Water Delivery in Accelerated Weathering Testing
加速老化测试中水的施加

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Q-Lab Corporation

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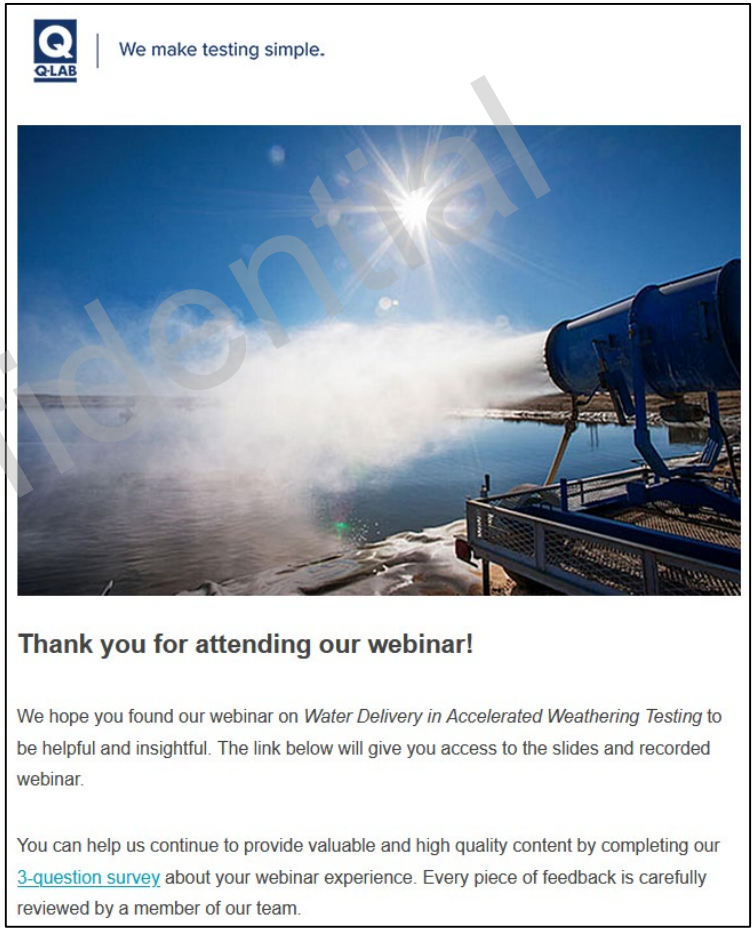


Accelerated Testing 加速老化测试

Simulation, Acceleration, and Correlation 模拟，加速，相关性

Forces of Weathering 老化因素

Sunlight 光

Heat 热

Water 水

How are these accelerated in laboratory testing?

在实验室测试中这些因素是如何加速的？

Sunlight in Laboratory Weathering Testing

实验室老化测试中光的因素

Defined light source 定义光源

Plastics — Methods of exposure to laboratory light sources —

Part 2:

Xenon-arc lamps

Irradiance values, control points, and tolerances
辐照度，控制点，偏差

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 光谱要求

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

实验室老化测试中热的因素

Black panel temp with tolerances
黑板温度及偏差

Black-standard temperature °C
65 ± 3 —

Thermal Cycling 热循环

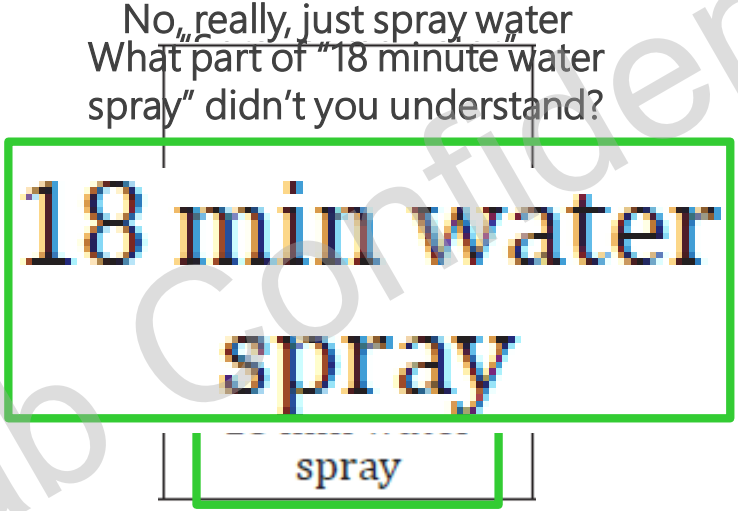
Step Number	Step Minutes	Black Panel Temperature Set Point[A]	Chamber Air Temperature Set Point[A]
1	240	—	40°C
2	30	50°C	42°C
3	270	70°C	50°C
4	30	50°C	42°C
5	150	—	40°C
6	30	—	40°C
7	20	50°C	42°C
8	120	70°C	50°C
9	10	—	40°C

Ambient temp with tolerances
箱体空气温度及偏差

Chamber temperature °C
38 ± 3 —

Water in Laboratory Weathering Testing

实验室老化测试中水的因素



This is not enough information!

Water Purity in Laboratory Weathering Testing
实验室老化测试中水的纯度

Water Purity 水的纯度

QUV Requirements QUV紫外老化试验机对水的纯度的要求

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 水的纯度

Q-SUN Requirements Q-SUN氙灯试验箱对水的纯度的要求

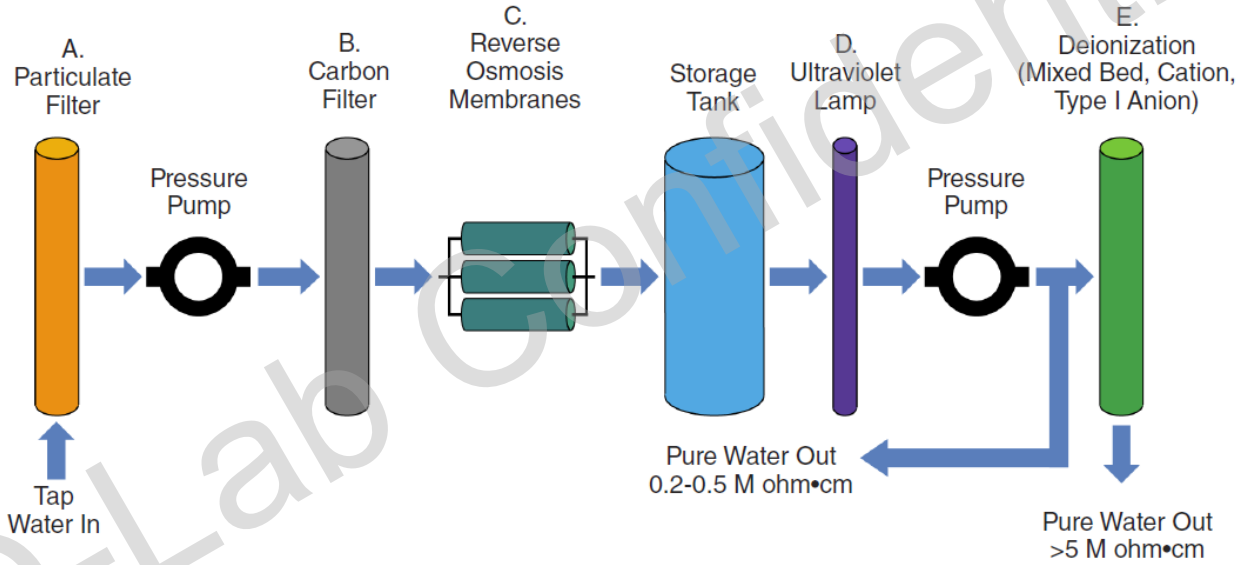
Spray System (Model)	Inlet Pressure	Flow Setting	Average Daily Volume	Resistivity	Conductivity	Silica	Total Dissolved Solids	pH
Front Spray* ("S" models)	30-90 psi (207-620 kPa)	1.4 liter/min	0.16 liter/minute × spray time***	>5M ohm•cm	<0.2 µS/cm	<0.1 ppm	<0.1 ppm	6-8
Front and Back Spray* ("B" models)		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 水的纯度

RO/DI system 反渗透/去离子系统



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

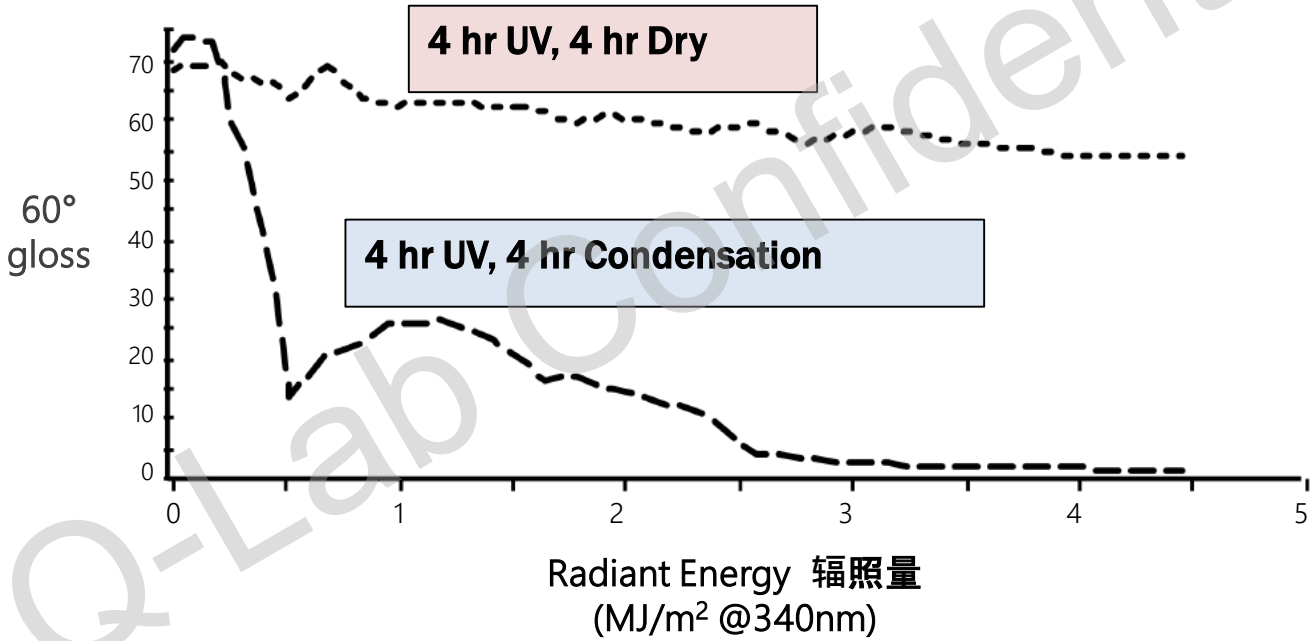
Water Delivery in Accelerated Lab Testing
加速实验室测试中水的施加

Water contributes to material degradation in many ways
水在很多方面有助于材料降解

- Plasticization 塑化
- Swelling 溶胀
- Blistering 起泡
- Adhesion 附着力
- Mass transport 迁移
- Mass loss 失重

UV Fluorescent Weathering 荧光紫外老化

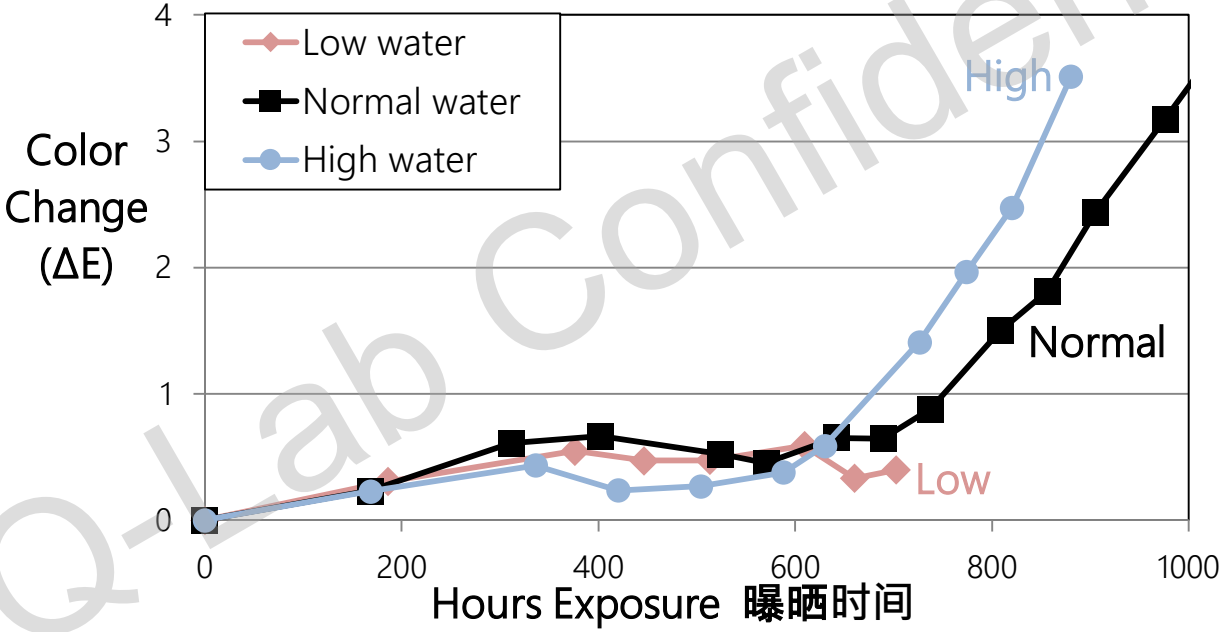
Water Delivery Accelerating Gloss Loss 水加速失光



Xenon arc Weathering 氙灯老化

Water Delivery Accelerating Color Change 水加速颜色变化

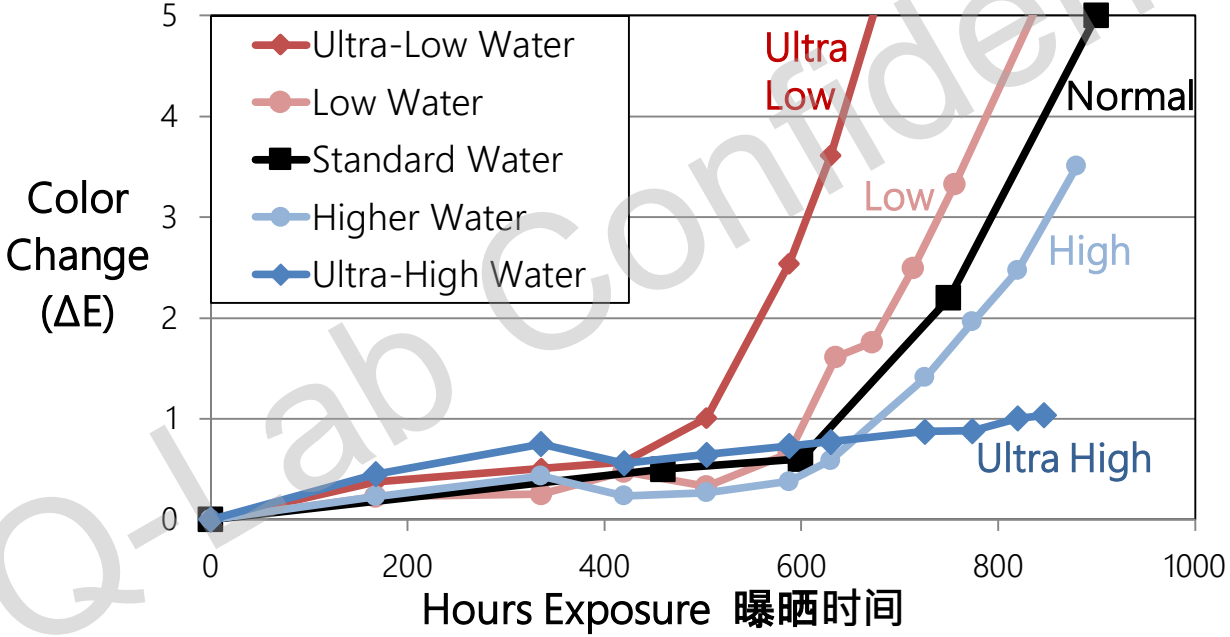
Polypropylene (Talc, Carbon Black, UV package 1) 聚丙烯 (滑石粉，炭黑)



Xenon arc Weathering 氙灯老化

Water Delivery Inhibiting Color Change 水抑制颜色变化

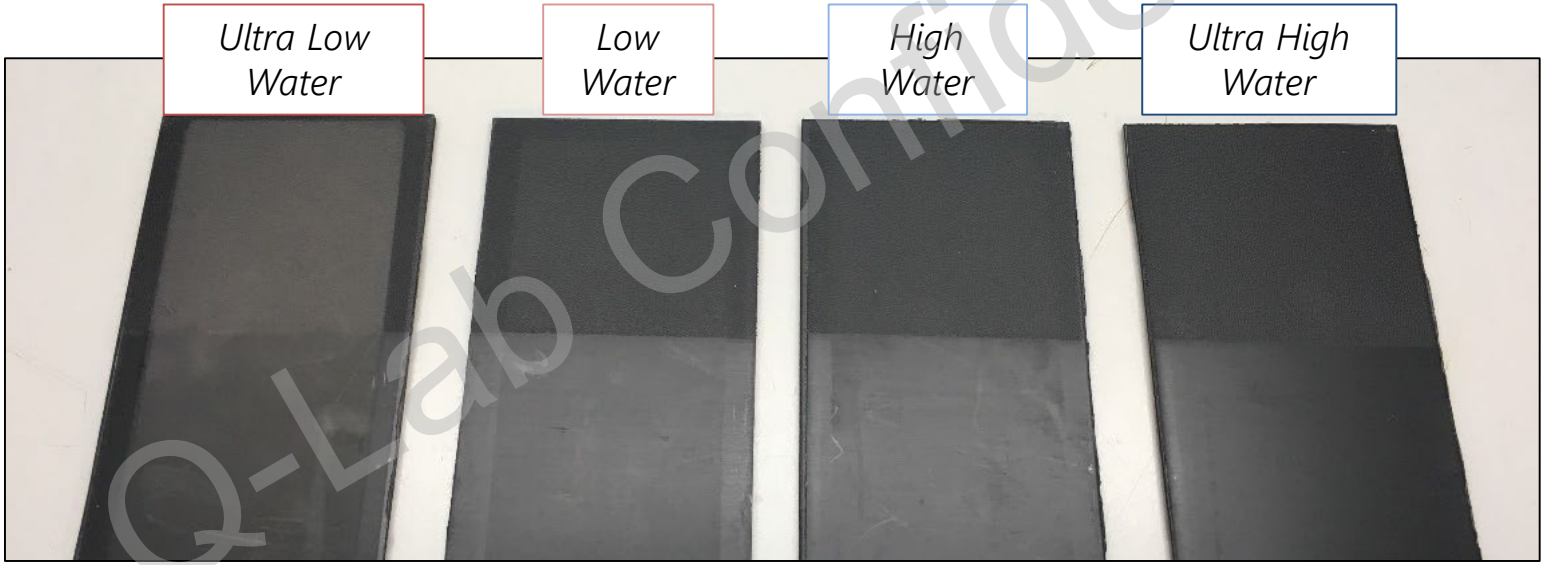
Polypropylene (Talc, Carbon Black, UV package 2) 聚丙烯 (滑石粉，炭黑)



Xenon arc Weathering 氙灯老化

Water Delivery Inhibiting Color Change 水抑制颜色变化

Polypropylene (Talc, Carbon Black, UV package 2)



Water in Laboratory Weathering Testing

- Water significantly influences test results for many materials
- 水对许多材料的试验结果有显著影响

- Compared to **Sunlight** and **Heat**, in lab testing **Water** is: 相比光和热，实验室测试中的水：
  - Less quantified 缺少量化
  - Less accelerated 难加速

- Today we will look at standards that *do* emphasize water
  - ASTM G90 (solar concentrator) 太阳光跟踪聚能装置
  - EN 927-6 (UV fluorescent) 荧光紫外
  - ASTM D7869 (xenon arc) 氙灯

Water Delivery in Accelerated Outdoor Testing
加速户外测试中水的施加

ASTM G90

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

Outdoor accelerated testing 户外加速测试

Natural solar concentrator 太阳光跟踪聚能装置

- 5× the UV light of natural exposure

- High temperatures from desert conditions and concentrated irradiance

Outdoor accelerated testing 户外加速测试

Daytime water delivery 白天水喷淋

- Daytime spray dries quickly, causes thermal shock
- 白天喷淋，很快干燥，形成热冲击
- Polymer matrices do not absorb any water!
- 聚合物基体不吸水！

Outdoor accelerated testing 户外加速测试

Nighttime water delivery 夜间水喷淋

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

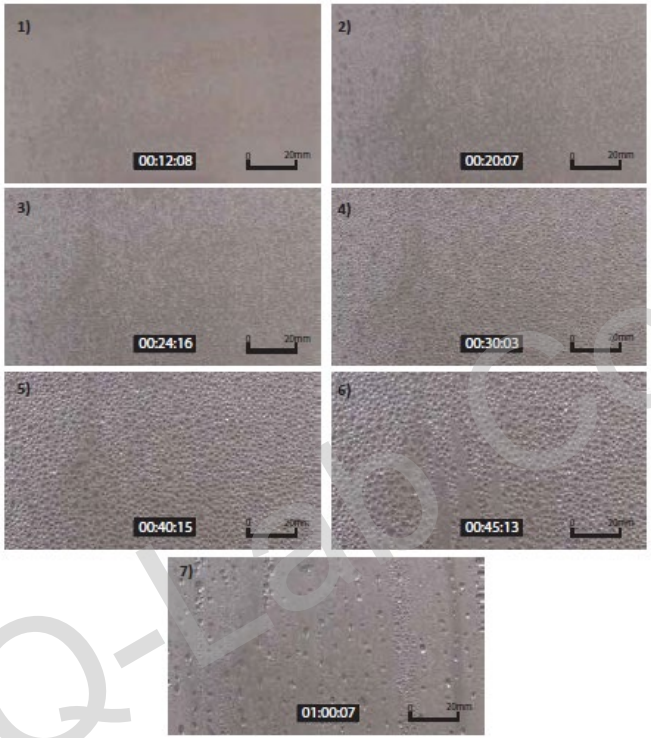
Water Delivery in Fluorescent UV Testing
荧光紫外测试中水的施加

EN 927-6

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

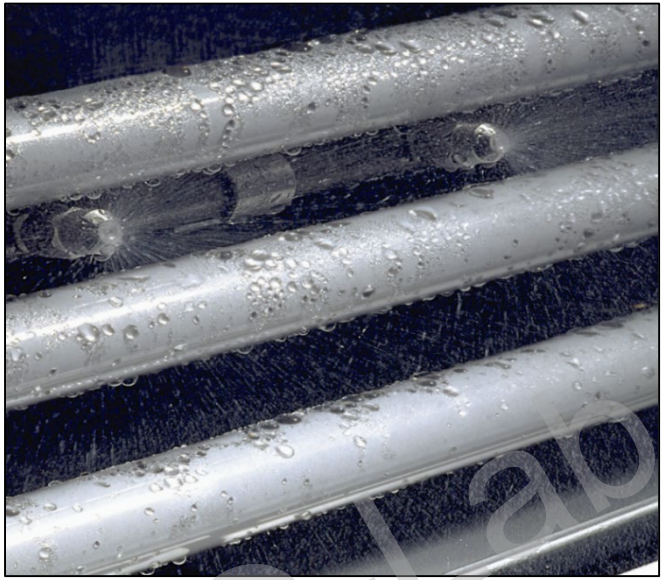
色漆和清漆– 木材的涂层和涂层体系

Fluorescent UV Testing: Condensation 冷凝



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

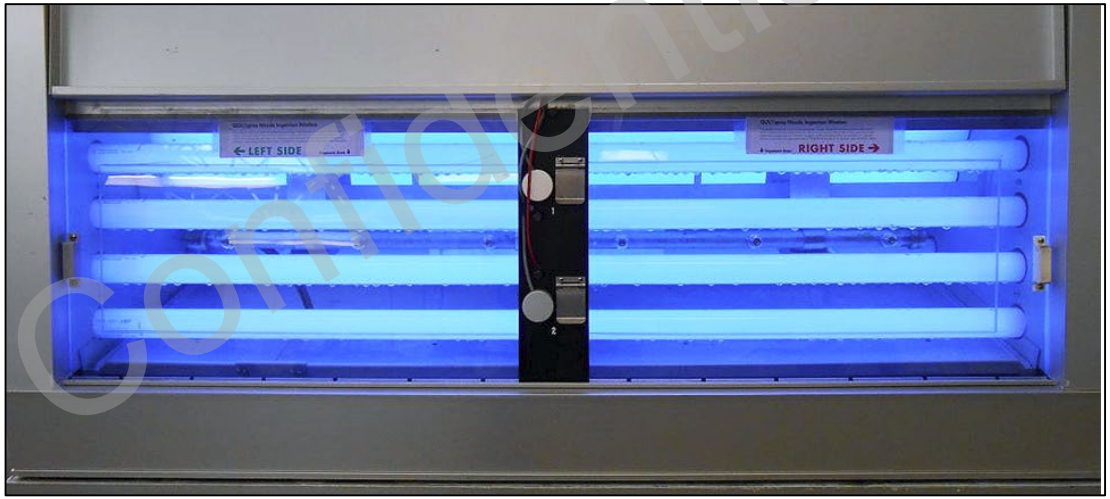
Fluorescent UV Testing: Water Spray 水喷淋



- Usually just short sprays for thermal shock
- 通常只进行短时间水喷淋，形成热冲击
- EN 927-6 introduces longer, frequent water spray to reproduce erosion in wood coatings
- EN927-6引入了时间长，频繁的水喷淋，以再现木材涂层的侵蚀

Water Spray Validation 水喷淋验证

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



Fluorescent UV Testing 荧光紫外测试

Erosion of wood coatings from water spray 水喷淋对木器漆的侵蚀

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

Water Delivery in Xenon arc Testing
氙灯测试中水的施加

ASTM D7869

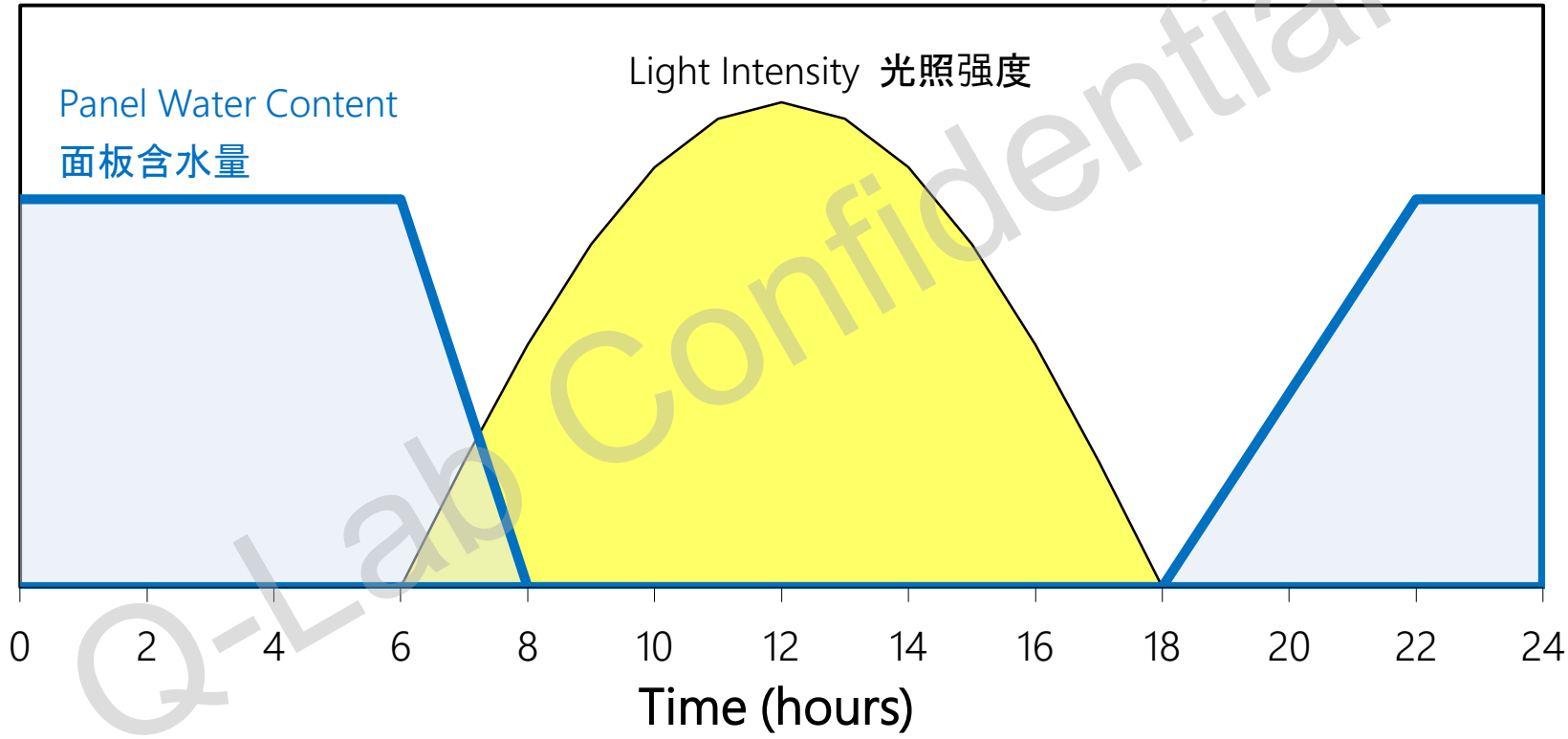
Standard Practice for Xenon Arc Exposure Test with Enhanced Light and Water Exposure for Transportation Coatings

Xenon arc Accelerated Lab Testing

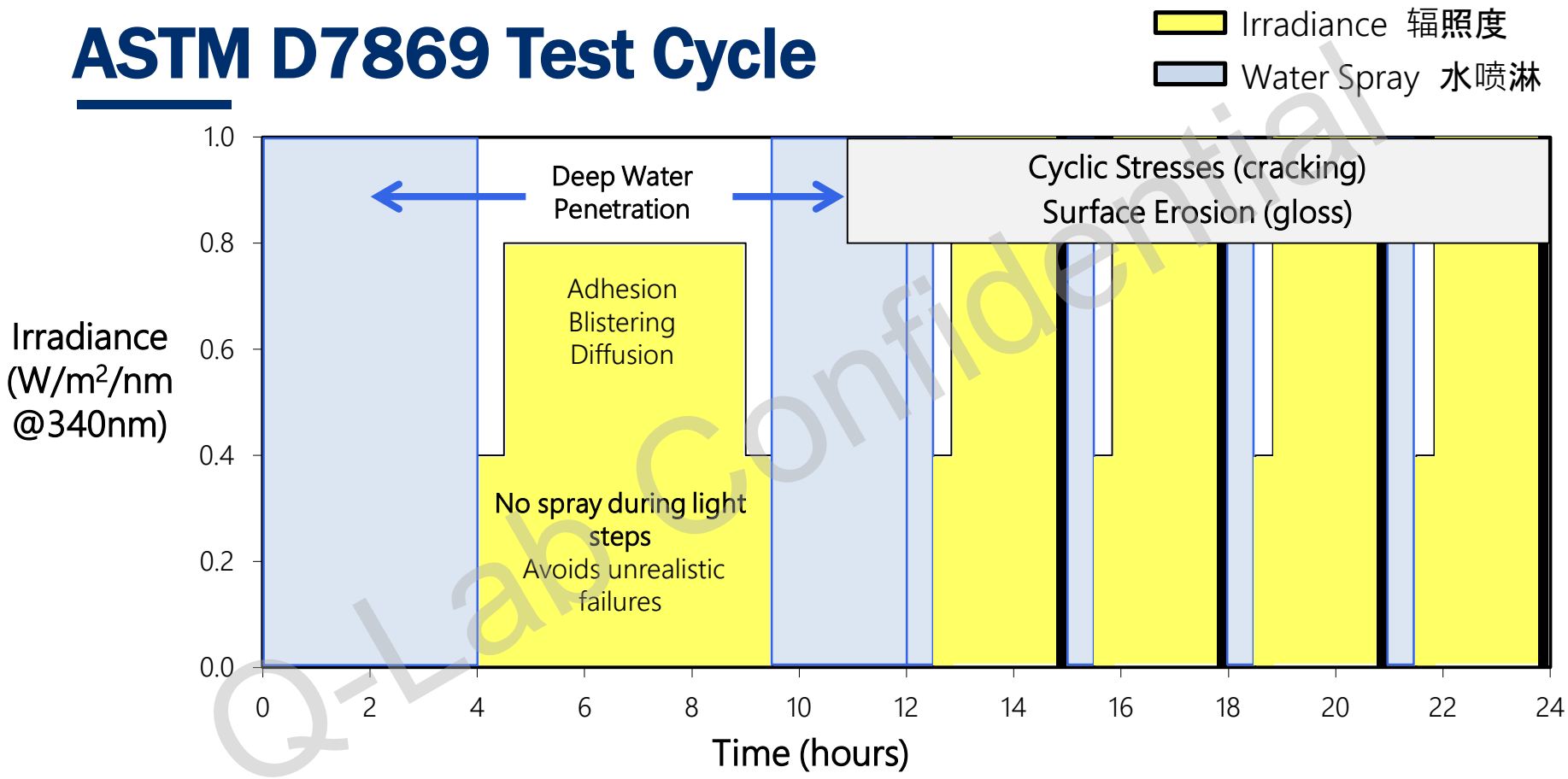
ASTM D7869

- ASTM D7869 **simulates** and **accelerates** Sunlight, Heat, and Water from outdoor weather 模拟并加速户外环境的光，热，水
- Test **validated** by comparison to long-term outdoor weathering data from aerospace and automotive coatings 通过对航空航天和汽车涂层的长期户外老化数据来验证ASTM D7869
- Test is **realistic** - it reproduces faithfully almost all physical failure mechanisms 测试更真实
- Test is fast – 30% **acceleration** over related test methods 测试更快
- Accelerated testing that **correlates** with outdoor test data for transportation coatings. May be suitable for other products as well
- 此加速测试与交通工具用涂料的户外测试数据相关性好，也可能适用于其它产品

Outdoor Daily Weather Cycle 户外日循环



ASTM D7869 Test Cycle

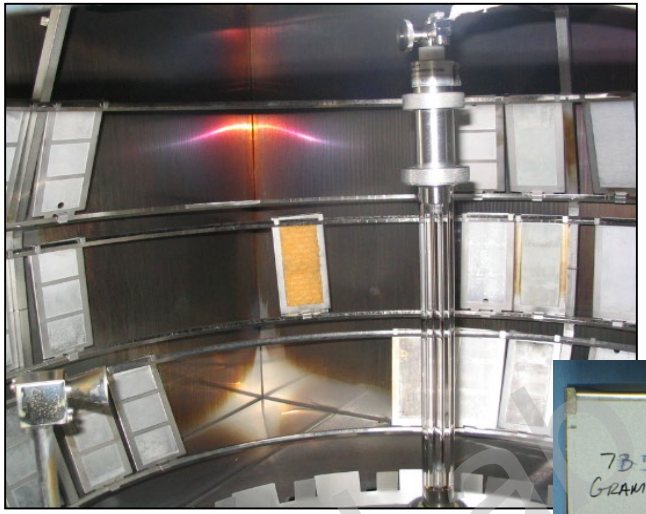


ASTM D7869 Water Delivery

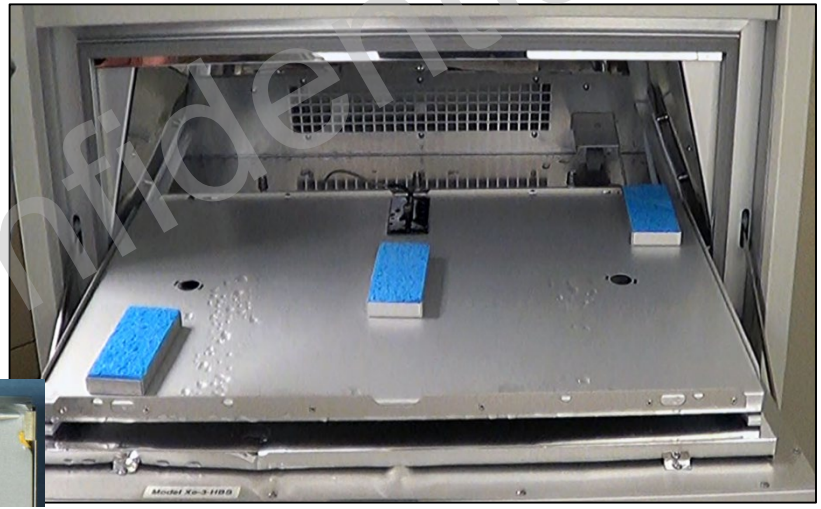
Calibrated sponge used to ensure coating saturation from water delivery

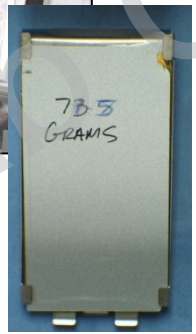
ASTM Water Delivery Calibration 水喷淋校准

Rotating Rack



Flat Array





Shielded sponge holder

ISO 23741: New Standard for Water Delivery

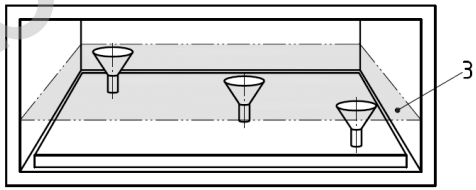
INTERNATIONAL STANDARD

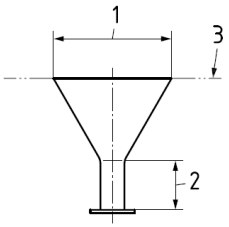
ISO 23741

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
- **氙灯试验箱中测定水施加的标准方法**
- Rotating rack or flat array

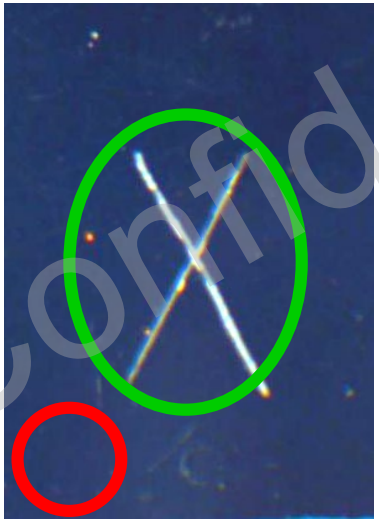




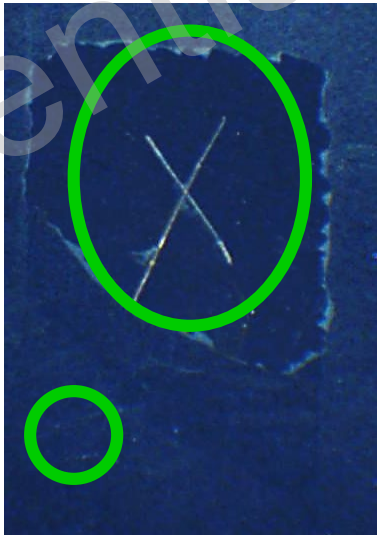
ASTM D7869 Test Result

Florida Exposure

SAE J2527



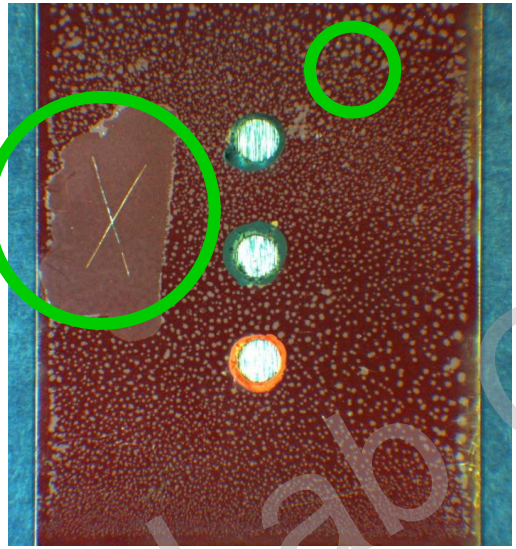
ASTM D7869



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

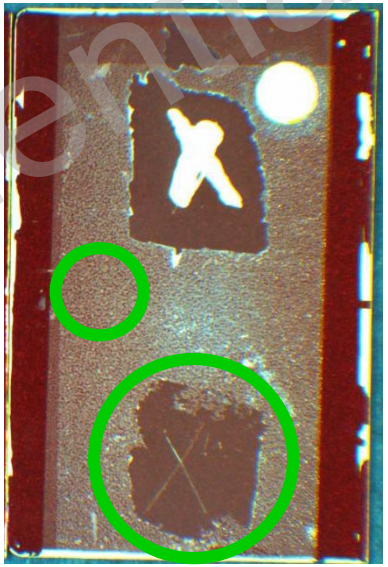
ASTM D7869 Test Result

Florida Exposure



SAE J2527

ASTM D7869



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

Conclusions 结论

- Sunlight, Heat, and Water are all delivered to specimens during accelerated weathering testing 加速老化测试中光，热，水都作用于试样
- Water contributes to many failure modes but is often underspecified and underdelivered in test standards 水会引起多种失效模式，但没有充分规定
- Some modern test standards including ASTM G90, EN 927-6, and ASTM D7869 take greater care to accelerate water delivery 现代标准注重水的施加
- ISO 23741 now standardizes quantification of water delivery to specimens 量化
- Effect of water on testing is highly material-dependent – important to actually conduct the testing! 水对测试的影响很大程度依赖于材料

Thank you for your attention!

Questions?

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