Evaluation of Waterborne Contact Adhesives for the Store Fixture Industry

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ABSTRACT

This paper presents the results of an evaluation of waterborne contact adhesives for attaching laminates to 45-lb-density particleboard. The evaluation site, like many similar manufacturing sites, currently uses solvent-borne contact adhesives for its lamination applications. Replacement of solvent-borne products could significantly reduce volatile organic compound (VOC) emissions and result in achieving environmental compliance while maintaining the production of a high-quality end product for laminating manufacturers. Three waterborne contact adhesives and one solvent-borne contact adhesive, serving as the control, were tested during a full-scale onsite evaluation at a store fixture manufacturing facility. Subjective evaluations of adhesive performance were made for each waterborne adhesive and compared to the performance of the currently used control adhesive. The quantity of adhesive used during application was measured, and samples of each adhesive will be analyzed for VOC content. From preliminary information, VOC emissions and cost estimates were made. In addition, a temperature-exposure test and a peel strength evaluation will be conducted to predict the performance and longevity of the waterborne adhesives as compared to the control adhesive. Results from the peel strength evaluation are not yet complete. Preliminary results show that selected waterborne contact adhesives evaluated performed as well as the control. All of the alternative adhesives had substantially lower applied VOC emissions as compared to the control adhesive.

INTRODUCTION

Solvent emissions to the atmosphere are the most common waste streams from contact adhesive applications, specifically those operations involving lamination. Solvents can represent more than 80 weight percent of these adhesives. Some solvents commonly used in formulating contact adhesives are hexane, methyl ethyl ketone (MEK), methylene chloride, and toluene, all of which are both VOCs and hazardous air pollutants (HAPs).[1]

Contact adhesives are generally defined as adhesives that are dry to the touch in a relatively short period of time and that instantaneously adhere to themselves upon contact.[2] These adhesives are used for laminating high-pressure laminates and low-pressure laminates to various substrates. They are fast-bonding adhesives used to manufacture kitchen cabinets, household and office furniture, and store fixtures. During assembly, both the laminate and substrate surfaces are coated with a contact adhesive and allowed to cure by air-drying, forced air-drying, or applying heat through an external source. The laminate and substrate are then pressed together manually or mechanically using a rotary press or nip roller to form a final bond.[3]

Many facilities in the laminating industry are looking for alternatives to replace currently used high-solvent-containing contact adhesives that can meet local, State, and Federal regulations. These facilities are interested in identifying alternative contact adhesives that not only meet regulations but also perform as well as, or better than, the currently used contact adhesives.

Project Objectives

This research project evaluated the performance, economics, and emission reduction potential of low-VOC waterborne contact adhesive formulations for manual laminating operations in assembling store fixtures. The evaluation was designed to show whether these waterborne contact adhesives perform as well as, or better than, a currently used solvent-borne contact adhesive and to show whether these products emit lower quantities of VOCs and/or HAPs in laminating operations. Participants in this evaluation include representatives from the U.S. Environmental Protection Agency's (EPA's) Air Pollution Prevention and Control Division (APPCD), Research Triangle Institute (RTI), a store fixture manufacturing facility, four contact adhesive suppliers, and one independent testing laboratory.

The primary objective of this evaluation project was to determine if three waterborne contact adhesives could achieve performance levels equivalent to, or exceeding that of, a currently used solvent-borne contact adhesive while emitting lower VOCs and/or HAPs. Two secondary objectives of this research project were to (1) determine the relative cost of using each alternative contact adhesive as compared to the currently used control, and (2) estimate the emission reduction potential from the use of each alternative contact adhesive. Required data for these secondary objectives included measurement of the quantity of adhesive used per unit area and the VOC content of each adhesive.

RTI evaluated commercially available contact adhesives during a full-scale simulated laminating operation. Each adhesive was applied to several pairs of test boards and finishes, or laminates, before laminating the two pieces to each other. Adhesive performance was evaluated based on application parameters, such as the total time it took to apply and drying time of each adhesive; temperature and percent relative humidity were recorded during adhesive application. Then, after allowing an approximately 24-h dry time, samples were cut from the laminated boards and evaluated using the following tests/factors:

- Onsite subjective peel test
- Offsite cyclic temperature-exposure test
- Offsite peel strength evaluation (not yet completed).

In addition, VOC content of each adhesive will be measured offsite, and the results will be used with adhesive usage data to calculate applied VOC emissions. Product density, weight percent solids, quantity of applied adhesive, and cost data, provided by technical data sheets from each adhesive manufacturer, were used to estimate relative cost data for each adhesive product. RTI will analyze, in triplicate, samples of each adhesive to confirm the product density, weight percent solids, and VOC content; however, at the time this paper was written, these results were not available.

Facility Operations

The evaluation facility has been operating as a custom manufacturer of retail store fixtures since October 1992. Their manufacturing space is approximately 22,000 ft^2 (2,044 m^2). The facility operates 8 hours per day, 5 days per week, 260 days per year with 27 employees.

Manufacture of retail store fixtures involves the forming and attachment of several types of finishes, or laminates, to particleboard or medium-density fiberboard substrates. Examples of finish materials used to make store fixtures include vinyl, top-coated papers, melamine-impregnated papers, and high-pressure laminates. The primary raw materials used at this facility consist of industrial-grade particleboard, medium-density fiberboard, and various finishes. Examples of retail store fixtures include refund counters, layaway department counters, and fitting rooms and stands for sunglass rollers. Approximately 98 percent of the laminating activities performed at the evaluation site are done in-house. Their manufacturing process has five main operations: substrate/laminate cutting, machining, edgebanding, laminating, and custom building. Two of these processes, edgebanding and laminating, require the use of adhesives and are described below.

Adhesive Applications

Edgebanding of boards is conducted on a machine operated by two persons: one person feeds cut boards into the machine, and the other person unloads and stacks the boards after they have been edgebanded. Rolls of edgeband made of polyvinyl chloride, or high-pressure laminate, mostly noncontoured, are placed on the automatic band feeder. The edgeband is then attached to the edge of cut boards with a hot melt polyvinyl acetate (PVAc) glue. After the boards are removed from the edgebander, one to four operators hand-file the edges of the board until they are smooth.

Currently, both PVAc glues and solvent-borne contact adhesives are used to attach edgebanding to contoured surfaces manually. The facility is in the process of converting their manual edgebanding operation to an automated system using PVAc adhesives in place of the currently used solvent-borne contact adhesive. Because they expect to make this conversion within the year, edgebanding adhesive applications were not a part of this evaluation.

The focus of this evaluation was on the application of laminates to 45-lb-density particleboard of relatively large surface area (4 ft^2 [0.186 m^2]). This process typically requires two operators. One operator cleans the surfaces of the substrate and laminate and applies two coats of contact adhesive to one side of the substrate and to the opposing side of the laminate. This operator uses a conventional air spray gun to spray apply a solvent-borne contact adhesive pumped from a 55-gal (208L) drum. (English units are typically used to describe commonly used materials and supplies in the lamination industry and will be used throughout the rest of this paper.) The two coats of contact adhesive are allowed to air-dry after each application. Then, the second operator attaches the laminate to the substrate by pressing the two surfaces firmly together and using a hand-held, 2-in. (5.08 cm)-diameter roller as a final press. The formed piece is allowed to air-dry for about 24 hours.

EXPERIMENTAL

This section describes materials and methods used to evaluate the waterborne contact adhesives as compared to the control adhesive.

Products Tested

Raw Materials - Adhesives. Three alternative contact adhesives and the currently used control adhesive were evaluated. Selection of alternative contact adhesives was based on the ability of each to meet the following criteria:

- Contain less than 540 g/L VOC
- Applicable to Formica topping or laminating
- Commercially available
- Vendor willingness to provide samples of, and technical information on, adhesives.

Two of the three contact adhesives were single-component, waterborne adhesives, and one was a two-component, waterborne adhesive. The control was a solvent-borne adhesive (see Table 1).

For the evaluation, project engineers estimated that approximately 1 to 2 gal (3.79 to 7.57 L) of adhesive would be used. Therefore, one 5-gal (18.95L) container of each adhesive was requested from each vendor. Each adhesive was assigned an identification (ID) number and labeled to simplify compilation of test data into a database for future analysis. This ensured data quality control and protected the identities of participating suppliers.

Table 1. Contact Adhesives Evaluated [a]

	Adhesive identification			
Property	**Adhesive 1**	**Adhesive 2**	**Adhesive 3**	**Control**
Generic description	Waterborne, two-component	Waterborne, single-component	Waterborne, single-component	Solvent-borne, single-component
Volatiles	Toluene, methanol	Toluene	Toluene	Acetone, n-hexane, hexane isomers, toluene
Volatile content, g/L	< 60	70-75	43	623
Solids, weight percent	47-51	45	45	17.5
Resin base	Polychloroprene	NA	NA	Polychloroprene and phenol
Density, lb/gal (g/mL)	8.9-9.3 (1.07-1.12)	9.2 (1.10)	8.98 (1.08)	6.3 (0.76)
Dry time, min	0.25-60	30	15-30	15

NA = Not available.
[a] Properties taken from material safety data sheets (MSDSs) and/or technical data sheets for each adhesive. Each adhesive was supplied by a different adhesive manufacturer.

Raw Materials - Substrate and Laminate Type. The substrate used in this evaluation was a 45-lb-density particleboard. Typically, the facility receives substrates in units, each containing 35 sheets 4 ft wide by 10 ft long by ¾ in. thick (1.22 m x 3.04 m x 1.9 cm). Four sheets were taken from one unit and cut into ten 4 ft by 1 ft (0.76m) by ¾ in. sheets. This provided 40 test boards for the evaluation.

The laminate applied to each 4 ft by 1 ft by ¾ in. board was Formica, taken from a common lot and cut to dimensions slightly larger than the substrate. Laminate is always cut larger than the substrate to which it is applied so that an even edge can be achieved after cutting away excess laminate. Each test board and laminate were labeled before adhesive application.

Measurements and Evaluations

The evaluation facility selected an operator for this evaluation. The operator had 5 years of experience using conventional air spray technology to spray solvent-borne adhesives and no experience using high-volume, low-pressure (HVLP) technology to spray adhesives. Efforts were made to meet manufacturer recommendations for spray equipment settings and handling for each adhesive.

Subjective evaluation of test samples was conducted at the facility shortly after adhesive application. Test samples for exposure testing were packaged and shipped to RTI's Analytical and Chemical Sciences (ACS) research laboratory and placed in an incubator for cyclic, temperature-exposure testing. The remaining test samples were packaged and shipped to SGS US Test Corporation, in Fairfield, New Jersey, for peel strength evaluation of adhesive bonds.

Subjective Evaluation. Approximately 24 hours after air-drying, a facility representative in charge of quality assurance (QA) performed a subjective peel test on test boards from each adhesive set. This test is normally conducted at the facility as part of their routine QA check of assembled products and consists of manually peeling back the laminate from the substrate to observe how easily it can be pulled back and to count the number of strands or legs of adhesive that remained on the substrate. This evaluation is unconventional but is a required pass/fail test for the facility. During and after this test, RTI used a simple questionnaire to evaluate the representative's response for the pass/fail of each test board.

Temperature-Exposure Testing at RTI. A temperature-exposure test for sample boards was conducted at RTI's ACS research laboratory. Upon its arrival at RTI, each sealed can containing four board samples each was inspected. These cans contained either control samples or test samples and were preconditioned for 7 days at 50 ± 2 percent relative humidity and 73.4 ± 1.8 °F (23 ± 1°C) immediately before testing. The control samples remained in the control environment throughout the test.

The preconditioned samples were subjected to two 24-h exposure cycles, cold then hot, at conditions specified in Table 2. At the end of the cold cycle, the exposed samples were photographed. At the end of the entire exposure period, the exposed test samples were allowed to reach room temperature. After the exposed test samples reached room temperature, the evaluation facility's QA representative performed a subjective peel test and compared their performance with the performance of the matched controlled samples. Although this test has been completed, data were not available in time for inclusion in this paper.

Table 2. Exposure Test Conditions

Exposure cycle	Temperature, °F [a]	Moisture conditions
Cold	32	Freezer, uncontrolled humidity
Hot	120	Open, uncontrolled humidity

[a] °C = (°F - 32 °F)/(1.8 °F/°C).

Peel Testing at SGS US Test Corporation. The SGS US Test Corporation in Fairfield, New Jersey, is conducting a peel test on each of the five test samples from test board 10 of each adhesive. The laboratory uses American Society for Testing and Materials (ASTM) standard test method D 903-93. The facility is modifying the test slightly. Test method D 903-93 is designed for a flexible laminate that can be pulled back at a 180 ° angle. However, because the Formica laminate used in this test is not that flexible, SGS US Test Corporation is making the necessary adjustments and conducting this test by pulling the flexible laminate back at a 90 ° angle.

Physical Properties of Each Adhesive. The physical properties of each adhesive are essential in calculating the VOC emissions and relative cost estimates. To determine these properties, samples were taken from each adhesive and will be analyzed in RTI's laboratory using standard test methods.

Samples of each adhesive were obtained before the evaluation began. Before adhesive application, an operator thoroughly mixed each 5-gal (18.75 L) container of adhesive. After the containers were opened, the operator took three grab samples from the center of each container using 500-mL (17-fl-oz) amber sample jars with sealing lids from VWR Scientific. These samples were packaged and shipped to RTI's analytical laboratory and will be analyzed in triplicate for total volatiles, water content, and density of each adhesive. The analyses will be conducted according to the standard test methods:

- VOC content — EPA Method 24, Determination of volatile matter content, water content, density, volume solids, and weight solids of surface coatings
- Nonvolatile content — ASTM D 1489-93, Standard test method for nonvolatile content of aqueous adhesives
- Water content — ASTM D 3792-79, Standard test method for water content of water-reducible paints by direct injection into a gas chromatograph
- Density — ASTM D 1875-90, Standard test method for density of adhesives in fluid form

RESULTS

This evaluation took place at a store fixture manufacturing facility over a 3-day period. The ambient air temperature and percent relative humidity were monitored and measured during adhesive application. The average temperature was 24°C (75°F), and the average relative humidity was 47 percent. These conditions fell within the application specifications of each adhesive manufacturer.

Adhesive Performance and Usage

The primary objective of this evaluation was to evaluate the performance of the alternative waterborne contact adhesives. To help meet this objective, the actual dry time of each adhesive and the total application time, or process time, for adhesive application to each assembly were calculated. The time it takes for an applied adhesive to dry affects not only the performance of the laminated assembly but also the time it takes an operator to put together that assembly.

The actual dry times for the control and Adhesive 2 were similar at 24 and 28 minutes, respectively. The dry time for Adhesive 1, 5 minutes, was less than the dry time for the control. Adhesive 3 had the longest dry time of 47 minutes. All of the other adhesives dried more slowly than the manufacturers' recommended values. Table 3 lists the actual dry time, recommended dry time, and total application time for each adhesive.

Table 3. Average Dry Times and Total Application Time, in Minutes

	Actual dry time	Recommended dry time [a]	Total application time
Adhesive 1	5	<1 to 120	6
Adhesive 2	28	15	31
Adhesive 3	47	30	48
Control	24	15	26

[a] Assumes acceptable temperature and percent relative humidity during application.

This facility defines total application time as the sum of the total time it takes an operator to apply adhesive to both substrates, allow each substrate to dry, and laminate the substrates together for further processing. The total application time for Adhesive 1 was approximately four times better than the control (see Table 3). Total application times for Adhesives 2 and 3 were greater than the control. This information is useful in predicting the effect on the production rate at the facility. Since application time is short (approximately 1 to 2 minutes per assembly), dry time has the greatest effect on a facility's capability to increase its production rate. Accordingly, Adhesive 1 had a superior dry time compared with the other alternative waterborne adhesives and to the solvent-borne control. The dry time for Adhesive 2 was considered acceptable by the facility.

The secondary objective of this evaluation was to estimate VOC emissions and relative costs of each adhesive, as applied. To make these estimates, the average quantity of each adhesive used to cover laminate assemblies was recorded, and the quantity of dry solids, both actual and theoretical, was calculated from vendor information (see Table 4). Although an attempt was made to apply each adhesive per its manufacturer's instructions, the resulting actual dry grams for each waterborne adhesive applied was two to three times greater than the theoretical value.

The reasons for the actual dry solids applied for the alternative waterborne adhesives' being greater than the manufacturer's recommendations resulted from two factors: (1) the unfamiliarity of the operator with HVLP spray gun equipment, and (2) the application of adhesive onto a larger area of laminate than the area of substrate. (The laminate area was about 10 percent larger than the substrate area; the overhang that was cut away was included in the weight measurements.)

For the control, the operator applied the adhesive as it is normally applied at this facility. The resulting quantity of actual dry solids applied for the control was 60 percent less than the theoretical quantity as recommended in the technical data sheet. This was due primarily to the operator's unfamiliarity with the use of the HVLP spray gun equipment with the control adhesive.

Table 4. Average Adhesive Usage Estimates for Laminate Assembly [a]

	Adhesive used, g	Dry solids, g	Dry solids per side, (g/ft^2) [b]	
			Actual	Theoretical
Adhesive 1	105	48.3	6	3
Adhesive 2	83	44.0	5.5	3
Adhesive 3	168	74.3	9.3	3
Control	64	5.6	0.7	2

[a] Usage is expressed as grams per square foot for a constant assembly area of 8 ft^2 (0.743 m^2).
[b] 1 g/ft^2 = 10.765 g/m^2.

Facility Evaluation of Each Adhesive

On occasion, 24 hours after adhesive application, the plant manager will conduct a subjective peel test on a few assembled parts to determine if the assemblies pass or fail the peel test. This test involves manually peeling back the laminate from the substrate to observe how easily the laminate pulls back and to count the number of adhesive strands that remain on the substrate. Each of the alternative waterborne adhesives passed the subjective peel test at the facility, except Adhesive 3. For Adhesive 3, each laminate fully delaminated from each assembly as it was pulled from the substrate. The plant manager performed the test on panels labeled A#S#5O through A#S#9O approximately 18 to 22 hours after application. Table 5 shows which adhesives passed and which failed for each set of tested panels.

Table 5. Subjective Evaluation Results

	Adhesive 1	Adhesive 2	Adhesive 3	Control
A#S#5O	Pass	Pass	Fail	Pass
A#S#6O	Pass	Pass	Fail	Pass
A#S#7O	Pass	Pass	Fail	Pass
A#S#8O	Pass	Pass	Fail	Pass
A#S#9O	Pass	Pass	Fail	Pass

Based on dry time, total application time, and subjective peel test, Adhesive 1 performed as well as or better than the control. Adhesive 2 also performed acceptably, although its dry time and application time exceeded those of the control by several minutes. However, Adhesive 3 performed poorly in all three categories. To compare the usage of alternative adhesives with the control is difficult because the actual adhesive application per unit area was higher than the recommendations of each adhesive manufacturer. While the overapplication of the alternative adhesives would be expected to increase their application and dry times, it is not clear how this affected their performance in the subjective peel test.

Applied VOC Emissions

The other secondary objective of this evaluation was to compare estimates of total applied VOC emissions of each adhesive. This type of assessment would help manufacturers in the store fixture industry to identify the impact alternative waterborne adhesives would have on emissions per square foot of area sprayed. VOC emissions per unit of area for each adhesive were estimated using vendor-supplied physical data, the average quantity of wet adhesive actually applied to each substrate, and the surface area of the assembly. Equation 1 was used to estimate the average actual VOC emissions:

$$E_{Act} = \frac{C_{VOC} \times V_{Adh}}{A} \qquad (1)$$

E_{Act} = average actual VOC emissions, g/ft^2
C_{VOC} = VOC content, g/L
V_{Adh} = wet adhesive used, L
A = assembly surface area, ft^2.

Estimates of theoretical VOC emissions for each adhesive were also made, using vendor-supplied physical data and recommended dry application coverage quantities (see Table 6).

Table 6. Applied VOC Emissions for Each Adhesive [a]

	Adhesive 1	Adhesive 2	Adhesive 3	Control
Actual VOC emissions [a] (g/ft^2) [b]	0.72	0.69	0.84	6.65
Theoretical VOC emissions (g/ft^2)	0.34	0.44	0.27	9.43

[a] Emissions are expressed as grams per square foot for a constant assembly area of 8 ft^2 (0.743 m^2).
[b] 1 g/ft^2 = 10.765 g/m^2.

Equation 2 was used to estimate theoretical VOC emissions:

$$E_{Theo} = \frac{C_{dry} \times C_{VOC}}{S_{wt} \times \rho} \qquad (2)$$

E_{Theo} = theoretical VOC emissions, g/ft^2
C_{dry} = manufacturer's recommended dry adhesive coverage, g/ft^2
C_{VOC} = VOC content, g/L
S_{wt} = weight fraction solids, g/g
ρ = density, g/L.

Table 6 shows that the estimates of average actual VOC emissions of the waterborne adhesives were lower than the control; this coincides with theoretical emission estimates. The emission estimates depend on the solids content of each adhesive, VOC content of each adhesive, and the quantity of adhesive applied to each assembly. Theoretical VOC emission rates based on vendor recommendations for adhesive quantity per unit area were substantially lower. Factors for deviations between actual and theoretical VOC emission estimates are adhesive overspray and the use of more adhesive than recommended by adhesive manufacturers (see Table 4).

Estimated Costs of Alternative Adhesives

Product density, weight percent solids, quantity applied (coverage), and cost data were used to calculate cost estimates for each waterborne contact adhesive. The cost per gallon, the theoretical coverage and cost, and the actual coverage and cost are listed in Table 7 for each adhesive. Cost estimates show that all of the waterborne products are more costly to use than the control for the same coverage area. Theoretically, only Adhesive 2 is less costly than the control at twice the coverage area. The cost estimate for each alternative waterborne contact adhesive was based solely on the cost of the adhesive and does not include equipment costs.

Table 7. Adhesive Coverage and Cost Information

	Adhesive 1	Adhesive 2	Adhesive 3	Control
Theoretical coverage, ft^2/gal	674 [a]	626 [a]	611 [a]	250 [b]
Actual coverage, ft^2/gal	337	341	197	714
Cost, US dollars/gal [c]	32.4	14.7	18.5	7.4
Theoretical cost, US dollars/ft^2 [c]	0.048	0.023	0.030	0.030
Actual cost, US dollars/ft^2 [c]	0.010	0.043	0.094	0.010

[a] At 3 g/ft^2 dry adhesive solids applied per side.
[b] At 2 g/ft^2 dry adhesive solids applied per side.
[c] Cost based on use of 55 gal (208 L) drum.

CONCLUSIONS

This evaluation suggests that selected waterborne contact adhesives can perform as well as a solvent-borne contact adhesive that is currently being used in the store fixture assembly industry. In fact, one of the better performing waterborne adhesives evaluated (Adhesive 1) had actual dry times that were approximately five times lower than the control. Adhesive 1 passed the onsite subjective peel test, and Adhesive 3 failed.

The actual and theoretical VOC emissions resulting from the use of the waterborne adhesives were significantly lower than the emissions resulting from the use of the control. Actual VOC emissions from this evaluation averaged about 0.75 g/ft^2 (8.07 g/m^2) for the waterborne products and 6.7 g/ft^2 (72.13 g/m^2) for the solvent-borne control. If the adhesives were applied at the generic application rates recommended by the manufacturers, then the theoretical VOC emissions from the application of the waterborne products would have averaged approximately 0.36 g/ft^2 (3.88 g/m^2). The theoretical application values were taken directly from the manufacturer's technical data sheets for each adhesive. These values are generic and cover a range of laminating applications for various industries. They do not apply specifically to laminating applications for the store fixture industry, nor specifically to this facility. Discussions with adhesive vendors indicated that wide variations in the amount of dry solids applied would not have an appreciable effect on performance; for Adhesive 3, the vendor stated that no appreciable performance effects would be noticed up to 15 g/ft^2 (161.5 g/m^2) of dry solids applied.

Based on the quantity of adhesive used during the evaluation, all waterborne products were more costly to use than the control. Again, if the adhesives were applied at the generic application rates recommended by the manufacturers, then the cost of using the waterborne products would have ranged from approximately \$0.023 to 0.048/ft^2 (\$0.25/m^2 to 0.52/m^2) for adhesive cost only.

The quantity of applied dry solids has a direct impact on the cost and VOC emissions resulting from the use of each adhesive. For this evaluation, the control was applied at a rate that is consistent with the manufacturers' recommendations. Therefore, the emissions shown in Table 6 and the cost estimates in Table 7 are reasonable approximations for the control adhesive. During the evaluation, due to the operator's lack of experience using HVLP equipment; the dry solids application rate, as shown in Table 6 for the waterborne adhesives exceeded the manufacturers' recommended quantities. The VOC emissions and cost of adhesive used would be substantially lower if these adhesives were applied as recommended by the manufacturers.

The performance effect of the application rate of dry solids for each waterborne adhesive is uncertain. It can be assumed that, if the adhesive is applied at a rate significantly lower than recommended by the manufacturer, then the performance will be poor. However, when the quantity of applied dry solids significantly exceeds the manufacturers' recommended application rates, as in this evaluation, the effect on performance is less intuitive. The greater-than-recommended quantity of dry solids could serve to reduce the performance of the adhesive by interfering in the drying and substrate bonding process. Therefore, although Adhesive 3 performed poorly in the subjective peel test, it cannot be concluded with certainty that this adhesive would have also performed poorly if the recommended amount had been applied. Conversely, because Adhesives 1 and 2 performed well in the subjective peel test, we cannot be certain that the performance would have been the same if the recommended quantity of adhesive had been applied.

The reader should note that the operator who applied the adhesive was unfamiliar with the use of waterborne adhesives and the HVLP spray system used to apply the waterborne adhesives. Although attempts were made to follow the spray equipment manufacturers' recommendations, this research suggests that the operator's familiarity with the waterborne adhesive products and application equipment can substantially affect the cost and VOC emissions associated with the adoption of a new product.

REFERENCES

1. Paul Crumpler. *Analysis of Pollution Prevention Opportunities and Impediments in the Wood Products Manufacturing Sector in Georgia.* Georgia Department of Natural Resources, Atlanta, Georgia. April 1, 1996.

2. D.H. McIlrath. A new approach to formulating waterborne contact adhesives. *Adhesive Age* 36(12): 38-41, November 1993.

3. Choosing the right laminating adhesives. *Furniture Design and Manufacturing* (60): 160-166, December 1988.

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17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS		b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group	
Pollution	Volatility	Pollution Prevention	13B	20M
Solvents	Organic Compounds	Stationary Sources	11K	07D
Adhesives		Contact Adhesives	11A	
Commercial Buildings		Store Fixtures	13M	
Evaluation		Volatile Organic Compounds	14G	
Laminates			11D	

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