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DESIGNING FOR DURABILITY: CONNECTING WEATHERING DECISIONS TO LONG-TERM POLYMER PERFORMANCE

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& Kayla Riebe, Weathering Scientist

INTRODUCTION: WEATHERING IS OFTEN CONSIDERED TOO LATE

A polymer component can meet every design requirement on day one and still fail before the end of its intended service life.

That failure may begin with fading, yellowing, gloss loss, or a subtle surface change. Over time, it can become cracking, warping, embrittlement, moisture damage, mechanical property loss, or surface degradation. Those material changes can lead to customer complaints, warranty risk, delayed launches, repeat testing, reformulation, or reduced confidence in long-term performance.

Weathering is often deprioritized because product teams are focused on immediate requirements: appearance, processing, cost, mechanical performance, customer specifications, and qualification timelines. Those priorities matter, but durability questions become harder to solve once material selection, formulation, tooling, and qualification requirements are locked.

By final validation, the polymer base may already be selected. Pigments and additive packages may be defined. Processing conditions, geometry, cost targets, and customer requirements may be difficult to change. If weathering concerns appear for the first time at that stage, the available solutions become narrower and more expensive.

Weathering data is most valuable before that point. Used early, it helps development teams compare materials, evaluate formulations, identify likely failure risks, and make better decisions while there is still room to adjust.

Appearance	Color Fade, Yellowing, Gloss loss
Environmental Stress	Heat build-up, Moisture damage, Thermal cycle
Development Impact	Late-stage redesigns, Qualification delays, Reformulation challenges
Customer Impact	Warranty claims, Appearance complaints, Reduced product confidence
Financial Impact	Increased testing costs, Delayed launch timelines, Supply chain disruptions

THE HIDDEN DURABILITY RISKS PRODUCT TEAMS MAY MISS

More Than UV Exposure

UV exposure is a major contributor to polymer degradation, but products rarely experience one clean stressor at a time.

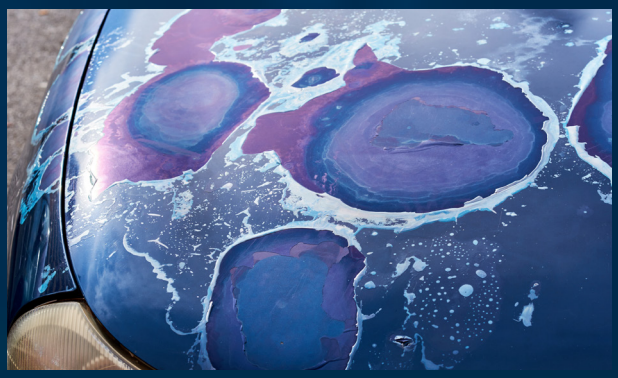
Heat can accelerate oxidation and aging. Moisture can contribute to swelling, blistering, hydrolytic degradation, adhesion loss, or surface erosion. Temperature cycling can create repeated expansion and contraction that leads to fatigue, cracking, or warping. Chemical exposure, abrasion, mechanical stress, cleaning agents, sterilization exposure, and installation conditions can further influence long-term performance.

More Than Outdoor Exposure

Durability concerns are not limited to outdoor applications.

A building product exposed for decades, an automotive component used across multiple climates, a roofing underlayment awaiting installation, an electronics housing in a semi-protected environment, and a healthcare device exposed to repeated cleaning or sterilization each creates a different durability question.

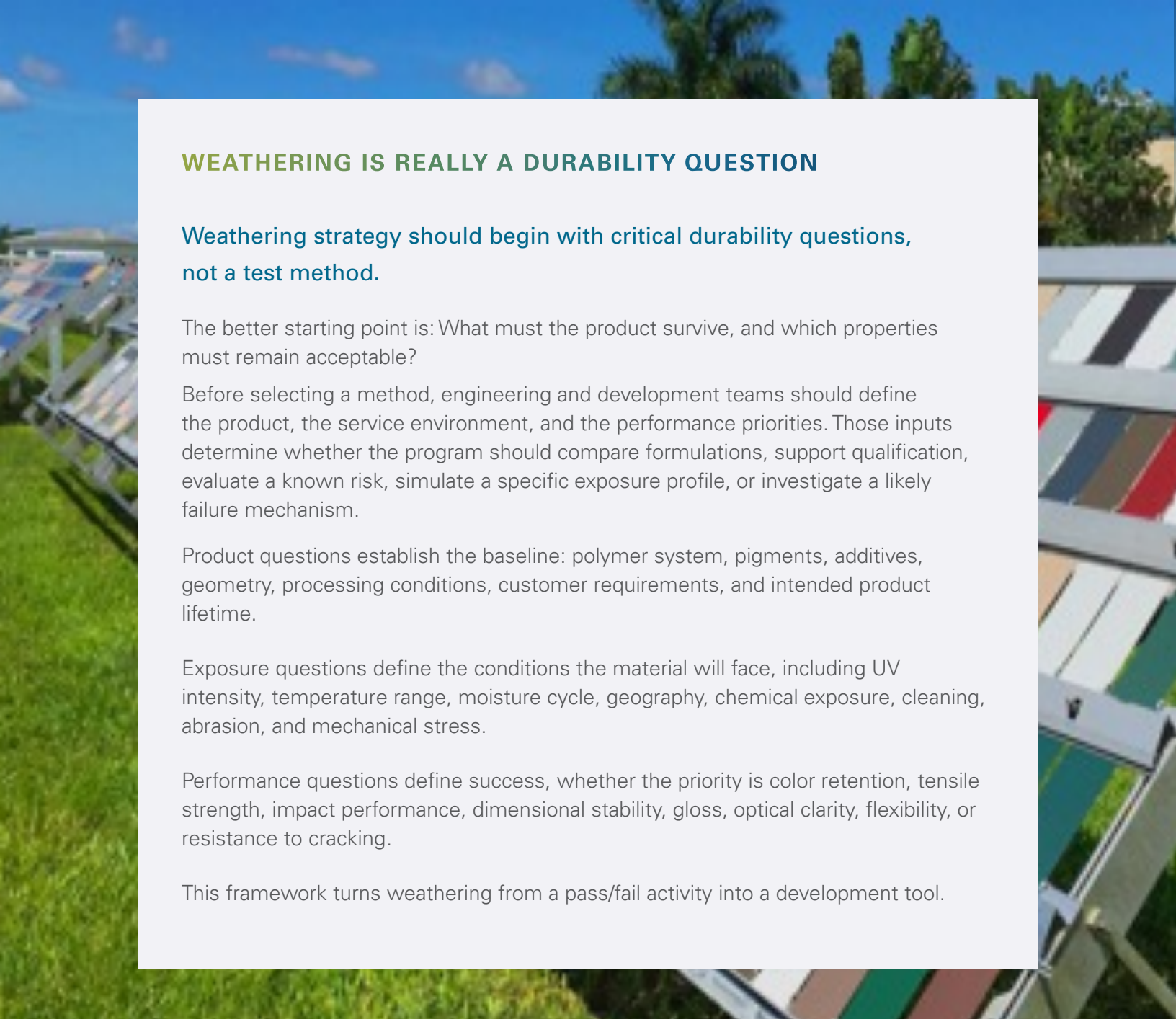
The practical question is not simply whether the product will see weather. It is what the product must survive, how those stressors may interact, and which properties must remain acceptable over time.



1. Surface degradation/appearance loss:
   UV exposure | Heat | Surface erosion

2. Cracking/physical performance loss:
   Moisture | Temperature cycling | Mechanical stress

3. Mechanical change in flexible materials:
   Abrasion | Flexing | Mechanical retention



WEATHERING IS REALLY A DURABILITY QUESTION

Weathering strategy should begin with critical durability questions, not a test method.

The better starting point is: What must the product survive, and which properties must remain acceptable?

Before selecting a method, engineering and development teams should define the product, the service environment, and the performance priorities. Those inputs determine whether the program should compare formulations, support qualification, evaluate a known risk, simulate a specific exposure profile, or investigate a likely failure mechanism.

Product questions establish the baseline: polymer system, pigments, additives, geometry, processing conditions, customer requirements, and intended product lifetime.

Exposure questions define the conditions the material will face, including UV intensity, temperature range, moisture cycle, geography, chemical exposure, cleaning, abrasion, and mechanical stress.

Performance questions define success, whether the priority is color retention, tensile strength, impact performance, dimensional stability, gloss, optical clarity, flexibility, or resistance to cracking.

This framework turns weathering from a pass/fail activity into a development tool.

Key Questions to Ask Before Weathering Begins

What are we designing?	What environment will it see?	What matters most?
Polymer system	UV Intensity	Color retention
Additives/pigments	Temperature range/cycling	Mechanical performance
Mechanical requirements	Moisture/humidity	Appearance
Regulatory or customer expectations	Indoor vs. outdooor exposure	Preferred vs. unacceptable failure modes
Intended product lifetime	Geographical location	Cost vs. durability targets

THREE WAYS WEATHERING DATA HELPS TEAMS MAKE BETTER DECISIONS

Weathering data supports better development decisions when it is connected to the application and used while material and formulation choices can still change.

1. Defines the Real Exposure Profile
A useful weathering strategy starts with the environment the product is expected to face. That may include UV intensity, heat, humidity, moisture cycling, geography, cleaning, sterilization, chemical exposure, abrasion, installation conditions, or mechanical stress.

Defining the exposure profile helps teams avoid testing for one condition while missing the stressors most likely to drive failure.

2. Compares Material and Formulation Options Earlier
Accelerated weathering can help teams compare resin systems, pigment packages, additive approaches, and stabilization options under controlled conditions.

The value is not predicting an exact number of years in service. The value is understanding how material options respond to relevant stressors before choices are locked.

3. Aligns the Test Strategy With the Application and Qualification Path
A test method is most useful when it reflects the product's service environment, performance priorities, and qualification expectations.

Testing may be used to support OEM qualification, compare formulations, evaluate color or gloss retention, assess mechanical property retention, or investigate a likely failure mechanism. The right strategy depends on the material, the environment, and the decision the team needs to make.

Weathering data is more useful when it connects controlled testing to the real exposure conditions the product is expected to face.

DESERT EXPOSURE PROFILE: DESIGNING A TEST AROUND THE SERVICE ENVIRONMENT

A realistic weathering strategy starts by defining the environment the product must survive.

For a plastic part used in a solar panel cleaning machine, the critical exposure conditions included high UV irradiance, elevated thermal load, abrasive dust and sand, low humidity, and extreme day-night temperature swings.

For this application, the team needed to evaluate a plastic part for a solar panel cleaning machine intended for use in a harsh Middle East desert environment. Because Saudi Arabia represented the target exposure region and Phoenix, Arizona, offered a well-defined desert comparison point, the two locations were compared to help shape the accelerated test approach.

The goal was not to create a universal conversion between laboratory hours and field years. It was to identify a representative desert exposure profile and select conditions that reflected the primary stressors expected in service.

Metric	Phoenix, Arizona	Riyadh, Saudi Arabia
Max Air Temp (°C)	~46°C	~50°C
Avg Daily Temp Swing	20-25°C	20-25°C
UV Index	10-11	11-12
Relative Humidity	10-20%	5-15%
Dust/Abrasion Risk	High	Very High

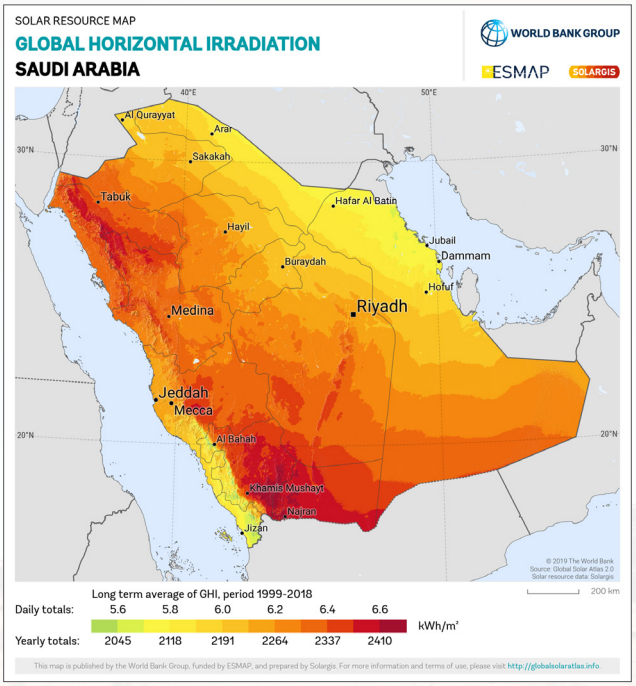
HARSH ENVIRONMENT CHARACTERISTICS:

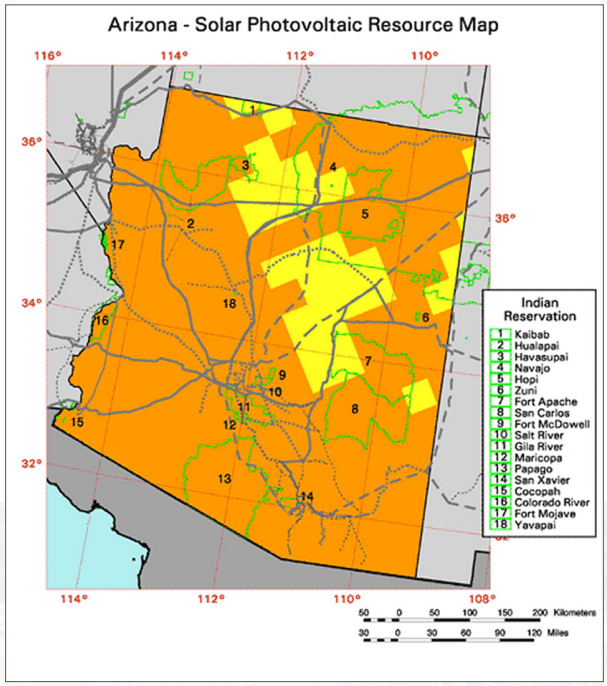
High UV irradiance.

Abrasive sand and dust exposure.

Extreme day-night temperature swings.

Low humidity and high thermal loads.





Region	Peak Solar Radiation (GHI) kWh/m²/day	Typical Range Annual Average
Saudi Arabia	~7.8–8.5	220–250 W/m²
Arizona	~7.3–8.0	210–240 W/m²

This comparison supports exposure-profile selection for a defined application, not a universal conversion between laboratory exposure hours and field years.

APPLYING THE FRAMEWORK ACROSS INDUSTRIES

The same durability principles apply across markets, but the strategy changes with the application.

Building products often prioritize long-term outdoor exposure, color retention, dimensional stability, and mechanical performance. Transportation components may need to perform across variable climates, interior and exterior UV exposure, heat buildup, moisture, abrasion, and customer appearance expectations.

Electronics, energy, and other emerging applications can connect appearance requirements with functional performance. Solar components, business equipment, optical films, memory storage applications, and exposed housings may face heat, UV, moisture, thermal cycling, or surface change depending on the service environment.

Fibers and textiles often face harsh exposure because of geometry and use conditions, including high surface area, thin cross sections, flexing, abrasion, and outdoor use.

Building & Construction

- Long-term exposure
- Color fade
- Crazing, warping
- ASTM G154, ASTM G155, ASTM G7

Transportation

- OEM qualification
- Color fade
- Crazing, gloss loss
- SAE J2412, SAE J2527, ISO 4892-2

Electronics, Energy & Emerging Applications

- Exposure-profile definition
- Color/clarity shift
- Dimensional change
- Surface degradation
- Functional requirements

Fibers & Textiles

- Mechanical retention
- Color fade
- Strength loss, fraying
- Microfracture
- AATCC 16, AATCC 169, SAE J2527

Healthcare

- Controlled-use durability, yellowing
- Embrittlement
- Clairty change
- Sterilization methods: EtO, gamma, autoclave, ebeam, VHP

DEVELOPMENT DECISIONS IN PRACTICE

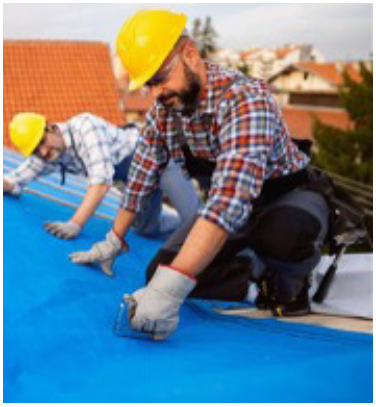
Weathering data is most useful when it supports a material, formulation, or design decision.

The following examples show weathering as a development tool. The result is useful when it helps a team decide what to change, what to keep, what to qualify, or what risk to avoid.

Transportation: Paint-Free Exterior Performance

The development question was whether a polymer solution could deliver deep-gloss, paint-like aesthetics while maintaining color consistency and outdoor performance.

Weathering helped support a paint-free material system designed to maintain appearance and durability while reducing manufacturing complexity.



Fibers: Roofing Underlayment Stabilization

The development question was how to preserve mechanical properties in polyester roofing underlayment before final installation.

Although the material is eventually covered, it may sit exposed on a job site for months. Comparative testing helped evaluate stabilization packages at different cost-performance points.

Building & Construction: Dark-Color PVC Design Flexibility

The development question was whether a PVC capstock solution could support darker design targets while maintaining more predictable weathering performance.

Weathering data helped connect formulation decisions to color stability, surface performance, heat behavior, and confidence in darker exterior applications.

HOW AMERICHEM HELPS

Weathering data is only valuable when it leads to a better material decision.

Americhem operates one of the country's most comprehensive dedicated weathering laboratories, combining accelerated and outdoor exposure capabilities with deep formulation, color science, additive, and compounding expertise.

That combination matters because durability issues rarely come from testing gaps alone. They often come from the interaction between material selection, pigments, additives, processing conditions, application requirements, and service environment.

Americhem approaches weathering as part of application-specific material development. The work begins by defining what the product must survive, which properties must be preserved, and where the greatest risk exists in the material system.

From there, Americhem helps customers connect the right testing strategy to the right formulation path. That may mean comparing pigment and additive packages, evaluating stabilization options, supporting qualification, investigating a likely failure mode, or determining whether a material system can meet durability expectations without unnecessary cost or complexity.

Americhem helps customers turn weathering results into practical formulation decisions that support performance, reduce downstream risk, and build confidence before launch.

Material Platforms

Americhem's weathering support is connected to a broad polymer solutions portfolio, including custom masterbatch, functional additives, engineered compounds, and performance compounds. This allows teams to evaluate durability questions in the context of the full material system, including resin selection, color, additive chemistry, processing requirements, and end-use performance.

Weathering & Testing Support

Americhem's weathering capabilities help customers compare material options, evaluate formulation changes, and understand how exposure conditions may affect long-term performance. Testing may include accelerated and outdoor weathering, xenon arc and fluorescent UV exposure, standard or custom test methods, physical and analytical testing, incremental observations during exposure, and access to outdoor exposure sites.

Xenon Arc Testing

For applications where sunlight exposure is a primary concern, xenon arc testing can help simulate key elements of solar radiation under controlled laboratory conditions. Test parameters such as irradiance, black panel temperature, humidity, moisture cycle, and duration can be selected based on the application, material type, and expected service environment.

In the desert exposure example, a modified AATCC TM 169 Option 3 cycle was used to approximate a dry, high-UV environment similar to Phoenix, Arizona. Xenon arc testing can help compare materials and formulations, evaluate color and gloss retention, and support decisions about whether additional testing, such as mechanical retention or sand erosion evaluation, may be needed.

Material Platforms
- Custom Masterbatch
- Functional Additives
- Engineered Compounds
- Performance Compounds

Weathering & Testing Support
- Physical and analytical testing
- Standards and custom test methods
- Access to outdoor exposure sites
- Accelerated and outdoor weathering
- Incremental observation during testing
- Xenon arc and fluorescent UV exposure

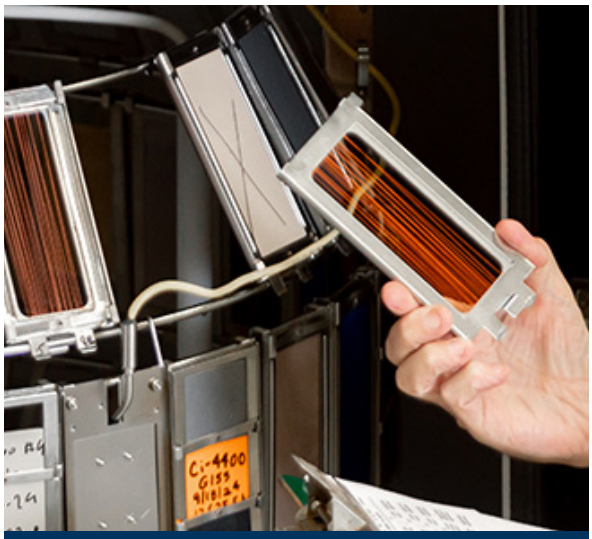
CONCLUSION: BETTER DURABILITY DECISIONS START EARLIER

The greatest opportunity to improve long-term durability exists while material selection, formulation, and design decisions can still change.

When used early, weathering becomes a development tool. It helps engineers compare material systems, identify likely failure risks, and make more confident decisions about performance, cost, and risk.

Addressing weathering earlier can also help reduce downstream issues, including costly redesigns, qualification delays, customer complaints, warranty risk, supply disruptions, and long-term performance concerns.

Long-term product performance begins with a clear understanding of what the material must survive, which properties must be preserved, and how each decision supports durability in the final application.



KEY TAKEAWAYS

1. **Durability decisions start early.**
2. **Weathering is more than UV exposure.**
3. **Accelerated testing is a decision-making tool.**
4. **Test methods should match the application.**
5. **Careful alignment early reduces downstream risk.**

MEET THE AUTHORS

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Roger Threadgill leads fiber technology development and maintenance, along with research and product development at Americhem. His experience spans product design, technical service, formulation, raw material evaluation, quality control, and fibers research and development.

Kayla Riebe
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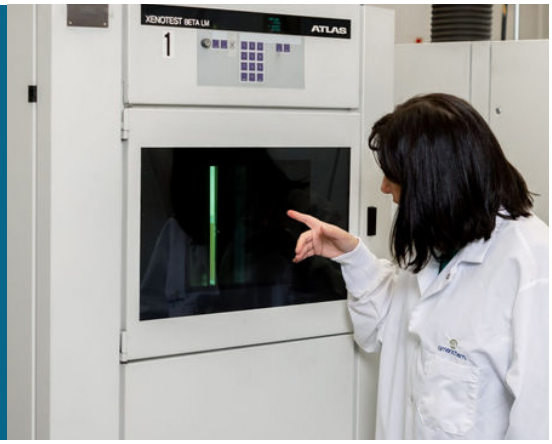
Kayla Riebe manages Americhem's weathering laboratory and supports global testing programs across a wide range of polymer applications. Her work focuses on accelerated weathering, material performance, and technical evaluation.

Ready to collaborate?

Contact Americhem to discuss the service environment, performance priorities, and weathering strategy for your next polymer application.



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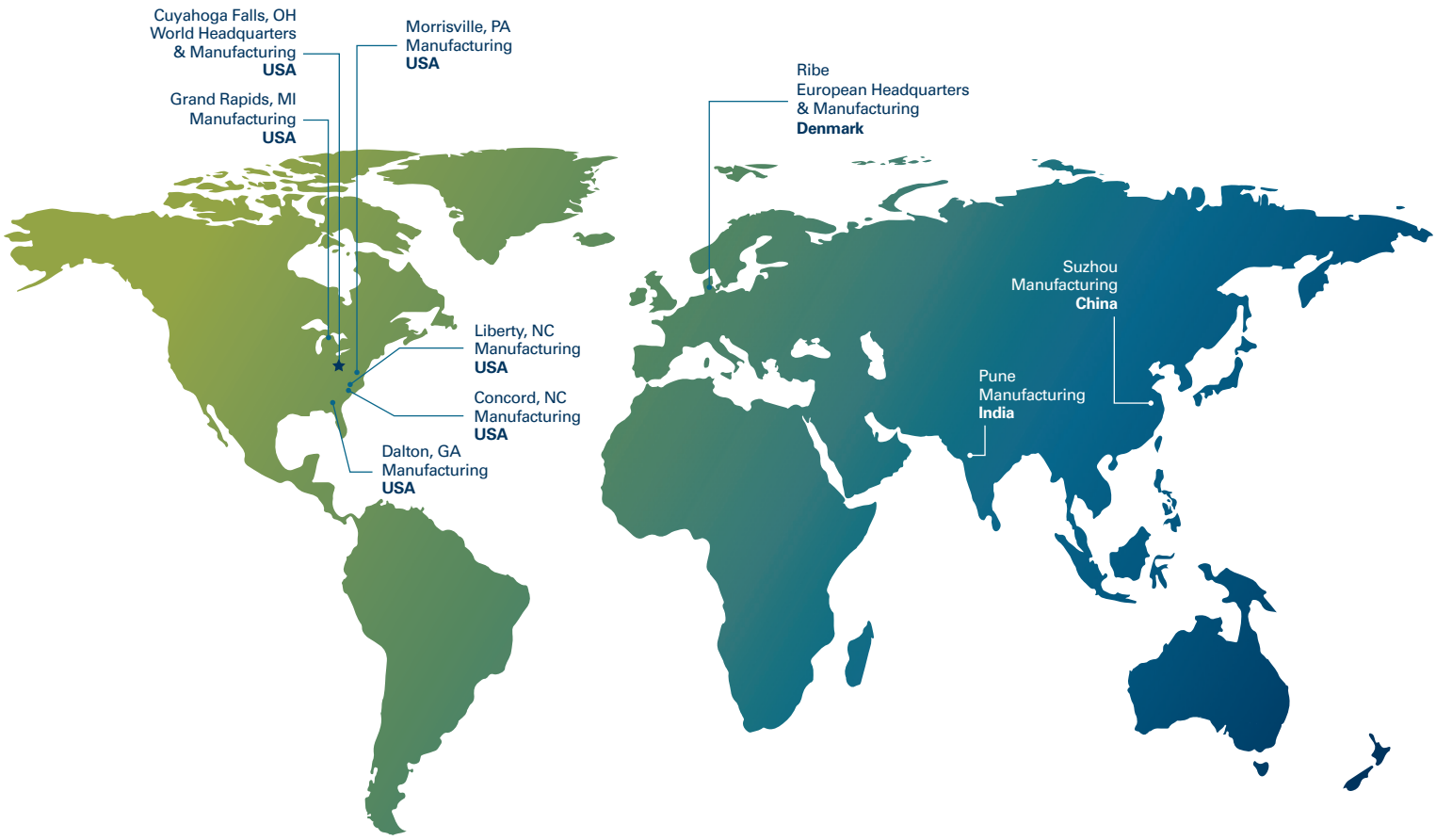

BATCH TO BATCH.
MARKET TO MARKET.
CONTINENT TO CONTINENT.

From our headquarters in Cuyahoga Falls, Ohio, to our manufacturing locations and sales offices across the world, our expansive footprint provides global reach for your organization's needs. Not only are we dedicated to getting your materials where they need to be, when they need to be there, we work behind the scenes to reduce your supply risks. In addition to our network of plants, regulatory and compliance teams, we have contingency plans and support services in place to secure your product against unforeseen interruptions.

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