

# Calibration and Documentation in Accelerated Weathering and Corrosion Laboratory Testing

## 老化和腐蚀测试中的校准和文件记录

Kobe Qu (瞿华盛)

Senior Technical and Marketing Manager

[kqu@q-lab.com](mailto:kqu@q-lab.com)

Q-Lab Corporation

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# Agenda

- Calibration and adjustment

校准和调整

- Benefits of calibration

校准的好处

- Calibration requirements in weathering and corrosion testing

在老化和腐蚀测试中的校准要求

- Q-Lab calibration recommendations

Q-Lab校准推荐

- Calibration documentation

校准文件

- Accuracy and uncertainty

准确度和不确定度

## Calibration and Adjustment

### 校准和调整

- **Calibration:** comparison to a known measurement standard. Often traceable back to a national metrological institute (e.g. NIST in the United States).

校准：与已知测量标准进行比较。通常可以追溯到国家计量机构（例如美国的NIST）

- **Adjustment:** change made to a measuring system so it outputs proper values of the quantity to be measured.

调整：对测量系统进行更改，使其输出待测量量的适当值

- *These procedures are often performed together, but not necessarily!*

两个程序通常一起执行，但不绝对



## Calibration vs Adjustment Example

### 校准 vs 调整

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**.

将手表与官方时间进行比较。如果手表显示10:55但官方时间为11:00，那么你的手表已经与已知参考值进行比较，显示慢了5分钟。这就是一个**校准**。

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!)

飞到邻近的时区，将手表向前移动一小时以进行补偿。这是一种**调整**。虽然不涉及与已知标准的比较，但这种调整应该可以使手表更接近显示正确的时间（除非您乘坐了错误的航班！）

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**.

把你的手表和官方时间比较，并尽可能调整和官方时间一致，这就是校准和调整。

*Proper weathering testing involves both calibrations and adjustments.*  
**老化测试中会同时涉及校准和调整**



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## Calibration Benefits

### 校准的好处

- Q-Lab and other manufacturers recommend regular calibrations of onboard irradiance and temperature sensors

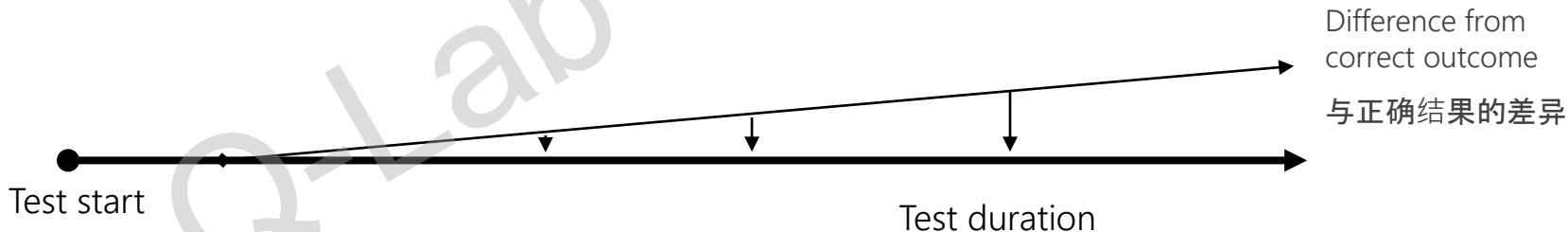
Q-Lab和其他制造商推荐对机器辐照度和温度传感器进行定期校准

- Calibration ensures that displayed values of irradiance, temperature, and relative humidity can be trusted

校准确保辐照度、温度和相对湿度的显示值可信

- Even small deviations in measurement and control can lead to significantly different results over a long test period.

即使测量和控制中存在微小偏差，也会导致在较长的测试期内产生显著差异。



## Calibration Benefits

### 校准的好处

- Calibrating all sensors regularly reduces deviations  
定期校准所有传感器可减少偏差
- Even with a long test duration, deviation remains small  
即使测试持续时间较长，偏差仍然很小



Only slight deviation  
from correct outcome

仅与正确结果略有偏差

## The biggest problem with calibrations in weathering testing... 在老化测试中校准的最大问题是。。。

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

很多客户忽视了校准，因为校准很麻烦也很贵。。。

## The biggest improvement we can make for calibrations... 我们对校准的最大的改进是。。。

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

让校准更简单更便宜，客户才会去做！



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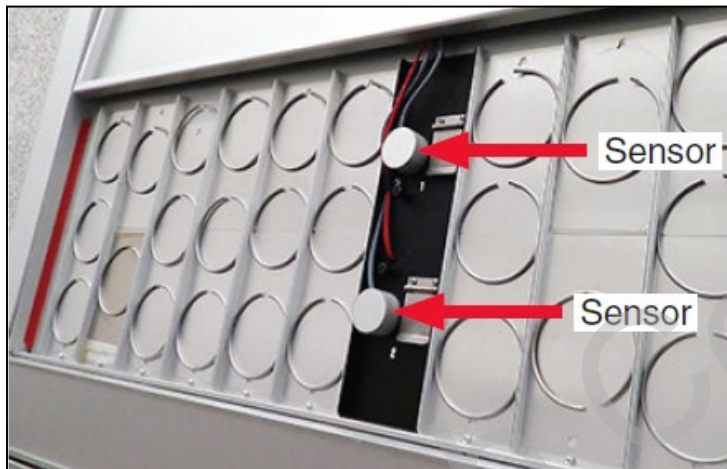
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## Sensor Terminology

### 传感器术语



**Onboard (or integrated)** sensors are part of the tester, and are used for measurement and control  
机带(或集成)传感器是设备的一部分, 用于测量和控制

**Calibration** sensors are external reference devices used for calibration and adjustment of onboard sensors  
校准传感器是外部的仪器用于校准和调整设备传感器

# Reference Devices vs. Onboard Sensors

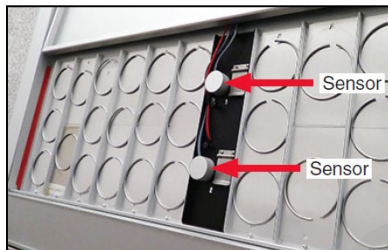
## 参考仪器 vs 设备传感器

QUV Irradiance

Q-SUN Irradiance

Q-SUN Temp

Onboard sensors  
设备传感器



Reference devices  
参考仪器



## Calibration in Test Standards

### 测试标准中的校准规范

- Test standards from ASTM, ISO, and other organizations often require calibrations, but there is not always consistency

ASTM、ISO和其他组织的测试标准通常规范了校准，但并不总是一致

- Consider ASTM G155 (xenon arc weathering). This gives very open-ended guidance on calibration:

ASTM G155 (氙弧老化) 对校准提供了非常开放的指导：

**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.

**6.3 仪器校准 - 确保标准化和精度**，与光老化设备相关的传感器（例如计时器、温度计、湿球传感器、干球传感器、湿度传感器、紫外线传感器、辐射计）需要定期校准，以确保测试结果的重复性。仪器校准应可追溯至国家或国际标准。校准频率和程序应符合制造商的说明和良好的实验室实践。

# Calibration in Test Standards

## 测试标准中的规范

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

常用的老化标准要求对设备传感器至少一年校准一次。有时还提供进一步的指导：

- **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 9370 要求设备传感器校准检查的频率高于每年一次，但未定义“频率”

- **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.

ISO 4892-1 推荐设备传感器校准检查的频率高于每年一次，但是并不要求

- **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.

ASTM G151 需要在每次更换灯管、滤光片或测试程序发生变化时进行设备传感器校准检查，以及参考辐照度仪的年度NMI可追溯校准和调整。

- **ISO 9370** and **ASTM G151** both require users to follow manufacturer’s recommendations.

ISO 9370和ASTM G151 都要求使用者遵循设备制造商的要求

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

对指导要求并不总是很清楚

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## Q-Lab's calibration recommendations

### Q-Lab校准推荐

- Q-Lab recommends frequent calibrations at regular intervals, for irradiance, temperature, relative humidity, & other parameters

Q-Lab 推荐定期校准，对辐照度，温度，相对湿度和其他参数

- We champion this within the standards community

我们在标准中一直倡导这点

- Technical documentation gives clear guidance on what to do and when
- 技术文档对于做什么，什么时候做给出了明确的指导

- Q-Lab's **Universal Calibrator** system makes calibration and adjustment simple in QUV and Q-SUN testers

Q-Lab的通用校准仪系统使得校准和调整很简单

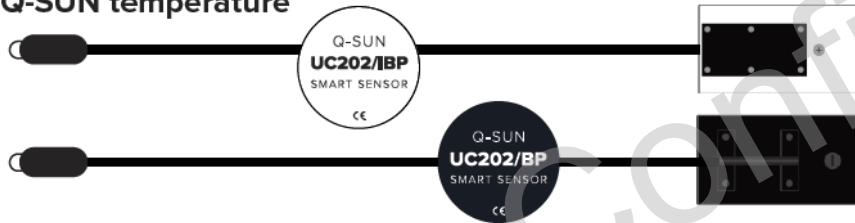
# Universal Calibrator System

## 通用校准系统

### Q-SUN irradiance



### Q-SUN temperature



### QUV irradiance





## Universal Calibrator Benefits

### 通用校准器的好处

- **Practicality 实用性**
  - Simplest and most cost-effective system on the market  
最简单最经济的系统
  - Doesn't require an expensive service visit  
不需要昂贵的服务拜访
  - Compatible with **all** Q-Lab testers  
兼容Q-Lab所有设备
- **Accuracy 准确性**
  - Proven, accurate, NIST-traceable calibration method  
验证的·准确的·NIST可追溯的校准方法
  - All calibrations of reference devices are performed under test conditions  
所有参考校准仪的校准都在测试条件下进行
    - This solidifies the traceability chain  
这巩固的追溯链
  - All calibrations of onboard sensors performed under actual test condition using reference devices of same type as the onboard sensors  
所有设备传感器的校准都是使用相同的参考校准仪在实际测试工况下进行的。

# Calibration: QUV Accelerated Weathering Testers

Sensor	Calibration Frequency	Calibration Instrument
Irradiance 辐照度	500 hours	UC10 Smart Sensor
Black Panel Temperature 黑板温度	6 months	Calibrated Reference Thermometer

- More frequent calibration is perfectly OK!  
更频繁的校准是好的
- Worth recalibrating also when test cycle, lamps, or sensors are changed  
当测试循环、灯管或传感器改变时，也需要重新校准



# Calibration: Q-SUN Accelerated Weathering Testers

Sensor	Calibration Frequency	Calibration Instrument
Irradiance 辐照度	500 hours	UC20 Smart Sensor
Black Panel Temperature 黑板温度	6 months	UC202 Smart Sensor
Chamber Air Temperature Relative Humidity 箱体空气/相对湿度	12 months	<i>Replacement</i>

- More frequent calibration is perfectly OK!  
更频繁的校准是好的
- Worth recalibrating also when test cycle, lamps, or sensors are changed  
当测试循环、灯管或传感器改变时，也需要重新校准



# Calibration: Q-FOG Corrosion Testers

Sensor	Calibration Frequency	Calibration Instrument
Temperature (Chamber Air, Wet/Dry Bulb) 温度 (箱体温度, 干球/湿球)	6 months	Reference thermometer
Shower and Fog deposition 喷淋和喷雾	Standards-dependent	Collections devices
Shower flow 喷淋流量	6 months	Tester sensors

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

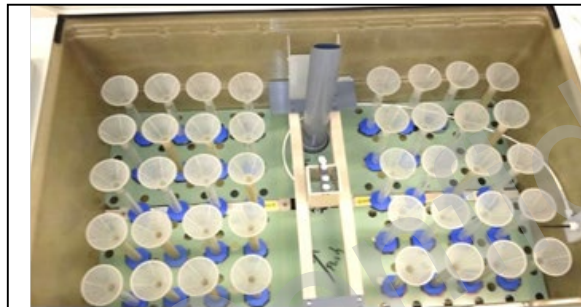
Q-FOG校准, 特别是沉降量收集的校准, 可能因测试而异



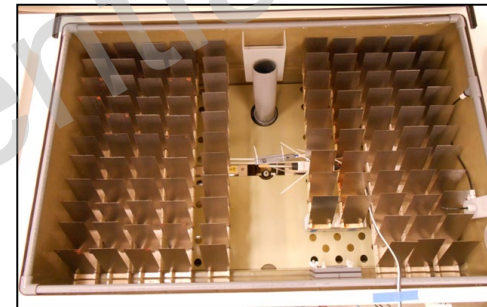
# Calibration: Q-FOG Corrosion Verification



Corrosion coupons  
参比样板



Pluviometry  
沉降量



Independent verification  
独立验证

- Widely-used calibration techniques (usually with adjustment) to ensure that the corrosivity delivered by the tester is what is expected.  
广泛使用的校准技术(通常带有调整), 以确保测试设备提供的腐蚀符合预期
- Different style than an onboard sensor calibration, but a calibration nonetheless  
和设备传感器校准不同, 但也是一种校准

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

### 为什么需要使用Q-Lab的辐照计和温度计进行校准？

- Irradiance (UC10, UC20) 辐照度
  - Calibrated to specific spectrum of xenon lamp/filter combination or UV lamp  
对特定氙灯光谱或紫外灯的校准
  - Eliminates effect of spectral mismatch  
消除光谱失配性
  - Avoids saturation issues with off-the-shelf spectrophotometers  
避免光谱仪的过饱和问题
- Temperature (UC202) 温度
  - Accounts for radiant heating from xenon lamps  
考虑氙灯产生的辐射
  - Includes convective cooling effects  
考虑对流冷却效果

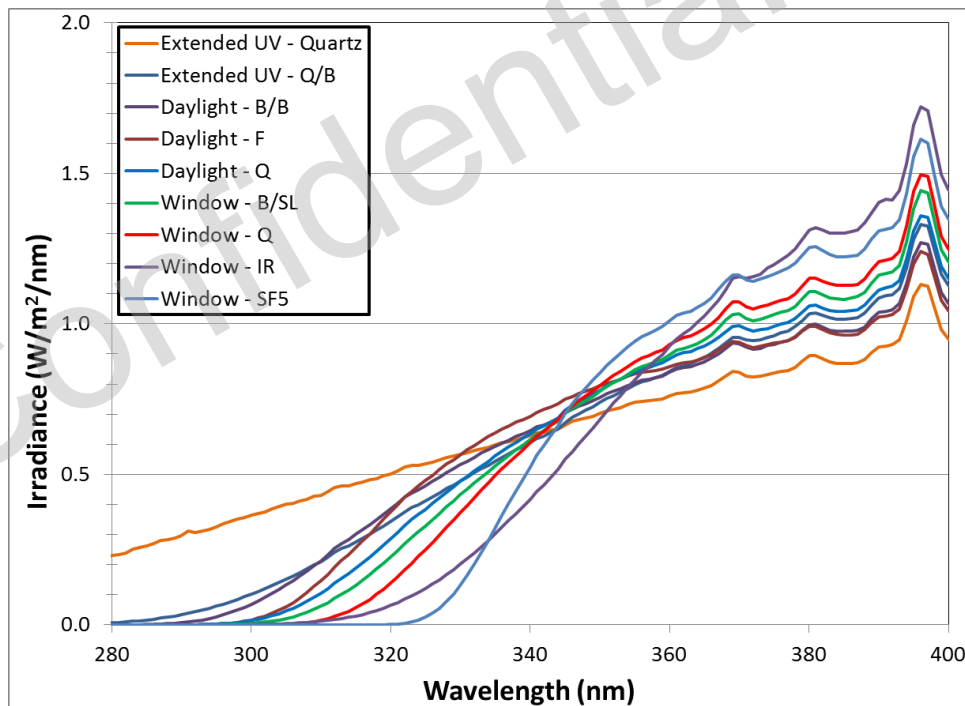
Reference thermometers and generic UV measurement devices do not calibrate onboard sensors properly for their service environment

**参考温度计和通用紫外辐射计不能针对其使用环境正确校准设备传感器**

## Spectral Mismatch - Optical Filters in Q-SUN Testers

### 光谱失配性 - Q-SUN氙灯设备的过滤片

- Differences between optical filters can lead to mis-calibration if not accounted for  
如果不考虑光学过滤器之间的差异，可能会导致校准错误
- This is known as spectral mismatch  
这就是光谱失配性



## Spectral Mismatch

### 光谱失配性

- If a UC20 calibrated for Daylight-Q filters measures a tester with Window-Q filters installed, an actual irradiance of  $1.00 \text{ W/m}^2/\text{nm}$  @340 nm will measure only  $0.94 \text{ W/m}^2/\text{nm}$   
如果设备使用的是Window-Q滤片，那么用UC20选择Daylight-Q选项做测量，测量值变成0.94而不是1（正确值）。
- That spectral mismatch-induced error is 6%  
光谱失配引起的误差为6%
  - This can significantly affect test results!  
严重影响测试结果
  - The opposite scenario (i.e. calibrating Daylight-Q with a Window-Q reference device) causes the reverse issue  
相反的情况（即使用Windows-Q设定来校准Daylight-Q）会导致相反的问题

**Imagine errors possible for a device not designed for Q-SUN testers at all!  
想象一下，一个根本不是为Q-SUN设备设计的校准仪会出现怎样的错误！**



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## Q-Lab Global Calibration Locations - ISO 17025 Accredited

### Q-Lab 全球校准机构 - ISO 17025 认证


- US
- UK
- China
- Germany



# Calibration Certificates - Onboard Sensors


## 校准证书 - 设备传感器

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:**

Model:

Serial No:

Prior Calibration Date:

**Working Standard Radiometer:**

Type:

Serial No:

Calibration Date:

**Tester Information:**

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 this user performs a calibration verification check every 500 light hours. Light hours since the last calibration can be found by pushing the "i" button and scrolling to 010 on the QUV tester or 05 on Q-SUN testers.

**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).

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

Lamp type (QUV only):       UV filter type (Q-SUN only):

Irradiance sensor wavelength (Q-SUN only):

	<input type="checkbox"/> Irradiance ( W/m <sup>2</sup> at nm** ) <input type="checkbox"/> Illuminance (lux)			
	Ch. 1	Ch. 2	Ch. 3	Ch. 4
As Found				
Zero - reference radiometer				
Zero - unit under test*				
Span - reference radiometer				
Span - unit under test				
As Left				
Zero - reference radiometer	Ch. 1	Ch. 2	Ch. 3	Ch. 4
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/cm<sup>2</sup>.  
The calibration uncertainty at a 95% confidence level using a coverage factor of k=2 is ±5.5%.

Calibration Performed By:       Approved By:

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Form LP-CAL-01, Rev. 20, 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:**

Model:

Serial No:

Prior Calibration Date:

**Tester Information:**

Model:

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	
<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

**Sensor Type:**

	1		2		1		2	
	1	2	1	2	1	2	1	2
Calibration Point: (or Hygrometer Reading):	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Reference Thermometer (or Hygrometer Reading):	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Tester Temperature (or RH Reading) As Found:	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Tester Temperature (or RH Reading) As Left:	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

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%

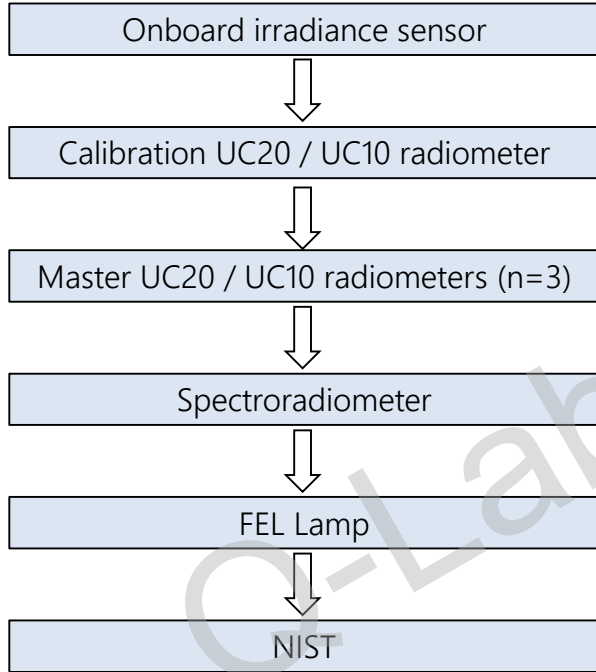
Calibration Performed By:       Approved By:

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# Traceability Chain – Irradiance

## 追溯链 – 辐照度





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


<b>Customer Name and Address:</b>  	<b>Tester Information:</b> Model: <input type="text"/> Serial No: <input type="text"/> Prior Calibration Date: <input type="text"/> <b>Working Standard Radiometer:</b> Type: <input type="text"/> Serial No: <input type="text"/> Calibration Date: <input type="text"/>	<b>Calibration Performed:</b> <input type="text"/> <b>Calibration Date:</b> <input type="text"/> <b>Valid Until:</b> <input type="text"/> <small>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.</small> <small>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.</small>
---	--	--


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	<input type="checkbox"/> Irradiance ( $W/m^2$ at $nm$ )**			<input type="checkbox"/> Illuminance (lux)	
	Ch. 1	Ch. 2	Ch. 3	Ch. 4	
Zero – reference radiometer					
Zero – unit under test*					
Span – reference radiometer					
Span – unit under test					
<b>As Left</b>	<b>Ch. 1</b>	<b>Ch. 2</b>	<b>Ch. 3</b>	<b>Ch. 4</b>	
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/cm<sup>2</sup>  
 The calibration uncertainty at a 95% confidence level using a coverage factor of k=2 is ±6.5%.

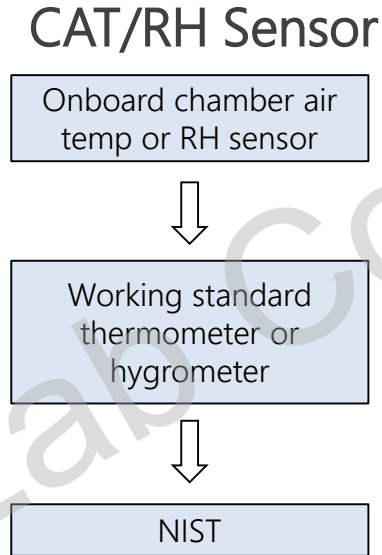
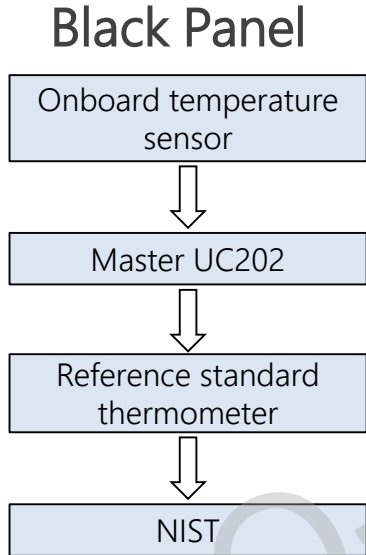
Calibration Performed By:   


Approved By:   



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# Traceability Chain – Temperature

## 追溯链 – 温度





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 GRH600-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:

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# Calibration Temperature Sensors

## 校准温度传感器



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

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

MASTER DATA	Initial			Final		
	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

UNIT UNDER TEST DATA	Initial (as received)			Final (after calibration)		
	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. The calibration uncertainty at a 95% confidence level using a coverage factor of k=2 is ± 1.5 °C

Comments: R8

# Calibration Certificate: Temperature Sensors - Traceability Chain

## 校准证书：温度传感器 - 追溯链

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 

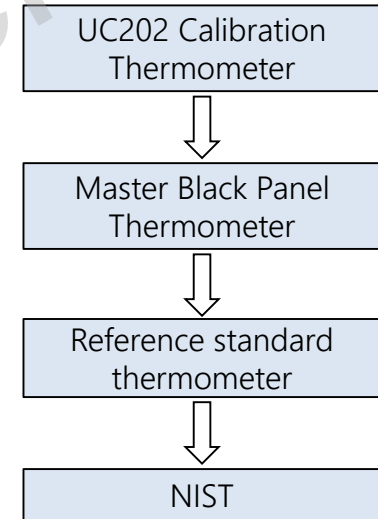
This Black Panel Calibration Thermometer has been calibrated to test procedure UC-11002-T using instrumentation traceable to the National Institute of Standards and Technology (NIST). It should only be used to calibrate the black panel temperature sensor in Q-SUN Xenon Test Chambers. The Q-Lab Corporation calibration lab is ISO 17025 accredited by A2LA.

**Traceability Chain**

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

<p>Q-Lab Corporation Repair Dept 800 Canterbury Road Westlake, OH 44145 United States</p>	<p>Serial No: <u>18-29924-11-UC202/BP</u> Prior Calibration: <u>20-Jan-2022</u></p>	<p>Calibration Date: <u>3-May-2022</u> Valid Until: <u>3-May-2023</u></p> <p>Certificate will be made valid for 12 months from date of calibration unless otherwise specified by the customer at the time of order placement.</p>
---	---	---

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



## Calibration Certificate: Temperature Sensors - Calibration Validity

### 校准证书：温度传感器 - 校准有效期

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

### 校准证书：温度传感器 - 测试数据

MASTER DATA	Initial			Final		
	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

UNIT UNDER TEST DATA	Initial (as received)			Final (after calibration)		
	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  $\pm 1.5$  °C

# Calibration Irradiance Sensors (Radiometers)



## 校准辐照度传感器 (辐照计)

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

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

```

            graph LR
            A[radiometer] --> B[3 master radiometers]
            B --> C[spectroradiometer]
            C --> D[FEL Lamp]
            D --> E[NIST]
            
```

Q-Lab Corporation Acceptance Testing 800 Canterbury Road Westlake, OH 44145 United States	Serial No: <u>20-21704-13-UC20/340</u> Prior Calibration: <u>26-Aug-2021</u>	Calibration Date: <u>30-Aug-2022</u> Valid Until: <u>30-Aug-2023</u> <small>ASTM G151, sec. 6.1.7.4 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.</small>
---	---	---

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

	Irradiance (W/m <sup>2</sup> /nm @340nm)			
	#1	#2	#3	Avg
MASTER DATA				
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. The calibration uncertainty at a  
 Comments: Working Standard R9 95% confidence level using a  
coverage factor of k=2 is ± 5.5%



# Calibration Certificate: Irradiance Sensors - Traceability Chain

## 校准证书：辐照度传感器 - 追溯链

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

**Q-LAB**

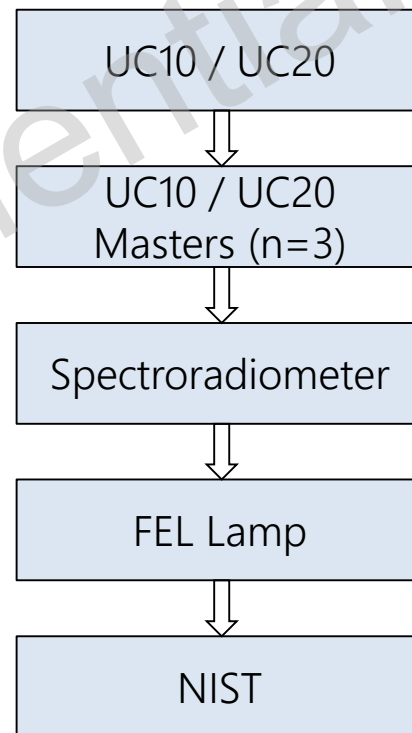
Calibration Certificate #300822202170413UC20/340  
UC20/340 Radiometer for Use with the SOLAR EYE  
Irradiance Control System on Q-SUN Xenon Test  
Chambers

   
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**

```
graph LR; A[radiometer] --> B[3 master radiometers]; B --> C[spectroradiometer]; C --> D[FEL Lamp]; D --> E[NIST]
```



## Calibration Certificate: Irradiance Sensors - Calibration Validity

### 校准证书：辐照度传感器 - 校准有效期

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

## 校准证书：辐照度传感器 - 测试数据

### Q-SUN UC20

MASTER DATA	Irradiance (W/m <sup>2</sup> /nm @340nm)			
	#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%

### QUV UC10

MASTER DATA (calibration version 2)	Irradiance UV-A Lamps (W/m <sup>2</sup> /nm @340nm)				UV-B Lamps (W/m <sup>2</sup> /nm @310nm)			
	#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								

Condition when received:  
Comments:

Good. Proceed with Calibration.  
Working Standard R9

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

# Agenda

- Calibration and adjustment

校准和调整

- Benefits of calibration

校准的好处

- Calibration requirements in weathering and corrosion testing

在老化和腐蚀测试中的校准要求

- Q-Lab calibration recommendations

Q-Lab校准推荐

- Calibration documentation

校准文件

- Accuracy and uncertainty

准确度和不确定度

# Calibration Uncertainty Budget

## 测量不确定度

- The accuracy of onboard sensors is determined by the accuracy of the references used to calibrate them  
设备传感器的准确度取决于用于校准它的参考设备的准确度
- This is calculated by preparing an uncertainty budget, shown here for UC20 irradiance smart sensors  
这是通过编制不确定性预算来计算的，如图所示，用于UC20辐照度智能传感器

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
<b>Combined Uncertainty</b>	<b>±5.6%</b>	<b>±2.8%</b>

## Accuracy and Uncertainty

### 准确度和不确定性

- A very common question in calibration: *What is the accuracy of my sensors?*

校准中一个非常常见的问题：传感器的准确度多少？

- Consider BP/IBP sensors:

考虑黑板/黑标传感器：

- Calibrated with a  $k=2$  measurement uncertainty of  $\pm 1.5\text{ }^{\circ}\text{C}$ . This is stated on the device calibration certificate.  
在 $k=2$ 下测量不确定度为 $\pm 1.5\text{ }^{\circ}\text{C}$ 的。这在设备校准证书上有说明
- 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.  
在氙弧灯的辐射下校准，专门用于Q-SUN氙灯设备。这是不确定性的主要来源
- We calibrate these devices using reference black panel sensors, and our laboratory accredited to perform the calibration in accordance with ISO 17025.  
我们使用参考黑板温度传感器校准这些设备，并且我们的实验室具备ISO 17025校准资质

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

设备传感器的准确度取决于用于校准它的参考计的准确度



## Summary – Calibration and Documentation

### 总结 – 校准和文件记录

- Calibration of onboard sensors is critical for correct, consistent performance of weathering and corrosion testers  
设备传感器的校准对于保证正确的一致老化和腐蚀测试至关重要
- Calibration requirements from test standards are not always very descriptive  
测试标准中对于校准要求不总是很详细
- The Universal Calibrator system makes irradiance and temperature calibration simple for QUV and Q-SUN testers  
通用校准系统使得辐照度和温度校准变得很简单
- Extensive documentation is provided with calibration certificates for onboard sensors and calibration devices, including:  
设备探头和校准设备的校准证书提供了大量的文件：
  - Traceability chain 追溯链
  - Customer information and calibration validity 客户信息和校准有效性
  - Test conditions 测试条件
  - Reference devices and test data 参考设备和测试数据
- Sensor accuracy is determined by the accuracy of the devices used to calibrate them  
设备传感器精度由校准设备的精度决定

# Thank you for your attention!

## Questions?

Send your inquiry to:  
[kqu@g-lab.com](mailto:kqu@g-lab.com)

# Q-Lab中国微信公众账号： 耐候腐蚀设备及测试专家

- ✓ 技术研讨会、网络研讨会信息
- ✓ 老化及腐蚀技术文章、最新测试标准解读等
- ✓ 相关技术问题，也可通过平台留言，我们会在24小时内和您联系

扫一扫，关注我们

