TECHNICAL BULLETIN LL-9035

Climate Data Enhances Interpretation of Weathering Results

Sunlight, moisture, and high temperatures are the primary forces which cause the deterioration known as "weathering." The fast material degradation that occurs at our benchmark exposure sites in Florida and Arizona is a result of the synergistic effect of these forces on test specimens.

The weather monitoring systems at Q-Lab's Arizona and Florida sites are essentially identical. Each system consists of numerous sensors which collect climate data and feed it to a computer-controlled Keithley 500 Data Acquisition System. All measurements are taken in the immediate specimen exposure area to precisely characterize actual test conditions.

Figure 1 - Total Ultraviolet Radiometers (TUVRs) are mounted at the common exposure angles (e.g. 45° South, 5° South, Latitude Angle) to measure UV radiation from the sun.

Sophisticated analysis of material degradation data and the interaction between the various climate factors can best be made by comparing data which has been collected simultaneously. This may be particularly true for computer modeling or for correlation studies. Q-Lab's weather monitoring and Data Acquisition Systems (DAS) continuously monitors and records all of the key variables.

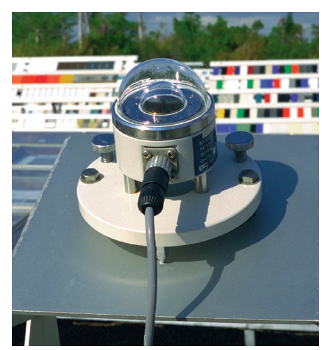

Figure 2 - Total Hemispherical Pyranometers can measure total sunlight energy directly and under glass.

Sunlight Energy

A series of sensors are mounted at the main static exposure angles (5° South, 45° South, Latitude Angle, etc.). These are used to quantify the radiant dosage received by test specimens in the conventional weathering exposures. Sunlight energy is measured both directly and through window-glass.

Total Solar Energy. We use Eppley and Eko brand Total Hemispherical Pyranometers to measure total hemispherical radiation. The Eppley is a Precision Spectral Pyranometer (PSP). The Eko NP62 is a double-dome sensor with thermopile. Both of these pyranometers measure the entire range of the sun's spectrum, including ultraviolet, visible and infrared radiation. These precision pyranometers have a 180 degree field of view so that they measure direct, diffuse and reflected sunlight.

Ultraviolet Solar Energy. We use Eppley Total Ultraviolet Radiometer (TUVR) sensors to measure UV energy at various exposure angles. These TUVRs use a photoelectric cell, protected behind a quartz filter. The white cover on the top of the instrument is a Teflon diffuser for enhanced cosine response. The TUVRs are limited to the ultraviolet wavelength range of 295 to 385 nm. Because they have a 180 degree field of view, they measure direct, diffuse and reflected UV energy.

G90 Shading Disk Measurements for Q-TRAC® Natural Sunlight Concentrators. Q-Lab Arizona also has a special system to calculate the amount of energy received by the test samples mounted in our Q-TRAC Natural Sunlight Concentrators. A specially made, dual axle, follow-the-sun tracking device enables us to continuously monitor the solar energy throughout the day at normal incidence. Two Eppley TUVRs and a Normal Incidence Pyrheliometer (NIP) are used. The NIP is a sensor which measures only the direct beam sunlight within a 6 degree field of view and uses a collimating tube to eliminate diffuse energy. Comparison of the shaded and unshaded TUVR shows how much direct beam ultraviolet is reflected onto the test specimens mounted in the Q-TRAC unit.

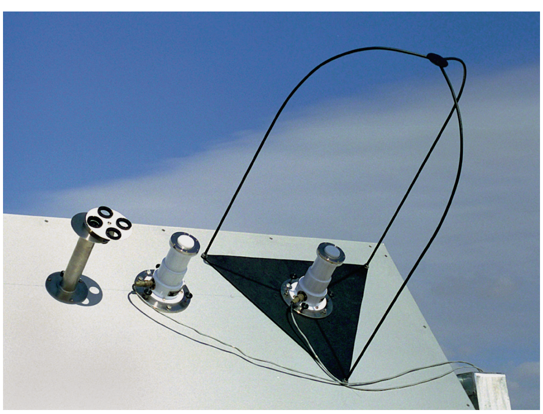

Figure 3 - Sensors for the Q-TRAC energy dosage include a Normal Incidence Pyrheliometer and TUVRs mounted on the follow-the-sun rack.

ASTM G90 Shading Disk Measurements for Q-TRAC Natural Sunlight Concentrators.

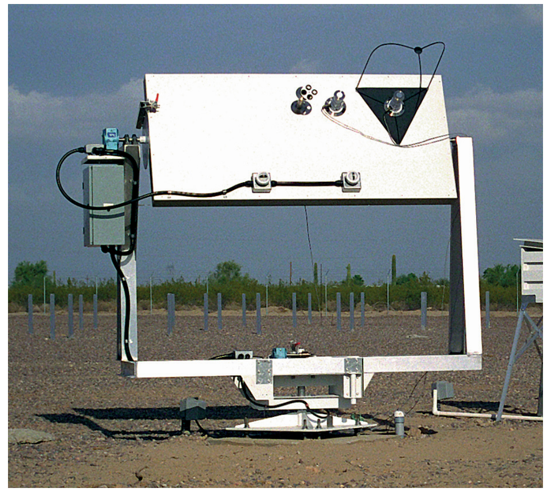

Figure 4 - Sensors for measuring Q-TRAC energy dosage include a Normal Incidence Pyrheliometer, an Eppley TUVR, and a shaded Eppley TUVR. They are mounted on a follow-the-sun rack identical to that used by the Q-TRAC concentrator.

Figure 5 - For a detailed description of this energy calculation method, see ASTM G90, Standard Practice for Performing Accelerated Outdoor Weathering of Nonmetallic Materials using Concentrated Natural Sunlight. G90 is available from the American Society for Testing and Materials, 100 Barr Harbor Dr., W. Conshohocken, PA 19426

Figure 6 - Miami, Florida Installation. Climate measurements are taken in the specimen exposure area to reflect the actual test conditions. (Miami, Florida: Subtropical); (Phoenix, Arizona: Desert)

Figure 7 - Phoenix, Arizona Installation

Temperature. Temperature is measured using Type T thermocouples. A special mini-rack is used to mount standard panels and test specimens for temperature measurement studies. Measurements include ambient, wet bulb, black panel, and white panel temperature.

Black Panel Temperature is used to estimate the maximum temperature that will be attained by a test specimen on exposure. A black panel is used because it will maximize radiant heat build up from solar energy.

White Panel Temperature is used to complement the black panel temperature and is used to estimate the temperature of a light colored test specimen.

Moisture. Moisture is monitored using rain gauges and humidity sensors connected directly to the data acquisition system. High relative humidity conditions are necessary for mildew growth and can help explain certain types of material failures.

Data Acquisition System. The Keithley Data Acquisition System records the data input from all theses different monitoring devices, converts the signals to engineering units, displays the information on a monitor, logs the data to a file, and prints a daily report. The DAS is expandable, allowing for additional solar measuring equipment, thermocouples, atmospheric sensors, or special customer requirements as needed.

Figure 8 - The Rain Gauge measures the amount and duration of rainfall, along with the rate of accumulation.

Q-Lab Weather Summary. Our standard weather measurements are reported each month in our weather summary. This information is sent to all our active clients and is also available on a subscription basis.

Custom Programs. With our new monitoring system and DAS, weathering data can now be customized to the client's specific needs. For example, with the new system, information can now be supplied to the client on exposure duration above a certain threshold irradiance or exposure time over a particular threshold temperature. Customized monitoring programs and reports are available on request.

Committed to Technology. We plan to continually upgrade our weather monitoring systems as advancing technology permits. Q-Lab is committed to supplying state-of-the-art weathering data to its customers.

Some Helpful Definitions

Except where otherwise noted, these definitions are from ASTM G113, Standard Terminology Relating to Natural and Artificial Weathering Tests of Nonmetallic Materials.

Figure 9 - The World Meteorological Organization standard Instrument Shelter houses temperature and humidity devices. It is designed to protect instruments, yet allow accurate sensing of ambient air conditions. The slotted sides allow free air circulation.

Pyranometer. A radiometer used to measure the total solar radiant energy incident upon a surface per unit time per area. This energy includes the direct radiant energy, diffuse radiant energy and reflected radiant energy from the background.

Pyrheliometer. A radiometer used to measure the direct or beam solar irradiance incidence on a surface normal to the sun's rays.

Solar Irradiance, Global. Solar irradiance received on an upward facing horizontal surface directly from the solid angle of the sun's disk and scattered or diffusely reflected in traversing the atmosphere, measured in watts per square meter (ASTM E772).

Solar Radiation, Ultraviolet. Radiation for which the wavelengths of the components are shorter than those for visible radiation and longer than about 1 nm.

Discussion: The limits of the spectral range of ultraviolet radiation are not well defined and may vary according to the user. Committee E-2.1.2 of the CIE distinguishes in the spectral range between 100 nm and 400 nm.

UV-A	315 to 400 nm
UV-B	280 to 315 nm
UV-C	200 to 280 nm

Solar Radiation, Visible. Any radiation capable of causing a visual sensation.

Discussion: The limits of the spectral range of visible radiation are not well defined and may vary according to the user. The shorter limit is generally taken between 380 and 400 nm and the longer limit between 760 and 780 nm. (Note: 1 nanometer, nm = 10^{-9} m).

Solar Radiation, Infrared. Radiation for which the wavelengths of the components are longer than those for the visible, and shorter than about 1 mm.

Discussion: The limits of the spectral range of infrared radiation are not well defined and may vary according to the user. Committee E-2.1.2 of the CIE distinguishes in the spectral range between 780 nm and 1 mm.

IR-A	780 to 1400 nm
IR-B	1.4 to 3 mm
IR-C	3 mm to 1 mm

Total Solar Ultraviolet. Solar Energy above the solar cut on and below the visible, when received after transmittance through the atmosphere.

Discussion: The total UV radiometer commonly used has a sensitive range of 290 to 385 nm.

Q-Lab Corporation www.q-lab.com

Q-Lab Headquarters
Westlake, OH USA
Tel: +1-440-835-8700
info@q-lab.com

Q-Lab Europe, Ltd.
Bolton, England
Tel: +44-1204-861616
info.eu@q-lab.com

Q-Lab Deutschland, GmbH
Saarbrücken, Germany
Tel: +49-681-857470
vertrieb@q-lab.com

Q-Lab Florida
Homestead, FL USA
Tel: +1-305-245-5600
q-lab@q-lab.com

Q-Lab Arizona
Buckeye, AZ USA
Tel: +1-623-386-5140
q-lab@q-lab.com

Q-Lab China 中国代表处
Shanghai, China 中国上海
电话：+86-21-5879-7970
info.cn@q-lab.com