Session CIEC 421

EVALUATION OF PAINT/PRIMERS ON WEATHERED WOOD

Aura Hernandez[1], Guadalupe Mendez[1], John Lindsey[1], Joshua Rivers[1], Bailey Walker[1], Jason Church[2], Mary Striegel[2], Jafar F. Al-Sharab[1]

[1]Northwestern State University, [2]National Center for Preservation Training and Technology, Natchitoches, LA

Abstract

Historic exterior wood is affected by water and UV exposure over an extended period of time. The best way to protect the wood is applying a durable paint/primer system specifically for historic, weathered wood. The main purpose of this study is to find the best primer and paint system to preserve historic exterior wood. The study consists of testing three different paint systems on 60 samples (15 control samples) of untreated weathered wood. The samples were prepared and treated using five different applications methods, depending on how many layers were applied, and if the primer was latex based or oil based. The QUV weatherometer was used to test the effect of weather on the samples for a period of 4300 hours. The study was conducted in accordance to ASTM ISO standard 11507. The tested samples were evaluated based on color, gloss, and visual appearance before and after UV exposure, using the following characterization techniques: colorimeter, glossmeter, photography, and a public opinion survey.

Introduction

Historic buildings that are constructed of wood are susceptible to many forms of deterioration such as, water damage, aging of the wood, and most crucial UV damage. The cost of constant maintenance on these historic structures are too much for the national parks or the homeowners of these structures to continue to pay. Since replacing of the boards are not an option because it takes away the historical value of the structure, the best action is to paint the wood. The National Park Service's Preservation Brief 47 states, "Over time, the cost of maintenance is substantially less than the replacement of deteriorated historic features and involves considerably less disruption. Stopping decay before it is widespread helps keep the scale and complexity of work manageable for the owner."[3]. During this research different paint and primer methods were tested on weathered wood to find the best system that will prove to be vital for the preservation of the wooden structures, and most cost effective for national parks and everyday homeowners of historic structures.

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Experimental design

The exterior wood for this project was provided by Mr. Jason Church from the National Center for Preservation Technology and Training (NCPTT). This wood is 78 years old and it was made of cedar and had an application of at least two to three layers of previous stain and paint on its surface. Samples were cut using a table saw in rectangles approximating 7.5x14.1 centimeter. Four samples were needed for each brand's five application methods: a, b, c, and d. Sample 'a' was used at the control for each set, not placed into the QUV. Scraping and sanding was performed to remove the previous paint layers. After this process, sample labels were soldered into the back of each sample in order to be able to differentiate them, using a basic soldering iron. Samples were coded according to the brand, application method number and a sample letter. Ex. P-2-b[3].

A total of sixty samples of wood were painted with a brush, using three different paint/primer brands, and five different application methods: oil primer with white latex paint, latex primer with white latex paint, wood stabilizer/conditioner with white latex paint, a self-priming white latex paint, and just white latex paint (Table 1)[3]. Pictures of each process have been taken: initial appearance, after scraping and sanding, after each layer application, and after QUV exposure. The purpose of taken pictures is to allow visual comparison[3].

The following tests were conducted after the final layer application but before placing the samples into the QUV: glossmeter and colorimeter. The glossmeter was set at an angle of incidence of 60° because of the surface of the samples. The samples were tested in four different spots. When using the colorimeter, the samples were tested in 5 different spots. The previous tests were done again after QUV exposure. All the data obtained before and after exposure is compared to see if any change had occurred[3].

The QUV Accelerated Weathering Tester was used to weather the samples for 4300 hours. The study was conducted in accordance to ASTM ISO standard 11507 which specifies exposure conditions for paint coatings exposed to artificial weathering in apparatus including fluorescent UV lamps and condensation or water spray. The samples were exposed to the following conditions in two cycles: a continuous cycle of 4 hours of UV exposure, t= 70°c, a continuous cycle of 4 hours condensation, t= 50°c, with a radiation of 0.71 nm. Samples were turned counterclockwise every week, in that way each sample got the same amount of exposure. Sampling test were performed every 20 days after 500 hours, until they get 4300 hours of exposure.

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Table 1. Application matrix.

Primer Brand	**Primer/Paint Application**			
Pittsburg paints	(1) Oil Primer (Alkyd)	1-Coat	White Latex-Satin Paint	2-Coat
	(2)Latex Primer (Acrylic)	1-Coat	White Latex-Satin Paint	2-Coat
	(3)Wood Stabilizer/Conditioner	1-Coat	White Latex-Satin Paint	2-Coat
	(4)Self-Priming White Latex- Satin Paint			2-Coat
	(5) White Latex-Satin Paint			1-Coat
Sherwin Williams	(1)Oil Primer (Oil)	1-Coat	White Latex-Satin Paint	2-Coat
	(2)Latex Primer	1-Coat	White Latex-Satin Paint	2-Coat
	(3)Wood Stabilizer/ Conditioner	1-Coat	White Latex-Satin Paint	2-Coat
	(4)Self-Priming White Latex- Satin Paint			2-Coat
	(5) White Latex-Satin Paint			1-Coat
Zinsser (Benjamin Moore paint)	(1)Oil Primer (Oil)	1-Coat	White Latex-Low Lustre Paint	2-Coat
	(2)Latex Primer (Water base)	1-Coat	White Latex- Low Lustre Paint	2-Coat
	(3)Wood Stabilizer/ Conditioner	1-Coat	White Latex- Low Lustre Paint	2-Coat
	(4)Self-Priming White Latex- Satin Paint			2-Coat
	(5) White Latex-Satin Paint			1-Coat

Hypothesis

Paint systems that are self-priming or have no primer will be less effective than the primer and paint system. This will lead to having to constantly repaint the structure to keep it aesthetic, and will result in a much faster degradation rate. Without a primer or an equivalent primer substitute, paint systems will be less effective and durable towards the protection of the historic exterior wood.

Results

Glossmeter: Table 1. Pre-QUV

Pre- QUV			
Highest		Lowest	
S-1-d	14.9	Z-5-d	3.7
P-3-c	11.8	S-5-c	4.3
Z-2-b	9.1	P-5-c	5.4

Table 2. Post-QUV (2800hrs)

Post QUV- 2800 hrs.			
Highest		Lowest	
P-2-d	10.2	Z-5-c	2.6
Z-1-c	5.5	S-5-b	2.6
S-2-b	4.7	P-5-b	3.4

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Table 3. Post-QUV (3300hrs)

Post QUV- 3300 hrs.			
Highest		Lowest	
P-1-c	13.65	S-5-d	2.5
Z-1-c	5.23	Z-5-c	2.7
S-2-b	4.53	P-5-c	3.68

Table 4. Post-QUV (3800hrs)

Post QUV- 3800 hrs.			
Highest		Lowest	
P-2-d	6.43	S-5-d	1.9
Z-1-d	4.45	Z-5-d	1.93
S-2-b	3.43	P-5-c	3.08

Table 5. Post-QUV (4300hrs)

Post QUV- 4300 hrs.			
Highest		Lowest	
P-2-b	8.78	Z-2-C	1.75
Z-1-d	4.275	S-5-d	1.98
S-2-b	3.55	P-3-d	2.75

Table 2. Glossmeter results (Pre-QUV vs Post-QUV, 4300hrs.)

GLOSSMETER	7-10-2012 PRE-QUV	11/6/2018
P-1-a	9.70	5.10
P-1-b	8.30	5.20
P-1-c	10.30	8.23
P-1-d	10.20	6.40
P-2-a	7.60	3.40
P-2-b	8.50	8.78
P-2-c	7.80	5.05
P-2-d	10.00	6.13
P-3-a	11.70	6.18
P-3-b	11.50	5.65
P-3-c	11.80	4.98
P-3-d	7.70	2.75
P-4-a	11.80	5.93
P-4-b	6.20	3.83
P-4-c	7.10	3.98
P-4-d	8.80	6.40
P-5-a	5.00	2.38
P-5-b	5.80	5.48
P-5-c	5.40	2.90
P-5-d	7.20	5.03
S-1-a	13.10	6.18
S-1-b	10.70	2.98
S-1-c	9.90	2.83
S-1-d	14.90	2.70

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S-2-a	9.60	2.38
S-2-b	12.30	3.55
S-2-c	12.00	3.40
S-2-d	10.50	2.75
S-3-a	8.30	3.58
S-3-b	9.30	3.00
S-3-c	5.50	2.93
S-3-d	5.30	2.68
S-4-a	8.00	5.50
S-4-b	8.90	2.63
S-4-c	6.20	2.73
S-4-d	9.40	2.53
S-5-a	8.20	2.70
S-5-b	7.50	2.10
S-5-c	4.30	2.90
S-5-d	5.50	1.98
Z-1-a	7.40	5.50
Z-1-b	6.60	3.35
Z-1-c	7.90	3.85
Z-1-d	7.10	4.28
Z-2-a	8.70	3.33
Z-2-b	9.10	3.05
Z-2-c	5.20	1.75
Z-2-d	6.00	2.73
Z-3-a	5.30	3.98
Z-3-b	4.40	3.13
Z-3-c	6.10	3.00
Z-3-d	6.80	3.05
Z-4-a	6.40	4.48
Z-4-b	5.70	2.35
Z-4-c	4.60	2.55
Z-4-d	4.00	2.60
Z-5-a	4.10	2.48
Z-5-b	4.40	2.55
Z-5-c	4.70	2.18
Z-5-d	3.70	2.25

The following tables contain information for TDS values (Technical Data sheet), Pre-QUV values and Post-QUV values after 4300hrs. of exposure for each primer/paint system from each brand.

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Highest control per date

Highest exposed at the QUV per date

Lowest control per date

Lowest exposed at the QUV per date

Reported data according to the TDS: S-1-a, S-1-ave, and S-2-ave.

Table 3. Pittsburg paint.

TDS VALUES[4]		7-10-2012 PRE-QUV	11/6/2018
(12 TO 22@ 60°)	P-1-a	9.70	5.10
	P-1-ave	9.60	6.61
(12 TO 22@ 60°)	P-2-a	7.60	3.40
	P-2-ave	8.76	6.65
(12 TO 22@ 60°)	P-3-a	11.70	6.18
	P-3-ave	10.33	4.46
(15 TO 25@ 60°)	P-4-a	11.80	5.93
	P-4-ave	7.40	4.73
(12 TO 22@ 60°)	P-5-a	5.00	2.38
	P-5-ave	6.13	4.47

P-(1,2,3,4,5)- ave = Average value for P-(1,2,3,4,5)-b, P-(1,2,3,4,5)-c, P-(1,2,3,4,5)-d.

None of the samples reported data according to TDS values.

Range for control sample: 4.76-11.80

Range for exposed sample: 3.50-10.33

Samples painted with application method #2 (latex primer) registered the highest values of gloss levels.

Samples painted with app method #5 (1 coat of While latex Satin paint) registered the lowest amount of gloss units.

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Table 4. Sherwin-Williams paint.

TDS VALUES[5]		7-10-2012 PRE-QUV	11/6/2018
(10 TO 20@ 60°)	S-1-a	13.1	6.18
	S-1-ave	11.8	2.83
(10 TO 20@ 60°)	S-2-a	9.6	2.38
	S-2-ave	11.6	3.23
(10 TO 20@ 60°)	S-3-a	8.3	3.58
	S-3-ave	6.7	2.87
(10 TO 20@ 60°)	S-4-a	8	5.5
	S-4-ave	8.16	2.63
(10 TO 20@ 60°)	S-5-a	8.2	2.7
	S-5-ave	5.76	2.33

S-(1,2,3,4,5)-ave= Average value for S-(1,2,3,4,5)-b, S-(1,2,3,4,5)-c, S-(1,2,3,4,5)-d.

The Following samples reported data according to TDS values: S-1-a, S-1-ave, S-2-ave.

Range for control samples: 2.58-13.1

Range for exposed samples: 2.46-11.6

Samples painted with application method #2 (latex primer) registered the highest values of gloss levels.

Samples painted with app method #5 (1 coat of While latex Satin paint) registered the lowest amount of gloss units.

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Table 5. Zinsser primer/ Benjamin Moore paint.

TDS VALUES[7]		7-10-2012 PRE-QUV	11/6/2018
(10 TO 15@ 60°)	Z-1-a	7.40	5.50
	Z-1-ave	7.20	3.83
(10 TO 15@ 60°)	Z-2-a	8.70	3.33
	Z-2-ave	6.77	2.51
(10 TO 15@ 60°)	Z-3-a	5.30	3.98
	Z-3-ave	5.77	3.06
(13 TO 23@ 60°)[6]	Z-4-a	6.40	4.48
	Z-4-ave	4.77	2.50
(10 TO 15@ 60°)	Z-5-a	4.10	2.48
	Z-5-ave	4.27	2.33

None of the samples reported data according to TDS values.

Range for control sample: 4.10-8.70

Range for exposed sample: 2.26-7.20

Samples painted with application method #1 (oil primer) registered the highest values of gloss levels.

Samples painted with application method #5 (1 coat of While latex Satin paint) registered the lowest amount of gloss units.

According to the TDS the highest range of gloss values corresponds to Pittsburg paint with 12 to 22 and 15 to 25[4] (application method 4) at 60°. Even before QUV none of the samples registered values for gloss within TDS ranges. Gloss levels in control samples have dropped but they have always been highest than samples exposed to certain environmental conditions at the QUV.

According to the TDS values the lowest range for gloss units corresponds to Zinsser primer and Benjamin Moore paint with 10 to 15[7] units and 13 to 23[6] (application method #4) units at 60°, none of the samples reported values within those ranges.

Between the three different paint/primer brand systems, Pittsburg have kept the highest gloss levels, and worst appearance in terms of degradation related to cracking and peeling of the paint. Although the lowest values for gloss have been for Zinsser/Benjamin, the best appearance in terms of cracking, peeling and blistering, have been for Sherwin-Williams, which also reported low values for gloss.

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Depending on the amount of light reflected by a surface (gloss), the surface is going to have shiny or lustrous, metallic or matte appearances. Many factors can influence the gloss of a surface, such as the amount and type of coating applied or the quality of the substrate. When products look different after a period of time, customers think there is a deformity, for that reason manufacturers want a maximum appeal on their products. “It is important therefore that gloss levels be consistent on every product or across different batches of products. Gloss can also be a measure of the quality of a surface, for instance a drop in the gloss of a coated surface may indicate problems with its cure- leading to other failures such as poor adhesion or lack of protection for the coated surface.”[1]

In this case, before QUV some of the samples gave gloss results between the ranges provided on the TDS of the paints, but most of them were under those values. None of them were higher than TDS. After QUV all the samples presented values lower than TDS.

Colorimeter: Reference values of standard white (L*: 97.18 a*:0.24 b*:1.69)

The colorimeter provides numerical value to color change. It gives an exact value that corresponds to each color. This information is based on three color attributes: hue (red, yellow, blue, etc.), (L) lightness (bright or dark), and saturation (vivid or dull). The colorimeter gives three points on the three axes- l*a*b spectrum system. The *a* axis goes from green (-a) to red (+a), the *b* axis goes from blue (-b) to yellow (+b), and the lightness (L) of color changes vertically on the color solid[2].

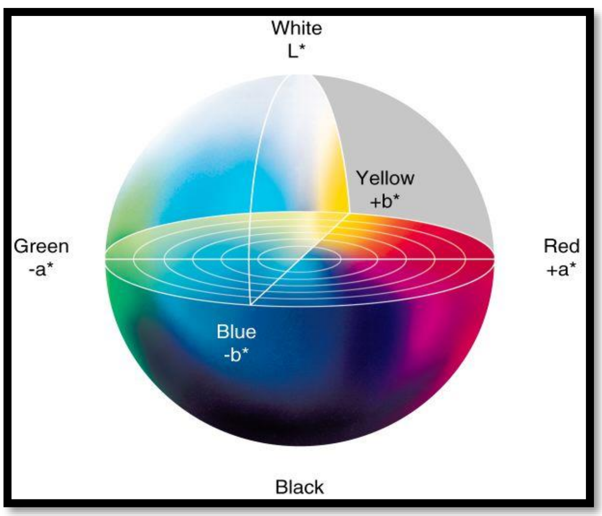

Fig.1. Color solid for L*a*b color space[2].

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Table 6. L*a*b* values after 4300 hrs. of exposure.

	Pre-QUV			Post-QUV (4300 hrs.)			Degradation	% of degradation
Name	L*(C)	a*(C)	b*(C)	L*(C)	a*(C)	b*(C)		
P-1-a	92.48	-0.73	1.56	91.32	-0.01	0.31	1.16	1.3%
P-1-b	92.94	-0.74	1.70	91.85	-0.69	3.06	1.09	1.2%
P-1-c (	93.37	-0.76	1.65	90.77	-0.12	2.84	2.60	2.8%
P-1-d	93.04	-0.74	1.82	91.74	-0.26	2.37	1.30	1.4%
P-2-a	93.11	-0.77	1.65	91.32	-0.24	2.76	1.79	1.9%
P-2-b	93.51	-0.81	1.65	91.06	-0.47	3.22	2.45	2.6%
P-2-c (	93.22	-0.77	1.64	92.78	-0.37	1.67	0.44	0.5%
P-2-d	93.12	-0.79	1.77	92.4	-0.4	1.72	0.72	0.8%
P-3-a	93.12	-0.82	1.52	92.24	-0.3	2.11	0.88	0.9%
P-3-b	93.07	-0.79	1.25	92.16	-0.7	2.93	0.91	1.0%
P-3-c (	91.90	-0.77	1.40	91.67	-0.26	2.55	0.23	0.3%
P-3-d	92.92	-0.80	1.33					
P-4-a	93.21	-0.61	1.15	91.61	-0.34	1.94	1.60	1.7%
P-4-b	92.46	-0.62	1.11	92.59	-0.48	1.94	0.13	0.1%
P-4-c (	92.80	-0.66	1.17	91.52	-0.31	1.45	1.28	1.4%
P-4-d	93.66	-0.69	1.42	91.76	-0.28	1.43	1.90	2.0%
P-5-a	90.60	-0.59	1.51	92.34	-0.28	1.46	1.74	1.9%
P-5-b	89.05	-0.53	1.42	87.86	-0.31	4.54	1.19	1.3%
P-5-c (	90.07	-0.72	1.36	88.39	-0.17	1.96	1.68	1.9%
P-5-d	92.21	-0.73	1.37	89.46	-0.35	1.93	2.75	3.0%
S-1-a (	94.04	-0.19	1.23	90.44	-0.24	2.22	3.60	3.8%
S-1-b	94.13	-0.18	1.21	93.49	-0.38	2.79	0.64	0.7%
S-1-c (	94.01	-0.20	1.15	92.72	0.06	1.39	1.29	1.4%
S-1-d	93.88	-0.20	1.04	92.46	0.08	1.65	1.42	1.5%
S-2-a (	93.36	-0.20	0.86	91.79	0.13	1.46	1.57	1.7%
S-2-b	94.33	-0.22	0.93	92.84	-0.14	1.33	1.49	1.6%
S-2-c (	94.11	-0.18	0.90	92.74	-0.03	1.6	1.37	1.5%
S-2-d	93.91	-0.17	1.01	92.64	-0.09	1.62	1.27	1.4%
S-3-a (	93.44	-0.22	0.87	92.8	-0.05	1.03	0.64	0.7%
S-3-b	91.86	-0.26	0.88	91.77	-0.19	2.12	0.09	0.1%
S-3-c (	93.56	-0.23	0.98	91.29	-0.08	1.2	2.27	2.4%
S-3-d	93.23	-0.26	0.81	92.11	-0.06	0.96	1.12	1.2%
S-4-a (	92.62	-0.19	0.89	91.31	-0.07	1.02	1.31	1.4%
S-4-b	93.49	-0.31	1.46	91.92	-0.22	1.54	1.57	1.7%
S-4-c (	93.12	-0.31	1.31	92.29	0.01	1.3	0.83	0.9%
S-4-d	93.44	-0.30	1.29	91.72	0.03	1.29	1.72	1.8%
S-5-a (	90.70	-0.21	1.32	91.94	0.1	1.69	1.24	1.4%
S-5-b	89.22	-0.12	1.97	88.83	-0.07	3.28	0.39	0.4%
S-5-c (	92.68	-0.16	1.70	87.06	0.16	3.24	5.62	6.1%
S-5-d	89.25	-0.25	0.44	91.15	0.09	2.35	1.90	2.1%
Z-1-a (	92.36	-0.26	0.40	88.56	-0.11	0.49	3.80	4.1%
Z-1-b	92.30	-0.29	0.31	91.81	-0.23	0.93	0.49	0.5%
Z-1-c (	92.18	-0.28	0.29	91.2	-0.04	0.62	0.98	1.1%
Z-1-d	92.36	-0.26	0.30	91.32	-0.01	0.31	1.04	1.1%

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Z-2-a	92.03	-0.26	0.42	90.54	0.12	1.18	1.49	1.6%
Z-2-b	92.04	-0.23	0.37	91.02	-0.07	1.56	1.02	1.1%
Z-2-c	91.52	-0.22	0.33	91.67	0.03	0.26	0.15	0.2%
Z-2-d	92.00	-0.23	0.21	90.84	0.08	-0.05	1.16	1.3%
Z-3-a	91.63	-0.31	0.19	91.15	0.08	-0.06	0.48	0.5%
Z-3-b	91.86	-0.30	0.27	91.04	-0.17	0.61	0.82	0.9%
Z-3-c	92.31	-0.27	0.38	90.46	0.01	0.15	1.85	2.0%
Z-3-d	92.19	-0.28	0.39	91.09	0.05	-0.01	1.10	1.2%
Z-4-a	92.10	-0.31	0.15	91.09	-0.01	0.34	1.01	1.1%
Z-4-b	91.71	-0.34	0.29	91.63	-0.16	0.44	0.08	0.1%
Z-4-c	92.26	-0.30	0.03	90.6	-0.04	0.19	1.66	1.8%
Z-4-d	92.53	-0.30	0.17	91.09	-0.04	0.4	1.44	1.6%
Z-5-a	89.95	-0.15	0.24	91.24	-0.06	0.17	1.29	1.4%
Z-5-b	90.06	-0.24	0.32	88.18	0.06	1.82	1.88	2.1%
Z-5-c	89.89	-0.25	0.75	89.51	0.03	0.47	0.38	0.4%
Z-5-d	87.20	-0.28	0.25	89.11	0.07	0.26	1.91	2.2%

$$Degradation = Lvalue\ Pre\ (QUV) - Lvalue\ Post\ (QUV) \quad \text{Eq. 1}$$

$$\%\ Degradation = \frac{Lvalue\ Pre\ (QUV) - Lvalue\ Post\ (QUV)}{L\ value\ Pre\ (QUV)} \quad \text{Eq. 2}$$

Control Samples (a samples) were never exposed to QUV conditions.

Fig.2. Degradation in terms of color change.

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<u>Color degradation on samples</u>

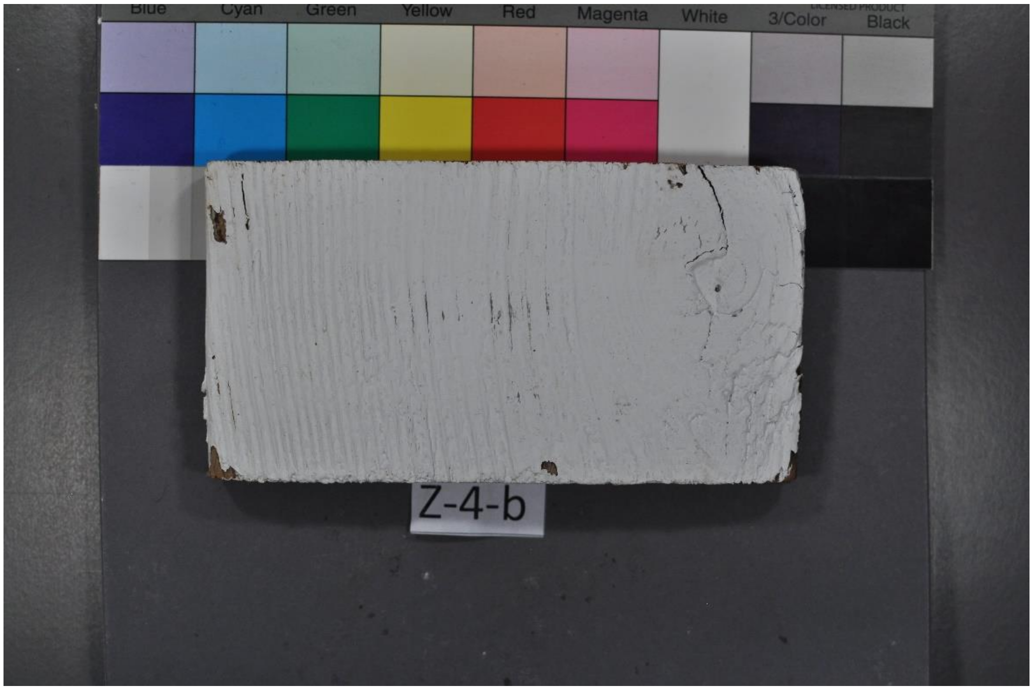

Fig.3. Sample with least amount of color degradation.

Fig .4. Sample with most amount of color degradation.

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For L values in general samples without a primer or a primer substitute, showed the lowest numerical values, which means they are darker than other samples. The brand and application method that showed the most change was Sherwin- Williams with application method number 5. The brand application that showed the least amount of change was Zinsser- Benjamin and application method number 4.

After 2300 hours of exposure, samples started to show degradation, in some of them the paint was off, and in others the paint was changing its color and turning yellow. According to the public opinion survey performed in 2012, Zinsser one-coat oil based primer with an additional two coats of latex paint maintained the best visual appearance after the first session of weathering. However, after 2800 hours of exposure, the glossmeter results showed that paint/brands with higher gloss measures had more degradation than those with less measures. In this case, samples painted with Pittsburg brand presented more degradation. On the other hand, samples painted with Sherwin-Williams brand had kept the best visual appearance, and they presented low gloss measures. From observations it seems that paint systems that were designed to have a high gloss measure were not designed to last against degradation or be used in harsh environments.

After 3800 hours of exposure all samples presented discoloration. Most of the samples exposed to the weather machine also presented peeling, and cracking or visible lines. Only one sample painted with application method #4 presented also blistering or bubbles on the paint.

Degradation have been studied in terms of cracking, peeling, blistering and color degradation. At this point all of them (including control samples) have changed color, but exposed samples have changed the most respect to control samples. According to the colorimeter results, the paint/primer system with more degradation in terms of change in color is Sherwin Williams with the application method #5 (just 1-coat of White-Latex Satin paint) as the most degraded. On the other hand, the paint/primer system with less degradation in terms of change in color is Zinsser/Benjamin Moore with application method #4 (Self-priming while latex satin paint) as the least degraded.

In terms of cracking and peeling, samples with Pittsburg paints have shown more degradation. Some of the paint got stuck in the holders. Samples with Zinsser and Benjamin Moore paint have also shown a considered amount of degradation. The best appearance in terms of cracking and peeling correspond to Sherwin-Williams.

Conclusion

Paint/primer systems with a primer or primer substitute are more effective than paint systems without primers. Primer inclusion into the paint system is imperative to have a long lasting, and more durable wood protector. Glossmeter results have shown that paint systems without primers always reported low gloss levels. Colorimeter results have shown that paint systems without primers reported low values for lightness, which means they are not as bright as those samples

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with primers or primer substitutes. Also, paint systems without primer presented more color change.

In terms of color degradation, the best paint/primer system corresponds to Zinsser primer/ Benjamin Moore paint with the application method #4 (Self-priming White-Latex Satin paint). On the other hand, in terms of cracking, peeling and blistering degradation, the best paint/primer system corresponds to the paint brand Sherwin-Williams.

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Biographical Information

AURA HERNANDEZ is a Colombian senior in the Industrial Engineering Technology program at Northwestern State University. Before coming to America she went to the University of Cartagena for five semesters to study Chemical Engineering. Currently she plays at the NSU Symphony Orchestra as principal for the second violin section, and works as a supervisor at the WRAC- Wellness Recreation & Activity Center at the same University.

JOHN LINDSEY from Urania, Louisiana is a senior majoring in Industrial Engineering Technology at Northwestern State University. Always having a fascination in engineering, he came to NSU in hopes of continuing the tradition of having a career in a STEM field set by his father and grandfather.

JOSHUA RIVERS is a senior in the Industrial Engineering Technology program at Northwestern State University. He is a proud father and an avid hunter. He works in the logging industry as well at Interstate Building Materials.

GUADALUPE MENDEZ is a senior in the Industrial Engineering Technology and Electronics Engineering Technology Departments at Northwestern State University. He is a student worker for the Engineering Technology Department at the same University.

BAILEY WALKER is a senior in the Industrial Engineering Technology program at Northwestern State University. He is was an athlete here on the basketball team, and is employed at the Sabine River Authority.

JASON CHURCH is a materials conservator in the Materials Conservation Program. Church coordinates and works to further develop the Center’s national cemetery training initiative and related research. His experience is in cemetery conservation with special attention placed on cemetery ironwork. Before joining NCPTT, he was a conservator and historic metals expert for the City of Savannah, Ga., Department of Cemeteries. He earned his M.F.A. in Historic Preservation from Savannah College of Art and Design.

DR. MARY STRIEGEL is responsible for NCPTT’s Materials Conservation Program. Mary came to NCPTT in 1995 from the Getty Conservation Institute. Her past work has included studies of the effects of formaldehyde on inorganic materials, uses of thin-layer chromatography for the analysis of binding media, and applications of digital

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imaging and technical photography in the analysis of works of art. Mary earned her Ph.D. in inorganic chemistry from Washington University in St. Louis, where she pursued interdisciplinary research on residual stresses in numismatics.

DR. JAFAR FARHAN AL-SHARAB is the Head of Engineering Technology Department at Northwestern State University. He received BS In Industrial Engineering from the University of Jordan, and PhD from Vanderbilt University/Nashville, TN. Prior joining NSU, Dr. Al-Sharab was an Instructional and Research Faculty at Rutgers University where he was heavily involved in research and teaching at both graduate and undergraduate levels. Dr. Al-Sharab was a visiting professor in the Department of Mechanical and Aerospace Engineering at New York University Tandem School of Engineering and also at AlBalqa Applied University/Jordan. In addition, Dr. Al-Sharab served as a consultant of various technological companies especially in the areas of structure-property-correlations and advanced characterizations.

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