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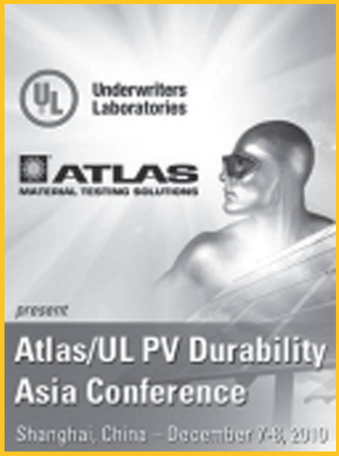

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Ultra-Accelerated Weathering System (UAWS) I: Design and Functional Considerations

By Henry K. Hardcastle, Atlas Material Testing Technology LLC; Gary J. Jorgensen, National Renewable Energy Laboratory; and Carl E. Bingham, National Renewable Energy Laboratory

This article was previously published in its entirety in CoatingsTech, *August 2010, "Ultra-Accelerated Weathering System I: Design and Functional Considerations."*

Introduction

Ultra-accelerated approaches to weathering testing differ significantly from prior approaches of "real-time" (non-accelerated) and "moderately accelerated" weathering test methods. In real time weathering, test specimens are directly exposed to weather in end-use or worst-case end-use environmental conditions. Test specimens mounted on racks that directly face the sun in South Florida or Arizona represent real time, non-accelerated exposures.

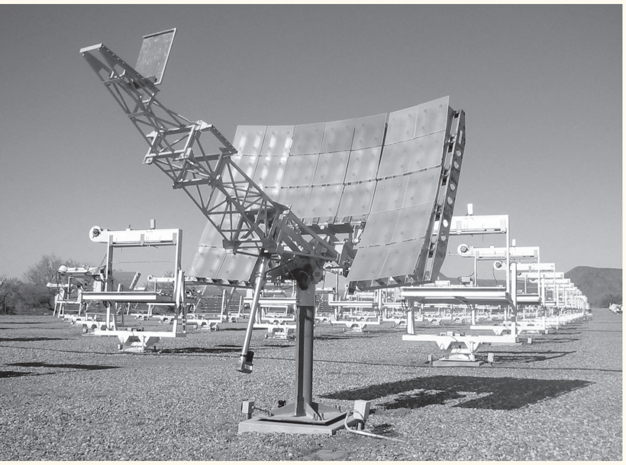

Figure 1: Ultra-Accelerated Weathering System (UAWS) installation, Arizona

Moderately accelerated techniques typically accelerate UV radiant exposures between two and 10 times over real time South Florida exposures. A historical average for an outdoor South Florida 5° global southern exposure is approximately 300 MJ/m2 UV (295–385 nm) per year. An average for moderately accelerated (~2X light intensity) artificial xenon exposure per SAE J2527 [1] is approximately 1040 MJ/m2 UV (295-385 nm) per year. A historical average for moderately accelerated natural exposure per ASTM G90 [2] is approximately 1500 MJ/m2 UV per year.

Ultra-accelerated weathering techniques attempt to dramatically increase the UV radiant exposure per unit time over what is attainable with current moderately accelerated techniques. However, a critical constraint

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ATLAS SHOWS

2010

K-Show 2010
Düsseldorf, Germany
October 27–November 3

Eurocoat
Genoa, Italy
November 9–11

Vietnam Hanoi Textile & Garment Industry Expo
Hanoi, Vietnam
November 10–12

2011

SIAT 2011
Pune, India
January 19–21

India Coatings Show
New Delhi, India
January 28–30

SSPC 2011
New Delhi, India
January 31–February 3

Expo Solar PV Korea
Seoul, Korea
February 16–18
Booth G-77

Knit Tech
Tirupur, India
February 18–21

SNEC PV Power Expo
Shanghai, China
February 22–24
Booth E3-107

PV Expo Japan
Tokyo, Japan
March 2–4

European Coatings Show
Nuremberg, Germany
March 29–31

Photovoltaic Technology Show Europe
Stuttgart, Germany
April 5–7
Hall 4, Booth C8

Green Energy Expo
Daegu, Korea
April 6–8
Booth A945

Vietnam Saigon Textile & Garment Industry Expo
Ho Chi Minh City, Vietnam
April 8–11

Asia Coatings Conference
Ho Chi Minh City, Vietnam
May 18–19
Booth 49

Korea Lab
Seoul, Korea
June 14–17

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Fundamentals of Weathering I	November 4	Paris, France	*Presented in French*
	November 16	Pretoria, South Africa	*Presented in English*
	December 1	Leipzig, Germany	*Presented in German*
Fundamentals of Weathering II	November 5	Paris, France	*Presented in French*
	November 17	Pretoria, South Africa	*Presented in English*
	December 2	Leipzig, Germany	*Presented in German*
Online Webinars*	November 4	Successful Weathering Testing (Free)	
	November 9	Weathering Design of Experiments (Weathering DOEs) (US$95/70 Euros)	
	November 10	Ultra Accelerated Weathering (US$95/70 Euros)	
	November 11	Durability\Reliability Across the PV Development Chain (US$95/70 Euros)	
	November 16	Environmental Durability of Photovoltaic Modules (Free)	
» *Special Start Time:* 19:00 CST »	November 18	Environmental Durability of Photovoltaic Modules (Free)	
	November 23	Correlation Between Natural & Artificial Weathering (US$95/70 Euros)	
	November 30	Understanding the Relation of Reliability, Durability, & Weatherability (Free)	
	December 1	Pharmaceutical Photostability Testing Small and Large Molecules According to ICH Guidelines (Free)	
	December 2	The Factors of Weather and Weathering Testing of Polymers (Free)	
	December 14	Weathering Design of Experiments (Weathering DOEs) (US$95/70 Euros)	
	December 15	Understanding the Relation of Reliability, Durability, & Weatherability (Free)	
	December 16	Status of Current Weather Durability Testing of Photovoltaics (Free)	

**All webinars start at 9:00 am CST (3:00 pm GMT) unless otherwise noted*

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becomes apparent at these intensities: the material exposure temperature is a co-variable of the increased light intensity, and moderately accelerated techniques have been limited by maximum allowable exposure temperatures for many materials [3,4]. Therefore, ultra-accelerated methods must include alternative specimen temperature management not found in real time or moderately accelerated techniques.

The objectives of the UAWS project were not simply a matter of exposing materials to high irradiance. It is a fairly simple task to increase the exposure light intensity by moving specimens closer to artificial sources and use the inverse square law or exposing materials to multiple light sources or more reflected images of the sun. The real challenge this project addressed was exposing test specimens to ultra high irradiances with high fidelity to natural solar spectra without burning or melting the test materials or otherwise introducing unrealistic thermal damage.

The system that was developed is an outdoor accelerated weathering device. As such, it must be robust enough to use in the outdoor environment and able to withstand weathering elements with a high degree of reliability. The intensity on specimens needed to be approximately an order of magnitude greater than conventionally accelerated weathering devices in order to study highly accelerated radiant exposures and the effects of significantly greater intensities. To achieve this, the design needed to attain a direct normal optical concentration factor of approximately 100:1 (defined as the ratio of the area of the highly reflective facets to the target area). The reflecting facets needed to have high spectral reflectance in the solar UV spectra and not excessively distort the solar spectrum being reflected.

Gerlock, Nichols, et al. at Ford Research have shown the possible consequences of unnatural UV spectra on photochemistry of degrading automotive coatings [5]. Temperature is a critical constraint in high intensity weathering exposures. The system could not excessively heat the specimens. Heat distortion, exceeding onset of glass transition, melting, burning, and other heat and temperature related effects often present the most challenging difficulties for accelerated weathering test systems. The system developed and used for this paper is shown in Figure 1.

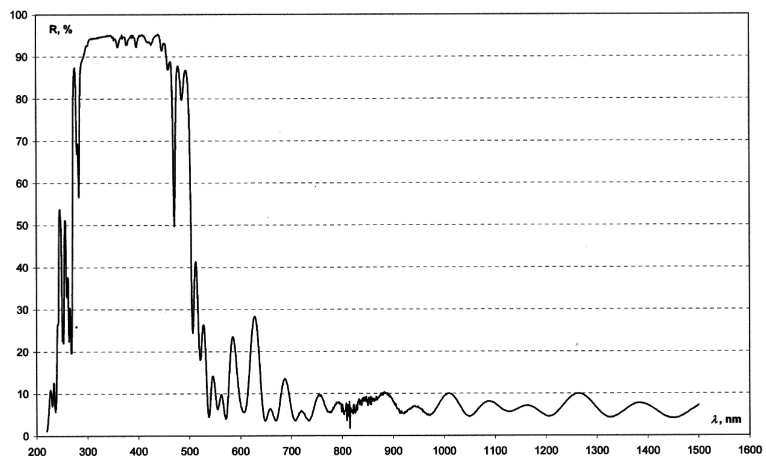

Figure 2: Reflectance spectrum of mirror face

Structure

Reflective Facets

By far, the most critical components of the system are the reflecting facets. Each reflecting facet of the system utilizes a 96-layer selective reflective coating. The coating technology used was based on conventional electron beam evaporation for deposition of interference coatings. The coating utilized a system of several quarter-wave interference reflectance packages, each consisting of alternating layers of materials with high and low refractive indexes. The absolute reflectance spectra obtained from this process is shown in Figure 2.

The key operating characteristics of the reflective interference coating included 1) providing extremely high reflectance in the UV portion of the solar spectrum responsible for photo degradation of test materials, 2) attenuating near infrared (and long wave visible) portions of the solar spectrum, contributing to thermal loading but not photo degradation of test materials, and 3) providing a robust reflective surface for outdoor use.

The 96-layer reflective coating was applied to 29 glass focusing elements formed from K-8 borosilicate crown glass. Each facet was ground (prior to coating deposition) and polished to a 10-meter radius and bevelled along the edges. Three attachment points for mounting and

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alignment were ground into the back of each facet. Figure 3 shows the construction for the reflective facets.

Attachment/alignment hardware was attached to the back of each reflecting facet, which allowed stable attachment to the concentrator structure as well as independent adjustable alignment of each facet.

Concentrator

The concentrator, designed and constructed by the Institute for Laser Optical Technology, is the assembled group of facets which collects sunlight and reflects and concentrates the light onto the target area. The concentrator was designed to hold the facets in a position approximating the concave surface of a 10-meter sphere. The supporting frame for the mirror facets included design elements that resulted in a radius in both horizontal and vertical axes. The 29 reflecting facets were then attached to the support structure using the three point attachment/alignment hardware. In order to accommodate the curvature of the support structure and facet interference, four of the facets were slightly trimmed. The resulting collector structure is shown in Figure 4. The focused beam in the target plane is shown in Figure 5.

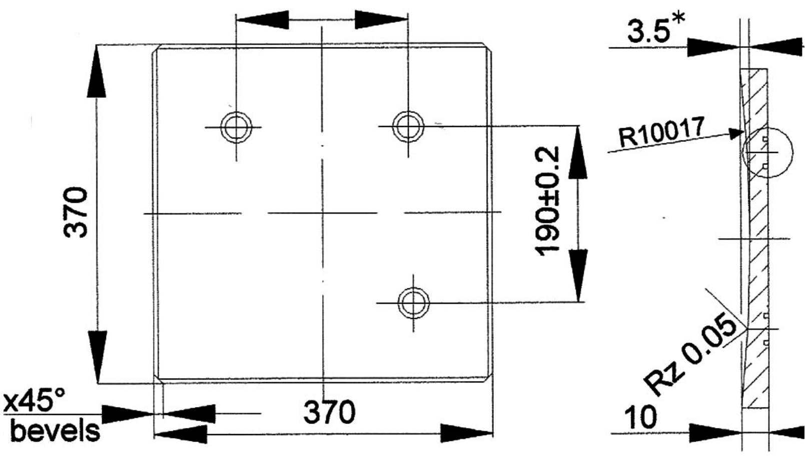

Figure 3: Reflective element construction (units in mm)

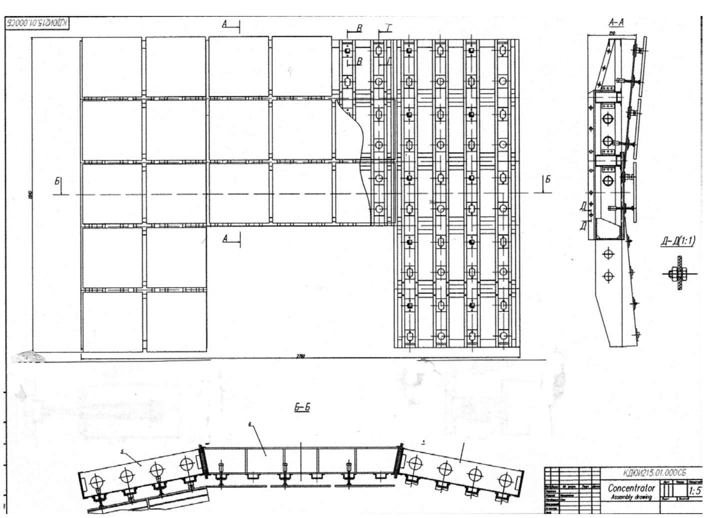

Figure 4: Collector support structure construction

Target Area

The 10-meter radius of each reflective facet and the 10-meter radius concave shape of the facet support structure result in a focusing optical system with a focal length of approximately 5 meters. In order to achieve the 100:1 direct normal concentration factor, specimens were mounted approximately 2.5 meters toward the focal point from the collector. In order to accommodate this position, a target area support arm was constructed and attached to the concentrator structure so the entire system could be aligned with and track the sun. In this configuration, this results in a 150 x 150 mm square target area with approximately 100:1 direct normal optical concentration.

At 2.5 meters from the reflector toward the focal point, the target area support arm has hard point attachments to accommodate a variety of specimen mounting devices. This flexible attachment platform can accommodate a variety of specimen target fixtures and thus provide a customizable testing platform for a variety of materials, mounting configurations, and research program requirements. Some of these configurations so far have included mounting specific for radiometric instruments, backed and unbacked specimen mounting, front clamping specimen fixtures, air cooled targets, backside water cooled mounting surfaces, multiple target area fixtures, and specially constructed environmental chambers. Electrical power, temperature measurement thermocouple wires, chilled water, and a vacuum have been successfully delivered to the target area via service feed lines along the target area support arm. Axial blowers and beam attenuators have also been successfully mounted to the target area support arm. This flexibility is an important aspect for accommodating the wide range of material types submitted for a variety of accelerated testing programs.

The concentrator and target area support arm are mounted on a high accuracy, commercially available solar tracking system which orients the tangent of the concentrator normal to the solar disc throughout the day (the system is not operated under cloudy conditions). The first device is installed and currently operating at Atlas' DSET laboratories (34°N, 112°W).

Uniformity in Target Area

A series of flux maps were generated at the Atlas Testing Services Arizona site to characterize the aiming and flux distribution of the UAWS. A 355 x 460 mm flame-sprayed alumina plate was used as the target. The flux mapping system consisted of a camera, a lens, and a frame grabber board, along with Beamview software from Coherent. The system provided the estimates of target uniformity shown in Figure 6.

The image on the left is a contour plot of the target, showing the brightness of the image, which is related to the flux intensity. The white square inscribed in the image is the nominal 150 x 150 mm target area for samples. The 3-D image is portrayed on the right side. With all facets uncovered, this represents the full 100X of the UV spectrum. Using the Beamview software, the standard deviation of the uniformity of the intensity inside this box was +/- 4.6% of the mean.

Figure 5: Reflective facets, collector structure, and focused beam in target area

Function

Radiometry

Material changes are typically measured as a function of light exposure. Material degradation behavior is usually characterized as a degradation curve with change in property on the y-axis and UV radiant exposure on the x-axis. Radiometry is typically a key part of weathering studies and must be carefully and correctly considered.

The direct normal UV irradiance, multiplied by the UV reflectance of the facets, multiplied by the number of facets, multiplied by the concentration factor of each facet is used to calculate the irradiance in the target area. The instantaneous irradiance multiplied by duration of exposure results in the radiant exposure of the exposed specimens in the 295–385nm spectral region expressed in MJ/m^2.

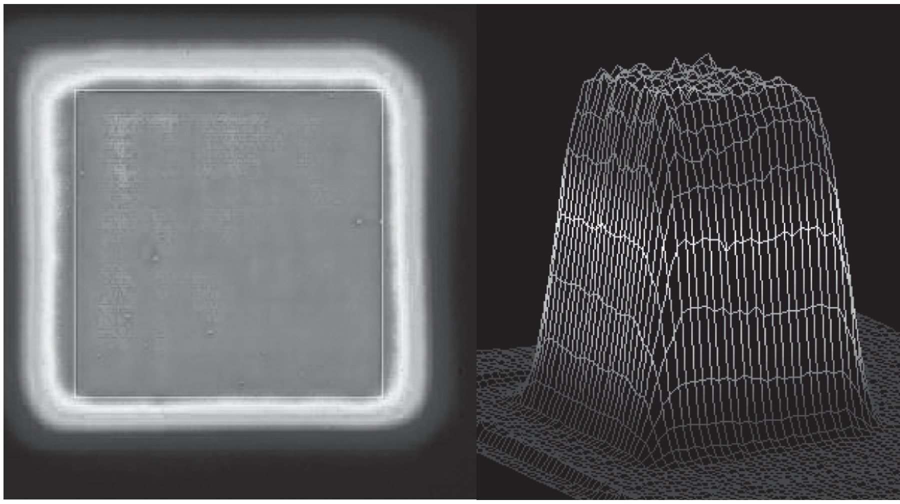

Figure 6: Images from flux uniformity measurements

The general calculated approach to properly deal with accelerated levels of radiant exposure has been developed, prescribed, and well documented by the standards community. The only adaptation needed here is to account for the concentration due to focusing optics. The infrastructure at Atlas and National Renewable Energy Laboratory (NREL) already exists to use this method. The method is theoretically sound and has been successfully confirmed with empirical measurements.

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Using these concepts, it is possible to calculate expected radiant exposure using the UAWS as well as compare radiant exposure rates using the UAWS with non-accelerated and moderately accelerated exposure methods. For example, from historical observations, the Arizona laboratory averages approximately 162 MJ/m² UV direct normal radiant exposure per year. Based on the above calculation using 28 facets, 0.95 UV reflectance, and an optical concentration of 4, the device may average approximately 17000 MJ/m² UV in the target area per year.

For comparison, real-time Florida historical observations indicate approximately 275 MJ/m² UV radiant exposure on a 45° facing south-facing surface in a single year. Dividing the potential average yearly UV radiant exposure using the ultra-accelerated device by the historical average yearly UV radiant exposure on 45° south in southern Florida (17000/275), results in a radiant exposure acceleration factor of approximately 63. Based on these assumptions, it appears possible to obtain 63 years 45° South Florida equivalent UV radiant exposure in a single year exposure on the ultra-accelerated device. Similar comparisons indicate it would take approximately 13 to 17 years in a xenon arc exposure using SAE J2527 (depending on settings and assumptions) to achieve the same radiant exposure as a single year on the ultra-accelerated device. Likewise, it would take approximately 13 to 14 years using current ASTM G90 exposures (depending on historical averages) to achieve the same radiant exposure as a single year on the ultra-accelerated device.

Exposure Temperature

Exposure temperatures for specimens undergoing ultra-accelerated weathering are a complex function of material characteristics and exposure conditions. Therefore, the actual temperature a specific specimen will achieve during ultra-accelerated exposure will be partly material dependent and partly exposure dependent.

The UAWS exposure temperatures for black coatings were compared to direct normal (DiNor) natural exposure temperatures using "T" thermocouples welded to automotive grade steel paint panels measuring approximately 150 x 100 x 0.76 mm. The thermocouple was welded to the exposed surface of black panels. Panels were then sprayed with primer and highly absorbing black paint.

Some of the panels were mounted direct normal to the sun in backed condition (mounted on plywood) while another was trimmed to approximately 75 x 55 mm and mounted in the target area of the UAWS backed by a water-chilled cooling platen. Cooled water was circulated to the cooling platen to allow for backside conductive cooling of the black panel. The cooling water was set for the system's minimum temperature to provide data on the minimum temperature capability of the system compared to natural exposure temperatures of the black panels.

Panels were simultaneously exposed to the sun on May 18, 2009. Full ultra-accelerated capability (28 facets) was used to reflect the UV light onto the exposed black

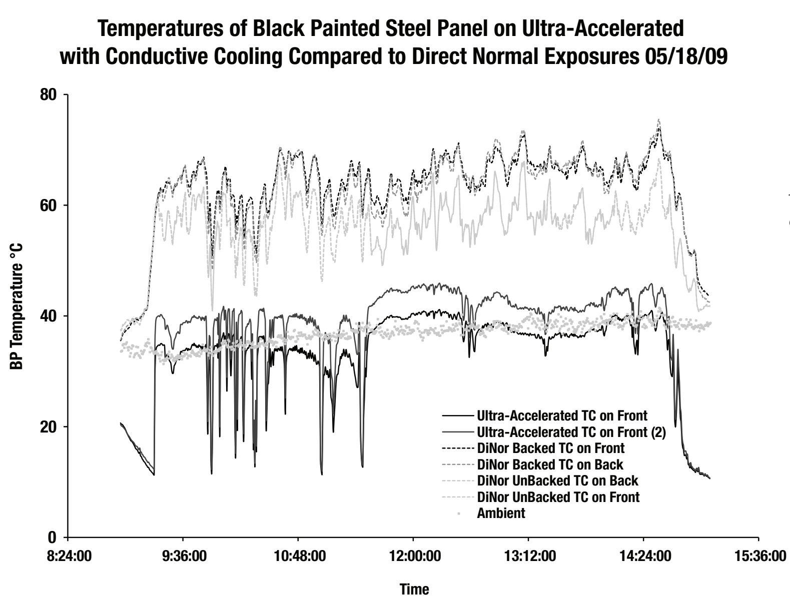

Figure 7: Ultra-accelerated and direct black panel temperatures

panel mounted on the water-chilled cooling plate. The temperature observations are shown in Figure 7. The data indicate the black panels on ultra-accelerated exposure ran close to ambient air and well below the temperatures of black panels on direct normal backed exposure.

Correlation and Acceleration

Typically, whenever a new weathering technique is developed, the first step is to show correlation with outdoor real-time exposures as well as the acceleration capability. For this initial correlation and acceleration study, the European standard reference material ORWET, produced by EMPA, was used. ORWET is a pigmented thin film on aluminium substrate, a paint of melamine resin with a Ciba pigment. The ORWET standard reference material has been highly characterized for color change as a function of UV radiant exposure and is specifically designed to be used as a reference material for testing weathering methods [6]. The material exhibits rapid color change related to UV radiant exposure.

A simple comparison of different types of exposures with ORWET shows correlation as a function of radiant exposure and acceleration as a function of time of exposure (days). The correlation data indicates how well the new device simulates the natural degradation function. The acceleration data indicates how fast the device performs the simulation. A specific material's degradation function is highly dependent on the material's characteristics, thus degradation functions for a model standard reference material may not be indicative of other materials with different characteristics. References 7–13 show examples of other materials under ultra-accelerated exposure.

Specimens of ORWET were exposed unbacked, oriented 5° south to real-time exposure in South Florida and Arizona during summer 2008 at Atlas Testing Services Florida (25° 52′ N, 80° 52′ W) and Arizona (33° 29′ N, 112° 8′ W) outdoor exposure laboratories in accordance with ASTM G7-05. Additional specimens from the same lot were also exposed to natural moderately accelerated exposure at the Arizona site in accordance with ASTM G90-05 with approximately the same start time as the real-time exposures. UV radiant exposure was measured in accordance with G90 and G7 ASTM standards. Additional specimens from the same lot were also exposed during fall 2008 using the UAWS device installed at Atlas' Arizona site.

Ultra-accelerated exposure specimens were mounted backed with the same cooling block used to obtain the black panel temperatures shown above. UV radiant exposure was measured as previously described in this paper. Throughout the exposures, specimens were removed intermittently, measured for color change (Delta E) in reflectance, and replaced to continue exposure. The correlation graph showing color change as a function of UV radiant exposure comparing the different exposure types is shown in Figure 8.

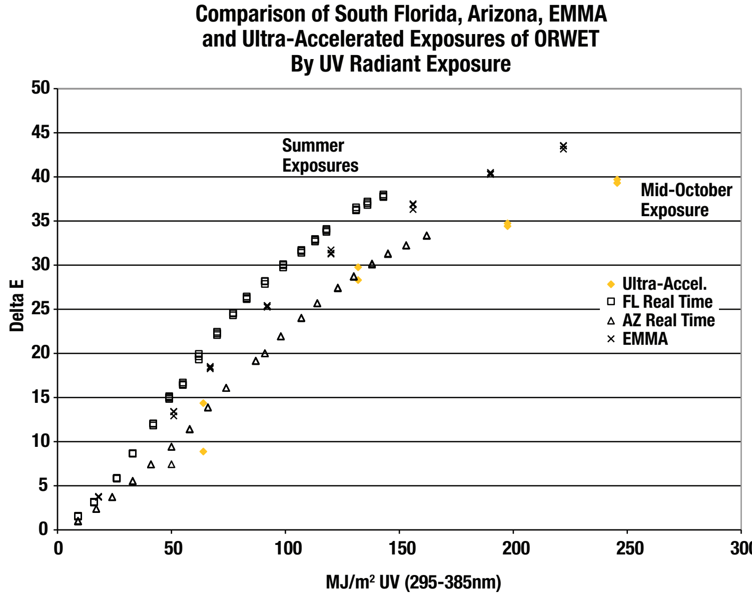

Figure 8

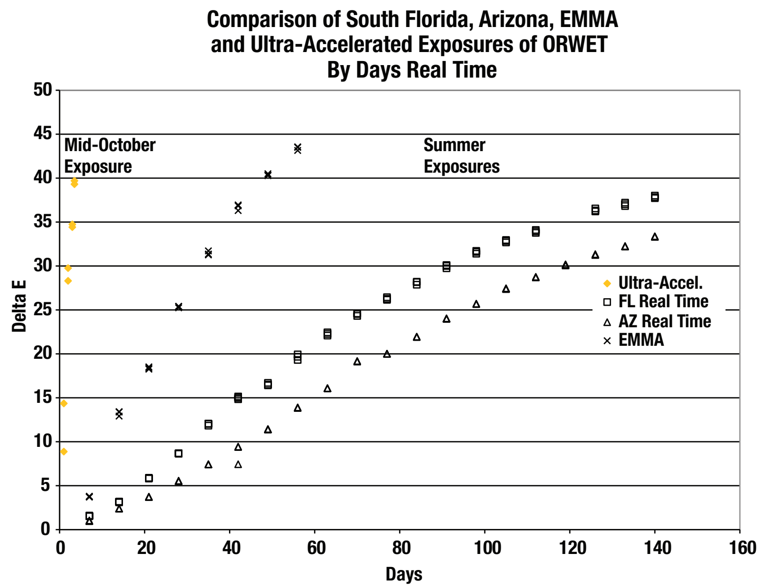

Figure 9

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The acceleration graph showing color change as a function of days of exposure comparing the different exposure types is shown in Figure 9.

The correlation demonstrated in Figure 8 has a number of significant implications. First, the color change of the standard reference material coating ORWET is approximately correct at ultra-accelerated rates compared with the Arizona natural exposure. This is an impressive result because the conventional wisdom has been that organic coatings could not be realistically and confidently tested at more than about 10 suns because of difficulties associated with adequately controlling sample temperature. Consequently, very abbreviated testing times can be substituted for long-time exposures at low intensity levels, as shown in Figure 9 for this material. References 7–13 seem to indicate ultra-accelerated testing may be successfully used with other materials as well. If verified for specific material characteristics, ultra-accelerated weathering could allow much shorter development cycle times for new products; manufacturers would not be forced to wait months or years to ascertain if prospective coating systems would exhibit adequate UV radiant exposure durability. This could provide a vital competitive advantage to such manufacturers and result in greatly improved new products.

Summary

Accelerated weathering exposures must be preceded with real-time, end-use, or worst-case end-use weathering exposures. Without such a base line for comparison with accelerated weathering results, highly questionable inferences and inappropriate extrapolations will result. Additionally, weathering data from a variety of sources should be used to make critical decisions about a material's weathering durability. These considerations are especially important, as industries demand ever higher acceleration rates for material weathering testing.

Due to industry demand, a commercial scale ultra-accelerated weathering system has been developed, allowing materials to be exposed to new levels of natural UV radiant exposure. Using this system, it is now possible to expose specimens to approximately 63 years 45° South Florida UV radiant exposure equivalent (or 56 years 5° South Florida UV radiant exposure equivalent) within a single year. Additionally, ultra-accelerated exposures can be conducted using natural solar spectra while maintaining appropriate specimen exposure temperatures for many material types.

The UAWS has been installed and successfully used. Initial data indicates a potential for correlation with real-time exposure at ultra-accelerated degradation rates for some materials. Additional verification exposures using different materials as well as system modifications for introducing moisture and other weathering variables are warranted by the results and planned for the near future.

For more information, please contact Henry K. Hardcastle at khardcastle@atlas-mts.com.

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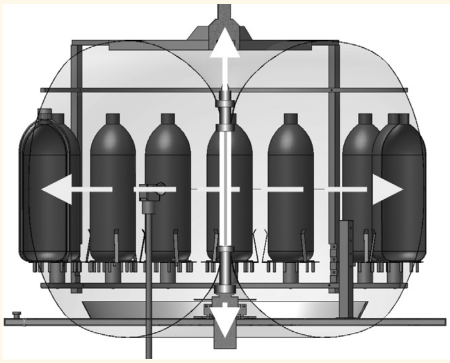

Atlas® Leads the Way in Rack Systems

Specimens ranging from panels* to full photovoltaic modules can be found on Atlas exposure rack systems around the world. Designed for a wide variety of applications, these versatile racks can be fastened to the ground or a rooftop, or even moved from place to place.

Upgrades in Atlas' racks in 2009 improved on the conventional rack designs typically used in the weathering industry, including:

- An ergonomically friendly cam-lock design to replace the flap assembly's traditional wing-nut fasteners
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- Mini-racks for clients who have limited space

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* *A panel is any flat specimen up to 305 mm (12 in) along one edge.*

Don't miss these talks by Atlas representatives:

Bewitterung von Kunststoffen in der Automobilindustrie
Wuerzburg, Germany | February 16–17, 2011

Grundlagen der witterungsbedingten Alterung
Presented by: Cees van Teylingen | February 16, 9:10 am (GMT+1)

Simulation der Sonneneinstrahlung bei der Bewitterungsprüfung – neue Technologien und Normung
Presented by: Dr. Artur Schoenlein | February 16, 2:00 pm (GMT+1)

26. Symposium Photovoltaische Solarenergie
Bad Staffelstein, Germany | March 2–4, 2011

Beschleunigte Alterungsprüfung für PV-Module – Herausforderungen und Lösungswege
Presented by: Andreas Riedl

European Coatings Congress
Nuremberg, Germany | March 30, 2011

System for deterministic acceleration of laboratory weathering
Presented by: Dr. Mkrtych Khudaverdyan | March 30, 4:00–4:30 pm (GMT+2)

Atlas® Mourns Loss of Company Pioneer

Robert Voelman

May 7, 1946–April 22, 2010

Rob Voelman, one of Atlas' leading entrepreneurs, died in April at the age of 63.

A gifted businessman, Rob started his Atlas career in the 1970s with THK, the company's Dutch representative in Lochem, The Netherlands. His drive for growth, as well as his close relationship with the Lane family (owners of Atlas until 2007), led to the founding of European subsidiary Atlas/SFTS BV in 1982. He played the lead role in Atlas' subsequent expansion into Europe, opening offices in Germany (1984), France (1984), and Switzerland (1992).

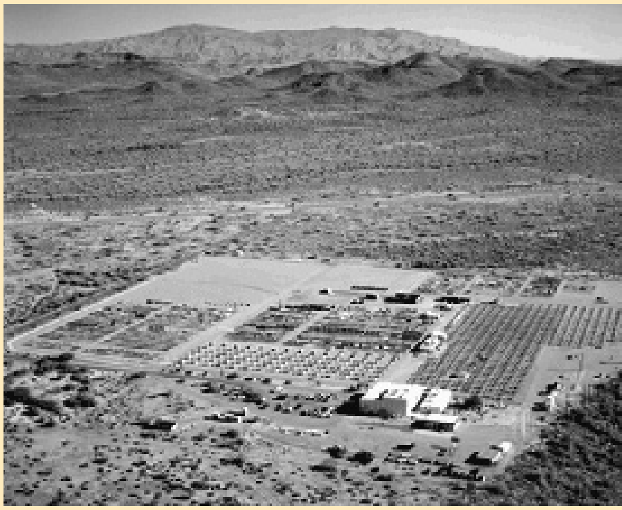
With close customer relationships and a keen understanding of the industry's needs, Rob was influential in the technological development of new lightfastness and weathering instruments. His ambition to expand the weathering market led to the acquisition of K.H. Steuernagel, which added solar simulation equipment to Atlas' product offerings.

He also recognized the importance of offering weathering services alongside weathering instruments. Consequently, Atlas developed test laboratories in The Netherlands and Germany, and built outdoor exposure sites in the Dutch cities of Lochem and Hoek van Holland, as well as in the Bandol region in the south of France.

In 1995, Rob guided Atlas toward the acquisition of the Xenotest® product range from Heraeus. Later, he played an important role as Atlas established a presence in India. In a joint venture with Seifert, the first Seifert-Atlas offices were opened in that country in 1998. In 2002, Atlas pushed on as an independent company with offices in different regions throughout India.

Health problems forced Rob to retire in 2004. He enjoyed post-retirement life and embraced spending more time with his family. With his death, we lose a beloved colleague, a mentor, and above all a dear friend. ■

Atlas Adds Grid-Tied PV Exposure Capabilities



Further enhancing our photovoltaic testing capabilities, Atlas now offers grid-tied PV testing and monitoring. Grid-tied testing allows for real-life durability/performance in the two leading benchmark locations of Phoenix, Arizona and Miami, Florida. We also offer other niche climates, such as a high altitude/cold climate.

Testing can be complemented with a suite of Atlas' PV testing capabilities, including:

- IV curve measurement
- Thermal imaging
- Digital imaging
- Visual inspections
- Custom data acquisition design and installation
- Empirical weather and sample temperature reporting

Atlas will work with client-provided engineering or provide engineering support to ensure that the array design is properly installed and permitted by local utilities and governing bodies.

Contact your Atlas customer service representative at 800-255-3738 for a quote today. ■

Weather Experimenter's Toolbox

Three-Variable Cubes Offer Greater Sophistication

By Henry K. Hardcastle, Atlas R & D

A simple enhancement to the often-used two-variable "square" concept is to add a third variable resulting in a "cube" experimental design. This simple advancement drives experimental sophistication to a new level of context. These designs are appropriate for weathering experiments since very rarely are only two weathering variables acting simultaneously on a product in end use.

This three-dimensional experimental volume involves the classic weathering interaction of temperature, irradiance, and moisture variables. A two-dimensional experimental design does not have the inherent level of context necessary to characterize temperature-irradiance-moisture interaction phenomenon. It is befuddling to this author why the vast majority of weathering research is conducted at less sophisticated levels of experimentation to gain understanding of systems that operate at high levels of context.

Questions that experimenters ask of two-variable square designs may also be asked of three-variable cube designs:

» For this thermoplastic, how do intensity, duration, and frequency of irradiance interact to cause failure, and which is most important?

» What effects do melt temperature differences, gate pressure differences, and dwell time differences have on cold temperature impact after 5 years of exposure?

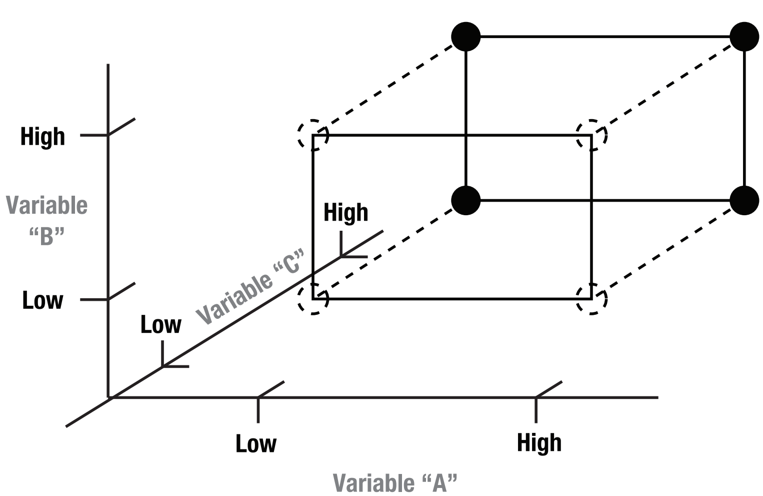
» Of the three variables—exposure in Arizona vs. Florida, exposure in backed vs. unbacked condition, and exposure with water spray vs. without water spray—which has the biggest effect on gloss change? What is the effect of interactions between any two or all three of these variables?

» Which has a bigger effect on impact after 3 years of Florida exposure, 10% differences in impact modifier level, 10% differences in lube package levels, or 10% differences in process aid levels? And is there an interaction between these three formulation components?

» If I change irradiance levels by 20%, temperature levels by 20%, and moisture levels by 20% in my Xenon Weather-Ometer®, can I identify a weak link in my formulation? Specifically, must I stabilize for all three variables or can I stabilize for just one and, due to the synergistic effect of these three variables, stabilize all three for the price of stabilizing just one?

3 Variable "Cubes"

(Full Factorial)



Application of this cube design also follows similar procedures as for square designs. Eight trials are performed with individual variables set to high and low settings independently of other variable settings. The design is full factorial (each variable at each setting of high and low) and orthogonally balanced.

The following graphic shows a representation of a three-variable design.

At the end of the experiment, the experimenter has obtained data from:

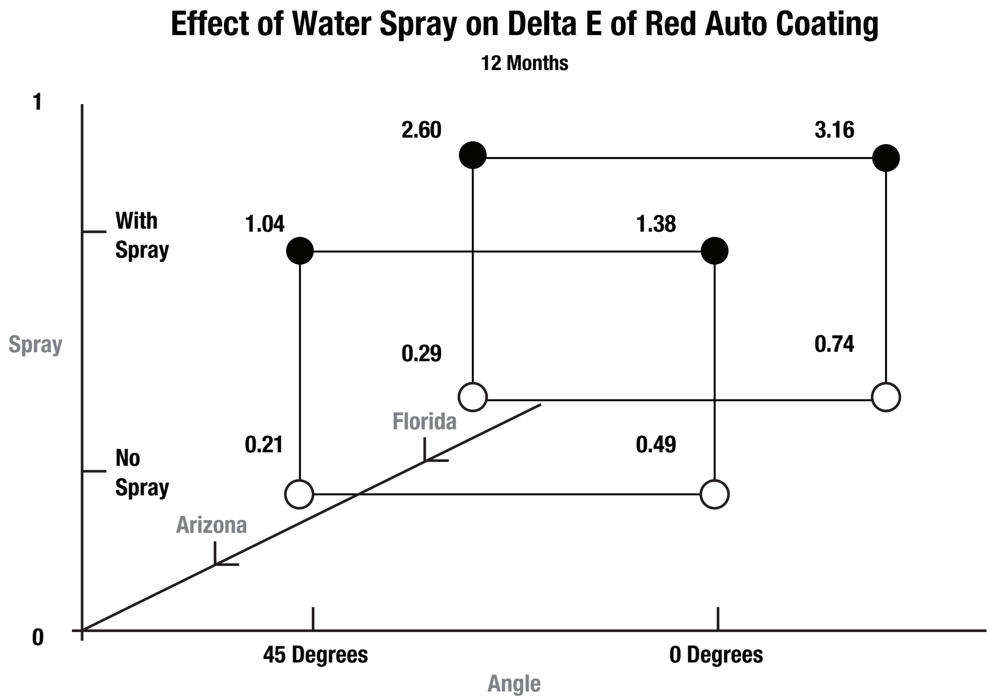
4 trials with “A” set low,
4 trials with “A” set high,
4 trials with “B” set low,
4 trials with “B” set high,
4 trials with “C” set low, and
4 trials with “C” set high

by only performing a total of eight trials! This experimental efficiency constitutes the advantages of full factorial orthogonal arrays over less sophisticated experimental designs typically used in weathering studies today.

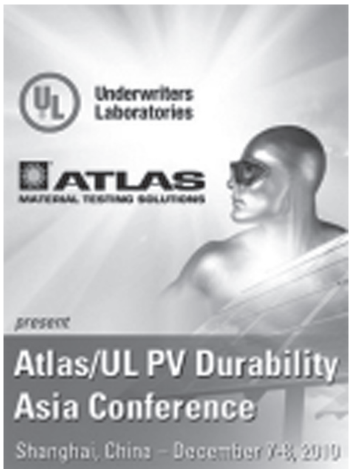
As an example, we wanted to compare the effects of three variables on the weathering behavior of a red automotive coating by observing: 1) the effect of daytime water spray, 2) the effect of exposure angle, and 3) the effect of an Arizona exposure compared to a Florida exposure. Specimens from the same batch of material were randomly selected and exposed under a unique set of conditions in a blocked manner.

The organization of the three variables and the results on the red automotive coating were obtained as follows:

The water spray and exposure location appear to have had a bigger effect than exposure angle in this experiment. There appears to be an interaction between angle and location. There appears to be an interaction between spray and location. An interaction between angle and spray does not appear obvious.



Atlas® and UL to Host Asian Conference in December



Focus: Solar Energy Product Durability and Performance

Atlas Material Testing Technology and Underwriters Laboratories have teamed up to plan PV Durability Asia, a technical conference focused on the growing solar energy market in that region and its emerging testing needs. It will take place December 7–8, 2010, at the Crowne Plaza Century Park Shanghai Hotel, China.

Conference presenters will discuss the latest developments, research, and innovative approaches in environmental durability, performance, and service life of materials, components and PV modules, as well as compliance and certification testing. Topics will be relevant to module manufacturers as well as to those in the supply chain.

The Asian solar energy market has grown dramatically in the last few years. Various materials such as glass, plastics, polymers, sealants, and metals are used to build PV modules, concentrating dishes, and other systems to convert solar into thermal or electrical energy. These systems are typically expected to last 20, 30, or even 40 years. Appropriate accelerated testing of the long-term durability of these components as well as the complete solar systems is crucial in product development, quality control, and certification and testing.

Conference speakers include:

- Dr. Sarah Kurtz, National Renewable Laboratory (NREL), USA
- Mr. Michael Köhl, Fraunhofer Institute for Solar Energy Systems (ISE), Germany
- Mr. William Gambogi, DuPont Photovoltaic Solutions, USA
- Dr. Xiaohong Gu, National Institute of Standards & Technology (NIST), USA
- Dr. Crystal Vanderpan, Underwriters Laboratories, USA
- Mr. Allen Zielnik, Atlas Material Testing Technology LLC, USA
- Mr. Liwang Jiang, Yangzhou Yangjie Electronic Technology Co. Ltd., China
- Dr. Nicolas Bogdanski, TÜV, Rheinland, Germany
- Mr. Liang Ji, Underwriters Laboratories, USA
- Mr. Wei Feng, SGEPRI, China
- Dr. Jacob Zhang, Atlas Material Testing Technology LLC, USA
- Mr. Hung-Sen Wu, Industrial Technology Research Institute, Taiwan
- Mr. Johnson Hsu, TA Instruments-Waters LLC, China
- Dr. Murray Cameron, European Photovoltaic Industry Association (EPIA) and Phoenix Solar AG, Belgium

For more information on the conference, e-mail Stefani Levine at **slevine@atlas-mts.com** or Joyce Wang at **uluniversity.cn@cn.ul.com.**

Register at www.atlas-mts.com/pvdurabilityasia

Atlas Textile Landing Page: Industry Solutions at a Glance

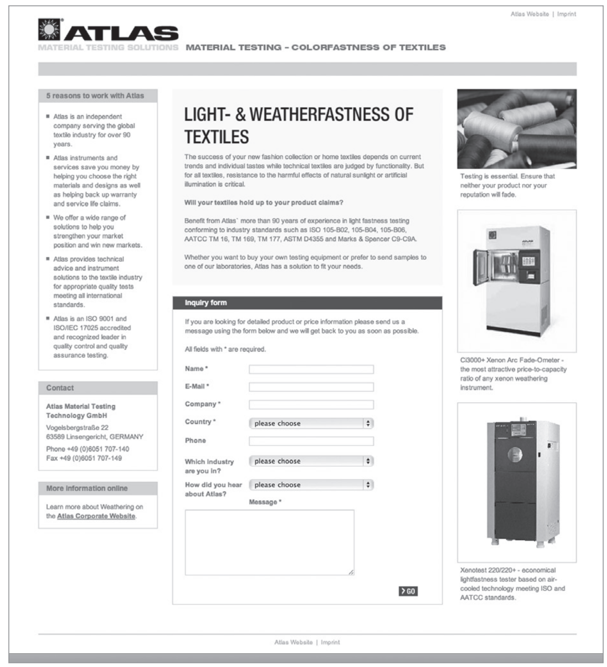
The success of a new fashion collection or home textiles largely depends on current trends and individual tastes, while technical textiles are judged by functionality.

With over 90 years of experience in lightfastness testing, Atlas understands that resistance to the harmful effects of natural sunlight or artificial illumination is critical in textile product development. That's why we've developed www.textiles.atlas-mts.com.

This textile-focused landing page is easily accessible for customers searching for a lightfastness testing solution. It's a quick resource for equipment and testing services information geared toward the specific needs of the textile industry.

Since the introduction of the first Xenotest® 150 instrument in 1954 through our recent launch of the Xenotest 220/220+, Atlas continues to work with the global textile industry to facilitate quality testing and speed to market.

Visit us at our textile or solar landing page (www.solar.atlas-mts.com) and watch for further industry-specific pages in the future. Don't see your industry addressed yet? Send your suggestions for additional landing pages you'd like to see to **info@atlas-mts.com.**



www.textiles.atlas-mts.com

Will Your Textiles Hold Up to Your Product Claims?

As the need for technical and high-performance textiles has grown, so have the questions concerning material durability. That's why Atlas is joining with DyStar and ASTM International in January to host the first-ever conference on light- and weatherfastness of textiles in India.

The conference aims to create awareness and improve the overall understanding in the specialized field of textile durability. Attendees will learn about the latest issues facing the textile industry as well as new technologies and solutions.

Speakers include Dr. Andreas Giehl, DyStar, Germany; Dr. Martin Bide, University of Rhode Island, USA; Professor Josep Valldeperas, INTEXTER, Spain; Mr. Adrian Meili, TESTEX AG, Switzerland; Mr. Rahul Bhajekar, Texanlab (DyStar) Laboratories, India; Dr. Peter J Hauser, North Carolina State University, USA; Dr. Wolfgang Schiller, German Colour Fastness Committee DEK, Germany; and Dr. Artur Schoenlein and Dr. Oliver Rahaeuser, Atlas Material Testing Technology, Germany.

Mumbai Textile Conference
January 21, 2011 • Textiles Committee facility, Mumbai
Available by webcast in North America and Europe
Contact Atlas for details: info@atlasmtt.de

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SunSpots

Connect with Atlas in India this winter! See page 2 for shows.

To receive SunSpots *electronically, please visit www.atlas-mts.com*

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