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DEVELOPMENT OF A NO-VOC/NO-HAP WOOD FURNITURE COATINGS SYSTEM

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16. ABSTRACT The report gives results of the development and demonstration of a no-VOC (volatile organic compound)/no-HAP (hazardous air pollutant) wood furniture coating system. The performance characteristics of the new coating system are excellent in terms of adhesion, drying time, gloss, hardness, mar resistance, chemical resistance, and stain resistance. The VOC contents of the topcoat, sanding sealer, and stain base are < 10 g/L. The HAP contents of the topcoat, sanding sealer, and stain base are not detected or less than the practical quantification limit. In addition to the field demonstration at a selected wood furniture manufacturing facility, a workshop was held to provide detailed information to wood furniture manufacturers, coating suppliers, corporate users, and regulatory agencies on what is required to change to a new coating system. Topics such as product performance data, application techniques, coating repair procedures, drying time, curing procedures, and spray equipment cleaning techniques were presented. In parallel with this demonstration project, surveys were conducted with the South Coast Air Quality Management District to gain an understanding of the effort required by the wood furniture industry to change over to water-based coating systems in general. The survey results were presented in the report.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS		b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group	
Pollution	Organic Compounds	Pollution Control	13B	07C
Wood Products	Volatility	Stationary Sources	11L	20M
Furniture		Volatile Organic Compounds (VOCs)	15E	
Coatings			11C	
Coating Processes		Hazardous Air Pollutants (HAPs)	13H	
Emission			14G	

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FOREWORD

The U.S. Environmental Protection Agency is charged by Congress with protecting the Nation's land, air, and water resources. Under a mandate of national environmental laws, the Agency strives to formulate and implement actions leading to a compatible balance between human activities and the ability of natural systems to support and nurture life. To meet this mandate, EPA's research program is providing data and technical support for solving environmental problems today and building a science knowledge base necessary to manage our ecological resources wisely, understand how pollutants affect our health, and prevent or reduce environmental risks in the future.

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This publication has been produced as part of the Laboratory's strategic long-term research plan. It is published and made available by EPA's Office of Research and Development to assist the user community and to link researchers with their clients.

E. Timothy Oppelt, Director
National Risk Management Research Laboratory

ABSTRACT

The United States Environmental Protection Agency has contracted with AeroVironment Environmental Services, Inc. and its subcontractor, Adhesive Coatings Co., to develop and demonstrate a no-VOC (volatile organic compound)/no-HAP (hazardous air pollutant) wood furniture coating system. The objectives of this project are to develop a new wood coating system that is sufficiently mature for demonstration and to develop a technology transfer plan to get the product into public use. The performance characteristics of this new coating system are excellent in terms of adhesion, drying times, gloss, hardness, mar resistance, chemical resistance, and stain resistance.

The VOC contents of the topcoat, sanding sealer, and stain base are less than 10 g/l. The HAP contents of the topcoat, sanding sealer, and stain base are not detected or less than the practical quantification limit. In addition to the field demonstration at a selected wood furniture manufacturing facility, a workshop was held to provide detailed information to wood furniture manufacturers, coating suppliers, corporate users, and regulatory agencies on what is required to change to the new coating system. Topics such as product performance data, application techniques, coating repair procedures, drying times and curing procedures, and spray equipment cleaning techniques were presented.

In parallel with this demonstration project, surveys were conducted with the South Coast Air Quality Management District (SCAQMD) to gain an understanding of the effort required by the wood furniture industry to change over to water-based coating systems in general. The survey results were presented in this report including coating performance, consumer acceptance, spray techniques, ease of use, repair procedures, dry times, equipment cleanup, and materials cost. A cost analysis, including costs of materials, capital outlay, and labor was conducted for this new system. An environmental impact study was included in this project to address emissions benefits, disposal cost saving, and energy conservation based on data gathered during the in-plant, full-scale demonstrations.

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ACKNOWLEDGMENTS

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1.0 INTRODUCTION

Under United States Environmental Protection Agency (USEPA) sponsorship, AeroVironment Environmental Services, Inc. and Adhesive Coatings Co. (ADCO) are teamed to develop and demonstrate a no-VOC (volatile organic compound)/no-HAP (hazardous air pollutant) wood furniture coating system. This two-part system consists, in general, of an epoxy resin emulsion and an aqueous solution of a reaction product of certain polyamines and urea-formaldehyde ether monomers[1,2,3]. The objectives of this project are to develop a new wood coating system that is sufficiently mature for demonstration and to develop a technology transfer plan to get the product into public use. The performance characteristics of this new coating system are excellent in terms of adhesion, drying times, gloss, hardness, mar resistance, level of solvents, and stain resistance[4].

In parallel with this demonstration project, surveys were conducted with the South Coast Air Quality Management District (SCAQMD) to gain an understanding of the effort required by the wood furniture industry to change over to water-based coating systems in general. The survey results are presented in this report: coating acceptance, cost, spray techniques, coating repair procedures, dry times and procedures, spray equipment cleanup, and materials and techniques.

In addition to the research and development work, a cost analysis was performed on furniture finished with the new wood coating system. The analysis considers new product introduction decisions such as realistic material cost, capital outlay requirements, and labor.

The VOC content of the new system (stain, sealer, and topcoat) is less than 10 g/l. This system's performance and properties on finished material compared favorably with other low-VOC waterborne systems[4]. The focus of the follow-on work will be to adapt this new system to other furniture lines. Also, effort will be spent on testing this new system on kitchen cabinets. Extended technology transfer efforts will be required to encourage widespread use of the new coating system. Results and overall findings of this research program are discussed in the following sections.

2.0 COATING CHARACTERISTICS

The goal of this program is to demonstrate a new no-VOC/no-HAP wood coating system (stain, sanding sealer and top coat) that will find wide applicability across the wood furniture industry. The efforts are directed at developing a complete wood coating system that exhibits the following attributes:

- Contains no VOCs
- Contains no HAPs
- Is "dry to touch" in 10 minutes or less
- Is "dry to handle" in 15 minutes or less
- Exhibits acceptable hardness
- Exhibits excellent intercoat adhesion with wood top/finishing coat
- Exhibits "sandable" characteristics
- Contains a demonstrated chemical, water stain, and chip resistance comparable to other products for the same general use
- Exhibits an acceptable level of wood discoloration

The new wood coating system includes a single-component epoxy stain, a two-part epoxy sanding sealer and a two-part epoxy top coat. The number of components for each coat in this system are list in Table 1. The basic compositions of each part of the coating system can be found in the Material Safety Data Sheets in the Appendix B of this report.

TABLE 1. NUMBER OF COMPONENTS FOR THE TOP COAT, SANDING SEALER, AND STAIN

	Topcoat	Sanding Sealer	Stain
Number of Components	2	2	1

2.1 VOC/HAP Contents

Most wood furniture is finished with nitrocellulose-resin-based coatings averaging 750 g/l (6.3 lb/gal) VOCs and 375 g/l (3.1 lb/gal) HAPs. In finishing a typical dining room table (4 x 6 ft), about 9 kg of VOCs and 4.5 kg of HAPs are emitted[4]. While progress has been made in formulating low-VOC coating systems, many use ethylene glycol ethers, which are more toxic than most solvents used with nitrocellulose systems. The SCAQMD/California Furniture Manufacturers Association/Southern California Edison Cooperative Study[5] of low-VOC wood furniture coatings confirmed that most commercially available water-based systems contained VOCs and air toxic compounds.

SCAQMD Method 304[6] (Determination of VOCs in Various Materials) was used to conduct VOC analysis. Method 304 is nearly identical to EPA Method 24[7]. ASTM D 1475[8] was used to determine the density of coatings. Total volatile content was measured by ASTM D 2369[9], and water content was determined by ASTM D 3792[10]. The number of tests for the topcoat, sanding

sealer, and stain are listed in Table 2. Table 3 summarizes the VOC content and the HAP level using EPA Method 8240 (GC-MS/gas chromatography-mass spectrometry)[11] for the final formulations including stain, sanding sealer (part A and part B mixed together), and topcoat (part A and part B mixed together).

TABLE 2. TOTAL NUMBER OF TESTS FOR THE TOP COAT, SANDING SEALER, AND STAIN

Measurement	Method	Topcoat (Part A, Part B, and A, B mixed)	Sanding Sealer (Part A, Part B, and A, B mixed)	Stain
Volatile organic compounds (VOC)				
Volatile content	ASTM-D-2369	9	9	3
Density	ASTM-D-1475	9	9	3
Water content	ASTM-D-3792 (GC)	9	9	3
Hazardous Air Pollutant (HAP)	EPA Method 8240, or equivalent (GC/MS)	9	9	3

2.2 Wood Panel Testing

Oak veneer was chosen for the first test set because it is a hard wood. Oak is also very unforgiving—it contains tannic acid which causes discoloration, and a coarse grain structure that is difficult to fill or obtain good flow out with the higher solids coatings. For the second test set, solid pine was chosen because it is a soft wood. The substrates were lightly sanded before the stain was applied and between each pair of coats. The effect of using stain on the two substrates was obtained. The shade of a stain is affected dramatically by the hardness of the wood. This illustrates how color matching will affect the conversion to a water-based coating. The two parts of the coating were mixed and then applied using a high volume low pressure (HVLP) spray gun. All of the coated panels were cured at room temperature. Two replicates were done of each wood/treatment combination. All tests were conducted based on standard ASTM methods, no controls were needed. The number of wood panel tests are listed in Table 4. Table 5 summarizes all performance characteristic test results. The test procedures are detailed below.

Hot/Cold Check. Sanding sealer and topcoat were tested in the Weatherometer on the stain-coated oak and pine samples. The methods described by ASTM D 1211[12] as modified to be used with the Atlas XR-35-A Weatherometer were followed. The following test cycle was performed:

- Maintain the relative humidity at 50% throughout the test.
- Run the test without ultraviolet (UV) radiation.
- Start the system at 70° F (21 °C).
- Raise the temperature to 120° F (49 °C) within 15 minutes.
- Hold this temperature for 1 hour.
- Lower the temperature to -5° F (-21 °C) within 30 minutes.
- Hold this temperature for 1 hour.
- Return the temperature to 70° F (21 °C) within 15 minutes.

- This comprises one cycle which takes 3 hours. Repeat this test cycle 8 times, which will take 24 hours.

TABLE 3. VOC AND HAP ANALYSIS RESULTS

Measurement	Method	Unit	PQL[a]	Concentration		
				Topcoat	Sanding Sealer	Stain
Volatile Organic Compounds (VOC)						
Density	ASTM-D-1475	g/cm^3		1.021	0.983	0.9313
Water content	ASTM-D-3792	%	0.1	65	68	79
Volatile content	ASTM-D-2369[b]	%	0.1	61	62	69
VOC Content	Calculated	%	0.1	N.D.[c]	N.D.	N.D.
Hazardous Air Pollutant (HAP)	EPA 8240 (GC/MS)					
Acetone		mg/kg	100	N.D.	N.D.	N.D.
Acrolein		mg/kg	100	N.D.	N.D.	N.D.
Acrylonitrile		mg/kg	50	N.D.	N.D.	N.D.
Benzene		mg/kg	5	N.D.	N.D.	N.D.
Bromodichloromethane		mg/kg	5	N.D.	N.D.	N.D.
Bromoform		mg/kg	5	N.D.	N.D.	N.D.
Bromomethane		mg/kg	10	N.D.	N.D.	N.D.
Methyl ethyl ketone (2-Butanone)		mg/kg	100	N.D.	N.D.	N.D.
Carbon disulfide		mg/kg	5	N.D.	N.D.	N.D.
Carbon tetrachloride		mg/kg	5	N.D.	N.D.	N.D.
Chlorobenzene		mg/kg	5	N.D.	N.D.	N.D.
Chlorodibromomethane		mg/kg	5	N.D.	N.D.	N.D.
Chloroethane		mg/kg	10	N.D.	N.D.	N.D.
2-Chloroethyl vinyl ether		mg/kg	10	N.D.	N.D.	N.D.
Chloroform		mg/kg	10	N.D.	N.D.	N.D.
Chloromethane		mg/kg	10	N.D.	N.D.	N.D.
Dibromomethane		mg/kg	5	N.D.	N.D.	N.D.
1,4-Dichloro-2-Butene		mg/kg	100	N.D.	N.D.	N.D.
Dichlorodifluoromethane		mg/kg	5	N.D.	N.D.	N.D.
1,1-Dichloroethane		mg/kg	5	N.D.	N.D.	N.D.
1,2-Dichloroethane		mg/kg	5	N.D.	N.D.	N.D.
1,1-Dichloroethene		mg/kg	5	N.D.	N.D.	N.D.
trans-1,2-Dichloroethene		mg/kg	5	N.D.	N.D.	N.D.
1,2-Dichloropropane		mg/kg	5	N.D.	N.D.	N.D.
cis-1,3-Dichloropropene		mg/kg	5	N.D.	N.D.	N.D.
trans-1,3-Dichloropropene		mg/kg	5	N.D.	N.D.	N.D.
Ethyl benzene		mg/kg	5	N.D.	N.D.	N.D.
Ethyl methacrylate		mg/kg	10	N.D.	N.D.	N.D.
2-Hexanone		mg/kg	50	N.D.	N.D.	N.D.
Iodomethane		mg/kg	5	N.D.	N.D.	N.D.
Methylene chloride		mg/kg	10	N.D.	N.D.	N.D.
4-Methyl-2-pentanone		mg/kg	50	N.D.	N.D.	N.D.
Styrene		mg/kg	5	N.D.	N.D.	N.D.
1,1,2,2-Tetrachloroethane		mg/kg	5	N.D.	N.D.	N.D.
Tetrachloroethene		mg/kg	5	N.D.	N.D.	N.D.
Toluene		mg/kg	5	N.D.	N.D.	N.D.
1,1,1-Trichloroethane		mg/kg	5	N.D.	N.D.	N.D.
1,1,2-Trichloroethane		mg/kg	5	N.D.	N.D.	N.D.
Trichloroethene		mg/kg	5	N.D.	N.D.	N.D.
Trichlorofluoromethane		mg/kg	5	N.D.	N.D.	N.D.
1,2,3-Trichloropropane		mg/kg	5	N.D.	N.D.	N.D.
Vinyl acetate		mg/kg	50	N.D.	N.D.	N.D.
Vinyl chloride		mg/kg	10	N.D.	N.D.	N.D.
o-Xylene		mg/kg	5	N.D.	N.D.	N.D.
m-Xylene, p-Xylene		mg/kg	5	N.D.	N.D.	5[d]

a. PQL: Practical Quantification Limit.
b. This method did not result in evaporation of all the water. D-1475, a GC method, yields a much more accurate measure of water content. As shown, VOCs were N.D. and there were no exempt solvents present.
c. N.D.: Not Detected or < PQL.
d. Likely a contaminant from tape used to seal sample jars.

TABLE 4. TOTAL NUMBER OF WOOD PANEL TESTS

Measurement	Method	Oak (Veneer) with Stain, Sealer, and Topcoat	Pine (Solid) with Stain, Sealer, and Topcoat
Pencil Hardness	ASTM D 3363	20	20
Gloss	ASTM D 523-89	20	20
Parallel Groove Adhesion	ASTM D 3359-90	6	6
Adhesion/Scrape/Mar	ASTM D 2197	6	6
Hot/Cold Check	ASTM D 1211-87	6	6
Household Chemical	ASTM D 1308-87	20	20
Dry Time	ASTM D 1640-83	20	20
Water Resistance	ASTM D 1308-87	20	20
UV Rresistance	ASTM G53-88	20	20
Printing/Block	ASTM D 2091-88	20	20

Using this evaluation method we determined the resistance to checking or cracking of coatings applied to wood substrates when subjected to sudden changes in temperature. Cold checks manifest themselves in two ways: (1) long continuous wavy lines either parallel with or at various angles that can be perpendicular to the grain; or (2) innumerable fine lines erratic in direction and length forming a network over a portion or all of the panel. This effect is similar to crazing of the coating film.

On plywood, the direction of the cracks often varies because of the stresses set up by other than the top stratum. For this reason, all checks were considered failures, and appropriate notations on the character of the cracks were made to assist in the interpretation. While it is recognized that the cracks in substrates may occur (veneer checking), failures in the coating may be due to action of moisture or of cold, or both. Checking because of moisture appears along the grain and is characterized by short cracks [usually not more than 0.5 in. (1.3cm) long] occurring either singly or in clusters. These lines or clusters may progress along the grain in a discontinuous fashion.

Results: There was no evidence of checking. The coating did not show any signs of failure due to changes in temperature and humidity.

Gloss. When evaluating the appearance of a surface, gloss is an optical phenomenon. The evaluation of gloss describes a surface's ability to reflect direct light. Gloss is often used as a criterion for evaluating a product's quality, especially where aesthetic appearance is important. A visual gloss evaluation includes

many subjective sources of error and is insufficient. To be objective, an instrument was used to put a measured value on the degree of gloss. However, it must be realized that gloss, as perceived by the human eye, is a subjective sensation, and visually observed differences cannot always be measured physically using glossmeters. The methods described in ASTM D 523[13] and the BYK Tri-gloss meter instructions were followed. This evaluation was performed on all substrates.

The degree of coating gloss on a wood substrate is dependant on the glossyness of the coating and the surface profile of the wood itself. In the case of the gloss reported on our samples, the coating gloss was high but the surface of the wood was translated to the coating film. In other words, if the coating were sprayed on a smooth surface (as opposed to the relatively rough surface of the wood) the gloss reading would be between 90 and 100 based on an 80 degree meter. However, the current industry practice in measuring gloss value is based on a 60 degree scale.

The gloss was specified to be a 65-degree sheen on a 60-degree scale. Variations of the gloss readings with the same coating on different substrates resulted from the absorptivity of the coating material into the substrate: the higher the gloss, the more the imperfections. A satin sheen tends to hide imperfections in the coating, and makes the coating look better. On the other hand, it can also make the coating look milky. The instrument was calibrated with black glass at a 60-degree incidence.

Results: Four gloss readings were taken on each panel, spaced evenly and vertically down the center of each panel (see Table 5 for averaged values). The panel having a softer grain, had a lower gloss reading. The panels with the higher gloss reading could have had a heavier coating on them than the panels with the lower gloss readings. If another coat of topcoat was applied to the panels, the readings would be higher. For this testing, glossy topcoat was sprayed on pine samples and satin-finished topcoat was applied on oak panels.

Parallel Groove Adhesion. If a coating is to fulfill its function of protecting or decorating a substrate, it must adhere to it for the expected service life. Surface preparation, or lack of it, has a drastic effect on a coating's adhesion. Evaluating adhesion to different substrates, or of different coatings to the same substrate, is of considerable importance to the industry.

Using the ASTM D 3359[14] evaluation method, the adequacy of a coating's adhesion was determined. A tool which cuts parallel grooves was used to cut a cross-hatch pattern in the coating down to the substrate, then tape was applied over the grooves and removed. After removing the tape, the cross-hatch and tape were inspected to detect any flakes lifted at the edge of the cuts. The appearance of the crosshatches were then rated against the standards listed below.

(The Gt numbers shown below are the ratings given by ASTM. However, for the purpose of this test anything worse than Gt 1/4 B was noted as a failure. Any reading equal to or higher than Gt 2/3 B was considered as having insufficient adhesion properties for most uses in furniture industry.)

- Gt 0/5 B: The edges of the cuts are completely smooth; no lattice squares are attached.

- Gt 1/4 B: Small coating flakes are detached at intersections; less than 5% of the lattice area is affected.
- Gt 2/3 B: Coating flakes are detached along the edges and/or at intersections of cuts; the lattice area affected is 5 to 15%.
- Gt 3/2 B: The coating has flaked along the edges and/or parts of the squares; the lattice area affected is 15 to 35%.
- Gt 4/1 B: The coating has flaked along the edges of cuts in large ribbons, and/or parts of the squares or whole squares have detached; the lattice area affected is 35 to 65%.
- Gt 5/0 B: Flaking and detachment are greater than 65% of the lattice squares.

Results: All samples showed a rating of Gt 0/5B, which is excellent. The coating was very hard and not brittle.

Adhesion/Scrape/Mar. Water-based coatings are more plastic and mar resistant than solvent-based coatings. When scraping pressure is applied to solvent-based coatings, the surface of the substrate tends to scrape off. Water-based coatings (being more plastic) are tougher and tend to indent the substrate, actually deforming the coating surface without rupturing it.

A modified version of ASTM D 2197[15] was followed. This evaluation method covers the determination of the adhesion of coatings when applied to smooth flat panels. After complete curing, the adhesion/scrape/mar resistance was determined by pushing the panels beneath a round stylus or loop with increasing pressure until marring of the coating was detected. This method has proven useful in characterizing a coating's degree of hardness, especially for relative ratings of a series of coated panels exhibiting significant differences in mar resistance.

The value given is the weight in grams applied to the stylus before marring was detected. The results of the tests are relative. The mean value of the weight amount to mar the surface of solvent-based coatings was 300 g. From previous studies comparing the mar resistance with solvent-based coatings, we concluded that any coating which mars at 300 g or higher is satisfactory.

Results: All samples were tested at 1000 g (maximum capacity of the test equipment) and showed no marks, which is excellent. In tests performed at Southern California Edison's Customer Technical Assistance Center[5], solvent-borne coatings tested at 300 g showed marks. Since water-based coatings were being compared to solvent- borne coatings in that test, 300 g was used as a standard. This proved that this newly developed water-based coating system is more than 3 times as durable as typical solvent-borne coatings.

Orange Peel. Orange peel is an irregularity in a paint film's surface which results from the wet film's inability to "level out" after being applied. Orange peel appears as an uneven or dimpled surface to the eye, but usually feels smooth to the touch.

Results: There was no indication of orange peel on the samples. The coating flowed out nicely.

Household Chemical. The ASTM D 1308[16] method was followed to test coatings using household chemicals. This evaluation method was used to determine the effect household chemicals have on organic finishes. Household chemicals may result in objectionable alteration of a surface; e.g., discoloration, change in gloss, blistering, softening, swelling, or loss of adhesion.

Resistance to various home-use chemicals is an important characteristic of organic finishes. Test methods provide the means by which the relative performance of coating systems may be evaluated. The open-spot evaluation method was used. That is, the reagent was placed directly on a surface and allowed to remain uncovered for an hour. The surface was then examined for a chemical reaction. It must be noted that chemicals such as acetone and nail polish remover do not remain (they evaporate quickly) on a surface for an hour. However, the time they do remain wet on a surface is normally long enough to mar it. In past tests with other coatings, they either melted the coatings, or turned them white.

The household chemicals used were catsup, mustard, coffee, acetone, margarine, vinegar, nail polish remover, and cold and hot tap water. The ratings were: (1) no effect, (2) slight effect, (3) medium effect, and (4) heavy effect.

Results: Only mustard showed very slight yellow stain on coated wood panels. The remaining chemicals showed no effect at all.

Aesthetics. Customer acceptance of new water-based coatings are based on both coating performance and aesthetics. The aesthetics evaluation was performed by JH Associates, an independent consultant in Anaheim, California.

The untrained eye knows when it sees a good finish, but can't explain why. Each panel was inspected and a value placed which best described the appearance, color, and clarity of each substrate's coating. Descriptors, used to best define how the coated panels looked, are described below.

(a) Appearance

The appearance was judged on 10 characteristics which would best describe the coating's flowing characteristics. They were: good, graininess, mottled, orange peel, flow problems, blistering, checking, cracking, flaking, and filling.

(b) Color

The color was judged on six different characteristics: good, bleached, red, green, natural, and yellowing.

(c) Clarity

The clarity was judged on two different characteristics: good and milky.

Results: The coating system has a nice slightly amber color. Both oak and pine panels received "good" ratings for appearance, color, and clarity.

Other Performance Tests. Pencil hardness test (ASTM D 3363)[17], drying time test (ASTM D 1640)[18], UV resistance to fading (ASTM G53-88)[19]and printing/blocking (ASTM D 2091)[20] test were also performed. The results are presented in Table 5.

TABLE 5. COATING PROPERTIES AND PERFORMANCE CHARACTERISTICS TEST RESULTS

		Results	
Measurement	**Method**	**OAK (VENEER) WITH STAIN, SEALER, AND TOPCOAT**	**PINE (SOLID) WITH STAIN, SEALER, AND TOPCOAT**
Pencil Hardness	ASTM D 3363	2H	2H
Gloss	ASTM D 523	29.2 (Satin)	49.1 (Glossy)
Parallel Groove Adhesion	ASTM D 3359	Gt 0/5B (excellent)	Gt 0/5B (excellent)
Adhesion/Scrape/Mar	ASTM D 2197	No marks at 1000 g (excellent)	No marks at 1000 g (excellent)
Hot/ColdCheck	ASTM D 1211	No checking or cracking	No checking or cracking
Household Chemical	ASTM D 1308		
Catsup		No effect	No effect
Mustard		Very slight yellow stain	Very slight yellow stain
Coffee		No effect	No effect
Acetone		No effect	No effect
Margarine		No effect	No effect
Vinegar		No effect	No effect
Cold tap water		No effect	No effect
Hot tap water		No effect	No effect
Nail polish remover		No effect	No effect
Drying Time (Air dry)	ASTM D 1640	30 minutes	30 minutes
Water Resistance [a]	ASTM D 1308	No effect	No effect
Printing/Block	ASTM D 2091	No effect	No effect
Orange Peel	Visual inspection	No indication of orange peel	No indication of orange peel
Aesthetics			
Appearance	Visual inspection	Good	Good
Color		Good	Good
Clarity		Good	Good

a Measure change in pencil hardness 1 hour after recovery from water.

3.0 OPERATING AND QA/QC PROCEDURES

3.1 QA/QC Procedures

The Quality Assurance Project Plan was based on information provided by EPA[21,22]. The Revised Quality Assurance Project Plan, reflecting EPA's comments on the original submittal, was approved by the EPA Project and QA Officers and is attached as Appendix A of this report.

Laboratory analyses for VOC content and HAP level were performed by Applied P & Ch Laboratory (APCL) in Chino, California. Coating properties and characteristics were performed by JH Associates, an independent consultant in Anaheim, California, and Adhesive Coating Co. in San Mateo, California. The sampling procedures, analytical procedures and calibration, and quality assurance procedures described in the QAPP were followed by the laboratory and independent consultant who performed the tests. The precision for the VOC analysis is <=25%, and the accuracy and precision for HAP analyses are +/- 25% and <=25%, respectively. QA objectives are not applicable to the wood panel tests. APCL is audited by government agencies or private companies approximately every two months. Some of the organization which performed the audits are California Department of Health Services, U.S. Navy, U.S. Army, International Technology Corporation, and James Montgomery Watson. All deficiencies were corrected during the system audits,

3.2 Operating Procedures

The basic operational methods for applying the no-VOC water-based coatings are listed below. These procedures are generalized for most wood products. A plan should be made to determine the actual procedures which is best applicable to the new product. The plan should consider many production steps other than only applying the finish to the product. The operating procedures include:

(1) Review the current finish steps
(2) Plan the steps required for the water-based finish
(3) Check the equipment
(4) Review advantages of new processes (ovens, conveyors, pumps)
(5) Train personnel
(6) Make the conversion

This report concentrates on the basic procedures for applying water-based stain, sealer and topcoat. Water-based products are supplied ready for use; no thinning or reducing is required.

They should be stirred well and strained before use in order to remove any dry particles that may collect around the lid of the containers and fall into the coating.

The containers should be made of plastic or be plastic-lined or coated. Because of the nature of the coating, metallic containers will rust or oxidize and, thus, contaminate the material. The coatings should be stirred to mix (not shaken). Shaking causes bubbles. Another method of mixing would be to lay the container on its side and gently roll it back and forth.

Water is absorbed by all woods: veneer, solids, particle board or MDF (medium density fiberboard). Some grain raising will occur depending on the type of wood used. There may be slight to heavy grain raising after a seal coat is applied. For instance, there is more grain raising on a solid wood panel than on a veneer panel. Grain raises less on veneer panels because the veneer is thinner (1/40 inch) and has a glue line immediately under it, which helps seal the wood. Grain raising is a function of how wet the substrate becomes and how much coating is applied to the raw substrate. Some coatings have much more wetting action than others which causes the grain raising. Softer open-pore woods will have more grain raising than the harder, closed-pore woods. However, it must be said that many of the coatings being manufactured today cause very little grain raising.

Some water-based stains raise the grain. A technique used to minimize grain raising when using a water-based stain would be to use 400-grit wet or dry sandpaper to cut the grain follicles off while applying the stain. By using this method the stain will re-color the wood substrate as the raised grain is being cut off and no raw wood surfaces will show. The stain would then be wiped off using conventional methods. The best way to minimize grain raising is to sand the piece properly prior to applying the finish. The substrate should be sanded within 24 hours of coating, using as a minimum, 180-grit stearated aluminum oxide sandpaper.

Stains

Stains are normally supplied ready for use and are either based on transparent soluble dyes (wood shades) or pigmented dispersions (pastel and bright colors). They are applied directly to the substrate prior to the sealer or topcoat. The stain may be applied with a brush, wiped on with a rag, or sprayed. The excess stain should then be wiped off with a rag. The wiping should be in the direction of the grain, and done until the desired wood grain appearance and shade of lightness or darkness is achieved. The difference between solvent- and water-based stains is in their application; there is not as much open time with the water-based stains. That is water-based stains dry faster; therefore you have to wipe them off sooner or they will be too dark or blotchy in spots due to uneven drying. Some water-based stains will wet back, that is, if they were rewetted they will dissolve and spread or blend out. Sometimes a damp rag can be used to spread the stain or cause highlights in the color.

As with solvent-based stains, blotchiness can also be attributed to uneven sanding. Since staining is the first process, grain raising will occur to a greater degree at this stage. However, sanding

should not be done until after the first seal coat is applied. Stains will normally take 10-15 minutes to air dry in temperatures above 72 degrees F.

Sealers

Sealing stained or unstained substrates should cause very little color change. However, the sealer will enhance the color and will make the surface look richer. It will also bring out the clarity of the color. After the stain has dried, the next step is to apply the sealer. After the sealer has dried (air drying will take approximately 30 minutes, with heat this could be reduced to approximately 10 minutes), scuff sanding or de-nibbing is required. Dry time is defined as the time required by the coating to where it can be sanded and recoated. If heat is used (140 degrees F max.), a minimum of two minutes should be allowed for the coating to flash (let the bubbles and solvents out of the coating and allow it to settle or flow out so it looks flat and smooth) prior to applying heat.

Single overlapping passes (which result in approximately 2-3 mils wet film thickness) should be applied. The proper application amount is when the wet coating looks slightly milky white or has a blue haze (depending on its chemistry). This color will disappear as it dries. Methods of spraying which cause overspray on adjacent surfaces or passes should be avoided. This will cause graininess and an orange peel effect and will require more sanding prior to the next coat.

Different types of abrasives can be used depending on the smoothness of the sealed substrate.

- 240- or 320-grit stearated aluminum oxide sandpaper
- medium grade Scotch Brite™

Steel wool should not be used because rust marks may occur as a result of the water in the coating. Care should be taken to sand off the raised grain and a little bit of the sealer until it turns to a white powder. Do not sand through the sealer into the stain so the color of the stain is sanded off to the bare wood. Sand in the direction of the grain to avoid any cross-grain scratches.

Sanding between water-based coatings is done for the following reasons: (1) to smooth the surface before the next coating is applied, (2) to cut-off any wood fibers that were raised from the water in the sealer, (3) to flatten the surface, and (4) to scratch the surface of the sealer for a good mechanical bond for the next coat. Water-based coatings require this bond, because unlike solvent-based coatings, they do not dissolve back into themselves for adhesion.

Depending on the substrate and appearance required, it may be necessary to apply one sealer coat and one topcoat, two sealer coats and one topcoat, or one sealer coat and two topcoats. In any case, sanding between coats is required as described above.

Topcoats

Topcoats are available in many sheens or glosses ranging from: dead flat, satin, semi-gloss, medium gloss, high gloss, and wet look. Numerically, they range from 0 to 100 degree sheen on a 60 degree gloss meter. In many cases the very-high gloss wet look has to be buffed and polished in order to obtain the final gloss. Topcoats should be applied in the same manner as the sealer coat. If more than one coat is applied, the surface should be sanded (as described above). Depending on number of coats applied, air drying takes 45 to 60 minutes; heat drying takes 15 minutes (allow three minutes for flash before applying heat).

3.3 Coating Refinishing/Repair Procedures

There are many reasons for refinishing or repair. Reasons for refinishing are described below:

(1) Damage caused in manufacturing (glue marks, putty marks, scratches, gouges, nail or screw holes, poor joints, etc.).
(2) Flaws in the grains of the wood (sap wood, light vs. dark grain, splits, cracks). Some may just require shading in the finishing process.
(3) Handling or stacking damage (printing/blocking, scuff marks, light scratches, deep scratches, gouges, chips, rub marks).
(4) Flaws in the finish process (incomplete finishing, runs, sags, overspray).

Usually, the defects from items one and two above are found and repaired in the finish room. Some of the flaws described above are very easy to repair, while others require a great deal of skill. In general, solvent-based coatings are easier to repair since new layer of coatings can melt with the existing layer. Water-based coatings will require sanding between new layer and existing layer. A visible flaw (e.g., in the center of a high gloss conference table) would require more skill to repair than one not so visible (e.g., on the side of a cabinet). A visible flaw may require resanding and respraying, or refinishing. Touch-up and refinishing is an art. Sometimes touch-up is required before shipping, and sometimes it is required after shipping. There are many different types and methods of refinishing.

4.0 DEMONSTRATION

Demonstration of the new no-VOC, no-HAP wood coating system was conducted at Commercial Casework, Inc. in Fremont, California, on February 6, 1997. They manufacture finished panels, desks, reception counters and other miscellaneous office furniture and architectural wood products. The purpose of the demonstration was to show that this new no-VOC, no-HAP wood coating system could be used successfully in a commercial wood finishing operation. The following summarizes the demonstration process.

Date:	February 6, 1997	
Place:	Commercial Casework, Inc. 41780 Christy Street Fremont, CA 94538	
Present:	Mr. Robert McCrillis - U.S. Environmental Protection Agency Dr. Eddy Huang - AeroVironment Environmental Services, Inc. Mr. John Kitlas - Commercial Casework, Inc. Mr. James Shannon - Adhesive Coatings Co. Mr. James Birdsall - Adhesive Coatings Co.	
Products used:	New No-VOC/No-HAP Wood Topcoat Gloss (WTC-96-RT4) New No-VOC/No-HAP Wood Topcoat Satin (WTC-96-ISA) New No-VOC/No-HAP Wood Sanding Sealer (WSS-96-25) New No-VOC/No-HAP Stain Base (WST-96-3)	
Conditions:	Temperature: Relative Humidity:	65°F 50%

A number of wood and laminates panels and molding strips (including cherry, maple, pine, and walnut) were laid out on finishing racks. They were lightly sanded and dusted.

Two stain colors were prepared by adding universal tints of burnt umber and yellow oxide to the new no-VOC/no-HAP stain base. The stains were applied to the wood products by rubbing with a rag until an even color was achieved. The stains were easy to work with, blended well, and gave a pleasing appearance.

Five minutes later the sanding sealer was applied to all panels at package viscosity using a DeVilbis cup gun. This was allowed to completely clear, about fifteen minutes, before sanding. Then the panels were lightly sanded using 200-grid sandpaper. As soon as the sanding sealer was dry to the touch it was easily sanded and smoothed.

After sanding and dusting, the new no-VOC/no-HAP wood topcoats were applied using the same gun at package viscosity. Some of the panels were coated with gloss and some with satin topcoat. These coats dried in approximately 20 minutes with good results. Some panels were given two topcoats.

As an experiment, a solvent-borne "toner" was applied to the finished panels to darken the color. On one panel, the toner was allowed to dry and then another coat of new no-VOC/no-HAP wood topcoat was applied. The solvent base of the toner seemed to interfere slightly with the topcoat and gave a rough look to the piece. On another panel, the topcoat was applied over the wet toner with good results.

The finished panels were cut into small pieces and given to the EPA project officer with a videotape that was taken during the demonstration. Some small pieces of panels were brought back to the laboratory for further testing.

5.0 ENVIRONMENTAL IMPACT STUDY AND COST ANALYSIS

Traditional coating technologies emit large quantities of pollutants into the air and consume energy in the drying processes. In addition to causing tropospheric ozone formation, acid rain formation, water contamination and hazardous waste, there are considerable health and safety concerns created in the workplace. By using this new, promising no-VOC water-based coating technology, significant air emission reductions, hazardous waste reductions, and energy savings could be achieved without installation of add-on controls. As a result, cost savings will be achieved from eliminating VOC control equipment and hazardous waste disposal, and from energy savings. Therefore, commercialization of the proposed technology will provide a cost-effective way to comply with current and future emissions standards for coating operations imposed by federal, state, and local government agencies. The energy savings, emission reductions, hazardous waste reductions, and cost savings presented below are estimated based on the data provided by ADCO and John L. Armitage & Company.

Energy Savings

This technology has great potential in affecting a sizable reduction in energy consumption in thermal oxidizing VOCs from solvent-based coating operations. Potential energy savings are estimated to be 8,400 million Btu (8.87 TJ) /yr/unit. Table 6 summarizes the energy reduction potential of this no-VOC water-based coating technology.

Air Emission Reductions and Hazardous Waste Reductions

Potential air emission reductions and hazardous waste reductions per year per unit are estimated to be 1,500 tons of VOCs, 492 tons of CO_2, 0.59 tons of NO_x, 0.01 tons of particulate matter and 8.50 tons of hazardous waste. Table 7 shows the reduction potential of VOC, CO_2, NO_x, PM, and hazardous waste.

Cost Savings

Potential cost savings are estimated to be $38,640 (U.S.) per year per unit. Table 8 summarizes the cost saving potential of this no-VOC water-based coating technology.

Cost Analysis

Based on the data provided by John L. Armitage & Company (Parsippany, NJ) and ADCO, a cost analysis was conducted on the new no-VOC/no-HAP coating system. The analysis considers new product introduction decisions such as realistic material cost, capital outlay requirements, and labor. Table 9 summarizes the preliminary raw material cost estimated for the no-VOC/no-HAP wood coating system in laboratory scale, and Table 10a to 10d summarizes the preliminary cost estimated for the development and manufacture of Resilex epoxy resin. All Tables

involving comparisons of "Current Technology" and "ADCO's No-VOC Technology" are based on the following assumptions:
Definition of "Unit"

A unit is an average size production plant which:

1. has 1 production lines.
2. operates 18 hours per day, 21 days per month, 12 months per year.
3. consumes 1 million gallons coatings per year.

Definition of Current Technology

1. Conventional solvent coatings.
2. VOC emissions from solvent-based coating operations are reduced by added-on control equipment. A typical thermal oxidizer burns eight-million cubic feet of natural gas per year (equivalent to 8.4-billion Btu of energy per year).

Definition of ADCO's "No-VOC Technology"

1. ADCO's no-VOC Coatings.
2. No VOC will be emitted from no-VOC coating operations; therefore, no added-on control equipment is required.

TABLE 6. ENERGY SAVINGS

	(a) Current Technology (MMBtu/yr /unit)	**(b) ADCO's No-VOC Technology (MMBtu/yr/unit)**	**(c)[a] Energy Savings (MMBtu/yr/unit)**	**(d) U.S. Units in Place in 2010**	**(e)[b] 2010 Energy Savings (MMBtu/yr)**
Thermal Oxidizer as Natural Gas	8,400	0	8,400	30	252,000

a. (c) = (a) - (b)
b. (e) = (d) x (c)

TABLE 7. TOTAL WASTE SAVINGS

Waste Generated	(a) Current Technology (Tons/yr /unit)	(b) ADCO's No-VOC Technology (Tons/yr/unit)	(c)[a] Waste Savings (Tons/yr /unit)	(d) U.S. Units in Place in 2010	(e)[b] Annual Waste Savings in 2010 (Tons/yr)
VOCs from Coating Applications	1,500	0	1,500	30	45,000
CO_2 Emissions from Natural Gas Combustion	492	0	492	30	14,760
NOx Emissions from Natural Gas Combustion	0.59	0	0.59	30	17.7
PM Emissions from Natural Gas Combustion	0.01	0	0.01	30	3
Hazardous Waste from Coating Overspray [c]	8.50	0	8.50	30	255
Total Discharge	**2001.10**	**0**	**2001.10**	**30**	**60,035.7**

a. (c) = (a) - (b)

b. (e) = (d) x (c)

c. Overspray by the coating applicator amounts to about 20% of the coating sprayed. An average coating density of 8.5 pounds per gallon was used in the overspray calculation. Hazardous waste amount was calculated as 1% of the overspray.

TABLE 8. COST SAVINGS[a]

	(a) Current Technology (U.S. Dollars)	(b) ADCO's No-VOC Technology (U.S. Dollars)	(c)[b] Cost Difference (U.S. Dollars)	(d) U.S. Units in 2010	(e)[c] Annual Cost Savings in 2010 (U.S. Dollars)
Routine Operation and Maintenance per Thermal Oxidizer per Year	16,000	0	16,000	30	480,000
Energy Cost for VOC Incineration (each Thermal Oxidizer)[d]	15,840	0	15,840	30	475,200
Cost for Hazardous Waste Disposal[e]	6,800	0	6,800	30	204,000
Total	**38,640**	**0**	**38,640**	**30**	**1,159,200**

b. Costs in U.S. dollars per unit.
b. (c) = (a) - (b)
c. (e) = (d) x (c)
d. Assumes natural gas cost of $1.98 per 1000 cubic feet.
e. Assumes hazardous waste disposal cost of $0.40 per pound.

TABLE 9. RAW MATERIAL COST FOR THE NO-VOC/NO-HAP WOOD COATING SYSTEM

Raw Material	Weight %	Unit Price ($/pound)
1. Topcoat:		
Water	24.50	--
Part A Resin	19.20	1.02
Part B Resin	9.60	0.90
Polyamine	5.00	0.90
Wax Emulsion	3.40	0.60
Epoxy Emulsion	38.30	0.62
Total for Topcoat	100.00	
2. Sanding Sealer:		
Part A Resin	33.90	1.02
Water	29.60	--
Defoamer	0.20	4.20
Part B Resin	6.20	0.90
Polyamine	2.50	0.90
Wax	2.20	0.60
Epoxy Emulsion	25.40	0.62
Total for Sanding Sealer	100.00	
3. Stain:		
Resin	87.00	1.20
Surfactant	4.00	3.10
Wetting Agent	4.00	2.50
Defoamer	0.20	--
Water	4.80	--
Total for Stain	100.00	

TABLE 10. COST FOR THE DEVELOPMENT AND MANUFACTURE OF RESILEX EPOXY RESIN

Table 10a. Raw materials

Raw material	Volume (Gallons)	Weight (Pounds)	Unit Price (per pound)	Cost ($)
Epoxy Resin	1,800	8,640	1.60	13,824.00
Emulsifier	275	1,150	1.33	1,529.00
Misc. Additives	2	17	3.00	51.00
Total Raw Materials Cost per 3,300 Gallons of Coating				15,404.00

Table 10b. Equipment

Equipment	Cost
2 Reactors, Copper Coils, Installation	$5,000.00
Blade Fabrication	$500.00
Controls, Solenoids, Electrical	$1,000.00
Total Equipment Cost	$6,500.00

Table 10c. Labor/Overhead

Personnel	Hours	Hourly Rate ($/Hr)	Cost ($)
Manager	300	62.50	18,750.00
Development Technician	800	37.50	30,000.00
Operator	200	18.75	3,750.00
Total			52,500.00

Table 10d. Total.

Category	Cost
Cost of Raw materials	$15,404.00
Cost of Equipment	$6,500.00
Labor/Overhead Cost	$52,500.00
Grand Total	**$74,404.00**

6.0 TECHNOLOGY TRANSFER

The goal is to exploit worldwide this new resin and coatings technology, technical data and know-how. The target is the wood coatings market, which offers the best opportunity for large and relatively rapid penetration. This market is estimated to represent over $1 billion in sales each year in the United States (Table 11). California comprises a significant portion of this market.

The technology transfer strategy is to form noncompetitive strategic alliances with established companies that have demonstrated a competitive advantage in certain coatings markets.

ADCO has already negotiated an alliance in the traffic paint market to exploit a new no-VOC traffic marking paint. In a strategy similar to traffic paint, the team will license its technology for manufacture and sale of environmental resins for use in the wood coatings industry. Discussions have already begun with several companies to form a strategic alliance for entry into various wood coatings markets including wood furniture and kitchen cabinet finishing.

While the potential application of these technologies is vast, the team has chosen to focus on wood coatings: a product area in a large market that appears to need the most help in reducing VOC emissions. In this area, federal, state and local legislation appear ready to crack down on excessive or extraneous VOC emissions. Unfortunately for manufacturers, reformulation has been both costly and difficult and in some cases quality standards have suffered. Alternative method technologies are growing in acceptance, but are greatly limited by both cost and difficulty of application.

This strategy is based on the principal competitive advantages of the successful basic research and development that has been done to date, the proprietary and patent-protected resin technology, our understanding of the worldwide coatings markets and customer needs, and ability to form a strategic alliance with major coatings companies that currently enjoy a large market share. The commercial success will be driven by the ability to: (a) consummate strategic alliances with dominant companies in the industry; (b) continuously enhance product performance; (c) concurrently start international sales and cross border alliances; (d) identify additional commercial applications for other related products that would employ these resin technologies.

The industry has set the market specification; i.e., the need for a water-borne spray, brush or roller applied, odor-free, solvent-free, chemical, solvent and grease resistant epoxy wood coating with very low or no-VOCs that can be used for wood application. Within the guidelines of these industry standards, this contract would allow us to incorporate the use of the technology into an wood coating with the following properties:

- The mixed components remain usable in excess of four hours.
- The mixed components have shown 10-hour pot life on a laboratory basis.

The new no-VOC wood coating can be applied by brush, roller, or spray. There is no wet or dry film odor, no color, very high gloss, no- or very low-VOCs; and the flexibility of the coating can be modified through polymer choice and amine curative choice.

In order to accelerate the spread of this new no-VOC/no-HAP wood coating technology to manufacturers, AeroVironment Environmental Services, Inc. (AVES) staff attended the "Emerging Solutions to VOC and Air Toxics Control" Specialty Conference held in San Diego

for technology transfer. The conference was sponsored by the Air and Waste Management Association (AWMA) and the U.S. Environmental Protection Agency on February 26-28, 1997. Conference attendees numbered about 100. The topics of this specialty conference included: Emerging and Innovative Technologies, Regulatory Issues and Hybrid Technologies, Compliance for Coatings Operations, and Air Management for Least-cost Abatement and Case Histories.

The paper[23] entitled "Demonstration of No-VOC/No-HAP Wood Furniture Coating System", was presented by AVES staff on February 27, 1997. The properties and performance testing data were summarized and discussed in detail. The wood panels coated with the new no-VOC/no-HAP stain, sealer, and topcoat were exhibited and the technical coating data sheets (see Appendix B) were handed out to the interested parties. AVES solicited manufacturers to participate in full-scale demonstration of this no-VOC/no-HAP wood coating.

TABLE 11. WOOD COATING MARKET[24,25]

Coatings Market	Coating Consumption (Million gal/yr)	Sales (U.S. Dollars/yr)
U.S. Wood Coatings Market	61	$595 Million
Furniture industry	34	$325 Million
Kitchen cabinets	12	$114 Million
Other industries[a]	15	$156 Million

(a) Other industries includes new case goods, plywood (hardboard), regenerated wood products, flat stock finishes, and specialty product finishes.

7.0 CONSUMER FOLLOW-UP PROGRAM

A survey was conducted under the sponsorship of U.S. EPA and SCAQMD. The objectives were to survey wood furniture manufacturers and determine:

- the extent of industry's conversion to date to compliant wood coatings.
- the degree to which compliant wood coatings are realistically available for use.
- existing problems with currently available technologies.
- consumer acceptability of furniture finished with water-based wood coating systems.
- relative advantages and disadvantages of available water-based wood coating systems.

The survey was based on a detailed questionnaire[26] covering the spectrum of issues faced by the wood coaters' industry that might affect their ability to achieve compliance with low-VOC coatings. It was amended several times to eliminate leading questions and to avoid any perceived biases by the SCAQMD staff and the Industry Working Group, which was comprised of representatives from coating manufacturers, wood coaters, spray equipment vendors, and consultants.

The SCAQMD provided the survey team with a computerized list of companies, locations, contact persons, phone numbers, permit numbers, and Standard Industrial Classifications (SICs). Tables 12 and 13 summarize the survey results.

TABLE 12. NUMBERS AND TYPES OF COMPANIES CONTACTED

Category	A	B	Total
Type of Business	Household Furniture	Office Furniture	
Number of Manufacturing Companies in the South Coast Air Basin	297	18	315
Companies Contacted	49	16	65
Using One or More Water-based Coatings	6	3	9
No Water-based Coatings Used	8	3	11

TABLE 13.RESULTS FOR COMPANIES THAT COMPLETED SURVEY[a]

Question	ANSWER[b]	
Are your finishing processes:		
Less than 6 coating steps?	14	
6 or more coating steps?	8	
Is the final product satisfactory?		
Depth of gloss	Yes/No/Don't Know:	9/9/0
Gloss	Yes/No/Don't Know:	12/6/1
Solvent resistance	Yes/No/Don't Know:	11/5/0
Durability	Yes/No/Don't Know:	11/6/0
Fade resistance	Yes/No/Don't Know:	10/8/0
Shipping durability	Yes/No/Don't Know:	9/7/0
Hardness	Yes/No/Don't Know:	10/7/0
Drying time	Yes/No/Don't Know:	5/13/0
Overall quality appearance	Yes/No/Don't Know:	9/10/0
Finish defects	Yes/No/Don't Know:	10/7/0
Color/stain matching	Yes/No/Don't Know:	10/7/0
Clarity	Yes/No/Don't Know:	11/7/0
Repairability	Yes/No/Don't Know:	9/9/0
Material cost	Yes/No/Don't Know:	6/12/0
Labor cost	Yes/No/Don't Know:	7/10/0
Safety	Yes/No/Don't Know:	16/3/0
Grain raising	Yes/No/Don't Know:	9/7/0
Overall cost	Yes/No/Don't Know:	6/12/0
How are you repairing low-VOC coatings? (Do you use a wash/barrier/tie coat?)	Not using water. Sand and touch-up stain, respray topcoat. Testing has been very limited. Can't fix a spot. Have to do a whole piece, wash off, and start over. Mohawk aerosol stain lacquer and sealer. Requires complete refinishing. It's more difficult. No tie coat. We must use a tie coat. Sand and recoat with washcoat. Strip and refinish.	
Are additional steps in your manufacturing process necessary in order to use the low-VOC coatings you've tried?	Yes/No/Don't Know:	11/7/0
Have the low-VOC coatings caused an increase in line rejections?	Yes/No/Don't Know:	6/4/1

What type of application equipment are you using?	Stain	Sealer	Topcoat	Other
High Volume Low Pressure (HVLP)	15	17	17	3
Air Assisted Airless	1	1	1	0
Manual	14	13	13	3
Wiping	1	0	0	1

(continued)

TABLE 13. RESULTS FOR COMPANIES THAT COMPLETED SURVEY (CONCLUDED)[a]

Question	ANSWER[b]	
Do you experience any problems cleaning the equipment?	Yes/No:	4/13
Does your coating need to be force dried?	Yes/No:	8/9
Do you have ovens or drying equipment?	Yes/No:	8/13
Gas	3	
Electric	1	
IR	4	
UV	0	
Will additional employees be required because of the implementation of low-VOC coatings?	Yes/No/Don't Know:	9/6/2
Is additional warehouse or floor space required for the drying or curing of the low-VOC coating before packaging?	Yes/No:	11/9
Approximately, how much will the conversion to low-VOC cost?	$2,000 - $3 million	
About how much has it cost so far?	$2,000 - over $2 million	
Do you have a conveyor? If so, at what line speed does it run?	Yes/No	7/13
Line speeds:	10 - 12 fpm	
	Varies	
	6.5 fpm	
	14 fpm	
	10 - 15 fpm	
Does the customer find the finish acceptable?	Yes/No	7/7
Rate customer response to low-VOC coatings:	Highly Positive	0
	Positive	4
	No Comment	8
	Somewhat Negative	2
	Negative	4
	Don't Know	2

a. All respondees did not answered all questions; therefore, the total number of answers may differ from question to question.

b. The survey results are based on answers from companies which used or tested water-based coatings. It was not the survey's objective to discuss the performance of solvent-based coatings.

8.0 CONCLUSIONS AND RECOMMENDATIONS

1. Some water-based coatings are currently available on the market.[27] However, they work well only in some applications, and cannot be applied across all finishing lines according to the results of the consumer following-up program.

2. The physical characteristics of these new wood coatings are excellent. They successfully passed all tests. Laboratory analysis confirmed that these new coatings have no VOCs and no HAPs.

3. The keys to successful conversion to new water-based coatings are staff training and technical support from the coating manufacturers. Personnel may need retraining on spraying techniques for water-based wood coating applications.[28]

4. When using the no-VOC, no-HAP water-based coatings developed in this project, additional finishing steps including sanding and force drying may be required. Increased labor costs may result because of the additional finishing steps.

5. By using this new, promising no-VOC water-based coating technology, significant air emission reductions, hazardous waste reductions, energy savings, and cost savings could be achieved without installation of add-on controls. Therefore, commercialization of the proposed technology will provide an alternative to comply with current and future emissions standards for coating operations imposed by federal, state, and local government agencies.

6. The new coating system should find wide applicability across many segments of the wood furniture industry.

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APPENDIX A QUALITY ASSURANCE PROJECT PLAN

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Quality Assurance Project Plan
for the

Development of a Zero-Volatile Organic Compound (VOC), Zero-Hazardous Air Pollutant (HAP) Wood Furniture Coating System

Submitted to

Robert C. McCrillis
United States Environmental Protection Agency
Emissions Characterizations & Prevention Branch (MD61)
National Risk Management Research Laboratory
Research Triangle Park, NC 27711

By

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Project Officer

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Quality Assurance Officer

April 1996

PREFACE

THE QUALITY ASSURANCE PROJECT PLAN

This Quality Assurance Project Plan (QAPP) is based on and consistent with the following:

1. AEERL Quality Assurance Procedures Manual for Contractors and Financial Assistance Recipients (EPA, 1994)[1].

2. Preparation Aids for the Development of Category III Quality Assurance Project Plans (EPA, 1991)[2].

3. Interim guidelines and specifications for preparing quality assurance project plans (EPA, 1980)[3].

The QAPP defines the data quality objectives of the project and presents, in specific terms, the policies, organization, objectives, and activities needed to achieve them. It details what quality assurance (QA) and quality control (QC) procedures will be used to ensure that the technical data are accurate, precise, complete, and representative of actual field conditions. It includes periodic calibrations, duplicate checks, and examination of the data for reasonableness and consistency. It provides documentation upon which claims of accuracy are, in part, based.

The QAPP covers all field and laboratory investigations that generate data. These include: (1) measurement of coating properties and performance characteristics, and (2) determination of the presence or absence of pollutants in the wood coating system.

The EPA has identified 15 elements that must be included in all QAPPs (EPA 1980).

1. Title Page

2. QA Project Plan Approval Form

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4. Project Description

5. Project Organization and Responsibilities

6. Quality Assurance Objectives for Measurement Data in Terms of Precision, Accuracy, Completeness, Representativeness and Comparability

7. Sampling Procedures.
8. Sample Custody
9. Analytical Procedures and Calibration
10. Data Reduction, Validation, and Reporting
11. Internal QC Checks
12. Performance and System Audits
13. Calculation of Data Quality Indicators
14. Corrective Action
15. References

Each of these items are described in this QAPP for the Development of a Zero-Volatile Organic Compound (VOC), Zero-Hazardous Air Pollutant (HAP)* Wood Furniture Coating System at AeroVironment Inc. (AV), 222 East Huntington Drive, Monrovia, CA 91016 and Adhesive Coating Company (ADCO), 2755 Campus Drive, Suite 125, San Mateo, CA 94403.

(*) In this QAPP, zero-VOC, zero-HAO is used in place of the no-VOC, no-HAP used in the rest of the report.

SECTION 1

PROJECT DESCRIPTION

1.1 GENERAL OVERVIEW

The U.S. Environmental Protection Agency (EPA) is implementing increasingly stringent environmental regulations designed to minimize or eliminate the emissions of volatile organic compounds (VOCs). It is estimated that the annual U.S. market for wood coatings is approximately 240,000 m^3 (63 million gallons)[4]. On this basis, between 57 and 91 million kilograms (125 to 200 million pounds) of VOCs are emitted into the air each year from the use of presently used water-borne and solvent-borne systems.

EPA actions have a profound effect on the marketing of coatings, and the organic and inorganic binders which are widely used in the industry. Some companies, in their panic to meet applicable EPA standards, seek to qualify coatings thinned with "conforming" solvents such as chlorinated hydrocarbons. Other companies have sought to approve latex-based coatings even with the knowledge that such materials require that they ignore the drying rate specifications and the chemical resistance or durability during those critical first days after application. There is an increasing use of durable water-borne and water reducible coatings which are, in fact, free of so-called "keying agent" or "coalescing agent" solvents. Finally, there is a resurgence of interest in solvent-free coatings such as powder and radiation-cure, which would probably not have reached such research intensity were it not for the air, water, and toxicity legislation at the state and federal levels.

The wood coating industry can be separated into two categories: flat stock coating and the coating of three-dimensional objects—each having different requirements with respect to application technique. Coating of flat stock is usually done on a continuous coating line of some type, and more complicated three-dimensional objects such as furniture, usually require spray application and batch drying. The kitchen cabinet industry uses nitrocellulose (N/C) for the high end, or conversion varnish/conversion lacquer for the bulk of its finishing needs. Conversion varnishes and lacquers contain up to 50% of urea or melamine formaldehyde resins which are only partially cured at the low temperatures allowable for wood surfaces; thus there is a significant level of free formaldehyde emanating from the coating throughout its useful life.

Formaldehyde has been designated by the EPA and California Air Resources Board as a suspected carcinogen. The N/C must be replaced to meet VOC regulations and the uncured urea/melamine formaldehyde-containing coatings replaced to meet the very low parts per million (ppm) of "free formaldehyde" requirements.

Water-based products have been introduced to much of the lumber industry to replace the high VOC materials previously used on plywood, hardboard, particle board, and

regenerated wood-finger jointed wood products. These products, however, are a full step down in performance properties such as hardness, toughness, adhesion, solvent and stain resistance. Their second weakness is in energy consumption; i.e., they require long time/temperature exposure for curing. They may or may not meet the free formaldehyde requirements that become more exacting each year.

The South Coast Air Quality Management District (SCAQMD) "Rule 1136 - Wood Products Coatings" regulates the allowable VOC concentration of wood coating products. It is estimated that SCAQMD-wide compliance with these rules would reduce VOC emissions by about 18 mg (20 tons) per day through a gradual shift from high to low VOC coatings. By phasing in low VOC coatings, instead of requiring installation of add-on controls, SCAQMD believes that furniture manufacturers will be able to comply with SCAQMD's rules without increased costs. Rule 1136 currently limits the VOC content to 680 g/l of clear topcoat and 600 g/l of pigmented coating, less water and less exempt compounds. A final compliance limit of 275 g/l[5]. for both clear topcoats and pigmented coatings is currently set to take effect by July 1, 1996.

AeroVironment Inc. and Adhesive Coating Co. (ADCO) are teaming on this EPA contract No. 68-D5-0128 entitled, "Development and Demonstration of a Zero-VOC/Zero-HAP Wood Furniture Coating System." A new zero-VOC wood coating which consists of an epoxy component and an amine curing component was developed by Adhesive Coatings Co. (ADCO), San Mateo, California. The two-component system exhibits extremely fast-drying, good sealer and sanding characteristics that are required for a sanding sealer coating. The complete absence of organic solvents means that this new coating system is not only less hazardous to use but emits practically no VOCs; and therefore, it does not significantly contribute to air pollution. This new two-component water-based epoxy wood coating system has the potential to set a new standard and therefore replace a very significant share of current organic solvent systems in use. This new zero-VOC coating's high gloss and excellent chemical resistance properties are ideal for the wood manufacturing industry for flat stock, particle, chip, and wood floor products, spray primers for door skins, and finishing systems for interior wood products such as furniture and kitchen cabinets. This material can be manufactured using readily available raw materials and standard resin manufacturing equipment without polluting the atmosphere.

1.1.1 STATEMENT OF PROJECT OBJECTIVES

The objective of this project is to develop a new zero-VOC/zero-HAP wood coating system through continuing research, formulation adjustments, and application testing. Efforts will be dedicated to develop a new, promising zero-VOC/zero-HAP wood coating system that is sufficiently mature for demonstration to wood furniture manufacturers. The high-value-added coating products will be developed using existing technical know-how and data related to the new water-based epoxy technologies. In addition to the research and development of a new zero-VOC/zero-HAP wood coating system, on-site demonstration and workshops will be included as part of this program.

ADCO currently holds patents on some of these formulations. The Center for Emissions Research and ADCO were awarded an initial contract (No. S-C93101) from EPA and SCAQMD to develop work on a no-VOC wood topcoat. Under this contract, ADCO's coatings were reformulated, and performance characteristics and emission testing were conducted. The resulting topcoat showed excellent performance characteristics in terms of adhesion, gloss value, dry time, hardness, level of solvents, and chemical/stain resistance. The VOC contents of both the clear topcoat and the white pigmented topcoat were less than 10 g/l. This coating's performance and properties in finished material compared favorably with other low-VOC waterborne wood coatings. However, low-/no-VOC "stain" and "sealer" wood coatings need to be developed so that a complete low-/no-VOC wood coating system will be available for public use. It would be desirable to determine the compatibility of coating components (a stain and a sealer) to go with the topcoat. Follow-on work would focus on adapting this new zero-VOC coating to other furniture lines. Some effort might also be needed to combine this new coating with other components (stains and sealers) to comprise complete low-/no-VOC coating systems. The transition to widespread application across the United States will require extended technology transfer efforts.

1.2 EXPERIMENTAL DESIGN

The tasks will be directed toward making the necessary formulation adjustments to the initially developed topcoat that will meet the following target parameters:

(a) The product will contain VOCs less than the detection limit as measured by ASTM Method D2369-90 et seq.

(b) The product will contain no HAP by EPA Method 311 or equivalent (GC-MS).

(c) The product will have a high-gloss value (90-100 range as measured on an 80-degree gloss meter) as well as a wide variety of other sheens.

(d) The product will "dry to the touch" in 10 minutes or less and "dry to handle" in 15 minutes or less for temperatures in the range of 45 to 60 degrees Celsius with a relative humidity not to exceed 80%.

(e) The coating will have a demonstrated pencil hardness of at least 2H.

(f) The product will have a demonstrated chemical, water stain and chip resistance comparable to other products for the same general use.

(g) The product will have a demonstrated adhesion/scrape/mar resistance comparable to other products for the same general use.

(h) The product will have a demonstrated resistance to checking, crazing and cracking comparable to other products for the same general use.

(i) The product will have a demonstrated UV resistance comparable to other products for the same general use.

(j) The product will have a demonstrated printing/blocking resistance comparable to other products for the same general use.

The number of tests for the topcoat and sanding sealer are listed in Table 1-1.

TABLE 1-1. TOTAL NUMBER OF TESTS FOR THE TOP COAT AND SANDING SEALER

MEASUREMENT	METHOD	TOPCOAT	SANDING SEALER	COMPLETED SYSTEM	DEMONSTRATION
Volatile organic compounds (VOC)					
Volatile content	ASTM-D-2369	2	2	-	-
Density	ASTM-D-1475	2	2	-	-
Water content	ASTM-D-3792 (GC)	2	2	-	-
Hazardous Air Pollutant (HAP)	EPA Method 311, or equivalent (GC/MS)	2	2	-	-
Pencil Hardness	ASTM D 3363	20	-	6	-
Gloss	ASTM D 523-89	20	-	6	300
Parallel groove adhesion	ASTM D 3359-90	-	-	6	-
Adhesion/Scrape/Mar	ASTM D 2197	-	-	6	-
Hot/Cold check	ASTM D 1211-87	-	-	6	-
Household Chemical	ASTM D 1308-87	20	-	6	-
Dry time	ASTM D 1640-83	20	20	-	300
Water resistance	ASTM D 1308-87	20	-	-	-
UV resistance	ASTM G53-88	20	-	-	-
Printing/Block	ASTM D 2091-88	20	-	-	-

1.3 SCHEDULE

Quality assurance activities will focus on coating performance tests. All coating performance tests will be conducted in Phase. The proposed project schedule is shown as follows:

NO-VOC/NO-HAP WOOD FURNITURE COATING PROJECT SCHEDULE

	Year	1995				199 6								
Task List	Project Month	9	10	11	12	1	2	3	4	5	6	7	8	9
PHASE I														
TASK 1	A - VOC ANALYSIS B - HAP ANALYSIS C - GLOSS VALUE D - DRY TIME E - HARDNESS F - RESISTANCE													
TASK 2	SANDING SEALER DEVELOPMENT													
TASK 3	QA/QC PROCEDURES													
TASK 4	REFINISHING REPAIR PROCEDURES													
TASK 5	REPORTING													
PROJECT MANAGEMENT														
PHASE II														
TASK 1	DEMONSTRATION													
TASK 2	COST ANALYSIS													
TASK 3	MARKETING PLAN & SEMINARS													
TASK 4	CUSTOMER SURVEY													
TASK 5	ENV. IMPACT ANALYSIS													
TASK 6	REPORTING													
PROJECT MANAGEMENT														

LEGEND: AEROVIRONMENT
ADCO

1.4 PROJECT ORGANIZATION AND RESPONSIBILITY

The organization chart for this project is presented in Figure 1-1.

Dr. Eddy Huang, Principal Air Quality Engineer, Ph.D., M.S., and B.S., Chemical Engineering, 11 years' experience. Dr. Huang is the project manager for this zero-VOC/zero-HAP coating system development and demonstration program.

Mr. Charles Botsford, P.E. Principal Air Quality Engineer. M.S. and B.S., Chemical Engineering. 12 years' experience. Mr. Charles Botsford is the assistant project manager for this program.

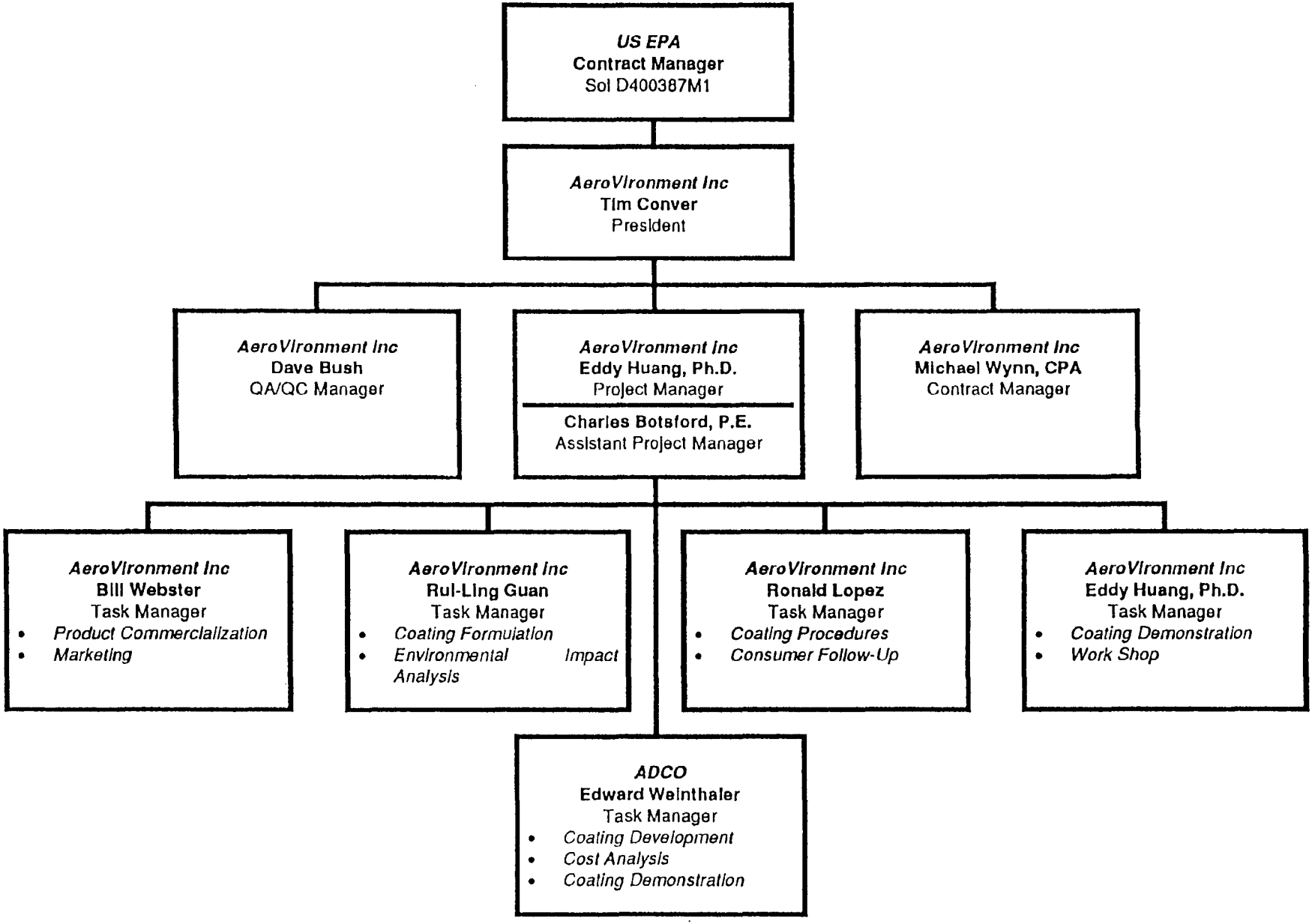
Mr. David Bush, Air Quality Scientist. B.S., Atmospheric Science. 15 years' experience. Mr. David Bush is assigned the task of managing the Quality Assurance and Quality Control program. He is responsible for overseeing the QAPP and the QA/QC activities for the project.

Ms. Ruiling Guan, Air Quality Engineer. M.S., Chemical Engineering, B.S., Polymer Science and Engineering, 6 years' experience. Ms. Guan is an air quality engineer and will be responsible for environmental impact analysis and coating formulation tasks.

Mr. Ronald Lopez, Hazardous Waste Engineer. M.S., Chemical Engineering, B.S., Chemistry, 12 years' experience. Mr. Lopez is the task manager for coating procedures and consumer follow-up.

Mr. William Webster, B.S., Business and B.A., Economics, 22 years' experience. Mr. Webster is the Head of Commercialization for AeroVironment. Mr. Webster is responsible for overseeing the commercialization of products, intellectual property, and new business areas. Mr. Webster is also responsible for assisting with new product design, development and management, and raising outside capital. Mr. Webster will assist with the marketing survey and commercialization task.

Figure 1-1. Zero VOC/Zero HAP Wood Furniture Coating System Project Organizational Chart



SECTION 2

QUALITY ASSURANCE OBJECTIVES

2.1 DETERMINING QUALITY ASSURANCE OBJECTIVES

The quality assurance (QA) objectives are to ensure that all laboratory investigation activities meet the requirements of federal, state and local air pollution agencies, and to ensure that reported data are valid, accurate, precise, complete, and representative of actual coating VOC, HAP contents, and coating properties and performance characteristics.

2.2 QUANTITATIVE QUALITY ASSURANCE OBJECTIVES: PRECISION, ACCURACY, METHOD DETECTION LIMIT AND COMPLETENESS

The project accuracy, precision, and completeness goals are based on the following EPA definition of these terms:

- Accuracy is the degree of agreement between the measurement or the average of measurements for a parameter and the accepted reference or true value. It is a combination of the bias and precision in a measurement system.

- Precision is a measure of mutual agreement among individual measurements of the same property.

- Completeness is a measure of the amount of valid data obtained from a measurement system compared to the amount that was expected to be obtained.

Specific QA objectives for this program are included in Table 2-1. Accuracy of the data will be obtained from the results of laboratory performance tests and internal audits. Precision will be determined using duplicate measurements. Any data that fail to satisfy the QA objectives listed in Table 2-1 will be rejected and corrective action will be taken.

2.3 QUALITATIVE QUALITY ASSURANCE OBJECTIVES: COMPARABILITY AND REPRESENTATIVENESS

The project comparability and representativeness are based on the following EPA definition of these terms:

- Comparability is the degree to which one data set can be compared to another.

- Representativeness is the degree to which a sample or group of samples is indicative of the population being studied.

Our contractor will use consistent methods and standards from reliable sources for all analyses and tests to ensure that adequate comparability is achieved.

Our contractor will take enough samples for all analyses and tests to ensure that adequate representativeness is achieved.

TABLE 2-1. QA OBJECTIVES FOR ACCURACY, PRECISION, AND COMPLETENESS

MEASUREMENT	METHOD	MDL	ACCURACY	PRECISION	COMPLETENESS
Volatile organic compounds (VOC)					
Volatile content	ASTM-D-2369	-	-	≤1.6%	90
Density	ASTM-D-1475	-	-	≤2.9%	90
Water content	ASTM-D-3792 (GC)	-	-	≤2.9%	90
Hazardous Air Pollutant (HAP)	EPA Method 311, or equivalent (GC/MS)	5 ppb ~ 100 ppb	+/- 25%	≤25%	90
Pencil Hardness	ASTM D 3363	-	-	+/- 1 Pencil Grade	90
Gloss	ASTM D 523-89	-	-	+/- 5%	90
Parallel groove adhesion	ASTM D 3359-90	-	-	+/- 10%	90
Adhesion/Scrape/Mar	ASTM D 2197	-	-	+/- 0.1 grams	90
Hot/Cold check	ASTM D 1211-87	-	-	+/- 20%	90
Relative Humidity		-	-	+/- 5%	
Temperature		-	-	+/- 2 °F	
Time		-	-	+/- 30 seconds	
Household Chemical	ASTM D 1308-87	-	-	+/- 10%	90
Dry time	ASTM D 1640-83	-	-	+/- 5%	90
Water resistance	ASTM D 1308-87	-	-	+/- 1 Pencil Grade [a]	90
UV resistance	ASTM G53-88	-	-	+/- 15%	90
Printing/Block	ASTM D 2091-88	-	-	+/- 20%	90

[a] Measure change in pencil hardness one hour after recovery from water.

SECTION 3

SAMPLING PROCEDURES

3.1 SAMPLING PROCEDURES

The following liquid sampling procedures for VOC and HAP analysis are based on SCAQMD Laboratory Sampling and Analytical Procedure 304[6]. and EPA Method 311[7].

- Prior to sample collection, the coating will be mixed to ensure that a representative, homogeneous sample is obtained.

- Each component of two-component coatings will be sampled separately. The component mix ratios will be submitted to the analytical laboratory.

- Select a sample collection container with at least 25 percent greater capacity than the paint can in which the sample is to be transported. Make sure both sample containers are clean and dry. Using clean, long-handled tongs, turn the sample collection container upside down and lower it into the coating reservoir. The mouth of the sample collection container should be at approximately the midpoint of the reservoir. Turn the sample collection container over and slowly bring it to the top of the coating reservoir. Rapidly pour the collected coating into the paint can, filling it completely to avoid any loss of volatiles due to volatilization into the headspace. Return any unused coating to the reservoir or dispose as appropriate.

- Once the sample is collected, place the paint can on a firm surface and place the lid on it, hammer the lid in place with a rubber mallet. Use clean towels or rags to remove all residual coating material from the outside of the paint can.

- Affix a sample label clearly identifying the sample, date collected, and person collecting the sample.

3.2 SAMPLE CUSTODY

3.2.1 Chain-of-Custody Record

A chain-of-custody form will be filled out for each sampling period. It will document sample possession from the time of collection to the time of receipt by the laboratory. It will include:

- sample identification number
- date and time of sampling

- analyses required
- sampling team members' names and appropriate signatures
- shipping time and date

A sample of the Chain-of-Custody form is shown in Table 3-1.

3.2.2 SAMPLE PACKAGING AND SHIPPING

When sample collection is complete, the samples will be placed in boxes for shipment to the laboratory. All shipping boxes will contain a chain-of-custody form. Shipping labels will be attached to the boxes and protected from water with clear label-protection tape. In case the shipping label is separated from the boxes during transport, the "to" and "from" addresses will appear somewhere on the outside of the container other than on the shipping label. The transported boxes will be securely closed with strapping tape. The samples will be shipped at ambient temperature using express courier services (the coating formulator does not recommend packaging and shipping the coating samples in a refrigerated container).

TABLE 3-1. Chain-of-Custody Form.

Send analysis results to:
AeroVironment Inc.
222 E. Huntington Drive
Monrovia, CA 91016
Attn: Eddy Huang
818-357-9980 ext. 397
FAX: 818-359-9628

Send samples to:
Weck Laboratories, Inc.
14859 East Clark Avenue
Industry, CA 91745
Attn: Alfredo E. Pierri
818-336-2139

Analyses required: ASTM Method D2369-90 for VOCs

Sample ID	Sample Date	Sample Time

AeroVironment Air Quality Engineer:
Samples Relinquished by:_____

Laboratory:
Samples Received by:_____

Shipping Date:_____
Shipping Time:_____

Send original chain-of-custody record with samples to analysis laboratory.

SECTION 4

ANALYTICAL PROCEDURES AND CALIBRATION

4.1 SAMPLE ANALYSES

Analysis of VOC and HAP samples will be performed using the following:

(a) VOC Analysis: Volatile content by ASTM-D-2369[8], density by ASTM-D-1475[9], water content by ASTM-D-3792 (GC)[10], and calculation by ASTM-D-3960 section 8.2.4.

(b) HAP Analysis: HAP content by EPA Method 311[7] - Analysis of Hazardous Air Pollutant Compounds in Paints and Coatings by Direct Injection into a Gas Chromatograph or equivalent (gas chromatograph-mass spectrometry).

Coating properties and performance characteristics will be quantified using the following methods.

Gloss

The methods described in ASTM D 523-89[11] and the BYK Tri-gloss meters instructions will be followed. This evaluation will be performed on all substrates. The gloss will be measured 24 hours after spraying.

Parallel Groove Adhesion

The method described by ASTM D3359-90[12] will be followed. This evaluation method is used to establish whether the adhesion of the coating is at an adequate level. A cutting tool which cuts parallel grooves will be used to cut a cross-hatch pattern in the coating down to the substrate. After the parallel grooves are cut into the coating, tape will be applied over the grooves and removed. After the tape is removed, the cross-hatch will be inspected through a magnifying glass and rated against the following standards:

Gt 0/5 B The edge of the cuts are completely smooth; none of the squares of the lattice are attached.

Gt 1/4 B Small flakes of the coating are detached at intersections; less than 5% of the area is affected.

Gt 2/3 B Flakes of the coating are detached along the edges and/or at intersections of cuts; the area affected is 5 to 15% of the lattice.

Gt 3/2 B The coating has flaked along the edges and/or parts of the squares; the area affected is 15 to 35% of the lattice.

Gt 4/1 B The coating has flaked along the edges of cuts in large ribbons and/or parts of the squares or whole squares have detached; the area affected is 35 to 65% of the lattice.

Gt 5/0 B Flaking and detachment is greater than 65% of the squares of the lattice.

Adhesion/Scrape/Mar

A modified version of ASTM D 2197[13] will be followed. This evaluation method covers the determination of the adhesion of coatings when applied to smooth, flat panels. After complete curing, the adhesion/scrape/mar resistance will be determined by pushing the panels beneath a round stylus or loop that is loaded in increasing amounts until marring of the coating is detected. This method has been found useful in differentiating the degree of hardness of coatings. This evaluation is more useful in providing relative ratings for a series of coated panels exhibiting significant differences in mar resistance.

In the methods described by ASTM D 2197, the adhesion/scrape/mar resistance is determined by scratching on a coated smooth, flat panel, and then inspecting the panel surface for flakes.

In the modified version of ASTM D 2197, which will be used for this program, the adhesion/scrape/mar resistance is determined by pushing the panels beneath a round stylus or loop that is loaded in increasing amounts until marring of the coating is detected. This modified method is machine controlled and repeatable.

Hot/Cold Check

The methods described by ASTM D 1211-87, as modified to be used with the Atlas XR-35-A Weatherometer, will be followed. This evaluation method includes the determination of the resistance to checking, crazing and cracking of coatings applied to wood or plywood substrates when subjected to sudden changes from high to low temperatures.

The following evaluation method will be used. The solid oak panels will be put in the Atlas XR-35-A Weatherometer, the system will be started at 70°F and the temperature will be raised to 120°F within a 15-minute period. The temperature will be held for one hour and then be lowered to minus 5°F within a 30-minute period and held for one hour. The temperature will then be returned to 70°F within a 15-minute period. This sequence of operations comprised one cycle, which takes three hours to complete. The cycle will be repeated eight times: a total of 24 hours to complete. The relative

humidity will be maintained at 50% during the test. The test will be run without UV radiation.

In the methods described by ASTM D 1211-87, wood panels are heated in an oven, and cooled in a refrigerator.

In the modified version of ASTM D 1211-87, which will be used for the Hot/Cold Check for this program, an Atlas XR-35-A Weatherometer, which automatically controls the relative humidity, temperature, and heating and cooling rate, is used to heat and cool the wood panels.

Household Chemicals

The methods described by ASTM D 1308-87[14] will be followed. This evaluation method covers the determination of the effects household chemicals have on organic finishes. These include any objectionable alternation of the surface, such as discoloration, change in gloss, blistering, softening, swelling, loss of adhesion, or special phenomena.

Resistance to various liquids used in the home is an important characteristic of organic finishes. These test methods provide the means by which the relative performance of coating systems may be evaluated. The open spot evaluation method will be used. That is, the agent will be placed directly on the surface and allowed to sit uncovered for one hour. The surface will then be examined for a reaction to the chemical.

Water Resistance

The methods described by ASTM D 1308-87[14] will be followed. This evaluation method covers determination of the effect cold distilled water would have on organic finishes. The immersion evaluation method will be used. That is, the wood panels will be immersed to a depth of 50% in cold distilled water contained in beakers at 20°C for 24 hours. The surface will then be examined for change in pencil hardness one hour after recovery from water.

Dry Time

A modified version of ASTM D 1640-83[15] will be followed. This evaluation method covers the determination of the various stages and rates of film formation in the drying or curing of organic coatings. All drying tests will be conducted in a well-ventilated room, free from direct drafts, dust, products of combustion, laboratory fumes and under diffused light. All measurements will be made at a temperature of 45 to 60 degree Celsius and a relative humidity of not to exceed 80% with the coated panels in a horizontal position while drying.

The following evaluation method will be used.

Dry-to-touch time—Lightly rub across the test film surface with a clean finger. The film is considered dry-to-touch when it no longer adheres to the finger and does not rub up appreciably. The test intervals will be 0.5 minutes.

Dry-to-handle time—The test panels will be placed in a horizontal position at a height such that when the thumb is placed on the film, the arm of the operator is in a vertical line from the wrist to the shoulder. The operator will bear down on the film with the thumb, exerting the maximum pressure of the arm, at the same time turning the thumb through an angle of 90° in the plane of the film. The film is considered dry-to-handle when there is no loosening, detachment, wrinkling, or other evidence of distortion of the film. The test intervals will be 0.5 minutes.

Deviation from standard conditions:

In the methods described by ASTM D 1640-83, all measurements should be made at a temperature of 23 ± 2°C and 50 ± 5% relative humidity. All drying tests on the Zero-VOC, Zero-HAP wood furniture coating will be made at a temperature of 45 to 60 degree Celsius and a relative humidity of not to exceed 80% with the coated panels in a horizontal position while drying.

UV Resistance

The methods described by ASTM G53-88[16] will be followed. This evaluation method covers the simulation of the deterioration caused by sunlight and water as rain or dew by using fluorescent ultraviolet (UV) and condensation apparatus. The test specimens will be mounted in the specimen racks with the surfaces facing the lamp. The test specimens will then be exposed to the repeated UV/condensation cycles under the selected test conditions (4 hour UV at 50°C/4 hour condensation at 50°C) until a certain number of total test hours or certain UV/water degradation has occurred in the test specimen. The test specimens will be inspected daily.

Pencil Hardness

The methods described by ASTM D 3363-74[17] will be followed. This evaluation method covers the determination of the film hardness of an organic coating on a substrate in terms of drawing leads or pencil leads of known hardness.

The following evaluation method will be used: The coated panel will be placed on a level, firm, horizontal surface. Starting with the hardest lead, the operator will hold the pencil or lead holder firmly with the lead against the film at a 45° angle (pointing away from the operator) and will push away from the operator. The operator will then exert

sufficient uniform pressure downward then forward either to cut or scratch the film or to crumble the edge of the lead. The gouge hardness (pencil hardness) will be determined by repeating the process down the hardness scale until a pencil is found that will not cut through the film for a stroke length of at least 1/8 in. (3 mm). The scratch hardness will be determined by continuing the process until a pencil is found that will not scratch the surface of the film.

Printing/Block

The printing and blocking evaluation will be conducted to evaluate the resistance of a coating to printing under conditions of packaging, shipping and warehousing as described in ASTM D 2091-88[18]. Those samples that are subjected to this evaluation will be placed under pressure for 16 to 18 hours after spraying.

Twenty-four hours after the spraying of the panel, a piece of cheesecloth and a block (usually a piece of wood) will be placed over a uniform area of the panel. Certain weight will be placed on the cheesecloth and block for a period of 18 hours at 73.5 ± 3.5°F (23 ± 2°C) and 50 ± 5% relative humility. The weight, applied to the surface area, will result in a pressure of 2 pounds per square inch. After 18 hours, the weight, block, and cloth will be removed. The panel surface will then be examined for impression of the fabric into the coated surface.

Laboratory analyses for VOC content will be performed by Weck Laboratories, Inc. in Industry, California, or other analytical laboratories certified by the South Coast Air Quality Management District. Laboratory analyses for HAP level will be performed by Applied P & Ch Laboratory (APCL) in Chino, California, or other analytical laboratories certified by the South Coast Air Quality Management District. Coating properties and characteristics will be performed by JH Associates in Anaheim, California, and Adhesive Coating Co. in San Mateo, California.

Attachment A contains the Standard Operating Procedures (SOPs) for VOC Analyses from Weck Laboratories, Inc., and the Quality Assurance Literature from APCL.

SECTION 5

DATA REDUCTION, VALIDATION, AND REPORTING

The objective of the data processing and validation effort is a quality assured data base containing the VOC, HAP and product characteristics data in a consistent format. The procedures that AeroVironment has implemented for data processing and validation ensure that reported data are valid. These procedures meet the requirements and guidelines of the U.S. EPA. Data processing procedures for this program are discussed below.

5.1 DATA REDUCTION

At the beginning of the project, before data are forwarded from the laboratories, AeroVironment will create a project database directory. This directory will contain information specific to the project.

The data will be entered into this data base directly, or uploaded onto AeroVironment's computer from a floppy disk provided by the analysis laboratory.

Data that are lost can be recovered either from the data logger printouts or from the floppy diskette backups.

The data will be processed using a personal computer and spreadsheet software. All data processing activities will be performed using a spreadsheet created specifically for this project. The following data for each sample will be forwarded from the laboratories:

- VOC concentrations
- HAP concentrations
- high gloss value as well as a wide variety of other sheens
- time for the product to "dry to the touch" for temperatures in the range of 45 to 60 degrees Celsius with a relative humidity not to exceed 80%
- time for the product to "dry to handle" for temperatures in the range of 45 to 60 degrees Celsius with a relative humidity not to exceed 80%
- pencil hardness of the coating
- chemical resistance of the coating
- water resistance of the coating
- printing resistance of the coating
- adhesion of the coating
- adhesion/scrape/mar resistance of the coating
- resistance to checking, crazing and cracking of the coatings
- UV resistance of the coating

5.2 DATA VALIDATION

All data produced by this project are reviewed before use. AeroVironment data validation procedures start with observations and reports made by the lab operator and continue with review and analysis of all logs, checklists and data.

All flagged or anomalous data are investigated. Unless there is substantial evidence that suspect data are erroneous, these data will be retained. AeroVironment's data processing procedures allow only the project's principal investigator (the project manager for this program) to invalidate data.

Most of the performance tests will be performed by JH Associates. JH Associates will report the test data to the principal investigator. Decisions about when performance tests should be repeated will be made between the test operator, John R. Hornung and the principal investigator, Eddy Huang.

5.3 DATA REPORT

A data report will be prepared by AeroVironment and sent to the U.S. EPA. The report will include a description of the measurements, average value of the measurements and standard deviations for all samples. Additionally, the data will be provided on a floppy disk in an IBM-PC format.

SECTION 6

INTERNAL QUALITY CONTROL CHECKS

Duplicate measurements will be made of all performance characteristics of the coating formula. If a comparison of the two measurements shows a measured difference outside of the precision goals for that measurement method (Table 2-1), corrective action will be taken and/or the measurements will be repeated.

The following summarizes additional quality control (QC) procedures that will be followed for this study.

Volatile Organic Compounds

- **Volatile Content**

We will follow the QC procedures described in ASTM-D-2369.

- **Density**

We will follow the QC procedures described in ASTM-D-1475. The density measurement method will be calibrated using freshly boiled deionized water at a specified temperature.

- **Water Content**

We will follow the QC procedures described in ASTM-D-3792(GC). One method blank will be analyzed for every 10 samples.

Hazardous Air Pollutants

The analytical laboratory will follow the QC procedures described in EPA Method 311 - Analysis of Hazardous Air Pollutant Compounds in Paints and Coatings by Direct Injection into a Gas Chromatograph or equivalent (gas chromatograph-mass spectrometry [GC/MS]). The GC/MS will be calibrated prior to sampling for potential target compounds across the working range for that compound using at least three NIST certified concentrations and a blank. A midpoint calibration check will be performed after every 10 samples and at the end of the analysis sequence. In addition, a method blank and a laboratory control sample will be analyzed with every batch of samples. Finally, a Matrix Spike sample and a Matrix Spike Duplicate sample will be analyzed after at least every 10 samples.

Field trip and system blanks will be collected during sampling and sent with the samples to the laboratory.

Performance Characteristics

Quality control for each of the following performance measurements will be obtained following the procedures presented in their respective ASTM method protocol:

- **Pencil Hardness** ASTM-D-3363
- **Gloss** ASTM-D-523-89
- **Parallel Groove Adhesion** ASTM-D-3359-90
- **Adhesion/Scrape/Mar** ASTM-D-2197
- **Hot/Cold Check** ASTM-D-1211-87
- **Household Chemical** ASTM-D-1308-87
- **Water Resistance** ASTM-D-1308-87
- **Dry Time** ASTM-D-1640-83
- **UV Resistance** ASTM-G-53-88
- **Printing/Blocking** ASTM-D-2091-88

SECTION 7

PERFORMANCE AND SYSTEM AUDITS

AeroVironment's Quality Assurance/Quality Control (QA/QC) department is a separately managed and operated subgroup of AeroVironment's Finance and Contracts Group, which reports directly to the Company's President. The QA/QC department maintains standards and personnel that are independent of those used by other subgroups of the Environmental Services Group. The Manager of the QA/QC department reports directly to the Contracts Manager, and is therefore not accountable to other subgroup project managers. For this project, the independence of QA personnel from routine project operations will be strictly maintained in order to ensure totally independent quality assessment of project results. Although not required by this contract, AeroVironment proposes a contract level QA/QC Program Plan which establishes the QA/QC requirements for each contract and the roles of all key management personnel.

AeroVironment will provide the personnel and materials required to carry out program system audits. AeroVironment's quality assurance department will perform system audits of each of the measurement laboratories. The U.S. EPA has established guidelines to assure the collection of accurate, complete, and precise data. A system audit verifies that relevant guidelines are being adhered to and that data of acceptable quality can be collected. It is a qualitative appraisal of the quality assurance/quality control system used for the total program.

During the system audit, the organization and operation of each of the laboratories are examined. The system audits will evaluate, where applicable, the instrument and measurement system operations, calibration procedures, preparation and storage of standards, QC checks (blanks and duplicates), chain-of-custody prtocols, data reduction methods and documentation procedures as compared with the procedures specified by the individual laboratories. A system audit checklist will be used when performing the system audit. This checklist documents audit findings and provides a standardized method for performing the system audit.

Upon completion of the system audits, the auditor will prepare a report detailing deficiencies found during the audits. In the report, he will, if necessary, recommend actions required to improve the project and to meet project data quality goals. Included in the report will be copies of the system audit checklist. Both the QA/QC manager and the project manager will receive the audit report.

SECTION 8

CALCULATION OF DATA QUALITY INDICATORS

8.1 DATA QUALITY INDICATORS

Precision

For duplicate measurements, precision is calculated as:

$$RPD = (y_1 - y_2) \times 100\% / [(y_1 + y_2) / 2]$$

where:

RPD = relative percent difference
y_1 = larger of the two observed values
y_2= smaller of the two observed values

For three or more replicates, precision is calculated as:

$$RSD = (s / y_{mean}) \times 100\%$$

where:

RSD = relative standard deviation
s = standard deviation
$y_{mean.}$ = mean of replicate analyses

Standard deviation will be calculated as:

$$s = \{ \sum [(y_i - y_{mean.})^2 / (n-1)] \}^{1/2}$$

$$y_{mean.} = (\sum y_i) / n$$

Where:

y_i = measured value of the ith sample
n = number of samples

Accuracy

Accuracy is frequently expressed in terms of percent recovery (%R) whether Standard Reference Materials (SRMs) or spiked samples (known concentrations of test materials added to samples) are used.

When SRMs are used, accuracy is expressed as follows:

$$\%R = 100\% \times (C_M/C_{SRM})$$

where:

%R = percent recovery
C_M = measured concentration of SRM
C_{SRM} = actual concentration of SRM

When matrix spikes are added to samples, %R is calculated as follows:

$$\%R = 100\% \times (C_s - C_u)/C_{sa}$$

where:

%R = percent recovery
C_s = measured concentration in spiked aliquot
C_u = measured concentration in unspiked aliquot
C_{sa} = actual concentration of spike added

Completeness

Completeness is calculated as follows for all measurements:

$$\%C = 100\% \times (V/T)$$

where:

%C = percent completeness
V = number of measurements judged valid
T = total number of measurements

8.2 VOC CONTENT

The VOC content of the sample expressed in grams VOC per liter of coating is calculated as follows:

$$\text{VOC, g/l (of coating)} = [(100\text{-}N\text{-}W) \times D_m] \times [100 - (W \times D_m) / D_w] \times 1000$$

where:

N = nonvolatile matter, %
W = percent water in sample, %

D_m = density of the sample, g/ml
D_w = density of water, g/ml, (D_w = 0.997 g/ml at 25°C

The VOC content of the sample expressed in grams VOC per liter of material is calculated as follows:

$$\text{VOC, g/l (of material)} = (100\text{-}N\text{-}W) \times D_m \times 10$$

SECTION 9

CORRECTIVE ACTION

Corrective action is initiated whenever a problem is identified. The goal of corrective action is to remedy any problem before the project or equipment and/or parameters drop below the desired accuracy, precision, or completeness.

The field and laboratory technicians are the primary individuals for identifying problems and initiating corrective action. Once a problem is identified, the person who found it will either remedy the problem, or will ask the project manager for assistance.

Whenever a problem is identified, the project manager is notified. A corrective action report is made each time a problem is found. The project manager is responsible for verifying that appropriate actions for maintaining the monitoring objective is performed.

SECTION 10

REFERENCES

1. Environmental Protection Agency (1994): AEERL Quality Assurance Procedures Manual for Contractors and Financial Assistance Recipients. Unnumbered EPA document.

2. Environmental Protection Agency (1991): Preparation Aids for the Development of Category III Quality Assurance Project Plans. EPA Document EPA-600/8-91-005.

3. Environmental Protection Agency (1980): Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans. EPA Document QAMS-005/80.

4. Huang, E. W., L. Watkins, and R. McCrillis (1993): Formulating Ultralow-VOC Wood Furniture Coatings, Modern Paint and Coatings, Volume 83, Number 12, 41-43.

5. South Coast Air Quality Management District (1996): Preliminary Staff Report for Proposed Amendments to Rule 1136 - Wood Products Coatings.

6. Choa, C.B. and S. Hom, South Coast Air Quality Management District (1991): Laboratory Methods of Analysis for Enforcement Samples. "Method 304-91, Determination of Volatile Organic Compounds (VOC) in Various Materials."

7. Environmental Protection Agency (undated): Method 311, "Analysis of Hazardous Air Pollutant Compounds in Paints and Coatings by Direct Injection into a Gas Chromatograph."

8. American Society for Testing and Materials: D-2369, "Standard Test Method for Volatile Content of Coatings."

9. American Society for Testing and Materials: D-1475, "Standard Test Method for Density of Paint, Varnish, Lacquer, and Related Products."

10. American Society for Testing and Materials: D-3792, "Standard Test Method for Water Content of Water-Reducible Paints by Direct Injection into a Gas Chromatograph."

11. American Society for Testing and Materials: D 523-89, "Standard Test Method for Specular Gloss".

12. American Society for Testing and Materials: D 3359-90, "Standard Test Method for Measuring Adhesion by Tape Test."

13. American Society for Testing and Materials: D 2197, "Standard Test Method for Adhesion of Organic Coatings by Scrape Adhesion."

14. American Society for Testing and Materials: D 1308-87, "Standard Test Method for Effect of Household Chemicals on Clear and Pigmented Organic Finishes."

15. American Society for Testing and Materials: D-1640-83, "Standard Test Method for Drying, Curing, or Film Formation of Organic Coatings at Room Temperature."

16. American Society for Testing and Materials: G 53-88, "Standard Practice for Operating Light- and Water-Exposure Apparatus (Fluorescent UV-Condensation Type) for Exposure of Nonmetallic Materials."

17. American Society for Testing and Materials: D-3363-74, "Standard Test Method for Film Hardness by Pencil Test."

18. American Society for Testing and Materials: D-2091-88, "Standard Test Method for Print Resistance of Lacquers."

ATTACHMENT A

Weck Laboratories SOP (Determination of Volatile Organic Content in Paints and Related Coatings).

Weck Laboratories, Inc. - Organic Section

Standard Operating Procedures ORG025.R02 Rev.07/94

Approved by: _____ Date: 7/21/94

Title: Determination of Volatile Organic Content(VOC) in Paints and Related Coatings.

1.0 Summary

1.1 This procedure describes the analysis of volatile organic content in paints and related coatings. The analysis consists of three parts: volatile content, density and water content. The VOC is calculated as grams per liter of paints or coatings.

2.0 Sample Collection, Preservation and Holding Times

2.1 Samples must be refrigerated at 4°C.

3.0 Apparatus

3.1 For Determination of Water Content

3.1.1 Gas Chromatograph: HP 5890.

3.1.2 Column: S5 from Alltech.

3.1.3 Detector: TCD @ 250 °C.

3.1.4 Data system: 486DX/50 mhz computer running HP 5595 Chemstation software.

3.1.5 Temperature program: 80 °C for 3 min. then to 220 °C @ 25 °C/min.

3.1.6 Reference gas: Helium @ 50 ml/min.

3.1.7 Carrier gas: Helium @ 20 psi.

3.1.8 Liquid Charging Device: Micro-syringe of 10 ul capacity.

3.1.9 Septum Sample Vials: 5-ml capacity with fluorocarbon-faced septa.

3.2 For Determination of Volatile Content

3.2.1 Forced Convection Oven: Cenco-Central Scientific Co.

3.2.2 Syringe: 5-ml capacity.

3.2.3 Aluminum Foil Dish: 58 mm in diameter by 18 mm high with a smooth bottom surface.

3.3 For Determination of Density

3.3.1 Pycnometer, Fisher.

3.3.2 Thermometer, graduated in 0.1°C.

3.3.3 Constant-Temperature Bath held at 25±0.1°C.

4.0 Reagents

4.1 Reagent grade chemicals shall be used in all test.

4.2 Organic-free water.

4.3 Carrier Gas: Helium of 99.995%.

4.4 N,N-Dimethyl formamide(DMF) from Fisher Scientific.

4.5 Isopropanol(IPA), analytical grade.

4.6 Toluene, analytical grade.

4.7 2-Ethoxyethyl Acetate.

5.0 Procedures

5.1 Determination of Density

5.1.1 Calibration of the Container: Determine the volume of the container at specified temperature by employing the following steps.

5.1.1.1 Clean and dry the container with solvents and bring it to constant weight (not exceed 0.001% of the weight of the container). Record the weight, M, in grams.

5.1.1.2 Fill the container with freshly boiled DI water at a temperature somewhat below that specified. Cap the container, leaving the overflow orifice open. Immediately remove excess overflowed water or water held in depressions by wiping dry with absorbent material. Avoid occluding air bubbles in the container.

5.1.1.3 Bring the container and contents to the specified temperature using the constant-temperature bath or room if necessary.

5.1.1.4 Remove the excess overflow by wiping carefully with absorbent material, avoiding wicking of water out of orifice, and immediately cap the overflow tube

5.1.1.4 (continued)
where such has been provided. Dry the outside of the container, if necessary, by wiping with absorbent material. Do not remove overflow that occurs subsequent to the first wiping after attainment of the desired temperature. Immediately weigh the filled container to the nearest 0.001% of its weight. Record this weight, N, in grams.

5.1.1.5 Calculate the container volume as follows:

$$V = (T - M)/p$$

where:
V = volume of container, ml.
T = weight of container and water, g.
M = weight of container, g.
p = absolute density of water at specified temperature, g/ml (see Table I).

5.1.1.6 Obtain the mean of at least three determinations.

5.1.2 Determination of density for samples

5.1.2.1 Repeat the steps in Section 5.1.1, substituting the sample for the DI water and a suitable nonresidual solvent for the acetone or alcohol. Record the weight of the filled container, W, and the weight of the empty container, w, in grams.

5.1.2.2 Calculate the density in grams per milliliter as follows:

$$D_s = (W - w)/V$$

where:
D_s = density, g/ml.

5.1.2.3 Calculate the density in pounds per gallon as follows:

$$D = (W - w)K/V$$

where:
D = density, lb/gal.
K = 8.3454.
V = volume of container, ml.

5.2 Determination of Volatile Content

5.2.1 Mix the sample, preferably on a mechanical shaker or roller, until homogeneous. If air bubbles become

5.2.1 (continued)
entrapped, stir by hand until the air has been removed.

5.2.2 Using a syringe, weigh to 0.1 mg, by difference, a specimen of 0.30±0.10 g for coatings believed to have a volatile content less than 40 weight% or a specimen of 0.5±0.10 g for coatings believed to have a volatile content greater than 40 weight%, into a tared aluminum foil dish into which has been added 3±1 ml of suitable solvent (normally water for water-reducible coatings, and toluene for solvent-reducible coatings). Note: In certain situations depending on the nature of the sample, the use of a pipet may be the best way to measure the sample. Add the specimen dropwise, shaking (swirling) the dish to disperse the specimen completely in the solvent. If the material forms a lump that cannot be dispersed, discard the specimen and prepare a new one. Similarly prepare a duplicate.

5.2.3 Heat the aluminum foil dishes containing the dispersed specimens in the forced convection oven for 60 min at 110°C ±5°C.

5.2.4 Remove the dishes from the oven, place immediately in a desiccator, cool to ambient temperature and weigh to 0.1 mg.

Note: If unusual decomposition or degradation of the specimen occurs during heating, the actual time and temperature used to cure the coating in practice may be substituted for the time and temperature specified in this method.

5.2.5 Calculate the percent volatile matter in the liquid coating as follows:

$$\text{Volatile matter, \%} = 100 - [((W_2 - W_1)/S) \times 100]$$

where:
W_1 = weight of dish.
W_2 = weight of dish plus specimen after heating.
S = weight of specimen.

5.2.6 The percent of nonvolatile matter in the coating may be calculated by difference as follows:

N = Nonvolatile matter, % = 100 - Volatile matter

5.3 Determination of Water Content

5.3.1 Determination of Relative Response Factor

5.3.1.1 Weigh about 0.2 g of water and 0.2 g of IPA to the nearest 0.1 mg into a septum vial. Add 2 ml of DMF

5.3.1.1 (continued)
to the vial and mix thoroughly.

5.3.1.2 Inject a 1 ul aliquot of the above solution onto the column and record the chromatogram. The retention order and approximate retention times after the air peak are (1) water, about 0.7 min; (2) IPA, about 2.8 min; and (3) DMF, about 7 min.

5.3.1.3 Inject the same size aliquot of DMF and IPA mixture, but without added water, as a blank. Note the area of the water peak in the blank.

5.3.1.4 Calculate the response factor for water as follows:

$$R = \frac{W_i \times (A_{H2O} - B)}{W_{H2O} \times A_i}$$

where:
R = response factor,
W_i = weight of IPA,
W_{H2O} = weight of the water,
A_i = area of IPA peak,
A_{H2O} = area of the water peak,
B = area of the water peak the blank.

5.3.2 Determination of Water Content in Samples

5.3.2.1 Weigh to the nearest 0.1 mg 0.6 g of water-reducible sample and 0.2 g of IPA into a septum vial. Add 2 ml of DMF into the vial. Seal the vial. Prepare a blank containing the IPA and DMF but no sample.

5.3.2.2 Shake the vials on a wrist action shaker for 15 min. To facilitate the settling of the solids allow the samples to stand for 15 min just prior to injection into the GC. Low speed centrifugation may also be used.

5.3.2.3 Inject a 1 ul sample of the supernatant from the prepared solutions onto the GC column. Record the chromatograms.

5.3.2.4 Measure the area of the water peak and the IPA internal standard peak. Calculate the percent water in samples as follows:

$$W = H2O,\% = \frac{A_{H2O} \times W_i \times 100}{A_i \times W_s \times R}$$

where:
A_{H2O} = area of water peak,

5.3.2.4 (continued)
A_i = area of IPA,
W_i = weight of IPA added,
W_s = weight of sample,
R = response factor determined in 5.3.1.4.

5.4 Calculations of VOC

5.4.1 The VOC content of the sample expressed in grams VOC per liter of coating is calculated as follows:

$$\text{VOC, g/L (of coating)} = \frac{(100-N-W) \times D_m}{100 - (W \times D_m)/D_w} \times 1000$$

where:
D_w = density of water, g/ml, (D_w=0.997 g/ml at 25°C).

5.4.2 The VOC content of the sample expressed in grams per liter of material is calculated as follows:

$$\text{VOC, g/L (of material)} = (100-N-W) \times D_m \times 10$$

6.0 Quality Control

6.1 Record the preparation of the standards.

6.2 Analyze one method blank per batch of samples or every 10 samples.

6.3 Analyze duplicate for all samples.

7.0 References:

7.1 EPA Method 24A
7.2 ASTM D 3960-81, published June 1981.
7.3 ASTM D 1475-60, October, 1980.
7.4 ASTM D 3792-79, October, 1980.
7.5 SCAQMD Method 304

TABLE 1 Absolute Density of Water, g/ml

°C	Density	°C	Density
15	0.999127	23	0.997566
16	0.998971	24	0.997324
17	0.998772	25	0.997072
18	0.998623	26	0.996811
19	0.998443	27	0.996540
20	0.998231	28	0.996260

APPENDIX B

COATING TECHNICAL DATA SHEETS AND MATERIAL SAFETY DATA SHEETS

TABLE OF CONTENTS

ADCO

CLEAR WOOD TOP COAT — PRODUCT DATA

Solvent Free / 2 Component Epoxy — (#WTC-96-RT4)

Product Description

This two component, high performance, water based wood top coat is a hard, durable, chemical and stain resistant interior wood coating that contains no organic solvents. This wood top coat is designed to be used with the companion Zero VOC Stain and Sanding Sealer.

Very low odor - no solvent smell
Non-flammable
Chemical and stain resistant
Bright, clear finish
Easily washed and cleaned
Surpasses all VOC air quality regulations

SPECIFICATIONS

Color: Clear
Finish: Glossy
Pot Life: 6 hours @ 70°F
Clean Up: Use warm, soapy water
Density: 8.85 #/gal (Mixed system)
Volume Solids: 33.7%
Weight Solids: 37.5%
Theor. Coverage @ 2 mils: 270 sq.ft/gal
Flash Point: >350°F
Shelf Life: >1 year
Dry Time @ 77°F & 50% RH, 3 mil film
- To Touch: 30 minutes
- To Recoat: 1 hour
- Light Traffic on Floors: 24 hours
- Full Cure: 1 week

Viscosity (Part A & B mixed) 25°C
- #3 spindle @ 12 rpm 500 cps

Usage:	Part A	Part B
By Weight	1.3	1.0
By Volume	1.2	1.0

Pencil Hardness: 2H
VOC: Coating 0 #/gal, 0 grams per liter
Material 0 #/gal, 0 grams per liter

Inter-coat Adhesion: Pass
KCMA A161.1 1990 Testing
Detergent & Water Resistance
Edge Test Pass
Hot Cold Check Pass
Stain Resistance: 24 Hours exposure
- Coffee
- Grape Juice
- Lemon Juice
- Orange Juice
- Olive Oil
- 100 proof alcohol
- Detergent
- Mustard (1 hour)
- Pine Sol
- Fantastic
- Simple Green
- Bleach
- Ketchup
- Distilled Water

MATERIAL SAFETY DATA SHEET

PRODUCT: WOOD TOP COAT - Part A (WTC-96-RT4A)

PART 1 - GENERAL INFORMATION

Manufacturer:
Adhesive Coatings Co.
2755 Campus Drive
San Mateo, CA 94403
(415) 571-7947

NPCA HMIS Rating

Health:	1
Flammability:	0
Reactivity:	1
Personal Protection:	D

Emergency Numbers: 1-800-424-9300 (Chemtrec)

Chemical Family:	Latex Paint
Generic Name:	Water Based Epoxy Paint
DOT Proper Shipping Name:	Water Based Paint, n.o.s.
DOT Hazard Class:	Not Regulated
Revision: 1 Date: 6/18/96	

PART 2 - Ingredients

Ingredient Name	CAS #	%weight	OSHA(pel)	ACGIH(tlv)
RESILEX™ Epoxy Polymer	025085-99-8	55%	N/A	N/A

PART 3 - PHYSICAL AND CHEMICAL DATA

VOC of Material: 0 grams/liter and 0 #/gal
VOC excluding water: 0 grams/liter and 0 #/gal
Boiling Point: 100°C
pH: 6.0 - 7.0
Volatile portion: 45.0 % wt
Freezing Point: 0°C
Specific Gravity: 1.09 @20°C
Viscosity: 1000 ± 50 cps
Solubility in water: Slight
Vapor Pressure: Negligible
Appearance and Odor: Milky white liquid/mild odor
Conditions and materials to avoid: High temperatures, oxidizing conditions.
Hazardous decomposition products: Acrid smoke, fumes, carbon monoxide/dioxide may be released upon decomposition.
Stability: Stable

PART 4 - FIRE AND EXPLOSION

Flash Point: > 212°C (Method: ISO 3679)
Autoignition temperature: N/DA
Flammable limits (%volume in air) Lower: N/DA Upper: N/DA
Fire and explosion hazards: Not-flammable
Extinguishing media: Dry chemical, CO_2, Water spray, Foam, Water fog.
Special firefighting procedures: Do not enter fire area without special protection. Fight fire from safe distance or protected location. Heat or impurities may increase temperature, build pressure, rupture closed containers spreading fire and increase the risk of burns and injuries. Use water spray/fog for cooling. Notify authorities if liquid enters sewer or public waters.

PART 5 - EMERGENCY AND FIRST AID

Inhalation: If overcome by exposure, remove victim to fresh air immediately. Give oxygen or artificial respiration as needed. Obtain emergency medical attention, prompt action is essential.
Eye Contact: In case of eye contact, immediately flush eyes with clean water for 20 - 30 minutes. Retract eyelids often. Obtain emergency medical attention if pain, blinking, tears, or redness persist.
Skin Contact: Remove contaminated clothing as needed. Wash skin thoroughly with mild soap and water. Flush with lukewarm water for 15 minutes. If sticky, use waterless hand cleaner first.
Ingestion: If large quantity is swallowed, give lukewarm water (1 pint) if victim is completely conscious and alert. Do not induce vomiting, risk of damage to lungs exceeds poisoning risk. Obtain emergency medical attention.
Emergency Medical Treatment: Treat symptomatically.

PART 6 - EFFECTS OF EXPOSURE

Routes of exposure:
Inhalation: This material is not expected to present an inhalation hazard at standard conditions due to its low volatility. However, overexposure to mists/aerosols may cause respiratory tract irritation such as coughing, shortness of breath, and mucus production.
Eye Contact: Potential route. May cause eye irritation. Symptoms may include tearing, blinking, redness and swelling.
Skin absorption: Potential route. Although no data was found for this product, the potential for skin absorption does exist.
Skin Irritation: Potential route. May produce skin irritation. May cause an allergic skin reaction in some individuals after repeated skin contact.
Ingestion: This material may be a health hazard if ingested in large quantities.
Medical conditions aggravated by exposure: No additional medical information found.

PART 7 - PROTECTIVE EQUIPMENT AND CONTROL MEASURES

Respiratory Protection: If this material is handled under mist forming conditions, use NIOSH/MSHA approved respiratory protection equipment.
Eye Protection: Eye protection such as chemical splash goggles and/or face shield must be worn when possibility exists for eye contact due to splashing or spraying, liquid, airborne particles, or vapor. Contact lenses should not be worn.
Skin Protection: Depending on the conditions for use, protective gloves, apron, boots, head, and face protection should be worn. This equipment should be cleaned after each use.
Engineering Controls: If handling results in mist or aerosol or vapor generation, local exhaust ventilation is recommended.
Other Hygienic Practices: Emergency eye wash fountains and safety showers should be available in the immediate vicinity of any potential exposure.
Other Work Practices: Use good personal hygiene. Wash hands before eating, drinking, smoking, or using the toilet facilities. Promptly remove soiled clothing and wash thoroughly before reuse. Shower after work using plenty of soap and water.

PART 8 - REACTIVITY DATA

Stability: Stable
Incompatibility: Strong bases and acids.
Hazardous polymerization: Will not occur.
Hazardous decomposition: Will not occur.

PART 9 - SPILL OR LEAK PROCEDURES

Avoid all personal contact. Take up with absorbent material. Scoop and vacuum up, place in closed container for disposal. Avoid dusting. Flush contaminated area with water. Dispose in accordance with federal, state, and local regulations.

PART 10 - STORAGE AND SPECIAL PRECAUTIONS

SPECIAL PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE:
Practice caution and personal cleanliness to avoid skin and eye contact. Avoid breathing vapors of heated material.

PART 11 - REGULATORY INFORMATION

None required for this product.

PART 12 - LABEL INFORMATION

FOR INDUSTRIAL USE ONLY!! Skin contact hazard. Eye and skin irritant. May cause allergic reaction. Avoid contact with eyes, skin, and clothing. Do not breath vapors or mist. Wash thoroughly after handling. Do not swallow. Prevent contact with food, chewing or smoking materials.

FIRST AID

EYES: Immediately flush with plenty of clean water

INHALATION: Remove to fresh air if effects occur. Consult a physician.

SKIN CONTACT: Wash thoroughly with mild soap and flowing water or shower.

INGESTION: Give fluids. Call a physician.

NOTE TO PHYSICIAN: No specific antidote. Supportive care. Treatment based on judgment of physician in response to reaction of the patient.

SPILLS

Avoid all personal contact. Take up with absorbent material. Shovel into closed container. Flush contaminated area with water. Dispose of collected materials in accordance with federal, state, and local regulations. Avoid breathing vapors of heated material.

DISCLAIMERS

Some of the information presented and conclusions drawn herein are from sources other than direct test data on the product itself. The information in this MSDS was obtained from sources which we believe are reliable. However, the information is provided without any warranty, express or implied, regarding its correctness. The conditions or methods of handling, storage, use and disposal of the product are beyond our control and may be beyond our knowledge. For this and other reasons, we do not assume responsibility and expressly disclaim liability for loss, damage, or expense arising out of or in any way connected with the handling, storage, use, or disposal of the product. This MSDS was prepared and is to be used only for this product. If the product is used as a component in another product, this MSDS information may not be applicable. This MSDS has been prepared in accordance with the requirements of the OSHA Hazard Communication Standard (29 CFR 1200).

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MATERIAL SAFETY DATA SHEET

PRODUCT: WOOD TOP COAT - PART B (WTC-96-RT4B)

PART 1 - GENERAL INFORMATION

Manufacturer:
Adhesive Coatings Co.
2755 Campus Drive
San Mateo, CA 94403
(415) 571-7947

NPCA HMIS Rating

Health:	1
Flammability:	0
Reactivity:	0
Personal Protection:	D

Emergency Numbers: 1-800-424-9300 (Chemtrec)

Chemical Family:	Polyamine
Generic Name:	Polyamine curing agent
DOT Proper Shipping Name:	Paint related materials, n.o.s.
DOT Hazard Class:	Not regulated

Revision: 1 Date: 6/18/96

PART 2 - Ingredients

Ingredient Name	CAS #	%weight	OSHA(pel)	ACGIH(tlv)
Tetraethylenepentamine (polyamine)	112-57-2	< 1%	N/A	N/A

PART 3 - PHYSICAL AND CHEMICAL DATA

VOC of Material: 0 grams/liter and 0 #/gal
VOC excluding water: 0 grams/liter and 0 #/gal
Volatile portion: 83.9 % wt
Specific Gravity: 1.02 @20°C
Solubility in water: Dilutable
Boiling Point: 100°C
pH: 10.8 - 11.2
Freezing Point: 0°C
Viscosity: 900 ± 50 cps
Vapor Pressure: Negligible
Appearance and Odor: Amber milky liquid / slight ammonia odor
Conditions and materials to avoid: High temperatures, oxidizing conditions.
Hazardous decomposition products: Acrid smoke, fumes, carbon monoxide/dioxide may be released upon decomposition.

PART 4 - FIRE AND EXPLOSION

Flash Point: > 250°C (Method: ISO 3679)
Autoignition temperature: N/DA
Flammable limits (%volume in air) Lower: N/DA Upper: N/DA
Fire and explosion hazards: Not-flammable
Extinguishing media: Dry chemical, CO_2, Water spray, Foam, Water fog.
Special firefighting procedures: Do not enter fire area without special protection. Fight fire from safe distance or protected location. Heat or impurities may increase temperature, build pressure, rupture closed containers spreading fire and increase the risk of burns and injuries. Use water spray/fog for cooling. Notify authorities if liquid enters sewer or public waters.

PART 5 - EMERGENCY AND FIRST AID

Inhalation: If overcome by exposure, remove victim to fresh air immediately. Give oxygen or artificial respiration as needed. Obtain emergency medical attention, prompt action is essential.
Eye Contact: In case of eye contact, immediately flush eyes with clean water for 20 - 30 minutes. Retract eyelids often. Obtain emergency medical attention if pain, blinking, tears, or redness persist.
Skin Contact: Remove contaminated clothing as needed. Wash skin thoroughly with mild soap and water. Flush with lukewarm water for 15 minutes. If sticky, use waterless hand cleaner first.
Ingestion: If large quantity is swallowed, give lukewarm water (1 pint) if victim is completely conscious and alert. Do not induce vomiting, risk of damage to lungs exceeds poisoning risk. Obtain emergency medical attention.
Emergency Medical Treatment: Treat symptomatically.

PART 6 - EFFECTS OF EXPOSURE

Routes of exposure:
Inhalation: This material is not expected to present an inhalation hazard at standard conditions due to its low volatility. However, overexposure to mists/aerosols may cause respiratory tract irritation such as coughing, shortness of breath, and mucus production.
Eye Contact: Potential route. May cause eye irritation. Symptoms may include tearing, blinking, redness and swelling.
Skin absorption: Potential route. Although no data was found for this product, the potential for skin absorption does exist.

Skin Irritation: Potential route. May produce skin irritation. May cause an allergic skin reaction in some individuals after repeated skin contact.
Ingestion: This material may be a health hazard if ingested in large quantities.
Medical conditions aggravated by exposure: No additional medical information found.

PART 7 - PROTECTIVE EQUIPMENT AND CONTROL MEASURES

Respiratory Protection: If this material is handled under mist forming conditions, use NIOSH/MSHA approved respiratory protection equipment.
Eye Protection: Eye protection such as chemical splash goggles and/or face shield must be worn when possibility exists for eye contact due to splashing or spraying, liquid, airborne particles, or vapor. Contact lenses should not be worn.
Skin Protection: Depending on the conditions for use, protective gloves, apron, boots, head, and face protection should be worn. This equipment should be cleaned after each use.
Engineering Controls: If handling results in mist or aerosol or vapor generation, local exhaust ventilation is recommended.
Other Hygienic Practices: Emergency eye wash fountains and safety showers should be available in the immediate vicinity of any potential exposure.
Other Work Practices: Use good personal hygiene. Wash hands before eating, drinking, smoking, or using the toilet facilities. Promptly remove soiled clothing and wash thoroughly before reuse. Shower after work using plenty of soap and water.

PART 8 - REACTIVITY DATA

Stability: Stable
Incompatibility: Strong bases and acids.
Hazardous polymerization: Will not occur.
Hazardous decomposition: Will not occur.

PART 9 - SPILL OR LEAK PROCEDURES

Avoid all personal contact. Take up with absorbent material. Scoop and vacuum up, place in closed container for disposal. Avoid dusting. Flush contaminated area with water. Dispose in accordance with federal, state, and local regulations.

PART 10 - STORAGE AND SPECIAL PRECAUTIONS

SPECIAL PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE:
Practice caution and personal cleanliness to avoid skin and eye contact. Avoid breathing vapors of heated material.

PART 11 - REGULATORY INFORMATION
TRANSPORTATION
Not regulated
California Proposition 65: NA

PART 12 - LABEL INFORMATION

FOR INDUSTRIAL USE ONLY!! Skin contact hazard. Eye and skin irritant.
May cause allergic reaction. Avoid contact with eyes, skin, and clothing. Do not breath vapors or mist. Wash thoroughly after handling. Do not swallow. Prevent contact with food, chewing or smoking materials.

FIRST AID

EYES: Immediately flush with plenty of clean water
INHALATION: Remove to fresh air if effects occur. Consult a physician.
SKIN CONTACT: Wash thoroughly with mild soap and flowing water or shower.
INGESTION: Give fluids. Call a physician.
NOTE TO PHYSICIAN: No specific antidote. Supportive care. Treatment based on judgment of physician in response to reaction of the patient.

ADCO

WOOD SANDING SEALER — PRODUCT DATA

Solvent Free / 2 Component Epoxy — (#WSS-96-25)

Product Description

This two component, clear sanding sealer is a fast drying sealer that provides a sandable surface for wood finishing that contains no organic solvents. This sanding sealer is designed to be used with the companion Zero VOC Stain and Top Coat.

Very low odor - no solvent smell
Non-flammable
Sandable
Fast drying
Surpasses all VOC air quality regulations

SPECIFICATIONS

Color: Clear
Finish: Matt
Pot Life: 6 hours @ 70°F
Clean Up: Use warm, soapy water
Density: 8.7 #/gal (Mixed system)
Volume Solids: 27.1%
Weight Solids: 30.1%
Theor. Coverage @ 1 mil: 435 sq.ft/gal
Flash Point: >350°F
Shelf Life: >1 year
Dry Time @ 77°F & 50% RH, 1 mil film
To Touch: 15 minutes
To Recoat: 20 minutes
VOC: Coating 0 #/gal, 0 grams per liter
Material 0 #/gal, 0 grams per liter

Viscosity #3 spindle @ 12 rpm 500 cps

Usage:	Part A	Part B
By Weight	1.0	2.3
By Volume	1.0	3.0

Detergent & Water Resistance
Edge Test Pass
Hot Cold Check Pass
Stain Resistance: 24 Hr exposure (w/top coat)
Coffee
Grape Juice
Lemon Juice
Orange Juice
Olive Oil
100 proof alcohol
Detergent
Mustard (1 hour)
Pine Sol
Fantastic
Simple Green
Bleach
Ketchup
Distilled Water

MATERIAL SAFETY DATA SHEET

PRODUCT: WOOD SANDING SEALER - PART A (WSS-96-25A)

PART 1 - GENERAL INFORMATION

Manufacturer:
Adhesive Coatings Co.
2755 Campus Drive
San Mateo, CA 94403
(415) 571-7947

NPCA HMIS Rating

Health:	1
Flammability:	0
Reactivity:	1
Personal Protection:	D

Emergency Numbers: 1-800-424-9300 (Chemtrec)

Chemical Family:	Latex Paint
Generic Name:	Water Based Epoxy Paint
DOT Proper Shipping Name:	Water Based Paint, n.o.s.
DOT Hazard Class:	Not Regulated
Revision: 1 Date: 6/18/96	

PART 2 - Ingredients

Ingredient Name	CAS #	%weight	OSHA(pel)	ACGIH(tlv)
RESILEX™ Epoxy Polymer	025085-99-8	55%	N/A	N/A

PART 3 - PHYSICAL AND CHEMICAL DATA

VOC of Material: 0 grams/liter and 0 #/gal
VOC excluding water: 0 grams/liter and 0 #/gal
Boiling Point: 100°C
pH: 6.0 - 7.0
Volatile portion: 45.0 % wt
Freezing Point: 0°C
Specific Gravity: 1.09 @20°C
Viscosity: 1000 ± 50 cps
Solubility in water: Slight
Vapor Pressure: Negligible
Appearance and Odor: Milky white liquid/mild odor
Conditions and materials to avoid: High temperatures, oxidizing conditions.
Hazardous decomposition products: Acrid smoke, fumes, carbon monoxide/dioxide may be released upon decomposition.
Stability: Stable

PART 4 - FIRE AND EXPLOSION

Flash Point: > 212°C (Method: ISO 3679)
Autoignition temperature: N/DA
Flammable limits (%volume in air) Lower: N/DA Upper: N/DA
Fire and explosion hazards: Not-flammable
Extinguishing media: Dry chemical, CO_2, Water spray, Foam, Water fog.
Special firefighting procedures: Do not enter fire area without special protection. Fight fire from safe distance or protected location. Heat or impurities may increase temperature, build pressure, rupture closed containers spreading fire and increase the risk of burns and injuries. Use water spray/fog for cooling. Notify authorities if liquid enters sewer or public waters.

PART 5 - EMERGENCY AND FIRST AID

Inhalation: If overcome by exposure, remove victim to fresh air immediately. Give oxygen or artificial respiration as needed. Obtain emergency medical attention, prompt action is essential.
Eye Contact: In case of eye contact, immediately flush eyes with clean water for 20 - 30 minutes. Retract eyelids often. Obtain emergency medical attention if pain, blinking, tears, or redness persist.
Skin Contact: Remove contaminated clothing as needed. Wash skin thoroughly with mild soap and water. Flush with lukewarm water for 15 minutes. If sticky, use waterless hand cleaner first.
Ingestion: If large quantity is swallowed, give lukewarm water (1 pint) if victim is completely conscious and alert. Do not induce vomiting, risk of damage to lungs exceeds poisoning risk. Obtain emergency medical attention.
Emergency Medical Treatment: Treat symptomatically.

PART 6 - EFFECTS OF EXPOSURE

Routes of exposure:
Inhalation: This material is not expected to present an inhalation hazard at standard conditions due to its low volatility. However, overexposure to mists/aerosols may cause respiratory tract irritation such as coughing, shortness of breath, and mucus production.
Eye Contact: Potential route. May cause eye irritation. Symptoms may include tearing, blinking, redness and swelling.
Skin absorption: Potential route. Although no data was found for this product, the potential for skin absorption does exist.
Skin Irritation: Potential route. May produce skin irritation. May cause an allergic skin reaction in some individuals after repeated skin contact.
Ingestion: This material may be a health hazard if ingested in large quantities.
Medical conditions aggravated by exposure: No additional medical information found.

PART 7 - PROTECTIVE EQUIPMENT AND CONTROL MEASURES

Respiratory Protection: If this material is handled under mist forming conditions, use NIOSH/MSHA approved respiratory protection equipment.
Eye Protection: Eye protection such as chemical splash goggles and/or face shield must be worn when possibility exists for eye contact due to splashing or spraying, liquid, airborne particles, or vapor. Contact lenses should not be worn.
Skin Protection: Depending on the conditions for use, protective gloves, apron, boots, head, and face protection should be worn. This equipment should be cleaned after each use.
Engineering Controls: If handling results in mist or aerosol or vapor generation, local exhaust ventilation is recommended.
Other Hygienic Practices: Emergency eye wash fountains and safety showers should be available in the immediate vicinity of any potential exposure.
Other Work Practices: Use good personal hygiene. Wash hands before eating, drinking, smoking, or using the toilet facilities. Promptly remove soiled clothing and wash thoroughly before reuse. Shower after work using plenty of soap and water.

PART 8 - REACTIVITY DATA

Stability: Stable
Incompatibility: Strong bases and acids.
Hazardous polymerization: Will not occur.
Hazardous decomposition: Will not occur.

PART 9 - SPILL OR LEAK PROCEDURES

Avoid all personal contact. Take up with absorbent material. Scoop and vacuum up, place in closed container for disposal. Avoid dusting. Flush contaminated area with water. Dispose in accordance with federal, state, and local regulations.

PART 10 - STORAGE AND SPECIAL PRECAUTIONS

SPECIAL PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE:
Practice caution and personal cleanliness to avoid skin and eye contact. Avoid breathing vapors of heated material.

PART 11 - REGULATORY INFORMATION

None required for this product.

PART 12 - LABEL INFORMATION

FOR INDUSTRIAL USE ONLY!! Skin contact hazard. Eye and skin irritant. May cause allergic reaction. Avoid contact with eyes, skin, and clothing. Do not breath vapors or mist. Wash thoroughly after handling. Do not swallow. Prevent contact with food, chewing or smoking materials.

FIRST AID

EYES: Immediately flush with plenty of clean water

INHALATION: Remove to fresh air if effects occur. Consult a physician.

SKIN CONTACT: Wash thoroughly with mild soap and flowing water or shower.

INGESTION: Give fluids. Call a physician.

NOTE TO PHYSICIAN: No specific antidote. Supportive care. Treatment based on judgment of physician in response to reaction of the patient.

SPILLS

Avoid all personal contact. Take up with absorbent material. Shovel into closed container. Flush contaminated area with water. Dispose of collected materials in accordance with federal, state, and local regulations. Avoid breathing vapors of heated material.

DISCLAIMERS

Some of the information presented and conclusions drawn herein are from sources other than direct test data on the product itself. The information in this MSDS was obtained from sources which we believe are reliable. However, the information is provided without any warranty, express or implied, regarding its correctness. The conditions or methods of handling, storage, use and disposal of the product are beyond our control and may be beyond our knowledge. For this and other reasons, we do not assume responsibility and expressly disclaim liability for loss, damage, or expense arising out of or in any way connected with the handling, storage, use, or disposal of the product. This MSDS was prepared and is to be used only for this product. If the product is used as a component in another product, this MSDS information may not be applicable. This MSDS has been prepared in accordance with the requirements of the OSHA Hazard Communication Standard (29 CFR 1200).

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MATERIAL SAFETY DATA SHEET

PRODUCT: WOOD SANDING SEALER - PART B (WSS-96-25B)

PART 1 - GENERAL INFORMATION

Manufacturer:
Adhesive Coatings Co.
2755 Campus Drive
San Mateo, CA 94403
(415) 571-7947

NPCA HMIS Rating

Health:	1
Flammability:	0
Reactivity:	1
Personal Protection:	D

Emergency Numbers: 1-800-424-9300 (Chemtrec)

Chemical Family:	Polyamine /LATEX BLEND
Generic Name:	Polyamine curing agent
DOT Proper Shipping Name:	Paint related materials, n.o.s.
DOT Hazard Class:	Not regulated

Revision: 1 Date: 6/18/96

PART 2 - Ingredients

Ingredient Name	CAS #	%weight	OSHA(pel)	ACGIH(tlv)
RESILINK™ B-2003 (polyamine)	170904-70-8	1.18%	N/A	N/A

PART 3 - PHYSICAL AND CHEMICAL DATA

VOC of Material: 0 grams/liter and 0 #/gal
VOC excluding water: 0 grams/liter and 0 #/gal
Volatile portion: 80.89 % wt
Specific Gravity: 1.03 @20°C
Solubility in water: Dilutable
Boiling Point: 100°C
pH: 9.5 - 10.0
Freezing Point: 0°C
Viscosity: 900 ± 50 cps
Vapor Pressure: Negligible
Appearance and Odor: Amber milky liquid / slight ammonia odor
Conditions and materials to avoid: High temperatures, oxidizing conditions.
Hazardous decomposition products: Acrid smoke, fumes, carbon monoxide/dioxide may be released upon decomposition.

PART 4 - FIRE AND EXPLOSION

Flash Point: > 250°C (Method: ISO 3679)
Autoignition temperature: N/DA
Flammable limits (%volume in air) Lower: N/DA Upper: N/DA
Fire and explosion hazards: Not-flammable
Extinguishing media: Dry chemical, CO_2, Water spray, Foam, Water fog.
Special firefighting procedures: Do not enter fire area without special protection. Fight fire from safe distance or protected location. Heat or impurities may increase temperature, build pressure, rupture closed containers spreading fire and increase the risk of burns and injuries. Use water spray/fog for cooling. Notify authorities if liquid enters sewer or public waters.

PART 5 - EMERGENCY AND FIRST AID

Inhalation: If overcome by exposure, remove victim to fresh air immediately. Give oxygen or artificial respiration as needed. Obtain emergency medical attention, prompt action is essential.
Eye Contact: In case of eye contact, immediately flush eyes with clean water for 20 - 30 minutes. Retract eyelids often. Obtain emergency medical attention if pain, blinking, tears, or redness persist.
Skin Contact: Remove contaminated clothing as needed. Wash skin thoroughly with mild soap and water. Flush with lukewarm water for 15 minutes. If sticky, use waterless hand cleaner first.
Ingestion: If large quantity is swallowed, give lukewarm water (1 pint) if victim is completely conscious and alert. Do not induce vomiting, risk of damage to lungs exceeds poisoning risk. Obtain emergency medical attention.
Emergency Medical Treatment: Treat symptomatically.

PART 6 - EFFECTS OF EXPOSURE

Routes of exposure:
Inhalation: This material is not expected to present an inhalation hazard at standard conditions due to its low volatility. However, overexposure to mists/aerosols may cause respiratory tract irritation such as coughing, shortness of breath, and mucus production.
Eye Contact: Potential route. May cause eye irritation. Symptoms may include tearing, blinking, redness and swelling.
Skin absorption: Potential route. Although no data was found for this product, the potential for skin absorption does exist.

Skin Irritation: Potential route. May produce skin irritation. May cause an allergic skin reaction in some individuals after repeated skin contact.
Ingestion: This material may be a health hazard if ingested in large quantities.
Medical conditions aggravated by exposure: No additional medical information found.

PART 7 - PROTECTIVE EQUIPMENT AND CONTROL MEASURES

Respiratory Protection: If this material is handled under mist forming conditions, use NIOSH/MSHA approved respiratory protection equipment.
Eye Protection: Eye protection such as chemical splash goggles and/or face shield must be worn when possibility exists for eye contact due to splashing or spraying, liquid, airborne particles, or vapor. Contact lenses should not be worn.
Skin Protection: Depending on the conditions for use, protective gloves, apron, boots, head, and face protection should be worn. This equipment should be cleaned after each use.
Engineering Controls: If handling results in mist or aerosol or vapor generation, local exhaust ventilation is recommended.
Other Hygienic Practices: Emergency eye wash fountains and safety showers should be available in the immediate vicinity of any potential exposure.
Other Work Practices: Use good personal hygiene. Wash hands before eating, drinking, smoking, or using the toilet facilities. Promptly remove soiled clothing and wash thoroughly before reuse. Shower after work using plenty of soap and water.

PART 8 - REACTIVITY DATA

Stability: Stable
Incompatibility: Strong bases and acids.
Hazardous polymerization: Will not occur.
Hazardous decomposition: Will not occur.

PART 9 - SPILL OR LEAK PROCEDURES

Avoid all personal contact. Take up with absorbent material. Scoop and vacuum up, place in closed container for disposal. Avoid dusting. Flush contaminated area with water. Dispose in accordance with federal, state, and local regulations.

PART 10 - STORAGE AND SPECIAL PRECAUTIONS

SPECIAL PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE:
Practice caution and personal cleanliness to avoid skin and eye contact. Avoid breathing vapors of heated material.

PART 11 - REGULATORY INFORMATION

TRANSPORTATION
Not regulated
California Proposition 65: NA

PART 12 - LABEL INFORMATION

FOR INDUSTRIAL USE ONLY!! Skin contact hazard. Eye and skin irritant.
May cause allergic reaction. Avoid contact with eyes, skin, and clothing. Do not breath vapors or mist. Wash thoroughly after handling. Do not swallow. Prevent contact with food, chewing or smoking materials.

FIRST AID

EYES: Immediately flush with plenty of clean water
INHALATION: Remove to fresh air if effects occur. Consult a physician.
SKIN CONTACT: Wash thoroughly with mild soap and flowing water or shower.
INGESTION: Give fluids. Call a physician.
NOTE TO PHYSICIAN: No specific antidote. Supportive care. Treatment based on judgment of physician in response to reaction of the patient.

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ADCO

WOOD STAIN BASE — PRODUCT DATA

Solvent Free — (#WST-96-3)

Product Description

This fast drying stain base can be colored with a variety of pigments, dyes and tints into a wide variety of hues, colors and stains and contains no organic solvents. This stain base is designed to be used with the companion Zero VOC Sanding Sealer and Top Coat.

Very low odor - no solvent smell
Non-flammable
Sandable
Fast drying
Surpasses all VOC air quality regulations

SPECIFICATIONS

Color: Clear
Finish: Matt
Pot Life: 6 hours @ 70°F
Clean Up: Use warm, soapy water
Density: 8.67 #/gal (Mixed system)
Volume Solids: 17.8%
Weight Solids: 19.8%
Theor. Coverage @ 1 mil: 285 sq.ft/gal
Flash Point: >350°F
Shelf Life: >1 year
Dry Time @ 77°F & 50% RH, 1 mil film
To Touch: 15 minutes
To Recoat: 20 minutes
Edge Test: Pass
VOC: Coating 0#/gal, 0 grams per liter
Material 0 #/gal, 0 grams per liter

MATERIAL SAFETY DATA SHEET

PRODUCT: WOOD STAIN BASE (WST-96-3)

PART 1 - GENERAL INFORMATION

Manufacturer:
Adhesive Coatings Co.
2755 Campus Drive
San Mateo, CA 94403
(415) 571-7947

NPCA HMIS Rating

Health:	1
Flammability:	0
Reactivity:	0
Personal Protection:	D

Emergency Numbers: 1-800-424-9300 (Chemtrec)

Chemical Family:	Latex Paint
Generic Name:	Water Based Stain
DOT Proper Shipping Name:	Water Based Paint, n.o.s.
DOT Hazard Class:	Not Regulated
Revision: 1 Date: 6/18/96	

PART 2 - Ingredients

Ingredient Name	CAS #	%weight	OSHA(pel)	ACGIH(tlv)
Acrylic Polymer	N/A	15%	N/A	N/A

PART 3 - PHYSICAL AND CHEMICAL DATA

VOC of Material: 0 grams/liter and 0 #/gal
VOC excluding water: 0 grams/liter and 0 #/gal
Boiling Point: 100°C
pH: 6.0 - 7.0
Volatile portion: 80.1 % wt
Freezing Point: 0°C
Specific Gravity: 1.03 @20°C
Viscosity: 500 ± 50 cps
Solubility in water: Slight
Vapor Pressure: Negligible
Appearance and Odor: Milky white liquid/mild odor
Conditions and materials to avoid: High temperatures, oxidizing conditions.
Hazardous decomposition products: Acrid smoke, fumes, carbon monoxide/dioxide may be released upon decomposition.
Stability: Stable

PART 4 - FIRE AND EXPLOSION

Flash Point: > 212°C (Method: ISO 3679)
Autoignition temperature: N/DA
Flammable limits (%volume in air) Lower: N/DA Upper: N/DA
Fire and explosion hazards: Not-flammable
Extinguishing media: Dry chemical, CO_2, Water spray, Foam, Water fog.
Special firefighting procedures: Do not enter fire area without special protection. Fight fire from safe distance or protected location. Heat or impurities may increase temperature, build pressure, rupture closed containers spreading fire and increase the risk of burns and injuries. Use water spray/fog for cooling. Notify authorities if liquid enters sewer or public waters.

PART 5 - EMERGENCY AND FIRST AID

Inhalation: If overcome by exposure, remove victim to fresh air immediately. Give oxygen or artificial respiration as needed. Obtain emergency medical attention, prompt action is essential.
Eye Contact: In case of eye contact, immediately flush eyes with clean water for 20 - 30 minutes. Retract eyelids often. Obtain emergency medical attention if pain, blinking, tears, or redness persist.
Skin Contact: Remove contaminated clothing as needed. Wash skin thoroughly with mild soap and water. Flush with lukewarm water for 15 minutes. If sticky, use waterless hand cleaner first.
Ingestion: If large quantity is swallowed, give lukewarm water (1 pint) if victim is completely conscious and alert. Do not induce vomiting, risk of damage to lungs exceeds poisoning risk. Obtain emergency medical attention.
Emergency Medical Treatment: Treat symptomatically.

PART 6 - EFFECTS OF EXPOSURE

Routes of exposure:
Inhalation: This material is not expected to present an inhalation hazard at standard conditions due to its low volatility. However, overexposure to mists/aerosols may cause respiratory tract irritation such as coughing, shortness of breath, and mucus production.
Eye Contact: Potential route. May cause eye irritation. Symptoms may include tearing, blinking, redness and swelling.
Skin absorption: Potential route. Although no data was found for this product, the potential for skin absorption does exist.
Skin Irritation: Potential route. May produce skin irritation. May cause an allergic skin reaction in some individuals after repeated skin contact.
Ingestion: This material may be a health hazard if ingested in large quantities.
Medical conditions aggravated by exposure: No additional medical information found.

PART 7 - PROTECTIVE EQUIPMENT AND CONTROL MEASURES

Respiratory Protection: If this material is handled under mist forming conditions, use NIOSH/MSHA approved respiratory protection equipment.
Eye Protection: Eye protection such as chemical splash goggles and/or face shield must be worn when possibility exists for eye contact due to splashing or spraying, liquid, airborne particles, or vapor. Contact lenses should not be worn.
Skin Protection: Depending on the conditions for use, protective gloves, apron, boots, head, and face protection should be worn. This equipment should be cleaned after each use.
Engineering Controls: If handling results in mist or aerosol or vapor generation, local exhaust ventilation is recommended.
Other Hygienic Practices: Emergency eye wash fountains and safety showers should be available in the immediate vicinity of any potential exposure.
Other Work Practices: Use good personal hygiene. Wash hands before eating, drinking, smoking, or using the toilet facilities. Promptly remove soiled clothing and wash thoroughly before reuse. Shower after work using plenty of soap and water.

PART 8 - REACTIVITY DATA

Stability: Stable
Incompatibility: Strong bases and acids.
Hazardous polymerization: Will not occur.
Hazardous decomposition: Will not occur.

PART 9 - SPILL OR LEAK PROCEDURES

Avoid all personal contact. Take up with absorbent material. Scoop and vacuum up, place in closed container for disposal. Avoid dusting. Flush contaminated area with water. Dispose in accordance with federal, state, and local regulations.

PART 10 - STORAGE AND SPECIAL PRECAUTIONS

SPECIAL PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE:
Practice caution and personal cleanliness to avoid skin and eye contact. Avoid breathing vapors of heated material.

PART 11 - REGULATORY INFORMATION

None required for this product.

PART 12 - LABEL INFORMATION

FOR INDUSTRIAL USE ONLY!! Skin contact hazard. Eye and skin irritant.

May cause allergic reaction. Avoid contact with eyes, skin, and clothing. Do not breath vapors or mist. Wash thoroughly after handling. Do not swallow. Prevent contact with food, chewing or smoking materials.

FIRST AID

EYES: Immediately flush with plenty of clean water

INHALATION: Remove to fresh air if effects occur. Consult a physician.

SKIN CONTACT: Wash thoroughly with mild soap and flowing water or shower.

INGESTION: Give fluids. Call a physician.

NOTE TO PHYSICIAN: No specific antidote. Supportive care. Treatment based on judgment of physician in response to reaction of the patient.

SPILLS

Avoid all personal contact. Take up with absorbent material. Shovel into closed container. Flush contaminated area with water. Dispose of collected materials in accordance with federal, state, and local regulations. Avoid breathing vapors of heated material.

DISCLAIMERS

Some of the information presented and conclusions drawn herein are from sources other than direct test data on the product itself. The information in this MSDS was obtained from sources which we believe are reliable. However, the information is provided without any warranty, express or implied, regarding its correctness. The conditions or methods of handling, storage, use and disposal of the product are beyond our control and may be beyond our knowledge. For this and other reasons, we do not assume responsibility and expressly disclaim liability for loss, damage, or expense arising out of or in any way connected with the handling, storage, use, or disposal of the product. This MSDS was prepared and is to be used only for this product. If the product is used as a component in another product, this MSDS information may not be applicable. This MSDS has been prepared in accordance with the requirements of the OSHA Hazard Communication Standard (29 CFR 1200).

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