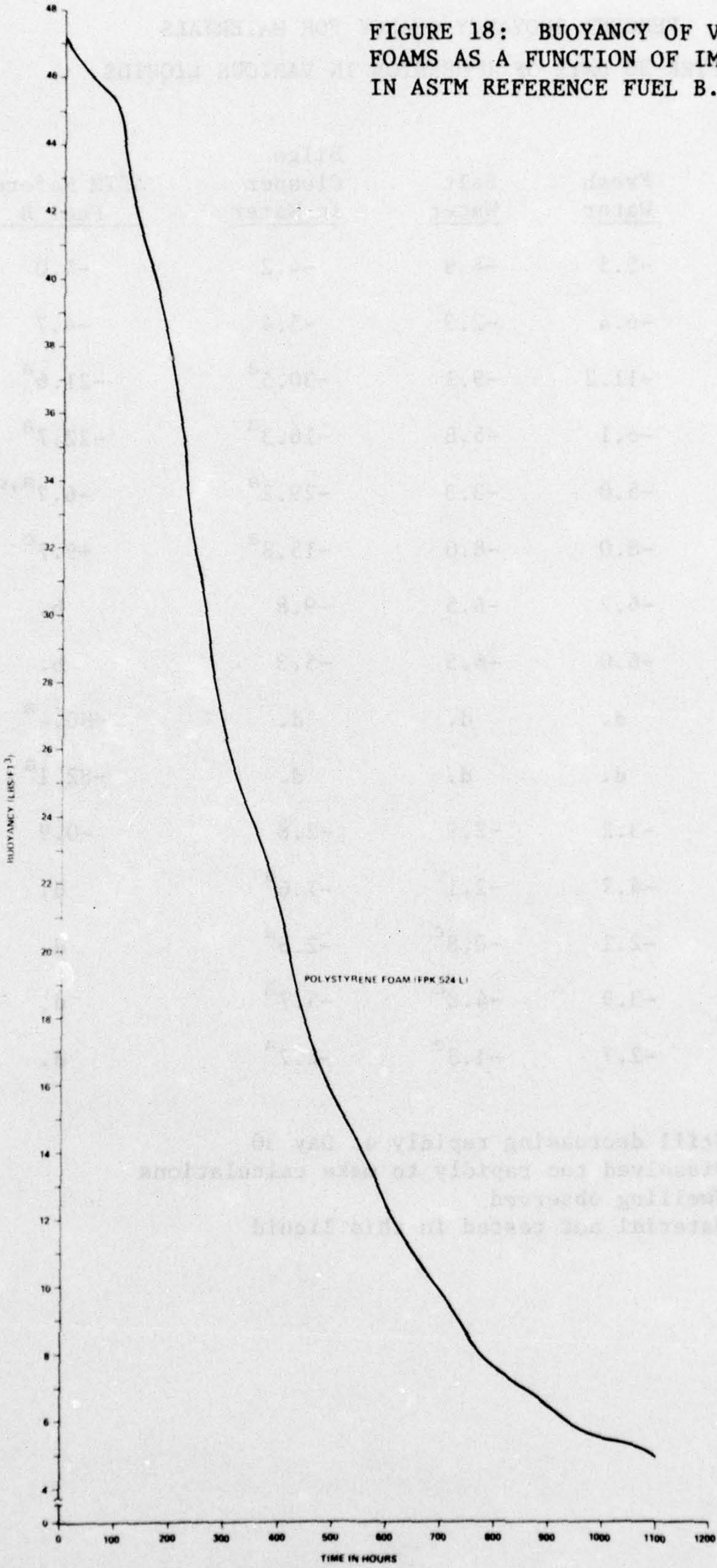


TABLE 3

PERCENT BUOYANCY CHANGE FOR MATERIALS AFTER 30 DAYS OF IMMERSION IN VARIOUS LIQUIDS

Foam Designation	Fresh Water	Salt Water	Bilge Cleaner in Water	ASTM Reference Fuel B
R-200	-5.5	-4.9	-4.2	-4.0
R-400	-6.4	-2.9	-5.4	-4.7
H-200	-11.2	-9.1	-30.5[a]	-21.6[a]
H-335	-6.1	-5.8	-16.3[a]	-22.7[a]
L-200	-5.0	-3.3	-29.2[a]	-6.7[a,c]
573-A	-8.0	-8.0	-15.8[a]	+9.7[c]
Wt. Styro.	-6.2	-6.5	-9.8	b.
Org. Styro.	-6.0	-6.5	-5.3	b.
FPK524-H	d.	d.	d.	-80.4[a]
FPK524-L	d.	d.	d.	-82.1[a]
Thuran	-3.2	-2.9	-2.8	-0.9
7359	-4.7	-2.1[c]	-7.6[a]	d.
7343	-2.1	-0.8[c]	-2.5[a]	d.
7438	-3.9	-4.8[c]	-5.7[a]	d.
7405	-2.7	-1.8[c]	-2.7[a]	d.

NOTES:
- a. Still decreasing rapidly at Day 30
- b. Dissolved too rapidly to make calculations
- c. Swelling observed
- d. Material not tested in this liquid

Some materials showed interesting behavior in the gasoline test. The normal polystyrenes (white and orange styrofoam) dissolved within minutes of immersion, leaving only a puddle of resin behind. (See Figures 19 and 20.) The solvent resistant polystyrenes did not dissolve, but the resin was leached out and the test specimens shrank to about one eighth their initial volumes without any weight loss. This is illustrated in Figures 21 and 22.

The values of percent change in Table 3 show that materials which did well in all test fluids, that is, that stabilized and resisted degradation, lost less than 7 percent of their buoyancy in all fluids. It is also evident that orange styrofoam did fairly well in all test liquids except gasoline. A modified gasoline test may give a better indication of this material's worth.

The free rise urethanes did not do so well as the controlled rise Thuran. The free rise materials have much larger voids than the Thuran, hence the density of the material varies more within any one piece. These differences seem to increase water absorption for the free rise materials.

3.2 Freeze-Thaw

Samples of polystyrene, polyurethane, polyvinyl chloride, and polyethylene foams were tested. Figures 23 through 28 illustrate the effects of the freeze-thaw cycling on the buoyancy of one specimen of each foam. On the basis of data from only one specimen of each foam, the results are inconclusive. For most materials the before and after freeze-thaw buoyant force curves did not vary significantly from one another. Any differences could be attributed to variations from specimen to specimen. However, both styrofoams tested did show a significant downward trend in buoyancy due to freeze-thaw effects. In fact, the white styrofoam, which was extruded bead stock, was ruptured by the end of the test and was nearly split lengthwise. None of the other materials showed any apparent physical changes.

After two weeks to assure thorough drying, the specimens were remeasured. All specimens (except R-400, an anomalous result) exhibited a small permanent decrease in buoyancy due to the freeze-thaw testing. The greatest change for polyethylene foam (573-A) was about 7 percent.

3.3 Friability

The results of the friability testing are summarized in Table 4. Only the urethanes are shown in this table because the other materials tested (the same as in Table 1), were not friable according to this test (<1%). Even after tumbling for 50 minutes these materials show no signs of wearing away. A new test will have to be devised in order to provide discrimination between materials.

It is evident from this data that the free expansion urethanes are much more friable than the controlled rise urethanes, even though all the urethanes have a density close to 2 LB/ft^3.

3.4 Gasoline Vapor Exposure

Samples of polystyrene, and polyurethane were tested as indicated in Table 2 in both 100°F and 140°F saturated atmospheres of ASTM Reference Fuel B. The solvent resistant polystyrene was tested only in the 100°F atmosphere. The

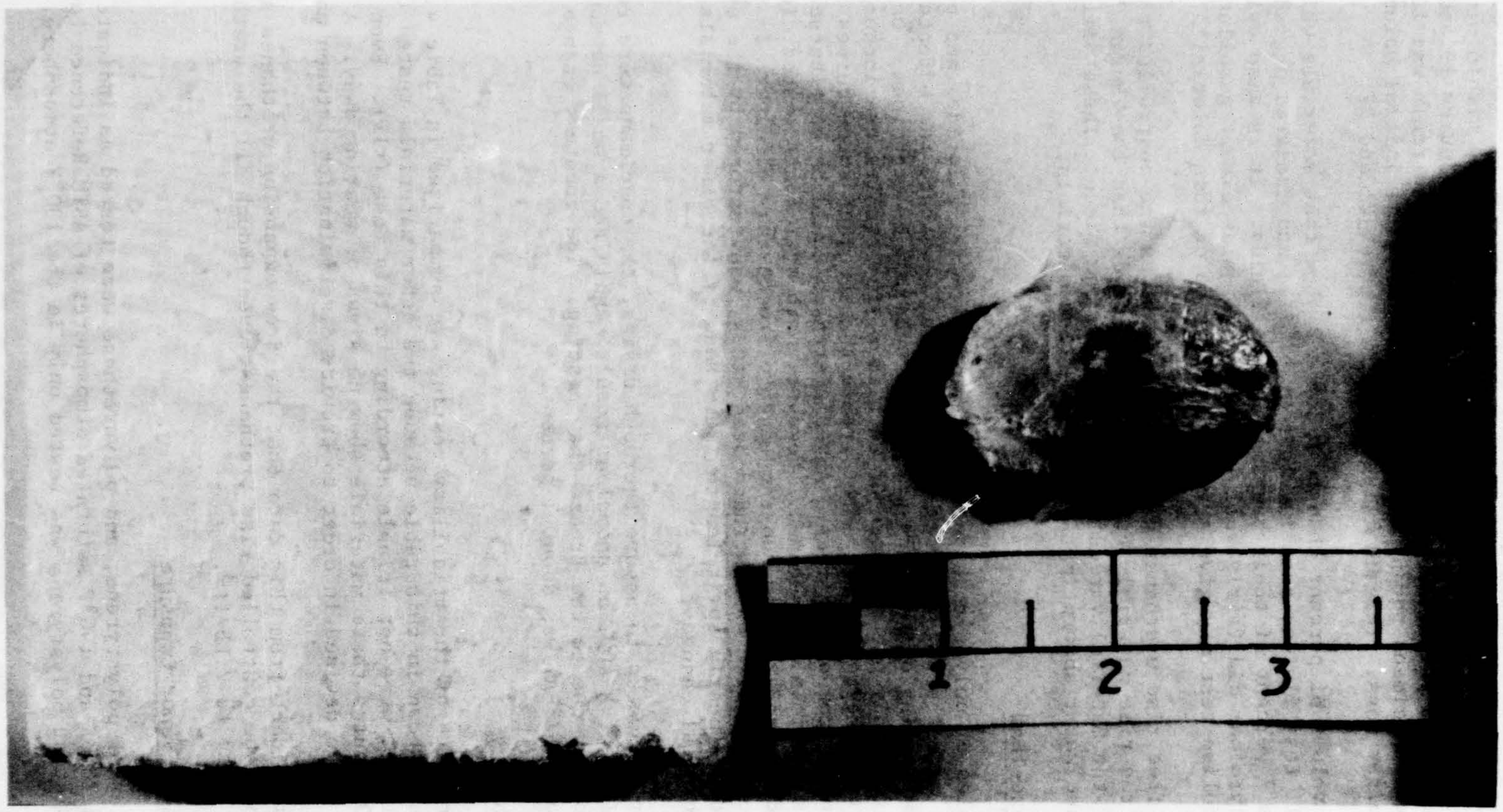


FIGURE 19. Polystyrene Foam (White Styrofoam) Before and After Immersion in ASTM Reference Fuel B

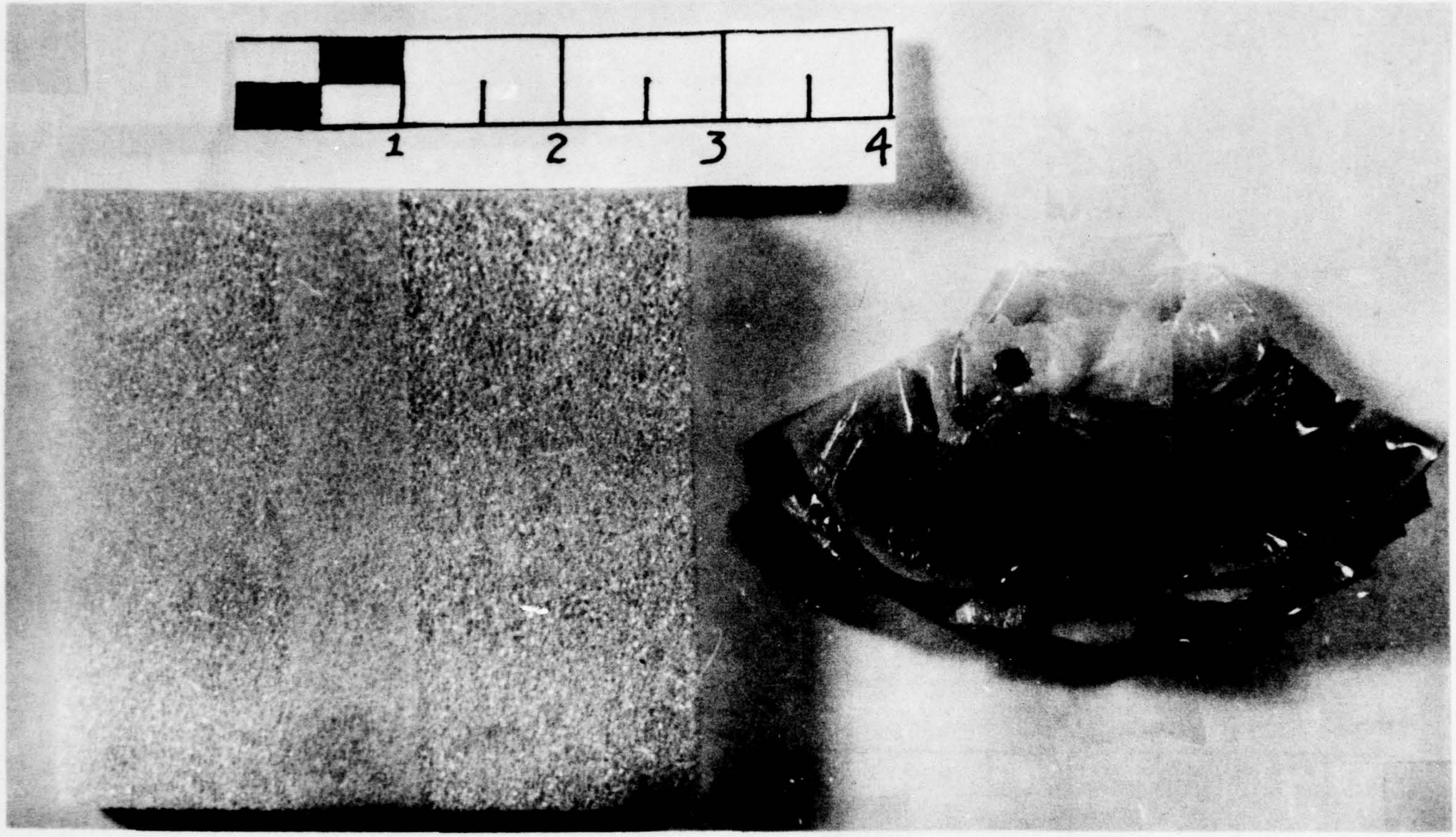


FIGURE 20. Polystyrene Foam (Orange Styrofoam) Before and After Immersion in ASTM Reference Fuel B

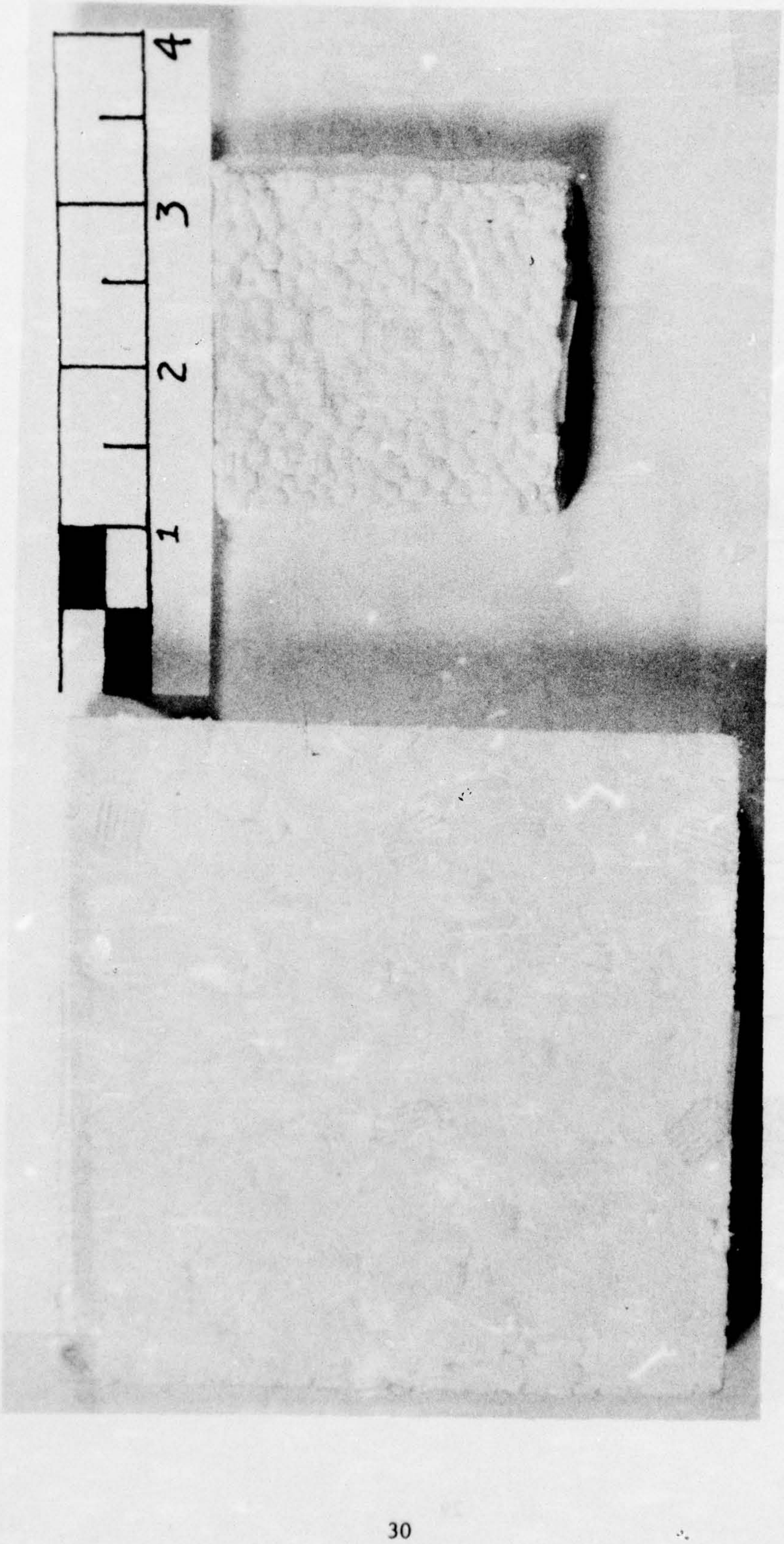


FIGURE 21. Solvent Resistant Polystyrene Foam (FPK524-H) Before and After Immersion in ASTM Reference Fuel B

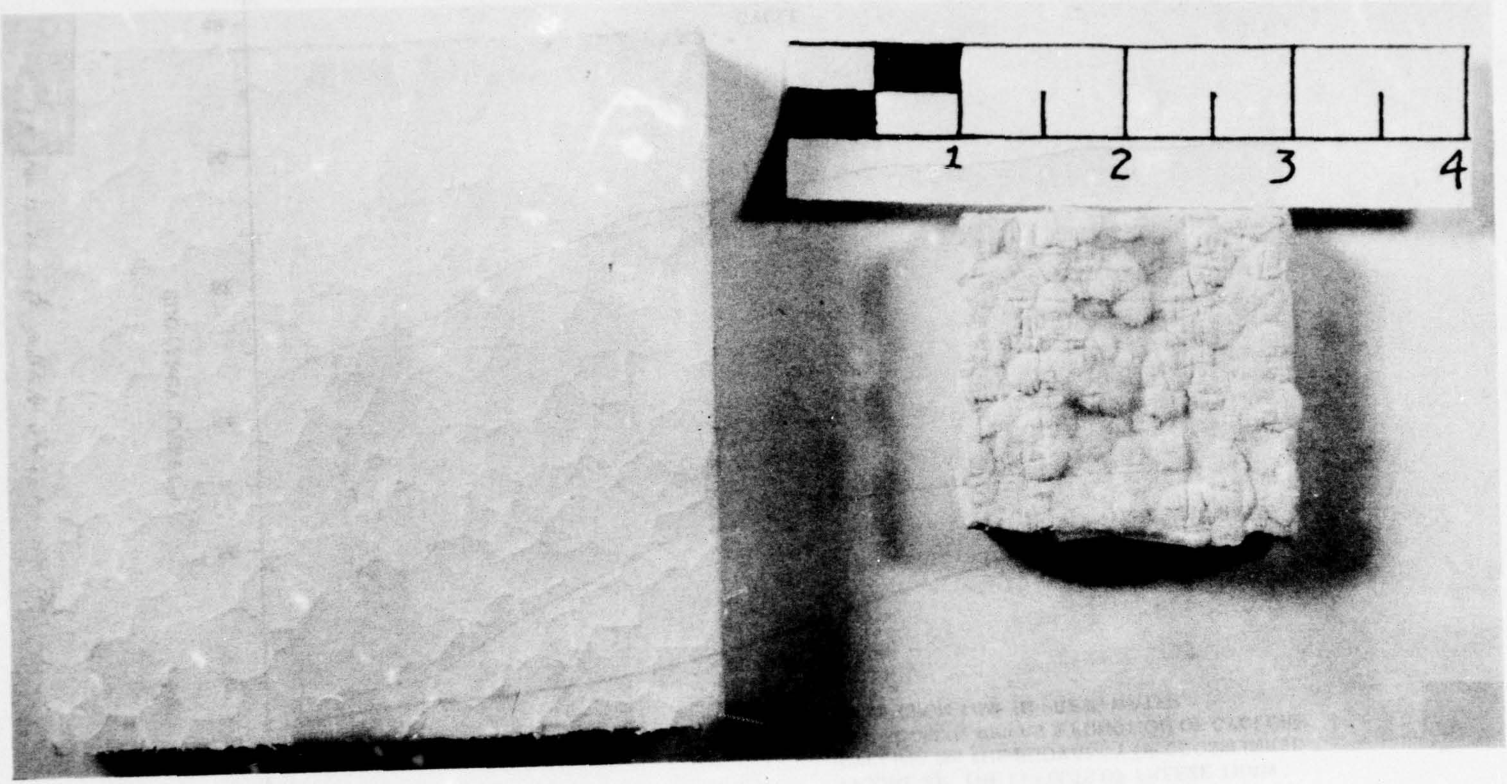


FIGURE 22. Solvent Resistant Polystyrene Foam (FPK524-L) Before and After Immersion in ASTM Reference Fuel B

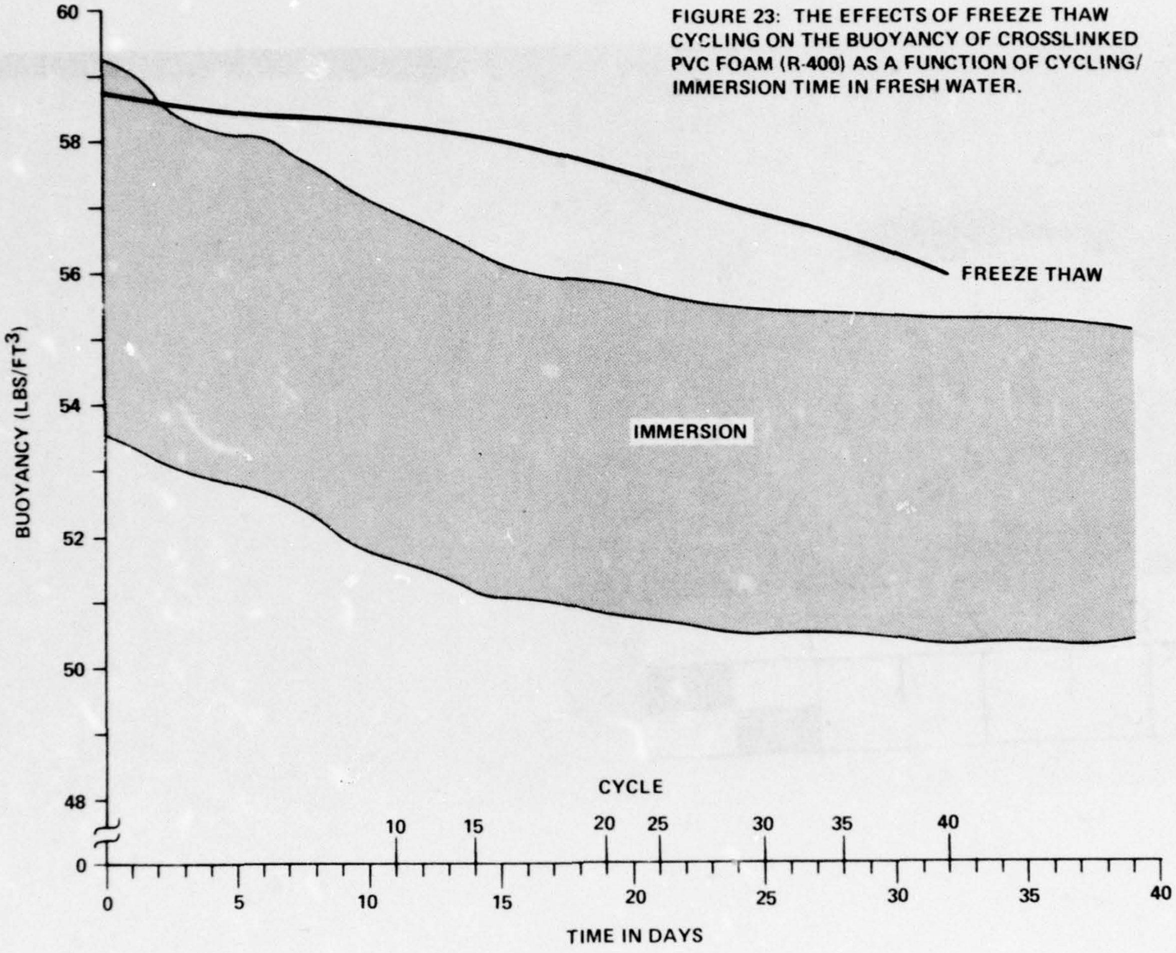


FIGURE 23: THE EFFECTS OF FREEZE THAW CYCLING ON THE BUOYANCY OF CROSSLINKED PVC FOAM (R-400) AS A FUNCTION OF CYCLING/ IMMERSION TIME IN FRESH WATER.

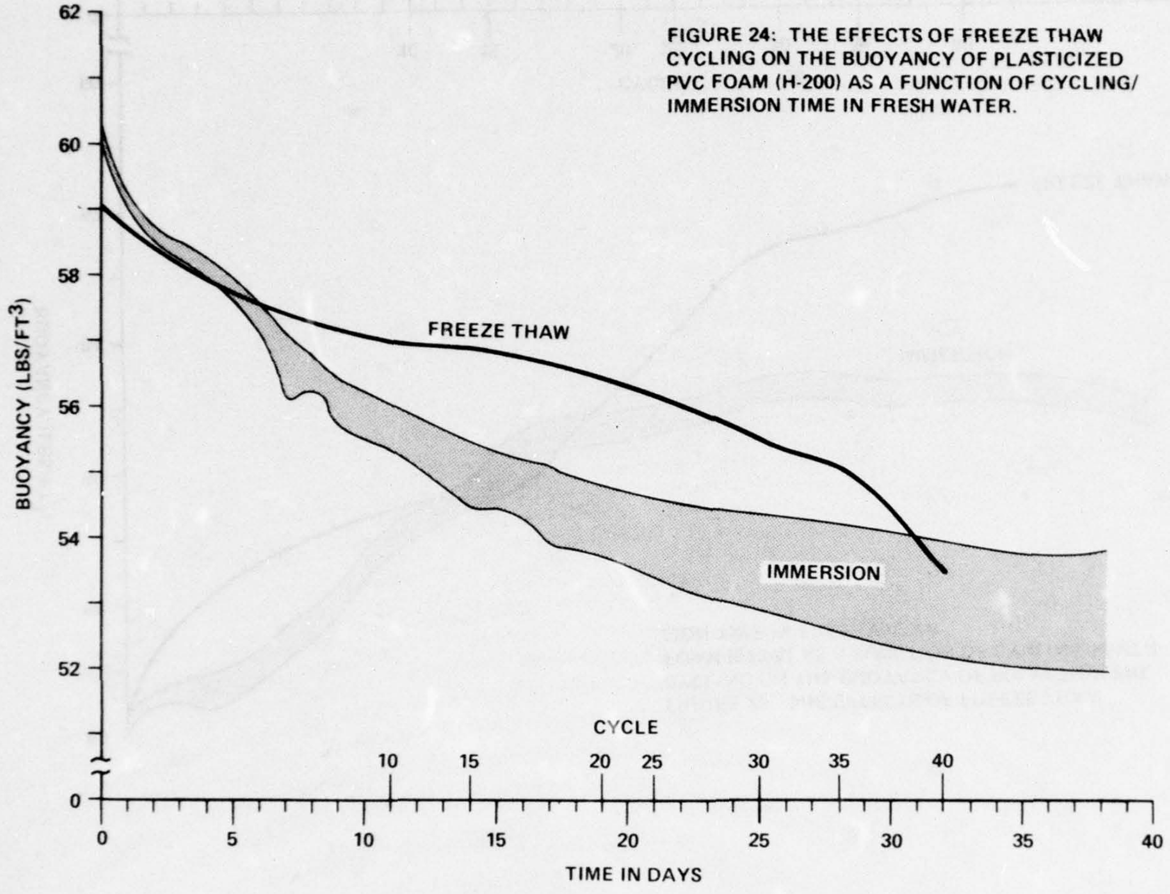


FIGURE 24: THE EFFECTS OF FREEZE THAW CYCLING ON THE BUOYANCY OF PLASTICIZED PVC FOAM (H-200) AS A FUNCTION OF CYCLING/IMMERSION TIME IN FRESH WATER.

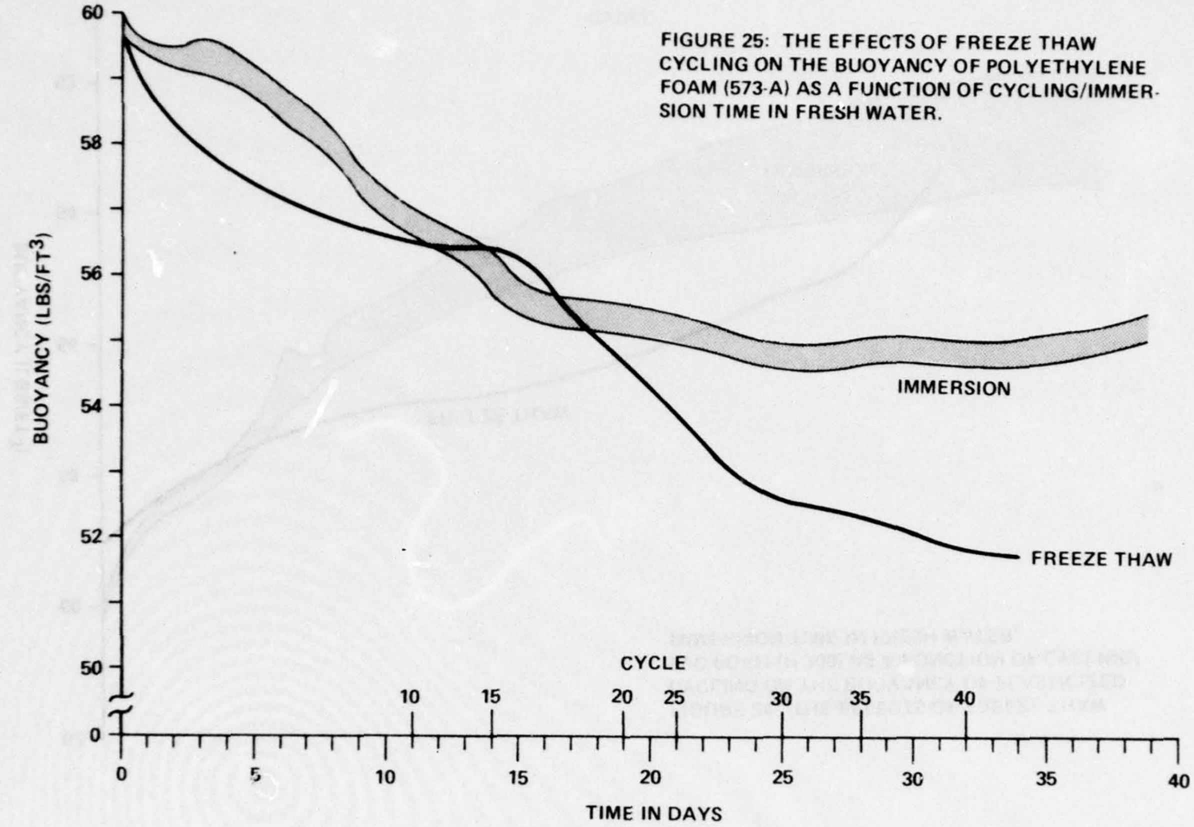


FIGURE 25: THE EFFECTS OF FREEZE THAW CYCLING ON THE BUOYANCY OF POLYETHYLENE FOAM (573-A) AS A FUNCTION OF CYCLING/IMMERSION TIME IN FRESH WATER.

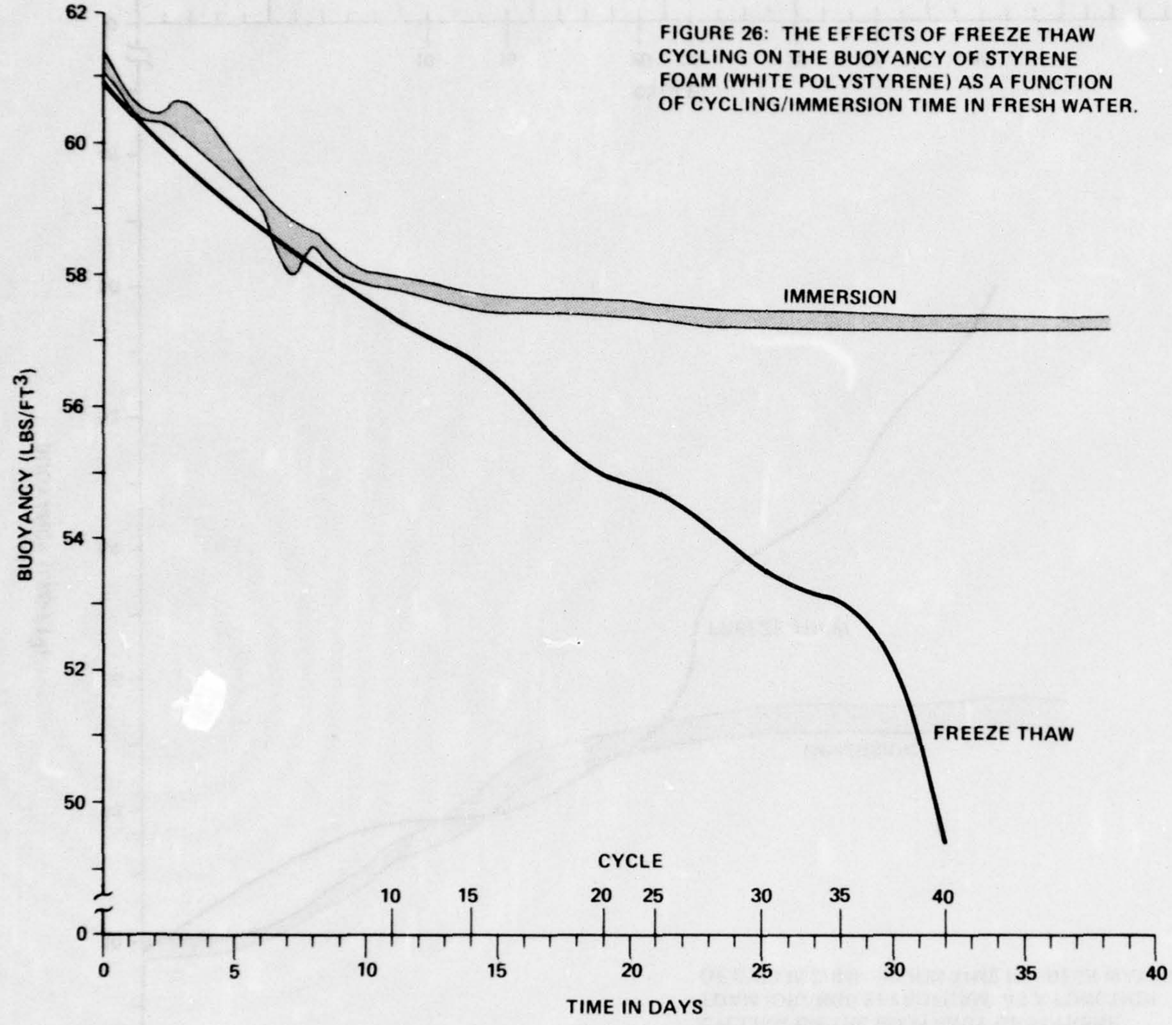


FIGURE 26: THE EFFECTS OF FREEZE THAW CYCLING ON THE BUOYANCY OF STYRENE FOAM (WHITE POLYSTYRENE) AS A FUNCTION OF CYCLING/IMMERSION TIME IN FRESH WATER.

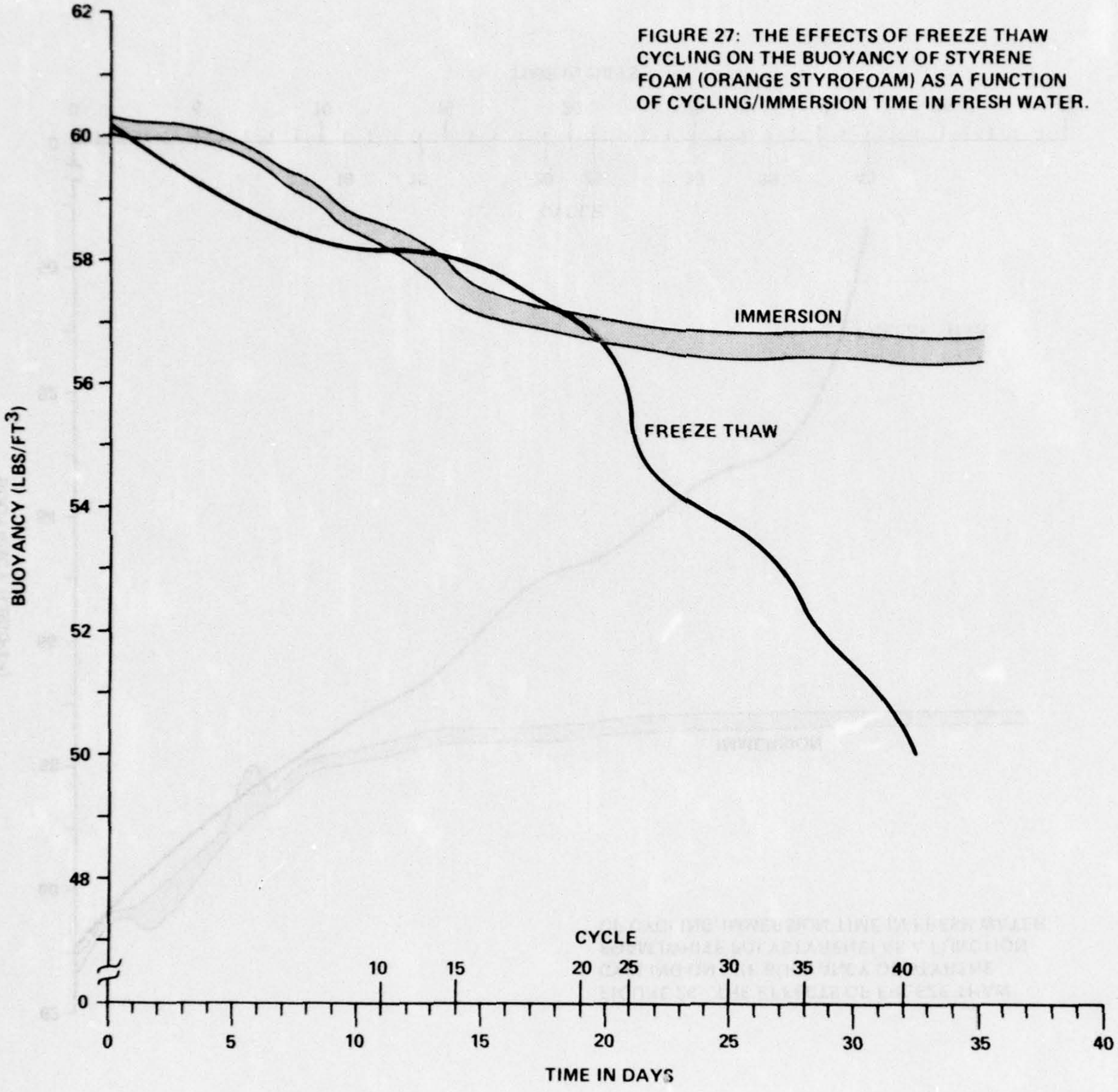


FIGURE 27: THE EFFECTS OF FREEZE THAW CYCLING ON THE BUOYANCY OF STYRENE FOAM (ORANGE STYROFOAM) AS A FUNCTION OF CYCLING/IMMERSION TIME IN FRESH WATER.

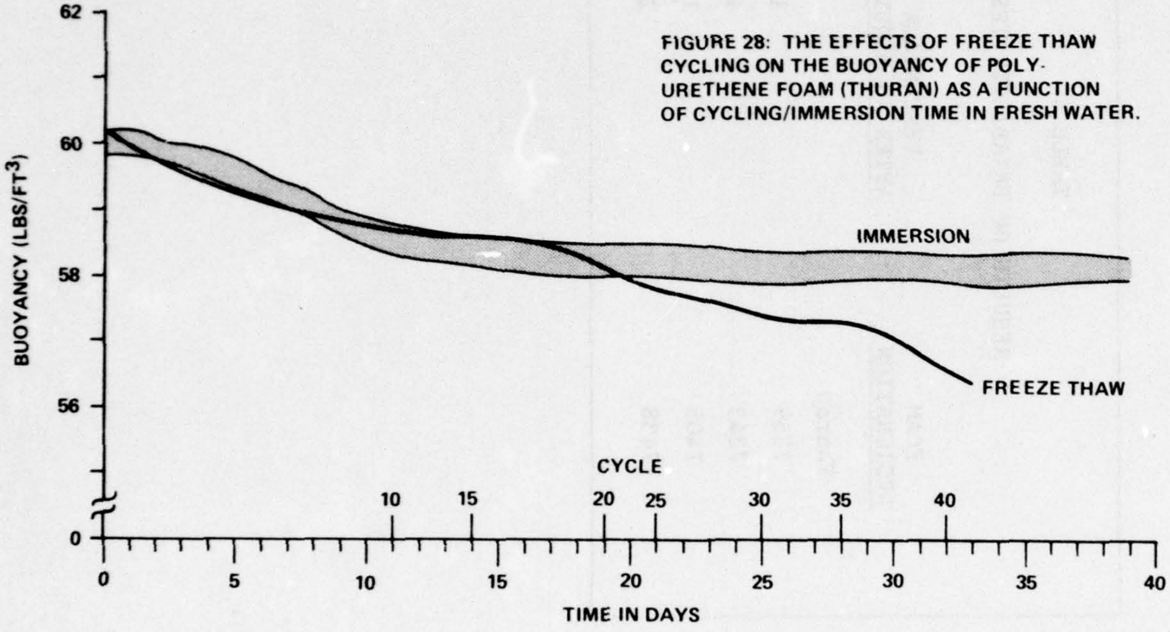


FIGURE 28: THE EFFECTS OF FREEZE THAW CYCLING ON THE BUOYANCY OF POLYURETHENE FOAM (THURAN) AS A FUNCTION OF CYCLING/IMMERSION TIME IN FRESH WATER.

TABLE 4

RESULTS OF FRIABILITY TESTING

FOAM DESIGNATION	PERCENTAGE WEIGHT LOSS AFTER 10 MINUTES OF TUMBLING
Thuran	5
7359	14.4
7343	10.5
7405	15.9
7438	27.6

effects of gasoline vapor exposure are illustrated in Figures 29 and 30. The polyurethane and solvent resistant polystyrene materials showed insignificant buoyancy changes over 90 days of exposure to the saturated atmospheres at 100°F and 140°F. The non-solvent resistant polystyrene showed a significant drop in buoyant force. It fell to 10 pounds per cubic foot in 20 days of exposure to the saturated atmosphere at 100°F. The drop in buoyant force during the 140°F exposure was even more severe yielding less than 4 pounds per cubic foot in ten days.

4.0 CONCLUSIONS

4.1 Immersion Tests

Materials which performed well in all tests were characterized by less than 7 percent loss in buoyancy in 30 days of immersion and were relatively stable after 15 days. A thirty-day test period is ample to delineate absorption rates and buoyancy trends.

Of the individual materials, the controlled-rise urethane performed best overall. The polyvinyl chlorides varied from among the best (R-200 and R-400) to worst (H-200 and H-335). The polyethylenes were poor overall. Polystyrenes were good except in gasoline.

Total immersion in gasoline is not considered to be a realistic test for flotation material in recreational boats. Exposure to gasoline vapor is considered to be a more realistic situation.

4.2 Freeze-Thaw

Freeze-thaw cycling of flotation materials damages the materials and decreases their buoyancy. Beaded styrofoam was particularly vulnerable to damage, and its specimen was effectively destroyed.

The freeze-thaw test needs further application and study to develop a better data base for analysis.

4.3 Friability

The urethanes show an unfavorably high tendency to crumble. Although they do well in immersion tests, their high friability may make them unacceptable for boat flotation applications unless located in areas where they are protected from possible abuse.

The ASTM standard friability test does not yield useful information on materials other than urethane and does not typify the type of abuse to which a material would be subjected in actual use. A different test needs to be developed.

4.4 Gasoline Vapor Exposure

As in the gasoline immersion tests, the vapor exposure tests affect only the polystyrene foams. The immersion test is a more severe test than either the vapor test at 100°F or 140°F. However, the 100°F vapor test is probably a more realistic test in the sense that flotation materials installed in recreational boats are more likely to experience saturated atmospheres of gasoline than they are total immersion in gasoline. On the basis of the data for the 100°F vapor test, the only material which is suspect is polystyrene foam without solvent-resistant formulation.

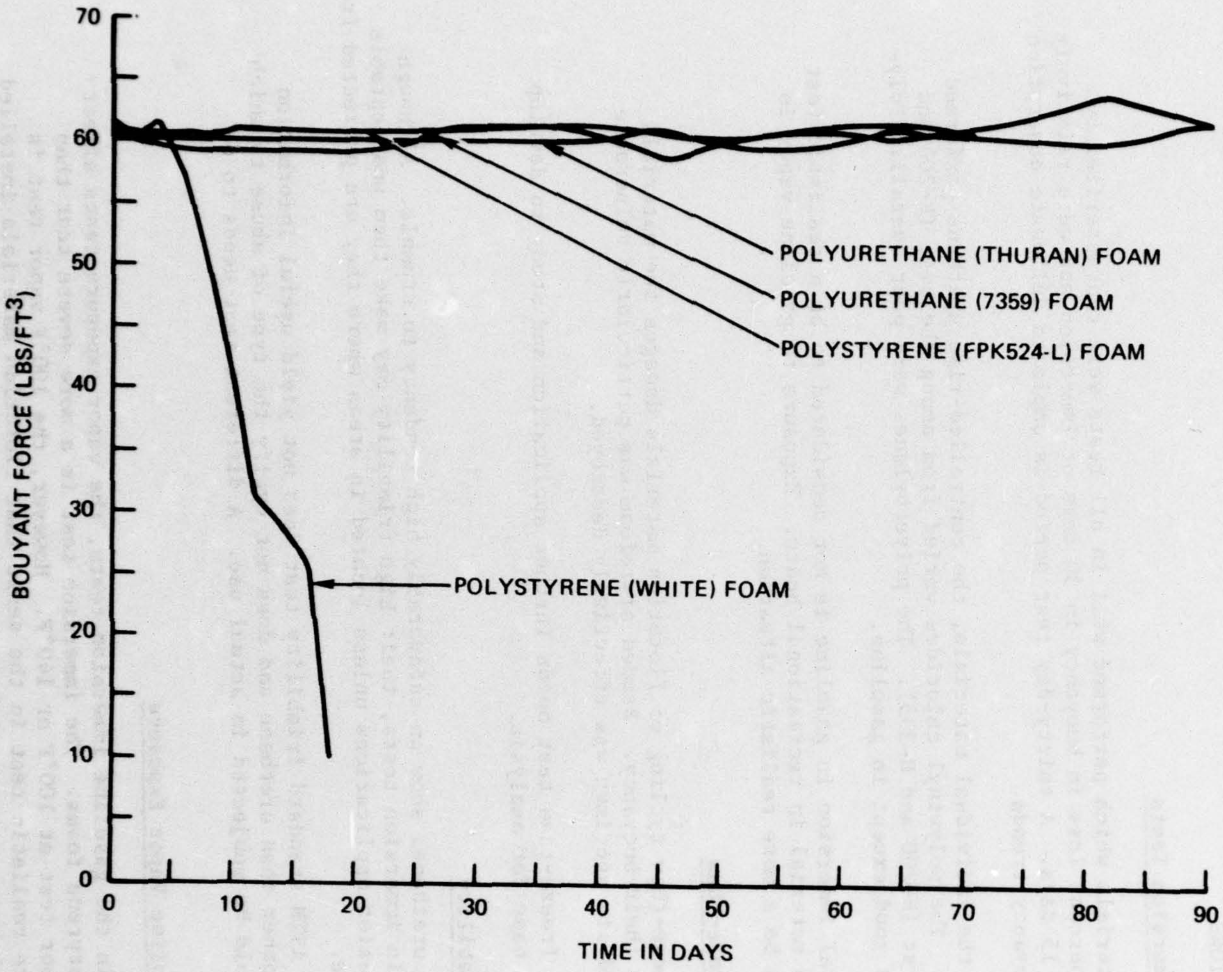


FIGURE 29. Buoyancy of flotation materials as a function of exposure time in a saturated atmosphere of ASTM Reference Fuel B at 100°F

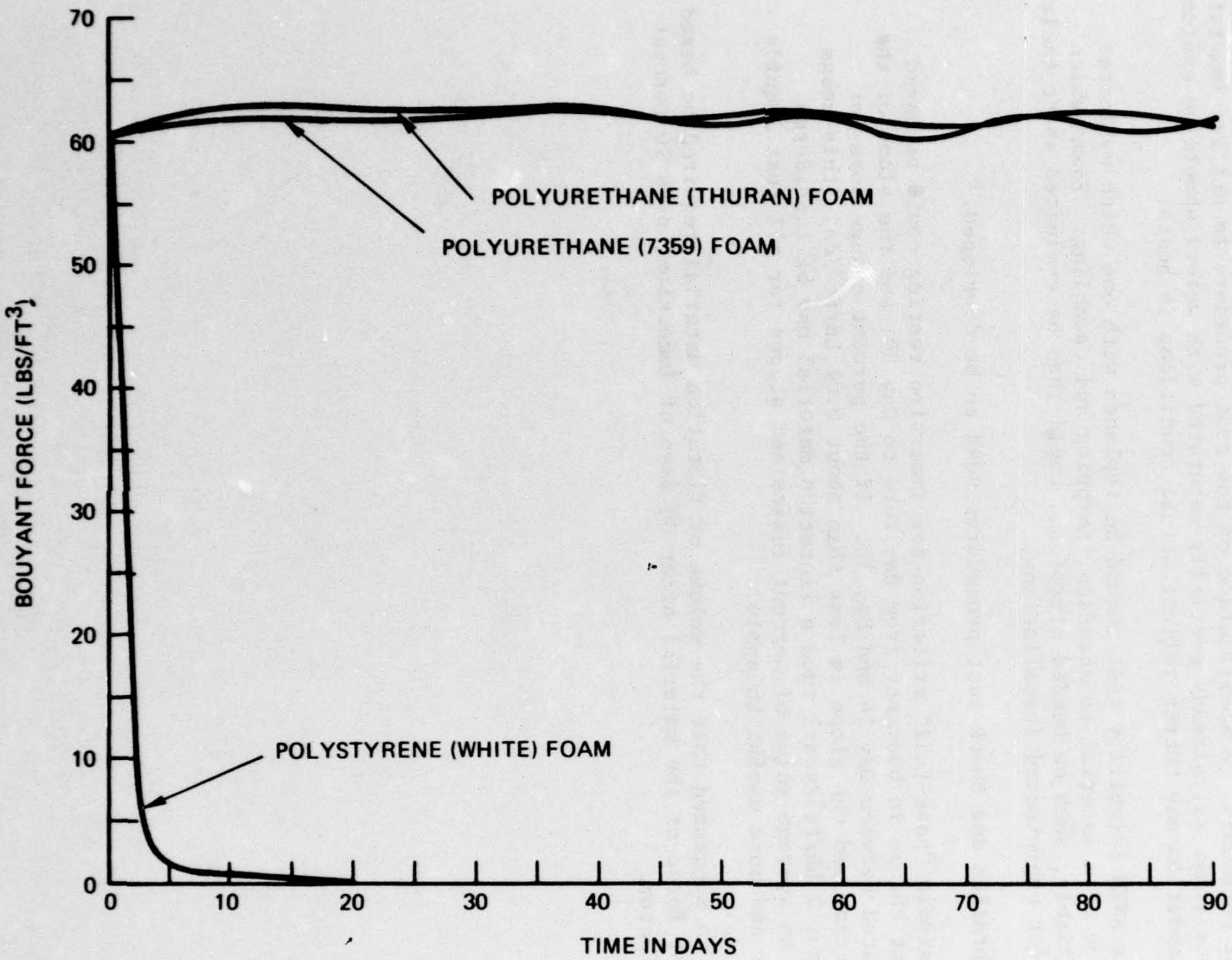


FIGURE 30. Buoyancy of flotation materials as a function of exposure time in a saturated atmosphere of ASTM Reference Fuel B at 140°F

5.0 RECOMMENDATIONS

5.1 The immersion test procedure detailed in Appendix A is recommended for determining the resistance to and retained buoyancy of flotation materials in fresh water, salt water, and water/bilge cleaner solution.

5.2 The gasoline total immersion test should be discontinued and replaced by a gasoline vapor test procedure at 100°F.

5.3 The freeze-thaw tests should be continued with more test specimens and different materials. A modification of the test procedure to utilize immersion test specimens (that is, already partially saturated with water) should be evaluated since this condition may better reflect actual conditions in boats.

5.4 The ASTM friability test should be replaced with one which evaluates the resistance of a material to abrasion, chipping and crumbling. Foams which may not be friable, such as beaded styrofoam, could then be evaluated as to their suitability for unprotected installations.

5.5 Vibration and shock test procedures need to be developed.

5.6 A simple "pass-fail" criterion for immersion testing could be based on the percent change in buoyancy from Day Zero to Day 30, and the slope of the curve calculated between Day 14 and Day 30. If the percent change does not exceed 10 percent and the slope is less than about 0.01 LB/ft^3/day (this means a loss of about 3 LB/ft^3/year) then a flotation material may be considered acceptable. An average value of percent losses and slopes for all test liquids may be easier and more useful to apply.

5.7 It is suggested that the volume of flotation material required be based on the buoyant force of the material after 30 days of immersion, plus 10 percent as a safety factor.

APPENDIX A
BUOYANCY MATERIALS IMMERSION TEST PROCEDURE

1. SCOPE

1.1 This test procedure describes the method for determining buoyancy changes in recreational boat flotation materials when immersed under a two-inch head of various test fluids. The method presented here is based upon and represents a minor modification of the ASTM Standard Test Method D2842-69.

2. SUMMARY OF METHOD

2.1 The buoyant force of an object less dense than the fluid in which it is immersed is equal to the weight of the volume of fluid it displaces when submerged, less the dry weight of the object. Absorption of the fluid or physical changes due to the effects of the fluid (swelling, degradation) will cause change in buoyancy. Direct measurements of buoyant force during the test can be utilized to draw conclusions regarding the suitability of a given material for buoyancy use.

3. SIGNIFICANCE

3.1 The purpose of this method is to provide a means of comparing relative buoyancy change tendencies between different flotation materials. It is intended for use in the evaluation of flotation materials for marine flotation application. It is applicable to this end use to the extent that the testing fluids are those which would commonly be encountered in a marine environment and the two-inch head specified for testing can be considered representative of the depth of bilge water which may be encountered in actual practice.

3.2 Buoyancy testing is subject to several variables which, if not considered, may result in differences in results of tests among various testers. The formulation of this method is designed to take the most serious of the possible sources of error into account.

<u>NOTE 1</u>: Errors due to initial rapid changes in buoyancy are taken into account by the many measurements made over an extended period of time. This extended period has been found to be sufficient to clearly delineate any trend in the buoyancy change.

<u>NOTE 2</u>: The increase in volume which occurs with some materials when immersed is countered by basing all buoyancy calculations on the initial volume of the specimen. This method has been chosen because all flotation material requirements for a desired buoyancy are designed from the dry volume of the material by the boat manufacturer per paragraph 183.67 of CFR 183.

<u>NOTE 3</u>: The problem of air bubbles clinging to the specimens and affecting the various measurements is minimized by specifying deaerated distilled water and appropriate methods for removing clinging air bubbles at each measuring session.

<u>NOTE 4</u>: Difficulties involved in calculating the specimen volume based upon direct measurement of the dimensions are eliminated by determining the volume of each specimen by a fluid displacement method immediately after immersion.

4. APPARATUS

4.1 A balance capable of weighing up to 2500 gpm to 0.1 ± 0.05 gm is required. It must have a provision for a taching wire sling below balance platform for making submerged weighings.

4.2 Underwater Weighing Jig constructed so that the specimen floats against jig ceiling 4" x 4" specimen face in the horizontal position. Jig should trap no air when submerged. Approximate dry weight should be 1500 g. ± 500 g. The heavier the jig, the less influence of disturbances in the fluid.

4.3 Immersion Vessel - For non-volatile fluid testing, any convenient immersion vessel may be used. For this purpose an open top tank capable of holding at least three specimens with the top 4" x 4" facing in the horizontal position and with additional space for the weighing jig is recommended. For volatile fluid testing, any convenient containers which can easily be accommodated in a fume hood, such as cans, can be used. Some provision for restraining the specimens at a two-inch depth must be made. Wire mesh screening is preferred for this purpose, since this minimizes the contact of the top surface of the specimen with any solid object.

4.4 Fume Hood - For testing with volatile fluids a fume hood of sufficient size to accommodate the desired number of test containers and permit convenient operation of the measuring apparatus is to be used.

4.5 Balance Platform - A convenient method for supporting the balance and immersion containers may be used as long as all measurements are made with a two-inch head. It is suggested that a separate container of fluid without a specimen be used to expedite the determination of the jig tare weight. However, if open top tanks are used it may be found more convenient to use a mounting platform placed across the top of the tank to support the balance. A hole in the platform should be provided at an appropriate location to accommodate the wire sling from the balance to the jig.

4.6 Hydrometer - For measuring the specific gravity of the test fluid.

4.7 pH Meter - To determine the pH of the test fluid, in particular that of the artificial sea water.

5. REAGENTS AND MATERIALS

5.1 For the purposes of the test, it is usually desirable to use the liquids with which the flotation materials will come into contact during actual service, such as gasoline, common bilge cleaner and fresh and salt water. For comparative tests with liquids of unknown or doubtful composition, samples of liquid from the same drum or shipment shall be used.

5.1.1 ASTM Reference Fuels - When gasolines are to be encountered in service, the test should be conducted in ASTM reference Fuel B (see ASTM Test Standard D471-42, Section 4 and Table 2).

5.1.2 Any non-fuel test liquid, such as bilge cleaner, shall be used in accordance with the manufacturer's recommended concentrations.

5.1.3 For fresh water tests and dilution purposes a sufficient amount of freshly deaerated distilled water to maintain a two-inch head over specimens and jig at all times shall be used.

5.1.4 Salt Water - For salt water tests any commercial product which simulates sea water, such as a premixed bag of salts, may be used, providing the following properties of sea water are met: salinity of 32 to 34 parts per thousand, pH of 8 ± 0.2 and a specific gravity of 1.03 ± 0.005, 68% of the salinity is due to N_aCl and 5% due to M_gCl_2. Other salts contribute individually to a much smaller degree.

5.2 Gas Barrier Film - A layer of low permeance (polyethylene, saran or equivalent) plastic film covering surface of liquid in open tank tests to retard pickup of air and evaporation is recommended.

6. TEST SPECIMENS

6.1 Three test specimens shall be tested for each sample.

6.2 Test Specimen Size

6.2.1 The recommended test specimen size is 4 inches in width by 4 inches in length by 1 inch in thickness for any material which can be cut to this size from larger stock without substantially changing its original character.

6.2.2 Test specimen size shall be 4 inches in width by 4 inches in length by the actual thickness for materials having less than 1 inch overall thickness. The specimen shall be cut to 1 inch thickness for materials in which the sample stock is more than 1 inch in thickness.

6.3 Test specimens should be machined or sawed from the sample so as to have smooth surfaces without any skins remaining from the molding process. Resulting dust should be blown from specimens.

6.3.1 In most free expansion materials large blow holes may be encountered during preparation of the specimens. These blow holes should not be excised.

7. PROCEDURE

7.1 Weigh each specimen prior to immersion to ± 0.1g and record (W_1).

7.2 Fill immersion vessel with test fluid such that an approximate two-inch head is obtained. Place hold-down mechanism in vessel.

7.3 Measure specific gravity and pH of fluid at 70F ± 5F.

7.4 Place underwater weighing jig attached to balance in immersion vessel such that the top horizontal surface of the jig is two inches below the fluid surface when balanced. Be sure the immersed jig is free of air bubbles. Weigh jig to nearest 0.1g and record. This procedure should be carried out at the beginning and end of each weighing session for an average tare weight (Wj_1, Wj_2).

7.5 Take the specimens one at a time and place them in the jig. Make sure that the specimen is free of clinging air bubbles and weigh immediately. Do not remove any specimens from the vessel after weighing. Record the weight to the nearest 0.1g (W_2).

7.6 After specimens have been weighed under fluid, adjust the fluid level to yield a two-inch head.

7.7 Leave specimens immersed for 720 h. (30 days) while maintaining the two-inch head of test fluid at 70F ±5F. The specimens should not be in contact with one another.

NOTE 6: The following schedule should be followed for specimen weighing: during the first 7 days at least three approximately equally spaced weighings, including the first, should be made. Thereafter weighings may be made once a week at the same time each week until the end of the test period. In addition, the specimens should be weighed on the last test day.

8. CALCULATIONS

8.1 Definition of Symbols

W_1 = Initial dry weight of each specimen in gms.

W_2 = Weight of submerged specimen and jig at each measuring session, in gms.

W_{j1}, W_{j2} = Weight of submerged jig at beginning and end of each measurement session respectively, in gms.

W_j = Average weight of submerged jig at each weighing session, in gms.

B_F = Calculated buoyancy factor, a constant conversion factor different for each specimen in $lb/ft^3/g$

ρ = Density of test fluid at 70F ± 5F, in gms/cm^3

W_{ji} = Weight of immersed jig for initial measurement, in gms

W_{2i} = Weight of submerged specimen and jig for initial measurement, in gms

F = Calculated buoyancy of specimen in lb/ft^3

8.2 Calculate average submerged weight of underwater weighing jig from measured quantities as follows:

$$W_j = \frac{W_{j1}+W_{j2}}{2}$$

Record to nearest 0.1g for each weighing session.

8.3 Calculate buoyancy of each specimen as follows:

$$F = \frac{62.26\rho\ (W_j - W_2)}{(W_{ji} - W_{w1} + W_1)} = B_F\ (W_j - W_2)$$

Record to nearest 0.01 lb/ft^3 for each specimen at each weighting session.

NOTE 7: The constant factor

$$B_F = \frac{62.26p}{(W_{ji} - W_{2i} + W_1)}$$

Is different for each specimen and it may be found most convenient to tabulate these values for use in the buoyant force calculations.

9. REPORT

9.1 The report shall consist of a graph of buoyant force versus time for each flotation materials and test fluid. The data points should appear on the graph as follows:

(1) Highest buoyancy calculated at a given point for any of the three sample specimens.

(2) Lowest buoyancy calculated at a given point for any of the three sample specimens.

(3) Average value of buoyancy calculated at a given point for all three sample specimens.

9.2 The slope of the curve calculated between Day 14 and the end of the test period should also be reported, in units of $lb/ft^3/1000$ hours.

Designation: C 421 - 71

American National Standard Z98.25
American National Standards Institute

Standard Method of Test for

MECHANICAL STABILITY OF PREFORMED THERMAL INSULATION BY TUMBLING[1]

This Standard is issued under the fixed designation C 421; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval.

1. Scope

1.1 This method covers the determination of weight loss of preformed thermal insulation as a result of a combination of abrasion and impact produced by a laboratory tumbling mechanism.

NOTE 1—The values stated in U.S. customary units are to be regarded as the standard.

2. Significance

2.1 Several methods for measuring weight loss by abrasion and impact of preformed thermal insulation have been used to some extent in the past. It is felt that no single test method completely covers all factors involving such forces for different kinds of insulation, but this method is intended to provide a procedure that will give reproducible results for determining the behavior of either block or pipe types of preformed insulations in a tumbling test. It may be used for comparing the weight loss by tumbling before and after a specific treatment of the insulation as agreed upon by the purchaser and the manufacturer.

3. Apparatus

3.1 *Box*—The test apparatus shall be a cubical box of oak wood, having inside dimensions 7½ by 7¾ by 7¾ in. (190 by 197 by 197 mm), mounted rigidly at the center of one 7¾ by 7¾-in. end, so that the axis normal to a face of the box is that of a rotatable horizontal shaft. One side of the box shall be hinged as a door and shall be gasketed to be dust-tight. The box shaft shall be motor driven at a constant speed of 60 ± 2 rpm.

3.2 *Cubes*—Twenty-four room-dry, solid oak, ¾ ± 1/32-in. (19 ± 0.8-mm) cubes shall be provided, to be placed in the box with the test specimens. The specific gravity of the oak cubes shall be approximately 0.65; white oak meets this requirement.

NOTE 2—When the corners of the wood cubes have been worn so that the radius of curvature is greater than 1/16 in. (1.6 mm) or the cubes have become altered so as not to be comparable with new cubes, they shall be discarded and new ones used. A conventional machinist's radius gage may be used for checking the edge wear.

4. Test Specimen

4.1 Saw the specimens with a fine tooth saw (similar to a 16-tooth band saw) to 1 ± 1/16-in. (25.4 ± 1.6-mm) cubes.

4.2 Test twelve cubes at a time for a given condition. Take them from one piece of insulation selected from the lot under test according to the sampling plan for insulations given in ASTM Method C 390, Sampling Preformed Thermal Insulation.[2] When flat insulation has special surfaces due to treatment or due to molding, cut each cube to include such special surface as one face, except that edges and corners of the insulation shall not be used.

4.3 Test one set of specimens, after only the oven-drying treatment described in Section 5 and, if used, one set each after special treatments agreed upon between the purchaser and the manufacturer. Carry out a number of tests to give statistical validity as agreed upon

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[1] This method is under the jurisdiction of ASTM Committee C-16 on Thermal and Cryogenic Insulating Materials and is the direct responsibility of Subcommittee C16.31 on Special Thermal Properties.

Current edition effective Dec. 22, 1971. Originally issued 1958. Replaces C 421 - 61 (1967).

[2] *Annual Book of ASTM Standards*, Part 14.

by the purchaser and the manufacturer.

5. Preparation of Test Specimen

5.1 After cutting the test specimens, oven-dry them between 215 and 250 F (102 and 121 C) to constant weight (Note 3) as determined by a loss in weight for the twelve specimens of less than 0.1 percent in 1 h. If the material may be adversely affected by heating to 215 F (102 C), it shall be dried in a desiccator at a temperature between 130 and 140 F (55 and 60 C) to constant weight as above. The dried weight shall be the reference weight of the test. Weigh on a balance accurate to 0.01 g or 0.1 percent whichever is larger.

NOTE 3—Usually, drying overnight or for 20 to 24 h is required for producing oven-dry material.

5.2 Prior to weighing, bring all specimens to approximately room temperature in a desiccator unless otherwise required.

6. Procedure

6.1 Remove the twelve specimens for a given test condition from the desiccator, place them, together with 24 oak cubes, in the clean test box and secure the lid tightly.

6.2 Rotate the box at 60 ± 2 rpm for two periods, the first 2 min and the second 8 min for a total tumbling time of 10 min. Timing of the periods shall be done to an accuracy of ±3 s. It is preferred that automatic revolution counting be used, such as a predetermined revolution counter that would stop the rotation after 120 revolutions and again after another 480 revolutions. Control of the total number of revolutions at the specified rate is the preferred procedure.

6.3 After each test period, promptly and carefully dump the contents of the test box onto a ⅜-in. (9.5-mm) mesh screen to remove dust and small particles. Count and record the number of pieces that remain on the screen. Carefully remove the 12 largest pieces of insulation from the screen and weigh promptly.

6.4 The second test period shall follow the first with a minimum of delay, and only the 12 largest pieces of insulation remaining on the screen shall be returned to the cleaned box.

6.5 Brush the oak cubes free of dust and adhering insulation after each test period.

7. Report

7.1 The report shall include the following:

7.1.1 Name and description of the material tested,

7.1.2 Date of receipt of the test material,

7.1.3 Dates of test,

7.1.4 Weight of oven-dried test specimens, as the reference weight,

7.1.5 Weight of specimens after each test period,

7.1.6 Weight differences from the reference weight and the corresponding percentages of loss in weight based on the reference weight,

7.1.7 The number of pieces remaining on the screen after the first period of test,

7.1.8 The number of pieces remaining on the screen after the second period of test,

7.1.9 The rate of rotation and the time of the test period, or the number of revolutions and the time of the test period, and

7.1.10 If used, a complete description of the special treatments that the samples or the specimens received before and after the tumbling test.

APPENDIX C
BUOYANCY MATERIALS GASOLINE VAPOR TEST PROCEDURE

1. SCOPE

1.1 This method covers the determination of buoyancy changes in materials used for marine flotation resulting from exposure to a gasoline-saturated atmosphere. The method presented here is based upon and represents a modification of the ASTM Standard Test Method D2842-69.

2. SUMMARY OF METHOD

2.1 The buoyant force of a plastic foam less dense than water is equal to the dry weight of the volume of water it displaces when submerged, less the dry weight of the object. Absorption of any fluid (e.g., gasoline) or physical changes due to the effects of this fluid (swelling, degradation) will cause change in buoyancy. Direct measurements of buoyant force can be utilized to draw conclusions regarding the suitability of these foams for use as flotation material.

3. SIGNIFICANCE

3.1 The purpose of this method is to provide a means of comparing relative buoyancy change tendencies of different flotation materials. It is intended for use in the evaluation of the flotation materials for marine flotation application.

3.2 Buoyancy testing is subject to several variables which, if not considered, may cause insufficient agreement among various testers. Attempts have been made in the formulation of this method to take the most serious of the possible sources of error into account.

NOTE 1: The increase in volume which may occur is countered by basing all buoyancy calculations on the initial volume of the specimen. This method has been chosen because all flotation material requirements for a desired buoyancy are designed from the dry volume of the material by the boat manufacturer per paragraph 183.67 of CFR 183.

NOTE 2: The problem of air bubbles clinging to the specimens and affecting the various measurements is minimized by specifying deaerated distilled water and appropriate methods for removing clinging air bubbles at each measuring session.

NOTE 3: Difficulties involved in calculating the specimen volume based upon direct measurement of the dimensions are eliminated by determining the volume of each specimen by a fluid displacement method immediately after immersion.

4. APPARATUS

4.1 A balance capable of weighing up to 2500 gm to 0.1 ± 0.05 gm is required. It must have a provision for attaching wire sling below balance platform for making submerged weighings.

4.2 Underwater Weighing Jig - constructed so that the specimen floats against jig ceiling with 4" x 4" specimen face in the horizontal position. The jig should trap no air when submerged. Approximate dry weight should be 1500 g ± 500 g. (The heavier the jig, the less the influence of disturbances in the fluid.)

4.3 Buoyancy Vessel. Any convenient vessel, such as an open-top tank, may be used.

4.4 Balance Platform. Any convenient method for supporting the balance and jig may be used as long as all measurements are made with a two-inch head of water.

4.5 Hydrometer. For measuring the specific gravity of water and the reference fuel.

4.6 Sample Environment. Any convenient container may be used as long as the sample environment is saturated with reference fuel vapor maintained at the specified temperature and 1 atm. Samples should be at least .50 inches apart. The flammable nature of gasoline vapor should be considered when designing the container.

5. REAGENTS AND MATERIALS

5.1 For the purposes of the test, it is desirable to use gasoline to saturate the sample environment and water to determine buoyancy.

5.1.1 ASTM Reference Fuel. In place of gasoline this test is to be conducted in ASTM reference fuel B. (See ASTM Test Standard D471-42, Section 4 and Table 2.) Samples of this liquid from the same drum shall be used.

5.1.2 For the buoyancy tests, a sufficient amount of freshly deaerated distilled water at 70°F to maintain a two-inch head over specimens and jig shall be used.

6. TEST SPECIMENS

6.1 Thirty-six samples of each plastic foam shall be tested.

6.2 The test specimen size is 4 inches in width by 4 inches in length by 1 inch in thickness. Test specimens should be machined or sawed from the sample so as to have smooth surfaces without any skins remaining from the molding process. Resulting dust should be blown from specimens.

6.2.1 In most free expansion materials large blow holes may be encountered during preparation of the specimens. These should not be used.

7. TESTING PROCEDURE

7.1 Weigh each specimen to ± 0.1g and record (W_1).

7.2 Measure and record buoyancy of each specimen as described in Section 8.

7.3 Store three control samples in an air only atmosphere maintained at the specified saturation temperature and one atmosphere.

7.4 Place 30 samples in an atmosphere saturated with the vapor of the reference fuel maintained at the specified temperature and one atmosphere. Record the specific gravity of the reference fuel.

7.5 Choose a length of time which will permit a complete determination of the effects of the fuel vapor on the specimen. Divide this into 10 equal increments. At the end of each of these increments withdraw three samples from the saturated atmosphere. Measure and record the following: time of exposure, buoyancy (per Section 8), and specific gravity of reference fuel.

7.6 Polyurethane, Autofroth

7.4.1 Thirty-six samples, 4" x 4" x 1", polyurethane, 2 lb/ft^3, Autofroth

7.4.2 thru 2.4.7 - Same as 7.3.2 thru 7.3.7, respectively

8. BUOYANCY PROCEDURE

8.1 Fill buoyancy vessel with water such that an approximate two-inch head is obtained.

8.2 Measure specific gravity of water (70°F).

8.3 Place underwater weighing jig attached to balance in buoyancy vessel such that the top horizontal surface of the jig is two inches below the surface when balanced. Be sure the immersed jig is free of air bubbles. Weigh jig to nearest 0.1g and record. This procedure should be carried out at the beginning and end of each weighing session for an average tare weight (Wj_1, Wj_2).

8.4 Take the specimens one at a time and place them in the vessel. Make sure that the specimen is free of clinging air bubbles and weigh immediately. Record the weight to the nearest 0.1g (W_2).

9. CALCULATIONS

9.1 Definition of Symbols

W_1 = Initial dry weight of each specimen in gms

W_2 = Weight of submerged specimen at each measuring session, in gms.

Wj_1, Wj_2 - Weight of submerged jig at beginning and end of each measurement session respectively, in gms.

Wj = Average weight of submerged jig at each weighing session, in gms.

B_F = Calculated buoyancy factor, a constant conversion factor different for each specimen in lb/ft^3/g

p = Density of test fluid at 70F ± 5F, in gms/cm^3

Wj_i = Weight of immersed jig for initial measurement, in gms

W_{2i} = Weight of submerged specimen for initial measurement, in gms

F = Calculated buoyancy of specimen in lb/ft^3

9.2 Calculate average submerged weight of underwater weighing jig from measured quantities as follows:

$$W_j = \frac{W_{j1} + W_{j2}}{2}$$

Record to nearest 0.1g for each weighing session.

9.3 Calculate buoyancy of each specimen as follows:

$$F = \frac{62.26p}{(W_{ji} - W_{2i} + W_1)} \quad (W_j - W_2) = B_F \ (W_j - W_2)$$

Record to nearest 0.01 lb/ft^3 for each specimen at each weighing session.

NOTE 4: The constant factor

$$B_F = \frac{62.26p}{(W_{ji} - W_{2i} + W_1)}$$

is different for each specimen and it may be found most convenient to tabulate these values for use in the buoyant force calculations.

10. REPORT

10.1 The report shall consist of a graph of buoyant force versus time in days for each flotation material. The data points should appear on the graph as follows:

(1)
(3)
(2)

(1) Highest buoyancy calculated at a given point for any of the three sample specimens.

(2) Lowest buoyancy calculated at a given point for any of the three sample specimens.

(3) Average value of buoyancy calculated at a given point for all three sample specimens.

10.2 Tables of initial sample weight, buoyancy factor, sample buoyancy with time, average buoyancy with time and specific gravity of reference fuel and water with time, as well as an explanation of procedure and construction of apparatus should be reported.

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