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In This Issue

Highly Predictive Accelerated Weathering of Engineering Thermoplastics

by James E. Pickett, GE Global Research

Introduction

Rationale and Program

Much effort and expense is put into the accelerated weathering of plastics and other materials for the purposes of optimizing stabilizer formulations, ranking performance, and meeting customer specifications. We assume that accelerated laboratory weathering is somehow predictive of outdoor performance, but often that is not the case. Some practitioners suggest that accelerated weathering tests at best are useful only for ranking materials [1], but ultimately, manufacturers need to know how long materials will last to make appropriate choices. Often, desired performance is expressed as survival for a certain period at a standard exposure site such as Miami, Florida. The goal of accelerated weathering then is to reproduce or predict weathering at that location [2, 3]. This is valid only if weathering in Florida (or elsewhere) is reproducible enough to serve as a benchmark, if other regions of the world relate in some way to that site, and if accelerated testing can predict performance for new materials.

An important consideration is that weatherability is not an inherent *material* property; it is a *system* property. That is, a particular material might weather poorly or well depending on the property being evaluated and on how it is stabilized, pigmented, blended, or textured. For example, a sample might have outstanding color retention but lose gloss rapidly. If gloss retention is not important for a particular application, then that material weathers well. Some formulations might do very well in black, where color shifts are hidden, but very poorly in white. An otherwise excellent formulation might weather poorly if the colorants are not stable. Since pure polymers are rarely used in any real application, the entire system must be tested, and the evaluation must have predictive value.

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AtlasCommitment to Education

2005

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May 13
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October 4–5
Linsengericht, Germany

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Linsengericht, Germany

March 14
Ci4000/Ci5000

March 15–16
Ci35/Ci65

April 14–15

Miami, Florida, USA

June 6
Ci4000/Ci5000

June 7–8
Ci35/Ci65

October 10
Ci4000/Ci5000

October 11–12
Ci35/Ci65

October 13
Advanced Ci35/Ci65

Paris, France

March 29
Ci3000

Fundamentals of Weathering I
March 8
Hof, Germany

March 17
Miami, Florida, USA

April 20
Oensingen, Switzerland

April 20
Paris, France

April 25
Cape Town, South Africa

April 26
Durban, South Africa

April 28
Johannesburg, South Africa

June 1
Vienna, Austria

June 14
Bursa, Turkey

June 16
Istanbul, Turkey

August 29
Chicago, Illinois, USA

November 1
Phoenix, Arizona, USA

Fundamentals of Weathering II
March 9
Hof, Germany

March 18
Miami, Florida, USA

April 21
Oensingen, Switzerland

April 21
Paris, France

August 30
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In 1999 we initiated an effort to accurately predict the weathering of engineering thermoplastics based on aromatic polymers such as BPA polycarbonate, acrylonitrile-styrene copolymers, and polyesters. We were acquiring considerable outdoor weathering data on a wide variety of fully formulated commercial samples as well as simpler model formulations, and we had a quantity of retain samples for accelerated experiments. Our program had several goals: 1) to understand the reproducibility of Florida data as a benchmark; 2) to understand the relationship of other global sites to Florida; 3) to understand the effect of environmental variables on a variety of materials; and 4) to develop laboratory weathering conditions predictive of the Florida benchmark, including an estimate of the statistical certainty of the predictions. In this report we will briefly describe our results for the first three goals and discuss the fourth in detail. Preliminary reports have already been published [4, 5], and we intend to publish full papers on all aspects in the near future.

Assumptions for Accelerated Weathering

We believed that a good accelerated weathering test would meet several criteria. First, the light source must be right. By this, we mean that the spectral distribution must match sunlight as closely as possible. Many studies have shown that radiation with wavelengths < 300 nm, which occur very little in nature, can unnaturally accelerate some polymers and coatings. BPA polycarbonate, the most widely used polymer in engineering thermoplastics and blends, is a well-known example [6] and Gerlock, et al, have recently described a particularly sensitive coating [7]. Colorants can degrade from visible light, making the balance of UV and visible light important for accurate predictions when both resin and colorants may degrade.

Second, one year's worth of photons in the lab should cause one year's worth of outdoor weathering. If it causes more or less, then the mechanisms of degradation must have been changed, and predictability will be poor. Since the spectral power distribution of any practical artificial source does not match outdoor sunlight exactly, the dose required to match one year cannot be accurately calculated. However, we can assume that roughly 3500 kJ/m^2/nm at 340 nm should give a light dose equivalent to one year in Florida based on the spectral distribution of average Florida sunlight, the annual broadband UV dose in Florida, and the spectral output of filtered xenon arc lamps.

Third, any accelerated test must, by definition, increase the rate at which light is applied to the samples. It must be shown experimentally that the material response is linear when increasing the light intensity and/or decreasing the dark periods. That is, the material must show reciprocity. In addition, the variables of temperature and moisture must be properly accounted for in the test procedure.

Finally, a test should run on the existing equipment base and not require techniques beyond the reach of reasonably skilled technicians if it is to gain acceptance. Specialized experiments are appropriate for research, but ultimately, procedures must be put into the hands of people doing routine testing.

Treatment of Data

Much weathering data is gathered in tables showing property changes after particular exposure periods. While this makes comparisons among samples easy, it is the least informative and least robust way to treat weathering data. One does not know the rate of property change at that point—has it leveled off, or is it deteriorating rapidly? Single points are susceptible to considerable experimental error—was this an outlier, or within the noise of the measurement? We are most interested in questions of rate: how long will something last; how rapidly does the property change; how much longer will it last in region A compared to site B? Tables of data usually do not adequately answer these questions.

Degradation data often are nonlinear and noisy, making it difficult to define a rate

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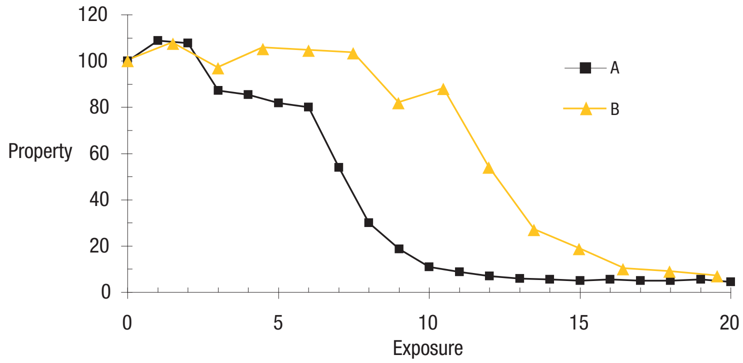

Figure 1a. *Hypothetical sets of weathering data.*

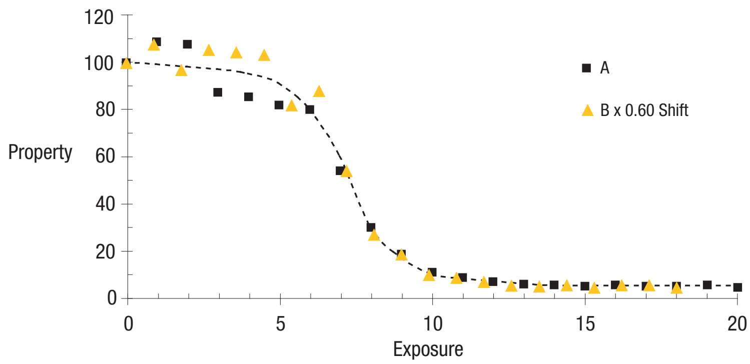

Figure 1b. *Data from Figure 1a with the abscissa of set B shifted by a factor of 0.60. The superposition is good.*

constant. A robust way of determining relative rates by the use of shift factors has been described by Simms and others [8, 9, 10] as shown in Figure 1b. All of the X values of a data set are multiplied by a factor so that the data points superpose on a reference curve. In Figure 1b, set B superposes on reference set A if the X values are all multiplied by 0.60. If the superposition is good, then the relative rate is this factor. If no superposition is possible, then it is not possible to define relative rates. The eye is very good at determining superposition, and it is usually possible to set up spreadsheets to make this fast and easy. This method is especially robust because it makes use of most of the data points. Determining arbitrary failure times—at 50% property retention, for example—emphasizes the importance of the two points nearest the failure criterion and ignores the rest. Any error in these points makes the results more uncertain. All of the rates in this work were determined in this way: selection of a reference data set and finding shift factors to superpose the other data sets on the reference. These shift factors are the relative rates.

Experimental Methods

Samples included BPA polycarbonate (PC), poly(butylene terephthalate) (PBT), acrylonitrile-styrene-butadiene copolymer (ABS), acrylonitrile-styrene-butyl acrylate copolymer (ASA), several developmental polymers, and various blends of these components. Full commercial formulations in several colors as well as simple formulations pigmented with coated rutile TiO_2 or carbon black were tested. We evaluated a set of approximately 110 samples for which good Miami data and retains were available. The measured properties were 60° gloss (using a BYK-Gardner micro TRI glossmeter) and color shift ($\Delta E = (\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2})^{0.5}$ or yellowness index according to ASTM D1925 using a GretagMacbeth 7000A colorimeter).

Samples were cut down to 0.5″× 1.25″ and attached to 2.625″× 6″ aluminum panels using silicone RTV adhesive to form arrays of 24 samples per panel. This allowed efficient use of retain samples and rapid collection of data without sacrifice of accuracy or precision. The arrays were placed *backwards* in standard xenon arc sample holders and hung on the *inside* of the rings in the sample chambers of Atlas Weather-Ometers®. Exposure conditions are shown in Table 1. (The ASTM G26A standard has been superceded by ASTM G155 Cycle 1). The SAE J1960 and ASTM G26A tests were run by Brian Keir of GE Plastics, Selkirk, New York. Outdoor exposures were unbacked, 45° south-facing at the Atlas South Florida Test Service Miami site or other global sites as mentioned.

Water spray was applied using a special nozzle provided by Atlas: VeeJet model H1/8VV11004 (Spraying Systems Co., Wheaton, Illinois). This provides a flat spray of 0.28 gal/min at 20 psi using at least 2 MΩ deionized/reverse osmosis water. This seemed to give a spray somewhat like rain. However, we found that some samples, particularly ones pigmented with carbon black, did not lose gloss properly even with our best water sprays. An occasional wipe with a sponge and deionized water was required. We gave four double wipes using moderate pressure every two weeks.

Table 1.
Weathering Exposure Conditions

	SAE J1960	ASTM G26A	New GE
Instrument	Atlas Ci65A	Atlas Ci65A	Atlas Ci4000
Inner Filter	Quartz	Boro	CIRA#
Outer Filter	Boro	Boro	Sodalime
Wavelength Cutoff (nm)	270	285	295
Irrad. (W/m²/nm @ 340 nm)	0.55	0.35	0.75
Air Temp (°C)	~50	~45	35
Black Panel Temp (°C)	70	63	55
Relative Humidity (%)	50	50	30
Cycle:			
Light (min)	100*	102	Continuous
Light/Mist (min)	20*	18	—
Dark (min)	60*	—	—
Dark/Rain Spray (min)	—	—	30 min once per week
Sponge Wipe	—	—	Biweekly

** Cycle is 40 light/20 light+mist/60 light/60 dark.*
 # IR-reflecting quartz filter from Atlas.

Data Analysis

Data were entered into an Microsoft® Excel spreadsheet, and xenon arc and Florida data were plotted on the same graph. Factors corresponding to kJ/m²/nm at 340 nm per year were applied to the Miami data by trial and error until the xenon arc and Miami data points gave best superposition as judged by eye. Repeated attempts gave very similar results, and we were unable to devise an analytical fit that did better than the eye. The shift factor becomes the correlation between the accelerated data and Miami. Samples that showed little property change, highly erratic Miami data, or complete change to steady state at the first checkpoint were not included in the analysis.

Results and Discussion

Reproducibility and Relevance of Florida Data

Weathering is caused by many factors but should be driven primarily by sunlight, heat, and moisture. The inherent variability in weather has caused some to question the value of outdoor exposures [11]. We have analyzed data from monthly weather summaries issued by the Atlas South Florida Test Service in Miami, Florida for the period of 1989 to 2002 and determined the means and standard deviations in the TUV dose (295–385 nm) for exposures of various lengths throughout this period. These were calculated with and without an assumed activation energy of 7 kcal/mol to account for temperature effects. The results are shown in Table 2 for the UV dose alone and in Table 3 for the temperature-weighted UV dose. The tables show that exposures <1 year have considerable variability, but that variability drops to about 12% (at 2σ) at one year and to 6–8% after two years. Temperature variability does not cause much difference for exposures of 1 year or more. Wet time and relative humidity are relatively constant from year to year, but rainfall is very highly variable. We therefore expect that weathering rates should be generally reproducible within about 10% for exposures of >1 year unless data are taken very close to a time when a property is changing rapidly.

An example of a sample showing such abrupt changes is in Figures 2a and 2b (page 8). Polycarbonate samples containing 2 or 3% coated rutile TiO_2 pigment were exposed several times at the Miami site. While the data generally define single curves for gloss loss and yellowing, the value at any particular time can vary considerably. It is therefore important

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to consider the data in its totality. This is especially difficult as the data are coming in slowly point-by-point, but it is the only robust way to look at the data. Surprisingly, replotting the data using MJ/m^2 of UV exposure instead of months as the abscissa did not seem to improve the fit. Other samples for which we have multiple exposures show generally the same results and will be described elsewhere. We believe that Florida exposure can serve as a useful benchmark if the data are treated properly and cautiously. [12]

Table 2.
Rolling average UV dose (MJ/m^2 295–385 nm; 45° S) at Miami for various exposure periods during 1989–2002.

Months	1	3	6	9	12	18	24	30	36	48	60
Dose (MJ/m^2)	23.8	71.5	142.9	214.1	285.2	421.7	571.9	716.3	861.1	1148.9	1435.5
Std. Dev.	3.7	9.2	14.2	16.2	16.9	28.6	19.0	19.7	16.5	18.8	19.3
Std. Dev. (%)	15.6	12.9	9.9	7.6	5.9	6.8	3.3	2.8	1.9	1.6	1.3

Table 3.
Rolling average UV dose (MJ/m^2 295–385 nm; 45° S) at Miami for various exposure periods during 1994–2002 weighted using an activation energy of 7 kcal/mol and the average high black panel temperatures for each month.

Months	1	3	6	9	12	18	24	30	36	48
Dose (MJ/m^2)	23.8	71.9	143.9	216.3	288.7	434.6	579.7	727.0	872.6	1019.2
Std. Dev.	4.9	11.1	16.3	17.2	17.8	23.7	22.5	24.7	21.9	23.3
Std. Dev. (%)	20.6	15.4	11.3	8.0	6.2	5.4	3.9	3.4	2.5	2.3

We have exposed sets of assorted engineering thermoplastic samples at eight sites worldwide for up to three years and compared the rates of color shift and gloss loss to the set exposed in Miami. Table 4 shows that the relative severity of the sites correlates very well with the relative annual light doses. Including a temperature term did not improve the correlation. There was considerable variability among the samples used in the experiment with standard deviations of 10 to 20% of the means. Thus, the predictability of weathering performance for any particular engineering thermoplastic at any particular site based on Miami data has considerable uncertainty. [13]

Table 4.
Harshness of global sites relative to Miami for gloss loss (29 samples) and color shift (14 samples).

	Niskayuna, New York	Phoenix, Arizona	Louisville, Kentucky	Bandol, France	Hoek van Holland, Neth.	Lochem, Netherlands	Melbourne, Australia
Relative Light Dose*	0.74	1.14	0.81	0.87	0.56	0.54	0.96
Mean Relative Rates	0.64	1.13	0.81	0.88	0.64	0.61	0.97
Std. Dev.	0.08	0.13	0.09	0.12	0.13	0.14	0.13

** Measured in Miami and Phoenix, calculated from published data for other sites.*

Effect of environmental Variables

Light. Effects of the spectral distribution of the light in the form of activation spectra have been published for many polymers. We have found that the CIRA/Soda Lime filter combination on xenon arc lamps gives approximately the same acceleration factor for all aromatic engineering thermoplastics. We have also found that the yellowing of PC, PBT, SAN, and various blends all show good reciprocity with light intensity up to an irradiance of at least 0.75 W/m^2/nm at 340 nm while ABS does not. We have found no effect of dark cycles other than that expected from reducing average light intensity.

Temperature. We exposed arrays of samples heated to four different temperatures in the xenon arc Weather-ometers and determined the activation energies for color shifts and gloss loss. The results are shown in Table 5. The values generally are small and range from 0 to 7 kcal/mol depending on the polymer, property being measured, and exposure conditions.

Table 5.
Activation energies (kcal/mol) and R^2 for xenon arc exposure.

Sample	Boro/Boro				CIRA/Soda Lime			
	ΔGloss		ΔYI		ΔGloss		ΔYI	
	E^a	R^2	E^a	R^2	E^a	R^2	E^a	R^2
PBT 3% TiO_2	3	0.97	3	0.99	2	0.94	4	0.98
PC 3% TiO_2	3	0.95	4	0.97	4	0.96	5	0.97
PC 0.60% Carbon Black	2	0.92			4	0.97		
PC/PBT Blend 3% TiO_2	1	0.91	4	0.99	3	0.91	5	0.96
PC/PBT Blend 0.60% Carbon Black	0				2	0.92		
SAN 3% TiO_2	3	0.99	4	0.99	4	0.91	5	0.97
ABS 3% TiO_2	3	0.99	5	0.99	4	0.96	7	0.94
ABS, Black Commercial Grade	4	0.92			5	0.96		
PC/ABS 3% TiO_2	3	0.99	5	0.96	4	0.90	7	0.97
ASA 3% TiO_2	2	0.96	3	0.97	5	0.98	4	0.96

Moisture. We found that humidity had no effect on gloss loss or color shift for these resins. An experiment in which a simulated acid rain spray was applied weekly also showed very little effect. However, the spray and washing protocol made a very large difference to gloss retention. The spray nozzles standard in the Weather-ometers apply a very fine mist that does not fully remove degraded polymer and pigment particles from the surface. Its effect is more like dew than rain. Carbon black, especially, builds up to make a velvety surface that is not observed on outdoor samples. We found that more aggressive sprays improved the appearance somewhat but still did not accurately reproduce Florida weathering. However, washing the samples with a sponge and deionized water once every week or two produced excellent results. Interestingly, very similar gloss loss is observed for aromatic engineering thermoplastic samples exposed in Arizona and Florida, indicating that even a small amount of natural rainfall is sufficient to drive erosion and gloss loss for these resins.

Improved Exposure Conditions

Our work on the effects of environmental variables led us to the exposure conditions shown in Table 1 as "New GE." The CIRA/soda lime filtered xenon arc gave the best fit to sunlight using readily available filters, especially at the critical lowest wavelength end of the spectrum as shown in Figure 3 (page 9). We tried to maintain the lowest air and black panel temperatures possible while setting the irradiance as high as practical. Since there seemed to be no benefit to a dark cycle, we eliminated it. Frequent misting spray cycles caused debris buildup on the samples, so this was replaced by a more aggressive weekly spray and a biweekly sponge wipe (four double strokes with moderate pressure) with deionized water before taking data.

To test the predictability of these conditions, we made arrays of 120 samples, including duplicates, of 117 samples for which we had at least two years of Florida data. The samples represented a wide variety of commercial and developmental engineering thermoplastics in many colors. These were exposed under the new conditions as well as under standard ASTM J1960, a widely used automotive exterior standard, and ASTM G26A (G155 Cycle 1), another common exterior standard. Samples were removed weekly for color and gloss measurements and replaced in the Weather-ometers. Upon completion of the exposures, the test data were superposed onto the Florida data by finding the best "correlation factor" for each sample as

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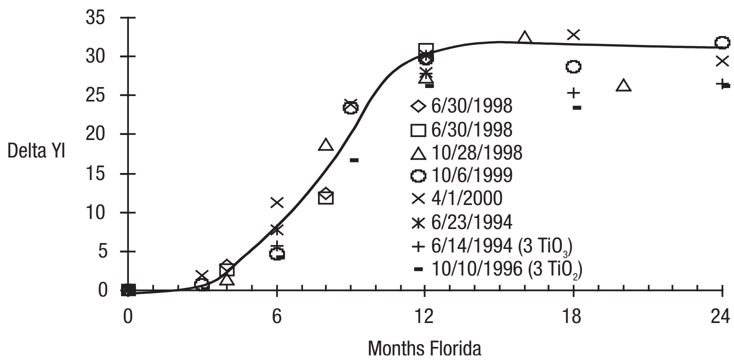

Figure 2a. *Gloss loss for white PC exposed at various start dates in Miami.*

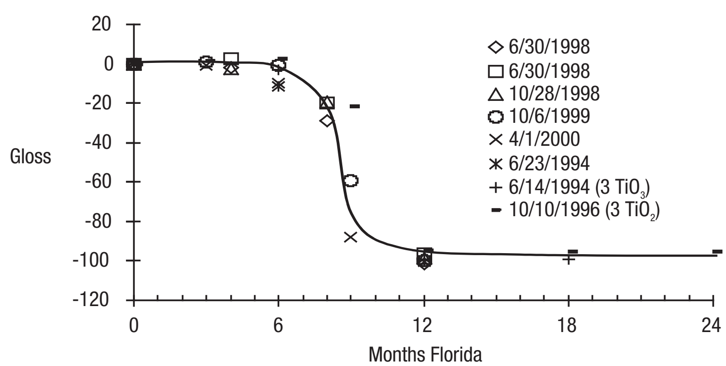

Figure 2b. *Yellowing of white PC exposed at various start dates in Miami.*

described above and shown in Figure 4. In addition, we estimated a "quality of fit" value of 0–3 where 3 was a perfect fit (as in Figure 4), 2 was within ~20%, 1 showed a vague trend, and 0 was no fit at all.

The results of this massive experiment are shown in Table 6. The means show the average of all 117 samples for both gloss retention and color shift (ΔE). The standard deviations do not represent the reproducibility of any particular sample, but rather the variability of the correlation factor among different kinds of samples. One sees that the mean correlation factors for J1960 and G26A are considerably less than the expected ~3500 $kJ/m^2/nm$ at 340 nm per year in Florida. In addition, the extreme variability from sample to sample gives J1960 no predictive value at the 95% confidence level. ASTM G26A is a little better but still not very predictable. Both did a moderate job at predicting the shape of the degradation curves. By contrast, the new GE conditions had a mean correlation factor of 3100 $kJ/m^2/nm$ at 340 nm per year in Florida, well within the expected range. The standard deviation was approximately 10% of the mean, giving error bars of approximately 20% at the 95% confidence level. Given that most of these samples showed considerable degradation within 12 months of exposure, and that Florida is reproducible only to within about 10% for one-year exposures, this amount of variability is not bad. In addition, the shapes of the curves were well reproduced in over 90% of the samples.

We attempted to decrease the variability by breaking out samples by resin type, expecting that those containing BPA polycarbonate might be accelerated disproportionately under J1960 and G26A. This turned out not to be the case for either color shifts or gloss retention. The effect of pigments, especially TiO_2 (whites) and carbon black, caused great variability even within resin types. We conclude that these testing protocols have little predictive value for aromatic engineering thermoplastics.

Reproducibility and robustness of the new GE conditions can be judged in Figure 5 (page 10) for polycarbonate pigmented with carbon black, a particularly difficult sample. These experiments had variations in spray and wiping procedures to test the robustness of the conditions. One sees generally good reproduction of the Florida data. By contrast, the G26 and J1960 conditions predict rapid total gloss loss and fail to predict the extended plateau period that we repeatedly found in outdoor weathered samples. Figure 6 (page 10) shows similar results with a black commercial ABS resin, another difficult sample. (Samples with TiO_2 rather than carbon black pigments had much better reproducibility.) Figure 7 (page 11) shows both color shift and gloss loss for an experimental resin containing blue colorants. Both the resin and colorants of this sample underwent color shifts. The new GE conditions gave a good indication of Florida weathering while G26 and J1960 accelerated gloss loss and color shift differently, causing much faster changes in gloss loss than in color shift. The Florida gloss loss for this sample showed a considerable decrease at the first checkpoint, and later it recovered. This point was taken after a particularly dry period with smoke from neighboring forest fires forming deposits not removed by the normal gentle wash procedure. The rainy summer period that followed washed away these deposits and restored the gloss. This is a good illustration of the kind of noise sometimes encountered in outdoor data and the need to evaluate the data in total.

Table 6.
Correlation of xenon arc to Florida for the set of 117 samples.

Conditions	Florida Correlation (kJ/m²/nm/year at 340 nm)		Quality of Fit (scale 0–3)
	Mean	Std. Dev. (% of mean)	% of Samples ≥ 2
SAE J1960 (gloss)	1500	700 (47%)	72%
SAE J1960 (color)	1800	860 (46%)	72%
ASTM G26 (gloss)	1900	680 (36%)	78%
ASTM G26 (color)	2100	670 (32%)	78%
New GE (gloss)	3100	340 (11%)	92%
New GE (color)	3100	340 (11%)	92%

We have restricted our studies to only appearance properties and do not know whether or not changes in mechanical properties are predicted under these exposure conditions. Testing mechanical properties requires large numbers of fairly large samples, so this kind of study involving >100 formulations probably is not practical.

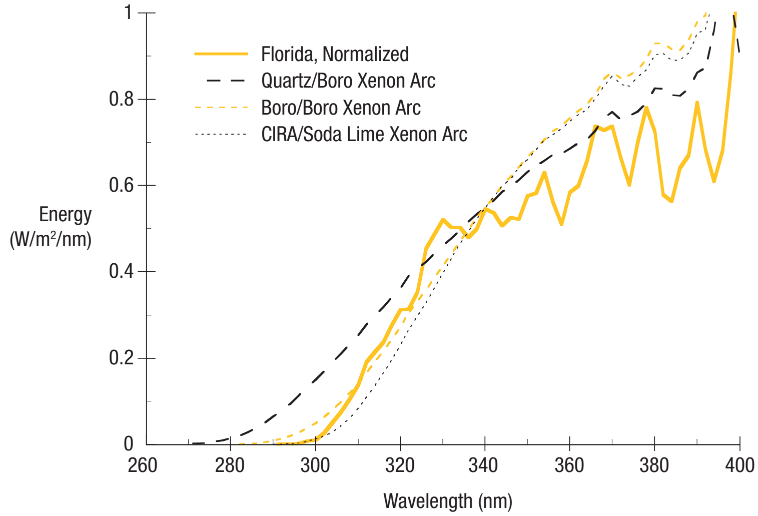

Figure 3. *Spectral distribution of light sources. Source: Atlas Material Testing Technologies, LLC, Chicago, Illinois.*

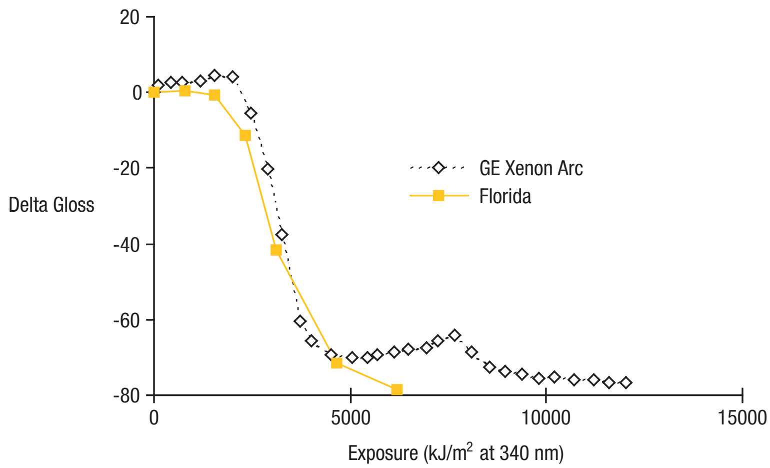

Figure 4. *Superposition of Miami data on xenon arc data for a sample of white ASA/PC blend using a shift factor of 3100 kJ/m²/nm (340 nm) per year of Miami exposure.*

Extension to Other Materials

In many ways, the group of aromatic engineering thermoplastics is an easy case because they degrade in a reproducible fashion. Most of the degradation usually is confined within about 50 microns of the surface, making oxygen diffusion relatively unimportant. In addition, additives and products do not diffuse significantly in the glassy polymers. Polyolefins have the opposite characteristics; they seem highly variable because impurities drive initiation reactions, and diffusion of oxygen and small molecules are both important. This may cause rates of polyolefin photodegradation to be non-linear with increasing light intensity due to diffusion-limited processes, thus making acceleration of any kind problematic. To our knowledge, no studies on polyolefins over a range of light intensities have been published. Until such work is undertaken, we cannot know if we can expect predictive weathering of polyolefins under any conditions.

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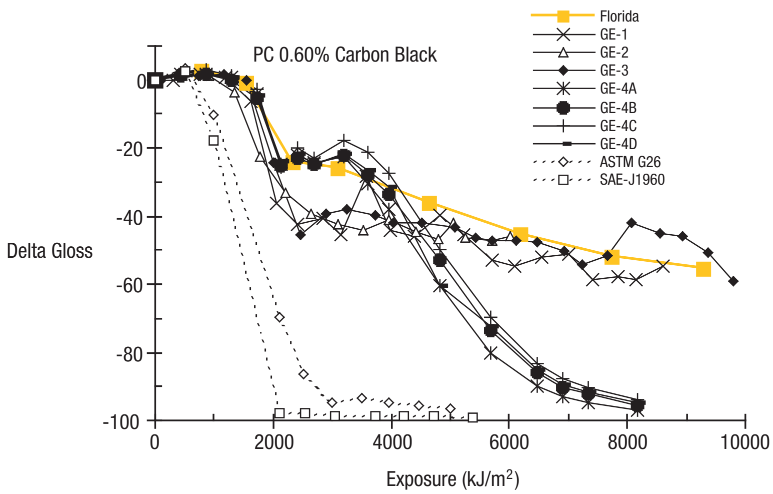

Figure 5. *PC containing carbon black tested repeatedly under new GE conditions, G26, J1960, and Florida (with correlation factor of 1 year=3100 kJ/m²/nm at 340 nm).*

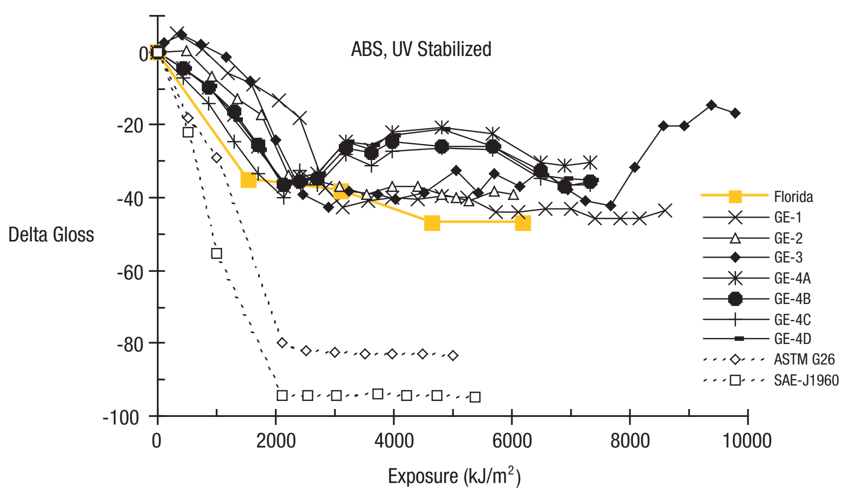

Figure 6. *ABS containing carbon black tested repeatedly under new GE conditions, G26, J1960, and Florida (with correlation factor of 1 year=3100 kJ/m²/nm at 340 nm).*

Conclusions

Our studies find Florida weathering to be an adequate benchmark as long as one considers many data points and exposures periods >1 year. Keys to good accelerated weathering of aromatic engineering thermoplastics are: 1) light with spectral distribution matching sunlight, especially at the short wavelength end of the spectrum, and 2) adequately simulating the cleansing effects of rainfall (and perhaps wind). We have shown that it is possible to predict Florida weathering performance for a wide variety of samples with error bars of approximately 20% at the 95% confidence level. This is much better than industry standard conditions that have error bars of 60–100% at the 95% confidence level. While far from perfect, these new conditions have the advantage of working on the existing equipment base and not being particularly difficult to run. At least one commercial test laboratory has begun to use these conditions.

Acknowledgements

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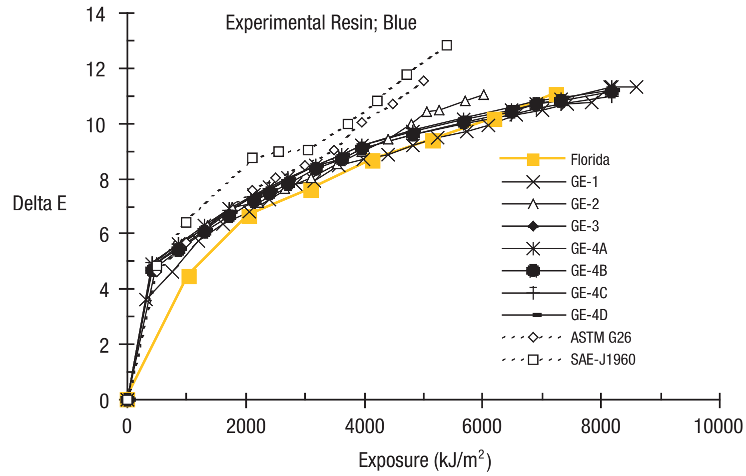

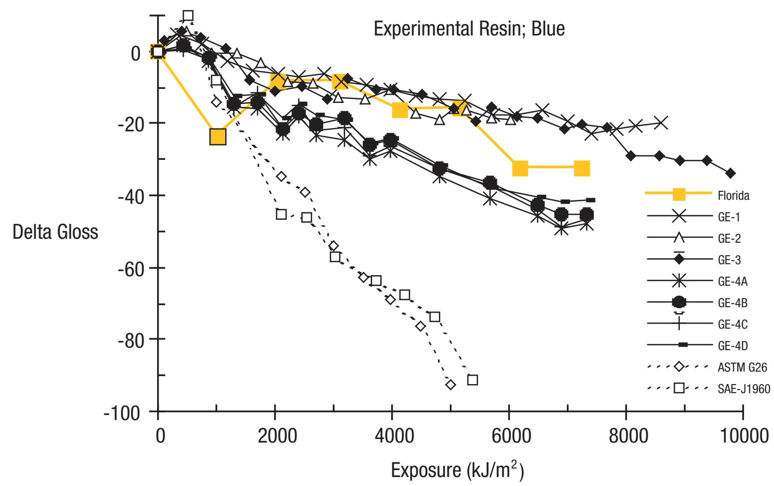

Figure 7. *Color shift and gloss loss for a blue experimental resin tested repeatedly under new GE conditions, G26, J1960, and Florida (with correlation factor of 1 year=3100 kJ/m²/nm at 340 nm). Both colorant and resin undergo a color shift.*

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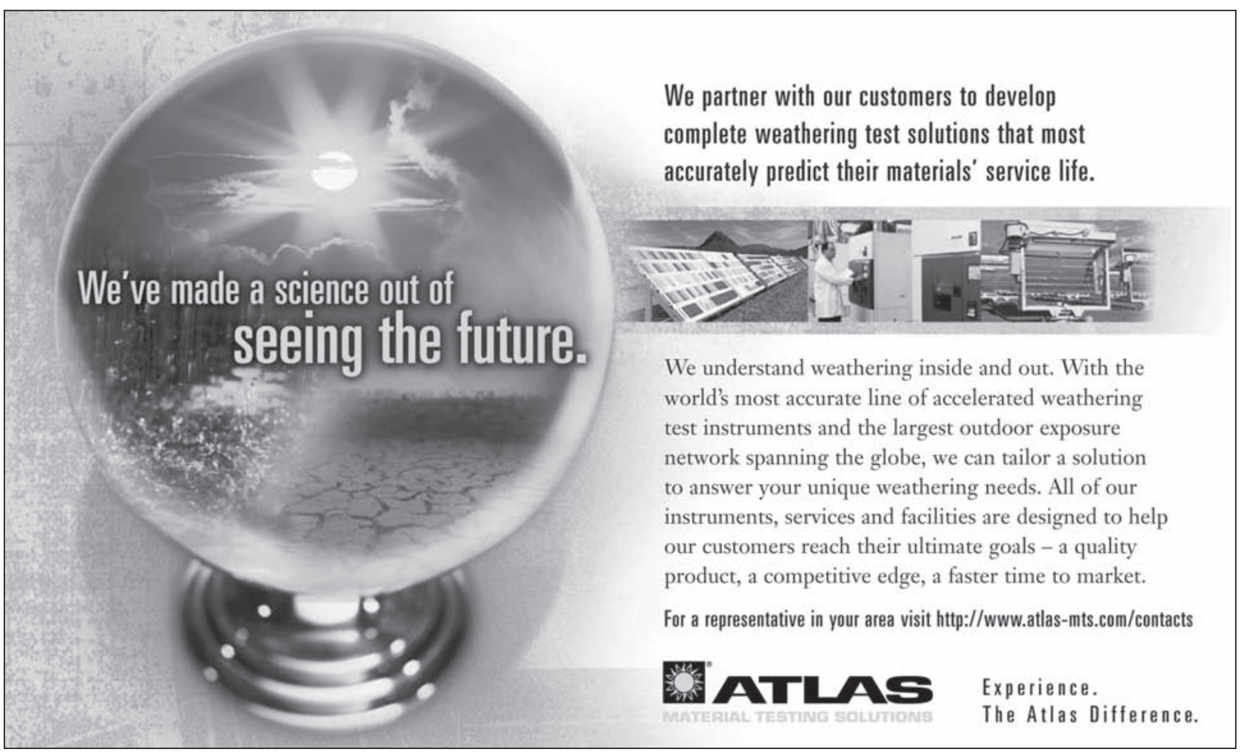
AtlasWeathering Services Group

AWSG Europe Update

Atlas Weathering Services Group offers the largest network of independent outdoor exposure and accelerated weathering laboratories in the world. In an effort to better serve our customers' needs in Europe, we have consolidated our laboratory in Lochem, The Netherlands into other existing European laboratories. Our accelerated lab and outdoor exposure site in Lochem closed on December 1, 2004. The accelerated lab business has been transitioned to our Duisburg, Germany and Paris, France facilities with no delay or inconvenience to any of our customers. The new testing resources for these locations will allow for increased customer support for country- and industry-specific test methods. The outdoor exposure site will remain operational for current tests only. All new outdoor tests will be referred to the Atlas exposure site in Sanary sur Mer (Bandol), France which is the benchmark European climate for the weathering of materials.

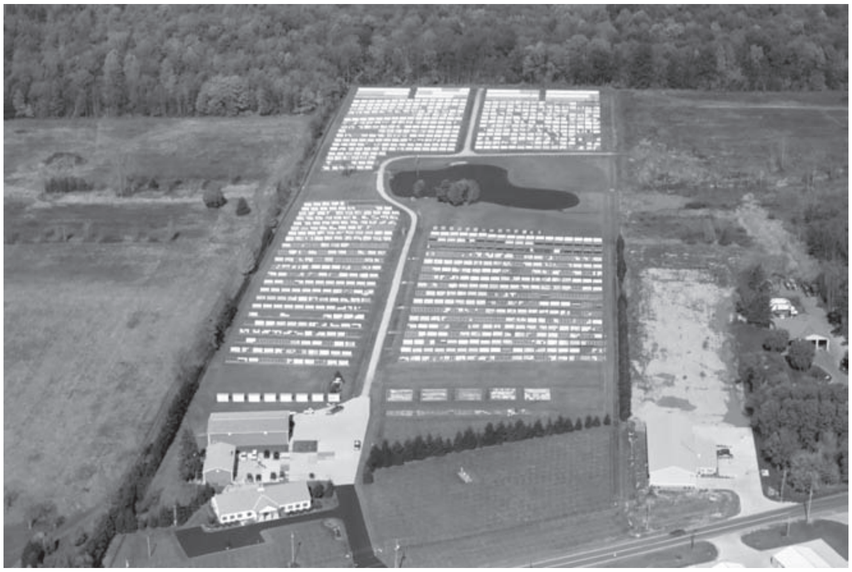
Atlas is also expanding its accelerated lab business in the United Kingdom. Atlas MTT Ltd. will be moving its laboratory into a larger facility to meet increasing demand. The move is scheduled to take place in March. Customers will be notified and kept abreast of the transition as it occurs.

For more information about the consolidation or upcoming move, please contact Siegfried Rößner at **+49-(0)206-576490** or **sroessner@atlasmtt.de.**



Atlas Expands WEN Offerings

AWSG Partners with Omega



Atlas Weathering Services Group (AWSG) is pleased to announce our newly formed partnership with Omega Testing and Weathering Services, LLC. This partnership will not only add a new outdoor exposure site to the AWSG Worldwide Exposure Network, but offer a host of complementary services to our customers.

Omega Testing and Weathering Services is located on 53 acres in Medina, Ohio, offering the full range of seasonal conditions consistent with a northern temperate climate. Warm, humid summers and winters with multiple freeze/thaw cycles produce an environment that is specified for many types of material testing, including Exposures of Rigid PVC Siding per ASTM D3679 and Atmospheric Environmental Exposure Testing of Nonmetallic Materials per ASTM G7 for coated wood products and general exposure testing.

In addition to exposure services, Omega also offers a number of performance evaluations such as visual and appearance property measurements including colorimetry and gloss loss. Analytical and physical testing is also available. The test site offers both solar and climatic data from a full array of onsite instrumentation.

To further enhance AWSG's testing scope, Omega brings a wealth of knowledge and services in the areas of substrate selection and preparation. Now AWSG has a partner that can specify substrates and actually prepare test specimens for outdoor and accelerated exposure tests.

AWSG is excited to collaborate with Omega and bring these new services and capabilities to our customers, offering the most complete material testing solutions available. For more information regarding Omega services or to schedule your testing, please contact your local Atlas representative or call AWSG directly at **+1-623-465-7356.** Please visit our website at **www.atlas-mts.com.**

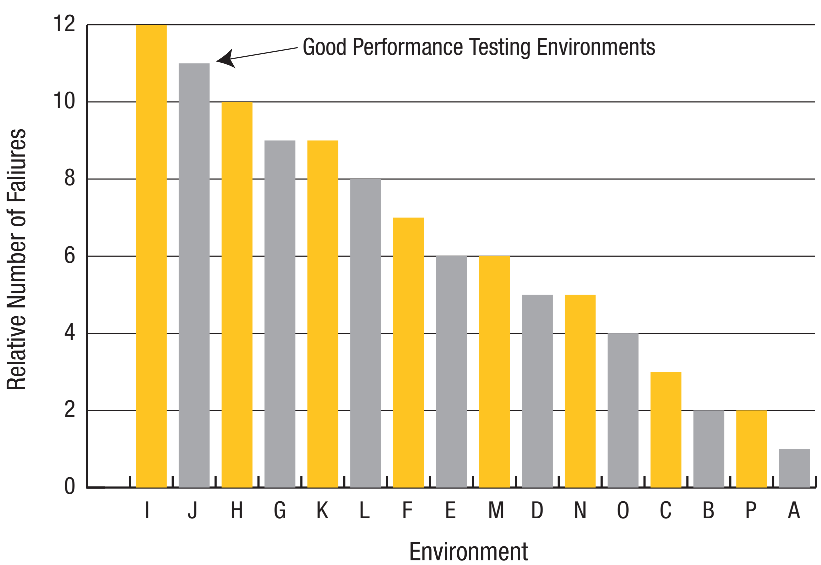
Climatological Data	
Latitude:	41°07' N
Longitude:	81°54' W
Elevation:	336 meters
Avg. Ambient Temp:	10°C
Avg. Ambient RH:	72%
Rainfall:	884 mm
Total Radiant Energy:	5100 MJ/m^2

AtlasCommitment to Growth

Weathering Experimenter's Toolbox: Surveillance Testing

Development engineers often need to show how accelerated results directly relate to natural exposures. Prudent engineers precede accelerated testing with identical specimens on natural, real-time exposures. Only direct comparison between identical specimens exposed to natural and accelerated methods can achieve confidence in the accelerated methods for specific material types, formulations, and lots. After initial product approval by a manufacturer, drifts in formulation, manufacturing process or handling often occur. "Surveillance testing" involves regular sampling from production lots and places samples on natural exposure using a quality control approach.

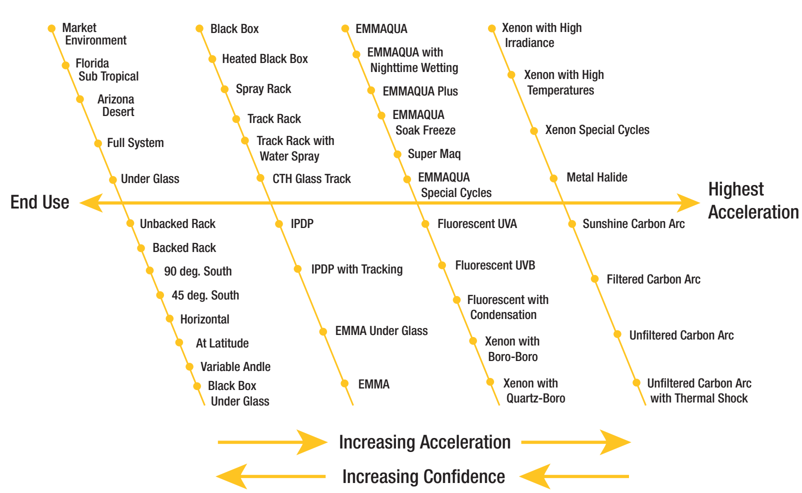
Pareto Plot of Failure Environments



For example, several manufacturers sample production lines once a year and place the samples on natural exposures with a very limited frequency of evaluation. In the unlikely event of customer complaints sometime in the future, reference data from surveillance testing is readily at hand. Surveillance data also offers opportunities to anticipate customer dissatisfaction before it arises in the market. Inexpensive, simple, regular surveillance testing provides a level of assurance throughout the product life cycle. Much of the data included in the Weathering Experimenter's Toolbox series has been obtained from AWSG surveillance tests. ■

Correction:

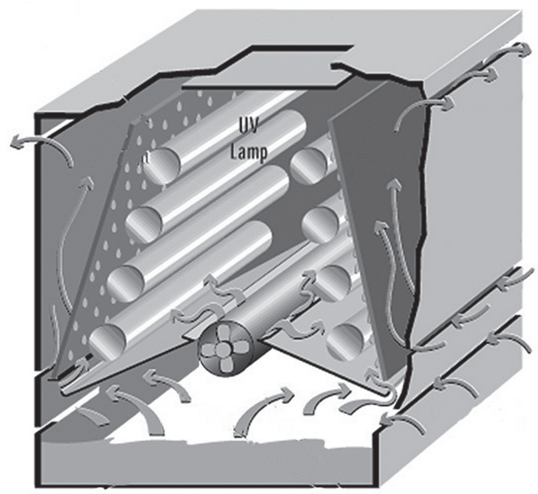
In the last issue of *Sun Spots* (Fall 2004), Atlas incorrectly labeled the bottom line in the chart in the Weathering Experimenter's Toolbox on page 12. It read "Decreasing Confidence" when it should have read "Increasing Confidence." The correct chart appears here. We apologize for the error.



Atlas Accredited to Calibrate UV Radiometers

Atlas to Provide Calibration Services for All QUV®, QUV/se®, CR10, and UV2000 Devices to Fulfill A2LA's ISO 17025 Audit Compliance Requirements

Atlas has been accredited by the A2LA to calibrate radiometer sensors for accelerated weathering devices, such as the QUV, to meet all ISO 17025 audit requirements. This accreditation qualifies Atlas as the only provider of ISO 17025 certified UV radiometer calibration services. Now all weathering test equipment not calibrated by Atlas will not comply with A2LA guidelines that labs must have their testing services calibrated by an ISO 17025-accredited calibration service (if available) recognized by A2LA. Atlas also announces that its ISO 17025 experts will be available to train technicians to calibrate radiometer sensors on all non-accredited equipment, particularly the QUV, QUV/se and CR10, devices provided by Q-Panel.



"We recognize that this development answers a need for a number of companies that are relying on their testing equipment to be compliant with the highest standards of quality, such as ISO 17025," said Matt McGreer, Director of Quality at Atlas. "We also recognize that several of these companies have significant investments made in testing equipment that do not comply with A2LA guidelines, which is why Atlas will add lab procedures to calibrate Q-Panel's line of UV testing equipment to our ISO 17025 scope of accreditation."

Since all calibration procedures under Atlas' scope of accreditation were developed specific to Atlas instruments, special attention was given to validate all measurements, determine best measurement uncertainty, and participate in proficiency testing according to A2LA's strict guidelines. Atlas successfully achieved these objectives and demonstrated their unique knowledge in irradiance calibration during the initial ISO 17025 audit in December 2003. This commitment has been carried forward as procedures for competitive testers were established.

Atlas's local factory-trained service technicians can schedule an on-site visit to perform ISO 17025 calibration on temperature and irradiance sensors to meet A2LA audit requirements. As part of this service, technicians can give any UV weathering testers a bi-annual tune-up in which experts inspect and adjust temperature control circuits, meters, timing devices, lamp components, motors, switches, relays, water systems, and mechanicals. In addition, technicians can replace any required parts and submit a written report of current updates and changes that affect the operation of your testers. Services are initially available in the U.S. only.

For more information about Atlas's ISO 17025-certified capabilities, contact Matt McGreer at **+1-773-289-5563** or **mmcgreer@atlas-mts.**

Alplas Officially Changes its Name to Atlas

In 2002, Atlas acquired its former representative company, Alplas Technology, in Oxford, England in an effort to better serve this important weathering market. Late last year, Atlas officially changed the name of Alplas Technology to Atlas Material Testing Technology Ltd to fall in line with other subsidiaries and to promote a greater global presence for Atlas as a whole.

In 2005, Atlas MTT Ltd will move into a larger facility to accommodate increased demand. The new facility will allow for further expansion of services and give Atlas the ability to bring Fundamentals of Weathering courses and Weather-Ometer® Workshops in-house. Furthermore, the increased space will facilitate Atlas MTT Ltd's ISO 17025 accreditation effort. The official move date will be the end of March. The new building will be in Bicester, seven miles northeast of Oxford, and only five minutes from the main London-to-Birmingham M40 motorway.

For more information regarding the move and how it will benefit you, please contact Paul Gibbon at **paul.gibbon@atlasmtt.co.uk.**

Symposium: Weathering of Polymers and Coatings in the Automotive Industry

Atlas is excited to announce that it participated in the 7th symposium held by the South German Plastics Center (Süddeutsches Kunststoff-Zentrum). The symposium provided a forum for experts from various automobile manufacturers, automotive suppliers, and test equipment manufacturers to present the latest technology in the industry.

Over the past several years, the weatherfastness demands made on materials and components for the automobile industry have increased enormously. New materials as well as the optimal utilization of additives have necessitated the development of new test procedures that are capable of more accurately reproducing actual usage conditions. Under pressure from ever shorter development cycles, new methods need to be developed very rapidly without compromises with regard to their precision and correlation to results from outdoor exposure tests.

Graduate physicist Andreas Riedl, of Atlas Material Testing Technology GmbH, discussed various polymer materials and their stabilization, and presented new test methods for materials and components for interior and exterior vehicle applications. Advances in equipment technology were also discussed, along with application possibilities for analytics and simulation. Finally, examples of current applications in the automotive industry were shown. The symposium featured such experts as Dr. Artur Schönlein, Atlas Material Testing Technology GmbH, and graduate engineer, Burkhard Severon, Atlas Material Testing Technology LLC.

The symposium took place February 16 and 17 in Würzburg, Germany. For more information, please visit **www.skz.de.**

AtlasSpeaks

2005

53rd International Relay & Switch Conference
April 18–20, Costa Mesa, California, USA
Harold Hilton will present a paper titled "Improvements in Lab Corrosion Testing Cabinets."

European Coatings Show
April 26–28, Numberg, Germany
Siegfried Rößner, Atlas Weathering Services Group, will present a paper on "New EMMAQUA Outdoor Accelerated Weathering Methods."

ESTECH
May 1–4, Chicago, Illinois, USA
Jay Lipscomb, Product Manager, Atlas Weathering Instrumentations Products, will present a paper on "A Statistical Determination of Uniformity in Xenon Exposure Chambers."

Detroit Society for Coatings Technology FOCUS 2005
May 5, Detroit, Michigan, USA
Kelly Hardcastle, Atlas Weathering Services Group, will present a workshop on "The Design of Experiments for Outdoor Weathering Effects."

Cleveland Society for Coatings Technology – Sink or Swim
May 24–25, Cleveland, Ohio, USA
Kelly Hardcastle, Atlas Weathering Services Group, will present a paper on "Using Concentrated Natural Sunlight to Accelerate Weathering—New Developments."

Third Congress on Ultraviolet Technologies IUVA *(International Ultraviolet Association)*
May 24–27, Whistler, British Columbia, Canada
Dr. Artur Schönlein, Manager Test Laboratory for Radio- and Photometric Measurements, will present a paper on "Filter Radiometer for Weathering Tests and Photostability Examinations."

European Weathering Seminar
June 15–17, Gothenburg, Sweden
Kelly Hardcastle, Atlas Weathering Services Group, will present a paper on "Characterizing Weathering Reciprocity of Polycarbonate."

ASTM "Sealants"
June 15–17, Reno, Nevada, USA
Fred Lee, Atlas Material Testing Technology LLC, will present "A Symposium on Durability of Building and Construction Sealants and Adhesives."

AtlasShows

2005

TEXTILE Asia 2005
March 19–21
Karachi, Pakistan

ROMPAINT 2005
March 29–31
Bucharest, Romania

Saigon Textile & Garment Expo 2005
April 5–8
Hochiminh City, Vietnam

SAE 2005
April 11–14
Booth #615
Cobo Center
Detroit, Michigan, USA

Igatex
April 13–16
Karachi, Pakistan

Quality Expo
April 19–20
Booth #442
Rosemont, Illinois, USA

European Coatings Show
April 26–28
Booth #1-256
Nuremberg, Germany

ANTEC 2005
May 2–4
Boston, Massachusetts, USA

FOCUS 2005
May 5
Troy, Michigan, USA

Sink or Swim
May 24–25
Akron, Ohio, USA

ShanghaiTex 2005
June 3–7
Shanghai, China

BITME
June 15–19
Bucharest, Romania

ChinaPlas 2005
June 21–24
Guangzhou, China

Forced Degradation (Large Molecule)
July 18–30
San Francisco, California, USA

Chemistry 2005
September 5–9
Moscow, Russia

EUROCOAT Lyon
September 27–29
Lyon, France

Flanders TEXTILE Valley 2005
September 29–October 1
Kortriyk, Belgium

Interplas
October 4–6
Birmingham, UK

Rich Mac 2005
October 4–7
Milano, Italy

Chemtec Praha
October 5–10
Praha, Czech Republic

ITMA Asia
October 17–21
Singapore

Fakuma
October 18–22
Friedrichshafen, Germany

Test Expo
October 26–28
Booth #16024
Detroit, Michigan, USA

IFAI
October 27–29
Booth #7106
San Antonio, Texas, USA

Industry Fair
October
Brno, Czech Republic

Expoquimia
November 14–18
Barcelona, Spain

ChinaCoat
November 16–18
Shanghai, China

AUTO PARTS 2005
December 6–9
Shanghai, China

*For the latest on Atlas shows and presentations, visit **www.atlas–mts.com.***

Atlas Test Instruments Group

Are Your Xenon Lamps Made for Weathering?

The experimental approach in weathering testing requires a well-defined and stable simulation of the main weathering parameters in a test instrument. The tighter the parameters are controlled, the better the precision (reproducibility and repeatability) of the test.

Radiation and heat are the most important factors. Therefore, Atlas has always put great emphasis on irradiance, spectral power distribution (SPD) and temperature in a weathering instrument. A key factor is the xenon lamp. Properly filtered, it is today's best simulation of solar radiation in the UV and visible wavelength range.

It is obvious that commercially available xenon lamps used in projectors or photocopying machines do not meet the advanced requirements of weathering testing. The manufacturers of these lamps designed them for use in projectors and photocopiers but, naturally, did not have to pay attention to a stable SPD or good ageing behavior in the actinic wavelength ranges.

For many decades, Atlas has developed special xenon lamps that meet the requirements of weathering testing:

- Excellent ageing behavior
- Tailored power supply and lamp operation
- Contractually specified SPD
- Guaranteed lifetime
- Best possible reproducibility and repeatability

A customer should never rely on a weathering device that employs commercial lamps designed for other purposes than weathering. The money that one seems to save at this point might be exceeded by orders of magnitude if the tested product fails. ■

EUROPEAN COATINGS SHOW 2005

plus **Adhesives, Sealants, Construction Chemicals**

Look for us at Booth #1-256!

Indispensable is how the international coatings world describes the importance of the EUROPEAN COATINGS SHOW. The next event takes place **April 26–28,** 2005, when Nuremberg becomes the world's biggest hub for paint and coatings industry experts. Some 650 exhibitors from more than 35 countries will present the full survey of new products and services for the production of paints, coatings, sealants, construction chemicals, and adhesives.

Atlas will exhibit two new innovations:

- **The new SUNTEST XXL/XXL+:** Atlas' largest flatbed SUNTEST instrument, introduced in September 2004. Providing best-in-class performance at an affordable price, the SUNTEST XXL/XXL+ is the largest iteration of nearly 30 years of research and design of the SUNTEST product line.
- **The new temperature-controlled EMMAQUA:** A new patented technology from Atlas Weathering Services Group.

For more information on these products and services, visit us at the show or contact your local Atlas sales representative or visit **www.atlas-mts.com.**

A Comparison of Freezing/Cooling Systems for CCX Advanced Corrosion Testing Cabinet

Suppliers to automotive, household appliance, military/defense, and other industries must often perform validation and qualification tests at temperatures well below freezing. For testing at temperatures down to –30°C/–22°F, the Atlas CCX Advanced Corrosion Testing Cabinet offers two options: the LN2 Freezing/Cooling System and the Mechanical Freezing/Cooling System. When strict control of *both* temperature and humidity is required, the Mechanical System should be selected. As you can see in the chart below, each system has advantages as well as possible disadvantages for the customer.

System	Advantages	Disadvantages
LN2 Freezing/Cooling	• Lower initial cost • Less floor space • Shorter lead time	• Controls temperature only • Higher cost to operate • LN2 canisters require special handling
Mechanical Freezing/Cooling	• Excellent control of both temperature and humidity • Lower cost to operate	• Higher initial cost • Larger floor area • Longer lead time

Both systems require computer controls for operation.

The LN2 (liquid nitrogen) system uses the inert gas for cabinet operation down to –30°C/–22°F. Short bursts of LN2 can also help reduce transition times from high to low temperature.

Because materials undergo little chemistry change at –30°C, and since greater stress is exerted during temperature transitions, there is no need to hold samples at a low temperature for an extended time. Therefore, the duration of each freezing episode is usually short. However, there are tests that require holding extremely low temperatures for several hours. For that type of test, we strongly recommend the Mechanical System due to the lower operating cost.

For more information regarding Freezing/Cooling Systems for advanced corrosion testing, please contact Harold Hilton at **hhilton@atlas-mts.com** or call your local Atlas sales representative. ■

Atlas Offers New, Full Coverage Warranty on 6500 Watt Lamps

Atlas is pleased to announce increased performance in our 6500 Watt lamp. To pass this benefit onto our customers, we are now providing a full 1200-hour warranty for every 6500 Watt lamp. Effective February 15, 2005, the warranty for 6500 Watt lamps is now 1200 hours, full warranty. It provides for a free replacement of any defective lamp properly reported and falling under the warranty conditions (failure to ignite within 24 months of purchase during the first 1200 hours of use as a result of a manufacturing defect). It does not provide for a full refund, credit, or exchange for any other Atlas product. The completed Warranty Log Card must be submitted and approved before the replacement lamp ships.

The new warranty has been extended only to those 6500 Watt lamps purchased after February 15, 2005. If you have concerns with previous lamps, please contact customer service immediately to activate the warranty stated on the Warranty Log Card.

For more information regarding this new warranty, please contact customer service at +1-773-327-4520. ■

To receive Sun Spots electronically, please visit www.atlas-mts.com/newsletter

(If you sent us your e-mail address in response to our Fall 2004 issue, you have been added to our e-mail list and no further action is needed.)

AtlasMaterial Testing Solutions

Atlas Material Testing Technology LLC
4114 North Ravenswood Avenue
Chicago, Illinois 60613, USA
Phone: +1-773-327-4520
Fax: +1-773-327-5787

Atlas Material Testing Technology GmbH
Vogelsbergstrasse 22
D-63589 Linsengericht/Altenhaßlau
Germany
Phone: +49-6051-707-140
Fax: +49-6051-707-149

K.H. Steuernagel Lichttechnik GmbH
Gerauer Straße 56a
64546 Mörfelden-Walldorf, Germany
Phone: +49-6105-91286
Fax: +49-6105-912880

Atlas Weathering Services Group
South Florida Test Service
17301 Okeechobee Road
Miami, Florida 33018, USA
Phone: +1-305-824-3900
Fax: +1-305-362-6276

DSET Laboratories
45601 North 47th Avenue
Phoenix, Arizona 85087, USA
Phone: +1-623-465-7356
Fax: +1-623-465-9409
Toll Free: 1-800-255-3738

KHS US Office
4114 North Ravenswood Avenue
Chicago, Illinois 60613, USA
Phone: +1-773-327-4520
Fax: +1-773-327-5787

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Chicago, Illinois 60613, USA

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