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Research Report

V54 ONE COAT MAINTENANCE FINISHES

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ABSTRACT

The formulation of a line of colored maintenance finishes based on vinyl dioxolane esters is discussed and these new coatings described. A 1/1 blend of V54 itaconate/V54 o-phthalate does not appear satisfactory as a vehicle for Industrial Maintenance top-coats.

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V54 ONE COAT MAINTENANCE FINISHES

INTRODUCTION:

This report summarizes the initial phase in the development of industrial maintenance topcoat/one-coat finishes systems based on V54 esters. These finishes are intended for use on structural steel as: (1) a single coat system, (2) topcoats over primer or (3) refinish over old maintenance paints. These finishes supplement the V54 primer development and should further improve F. & F.'s position in the field of maintenance paints.

OBJECTIVES:

The objective of this work was to utilize vinyl dioxolane chemistry in the field of maintenance paints. It was hoped these new finishes would have a unique balance of application properties, tolerance toward poor surface preparation, protective character and universality over varying substrates (bare, primed and painted metal), which would supplement the V54 primer in enabling F. & F. to capture a larger share of the maintenance paint market.

SUMMARY AND CONCLUSIONS:

V54 topcoat/one-coat finishes were formulated in eight colors for expansion of the V54 field test program. These formulations met the initial requirements for sag, wrinkle resistance and dry time.

Field testing of the eight colors showed them to fail by cracking and peeling. In addition, they were generally low in gloss, high in brush marks, subject to severe rust staining and lacking in stability. The long time needed to reach a tack-free state (same length of time as for through cure) was unacceptable because of the excessive bug and dirt pick-up.

Complete reformulation of the topcoat system must be carried out before large scale field testing or sale can be considered.

ACTION TAKEN:

The entire line of colors is being reformulated to eliminate the deficiencies found in field testing these initial formulations.

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PATENT STATUS:

The vinyl dioxolane esters used in these paints are covered in Du Pont patent application 1635-A which has been allowed by the Patent Office. Also Du Pont patent file 1644 covering the use of these esters in maintenance paints has been allowed by the Patent Office.

PUBLICATION STATUS:

The V54 maintenance paint development as a whole should be the subject of a publication or presentation at the appropriate time in the future.

ACKNOWLEDGEMENTS:

Acknowledgement is made to F. Lucci for his invaluable assistance and to W. M. Duffy, G. H. Westcott and K. C. Lampert for their patience and advice.

DISCUSSION:

I. Vehicle:

The vehicle system adopted for the colored V54 maintenance paints was that used in the V54 primer. The basic vehicle was a 1/1 blend of V54 itaconate/V54 o-phthalate. The blend is necessary to get a balance of dry time, penetration, wrinkle resistance, flexibility and application properties.[1]

Field test results indicate that this vehicle upon aging becomes excessively hard and brittle with subsequent early failure on exposure. Accelerated weathering exposure[2] did not show this failure when the Tank White formula was tested over both V54 and standard primers. The chalk rate was slightly slower than conventional tank white but there was no loss of adhesion, no cracking, no blistering and no excessive chippiness.

The basic vehicle was modified for use in the topcoat/one coat system by the addition of a small percentage of alkyd. The alkyd was added to improve the pigment wetting. Better wetting of the pigment was necessary for processing as well as the development of gloss in the dry film. The better pigment wetting resulted in a loss of sag resistance.

The sag resistance in some formulas was obtained by the use of Jel-O-Mer 903, an oleoresinous vehicle, which gave a thixotropic paint at some sacrifice in gloss. The level of this additive necessary for good application was found to be 5 gms. per 1000 gms. of paint. The addition of Jel-O-Mer 903 raised the viscosity as well as imparting thixotropy but this was overcome by the addition of small amounts of aromatic solvent.

II. Pigmentation

In some formulations the sag resistance was obtained by increasing the volume of extender. This technique gave lower gloss than did the corresponding Jel-O-Mer 903 technique.

However, the balancing of the amount and type of extender gave rheologically stable systems of medium gloss. A white formulation using a combination of barytes and talc gave a paint with an acceptable sag/flow balance but the 60° gloss averaged 50 units. This formulation used a chalk resistant TiO_2 as the prime pigment and had shelf stability greater than six months. The gloss level and unchanged dry time (16 hrs. at 77°F) of this modification made it unacceptable.

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7025-5001 Tank White

Code	Material	Lbs./100 Gals.
CP-502	V54 o-Phthalate	323.90
CP-503	V54 Itaconate	323.90
W-19	Zinc Oxide	72.41
W-93	Titanium Dioxide	253.78
W-5	Titanium Dioxide	117.57
W-12	Barytes	260.05
W-98	Talc	93.43
KH-5962	Lead Butyl Phthalate	40.49
KH-5922	Cobalt Butyl Phthalate	12.15
KH-5948	Anti-Skinning Agent	.12
H-596	Hydrocarbon Solvent	10.20
		1508.00

Properties

Gal. Wt.	15.08
Pig. Vol. Conc.	24.98
Solids, %	
Wt.	97.0
Vol.	93.7
Gloss (60°)	66
Sag (DFT)	12 mils
Dry (77°F)	16 hrs.

Tank White was patterned after 28-5049 "Dulux"* Hi-Build Tank White to give a self-cleaning surface with high heat reflection. This formulation was first made-up using titanium dioxide as the major pigment as in the 28-Line counterpart and using zinc oxide for corrosion inhibition and mildew resistance.

Exposure of this original formulation with and without zinc oxide, to accelerated weathering (AWC-II) for 2500 hours showed it to be slightly slower in chalk rate than 28-5049. This was judged acceptable and initial field testing carried out.

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Later in the program a comparison of costs showed the desirability of reducing the titanium dioxide content to lower the cost. The prime pigment was reduced from 21% to 16% by volume, a level consistent with the hiding power needed, and the bulk made up with extenders. The use of extender improved the sag resistance and eliminated the use of Jel-O-Mer 903. In addition to lower cost it was hoped that the use of high oil absorption extender pigments would improve the shelf stability; however, this did not prove to be the case. Further work on the kind and amount of extender pigments and their effect on sag resistance, gloss and shelf stability was carried out. No system embodying high gloss and sag resistance was developed.

7025-5002 Black

Code	Material	Lbs./100 Gals.
CP-502	V54 o-Phthalate	320.05
CP-503	V54 Itaconate	320.05
RC-121	Alkyd	39.93
W-222	Molacco Black	42.35
W-19	Zinc Oxide	84.10
W-98	Talc	327.18
KH-5962	Lead Butyl Phthalate	63.88
KH-5922	Cobalt Butyl Phthalate	12.10
KH-5948	Anti-Skinning Agent	.36
		1210.00

Properties:

Gal. Wt.	12.10
Pig. Vol. Conc.	19.50
Solids, %	
Wt.	
Vol.	92.8
Gloss (60°)	50
Sag (DFT)	8 mils
Dry (77°F)	16 hrs.

The pigmentation of the black was that of W-98150 which in turn was adapted from the alkyd antoxide black primer. The only change was the removal of barium lanolate from the formulation.

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An initial formulation was tried using National Lead's M-50 Basic Lead Silico Chromate as the corrosion inhibitive pigment. Initial field testing showed this formulation gave rapid loss of dry and settling on shelf storage and travel.

Replacement of the basic lead silico chromate with zinc oxide gave a stable formulation which had soft settling characteristics and retained drying potential.

Field testing showed this paint to be low in gloss, slow in dry (16 hrs. at 77°F) and low in wrinkle resistance (6 mils max.) Shelf stability of the zinc oxide formulation was good.

7025-5003 Gray:

Code	Material	Lbs./100 Gals.
CP-502	V54 o-Phthalate	323.32
CP-503	V54 Itaconate	323.32
KH-5962	Lead Butyl Phthalate	47.70
RC-121	Alkyd	.84
W-19	Zinc Oxide	70.70
W-93	Titanium Dioxide	368.00
W-12	Barytes	247.00
W-98	Talc	88.00
W-222	Molacco Black	3.43
W-630	Ferrite Yellow	13.65
KH-5922	Cobalt Butyl Phthalate	13.90
KH-5948	Anti-Skinning Agent	.14
H-596	Hydrocarbon Solvent	5.00
		1505.00

Properties

Gal. Wt.	15.05
Pig. Vol. Conc.	24.40
Solids, %	
Wt.	94.0
Vol.	97.0
Gloss (60°)	57
Sag (DFT)	10 mils
Dry (77°F)	16 hrs.

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The pigmentation of the gray matching 25-415 "Dulux" Gray was basically that of the Hull and Super Structure White with tinting bases added. The shading required not only black but ferrite yellow and red as well to approximate the shade and tone. Difficulty was encountered in the shading in that there was a definite shift of color between wet and dry state. The dry time of 12-16 hours made color matching to a Dry Plate Standard a very long term process which was unsatisfactory for production. Wet standards were set-up and used in shading the production batches made for field testing.

The shading required relatively large amounts of shading bases since the only blacks which could be used in V54 esters gave an undesirable blue tone to the gray. Investigation of other available carbon blacks having the requisite lack of acidity did not uncover a better pigment for this color.

7025-5004 Gray-Green

Code	Material	Lbs./100 gals.
CP-502	V54 o-Phthalate	323.35
CP-503	V54 Itaconate	323.35
RC-121	Alkyd	.10
KH-5962	Lead Butyl Phthalate	46.78
W-19	Zinc Oxide	68.04
W-93	Titanium Dioxide	91.40
W-12	Barytes	331.00
W-98	Talc	166.50
W-754	Chromium Oxide Light	47.16
W-630	Ferrite Yellow	20.96
W-222	Molacco Black	4.52
34-527	Alkyd Shading Base	8.73
34-312	Alkyd Shading Base	Trace
KH-5922	Cobalt Butyl Phthalate	13.61
KH-5948	Anti-Skinning Agent	.14
H-596	Hydrocarbon Solvent	1.36
		1447.00

Properties	
Gal. Wt.	14.47
Pig. Vol. Conc.	24.0
Solids, %	
Wt.	96.1
Vol.	93.1
Gloss (60°)	60
Sag (DFT)	10 mils
Dry (77°F)	16 hrs.

DUP030009669

Pigmentation of the Gray-Green was adapted from 25-467. The prime colored pigments were the same as those used in 25-467 and the remainder was W-98 Talc extender pigment for body. This gave a paint low in gloss, high in sag resistance and high in brush marks. Revision of this formula in which the extender pigment was reduced in an effort to improve gloss and brush marks resulted in non-stable sag resistance. The shading problems in this color were the same as with the Gray.

Attempts were made to reformulate this color on a non-composite grinding basis but the amounts of shading bases required was prohibitive. Composite pigment grinds are undesirable in production but may have to be tolerated in some colors.

7025-5005 Aluminum

Code	Material	Lbs./100 Gals.
CP-502	V54 o-Phthalate	207.25
CP-503	V54 Itaconate	404.12
W-19	Zinc Oxide	49.07
W-12	Barytes	64.71
KW-8019	Aluminum Paste	266.04
KH-5922	Cobalt Butyl Phthalate	7.63
KH-5948	Anti-Skinning Agent	.15
H-596	Hydrocarbon Solvent	66.00
		1065.00

Properties

Gal. Wt.	10.65
Pig. Vol. Conc.	14.98
Solids, %	
Wt.	84.5
Vol.	76.9
Gloss (Brilliance)	Fair-Poor
Sag (DFT)	10-12 mils
Dry (77°F)	8-10 hrs.

The formulation of the V54 Aluminum was carried out using only the basic specification normally applied to ready-mixed aluminum paints. The aluminum paste content was set at 2.5 lbs. per gallon which is low compared to standard paints when considered on a solids basis (P/B or PVC).

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The aluminum paste used in making a V54 Ready-Mixed Aluminum was Alcoa HF-905. This is a standard leafing aluminum powder wetted to paste form with aromatic solvent instead of mineral spirits. This paste avoids the incompatible solvent present in aluminum pastes used in standard products. The use of Alcoa HF-905 Aluminum paste presents very few problems since it is commercially available and the cost is the same.

The initial formulation contained National Lead Co.'s M-50 basic lead silico chromate pigment to inhibit corrosion. In this color, as in the V54 Black, loss of dry potential and hard settling were apparent after one month storage. Reformulation replaced the M-50 with zinc oxide and overcame these deficiencies.

Sag resistance in the aluminum was gotten by the use of a relatively high level of W-98 Talc extender. This coupled with the low aluminum level resulted in a paint having excessive brush marks and low brilliance. Revision of this formula to a much lower talc level and a slightly higher aluminum paste level gave noticeable improvement but the brilliance or metallic sheen was still inferior to standard alkyd or phenolic aluminum paints.

7025-5006 Hull & Super Structure White

Code	Material	Lbs./100 Gals.
CP-502	V54 o-Phthalate	320.00
CP-503	V54 Itaconate	320.00
KH-5962	Lead Butyl Phthalate	47.40
W-19	Zinc Oxide	72.60
W-93	Titanium Dioxide	378.00
W-12	Barytes	252.50
W-98	Talc	90.50
KH-5922	Cobalt Butyl Phthalate	14.20
KH-5948	Anti-Skinning Agent	.14
7025-5002	V54 Black	1.25
H-596	Hydrocarbon Solvent	12.41
		1509.00

Properties	
Gal. Wt.	15.09
Pig. Vol. Conc.	24.6
Solids, %	
Wt.	97.0
Vol.	94.0
Gloss (60°)	70
Sag (DFT)	8-10 mils
Dry (77°F)	16 hrs.

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The V54 H & S White used the pigmentation of the "Dulux" H & S White D-210 with zinc oxide added for corrosion inhibition. Shading was carried out with V54 Black.

The pigmentation used for sag resistance was a mixture of talc and barytes in which the high oil absorption of the talc was the critical factor. The level of talc was maintained at a minimum to keep the gloss as high as possible. This formulation lost sag resistance on storage and showed bad rust staining in field testing on the hull of the S/S Constitution.

7025-5007 Non-Chalk Type White

Code	Material	Lbs./100 Gals.
CP-502	V54 o-Phthalate	320.00
CP-503	V54 Itaconate	320.00
KH-5962	Lead Butyl Phthalate	47.40
W-19	Zinc Oxide	72.60
W-93	Titanium Dioxide	378.00
W-12	Barytes	252.50
W-98	Talc	90.50
KH-5922	Cobalt Butyl Phthalate	14.20
KH-5948	Anti-Skinning Agent	.14
H-596	Hydrocarbon Solvent	12.66
		1508.00

Properties	
Gal. Wt.	15.08
Pig. Vol. Conc.	24.6
Solids, %	
Wt.	97.0
Vol.	94.0
Gloss (60°)	70.0
Sag (DFT)	8 mils
Dry (77°F)	16 hrs.

The formula for this color was the formula for the Hull & Superstructure White without shading. This was done in order to reduce development time and the number of intermediate bases needed for the V54 color line.

Later work resulted in a revision of this formulation but the basic principles remained the same. The revised base was incorporated into the Gray and the Hull & Superstructure White.

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IV. Field Testing

The initial limited field testing of the V54 One Coat Finishes brought out the following deficiencies:

1. Low gloss (lower than 25 or 28-Line)
2. Long open time
3. Excessive brush marks - especially with Aluminum and Gray-Green.
4. Loss of sag resistance on storage.

Inspection of the field tests in 1961 and six months later showed the V54 One-Coat Finishes to be generally failing due to cracking and peeling. Although some tests were exhibiting good performance, a majority were failing. In addition to the cracking and peeling failure there was excessive rust staining and loss of gloss with these systems which gave them a very poor appearance compared to standard products of the same exposure age.

A list of representative field tests is given along with the inspection results in Table I.

EXPERIMENTAL DETAILS:

A. Materials

All V54 esters used complied with specifications. All other materials were either commercial standard materials or Du Pont coded materials.

B. Procedures

1. Drying Time Studies

The standard test was "dry to touch". The drying time specification for these paints was 16 hours maximum at 77°F/ 50% R.H. The cobalt level used to give this drying time was 0.05% based on vehicle solids in the Aluminum and 0.075% in all other colors. Lesser amounts gave good initial dry times but 0.075%cobalt allowed for some drier absorption on aging.

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2. Wrinkling

Wrinkle resistance was tested using a doctor blade which gave a dry film thickness of 2.0 to 8.0 mils. A drawdown on glass was allowed to dry in the CTR, the dry film peeled from the panel and the thickness measured for the maximum wrinkle freedom. Work in the later stages made use of the Shell Sag Blade in which 1/4" wide openings in a doctor blade are graduated from 2-8 mils in 1 mil steps and from 8-20 mils in 2 mil steps. The thickest film free of wrinkling was stripped from the panel and measured with a micrometer.

3. Sag Resistance

Sag resistance was determined using the Shell Sag Blades previously described. A drawdown was made on glass and the panel placed in a vertical position. Sag resistance is easily seen and the dry films (1/4" x 6") can then be stripped, with a razor blade and their thickness measured with a micrometer.

4. Gloss

Gloss was measured at 60° using the standard glossmeter in the Constant Temperature Room. Panels for gloss determination were normally prepared by brushing since this is the most severe condition commonly met in the field. Panels prepared by spraying usually give higher gloss readings than those prepared by brushing.

5. Application Properties

Application properties were determined by brushing on cold rolled steel panels to a wet film thickness of 6-7 mils. Spray application was not normally used in the laboratory since only air spray is available and air spray is used in the field only in conjunction with high pressure pot feed systems.

6. Storage Stability

The normal procedure was to simply store cans on the shelf in the laboratory and examine at periodic intervals. In one instance however, extreme measures were resorted to and gallon cans of the Aluminum and Black formulas were shipped to South San Francisco by truck and returned by rail. This was done because of the difficulty encountered in a field test in Louisiana with material less than one month old. When reformulated the new paints were tested by shipping as well as by Travelometer and shelf storage.

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7. Field Testing

The field tests were arranged by the V54 Market Development Group through Sales. The materials for field testing were prepared in the laboratory or in production equipment depending on the timing and quantity.

A list of typical field tests is given in appended Table I. This is not a complete listing but is intended only to show representative tests. The results of these representative field tests show the deficiencies that made these initial formulations unacceptable.

LAH:dk

DUP030009675

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2. "V54 Maintenance Paint White Topcoats", Exposure Study Series #18574.

DUP030009676

TABLE I

V54 TOPCOAT/ONE COAT FIELD TESTS

Color	Primer	Structure and Conditions	Months Age	Performance
T. White	None	St. Tank M. Corr.	8	Some rust staining. Cracking & flaking from old paint and metal.
T. White	V54 ZC	St. Tank M. Corr.	7	Cracking & peeling. No corrosion.
T. White	Old Alk.	St. Tank M. Corr.	12	Severe cracking.
Black	None	Struct. Steel	12	Rust and corrosion.
	V54 RL	Mod. Corr.	12	Corrosion OK.
Black	None	Struct. Steel	14	Wrinkled-equal control.
Black	None	Struct. Steel High Corr.	20	Peeling from old paint.
Gray	V54 RL	Fan Cooler High Corr.	11	Considerable corrosion failure. Severe rust staining.
Gray	V54 RL	Struct. Steel High Corr.	9	Inside - Good. Outside- Topcoat peeling.
Gray	None	Water Tank	9	Excellent-no failure.
	V54 RL	" "	9	Excellent-hard & adherent.
Gray	None	Insul.Tank	9	Adhesion good to aged alkyd.
	V54 RL	Stor. Tank	9	Appearance & adhesion good.

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Table I
(Continued)

Color	Primer	Structure and Conditions	Age	Performance
Gray Green	None V54 RL	Stor. Tank " "	11 11	Low gloss. Otherwise satisfactory.
Gray Green	V54 RL None	Struct. Steel Mod. Corr.	9 9	Cracking & peeling. Edge rusting. No peeling.
Gray Green	V54 RL	Struct. Steel Med. Corr.	9	No corrosion. TC chippy to primer.
Aluminum	V54 RL None V54 RL	Bridge Girder Mildly Corrosive	12 12	Appearance & adhesion OK. Appearance of V54 Alum. has improved since six months.
Aluminum	PPG None	Light Stds. Mild Corr.	4	Basically OK. Long dry time unacceptable.
Aluminum	None	Wire Fence Mild Corr.	6	Slow dry unacceptable. Low brilliance.
Aluminum	None	Heat Exch. Mild Corr.	6	Adhesion OK. Not as stained or dirty as control but dull.
Aluminum	V54 RL	Bridge Mild Corr.	12	Very dull.
H & S White	None V54 RL	Ship Hull Sev. Corr.	1	Severe rust stain.
N.C. White	V54 RL	Roof Mild Corr.	9	Topcoat adhesion chippy.
N.C. White	V54 RL	Tank Sphere Mild Corr.	9	Poor appearance-initial & retained adhesion is fair.
N.C. White	PPG	Tank Sphere Mild Corr.	8	Appearance poor-dirt & rust stain.
Fol. Green	None V54 RL	Bridge Curb Mild Corr.	15 15	Cracking & peeling. Good adh. to primer.

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