Shakespeare Composite Structures

2/10–2005

The facts Regardless of who makes it or how it's made, unprotected polyester fiberglass resin will deteriorate over time in strong UV light from the sun. This problem is easily controlled and greatly reduced, however, by application of UV-blockers and sophisticated coatings to the finished goods. The resulting composite poles and crossarms will continue to be structurally sound long after other types of materials have gone to the scrap heap. It's important to remember that UV affects only the appearance of Tuff-Poles®, not the structural qualities, and we go to great lengths to minimize the aesthetic changes.

The Manufacturing Process All of Shakespeare Composite Structures Tuff-Poles and crossarms are protected with an integrated system of weather blockers in both resin and coatings. The components of the system will stand alone, but they work together for best, longest lasting results. Our Tuff-Pole technology incorporates UV absorbers into the basic resin formulations, so that even if the resin subsurface is exposed it will stand up to UV assault for some time. Our smooth-finish and veil-finish (unsanded smooth) poles have an additional resin-rich, non-woven, polyester veil cloth surfacing medium. All Tuff-Poles and Lewtex crossarms have a thickness-controlled, UV-absorbing, polyurethane coating for further protection from fiber exposure. The result is a systematic approach to protection from weathering with scientifically tested, provable results.

Sunlight/UV Exposure Test Results Shakespeare Composite Structures tests its weather-blocker protection system in accordance with the American Society for Testing and Materials (ASTM) G154, Standard Practice for Operating Light and Water Exposure Apparatus for Exposure of Non-Metallic Materials using a fluorescent UV-condensation apparatus. (See Performance Testing and Verification for details of the test setup). The testing equipment mimics a very severe Florida-level environment. Among scientists, Florida is the international benchmark for durability testing of materials because it is considered worst-case and produces faster deterioration than northern climates.

Under these conditions, Shakespeare composite poles and crossarms exhibited no fiber exposure, crazing, chalking or color change within a 2,500-hour test period. Further accelerated tests have substantiated our products' UV weathering abilities beyond 15,000 hours. Shakespeare has also conducted extensive accelerated testing by other means, including a 996-day test utilizing the EMMAQUA sunlight concentrating machine in the Arizona desert (ASTM G90-91 Procedure B). In addition, our engineers have been able to observe real-time, real-world weathering effects on our products that have been in service for more than 35 years.

Left: Installed along a driveway at Shakespeare Composite Structures' Newberry, South Carolina, factory more than three decades ago, this composite pole is one of the many real-world, real weather, real sunshine tests our engineers have studied over a long time. Still as sturdy as it was when installed, the pole was taken down at the end of 2004 to make room for factory upgrading and renovation.

Right: Shakespeare Composite Structures' Lewtex® Composite Crossarms on a Shakespeare composite pole.

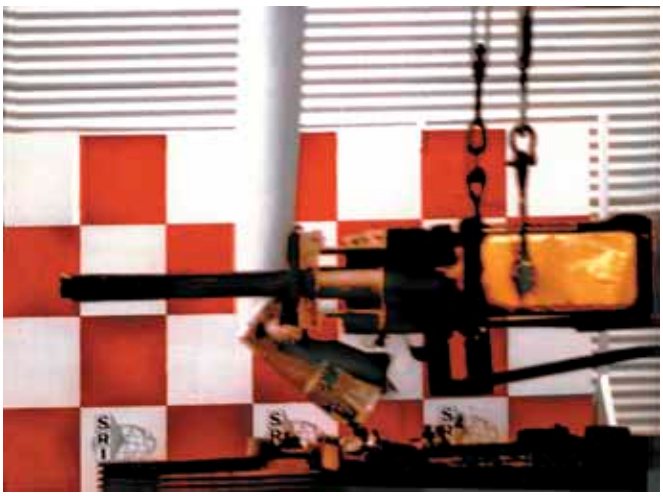
Moisture/UV Exposure Test Results Using the accelerated testing guidelines of ASTM G154, Shakespeare composite poles were exposed to saturated air and water vapor on one side of the specimens and cooling ambient room air on the other, further mimicking Florida's climate.

Under these conditions, the poles exhibited no fiber exposure, crazing, chalking or color change within an accelerated 2,500-hour test period.

According to ASTM D-2565, using a water-cooled xenon arc light source with alternating periods of water spray, the composite pole material underwent 7,000 hours of testing with no significant change in appearance.

Experience has shown that materials initially resistant to UV alone or to moisture alone can fail when exposed to UV and moisture in combination. For this reason, the accelerated testing per ASTM G154 also includes exposure to saturated air and water vapor on one side of the specimens being tested, and exposure to cooling ambient room air on the other side.

Applications Shakespeare composite poles are currently resisting the adverse effects of the combination of UV rays and moisture in Louisiana, Hawaii, California, Mississippi and Texas, among other locations.

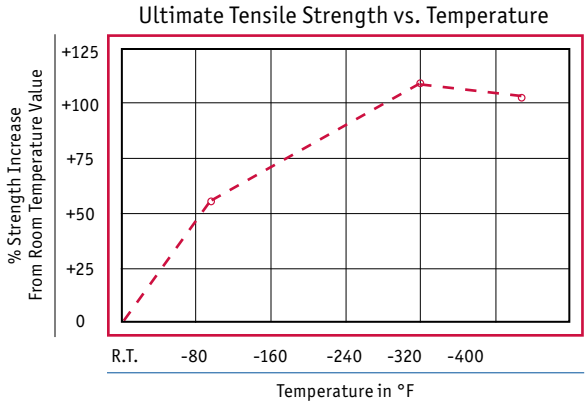


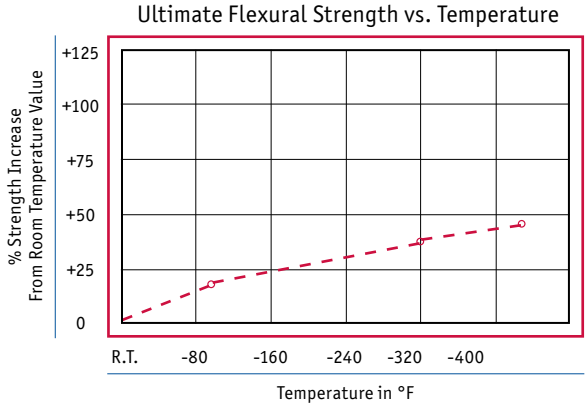
Above right: Fiberglass strands are not affected by UV light. Only the polyester resin that binds the composite is susceptible.

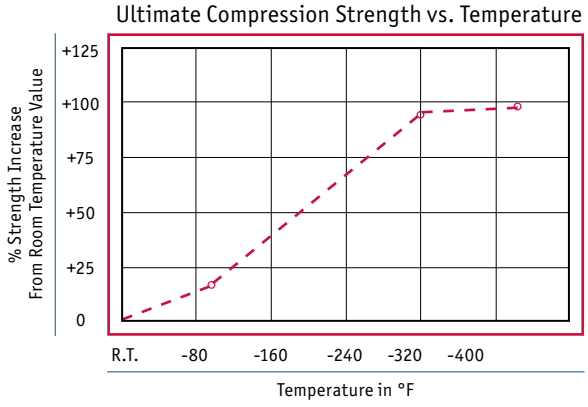
Above left: Pendulum break testing for a large anchor-base Shakespeare Breakaway pole. Our program of scientific testing extends to raw materials as well as finished goods.

Low Temperature Exposure Test Results The following tests of fiberglass-reinforced composite materials were conducted by Owens Corning® Research Labs.

Under temperatures ranging from room temperature to -425° F, scientists attempted to pull apart (tensile), bend (flexural) or compress (ultimate compression) fiberglass-reinforced composite materials in order to induce failure. The results, as cited below, show the percentage of strength increase in cold air.







Above: Shakespeare composite poles replace wooden ones that don't last long under these Alaskan condition.

Applications Shakespeare composite poles are currently resisting the effects of low temperatures in Alaska, Montana, Wyoming, Colorado and near the Arctic Circle, among other locations.

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High Temperature Exposure Test Results Shakespeare Composite Structures engineers have repeatedly tested the Tuff-Pole fiberglass formulations for strength retention when exposed to high temperatures. The temperature inside a pole, particularly a dark-colored one, can be considerably higher than ambient in sunny climates. We put our scientists to work to document the effects of heat on our products, and found no problem well beyond the temperatures you'd expect in a sauna – 200° F. Indeed, the performance is excellent at oven temperature - up to 400° F. When subjected to a standard 5000-lb. load (refer to ASTM D198) additional deflection due to extreme heat was nominal–see chart below.

Strength vs. Temperature

Results of Test

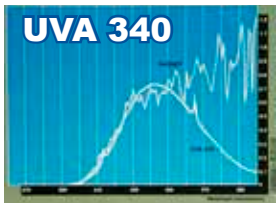
	Temperature F	Deflection @ 5000 lbs.	Efffective MOE
TEST A	72° F	1.15"	$2.1x10^6$
TEST B	200° F	1.24"	$2.0x10^6$

Effective MOE and MOR is computed with the full section of the beam.

Applications Shakespeare composite poles are currently resisting the effects of high temperatures in Florida, Arizona, Texas, California and near the Equator, among other locations.

The Testing Process Shakespeare Composite Structures conducts extensive testing to establish and verify the performance of its products for mechanical strengths, weathering qualities, and conformance to Tuff-Pole standards for finish and sheen. We test the raw materials delivered by our suppliers, and closely monitor the manufacturing processes. Before we make claims about our products' ability to withstand weathering, we test them–thoroughly and scientifically. Extensive testing is performed in-house. In addition, we employ outside independent labs for additional tests.

The most frequent question we're asked is about weathering, including the ability of fiberglass composites to withstand extremes of heat, cold, humidity, UV exposure, and other environmental factors. We are experts on the subject. Since the beginning, we have employed testing methods and a variety of technologies to quantify and greatly extend the outdoor longevity of our composite products. We scientifically test these factors in a variety of ways, in accordance with applicable ASTM standards. However, the most convincing test results come from more than thirty-five years of real-world, real-time observations of our installed products. Over time we refined our resin formulations, specified newer, more durable coatings, and implemented sophisticated, computer-controlled manufacturing technologies, all aimed at delivering quality composite products.



An important point of weathering testing is that UV exposure and weather do not significantly affect the strength of the composites. The poles we made in the 1960's are as strong today as they were when they were installed, and they still look good. With todays technologies, we continue to refine our products, and increase their useful life even further.

Unprotected fiberglass polyester resin no matter who makes it or how it's formulated, will deteriorate over time from exposure to sunlight. That's why Shakespeare engineers have developed a multi-layered weather-beater approach. We incorporate UV inhibitors into the resins' formulation during manufacture, wrap the poles (except "natural" finish) in additional layer(s) of protection, and coat the finished product, including natural finish poles and crossarms, with our specially designed, UV-inhibiting coatings for still another layer of protection. The result is a composite product that easily passes the most rigorous weathering tests, and one which we expect to see–still looking good–many decades from now.

Is it possible to design fiberglass resins that are virtually impermeable to UV? Yes. We've tested technologies which would extend the life of our composites far beyond human lifespans. Unfortunately, those solutions multiply the products' cost by 1,000% or more – far greater than anyone could justify. The "annual owning cost" for an asset should decrease, not increase, with applied technologies. We continue to maximize the results from affordable resins that are field tested to withstand the rigors of time. When other technologies can deliver performance and affordability, we'll be there.

Above: Inside the EMMAQUA concentrated sunlight machine in the Arizona desert, coated and uncoated samples of Shakespeare fiberglass composites on their way to 996 days of exposure to prism/mirror amplified sunlight with intermittent water baths and flows of cooling, drying air.

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Specify product testing standards to get the product you need. We suggest you specify the performance testing you expect when you specify your poles and crossarms. To make your investment pay off, composite poles and crossarms should have been tested in accordance with ASTM standards for a minimum of 15,000 hours of accelerated UV exposure tests.

UV Exposure Testing Shakespeare Composite Structures maintains an in-house accelerated UV exposure testing facility that has been in continuous operation for decades. We perform accelerated weathering tests using UV lamps, concentrated sunlight, and normal sunlight in accordance with scientific standards.

The QUV Test Our engineers perform UV testing in accordance with the American Society for Testing and Materials (ASTM) G154, Standard Practice for Operating Light and Water Exposure Apparatus for Exposure of Non-Metallic Materials using a fluorescent UV-condensation apparatus. The primary testing equipment is the QUV Accelerated Weathering Tester made by the Q-Panel Company of Cleveland, Ohio. This equipment exposes samples to intense UV lamps for a four-hour on, four-off cycle, with sprays of water at intervals. The device is equipped with UVA lamps, which have peak emission at 340 nm. These lamps create one of the most severe exposures used for accelerated UV testing and mimics very highly concentrated Florida-level sunlight. Among scientists, Florida is the international benchmark for durability testing of materials because it is considered worst-case and produces faster deterioration than northern climates. QUV exposure for 1,000 hours (about 6 days) is approximately equivalent to one year of Florida sunshine. Our accelerated testing has been applied to coated and uncoated fiberglass specimens for more than 15,000 hours.

Unlike real sunlight, the lamp's spectrum begins to fall off after 340nm. Therefore, although the emitted spectrum comprises most of the damaging wavelengths, we also conduct tests with both concentrated and natural sunlight. Concentrated sunlight is another way to simulate long-term effects of weathering.

Above right: QUV test machine with some specimen holders removed to show UVA-340 lamps.

Above left: Shakespeare composite specimens approaching 15000 hours of QUV exposure testing (the background) and unexposed control. Most of the color difference is caused by the fact that the tested sample is wet, and the comparison control is dry.

Below right: Shakespeare composite specimens at 7500 hours of QUV exposure testing (the right-hand sample, with aluminum binding taped edges) alongside an unexposed control.

Concentrated Sunlight Testing Shakespeare has contracted with independent test facilities for extensive accelerated testing with concentrated sunlight using the EMMAQUA® sunlight concentrating machine in the Arizona desert (ASTM G90-91 Procedure B). This includes a 996-day test of coated and uncoated sidewall samples from our Lewtex® crossarms.

The EMMAQUA system comprises a mirror system on a motorized platform that tracks the sun, just as telescopes track the stars. The result is about five times the normal exposure to sunlight. The systems also impose heating/cooling cycles and intervals of water spray to mimic weather, dew, and rain.

Natural Sunlight Tests Since the beginning, we have continuously tested our fiberglass products and coatings at our plants with natural sunlight in South Carolina and Florida. This test entails a rack on which samples are mounted at a angle which optimizes exposure. Such testing has been ongoing at our factory in South Carolina for more than 35 years. In addition, our engineers have been observing and documenting real-time, real-world weathering on our products that have been in service for more than 35 years.

Xenon light source Test According to ASTM D-2565, using a water-cooled xenon arc light source with alternating periods of water spray, the composite pole material underwent 7,000 hours of testing with no significant change in appearance.

Above right: EMMAQUA machine in the Arizona desert.

Above left: Shakespeare specimen after 996-day EMMAQUA exposure, along with unexposed control sample.

Below right: Polishing operation for a Shakespeare smooth composite pole. These poles, as well as veil finish (un-sanded) receive an additional non-woven, resin-soaked winding that further extends UV life.

Applications Shakespeare composite poles are currently resisting the adverse effects of the combination of UV rays and moisture in Florida, Hawaii, California, Mississippi and Texas, among other locations.