QUV & Q-SUN

A Comparison of Two Effective Approaches to Accelerated Weathering & Light Stability Testing

The Need For Testing

Light, high temperature, and moisture can cause damage to coatings, plastics, inks, and other organic materials. The resulting damage can be seen in many different types of polymer degradation. These include changes in physical properties such as cracking, peeling, embrittlement, and loss of tensile strength; as well as visual properties such as gloss loss, fading, yellowing, color fade, and color change.

This paper will explore the ways in which these two testers differ, focusing on light spectra and method of moisture simulation. Both testers deliver elevated temperatures to specimens and control by Black Panel temperature; most Q-SUN xenon arc testers can also simultaneously control chamber air temperature. The inherent strengths and weaknesses of each tester will be discussed, including purchase price and operating costs. Guidelines will be given for which tester is generally recommended for a particular material or application.

Two Different Approaches

QUV® accelerated weathering testers and Q-SUN® xenon test chambers are both affordable and easy-to-use apparatuses for laboratory weathering tests. The QUV tester meets the requirements of ASTM G154, ISO 4892-3, and others; the Q-SUN tester meets ASTM G155, ISO 4892-2, and others.

This paper will explore the ways in which these two testers differ, including light spectra and method of moisture simulation. The inherent strengths and weaknesses of each tester will be discussed, including purchase price and operating costs. Guidelines will be given for which tester is generally recommended for a particular material or application.

The QUV tester is the world's most widely used weathering tester. It is based on the concept that, for durable materials, short-wave UV causes most weathering damage.

Q-SUN Xenon Test Chambers reproduce the full spectrum of sunlight, including ultraviolet, visible light and infrared.

Q-LAB

Historical Perspective

While it is clear that weatherability and light stability are important for many products, the best way to test is sometimes controversial. Various methods have been used over the years. Most researchers now use natural exposure testing, a fluorescent UV apparatus, and/or a xenon arc apparatus.

Natural exposure testing has many advantages: it is realistic, inexpensive, and easy to perform. However, many manufacturers do not have several years to wait and see if a “new and improved” product formulation is truly an improvement.

The Q-SUN (xenon arc) and QUV (fluorescent UV) are the most commonly-used accelerated weathering testers. The two testers are based on completely different approaches, but both deliver light, heat, and water to test specimens. The xenon test chamber reproduces the entire spectrum of sunlight, including ultraviolet (UV), visible light, and infrared (IR). A xenon arc lamp with appropriate optical filters essentially simulates sunlight itself from 295-800 nm (see Figure 1 below).

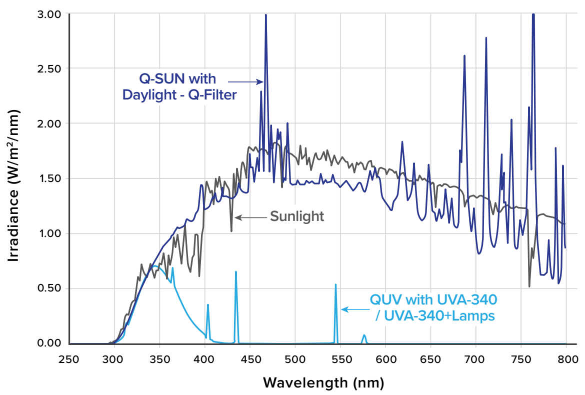

Figure 1- Q-SUN and QUV Testers vs Sunlight

Sunlight compared to the QUV and the Q-SUN testers. The QUV weathering tester provides the best available simulation of sunlight in the short-wave UV region from 365 nm down to the solar cut-on. However, it is deficient in longer wavelengths. The Q-SUN chamber reproduces sunlight's full spectrum, which is critical for testing many products that are sensitive to long-wave UV, visible light, and infrared.

The sunlight spectrum consists of various wavelengths, which determine a material's mode of degradation in an outdoor environment.

The QUV Accelerated Weathering Tester, on the other hand, does not attempt to reproduce sunlight, just the damaging effects of sunlight that can occur from 300-400 nm (Figure 1). It is based on the concept that, for durable materials exposed outdoors, short-wave UV causes the most weathering damage.

Which is the better way to test? There is no simple answer to this question. Depending on your application, either approach can be quite effective. Your choice of tester should depend on the product or material you are testing, the end-use application, the degradation mode with which you are concerned, and your budgetary restrictions.

To understand the differences between Q-SUN and QUV testers, it is necessary to first look more closely at why materials degrade.

Forces of Weathering: Sunlight, Heat, and Water

Most weathering damage is caused by three factors: sunlight, heat, and water. Any one of these factors may cause deterioration. Together, they often work synergistically to cause more damage than any one factor alone.

Sunlight Materials differ significantly in their response to various wavelengths of light (spectral sensitivity). For durable materials, like most coatings and plastics, short-wave UV is the cause of most polymer degradation. However, for less durable materials, such as some pigments and dyes, longer wave UV and even visible light can cause significant damage.

Heat The destructive effects of light exposure are typically accelerated when temperature is increased. Although temperature does not affect the primary photochemical reaction, it does affect secondary reactions involving the by-products of the primary photon/electron collision. A laboratory weathering test must provide accurate control of temperature, and it usually should provide a means to elevate the temperature to produce acceleration.

Products exposed outdoors often remain wet 8-12 hours each day. Dew, not rain, is responsible for most of the damage caused by outdoor wetness.

Water plays a role in many different physical and chemical failure modes.

Both sunlight through window glass and bright indoor lighting can degrade some materials.

Water Dew, rain, and high humidity are the main causes of moisture damage. Our research shows that objects stay wet outdoors for a surprisingly long amount of time each day (8-12 hours daily, on average). Studies have shown that condensation, in the form of dew, is responsible for most outdoor wetness. Dew is more damaging than rain because it remains on the material for a long time, allowing significant moisture absorption.

Of course, rain can also be very damaging to some materials. Rain can cause thermal shock, a phenomenon that occurs, for example, when the heat that builds up in an automobile coating over the course of a hot summer day is rapidly dissipated by a sudden shower. Mechanical erosion is caused by the scrubbing action of rain. This can also degrade materials such as wood coatings. Because rain wears away the surface, fresh material is continually exposed to the damaging effects of sunlight.

The major effect of humidity on indoor materials is often the physical stress caused by the material trying to maintain moisture equilibrium with its surroundings. The greater the range of humidity the material is exposed to, the greater the overall stress. Although indoor products, such as textiles and inks, may only be exposed to moisture in the form of humidity, it can also be an important factor in the degradation of outdoor materials. Outdoors, the ambient relative humidity (RH) will affect the speed at which a wet material dries.

QUV and Q-SUN testers each reproduce sunlight, heat, and water in different ways.

QUV Weathering Tester

Sunlight Simulation The QUV is designed to reproduce the damaging effects of sunlight on durable materials using fluorescent UV lamps. These lamps are electrically similar to the common cool white lamps used in general lighting, but are designed to produce mainly UV rather than visible light or infrared.

There are different types of lamps with different spectra. The type of lamp should best resemble the light conditions found in your end use environment.

- **UVA-340** lamps provide the best available simulation of sunlight in the critical short-wave UV region. The spectral irradiance (also called spectral power distribution, or SPD) of the UVA-340 matches sunlight very closely from the solar cut-on to about 360 nm (Figure 2).
- **UVB-313EL** lamps (Figure 3) are also commonly used in the QUV. They typically cause faster degradation than UVA lamps, but their short wavelength output below the solar cut-on can cause unrealistic results.
- **UVB-340+ and UVB-313EL+ "Plus"** lamps are available for QUV testers to perform high-irradiance testing.
- **UVA-351** lamps simulate the UV portion of sunlight through window glass.
- **UVC-254** lamps are used to simulate exposures to UVC light typically used in ultraviolet germicidal irradiance (UVGI) applications.
- **Cool White** lamps simulate indoor office environments.
- **TUV-421** lamps deliver an extended spectrum including longer-wavelength UV and visible light.

In just a few days or weeks, the QUV can reproduce the damage that occurs over months or years outdoors.

Control of Irradiance Control of irradiance (light intensity) is necessary to achieve accurate and reproducible test results. Most QUV models are equipped with the SOLAR EYE® Irradiance Controller.[1] This precision light control system allows the user to choose the level of irradiance. With the SOLAR EYE controller's feedback loop system, the irradiance is continuously and automatically monitored and precisely maintained. The SOLAR EYE automatically compensates for lamp aging or any other variability by adjusting power to the lamps. Figure 4 shows how the irradiance control system works.

The QUV Accelerated Weathering Tester uses fluorescent UV lamps to reproduce the damaging effects of sunlight on durable materials.

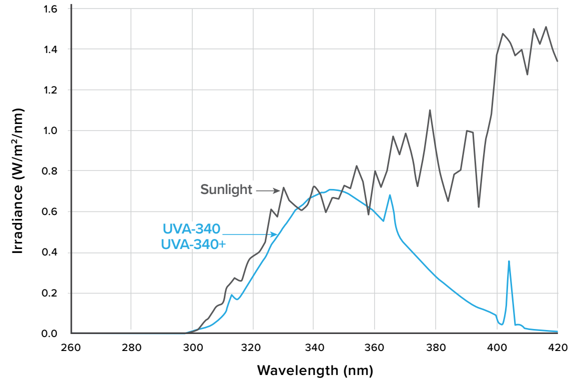

Figure 2 - Noon Summer Sunlight vs UVA-340 Irradiance

UVA-340 lamps provide the best available simulation of sunlight in the critical short-wave UV region.

[1] The SOLAR EYE Irradiance Controller is used in models QUV/se, QUV/spray, and QUV/uvc. The SOLAR EYE controller allows better reproducibility and repeatability than the manual irradiance control procedure used for the model QUV/basic. The SOLAR EYE controller also reduces maintenance because the lamps do not have to be rotated and replacement of lamps is less frequent.

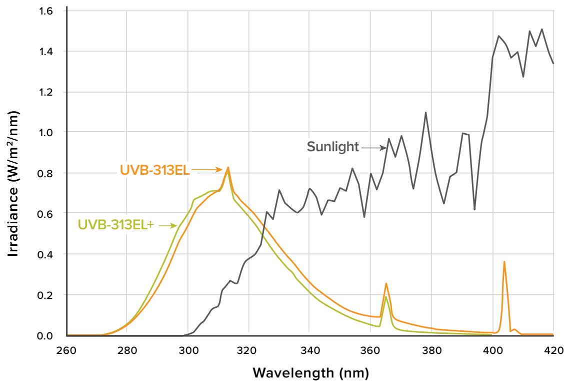

Figure 3 - Sunlight and UVB-313 lamps

UVB lamps utilize short-wave UV for maximum acceleration and are most useful for testing very durable materials, or for quality control.

QUV SOLAR EYE Irradiance Controller

With the SOLAR EYE controller's automatic feedback loop system, the irradiance is continuously monitored and precisely maintained.

How it Works

Step 1: The operator selects the desired irradiance level. The level selected is the "set point."

Step 2: During the UV cycle, built-in sensors measure the light from each pair of lamps and transmit this data to the controller.

Step 3: Both the set point and the actual irradiance are continuously displayed for each pair of lamps.

Step 4: The controller compares the measured irradiance to the set point.

Step 5: The controller instructs the power supply to adjust the voltage to the lamps to maintain the set point.

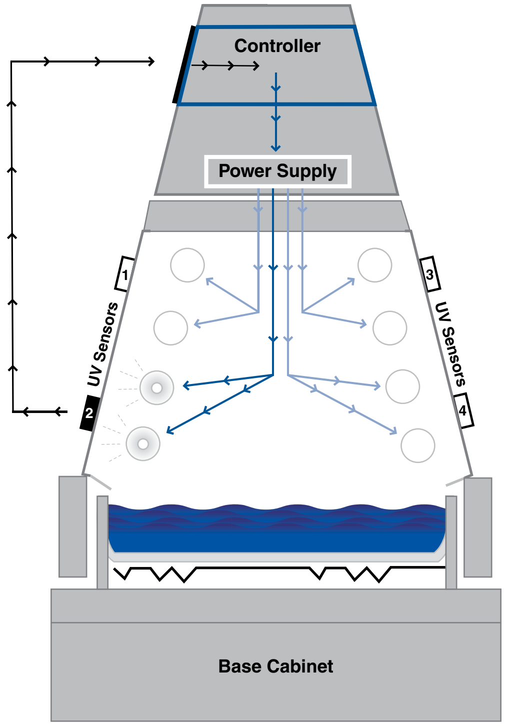

Figure 4 - QUV Weathering Tester Irradiance Control

The QUV tester with the SOLAR EYE Irradiance Controller provides better lamp life and better reproducibility and repeatability than testers with manual irradiance control. Maintenance is simplified because lamps do not have to be rotated.

In Figure 4, notice that the SOLAR EYE Irradiance Sensor #2 is reporting data back to the Controller and the Controller is supplying information back to the sensor. During actual use, all sensors will be activated.

QUV Weathering Tester cont.

In the QUV weathering tester, control of irradiance is simplified by the inherent spectral stability of its fluorescent UV lamps. All light sources decline in output as they age. However, unlike most other lamp types, fluorescent lamps experience no shift in spectral irradiance over time. This enhances the reproducibility of test results and is a major advantage of testing with QUV apparatuses.

Figure 5 shows a comparison between a new lamp and a used (aged) lamp in a QUV model with irradiance control. The difference in output between the new and aged lamps is nearly indistinguishable. The SOLAR EYE Irradiance Controller has maintained the light intensity. In addition, due to the inherent spectral stability of fluorescent lamps, the spectral power distribution remains virtually unchanged. The same data is graphed as a *percentage difference* in Figure 6.

In addition to its other advantages, the patented SOLAR EYE system allows for easy calibration, NIST traceability, and ISO 17025 compliance.

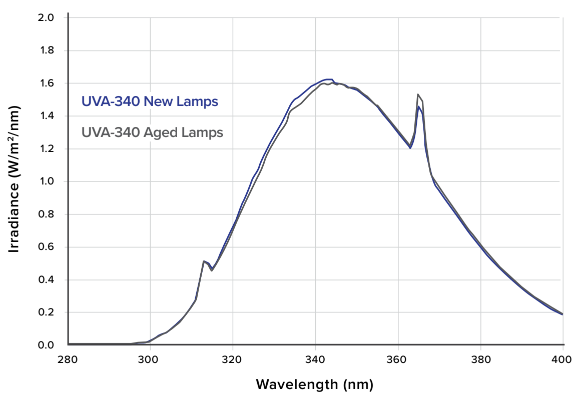

Figure 5 - QUV Tester Lamp Aging

While all light sources decline in output as they age, the QUV tester's SOLAR EYE control system keeps the irradiance at a consistent level by adjusting the power to the lamps.

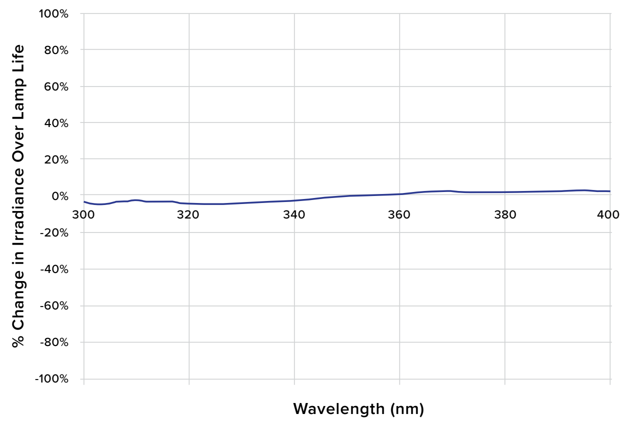

Figure 6 - % Difference in Aged QUV Tester Lamps

The QUV tester's spectrum changes very little because of the inherent spectral stability of fluorescent lamps.

With the patented AUTOCAL® system and the UC10, calibration takes only minutes, is NIST traceable, and complies with ISO 17025 requirements.

UC10 smart sensors should be replaced or recalibrated annually by Q-Lab's A2LA-accredited, ISO 17025-compliant lab.

Moisture Simulation A major benefit of using the QUV accelerated weathering tester is that it allows the most realistic simulation of outdoor moisture attack. Outdoors, materials are frequently wet up to 12 hours a day. Because most of this moisture is the result of dew, the QUV machine uses a unique condensation mechanism to reproduce outdoor moisture.

During the QUV tester's condensation cycle, a water reservoir in the bottom of the test chamber is heated to produce vapor. The hot vapor maintains the chamber environment at 100% relative humidity, at an elevated temperature. The QUV unit is designed so that the test specimens actually form the sidewalls of the chamber. Thus, the reverse side of the specimens is exposed to ambient room air. Room air cooling causes the test surface to drop a few degrees below the vapor temperature. This temperature difference causes liquid water to continually condense on the test surface throughout the condensation cycle. (Figure 7).

The resulting condensate is naturally distilled, pure water. This pure water increases the reproducibility of test results, precludes water-spotting problems, and simplifies the QUV tester's installation and operation.

Optional water spray is particularly useful for roofing materials and coatings used on wood.

Because materials experience such long wet times outdoors, the typical QUV unit's condensation cycle is at least 4 hours. Furthermore, the condensation is conducted at an elevated temperature (typically 50˚C). This greatly accelerates moisture attack. The QUV tester's long, hot condensation cycle reproduces the outdoor moisture phenomenon far better than other methods such as water spray, immersion, or high humidity.

In addition to the standard condensation mechanism, the QUV tester can also be fitted with a water spray system to simulate other damaging end-use conditions, such as thermal shock or mechanical erosion. The user can program the QUV weathering tester to produce cycles of wetness alternating with UV, a situation that closely correlates to natural weathering.

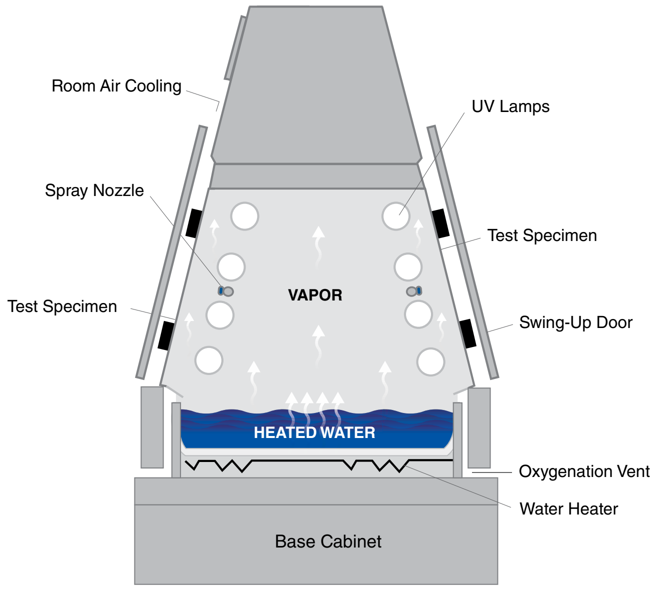

Figure 7 - QUV Accelerated Weathering Tester Cross Section During Condensation Period

The QUV tester simulates outdoor moisture attack through a realistic, hot condensation system.

Q-SUN Xenon Test Chamber

Sunlight Simulation Xenon arc testers are considered the best simulation of full-spectrum sunlight because they produce UV, visible light, and infrared energy. The Q-SUN product line includes two rotating rack testers: the Xe-2 and the large-capacity Xe-8; and two flat array testers: the versatile Xe-3 and tabletop Xe-1 model (see Figures 8-11).

Xenon arc spectra are influenced by two factors: optical filter systems and lamp stability. Xenon arc lamps must be filtered to reduce unwanted radiation. Several types of glass filters are available to achieve various spectra. The filters used depend on the material tested and the end-use application. Different filter types allow for varying amounts of short-wave UV, which can significantly affect the speed and type of degradation. There are three commonly used filter categories, as defined by ASTM G155: Daylight, Window Glass, and Extended UV. Figures 12-14 show the spectra that these filters produce. There are several types of Daylight, Window Glass, and Extended UV filters. A complete explanation is available in the *Choice of Filters* technical bulletin, LX-5060. Also included is a close-up look at these spectra in the critical short-wave UV region from about 295-400 nm.

Q-SUN Xenon Test Chambers reproduce full-spectrum sunlight, which is filtered to eliminate unwanted wavelengths.

Q-SUN low-cost, air-cooled xenon arc lamps and optical filters are easy to install and replace.

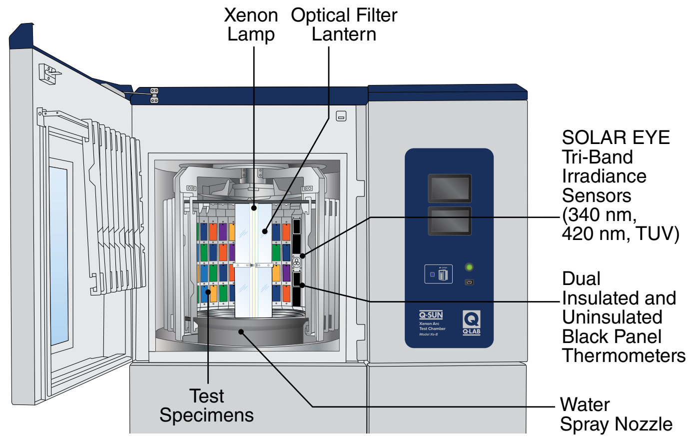

Figure 8 - Q-SUN Xe-8

The Q-SUN Xe-8 is a large-capacity rotating rack xenon arc tester with four lamps

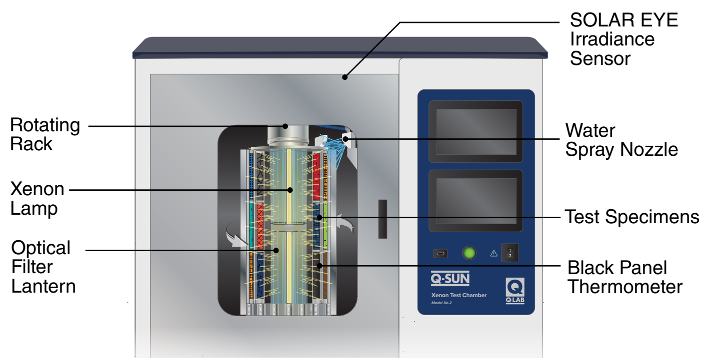

Figure 9 - Q-SUN Xe-2

The Q-SUN Xe-2 rotating rack xenon arc test chamber uses a single lamp

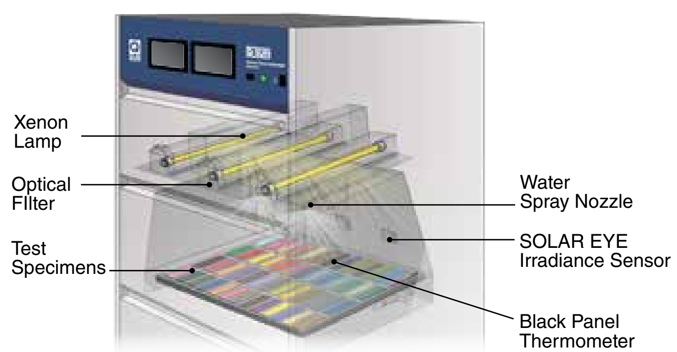

Figure 10 - Q-SUN Xe-3

The Q-SUN Xe-3 is a full-size test chamber that has three xenon arc lamps

Figure 11 - Q-SUN Xe-1

The Q-SUN Xe-1 tabletop model uses one xenon arc lamp

Q-SUN Flat Array Xenon Test Chambers are available in both full size and table top models to accommodate your test specimens

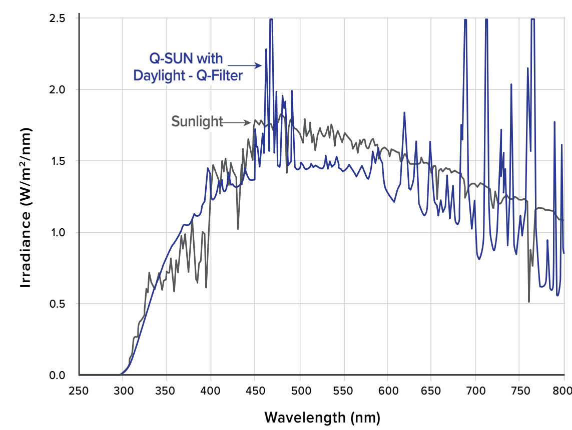

Figure 12a - Daylight Filters and Sunlight

Full Spectrum

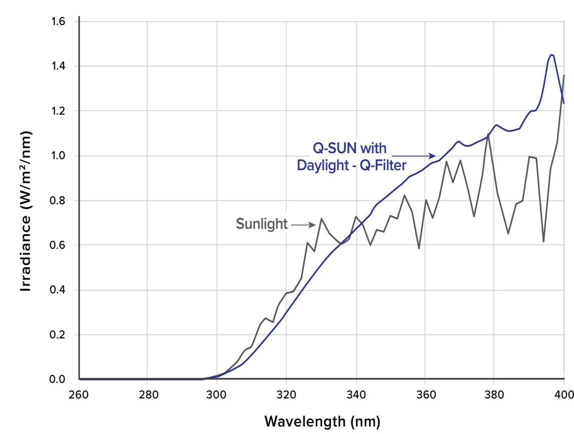

Figure 12b - Daylight Filters and Sunlight

UV Region

Sunlight compared to the Q-SUN chamber with Daylight Filters. Daylight Filters are commonly used for simulations of outdoor exposure. They are an excellent reproduction of the full spectrum of natural sunlight, and are recommended for studies that value correlation to natural weathering.

Q-SUN Rotating Rack Xenon testers are also available in two sizes

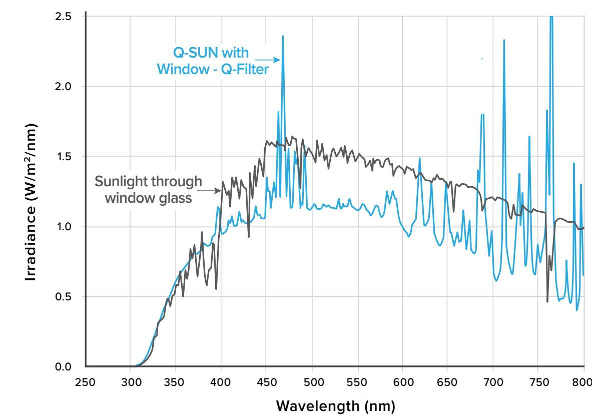

Figure 13a - Window Glass Filters and Sunlight Through Glass

Full Spectrum

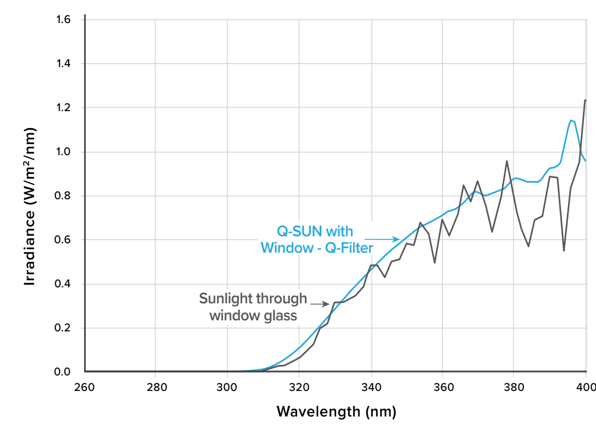

Figure 13b - Window Glass Filters and Sunlight Through Glass

UV Region

Sunlight through glass compared to the Q-SUN tester with Window Glass Filters. Designed for indoor light stability testing, these filters provide a spectrum that is essentially identical to sunlight through window glass. The spectrum is also useful for simulating general lighting conditions because it encompasses the same damaging wavelengths.

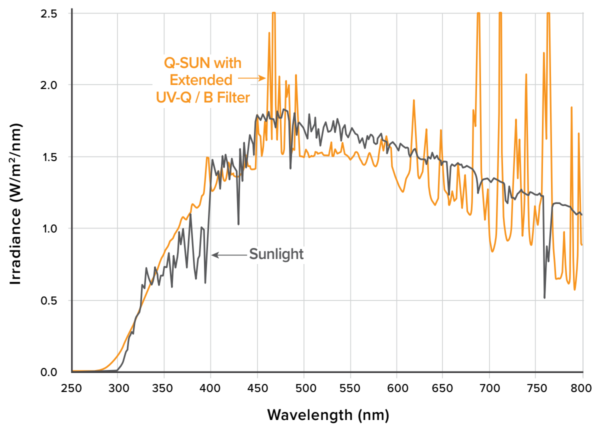

Figure 14a - Extended UV Filters and Sunlight

Full Spectrum

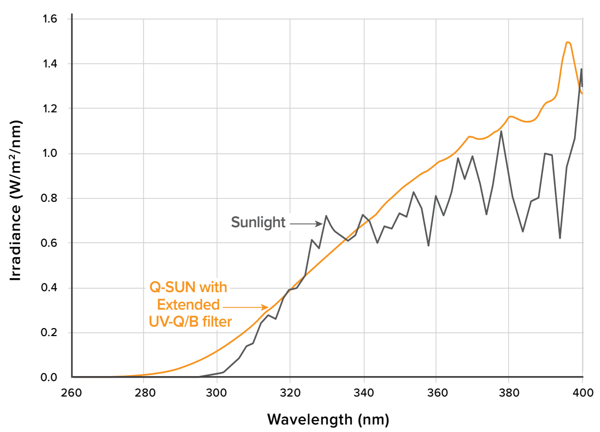

Figure 14b - Extended UV Filters and Sunlight

UV Region

Sunlight compared to the Q-SUN xenon test chamber with Extended UV Filters. Certain automotive test methods require a spectrum that includes short-wave UV below the sunlight cutoff of 295 nm. Extended UV-Q/B Filters produce that spectrum. Although they allow an unrealistic amount of short-wave UV, these filters often provide faster results. Extended UV-Quartz filters effectively offer no filtering of the xenon arc spectrum, resulting in even more very short-wave UV light transmission that may be suitable for specialty aerospace and extraterrestrial applications.

Q-SUN Xenon Test Chamber cont.

Control of Irradiance Xenon arc testers are equipped with an irradiance control system. The Q-SUN tester's SOLAR EYE system is illustrated in Figure 15.

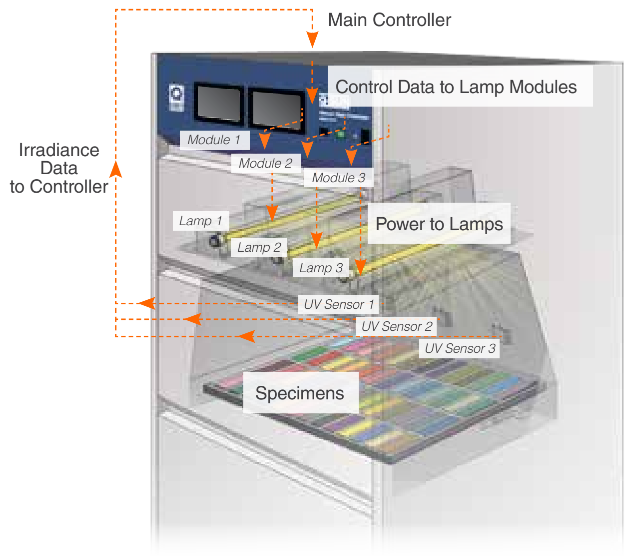

Figure 15 - Q-SUN Xenon Test Chamber's SOLAR EYE Irradiance Control

How it Works

Step 1: The operator selects the desired irradiance level (set point). The Q-SUN irradiance display shows the "Set" and "Actual" irradiance of the lamp(s).

Step 2: The built-in SOLAR EYE irradiance sensor measures the light intensity and transmits it to the controller.

Step 3: The SOLAR EYE Irradiance Controller compares the "Actual" measured irradiance to the "Set" irradiance point.

Step 4: The SOLAR EYE Controller adjusts power to the lamp to maintain the set point irradiance.

Control of irradiance is especially important in a xenon tester, because xenon lamps are inherently less spectrally stable than fluorescent UV lamps. All Q-SUN testers are equipped with the patented, precision SOLAR EYE system. It automatically monitors and maintains the user's desired, programmed light intensity. Irradiance is monitored and controlled at 340 nm, 420 nm or TUV (300-400 nm).

Figure 16 illustrates the difference in spectrum between a new lamp and a lamp that has been operated for 3000 hours. It is clear that, over time, the irradiance intensity increases significantly in the longer wavelengths. However, when this same data is graphed as a percentage of change over time (Figure 17), it also becomes apparent that there is a corresponding decrease in the shortwave UV portion of the spectrum. However, the SOLAR EYE system does an excellent job at maintaining a consistent spectrum in the wavelength region of interest - 340 nm in this case.

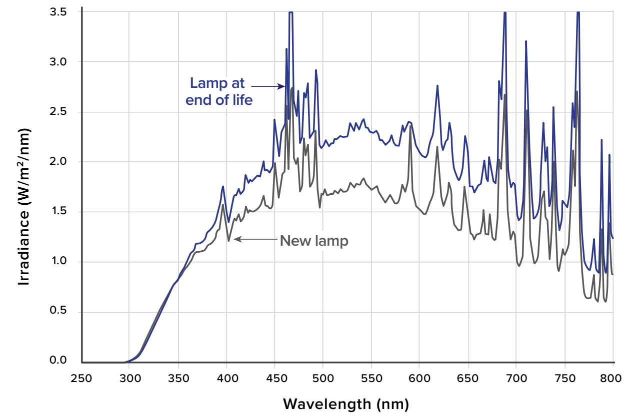

Figure 16 - Xenon Lamps Spectral Output at 3000 Hours vs 0 Hours

After 3000 hours of use, xenon lamps change in spectral output, but the controller accurately maintains the spectrum at the control point.

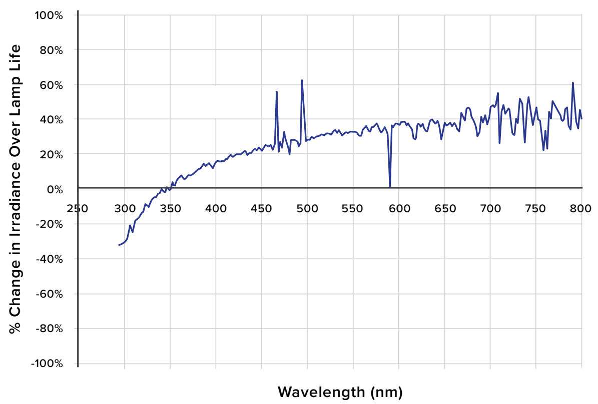

Figure 17 - Xenon Lamps Spectral Output Over Time

As xenon lamps age, the spectral output shifts in both the short and long wavelengths of light.

This change in spectrum due to aging is an inherent characteristic of xenon arc lamps. However, there are ways to compensate for this. For instance, lamps can be replaced on a more frequent basis to minimize the effects of lamp aging. Also, by selecting an irradiance control point in the wavelength region of interest (340 nm, 420 nm, or 300-400 nm TUV), the amount of spectral change in a particular area can be minimized.

Despite the spectral shift from lamp aging, the xenon arc lamp has proven to be a reliable and realistic light source for weatherability and light stability testing.

In addition to its other advantages, the patented SOLAR EYE system allows for easy calibration, NIST traceability, and ISO compliance. It is encouraged to replace the UC20 calibration radiometers or they can be returned annually to Q-Lab's A2LA accredited lab for ISO 17025-compliant recalibration.

UC20 irradiance smart sensors and UC1 Handheld Display

Moisture Simulation Most xenon arc testers simulate the effects of moisture through water spray and/or humidity control systems. The limitation of water spray is that when relatively cold water is sprayed onto a relatively hot test specimen, the specimen cools down. This may slow down the rate of degradation. However, water spray is very useful for simulating thermal shock and erosion. In a xenon arc weathering tester, highly purified DI water is necessary to prevent water spotting.

Because humidity can affect the degradation type and rate of certain indoor products, such as many textiles and inks, control of relative humidity is recommended in many test specifications. Q-SUN Xe-2, Xe-3, and Xe-8 models have relative humidity control as a standard feature.

Programmable water spray periods can operate during either the light or dark periods.

Practical Considerations

Of course, no matter how good the performance of a piece of testing equipment is, it will not be practical if it is too expensive to purchase or operate. That is why purchase price, operating costs, and maintenance are critical issues and must be weighed against the benefits of owning a tester.

Purchase Price In general, the QUV Accelerated Weathering Tester is more economical than a xenon arc chamber. For example, the Q-SUN Xenon Test Chamber may cost three times as much as the QUV tester, depending on the features and size of the unit.[3]

Capacity Although the QUV/se model and the Q-SUN Xe-1 have a similar purchase price, they are very different in specimen capacity. The QUV has almost five times the specimen capacity of the Q-SUN Xe-1, and nearly 150% the capacity of the Q-SUN Xe-3. The Q-SUN Xe-8 boasts up to a 164 specimen capacity.

Specimen Mounting The QUV's standard test sample holders were designed for flat, relatively thin panels or specimens, although special specimen holders are available for a wide variety of 3D parts. Q-SUN flat array testers (Xe-1 and Xe-3) allow more flexibility in terms of the types of specimens that can be mounted. It accommodates 3D parts, test tubes and petri dishes, as well as flat panels.

Specimen mounting shown inside the Q-SUN Xe-2 model.

Specimen mounting and repositioning are simplified with specially-designed specimen holders in the Q-SUN Xe-8 model.

A QUV tester can accomodate 48 specimens.

Q-SUN Xe-1 and Xe-3 testers allow for versatile specimen mounting, including 3D parts and flat panels.

Ease of Use and Maintenance Both QUV and Q-SUN testers are easy to use and easy to maintain. Both testers are completely automated and can operate continuously, 24 hours per day, 7 days per week. Automatic shutdown timers allow tests to finish at any time that is specified. Calibration is also simple with the patented AUTOCAL system and calibration radiometers. Calibration is accomplished with a button press as the instrument automatically measures the lamp output and automatically adjusts the on-board control system accordingly. Test specimens and lamps all stay in place during the procedure.

Q-SUN xenon arc test chambers[2] and QUV accelerated weathering testers are both designed to be user-friendly. Lamp loading and specimen mounting are simplified by the front and top access of Q-SUN testers, and the double-sided access of QUV testers.

Q-SUN and QUV user interfaces are designed to be functional, highly reliable, and easy to use. The controller allows for complete self-diagnostic error checking and can be programmed in 17 languages, including Japanese, Chinese, and Korean.

Maintenance Costs Both QUV and Q-SUN machines offer relatively low maintenance costs. Q-SUN chamber annual lamp costs are significantly higher for QUV testers. Q-SUN tester electrical costs are also higher. Additionally, ordinary tap water can be used in the QUV testers without water spray, whereas the Q-SUN chamber requires pure, deionized water. In summary, a QUV weathering tester's annual operating costs are considerably less than those of a Q-SUN xenon test chamber.[3]

2 Competitive xenon arc models that feature water-cooled lamps generally require significantly more maintenance than Q-SUN Xenon Test Chambers. Calibration is more time consuming and cumbersome. Specimens are more difficult to mount, and the lamp/filter housing is much more complicated.

3 Q-SUN tester maintenance costs, while higher than those of the QUV tester, are far less than those of competitive xenon arc testers. Q-SUN chamber lamps are considerably more economical than most xenon arc lamps, and Q-SUN optical filters never need replacement.

Q-SUN chamber lamp replacement is almost effortless: just open the hinged door, disconnect and slide out the lamp.

Irradiance-controlled QUV models do not require lamp rotation. However, when the time comes to replace a lamp, double sided access makes the job easy to perform.

Technical Summary: The Right Tester for the Right Job

Deciding on the right weathering or light stability device can be confusing, especially if you are new to this type of testing. Which is the better for you? Below are some general guidelines. As with any generalization, there may be exceptions to the rule.

QUV

The QUV tester is better in the short-wave UV.

QUV accelerated weathering testers with UVA-340 lamps provides the best available simulation of sunlight in the critical short-wave UV region. Short-wave UV typically causes polymer degradation in the form of gloss loss, strength loss, yellowing, cracking, crazing, and embrittlement. In addition, the QUV tester's fluorescent UV lamps are spectrally stable, with very little change in the SPD over time. This enhances reproducibility and repeatability. For more information, refer to the *Choice of Lamps* technical bulletin, LU-8160. TUV-421 lamps give QUV testers the ability to reproduce some color fade effects caused by longer wavelengths.

The QUV tester is better at simulating the effects of outdoor moisture.

The QUV instrument's condensation system (100% RH) is more aggressive and realistic than the Q-SUN's water spray and humidity control systems. Deeply penetrating moisture may cause damage such as blistering in paints.

Q-SUN

The Q-SUN chamber is a better match with sunlight in the long-wave UV and visible spectrum.

Long-wave UV and even visible light can cause polymer degradation represented by color fade and color change for pigments and dyes. Where color change is the issue, the Q-SUN chamber is usually recommended.

The Q-SUN tester, using Window Glass filters, is also generally better than the QUV tester for testing indoor products. For more information, refer to the *Choice of Filters* technical bulletin, LX-5060.

The Q-SUN chamber is better for controlling humidity.

The Q-SUN chamber can control relative humidity. This can be an important feature for humidity-sensitive materials like many textiles and inks. High humidity can cause color shift and uneven dye concentrations, and can affect time of wetness.

A Two-Tiered Approach.
Because many researchers are concerned with all modes of polymer degradation, a two-tier testing program is often the best approach. Many manufacturers get cost-effective results by using the QUV Accelerated Weathering Tester for physical property degradation and a Q-SUN Xenon Test Chamber for color degradation.

OUR GLOBAL NETWORK

We are committed to provide world-class technical, sales, and repair support in each of the 120 countries in which we operate. Visit **Q-Lab.com/support** for contact information specific to your location and inquiry type.

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