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Correlations Between Xenon Arc Accelerated Weathering Tests and Outdoor Weathering

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Abstract

The ability to predict the long-term outdoor weathering of coatings and printed graphics is essential to many industries. However, this is a difficult task. Rates of photo-oxidation and hydrolysis for different materials often do not increase by the same factors in accelerated weathering tests, primarily because of differences between the spectral power distributions of sunlight and artificial light sources. For some materials, accelerated testing results correspond poorly to phenomena observed in outdoor exposures. Because of these difficulties, few correlation studies have been published. This paper describes a correlation study between Atlas' Xenon Arc Weather-Ometer® and Milwaukee, Wisconsin, outdoor weathering. Color changes of signs and printed ink jet media were measured with colorimeters and optical densitometers. Correlations were determined for both individual materials and overall data sets. The merits of measuring color changes with colorimeters and optical densitometers will be discussed. The efficacy of the ASTM G26 and SAE J1960 testing cycles will also be considered.

Introduction

Just think about the number of times you hear the questions: "How long will this product last outdoors?" and "This sample failed after x hours in the accelerated weathering test—how many years is that outdoors?" Unfortunately, there is no simple answer to these questions. There is no universal correlation that relates outdoor weathering to time spent in an

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Xenotest® 150 turns 50!
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AtlasSpeaks

2005

DEK Symposium on Colour Fastness
October 10–12
Erding, Germany

Dr. Artur Schoenlein, Atlas Material Testing Technology GmbH, will present "Color Fastness and Automotive Lightfastness with Enhanced Irradiance."

Robert Lattie, SDL Atlas, will present "Objective Measurements of Colour Fastness of Textiles."

Andreas Riedl, Atlas Material Testing Technology GmbH, will chair the conference session "Testing Technology."

Fakuma
October 20
Friedrichshafen, Germany

Uwe Wendt, Atlas Material Testing Technology GmbH, will present "New Device-Related Possibilities for the Weathering of Plastics."

IFAI Expo 2005
October 27–29
San Antonio, Texas, USA

Matt McGreer will give an overview of automotive testing standards.

CORCON 2005 International Conference on Corrosion
November 28–30
Chennai, India

Harold Hilton, Atlas Material Testing Technology LLC, will present "Advances in Lab Corrosion Testing Cabinets."

2006

The Institute of Environmental Sciences & Technology (IEST) Annual Meeting
May 7–10
Phoenix, Arizona, USA

Allen Zielnik, Atlas Material Testing Technology LLC, will present "Terrestrial Climatic/Solar Simulation for Material & Product Durability Assessment."

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AtlasShows

2005

ITMA Asia
October 17–21
Singapore

Fakuma
October 18–22
Friedrichshafen, Germany

Test Expo
October 25–27
Detroit, Michigan, USA

IFAI
October 27–29
San Antonio, Texas, USA

AAPS
November 6–10
Nashville, Tennessee, USA

Expoquimia
November 14–18
Barcelona, Spain

Food Tech / Pharma Tech
November 15–17
Herning, Denmark

ChinaCoat
November 16–18
Shanghai, China

AUTO PARTS 2005
December 6–9
Shanghai, China

2006

Middle East Coatings Show
February 27–March 1
Dubai
Booth No. 48, Hall 6/7

3rd Annual Forced Degradation Studies
February 28–March 2
Location to be determined

SAE
April 3–6
Detroit, Michigan, USA

ANTEC
May 7–11
Charlotte, North Carolina, USA

NPE International Plastics Showcase
June 19–23
Chicago, Illinois, USA

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accelerated weathering chamber.

Intuitively, this makes sense. Outdoor weathering varies from year to year and site to site. There are currently no light source and filter combinations that can exactly reproduce the spectrum of sunlight. Accelerated weathering instruments use three factors to test materials: light, temperature, and water exposure. Each of these factors affect materials differently by activating one or more degradation pathways. There is no way to ensure that the scale factors relating the rates of these degradation mechanisms in the weathering chamber and outdoors will be the same for all mechanisms. Consequently, it is really only possible to develop weathering correlations for a single material tested with one standard test cycle rather than a universal correlation for all possible materials. It should also be noted that even for one material, the correlations for changes in color, gloss, and mechanical properties may all be different.

Forecasts of material or product performance in outdoor environments have long been sought. A fast, accurate predictive weathering test would be invaluable. However, no such universal test method has been established. Efforts to mimic the spectrum of sunlight with artificial light sources have continued since early in the 20th century.

The spectrum of sunlight is heavily weighted toward the visible and infrared. However, it is the small fraction (6.0%) of ultraviolet (UV) light that is responsible for most of the damage to polymers and colorants. In particular, it is the UVC (100–290 nm) that is the most destructive. It is critical to filter out all UVC radiation in an accelerated test, or the results are likely to be nonphysical, because the earth's ozone layer filters out all UV radiation below 295 nm.

There are many types of accelerated weather testing instruments. Their usefulness may be characterized by two parameters: correlation and acceleration factor. Correlation is the degree to which data obtained in the testing chamber agrees with data obtained outdoors. The acceleration factor is the ratio of failure time outdoors to failure time in the test instrument. For example, an acceleration factor of 12 means that a one-month accelerated weathering test corresponds to one year outdoors. Of course, acceleration factors will vary with the outdoor site. The most cited outdoor weathering facility is that of the South Florida Test Service, a subsidiary of Atlas Material Testing Technology LLC.

The primary determinant of the degree of correlation for a weather-testing instrument is the degree to which the artificial light source approximates the spectral power distribution of sunlight [1]. Xenon arc lamps provide the best available match to sunlight. Indeed, in a comprehensive study of the accelerated weathering of polyester gel coats, Crump [2] found that xenon arc weathering gave higher correlation coefficients than methods employing carbon arc or a fluorescent light source. However, most of the comprehensive comparisons of various types of weathering tests in the literature do not include correlation data. It may be assumed that many proprietary correlations have been developed but not published.

Materials and Methods

Test Samples

A variety of sign and graphics materials were tested in order to include several different classes of polymers. All ink and substrate colorants were pigments rather than dyes.

1) Vinyl ink jet graphics materials with polyamide-silica top coats were printed with process color blocks on a Brady ColorPix® Pro 36 ink jet printer; some of these graphics were covered with acrylic or two-pack urethane clear coats.
2) Two types of high-impact polystyrene (HIPS) signs were tested: one printed with an acrylic UV curable ink, the other printed with a wax-based ink and protected by a 1.0 mil polyester overlaminate.
3) Aluminum signs coated with a white polyester enamel were printed with a wax-based ink and protected by a 1.0 mil polyester overlaminate.

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4) Polyester (PET) film printed with a UV curable ink was protected with a 1.0 mil polyvinyl fluoride (PVF) film.
5) Pigmented vinyl films were printed with UV curable inks.

Outdoor Testing

Small (4 cm x 4 cm) samples were cut, adhered to large aluminum plates, and then placed on a weathering rack in Milwaukee, Wisconsin. The panels were oriented to face south at an inclination of 45°. Each panel stayed out on the rack until the end of its weather exposure, and was then brought inside for colorimeter and densitometer testing. Panels were weathered for 1, 2, 3, 6, 9, 12, 18, and 24 months. Due to variations in weathering throughout the year, only data for 0, 12, and 24 months were used in calculations of correlation coefficients.

Atlas Weather-Ometer® Tests

Accelerated weathering was conducted in a Ci5000 Xenon Arc Weather-Ometer from Atlas. The filter combination and environmental conditions were taken from the following two test standards:

The **ASTM G26** standard [3] employs Borosilicate inner and outer filters for the xenon arc lamp. The light cycle has two parts:

1) Irradiance for 102 min with a set point of 0.35 ± 0.01 W/m^2 at 340 nm, a black panel temperature of 63 ± 3°C, and 50% relative humidity.
2) Front water spray for 18 min; same irradiance as above.

Note that ASTM G26 has been replaced by ASTM G155 since the start of this experiment. The above conditions correspond to cycle 2 on Table X3.1 of Common Exposure Conditions in ASTM G155.

The **SAE J1960** standard [4] calls for a Quartz inner filter and a Borosilicate outer filter for the xenon arc lamp. The cycle has four stages:

1) Irradiance for 40 min with a set point of 0.55 ± 0.01 W/m^2 at 340 nm, 50% relative humidity, and a black panel temperature of 70 ± 2°C.
2) Front water spray for 20 min; same irradiance as (1).
3) Same conditions as (1) for 60 min.
4) Dark cycle for 60 min at 38 ± 2°C dry bulb temperature 95 ± 5% relative humidity with back water spray.

Reflected optical density and color values were measured after approximately every 200 hr of exposure out to 3000 hr. Two SAE J1960 Weather-Ometer samples were tested for each material and color, while only one was run with the ASTM G26 method.

Color Measurements

Reflected optical densities were measured with a Gretag Macbeth RD-1200 or RD-1255 densitometer. For the process primary colors, only one color was measured. For red samples, magenta and yellow were measured; for green samples, cyan and yellow were measured; and for blue samples, only cyan was measured. Each data point was taken as the average of five measurements—the four corners and the center point of the rectangular color patch.

A Hunter Ultrascan colorimeter was used for color difference measurements in *L,a,b* space. The small area aperture (1/4") was used for all samples. The colorimeter was configured for a D65 light source, a 10° angle of view, and specular reflections included. All data points were taken as the average of five measurements—the four corners and the center point of the rectangular patch of color.

Results and Discussion

Weathering Test Results

Data from the Atlas Weather-Ometer® was correlated to one- and two-year data from the Brady outdoor weathering racks in Milwaukee. The results are summarized in Tables 1 and 2. The uncertainties, taken as two standard deviations, in the number of hours in the Weather-Ometer corresponding to a year outdoors are significantly higher for the SAE J1960 test cycle than for ASTM G26. The reasons for this will be addressed in the Results and Discussion section. The uncertainty is also relatively small for the only large data set, Ink Jet Vinyl, that was tested under SAE conditions.

The acceleration factor varies with the material tested, as is expected for an accelerated weathering test. The largest is approximately twice the smallest, so none of the numbers are unambiguously anomalous.

Table 1
SAE J1960 Weathering Results

Material	N	WOM hr = to 1 yr in Milw.	Acceleration Factor
Ink Jet Vinyl	19	762 ± 236	11.5 ± 2.7
Aluminum	7	681 ± 344	12.9 ± 4.3
Polystyrene	7	1539 ± 1557	5.7 ± 2.9
Polystyrene with PET Overlaminate	7	894 ± 330	9.8 ± 2.7
Polyester with PVF Overlaminate	4	1665 ± 553	5.3 ± 1.4
Colored Vinyl	5	861 ± 475	10.2 ± 3.6

Table 2
ASTM G26 Weathering Results

Material	N	WOM hr = to 1 yr in Milw.	Acceleration Factor
Aluminum	7	840 ± 330	10.4 ± 2.9
Polystyrene	7	1274 ± 552	6.9 ± 4.8
Polystyrene with PET Overlaminate	7	845 ± 58	10.4 ± 0.7
B-689 Polyester Pipe Marker	4	1329 ± 1262	6.6 ± 3.2
B-946 Vinyl	5	684 ± 175	12.8 ± 2.6

Failure Criteria

The effectiveness of an experimental weathering test is dependent upon the failure criteria chosen. One may choose to monitor changes in color, gloss, or mechanical properties. These categories may also be broken down further. For example, color change may be designated as color fade measured with an optical densitometer, color difference measured with a colorimeter, or yellowing as quantified by a yellowness index.

In this experiment two failure criteria were employed. Color fade was measured with a

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Gretag Macbeth Densitometer. The percent reduction in reflected optical density of one or two of the process color primaries was tracked as the samples weathered. Color difference, ΔE, was also measured with the Hunter Ultrascan Colorimeter. It may be defined in L,a,b color space as:

$$\Delta E = \left[(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2\right]^{1/2} \qquad (1)$$

where ΔE = color difference, ΔL = difference in lightness index, Δa = difference in a value (green/red axis), and Δb = difference in b value (blue/yellow axis).

In general, better results were obtained when optical densities were measured. This was particularly true for yellow and black samples. In both cases, only one value in L,a,b color space changes significantly as the specimen ages. For yellow, this is the b value. For black, only the lightness, L, changes unless there is a significant yellowing problem. Consequently, for specimens that appear to have the same degree of change visually, the yellow and black materials tend to have smaller ΔE values than other colors. Colorimeter results for black samples often show little correspondence to visual observations. Samples with a mid-gray appearance often still have relatively low L values, and if there is no yellowing, both the a and b values will still be negligible.

Another problem with using color difference as the failure criterion is that a significant fraction of samples show a color change (ΔE) of 3–6 within the first day of exposure and then do not change again for hundreds or thousands of hours. Often, the failure criterion is exceeded on the first day for a sample that actually is quite resistant to sunlight and water. This can skew the results considerably. Essentially, this means that experiments must be long enough in time scale that the color change for all samples is several times the size of these initial step-changes.

The large Ink Jet Vinyl data set was used to examine any variations in the acceleration factor and correlation for different ink colors (Table 3). No differences were observed between cyan, magenta, and yellow, but the acceleration factor was a little lower for black. For that ink set, there appears to be little influence of color on weathering.

Table 3
Effects of Color on Ink Jet Vinyl Weathering

Color	WOM hr = to 1 yr in Milw.
Cyan	681 ± 205
Magenta	677 ± 284
Yellow	675 ± 136
Black	871 ± 150
Overall Average	715 ± 200

ASTM G26 vs. SAE J1960

Both ASTM G26 [3] and SAE J1960 [4] have their strengths as testing cycles that may make them particularly suited for testing certain types of materials (see the Materials and Methods section for complete descriptions of the testing cycles). The Borosilicate inner/Borosilicate outer filter combination used in ASTM G26 provides a better match to the spectral power distribution of sunlight, with less radiation in the 280–300 nm range. However, it also runs at a constant temperature when the xenon arc lamp is on continuously. SAE J1960, on the other hand, includes a dark cycle with water spray at lower temperature to simulate the condensation that occurs when the temperature drops to the dew point at night. When the light comes back on and the temperature is increased, SAE J1960 test specimens experience simultaneous heating and drying. Materials that are sensitive to expansion and contraction, especially porous samples, may show early failures due to cracking in SAE tests that are not reproduced in ASTM tests. For automotive coatings, this is often deemed to be critical. Early in the development of the Ink Jet Vinyl topcoat, the SAE test method was found to be a better predictor of outdoor performance because the main failure mode was cracking and chalking of a somewhat brittle, silica-filled, porous, polyamide topcoat.

For the materials that were tested under each cycle (ink jet graphics were only tested under SAE J1960), better correlation with Milwaukee, Wisconsin outdoor weathering was obtained with the ASTM G26 method. This can be seen to some extent in Table 4, but is even more evident in the overall data sets shown in Table 5. The standard deviation in Table 5 is approximately three times as large for current Brady products when tested by the SAE J1960 standard as opposed to ASTM G26. Other than Ink Jet Vinyl, all of the products investigated in this series of experiments comprise non-porous substrates, inks, and overlaminates exclusively. Thus, the effects of expansions, contractions, and water absorption are not strong, so the main factor determining the degree of correlation with outdoor weathering is expected to be the difference in the spectral power distributions of the light sources.

Table 4
Correlation Coefficients Between Atlas Ci5000 Weather-Ometer® and Milwaukee Outdoor Weathering

Sample Set	Test Cycle	Metric	N	r^2
All	ASTM G26	Density	76	0.68
All	ASTM G26	ΔE	39	0.67
w/o Ink Jet	SAE J1960	Density	60	0.64
w/o Ink Jet	SAE J1960	ΔE	36	0.27
All	SAE J1960	Density	207	0.70
Ink Jet Vinyl	SAE J1960	Density	147	0.75

One unexpected result, however, was that the acceleration factors of the two methods were very similar. Because there is more radiation present in the damaging 280–300 nm range, SAE J1960 tests typically are more damaging and show a higher acceleration factor than ASTM G26 tests. For example, in a study of color and gloss changes in acrylic automotive coatings, Bauer [5] obtained acceleration factors of 8–20 and 6–9 for Xenon Quartz/Boro (SAE J1960) and Xenon Boro/Boro (ASTM G26), respectively. Bauer also found that acrylic coatings could be tested by either method, but outdoor weathering of polyester coatings only correlated with accelerated tests using the Borosilicate/Borosilicate filter combination.

It is the belief of the author that a combination of the two testing cycles may correlate even more closely to outdoor weathering. If the four-part SAE J1960 method were run with Borosilicate inner and outer filters, the resulting test would have a better match to the spectral power distribution of sunlight along with the expansion and contraction cycles that destroy many porous or brittle samples as well. Options that could further improve the match to the spectrum of sunlight, such as using ozone as a filter [1], are somewhat impractical at this time.

Discussion of Overall Correlations

To begin this discussion, a few caveats should be offered:

- Correlations for an individual material are the most accurate.
- The accuracy will be even better if the data is for only a single color.
- With most Brady products, multiple layers of dissimilar materials also need to be considered.
- As can be seen in the preceding sections, weathering correlations vary strongly with the types and combinations of materials.

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However, often in materials research and development we would like to predict the lifetime of a construction for which no previous test results exist. In order to provide a "rule of thumb" for this type of prediction, the data sets for different materials were combined (Table 5). The overall correlations show that a year of outdoor weathering in Milwaukee corresponds to approximately 800 ± 400 hr in the Atlas Ci5000 Xenon Arc Weather-Ometer®. The average for each product tested lies within this range. Of course, the standard deviations for some materials are quite large. Most correlation coefficients are in the 0.6–0.8 range.

Problems with certain types of materials are to be expected in weathering tests. For some materials, the spectral power distribution of the artificial light source, the thermal energy, and the water applied in a test do not result in a simple acceleration of the weathering chemistry in outdoor exposure. Instead, other degradation pathways are activated, and the test results are anomalous. For example, Gerlock [1] used FTIR spectroscopy to follow the weathering chemistry of polyester/urethane and acrylic/melamine automotive clear coats. The acrylic/melamine clear coats were found to be much less sensitive to exposure conditions than the polyester/urethane clear coats. Changes in the weathering chemistry of the polyester/urethane coatings resulted in poor correlation of xenon arc weathering with South Florida and Arizona weathering. The effectiveness of light stabilizers added to the coating formulations was also found to be distorted due to thermal migration of the stabilizers [1].

Another factor that may have affected the acceleration factors that were determined is the two-year time scale of our experiments. For all materials, the acceleration factor was lower for two-year than for one-year outdoor data. For example, for Ink Jet Vinyl, one year of outdoor weathering was equivalent to 983 hr of SAE J1960 Weather-Ometer testing, but after a second year of testing this equivalent had dropped to only 715 hr. Indeed, this figure may drop even further in a longer test (which corresponds to a higher acceleration factor). It is expected that it may eventually approach a stable, long-term value.

When these experiments commenced, the author was expecting to find that about 400–600 hrs in the Weather-Ometer was equivalent to a year outdoors in Milwaukee, Wisconsin. However, the overall average for this experiment is approximately 800 ± 400 hr in the Weather-Ometer/year outdoors, which corresponds to an acceleration factor of 11.0 ± 3.7. It is difficult to compare this to the literature, because nearly all of the published studies cite data for the Atlas South Florida Test Service or DSET in Arizona. In a comprehensive study of the accelerated weathering of polyester gel coats, Crump [2] found an acceleration factor of 8.4 relative to South Florida weathering for ASTM G26 xenon arc weathering. Model predictions and experimental values of Bauer [5] for acceleration factors in South Florida and Arizona weathering range from 4.5 to 15.0 (Borosilicate/Borosilicate filters) depending upon the type of material. Bauer has estimated that one year in Florida or Arizona is approximately equal to two years at Ford Motor Company in Dearborn, Michigan [6]. In order to make a fair comparison, data collected at the South Florida Test Service is needed.

Table 5
Overall Weathering Correlations

Sample Set	Test Cycle	Metric	Hr/Yr in Milwaukee
Overall	ASTM G26	Density	928 ± 564
Overall	ASTM G26	ΔE	1031 ± 862
Current Products	ASTM G26	Density	801 ± 284
Overall	SAE J1960	Density	864 ± 964
Overall	SAE J1960	ΔE	802 ± 1108
Current Products	SAE J1960	Density	807 ± 746

Conclusions and Recommendations

The Atlas Xenon Arc Weather-Ometer® is an effective accelerated weather-testing device. When used with Borosilicate inner and outer filters, as is recommended for the ASTM G26 method, the xenon arc lamp provides the best available fit to the spectral power distribution of sunlight of all available artificial light sources. This is the "gold standard" of accelerated weather testing chambers that employ artificial light sources (as opposed to solar reflectors and concentrators). The Quartz inner/Borosilicate outer filter combination used in the SAE J1960 exposes samples to more light in the 280–295 nm range that is screened out by the earth's ozone layer. The strength of the SAE test method is that it includes a dark cycle with water spray at a lower temperature to simulate nightly condensation and the subsequent drying concurrent with temperature increase during the morning. Because of the expansion and contraction due to the thermal cycling and drying provided by this method, it often works well for materials that are brittle, porous, or hygroscopic. A hybrid test method in which the Borosilicate inner and outer filters of ASTM G26 are combined with the four-part SAE J1960 cycle is predicted to be superior to either standard test method.

Correlations for color changes are better when reflected optical densities are measured on a densitometer than when color differences are tracked with a colorimeter. This is especially true for very minute changes, or for black or yellow samples. For white materials, yellowness indices should be measured with a colorimeter.

A more comprehensive future study is recommended. The duration of the study should be long enough that the acceleration factor for each material becomes essentially constant. It is surmised that five years may be sufficient. In order to be able to compare results with literature values, it is imperative that some samples be tested at the South Florida Test Service weathering site run by Atlas Material Testing Technology. ■

References

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[3] ASTM G26-96, *Standard Practice for Operating Light-Exposure Apparatus (Xenon-Arc Type) With and Without Water for Exposure of Nonmetallic Materials*, American Society for Testing and Materials, 1996.

[4] SAE J1960 Materials Standard, *Accelerated Exposure of Automotive Exterior Materials Using a Controlled Irradiance Water-Cooled Xenon Arc Apparatus*, Society of Automotive Engineers, Inc., 1989.

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Biography

Bruce M. Klemann is a Senior Materials Scientist at Brady Corporation, where he has worked since 1994. His research interests include digital printing media, ink jet printing inks, novel imaging and marking processes, thermal stability of coatings, accelerated weather testing, rheology of thin films and viscous liquids, materials for flat panel displays, and security imaging. He received a B.S. in chemical engineering and a Ph.D. in Materials Science from the University of Wisconsin-Madison. He is a member of IS&T, MRS, and SPE.

AtlasTest Instruments Group

Instrument Makes Industry History

One of the most revolutionary testing instruments celebrates its 50th anniversary this year: the **Xenotest® 150,** originally developed by the German company Orginal Hanau Quarzlampen. The Xenotest 150 made industry history when the first German industrial standard for lightfastness was customized and directly connected to the instrument and its features.

Today, the **Xenotest 150 S+,** successor of the Xenotest 150, is produced by Atlas Material Testing Technology LLC.

A Brief Look Back into History

During the 19th and 20th centuries, synthetic dyestuffs began to replace natural pigments, and soon test methods were required to compare the new products. As a consequence, in 1911, chemists founded the German Textile Fastness Committee (DEK) and developed a standardized test method for lightfastness.

During the first lightfastness tests, dyestuffs and printed textiles were exposed to natural sunlight behind window glass. Soon it was noticed that different test sites produced different results. The chemists also found that these lightfastness tests were time-consuming. Thus, artificial light sources were introduced to simulate natural sunlight and to accelerate the testing procedures. However, neither the quartz and carbon arc lamps nor the other light sources of the time met the requirements set forth by the DEK.

The Artificial Sun

It was not until the 1950s, when more and more synthetic colors and fibers were being developed, that a solution was found. Mr. Klaus Toepfer, a member of the Textile Fastness Committee and a chemist at the Frankfurt dyestuffs company, Cassella, sought a manufacturer of lamps. They found the ideal partner in the company Original Hanau Quarzlampen. In close collaboration, they developed the first test instrument with xenon arc lamps, which closely simulated sunlight. Soon the Xenotest 150 was built around this idea, and testing time was reduced to one-tenth of the time needed to test with natural sunlight. The German standard of lightfastness was then tailored around this instrument. Years later, the benefits of xenon arc lamps were also recognized on an international level, and the lamp was used for various other needs.

Rain Follows Sun

After its introduction to the market in 1955, the Xenotest 150 soon evolved. A special humidity and rain system ensured that weatherfastness of specimens could be tested, in addition to lightfastness. Currently an advanced system, which includes a microprocessor, sensors, control units, and filters ensures that the light- and weatherfastness of virtually all textile materials can be tested.

When it was invented, it seemed that only the textile industry needed the Xenotest 150, but currently numerous Atlas instruments are used in the automotive industry for testing plastics, coatings, and car interior materials.

Many Atlas customers still use the Xenotest 150 regularly. In celebration of its 50th anniversary, a Xenotest 150 will be shown at the 75th DEK Annual Meeting in October in Erding, Germany (near Munich).

New Representative for South Korea

Atlas Material Testing Technology LLC is pleased to announce a new representative for South Korea. Effective August 1, 2005, AB Nexo Co., LTD is the exclusive representative for sales and support for Atlas manufactured instruments and Atlas Weathering Services Group in South Korea. MC Corporation, who has been part of the Atlas family for over 30 years, passed on the representation to AB Nexo. Located in Seocho-ku Seoul, AB Nexo is managed by Mr. Y H Moon and staffed entirely by former MC Corp personnel, maintaining continuity of the Atlas business. Atlas would like to show our appreciation to Mr. M I Lee, president of MC Corporation, for his long support and friendship. Atlas also wishes the best for Mr. Y H Moon and his staff at AB Nexo Co., LTD.

In commemorating the occasion, Atlas will publish the Atlas Weathering Testing Guidebook in Korean language. The Atlas Weathering Testing Guidebook is a technical resource for all weathering topics. The Korean version of the Atlas Weathering Testing Guidebook will be introduced in early November at the Atlas Annual Weathering Seminar, co-sponsored by the Korean Institute of Construction Materials (KICM) and the Korean Weathering Test and Evaluation Center (KWTEC).

For more information, please contact AB Nexo Co., LTD 82-2-3473-1411 or **visit www.abnexo.com.**

Atlas Expands Customer Care Program in United States

Atlas Material Testing Technology LLC, the leading manufacturer of weathering testing equipment, is pleased to announce the expansion of our innovative Customer Care Program. Over the last 12 months Atlas has offered the Customer Care Program free of charge with all new instrument purchases. The program offers an unparalleled level of service and support to its customers that use xenon, fluorescent, and environmental testing instruments as well as corrosion cabinets. The program delivers extraordinary levels of expert guidance and assistance as well as routine preventive maintenance and ISO 17025 accredited calibrations.

"The program has been so successful with new instrument users that we needed to find a way to provide this same service to all of our customers," said Walt Watford, Atlas' senior service technician.

Atlas now makes this same level of service available to all of its customers through the following programs:

- **ISO 17025 Accredited Calibrations**
  - Atlas is currently the only manufacturer of weathering testing equipment that offers field calibration services accredited by A2LA to meet ISO 17025 requirements.
  - Atlas can provide ISO 17025 accredited calibrations for light, temperature, and humidity, including documentation for traceability, for all of our instruments as well as many of those manufactured by others.
  - Using state-of-the-art irradiance measurement equipment, our Chicago-based calibration laboratory performs accredited calibrations on irradiance calibration tools for xenon and UV-based testing devices such as Atlas calibrated lamps and UV2000 Calibrators, and the equivalent offerings from other manufacturers. (Register your lamp today at **www.atlas-mts.com/recalibration.**)

- **Customer Care Program**
  - A twelve-month program included with every qualifying purchase, featuring a thorough combination of training, maintenance, and ongoing visits in addition to our standard full coverage warranty
  - Technical expert onsite at installation to provide start-up, demonstration, and operator training
  - Periodic satisfaction follow-ups
  - Six- and twelve-month preventive maintenance and ISO 17025-accredited calibration visits to ensure the smooth, reliable, trouble-free operation of Atlas' high-quality testing instruments

- **Preventive Maintenance and Calibration Agreements**
  - Extended Customer Care Programs available for all Ci Series, SUNTEST, corrosion, and UV2000 instruments after the first year
  - Preventive Maintenance and Calibration Agreements available for xenon and carbon arc instruments that can be tailored to meet customers' needs
  - Our agreements include maintenance programs designed by Atlas and performed by our factory-certified technicians to save you time and effort, routine schedules that maximize instrument performance and eliminate unintended down time, detailed inspection and calibration reports that meet ISO 17025 requirements for traceability, and a package pricing concept that simplifies budgeting, ordering, and payment.

Atlas will tailor our programs to fulfill all the needs of its customers. Our extensive network of field service technicians are located throughout the United States and offer industry-leading response time and experience. For more information about our Technical Service Programs, please contact Atlas at **+1-773-327-4520** or **info@atlas-mts.com.**

Atlas Approved as NYC Department of Buildings 'Qualified/Certified' Lab

Since September 11, 2001, the New York City Department of Buildings has sought to increase the brightness and clarity of exit signs in buildings throughout the city. To this end, it has developed a listing of laboratories that are qualified to perform accelerated testing on these signs. As a "qualified/certified lab," Atlas Material Testing Technology LLC will now appear on the Department's website. Atlas was added to the list of laboratories based on its xenon instruments that offer the best spectral match to sunlight.

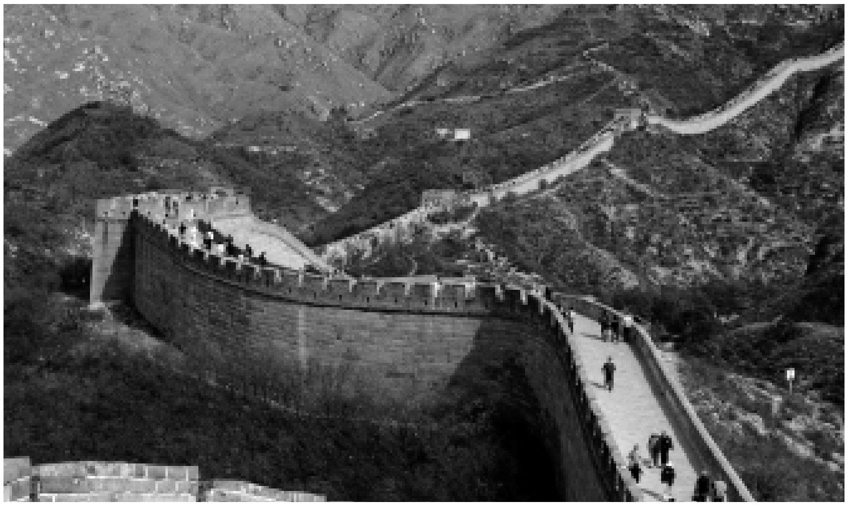
Clients wanting their products certified for use in New York City can visit **http://www.nyc.gov/html/dob/html/reference/reference.shtml** to view the listing of laboratories. For more information, please contact your local sales representative or e-mail us at **info@atlas-mts.com.**

AtlasCommitment to Growth

Atlas and GEARI Team Up to Provide Testing Services in China

A new joint venture (JV) between Atlas and Guangzhou Electric Apparatus Research Institute (GEARI) will provide commercial weathering testing services within China.

The joint venture will include established GEARI weathering laboratories as well as a new laboratory and outdoor exposure site in Hainan, China, and will be an integrated component of the AWSG Worldwide Exposure Network. The scope of the JV will include laboratory weathering, outdoor exposure testing, and evaluation services. Customers will be able to count on the well-established high quality testing per ISO 17025 requirements and proven confidentiality of both Atlas and GEARI services.



"China's growth in the global marketplace has made it an important center for product development, and the need for quality materials durability testing and service life prediction will play an increased role," said AWSG President Jack L. Martin. "Atlas and GEARI are now aligning resources to continue to meet the increasing demand."

The Atlas and GEARI partnership in China was established in 1999 through a mutual recognition agreement. Since then, Atlas and GEARI have implemented several training activities and quality initiatives to offer outdoor weathering, laboratory accelerated weathering using xenon and fluorescent devices, and evaluation services as specified in ASTM, ISO, and SAE standards. For the last three years, Atlas and GEARI have served the Chinese weathering market with quality products and services. The new JV will build on this already strong relationship to help clients to reach their ultimate goals: a quality product, a competitive edge, and a faster time to market.

"Atlas and GEARI are excited about this opportunity to expand the testing capabilities in China," said Mr. Lu, GEARI Vice President. "As the JV progresses, we will do our best to keep the Chinese weathering community informed."

For more information about the JV, please contact Atlas at **+1-623-465-7356** or GEARI at **+86-20-89022301.**

Atlas MTT GmbH Trains the 'Next Generation'

Atlas' Client Education Department in Germany is introducing college and university students to materials testing technology.

Last year, Atlas MTT GmbH began bringing first hand knowledge of materials testing to universities and colleges beginning with the local college in Gelnhausen, Germany. Atlas plans to continue these educational courses with other universities and colleges in the coming years.

During these courses, students are given the opportunity to combine their studies with practical examples from the real world. Those hoping to work for industries that need to test for weathering and lightfastness—e.g., plastics coatings or automotive sector—are given insight into relevant and current testing procedures.

Asked why Atlas is extending its knowledge sharing seminars—normally offered only to customers—to colleges and universities, Bruno Bentjerodt (Client Education Department, Germany) answered, "Students are our future. To impart our knowledge to them means to make them experts—experts who may shape the material testing world of tomorrow."

For more information about seminars for colleges and universities, please contact Bruno Bentjerodt at +49 6051 707 245 or **bbentjerodt@atlasmtt.de.**

Atlas Welcomes New U.S. Sales Manager

Atlas welcomes **David Foy** as the new General Manager-USA Sales. David's primary role within Atlas will be to plan and direct the Atlas Network of Weathering domestic sales activities while managing the direct sales staff and ongoing relationships with regional distributors. He brings to the position over 14 years of sales management experience.

David most recently served as Global Business Director for DuPont Liquid Packaging Systems' water packaging division, where he oversaw sales and marketing for a $55 million product line that included capital equipment sales as well as consumable sales. David's background also includes start-up experience. As Vice President and General Manager of National Wine & Spirits Corporation's Cameron Springs Division, he oversaw the launch and growth of the company to one of the largest bottled water companies in the Midwestern United States.

David has an active plan for his first few months with Atlas. He will be traveling extensively in order to introduce himself to customers and familiarize himself with various materials testing markets. His goal is to quickly understand how Atlas can continue to improve its products and meet our customer needs.

Please join us in welcoming David to the Atlas team! He can be reached at **+1-773-327-4520** or **dfoy@atlas-mts.com.**

Weathering Experimenter's Toolbox: Evolutionary Jumps in Natural Weathering Test Methods

Advances in weathering test methods can be visualized as levels of evolutionary jumps in weathering test method sophistication:

> Level 1

Exposures in reference environments represent a first step in accelerating degradation from traditional end use markets. Comparison between South Florida and Phoenix, Arizona, offers an effective technique for understanding these environments with respect to solar radiant exposure, temperature, and moisture.

> Level 2

Modern exposure facilities employ racks attached by a single axle to fixed vertical members. The axle allows rack pivoting to the appropriate angles from horizontal as needs arise. Unbacked, backed, under glass, or other exposure enhancements then clamp to the pivoted frame. Although simple in retrospect, the pivoting frame advancement provided a basis for considerable development of natural weathering test methods. This simple improvement in rack design has allowed more advances in conventional weathering technology than any other single advancement. Static exposures easily relate back to full system end-use exposures. Increases in critical weathering variables can significantly affect the rate at which materials degrade. Simple optimization of location, backing, and angles can modestly accelerate degradation rates.

> Level 3

Data from the static exposure angles discussed shows the effect of angle on increasing critical weathering variables. A dynamic exposure, which varies orientation in response to the seasonal variation in the sun's path, can increase critical weathering variables throughout the year.

> Level 4

The evolution in exposure methods from static to variable angle exposure racks dramatically increased levels of radiant energy deposited on specimens. A similar jump in exposure development occurred with automatic tracking mounts that follow the sun's path from sunrise to sunset. These sun-tracking mechanisms dramatically increase solar irradiance and represent the next milestone in natural weathering acceleration methods.

> Level 5

After obtaining maximum acceleration from normal incidence sun tracking exposures, engineers often want to accelerate UV degradation beyond these methods using *natural* sunlight. Inventors developed an elegant solution to concentrate the image of several suns onto a single target area of the test material. This method became known as the "EMMA®," an acronym for Equatorial Mount with Mirrors for Acceleration. Standards for this test method include ASTM G90, ASTM D4364 A, ISO 877, and SAE J1961.

> Level 6

The next quantum leap in evolution of natural accelerated weathering test methods (like the pivoting rack, follow-the-sun trackers, and EMMAQUA® concentrators) may come from hybrid test methods, utilizing combinations of different natural, accelerated, and artificial weathering test methods. The design for special exposures is only limited by the engineer's ability to link back or correlate to the reference environments, by imagination, and by funding. Remaining within the parameters represented by standards is important for comparisons of performance between different vendors, materials, processes, quality control issues, and other factors. For research and development of materials and processes, however, understandings often come from experimentation outside the standards requirements and utilize novel test method approaches. ■

Note

Methods of acceleration and increasing critical weathering variables may present considerable risks for correlating testing results back to full system end-use exposures. Engineers should only use accelerated test methods in conjunction with the test methods presented so far.

2005

Fundamentals of Weathering I

October 26
Seligenstadt, Germany

November 1
Phoenix, Arizona, USA

November 9–10
Kolding, Denmark

November 10
Bicester, UK

Fundamentals of Weathering II

October 27
Seligenstadt, Germany

November 2
Phoenix, Arizona, USA

November 9–10
Kolding, Denmark

Weather-Ometer® Workshops

Linsengericht, Germany

November 30
Weather-Ometer® Workshop

December 1
Weather-Ometer® Workshop

Miami, Florida, USA

October 10
Ci4000/Ci5000

October 11–12
Ci35/Ci65

October 13
Advanced Ci35/Ci65

October 18
Ci4000/Ci5000

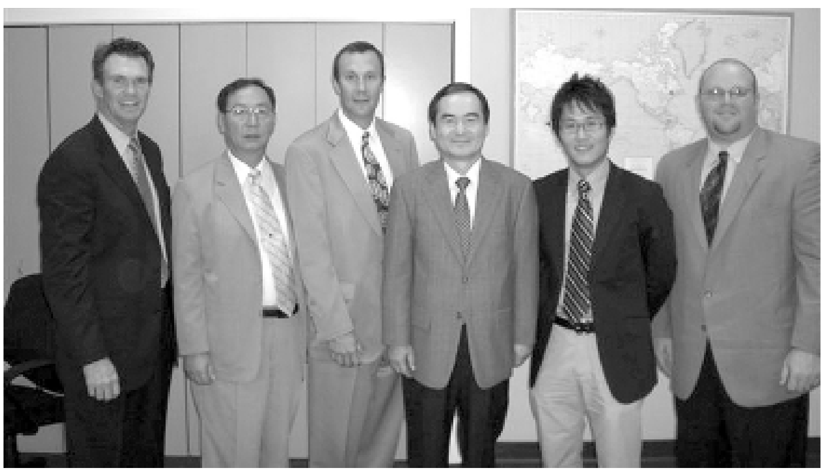
For more information on courses in Europe, contact Atlas MTT GmbH, attention Bruno Bentjerodt, +49-6051-707-245 or clienteducation@atlasmtt.de. For more information on courses in North America, contact Kerry Larmon at +1-773-327-4520 or klarmon@atlas-mts.com. Or visit our website at www.atlas-mts.com.

Atlas Weathering Services Group

AWSG and KICM Expand Partnership in Korea

Atlas is proud to announce the signing of a mutual recognition agreement with Korea Institute of Construction Materials (KICM). KICM and AWSG will now share resources for testing, analysis, client education, and R&D activities in Korea. The new agreement strengthens our existing relationship with KICM and further highlights the importance of the South Korea market in the global economy.

South Korea has become one of the world's leading economic forces, producing high-quality, world-class goods ranging from personal electronics to automobiles. As Korean companies emerge to compete with the world's leading firms, reliability and quality are at the forefront of the Korean manufacturers' focus. To further drive quality, the Korean Ministry of Commerce has set forth reliability-focused initiatives through its vast network of technical agencies. This nationwide quality push is giving birth to the first weathering test center in Korea under the direct management of KICM.



Atlas and KICM representatives meet in Miami to formalize an agreement that will expand service in Korea.

The Korea Weathering Test and Evaluation Center (KWTEC), with its main outdoor and accelerated test facility located in Seosan, provides a full gamut of weathering related services to their local clients including outdoor natural exposure in a marine industrial climate, accelerated weathering testing, corrosion testing, analytical services, and R&D-related consulting services.

Mr. K E Park, President of KICM, and Mr. H O Jeong, Head of KWTEC, traveled to Miami on September 2 for the signing of the agreement with Russell Lane, President of Atlas Material Testing Technology LLC; Jack Martin, President of AWSG; and Fred Lee, Territory Manager for South Korea.

Atlas looks forward to a long and successful partnership with KICM and KWTEC. For more information, contact your local Atlas representative or call AWSG at **+1-623-465-7356.**

Correction of *Sun Spots,* Issue 74, page 13:

It has been brought to our attention by the Automotive Materials Association (AMA), a division of the Industrial Fabrics Association International, that the article regarding availability of polystyrene reference materials was not stated correctly.

For clarification, the committee had decided to have an impartial third party administer the round robin to maintain confidentiality. This step was taken to encourage interested participants to take part in the round robin. It was discussed and decided that Kurt Scott would remain the task group chair but the round robin data would be prepared and sent by an impartial third party. It was noted that Kurt Scott, with his knowledge and experience, would be of great assistance to this person.

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.)

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