Calibration and Documentation in Accelerated Weathering and Corrosion Laboratory Testing

Andy Francis – Marketing Director

Bill Tobin – Senior Technical Marketing Specialist

Dave Duecker – Senior Technical Marketing Specialist

Sean Fowler – Senior Technical Director

Q-Lab

View Recorded Presentation

Q-Lab's Standards and Calibration Series

Today is the 1st of a three-part webinar series on standards, calibration, and documentation

All upcoming and archived webinars can be accessed at: q-lab.com/webinars

Date	Topic
01 Sep	Calibration and Documentation
08 Sep	What's New in Standards
15 Sep	How to Run ISO 105-B02

Administrative Notes

You'll receive a follow-up email from info@email.q-lab.com with links to a survey, registration for future webinars, and to download the slides

Use the **Q&A feature in Zoom** to ask us questions today!

We make testing simple.

Thank you for attending our webinar!

We hope you found our webinar on ***Calibration and Documentation in Weathering and Corrosion Testing*** to be helpful and insightful. The link below will give you access to the slides and recorded webinar.

You can help us continue to provide valuable and high quality content by completing our 3-question survey about your webinar experience. Every piece of feedback is carefully reviewed by a member of our team.

Agenda

- Calibration and adjustment
- Benefits of calibration
- Calibration requirements in weathering and corrosion testing
- Q-Lab calibration recommendations
- Calibration documentation
- Accuracy and uncertainty

Calibration and Adjustment

- **Calibration:** comparison to a known measurement standard. Often traceable back to a national metrological institute (e.g. NIST in the United States).
- **Adjustment**: change made to a measuring system so it outputs proper values of the quantity to be measured.
- *These procedures are often performed together, but not necessarily!*

Calibration vs Adjustment Example

1. Compare the watch to the official US time, at time.gov. If the watch reads 10:55 and time.gov says 11:00, then your watch has been compared to a known reference and shown to be 5 minutes slow. This is a **calibration**.

2. Fly to a neighboring time zone and move your watch ahead one hour to compensate. This is an **adjustment**. No comparison to a known standard is involved, but this adjustment should get the watch closer to displaying the correct time (unless you got on the wrong flight!)

3. Compare the time on your watch to time.gov and then set your watch to match that time as closely as possible. This is both **calibration and adjustment.**

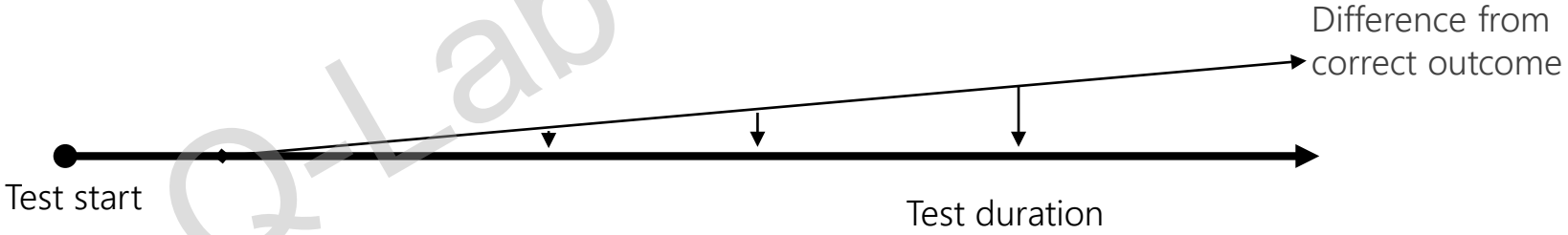
Proper weathering testing involves both calibrations and adjustments.

Agenda

- Calibration and adjustment
- **Benefits of calibration**
- Calibration requirements in weathering and corrosion testing
- Q-Lab calibration recommendations
- Calibration documentation
- Accuracy and uncertainty

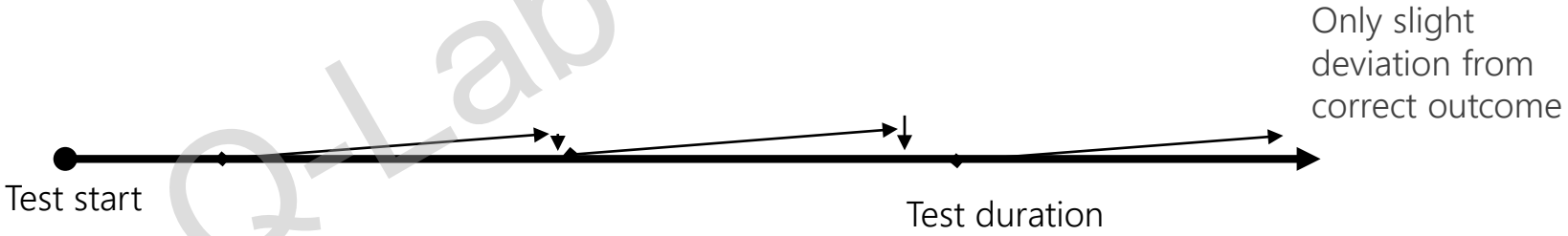
Calibration Benefits

- Q-Lab and other manufacturers recommend regular calibrations of onboard irradiance and temperature sensors
- Calibration ensures that displayed values of irradiance, temperature, and relative humidity can be trusted
- Even small deviations in measurement and control can lead to significantly different results over a long test period.



Calibration Benefits

- Calibrating all sensors regularly reduces deviations
- Even with a long test duration, deviation remains small



The biggest problem with calibrations in weathering testing…

Many end-users neglect to do them, because they often are difficult and/or expensive…

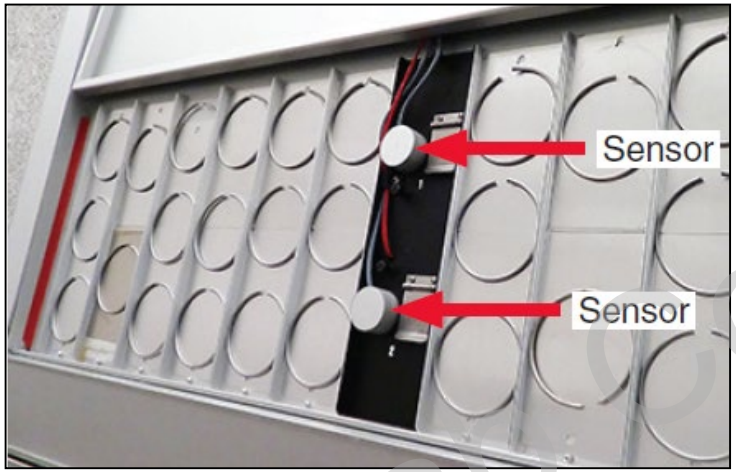
The biggest improvement we can make for calibrations…

Make it easier and less expensive, so it is more likely that end-users will do them!

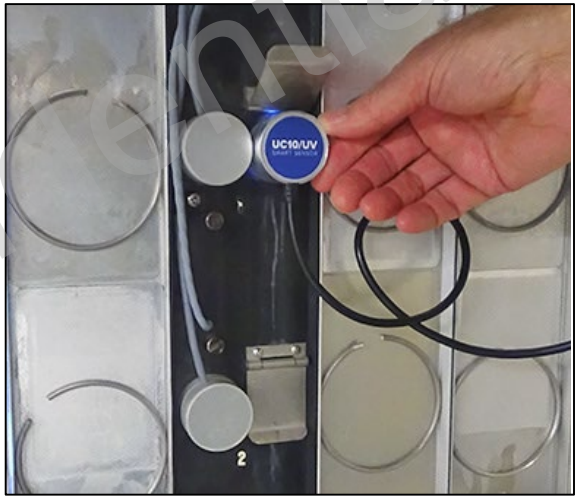
Agenda

- Calibration and adjustment
- Benefits of calibration
- **Calibration requirements in weathering and corrosion testing**
- Q-Lab calibration recommendations
- Calibration documentation
- Accuracy and uncertainty

Sensor Terminology

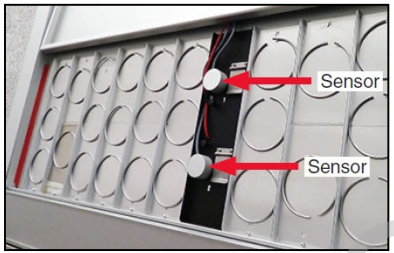
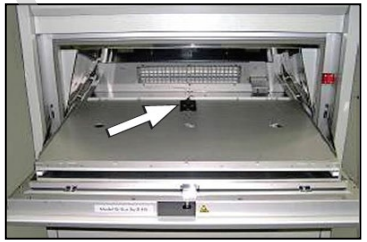


Onboard (or **integrated**) sensors are part of the tester, and are used for measurement and control



Calibration sensors are external reference devices used for calibration and adjustment of onboard sensors

Reference Devices vs. Onboard Sensors

	QUV Irradiance	Q-SUN Irradiance	Q-SUN Temp
Onboard sensors			
Reference devices			 UC202

Calibration in Test Standards

- Test standards from ASTM, ISO, and other organizations often require calibrations, but there is not always consistency
- Consider ASTM G155 (xenon arc weathering). This gives very open-ended guidance on calibration:

> 6.3 *Instrument Calibration*—To ensure standardization and accuracy, the instruments associated with the exposure apparatus (such as timers, thermometers, wet bulb sensors, dry bulb sensors, humidity sensors, UV sensors, radiometers) require periodic calibration to ensure repeatability of test results. Instrument calibration should be traceable to national or international standards. Calibration frequency and procedure should be in accordance with manufacturer's instructions and good laboratory practices.

Calibration in Test Standards

Major, frequently-referenced weathering standards require **at least annual** calibration of onboard sensors. Further guidance is sometimes also provided:

- ISO 9370 (*Plastics — Instrumental determination of radiant exposure in weathering tests — General guidance and basic test method*) requires onboard sensor calibration checks more frequently than annually, but does not define "frequent."
- ISO 4892-1 *(Plastics — Methods of exposure to laboratory light sources — Part 1: General guidance)* recommends onboard sensor calibration checks more frequently than annually, but does not require them.
- ASTM G151 *(Standard Practice for Exposing Materials in Accelerated Test Devices that Use Laboratory Light Sources)* requires onboard sensor calibration checks every time a lamp, optical filter, or test cycle is changed, and annual NMI-traceable calibration and adjustment of reference radiometers.
- ISO 9370 and ASTM G151 both require users to follow manufacturer's recommendations.

- It's not always clear how to meet this guidance!

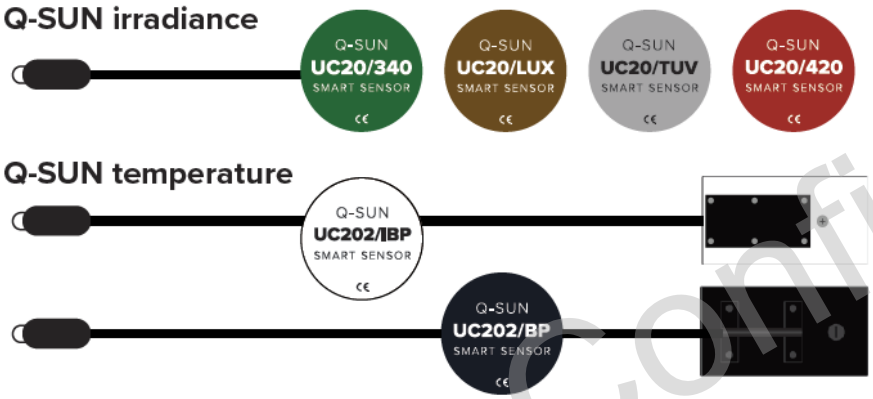
Agenda

- Calibration and adjustment
- Benefits of calibration
- Calibration requirements in weathering and corrosion testing
- **Q-Lab calibration recommendations**
- Calibration documentation
- Accuracy and uncertainty

Q-Lab's calibration recommendations

- Q-Lab recommends frequent calibrations at regular intervals, for irradiance, temperature, relative humidity, & other parameters
  - We champion this within the standards community
- Technical documentation gives clear guidance on what to do and when
- Q-Lab's **Universal Calibrator** system makes calibration and adjustment simple in QUV and Q-SUN testers

Universal Calibrator System



Universal Calibrator Benefits

- Practicality
  - Simplest and most cost-effective system on the market
  - Doesn't require an expensive service visit
  - Compatible with **all** Q-Lab testers
- Accuracy
  - Proven, accurate, NIST-traceable calibration method
  - All calibrations of reference devices are performed under test conditions
    - This solidifies the traceability chain
  - All calibrations of onboard sensors performed under actual test condition using reference devices of same type as the onboard sensors

Calibration: QUV Accelerated Weathering Testers

Sensor	Calibration Frequency	Calibration Instrument
Irradiance	500 hours	UC10 Smart Sensor
Black Panel Temperature	6 months	Calibrated Reference Thermometer

- More frequent calibration is perfectly OK!
- Worth recalibrating also when test cycle, lamps, or sensors are changed

Calibration: Q-SUN Accelerated Weathering Testers

Sensor	Calibration Frequency	Calibration Instrument
Irradiance	500 hours	UC20 Smart Sensor
Black Panel Temperature	6 months	UC202 Smart Sensor
Chamber Air Temperature Relative Humidity	12 months	*Replacement*

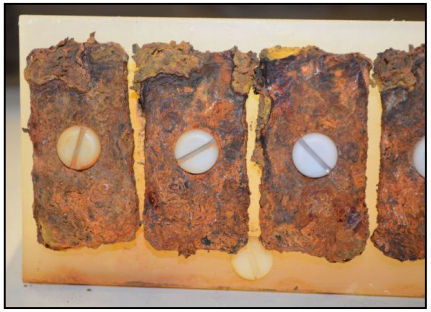
- More frequent calibration is perfectly OK!
- Worth recalibrating also when test cycle, lamps, filters, or sensors are changed

Calibration: Q-FOG Corrosion Testers

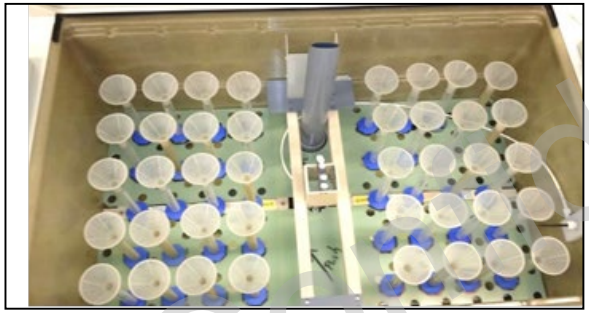
Sensor	Calibration Frequency	Calibration Instrument
Temperature (Chamber Air, Wet/Dry Bulb)	6 months	Reference thermometer
Shower and Fog deposition	Standards-dependent	Collections devices
Shower flow	6 months	Tester sensors

Q-FOG calibrations, especially for collections, can vary depending on test

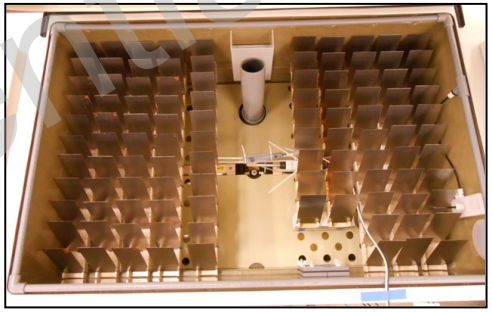
Calibration: Q-FOG Corrosion Verification



Corrosion coupons



Pluviometry



Independent verification

- Widely-used **calibration** techniques (usually with **adjustment**) to ensure that the corrosivity delivered by the tester is what is expected.
- Different style than an onboard sensor calibration, but a calibration nonetheless

Why Use Q-Lab's Irradiance and Temperature Devices for Calibration?

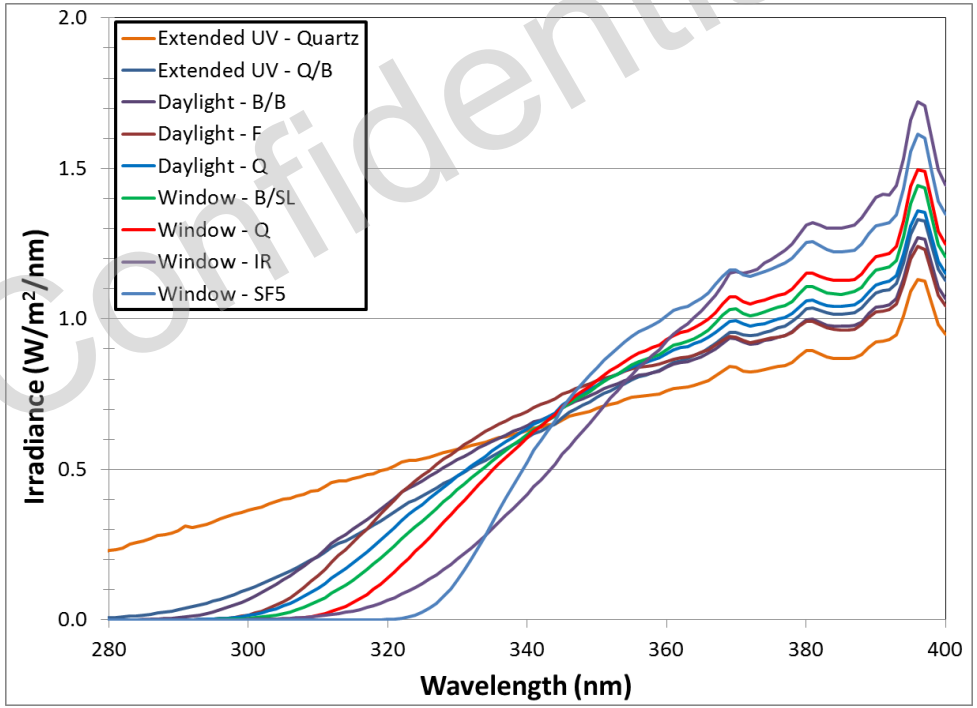
- Irradiance (UC10, UC20)
  - Calibrated to specific spectrum of xenon lamp/filter combination or UV lamp
  - Eliminates effect of spectral mismatch
  - Avoids saturation issues with off-the-shelf spectrophotometers
- Temperature (UC202)
  - Accounts for radiant heating from xenon lamps
  - Includes convective cooling effects

Reference thermometers and generic UV measurement devices do not calibrate onboard sensors properly for their service environment

Spectral Mismatch

Optical Filters in Q-SUN Testers

- Differences between optical filters can lead to mis-calibration if not accounted for
- This is known as **spectral mismatch**



Spectral Mismatch

- If a UC20 calibrated for **Daylight-Q** filters measures a tester with **Window-Q** filters installed, an actual irradiance of 1.00 W/m^2/nm @340 nm will measure only 0.94 W/m^2/nm
- That spectral mismatch-induced error is 6%
  - This can significantly affect test results!
  - The opposite scenario (i.e. calibrating Daylight-Q with a Window-Q reference device) causes the reverse issue

Imagine errors possible for a device not designed for Q-SUN testers at all!

Agenda

- Calibration and adjustment
- Benefits of calibration
- Calibration requirements in weathering and corrosion testing
- Q-Lab calibration recommendations
- **Calibration documentation**
- Accuracy and uncertainty

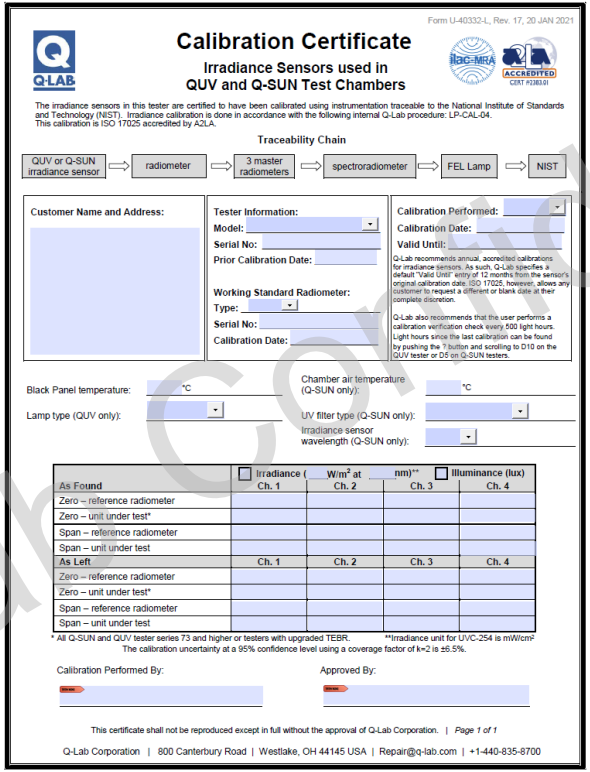
Q-Lab Global Calibration Locations

ISO 17025-Accredited

- US
- UK
- China
- Germany

Calibration Certificates

Onboard Sensors



Form U-40332-L, Rev. 17, 20 JAN 2021

Calibration Certificate

Irradiance Sensors used in QUV and Q-SUN Test Chambers

The irradiance sensors in this tester are certified to have been calibrated using instrumentation traceable to the National Institute of Standards and Technology (NIST). Irradiance calibration is done in accordance with the following internal Q-Lab procedure: LP-CAL-04. This calibration is ISO 17025 accredited by A2LA.

Traceability Chain

QUV or Q-SUN irradiance sensor ⇨ radiometer ⇨ 3 master radiometers ⇨ spectroradiometer ⇨ FEL Lamp ⇨ NIST

Customer Name and Address:

Tester Information: Model: Serial No: Prior Calibration Date:

Working Standard Radiometer: Type: Serial No: Calibration Date:

Calibration Performed: Calibration Date: Valid Until:

Q-Lab recommends annual, accredited calibrations for irradiance sensors. As such, Q-Lab specifies a default "Valid Until" entry of 12 months from the sensor's original calibration date. ISO 17025, however, allows any customer to request a different or blank date at their complete discretion.

Q-Lab also recommends that the user performs a calibration verification check every 500 light hours. Light hours since the last calibration can be found by pushing the ? button and scrolling to D10 on the QUV tester or D5 on Q-SUN testers.

Black Panel temperature: °C

Lamp type (QUV only):

Chamber air temperature (Q-SUN only): °C

UV filter type (Q-SUN only):

Irradiance sensor wavelength (Q-SUN only):

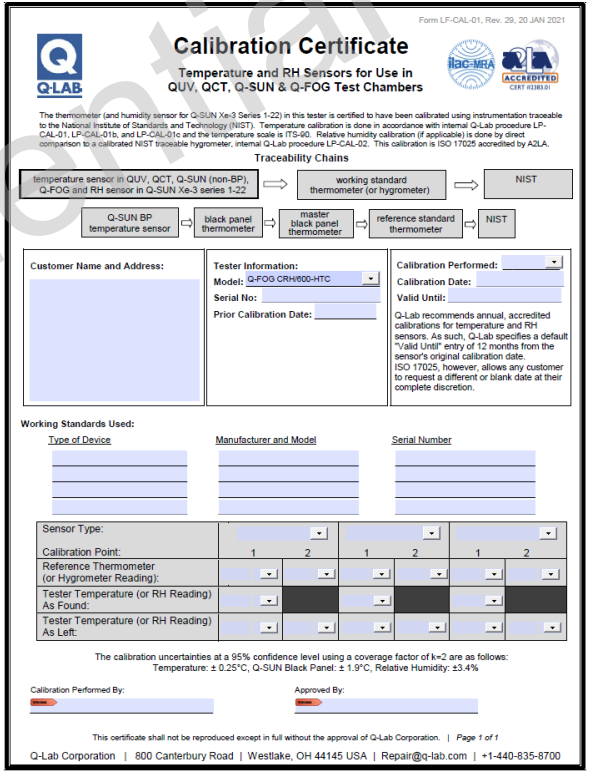
As Found	☐ Irradiance (W/m² at nm)** Ch. 1	Ch. 2	Ch. 3	☐ Illuminance (lux) Ch. 4
Zero – reference radiometer				
Zero – unit under test*				
Span – reference radiometer				
Span – unit under test				
As Left	**Ch. 1**	**Ch. 2**	**Ch. 3**	**Ch. 4**
Zero – reference radiometer				
Zero – unit under test*				
Span – reference radiometer				
Span – unit under test				

* All Q-SUN and QUV tester series 73 and higher or testers with upgraded TEBR. **Irradiance unit for UVC-254 is mW/cm²

The calibration uncertainty at a 95% confidence level using a coverage factor of k=2 is ±6.5%.

Calibration Performed By: Approved By:

Q-Lab Corporation | 800 Canterbury Road | Westlake, OH 44145 USA | Repair@q-lab.com | +1-440-835-8700



Form LF-CAL-01, Rev. 29, 20 JAN 2021

Calibration Certificate

Temperature and RH Sensors for Use in QUV, QCT, Q-SUN & Q-FOG Test Chambers

The thermometer (and humidity sensor for Q-SUN Xe-3 Series 1-22) in this tester is certified to have been calibrated using instrumentation traceable to the National Institute of Standards and Technology (NIST). Temperature calibration is done in accordance with internal Q-Lab procedure LP-CAL-01, LP-CAL-01b, and LP-CAL-01c and the temperature scale is ITS-90. Relative humidity calibration (if applicable) is done by direct comparison to a calibrated NIST traceable hygrometer, internal Q-Lab procedure LP-CAL-02. This calibration is ISO 17025 accredited by A2LA.

Traceability Chains

temperature sensor in QUV, QCT, Q-SUN (non-BP), Q-FOG and RH sensor in Q-SUN Xe-3 series 1-22 ⇨ working standard thermometer (or hygrometer) ⇨ NIST

Q-SUN BP temperature sensor ⇨ black panel thermometer ⇨ master black panel thermometer ⇨ reference standard thermometer ⇨ NIST

Customer Name and Address:

Tester Information: Model: Q-FOG CRH/600-HTC Serial No: Prior Calibration Date:

Calibration Performed: Calibration Date: Valid Until:

Q-Lab recommends annual, accredited calibrations for temperature and RH sensors. As such, Q-Lab specifies a default "Valid Until" entry of 12 months from the sensor's original calibration date. ISO 17025, however, allows any customer to request a different or blank date at their complete discretion.

Working Standards Used:

Type of Device	Manufacturer and Model	Serial Number

Sensor Type:						
Calibration Point:	1	2	1	2	1	2
Reference Thermometer (or Hygrometer Reading):						
Tester Temperature (or RH Reading) As Found:						
Tester Temperature (or RH Reading) As Left:						

The calibration uncertainties at a 95% confidence level using a coverage factor of k=2 are as follows: Temperature: ± 0.25°C, Q-SUN Black Panel: ± 1.9°C, Relative Humidity: ±3.4%

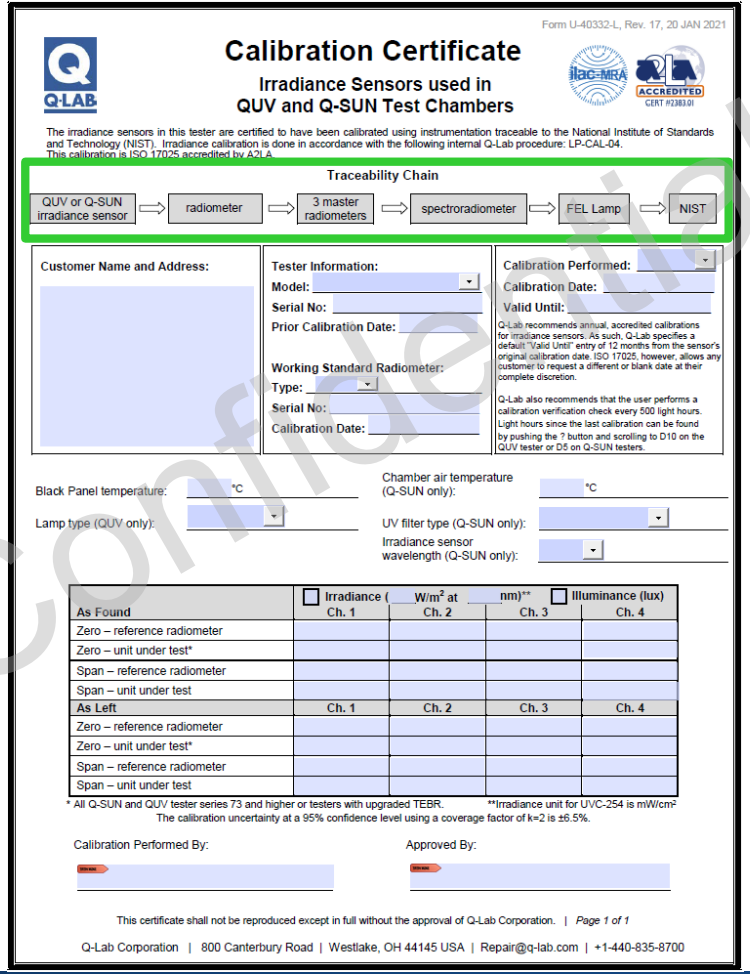
Calibration Performed By: Approved By:

Q-Lab Corporation | 800 Canterbury Road | Westlake, OH 44145 USA | Repair@q-lab.com | +1-440-835-8700

Traceability Chain

Irradiance

- Onboard irradiance sensor
- ↓
- Calibration UC20 / UC10 radiometer
- ↓
- Master UC20 / UC10 radiometers (n=3)
- ↓
- Spectroradiometer
- ↓
- FEL Lamp
- ↓
- NIST



Form U-40332-L, Rev. 17, 20 JAN 2021

Calibration Certificate

Irradiance Sensors used in QUV and Q-SUN Test Chambers

ACCREDITED CERT #2383.01

The irradiance sensors in this tester are certified to have been calibrated using instrumentation traceable to the National Institute of Standards and Technology (NIST). Irradiance calibration is done in accordance with the following internal Q-Lab procedure: LP-CAL-04. This calibration is ISO 17025 accredited by A2LA.

Traceability Chain

QUV or Q-SUN irradiance sensor ⇒ radiometer ⇒ 3 master radiometers ⇒ spectroradiometer ⇒ FEL Lamp ⇒ NIST

Customer Name and Address:

Tester Information:
Model:
Serial No:
Prior Calibration Date:

Working Standard Radiometer:
Type:
Serial No:
Calibration Date:

Calibration Performed:
Calibration Date:
Valid Until:

Q-Lab recommends annual, accredited calibrations for irradiance sensors. As such, Q-Lab specifies a default "Valid Until" entry of 12 months from the sensor's original calibration date. ISO 17025, however, allows any customer to request a different or blank date at their complete discretion.

Q-Lab also recommends that the user performs a calibration verification check every 500 light hours. Light hours since the last calibration can be found by pushing the ? button and scrolling to D10 on the QUV tester or D5 on Q-SUN testers.

Black Panel temperature: °C
Lamp type (QUV only):
Chamber air temperature (Q-SUN only): °C
UV filter type (Q-SUN only):
Irradiance sensor wavelength (Q-SUN only):

As Found	☐ Irradiance (W/m² at nm)** Ch. 1	Ch. 2	Ch. 3	☐ Illuminance (lux) Ch. 4
Zero – reference radiometer				
Zero – unit under test*				
Span – reference radiometer				
Span – unit under test				
As Left	**Ch. 1**	**Ch. 2**	**Ch. 3**	**Ch. 4**
Zero – reference radiometer				
Zero – unit under test*				
Span – reference radiometer				
Span – unit under test				

* All Q-SUN and QUV tester series 73 and higher or testers with upgraded TEBR. **Irradiance unit for UVC-254 is mW/cm²

The calibration uncertainty at a 95% confidence level using a coverage factor of k=2 is ±6.5%.

Calibration Performed By:

Approved By:

This certificate shall not be reproduced except in full without the approval of Q-Lab Corporation. | *Page 1 of 1*

Q-Lab Corporation | 800 Canterbury Road | Westlake, OH 44145 USA | Repair@q-lab.com | +1-440-835-8700

Traceability Chain

Temperature

Black Panel

Onboard temperature sensor

⇩

Master UC202

⇩

Reference standard thermometer

⇩

NIST

CAT/RH Sensor

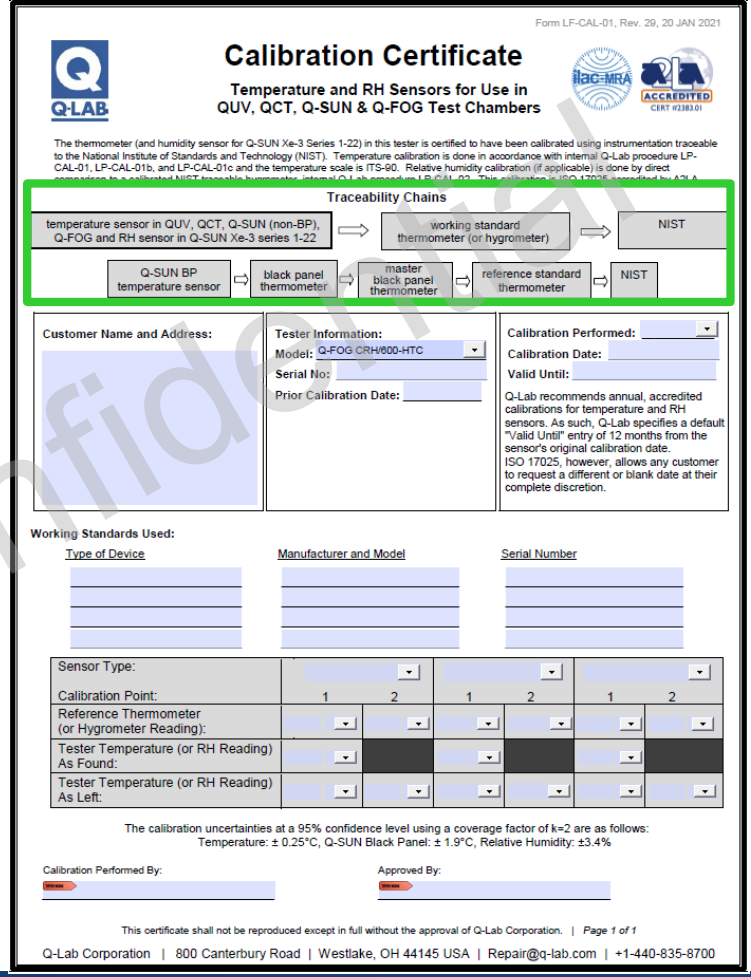
Onboard chamber air temp or RH sensor

⇩

Working standard thermometer or hygrometer

⇩

NIST



Form LF-CAL-01, Rev. 29, 20 JAN 2021

Q-LAB

Calibration Certificate

Temperature and RH Sensors for Use in QUV, QCT, Q-SUN & Q-FOG Test Chambers

ilac-MRA ACCREDITED CERT #2383.01

The thermometer (and humidity sensor for Q-SUN Xe-3 Series 1-22) in this tester is certified to have been calibrated using instrumentation traceable to the National Institute of Standards and Technology (NIST). Temperature calibration is done in accordance with internal Q-Lab procedure LP-CAL-01, LP-CAL-01b, and LP-CAL-01c and the temperature scale is ITS-90. Relative humidity calibration (if applicable) is done by direct comparison to a calibrated NIST traceable hygrometer, internal Q-Lab procedure LP-CAL-03. This calibration is ISO 17025 accredited by A2LA

Traceability Chains

temperature sensor in QUV, QCT, Q-SUN (non-BP), Q-FOG and RH sensor in Q-SUN Xe-3 series 1-22 ⇨ working standard thermometer (or hygrometer) ⇨ NIST

Q-SUN BP temperature sensor ⇨ black panel thermometer ⇨ master black panel thermometer ⇨ reference standard thermometer ⇨ NIST

Customer Name and Address:

Tester Information:
Model: Q-FOG CRH/600-HTC
Serial No:
Prior Calibration Date:

Calibration Performed:
Calibration Date:
Valid Until:

Q-Lab recommends annual, accredited calibrations for temperature and RH sensors. As such, Q-Lab specifies a default "Valid Until" entry of 12 months from the sensor's original calibration date. ISO 17025, however, allows any customer to request a different or blank date at their complete discretion.

Working Standards Used:

Type of Device	Manufacturer and Model	Serial Number

Sensor Type:						
Calibration Point:	1	2	1	2	1	2
Reference Thermometer (or Hygrometer Reading):						
Tester Temperature (or RH Reading) As Found:						
Tester Temperature (or RH Reading) As Left:						

The calibration uncertainties at a 95% confidence level using a coverage factor of k=2 are as follows:
Temperature: ± 0.25°C, Q-SUN Black Panel: ± 1.9°C, Relative Humidity: ±3.4%

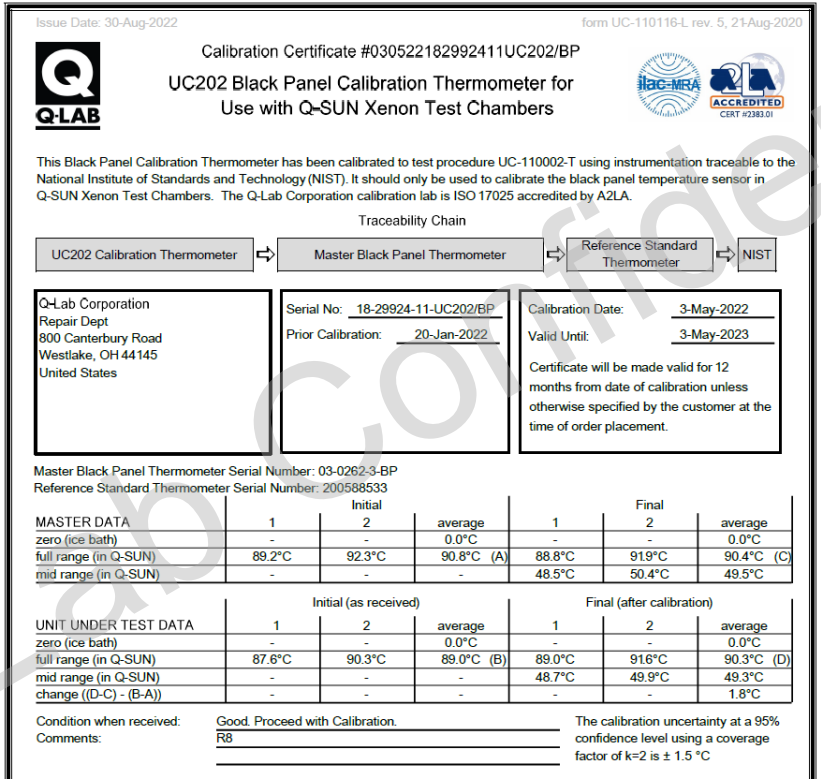
Calibration Performed By:

Approved By:

 | *Page 1 of 1*

Q-Lab Corporation | 800 Canterbury Road | Westlake, OH 44145 USA | Repair@q-lab.com | +1-440-835-8700

Calibration Temperature Sensors



Issue Date: 30-Aug-2022 form UC-110116-L rev. 5, 21-Aug-2020

Calibration Certificate #030522182992411UC202/BP

UC202 Black Panel Calibration Thermometer for Use with Q-SUN Xenon Test Chambers

ACCREDITED CERT #2383.01

This Black Panel Calibration Thermometer has been calibrated to test procedure UC-110002-T using instrumentation traceable to the National Institute of Standards and Technology (NIST). It should only be used to calibrate the black panel temperature sensor in Q-SUN Xenon Test Chambers. The Q-Lab Corporation calibration lab is ISO 17025 accredited by A2LA.

Traceability Chain

UC202 Calibration Thermometer ⇨ Master Black Panel Thermometer ⇨ Reference Standard Thermometer ⇨ NIST

Q-Lab Corporation
Repair Dept
800 Canterbury Road
Westlake, OH 44145
United States

Serial No: 18-29924-11-UC202/BP
Prior Calibration: 20-Jan-2022

Calibration Date: 3-May-2022
Valid Until: 3-May-2023

Certificate will be made valid for 12 months from date of calibration unless otherwise specified by the customer at the time of order placement.

Master Black Panel Thermometer Serial Number: 03-0262-3-BP
Reference Standard Thermometer Serial Number: 200588533

	Initial			Final		
MASTER DATA	1	2	average	1	2	average
zero (ice bath)	-	-	0.0°C	-	-	0.0°C
full range (in Q-SUN)	89.2°C	92.3°C	90.8°C (A)	88.8°C	91.9°C	90.4°C (C)
mid range (in Q-SUN)	-	-	-	48.5°C	50.4°C	49.5°C

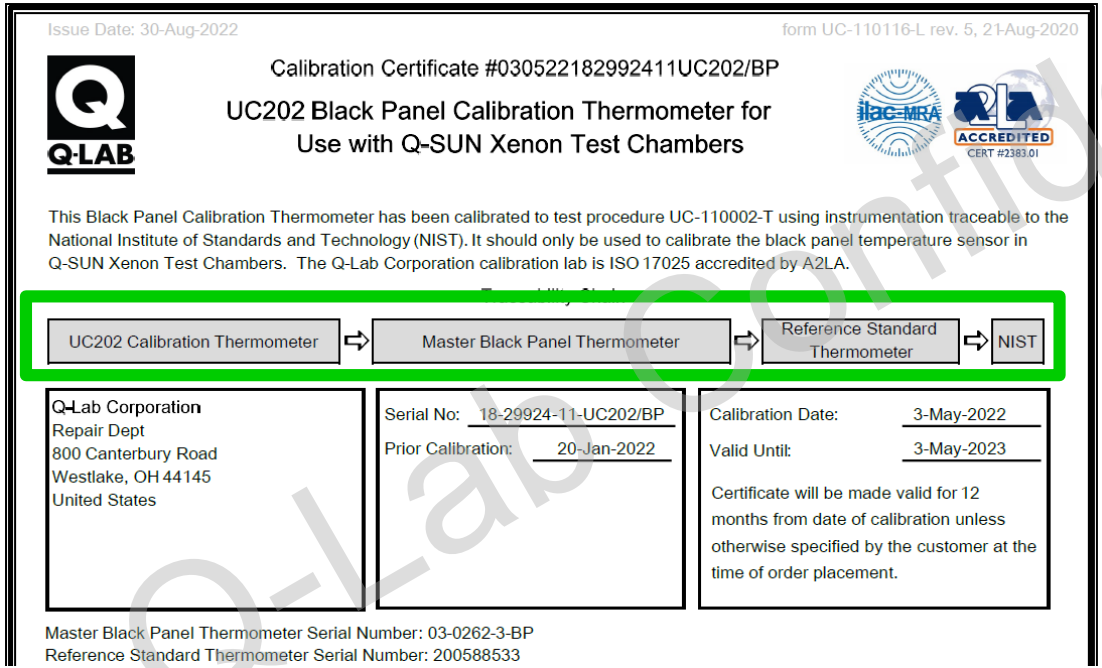
	Initial (as received)			Final (after calibration)		
UNIT UNDER TEST DATA	1	2	average	1	2	average
zero (ice bath)	-	-	0.0°C	-	-	0.0°C
full range (in Q-SUN)	87.6°C	90.3°C	89.0°C (B)	89.0°C	91.6°C	90.3°C (D)
mid range (in Q-SUN)	-	-	-	48.7°C	49.9°C	49.3°C
change ((D-C) - (B-A))	-	-	-	-	-	1.8°C

Condition when received: Good. Proceed with Calibration.
Comments: R8

The calibration uncertainty at a 95% confidence level using a coverage factor of k=2 is ± 1.5 °C

Calibration Certificate: Temperature Sensors

Traceability Chain



Issue Date: 30-Aug-2022 form UC-110116-L rev. 5, 21-Aug-2020

Q-LAB

Calibration Certificate #030522182992411UC202/BP

UC202 Black Panel Calibration Thermometer for Use with Q-SUN Xenon Test Chambers

ilac-MRA A2LA ACCREDITED CERT #2383.01

This Black Panel Calibration Thermometer has been calibrated to test procedure UC-110002-T using instrumentation traceable to the National Institute of Standards and Technology (NIST). It should only be used to calibrate the black panel temperature sensor in Q-SUN Xenon Test Chambers. The Q-Lab Corporation calibration lab is ISO 17025 accredited by A2LA.

UC202 Calibration Thermometer ⇨ Master Black Panel Thermometer ⇨ Reference Standard Thermometer ⇨ NIST

Q-Lab Corporation
Repair Dept
800 Canterbury Road
Westlake, OH 44145
United States

Serial No: 18-29924-11-UC202/BP
Prior Calibration: 20-Jan-2022

Calibration Date: 3-May-2022
Valid Until: 3-May-2023

Certificate will be made valid for 12 months from date of calibration unless otherwise specified by the customer at the time of order placement.

Master Black Panel Thermometer Serial Number: 03-0262-3-BP
Reference Standard Thermometer Serial Number: 200588533

UC202 Calibration Thermometer

⇩

Master Black Panel Thermometer

⇩

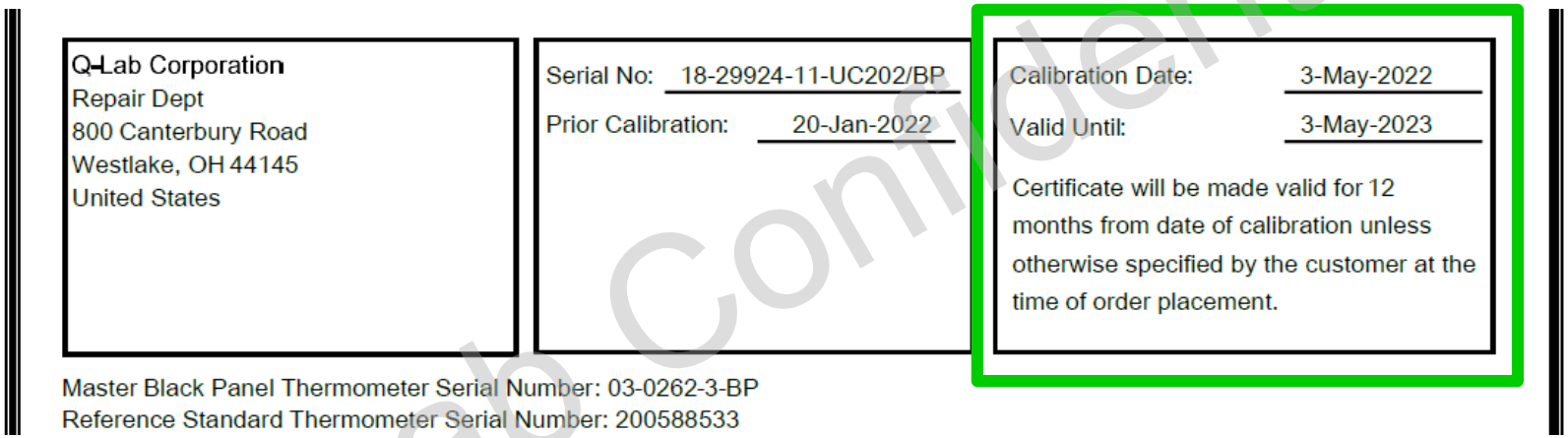
Reference standard thermometer

⇩

NIST

Calibration Certificate: Temperature Sensors

Calibration Validity



Q-Lab Corporation
Repair Dept
800 Canterbury Road
Westlake, OH 44145
United States

Serial No: 18-29924-11-UC202/BP
Prior Calibration: 20-Jan-2022

Calibration Date: 3-May-2022
Valid Until: 3-May-2023

Certificate will be made valid for 12 months from date of calibration unless otherwise specified by the customer at the time of order placement.

Master Black Panel Thermometer Serial Number: 03-0262-3-BP
Reference Standard Thermometer Serial Number: 200588533

Calibration Certificate: Temperature Sensors

Test Data

	Initial			Final		
MASTER DATA	1	2	average	1	2	average
zero (ice bath)	-	-	0.0°C	-	-	0.0°C
full range (in Q-SUN)	89.2°C	92.3°C	90.8°C (A)	88.8°C	91.9°C	90.4°C (C)
mid range (in Q-SUN)	-	-	-	48.5°C	50.4°C	49.5°C

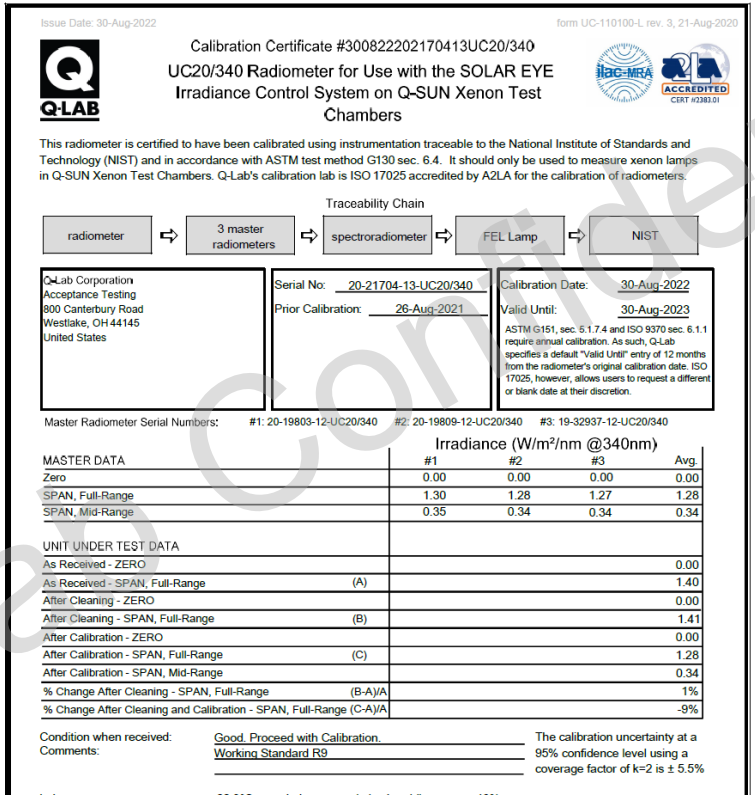
	Initial (as received)			Final (after calibration)		
UNIT UNDER TEST DATA	1	2	average	1	2	average
zero (ice bath)	-	-	0.0°C	-	-	0.0°C
full range (in Q-SUN)	87.6°C	90.3°C	89.0°C (B)	89.0°C	91.6°C	90.3°C (D)
mid range (in Q-SUN)	-	-	-	48.7°C	49.9°C	49.3°C
change ((D-C) - (B-A))	-	-	-	-	-	1.8°C

Condition when received: Good. Proceed with Calibration.

Comments: R8

The calibration uncertainty at a 95% confidence level using a coverage factor of k=2 is ± 1.5 °C

Calibration Irradiance Sensors (Radiometers)



Issue Date: 30-Aug-2022 form UC-110100-L rev. 3, 21-Aug-2020

Q-LAB

Calibration Certificate #300822202170413UC20/340

UC20/340 Radiometer for Use with the SOLAR EYE Irradiance Control System on Q-SUN Xenon Test Chambers

ilac-MRA A2LA ACCREDITED CERT #2383.01

This radiometer is certified to have been calibrated using instrumentation traceable to the National Institute of Standards and Technology (NIST) and in accordance with ASTM test method G130 sec. 6.4. It should only be used to measure xenon lamps in Q-SUN Xenon Test Chambers. Q-Lab's calibration lab is ISO 17025 accredited by A2LA for the calibration of radiometers.

Traceability Chain

radiometer ⇨ 3 master radiometers ⇨ spectroradiometer ⇨ FEL Lamp ⇨ NIST

Q-Lab Corporation
Acceptance Testing
800 Canterbury Road
Westlake, OH 44145
United States

Serial No: 20-21704-13-UC20/340
Prior Calibration: 26-Aug-2021

Calibration Date: 30-Aug-2022
Valid Until: 30-Aug-2023

ASTM G151, sec. 5.1.7.4 and ISO 9370 sec. 6.1.1 require annual calibration. As such, Q-Lab specifies a default "Valid Until" entry of 12 months from the radiometer's original calibration date. ISO 17025, however, allows users to request a different or blank date at their discretion.

Master Radiometer Serial Numbers: #1: 20-19803-12-UC20/340 #2: 20-19809-12-UC20/340 #3: 19-32937-12-UC20/340

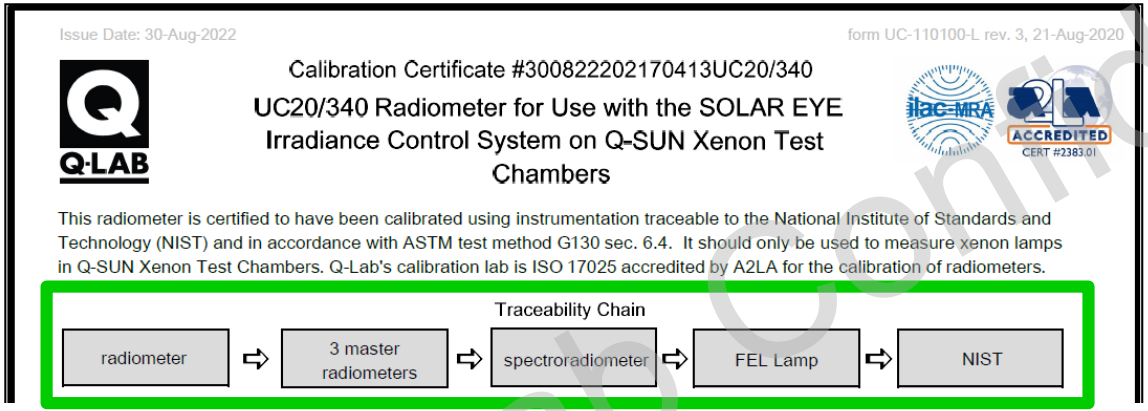
		Irradiance (W/m²/nm @340nm)			
MASTER DATA		#1	#2	#3	Avg.
Zero		0.00	0.00	0.00	0.00
SPAN, Full-Range		1.30	1.28	1.27	1.28
SPAN, Mid-Range		0.35	0.34	0.34	0.34
UNIT UNDER TEST DATA					
As Received - ZERO					0.00
As Received - SPAN, Full-Range	(A)				1.40
After Cleaning - ZERO					0.00
After Cleaning - SPAN, Full-Range	(B)				1.41
After Calibration - ZERO					0.00
After Calibration - SPAN, Full-Range	(C)				1.28
After Calibration - SPAN, Mid-Range					0.34
% Change After Cleaning - SPAN, Full-Range	(B-A)/A				1%
% Change After Cleaning and Calibration - SPAN, Full-Range	(C-A)/A				-9%

Condition when received: Good. Proceed with Calibration.
Comments: Working Standard R9

The calibration uncertainty at a 95% confidence level using a coverage factor of k=2 is ± 5.5%

Calibration Certificate: Irradiance Sensors

Traceability Chain



Issue Date: 30-Aug-2022 form UC-110100-L rev. 3, 21-Aug-2020

Q-LAB

Calibration Certificate #300822202170413UC20/340

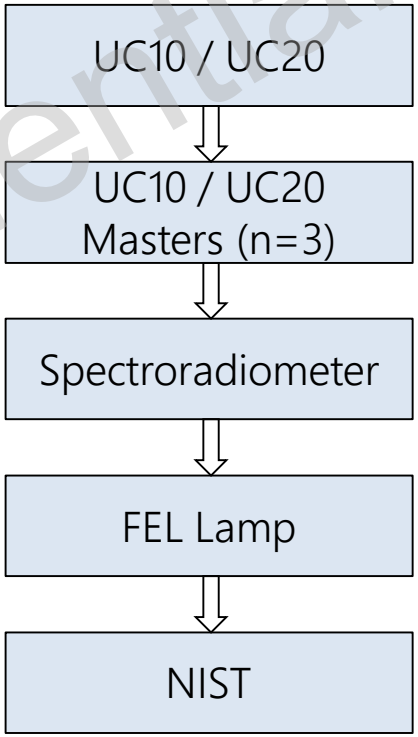
UC20/340 Radiometer for Use with the SOLAR EYE Irradiance Control System on Q-SUN Xenon Test Chambers

ilac-MRA A2LA ACCREDITED CERT #2383.01

This radiometer is certified to have been calibrated using instrumentation traceable to the National Institute of Standards and Technology (NIST) and in accordance with ASTM test method G130 sec. 6.4. It should only be used to measure xenon lamps in Q-SUN Xenon Test Chambers. Q-Lab's calibration lab is ISO 17025 accredited by A2LA for the calibration of radiometers.

Traceability Chain

radiometer ⇨ 3 master radiometers ⇨ spectroradiometer ⇨ FEL Lamp ⇨ NIST



Calibration Certificate: Irradiance Sensors

Calibration Validity

Q-Lab Corporation
Acceptance Testing
800 Canterbury Road
Westlake, OH 44145
United States

Serial No: 20-21704-13-UC20/340

Prior Calibration: 26-Aug-2021

Calibration Date: 30-Aug-2022

Valid Until: 30-Aug-2023

ASTM G151, sec. 5.1.7.4 and ISO 9370 sec. 6.1.1 require annual calibration. As such, Q-Lab specifies a default "Valid Until" entry of 12 months from the radiometer's original calibration date. ISO 17025, however, allows users to request a different or blank date at their discretion.

Master Radiometer Serial Numbers: #1: 20-19803-12-UC20/340 #2: 20-19809-12-UC20/340 #3: 19-32937-12-UC20/340

Calibration Certificate: Irradiance Sensors

Test Data

Q-SUN UC20

		Irradiance (W/m²/nm @340nm)			
MASTER DATA		#1	#2	#3	Avg.
Zero		0.00	0.00	0.00	0.00
SPAN, Full-Range		1.30	1.28	1.27	1.28
SPAN, Mid-Range		0.35	0.34	0.34	0.34
UNIT UNDER TEST DATA					
As Received - ZERO					0.00
As Received - SPAN, Full-Range	(A)				1.40
After Cleaning - ZERO					0.00
After Cleaning - SPAN, Full-Range	(B)				1.41
After Calibration - ZERO					0.00
After Calibration - SPAN, Full-Range	(C)				1.28
After Calibration - SPAN, Mid-Range					0.34
% Change After Cleaning - SPAN, Full-Range	(B-A)/A				1%
% Change After Cleaning and Calibration - SPAN, Full-Range	(C-A)/A				-9%

Condition when received: Good. Proceed with Calibration.
Comments: Working Standard R9

The calibration uncertainty at a 95% confidence level using a coverage factor of k=2 is ± 5.5%

QUV UC10

		Irradiance							
		UV-A Lamps (W/m²nm @340nm)				UV-B Lamps (W/m²nm @310nm)			
MASTER DATA (calibration version 2)		#1	#2	#3	Avg.	#1	#2	#3	Avg.
Zero									
SPAN, Full-Range									
SPAN, Mid-Range									
UNIT UNDER TEST DATA (calibration version 2)									
As Received - ZERO									
As Received - SPAN, Full-Range	(A)								
After Cleaning - ZERO									
After Cleaning - SPAN, Full-Range	(B)								
After Calibration - ZERO									
After Calibration - SPAN, Full-Range	(C)								
After Calibration - SPAN, Mid-Range									

Agenda

- Calibration and adjustment
- Benefits of calibration
- Calibration requirements in weathering and corrosion testing
- Q-Lab calibration recommendations
- Calibration documentation
- Accuracy and uncertainty

Calibration Uncertainty Budget

- The accuracy of onboard sensors is determined by the accuracy of the references used to calibrate them.
- This is calculated by preparing an uncertainty budget, shown here for UC20 irradiance smart sensors

UC 20 source of uncertainty	Est. uncertainty (%) 2 Std-Dev	Std. uncertainty (%) 1 Std-Dev
Parameter #1	1.16	0.58
Parameter #2	1.00	0.50
Parameter #3	1.00	0.50
Parameter #4	0.08	0.04
Parameter #5	0.08	0.04
Parameter #6	0.20	0.10
Parameter #7	2.50	1.25
Parameter #8	1.00	0.58
Parameter #9	0.28	0.14
Parameter #10	4.80	2.40
Parameter #11	0.30	0.20
Parameter #12	0.60	0.30
Parameter #13	1.43	0.71
Parameter #14	2.00	1.00
Parameter #15	0.70	0.35
Parameter #16	2.86	1.43
Parameter #17	1.43	0.71
Combined Uncertainty	±5.6%	±2.8%

Accuracy and Uncertainty

- A very common question in calibration: *What is the accuracy of my sensors?*
- Consider BP/IBP sensors:
  - Calibrated with a k=2 measurement uncertainty of +/- 1.5 °C. This is stated on the device calibration certificate.
  - Calibrated under a radiant load from a xenon-arc lamp and are intended for use specifically in a Q-SUN Xenon Arc tester. This is the main source of uncertainty.
  - We calibrate these devices using reference black panel sensors, and our laboratory accredited to perform the calibration in accordance with ISO 17025.

The accuracy of onboard sensors is determined by the accuracy of the references used to calibrate them

Summary – Calibration and Documentation

- Calibration of onboard sensors is critical for correct, consistent performance of weathering and corrosion testers
- Calibration requirements from test standards are not always very descriptive
- The Universal Calibrator system makes irradiance and temperature calibration simple for QUV and Q-SUN testers
- Extensive documentation is provided with calibration certificates for onboard sensors and calibration devices, including:
  - Traceability chain
  - Customer information and calibration validity
  - Test conditions
  - Reference devices and test data
- Sensor accuracy is determined by the accuracy of the devices used to calibrate them

Thank you for your attention!

Questions?

Send your inquiry to:
info@q-lab.com