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Marshall Laboratory

Research Report

V54-MAINTENANCE PRIMERS PROGRESS REPORT

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ABSTRACT

This report describes the work done to correct the deficiencies in the V54 primers which were uncovered during the field test program. This report also contains a list of the V54 field test installations which were inspected by Sales and Research Personnel in April, 1962.

SYMBOLS AND ABBREVIATIONS

V54-OP	-	o-phthalate ester of 2-vinyl-1,3-dioxolane-4-n-butanol
V54-I	-	Itaconate ester of 2-vinyl-1,3-dioxolane-4-n-butanol
V54-O	-	Oleate ester of 2-vinyl-1,3-dioxolane-4-n-butanol
V54-Lo	-	Linoleate ester of 2-vinyl-1,3-dioxolane-4-n-butanol
RC-384	-	A dehydrated castor oil alkyd
THF-MA	-	Tetrahydrofurfurylmethacrylate
THF-IB	-	Tetrahydrofurfurylisobutyrate
TMG	-	Tetramethylguanidine

V54 MAINTENANCE PRIMERS

INTRODUCTION:

The oldest V54 field tests are now over three and one-half years old. Judging the results to date specifically for corrosion resistance, and restricting ourselves to the area of adequately controlled tests, the primers are performing satisfactorily. We have no absolute basis on which to judge the uncontrolled tests where failures were observed.

The field inspections have uncovered some deficiencies which must be corrected before the V54 primers can be commercialized.

The principal deficiencies were: (1) Poor topcoat adhesion, particularly "Dulux"* Hi-Build Tank White 28-5049; Phenolic Aluminum 354-751; and some vinyls; (2) Poor adhesion of the primers on shop-primed structural steel; this is believed to be due to the presence of oily (hydrocarbon) contamination; (3) The primer was judged to be too hard, based on experience with "Dulux" primers, although no direct evidence of failure was found which could be traced to hardness as such; (4) Finally the drying time characteristics of the V54 primers were judged to be too slow for widespread commercial acceptance in the maintenance paint market.

This report describes the work carried out to correct the deficiencies without sacrificing any of our corrosion resistance or good application properties.

OBJECTIVES:

The objectives of this work were to correct the deficiencies of the V54 primers so that the primers would have a commercially acceptable balance of properties. Specifically the following objectives were set as product goals.

1. Reformulate the V54 primers to obtain adhesion (initial and retained) of "Dulux" 28-5049, Phenolic Aluminum 354-751, at levels which are at least equivalent to 67-Line controls.

2. Improve the adhesion of V54 primers to unweathered, oily, scale-bearing metal to a level equal to 67-Line primers.

3. Improve the hardness/flexibility balance of the V54 primers so that they are comparable to 67-Line controls.

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4. Improve the drying time/wrinkle balance of the V54 primers to obtain minimum wrinkle resistant film thicknesses of 7.0 dry mils and maximum drying times of 16 hours at 40°F. The minimum wrinkle resistant film thickness must be applicable up to 130°F and under all conditions of relative humidity.

SUMMARY AND CONCLUSIONS:

We have modified the V54 maintenance primer vehicle (V54-OP/V54-I, 1:1) by replacing part of the V54-OP with a blend of dehydrated castor oil alkyd (RC-384) and V54 oleate to obtain improved oily metal adhesion and improved adhesion of "Dulux" 28-5049 topcoats to the primer.

The new vehicle also contains a substantial amount of tetrahydrofurfuryl methacrylate for an improved dry/wrinkle balance and a new combination of driers based on cobalt, zirconium and tetramethyl guanidine. The new vehicle contains V54-OP/V54-I/V54-O/RC-384/THF-MA in the following ratio: (24/32/8/20/16).

The new primers are equal to the old primers in wetting and application properties but have much superior drying rates, improved adhesion to oily mill scale and improved adhesion of "Dulux" (28-5049) topcoats.

Initial laboratory screening indicates that we have not hurt the corrosion resistance of the primers at operating film thicknesses, 4-5 mils, but below that our salt spray resistance is poorer than that of the old formula.

We are starting small scale field tests, in Company plants, to confirm the application properties and drying characteristics that we obtained in the laboratory, because we do not have good correlation between laboratory tests (e.g., sun wrinkling) and field performance.

ACTION TAKEN OR PROPOSED:

Work is continuing to characterize the new vehicle in terms of optimum pigmentation (corrosion-inhibitive), mechanical properties (initial and aged), adhesion under topcoats and over contaminated substrates, storage characteristics and corrosion resistance.

PATENT SITUATION:

The paint compositions discussed in this report are covered generally by U.S. Patent 3,010,924 (to Du Pont). The V54-I/V54-OP are covered by U.S. Patent 3,010,923 (to Du Pont). V54-Oleate is the subject of patent application FFD-1732. THF-MA is disclosed generically in U.S. Patent 3,010,924 (to Du Pont) as: "the presence of polymerizable monomers in V54 esters which are used as metal protective paints". Zirco driers are the subject of patent application FFD-1744. Tetramethyl guanidine is the subject of patent application FFD-1730 and cobalt butyl phthalate is covered by U.S. Patent 3,010,945 (to Du Pont).

PUBLICATION STATUS:

The subject matter of this report is not suitable for publication at this time.

ACKNOWLEDGEMENTS:

The writer wishes to acknowledge the helpful discussions with L. A. Henderson and J. G. McNally. R. W. LaBerge suggested the use of RC-384 for promoting oily metal adhesion.

DISCUSSION:

The field test results (Table I, Appendix) have shown that the V54 primers (7067-5001 and 7067-5002), which are based on a 1:1 blend of V54-OP/V54-I, have an acceptable level of corrosion resistance (Table II, Appendix) under controlled field conditions, but they are deficient in other properties. The three properties which have to be corrected before the V54 primers can be commercialized are: (1) more foolproof topcoat adhesion; (2) greatly improved adhesion of the primers over contaminated mill-scale, such as found under shop-priming conditions, and (3) improved drying characteristics under field conditions.

The drying problem has been studied by McNally (1). He found that a combination of cobalt, Zirco, TMG and THF-MA would, when added to V54-OP/V54-I primer formulations, provide a balance of wrinkle resistance and dry that was better than anything then available.

The writer, following the suggestion of R. W. LaBerge, found that incorporating RC-384 into V54 primers (7067-5001) would bring about an improvement in oily metal adhesion.

The problem was to combine the drying system of McNally with the adhesion promoting system based on RC-384 and to determine whether the beneficial properties of both systems would remain intact or be mutually harmful. Also it was necessary to determine what effects these compositional changes would have on topcoat adhesion, corrosion resistance, recoat time, application properties, mechanical properties, package stability and wetting characteristics.

Adhesion to Oily Mill-Scale (N.B. 7534-72, 73)

Three field tests involving V54 shop primed steel have shown early failure. Two of these were known to have oil contamination on the metal at the time of painting. A fourth test which was over oil-free, blue scale is not failing. These results, coupled with the known incompatibility of V54-OP/V54-I with aliphatic hydrocarbons led us to check the performance of V54 primers and controls over clean and contaminated (cutting oils or lubricating oils) unweathered, smooth, blue, mill-scale. The scale was degreased with xylene and coated lightly with a "cutting" oil. The V54 primer had no adhesion to scale which had been oiled but had equal adhesion to 67-Line controls over oil free scale. The V54 (7067-5001) could be stripped cleanly from the oiled areas by using an adhesive tape-test, but it could not be stripped by this method over oil-free scale.

We found that by replacing 5-25% (volume) of the V54-OP in the primer vehicle with V54 oleate, V54-linoleate or V54-eleostearate we could make the primers compatible with aliphatic hydrocarbons. However, the use of these levels of mono esters did not give us a level of oily metal adhesion that was equal to the controls.

We also found that by replacing 5-25% volume of the V54-OP with a dehydrated castor oil alkyd we could obtain a level of adhesion equal to "Dulux" 67-Line primers over oily mill scale bearing metal. These results over oily, scale bearing metal were confirmed both initially and after oven aging the cured primed panels for one month at 150°F.

Fast Dry-Wrinkle Resistance (N.B. 7534-91)

McNally established that we had to use at least 15% THF-MA to replace V54-OP in the primers to obtain fast dry and wrinkle resistance.

To check the effect of THF-MA on primer formulations we prepared paints based on THF-MA and THF-IB and various combinations of cobalt, Zirco and TMG. The THF-IB was used to evaluate the effect of a model compound which had similar solvent properties, boiling point and peroxidizability, but which lacked the polymerizable double bond of THF-MA, on drying time and wrinkle resistance.

The results are tabulated as follows:

TABLE I

THE EFFECT OF THF-MA ON DRYING TIME AND WRINKLE RESISTANCE

Vehicle Components[1]				Driers[3]	Drying Time[2] (Zapon #2) (Hours)	Maximum Wrinkle Free Film Thickness (Mils)
V54-OP/V54-I/THF-MA/THF-IB				Co^{++}/Zirco/TMG		
50	50	0	0	0.075/0/0	8 - 12	10.0
50	50	0	0	0.150/0/0.50	6	5.0
50	50	0	0	0.150/0.20/0.50	7	5.0
42	42	16	0	0.100/0.20/0.50	3	7.0
42	42	16	0	0.100/0/0.50	4	7.0
42	42	16	0	0.100/0.20/0	5	7.0
42	42	16	0	0.150/0.20/0.50	3	5.0
42	42	0	16	0.100/0.20/0.50	7	7.0
42	42	0	16	0.100/0/0.50	8	7.0
42	42	0	16	0.100/0.20/0	8	7.0
42	42	0	16	0.150/0.20/0.50	7	7.0

(1) All paints at 30% PVC (Pb_3O_4: Iron Oxide, 1:5)

(2) Drying time data taken at 77°F and 50% R.H.

(3) Percent based on vehicle solids.

These data show that a model compound which has similar peroxidizing characteristics, solvent power and volatility to THF-MA will improve the wrinkle resistance of the primer, but that it will not speed up the dry rate. Also these results indicate that there is an interaction between cobalt, Zirco and TMG which cannot be obtained without the combination of all three.

Modification of V54 Primers with THF-MA and RC-384 (7534-98)

Primers were prepared from a 7067-5001 mill base using THF-MA, RC-384 and cobalt, Zirco and TMG drier systems. From these studies we established that it was possible to obtain the oily metal adhesive characteristics of the RC-384 and the rapid cure and wrinkle-resistance of the THF-MA modified systems in the same formula.

The data from these studies are given below:

TABLE II

OILY METAL ADHESION OF MODIFIED V54 PRIMERS

Vehicle Components						Oily Metal Adhesion[1]	Dry[3] Time	Wrinkle Resistance
V54-OP/V54-I/V54-O/RC-384/THF-MA/V54-LO							(Hrs.)	(Mils)
50	50	0	0	0	0	Very poor[2]	8	7[4]
42	42	0	0	16	0	Very poor	3	7
42	42	0	0	0	16	Fair	8	7
25	50	25	0	0	0	Fair	8	7
25	50	0	25	0	0	Good	8	4
25	50	0	0	0	25	Fair	8	7
25	50	5	20	0	0	Good	8	4
25	35	0	24	16	0	Good	5	7
25	35	24	0	16	0	Fair	5	7
25	35	0	0	16	24	Fair	5	7
24	32	8	20	16	0	Good	5	7

1. Panels contained 0.5 mil of "Rigid" cutting oil.
2. Ratings based on adhesive tape test of scored area.
3. Dry time at 77°F and 50% R.H.
4. All paints at 30% P.V.C.

From Table II it can be seen that the blends of V54-OP/V54-I V54-O/RC-384/THF-MA give the best balance of dry, wrinkle resistance and oily metal adhesion.

Effect of Drier Concentrations on the New Vehicle (N.B. 7534)

The effect of several levels of cobalt on the drying time/ wrinkle balance of the new vehicle pigmented with 25 volume per cent iron oxide and 5 volume per cent red lead is given in Table III:

TABLE III

DRYING TIME VS. CATALYST CONCENTRATION

Drier Composition Percentages[1]			Drying Time[2,3] (77°F & 50% R.H.) (Hours)	Maximum Wrinkle Free Film Thick. (Mils)
Co	Zirco	TMG		
0.150	0.20	0.50	4.5	4-5
0.125	0.20	0.50	5.0	5-6
0.100	0.20	0.50	5.0	9-10
0.081	0.20	0.50	6.0	8-9
0.063	0.20	0.50	6.5	8-9
0.044	0.20	0.50	8.0	8-9
0.150	0.30	0.50	5.0	3-4
0.150	0.10	0.50	6.0	3-4
0.150	0.20	0.75	5.0	3-4
0.150	0.20	0.25	6.0	4-5
0.100	0.10	0.50	6.0	5-6
0.100	0.30	0.50	6.0	6-7
0.100	0.20	0.25	6.0	9-10
0.100	0.20	0.75	4.5	5-6

1. Percentage based on vehicle solids.
2. Paints are at thirty percent pigment volume.
3. Vehicle composition = V54-OP/V54-I/V54-O/RC-384/THF-MA, 24/32/8/20/16.

From these data the level of 0.1% Cobalt, 0.2% Zirco and 0.5% TMG were selected as being best for drying time and wrinkle resistance.

Rheological Studies (N.B. 7534-120, 121, 129)

Because of the gross change in the polarity of the new vehicle the old flocculating agent (VM-5617, a polyethylene dispersion) was no longer useful. We did not have an adequate sag/flow balance.

We found that by using soya lecithin in the new vehicle we could control our flocculation index from 1.07 to above 37. The effect of soya lecithin on flocculation index, gloss and sag-resistance is given below in Table IV.

TABLE IV

EFFECT OF FLOCCULATION ON SAG RESISTANCE

Primer	Percent Soya Lecithin	Gloss (20°)	Flocculation Index	Sag Test (Shell Sag Blade) (Wet Mils)
1	0	60	1.06	Sag 4
2	0.23	65	1.15	Sag 4
3	0.46	55	1.23	Sag 4
4	0.69	5-7 (Flat)	10.81	Sag 5
5	0.92	5-7 (Flat)	29.4	Sag 5
6	1.15	5-7 (Flat)	32.9	Sag 5
7	1.38	5-7 (Flat)	37.1	Sag 5
8	1.51	5-7 (Flat)	37.4	Sag 5
9	1.75	5-7 (Flat)	37.5	Sag 5
10	1.97	5-7 (Flat)	37.0	Sag 5
11	2.30	5-7 (Flat)	32.7	Sag 5

From the data in Table IV it is seen that the control of sag/flow balance is not simply a matter of the degree of flocculation.

L. A. Henderson observed that aluminum stearate (G-217) was effective in promoting a good balance of sag/flow characteristics in the topcoat formulations. We repeated his work in the primer formulations with the same success as he had in the topcoat program. We found that two percent aluminum stearate gave good sag resistance up to ten dry mils and gave sufficient "drag" to insure thick film application with no sacrifice in penetration characteristics. The data for some of the other rheological control agents that were tried are given in Table V.

TABLE V

RHEOLOGICAL CONTROL AGENTS USED IN V54 PRIMERS

Component	Sag Resistance	Penetration	Brushing Ease
VM-5617 (polyethylene dispersion)	5	10	Good
(G-12) Soya Lecithin	5	10	Good
W-98 (Talc)	10	0	Poor
W-1003 (Bentone)	10	0	Poor
(G-217) Aluminum Stearate	10	10	Good
VM-5617 in 7067-5001 (Control)	10	10	Good

Sag and Penetration ratings are based on control being rated 10.

Drying Characteristics of the New Primer (N.B. 7534-104,106)

Tabulated in Table VI are the drying times and minimum wrinkle free film thicknesses of the new primer vehicle as a function of temperature and humidity.

TABLE VI

DRYING TIME VS. RELATIVE HUMIDITY

Temperature	Humidity	Maximum Wrinkle Free Film Thickness	Dry Time (Zapon #2)
120°F	50%	7.0 Mils	1.0 hrs.
100°F	90%	12.0 "	4.0 hrs.
95°F	50%	9.0 "	2.75 "
77°F	50%	9.0 "	5.0 "
77°F	20%	9.0 "	2.5 "
50°F	50%	12.0 "	16 "
40°F	50%	12.0 "	31 "
40°F	25%	12.0 "	20 "

Volatility of THF-MA (N.B. 7534-146,150)

Because of the volatility of THF-MA we felt that it was necessary to check weight losses which occurred on clear films during curing under various conditions of temperature and humidity. In this study we used tetrahydrofurfuryl isobutyrate as a model compound which would not be expected to cure into the film and which should provide us with a built-in indicator as to the amount of tetrahydrofurfuryl methacrylate that was being retained in the film. The data are tabulated in Table VI.

TABLE VII

LOSS OF WEIGHT STUDIES

Vehicle Components	Film Thickness Mils	Curing Conditions (Air Dried 1 Week)	Solids
V54-OP/V54-I/V54-O/RC-384/THF-MA[1]/Xylene[2]	10.0	77°F+50%R.H.	84.8%
	4.0	77°F+50%R.H.	
	10.0	40°F+25%R.H.	83.5%
	4.0	40°F+25%R.H.	
	10.0	150°C X 1 Hr.	74.9%
	4.0	150°C x 1 Hr.	
V54-OP/V54-I/V54-O/RC-384/THF-IB/Xylene	10.0	77°F+50%R.H.	77.5%
	4.0	77°F+50%R.H.	
	10.0	40°F+25%R.H.	70.1%
	4.0	40°F+25%R.H.	
	10.0	150°C X 1 Hr.	69.2%
	4.0	150°C X 1 hr.	

(1) Theoretical solids if all xylene is lost 81.6%

(2) Theoretical solids if all xylene and THF-MA or xylene and THF-IB are lost = 68.2%.

From the data in Table VII it can be seen that the rapid curing rates obtained with THF-MA are not obtained due to volatility; because if this were the case the primers containing THF-IB would cure just as rapidly. Also the films containing THF-IB lose the theoretical amount of weight due to combined solvent and THF-IB volatility when cured at 150°C for 1 hour (solids found: 69.2%; theory 68.2%). However, under the identical conditions the films containing THF-MA lose only 50% of the THF-MA that is in the film initially (solids found: 74.9; theory 81.6).

These data suggest that under the severe curing conditions of temperature, 150°C, 50 percent of the THF-MA remains in the film but all of the saturated analog is distilled out.

The second abuse condition is that of long open times at 40°F and 25% R.H. The long drying time under these conditions will provide ample opportunity for the THF derivatives to evaporate if that is characteristic of them. Again from Table VI we can see that under these conditions the THF-IB is in fact being lost but the THF-MA is not.

It must be pointed out that these weight loss studies do not positively identify the volatile component. It is possible that we are co-distilling a mixture of THF-MA/xylene out of the film and that the amount of THF-MA that is indicated to be left in the film by these studies is illusory, except in the case at 150°C. However, based on the relative boiling points and volatilities of xylene and THF-MA the assumptions made regarding the composition of the residual material appears to be not unrealistic. We will confirm the composition of the volatiles by gas chromatography in further studies.

Package Stability (7534-161)

We now have two months shelf and oven stability (120°F) on the new primers with no change in drying characteristics or viscosity increase. We are stabilizing the system with 100 ppm of hydroquinone, based on THF-MA, and we obtain anti-skinning properties from 0.05% methyl ethyl ketoxine (Exkin #2).

The new primers skin badly in partially filled containers but not in filled cans. The skinning tendencies of the new primer are more like semi-alkyd (67-739) and short oil phenolics (373-759) than they are like straight linseed oil primers.

Corrosion Resistance (7534 - 139,140,141)

Although there is no reliable test, short of field exposure, which will predict the corrosion resistance of coatings, we felt that by comparing the performance of the new formulations against 7067-5001 and "Dulux"* primers in salt spray, humidity cabinet and fresh water immersion we might be able to make rational judgements about the effects of compositional changes on corrosion resistance.

We studied the salt spray resistance, humidity cabinet and fresh water immersion resistance of the new vehicle as a function of substrate, inhibitive pigment concentration, film thickness and vehicle components.

The salt spray results over oily mill-scale indicate that the new vehicle has better wet adhesion to scale after 1000 hours than the old formula (7067-5001). The new formula appears to be equal to 67-739, and superior to 67-746 over these substrates.

Primers formulated from the new vehicle appear to have about 1 mil less corrosion resistance than the old V54 formulation at equivalent pigmentation and after 1000 hours exposure to 5% salt spray. This deficiency disappears at 5 mils film thickness. At 5 mils film thickness both the new formula and old formulations show superior wet adhesion to substrates using "Dulux" 67-739 and 67-746 as controls.

The "Dulux" 67-746 films are very poor in salt spray, humidity cabinet and immersion tests. They have practically no wet adhesion but the corrosion resistance is very high. This is probably due to the soluble chromates which are bleached out of the film. The greenish-yellow color of the chromate solutions are clearly visible after the films are removed.

The effect of various levels of red-lead in the new vehicle was evaluated by salt spray testing. The corrosion resistance of the films (2-3 mils) was optimum for ten volume percent red lead (W-349) and 20 volume percent iron oxide (W-870). The worse system was thirty volume percent iron oxide (W-870). Because of these results we will field test the primer at the ten percent level of red lead. However, we are also checking these levels by panel exposure (Series #18972).

The immersion resistance (1000 hrs.) and humidity cabinet resistance (blistering) of the new vehicle is directly proportional to film thickness. This is in contrast to the old formula (7067-5001), whose blister resistance is inversely proportional to film thickness. The new formula appears to be equivalent to 67-739 and superior to 67-746 over these substrates.

We have two large panel exposure tests out in Belle, W. Va. and Niagara Falls plants to check the corrosion resistance of the new formula as a function of film thickness, inhibitive pigment level, substrate (sand-blasted and rusted) and topcoated and untopcoated. We have Florida exposures out to cover all the initially important compositional variables over sandblasted steel.

Hardness and Topcoat Adhesion (7534-141)

We have one month Florida exposure panels and 1000 hours accelerated weathering panels on the new formula for comparative hardness measurements. We observed that the new formula was initially softer than the old vehicle; however the AWC-2 results showed that after 330 hours the new formula became just as hard as the old formula. The one month Florida panels do not confirm this and what we may be observing so far is just a rate phenomena. It is interesting to note how hard "Dulux" 67-739 gets and particularly how slowly 67-746 gets hard. Standard primers containing red lead pigmentation get much harder than those which contain zinc chromate as the inhibitive pigmentation. The Tukon Hardness data are given in Table VIII.

TABLE VIII

Primer	Vehicle	Pigment	Exposure Conditions	Tukon Hardness (Knoop Units	
7067-5001	V54-OP/V54-I (1:1)	Pb_3O_4:Fe_2O_5	Initial(1 wk.air dry)	5.0	(5.0 mil
			1 month 45°S Fla.	14.0	" "
			AWC-2 330 hrs.	18.0	" "
7067-5010	V54-OP/V54-I/ V54-O/RC-384/ THF-MA	"	Initial	3.0	(5.0 mil
			1 month 45°S Fla.	8.0	" "
			330 hrs. AWC-2	18.0	" "
67-739	LO Alkyd/ Linseed Oil (1:2)	Pb_3O_4:Talc	Initial	1.0	(2.0 mil
			1 month 45°S Fla.	14.0	" "
			330 hrs. AWC-2	16.1	" "
67-746	LO Alkyd/ Linseed Oil (1:1)	Fe_2O_3: $ZnCrO_4$:Talc	Initial	1.0	(2.5 mil
			1 month 45°S Fla.	2.4	" "
			330 hrs. AWC-2	4.5	" "

We expected that the use of V54-oleate and RC-384 in the new vehicle would make the "Dulux" topcoats 28-5049 adhere better to the new primer because the softness of the new primer would enable the topcoat solvents to bight in better. This was confirmed initially and after 2 months Florida exposure in Series #190021. Other series which are in exposure covering the new vehicle are: #19023, 18972, 19028, 19036, 19027 and 19089. These studies will be reported on as results develop.

Thin Film Inhibition (7534 - 181)

The new vehicle appears to be more susceptible to thin film inhibition than the old formula (7067-5001). Under laboratory conditions under which a 5.0 mil film of the primer formulated from the new vehicle dries in four hours, a film of the same material less than 0.4 mils thick took 16-18 hours to cure. This problem has not manifested itself on primed edges (thin films) in laboratory studies. We first observed it when we obtained thin films during sag tests. We will look for this deficiency in our field test program.

EXPERIMENTAL DETAILS:

The experimental details of paint preparations, panel preparation and drying time measurements are standard procedures outlined in other reports or standard Marshall Laboratory Test Methods.

Drying times are reproducible to one half hour with the Zapon Method.

The data tabulated throughout this report have been gathered from studies made with at least two different batches of plant materials. Other materials used in this work were standard raw materials wherever possible.

Weight Loss Studies (N.B. 7534, 146, 150)

The weight loss studies which were carried out in this work were accomplished as follows:

Pieces of aluminum foil 4" x 6" x 0.002" were pre-cut and weighed to the nearest milligram on an automatic balance in the constant temperature room. Immediately after weighing drawdowns of the catalyzed clear vehicle were made using a one inch wide Bird Applicator of 20 and 5.6 mil clearance. The strips were carefully and immediately re-weighed on the automatic balance. The strip was then placed on a flat surface and allowed to dry in the desired atmosphere. The weight of the aluminum strips ranged from 1.1910 grams to 1.4350 grams. The weight of clear applied to these strips ranged from 1.2820 grams to 1.0490 grams. The amount of xylene in the film was 18.35 percent and combined weight of the xylene and Tetrahydrofurfuryl methacrylate amounted to 31.8 percent of the total film. Therefore, the weight losses we are measuring are 10-20% of the total initial weights which makes our weighing measurements on an analytical balance fairly accurate.

Preparation of Tetrahydrofurfurylisobutyrate (N.B. 7534-88,89,90)

Tetrahydrofurfurylisobutyrate was prepared by direct esterification of tetrahydrofurfuryl alcohol (DS-48258) with isobutyric acid (Matheson Culeman & Bell #12890) using 0.3 percent p-toluene sulfuric acid as catalyst and toluene as an azeotroping agent for the by-product water. The water was removed from the reaction mixture as soon as it formed. The I.R. Cure of the product can be found in N.B. 7534-90. The yield of distilled product (B.P. 80-85°C at 1-1.5 MM of Hg) was 94 percent based on isobutyric acid charged. Saponification number: found 324.8, 326.6; calculated 325.2, N_D^{25} 1.4350.

BIBLIOGRAPHY

1. McNally, J. G., Marshall Laboratory Report 62-43.

FIGURE I

V-54 INSPECTION RESULTS

V-54 SYSTEM		CONTROL SYSTEM		SURF.	AGE	RATING					
PRIMER	TOPCOAT	PRIMER	TOPCOAT	PREP.	(Mos)	SPECIFIC	VS. CONTROL	CUST.* REACTION	COMMENTS	CUSTOMER	STRUCTURE PAINTED AND CONDITIONS
V-54 R.L. V-54 Z.C.	None None	67-800 (2 mils) Rust-Oleum (1.5 mils)	None None	HC	42	Fair	Worse	N	Greater corrosion failure on V-54 than on 67-800, better than Rust-Oleum. NOTE: V-54 systems (3 & 5 mils) were superior to controls up to 30 mos. exposure, poorer than controls after 36 mos. exposure.	Atlantic Ref. Co. Phila., Pa.	Small storage tank (Mildly corrosive)
V-54 Z.C.	None	None	None	HC	16	Poor		U	V-54 shows gen'l failure by cracking and peeling.	"	Old alkylation unit (storage tanks) - V-54 over old vinyl (Moderately corrosive)
V-54 R.L.	Competitive epoxy (2 cts.)	None	None	SB	17	Fair		N	Structural steel showing a moderate amount of edge rusting.	"	New alkylation unit (SB, shop primed steel) (Moderately corrosive)
V-54 R.L.	?	Conventional	None	HC	15	?	?	?	Very poor surface preparation, location of V-54 and controls unknown. Test inconclusive.	"	Defogging apparatus on top of cooling tower (Highly corrosive)
V-54 R.L. over Glidden's Nupon Epoxy Ester	V-54 Gray	None	None	SB	11	Poor		U	Considerable corrosion failure. Severe staining of V-54 Gray.	"	Fin-fan Cooler (Highly corrosive)
V-54 R.L.	Bruder's Alkyd Gray (2 cts.)	None	None	HC	16	Fair		N	Some edge rusting. Adhesion of topcoat to primer fair.	"	Transmission Tower (Mildly corrosive)
V-54 R.L.	Bruder's Alkyd Red	None	None	HC	19	Poor		U	Poor adhesion of alkyd to V-54.	"	Window Sash & Door (Mildly corrosive)
V-54 R.L.	Epoxy Ester Alum.	Penetrant + 67-746	Epoxy Ester Alum.	HC	41	Good	Equal	F	Slightly more corrosion at base of tank on V-54 area than on control area.	Texaco Westville, N.J.	Storage Tank #69 (Mildly corrosive)
V-54 R.L. (1 ct.)	"Dulux" Gray	67-800 (1 ct.)	"Dulux" Gray	SB	18	Good	Equal	N	No failure.	Tidewater Oil Delaware City, Del.	Storage Tanks (Mildly Corrosive)
V-54 R.L.	Prufcoat Vinyl Socony Vinyl	Prufcoat P-50	Prufcoat Vinyl Socony Vinyl	SB	5	Good	Equal	N	No failure. Excellent adhesion of both vinyls to V-54.	Allied Chem. Corp. Gen'l Chem. Div. Claymont, Del.	Storage Tanks and Structural Steel (Moderately corrosive)

*F = Favorable
N = Neutral
U = Unsatisfactory

Figure I (Continued)

V-54 SYSTEM		CONTROL SYSTEM		SURF. PREP.	AGE (Mos)	RATING			COMMENTS	CUSTOMER	STRUCTURE PAINTED AND CONDITIONS
PRIMER	TOPCOAT	PRIMER	TOPCOAT			SPECIFIC	VS. CONTROL	CUST. REACTION			
V-54 R.L. (1 ct.)	V-54 R.L. with Anti-Slip Agent added (1 ct.)	None	None	SB	12	Good		F	No corrosion failure. Intercoat adhesion failure between V-54 coats in traffic areas only. Appearance retention of primer is poor.	U. S. Army Corps of Eng'rs Del-Chesapeake Canal	Deck of Escort Vessel (Mildly corrosive)
V-54 R.L. (1 ct.)	Epoxy Green (1 ct.)	Glidden Nat'l Lead (M-50) Con-Lux	Glidden Nat'l Lead (M-50) Con-Lux	HC	15	Good	Better	F	Adhesion of epoxy to V-54 is good, V-54 to old paint is generally good. Some spots of failure of V-54 Primer to old alum. paint. No corrosion failure on V-54. Underrusting occurring on controls. No cracking or peeling on V-54.	Garden State Parkway Raritan River Bridge Perth Amboy, N.J.	Steel curbing (Mildly corrosive)
V-54 R.L.	V-54 Foliage Green	"	"	HC	15	Fair	Equal	N	Good intercoat adhesion between V-54 coats. Spots of adhesion failure of V-54 Primer to old alum. No cracking or peeling.	"	"
None	V-54 Foliage Green	"	"	HC	15	Poor	Worse	U	Cracking and peeling over old alum. paint. Only system on bridge showing serious failure after 15 mos.	"	"
None	V-54 Zinc Dust (1 ct.)	None	348-791 (1 ct.)	HC	23	Poor	Worse	U	No failure of V-54 after 12 mos., after 23 mos. V-54 showing pinpoint rusting over 10% of surface. 348-791 shows no failure and good appearance retention.	Consumers Power Co. Jackson, Mich.	Weathered, painted galvanized transmission towers (Mildly corrosive)
V-54 R.L.	None	None	348-791	HC	23	Good	Equal	N	Good adhesion and no corrosion failure. Very hard. Dull appearance.		
None	V-54 Zinc Dust	None	None	HC	7	Fair		N	Some localized cracking and peeling on one tower. Adjacent tower is OK after 6 yrs. High film thickness of V-54 (10-20 mils) is "cheesy".	Consumers Power Co. Battle Creek, Mich.	Weathered, painted galvanized transmission towers (Mildly corrosive)
V-54 R.L. (Spot + 1 ct.) (15 vol. % R.L.)	353-781 (1 ct.) + 353-793 (1 ct.)	373-759 (Spot + 1 ct.)	353-781 + 353-793	HC	33	Good	Equal	N	Spill (ethyl benzene) has removed topcoats but has not attacked primer (no spill on control area). Good adhesion of phenolic topcoats to both V-54 and control primer.	Dow Chemical Co. Freeport, Texas Plant B	Weathered Vinyl Toluene Topcoat (Mildly corrosive)
		S-W Phenolic	Dow Vinyl Toluene Control	HC	33						
V-54 R.L. (1 ct.) (5 vol. % R.L.)	Chlor. Rubber (2 cts.)	Oleoresinous Primer	Silicone Alkyd (2 cts.)	HC	8	Good	Equal	N	All systems OK.	Dow Chemical Co. Freeport, Texas Plant A	Roof of Bldg. A2711 Weathered Chlor. rubber coating and rusty metal (Mildly corrosive)
		S-W Chlor. Rubber	Chlor. Rubber (2 cts.)	HC	8						
		"Universal"	Chlor. Rubber (2 cts.)	HC	8						

Figure I (Continued)

V-54 SYSTEM		CONTROL SYSTEM		SURF.	AGE	RATING			COMMENTS	CUSTOMER	STRUCTURE PAINTED AND CONDITIONS
PRIMER	TOPCOAT	PRIMER	TOPCOAT	PREP.	(Mos)	SPECIFIC	VS. CONTROL	CUST. REACTION			
V-54 R.L. (2 cts.)	V-54 Chalking White (1 ct.)	Cook's Gen'l Purpose + S-W Kromik (2 cts. total)	Alkyd Tank White (2 cts.)	SB	6	Good	Equal	F	V-54 White chalking heavily; control Alkyd White not chalking as yet, resulting in better appearance of V-54 topcoat. Best looking V-54 White we have seen. NOTE: V-54 Primer off standard in sag resistance. Required 2 coats to obtain 4 mils.	Dow Chemical Co. Freeport, Texas Plant A	Storage Tank (#87 Light Hydrocarbon) (Mildly Corrosive)
		Oleoresinous + Acrylic Emulsion (2 cts. total)	Acrylic Emulsion White (2 cts.)	SB	6						
V-54 R.L. (1 ct.)	V-54 Gray (1 & 2 cts.)	None	None	HC Bad Spots	9	Poor to Good		F	Where film is exposed to exterior weathering, Gray is peeling from first coat of Gray and in several places from the primer. Interior of bldg. in good shape from a corrosion standpoint. Four-coat alkyd system previously lasted 4-5 yrs. in this area with spot repair periodically. Customer wants to buy more primer for acid area.	U.S.I. Tuscola, Ill.	Interior & Exterior Structural Steel in Ethyl Chlor. Bldg. (Highly corrosive)
V-54 R.L.	28-645 L.O. Tank White (2 cts.)	Wash Primer	28-645 (2 cts.)	SB	35	Good	Equal	F	Topcoat adhesion to V-54 Primer is only fair. No failure on any system. Topcoat adhesion to control primers good. V-54 Primer adhesion to metal good.	Northern Ill. Gas Bellewood, Ill.	Top of Gas Holder (Mildly corrosive)
Wash Primer + V-54 R.L.	28-645 (2 cts.)	Wash Primer 67-800	28-645 (2 cts.)								
		Wash Primer	28-8349 Int. Orange (2 cts.)								
		Wash Primer	28-8349 Int. Orange (1 ct.)								
		Wash Primer 67-800	28-8349 (2 cts.)								
		Wash Primer 67-800	28-8349 (1 ct.)								
None	Spots - V-54 French Gray (1 ct.)	None	None	HC	7	Good		F	V-54 adhesion good. Doesn't feel as chippy as usual. Film seems thin.	Northern Ill. Gas Bellewood, Ill.	Spot touch-up of peeled areas on gass holder. (Mildly corrosive)
V-54 R.L.	V-54 Gray-Green	67-718 (1 ct.)	"Dulux" Gray-Green 25-467 (1 ct.)	SB	11	Poor	Worse	U	Cracking of topcoat from primer on top of tank, gen'l edge rusting on stairway. Side of tank OK.	Du Pont Belle, W. Va.	Large Storage Tank (Moderately corrosive)

Figure I (Continued)

V-54 SYSTEM		CONTROL SYSTEM		SURF.	AGE	RATING					
PRIMER	TOPCOAT	PRIMER	TOPCOAT	PREP.	(Mos)	SPECIFIC	VS. CONTROL	CUST. REACTION	COMMENTS	CUSTOMER	STRUCTURE PAINTED AND CONDITIONS
V-54 R.L.	V-54 Gray-Green	67-718 (2 cts.)	"Dulux" Gray-Green 25-467 (1 ct.)	SB	9	Poor	Worse	U	Topcoat cracking and flaking. Gen'l edge rusting. No failure on control system. Control columns were spot blasted only.	Du Pont Belle, W. Va.	Structural Steel Columns. (Moderately corrosive)
"	"	"	"	HC	9	Poor	Worse	N	Topcoat cracking. Edge rusting in spots. Lots of old paint here.	"	"
None	"	"	"	HC	9	Poor	Worse	U	Bad edge rusting, some face rusting. No peeling from old paint.	"	"
V-54 Zinc Dust	None	67-718 (2 cts.)	"Dulux" Gray-Green 25-467 (1 ct.)	HC Gal. Mtl.	10	Good	Equal	F	No corrosion failure on either system. Adhesion of V-54 system fair. Couldn't get to control system but wouldn't expect to be better.	Du Pont Belle, W. Va.	Structural Steel (Moderately corrosive)
V-54 Spot Primer + 67-718 (1 ct.)	"Dulux" Gray-Green 25-467 (1 ct.)	67-718 (2 cts.)	"Dulux" Gray-Green 25-467 (1 ct.)	Spot Blast	9	Good	Equal	N	Adhesion good on both exp. and control. No corrosion on either.	Du Pont Belle, W. Va.	Structural Steel pipe supports (Moderately corrosive)
V-54 R.L.	V-54 Gray-Green	"	"		9	Good	Equal	N	No corrosion. Topcoat very chippy to primer.		
V-54 R.L.	Tank White 28-5049 (2 cts.) Soil Retardant (1 ct.)	Arco (1 ct.)	Porter White (2 cts.)	HC	19	Fair	Worse	N	Tank White adhesion very poor—can be removed with fingernail. Flaking in one small spot. Control tanks OK. Total film thickness on V-54 tank - 8 mils; control tanks - 5 mils.	Union Carbide Institute, W. Va.	Storage Tank (Moderately corrosive)
None	V-54 Black	Spot with Arco	Porter Alkyd Black (1 ct.)	HC Bad Spots	20	Poor	Worse	U	V-54 Black peeling from old paint in most of area. Competitive system OK.	Union Carbide Institute, W. Va.	Structural Steel (Highly corrosive)
Spot Prime Prufkote P-50	V-54 Gray	Spot Prime Prufkote P-50	S-W Phenolic (1 ct.)	HC	7	Poor	Worse	U	Four tanks with V-54. V-54 peeling from Prufkote on one and showing corrosion failure on another where it looks like application direct to metal. Competitive topcoat adhesion only fair, but no failure showing. V-54 adhesion poor to Prufkote and fair to old paint.	Gen'l Chem. Div. Allied Chem. & Dye Niter, W. Va.	H_2SO_4 Storage Tanks (Moderately corrosive)
None	V-54 White	None	None	HC	6	Good		F	Touched-up peeled areas on one tank. Peeling seemed to be mostly to old alum. paint rather than to metal.	Union Carbide Institute, W. Va.	Storage Tank (Moderately corrosive)

Figure I (Continued)

V-54 SYSTEM		CONTROL SYSTEM		SURF.	AGE	RATING					
PRIMER	TOPCOAT	PRIMER	TOPCOAT	PREP.	(Mos.)	SPECIFIC	Vs. CONTROL	CUST.* REACTION	COMMENTS	CUSTOMER	STRUCTURE PAINTED AND CONDITIONS
V-54 R.L.	"Corlar" Epoxy Green (2 cts.)	S-W Metalastic	S-W Chlorinated Rubber (2 cts.)	SB	12	Good	Equal	N	No failure observed on V-54 or control. Gloss & color retention of chlorinated rubber better than epoxy. NOTE: Some rusting occurring at cleats, weld spotter & lip of roof on V-54 tank--not occurring on controls. Amer. Cy. discounts difference because control tanks were treated more carefully to avoid this type of failure.	American Cyanamid Co. Fortier Plant Avondale, La.	Acrylo Storage Tank TA-730 (Mildly corrosive)
V-54 R.L.	V-54 White (7025-5001)			SB	1-7	Poor		U	V-54 Primer off-std.-heavy settling, sagging & bleeding noted under V-54 White. V-54 White was also off-std. in sag resistance resulting in low film build & poor hiding. Tank was reprimed (V-54 Primer OK) and recoated with V-54 White. White off-std. & sagged.	American Cyanamid Avondale, La.	Storage Tank TA-735 (Mildly corrosive)
V-54 R.L.	V-54 Alum.	Glidden R.L. in Oil (2 cts.)	Alkyd Aluminum	HC	12	Good	Equal	N	Appearance OK. Adhesion OK. Old primer has poor adhesion to metal.	Huey Long Bridge New Orleans, La.	Bridge Girder (Mildly orrosive)
None	V-54 Alum.			HC & SB	12	Good			Appearance of V-54 Aluminum has improved (more metallic) since 6 mos. inspection.		
V-54 R.L.	V-54 Alum.			SB	12	Good					
None	V-54 Black (1 ct.)			SB	12	Poor		U	System has failed--gen'l rust through over 50% of surface	Allied Chem. Corp. Solvay Process Baton Rouge, La.	Structural Steel (Soda Ash Conveyor) (Moderately corrosive)
None	"			HC	12	Poor		U	Columns under building (shielded from weather)--one has failed by gen'l rust through, other column in fair condition.	"	"
V-54 R.L.	V-54 Black			SB	12	Fair		N	Little or no corrosion failure. V-54 Black removed from primer on several spots on horizontal surfaces.	"	"
V-54 R.L.	V-54 Black			HC	12	Good		N	Protected columns under building holding up well.	"	"
V-54 R.L. (1 ct.)	Du Pont Chlorinated Rubber Black 353-W-20363 (1 ct.)	Napko Chlor. Rubber (1 ct.)	Napko Chlor. Rubber (2 cts.)	SB	12	Good	Equal	N	No failure. Adhesion of chlorinated rubber black is excellent. Appearance of Du Pont topcoat better than control. Customer now using 2 coat Napko system.	Dow Chemical Corp. Plaquemine, La.	Tank Car in HCl service (Moderately corrosive)

Figure 1 (Continued)

V-54 SYSTEM		CONTROL SYSTEM		SURF.	AGE	RATING					
PRIMER	TOPCOAT	PRIMER	TOPCOAT	PREP.	(Mos)	SPECIFIC	VS. CONTROL	CUST. REACTION	COMMENTS	CUSTOMER	STRUCTURE PAINTED AND CONDITIONS
V-54 R.L. (1 ct.)	"Dulux" Gray 25-415	Oil/Alkyd	Butes Sea Bubble Gray Alkyd	HC	11	Good	Better	F	V-54 Primer/"Dulux" Gray shows no corrosion failure, controls both show failure.	Houston Lighting & Power Company (Ebasco Services) Webster, Texas	Rusted steel boiler roof casing (Mildly corrosive)
		Modified Vinyl	"	HC	11						
V-54 R.L. (1 ct.)	None	None	None	HC	11	Fair		N	A number of spots of corrosion failure about size of dime.	"	"
V-54 R.L.	Humble's Alkyd Green	Humble's Rust-Ban	Humble's Alkyd Pastel Green	SB	11	Good	Equal	N	Good adhesion of Humble Alkyd to both V-54 R.L. and zinc chromate primers. No corrosion failure on V-54 or controls.	Humble Oil Baytown, Texas	Cone roof of storage tank (#1261) (Mildly corrosive)
V-54 Z.C.	Humble's Alkyd Green	None	None	SB	11	Good	Equal	N			
V-54 R.L. (2-4 mils)	None	Humble's Rust-Ban	None	SB	11	Fair	Better(?)	F	Control primer shows general rust-through (2-2.5 mils). V-54 OK at 3-4 mils but shows rust-through at film thicknesses equal to controls.	Humble Oil Baytown, Texas	"
V-54 R.L.	None	"	None	HC	11	Good	Equal	N	No failure of V-54 or controls over HC Steel		
V-54 Z.C.	None	"	None	SB	11	Good	Better(?)	F	V-54 Zinc Chrom. applied at 4-6 mils shows no failure over SB Steel.		
V-54 Zinc Dust	None	Subox #111 (spot)	Subox 508	HC	8	Good	Equal	U	All systems in good condition after 8 mos. Complaint of slow dry of V-54, rain damage to wet V-54 film and color of V-54 Zinc Dust too dark.	Houston Lighting & Power Company Houston, Texas Magnolia Park Substation	Galvanized Structural Steel (unpainted, showing red rust) (Mildly corrosive)
		Debevoise (full coat)	Debevoise #595								
		Galvacon	None								
PPG	V-54 Alum.	PPG (1 ct.)	PPG's R-M Alum.	HC	4	Good	Equal	U	Customer says V-54 alum. is unsatisfactory for his use in Gulf Coast—rain on wet V-54 washed off 25% of paint and necessitated repainting of 3 poles.	Houston Lighting & Power Company Gulf Freeway Houston, Texas	Light Standards (Mildly Corrosive)
None	V-54 Alum.	"	"	HC	4	Good	Equal	U	A minor amount of pinpoint rusting showed up—only on high spots.		
V-54 Z.C.	V-54 White	Socony R.L. (2 cts.)	Socony White (1 ct.)	SB	7	Poor	Worse	U	V-54 White is cracking and peeling on sunny side of tank on some part of seven plates (4' x 20'). Adhesion seems normal on areas adjacent to peeling. No corrosion. No failure on any other tanks.	Standard Oil of Kentucky Louisville, Ky.	Gasoline Storage Tank (Mildly corrosive)

Figure I (Continued)

V-54 SYSTEM		CONTROL SYSTEM		SURF.	AGE	RATING					
PRIMER	TOPCOAT	PRIMER	TOPCOAT	PREP.	(Mos.)	SPECIFIC	Vs. CONTROL	CUST.* REACTION	COMMENTS	CUSTOMER	STRUCTURE PAINTED AND CONDITIONS
V-54 R.L.	"Dulux" Tank White 28-5049 (2 cts.)	67-733 (1 ct.) + 67-718 (1 ct.)	"Dulux" Tank White 28-5049 (2 cts.)	SB	19	Poor	Worse	U	Considerably more spot corrosion failure on V-54 system than on control. Adhesion of 28-5049 to V-54 Primer is poor. Customer prefers control system to V-54	Gulf Oil Company Port Arthur, Texas	Storage Tank - cone roof (Mildly corrosive)
V-54 R.L. ("A" type Primer faster drying)	V-54 White (?) 7025-5001	"Dulux" Z.C. 67-746 (2 cts.)	V-54 White (?) 7025-5001	SB	6	Good	Equal	N	V-54A Primer (modified with TMS) showed bad wrinkling at film thicknesses of 6 mils and above. No. corrosion failure on tank. NOTE: White topcoat is soft, flexible & elastic--does not appear to be V-54 White although Atlantic says it is.	Atlantic Ref. Co. Port Arthur, Texas	Storage Tank #533 (Moderately corrosive)
V-54 Z.C.	V-54 White (?) 7025-5001										
V-54 R.L.	"Corlar" Epoxy (1 and 2 cts.)	"Corlar" Epoxy (1 ct.)	"Corlar" Epoxy (2 cts.)	SB	20	Poor	Equal	N	Corrosion failure particularly edge rusting, occurring on both V-54 & control areas. One coat and two coats of epoxy over V-54 are equal.	Atlantic Ref. Co. Port Arthur, Texas	Structural Steel - Stabilizer Unit (Highly corrosive)
V-54 R.L.	None			SB	20	Poor		U	Area too corrosive for untopcoated V-54 Primer	"	"
V-54 Zinc Dust				HC	2-6	Poor		U	Some weld seams OK; many show rust through	Du Pont Company Beaumont Plant Beaumont, Texas	Galvanized Structural Steel - repair of welded areas. (Mildly corrosive)
V-54 R.L.				HC	2-3	Poor	Worse	U	V-54 Primer completely failed before topcoat could be applied (1-2 mos.) Du Pont Submarine Primer (phenolic) used successfully subsequently even though it too was untopcoated for quite some time. NOTE: It is quite possible that any slow drying primer, 67-746 or 67-800, would perform the same as the V-54 Primer.	Du Pont Company Sabine Plant Orange, Texas	Structural Steel - Area subjected to vapor, steam, salt spray, etc. (Highly corrosive)
V-54 R.L.	Du Pont Phenolic Aluminum (354-751)	Du Pont Submarine Primer	354-751	HC	13	Poor	Worse	U	Very poor adhesion of 354-751 to V-54 Primer. Topcoat adhesion failure has occurred in "puddles" on roof & also in dry areas. Corrosion failure of V-54 Primer where water lays on roof. Customer has requested that we pay for repainting the roof (surface prep. & topcoating.	Texas Pipeline Co. Houma, Louisiana	Storage Tank - floating roof (Mildly corrosive)

Figure I (Continued)

V-54 SYSTEM		CONTROL SYSTEM		SURF.	AGE	RATING				
PRIMER	TOPCOAT	PRIMER	TOPCOAT	PREP.	(Mos)	SPECIFIC	VS. CONTROL	CUST. REACTION	COMMENTS	CUSTOMER
V-54 R.L. (1 ct.)	"Dulux" Green (28-941)	Dow #5 Oxide (1 ct.)	"Dulux" Green (28-941)	HC	19	Good	Equal	N	No failure.	Dow Chemical Co. Midland, Mich.
V-54 R.L.	"Dulux" Green	None	None	BB	19	Good			No Failure	"
None	None	Dow #5	28-941	SB (White)	19	Good			No Failure	"
V-54 R.L.	Competitive Vinyl Toluene Green	None	None	HC	19	Good			No failure. Gloss and appearance of competitive Vinyl Toluene Green much poorer than that of 28-941.	"
None	None	Dow #70 Yellow Z.C. (Fast Dry)	Competitive Vinyl Toluene Green	SB (White)	19	Good			No failure. Topcoat dull.	"
V-54 R.L.	V-54 Gray	None	None	SB	9	Good		F	Appearance, corrosion protection and adhesion OK. Very little chalking as yet.	Shawinigan Resins Co Trenton, Mich.
None	V-54 Gray	"	"	SB	9	Good		F	Same	"
V-54 R.L.	"Dulux" Black (25 Line)	"	"	SB	9	Good		F	Intercoat adhesion good.	"
V-54 R.L.	"Dulux" Yellow (88 Line)	67-739	"Dulux" Yellow (88 Line)	SB	9	Fair	Worse	U	Very poor intercoat adhesion.	"
V-54 R.L.	V-54 Chalking White	67-739 (1 ct.)	"Dulux" High Build Tank White	SB	6	Poor	Worse	U	Bad dirt collection and streaking vs. controls. Also bad bug pickup.	"
None	V-54 Gray	None	None	HC	9	Good		N	Adhesion to aged gray alkyd OK.	"
V-54 R.L.	V-54 Chalk Resistant White + Soil Retardant	None	None	SB	9	Poor		U	Poor initial appearance and poor appearance retention. Low film thickness application (2 mils) resulted in shadowy appearance. V-54 White is badly dirt streaked. Adhesion to metal good, intercoat adhesion is fair.	Standard Oil - Ohio Toledo, Ohio
PPG (Spot Primed)	7025-5007 (Spot and full coat) + Soil Retardant	None	None	HC	8	Poor		U	Appearance retention poor -- dirt staining and streaking, rust staining.	"
None	V-54 Alum. (1 ct.)	None	S-W Silver-Brite Alum. (1 ct.)	HC	6	Good	Better	F	Adhesion to old paint OK. V-54 Alum. better in appearance (not as stained or dirty).	"

Figure I (Continued)

V-54 SYSTEM		CONTROL SYSTEM		SURF.	AGE	RATING VS.		CUST.			
PRIMER	TOPCOAT	PRIMER	TOPCOAT	PREP.	(Mos)	SPECIFIC	CONTROL	REACTION	COMMENTS	CUSTOMER	STRUCTURE PAINTED AND CONDITIONS
V-54 R.L. (Shop Prime)	V-54 Alum.	None	None	HC	9 Pr.	Poor		U	Considerable flaking of primer required touch-up before topcoating. There are still areas of very poor adhesion of primer to metal. Topcoat to primer OK.	City of St. Louis Grand Avenue Bridge	Hand Rails (Mildly corrosive)
					1-6 Top.	Good		N			
"	Competitive Alkyd	Competitive material (Shop Prime)	Alkyd (2 cts.)	HC	14	Good	Equal	F	Can't get close enough to scratch. Looks OK from ground.	"	Girder under same bridge
V-54 R.L.	V-54 White	None	Competitive Vinyl/Alkyd (3 cts.)	SB	9	Good	Equal	?	No failure on either system. Topcoat adhesion chippy on V-54 system.	Cargill E. St. Louis	Roof of grain elevator (Moderately corrosive)
None	V-54 Alum.	None	Competitive Alkyd Alum.	None	6	Good	Equal	N	V-54 Alum. adhesion better than competitive alum. finish to old paint. Customer likes idea of V-54 but can't stand slow dry in chemical atmosphere.	Monsanto St. Louis, Mo.	Wire fence (Moderately corrosive)
-54 R.L. (Spot Prime)	None	None	None	HC	8	Good		N	Several spots showed peeling of primer from old paint adjacent to spotted area. However, not gen'l.	Monsanto St. Louis, Mo.	Structural Steel (Moderately corrosive)
-54 R.L.	Coal Tar Epoxy	None	None	SB	8	Good		N	No failure, topcoat adhesion good.	Monsanto St. Louis, Mo.	Structural Steel (Moderately corrosive)
-54 R.L.	None	Competitive Zinc-Rich	None	HC	9	Good	Equal	N	No corrosion failure of V-54 and several Zinc-Rich materials. Zinc containing materials showed considerable discoloration.	Monsanto St. Louis, Mo.	Several small patches on side of tank (Moderately corrosive)
-54 R.L.	V-54 Black	None	None	HC	8	Fair		F	High temperature stack. Black charred. Primer OK. Customer said system worked better than other systems on this area.	General Chem. E. St. Louis, Ill.	Stack for flue gases from process. Gets to high temp. (7500°F) (Highly corrosive)
ne	V-54 Zinc Dust (1 ct.)	Cook's Perma-Grip (1 ct.)	Dow Alum.	HC	7	Fair	Worse	N	Some rusty areas in V-54 section as a result of incomplete coverage by one-coat system. Not present in 2-cost control. Appearance of V-54 is poor due to pickup of fly ask in wet V-54 film.	Dow Chemical Co. Midland, Mich.	Rusty, galvanized Storage Hangar (Mildly corrosive)

Figure I (Continued)

V-54 SYSTEM		CONTROL SYSTEM		SURF.	AGE	RATING				
PRIMER	TOPCOAT	PRIMER	TOPCOAT	PREP.	(Mos)	SPECIFIC	Vs. CONTROL	CUST.* REACTION	COMMENTS	CUSTOMER
V-54 R.L.		Prufcoat Primastic		HC	11	Good		N	No corrosion failure	Ormet Corp. Burnside, La.
V-54 R.L.	"Corlar" Epoxy Mastic Gray			HC	11	Poor		U	Adhesion failure of epoxy to V-54. No failure of V-54 Primer.	"
V-54 R.L.	Du Pont Chlorinated Rubber Black 323-W-20363			HC	11	Poor		U	Adhesion failure of chlorinated rubber black to V-54. No failure of V-54 Primer.	"
V-54 Z.C.	None	Rowe Epoxy Mastic Gray PRS Chemtite Mastic		HC	6	Poor	Worse		Untopcoated V-54 attacked by caustic. (Area was to be topcoated with epoxy but not done) NOTE: Equivalent exposure conditions at Ormet & Kaiser show different results.	Kaiser Aluminum & Chemical Corp. Gramercy, La.
V-54 R.L.	PPG's Marinehide Hulltek Red Vinyl	None	None	SB	19	Poor		U	Complete failure--rust through Poor adhesion of vinyl to V-54	Sun Oil-Marine Dept Chester, Pa.
V-54 R.L. + V-54/Vinyl Intermediate Ct.	"	None	None	SB	19	Poor		U	Complete failure--gen'l rust through. Same conditions as above.	"Sabine Sun" "
V-54 R.L.	"	None	PPG's Red Vinyl	HC	19	Poor	Equal	U	Poor surface preparation. Fair amount of corrosion failure. Both V-54 & control areas in better condition than SB area. Poor adhesion of vinyl to V-54.	"
V-54 R.L.	None	67-800 67-746	None None	HC	20	Poor	Worse	U	V-54 shows more corrosion failure than controls. NOTE: V-54 equal or better than 67-800 up to 10 mos. exposure, then worse.	Bethlehem Steel Co. Bethlehem, Pa.
V-54 R.L.	Black Mastic	67-800	Black Mastic	HC	10	Poor	Worse	U	V-54 showing loss of adhesion and corrosion failure.	Bethlehem Steel Co. Bethlehem, Pa.
V-54 R.L. V-Oil	None	67-800 PPG's Fractionated Oil		HC	6	Good	Equal	N	All systems equal. Small amount of scale popping.	Bethlehem Steel Co. Bethlehem, Pa.
V-54 R.L. (1 ct.)	V-54 Gray-Green (1 ct.)	R.L./Oil (1 ct.)	"Dulux" Gray-Green (1 ct.)	HC	11	Good	Equal	F	No failure--all systems equal V-54 gray-green lower in gloss than "Dulux". Very little chalking of V-54. Appearance retention satisfactory.	Shawinigan Resins Indian Orchard, Ma
None	V-54 Gray-Green (1 ct.)									
None	V-54 Gray-Green (2 cts.)									

Figure I (Continued)

V-54 SYSTEM		CONTROL SYSTEM		SURF.	AGE	RATING					STRUCTURE PAINTED
PRIMER	TOPCOAT	PRIMER	TOPCOAT	PREP.	(Mos)	SPECIFIC	Vs. CONTROL	CUST.* REACTION	COMMENTS	CUSTOMER	AND CONDITIONS
None	V-54 Tank White (1 ct.)	None	None	HC	8	Fair to Poor		N	Some rust staining. Appearance retention fair. Some cracking & flaking from old paint & base metal. Adhesion of V-54 to old paint & bare metal is poor.	Shawinigan Resins Indian Orchard, Mass.	Storage Tank (Mildly corrosive)
None	V-54 Gray (1 ct.)	None	None	HC	6	Poor		U	Severe cracking & flaking of V-54 from old paint. Caustic spills have removed V-54 in some areas.	Shawinigan Resins Indian Orchard, Mass.	Storage Tank (Highly corrosive)
None	V-54 Gray	None	None	HC	3-6	Poor		U	Severe cracking & flaking failure over old paint & bare metal	Shawinigan Resins Indian Orchard, Mass.	Fence (Mildly corrosive)

FIGURE II

CORROSION RESISTANCE
CONTROLLED V54 FIELD TESTS

Test Location	Age (Mo.)	Top-coats	Control	Coats	Film Thickness	V54	Coats	Film Thickness	Comments
Atlantic Refinery, Phila., Pa.	42	No	Dulux 67-800	1	1.5 - 2.5 mils	7067-5001	1	5-6	V54 superior to control at 30 months.
Atlantic Refinery, Phila., Pa.	42	No	Rustoleum	1	1.5 - 2.5 mils	" "	1	5-6	At 36 months both systems showing rust.
Phillips' Sweeney, Texas	40	Yes	Dulux 67-746	2	3.0 - 4.0 mils	" "	1	4-5	Rustoleum failing at 18-20 months.
Texaco, Eagle Point, N.J.	32	Yes	Dulux 67-746 linseed oil-penetrant	2	2.5 - 3.5 mils	" "	1	4-6	Both systems perfect.
Sun Oil, Marcus Hook, Pa.	22	Yes	Dulux 67-746	1	1.5 - 2.5 mils	" "	1	4-5	Both systems perfect.
Gulf, Port Arthur, Tex.	20	Yes	Dulux 67-733	1	2.0 - 3.0 mils	" "	1	5-6	90-95% control showing rust through. 20-25% V54 showing rust.
Dow, Midland, Mich.	20	Yes	Redlead; oil/Alkyd	1	2.0 - 3.0 mils	" "	1	5-6	V54 67-733
Oil Terminal, N. Tonawanda, N.Y.	22	No	67-746	1	1.5 - 2.5 mils	" "	1	4-6	V54 equals control.
Atlantic, Port Arthur, Tex.	15	Yes	Catalyzed epoxy	2	3.0 - 4.0 mils	" "	1	4-6	Control failed - V54 intact.
Phila. Gas Works, Phila., Pa.	22	Yes	Phenolic/Zinc Dust	1	2.0 - 3.0 mils	" "	1	4-6	V54=2 coat control.
Stauffer Chem. Co. Lewistown, N.Y.	8	Yes	Prufcote - P.50	1	1.5 - 2.0 mils	" "	1	4-6	V54=control
Shawinigan, Indian Orchard, Mass.	12	Yes	Red Lead/oil	1	1.5 - 2.0 mils	" "	1	4-6	V54=control
U.S.Steel, 2 locations	6	No	PPG Red lead/oil	1	8.0 - 2.5 mils	" "	1	4-6	V54-Failed Control O.K.
Rhode Island, Eddy St. Bridge	11	No	None	-	-	" "	1	4-6	V54-Failed (Oily metal)
Union Carbide, Institute W.Va.	17	Yes	Arco #39 Primer	1	2.0 - 2.5 mils	" "	1	4-6	V54=control
DuPont, Belle, W.Va.	9	Yes	67-738	2	3.5 - 4.0 mils	" "	1	4-6	V54- control
State of Me. S.Berwick, Me.	24	Yes	Red lead, Alkyd/oil	3	3.5 - 4.0 mils	" "	2	4-6	1 coat spot prime, V54=control.
Con. Pipeline, Houma, La.	14	Yes	373-759(phenolic)	1	1.5 - 2.0 mils	" "	1	4-6	V54(Roof)=control (Side).
Allied Chem. Marcus Hook, Pa.	6	Yes	Prufcote-P-50	1	1.5 - 2.0 mils	" "	1	4-6	V54=control
Shawinigan, Old Orchard, Mass.	8	Yes	67-739	1	2.0 - 3.0 mils	" "	1	4-6	V54=control
Huston Power & Light Webster, Texas	11	Yes	67-800(Type)	1	3.5 - 4.0 mils	" "	1	4-6	V54 Control
			Vinyl	1	2.0 - 3.0 mils	" "	1	4-6	V54 Control
Humble Oil, Baytown Texas	11	Yes	Humble Rust-Ban (67-800 Type)	2	3-5 mils	" "	1	4-5 mils	V54=control