Water Delivery in Accelerated Weathering Testing

Andy Francis	Marketing Director
Dave Duecker	Senior Technical Marketing Specialist
Bill Tobin	Senior Technical Marketing Specialist
Sean Fowler	Senior Technical Director

Q-Lab Corporation

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Q-Lab's Weathering Webinar Series

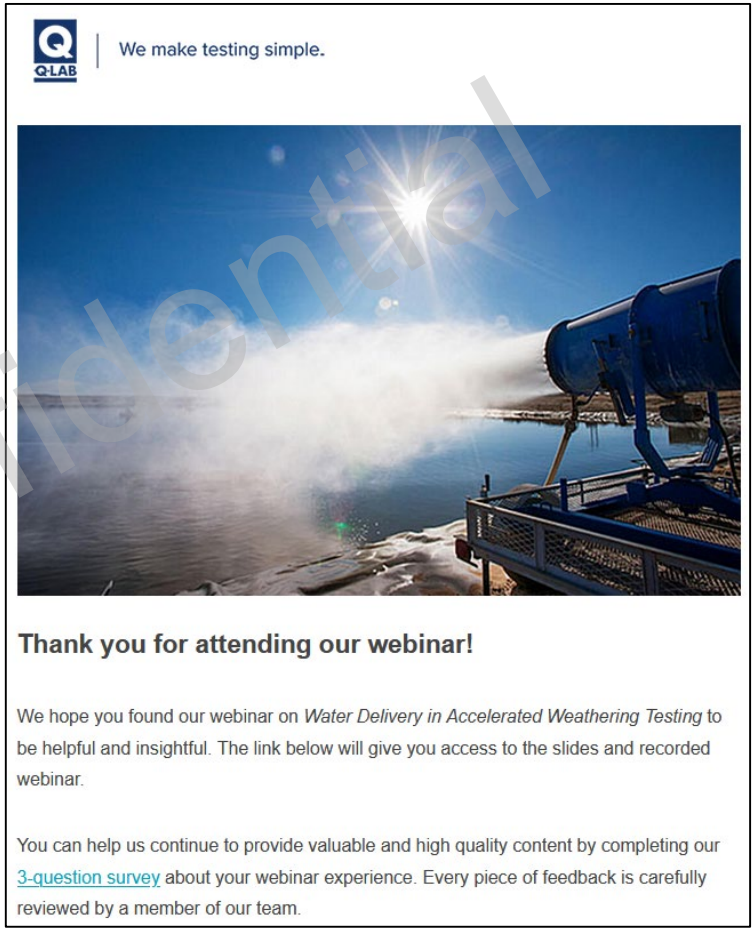
- Today is the 4th of our five-part webinar series on special weathering testing topics
- Our upcoming and archived webinars are hosted at: q-lab.com/webinars

Date	Topic
14 Apr	Automotive Interior and Exterior Weathering Testing
21 Apr	Modern Automotive Weathering Test: ASTM D7869
28 Apr	Light Stability Testing of Home and Personal Care Products
05 May	**Water Delivery in Accelerated Weathering Testing**
12 May	Correlation in Accelerated Weathering and Corrosion Testing

Housekeeping

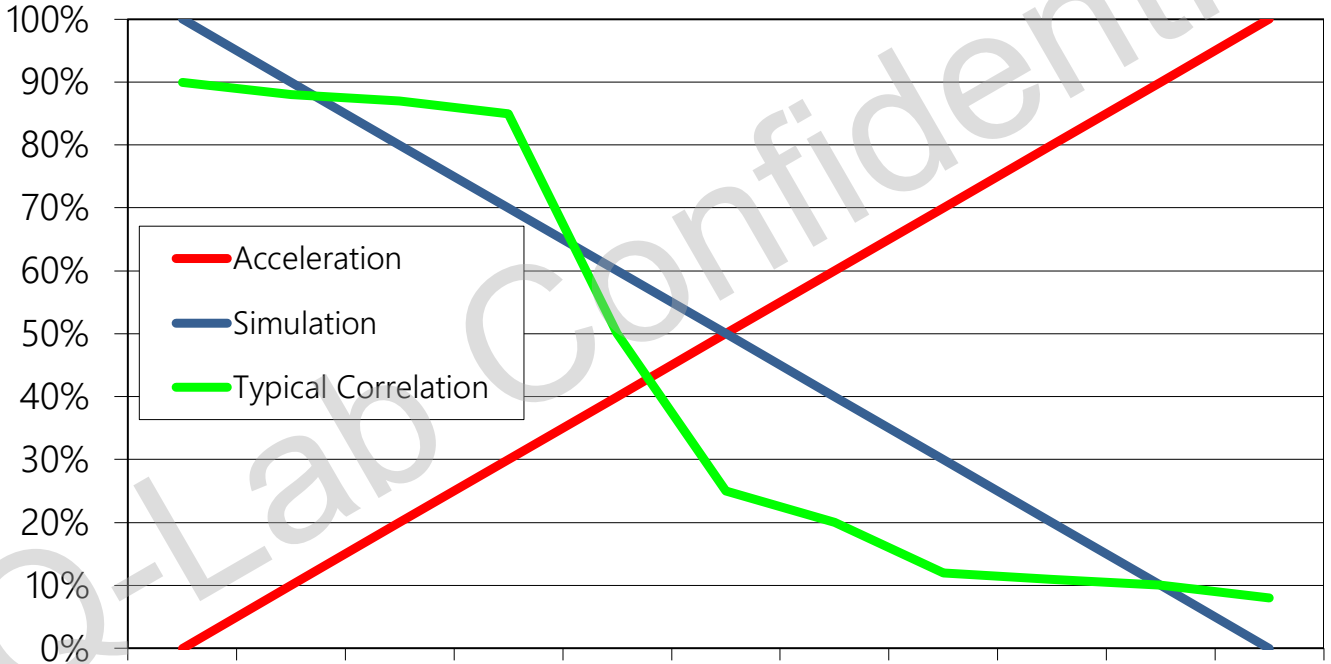
You'll receive a follow-up email from info@email.q-lab.com with links to a survey, registration for future webinars, and to download the slides

- Our ongoing webinar series can be found at: q-lab.com/webinarseries
- Our archived webinars are hosted at: q-lab.com/webinars
- Use the **Q&A feature in Zoom** to ask us questions today!



Accelerated Testing

Simulation, Acceleration, and Correlation



Forces of Weathering

Sunlight

Heat

Water

How are these accelerated in laboratory testing?

Sunlight in Laboratory Weathering Testing

Defined light source

Plastics — Methods of exposure to laboratory light sources —

Part 2:

Xenon-arc lamps

Irradiance values, control points, and tolerances

Irradiance[b]	
Broadband (300 nm to 400 nm) W/m²	**Narrowband (340 nm)** W/(m²·nm)
60 ± 2 60 ± 2	0,51 ± 0,02 0,51 ± 0,02

Spectral requirements

Spectral passband (λ = wavelength in nm)	Minimum[c] %	CIE No. 85:1989, Table 4[de] %	Maximum[c] %
λ < 290			0,15
290 ≤ λ ≤ 320	2,6	5,4	7,9
320 < λ ≤ 360	28,2	38,2	39,8
360 < λ ≤ 400	54,2	56,4	67,5

Heat in Laboratory Weathering Testing

Black panel temp with tolerances

Black-standard temperature °C
65 ± 3 —

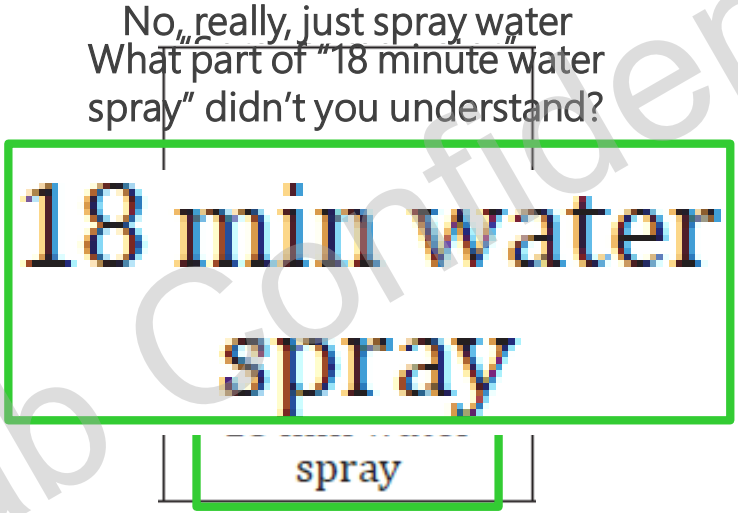
Thermal Cycling

Step Number	Step Minutes	Black Panel Temperature Set Point[A]	Chamber Air Temperature Set Point[A]
1	240	—	40°C
2	30	50°C	42°C
3	270	70°C	50°C
4	30	50°C	42°C
5	150	—	40°C
6	30	—	40°C
7	20	50°C	42°C
8	120	70°C	50°C
9	10	—	40°C

Ambient temp with tolerances

Chamber temperature °C
38 ± 3 —

Water in Laboratory Weathering Testing



This is not enough information!

Water Purity in Laboratory Weathering Testing

Water Purity

QUV Requirements

Model	Pressure	Condensation Volume	Spray Volume	Resistivity	Conductivity	Total Dissolved Solids	pH
QUV/spray	45-80 psi* (280-550 kpa)	5.0 liters/day	7.0 liters/min	>200k ohm•cm	<5.0 µS/cm	<2.5 ppm	6-8
QUV/spray/rp	2-80 psi (20-550 kpa)		7.0 liters/min**				
QUV/se QUV/cw	2-80 psi (20-550 kpa)		NA	Tap Water			

Spray systems require higher-purity water than condensation-only systems

Repurification system is NOT a primary purification system

Tap water in non-spray systems will require more frequent cleaning

Water Purity

Q-SUN Requirements

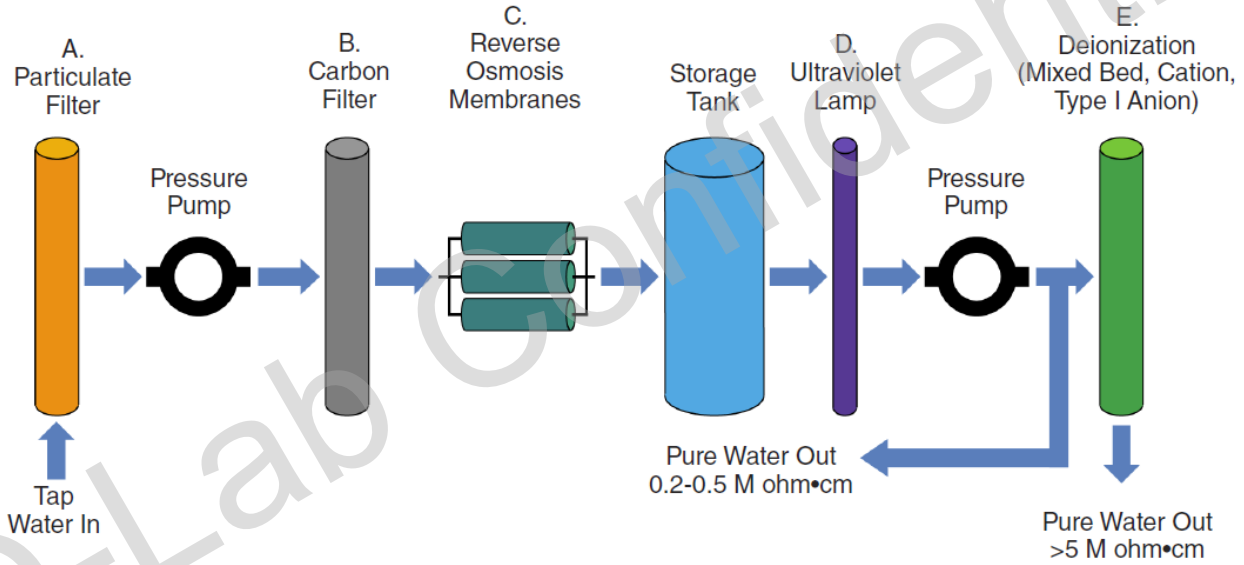
Spray System (Model)	Inlet Pressure	Flow Setting	Average Daily Volume	Resistivity	Conductivity	Silica	Total Dissolved Solids	pH
Front Spray* ("S" models)	30-90 psi (207-620 kPa)	1.4 liter/min	0.16 liter/minute × spray time***	>5M ohm•cm	<0.2 µS/cm	<0.1 ppm	<0.1 ppm	6-8
Front and Back Spray* ("B" models)		15 psi**	0.65 liter/minute × spray time***					
Humidifier (non-"S" models)	10-90 psi (69-620 kPa)	0.1 liter/min	44 liters/day	> 200k ohm•cm	<5.0 µS/cm	Not Important	<2.5 ppm	6-8

Spray systems require higher-purity water than humidity-only systems

Repurification system is NOT a primary purification system

Water Purity

RO/DI system



Q-Lab recommends this type of system for all Q-SUN xenon and QUV spray instruments

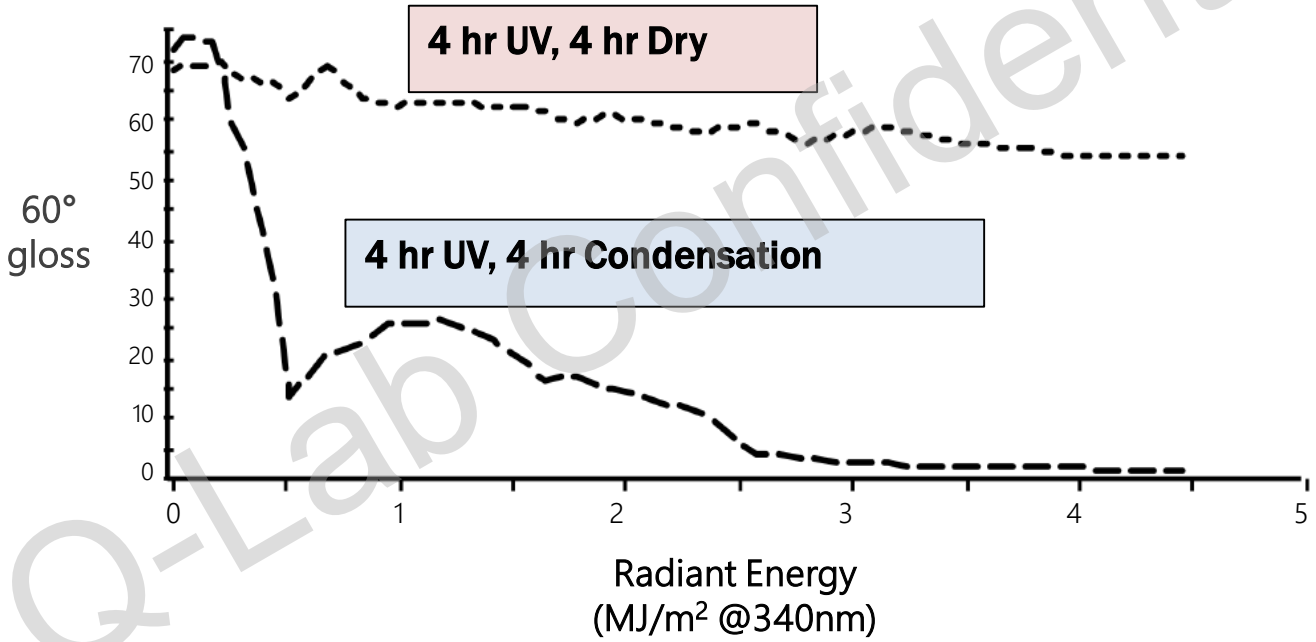
Water Delivery in Accelerated Lab Testing

Water contributes to material degradation in many ways

- Plasticization
- Swelling
- Blistering
- Adhesion
- Mass transport
- Mass loss

UV Fluorescent Weathering

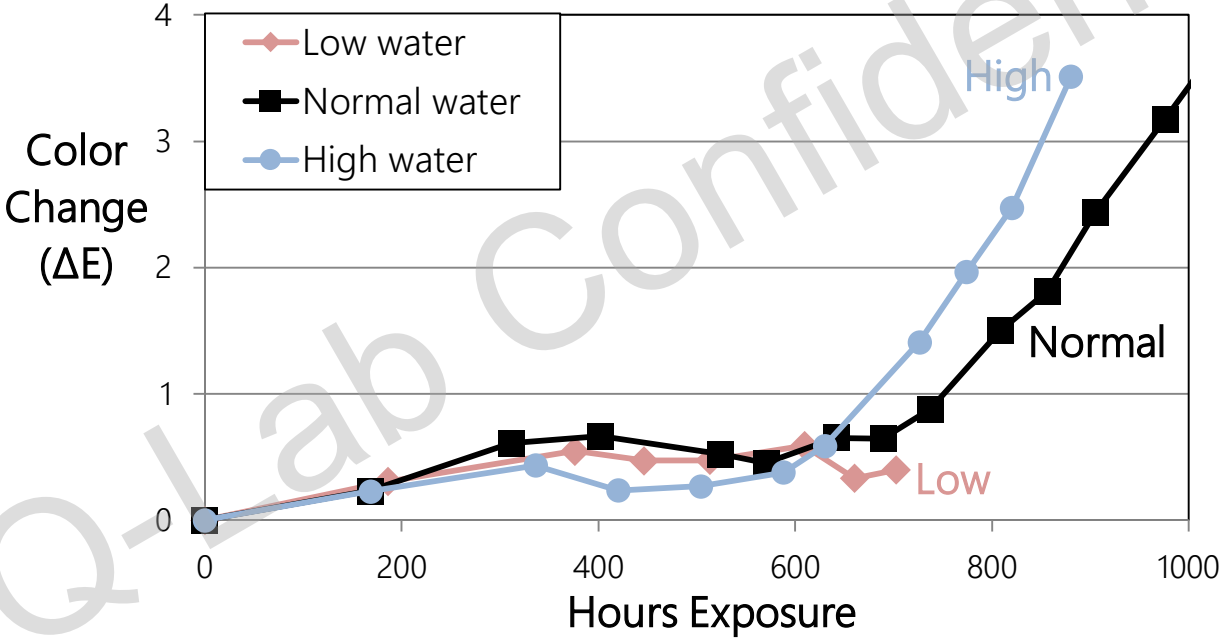
Water Delivery Accelerating Gloss Loss



Xenon arc Weathering

Water Delivery Accelerating Color Change

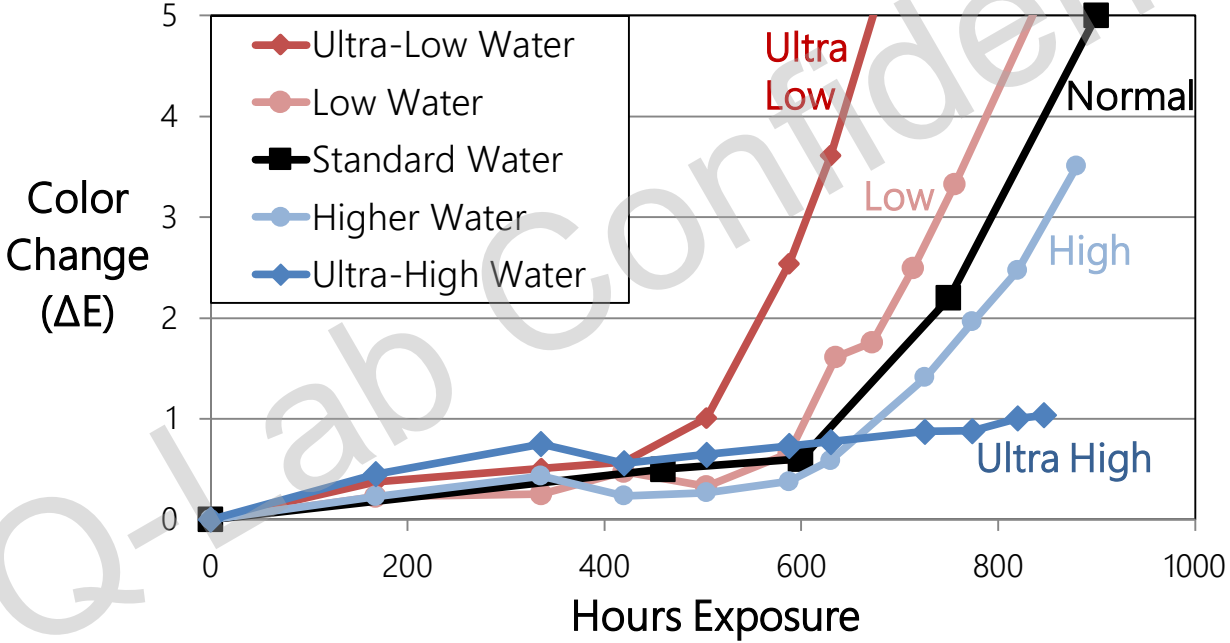
Polypropylene (Talc, Carbon Black, UV package 1)



Xenon arc Weathering

Water Delivery Inhibiting Color Change

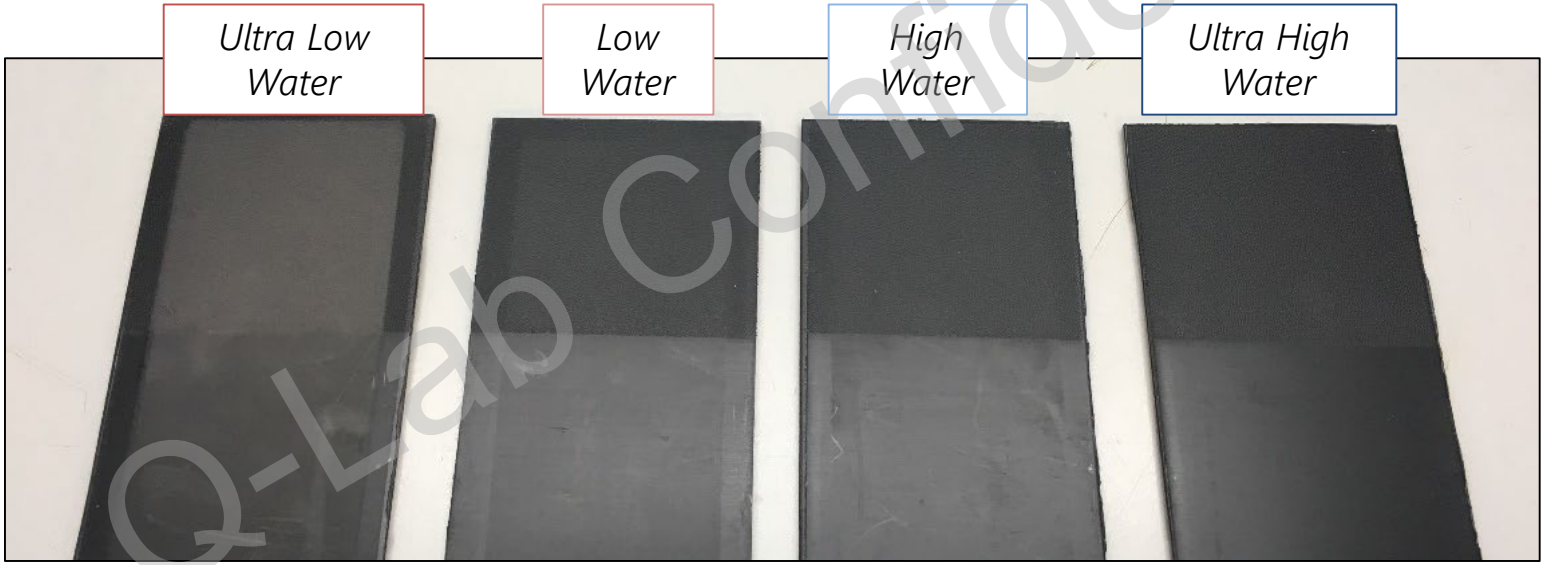
Polypropylene (Talc, Carbon Black, UV package 2)



Xenon arc Weathering

Water Delivery Inhibiting Color Change

Polypropylene (Talc, Carbon Black, UV package 2)



Water in Laboratory Weathering Testing

- Water significantly influences test results for many materials

- Compared to **Sunlight** and **Heat**, in lab testing **Water** is:
  - Less quantified
  - Less accelerated

- Today we will look at standards that *do* emphasize water
  - **ASTM G90** (solar concentrator)
  - **EN 927-6** (UV fluorescent)
  - **ASTM D7869** (xenon arc)

Water Delivery in Accelerated Outdoor Testing

ASTM G90

Standard Practice for Performing Accelerated Outdoor Weathering of Materials Using Concentrated Natural Sunlight

Outdoor accelerated testing

Natural solar concentrator

- 5× the UV light of natural exposure

- High temperatures from desert conditions and concentrated irradiance

Outdoor accelerated testing

Daytime water delivery

- Daytime spray dries quickly, causes thermal shock
- Polymer matrices do not absorb any water!

Outdoor accelerated testing

Nighttime water delivery

Test Cycle	Daytime			Nighttime		
	Spray duration	Dry duration	Cycles	Spray duration	Dry duration	Cycles
1	8 min	52 min	1 / hr	8 min		3 per night: 21:00, 00:00, 03:00
3	none			3 min	12 min	4 per hour (40 total) 19:00-05:00

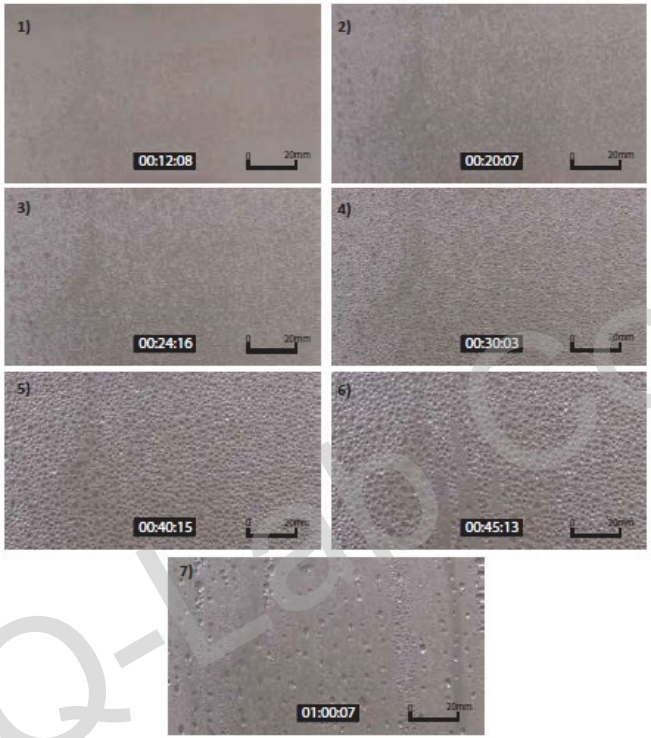
- Frequent nighttime spray cycles = high Time of Wetness
- Increased water uptake of coatings – more realistic test

Water Delivery in Fluorescent UV Testing

EN 927-6

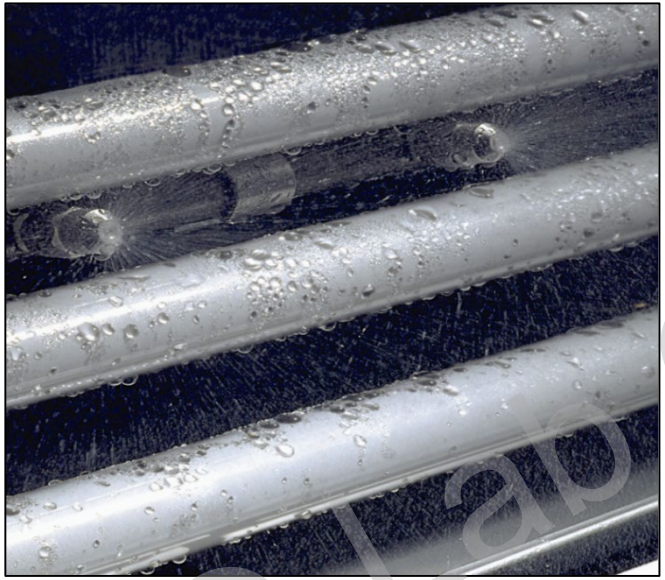
Paints and Varnishes - Coating Materials and Coating Systems for Exterior Wood

Fluorescent UV Testing: Condensation



- Condensation function an excellent simulation of natural dew
- Hot condensation (~50 °C) accelerates moisture attack

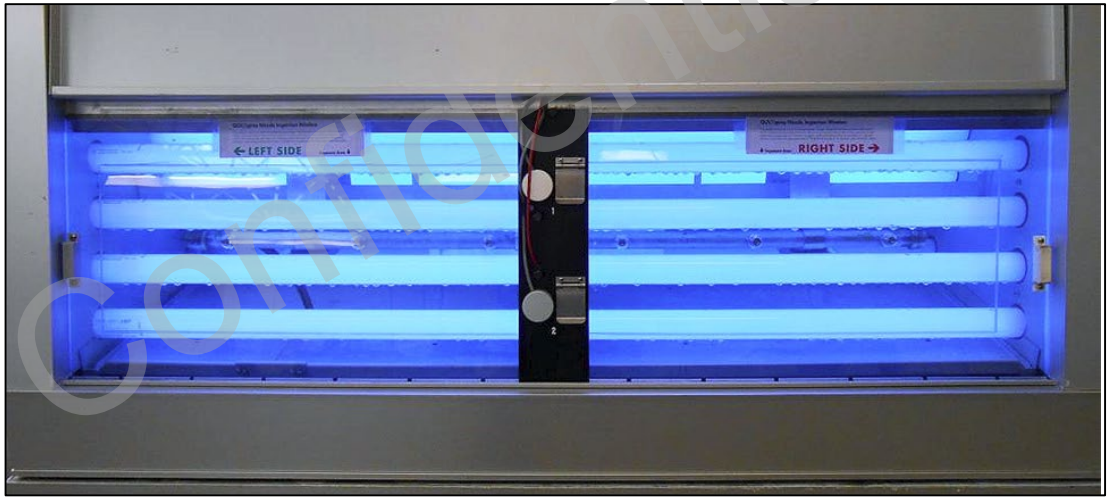
Fluorescent UV Testing: Water Spray



- Usually just short sprays for thermal shock
- EN 927-6 introduces longer, frequent water spray to reproduce erosion in wood coatings

Water Spray Validation

- QUV testers have a spray window
- Disables interlocks but blocks UV light for safety
- Easy verification of proper spray nozzle operation



Fluorescent UV Testing

Erosion of wood coatings from water spray

"Improving of coatings durability on selected kinds of wood in the exterior applications", No. TH02020873 financed by TAČR

Water Delivery in Xenon arc Testing

ASTM D7869

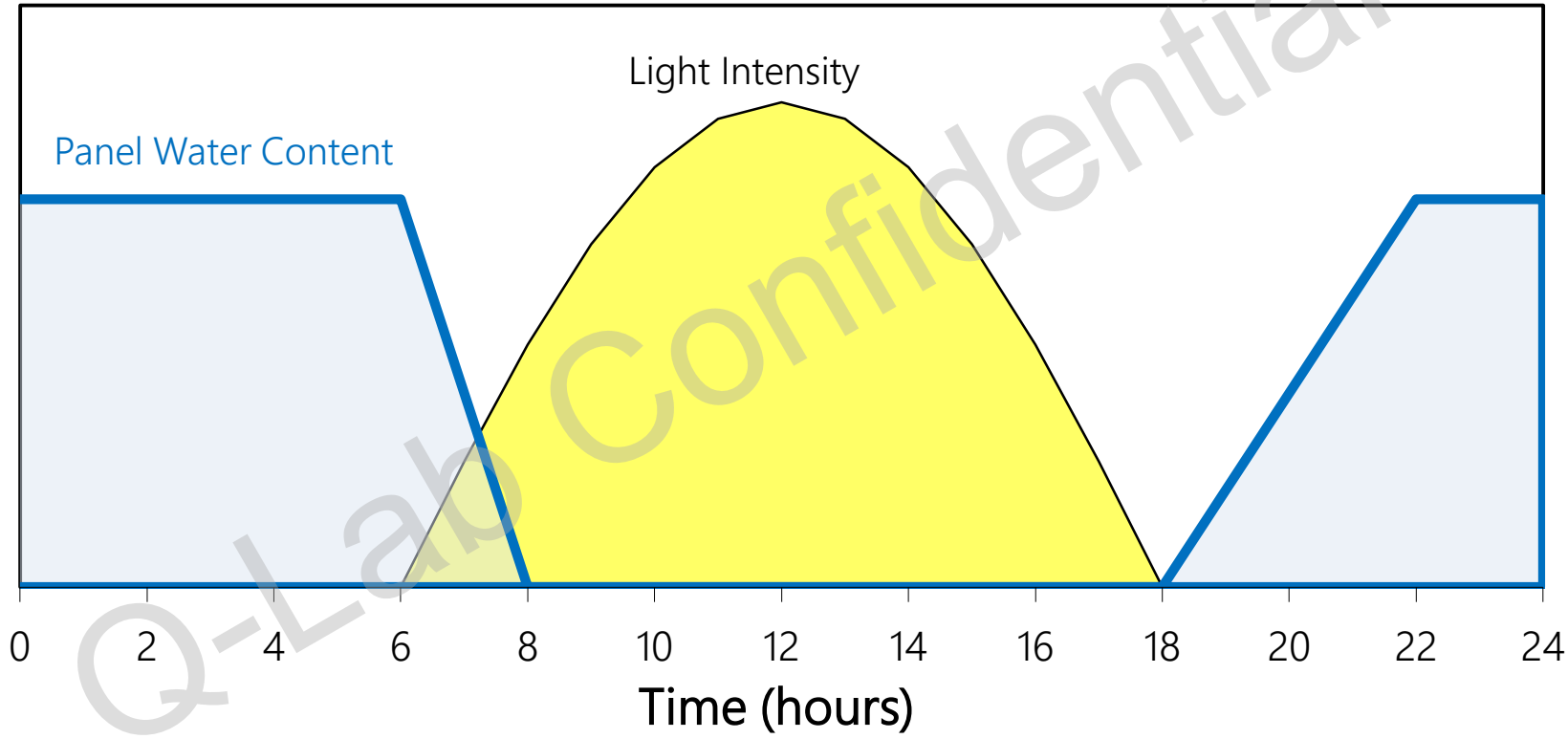
Standard Practice for Xenon Arc Exposure Test with Enhanced Light and Water Exposure for Transportation Coatings

Xenon arc Accelerated Lab Testing

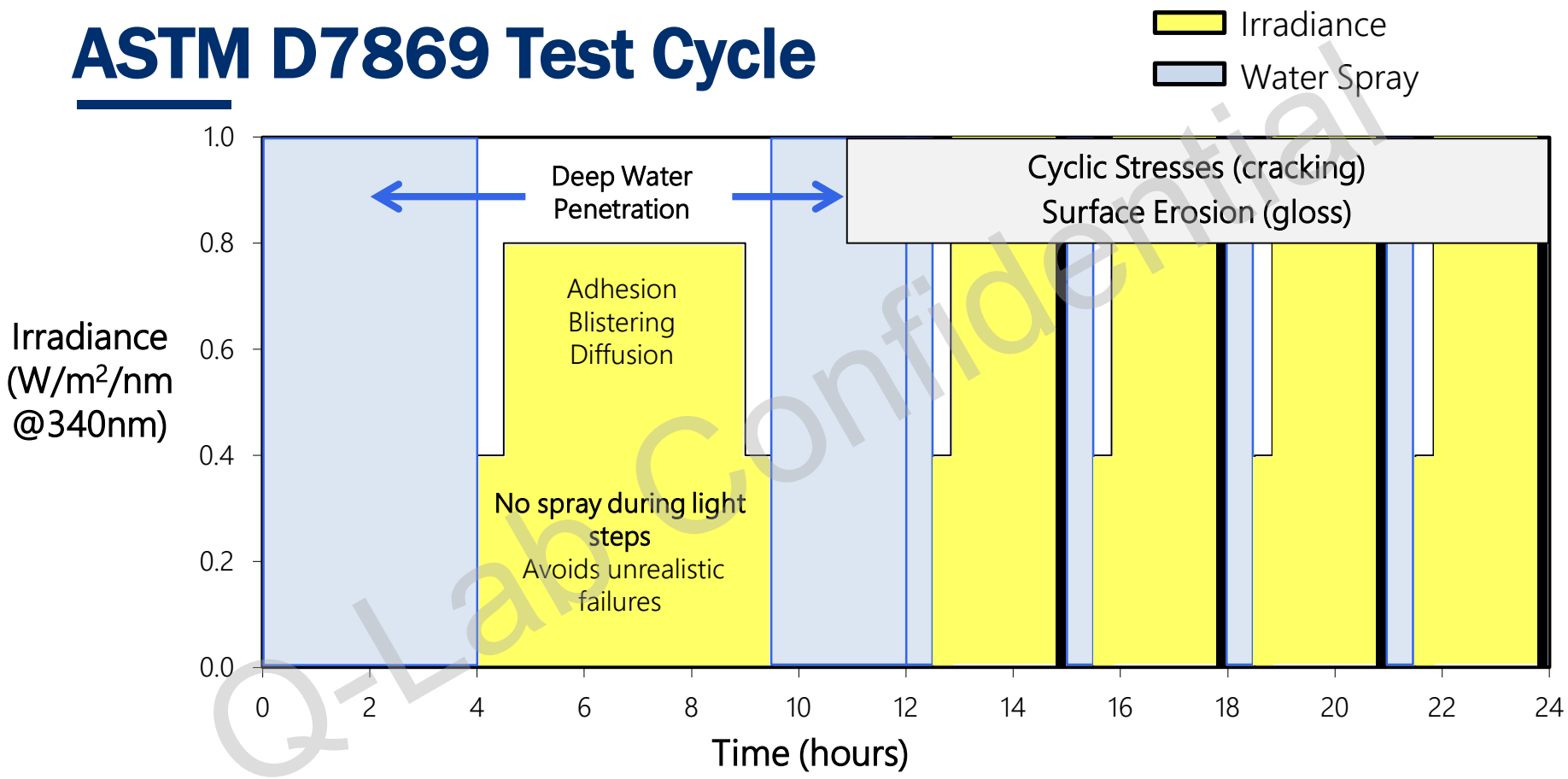
ASTM D7869

- ASTM D7869 **simulates** and **accelerates** Sunlight, Heat, and Water from outdoor weather
- Test **validated** by comparison to long-term outdoor weathering data from aerospace and automotive coatings
- Test is **realistic** - it reproduces faithfully almost all physical failure mechanisms.
- Test is fast – 30% **acceleration** over related test methods.
- Accelerated testing that **correlates** with outdoor test data for transportation coatings. May be suitable for other products as well

Outdoor Daily Weather Cycle



ASTM D7869 Test Cycle

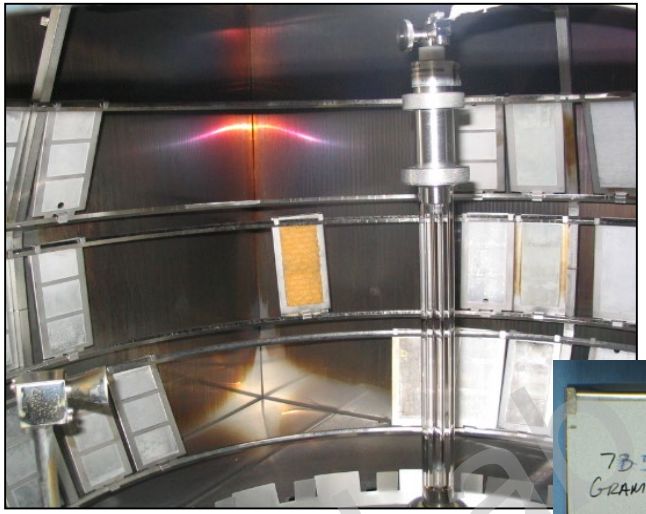


ASTM D7869 Water Delivery

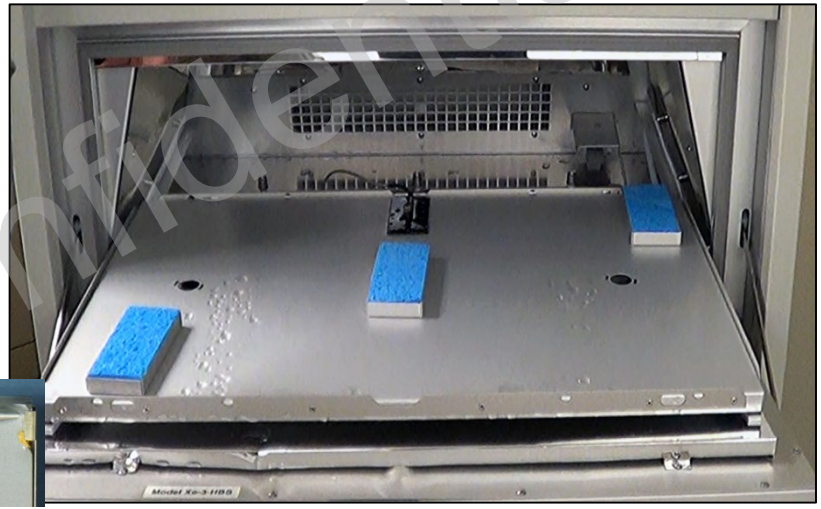
Calibrated sponge used to ensure coating saturation from water delivery

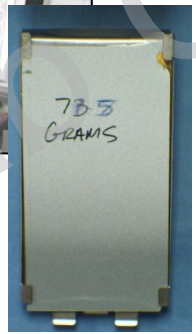
ASTM Water Delivery Calibration

Rotating Rack



Flat Array





Shielded sponge holder

ISO 23741: New Standard for Water Delivery

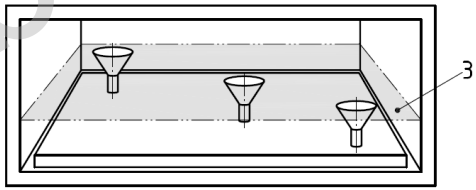
INTERNATIONAL STANDARD

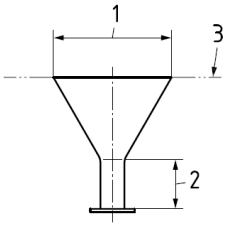
ISO 23741

First edition
2021-03

Plastics — Determination of spray water delivery during spray cycles when using a xenon arc weathering test apparatus

- Standard method to determine water delivery in xenon arc testers
- Rotating rack or flat array

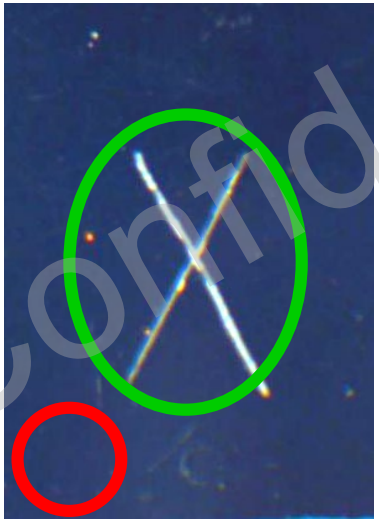




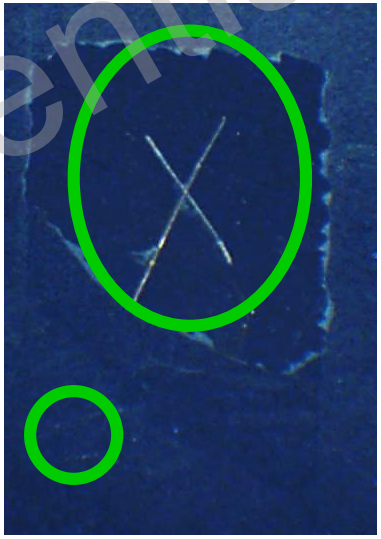
ASTM D7869 Test Result

Florida Exposure

SAE J2527



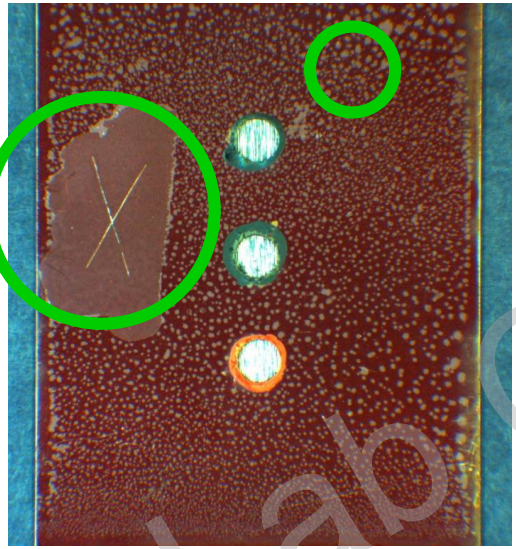
ASTM D7869



- Water-deficient tests reproduce some coating failure modes
- ASTM D7869 reproduces more, including water-based **delamination**

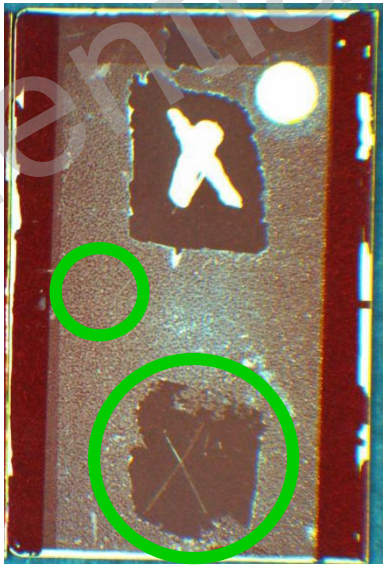
ASTM D7869 Test Result

Florida Exposure



SAE J2527

ASTM D7869



- Water-deficient tests reproduce some coating failure modes
- ASTM D7869 reproduces more, including water-based **blistering**

Conclusions

- Sunlight, Heat, and Water are all delivered to specimens during accelerated weathering testing
- Water contributes to many failure modes but is often underspecified and underdelivered in test standards
- Some modern test standards including ASTM G90, EN 927-6, and ASTM D7869 take greater care to accelerate water delivery
- ISO 23741 now standardizes quantification of water delivery to specimens
- Effect of water on testing is highly material-dependent – important to actually conduct the testing!

Thank you for your attention!

Questions?

Send your inquiry to:
info@q-lab.com