Weathering Testing of Wood Coatings

Andy Francis

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View Recorded Presentation

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Q-Lab's New Webinar Series

Today is the first of two new webinars this fall from Q-Lab about specialty weathering testing

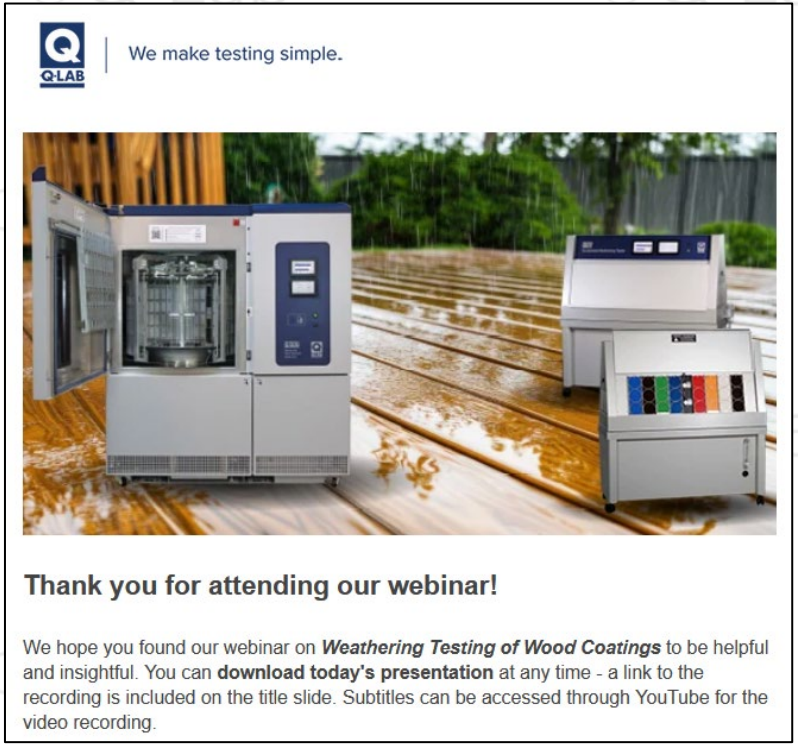
All upcoming and archived webinars can be accessed at:
q-lab.com/webinars

Date	Topic
25 Sep	Weathering of wood coatings
02 Oct	Weathering of photovoltaics

Administrative Notes

You'll receive a follow-up email from info@email.q-lab.com with links to a survey, registration for future webinars, and to download the slides

Use the **Q&A feature in Zoom** to ask us questions today!



Agenda

- Natural Weathering
- Accelerated Lab Weathering
- Case Study – Arwood study
- Correlation
- Conclusions

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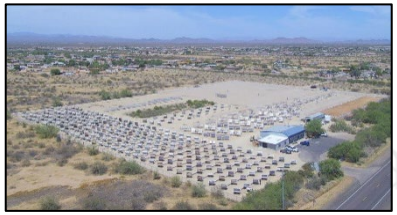
Weathering – Natural Outdoor

- Provides real-world results
- Results used to validate lab weathering
- 3 standard locations
  - Sub-tropical (Florida)
  - Desert (Arizona)
  - Northern Industrial (Ohio)

Florida



Arizona

Ohio

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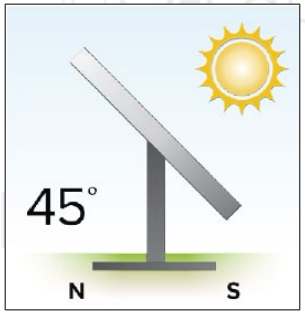
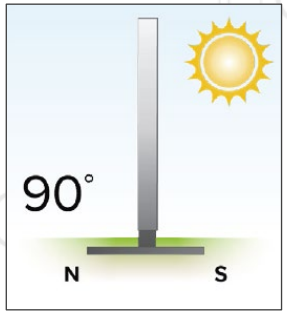
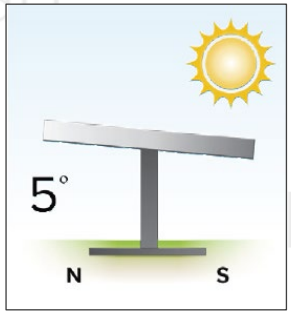
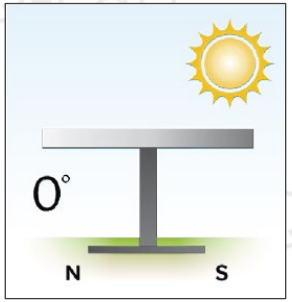
Outdoor Exposure Angles

45° South	90° South	5° South	0°
			
			

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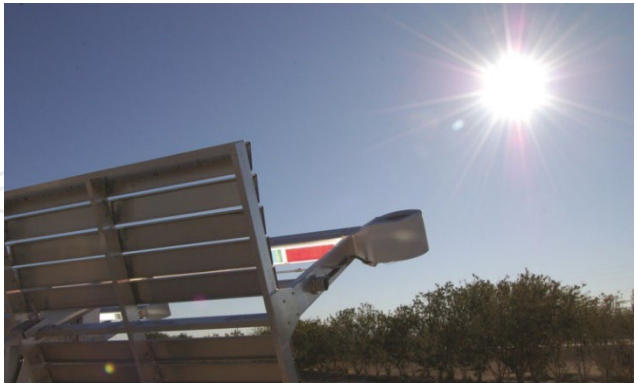
Q-TRAC Natural Sunlight Concentrator

- Super-fast results
- Full-spectrum natural sunlight with tracking
- High temperature (temp control available)
- Multiple water spray cycles available
- Nighttime Freezing option
- ASTM G90 and G5722



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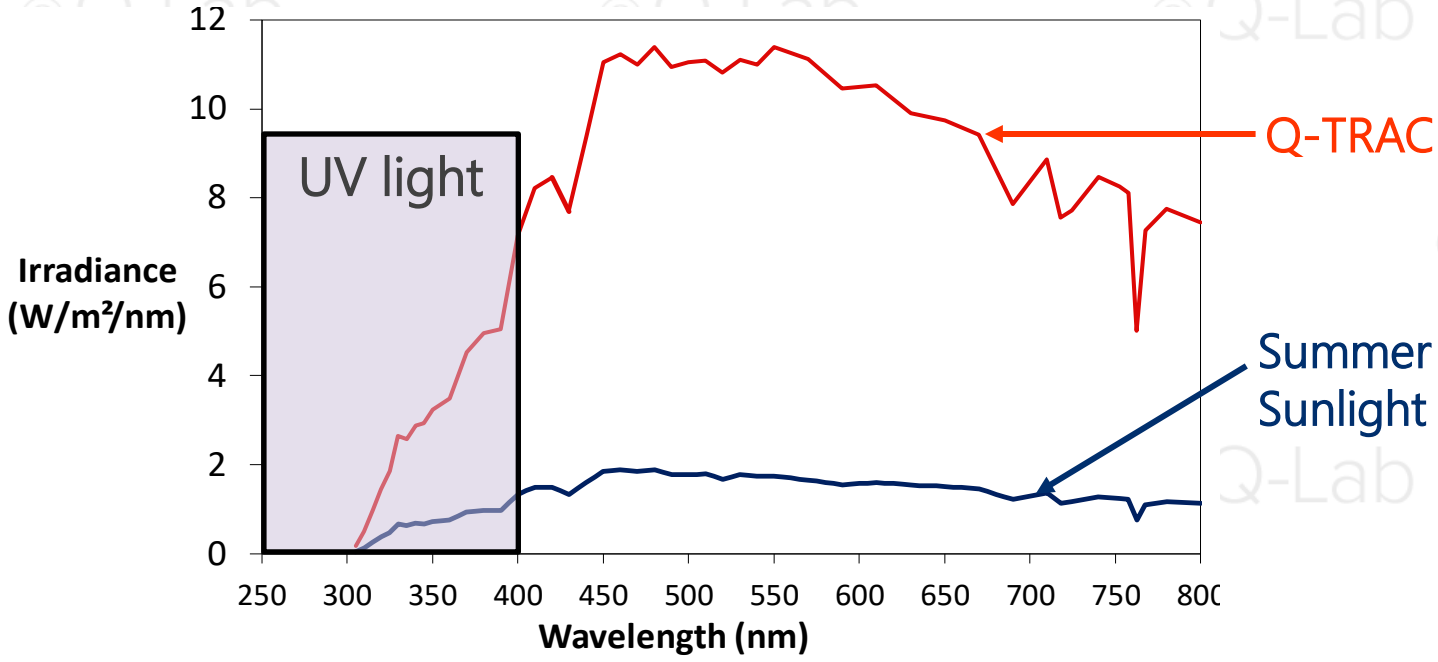
Summer Sunlight vs. Q-TRAC

~5× UV Irradiance of Natural



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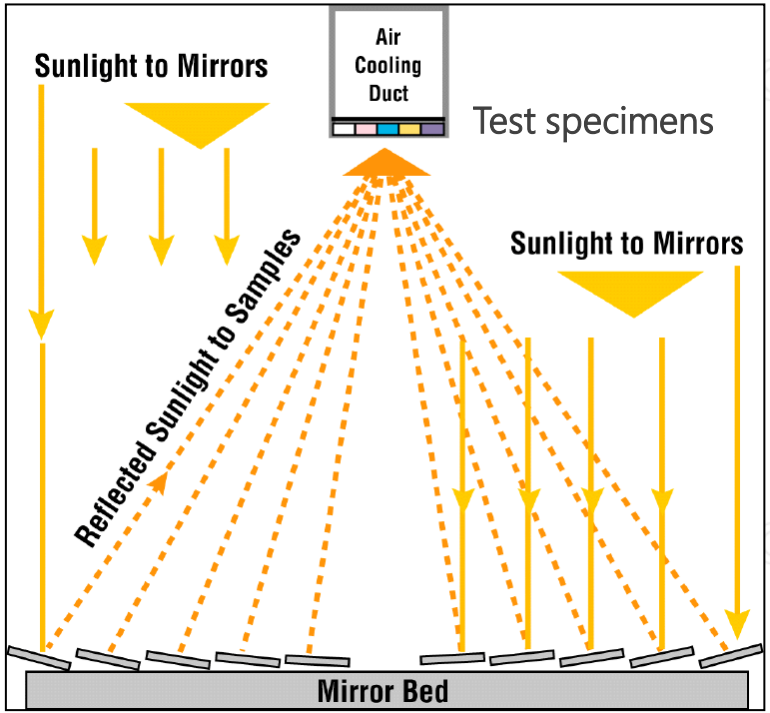
Sunlight Concentrating Mirrors



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Tracking the Sun

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Natural Sunlight Concentrator Cycles

Cycle	Application	Day	Night
Desert	Inks, Textiles, Building Materials	Sunlight only	Ambient
Spray (Day/Night)	Plastics, Coatings, Sealants, Building Materials, Wood Sealers	• Sunlight • Water Spray 8 min/hr	8 min Water Spray, 3 times a night
Spray (Night)	Plastics, Coatings, Sealants, Building Materials, Roofing	Sunlight only	3 min Water Spray every 15 min inverted position *(Wet like Florida)*
Soak/Freeze	Extremely Durable Factory Coated Hardboard, Roofing	• Sunlight • Water Spray 8 min/hr	Water Bath Soak 1 hour Overnight in Freezer -18 °C

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Q-TRAC Freeze-Thaw testing

ASTM D5722

- Hardboard test using sunlight concentrator with a soak-freeze-thaw procedure
  - Very realistic – very harsh
- Test cycle:
  - ASTM G90 (Cycle 1) during day
  - Immersed in tank of deionized water (21 ± 3 ºC , 1 hour)
  - Frozen at (-18 ºC, 12 hours)
  - Lab temperature (minimum 1 hour)
  - Returned to the Q-TRAC

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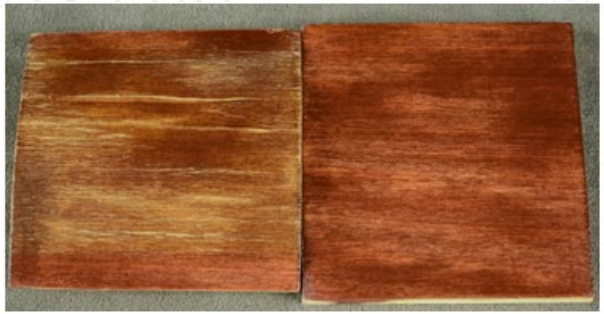
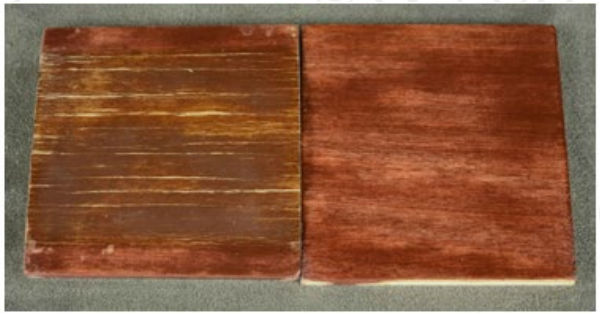
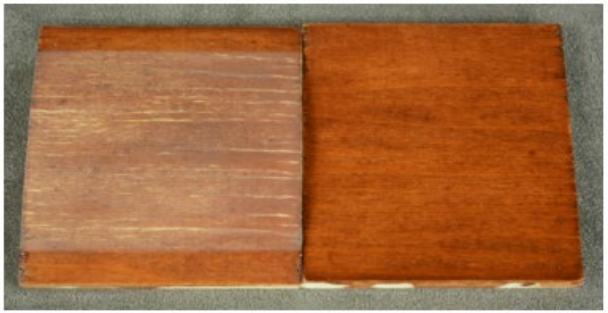
Q-TRAC Freeze/Thaw Cycle: Good Correlation

	Direct Outdoor 365 Days	Q-TRAC Freeze/Thaw 42 Days
Wood A		
Wood B		

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Accelerated Laboratory Weathering

- Two main approaches
  - Xenon
  - Fluorescent UV
- Both have strengths and weaknesses

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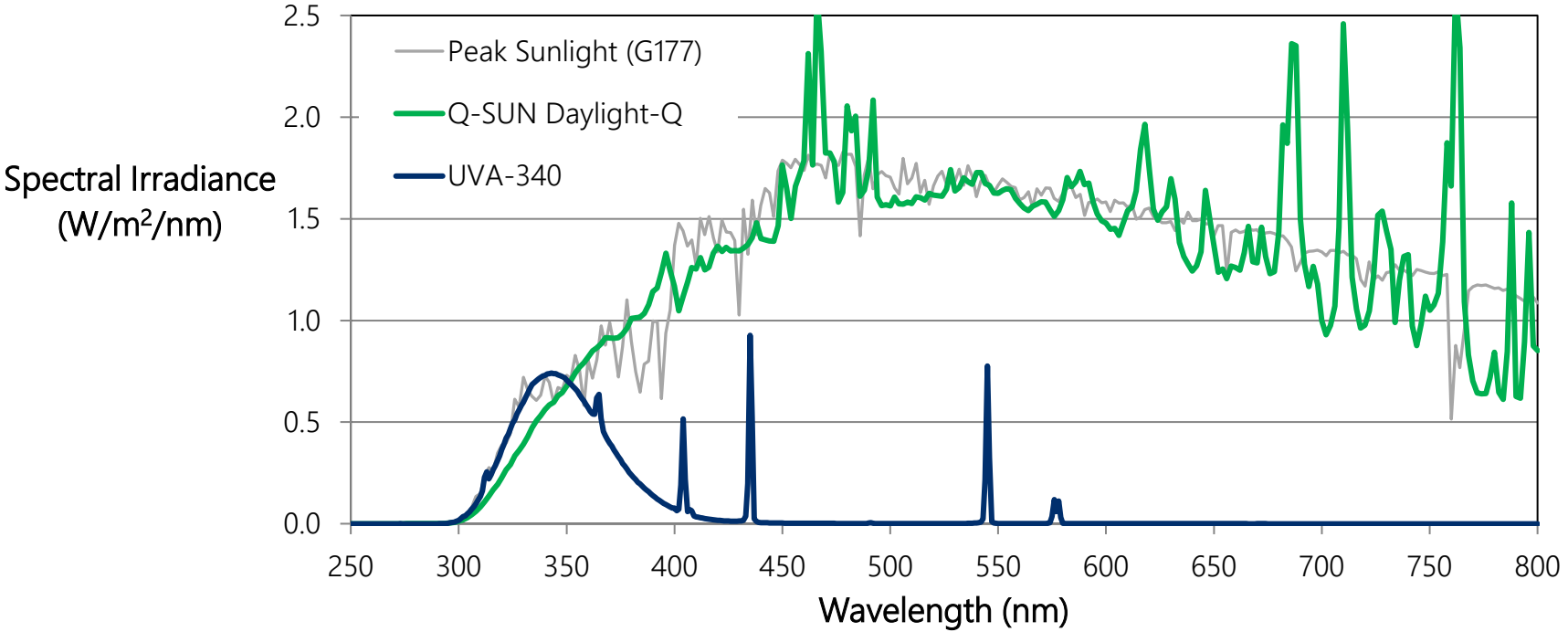
Spectral Irradiance

Fluorescent UV, Xenon Arc, and Sunlight



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Xenon arc weathering testing

- Full-spectrum sunlight
- Optical filters used to modify spectrum
- Spectrum changes as lamps age
  - Less UV; more visible & IR
- May be moisture-deficient
  - Water spray, not condensing humidity
  - Some may control RH

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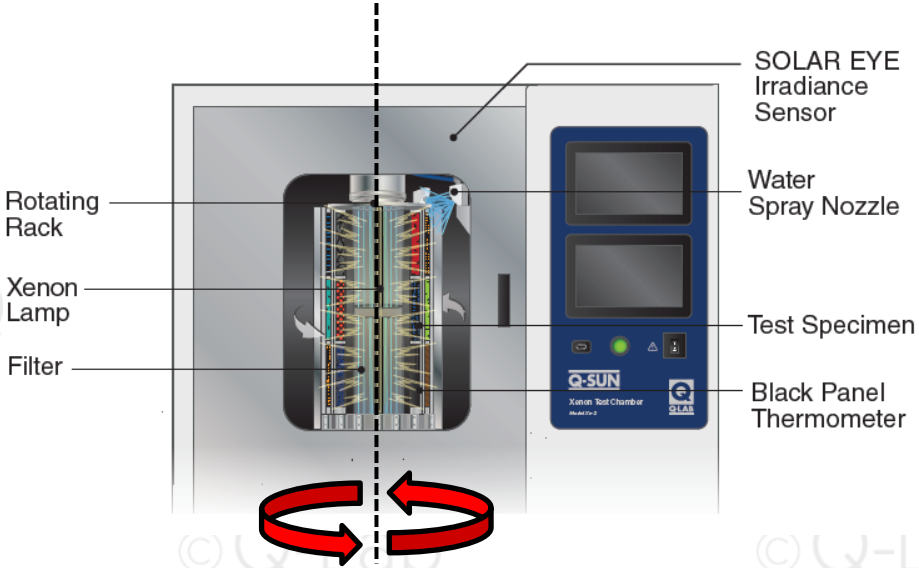
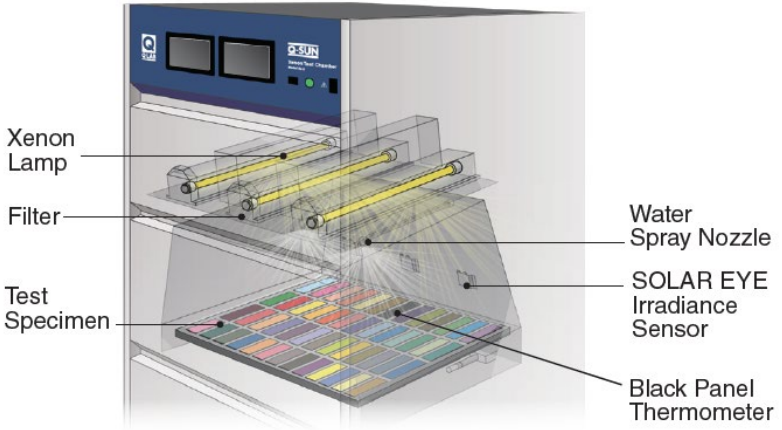
Xenon Arc Test Chambers



Rotating Rack



Flat Array

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Fluorescent UV

- Shortwave UV portion of spectrum
- Lamp determines spectrum
  - UVA-340 best match to sunlight
- Very stable spectrum
- Hot condensation is best match for natural moisture

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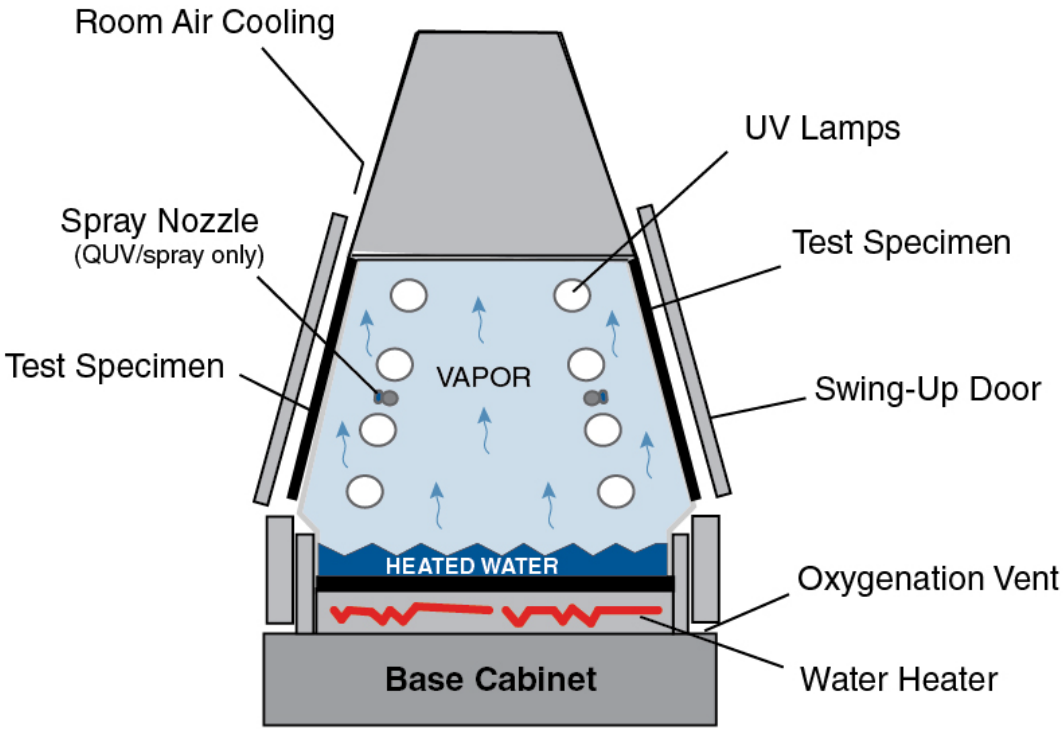
QUV Operation



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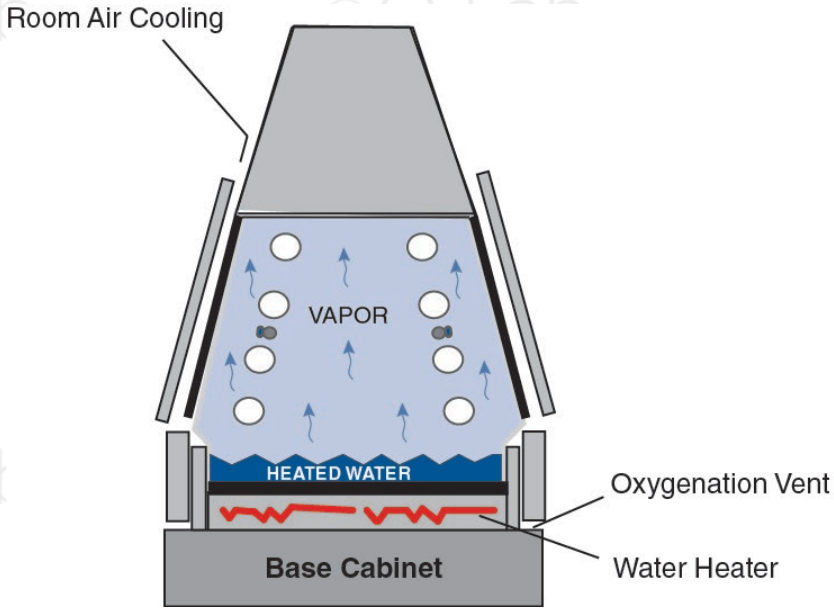
QUV Condensation

- Closest match to natural wetness
- Best way to accelerate water in an laboratory tester
- Elevated temperature
- High O_2 content
- Tester performs distilling – you cannot deposit debris on specimens! Water is guaranteed to be clean.



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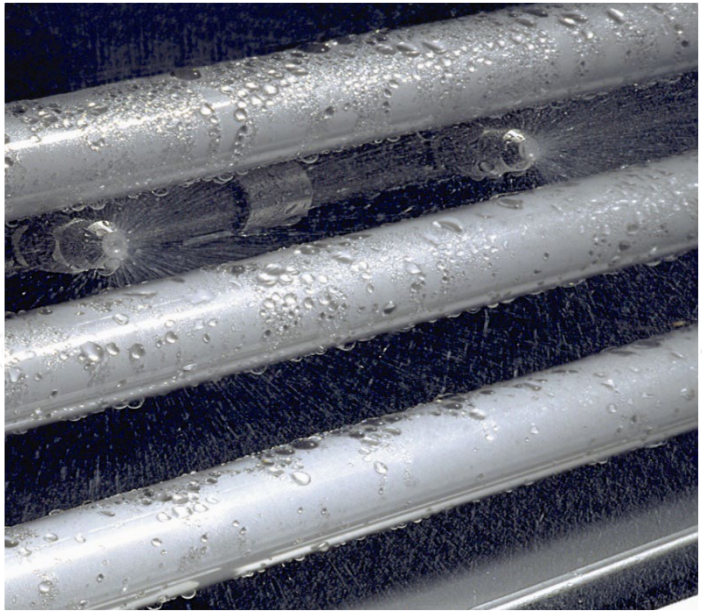
Water Spray

- Ensures that parts get fully saturated
- Creates erosion & thermal shock
- Purified water is required



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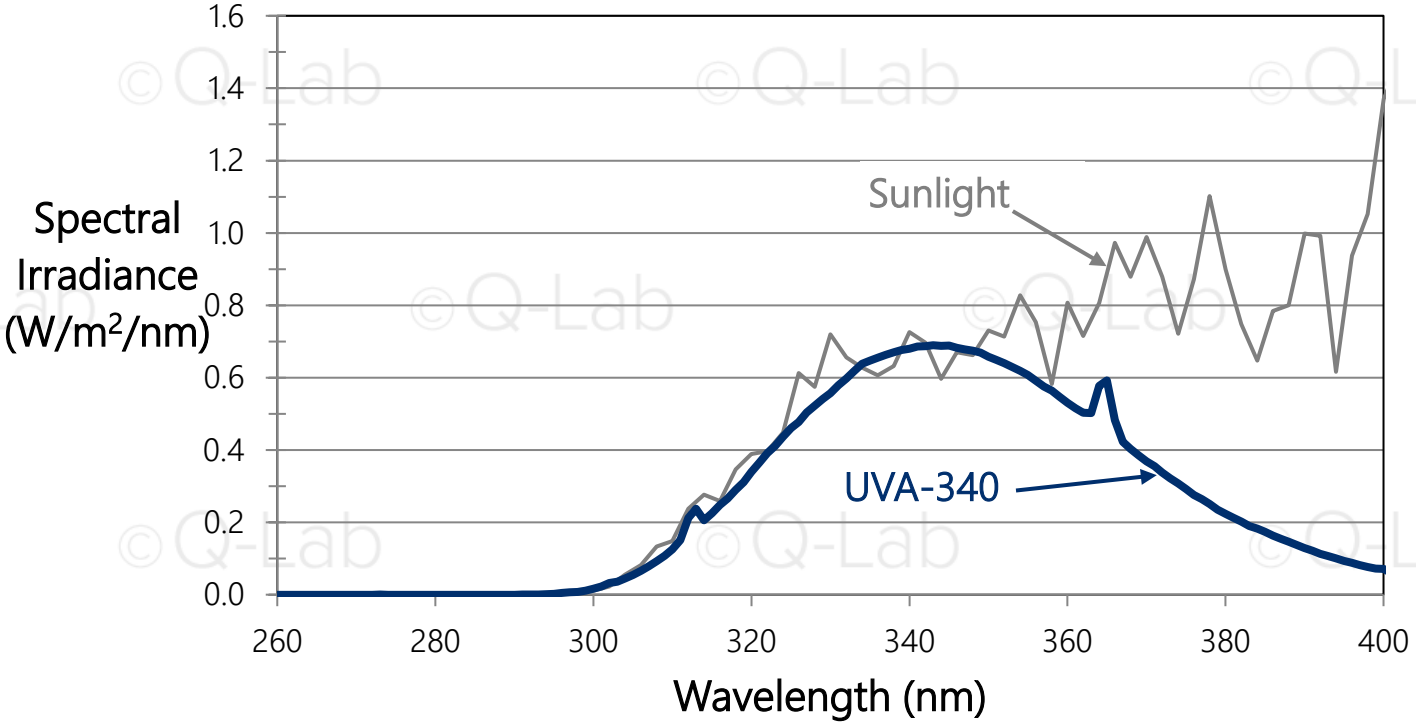
UVA-340 Lamps



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Arwood Study

A Reliable Artificial Weathering Test For Wood Coatings

Coatings World; 2003-02-01
Laurence Podgorski (CTBA-FCBA France)
Martin Arnold (EMPA Switzerland)
Guido Hora (WKI Germany)

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Arwood Study Overview

- **Goal:** determine an artificial accelerated weathering laboratory test suitable for coatings on wood substrates
- **Practical Consideration:** Use equipment that is cost-effective for small to medium size companies
- **Technical Requirement**: Test method gives good correlation to natural outdoor weathering
- **Publication:** Work to serve as basis for a new CEN standard

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Arwood Participants

10 Research Institutes

- CTBA-FCBA: The Wood and Furniture Technical Center (France)
- BRE: Building Research Establishment (UK)
- WKI: Society for Applied Research (Germany)
- VTT: Technical Research Center of (Finland)
- Trätek: Institute for Wood Technology Research (Sweden)
- EMPA: Federal Laboratories for Material Testing & Research (Switzerland)
- CC: Coating Consultancy (Denmark)
- AITIM : Association of Technical Investigation of the Wood and Cork Industries (Spain)
- NIT: National Institute of Technology (Norway)
- RUG: University Gent (Belgium)

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Arwood Participants

4 Industrial Partners

- Tikkurila Oy (Finland)
- Gori-Dyrup (Denmark)
- Imperial Chemical Industries (United Kingdom)
- Cecil (France)

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Test Chamber: Fluorescent UV

Selected by study authors

- Economical
- Consistent spectrum
- Reliable
- Credibility in several industries, particularly steel and plastics

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Previous Work

- Several Interlaboratory Comparison tests conducted on different substrates and coatings systems
  - Outdoors
  - Artificial exposure with fluorescent UV and water spray

- This presentation reports on the optimized exposure cycles identified for the artificial exposure with fluorescent UV with water spray

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Materials

- **Substrate:** Coated Wood Panel (EN 927-3)
  - Planed and defect-free
  - Pine sapwood (pinus sylvestris)
  - Three replicate samples per coating system
- **Coatings:** 6 surfaces used, prepared by same lab
  - 2 white paints
    - 1 solvent; 1 water
  - 2 high-build wood stains
    - 1 solvent; 1 water
  - 1 low-build solvent wood stain
  - 1 uncoated

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Evaluations

- EN 927-3
  - Cracking
  - Blistering
  - Chalking
  - Color
  - Gloss

- General Appearance
  - Visual inspection rated scale of 0-5 (5 being most severe)
  - Performed by each laboratory (on-site assessment)
  - Final assessment repeated by one technician (common assessment)

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Evaluation Test Series

7 QUV exposure cycles

Partner	cycle	Exposure cycle	Duration of 1 cycle	Total exposure time
WKI	1	[-24h condensation (45°C)][1] -(3h UV-340nm then 1h Spray) during 120h -48h stored outside device (ambient conditions)	7 days	1860 hours
EMPA	2	-24h condensation (45°C) -(5h UV-340nm then 1h Spray) during 96h	5 days	2033 hours
GORI	3	-24h condensation (45°C) -(5h UV-340nm then 1h Spray) during 144h	7 days	2016 hours
BRE	4	-4h condensation (40°C) -4h UV-351nm	8 hours	2000 hours
Tikkurila and VTT	5	-4h condensation (40°C) -4h UV-340nm	8 hours	1500 hours
CTBA	6	-48h freezing (-20°C) -24h condensation (45°C) -(3h UV-340nm then 1h Spray) during 96h	7 days	2016 hours
Traetek	7	-24h freezing/soaking in water [2] -(4h condensation (40°C) thenUV-340nm) during 72 hours -72h Soaking in water	7 days	2016 hours

Notes :
[1] 24h condensation only once at start of exposure
[2] 2h freezing + 2h Soaking + 2h freezing + 18 h Soaking

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Test Results

Visual Evaluation

Coating System E

System F (untreated)

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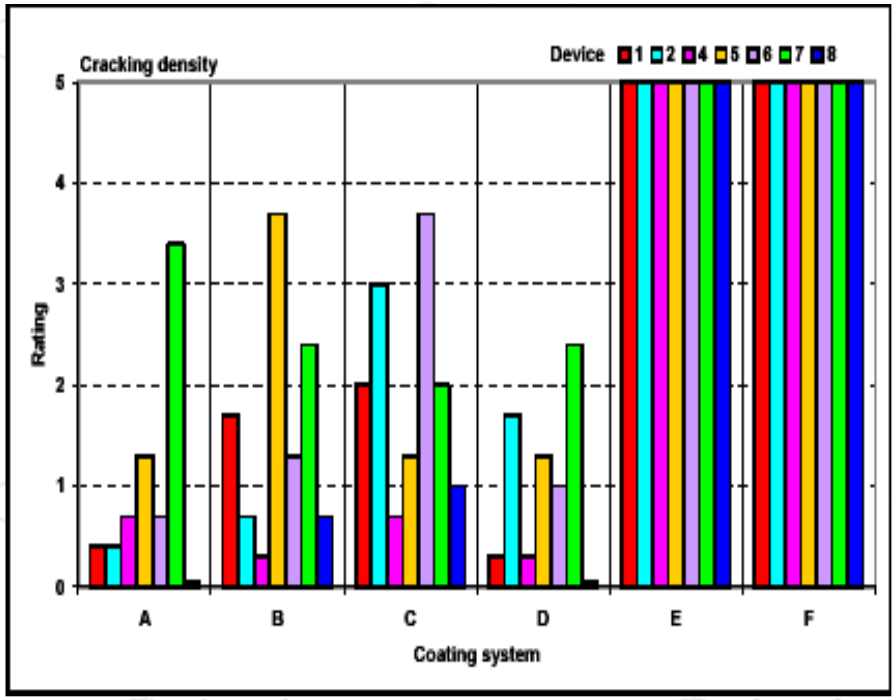
Test Results

Cracking Density



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Test Results

Summary

- UV fluorescent testing with UVA-340 lamps is the best choice
- Extended condensation cycles
- Include water spray to remove surface material
  - Important to maintain spray system
- Special treatments (freeze or soaking) do not appear to affect weathering
- Cycles 1, 2, and 3 clearly showed the fastest cracking & gloss loss

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Optimized QUV Cycle for Wood Coatings

EN 927-6 and ISO 16053-2

STEP	FUNCTION	Irradiance (W/m²/nm)	Temperature (°C)	Time (hh:mm)
1	Condensation	N/A	45	24:00
2	Subcycle repeat steps 3-4 48x			
3	UV	0.89	60	2:30
4	Spray	N/A	N/A	0:30
5	Final Step - Go to Step 1			

2000 hour test duration

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Arwood Conclusions

Accelerated Test Sources of variation

- Wood substrate (e.g. growth ring angle)
- Sample planing
- Room climate (temp. & humidity)
- Water quality
- Equipment maintenance
- Assessment methodology

Considering the high variation of test results obtained with wood samples, the available preliminary results indicate that the reproducibility of the test is “acceptable”.

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Correlation

- Correlation to natural weathering can be demonstrated by overlaying and visually comparing the time-series curves of selected performance parameters.
  - Cracking density
  - Gloss
- The time axis for natural exposure has been scaled down empirically to give the best overall correspondence for all coating systems.

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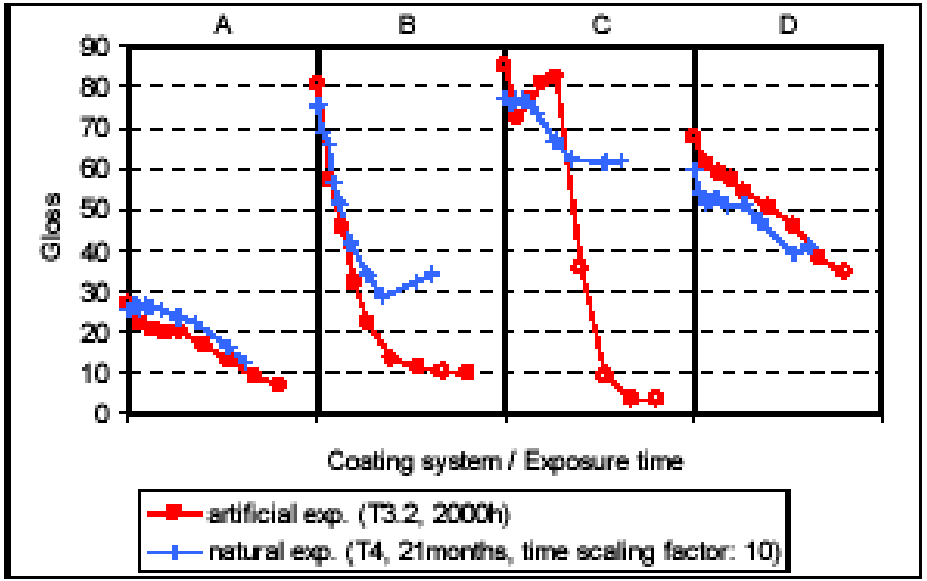
Correlation

Gloss

- Gloss loss reproduced quite well in lab testing
- High acceleration factor of about 10× (21 months vs ~2 months)
- System C is degraded much more in the artificial exposure than outdoors



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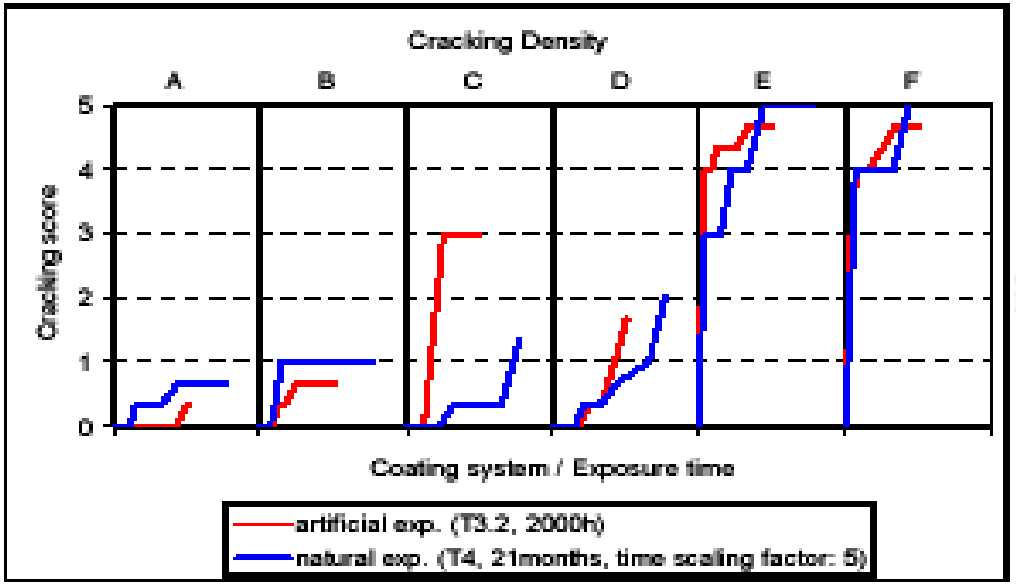
Correlation

Cracking Density

- Cracking density also reproduced well in lab testing
- System C again degraded much more in the artificial exposure than outdoors



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Additional Verification

- 12 coatings were tested with some key components changed
  - UV absorbers removed
  - High or low glass transition temperature etc.

- The original 6 coatings applied to 5 NEW substrates:
  - Beech
  - Oak
  - Spruce
  - Meranti
  - Exterior plywood

- Accelerated Test continued to match outdoor testing very well

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Conclusions of Arwood

- Optimized cycle proven to be reproducible and repeatable
  - 8 partners tested this cycle with the same 6 coatings
- Results indicate that Optimized Cycle enables:
  - Differentiation between the performance of different coating systems
  - Differentiation between coating performance on different wood substrates
- New international standard published based on this work
  - EN 927-6 (2006)
  - Adopted as ISO 16053-2 (2024)

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Lessons for Weathering Testing

- Must use natural outdoor weathering to verify lab weathering
  - Understand location and exposure angle
- Accelerated natural weathering – Q-TRAC
  - ASTM D5722
  - Very realistic – very aggressive
  - May correlate well with natural outdoor exposures

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Conclusions

- Xenon arc accelerated lab weathering
  - Full-spectrum light
  - Might be moisture-deficient
- Fluorescent lab weathering – QUV
  - Best match for shortwave UV light
  - Best simulation of natural moisture
  - Proven to work for wood coatings
- Good lab results require natural outdoor weathering
- Develop a testing program that best simulates your field failures

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Thank you for your time.

info@q-lab.com

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