ATLAS MATERIAL TESTING SOLUTIONS
AMETEK® MEASUREMENT & CALIBRATION TECHNOLOGIES

SunSpots®

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Introduction

In weathering applications, the specimen temperature has an effect on the reaction kinetics. This means that it is important to know the specific temperature of a material in use. Such materials can be window profiles or other polymeric materials. The actual temperature of a building or a car, which is caused by solar radiation, has an effect on heat management. If the temperature is known, measures can be taken to reduce or control the temperature.

The first article, "Coloristic Ways to a Cool Facade — Heat Management: Keeping Temperature Under Control Despite Dark Color Shades," demonstrates the efforts to reduce the temperature of a building through the use of appropriate facade paint. The second article, "Simulation of Temperature on Surfaces Exposed to Solar Radiation," shows a way to estimate relevant temperatures with a simplified calculation model or to simulate the temperatures in a climate chamber. In both cases, the user gets a realistic estimate of the expected object temperatures.

Coloristic Ways to a Cool Facade

Heat Management: Keeping Temperature Under Control Despite Dark Color Shades

By Dr. Volker Ptatschek, DAW SE, Ober-Ramstadt, Germany

The trend toward more intensive shades of color on energy-efficient facades using External Thermal Insulation Composite Systems (ETICS), also referred to as Exterior Insulation and Finishing Systems (EIFS), cannot be ignored. Customers increasingly want dark shades. The problem is, these surfaces heat up more than light facades under solar radiation. In addition, ETICS surfaces heat up more intensively than a solid brick facade. The final coating of plaster is therefore exposed to great tensions. The heavy fluctuations in the surface temperature that occur can cause cracking and deformation.

To avoid the risk of damaging the ETIC system, a standard limitation for the relative luminance (RL) was defined at not less than 20 in Germany. RL corresponds to the tristimulus value Y of the CIE XYZ color space (RL = 0 yields black and RL = 100 indicates diffuse white). If the RL drops below 20, an expert must be aware that the risk of damaging the ETICS increases significantly.

Heating Up and Relative Luminance

RL doesn't sufficiently describe the solar reflectivity and the resulting heating up of coating. The Total Solar Reflectance (TSR) is a better parameter to describe this phenomenon. TSR is the percentage of sunlight reflected from a

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Atlas introduces UA-EMMA®, the latest innovation in ultra-accelerated weathering Page 14

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CLIENT EDUCATION ATLAS

Keep Your Team Up to Date!

Fundamentals of Weathering I

April 29, 2014	Kolding, Denmark	Presented in Danish
May 7, 2014	Mannheim, Germany	Presented in German
June 11, 2014	Leicester, UK	Presented in English
June 18, 2014	Chicago, IL, USA	Presented in English
September 2, 2014	Olten, Switzerland	Presented in German
October 22, 2014	Chicago, IL, USA	Presented in English
November 4, 2014	Paris, France	Presented in French
November 4, 2014	Oldenburg, Germany	Presented in German

Fundamentals of Weathering II

April 30, 2014	Kolding, Denmark	Presented in English
May 8, 2014	Mannheim, Germany	Presented in German
June 12, 2014	Leicester, UK	Presented in English
June 19, 2014	Chicago, IL, USA	Presented in English
September 3, 2014	Olten, Switzerland	Presented in German
October 23, 2014	Chicago, IL, USA	Presented in English
November 5, 2014	Paris, France	Presented in French
November 5, 2014	Oldenburg, Germany	Presented in German

Weather-Ometer® Workshop

June 17, 2014	Chicago, IL, USA	Presented in English
September 9–10, 2014	Linsengericht, Germany	Presented in German
October 21, 2014	Chicago, IL, USA	Presented in English

SUNTEST® Workshop

September 18, 2014	Linsengericht, Germany	Presented in German

Xenotest® Workshop

September 16–17, 2014	Linsengericht, Germany	Presented in German

Sample Preparation Workshop

October 8, 2014	Linsengericht, Germany	Presented in German

UVTest Workshop

June 4, 2014	Linsengericht, Germany	Presented in German

ATLAS • SPEAKS

Fundamentals of Weathering Seminar

May 20, 2014
STZ Institute of Plastic Engineers and Development IKET
Horb am Neckar, Germany

"Fundamentals of Weathering"

Presenters: Cees van Teylingen and Uwe Wendt,
Atlas Material Testing Technology GmbH

D + D 2014 Conference

May 22, 2014
Hilton Netherland Plaza Hotel
Cincinnati, OH, USA

"The Continuing Need for Coating Standards"

Presenter: Allen Zielnik,
Atlas Material Testing Technology LLC

ATLAS • SHOWS

Chinaplas 2014
April 23–26, 2014
Shanghai, China
Booth #W1J61, Hall W1

Indo Intertex 2014
April 23–26, 2014
Jakarta, Indonesia
PT Sarana Dinamika Pratama
Booth #A 68-69

SafetyWeek 2014
May 20–22, 2014
Aschaffenburg, Germany
Booth #19

2014 Automotive Engineering Exposition
May 21–23, 2014
Tokyo, Japan

ITMA ASIA 2014
June 16–20, 2014
Shanghai, China
Book #E3F09

InterPlas Thailand 2014
June 19–22, 2014
Bangkok, Thailand
Booth #6P08, Hall 106

InterSolar North America
July 8–10, 2014
San Francisco, CA, USA
Booth #7726

Asia Pacific Coatings Show 2014
September 3–5, 2014
Jakarta, Indonesia
Booth #D12

Automotive Testing Expo China 2014
September 15–17, 2014
Shanghai, China
Booth #4018

Enova
September 16–18, 2014
Paris, France

Interplas UK 2014
September 30–October 2, 2014
Birmingham, UK
Booth #H14 (shared booth with Lloyd Materials Testing)

testXpo
October 13–16, 2014
Ulm, Germany

Plastimagen 2014
November 18–21, 2014
Mexico City, Mexico
EQUIPOS Y SERVICIOS WESTEK
Booth #602

NPE 2015
March 23–27, 2015
Orlando, FL, USA
Booth #S18018

European Coatings Show
April 21–23, 2015
Nuremberg, Germany

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 http://atlas-mts.com/news-events/trade-shows/

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coating. The TSR also takes into consideration the near infrared light (NIR) in addition to the ultraviolet and visible light (UV-Vis) and therefore covers the whole solar spectrum from 250 to 2,500 nm (Figure 1).

In the determination of the RL, on the other hand, only part of the visible light between 400 nm and 700 nm is considered — only a fraction from an energy point of view — due to the fact that solar radiation is made up of 42 percent UV-Vis and 58 percent invisible NIR. This is confirmed by the results of practical measurements at the Dr. Robert Murjahn Institute (RMI) in Ober-Ramstadt, Germany.

On an ETIC system, the surface temperatures of four coatings with identical color but different TSR values were measured (Table 1, Figure 2). Result: Despite identical RL surface, temperatures from 71°C (160 °F) to 81°C (178 °F) are measured. Coatings with low TSR values create the highest temperatures. Coatings with high TSR values generate the lowest temperatures. The TSR value is the suitable variable for predicting the surface temperatures of facade surfaces. When using TSR values, keep in mind that no standardized test methods currently exist. In addition to this, the TSR is influenced by coating thickness, background surface, and solar spectrum. The comparisons of TSR data must therefore be handled with caution. The TSR values of a facade are almost impossible to determine practically on site as well. Therefore, this limits the use of the TSR value.

More intensive shades of color are being used on energy-efficient facades. This house in Stuttgart, Germany (built in 1938), was completely renovated with carbon fiber-reinforced ETICS. The insulating system that was used, Carbon DarkSide from Caparol (the market leader in building paints in Germany), offers maximum design possibilities.

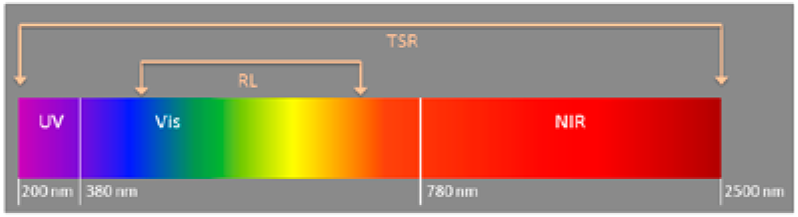

Figure 1: *Chart (not to scale) of the electromagnetic spectrum of solar radiation relevant to heating. The wavelength ranges for the determination of the RL value and the TSR value are marked.*

Solar Reflection of Pigments

The use of the TSR value is closely linked with a new technological solution for reducing the solar heating of facades. The technical principle: Special pigments are used in the color shade formulations of facade paints that better reflect the sunlight. Since color shades are nothing more than pigment mixtures, it is worth having a look at the individual pigments (Table 2).

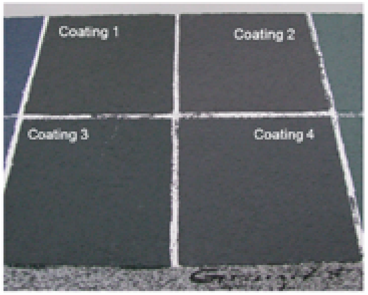

Figure 2: *ETICS test board for measuring the surface temperatures. It was painted twice with four different pigmented paints on white scraped plaster. (System structure: 120 mm board of expanded polystyrene (EPS); adhesive and reinforcement compound with fabric; white scraped plaster (K20); two final coats of paint)*

Table 1: Surface temperatures of four coatings with idential color but different TSR values on an ETIC system

	Coating 1	Coating 2	Coating 3	Coating 4
RL	6.8	6.8	6.8	6.8
TSR* [%]	5.4	14.5	22.6	28.7
T_{max} [°C / °F]	81 / 178	77 / 171	73 / 163	71 / 160

**According to ASTM G173; measured over white background surface; 200 µm dry film thickness*

Titanium dioxide is the most important pigment and has the highest TSR value. As a result, it has the lowest surface heating. At the other end of the spectrum, carbon black and iron oxide black pigments have the lowest TSR values of about 5 percent. These pigments are responsible for the problem of intensely heating the surfaces. When considering common colored pigments, the TSR values are considerably higher than those of all black pigments, even the special IR-black pigments. Colored pigments, therefore, play a minor role in the heating up, especially in very intensive shades.

Formulations of Very Intensive Color Shades

If you analyze the pigment composition of dark shades with RL < 20, you can see that black pigments play a crucial role. The darker the shade, the more black pigment is used, because black pigments are coloristically, economically, and technically (keyword *color fastness*) the pigment of first choice. This causes a dilemma due to the fact that dark shades heat up more as a result of having a higher amount of black pigment. Experience shows that the highest surface temperatures are obtained with dark gray and black shades. As a result, black pigments are the key to dark coatings. If you want to reduce this heating effect, then you have two coloristic possibilities:

Table 2: TSR values of pigments

Pigment	TSR* [%]
Phthalocyanine blue	31.7
Phthalocyanine green	29.1
Diketopyrrolopyrrole red	55.5
Dioxazine violet	41.1
Iron oxide red	36.3
Iron oxide yellow	45.0
Bismuth vanadate	71.1
Cobalt blue	50.9
Titanium dioxide	83.5
Carbon black	5.4
Iron oxide black	5.4
IR-black pigments	14.4 - 22.6

**According to ASTM G173; measured over white background surface; 200 µm dry film thickness*

1. Elimination of carbon black and iron oxide black pigments and use of black pigments with higher NIR reflectance
2. Total elimination of black pigments

However, the latter alternative demands the use of intensive colored organic pigments. In addition, complementary colors must be mixed to create neutral gray and black shades. This is considered to be a coloristically unsatisfactory method because of undesirable deviations in shade accuracy and color fastness. This increases the risk of having “multi-colored” facades.

Moreover, a pure white intermediate coating or plaster must be applied as an NIR-reflector in order to take advantage of the higher NIR-transparency of these pigments. The trade-off is that damages to the corners and stressed areas are prominent resulting in visual defects.

What Performance Do the Systems Really Have?

In order to assess the performance of the above-mentioned pigmentation concepts on ETICS, a series of tests was carried out in Germany by the R&D of DAW SE (a leading coating manufacturer in Germany) and the RMI. These tests were conducted using only natural sunlight in order to get the most reliable results.

Coating structures on single insulation boards as well as complete facades were tested. The temperatures were measured by built-in sensors over a period of several months to obtain long-term results. These outdoor tests confirm that carbon black and iron oxide pigments lead to the highest surface temperatures (Figure 3). Temperatures greater than 80 °C (176 °F) are often reached in this area. By using IR-black pigments or organic pigment mixtures, the surface temperatures can be reduced by up to 10 K. This reduction in temperature has a technical advantage for temperature-dependent degradation processes of facade coatings. On the other hand, temperatures over 70 °C (158 °F) were also measured on surfaces with optimized IR reflection. The temperature advantages of up to 20 K that are advertised in the brochures were never achieved in the practice

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test. The reason for this discrepancy is the result of using artificial radiation sources in laboratory tests. For Halogen lamps, about 80% of the emitted energy lies in the IR and NIR parts of the spectrum. Only about 20 percent falls into the UV-Vis part. These light sources cannot fully imitate the natural sunlight and, therefore, leads to different results. Light sources that simulate natural sunlight are essential for obtaining comparable results.

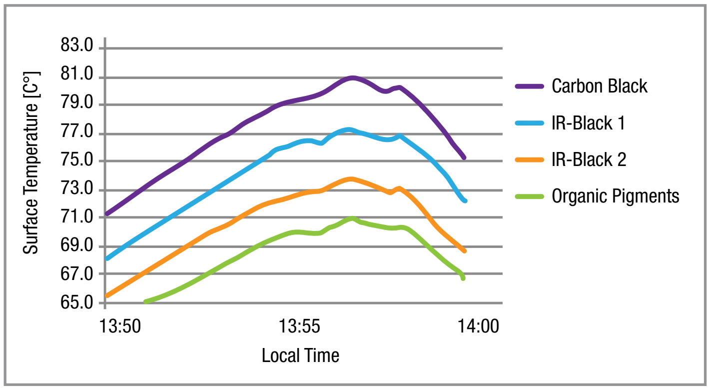

Figure 3: *Measured surface temperatures on August 18, 2011 of four coatings with identical color but different pigment formulations on ETICS. (System structure: 120 mm EPS board; adhesive and reinforcement compound with fabric; white scraped plaster (K20); two final coats of paint)*

Conclusion

The TSR value can be used to describe and forecast the heating up of facade surfaces. By using suitable pigments with optimized NIR reflectance, the surface temperatures can be reduced by up to 10 K. Temperatures of above 70 °C (158 °F) still cannot be avoided in practice. Carbon black and iron oxide black pigments are mainly responsible for heating up and should be avoided. Inorganic black pigments with increased NIR reflectance give coatings the following advantages: optimized TSR values, reduced heating, and weathering fastness for all silicate, silicone resin, and dispersion-based facade paints. ■

Simulation of Temperatures on Surfaces Exposed to Solar Radiation

By Artur Schönlein and Sönke Senff, Atlas Material Testing Technology GmbH

Objects that are exposed to and absorb radiation from the sun heat up. The actual surface temperature depends on the material, the shape of the object and the weather factors (sun, air temperature, wind, humidity) [1, 2].

A simple model for calculating surface temperatures is presented in this study. The input data are the actual weather data and the specific material properties. The possibilities and limitations of the model are discussed.

An additional backup and often the only possibility for a realistic estimation of the surface temperature to be expected under natural conditions is a simulation in a climate chamber. A prerequisite for this is that it simulates the natural weather conditions as realistically as possible.

A climate chamber with a laboratory light source is considered, by means of which temperatures can be simulated and measured on surfaces exposed to the sun's radiation. Surface temperature sensors with different solar absorption are used to validate such a climate chamber.

Material Temperatures Influence Properties of Use

The properties of use of most materials are also determined by the actual temperatures in the application [3, 4]. These materials may be window profiles [5] or other polymer base materials, for example. The micro climate on and in building walls is also essentially influenced by the absorbed solar radiation, depending on the material properties [6]. The same applies for temperatures inside buildings and automobiles.

These examples clearly show that the knowledge of the temperatures on surfaces exposed to solar radiation is important, because if it is known what temperature values can be realistically expected, measures for optimizing the micro climate can be taken — for example, reducing the useful temperature though improved spectral reflection properties or adapted design measures as well as improved acclimatization.

Calculation of Surface Temperatures

A simple model in which temperatures on surfaces with simple geometries exposed to the sun's radiation can be calculated is presented below (see also Figure 1).

This is a balance equation for the energy that is absorbed or emitted by the area per unit of time in stationary balance. The variable to be determined in the equation is the surface temperature $T_{SURFACE}$. The equation is:

$$S + L(T_{SURFACE}) + H(T_{SURFACE}) + K(T_{SURFACE}) = 0 \qquad \textbf{\textit{Equation 1}}$$

Legend:

S	absorbed solar radiation
$L(T_{SURFACE})$	long-wave radiation exposure and emission
$H(T_{SURFACE})$	heat exchange with the ambient air (convection)
$K(T_{SURFACE})$	heat exchange by heat conduction

The expressions depending on $T_{SURFACE}$ are described:

$L(T_{SURFACE}) = \varepsilon_K \cdot (A + E - \sigma \cdot T^4_{SURFACE})$ and $H(T_{SURFACE}) = \alpha \cdot (T_{SURFACE} - T_{AMBIENT})$ as well as $K(T_{SURFACE}) = \lambda \cdot (T_{SURFACE} - T_{AMBIENT})/d$. The long-wave radiation balance is described in the directive VDI 3789 part 2

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Simulation of Surface Temperatures, from previous page

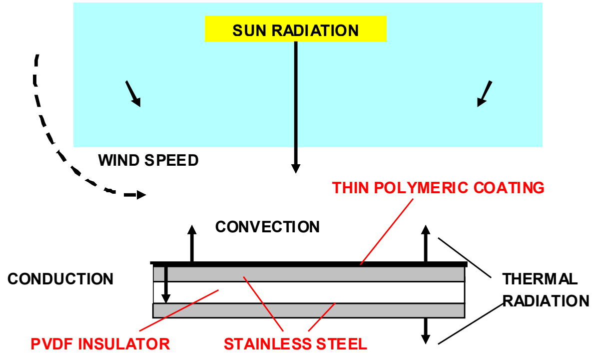

Figure 1: *Schematic diagram of a painted, insulated stainless steel plate that is exposed to the natural weather factors solar radiation, ambient temperature, and wind*

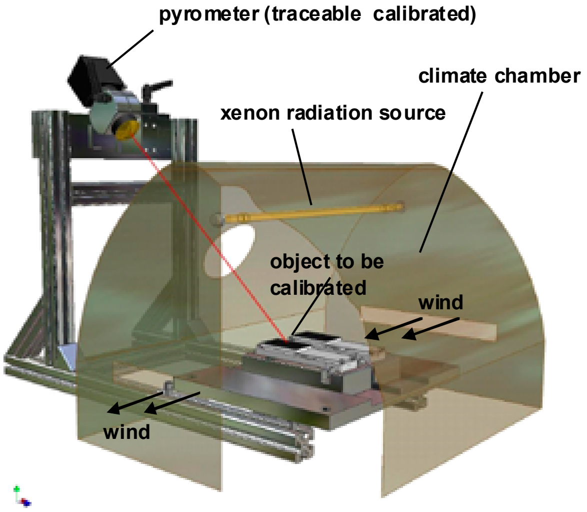

Figure 2: *Schematic diagram of a climate chamber for simulation of temperatures on surfaces exposed to solar radiation*

[7]: A is the radiation from the atmosphere, E the radiation from the environment, the emitted radiation is proportional to $T^4_{SURFACE}$. As absorption or emission, $\varepsilon_K = 0.9$ is used. The coefficient of heat conduction is represented by λ, the thickness of the insulator by d.

$T_{AMBIENT}$ is the temperature of the surrounding air. For $T_{SURFACE} > T_{AMBIENT}$ the heat flow is directed from the surface $H(T_{SURFACE}) < 0$ against the solar radiation $S > 0$ so that energy is emitted from the surface. The heat transfer coefficient $\alpha > 0$ depends on the wind velocity, whereby the case "forced turbulent air circulation" [8] is assumed. Depending on the value of the other terms, the solution of the equation responds more or less sensitively to a change in the input variable "wind velocity." The equation is solved with a Newton iteration.

Surface temperatures of more complex objects and flows can be calculated by the procedure applied in [9].

Climate Chamber with Laboratory Light Source

Although a climate chamber can only approximate real conditions, it appears useful to simulate naturally occurring surface temperatures in a climate chamber — not only as a supplement to the calculation but also as a backup to the calculated surface temperatures. Such a climate chamber must be able to simulate the real weather factors as well as possible. The relevant factors are the solar radiation, the air temperature, the wind velocity as well are the air flow on the object, and the relative humidity. The devices currently being used for laboratory weathering are largely suitable. The requirements for laboratory weathering devices are described, for example, in ISO 4892-1 [10]. The special requirements regarding the laboratory light source are described later in this study. Climate chambers with laboratory light sources arranged horizontally over the objects are preferred for objects with complicated shapes (see Figure 2). The advantage of such chambers is that the radiation on the horizontal specimen surface is not (or is only minimally) dependent on the reflection from the specimen. The surface temperature of the specimen can be measured without contact by a pyrometer, for example.

Simulation of the Solar Radiation

The effect of solar radiation (global radiation) is one of the most important weather factors in the simulation of temperatures on surfaces exposed to solar radiation. The spectral irradiance of the solar radiation is dependent on the wavelength and is widely variable locally and in time on the earth's surface. A spectral energy distribution calculated with CESORA [11] or according to [7] can be used to calculate surface temperatures with Equation 1.

What spectral distribution is sufficient for simulation of surface temperatures in a climate chamber? First of all, the laboratory light source should have a spectrum as similar as possible to the sun over the whole spectral range (UV, VIS, IR). Irradiances calculated with CESORA at noon at different locations on June 21 (see Table 1) show that a laboratory light source should have about 60% of the total irradiance in the wavelength range of 300 to 800 nm. This prerequisite can be satisfied very well with filtered xenon and metal halide radiation (see spectra in Figure 3).

Validation of a Climate Chamber with Laboratory Light Source

Sensors that basically comply with the specification of the black and white standard sensors of ISO 4892-1 [10] are used to check the laboratory light source. Only the surfaces are painted with different colors. Although the different RAL colors are similar or identical, the spectral reflections of the two sets used are clearly different, especially above 800 nm (see Figures 4 and 5). The calculated solar absorption of the two sets can be seen in Table 2 (columns 4 and 5). A change in the order can be observed in Set B (orange and red).

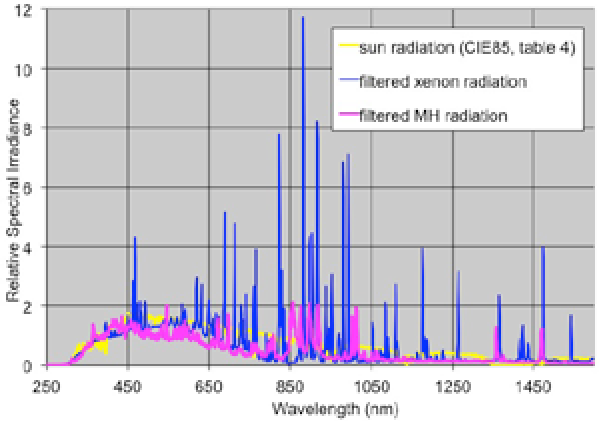

Figure 3: *Spectra of filtered xenon and metal halide (MH) radiation as well as solar radiation spectra according to CIE85, Table 4 [12] recalculated with CESORA [13]*

Table 1: Irradiances in different wavelength ranges calculated with CESORA [11] for the reference climates in Arizona and Florida as well as for a typical soccer venue in Central Europe and Cape Town (Soccer World Cup 2010). The spectra are calculated at noon — highest position of the sun — on June 21. The last column of the table contains the irradiances for the reference spectrum for laboratory weathering tests of CIE85, Table 4 [12] recalculated with CESORA [13]

Wavelength Range	Arizona	Florida	Frankfurt	Cape Town	CIE85 Table 4
(nm)	E (W/m²)	E (W/m²)	E (W/m²)	E (W/m²)	E (W/m²)
280-300	0.02	0.02	0.01	0.02	0.01
300-400	60	62	48	62	66
400-800	566	584	468	567	617
800-4000	420	387	350	430	434
280-4000	1046	1033	866	1059	1117

Table 2: Solar absorption properties of the coatings for measuring surface temperatures. Second and third line: RAL colors; fourth and fifth line: percentage of absorbed solar radiation. The percentage of absorbed radiation is calculated by the measured spectral reflection and the global radiation is calculated with CESORA [11] (for example, in September).

Color	White	Yellow	Orange	Red	Blue	Green	Black
RAL (Set A)	9003	1023	2011	3020	5002	6001	9005
RAL (Set B)	9003	1023	2001	3020	5002	6001	9005
Absorption (A)	25%	53%	62%	70%	79%	82%	96%
Absorption (B)	25%	48%	63%	56%	77%	81%	96%

The colored surface temperature sensors are basically painted 1 mm thick stainless steel sheets (RAL colors) with 5 mm thick PVDF insulation. The temperature is measured at intervals of 0.5 s. The average value is then recorded every minute. A total of 100 hours can be saved. The sensors are calibrated according to a special procedure in accordance with ISO 17025 [14].

These surface temperature sensors can be used, for example, to carry out outdoor measurements in the reference climates in Florida and Arizona and compare them with measurements in a climate chamber with a laboratory radiation source. For this purpose, the following weather data must be recorded outdoors in addition to the surface temperatures: ambient temperature, wind velocity, relative humidity, and, with the appropriate orientation against the earth's surface (0°, 45°, 90°), the total irradiance in the wavelength from 300 nm to 3,000 nm.

The weather data measured outdoors can be compared directly with that of a climate chamber. The procedure for this is as follows:

1. Measurement of the surface temperatures and weather data outdoors
2. Calculation of 10-minute averages (because of possible fluctuations)
3. Setting of the measured weather data (10-minute averages) in the climate chamber (total irradiance, ambient temperature, relative humidity, wind velocity)
4. Measurement of the surface temperatures in the climate chamber in stationary balance
5. Comparison of the surface temperatures of the colored sensors with the surface temperatures measured outdoors (10-minute values)

The absolute temperatures as well as the order of surface temperatures in the climate chamber and outdoors can be compared using this procedure.

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Simulation of Surface Temperatures, from previous page

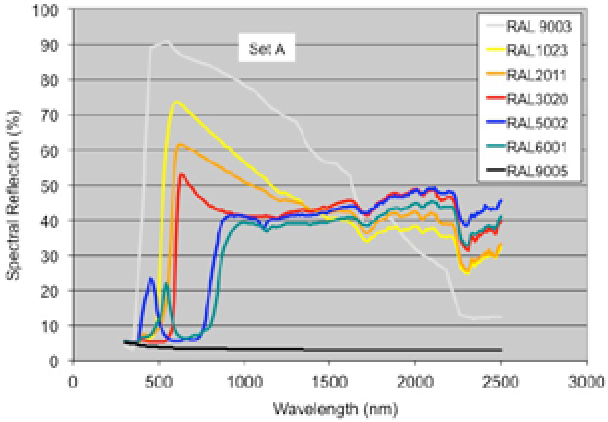

Figure 4: *Spectral reflection of Set A of the color painted surface temperature sensors for validation of a climate chamber*

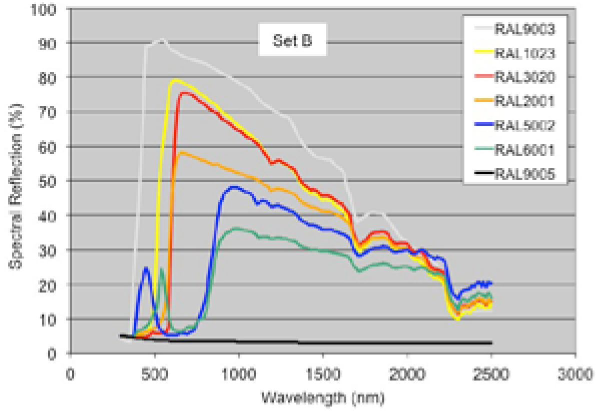

Figure 5: *Spectral reflection of Set B of the color painted surface temperature sensors for validation of a climate chamber*

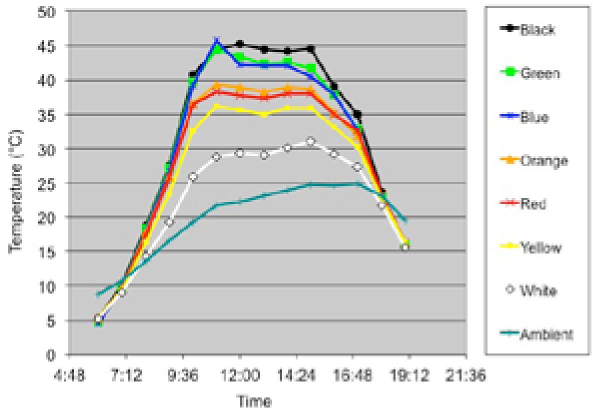

Figure 6: *Daily path (10-minute averages per hour) for Set B of the colored sheets in Arizona on March 28, 2009; a partly cloudy day with strong winds in the morning*

Measuring Results Outdoors

The weather data and surface temperatures recorded outdoors fluctuate heavily depending on the weather situation (e.g., wind gusts, clouds). Ten-minute averages are calculated to simplify the evaluation. Figure 6 shows a daily path for Set B of the color-painted sheets. The temperature separation of the different painted sheets clearly starts and ends as soon as the global radiation reaches approximately 300 W/m^2. This is the case between 8 and 9 am and between 4 and 5 pm. It must be noted that the additionally recorded weather data are frequently not recorded in the same place as the temperatures of the materials to be examined (color painted sheets in our case) so it is quite possible that the micro climate may deviate there. Table 3 lists the 10-minute averages together with the surface temperatures calculated using Equation 1 for Arizona at different times of the day on September 4, 2008. The measured weather data are used as input variables. The calculated temperatures are of the same size and order as the actually measured temperatures. Smaller and slightly greater deviations depending on the color and time of day are revealed, which can be explained by insufficient local weather data and to the simple calculation model (see section 2). Other examples for calculated surface temperatures can be found in [2].

Measuring Results in a Climate Chamber

Xenon and metal halide lamps provide a temperature separation that rises with the irradiance (examples: Figure 7, Set A and Figure 8, Set B) which can also be influenced by the change in the air velocity (air flow on the object) above the surface.

A change in the ambient temperature increases the surface temperature of irradiated objects by the same amount [15], [16]. Therefore, different surface temperatures in laboratory weathering devices and outdoors can be compared with each other when the ambient temperature (measured according to meteorological principles 2 m above the earth's surface with radiation protection) is subtracted from the measured surface temperature ($\Delta T = T_{SURFACE} - T_{AMBIENT}$, often referred to as COLOR – AMB in the text).

Comparison of Measured Surface Temperatures Outdoors and in a Climate Chamber with Laboratory Light Source

The measured surface temperatures outdoors and in the climate chamber are compared with each other to validate the laboratory light source. Several daily paths are evaluated for this purpose. Figure 9 shows an example for September 4, 2008 at 1 pm. The same order and size of temperatures is reproduced as outdoors for xenon and MH radiation for the color-painted Set A.

The comparison for Set B (Figure 10) shows a good match of the order and absolute temperatures for the measurement in Arizona on March 30, 2009 and in the xenon climate chamber. In the MH climate chamber, the order of the surface temperatures of the red and orange temperature sensor is different. This may be due to temperature differences on the measuring level in the device. The order may also occasionally be different outdoors in the case of slighter temperature differences (for example, with orange/red or blue/green) due to heavy fluctuations (wind gusts or clouds at the measuring location), especially at total irradiances of <600 W/m^2 (example: Table 4, Set B, 4 pm).

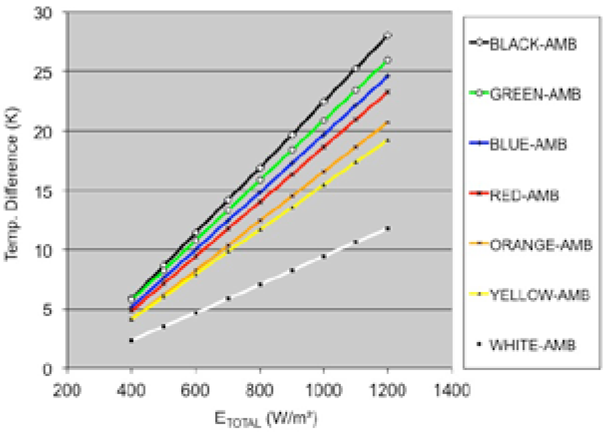

Figure 7: *Surface temperature differences ($\Delta T = T_{SURFACE} - T_{AMBIENT}$ = COLOR - AMB) of colored sheets (Set A) in a laboratory weathering device with xenon lamp at low air velocity, about 1m/s (Xenotest® Beta, filter XENOCHROME® 300 (direct solar radiation according to CIE85, Table 4))*

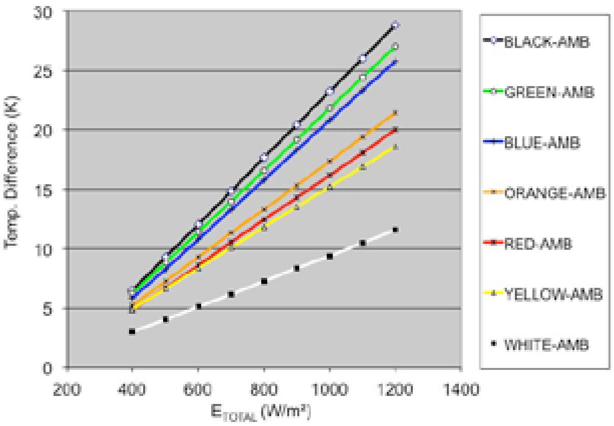

Figure 8: *Surface temperature differences ($\Delta T = T_{SURFACE} - T_{AMBIENT}$ = COLOR - AMB) of colored sheets (set B) in a laboratory weathering device with xenon lamp at low air velocity, about 1m/s (Xenotest Beta, filter XENOCHROME 300 (direct solar radiation according to CIE85, Table 4))*

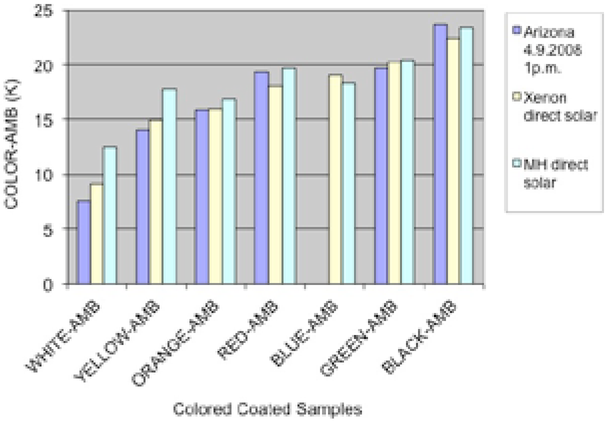

Figure 9: *$T_{SURFACE} - T_{AMBIENT}$ = COLOR - AMB of color painted sheets (set A) in Arizona on September 4, 2008 at 1 pm in a xenon and an MH laboratory weathering device. The total irradiance E_{TOTAL} is 990 W/m^2. The wind velocities are between 3 m/s and 1.5 m/s for Arizona and xenon, for MH approximately 0.2 to 0.4 m/s.*

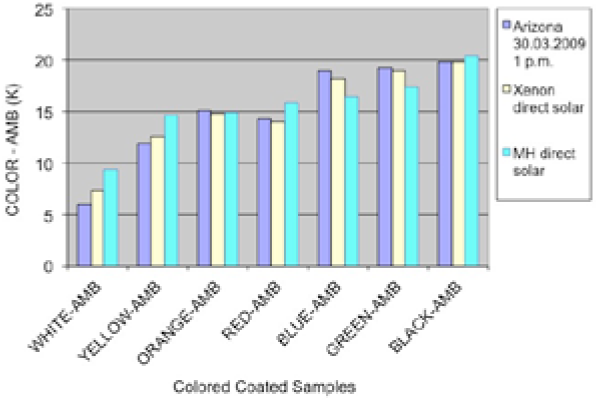

Figure 10: *$T_{SURFACE} - T_{AMBIENT}$ = COLOR - AMB MG of color painted sheets (set B) in Arizona on March 30, 2009 at 1 pm in a xenon and an MH laboratory weathering device. The total irradiance E_{TOTAL} is 1070 W/m^2. The wind velocities are between 3 m/s and 6 m/s for Arizona and for xenon approx. 3 m/s, for MH approx. 0.2 to 0.4 m/s. For MH the total irradiance had to be set to 850 W/m^2 for the measurement to achieve the specified temperatures because it was not possible to increase the air speed in the special device.*

Continued on next page

Simulation of Surface Temperatures, from previous page

Table 3: Measured (meas) and calculated (calc) surface temperatures by Equation 1 for Set A and weather parameters at different times of the day in Arizona on a cloudless day on September 4, 2008 (10-minute averages).

Unit	Date	September 4, 2008				
h	Time of Day	9:00 am	11:00 am	1:00 pm	3:00 pm	4:00 pm
W/m^2	E_{TOTAL}	593	939	990	743	523
°C	$T_{AMBIENT}$	32.3	36.2	38.5	39.8	39.5
%	U	16.5	17.4	11.6	8.6	9.1
m/s	Wind	2.7	2.4	1.7	3.0	2.1
°C	White (meas)	37.4	43.5	46.1	45.0	44.0
	White (calc)	36.2	43.0	46.4	44.4	43.2
	Yellow (meas)	40.9	49.8	52.5	49.5	47.8
	Yellow (calc)	39.2	47.9	52.0	48.0	46.0
	Orange (meas)	42.0	50.4	54.4	50.5	48.0
	Orange (calc)	40.4	49.4	53.8	49.1	46.9
	Red (meas)	44.2	51.9	57.8	53.5	49.7
	Red (calc)	41.0	50.8	55.4	50.1	47.7
	Blue (meas)	Measured Data Unavailable				
	Blue (calc)	42.0	52.4	57.2	51.3	48.6
	Green (meas)	44.7	55.4	58.2	53.0	51.1
	Green (calc)	42.3	52.9	57.8	51.7	58.9
	Black (meas)	45.9	55.9	60.2	55.3	52.1
	Black (calc)	43.7	55.3	60.6	53.5	50.3

Summary

The surface temperature increase due to global radiation begins as soon as the solar radiation reaches the material surface. For example, at $E_{TOTAL} = 360$ W/m^2, the maximum surface temperature is already heated up about 5 K (depending on the wind velocity at the measurement location) above the ambient temperature.

The surface temperatures measured outdoors can be estimated effectively with a simple model (Equation 1). The greatest factors of uncertainty are the insufficient knowledge of the wind velocities at the location of the measurement and the heat transfer coefficient for the convection, which can often be only a good approximation from the references.

At a given material geometry and solar absorption, the temperature difference $\Delta T = T_{SURFACE} - T_{AMBIENT}$ is only dependent on the total irradiance and the free and/or forced convection (wind velocity, wind direction).

Laboratory weathering devices with xenon and metal halide lamps can reproduce the natural temperature separation of color-painted sheets effectively when the weather parameters irradiance (UV+VIS approx. 60% of the total radiation), wind velocity, and ambient temperature are suitably simulated. This does not apply only for midday but also for the whole daily path.

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Table 4: $T_{SURFACE}$ - $T_{AMBIENT}$ = COLOR - AMB of color-painted sheets (Set B) in Arizona on March 30, 2009 at 9 am and 4 pm in a xenon and an MH laboratory weathering device; a fine, cloudless day.

	ΔT (K)	Arizona	Xenon Direct	MH Direct
E_{TOTAL}= 590 W/m² v_{WIND} = 4.0 m/s 9 am	White-UMG	2.7	3.7	5.3
	Yellow-UMG	6.0	6.4	8.6
	Orange-UMG	8.1	7.4	8.8
	Red-UMG	7.9	7.2	9.6
	Blue-UMG	9.0	9.2	8.7
	Green-UMG	9.4	9.5	10.2
	Black-UMG	11.3	9.7	12.4
	ΔT (K)	Arizona	Xenon Direct	MH Direct
E_{TOTAL}= 587 W/m² v_{WIND} = 2.5 m/s 4 pm	White-UMG	3.9	4.97	5.2
	Yellow-UMG	7.5	8.11	8.6
	Orange-UMG	9.7	9.34	8.8
	Red-UMG	10.3	9.04	9.6
	Blue-UMG	11.1	11.51	8.6
	Green-UMG	11.2	11.86	10.2
	Black-UMG	15.6	13.10	12.3

Atlas Introduces UA-EMMA®

The Latest Innovation in Ultra-Accelerated Weathering

Atlas is excited to introduce its latest advancement in exposure testing, the Ultra-Accelerated EMMA® (UA-EMMA®). This new outdoor testing device provides approximately 10-12 years of equivalent radiation exposure as would be received in South Florida in a single year. Atlas developed this new solar concentrator technology utilizing the same "cool mirror" technology used in its Ultra-Accelerated Weathering System (UAWS).

Similar in concept to Atlas' Equatorial Mount with Mirrors for Acceleration (EMMA) technology, the new ultra-accelerated EMMA device tracks the sun while concentrating reflected sunlight on test specimens mounted in a target area. The difference, however, lies in the new patented mirror system used in the UA-EMMA, which has very high reflectance in the UV and near visible wavelength ranges while attenuating reflectance in the longer wavelength visible and IR portions of the solar spectrum. This leading-edge technology allows for very high concentrations of UV energy without excessive heating of test samples.

High-irradiance solar concentrators or laboratory solar simulators built for ultra-high-irradiance durability testing often cause test samples to overheat, resulting in unnatural material changes compared to those in an end-use environment. Atlas' new technology is different in that it simultaneously fulfills three requirements critical for ultra- accelerated exposure testing:

- Allows for the exposure of many different types of materials to ultra-high UV irradiances
- Maintains high fidelity to the natural solar UV spectrum
- Keeps specimens at acceptable exposure temperatures

The UA-EMMA employs 20 focusing mirrors arranged as parabolic facets to variably concentrate UV energy on a target area approximately 15 cm x 76 cm (6 in x 30 in). UA-EMMA is also fully compliant with existing industry standards such as ASTM G90 – 10 *Standard Practice for Performing Accelerated Outdoor Weathering of Nonmetallic Materials Using Concentrated Natural Sunlight.*

Materials/products that are ideal candidates for UA-EMMA testing:

- Materials that require a long service life
- Transparent and glazing materials
- Temperature sensitive materials such as PVC
- Coatings applied to metal panels
- Materials that perform well in EMMA® or EMMAQUA® exposure testing

For more information on UA-EMMA testing, please contact Atlas at atlas.info@ametek.com. ■

The Florida Keys: A Paradise for Corrosion

For many, the idea of living on a tropical island is the ultimate dream. But not all is always perfect in paradise.

One downside to a marine island environment is its corrosive effect on materials. The Florida Keys are classified as a Tropical Savanna (Aw) [1]. A Tropical Savanna climate, or tropical wet dry climate, experiences equal parts wet and dry seasons with warm to hot daily temperatures with minimal deviation through the seasons. [2] The Florida Keys are also a chain of coral-based islands that are completely enveloped by the Atlantic Ocean and Southeastern Gulf of Mexico. [3]

This unique combination of environmental factors creates a paradise for residents and visitors but a harsh environment for everyday materials. This is due to the synergistic effects of chloride deposition, condensing humidity, intense solar radiation and warm temperature cycling.

For example, over the past several years, many premature failures of powder-coated railings have been observed in the region from Ft. Lauderdale, FL to Marco Island, FL due to under-film corrosion. [4] Examples can be seen in Figure 2 and Figure 3, images taken at a newly renonovated oceanside hotel in Islamorada, FL (Florida Keys) in the fall of 2013. The under-film corrosion issue was determined to be linked to pre-treatment of the metal material prior to coating.

Atlas Weathering Services Group (AWSG) has been involved in many standards organizations over the years to address this type of corrosion. Efforts have included defining a coastal corrosion test method and particpating in correlation studies to define an accelerated corrosion method for coastal corrosion.

It is due to these efforts and requests by our customers that AWSG has been researching coastal locations to conduct coastal corrosion studies. Our goal is to help our customers vet issues such as the above prior to the product entering the marketplace.

In 2012, AWSG embarked on such a study at its newly opened test site in Layton City, Long Key in the Florida Keys. AWSG followed the parameters of ASTM G92 – 86 (2010) Standard Practice for Characterization of Atmospheric Test Sites. Specially prepared A36 finished steel and mill finished zinc panels were exposed according to ASTM G92.

Prior to exposure, the panels were properly cleaned of all oil and debris utilizing an organic citric acid pickling. Each panel was dried in a desiccant chamber and weighed, with initial weights recorded. Panels were then exposed at the Long Key site (Figure 4 and Figure 5).

Panels were removed at 3-month and 6-month intervals, cleaned of debris by media blast, dried and weighed. In Figure 6, you can see an example of an A36 steel panel after only 3 months.

At the end of the 12-month study, the final sets of panels were media blasted, dried and weighed. Final weights were then used to calculate mass loss over time (g/m^2) per ISO 12944-2. The following was discovered:

- A-36 steel exhibited an average mass loss 417 g/m^2 after 12 months of exposure. This equals a corrosivity category of C4 (high atmospheric-corrosivity) following ISO 12944:1998.

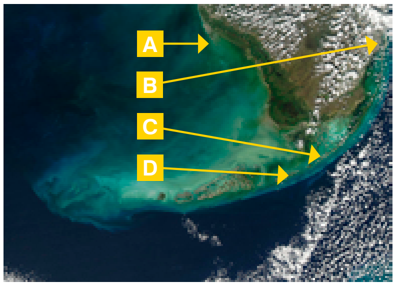

Figure 1: *(A) Marco Island, FL, (B) Ft. Lauderdale, FL, (C) Islamorada - Florida Keys, (D) Layton City, Long Key, FL - AWSG Coastal Corrosion Site*

(http://en.wikipedia.org/wiki/File:Floridakeys-nasa.jpg)

Figure 2

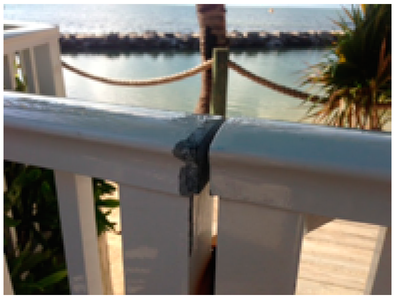

Figure 3

Continued on next page

Florida Keys, from previous page

- Rolled zinc exhibited an average mass loss 52 g/m^2 after 12 months of exposure. This equals a corrosivity category of C5-M (very high [marine] atmospheric-corrosivity) following ISO 12944:1998.

  Further studies are ongoing to develop a multi-year average.

The Florida Keys and South Florida are truly a subtropical paradise. But even paradise has its flaws. There are legitimate concerns of durability of many products with an end use in a coastal corrosive environment. However, these concerns can be mitigated by the due diligence of testing in end use environments. ■

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Figure 4

Figure 5

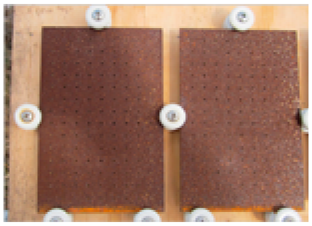


Figure 6

Atlas Now Offers Accredited Reference Cell Calibration Services

Atlas Weathering Services Group (AWSG) recently received ISO 17025 accreditation by A2LA to perform primary reference cell calibrations at our DSET Laboratories in Phoenix, AZ.

With this new accreditation, AWSG is pleased to announce the addition of reference cell calibration to our service offerings. We are now able to perform the following calibrations:

- Primary reference cell calibrations to ASTM E1125 in the wavelength range of 250-1700 nm
- Spectral response of reference cells and radiometers to ASTM E1021 in the wavelength range of 250-1700 nm
- I-V curve measurements to IEC 60904-1 in the range of 0-10 amps

As the first ISO 17025 laboratory accredited to offer radiometry calibration, AWSG has continually striven to expand our capabilities to meet the needs of our clients. In addition to this latest offering, we expect to announce the availability of secondary reference cell calibration services in the near future.

For a quote for reference cell calibrations or any of our other calibration services, please call +1-623-465-7356 x 101 or email john.wonders@ametek.com.

To view or download Atlas Weathering Services Group's Scope of Accreditation, please visit www.atlas-mts.com. ■

Atlas Announces Alliance with Pearl Laboratories

Two PV Durability Testing Laboratories Partner to Meet Solar Industry Needs

Atlas Material Testing Technology, the global leader in weathering technology and services, has entered into an alliance with Pearl Laboratories, a state-of-the art, third-party testing facility that offers reliable energy yield and performance evaluations for solar industry components. The collaboration between Atlas and Pearl Labs allows clients to obtain both Atlas' PV testing capabilities and Pearl's extensive testing services from a single source.

In addition to performance-based testing such as grid-tied testing in benchmark climates, material and component durability testing, and BOS durability studies, Atlas has developed a comprehensive, multi-dimensional, environmental weatherability program specifically for photovoltaic (PV) modules - Atlas 25$^{+®}$. A complement to the International Electrotechnical Commission's (IEC) "infant mortality" tests, this one-year program delivers:

- Weathering stresses representative of long-term outdoor exposure otherwise unattainable without lengthy real-time testing
- Independent third-party data to support R&D, cost reduction efforts and warranty and performance claims
- Validation to financial stakeholders at all levels

Pearl's testing services include PV grid-tied testing, shading and snow load studies, PID characterization, thermography, and PV module performance characterization.

"Atlas is extremely pleased to partner with Pearl Laboratories to provide expanded capabilities to our customers," said Rich Slomko, Global Testing Manager for Atlas Material Testing Technology. "The entire PV industry will benefit from this partnership. The combination of our joint capabilities will provide manufacturers with information that is critical to product development, while at the same time supportive of warranty and competitive sales positions."

"With the combined facilities, capabilities, and know-how of Atlas and Pearl Laboratories, we can now offer the PV industry a complete set of services for the testing, verification, and analysis of PV systems and components and how they will perform in the real world," said Anders Olsson, CEO of Pearl Laboratories. "Together, we provide critical services for the entire PV supply chain, from component R&D to performance verification and financial modeling." ■

> "The entire PV industry will benefit from this partnership."
>
> *» Rich Slomko*
> *Global Testing Manager,*
> *Atlas Material Testing Technology*

Atlas Consulting Services: Preparing Clients for Success

100 *consulting projects completed*

What Is Atlas Weathering Consulting?

Do you plan to introduce a new product or an innovative material system? Looking to target a new market with specific environmental stresses? Existing ISO, ASTM, or IEC standards not matching your testing needs?

The Atlas Consulting Group, a team of experienced and skilled chemists, physicists, and engineers, are able to develop, implement, execute, and validate the right test program for you — one that is tailored to your specific needs, materials, target climates, and application.

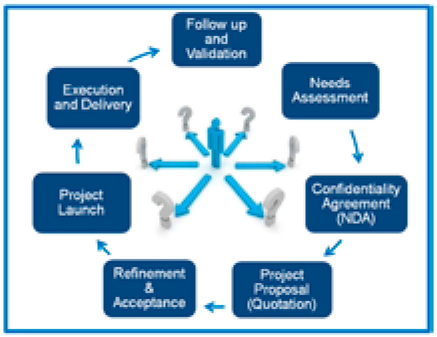
Since 2006, Atlas has successfully executed 100 consulting projects globally across many different industries.

When Is Weathering Consulting Needed?

Atlas Consulting Services' portfolio spans everything from two-day weatherability assessments to multi-year test program development and implementation projects. Regardless of the time frame, 90 percent of all projects start with the same question: How can I test my product to get the most relevant, reliable, and precise information about real-world aging in the shortest time possible?

Although there are more than a thousand published weathering standards and specifications, they may not be tailored to your specific situation. For example, there are several testing standards for paints and coatings, but how do you test your anti-reflective coating for office-tower windows in the Arabian Peninsula that will face the additional stress of sand abrasion? There are test methods for plastic materials, but how do you test the plastic housing of specific electric device enclosures for offshore use in the North Atlantic? How do you make sure a new parachute material performs over its guaranteed lifetime?

The Atlas Consulting Group is dedicated to problem solving. We research end-use conditions, model the worst-case environment, and develop a set of state-of-the-art test methods (i.e., a test program) for specific applications.



How Does Weathering Consulting Work?

When the Atlas Consulting Group embarks on a project, our first step is to conduct a needs assessment, reaching an agreement with the client on the exact scope, project deliverables, and milestones. Based on the results and the client's requirements, a detailed quote is provided. The actual consulting project is usually structured in phases with individual milestones, foe example: 1) FMEA workshop, 2) test method development, 3) implementation, and 4) validation. Often this procedure includes milestone-specific deliverables and reports. ■

To learn more about how Atlas Consulting Services can assist you with your test program development or testing strategy, contact your Atlas sales representative.

New ISO 16474 Series Combines Two Previous Standards for Paint and Varnish Weathering

In past years, the ISO standards for artificial accelerated weathering or artificial accelerated irradiation exposures on coatings were ISO 11341 Paints and Varnishes – Artificial weathering and exposure to artificial radiation – Exposure to filtered xenon-arc radiation, and ISO 11507 *Paints and Varnishes – Exposure of coatings to artificial weathering – Exposure to fluorescent UV lamps and water.* Instead of waiting extended periods for natural exposures, these methods allowed users to assess the effects of light, heat, and moisture on coatings properties in much shorter time periods. However, the overlap in these two standards proved confusing, not just for users but for the ISO/TC 35 (Coatings) technical committee responsible for their oversight.

Recently, the committee decided to clarify the structure to make the standards not only easier to use and understand, but also easier to maintain. ISO/TC 61 (*Plastics*) had addressed this same challenge for like standards for plastics by developing the ISO 4892 (*Plastics – Methods of exposure to laboratory light sources*) series of standards, consisting of four parts.

ISO/TC 35 decided to take the same approach, combining ISO 11341 and ISO 11507 into one series, having one part for common content and separate parts for xenon-arc and fluorescent UV lamp devices. Additionally, a new part for open-flame carbon-arc lamps was developed.

ISO 11341 and ISO 11507 have now been withdrawn, and the new series of standards is now published and available as ISO 16474, Parts 1 through 4. ISO 16474 has the following parts, under the general title Paints and varnishes – Methods of exposure to laboratory light sources:

- Part 1: General guidance
- Part 2: Xenon-arc lamps
- Part 3: Fluorescent UV lamps
- Part 4: Open-flame carbon-arc lamps

For brief summaries of ISO 16474, Parts 1 through 4, **click here**. ■

CLIENT EDUCATION • ATLAS •

Atlas and CEI to Host Asia Solar Energy Durability Conference

November 19–20, 2014
Shanghai, China
Focus: Solar Energy Product Durability and Performance

Save the Date!

Even as the solar market has become more mature, it continues to grow at impressive rates. With solar system life expectancies of 20, 25, and even 30 years, appropriate accelerated testing of long-term durability is crucial, and accurate weathering testing has never been more important to product development, quality control and certification testing. In addition, more emphasis is being placed on “solar bankability” and how it is impacted by product durability and reliability.

In response, Atlas Material Testing Technology and China National Electric Apparatus Research Institute Co., Ltd. (CEI) are hosting a two-day conference for the global weathering and solar energy community. Scheduled for November 19–20, the Atlas/CEI Asia Solar Energy Durability Conference is your chance to hear from global technical leaders in the solar energy industry on the latest developments in:

- Environmental durability research and testing
- Materials performance
- Advancements in service life testing and estimation
- Certification and testing programs for PV modules, materials, components, and systems
- New enhanced PV “Qualification Plus” test methods and their impact on IEC

This event will be held simultaneously in Chinese and English. To receive detailed conference information as it becomes available, **click here**. ■

Atlas Introduces New UVTest Workshop

Responding to client requests, Atlas has developed a new one-day workshop that focuses on the theory of UV weathering testing as well as hands-on UVTest instrument training.

The UVTest Workshop is designed for instrument operators, quality assurance and control personnel, laboratory technicians, and anyone who is responsible for equipment operation, calibration, and maintenance of this device. Detailed lectures provide participants with the basic understanding they need to optimize the reliability of their test equipment and the reproducibility of their test results.

The workshop covers various theoretical aspects such as weather factors and how they are reproduced in an artificial device and the differences between fluorescent lamps like UVA and UVB compared to sunlight and other artificial light sources. In addition, participants receive hands-on instrument training that guides them through:

- Fundamentals of operation
- Functionality of components
- Calibration and preventive maintenance tips
- How to modify existing or write new custom test programs

Whether attendees are new or experienced operators, this course provides them with the skills they need to keep their test equipment operating longer and in specification.

UVTest Workshops are held in various European locations or one of Atlas' European laboratory facilities. Courses are held in different languages, depending on the location.

For details on this workshop and other Atlas course offerings, visit http://atlasmtt.com/courses. ■

ATLAS • ONLINE

High Irradiance Landing Page Goes Live

Atlas is pleased to announce the launch of a new landing page devoted specifically to high irradiance testing: **www.high-irradiance.atlas-mts.com**.

The new page details the benefits of high irradiance testing and links to Atlas' testing instrument solutions. It also allows visitors to download a high irradiance brochure, white paper and case studies. It will serve as a valuable resource for those who wish to become more educated on the topic and seek guidance in this area from weathering experts. ■

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