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WADC TECHNICAL REPORT 55-258

(U) INVESTIGATION OF PROTECTIVE COATING TO DECREASE VULNERABILITY OF AIRCRAFT TO THERMAL RADIATION (u)

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April 1956

MATERIALS LABORATORY
CONTRACT NO. AF 33(616)-2317
PROJECT NO. 7312
TASK NO. 73121

JAN - 2 1957

WRIGHT AIR DEVELOPMENT CENTER
AIR RESEARCH AND DEVELOPMENT COMMAND
UNITED STATES AIR FORCE
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

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55WCRT-1349

FOREWORD

This report was prepared by the Vita-Var Corporation under USAF Contract No. AF 33(616)-2317. This Contract was initiated under Project No. 7312, "Organic Protective Coatings", Task No. 73121, "Thermal Radiation Resistant Coatings", and was administered under the direction of the Materials Laboratory, Directorate of Research, Wright Air Development Center, with Mr. R. L. Stout acting as Project Engineer. This report covers work conducted from April 1954 to April 1955.

The authors wish to express their appreciation for the close cooperation given by the Optics and Nucleonics Branch of the Naval Materials Laboratory, Brooklyn, New York, without whose close support in the evaluation of the critical thermal energies this report would not have been possible.

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ABSTRACT

The purpose of this investigation, which was to strive to develop a coating to reduce the vulnerability of aircraft to thermal radiation, has to a large extent, been accomplished.

Eighteen typical organic resins and resin combinations have been evaluated for resistance to thermal radiation and for general paint performance.

Three different white pigments, and one extender pigment, have been evaluated for resistance to thermal radiation.

Of the vehicles or resins tested, silicone-alkyd copolymers, vinyl toluene modified epoxy esters, catalyzed epoxy resin and epoxy esters of fatty acids have been found to be outstanding.

Of the pigments tested, titanium dioxide has been determined to be the most suitable prime pigment, and probably should be used in combination of zinc oxide. The sole extender pigment tested, calcined clay, has been found to contribute considerably to thermal resistance properties.

The recommended finishing systems based on this work are formulated containing silicone-alkyd copolymer as the vehicle and titanium dioxide with calcined clay as the pigment component. The pigment volume concentration for optimum thermal resistant properties of 60% is used in these formulations. These formulations have been identified by the numbers PV-6 and PV-7.

A limited amount of work is described on the development of an improved primer. The work on the primer is insufficient for any definite recommendation.

Complete formulae for all the coatings and primers are shown in Appendix A.

PUBLICATION REVIEW.

This report has been reviewed and is approved.

FOR THE COMMANDER:

M. R. WHITMORE
Technical Director
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INTRODUCTION

When aircraft are exposed to the thermal effect of an atomic blast, the surface of the aircraft is heated at a rapid rate, the exact extent depending on a number of external factors such as distance from the blast, bomb design and absorptive conditions of the atmosphere. There are also a number of internal factors such as surface reflectivity, insulation and thermal properties of the coating and the geometry of the structure.

If the exposed surface is close enough to the blast, the more flammable materials such as doped fabric will burst forth into flame and other less combustible organic materials will char. Such charring increases the rate of absorption of radiation consequently increasing the rate of temperature rise.

Unpainted aluminum alloy skins are capable of absorbing enough heat to wrinkle the skin due to mechanical stresses induced by uneven temperature. Unpainted magnesium alloy would be even more greatly affected due to the lower reflective properties of this metal.

By experiment, some white paints have been shown to afford some measure of protection. However, this field, as far as is known, has not up to this time, been systematically explored.

This project is concerned with a systematic study of paint formulation so as to produce a practical coating for aircraft having the highest attainable capacity for the dissipation of thermal radiation while retaining, as far as possible, the normal functional properties of a protective coating for aircraft.

In addition to thermal properties, it is desirable that the proposed coating be designed to meet the following general requirements:

(1) Shall be air drying and suitable for spray application
(2) Shall have good adhesion to primed and unprimed alclad aluminum and magnesium
(3) Shall exhibit good flexibility properties at normal and low temperatures.
(4) Shall be resistant to water and hydrocarbons
(5) Shall possess good weathering properties, particularly color retention.

It was planned to conduct a screening study of various vehicles or binders and concurrently study the effect of various logical white pigment combinations. With the information obtained from this work, a study of pigment volume concentration was inaugerated utilizing the indicated pigments with the more promising vehicles.

Although the formulation of improved primers was not a part of the purpose of this contract, it became apparent, as the work progressed, that modification of the primer might be of considerable value. Therefore, a limited amount of work on primer composition has been included in the project.

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SECTION I

TEST METHODS

PREPARATION AND PRETREATMENT OF PANELS

A. Aluminum Panels

Early in the work, anodized aluminum panels (Clad 24-S) .016" in thickness, conforming to Specification QQ-A-362, were used to prepare test specimens. However, it was found that the anodizing interferred with electrical conductance so that it was not possible to obtain reliable thermal data in the Navy Searchlight test. At the direction of WADC, therefore, the anodizing was eliminated.

B. Magnesium Panels

Magnesium test panels (Magnesium Alloy FS-1) .016" in thickness, conforming to Specification QQ-M-44, were used to prepare test specimens. All magnesium panels were treated with Dow #7 pretreatment in accordance with Specification MIL-M-3171, Type III.

The panels were solvent cleaned with toluene prior to application of the primer coat.

The uncoated side of the magnesium panels were sanded to remove the Dow #7 pretreatment in order to provide electrical conductivity for measuring specific temperature rise.

C. Primer Coat

Both metals, aluminum and magnesium, were coated with primer, zinc chromate for aircraft use, in accordance with Specification MIL-P-6889A, Type II dated 30 October 1950. Both metals were dip coated.

The primer was reduced with xylene for dip application to obtain a 0.25 to 0.5 mil dry film thickness. The primer was air dried for a minimum of 24 hours prior to application of the finish coat to be tested.

D. Finish Coat

The primed aluminum and magnesium panels were both coated by dip application with the experimental finish coat to be tested. Total film thickness on the aluminum was controlled at 2 mils plus or minus .2 mil. Because of the additional primer coat on magnesium, the total film thickness was controlled at 2.5 mils plus or minus .2 mil. The finish coats were allowed a minimum of 48 hours air drying time before preparation of the test discs.

E. Application of Coatings

All coatings were applied by dip application. It was determined by laboratory tests that the most uniform film thickness could be obtained by means of the dipping method. The coatings were reduced with

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thinners to a suitable consistency to give the best working properties and also to provide the required dry film thickness.

The coatings were dipped by means of a Payne automatic dipping apparatus. The rate of withdrawal was varied accordingly to compensate for the inherent physical properties of the particular coating being applied.

F. Film Thickness

The thickness of the applied films, both primer and experimental finish coats, were measured by means of a Filmeter, manufactured by American Instrument Company, Inc.

Readings were taken on both primer and finish coat. These readings were made at several points in the central area of the test specimen.

G. Method of Test

The film properties of the experimental finish coats were tested in accordance with MIL-E-7729, Type I, Enamel, Gloss for Aircraft use. For purposes of expediting the evaluation and screening out of inferior films, a number of tests have been omitted, and modifications have been made on some of the test methods which have been selected.

H. Drying Time

The test for drying was made in accordance with Specification TT-P-141B, Method 406.1.

A drawdown of the material on a cleaned plate glass to a wet film thickness of approximately .0015 inches was made, placed in a horizontal position, and allowed to dry under ordinary laboratory conditions. The film was observed for the following states of drying:

(1) Set to touch
(2) Dust free
(3) Dry Hard
(4) Full hardness

I. Flexibility

The coating to be tested was applied to a flat tin panel by dip method to a dry film thickness of 1.0 plus or minus .2 mil. The film was air dried at room temperature for 24 hours. It was then baked for 48 hours at 220°F and conditioned for 1/2 hour at room temperature. The panel was then bent over a 1/8 inch mandrel and examined in a strong light for cracks over the area of the bend.

J. Specular Gloss

The test for gloss was conducted in accordance with Specification TT-P-141b, Method 610.1. The sample to be tested was drawn down with a doctor blade having a set clearance of 0.006 inch to yield a dry film

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thickness of approximately 0.003 inch on a glass panel. Measurements were made with a Gardner Laboratory 60° Glossmeter after the panel had been dried for 48 hours at room temperature.

K. Water Resistance

The coating to be tested was applied to a flat unprimed aluminum panel by dip method to a dry film thickness of 1.0 plus or minus 0.2 mil The film was dried for 48 hours at room temperature before immersion. The panel was then immersed in distilled water to a depth corresponding to two-thirds of the height of the painted surface for a period of 16 hours.

Immediately upon removal of the panel, it was examined for wrinkling and blistering. Two hours after removal, the panel was examined again to observe the extent of recovery.

L. Hydrocarbon Resistance

The coating to be tested was applied to a flat unprimed aluminum panel by dip method to a dry film thickness of 1.0 plus or minus 0.2 mil. The film was dried for 48 hours at room temperature before immersion. The panel was immersed in hydrocarbon test fluid conforming to Specification MIL-H-3136, Type III, to a depth corresponding to two-thirds of the height of the painted surface for a period of 4 hours.

Immediately upon removal of the panel, it was examined for blistering, wrinkling or other film failure. Twenty-four hours after removal the film was examined for extent of recovery.

M. Accelerated Weathering

The coating to be tested was applied to a primed aluminum panel to a dry film thickness of 1.0 plus or minus 0.2 mil and allowed to air dry for 48 hours. The panels were then exposed in a National Carbon Weather-ometer for a total of 300 hours, after which they were examined for film failure.

N. Anchorage

The coating to be tested was applied over a primed aluminum panel to a dry film thickness of 1.0 plus or minus 0.2 mil, and air dried for 24 hours. It was then baked for 48 hours at 220°F. After removal from the oven, the panel was conditioned for 1/2 hour at room temperature, after which flexibility and toughness was determined by cutting a narrow ribbon of the film loose from the panel by means of a knife blade held at an angle of about 30°.

Observations were made to determine whether the film could be cut loose in the form of a ribbon without flaking or chipping.

O. Critical Energy and Specific Temperature Rise.

The critical energy and specific temperature rise data were compiled in the Naval Materials Laboratory at Brooklyn. These data were determined by means of the Searchlight test on specimens prepared in the laboratories of the Vita-Var Corporation.

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The method used by the Naval Materials Laboratory is described below:

1. Source of Radiation

The source employed for the exposure of the paint specimens to intense thermal radiation consists essentially of a carbon arc and two parabolic reflectors, one to collimate the radiation, the other to focus the collimated rays upon the sample. The source is operated at 80 volts and 150 amperes. The condensing mirror, placed coaxially with the collimating mirror and of the same size and shape as the latter, focuses the collimated beam upon the paint specimen which is mounted in a holder of glass silicone laminate.

The irradiance of the source at the receiving focal plane is 60 cal/cm^2 sec. over the 9 mm area employed. To attenuate this irradiance to the desired levels, attenuating screens were employed in the path of the collimated beam. The exposure time was controlled by means of a knife-bladed shutter which is activated by an electronic timer and an energized solenoid.

2. Measurement of Temperature Rise

The temperature rise of the unpainted rear surface of the specimens was determined by means of iron-constantan thermocouples (No.30), pressed against the metallic surface, connected to a recording ("Speedomax") potentiometer. The potentiometer measures and records the electromotive force of the thermocouples which is generated as a result of the temperature rise of the metallic surface. From the electromotive force determined, the temperature rise of the specimens is computed in a conventional manner.

The Spectrophotometric data were obtained on specimens prepared by the Vita-Var Corporation Laboratories, and tested at Wright-Air Development Center, WPAFB, Ohio, in accordance with the methods described in Appendix D.

For all of the testing excepting exterior exposure, including those sent to WADC, 3" x 5" x .016" panels were used. For exterior exposure the panels used were 5" x 12". 130 discs, 9 millimeters in diameter, were punched from the 3" x 5" panels, and submitted to the Naval Materials Laboratory for each of the searchlight tests.

SECTION II

VEHICLES

Eighteen typical resinous binders and/or combinations have been compounded with titanium dioxide and evaluated for resistance to thermal radiation. The various vehicles tested are listed below:

1. Soya Modified Alkyd
2. Pure Silicone Resin
3. Silicone-Alkyd Copolymer
4. Vinylidene Chloride - Acrylonitrile
5. Vinyl Chloride - Acetate Copolymer
6. Cellulose Acetate - Butyrate
7. Acrylic Polymer
8. Plasticized Nitrocellulose
9. Oil Plasticized Phenolic Resin
10. Catalyzed Epoxy Resin
11. Alkyd Plasticized Catalyzed Urea-formaldehyde
12. Epoxy Ester
13. Alkyd Silicone blend
14. M. W. Kellogg X200
15. Vinyl Toluene Modified Ether-Ester
16. Polyester - Toluene diisocyanate
17. Combination of Silicone Resin with Acrylic Polymer
18. Special Kel F Elastomer Gum

With two exceptions, all of the above resins were compounded with titanium dioxide at a ratio of 50% non volatile resin to 50% pigment. The M. W. Kellogg X200 and the Vinyl Toluene Modified Ether-Ester were tested later in the work when it had become apparant that higher pigment volume concentration was desirable. The two latter binders were, therefore, tested at what was considered their optimum pigment volume concentration. Hereafter referred to as P.V.C.

Formulations A-1 through A-3 are based on a soya modified alkyd prepared in this laboratory. This series was prepared to determine whether different performance might be expected from different grades of titanium dioxide. A-1 contains non-chalking type rutile titanium dioxide. A-2 contains medium chalking type rutile and A-3 contains free chalking anatase titanium dioxide. Reference to Table I will show that there is little or no difference in the performance of the three different grades of titanium dioxide pigment samples when exposed to the searchlight test. From the standpoint of probable exterior durability and economy, it was decided to use the non-chalking rutile as the standard pigment for screening the remaining resinous binders.

The pure silicone chosen for evaluation was General Electric's SR82. This resin was used in formulation A-4. While this appeared to dry to touch, it was found impossible to cure the film under atmospheric conditions, as the film remained so soft and pressure sensitive that test specimens could not be prepared. The pure silicone was therefore discarded. Several attempts were made to modify the silicone resin to improve this condition. In A-15 the silicone resin was modified with 20% of acrylic

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polymer and in A-16 with 30% of the same acrylic polymer. In formulation A-20, the silicone resin was modified with 30% of epoxy resin (Shell 864) and in A-21 30% of a second epoxy resin (Shell 834). None of these modifications provided films suitable for the preparation of test specimens for the searchlight test. This line of approach was, therefore, abandoned.

Formulations A-5 and A-19 contain silicone-alkyd copolymers as the binder. The former is made with Plaskon ST873 and the latter with Dow Corning 807. Reference to Table I will show that these two materials were approximately equal for Critical Energy values. The Dow Corning resin was somewhat superior for specific temperature rise.

Table I will show that the silicone-alkyd copolymers gave better results in the searchlight tests than most of the other resins tested. This is particularly true of the A-5 formulation at the higher intensity of irradiance (45 cal/cm^2/sec). The need for further study of this type vehicle is definitely indicated by these results. Furthermore, a study of Table III will show that the film properties of both A-5 and A-19 are sufficiently good so that good exterior durability can be expected.

The results for A-6, A-7 and A-8 show the thermal properties for Vinylidene Chloride-Acrylonitrile Copolymer, Vinyl Chloride-Acetate Copolymer and Cellulose Acetate-Butyrate respectively. It will be seen that these polymers, in general, gave results almost equal or inferior to those reported for the oil modified alkyd resin.

Because it was listed in the contract as one of the binders to be tested, nitrocellulose was included in this screening series. Formulation A-11 contains nitrocellulose plasticized with a non-drying oil modified alkyd. The searchlight test results shown for this formulation in Table I are surprisingly good. However, in view of the well known property of nitrocellulose to violently decompose under heat, it is doubtful whether further work with this material would be worth while.

Exhibit A of the contract requires that a phenolic resin be evaluated. To fulfill this requirement, formulation A-12 was prepared. Since it would be impractical to formulate with a phenolic without plasticizer, a 25 gallon varnish was prepared using a para phenyl-phenol formaldehyde resin (Bakelite 254) cooked with equal parts of tung and alkali refined linseed oil. Reference to Table I will show relatively good results for A-12 when exposed to the searchlight test. However, Table III which gives results on general paint performance shows considerable yellowing on exposure to artificial weathering. This is what might be expected from a phenolic vehicle and it can probably be assumed that this after yellowing would detract sufficiently from the reflective properties to detract materially from the ability to reflect thermal radiation.

A-13 shows the effect of using a combination of an epoxy resin (Shell 1001) with a urea formaldehyde resin and catalyzed with ethylene diamine. It will be seen from Table I that, while not quite as good as the silicone-alkyd, the results are sufficiently good to warrant further attention.

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A-14 was formulated to evaluate a plasticized urea formaldehyde resin. The urea resin was plasticized with an alkyd and was catalyzed with a proprietary acidic catalyst just prior to application. Reference to Table I will show that while this formulation gave fairly good results, it was not sufficiently outstanding to merit further consideration.

Formula A-18 is based on an epoxy ester of soya fatty acids. This vehicle is a half ester. That is, it contains one-half of the fatty acid equivalents theoretically required to completely esterify the hydroxyls of the epoxy resin. The epoxy resin used is Shell Chemical #1007. Reference to Table I shows this vehicle to be among the outstanding resins tested in the searchlight test. Table III will show this coating to have good general paint properties, with the exception of a slight chalking tendency.

Past experience has also shown this type of vehicle to give very good exterior durability and chemical resistance. Further work with the epoxy type resins is clearly indicated.

As mentioned earlier, several attempts were made to modify the pure silicone resin SR82 in order to obtain a sufficiently cured film for satisfactory coating performance. Later in the work the resin supplier recommended that it be modified with a special proprietary alkyd resin. A-22 is such a formulation containing 60% silicone resin and 40% of alkyd resin (GE #2520 Glyptal). Table III shows this coating to have produced a fairly satisfactory film although it is fairly brittle as shown by the flexibility test and is somewhat susceptible to water immersion. However, reference to Table I will show that the resistance to thermal decomposition is excellent as indicated by the critical energy value. For some reason the specific temperature rise is higher than some of the better performing resins tested. It is doubtful that it would be of value to investigate this vehicle combination further.

The vehicle used in A-25 is a combination of a poly ester resin with toluene diisocyanate. The poly ester is made by esterifying trimethylol propane with adipic acid and phthalic anhydride with subsequent polymerization. Table I shows this vehicle to have excellent resistance to thermal radiation. The general paint performance properties can be expected to be good in view of the results reported in Table III. An important disadvantage in the possible use of this type of coating lies in the fact that it must be supplied as a two package system since it is quite unstable after the poly ester and diisocyanate have been mixed, and has a limited pot life. The two components, therefore, must be combined immediately prior to application.

As explained earlier, A-23 and A-24 were prepared near the end of the work. At this time information had been compiled on the effect of increased pigment volume concentration, and on the use of calcined clay. The earlier formulations had been designed to contain 50% titanium dioxide and 50% vehicle solids. This ratio results in a pigment volume concentration of approximately 21%, with some minor variations dependent on the density of the resin involved. A-23 and A-24 are designed as exploratory evaluation formulations using the best available information at the time of their formulation. A-23 contains M. W. Kellogg X200 as

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the binder. The binder contained in A-24 is a vinyl toluene modified ether ester furnished by WADC under the number XOR-7*. This vehicle is described in WADC Technical Report 54-373, Page 124D, Paragraph 3.

Reference to Table I shows outstanding results for both M. W. Kellogg X200 and XOR-7 vehicle in the thermal radiation test.

Table III shows that except for some lack of flexibility as shown by the hairline cracking reported, the WADC vehicle could be expected to give good coating performance.

The vinyl toluene modified epoxy ester then certainly merits further consideration. Because of economy and availability problems, it is questionable whether any further work should be planned for the M. W. Kellogg X200.

Of the group of resins tested and reported, five stand out as having good thermal properties and general performance properties sufficient to assume that practical aircraft finishes could be developed. These include the following:

1 Silicone - Alkyd Copolymers

2 Catalyzed Epoxy Resins

3 Epoxy Esters

4 Vinyl Toluene Modified Epoxy Esters

5 M. W. Kellogg X200

Of the five polymers listed above, it is probable that the M. W. Kellogg X200 should be eliminated for reasons of economy and availability.

All of the searchlight test results on the vehicles tested, as determined by Naval Materials Laboratory, as shown in Tables I and II. The accelerated paint performance test results on the vehicles are shown in Table III.

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* Sherwin-Williams Company

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SECTION III

PIGMENTS

Concurrently with the study of vehicles, a study of pigments was conducted. Since the maximum reflectance was required, it is obvious that the pigment or pigments chosen would be white. It was believed that since brightness and opacity were prerequisite, titanium dioxide would be the indicated pigment. However, since the field of the current investigation was little known, it was decided to include in part two additional hiding pigments in the study. These pigments are antimony oxide and zinc oxide. Because the opacity of titanium dioxide would obviously be required to attain the objective, it was included to a greater or less extent in all of the pigment experiments.

Formulae PE-1, PE-2 and PE-3 were designed to show the effect of replacing 10%, 20% and 30% respectively, of Ti O^2 in formula A-1 and adjusting to a constant PVC of 21%.

It will be noted from Table IV that PE-1 which contains 10% zinc oxide is a definite improvement over the control for both critical energy and temperature rise. The control used in this formulation is A-1. PE-2 containing the 20% substitution of zinc oxide is about equal to PE-1. However, PE-3 containing the 30% substitution of zinc oxide shows no substantial improvement over the control. From these results, it appears that there is an optimum level of zinc oxide in the neighborhood of 10% which contributes to resistance to thermal radiation.

Reference to Table V will show that the zinc oxide has improved resistance to hydrocarbon and also, to some extent, gloss retention. However, as might be expected, it has decreased flexibility as shown by cracking on the mandrel flex test.

In formulations PE-4 and PE-5 the titanium dioxide was held constant at a ratio of 1-1 to the vehicle solids and zinc oxide loaded at 50% and 200% levels based on the titanium dioxide content. This was done to determine the effect on thermal properties when zinc oxide comprised a major part of the film.

It will be seen from Table IV that no significant benefit is obtained from the high loading of zinc oxide.

The same procedure as outlined for zinc oxide was followed to evaluate antimony oxide. PE-6, PE-7 and PE-8 represent 10%, 20% and 30% antimony oxide respectively. In each case the pigment volume concentration was adjusted to 21% by manipulation of the titanium dioxide concentration. In PE-9 and PE-10 the titanium dioxide was held constant as outlined for the zinc oxide series and antimony oxide loaded at levels of 50% based on titanium dioxide content in the case of PE-8, and 200% for PE-10.

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Table IV shows that no significant benefit is obtained at any level of antimony oxide loading. PE-6 and PE-7 show some improvement for critical energy but no advantage in specific temperature rise. From these results it is evident that antimony oxide offers no advantages for the purposes of this project.

Since this laboratory has had some experience in the incorporation of ceramic frits in organic and semi organic coatings to achieve heat resistance, two formulations were prepared containing such materials. Formulation PE-11 contains a frit having a fusion range of 900°F - 950°F, while PE-12 contains a higher melting frit with a fusion range of 1300°F - 1400°F. It was thought possible that these frits might provide sufficient insulation properties to contribute to reduction of specific temperature rise. The vehicle chosen for these experiments was the silicone-alkyd copolymer (Plaskon 873) which had given good thermal results in the vehicle screening series in formulation A-5.

Reference to Table IV will show no advantage in the incorporation of the ceramic materials. PE-11 gave a specific temperature rise of 9.1° C/cal/cm^2 and PE-12 of 8.5°C/cal/cm^2. Formulation A-5 which contained no frit allowed temperature rise of 8.2 calories at approximately equal irradiance. In view of these results, the ceramic materials have been given no further consideration.

Formulations PE-13 and PE-14 were designed to evaluate the three major types of titanium dioxide pigment in one of the more heat resistant vehicles. PE-13 contains the medium chalking type rutile titanium dioxide, while PE-14 contains the free chalking anatase pigment.

Formulation A-5 which contains the non chalking rutile type pigment is included in the comparison. The vehicle in all three coatings is the silicone-alkyd copolymer Plaskon ST 873.

Reference to Table IV will show the anatase to be inferior in critical energy value. This might be expected due to the known fact that anatase is less opaque than rutile. The difference of 0.8° C/cal/cm^2 in specific temperature rise of the two types of rutile may or may not be significant. It will be noted that these two specimens have been tested at a single level of irradiance and A-5 was subjected to 9.7 cal/cm^2 while PE-13 received only 8.6 cal/cm^2. In order to draw conclusions, these coatings should be tested over a much wider range of irradiance.

It will be noted from Table V that all three of these formulations gave good results in the laboratory tests for general paint performance. It will be further noted that, as might be expected, the coating containing the anatase pigment PE-14 has begun to chalk after 300 hours of artificial weathering. The medium chalking type rutile shows slight loss of gloss while the coating containing the chalk resistant pigment, formula A-5, has retained its gloss.

Exhibit A of the contract directed that ceramic grade titanium dioxide be used in this work. It was the opinion of this laboratory that

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use of this grade of pigment would not produce a practical surface coating. Notwithstanding, an experimental coating was attempted using the ceramic pigment in the soya alkyd vehicle (formula A-10). This combination gelled to a rubbery mass in the process of dispersion in the porcelain ball mill. The ceramic grade titanium was, therefore, given no further consideration.

From the results reported, it becomes evident that the proper hiding pigment for continuance of the work should be rutile titanium dioxide. It is probable that zinc oxide should be included at the approximate level of 10% of total pigment.

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SECTION IV

VARIATION IN PIGMENT VOLUME CONCENTRATIONS

Exhibit A of the contract provides for the preparation and testing at two pigment levels in addition to the original 50% pigment - 50% resin ratio. These have been calculated in terms of pigment volume concentration (P.V.C.) Formula PV1 was prepared at a P.V.C. of 40% and PV2 has a 60% pigment volume concentration. The original 50-50 weight ratio is equivalent to approximately 21% P.V.C. All three of these contain titanium dioxide as the sole pigment. Since preliminary thermal radiation results indicated the silicone-alkyd copolymer to be outstanding, this resin was chosen as the vehicle for these experiments. Although some advantage was shown for the incorporation of zinc oxide in Section III, this pigment could not be used because the resin used is unstable in the presence of zinc oxide.

Reference to Table VI shows no improvement in the increase in P.V.C. from 21% to 40%. However, PV2 with a P.V.C. of 60% shows a decided improvement both in critical energy for failure and specific temperature rise.

Reference to Table VII shows that as the pigmentation is increased there is a tendency toward embrittlement as shown by cracking in the mandrel test. However, it does not necessarily follow that a less flexible film would have unsatisfactory durability since PV2 is in relatively good condition after 300 hours of artificial weathering.

Since such dramatic improvement was obtained in going from 40% P.V.C. to 60% P.V.C. it was decided to formulate a third variation at 70% P.V.C. Formula PV-3 was prepared for this purpose. This formulation is definitely over pigmented producing a chalky film of poor integrity.

Based on the results obtained at 60% P.V.C. with the silicone-alkyd copolymer and, in view of the fact that good results were obtained in the vehicle study using the catalyzed epoxy resin, PV4 and PV5 were prepared to evaluate that vehicle at 60% and 70% P.V.C. respectively.

The vehicle, in each case, was Shell Chemical's XA-200 formulation.

Both PV4 and PV5 proved to be unsatisfactory coatings being formulated for over the critical P.V.C. for the epoxy vehicle. The pigment volume was then reduced to 45% in PV8. This, too, proved to be overpigmented since the film showed hairline cracking on drying.

It was found possible to formulate a reasonably satisfactory coating using the catalyzed epoxy vehicle at a P.V.C. of 40%. This was accomplished with formulation PV12. However, Table VI shows PV12 to be considerably inferior to PV6 both for critical energy for failure and specific temperature rise. It can be concluded, then, that the silicone-alkyd at its highest practical P.V.C. is superior to the XA-200 catalyzed epoxy vehicle at its highest practical P.V.C.

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Since it had been established that higher P.V.C. with titanium dioxide had produced superior results, experiments were designed to determine the effect of the incorporation of an extender pigment replacing a part of the titanium dioxide at a P.V.C. of 60%. PV6 and PV7 were made for this purpose. In PV6 the titanium dioxide was held at a level arbitrarily considered optimum for hiding and the P.V.C. adjusted to 60% using a special calcined clay (Whitetex) which was chosen for its thermal and chemical stability. In PV7, to determine the effect of increased opacity together with the incorporation of clay, the titanium dioxide was increased 33% over PV6 and the P.V.C. adjusted to 60% with the clay.

Table VI shows an improvement in specific temperature rise for PV6 and PV2, and an improvement for PV7 over PV6. The clay, then, does have a beneficial effect in reducing temperature rise and the added opacity in the PV7 apparently tends also to reduce temperature rise. However, no positive conclusions can be drawn until these coatings have been tested over a wider irradience range.

In Table VII it will be found that both PV6 and PV7 gave reasonably good results in the general paint performance testing with the exception that both showed slight cracking in the flexibility test.

However, reference to Table XI will show that neither PV6 or PV7 showed any failure after 500 hours of accelerated weathering. From past experience, this would indicate durability of at least one year under normal atmospheric conditions.

Since the higher pigment loadings as demonstrated by PV2 and PV6 and PV7 showed lack of flexibility, and PV1 at 40% P.V.C. did not, it was decided to investigate the effect of reducing pigment loading so as to explore the region between 60% P.V.C. and 40% P.V.C. To accomplish this, a series of five coatings were prepared and tested. PV9 and PV10 utilize titanium dioxide as the sole pigment and may be compared directly with PV2. PV9 is formulated at 50% P.V.C. and PV-10 at 55% P.V.C. The data in Table VI indicate a slight sacrifice in thermal properties when compared to PV2. Comparisons of the data in Table VII indicated no substantial gain in film flexibility. It is apparent, then, that compromise downward in P.V.C. would offer no advantage over the PV2 formulation either in thermal properties or flexibility.

The series of formulations PV14, PV15 and PV16 represent an attempt to reduce pigment volume to a level below that of PV6 using a combination of titanium dioxide and clay but reducing the P.V.C. to 55% in the case of PV14 and to 50% and 45% respectively for PV15 and PV16.

Comparison of the results on PV14, PV15 and PV16 in Table VII will show that when the P.V.C. is decreased to 45% as in PV16 it becomes possible to pass the mandrel test for flexibility. However, it is demonstrated in Table VI that the critical energy value for failure drops and the specific temperature rise increases for the 45% P.V.C. formulation. It would appear advantageous then to remain in the area of 50% - 60% pigment volume concentration for best results under exposure to thermal radiation.

It will be recalled that in the vehicle screening series it was not found practical to utilize the pure silicone resin (GE SR-82) because of the difficulty in obtaining a satisfactory cure under atmospheric conditions. This has been found to be true in spite of modification with other fast curing film formers. It was thought possible that if the silicone resin were modified with an epoxy resin and formulated into a coating at the relatively high pigment volume concentration of 60% a satisfactory coating might be produced. This led to the preparation of PV-11. This formulation consists of 60% silicone resin and 30% epoxy resin (Shell Chemical #864) as the binder and titanium dioxide as the sole pigment. The pigment volume is 60%.

The results on the thermal testing of PV-11 while good were not particularly impressive. These results may be found in Table VI. Table VII will show that the general paint performance results on this combination of vehicles at 60% P.V.C. are certainly not outstanding.

It appears from the results outlined, that two outstanding coatings have been produced from the standpoint of evaluation by means of the searchlight test as developed at N.M.L. These coatings are PV-6 which contains titanium dioxide at a level of 3.24 lb/gal. and calcined clay to bring the pigment volume to 60%, and PV-7 which is also 60% in P.V.C. but contains 33% additional titanium dioxide. Because of the lack of complete data in the testing of thermal properties and because of the economy effected by the use of calcined clay rather than titanium dioxide, it becomes apparent that the most suitable coating for attainment of the objective, to date, is PV-6.

Coating PV-6 has been prepared commercially and a quantity sufficient to coat a number of aircraft has been supplied. It has been successfully applied by common commercial methods and, to date, has fulfilled all of the requirements of a useful and practical aircraft coating. However, there may be a problem in maintenance, since this is a low gloss material and may present some problem in cleaning.

There have been several references in the foregoing to insufficient irradiance data. This matter should probably be clarified at this point. Early in the project it became apparent that the time consuming thermal testing was hampering progress of the work because planning of the coating development work had to await results on irradiation testing.

It was decided, therefore, at a meeting among WADC, NML and Vita-Var Personnel to reduce the searchlight testing to a single irradiance on aluminum alloy only, for the screening work, and to develope complete data, if required at a future time, on such coatings as had shown promise in the preliminary screening. Time did not, however, permit the completion of this plan.

Should further work be initiated on this project, it would be of value to test such coatings as A-11, PV-2, PV-6 and PV-7 at irradiance levels both above and below the 10 calories (approximate) reported in the present work.

[redacted]

SECTION V

FILM THICKNESS

Three coatings previously described were chosen to study the effect on thermal radiation resistance when the film thickness of the coating is varied. The coatings chosen were Al which meets the requirements of MIL-E-7729, PV2 which is formulated at 60% P.V.C. using titanium dioxide as the sole pigment and a silicone-alkyd copolymer as the vehicle, and PV6 which is pigmented with a combination of titanium dioxide and calcined clay and contains the same silicone-alkyd (Plaskon ST-873) as the vehicle.

Table VIII shows the results obtained when the film thickness was varied for each of these coatings. It will be seen that coating Al was tested at 2,4,6 and 8 mil thicknesses. PV2 and PV6 were tested at 2,3 and 4 mils. The results show that as the thickness is increased the thermal properties are considerably improved. In the case of Al the critical energy value and specific temperature rise are shown to reach optimum at 6 mils.

In the case of PV2 the critical energy for failure rises sharply between 3 and 4 mils and the specific temperature rise value progressively decreases as the thickness is increased. On PV6 the critical energy value remains fairly constant. However, the specific temperature rise value progressively improves as the thickness is increased. It is not known what might result if the thickness of films of the two latter coatings were increased beyond 4 mils.

From these data, it would appear that for best results, Al should be applied at a dry thickness of 6 mils and PV2 and PV6 at a dry film thickness of at least 4 mils.

[redacted]

SECTION VI

PRIMERS

It was observed by Mr. Bracciaventi of Naval Materials Laboratory that when some of the better coatings were subjected to the conditions of the searchlight test the primer sometimes decomposed before initial failure of the finish coat was observed.

It was thought possible that if the thermal properties of the primer vehicle could be improved, the performance of the overall paint system could be substantially improved. It was also felt that if the reflectance of the primer could be increased, the reflectance of the total coating system might be increased.

A series of modifications of the standard primer was begun. The first three primers were of an exploratory nature to determine whether the idea of primer modification had merit. The modified primers have been numbered with the prefix PX, indicating Primer Experiment.

PX1 is pigmented with approximately equal parts of zinc yellow, titanium dioxide and calcined clay. The MIL-P-6889a vehicle has been totally replaced with silicone-alkyd vehicle. The pigment volume concentration has been maintained at 28.5% which is equal to that of MIL-P-6889a.

Comparison of results on PX1 in Table IX with those for the control primer will show a substantial increase in the critical energy value for failure. There is no substantial difference in specific temperature rise.

PX2 is formulated along lines similar to PX1 excepting that the pigment volume concentration has been increased to 35%. This was done in anticipation of poorer drying with the silicone-alkyd vehicle.

PX3 was prepared to check the effect of increased reflectance alone. This primer is made exactly on the MIL-P-6889a formula except that 2 lbs per gallon of Ti O_2 has been incorporated and an equal volume of zinc yellow removed.

Reference to Table IX shows that on these two primers also, the critical energy value has been increased with no substantial change for specific temperature rise.

It will be recalled from previous work that good results were obtained when the vinyl epoxy ester XOR-7 was used as the vehicle in the finish coat. For this reason a series of primers were made and evaluated using the vinyl epoxy ester as the vehicle. PX4 was prepared exactly on the MIL-P-6889a formula but the entire vehicle was replaced with the vinyl epoxy ester. PX5 used the same vehicle but the zinc yellow was reduced by approximately 50% and replaced with Ti O_2 to increase reflectance. The same procedure was followed for PX6 but decreasing the zinc yellow 75% and replacing with Ti O_2.

[redacted]

All three of these primers had poor adhesion to aluminum alloy and it was found impossible to prepare test specimens on aluminum alloy. It was possible to prepare test panels of Dow treated magnesium. Therefore, magnesium alloy samples were submitted to N.M.L.

Reference to Table IX will show an improvement in specific temperature rise for all three primers when compared with the standard. From these results it would appear that further work with this vehicle to improve primer adhesion should prove rewarding.

PX8 was made to evaluate a poly ester-toluene diisocyante combination as the vehicle. Zinc yellow is used as the sole pigment. The same adhesion problem was encountered for aluminum alloy panels and specimens were prepared on Dow treated magnesium panels. Table IX shows PX8 to be approximately equal to the vinyl epoxy ester primers and having a definitely lower specific temperature rise when compared with the standard primer on magnesium alloy.

In PX7, the primer vehicle was replaced with an epoxy ester of dehydrated castor oil fatty acids and 50% of the zinc yellow removed and replaced with titanium dioxide. In PX9 the same procedure was followed but the vehicle was styrenated dehydrated castor oil.

Data shown in Table IX indicate no advantage over the standard primer for either PX7 or PX9.

It was thought possible that if the vinyl epoxy ester evaluated in PX4, PX5 and PX6 were modified with silicone resin, the adhesion to aluminum and resistance to heat might be improved . PX10 was therefore prepared using 75% vinyl epoxy ester with 25% of a compatible silicone-alkyd (Dow Corning XR-807)

The adhesion of PX10 was found to be satisfactory on aluminum and it was possible to prepare test specimens. Table IX will show no advantage for this primer on aluminum when compared to the results on the standard primer. This is contradictory to the results obtained on magnesium using the unmodified vinyl epoxy ester and should be investigated further.

At the direction of WADC, a primer was prepared substituting strontium chromate for zinc yellow in the standard MIL-P-6889a, formula. This is experimental primer PX11.

As might be expected, strontium chromate showed no advantage over the standard primer. There are, as yet, no data available on comparative exterior durability.

For all of the testing of primers described above, the finish coat used was formula number PV6.

Time did not permit exposure testing on the experimental primers.

[redacted]

[redacted]

SECTION VII

COMPARISON WITH WADC STANDARD MIL-E-7729

During the course of the work, it became evident that because of improvements in technique at Naval Materials Laboratory, no data were available on the present standard aircraft White, MIL-E-7729. It was, therefore, decided to run a comparison of the standard enamel with the latest developments using up to date methods. A sample of white enamel, MIL-E-7729 was obtained from stock at WADC.

Table X shows the results obtained at NML on MIL-E-7729, Vita-Var Experimental Coating A-1 which meets the requirements of MIL-E-7729 and PV6 which is considered to be the best coating to date for resistance to thermal radiation. The data will show that the MIL-E-7729 prepared in this laboratory is considerably superior to the sample from WADC stock (Code W-1) and the PV6 to be far superior to either for both critical energy value and specific temperature rise.

[redacted]

SECTION VIII

ENVIRONMENTAL TESTING

Seven coatings were chosen for comparative exposure to 500 hours accelerated weathering, 1000 hours salt fog and 8 days of tropicalization. The weathering machine used is made by National Carbon Co. A 20% saline solution was used in the salt fog test. The tropicalization was conducted in a chamber which varied in temperature from 87°F to 105°F and in relative humidity from 85% to 98%. The variations were made over 24 hour cycles to simulate a tropical day.

The coatings chosen for these exposure tests include the following:

A-1	MIL-E-7729 prepared by Vita-Var
A-5	Silicone-Alkyd-TiO_2 21% P.V.C.
A-24	Vinyl Toluene Epoxy Ester 60% P.V.C.
PV-2	Silicone-Alkyd-TiO_2 60% P.V.C.
PV-6	Silicone-Alkyd-Calcined Clay-TiO_2 60% P.V.C.
PV-7	Silicone-Alkyd-Calcined Clay-TiO_2 60% P.V.C.
W-1	MIL-E-7729 Wright Field Sample - White

It will be seen from Table XI that except for some loss in gloss no failure was observed on any of the coatings in the accelerated weathering test. It should be noted that on the high pigment volume coatings where no loss of gloss is shown, the initial gloss is low so that gloss observations could not be made.

In the salt fog test on aluminum and on magnesium, wherever failure has occurred it has been confined to the area adjacent to the scribe, which had been intentionally cut through the film to the metal prior to exposure. In general, the higher P.V.C. coatings show less tendency to blister. On the coupled aluminum-magnesium panels, all of the coatings failed. After 48 hours of salt fog exposure, all of the panels including the control (W-1) had corroded so badly that the coupled panels had fallen apart at the joint.

It will be noted from Table XI that in the tropicalization exposure that all of the low P.V.C. coatings show considerable amounts of blistering. The best performance was observed for A-24 which contains the vinyl epoxy ester with a P.V.C. of 60%. This coating gave excellent results on aluminum, magnesium and coupled aluminum-magnesium.

All four high P.V.C. coatings gave excellent results on aluminum. However, PV-2 and PV-7 showed slight blistering on magnesium, while PV-6 blistered considerably on magnesium. It may be that the higher clay content in PV-6 produced a "tighter" film, impeding the passage of vapor from inside out to a greater extent.

It was observed on all of the 60% P.V.C. coatings in the tropicalization test that soluble salts were leached from the primer through the finish coat, leaving a yellow deposit on the surface. Should it be decided to use the higher P.V.C. coatings under conditions of high

[redacted]

humidity, it will probably be necessary to revise the primer to contain a pigment combination having minimum solubility in water.

Both aluminum and magnesium panels have been coated at a thickness of four mils with the same series of seven coatings. These panels are now on exposure at Newark, New Jersey, and at Miami, Florida.

It is too early in the exposure to draw any conclusions, as yet. These results will be made available to the Air Force when the exposure tests have been completed.

[redacted]

[redacted]

SECTION IX

CONCLUSIONS

1. Of the vehicles tested, five resins are outstanding for thermal resistnace properties and produce coating films of reasonable durability. These resins include the following:

   Silicone - alkyd copolymers
   Catalyzed epoxy resin (Shell Chemical XA200)
   Epoxy Ester
   Vinyl Toluene Epoxy Ester
   M. W. Kellogg X200

   At this time the silicone-alkyds appear to be most suitable. However, the others are worthy of further investigation. Because of economic and availability problems M.W. Kellogg X200 can probably be eliminated.

2. The most suitable prime pigment tested is titanium dioxide. Where it can be tolerated by the vehicle, limited concentration of zinc oxide is desirable. Calcined Clay contributes to resistance to thermal radiation.

3. Using silicone-alkyd as the vehicle a pigment volume concentration of 60% gives heat resistance to thermal radiation while retaining reasonably good film properties.

4. The incorporation of two different ceramic frits in coatings provided no advantage.

5. The two outstanding coatings developed for this project are PV6 and PV7. Both are formulated with silicone-alkyd as the vehicle and both contain titanium dioxide and calcined clay as the pigment component. Both are formulated at 60% pigment volume concentration.

6. Based on accelerated laboratory testing both PV6 and PV7 are practical aircraft coatings of reasonably good outdoor durability. Both leave something to be desired in the matter of gloss.

7. Control of film thickness is important in obtaining best resistance to thermal radiation. For coatings PV6 and PV7 optimum thickness appears to be in the neighborhood of .004 inches dry thickness. This applies to overall paint system thickness including the primer coat.

8. From a limited volume of work, it would appear that modification of the primer formulation might result in improvement in thermal properties for the entire paint system.

[redacted]

[redacted]

APPENDIX A - FORMULATIONS

A-1

	lbs.
Titanium Dioxide (Rutile Type, Non-Chalking)	300.0
*Alkyd Resin Solution 50% N.V.	200.0
Mineral Spirits	40.0
GRIND IN PEBBLE MILL AND ADD:	
*Alkyd Resin Solution 50% N.V.	400.0
24% Lead Naphthenate	6.4
6% Cobalt Naphthenate	3.0
Mineral Spirits	10.0
Xylol	30.0
Anti Skinning Agent	0.6

Grind 7

Viscosity 80" #4 Ford Cup

Weight per Gal. 9.95 lbs

*Alkyd:- Soya Type
30% Phthalic Anhydride
58% Oil

[redacted]

[redacted]

A-2

	Lbs.
Titanium Dioxide (Rutile Type, Med. chalking)	300.0
*Alkyd Resin Solution 50% N.V.	200.0
Mineral Spirits	40.0
GRIND IN PEBBLE MILL AND ADD:	
*Alkyd Resin Solution 50% N.V.	400.0
24% Lead Naphthenate	6.4
6% Cobalt Naphthenate	3.0
Mineral Spirits	10.0
Xylol	45.0
Anti Skinning Agent	0.6

Grind	7
Viscosity	84" #4 Ford Cup
Weight per Gal.	9.93 lbs

*Alkyd: Soya Type
30% Phthalic Anhydride
58% Oil

[redacted]

[redacted]

A-3

	Lbs
Titanium Dioxide (Anatase Type, Free Chalking)	300.0
*Alkyd Resin Solution 50% N.V.	200.0
Mineral Spirits	40.0

GRIND IN PEBBLE MILL AND ADD:

*Alkyd Resin Solution 50% N.V.	400.0
24% Lead Naphthenate	6.4
6% Cobalt Naphthenate	3.0
Mineral Spirits	10.0
Xylol	45.0
Anti Skinning Agent	0.6

Grind	7
Viscosity	82" #4 Ford Cup
Weight per Gal.	9.87

*Alkyd: Soya Type
30% Phthalic Anhydride
58% Oil

[redacted]

[redacted]

A-4

	Lbs
Titanium Dioxide (Rutile Type, Non-chalking)	300.0
*Silicone Resin Solution 60% N.V.	200.0

GRIND IN PEBBLE MILL AND ADD:

*Silicone Resin Solution 60% N.V.	300.0
8% Zinc Naphthenate	1.5
2% Cobalt Naphthenate	2.5
Toluol	30.0

Grind	7
Viscosity	19" #4 Ford Cup
Weight per Gal.	12.35 lbs.

*General Electric Silicone Resin SR-82

[redacted]

[redacted]

A-5

	Lbs
Titanium Dioxide (Rutile Type, Non Chalking)	300.0
*Silicone Alkyd Copolymer Solution 60% N.V.	200.0
Mineral Spirits	40.0

GRIND IN PEBBLE MILL AND ADD:

*Silicone Alkyd Copolymer 60% N.V.	300.0
8% Lead Naphthenate	12.0
2% Manganese Naphthenate	9.0
Mineral Spirits	25.0
Anti Skinning Agent	3.0
Xylol	45.0

Grind	7
Viscosity	80" #4 Ford Cup
Weight per Gal.	10.5 lbs.

*Plaskon Silicone Alkyd Copolymer ST873

[redacted]

A-6

	Lbs.
Titanium Dioxide (Rutile Type, Non Chalking)	130.0
*Vinylidene Chloride Acrylonitrile Copolymer Resin	130.0
Butyl Acetate	160.0
Methyl Isobutyl Ketone	250.0
Tri Cresyl Phosphate	20.0

GRIND IN PEBBLE MILL AND ADD:

Butyl Acetate	140.0
Methyl Isobutyl Ketone	50.0

Grind	7
Viscosity	100" #4 Ford Cup
Weight per Gal	8.65 lbs

*Dow Chemical Co. Saran F-120

[redacted]

A-7

	Lbs.
Titanium Dioxide (Rutile Type, Non-chalking)	130.0
*1/2 Sec. Cellulose Acetate-Butyrate Resin	130.0
Ethyl Alcohol	60.0
Toluol	225.0
Methyl Isobutyl Ketone	150.0
Tri Cresyl Phosphate	20.0
Dioctyl Phthalate	30.0

GRIND IN PEBBLE MILL AND ADD:

Ethyl Alcohol	60.0
Toluol	75.0
Methyl Isobutyl Ketone	30.0

Grind	7
Viscosity	100" #4 Ford Cup
Weight per Gal.	8.6 lbs

*Eastman Chemical Products Inc.

[redacted]

A-8

	Lbs
Titanium Dioxide (Rutile Type, Non-Chalking)	120.0
*Vinyl Chloride Resin	120.0
Tri Cresyl Phosphate	37.0
Methyl Isobutyl Ketone	235.0
Toluol	235.0

GRIND IN PEBBLE MILL AND ADD:

Methyl Isobutyl Ketone	50.0
Toluol	50.0

Grind	7
Viscosity	103" #4 Ford Cup
Weight/Gal	9.6 lbs

*Bakelite VAGH

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A-9

	Lbs
Titanium Dioxide (Rutile Type, Non-Chalking)	250.0
*Acrylic Resin Solution 40% N.V.	150.0
Toluol	50.0

GRIND IN PEBBLE MILL AND ADD:

*Acrylic Resin Solution 40% N.V.	475.0
Toluol	65.0

Grind	7
Viscosity	80" #4 Ford Cup
Weight/gal	9.13 lbs

*Rohm & Haas Co., Acryloid B-72

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[redacted]

A-10

	Lbs
Ceramic Grade Titanium Dioxide	300.0
Alkyd Resin Solution 50% N.V.	200.0
Mineral Spirits	40.0

GRIND IN PEBBLE MILL

Gelled - Discarded

[redacted]

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A-11

	Lbs
Titanium Dioxide (Rutile Type, Non Chalking)	240.0
*Alkyd Resin Solution 60% N.V.	236.0
Toluol	98.0

GRIND IN PEBBLE MILL AND ADD:

**1/2 Sec. Nitro Cellulose Solution 35% N.V.	202.0
Tri Cresyl Phosphate	28.0
Methyl Isobutyl Ketone	111.0
Butyl Acetate	13.0
Methyl Isobutyl Carbinol	45.5
Toluol	67.5

Grind	7
Viscosity	70" #4 Ford Cup
Weight/Gal	9.67 lbs

*Rohm & Haas Co. Duraplex ND 78

**35% 1/2 sec. Nitro Cellulose Solution

Aliphatic Hydrocarbons	70.0 lbs
Toluol	137.0
Ethyl Acetate	252.0
½ Sec. Nitro Cellulose	541.0

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A-12

	Lbs
Titanium Dioxide (Rutile Type, Non Chalking)	300.0
*Phenolic Resin Varnish Solution 60% N.V.	170.0
Mineral Spirits	50.0
Xylol	25.0
GRIND IN PEBBLE MILL AND ADD:	
Phenolic Resin Varnish Solution 60% NV	330.0
24% Lead Napthenate	4.2
6% Cobalt Naphthenate	1.7
Mineral Spirits	65.0
Xylol	56.0
Anti Skinning Agent	1.0

Grind	7
Viscosity	30" #4 Ford Cup
Weight/Gal	9.78 lbs

*33.3% Phenolic Resin BR 254 (Bakelite)
33.3% Tung Oil
33.3% Linseed Oil

A-13

	Lbs
Titanium Dioxide (Rutile Type, Non-chalking)	300.0
*Epoxy Resin Solution 60% N.V.	200.0
Methyl Isobutyl Ketone	16.0
Xylol	16.0

GRIND IN PEBBLE MILL AND ADD:

Epoxy Resin Solution 60% N.V.	300.0
Methyl Isobutyl Ketone	50.0
Xylol	50.0

Add 6 P.H.R. Diethylene Triamine
Based on Epoxy Solids prior to use.

Grind	7
Viscosity	30" #4 Ford Cup
Weight/Gal	10.95 lbs

*Epoxy - Urea - Formaldehyde Resin Solution
Shell Chemical Co. XA-200

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A-14

	Lbs
Titanium Dioxide (Rutile Type, Non Chalking)	300.0
*Alkyd Resin Solution 50% NV	150.0
Xylol	20.0

GRIND IN PEBBLE MILL AND ADD:

*Alkyd Resin Solution 50% NV	150.0
**Urea Formaldehyde Resin Solution 60% NV	250.0
8% Lead Napthenate	5.5
2¢ Cobalt Napthenate	4.5
Mineral Spirits	15.0
Anti-Skinning Agent	.6

ADD: 4.75% Reichold Chemical Co. P-198 Beckamine Accelerator Based on Urea Formaldehyde Solids prior to use

Grind	7
Biscosity	65" #4 Ford Cup
Weight/Gal	10.66 lbs.

*Alkyd Linseed Type
35% Phthalic Anhydride
50% Oil
**Reichold Chemical Co. Beckamine P-196

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A-15

Titanium Dioxide (Rutile Type-Non Chalking)	300.0
*Acrylic Resin Solution 40%	150.0
**Silicone Resin Solution 50%	125.0
Xylol	25.0

GRIND IN PEBBLE MILL AND ADD:

**Silicone Resin Solution 50%	355.0
Mineral Spirits	20.0

Grind	7
Viscosity	66" #4 Ford Cup
Weight/Gal.	10.55 lbs

*Rohm & Haas Co., Acryloid B-72

**General Electric, Silicone Resin Sr-111

A-16

	Lbs
Titanium Dioxide (Rutile Non-Chalking)	300.0
*Acrylic Resin Solution 40% N.V.	150.0
**Silicone Resin Solution 50% N.V.	125.0
Xylol	25.0

GRIND IN PEBBLE MILL AND ADD:

*Acrylic Resin Solution - 40% N.V.	295.0
**Silicone Resin Solution - 50% N.V.	75.0
Mineral Spirits	35.0

Grind	7
Viscosity	76" #4 Ford Cup
Weight/gal.	10.6 lbs

*Rohm & Haas Co. Acryloid B-72

**General Electric Silicone Resin SR-111

A-17

Titanium Dioxide (Rutile-Non Chalking)	100.0
*Kel F Elastomer Gum	100.0
Zinc Oxide	10.0
**D. Basic Lead Phosphate	10.0
Methyl Isobutyl Ketone	285.0
Methyl Ethyl Ketone	260.0
Butyl Alcohol	75.0
Toluol	25.0

GRIND IN PEBBLE MILL AND ADD:

Methyl Ethyl Ketone	180.0
Methyl Isobutyl Ketone	210.0
Butyl Alcohol	54.0
Toluol	18.0
Benzoyl Peroxide	3.0

Grind	6
Weight/Gal	7.59 lbs

*M. W. Kellogg Co. - Kel F. Elastomer Gum
**National Lead Co. - Dyphos

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A-18

	Lbs
Titanium Dioxide (Rutile-Non Chalking)	300.0
*Epoxy Ester Solution 50% N.V.	200.0
Xylol	40.0
GRIND IN PEBBLE MILL AND ADD:	
*Epoxy Ester Solution 50% N.V.	400.0
2% Cobalt Napthenate	4.5
2% Manganese Napthenate	4.5
Xylol	40.0
High Flash Naptha	135.0
Anti Skinning Agent	0.6

Grind	7
Viscosity	80" #4 Ford Cup
Weight/Gal.	10.0 lbs.

*Shell Chemical Corp., Epon Ester YS-5

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A-19

	Lbs
Titanium Dioxide (Rutile-Non Chalking)	300.0
*Silicone Alkyd Resin Solution 50% NV	200.0
Xylol	40.0
GRIND IN PEBBLE MILL AND ADD:	
*Silicone Alkyd Resin Solution 50% NV	400.0
2% Cobalt Napthenate	4.5
2% Manganese Napthenate	4.5
Mineral Spirits	25.0
Xylol	20.0
Anti Skinning Agent	0.3

Grind	7
Viscosity	76" #4 Ford Cup
Weight/Gal.	10.65 lbs

*Dow Corning Silicone Alkyd XR-807

A-20

	Lbs
Titanium Dioxide (Rutile-Non Chalking)	300.0
*Silicone Resin Solution 60% NV	350.0
GRIND IN PEBBLE MILL AND ADD:	
**Epoxy Resin Solution 40% NV	225.0
2% Cobalt Octoate	8.0
8% Zinc Octoate	6.0

Grind	7
Viscosity	14" #4 Ford Cup
Weight/Gal.	11.45 lbs

*General Electric Co., Silicone Resin SR-82

**<u>40% Epoxy Resin Solution</u>

Shell Chemical Epon 864	40% by weight
Methyl Ethyl Ketone	60% by weight

A-21

	Lbs
Titanium Dioxide (Rutile-Non Chalking)	300.0
*Silicone Resin Solution	350.0
GRIND IN PEBBLE MILL AND ADD:	
**Epoxy Resin Solution	225.0
2% Cobalt Octoate	8.0
8% Zinc Octoate	6.0

Grind	7
Viscosity	13" #4 Ford Cup
Weight/Gal	11.38 lbs

*General Electric Co. Silicone Resin SR-82

**<u>40% Epoxy Resin Solution</u>

Shell Chemical Epon	834	40% by weight
Methyl Ethyl Ketone		60% by weight

A-22

	Lbs
Titanium Dioxide (Rutile-Non Chalking)	300.0
*Alkyd Resin Solution	200.0
Toluol	60.0

GRIND IN PEBBLE MILL AND ADD:

*Alkyd Resin Solution	100.0
**Silicone Resin Solution	380.0
2% Cobalt Napthenate	7.5
8% Zinc Napthenate	10.5
Toluol	50.0

Grind	6½
Viscosity	35"
Weight/gal.	10.9 lbs

*GE Glyptal Solution 2520
**GE Silicone SR-82

A-23

	Lbs
Titanium Dioxide (Rutile-Non Chalking)	244.0
Calcined Clay	140.0
*Experimental Polymer 20% Sol.	515.0

GRIND IN PEBBLE MILL AND ADD:

Methyl Isobutyl Ketone	134.0

Grind	6
Viscosity	72"
Weight/gal	10.5 lbs.

*Experimental Polymer X-200 M. W. Kellogg

A-24

	Lbs
Titanium Dioxide (Rutile-Non Chalking)	300.0
Calcined Clay	301.0
*Vinyl Toluene Modified Epoxy Ester	282.0
Xylol	251.0
DISPERSE IN PEBBLE MILL AND ADD:	
2% Cobalt Naphthenate	5.1
8% Lead Naphthenate	7.3
Xylol	61.5
Anti Skinning Agent	1.8

Grind	6½
Viscosity	59"
Weight/gal.	11.7 lbs

*WADC 7400 NL

A-25

	Lbs
*Poly Ester	200.0
Butyl Acetate	100.0
Titanium Dioxide (Rutile-Non Chalking)	333.0

GRIND IN PEBBLE MILL

*ADD IMMEDIATELY BEFORE USE - THEN LET STAND 40 MIN.

Toluene Di Iso Cyanate	133.0
Butyl Acetate	244.0
2% Cobalt Napthenate	6.0

Grind	6
Viscosity	65 KU

*Trimethylol Propane	55%
Adipic Acid	37.5%
Phthalic Anhydride	7.5%

PE #1

	Lbs
Titanium Dioxide (Rutile Type, Non Chalking)	280.0
Zinc Oxide	30.0
*Alkyd Resin Solution 50% NV	200.0
Mineral Spirits	30.0
Xylol	15.0
GRIND IN PEBBLE MILL AND ADD:	
*Alkyd Resin Solution 50% NV	400.0
8% Lead Naphthenate	11.0
2% Cobalt Naphthenate	9.0
Mineral Spirits	45.0
Xylol	10.0
Anti Skinning Agent	0.6

Grind	7
Viscosity	80" #4 Ford Cup
Weight/Gal.	9.85 lbs
P.V.C.	21.0%

*Alkyd Soya Type
30% Phthalic Anhydride
58% Oil

PE-2

	Lbs
Titanium Dioxide (Rutile Type, Non Chalking)	255.0
Zinc Oxide	60.0
*Alkyd Resin Solution 50% NV	230.0
Mineral Spirits	30.0

GRIND IN PEBBLE MILL AND ADD:

*Alkyd Resin Solution 50% NV	370.0
8% Lead Naphthenate	11.0
2% Cobalt Naphthenate	9.0
Mineral Spirits	15.0
Xylol	42.0
Anti Skinning Agent	0.6

Grind	7
Viscosity	76" #4 Ford Cup
Weight/Gal	9.9 lbs.

*Alkyd Soya Type
30% Phthalic Anhydride
58% Oil

PE -3

	Lbs
Titanium Dioxide (Rutile Type-Non Chalking)	232.0
Zinc Oxide	90.0
*Alkyd Resin Solution 50% NV	300.0
Mineral Spirits	25.0

GRIND IN PEBBLE MILL AND ADD:

*Alkyd Resin Solution 50% NV	300.0
8% Lead Naphthenate	11.0
2% Cobalt Naphthenate	9.0
Mineral Spirits	30.0
Xylol	40.0
Anti Skinning Agent	0.6

Grind	7
Viscosity	80" #4 Ford Cup
Weight/Gal.	10.10 lbs

*Alkyd - Soya Type
30% Phthalic Anhydride
58% Oil

PE-4

	Lbs
Titanium Dioxide (Rutile Type - Non Chalking)	300.0
Zinc Oxide	150.0
*Alkyd Resin Solution 50% NV	230.0
Mineral Spirits	75.0
GRIND IN PEBBLE MILL AND ADD:	
Alkyd Resin Solution 50% NV	370.0
8% Lead Naphthenate	11.0
2% Cobalt Naphthenate	9.0
Mineral Spirits	15.0
Xylol	35.0
Anti Skinning Agent	0.6

Grind	7
Viscosity	55" #4 Ford Cup
Weight/Gal.	10.7 lbs

*Alkyd - Soya Type

30% Phthalic Anhydride
58% Oil

PE-5

	Lbs
Titanium Dioxide (Rutile Type-Non Chalking)	300.0
Zinc Oxide	600.0
*Alkyd Resin Solution 50% NV	400.0
Mineral Spirits	80.0
Xylol	30.0
GRIND IN PEBBLE MILL AND ADD:	
*Alkyd Resin Solution 50% NV	200.0
8% Lead Naphthenate	11.0
2% Cobalt Naphthenate	9.0
Mineral Spirits	20.0
Anti Skinning Agent	0.6
Xylol	20.0

Grind	7
Viscosity	83" #4 Ford Cup
Weight/Gal.	13.45 lbs.

*Alkyd - Soya Type
30% Phthalic Anhydride
58% Oil

PE-6

	Lbs
Titanium Dioxide (Rutile Type-Non Chalking)	280.0
Antimony Oxide	30.0
*Alkyd Resin Solution 50% NV	200.0
Mineral Spirits	30.0
GRIND IN PEBBLE MILL AND ADD:	
*Alkyd Resin Solution 50% NV	400.0
8% Lead Napthenate	11.0
2% Cobalt Napthenate	9.0
Mineral Spirits	45.0
Anti Skinning Agent	0.6

Grind	7.
Viscosity	85" #4 Ford Cup
Weight/Gal.	10.0 lbs

*Alkyd Soya Type

30% Phthalic Anhydride
58% Oil

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PE-7

	Lbs
Titanium Dioxide (Rutile Type, Non Chalking)	255.0
Antimony Oxide	60.0
*Alkyd Resin Solution 50% NV	230.0
Mineral Spirits	30.0

GRIND IN PEBBLE MILL AND ADD:

*Alkyd Resin Solution 50% NV	370.0
8% Lead Napthenate	11.0
2% Cobalt Napthenate	9.0
Mineral Spirits	20.0
Xylol	20.0
Anti Skinning Agent	0.6

Grind	7
Viscosity	85" #4 Ford Cup
Weight/Gal.	10.1 lbs

*Alkyd - Soya Type
30% Phthalic Anhydride
58% Oil

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PE-8

	Lbs
Titanium Dioxide (Rutile Type, Non Chalking)	232.0
Antimony Oxide	90.0
*Alkyd Resin Solution 50% NV	300.0
Mineral Spirits	10.0
GRIND IN PEBBLE MILL AND ADD:	
*Alkyd Resin Solution 50% NV	300.0
8% Lead Naphthenate	11.0
2% Cobalt Naphthenate	9.0
Mineral Spirits	45.0
Xylol	10.0
Anti Skinning Agent	0.6

Grind	7
Viscosity	80" #4 Ford Cup
Weight/gal.	10.37 lbs

*Alkyd - Soya Type

30% Phthalic Anhydride
58% Oil

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PE-9

	Lbs
Titanium Dioxide (Rutile Type-Non Chalking)	300.0
Antimony Oxide	150.0
*Alkyd Resin Solution 50% NV	225.0
Mineral Spirits	50.0
GRIND IN PEBBLE MILL AND ADD:	
*Alkyd Resin Solution 50% NV	375.0
8% Lead Naphthenate	11.0
2% Cobalt Naphthenate	9.0
Mineral Spirits	15.0
Xylol	20.0
Anti Skinning Agent	0.6

Grind	7
Viscosity	69" #4 Ford Cup
Weight/Gal.	10.97 lbs

*Alkyd - Soya Type

30% Phthalic Anhydride
58% Oil

PE-10

	Lbs
Titanium Dioxide (Rutile Type, Non-Chalking)	300.0
Antimony Oxide	600.0
*Alkyd Resin Solution 50% NV	350.0
Mineral Spirits	30.0
Xylol	10.0

GRIND IN PEBBLE MILL AND ADD:

*Alkyd Resin Solution 50% NV	250.0
8% Lead Naphthenate	11.0
2% Cobalt Naphthenate	9.0
Mineral Spirits	20.0
Xylol	20.0
Anti Skinning Agent	0.6

Grind	7
Viscosity	66" #4 Ford Cup
Weight/Gal	14.23 lbs

*Alkyd - Soya Type
30% Phthalic Anhydride
58% Oil

PE-11

	Lbs
Titanium Dioxide)Rutile-Non Chalking)	300.0
Ceramic Frit #12	205.0
*Silicone Alkyd Copolymer Resin 60% NV	243.0
Mineral Spirits	25.0
Xylol	55.0

GRIND IN PEBBLE MILL AND ADD:

*Silicone Alkyd Copolymer Resin 60% NV	200.0
8% Lead Napthenate	10.0
2% Manganese Napthenate	7.5
Mineral Spirits	70.0
Xylol	25.0
Anti Skinning Agent	2.6

Grind	5
Viscosity	110" #4 Ford Cup
Weight/Gal.	10.5 lbs
PVC	35%

*Plaskon Silicone Alkyd Copolymer Resin ST-873

PE-12

	Lbs
Titanium Dioxide (Rutile-Non Chalking)	300.0
Ceramic Frit #2	168.0
*Silicone-Alkyd Copolymer Resin 60% NV	243.0
Mineral Spirits	25.0
Xylol	50.0

GRIND IN PEBBLE MILL AND ADD:

*Silicone-Alkyd Copolymer Resin 60% NV	200.0
8% Lead Napthenate	10.0
2% Manganese Napthenate	7.5
Mineral Spirits	50.0
Xylol	20.0
Anti Skinning Agent	2.6

Grind	5½
Viscosity	72" #4 Ford Cup
Weight/Gal.	11.2 lbs

PVC 35%

*Plaskon, Silicone-Alkyd Copolymer Resin ST-873

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PE-13

	Lbs
Titanium Dioxide (Med. Chalking)	300.
*Silicone-Alkyd Copolymer Resin 60% NV	120.
Mineral Spirits	35.
Xylol	15.

GRIND IN PEBBLE MILL AND ADD:

*Silicone-Alkyd Copolymer Resin 60% NV	380.
8% Lead Napthenate	12.
2% Manganese Naphthenate	9.
Mineral Spirits	30.
Xylol	25.
Anti Skinning Agent	3.

Grind	7
Viscosity	73" #4 Ford Cup
Weight/Gal.	10.18 lbs

*Plaskon, Silicone-Alkyd Copolymer ResinST.873

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PE-14

	Lbs
Titanium Dioxide (Anatase-Free Chalking)	300.0
*Silicone-Alkyd Copolymer Resin Solution 60%NV	120.0
Mineral Spirits	70.0
Xylol	20.0

GRIND IN PEBBLE MILL AND ADD:

*Silicone-Alkyd Copolymer Resin Solution 60%NV	380.0
8% Lead Napthenate	12.0
2% Manganese Napthenate	9.0
Mineral Spirits	20.0
Xylol	35.0
Anti Skinning Agent	3.0

Grind	7
Viscosity	72" #4 Ford Cup
Weight/Gal.	10.1 lbs

*Plaskon, Silicone-Alkyd Copolymer Resin ST-873

PV-1

	Lbs
Titanium Dioxide (Rutile Type-Non Chalking)	710.0
*Silicone Alkyd Copolymer Resin Solution 60%NV	270.0
Mineral Spirits	60.0
Xylol	40.0

GRIND IN PEBBLE MILL AND ADD:

*Silicone Alkyd Copolymer Resin Solution 60% NV	200.0
2% Manganese Napthenate	8.0
Mineral Spirits	65.0
Anti Skinning Agent	2.8

Grind	7
Viscosity	80" #4 Ford Cup
Weight/Gal.	12.8 lbs
PVC	40%

*Plaskon Silicone Alkyd Copolymer ST873

PV-2

	Lbs
Titanium Dioxide (Rutile Type, Non-Chalking)	847.0
*Silicone Alkyd Copolymer Resin Solution 60%NV	256.0
Mineral Spirits	107.0
Xylol	50.0

GRIND IN PEBBLE MILL AND ADD:

2% Manganese Napthenate	4.5
Mineral Spirits	50.0
Anti Skinning Agent	1.5

Grind	7
Viscosity	78" #4 Ford Cup
Weight/Gal.	14.94 lbs
PVC	60%

*Plaskon Silicone-Alkyd Copolymer ST-873

PV-3

	Lbs
Titanium Dioxide (Rutile-Non Chalking)	906.0
*Silicone Alkyd Copolymer Resin Solution 60%NV	174.0
Mineral Spirits	120.0
Xylol	70.0

GRIND IN PEBBLE MILL AND ADD:

2% Manganese Napthenate	4.1
8% Lead Napthenate	5.0
Mineral Spirits	40.0
Anti Skinning Agent	1.0

Grind	7
Viscosity	65" #4 Ford Cup
Weight/Gal.	15.5 lbs
PVC	70%

*Plaskon - Silicone Alkyd Copolymer ST-873

PV-4

	Lbs
Titanium Dioxide (Rutile-Non Chalking)	847.0
*Epoxy Resin Solution 60% NV	256.0
Methyl Isobutyl Ketone	300.0
Xylol	400.0

GRIND IN PEBBLE MILL AND ADD:

Methyl Isobutyl Ketone	50.0
Xylol	50.0

PVC 60%

OVER PIGMENTED -

DISCARDED AS IMPRACTICAL

*Epon 1001 Resin Solution - Shell Chemical XA-200

PV-5

	Lbs
Titanuim Dioxide (Rutile-Non Chalking)	906.0
*Epoxy Resin Solution 60% NV	174.0
Methyl Isobutyl Ketone	220.0
Xylol	420.0

GRIND IN PEBBLE MILL AND ADD:

Methyl Isobutyl Ketone	175.0
Xylol	175.0

OVERPIGMENTED -

DISCARDED AS IMPRACTICAL

*Epon 1001 Resin Solution - Shell Chemical XA-200

PV-6

	Lbs
Titanium Dioxide (Rutile-Non Chalking)	300.0
*Calcined Clay	344.0
**Silicone Alkyd Copolymer Resin Solution 60%NV	256.0
Mineral Spirits	132.0
Xylol	50.0

GRIND IN PEBBLE MILL AND ADD:

2% Manganese Napthenate	5.5
8% Lead Napthenate	8.8
Mineral Spirits	25.0
Xylol	15.0
Anti Skinning Agent	3.0

Grind	7
Viscosity	65" #4 Ford Cup
Weight/gal.	12.5 lbs
PVC	60%

*Southern Clay - Whitex
**Plaskon, Silicone Alkyd Copolymer ST-873

PV-7

	Lbs
Titanium Dioxide (Rutile-Non Chalking)	400.0
*Calcined Clay	282.0
**Silicone Alkyd Copolymer Resin 60% NV	256.0
Mineral Spirits	157.0
Xylol	50.0

GRIND IN PEBBLE MILL AND ADD:

2% Manganese Naphthenate	5.5
8% Lead Naphthenate	8.8
Mineral Spirits	30.0
Anti Skinning Agent	3.0

Grind	7
Viscosity	70" #4 Ford Cup
Weight/Gallon	12.97 lbs
PVC	60%

*Southern Clay - Whitex

**Plaskon - Silicone Alkyd Copolymer ST-873

PV-8

	Lbs
Titanium Dioxide (Rutile-Non Chalking)	658.0
*Epoxy Resin Solution 60% NV	366.0
Methyl Isobutyl Ketone	264.0
Xylol	200.0
GRIND IN PEBBLE MILL AND ADD:	
Xylol	64.0

Grind	7
Viscosity	18" #4 Ford Cup
Weight/Gallon	11.3 lbs
PVC	45%

*Shell Chemical Co. Epon 1001 Resin Solution XA-200

NOTE: 6 parts per hundred of diethylene triamine based on epoxy solids added prior to use.

PV-9

	Lbs
Titanium Dioxide (Rutile-Non Chalking)	566.0
*Silicone Alkyd Copolymer Resin Solution 60%NV	256.0
Mineral Spirits	65.0
Xylol	25.0

GRIND IN PEBBLE MILL AND ADD:

2% Manganese Napthenate	4.5
8% Lead Napthenate	5.8
Mineral Spirits	60.0
Anti Skinning Agent	1.5

Grind	7
Viscosity	60" #4 Ford Cup
Weight/Gal	13.7
PVC	50%

*Plaskon - Silicone Alkyd Copolymer Resin ST-873

PV-10

	Lbs
Titanium Dioxide (Rutile-Non Chalking)	692.0
*Silicone Alkyd Copolymer Resin Solution 60%NV	256.0
Mineral Spirits	90.0
Xylol	35.0

GRIND IN PEBBLE MILL AND ADD:

2% Manganese Napthenate	4.5
8% Lead Napthenate	5.8
Mineral Spirits	75.0
Anti Skinning Agent	1.5

Grind	7
Viscosity	60" #4 Ford Cup
Weight/Gal.	13.95 lbs
PVC	55%

*Plaskon, Silicone Alkyd Copolymer Resin ST-873

PV-11

	Lbs
Titanium Dioxide (Rutile-Non Chalking)	824.0
Zinc Oxide	19.8
*Silicone Resin Solution 60% NV	178.0
**Epoxy Resin Solution 40% NV	115.0
Xylol	50.0

GRIND IN PEBBLE MILL AND ADD:

2% Cobalt Napthenate	2.0
8% Zinc Napthenate	2.5
Xylol	15.0

Grind	7
Viscosity	35" #4 Ford Cup
Weight/Gallon	17.4 lbs
PVC	60%

*General Electric Co. Silicone Resin SR-82

**40% Epoxy Resin Solution

Shell Chemical Epon 864	40% by weight
Methyl Ethyl Ketone	60% by weight

PV-12

	Lbs
Titanium Dioxide (Rutile-Non Chalking)	535.0
*Epoxy Resin Solution XA-200	366.0
Methyl Isobutyl Ketone	150.0
Xylol	150.0

NOTE:

ADD - 6 Parts/100 Deithylene Triamine Based on Epon Resin Solids prior to use.

Grind	7
Viscosity	37" #4 Ford Cup
Weight/Gal.	11.9 lbs

*Shell Chemical Co., XA-200

PV-13

	Lbs
Titanium Dioxide (Rutile-Non Chalking)	300.0
Calcined Clay	157.0
*Epoxy Resin Solution XA-200	366.0
Aluminum Stearate	3.0
Methyl Isobutyl Ketone	33.0
Xylol	33.0

GRIND IN PEBBLE MILL AND ADD:

Xylol	117.0
Cyclohexanol	13.0
Methyl Isobutyl Ketone	90.0

Grind	7
Viscosity	42" #4 Ford Cup
Weight/Gal.	11.8 lbs

*Shell Chemical Co. XA-200

NOTE: 6 parts per hundred of Diethylene Triamine based on Epoxy Resin Solids added prior to use.

[redacted]

PV-14

	Lbs
Titanium Dioxide (Rutile-Non Chalking)	300.0
Calcined Clay	349.0
*Silicone Alkyd Copolymer	297.0
High Flash Naptha	184.0

GRIND IN PEBBLE MILL AND ADD:

2% Manganese Napthenate	6.4
8% Lead Napthenate	10.2
Mineral Spirits	67.0
Anti-Skinning Agent	2.9

Grind	7
Viscosity	60"
Weight/Gal.	12.3 lbs

*Plaskon ST-873

[redacted]

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PV-15

	Lbs
Titanuim Dioxide (Rutile-Non Chalking)	300.0
Calcined Clay	346.0
*Silicone Alkyd Copolymer	329.0
High Flash Naptha	182.5

GRIND IN PEBBLE MILL AND ADD:

2% Manganese Napthenate	7.13
8% Lead Napthenate	11.35
Mineral Spirits	47.3
Anti Skinning Agent	3.

Grind	7
Viscosity	68"
Weight/Gal.	12.2 lbs

*Plaskon ST-873

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PV-16

	Lbs
Titanuim Dioxide (Rutile-Non Chalking)	300.0
Calcined Clay	275.0
*Silicone Alkyd Copolymer	346.0
High Flash Naptha	166.0

GRIND IN PEBBLE MILL AND ADD:

High Flash Naptha	80.8
2% Manganese Napthenate	5.7
8% Lead Napthenate	12.3
Anti Skinning Agent	2.5

Grind	7
Viscosity	55"
Weight/Gal.	11.7 lbs.

*Plaskon ST-873

PX-1

	Lbs
Zinc Yellow	107.0
Calcined Clay	105.0
Titanium Dioxide (Rutile-Non Chalking)	107.0
Alum. Stearate Gel (10% in Xylol	38.9
Malic Acid	.98
*Silicone Alkyd Copolymer	61.5
Xylol	105.0

DISPERSE IN PEBBLE MILL	48 hours
ADD BELOW, THEN CONTINUE TO GRIND	4 more hours

*Silicone Alkyd Copolymer	371.0
Xylol	87.8
2% Manganese Napthenate	8.0
6% Lead Napthenate	10.7

Grind	7
Viscosity	47"
Weight/gal.	10.05 lbs

*Plaskon ST-873

PX-2

	Lbs
Zinc Yellow	107.0
Calcined Clay	188.0
Titanium Dioxide (Rutile-Non Chalking)	107.0
Aluminum Stearate	2.0
Malic Acid	.98
*Silicone Alkyd Copolymer	65.0
Xylol	105.0

DISPERSE IN PEBBLE MILL 48 hours

ADD BELOW THEN CONTINUE TO GRIND 4 more hours

*Silicone Alkyd Copolymer	366.5
Xylol	87.8
2% Manganese Napthenate	8.0
6% Lead Napthenate	10.7

Grind	6
Viscosity	79"
Weight/gal.	10.5 lbs

*Plaskon ST-873

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PX-3

	Lbs
Zinc Yellow	83.0
Magnesium Silicate	44.3
Titanium Dioxide (Rutile-Non Chalking)	200.0
Aluminum Stearate	3.6
Malic Acid	0.91
*Alkyd Resin Solution	68.5
Xylol	89.0

DISPERSE IN PEBBLE MILL	48 hours
ADD BELOW THEN CONTINUE TO GRIND	4 more hours

*Alkyd Resin Solution	233.0
**Phenolic Dispersion Resin Solution	182.0
24% Lead Napthenate	2.0
6% Cobalt Napthenate	0.8
Anti-Skinning Agent	0.91
Xylol	96.0

Grind	6
Viscosity	84KU
Weight/Gal.	10.5 lbs

*American Cyanimid Co. - Rezyl 728-5

**Bakelite BK-3962

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PX-4

	Lbs
Zinc Yellow	254.0
*Magnesium Silicate	44.3
Aluminum Stearate (10% in Xylol)	36.3
Malic Acid	0.91
Vinyl Toluene Modified Epoxy Ester	68.5
Xylol	89.0

DISPERSE IN PEBBLE MILL 48 hours

ADD BELOW AND CONTINUE TO GRIND 4 hours more

**Vinyl Toluene Modified Epoxy Ester	415.0
24% Lead Napthenate	2.0
6% Cobalt Napthenate	0.8
Anti Skinning Agent	0.91
Xylol	96.0

Grind	6
Viscosity	65 KU
Weight/Gal.	10.1 lbs

*W.C. & D. 1767 Talc

**WADC 7400 NL

PX-5

	Lbs
Zinc Yellow	140.0
Magnesium Silicate	44.3
Titanium Dioxide (Rutile-Non Chalking)	182.0
Aluminum Stearate Gel (10% in Xylol)	36.3
Malic Aced	0.91
*Vinyl Toluene Modified Epoxy Ester	68.5
Xylol	89.

DISPERSE IN PEBBLE MILL	48 hours
ADD BELOW AND CONTINUE TO GRIND	4 hours more

Vinyl Toluene Modified Alkyd	415.0
24% Lead Napthenate	1.5
6% Cobalt Napthenate	0.8
Anti Skinning Agent	0.9
Xylol	96.0

Grind	6
Viscosity	68 KU
Weight/Gal.	10.5 lbs

*WADC 7400 NL

PX-6

	Lbs
Zinc Yellow	78.0
Titanium Dioxide (Rutile Non Chalking)	292.0
Magnesium Silicate	44.3
Aluminum Stearate (10% in Xylol)	36.3
Malic Acid	0.91
*Vinyl Toluene Modified Epoxy Ester	68.5
Xylol	89.0

DISPERSE IN PEBBLE MILL FOR	48 hours
ADD BELOW AND CONTINUE TO GRIND	4 hours

*Vinyl Toluene Modified Epoxy Ester	415.1
24% Lead Napthenate	2.0
6% Cobalt Napthenate	0.8
Anti Skinning Agent	0.9
Xylol	96.0

Weight/Gal.	10.8
Viscosity	64 KU
Grind	6

*WADC 7400 NL

PX-7

	Lbs
Zinc Yellow	140.0
Magnesium Silicate (Med)	44.3
Titanium Dioxide (Rutile-Non Chalking)	182.0
Aluminum Stearate Gel (10% in Xylol)	36.3
Malic Acid	0.91
*Epon Ester	68.5
Xylol	89.0

DISPERSE IN PEBBLE MILL 48 hours

ADD BELOW AND CONTINUE TO GRIND 4 hours more

*Epon Ester	415.1
2% Cobalt Napthenate	4.8
Xylol	96.0

Grind	6
Viscosity	63 KU
Weight/Gal.	10.3 lbs

*Epon Ester D-4, Shell Chemical Co.

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PX-8

	Lbs
*Poly Ester	60.0
Butyl Acetate	74.0
Zinc Yellow	105.0

GRIND IN PEBBLE MILL

THEN ADD BELOW - LET STAND 40 MIN. AND USE IMMEDIATELY

Toluene Di Iso Cyanate	40.0
Butyl Acetate	70.0

Grind	6
Viscosity	71 KU

*Trimethylol Propane	55%
Adipic Acid	37.5%
Phthalic Anhydride	7.5%

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PX-9

	Lbs
Zinc Yellow	140.0
Magnesium Silicate (Med)	44.3
Titanium Dioxide (Rutile-Non Chalking)	182.0
Aluminum Stearate Gel (10% in Xylol)	36.3
Malic Acid	0.91
*Styrenated Dehydrated Castor Oil	68.5
Xylol	89.0

DISPDRSE IN PEBBLE MILL 48 hours

ADD BELOW AND CONTINUE TO GRIND 4 hours more

*Styrenated Dehydrated Castor Oil	415.1
24% Lead Napthenate	2.0
6% Cobalt Napthenate	0.8
Anti Skinning Agent	0.9
Xylol	96.0

Grind	6
Weight/gal	10.1 lbs
Viscosity	94 KU

*Isostyre 55 Z Woburn Chemical Co.

PX-10

	Lbs
Zinc Yellow	140.0
Magnesium Silicate (Med)	44.3
Titanium Dioxide (Rutile-Non Chalking)	182.0
Aluminum Stearate Gel (10% in Xylol)	36.3
Malic Acid	0.91
*Vinyl Toluene Modified Epoxy Ester	68.5
Xylol	89.0

DISPERSE IN PEBBLE MILL 48 hours

ADD BELOW AND CONTINUE TO GRIND 4 hours more

**Silicone Alkyd	121.0
*Vinyl Toluene Modified Epoxy Ester	294.0
6% Cobalt Napthenate	1.5
Anti Skinning Agent	0.9
Xylol	96.0

Grind	6
Weight/Gal.	10.5 lbs
Viscosity	63 KU

*WADC - XDR-7
**XR-807 Dow Corning

[redacted]

PX-11

	Lbs
Strontium Chromate	254.2
Magnesium Silicate (Med)	44.3
Aluminum Stearate Gel (10% in Xylol)	36.3
Malic Acid	.91
Soya Alkyd Resin Solution	68.5
Xylol	134.0

DISPERSE IN PEBBLE MILL	48 hours
ADD BELOW AND CONTINUE TO GRIND	4 more hours

Soya Alkyd Resin Solution	233.0
**Phenolic Dispersion Resin	182.1
24% Lead Napthenate	2.0
6% Cobalt Napthenate	0.8
Anti Skinning Agent	0.91
Xylol	51.0

Grind	6
Viscosity	66 KU
Weight/Gal	9.85 lbs

*Bk-3962 Bakelite

[redacted]

APPENDIX B

TABLE I

THERMAL PROPERTIES OF VARIOUS VEHICLES WITH TiO_2 PIGMENT .016 ALUMINUM ALLOY

FORM NO.	DESCRIPTION	IRRADIANCE $(Cal/Cm^2/Sec)$	CRITICAL ENERGY FOR BLISTERING (Cal/Cm^2)	SPECIFIC TEMPERATURE RISES $(^{\circ}C/Cal/Cm^2)$
A-1	50% Alkyd Soya Type 50% Titanium Dioxide (Non-Chalking)	42	13.5-15.2	10.9
		30	16.2-16.5	8.7
		21	17.1-17.3	8.4
		9.9	15.3	8.3
		5.4	17.6-17.8	8.3
A-2	50% Alkyd Soya Type 50% Titanium Dioxide (Med-Chalking Rutile)	42	12.7-13.1	12.7
		30	16.7-17.1	7.9
		19	14.1-15.1	8.8
		9.9	15.6-15.9	7.8
		5.4	16.3-17.6	8
A-3	50% Alkyd Soya Type 50% Titanium Dioxide (Free Chalking Anatace)	45	11.2-12.1	10.4
		30	12.9-13.7	10.1
		19	12.5-12.9	10.0
		9.7	13.8-15.	9.5
		5.4	14.9-16.8	8.8
A-5	*50% Silicone Alkyd Copolymer 50% Titanium Dioxide (Rutile-Non Chalking)	45	20.3-22.1	8.1
		30	16.6-17.5	8.4
		19	17.2-17.6	8.4
		9.7	18.0-19.6	8.2
	*Plaskon ST-873	5.4	19.2-20.8	7.1
A-6	*50% Vinylidene Chloride Acrylonitrile 50% Titanium Dioxide (Rutile-Non Chalking) *Saran Dow Chemical	10.4	15.5-16.6	9.5
A-7	*50% $\frac{1}{2}$ Sec.Cellulose Acetate Butyrate 50% Titanium Dioxide (Rutile-Non Chalking) *Tenn. Eastman	45	12.1-12.9	10.6
		5.4	14.4-15.2	8.7
A-8	*50% Vinyl Chloride Acetate 50% Titanium Dioxide (Rutile-Non Chalking) *Bakelite Corp. VAGH	44	11.5-11.9	12.1
		5.4	16.5-18	8.5
A-9	*50% Acrylic Polymer 50% Titanium Dioxide (Rutile-Non-Chalking) *Acryloid B-72 Rohm & Haas	10.4	17.5-17.8	8.9
A-11	50% Nitrocellulose Alkyd Plasticized 50% Titanium Dioxide (Rutile-Non Chalking)	10.5	18.3	8.7
A-12	50% Phenolic Resin Varnish 50% Titanium Dioxide (Rutile-Non Chalking)	10.5	17.7	7.9
A-13	*50% Epon Urea Formaldehyde Resin 50% Titanium Dioxide (Rutile-Non Chalking) *Shell Chemical XA-200	11.1	17.4-18.0	8.3

TABLE I (Con't)

THERMAL PROPERTIES OF VARIOUS VEHICLES WITH Ti o2 PIGMENT
.016 ALUMINUM ALLOY

FORM NO.	DESCRIPTION	IRRADIANCE $(Cal/Cm^2/Sec)$	CRITICAL ENERGY FOR BLISTERING (Cal/Cm^2)	SPECIFIC TEMPERATURE RISE $(^{\circ}C/Cal/Cm^2)$
A-14	*50% Urea Formaldehyde & Alkyd Resin 50% Titanium Dioxide (Rutile-Non Chalking) *Beckamine-Reichold Chemicals	10.1	16.3-16.4	8.4
A-18	*50% Epon Ester 50% Titanium Dioxide (Rutile-Non Chalking) *Shell Chemical YS-5	9.4	21.	7.9
A-19	*50% Silicone Alkyd 50% Titanium Dioxide (Rutile-Non Chalking) *Dow Corning XR-807	9.6	18.	6.8
A-22	50% (*60% Pure Silicone (**40% Short Oil Alkyd 50% Titanium Dioxide (Rutile-Non Chalking) *GE - SR-82 **GE - Glyptal Solution 2520	9.5	24.	9.9
A-23	*21% M.W. Kellogg X200 50% Titanium Dioxide (Rutile-Non Chalking) 29% Calcined Clay *Experimental Polymer X200 - M.W. Kellogg	9.8	68-78 **Yellows at 60**	6.5
** A-24	*19.7% Vinyl Toluene Modified Epoxy Ester 40.4% Titanium Dioxide (Non Chalking) 40.6% Calcined Clay *WADC XOR 7	9.8	69-73 **Yellows at 58**	6.3
A-25	29.8% Poly Ester Resin 20.% Toluene Diisocyanate 50.2% Titanium Dioxide (Non Chalking)	10.	25.	8.3

** NOTE: Vinyl Toluene Ester tested at 60% pigment volume concentration.

TABLE II

THERMAL PROPERTIES OF VARIOUS VEHICLES WITH TiO_2 PIGMENT
MAGNESIUM ALLOY

FORM NO.	DESCRIPTION	IRRADIANCE (Cal/Cm^2Sec)	CRITICAL ENERGY FOR BLISTERING (Cal/Cm^2)	SPECIFIC TEMPERATURE RISE ($^{o}C/Cal/Cm^2$)
A-1	50% Alkyd Soya Type	45	7.8-8.1	17.4
	50% Titanium Dioxide (Non Chalking)	31	9.3	11.2
		20	12.5-12.9	10.4
		10	11.6-12.0	10.3
		5.5	11.4-12.2	10.9
A-2	50% Alkyd Soya Type	46	11.6-12.7	11.8
	50% Titanium Dioxide (Med.Chalking Rutile)	31	10.5-11.1	10.6
		20	11.3-12.1	11.1
		10	11.6-12.0	10.6
		5.5	12.0-12.4	10.4
A-3	50% Alkyd Soya Type	46	7.9-8.3	15.1
	50% Titanium Dioxide (Free Chalking Anatace)	31	8.7-9.0	14.0
		20	10.6-11.2	12.1
		10	9.9-10.2	12.4
		5.5	10.2-10.6	12.1
A-5	*50% Silicone Alkyd Copolymer	46	12.5-13.9	12.1
	50% Titanium Dioxide (Rutile Non-Chalking)	31	13.0-14.8	11.2
	*Plaskon ST-873	19	15.1-15.5	11.4
		10	16.2-17.0	9.3
		5.4	16.4-17.0	10.8
A-7	*50% ½ Sec. Cellulose Acetate Butyrate	49	6.4-7.4	16.7
	50% Titanium Dioxide (Rutile-Non Chalking)	34	9.2-11.2	10.7
	*Tenn. Eastman	19	11.2-11.7	10.9
A-8	*50% Vinyl Chloride Acetate	49	6.9-8.8	15.1
	50% Titanium Dioxide (Rutile-Non Chalking)	34	9.9	12.
	*Bakelite Corp. VAGH	19	12.8-13.8	11.3

TABLE III ~~CONFIDENTIAL~~

GENERAL PAINT PERFORMANCE TEST RESULTS USING VARIOUS VEHICLES WITH TITANIUM DIOXIDE

FORM NO.	SET TO TOUCH	DUST FREE	DRY HARD	FULL HARDNESS	SPECULAR GLOSS	FLEXABILITY 1/8"MANDREL	ANCHORAGE	DISTILLED WATER TEST		HYDROCARBON TEST		ACCELERATED WEATHERING (300 HRS)
								16 HOURS IMMERSION	2 HOURS RECOVERY	4 HOURS IMMERSION	24 HOURS RECOVERY	
A-1	35 min	50 min	8 hrs	28 hrs	90°	Passed	OK	Some blisters	Slight recovery	Small blisters	Slight recovery	V.sl.dulling Ex. condition
A-2	35 min	40 min	8 hrs	28 hrs	94°	Passed	OK	Med. blisters	Slight recovery	Small blisters thruout	Slight recovery	Excellent condition
A-3	45 min	50 min	6 hrs	28 hrs	93°	Passed	OK	Some blisters	Slight recovery	Small blisters thruout	Slight recovery	Sl.chalking Excellent condition
A-4	15 min	20 min	Remains soft - Easily marred		DID NOT DRY HARD ENOUGH - DISCARDED							
A-5	35 min	1 hr	10 hrs	26 hrs	91°	Passed	OK	Un-effected	-	Some blisters	Re-covered	Ex.condition & Gl.retention
A-6	5 min	5 min	5 min	20 hrs	3°	Cracked	Flakes fr panel	Un-effected	-	V.sl. blisters & wrinkles	Re-covered	Excellent condition
A-7	3 min	3 min	3 min	4 hrs	26°	Cracked	Flakes fr panel	Sl.amt. sm.blist.	Re-covered	Un-effected	-	Excellent condition
A-8	3 min	3 min	10 min	27 hrs	30°	Passed	OK	Sl.amt. blisters	Re-covered	Un-effected	-	Excellent condition
A-9	3 min	3 min	35 min	4 hrs	80°	Cracked	OK	V.sl. haze & v. sm.blist.	Re-covered	Un-effected	-	Excellent condition
A-10	-	-	-	Gelled								
A-11	3 min	3 min	30 min	30 hrs	84°	Passed	OK	Hazed	Re-covered	Un-effected	-	Excellent condition
A-12	30 min	40 min	15 hrs	26 hrs	98°	Passed	OK	V.sl. amt.sm. blisters	Re-covered	Un-effected	-	Chalked sl. loss of gloss Cons.yellowing
A-13	$1\frac{1}{2}$ hrs	1-3/4h.	3 hrs	20 hrs	70°	Passed	OK	Un-effected	-	Un-effected	-	Chalked - Loss of gloss

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TABLE III (Con't) ~~CONFIDENTIAL~~

GENERAL PAINT PERFORMANCE TEST RESULTS USING VARIOUS VEHICLES WITH TITANIUM DIOXIDE

FORM NO.	DRY TIME				SPECULAR GLOSS	FLEXABILITY 1/8"MANDREL	ANCHORAGE	DISTILLED WATER TEST		HYDROCARBON TEST		ACCELERATED WEATHERING (300 HRS)
	SET TO TOUCH	DUST FREE	DRY HARD	FULL HARDNESS				16 HRS IMMERSION	2 HRS RECOVERY	4 HRS IMMERSION	24 HRS RECOVERY	
A-14	50 min	60 min	Top tack (Cured at 200°F for 10 min.)		96°	Severe cracking	Flakes off panel	Slight softening	Recovered	Slight softening	Recovered	Sl.loss of gloss
A-18	20 min	22 min	4 hrs	24 hrs	98°	Passed	OK	Un-effected	-	Un-effected	-	Some chalking
A-19	11 min	12 min	7 hrs	24 hrs	97°	Passed	OK	Softened	Recovered	Un-effected	-	Sl. loss of gloss-Excellent condition
A-22	15 min	15 min	8 hrs	24 hrs	100°	Failed	OK	Loss of gloss	Recovered	Slight	Recovered	Loss of gloss V.sl.chalking
A-23	$1\frac{1}{2}$ min	$1\frac{1}{2}$ min	8 min	8 hrs	4°	Passed	Flakes off panel	V.sl. softening	Recovered	Slight softening	Recovered	Sl.chalking-Ex. condition
A-24	5 min	7 min	10 min	8 hrs	3°	Passed	Adhesion or sl. brittle	V.sl. softening	Recovered	Slight softening	Recovered	V.sl. chalking
A-25	7 min	7 min	4 hrs	24 hrs	90°	Passed	Flakes fr panel	Un-effected	-	Un-effected	-	Some loss of gloss. Medium amt yellowing
W-1	8 min	9 min	12 hrs	24 hrs	90°	Passed	OK	V.soft	Recovered	Slight softening	Recovered	Very good

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TABLE IV

EFFECT OF VARIATION OF WHITE PIGMENT COMBINATION .016 ALUMINUM ALLOY

FORM NO.	DESCRIPTION	IRRADIANCE ($Cal/Cm^2/Sec$)	CRITICAL ENERGY FOR BLISTERING (Cal/Cm^2)	SPECIFIC TEMPERATURE RISE ($^{\circ}C/Cal/Cm^2$)
A-1	(Control)	9.9	15.3	8.3
PE-1	49.3% Alkyd Soya Type 45.8% Titanium Dioxide(Rutile-Non Chalking)	11.0	18.7-19.1	7.
PE-2	48.7% Alkyd Soya Type 41.5% Titanium Dioxide(Rutile-Non Chalking) 9.8% Zinc Oxide	11.1	19.1-19.4	7.9
PE-3	48.2% Alkyd Soya Type 37.3% Titanium Dioxide(Rutile-Non Chalking) 14.5% Zinc Oxide	10.3	16.3-16.5	8.1
PE-4	40.0% Alkyd Soya Type 40.0% Titanium Dioxide(Rutile-Non Chalking) 20.0% Zinc Oxide	10.3	16.4-16.8	8.1
PE-5	25.0% Alkyd Soya Type 25.0% Titanium Dioxide(Rutile-Non Chalking) 50.0% Zinc Oxide	10.3	19.8-21.9	8.8
PE-6	49.3% Alkyd Soya Type 45.8% Titanium Dioxide(Rutile-Non Chalking) 4.9% Antimony Oxide	10.1	17.6-17.9	8.1
PE-7	48.7% Alkyd Soya Type 41.5% Titanium Dioxide(Rutile-Non Chalking) 9.8% Antimony Oxide	9.5	17.1-17.5	8.9
PE-8	48.2% Alkyd Soya Type 37.3% Titanium Dioxide(Rutile-Non Chalking) 14.5% Antimony Oxide	9.5	9.6-10.3	13.7
PE-9	40.0% Alkyd Soya Type 40.0% Titanium Dioxide(Rutile-Non Chalking) 20.0% Antimony Oxide	9.5	15.0-16.4	9.1
PE-10	25% Alkyd Soya Type 25% Titanium Dioxide(Rutile-Non Chalking) 50% Antimony Oxide	9.8	15.4-17.0	9.1
PE-11	*37.3% Silicone Alkyd Copolymer 37.3% Titanium Dioxide(Rutile-Non Chalking) 25.4% Frit #12 *ST-873 Plaskon	9.8	17.4-18.2	9.1
PE-12	*39.0% Silicone Alkyd Copolymer 39.0% Titanium Dioxide(Rutile-Non Chalking) 22.0% Frit #2 *ST-873 Plaskon	9.8	18.5-18.5	8.5

[redacted]

TABLE IV (CON'T)

EFFECT OF VARIATION OF WHITE PIGMENT COMBINATION
.016 ALUMINUM ALLOY

FORM NO.	DESCRIPTION	IRRADIANCE $(Cal/Cm^2/Sec)$	CRITICAL ENERGY FOR BLISTERING (Cal/Cm^2)	SPECIFIC TEMPERATURE RISE $(^\circ C/Cal/Cm^2)$
PE-13	* 50% Silicone Alkyd Copolymer 50% Titanium Dioxide (Rutile-Med.chalking) * ST-873 Plaskon	8.6	20.	7.4
PE-14	*50% Silicone Alkyd Copolymer 50% Titanium Dioxide (Anatase-Free Chalking) *ST-873 Plaskon	8.6	16.	8.1
A-5	*50% Silicone-Alkyd Copolymer 50% Titanium Dioxide (Rutile-Non Chalking) *ST-873 Plaskon	9.7	18.0-19.6	8.2

[redacted]

TABLE V ~~CONFIDENTIAL~~

EFFECT OF COMBINATIONS OF OTHER WHITE PIGMENTS WITH TiO_2 GENERAL PAINT PERFORMANCE

FORM NO.	DRY TIME SET TO TOUCH	DUST FREE	DRY HARD	FULL HARDNESS	SPECULAR GLOSS	FLEXIBILITY 1/8"MANDREL	ANCHORAGE	DIST. WATER TEST 16 hrs IMMERSION	2 hrs RECOVERY	HYDROCARBON TEST 4 hrs IMMERSION	24 hrs RECOVERY	ACCELERATED WEATHERING (300 hrs)
PE-1	15 min	25 min	6 hrs	23 hrs	98°	Passed	Passed	Unaffected	-	Wrinkled-blistered	Partial recovery	Chalked-Loss of gloss
PE-2	16 min	16 min	6½ hrs	30 hrs	81°	Some cracking	OK	V.sl.soft-Sl.blist.	Partial recovery	Unaffected	-	Loss of gloss
PE-3	18 min	18 min	7 hrs	48 hrs	71°	Some cracking	OK	Sl. soft	Sl. soft	Unaffected	-	Slight loss of gloss
PE-4	20 min	30 min	5½ hrs	22 hrs	97°	Some cracking	OK	V.sl. blisters	Recovered	Numerous blisters	Partial recovery	Some chalking Loss of gloss
PE-5	20 min	30 min	2 hrs	40 hrs	5°	Failed	Flakes fr panel	V.slight soft	Recovered	Unaffected	-	Some chalking
PE-6	20 min	25 min	7 hrs	40 hrs	86°	Passed	OK	Slight softening	Partial recovery	Unaffected	-	Excellent
PE-7	20 min	20 min	7 hrs	21 hrs	84°	Passed	OK	V.slight blisters	Recovered	V. slight softening	Recovered	Some chalking
PE-8	18 min	18 min	7 hrs	29 hrs	81°	Passed	OK	Slight softening	Recovered	V.slight wrinkling	Recovered	Sl.chalking & Loss of gloss
PE-9	18 min	20 min	7 hrs	33 hrs	96°	Passed	OK	V.slight blisters	Recovered	Slight softening	Recovered	Slight loss of gloss
PE-10	15 min	20 min	7 hrs	35 hrs	83°	Failed	OK	Slight	Recovered	Sl.wrinkles & softening	Recovered	Loss of gloss
PE-11	15 min	20 min	3 hrs	20 hrs	54°	Failed	Flakes fr panel	V.slight blisters	Recovered	Slight softening	Recovered	Very good
PE-12	24 min	24 min	7 hrs	48 hrs	83°	Failed	Flakes fr panel	V.slight blisters	Recovered	Slight softening	Recovered	Slight loss of gloss
PE-13	25 min	25 min	10 hrs	48 hrs	85°	Passed	OK	Slight softening	Recovered	Softened	Recovered	Slight loss of gloss
PE-14	25 min	25 min	10 hrs	48 hrs	81°	Passed	OK	Slight soft	V. slight soft	Softened	Recovered	Slight chalking
A-5	35 min	1 hr	10 hrs	26 hrs	91°	Passed	OK	Unaffected	-	Some blisters	Recovered	Ex. condition & gloss reten.

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TABLE VI

EFFECT OF VARIATION IN PIGMENT VOLUME CONCENTRATION ON THERMAL RADIATION PROPERTIES

FORM NO.	DESCRIPTION			IRRADIANCE (Cal/Cm^2/Sec)	CRITICAL ENERGY FOR BLISTERING (Cal/Cm^2)	SPECIFIC TEMPERATURE RISE (°C/Cal/Cm^2)
A-5	Control	21% PVC		9.7	18.0-19.6	8.2
PV-1	*28.4% Silicone Alkyd Copolymer 71.6% Titanium Dioxide (Non chalk) *Plaskon ST-873	40% PVC		10.5	16.2-16.4	8.7
PV-2	*15.3% Silicone Alkyd Copolymer 84.7% Titanium Dioxide (Non chalk) *Plaskon ST-873	60% PVC		11.0	50-72 Yellows at 40 Burnt to ash 77-95	7.7
PV-6	*19.3% Silicone Alkyd Copolymer 47.8% Titanium Dioxide (Non chalk) 33.8% Calcined Clay *Plaskon ST-873	60% PVC	AL.	9.6	56-59 Yellows at 32-46 Chars and flakes off 56-59	6.7
			MG.	10.	30-33	11.
PV-7	*18.4% Silicone Alkyd Copolymer 47.8% Titanium Dioxide (Non chalk) 33.8% Calcined Clay *Plaskon ST-873	60% PVC		8.6	Yellows at 43 Burnt to ash 70-77	6.0
PV-8	*25% Epon Resin 75% Titanium Dioxide (Non chalk) *Shell Chemical XA-200	45% PVC		8.6	Yellows at 52 Burnt to ash 59-69	8.0
PV-9	*21.4% Silicone Alkyd Copolymer 78.6% Titanium Dioxide (Non chalk) *Plaskon ST-873	50% PVC		9.5	40 Yellows at 30	8.1
PV-10	*18.2% Silicone Alkyd Copolymer 81.8% Titanium Dioxide (Non chalk) *Plaskon ST-873	55% PVC		10	Yellows at 41 Destroyed at 52-56	8.3
PV-11	*10.7% Silicone Resin **4.6% Epon Resin 82.7% Titanium Dioxide (Non chalk) 2.0% Zinc Oxide *GE - SR-82 **Epon Resin - 864 Shell	60% PVC		10	Yellow and cracks at 51 Destroyed at 61-70	8.7
PV-12	*29% Epon Resin 71% Titanium Dioxide (Non chalk) *Shell XA-200	40% PVC		9.6	16	9.9
PV-13	*36% Epon Resin 42% Titanium Dioxide (Non chalk) 22% Calcined Clay *XA-200 Shell Chemical	40% PVC		9.8	18 - 19	9.8
PV-14	*21.3% Silicone Alkyd Copolymer 37.7% Titanium Dioxide (Non chalk) 41% Calcined Clay *ST-873 Plaskon	55% PVC		10	47-50 Yellows at 39	7.6

TABLE VI (Con't)

EFFECT OF VARIATION IN PIGMENT VOLUME CONCENTRATION ON THERMAL RADIATION PROPERTIES

FORM NO.	DESCRIPTION	IRRADIANCE (Cal/Cm^2/Sec)	CRITICAL ENERGY FOR BLISTERING (Cal/Cm^2)	SPECIFIC TEMPERATURE RISE ($^\circ$C/Cal/Cm^2)
PV-15	*23.2% Silicone Alkyd Copolymer 38.0% Titanium Dioxide (Non chalk) 38.8% Calcined Clay *ST-873 Plaskon 50% PVC	10	50-53 **Yellows at 41**	7.6
PV-16	*35.0% Silicone Alkyd Copolymer 37.2% Titanium Dioxide (Non Chalk) 27.8% Calcined Clay *ST-873 Plaskon 45% PVC	10	46 **Yellows at 39**	8.4

TABLE VII

EFFECT OF VARIATION IN PIGMENT VOLUME CONCENTRATION ON GENERAL PAINT PERFORMANCE

FORM NO.	SET TO TOUCH	DUST FREE	DRY HARD	FULL HARDNESS	SPECULAR GLOSS	FLEXIBILITY 1/8"MANDREL	ANCHORAGE	DIST. WATER TEST		HYDROCARBON TEST		ACCELERATED WEATHERING (300 hrs)
								16 hrs IMMEDSION	2 hrs RECOVERY	4 hrs IMMERSION	24 hrs RECOVERY	
A-5	35 min	60 min	10 hrs	26 hrs	91°	Passed	OK	Unaffected	-	Some blisters	Recovered	Excellent Good gloss retention
PV-1	15 min	18 min	7 hrs	48 hrs	74°	Passed	OK	V.slight blistering	Recovered	Unaffected	-	Excellent
PV-2	5 min	8 min	5 hrs	48 hrs	64°	V.slight chalking	Good adhesion. Slight brittle	Unaffected	-	Unaffected	-	V.slight loss of gloss
PV-6	3 min	4 min	1 hr	24 hrs	11°	Slight cracking	Good adh. Sl.brittle	Unaffected	-	V.slight softening	Recovered	No chalking Good
PV-7	3 min	5 min	1 hr	24 hrs	13°	V.slight cracking	Good adh. Sl.brittle	Unaffected	-	V.slight softening	Recovered	No chalking Good
PV-9	10 min	10 min	5 hrs	24 hrs	41°	Slight cracking	Good adh. Sl.brittle	Slight softening	Recovered	Slight softening	Recovered	Very good condition
PV-10	20 min	22 min	5 hrs	24 hrs	61°	V.slight cracking	Good adh. Sl.brittle	Slight softening	Recovered	Slight softening	Recovered	Very good condition
PV-11	3 min	6 min	3 hrs	12 hrs	50°	Failed	Good adh. Sl.brittle	Slight softening	Recovered	Very soft	Slightly soft	Very good condition
PV-12	3 min	5 min	$2\frac{1}{2}$ hrs	24 hrs	4°	Failed	Good adh. Sl.brittle	V.slight blistering	Recovered	Slight soft	Recovered	Very good
PV-13	5 min	8 min	$2\frac{1}{2}$ hrs	24 hrs	15°	Passed	Good adh. Sl.brittle	V.slight soft	Recovered	Unaffected	-	Loss of gloss
PV-14	30 min	39 min	3 hrs	24 hrs	8°	Hairline cracks	Good adh. Sl.brittle	Slight soft	Recovered	Slight soft	Recovered	Very good
PV-15	28 min	35 min	3 hrs	24 hrs	8°	Hairline cracks	Good adh. Sl.brittle	Slight soft	Recovered	Slight soft	Recovered	Very good
PV-16	25 min	35 min	3 hrs	24 hrs	8°	Passed	Good adh. Sl.brittle	Slight soft	Recovered	Slight soft	Recovered	Very good

TABLE VIII

CRITICAL THERMAL ENERGIES AND TEMPERATURE RISES
EFFECT OF VARIATION IN FILM THICKNESS
.016 ALUMINUM ALLOY

FORM NO	DESCRIPTION	Thickness of PAINT FILM (Mils)	IRRADIANCE (Cal/Cm^2/Sec)	CRITICAL ENERGY FOR BLISTERING (Cal/Cm^2)	SPECIFIC TEMPERATURE RISE (°C/Cal/Cm^2)
A-1	50% Alkyd Soya Type 50% Titanium Dioxide(Non Chalk)	2	9.9	15.3	8.3
		4	11.1	20.3-20.9	6.5
		6	11.1	25.6	5.1
		8	11.1	25.4-25.7	5.5
PV-2	*15.3% Silicone Alkyd Copolymer 84.7% Titanium Dioxide (Non Chalk) *Plaskon ST-873	2	11.	50-72	7.7
		3	10.	50-60	6.7
		4	9.4	77-95 Yellows at 40	5.2
PV-6	*19.3% Silicone Alkyd Copolymer 47.8% Titanium Dioxide(Non Chalk) 33.8% Calcined Clay *Plaskon ST-873	2	9.6	56-59	6.7.
		3	9.6	57	7.0
		4	9.6	48-59	5.7
A-13	50% Epon Urea Formaldehyde Resin 50% Titanium Dioxide (Non-Chalk) Shell Chemical XA-200	2	11.1	17.4-18.0	8.3
		4	9.4	37-38	5.9

TABLE IX

EFFECT OF VARIATION OF PRIMER FORMULATION
ON THERMAL PROPERTIES OF COATING SYSTEM
FINISH COAT ON ALL SYSTEMS, PV-6

FORM NO.	DESCRIPTION	TYPE METAL	IRRADIANCE (Cal/Cm^2/Sec)	CRITICAL ENERGY FOR BLISTERING (Cal/Cm^2)	SPECIFIC TEMPERATURE RISE (°C/Cal/Cm^2)
	Std. Primer MIL-P-6689a (Control)	Al	9.6	56-59	6.7
	Std. Primer MIL-P-6889a	Mg	10	30-33	11
PX-1	18.5% Zinc Yellow 18.0% Calcined Clay 18.5% Titanium Dioxide(Non Chalk) *45.0% Silicone Alkyd Copolymer *ST-873 Plaskon	Al	10	70-75 Yellows at 50	6.9
PX-2	16.2% Zinc Yellow 28.4% Calcined Clay 16.2% Titanium Dioxide(Non Chalk) *39.2% Silicone Alkyd Copolymer *ST-873 Plaskon	Al	10	71-77 Yellows at 60	6.4
PX-3	14.6% Zinc Yellow 7.8% Magnesium Silicate 35.0% Titanium Dioxide (Non Chalk) *26.5% Short Oil Modified Alkyd **16.1% Phenolic Dispersion Resin *Rezyl 728-5 (Am. Cyanamid) **Bk-3962 Bakelite	Al	10	73-75 Yellows at 40-50	6.4
PX-4	47.0% Zinc Yellow 8.2% Magnesium Silicate *44.8% Vinyl Toluene Modified Epoxy Ester *WADC XOR-7	Mg	9.7	21-22	9.5
PX-5	23.0% Zinc Yellow 7.3% Magnesium Silicate 30.0% Titanium Dioxide (Non Chalk) *39.7% Vinyl Toluene Modified Epoxy Ester *WADC 7400 NL	Mg	10	31-35	9.3
PX-6	11.9% Zinc Yellow 6.8% Magnesium Silicate 44.5% Titanium Dioxide (Non Chalk) *36.8% Vinyl Toluene Modified Epoxy Ester *WADC XOR-7	Mg	9.7	23-24	9.7
PX-7	23.0% Zinc Yellow 7.3% Magnesium Silicate 30.3% Titanium Dioxide (Non Chalk) *39.7% Epon Resin *D-4 Shell Chemical	Al	10	55-60 Yellows at 30-40	7.8
PX-8	*21.5% Polyester 34.55% Butyl Acetate 37.6% Zinc Yellow 14.35% Toluene Diisocyanate	Mg	9.7	34	9.9

TABLE IX (Con't)

EFFECT OF VARIATION OF PRIMER FORMULATION ON THERMAL PROPERTIES OF COATING SYSTEM
FINISH COAT ON ALL SYSTEMS, PV-6

FORM NO.	DESCRIPTION	TYPE METAL	IRRADIANCE (Cal/Cm2/Sec)	CRITICAL ENERGY FOR BLISTERING (Cal/Cm2)	TEMPERATURE RISE (°C/Cal/Cm^2)
PX-9	23.0% Zinc Yellow 7.3% Magnesium Silicate 30.0% Titanium Dioxide (Non Chalk) *39.7% Styrenated Dehydrated Castor Oil *Isostyre 55Z - Woburn Chemical	Al.	10	60-63	7.2
PX-10	23.0% Zinc Yellow 7.3% Magnesium Silicate 29.9% Titanium Dioxide (Non Chalk) *29.8% Vinyl Toluene Modified Alkyd **10.0% Silicone Alkyd *WADC XOR-7 **XR-807 Dow Corning	Al.	10	52-56	7.8
PX-11	47.0% Strontium Chromate 8.2% Magnesium Silicate *17.0% Phenolic Dispersion Resin 27.8% Med. length Soya Alkyd *Bakelite BK-3962	Al.	10	54-59	7.6

TABLE X

WADC SAMPLE MIL-E-7729 VERSUS COMPARABLE COATING AND PV-6

NO.	DESCRIPTION	IRRADIANCE (Cal/Cm^2)	CRITICAL ENERGY FOR BLISTERING (Cal/Cm^2)	SPECIFIC TEMPERATURE RISE (°C/Cal/Cm^2)
W-1	MIL-E-7729 WADC	9.6	12	10
A-1	MIL-E-7729 Vita-Var	9.9	15.3	8.3
PV-6	Best to date for Thermal Radiation	9.6	56-59	6.7

TABLE XI

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ENVIRONMENTAL TESTING OF SELECTED FORMULATIONS

FORM NO.	ALUMINUM	MAGNESIUM	COUPLED ALUM.& MAG.	ALUMINUM	MAGNESION	COUPLED ALUM. & MAG.	ALUMINUM	MAGNESIUM	COUPLED ALUMINUM AND	MAGNESIUM
A-1	Cons.loss of gloss	Cons.loss of gloss	Cons.loss of gloss	Sl.corrosion.3-10 MM blister	4-5MM Corrosion at scribe. Some blist. at scribe	Completely corroded so panels fell apt at joint in 48 hrs	Med.amt. large blisters	Cons.amt. of small blisters	Cons.amt. of blisters	Cons.amt. of blisters
A-5	Slight loss of gloss	Slight loss of gloss	Slight loss of gloss	Few large blisters at scribe Slt corrosion at scribe	3-5MM corrosion at scribe	Completely corroded so panels fell apt at joint in 48 hrs	Cons.amt. small blisters	Cons.amt. small blisters	Cons.amt. tiny blisters	Cons.amt. tiny blisters
A-24	Very good condition	Very good condition	Very good condition	Excellent	V.slight corrosion at scribe	Completely corroded so panels fell apt at joint in 48 hrs	Excellent	Excellent	Excellent	Excellent
PV-2	Very good condition	Very good condition	Very good condition	Excellent	1-2MM corrosion at scribe	Completely corroded so panels fell apt at joint in 48 hrs	Excellent	Slt. amt. med.size blisters	V.slt.amt. of blisters	Cons.amt. of blisters
PV-6	Very good condition	Very good condition	Very good condition	Slt.corrosion scribe Couple lg. blisters scribe	V.slight corrosion at scribe	Completely corroded so panels fell apt at joint in 48 hrs	Excellent	Cons.amt. med. size blisters	Cons.amt. blisters	Cons.amt. blisters
PV-7	Very good condition	Very good condition	Very good condition	Excellent	2MM corrosion at scribe	Completely corroded so panels fell apt at joint in 48 hrs	Excellent	V. slight amt.small blisters	Excellent	Excellent
W-1	Cons.loss of gloss	Cons.loss of gloss	Cons.loss of gloss	V.sl.corrosion at scribe.Few lg.blisters at scribe	3-5MM corrosion & blisters at scribe	Completely corroded so panels fell apt at joint in 48 hrs	Med.amt. small blisters	Cons.amt. small blisters	Med.amt. small blisters	Cons.amt. blisters

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TABLF XII

THERMAL PROPERTIES OF VARIOUS VEHICLES WITH TIO_2 PIGMENT ON .016 ALUMINUM ALLOY

FORM NO.	DESCRIPTION	THICKNESS OF PAINT FILM (MILS)	IRRADIANCE ($Cal/Cm^2/Sec$)	CRITICAL ENERGY FOR BLISTERING (Cal/Cm^2)	SPECIFIC TEMPERATURE RISES ($^{\circ}C/Cal/Cm^2$)
FP-1	Silicone Alkyd Copolymer - 17.4% Pure Silicone Resin - 2.1% Titanium Dioxide, Rutile, Non-Chalk - 37.5% Calcined Clay - 43%	2	9.6	Yellows at 30 Chars 39-45	9.2
FP-2	Silicone Alkyd Copolymer - 15.5% Pure Silicone Resin 4.0% Titanium Dioxide, Rutile, Non-Chalk - 37.5% Calcined Clay - 43%	2	9.9	Yellows at 45 Chars 50-52	8.4
FP-3	Silicone Alkyd Copolymer - 14.3% Pure Silicone Resin - 6.0% Titanium Dioxide, Rutile, Non-Chalk - 37.2% Calcined Clay - 42.5%	2	9.9	Chars 45	9.3

APPENDIX C

SPECTROPHOTOMETRIC DATA

All of the experimental coatings prepared during the course of this work were coated on aluminum panels for the purpose of determining their reflectance. These panels were forwarded to W.A.D.C. where the reflectance of the coatings was determined by means of a recording spectrophotometer. In Figure 1 are shown typical reflectance curves obtained when the vehicle was varied while maintaining a constant pigmentation. Figure 2 shows examples of typical curves obtained when the pigmentation was varied while maintaining the vehicle constant. In Figure 3 are shown curves obtained when the pigment volume concentration was varied from 20% P.V.C. through 60% P.V.C. using the same vehicle.

Some of these data are rather difficult to explain in light of previous knowledge. For instance, it would not be expected that the acrylic ester as represented by A-12 would show lower reflectance than the alkyd A-1 as shown in Figure 1. This might possibly be explained by the well known difficulty commonly experienced in obtaining efficient pigment dispersion in an acrylic type vehicle. In Figure 2 the data shown are also contradictory to expectation. It will be seen that PV-1 and PV-2 having a P.V.C. of 40% and 60% respectively are plotted below the curve for A-1 which has a P.V.C. of 20%. The only explanation that can be offered for this inconsistency is the possibility that there may have been a long time interval between preparation of the panels in this laboratory and the determination of reflectance at W.A.D.C. If the panels had remained wrapped during such an interval, it is possible that sufficient "yellowing" might have occurred due to lack of light to reduce reflectance values.

PROCEDURE FOR REFLECTANCE MEASUREMENTS

Absolute spectral reflectance can be obtained by determining for each spectral (wave length) band the ratio of radiant energy reflected from a surface to that incident upon it. The optical system must be so arranged to measure directly the incident and reflected components. Measurement of absolute reflectance, consequently, requires accurately calibrated standard sources and reliable, unvarying detectors.

For a comparative evaluation of paints as covered in this report, it is generally sufficient and acceptable to measure reflectance relative to some standard reflector, which has high absolute reflectance throughout the wave length region of interest. All reflectance values in this report are of a relative nature.

The reflectance in the visible and near infrared range (0.4 to 1.0 micron) was measured with a General Electric Recording Spectrophotometer. The values obtained on this instrument are measured relative to a magnesium carbonate standard and are reproducible within ± 0.5 persent.

According to Benford, Schwarz and Lloyd of the General Electric Research Laboratory (JOSA-Vol 38), magnesium carbonate has an absolute reflectance, which varies from 97 percent at 0.4 micron to 99% at 0.7 micron. Magnesium oxide in the same wave length range, they report, has an absolute reflectance varying from 98 to 99 percent.

In the range 0.7 to 1.0 micron, no data is availble on the absolute reflectance of magnesium carbonate. Sanders and Middleton of the National Research Council, Ottowa, Canada, however, have reported the absolute reflectance of magnesium oxide to vary from 97 percent at 0.7 micron to 96 percent at 1.0 micron, (JOSA-Vol 43). The two percent difference at 0.7 micron between the values of the latter investigators and those of the former for magnesium oxide is perhaps due to a difference in sample preparation or to differences in measurements techniques.

To justify the use of magnesium carbonate as a reflectance standard throughout the wave length range 0.4 to 1.0 micron for this report, curves were obtained on the General Electric Spectrophotometer showing the reflectance of magnesium carbonate relative to that of magnesium oxide. The reflectance of the magnesium carbonate was approximately 0.5 percent less than that of magnesium oxide in the wave length range 0.5 to 1.0 microns. From 0.4 to 0.5 micron this deficiency was greater being as much as 3 percent at 0.4 micron and decreasing gradually to the nominal 0.5 percent at 0.5 micron.

The Perkin-Elmer infrared spectrometer with the White Reflectometer attachment was used throughout the spectral range 1.0 to 2.0 microns. The White Reflectometer utilizes a hemisphere reflector to collect the reflected radiant energy and to focus it on the thermocouple detector. It is subject to many light losses particularly those occurring at the detector window at grazing angles of incidence and those that result from a masking of the hemisphere by other parts such as the rotating sector mirror. These losses preclude the possibility of making reflectance measurements without calibration of the instrument against some known standard reflector.

The most efficient method for obtaining such a calibration is a direct comparison with reflectance values obtained on well-established and time proven instruments, such as the General Electric Spectrophotometer. A factor, therefore, was obtained for each sample by determining the ratio of the reflectance at a specific wave length on the General Electric Spectrophotometer to that obtained at the same wave length on the White Reflectometer.

To obtain an average value, the ratio was determined for several wave lengths in the region of over lap (0.8 to 1.0 micron) of the useful range of the two instruments. The factor was then used to adjust all subsequent values obtained on the White Reflectometer in the 1.0 to 2.0 micron range.

Polished aluminum was used as the standard in the White Reflectometer. Like most metals, polished aluminum is considered to be a "near perfect reflector" in the infrared region. Although there are some disagreements in the literature on the infrared reflectance of aluminum, it was assumed that it was of approximately the same order of magnitude and of the same non-selective nature as that of the magnesium carbonate standard in the visible.

Polished aluminum of course is a specular reflector and as such is very effective in the White Reflectometer, whose hemisphere is from all indications not a perfect intergrator. This should not be a detrimental factor unless the samples to be measured are perfectly diffuse.

The paint samples covered in this report exhibited some degree of specularity. It is estimated that the results obtained with the White Reflectometer are reproducible only within ± 5 percent because of various instrument errors.

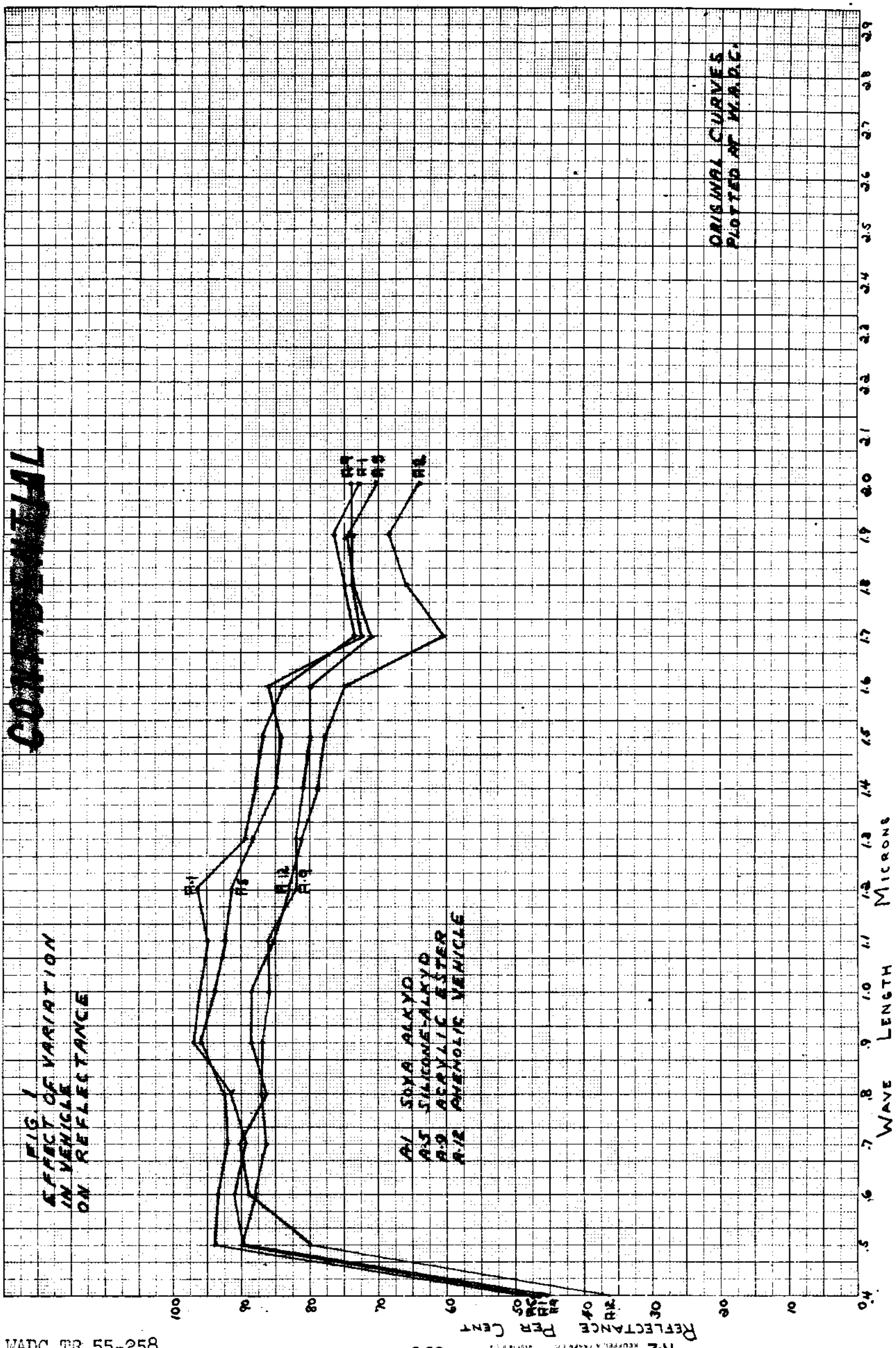

FIG 1
EFFECT OF VARIATION
IN VEHICLE
ON REFLECTANCE

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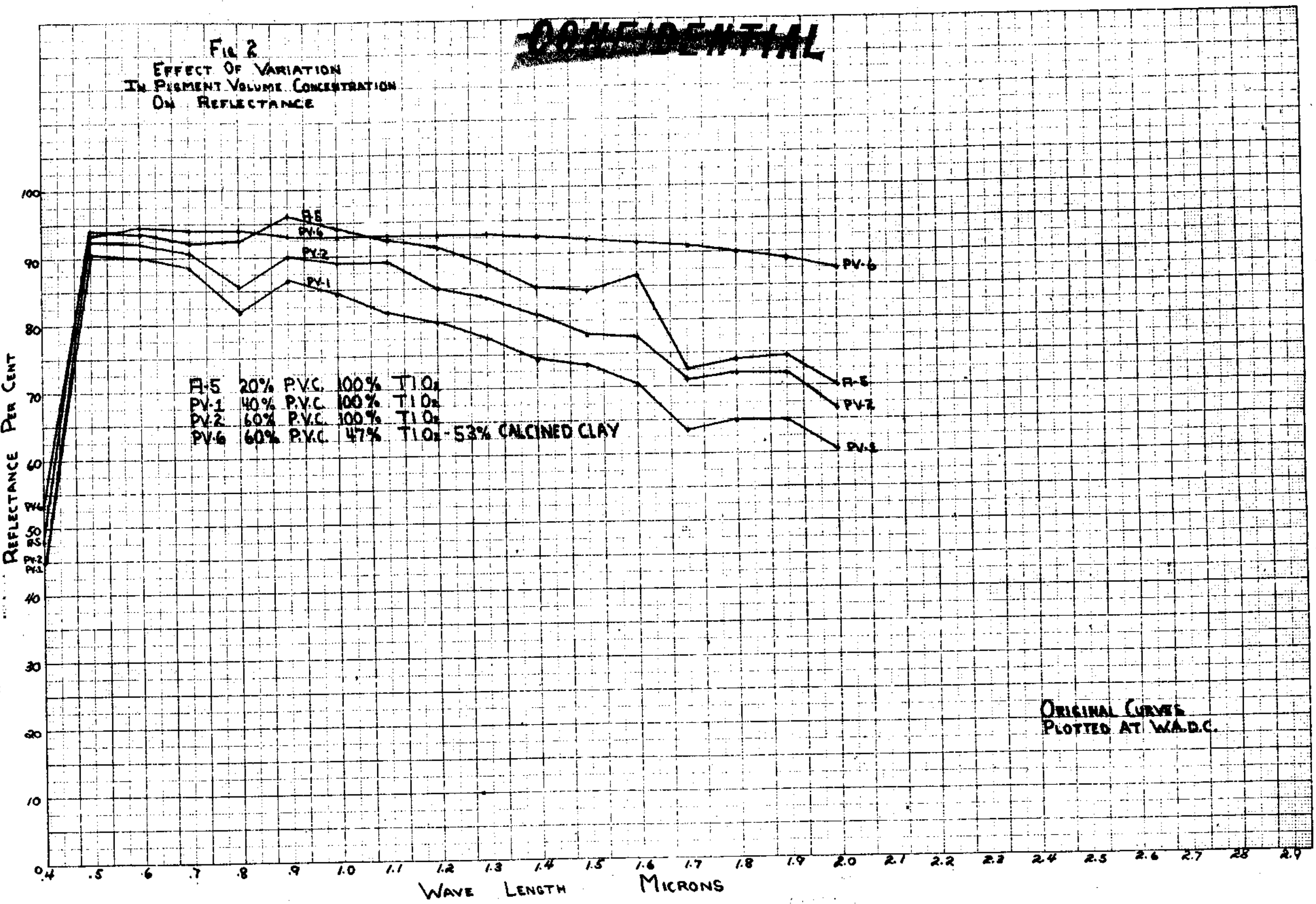

Fig 2
Effect Of Variation
In Pigment Volume Concentration
On Reflectance

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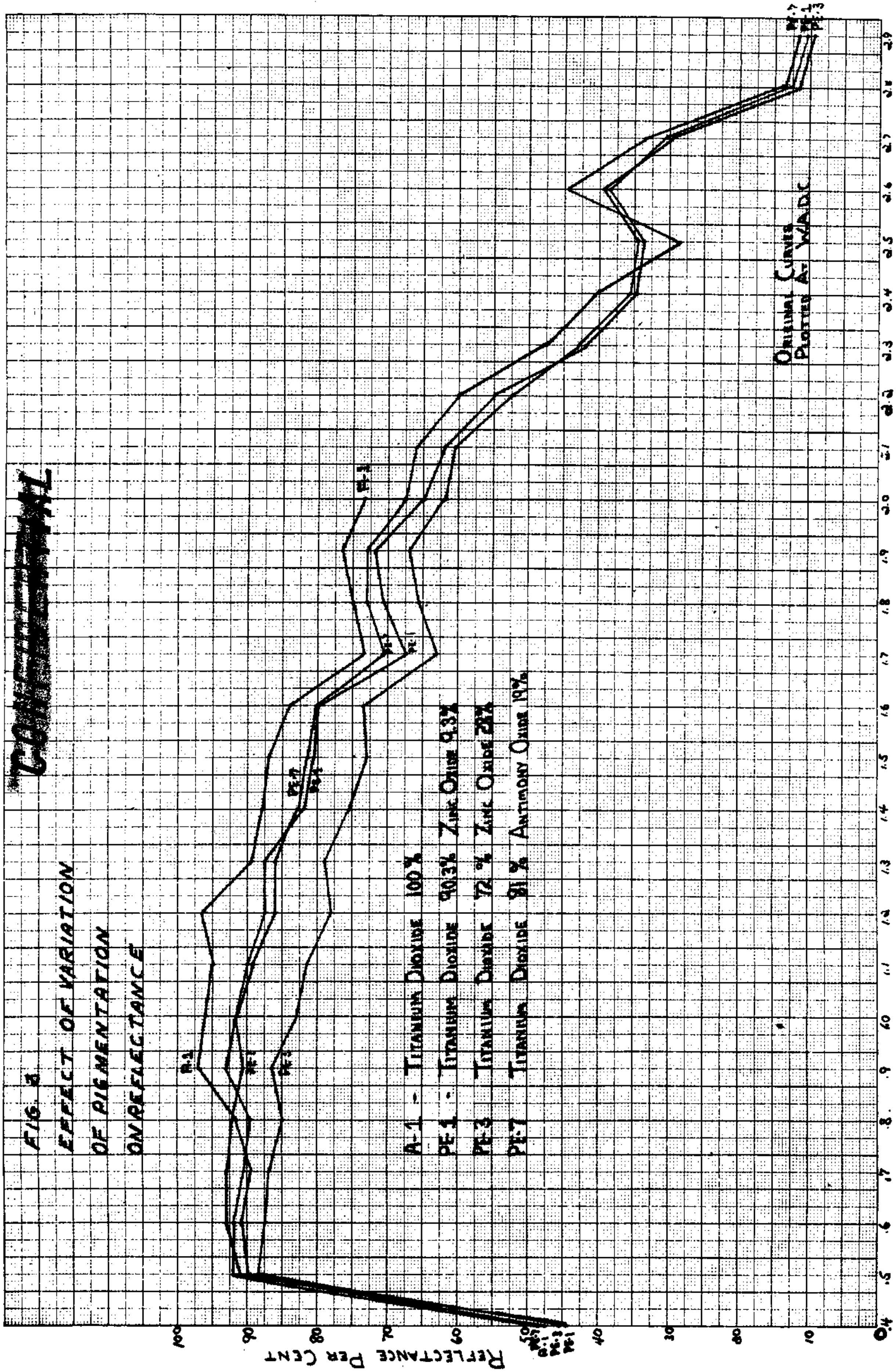

FIG. 3 EFFECT OF VARIATION OF PIGMENTATION ON REFLECTANCE

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