ATLAS®
MATERIAL TESTING SOLUTIONS

ACCELERATING YOUR EXPERTISE

HIGH IRRADIANCE WEATHERING TESTING

HIGH
HIGH
IRRADIANCE

The Track to Faster Results

AMETEK®
MEASUREMENT & CALIBRATION
TECHNOLOGIES

THE BENEFITS OF HIGH IRRADIANCE TESTING

Why Perform High Irradiance Testing?

High irradiance testing has two key advantages, resulting in several potential benefits.

Shorter test times for an equivalent radiant exposure

- Larger sample turnover
- Lower testing costs
- Faster time to market

Longer outdoor equivalent (in terms of radiant exposure) for a given test time

- Earlier failure detection
- Reduced risk of extrapolation
- Important for long-living durable products

What is High Irradiance Testing?

- Testing at full spectrum solar irradiance levels that are multiples (e.g. 2X, 3X, 5X) of standard reference daylight.
- International CIE, IEC, and ISO standards define 1 sun = 0.51 W/(m²nm) at 340 nm, or 60 W/m² between 300 and 400 nm or 1000 W/m² in the range 300 to 3000 nm, all of which are approximately equivalent, and representing maximum reference daylight.
- It is required that the light source is a good spectral match for the sun in both the UV and visible wavelength region, and does not change significantly when testing at different irradiance levels.

Does It Work?

Selected examples for applications where high irradiance testing has been successfully applied:

APPLICATION	IRRADIANCE (UV)	INSTRUMENT / TECHNOLOGY	REFERENCE
Textiles	up to 3-sun	Xenotest® Alpha	1), 2)
Automotive Interior Materials	up to 3-sun	Xenotest® Alpha	1), 3)
Automotive Coatings	up to 3-sun acceleration factor to South Florida up to 63	Xenotest® Alpha Ultra Accelerated Weathering System (UAWS)	1) 4)
Polymers	up to 2-sun up to 4-sun	Ci35, Ci4000, Ci5000 Weather-Ometer® EMMAQUA®	5) 6) 7)
Solar Materials/ CPV Encapsulants	up to 32-sun	Modified Ci4000 Weather-Ometer®	8)

1) Artur Schönlein et al. GUS-Jahrestagung, Stutensee (2013).
2) Jochen-Wilfried Stuck, DEK Fachtagung „Echtheitsprüfungen in der Textilindustrie", Gelnhausen (1996).
3) Jörg Boxhammer, Polymer Testing 20 (2001), 719 ff.
4) Henry K. Hardcastle et al. SunSpots Volume 40, Issue 88 (2010).
5) James Pickett et al. Polym. Degrad. Stab. 93 (2008), 1597 ff.
6) Kurt Scott et al. Service Life Prediction of Polymeric Materials (2009), 83 ff.
7) Henry K. Hardcastle et al. 2nd European Weathering Symposium, Gothenburg (2005).
8) Michael Kempe et al. SunSpots Volume 39, Issue 85 (2009).

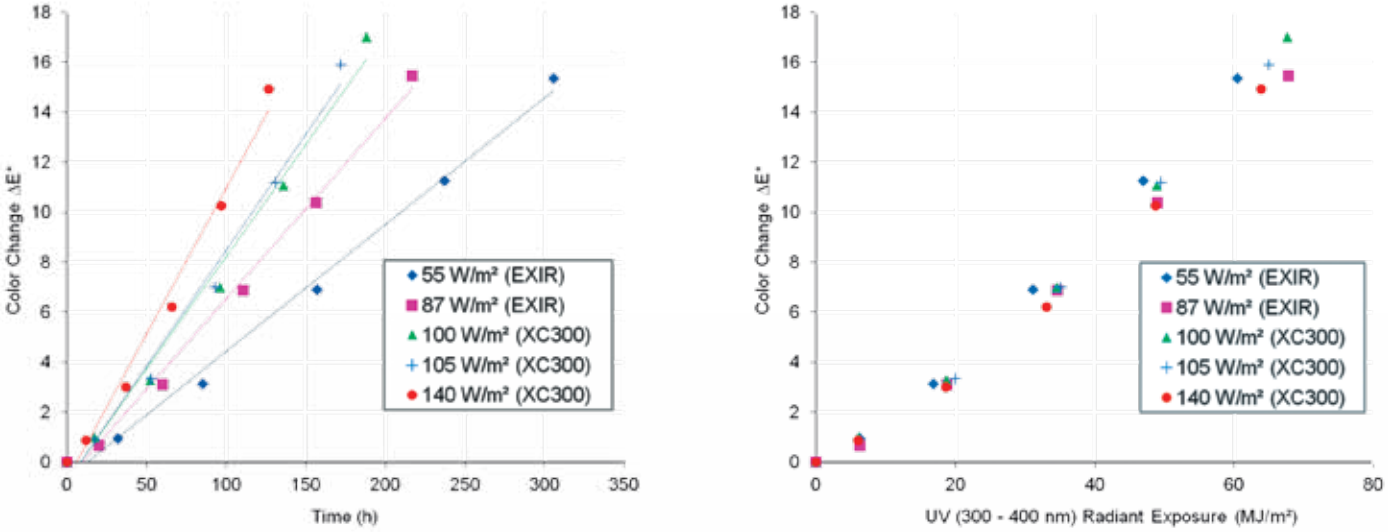
Validation

Does testing at higher irradiances and shorter times produce the same results as does testing at lower irradiances for longer times?

- Yes, if the photochemical degradation reactions obey the reciprocity principle.
- Reciprocity means that the same results are obtained from an equivalent radiant exposure, regardless of the irradiance used to obtain it.
- Determining reciprocity requires a correlation study at different irradiance levels.
- Reciprocity has to be validated for each material and each application.

Example of High Irradiance Correlation Study

This example demonstrates that high irradiance testing can lead to shortening the test time by a factor of almost three, without changing the ageing behavior of the material (in this case color change of the ORWET reference material).



ORWET Orange coatings exposed in a Xenotest® Alpha at different irradiance levels according to ISO 4892-2 without rain cycle. Color difference as function of time and radiant exposure (XC300 = XENOCHROME® 300 daylight filter, EXIR = daylight extended infrared filter for better temperature control at low irradiance levels).

Challenges

- In addition to irradiance, weathering involves other factors such as heat and moisture.
- Some materials obey reciprocity, others do not. Therefore, correlation must be validated. The consequence of not doing so results often in an underestimation of the degradation and an overestimation of the service life.
- Isolating the effects of radiant exposure from those of heat and moisture is complex. The simplest approach is to maintain them constant while varying the irradiance.

HIGH IRRADIANCE XENON WEATHERING INSTRUMENTS

Superior air-cooled and water-cooled xenon-arc instruments enable testing at up to 3-sun irradiance levels. Rotating-rack technology optimizes uniformity of irradiance and temperature at the sample plane. These instruments are the ideal solutions for testing various materials including plastics, coatings, building materials, automotive parts, paints, and textiles.

Today, only companies that can quickly introduce superior products to the market are able to survive a globally competitive environment. Accelerated and accurate weathering testing is a critical component in product development for any material expected to withstand the damaging effects of sunlight, temperature, and moisture. Weathering testing by high irradiance can accelerate your product development program and increase the competitive advantage.

Xenotest® Alpha+

Xenotest® Alpha+ is a compact stand-alone rotating rack xenon instrument. Irradiance and temperature are controlled on-rack on specimen level. Its special lamp design and low-infrared filter systems enable high irradiance testing up to 3-sun levels, while simultaneously optimizing test temperature range.

- Irradiance range 40 - 180 W/m^2 (300 - 400 nm)
- Excellent simulation of natural indoor/outdoor sunlight
- Automatic, simultaneous control of irradiance, temperature and relative humidity
- Specimen spray
- Rotating rack for 10 specimens (135 mm x 45 mm exposure size)

Ci5000 Weather-Ometer® HE

The Ci5000 Weather-Ometer® HE combines high capacity with a rotating rack mounting configuration, which optimizes uniformity of air flow, relative humidity, temperature, and irradiance on sample surfaces. This instrument is specifically designed to perform high-irradiance testing in order to reduce testing time and cost.

- Irradiance range 40 - 200 W/m^2 (300 - 400 nm)
- Excellent simulation of natural indoor/outdoor sunlight
- Automatic, simultaneous control of irradiance, temperature and relative humidity
- Rotating rack for 68 specimens (135 mm x 55 mm exposure size)

HIGH IRRADIANCE SOLAR ENVIRONMENTAL CHAMBERS

SEC 3 SUN

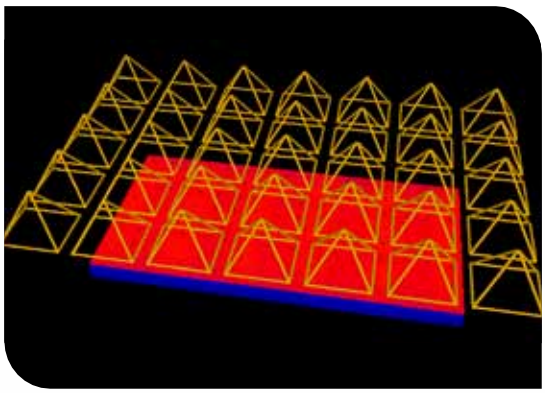
The SEC 3 SUN test chamber is designed for high irradiance solar simulation testing. It combines superior temperature and humidity control with adjustable solar irradiation range from 1- to 3-sun level.

- Irradiance range 1000 to 3000 W/m² (300 - 3000 nm)
- 1.6 x 3.0 m² exposure area
- 14 m³ chamber size
- 9 x 4000 W metal halide light source
- -20°C to +100°C ±1°C temperature operating range with light
- 20 – 80 % RH ± 5% humidity operating range with light

SEC 10 SUN

The SEC 10 SUN instrument is capable of very high irradiance solar simulation testing. Moving four MHG luminaries up and down to precise linear and angular positions, an irradiance level of up to 10 suns can be achieved, while offering full climatic control features.

- Irradiance range up to 10,000 W/m² (300 - 3000 nm)
- 40 x 40 cm² exposure area
- 600 l chamber size
- 4 x 4000 W metal halide light source
- 0°C to +90°C ±1°C temperature operating range with light



CUSTOM HIGH IRRADIANCE LIGHTING SOLUTIONS

Some applications require specific technical conditions, e.g. testing of large specimens or complex 3-dimensional objects. In such cases, Atlas Custom Systems is able to design customized high irradiance testing solutions based on state-of-the-art metal halide lamp technology. Lighting system concepts can be designed for almost every purpose. In the first step, the system is designed and simulated with a special computer program, then optimized, and finally engineered, manufactured, and installed.

As an example, the figure on the upper left shows a computer-simulated 35-lamp metal halide daylight-spectrum lighting array, providing an irradiance of 5000 W/m² (300 - 3000 nm) on an 8 m² area, with a uniformity of +/- 5 %. The figure on the lower left shows an actual large-scale solar simulation system.

HIGH IRRADIANCE OUTDOOR TESTING

Altazimuth Tracking Fresnel Reflectors: EMMA®/EMMAQUA®

EMMAQUA® employs 10 highly-reflective mirrors and a sun-tracking system to concentrate sunlight onto test specimens. The result is natural weathering testing in a fraction of the time, with excellent correlation to end-use conditions.

DSET Laboratories pioneered the development of the EMMAQUA® outdoor accelerated tests in the late 1950's. The method employs Fresnel reflecting solar concentrator systems that use ten flat mirrors to uniformly focus natural sunlight onto specimens mounted in the target plane. High quality, first-surface mirrors provide an irradiance of approximately eight "total suns" (300 - 3000 nm) and four to five suns in the UV.

Features

- Microprocessor control
- Programmable cycles
- Dual axis tracking
- Thermal shocks
- Night time dew
- Patented temperature control

Ultra Accelerated Weathering System (UAWS)

Advancing beyond Atlas' moderately accelerated EMMAQUA® technology, the UAWS tracks the sun while concentrating reflected sunlight on test specimens mounted in a target area. The patented mirror system has very high reflectance in the UV and near-visible wavelength ranges, while attenuating reflectance in the longer wavelength-visible and IR portions of the solar spectrum.

This advanced technology allows for very high concentrations of UV energy without excessive heating of test samples. The system is able to deliver approximately 63 years of South Florida UV radiant exposure in a single year.

ULTRA ACCELERATED UA-EMMA

UA-EMMA is the latest advancement in EMMAQUA testing. It uses both EMMA® and UAWS technologies to accelerate the weathering process. This device uses the current EMMA® platform with the patented mirror technology of UAWS and meets the requirements of ASTM G90. The very high concentration of UV irradiance allows for double the amount of UV radiant exposure achieved on conventional EMMA®. Also, the lack of excessive heating of the specimens leads to an optimized real-world correlation.

HIGH IRRADIANCE TESTING STANDARDS

Xenon Weathering Standards

The table below lists selected standards for laboratory xenon weathering, which allow use of high irradiance up to 3-sun levels. For details, refer to the individual standards. Test methods which are proprietary to individual companies and which also specify high irradiance testing are not listed here.

XENON WEATHERING STANDARD	SCOPE	ALLOWED IRRADIANCE LEVELS UP TO 3 SUN (i.e. 180 W/m2 (UV) for daylight filters)	COUNTRY
ISO 4892-2	Plastics	Daylight and window glass	International
ISO 11341	Coatings	Daylight and window glass	International
ISO 105-B06	Automotive interior	Window glass, set of exp. cond. no. 6	International
ISO 105-B10	Textiles	Daylight	International
ASTM G155	Non-metallic materials	Daylight (cycle 9); window glass (cycle 10)	USA
ASTM D6695	Coatings	Daylight (cycle 1)	USA
VDA 75202	Automotive interior	Window glass, option A	Germany
JASO M346	Automotive interior	Window glass	Japan
JASO M351	Automotive exterior	Daylight	Japan

EMMAQUA® Weathering Standards

The table below lists selected standards for EMMAQUA® exposure. For details, refer to the individual standards. Test methods which are proprietary to individual companies and which also specify Fresnel-based exposure methods are not listed here.

EMMAQUA® STANDARD	SCOPE	COUNTRY
ISO 877-3	Plastics	International
ASTM D3841	Glass-fiber reinforced polyester	USA
ASTM D4141	Coatings	USA
ASTM D4364	Plastics	USA
ASTM D5722	Coated hardboard	USA
ASTM E1596	PV modules	USA
ASTM G90	Non-metallic materials	USA
SAE J576	Optical automotive plastics	USA
SAE J1961	Automotive exterior	USA
SAE-AMS-T-22085	Preservation sealing tape	USA
JIS Z2381	General	Japan

Global Support, Weathering Exposure Sites & Laboratories

■ Corporate Offices

■ Chicago, Illinois ■ Élancourt, France ■ Leicester, United Kingdom
Linsengericht, Germany ■ Bangelore, India ■ São Paulo, Brazil ■ Shanghai, China

● Outdoor Exposure Sites & Laboratories

Prescott, Arizona ● Phoenix, Arizona ● Chicago, Illinois ● Medina, Ohio
Keys, Florida ● Jacksonville, Florida Miami, ● Florida Alberta, Michigan ● Ottawa, Canada
Leicester, United Kingdom ● Hoek van Holland, The Netherlands ● Sanary, France ● Mörfelden-Walldorf, Germany
Novorossiysk, Russia ● Chennai, India ● Singapore (Changi Airport)
Hainan, China ● Guangzhou, China ● Seosan, Korea ● Miyakojima, Okinawa ● Choshi, Japan
Melbourne, Australia ● Townsville, Australia

▲ Local Sales & Service Support

To contact your local Atlas Sales representative please visit http://atlasmtt.com/representative

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ATLAS
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