Accelerated Outdoor Weathering Testing

Principles, Challenges and Case Studies

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

Q-Lab Corporation

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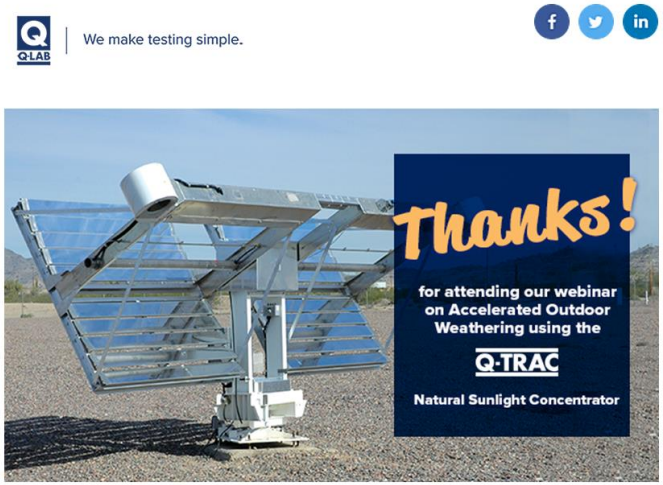


What is *Accelerated Outdoor Weathering*?

… outdoor weathering using the sun as the source of irradiance, and where the rate of deterioration is accelerated by increasing one or more of the influencing parameters above a level obtained in the natural environment.

From ASTM G113 “Standard Terminology Relating to Natural and Artificial Weathering Tests of Nonmetallic Materials

Why Accelerated Outdoor vs. Laboratory?

Real world conditions are **variable**

Real world conditions are **complex**

Excellent balance between **speed** and **realism**

Common forms of Acceleration in Outdoor Testing

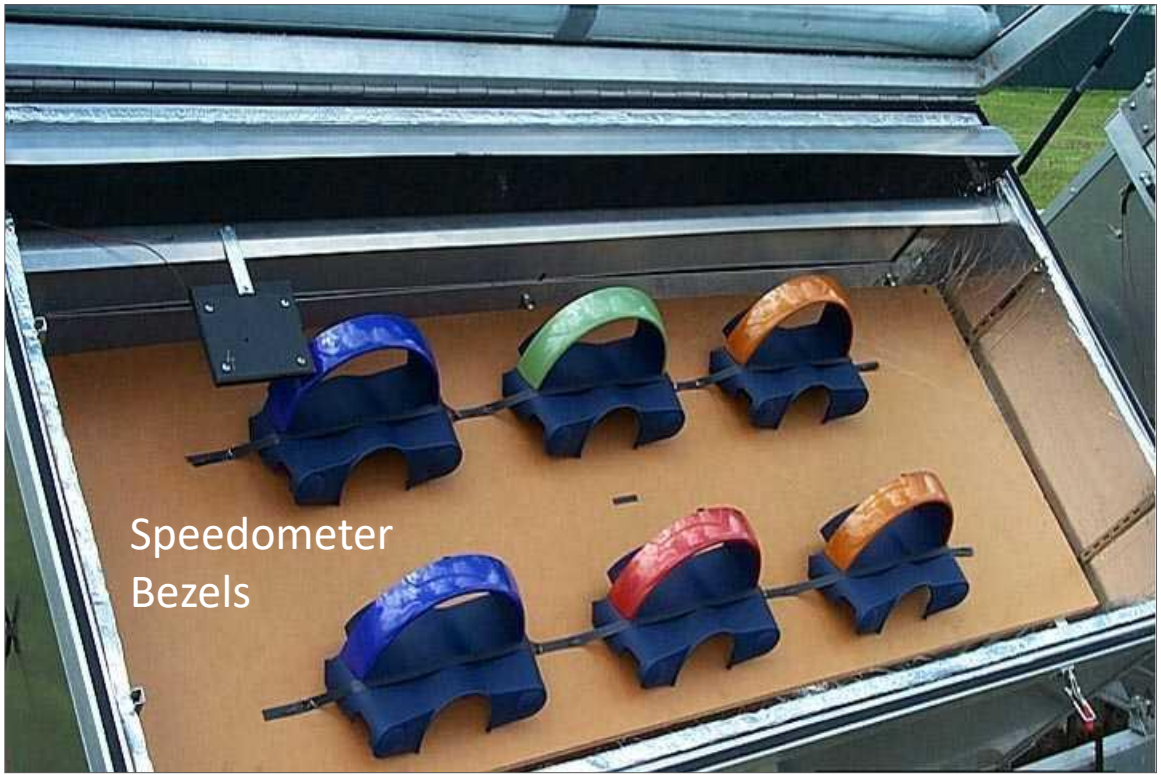
- Increased Irradiance
  - Solar concentration and/or tracking the sun
- Modified Temperature
  - Trapping/Adding heat or Freezing periods
- Increased Moisture
  - Supplementary water spray

Interior Materials Testing

AIM Box

TRUE-AIM Box

Outdoor Tests for Interior Components



Automotive Interior Materials

AIM Box

- Reproduces extreme heat from automotive interior
- Can test entire instrument panel
- Different plastics experience different thermal expansion
- Generates differential stresses between different interior plastics

AIM Box Configurations

- Tempered clear or laminated glass
- Static 45° S or Tracking 51° S
- Over-temperature shade protection

AIM Boxes

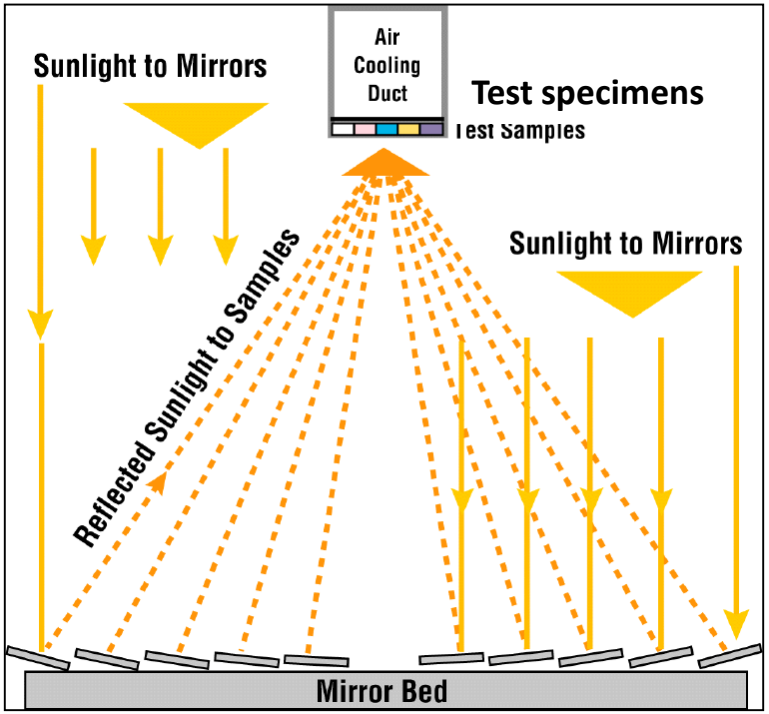
TRUE-AIM Box

- TRUE (Tracking Reflecting Ultra Exposure) AIM box increases total solar radiation exposure
- Highly reflective mirrors and dual-axis tracking (azimuth and elevation) to focus more sunlight into the box interior.
- Approximately doubles total sunlight received by specimens.

Natural Sunlight Concentrators

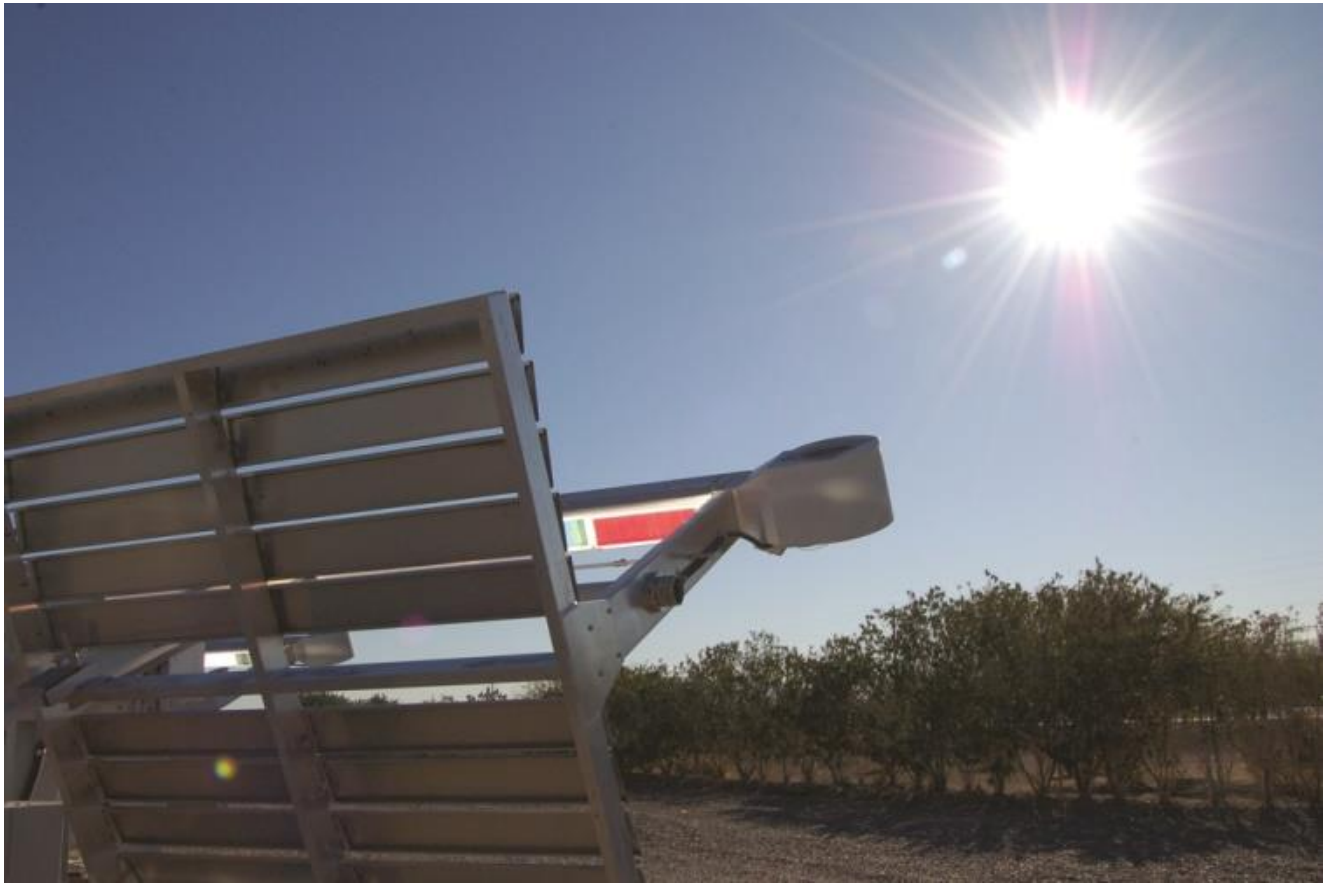
Fresnel Concentrator
Solar Concentrator
Q-TRAC

Sunlight Concentrating Mirrors

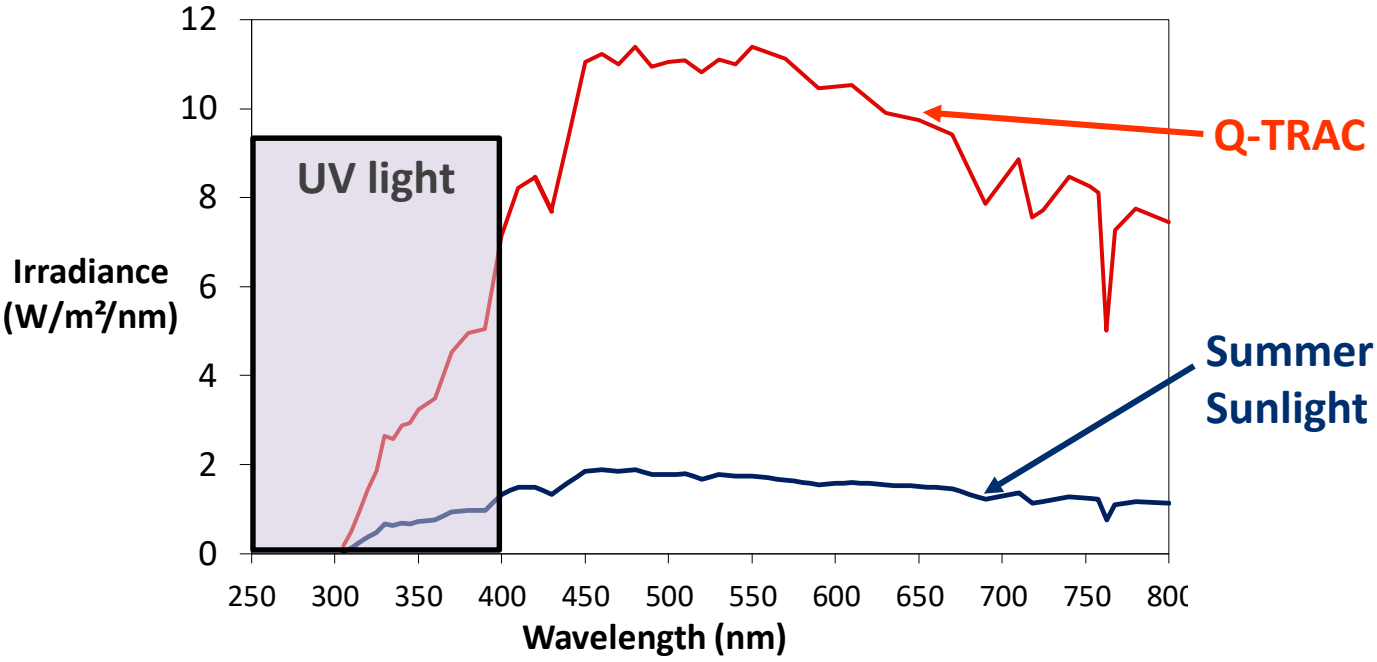


Mirrors Reflect Sunlight onto Specimens

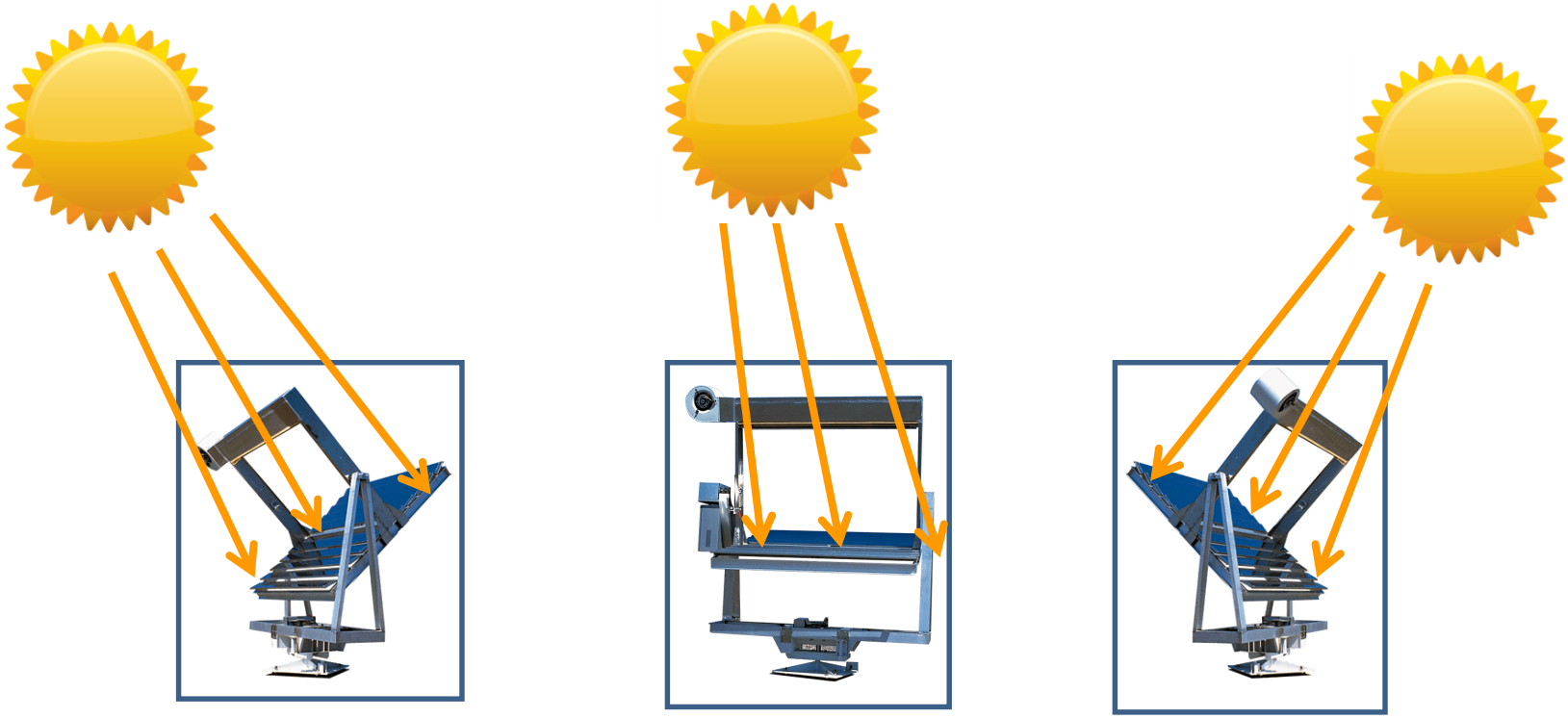
Mirrors on average reflect 80% of solar UV radiation



Summer Sunlight vs. Q-TRAC
~5× UV Irradiance of Natural



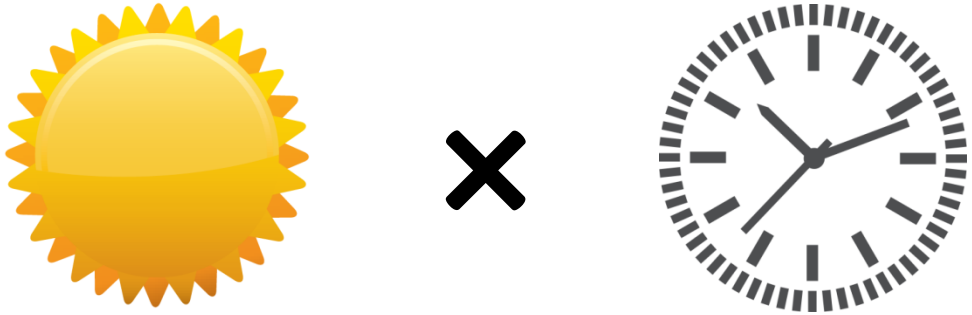
Following the Sun...



Arizona Only

- Tracking is required for concentration to work
- Doesn’t work when light is diffuse (cloud cover)
- Doesn’t work in inclement weather!

Radiant Exposure



The accumulated light energy falling on a surface over a period of time, per unit area [usually MJ/m^2]

Q-TRAC tests are measured in radiant exposure – higher during summer months than winter

Q-TRAC Tests Are Usually Timed by Accumulated Radiant Dosage

Exposure Angle	1 Year Florida Energy (MJ/m^2 TUV)
0˚ South	322
5˚ South	339
26˚ South	345
45˚ South	320
90˚ South	170

Q-TRAC delivers ~**1400** MJ/m^2 annually - ~**5×** a typical year in Florida*

True or False?

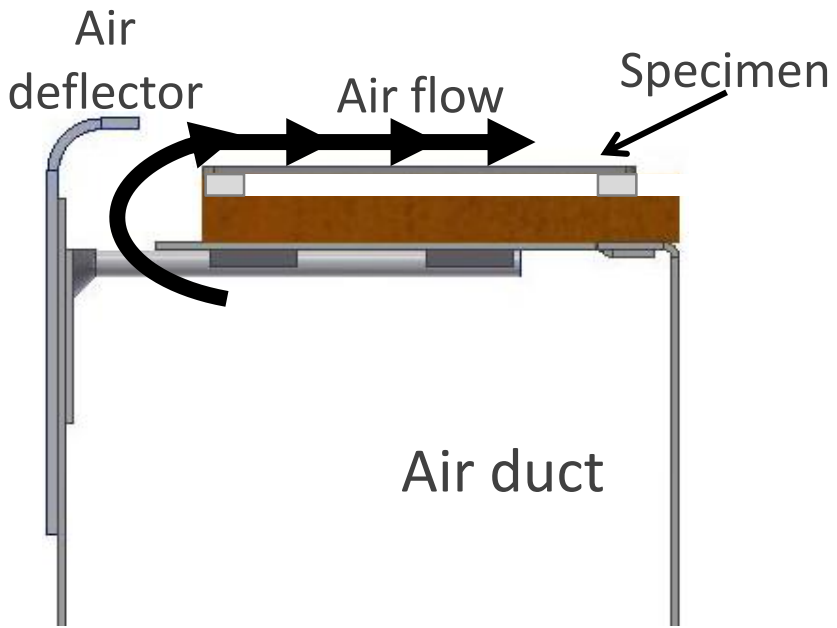
5× the sunlight
means
5× the degradation

Q-TRAC Acceleration

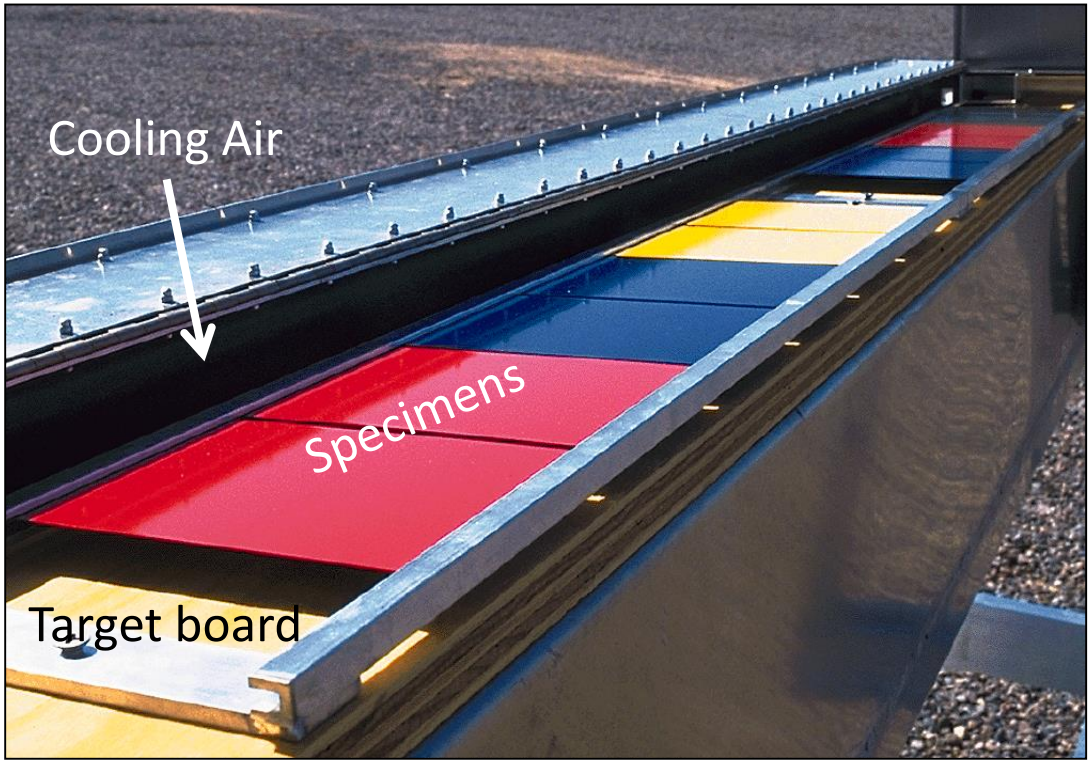
- ~5 times more UV
- ~5 years Florida sunlight in 1 year
- However: Light intensity is only one stressor

Q-TRAC Specimen Mounting

- Flat Specimens
  - Backed or unbacked
- Width < 14 cm (5.5 in)
  - Tests are charged by length along target board
- Thickness < 2.5 cm (1 in)
  - All specimens should be similar thickness



Q-TRAC Target Board



Outdoor accelerated testing

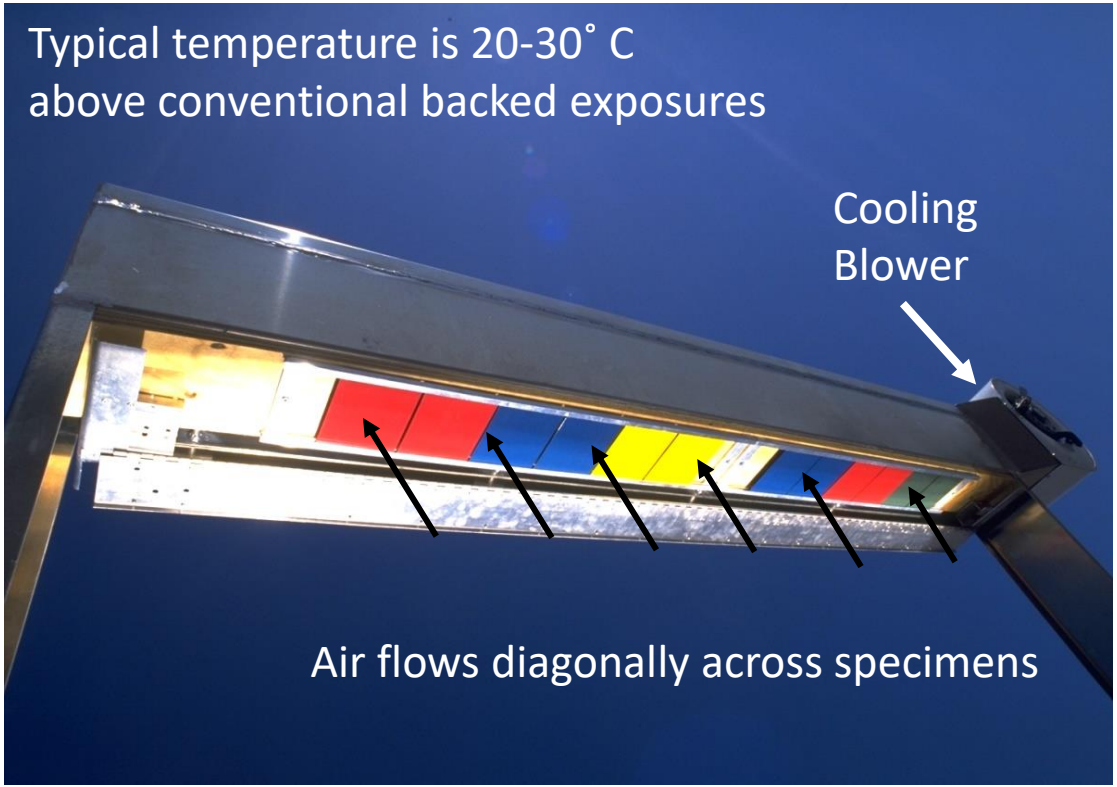
Temperature Effects

High temperatures from both desert conditions and concentrated irradiance

Temperature Effect of Mounting

	Open / Mesh	Plywood Backed	Black Box	Natural Sunlight Concentrator	
				Conventional	Temp controlled
Black Panel (˚C)	50	70	80	100	70
White Panel (˚C)	40	50	60	80	50

Q-TRAC Specimen Cooling



Outdoor accelerated testing

Daytime water delivery

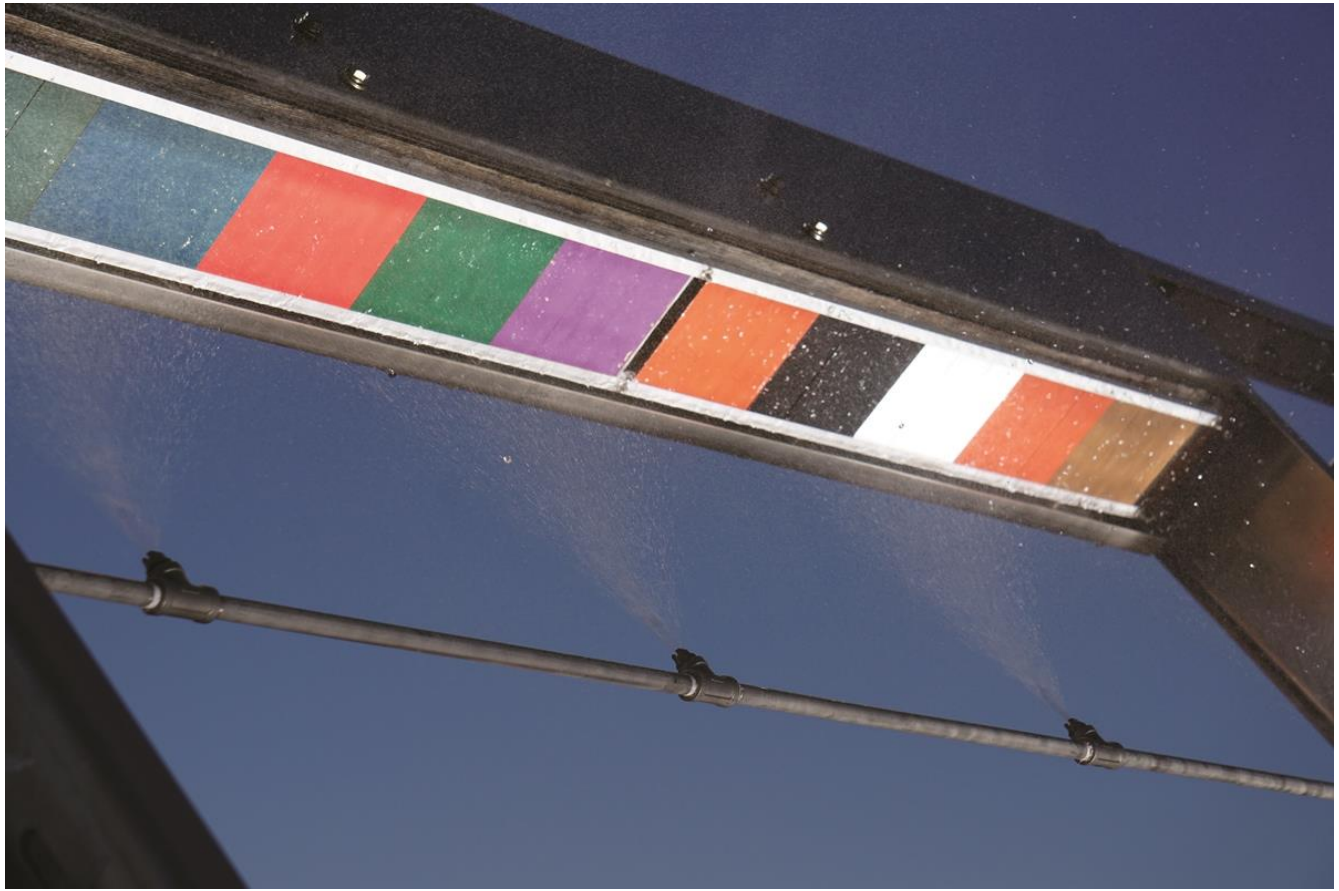
- Daytime spray dries quickly, causes thermal shock
- *Coatings do not absorb any water!*

Outdoor accelerated testing

Nighttime water delivery

Test Cycle	Daytime			Nighttime		
	Spray duration	Dry duration	Cycles	Spray duration	Dry duration	Cycles
1 "Spray 1"	8 min	52 min	1 / hr	8 min		3 per night: 21:00, 00:00, 03:00
3 "Spray 2"	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**



Applications

Natural sunlight concentrator particularly useful for durable, high-temperature materials

- Coil Coatings
- Powder Coatings
- Some Plastics
- Roofing

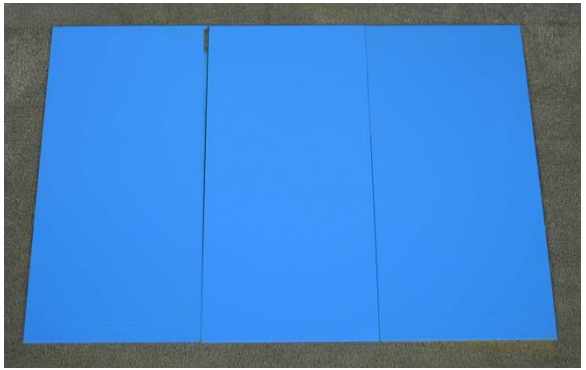
Natural Sunlight Concentrator Cycles

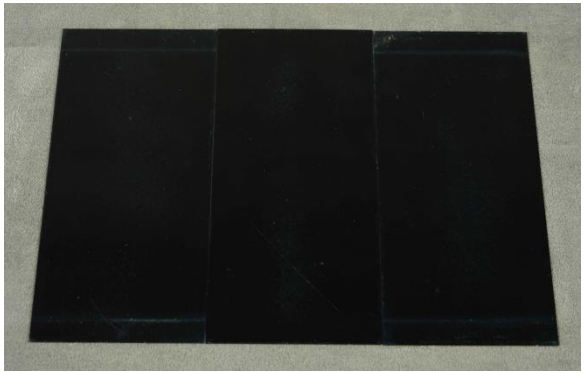
Cycle	Application	Day	Night
Desert	Plastics, Coatings, Inks, Textiles, Building Materials	Sunlight only	Ambient
Spray-1	Plastics, Coatings, Sealants, Textiles, Building Materials	Sunlight Spray 8 min/hr	8 min water 3 times a night
Spray-2	Plastics, Coatings, Sealants, Textiles, Building Materials	Sunlight only	3 min water every 15 min *(ToW like Florida)*
Interior (behind glass)	Auto Interior, Textiles, Inks, Indoor Products	Sunlight only	Ambient

Q-TRAC Test Examples

Q-TRAC Control Specimens

- 42 day Q-TRAC exposures
- Center panel is control
- High-performing coatings from ASTM D7869 study

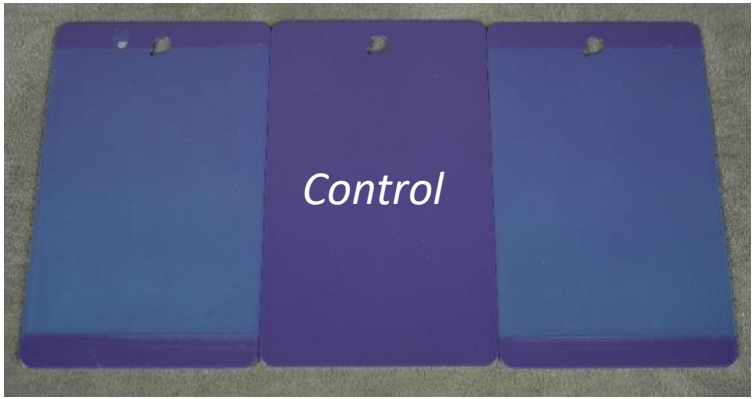




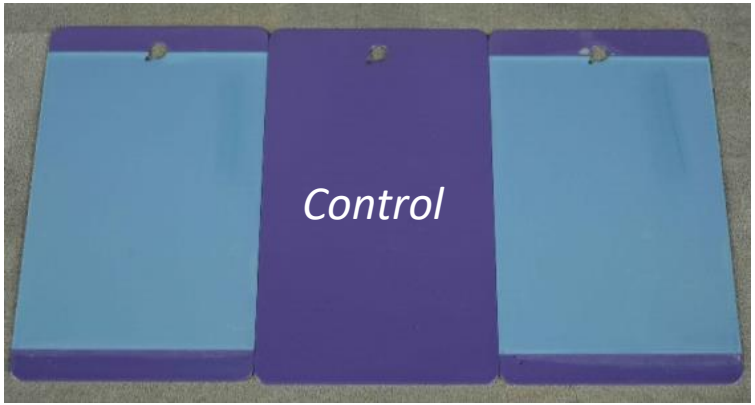
Single-Stage Paint

Direct Exposure: 90 Days

Q-TRAC Exposure



29 Days

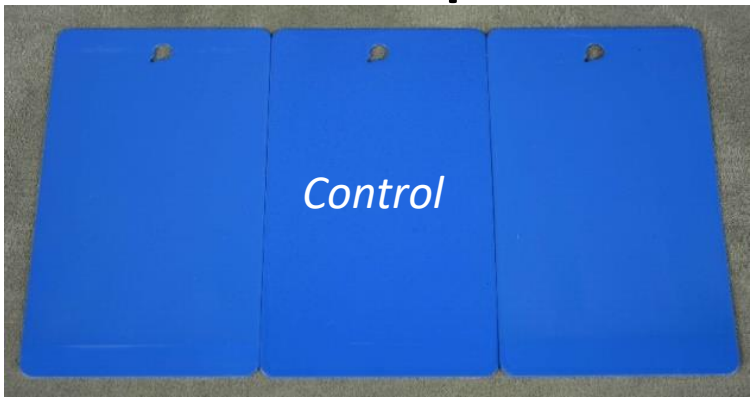


42 Days

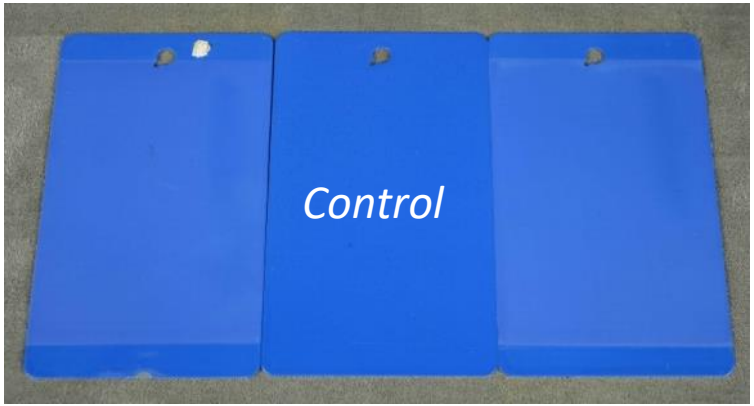
Single-Stage Paint

Direct Exposure: 90 Days

Q-TRAC Exposure



29 Days



42 Days

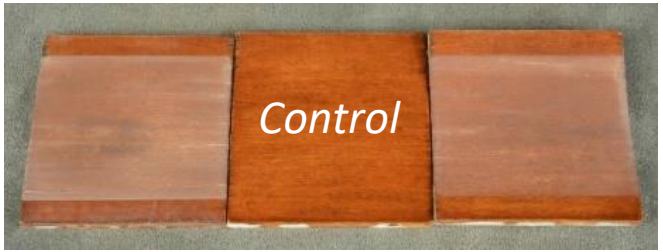
Wood Coating

Direct Exposure: 90 Days

115 MJ/m^2 TUVR

Q-TRAC Exposure

29 Days
106 MJ/m^2



42 Days
153 MJ/m^2

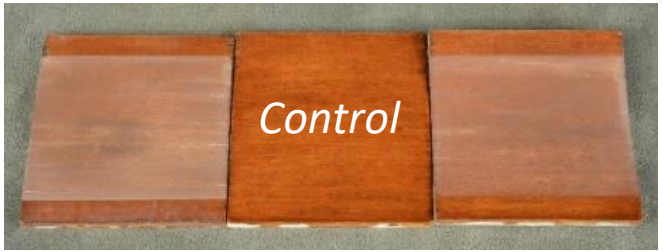
Wood Coating

Direct Exposure: 90 Days

115 MJ/m^2 TUVR

Q-TRAC Exposure

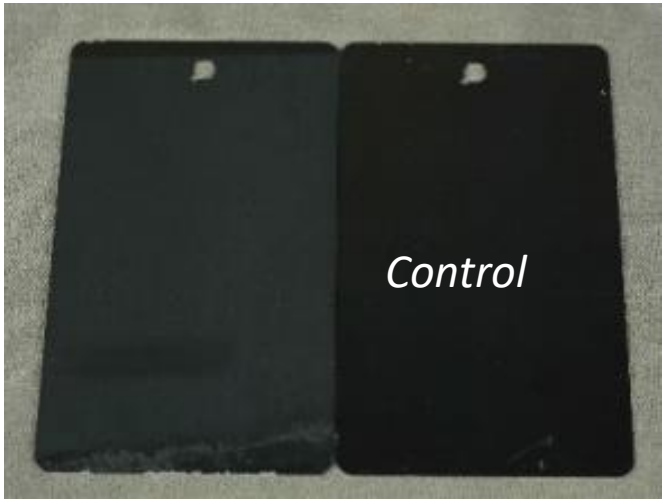
Freeze/thaw
42 Days
136 MJ/m^2



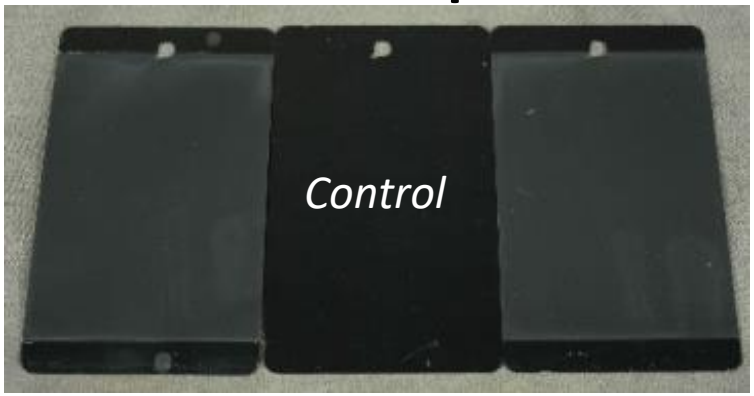
42 Days
153 MJ/m^2

Single-Stage Paint Black “A”

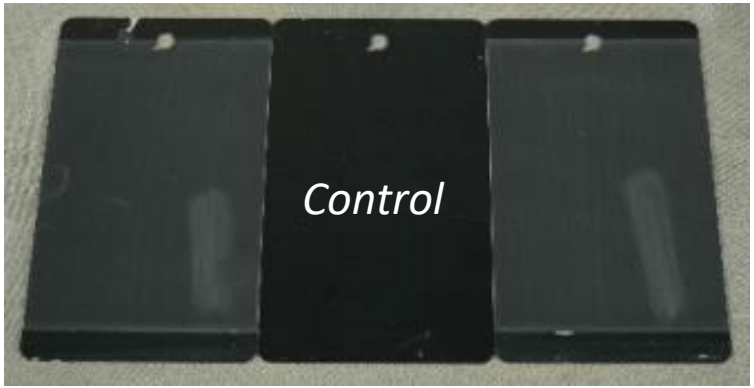
Direct Exposure: 90 Days



Q-TRAC Exposure



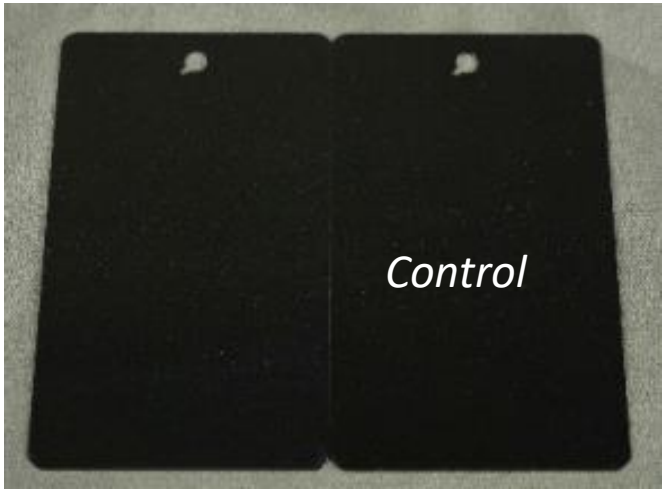
29 Days



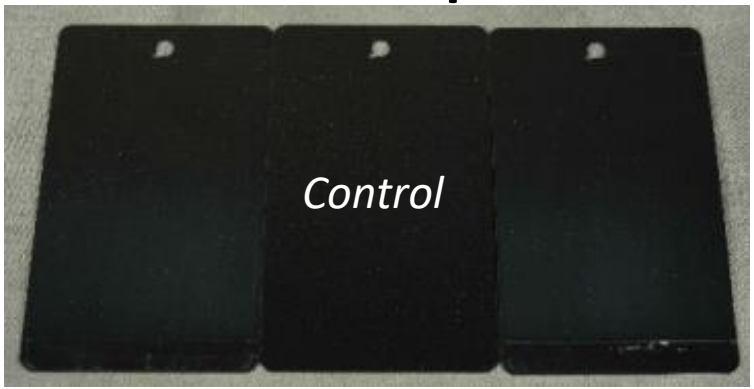
42 Days

Single-Stage Paint Black “B”

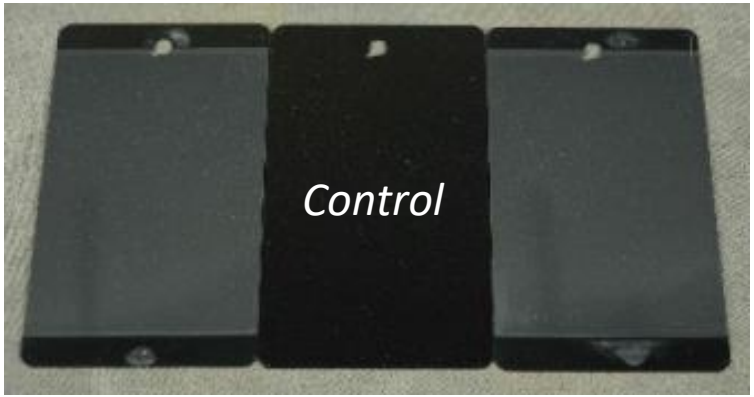
Direct Exposure: 90 Days



Q-TRAC Exposure



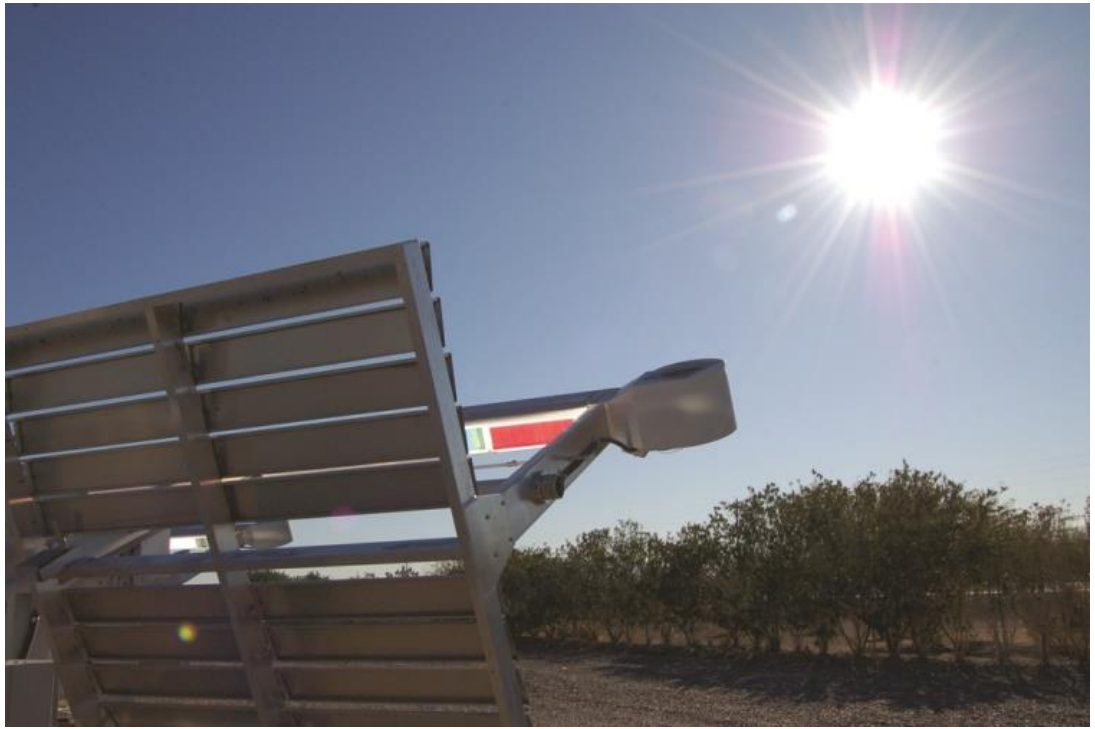
29 Days



42 Days

Q-TRAC Natural Sunlight Concentrator

- Fast Results
- Full-spectrum natural sunlight
- High temperature (temp control available)
- Multiple water spray cycles available
- Nighttime Freezing option



Thank you for your attention!

Questions?

info@q-lab.com