

EVALUATION OF LOW-SOLVENT AUTOMOTIVE REFINISHING COATINGS

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ABSTRACT

Automotive coatings supplied to Original Equipment Manufacturers (OEM) and for automobile repainting are estimated to reach 144 million gallons by 1993. The enormous problem of volatile organic compound (VOC) emissions which accompanies this growing volume of coating usage has led to developing technologies such as water-based, high-solids and multiple-component systems which are replacing conventional low-solids high-VOC coatings. This study compares the physical, compositional and performance properties of emerging technology coatings to those of existing coatings non-compliant with Bay Area and South Coast Air Quality Management District rules. All of the coatings evaluated were ranked in accordance with a set of ten weighted criteria. The performance properties of some VOC-compliant coatings equal or exceed those of non-VOC compliant coatings used for the same purpose.

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DISCLAIMER

The statements and conclusions in this report are those of the contractor and not necessarily those of the California Air Resources Board. The mention of commercial products, their source, or their use in connection with material reported herein is not to be construed as either an actual or implied endorsement of such products.

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1. SUMMARY AND CONCLUSIONS

For the purpose of this evaluation, we assigned weighting factors (noted in each of the performance rating tables) to the various test criteria to arrive at a numerical rating for each of the samples tested. All VOC (Volatile Organic Content) levels shown represent those present when the coating was applied, taking into account the amount of reduction required to achieve desired spraying properties.

A. Category 1: Primers

A total of fifteen coatings were evaluated in this category. The category was subdivided into three subgroups based on generic resin composition and included eight multiple component samples, seven single component samples and two waterborne primers.

One primer was VOC compliant with respect to South Coast AQMD (Air Quality Management District) rule 1151. Eight of the primers complied to Bay Area AQMD rule 45. Sample 1A-9, which had the lowest VOC of 165 g/l, could not be ranked because the test protocol could not be completed since the manufacturer would not allow the laboratory to maintain a sample. All single-component primers failed to comply with VOC limits.

There is apparently no correlation between the VOC levels and overall performance of the samples evaluated. VOC-compliant coatings (BAAQMD rule 45) achieved the highest ranking and second to the lowest ranking.

Table 1 -- Performance Rating vs. VOC Levels for Primers

<u>Sample</u>	<u>Rating</u>	<u>VOC</u>
1A-7	92	551
1B-5	88	741
1A-6	87	742
1A-2	86	621
1A-1	85	674
1B-4	85	732
1A-3	82	354
1A-5	80	725
1C-1	79	344
1B-1	77	725
1C-2	76	284
1B-3	74	754
1A-8	73	350
1B-2	60	739
1A-9 (not rated - see text)		165

Sample 1C-2, a waterborne acrylic with a VOC of 284 g/l is close to the current 250 g/l required by South Coast AQMD rule 1151. It showed fair performance properties. Salt spray resistance, water immersion and humidity resistance were rated fair to poor due to lack of corrosion resistance.

B. Category 2: Sealers

A total of four coatings were evaluated in this category. Two samples of coatings were VOC compliant with the established 720 g/l limit set by Bay Area AQMD. The South Coast AQMD does not define sealers.

Table 2 -- Performance Rating vs. VOC Levels for Sealers

<u>Sample</u>	<u>Rating</u>	<u>VOC</u>
2-1	98	737
2-4	97	596
2-3	94	689
2-2	85	895

Sample 2-1 is a polyester based coating; sample 2-2 and 2-4 are synthetic enamels and sample 2-3 is an acrylic lacquer.

Sample 2-3 and 2-4 (VOC compliant) were rated as excellent with a ranking of 94 and 97 respectively.

We conclude that VOC compliant sealers are currently being marketed by the coatings manufacturing industry.

C. Category 3: Topcoats

A total of eighteen automotive topcoats were evaluated and subdivided into three groups. Of the total topcoats seventeen coatings were VOC compliant with respect to Bay Area AQMD rule 45, (720 g/l) and seven complied to South Coast AQMD rule 1151 VOC limits of 624 g/l.

The VOC compliant coatings included acrylic urethanes, synthetic enamels, and acrylic enamels.

The highest-rated topcoat (93) was sample 3C-1, a VOC-compliant synthetic enamel. The lowest-rated topcoat (68) was also VOC compliant.

There is apparently no correlation between the VOC levels and overall performance of the samples evaluated.

Table 3 -- Performance Rating vs. VOC Levels for Topcoats

<u>Sample</u>	<u>Rating</u>	<u>VOC</u>
3C-1	93	586
3B-2	92	637
3C-5 (E-2)	92	778
3A-2	91	705
3B-4	91	723
3A-5	90	666
3A-6 (E-1)	90	662
3C-3 (E-1)	90	778
3C-2	89	687
3A-1	88	678
3C2-2	87	668
3B-5	86	713
3B-6	85	102
3A-3	83	603
3A-7	82	648
3B-1	77	550
3A2-1	76	577
3B-3	68	597

The lowest VOC (102 g/l) sample (3B-6, a polyester-based coating) received a good overall performance rating of 85.

We conclude that VOC-compliant automotive topcoats are currently being marketed by the coatings manufacturing industry in several technologies, including single and multiple component, acrylics, urethanes, synthetic enamels and polyesters.

2. RECOMMENDATIONS

- A. We recommend that some mechanism be provided to ensure the cooperation of automotive paint manufacturers. Several months were spent soliciting samples of experimental or emerging technology coatings with lower VOC than conventional coatings. Laboratory personnel contacted manufacturers both directly and through the representative of the National Paint and Coatings Association. The Air Resources Board also sent correspondence directly to the manufacturers to solicit support for the study.

One manufacturer offered Calcoast Laboratory personnel the opportunity to visit its testing laboratory, but not to observe testing of experimental coatings during the visit. Every manufacturer refused to discuss or submit samples of lower-solvent coatings currently being developed.

As a result, we achieved only a fair representation of experimental or lower VOC coatings. Some coatings that were tested meet current AQMD VOC limits but may not meet subsequent limit reductions that are scheduled to take effect in upcoming years.

- B. We recommend that this project be expanded to include a larger sampling of new coating technologies. All of the thirty-nine (39) coatings we tested are commercially available. Six of the primers and two of the topcoats were advertised as containing lower VOC than conventional coatings.
- C. We recommend that samples be drawn from a larger set of manufacturers than the eight we used. The table "Selected Automotive Finish Manufacturers, 1988" indicates additional potential sources of samples.

3. INTRODUCTION

Air pollution created by organic solvent emissions during the manufacturing and curing process of applied coatings creates serious health and environmental problems. Photochemically reactive solvents such as branched ketones and various aromatics normally associated with other low molecular weight hydrocarbon emissions create smog. Current Environmental Protection Agency (EPA) rulings regulate volatile organic emissions regardless of chemical type. Low volume organic solvent systems for coatings provide a means of significant reduction from current volatile organic pollutant levels.

Automotive refinishing coatings contribute significantly to the air pollution in California with the emission of organic solvents during and after application. Air pollution control districts and air quality management districts (specifically Bay Area and South Coast) have drafted regulations with specific limitations on the Volatile Organic Content, or VOC, allowed in various categories of coatings used in the automotive refinishing industry.

Most currently acceptable coatings are solvent dispersible resin systems. The substitution for solvent dispersible resin systems of low molecular weight hydrophilic dispersion resins, colloidal dispersions macromolecular emulsion polymers and two component epoxy-polyamide resins in coatings creates physical and performance problems intrinsic in the chemical and physical properties of the molecular system which must be overcome by formulation to comply with product use requirements. Low molecular weight (low intrinsic viscosity) resins often require catalysis or crosslinking with corrective oligomers to meet required cure times.

Air-curable coatings have presented greater formulation problems than low temperature bake-curable coatings. There are categories of organic coatings for special uses which require different performance properties than architectural or consumer coatings. The need to comply with current or proposed VOC (Volatile Organic Content) levels and PROC (Photochemically Reactive Organic Content) levels has resulted in the development of new polymers and reformulation of coating systems which will meet the minimum physical performance and application property requirements demanded by consumers.

New epoxy high solids technology is developing, using solid latent hardeners in combination with liquid epoxy resins to create single-package low-bake systems for automotive primers. Automotive coatings using acrylic and acrylic

urethane microgel additives have evolved, creating high-solids cross-linked nonaqueous dispersions.

While many coatings manufacturers represent that they are able to provide conforming formulations, consumers often find unsuitable application properties under conditions of actual use.

The objectives of this study were:

1. To apply carefully chosen tests to samples of currently marketed and emerging technologies in ambient-temperature and low-bake cure automotive refinishing coatings in order to assess their capabilities.
2. To provide pragmatic evaluations of the test results to assess the available and developing low-VOC coatings for automotive refinishing.

4. SAMPLING PROGRAM

During the early portion of 1989, Ron Joseph & Associates designed and implemented a sampling program for coatings in each of seven categories that would comprise a typical manufacturer's refinishing system.

These preliminary categories were:

1. Body Fillers (later eliminated)
2. Precoats, such as wash primers (later eliminated)
3. Precoats (as defined by AQMD for use with water-based primer)
4. Primers
5. Primer Surfacer (later combined with Primers)
6. Sealers
7. Topcoats (later subdivided differently)
 - A. Solid Colors
 - B. Metallics
 - C. Basecoat
 - D. Clear coat

In planning the sampling portion of this project, consideration was given to both currently accepted commercially available coatings and developmental lower VOC resins systems. Therefore, sampling was not haphazard. The plan was to obtain a range of samples broad enough to adequately represent both existing and new resin technologies in each category.

To ensure that coating suppliers were given a fair opportunity to supply coatings for this study, eight companies were contacted:

Akzo NV (Sikkens)
PPG Industries Inc.
Fuller (H.B.) Co. (NASON)
House of Kolor
Sherwin Williams Co. (Western Specialties)
Dupont (E.I.) de Nemours & Co.
R-M (BASF)
Gemstar

Of these companies, four submitted a total of twelve (12) conventional samples. The remaining 27 samples tested were procured from local retailers. All manufacturers refused to discuss or submit samples of lower-solvent coatings they are currently developing.

The table below is a list of automotive coatings manufacturers published in Modern Coatings, July 1990. Six of the manufacturers in this study appear on the list, with corporate sales in the small, medium, and large ranges. This indicates that the sources of the samples were fairly representative of the industry.

Table 4 -- Selected Automotive Finish Manufacturers, 1988

Selected Automotive Finish Manufacturers, 1988		
Company	Corporate Sales (mil \$)*	Segment/Division/Subsidiary
Akzo NV	8388	Coatings Segment
Ameron Inc.	384	Protective Coatings Segment
BASF Corp.	5000	Coatings & Inks Division
Bayer USA Inc.	4719	Mobay Corp.
Beckers AB	320	Industrial Coatings Division
Borden Inc.	7200	Non-Food Consumer Segment
Chrysler Corp.	35473	Chemical Division
Courtaulds plc	4500	International Paint Inc.
DeSoto Inc.	403	Coatings & Polymers Segment
Detrex Corp.	105	Siebert-Oxiderma Inc.
Dexter Corp.	827	Midland
Dow Chemical Co.	16682	
DuPont (E.I.) de Nemours & Co.	32917	Automotive Products Group
Elco Industries Inc.	141	Coatings & Finishing Division
Farboil Co.	15	
Ferro Corp.	1009	Specialty Coatings Segment
Fuller (H.B.) Co.	685	Industrial Coatings Division
Grow Group Inc.	383	Coatings & Chemicals Segment
Henkel Group	5138	Henkel of America Inc.
Imperial Chemical Industries plc	21058	ICI Americas
Lilly Industrial Coatings Inc.	197	American Lacquer & Solvents
Minnesota Mining & Manufacturing	10581	Decorative Products Division
Morton Thiokol Inc.	2316	Specialty Chemicals Segment
O'Brien Corp.	140	Nason Automotive Finishes
PPG Industries Inc.	5617	Coatings & Resins Segment
Plasti-Kote Co.	50	
Pratt & Lambert Inc.	233	Southern Coatings
Premier Industrial Corp.	596	General Products Segment
Rust-Oleum Corp.	50	
Scheib (Earl) Inc.	58	
Sherwin-Williams Co.	1951	Automotive Division
Valspar Corp.	480	Industrial Coatings Group
Whittaker Corp.	499	

*Fiscal years may vary
SOURCE: The Freedonia Group, Cleveland

A. Body Fillers

Body Fillers are not coatings but are used to fill large flaws before primer or putty is applied. Fillers are generally catalyzed polyester plastic material filled with magnesium silicate. Body Fillers have not been identified in either the Bay Area Rule 45 or South Coast Rule 1151.

We eliminated this category from this study because of its specialty use and exemption from the aforementioned rules.

B. Precoats

Precoats are divided into two categories: pretreatment wash primers, and a precoat for use with subsequent water-based coatings. They are each defined by Bay Area AQMD Rule 45 as follows:

Pretreatment Wash Primer: Any coating which contains a minimum of 0.5% acid by weight, is necessary to provide surface etching and is applied directly to bare metal surfaces to provide corrosion resistance and adhesion.

Precoat: Any coating which is applied to bare metal primarily to deactivate the metal surface for corrosion resistance to a subsequent water-based primer. It was found that these coatings have low volume usage in the auto refinishing market. The regulatory values established by the AQMD are also relatively high.

We eliminated this category from the study because of its special characteristics and small usage volume.

C. Primers

Primers are coatings applied prior to the application of a topcoat, to provide corrosion resistance and adhesion of the topcoat.

The resin system of the primer varies, but it must be compatible with the subsequent topcoat.

The advancements in primers have been in response to changing substrates used in automobile construction. New developments are also related to specific resin types, with most companies marketing new multi-component primers.

The sampling was subsequently directed to provide samples in three broad resin categories:

- A. Multi-component
- B. Single-component
- C. Water-based

D. Primer Surfacer

Primer Surfacer is defined by Bay Area AQMD Rule 45 as "any coating applied prior to the application of a topcoat for the purpose of corrosion resistance, adhesion of the topcoat, and which promotes a uniform surface by filling in surface imperfections".

Both the Bay Area and South Coast AQMD combine the primer surfacer with the primer for a regulatory value. We decided to combine this category with the previous primer category in each applicable resin type subgroup.

E. Sealers

Sealers are used to provide adhesion between the old finish and the new, improve color uniformity, and promote the ability of the undercoat to resist penetration by the topcoat. Sealers cannot be used as a primer and are not always required. We observed that refinishing shops frequently use sealers when doing panel repairs and color matching on old finishes.

F. Topcoats

Automotive topcoats are applied for the purpose of protection and appearance. The appearance of the coating is the primary concern of the consumer.

The motivating factor for the development of refinishing topcoats is matching OEM (original equipment manufacturer) finishes. The current OEM topcoats include more sophisticated finishes. Coatings that are easily applied in the controlled environment of the manufacturers are not easily used for refinishing. An increasing number of finishes include metallic colors and combined basecoat and clearcoat systems.

The Air Quality Management Districts have different categories regulating topcoats. For the purpose of this study we subdivided topcoats into the following categories:

- A. Single Component Resins
- B. Multi-Component Resins
- C. Metallic Colors

5. TEST PROCEDURES

The test procedures used in this study were derived from applicable American Societies for Testing and Materials (ASTM) procedures and from Federal Test Method Standard 141B (1987).

Table 5 -- Test Procedures Used in This Study

1. Total Non-Volatile (wt. %)	ASTM D2369
2. Specific Gravity (Lbs/Gallon)	ASTM D1475
3. Water (wt. %)	ASTM D1364 and ASTM D3792
4. Volatile Organic Compounds (VOC)	ASTM D3960
5. Viscosity, Ford Cup	ASTM D1200
6. Stability 120°F	ASTM D1849
7. Freeze-Thaw Resistance	ASTM D2243
8. Water Cleanup	
9. Drytime, S.T.T. and D.H.	ASTM D1640
10. Adhesion	ASTM D3359
11. Appearance	
12. Application Properties	STD 141 and FTM 2131
13. Humidity Resistance	ASTM D2247
14. Salt Spray Resistance	ASTM B117
15. Water Immersion Resistance	ASTM D1647
16. Color and Color Retention	ASTM D2244
17. Hardness - Pencil	ASTM D3363
18. 60° Gloss	ASTM D523
19. Abrasion Resistance	ASTM D4060
20. Flexibility	ASTM D1737
21. Impact Resistance	ASTM D2794
22. Contrast Ratio	ASTM D2805
23. Sag Resistance	STD 141B FTM 4494
24. Levelling	ASTM D2801
25. Accelerated Weathering	ASTM G26
26. Fungus Resistance	ASTM D3273 and ASTM 3274
27. Heat Resistance	STD 141B, Method 6051
28. Chemical Resistance	ASTM D1540
29. Sanding Properties	STD 141B and FTM 6321

Evaluation of ease of water cleanup of waterbased coatings, application properties using conventional spray equipment, and appearance of the dried film are subjective, qualitative tests. The rating used is typically "poor, fair, good or excellent".

1. ASTM D2369 Standard Test Method for Volatile Content of Coatings

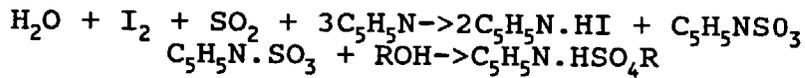
A designated quantity of coating specimen is weighed into an aluminum foil dish containing 3 ml of an appropriate solvent, dispersed and heated in an oven at $110 \pm 5^\circ\text{C}$ for 60 minutes. The percent volatile is calculated from the loss in weight.

2. ASTM D1475-85 Standard Test Method for Density of Paint, Varnish, Lacquer, and Related Products.

The accurately known absolute density of distilled water at various temperatures is used to calibrate the volume of a container. The weight of the paint liquid contents of the same container at the standard temperature (25°C) is then determined and density of the contents calculated in terms of grams per milliliter, or pounds per gallon at the specified temperature.

3a. ASTM D1364-87 Standard Test Method for Water in Volatile Solvents (Fischer Reagent Titration Method).

This test method is based essentially upon the reduction of iodine by sulfur dioxide in the presence of water. This reaction can be used quantitatively only when pyridine and an alcohol are present to react with the sulfur trioxide and hydriodic acid produced according to the following reactions:



To determine water, Fischer Reagent (a solution of iodine, pyridine, and sulfur dioxide, in the molar ratio of 1+10+3) dissolved in anhydrous 2-methoxyethanol is added to a solution of the sample in anhydrous pyridine-ethylene glycol (1+4) until all water present has been consumed. This is evidenced by the persistence of the orange-red end-point color; or alternatively by an indication on a galvanometer or similar current-indicating device which records the depolarization of a pair of noble metal electrodes. The reagent is standardized by titration of water.

3b. ASTM D3792-86 Standard Test Method for Water Content of Water Reducible Paints by Direct Injection into a Gas Chromatograph

A suitable aliquot of whole paint is internally standardized with anhydrous 2-propanol, diluted with dimethylformamide and then injected into a gas chromatographic column containing a porous polymer packing that separates water from other volatile components. The water content is determined from area calculations of the materials producing peaks on the chromatogram.

With the need to calculate volatile organic content (VOC) of water-reducible paints, it is necessary to know the water content. This gas chromatographic test method provides a relatively simple and direct way to determine water content.

4. ASTM D3960-89 Standard Practice for Determining Volatile Organic Compound Content of Paints and Related Coatings

The non-volatile content and density of the coating are determined in accordance with appropriate methods. For solvent reducible coatings, shown by tests to contain no water, the volatile content is equivalent to the VOC. For water-reducible coatings, the water content is determined separately and subtracted from the total volatile content. The percent water should be determined on all water-reducible coatings and on all solvent-reducible coatings thought to contain water since water is volatile under the conditions used for determining non-volatile content and, if present, would be included in the volatile organic content. The VOC is calculated as grams per litre of paint or coating.

Since some solvents are exempt, they also should be determined and subtracted from the total volatile and not included in the VOC calculations.

As the applicable ASTM standards show, different types of coatings are heated at different temperatures and for different times in determining non-volatile or volatile and results may vary with test conditions. It is imperative, therefore, to define clearly all test conditions used to calculate VOC.

5. ASTM D1200-82 Standard Test Method for Viscosity of Paints, Varnishes, and Lacquers by Ford Viscosity Cup

The Ford viscosity cup is filled level full with the liquid under test, and the time for the material to flow through one of the standard orifices is measured.

6. ASTM D1849-80 Standard Test Method for Package Stability of Paint

This test method covers the change in consistency and certain other properties that may take place when packaged paint of either the solvent-reducible or water-reducible type is stored at a temperature above freezing.

7. ASTM D2243-82 Standard Test Method for Freeze-Thaw Resistance of Water-Borne Paints

This test method covers the determination of the extent to which water-borne paints retain their original properties free of detrimental changes in consistency and resist coagulation or the formation of lumps and specks when subjected to freezing and subsequent thawing.

8. Water Cleanup

The ease of water cleanup of waterbased coatings is a subjective test. Evaluation is made by the cleaning of handling and application equipment with tap water.

9. ASTM D1640-84 Standard Test Method for Drying, Curing, or Film Formation of Organic Coatings at Room Temperature.

These test methods are used to determine the various stages and rates of drying, curing, and film formation of organic coatings for the purpose of comparing types of coatings or ingredient changes, or both. This is significant in the development of organic coatings for various end uses and also for production quality control.

10. ASTM D3359-87 Standard Test Method for Measuring Adhesion by Tape Test

Test Method B - A lattice pattern with six cuts in each direction is made in the film to the substrate, pressure-sensitive tape is applied over the lattice and then removed, Adhesion is evaluated by comparison of the amount of coating area removed with descriptions and illustrations in the ASTM procedure manual.

11. Appearance

The subjective evaluation of the general appearance of the coating film was evaluated. Appearance properties such as smoothness, lack of defects, depth of image (for gloss coatings) and other visually determined properties not instrumentally measured.

12. Federal Test Method Standard 141B Test Method 2131 - Application of Sprayed Film

The coatings were applied in a Binks Spray Booth measuring 42" x 42" x 24" (24.5 cu.ft). The spray gun was a Bink's model 2001 with a 6650 spray tip. The air supply at 60 psi was a Worthington compressor equipped with dual filters and moisture traps.

This method covers procedures for both manual and automatic application of finishing materials by using spraying apparatus.

13. ASTM D2247-87 Standard Practice for Testing Water Resistance of Coatings in 100% Relative Humidity

Coated specimens are placed in an enclosed chamber containing a heated, saturated mixture of air and water vapor. The temperature of the chamber is usually maintained at 100°F (38°C). At 100% relative humidity (RH), a very small temperature difference between the specimen and the surrounding vapor causes the formation of condensation on the specimens. The exposure condition is varied by selecting the duration of the test. Water permeates the coating at rates that are dependent upon the characteristics of the coating. Any effects such as color change, blistering, loss of adhesion, softening, or embrittlement are observed and reported.

14. ASTM B117 Standard Test Method of Salt Spray (Fog) Testing

This method sets forth the conditions required in salt spray (fog) testing for specification purposes. The method does not prescribe the type of test specimen or exposure periods to be used for a specific product, nor the interpretation to be given to the results. It should be noted that there is seldom a direct relation between salt spray (fog) resistance and resistance to corrosion in other media, because the chemistry of the reactions, including the formation of films and their protective value, frequently varies greatly with the precise conditions encountered.

15. ASTM D1647-83 Standard Test Methods for Resistance of Dried Films of Varnishes to Water and Alkali.

The material under test is flowed onto tinfoil panels and dried for 48 h. The panels are then immersed to half their length in reagent water for 18 h, or other agreed upon time, removed, and examined visually.

16. ASTM D2244-85 Standard Method for Calculation of Color Differences from Instrumentally Measured Color Coordinates

The differences in color between a reference and a test specimen are determined from measurements made by use of a spectrophotometer or a colorimeter. Reflectance readings from such instruments are converted by computations to color-scale values, or these color-scale values may be read directly from instruments that automatically make the computations. Color difference magnitudes are computed from differences in these color-scale values, that represent the perceived color differences between the reference and the test specimen.

The instrument used was an X-Rite 968 spectrophotometer in conjunction with SpectroStart software package.

17. ASTM D3363-74 Standard Test Method for Film Hardness by Pencil Test

The coated panel is placed on a firm horizontal surface. The pencil is held firmly against the film at a 45° angle (point away from the operator) and pushed away from the operator in a 1/4-in. (6.5-mm) stroke. The process is started with the hardest pencil and continued down the scale of hardness to either of two end points: one, the pencil that will not cut into or gouge the film (pencil hardness), or two, the pencil that will not scratch the film (scratch hardness).

18. ASTM D523-85 Standard Test Method for Specular Gloss

Measurements are made with 60°, 20°, or 85° geometry. The geometry of angles and apertures is chosen so that these procedures may be used as follows:

The 60° geometry is used for intercomparing most specimens and for determining when the 20° geometry may be more applicable.

19. ASTM D4060-84 Standard Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser

The organic coating is applied at uniform thickness to a steel rigid panel and, after curing, the surface is abraded by rotating the panel under weighted abrasive wheels.

Abrasion resistance is calculated as loss in weight at a specified number of abrasion cycles, as loss in weight per cycle, or as number of cycles required to remove a unit amount of coating thickness.

20. ASTM D1737-85 Standard Test Method for Elongation of Attached Organic Coatings with Cylindrical Mandrel Apparatus

The materials under test are applied at uniform thickness to flat sheet metal panels. After the coatings are dried or baked, the panels are bent over cylindrical mandrels of various diameters. The elongation is determined from the largest diameter mandrel that produces visible cracking in the coating.

21. ASTM D2794-84 Standard Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact)

The organic coatings under test are applied to suitable thin metal panels 0.10" cold rolled steel. After the coatings have cured, a standard weight is dropped a distance so as to strike an indenter that deforms the coating and the substrate. The indentation can be either an intrusion or an extrusion. By gradually increasing the distance the weight drops, the point at which failure usually occurs can be determined. Films generally fail by cracking, which is made more visible by the use of a magnifier, by the application of a copper sulfate (CuSO_4) solution on steel, or by the use of a pin hole detector.

22. ASTM D2805-85 Standard Test Method for Hiding Power of Paint by Reflectometry

This test method covers the determination, without reference to a material paint standard, of the hiding power of paints with Y tristimulus values greater than about 15%.

This is a precise instrumental method, giving results having absolute physical significance without reference to a comparison paint. It should be used when maximum precision and minimum subjectivity are required, as in testing specification coatings or evaluating the hiding efficiency of pigments.

23. Federal Test Method Standard 141B, Test Method 4494 Sag Test (Multrinotch Blade)

This method provides a procedure for determining the sag characteristics of surface coatings. It is intended that this method be used primarily in the laboratory since the physical performance of this test does not lend itself to normal "on the job" conditions.

24. ASTM D2801-69 Standard Test Method for Leveling Characteristics of Paints by Draw-Down Method

The coating to be tested is applied to a smooth-surfaced, hiding-power chart, by means of a special leveling test blade designed to lay down the coating in parallel pairs of stripes of varying film thickness. The complete draw-down is allowed to dry in a horizontal position and the number of parallel stripes that have completely and partially flowed together are recorded.

25. ASTM G26-84 Standard Practice for Operating Light-Exposure Apparatus (Xenon Arc Type) with and without water

This practice covers the basic principles and operating procedure for water or light exposure apparatus, or both, employing a xenon-arc light source.

Method 1 - Continuous exposure to light and intermittent exposure to water spray was used with at Type A apparatus.

Since the natural environment varies with respect to time, geography, and topography, it may be expected that the effects of natural exposure will vary accordingly. All materials are not affected equally by the same environment. Results obtained by use of this practice should not be represented as equivalent to those of any natural weathering test until the degree of quantitative correlation has been established for the material in question.

- 26a. ASTM D3273-86 Standard Test Method for Resistance to Growth of Mold on the Surface of Coatings in an Environmental Chamber.

This test method describes a small environmental chamber and the conditions of operation to evaluate reproducibly in a 4-week period the resistance of a paint film to surface mold growth in a severe interior mold environment. The apparatus is designed so it can be easily built or obtained by any interested party and will duplicate results obtained in a large tropical chamber.

Temperature and humidity must be effectively controlled within the relatively narrow limits specified in order for the chamber to function reproducibly during the short test period. Severity and rate of mold growth on a film is a function of the moisture content of both the film and the substrate. A relative humidity of 95 to 98% at a temperature of $90 \pm 2^{\circ}\text{F}$ ($325 \pm 1^{\circ}\text{C}$) is necessary for test panels to develop rapidly and maintain an adequate moisture level to support mold growth.

- 26b. ASTM D3274-82 Standard Method of Evaluating Degree of Surface Disfigurement of Paint Films by Microbial (Fungal or Algal) Growth or Soil and Dirt accumulation.

The photographic reference standards reference to in this method provide a numerical basis for rating the degree of fungal and algal growth or dirt accumulation on paint films.

27. Federal Test Method Standard 141B, Method 6051 (Heat Resistance)

The coated panels are arranged in a well-ventilated electric oven or thermostatically controlled muffle furnace and heat at the specified temperature for the specified exposure period. The panels are removed and the coating examined as specified for conformance to the requirements of the product specification.

28. ASTM D1540-82 Standard Practice for Effect of Chemical Agents on Organic Finishes Used in the Transportation Industry

This practice is designed to provide a working procedure for the examination of the effect of chemical agents on applied transportation finishes. Any change in surface appearance or condition reflects an objectionable tendency of the finish to be affected by the agent used. The change is manifested by softening, swelling, discoloration, loss of gloss, blistering, loss of adhesion, or other special phenomena.

29. Federal Test Method Standard 141B, Test Method 6321, Sanding Characteristics

This method should be used to determine the quality of coatings to be sanded for any purpose. Specifically, the ability of the coating to abrade evenly when using a fine grit paper and not to gum up or adhere to the sand paper.

6. TEST PROTOCOL

The following table represents the specific tests performed on each coating within the three categories.

Table 6 -- Tests Performed on Each Sample Category

<u>TESTS</u>	<u>CATEGORY</u>		
	1 Primers	2 Sealers	3 Topcoats
1. Total Non-Volatile (wt %)	X	X	X
2. Specific Gravity	X	X	X
3. Water (wt%)	X	X	X
4. Volatile Organic Compounds	X	X	X
5. Viscosity, Ford Cup	X	X	X
6. Stability 120°F	X	X	X
7. Freeze-Thaw Resistance	ALL WATER-BASED PRODUCTS		
8. Water Cleanup	ALL WATER-BASED PRODUCTS		
9. Dry Time	X	X	X
10. Adhesion	X	X	X
11. Appearance	X	X	X
12. App. Properties	X	X	X
13. Humidity Resistance	X	X	X
14. Salt Spray Resistance	X	-	X
15. Water Resistance	X	X	X
16. Color/Color Retention	-	-	X
17. Hardness	-	-	X
18. 60° Gloss	-	-	X
19. Abrasion Resistance	-	-	X
20. Flexibility	X	X	X
21. Impact Resistance	X	X	X
22. Contrast Ratio	-	-	X
23. Sag Resistance	X	X	X
24. Levelling	X	X	X
25. Acc. Weathering Resistance	-	-	X
26. Fungus Resistance	-	-	X
27. Heat Resistance	-	-	X
28. Chemical Resistance	-	-	X
29. Sanding Properties	X	-	-
Total Tests	20	18	29

A. Volatile Organic Compounds (VOC)

In order to calculate VOC, certain tests must be performed:

1. Total Non-Volatile Percent Weight
2. Specific Gravity
3. Percent Water by weight using Karl Fischer and Gas Chromatography and Analysis for Exempt Solvents (Chlorinated Hydrocarbons) by Gas Chromatography

B. Stability

Tests such as:

5. Viscosity - initial
6. Stability 120°F

Monitor viscosity changes with aging of the coating in the container and provide information with respect to application properties and modes of application.

C. Water Based Products

Water based products only are tested for:

7. Freeze thaw resistance
8. Water cleanup of application tools

D. All Coatings:

Tests applicable to all coatings include:

9. Drytime - set to touch (S.T.T) and dry hard (D.H.)
10. Adhesion - to a specific substrate according to use
11. Appearance
12. Application Properties

E. Water Resistance:

Water resistance properties of the cured film include:

13. Humidity Resistance
14. Salt Spray Resistance
15. Water Immersion Resistance

F. Dried Film Properties:

Physical property tests of the dried film include:

16. Color
17. Hardness
18. 60° Gloss
19. Abrasion Resistance
20. Flexibility
21. Impact Resistance
22. Contrast Ratio - Hiding Power
29. Sanding Properties

G. Wet Film Properties

23. Sag Resistance
24. Levelling

H. Other Specialty Tests:

25. Accelerated U.V. Resistance (Xenon Arc Weatherometer)
 - a. gloss retention
 - b. color change
26. Fungus Resistance
27. Heat Resistance - color change
28. Chemical Resistance

7. TEST CONDITIONS

The following conditions relate to tests cited in the Test Protocol.

Table 7 -- Test Conditions

1. Total Non-Volatile (wt %)	110°C, 60min, 0.5 gram sample
2. Spec. Gravity	Weight/gallon cup, 77°F
3. Water (wt %)	Karl Fischer, G.C. (see note, below)
4. Volatile Organic Compounds	Gas Chromatography Analysis
5. Viscosity	Ford Cup
6. Stability 120°F	30 days, 3/4 full pint
7. Freeze-Thaw Resistance	3 cycles, 16 hrs., 20°F, 8 hrs. 77°F
10. Adhesion	Crosshatch, Tape
12. Application Prop.	spray (conventional)
13. Humidity Resistance	48 hrs. cure, 100 hrs exposure, 100°F, 100% Relative Humidity
14. Salt Spray Resistance	240 Hrs., 5% NaCl, Bonderite 1000 Panels
15. Water Immersion Resistance	Q panel, 1/2 immersed deionized H ₂ O, 22 hrs
16. Color	Instrumental, Gardner Neotec colorimeter
17. Hardness	Pencil, 7 day cure, 77°F
18. 60° Gloss	48 hrs. dry
19. Abrasion Resistance	48 hrs. cure, 1000 g, CS10, 1000 rev.
20. Flexibility	Cylindrical mandrel
21. Impact Resistance	Forward
25. Acc. Weathering	topcoat on compatible primer, ASTM G26 Xenon Arc Weatherometer, 300 hrs
26. Fungus Resistance	30 day exposure ENVIRONMENTAL CABINET
27. Heat Resistance	96 hours at 140°C

NOTE: Water Content Test Conditions

The determination of water content of the coating is necessary to determine VOC content. The method selected was determined by anticipated water concentration and the presence of interfering solvents. The two methods commonly used to determine the water content of paints and coatings are:

1. Karl Fischer water titration
2. Direct injection into a gas chromatograph

Water Content Test Conditions for Gas Chromatography

Water Content of Water Reducible Paints by Direct Injection into a Gas Chromatograph - ASTM D3792-86 (modified)

A. Conditions Used:

1. Column:
 - a. type: PORAPAC Q
 - b. length: 10'
 - c. dia.: 1/8"
 - d. mesh: 80/100
2. Carrier
 - a. type: Helium
 - b. inlet pressure: 70 psi
 - c. flow rate: 35.0 ml/minute
3. Integrator
type: HP 3390A
Chart speed: 0.5 cm/minute
4. Injector Temp.: 210°C
5. Detector:
 - a. type: hot wire detector
 - b. temp.: 250°C
 - c. current: 150 mA
6. Temp. Program:
 - a. T_i : 75°C
 - b. T_f : 175°C/ 12 minute hold
 - c. rate 16°C/minute

B. Procedure Used:

Approximately 0.6g paint weighed to the nearest mg was added to 0.2 g Isopropyl alcohol and 2 mls N,N Dimethyl-formamide (note: all reagents used were Analytical Reagent grade). The above solution was placed in a headspace vial and sealed with a silicone septum. The mixture was shaken for 5 minutes and then centrifuged at 6,000 rpm for 20 minutes. The supernatant was then directly injected into the gas chromatograph using a Hamilton microliter syringe. (Note: the syringe should contain at least one-half microliter of air and 1 microliter of supernatant.)

8. COATING SYSTEMS USED FOR EVALUATION

Coating systems were selected using manufacturer's recommendations. Primers were evaluated on Bonderite 1000 cold rolled steel panels and aluminum Q panels. Panels were cleaned and conditioned prior to coating per ASTM D609.

We determined, with CARB, that testing of coatings on plastic and fiberglass substrata was beyond the scope of this contract.

In order to evaluate topcoats, primers were used which were compatible and marketed by the same manufacturer. Sealers were used only when recommended. Clear coats (E) were supplied as a kit with the basecoats.

Table 8 -- Coating Systems Used for Evaluation

<u>Topcoat</u>	<u>Primer</u>	<u>Sealer</u>
3A-1	1B-2	--
3A-2	1B-1	2-1
3A-3	1C-1	--
3A-5	1B-3	2-3
3A-6 (E-1)	1A-5	--
3A-7	1B-4	2-4
3A2-1	1A-8	--
3B-1	1A-1	--
3B-2	1B-2	2-2
3B-3	1A-2	--
3B-4	1A-6	--
3B-5	1A-3	--
3B-6	1A-9	--
3C-1	1B-2	--
3C-2	1B-3	--
3C-3 (E-1)	1A-5	2-3
3C-5 (E-2)	1B-4	--
3C-2-2	1A-4	--

9. VOC COMPLIANCE, SUMMARY AND REVIEW

VOC Compliance levels

The following table indicates compliance levels cited in both Air Quality Management District, Bay Area (BAAQMD) Rule 45 and South Coast (SCAQMD) Rule 1151 for the coating categories evaluated in this study. The volatile organic levels (VOC) are given in grams per litre.

Table 9 -- VOC Compliance Levels for Coating Categories

Category	VOC Limit (g/l)	
	Bay Area	South Coast
	Jan. 1, 1990/1992	July 1, 1990/Jan 1, 1992
1. Primers	720/340	250/250
2. Sealers	720/420	Not Defined
3. Topcoats	720/600	--/420
Acrylic Enamel	--	624/--
Alkyd Enamel	--	588/--
Poly Urethane	--	624/--
Lacquer	--	744/--
Metallic/Iridescent	720/600	--

VOC Calculations

Calculations for Volatile Organic Content (VOC) for solvent-based and water reducible coatings were made using the following formula from ASTM D3960:

$$V_1 = (100-N) (D_m) 10$$

where

V_1 = Volatile Organic Content g/l

N = Weight % non volatile

D_m = Density of coating g/ml

10 = Factor for converting results to g/l

For compliance evaluation purposes, the VOC content minus water for coatings containing water was calculated using the following formula from ASTM D3960:

$$A = (V_2 - W) (D_m) 10$$

where

A = VOC in water-reducible coating, g/l

V_2 = Total volatiles, weight %

W = Weight % water

We assumed $D_w = 1.0$ (25°C) since the factor 0.997 has a trivial effect compared to errors in density measurement.

VOC COMPLIANCE, SUMMARY AND REVIEW - continued

Study Summary

Compliance with the BAAQMD and SCAQMD acceptable VOC levels was evaluated using the following laboratory data:

1. Specific Gravity - ASTM D1475
2. Non-volatile wt % - ASTM D2369
3. Water (% wt) - ASTM D3792 and ASTM D1364

Water content of water-based coatings was analyzed primarily by gas chromatography and cross-checked with Karl Fischer Titration for coatings containing lower total water levels.

Using gas chromatography and Karl Fischer water determinations gives a standard deviation of $\pm 2.65\%$ for water content. The standard deviation for specific gravity is 1.08, and for total volatile content is 1.2. Using the minus-water calculation leads to significant variations in VOC level ($\pm 20\%$). These values are derived from the following table:

Table 10 - Results Compared with Other Studies

	<u>GC (H₂O)</u>	<u>KF(H₂O)</u>	<u>Density</u>	<u>NV</u>	<u>VOC Solvent-Based</u> (No Exempts)	
ASTM Published (1989)						
Sr	2.9	4.7	0.6	1.5		
SR	75	15.0	1.8	4.7		
ASTM D01 RR TG 24 1/19/90						
Sr	0.54	0.82	0.14	0.5	4.66 GC	3.63 KF
SR	2.65	1.70	1.08	1.18	26.08 GC	18.38 KF
Calcoast						
Sr	0.46					
SR	0.60					
Collaborative Testing Service						
Sr	3.4*	3.4*	0.36*	0.61*	18.3*	
SR	-	-	0.51**	1.2**	1.3**	
	*Report #22	6/26/89				
	**Report #28	11/19/90				
Sr = STD. DEV. (Intralab)						
SR = STD. DEV. (Interlab)						

Table 11 - VOC Compliance, Summarized by Category

<u>Category</u>	<u>VOC Compliant</u>		<u>Non-Compliant</u>	<u>Total Samples</u>
	<u>BA</u> ¹	<u>SC</u> ²		
1. Primer				
A. Multi comp.	6	1	1	8
B. Single comp.	0	0	5	5
C. Water based	2	0	0	2
2. Sealers	2	NA	2	4
3. Topcoat				
A. Single	6	2	0	7
B. Multi comp.	5	3	0	6
C. Metallic	<u>3</u>	<u>1</u>	<u>2</u>	<u>5</u>
Total	25	7	10	37

¹ BA - Bay Area AQMD Rule 45 regulatory limits of Jan. 1, 1990.

² SC - South Coast AQMD Rule 1151 regulatory limits of July 1, 1990.

VOC COMPLIANCE, SUMMARY AND REVIEW - continued

Category 1 - Primers - VOC Limits 720 g/l (Bay Area AQMD)
250 g/l (South Coast AQMD)

Table 12 - VOC Compliance, Primer Samples

<u>Sample</u>	<u>VOC</u>	<u>Resin System</u>	Compliant with:	
			<u>BA</u>	<u>SC</u>
1A-1	674	Epoxy	X	
1A-2	621	Two component vinyl	X	
1A-3	355	Epoxy	X	
1A-5	725	Urethane		
1A-6	743	Acrylic Urethane		
1A-7	551	Epoxy Urethane	X	
1A-8	350	Acrylic Urethane	X	
1A-9	165	Urethane	X	X
1B-1	726	Acrylic		
1B-2	739	Acrylic		
1B-3	754	Acrylic Lacquer		
1B-4	732	Epoxy Ester		
1B-5	741	Epoxy Ester Acrylic		
1C-1	344	Waterborne	X	
1C-2	284	Acrylic Hydrosol	X	
Total Compliant			8	1
Total Samples 15				

Category 2 - Sealers - VOC Limits 720 g/l
Bay Area AQMD

Table 13 - VOC Compliance, Sealer Samples

<u>Sample</u>	<u>VOC</u>	<u>Resin System</u>	Compliant with:	
			<u>BA</u>	<u>SC</u>
2-1	737	Acrylic Polyester		
2-2	578	Synthetic Enamel	X	No Category
2-3	689	Acrylic Lacquer	X	
2-4	596	Synthetic Enamel	X	
Total Compliant			3	
Total Samples 4				

VOC COMPLIANCE, SUMMARY AND REVIEW - continued

Category 3 - Topcoats - VOC Limits 720 g/l (Bay Area AQMD)
 624 g/l acrylic + polyurethane
 (South Coast AQMD)

Table 14 - VOC Compliance, Topcoat Samples

<u>Sample</u>	<u>VOC</u> as applied	<u>Resin System</u>	<u>Compliant with:</u>	
			<u>BA</u>	<u>SC</u>
3A-1	678	Acrylic Enamel	X	
3A-2	705	Synthetic Enamel	X	
3A-3	602	Acrylic Urethane	X	X
3A-5	666	Acrylic Enamel	X	
3A-6	662	Acrylic Enamel	X	
3A-7	648	Acrylic Urethane	X	
3A2-1	577	Acrylic Urethane	X	X
3B-1	550	Acrylic Urethane	X	X
3B-2	637	Urethane	X	
3B-3	597	Polyoxithane	X	X
3B-4	723	Acrylic Urethane		
3B-5	713	Acrylic Urethane	X	
3B-6	102	Polyester	X	X
3C-1	586	Synthetic Enamel	X	X
3C-2	687	Acrylic Enamel	X	
3C2-2	668	Polyurethane Enamel	X	
3C-3	778	Acrylic Enamel		
3C-5	778	Acrylic Enamel		
3E-1	620	Acrylic Urethane	X	X
3E-2	667	Acrylic Urethane	<u>X</u>	<u>—</u>
Total Samples 20		Total Compliant:	17	7

Table 15 - Sample Log for Primers

1. Primers

VOC Regulatory Value		Bay Area		South Coast	
		Rule 45		Rule 1151	
		1 Jan 1990/92/95	1 July	1990/1 Jan 1992	
		720/340/250		250/250	
A. Multi-Component		VOC	Literature Value	VOC Applied	
1A-1	Two-Component Epoxy Polyamide Primer	674.1	NL*	674.1	
1A-2	Two-Component Vinyl-Butyral Primer	621.3	NL	621.3	
**1A-3	Two-Component Epoxy Primer (low VOC)	354.6	420	354.6	
1A-5	Two-Component Urethane Primer-Filler	508.4	NL	725.1	
1A-6	Two-Component Acrylic Urethane Primer Surfacer	360.2	NL	742.8	
1A-7	Two-Component Epoxy	504.0	NL	551.4	
**1A-8	Two-Component Acrylic Urethane Primer	292.7	314	350.2	
**1A-9	Three-Component Urethane Primer	165.1	96	165.1	
B. Single-Component					
1B-1	Acrylic Primer-Surfacer	484.4	NL	725.5	
1B-2	Acrylic Primer-Surfacer	498.9	NL	739.0	
1B-3	Acrylic Lacquer Primer-Surfacer	488.8	NL	754.2	
1B-4	Epoxy Ester Primer	574.6	563.1	732.3	
**1B-5	Acrylic Primer (high solids)	525.1	NL	741.1	

*NL - VOC value is not listed in literature.
 **New technology coatings and advertised as lower VOC content.

Primers, continued

C. Waterborne				
**1C-1	Waterborne Primer-Surfacer	344.3	154.5	344.3
**1C-2	Waterborne Acrylic Primer-Surfacer	284.0	236.0	284.0

Table 16 - Sample Log for Sealers

VOC Regulatory Values		Bay Area	South Coast	Literature	VOC applied
		<u>Rule 45</u>	<u>Rule 1151</u>		
		1 Jan 1990/92/95 720/420/340	1 July 1990/1 Jan 1992 not defined		
2-1	Polyester Sealer	737.2	NL	NL	737.2
2-2	Synthetic Enamel Sealer	578.3	NL	NL	895
2-3	Acrylic Lacquer Sealer	688.7	NL	NL	688.7
2-4	Synthetic Enamel Sealer	596.2	623.0	623.0	596.2

Table 17 - Sample Log for Topcoats

A. Single Component			
VOC Regulatory Value	Bay Area <u>Rule 45</u>		South Coast
	1 Jan 1990/92/95 720/600/460	1 July 1990/1 Jan 1992 624-588/420	<u>Rule 1151</u>
	<u>VOC</u>	<u>Literature Value</u>	<u>VOC applied</u>
3A-1 Acrylic Enamel	493.7	NL	678.1
3A-2 Synthetic Enamel (catalyzed)	607.6	NL	704.9
3A-3 Acrylic Urethane (catalyzed)	524.4	436-594	602.9
3A-5 Acrylic Enamel (catalyzed)	534.2	480-720	666.1
3A-6 Acrylic Enamel Basecoat	661.8	NL	756.4
3A-7 Acrylic Urethane	512.8	473-674	647.8
**3A2-1 Acrylic Urethane	335.7	NL	577.2
B. Multi-component			
VOC Regulatory value	Bay Area <u>Rule 45</u>		South Coast
	1 Jan 1990/92/95 720/600/460	1 July 1990/1 Jan 1992 624/420	<u>Rule 1151</u>
	<u>VOC</u>	<u>Literature Value</u>	<u>VOC applied</u>
3B-1 Acrylic Urethane Enamel	439.9	NL	550.4
3B-2 Urethane Enamel	515.7	NL	637.3
3B-3 Polyoxithane Enamel	517.8	NL	597.2
3B-4 Acrylic Urethane Enamel	547.2	NL	723.3
3B-5 Acrylic Urethane Enamel	500.7	NL	713.4
**3B-6 Three Component Polyester	102.4	36	102.4

Topcoats, continued

C. Metallic Topcoats

VOC Regulatory	Bay Area <u>Rule 45</u> 1 Jan 1990/92/95	South Coast <u>Rule 1151</u> 1 July 1990/1 Jan 1992		
	624/420	720/600/540		
	<u>VOC</u>	<u>Literature Value</u>		<u>VOC applied</u>
3C-1 Synthetic Enamel	544.4	NL		585.5
3C-2 Acrylic Enamel	544.4	480-720		686.9
3C-3 Acrylic Enamel Basecoat	704.4	NL		778.0
3C-5 Acrylic Enamel Basecoat (catalyzed)	546.4	799.9		778.2
3C2-2 Polyurethane Enamel	515.0	NL		667.8

D. Clearcoats

3E-1 Acrylic Urethane Enamel	620.0	684-708		620.0
3E-2 Acrylic Urethane	667.2	659		667.2

10. RATING OF PERFORMANCE PROPERTIES

The coatings evaluated were ranked according to level of achievement in performance properties evaluated. Weighting criteria for each performance property were developed from both the ultimate function and definition of the coating.

Weighting factors are based on from seven to ten characteristics and the weighting value predicated on ultimate coating use. Values assigned to performance properties (high values indicate best performance) were based on previous evaluations of coatings which are commercially available and acceptable but not necessarily VOC-compliant.

Table 18 - Performance Properties for Primers

		VOC Limit: 720 g/l (BAAQMD) 250 g/l (SCAQMD)							
		Weighting	1	2	3	5	6	7	8
A. Multi Component		Factor							
1.	Salt Spray Res.	15	8	12	12	9	12	15	6
2.	Water Imm. Res.	5	5	5	5	5	5	5	5
3.	Humidity Res.	5	5	5	5	5	5	5	5
4.	Application Prop.	20	18	15	18	18	18	18	18
5.	Adhesion	20	20	20	20	15	20	20	20
6.	Stability	5	4	4	3	4	4	3	0
7.	Impact Res.	5	5	5	4	4	5	5	0
8.	Dry Time	15	15	15	5	12	10	12	10
9.	Sanding Prop.	5	0	0	5	5	5	5	5
10.	Sag/Levelling	5	5	5	5	3	3	4	4
Total		100	85	86	82	80	87	92	73
VOC (applied)			674*	621*	354*	725	742	551*	350*
B. Single Component		Weighting	1	2	3	4	5		
		Factor							
1.	Salt Spray Res.	15	10	7	9	15	15		
2.	Water Imm. Res.	5	5	5	5	5	5		
3.	Humidity Res.	5	5	5	5	5	5		
4.	Application Prop.	20	15	5	4	10	10		
5.	Adhesion	20	15	10	20	20	20		
6.	Stability	5	0	1	1	0	3		
7.	Impact Res.	5	2	2	5	5	5		
8.	Dry Time	15	15	15	15	15	15		
9.	Sanding Prop.	5	5	5	5	5	5		
10.	Sag/Levelling	5	5	5	5	5	5		
Total		100	77	60	74	88	88		
VOC (Applied)			725	739	754	732	741		

* = complies with BAAQMD

** = complies with BAAQMD and SCAQMD

Primers, continued

C. Water Based	Weighting Factor	1		2	
1. Salt Spray Res.	15	6	2		
2. Water Imm. Res.	5	4	2		
3. Humidity Res.	5	4	2		
4. Application Prop.	20	15	20		
5. Adhesion	20	20	20		
6. Stability	5	5	5		
7. Impact Res.	5	5	5		
8. Dry Time	15	10	10		
9. Sanding Prop.	5	5	5		
10. Sag/Levelling	<u>5</u>	<u>5</u>	<u>5</u>		
Total	100	79	76		
VOC (Applied)		344*	284*		

Table 19 - Performance Properties for Sealers

	Weighting Factor	VOC Limit: 720 g/l (BAAQMD) no regulation (SCAQMD)			
		1	2	3	4
1. Adhesion	20	20	15	20	20
2. Application Prop.	20	20	10	20	20
3. Humidity Res.	10	10	10	10	10
4. Water Imm. Res.	10	10	10	10	10
5. Stability	5	5	5	5	5
6. Dry Time	15	15	15	15	15
7. Sag/Levelling	10	8	10	10	8
8. Impact/flex	<u>10</u>	<u>10</u>	<u>10</u>	<u>4</u>	<u>9</u>
Total	100	98	85	94	97
VOC (Applied)		737	895	689*	596*

* = complies BAAQMD

** = complies with BAAQMD and SCAQMD

Table 20 - Performance Properties for Topcoats

VOC Limit: 720 g/l (BAAQMD)
624 g/l (SCAQMD)

W.F. = Weighting Factor

A. Single Component	W.F.	1	2	3	5	6(E-1)	7	2-1
1 Acc. Weathering Res.	20	20	20	15	20	20	20	20
2 Salt Spray Res.	15	15	15	10	10	15	10	9
3 Humidity Res.	5	5	5	5	5	5	5	5
4 Chemical Res.	5	2	5	5	5	5	4	5
5 Heat Res.	5	5	5	5	5	3	3	5
6 Applic. Prop/Sag/Level	15	6	8	8	10	7	12	12
7 Adhesion	15	15	15	15	15	15	15	0
8 Impact Res.	10	10	10	10	10	10	5	10
9 Hardness/Flex/Abrasion	<u>10</u>	<u>10</u>	<u>8</u>	<u>10</u>	<u>10</u>	<u>10</u>	<u>8</u>	<u>10</u>
Total	100	88	91	83	90	90	82	76
VOC (Applied)		678*	705*	603**	666*	662*	648*	577**
B. Multi-Component	W.F.	1	2	3	4	5	6	
1 Acc. Weathering Res.	20	20	20	20	20	20	20	
2 Salt Spray Res.	15	10	15	12	14	15	15	
3 Humidity Res.	5	5	5	5	5	5	5	
4 Chemical Res.	5	3	5	3	5	5	5	
5 Heat Res.	5	5	5	5	5	5	5	
6 Applic. Prop/Sag/Level	15	12	10	10	10	5	10	
7 Adhesion	15	15	12	10	12	15	5	
8 Impact Res.	10	2	10	0	10	10	10	
9 Hardness/Flex/Abrasion	<u>10</u>	<u>5</u>	<u>10</u>	<u>3</u>	<u>10</u>	<u>6</u>	<u>10</u>	
Total	100	77	92	68	91	86	85	
VOC (Applied)		550**	637*	597**	723	713*	102**	
C. Metallic	W.F.	1	2	2-2	3 (E-1)	5 (E-2)		
1 Acc. Weathering Res.	20	20	20	18	18	20		
2 Salt Spray Res.	15	12	12	12	15	15		
3 Humidity Res.	5	5	5	5	5	5		
4 Chemical Res.	5	3	4	3	5	5		
5 Heat Res.	5	5	5	5	5	2		
6 Applic. Prop/Sag/Level	15	15	8	9	7	10		
7 Adhesion	15	15	15	15	15	15		
8 Impact Res.	10	10	10	10	10	10		
9 Hardness/Flex/Abrasion	<u>10</u>	<u>8</u>	<u>10</u>	<u>10</u>	<u>10</u>	<u>10</u>		
Total	100	93	89	87	90	92		
VOC (Applied)		586**	687*	668*	778	778		

* = complies BAAQMD

** = complies with BAAQMD and SCAQMD

11. DISCUSSION OF TEST RESULTS

Currently available low-solvent organic coatings and a limited sampling of emerging technologies have been evaluated and compared with traditionally acceptable high-solvent coatings for automotive refinishing. The physical, compositional and exposure performance properties evaluated are those necessary to compare low-solvent and waterborne systems with existing acceptable solvent-based coatings which are noncompliant with respect to volatile organic content (VOC).

The exterior automotive finish has several coats of two or more different materials; generally primers, undercoats and topcoats. The undercoat provides for corrosion resistance and improved topcoat adhesion. The topcoat provides the aesthetic appearance, but must also be tough and durable. We developed three categories for each functional coating and subdivided them by general resin system type.

The coatings were evaluated using a ranking system based on achievement of performance characteristics and on ultimate coating use.

A. Category 1: Primers

Primers are used to smooth minor surface imperfections and increase topcoat holdout, in addition to providing corrosion resistance and adhesion of the topcoat. The resin systems of primers vary, but must be compatible with the subsequent topcoat applied. We tested a total of fifteen primers, divided into three broad resin categories.

In category 1A (multi-component) the eight samples included urethanes, acrylic urethanes, epoxy, and vinyl-butynal resin systems.

In category 1B (single-component) the five samples were predominantly acrylic based coatings.

In category 1C (water-based) the two samples were both acrylics.

We evaluated the primers with ten weighted characteristics, with a maximum possible score of 100 points (see table). The emphasis (65% of the assigned weighting) was placed on the properties of application, adhesion and corrosion resistance. The balance of the rating was based on stability, impact resistance, dry time, sanding properties and sag/levelling. The multi-component primers achieved performance points ranging from 73 to 92. The single-component primers ranged from 60 to 88, and the water-based coatings achieved total performance points of 76 and 79.

The regulatory VOC limits set by the AQMD rules for primers are 250 g/l (SCAQMD July 1, 1990) and 720 g/l (BAAQMD Jan 1, 1990). Of the samples tested, six multi-component and two water-based primers comply with the Bay Area AQMD rule 45 VOC limit for primers. One of the primers complies with the South Coast AQMD rule 1151 VOC limits. All five of the single component primers exceed the regulatory values for VOC.

The primer coatings that comply with the BAAQMD VOC limits (720 g/l) had performance scores ranging from 73 to 92.

The VOC-compliant coatings were rated as follows:

Sample 1A-1

This two-component epoxy polyamide primer was rated good, with an overall rating of 85. The salt spray resistance was fair, with fileform corrosion evident. VOC level: 674 g/l.

Sample 1A-2

This two-component vinyl-butyl primer was rated good, with the third highest overall rating of 86. VOC level: 621 g/l.

Sample 1A-3

This two-component epoxy (advertised as low VOC) rated good, with an overall rating of 82. The sample has very heavy sediment and 120°F stability was poor. VOC level: 354 g/l.

Sample 1A-7

This two-component epoxy was rated as excellent, with the highest rating (92) achieved by any of the primers evaluated. VOC level: 551 g/l.

Sample 1A-8

This two-component acrylic urethane primer was rated as fair, with an overall rating of 73. The 120°F stability failed and salt spray resistance was poor. VOC level: 350 g/l.

Sample 1A-9

This three-component urethane primer was not rated. Testing was not completed, because the manufacturer would not allow retention of a wet sample. VOC level: 165 g/l.

Sample 1C-1

This waterborne acrylic primer was rated fair, with a total of 79. The coating application was difficult and salt spray resistance poor. VOC level: 344 g/l.

Sample 1C-2

This waterborne acrylic primer was rated fair, with an overall rating of 76. The coating had poor salt spray resistance. VOC level: 284 g/l.

B. Category 2: Sealers

Sealers are used to improve the adhesion of new finish, provide color uniformity, and promote the ability of the undercoat to resist penetration by the topcoat. The use of a sealer is not always required and it does not take the place of a primer. The use of a sealer is based on the circumstances associated with the refinishing. We tested four samples, of various resin composition.

The sealers were evaluated on eight weighted performance properties (see table) with a maximum possible score of 100 points. The major weighting factors (20% each) were adhesion and application properties.

The sealers achieved ratings ranging from 85 to 98 points. A non-compliant polyester based sealer with a VOC level of 737 g/l received the highest rating.

The Bay Area AQMD rule 45 defines the VOC limit of primer sealer as 720 g/l. Sealers are not defined or regulated by the South Coast AQMD rule 1151. Of the four samples tested, two comply with the BAAQMD VOC limit.

The VOC-compliant coatings were rated as follows:

Sample 2-3

This acrylic lacquer sealer is rated as excellent, with a total score of 94. The coating has poor impact resistance and poor flexibility. VOC level: 689 g/l.

Sample 2-4

This synthetic enamel was rated as excellent, with a rating of 97. VOC level: 596 g/l.

C. Category 3: Topcoats

The topcoat is the finish product that provides the high-gloss appearance and ultra-violet light protection of the subsurface coating layers. There is a wide variety of resin systems and there are many functional uses for topcoats. South Coast AQMD categorizes the topcoats by resin system, each having a regulatory VOC limit. The Bay Area AQMD divides topcoats into topcoat and metallic/iridescent topcoat. We evaluated twenty (20) topcoat samples, divided into three categories.

In category 3A (single-component systems) the seven samples included acrylics and synthetic enamel coatings.

In category 3B (multiple-component coatings) the six samples were predominantly urethanes.

In category 3C (metallic finish topcoats) the five samples included both single and multiple-component resin systems. One multiple-component topcoat (3A-6) and two metallic base coats (3C-3 and 3C-5) were evaluated as a combination basecoat/clearcoat finish. Both clearcoats used were urethane resin systems.

The topcoats were evaluated on nine weighted performance criteria (see table) with the subjective evaluation of overall appearance factored into the rating. The primary weightings were 20% for weathering resistance and 15% each for salt spray resistance, application properties, and adhesion.

The South Coast and Bay Area AQMDs automotive refinish regulations concerning topcoats have different categories, as shown below.

Table 21 - VOC Limits for Topcoats: South Coast & Bay Area

<u>Coating</u>	South Coast	<u>Coating</u>	Bay Area
	VOC g/l <u>July 1, 1990</u>		VOC g/l <u>Jan 1, 1990</u>
Topcoats			
Acrylic Enamel	624	Topcoat	720 g/l
Alkyd Enamel	588		
Polyurethane Enamel	624	Metallic/ Iridescent	720 g/l
Lacquer	744		

Of the seven single-component topcoats, two comply with SCAQMD rule 1151 and seven comply with BAAQMD rule 45. The six multiple-component topcoats all comply with BAAQMD rule 45, and three comply with SCAQMD rule 1151.

The VOC compliant coatings were rated as follows:

Sample 3A-1

This acrylic enamel was rated good, with an overall rating of 88. VOC level: 678 g/l.

Sample 3A-2

This catalyzed synthetic enamel was rated excellent, with the highest rating (91) of all the single-component topcoats. VOC level: 705 g/l.

Sample 3A-3

This catalyzed acrylic enamel was rated fair, with a rating of 83. The coating had significant decrease of gloss upon accelerated weathering. VOC level: 603 g/l, which complies with both districts.

Sample 3A-5

This catalyzed acrylic enamel was rated very good, with a rating of 90. VOC level: 666 g/l.

Sample 3A-6 (E-1)

This acrylic enamel basecoat and urethane clearcoat was rated very good, with a rating of 90. VOC level: 662 g/l.

Sample 3A-7

This acrylic enamel was rated good, with a rating of 82. VOC level: 648 g/l.

Sample 3A2-1

This acrylic enamel was rated fair, and ranked lowest of all topcoats, with a rating of 76. The coating had zero adhesion and low corrosion resistance. VOC level: 577 g/l, which complies in both districts.

Sample 3B-1

This acrylic urethane enamel was ranked fair, with a rating of 77. The impact resistance, hardness and flexibility were poor. VOC level: 550 g/l, complies in both districts.

Sample 3B-2

This urethane enamel was ranked excellent overall, with the second highest rating (92) for the topcoats we evaluated. VOC level: 637 g/l.

Sample 3B-3

This polyoxithane enamel, rated fair, had the lowest ranking of all coatings (68). The coating did poorly on all of the dry film physical properties tests. VOC level: 597 g/l, which complies in both districts.

Sample 3B-5

This acrylic urethane rated good, with a rating of 86. Application of the coating was fair. VOC level: 713 g/l.

Sample 3B-6

This three-component urethane rated good, with an overall rating of 86. Adhesion was fair. VOC level: 102 g/l, which complies in both districts and was the lowest level among the topcoat samples.

Sample 3C-1

This synthetic enamel metallic coating rated excellent, with a rating of 93. Adhesion and hardness/flexibility were fair. VOC level: 586 g/l, which complies in both districts.

Sample 3C-2

This acrylic enamel metallic coating rated very good, with a rating of 89. Application of the coating was fair and adhesion poor. VOC level: 687 g/l.

Sample 3C2-2

This polyurethane enamel rated good, with rating of 77. VOC level: 668 g/l.

APPENDIX I

GLOSSARY OF TERMS AND ABBREVIATIONS

APPENDIX I - GLOSSARY OF TERMS AND ABBREVIATIONS

AQMD - Air Quality Management District

Automotive Refinishing - any coating of vehicles, their parts and components or mobile equipment, including partial body collision repairs, for the purpose of protection or beautification, and which is subsequent to the original coating applied at an Original Equipment Manufacturing Plant Coating Assembly Line.

Contrast Ratio - the ratio of the reflectance of a paint film over a black substrate to the reflectance of a film over a white substrate.

Conventional Coating - currently available high-solvent and commercially acceptable coatings.

D.H. (Dry-Hard) - a film is dry-hard when squeezing the panel between the thumb and forefinger with maximum pressure leaves no noticeable mark after the spot has been lightly polished with a soft cloth. The coating is generally ripped at the D.H. stage using a circular dry time recorder.

Gloss, specular - the relative luminous reflectance factor of a specimen in the minor direction.

Hiding Power - the spreading rate required to produce the specified contrast ratio. The ability of the coating to obscure the substrata.

Leveling - The relative leveling is a measure of the ability of that coating to flow out after application and obliterate any surface irregularities such as brush marks, orange peel, or peaks and craters, that have been produced by the process of applying the coating.

Metallic/Iridescent Topcoat - Any coating which contains metal or iridescent particles, where such particles are visible in the dried film.

Multiple Component (multi-component) - A coating which requires the addition of a separately packaged catalyst or second component to cure to a satisfactory finish.

Non-Volatile Content - The solid material remaining after the volatiles have been driven from the film under specified test conditions. The total percentage volatile present is obtained by subtracting the nonvolatile content from 100.

OEM - Original Equipment Manufacturer

PROC - Photochemically reactive organic content

Sag - The relative property of the coating to run vertically, at a certain film thickness prior to curing.

S.T.T. (Set-To-Touch) - Paints and enamels are considered set-to-touch or simply "dry" when the paint does not adhere to the finger and does not rub up appreciably when the finger is rubbed lightly across its surface.

VOC - Volatile Organic Content - in coatings, any compound of carbon that evaporates from a paint or coating film under specific test conditions. VOC does not include water and exempt solvents that are volatile. VOC may be determined at a specified temperature for a specified baking or air dry time and at a controlled film thickness.

VOC Applied - The VOC of the coating after volatile solvents are added to reduce the coating viscosity to enable satisfactory application properties.

APPENDIX II

LABORATORY TEST DATA

Appendix II

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Laboratory Test Data

Category 1, Primers

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LABORATORY REPORT FORM

Sample No.: 1A-1
 Contract No.: A832-115
 Date received: 6/16/89
 Log No.: 1A-1A-0616 1A-1B-0616
 Lab code: 1A- 1 Epoxy Primer
 Quantity: 1qt.
 Test initiated: 6/20/89
 Test completed: 8/10/89

Chemist: L. Cumming
 L. Kudela

Product Category: 1. PRIMER

<u>Tests</u>	<u>Procedure</u>	<u>Results</u>	<u>Applied</u>
1. Total Non-Volatile (wt. %)	ASTM D2369	36.67	
2. Specific Gravity (lbs/gal.)	ASTM D1475	8.79	
3. Water (wt. %)	ASTM D1364	0	
	ASTM D3792	-	
4. Volatile Organic Content (VOC)	ASTM D3960	674.1 g/l	674.1
5. Viscosity, Ford Cup #4	ASTM D1200	16 sec.	
6. Stability 120°F *	ASTM D1849	see attached	
7. Freeze - Thaw Resistance (All H ₂ O Based Products)	ASTM D2243	N/A	
8. Water cleanup (all H ₂ O based products)		N/A	
9. Dry Time S.T.T. and D.H.	ASTM D1640	S.T.T.: 11 min. D.H.: 25 min.	
10. Adhesion	ASTM D3359	5	
11. Appearance		very smooth	
12. Application Properties *		see attached	
13. Humidity Resistance *	ASTM D2247	see attached	
14. Salt Spray Resistance (240 Hrs) *	ASTM B117	see attached	
15. Water Immersion Resistance *	ASTM D1647	see attached	
29. Sanding Properties	STD 141B FTM 6321	not applicable	
20. Flexibility	ASTM D1737	< 1/8 inch	
21. Impact Resistance (Forward)	ASTM D2794	> 87 inch lbs	
23. Sag Resistance	STD 141B FTM 4494	6	
24. Levelling	ASTM D2801	10	

Note: Items 8, 11, 12 are qualitative tests.

* All tests (6, 12, 13, 14 and 15) evaluated on page 2 of report form

PRIMERS 1A-1

6. Stability 120°F - Centipoises, cP (spindle, RPM)

Viscosity: initial 1381 cP (3, 100)
 final 1460 cP (3, 100)

Comments: no other change; stable

12. Application Properties 50 psi very good, no reduction

13. Humidity Resistance

	Panel D.F.T. (mils)	Size	Frequency	Pattern	Extent of Corrosion
A. Blistering	1.0	No Blistering			
B. Corrosion		No Corrosion			

14. Salt Spray Resistance

	D.F.T. (mils)	Size	Frequency	Pattern	Extent of Corrosion
A. Blistering	1.4	No Blistering			
B. Corrosion		Fileform corrosion at scribes		Uniform at both scribes no field corrosion 1/4" from scribes	Field: none Scribe: light

15. Water Immersion Resistance

	D.F.T. (mils)	Size	Frequency	Pattern	Extent of Corrosion
	1.0				
A. Blistering		No Blistering			
B. Corrosion		No Corrosion			
C. Adhesion		5			
D. Hardness		> 2H			

LABORATORY REPORT FORM

Sample No.: 1A-2
 Contract No.: A832-115
 Date received: 7/06/89
 Log No.: 1A-2A-0706
 Lab code: 2 Component Vinyl
 Quantity: 1qt.
 Test initiated: 7/10/89
 Test completed: 8/10/89

Chemist: L. Cumming
 L. Kudela

Product Category: 1. PRIMER

<u>Tests</u>	<u>Procedure</u>	<u>Results</u>	<u>Applied</u>
1. Total Non-Volatile (wt %)	ASTM D2369	46.60	
2. Specific Gravity (lbs/gal.)	ASTM D1475	9.71	
3. Water (wt. %)	ASTM D1364	0	
	ASTM D3792	-	
4. Volatile Organic Content (VOC)	ASTM D3960	621.3 g/l	621.3
5. Viscosity, Ford Cup #4	ASTM D1200	13 sec.	
6. Stability 120°F *	ASTM D1849	see attached	
7. Freeze - Thaw Resistance (All H ₂ O Based Products)	ASTM D2243	N/A	
8. Water Cleanup (all H ₂ O based products)		N/A	
9. Dry Time S.T.T. and D.H.	ASTM D1640	S.T.T.: 7 min D.H.: 15 min.	
10. Adhesion	ASTM D3359	5	
11. Appearance		smooth	
12. Application Properties *		see attached	
13. Humidity Resistance *	ASTM D2247	see attached	
14. Salt Spray Resistance (240 Hrs) *	ASTM B117	see attached	
15. Water Immersion Resistance *	ASTM D1647	see attached	
29. Sanding Properties	STD 141B FTM 6321	not applicable	
20. Flexibility	ASTM D1737	<1/8"	
21. Impact Resistance (forward)	ASTM D2794	>87 inch lbs.	
23. Sag Resistance	STD 141B FTM 4494	12	
24. Levelling	ASTM D2801	10	

Note: Items 8, 11, 12 are qualitative tests.

* All tests (6, 12, 13, 14 and 15) evaluated on page 2 of report form

PRIMERS 1A-2

6. Stability 120°F - Centipoises, cP (spindle, RPM)

Viscosity: initial 694 cP (3, 100)
 final 501 cP (3, 100)

Comments: no other change

12. Application Properties: 35 psi very good, mix 1:1, no reduction

13. Humidity Resistance

	<u>Panel</u> <u>D.F.T. (mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of</u> <u>Corrosion</u>
	1.2				
A. Blistering		No Blistering			
B. Corrosion		No Corrosion			

14. Salt Spray Resistance

	<u>D.F.T.</u> <u>(mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of</u> <u>Corrosion</u>
	1.2				
A. Blistering		No Blistering			
B. Corrosion				Uniform on both scribes, 1/8" from scribes	Field: none Scribe: medium

15. Water Immersion Resistance

	<u>D.F.T. (mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of</u> <u>Corrosion</u>
	1.2				
A. Blistering		No Blistering			
B. Corrosion		No Corrosion			
C. Adhesion		5			
D. Hardness		Pass 3H			

LABORATORY REPORT FORM

Sample No.: 1A-3
 Contract No.: A832-115
 Date received: 7/19/89
 Log No.: 1A-3A-0719
 Lab code: Epoxy Primer (low VOC)
 Quantity: 1 gal
 Test initiated: 8/17/89
 Test completed: 9/20/89

Chemist: L. Cumming
 L. Kudela

Product Category: 1. PRIMER

<u>Tests</u>	<u>Procedure</u>	<u>Results</u>	<u>Applied</u>
1. Total Non-Volatile (wt. %)	ASTM D2369	74.96 mixed	
2. Specific Gravity (lbs/gal.)	ASTM D1475	11.82 mixed	
3. Water (wt. %)	ASTM D1364	0	
4. Volatile Organic Content (VOC)	ASTM D3792 ASTM D3960	- 354.6 g/l	354.6
5. Viscosity, Ford Cup #4	ASTM D1200	63 sec.	
6. Stability 120°F *	ASTM D1849	see attached	
7. Freeze - Thaw Resistance (All H ₂ O Based Products)	ASTM D2243	N/A	
8. Water cleanup (all H ₂ O based products)		N/A	
9. Dry Time S.T.T. and D.H.	ASTM D1640	S.T.T.: 62 min D.H.: >8 hrs.	
10. Adhesion	ASTM D3359	5	
11. Appearance		smooth	
12. Application Properties *		see attached	
13. Humidity Resistance *	ASTM D2247	see attached	
14. Salt Spray Resistance (240 Hrs) *	ASTM B117	see attached	
15. Water Immersion Resistance *	ASTM D1647	see attached	
29. Sanding Properties	STD 141B FTM 6321	good, no gumming	
20. Flexibility	ASTM D1737	1/4 inch	
21. Impact Resistance (forward)	ASTM D2794	63 inch lbs.	
23. Sag Resistance	STD 141B FTM 4494	11	
24. Levelling	ASTM D2801	10	

Note: Items 8, 11, 12 are qualitative tests.

* All tests (6, 12, 13, 14 and 15) evaluated on page 2 of report form.

PRIMERS 1A-3

6. Stability 120°F - Centipoises, cP (spindle, RPM)

Viscosity: initial 911 cP (3, 100)
 final 1439 cP (3, 100)

Comments: very heavy settlement, large viscosity increase

12. Application properties - very good at 70 psi, mix ratio 4:1, extremely heavy sediment in container

13. Humidity Resistance

	<u>D.F.T.</u> <u>(mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of</u> <u>Corrosion</u>
A. Blistering	3.2	No Blistering			
B. Corrosion		No Corrosion			

14. Salt Spray Resistance

	<u>D.F.T.</u> <u>(mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of</u> <u>Corrosion</u>
A. Blistering	2.6	#6	Few		
B. Corrosion				At the scribes	Field: none Scribe: light

15. Water Immersion Resistance

	<u>D.F.T.</u> <u>(mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of</u> <u>Corrosion</u>
A. Blistering	3.4	No Blistering			
B. Corrosion		No Corrosion			
C. Adhesion		5			
D. Hardness		Pass 2H			

LABORATORY REPORT FORM

Sample No.: 1A-5
 Contract No.: A832-115
 Date received: 7/24/89
 Log No.: 1A-5A-0724
 Lab code: Two component Urethane
 Quantity: 4 qts.
 Test initiated: 7/31/89
 Test completed: 9/20/89

Chemist: L. Cumming
 L. Kudela

Product Category: 1. PRIMER

<u>Tests</u>	<u>Procedure</u>	<u>Results</u>	<u>Applied</u>
1. Total Non-Volatile (wt. %)	ASTM D2369	61.84	
2. Specific Gravity (lbs/gal.)	ASTM D1475	11.12	
3. Water (wt. %)	ASTM D1364	0	
	ASTM D3792	-	
4. Volatile Organic Content (VOC)	ASTM D3960	508.44 g/l	725.1
5. Viscosity, Ford Cup #4	ASTM D1200	13 sec	
6. Stability 120°F *	ASTM D1849	see attached	
7. Freeze - Thaw Resistance (All H ₂ O Based Products)	ASTM D2243	N/A	
8. Water Cleanup (all H ₂ O based products)		N/A	
9. Dry Time S.T.T. and D.H.	ASTM D1640	S.T.T.: 14 min. D.H.: 65 min.	
10. Adhesion	ASTM D3359	4	
11. Appearance		smooth	
12. Application Properties *		see attached	
13. Humidity Resistance *	ASTM D2247	see attached	
14. Salt Spray Resistance (240 Hrs) *	ASTM B117	see attached	
15. Water Immersion Resistance *	ASTM D1647	see attached	
29. Sanding Properties	STD 141B FTM 6321	good, no gumming	
20. Flexibility	ASTM D1737	< 1/8 inch	
21. Impact Resistance (forward)	ASTM D2794	> 88 inch lbs	
23. Sag Resistance	STD 141B FTM 4494	6.8	
24. Levelling	ASTM D2801	2	

Note: Items 8, 11, 12 are qualitative tests.

* All tests (6, 12, 13, 14 and 15) evaluated on page 2 of report form

PRIMERS 1A-5

6. Stability 120°F - Centipoises, cP (spindle, RPM)

Viscosity: initial 5646 cP (5, 100)
 final 6348 cP (5, 100)

Comments: no other change

12. Application Properties - 50 psi, very good, reduced 40%

13. Humidity Resistance

	<u>Panel D.F.T. (mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of Corrosion</u>
	3.3				
A. Blistering		No Blistering			
B. Corrosion		No Corrosion			

14. Salt Spray Resistance

	<u>D.F.T. (mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of Corrosion</u>
	2.8				
A. Blistering		No Blistering			
B. Corrosion				Light corrosion on both scribes less than 1/8"	Field: none Scribe: light

15. Water Immersion Resistance

	<u>D.F.T. (mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of Corrosion</u>
	3.2				
A. Blistering		No Blistering			
B. Corrosion		No Corrosion			
C. Adhesion		5			
D. Hardness		Pass H			

LABORATORY REPORT FORM

Sample No.: 1A-6
 Contract No.: A832-115
 Date received: 8/4/89
 Log No.: 1A-6-0804
 Lab code: 1A-6 Acrylic Urethane Primer Surfacer
 Quantity: 1 gal
 Test initiated: 8/21/89
 Test completed: 10/27/89

Chemist: L. Cumming
 L. Kudela

Product Category: 1. PRIMER

<u>Tests</u>	<u>Procedure</u>	<u>Results</u>	<u>Applied</u>
1. Total Non-Volatile (wt. %)	ASTM D2369	78.92	
2. Specific Gravity (lbs/gal.)	ASTM D1475	14.26	
3. Water (wt. %)	ASTM D1364	0	
	ASTM D3792	-	
4. Volatile Organic Content (VOC)	ASTM D3960	360.2 g/l	742.8
5. Viscosity, Ford Cup #4	ASTM D1200	18 sec.	
6. Stability 120°F *	ASTM D1849	stable	
7. Freeze - Thaw Resistance (All H ₂ O Based Products)	ASTM D2243	N/A	
8. Water cleanup (all H ₂ O based products)		N/A	
9. Dry Time S.T.T. and D.H.	ASTM D1640	S.T.T.: 18 min D.H.: 88 min	
10. Adhesion	ASTM D3359	5	
11. Appearance		very smooth	
12. Application Properties *		see attached	
13. Humidity Resistance *	ASTM D2247	see attached	
14. Salt Spray Resistance (240 Hrs) *	ASTM B117	see attached	
15. Water Immersion Resistance *	ASTM D1647	see attached	
29. Sanding Properties	STD 141B FTM 6321	good no gumming	
20. Flexibility	ASTM D1737	1/8"	
21. Impact Resistance (forward)	ASTM D2794	> 87 inch lbs.	
23. Sag Resistance	STD 141B FTM 4494	3	
24. Levelling	ASTM D2801	10	

Note: Items 8, 11, 12 are qualitative tests.

* All tests (6, 12, 13, 14 and 15) evaluated page 2 of report form

PRIMERS 1A-6

6. Stability 120°F - Centipoises, cP (spindle, RPM)

Viscosity: initial 2016 cP (5,100)
 final 2240 cP (5,100)

Comments: no other change

12. Application Properties - Very good at 50 psi, mix ratio 1: 0.5: 0.3
 (Paint: Hard: Red)

13. Humidity Resistance

	<u>Panel</u> <u>D.F.T. (mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of</u> <u>Corrosion</u>
	2.9				
A. Blistering		No blistering			
B. Corrosion		No corrosion			

14. Salt Spray Resistance

	<u>D.F.T.</u> <u>(mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of</u> <u>Corrosion</u>
	2.5				
A. Blistering		No blistering			
B. Corrosion				Minor isolated corrosion on both scribes	Field: none Scribe: minor

15. Water Immersion Resistance

	<u>D.F.T.</u> <u>(mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of</u> <u>Corrosion</u>
	2.9				
A. Blistering		No blistering			
B. Corrosion		No corrosion			
C. Adhesion		5			
D. Hardness		> 3H			

LABORATORY REPORT FORM

Sample No.: 1A-7
 Contract No.: A832-115
 Date received: 8/7/89
 Log No.: 1A-8-0719
 Lab code: 1A-7 Epoxy Urethane
 Quantity: 1 qt
 Test initiated: 8/25/89
 Test completed: 10/27/89

Chemist: L. Cumming
 L. Kudela

Product Category: 1. PRIMER

<u>Tests</u>	<u>Procedure</u>	<u>Results</u>	<u>Applied</u>
1. Total Non-Volatile (wt. %)	ASTM D2369	61.67	
2. Specific Gravity (lbs/gal.)	ASTM D1475	10.82	
3. Water (wt. %)	ASTM D1364	0	
	ASTM D3792	-	
4. Volatile Organic Content (VOC)	ASTM D3960	504.0 g/l	551.4
5. Viscosity, Ford Cup #4	ASTM D1200	37 sec.	
6. Stability 120°F *	ASTM D1849	see attached	
7. Freeze - Thaw Resistance (All H ₂ O Based Products)	ASTM D2243	N/A	
8. Water Cleanup (all H ₂ O based products)		N/A	
9. Dry Time S.T.T. and D.H.	ASTM D1640	S.T.T.: 14 min. D.H.: 55 min.	
10. Adhesion	ASTM D3359	5	
11. Appearance		very smooth	
12. Application Properties *		see attached	
13. Humidity Resistance *	ASTM D2247	see attached	
14. Salt Spray Resistance (240 Hrs) *	ASTM B117	see attached	
15. Water Immersion Resistance *	ASTM D1647	see attached	
29. Sanding Properties	STD 141B FTM 6321	good - no gumming	
20. Flexibility	ASTM D1737	1/4 inch	
21. Impact Resistance (forward)	ASTM D2794	> 87 inch lbs.	
23. Sag Resistance	STD 141B FTM 4494	8	
24. Levelling	ASTM D2801	7	

Note: Items 8, 11, 12 are qualitative tests.

* All tests (6, 12, 13, 14 and 15) evaluated on page 2 of report form

PRIMERS 1A-7

6. Stability 120°F - Centipoises, cP (spindle, RPM)

Viscosity: initial 460 cP (3,100)
 final 283 cP (2,100)

Comments: no other change

12. Application Properties: Spraying very good, mix (1:1) + 10%, 55 psi

13. Humidity Resistance

	<u>Panel</u> <u>D.F.T. (mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of</u> <u>Corrosion</u>
	2.9				
A. Blistering		No blistering			
B. Corrosion		No corrosion			

14. Salt Spray Resistance

	<u>D.F.T.</u> <u>(mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of</u> <u>Corrosion</u>
	3.2				
A. Blistering		No blistering			
B. Corrosion		No corrosion			Field: none Scribe: none

15. Water Immersion Resistance

	<u>D.F.T.</u> <u>(mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of</u> <u>Corrosion</u>
	2.7				
A. Blistering		No blistering			
B. Corrosion		No corrosion			
C. Adhesion		5			
D. Hardness		pass 3H			

LABORATORY REPORT FORM

Sample No.: 1A-8
 Contract No.: A832-115
 Date received: 8/28/89
 Log No.: 1A-8-0719
 Lab code: 1A-8 Acrylic Urethane Primer
 Quantity: 1 gal
 Test initiated: 8/30/89
 Test completed: 10/27/89

Chemist: L. Cumming
 L. Kudela

Product Category: 1. PRIMER

<u>Tests</u>	<u>Procedure</u>	<u>Results</u>	<u>Applied</u>
1. Total Non-Volatile (wt. %)	ASTM D2369	84.50	
2. Specific Gravity (lbs/gal.)	ASTM D1475	15.76	
3. Water (wt. %)	ASTM D1364	0	
	ASTM D3792	-	
4. Volatile Organic Content (VOC)	ASTM D3960	292.7 g/l	350.2
5. Viscosity, Ford Cup #4	ASTM D1200	33 sec	
6. Stability 120°F *	ASTM D1849	see attached	
7. Freeze - Thaw Resistance (All H ₂ O Based Products)	ASTM D2243	N/A	
8. Water cleanup (all H ₂ O based products)		N/A	
9. Dry Time S.T.T. and D.H.	ASTM D1640	S.T.T.: 11 min. D.H.: 94 min.	
10. Adhesion	ASTM D3359	5	
11. Appearance		very smooth	
12. Application Properties *		see attached	
13. Humidity Resistance *	ASTM D2247	see attached	
14. Salt Spray Resistance (240 Hrs) *	ASTM B117	see attached	
15. Water Immersion Resistance *	ASTM D1647	see attached	
29. Sanding Properties	STD 141B FTM 6321	good, no gumming	
20. Flexibility	ASTM D1737	> 1 inch	
21. Impact Resistance (forward)	ASTM D2794	< 10 inch lbs.	
23. Sag Resistance	STD 141B FTM 4494	7	
24. Levelling	ASTM D2801	7	

Note: Items 8, 11, 12 are qualitative tests.

* All tests (6, 12, 13, 14 and 15) evaluated on page 2 of report form

PRIMERS 1A-8

6. Stability 120°F - Centipoises, cP (spindle, RPM)

Viscosity: initial 205 cP (3,100)
 final 203 cP (3,100)

Comments: Very heavy sediment, unable to disperse, unstable.

12. Application Properties - very good mix ratio (16:3) + 5% RED (RKG202)
 55 psi at the gun

13. Humidity Resistance

	<u>Panel</u> <u>D.F.T (mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of</u> <u>Corrosion</u>
	2.6				
A. Blistering		No blistering			
B. Corrosion		No corrosion			

14. Salt Spray Resistance

	<u>D.F.T.</u> <u>(mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of</u> <u>Corrosion</u>
	2.9				
A. Blistering		#4 at scribe heavy			
B. Corrosion				No field corrosion.	Field: none Scribe: none

15. Water Immersion Resistance

	<u>D.F.T.</u> <u>(mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of</u> <u>Corrosion</u>
	2.2				
A. Blistering		No blistering			
B. Corrosion		No corrosion			
C. Adhesion		5			
D. Hardness		pass 3H			

LABORATORY REPORT FORM

Sample No.: 1A-9
 Contract No.: A832-115
 Date received: 9/29/89
 Log No.: 1A-9-0929
 Lab code: Three Component Primer
 Quantity: 2 qt
 Test initiated: 10/10/89
 Test completed:

Chemist: L. Cumming
 L. Kudela

Product Category: 1. PRIMER

<u>Tests</u>	<u>Procedure</u>	<u>Results</u>	<u>Applied</u>
1. Total Non-Volatile (wt. %)	ASTM D2369	85.06	
2. Specific Gravity (lbs/gal.)	ASTM D1475	9.22	
3. Water (wt. %)	ASTM D1364	0	
	ASTM D3792	-	
4. Volatile Organic Content (VOC)	ASTM D3960	165.0 g/l	165.1
5. Viscosity, Ford Cup #4	ASTM D1200	20 sec.	
6. Stability 120°F *	ASTM D1849	N/A	
7. Freeze - Thaw Resistance (All H ₂ O Based Products)	ASTM D2243	N/A	
8. Water cleanup (all H ₂ O based products)		N/A	
9. Dry Time S.T.T. and D.H.	ASTM D1640	S.T.T.: 15 min	
10. Adhesion	ASTM D3359	D.H.:	
11. Appearance			
12. Application Properties *			
13. Humidity Resistance *	ASTM D2247		
14. Salt Spray Resistance (240 Hrs) *	ASTM B117		
15. Water Immersion Resistance *	ASTM D1647		
29. Sanding Properties	STD 141B FTM 6321		
20. Flexibility	ASTM D1737		
21. Impact Resistance (forward)	ASTM D2794		
23. Sag Resistance	STD 141B FTM 4494		
24. Levelling	ASTM D2801		

Note: Items 8, 11, 12 are qualitative tests.

* All tests (6, 12, 13, 14 and 15) evaluated on page 2 of report form

Testing terminated due to manufacturer retaining wet sample and limited prepared panels offered.

PRIMERS 1A-9

6. Stability 120°F - Centipoises, cP (spindle, RPM)

Viscosity: initial
 final

Comments:

13. Humidity Resistance

<u>Panel</u> <u>D.F.T. (mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of</u> <u>Corrosion</u>
A. Blistering				
B. Corrosion				

14. Salt Spray Resistance

<u>D.F.T.</u> <u>(mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of</u> <u>Corrosion</u>
A. Blistering				
B. Corrosion				

15. Water Immersion Resistance

<u>D.F.T.</u> <u>(mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of</u> <u>Corrosion</u>
A. Blistering				
B. Corrosion				
C. Adhesion				
D. Hardness				

LABORATORY REPORT FORM

Sample No.: 1B-1
 Contract No.: A832-115
 Date received: 06/16/89
 Log No.: 1B-1-0616
 Lab code: 1B-1 Acrylic Primer Surfacer
 Quantity: 1qt.
 Test initiated: 6/20/89
 Test completed: 8/10/89

Chemist: L. Cumming
 L. Kudela

Product Category: 1. PRIMER

<u>Tests</u>	<u>Procedure</u>	<u>Results</u>	<u>Applied</u>
1. Total Non-Volatile (wt. %)	ASTM D2369	61.05	
2. Specific Gravity (lbs/gal.)	ASTM D1475	10.38 lbs/gal	
3. Water (wt. %)	ASTM D1364	0	
	ASTM D3792	-	
4. Volatile Organic Content (VOC)	ASTM D3960	484.4 g/l	725.5
5. Viscosity, Ford Cup #4	ASTM D1200	15 sec	
6. Stability 120°F *	ASTM D1849	see attached	
7. Freeze - Thaw Resistance (All H ₂ O Based Products)	ASTM D2243	N/A	
8. Water cleanup (all H ₂ O based products)		N/A	
9. Dry Time S.T.T. and D.H.	ASTM D1640	S.T.T.: 5 min D.H.: 11 min.	
10. Adhesion	ASTM D3359	4	
11. Appearance		rough	
12. Application Properties *		see attached	
13. Humidity Resistance *	ASTM D2247	see attached	
14. Salt Spray Resistance (240 Hrs) *	ASTM B117	see attached	
15. Water Immersion Resistance *	ASTM D1647	see attached	
29. Sanding Properties	STD 141B FTM 6321	good, no gumming	
20. Flexibility	ASTM D1737	1 inch	
21. Impact Resistance (forward)	ASTM D2794	10 inch lbs	
23. Sag Resistance	STD 141B FTM 4494	8	
24. Levelling	ASTM D2801	7	

Note: Items 8, 11, 12 are qualitative tests.

* All tests (6, 12, 13 and 14) evaluated on page 2 of report form

PRIMERS 1B-1

6. Stability 120°F - Centipoises, cP (spindle, RPM)

Viscosity: initial 4400 cP (4, 100)
 final 6335 cP (4, 100)

Comments: no other change, unstable

12. Application Properties - 35 psi, satisfactory

13. Humidity Resistance

	<u>Panel</u> <u>D.F.T (mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of</u> <u>Corrosion</u>
	2.0				
A. Blistering		No Blistering			
B. Corrosion		No Corrosion			

14. Salt Spray Resistance

	<u>D.F.T.</u> <u>(mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of</u> <u>Corrosion</u>
	2.4				
A. Blistering		No Blistering			
B. Corrosion				Uniform corrosion at both scribes 1/4" from both scribes	Field: none Scribe: none

15. Water Immersion Resistance

	<u>D.F.T.</u> <u>(mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of</u> <u>Corrosion</u>
	2.4				
A. Blistering		No Blistering			
B. Corrosion		No Corrosion			
C. Adhesion		3			
D. Hardness		Pass 2H			

LABORATORY REPORT FORM

Sample No.: 1B-2
 Contract No.: A832-115
 Date received: 6/16/89
 Log No.: 1B-2-0616
 Lab code: Acrylic Primer Surfacer
 Quantity: 1 gal
 Test initiated: 6/20/89
 Test completed: 8/10/89

Chemist: L. Cumming
 L. Kudela

Product Category: 1. PRIMER

<u>Tests</u>	<u>Procedure</u>	<u>Results</u>	<u>Applied</u>
1. Total Non-Volatile (wt. %)	ASTM D2369	60.08	
2. Specific Gravity (lbs/gal.)	ASTM D1475	10.3	
3. Water (wt. %)	ASTM D1364	0	
	ASTM D3792	-	
4. Volatile Organic Content (VOC)	ASTM D3960	498.88 g/l	739.0
5. Viscosity, Ford Cup #4	ASTM D1200	15 sec	
6. Stability 120°F *	ASTM D1849	see attached	
7. Freeze - Thaw Resistance (All H ₂ O Based Products)	ASTM D2243	N/A	
8. Water cleanup (all H ₂ O based products)		N/A	
9. Dry Time S.T.T. and D.H.	ASTM D1640	S.T.T: 3 min D.H.: 16 min.	
10. Adhesion	ASTM D3359	3	
11. Appearance		rough	
12. Application Properties *		see attached	
13. Humidity Resistance *	ASTM D2247	see attached	
14. Salt Spray Resistance (240 Hrs) *	ASTM B117	see attached	
15. Water Immersion Resistance *	ASTM D1647	see attached	
29. Sanding Properties	STD 141B FTM 6321	good, no gumming	
20. Flexibility	ASTM D1737	> 1/2 inch	
21. Impact Resistance (forward)	ASTM D2794	17 inch lbs.	
23. Sag Resistance	STD 141B FTM 4494	10	
24. Levelling	ASTM D2801	6	

Note: Items 8, 11, 12 are qualitative tests.

* All tests (6, 12, 13 and 14) evaluated on page 2 of report form

PRIMERS 1B-2

6. Stability 120°F - Centipoises, cP (spindle, RPM)

Viscosity: initial 9500 cP (4, 100)
final 11415 cP (4, 100)

Comments: no other change, unstable

12. Application Properties - Spraying difficult - 40 psi, 110% reduction

13. Humidity Resistance

	<u>Panel</u> <u>D.F.T. (mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of</u> <u>Corrosion</u>
	3.5				
A. Blistering		No Blistering			
B. Corrosion		No Corrosion			

14. Salt Spray Resistance

	<u>D.F.T.</u> <u>(mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of</u> <u>Corrosion</u>
	3.4				
A. Blistering		No Blistering			
B. Corrosion				Uniform corrosion on both scribes 1/4" from both scribes	Field: none Scribe: none

15. Water Immersion Resistance

	<u>D.F.T.</u> <u>(mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of</u> <u>Corrosion</u>
	3.8				
A. Blistering		No Blistering			
B. Corrosion		No Corrosion			
C. Adhesion		3			
D. Hardness		Pass 2H			

LABORATORY REPORT FORM

Sample No.: 1B-3
 Contract No.: A832-115
 Date received: 7/24/89
 Log No.: 1B-3-0724
 Lab code: Acrylic Primer Surfacer
 Quantity: 1 gal
 Test initiated: 7/26/89
 Test completed: 9/27/89

Chemist: L. Cumming
 L. Kudela

Product Category: 1. PRIMER

<u>Tests</u>	<u>Procedure</u>	<u>Results</u>	<u>Applied</u>
1. Total Non-Volatile (wt. %)	ASTM D2369	62.81	
2. Specific Gravity (lbs/gal.)	ASTM D1475	10.97	
3. Water (wt. %)	ASTM D1364	0	
	ASTM D3792	-	
4. Volatile Organic Content (VOC)	ASTM D3960	488.8 g/l	754.2
5. Viscosity, Ford Cup #4	ASTM D1200	13 sec	
6. Stability 120°F *	ASTM D1849	see attached	
7. Freeze - Thaw Resistance (All H ₂ O Based Products)	ASTM D2243	N/A	
8. Water cleanup (all H ₂ O based products)		N/A	
9. Dry Time S.T.T. and D.H.	ASTM D1640	S.T.T.: 3 min. D.H.: 34 min.	
10. Adhesion	ASTM D3359	5	
11. Appearance		fair	
12. Application Properties *		see attached	
13. Humidity Resistance *	ASTM D2247	see attached	
14. Salt Spray Resistance (240 Hrs) *	ASTM B117	see attached	
15. Water Immersion Resistance *	ASTM D1647	see attached	
29. Sanding Properties	STD 141B FTM 6321	very good, no gumming	
20. Flexibility	ASTM D1737	<1/8 inch	
21. Impact Resistance (forward)	ASTM D2794	77 inch lbs.	
23. Sag Resistance	STD 141B FTM 4494	5	
24. Levelling	ASTM D2801	9	

Note: Items 8, 11, 12 are qualitative tests.

* All tests (6, 12, 13 and 14) evaluated on page 2 of report form

PRIMERS 1B-3

6. Stability 120°F - Centipoises, cP (spindle, RPM)

Viscosity: initial 2720 cP (4,100)
 final 4060 cP (4, 50)

Comments: no other change

12. Application Properties - Spraying difficult, used heavy solvent, 120% reduction 40 psi

13. Humidity Resistance

<u>D.F.T. (mils)</u> 4.4	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of Corrosion</u>
A. Blistering	No Blistering			
B. Corrosion	No Corrosion			

14. Salt Spray Resistance

<u>D.F.T. (mils)</u> 4.4	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of Corrosion</u>
A. Blistering	No Blistering			
B. Corrosion			Uniform corrosion at scribes 1/6" from both scribes	Field: none Scribe: light

15. Water Immersion Resistance

<u>D.F.T. (mils)</u> 5.2	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of Corrosion</u>
A. Blistering	No Blistering			
B. Corrosion	No Corrosion			
C. Adhesion	5			
D. Hardness	Pass H			

LABORATORY REPORT FORM

Sample No.: 1B-4
 Contract No.: A832-115
 Date received: 8/8/89
 Log No.: 1B-4-0808
 Lab code: Epoxy Ester
 Quantity: 1qt.
 Test initiated: 8/10/89
 Test completed: 10/6/89

Chemist: L. Cumming
 L. Kudela

Product Category: 1. PRIMER

<u>Tests</u>	<u>Procedure</u>	<u>Results</u>	<u>Applied</u>
1. Total Non-Volatile (wt. %)	ASTM D2369	45.75	
2. Specific Gravity (lbs/gal.)	ASTM D1475	8.84	
3. Water (wt. %)	ASTM D1364	0	
	ASTM D3792	-	
4. Volatile Organic Content (VOC)	ASTM D3960	574.6 g/l	732.3
5. Viscosity, Ford Cup #4	ASTM D1200	19 sec	
6. Stability 120°F *	ASTM D1849	see attached	
7. Freeze - Thaw Resistance (All H ₂ O Based Products)	ASTM D2243	N/A	
8. Water cleanup (all H ₂ O based products)		N/A	
9. Dry Time S.T.T. and D.H.	ASTM D1640	S.T.T.: 6 min D.H.: 22 min.	
10. Adhesion	ASTM D3359	5	
11. Appearance		very smooth	
12. Application Properties *		see attached	
13. Humidity Resistance *	ASTM D2247	see attached	
14. Salt Spray Resistance (240 Hrs) *	ASTM B117	see attached	
15. Water Immersion Resistance *	ASTM D1647	see attached	
29. Sanding Properties	STD 141B FTM 6321	good, no gumming	
20. Flexibility	ASTM D1737	1/8 inch	
21. Impact Resistance (forward)	ASTM D2794	> 87 inch lbs.	
23. Sag Resistance	STD 141B FTM 4494	5	
24. Levelling	ASTM D2801	9	

Note: Items 8, 11, 12 are qualitative tests.

* All tests (6, 12, 13 and 14) evaluated on page 2 of report form

PRIMERS 1B-4

6. Stability 120°F - Centipoises, cP (spindle, RPM)

Viscosity: initial 970 cP (3,100)
 final 4500 cP (3, 20)

Comments: no other change

12. Application Properties - good, reduced 100%, 45 psi at the gun

13. Humidity Resistance

Panel D.F.T. (mils)	Size	Frequency	Pattern	Extent of Corrosion
1.5				
A. Blistering	No Blistering			
B. Corrosion	No Rust			

14. Salt Spray Resistance

D.F.T. (mils)	Size	Frequency	Pattern	Extent of Corrosion
1.5				
A. Blistering	No Blistering			
B. Corrosion			Uniform corrosion on scribes 1/16" from both scribes	Field: none Scribe: medium

15. Water Immersion Resistance

D.F.T. (mils)	Size	Frequency	Pattern	Extent of Corrosion
1.6				
A. Blistering	No Blistering			
B. Corrosion	No Corrosion			
C. Adhesion	5			
D. Hardness	Pass 2H			

LABORATORY REPORT FORM

Sample No.: 1B-5
 Contract No.: A832-115
 Date received: 7/21/89
 Log No.: 1B-5-0721
 Lab code: Acrylic High Solids Primer
 Quantity: 1 gal
 Test initiated: 7/24/89
 Test completed: 9/30/89

Chemist: L. Cumming
 L. Kudela

Product Category: 1. PRIMER

<u>Tests</u>	<u>Procedure</u>	<u>Results</u>	<u>Applied</u>
1. Total Non-Volatile (wt. %)	ASTM D2369	57.82	
2. Specific Gravity (lbs/gal.)	ASTM D1475	10.39	
3. Water (wt. %)	ASTM D1364	0	
	ASTM D3792	-	
4. Volatile Organic Content (VOC)	ASTM D3960	525.1 g/l	741.1
5. Viscosity, Ford Cup #4	ASTM D1200	13 sec	
6. Stability 120°F *	ASTM D1849	see attached	
7. Freeze - Thaw Resistance (All H ₂ O Based Products)	ASTM D2243	N/A	
8. Water cleanup (all H ₂ O based products)		N/A	
9. Dry Time S.T.T. and D.H.	ASTM D1640	S.T.T.: 8 min D.H.: 24 min.	
10. Adhesion	ASTM D3359	5	
11. Appearance		smooth	
12. Application Properties *		see attached	
13. Humidity Resistance *	ASTM D2247	see attached	
14. Salt Spray Resistance (240 Hrs) *	ASTM B117	see attached	
15. Water Immersion Resistance *	ASTM D1647	see attached	
29. Sanding Properties	STD 141B FTM 6321	good, no gumming	
20. Flexibility	ASTM D1737	1/8 inch	
21. Impact Resistance (forward)	ASTM D2794	70 inch lbs.	
23. Sag Resistance	STD 141B FTM 4494	6	
24. Levelling	ASTM D2801	8	

Note: Items 8, 11, 12 are qualitative tests.

* All tests (6, 12, 13 and 14) evaluated on page 2 of report form

PRIMERS 1B-5

6. Stability 120°F - Centipoises, cP (spindle, RPM)

Viscosity: initial 342 cP (2, 100)
 final 141 cP (2, 100)

Comments: no other change

12. Application Properties - Spraying very good, reduced 100%, 50 psi

13. Humidity Resistance

	<u>Panel</u> <u>D.F.T. (mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of</u> <u>Corrosion</u>
	1.2				
A. Blistering		No Blistering			
B. Corrosion		No Rust			

14. Salt Spray Resistance

	<u>D.F.T.</u> <u>(mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of</u> <u>Corrosion</u>
	1.3				
A. Blistering		No Blistering			
B. Corrosion				Starting Field: none corrosion Scribe: none on scribes	

15. Water Immersion Resistance

	<u>D.F.T.</u> <u>(mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of</u> <u>Corrosion</u>
	1.3				
A. Blistering		No Blistering			
B. Corrosion		No Corrosion			
C. Adhesion		5			
D. Hardness		Pass 2H			

LABORATORY REPORT FORM

Sample No.: 1C-1
 Contract No.: A832-115
 Date received: 7/6/89
 Log No.: 1C-1-0706
 Lab code: Water-borne Primer Surfacer
 Quantity: 1qt.
 Test initiated: 7/10/89
 Test completed: 8/25/89

Chemist: L. Cumming
 L. Kudela

Product Category: 1. PRIMER

<u>Tests</u>	<u>Procedure</u>	<u>Results</u>	<u>Applied</u>
1. Total Non-Volatile (wt. %)	ASTM D2369	44.48	
2. Specific Gravity (lbs/gal.)	ASTM D1475	10.82	
3. Water (wt. %)	ASTM D1364	-	
	ASTM D3792	44.17%	
4. Volatile Organic Content (VOC)	ASTM D3960	344.3 g/l	344.3
5. Viscosity, Ford Cup #4	ASTM D1200	61 sec	
6. Stability 120°F *	ASTM D1849	see attached	
7. Freeze - Thaw Resistance (All H ₂ O Based Products)	ASTM D2243	240 cp (3, 100) not resistance	
8. Water Cleanup (all H ₂ O based products)		very good	
9. Dry Time S.T.T. and D.H.	ASTM D1640	S.T.T.: 28 min D.H.: 52 min.	
10. Adhesion	ASTM D3359	5	
11. Appearance		not smooth	
12. Application Properties *		see attached	
13. Humidity Resistance *	ASTM D2247	see attached	
14. Salt Spray Resistance (240 Hrs) *	ASTM B117	see attached	
15. Water Immersion Resistance *	ASTM D1647	see attached	
29. Sanding Properties	STD 141B FTM 6321	good, no gumming	
20. Flexibility	ASTM D1737	1/8 inch	
21. Impact Resistance (forward)	ASTM D2794	75 inch lbs.	
23. Sag Resistance	STD 141B FTM 4494	9	
24. Levelling	ASTM D2801	5	

Note: Items 8, 11, 12 are qualitative tests.

* All tests (6, 12, 13 and 14) evaluated on page 2 of report form

PRIMERS 1C-1

6. Stability 120°F - Centipoises, cP (spindle, RPM)

Viscosity: initial 996 cP (3, 100)
final 1155 cP (3, 100)

Comments: no other change

12. Application Properties - Spraying at 45 psi difficult, no reduction.

13. Humidity Resistance

	<u>Panels</u> <u>D.F.T. (mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of</u> <u>Corrosion</u>
	2.4				
A. Blistering		No Blistering			
B. Corrosion		No Corrosion			

14. Salt Spray Resistance

	<u>D.F.T.</u> <u>(mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of</u> <u>Corrosion</u>
	3.0				
A. Blistering		No Blistering			
B. Corrosion					Light corrosion on scribes, field entire panel. Field: heavy Scribe: light corrosion over

15. Water Immersion Resistance

	<u>D.F.T.</u> <u>(mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of</u> <u>Corrosion</u>
	2.0				
A. Blistering		No Blistering			
B. Corrosion		Random field corrosion			
C. Adhesion		3			
D. Hardness		Pass F			

LABORATORY REPORT FORM

Sample No.: 1C-2
 Contract No.: A832-115
 Date received: 7/6/89
 Log No.: 1C-1-0706
 Lab code: Acrylic Hydrosol Primer Surfacer
 Quantity: 1qt.
 Test initiated: 7/10/89
 Test completed: 9/27/89

Chemist: L. Cumming
 L. Kudela

Product Category: 1. PRIMER

<u>Tests</u>	<u>Procedure</u>	<u>Results</u>	<u>Applied</u>
1. Total Non-Volatile (wt. %)	ASTM D2369	47.58	
2. Specific Gravity (lbs/gal.)	ASTM D1475	10.94	
3. Water (wt. %)	ASTM D1364	-	
	ASTM D3792	41.53	
4. Volatile Organic Content (VOC)	ASTM D3960	284 g/l	284.0
5. Viscosity, Ford Cup #4	ASTM D1200	63 sec.	
6. Stability 120°F *	ASTM D1849	see attached	
7. Freeze - Thaw Resistance (All H ₂ O Based Products)	ASTM D2243	438 cP (2, 100) fair	
8. Water cleanup (all H ₂ O based products)		very good	
9. Dry Time S.T.T. and D.H.	ASTM D1640	S.T.T.: 39 min D.H.: 56 min.	
10. Adhesion	ASTM D3359	5	
11. Appearance		smooth	
12. Application Properties *		see attached	
13. Humidity Resistance *	ASTM D2247	see attached	
14. Salt Spray Resistance (240 Hrs) *	ASTM B117	see attached	
15. Water Immersion Resistance *	ASTM D1647	see attached	
29. Sanding Properties	STD 141B FTM 6321	good - no gumming	
20. Flexibility	ASTM D1737	1/8 inch	
21. Impact Resistance (forward)	ASTM D2794	>87 inch lb	
23. Sag Resistance	STD 141B FTM 4494	8	
24. Levelling	ASTM D2801	6	

Note: Items 8, 11, 12 are qualitative tests.

* All tests (6, 12, 13 and 14) evaluated on page 2 of report form

PRIMERS 1C-2

6. Stability 120°F - Centipoises, cP (spindle, RPM)

Viscosity: initial 518 cP (2, 100)
 final 446 cP (2, 100)

Comments: no other change, stable

12. Application Properties - very good, no reducing, air pressure - 45 psi.

13. Humidity Resistance

	<u>Panels</u> <u>D.F.T. (mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of</u> <u>Corrosion</u>
	1.6				
A. Blistering		No Blistering			
B. Corrosion		No Corrosion			

14. Salt Spray Resistance

	<u>D.F.T.</u> <u>(mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of</u> <u>Corrosion</u>
	1.8				
A. Blistering		No Blistering			
B. Corrosion				Uniform corrosion at the scribes. Extensive field corrosion	Field: extensive Scribe: major

15. Water Immersion Resistance

	<u>D.F.T.</u> <u>(mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of</u> <u>Corrosion</u>
	1.5				
A. Blistering		No Blistering			
B. Corrosion		No field corrosion			
C. Adhesion		5			
D. Hardness		Pass 3H			

LABORATORY REPORT FORM

Sample No.: 2-1
 Contract No.: A832-115
 Date received: 6/16/89
 Log No.: 2-1-0616
 Lab code: Acrylic Sealer
 Quantity: 1qt.
 Test initiated: 6/20/89
 Test completed: 8/8/89

Chemist: L. Cumming
 L. Kudela

Product Category: 2. SEALERS

<u>Tests</u>	<u>Procedure</u>	<u>Results</u>	<u>Applied</u>
1. Total Non-Volatile (wt. %)	ASTM D2369	15.25	
2. Specific Gravity (lbs/gal.)	ASTM D1475	7.28	
3. Water % (wt.)	ASTM D1364	0	
	ASTM D3792	-	
4. Volatile Organic Content (VOC)	ASTM D3960	737.2g/l	737.2
5. Viscosity, Ford Cup #4	ASTM D1200	14 sec.	
6. Stability 120°F *	ASTM D1849	see attached	
7. Freeze - Thaw Resistance (All H ₂ O Based Products)	ASTM D2243	N/A	
8. Water cleanup (all H ₂ O based products)		N/A	
9. Dry Time S.T.T. and D.H.	ASTM D1640	S.T.T.: 4 min D.H.: 11 min.	
10. Adhesion	ASTM D3359	5	
11. Appearance		smooth	
12. Application Properties *		see attached	
13. Humidity Resistance *	ASTM D2247	see attached	
15. Water Immersion Resistance *	ASTM D1647	see attached	
20. Flexibility	ASTM D1737	1/8 inch	
21. Impact Resistance (forward)	ASTM D2794	52 inch lbs	
23. Sag Resistance	STD 141B FTM 4494	4	
24. Leveling	ASTM D2801	10	

Note: Items 8, 11, 12 are qualitative tests.

* All tests (6, 12, 13 and 15) evaluated on page 2 of report form

SEALERS 2-1

6. Stability 120°F Centipoise, cP (spindle, RPM)

Viscosity: initial 49.8 cP (2, 100)
 final 27.2 cP (2, 100)

Comments: no other change

12. Application Properties - 60 psi very good, no reduction

13. Humidity Resistance

	<u>Panel</u> <u>D.F.T. (mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of</u> <u>Corrosion</u>
	0.4				
A. Blistering		No Blistering			
B. Corrosion		No Corrosion			

15. Water Immersion Resistance

	<u>D.F.T.</u> <u>(mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of</u> <u>Corrosion</u>
	0.4				
A. Blistering		No Blistering			
B. Corrosion		No Corrosion			
C. Adhesion		5			
D. Hardness		Pass 3H			

LABORATORY REPORT FORM

Sample No.: 2-2
 Contract No.: A832-115
 Date received: 6/16/89
 Log No.: 2-2-0616
 Lab code: Enamel Sealer
 Quantity: 1qt.
 Test initiated: 6/20/89
 Test completed: 8/8/89

Chemist: L. Cumming
 L. Kudela

Product Category: 2. SEALERS

<u>Tests</u>	<u>Procedure</u>	<u>Results</u>	<u>Applied</u>
1. Total Non-Volatile (wt. %)	ASTM D2369	41.43	
2. Specific Gravity (lbs/gal.)	ASTM D1475	8.24	
3. Water (wt. %)	ASTM D1364	0	
	ASTM D3792	-	
4. Volatile Organic Content (VOC)	ASTM D3960	578.26 g/l	895.4
5. Viscosity, Ford Cup #4	ASTM D1200	3 sec.	
6. Stability 120°F *	ASTM D1849	see attached	
		see attached	
7. Freeze - Thaw Resistance (All H ₂ O Based Products)	ASTM D2243	N/A	
8. Water cleanup (all H ₂ O based products)		N/A	
9. Dry Time S.T.T. and D.H.	ASTM D1640	S.T.T.: 7 min D.H.: 245 min.	
10. Adhesion	ASTM D3359	4	
11. Appearance		smooth and glossy	
12. Application Properties *		see attached	
13. Humidity Resistance *	ASTM D2247	see attached	
15. Water Immersion Resistance *	ASTM D1647	see attached	
20. Flexibility	ASTM D1737	1/8 inch	
21. Impact Resistance (forward)	ASTM D2794	>88 inch lbs.	
23. Sag Resistance	STD 141B FTM 4494	6	
24. Leveling	ASTM D2801	7	

Note: Items 8, 11, 12 are qualitative tests.

* All tests (6, 12, 13 and 15) evaluated on page 2 of report form

SEALERS 2-2

6. Stability 120°F Centipoise, cP (spindle, RPM)

Viscosity: initial 152 cP (3, 100)
 final 104 cP (3, 100)

Comments: no other change, stable

12. Application Properties - 60 psi very good, 50% reduction

13. Humidity Resistance

	<u>Panel</u> <u>D.F.T. (mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of</u> <u>Corrosion</u>
	0.5				
A. Blistering		No Blistering			
B. Corrosion		No Corrosion			

15. Water Immersion Resistance

	<u>D.F.T.</u> <u>(mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of</u> <u>Corrosion</u>
	0.5				
A. Blistering		No Blistering			
B. Corrosion		No Corrosion			
C. Adhesion		5			
D. Hardness		Pass 2H			

LABORATORY REPORT FORM

Sample No.: 2-3
 Contract No.: A832-115
 Date received: 7/24/89
 Log No.: 2-3-0724
 Lab code: Acrylic Sealer
 Quantity: 1 gal
 Test initiated: 7/31/89
 Test completed: 8/8/89

Chemist: L. Cumming
 L. Kudela

Product Category: 2. SEALERS

<u>Tests</u>	<u>Procedure</u>	<u>Results</u>	<u>Applied</u>
1. Total Non-Volatile (wt. %)	ASTM D2369	27.79	
2. Specific Gravity (lbs/gal.)	ASTM D1475	7.46	
3. Water (wt. %)	ASTM D1364	0	
	ASTM D3792	-	
4. Volatile Organic Content (VOC)	ASTM D3960	688.7 g/l	688.7
5. Viscosity, Ford Cup #4	ASTM D1200	13 sec.	
6. Stability 120°F *	ASTM D1849	see attached	
7. Freeze - Thaw Resistance (All H ₂ O Based Products)	ASTM D2243	N/A	
8. Water cleanup (all H ₂ O based products)		N/A	
9. Dry Time S.T.T. and D.H	ASTM D1640	S.T.T.: 6 min D.H.: 9 min.	
10. Adhesion	ASTM D3359	5	
11. Appearance		fair-gritty	
12. Application Properties *			
13. Humidity Resistance *	ASTM D2247	see attached	
15. Water Immersion Resistance *	ASTM D1647	see attached	
20. Flexibility	ASTM D1737	pass 1/2 inch	
21. Impact Resistance (forward)	ASTM D2794	21 inch lbs.	
23. Sag Resistance	STD 141B FTM 4494	9	
24. Leveling	ASTM D2801	8	

Note: Items 8, 11, 12 are qualitative tests.

* All tests (6, 12, 13 and 15) evaluated on page 2 of report form

SEALERS 2-3

6. Stability 120°F Centipoise, cP (spindle, RPM)

Viscosity: initial 45.5 cP (1, 100)
 final 35.0 cP (1, 100)

Comments: no other change

12. Application Properties - good at 40 psi, no reduction

13. Humidity Resistance

	<u>Panel</u> <u>D.F.T. (mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of</u> <u>Corrosion</u>
	2.3				
A. Blistering		No Blistering			
B. Corrosion		No Corrosion			

15. Water Immersion Resistance

	<u>D.F.T.</u> <u>(mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of</u> <u>Corrosion</u>
	2.1				
A. Blistering		No Blistering			
B. Corrosion		No Corrosion			
C. Adhesion		5			
D. Hardness		Pass 2H			

LABORATORY REPORT FORM

Sample No.: 2-4
 Contract No.: A832-115
 Date received: 8/8/89
 Log No.: 2-4-0808
 Lab code: Enamel Sealer
 Quantity: 1 qt
 Test initiated: 8/14/89
 Test completed: 9/27/89

Chemist: L. Cumming
 L. Kudela

Product Category: 2. SEALERS

<u>Tests</u>	<u>Procedure</u>	<u>Results</u>	<u>Applied</u>
1. Total Non-Volatile (wt. %)	ASTM D2369	38.95	
2. Specific Gravity (lbs/gal.)	ASTM D1475	8.15	
3. Water (wt. %)	ASTM D1364	0	
	ASTM D3792	-	
4. Volatile Organic Content (VOC)	ASTM D3960	596.2 g/l	596.2
5. Viscosity, Ford Cup #4	ASTM D1200	13 sec	
6. Stability 120°F *	ASTM D1849	see attached	
7. Freeze - Thaw Resistance (All H ₂ O Based Products)	ASTM D2243	N/A	
8. Water cleanup (all H ₂ O based products)		N/A	
9. Dry Time S.T.T. and D.H.	ASTM D1640	S.T.T.: 3 min D.H.: 112 min.	
10. Adhesion	ASTM D3359	5	
11. Appearance		very smooth	
12. Application Properties *		see attached	
13. Humidity Resistance *	ASTM D2247	see attached	
15. Water Immersion Resistance *	ASTM D1647	see attached	
20. Flexibility	ASTM D1737	1/8 inch	
21. Impact Resistance (forward)	ASTM D2794	>88 inch lbs.	
23. Sag Resistance	STD 141B FTM 4494	4	
24. Leveling	ASTM D2801	9	

Note: Items 8, 11, 12 are qualitative tests.

8 All tests (6, 12, 13 and 15) evaluated on page 2 of report form

SEALERS 2-4

6. Stability 120°F Centipoise, cP (spindle, RPM)

Viscosity: initial 241 cP (2, 100)
final 200 cP (2, 100)

Comments: no other change, stable

12. Application Properties - very good, no reduction, air pressure 45 psi

13. Humidity Resistance

	<u>Panel</u> <u>D.F.T. (mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of</u> <u>Corrosion</u>
	0.7				
A. Blistering		No Blistering			
B. Corrosion		No Corrosion			

15. Water Immersion Resistance

	<u>D.F.T.</u> <u>(mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of</u> <u>Corrosion</u>
	0.8				
A. Blistering		No Blistering			
B. Corrosion		No Corrosion			
C. Adhesion		4			
D. Hardness		Pass 2H			

LABORATORY REPORT FORM

Sample No. 3A-1
 Contract No. A832-115
 Date received: 6/16/89
 Log No.: 3A1-1-0616
 Lab code: Acrylic Enamel
 Quantity: 1 qt
 Test initiated: 6/20/89
 Test completed: 10/27/89

Chemist: L. Cumming
 L. Kudela

Product Category: 3. ENAMEL TOPCOAT

<u>Tests</u>	<u>Procedure</u>	<u>Results</u>	<u>Applied</u>
1. Total Non-Volatile (wt. %)	ASTM D2369	55.36	
2. Specific Gravity (lbs/gal.)	ASTM D1475	9.23	
3. Water (wt. %)	ASTM D1364	0	
	ASTM D3792	-	
4. Volatile Organic Content (VOC)	ASTM D3960	493.7 g/l	678.1
5. Viscosity, Ford Cup #4	ASTM D1200	15 sec.	
6. Stability 120°F *	ASTM D1849	see attached	
7. Freeze - Thaw Resistance (All H ₂ O Based Products)	ASTM D2243	N/A	
8. Water cleanup (all H ₂ O based products)		N/A	
9. Dry Time S.T.T. and D.H.	ASTM D1640	S.T.T.: 10 min D.H.: 37 min	
17. Hardness Pencil	ASTM D3363	5	
10. Adhesion	ASTM D3359	5	
11. Appearance		very smooth	
18. 60° Gloss	ASTM D523	91.4	
12. Application Properties *		see attached	
13. Humidity Resistance *	ASTM D2247	see attached	
14. Salt Spray Resistance (240 Hrs)	ASTM B117	see attached	
15. Water Immersion Resistance *	ASTM D1647	see attached	
16. Color and Color Retention	ASTM D2244	Δ E = 10.91	
19. Abrasion Resistance	ASTM D4060	82.9 mg/1000 REV	
20. Flexibility	ASTM D1737	< 1/8 inch	
21. Impact Resistance (forward)	ASTM D2794	>88 inch lbs.	
23. Sag Resistance	STD 141B FTM 4494	6	
24. Levelling	ASTM D2801	8	
22. Contrast Ratio	ASTM D2805	0.88	
25. Acc. Weathering (300 Hrs.) * 60° specular gloss	ASTM G26	see attached	
26. Fungus Resistance	ASTM D3273 ASTM D3274	pass	
27. Heat Resistance		Δ E = 0.97	
28. Chemical Resistance *	ASTM D1540	see attached	

Note: Items 8, 11, 12 are qualitative tests.

* All tests (6, 12, 13, 14, 15, 25 and 28) evaluated on page 2 of report form.

TOPCOATS 3A-1

6. Stability 120°F Centipoise, cP (spindle, RPM)

Viscosity: initial 334 cP (2, 100)
 final 236 cP (2, 100)

Observations: No other changes, stable

12. Application Properties - Fair at 55 psi, 75% reduction

13. Humidity Resistance

	<u>D.F.T.</u> <u>(mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of</u> <u>Corrosion</u>
	3.6				
A. Blistering		No Blistering			
B. Corrosion		No Corrosion			

14. Salt Spray Resistance

	<u>D.F.T.</u> <u>(mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of</u> <u>Corrosion</u>
	5.7				
A. Blistering		No Blistering			
B. Corrosion		No Corrosion			
C. Color Change		$\Delta E = 9.18$			
D. Gloss Change		4.4			

15. Water Immersion Resistance

	<u>D.F.T.</u> <u>(mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of</u> <u>Corrosion</u>
	4.2				
A. Blistering		No Blistering			
B. Corrosion		No Corrosion			
C. Adhesion		5			
D. Hardness		Pass H			

25. Accelerated Weathering (300 hrs)

	<u>D.F.T.</u> <u>(mils)</u>	<u>Initial</u>	<u>After Exposure</u>
	4.7		
A. Color			$\Delta E = 10.91$
B. Gloss		91.4	88.1

28. Chemical Resistance

A. Gasoline			Film softening
B. Hydrocarbon Oil		Color change	$\Delta E = 9.56$
C. Pine Oil		Slight Staining	
D. Uric Acid		Pass	
E. Windshield Washer fluid		Pass	

LABORATORY REPORT FORM

Sample No. 3A-2
 Contract No. A832-115
 Date received: 6/16/89
 Log No.: 3A1-2-0616
 Lab code: Synthetic Enamel
 Quantity: 1 gal
 Test initiated: 6/20/89
 Test completed: 10/27/89

Chemist: L. Cumming
 L. Kudela

Product Category: 3. ENAMEL TOPCOAT

<u>Tests</u>	<u>Procedure</u>	<u>Results</u>	<u>Applied</u>
1. Total Non-Volatile (wt. %)	ASTM D2369	41.91	
2. Specific Gravity (lbs/gal.)	ASTM D1475	8.73	
3. Water (wt. %)	ASTM D1364	0	
	ASTM D3792	-	
4. Volatile Organic Content (VOC)	ASTM D3960	607.6 g/l	704.9
5. Viscosity, Ford Cup #4	ASTM D1200	15 sec	
6. Stability 120°F *	ASTM D1849	see attached	
7. Freeze - Thaw Resistance (All H ₂ O Based Products)	ASTM D2243	N/A	
8. Water cleanup (all H ₂ O based products)		N/A	
9. Dry Time S.T.T. and D.H.	ASTM D1640	S.T.T.: 26 min D.H.: 265 min	
17. Hardness - Pencil	ASTM D3363	pass HB	
10. Adhesion	ASTM D3359	5	
11. Appearance		very smooth	
18. 60° Gloss	ASTM D523	89.5	
12. Application Properties *		see attached	
13. Humidity Resistance *	ASTM D2247	see attached	
14. Salt Spray Resistance (240 Hrs) *	ASTM B117	see attached	
15. Water Immersion Resistance *	ASTM D1647	see attached	
16. Color and Color Retention	ASTM D2244	Δ E = 1.77	
19. Abrasion Resistance	ASTM D4060	121.8 mg/1000 REV	
20. Flexibility	ASTM D1737	< 1/8 inch	
21. Impact Resistance (forward)	ASTM D2794	>88 inch lbs.	
23. Sag Resistance	STD 141B FTM 4494	9	
24. Levelling	ASTM D2801	5	
22. Contrast Ratio	ASTM D2805	0.95	
25. Acc. Weathering (300 Hrs.) * 60° specular gloss	ASTM G26	see attached	
26. Fungus Resistance	ASTM D3273 ASTM D3274	pass	
27. Heat Resistance		Δ E = 2.64	
28. Chemical Resistance *	ASTM D1450	see attached	

Note: Items 8, 11, 12 are qualitative tests.

* All tests (6, 12, 13, 14, 15, 25 and 28) evaluated on page 2 of report form

TOPCOATS 3A-2

6. Stability 120°F Centipoise, cP (spindle, RPM)

Viscosity: initial 401 cP (2, 100)
 final 301 cP (2, 100)

Observations: No other changes, stable

12. Application Properties - fair at 70 psi, 15% reduction

13. Humidity Resistance

	<u>Panel</u> <u>D.F.T. (mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of Corrosion</u>
	3.4				
A. Blistering		No Blistering			
B. Corrosion		No Corrosion			

14. Salt Spray Resistance

	<u>D.F.T.</u> <u>(mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of Corrosion</u>
	2.7				
A. Blistering		No Blistering			
B. Corrosion		No Corrosion			
C. Color Change		Δ E = 1.12			
D. Gloss Change		7.6			

15. Water Immersion Resistance

	<u>D.F.T.</u> <u>(mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of Corrosion</u>
	3.6				
A. Blistering		No Blistering			
B. Corrosion		No Corrosion			
C. Adhesion		5			
D. Hardness		Pass H			

25. Accelerated Weathering (300 hrs)

	<u>D.F.T.</u> <u>(mils)</u>	<u>Initial</u>	<u>After Exposure</u>
	3.2		
A. Color			Δ E = 1.77
B. Gloss		89.5	82.8

28. Chemical Resistance

A. Gasoline	No change
B. Hydrocarbon Oil	No change
C. Pine Oil	Slight staining
D. Uric Acid	Pass
E. Windshield Washer Fluid	Pass

LABORATORY REPORT FORM

Sample No. 3A-3
 Contract No. A832-115
 Date received: 7/11/89
 Log No.: 3A1-3-0616
 Lab code: Acrylic Enamel
 Quantity: 1 gal
 Test initiated: 7/14/89
 Test completed: 9/27/89

Chemist: L. Cumming
 L. Kudela

Product Category: 3. ENAMEL TOPCOAT

<u>Tests</u>	<u>Procedure</u>	<u>Results</u>	<u>Applied</u>
1. Total Non-Volatile (wt. %)	ASTM D2369	43.60	
2. Specific Gravity (lbs/gal.)	ASTM D1475	7.74	
3. Water (wt. %)	ASTM D1364	0	
	ASTM D3792	-	
4. Volatile Organic Content (VOC)	ASTM D3960	524.4 g/l	602.9
5. Viscosity, Ford Cup #4	ASTM D1200	13 sec.	
6. Stability 120°F *	ASTM D1849	see attached	
7. Freeze - Thaw Resistance (All H ₂ O Based Products)	ASTM D2243	N/A	
8. Water cleanup (all H ₂ O based products)		N/A	
9. Dry Time S.T.T. and D.H.	ASTM D1640	S.T.T.: 14 min D.H.: 290 min	
17. Hardness - Pencil	ASTM D3363	Pass F	
10. Adhesion	ASTM D3359	5	
11. Appearance		very smooth	
18. 60° Gloss	ASTM D523	92.0	
12. Application Properties *		see attached	
13. Humidity Resistance *	ASTM D2247	see attached	
14. Salt Spray Resistance (240 Hrs) *	ASTM B117	see attached	
15. Water Immersion Resistance *	ASTM D1647	see attached	
16. Color and Color Retention	ASTM D2249	Δ E = 1.06	
19. Abrasion Resistance	ASTM D4060	128 mg/1000 REV	
20. Flexibility	ASTM D1737	1/8 inch	
21. Impact Resistance (forward)	ASTM D2794	70 inch lbs.	
23. Sag Resistance	STD 141B FTM 4494	5	
24. Levelling	ASTM D2801	9	
22. Contrast Ratio	ASTM D2805	1.0	
25. Acc. Weathering (300 Hrs.) * 60° specular gloss	ASTM G26	see attached	
26. Fungus Resistance	ASTM D3273 ASTM D3274	pass	
27. Heat Resistance		Δ E = 0.47	
28. Chemical Resistance *	ASTM D1540	see attached	

Note: Items 8, 11, 12 are qualitative tests.

* All tests (6, 12, 13, 14, 15, 25 and 28) evaluated on page 2 of report form

TOPCOATS 3A-3

6. Stability 120°F Centipoise, cP (spindle, RPM)

Viscosity: initial 232 cP (2, 100)
 final 219 cP (2, 100)

Observations: No other changes, stable

12. Application Properties - difficult at 30 psi, 30% reduction

13. Humidity Resistance

	<u>Panel</u> <u>D.F.T.</u> <u>(mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of</u> <u>Corrosion</u>
	1.6				
A. Blistering		No Blistering			
B. Corrosion		No Corrosion			

14. Salt Spray Resistance

	<u>D.F.T.</u> <u>(mils)</u>	<u>Size</u>	<u>Extent of</u> <u>Frequency</u>	<u>Pattern</u>	<u>Corrosion</u>
	1.7				
A. Blistering		No Blistering			
B. Corrosion		No Corrosion			
C. Color Change		$\Delta E = 0.81$			
D. Gloss Change		30.1			

15. Water Immersion Resistance

	<u>D.F.T.</u> <u>(mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Extent of</u> <u>Pattern</u>	<u>Corrosion</u>
	1.8				
A. Blistering		No Blistering			
B. Corrosion		No Corrosion			
C. Adhesion		0			
D. Hardness		Pass F			

25. Accelerated Weathering (300 hrs)

	<u>D.F.T.</u> <u>(mils)</u>	<u>Initial</u>	<u>After Exposure</u>
	1.5		
A. Color			$\Delta E = 1.06$
B. Gloss		92.0	73.7

28. Chemical Resistance

A. Gasoline	No Change
B. Hydrocarbon Oil	No Change
C. Pine Oil	Pass
D. Uric Acid	Pass
E. Windshield Washer Fluid	Pass

LABORATORY REPORT FORM

Sample No. 3A-5
 Contract No. A832-115
 Date received: 7/24/89
 Log No.: 3A1-5-0724
 Lab code: Acrylic Enamel
 Quantity: 1 gal
 Test initiated: 8/1/89
 Test completed: 10/27/89

Chemist: L. Cumming
 L. Kudela

Product Category: 3. ENAMEL TOPCOAT

<u>Tests</u>	<u>Procedure</u>	<u>Results</u>	<u>Applied</u>
1. Total Non-Volatile (wt. %)	ASTM D2369	45.16	
2. Specific Gravity (lbs/gal.)	ASTM D1475	8.13	
3. Water (wt. %)	ASTM D1364	0	
	ASTM D3792	-	
4. Volatile Organic Content (VOC)	ASTM D3960	534.2 g/l	666.1
5. Viscosity, Ford Cup #4	ASTM D1200	21 sec.	
6. Stability 120°F *	ASTM D1849	see attached	
7. Freeze - Thaw Resistance (All H ₂ O Based Products)	ASTM D2243	N/A	
8. Water cleanup (all H ₂ O based products)		N/A	
9. Dry Time S.T.T. and D.H.	ASTM D1640	S.T.T.: 24 min D.H.: 47 min	
17. Hardness - PENCIL	ASTM D3363	pass 1H	
10. Adhesion	ASTM D3359	5	
11. Appearance		very smooth, glossy	
18. 60° Gloss	ASTM D523	89.7	
12. Application Properties *		see attached	
13. Humidity Resistance *	ASTM D2247	see attached	
14. Salt Spray Resistance (240 Hrs) *	ASTM B117	see attached	
15. Water Immersion Resistance *	ASTM D1647	see attached	
16. Color and Color Retention	ASTM D2244	Δ E = 0.50	
19. Abrasion Resistance	ASTM D4060	36.1 mg/1000 Rev.	
20. Flexibility	ASTM D1737	1/8 inch	
21. Impact Resistance (forward)	ASTM D2794	>88 inch lbs.	
23. Sag Resistance	STD 141B FTM 4494	3	
24. Levelling	ASTM D2801	10	
22. Contrast Ratio	ASTM D2805	0.79	
25. Acc. Weathering (300 Hrs.) * 60° specular gloss	ASTM G26	see attached	
26. Fungus Resistance	ASTM D3273	pass	
	ASTM D3274		
27. Heat Resistance		Δ E = 0.60	
28. Chemical Resistance *	ASTM D1540	see attached	

Note: Items 8, 11, 12 are qualitative tests.

* All tests (6, 12, 13, 14, 15, 25 and 28) evaluated on page 2 of report form

6. Stability 120°F Centipoise, cP (spindle, RPM)
 Viscosity: initial 388 cP (3,100)
 final 335 cP (3, 100)

Observations: No change, stable

12. Application Properties - good, 50 psi mixing 8:4:1 (paint, reducer, hardener)

13. Humidity Resistance

	<u>Panel</u> <u>D.F.T.</u> <u>(mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of</u> <u>Corrosion</u>
	2.2				
A. Blistering		No Blisters			
B. Corrosion		No Corrosion			

14. Salt Spray Resistance

	<u>D.T.T.</u> <u>(mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of</u> <u>Corrosion</u>
	1.9				
A. Blistering		No Blistering			
B. Corrosion				Random corrosion on scribes	1/16 inch from both scribes
C. Color Change		$\Delta E = 2.44$			
D. Gloss Change		10.5			

15. Water Immersion Resistance

	<u>D.F.T.</u> <u>(mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of</u> <u>Corrosion</u>
	2.7				
A. Blistering		No blistering			
B. Corrosion		No corrosion			
C. Adhesion		5			
D. Hardness		pass H			

25. Accelerated Weathering (300 hrs)

	<u>Initial</u>	<u>After Exposure</u>
A. Color		$\Delta E = 0.50$
B. Gloss	89.7	86.8

28. Chemical Resistance

A. Gasoline	No color or other film changes
B. Hydrocarbon Oil	No color or other film changes
C. Pine Oil	Pass
D. Uric Acid	Pass
E. Windshield Washer Fluid	Pass

LABORATORY REPORT FORM

Sample No. 3A-6 * 3E1
 Contract No. A832-115
 Date received: 7/24/89
 Log No.: BA1-6-0724, 3E-1-10724
 Lab code: Acrylic Enamel Basecoat clearcoat
 Quantity: 1 gal
 Test initiated: 8/15/89
 Test completed: 10/27/89

Chemist: L. Cumming
 L. Kudela

Product Category: 3. ENAMEL BASECOAT/CLEARCOAT

<u>Tests</u>	<u>Procedure</u>	<u>Results 3A-6/3E1</u>
1. Total Non-Volatile (wt. %)	ASTM D2369	27.89 / 34.91
2. Specific Gravity (lbs/gal.)	ASTM D1475	7.66 / 7.95
3. Water (wt. %)	ASTM D1364	0
	ASTM D3792	-
4. Volatile Organic Content (VOC)	ASTM D3960	661.81 620.1 g/l
5. Viscosity, Ford Cup #4	ASTM D1200	12 sec.
6. Stability 120°F *	ASTM D1849	see attached
7. Freeze - Thaw Resistance (All H ₂ O Based Products)	ASTM D2243	N/A
8. Water cleanup (all H ₂ O based products)		N/A
9. Dry Time S.T.T. and D.H.	ASTM D1640	S.T.T.: 9 min D.H.: 52 min
17. Hardness - Pencil	ASTM D3363	pass 2H
10. Adhesion	ASTM D3359	5
11. Appearance		very smooth
18. 60° Gloss	ASTM D523	94.8
12. Application Properties *		see attached
13. Humidity Resistance *	ASTM D2247	see attached
14. Salt Spray Resistance (240 Hrs) *	ASTM B117	see attached
15. Water Immersion Resistance *	ASTM D1647	see attached
16. Color and Color Retention	ASTM D2244	Δ E = 0.88
19. Abrasion Resistance	ASTM D4060	29.9 mg/1000 Rev.
20. Flexibility	ASTM D1737	1/8 inch
21. Impact Resistance (forward)	ASTM D2794	> 88 inch lbs.
23. Sag Resistance	STD 141B FTM 4494	4.5
24. Levelling	ASTM D2801	9
22. Contrast Ratio	ASTM D2805	0.80
25. Acc. Weathering (300 Hrs.) * 60° specular gloss	ASTM G26	see attached
26. Fungus Resistance	ASTM D3273 ASTM D3274	pass
27. Heat Resistance		Δ E = 0.59
28. Chemical Resistance *	ASTM D1540	see attached

Note: Items 8, 11, 12 are qualitative tests.

* All tests (6, 12, 13, 14, 15, 25 and 28) evaluated on page 2 of report form

TOPCOATS 3A-6

6. Stability 120°F Centipoise, cP (spindle, RPM)
 Viscosity: initial 402 cP (2, 100)
 final 424 cP (2, 100)

Observations: Stable

12. Application Properties - difficult 50 psi, reduction 1:1

13. Humidity Resistance

	<u>D.F.T. (mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of Corrosion</u>
	1.6/2.8				
A. Blistering		No Blistering			
B. Corrosion		No Corrosion			

14. Salt Spray Resistance

	<u>D.F.T. (mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of Corrosion</u>
	1.9/2.4				
A. Blistering		No Blistering			
B. Corrosion		No Corrosion			
C. Color Change		$\Delta E = 2.0$			
D. Gloss Change		7.2			

15. Water Immersion Resistance

	<u>D.F.T. (mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of Corrosion</u>
	0.8/1.6				
A. Blistering		No blistering			
B. Corrosion		No corrosion			
C. Adhesion		5			
D. Hardness		Pass 2H			

25. Accelerated Weathering (300 hrs)

	<u>D.F.T. (mils)</u>	<u>Initial</u>	<u>After Exposure</u>
	1.4/2.4		
A. Color			$\Delta E = 0.88$
B. Gloss		94.8	94.2

28. Chemical Resistance

A. Gasoline	No color or other film changes
B. Hydrocarbon Oil	No color or other film changes
C. Pine Oil	Pass
D. Uric Acid	Pass
E. Windshield Washer Fluid	Pass

LABORATORY REPORT FORM

Sample No. 3A-7
 Contract No. A832-115
 Date received: 8/14/89
 Log No.: 3A1-7-0814
 Lab code: Acrylic urethane enamel
 Quantity: 1 qt
 Test initiated: 8/17/89
 Test completed: 10/27/89
 Product Category: 3. ENAMEL TOPCOAT

Chemist: L. Cumming
 L. Kudela

<u>Tests</u>	<u>Procedure</u>	<u>Results</u>	<u>Applied</u>
1. Total Non-Volatile (wt. %)	ASTM D2369	50.35	
2. Specific Gravity (lbs/gal.)	ASTM D1475	8.62	
3. Water (wt. %)	ASTM D1364	0	
	ASTM D3792	-	
4. Volatile Organic Content (VOC)	ASTM D3960	512.8 g/l	647.8
5. Viscosity, Ford Cup #4	ASTM D1200	14 sec	
6. Stability 120°F *	ASTM D1849	see attached	
7. Freeze - Thaw Resistance (All H ₂ O Based Products)	ASTM D2243	N/A	
8. Water cleanup (all H ₂ O based products)		N/A	
9. Dry Time S.T.T. and D.H.	ASTM D1640	S.T.T.: 6 min D.H.: 27 min	
17. Hardness - Pencil	ASTM D3363	Pass H10	
10. Adhesion	ASTM D3359	5	
11. Appearance		very smooth	
18. 60° Gloss	ASTM D523	94.2	
12. Application Properties *		see attached	
13. Humidity Resistance *	ASTM D2247	see attached	
14. Salt Spray Resistance (240 Hrs) *	ASTM B117	see attached	
15. Water Immersion Resistance *	ASTM D1647	see attached	
16. Color and Color Retention	ASTM D2244	Δ E = 0.33	
19. Abrasion Resistance	ASTM D4060	106.7 mg/1000 Rev	
20. Flexibility	ASTM D1737	3/8 inch	
21. Impact Resistance (forward)	ASTM D2794	18 inch lbs	
23. Sag Resistance	STD 141B FTM 4494	0	
24. Levelling	ASTM D2801	10	
22. Contrast Ratio	ASTM D2805	0.91	
25. Acc. Weathering (300 Hrs.) * 60° specular gloss	ASTM G26	see attached	
26. Fungus Resistance	ASTM D3273 ASTM D3274	pass	
27. Heat Resistance		Δ E = 2.97	
28. Chemical Resistance *	ASTM D1540	see attached	

Note: Items 8, 11, 12 are qualitative tests.

* All tests (6, 12, 13, 14, 15 25 and 28) evaluated on page 2 of report form

TOPCOATS 3A-7

6. Stability 120°F Centipoise, cP (spindle, RPM)
 Viscosity: initial 463.0 cP (2, 100)
 final 522.0 cP (2, 100)
 Observations: No changes, stable

12. Application Properties - very good, 50 psi reduction 2:1

13. Humidity Resistance

	Panel D.F.T. (mils)	Size	Frequency	Pattern	Extent of Corrosion
	1.7				
A. Blistering		No Blistering			
B. Corrosion		No Corrosion			

14. Salt Spray Resistance

	D.F.T. (mils)	Size	Frequency	Pattern	Extent of Corrosion
	1.8				
A. Blistering		No Blistering			
B. Corrosion				Random	1/32 inch on both scribes
C. Color Change		$\Delta E = 2.69$			
D. Gloss Change		8.1			

15. Water Immersion Resistance *

	D.F.T. (mils)	Size	Frequency	Pattern	Extent of Corrosion
	1.9				
A. Blistering		No blistering			
B. Corrosion		No corrosion			
C. Adhesion		5			
D. Hardness		Pass HB			

25. Accelerated Weathering (300 hrs)

	D.F.T. (mils)	Initial	After Exposure
	2.1		
A. Color			$\Delta E = 0.33$
B. Gloss		94.2	90.6

28. Chemical Resistance

A. Gasoline	Strong stain, film softening
B. Hydrocarbon Oil	No change
C. Pine Oil	Pass
D. Uric Acid	Pass
E. Windshield Washer Fluid	Pass

LABORATORY REPORT FORM

Sample No. 3A2-1
 Contract No. A832-115
 Date received: 7/19/89
 Log No.: 3A2-1-0719
 Lab code: Acrylic Urethane Enamel
 Quantity: 1 qt
 Test initiated: 7/20/89
 Test completed: 10/27/89

Chemist: L. Cumming
 L. Kudela

Product Category: 3. URETHANE TOPCOAT

<u>Tests</u>	<u>Procedure</u>	<u>Results</u>	<u>Applied</u>
1. Total Non-Volatile (wt. %)	ASTM D2369	66.33	
2. Specific Gravity (lbs/gal.)	ASTM D1475	8.32	
3. Water (wt. %)	ASTM D1364 ASTM D3792	0 -	
4. Volatile Organic Content (VOC)	ASTM D3960	335.7 g/l	577.2
5. Viscosity, Ford Cup #4	ASTM D1200	15 sec	
6. Stability 120°F *	ASTM D1849	see attached	
7. Freeze - Thaw Resistance (All H ₂ O Based Products)	ASTM D2243	N/A	
8. Water cleanup (all H ₂ O based products)		N/A	
9. Dry Time S.T.T. and D.H.	ASTM D1640	S.T.T.: 7 min D.H.: 44 min	
17. Hardness - Pencil	ASTM D3363	pass 2H	
10. Adhesion	ASTM D3359	0	
11. Appearance		very smooth	
18. 60° Gloss	ASTM D523	90.7	
12. Application Properties *		see attached	
13. Humidity Resistance *	ASTM D2247	see attached	
14. Salt Spray Resistance (240 Hrs) *	ASTM B117	see attached	
15. Water Immersion Resistance *	ASTM D1647	see attached	
16. Color and Color Retention	ASTM D2244	Δ E = 1.14	
19. Abrasion Resistance	ASTM D4060	27.0 mg/1000 REV.	
20. Flexibility	ASTM D1737	1/8 inch	
21. Impact Resistance (forward)	ASTM D2794	>88 inch lbs.	
23. Sag Resistance	STD 141B FTM 4494	7	
24. Levelling	ASTM D2801	6	
22. Contrast Ratio	ASTM D2805	0.99	
25. Acc. Weathering (300 Hrs.) * 60° specular gloss	ASTM G26	see attached	
26. Fungus Resistance	ASTM D3273 ASTM D3274	pass	
27. Heat Resistance		Δ E = 0.96	
28. Chemical Resistance *	ASTM D1540	see attached	

Note: Items 8, 11, 12 are qualitative tests.

* All test (6, 12, 13, 14, 15, 25 and 28) evaluated on page 2 of report form

TOPCOATS 3A2-1

6. Stability 120°F Centipoise, cP (spindle, RPM)
 Viscosity: initial 836 cP (3, 100)
 final 572 cP (3, 100)
 Observations: No changes, slightly unstable

12. Application Properties - fair at 60 psi, 30% reduction

13. Humidity Resistance

	<u>Panel</u> <u>D.F.T. (mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of</u> <u>Corrosion</u>
	2.6				
A. Blistering		No blistering			
B. Corrosion		No corrosion			

14. Salt Spray Resistance

	<u>D.F.T.</u> <u>(mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of</u> <u>Corrosion</u>
	3.1				
A. Blistering		#4	Dense	along both scribes	
B. Corrosion		No corrosion			
C. Color Change		$\Delta E = 0.51$			
D. Gloss Change		0.4			

15. Water Immersion Resistance

	<u>D.F.T.</u> <u>(mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of</u> <u>Corrosion</u>
	3.3				
A. Blistering		No blistering			
B. Corrosion		No corrosion			
C. Adhesion		5			
D. Hardness		Pass 3H			

25. Accelerated Weathering (300 hrs)

	<u>D.F.T.</u> <u>(mils)</u>	<u>Initial</u>	<u>After Exposure</u>
	3.2		
A. Color			$\Delta E = 1.14$
B. Gloss		90.7	83.1

28. Chemical Resistance

A. Gasoline	Slight stain
B. Hydrocarbon Oil	No surface change
C. Pine Oil	Pass
D. Uric Acid	Pass
E. Windshield Washer Fluid	Pass

LABORATORY REPORT FORM

Sample No. 3B-1
 Contract No. A832-115
 Date received: 6/16/89
 Log No.: 3B1-1-0616
 Lab code: Acrylic Urethane
 Quantity: 1 pt
 Test initiated: 6/20/89
 Test completed: 10/20/89

Chemist: L. Cumming
 L. Kudela

Product Category: 3. URETHANE TOPCOAT

<u>Tests</u>	<u>Procedure</u>	<u>Results</u>	<u>Applied</u>
1. Total Non-Volatile (wt. %)	ASTM D2369	61.72	
2. Specific Gravity (lbs/gal.)	ASTM D1475	9.59	
3. Water (wt. %)	ASTM D1364 ASTM D3792	0 -	
4. Volatile Organic Content (VOC)	ASTM D3960	439.9 g/l	550.4
5. Viscosity, Ford Cup #4	ASTM D1200	16 sec.	
6. Stability 120°F *	ASTM D1849	see attached	
7. Freeze - Thaw Resistance (All H ₂ O Based Products)	ASTM D2243	N/A	
8. Water cleanup (all H ₂ O based products)		N/A	
9. Dry Time S.T.T. and D.H.	ASTM D1640	S.T.T.: 6 min D.H.: >3 hrs	
17. Hardness - Pencil	ASTM D3363	pass 3H	
10. Adhesion	ASTM D3359	5	
11. Appearance		very smooth	
18. 60° Gloss	ASTM D523	91.0	
12. Application Properties *		see attached	
13. Humidity Resistance *	ASTM D2247	see attached	
14. Salt Spray Resistance (240 Hrs) *	ASTM B117	see attached see attached	
15. Water Immersion Resistance *	ASTM D1647	see attached	
16. Color and Color Retention	ASTM D2244	ΔE = 0.75	
19. Abrasion Resistance	ASTM D4060	64.6 mg/1000 REV.	
20. Flexibility	ASTM D1737	7/16	
21. Impact Resistance (forward)	ASTM D2794	> 88 inch lbs.	
23. Sag Resistance	STD 141B FTM 4494	8	
24. Levelling	ASTM D2801	7	
22. Contrast Ratio	ASTM D2805	0.99	
25. Acc. Weathering (300 Hrs.) * 60° specular gloss	ASTM G26	see attached	
26. Fungus Resistance	ASTM D3273 ASTM D3274	pass	
27. Heat Resistance		ΔE = 0.27	
28. Chemical Resistance *	ASTM D1540	see attached	

Note: Items 8, 11, 12 are qualitative tests.

* All tests (6, 12, 13, 14, 15, 25 and 28) evaluated on page 2 of report form

TOPCOATS 3B-1

6. Stability 120°F Centipoise, cP (spindle, RPM)
 Viscosity: initial 479 cP (2, 50)
 final 508 cP (2, 50)
 Observations: No changes, stable

12. Application Properties - very good at 45 psi, 25% reduction

13. Humidity Resistance

Panel	<u>D.F.T. (mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of Corrosion</u>
	3.8				
A. Blistering		No Blistering			
B. Corrosion		No Corrosion			

14. Salt Spray Resistance

	<u>D.F.T. (mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of Corrosion</u>
	4.3				
A. Blistering		No Blistering			
B. Corrosion				Corrosion on both scribes	1/32" from both scribes
C. Color Change		$\Delta E = 1.06$			
D. Gloss Change		3.8			

15. Water Immersion Resistance

	<u>D.F.T. (mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of Corrosion</u>
	3.9				
A. Blistering		No Blistering			
B. Corrosion		No Corrosion			
C. Adhesion		5			
D. Hardness		Pass 3H			

25. Accelerated Weathering (300 hrs)

	<u>D.F.T. (mils)</u>	<u>Initial</u>	<u>After Exposure</u>
	4.4		
A. Color		$\Delta E = 0.75$	
B. Gloss		91.0	86.1

28. Chemical Resistance

A. Gasoline	Staining - no other surface change
B. Hydrocarbon Oil	No stain on other film change
C. Pine Oil	Pass
D. Uric Acid	Pass
E. Windshield Washer Fluid	Pass

LABORATORY REPORT FORM

Sample No. 3B-2
 Contract No. A832-115
 Date received: 6/16/89
 Log No.: 3B-2-0616
 Lab code: Urethane
 Quantity: 1 gal
 Test initiated: 6/20/89
 Test completed: 10/20/89

Chemist: L. Cumming
 L. Kudela

Product Category: 3. URETHANE TOPCOAT

<u>Tests</u>	<u>Procedure</u>	<u>Results</u>	<u>Applied</u>
1. Total Non-Volatile (wt. %)	ASTM D2369	53.37	
2. Specific Gravity (lbs/gal.)	ASTM D1475	9.23	
3. Water (wt. %)	ASTM D1364	0	
	ASTM D3792	-	
4. Volatile Organic Content (VOC)	ASTM D3960	515.7 g/l	637.3
5. Viscosity, Ford Cup #4	ASTM D1200	12 sec.	
6. Stability 120°F *	ASTM D1849	see attached	
7. Freeze - Thaw Resistance (All H ₂ O Based Products)	ASTM D2243	N/A	
8. Water cleanup (all H ₂ O based products)		N/A	
9. Dry Time S.T.T. and D.H.	ASTM D1640	S.T.T.: 48 min D.H.: > 3 hrs	
17. Hardness - Pencil	ASTM D3363	pass 3H	
10. Adhesion	ASTM D3359	4	
11. Appearance		very smooth	
18. 60° Gloss	ASTM D523	96.3	
12. Application Properties *		see attached	
13. Humidity Resistance *	ASTM D2247	see attached	
14. Salt Spray Resistance (240 Hrs) *	ASTM B117	see attached	
15. Water Immersion Resistance *	ASTM D1647	see attached	
16. Color and Color Retention	ASTM D2244	ΔE = 0.59	
19. Abrasion Resistance	ASTM D4060	38.1 mg/1000 REV	
20. Flexibility	ASTM D1737	1/8 inch	
21. Impact Resistance (forward)	ASTM D2794	>88 inch lbs.	
23. Sag Resistance	STD 141B FTM 4494	6	
24. Levelling	ASTM D2801	7	
22. Contrast Ratio	ASTM D2805	pass	
25. Acc. Weathering (300 Hrs.) * 60° specular gloss	ASTM G26	see attached	
26. Fungus Resistance	ASTM D3273 ASTM D3274	pass	
27. Heat Resistance		ΔE = 0.41	
28. Chemical Resistance *	ASTM D1540	see attached	

Note: Items 8, 11, 12 are qualitative tests.

* All test (6, 12, 13, 14, 15, 25 and 28) evaluated on page 2 of report form

TOPCOATS 3B-2

6. Stability 120°F Centipoise, cP (spindle, RPM)
 Viscosity: initial 110 cP (2,100)
 final 95 cP (2,100)
 Observations: Heavy Settlement, unstable

12. Application Properties - very good at 70 psi, 40% reduction

13. Humidity Resistance

Panel	<u>D.F.T. (mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of Corrosion</u>
A. Blistering		No Blistering			
B. Corrosion		No Corrosion			

14. Salt Spray Resistance

	<u>D.F.T. (mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of Corrosion</u>
	4.7				
A. Blistering		No Blistering			
B. Corrosion		No Corrosion			
C. Color Change		$\Delta E = 0.58$			
D. Gloss Change		1.5			

15. Water Immersion Resistance

	<u>D.F.T. (mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of Corrosion</u>
A. Blistering		No Blistering			
B. Corrosion		No Corrosion			
C. Adhesion		5			
D. Hardness		Pass 3H			

25. Accelerated Weathering (300 hrs)

	<u>D.F.T. (mils)</u>	<u>Initial</u>	<u>After Exposure</u>
	2.1		
A. Color		$\Delta E = 0.59$	
B. Gloss		94.6	91.2

28. Chemical Resistance

A. Gasoline	No staining or film changes
B. Hydrocarbon Oil	No staining or film changes
C. Pine Oil	Pass
D. Uric Acid	Pass
E. Windshield Washer Fluid	Pass

LABORATORY REPORT FORM

Sample No. 3B-3
 Contract No. A832-115
 Date received: 7/6/89
 Log No.: 3B-3-0706
 Lab code: Polyoxithane
 Quantity: 1 qt
 Test initiated: 7/10/89
 Test completed:

Chemist: L. Cumming
 L. Kudela

Product Category: 3. ENAMEL TOPCOAT

<u>Tests</u>	<u>Procedure</u>	<u>Results</u>	<u>Applied</u>
1. Total Non-Volatile (wt.%)	ASTM D2369	55.93	
2. Specific Gravity (lbs/gal.)	ASTM D1475	9.80	
3. Water (wt.%)	ASTM D1364	0	
	ASTM D3792	--	
4. Volatile Organic Content (VOC)	ASTM D3960	517.8 g/l	597.2
5. Viscosity, Ford cup #4	ASTM D1200	18 sec.	
6. Stability 120°F *	ASTM D1849	see attached	
7. Freeze - Thaw Resistance (All H ₂ O Based Products)	ASTM D2243	N/A	
8. Water cleanup (all H ₂ O based products)		N/A	
9. Dry Time S.T.T. and D.H.	ASTM D1640	S.T.T.: 7 min D.H.: 110 min	
17. Hardness - Pencil	ASTM D3363	pass H	
10. Adhesion	ASTM D3359	3	
11. Appearance		very smooth	
18. 60° Gloss	ASTM D523	92.1	
12. Application Properties *		see attached	
13. Humidity Resistance *	ASTM D2247	see attached	
14. Salt Spray Resistance (240 Hrs) *	ASTM B117	see attached	
15. Water Immersion Resistance *	ASTM D1647	see attached	
16. Color and Color Retention	ASTM D2244	ΔE = 0.14	
19. Abrasion Resistance	ASTM D4060	82.2 mg/1000 Rev.	
20. Flexibility	ASTM D1737	1/2 inch	
21. Impact Resistance (forward)	ASTM D2794	<3.0 inch lb	
23. Sag Resistance	STD 141B FTM 4494	5	
24. Levelling	ASTM D2801	9	
22. Contrast Ratio	ASTM D2805	0.98	
25. Acc. Weathering (300 Hrs.)* 60° specular gloss	ASTM G26	see attached	
26. Fungus Resistance	ASTM D3273 ASTM D3274	pass	
27. Heat Resistance		ΔE = 0.70	
28. Chemical Resistance*	ASTM D1540	see attached	

Note: Items 8, 11, 12 are qualitative tests.

* All Tests (6,12,13,14,15,25 and 28) evaluated on page 2 of report form.

6. Stability 120°F centipoise, cP (spindle, RPM)
 Viscosity: initial 123 cP (2, 100)
 final 107 cP (2, 100)
 Observations: No other changes, stable

12. Application Properties - fair at 55 psi, 20% reduction

13. Humidity Resistance

	<u>D.F.T. (mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of Corrosion</u>
	5.3				
A. Blistering		No Blistering			
B. Corrosion		No Corrosion			

14. Salt Spray Resistance

	<u>D.F.T. (mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of Corrosion</u>
	3.8				
A. Blistering		No Blistering			
B. Corrosion				Starting 1/6" from corrosion both on both sides scribes	1/6" from both sides random
C. Color Change		$\Delta E = 1.61$			
D. Gloss Change		6.7			

15. Water Immersion Resistance

	<u>D.F.T. (mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of Corrosion</u>
	4.1				
A. Blistering		No blisering			
B. Corrosion		No corrosion			
C. Adhesion		4			
D. Hardness		pass H			

25. Accelerated Weathering (300 hrs)

	<u>D.F.T. (mils)</u>	<u>Initial</u>	<u>After Exposure</u>
	5.1		
A. Color			$\Delta E = 0.14$
B. Gloss		92.1	83.5

28. Chemical Resistance

A. Gasoline	Stains, no film change
B. Hydrocarbon Oil	No staining
C. Pine Oil	Pass
D. Uric Acid	Pass
E. Windshield Washer Fluid	Pass

LABORATORY REPORT FORM

Sample No. 3B-4
 Contract No. A832-115
 Date received: 8/4/89
 Log No.: 3B-4-0804
 Lab code: 3B-4 Acrylic Urethane
 Quantity: 1 qt.
 Test initiated: 8/28/89
 Test completed: 10/27/89

Chemist: L. Cumming
 L. Kudela

Product Category: 3 URETHANE TOPCOAT

<u>Tests</u>	<u>Procedure</u>	<u>Results</u>	<u>Applied</u>
1. Total Non-Volatile (wt.%)	ASTM D2369	53.87	
2. Specific Gravity (lbs/gal.)	ASTM D1475	9.90	
3. Water (wt.%)	ASTM D1364	0	
	ASTM D3792	-	
4. Volatile Organic Content (VOC)	ASTM D3960	547.2 g/l	723.3
5. Viscosity, Ford cup #4	ASTM D1200	22 sec.	
6. Stability 120°F *	ASTM D1849	see attached	
7. Freeze - Thaw Resistance (All H ₂ O Based Products)	ASTM D2243	N/A	
8. Water cleanup (all H ₂ O based products)		N/A	
9. Dry Time S.T.T. and D.H.	ASTM D1640	S.T.T.: 19 min. D.H.: 135 min.	
17. Hardness - PENCIL	ASTM D3363	F	
10. Adhesion	ASTM D3359	4	
11. Appearance		Very smooth & glossy	
18. 60° Gloss	ASTM D523	94.6	
12. Application Properties *		see attached	
13. Humidity Resistance *	ASTM D2247	see attached	
14. Salt Spray Resistance (240 Hrs) *	ASTM B117	see attached	
15. Water Immersion Resistance *	ASTM D1647	see attached	
16. Color and Color Retention	ASTM D2244	ΔE = 1.96	
19. Abrasion Resistance	ASTM D4060	47.6 mg / 1000 REV	
20. Flexibility	ASTM D1737	1/8 inch	
21. Impact Resistance (forward)	ASTM D2794	> 88 inch lb	
23. Sag Resistance	STD 141B FTM 4494	4	
24. Levelling	ASTM D2801	10	
22. Contrast Ratio	ASTM D2805	0.91	
25. Acc. Weathering (300 Hrs) * 60° specular gloss	ASTM G26	see attached	
26. Fungus Resistance	ASTM D3273 ASTM D3274	pass	
27. Heat Resistance		ΔE = 0.78	
28. Chemical Resistance *	ASTM D1540	see attached	

Note: Items 8, 11, 12 are qualitative tests.

* All Tests (6,12,13,14,15,25, and 28) evaluated on page 2 of report form.

TOPCOATS 3B-4

6. Stability 120°F centipoise, cP (spindle, RPM)

Viscosity: initial 678 cP (2, 50)
 final 574 cP (2, 50)

Observations: No changes, unstable

12. Application Properties Very good, mix ratio 1: 0.5: 0.3 (paint: hard: red)
 50psi at the gun

13. Humidity Resistance

	<u>D.F.T.</u> <u>(mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of</u> <u>Corrosion</u>
	2.7				
A. Blistering		No blistering			
B. Corrosion		No corrosion			

14. Salt Spray Resistance

	<u>D.F.T.</u> <u>(mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of</u> <u>Corrosion</u>
	2.5				
A. Blistering		#4	Medium Dense	along both scribes	
B. Corrosion		No corrosion			
C. Color Change		$\Delta E = 0.66$			
D. Gloss Change		3.1			

15. Water Immersion Resistance

	<u>D.F.T.</u> <u>(mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of</u> <u>Corrosion</u>
	4.2				
A. Blistering		No blistering			
B. Corrosion		No corrosion			
C. Adhesion		5			
D. Hardness		Pass F			

25. Accelerated Weathering (300 hrs)

	<u>D.F.T.</u> <u>(mils)</u>	<u>Initial</u>	<u>After Exposure</u>
A. Color	2.4		$\Delta E = 1.96$
B. Gloss		94.6	88.3

28. Chemical Resistance

A. Gasoline	No color, or other film changes
B. Hydrocarbon Oil	No change
C. Pine Oil	Pass
D. Uric Acid	Pass
E. Windshield Washer Fluid	Pass

LABORATORY REPORT FORM

Sample No. 3B-5
 Contract No. A832-115
 Date received: 7/18/89
 Log No.: 3B-5-0718
 Lab code: Acrylic Urethane Enamel
 Quantity: 1 qt
 Test initiated: 7/20/89
 Test completed:

Chemist: L. Cumming
 L. Kudela

Product Category: 3. URETHANE TOPCOAT

<u>Tests</u>	<u>Procedure</u>	<u>Results</u>	<u>Applied</u>
1. Total Non-Volatile (wt.%)	ASTM D2369	56.29	
2. Specific Gravity (lbs/gal.)	ASTM D1475	9.56	
3. Water (wt.%)	ASTM D1364	0	
	ASTM D3792	-	
4. Volatile Organic Content (VOC)	ASTM D3960	500.7 g/l	713.4
5. Viscosity, Ford cup #4	ASTM D1200	13 sec.	
6. Stability 120°F *	ASTM D1849	see attached	
7. Freeze - Thaw Resistance (All H ₂ O Based Products)	ASTM D2243	N/A	
8. Water cleanup (all H ₂ O based products)		N/A	
9. Dry Time S.T.T. and D.H.	ASTM D1640	S.T.T.: 6 min D.H.: 25 min	
17. Hardness - Pencil	ASTM D3363	pass 2H	
10. Adhesion	ASTM D3359	5 very smooth	
11. Appearance		90.5	
18. 60° Gloss	ASTM D523		
12. Application Properties *		see attached	
13. Humidity Resistance *	ASTM D2247	see attached	
14. Salt Spray Resistance (240 Hrs)*	ASTM B117	see attached	
15. Water Immersion Resistance	ASTM D1647	see attached	
16. Color and Color Retention	ASTM D2244	ΔE = 1.33	
19. Abrasion Resistance	ASTM D4060	88.4 mg/1000 rev	
20. Flexibility	ASTM D1737	1/8	
21. Impact Resistance (forward)	ASTM D2794	> 87 inch lb	
23. Sag Resistance	STD 141B FTM 4494	7	
24. Levelling	ASTM D2801	10	
22. Contrast Ratio	ASTM D2805	0.99	
25. Acc. Weathering (300 Hrs) * 60° specular gloss	ASTM G26	see attached	
26. Fungus Resistance	ASTM D3273		
	ASTM D3274	ΔE = 1.87	
27. Heat Resistance			
28. Chemical Resistance *	ASTM D1540	see attached	

Note: Items 8, 11, 12 are qualitative tests.

* All Tests (6,14,15,16,17,25, and 28) evaluated on page 2 of report form.

TOPCOATS 3B-5

6. Stability 120°F centipoise cP (spindle, RPM)

Viscosity: initial 1266 cP (2, 100)
 final 1340 cP (2, 100)

Observations: No changes, stable

12. Application Properties

difficult at 48 psi (dry film), used heavy reducer (2%) mix ratio
 4: 3: 1 (Paint: Reducer: Hardener)

13. Humidity Resistance

	Panel	<u>D.F.T. (mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of Corrosion</u>
		2.2				
A. Blistering			No blistering			
B. Corrosion			No corrosion			

14. Salt Spray Resistance

	D.F.T.	<u>(mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of Corrosion</u>
		2.5				
A. Blistering			None			
B. Corrosion			None			
C. Color Change			$\Delta E = 1.17$			
D. Gloss Change			4.6			

15. Water Immersion Resistance

	D.F.T.	<u>(mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of Corrosion</u>
		3.3				
A. Blistering			None			
B. Corrosion			None			
C. Adhesion			5			
D. Hardness			Pass 2H			

25. Accelerated Weathering (300 hrs)

	D.F.T.	<u>(mils)</u>	<u>Initial</u>	<u>After Exposure</u>
		2.0		
A. Color				$\Delta E = 1.33$
B. Gloss			90.5	84.3

28. Chemical Resistance

A. Gasoline	Slight stain
B. Hydrocarbon Oil	No surface change
C. Pine Oil	Pass
D. Uric Acid	Pass
E. Windshield Washer Fluid	Pass

LABORATORY REPORT FORM

Sample No. 3B-6
 Contract No. A832-115
 Date received: 9/29/89
 Log No.: 3B-6-0928
 Lab code: Three Component Polyester
 Quantity: 2 qts
 Test initiated: 10/10/89
 Test completed:

Chemist: L. Cumming
 L. Kudela

Product Category: 3. TOPCOAT

<u>Tests</u>	<u>Procedure</u>	<u>Results</u>	<u>Applied</u>
1. Total Non-Volatile (wt.%)	ASTM D2369	90.26	
2. Specific Gravity (lbs/gal.)	ASTM D1475	8.77	
3. Water (wt.%)	ASTM D1364	0	
	ASTM D3792	--	
4. Volatile Organic Content (VOC)	ASTM D3960	102.4 g/l	102.4
5. Viscosity, Ford Cup #4	ASTM D1200	27 sec.	
6. Stability 120°F *	ASTM D1849	N/A	
7. Freeze - Thaw Resistance (All H ₂ O Based Products)	ASTM D2243	N/A	
8. Water cleanup (all H ₂ O based products)		N/A	
9. Dry Time S.T.T. and D.H.	ASTM D1640	S.T.T.: 15 min. heatcure D.H.: 1hr. heatcure	
17. Hardness - Pencil	ASTM D2143	2H	
10. Adhesion	ASTM D3359	5	
11. Appearance		very smooth	
18. 60° Gloss	ASTM D523	90.0	
12. Application Properties *		see attached	
13. Humidity Resistance *	ASTM D2247	see attached	
14. Salt Spray Resistance (240 Hrs) *	ASTM B117	see attached	
15. Water Immersion Resistance *	ASTM D1647	see attached	
16. Color and Color Retention	ASTM D2244	ΔE = 0.46	
19. Abrasion Resistance	ASTM D4060	33 mg/1000 REV	
20. Flexibility	ASTM D1737	< 1/8"	
21. Impact Resistance (forward)	ASTM D2794	> 88 inch lbs.	
23. Sag Resistance	STD 141B FTM 4494	8	
24. Levelling	ASTM D2801	9	
22. Contrast Ratio	ASTM D2805	1.0	
25. Acc. Weathering (300 Hrs) * 60° specular gloss	ASTM G26	see attached	
26. Fungus Resistance	ASTM D3273 ASTM D3274	pass	
27. Heat Resistance		ΔE = 0.24	
28. Chemical Resistance *	ASTM D1540	see attached	

Note: Items 8, 11, 12 are qualitative tests.
 * All Tests (6,12,13,14,15,25, and 28) evaluated on page 2 of report form.

TOPCOATS 3B-6

6. Stability 120°F centipoise cP (spindle, RPM) - not tested, wet.
 sample was not retained

Viscosity: initial
 final

Observations:

12. Application Properties - good at 40 psi, mix part A, B and C
 as prepackaged, no reduction

13. Humidity Resistance

Panel	<u>D.F.T. (mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of Corrosion</u>
	3.0				
A. Blistering		No blistering			
B. Corrosion		No corrosion			

14. Salt Spray Resistance

D.F.T. (mils)	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of Corrosion</u>
2.6	#8	medium dense	along scribes	
A. Blistering				
B. Corrosion				
C. Color Change	ΔE = 1.55		Uniform corrosion on both scribes 1/8" from scribe	Field: none
D. Gloss Change	14.4			

15. Water Immersion Resistance

D.F.T. (mils)	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of Corrosion</u>
3.1				
A. Blistering	None			
B. Corrosion	None			
C. Adhesion	5			
D. Hardness	Pass 2H			

25. Accelerated Weathering (300 hrs)

D.F.T. (mils)	<u>Initial</u>	<u>After Exposure</u>
2.8		Δ E = 0.46
A. Color		
B. Gloss	90.0	84.2

28. Chemical Resistance

A. Gasoline	No color or film changes
B. Hydrocarbon Oil	No changes
C. Pine Oil	Pass
D. Uric Acid	Pass
E. Windshield Washer Fluid	Pass

LABORATORY REPORT FORM

Sample No. 3C-1
 Contract No. A832-115
 Date received: 7/21/89
 Log No.: 3C1-1-0721
 Lab code: Synthetic Enamel
 Quantity: 1 gal
 Test initiated: 7/24/89
 Test completed: 10/27/89

Chemist: L. Cumming
 L. Kudela

Product Category: 3. METALLIC TOPCOAT

<u>Tests</u>	<u>Procedure</u>	<u>Results</u>	<u>Applied</u>
1. Total Non-Volatile (wt.%)	ASTM D2369	39.34	
2. Specific Gravity (lbs/gal.)	ASTM D1475	7.49	
3. Water (wt.%)	ASTM D1364	0	
	ASTM D3792	--	
4. Volatile Organic Content (VOC)	ASTM D3960	544.4	585.5
5. Viscosity, Ford cup #4	ASTM D1200	15 sec	
6. Stability 120°F *	ASTM D1849	see attached	
7. Freeze - Thaw Resistance (All H ₂ O Based Products)	ASTM D2243	N/A	
8. Water cleanup (all H ₂ O based products)		N/A	
9. Dry Time S.T.T. and D.H.	ASTM D1640	S.T.T.: 68 min D.H.: >5 hrs	
17. Hardness - Pencil	ASTM D3363	pass F	
10. Adhesion	ASTM D3359	5	
11. Appearance		very smooth	
18. 60° Gloss	ASTM D523	93.2	
12. Application Properties *		see attached	
13. Humidity Resistance *	ASTM D2247	see attached	
14. Salt Spray Resistance (240 Hrs) *	ASTM B117	see attached	
15. Water Immersion Resistance *	ASTM D1647	see attached	
16. Color and Color Retention	ASTM D2244	ΔE = 0.91	
19. Abrasion Resistance	ASTM D4060	95.5 mg/1000 Rev.	
20. Flexibility	ASTM D1737	1/8 inch	
21. Impact Resistance (forward)	ASTM D2794	> 87 inch lb	
23. Sag Resistance	STD 141B FTM 4494	5	
24. Levelling	ASTM D2801	9	
22. Contrast Ratio	ASTM D2805	0.59	
25. Acc. Weathering (300 Hrs) * 60° specular gloss	ASTM G26	see attached	
26. Fungus Resistance	ASTM D3273 ASTM D3274	pass	
27. Heat Resistance		ΔE = 1.56	
28. Chemical Resistance *	ASTM D1540	see attached	

Note: Items 8, 11, 12 are qualitative tests.

* All Tests (6,12,13,14,15,25, and 28) evaluated on page 2 of report form.

TOPCOATS 3C1-1

6. Stability 120°F centipoise, cP (spindle, RPM)
 Viscosity: initial 405 cP (3, 100)
 final 444 cP (2, 100)
 Observations: No changes, stable

12. Application Properties - very good at 70 psi, 15% reduction

13. Humidity Resistance

Panel	<u>D.F.T. (mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of Corrosion</u>
	3.5				
A. Blistering		None			
B. Corrosion		None			

14. Salt Spray Resistance

D.F.T. (mils)	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of Corrosion</u>
4.5				
A. Blistering	None			
B. Corrosion	None			
C. Color Change	$\Delta E = 0.67$			
D. Gloss Change	19.9			

15. Water Immersion Resistance

D.F.T. (mils)	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of Corrosion</u>
4.0				
A. Blistering	None			
B. Corrosion	None			
C. Adhesion	5			
D. Hardness	pass F			

25. Accelerated Weathering (300 hrs)

D.F.T. (mils)	<u>Initial</u>	<u>After Exposure</u>
4.8		$\Delta E = 0.91$
A. Color		
B. Gloss	93.2	80.8

28. Chemical Resistance

A. Gasoline	Strong stain, blisters #8, dense
B. Hydrocarbon Oil	No stain, no film softening
C. Pine Oil	Slight staining
D. Uric Acid	Pass
E. Windshield Washer Fluid	Pass

LABORATORY REPORT FORM

Sample No. 3C-2
 Contract No. A832-115
 Date received: 7/24/89
 Log No.: 3C1-2-0721
 Lab code: Acrylic Enamel
 Quantity: 1 gal
 Test initiated: 8/1/89
 Test completed: 11/5/89

Chemist: L. Cumming
 L. Kudela

Product Category: 3. METALLIC TOPCOAT

<u>Tests</u>	<u>Procedure</u>	<u>Results</u>	<u>Applied</u>
1. Total Non-Volatile (wt.%)	ASTM D2369	41.06	
2. Specific Gravity (lbs/gal.)	ASTM D1475	7.85	
3. Water (wt.%)	ASTM D1364	0	
	ASTM D3792	--	
4. Volatile Organic Content (VOC)	ASTM D3960	544.4 g/l	686.9
5. Viscosity, Ford cup #4	ASTM D1200	14 sec	
6. Stability 120°F *	ASTM D1849	see attached	
7. Freeze - Thaw Resistance (All H ₂ O Based Products)	ASTM D2243	N/A	
8. Water Cleanup (all H ₂ O based products)		N/A	
9. Dry Time S.T.T. and D.H.	ASTM D1640	S.T.T.: 16 min D.H.: >4 hrs	
17. Hardness - Pencil	ASTM D3363	Pass F	
10. Adhesion	ASTM D3359	5	
11. Appearance		very smooth	
18. 60° Gloss	ASTM D523	90.8	
12. Application Properties *		see attached	
13. Humidity Resistance *	ASTM D2247	see attached	
14. Salt Spray Resistance (240 Hrs)	ASTM B117	see attached	
15. Water Immersion Resistance	ASTM D1647	see attached	
16. Color and Color Retention	ASTM D2244	Δ E = 1.37	
19. Abrasion Resistance	ASTM D4060	46.3 mg/1000 Rev	
20. Flexibility	ASTM D1737	1/8 inch	
21. Impact Resistance (forward)	ASTM D2794	75 - inch 1b	
23. Sag Resistance	STD 141B FTM 4494	4	
24. Levelling	ASTM D2801	10	
22. Contrast Ratio	ASTM D2805	0.89	
25. Acc. Weathering (300 Hrs) * 60° specular gloss	ASTM G26	see attached	
26. Fungus Resistance	ASTM D3273; ASTM D3274	pass	
27. Heat Resistance		Δ E = 4.86	
28. Chemical Resistance *	ASTM D1540	see attached	

Note: Items 8, 11, 12 are qualitative tests.

* All Tests (6,12,13,14,15,25, and 28) evaluated on page 2 of report form.

TOPCOATS 3C-2

6. Stability 120°F centipoise cP (spindle, RPM)
 Viscosity: initial 324 cP (2, 100)
 final 232 cP (2, 100)
 Observations: No changes, stable

12. Application Properties - good at 60 psi, mis 4:2:1
 (resin: reducer: hardner)

13. Humidity Resistance

	Panel				
	<u>D.F.T (mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of Corrosion</u>
	2.6				
A. Blistering		None			
B. Corrosion		None			

14. Salt Spray Resistance

	D.F.T.				
	<u>(mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of Corrosion</u>
	3.0				
A. Blistering		None			
B. Corrosion		None			
C. Color Change		Δ E = 1.75			
D. Gloss Change		7.3			

15. Water Immersion Resistance

	D.F.T.				
	<u>(mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of Corrosion</u>
	1.1				
A. Blistering		None			
B. Corrosion		None			
C. Adhesion		5			
D. Hardness		Pass F			

25. Accelerated Weathering (300 hrs)

	D.F.T.			
	<u>(mils)</u>	<u>Initial</u>	<u>After Exposure</u>	
A. Color	2.7		Δ E = 1.37	
B. Gloss		90.8	84.2	

28. Chemical Resistance

A. Gasoline	No color change, no film softening
B. Hydrocarbon Oil	No change
C. Pine Oil	Slight staining
D. Uric Acid	Pass
E. Windshield Washer Fluid	Pass

LABORATORY REPORT FORM

Sample No. 3C-3 (3E1)
 Contract No. A832-115
 Date received: 7/24/89
 Log No.: 3C1-3-0721
 Lab code: Enamel Basecoat/Clearcoat
 Quantity: 1 gal
 Test initiated: 8/14/89
 Test completed: 10/27/89

Chemist: L. Cumming
 L. Kudela

Product Category: 3. METALLIC TOPCOAT/Clearcoat

<u>Tests</u>	<u>Procedure</u>	<u>Results</u>	<u>Applied</u>
1. Total Non-Volatile (wt.%)	ASTM D2369	24.53	
2. Specific Gravity (lbs/gal.)	ASTM D1475	7.79	
3. Water (wt.%)	ASTM D1364	0	
	ASTM D3792	--	
4. Volatile Organic Content (VOC)	ASTM D3960	704.4 g/l	778.0
5. Viscosity, Ford cup #4	ASTM D1200	12 sec	
6. Stability 120°F *	ASTM D1849	see attached	
7. Freeze - Thaw Resistance (All H ₂ O Based Products)	ASTM D2243	N/A	
8. Water cleanup (all H ₂ O based products)		N/A	
9. Dry Time S.T.T. and D.H.	ASTM D1640	S.T.T.: 7 min D.H.: 24 hrs	
17. Hardness - Pencil	ASTM D3363	pass - 3H	
10. Adhesion	ASTM D3359	5	
11. Appearance		fair, gritty	
18. 60° Gloss	ASTM D523	95.8	
12. Application Properties *		see attached	
13. Humidity Resistance *	ASTM D2247	see attached	
14. Salt Spray Resistance (240 Hrs)*	ASTM B117	see attached	
15. Water Immersion Resistance	ASTM D1647	see attached	
16. Color and Color Retention	ASTM D2244	ΔE = 3.52	
19. Abrasion Resistance	ASTM D4060	36.4 mg/1000 Rev.	
20. Flexibility	ASTM D1737	< 1/8 inch	
21. Impact Resistance (forward)	ASTM D2794	> 88 inch/lb	
23. Sag Resistance	STD 141B FTM 4494	4	
24. Levelling	ASTM D2801	9	
22. Contrast Ratio	ASTM D2805	0.29	
25. Acc. Weathering (300 Hrs) * 60° specular gloss	ASTM G26	see attached	
26. Fungus Resistance	ASTM D3273; ASTM D3274	pass	
27. Heat Resistance		ΔE = 1.63	
28. Chemical Resistance *	ASTM D1540	see attached	

Note: Items 8, 11, 12 are qualitative tests.

* All Tests (6, 12, 13, 14, 15, 25, and 28) evaluated on page 2 of report form.

TOPCOATS 3C-3 (3E1)

6. Stability 120°F Centipoise cP (spindle, RPM)
 Viscosity: initial 756 cP (2, 50)
 final 2107 cP (2, 50)
 Observations: No changes, unstable
12. Application Properties very good, reducing 1:1; 45 psi at the gun
13. Humidity Resistance
- | Panel | D.F.T. (mils) | Size | Frequency | Pattern | Extent of Corrosion |
|---------------|---------------|------|-----------|---------|---------------------|
| | 3.9/2.2 | | | | |
| A. Blistering | | None | | | |
| B. Corrosion | | None | | | |
15. Salt Spray Resistance
- | D.F.T. (mils) | Size | Frequency | Pattern | Extent of Corrosion |
|-----------------|-------------------|-----------|---------|---------------------|
| 2.9 | | | | |
| A. Blistering | None | | | |
| B. Corrosion | None | | | |
| C. Color Change | $\Delta E = 1.36$ | | | |
| D. Gloss Change | 5.6 | | | |
15. Water Immersion Resistance
- | D.F.T. (mils) | Size | Frequency | Pattern | Extent of Corrosion |
|---------------|--------|-----------|---------|---------------------|
| 4.2 | | | | |
| A. Blistering | None | | | |
| B. Corrosion | None | | | |
| C. Adhesion | 5 | | | |
| D. Hardness | Pass H | | | |
25. Accelerated Weathering (300 hrs)
- | D.F.T. (mils) | Initial | After Exposure |
|---------------|---------|-------------------|
| 3.8/3.3 | | |
| A. Color | | $\Delta E = 3.52$ |
| B. Gloss | 95.8 | 86.0 |
28. Chemical Resistance
- | | |
|----------------------------|-----------------------------------|
| A. Gasoline | No color change or film softening |
| B. Hydrocarbon Oil | No change |
| C. Pine Oil | Pass |
| D. Uric Acid | Pass |
| E. Windshield Washer Fluid | Pass |

LABORATORY REPORT FORM

Sample No. 3C-5 (3E2)
 Contract No. A832-115
 Date received: 8/8/89 Chemist: L. Cumming
 Log No.: 3C1-5-0808 * 3E2 L. Kudela
 Lab code: Acrylic Enamel Metallic Basecoat/Clearcoat
 Quantity: 1 qt
 Test initiated: 8/16/89
 Test completed: 11/5/89

Product Category: 3. METALLIC BASECOAT/CLEARCOAT

<u>Tests</u>	<u>Procedure</u>	<u>Results</u> 3C1-5/3E2
1. Total Non-Volatile (wt.%)	ASTM D2369	24.53//28.60
2. Specific Gravity (lbs/gal.)	ASTM D1475	7.79//7.91
3. Water (wt.%)	ASTM D1364	0//0
	ASTM D3792	--
4. Volatile Organic Content (VOC)	ASTM D3960	546.4//667.2 g/l
5. Viscosity, Ford cup #4	ASTM D1200	15 sec
6. Stability 120°F *	ASTM D1849	see attached
7. Freeze - Thaw Resistance (All H ₂ O Based Products)	ASTM D2243	NA
8. Water Cleanup (all H ₂ O based products)		NA
9. Dry Time S.T.T. and D.H.	ASTM D1640	S.T.T.: 18 min D.H.: 2 hrs
17. Hardness - Pencil	ASTM D3363	pass - 3H
10. Adhesion	ASTM D3359	5
11. Appearance		very smooth
18. 60° Gloss	ASTM D523	91.7
12. Application Properties *		see attached
13. Humidity Resistance *	ASTM D2247	see attached
14. Salt Spray Resistance (240 Hrs) *	ASTM B117	see attached
15. Water Immersion Resistance *	ASTM D1647	see attached
16. Color and Color Retention	ASTM D2244	ΔE = 3.69
19. Abrasion Resistance	ASTM D4060	23.3 mg/1000 Rev.
20. Flexibility	ASTM D1737	1/8 inch
21. Impact Resistance (forward)	ASTM D2794	> 88 inch lb
23. Sag Resistance	STD 141B FTM 4494	3
24. Levelling	ASTM D2801	10
22. Contrast Ratio	ASTM D2805	0.71
25. Acc. Weathering (300 Hrs) * 60° specular gloss	ASTM G26	see attached
26. Fungus Resistance	ASTM D3273	pass
	ASTM D3274	
27. Heat Resistance		Δ E = 2.49
28. Chemical Resistance *		see attached

Note: Items 8, 11, 12 are qualitative tests.

* All Tests (6, 12, 13, 14, 15, 25, and 28) evaluated on page 2 of report form.

TOPCOATS 3C-5 (3E2)

6. Stability 120°F centipoise cP (spindle, RPM)
 Viscosity: initial 156 cP (2, 100)
 final 176 cP (2, 100)
 Observations: No changes - stable

12. Application Properties - spraying very good 50 psi, reducing 2:1;

13. Humidity Resistance

	Panel	<u>D.F.T. (mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of Corrosion</u>
		1.6/0.9				
A. Blistering			None			
B. Corrosion			None			

14. Salt Spray Resistance

	<u>D.F.T. (mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of Corrosion</u>
	1.9/1.3				
A. Blistering		None			
B. Corrosion		None			
C. Color Change		Δ E = 5.84			
D. Gloss Change		4.7			

15. Water Immersion Resistance

	<u>D.F.T. (mils)</u>	<u>Size</u>	<u>Frequency</u>	<u>Pattern</u>	<u>Extent of Corrosion</u>
	1.6/0.8				
A. Blistering		None			
B. Corrosion		None			
C. Adhesion		5			
D. Hardness		Pass 2H			

25. Accelerated Weathering (300 hrs)

	<u>D.F.T. (mils)</u>	<u>Initial</u>	<u>After Exposure</u>
	1.4/1.0		
A. Color			Δ E = 3.69
B. Gloss		91.7	87.3

28. Chemical Resistance

A. Gasoline	Slight discoloration - no other changes
B. Hydrocarbon Oil	No color change
C. Pine Oil	Pass
D. Uric Acid	Pass
E. Windshield Washer fluid	Pass

LABORATORY REPORT FORM

Sample No. 3C2-2
 Contract No. A832-115
 Date received: 7/21/89
 Log No.: 3C2-2-0721
 Lab code: Acrylic Enamel
 Quantity: 1 qt
 Test initiated: 8/8/89
 Test completed: 11/5/89

Chemist: L. Cumming
 L. Kudela

Product Category: 3. METALLIC TOPCOAT

<u>Tests</u>	<u>Procedure</u>	<u>Results</u>	<u>Applied</u>
1. Total Non-Volatile (wt.%)	ASTM D2369	46.34	
2. Specific Gravity (lbs/gal.)	ASTM D1475	8.01	
3. Water (wt.%)	ASTM D1364	0	
	ASTM D3792	--	
4. Volatile Organic Content (VOC)	ASTM D3960	515 g/l	667.8
5. Viscosity, Ford cup #4	ASTM D1200	14 sec	
6. Stability 120°F *	ASTM D1849	see attached	
7. Freeze - Thaw Resistance (All H ₂ O Based Products)	ASTM D2243	N/A	
8. Water cleanup (all H ₂ O based products)		N/A	
9. Dry Time S.T.T. and D.H.	ASTM D1640	S.T.T.: 38 min D.H.: >4 hrs	
17. Hardness - Pencil	ASTM D3363	3H	
10. Adhesion	ASTM D3359	5	
11. Appearance		very smooth	
18. 60° Gloss	ASTM D523	94.1	
12. Application Properties *		see attached	
13. Humidity Resistance *	ASTM D2247	see attached	
14. Salt Spray Resistance (240 hrs) *	ASTM B117	see attached	
15. Water Immersion Resistance *	ASTM D1647	see attached	
16. Color and Color Retention	ASTM D2244	Δ E = 6.25	
19. Abrasion Resistance	ASTM D4060	40.8 mg/1000 Rev	
20. Flexibility	ASTM D1737	1/8 inch	
21. Impact Resistance (forward)	ASTM D2794	88 inch lb	
23. Sag Resistance	STD 141B FTM 4494	4.5	
24. Levelling	ASTM D2801	10	
22. Contrast Ratio	ASTM D2805	0.52	
25. Acc. Weathering (300 Hrs.) * 60° specular gloss	ASTM G26	see attached	
26. Fungus Resistance	ASTM D3273 ASTM D3274	Pass	
27. Heat Resistance		ΔE = 5.18	
28. Chemical Resistance *		see attached	

Note: Items 8 ,11, 12 are qualitative test.

* All test (6, 12, 13, 14, 15, 25, and 28) evaluated on page 2 of report form.

TOPCOATS 3C2-2

6. Stability 120°F, centipoise cP (spindle RPM)
 Viscosity: initial 220 cP (2, 100)
 final 220 cP (2, 100)
 Observations: No changes, stable
12. Application Properties - fair at 55 psi, 40% reduction, mix 4:2:1
13. Humidity Resistance
- | Panel | <u>D.F.T. (mils)</u> | <u>Size</u> | <u>Frequency</u> | <u>Pattern</u> | <u>Extent of Corrosion</u> |
|---------------|----------------------|-------------|------------------|----------------|----------------------------|
| | 2.4 | | | | |
| A. Blistering | | None | | | |
| B. Corrosion | | None | | | |
14. Salt Spray Resistance
- | | <u>D.F.T. (mils)</u> | <u>Size</u> | <u>Frequency</u> | <u>Pattern</u> | <u>Extent of Corrosion</u> |
|-----------------|----------------------|-------------------|------------------|----------------|----------------------------|
| | 2.8 | | | | |
| A. Blistering | | None | | | |
| B. Corrosion | | None | | | |
| C. Color Change | | $\Delta E = 4.55$ | | | |
| D. Gloss Change | | 3.9 | | | |
15. Water Immersion Resistance
- | | <u>D.F.T. (mils)</u> | <u>Size</u> | <u>Frequency</u> | <u>Pattern</u> | <u>Extent of Corrosion</u> |
|---------------|----------------------|-------------|------------------|----------------|----------------------------|
| | 3.0 | | | | |
| A. Blistering | | None | | | |
| B. Corrosion | | None | | | |
| C. Adhesion | | 5 | | | |
| D. Hardness | | Pass 2H | | | |
25. Accelerated Weathering (300 hrs)
- | | <u>D.F.T. (mils)</u> | <u>Initial</u> | <u>After Exposure</u> |
|----------|----------------------|----------------|-----------------------|
| | 3.0 | | |
| A. Color | | | $\Delta E = 6.25$ |
| B. Gloss | | 94.1 | 91.4 |
28. Chemical Resistance
- | | |
|----------------------------|--------------------------|
| A. Gasoline | Stain, no film softening |
| B. Hydrocarbon Oil | No change |
| C. Pine Oil | Pass |
| D. Uric Acid | Pass |
| E. Windshield Washer fluid | Pass |

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ASSET