Black Panel Temperature Control in Accelerated Laboratory Weathering Testing
实验室光老化测试中的黑板温度控制

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Temperature in Accelerated Weathering Testing
光老化测试中的温度

- Temperature is specified in nearly every accelerated weathering test

几乎每个老化测试都要求温度控制

  - Black panel temperature (UV fluorescent, xenon arc)

    黑板温度（荧光紫外，氙灯）

  - Chamber air temperature (xenon arc)

    箱体空气温度（氙灯）

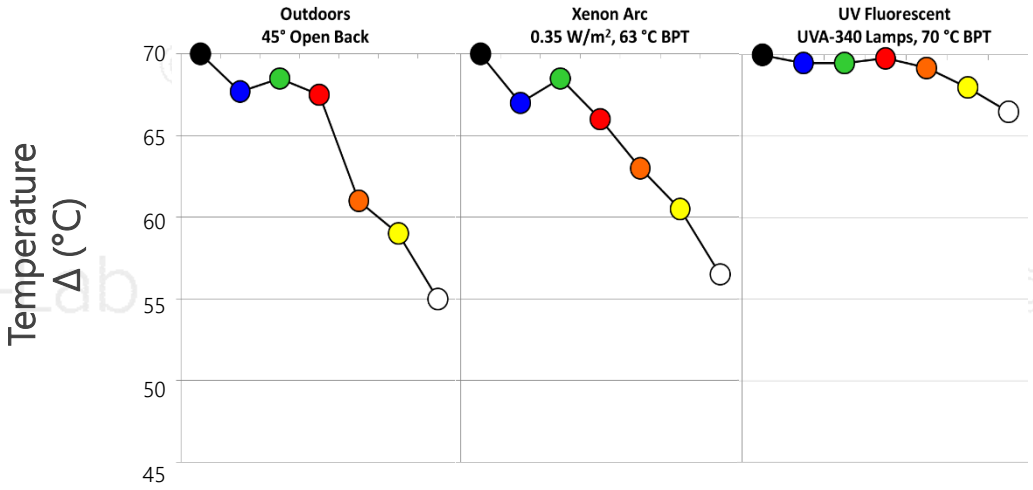
- Goal is typically to accelerate degradation by testing at elevated temperatures

材料在高温下加速老化

- **Tester** control temperature often differs significantly from actual **specimen** temperature

实际的样品温度和设备控制的温度是有很大差异的

Temperature and color 温度和颜色



- Specimen color affects strongly temperature when exposed outdoors

在太阳下曝晒，材料颜色影响表面温度

- Specimens in xenon testers absorb visible and IR light, increasing their temperature much like outdoors

样品在氙灯老化箱中吸收灯管发出的可见光和红外线，类似于户外的现象

- UV fluorescent testers do not generate much radiant heat for specimens; color differences are small

荧光紫外不会为试样产生太多的热辐射；色差很小

Black Panel Temperature Control 黑板温度控制

- Most common in test standards

黑板在测试标准中很常见

- Approximates maximum specimen surface temperature better than air temp

比空气温度更接近试样表面的最高温度

- Can be used in combination with chamber air temp sensor and control

黑板温度和空气温度可以一同控制

- Typically not practical to monitor sample surface temp

监测试样表面温度操作性不强

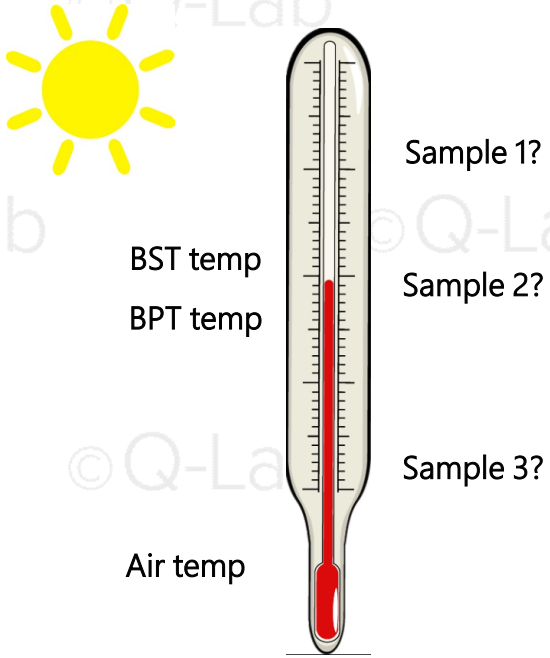
- Samples might melt due to unrealistic high surface temperature if uncontrolled

如不加以控制黑板温度，试样可能会因为过高的表面温度而熔化

- BP control improves test repeatability and reproducibility

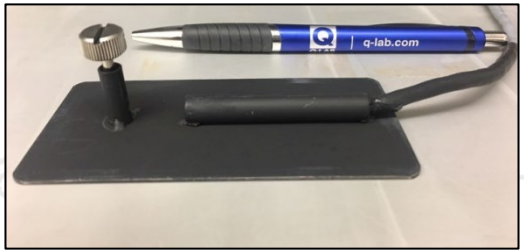
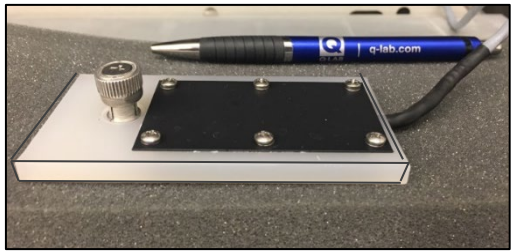
黑板温度控制提高了测试的可重复性和可再现性

Where is your sample surface temp?
你的样品温度是多少?



- Painted steel panel
- White plastic
- Black plastic
- Transparent plastic
- Display
- Leather and textile

Terminology: Black Surface Temperature Sensors

Panel	Construction	ASTM Designation	ISO Designation
	Black painted stainless steel	Uninsulated Black Panel 非绝缘黑板	Black Panel 黑板
	Black painted stainless steel mounted on 0.6 cm white PVDF	Insulated Black Panel 绝缘黑板	Black Standard 黑标

Black Panel (BP) Temperature Control

- BP temp sensor mimics specimen temperature; does not match chamber air temperature

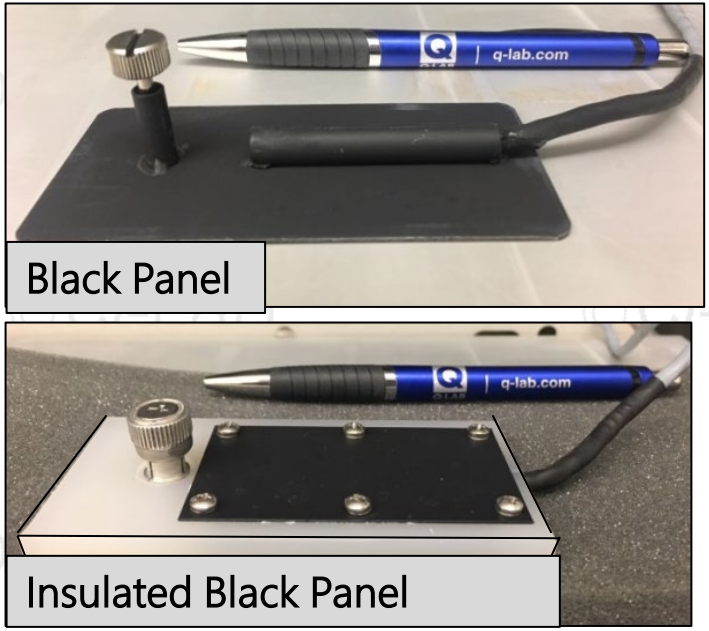
黑板温度模拟样品温度，和箱体空气差别较大

- BPT standardizes conditions experienced by specimens, independent of room conditions

黑板温度标准化了试样经受的环境，和实验室环境无关

- BPT does not *necessarily* match any particular specimen temperature or represent the hottest temperature in the tester!

黑板温度不一定和特定的试样温度相匹配，也不一定代表试样表面的最高温度！



Xenon arc temp sensors

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UV fluorescent temp sensors

What influences Black Panel Temp?

- Radiation (mainly visible light and infrared radiation)

辐射（主要是可见光和红外线）

  - More significant for Xenon Arc than UV fluorescent

    氙灯比荧光紫外更明显

  - Irradiance level

    辐照强度

  - Optical filter type (infrared absorbing or reflecting)

    光过滤片种类（红外吸收或反射）

- Thermal conduction construction (insulated vs. uninsulated)

热传导（黑板和黑标的结构）

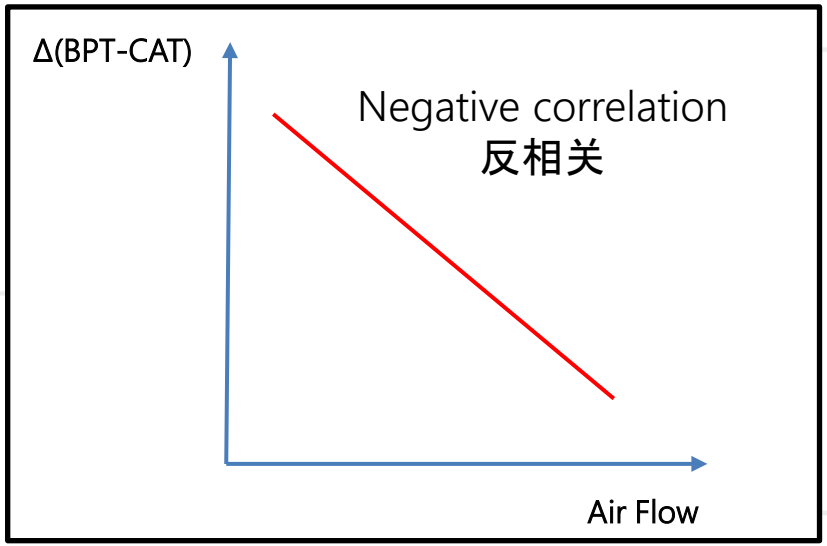
- Chamber air flow and temperature

箱体空气温度和气流

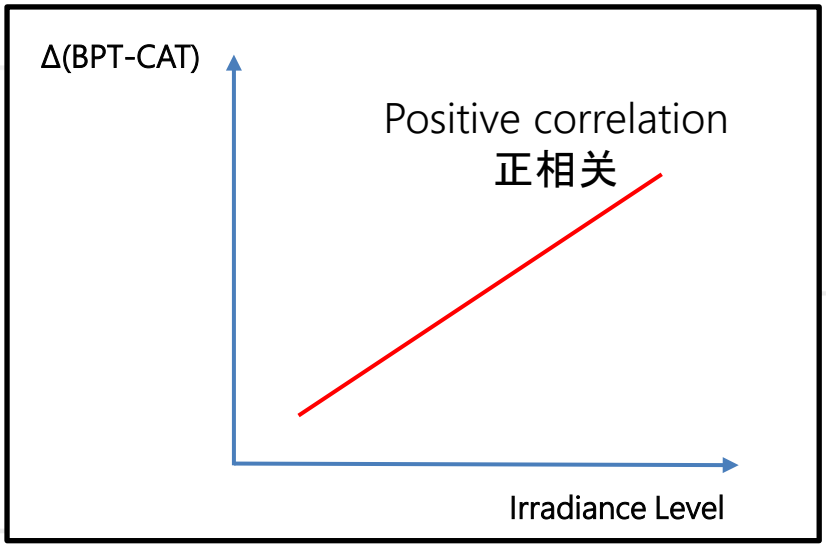
- Water Spray (though BP temp is not *typically* controlled)

水喷淋（黑板在水喷淋阶段通常不受控）

BPT, CAT, Airflow, and Irradiance



Greater airflow narrows the temperature differential
气流越大温差越小



Higher irradiance widens the temperature differential
辐照越高温差越大

Black Panel Specification

- In **theory**, an insulated black panel is intended for plastic materials and an uninsulated black panel is meant for painted metals.

理论上，绝缘黑板用于塑料，非绝缘黑板用于金属涂层板

- In **practice** … 但实际上
  - BP are more popular in the USA; IBP are more popular in Europe

    BP在北美更多，IBP在欧洲更多
  - Many standards allow both types, with no guidance

    许多标准允许两种温度计，没有指导意见
  - Standards for general testing may only allow BP, like ASTM does

    比如ASTM 标准仅允许BP
  - ISO plastics and paint standards both list IBP first

    ISO 塑料和涂料标准两者都允许，但优先IBP
  - "Equivalent" temperature setpoints for BP and IBP are not aligned

    BP和IBP的所谓的"等效"温度设定点并未对齐
  - IBP are never, ever specified in UV fluorescent tests

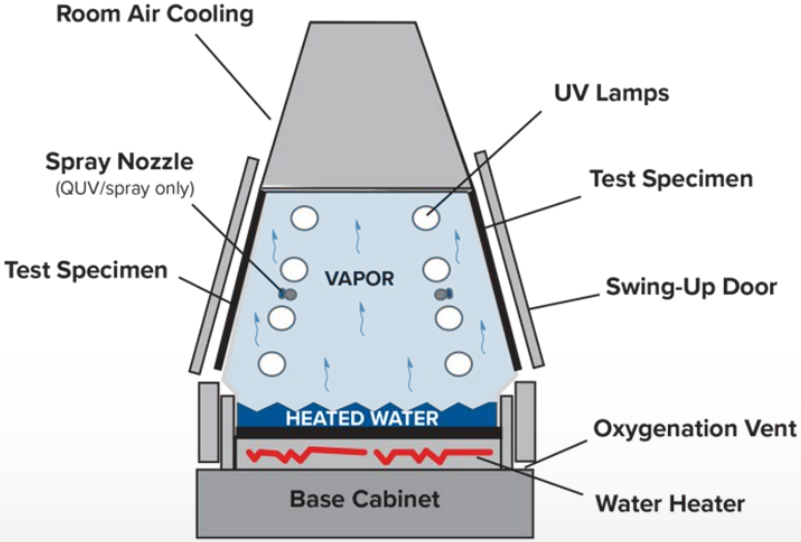
    IBP之前不在荧光紫外标准里

Selecting a Black Panel Type

- Test results demonstrate that proper choice of black panel type can bring specimen temperatures in line with test setpoints
测试结果表明正确选择黑板类型可以使得试样温度更匹配设定值
  - Painted metals match BP
  金属涂层板更符合黑板
  - Plastics match IBP
  塑料材料更符合黑标
  - IBP should be used more in UV fluorescent testing for Plastic
  IBP应更多使用于塑料材料的荧光紫外老化测试
  - 3D specimen testing also better suited to IBP
  三维试样更应该用IBP

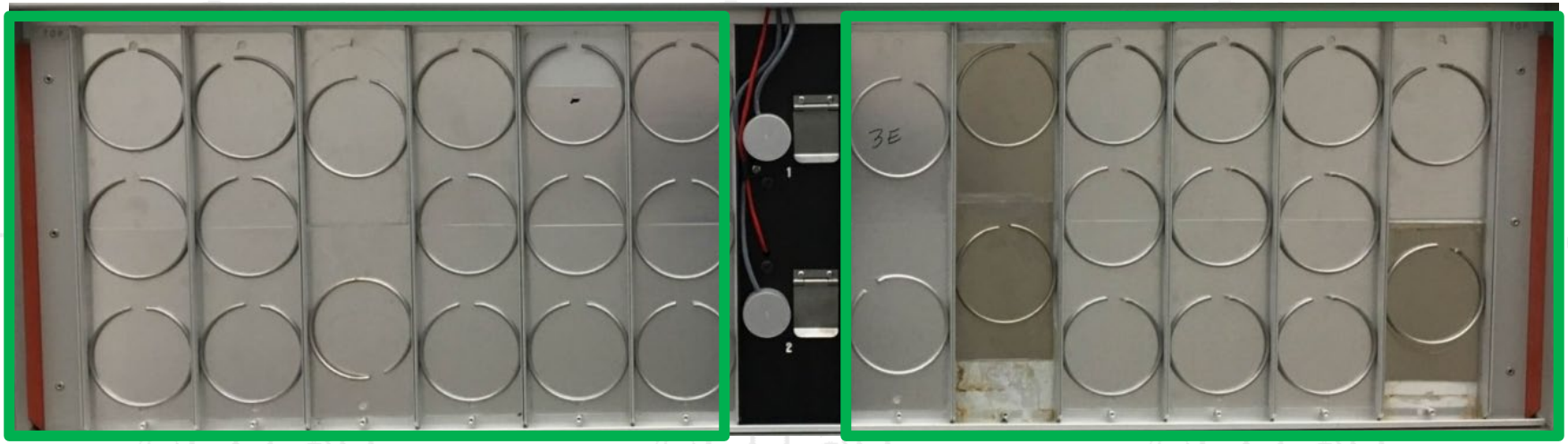
- Construction of a “Black Standard” IBP is carefully specified
“黑标”温度计的结构有明确规范
  - Other insulating BP designs are not expressly permitted
  其他绝缘黑板设计未明确允许
  - They can be shown to match well results from a Black Standard
  这些绝缘黑板可以很好匹配黑标的结果

Specimen Temperatures: Fluorescent UV



Fluorescent UV testing

Standard “2D” Specimen mounting



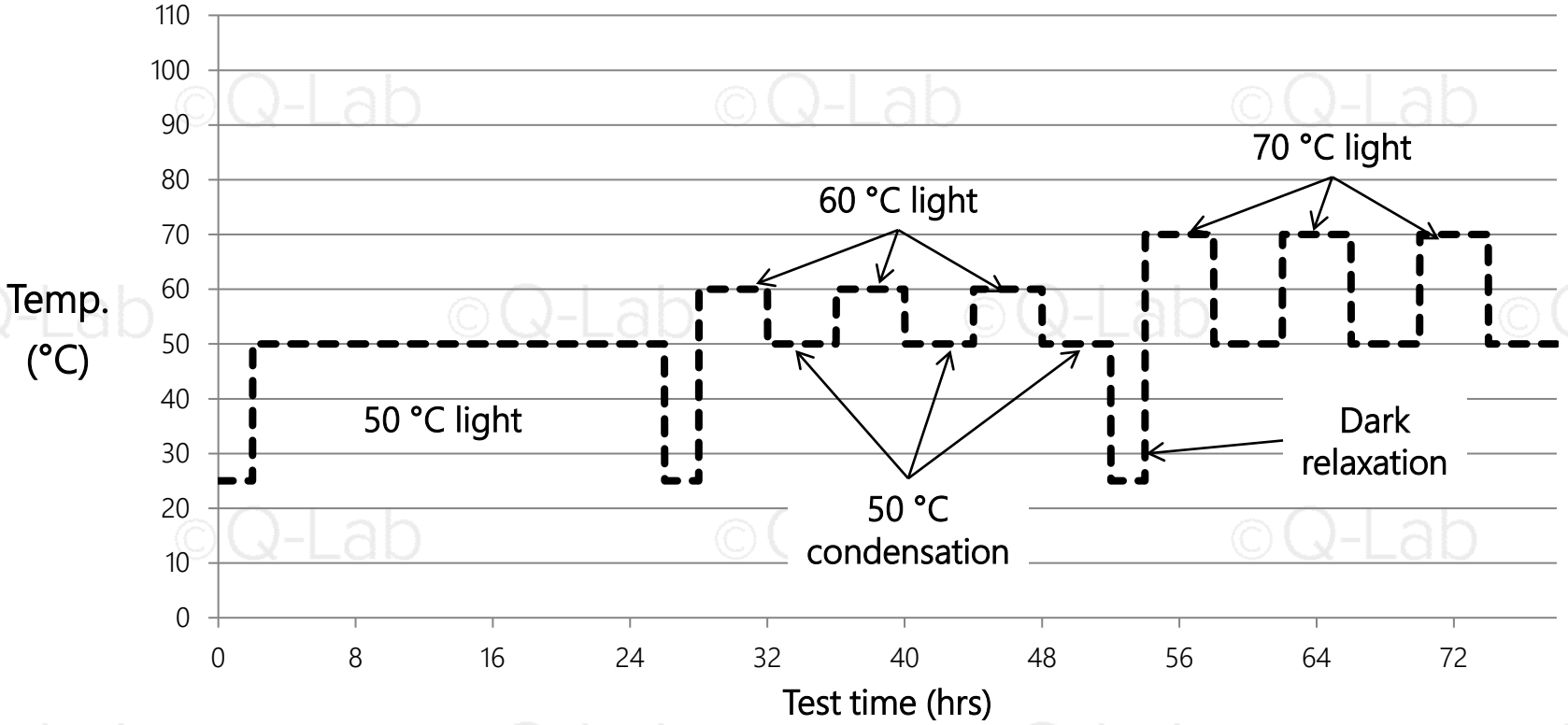
- Typical mounting for flat panels in a fluorescent UV tester

典型的紫外老化箱中的平板样品

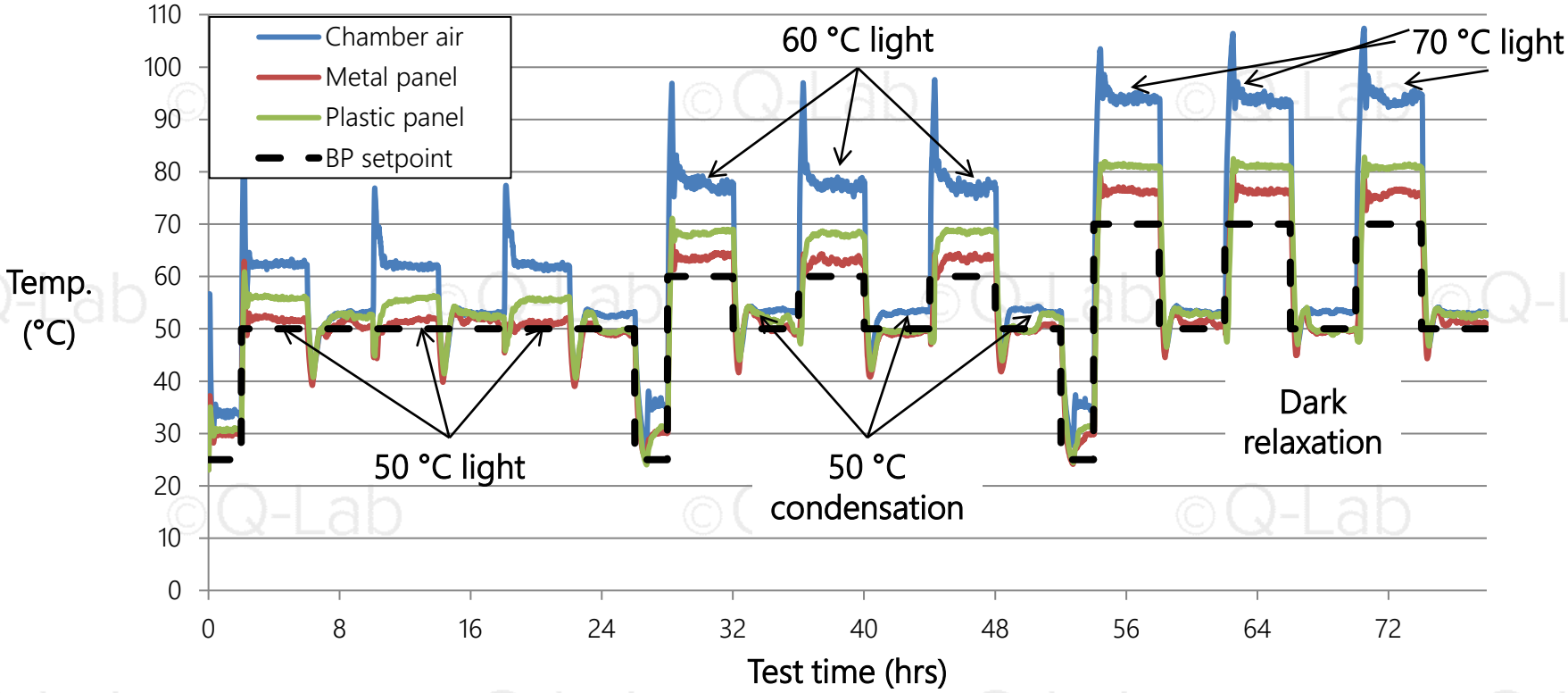
- Front two “quadrants” are shown

机器正面的放样区域

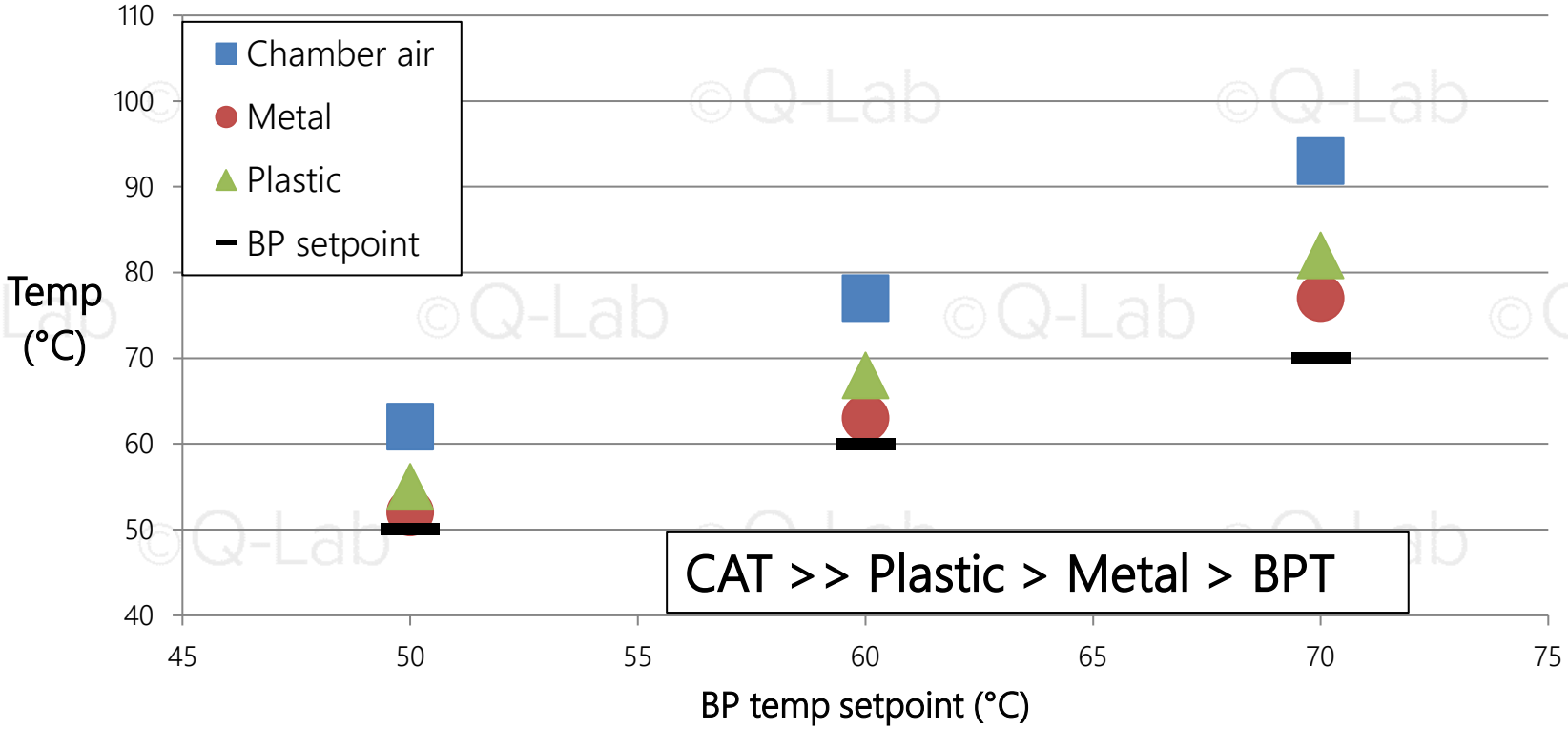
Fluorescent UV Test Cycle



Fluorescent UV Experimental Results

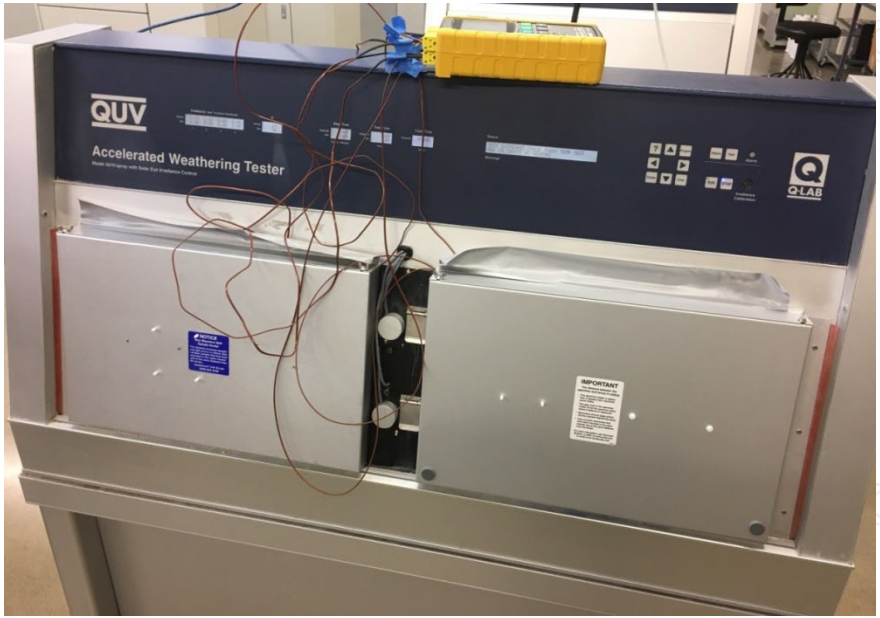


Fluorescent UV Test Cycle: Simplified View



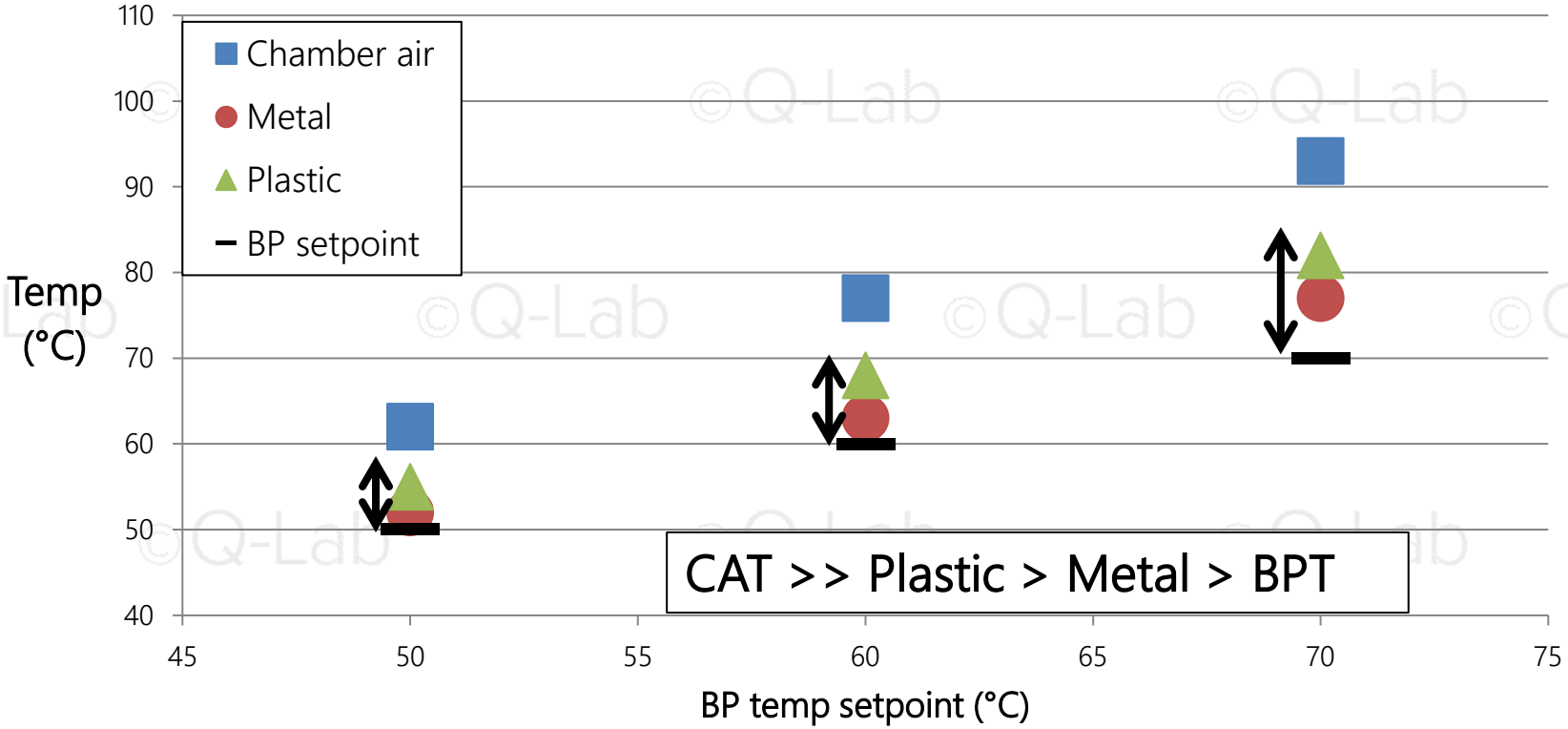
Fluorescent UV testing

“3D” Specimen mounting

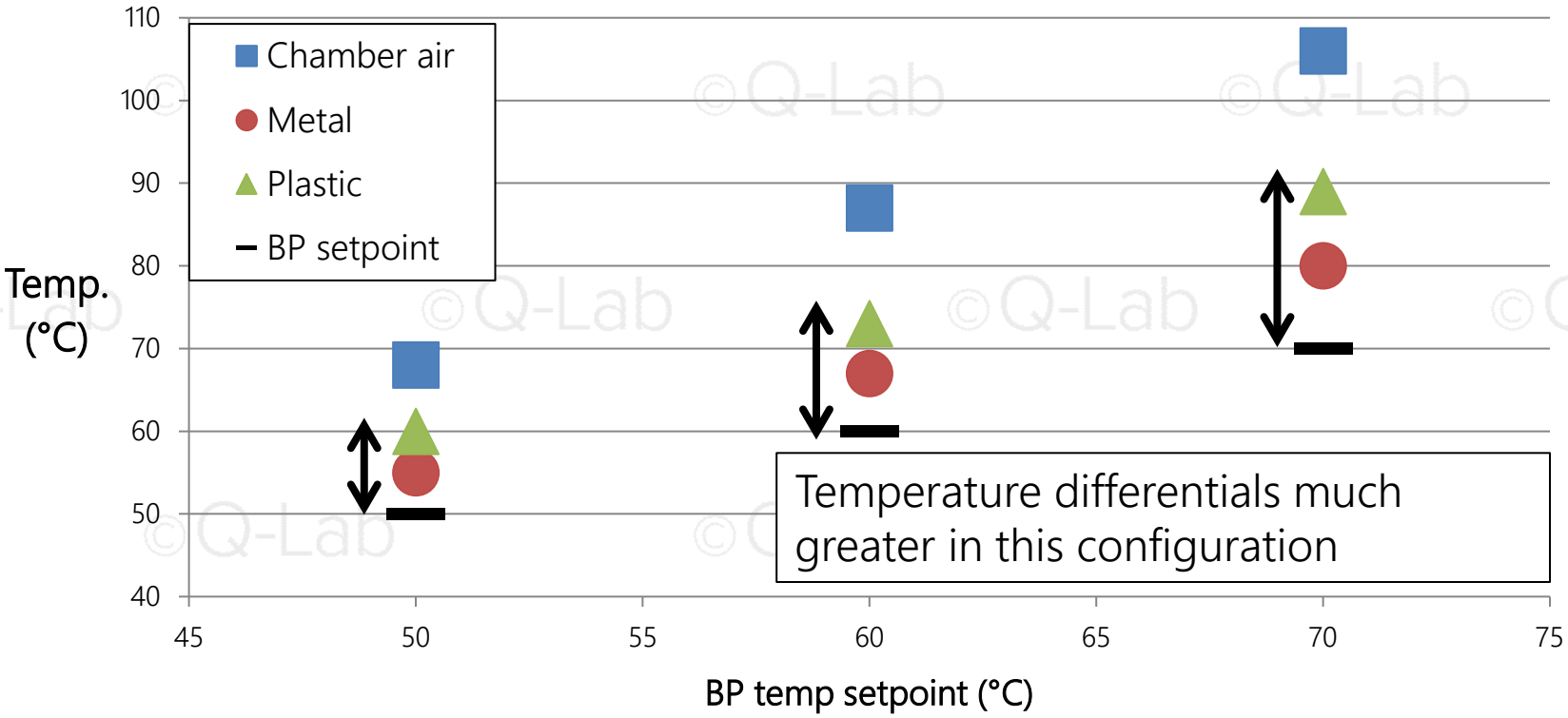


Quadrant boxes allow weathering of three-dimensional specimens

Test Cycle: 2D results (reminder)



Specimen temperatures: 3D configuration



Why the temperature differences?

- Black panel was cooled by laboratory air

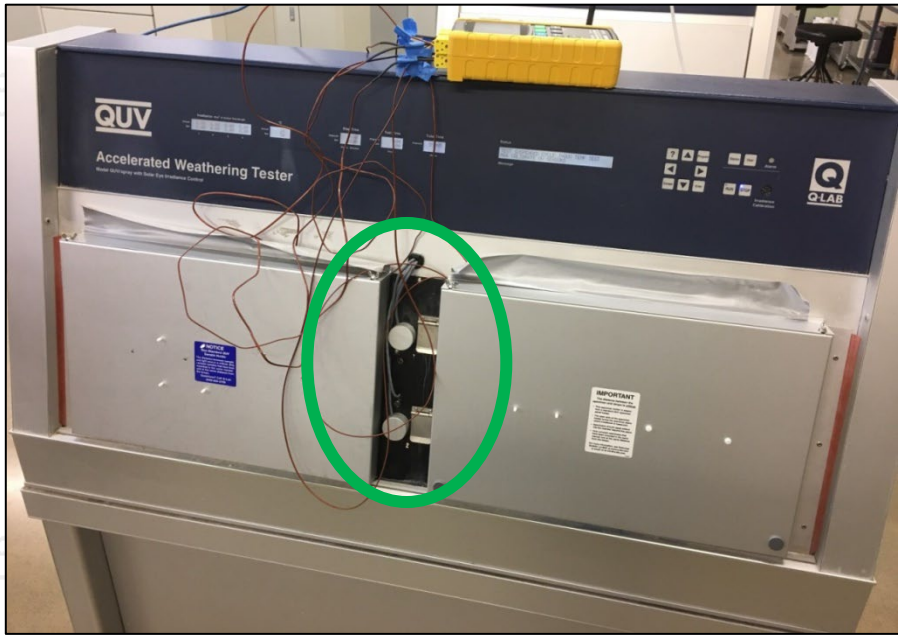
实验室冷空气使黑板冷却

- This increases heater output, leading to higher temperatures

这会增加加热器输出，导致更高的空气温度

- This can lead to melting and glass transition when testing plastics

进而导致塑料材料超过其玻璃化温度而熔化



Insulating Black Panel

- IBP will retain heat better than BP, offsetting some of the heat loss to the chamber air

相比BP, IBP更容易保持热量，抵消部分热量损失

- How will specimen temperatures be affected by use of an IBP?

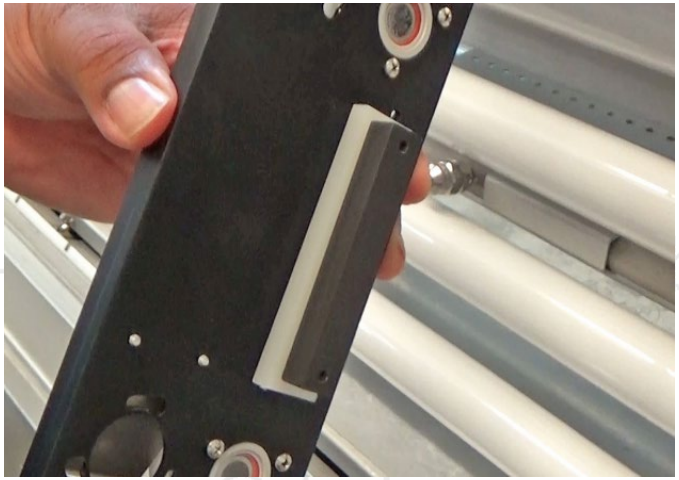
使用IBP会如何影响到试样温度？

  - Metals vs plastics

    金属 vs 塑料

  - 2D vs 3D

    二维试样 vs 三维试样

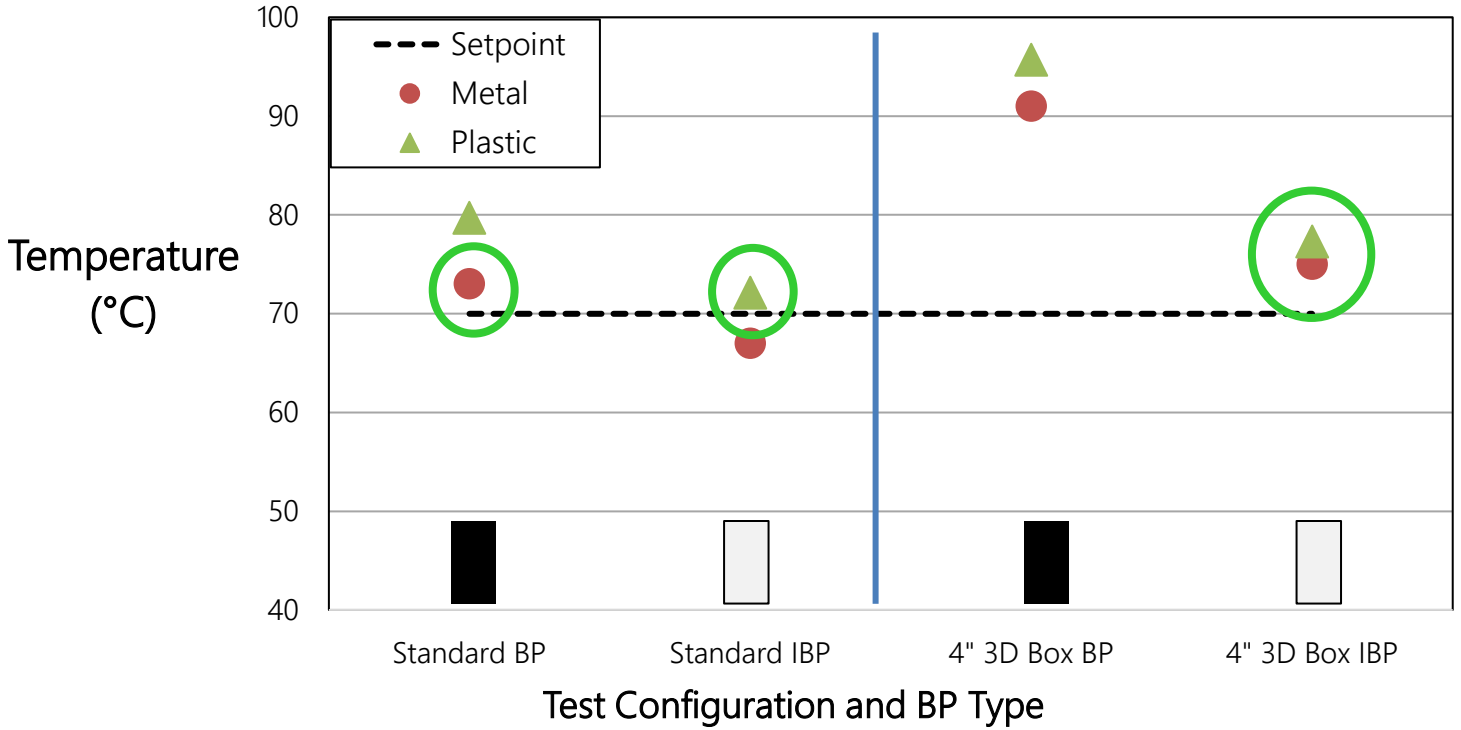


Specimen Temperatures – 70 °C setpoint

		Specimen Material		
Front Door	Black Panel Type	steel	aluminum	plastic
standard configuration	BP	73	71	80
	IBP	67	63	72
4" 3D Specimen Quadrant Box	BP	91	91	96
	IBP	75	76	77

IBP better match for 2D plastics, and all 3D specimens

Specimen Temperatures – 70 °C setpoint



Use of IBP in UV Fluorescent Testing

- ISO standards define precisely the construction of a “Black Standard”*

ISO 标准精确定义了“黑标”的结构

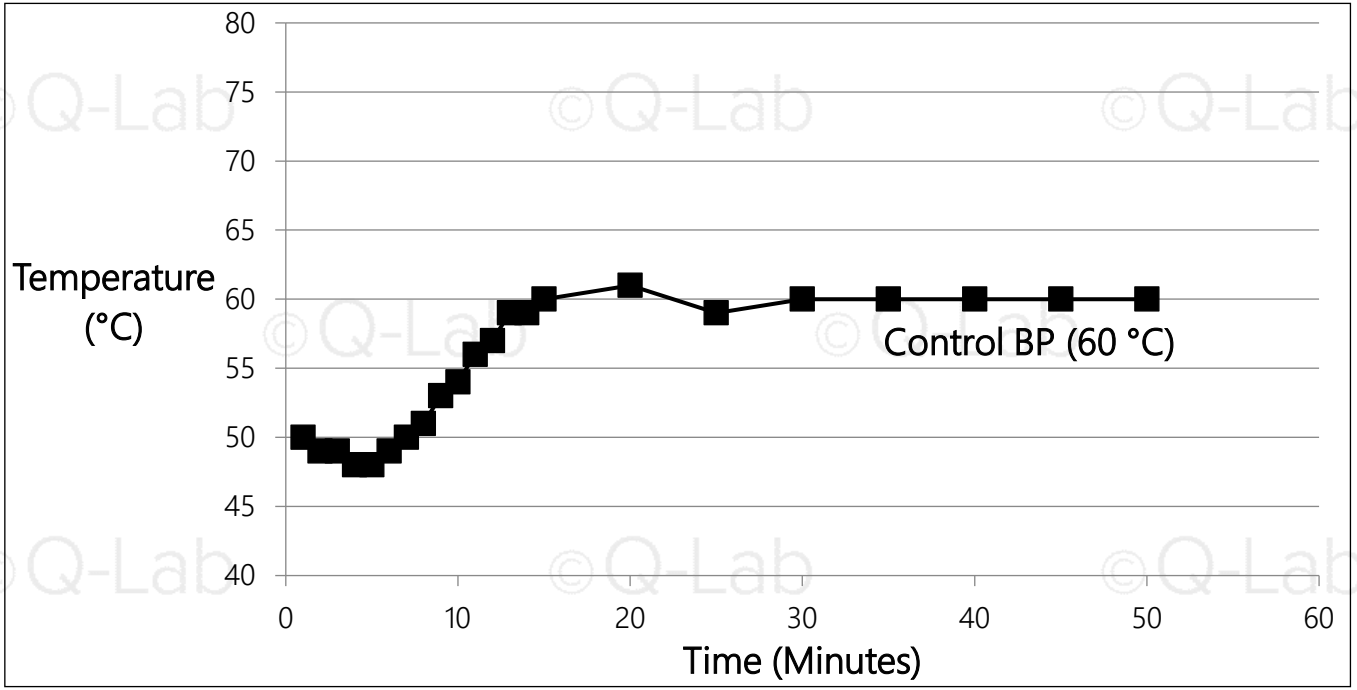
  - Dimensions 尺寸
  - Materials 材质
  - Sensor location (not facing specimens) 传感器位置

- Other insulated black panels are not expressly allowed *unless they produce the same results*

除非产生相同的结果，否则不允许使用其他绝缘黑板

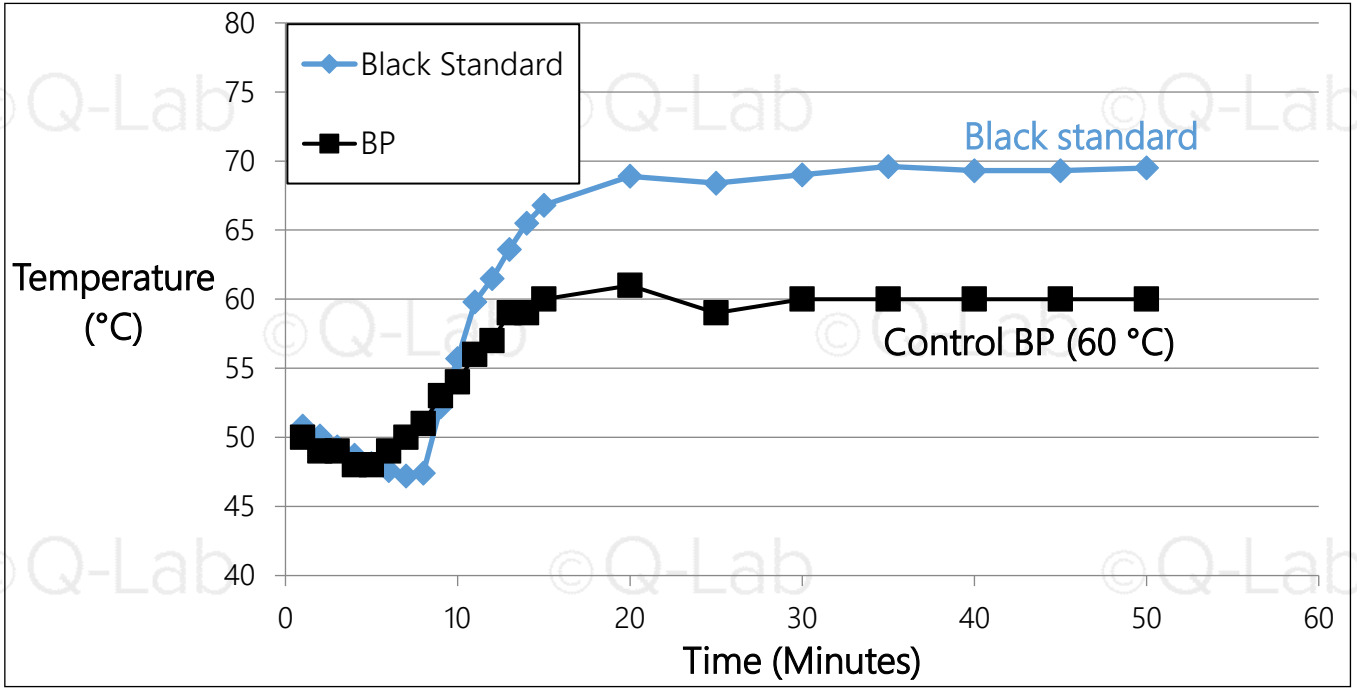
**ASTM defines the identical construction and calls it an Insulated Black Panel*
ASTM定义了相同的结构，并称之为绝缘黑板***

3D configuration with Insulation



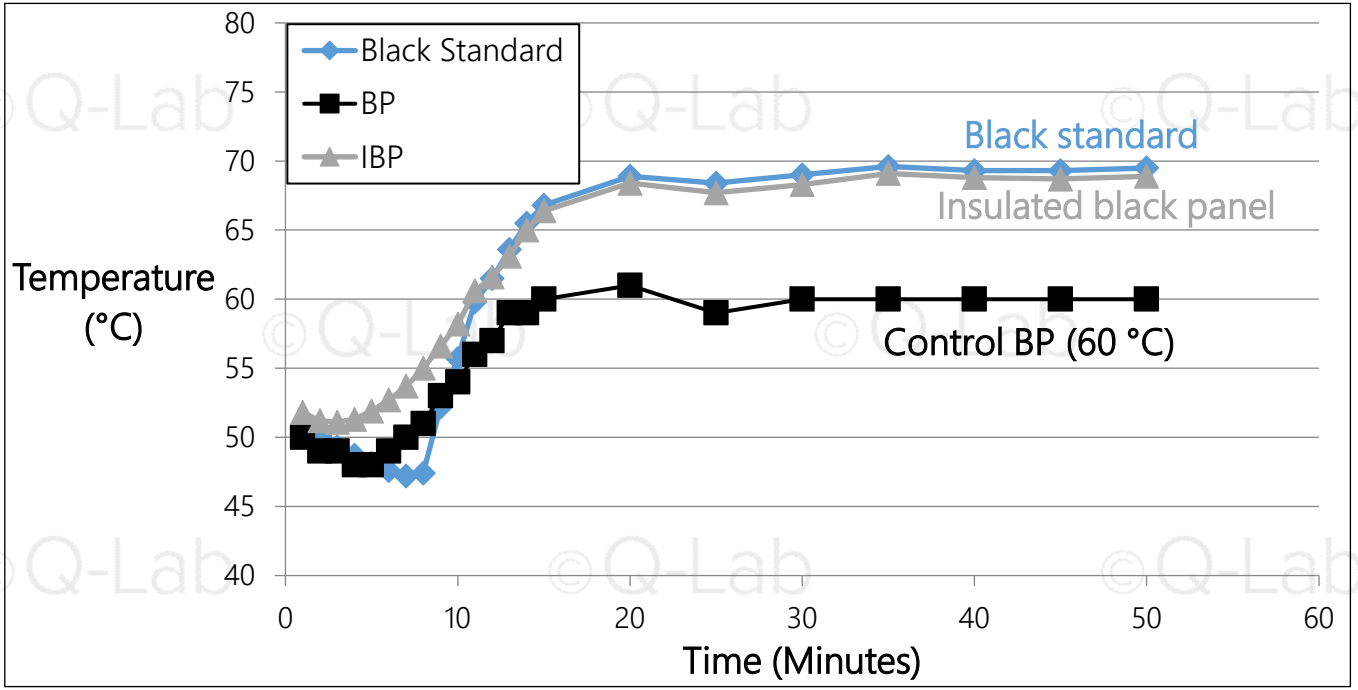
Temperature controlled by a BP to 60 °C

3D configuration with Insulation



Black standard runs hotter because it holds in heat

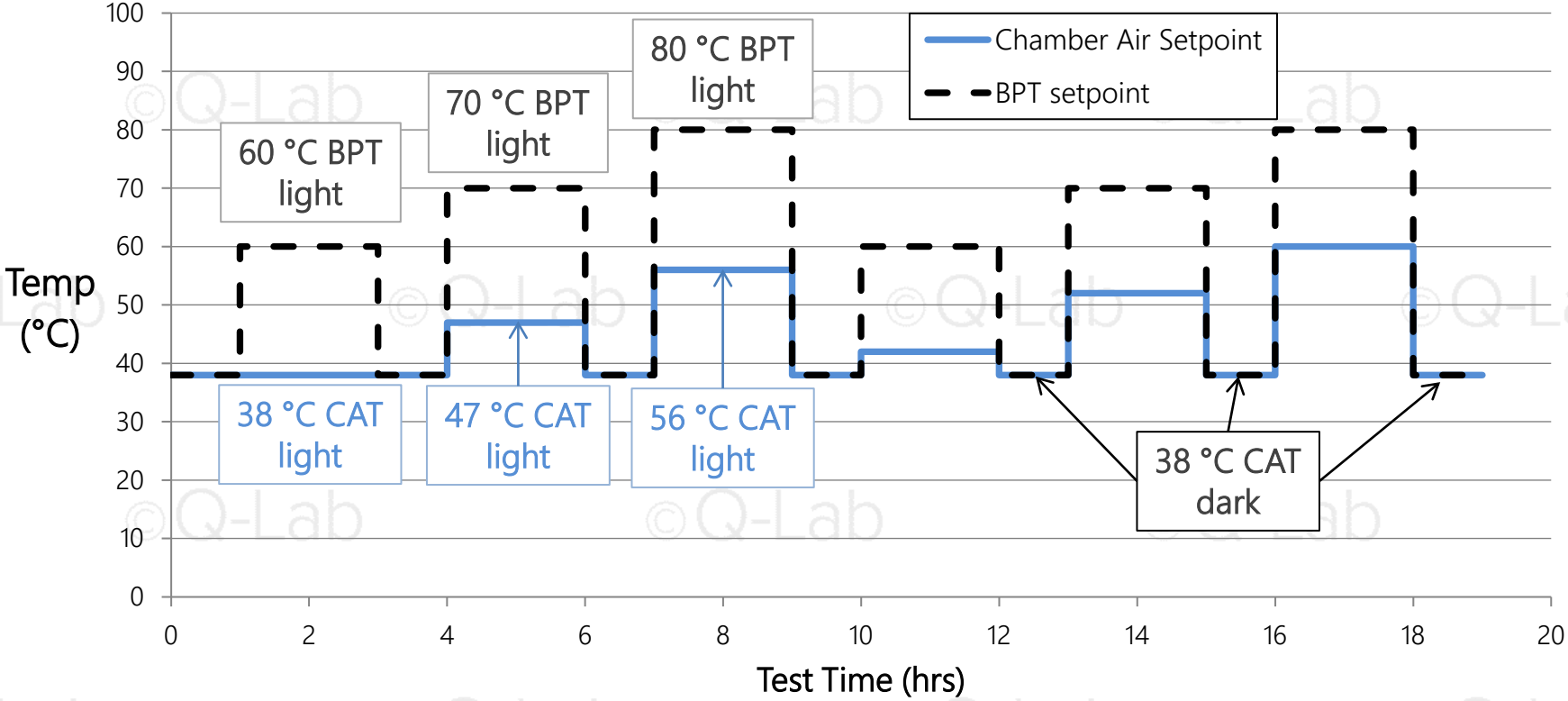
3D configuration with Insulation



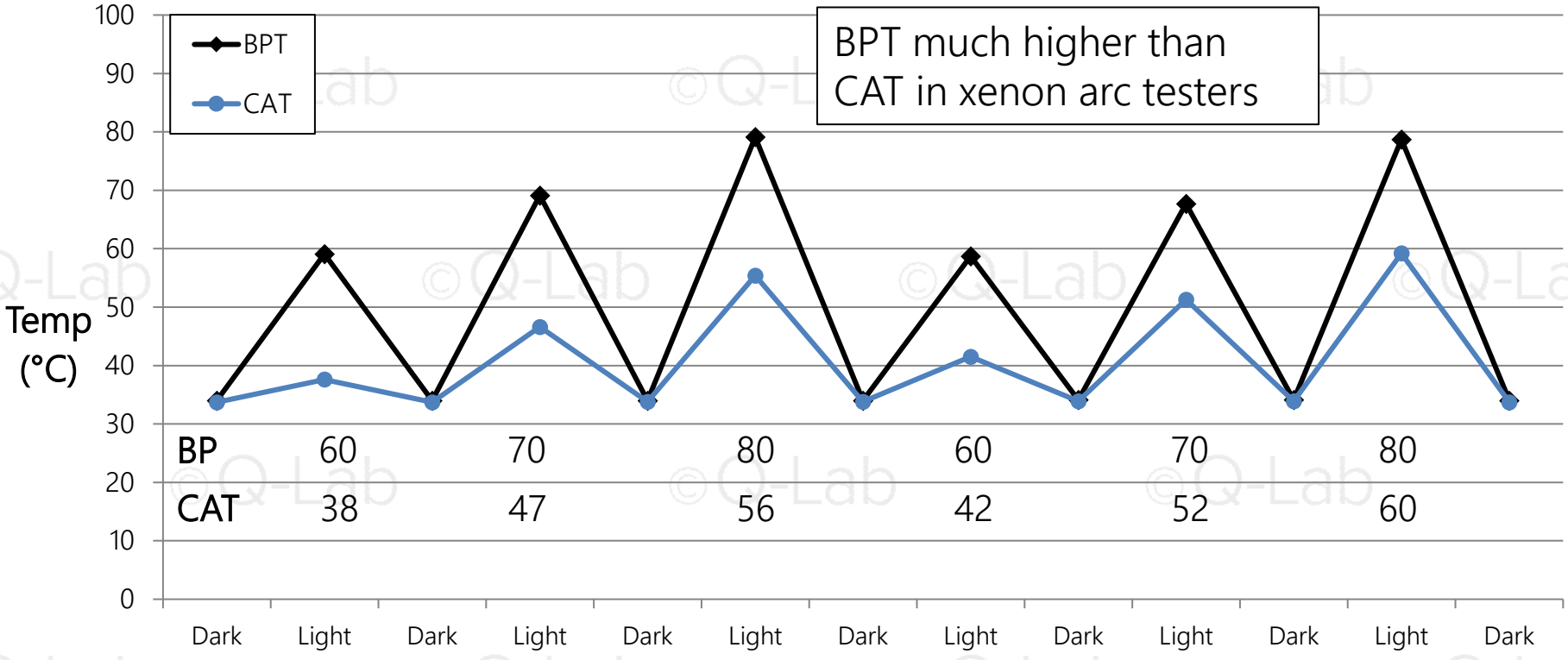
Insulated black panel delivers the same values as a Black Standard

Specimen Temperatures: Xenon arc

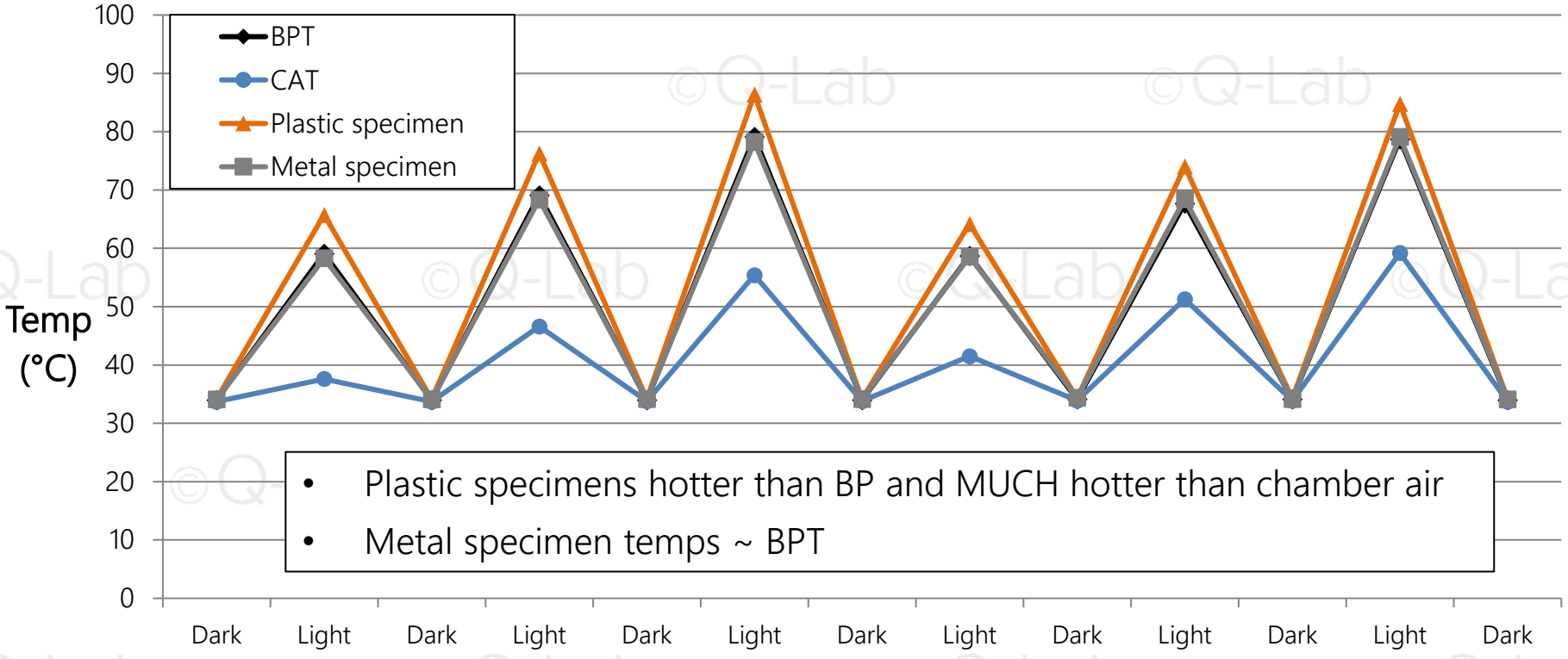
Xenon Arc Experimental Test Cycle



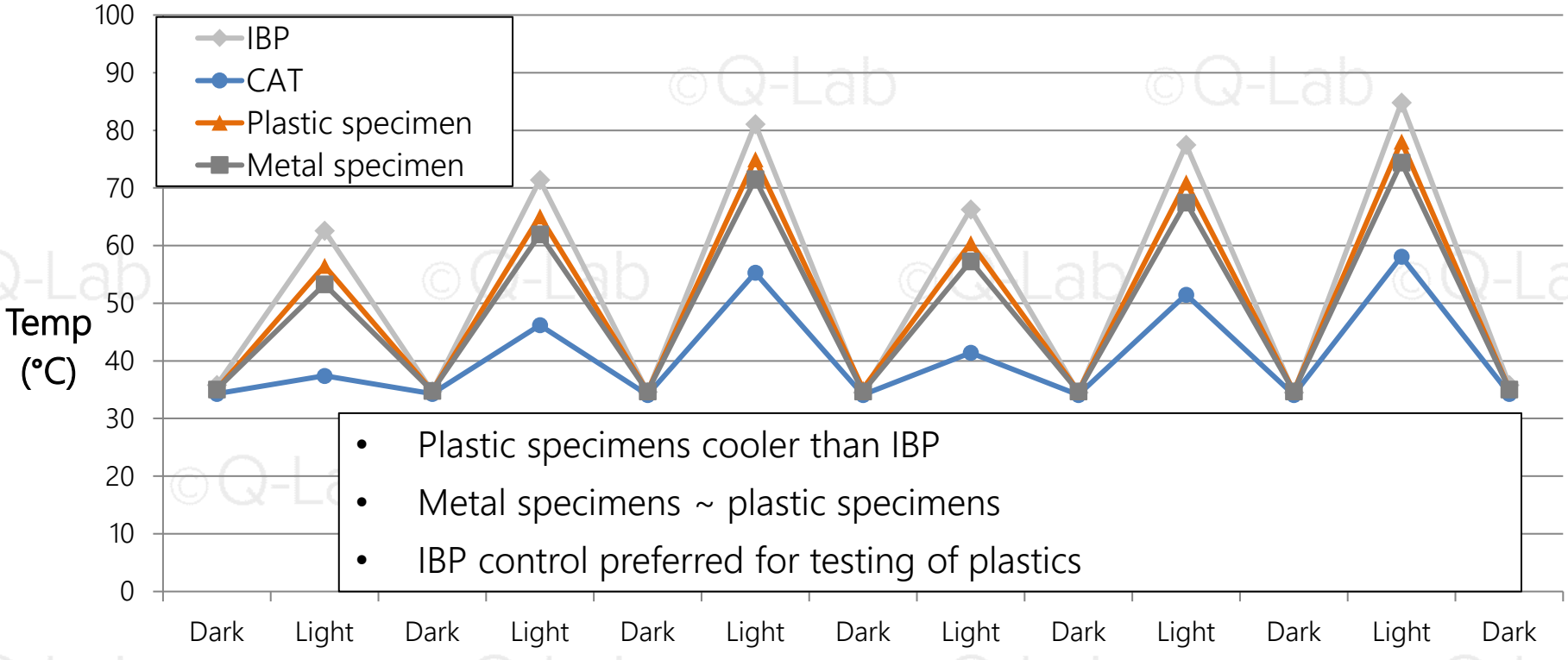
Xenon Arc Temps: Simplified View



Xenon Arc: Specimen Temps w/ BP control



Xenon Arc: Specimen Temps w/IBP control



Black Panel Transition Times and Test Results
黑板温度转换时间对测试结果的影响

SAE J2527 Case Study

Case Study: SAE J2527 BPT ramp adjustment

- Q-SUN Xe-3 tests were showing less color change than tests performed in other xenon chambers

Q-SUN Xe-3色差较小

- Red dots are Q-SUN Xe-3 testers

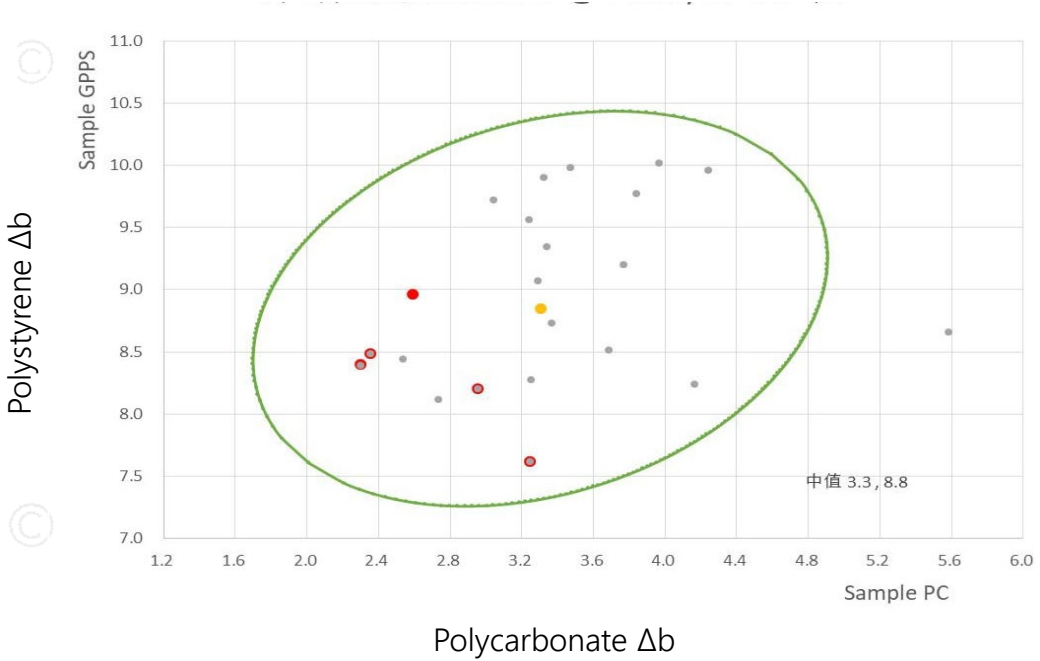
红点是Q-SUN Xe-3设备

- Gray dots are different xenon chambers

灰点是其他氙灯设备

- Yellow dot is the average

黄点是平均值



Case Study: SAE J2527 BPT ramp adjustment

- Optical filters and water spray were adjusted, but did not produce additional color change for transparent plastic (PS, PC)

调整了光学滤片和水喷淋，但并不能使得这些透明塑料试样的色差更大

- Alternative chambers in this case had faster temp increase rate, and significant temperature overshoot

本次比对中的其他试验箱的温度爬升更快，甚至有明显的温度过冲

- Q-SUN Xe-3 testers had a moderate temperature increase rate, and no temperature overshoot

Q-SUN Xe-3设备温度上升慢，没有温度过冲现象

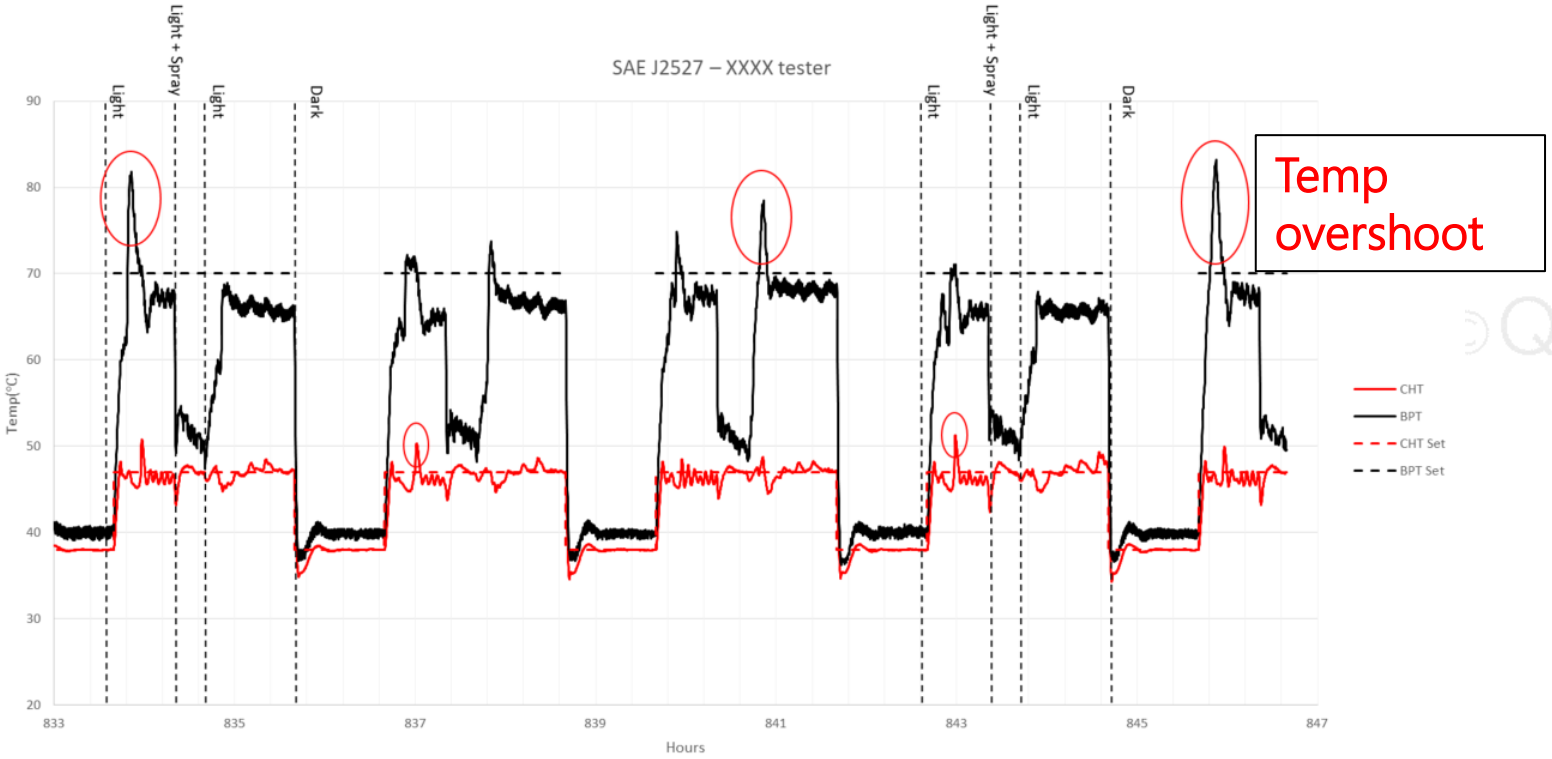
- Polystyrene (PS) Lot 9, a standard reference material, is sensitive to UV cut-on and temp, but insensitive to moisture

标准试板PS lot9 对紫外截至点和温度敏感，但是潮湿不敏感

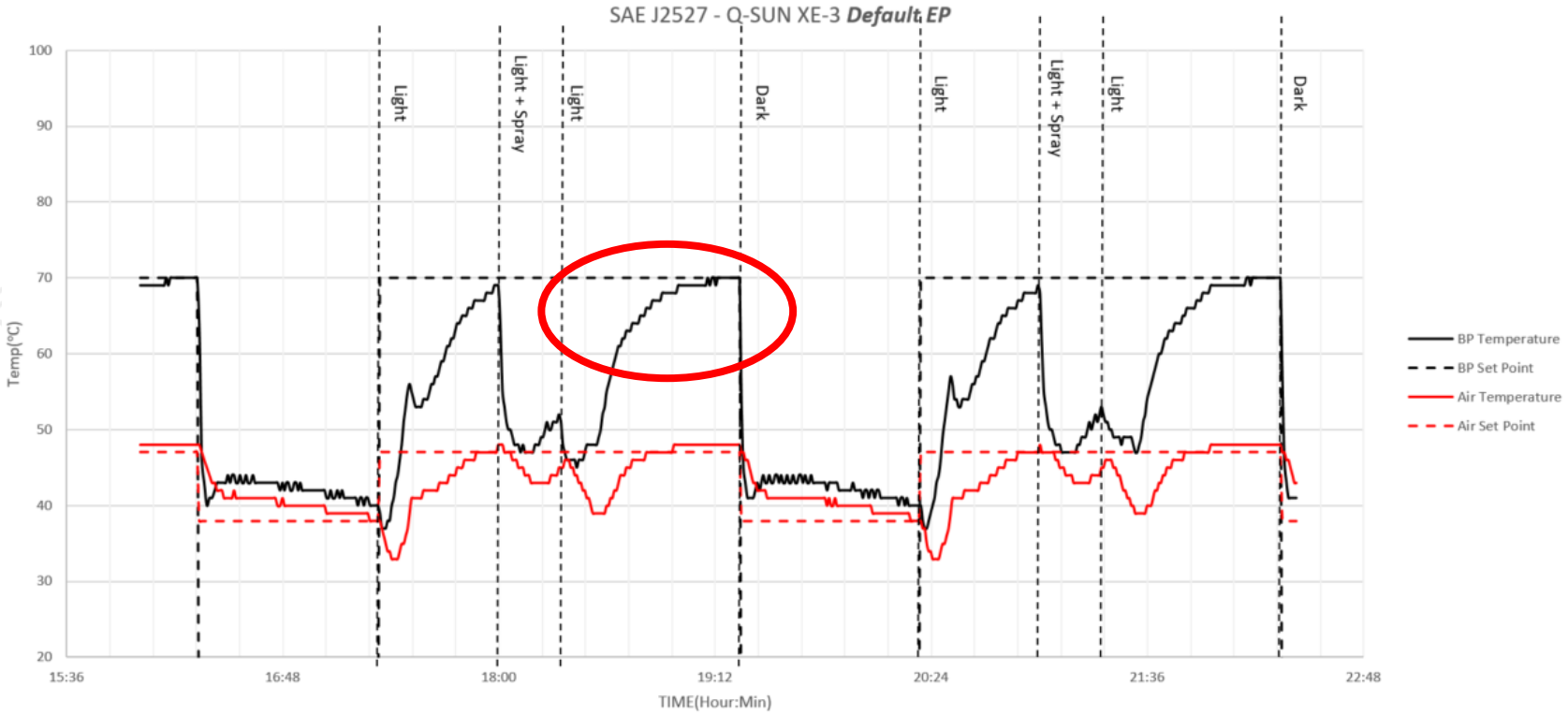
- Temperature transition time can be adjusted to affect results

温度爬升速率可以调整来影响测试结果

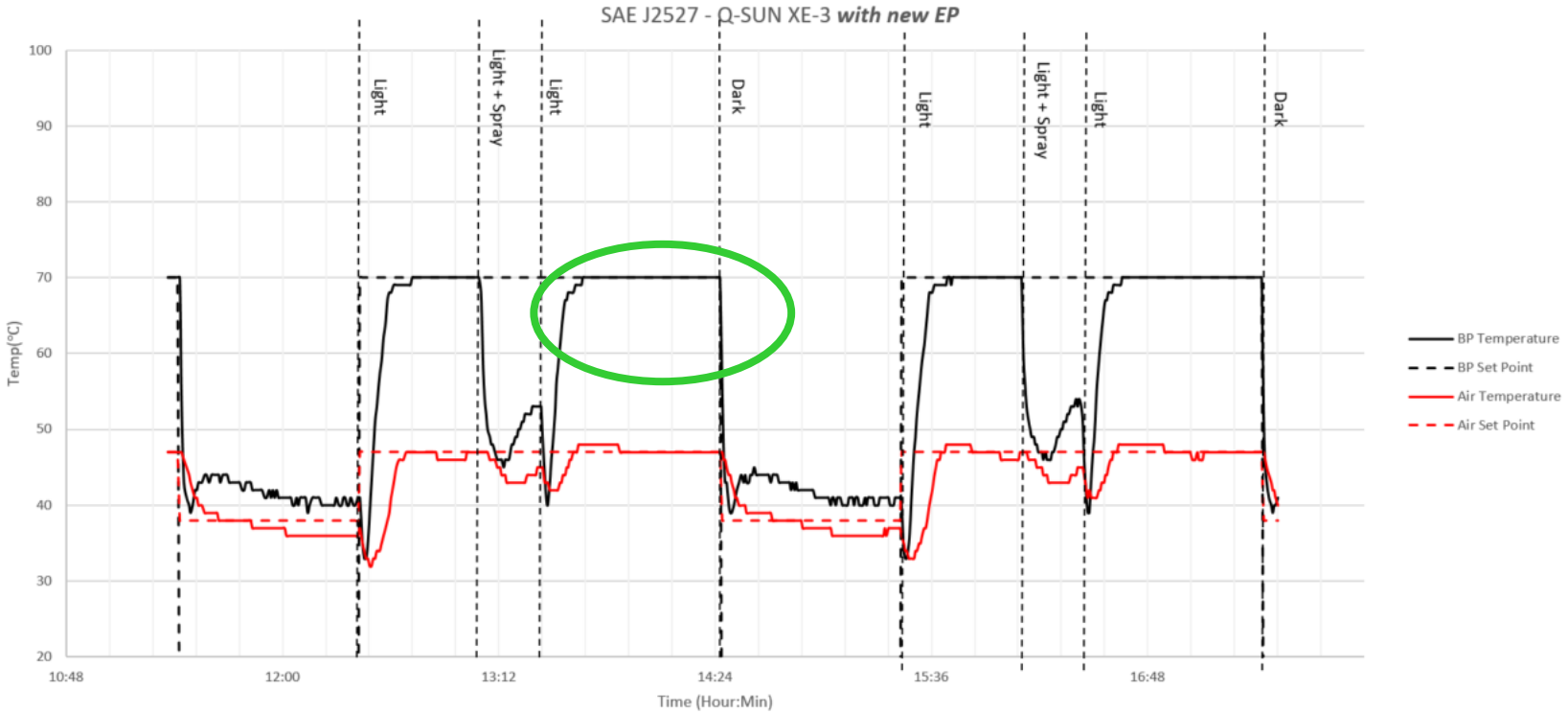
SAE J2527 in alternative tester



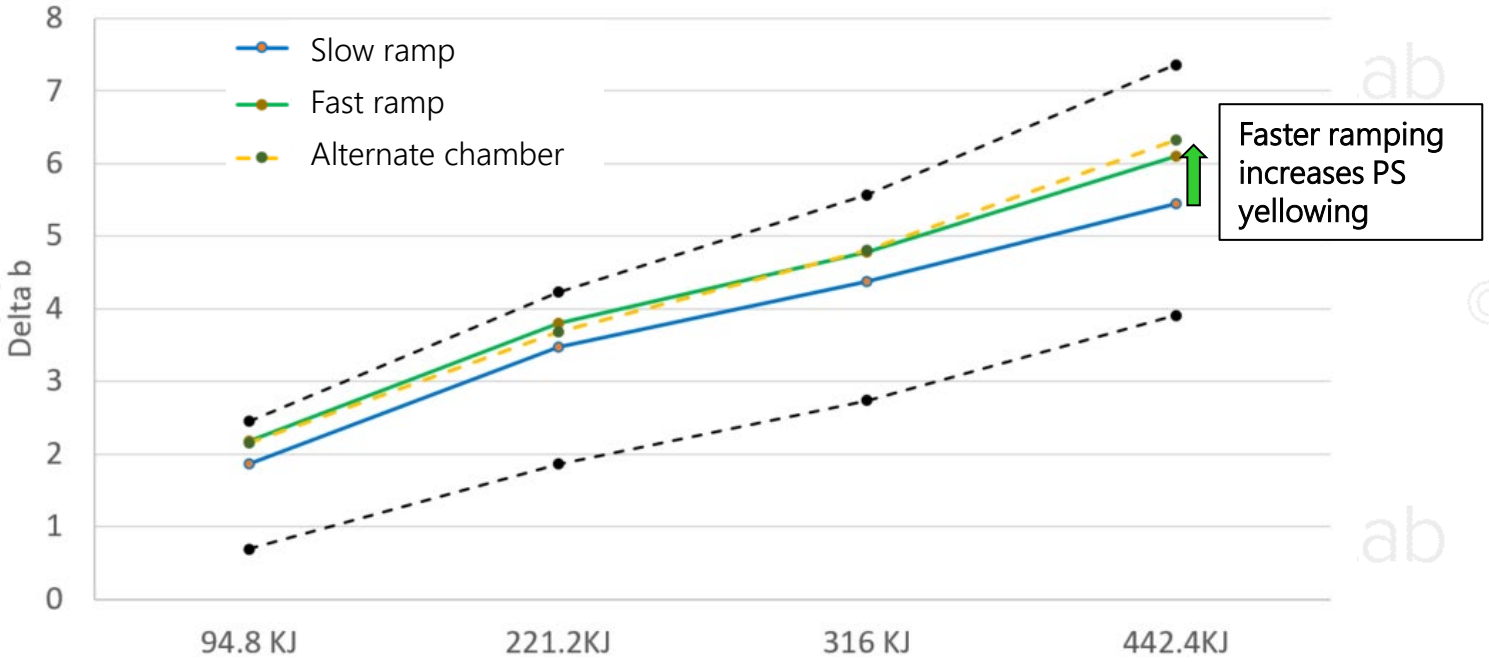
SAE J2527 in Q-SUN Xe-3: *Slow Temperature Increase*



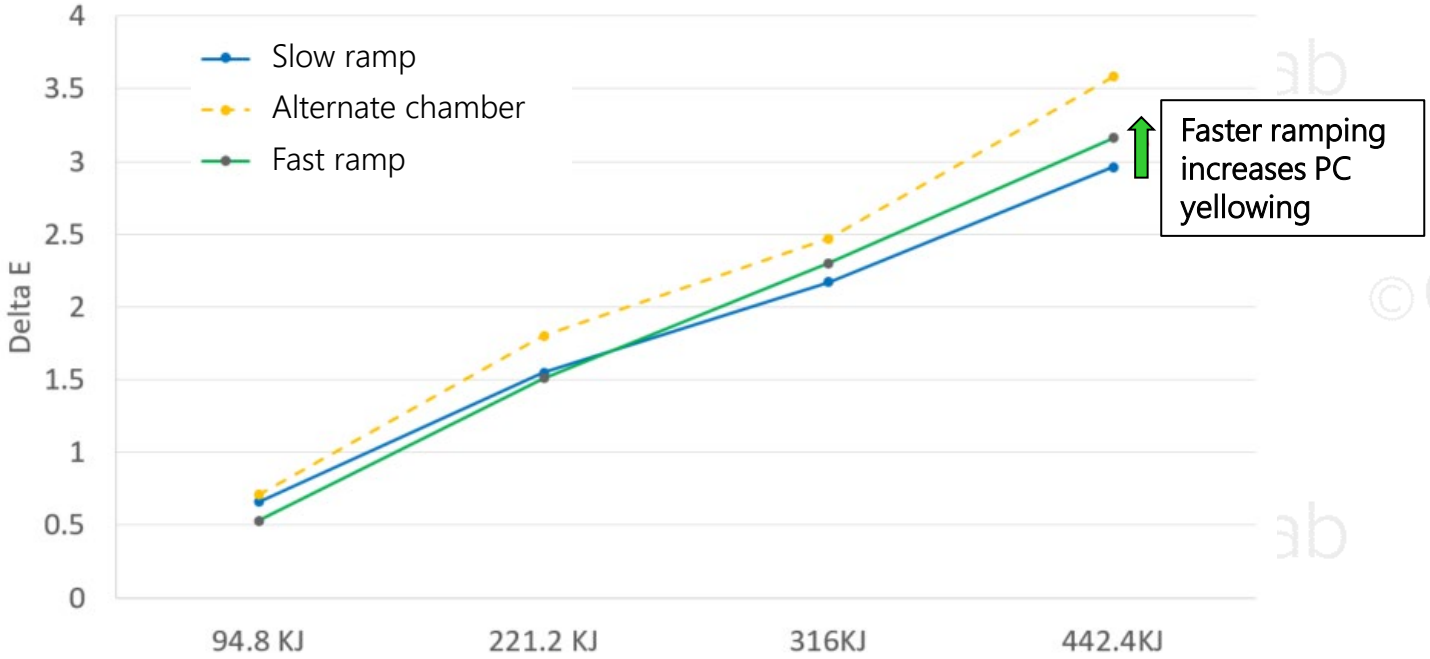
SAE J2527 in Q-SUN Xe-3: *Fast temperature increase*



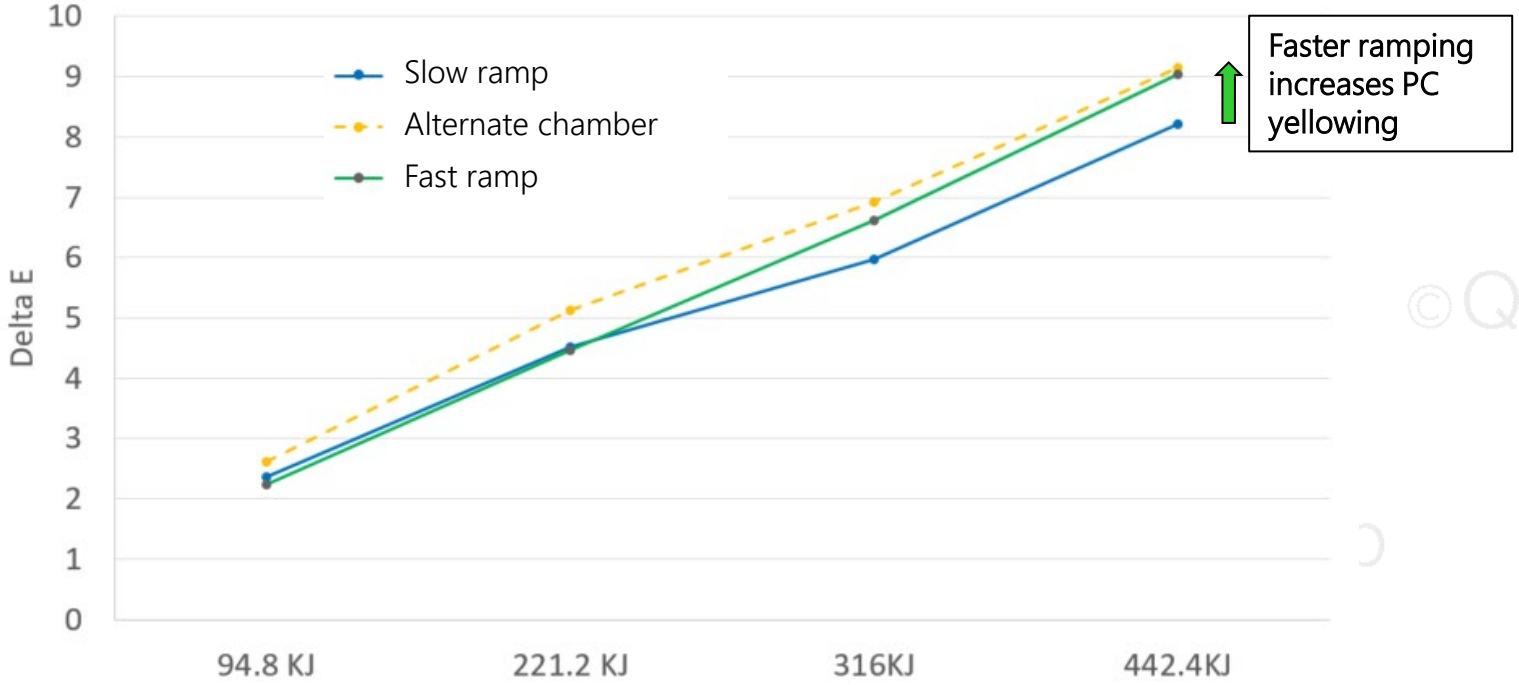
Delta b (yellowing) – PS lot9, SAE J2527



Delta E (color change) - PC, SAE J2527



Delta E (color change) - GPPS, SAE J2527



Conclusions: Fast BPT ramp affects results

- More color change for these three transparent materials using a faster BPT ramp

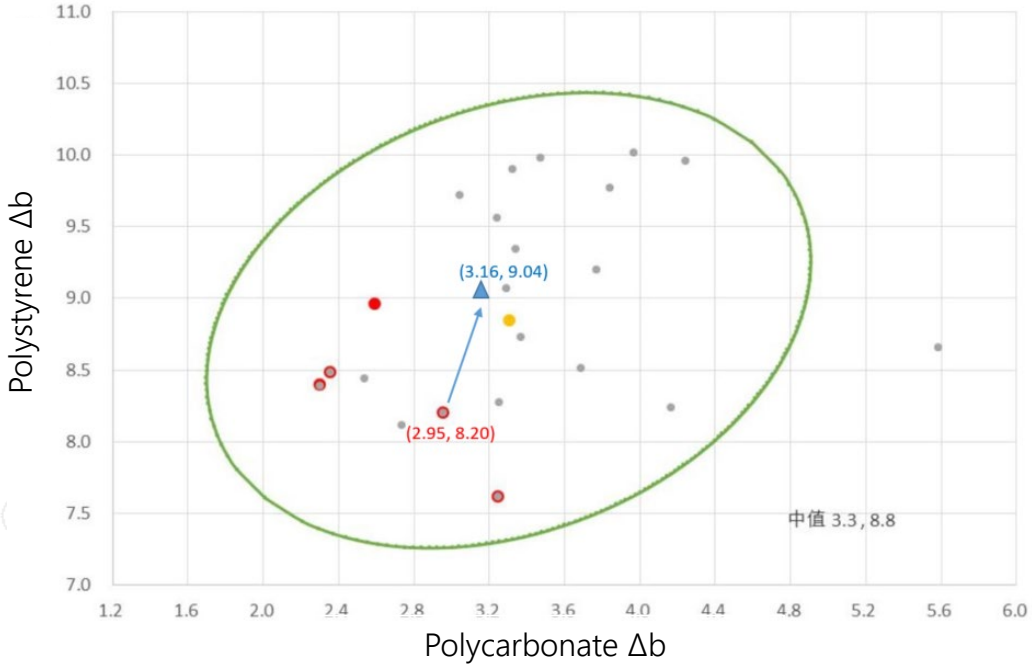
黑板温度爬升越快，色差越大

- Red dots are default ramp

红点是黑板默认值

- Blue dot is faster ramp

蓝点是更快的黑板爬升



Conclusions

- UV Fluorescent testing 荧光紫外测试
  - BP for flat, conducting metal specimens
    黑板针对扁平的导热金属样板
  - Insulated BP for flat, insulating plastic specimens
    IBP针对平整的绝热塑料试样
  - Insulated BP for **any** specimens tested in 3D boxes
    IBP针对所有的3D样品
  - UV fluorescent IBP matches performance of Black Standard
    荧光紫外老化箱中的IBP和黑标性能一致
- Xenon arc 氙灯
  - BP for metals
    黑板针对金属
  - Insulated BP for plastics
    IBP针对塑料
- Transition times 转换时间
  - Not specified in any weathering test standards
    在老化测试标准中没有规范
  - May influence severity of test results
    可能会影响测试结果

Thank you for your attention!

Questions?

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

Q-Lab中国微信公众账号:
耐候腐蚀设备及测试专家

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✓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

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