Weathering of Vinyl Siding

Developing a Test Protocol

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We make testing simple.

Thank you for attending our webinar!

We hope you found our webinar on *Weathering of Vinyl Siding* to be helpful and insightful. The link below will give you access to the slides and recorded webinar.

You can help us continue to provide valuable and high quality content by completing our 3-question survey about your webinar experience. Every piece of feedback is carefully reviewed by a member of our team.

We consistently hold seminars and webinars about weathering, corrosion, standards and more. The best way to keep up with news and events is by following us on Facebook, Twitter and LinkedIn.

Today's webinar was part of a weekly series on weathering and corrosion. You can register for the remaining webinars in the series or watch previous ones here.

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Accelerated Test Types

Accelerated Test Type	Result	Test Time	Results compared to
Quality Control	Pass / fail	• Defined • Short	Material specification
Qualification / validation	Pass / fail	• Defined • Medium-long	Reference material or specification
Correlative	Rank-ordered data	• Open-ended • Medium	Natural exposure (Benchmark site)
Predictive	Service life Acceleration factor	• Open-ended • Long	Natural exposure (Service environment)

What is Vinyl Siding

- Co-extruded building cladding material
  - PVC base stock, PVC or ACA cap stock
- Developed in the 1960's, became popular in the 1970's
- In 1995 became the most common residential cladding material in US & Canada

How Long does Vinyl Siding Last

- Early in adoption, a manufacturer started advertising a claim that it will last 25 years
- This made the industry a little uneasy, as early failures of their product could reduce public perception of quality of all vinyl siding
- So a test protocol was needed!

Enter the Vinyl Siding Institute (VSI)

- A trade association for siding manufactures, equipment suppliers and raw material suppliers
- Offers training and certification for installers
- Certifies that members product meets industry standards
  - ASTM D3679 & D7254, describing the product
  - ASTM D6864 & D7251, color & appearance

Outdoor Weathering Program

- Ongoing 25 year outdoor studies
- New test started every 5 years
  - First started May 1984
  - Still going on today
- Data has been used to develop 2 year outdoor certification test (AZ, FL, OH)
- Developed ASTM D6864 & D7251

How it Fails

- As this is primarily used as cosmetic building cladding, the main concern is the appearance. So the focus is on common failure modes that would be visible to a customer.
- Common failures include:
  - Color change (yellowing and fading)
  - Chalking

VSI Certification Program

- Administer by an independent 3rd party
- 2 Year Exposure in FL, AZ, OH
- Meet requirements of D3679 and D7254
- Pass D6864 or D7251 with a ellipsoid value of 1 or less

- Receive a VSI stamp and can give a 25 year warranty

Two Year Outdoor Certification is…

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Certification Program

- 15+ manufactures representing 30+ brands are on the “ VSI Product Certification Program’s Official List of Certified Product”
- On average each brand has about 10 certified colors

Evaluations: ASTM D6864/D7251

- Color retention standard
- 16 “color regions” defined
- ΔL Δa Δb values entered into ellipsoid equations
- Ellipsoid color retention value (EV) better represents perceivable color shifts compared to simple Delta E value
- Ellipsoid of 1.0 or lower passes

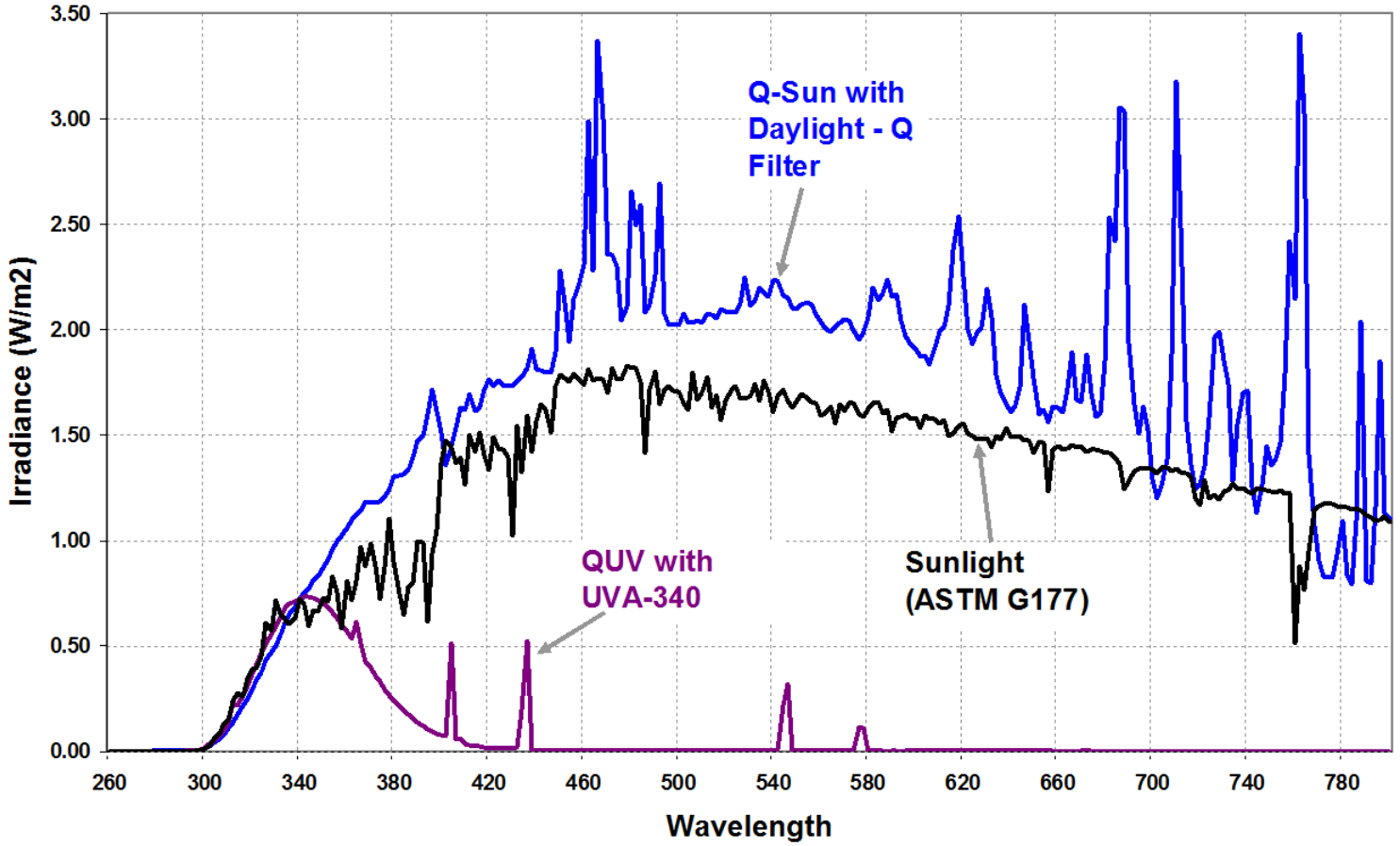
But how can we get results faster?

- Accelerated Weathering Testing!

VSI Accelerated Weathering Task Group

- Attempted to develop accelerated test protocol for "fast-track" provisional certification
- 6 (7) Rounds of Testing
- Fresnel sunlight concentrator not considered (too hot for PVC)
- Fluorescent UV and Xenon Arc were both tested using various test cycles

Accelerated Weathering: Light Sources



VSI Accelerated Weathering Task Group

- Most (submitted) materials perform well in Florida
- White materials perform worst in Arizona (yellowing)
- Colored materials perform worst in Ohio and other northern climates
  - Replicating Ohio failures key to this study

Round 1

- 24 month outdoor test
  - Louisville, KY
  - Cuyahoga Falls, OH (Cleveland/Akron)
  - Chicago, IL
  - LaQue, NC
- Use specimens from ongoing outdoor tests in Arizona and Florida
- Compare Xenon, QUV to average ΔL values from 4 sites

Round 1 Results

Xenon:

- SAE J1960 Daylight **Pearson Correlation** 0.51
- ASTM G155 cycle 1 **Pearson Correlation** 0.67

Fluorescent UV:

- QUV 2000hr* **Pearson Correlation** 0.75
- QUV 3000hr* **Pearson Correlation** 0.92

* Cycle: UVA-340 lamps, 12 hours of light at 0.89 W/m2 at 50°C, followed by 12 hours of condensation at 60°C.

Round 1 Results

Outdoor

Target		
Replicate Study 24-Month Outdoor Data		
	Mean ΔL	Rank
18S	-2.60	1
12K	3.10	2
2B	4.51	3
18H	5.31	4
17J	6.25	5
13D	7.54	6
16H	9.56	7
Data Range: 12.16		
StDev: 3.88		

Xenon Arc

2016 Hour G155 Xenon			
	Mean ΔL	StDev	Rank
2B	-0.44	0.23	2.5
12K	-0.41	0.08	2.5
18S	-0.21	0.23	2.5
17J	-0.06	0.12	2.5
18H	0.37	0.10	5
13D	0.93	0.04	6
16H	3.40	0.09	7
Data Range: 3.84			
StDev: 1.36			
Pearson Correlation = 0.67			

1500 Hour J1960 Xenon			
	Mean ΔL	StDev	Rank
17J	-0.77	0.05	2
2B	-0.70	0.20	2
12K	-0.67	0.13	2
18H	-0.36	0.11	5
18S	-0.22	0.33	5
13D	0.02	0.33	5
16H	2.60	0.07	7
Data Range: 3.37			
StDev: 1.19			
Pearson Correlation = 0.51			

Round 1 Results

Outdoor

Target		
Replicate Study 24-Month Outdoor Data		
	Mean ΔL	Rank
18S	-2.60	1
12K	3.10	2
2B	4.51	3
18H	5.31	4
17J	6.25	5
13D	7.54	6
16H	9.56	7
Data Range: 12.16		
StDev: 3.88		

Fluorescent UV

2000 Hour Fluorescent/Condensation			
	Mean ΔL	StDev	Rank
18S	0.48	0.14	1
12K	2.45	1.59	2
17J	4.53	1.48	4.5
13D	4.59	1.73	4.5
16H	4.65	1.70	4.5
18H	4.87	0.13	4.5
2B	6.45	0.05	7
Data Range: 5.97			
StDev: 1.94			
Pearson Correlation = 0.75			

3000 Hour Fluorescent/Condensation			
	Mean ΔL	StDev	Rank
18S	1.03	0.12	1
12K	5.18	0.15	2
18H	5.90	0.31	3.5
17J	5.95	0.07	3.5
2B	7.91	0.11	5
13D	8.23	0.22	6.5
16H	8.24	0.12	6.5
Data Range: 7.21			
StDev: 2.55			
Pearson Correlation = 0.92			

Round 1 Testing

An Example of…

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Rounds 2 and 3

- Round 2 – Repeated UV test, added three additional labs, focused on quantifying false positives/negatives
- Round 3 – Added a new UV test cycle and revisited Xenon arc with no improvement

The result of these tests is that the new focus should be on eliminating false results (particularly false positive) instead of pearson

False Positives/Negatives

- A *False Positive* represents a specimen that passes an accelerated test, but fails outdoors
  - False Positives create risk of product failures and customer complaints
- A *False Negative* represents a specimen that fails an accelerated test, but passes outdoors
  - False Negatives create risk of over-engineering a formulation or passing on a good product

Round 4

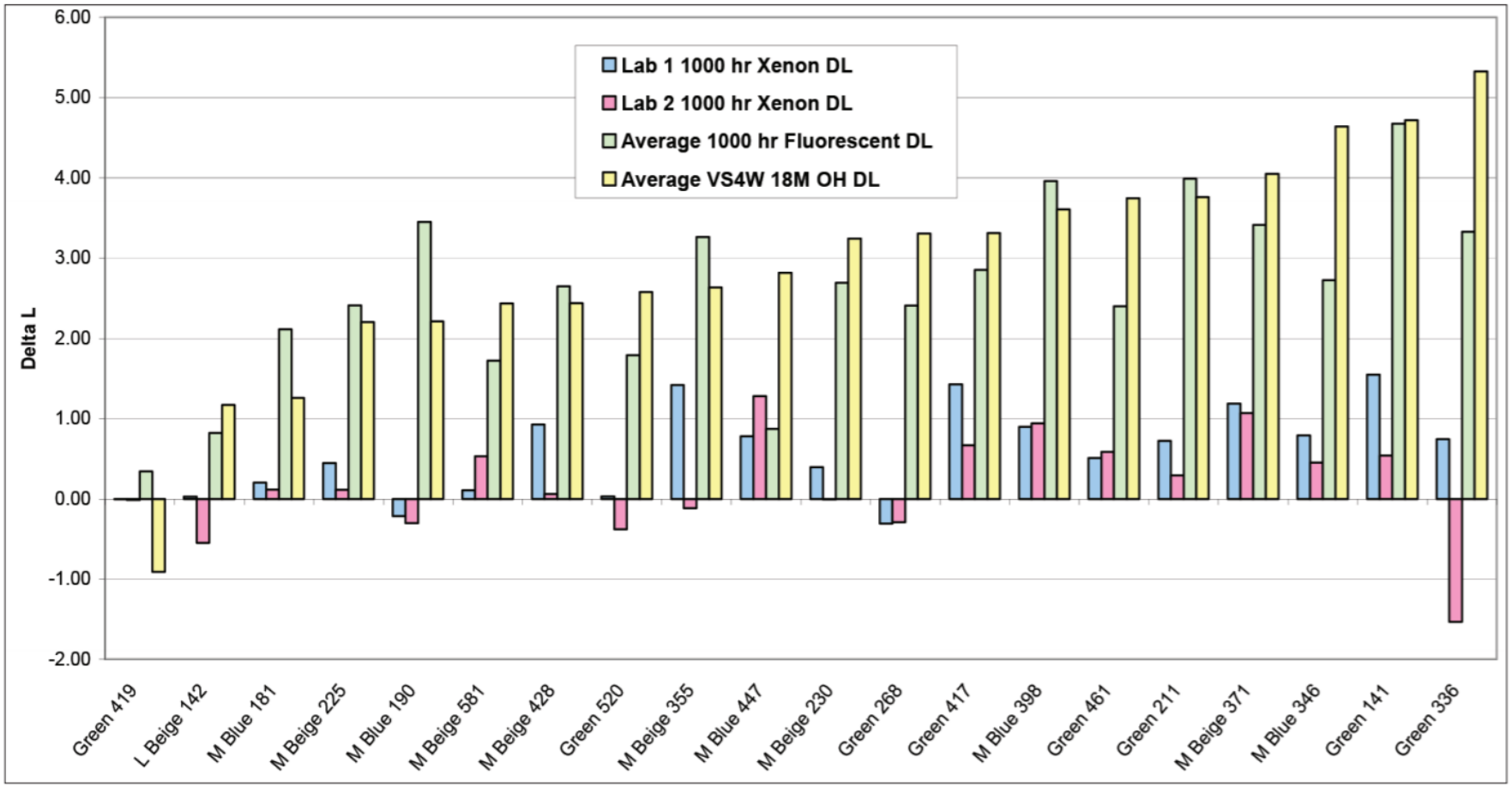
- Expanded the specimens and added more laboratories for the UV test.
  - 29 colored PVC specimens
  - 3 white PVC specimens
  - 9 colored non-PVC specimens

- Unofficial Xenon arc testing also happened, trying to replicate the 12h on, 12h off test.

Round 4 Results

- The Xenon arc test method once again had poor correlation to outdoors, and so it wasn't pursued further
- The QUV testing showed that for a pass/fail test, 1500 hours was enough to see the majority of color change
- No accelerated tests worked well for white materials that saw the majority of degradation in Arizona

Color Performance in Round 4



Round 4 Results

- Correlation was good, but there were still too many false positives to make it a certification

	Accelerated and Outdoor		
	Results Agree	**Results Disagree**	
Outdoor Failures 38 Comparisons PVC vs. PVC Ref.	93.40%	6.60%	False Positives
Outdoor Passes 21 Comparisons Non-PVC vs. PVC Ref.	90.50%	9.50%	False Negatives

Round 5

- Expanded the specimens and included some from previous tests
  - 31 colored specimens (15 non-PVC)
  - 9 white specimens (2 non-PVC)
- Add a continuous light cycle (0.95 $W/m^2/nm$) to simulate Arizona (must pass both tests)
- Pass/fail threshold of 0.90 and 1.50 EV used to eliminate false positives

Round 5 Results

- Both tests could be run for a shorter duration to achieve color change
  - **Dry:** 1800 hours -> 900 hours
  - **Cond/Light:** 3000 hours -> 2000 hours

- However, one false positive (a dark red color) was still present in this test.

Round 6

- One final test with 43 specimens, in an attempt to reduce false negatives and eliminate the one false positive.
  - Condensation temperature was reduced by 5 °C to prevent overheating of specimens
  - Irradiance was bumped up to 0.95 W/m^2/nm in the condensation/light cycle

Round 6 Results

- While the number of false negatives was reduced, the one specimen still failed outdoors and passed the accelerated test

	Outdoor Fail	Outdoor Pass
Accelerated Pass	1 (2%)	18
Accelerated Fail	16	8 (19%)
Accelerated Passing EV <= 0.35		

Overall results

- While the test had good correlation, it wasn't perfect.
- The one false positive that existed prevented this test from being a fast track to certification
- The test is still very useful for R&D, but there is no substitution for outdoor exposures for certification.

How would you use this accelerated test?

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General Conclusions

- Correlating accelerated weathering to natural exposures is hard, but possible!
- For these siding products, temperature and moisture were important…
- But matching the visible and IR spectrum was not necessary.
- Reducing commonly used accelerated weathering temperatures was important

Thank you for your attention!

For more information:
LW-6039 Accelerated Weathering of Vinyl Siding

Questions?

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