ATLAS MATERIAL TESTING SOLUTIONS
AMETEK MEASUREMENT & CALIBRATION TECHNOLOGIES

SunSpots®

Material Testing Product and Technology News

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Spring 2012

New SunCal™ Sensor calibrates both light and temperature
Page 8

Accurately Measuring Specimen Temperature in Xenon-Arc Accelerated Weathering Instruments

By Matthew McGreer and Dr. Jacob Zhang
Atlas Material Testing Technology LLC

Abstract

The temperature of a material during a weathering test is one of the primary factors in determining the rate of degradation and accurately predicting service life. The use of a non-contact thermal infrared measurement provides accurate temperature profiling during exposure. A system using this technology called S³T (Specimen Specific Surface Temperature) is now available from Atlas. The system provides accurate surface temperature measurements for a variety of materials under a wide range of weathering test conditions.

Importance of Temperature

Weathering of materials is primarily caused by the stresses of solar irradiation, temperature, and humidity. Although solar radiation (primarily UV wavelengths between 300–400 nm) is the primary initiator of most chemical reactions, sample temperature is often a controlling factor. The effect of sample temperature on degradation rate can be quantified through the Arrhenius equation shown on the right.

This equation shows that the temperature is the critical parameter in determining the material degradation rate. The actual sample temperature varies during a weathering test, primarily due to the emissivity, or solar absorptivity, and surface thermal conductivity of the sample. Variations in temperature among samples of different colors or materials can be significant. For example, aluminum panels with various colored organic paints undergoing simultaneous weathering tests showed temperature variations of up to 25°C [1]. Such observations can compromise the validity of many of the service-life predictions that rely on an accelerated test.

Equation 1

$$K_d = Ae^{-\frac{E}{KT}}$$

K_d = rate constant of chemical reaction
E = activation energy
A = reaction constant relating to materials properties and test conditions
K = Boltzmann constant
T = absolute temperature

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In This Issue

CLIENT EDUCATION • ATLAS •

Keep Your Team Up to Date!

Atlas' education and training solutions will help you and your staff master the skills now needed to develop long-lived products in shortened development cycles. Our programs are designed for all levels to ensure that everyone on your team understands the fundamentals of weathering and how to operate our instruments. For the latest schedules and locations, visit www.atlas-mts.com or e-mail atlasinfo.us@ametek.com.

Fundamentals of Weathering I	June 12	Vienna, Austria	Presented in German
	June 20	Chicago, IL, USA	Presented in English
	September 19	Chicago, IL, USA	Presented in English
	November 6	Cologne Germany	Presented In German
Fundamentals of Weathering II	June 13	Vienna, Austria	Presented in German
	June 21	Chicago, IL, USA	Presented in English
	September 20	Chicago, IL, USA	Presented in English
	November 7	Cologne, Germany	Presented in German
Sample Preparation Workshop	December 5	Linsengericht, Germany	Presented in German
SUNTEST® Workshop (XLS+ / XXL / XXL+ touch screen models)	November 23	Linsengericht, Germany	Presented in German
Weather-Ometer® Workshop	April 25–26	Linsengericht, Germany	Presented in German
	June 19	Chicago, IL, USA	Presented in English
	September 18	Chicago, IL, USA	Presented in English
Xenotest® Workshop	November 20–21	Linsengericht, Germany	Presented in German

ATLAS • SHOWS

2012

ChinaPlas
April 18–21
Shanghai, China
Booth #W1K67

Control 2012
May 8–11
Stuttgart, Germany
Booth # Hall 1 #1302

Plast 2012
May 8–12
Milan, Italy
Booth #A49

SNEC PV Power Expo Japan
May 16–18
Shanghai, China
Booth #E3-103

Korea Lab
May 22–25
Seoul, South Korea
Booth #E602

Feira da Mecanica
May 22–26
São Paulo, Brazil
Panambra Zwick Booth

Interphex Aisa
May 28–29
Suntec, Singapore
Booth #205

Automotive Testing Expo Europe 2012
June 12–14
Stuttgart, Germany
Booth #1658

ITMA Asia + CITME 2012
June 12–16
Shanghai, China

Visit Atlas' booth at these shows to learn about the latest weathering developments and how we can help advance your testing program.

*For a complete list of Atlas shows, visit **www.atlas-mts.com.***

Measuring Specimen Temperature, from page 1

A large portion of absorbed radiation is converted to heat, and the amount absorbed is also loosely linked to color, with white materials absorbing only about 20% of the visible light and black about 90%. Thus, the darker the color, the higher the temperature. Surface temperatures of exposed plastic specimens can reach 77°C [2], and specimens inside a closed automobile exposed to sunlight can reach 120°C [3].

Elevated temperatures can significantly influence the destructive effects of light on polymeric materials by accelerating the rate of the secondary reactions and by altering the reaction processes following the primary photochemical step of bond breakage. For example, the increase in the rate of oxygen diffusion and the reduced probability of recombination of free radicals can alter the main mechanism of degradation. Therefore, temperature differences in various climatic zones are responsible to a large extent for the variations in weathering, regardless of the amount of solar radiation received annually. As an example, the higher, cooler altitudes of central New Mexico receive very high levels of UV radiation but, generally speaking, will not degrade materials as fast as the weathering benchmark climate of southern Arizona [4], [5]. (See Figures 1 and 2.)

Because of differences among materials in the effect of temperature on the secondary reactions, the stability ranking of materials can change with an increase in temperature.

Although daily averages and extremes of air temperature are measured to quantify temperature conditions during exposure of specimens to natural weathering, the temperatures that materials attain are higher than that of the surrounding atmosphere.

Temperature differences between the surface and bulk of polymeric materials due to the low thermal conductivity and heat capacity of these materials cause physical stresses. Daily and seasonal temperature cycling can cause mechanical stress in composite systems, such as between a coating and a substrate or between coating layers, because of a mismatch in the thermal expansion coefficients. This difference often results in cracking and loss of adhesion of the coating.

Temperature and its cycles also affect the weathering of polymeric materials by influencing the effect of moisture. An increase in temperature accelerates hydrolysis reactions, while a reduction in temperature results in condensation or dew on the material. Freeze/thaw cycling or thermal shocks due to cool rain hitting hot, dry surfaces induces mechanical stress, which can cause structural failures in some systems, or accelerate degradation that has already been initiated.

It is often not practical to measure the surface temperature of individual test specimens due to the location of the exposed specimen with respect to available data acquisition systems and/or the additional financial and labor requirements to mount temperature sensing elements to each panel.

Continued on next page

ATLAS • SPEAKS

The Detroit Society for Coatings Technology Future of Coatings Under Study - FOCUS 2012

May 3, 2012
Michigan State University
Troy, MI, USA

"Accurately Measuring Specimen Temperature in Accelerated Weathering Instruments"

Presenter: Matthew McGreer
Atlas Material Testing Technology LLC

Produktqualifikation - Wirkungen auf Produkte

May 9–10, 2012
Maritim Hotel
Nürnberg, Germany

"System for Deterministic Acceleration of Laboratory Weathering"

Presenter: Dr. Artur Schönlein
Atlas Material Testing Technology GmbH

World Flexible Intermediate Bulk Container (FIBC) Congress 2012

June 27–28, 2012
Hilton Miami Downtown
Miami, FL, USA

"Weathering Testing for Bulk Bag Material"

Presenter: Jack Martin
Atlas Material Testing Technology LLC

Measuring Specimen Temperature, from previous page

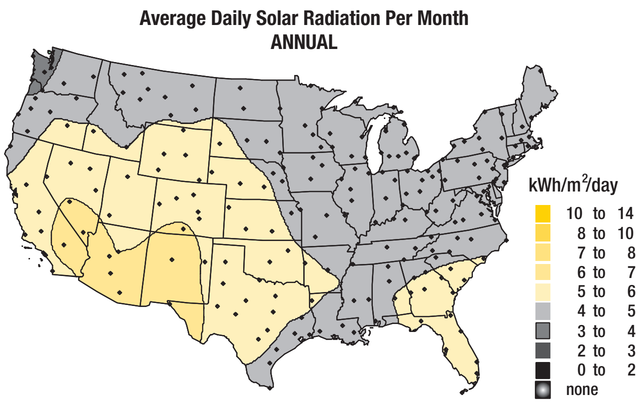

Figure 1

U.S. map of solar radiation – annual dosage; at latitude

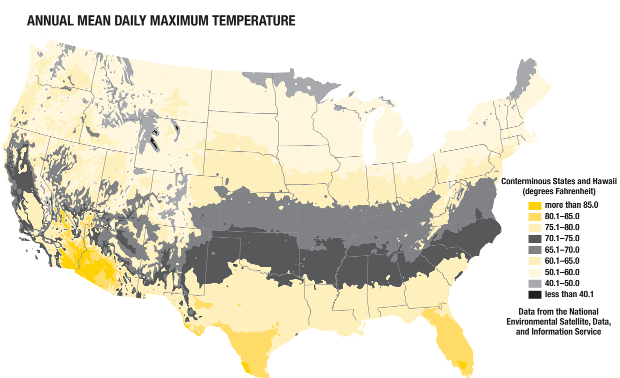

Figure 2

U.S. map of mean daily maximum temperature – annual

Figure 3

Graphical representation of an uninsulated black panel (BPT)

Sample Temperature in Accelerated Testing Instruments

The goal of artificial weathering testing is to simulate, then accelerate natural or end-use weathering processes. It is therefore logical that measuring and controlling sample temperatures are important factors within these chambers. As with natural weathering tests, black panels are commonly used to represent the maximum temperature achieved.

These black panels have been defined by many standards institutions. For example, both ASTM G151, Standard Practice for Exposing Nonmetallic Materials in Accelerated Test Devices that Use Laboratory Light Sources, and ISO 4892-2, Plastics – Methods of Exposure to Laboratory Light Sources – General Guidance, describe in detail the characteristics of these panels. Weathering instrument manufacturers add these panels as standard features in the chamber, and tests run in these instruments typically will define a black panel temperature set point as one of the many parameters.

There are two common types of black panels. An uninsulated black panel consists of a flat metal plate coated with a black layer which has good resistance to aging and absorbs at least 90% of irradiation received during exposure. A thermal sensitive element is firmly attached to the center of the exposed surface [6]. An insulated black panel is similarly coated, but the temperature sensor is attached to the side opposite the radiation source. The metal is then attached to a 5 mm-thick base plate made of unfilled polyvinylidene fluoride (PVDF) [7]. In common weathering terminology, the uninsulated black panel is referenced as a “BPT,” and the insulated black panel is referenced as a “BST” or “black standard thermometer.”

While these descriptions provide a general basis for construction, certain details are omitted, such as the thickness of the panel, specific type of metal used, and type and mounting method of the temperature sensor utilized. Further, different weathering instrument manufacturers may use different mounting techniques for the black panel, depending on the orientation of the light source and exposed specimens.

As mentioned above, it is not practical to measure the surface of individual test specimens, and this is even more impractical because of the rotation of the specimen rack during exposure and/or the need to route wires through the chamber door or other orifice of the test chamber, which could present a safety hazard.

The fact that actual specimen surface temperatures are not measured is an inherent weakness of common artificial weathering tests. This is especially true when the focus of the research question is to determine the acceleration factor of the artificial test or to approximate the end-use service life of the material under study because, as already established, temperature is a primary factor in the degradation rate of a material.

New Methodology for Determining Specimen Temperature During Artificial Tests

A temperature-dependant radiation spectrum is emitted from all materials. Planck‘s Law (Equation 2) and its derived forms describe the spectral distribution for an ideal black body and is illustrated in Figure 4 for various temperatures. The emission is primarily in the infrared region. Real materials do not behave as an ideal black body, and thus one frequently must consider the emissivity (defined as the ratio of the material emittance at a specific wavelength and temperature to the emmitance of an ideal black body). Fortunately, a simple calibration can account for material-dependant emissivity. The measurement of (infrared) emission forms the basis of infrared pyrometry.

Based on this fundamental premise, Research and Development staff at Atlas Material Testing Technology LLC undertook a project to incorporate existing temperature sensing technology into the rotating-rack xenon-arc artificial weathering instrument, the Weather-Ometer®. An appropriate IR pyrometer was selected based on the following criteria:

- **Sensor head size –** Must be small enough not to significantly interfere with (shadow) the radiation from the xenon-arc lamp
- **Response time –** Must be rapid enough to provide several measurements across the surface of a typical sample width of 2.5" (7 mm)
- **Spectral response –** Must not be affected by the spectral range of the xenon-arc lamp
- **Spatial resolution –** Must provide a small enough measurement surface area to view only the specimen surface and not the chamber wall or sample holder
- **Working ambient temperature/relative humidity –** Must withstand the harsh environment of the weathering chamber during actual weathering tests

Initial work validated the IR pyrometer chosen, and further R&D efforts were made to develop a method to allow the instrument to determine which specimen temperature was being measured at any given time. Different specimen indexing methods were considered and, ultimately the use of common RFID (radio frequency identification) technology was chosen. This method required the incorporation of an RFID reader that could identify tags mounted to sample holders that corresponded with specific specimens. A graphical representation of these components as they are used in a rotating rack xenon-arc weathering instrument is shown in Figure 5.

Equation 2

$$M_{BB}(\lambda, T) = \frac{2\pi c^2 h}{\lambda^5\left(exp\left(\frac{hc}{\lambda kT}\right) - 1\right)}$$

M_{BB} = radiant emittance of a black body
h = Planck's constant
k = Boltzmann's constant
c = speed of light and
T = absolute temperature

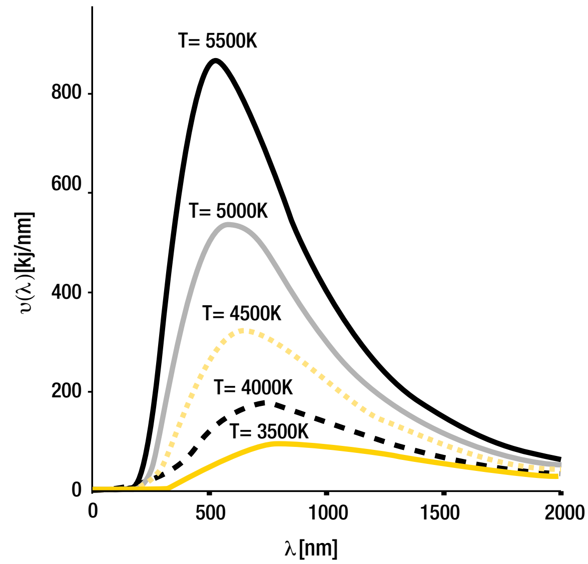

Figure 4

Spectral distributions from a black body source at various temperatures [8]

The exposed specimens rotate around the light source at one revolution per minute. The IR pyrometer takes continual readings every 0.2 seconds. As the specimens pass within the field of view of the pyrometer, at least five readings are taken horizontally along the specimen surface. Simultaneously, the RFID tag mounted on the back of the sample holder comes into the field of view of the RFID reader mounted behind protective glass outside the chamber. This "triggers" the appropriate temperature measurement from the IR pyrometer, which is then displayed on the graphical user interface of the Weather-Ometer. Temperatures can be displayed in table or trend plot format, and both the triggered specimen temperature measurement and the raw data from the continual readings from the IR pyrometer can be stored and retrieved through common data collection methods.

Validation of the S³T System

Once components were chosen and all hardware/software incorporated into the design of the Weather-Ometer, several aspects of product validation were required. These included:

- **Comparison to traditional temperature measuring techniques –** Tests were conducted with a standard set of materials with thermocouples and/or RTDs mounted to the surface to determine if comparable temperature measurements could be achieved.
- **Range of temperatures –** The system was utilized with a wide variety of commonly used temperature black panel set points, from lower temperatures in AATCC TM16 (63°C) to SAE J2412 (89°C).

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Measuring Specimen Temperature, from previous page

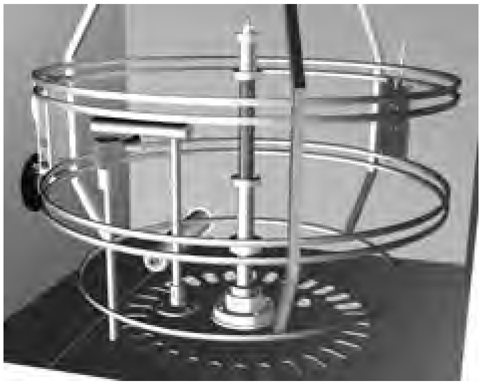

Figure 5

Components of the Specific Specimen Surface Temperature (S³T) system

- **Range of materials/colors –** Several types of materials (textiles, coatings, plastics) along with a variety of colors were used to determine if valid temperatures could be attained with the system.
- **IR pyrometer measurement of BPT/BST –** Tests were conducted comparing the measurement of the standard insulated and uninsulated black panels to ensure there was agreement with the standardized method of data acquisition.
- **Stress testing –** The system was tested to the extremes of the performance envelope of the Weather-Ometer in terms of irradiance levels, chamber temperature, relative humidity, light/dark cycling, and spray.

Following are specific validation test data gathered during the development of the system. The first example combines the first three aspects of product validation listed above [9].

Seven aluminum panels coated with colored PVC films with Type T thermocouples embedded between the coatings and the substrates were employed in these tests. The colors were white, yellow, orange, red, green, blue, and black. The tests in this validation are listed in Figure 6.

Figure 6

Tests used to validate the S³T system

Test Name	BPT/BST (ºC)	Chamber Temp (ºC)	RH (%)	Irradiance (W/m²)
SAE J2412	BPT 89	62	50	0.55 @ 340 nm
SAE J2527	BPT 70	47	50	0.55 @ 340 nm
GM 3414TM	BPT 105	65	25	2.20 @ 420 nm
AATCC 169-1	BPT 77	52	70	0.35 @ 340 nm
ISO 105-B02	BST 63	42	30	1.10 @ 420 nm
ISO 105-B06	BST 100	65	30	1.20 @ 420 nm
ISO 11341-1	BST 65	38	70	60 @ 300-400 nm

For each test, the surface temperatures for each of the seven colored panels were recorded and tracked by both the S³T system and the thermocouples. The measured temperatures were averaged over 10-minute periods during stable test stages for each colored sample, and the results are shown in Figure 7.

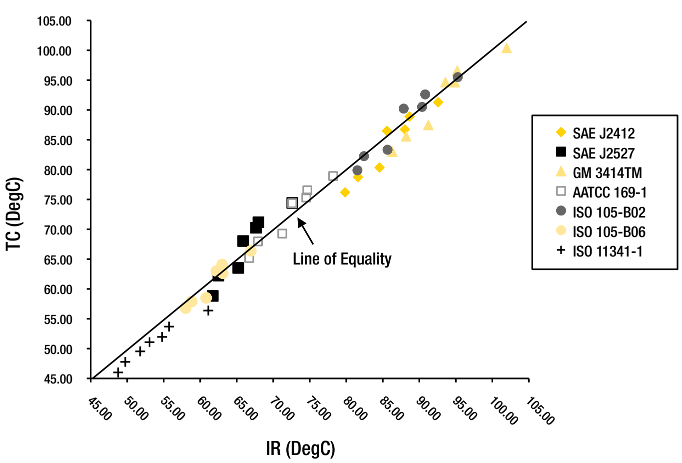

Figure 7

Results of S³T validation testing, showing strong correlation with temperatures using traditional method of acquisition

Another validation was conducted with an alkyd monocoat on stainless steel. Alkyd coating is the primary choice of oil-based coating, especially in the architectural coating market. Five painted samples of various colors with embedded RTD were tested to the cycles noted in Figures 8 and 9 with two distinct black panel temperature settings in the Atlas Ci5000 Weather-Ometer®. The temperature readings from S³T are compared to RTDs. The results show that the measurements based on S³T technology agree with those of the traditional RTD technique very well, within ±2°C.

While the test listed above worked well on painted metal samples, an additional validation step to include plastic automotive bumper materials from a leading automotive OEM was needed. The sample with the embedded RTD represent various user conditions – from relatively new to fairly worn out. Temperature measurements from the light cycle are compared between S³T and RTD. Once again, S³T precisely captured the temperature gradient of samples with various colors and surface conditions.

Limits of the S³T System

While the incorporation of the S³T system into artificial weathering testing represents a revolutionary advancement, the system has certain limits that are worth mentioning.

- **Emissivity of material –** Fundamentally, the use of IR pyrometry works best with materials that have relatively high emissivity. This includes a wide range of materials from plastics to textiles to paints/coatings. Most opaque materials have an emissivity above 0.85 and the IR pyrometer used in the S³T system can be calibrated to specific emissivity levels. However, bare metals and low-E coatings used in fenestration applications are not appropriate for S³T.

- **Position of specimens –** In the Weather-Ometer, the standard rotating rack has three tiers on which specimens can be mounted. Due to potential shadowing of the IR pyrometer, only specimens on the middle tier of the rack can be measured.
- **Rack rotation speed/high irradiance –** To maintain appropriate temperature and irradiance uniformity during a test, the rack of the Weather-Ometer rotates at higher speeds for tests requiring high irradiance levels. Despite the fast response time of the IR pyrometer chosen (0.2 seconds), a rack rotation speed of one revolution per minute must be used for the RFID components and the IR pyrometer to synchronize correctly.

Acknowledgements

The authors would like to acknowledge the following Atlas colleagues for their valuable contributions to the development of the S³T system, including the efforts to gather much of the data referenced in this article: Richard Schultz, Paula Henn, Maria Almader, Richard Donato, and Kurt Scott.

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Figure 8

Test parameters for painted stainless steel validation test

Cycling Information			
Segment	Phase 1	Phase 2	Phase 3
Irradiance (W/m²)	0.38	0	0.69
BPT(°C)	50	38	120
CHT(°C)	40	38	85
Humidity	85%	95%	10%
Spray – Rack	Off	Off	Off
Spray – Specimen	Off	Off	Off
Time (minutes)	90	30	90

Figure 9

Results of the painted stainless steel validation test

	Phase 1			Phase 3		
Color	S³T	RTD	Delta	S³T	RTD	Delta
Black	53.47	52.99	0.48	122.04	122.08	-0.04
Blue	49.65	48.80	0.85	114.64	113.36	1.28
Red	50.41	49.49	0.91	115.51	114.95	0.56
Yellow	45.86	44.74	1.12	105.68	104.33	1.34
White	45.53	44.32	1.21	105.27	103.61	1.66

Figure 10

Test results of the plastic automotive bumper validation test

Color	S³T	RTD	Delta
White	73.78	73.69	0.09
Silver	85.71	84.82	0.89
Red	92.69	92.80	-0.10
Blue	100.00	97.93	2.07
Black	101.69	100.63	1.06

Xenon Lamp Calibration Services Now Available in China

NT staff receives calibration training from Dr. Jacob Zhang

Atlas is pleased to announce a new calibration service for our xenon weathering instrument customers in China. We have reached an agreement with the Optics Research Institute of China's National Institute of Measuring and Testing Technology (NT), a nationally accredited metrology and testing laboratory, to perform irradiance calibrations. Currently, our Ci4000 Weather-Ometer® customers in China send calibration lamps back and forth to Atlas' headquarters in Chicago. Our new local partnership will reduce the turnaround time of a calibration by several weeks, save customers considerable shipping costs and become part of the China national accreditation system (CNAS), which continues to grow in importance.

As China has become one of the most important markets for weathering instruments, Atlas recognized the need to expand our local services to better accommodate our customers. Our local distributor, SDL Atlas Ltd., has long provided factory-trained calibration for temperature, humidity, and wattage at the customer site. By adding an approved irradiance calibration service in China with a local partner, we can now offer complete after-sales support in-country, while maintaining the same high level of technical accuracy offered by our Chicago headquarters.

Founded in 1965, NT is one of two nationally certified metrological organizations in China. NT boasts leading metrology and optics instrumentation, has over 130 senior technical staff members, and enjoys an excellent reputation in the industry for customer service and response time. Dr. Jacob Zhang, Atlas' Calibration Laboratory Manager, fully trained the NT team at its Chengdu headquarters to perform the calibration using the same methods applied in Chicago. After multiple proficiency tests over the course of several months, the calibrations at NT were found to be consistent with Atlas and resulted in deviations well below our minimum requirements.

We are pleased to begin this service for the Ci4000 immediately and look forward to expanding the NT partnership to other Weather-Ometer models over the course of the year. ■

Atlas Launches New SunCal™ Sensor Series

Simultaneously Calibrates Light and Temperature

SunCal™ Sensor

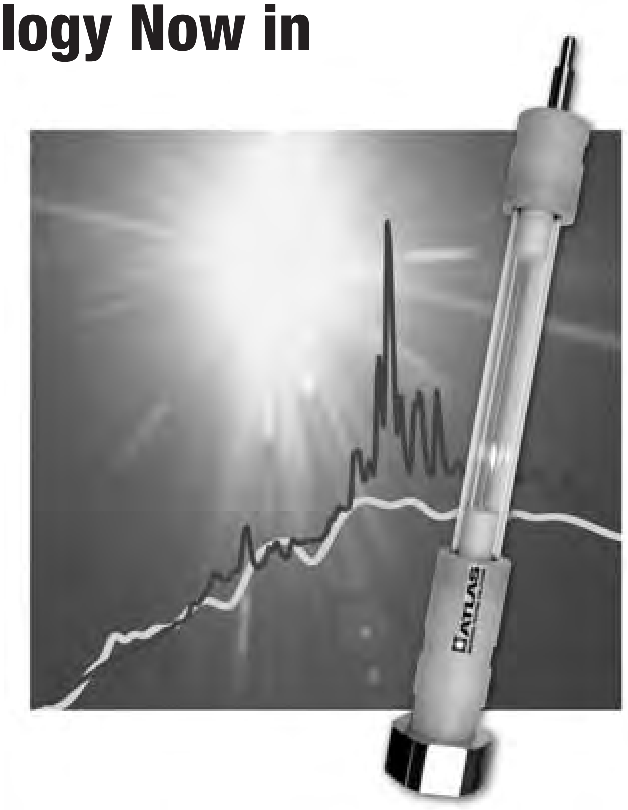
Atlas has designed a new series of calibration sensors to provide low-cost and precise do-it-yourself maintenance on the SUNTEST® Family of xenon instruments.

Accurate irradiance and Black Standard Temperature (BST) inside of a SUNTEST instrument are critical and the calibration process must be reliable and easy to perform. The new SunCal Sensor design addresses these needs.

This new sensor allows simultaneous calibration of light and temperature. By combining two sensors into one device, users can perform two measurements at the same time under identical conditions for a higher level of accuracy, thus significantly reducing the time required to perform calibrations. In addition, tailored sensor adapters ensure the correct sensor positioning, guaranteeing reliable calibration routines.

SunCal sensors are specifically designed to support do-it-yourself calibration routines of all SUNTEST models and are available as SunCal WB300-800 BST, BB300-400 BST, and LUX BST. ■

New Sealed Lamp Technology Now in 6.5 kW Calibrated Lamps



In 2011 Atlas introduced its revolutionary Sealed Lamp. Along with a new design to address the root cause of most premature failures, the lamp used new filter technology to significantly reduce solarization and allowed for continuous use without interim inner filter replacement.

This spring, Atlas is further integrating this new technology by replacing current production of its traditional calibrated lamps for the Ci4000 Weather-Ometer® with a new calibrated sealed lamp. The lamp assembly will utilize the same Type S Borosilicate inner and outer filters and maintain the high quality standard of the current 6.5 kW calibration lamps.

Additional benefits of the Sealed Lamp technology include a reduced risk of damage or accidental disassembly as a result of its superior ergonomic design.

For more information about the Sealed Calibration Lamp, contact your local sales or service representative. ■

Atlas Expands Solar Thermal Testing Capabilities

The Atlas Solar Test Center is expanding its solar thermal testing capabilities and capacity during the second quarter of 2012.

Adding to our existing SRCC Standard 100 testing accreditation by the Solar Rating and Certification Corporation (SRCC) organization, the Atlas Solar Test Center is introducing the capability to perform reliability and performance testing according to European standard EN12975. Once this accreditation has been established by DIN CERTCO, Atlas will be able to support Solar Keymark certification.

This new capability will allow Atlas to offer combined test programs for solar collector manufacturers who want to enter North American and European markets. Since there is significant overlap between the relevant standards' requirements, this "one-stop" collector test service will save time and cost for clients who typically send multiple standards to different labs for these qualification tests.

The incorporation of the EN12975 standard also enables support of SRCC Standard 600, which is required for certifying tracking/concentrating collectors for the North American market.

In an effort to shorten queue times for solar thermal performance testing, the Atlas Solar Test Center is also adding a new, dual-mount tracker for accumulating performance data on separate collectors simultaneously. Atlas will now be able to test three collectors at the same time, significantly improving project throughput times.

Stay tuned for updates on our Solar Test Center expansion, and call Customer Support at 800-255-3738 or e-mail john.wonders@ametek.com for a quotation. ■

Enhancements to Atlas 25^+ Multi-Dimensional Test Program Give Added Insight into Product Performance

Atlas has introduced an enhanced version of its industry-leading Atlas 25^+ multi-dimensional test program, which is designed to determine the durability of PV modules. With growing technology, PV modules are expected to perform reliably for 25 years or more. In addition to hardware warranties for material defects, performance warranties for power generation typically guarantee that output will not fall below 90% in the first 10 years or 80% after 20+ years.

The Atlas 25^+ program improves upon basic accelerated weathering tests by combining wider climate-based parameter ratings and sequencing between short-term diurnal and long-term seasonal cycles. Utilizing the large-scale accelerated weathering capabilities at Atlas' Solar Test Center, this one-year testing program is designed to offer natural and laboratory accelerated weathering stresses and provide data to support warranty and performance claims.

Atlas 25^+ combines accelerated outdoor and laboratory exposures:

- UV, salt fog corrosion, and condensing humidity tests
- Solar tracking in Arizona, including peak summer
- Chamber exposure cycles combining full-spectrum solar, temperature, humidity, and freezing in both climate-based short-term and long-term patterns to replicate natural delivery
- Modules powered under resistive load during solar exposures
- Periodic measurements of IV performance factors, visual inspections, digital photographs, and IT thermal imaging

New enhancements to the Atlas 25^+ program include the following:

- Photographic electroluminescence, which provides details about efficiency-degrading mechanisms in a photovoltaic cell or panel
- Wet leakage, which is used to test the electrical isolation of the PV housing
- Advancements in reporting format

For more information on the Atlas 25^+ program or a quotation, please call Customer Support at 800-255-3738 or e-mail john.wonders@ametek.com.

Atlas Adds Acidic Test Site to Worldwide Exposure Network

Temperature	Avg. Max	19.9 °C
	Avg. Min	11.9 °C
	Average	15.5 °C
Annual Rainfall		1912 mm
Radiant Energy	300–400 nm	330 mJ/m^2
Distance from Shoreline		2.3 km

Atlas has partnered with a private laboratory in Kirishima, Japan to offer acidic environment testing. The new test site is on the rooftop of a laboratory building located in the Kagoshima Prefecture on Japan's southernmost island of Kyushu. Surrounded by mountains and active volcanoes (including Mt. Sakurajima and Mt. Shinmoedake) the site sits near Kinko Bay at an altitude of 320 meters above sea level.

The new test site offers the following:

» direct and underglass exposures
» evaluation services
» collection of climatological data including temperature, rainfall, radiant energy, pH, rain conductivity, and rainwater compositions (Cl, NO^3 and $SO4^2$)

The Kirishima exposure site is located at 31° 41' North Latitude and 130° 49' East Longitude. See table to the left for the site's average climatological data.

The Atlas Worldwide Exposure Network consists of over 20 sites around the world in multiple climates. If you would like to expose specimens at the Kirishima site or any of our other worldwide sites, please call Customer Support at 800-255-3738 or e-mail john.wonders@ametek.com.

Atlas Broadens Scope of UL Data Acceptance Program

After completing another UL audit for its Data Acceptance Program (DAP), Atlas has added over 35 new tests to its scope. The DAP allows UL to accept externally generated test data for approved laboratories in support of UL certification. Atlas' original scope included a handful of tests per UL 1703, IEC 61215, IECF 61646, IEC 61730, and IEC 62108. The recently expanded scope includes 14 new tests for CPV standard IEC 62108, which enables most testing per UL 8703 requirements.

The new scope also includes:

- Environmental Stress Testing
  - Thermal Cycling
  - Damp Heat
  - Humidity Freeze
- Electrical Insulation Tests for IEC 61215, IEC 61646 and UL 1703

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ATCAE Solar Draws Experts to Berlin

2011 Conference Wrap-Up

Representatives from the global solar energy industry convened in Germany last December 7–8 to discuss the latest developments, research, and innovative approaches addressing the environmental durability, aging behavior, and service life of photovoltaic (PV) products. During the two-day Atlas Technical Conference on Accelerated Aging and Evaluation (ATCAE) at Berlin's Hotel Concorde, 100 participants from Europe, Asia, and the U.S. discussed the long-term effects of weather factors such as heat, water, and solar radiation on polymeric materials and PV modules.

In addition to economic, political, and market-related issues, the PV industry is challenged with long lifetime expectations for PV modules, relatively little experience and data, and a lack of consensus-based weathering standards. While the existing IEC design qualification and safety standards are necessary in helping to discover and avoid early "infant mortality" issues, these standards do not include weathering or long-term environmental durability testing. Therefore, ATCAE Solar focused on assessing and identifying options for testing PV products in an accelerated and realistic way to gain information about lifetime and environmental aging as early as possible.

Nineteen experts from industry, test houses, and research institutes presented their data, results, and recommendations for suitable test procedures. Presenters and participants expressed that single or dual parameter tests like the popular "damp-heat test" are not able to deliver realistic information about long-term aging of PV modules under the influence of weather. It was agreed that that there are several promising concepts in discussion but that there is still considerable work to be done toward having internationally accepted weathering standards for PV modules.

Atlas, being the leader in weathering technology, will continue to facilitate and advance the dialogue among international experts on weathering and lifetime testing of PV modules by organizing further local and international events, as well as contributing to national and international consortia, standard developing committees, and industry workshops and symposia.

Atlas will host its next solar conference this year in Shanghai, China.

Watch for information soon at www.atlas-mts.com.

Water Purity for Accelerated Weathering Testing

Industry Specifications, Water Treatment Methods, and Measurement of Water Quality for Compliance

The quality of the water used in Atlas water-cooled xenon-arc weathering instruments is very important. Water containing a high level of minerals and other contaminants will shorten the useful life of the xenon lamps. Specimen sprays and humidity created from poor water quality can coat the samples and shield them from the light. Many popular industry standards now specify the quality of the water used for this application. Listed on page 13 are some of the more well-known industry standards.

The objectives of this article are to help users of accelerated weathering test equipment understand the requirements of the applicable test methods, and how to relate the required specifications for pure water — in terms of resistivity in meg-ohms, vs conductivity in micro-Siemens (vs ppm of solids — that can include both total dissolved solids (TDS) and un-dissolved solids.

Resistivity and Conductivity

Resistivity and conductivity are electrical measurements that are made between two electrodes 1 cm apart and immersed into a sample of water. Resistivity is normally expressed in terms of meg-ohms/cm. Conductivity is the reciprocal of resistivity (1/meg-ohms) and is expressed in micro-Siemens/cm (μ-S). In brief, a high resistivity reading means higher-purity water. Conversely, a high conductivity reading means lower-purity water.

For example:	1 meg-ohm resistivity	=	1 μ-S
	5 meg-ohm resistivity	=	0.2 μ-S
	0.2 meg-ohm resistivity	=	5.0 μ-S

A resistivity meter or conductivity meter provides a fast and reliable in-line reading that is non-destructive to the water sample, inexpensive, and an easy means of measuring the ionic content of a water stream. These measurements are non-specific and cannot distinguish between the types of ions in the water stream. The measurement value is proportional to the combined effect of all ions present in the water.

Converting the resistivity or conductivity value to TDS is an approximate conversion that will vary with the type of ions in the water. For more information, refer to the Table of Water Quality on page 14.

An accurate TDS can be measured by carefully evaporating a measured sample of water to complete dryness and weighing the amount of dry solids remaining. While this procedure is the most accurate, it is slow, expensive, and not practical for a flowing stream of water. The use of a resistivity meter or conductivity meter is much faster and the accuracy is acceptable for most applications, including measuring/monitoring water quality for accelerated weathering testing.

Atlas xenon-arc instruments such as the Ci Series Weather-Ometers® include a built-in water purity meter that measures the resistivity of the water and is easily converted to conductivity or approximate TDS. TDS is normally expressed as ppm or mg/L.

Steps to ensure compliance with ASTM and SAE requirements of less than 1 ppm total solids (dissolved and un-dissolved), less that 0.1 ppm silica (ASTM), and less than 0.2 ppm silica (SAE) are as follows:

1) Use an RO system to pre-treat the feed water prior to the use of DI filters. The RO will remove very small particles, including colloidal silica that can pass through the DI filters.
2) Monitor the final RO/DI water quality going into the weathering instrument (resistivity must be greater than 0.5 meg-ohms; conductivity must be less than 2.0 μ-S)
3) Monitor the final RO/DI for silica and take steps to control the concentration of silica to less than 0.1 ppm (ASTM) or 0.2 ppm (SAE). Refer to the next section on silica for more information on how to measure and control.

Silica

The presence of silica in the water used for specimen sprays, humidity, and cooling the xenon-arc lamp can result in coating of the specimens, lamp, and interior of the test chamber with glass-like deposits that are difficult to remove. This coating on the specimens can negatively influence the test results.

Water Quality Requirements for Some Typical Weathering / Fading Test Methods

Test Method	Type of Water Treatment	Specified Quality
ASTM G155	Distillation or RO + DI	Below 5 µ-S conductivity, less than 1 ppm solids, less than 0.1 ppm silica (see note)
ASTM G154	Distillation or RO + DI	Below 5 µ-S conductivity, less than 1 ppm solids, less than 0.1 ppm silica (see note)
ASTM B-117	Specifies "Type IV" water per ASTM D1193	0.2 meg-ohms resistivity or greater
SAE J2527 / J2412	RO + DI	No more than 1 ppm solids, max. of 0.2 ppm silica
AATCC TM16	Demineralized, Distilled, RO	Below 17 ppm; less than 8 ppm preferred
AATCC TM169	Demineralized, Distilled, RO	Below 17 ppm; less than 6-8 ppm preferred
DIN 53-387	Demineralized, Distilled	Below 5 µ-S conductivity (0.2 meg-ohms, approx. 2.5 ppm)
ISO 4892-1	Distilled, RO + DI	Max. of 1 ppm solids, max. 0.2 ppm silica (recirculation of spray water not recommended)
ISO 11341	Distilled or Demineralized	Below 2.0 µ-S , less than 1 mg / L (1 ppm) solids

Notes for ASTM G155, G154
5 µ-S conductivity is inconsistent with the requirement for less than 1 ppm total solids (both dissolved and un-dissolved solids). Since the 1 ppm requirement is approx. 2 µ-S or approx. 0.5 meg-ohms, using the 1 ppm total solids.

ASTM and SAE test methods (listed above) include limits on the amount of silica that is acceptable in the pure water used for testing. Silica is a very "sneaky" ion. It does not add resistivity or conductivity to the water, and while the water purity meter may show that the water is in the ultra-pure range, it may contain unacceptable levels of silica.

Silica has very complex chemistry, which is beyond the scope of this article. In water, silica exists in two forms. Reactive silica is dissolved in water and is slightly ionized. Unreactive silica, or colloidal silica, acts more like a solid than a dissolved ion. Colloidal silica particles are very small, less than 0.001 micros, and will easily pass through a fine sediment filter and a DI filter and into the weathering instrument. Dissolved silica is also difficult to remove by using only a DI filter.

The combination of using an RO system equipped with thin film composite (TFC) membranes and the correct type of DI filter as a "polisher" is effective for removing silica down to a level as required in ASTM G155 (less than 0.1 ppm). SAE J2527 and J2412 both require less than 0.2 ppm.

ASTM now recommends the use of both RO and DI treatment for meeting the water quality requirements of G155. The Harris Water Systems Division of Harris Weathering Products had been supplying combination RO/DI water systems long before ASTM tightened up the water quality requirements for accelerated weathering testing and began recommending the use of a combination of RO/DI treatment.

If an RO/DI system is using water with the presence of silica in the feed water, special care has

Continued on next page

Water Purity, from previous page

Table of Water Quality[1]

Resistance Meg-Ohm/cm	Conductance µ-S/cm	Parts per Million as NaCl	Parts per Million as $CaCO_3$	Grains per Gallon as $CaCO_3$
18.3[2]	0.055	None	None	None
16.0	0.063	0.025	0.031	0.002
12.0	0.083	0.033	0.043	0.002
10.0	0.100	0.040	0.050	0.003
6.0	0.167	0.067	0.083	0.005
2.0	0.500	0.200	0.250	0.015
1.0	1.000	0.400	0.500	0.029
0.6	1.67	0.67	0.83	0.05
0.4	2.50	1.00	1.25	0.07
0.2	5.00	2.00	2.50	0.15
0.100	10.00	4.0	5.0	0.29
0.050	20.00	8.0	10.0	0.59
0.023	42.7	20.0	17.1	1.00
0.010	100	50	43	2.5
0.005	210	100	85	5.0
0.002	415	200	170	10.0
0.001	1020	500	425	25.0

[1] All data at 25°C water temperature
[2] Theoretical maximum – chemically pure water

to be taken to replace the DI filter before it is near exhaustion. When this filter is exhausted, any silica that has been trapped by the DI filter will be released into the final RO/DI water and can contaminate the instrument and specimens under test.

It may also be necessary to switch from a standard mixed bed DI filter to a nuclear grade mixed bed resin or to a semi-conductor (SC) grade mixed bed resin. The SC-type is more effective in blocking silica than the nuclear grade.

The following sections of this article contain information on how to measure the level of silica in the final RO/DI water in order to comply with the test method and help prove to an ISO auditor that your testing is in compliance.

Measuring the Amount of Silica in the Final RO/DI Water

In addition to measuring and monitoring the TDS in the final RO/DI water, a sample of the water should also be periodically measured for silica. A sample can be sent to a water testing laboratory or you can purchase your own testing apparatus.

Harris Water Systems offers a relatively inexpensive silica testing meter that complies with ASTM D859. It has a digital range of 0.000 to 2.00 mg/L (0.00 to 2.00 ppm), with a resolution of 0.01 mg/L.

The measurement method is an adaptation of the heteropoly blue method referenced in ASTM D859. The reaction between silica and reagents causes a blue tint in the sample, which is measured by the digital meter.

Special Dual Filter DI "Polisher" with Conductivity Meter

Harris Water Systems offers a small dual filter DI "polisher" that is mounted externally from than RO water system in the RO/DI water line going into the weathering instrument. After theRO-permeated water passes through the first 20" mixed bed DI filters, it passes through an in-line conductivity sensor equipped with an alarm that will warn the user that the first DI filter is nearing exhaustion. This early warning allows the user to replace the first DI filter cartridge before the second cartridge is exhausted, and prevents the DI filters from releasing the silica stored in the filters.

For further information on Harris Water Systems, visit **www.harriswatersystems.com**. You may also contact Atlas at atlas.info@ametek.com.

Atlas and Lloyd Instruments Provide Exposure/Evaluation Solution

By Thomas Hansen, AMETEK Denmark A/S, Gydevang 32-34, 3450 Allerod, Denmark

A host of material properties can be affected by exposure to natural influences such as solar radiation, temperature, moisture, polluted atmospheres, and wind. These not only include color and surface finish but mechanical properties as well, such as tensile strength, tear strength, break load, and ductility. Tensile and compression materials testing has a great synergy with weathering testing since key mechanical properties can be tested before and after either natural or accelerated weather testing.

Figure 1: Single & Twin Column Universal Materials Testing Machines

Testing Principles

The basic principle of universal testing machines involves the application of controlled forces in tension or compression being applied to samples under test over a specific period of time in order to determine their physical and mechanical properties. The availability of various grips and fixtures allows the machines to be adapted to make an extraordinary range of measurements for performing different types of testing, often to internationally recognized standards such as ASTM, ISO, and FINAT (Figure 1). In addition, these instruments offer sophisticated PC control as well as data analysis packages. PC control allows the machines to be programmed to perform the test exactly as outlined in a particular standard, ensuring repeatable testing, while software packages contain a library of testing standards for easier programming.

Testing Applicability

Universal testing machines are just that; they can be used to test almost any type of material, including metals, plastics, rubber, composites, laminates, textiles, concrete, glass, wood — the list is almost endless. One of the key benefits to utilizing these machines is that materials can be tested in their basic form, but also in the final product, by choosing the appropriate grip. The list below indicates some of mechanical properties that can be made using a universal testing machine.

Adhesion Strength • Bond Strength • Break Load • Coefficient of Friction • Compression • Creep and Stress Relaxation • Crush Resistance • Deformation Strength • Delamination Strength • Ductility • Elastic Limit • Elongation • Flexure/Bend Strength • Peel Strength • Puncture Strength • Rupture Strength • Shear Strength • Tear Resistance • Tensile Strength • Torsion • Toughness • Young's Modulus

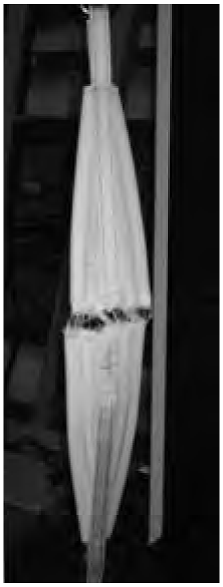

Figure 2

Testing for Yachts

The yachting environment provides an interesting example of the synergistic use of environmental and materials testing. A number of different components used on a yacht require testing, from the rigging, wire terminations, compression, and swage fittings to the sailcloth itself. The way one component interacts with another can have a huge effect on the functionality, not only of the system but also the components themselves. Yachts are equipped with sophisticated hydraulic/electric handling systems, which impose high loads. This means that the webbing attachment points must be absolutely fail-safe. These attachment points are frequently made from ultra-high molecular weight polyethylene fibers and polyester because of their weight and resistance to stretch, resistance to photodegradation in UV light, and excellent performance in wet and salty conditions. Pull-to-break tests have also been conducted on webbing attachment points (Figure 2) to provide valuable data to ensure that individual sails are fully compatible with the specific handling system. Simple sailcloth materials may be woven and treated with UV protection or clear resin coatings, while more sophisticated products include low-stretch, durable, multi-layer, laminated high-tech sails. While factory testing evaluates UV resistant coatings and strength parameters such as flogging fatigue, tear strength, and tensile strength, weathering testing plays a key role in the evaluation of sailcloth performance. Atlas has many natural weathering sites around the world and has been involved with sail makers in need of comprehensive exposure testing.

Samples can be tested for tensile strength at regular intervals to evaluate any degradation. For mechanical testing, Lloyd Instruments provides single and dual column materials testing machines. Atlas Material Testing Solutions and Lloyd Instruments are a part of the AMETEK Measurement & Calibration Technologies Division.

For further information on mechanical materials testing and services, visit **www.lloyd-instruments.co.uk.** Specific inquiries may be sent to uk-far.general@ametek.co.uk.

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