

Selecting a Weathering Testing Program

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Thank you for attending our webinar!

What We Will Talk About

- **Benefits and Limitations of Different Tester Architectures**
 - Fluorescent UV
 - Xenon Arc
- Types of Tests
- Examples of Different Types of Tests and Architecture
 - Quality Control
 - Qualification
 - Correlation
- Putting It Together

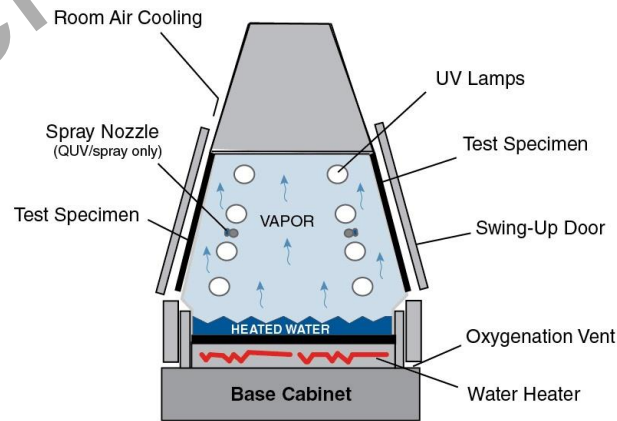
Fluorescent UV Benefits

- Extremely stable spectrum
 - Repeatable and reproducible
- Low operating cost
 - Allows for more testing, which means more data
- Condensation is most realistic form of wetness
 - Hot condensation is the best way to “accelerate” water delivery



Fluorescent UV Limitations

- Spectrum is UV-only
 - Materials that are sensitive to long wave UV and visible light may not see realistic results
- Cannot Control Relative Humidity
 - Indoor applications sensitive to moisture may not see realistic results
- Specimen Temperature
 - Lack of IR component means all specimens will be about the same temperature, regardless of color



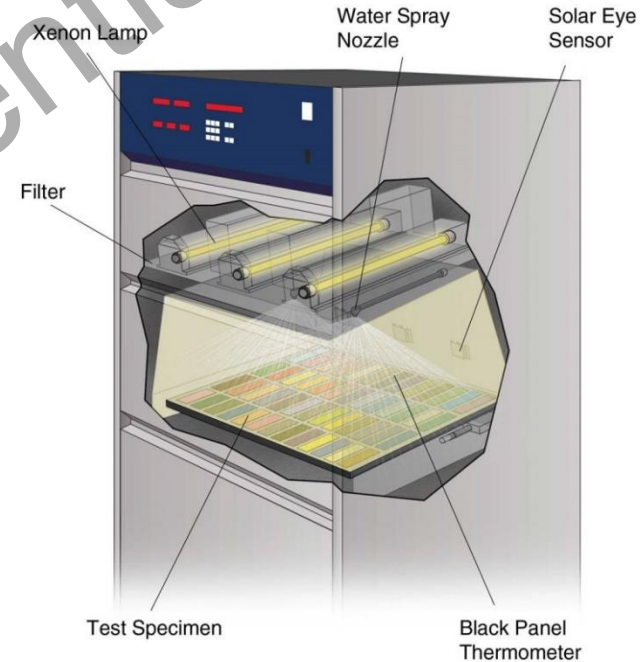
Xenon Arc Benefits

- Full Spectrum Sunlight
 - Most realistic simulation of longwave UV, visible, and IR
- Controlled Relative Humidity
 - Better repeatability and reproducibility in materials sensitive to relative humidity
- Realistic Color Temperatures
 - Better simulation of end use environment when testing different color specimens in the same tester



Xenon Arc Limitations

- Lamp Aging
 - Spectrum changes as lamps age, requiring frequent lamp changes
- Cannot Create Condensation
 - Water spray can simulate wetting, but requires long wetting periods
- Historic Test Cycles
 - Most historic test cycles are based on obsolete hardware and don't simulate weathering!
- Higher operating costs
 - Consumables, maintenance, water consumption, and electrical power consumption



Fluorescent UV and Xenon Arc

Fluorescent UV

- UVA-340 best simulation of shortwave UV
- UVB-313 might be too severe
- No visible light
- Stable spectrum
- No RH control necessary
- Condensation or water spray
- Relatively inexpensive and simple

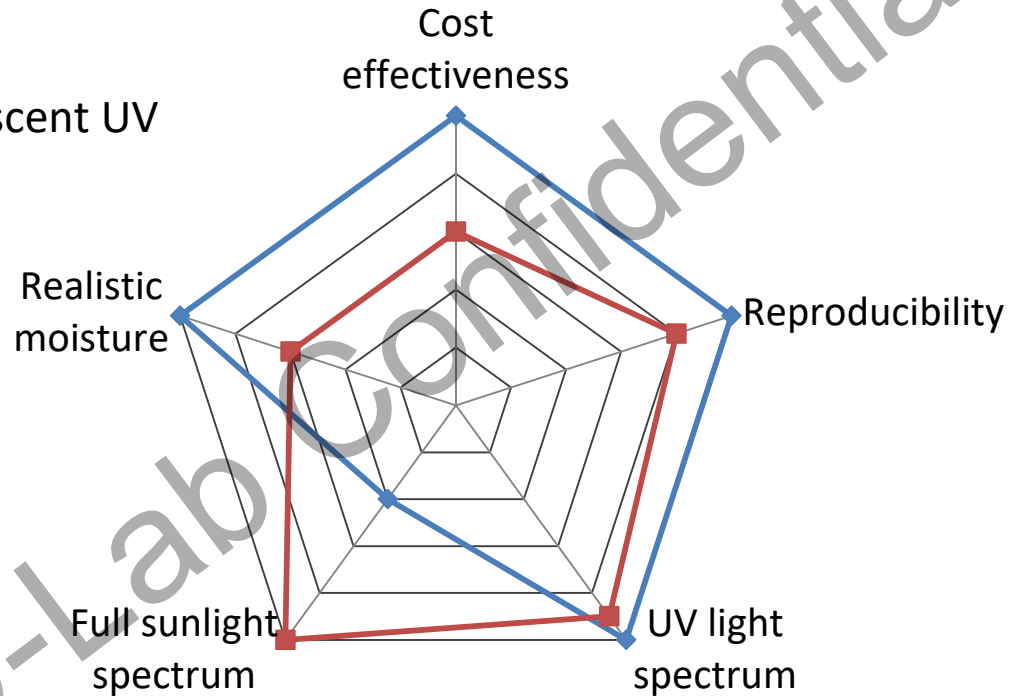
Xenon Arc

- Full spectrum (UV-VIS-IR)
- Best simulation of long wave UV & visible light
- Spectrum Changes
- RH control
- Water spray
- More expensive and complex

Fluorescent UV and Xenon

— Xenon

— Fluorescent UV



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Laboratory Testing is a Tool for Directional Decision-Making

Laboratory Accelerated tests can help you

- Make decisions better and/or faster.
- Reduce risk of making bad decisions.
- Reduce risk of making decisions too slowly.

What Kind of Test Should I Run?

Accelerated Test Type	Result	Test Time	Results compared to
Quality Control	Pass / fail	<ul style="list-style-type: none">• Defined• Short	Material specification

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Quality Control Test

- Needs to be quick and inexpensive
- Does not need to be realistic
- QC Tests include:
 - Verifying supplier claims
 - Material testing per lot

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What Kind of Test Should I Run?

Accelerated Test Type	Result	Test Time	Results compared to
Quality Control	Pass / fail	<ul style="list-style-type: none">• Defined• Short	Material specification
Qualification / validation	Pass / fail	<ul style="list-style-type: none">• Defined• Medium-long	Reference material or specification

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Qualification/Validation

- Typically only run once per formulation/product
- Not necessarily realistic, but is *usually* built from data
- Qualification Examples
 - OEM Supplier Testing
 - Classification of material to a specification

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What Kind of Test Should I Run?

Accelerated Test Type	Result	Test Time	Results compared to
Quality Control	Pass / fail	<ul style="list-style-type: none">• Defined• Short	Material specification
Qualification / validation	Pass / fail	<ul style="list-style-type: none">• Defined• Medium-long	Reference material or specification
Correlative	Rank-ordered data	<ul style="list-style-type: none">• Open-ended• Medium	Natural exposure (Benchmark site)

Correlative Testing

- Ongoing testing of various formulations
- Outdoor Testing / Service Environment Data required
- Rank-order data compares two datasets
 - Accelerated versus Outdoor
 - Accelerated versus Accelerated
 - Outdoor versus Outdoor
- Correlative Examples
 - Reformulating for Environmental Restrictions or Lower Cost
 - Comparing to competitors' materials

What Kind of Test Should I Run?

Accelerated Test Type	Result	Test Time	Results compared to
Quality Control	Pass / fail	<ul style="list-style-type: none"> • Defined • Short 	Material specification
Qualification / validation	Pass / fail	<ul style="list-style-type: none"> • Defined • Medium-long 	Reference material or specification
Correlative	Rank-ordered data	<ul style="list-style-type: none"> • Open-ended • Medium 	Natural exposure (Benchmark site)
Predictive	Service life Acceleration factor	<ul style="list-style-type: none"> • Open-ended • Long 	Natural exposure (Service environment)

Predictive Testing

- Prediction of performance outdoors based on accelerated test (quantitative)
- Requires extensive outdoor/service life data
- No “One size fits all” answer
- Predictive Examples
 - Does every 100 hours in a tester correspond to one year outdoors in South Florida?

Predictive Testing

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Lindstrand Balloons

Quality Control / Qualification Test

Situation

- Leading gas balloon manufacturer; works closely with NASA and European Space Agency
- Static-cable balloons reach 70m high, hot air reach 3,657m and the Global Challenger reached 19,812m
- At 8 kilometers high, a product failure cannot be tolerated

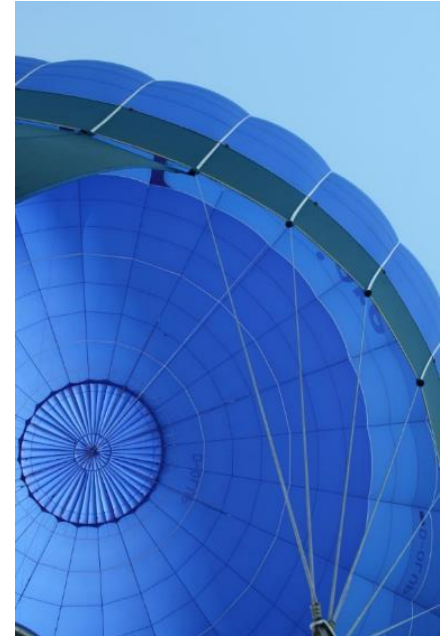


Lindstrand Balloons

Quality Control / Qualification Test

Solution

- Fluorescent UV testing in QUV
 - UVB-313 lamps for fast pass/fail type results
 - High temperatures and condensation to simulate moisture attack
 - Short sprays for thermal shock
- Total test duration: 1960 hours (over 11 weeks)



Hair Care Products & Dyes

Quality Control Test

Requirements

- Hair dyes that resist fade
- Hair maintenance products that protect from the sun's effects

Problem

- Sun may cause hair to fade, change color and become brittle
- High humidity tends to accelerate these effects



Hair Care Products & Dyes

Quality Control Test

Solution

- Xenon testing to reproduce the effects of sunlight & humidity
- One study found noticeable color change in dyed hair after 48 hours of xenon exposure



Flexible Intermediate Bulk Containers

Quality Control / Correlative Testing

Situation

Flexible Intermediate Bulk Containers (FIBC's) are used to carry goods. They need to survive at a job site for up to 6 months without losing tensile strength. The current QC test uses UVB-313 lamps for 200-300 hours.

Various test methods with Xenon and Fluorescent UV were compared to outdoor performance.



Flexible Intermediate Bulk Containers

Quality Control / Correlative Testing

Solution

Existing UVB-313 test seemed to be good **QC** pass/fail test due to the speed of the test.

Xenon and UVA-340 test methods took longer, but had better **correlation** for R&D.

Accelerated Tests vs. 4 Months Florida Tensile Strength, Spearman's Rank Order

Test Type	200 hr Test	300 hr Test
UVB-313 (ISO 21898)	0.37	0.37
UVA-340 (ASTM G154)	0.30	0.76
Xenon (Light Only)	0.37	0.77
Xenon (Light/Dark+Spray)	0.54	0.83

Arwood European Wood Coatings

Qualification / Correlative Testing

Situation

- Quickly assess the durability of exterior wood coatings to meet environmental issues
- Develop accelerated test device for small- to medium-size companies
- Participants:
 - 10 wood research institutes
 - 4 industrial partners: Tikkurila Oy, Gori-Dyrup, ICI Paints Inc., Cecil



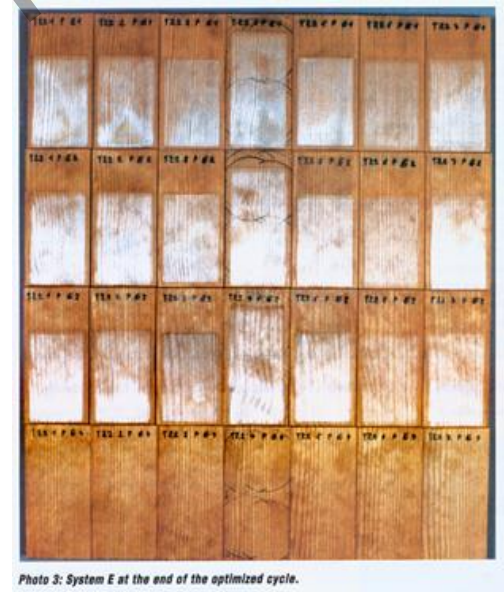
Photo 2: System F at the end of the seven exposure cycles.

Arwood European Wood Coatings

Qualification / Correlative Testing

Solution

- Fluorescent UV testing
 - UVA-340 lamps to simulate UV effects
 - Condensation to increase moisture content of wood
 - Spray to produce surface erosion & remove degraded material
- Duration of test: 2016 hours (12 test cycles = 12 weeks)
- Now test method **EN 927-6** “Paints & Varnishes - Coating Systems for Exterior Wood”



Digger Specialties

Correlative Case Study

Situation

- Fabricator of vinyl fences and porch railings, an alternative to higher-cost systems
- Critical that all fence components (caps, posts, boards, etc.) weather at the same rate



Digger Specialties

Correlative Case Study

Solution

- Fluorescent UV testing - realistic conditions (UVA-340 lamps)
- Duration 14,000 hours (estimated equivalent to 20 years outdoors)
- Color checks every 336 hours
- “Good results with high reproducibility”



Graphics Art Technical Foundation

Correlative Testing

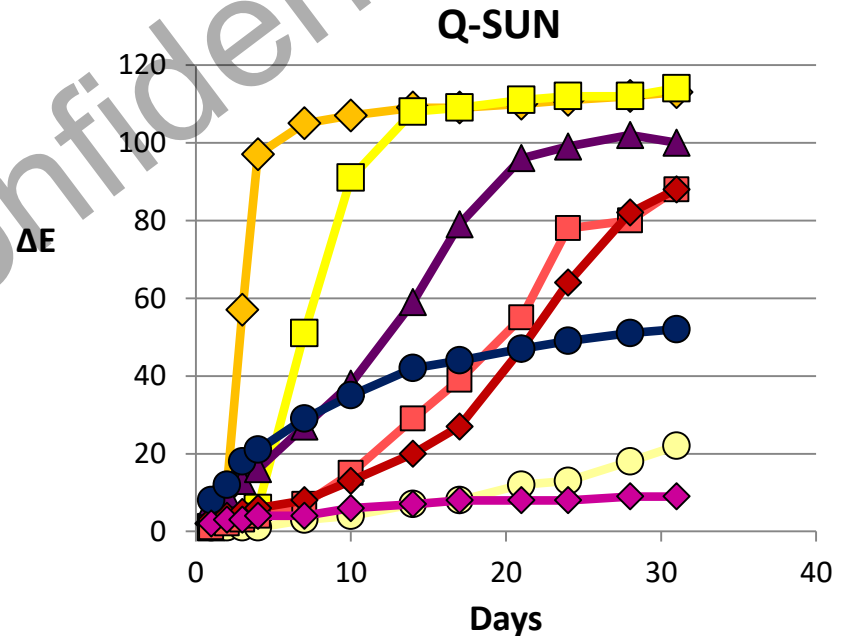
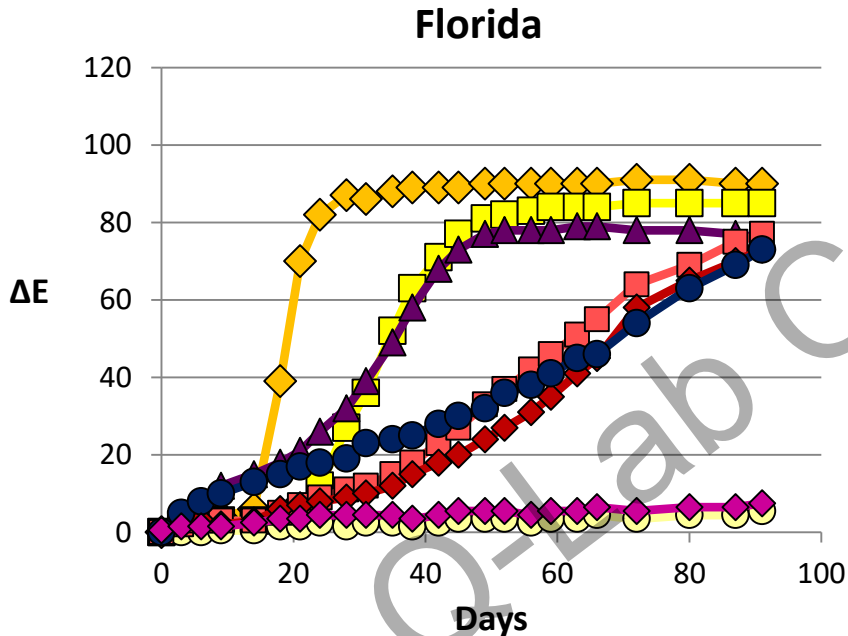
Situation

- Evaluate the light stability of lithographic inks
- Test Program
 - Natural outdoor tests
 - Q-SUN Xenon Arc tests



Graphics Art Technical Foundation

Correlative Testing

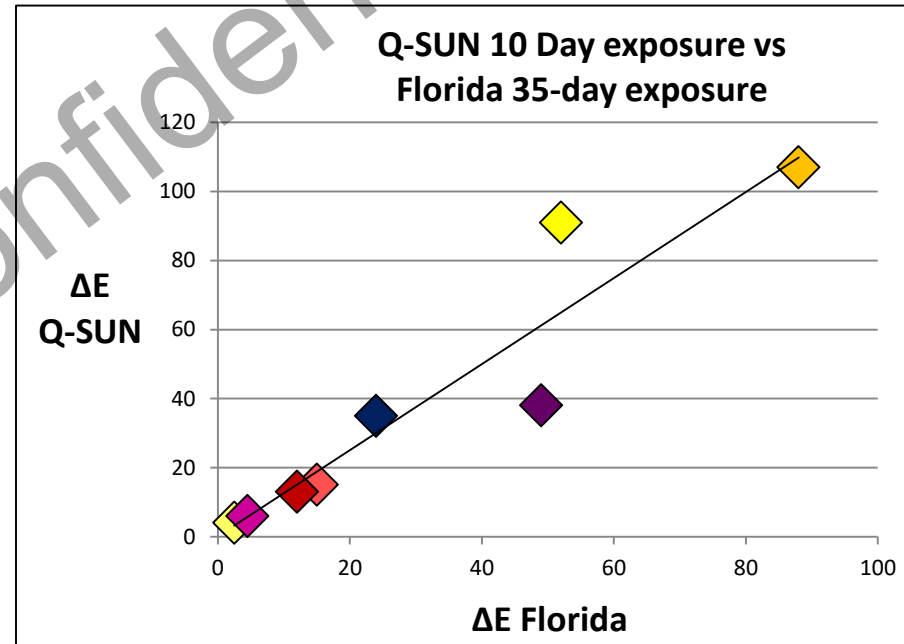


Graphics Art Technical Foundation

Correlative Testing

Conclusion

- Excellent **rank order correlation** between outdoor & lab results
- Test technique can be applied to any ink, ink/substrate combination
- Different materials will have different acceleration factors



Becker Underwood

Correlative Testing

Situation

- Leader in colorants for decorative mulches, synthetic turfs, and sands for golf courses and gardens

Requirement

- Appearance is crucial- need formulations that can withstand fade



Becker Underwood

Correlative Testing

Testing Solution

- Comprehensive regimen of outdoor Florida exposures and xenon testing
 - **Outdoor** Direct Exposure tests
 - **Xenon** ASTM G155 Cycle 1

Result

- Good correlation with outdoor; used in product development
- Acceleration factors are customer's proprietary data



Vinyl Siding Institute (VSI)

Qualification / Correlation / Service Life Testing

- Co-extruded building cladding material
 - Manufactured mostly from Polyvinyl Chloride (PVC)
 - Top layer (capstock) is durable and UV-stabilized
 - Also known as uPVC Weatherboarding in some regions
- Developed in the 1960's, became popular in the 1970's
- Most common residential exterior cladding material in US & Canada – about 20 million m² used per year



Vinyl Siding Institute (VSI)

Qualification / Correlation / Service Life Testing

- Large-scale, long-term study
- Outdoor data collection ongoing since 1984
- New tests started every 5 years; thousands of specimens and replicates tested
- Long-term material degradation mechanisms are now well understood

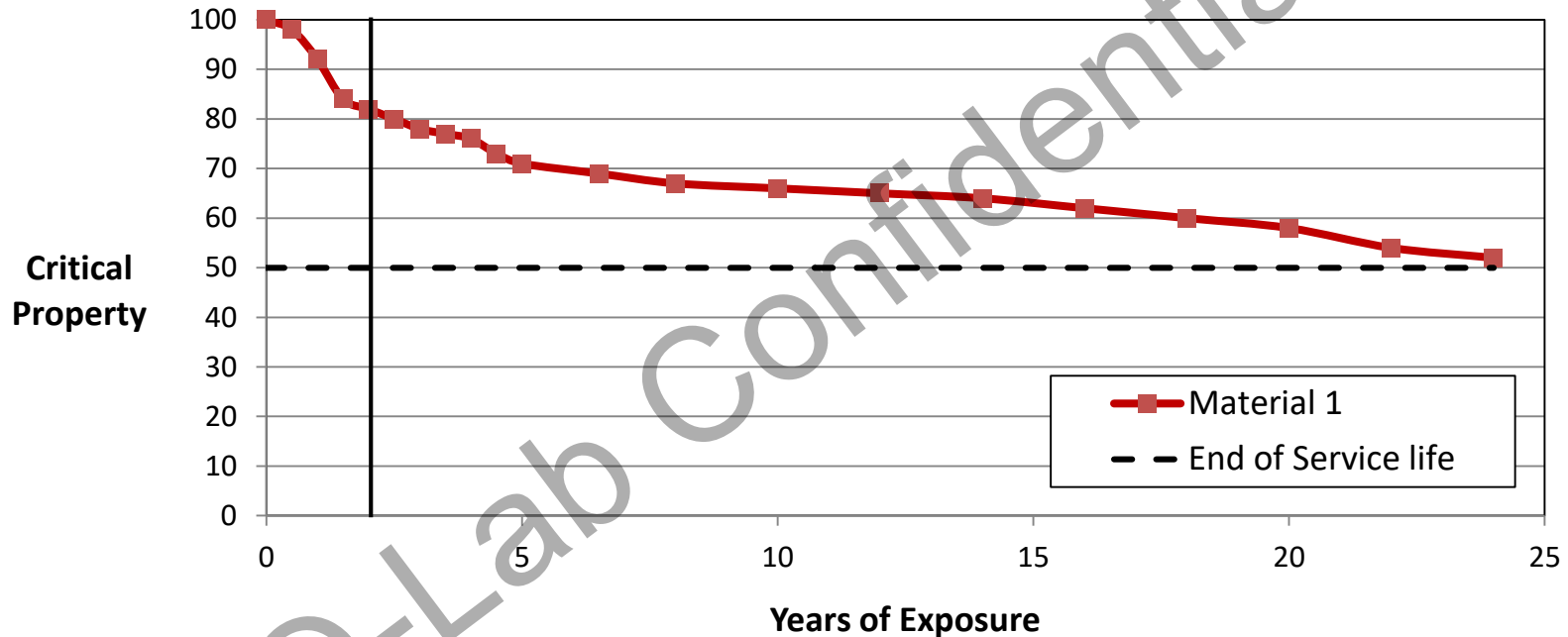


Vinyl Siding Institute (VSI)

Qualification / Correlation / Service Life Testing

- Accurate service life *estimate* based on 2-year outdoor testing
 - If after 2 years of exposure, color change (ΔE) is <1 , then after 25 years it has a high probability of color change (ΔE) <4
- 2 year outdoor certification program
 - Administered by ISO 17025-accredited, independent 3rd party
 - Exposures in FL, AZ, OH
 - Tests performed in accordance with ASTM test standards
 - Receive a VSI stamp, gives credibility to a 25-year warranty

Hypothetical Example



Long-term outdoor exposure adds confidence to service life predictions

Vinyl Siding Institute (VSI)

Qualification / Correlation / Service Life Testing

Goal: correlate accelerated test to 2-year outdoor results

- Six rounds of accelerated testing conducted by multiple labs – examined test cycles of both UV fluorescent and xenon
- Unique Fluorescent UV cycle provided best correlation for PVC siding material
 - Hot condensation best for accelerating realistic moisture attack synergistically with UV
 - Example of where the cheaper, simpler technology is superior
- UV fluorescent test not adopted for certification program, but used by members for product development

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Putting It All Together

Identify which type of weathering test
you're trying to perform

If you want to check every lot of material,
you need a Quality Control test

If you're looking to meet a customer requirement,
you need a Qualification Test

If you're comparing materials to one another,
you need a Correlative Test

Putting It All Together

Figure out which accelerated weathering tests need to be performed

If you need to test many materials,
if you need realistic water simulation,
or if you want a fast test,
you may want to use a Fluorescent UV test

If you need a full spectrum simulation,
if you need control of relative humidity,
or if you need realistic color temperature
you may want to use a Xenon Arc test

Putting It All Together

Figure out whether you need
natural weathering data

If you're performing a correlative testing,
if you want verify the accelerated test,
or if you want to know how your material actually performs,
you may want to perform natural weathering testing

Fluorescent UV and Xenon: Complementary Technologies

- These technologies work together!
 - The best weathering programs use Xenon Arc, Fluorescent UV, and natural exposure data
- Fluorescent UV
 - Low operating cost allows high quantities of data
 - Higher irradiance allows for greater acceleration
 - Realistic water uptake with condensation
- Xenon Arc
 - Best for testing specimens with unknown spectral sensitivity
 - Realistic specimen temperatures
 - Use for qualification tests that require xenon arc

Final Notes

- Understanding the benefits and limitations of any weathering apparatus is important
- Just because something isn't "realistic" doesn't mean it's not a good QC or Qualification test
- Different architectures (UV Fluorescent, Xenon Arc) are complimentary technologies
- Having a comprehensive collection of weathering data is a competitive advantage

Questions?



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