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An AMETEK® Company

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SunSpots®

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A Look at Accelerated Photostability Testing for Packaged Food and Drinks

By Dr. Oliver Rahäuser and Dr. Artur Schönlein
Atlas Material Testing Technology GmbH
Vogelsbergstr. 22, 63589 Linsengericht-Altenhaßlau, Germany

The authors discuss the effects of light and temperature on packaged food and drinks and the tests undertaken to establish correct requirements.

Today's world of packaged food and drinks is different than previous eras. Modern recipes are often more complex. With an increase in the number of available ingredients and the strong differentiation in target groups, product variety has grown considerably in recent years. Today's products are considered as multi-component systems from a laboratory point of view. In addition, food and beverage producers favor transparent plastic packaging more than ever for a lightweight, visually attractive, and low-cost presentation of their contents to the consumer. But the transparency of plastic packaging also has disadvantages; as considerable amounts of light penetrate the packaging, there is a demand for suitable light protection. This applies both for the product formulation and the packaging itself.

Stability tests under the effects of light and temperature must not be neglected in favor of product marketing, user friendliness, or appearance. The risks of undesirable chemical interactions have risen due to an increase in formulations that are now technologically possible. UV light and various ingredients in drinks can lead to extremely complex interactions which often have a negative effect on elementary properties essential to the brand [1]. (See Figure 1 for examples of exposures.)

Where traditional methods for determining "best before" dates are too slow or inaccurate, faster methods are required. Until now, there have been no national or international standards for the accelerated photostability testing of food and beverages. What do exist are independently developed internal tests by individual members of the process chain, mainly the color and flavor manufacturers and compounders.

Photostability and Test Requirements

Many factors must be considered for photostability testing in the laboratory in order to handle the increased chemical and physical complexity and to test as realistically as possible. The discoloration risks to which recipes are exposed by interaction with sunlight are a primary concern.

Oxygen that gets into the product by permeation through the plastic material or through a seal can very easily be transformed into singlet oxygen

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Solar energy industry relies on Atlas EMMAQUA® to speed time to market and support service life prediction
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In This Issue

Keep Your Team Up to Date!

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

Weather-Ometer® Workshop	April 12	Chicago, Illinois, USA	*Presented in English*
	June 21	Chicago, Illinois, USA	*Presented in English*
	September 20	Chicago, Illinois, USA	*Presented in English*
	November 30–December 1	Linsengericht, Germany	*Presented in German*
Fundamentals of Weathering I	April 6	Jakarta, Indonesia	*Presented in English*
	April 13	Chicago, Illinois, USA	*Presented in English*
	May 24	Germany	*Presented in German*
	June 7	Switzerland	*Presented in German*
	June 22	Chicago, Illinois, USA	*Presented in English*
	September 21	Chicago, Illinois, USA	*Presented in English*
	November 15	Germany	*Presented in German*
Fundamentals of Weathering II	April 14	Chicago, Illinois, USA	*Presented in English*
	May 25	Germany	*Presented in German*
	June 8	Switzerland	*Presented in German*
	June 23	Chicago, Illinois, USA	*Presented in English*
	September 22	Chicago, Illinois, USA	*Presented in English*
	November 16	Germany	*Presented in German*
SUNTEST® Workshop (CPS/XLS Models)	May 12	Linsengericht, Germany	*Presented in German*
Online Webinars	April 6	Understanding the Relation of Reliability, Durability and Weatherability (Free)	
	April 12	Durability/Reliability Testing Across the PV Development Value Chain (US$95/70 Euros)	
	May 10	Pharmaceutical Photostability Testing Small and Large Molecules According to ICH Guidelines (Free)	
	May 11	Successful Weathering Testing (Free)	
	May 17	Status of Current Weather Durability Testing of Photovoltaics: An Assessment of Where We Are and Where We Need to Go (Free)	
	May 18	Correlation between Natural and Artificial Weathering (US$95/70 Euros)	
	May 24	Environmental Durability of PV Modules (Free)	
	May 25	Ultra Accelerated Weathering (US$95/70 Euros)	
	June 7	Standards for Weathering (Free)	

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

Accelerated Photostability, from page 1

by excitation and very quickly oxidize ingredients that are sensitive to oxidation. Partial or complete discoloration is possible, or even the loss of vitamins such as vitamin C. Citric acids and trace metals can lead to destabilization of the product color under exposure to UV light. While vitamin B12 by itself is relatively stable, it decomposes in contact with vitamin C and UV light [1].

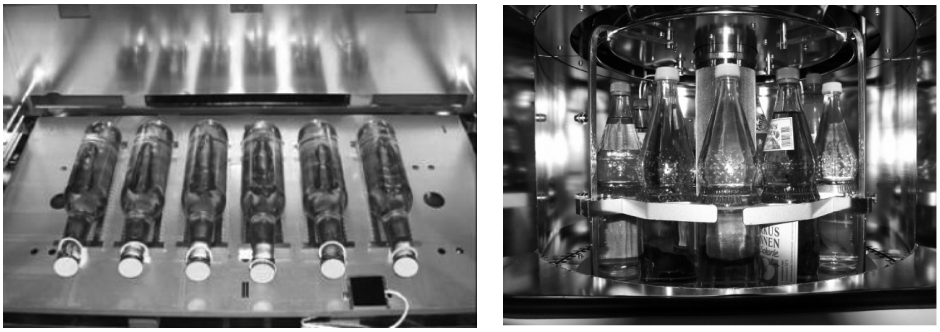

Figure 1: Xenon technology performs accelerated photostability tests under realistic conditions. Test chamber options include a flat bed (left, SUNTEST® XXL+) and a carousel (right, Xenotest® Beta+)

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ATLAS • SHOWS

2011

European Coatings Show
Mar 29–31
Nuremberg, Germany
Booth 9-256

Green Energy Expo
Apr 6–8
Daegu, Korea
Booth A944

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

Scandinavian Coatings Show 2011
Apr 13–14
Copenhagen, Denmark
Booth K

ChinaPlas 2011
May 17–20
Guangzhou, China
Hall 9.2
Booth 9.2F75

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

Latin American Coatings Show
Jun 13–14
Mexico City, Mexico
Booth 4

Korea Lab
Jun 14–17
Seoul, Korea

Shanghai Tex
Jun 14–17
Shanghai, China
Hall W4
Booth W4D05

PVSEC
Sept 5–8
Hamburg, Germany

Asia Pacific Coatings Show
Sept 14–15
Marina Bay Sands, Singapore
Booth G25

Automotive Testing Expo
Sept 14–16
Shanghai, China
Booth 4018

ITMA
Sept 22–29
Barcelona, Spain
Booth H2-B108

FAKUMA
Oct 18–22
Friedrichshafen, Germany

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

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

ATLAS • SPEAKS

European Coatings Congress
March 30, 2011 • Nuremberg, Germany
"System for Deterministic Acceleration of Laboratory Weathering"
Presenter: Dr. Artur Schönlein, Atlas Material Testing Technology GmbH

Institute of Environmental Science & Technology (IEST) ESTECH 2011 Conference
May 5, 2011 • Schaumburg, IL
"Determining Environmental Durability & Reliability: Beyond Passing the Qualification Test"
Presenter: Allen Zielnik, Atlas Material Testing Technology LLC

European Weathering Symposium
September 21–23 • Lisbon, Portugal

"Methodology for Developing Tailored Weathering Test Programs"
Presenter: Andreas Riedl, Atlas Material Testing Technology GmbH

"Parameters Characterizing the Grade of Fitting the Spectral Distribution of Solar Simulators to a 'Reference Sun'"
Presenters: Dr. Dieter Kockott, Technical Consultant and Dr. Artur Schöenlein, Atlas Material Testing Technology GmbH

Accelerated Photostability, from previous page

The decomposition of fruit flavor was observed in drinks filled into PET bottles [2]. In addition to oxygen permeation into the product, the permeation speed of carbon dioxide—for example, in the case of beer and non-alcoholic beverages—must also be examined. A reliable statement finally has to be made on whether the product is suitable for the intended container or whether greater packaging protection is required.

The actual temperatures that occur in the process chain also have to be considered among the stress factors. Real temperatures are largely responsible for the speed of the chemical decomposition reactions as a product moves from the manufacturer or producer to the shelf via various distribution routes, and finally to the consumer.

Packaging Materials

The plastics most frequently used for food and beverages are the thermoplastics polyethylene (HDPE), polypropylene (PP), and polyethylenterephthalate (PET). These are used to produce packaging and different bottle types by extrusion, blow molding, or injection molding processes. PET bottles are produced in different wall thicknesses, whereby types with very thin walls allow relatively strong oxygen permeation. However, processes now exist from which special barrier properties can be achieved—a cost factor that must be carefully weighed .

The individual spectral transmission property of materials in the wavelength range between 290 nm and 600 nm is important. PET is permeable for UVA radiation, for example. The same applies for transparent PE and PP foils or bottles.

The types of plastic listed above age under the influence of light and temperature depending on the type and degree of incorporation of light protectors and their sensitivity to radiation. The result is a change in the physical properties that can have a negative influence on the protective properties of the packaging. Equally important is the migration of connections from the packaging into the product and from the product into the packaging. Even if a packaging material does not exceed the permissible limits for pollutants when it is new, harmful migratable decomposition products may evolve in the course of photo-oxidative aging.

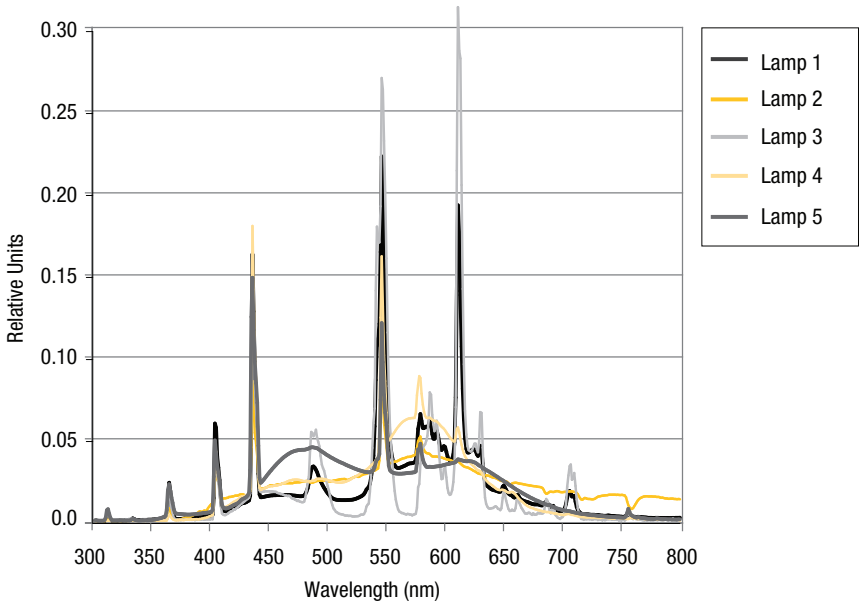


Figure 2: Typical spectra of fluorescent lamps which can affect products in the process chain in production, storage, and processing

Ambient Influences (Stress Factors)

The most important stress parameters in the food industry are radiation, oxygen, and temperature [1, 2]. At right is a closer look at the individual stress parameters in respect to their real effects in the process chain.

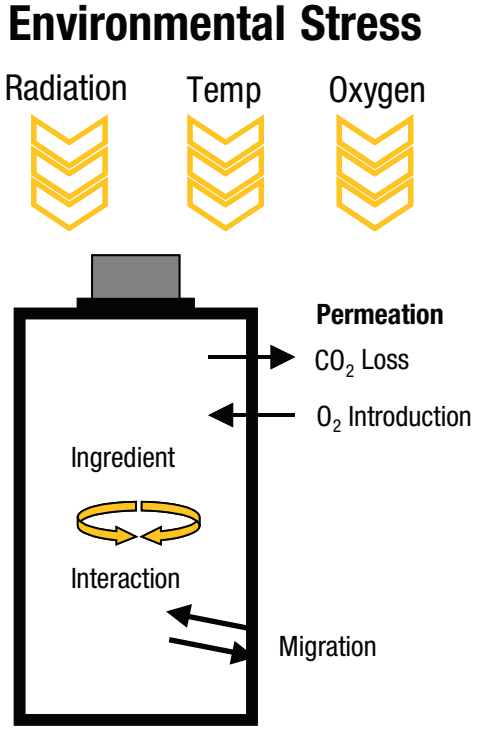
Stress Factor Radiation

The most important stress factor in the photochemically initiated change is the relevant radiation to which food or beverages are exposed. The entire process chain must be considered: production (processing) » storage » transport » storage » processing (consumption). The parts of the process chain that warrant special attention will certainly depend on the specific product and the protective measures used against the effects of radiation.

Conventional fluorescent lamps are normally used in production, storage, and processing (see Figure 2 for spectra). These lamps have a mercury low-pressure discharge (characteristic lines) with special coatings on the inside of the tubes. The irradiances in the wavelength range of 300 nm–800 nm at the location of the object depend on the distance between the object and the light source and are about 2–20 W/m². 100 W/m² may also be reached very close to the lamp. No relevant radiation occurs below 350 nm. The large number of spectra can be simulated fairly well by filtered xenon radiation, which blocks radiation below 360 nm (see Figure 3). The power of the xenon lamp must be reduced so that low irradiances can be achieved as well as possible, which is often possible only with additional neutral filters.

Food and beverage products may also be exposed to direct sunlight or sunlight behind window glass during transport and storage (see Figure 4 for spectra). For example, products are often stored outdoors in a yard, transported on an open truck, or stored in a room with windows or a skylight. In this case, the irradiance in the wavelength range from 300 nm–800 nm will vary between approximately 200 W/m² and 550 W/m². The maximum value is usually used in the radiation simulation. These solar spectra are best simulated with filtered xenon radiation as shown in Figure 4.

Fluorescent lamps (also known as low energy lamps), halogen lamps, and normal filament bulbs may play a role in



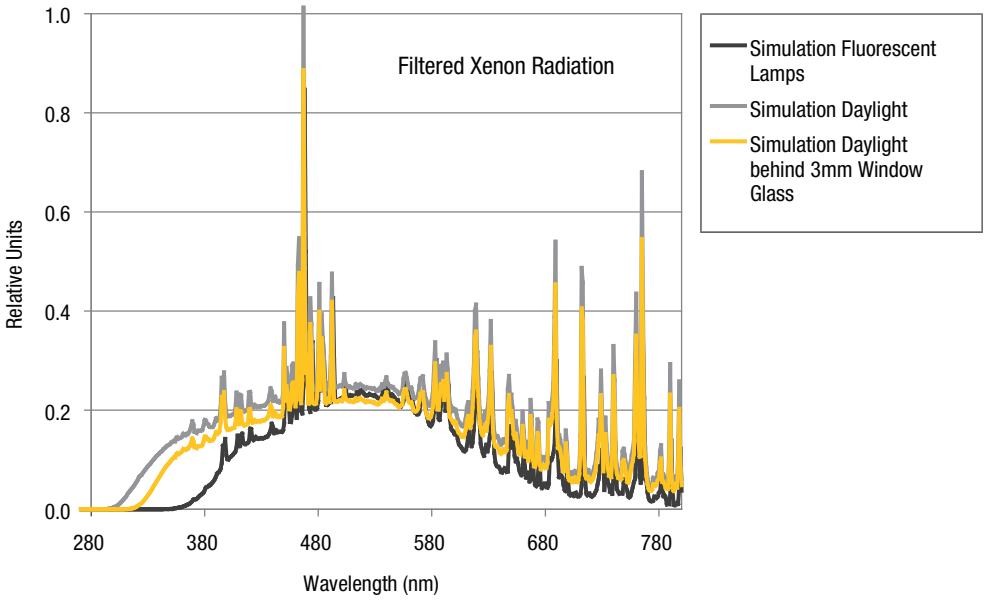


Figure 3: Filtered xenon radiation for simulation of different light sources in the process chain

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Accelerated Photostability, from previous page

processing before consumption, whereby the color temperature for the latter two types may fall approximately between 2000K and 3000K. The irradiances at the location of the object will also vary between 2 and 20 W/m² in these cases. The simulation can also be made with filtered xenon radiation (Simulation Fluorescent Lamps in Figure 3).

Stress Factor Temperature

The second factor for the photostability test is temperature. The speed of chemical reactions can be described by the Arrhenius equation: generally, the higher the temperature, the faster the chemical reaction. To what extent process temperatures need to be considered in manufacturing for realistic testing will have to be decided by the manufacturer depending on the product.

In most cases, cold aseptic filling has been implemented in Europe. Realistic temperatures in storage and processing are usually below 22°C, and during transport above 22°C. Where solar radiation is effective, temperatures quickly rise above 22°C because visible and infrared radiation can be absorbed by the product. In these cases, the product temperature will be well above the ambient temperature, perhaps as high as 30–35°C. Therefore, the temperatures to be assumed in realistic conditions will have to be examined in careful tests.

Test Method

The test method depends on the stress factors that need to be considered (see Table 1 for a summary). The question of whether the entire process chain or only parts of it are to be simulated must also be answered. If the entire process chain appears to be relevant, an already standardized test procedure could be applied, for example ISO 4892-2 [5]. However, the test temperatures, air, and black standard temperature will probably need

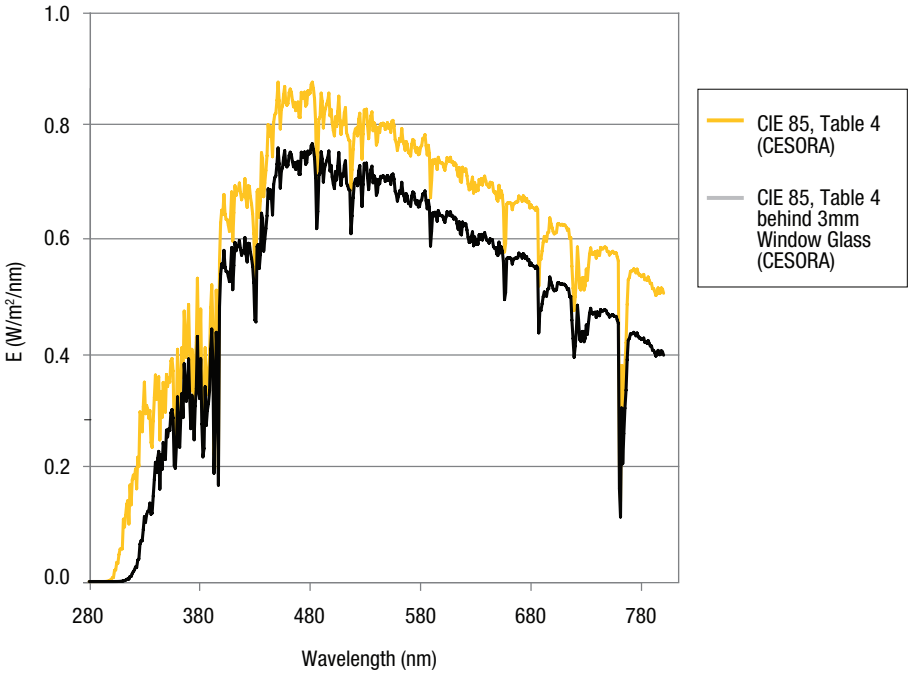


Figure 4: Solar spectrum according to CIE No. 85, Table 4 [3] calculated with CESORA [4]

to be adapted. The usual wet/dry cycles that simulate the effects of rain and humidity can be omitted. The choice of instrument technology, flat bed or rotating rack, is determined by user demand for accuracy and the specimen geometry.

If the influence of solar radiation is ruled out during storage and outdoor transport, the filtered xenon radiation shown in Figure 3 could be used to simulate fluorescent tubes as a light source ("Store Light" conditions). The air temperature should then be selected so that the product temperatures are not above 30°C, and the relative humidity should be controlled constantly.

Quick tests with good results in the Atlas SUNTEST® (flat bed technique) have been implemented recently with similar test setups—partly, as desired, with very high acceleration factors of >50 in comparison with the real time test [6]. The importance of the tests is uncontested and it will be exciting to watch how other test methods develop to ultimately confirm the large variety of food and beverages and their appropriate packaging with regard to photostability. ■

Table 1. Requirements for a realistic test method for testing the photostability of packed food and drinks

Process Chain	Production, Storage, Processing	Transport, Storage
Spectra	Fluorescent lamps Halogen lamps Filament bulbs	Solar spectrum directly and behind window glass
UV Limiting	Blocking below 360 nm	Blocking below 295 nm and below 310 nm
Simulation radiation	Filtered xenon radiation, neutral filter	Filtered xenon radiation
E (300–800 nm) in W/m²	20–100 nm	200–550 nm
Product Temperature in °C	20–25°C	30–35°C*
Relative Humidity in %	20–50%	20–50%

**Realistic product temperature must still be examined carefully*

References

[1] Plastverabeiter (55) Nr. 5, Jahrgang 2004

[2] Marco Schmidt, Gerhard Hübner, Joachim Tretzel, LVT Lebensmittel Industrie 7/8, 2002

[3] Publ. No. CIE85 1st Edition 1989, Technical Report "Solar Spectral Irradiance," 1989

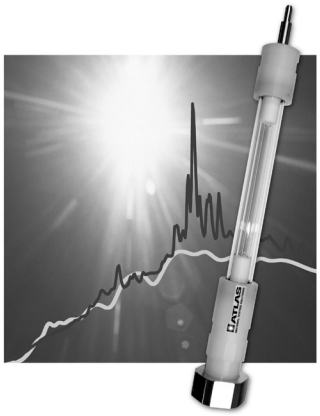
[4] A. Kühlen, B. Severon, "Kalkulation solarer Strahlungsparameter in der Materialprüfung," 33rd Annual Convention of GUS 2004

[5] ISO 4892-2: "Plastics - Methods of exposure to laboratory light sources - Part 2: Xenon arc sources" (Revision of ISO 4892-2: 1994), 2006

[6] Marco Schmidt, Gerhard Hübner, Joachim Tretzel, AFG Wirtschaft 4, 2002

Atlas® Sealed Lamp Improves Quality, Efficiency in Weather-Ometer® Testing

Revolutionary New Lamp Now Available Worldwide



Atlas is pleased to introduce a new one-piece lamp assembly for our 6.5kW xenon arc-compatible weathering instruments. The Sealed Lamp, which can be used with all versions of the Ci35/Ci65 and Ci4000 Weather-Ometers, offers unprecedented ease of use and quality benefits.

A typical lamp assembly is made up of multiple components, including the lamp, the upper and lower filter housings, the inner and outer filters, and a burner socket. These components are assembled by the operator before every use as well as every time a filter is replaced, introducing the risk of mishandling or damage to one or more of the fragile components. The new Sealed Lamp is sold as one component with no assembly or disassembly required.

Through continuous improvement efforts with our suppliers, we have resolved the need for intermediate filter changes. All combinations of the Sealed Lamp have a recommended service life of 2,000 hours. Less handling means improved repeatability and decreased failures due to assembly issues. Sealed Lamp users also get more uptime from their instruments, as tests do not need to be disrupted prior to the 2,000-hour lifetime of the lamp assembly.

Filter combinations are clearly marked on the outer packaging of the Sealed Lamp as well as on the lamp housing to reduce filter selection errors. As standards have moved from "hardware-based" to "performance-based," the critical requirement for the xenon-arc lamp is the spectral power distribution (SPD). Sealed Lamp filter combinations use filter types with the same transmittance specifications as traditional assemblies, thus the SPD will not change and will still meet the standards.

The Sealed Lamp is available in the following filter combinations:

Filter Combination	Typical Use
Right Light™/Quartz	Best match to natural sunlight; meets all specifications referencing the "Daylight" spectral power distribution
Right Light™/CIRA on Quartz	Best match to natural sunlight with ability to meet lower BPT/BST temperatures
Type S Boro/Type S Boro	Traditional filter combination that meets all specifications referencing "Daylight"
Quartz/Type S Boro	Filter combination that meets all specifications referencing "Extended UV"
Type S Boro/Soda Lime	Filter combination that meets all specifications referencing "Daylight Behind Window Glass"

For more information on the Sealed Lamp and how it can benefit your testing processes, please contact us at **info@atlas-mts.com.** ■

New Xenotest® Beta+ FD Improves Consumer Goods Testing

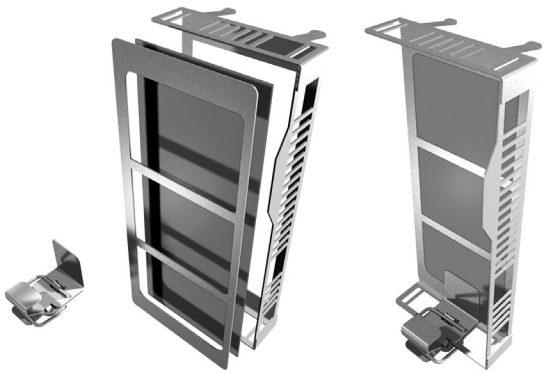
The success of today's consumer goods such as drinks, foodstuffs, personal care, and household products, is highly dependent upon their packaging. The use of transparent packaging is often preferred by manufacturers as it enables contents to easily be seen by consumers. Oftentimes, the ability to see attractive colors through transparent packaging plays a key role in influencing spontaneous purchasing decisions of certain products or brands. However, wherever there is light, there is a risk for photo-induced reactions that can impact colorants, vitamins, flavors, scents, or product homogeneity.

Atlas' new Xenotest Beta+ FD enables consumer goods manufacturers to test products realistically under accelerated conditions—typically with time-saving factors of >10 vs. real time.

The Beta+ FD offers two custom racks: a 1-tier bottle rack and a 2-tier soft-packaging rack. Both carry loads up to 20 kg and fit a wide variety of specimen shapes and sizes. Other features include the use of economical non-aging XENOCHROME filters which consistently deliver the right light, an efficient chiller that guarantees realistic test temperatures even at high acceleration levels, and easy programming and monitoring using new online features.

The Beta+ FD is an ideal instrument for helping you choose the right ingredients and packaging materials for your products, as well as supporting your service life claims. ■

New Specimen Holders Boost Weather-Ometer® Efficiency



Atlas has offered a variety of unique solutions for mounting different specimen types onto the rotating rack of Ci Series Weather-Ometers. Holders have been designed for products ranging from glass to solar panels to thick carpet—even construction helmets and nail polish bottles. However, the standard panel and sample holder with the spring clip back have not changed significantly for many years.

Answering the needs of our customers, Atlas has partnered with a well-established industrial design firm to develop revolutionary sample holders that will accommodate a wide range of specimen sizes and thicknesses, as well as reduce the rack-loading time by more than 50%. During the design process, Atlas conducted multiple interviews with customers who test a wide range of specimen types. The new state-of-the art designs incorporate their feedback as well as observations of sample loading best practices.

The new holders still allow the specimen surface to be precisely oriented at the appropriate distance from the lamp to maximize irradiance uniformity. However, loading samples is now safer and more ergonomic, and the holders allow for multiple thicknesses. One specific holder design can remain on the rack and simply be folded together—similar to vertical blinds—for easy access to the lamp and chamber, without the clutter of hard-to-stack holders. The holders can be used on any existing Ci Series instrument.

For more information on the new specimen holders and other custom rack capabilities, please contact us at **info@atlas-mts.com.** ■

EMMAQUA® Continues to Advance Work in PV Industry

In addition to traditional durability testing, Atlas' EMMAQUA® has played a role in testing important new technologies over the years. One of the most high-profile examples was solar panel performance testing in the 1960s for Skylab 1, the United States' first space station. In fact, Atlas® developed a one-of-a-kind SuperMAQ to test the durability of deployable modules for Skylab 1, which launched in 1973.

Today, EMMAQUA devices are advancing the solar energy industry through the testing of photovoltaic (PV) products. EMMAQUA tests the performance and durability of mini-modules; PV components such as back sheet, front (top) sheet, and barrier films; cell technologies; and BOS components such as polymeric framing, J-boxes, and cable/connectors for service lifetime.

The EMMAQUA provides accelerated weathering parameters that can help determine the following for each product:

Off-Grid Modules:

- Performace characteristics
- Durability testing

Back Sheet and Barrier Films:

- UV stability
- Adhesion (to EVA) properties
- Moisture barrier properties
- Electrical insulation integrity

Front (Top) Sheet:

- Same as back sheet plus transmittance properties

  Note: Failures mentioned for back sheet, front sheet, and barrier films can lead to long-term failures associated with transparent conductive oxide (TCO).

Cell Technologies (e.g., roll to roll and printed film):

- Performance characteristics
- Durability testing

BOS Components (framing, J-boxes, and cable/connectors):

- Cracking
- Warping
- Loss of functionality
- Aesthetic changes such as color

As the next generation of products come on line for the PV industry, testing that allows for faster time to market and provides data that can support service life prediction will be needed. Atlas has the experience and technology to support this demand.

Please contact Customer Support at **800-255-3738** or **jwonders@atlas-mts.com** for further information or a quote for EMMAQUA testing. ■

Atlas® Expands Jacksonville Site

Now Offering More Than Automotive Coating Testing

Responding to growing demand, Atlas Testing Services has acquired new land to expand and equip its Jacksonville, Florida exposure site for additional types of testing.

The site is situated near the Port of Jacksonville, which for years has been used by the automotive coatings industry as a benchmark for acid rain and industrial environment testing. The proximity to the ocean and the combination of salt, heavy industry, UV radiation, high temperature, and humidity make this an ideal outdoor exposure environment.

The expansion has enabled Atlas to extend its offerings beyond automotive coating testing. We can now accommodate the numerous requests we have received from PV and inverter manufacturers to test their products in a harsh marine/industrial environment.

Future offerings at the newly expanded site will include resistive load and grid tied testing as well as a variety of special projects.

To learn more or for a testing quote, please contact Customer Support at **800-255-3738** or **jwonders@atlas-mts.com.** ■

Atlas Approved as AAMA Component Lab

Good News for Architectural Manufacturers and Suppliers

Producers of windows, doors, and other architectural components will be glad to hear this news: The American Architectural Manufacturers Association (AAMA) has accredited Atlas as a Component Laboratory.

Atlas' laboratories in Phoenix, Arizona; Miami, Florida; and Chicago, Illinois have been audited and approved to perform outdoor and laboratory accelerated weathering testing per the following AAMA test methods:

- AAMA 303
- AAMA 305
- AAMA 308
- AAMA 613
- AAMA 614
- AAMA 615
- AAMA 623
- AAMA 624
- AAMA 625
- AAMA 2603
- AAMA 2604
- AAMA 2605

Atlas has also been approved by AAMA to provide testing on ASTM standards.

Founded in 1936, AAMA is a material-neutral organization that brings together window, door, skylight, curtain wall, and storefront manufacturers, suppliers, and test labs to represent both individual and shared concerns as they pertain to the areas of product certification, standards development, education and training, legislative regulations, and building and energy codes.

Please contact Customer Support at **800-255-3738** or **jwonders@atlas-mts.com** for more information and a complete list of AAMA approved test methods. ■

Utilizing Fractional Factorial Screening to Improve Processes and Performance

By Henry K. Hardcastle, Atlas R & D

Fractional factorial screening experiments are widely used by manufacturing process engineers to screen out the "trivial many" variables from the "important few" variables. A small confirmation experiment (typically two to four additional trials) follows a screening experiment to confirm the results. Once the important variables are identified, the engineer can focus his or her process improvement efforts on those variables, creating greater speed and efficiency.

This method for characterizing and improving manufacturing processes also applies to improving weathering performance. Weathering processes are multi-variable, complex, and highly material dependent. Weathering investigators can use fractional factorial screening experiments to screen out the trivial many variables from the important few variables. After the most important variables for a particular material are identified, a small confirmation experiment always confirms the results.

Once the weathering investigator identifies the important variables, he or she can affect the material formulation, processing variables, and in-service environments to improve weatherability. Equally important, the investigator can optimize variables identified as "trivial" to reduce manufacturing costs! The materials weathering research efforts can then be focused in an efficient manner on these variables that the process indicates are important.

Fractional factorial experimental design answers questions such as:

- Of the nine components in this vinyl formulation, which have the biggest effect on yellowing after five years of Florida exposure, what is each component's order and magnitude of importance on yellowing, and which components can be optimized for cost without sacrificing weathering performance?
- Of the 10 major production line variables the line operator can control, on which should I establish control charting to improve quality of weatherability, and approximately what mean and tolerances should I begin with?
- Of the major weathering agents this product will be exposed to (temperature, moisture, irradiance, pollution, abrasion, solvents, biologicals, cycling, etc.) which require research efforts to improve customer satisfaction for weathering performance?
- For the major weathering failure modes I have identified in the FMEA, what are the risks associated with each?
- For my material, which of the many weathering variables can be increased in order to accelerate weathering for test development?
- For this vendor's candidate material, which environmental variables have the biggest effect on the system's weatherability?

Application of fractional factorial screening and confirmation designs is relatively simple to implement but somewhat complicated to describe thoroughly. This article describes a straightforward 10-step procedure leaving the "why" to more esoteric and involved statistical publications. The reader should become familiar with theoretical underpinnings of these designs. The reader should also practice application of these designs—beginning with inexpensive, simple, non-critical investigations—to gain experience with these techniques. The reader should not become dissuaded by complex, restrictive theoretical considerations that often become barriers to beginning these types of empirical applications in experimentation.

Atlas® has used the following 10-step procedure effectively in screening experiments for investigating both manufacturing processes and weathering processes. It may need modification for specific applications and is not exhaustive in detail, but it will serve to identify the major components and sequence for most uses. This 10-step procedure was used to perform the case study described in this article.

10-Step Procedure:

1. Write a simple, concise research question.
2. List the variables to be investigated. Check that these variables are truly independent.
3. Select high and low settings (if a two-level experiment) or high, middle, low (if three-level experiment), etc. Check to make sure settings are not so far apart as to cause catastrophic failure if all variables are set high or low simultaneously. Check to make sure variable settings are far enough apart that they can be described as "significantly different."
4. Select an appropriate fractional factorial orthogonal array for the number of variables under investigation—L^{16}, L^{8}, L^{64}, etc. Use published arrays. Assign specific variables to specific columns in the design with regard to known interactions and alias concerns of the fractional factorial. Table 1 shows an L^{16} fractional factorial array.
5. Perform trials according to the fractional factorial array schedule. Include multiple replicates within each trial as necessary as they relate to trial and gauge variability. Control the input variables to described levels for each trial in the array. Block other variables not designed into the experiment.
6. Measure the desired output variables from each trial.
7. Perform a quality control check on all work. Recheck that all trials were performed in accordance with the array. Recheck all measurement values. Recheck all data entry. A simple error in variable settings, data entry, measurements, etc., may void the orthogonal basis, resulting in erroneous decisions.
8. Analyze the output using samples collected, effects graphs, and ANOVA techniques.
9. Determine the significance and importance of each variable's effect on the output using the analysis.
10. Confirm the conclusions. Run a minimum of two confirmation trials—one with the variables indicated as significant and important set to high levels and another with significant and important variables set to low levels. Set insignificant variables to cost-effective settings for both of these trials. Check that the results of these two confirmation trials confirm predictions of the screening experiment in both direction and magnitude of differences. Additional confirmation trials can be run for further understanding of main effects, interactions, and aliases.

After the experiments in the fractional factorial array were performed, the data in Figure 2 was obtained on randomly selected polystyrene reference chips. ■

	Temperature	Irradiance	Day Time Spray		Pretreat Soak-Freeze-Thaw Night Time Soak						Pretreat Abrasion		Pretreat Oven	Pretreat Chemical	Pretreat Carbon Arc
Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Trial No.															
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2
3	1	1	1	2	2	2	2	1	1	1	1	2	2	2	2
4	1	1	1	2	2	2	2	2	2	2	2	1	1	1	1
5	1	2	2	1	1	2	2	1	1	2	2	1	1	2	2
6	1	2	2	1	1	2	2	2	2	1	1	2	2	1	1
7	1	2	2	2	2	1	1	1	1	2	2	2	2	1	1
8	1	2	2	2	2	1	1	2	2	1	1	1	1	2	2
9	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
10	2	1	2	1	2	1	2	2	1	2	1	2	1	2	1
11	2	1	2	2	1	2	1	1	2	1	2	2	1	2	1
12	2	1	2	2	1	2	1	2	1	2	1	1	2	1	2
13	2	2	1	1	2	2	1	1	2	2	1	1	2	2	1
14	2	2	1	1	2	2	1	2	1	1	2	2	1	1	2
15	2	2	1	2	1	1	2	1	2	2	1	2	1	1	2
16	2	2	1	2	1	1	2	2	1	1	2	1	2	2	1
	A	B	A B	C	A C	B C	A B	D	A D	B D	A B D	C D	A C D	B C D	A B C D

1 = Variable at Low Setting 2 = Variable at High Setting

Figure 1: An L^{16} fractional factorial array

Trial Number	Delta Yellowness Index of Replicate "A"	Delta Yellowness Index of Replicate "B"
T01	12.92	13.26
T02	23.19	22.79
T03	11.95	12.34
T04	24.80	26.00
T05	18.62	17.99
T06	25.54	26.38
T07	20.05	19.18
T08	22.45	20.56
T09	15.53	14.78
T10	24.58	24.63
T11	16.48	17.73
T12	16.43	17.84
T13	17.93	17.63
T14	26.6	26.57
T15	13.13	12.86
T16	29.04	29.71

Figure 2: Data obtained on polystyrene reference chips

Atlas®/UL® Conference in China Spotlights Solar Energy

PV Durability Asia, staged by Atlas Material Testing Technology and Underwriters Laboratories in 2010, drew more than 170 people from 11 countries to Shanghai, China.

The two-day event at the Crowne Plaza Century Park Shanghai hotel featured more than a dozen solar industry experts on a variety of topics related to reliability, durability, and certification testing. Presenters focused on the latest developments, research, and innovative approaches in environmental durability, performance, and service life of materials, components, and PV modules.

The conference aimed to help module manufacturers as well as those in the supply chain gain a better understanding of the issues they need to address for better quality and efficiency. ■

The conference speakers gathered for a photo: *(Standing, left to right) Mr. Liang Ji, Mr. Allen Zielnik, Mr. Johnson Zhang (host), Dr. Jacob Zhang, Mr. Hung-Sen Wu, Mr. Michael Köhl, Mr. Kurt Scott (host) (Seated, left to right) Dr. Xiaohong Gu, Dr. Sarah Kurtz, Dr. Nicolas Bogdanksi, Dr. Murray Cameron, Mr. William Gambogi, Mr. Johnson Hsu (Not pictured) Mr. Wei Feng, Mr. Liwang Jiang, Dr. Crystal Vanderpan*

Atlas Material Testing Technology Acquired by AMETEK®

In November 2010, Atlas joined AMETEK as part of AMETEK Measurement & Calibration Technologies (M&CT), a division of AMETEK's Electronic Instruments Group (EIG)—a recognized leader in advanced monitoring, testing, calibrating, and display instruments.

Atlas' products and services are used by its customers in both new product development and quality assurance applications in order to assess product performance, reliability, and compliance with industry standards and specifications. These instruments test the effects of weathering by simulating exposure to sunlight, temperature, moisture, and corrosion.

"Atlas is an excellent addition to AMETEK. It is the clear global leader in this niche market and enjoys an excellent reputation with its customers and international standards setting organizations," said Frank S. Hermance, AMETEK Chairman and Chief Executive Officer. "Atlas provides us with another growth platform in the highly attractive materials testing equipment market and broadens our presence in the fast-growing photovoltaic testing market."

AMETEK M&CT designs, manufactures, and distributes material test instruments for a wide range of applications such as tensile, hardness and force testing; instruments for high accuracy temperature, pressure and signal calibration; and a suite of sensors for pressure, level, position, and temperature.

AMETEK M&CT serves a global and diverse customer base with manufacturing and engineering operations in the United States, Denmark, and the United Kingdom, and a worldwide network of sales and service locations. For further information, visit www.ametek.com. ■

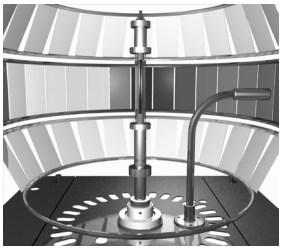
Atlas® Launches China-Automotive Landing Page

The Chinese automobile industry has been in rapid development for the past 20 years. Currently, there are over 100 automobile ventures in China. Counting local manufacturers and joint ventures with global automobile manufacturers, China now produces more cars than any other nation.

Atlas has been there from the beginning, offering materials testing solutions for the Chinese automotive market, including accelerated weathering instruments, partnerships for outdoor testing sites, and consultative services for test method development. In support of these activities, we are pleased to announce the launch of the new Atlas Chinese Automotive Landing Page at www.china-automotive.atlas-mts.com.

This is just the latest in a series of new landing pages Atlas has recently launched. Please visit us at our textile (www.textiles.atlas-mts.com) and solar (www.solar.atlas-mts.com) pages, and look for more industry- and product-specific sites to be developed in the near future. ■

www.china-automotive.atlas-mts.com



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ATLAS MATERIAL TESTING TECHNOLOGY LLC
4114 North Ravenswood Avenue
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Connect with Atlas at the European Coatings Show in Germany! See page 3 for upcoming shows where you can find us.

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Atlas Material 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

KHS Germany Office
Gerauer Straße 56a
64546 Mörfelden-Walldorf, Germany
Phone: +49-6105-91286
Fax: +49-6105-912880

Atlas Weathering Services Group
South Florida Test Service
16100 SW 216th Street
Miami, Florida 33170, 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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