# Effects of Natural Sunlight on Fiberglass Reinforced Polymers for Crossarms

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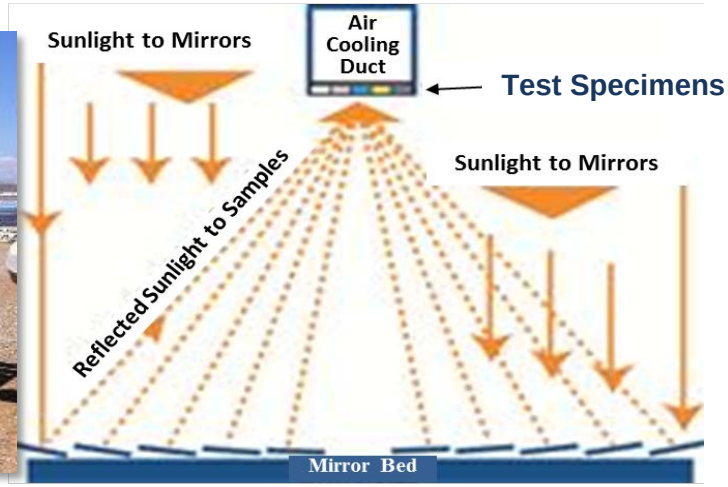
## Composite Crossarms in Brief

- ✓ Composite Crossarms are manufactured from fiber(glass) reinforced polymer (FRP)
- ✓ Composite crossarms are an engineered material and properties can be tailored to the application
- ✓ Composite crossarms are typically manufactured using the pultrusion process
- ✓ The first composite crossarms were installed over 27 years ago (early 1990's)

# Introduction

**What Is Accelerated Outdoor Weathering Test (ASTM G90)?**




**Notes:**

- Accelerated outdoor weathering test was conducted by Q-Lab Arizona based on ASTM G90 “Standard Practice for Performing Accelerated Outdoor Weathering of Nonmetallic Materials Using Concentrated Natural Sunlight”.
- Cycle 1 per ASTM G90: 8 min. water spray once per hr. during daytime and 8 min. every 3 hr. at night.
- Total UV radiation (295 ~ 385 nm) and total direct solar radiation (295 ~ 3000 nm) during the test period were recorded by using a solar tracking device equipped with two Eppley TUVRs and a Normal Incidence Pyrheliometer.

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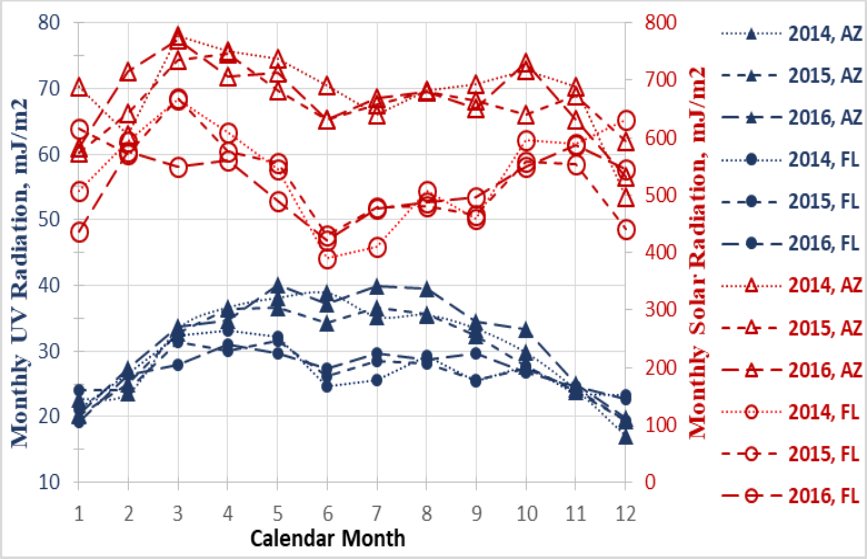
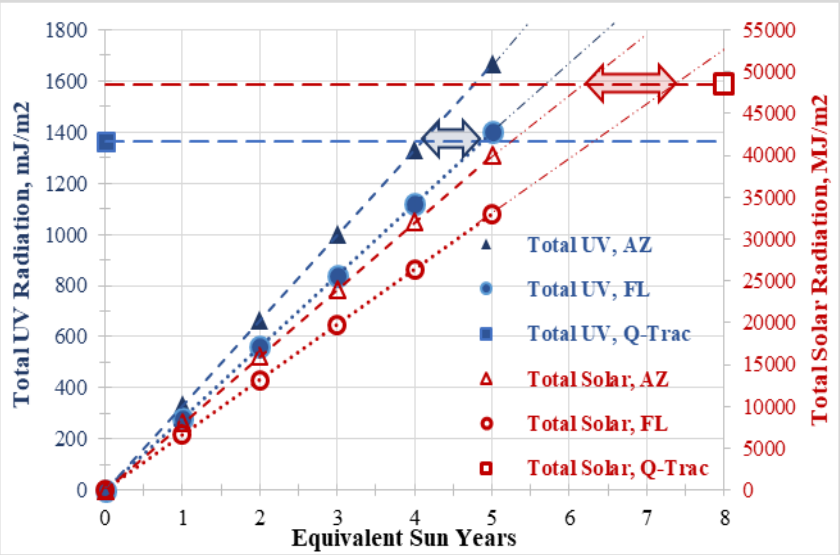
## Introduction

**What Are Equivalent Sun Years?**




**Notes and Comments:**

- After 12 months of accelerated outdoor weathering test completed in 2015, calculated total UV radiation and total solar radiation on the test specimens were **1,363** MJ/m$^2$ and **48,483** MJ/m$^2$, respectively.
- Based on total UV radiation, **1,363** MJ/m$^2$ is approximately equivalent to **~ 4 yr. in Arizona** or ~ **5 yr. in Florida**.
- Based on total solar radiation**, 48,483** MJ/m$^2$ is approximately equivalent to **~ 6 yr. in Arizona** or **~ 7.5 yr. in Florida**.

* Recorded monthly weather summary data by Q-Labs at Arizona site and Florida site, respectively. https://www.myweathertest.com/WeatherData.aspx.

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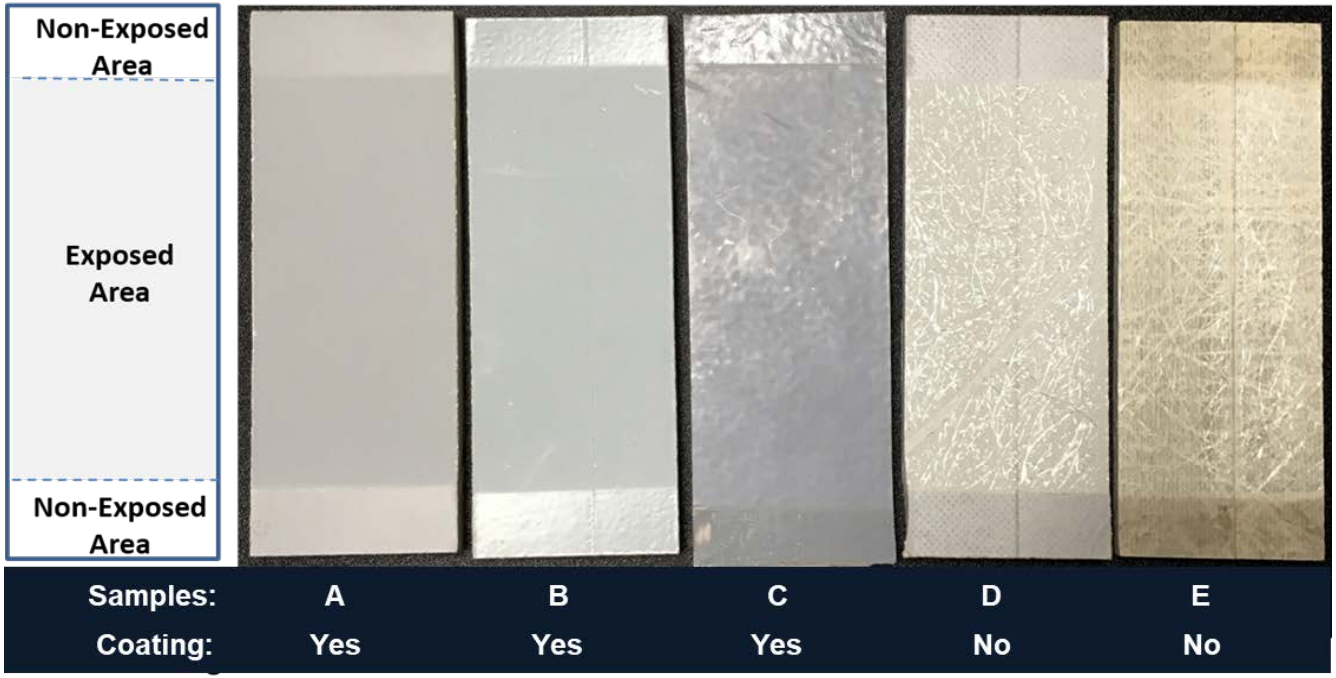
  - What Are Equivalent Sun Years
- **Effects of Concentrated Natural Sunlight on FRP Crossarms**
  - Digital Images of Tested Sample Surfaces
  - Surface Analysis by Colored Water Drops
  - Arc Tracking Resistance on Tested Sample Surfaces
  - Total Color Changes on Tested Sample Surfaces
  - Practical Impact of UV Weathering
- Summary and Conclusions

# Effects of Natural Sunlight on Fiberglass Reinforced Polymers for Crossarms

## *Digital Images of Tested Sample Surfaces*

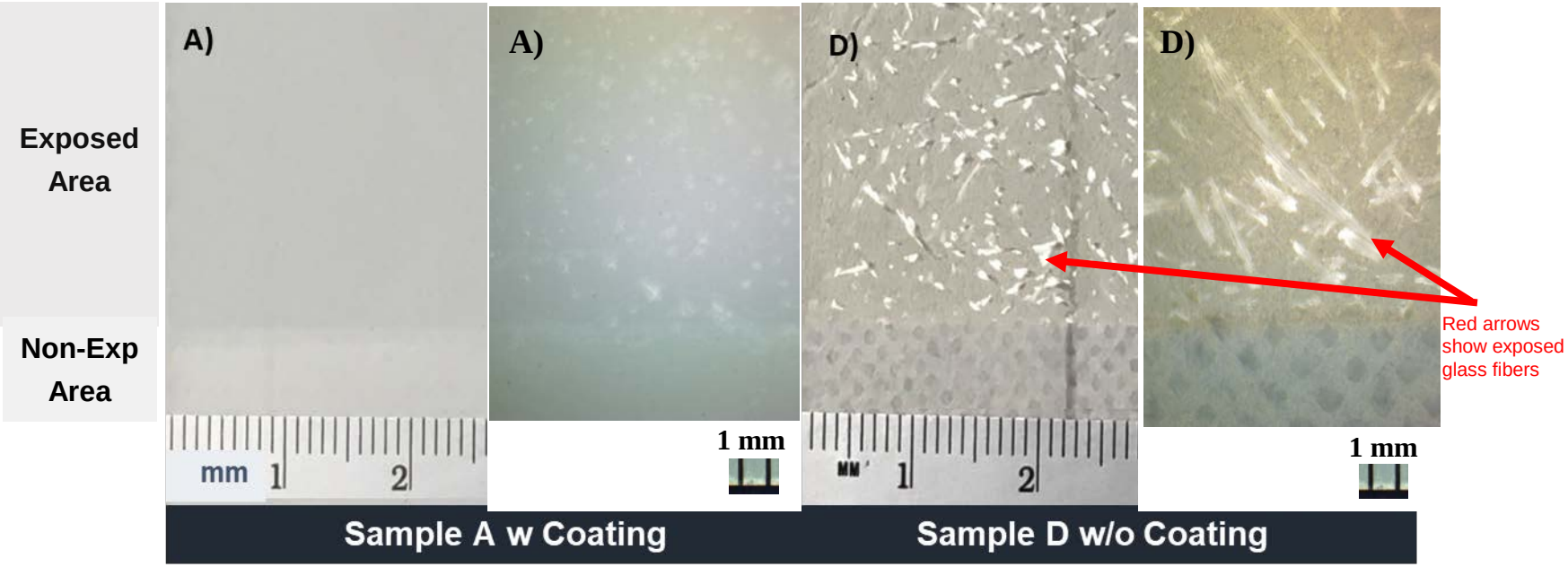



**Notes and Comments:**

- The exposed area on samples with a UV protective coating remained smooth while those without any coating became rough with exposed glass fibers.

# Effects of Natural Sunlight on Fiberglass Reinforced Polymers for Crossarms

## *Digital Images of Tested Sample Surfaces*




**Notes and Comments:**

- The exposed area on Sample A with a UV protective coating remained smooth while the exposed area on Sample D without coating showed exposed fibers (i.e., fiberglass mats or rovings).
- Fiber blooming is an undesirable condition where the polymer matrix has degraded due to UV exposure, and can reduce service life due to aesthetics, handling issues, increased arc tracking, and other potential issues

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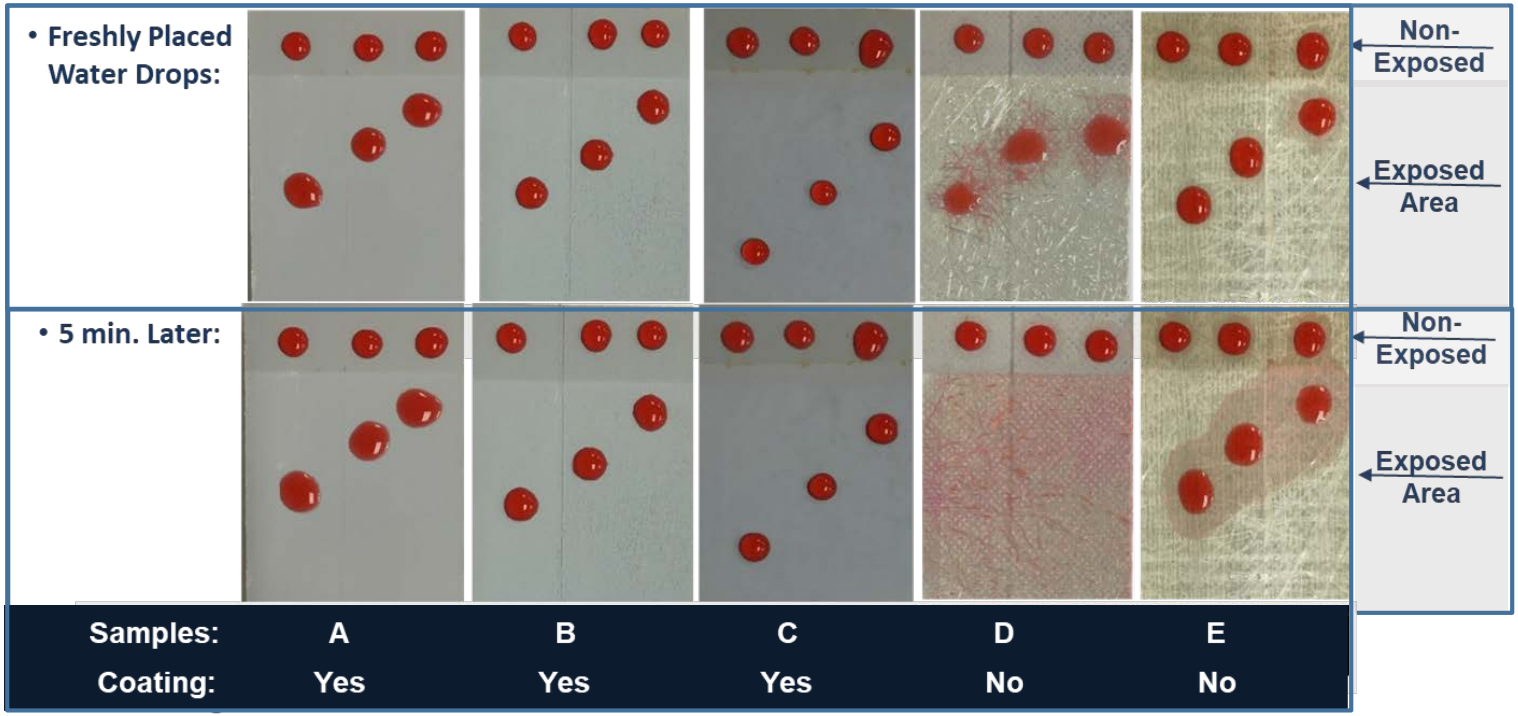
## *Surface Analysis Using Colored Water Drops*

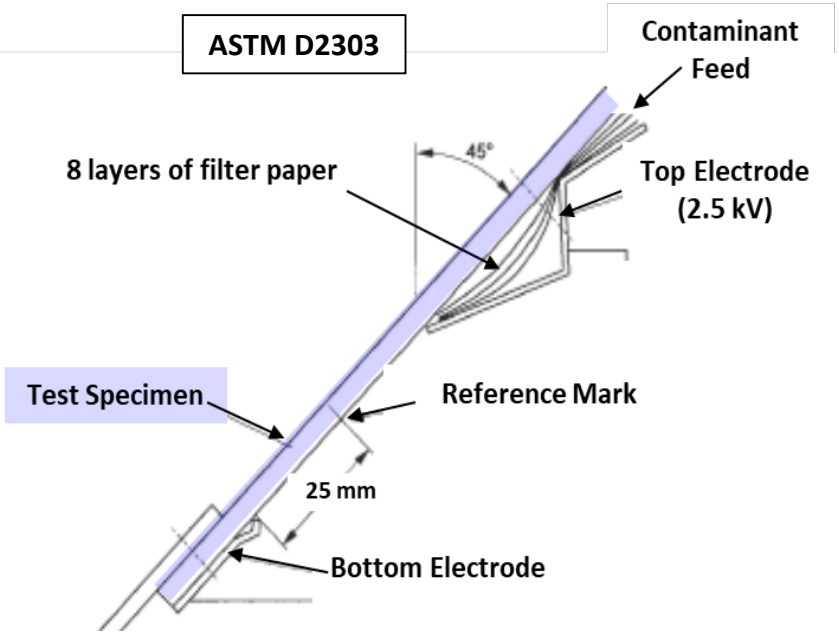



**Notes and Comments:**

- Both exposed and non-exposed area on samples with a UV-protective coating showed well-defined edge for water drops, indicating the surface remained smooth and hydrophobic.
- The exposed area on samples without any coating showed colored stain around water drops, indicating diffusion of water into the substrates which can trap contaminates and cause arc tracking.

# Effects of Natural Sunlight on Fiberglass Reinforced Polymers for Crossarms

## Arc *Tracking Resistance on Tested Sample Surfaces*




| Specimen ID | Coating | Time-to-Track, min | | |
|---|---|---|---|---|
| | | Non-Exp | Exposed | Change % |
| A | Yes | 12 | 8 | -33% |
| D | No | 11 | 3 | -73% |

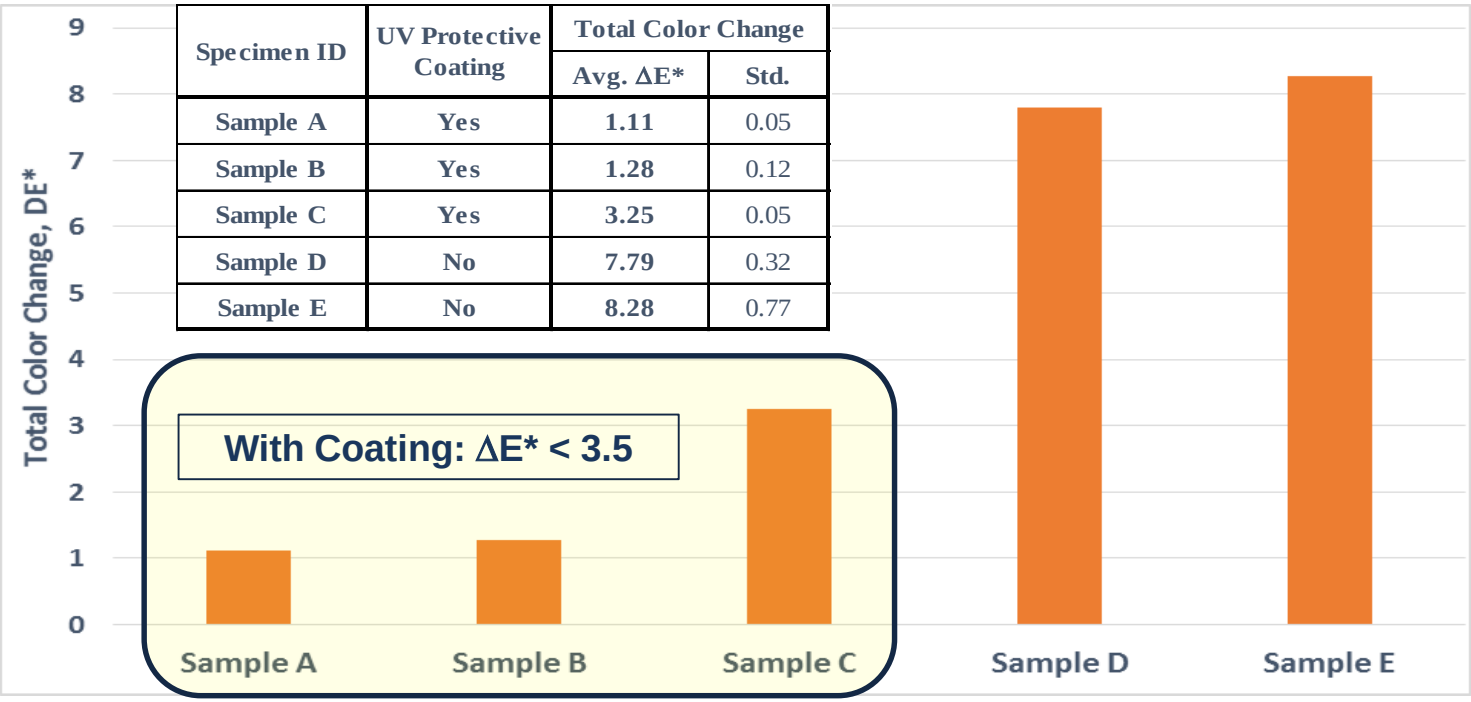
**Notes and Comments:**

- After exposing to accelerated weathering test, the specimen without coating showed ~ 2X reduction in tested time-to-track comparing to the one with coating, indicating it is more susceptible to arc tracking.
- The exposed fibers (i.e. rough surface) of specimen D (after UV exposure) are believed to be trapping and holding the test fluid, increasing the electrical conductivity of the surface, resulting in a lower time-to-track.

# Effects of Natural Sunlight on Fiberglass Reinforced Polymers for Crossarms

## *Measured Color Changes on Tested Sample Surfaces*

| Specimen ID | UV Protective Coating | Total Color Change | |
|---|---|---|---|
| | | Avg. ΔE* | Std. |
| Sample A | Yes | 1.11 | 0.05 |
| Sample B | Yes | 1.28 | 0.12 |
| Sample C | Yes | 3.25 | 0.05 |
| Sample D | No | 7.79 | 0.32 |
| Sample E | No | 8.28 | 0.77 |




**Notes and Comments:**

- Samples with a UV-protective coating showed significantly lower values for ΔE* than those without coating, indicating good color stability and therefore less changes due to UV-induced polymer degradations.

# Effects of Natural Sunlight on Fiberglass Reinforced Polymers for Crossarms

## What does this mean for fiberglass crossarms?

- Effective UV protection should be a requirement at the utility - Occurrence of fiber blooming is failure criterion
- Fiber blooming is an undesirable condition where the polymer matrix undergoes UV degradation, exposing the glass fibers underneath
- Effects of fiber blooming include
  - Poor aesthetics
  - Difficulty handling by linemen (i.e. fiber splinters)
  - Increased risk of arc tracking or flashover (i.e. reduced surface hydrophobicity, leading to trapped surface contaminants, resulting in lower surface resistivity)
  - Among other potential longer term effects

**Early onset of fiber blooming can result in shortened service life for fiberglass crossarms**

# Summary and Conclusions

~ 4 yr. in Arizona or ~ 5 yr. in Florida

Total UV Radiation (295 ~ 385 nm)

~ 6 yr. in Arizona or ~ 7.5 yr. in Florida

Total Solar Radiation (295 ~3000 nm)

Five Samples for 12 Month Accelerated Outdoor Weathering Test

With Coating

- Smooth surface w/o fiber blooming
- Excellent arc track resistance
- Light color Change with $\Delta E^* = 1.1 \sim 3.3$

Without Coating

- Rough surface with fiber blooming
- Poor arc track resistance
- Visible color with $\Delta E^* = 7.9 \sim 8.3$

**Fiberglass crossarms with a UV protective coating will have better UV stability to prevent UV-induced polymer degradations when exposing to sunlight and therefore have a longer service life than those without any coating**

# Thank You!

For additional information, please contact GEOTEK or email

jzhu@geotekinc.com

DISCLAIMER

1. GEOTEK performed mechanical strength testing in connection with the tests underlying this publication, but the strength tests were inconclusive and are not referenced herein.

2. Other environmental factors aside from UV radiation that may affect crossarm degradation and coating reliability, such as pollution, freeze-thaw cycling, wind-blown particulates, salt fog, and/or bird feces, were not considered as part of the testing underlying this publication. As Q-Lab document LL-9031 states, while the accelerated UV testing will result in the "same amount of UV deposited over five years of Florida (subtropical) testing" ... "[t]his is not meant to imply that the degradation that occurs over one year of Q-TRAC natural sunlight concentrator testing will necessarily be the same as five years of Florida testing." Q-Lab document LL-9031 further states: "As with all accelerated testing, the amount of acceleration depends on many variables such as material composition, mode of degradation, temperature response and moisture.“

3. ASTM G90 states that the "relative durability of materials in natural or field exposure can be very different depending on the location of the exposure because of differences in UV radiation, time of wetness, temperature, pollutants, and other factors. Therefore, even if results from a specific accelerated test condition are found to be useful for comparing the relative durability of materials exposed in a particular exterior location, it cannot be assumed that they will be useful for determining relative durability for a different location." The accelerated testing underlying this publication was performed in Arizona.

4. Q-Lab document LU-8030 states that "Joules do not reflect variations in degradation caused by differences in exposure to moisture, temperature, or wavelength spectrum of the light source. Characterization and control of these other parameters is often more important than Joules of radiant dosage." While the accelerated testing described herein was not timed in Joules, one may note that Q-Lab document LU-8030 states: "Exposures of equal Joules do not necessarily produce equivalent degradation."