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Research Report

IMMERSION TESTING OF V54 MAINTENANCE PAINT SYSTEMS

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IMMERSION TESTING OF V54 MAINTENANCE PAINT SYSTEMS

INTRODUCTION:

In order to hasten and augment acceptance of V54 maintenance paint systems it is necessary that the resistance of subject systems to long-term immersion in a wide variety of liquids be known. Successful performance would allow wider V54 penetration into the Marine field (cargo tank interiors, ballast tanks, deck paints, dock equipment, etc.); Petroleum field (storage tanks, process equipment, loading racks, piping, etc.); Chemical field (process and storage equipment for solvent, monomers, and intermediates, loading racks, tank cars, piping, etc.); and Maintenance Finishing field (water storage tanks, locks, dams, bridges, gas holders, etc.).

OBJECTIVES:

To determine resistance of V54 Maintenance Paint systems to long-term immersion in a wide range of solvents, water solutions, acids and alkali, edible oils, crude oils, etc.

SUMMARY AND CONCLUSIONS:

It should be noted that the main objective was to determine ultimate resistance properties which we believe could be accomplished by artificially aging all paint systems.

I. V54 systems will not be generally useful for tank interiors. Specific instances will undoubtedly exist where satisfactory performance can be expected if the coating is thoroughly cured. Tests indicate this cure may be obtained only at elevated temperatures or after extremely long periods at lower temperatures.

II. Thoroughly cured (baked) V54 coatings are better than alkyd, phenolic, and epon ester coatings, about equal to vinyl and poorer than catalyzed epoxy, urethane and inorganic (Dimetcote*) coatings for resistance to organic solvents and chemicals.

III. Air dried V54 films are slow in curing to a resistant state. Eight weeks cure at 77°F. - 50% R.H. has not produced an acceptable degree of resistance in V54 Red Lead Primer (7067-5001), to the more active solvents. In contrast catalyzed epoxy has a relatively high degree of resistance after a short drying period (one day at room temperature).

*-Inorganic Zinc Silicate Coating - Amercoat Corp.

Although a urethane system gave erratic results a much faster rate of cure was indicated than for the V54 primer.

IV. Standard topcoats perform no better (and in some instances are inferior) over V54 primer than over their own recommended primer.

V. V54 coatings are poorer than any of the controls tested for resistance to water solutions because of their tendency to soften and/or dissolve in alkaline solutions. This softening is a surface phenomenon which occurs quickly and is worse on air dried samples.

VII. The superiority of V54 coatings in resistance properties to alkyd systems makes them useful as exterior coatings for solvent and chemical tanks where only occasional spills are encountered.

ACTION TAKEN OR PROPOSED:

Any recommendation for the use of V54 systems where solvent resistance is required will have to be answered on an individual basis as is the practice in the maintenance paint field. When an improved product is developed additional immersion testing on a smaller scale will be required and the program will be designed to take advantage of the developed background.

PATENT SITUATION:

The work has not led to any patentable discoveries.

PUBLICATION PROPOSAL:

No publication of the data of this report is currently planned. However, when the work is complete, bulletinization of the results may be useful to Sales.

DISCUSSION:

General

At present there is no universal coating system that satisfies the requirements for resistance to the wide range of materials handled, shipped, stored or processed in the Marine, Petroleum and Chemical Processing industries. Catalyzed epoxy and inorganic systems have a high degree of resistance but have other shortcomings. Dimetcote, a widely used coating, is a three package system with a mixed pot life of 4 hours, requires scrupulous surface preparation, cannot be applied in thick films (over 5 mils), costs $22/gal. with a coverage rate of 225 to 300 ft.^{2}/gal., must be chemically cured for 24 hours or heat cured at 350°F, must be cured between coats if 2 coats are required and must be kept moisturefree for 24 hours after curing. A four page instruction booklet accompanies each gallon of paint.

It is the practice in the field to make recommendations on an individual basis - in some cases a field trial in the customer's plant being required. In some instances the customer must resort to exotic and expensive coatings such as porcelain, stainless steel and other alloys, Saran* sheeting, etc. to obtain adequate resistance.

The results obtained in this study in no way detract from the usefulness of V54 systems as exterior coatings but rather solidifies their advantage over systems such as alkyd, phenolics, and epon esters.

Organic Chemical and Solvent Resistance

Results after 12 weeks immersion are presented in Table I. The principal or initial cause of failure is listed although more than one type of failure frequently occurred with the same sample. Samples were inspected after being immersed one day, weekly thereafter until six weeks and then every other week. Failure noted as being after 14 days, therefore, indicates that the failure occurred between 7 and 14 days.

When some softening of topcoats by solvents occurred this was not considered a failure if no dissolution was noted and if the topcoats recovered hardness within one day.

*-Dow Chemical Company

As previously noted V54 coatings are generally better than alkyd, phenolic, and epon ester, about equal to vinyl and are inferior to catalyzed epoxy, urethane and inorganic coatings. This is, of course, a general statement because of the variation of failure in different classes of solvents between the coatings. As expected the alkyd control had the least resistance while the epoxy and inorganic coatings performed best. Several chemicals produced no failures, while several were quite severe, especially the primary amines, where all coatings failed.

Percent Resistance (See Table I)

In an attempt to give an overall rating to the V54 systems relative to the various controls a formula was devised which takes into account the number of failures as well as the immersion time to failure. This formula is useful, of course, only for giving the average rating of the various systems against each other in this group of test solutions. The % resistance figure cannot be used in predicting resistance to other liquids, or even to individual members of the present group of test liquids.

$$\% \text{ Resistance} = \frac{84 \text{ days} \times 34 \text{ solutions} - \text{days failed}}{84 \text{ days} \times 34 \text{ solutions}} \times 100$$

No failure equals 100% Resistance

Effect of Air Dry on Resistance

Oven cured V54 Red Lead primer (7067-5001) showed no failure after 16 weeks immersion in butyl acetate (BA) and methyl isobutyl ketone (MIBK) and failed by lifting some time between 1 and 2 weeks in ethyl acrylate monomer (EA). These three solvents were selected as a basis for determining the aging period required at room temperature to develop solvent resistance of the Red Lead primer. After 8 weeks cure at 77°F - 50% R.H. the primer has not developed an acceptable degree of resistance, the samples failing after 1 day in BA and EA and 2 days in MIBK. High spot tests indicate that air dried (10 days at 77°F - 50% R.H.) primer is softened more by alkaline water solution than oven-cured primer. A catalyzed epoxy coating air-dried one day at room temperature has not failed after 12 weeks immersion in BA, EA, MIBK as well as in acetone and ethyl acetate. Fresh epoxy failed more rapidly in acetic acid and monoethanolamine than did the oven cured epoxy sample.

Results with urethane topcoats were erratic probably due to lack of control of curing environment. A much faster rate of cure, however, was indicated for urethanes as compared with V54 primer when both were cured in the Constant Temperature Room.

Vinyls cure rapidly but even baked films have poor resistance to strong solvents.

Effect of Temperature of Immersion Solvent

Generally, weak systems fail more rapidly at higher immersion temperature (120°F). The more resistant finishes were somewhat softened but did not fail by lifting or blistering and regained hardness quickly after removal from the solvents..

More tests are planned to further define time required to attain resistance as well as the effect on resistance of immersion temperature with proposed (fast drying) systems.

Water Solutions

Results after 10 weeks immersion are presented in Table II. V54 systems are softened and/or dissolved in alkaline solutions. At high pH (9.6) the V54 Tank White (7025-5001) flakes away and at lower pH (6.1) is softened. The Red Lead primer exhibits a surface softening at pH 6.1, pH 7.7 and pH 9.6. This softening is apparent by the ease with which the surface can be removed by rubbing. Reimmersion (after removal of the surface by rubbing) produces the same softening of the new surface. This softening occurs quickly both on initial immersion and reimmersion. None of the controls exhibit softening to any extent except in NaOH or H_2SO_4. Air dried V54 Red Lead primer was softened more readily by buffer solutions at pH 6 and 9.6 than were cured samples.

EXPERIMENTAL DETAILS:

I. Substrate

Hot rolled steel rods (4" x 3/8")

II. Metal Treatment

The rods were "sandblasted" by rolling overnight in a steel ball mill charged with sand and toluene. The rods were then "pickled" for a short period in dilute sulfuric acid/triethyl amine solution, washed with water, rinsed with acetone, and stored in a desiccator until needed.

III. Sample Preparation

Primers were applied by dipping and air dried overnight. Topcoats (where used) were also applied by dipping and air dried overnight. Where two coats were required an overnight air dry was employed between coats. All coatings were applied at their recommended thicknesses.

IV. Aging Period

Except where noted all samples were aged one week at 150°F. All samples were held in the laboratory until sample preparation was completed and all were immersed in each solution at the same time.

V. Systems Tested (See Table I)

1.	V54 Red Lead Primer	7067-5001
2.	V54 Zinc Dust Primer	7067-5004
3.	V54 Tank White	7025-5001
4.	Alkyd Primer	67-746
5.	Epoxy Primer	825-8031
6.	Phenolic Primer	373-763
7.	Phenolic Primer	373-759
8.	Vinyl Wash Primer	818-012
9.	Vinyl Primer	818-011
10.	Vinyl Intermediate	818-003
11.	Alkyd Enamel	28-5049
12.	Catalyzed Epoxy Enamel	823-8021
13.	Phenolic Enamel	353-922
14.	Vinyl Enamel	802-006
15.	Urethane Enamels 813-906	and 813-901
16.	Epon Ester Enamel	840-66951
17.	Dimetcote (Amercoat Corp.)	

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Primer	Topcoat	Acetone	MIBK	Ethyl Acetate	Butyl Acetate	Butanol	Methanol	Benzol	Xylene	Monoethanolamine	Triethanolamine	Monobutylamine	Tributylamine	Castor Oil	Olive Oil (Edible)	Tall Oil F.A.	Linseed Oil F.A.	Dibutyl Phthalate
V54 Red Lead	None	L_1		L_{28}			·	L_{14}		D_1	D_{14}	$L_{1/2}$						
"	V54 White	L_7		B_{24}		·	B_{14}			$D_{1/2}$	D_{14}	$D_{1/2}$						
"	Alkyd	$L_{1/4}$	L_1	$L_{1/2}$	L_1	·	L_{14}	L_1	L_7	$D_{1/2}$	B_{14}	$D_{1/2}$					B_{24}	
"	Epoxy	L_7		B_{14}		·		L_{14}		L_7		$L_{1/2}$				L_{21}	L_{28}	
"	Phenolic	L_1	L_{14}	B_{14}	·		·	L_7	D_{14}	$D_{1/2}$	D_{70}	$D_{1/2}$	·					
"	Urethane	L_1		L_7	B_{28}		L_7	L_7		L_1		$L_{1/2}$						
"	Vinyl	$D_{1/2}$	$D_{1/2}$	$D_{1/2}$	D_1		·	B_{14}		L_{14}		$D_{1/2}$						D_1
V54 Zn Dust	None	L_1		B_{14}				B_{14}		D_1	D_{14}	$L_{1/2}$				D_{14}	D_{21}	
"	V54 White	L_7		B_{70}		·	B_{14}			$D_{1/2}$	D_{14}	$D_{1/2}$						
"	Alkyd	$L_{1/2}$	L_1	$L_{1/2}$	L_1	L_7	L_{14}	L_1	$L_{1/2}$	$L_{1/2}$	D_{42}	$D_{1/2}$	L_{56}					·
"	Epoxy	L_7		B_{14}	·		B_{28}	L_{14}		L_7		$L_{1/2}$				L_7	L_7	
"	Phenolic	L_1	L_{14}	L_7	L_1		B_{14}	$L_{1/2}$	L_7	$D_{1/2}$	D_{70}	$D_{1/2}$	·			L_{14}	L_{21}	
"	Urethane	L_1		L_{14}			L_1	·		L_1		$L_{1/2}$				L_{56}		
"	Vinyl	$D_{1/2}$	$D_{1/2}$	$D_{1/2}$	L_7			·		L_{28}		$D_{1/2}$						D_1
None	V54 White	L_1		·			B_7	·		$D_{1/2}$	D_{14}	$D_{1/2}$						
Alkyd	Alkyd	$L_{1/2}$	$L_{1/2}$	$L_{1/2}$	L_1	L_7	L_7	L_1	$L_{1/2}$	$D_{1/2}$	D_{42}	$L_{1/2}$	L_{42}			B_{28}	B_{14}	B_{14}
Epoxy	Epoxy									L_{56}		$L_{1/2}$				L_{21}	L_{28}	
Phenolic	Phenolic	$L_{1/2}$	$L_{1/2}$	$L_{1/2}$	L_1		·	$L_{1/2}$	$L_{1/2}$	$D_{1/2}$	D_{14}	$L_{1/2}$						
Epoxy	Urethane									L_7		$L_{1/2}$				B_{70}		
Vinyl	Vinyl	$D_{1/2}$	$D_{1/2}$	$D_{1/2}$	$D_{1/2}$		$_{7}B$			·		$D_{1/2}$						D_7
Phenolic	Epon Ester	$D_{1/2}$	$L_{1/2}$	$L_{1/2}$	L_1	L_{14}	B_{24}	$L_{1/2}$	$L_{1/2}$	L_1		$D_{1/2}$	L_{70}				B_{70}	B_{28}
Dimetcote	None						·			D_{14}		D_{14}	D_{14}			L_{21}	L_{28}	

Primer	Topcoat	CCl_4	Perclene	Triclene	Rhoplex AC33	Glycerine	Ethylene Glycol	Tide Solution	Cresylic Acid (100%)	Cresylic Acid (10%)	Acetic Acid (100%)	Acetic Acid (10%)	Styrene	Ethyl Acrylate	Esso Regular	Esso Golden Extra	Crude Oil-Lo Sulfur	Crude Oil-Hi S	No. F	•
V54 Red Lead	None			L_1	D_7			D_1	B_7	L_{28}	L_7	L_{21}	L_{21}	L_{14}					15	61
"	V54 White			B_{42}	D_7			D_1	L_{28}		L_7	B_{14}	L_{21}	L_{14}					14	68
"	Alkyd	L_7	L_{14}	$L_{1/2}$	B_{14}			D_{70}	L_1	L_1	$L_{1/2}$	B_{14}	$L_{1/2}$	$L_{1/2}$	·				22	
"	Epoxy			L_1	·				L_1	L_1	$L_{1/2}$	B_{21}	L_{14}	L_{14}					14	
"	Phenolic	D_{28}		L_1	B_{28}				L_1	L_{21}	L_1	B_{14}	L_{14}	$L_{1/2}$					17	
"	Urethane			L_1	B_{14}				L_1	L_7	$L_{1/2}$	B_{14}	L_{14}	L_7					15	
"	Vinyl			L_7	·				L_{14}	L_{28}	B_1	·	B_1	$L_{1/2}$					14	
V54 Zn Dust	None			B_7	D_7			D_1	L_1	L_7	L_1	B_{14}	L_{14}	B_{21}					17	55
"	V54 White			B_{42}	D_7			D_1	L_{21}	L_{21}	L_1	B_{14}	L_{14}	B_{21}					15	64
"	Alkyd	L_1	L_1	$L_{1/2}$	B_{14}			L_{42}	L_1	L_1	$L_{1/2}$	B_{14}	$L_{1/2}$	$L_{1/2}$	B_{28}	B_{14}			25	
"	Epoxy			L_1	·				L_1	L_1	$L_{1/2}$	B_{14}	L_7	B_{21}					15	
"	Phenolic	L_1	L_7	$L_{1/2}$	B_{28}			B_{70}	$L_{1/2}$	$L_{1/2}$	$L_{1/2}$	B_{14}	$L_{1/2}$	L_7					23	
"	Urethane			$L_{1/2}$	B_{14}				$L_{1/2}$	$L_{1/2}$	$L_{1/2}$	B_{14}	L_{14}	L_{21}					14	
"	Vinyl			·	·			·	L_7	L_{14}	L_1	·	B_1	$D_{1/2}$					12	
None	V54 White			B_7	D_7			D_1	L_{28}	L_{70}	L_7	B_{21}	L_{21}	L_{21}					14	66
Alkyd	Alkyd	L_1	L_1	$L_{1/2}$	B_{28}			B_{70}	L_1	L_1	$L_{1/2}$	B_{14}	$L_{1/2}$	$L_{1/2}$	L_7	L_1			28	33
Epoxy	Epoxy								L_7	·	$L_{1/2}$	B_{21}							7	84
Phenolic	Phenolic	$L_{1/2}$	$L_{1/2}$	$L_{1/2}$				·	L_1	L_7	L_1	B_{21}	$L_{1/2}$	$L_{1/2}$		L_1			19	48
Epoxy	Urethane							·	L_1	L_7	$L_{1/2}$	B_{21}							7	83
Vinyl	Vinyl			·					L_7	·	L_7	·	$B_{1/2}$	$D_{1/2}$					11	71
Phenolic	Epon Ester	$L_{1/2}$	$L_{1/2}$	$L_{1/2}$					L_1	L_1	L_1	B_{28}	$L_{1/2}$	$L_{1/2}$	·	·			22	47
Dimetcote	None						·	·			$D_{1/2}$	D·							7	82

TABLE I

Chemical Resistance of Cured Maintenance Paint Systems
(All Systems Aged One Week at 150°F.)

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Table II
Resistance of Cured* Maintenance Paint Systems-Water Solutions

Primer	Topcoat	Tide Solution	Rhoplex AC33	10% Acetic Acid	50% NaOH	5% NaOH	50% H_2SO_4	5% H_2SO_4	Synthetic Sea Water	Tap Water	Water PH = 9.6	Water PH = 7.7	Water PH = 6.1	Water PH = 4.4
V54 Red Lead	None	D 1	D 1	B 21	S 21	D <1/6	BL 14				S 7	S 14	S 7	
"	V54 White	D 1	D 1	B 14	S 21	D <1/6	B 7	·	·	·	SD 7	S 7	S 7	·
"	Alkyd	·	B 14	B 14	·	D <1/6	B 7	B 42		·	·	·		·
"	Epoxy		·	B 21			L 42							
"	Phenolic	·	B 56	B 14	·	D 1	L 42			·	·	·	·	
"	Urethane		B 14	B 14		·	L 7							·
"	Vinyl		·	·	·		L 42					·	·	
V54 Zn Dust	None	D 1	D 1	B 14	D 1/6	D <1/6	L 1			·	S 21	S 7	S 1	
"	V54 White	D 1	D 1	B 14	S 21	D <1/6	L 1	B 21	·	·	SD 14	S 7	S 7	·
"	Alkyd	L 42	B 14	B 15	·	D <1/6	B 21	B 7		·				
"	Epoxy		·	B 14			BL 14							
"	Phenolic	·	B 28	B 14	·	D 1	L 42	B 7	·					
"	Urethane		B 14	B 14		·	L 1			B 42	B 56	B 56	B 56	B 56
"	Vinyl	·	·	·	·		L 28			·		·	·	
None	V54 White	D 1	D 1	B 21	S 21	D <1/6	B 7	·	·	·	SD 1	S 14	S 21	·
Alkyd	Alkyd	·	B 28	B 14		D <1/6	B 14	B 7		·	·	·		·
Epoxy	Epoxy			B 21			·							
Phenolic	Phenolic	·		B 21	·	D 1								
Epoxy	Urethane			B 21		·	L 7							
Vinyl	Vinyl			·	·	·	·	L 42						
Phenolic	Epon Ester			B 28		B 7								
Dimetcote	None	·		D 7	D <1/6	D <1/6	D <1/6	D <1/6	D 1	D 1			D 7	D 7

Results 10 Weeks Immersion

D - Dissolved

B - Blistered

L = Lifted

S - Softened

Number Indicates Days To Failure

· = Questionable

* All Systems Aged One Week at 150°F.