BOARD MEETING DATE: September 7, 2007 AGENDA NO. 39

PROPOSAL: Annual Status Report on Rule 1113 – Architectural Coatings

SYNOPSIS: This final annual report for Rule 1113 describes program achievements with respect to the Workplan Objectives established by the Board in 1999. Rule-compliant architectural coatings are available in the marketplace and continue to demonstrate quality performance. Findings of the technology assessment for the Flat coatings category limit, whose future compliance date is July 1, 2008, are discussed.

COMMITTEE: Stationary Source, July 27, 2007

RECOMMENDED ACTION:
Receive and file.

Barry R. Wallerstein, D.Env.
Executive Officer

EC:LT:LL:DB:HF

Background
Architectural coatings are the single largest source category of volatile organic compound (VOC) emissions under the regulatory authority of the South Coast Air Quality Management District (AQMD) and one of the largest non-mobile source of VOC emissions in the South Coast Air Basin (Basin). The VOC emissions from architectural coatings are a significant source of ozone formation in the Basin and continue to be a critical component for attainment of Federal and State standards. In 1997, architectural coatings were responsible for 50.9 tons of VOC emissions per day in the Basin on an annual average basis. Although the population has grown, as has the usage of architectural coatings, the 2005 annual average emissions were 38.8 tons per day, and are forecast to be reduced to 23.1 tons per day by the year 2010 according to the 2007 Air Quality Management Plan (AQMP). Through the

regulatory limits adopted in Rule 1113, the AQMD has made great strides in reducing emissions from architectural coatings, thereby decreasing ground level ozone formation and improving the overall quality of the air and the health of the greater than 16 million people residing in the AQMD.

To assist with the implementation of Rule 1113 – Architectural Coatings, the Board approved a Workplan on August 13, 1999 that required submittal of annual status reports through the year 2007, to provide the Board with a summary of technical assessments, new developments in coatings technology, market trends and outreach and training programs. The first report, submitted on July 21, 2000, has been followed each year by new information on the implementation of future VOC limits, the averaging compliance option, and other related programs. In addition to rule requirements for technology assessments of specific coating categories, a Board approved resolution in December 2002, ensured the continuance of annual reports with a focus on the progress towards achieving the 2006 VOC limits found in the rule. This is the seventh and final such report that staff will have presented to the Board.

The main focus of this final annual report, provided in Attachment B, is to furnish the latest information on the availability and performance of Flat coatings which are subject to a future compliance limit of 50g/l on July 1, 2008. The results of surveys, internet data searches, laboratory testing and evaluation of coatings, in-situ coating performance reviews and available compliance options built into the rule are some of the topics covered in this report.

Flat Coating Technology Assessment
Staff relied on a number of key sources of data and information for determining the availability and performance of Flat coatings formulated to meet the future VOC limit of 50g/l. These include:

1. **Flat Coating Laboratory Performance Study.** Staff has contracted with industry experts to conduct laboratory studies to assess the performance characteristics of Flat coatings to determine whether key characteristics are compromised when formulated to comply with the future VOC limit of 50g/l. A review of these studies supports staff conclusions that overall, future-compliant and even super-compliant coatings meet or exceed expected characteristic performance standards when compared to products that have a much higher VOC content.

   On the whole, results of the recent architectural coatings laboratory-based evaluation by the University of Missouri at Rolla, continues to support staff's conclusions. Commercially available interior and exterior Flat coatings that meet the 2008 VOC limit of 50g/l have performance characteristics that are similar to and in many cases better than their higher-VOC counterparts. The results of the findings are summarized in the report with the empirical data and are available for review in Appendix B.

2. **Compliant Products Found in Internet Searches**. Staff continues to search for and find future compliant and super-compliant Flat coatings listed by large and small manufacturers on their websites. Staff verifies product characteristics by examining Technical Data Sheets and Material Safety Data Sheets for each coating listed, as well as discussing the performance capabilities with manufacturers. (See Appendix A.)

3. **Store Shelf Survey.** Staff conducted a survey of local store inventories in the first quarter of 2007. The primary purpose of the survey was to obtain a snapshot of the currently available architectural products being sold at various points of distribution. A secondary benefit of the survey was to alert store owners to the future rule requirements. This limited survey indicates that products meeting the current and future VOC limit are currently available and being sold to consumers in all categories, including Flat coatings.

4. **Meetings with Local Manufacturers (Large and Small).** Staff continues to visit local paint manufacturers individually to inquire about their successes and any failures in formulating Flat coatings to meet the July 2008 VOC limit of 50g/l. Manufacturers indicate that compliant products are available and that they exhibit acceptable performance characteristics for their markets.

5. **Further Studies.** Additional studies include staff's documentation of low-VOC flat coating projects at a local university, addition of more flat coatings to the list of manufacturers producing super-compliant coatings, and research of articles on new technologies in low-VOC coatings.

Additional Technical Programs and Studies

1. **Draft California Air Resources Board (CARB) 2005 Architectural Coatings Survey**. The most recent sales data provided by the coating manufacturers and included in the latest draft CARB survey, indicate an increase in the overall sales volume of lower-VOC products in many categories in comparison to the sales data from previous CARB surveys. The information contained in the most recent draft CARB survey represents sales data from 2004; this is four years prior to the lower-VOC limit for Flat coatings taking effect. This data demonstrates that manufacturers are developing and marketing coatings compliant with the future VOC limits in Rule 1113.

2. **CARB/AQMD Reactivity Study.** Staff will continue to monitor reactivity-related research and assess the reactivity and availability of solvents typically used in the formulation of architectural coatings

3. **Alternate Means of Compliance Provided by the Rule.** By examining the number of manufacturers who have taken advantage of alternate means of compliance allowed by Rule 1113, staff has concluded that these flexibilities in the rule have allowed manufacturers additional time for product reformulation. These alternate methods include the averaging compliance and sell-through options, as well as the small container exemption.

4. **Past Studies.** Staff also summarizes previous technology assessments conducted relative to coatings research and VOC limits within Rule 1113.

5. **Future Programs.** Staff will continue to research new technologies in the development of lower-VOC products and continue the strong working relationship with members of the coatings industry. Among the future plans are a Roundtable discussion on reactivity, an Architectural Coatings Technology Symposium, and a Clean Coating Certification Program.

Conclusions

As detailed in this report, AQMD staff research of technical information from many coating manufacturers, coating performance studies, assessments of sales data, marketing brochures, Material Safety Data Sheets and other sources, clearly shows an ever-increasing number and volume of products that perform well and meet the future proposed limits.

Attachments

A. Key Contacts

B. Annual Status Report on Rule 1113- Architectural Coatings

ATTACHMENT A

KEY CONTACTS LIST

The following lists of key contacts are individuals that the AQMD has had direct contact with over the years. AQMD staff appreciates all of their help and assistance with the implementation of Rule 1113.

KEY CONTACTS LIST	
Kevin R. Merlo	Air Products Polymers
Christine Stanley	Ameron Protective Coatings Systems
John Woods	Ameron Protective Coatings Systems
Norm Mowrer	Ameron Protective Coatings Systems
Brian Turk	BASF
Kathy Allen	Bayer Material Science
Michael Butler	BEHR Process Corporation
Parker Pace	BEHR Process Corporation
Kip Cleverly	Benjamin Moore Paints
Ron Widner	Benjamin Moore Paints
Gerald Thompson	BonaKemi USA, Inc.
Dane Jones, Ph.D.	Cal Poly, SLO
Max Wills, Ph.D.	Cal Poly, SLO
Andy Rogerson	Caltrans
Monique Davis	CARB
Jim Nyarady	CARB
Christian Hurley	CARB
Barry Barman	CSI Services, Inc.
Bud Jenkins	CSU Pomona
Charles Milner Ph.D.	CSU Pomona
Dennis St. Laurent	CYTEC
Lloyd Haanstra	Deft Coatings
Randall J, Brady	Deft Coatings
Marc N. Hiraoka	Disneyland Resort
Raymond Russell	Diversified Coatings, Inc.
Robert Wendoll	Dunn-Edwards Paints
Gil B. Mislang	Dunn-Edwards Paints
Kevin McCreight	Eastman Chemical Company
Ronald J. Regan	Eastman Chemical Company
Joseph Tashjian	Ellis Paint Company
Howard Berman	DUTKO Worldwide
Robert Henderson	EPMAR
Dave/Adam Fuhr	Fuhr International
Richard Hart	Hart Polymers
Jim Kantola	ICI Dulux Sinclair
Jeffrey P. Mulford	Lifeguard

KEY CONTACTS LIST, CONT'D	
David Sibbrel	Life Paint Company
Daniel B. Pourreau, Ph.D	Lyondell
Barry Law	Master Painters Institute®
Bob Coleman	Merecole, Inc.
Tony Khalil	Monopole, Inc.
Stephen Murphy	Murphy Industrial Coatings
Carol Kaufman	MWD
John Wallace	MWD
David Darling	National Paint & Coatings Association
Tony Olson	NBC Universal
Dinkar Naik	Pacific Polymers
Michelle Richards	Paramount Studios
Robert Gross	PPG Industries, Inc.
Claude Florent	Rainguard
Aqua Mix	Real Bourdage
Brough Richey, Ph.D.	Rohm and Hass Company
Clare Doyle	Rohm and Hass Company
William H. Hill	Rohm and Hass Company
Madelyn Harding	Sherwin-Williams Company
Albert G. Silverton	Silvertown Products, inc.
Darin A. Shields	Specialty Polymers, Inc.
Tony Hobbs	Tnemec Corporation
Kathryn Sandefur	UMR Coatings Institute
Michael R. Van De Mark, Ph.D.	UMR Coatings Institute
Don Sudduth	UV Chemistry Company, Inc
Duncan Gamble	UV Chemistry Company, Inc.
Hamid Pourshirazi	Vista Paint
Jerome Fischer	Vista Paint
John Long	Vista Paint

ATTACHMENT B

ANNUAL STATUS REPORT ON RULE 1113 – ARCHITECTURAL COATINGS

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

ANNUAL STATUS REPORT ON RULE 1113 – ARCHITECTURAL COATINGS

Dated: September 7, 2007

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Planning, Rule Development, and Area Sources
Elaine Chang, DrPH

Assistant Deputy Executive Officer
Planning, Rule Development, and Area Sources
Laki Tisopulos, Ph.D., P.E.

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SOUTH COAST AIR QUALITY MANAGEMENT AQMD

GOVERNING BOARD

Chair: WILLIAM A. BURKE, Ed.D.
Speaker of the Assembly Appointee

Vice Chair: S. ROY WILSON, Ed.D.
Supervisor, Fourth District
Riverside County Representative

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Cities Representative, Riverside County

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TONIA REYES URANGA
Councilmember, City of Long Beach
Cities Representative, Los Angeles County, Eastern Region

DENNIS YATES
Mayor, City of Chino
Cities Representative, San Bernardino County

<u>EXECUTIVE OFFICER</u>

BARRY R. WALLERSTEIN, D.Env.

ACKNOWLEDGEMENT

AQMD staff would like to recognize the contributions of and thank the past and current Rule 1113 Technical Advisory Committee (TAC) members for the valuable input and guidance they provided in designing and executing past technology assessments. Staff would especially like to recognize posthumously, former TAC member Dr. John A. Gordon, for his dedication, wealth of knowledge and integrity. Dr. Gordon was instrumental in introducing the concept of forming a committee comprised of members of industry, academia, and AQMD staff which became the TAC. Staff is looking forward to continuing the productive working relationship with the TAC in the future, including relying on NPCA to facilitate participation in the upcoming AQMD Architectural Coatings Technology Symposium.

Current Technical Advisory Committee Members:

Barry Barman	CSI Services, Inc.
Charles Milner Ph.D.	CSU Pomona
Christian Hurley	CARB
David Darling	National Paint & Coatings Association
Jim Nyarady	CARB
Madelyn Harding	Sherwin-Williams Company
Raymond Russell	Diversified Coatings, Inc.
Robert Henderson	EPMAR
Robert Wendoll	Dunn-Edwards Paints
Stephen Murphy	Murphy Industrial Coatings
Bud Jenkins	CSU Pomona
David/Adam Fuhr	Fuhr International

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PURPOSE OF THIS REPORT

This report is the final annual progress report required in accordance with the 1999 Board approved Workplan for Implementation of Rule 1113 – Architectural Coatings. The report includes the findings of the required technology assessment for the Flat coatings category, future activities to encourage technology advancements by coating manufacturers and actions to enhance on-shelf and in-use compliance with the rule. This report also includes the following:

- Information on the increasing number of compliant and super-compliant products already available in the market;
- A detailed report including empirical data for the most recent laboratory study;
- Progress on the reactivity and availability assessment of solvents found in architectural coatings, and
- Conclusions to be drawn from the technology assessment.

As part of the Flat coating technology assessment, the South Coast Air Quality Management District (AQMD) contracted with the University of Missouri – Rolla Coatings Institute (UMR) to conduct the most recent laboratory study. This report includes the results of the completed testing, staff conclusions and recommendations.

BACKGROUND

Architectural coatings are the single largest source category of volatile organic compound (VOC) emissions under the regulatory authority of the AQMD and one of the largest non-mobile source of VOC emissions in the South Coast Air Basin (Basin). The VOC emissions from architectural coatings are a significant source of ozone formation in the Basin and continue to be a critical component for attainment of Federal and State standards. In 1997, architectural coatings were responsible for 50.9 tons of VOC emissions per day in the Basin. Although the population has grown, as has the usage of architectural coatings, the 2005 annual average emissions were 38.8 tons per day, and the emissions are forecast to be reduced to 23.1 tons per day by the year 2010 according to the 2007 Air Quality Management Plan (AQMP). Through the regulatory limits adopted in Rule 1113, the AQMD has made great strides in reducing emissions from architectural coatings, thereby decreasing ground level ozone formation and improving the overall quality of the air and the health of the greater than 16 million people residing in the AQMD.

To assist with the implementation of Rule 1113 – Architectural Coatings, the Board approved a Workplan on August 13, 1999 that required submittal of annual status reports through the year 2007 summarizing technical assessments, new developments in coatings technology, market trends and outreach and training programs. The first report, submitted on July 21, 2000, has been followed each year by new information on the implementation of future VOC limits in the rule. In addition to rule requirements for technology assessments of specific coating categories, a Board approved resolution in December of 2002, ensured the continuance of annual reports with a focus on the progress towards achieving the 2006 VOC limits found in the rule. This is the seventh and final such report that staff will have presented to the Board.

The focus of this annual report is to provide the latest information on the availability and performance of Flat coatings which are subject to a future compliance limit of 50g/l on July 1, 2008. The results of surveys, internet data searches, laboratory testing and evaluation of coatings, in-situ coating performance and available compliance options built into the rule are some of the topics covered in this report. The information contained in this report also includes the following:

- Technical information from Technical Data Sheets (TDS), Material Safety Data Sheets (MSDS), and technical papers that demonstrate that Flat coatings meeting the future VOC limits are in use and available to all consumers.
- Product surveys and laboratory test results that show an increase in availability of quality compliant and super-compliant coatings meeting the 2008 VOC limit for Flat coatings.
- Information gathered from meetings with manufacturers with respect to their preparation for making compliant flat coatings.

TECHNICAL COMMITTEES

To assist with the assessments included in this annual report, AQMD staff relies upon technical expertise and valuable feedback on all aspects of architectural coatings from a Technical Advisory Committee (TAC). The TAC was first formed in February 1998 to provide technical oversight of the Phase II Assessment Study and future technology assessments, including selection of coatings, relevant testing, and the report formats. The current makeup of the TAC includes representatives of several large and small manufacturing companies, the California Air Resources Board (CARB), the National Paint and Coatings Association (NPCA), a consulting and engineering firm, a painting contractor and several members from academia. This past year, the TAC assisted staff designing and implementing the laboratory performance study for flat coatings and in developing a performance ranking system for the Flat coating technology assessment based on discussions and recommendations from the ad hoc committee for architectural coatings.

In addition to the TAC, in early 2005, at the request of Governing Board Chairman William Burke, an ad hoc committee was formed for the purpose of providing an open forum to discuss key regulatory issues relative to the coatings industry. This committee is made up of AQMD Board Members Michael Antonovich and Jan Perry, AQMD Management representatives Dr. Barry Wallerstein and Dr. Laki Tisopulos, and industry representatives Christine Stanley of Ameron and Ron Widner of Benjamin Moore. Steve Sanchez of U.S. Can Company is an industry alternate. One key recommendation of this committee was for staff to work closely with the TAC to develop the performance ranking and scoring system as a basis for judging the quality of coatings with respect to key performance characteristics.

FLAT COATING TECHNOLOGY ASSESSMENT

A. Flat Coating Laboratory Performance Study

The requirements under Rule 1113 state that a technology assessment for Flat coatings shall be completed prior to July 1, 2007. In February 2007, the AQMD contracted with University of Missouri - Rolla Coatings Institute (UMR) to conduct laboratory tests on recently developed and commercially available Flat coatings.

The results of this most recent architectural coatings laboratory evaluation have shown that the 2008 VOC limit of 50g/l for Flat coatings is technically feasible and that many already commercially available compliant products have performance characteristics that are similar to and in many cases better than their higher-VOC counterparts. The findings are summarized on the following pages, with the empirical data available for review in Appendix B of this report.

The flat coatings included in the UMR study were selected and approved by the TAC and AQMD staff. A total of twenty Flat coatings were tested; eight of the coatings selected have a VOC content greater than 50g/l but less than or equal to 100g/l. The remaining twelve coatings have a VOC content meeting our future limit of less than or equal to 50g/l. The coatings were separated into the following categories: seven interior, seven exterior and two interior/exterior coatings and tested for a range of properties and then ranked according to the test results. The coatings that were tested are not coatings that are solely available in the AQMD. Depending on the manufacturer, some are marketed and sold throughout California if not throughout the country. The following pages summarize the UMR testing results.

Included with this study are the results of the weighting and rating system developed by the TAC as a result of the ad hoc committee discussions. The rating was designed to be a numerical representation of how well the coating performed for each individual test. The weighting factor was designed to assign the importance of each test relative to industry expectations for the different characteristics of Flat coatings. The concept of this rating and weighting system is to condense the results of the performance test of each coating to a single number. This then allows for a direct comparison on the overall performance of the coatings. Table 1 shows the system that was developed.

Table 1
Weighting System for Flat Coating Laboratory Performance Study

Property	Standard Test	Weighting Factor (1-10) [1]
Interior and Exterior		
VOC Content	Method 24 & ASTM D 6886	Pass/Fail
Gloss at 60° & 85°	ASTM D523	Pass/Fail
Stability - Viscosity Change	ASTM D1849	8
Stability - Overall Character[1]	ASTM D1849	8
Stability -pigment / colorant float	Industry Protocol	8
Open Time / Wet Edge	Industry Protocol	9
Freeze/thaw resistance	ASTM D2243	5
Flow & Leveling	ASTM D4062	N/A
Sag Resistance	ASTM D 4400	N/A
Dry Time	ASTM D5895	N/A
Hide	Spectrophotometer	10
Adhesion	ASTM D3359	10
Interior Only		
Scrub Resistance	ASTM D2486	8
Stain Resistance[2]	ASTM D4828	8
Touch up	ASTM D3928	9
Exterior Only		
Tannin Stain Blocking	ASTM D6686	6
Alkalinity Resistance	Industry Protocol	7

N/A = not applicable

1. Skinning, pressure, corrosion of the container, and odor of spoilage.
2. Modified to reflect common materials to architectural coatings.

Performance Summary

One of the coatings selected to be included in this study, Coating E, tested outside of the AQMD definition of a Flat coating even though it was listed by The Masters Painters Institute™ (MPI) at a gloss level 1, which is stricter than the Rule 1113 definition of a Flat coating. This coating has been re-categorized by MPI since our coating selection began and is in a category consistent with the gloss level tested at UMR. All of the following calculations, tables and charts exclude this coating.

Stability

The stability of the coatings was analyzed by ASTM D 1849, in this test the coatings are held at an elevated temperature for 30 days. Two different parameters are evaluated, the change in viscosity and the overall character rating which is a measure of the separation, can corrosion, skinning, and odor. Both of these parameters were assigned an 8 on the weighting scale indicating equal importance. While the overall character average for the ≤50g/l coatings was lower than the ≤100g/l coatings (7.3 to 5.8), the viscosity change was just the opposite with the average of the ≤50g/l coatings outperforming the ≤ 100g/l coatings (7.0 to 4.0). The four lowest rated coatings for viscosity change are the ≤100g/l coatings, leading AQMD staff to conclude that the stability of the coatings is independent of the VOC level.

Further, the differences in the overall character ratings for the coatings were primarily due to in-can settling. Upon stirring the coatings, they were restored to an acceptable homogeneous state.

Staff conclusion: Overall character average rating was lower for the low-VOC coatings tested; however, they were restored to an acceptable level after stirring. Average viscosity change showed low-VOC coatings outperforming higher-VOC coatings.

Pigment Float

The pigment float test also measures stability, in this test the coatings are held at an elevated temperature for 10 days and then the separation and settling of the pigment is measured. Pigment float was assigned an 8 on the weighting scale. The testing that was conducted by UMR showed no discernable difference between any of the coatings in regard to pigment float.

Staff conclusion: All coatings performed well.

Open Time/Wet Edge

The open time or wet edge test measures the time in which a coating remains in a fluid state such that a brush can go over the surface without leaving brush marks. This is an important characteristic for the application of coatings. In the past, this characteristic was commonly cited as problematic for low-VOC coatings. Open time/wet edge was assigned a 9 on the weighting scale. The UMR testing revealed that although four of the ≤50g/l coatings ranked lower compared to the other coatings tested, all of the coatings actually performed quite well. The testing was conducted in a laboratory setting under ambient conditions which do not represent the more extreme conditions that at times exist in the Basin. The ranking system that the TAC developed was based on a 0 to 10 scale for open time from 0 to 10 minutes. Three of the coatings scored an 8 and one coating scored a 9 with the remaining being at 10 or 10+ for greater than ten minutes of open time. All but two of the coatings that scored less than a 10 were coatings that AQMD staff would define as super-compliant coatings because they have a VOC content of

≤10g/l. One of the super-compliant coatings tested (Coating N) scored a 10+ proving that even a coating with virtually zero-VOCs can have an open time equal to or better than a higher-VOC coating.

Staff conclusion: Although all coatings performed well, some of the super-compliant coatings scored slightly lower than their higher-VOC counterparts.

Freeze/Thaw

The freeze/thaw test measures how many times a coating can endure a freeze/thaw cycle and still remain a viable coating. This is a parameter that tends to be inferior for low and ultra low-VOC coatings. Fortunately due to the favorable and mild climatic conditions, freeze/thaw is not a major issue in the Basin; however, it was deemed important enough by several TAC members that it was included in the laboratory performance study. Manufacturers cite freeze/thaw as an issue when shipping coatings in or out of the Basin and also wanted the test to be included because other air quality agencies look to the AQMD technology assessments in establishing their VOC limits. Freeze/thaw was assigned a 5 on the weighting scale. The statistical evaluation that follows this discussion contains data both with and without the freeze/thaw results included.

In this technology assessment, the interior coatings at ≤100g/l performed almost as poorly as the ≤50g/l coatings with only one of the higher-VOC coatings passing a single freeze/thaw cycle. The higher-VOC exterior coatings performed considerably better with only one of the ≤100g/l unable to pass even a single freeze/thaw cycle while the other three passed all 5 cycles. However, the UMR tests also indicated that two of the ≤50g/l scored quite well, with Coating H passing four of the five cycles and Coating I passing all five of the cycles. This is evidence that formulators have made progress in addressing freeze/thaw issues in Flat coatings with a VOC of ≤50g/l.

Staff conclusion: 75% of low-VOC coatings failed after 1st cycle; however, 1 of the low-VOC coatings passed 4 cycles and 1 passed all 5 cycles.

Adhesion

The adhesion test measures how well a coating will stick to a substrate and was assigned a 10 on the weighting scale. The substrate used to test the exterior coatings was glass and the substrate used to test the interior coatings was a Leneta test chart, which are sealed paper charts used to test coatings in laboratory settings. Three out of the seven ≤50g/l interior and interior/exterior coatings tested on Leneta charts exhibited poor adhesion, in that there was adhesion failure not substrate failure on the cross hatch adhesion test. The remaining four low-VOC coatings performed comparably to the ≤100g/l coatings, including Coating N which is a super-compliant coating with a VOC content measured at only 3g/l.

Based on discussions with the TAC and UMR after the testing was completed, the Leneta cards may not have been the best substrate for testing the adhesion of interior coatings. Most of the coatings experienced substrate failure; the paint adhered to the Leneta card but the top layer of the Leneta card was removed during the test. This is a substrate failure and not a coating failure but it makes distinguishing adhesion differences between those coatings impracticable.

Staff conclusion: Only 3 out of 7 low-VOC coatings showed adhesion failure, others performed comparably.

Scrub Resistance

The scrub test measures how many times a brush can cycle back and forth over a coating before the paint film is removed. This test is designed to mimic the erosion that occurs when walls are washed or scrubbed. This coating characteristic was only tested on the interior coatings where the TAC committee concluded it is more critical; it was assigned an 8 on the weighing scale. The repeatability and reproducibility of this test is fairly high for an ASTM test method (30 and 50%, respectively) and the differences in replicate test panels for this test were at times significant. Coating M at ≤100g/l performed far superior to the rest of the Flat coatings tested for scrub resistance. It surpassed 2106 scrub cycles, almost twice as many as the next best performer. The next best performer was Coating T, one of the ≤50g/l coatings, and it lasted for 1231 scrub cycles. Further, several of the super-compliant coatings performed quite well with a scrub resistance at the median of the test results, around 900 scrub cycles. From these results it is clear that low-VOC coatings can be formulated to have good scrub resistance.

Staff conclusion: The best score was one of the higher-VOC coatings with the next best being a low-VOC coating. Several of the super-compliant coatings performed at the median of the test results, around 900 scrub cycles.

Alkalinity Resistance

Concrete masonry surfaces are naturally alkaline which can lead to color change. The alkalinity resistance test measures how well a coating will withstand this alkaline environment such as fresh concrete, stucco or other masonry and is an important characteristic for coatings designed to be applied to those substrates. Not all exterior coatings are specified for application to masonry; hence not all are designed to be resistant to an alkaline environment. Alkalinity resistance was assigned a 7 on the weighting scale.

This test is extremely aggressive in that the coatings are not given time to fully cure and form a film before being immersed in water and exposed to UV. There is no ASTM test method, so the test method was provided by Dunn Edwards along with the necessary panels and pigment additives for the testing. Although there is no repeatability or reproducibility data for this test, the members of the TAC came to a consensus that it is an appropriate method to measure alkalinity resistance. For this test, fresh concrete panels were painted with coatings that contain two different pigment packages; one that is alkali-resistant and one that is alkali-sensitive. The panels are initially pink and then change to yellow if the coatings are unable to withstand the alkalinity. The result of this test was that all of the coatings experienced a severe color change to yellow, either entirely or in splotches. In evaluating the results, the different degree of failure is being rated.

This test is essentially evaluating the ability of the coatings to stabilize the pigments that were used. An additional variable to this test is the ability of each coating to stabilize the particular pigment independent of the alkalinity. The change in color of the coatings does not necessarily indicate film failure. A more accurate measurement of coating failure would be loss of adhesion resulting from the alkaline environment.

Of all of the coatings, two of the ≤100g/l and one of the ≤50g/l coatings performed moderately better than the rest based on the visual rating conducted by UMR. According to the TDS, these three coatings are the only ones in this study that were specifically designed for masonry tilt-up construction. Additionally, the remaining coatings all list properly prepared concrete, masonry and stucco on their TDS as recommended uses, but they do not recommend and were not formulated to withstand the demanding alkaline environment of freshly poured concrete. Further, all of the coatings tested specify an alkaline resistant primer when the coatings are to be applied to concrete and masonry, including the coatings that had relatively lower delta E readings. However, under the Dunn Edwards test method, no primers were used. In addition, as stated earlier, the coatings were not fully cured as recommended by the manufacturer. Thus, this test has limitations and does not represent recommended painting practices.

The two worst performers were the dual-use interior/exterior low-VOC coatings. These two coatings tended to perform worse than the coatings that were specifically designed for exterior exposures, but performed quite well compared to the coatings designed for interior applications.

Staff conclusion: All coatings failed this stringent test. This test does not follow recommended painting practices and only a few of the tested coatings were specifically designed to withstand an alkaline environment. Coating manufacturers specify an alkaline resistant primer which was not used in the testing.

Tannin Blocking

The tannin blocking test measures the ability of a coating to resist tannin bleed-through from the wood. This is an important characteristic for coatings applied to wood and was assigned a 6 on the weighting scale. On average the ≤50g/l coatings performed twice as well on Tannin Blocking than their higher-VOC counterparts. Tannin Blocking was given a rating of 6 by the TAC committee making it a characteristic considered almost as important as alkalinity resistance (weighted as 7). The top three performers for this coating characteristic were the ≤50g/l coatings.

Staff conclusion: Low-VOC coatings outperformed the higher-VOC coatings.

Statistical Analysis

The following tables show how each coating was rated and then the final result once the weighting factors were applied. Table 2 contains the results of the exterior coatings and Table 3 contains the results of the interior coatings. Both tables contain the two interior/exterior coatings. The totals at the bottom were calculated with and without the freeze/thaw results because AQMD staff does not consider this to be an important characteristic in the Basin.

Table 2
Exterior Flat Coating Performance Summary

Property	Weighting Factor	Exterior ≤100g/L A	B	C	D	Exterior ≤50g/L F	G	H	I	Ext/Int ≤50g/L S	T
VOC Content	Pass/Fail	80	91	100	90	46	35	45	46	0	50
Gloss 60°	Pass/Fail	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Sheen 85°	Pass/Fail	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
		Rating (0 - 10 from worst to best)									
Stability - Viscosity Change	8	6	8	0	8	4	10	9	8	5	9
Stability - Overall Character	8	8	6	8	8	8	6	6	6	6	4
Colorant /Pigment Float	8	9	9	9	9	9	9	9	9	9	9
Open Time/Wet Edge	9	10	10	10	10	10	10	10	10	10	10
Freeze/Thaw	5	8	8	0	8	0	2	6	8	0	0
Flow & Leveling[1]	N/A	0	0	0	0	0	0	0	0	0	0
Sag[1]	N/A	12	12	12	12	12	12	12	12	12	12
Dry Time[1]	N/A										
Hide	10	6	6	6	6	8	4	6	6	6	4
Adhesion	10	3	4	2	4	2	2	4	4	2	3
Tannin Stain Blocking	6	9	3	4	2	13	8	10	11	7	7
Alkalinity Resistance	7	0	1	0	1	0	1	0	0	0	0
	Total	59	55	39	56	54	52	60	62	45	46
	Adjusted for Weighting Factor	**458**	**439**	**330**	**449**	**436**	**415**	**472**	**480**	**372**	**378**
	Without Freeze/thaw	*418*	*399*	*330*	*409*	*436*	*405*	*442*	*440*	*372*	*378*
		Maximum Possible Score: 678									

N/A = not applicable

1. Flow and leveling, sag and dry time were not included in the totals for the coatings performance.

Table 3
Interior Flat Coating Performance Summary

		Interior ≤100g/L				Interior ≤50g/L					Ext/Int ≤50g/L	
Property	**Weighting Factor**	**J**	**K**	**L**	**M**	**N**	**O**	**P**	**Q**	**R**	**S**	**T**
VOC Content	Pass/Fail	100	95	92	91	0	<10	<15	0	37	0	50
Gloss 60°	Pass/Fail	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Sheen 85°	Pass/Fail	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
		Rating (0 - 10 from worst to best)										
Stability - Viscosity Change	8	1	0	0	9	9	7	8	7	1	5	9
Stability - Overall Character	8	10	8	6	4	6	6	4	6	6	6	4
Colorant/Pigment Float	8	9	8	8	9	9	8	9	9	9	9	9
Open Time / Wet Edge	9	10	10	10	10	10	9	8	8	8	10	10
Freeze/Thaw	5	0	2	0	0	0	0	0	0	0	0	0
Flow & Leveling[1]	N/A	5	1	0	0	0	3	0	0	0	0	0
Sag[1]	N/A	10	12	12	12	12	12	12	12	12	12	12
Dry Time[1]	N/A											
Hide	10	8	6	6	6	8	6	6	6	8	6	4
Adhesion	10	4	4	3	5	4	3	3	2	4	4	5
Scrub Resistance	8	6	4	3	10	3	3	4	4	3	1	6
Stain Resistance	8	7	6	5	6	6	6	5	5	5	3	4
Touch up	9	10	10	10	10	10	10	10	10	10	10	10
	Total	65	58	51	69	65	58	57	57	54	54	61
	Adjusted for Weighting Factor	**561**	**496**	**448**	**592**	**562**	**499**	**488**	**486**	**470**	**474**	**526**
	Without Freeze/thaw	*561*	*486*	*448*	*592*	*562*	*499*	*488*	*486*	*470*	*474*	*526*

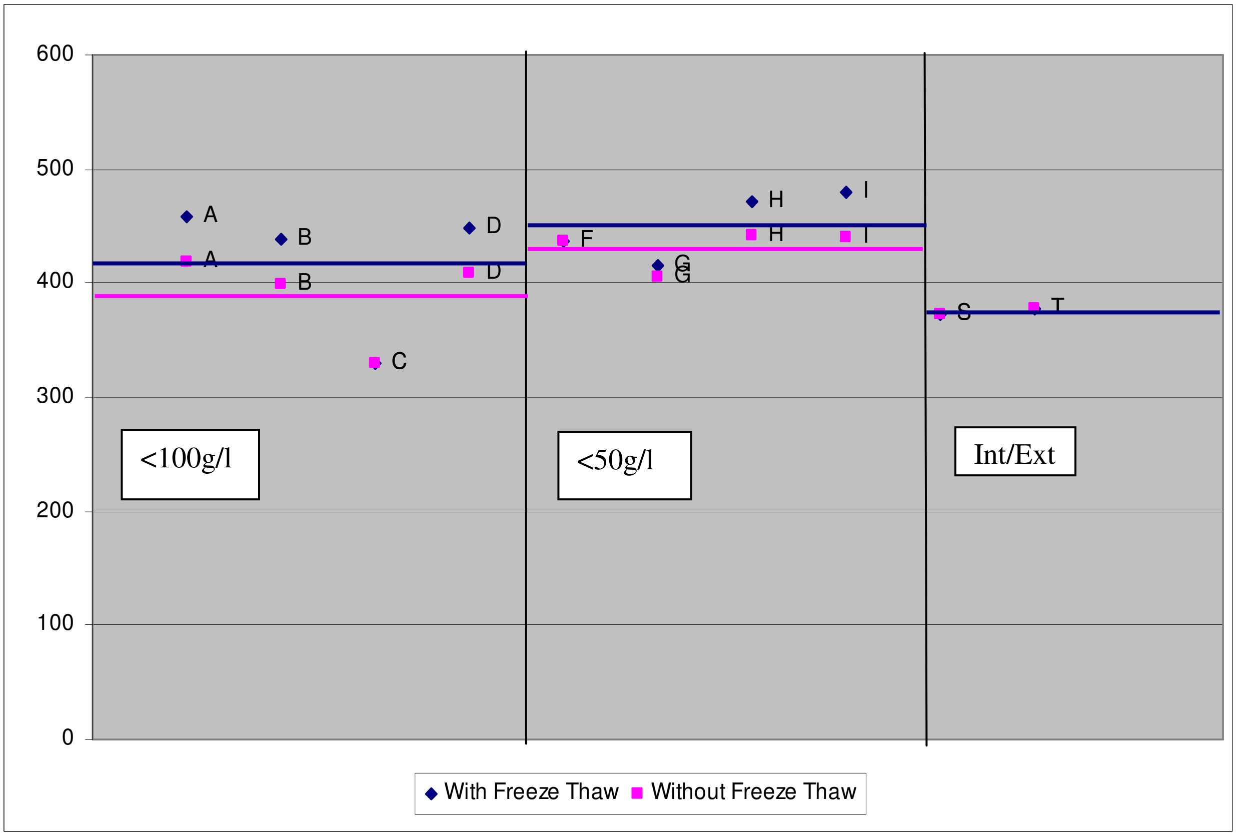
Maximum Possible Score: 780

N/A = not applicable

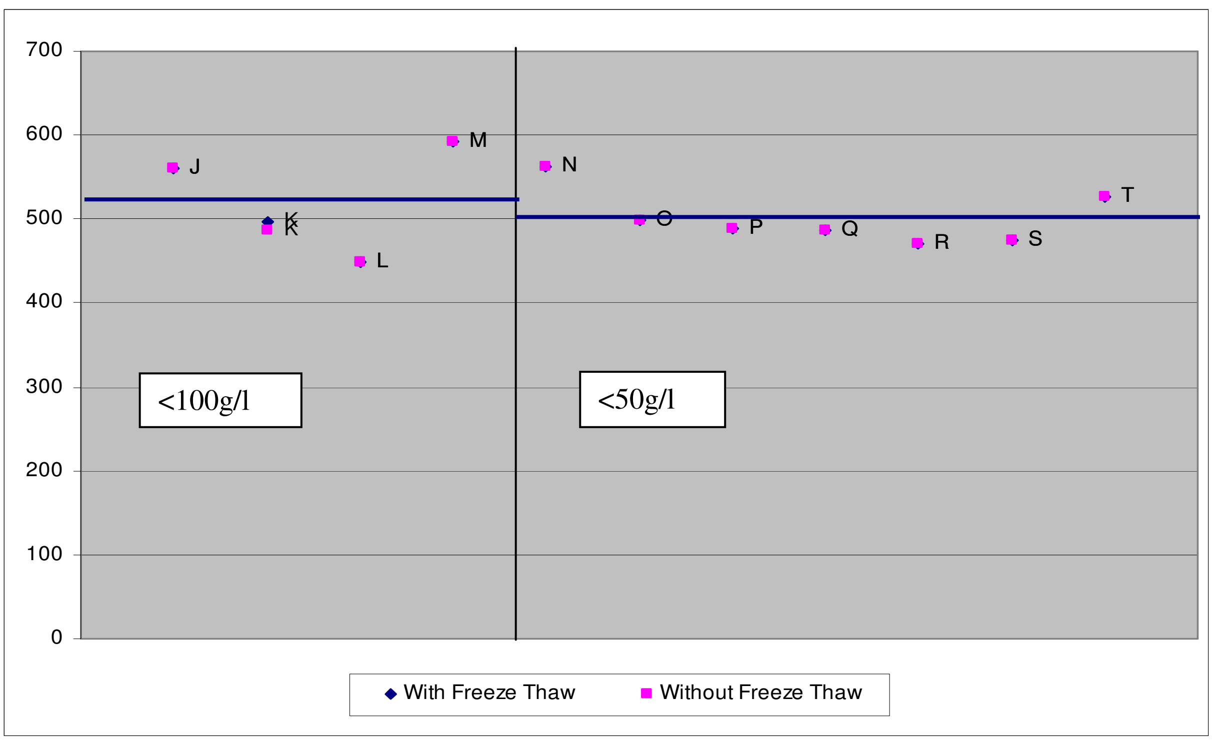
1. Flow and leveling, sag and dry time were not included in the totals for the coatings performance.

Graph 1 and 2 give a visual depiction of the final score, with and without freeze/thaw. The horizontal lines represent the average scores for each category; a separate average line was not included on the interior plot for the two interior/exterior coating because the average remained the same with or without the inclusion of those coatings.

Graph 1
Scatter plot of Exterior Coatings



Graph 2
Scatter plot of Interior Coatings



Comments

AQMD staff worked closely with TAC members prior to the start, during and following the completion of the UMR Flat coatings technological assessment. Several meetings were scheduled at the AQMD and many conference calls were conducted prior to and during the study, including extensive e-mail correspondence.

UMR's Project Manager, Dr. Michael R. Van de Mark, prepared a Draft Final report in June of 2007, which staff distributed to the TAC members for review and comment. Staff received only one comment letter dated July 18, 2007 from NPCA. In the letter, NPCA asserted that the test results for performance characteristics that included stability, open time, freeze/thaw, adhesion, scrub resistance and alkalinity resistance, demonstrated that the lower-VOC coatings did not perform as well as their higher-VOC counterparts and recommended revising the current VOC limits. NPCA also stated that Flat coatings formulated to meet the 50g/l limit are unique and may not perform adequately in other regions of California and the rest of the country.

AQMD staff has reviewed the comments from NPCA and strongly disagrees with NPCA's overall conclusions. A thorough evaluation of the performance testing results summarized in prior sections of this report indicates the comparable overall performance between low-VOC coatings and their higher-VOC counterparts. Moreover, the similarity in the overall performance between the two sets of coatings becomes even more evident if one utilizes the weighting and rating scale developed by the TAC. Based upon this empirical data, AQMD staff believes that the lower-VOC coatings perform equal to and in some instances better than their higher-VOC counterparts. Further, staff disagrees with the claim of NPCA regarding the coatings inability to perform outside of the Basin. The coatings tested are not solely available in the Basin. Depending on the manufacturer, some are marketed and sold throughout California and a few are sold throughout the country. However, relative to the freeze/thaw issue, AQMD staff recognizes that some areas outside of Southern California may have problems associated with this coating characteristic. As mentioned previously, a few of the low-VOC coatings did perform well in the freeze/thaw testing, demonstrating technology improvements relative to this coating characteristic. Regardless of the interpretation of the results however, the AQMD focuses its technology assessments on environmental conditions in the Basin and does not state that these conclusions necessarily apply to areas outside of the AQMD. Thus staff recommends maintaining the VOC limits adopted by the Board in the AQMD.

NPCA also commented in the letter that higher-VOC coatings are necessary for applications under ambient conditions of high heat and low humidity. This concern had been introduced during earlier meetings with the TAC, which AQMD staff attempted to address. A considerable effort went into developing a draft protocol and cost analysis including the hiring of a paint contractor, for performing a field study to evaluate the applicability of future compliant Flat coatings under non-ideal application conditions, such as, high heat accompanied by low humidity, representative of desert areas and low temperatures accompanied by high humidity typically found in coastal areas. However, the focus of the TAC was diverted to the laboratory performance study, and this study was not pursued. AQMD staff has received feedback from a member of the TAC committee who has performed field application of ultra-low VOC flat coatings under hot dry conditions. There was no report of application problems under these conditions. Details on this project can be found in section E. Cal. Poly Pomona's House Painting Project. Further, AQMD staff supports the results of the laboratory studies as a reliable reflection of performance of the coatings in the field. In addition, staff supports testing coatings according to the manufacturers' recommendations, and not under extreme conditions.

As discussed earlier in this report, AQMD staff continues to evaluate field applied applications of low-VOC coatings that include flats in all areas of the Basin and have not encountered any negative application comments to date. Staff is committed to a continued effort in the analysis of coating application and performance over the long-term at projects throughout the Basin using low-VOC flat coatings. Manufacturers and applicators are encouraged to contact AQMD staff in order to document projects as they occur.

Conclusions

The overall results show that the lower-VOC coatings, even the super-compliant coatings tested, performed comparably to their higher-VOC counterparts. As with all architectural coatings, some coatings are formulated for, and therefore perform better in certain areas; however, overall the coatings at the 50g/l limit or less performed very well.

B. Compliant Products Found in Internet Searches

Staff analyzed the TDS and the MSDS published by coating manufacturers to assess the availability of Flat coatings at the future VOC limit of 50g/l. Table 4 summarizes the internet-based search for available coatings with more complete details of those findings presented in Appendix A of this report. The TAC has also contributed to and reviewed this list for accuracy.

Table 4

Internet Search for Available Future Compliant Flat Coatings ≤50g/l

Coating Category	No. of Products	Exterior(E), Interior(I), Dual(D)	Substrates
Flats	113	23-E 80-I 10-D	Formulated for use on most substrates, commonly used on plaster, drywall, concrete block, wood, brick and stucco.

In addition to TDS and MSDS review, staff continues to visit sites where architectural coatings are applied, and has conducted follow-up visits to previously documented applications of low- and near zero-VOC coatings. The data gathered is used to substantiate the availability, use and especially the continued performance of low-VOC coating products.

C. Store Shelf Survey

In early 2007, AQMD staff conducted a survey of coatings being offered for sale at a variety of stores, including ‘big box’ stores, company owned stores and small paint and hardware stores in order to assess availability of coatings meeting current and future VOC limits.

Table 5 shows the availability of Flat coatings with their respective percentage compliance for ‘big box’ stores and company owned stores. Many of the smaller paint stores do not have a high turnover of products, so they are less likely to stock the latest paint formulations. Flexibility written into Rule 1113 allows for a 3 year sell-through of coatings manufactured prior to the implementation of a lower-VOC limit; therefore, it is not uncommon to find older paints on store shelves that exceed the current VOC limit. The numbers listed in the table below do not necessarily represent unique coatings and no attempt was made to eliminate duplicate coatings surveyed at different stores, and simply provides a snapshot of available coatings.

Table 5

Store Shelf Survey of Available Future Compliant Flat Coatings ≤50g/l

Flat Coatings	All Stores Surveyed	Big Box Stores	Company Owned Stores
Number of Compliant Coatings	28	9	7
Number of Coatings Surveyed	175	40	26
Percentage Compliance	16%	23%	27%

This shelf survey indicates a higher percentage of compliance for Flat coatings than the 2005 Draft CARB Architectural Coating Survey, especially for the big box stores and company owned stores. As indicated earlier in this report, CARB’s draft survey found the number of future compliant Flat coatings at 15% in the year 2004.

D. Meetings with Manufacturers

AQMD staff met with several large and small paint manufacturers during 2006 and 2007 to discuss issues that they were experiencing and recent technological advances in coatings formulations. The discussions included many of the coating categories listed on the Table of Standards, including Flat coatings. No major technological difficulties were mentioned in regard to formulating Flat coatings at the future limit of 50g/l. Freeze/thaw was cited as one area that needs improvement, though it is a characteristic that is not considered critical, especially in Southern California. The manufactures were cautiously optimistic due to recent technological advances in this area. Based on these meetings, AQMD staff believes that manufacturers will not experience any hardships in bringing quality Flat coatings to the marketplace meeting the July 2008 VOC limit.

E. Cal Poly Pomona's House Painting Project

California Polytechnic University (Cal Poly) in Pomona has a Paint and Coatings Institute within their Chemistry Department where students learn about, formulate and test near zero-VOC containing coatings. Starting in 2004, the Paint and Coatings Institute, under the direct supervision of the professors, teamed up with a Pomona based charitable organization that provides assistance to needy families in the community, to identify annually a neglected home in need of paint. The students then volunteer their time to paint the selected house which serves not only to help a needy family, but also gives the students an opportunity to test their paints in a real life situation, far different from testing the paint on small panels in a laboratory setting. This project has become an annual event resulting in four houses now painted with near zero-VOC coatings. The professors are able to monitor the environmental exposure over time for any signs of weathering, UV deterioration, dirt pick up, and color or gloss loss.

AQMD staff had an opportunity to document the most recent project during the preparation and painting phases and viewed the previous three projects dating back to 2004. Each project underwent minimum surface preparation that included the use of a garden hose and a broom, with the most recent jobs utilizing a small pressure washer. The houses were in very poor condition with peeling paint, weathered wood, and deteriorating stucco. Although each project was completed by students and teachers, equipped with only brushes and rollers and no primers were used, the previously painted homes have held up well over the years. Also, the painting was conducted in Pomona, California during the summer when the ambient conditions are typically hot and dry. The professors did not observe any application problems such as brush marks or lap marks, even with untrained applicators.

The coatings formulations used are from manufacturer donations, are relatively simple, and contain no tannin blocking or rust preventative additives. Each painting project viewed by staff continues to exhibit good adhesion, flexibility and show no signs of dirt pick up or other failures. In a few locations on the houses where the substrate was failing and no preparatory work was done, there are signs of adhesion failure due to the distressed condition of the stucco prior to painting. Remarkably, even with minimal preparation and non-professional application, these near zero-VOC coatings are performing very well.

F. Super-compliant Coatings

Architectural coating manufacturers continue to improve the coating characteristics of their products while lowering the VOC content by introducing new types of resins and other paint constituents that are extremely low in VOC and even approach zero-VOC. Table 6, updated from previous annual reports to the Board, reflects a portion of super-compliant coatings currently available. Staff has given the nomenclature "Super-compliant coatings" to those coatings that are well below the current and/or future limits for the applicable coatings categories as set forth in the Table of Standards and are indicated by the manufacturer as having less than 10g/l of VOC. These also include those coatings that meet future limits in advance of their effective date. This list can be found at:

http://www.aqmd.gov/prdas/brochures/Super-Compliant_AIM.pdf.

Table 6

Super-compliant Architectural Coating Manufacturers*

Manufacturer	Type of Coatings	Interior	Exterior	Phone Number
Alistagen Corporation http://www.caliwel.com	PSU, F	YES	NO	866-280-0001 305-936-8691
American Formulators Mfg http://www.safecoatpaint.com	F, NFE, NFSG	YES	NO	619-239-0321
Anchor Paint http://www.anchorpaint.com	WPC/MS	NO	YES	918-836-4626
Benjamin Moore & Co http://www.benjaminmoore.com	PSU, F, NFS, NFE, NFSG	YES	NO	201-573-9600
Cloverdale Paint Inc http://www.cloverdalepaint.com	PSU, NF, IM	YES	YES	604 596 6261
Coronado Paint Co http://www.coronadopaint.com	F, NF, PSU	YES	NO	386-428-6461 x115
Diamond Vogel http://www.diamondvogel.com	F, NF, P	YES	NO	800-728-6435
Dunn Edwards http://www.dunnedwards.com	F, NF	YES	NO	888-337-2468
E-3 Coatings, Inc http://www.envirolast.com	S	NO	YES	530-308-2189
Frazee Industries http://www.frazeepaint.com	PSU, F, NFS, NFE, NFSG	YES	NO	858-626-3490
Fuhr International, LLC http://www.fuhrinternational.com	PSU, F, NF	YES	YES	800-558-7437 816-809-4403
ICI Paints http://www.iciduluxpaints.com Pro painters http://www.devoecoatings.com IM coatings http://www.duspec.com MSDS & PDS http://www.glidden.com Retail for homeowners http://www.ici.com Corporate	PSU, F, NFS, NFE, NFSG**	YES	YES	440-826-5519
Kryton http://www.kryton.com	WPS	YES	YES	246-437-3202
Miller Paint http://www.millerpaint.com	PSU, F, NFE, NFS	YES	NO	503-407-2532
Monopole Inc. http://www.monopoleinc.com	IM, WPS, WPC/MS	YES	YES	818-500-8585
PPG Industries - Architectural Finishes www.pittsburghpaints.com	PSU, F, NFE, NFSG	YES	NO	800-441-9695
Polibrid Coatings http://www.polibrid.com	F, NF, PSU	YES	YES	956-831-7818
Richards Paints http://www.richardspaint.com/	F, NFR, NFS	YES	NO	800-432-0983
Rodda Paints http://www.roddapaint.com/	PSU, F, NFE, NFS	YES	NO	503-737-6031 x6051
Sampson Coatings, Inc. http://www.sampsoncoatings.com	PSU, F, NF	YES	YES	804-359-5011
Samuel Cabot, Inc http://www.cabotstain.com	WPS	NO	YES	800-877-8246
Seal-Krete Inc. http://www.seal-krete.com	PSU, F	YES	YES	800-323-7357 x541
Sierra Performance by Rust-Oleum http://www.rustoleum.com	PSU, F, NF	YES	YES	800-553-8444
Silvertown Products http://www.rhinoguard.com	S, CWF	NO	YES	909-986-7061
Spectra-Tone Paint http://www.spectra-tone.com/	F, NFE, NFSG	YES	NO	800-272-4687
TPR^2 - Thermal Product Research http://www.tpr2.com/	NF-FR, PSU-FR	YES	YES	203-756-8772
Tried & True Wood Finishes http://www.triedandtruewoodfinish.com	CWF	YES	NO	607-387-9280
VOC Free No Website	FLOOR SEALER, PSU, F, NF	YES	YES	201-457-1221

Table 6 Cont'd

Super-compliant Architectural Coating Manufacturers*

Industrial Maintenance Coatings				
Manufacturer	**Type of Coatings**	**Interior**	**Exterior**	**Phone Number**
Ameron, Intl. http://www.ameroncoatings.com/welcome.cfm	VARIOUS SYSTEMS	YES	YES	800-926-3766
Duromar http://www.duromar.com/	VARIOUS SYSTEMS	YES	YES	781-826-2525
JFB Hart Polymers http://www.jfbhartcoatings.com/	VARIOUS SYSTEMS	YES	YES	630-574-1729
Novocoat (Formerly) Superior Environmental Products, Inc http://www.novocoat.com	VARIOUS SYSTEMS	YES	YES	972-490-0566
Pacific Polymer http://www.pacpoly.com/	VARIOUS SYSTEMS	YES	YES	800-888-8340
Specialty Products Inc. http://www.specialty-products.com	VARIOUS SYSTEMS	YES	YES	253- 983-7530
United Coatings http://www.unitedcoatings.com/	VARIOUS SYSTEMS	YES	YES	800-541-4383

CWF	Clear Wood Finish
F	Flats
NF	Non-flat
NFS	Non-flat - satin
NFE	Non-flat - eggshell
NFSG	Non-flat - semi-gloss
PSU	Primers, sealers, and undercoaters
S	Stains
WPS	Waterproofing Sealer
WPCMS	Waterproofing Concrete/Masonry Sealers

** Super-compliant coatings are defined as those coatings that have a VOC content less than the VOC content limits set forth for the current and/or future limits in the Table of Standards found in paragraph (c)(2)of Rule 1113 and specify a VOC content less than 10 g/L.*

*** Not available for exterior use.*

This is not an all-inclusive list of super-compliant coatings available from manufacturers/suppliers who have informed SCAQMD that they can provide the super-compliant products listed.

The SCAQMD in no way endorses any of these companies nor does it certify their ability to meet the requirements of Rule 1113 Architectural Coatings. If you want your company included in this page, please send your request to hfarr@aqmd.gov or call Heather Farr at (909) 396-3672.

G. Master Painters Institute® (MPI)

MPI is a Canadian based organization founded to develop performance-based standards in conjunction with paint manufacturers and paint technologists. The performance based standards are widely accepted and are approved by the US Navy, Army, and Air Force as well as other US and Canadian agencies. MPI develops lists of approved products in almost 200 categories. In 2005, MPI developed a Green Performance Standard (GPS-1) which sought to consider not only the VOC content of a coating but also the performance of the coating. More recently, MPI developed a more stringent Green Performance Standard (GPS-2) for coatings with a maximum VOC content of 50g/l. MPI's Green Performance Standards and approved product lists are the only green certification program to include performance based testing along with VOC content. The MPI approved product lists are an excellent resource for high quality coatings that have been tested in a laboratory using widely accepted test methods with regard to each category type. MPI has 10 categories for Flat coatings[1] containing 61 approved products meeting the AQMD's future VOC limit of 50g/l and they have a category for Institutional Low Odor/VOC Interior Latex (MPI#143) for coatings with a VOC content less than 10g/l containing 26 approved products.

The lists of products meeting MPI Green Performance Standards can be found at:

www.specifygreen.com

H. Papers Presented at Recent Conference in 2007

In addition to the articles researched relative to the development of lower-VOC architectural coatings, recent papers and presentations made at coatings symposiums indicate the availability and support from resin and additive suppliers of low-VOC coating components that meet or are lower than future VOC limits in Rule 1113.

The Federation of Societies for Coatings Technology (FSCT) sponsors an annual event that is the largest North American exposition in the coatings industry, the International Coatings Expo (ICE). Included in the exposition is a technical forum featuring three days of lectures. Both the 2006 and the upcoming 2007 forums feature a track that focuses exclusively on green chemistry and include the developments of innovative resins and additives that enable formulating of low-VOC to near zero-VOC coatings.

The upcoming Western Coatings Symposium sponsored by the Los Angeles Society for Coatings Technology also features a lecture series on green chemistry including new resin and additive technologies. Clearly there is an increasing interest in green coatings to meet regulations, but also as a tool for marketing coatings.

[1] Gloss level 1 defined as a coating that registers a gloss of <5 at 60° and <10 at 85° meeting the Rule 1113 definition of a Flat coating.

ADDITIONAL TECHNICAL PROGRAMS AND STUDIES

A. Draft CARB 2005 Architectural Coatings Survey

Rule 1113 requires AQMD technology assessments to consider any applicable CARB surveys on architectural coatings. Approximately every four or five years since 1976, CARB has conducted architectural coating surveys. The survey methodology serves as a tool to obtain information such as VOC content and sales volume of coatings from manufacturers that offer products for sale in California. Draft data obtained from the 2005 Architectural Survey represents a comprehensive evaluation of sales data and coating chemistries from the 2004 calendar year based on the latest information available from participating manufacturers. A more thorough evaluation of the CARB survey will be conducted once the survey is finalized and the data is released this fall.

The sales data obtained for 2004 separates architectural coatings statewide into 48 categories, identifying more than 111 million gallons of architectural coatings sold in California in 2004, with 88% of that volume coming from waterborne products, an increase from the 83% reported in 2000. However, waterborne products contributed to only 48% of the total emissions, while the remaining 12% solvent-based volume reported, contributed to 52% of the total emissions. The sales of architectural coatings in the AQMD are based on an estimated population representing 45% of all coatings sold statewide. Table 7 summarizes the use and contribution of waterborne and solvent-based coatings from the most recent CARB survey.

Table 7
CARB Survey - California

Survey Results	Waterborne	Solvent-Based
Total Volume (%)	88	12
Total Emissions (%)	48	52
Annual Volume (Gal/Yr)	97,365,588	13,311,087
AQMD Annual Volume (Gal/Yr)	43,814,515	5,989,989

When comparing this recent data relative to the overall sales volume of lower-VOC products with data from previous CARB surveys, sales information indicates an increase in manufactured products that meet or are lower than current VOC limits in Rule 1113.

CARB has also calculated the associated emissions using this data. Table 8 shows coating volume and emission trends. Please note that the surveys have varied in content and format; therefore, it is not always possible to make a direct comparison between results from different survey years.

Table 8
CARB Architectural Coatings Volume and Emissions Trends

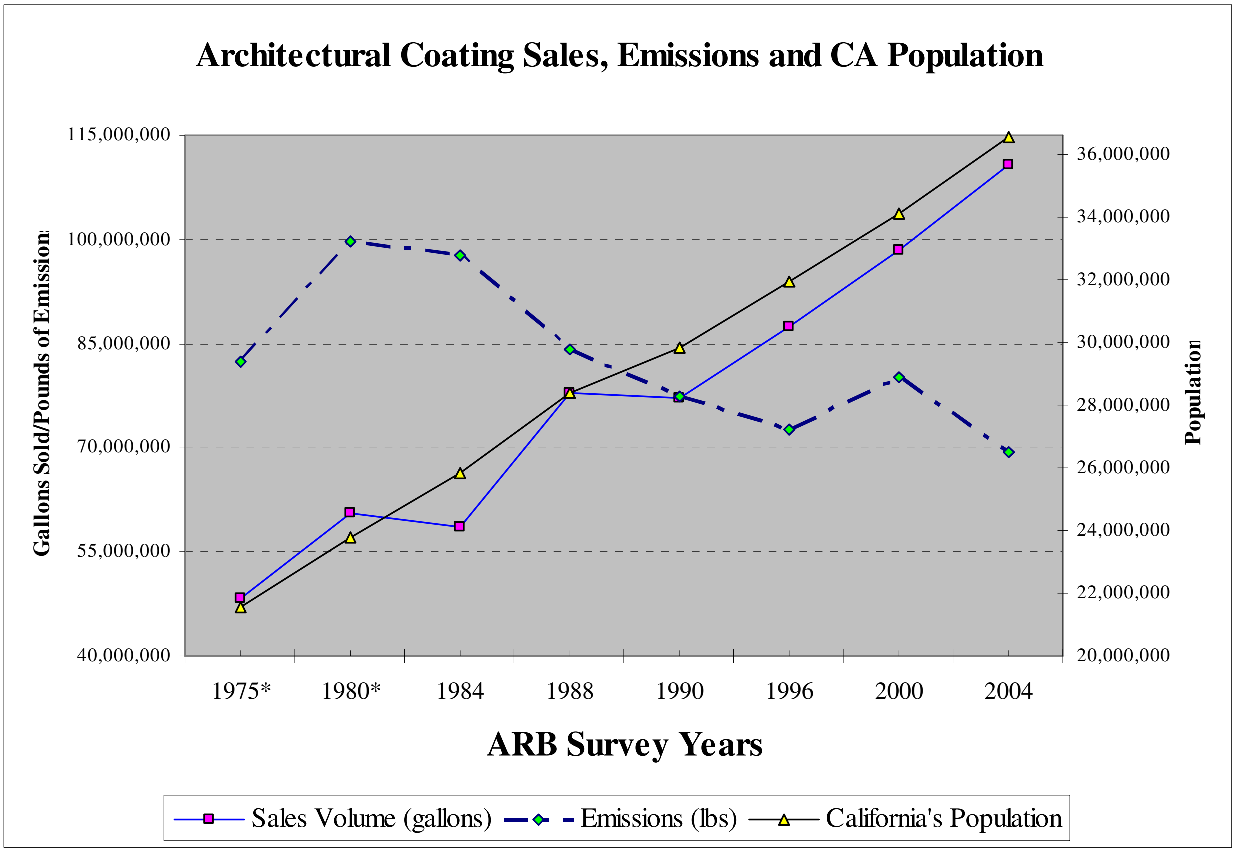
Survey Year	Sales Volume (gallons)	Emissions (lbs)[1]	California's Population[2]	Pounds of VOC Emissions per capita	# of Surveys Mailed Out	# of Companies Reporting Sales
1975*	48,206,000	82,490,000	21,538,000	3.8	N/A	N/A
1980*	60,489,756	99,791,000	23,782,000	4.2	N/A	N/A
1984	58,481,000	97,747,000	25,816,000	3.8	~400	143
1988	77,876,000	84,096,000	28,393,000	3.0	N/A	130
1990	77,056,000	77,380,000	29,828,000	2.6	N/A	174
1996	87,496,000	72,562,000	31,963,000	2.3	>700	152
2000	98,455,172	80,081,000	34,099,000	2.3	700	183
2004	110,676,675	69,423,000	36,522,000	1.9	900	197

* Incomplete surveys
N/A = Not Available

1. Thinning and clean-up or additive emissions not included because CARB changed the methodology for calculating cleanup solvents in 2004.
2. Population data from CA Department of Finance, Demographic Research Unit, Dec. 2006.
3. Staff is studying whether the sales volume increase is attributed to population increase, larger average gross living area of homes, and more frequent turnover of single family residences and apartments.

The trends shown in Table 8 are illustrated in Graph 3, showing that overall emissions continue to decline despite increased production and sales of coatings in the state.

Graph 3



While California's population and sales volume of coatings grew significantly over the last 29 years, statewide VOC regulations requiring lower-VOC limits have managed to reduce the emissions from architectural coatings to lower than the 1975 emission levels. Regulations began having an effect on architectural coating emissions by 1984. Emissions continued to decline through the real estate recession until 1996, and resumed their increase from that point until 2000. As predicted in the 2006 Annual Report, emissions declined from 2000 to 2004, most likely reflecting the effect of regulatory action. The next CARB survey should begin to show the effects of the recent VOC reductions in Rule 1113.

I. Flat Coatings Data from Draft CARB 2005 Architectural Coatings Survey

Table 9 summarizes information extracted from the 2004 sales data on Flat coatings. The information contained in the most recent CARB survey represents sales data from 2004, four years prior to the lower-VOC limit taking effect. This data demonstrates that manufacturers are developing and marketing coatings compliant with the future VOC limits in Rule 1113.

Table 9
CARB 2004 Sales Results – California (excludes quart containers or smaller)

Coating Category	Total Products Listed	Total 2004 Sales Volume (gallons)	# of Products Meeting Future VOC Limits	Sales Volume meeting Future VOC Limits	% of Products Meeting Future VOC Limits	% of Sales Meeting Future VOC Limits
Flats	2,438	36,699,154	360	2,390,135	15%	7%

The sales volume of products meeting the future VOC limit for Flat coatings decreased slightly from the last survey conducted by CARB for the calendar year 2000. That survey indicated 8% future complying market share with the 2008 limit, while the 2004 sales data indicates 7%. The future complying market shares obtained from the CARB surveys represent coatings sold throughout California. AQMD staff has always assumed that the percent complying market share is higher in the South Coast Air Basin where stricter limits require the use of lower-VOC coatings. As this data cannot be extracted from the CARB surveys, there is a clear need for survey data of coatings sold throughout the AQMD.

B. CARB/AQMD Reactivity Study

As a part of the 1999 amendments to Rule 1113 – Architectural Coatings, the AQMD Board approved a resolution directing staff to assess the reactivity and availability of solvents typically used in the formulation of architectural coatings. As a part of that effort, staff has also been assessing interactions between architectural coating and mobile emission sources on particulate matter (PM) formation.

The Reactivity Research Working Group (RRWG) is a public-private partnership with a charter to conduct research on reactivity-based controls to determine whether it is feasible as an alternative compliance option. As a member of RRWG, AQMD staff has coordinated their current efforts with CARB, as well as recommendations by the RRWG. As part of the collaborative effort, a study was completed in 2005 using an environmental chamber at the University of California at Riverside (UCR). The study used the chamber to evaluate mechanisms for photochemical O_3 formation under low NO_x conditions (Carter 2004) and for other projects. A final report has recently been released and the CARB and AQMD will continue to address the possibility of an alternate ozone control strategy. However, to date, industry has not reached consensus on the methodology to potentially implement such an approach. Staff plans to conduct a Technology Roundtable in the fall of 2007 to discuss the strengths, weakness, and potential next steps for a reactivity-based ozone control strategy.

Staff will continue to monitor all reactivity-related research and plans to work closely with CARB staff and industry on additional studies, including the Paints and Coatings Environmental Study currently under development at CE-CERT.

C. Alternate Means of Compliance

I. Averaging Compliance Option

History

The averaging compliance option (ACO) program was developed to provide flexibility to manufacturers by allowing additional time to reformulate certain coatings that would be affected by upcoming VOC limit reductions in Rule 1113. This provision allows a coating manufacturer the option to continue selling higher-VOC coatings in certain categories by offsetting those emissions with low-VOC coatings such that the total emissions are less than the allowable emissions.

The ACO program was started in July 2001. Table 10 provides an overview of the ACO program, including the number of participating manufacturers and the coating categories averaged.

Table 10

ACO Period and Number of Coating Manufacturers

Year of ACO Period	Number of Manufacturers	Coating Categories Allowed for Averaging
2002 *	3	F
2003	8	FL, PSU, QDE, QDPSU, RPC, SP, STN, WS, IMC, NF
2004	9	
2005	8	
2006	10	Same as above plus**: FRC, FRP, HGNF, MPC, RP, SS, STNi, CWF-V, WCMS, CWF-SSsc, CWF-Vsc
2007	12	

*2002 is actually the July 1, 2001 through June 30, 2002 ACO period
**Effective July 1, 2006

KEY

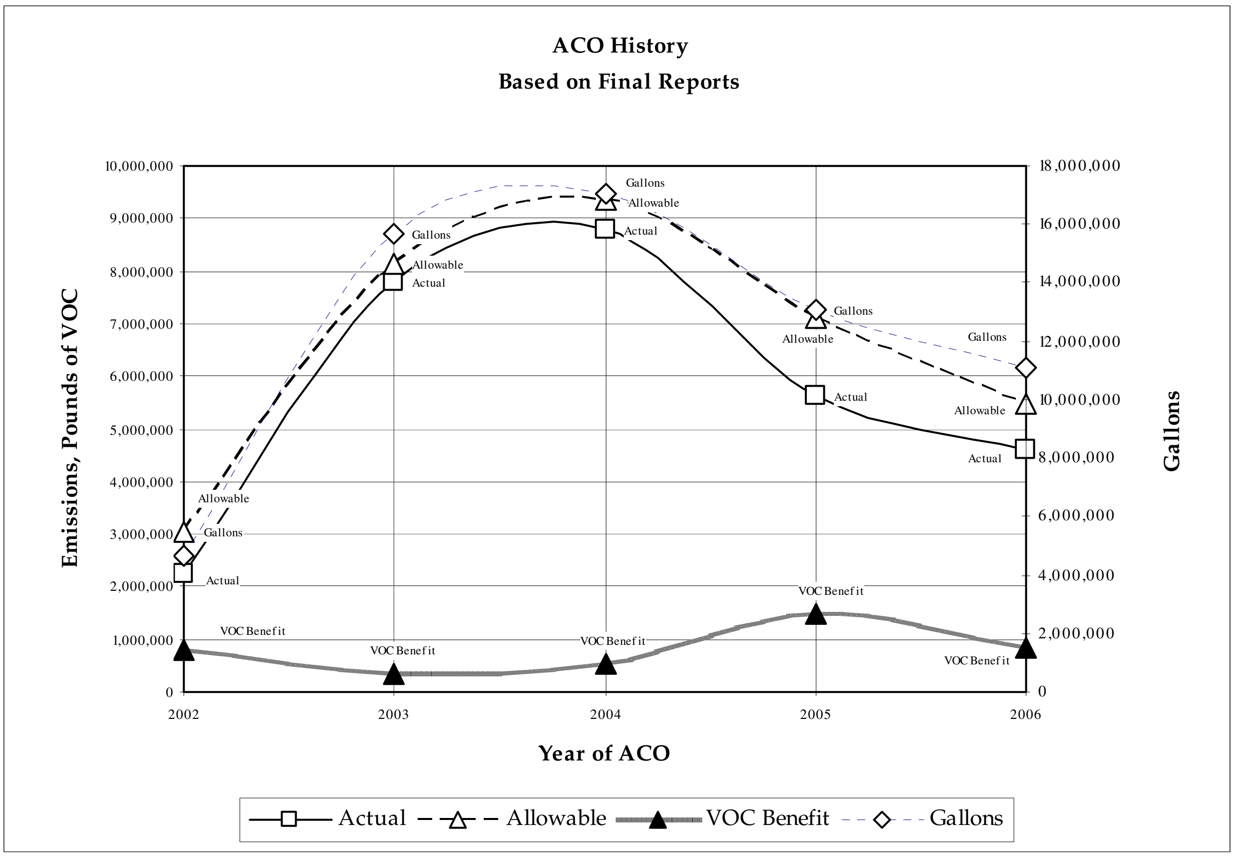
CWF-SSsc = Clear Wood Finish-Sanding Sealer (small container size),
CWF-V = Clear Wood Finish-Varnish,
CWF-Vsc = Clear Wood Finish-Varnish (small container size),
F = Flat Coatings,
FL = Floor Coatings,
FRC = Fire Retardant-Clear Coating,
FRP = Fire Retardant-Pigmented Coatings,
HGNF = High Gloss Non-flat Coatings,
IMC = Industrial Maintenance Coatings,
MPC = Metallic Pigmented Coatings,
NF = Non-flat Coatings
PSU = Primers, Sealers, Undercoaters,
QDE = Quick-dry Enamels,
QDPSU = Quick-dry Primers, Sealers, Undercoaters,
RP = Roof Primers, Bituminous,
RPC = Rust Preventative Coatings,
SP = Specialty Primers,
SS = Sanding Sealers,
STN = Stain,
STNi = Stains, Interior,
WCMS = Waterproofing Concrete Masonry Sealers,
WS = Waterproofing Sealers

AQMD staff has completed audits on four ACO programs and determined all were in compliance. Three of the audits were for the July 1, 2001 to June 30, 2002 period and the fourth audit was for the 2003 calendar year. Staff is currently auditing the remainder of the ACO plans and is working with the coating manufacturers to complete the process.

Statistics

The ACO program has been available to manufacturers since 2001, enabling staff to analyze statistics related to the coatings. Graph 4 shows a cumulative overview of the gallons sold, the actual emissions, and the allowable emissions for coating manufacturers that have participated in the averaging compliance option to date. The graph shows a timeframe ranging from 2002 to 2006 (year 2007 data is not yet available); the year 2002 includes the averaging period July 1, 2001 through June 30, 2002.

Graph 4



Graph Discussion

Graph 4 shows trend lines for actual emissions, allowable emissions, VOC benefit and gallons. There is a marked increase from the year 2002 to 2003. This is because the year 2002 included three coating manufacturers, while the year 2003 included eight coating manufacturers. The increase is also due to additional coatings categories being allowed in the ACO program. The year 2003 was a milestone in Rule 1113, since multiple coating categories had VOC limit reductions starting on January 1, 2003. The trend lines increase slightly from the year 2003 to 2004 because there were nine coating manufacturers averaging for 2004, an increase of 12.5%. The trend lines between the year 2004 and the year 2005 show a large decrease. There were nine coating manufacturers reporting in 2004 and eight coating manufacturers reporting in 2005. The area between the actual emissions and the allowable emissions show that the year 2005 had a larger gap (greater emission reduction benefit) than the year 2004. This shows that the coating manufacturers have continued to reformulate coatings to meet the upcoming VOC limits. There were three coating categories that had VOC reductions for year 2005 but they were not used in any of the ACO programs. The trend lines between the year 2005 and 2006 show another decrease, but the area between the actual emissions and the allowable emissions is less for 2006 than 2005. The year 2006 affected several coating categories, additional VOC limit reductions began in the middle of the year on July 1, 2006. Many coating manufacturers had to make mid-year adjustments to comply with their ACO programs, some also had to eliminate their supply of the higher-VOC products. The reduction of actual emissions from 2004 to 2006 calculates to 47.5% even though year 2006 had one more coating manufacturer averaging than year 2004.

The VOC benefit trend line in Graph 4 reflects the emission reduction benefit in any prior year. This is the difference between the allowable emissions and the actual emissions. The allowable emissions are the maximum that can be emitted at the regulatory limits, while the actual emissions are those that were emitted based on sales of coatings in the manufacturers ACO reports. The difference demonstrates that through the ACO program, the actual emissions were significantly lower than the allowable emissions. Table 11 shows Graph 4 in tabular format.

Table 11

Annual Summary of ACO Plans

Year	Volume (gal/yr)	Actual (lbs/yr)	Allowable (lbs/yr)	VOC Benefit (lbs)
2002	4,679,617	2,241,674	3,053,318	811,644
2003	15,698,206	7,775,839	8,120,810	344,971
2004	17,075,532	8,787,633	9,337,542	539,908
2005	13,095,173	5,614,696	7,093,904	1,479,208
2006	11,080,033	4,616,066	5,467,371	851,304
			Total Benefit	**4,027,035**

The data shows that the coating manufacturers are reformulating their products and meeting the VOC requirements in Rule 1113. Many of the large manufacturers continue to use the ACO and utilize new low-VOC coating products that are used to offset their sales of higher-VOC products. In addition, as the VOC limits of several coating categories have been reduced through rule amendments, most of these same categories are also included in the ACO projection, allowing the manufacturers to offset the higher-VOC coatings with the new low-VOC coatings. In 2007, there are twelve coating manufacturers participating in the ACO program.

ACO – Conclusion

The manufacturers have expressed the benefits of utilizing the ACO, since it provides them with compliance flexibility by allowing them to continue marketing some niche higher-VOC products and offsetting them with low-VOC products. Similarly, recent court decisions have also supported the ACO and recognized this provision as an "escape clause" that provides manufacturers with compliance flexibility, while retaining the more stringent limits.

Staff recognizes that the ACO cannot be used by all manufacturers, but will continue the provision for other manufacturers who have demonstrated its benefits.

II. Sell Through Option

As mentioned in previous reports to the board, another compliance option available to architectural coating manufacturers allows the sale or application of a coating manufactured prior to the effective date of the corresponding standard in the Table of Standards for up to three years after the effective date of the standard. This sell-through provision applies to all coatings listed in the Table of Standards and any effective dates applicable to the specific coating. Many manufacturers continue to take advantage of this available option in order to allow them additional time to reformulate their products just prior to the effective date change in the limits. This allows the manufacturers to eliminate any potential losses in revenue due to excess stock of non-compliant coatings.

III. Small Container Exemption

Another compliance option is the small container exemption which provides regulatory relief to the manufacturers provided they submit an annual report within three months of the end of each calendar year for their products that are sold in quart size containers or less in select categories. If a manufacturer fails to submit their annual report, the manufacturer cannot claim the exemption for the previous year. The number of reporting manufacturers selling coatings within the jurisdiction of the AQMD under this exemption has increased over the years. Table 12 below shows the trend.

Table 12

AQMD Small Container trends, 2000-2006, Companies Reporting

	2000	2001	2002	2003	2004	2005	2006
Number of Companies Reporting	12	13	15	24	29	30	34

Staff has been actively tracking the statistics of the small container exemption under Rule 1113. These reporting requirements assist AQMD staff in tracking the excess emissions that result from the small container exemptions and assist in tracking other coating categories of interest. In the last rule amendment, the exemption was removed for Clear Wood Finishes as the reporting requirement revealed a sharp increase in sales, indicating a possible circumvention of the VOC limit for that category.

In 2006, the small container exemption resulted in excess emissions of approximately 1.1 tons per day; a slight decrease from 2005 where there was approximately 1.5 tons per day of excess emissions. Table 13 displays the data from the year 2000 through 2006. The table also summarizes the total volume of coatings sold under the small container exemption in Rule 1113.

Table 13
AQMD Small Container Trends, 2000-2006, Product Category Sales Reported in Gallons

Coating Category	2000	2001	2002	2003	2004	2005	2006
Faux Finishes	128	190	0	9,943	6,202	4,615	5,032
Flat	246	4,813	24,613	10,645	6,358	5,678	728
Floor	0	70	0	1,709	840	980	1,054
Industrial Maintenance	641	0	169	21,998	364	2,355	1,950
Lacquers	237	1,333	1,964	745	2,404	2,860	2,068
Mastic Coating	0	0	0	35	0	0	0
Metallic Pigmented	0	101	0	1,487	154	63	76
Multi-Color	109	0	0	0	0	0	0
Non-Flat	13,819	19,748	9,503	98,753	36,640	14,945	28,164
Non-Flat High Gloss							5,856
PSU	18,864	13,225	26,197	25,043	21,904	21,658	18,533
QD-E	0	0	0	4,605	4,683	1,722	2,550
QDPSU	1,335	1,651	327	4,465	14,826	24,265	26,755
Roof Coating	0	0	0	32,969	9	0	0
Rust Preventative	0	0	0	70	107	68,826	50,107
Sanding Sealer	583	735	4,061	2,825	3,654	3,686	2,332
Stain	120,299	141,650	220,058	250,243	270,601	246,868	224,711
Traffic Coating	0	0	0	7,250	0	0	0
Varnishes	125,764	130,197	186,557	217,289	235,140	253,906	125,056
Waterproofing Sealers	197	48	1,798	1,478	92	45	29
WCMS	0	0	0	229	17	1,932	11,349
Total:	**282,221**	**313,760**	**475,247**	**691,781**	**603,995**	**654,404**	**506,349**

One can see from Table 13 that the total sales for each year increased except for year 2004 and 2006. Interpreting the data in 2006 was complicated by several changes in Rule 1113. Due to the elimination of the small container exemption for the Clear Wood Finishes, manufacturers were only required to report small container sales for Clear Wood Finishes up to June 30, 2006. This resulted in an expected decrease in reported sales. If it is assumed that the sales volume of Clear Wood Finish for the full calendar year is double what was reported, then the gallons sold under the exemption would increase to approximately 635,000, which is still a decrease from 2005.

Sales of Flat coatings, under the small container exemption have decreased sharply since 2002. During the 2006 calendar year only 727 gallons were reported sold. This indicates that manufacturers do not need this exemption to produce compliant Flat coatings or to produce niche products requiring higher-VOC formulations.

Graph 5 presents the totals shown in Table 13 in graphical format.

Graph 5

D. Summary of Past AQMD Sponsored and Other Coating Studies

To address concerns by industry representatives and coating manufacturers that lowering the allowable VOCs in products to meet the future limits may compromise coating characteristics such as applicability and durability; staff has contracted with industry experts and conducted several studies over the years. Staff also continues to review those completed by other agencies and the industry.

Prior reports and summaries submitted to the Board regarding architectural coatings include coating technology assessments and product availability studies that indicated the availability of compliant coatings in the specific categories studied. A review of those studies supports staffs contention that low-VOC and super-compliant coatings meet or exceed expected characteristic performance standards compared to products that have much higher-VOC content. For a summary of past studies refer to the 2006 Annual Status Report for Rule 1113 which can be found at:

http://www.aqmd.gov/hb/2006/060126a.html

E. Future Program Activities and Studies

AQMD staff will continue to review and maintain a current database of compliant and super-compliant products in all coating categories for additional products with VOCs less than current and future rule limits. As technology improves and VOCs in all categories get closer to zero, staff will continue to evaluate the feasibility of further reductions in the VOC content of all architectural coating categories as currently listed in the Table of Standards in Rule 1113. Voluntary use of available low-VOC or near zero-VOC technology is evidence that the coatings are performing at or above industry expectations.

Staff will be involved in the following activities over the next year:

I. Technology Roundtable on Reactivity Fall 2007

As a part of the 1999 amendments to Rule 1113 – Architectural Coatings, the AQMD Board approved a resolution directing the staff to assess the reactivity and availability of solvents typically used in the formulation of architectural coatings. To assist in the assessment, a Technology Roundtable will be held in the fall of 2007 to discuss the strengths, weakness, and potential next steps for a reactivity-based ozone control strategy.

II. Architectural Coatings Technical Symposium 2008

Staff will hold an Architectural Coatings Technical Symposium (ACTS) in 2008 as an outreach to manufacturers, contractors, architects and painters. The goal is to provide an open forum of communication and to exchange information among all parties impacted by Rule 1113.

III. More Robust Enforcement Program

As VOC limits continue to decrease, AQMD will enhance enforcement efforts by continuing a strong field presence at construction sites, points of distribution, and other architectural coating projects.

IV. Clean Coatings Certification Program

The 2007 AQMP contains a control measure (#CTS-02) to implement a certification program for coatings with low-, ultra low- or near zero-VOC content. The intent is to positively influence the manufacturing, marketing, and consumer purchase decisions towards products that produce fewer emissions. This suggested control measure could potentially foster the marketing of cleaner technologies by encouraging manufacturers to lower their VOC content to levels below what traditional control rules mandate, in an effort to reduce the overall VOC emissions in the Basin.

V. Test Methodology for VOC Analysis

EPA Method 24 and SCAMQD Method 304[2] are rigorous test methods that provide accurate and reliable results when measuring the volatile organic compounds (VOC) in many architectural coatings, but there is inherent variability when employing Method 24 to analyze the VOC content of low-VOC waterborne coatings. The AQMD has invested a significant effort in working with industry, CARB, US EPA, and academic institutions in identifying a superior alternative to Method 24.

Specifically, the AQMD has spent considerable effort investigating ASTM Method D6886 as an alternate to Method 24 for the analysis of low-VOC waterborne coatings. Method D6886 appears to be an improvement to Method 24 because it directly measures the VOC content of a coating yielding far greater precision. AQMD staff will continue to investigate this new method and if it proves to be a reliable alternative to current Method 24, staff will seek EPA approval for incorporating Method D6886, or an equivalent method, into AQMD 304 for the analysis of low-VOC waterborne coatings.

VI. Proposed Coating Registration

AQMD staff will be proposing a rule for architectural coatings to require registration of all architectural coatings manufactured, supplied, sold, or offered for sale for use within the South Coast Air Basin. For over 30 years the AQMD has regulated architectural coatings, mainly relying on California Air Resources Board (CARB) architectural coating surveys for sales and emission data relative to rule and Air Quality Management Plans development. The data provided by CARB relates to all of California, and the South Coast Air Basin portion of the sales and emissions are typically estimated by population demographics, which may or may not estimate the correct emission inventory from the sale and use of architectural coatings. The data is often three to six years old and may not reflect newer technologies recently released into the consumer market, particularly lower-VOC containing products. With the adoption of this proposed rule, staff will have the

[2] EPA Method 24 and AQMD 304 are not identical but they use the same principles, cite the same ASTM methods, and are included in Rule 1113.

most current and reliable architectural coating information for compliance, Rule Development and Air Quality Management Plans.

In addition to the registration aspect, the proposed rule is also intended to recover program costs associated with the AQMD's architectural coatings program. The current Rule 1113 program is extensive and includes staff assigned to inspections, planning and rule development, laboratory services, legal, administrative, and monitoring and analysis as well as support personnel

VII. Other Future Activities

1. Further Evaluation of the Final 2005 CARB Architectural Coatings Survey for Year 2004 Sales
2. Updates of Low- and Super-Compliant- VOC Product Availability Lists
3. Compliance Audits of Averaging Compliance Plans

CONCLUSIONS

AQMD's performance studies and research of technical information from many coating manufacturers, coating studies, assessments of sales data, marketing brochures, Material Safety Data Sheets and other sources, clearly shows an ever increasing number and volume of products that meet the future proposed limits, or are well below current limits.

The completion of the most recent technology assessment by the University of Missouri-Rolla-Coatings Institute demonstrates that the 2008 limit for Flat coatings is feasible. Field and product availability surveys also demonstrate that there currently are more than adequate replacement products for the higher-VOC Flats, many of which are well below the current lowest effective limit of 50 g/l VOC.

APPENDIX A

Internet Search of Future Compliant Flat Coatings

Rule 1113 Future Flat Compliant Coatings
2006-2007 Technology Assessment

Flats (≤ 50 g/l)						
Coating Company and Product Name	Interior Exterior	VOC content (g/l)	Solids (% by volume)	Coverage (sq ft/gal)	Coating Characteristics	Dry time
Alistagen Caliwel with BNA Antimicrobial Interior Latex Covering	Interior	0		250	Protects surface coating from microorganisms such as odor-causing bacteria, mold, mildew algae and fungi for years after application.	15 min touch 4 hr recoat
American Formulating & Manufacturing Safecoat Flat Zero VOC 1411	Interior	0	33	350	Premium quality, fast curing paint designed for interior surfaces where a flat finish and superior film formation properties are needed.	1 hr touch 4 hr recoat
American Pride Paint Interior Flat Latex Paint 100 Line	Interior	0	38	400	This product can be used in occupied areas without typical odor complaints because of the very low odor during application and drying.	2 hr touch Overnight recoat
Benjamin Moore M59 220 Latex Fire Retardant Coating	Interior	0	48	150-300	A premium quality decorative, intumescent, fire retardant paint for interior ceilings, walls and trim.	1 hr touch 4 hr recoat
Benjamin Moore MoorGard® N103 100% Acrylic Low Lustre Latex House Paint	Exterior	37	43	300-400	Protective exterior coating that will remain looking freshly painted years after the job is finished and can be applied at a wider temperature range.	2-4 hr touch 4 hr recoat
Benjamin Moore Moorcraft Super Spec® 100% Acrylic Latex Low Lustre House Paint N185	Exterior	48	34	350-475	100% acrylic exterior latex house paint with a low lustre finish. This product is suitable for use on a wide variety of exterior surfaces and for application at temperatures as low as 40°F.	1 hr touch 4 hr recoat
Benjamin Moore Pristine Eco® Spec Interior Latex Flat 219	Interior	0	34	400-450	A low odor, low VOC, 100% acrylic latex flat that provides high hiding, excellent touch up, and a uniform flat finish.	1 hr touch 2 hr recoat
Benjamin Moore MoorLife® N105 100% Acrylic Flat Latex House Paint	Exterior	46	42	300-400	Protective coating that will remain looking freshly painted years after the job is finished and can be applied at a wider temperature range.	2-4 hr touch 4 hr recoat
California Paints Fres~Coat Low VOC Low Odor Flat with Microban 63391	Interior	15	32	250-350	Provides excellent hide, minimizes surface imperfections, has excellent color retention and is washable with Microban® that will inhibit the growth of stain and odor causing bacteria, mold & mildew.	1 hr touch 2 hr recoat
Cloverdale Paint Horizon Interior Flat Latex Wall Paint 90763	Interior	<1	40	317-420	Designed to significantly reduce odor and polluting vapors. A durable finish that hides small surface imperfections due to its smooth appearing flat wall finish.	30 min touch 3 hr recoat
Columbia Professional High-Build Interior Latex Flat 02-558	Interior	50	38-40	100	Provides excellent high build properties, fills and seals porous surfaces, minimizes surfaces imperfections, and offers very good low temperature low flexibility.	2 hr touch 24 hr recoat

Rule 1113 Future Flat Compliant Coatings
2006-2007 Technology Assessment

Flats (≤ 50 g/l)						
Coating Company and Product Name	Interior Exterior	VOC content (g/l)	Solids (% by volume)	Coverage (sq ft/gal)	Coating Characteristics	Dry time
Columbia Paint Professional Interior Latex Flat Primer Finish 02-737	Interior	22	28-30	320	Good hiding and touch-up, dries to smooth uniform flat finish with easy application and clean up.	.5 - 1 hr touch 2 - 4 hr recoat
Columbia Paint Professional Pro-Choice Interior Latex Flat Primer Finish 02-790	Interior	47	24-26	325	Dries to a durable flat finish. Offers excellent touch up, is easy to apply by brush, roller and cleans up easily with soap and water. Dries rapidly and has low odor.	.5 - 1 hr touch 2 - 4 hr recoat
Columbia Paints PURECOAT Low Odor Acrylic Flat 05-578	Interior	0	34-36	360	Features very good flow and leveling, water clean up, good hiding, excellent spatter resistance, and adhesion to a variety of properly prepared glossy surfaces. Fortified with Microban® Antimicrobial Protection.	0.5-1 hr touch 4-6 hr recoat
Coronado Paint Air Care Odorless Acrylic Flat	Interior	0	35.5	450	It is spatterless during application, flows easily, has excellent hiding power, dries quickly and cleans up readily with soap and water and can withstand repeated washings.	30 min touch 4 hr recoat
Devoe Paint Wonder-Pure™ No-VOC/Odor Interior Flat Wall Paint DR 31XX	Interior	0	34	400	Virtually no odor, quick drying and recoat, uniform appearance, excellent touch-up, super hide, washable and scrubbable.	.5 - 1 hr touch 2 hr recoat
Diamond Vogel Health Kote Interior Latex Flat DF-1591	Interior	0	39	626	High quality low odor, Zero VOC product that dries to a durable velvety flat finish and has excellent washability and easy cleaning.	1 - 2 hr touch 4 -6 hr recoat
Dunn-Edwards Ultra-Scrub™ Interior Srubable Latex Flat Paint W 6400	Interior	50	36	300-375	Providing a tough, durable finish that is extremely washable. Excellent touch up qualities, very good hide, and is self priming on new drywall.	30 - 60 min touch 2 - 4 hr recoat
Dunn-Edwards Flex-Tex® Texture Coating Medium W 322	Exterior	50	48	40-50	Quality medium textured coating that provides good flexibility and good weather resistance.	1 - 2 hr touch 4 -6 hr recoat
Dunn-Edwards Athletic Field Striping W 5361	Exterior	0	37	12-15 gal per field	Produces a hard breathable film that is resistant to the blistering effects from the sun.	30 - 60 min touch 2 - 4 hr recoat
Dunn-Edwards Dura-Tilt® Latex Tilt-Up Flat Plat W 6310	Exterior	35	36	200-375	Extremely flat finish that has excellent touch up, good hide and good alkali resistance.	20 - 30 min touch 1 - 2 hr recoat
Dunn-Edwards Flex-Tex® Coating Fine W 320	Exterior	50	49	40-50	Quality fine-textured coating that provides good flexibility and weather resistance.	1 - 2 hr touch 4 -6 hr recoat

Flats (≤ 50 g/l)						
Coating Company and Product Name	Interior Exterior	VOC content (g/l)	Solids (% by volume)	Coverage (sq ft/gal)	Coating Characteristics	Dry time
Dunn-Edwards Acri-Flat® Exterior Acrylic Wood Stain & Masonry Flat Paint W 704 V	Exterior	45	41	300-400	Provides dependable performance, excellent color retention and good grain-crack resistance for long term exterior durability.	1 - 2 hr touch 4 -6 hr recoat
Dunn-Edwards Quik-Wall® Interior Washable Latex Flat Paint W 6401	Interior	50	43	250-350	Heavy bodied washable flat wall paint that offers good hide and very good touch up properties.	30 - 60 min touch 2 - 4 hr recoat
Dunn-Edwards Super-Wall® Interior Latex Flat Paint W 6402	Interior	50	35	250-350	Professional heavy bodied interior washable latex flat paint that provides excellent touch up and good hide.	30 - 60 min touch 2 - 4 hr recoat
Dunn-Edwards Flex-Tex® Elastomeric Coating Smooth W 321	Exterior	45	48	75-100	Quality, smooth elastomeric coating that provides very good flexibility alkali resistance.	1 - 2 hr touch 24 hr recoat
Dunn-Edwards Super-Wall® Ready-To-Use Interior Latex Flat Paint W 6403	Interior	50	30	200-300	Interior washable latex flat paint that provides excellent touch up and good hide.	30 - 60 min touch 2 - 4 hr recoat
Dunn-Edwards Exterior Paint Tan W 5995	Exterior	35	36	200-400	Has good hide and applies easily.	20 - 30 min touch 1 - 2 hr recoat
Dunn-Edwards Ready-To-Use Nevada Ext Flat W 6267	Exterior	40	33	300-340	Easy to apply, touches up well and provides good weather resistance.	2 hr touch 4 hr recoat
Dunn-Edwards Walltone® Interior Latex Flat W 420	Interior	35	36	250-350	Quality interior latex flat paint designed for use in apartments, condos, rental, and commercial properties that are repainted frequently.	30 - 60 min touch 2 - 4 hr recoat
Dunn-Edwards Exterior Paint Gray W 5996	Exterior	30	38	200-400	Has good hide and applies easily.	20 - 30 min touch 1 - 2 hr recoat
Dunn-Edwards EnduraWall® Elastomeric Wall Coating Smooth W 370	Exterior	40	50	40-100	Provides superior protection against wind-driven rain, and moisture by bridging hairline cracks and other small cracks with outstanding resistance to ultra violet and dirt pick up, easy touched.	1 - 2 hr touch 24 hr recoat
Dunn-Edwards VersaFlat® Int/Ext Latex Flat Paint W 6240	Int/Ext	35	36	200-375	Extremely flat finish that has excellent touch up, good hide and good alkali resistance.	20 - 30 min touch 1 - 2 hr recoat

Flats (≤ 50 g/l)						
Coating Company and Product Name	Interior Exterior	VOC content (g/l)	Solids (% by volume)	Coverage (sq ft/gal)	Coating Characteristics	Dry time
Dunn-Edwards Acoustikote® Latex Flat Ceiling Paint W 615	Interior	0	34	150-300	Has a good hide and little effect upon the sound deadening qualities of acoustical surfaces. Applies easily and dries fast.	.5 - 1 hr touch 1 - 2 hr recoat
Dunn-Edwards Ecoshield™ Low-Odor / Zero-VOC Interior Latex Flat Paint W 601	Interior	10	40	350-400	Very low odor and no added solvents, provide a durable, washable film and has excellent hide and good adhesion. Applies easily and low odor.	.5 - 1 hr touch 2 - 4 hr recoat
Duron Paints & Wall Coverings Genesis Odor Free Interior Acrylic Latex Flat	Interior	35	35	400	Excellent hiding, easy to apply, resists household dirt, stain absorption & will withstand light to moderate hand washings.	30 min touch 4 hr recoat
EVR-GARD Coatings 100 Vinyl Acrylic Int/Ext Flat	Int/Ext	0	72	200-350	Economical product designed to cover most surfaces in one coat.	1 hr touch 4 - 6 hr recoat
EVR-GARD Coatings 400 Elast-A-Bond Vinyl Acrylic Coatings	Int/Ext	0	36	200-400	To resist blistering and peeling, but also exhibits extremely fine weather resistance. Superior hiding power, durability, ease of application and rapid drying.	1 hr touch 4 - 6 hr recoat
Farrell-Calhoun, Inc. 200 Line 100% Acrylic Exterior Latex Flat House Paint	Exterior	52.7	41	300-400	Excellent flexibility & resistant to cracking, blistering, and mildew. Outstanding adhesion, color and gloss retention and blocking resistance.	30 min touch 2 - 4 hr recoat
Farrell-Calhoun, Inc. 300 Line Interior Premium Flat Latex Wall Paint	Interior	35	37	300-400	Soft pleasing appearance, unsurpassed washability and resistance. Outstanding touch-up.	30 min touch 4 hr recoat
Farrell-Calhoun, Inc. 400 Line Vinyl Acrylic Interior Flat Latex Wall Paint	Interior	37	30	300-400	Superior hiding & ease of application. Outstanding touch-up. Good flow and leveling, low odor, non-splattering.	30 min touch 4 hr recoat
Frazee Paint 018 Envirokote Interior Low Odor-Low VOC Flat Finish	Interior	<10	41	200-400	Top of the line interior flat paint ideal for use where low odor and reduced chemical exposure are desired.	30 min touch 3 - 4 hr recoat
Fuhr ZVOC® Interior Acrylic Latex Paint 6100	Interior	0	41	100	Excellent wet adhesion, blister resistance, superior touch up qualities, along with a low, non-obtrusive odor & enamel holdout on wood, as well as great color retention and full scrub potential.	20 min touch 30 min recoat
Fuller O'Brien Crown Coat™ Interior-Exterior Flat Latex Finish FOB 802-10	Int/Ext	18	24	400	Self-sealing, has good touch-up and mild odor, and cleans up with water.	30 min touch 2 hr recoat

Flats (≤ 50 g/l)						
Coating Company and Product Name	Interior Exterior	VOC content (g/l)	Solids (% by volume)	Coverage (sq ft/gal)	Coating Characteristics	Dry time
Fuller O'Brien Crown Coat™ Interior Flat Latex Wall Paint FOB 600-XX	Interior	18	25	350-400	Excellent hiding properties & low odor. It is fast drying and has good washability and stain resistance.	30 min touch 2 - 4 hr recoat
Hallman Lindsay CLASSIC BUILDER SKIM-KOTE Level 5 Surface 371	Interior	21	59	150	It provides an excellent primed surface or can be left unpainted on ceilings as a finish coat.	1 to 24 hr touch 2 - 24 hr recoat
Hallman Lindsay CLASSIC BUILDER Smooth Flat Hi-Build 353-2	Interior	15	33	160	Economical choice for either a one-coat prime and finish that provides a high-build finish with good touch-up and sealing properties.	1 hr touch overnight recoat
Hallman Lindsay COMFORT KOTE Low-Odor Latex Flat 261	Interior	3	37	350	Provides excellent hiding and touch-up in addition to good stain removal and washability where old odor is important.	2 hr touch 4 hr recoat
Hallman Lindsay FARM & RANCH Acrylic Flat Exterior 202	Exterior	26	38	400	High hiding, quality exterior finish featuring outstanding color retention, durability and shaking resistance.	1 hr touch 2-4 hr recoat
Hallman Lindsay MASONRY KOTE 100% Acrylic Flat Masonry Paint 165	Exterior	28	35	400	Provides outstanding color and gloss retention, early moisture resistance and good mildew resistance.	1 hr touch overnight recoat
Hallman Lindsay MASTER BUILDER Latex Flat Wall Paint 364	Interior	23	31	350	Provides good coverage, appearance and application properties with high-hide and excellent touch up.	1 hr touch 4 hr recoat
Hallman Lindsay PRO HIDE Latex Flat Wall Paint 269N	Interior	25	28	400	High production flat coating with excellent touch-up designed for superior appearance and hiding.	1 hr touch 4 hr recoat
Hallman Lindsay PRO KOTE Latex Flat Wall Paint 264	Interior	22	32	400	Provides high-hiding finish with excellent touch-up when applied by brush, roll and/or spray.	1hr touch 4 hr recoat
Hallman Lindsay STRIPE KOTE Athletic Field Marking 305	Exterior	14	44	250-300	Mon-toxic, non-poisonous, non-irritating and harmless to grass or sod.	2 hr dry time
Hallman Lindsay WOODTONE Acrylic Solid Hide Stain 186	Exterior	49	36	400	Designed for both new and repaint work exhibiting outstanding color retention, blocks tannin discoloration, and resists mildew and blistering.	2 hr touch overnight recoat

Flats (≤ 50 g/l)						
Coating Company and Product Name	Interior Exterior	VOC content (g/l)	Solids (% by volume)	Coverage (sq ft/gal)	Coating Characteristics	Dry time
ICI Glidden MP 6400 Flat Latex Wall & Ceiling Paint	Interior	25	22	400	Fast drying matte finish minimizes surface imperfections & offers one-coat possibilities.	30 min touch 2 hr recoat
ICI Glidden Professional Finishes Ultra-Build Interior Latex Flat GL8020	Interior	36	15	400	Easy to apply, dries in as little as 30 minutes to a smooth, uniform appearance.	30 min touch 2 hr recoat
ICI Paints Ultra-Wall® Latex Flat Interior Wall Paint 1230-xxxx	Interior	50	28	400	Designed as a high hiding product with very good touch-up when applied by brush roller or spray that forms a spatter free uniform finish.	30 min touch 2 - 4 hr recoat
ICI Paints Dulux® LIFEMASTER™ Flat Interior Latex Enamel 9100-xxxx	Interior	0	35	400	Premium quality acrylic that brings increased washability and durable yet extremely uniform surfaces.	30 min touch 4 hr recoat
ICI Paints Speed-Wall® Latex Flat Interior Wall Paint 1250-xxxx	Interior	18	25	400	Delivers high production with excellent hide, easy application, quick drying and recoat when applied by brush, roller or spray.	30 min touch 2 hr recoat
ICI Paints Speed-Wall® Latex Matte Flat Interior Wall Paint 1251-xxxx	Interior	33	25	400	Delivers high production with good hide and excellent tough-up ability with easy application, quick drying and recoat.	30 min touch 2 hr recoat
ICI Paints Ultra-Hide® High-Build Latex Flat Interior Primer/Finish 1260-xxxx	Interior	46	32	205-257	Quickly and easily applied by airless spray and dries to a uniform flat finish which minimizes surface imperfections with excellent touch-up and superior uniformity.	30 min touch 4 hr recoat
ICI Paints Ultra-Hide® Speed-Wall® Latex Flat Interior Wall Paint 6400-xxxx	Interior	24	23	400	Delivers high production with excellent hide, easy application, quick drying and recoat when applied by brush, roller or spray.	30 min touch 2 hr recoat
ICI Paints Speed-Cote™ Exterior Latex Flat Masonry Finish 2240-xxxx	Exterior	22	24	400-500	Uniform flat finish, easy application, quick drying and recoat, low odor.	1-2 hr touch 4 hr recoat
Kelly-Moore Paints™ 119 KEL-PRO Interior Latex Flat Wall	Interior	39	27	200-300	Designed to provide an economical and decorative flat finish for wall and ceiling surfaces.	1 hr touch 4 hr recoat
Kelly-Moore Paints™ 1500 ENVIRO-COTE Interior Acrylic Flat Wall Paint	Interior	<15	42	350-450	A premium quality interior acrylic flat wall paint featuring low odor and low VOC.	1 hr touch 4 hr recoat

Flats (≤ 50 g/l)						
Coating Company and Product Name	Interior Exterior	VOC content (g/l)	Solids (% by volume)	Coverage (sq ft/gal)	Coating Characteristics	Dry time
Kelly-Moore Paints™ 485 EZY-COAT Interior Acrylic Flat Wall Paint	Interior	33	32	250-350	Designed to provide a decorative flat finish for interior wall and ceiling surfaces, excellent touch up and uniformity.	1 hr touch 4 hr recoat
MAB Paints Enviro-Pure Latex Flat	Interior	10	40	640	Designed for very low odor during application and drying and features water clean-up, two coat application in one day and self priming on drywall.	1 hr touch 5-6 hr recoat
McCormick Paints Natural Odor Free Interior Latex Flat Wall Paint 39 Series	Interior	0	40	400	This unique product technology is designed for painting in areas where minimal disruption of work or household routine is desired.	30 min touch 4 hr recoat
Miller Paint Co. Super Premium Flat 4780	Interior	46	34	400-500	High quality acrylic wall paint that offers an elegant finish formulated to give rich color and maximum coverage and hid.	30 min touch 4 hr recoat
Miller Paint Co. Acro Flat 6450	Interior	0	30	300-350	Formulated for exceptional wall coverage and durability. Acro is enhanced to fight the growth of mold, bacteria and mildew.	30 min touch 4 hr recoat
Miller Paint Co. Acro Flat 6350	Interior	0	39	300-350	Formulated for exceptional wall coverage and durability. Acro is enhanced to fight the growth of mold, bacteria and mildew.	30 min touch 4 hr recoat
Miller Paint Co. Premium Flat 3780	Interior	48	33	400-500	This product offers an elegant finish with exceptional coverage, rich lasting color and very low odor.	30 min touch 4 hr recoat
PPG Pittsburgh™ Paints Builder's Spec™ High Build Interior Flat Latex 57-610 Series	Interior	32	28	400-500	Formulated to meet the application and touch-up requirements of the new home construction market. Excellent dry hide.	30 min touch 4 hr recoat
PPG Pittsburgh™ Paints Interior Hi Build Touch Up Flat Pastel UC65307	Interior	17	28	400-500	High build finish, good touch up, soap and water clean-up.	4 hr recoat 30 days recoat
PPG Pittsburgh™ Paints Pure Performance® Interior Flat Latex 9-100 Series	Interior	0	40	350-400	It is formulated to provide excellent hiding, touch up and application properties in addition to minimal odor, zero VOC's, and anti-microbial properties.	1 hr touch 4 hr recoat
PPG Pittsburgh™ Paints Speed Finish Plus™ Interior Flat Wall and Ceiling Paint 8-112 Series	Interior	47	30	350-450	Designed as a good-hiding latex paint with excellent touch-up properties.	30 min touch 4 hr recoat

Flats (≤ 50 g/l)						
Coating Company and Product Name	Interior Exterior	VOC content (g/l)	Solids (% by volume)	Coverage (sq ft/gal)	Coating Characteristics	Dry time
PPG Pittsburgh™ Paints Speedcraft® Interior Wall & Ceiling Flat Latex 5-70 Series	Interior	32	29	400-500	It has good adhesion, application and touch-up properties on walls, ceilings and trim surfaces.	30 min touch 4 hr recoat
PPG Pittsburgh™ Paints SpeedPro® Interior Wall & Ceiling Flat Latex 14-110 Series	Interior	38	28	400-500	Formulated to be used in commercial markets where application speed and good quality are needed.	30 min touch 4 hr recoat
PPG Pittsburgh™ Paints Speedhide® Ultra Interior Wall Flat Latex 100% Acrylic 6-700	Interior	51	34	350-400	Designed as a high hiding product with excellent touch-up properties. The uniform, flat finish has excellent scrubability and stain resistance.	30 min touch 4 hr recoat
PPG Pittsburgh™ Paints Interior Ceiling Paint Flat Latex 50-35	Interior	42	29	400-500	A high hiding latex designed specifically for finishing interior ceilings.	30 min touch 4 hr recoat
PPG Pittsburgh™ Paints Speedhide® Interior Fire Retardant Flat Latex 42-7	Interior	32	50	150-335	It is formulated to meet the performance requirements of professional application. The paint film intumesces when exposed to flame or high temperatures.	30 min touch 4 hr recoat
PPG Pittsburgh™ Paints Speedhide® Interior Low Odor Wall Flat Latex UC80021	Interior	17	31	400-500	Ideal for use anywhere that odor is a concern during application and drying; it has excellent hiding and excellent touch-up properties.	30 min touch 4 hr recoat
PPG Pittsburgh™ Paints Speedhide® Interior Wall Flat Latex 6-70 Series	Interior	24	32	400-500	An excellent hiding latex with excellent touch-up properties that dries to a flat finish to help hide tape joints and surface imperfections	30 min touch 4 hr recoat
PPG Pittsburgh™ Paints GLB2005 Interior Flat Wall and Ceiling Paint	Interior	48	34	300-440	An excellent hiding latex with superior touch-up properties that dries to a dead flat finish to help hide tape joints and surface imperfections.	30 min touch 4 hr recoat
Rodda Paint Interior Flat Wall Paint - White Base 33663	Interior	46	35	300	A flat finish, latex resin emulsion formulated to protect and beautify interior surfaces.	1.5 hr touch 2 hr recoat
Rodda Paint Horizon Flat Interior Wall Paint 513501	Interior	<5	40	320	Provides a durable, low odor / low VOC enamel finish; has very low odor during application and drying	30 min touch 2 hr recoat
Sherwin Williams® Duration® Interior Latex Matte A96-100 Series	Interior	37	40	350-400	Low odor, low VOC coating stands up to the wear and tear of daily lining and high traffic areas.	

Flats (≤ 50 g/l)						
Coating Company and Product Name	Interior Exterior	VOC content (g/l)	Solids (% by volume)	Coverage (sq ft/gal)	Coating Characteristics	Dry time
Sherwin Williams® Harmony® Interior Latex Flat B5 Series	Interior	0	42	350-400	Provides a durable, low-odor, antimicrobial, interior paint formulated without silica.	1 hr touch 4 hr recoat
Sherwin Williams® #6057 ISOWALL Interior Latex Washable Flat Paint	Interior	48	32	200	Provides a heavy bodied, self-primed, waterborne flat designed to hide wall imperfections and give good durability.	30 min touch 2 hr recoat
Sherwin Williams® AcryShell 100% Acrylic Exterior Latex Flat B42WT6007	Exterior	42	29	400	AcryShell is ideal for professional use.	1 hr touch 4 hr recoat
Sherwin Williams® CAL-SCRUB Interior Scrubbable Flat B30WJ551	Interior	50	38	400	An upgraded interior flat wit exceptional scrub resistance.	1 hr touch 4 hr recoat
Sherwin Williams® ColorAccents™ Interior Latex Flat Y10 Series	Interior	50	34	350-400	Provides bright and deep colors for walls, trim, or ceilings with superior resistance to burnishing and marring.	1 hr touch 4 hr recoat
Sherwin Williams® ProMar™ 700 Interior Latex Flat B30W7700	Interior	41	26	350-400	Economical, interior latex flat wall paint .	1 hr touch 4 hr recoat
Sherwin Williams® ProTouch™ Interior Latex Flat B30W351	Interior	49	31	350-400	This product provides good washability and durability as well as excellent touch-up.	1 hr touch 4 hr recoat
Surface Protection Industries High Hide Set White 5006-0001	Interior	<50		250-400	Formulated to provide excellent hiding and tinting, with good adhesion, hold out and toughness.	30 min recoat
Surface Protection Industries Studio White 5050-1	Int/Ext	14		250-400	Provides excellent whiteness and very good hide with toughness, adhesion, hold-out, controlled penetration and color acceptance.	30 min recoat
Surface Protection Industries Vara-Bond Series 85	Int/Ext	8		250-400	Versatile paint formulated to be tough, durable and economical; weather resistant, moisture and permeable.	30 min recoat
Surface Protection Industries Vara-Bond Water Base Flat Latex 8507-00	Int/Ext	11		250-400	Versatile paint formulated to be tough, durable and economical; weather resistant, moisture permeable and elastic.	30 min recoat

Rule 1113 Future Flat Compliant Coatings
2006-2007 Technology Assessment

Flats (≤ 50 g/l)						
Coating Company and Product Name	Interior Exterior	VOC content (g/l)	Solids (% by volume)	Coverage (sq ft/gal)	Coating Characteristics	Dry time
Surface Protection Industries VYN-WALL 69-01	Interior	14		250-350	Combines quality and moderate coat with good film toughness, excellent coverage and adhesion to many surfaces.	30 min recoat
Teifs Professional Coatings PC1100 Interior Flat Wall #335	Interior	19		350-400	Interior flat latex designed for the professional contractor. Provides performance.	1 hr touch 4 hr recoat
Tibbetts - Newport Corp. 900 Acra Kote Flat	Int/Ext	35		300-350	Provides excellent hide, washability, spot resistance and easy application.	1 hr touch 2 hr recoat
Tibbetts - Newport Corp. 1500 WALL KOTE	Interior	15		300-400	Offers an economical and durable finish with fast dry with good washable properties	1 - 2 hr touch 4 hr recoat
Tibbetts - Newport Corp. 1900 ACRA-VEL	Interior	<50		300-400	Velvet flat finish with fast drying and good washable properties offering a long lasting low maintenance finish.	1 - 2 hr touch 4 hr recoat
Tibbetts - Newport Corp. 3600 DECOBOND	Int/Ext	<50		300-400	Offers an economical and durable finish with good hide and easy application	1 hr recoat
Tibbetts - Newport Corp. Permanox Stain Flat	Exterior	7		300-350	Delivers maximum protection with a breathable finish that applies easily, dries fast and cleans-up easily with water	2 - 4 hr touch 4 hr recoat
Vista Paint 1000 Duraglide	Int/Ext	50	41.8	300-400	A fortified vinyl acrylic exterior and interior flat. Excellent touch-up, outstanding hid and good washability.	1 hr touch 4 hr recoat
Vista Paint 2000 Duratone	Exterior	17	43.6	350-420	100% acrylic exterior flat that produces a tough flexible film with outstanding resistance to fading and chalking.	1 hr touch 4-6 hr recoat
Vista Paint 6100 Carefree Earth Coat Flat	Interior	2	40	350-400	Environmentally preferable odor free, low VOC interior acrylic flat with exceptional hide, touch-up with superior adhesion, resistant to scuffing, staining and abrasion.	45 min touch 6 hr recoat
Vista Paint 2800 Coverall Exterior Flat	Exterior	46	42	300-400	Provides a tough, flexible matte flat finish with outstanding resistance to chalking and fading.	1 hr touch 4 hr recoat

Flats (≤ 50 g/l)						
Coating Company and Product Name	Interior Exterior	VOC content (g/l)	Solids (% by volume)	Coverage (sq ft/gal)	Coating Characteristics	Dry time
Vista Paint 3600 Coverall Maintenance Flat	Interior	49	38	350-500	Provides an outstanding hide, coupled with excellent touch-up characteristics.	1 hr touch 2 hr recoat
Vista Paint 013Acoustic Kote	Interior	31	29	50-400	A high-hiding, non-bridging vinyl flat for acoustical ceilings.	30 min touch 4 hr recoat
Vista Paint RC10 Latex Roll Coat	Interior	26	37	600	Water-based latex, very low VOC formulated for roll coating applications.	45 -60 min dry time

APPENDIX B

UMR Coatings Institute - Flat Coating Laboratory Performance Study

FINAL REPORT
Flat Coatings Technology Assessment

RFP # P2007-22

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Executive Summary

Introduction

This study was a critical component of the ongoing technology assessment for Rule 1113 – Architectural Coatings. The assurance that performance of paints is not hindered by lower VOC requirements is an important aspect of the rule. Of particular interest were the physical properties of twenty flat coatings in interior and exterior paint categories. Nine interior, nine exterior, and two interior/exterior coatings were tested. A series of general tests for all the paints and some specific tests for the two categories were performed.

Task 1 - Testing Protocol

Tests for General Properties of All Paints

Property	Standard	Number of Replicates	Substrate	Film Thickness/ Bar Type
Appearance	Observation	1 gallon as received	------------	-----------
Gloss	ASTM D523-89	2	Leneta Card	3mil/Bird bar
Stability	ASTM D1849-95	1	N/A	3mil/Bird bar
Stability - Syneresis	Rohm&Haas Method 807	3	N/A	N/A
Open Time/Wet Edge	Rohm&Haas Method 301	3	Plastic	7 mil/Dow bar
Freeze-Thaw Resistance	ASTM D2243-95	3	Leneta Card	3 mil/Bird bar
Flow & Leveling	ASTM D 4062-99	3	Leneta Card	NPCA bar
Sag Resistance	ASTM D4400-99	3	Leneta Card	Anti-sag meter
Dry Time - Mechanical	ASTM D5895-03	3	Glass	3mil Cube Applicator
Hide	Spectrophotometer	3	Leneta Card	3mil/Bird bar

Tests for Interior Flat Paints

Property	Standard	Number of Replicates	Substrate	Film Thickness/ Bar type
Adhesion	ASTM D 3359	3	Leneta Card	3mil/Bird bar
Scrub Resistance	ASTM D2486-00	3	Plastic	7 mil/Dow bar
Stain Resistance	ASTM D4828 mod.	3	Plastic	7 mil/Dow bar
Touch-Up	ASTM D 3928	3	Drywall	Brush/Roller

Tests for Exterior Flat Paints

Property	Standard	Number of Replicates	Substrate	Film Thickness/ Bar type
Adhesion	ASTM D 3359	3	Glass	3mil/Bird bar
Tannin Stain Blocking	Prior SCAQMD Study Protocol	3	Cedar	Brush
Alkalinity Resistance	Dunn Edwards Method	3	Concrete	Brush

Tests for General Properties Summary

Appearance – The coatings were evaluated upon receipt for general appearance including odor of spoilage, skinning, pressure, can corrosion, etc.

Appearance Summary

	Observations – 1 gallon can as received: Notes on Odor, Skinning, Pressure, Can Corrosion
A	None
B	Very Trace Can Corrosion
C	None
D	None
E	None
F	None
G	Trace Can Corrosion
H	Very Slight Separation
I	None
J	None
K	None
L	None
M	1 ¾ inch medium yellow separation layer with darker spots
N	None
O	None
P	None
Q	None
R	Very Slight Separation
S	Trace Can Corrosion
T	None

Gloss – ASTM D 523 was used with a BYK-Gardner micro-TRI-gloss meter calibrated just prior to use. Measurements were taken for 60° and 85°.

Gloss Summary*

	60°Mean	**60° SD**	**85°Mean**	**85° SD**
A	1.9	0.1	0.8	0.1
B	2.7	0.1	2.2	0.1
C	2.3	0.1	2.5	0.1
D	2.1	0.1	1.6	0.1
*E***	*8.7*	*0.1*	*28.0*	*0.2*
F	2.5	0.1	2.7	0.1
G	1.7	0.1	0.6	0.1
H	1.9	0.1	1.1	0.1
I	2.0	0.1	1.0	0.1
J	2.5	0.1	4.4	0.1
K	2.0	0.1	2.0	0.1
L	2.1	0.1	3.2	0.1
M	1.9	0.1	1.1	0.1
N	2.3	0.1	4.9	0.1
O	2.0	0.1	2.4	0.1
P	2.3	0.1	2.3	0.1
Q	2.1	0.1	2.8	0.1
R	3.0	0.1	1.3	0.1
S	2.3	0.1	1.9	0.1
T	1.9	0.1	1.3	0.1

*Average values

**The gloss readings for coating E exceed the Rule 1113 definition of a flat coating therefore, according to the Rule 1113, this coating is considered a non-flat coating and the data concerning this coating is not applicable to the flat coatings study.

Stability – ASTM D 1849 was used with one pint sample of each being kept at 125°F for 30 days, followed by evaluation as indicated in the ASTM method. Gloss measurements were also taken of the samples during evaluation. The change in viscosity of the samples was rated from 0-10 with rating of 0, 2, 4, 6, 8, and 10 for changes in viscosity (KU) of 10 or higher, 8, 6, 4, 2, and 0 respectively. The overall character (separation, skinning, pressure, can corrosion, and odor of spoilage) of the coating was also put into a 0-10 scale with ratings of 0, 2, 4, 6, 8, and 10 for complete failure, considerable, moderate, slight, very slight, and none, respectively.

Stability Summary

	Stormer (original)	**Stormer (post-test)**	**Viscosity Rating**	**Overall Character Rating**	**Character**
A	97	101	6	8	Separation - spots
B	94	96	8	6	Separation – thin layer < 1/8”
C	102	114	0	8	Separation – spots
D	101	103	8	8	Separation - spots
E	*103*	*108*	*5*	*4*	*Separation – ¼” layer*
F	108	114	4	8	Separation – spots
G	115	115	10	6	Separation – thin layer < 1/8”
H	104	103	9	6	Separation – thin layer < 1/8”
I	100	102	8	6	Separation – thin layer < 1/8”
J	95	104	1	10	No failure
K	110	120	0	8	Separation – spots
L	107	124	0	6	Separation – thin layer < 1/8”
M	100	101	9	4	Separation – ¼” layer
N	102	101	9	6	Separation – thin layer < 1/8”
O	97	94	7	6	Separation – thin layer < 1/8”
P	102	104	8	4	Separation – ¼” layer
Q	109	112	7	6	Separation – thin layer < 1/8”
R	117	126	1	6	Separation – thin layer < 1/8”
S	99	94	5	6	Separation – thin layer < 1/8”
T	99	100	9	4	Separation – ¼” layer

Stability Summary - Gloss Measurements (Before/After)

	60°Mean	**60 SD**	**85°Mean**	**85 SD**
A	1.9 / 1.9	0.1 / 0.1	0.8 / 0.8	0.1 / 0.1
B	2.7 / 2.6	0.1 / 0.1	2.2 / 2.3	0.1 / 0.1
C	2.3 / 2.3	0.1 / 0.1	2.5 / 2.7	0.1 / 0.1
D	2.1 / 2.1	0.1 / 0.1	1.6 / 1.7	0.1 / 0.1
E	*8.7 / 9.7*	*0.1 / 0.2*	*28.0 / 29.3*	*0.2 / 0.2*
F	2.5 / 2.5	0.1 / 0.1	2.7 / 2.8	0.1 / 0.1
G	1.7 / 1.7	0.1 / 0.1	0.6 / 0.6	0.1 / 0.1
H	1.9 / 1.9	0.1 / 0.1	1.1 / 1.0	0.1 / 0.1
I	2.0 / 2.0	0.1 / 0.1	1.0 / 0.9	0.1 / 0.1
J	2.5 / 2.4	0.1 / 0.1	4.4 / 4.7	0.1 / 0.2
K	2.0 / 2.1	0.1 / 0.1	2.0 / 2.0	0.1 / 0.1
L	2.1 / 2.1	0.1 / 0.1	3.2 / 3.2	0.1 / 0.1
M	1.9 / 2.0	0.1 / 0.1	1.1 / 1.3	0.1 / 0.1
N	2.3 / 2.2	0.1 / 0.1	4.9 / 5.0	0.1 / 0.1
O	2.0 / 2.0	0.1 / 0.1	2.4 / 2.4	0.1 / 0.1
P	2.3 / 2.3	0.1 / 0.1	2.3 / 2.4	0.1 / 0.1
Q	2.1 / 2.1	0.1 / 0.1	2.8 / 2.8	0.1 / 0.1
R	3.0 / 2.9	0.1 / 0.1	1.3 / 1.3	0.1 / 0.1
S	2.3 / 2.3	0.1 / 0.1	1.9 / 2.0	0.1 / 0.1
T	1.9 / 1.9	0.1 / 0.1	1.3 / 1.3	0.1 / 0.1

Stability – Syneresis – Rohm&Haas Method 807 was used. 40mm pieces of graph paper were attached to the back of 1 oz. vials and the vials were filled with paint to the top of the graph paper. The vials were put in an oven at 60℃ (140℉) for 10 days and the separation and settling were evaluated. The separation was evaluated by measuring the clear liquid on top of the coating in mm and putting these values into a 0-10 scale in which the ratings are 0, 2, 4, 6, 8, and 10 for 10mm, 8mm, 6mm, 4mm, 2mm, and 0mm, respectively.

Stability – Colorant/pigment float – Syneresis*

	Separation, mm	Rating	Settling
A	0.75	9	None
B	1.0	9	Soft Pack
C	0.5	9	Hard Pack
D	1.0	9	Soft Pack
E	*2.0*	*8*	*Soft Pack*
F	0.5	9	Soft Pack
G	1.0	9	Soft Pack
H	1.0	9	Soft Pack
I	0.5	9	Soft Pack
J	1.0	9	Hard Pack
K	2.0	8	Soft Pack
L	2.0	8	Hard Pack
M	1.0	9	None
N	1.0	9	Soft Pack
O	2.0	8	Soft Pack
P	1.0	9	Soft Pack
Q	1.0	9	Soft Pack
R	0.5	9	Soft Pack
S	1.0	9	None
T	1.0	9	None

*Average Values

Open Time/Wet Edge – Rohm&Haas Method 301A was used. The coatings were drawndown on plastic scrub panels and horizontal squiggles were made at 2 minute intervals. The squiggle was painted over with a set number of strokes (5 full) immediately after being made and the panels were allowed to dry 24 hours before evaluation to determine which squiggle was first visible. The time before the squiggle was first visible was recorded. A 0-10 rating system was then applied to the results with ratings of 0, 2, 4, 6, 8, and 10 for 0 minutes, 2, 4, 6, 8, and 10 minutes, respectively.

Open Time/ Wet Edge Summary*

	Last Non-Visible Squiggle Time, min	Rating
A	14	10+
B	10	10
C	12	10+
D	15	10+
E	*15*	*10*+
F	14	10+
G	13	10+
H	16	10+
I	13	10+
J	11	10+
K	12	10+
L	12	10+
M	12	10+
N	13	10+
O	9	9
P	8	8
Q	8	8
R	8	8
S	10	10
T	14	10+

*Average Values

<u>Freeze-thaw Resistance</u> – ASTM D 2243 was used for the water-borne paints for three samples of each with the paints applied to black and white Leneta charts after each of the five cycles. A cycle was defined according to the ASTM method. Viscosity and gloss measurements were taken of the sample after each cycle, as long as it had not failed. The overall results were fitted into a 0-10 scale with ratings of 0, 2, 4, 6, 8, and 10 for 0 cycles passed, 1, 2, 3, 4, and 5 cycles passed, respectively.

Freeze-Thaw Resistance: Pass/Fail Summary

	After 1 Cycle	After 2 Cycles	After 3 Cycles	After 4 Cycles	After 5 Cycles	Rating
A	Pass	Pass	Pass	Pass	Pass	10
B	Pass	Pass	Pass	Pass	Pass	10
C	Fail	-----------	-----------	-----------	-----------	0
D	Pass	Pass	Pass	Pass	Pass	10
E	*Fail*	-----------	-----------	-----------	-----------	*0*
F	Fail	-----------	-----------	-----------	-----------	0
G	Pass	Fail	-----------	-----------	-----------	2
H	Pass	Pass	Pass	Pass	Fail	8
I	Pass	Pass	Pass	Pass	Pass	10
J	Fail	-----------	-----------	-----------	-----------	0
K	Pass	Fail	-----------	-----------	-----------	2
L	Fail	-----------	-----------	-----------	-----------	0
M	Fail	-----------	-----------	-----------	-----------	0
N	Fail	-----------	-----------	-----------	-----------	0
O	Fail	-----------	-----------	-----------	-----------	0
P	Fail	-----------	-----------	-----------	-----------	0
Q	Fail	-----------	-----------	-----------	-----------	0
R	Fail	-----------	-----------	-----------	-----------	0
S	Fail	-----------	-----------	-----------	-----------	0
T	Fail	-----------	-----------	-----------	-----------	0

*Average values

Flow & Leveling – ASTM D 4062 was used. This is an old ASTM method that is analogous to the New York Society for Paint Technology "Official Digest" No. 44 Vol. 32, No. 430, p. 1435. The NYPC Level Blade was used.

Sag Resistance – ASTM D4400 was used. An anti-sag bar was used to apply paint to a black and white Leneta chart. This bar deposits strips of paint from 3 to 12 mils thick approximately ½" wide. The chart was immediately lifted to a vertical position with the 12 mil thick strip at the bottom. Evaluation was based upon how much the strips flow into the strips below.

Flow & Leveling and Sag are often used in conjunction to help gauge the application performance of a coating, often for vertical wall applications, although Flow & Leveling is also important for coatings for horizontal applications such as floors. Flow & Leveling represents short term and Sag represents a longer time effect. Flow & Leveling ratings represent a coatings ability to reduce the appearance of brush strokes and similar marks by flowing from the thicker areas to the adjacent thinner areas. Sag Resistance gauges how thick a coating can be applied before the coating shifts and causes visual defects. Typically, flat coatings are applied to about 3mil dry film, but sometimes thicker, so the coating needs to be able to withstand 6-8 wet mils before sagging to ensure that there will be no sagging of the coating in the desired application thickness range. Sag Resistance values are the highest mil thickness that can be applied without the coating sagging.

Flow/Level and Sag Resistance Summary*

	Flow/Level	**Sag**
A	0	12+
B	0	12+
C	0	12+
D	0	12+
E	*0*	*12*+
F	0	12+
G	0	12+
H	0	12+
I	0	12+
J	5	10
K	1	12+
L	0	12+
M	0	12+
N	0	12+
O	3	12+
P	0	12+
Q	0	12+
R	0	12+
S	0	12+
T	0	12+

*Average values

Mechanical Dry Time – ASTM D 5895 was used to determine dry time with a mechanical straight line drying time recorder.

Mechanical Dry Time Summary (in minutes)*

	Set-Touch	Tack-Free	Dry-Hard	Dry-Through
A	6	10	24	> 6 Hours
B	3	12	22	> 6 Hours
C	5	12	43	> 6 Hours
D	8	14	36	> 6 Hours
E	*4*	*10*	*23*	*> 6 Hours*
F	2	4	23	> 6 Hours
G	10	18	26	> 6 Hours
H	6	15	19	> 6 Hours
I	1	9	12	> 6 Hours
J	2	7	19	> 6 Hours
K	6	11	58	> 6 Hours
L	1	4	6	> 6 Hours
M	2	6	113	> 6 Hours
N	6	12	14	> 6 Hours
O	5	8	40	> 6 Hours
P	4	7	14	> 6 Hours
Q	3	5	8	> 6 Hours
R	1	8	20	> 6 Hours
S	3	8	12	> 6 Hours
T	2	5	66	> 6 Hours

*Average values; times in minutes; stylus diameter = 1mm; speed = 6 hours

Hide – For dry hide and gloss, a three-mil Bird bar was used to apply paint to three black and white Leneta charts. The color was measured using a Minolta CM-2002 spectrophotometer and the CIE XYZ value for Y was recorded. The Y values over the white section and the black section were used to calculate dry hide. Due to Beer's and Lambert's Law, hide increases as film thickness increases. Hide also increases as concentration of hiding pigments increases. A 0-10 rating scale was applied to the contrast ratios with ratings of 0, 2, 4, 6, 8, and 10 being contrast ratios of 0.95, 0.96, 0.97, 0.98, 0.99, and 1.00, respectively.

Hide Summary – Contrast Ratio*

	3 mil #1	3 mil #2	3 mil #3	Average	Rating
A	0.976	0.976	0.975	0.976	6
B	0.974	0.976	0.977	0.976	6
C	0.980	0.979	0.980	0.980	6
D	0.979	0.976	0.979	0.978	6
E	*0.996*	*0.999*	*0.998*	*0.998*	*10*
F	0.992	0.994	0.994	0.993	8
G	0.966	0.967	0.964	0.966	4
H	0.982	0.983	0.981	0.982	6
I	0.976	0.977	0.977	0.976	6
J	0.985	0.986	0.987	0.986	8
K	0.979	0.980	0.979	0.980	6
L	0.981	0.980	0.979	0.980	6
M	0.981	0.982	0.983	0.982	6
N	0.984	0.986	0.987	0.986	8
O	0.982	0.982	0.983	0.982	6
P	0.983	0.982	0.983	0.983	6
Q	0.984	0.983	0.984	0.983	6
R	0.988	0.988	0.988	0.988	8
S	0.978	0.978	0.977	0.978	6
T	0.970	0.969	0.969	0.970	4

*Average values

Tests for Interior Flat Paints Summary

Adhesion – ASTM D 3359-Method B was used to determine adhesion of a 3mil drawdown on a Leneta chart. This method used a cutting tool and 3mm cutting guide to make a series of perpendicular cuts in the surface. Pressure sensitive tape in accordance with the ASTM procedure was then applied and removed after 90 seconds and the adhesion was qualitatively analyzed based on how much coating was removed by the tape. The ASTM classification of 0B-5B was put into a rating system of 0-5, respectively, with 5 being 0% removed and a 0 being greater than 65% removed.

Adhesion (on Leneta chart)*

	ASTM Rating	% Failure	Failure Mechanism	AQMD Rating
J	4B	3.5	Substrate	4
K	4B	13.3	Substrate	4
L	3B	6.7	Substrate	3
M	5B	0.2	Substrate	5
N	4B	8.5	Substrate	4
O	3B	6.0	Adhesion	3
P	3B	6.7	Adhesion	3
Q	2B	23.3	Adhesion	2
R	4B	2.7	Substrate	4
S	4B	4.0	Substrate	4
T	5B	1.0	Substrate	5

*Average Values

Note: When substrate failure occurs, the adhesion of the tape to the coating and the adhesion of the coating to the substrate are stronger than the substrate's cohesive strength which results in a lower rating even though the coating did not fail

Scrub Resistance – Test method B of ASTM D2486 was used with a new brush to insure correct data. Sherwin Williams Harmony was used as the standard.

Scrub Resistance Summary*

	Standard Average**	Sample Average	Sample/Standard
J	196	1089	5.56
K	199	864	4.34
L	210	685	3.26
M	213	2106	9.89
N	282	890	3.16
O***	223	645	2.89
P	232	908	3.91
Q	209	915	4.38
R	217	673	3.10
S	206	308	1.50
T	216	1231	5.70

*Average Values

**The standard is Sherwin Williams' Harmony

***Average of 4 Panels

Stain Resistance – ASTM D 4828 was modified for this test. This method was actually a washability test and provides information about the changes which occur as a result of sponge cleaning a stained area rather than the paint's likelihood of resisting a stain. To better determine the paint's resistance to staining, the paint was applied to four plastic panels and allowed to dry for 7 days as described in the ASTM method. Color was measured on each stripe on each panel using a Minolta CM-2002 spectrophotometer and the CIE XYZ values were recorded. Four staining materials, ketchup, mustard, wine and red crayon, were applied with each panel having three approximately one-inch stripes that were approximately half an inch apart of one stain resulting in three stripes per stain, and one stain per panel. The materials were left on the panels for 24 hours and then rinsed with de-ionized water and washed for 100 cycles with non-abrasive cleaner and a sponge according to the ASTM method. The panel was patted dry with paper towels to remove standing water, and was then allowed to air dry for one day. Then, averaged color measurements were taken of the stripes with CIE XYZ values and ΔE values recorded. A crude visual gloss, stain, and erosion evaluation was performed and rated. The crude visual gloss rating system included 5 levels: None (N), Increase (I), Large Increase (LI), Decrease (D), and Large Decrease (LD). The crude visual stain rating system rated the samples from 0-10 with 0 being highly stained, and 10 being highly stain resistant. The crude visual erosion rating included 3 levels: None (N), Slight (S), and Moderate (M). Numerical gloss measurements were taken with the gloss meter of each stripe after washing.

Stain Resistance – Stain Visual Rating Summary*

	Ketchup	**Mustard**	**Wine**	**Red Crayon**
J	10	10	3	3
K	10	7	3	3
L	10	5	3	3
M	10	7	3	3
N	10	7	3	3
O	10	5	5	3
P	7	5	3	3
Q	7	5	3	3
R	10	3	5	0
S	7	3	3	0
T	10	3	3	0

*Average Values

Stain Resistance – Gloss Change Visual Rating Summary*

	Ketchup	Mustard	Wine	Red Crayon
J	None	None	None	None
K	None	None	None	None
L	None	None	None	None
M	None	None	None	None
N	None	None	None	None
O	None	None	None	None
P	None	None	None	None
Q	None	None	None	None
R	None	None	None	None
S	None	None	None	None
T	None	None	None	None

*Average Values

Stain Resistance – Erosion Visual Rating Summary*

	Ketchup	Mustard	Wine	Red Crayon
J	None	None	None	None
K	None	None	None	None
L	None	None	None	None
M	None	None	None	None
N	None	None	None	None
O	None	None	None	None
P	None	None	None	None
Q	None	None	None	None
R	None	None	None	None
S	None	None	None	None
T	None	None	None	None

*Average Values

Stain Resistance – ΔE Summary*

	Ketchup	Mustard	Wine	Red Crayon**
J	0.40	0.43	2.25	12.19
K	0.39	0.45	1.99	15.19
L	0.23	1.38	3.28	13.21
M	0.05	0.22	1.61	12.53
N	0.08	0.68	2.50	23.27
O	0.09	0.85	1.15	29.28
P	0.40	0.75	2.44	12.79
Q	0.31	1.51	3.18	16.11
R	0.24	5.49	0.91	8.98
S	0.66	3.98	2.04	8.74
T	0.31	4.56	1.67	10.25

*Average Values **The red crayon was not removed by the non-abrasive cleaner and water, therefore the color represents the color of the crayon

Stain Resistance – Gloss Summary*

Washed Area – Ketchup (Pre/Post)				
	60° Mean	**60° SD**	**85° Mean**	**85° SD**
J	2.4 / 2.6	0.1 / 0.1	4.0 / 4.6	0.2 / 0.2
K	2.0 / 2.1	0.1 / 0.1	1.8 / 2.6	0.1 / 0.2
L	2.0 / 2.1	0.1 / 0.1	3.0 / 4.2	0.1 / 0.2
M	1.9 / 1.9	0.1 / 0.1	1.1 / 1.5	0.1 / 0.1
N	2.3 / 2.3	0.1 / 0.1	4.5 / 6.1	0.1 / 0.2
O	2.0 / 2.0	0.1 / 0.1	2.3 / 3.0	0.1 / 0.1
P	2.2 / 2.4	0.1 / 0.1	2.1 / 2.5	0.1 / 0.1
Q	2.0 / 2.2	0.1 / 0.1	2.5 / 3.0	0.1 / 0.2
R	2.8 / 2.9	0.1 / 0.1	1.2 / 1.5	0.1 / 0.1
S	2.2 / 2.3	0.1 / 0.1	1.7 / 2.5	0.1 / 0.2
T	1.9 / 2.0	0.1 / 0.1	1.2 / 1.9	0.1 / 0.1

Washed Area – Mustard (Pre/Post)				
	60° Mean	**60° SD**	**85° Mean**	**85° SD**
J	2.4 / 2.5	0.1 / 0.1	3.9 / 4.5	0.2 / 0.1
K	1.9 / 2.1	0.1 / 0.1	1.8 / 2.5	0.1 / 0.1
L	2.0 / 2.4	0.1 / 0.1	3.0 / 4.5	0.1 / 0.2
M	1.9 / 1.9	0.1 / 0.1	0.8 / 1.5	0.2 / 0.1
N	2.3 / 2.6	0.1 / 0.1	4.6 / 6.5	0.1 / 0.1
O	2.0 / 2.3	0.1 / 0.1	2.3 / 3.3	0.1 / 0.1
P	2.2 / 2.5	0.1 / 0.1	2.1 / 2.5	0.1 / 0.1
Q	2.0 / 2.5	0.1 / 0.1	2.5 / 3.5	0.1 / 0.1
R	2.8 / 3.3	0.1 / 0.1	1.2 / 1.7	0.1 / 0.1
S	2.2 / 2.3	0.1 / 0.2	1.8 / 2.8	0.1 / 0.2
T	1.9 / 2.1	0.1 / 0.1	1.2 / 1.8	0.1 / 0.1

Washed Area – Wine (Pre/Post)				
	60° Mean	**60° SD**	**85° Mean**	**85° SD**
J	2.4 / 2.5	0.1 / 0.1	3.9 / 4.6	0.2 / 0.2
K	2.0 / 2.0	0.1 / 0.1	1.8 / 2.7	0.1 / 0.1
L	2.0 / 2.0	0.1 / 0.1	3.0 / 4.2	0.1 / 0.2
M	1.9 / 1.8	0.1 / 0.1	1.1 / 1.5	0.1 / 0.1
N	2.2 / 2.3	0.1 / 0.1	4.3 / 7.2	0.1 / 0.1
O	2.0 / 2.0	0.1 / 0.1	2.3 / 3.4	0.1 / 0.2
P	2.2 / 2.2	0.1 / 0.1	2.1 / 2.6	0.1 / 0.1
Q	2.0 / 2.1	0.1 / 0.1	2.5 / 3.4	0.1 / 0.2
R	2.8 / 2.9	0.1 / 0.1	1.2 / 1.5	0.1 / 0.1
S	2.2 / 2.3	0.1 / 0.1	1.8 / 2.9	0.1 / 0.1
T	1.9 / 1.9	0.1 / 0.1	1.2 / 2.0	0.1 / 0.1

Washed Area – Red Crayon (Pre/Post)**				
	60° Mean	**60° SD**	**85° Mean**	**85° SD**
J	2.4 / 3.2	0.1 / 0.2	3.9 / 8.9	0.1 / 0.5
K	1.9 / 2.4	0.1 / 0.1	1.8 / 5.4	0.1 / 0.2
L	2.0 / 2.8	0.1 / 0.2	3.0 / 8.8	0.1 / 0.9
M	1.9 / 2.1	0.1 / 0.1	1.1 / 3.6	0.1 / 0.3
N	2.3 / 3.7	0.1 / 0.2	4.6 / 15.8	0.1 / 1.0
O	2.0 / 3.0	0.1 / 0.2	2.3 / 10.5	0.1 / 0.5
P	2.2 / 2.7	0.1 / 0.1	2.0 / 5.4	0.1 / 0.4
Q	2.0 / 2.6	0.1 / 0.2	2.5 / 7.1	0.1 / 0.3
R	2.8 / 2.8	0.1 / 0.1	1.2 / 2.3	0.1 / 0.2
S	2.2 / 2.4	0.1 / 0.1	1.8 / 4.2	0.1 / 0.2
T	1.9 / 2.1	0.1 / 0.1	1.2 / 3.3	0.1 / 0.2

*Average Values

**The red crayon was not removed by the non-abrasive cleaner and water; therefore the gloss measurements for the red crayon stripes reflect the gloss of the crayon, not the gloss of the coating.

Touch-Up – This procedure was performed as indicated in ASTM D 3928 on primed (Behr P.V.A. Drywall Primer & Sealer No. 73) drywall panels, involving two sections (A and B) painted with the test paint 1 minute apart with a two inch overlap between them (C), an 'X' (D) painted on the second section 30 seconds after being painted, and a rectangle (E) painted on the first section 24 hours later. Gloss measurements were used to evaluate the results by taking two measurements on the bulk sections (A and B) and the overlapped and touched up sections (C, D, and E) at perpendicular angles (one reading horizontal, one reading vertical). The panels was also checked for visible gloss variations at the touched up sections. The results were fitted to a 0-10 scale.

The A and B sections represent non-touched up and non-overlapped sections after normal application, and the C section represents overlap during application. The D and E sections represent touched up sections where D was an immediate touch up and E was a touch up a day later. The gloss difference between A/B and C represents the gloss difference of overlapped sections that were not painted over repeatedly. The difference in gloss between A/B and D represents the gloss change that results from immediate touching up, and the difference between A/B and E represents the gloss difference that results from touching up a wall a day later.

Touch-Up - Gloss Summary*

	A1	**A2**	**B1**	**B2**	**C1**	**C2**	**D1**	**D2**	**E1**	**E2**	**Visual Rating****
J	3.4	3.9	3.7	3.4	4.1	3.8	3.6	3.6	3.8	3.9	10
K	1.6	1.8	1.7	1.7	2.0	1.9	1.8	1.8	2.2	2.0	10
L	2.4	2.6	2.5	2.5	2.6	2.6	2.5	2.6	2.5	2.4	10
M	0.9	1.1	1.3	0.9	1.3	0.9	1.2	1.2	1.2	1.1	10
N	2.8	3.2	3.4	3.1	4.0	3.3	3.5	3.4	3.5	3.9	10
O	1.7	2.1	2.0	1.8	2.1	1.8	2.0	2.0	2.0	1.9	10
P	1.6	2.0	2.1	1.8	2.2	1.7	2.1	2.1	1.9	1.9	10
Q	1.9	2.2	2.1	1.9	2.3	1.9	2.1	2.1	2.2	1.9	10
R	1.1	1.3	1.2	1.1	1.4	1.2	1.1	1.1	0.9	0.9	10
S	1.2	1.6	1.6	1.2	1.4	1.1	1.6	1.6	1.5	1.5	10
T	0.9	1.3	1.2	1.0	1.3	1.0	1.1	1.2	1.1	1.2	10

*Average Values

**Because these paints are flat, there was no discernable visual gloss difference at 85°

***Note: A1, B1, C1, and E1 are all horizontal gloss measurements along the length of the panel and A2, B2, C2, and E2 were all vertical measurements along the width of the panel. D1 was a measurement along the diagonal stroke that goes from the upper left to the lower right, and D2 was a measurement along the diagonal stroke that goes from the upper right to the lower left

Tests for Exterior Flat Paints Summary

Adhesion – ASTM D 3359-Method B was used to determine adhesion of a 3mil drawdown on a Leneta chart. This method used a cutting tool and 3mm cutting guide to make a series of perpendicular cuts in the surface. Pressure sensitive tape in accordance with the ASTM procedure was then applied and removed after 90 seconds and the adhesion was qualitatively analyzed based on how much coating was removed by the tape. The ASTM classification of 0B-5B was put into a rating system of 0-5, respectively, with 5 being 0% removed and a 0 being greater than 65% removed.

Adhesion Summary – Glass*

	ASTM Rating	Failure %	Failure Mechanism	AQMD Rating
A	3B	10	Adhesion	3
B	4B	2	Adhesion	4
C	2B	20	Adhesion	2
D	4B	4	Adhesion	4
E	*5B*	*0*	--------------	*5*
F	2B	18	Adhesion	2
G	2B	17	Adhesion	2
H	4B	3	Adhesion	4
I	4B	1	Adhesion	4
S	2B	20	Adhesion	2
T	3B	7	Adhesion	3

*Average Values

Tannin Stain Blocking – Protocol from prior SCAQMD study was used. This test evaluates a coating's ability to resist tannin bleed-through from wood substrates. Cedar was used as the substrate. The panels were coated by weight, allowed to dry 24 hours in ambient conditions, and then were dried for two weeks at 50℃. The panels were then evaluated for color change by spectrophotometer before and after drying in the oven, as well as being ranked relative to positive (Morewear 1150 Acrylic Stain Blocking Primer) and negative (Valspar Ultra Premium 72926) tannin controls on the boards. Each of the three sets of coatings were visually ranked from 1-13 with 13 being the most white coating, and 1 being the least white coating.

Color difference (ΔE) measurements were taken for two different comparisons. The first one was the tannin bleed which was measured as the difference in color between the coating after initial drying on the cedar panels and the final after the panels were removed from the oven. The second color difference measured incorporates the flash tannin bleed which was the tannin bleed that occurs during the application and drying of the coating by measuring the panels after the test versus the color on a Leneta chart drawdown. A high color difference between the Leneta and the final and a low color difference between the tannin board before and after oven drying indicates that a coating had a large amount of flash tannin bleed, but had less tannin bleed once the coating was initially dry.

Tannin Stain Blocking Summary*

	ΔE (Initial Cedar)	Visual Ranking**	ΔE (Leneta)
Positive Standard	1.27	5	4.48
Negative Standard	0.67	1	2.77
A	1.17	9	4.38
B	0.79	3	4.93
C	0.88	4	4.28
D	0.81	2	4.78
E	*0.91*	*12*	*1.54*
F	1.00	13	1.70
G	0.98	8	3.69
H	0.86	10	3.15
I	1.35	11	4.23
S	1.08	7	4.15
T	1.23	7	4.95

*Average Values

**These values are the average of the three visual rankings

Alkalinity Resistance – The Dunn Edwards Alkali Resistance Test Method was used with Dunn Edwards concrete test panels. A sample of the coating was tinted with a mixture of D-E QTC1 and QTC 7 tints and applied to the test panel. The back of the test panel was immersed in a tub of water and the tub was placed outdoors for full exposure. The panels were examined every day for 7 days and the spectrophotometer was used to determine color changes. The panels were also visually examined for color change. The results were fitted into a 0-10 scale with 10 being no color change and 0 being severe color change.

The spectrophotometer ΔE readings provide a numerical representation of the color changes. For example, a reading of 0.50 is often considered a visual match between a standard and a sample. For this test, a ΔE reading less than 1.00 would indicate an excellent resistance, a reading of 2.00 would indicate very good, 3.00 good, 4.00 poor, and 5.00 complete failure.

The coatings in this test were only allowed to dry one day before severe exposure, which includes the concrete being placed in water. Because these coatings are only allowed to dry one day, they are tested before they are fully coalesced. The amount of time required for a given coating to fully coalesce depends on the particle size and molecular weight of that particular coating's resin. A coating that has not fully coalesced tends to be more permeable to both water and base, resulting in accelerated failure for most of the coatings under these conditions.

Alkalinity Resistance - ΔE Summary*

	1 Day	2 Days	3 Days	4 Days	5Days	6 Days	7 Days	Final	Visual
A	1.31	2.23	4.19	6.14	7.47	8.99	9.95	8.75	0
B	0.95	1.25	1.77	2.38	2.99	2.97	3.13	3.20	1
C	0.97	3.20	5.14	7.17	7.73	8.42	8.53	8.79	0
D	0.66	1.04	1.37	1.94	2.34	2.45	2.79	2.42	1
E	*1.03*	*3.37*	*6.36*	*9.65*	*11.57*	*11.34*	*12.81*	*12.92*	*0*
F	2.11	4.14	8.52	12.54	13.65	15.75	15.51	15.32	0
G	2.31	4.18	6.86	9.57	11.77	12.89	13.60	14.12	1
H	1.14	1.90	3.59	6.31	9.04	9.66	11.32	11.87	0
I	1.35	3.13	5.82	9.68	13.83	14.92	15.68	14.95	0
S	0.84	2.77	8.78	13.71	19.30	19.76	20.72	20.96	0
T	1.65	5.88	16.30	22.03	25.38	26.48	27.58	26.50	0

*Average Values

Test Results

Tests for General Properties of All Paints

Appearance

	Observations – 1 gallon can as received: Notes on Odor, Skinning, Pressure, Can Corrosion
A	None
B	Very Trace Can Corrosion
C	None
D	None
E	*None*
F	None
G	Trace Can Corrosion
H	Very Slight Separation
I	None
J	None
K	None
L	None
M	1 ¾ inch medium yellow separation layer with darker spots
N	None
O	None
P	None
Q	None
R	Very Slight Separation
S	Trace Can Corrosion
T	None

Gloss (60° & 85°)

	Gloss (5 readings per replicate)			
	60° Mean	**60° Std. Dev.**	**85° Mean**	**85° Std. Dev.**
A	1.9	0.1	0.8	0.1
Replicate 2	1.9	0.1	0.8	0.1
Average	**1.9**	**0.1**	**0.8**	**0.1**
B	2.7	0.1	2.2	0.1
Replicate 2	2.7	0.1	2.2	0.1
Average	**2.7**	**0.1**	**2.2**	**0.1**
C	2.3	0.1	2.5	0.1
Replicate 2	2.3	0.1	2.5	0.1
Average	**2.3**	**0.1**	**2.5**	**0.1**
D	2.1	0.1	1.6	0.1
Replicate 2	2.1	0.1	1.6	0.1
Average	**2.1**	**0.1**	**1.6**	**0.1**
E	*8.7*	*0.1*	*28.0*	*0.1*
Replicate 2	*8.7*	*0.1*	*28.0*	*0.2*
Average	***8.7***	***0.1***	***28.0***	***0.2***
F	2.5	0.1	2.7	0.1
Replicate 2	2.5	0.1	2.7	0.1

Average	**2.5**	**0.1**	**2.7**	**0.1**
G	1.7	0.1	0.6	0.1
Replicate 2	1.6	0.1	0.6	0.1
Average	**1.7**	**0.1**	**0.6**	**0.1**
H	1.9	0.1	1.1	0.1
Replicate 2	1.9	0.1	1.1	0.1
Average	**1.9**	**0.1**	**1.1**	**0.1**
I	2.0	0.1	1.0	0.1
Replicate 2	2.0	0.1	1.0	0.1
Average	**2.0**	**0.1**	**1.0**	**0.1**
J	2.4	0.1	4.3	0.1
Replicate 2	2.5	0.1	4.4	0.1
Average	**2.5**	**0.1**	**4.4**	**0.1**
K	2.0	0.1	2.0	0.1
Replicate 2	2.0	0.1	1.9	0.1
Average	**2.0**	**0.1**	**2.0**	**0.1**
L	2.1	0.1	3.2	0.1
Replicate 2	2.1	0.1	3.2	0.1
Average	**2.1**	**0.1**	**3.2**	**0.1**
M	1.9	0.1	1.1	0.1
Replicate 2	1.9	0.1	1.1	0.1
Average	**1.9**	**0.1**	**1.1**	**0.1**
N	2.3	0.1	4.9	0.1
Replicate 2	2.3	0.1	4.9	0.1
Average	**2.3**	**0.1**	**4.9**	**0.1**
O	2.0	0.1	2.4	0.1
Replicate 2	2.0	0.1	2.4	0.1
Average	**2.0**	**0.1**	**2.4**	**0.1**
P	2.3	0.1	2.3	0.1
Replicate 2	2.3	0.1	2.3	0.1
Average	**2.3**	**0.1**	**2.3**	**0.1**
Q	2.1	0.1	2.8	0.1
Replicate 2	2.1	0.1	2.8	0.1
Average	**2.1**	**0.1**	**2.8**	**0.1**
R	2.9	0.1	1.3	0.1
Replicate 2	3.0	0.1	1.3	0.1
Average	**3.0**	**0.1**	**1.3**	**0.1**
S	2.3	0.1	1.9	0.1
Replicate 2	2.3	0.1	1.9	0.1
Average	**2.3**	**0.1**	**1.9**	**0.1**
T	1.9	0.1	1.3	0.1
Replicate 2	1.9	0.1	1.3	0.1
Average	**1.9**	**0.1**	**1.3**	**0.1**

Stability

	Initial	Storage	Stormer Visc.		Viscosity	Character	Gloss (5 readings per replicate)			
	Stormer	**Time**	**Viscosity**	**Temp**	**Rating**	**Rating**	**60°Mean**	**60°SD**	**85°Mean**	**85°SD**
A	97	30 Days	101	25	6	8	1.9	0.1	0.8	0.1
B	94	30 Days	96	25	8	6	2.6	0.1	2.3	0.1
C	102	30 Days	114	25	0	8	2.3	0.1	2.7	0.1
D	101	30 Days	103	25	8	8	2.1	0.1	1.7	0.1
E	*103*	*30 Days*	*108*	*25*	*5*	*4*	*9.7*	*0.2*	*29.3*	*0.2*
F	108	30 Days	114	25	4	8	2.5	0.1	2.8	0.1
G	115	30 Days	115	25	10	6	1.7	0.1	0.6	0.1
H	104	30 Days	103	25	9	6	1.9	0.1	1.0	0.1
I	100	30 Days	102	25	8	6	2.0	0.1	0.9	0.1
J	95	30 Days	104	25	1	10	2.4	0.1	4.7	0.2
K	110	30 Days	120	25	0	8	2.0	0.1	2.0	0.1
L	107	30 Days	124	25	0	6	2.1	0.1	3.2	0.1
M	100	30 Days	101	25	9	4	2.0	0.1	1.3	0.1
N	102	30 Days	101	25	9	6	2.2	0.1	5.0	0.1
O	97	30 Days	94	25	7	6	2.0	0.1	2.4	0.1
P	102	30 Days	104	25	8	4	2.3	0.1	2.4	0.1
Q	109	30 Days	112	25	7	6	2.1	0.1	2.8	0.1
R	117	30 Days	126	25	1	6	2.9	0.1	1.3	0.1
S	99	30 Days	94	25	5	6	2.3	0.1	2.0	0.1
T	99	30 Days	100	25	9	4	1.9	0.1	1.3	0.1

Stability – Syneresis

		Clear Layer	AQMD					Clear Layer	AQMD	
	Time	**(mm)**	**Rating**	**Settling Notes**			**Time**	**(mm)**	**Rating**	**Settling Notes**
A	10 Days	0.75	9	None		K	10 Days	2	8	Soft Pack
Replicate 2		0.75	9	None		Replicate 2		2	8	Soft Pack
Replicate 3		0.75	9	None		Replicate 3		2	8	Soft Pack
Average		**0.75**	**9**	**None**		**Average**		**2**	**8**	**Soft Pack**
B	10 Days	1	9	Soft Pack		L	10 Days	2	8	Hard Pack
Replicate 2		1	9	Soft Pack		Replicate 2		2	8	Hard Pack
Replicate 3		1	9	Soft Pack		Replicate 3		2	8	Hard Pack
Average		**1**	**9**	**Soft Pack**		**Average**		**2**	**8**	**Hard Pack**
C	10 Days	0.5	9	Hard Pack		M	10 Days	1	9	None
Replicate 2		0.5	9	Hard Pack		Replicate 2		1	9	None
Replicate 3		0.5	9	Hard Pack		Replicate 3		1	9	None
Average		**0.5**	**9**	**Hard Pack**		**Average**		**1**	**9**	**None**
D	10 Days	1	9	Soft Pack		N	10 Days	1	9	Soft Pack

Replicate 2		1	9	Soft Pack		Replicate 2		1	9	Soft Pack
Replicate 3		1	9	Soft Pack		Replicate 3		1	9	Soft Pack
Average		**1**	**9**	**Soft Pack**		**Average**		**1**	**9**	**Soft Pack**
E	*10 Days*	*2*	*8*	*Soft Pack*		O	10 Days	2	8	Soft Pack
Replicate 2		*2*	*8*	*Soft Pack*		Replicate 2		2	8	Soft Pack
Replicate 3		*2*	*8*	*Soft Pack*		Replicate 3		2	8	Soft Pack
Average		***2***	***8***	***Soft Pack***		**Average**		**2**	**8**	**Soft Pack**
F	10 Days	0.5	9	Soft Pack		P	10 Days	1	9	Soft Pack
Replicate 2		0.5	9	Soft Pack		Replicate 2		1	9	Soft Pack
Replicate 3		0.5	9	Soft Pack		Replicate 3		1	9	Soft Pack
Average		**0.5**	**9**	**Soft Pack**		**Average**		**1**	**9**	**Soft Pack**
G	10 Days	1	9	Soft Pack		Q	10 Days	1	9	Soft Pack
Replicate 2		1	9	Soft Pack		Replicate 2		1	9	Soft Pack
Replicate 3		1	9	Soft Pack		Replicate 3		1	9	Soft Pack
Average		**1**	**9**	**Soft Pack**		**Average**		**1**	**9**	**Soft Pack**
H	10 Days	1	9	Soft Pack		R	10 Days	0.5	9	Soft Pack
Replicate 2		1	9	Soft Pack		Replicate 2		0.5	9	Soft Pack
Replicate 3		1	9	Soft Pack		Replicate 3		0.5	9	Soft Pack
Average		**1**	**9**	**Soft Pack**		**Average**		**0.5**	**9**	**Soft Pack**
I	10 Days	0.5	9	Soft Pack		S	10 Days	1	9	None
Replicate 2		0.5	9	Soft Pack		Replicate 2		1	9	None
Replicate 3		0.5	9	Soft Pack		Replicate 3		1	9	None
Average		**0.5**	**9**	**Soft Pack**		**Average**		**1**	**9**	**None**
J	10 Days	1	9	Hard Pack		T	10 Days	1	9	None
Replicate 2		1	9	Hard Pack		Replicate 2		1	9	None
Replicate 3		1	9	Hard Pack		Replicate 3		1	9	None
Average		**1**	**9**	**Hard Pack**		**Average**		**1**	**9**	**None**

Open Time/ Wet Edge

	Last Non-Visible Squiggle	**AQMD**			**Last Non-Visible Squiggle**	**AQMD**
	Time (min)	**Rating**			**Time (min)**	**Rating**
A	16	10+		K	14	10+
Replicate 2	14	10+		Replicate 2	10	10
Replicate 3	12	10+		Replicate 3	12	10+
Average	**14**	**10+**		**Average**	**12**	**10+**
B	10	10		L	12	10+
Replicate 2	10	10		Replicate 2	12	10+
Replicate 3	10	10		Replicate 3	12	10+
Average	**10**	**10**		**Average**	**12**	**10+**

C	12	10+		M	12	10+
Replicate 2	12	10+		Replicate 2	12	10+
Replicate 3	12	10+		Replicate 3	12	10+
Average	**12**	**10+**		**Average**	**12**	**10+**
D	16	10+		N	12	10+
Replicate 2	14	10+		Replicate 2	12	10+
Replicate 3	14	10+		Replicate 3	14	10+
Average	**15**	**10+**		**Average**	**13**	**10+**
E	*16*	*10+*		O	10	10
Replicate 2	*14*	*10+*		Replicate 2	8	8
Replicate 3	*14*	*10+*		Replicate 3	8	8
Average	***15***	***10+***		**Average**	**9**	**9**
F	14	10+		P	8	8
Replicate 2	14	10+		Replicate 2	8	8
Replicate 3	14	10+		Replicate 3	8	8
Average	**14**	**10+**		**Average**	**8**	**8**
G	12	10+		Q	8	8
Replicate 2	14	10+		Replicate 2	8	8
Replicate 3	14	10+		Replicate 3	8	8
Average	**13**	**10+**		**Average**	**8**	**8**
H	16	10+		R	8	8
Replicate 2	16	10+		Replicate 2	8	8
Replicate 3	16	10+		Replicate 3	8	8
Average	**16**	**10+**		**Average**	**8**	**8**
I	14	10+		S	10	10
Replicate 2	14	10+		Replicate 2	10	10
Replicate 3	12	10+		Replicate 3	10	10
Average	**13**	**10+**		**Average**	**10**	**10**
J	10	10		T	14	10+
Replicate 2	12	10+		Replicate 2	14	10+
Replicate 3	12	10+		Replicate 3	14	10+
Average	**11**	**10+**		**Average**	**14**	**10+**

Freeze-Thaw Resistance

	Original	After 1 Cycle			After 2 Cycles			After 3 Cycles			After 4 Cycles			After 5 Cycles			AQMD
	Stormer	S/G/C	Stormer	Temp	S/G/C	Stormer	Temp	S/G/C	Stormer	Temp	S/G/C	Stormer	Temp	S/G/C	Stormer	Temp	Rating
A	97	10	99	25	8	97	25	8	94	25	6	94	25	4	102	25	10
Can 2	97	10	96	25	8	95	25	8	94	25	6	94	25	4	101	25	10
Can 3	97	10	98	25	8	98	25	8	98	25	6	94	25	4	104	25	10
B	94	10	94	25	6	95	25	6	96	25	4	96	25	4	99	25	10
Can 2	94	10	94	25	6	93	25	6	93	25	4	93	25	4	100	25	10
Can 3	94	10	93	25	6	92	25	6	92	25	4	93	25	4	98	25	10
C	101		Failure			-------------------------			-------------------------			-------------------------			-------------------------		0
Can 2	102		Failure			-------------------------			-------------------------			-------------------------			-------------------------		0
Can 3	102		Failure			-------------------------			-------------------------			-------------------------			-------------------------		0
D	100	8	100	25	6	103	25	6	102	25	4	107	25	2	109	25	10
Can 2	102	8	104	25	6	104	25	6	104	25	4	109	25	2	109	25	10
Can 3	101	8	102	25	6	104	25	6	105	25	4	109	25	2	109	25	10
E	*103*		*Failure*			-------------------------			-------------------------			-------------------------			-------------------------		*0*
Can 2	*103*		*Failure*			-------------------------			-------------------------			-------------------------			-------------------------		*0*
Can 3	*103*		*Failure*			-------------------------			-------------------------			-------------------------			-------------------------		*0*
F	108		Failure			-------------------------			-------------------------			-------------------------			-------------------------		0
Can 2	109		Failure			-------------------------			-------------------------			-------------------------			-------------------------		0
Can 3	108		Failure			-------------------------			-------------------------			-------------------------			-------------------------		0
G	115	4	138	25		Failure			-------------------------			-------------------------			-------------------------		2
Can 2	115	4	141	25		Failure			-------------------------			-------------------------			-------------------------		2
Can 3	116	4	141	25		Failure			-------------------------			-------------------------			-------------------------		2
H	104	6	118	25	4	125	25	2	131	25	2	131	25		Failure		8
Can 2	104	6	117	25	4	123	25	2	131	25	2	133	25		Failure		8
Can 3	104	6	117	25	4	123	25	2	130	25	2	132	25		Failure		8
I	101	8	103	25	6	105	25	6	104	25	4	106	25	2	113	25	10
Can 2	98	8	99	25	6	101	25	6	102	25	4	103	25	2	113	25	10
Can 3	101	8	102	25	6	103	25	6	103	25	4	105	25	2	112	25	10
J	94		Failure			-------------------------			-------------------------			-------------------------			-------------------------		0
Can 2	95		Failure			-------------------------			-------------------------			-------------------------			-------------------------		0
Can 3	95		Failure			-------------------------			-------------------------			-------------------------			-------------------------		0
K	110	4	122	25		Failure			-------------------------			-------------------------			-------------------------		2
Can 2	109	4	132	25		Failure			-------------------------			-------------------------			-------------------------		2
Can 3	110	4	133	25		Failure			-------------------------			-------------------------			-------------------------		2
L	108		Failure			-------------------------			-------------------------			-------------------------			-------------------------		0
Can 2	107		Failure			-------------------------			-------------------------			-------------------------			-------------------------		0
Can 3	107		Failure			-------------------------			-------------------------			-------------------------			-------------------------		0

M	99	Failure			--------------------------			--------------------------			--------------------------			--------------------------			0
Can 2	100	Failure			--------------------------			--------------------------			--------------------------			--------------------------			0
Can 3	100	Failure			--------------------------			--------------------------			--------------------------			--------------------------			0
N	102	Failure			--------------------------			--------------------------			--------------------------			--------------------------			0
Can 2	101	Failure			--------------------------			--------------------------			--------------------------			--------------------------			0
Can 3	102	Failure			--------------------------			--------------------------			--------------------------			--------------------------			0
	Original	**After 1 Cycle**			**After 3 Cycles**			**After 5 Cycles**			**After 8 Cycles**			**After 8 Cycles**			
	Stormer	**S/G/C**	**Stormer**	**Temp**	**S/G/C**	**Stormer**	**Temp**	**S/G/C**	**Stormer**	**Temp**	**S/G/C**	**Stormer**	**Temp**	**S/G/C**	**Stormer**	**Temp**	
O	97	Failure			--------------------------			--------------------------			--------------------------			--------------------------			0
Can 2	97	Failure			--------------------------			--------------------------			--------------------------			--------------------------			0
Can 3	96	Failure			--------------------------			--------------------------			--------------------------			--------------------------			0
P	102	Failure			--------------------------			--------------------------			--------------------------			--------------------------			0
Can 2	103	Failure			--------------------------			--------------------------			--------------------------			--------------------------			0
Can 3	101	Failure			--------------------------			--------------------------			--------------------------			--------------------------			0
Q	109	Failure			--------------------------			--------------------------			--------------------------			--------------------------			0
Can 2	109	Failure			--------------------------			--------------------------			--------------------------			--------------------------			0
Can 3	109	Failure			--------------------------			--------------------------			--------------------------			--------------------------			0
R	114	Failure			--------------------------			--------------------------			--------------------------			--------------------------			0
Can 2	118	Failure			--------------------------			--------------------------			--------------------------			--------------------------			0
Can 3	119	Failure			--------------------------			--------------------------			--------------------------			--------------------------			0
S	100	Failure			--------------------------			--------------------------			--------------------------			--------------------------			0
Can 2	99	Failure			--------------------------			--------------------------			--------------------------			--------------------------			0
Can 3	99	Failure			--------------------------			--------------------------			--------------------------			--------------------------			0
T	99	Failure			--------------------------			--------------------------			--------------------------			--------------------------			0
Can 2	100	Failure			--------------------------			--------------------------			--------------------------			--------------------------			0
Can 3	99	Failure			--------------------------			--------------------------			--------------------------			--------------------------			0

Freeze-Thaw Resistance: Gloss

	After 1 Cycle				**After 2 Cycles**				**After 3 Cycles**			
	60° M	**60°SD**	**85° M**	**85°SD**	**60° M**	**60°SD**	**85° M**	**85°SD**	**60° M**	**60°SD**	**85° M**	**85°SD**
A	1.9	0.1	0.8	0.1	1.8	0.1	0.8	0.1	1.9	0.1	0.8	0.1
Can 2	1.9	0.1	0.8	0.1	1.9	0.1	0.8	0.1	1.9	0.1	0.8	0.1
Can 3	1.9	0.1	0.8	0.1	1.8	0.1	0.8	0.1	1.9	0.1	0.8	0.1
B	2.6	0.1	2.2	0.1	2.4	0.1	2.1	0.1	2.5	0.1	2.2	0.1
Can 2	2.6	0.1	2.2	0.1	2.4	0.1	2.1	0.2	2.5	0.1	2.2	0.1
Can 3	2.6	0.1	2.2	0.1	2.4	0.1	2.1	0.2	2.5	0.1	2.1	0.1
C	2	0.1	2	0.1	Failure				---			
Can 2	2	0.1	2	0.1	Failure				---			
Can 3	2	0.1	2.1	0.1	Failure				---			

D	2.1	0.1	1.6	0.1	2	0.1	1.6	0.1	2.1	0.1	1.6	0.1
Can 2	2.1	0.1	1.6	0.1	2	0.1	1.5	0.1	2.2	0.1	1.5	0.1
Can 3	2.1	0.1	1.6	0.1	2	0.1	1.5	0.1	2.2	0.1	1.6	0.1
E	*Failure*				--				--			
Can 2	*Failure*				--				--			
Can 3	*Failure*				--				--			
F	Failure				--				--			
Can 2	Failure				--				--			
Can 3	Failure				--				--			
G	1.7	0.1	0.6	0.1	Failure				--			
Can 2	1.7	0.1	0.6	0.1	Failure				--			
Can 3	1.7	0.1	0.7	0.2	Failure				--			
H	1.8	0.1	1	0.2	1.9	0.1	1.1	0.1	1.9	0.1	1.1	0.1
Can 2	1.8	0.2	1.1	0.1	1.9	0.1	1.1	0.1	1.9	0.1	1.2	0.1
Can 3	1.8	0.1	1.1	0.1	1.9	0.1	1.1	0.1	1.9	0.1	1.1	0.1
I	1.9	0.1	0.9	0.1	1.9	0.1	0.9	0.1	2	0.1	0.9	0.1
Can 2	1.9	0.1	0.9	0.1	1.9	0.1	0.9	0.1	1.9	0.1	0.9	0.1
Can 3	1.9	0.1	0.9	0.1	1.9	0.1	0.9	0.1	1.9	0.1	0.9	0.1
J	Failure				--				--			
Can 2	Failure				--				--			
Can 3	Failure				--				--			
K	2	0.1	1.8	0.1	Failure				--			
Can 2	2	0.1	1.8	0.1	Failure				--			
Can 3	2	0.1	1.8	0.1	Failure				--			
L	Failure				--				--			
Can 2	Failure				--				--			
Can 3	Failure				--				--			
M	Failure				--				--			
Can 2	Failure				--				--			
Can 3	Failure				--				--			
N	Failure				--				--			
Can 2	Failure				--				--			
Can 3	Failure				--				--			
O	Failure				--				--			
Can 2	Failure				--				--			
Can 3	Failure				--				--			
P	Failure				--				--			
Can 2	Failure				--				--			
Can 3	Failure				--				--			
Q	Failure				--				--			

Can 2	Failure	--	--
Can 3	Failure	--	--
R	Failure	--	--
Can 2	Failure	--	--
Can 3	Failure	--	--
S	Failure	--	--
Can 2	Failure	--	--
Can 3	Failure	--	--
T	Failure	--	--
Can 2	Failure	--	--
Can 3	Failure	--	--

Continued…	**After 4 Cycles**				**After 5 Cycles**			
	60° M	**60°SD**	**85° M**	**85°SD**	**60° M**	**60°SD**	**85° M**	**85°SD**
A	1.9	0.1	0.8	0.1	1.8	0.2	1.8	0.1
Can 2	1.9	0.1	0.8	0.1	1.9	0.1	0.8	0.1
Can 3	1.9	0.1	0.8	0.1	1.9	0.1	0.8	0.1
B	2.6	0.1	2.2	0.1	2.5	0.1	2.2	0.1
Can 2	2.6	0.1	2.2	0.1	2.5	0.1	2.2	0.1
Can 3	2.6	0.1	2.2	0.1	2.5	0.1	2.2	0.1
C	--				--			
Can 2	--				--			
Can 3	--				--			
D	2.1	0.1	1.6	0.1	2.1	0.1	1.6	0.1
Can 2	2.1	0.1	1.6	0.1	2.1	0.1	1.6	0.1
Can 3	2.1	0.1	1.6	0.1	2.1	0.1	1.6	0.1
E	--				--			
Can 2	--				--			
Can 3	--				--			
F	--				--			
Can 2	--				--			
Can 3	--				--			
G	--				--			
Can 2	--				--			
Can 3	--				--			
H	1.9	0.1	1.2	0.1	Failure			
Can 2	1.9	0.1	1.2	0.1	Failure			
Can 3	1.9	0.1	1.2	0.1	Failure			
I	1.9	0.1	1	0.1	1.9	0.1	1	0.1
Can 2	2	0.1	0.9	0.1	1.9	0.1	1	0.1

Can 3	2	0.1	1	0.1	1.9	0.1	0.9	0.2
J	----------				----------			
Can 2	----------				----------			
Can 3	----------				----------			
K	----------				----------			
Can 2	----------				----------			
Can 3	----------				----------			
L	----------				----------			
Can 2	----------				----------			
Can 3	----------				----------			
M	----------				----------			
Can 2	----------				----------			
Can 3	----------				----------			
N	----------				----------			
Can 2	----------				----------			
Can 3	----------				----------			
O	----------				----------			
Can 2	----------				----------			
Can 3	----------				----------			
P	----------				----------			
Can 2	----------				----------			
Can 3	----------				----------			
Q	----------				----------			
Can 2	----------				----------			
Can 3	----------				----------			
R	----------				----------			
Can 2	----------				----------			
Can 3	----------				----------			
S	----------				----------			
Can 2	----------				----------			
Can 3	----------				----------			
T	----------				----------			
Can 2	----------				----------			
Can 3	----------				----------			

Flow & Leveling

	Flow and Leveling			
Flat	**1**	**2**	**3**	**Average**
A	0	0	0	**0**
B	0	0	0	**0**
C	0	0	0	**0**
D	0	0	0	**0**
E	*0*	*0*	*0*	***0***
F	0	0	0	**0**
G	0	0	0	**0**
H	0	0	0	**0**
I	0	0	0	**0**
J	5	5	5	**5**
K	1	1	0	**1**
L	0	0	0	**0**
M	0	0	0	**0**
N	0	0	0	**0**
O	3	3	3	**3**
P	0	0	1	**0**
Q	0	0	0	**0**
R	0	0	0	**0**
S	0	0	0	**0**
T	0	0	0	**0**

Sag Resistance

	Sag			
Flat	**1**	**2**	**3**	**Average**
A	12+	12+	12+	**12+**
B	12+	12+	12+	**12+**
C	12+	12+	12+	**12+**
D	12+	12+	12+	**12+**
E	*12+*	*12+*	*12+*	***12+***
F	12+	12+	12+	**12+**
G	12+	12+	12+	**12+**
H	12+	12+	12+	**12+**
I	12+	12+	12+	**12+**
J	11	10	10	**10**
K	12+	12+	12+	**12+**
L	12+	12+	12+	**12+**
M	12+	12+	12+	**12+**
N	12+	12+	12+	**12+**
O	12+	12+	12+	**12+**
P	12+	12+	12+	**12+**
Q	12+	12+	12+	**12+**
R	12+	12+	12+	**12+**
S	12+	12+	12+	**12+**
T	12+	12+	12+	**12+**

Dry Time – Mechanical

	Replicate 1				Replicate 2				Replicate 3			
	Stage 1	**Stage 2**	**Stage 3**	**Stage 4**	**Stage 1**	**Stage 2**	**Stage 3**	**Stage 4**	**Stage 1**	**Stage 2**	**Stage 3**	**Stage 4**
A	7	9	21	> 300	7	9	17	> 300	1	7	21	> 300
Time (min)	8	11	25	> 6 Hours	8	11	20	> 6 Hours	1	8	25	> 6 Hours
Average (min)	**6**	**10**	**24**	**> 6 Hours**	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------
B	5	11	25	> 300	1	11	14	> 300	2	7	17	> 300
Time (min)	6	13	30	> 6 Hours	1	13	17	> 6 Hours	2	8	20	> 6 Hours
Average (min)	**3**	**12**	**22**	**> 6 Hours**	-----------	-----------	-----------	-------------	-----------	-----------	-----------	-------------
C	4	11	30	> 300	3	6	39	> 300	6	14	38	> 300
Time (min)	5	13	36	> 6 Hours	4	7	47	> 6 Hours	7	17	46	> 6 Hours
Average (min)	**5**	**12**	**43**	**> 6 Hours**	-----------	-----------	-----------	-------------	----------	-----------	-----------	-------------
D	10	12	16	> 300	5	10	36	> 300	6	13	37	> 300
Time (min)	12	14	19	> 6 Hours	6	12	43	> 6 Hours	7	16	44	> 6 Hours
Average (min)	**8**	**14**	**36**	**> 6 Hours**	-----------	-----------	-----------	-------------	-----------	-----------	-----------	-------------
E	*1*	*10*	*19*	*> 300*	*8*	*11*	*20*	*> 300*	*1*	*4*	*19*	*> 300*
Time (min)	*1*	*12*	*23*	*> 6 Hours*	*10*	*13*	*24*	*> 6 Hours*	*1*	*5*	*23*	*> 6 Hours*
Average (min)	***4***	***10***	***23***	***> 6 Hours***	-----------	-----------	-----------	-------------	-----------	-----------	-----------	-------------
F	1	4	18	> 300	2	3	25	> 300	1	2	14	> 300
Time (min)	1	5	22	> 6 Hours	2	4	30	> 6 Hours	1	2	17	> 6 Hours
Average (min)	**2**	**4**	**23**	**> 6 Hours**	-----------	-----------	-----------	-------------	-----------	-----------	-----------	-------------
G	11	14	26	> 300	12	15	19	> 300	2	15	19	> 300
Time (min)	13	17	31	> 6 Hours	14	18	23	> 6 Hours	2	18	23	> 6 Hours
Average (min)	**10**	**18**	**26**	**> 6 Hours**	-----------	-----------	-----------	-------------	-----------	-----------	-----------	-------------
H	12	14	18	> 300	1	12	14	> 300	1	12	15	> 300
Time (min)	14	17	22	> 6 Hours	1	14	17	> 6 Hours	1	14	18	> 6 Hours
Average (min)	**6**	**15**	**19**	**> 6 Hours**	-----------	-----------	-----------	-------------	-----------	-----------	-----------	-------------
I	1	11	13	> 300	1	8	10	> 300	1	4	7	> 300
Time (min)	1	13	16	> 6 Hours	1	10	12	> 6 Hours	1	5	8	> 6 Hours
Average (min)	**1**	**9**	**12**	**> 6 Hours**	-----------	-----------	-----------	-------------	-----------	-----------	-----------	-------------
J	2	6	21	> 300	3	7	13	> 300	1	5	13	> 300
Time (min)	2	7	25	> 6 Hours	4	8	16	> 6 Hours	1	6	16	> 6 Hours
Average (min)	**2**	**7**	**19**	**> 6 Hours**	-----------	-----------	-----------	-------------	-----------	-----------	-----------	-------------
K	6	10	55	> 300	8	11	31	> 300	2	6	58	> 300
Time (min)	7	12	66	> 6 Hours	10	13	37	> 6 Hours	2	7	70	> 6 Hours
Average (min)	**6**	**11**	**58**	**> 6 Hours**	-----------	-----------	-----------	-------------	-----------	-----------	-----------	-------------
L	1	6	8	> 300	1	2	3	> 300	1	2	4	> 300
Time (min)	1	7	10	> 6 Hours	1	2	4	> 6 Hours	1	2	5	> 6 Hours
Average (min)	**1**	**4**	**6**	**> 6 Hours**	-----------	-----------	-----------	-------------	-----------	-----------	-----------	-------------

M	2	4	90	> 300	1	3	98	> 300	1	7	95	> 300
Time (min)	2	5	108	> 6 Hours	1	4	118	> 6 Hours	1	8	114	> 6 Hours
Average (min)	**2**	**6**	**113**	**> 6 Hours**	-----------	-----------	-----------	-------------	-----------	----------	-----------	-------------
N	5	10	12	> 300	3	10	12	> 300	6	9	11	> 300
Time (min)	6	12	14	> 6 Hours	4	12	14	> 6 Hours	7	11	13	> 6 Hours
Average (min)	**6**	**12**	**14**	**> 6 Hours**	-----------	-----------	-----------	-------------	-----------	-----------	-----------	-------------
O	4	6	53	> 300	4	7	15	> 300	4	7	31	> 300
Time (min)	5	7	64	> 6 Hours	5	8	18	> 6 Hours	5	8	37	> 6 Hours
Average (min)	**5**	**8**	**40**	**> 6 Hours**	-----------	-----------	-----------	-------------	-----------	-----------	-----------	-------------
P	4	6	14	> 300	6	9	15	> 300	1	2	6	> 300
Time (min)	5	7	17	> 6 Hours	7	11	18	> 6 Hours	1	2	7	> 6 Hours
Average (min)	**4**	**7**	**14**	**> 6 Hours**	-----------	-----------	-----------	-------------	-----------	-----------	-----------	-------------
Q	1	3	6	> 300	1	2	4	> 300	5	7	10	> 300
Time (min)	1	4	7	> 6 Hours	1	2	5	> 6 Hours	6	8	12	> 6 Hours
Average (min)	**3**	**5**	**8**	**> 6 Hours**	-----------	-----------	----------	-------------	-----------	-----------	-----------	-------------
R	1	8	18	> 300	1	7	14	> 300	1	6	18	> 300
Time (min)	1	10	22	> 6 Hours	1	8	17	> 6 Hours	1	7	22	> 6 Hours
Average (min)	**1**	**8**	**20**	**> 6 Hours**	-----------	-----------	-----------	-------------	-----------	-----------	-----------	-------------
S	1	5	8	> 300	6	8	11	> 300	1	7	11	> 300
Time (min)	1	6	10	> 6 Hours	7	10	13	> 6 Hours	1	8	13	> 6 Hours
Average (min)	**3**	**8**	**12**	**> 6 Hours**	-----------	-----------	-----------	-------------	-----------	-----------	-----------	-------------
T	2	5	53	> 300	1	2	56	> 300	1	6	56	> 300
Time (min)	2	6	64	> 6 Hours	1	2	67	> 6 Hours	1	7	67	> 6 Hours
Average (min)	**2**	**5**	**66**	**> 6 Hours**	-----------	-----------	-----------	-------------	-----------	-----------	-----------	-------------

Hide

	3mi l- 1			3mil - 2			3mil - 3				AQMD
	Y (Black)	Y (White)	Cont. Rat.	Y (Black)	Y (White)	Cont. Rat.	Y (Black)	Y (White)	Cont. Rat.	Avg	Rating
A	87.29	89.57	0.975	87.13	89.49	0.974	87.19	89.50	0.974		
Reading 2	87.33	89.44	0.976	87.38	89.51	0.976	87.20	89.46	0.975		
Reading 3	87.36	89.46	0.977	87.44	89.48	0.977	87.37	89.45	0.977		
Average			**0.976**			**0.976**			**0.975**	**0.976**	6
B	87.92	90.55	0.971	88.27	90.59	0.974	88.48	90.71	0.975		
Reading 2	88.35	90.63	0.975	88.38	90.41	0.978	88.53	90.61	0.977		
Reading 3	88.41	90.46	0.977	88.40	90.46	0.977	88.61	90.56	0.978		
Average			**0.974**			**0.976**			**0.977**	**0.976**	6
C	87.97	89.87	0.979	87.93	89.87	0.978	88.14	89.97	0.980		
Reading 2	88.02	89.81	0.980	87.97	89.85	0.979	88.00	89.91	0.979		
Reading 3	88.23	89.85	0.982	87.94	89.77	0.980	88.22	89.83	0.982		
Average			**0.980**			**0.979**			**0.980**	**0.980**	6
D	87.69	89.70	0.978	87.53	89.86	0.974	87.82	89.75	0.978		
Reading 2	87.87	89.76	0.979	87.85	89.84	0.978	87.87	89.78	0.979		
Reading 3	87.86	89.61	0.980	87.58	89.64	0.977	87.79	89.68	0.979		
Average			**0.979**			**0.976**			**0.979**	**0.978**	6
E	*83.23*	*83.56*	*0.996*	*83.42*	*83.45*	*1.000*	*83.34*	*83.55*	*0.997*		
Reading 2	*83.26*	*83.58*	*0.996*	*83.24*	*83.48*	*0.997*	*83.27*	*83.49*	*0.997*		
Reading 3	*83.25*	*83.50*	*0.997*	*83.39*	*83.47*	*0.999*	*83.30*	*83.42*	*0.999*		
Average			***0.996***			***0.999***			***0.998***	***0.998***	*10*
F	82.82	83.50	0.992	83.09	83.50	0.995	82.99	83.55	0.993		
Reading 2	82.96	83.52	0.993	83.06	83.57	0.994	83.05	83.60	0.993		
Reading 3	82.71	83.50	0.991	83.00	83.51	0.994	82.98	83.47	0.994		
Average			**0.992**			**0.994**			**0.994**	**0.993**	8
G	85.27	88.37	0.965	85.39	88.35	0.966	84.96	88.05	0.965		
Reading 2	85.24	88.27	0.966	85.35	88.24	0.967	85.18	88.25	0.965		
Reading 3	85.33	88.20	0.967	85.46	88.32	0.968	84.91	88.15	0.963		
Average			**0.966**			**0.967**			**0.964**	**0.966**	4
H	88.71	90.34	0.982	88.63	90.26	0.982	88.33	90.35	0.978		
Reading 2	88.74	90.37	0.982	88.84	90.27	0.984	88.75	90.39	0.982		
Reading 3	88.60	90.28	0.981	88.75	90.18	0.984	88.90	90.28	0.985		
Average			**0.982**			**0.983**			**0.981**	**0.982**	6
I	86.83	89.07	0.975	87.10	89.27	0.976	86.91	89.07	0.976		
Reading 2	87.05	89.09	0.977	87.36	89.20	0.979	87.08	89.13	0.977		
Reading 3	86.86	89.10	0.975	86.98	89.21	0.975	87.14	89.13	0.978		
Average			**0.976**			**0.977**			**0.977**	**0.976**	6
J	81.69	82.94	0.985	81.76	82.89	0.986	81.59	82.78	0.986		
Reading 2	81.64	82.77	0.986	81.62	82.96	0.984	81.68	82.76	0.987		
Reading 3	81.62	82.92	0.984	81.72	82.83	0.987	81.75	82.70	0.989		
Average			**0.985**			**0.986**			**0.987**	**0.986**	8
K	88.97	91.17	0.976	88.81	90.79	0.978	88.79	90.75	0.978		
Reading 2	88.97	90.62	0.982	89.12	90.88	0.981	89.08	90.93	0.980		
Reading 3	88.91	90.65	0.981	88.95	90.54	0.982	88.90	90.74	0.980		
Average			**0.979**			**0.980**			**0.979**	**0.980**	6
L	89.72	91.53	0.980	89.73	91.53	0.980	89.64	91.56	0.979		
Reading 2	89.73	91.51	0.981	89.69	91.46	0.981	89.45	91.37	0.979		
Reading 3	89.72	91.37	0.982	89.53	91.40	0.980	89.58	91.55	0.978		

Average			**0.981**			**0.980**			**0.979**	**0.980**	6
	3mi l- 1			**3mil - 2**			**3mil - 3**				
Continued	**Y (Black)**	**Y (White)**	**Cont. Rat.**	**Y (Black)**	**Y (White)**	**Cont. Rat.**	**Y (Black)**	**Y (White)**	**Cont. Rat.**		
M	83.51	85.14	0.981	83.46	85.22	0.979	83.40	84.98	0.981		
Reading 2	83.46	85.14	0.980	83.55	85.01	0.983	83.53	84.87	0.984		
Reading 3	83.46	85.06	0.981	83.54	84.91	0.984	83.54	84.89	0.984		
Average			**0.981**			**0.982**			**0.983**	**0.982**	6
N	85.73	87.16	0.984	85.87	87.24	0.984	86.09	87.18	0.987		
Reading 2	85.84	87.17	0.985	85.94	87.16	0.986	85.85	87.18	0.985		
Reading 3	85.83	87.13	0.985	86.08	87.20	0.987	86.11	87.13	0.988		
Average			**0.984**			**0.986**			**0.987**	**0.986**	8
O	89.69	91.32	0.982	89.70	91.31	0.982	89.67	91.31	0.982		
Reading 2	89.58	91.29	0.981	89.65	91.20	0.983	89.81	91.29	0.984		
Reading 3	89.66	91.23	0.983	89.58	91.27	0.981	89.70	91.27	0.983		
Average			**0.982**			**0.982**			**0.983**	**0.982**	6
P	88.73	90.37	0.982	88.69	90.33	0.982	88.64	90.34	0.981		
Reading 2	88.67	90.33	0.982	88.80	90.34	0.983	88.92	90.32	0.984		
Reading 3	88.91	90.33	0.984	88.62	90.24	0.982	88.70	90.30	0.982		
Average			**0.983**			**0.982**			**0.983**	**0.983**	6
Q	89.65	91.12	0.984	89.47	91.16	0.981	89.48	91.08	0.982		
Reading 2	89.66	91.11	0.984	89.62	91.14	0.983	89.64	91.07	0.984		
Reading 3	89.51	91.05	0.983	89.55	91.09	0.983	89.66	91.07	0.985		
Average			**0.984**			**0.983**			**0.984**	**0.983**	6
R	84.33	85.34	0.988	84.28	85.37	0.987	84.19	85.32	0.987		
Reading 2	84.28	85.32	0.988	84.31	85.33	0.988	84.31	85.33	0.988		
Reading 3	84.27	85.33	0.988	84.25	85.30	0.988	84.37	85.33	0.989		
Average			**0.988**			**0.988**			**0.988**	**0.988**	8
S	88.30	90.38	0.977	88.27	90.39	0.977	88.18	90.36	0.976		
Reading 2	88.33	90.37	0.977	88.32	90.33	0.978	88.36	90.37	0.978		
Reading 3	88.43	90.29	0.979	88.44	90.33	0.979	88.33	90.33	0.978		
Average			**0.978**			**0.978**			**0.977**	**0.978**	6
T	87.85	90.67	0.969	87.84	90.76	0.968	87.64	90.72	0.966		
Reading 2	87.89	90.60	0.970	88.08	90.73	0.971	87.96	90.65	0.970		
Reading 3	88.03	90.61	0.972	87.75	90.64	0.968	88.16	90.69	0.972		
Average			**0.970**			**0.969**			**0.969**	**0.970**	4

Tests for Interior Flat Paints

Adhesion

	Cross-Hatch Adhesion - Leneta Chart			AQMD
	Rating	**Failure %**	**Failure Mechanism**	Rating
J	5B	0.5	Substrate	5
Replicate 2	3B	10.0	Substrate	3
Replicate 3	5B	0.0	---------------------------	5
Average	**4B**	**3.5**	**Substrate**	**4**
K	5B	0.0	---------------------------	5
Replicate 2	1B	40.0	Substrate	1

Replicate 3	5B	0.0	----------------------------	5
Average	**4B**	**13.3**	**Substrate**	**4**
L	3B	10.0	Substrate	3
Replicate 2	3B	5.0	Substrate	3
Replicate 3	3B	5.0	Substrate	3
Average	**3B**	**6.7**	**Substrate**	**3**
M	5B	0.5	Substrate	5
Replicate 2	5B	0.0	----------------------------	5
Replicate 3	5B	0.0	----------------------------	5
Average	**5B**	**0.2**	**Substrate**	**5**
N	2B	25.0	20 Substrate 5 Adhesion	2
Replicate 2	5B	0.0	----------------------------	5
Replicate 3	5B	0.5	Substrate	5
Average	**4B**	**8.5**	**Substrate**	**4**
O	3B	6.0	1 Substrate 5 Adhesion	3
Replicate 2	4B	4.0	3 Substrate 1 Adhesion	4
Replicate 3	3B	8.0	1 Substrate 7 Adhesion	3
Average	**3B**	**6.0**	**Adhesion**	**3**
P	3B	5.0	Adhesion	3
Replicate 2	3B	5.0	Adhesion	3
Replicate 3	3B	10.0	Adhesion	3
Average	**3B**	**6.7**	**Adhesion**	**3**
Q	2B	20.0	Adhesion	2
Replicate 2	2B	25.0	Adhesion	2
Replicate 3	2B	25.0	Adhesion	2
Average	**2B**	**23.3**	**Adhesion**	**2**
R	4B	2.0	Substrate	4
Replicate 2	4B	1.0	Substrate	4
Replicate 3	3B	5.0	Substrate	3
Average	**4B**	**2.7**	**Substrate**	**4**
S	3B	5.0	4 Substrate 1 Adhesion	3
Replicate 2	4B	4.0	1 Substrate 3 Adhesion	4
Replicate 3	4B	3.0	Substrate	4
Average	**4B**	**4.0**	**Substrate**	**4**
T	4B	3.0	2 Substrate 1 Adhesion	4
Replicate 2	5B	0.0	----------------------------	5
Replicate 3	5B	0.0	----------------------------	5
Average	**5B**	**1.0**	**Substrate**	**5**

Scrub

	Panel 1		**Panel 2**		**Panel 3**		**Standard**	**Sample**	**Panel 4**	
	Standard	**Sample**	**Standard**	**Sample**	**Standard**	**Sample**	**Avg**	**Avg**	**Standard**	**Sample**
J	200	1081	206	1161	182	1025	196	1089	------------	---------
K	192	779	203	739	202	1074	199	864	------------	---------
L	197	620	206	714	228	720	210	685	------------	---------
M	240	2156	195	1765	203	2397	213	2106	------------	---------
N	304	962	265	787	277	921	282	890	------------	---------
O	257	691	219	297	221	625	223	645	195	965
P	254	1008	237	798	206	917	232	908	------------	---------
Q	223	1004	203	1015	200	726	209	915	------------	---------

R	230	754	226	666	195	600	217	673	------------	---------
S	218	334	203	303	198	287	206	308	------------	---------
T	239	1408	194	992	216	1292	216	1231		

Stain Resistance – Visual Ratings

	Visual Rating - Staining				Visual Rating - Gloss				Visual Rating - Erosion			
	Ketchup	**Mustard**	**Wine**	**Crayon**	**Ketchup**	**Mustard**	**Wine**	**Crayon**	**Ketchup**	**Mustard**	**Wine**	**Crayon**
J	10	10	3	3	None	None	None	None	None	None	None	None
Replicate 2	10	10	3	3	None	None	None	None	None	None	None	None
Replicate 3	10	10	3	3	None	None	None	None	None	None	None	None
Average	**10**	**10**	**3**	**3**	**None**	**None**	**None**	**None**	**None**	**None**	**None**	**None**
K	10	7	3	3	None	None	None	None	None	None	None	None
Replicate 2	10	7	3	3	None	None	None	None	None	None	None	None
Replicate 3	10	7	3	3	None	None	None	None	None	None	None	None
Average	**10**	**7**	**3**	**3**	**None**	**None**	**None**	**None**	**None**	**None**	**None**	**None**
L	10	5	3	3	None	None	None	None	None	None	None	None
Replicate 2	10	5	3	3	None	None	None	None	None	None	None	None
Replicate 3	10	5	3	3	None	None	None	None	None	None	None	None
Average	**10**	**5**	**3**	**3**	**None**	**None**	**None**	**None**	**None**	**None**	**None**	**None**
M	10	7	3	3	None	None	None	None	None	None	None	None
Replicate 2	10	7	3	3	None	None	None	None	None	None	None	None
Replicate 3	10	7	3	3	None	None	None	None	None	None	None	None
Average	**10**	**7**	**3**	**3**	**None**	**None**	**None**	**None**	**None**	**None**	**None**	**None**
N	10	7	3	3	None	None	None	None	None	None	None	None
Replicate 2	10	7	3	3	None	None	None	None	None	None	None	None
Replicate 3	10	7	3	3	None	None	None	None	None	None	None	None
Average	**10**	**7**	**3**	**3**	**None**	**None**	**None**	**None**	**None**	**None**	**None**	**None**
O	10	5	5	3	None	None	None	None	None	None	None	None
Replicate 2	10	5	5	3	None	None	None	None	None	None	None	None
Replicate 3	10	5	5	3	None	None	None	None	None	None	None	None
Average	**10**	**5**	**5**	**3**	**None**	**None**	**None**	**None**	**None**	**None**	**None**	**None**
P	7	5	3	3	None	None	None	None	None	None	None	None
Replicate 2	7	5	3	3	None	None	None	None	None	None	None	None
Replicate 3	7	5	3	3	None	None	None	None	None	None	None	None
Average	**7**	**5**	**3**	**3**	**None**	**None**	**None**	**None**	**None**	**None**	**None**	**None**
Q	7	5	3	3	None	None	None	None	None	None	None	None
Replicate 2	7	5	3	3	None	None	None	None	None	None	None	None
Replicate 3	7	5	3	3	None	None	None	None	None	None	None	None
Average	**7**	**5**	**3**	**3**	**None**	**None**	**None**	**None**	**None**	**None**	**None**	**None**
R	10	3	5	0	None	None	None	None	None	None	None	None
Replicate 2	10	3	5	0	None	None	None	None	None	None	None	None
Replicate 3	10	3	5	0	None	None	None	None	None	None	None	None
Average	**10**	**3**	**5**	**0**	**None**	**None**	**None**	**None**	**None**	**None**	**None**	**None**
S	7	3	3	0	None	None	None	None	None	None	None	None

Replicate 2	7	3	3	0	None	None	None	None	None	None	None	None
Replicate 3	7	3	3	0	None	None	None	None	None	None	None	None
Average	**7**	**3**	**3**	**0**	**None**	**None**	**None**	**None**	**None**	**None**	**None**	**None**
T	10	3	3	0	None	None	None	None	None	None	None	None
Replicate 2	10	3	3	0	None	None	None	None	None	None	None	None
Replicate 3	10	3	3	0	None	None	None	None	None	None	None	None
Average	**10**	**3**	**3**	**0**	**None**	**None**	**None**	**None**	**None**	**None**	**None**	**None**

Stain Resistance - Color

	Ketchup							Mustard						
	X (Pre)	**X**	**Y (Pre)**	**Y**	**Z (Pre)**	**Z**	**ΔE**	**X (Pre)**	**X**	**Y (Pre)**	**Y**	**Z (Pre)**	**Z**	**ΔE**
J	76.36	77.27	80.97	81.97	85.79	86.69	0.46	76.68	77.34	81.30	82.03	86.13	86.60	0.40
Replicate 2	76.46	77.24	81.07	81.93	85.89	86.68	0.40	76.40	77.34	81.00	82.04	85.83	86.67	0.50
Replicate 3	76.43	77.11	81.05	81.81	85.97	86.71	0.35	76.40	77.08	81.02	81.78	85.94	86.54	0.38
Average	76.42	77.21	81.03	81.90	85.88	86.69	**0.40**	76.49	77.25	81.11	81.95	85.97	86.60	**0.43**
K	82.49	83.22	87.59	88.43	92.45	93.23	0.38	82.90	83.28	88.02	88.51	92.95	92.91	0.45
Replicate 2	82.06	83.09	87.14	88.29	92.03	93.21	0.50	82.50	83.19	87.60	88.42	92.46	92.83	0.50
Replicate 3	82.13	82.63	87.21	87.82	92.23	92.87	0.29	82.36	82.88	87.46	88.10	92.46	92.73	0.41
Average	82.23	82.98	87.31	88.18	92.24	93.10	**0.39**	82.59	83.12	87.69	88.34	92.62	92.82	**0.45**
L	84.68	84.60	89.84	89.78	94.84	94.42	0.25	84.79	83.90	89.95	89.13	94.92	92.15	1.36
Replicate 2	84.46	84.30	89.61	89.47	94.68	94.22	0.22	84.60	83.47	89.76	88.70	94.81	91.65	1.48
Replicate 3	84.32	84.08	89.46	89.23	94.55	94.00	0.23	84.32	83.32	89.46	88.53	94.55	91.77	1.31
Average	84.49	84.33	89.64	89.49	94.69	94.21	**0.23**	84.57	83.56	89.72	88.79	94.76	91.86	**1.38**
M	78.59	78.67	83.41	83.52	87.06	87.12	0.07	78.75	78.51	83.59	83.36	87.28	86.59	0.34
Replicate 2	78.51	78.55	83.33	83.39	87.06	87.11	0.03	78.48	78.17	83.30	83.00	87.07	86.53	0.21
Replicate 3	78.29	78.28	83.11	83.11	86.92	86.98	0.04	78.33	78.16	83.15	82.99	87.00	86.69	0.12
Average	78.46	78.50	83.28	83.34	87.01	87.07	**0.05**	78.52	78.28	83.35	83.12	87.12	86.60	**0.22**
N	80.34	80.37	85.22	85.28	89.58	89.62	0.06	80.52	80.29	85.40	85.21	89.75	88.89	0.48
Replicate 2	80.22	80.21	85.11	85.13	89.57	89.48	0.11	80.39	79.92	85.28	84.86	89.70	88.37	0.67
Replicate 3	80.02	80.05	84.90	84.96	89.44	89.46	0.08	80.22	79.79	85.11	84.75	89.61	88.02	0.89
Average	80.19	80.21	85.08	85.12	89.53	89.52	**0.08**	80.38	80.00	85.26	84.94	89.69	88.43	**0.68**
O	83.87	83.74	88.90	88.88	93.21	93.15	0.07	83.76	82.97	88.88	88.15	93.14	90.71	1.20
Replicate 2	83.53	83.51	88.64	88.64	92.97	93.12	0.11	83.39	82.98	88.49	88.14	92.78	91.61	0.59
Replicate 3	83.40	83.39	88.50	88.51	92.88	93.01	0.09	83.41	82.81	88.52	87.97	92.92	91.30	0.75
Average	83.60	83.55	88.68	88.68	93.02	93.09	**0.09**	83.52	82.92	88.63	88.09	92.95	91.21	**0.85**
P	83.03	82.57	88.12	87.75	92.97	91.99	0.49	83.09	82.24	88.19	87.41	93.06	91.24	0.79
Replicate 2	82.65	82.30	87.72	87.45	92.62	92.09	0.28	82.79	81.83	87.88	87.00	92.84	90.76	0.91
Replicate 3	82.73	82.17	87.81	87.33	92.79	91.81	0.44	82.81	82.01	87.90	87.15	92.90	91.52	0.54
Average	82.80	82.35	87.88	87.51	92.79	91.96	**0.40**	82.90	82.03	87.99	87.19	92.93	91.17	**0.75**

Q	84.06	83.53	89.23	88.73	92.92	92.05	0.34	83.99	82.71	89.15	87.96	92.91	89.71	1.47
Replicate 2	83.74	83.18	88.89	88.36	92.67	91.81	0.33	83.77	82.17	88.92	87.42	92.75	88.59	1.95
Replicate 3	83.56	83.06	88.71	88.24	92.57	91.88	0.26	83.62	82.57	88.77	87.78	92.65	90.17	1.10
Average	83.79	83.26	88.94	88.44	92.72	91.91	**0.31**	83.79	82.48	88.95	87.72	92.77	89.49	**1.51**
R	78.54	78.52	83.52	83.53	87.51	87.23	0.21	78.68	76.86	83.68	82.42	87.76	79.26	5.48
Replicate 2	78.38	78.23	83.37	83.23	87.53	87.00	0.28	78.49	76.73	83.49	82.28	87.67	79.38	5.35
Replicate 3	78.34	78.22	83.33	83.23	87.48	87.06	0.23	78.37	76.63	83.36	82.22	87.52	78.95	5.63
Average	78.42	78.32	83.41	83.33	87.51	87.10	**0.24**	78.51	76.74	83.51	82.31	87.65	79.20	**5.49**
S	81.33	81.02	86.44	86.23	91.01	89.80	0.74	81.83	79.26	86.96	84.95	91.37	82.32	5.24
Replicate 2	81.06	80.71	86.46	85.91	90.87	89.77	0.62	81.47	79.75	86.59	85.17	91.15	85.39	3.18
Replicate 3	81.01	80.79	86.12	85.99	90.83	89.82	0.63	81.46	79.59	86.58	85.07	91.18	84.90	3.51
Average	81.13	80.84	86.34	86.04	90.90	89.80	**0.66**	81.59	79.53	86.71	85.06	91.23	84.20	**3.98**
T	81.25	81.08	86.29	86.18	91.61	91.13	0.28	81.15	78.97	86.19	84.46	91.53	84.05	4.24
Replicate 2	80.81	80.67	85.83	85.78	91.21	90.73	0.30	80.87	78.32	85.90	83.87	91.29	82.73	4.87
Replicate 3	80.68	80.61	85.70	85.70	91.17	90.71	0.35	80.62	78.21	85.64	83.73	91.11	83.07	4.57
Average	80.91	80.79	85.94	85.89	91.33	90.86	**0.31**	80.88	78.50	85.91	84.02	91.31	83.28	**4.56**
	Wine							**Red Crayon**						
	X (Pre)	**X**	**Y (Pre)**	**Y**	**Z (Pre)**	**Z**	**ΔE**	**X (Pre)**	**X**	**Y (Pre)**	**Y**	**Z (Pre)**	**Z**	**ΔE**
J	76.84	74.09	81.47	78.65	86.30	80.61	2.37	76.58	66.17	81.20	66.47	85.97	60.43	13.62
Replicate 2	76.46	74.32	81.07	78.89	85.91	81.12	2.08	76.57	67.26	81.19	68.01	86.02	62.96	12.11
Replicate 3	76.52	73.85	81.15	78.42	86.08	80.56	2.31	76.33	68.29	80.94	69.50	85.82	65.06	10.83
Average	76.61	74.09	81.23	78.65	86.10	80.76	**2.25**	76.49	67.24	81.11	67.99	85.94	62.82	**12.19**
K	83.00	80.81	88.13	85.79	93.05	88.16	1.96	82.68	69.73	87.80	69.19	92.67	64.21	15.12
Replicate 2	82.50	80.50	87.60	85.47	92.44	87.70	1.97	82.44	69.42	87.54	68.84	92.36	62.58	15.78
Replicate 3	82.25	80.04	87.35	84.99	92.35	87.33	2.04	82.27	69.92	87.37	69.54	92.34	64.71	14.68
Average	82.58	80.45	87.69	85.42	92.61	87.73	**1.99**	82.46	69.69	87.57	69.19	92.46	63.83	**15.19**
L	84.91	80.40	90.08	85.37	94.97	85.97	3.47	84.83	72.10	90.00	72.19	94.95	64.34	15.29
Replicate 2	84.67	80.06	89.83	85.04	94.78	85.79	3.45	84.52	72.91	89.67	73.43	94.70	67.01	13.66
Replicate 3	84.43	80.99	89.58	86.00	94.61	87.27	2.91	84.43	74.84	89.58	76.27	94.65	72.24	10.69
Average	84.67	80.48	89.83	85.47	94.79	86.34	**3.28**	84.59	73.28	89.75	73.96	94.77	67.86	**13.21**
M	78.71	77.15	83.53	81.86	87.16	83.77	1.40	78.85	69.36	83.68	70.09	87.29	64.79	11.85
Replicate 2	78.50	76.37	83.32	81.02	87.02	82.68	1.73	78.61	68.46	83.43	68.79	87.12	62.89	13.00
Replicate 3	78.39	76.22	83.21	80.87	87.04	82.71	1.71	78.45	68.36	83.27	68.72	87.02	63.25	12.75
Average	78.53	76.58	83.35	81.25	87.07	83.05	**1.61**	78.64	68.73	83.46	69.20	87.14	63.64	**12.53**
N	80.52	77.09	85.42	81.75	89.79	83.40	2.43	80.46	62.38	85.35	59.80	89.76	54.20	20.64
Replicate 2	80.34	76.11	85.23	80.71	89.69	82.11	2.85	80.36	60.71	85.24	57.57	89.67	51.71	22.47
Replicate 3	80.18	77.16	85.06	81.86	89.56	83.79	2.22	80.34	57.52	85.22	53.18	89.69	46.35	26.70
Average	80.35	76.79	85.24	81.44	89.68	83.10	**2.50**	80.39	60.20	85.27	56.85	89.71	50.75	**23.27**
O	83.79	81.89	88.91	86.87	93.14	89.32	1.45	83.91	58.92	89.03	53.80	92.37	46.31	28.96
Replicate 2	83.56	82.31	88.67	87.35	92.99	90.36	1.02	83.66	56.70	88.78	50.80	93.06	42.64	31.98

Replicate 3	83.38	82.08	88.49	87.12	92.89	90.33	0.97	83.52	59.97	88.63	55.44	92.99	48.62	26.89
Average	83.58	82.09	88.69	87.11	93.01	90.00	**1.15**	83.70	58.53	88.81	53.35	92.81	45.86	**29.28**
P	83.08	78.37	88.17	83.24	93.04	85.77	2.57	83.02	71.41	88.10	71.51	92.98	64.97	14.38
Replicate 2	82.86	78.55	87.95	83.45	92.92	86.33	2.32	82.76	72.76	87.84	73.49	92.81	68.52	12.31
Replicate 3	82.77	78.24	87.85	83.14	92.86	85.98	2.43	82.65	72.57	87.73	73.31	92.74	69.74	11.69
Average	82.90	78.39	87.99	83.28	92.94	86.03	**2.44**	82.81	72.25	87.89	72.77	92.84	67.74	**12.79**
Q	83.99	79.33	89.14	84.24	93.00	84.18	2.36	84.04	68.27	89.19	66.95	93.01	61.92	16.90
Replicate 2	83.73	78.07	88.87	82.92	92.80	82.40	3.94	83.84	70.90	88.98	70.78	92.85	67.05	13.52
Replicate 3	83.60	79.22	88.74	84.16	92.73	84.32	3.23	83.71	67.66	88.86	66.30	92.81	59.30	17.92
Average	83.77	78.87	88.92	83.77	92.84	83.63	**3.18**	83.86	68.94	89.01	68.01	92.89	62.76	**16.11**
R	78.56	77.12	83.55	82.12	87.62	85.17	0.95	78.55	69.23	83.55	70.73	87.64	70.80	8.86
Replicate 2	78.44	77	83.43	82.01	87.58	85.23	0.90	78.39	67.67	83.38	68.71	87.55	68.60	10.14
Replicate 3	78.39	77.04	83.39	82.04	87.63	85.32	0.89	78.26	69.89	83.25	71.72	87.52	72.34	7.95
Average	78.46	77.05	83.46	82.06	87.61	85.24	**0.91**	78.40	68.93	83.39	70.39	87.57	70.58	**8.98**
S	81.70	77.67	86.82	82.69	91.23	86.05	1.90	81.63	74.14	86.75	76.13	91.17	77.38	7.34
Replicate 2	81.46	76.88	86.57	81.87	91.13	85.33	2.14	81.40	72.32	86.51	73.75	91.01	74.62	8.81
Replicate 3	81.28	76.87	86.39	81.87	91.00	85.36	2.08	81.37	70.94	86.48	71.95	91.06	72.18	10.06
Average	81.48	77.14	86.59	82.14	91.12	85.58	**2.04**	81.47	72.47	86.58	73.94	91.08	74.73	**8.74**
T	81.22	78.98	86.25	83.94	91.58	87.53	1.50	81.16	70.68	86.20	71.40	91.55	71.19	10.77
Replicate 2	80.80	77.87	85.83	82.8	91.24	86.2	1.85	80.82	70.87	85.84	71.86	91.23	72.33	9.99
Replicate 3	80.65	78.12	85.67	83.06	91.15	86.69	1.65	80.64	70.89	85.65	71.93	91.11	71.98	9.99
Average	80.89	78.32	85.92	83.27	91.32	86.81	**1.67**	80.87	70.81	85.90	71.73	91.30	71.83	**10.25**

Stain Resistance - Gloss

	Ketchup - After				Mustard - After				Wine - After				Red Crayon - After			
	60° M	**60°SD**	**85° M**	**85°SD**	**60° M**	**60°SD**	**85° M**	**85°SD**	**60° M**	**60°SD**	**85° M**	**85°SD**	**60° M**	**60°SD**	**85° M**	**85°SD**
J-Pre	2.4	0.1	4.0	0.2	2.4	0.1	3.9	0.2	2.4	0.1	3.9	0.2	2.4	0.1	3.9	0.1
Strip 1	2.6	0.1	4.6	0.2	2.5	0.1	4.5	0.1	2.5	0.1	4.8	0.2	3.3	0.1	9.3	0.2
Strip 2	2.6	0.1	4.7	0.1	2.5	0.1	4.5	0.1	2.5	0.1	4.6	0.2	3.2	0.2	8.8	0.6
Strip 3	2.6	0.1	4.6	0.2	2.5	0.1	4.4	0.1	2.5	0.1	4.3	0.2	3.1	0.2	8.7	0.6
Avg	**2.6**	**0.1**	**4.6**	**0.2**	**2.5**	**0.1**	**4.5**	**0.1**	**2.5**	**0.1**	**4.6**	**0.2**	**3.2**	**0.2**	**8.9**	**0.5**
K-Pre	2.0	0.1	1.8	0.1	1.9	0.1	1.8	0.1	2.0	0.1	1.8	0.1	1.9	0.1	1.8	0.1
Strip 1	2.1	0.1	2.7	0.2	2.1	0.1	2.6	0.1	2.0	0.1	2.7	0.1	2.3	0.1	5.2	0.1
Strip 2	2.1	0.1	2.5	0.2	2.1	0.1	2.5	0.1	2.0	0.1	2.7	0.1	2.4	0.1	5.5	0.2
Strip 3	2.1	0.1	2.5	0.2	2.1	0.1	2.5	0.1	2.0	0.1	2.6	0.1	2.4	0.1	5.6	0.2
Avg	**2.1**	**0.1**	**2.6**	**0.2**	**2.1**	**0.1**	**2.5**	**0.1**	**2.0**	**0.1**	**2.7**	**0.1**	**2.4**	**0.1**	**5.4**	**0.2**
L-Pre	2.0	0.1	3.0	0.1	2.0	0.1	3.0	0.1	2.0	0.1	3.0	0.1	2.0	0.1	3.0	0.1
Strip 1	2.1	0.1	4.5	0.2	2.4	0.1	4.6	0.2	2.0	0.1	4.5	0.2	3.0	0.2	9.4	1.4
Strip 2	2.1	0.1	4.1	0.2	2.4	0.1	4.5	0.2	2.0	0.1	4.1	0.1	2.9	0.2	9.4	0.6

Strip 3	2.1	0.1	4.1	0.2	2.3	0.1	4.3	0.1	2.0	0.1	4.1	0.2	2.5	0.2	7.5	0.6
Avg	**2.1**	**0.1**	**4.2**	**0.2**	**2.4**	**0.1**	**4.5**	**0.2**	**2.0**	**0.1**	**4.2**	**0.2**	**2.8**	**0.2**	**8.8**	**0.9**
M-Pre	1.9	0.1	1.1	0.1	1.9	0.1	0.8	0.2	1.9	0.1	1.1	0.1	1.9	0.1	1.1	0.1
Strip 1	1.9	0.1	1.6	0.1	1.9	0.1	1.5	0.1	1.8	0.1	1.5	0.1	2.1	0.2	3.7	0.4
Strip 2	1.9	0.1	1.6	0.1	1.9	0.1	1.5	0.1	1.8	0.1	1.5	0.1	2.0	0.1	3.6	0.4
Strip 3	1.8	0.1	1.4	0.1	1.8	0.1	1.5	0.2	1.8	0.1	1.5	0.1	2.2	0.1	3.6	0.2
Avg	**1.9**	**0.1**	**1.5**	**0.1**	**1.9**	**0.1**	**1.5**	**0.1**	**1.8**	**0.1**	**1.5**	**0.1**	**2.1**	**0.1**	**3.6**	**0.3**
N-Pre	2.3	0.1	4.5	0.1	2.3	0.1	4.6	0.1	2.2	0.1	4.3	0.1	2.3	0.1	4.6	0.1
Strip 1	2.3	0.1	6.2	0.2	2.7	0.1	6.6	0.2	2.3	0.1	7.1	0.1	3.1	0.2	11.4	0.8
Strip 2	2.3	0.1	6.1	0.2	2.7	0.1	6.5	0.1	2.3	0.1	7.0	0.1	3.8	0.1	15.3	1.6
Strip 3	2.3	0.1	6.1	0.2	2.5	0.1	6.3	0.1	2.4	0.1	7.4	0.2	4.1	0.2	20.6	0.6
Avg	**2.3**	**0.1**	**6.1**	**0.2**	**2.6**	**0.1**	**6.5**	**0.1**	**2.3**	**0.1**	**7.2**	**0.1**	**3.7**	**0.2**	**15.8**	**1.0**
O-Pre	2.0	0.1	2.3	0.1	2.0	0.1	2.3	0.1	2.0	0.1	2.3	0.1	2.0	0.1	2.3	0.1
Strip 1	2.1	0.1	3.1	0.1	2.3	0.1	3.3	0.1	2.0	0.1	3.4	0.2	2.8	0.2	9.8	0.2
Strip 2	2.0	0.1	2.8	0.1	2.3	0.2	3.3	0.2	2.0	0.1	3.2	0.2	3.2	0.2	11.2	0.6
Strip 3	2.0	0.1	3.2	0.1	2.2	0.1	3.2	0.1	2.0	0.1	3.5	0.1	2.9	0.2	10.4	0.6
Avg	**2.0**	**0.1**	**3.0**	**0.1**	**2.3**	**0.1**	**3.3**	**0.1**	**2.0**	**0.1**	**3.4**	**0.2**	**3.0**	**0.2**	**10.5**	**0.5**
P-Pre	2.2	0.1	2.1	0.1	2.2	0.1	2.1	0.1	2.2	0.1	2.1	0.1	2.2	0.1	2.0	0.1
Strip 1	2.4	0.1	2.5	0.1	2.5	0.1	2.6	0.1	2.3	0.2	2.7	0.1	2.8	0.1	6.2	0.4
Strip 2	2.4	0.1	2.5	0.1	2.5	0.1	2.6	0.1	2.2	0.1	2.5	0.2	2.7	0.1	5.3	0.4
Strip 3	2.3	0.1	2.5	0.1	2.4	0.1	2.4	0.1	2.2	0.1	2.6	0.1	2.6	0.1	4.8	0.4
Avg	**2.4**	**0.1**	**2.5**	**0.1**	**2.5**	**0.1**	**2.5**	**0.1**	**2.2**	**0.1**	**2.6**	**0.1**	**2.7**	**0.1**	**5.4**	**0.4**
Q-Pre	2.0	0.1	2.5	0.1	2.0	0.1	2.5	0.1	2.0	0.1	2.5	0.1	2.0	0.1	2.5	0.1
Strip 1	2.2	0.1	3.2	0.1	2.4	0.1	3.6	0.1	2.1	0.1	3.6	0.1	2.8	0.2	8.8	0.2
Strip 2	2.2	0.1	2.9	0.2	2.6	0.1	3.5	0.1	2.1	0.1	3.3	0.2	2.5	0.2	5.9	0.4
Strip 3	2.1	0.1	2.9	0.2	2.5	0.1	3.4	0.1	2.0	0.1	3.2	0.2	2.6	0.1	6.6	0.4
Avg	**2.2**	**0.1**	**3.0**	**0.2**	**2.5**	**0.1**	**3.5**	**0.1**	**2.1**	**0.1**	**3.4**	**0.2**	**2.6**	**0.2**	**7.1**	**0.3**
R-Pre	2.8	0.1	1.2	0.1	2.8	0.1	1.2	0.1	2.8	0.1	1.2	0.1	2.8	0.1	1.2	0.1
Strip 1	2.9	0.1	1.5	0.1	3.3	0.1	1.7	0.1	3.0	0.1	1.6	0.1	2.8	0.1	2.4	0.2
Strip 2	3.0	0.1	1.5	0.1	3.3	0.1	1.7	0.1	2.9	0.1	1.5	0.1	2.8	0.1	2.7	0.2
Strip 3	2.9	0.1	1.4	0.1	3.3	0.1	1.7	0.1	2.9	0.1	1.5	0.1	2.7	0.1	1.9	0.2
Avg	**2.9**	**0.1**	**1.5**	**0.1**	**3.3**	**0.1**	**1.7**	**0.1**	**2.9**	**0.1**	**1.5**	**0.1**	**2.8**	**0.1**	**2.3**	**0.2**
S-Pre	2.2	0.1	1.7	0.1	2.2	0.1	1.8	0.1	2.2	0.1	1.8	0.1	2.2	0.1	1.8	0.1
Strip 1	2.3	0.1	2.6	0.2	2.4	0.1	2.7	0.2	2.3	0.1	2.8	0.1	2.3	0.1	3.4	0.2
Strip 2	2.3	0.1	2.5	0.2	2.3	0.2	2.8	0.1	2.3	0.1	2.9	0.1	2.5	0.1	4.4	0.2
Strip 3	2.3	0.1	2.5	0.1	2.3	0.2	2.8	0.2	2.2	0.1	3.0	0.1	2.5	0.1	4.8	0.2
Avg	**2.3**	**0.1**	**2.5**	**0.2**	**2.3**	**0.2**	**2.8**	**0.2**	**2.3**	**0.1**	**2.9**	**0.1**	**2.4**	**0.1**	**4.2**	**0.2**
T-Pre	1.9	0.1	1.2	0.1	1.9	0.1	1.2	0.1	1.9	0.1	1.2	0.1	1.9	0.1	1.2	0.1
Strip 1	2.0	0.1	1.9	0.1	2.2	0.1	1.9	0.1	1.9	0.1	2.1	0.1	2.1	0.1	3.6	0.4
Strip 2	2.0	0.1	1.9	0.1	2.0	0.1	1.8	0.1	1.9	0.1	1.9	0.1	2.1	0.1	3.1	0.2

Strip 3	2.0	0.1	1.9	0.1	2.1	0.1	1.8	0.1	1.9	0.1	1.9	0.1	2.1	0.1	3.2	0.1
Avg	**2.0**	**0.1**	**1.9**	**0.1**	**2.1**	**0.1**	**1.8**	**0.1**	**1.9**	**0.1**	**2.0**	**0.1**	**2.1**	**0.1**	**3.3**	**0.2**

Touch – Up

	Gloss 85°										**Gloss - Visual Rating**			AQMD
	A1	**A2**	**B1**	**B2**	**C1**	**C2**	**D1**	**D2**	**E1**	**E2**	**C**	**D**	**E**	Rating
J	3.3	3.9	3.6	3.3	4.3	3.7	3.6	3.7	3.5	4.1	10	10	10	10
Replicate 2	3.6	4.0	3.9	3.6	4.1	3.9	3.8	3.8	4.3	4.1	10	10	10	10
Replicate 3	3.4	3.9	3.6	3.3	3.8	3.7	3.5	3.4	3.6	3.4	10	10	10	10
Average	**3.4**	**3.9**	**3.7**	**3.4**	**4.1**	**3.8**	**3.6**	**3.6**	**3.8**	**3.9**	**10**	**10**	**10**	**10**
K	1.5	1.6	1.7	1.7	2.0	1.9	1.7	1.8	1.8	2.0	10	10	10	10
Replicate 2	1.7	1.9	1.7	1.6	2.1	2.0	1.9	1.9	2.5	2.0	10	10	10	10
Replicate 3	1.7	1.9	1.8	1.7	1.8	1.9	1.8	1.8	2.2	1.9	10	10	10	10
Average	**1.6**	**1.8**	**1.7**	**1.7**	**2.0**	**1.9**	**1.8**	**1.8**	**2.2**	**2.0**	**10**	**10**	**10**	**10**
L	2.3	2.7	2.5	2.6	2.5	2.6	2.5	2.6	2.4	2.3	10	10	10	10
Replicate 2	2.3	2.6	2.4	2.4	2.5	2.5	2.5	2.6	2.6	2.5	10	10	10	10
Replicate 3	2.5	2.6	2.5	2.5	2.7	2.6	2.4	2.5	2.4	2.3	10	10	10	10
Average	**2.4**	**2.6**	**2.5**	**2.5**	**2.6**	**2.6**	**2.5**	**2.6**	**2.5**	**2.4**	**10**	**10**	**10**	**10**
M	0.8	1.2	1.3	0.9	1.2	0.9	1.1	1.2	1.2	1.2	10	10	10	10
Replicate 2	0.9	1.0	1.2	0.9	1.3	0.9	1.2	1.2	1.3	1.1	10	10	10	10
Replicate 3	0.9	1.2	1.3	0.9	1.3	0.9	1.2	1.2	1.1	1.1	10	10	10	10
Average	**0.9**	**1.1**	**1.3**	**0.9**	**1.3**	**0.9**	**1.2**	**1.2**	**1.2**	**1.1**	**10**	**10**	**10**	**10**
N	2.8	3.5	3.1	3.0	3.9	3.3	3.6	3.4	4.1	4.1	10	10	10	10
Replicate 2	2.9	2.7	3.6	3.2	4.2	3.4	3.1	3.1	2.7	3.7	10	10	10	10
Replicate 3	2.7	3.5	3.4	3.1	3.9	3.3	3.7	3.6	3.7	4.0	10	10	10	10
Average	**2.8**	**3.2**	**3.4**	**3.1**	**4.0**	**3.3**	**3.5**	**3.4**	**3.5**	**3.9**	**10**	**10**	**10**	**10**
O	1.8	2.1	2.0	1.8	2.1	1.9	1.9	1.9	1.9	1.8	10	10	10	10
Replicate 2	1.7	2.2	1.9	1.8	2.2	1.9	2.1	1.9	2.0	2.0	10	10	10	10
Replicate 3	1.6	2.1	2.0	1.7	2.1	1.7	2.0	2.1	2.0	1.9	10	10	10	10
Average	**1.7**	**2.1**	**2.0**	**1.8**	**2.1**	**1.8**	**2.0**	**2.0**	**2.0**	**1.9**	**10**	**10**	**10**	**10**
P	1.6	2.0	2.1	1.8	2.3	1.8	2.0	2.0	1.9	1.8	10	10	10	10
Replicate 2	1.7	2.0	2.0	1.8	2.3	1.6	2.1	2.2	2.2	2.0	10	10	10	10
Replicate 3	1.6	2.0	2.1	1.7	2.0	1.8	2.1	2.1	1.7	1.8	10	10	10	10
Average	**1.6**	**2.0**	**2.1**	**1.8**	**2.2**	**1.7**	**2.1**	**2.1**	**1.9**	**1.9**	**10**	**10**	**10**	**10**
Q	2.0	2.1	2.0	2.0	2.1	2.0	1.9	2.0	2.2	1.8	10	10	10	10
Replicate 2	1.8	2.3	2.2	1.9	2.5	1.9	2.2	2.2	1.9	1.8	10	10	10	10
Replicate 3	1.8	2.3	2.2	1.8	2.4	1.9	2.2	2.2	2.6	2.2	10	10	10	10
Average	**1.9**	**2.2**	**2.1**	**1.9**	**2.3**	**1.9**	**2.1**	**2.1**	**2.2**	**1.9**	**10**	**10**	**10**	**10**
R	1.1	1.3	1.2	1.1	1.6	1.1	1.2	1.1	0.8	0.9	10	10	10	10

Replicate 2	1.1	1.3	1.2	1.1	1.5	1.4	1.1	1.1	0.9	0.9	10	10	10	10
Replicate 3	1.1	1.2	1.1	1.2	1.1	1.2	1.1	1.1	1.0	0.9	10	10	10	10
Average	**1.1**	**1.3**	**1.2**	**1.1**	**1.4**	**1.2**	**1.1**	**1.1**	**0.9**	**0.9**	**10**	**10**	**10**	**10**
S	1.2	1.4	1.5	1.2	1.2	1.1	1.5	1.5	1.6	1.4	10	10	10	10
Replicate 2	1.2	1.7	1.7	1.2	1.5	1.2	1.7	1.7	1.5	1.6	10	10	10	10
Replicate 3	1.2	1.7	1.5	1.2	1.4	1.1	1.5	1.5	1.5	1.6	10	10	10	10
Average	**1.2**	**1.6**	**1.6**	**1.2**	**1.4**	**1.1**	**1.6**	**1.6**	**1.5**	**1.5**	**10**	**10**	**10**	**10**
T	1.0	1.3	1.2	0.9	1.2	1.0	1.0	1.2	1.0	1.5	10	10	10	10
Replicate 2	0.9	1.3	1.2	1.0	1.3	1.0	1.1	1.2	1.0	1.0	10	10	10	10
Replicate 3	0.9	1.3	1.3	1.0	1.4	1.1	1.1	1.2	1.2	1.0	10	10	10	10
Average	**0.9**	**1.3**	**1.2**	**1.0**	**1.3**	**1.0**	**1.1**	**1.2**	**1.1**	**1.2**	**10**	**10**	**10**	**10**

Tests for Exterior Flat Paints

Adhesion – Glass

	Cross-Hatch Adhesion - Glass			AQMD
	Rating	**Failure %**	**Failure Mechanism**	**Rating**
A	4B	4	Adhesion	4
Replicate 2	3B	10	Adhesion	3
Replicate 3	3B	15	Adhesion	3
Average	**3B**	**10**	**Adhesion**	**3**
B	5B	0	----------------------------	5
Replicate 2	4B	2	Adhesion	4
Replicate 3	4B	3	Adhesion	4
Average	**4B**	**2**	**Adhesion**	**4**
C	2B	15	Adhesion	2
Replicate 2	2B	20	Adhesion	2
Replicate 3	3B	25	Adhesion	3
Average	**2B**	**20**	**Adhesion**	**2**
D	4B	3	Adhesion	4
Replicate 2	3B	5	Adhesion	3
Replicate 3	4B	4	Adhesion	4
Average	**4B**	**4**	**Adhesion**	**4**
E	*4B*	*1*	*Adhesion*	*4*
Replicate 2	*5B*	*0*	----------------------------	*5*
Replicate 3	*5B*	*0*	----------------------------	*5*
Average	***5B***	***0***	***Adhesion***	***5***
F	2B	20	Adhesion	2

Replicate 2	2B	15	Adhesion	2
Replicate 3	2B	20	Adhesion	2
Average	**2B**	**18**	**Adhesion**	**2**
G	2B	20	Adhesion	2
Replicate 2	3B	10	Adhesion	3
Replicate 3	2B	20	Adhesion	2
Average	**2B**	**17**	**Adhesion**	**2**
H	4B	2	Adhesion	4
Replicate 2	4B	4	Adhesion	4
Replicate 3	4B	3	Adhesion	4
Average	**4B**	**3**	**Adhesion**	**4**
I	4B	1	Adhesion	4
Replicate 2	4B	1	Adhesion	4
Replicate 3	4B	1	Adhesion	4
Average	**4B**	**1**	**Adhesion**	**4**
S	2B	20	Adhesion	2
Replicate 2	2B	20	Adhesion	2
Replicate 3	2B	20	Adhesion	2
Average	**2B**	**20**	**Adhesion**	**2**
T	3B	5	Adhesion	3
Replicate 2	3B	5	Adhesion	3
Replicate 3	3B	10	Adhesion	3
Average	**3B**	**7**	**Adhesion**	**3**

Tannin Stain Resistance

	Cedar-Initial			**Cedar**				**Visual**	**Leneta-Initial**			**Cedar**			
	X	**Y**	**Z**	**X**	**Y**	**Z**	**ΔE**	**Ranking**	**X**	**Y**	**Z**	**X**	**Y**	**Z**	**ΔE**
Positive Standard	71.02	75.18	75.48	71.75	75.95	74.81	1.20		79.25	83.76	86.81	73.96	78.20	78.71	3.01
Replicate 2	70.18	74.37	74.50	71.65	75.89	74.53	1.40	5				71.46	75.62	74.82	4.55
Replicate 3	69.36	73.36	73.17	69.33	73.29	71.61	1.21					68.80	72.63	72.30	5.56
Replicate 4	71.20	75.26	75.13	71.82	75.94	74.75	0.89	5				71.95	76.00	76.03	4.04
Replicate 5	71.22	75.30	75.84	72.36	76.56	75.67	1.29					73.02	77.16	77.43	3.50
Replicate 6	67.86	71.61	71.31	70.01	74.02	72.35	1.65	5				68.76	72.52	70.75	6.19
Average	**70.14**	**74.18**	**74.24**	**71.15**	**75.28**	**73.95**	**1.27**	**5**				**71.33**	**75.36**	**75.01**	**4.48**
Negative Standard	69.67	73.29	68.49	70.37	73.98	68.73	0.49		74.44	78.07	72.60	68.29	71.89	66.66	2.96
Replicate 2	69.27	72.88	68.08	70.13	73.74	68.50	0.56	1				67.71	71.27	66.15	3.25
Replicate 3	67.82	71.35	66.62	69.25	72.81	67.71	0.76					66.84	70.33	65.77	3.74
Replicate 4	68.72	72.20	67.03	70.27	73.78	68.29	0.79	1				68.91	72.41	67.36	2.68
Replicate 5	70.17	73.75	68.65	71.20	74.76	69.18	0.63	1				70.40	73.99	68.27	1.95

Replicate 6	70.16	73.74	68.54	71.68	75.28	69.71	0.78					70.20	73.77	68.40	2.03
Average	**69.30**	**72.87**	**67.90**	**70.48**	**74.06**	**68.69**	**0.67**	**1**				**68.73**	**72.28**	**67.10**	**2.77**
A	74.23	78.49	79.49	75.51	79.77	79.83	0.95	10	84.64	89.57	91.98	75.53	79.77	80.07	4.44
Replicate 2	73.43	77.72	77.81	75.88	80.26	79.61	1.30	9				75.77	80.13	79.58	4.51
Replicate 3	73.50	77.60	78.70	75.86	80.08	80.46	1.27	9				76.04	80.27	80.75	4.19
Average	**73.72**	**77.94**	**78.67**	**75.75**	**80.04**	**79.97**	**1.17**	**9**				**75.78**	**80.06**	**80.13**	**4.38**
B	77.04	81.62	79.76	77.62	82.03	79.28	0.80	3	85.52	90.55	93.66	77.62	82.01	79.36	5.42
Replicate 2	76.64	81.05	79.24	78.69	83.10	80.93	0.97	3				78.57	82.98	80.91	4.81
Replicate 3	78.80	83.46	81.79	79.55	84.06	81.85	0.61	3				79.42	83.92	81.80	4.57
Average	**77.49**	**82.04**	**80.26**	**78.62**	**83.06**	**80.69**	**0.79**	**3**				**78.54**	**82.97**	**80.69**	**4.93**
C	74.54	79.13	78.79	75.98	80.50	79.53	0.85	4	84.89	89.87	92.20	76.20	80.71	79.71	4.52
Replicate 2	74.02	78.52	77.60	75.80	80.29	78.92	0.90	4				75.85	80.33	78.79	4.87
Replicate 3	76.25	80.90	80.58	78.14	82.80	82.19	0.90	4				78.62	83.30	82.61	3.45
Average	**74.94**	**79.52**	**78.99**	**76.64**	**81.20**	**80.21**	**0.88**	**4**				**76.89**	**81.45**	**80.37**	**4.28**
D	77.16	81.69	79.22	77.46	81.78	78.65	0.67	2	84.76	89.70	92.14	77.56	81.87	78.78	5.15
Replicate 2	76.49	80.86	78.75	78.16	82.53	80.32	0.76	2				77.43	81.71	79.21	4.87
Replicate 3	77.28	81.79	79.95	79.03	83.44	80.87	1.00	2				79.06	83.47	81.01	4.33
Average	**76.98**	**81.45**	**79.31**	**78.22**	**82.58**	**79.95**	**0.81**	**2**				**78.02**	**82.35**	**79.67**	**4.78**
E	75.04	79.50	81.97	76.24	80.72	82.32	0.88	12	78.79	83.56	86.26	76.26	80.73	82.29	1.48
Replicate 2	74.11	78.49	80.35	75.74	80.20	81.38	0.94	12				75.26	79.68	80.91	1.99
Replicate 3	75.25	79.69	82.19	76.87	81.39	83.26	0.92	12				76.91	81.41	83.20	1.16
Average	**74.80**	**79.23**	**81.50**	**76.28**	**80.77**	**82.32**	**0.91**	**12**				**76.14**	**80.61**	**82.13**	**1.54**
F	74.22	78.63	80.73	75.34	79.72	80.75	0.99	13	78.76	83.50	85.76	75.22	79.59	80.67	1.92
Replicate 2	73.84	78.12	79.53	75.66	80.00	80.90	0.96	13				75.58	79.90	80.90	1.85
Replicate 3	74.83	79.25	81.43	76.48	80.93	82.23	1.04	13				76.49	80.93	82.27	1.32
Average	**74.30**	**78.67**	**80.56**	**75.83**	**80.22**	**81.29**	**1.00**	**13**				**75.76**	**80.14**	**81.28**	**1.70**
G	74.54	78.86	79.20	76.05	80.42	80.08	0.90	9	83.51	88.37	90.15	75.64	80.00	79.82	3.84
Replicate 2	74.18	78.52	77.72	76.25	80.67	79.29	1.08	8				76.36	80.78	79.38	3.94
Replicate 3	75.66	80.01	80.43	77.39	81.83	81.56	0.97	7				77.03	81.42	81.12	3.30
Average	**74.79**	**79.13**	**79.12**	**76.56**	**80.97**	**80.31**	**0.98**	**8**				**76.34**	**80.73**	**80.11**	**3.69**
H	78.45	83.04	83.46	79.64	84.19	83.97	0.73	8	85.37	90.34	92.72	79.83	84.39	84.20	3.04
Replicate 2	75.21	79.43	79.77	77.20	81.49	81.56	0.95	11				77.57	81.88	82.08	3.88
Replicate 3	78.85	83.39	83.82	80.82	85.44	85.67	0.90	10				81.07	85.67	85.65	2.53
Average	**77.50**	**81.95**	**82.35**	**79.22**	**83.71**	**83.73**	**0.86**	**10**				**79.49**	**83.98**	**83.98**	**3.15**
I	72.26	76.46	77.98	74.47	78.75	79.20	1.37	11	84.12	89.07	91.61	74.19	78.45	79.00	4.77
Replicate 2	73.97	78.27	77.88	76.42	80.82	79.67	1.30	10				76.14	80.50	79.44	4.43
Replicate 3	75.07	79.42	80.73	77.20	81.65	81.76	1.37	11				77.25	81.70	81.97	3.48
Average	**73.77**	**78.05**	**78.86**	**76.03**	**80.41**	**80.21**	**1.35**	**11**				**75.86**	**80.22**	**80.14**	**4.23**
S	75.52	80.01	80.44	76.46	80.90	80.65	0.69	6	85.32	90.38	92.75	76.85	81.32	81.13	4.21
Replicate 2	73.83	78.21	78.55	76.75	81.27	80.89	1.51	6				75.90	80.34	80.02	4.64

Replicate 3	76.64	81.12	81.54	78.39	82.89	82.43	1.05	8				78.46	82.96	82.67	3.61
Average	**75.33**	**79.78**	**80.18**	**77.20**	**81.69**	**81.32**	**1.08**	**7**				**77.07**	**81.54**	**81.27**	**4.15**
T	74.20	78.64	80.47	75.65	80.04	80.54	1.25	7	85.59	90.67	93.85	75.84	80.24	80.63	4.80
Replicate 2	73.27	77.64	78.79	74.44	78.75	78.72	1.09	7				73.84	78.10	78.05	5.81
Replicate 3	76.29	80.78	82.73	77.51	81.97	82.30	1.35	6				77.39	81.82	82.04	4.23
Average	**74.59**	**79.02**	**80.66**	**75.87**	**80.25**	**80.52**	**1.23**	**7**				**75.69**	**80.05**	**80.24**	**4.95**

Alkalinity

	0 Days			**Day 1**				**Day 2**				**Day 3**			
	X	**Y**	**Z**	**X**	**Y**	**Z**	**ΔE**	**X**	**Y**	**Z**	**ΔE**	**X**	**Y**	**Z**	**ΔE**
A	66.12	60.60	48.17	66.37	61.10	48.23	0.78	66.57	61.56	48.18	1.62	67.13	62.85	48.28	3.74
Replicate 2	65.60	60.03	47.44	65.83	60.92	47.36	1.90	65.98	61.41	47.12	2.96	66.91	63.32	47.67	5.70
Replicate 3	65.87	60.40	47.93	65.80	60.83	47.97	1.25	66.07	61.35	47.78	2.11	66.28	61.94	47.92	3.12
Average	**65.86**	**60.34**	**47.85**	**66.00**	**60.95**	**47.85**	**1.31**	**66.21**	**61.44**	**47.69**	**2.23**	**66.77**	**62.70**	**47.96**	**4.19**
B	68.24	62.88	51.24	68.09	63.10	51.25	0.86	67.69	62.72	50.56	1.01	67.88	63.14	50.99	1.48
Replicate 2	68.37	62.92	51.16	67.99	63.00	50.98	1.05	67.91	63.05	50.70	1.43	68.18	63.55	51.11	1.97
Replicate 3	68.24	62.92	51.33	68.14	63.23	51.40	0.95	67.57	62.80	50.63	1.32	68.12	63.56	51.23	1.86
Average	**68.28**	**62.91**	**51.24**	**68.07**	**63.11**	**51.21**	**0.95**	**67.72**	**62.86**	**50.63**	**1.25**	**68.06**	**63.42**	**51.11**	**1.77**
C	66.65	62.07	50.35	66.30	62.36	50.48	1.45	66.30	63.97	50.00	5.58	67.39	66.68	50.92	9.65
Replicate 2	68.14	63.03	50.87	67.73	62.88	50.71	0.58	67.75	63.71	50.60	2.58	67.06	63.37	50.32	3.29
Replicate 3	68.10	63.05	50.89	67.70	63.05	50.84	0.89	67.17	62.75	50.18	1.45	67.27	63.28	50.35	2.47
Average	**67.63**	**62.72**	**50.70**	**67.24**	**62.76**	**50.68**	**0.97**	**67.07**	**63.48**	**50.26**	**3.20**	**67.24**	**64.44**	**50.53**	**5.14**
D	68.07	62.53	51.09	67.50	62.15	50.75	0.44	66.81	61.59	50.13	0.81	67.07	61.88	50.48	0.79
Replicate 2	67.71	62.16	50.75	67.46	62.26	50.65	0.81	67.18	62.14	50.19	1.25	67.34	62.44	50.47	1.57
Replicate 3	67.62	62.19	50.94	67.42	62.29	50.87	0.72	67.25	62.24	50.54	1.05	67.29	62.56	50.55	1.76
Average	**67.80**	**62.29**	**50.93**	**67.46**	**62.23**	**50.76**	**0.66**	**67.08**	**61.99**	**50.29**	**1.04**	**67.23**	**62.29**	**50.50**	**1.37**
E	*67.77*	*64.87*	*56.77*	*67.61*	*65.11*	*56.62*	*0.96*	*67.63*	*66.09*	*55.89*	*3.62*	*69.32*	*69.69*	*57.13*	*8.43*
Replicate 2	*67.24*	*64.38*	*56.24*	*67.46*	*65.06*	*56.47*	*1.11*	*67.34*	*65.68*	*55.78*	*3.20*	*67.78*	*66.85*	*56.13*	*5.00*
Replicate 3	*67.80*	*64.90*	*56.78*	*67.76*	*65.29*	*56.78*	*1.02*	*67.68*	*66.04*	*56.07*	*3.29*	*68.25*	*67.53*	*56.30*	*5.66*
Average	***67.60***	***64.72***	***56.60***	***67.61***	***65.15***	***56.62***	***1.03***	***67.55***	***65.94***	***55.91***	***3.37***	***68.45***	***68.02***	***56.52***	***6.36***
F	65.55	62.07	53.52	66.88	64.35	54.20	2.85	66.98	65.42	53.67	5.47	68.51	68.48	54.87	9.38
Replicate 2	66.22	62.65	53.98	66.64	63.89	54.16	2.17	66.82	64.76	53.77	4.14	67.72	66.71	54.53	6.82
Replicate 3	66.35	62.73	53.98	66.54	63.44	54.14	1.32	66.74	64.16	53.93	2.81	68.63	68.55	54.89	9.37
Average	**66.04**	**62.48**	**53.83**	**66.69**	**63.89**	**54.17**	**2.11**	**66.85**	**64.78**	**53.79**	**4.14**	**68.29**	**67.91**	**54.76**	**8.52**
G	64.07	57.65	43.28	63.94	57.78	43.36	0.62	63.35	57.38	42.94	1.03	63.37	57.47	43.03	1.18
Replicate 2	64.65	58.07	43.56	64.71	59.08	43.69	2.50	65.12	60.42	43.60	5.16	66.63	63.79	44.38	10.31
Replicate 3	64.12	57.70	43.36	64.99	59.88	43.78	3.80	65.28	61.06	43.59	6.34	66.22	62.95	43.98	9.09
Average	**64.28**	**57.81**	**43.40**	**64.55**	**58.91**	**43.61**	**2.31**	**64.58**	**59.62**	**43.38**	**4.18**	**65.41**	**61.40**	**43.80**	**6.86**
H	67.64	62.58	50.52	67.42	62.90	50.64	1.23	67.44	63.20	50.36	2.02	67.75	64.12	50.45	3.65

Replicate 2	68.29	63.08	50.84	68.01	63.14	50.80	0.74	67.71	63.16	50.36	1.57	68.10	64.00	50.52	2.79
Replicate 3	68.07	63.00	50.96	67.95	63.49	50.94	1.46	67.80	63.56	50.50	2.10	68.45	65.02	50.82	4.32
Average	**68.00**	**62.89**	**50.77**	**67.79**	**63.18**	**50.79**	**1.14**	**67.65**	**63.31**	**50.41**	**1.90**	**68.10**	**64.38**	**50.60**	**3.59**
I	66.18	60.62	46.23	66.15	61.06	46.35	1.15	66.26	61.84	46.15	2.97	67.25	63.63	46.69	5.30
Replicate 2	66.30	60.79	46.46	66.05	61.02	46.46	1.12	66.26	61.77	46.38	2.61	67.14	63.59	46.74	5.28
Replicate 3	66.17	60.71	46.44	66.33	61.55	46.56	1.79	66.74	62.67	46.53	3.80	67.77	64.76	46.85	6.87
Average	**66.22**	**60.71**	**46.38**	**66.18**	**61.21**	**46.46**	**1.35**	**66.42**	**62.09**	**46.35**	**3.13**	**67.39**	**63.99**	**46.76**	**5.82**
S	67.73	62.39	50.33	67.52	62.51	50.55	0.76	68.13	64.30	50.37	3.96	71.04	70.29	52.10	12.07
Replicate 2	67.08	61.82	49.81	67.01	62.04	50.11	0.67	66.82	62.28	49.16	1.97	68.79	66.14	50.84	6.94
Replicate 3	67.68	62.44	50.43	67.91	63.08	50.63	1.08	67.96	63.55	50.15	2.39	69.60	67.05	51.19	7.34
Average	**67.50**	**62.22**	**50.19**	**67.48**	**62.54**	**50.43**	**0.84**	**67.64**	**63.38**	**49.89**	**2.77**	**69.81**	**67.83**	**51.38**	**8.78**
T	66.46	60.53	47.17	66.94	61.65	47.40	1.83	67.89	64.44	47.41	6.96	70.76	70.42	49.26	15.01
Replicate 2	66.47	60.21	46.49	66.01	60.17	46.44	0.93	66.89	62.22	46.51	4.28	71.12	71.10	48.87	16.58
Replicate 3	66.71	60.62	47.08	66.88	61.65	47.27	2.20	68.05	64.24	47.36	6.39	71.64	72.08	49.45	17.31
Average	**66.55**	**60.45**	**46.91**	**66.61**	**61.16**	**47.04**	**1.65**	**67.61**	**63.63**	**47.09**	**5.88**	**71.17**	**71.20**	**49.19**	**16.30**

	Day 4				**Day 5**				**Day 6**				**Day 7**			
	X	**Y**	**Z**	**ΔE**	**X**	**Y**	**Z**	**ΔE**	**X**	**Y**	**Z**	**ΔE**	**X**	**Y**	**Z**	**ΔE**
A	67.88	64.38	48.59	5.95	68.28	65.32	48.59	7.52	68.68	66.33	48.68	9.17	69.11	67.22	48.83	10.42
Replicate 2	68.06	65.22	48.26	7.96	67.70	65.57	47.92	9.61	68.89	67.63	48.51	12.04	69.20	68.23	48.59	12.86
Replicate 3	66.72	62.86	48.07	4.52	66.64	63.08	47.95	5.28	66.85	63.45	48.00	5.76	67.16	64.00	47.97	6.57
Average	**67.55**	**64.15**	**48.31**	**6.14**	**67.54**	**64.66**	**48.15**	**7.47**	**68.14**	**65.80**	**48.40**	**8.99**	**68.49**	**66.48**	**48.46**	**9.95**
B	67.97	63.56	50.93	2.36	67.90	63.56	50.79	2.55	67.82	63.47	50.82	2.48	67.78	63.50	50.71	2.66
Replicate 2	68.32	63.92	51.17	2.58	68.28	64.28	50.99	3.62	68.11	64.02	50.85	3.35	67.87	63.91	50.62	3.67
Replicate 3	67.94	63.53	51.06	2.19	68.03	63.84	51.05	2.80	68.05	63.96	51.03	3.07	67.74	63.66	50.75	3.06
Average	**68.08**	**63.67**	**51.05**	**2.38**	**68.07**	**63.89**	**50.94**	**2.99**	**67.99**	**63.82**	**50.90**	**2.97**	**67.80**	**63.69**	**50.69**	**3.13**
C	68.84	69.51	51.94	13.17	68.44	69.10	51.53	13.11	69.10	69.50	51.67	12.76	68.66	68.87	51.36	12.24
Replicate 2	67.45	64.63	50.34	5.56	67.88	65.64	50.78	7.00	68.17	66.58	51.01	8.60	67.96	66.61	50.77	9.20
Replicate 3	67.23	63.36	50.31	2.77	67.07	63.33	50.17	3.07	66.61	63.20	49.61	3.91	66.71	63.42	49.85	4.16
Average	**67.84**	**65.83**	**50.86**	**7.17**	**67.80**	**66.02**	**50.83**	**7.73**	**67.96**	**66.43**	**50.76**	**8.42**	**67.78**	**66.30**	**50.66**	**8.53**
D	67.00	61.92	50.52	1.02	66.66	61.62	50.20	1.14	66.96	61.88	50.45	1.02	66.91	61.91	50.35	1.21
Replicate 2	67.53	62.93	50.54	2.36	67.49	63.01	50.46	2.69	67.65	63.34	50.52	3.16	67.19	62.96	50.06	3.33
Replicate 3	67.60	63.11	50.72	2.43	67.33	63.14	50.39	3.19	67.32	63.12	50.38	3.17	67.31	63.35	50.21	3.84
Average	**67.38**	**62.65**	**50.59**	**1.94**	**67.16**	**62.59**	**50.35**	**2.34**	**67.31**	**62.78**	**50.45**	**2.45**	**67.14**	**62.74**	**50.21**	**2.79**
E	*70.91*	*72.97*	*58.67*	*12.38*	*71.60*	*75.07*	*59.23*	*15.60*	*71.79*	*75.62*	*59.37*	*16.41*	*71.62*	*75.82*	*59.12*	*17.25*
Replicate 2	*68.98*	*69.30*	*57.16*	*8.12*	*69.34*	*69.97*	*57.49*	*8.88*	*69.04*	*69.93*	*57.15*	*8.78*	*69.64*	*70.80*	*57.56*	*10.21*
Replicate 3	*69.32*	*69.71*	*57.10*	*8.45*	*69.87*	*71.02*	*57.63*	*10.23*	*69.59*	*70.19*	*57.66*	*8.84*	*69.79*	*71.25*	*57.45*	*10.98*
Average	***69.74***	***70.66***	***57.64***	***9.65***	***70.27***	***72.02***	***58.12***	***11.57***	***70.14***	***71.91***	***58.06***	***11.34***	***70.35***	***72.62***	***58.04***	***12.81***
F	70.26	72.70	56.45	15.19	70.42	73.48	56.51	16.62	70.25	73.11	56.23	16.23	70.43	74.18	56.32	18.26
Replicate 2	68.68	68.87	55.23	9.83	68.30	68.16	54.96	8.98	69.43	71.20	55.60	13.69	68.25	68.76	54.77	10.56

Replicate 3	69.65	70.92	55.82	12.59	70.29	72.73	56.28	15.35	70.69	74.01	56.63	17.34	70.62	74.11	56.57	17.72
Average	**69.53**	**70.83**	**55.83**	**12.54**	**69.67**	**71.46**	**55.92**	**13.65**	**70.12**	**72.77**	**56.15**	**15.75**	**69.77**	**72.35**	**55.89**	**15.51**
G	63.54	57.70	43.05	1.38	63.10	57.41	42.64	1.73	63.16	57.71	42.76	2.31	62.79	57.29	42.39	2.19
Replicate 2	68.60	67.63	45.41	15.40	69.42	69.64	45.74	18.42	70.06	70.96	46.17	20.13	70.12	71.66	45.88	21.74
Replicate 3	66.78	64.63	44.43	11.93	68.18	67.19	45.07	15.16	68.26	67.71	45.08	16.24	68.36	68.06	45.10	16.86
Average	**66.31**	**63.32**	**44.30**	**9.57**	**66.90**	**64.75**	**44.48**	**11.77**	**67.16**	**65.46**	**44.67**	**12.89**	**67.09**	**65.67**	**44.46**	**13.60**
H	69.07	66.73	51.14	7.19	69.93	68.92	51.46	10.62	70.03	69.10	51.46	10.86	70.42	69.82	51.55	11.78
Replicate 2	68.81	65.32	50.86	4.52	69.37	66.72	51.01	6.77	69.49	67.70	50.99	7.41	69.76	68.11	50.93	9.41
Replicate 3	69.46	67.11	51.38	7.22	69.77	68.36	51.10	9.73	70.37	69.40	51.82	10.72	70.51	70.31	51.42	12.77
Average	**69.11**	**66.39**	**51.13**	**6.31**	**69.69**	**68.00**	**51.19**	**9.04**	**69.96**	**68.73**	**51.42**	**9.66**	**70.23**	**69.41**	**51.30**	**11.32**
I	69.46	68.42	48.11	12.04	70.82	72.31	49.08	18.08	71.15	73.16	49.35	19.29	71.22	73.58	49.17	20.18
Replicate 2	68.11	65.29	47.29	7.38	69.30	66.01	47.32	8.73	68.82	67.50	47.70	11.15	69.24	68.22	47.73	12.05
Replicate 3	68.91	66.92	47.57	9.61	69.88	69.95	48.12	14.68	70.08	69.94	48.07	14.32	69.92	70.01	47.97	14.82
Average	**68.83**	**66.88**	**47.66**	**9.68**	**70.00**	**69.42**	**48.17**	**13.83**	**70.02**	**70.20**	**48.37**	**14.92**	**70.13**	**70.60**	**48.29**	**15.68**
S	73.69	76.25	53.91	19.92	74.81	79.01	54.59	23.62	75.19	79.85	54.77	24.65	74.85	79.65	54.30	25.01
Replicate 2	70.17	68.80	51.68	10.34	72.96	75.78	53.47	20.34	73.77	76.92	54.01	21.17	73.49	77.48	53.57	23.06
Replicate 3	70.83	69.68	52.09	10.88	71.58	71.65	52.37	13.94	71.53	71.42	52.45	13.45	71.30	71.42	51.95	14.10
Average	**71.56**	**71.58**	**52.56**	**13.71**	**73.12**	**75.48**	**53.48**	**19.30**	**73.50**	**76.06**	**53.74**	**19.76**	**73.21**	**76.18**	**53.27**	**20.72**
T	72.40	73.62	50.38	18.83	73.45	76.80	51.01	23.65	73.77	77.69	51.10	24.97	73.45	77.77	50.85	25.82
Replicate 2	73.76	76.38	50.44	22.97	74.86	78.92	51.00	26.26	75.00	79.66	50.96	27.61	74.55	79.55	50.51	28.34
Replicate 3	74.13	77.55	51.05	24.28	74.54	78.80	51.08	26.22	75.39	79.88	51.52	26.85	74.69	80.08	51.25	28.59
Average	**73.43**	**75.85**	**50.62**	**22.03**	**74.28**	**78.17**	**51.03**	**25.38**	**74.72**	**79.08**	**51.19**	**26.48**	**74.23**	**79.13**	**50.87**	**27.58**

	X	**Y**	**Z**	**ΔE**	**Visual**
A	68.03	65.98	48.01	9.83	0
Replicate 2	68.19	67.06	47.89	12.29	0
Replicate 3	65.79	61.84	47.29	4.14	0
Average	**67.34**	**64.96**	**47.73**	**8.75**	**0**
B	67.70	63.33	50.48	2.51	2
Replicate 2	67.47	63.62	50.04	3.98	0
Replicate 3	67.27	63.20	50.20	3.11	0
Average	**67.48**	**63.38**	**50.24**	**3.20**	**1**
C	68.32	68.29	50.73	11.78	0
Replicate 2	67.88	66.72	50.45	9.72	0
Replicate 3	66.42	63.37	49.24	4.87	0
Average	**67.54**	**66.13**	**50.14**	**8.79**	**0**
D	66.27	61.38	49.80	1.51	4
Replicate 2	66.72	62.21	49.72	2.54	0
Replicate 3	66.19	61.99	49.14	3.20	0
Average	**66.39**	**61.86**	**49.55**	**2.42**	**1**

E	70.56	74.46	58.14	16.55	0
Replicate 2	69.43	71.15	57.23	11.52	0
Replicate 3	69.29	70.61	56.86	10.69	0
Average	**69.76**	**72.07**	**57.41**	**12.92**	**0**
F	69.61	72.93	55.37	17.34	0
Replicate 2	67.93	68.61	54.22	11.05	0
Replicate 3	70.00	73.38	55.71	17.57	0
Average	**69.18**	**71.64**	**55.10**	**15.32**	**0**
G	61.65	56.51	41.54	3.04	2
Replicate 2	69.39	70.43	45.08	20.64	0
Replicate 3	68.30	68.69	44.64	18.69	0
Average	**66.45**	**65.21**	**43.75**	**14.12**	**1**
H	70.00	70.05	51.13	13.26	0
Replicate 2	70.08	69.23	51.17	11.32	0
Replicate 3	69.54	68.61	50.49	11.04	0
Average	**69.87**	**69.30**	**50.93**	**11.87**	**0**
I	70.77	73.35	48.75	20.66	0
Replicate 2	69.13	68.45	47.66	12.82	0
Replicate 3	68.25	66.93	46.50	11.38	0
Average	**69.38**	**69.58**	**47.64**	**14.95**	**0**
S	74.35	79.17	54.10	24.95	0
Replicate 2	72.21	75.51	52.87	21.34	0
Replicate 3	71.79	72.93	52.03	16.60	0
Average	**72.78**	**75.87**	**53.00**	**20.96**	**0**
T	72.98	76.76	50.43	24.66	0
Replicate 2	74.59	79.33	50.00	28.05	0
Replicate 3	74.99	79.34	50.64	26.78	0
Average	**74.19**	**78.48**	**50.36**	**26.50**	**0**