Black Panel Temperature Control in Accelerated Laboratory Weathering Testing

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Q-Lab

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Today is the last of four new webinars this spring and summer from Q-Lab on weathering and corrosion testing topics

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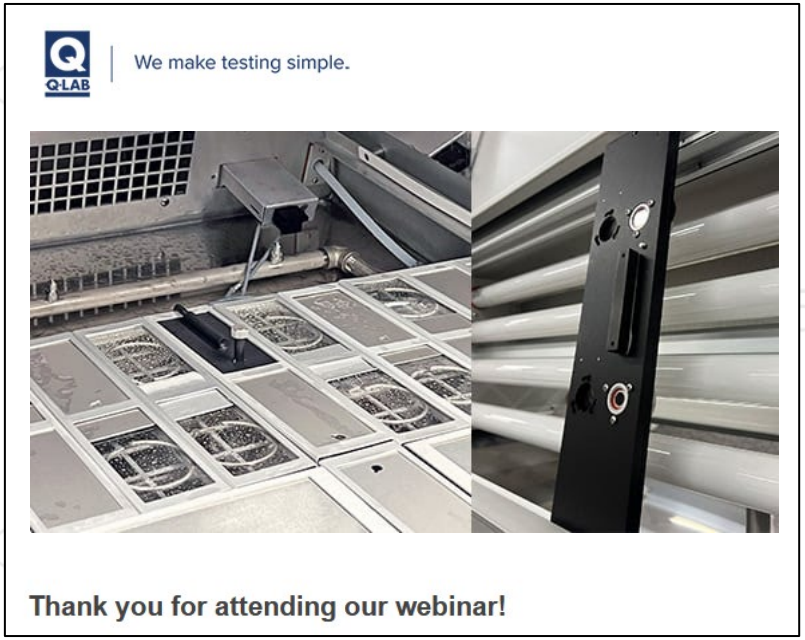
Date	Topic
29 May	How to Perform a Comparison Test
12 Jun	New Developments in Testing Standards
01 Jul	Q-PANEL Standard Substrates
29 Jul	Black panel selection in weathering testing

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

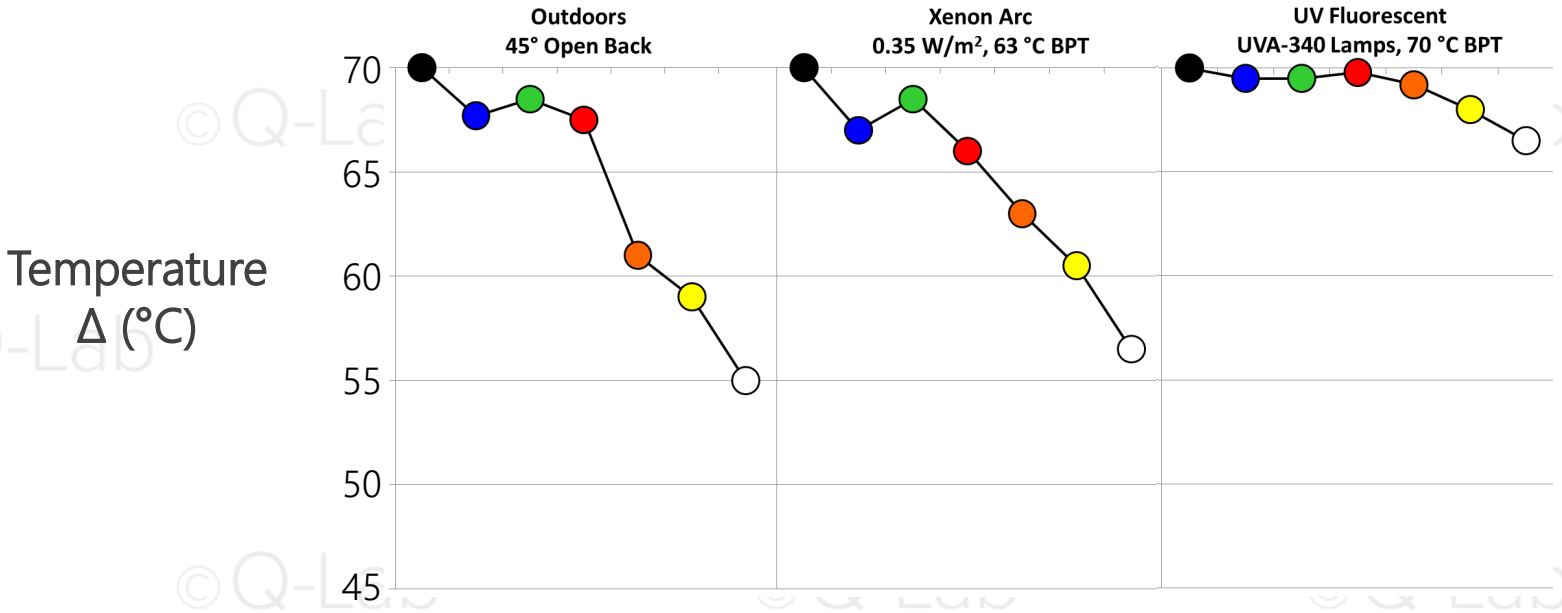
Use the **Q&A feature in Zoom** to ask us questions today!



Temperature in Accelerated Weathering Testing

- Temperature is specified in nearly every accelerated weathering test
  - Black panel temperature (UV fluorescent, xenon arc)
  - Chamber air temperature (xenon arc)
- Goal is typically to accelerate degradation by testing at elevated temperatures
- **Tester** control temperature often differs significantly from actual **specimen** temperature

Temperature and color

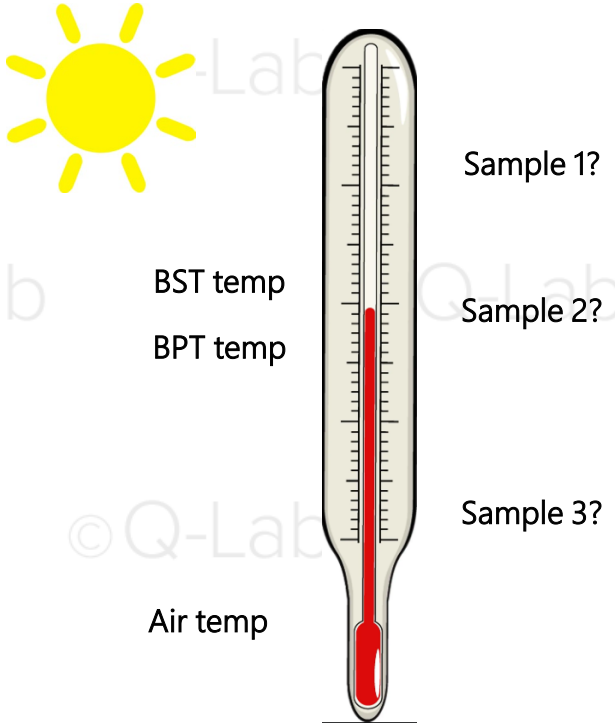


- Specimen color affects strongly temperature when exposed outdoors
- Specimens in xenon testers absorb visible and IR light, increasing their temperature much like outdoors
- UV fluorescent testers do not generate much radiant heat for specimens; color differences are small

Black Panel Temperature Control

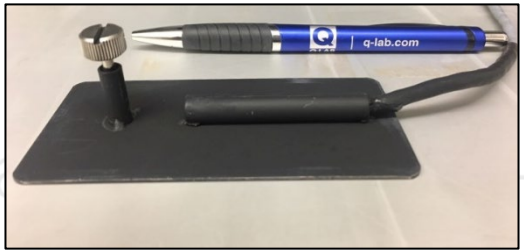
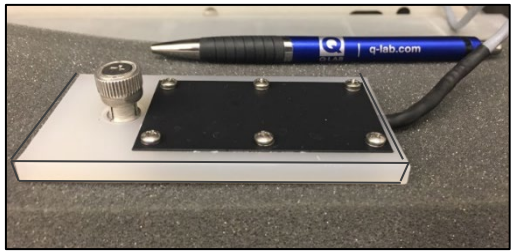
- Most common in test standards
- Approximates maximum specimen surface temperature better than air temp
- Can be used in combination with chamber air temp sensor and control
- Typically not practical to monitor sample surface temp
- Samples might melt due to unrealistic high surface temperature if uncontrolled
- BP control improves test repeatability and reproducibility

Where is your sample surface temp?



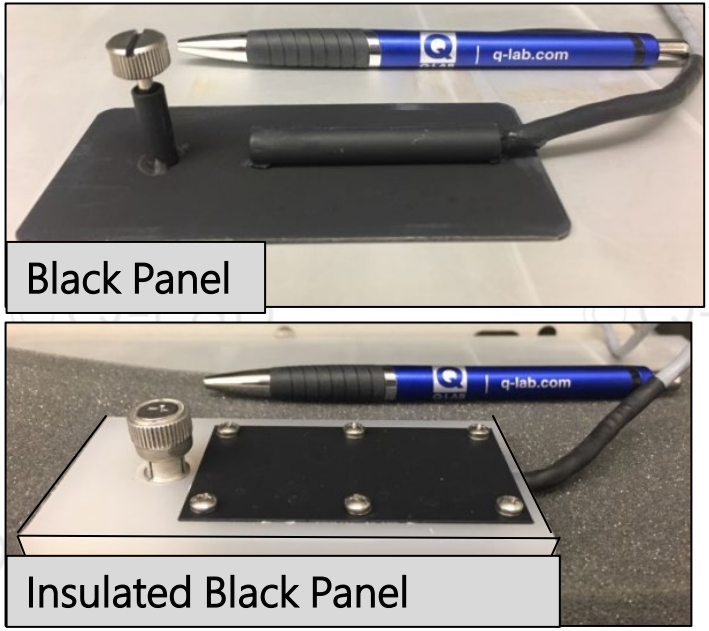
- Painted steel panel
- White plastic
- Black plastic
- Transparent plastic
- Display
- Leather and textile

Terminology: Black Surface Temperature Sensors

Panel	Construction	ASTM Designation	ISO Designation
	Black painted stainless steel	Uninsulated Black Panel	Black Panel
	Black painted stainless steel mounted on 0.6 cm white PVDF	Insulated Black Panel	Black Standard

Black Panel (BP) Temperature Control

- BP temp sensor mimics specimen temperature; does not match chamber air temperature
- BPT standardizes conditions experienced by specimens, independent of room conditions
- BPT does not *necessarily* match any particular specimen temperature or represent the hottest temperature in the tester!



Xenon arc temp sensors

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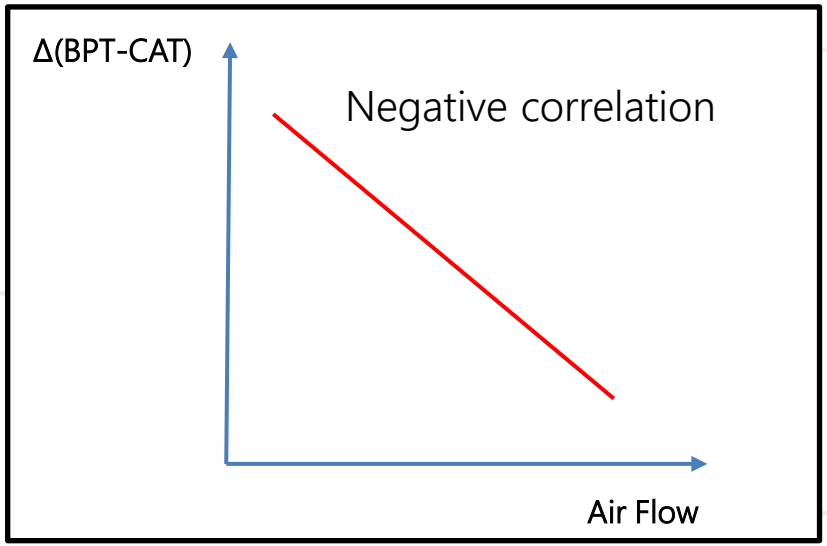
UV fluorescent temp sensors

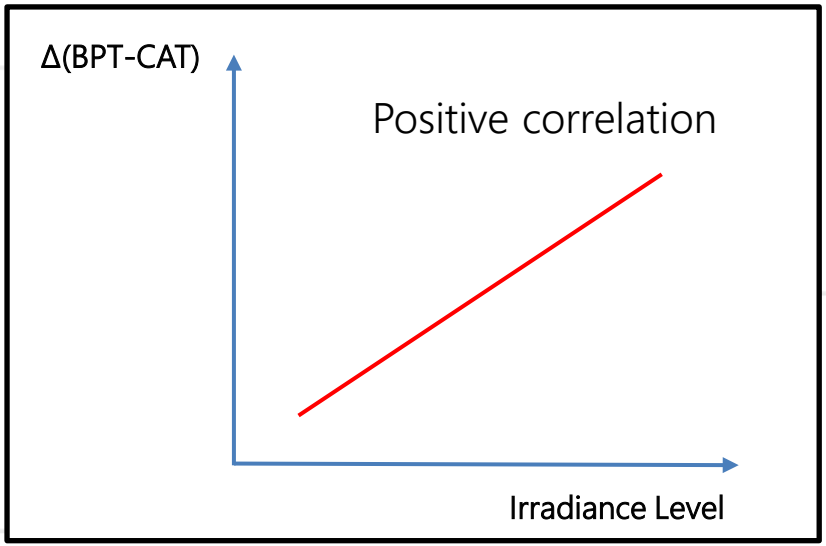
What influences Black Panel Temp?

- Radiation (mainly visible light and infrared radiation)
  - More significant for Xenon Arc than UV fluorescent
  - Irradiance level
  - Optical filter type (infrared absorbing or reflecting)
- Thermal conduction construction (insulated vs. uninsulated)
- Chamber air flow and temperature
- Water Spray (though BP temp is not *typically* controlled)

BPT, CAT, Airflow, and Irradiance



Greater airflow narrows the temperature differential



Higher irradiance widens the temperature differential

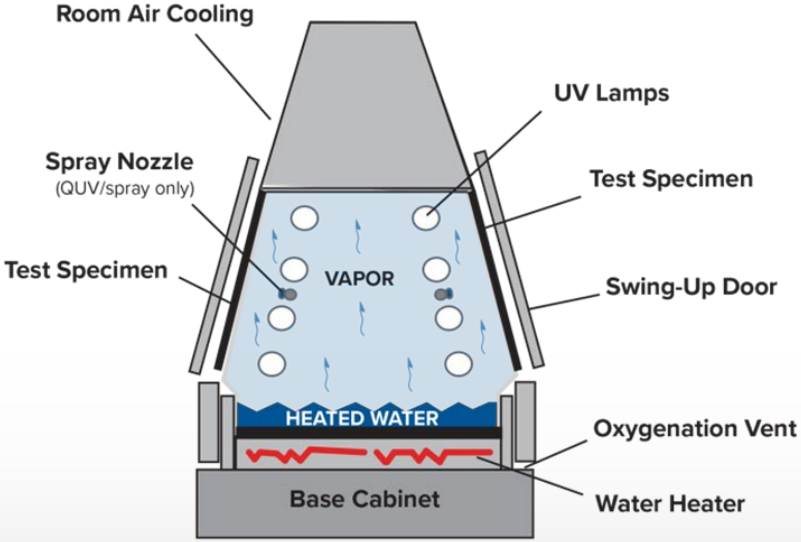
Black Panel Specification

- In **theory**, an insulated black panel is intended for plastic materials and an uninsulated black panel is meant for painted metals.
- In **practice** …
  - BP are more popular in the USA; IBP are more popular in Europe
  - Many standards allow both types, with no guidance
  - Standards for general testing may only allow BP, like ASTM does
  - ISO plastics and paint standards both list IBP first
  - "Equivalent" temperature setpoints for BP and IBP are not aligned
  - IBP are never, ever specified in UV fluorescent tests

Selecting a Black Panel Type

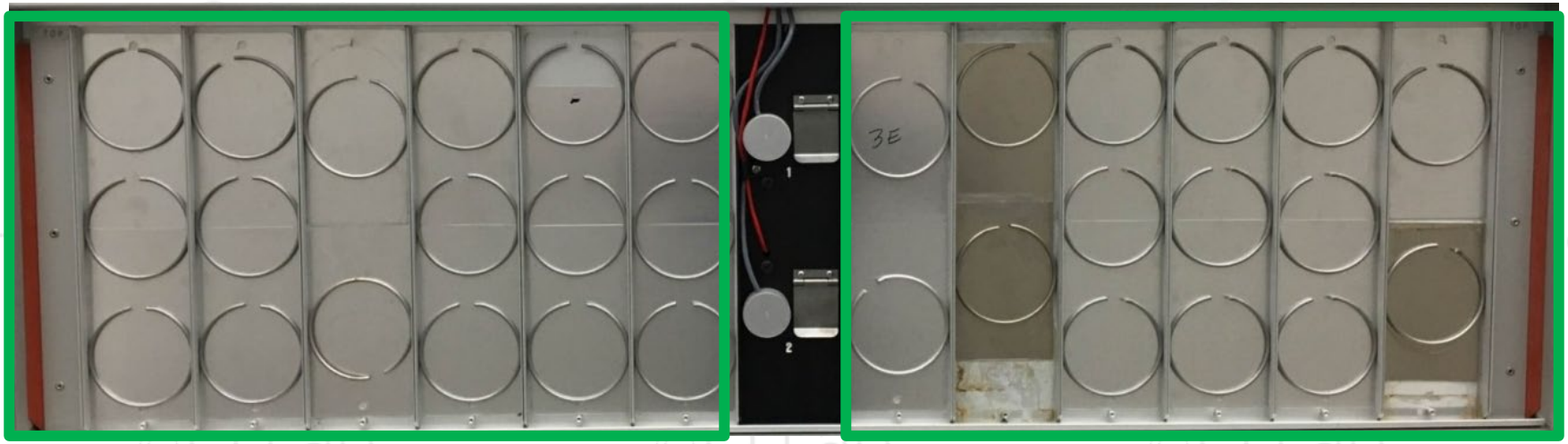
- Test results demonstrate that proper choice of black panel type can bring specimen temperatures in line with test setpoints
  - Painted metals match BP
  - Plastics match IBP
- This is true for both types of test instruments
  - IBP should be used more in UV fluorescent testing
  - 3D specimen testing also better suited to IBP
- Construction of a "Black Standard" IBP is carefully specified
  - Other insulating BP designs are not expressly permitted
  - They can be shown to match well results from a Black Standard

Specimen Temperatures: Fluorescent UV



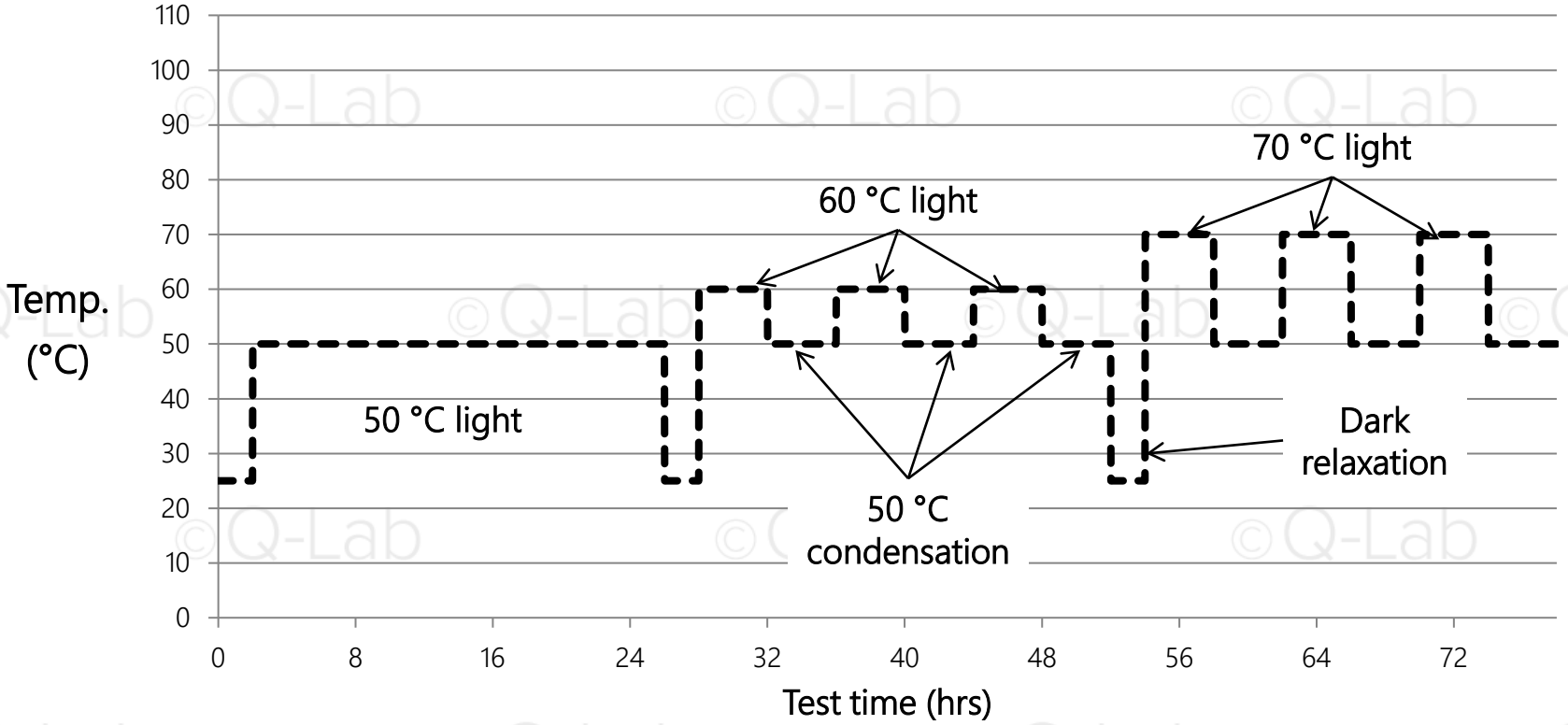
Fluorescent UV testing

Standard “2D” Specimen mounting

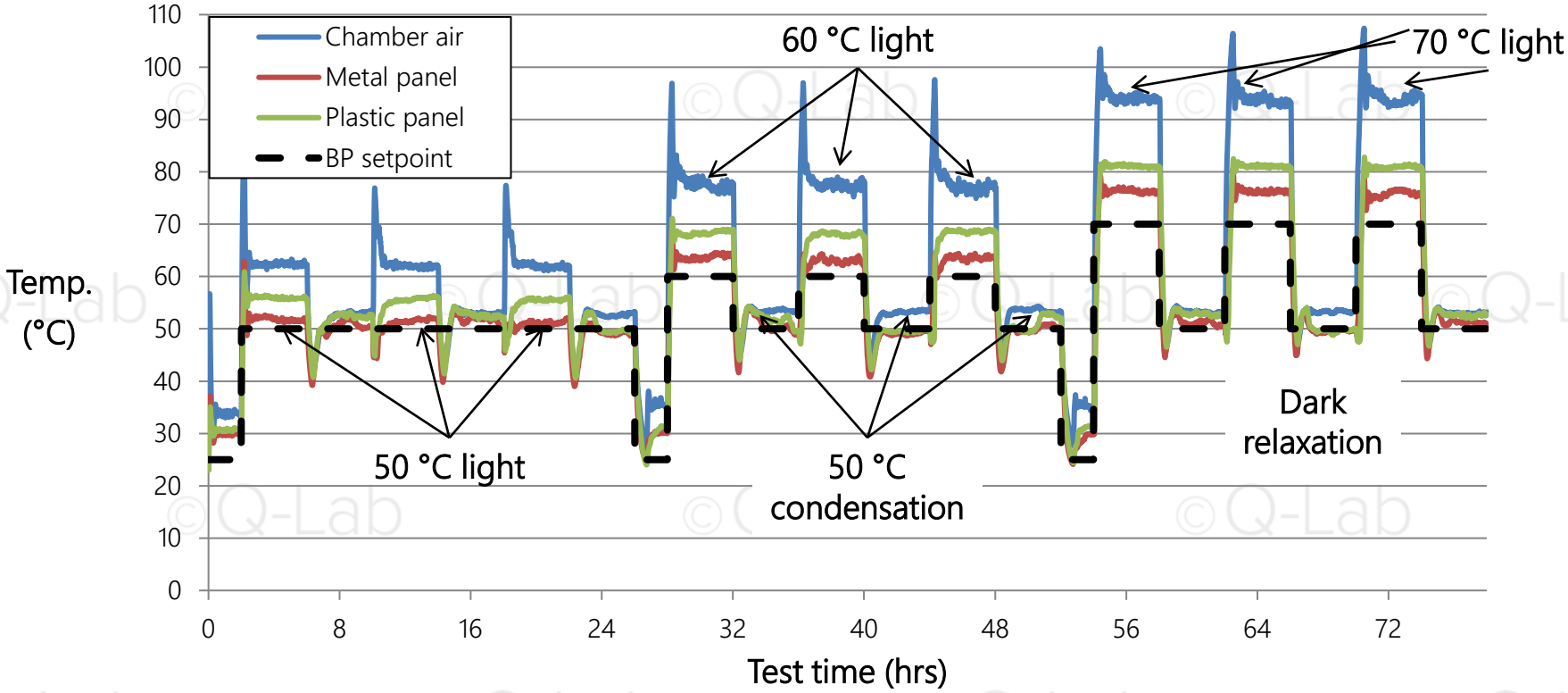


- Typical mounting for flat panels in a fluorescent UV tester
- Front two “quadrants” are shown

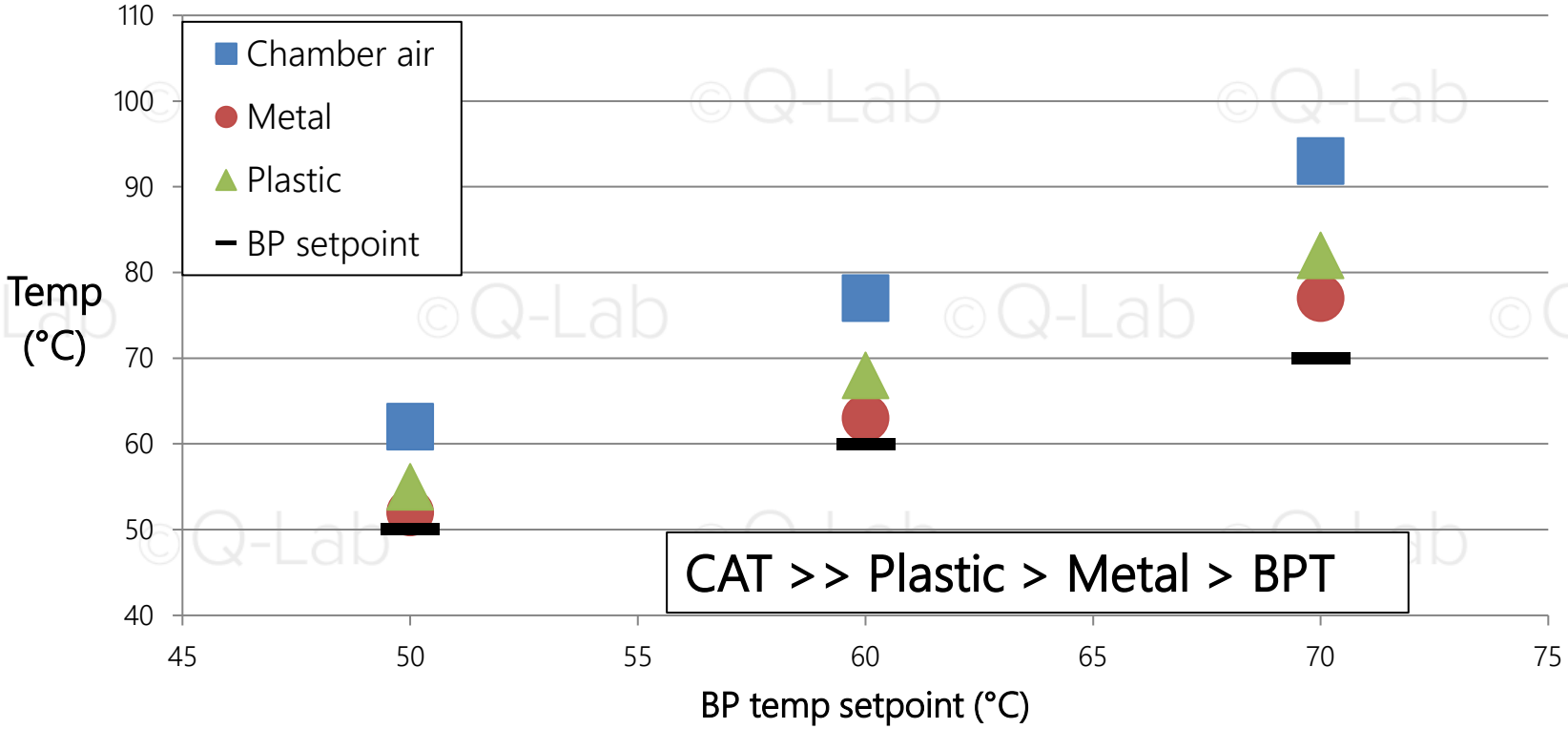
Fluorescent UV Test Cycle



Fluorescent UV Experimental Results

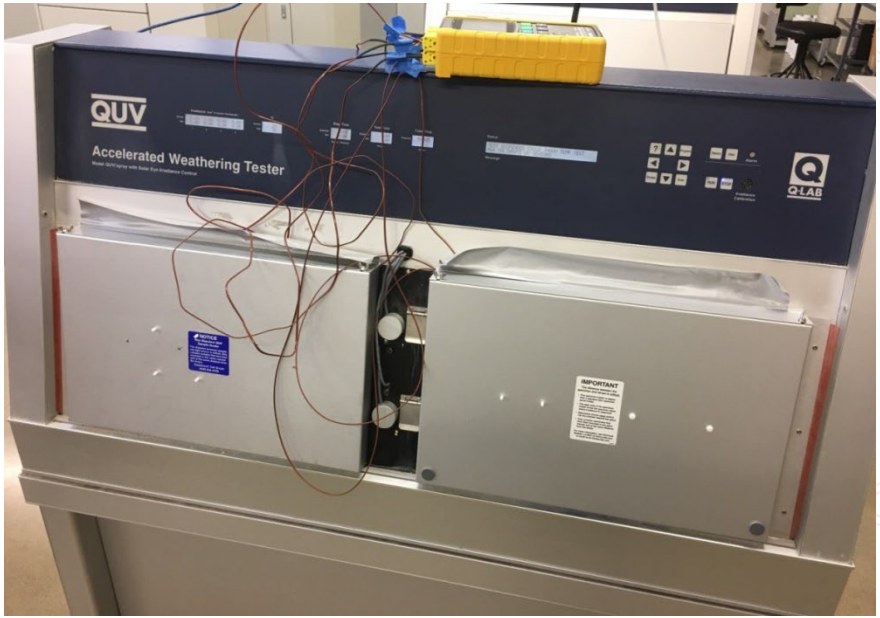


Fluorescent UV Test Cycle: Simplified View



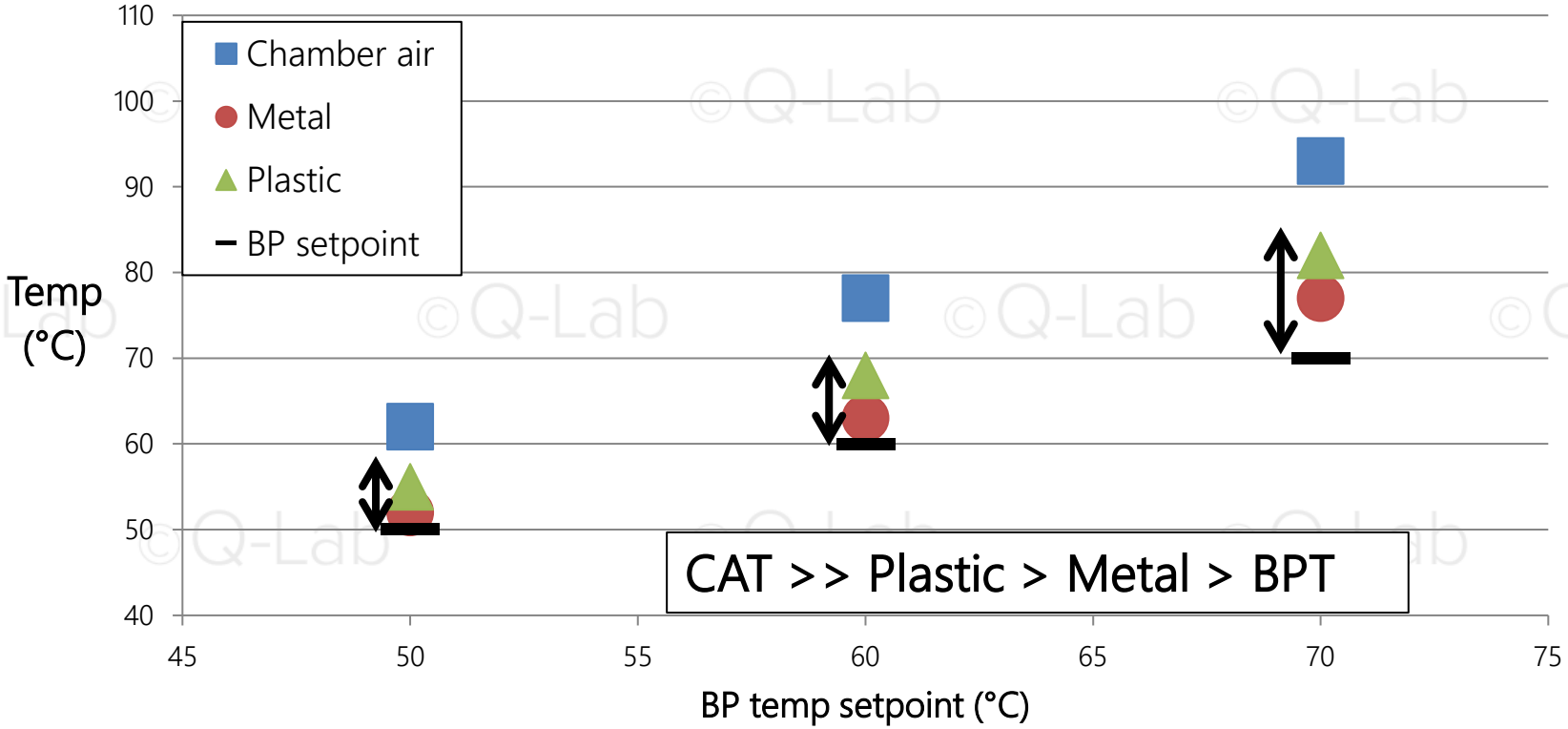
Fluorescent UV testing

“3D” Specimen mounting

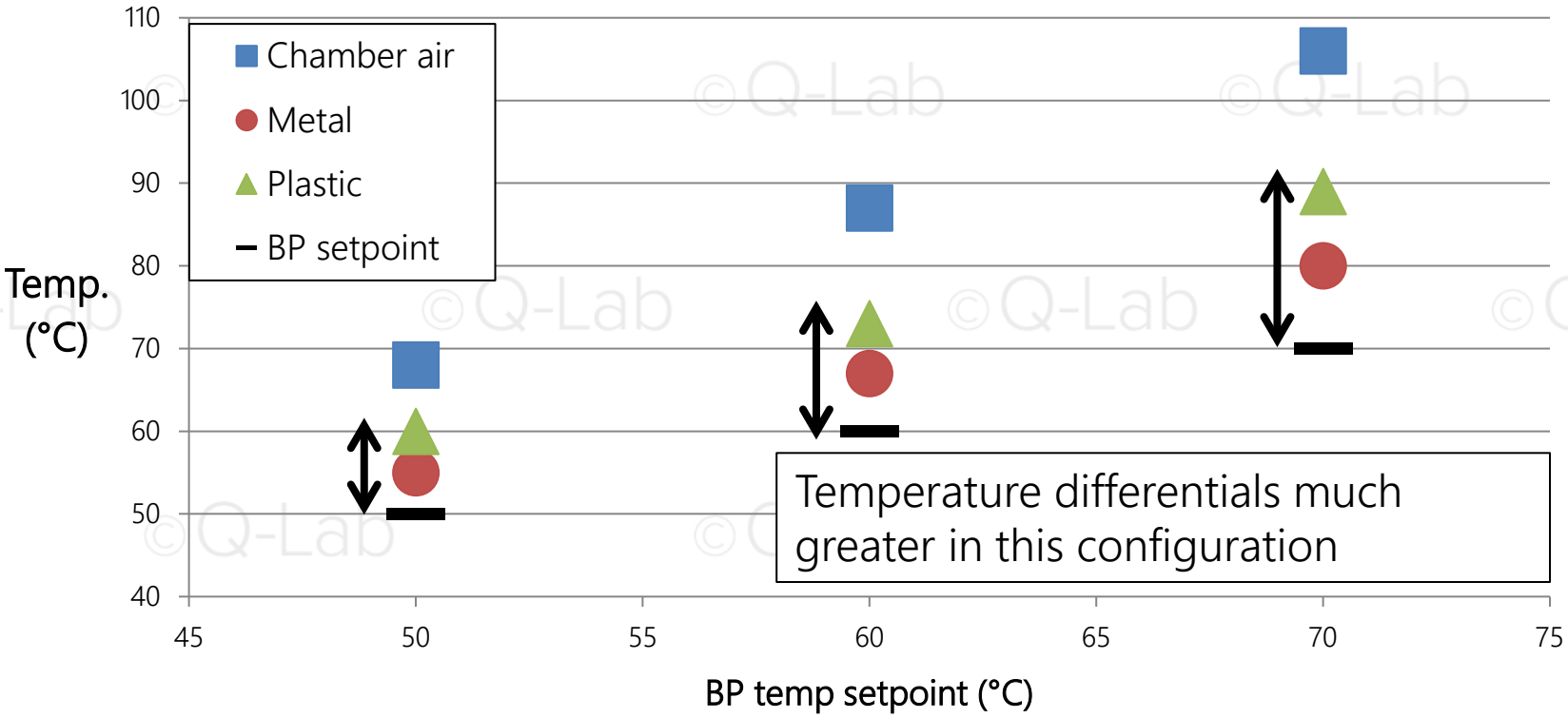


Quadrant boxes allow weathering of three-dimensional specimens

Test Cycle: 2D results (reminder)

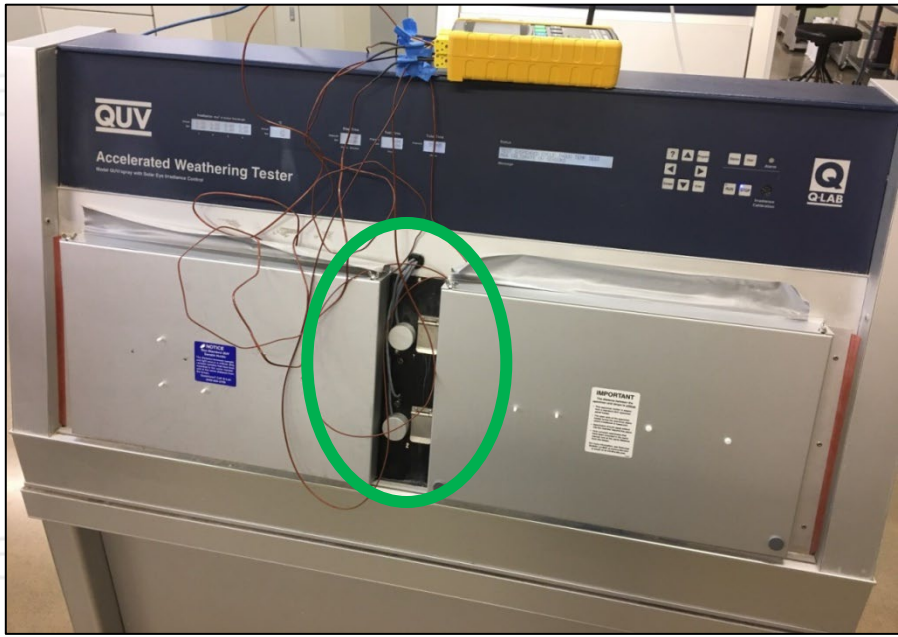


Specimen temperatures: 3D configuration



Why the temperature differences?

- Black panel was cooled by laboratory air
- This increases heater output, leading to higher temperatures
- This can lead to melting and glass transition when testing plastics



Insulating Black Panel

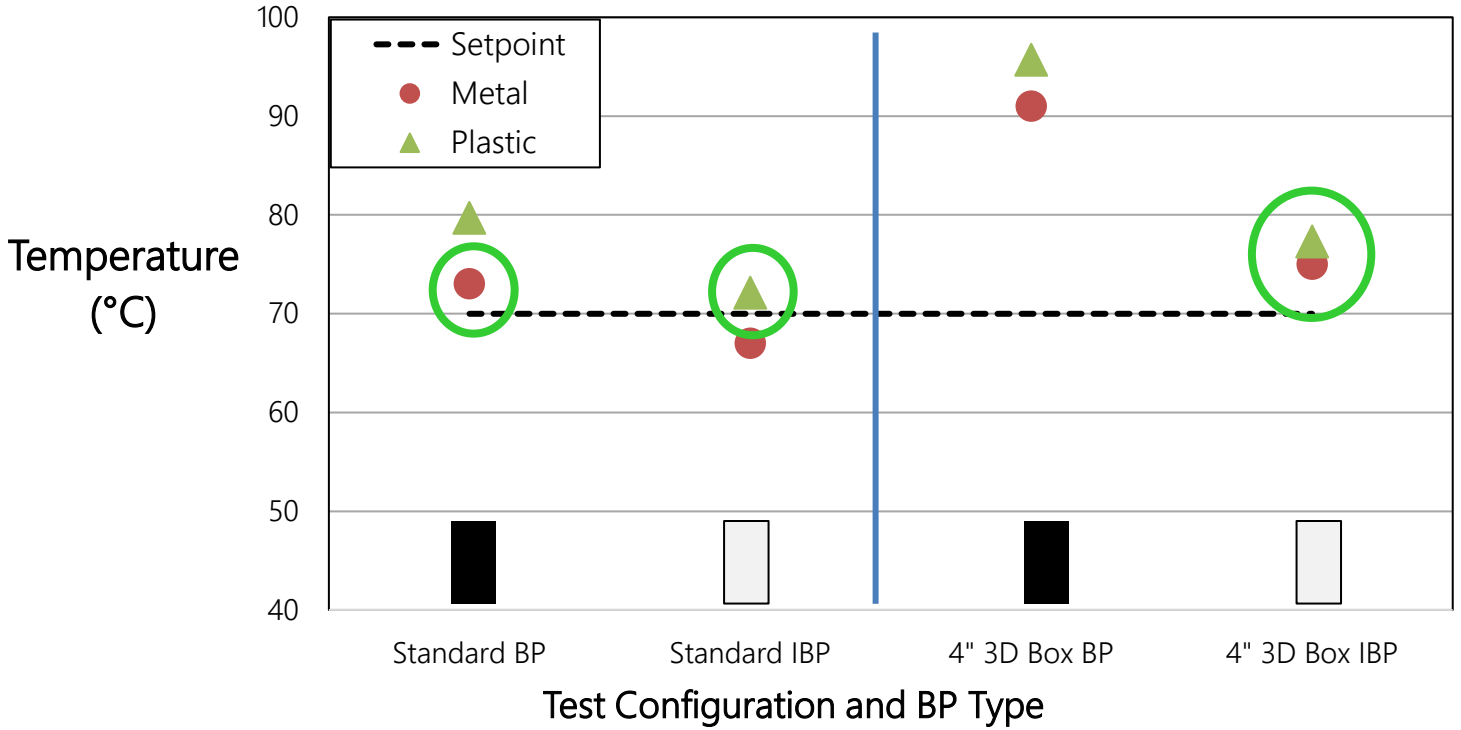
- IBP will retain heat better than BP, offsetting some of the heat loss to the chamber air
- How will specimen temperatures be affected by use of an IBP?
  - Metals vs plastics
  - 2D vs 3D

Specimen Temperatures – 70 °C setpoint

Front Door	Black Panel Type	Specimen Material: steel	Specimen Material: aluminum	Specimen Material: 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

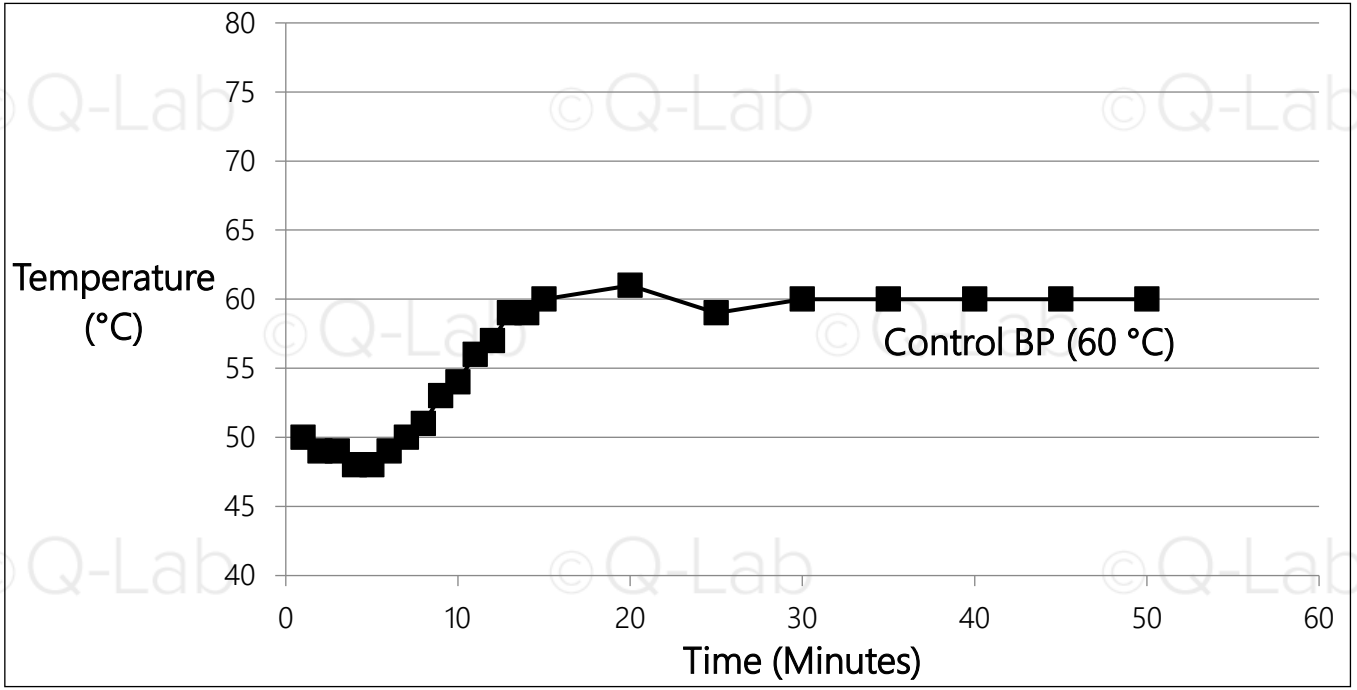


Use of IBP in UV Fluorescent Testing

- ISO standards define precisely the construction of a “Black Standard”*
  - Dimensions
  - Materials
  - Sensor location (not facing specimens)
- Other insulated black panels are not expressly allowed *unless they produce the same results*

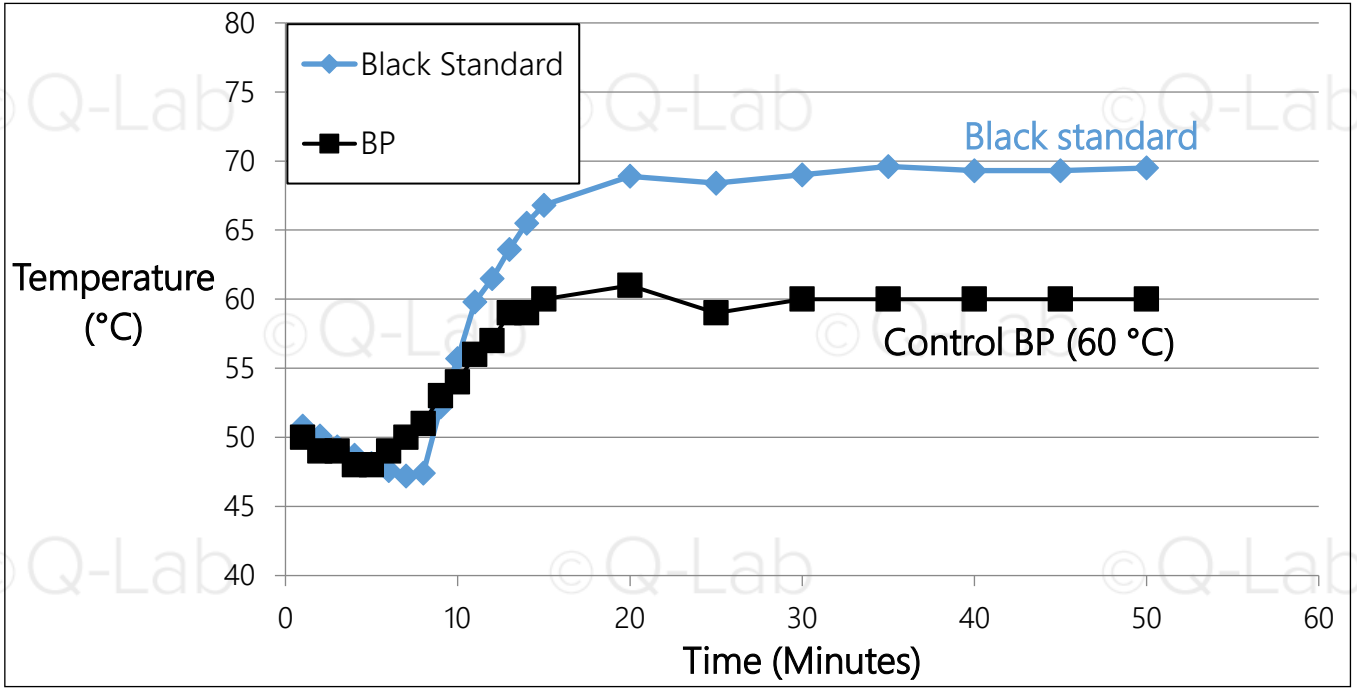
**ASTM defines the identical construction and calls it an Insulated Black Panel*

3D configuration with Insulation



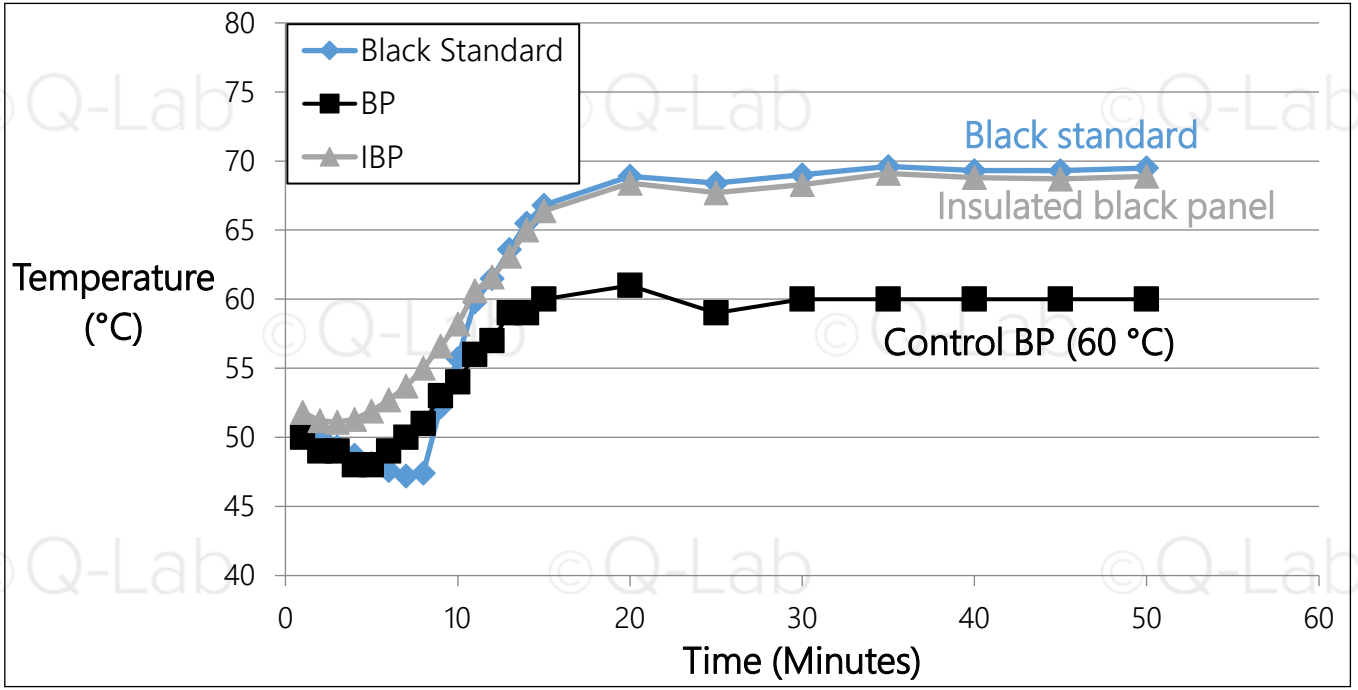
Temperature controlled by a BP to 60 °C

3D configuration with Insulation



Black standard runs hotter because it holds in heat

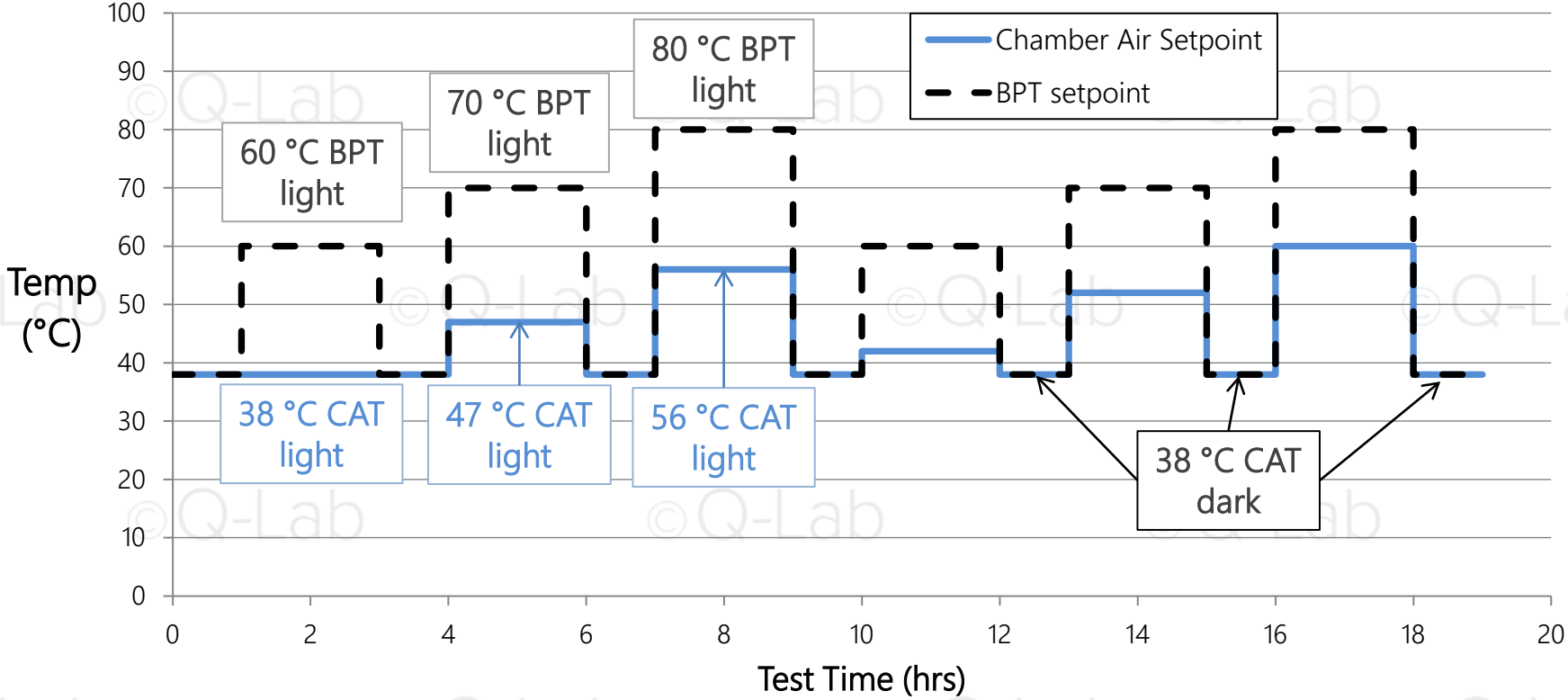
3D configuration with Insulation



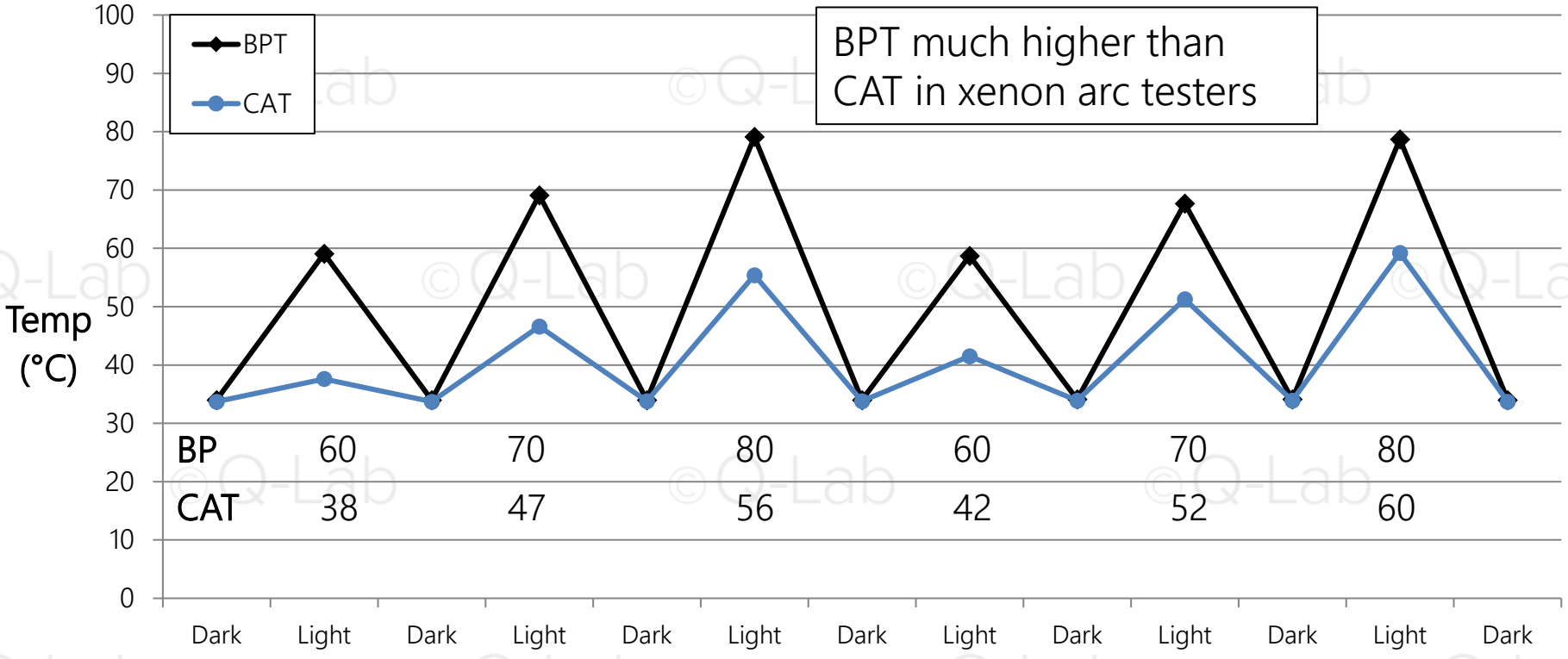
Insulated black panel delivers the same values as a Black Standard

Specimen Temperatures: Xenon arc

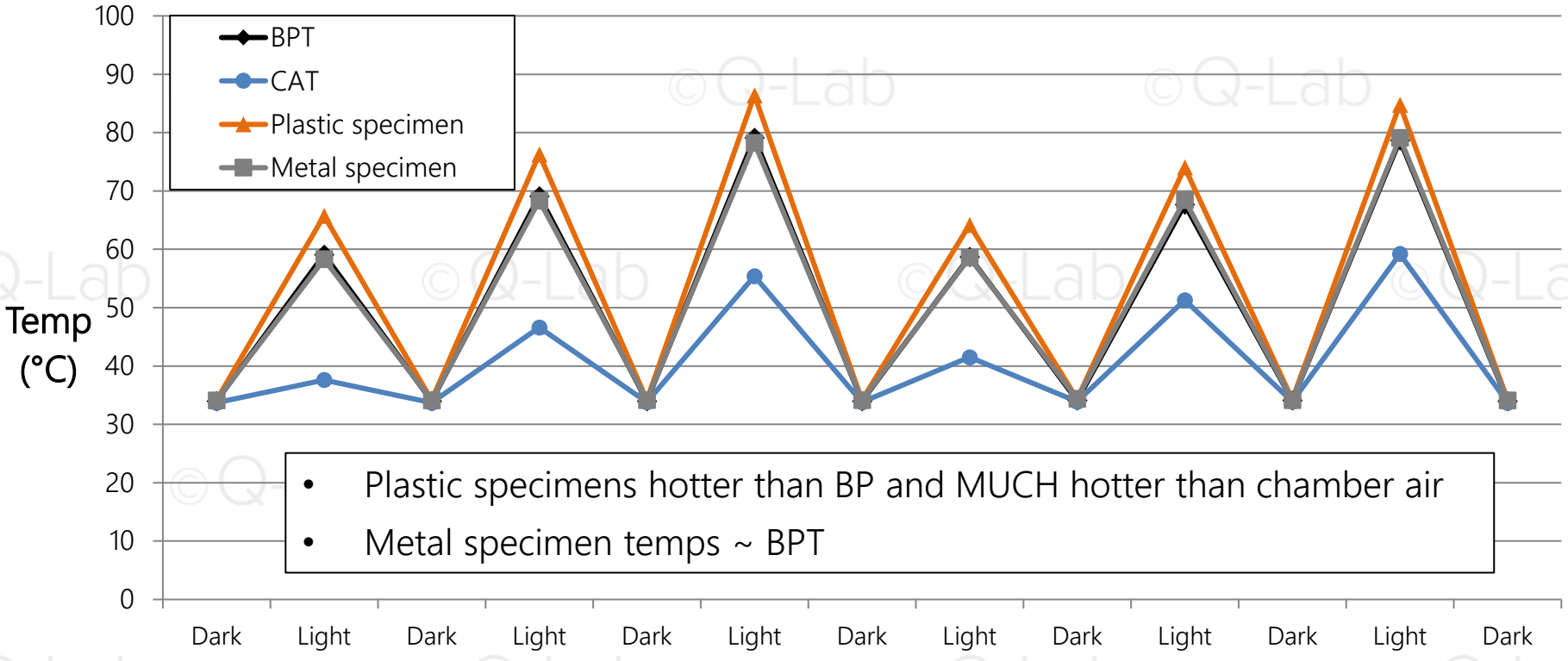
Xenon Arc Experimental Test Cycle



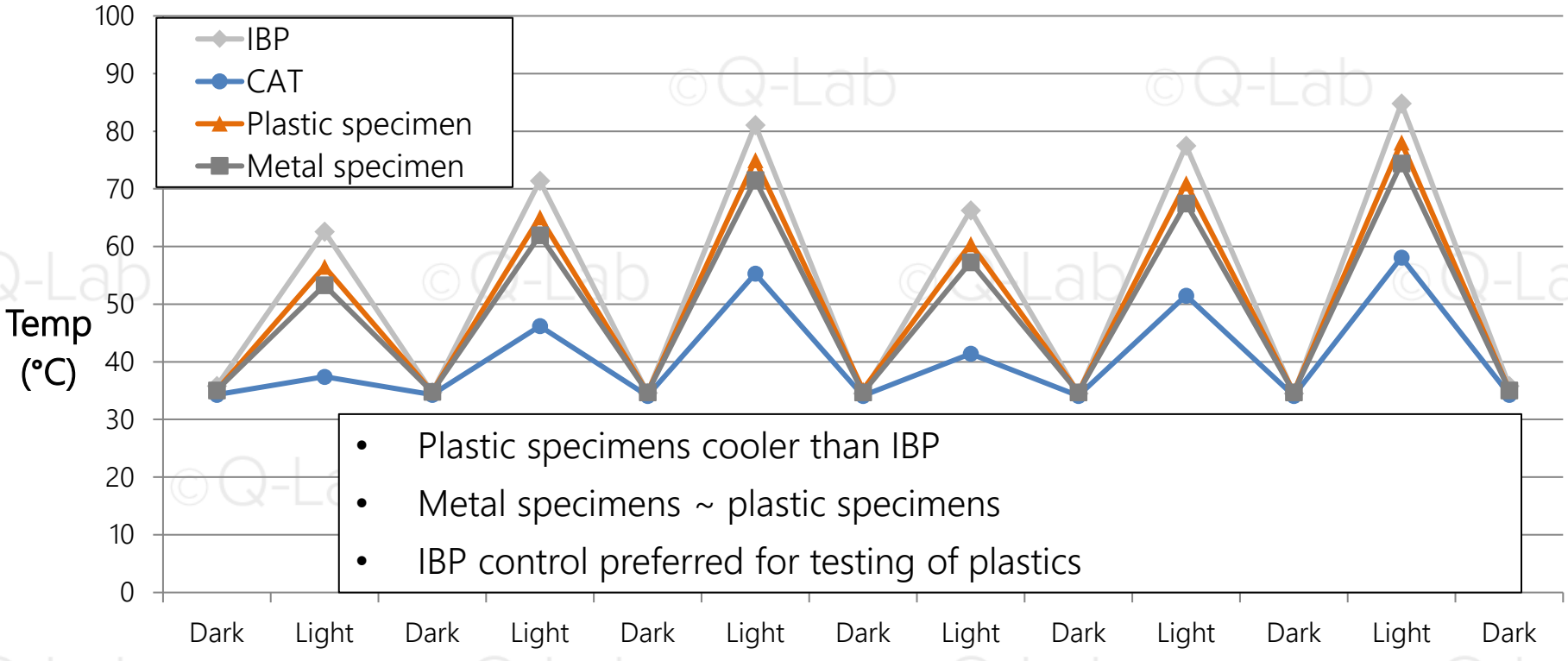
Xenon Arc Temps: Simplified View



Xenon Arc: Specimen Temps w/ BP control



Xenon Arc: Specimen Temps w/IBP control

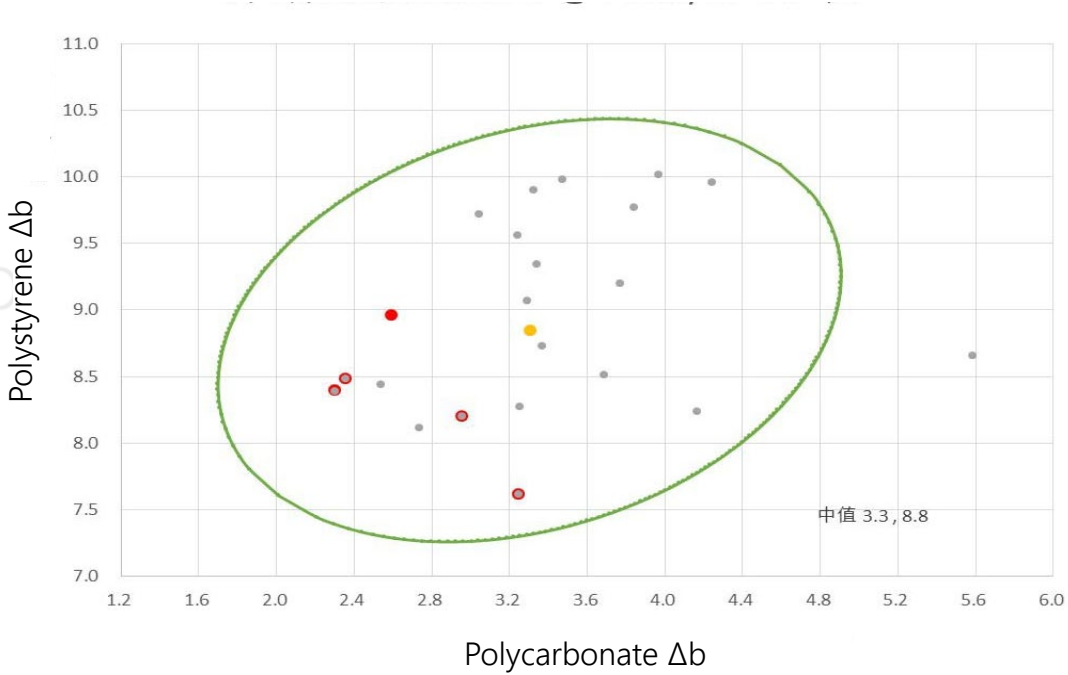


Black Panel Transition Times and Test Results

SAE J2527 Case Study

Case Study: SAE J2527 BPT ramp adjustment

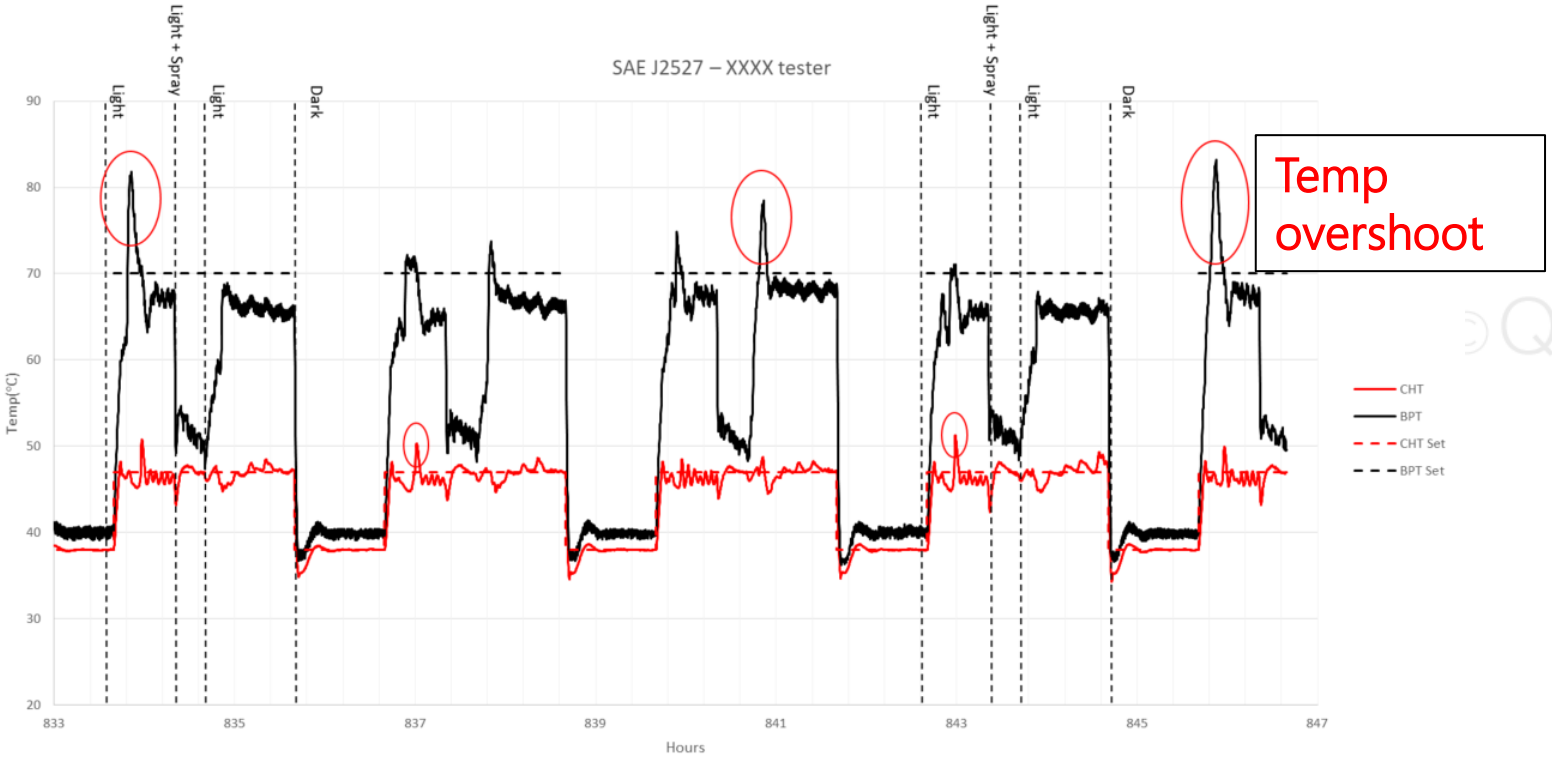
- Q-SUN Xe-3 tests were showing less color change than tests performed in other xenon chambers
- Red dots are Q-SUN Xe-3 testers
- Gray dots are different xenon chambers
- Yellow dot is the average



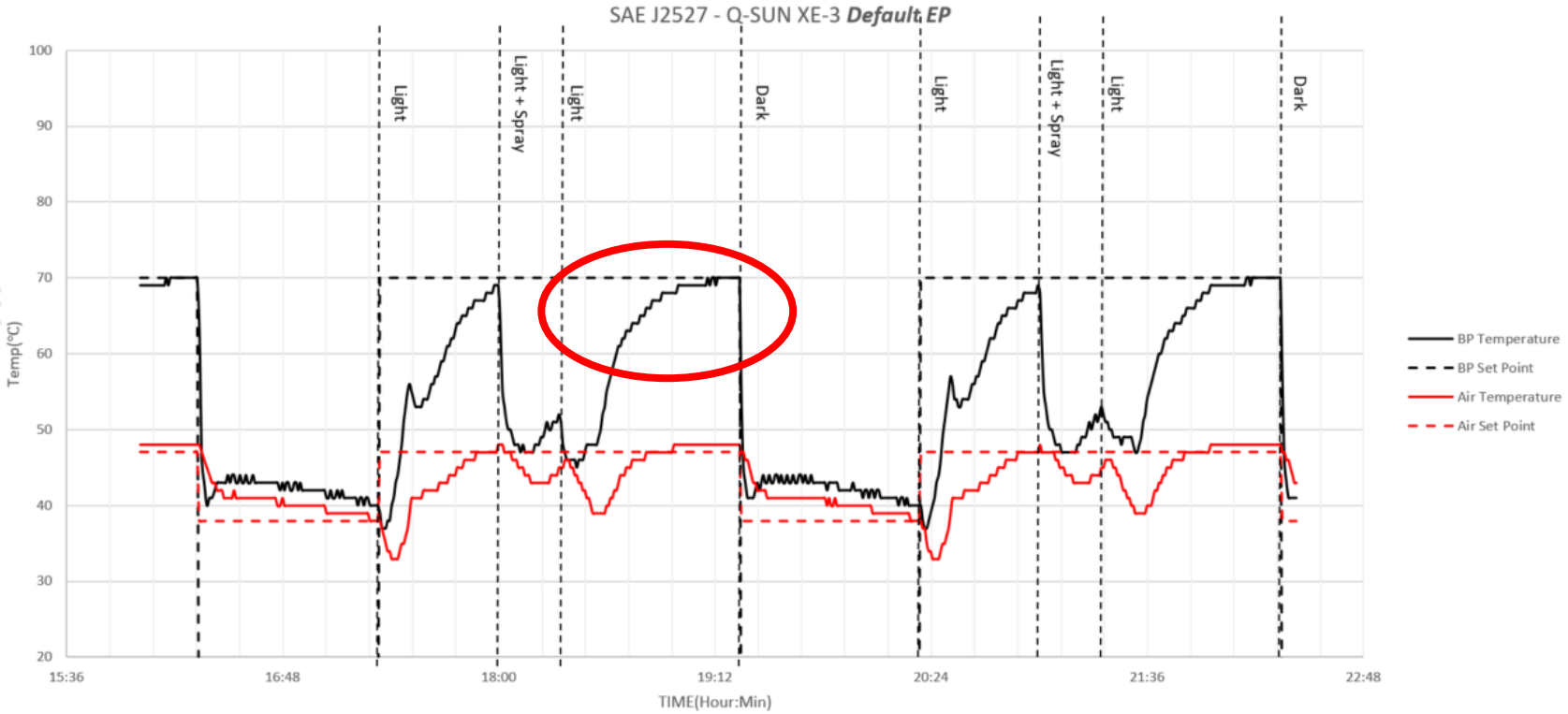
Case Study: SAE J2527 BPT ramp adjustment

- Optical filters and water spray were adjusted, but did not produce additional color change for transparent plastic (PS, PC)
- Alternative chambers in this case had faster temp increase rate, and significant temperature overshoot
- Q-SUN Xe-3 testers had a moderate temperature increase rate, and no temperature overshoot
- Polystyrene (PS) Lot 9, a standard reference material, is sensitive to UV cut-on and temp, but insensitive to moisture
- Temperature transition time can be adjusted to affect results

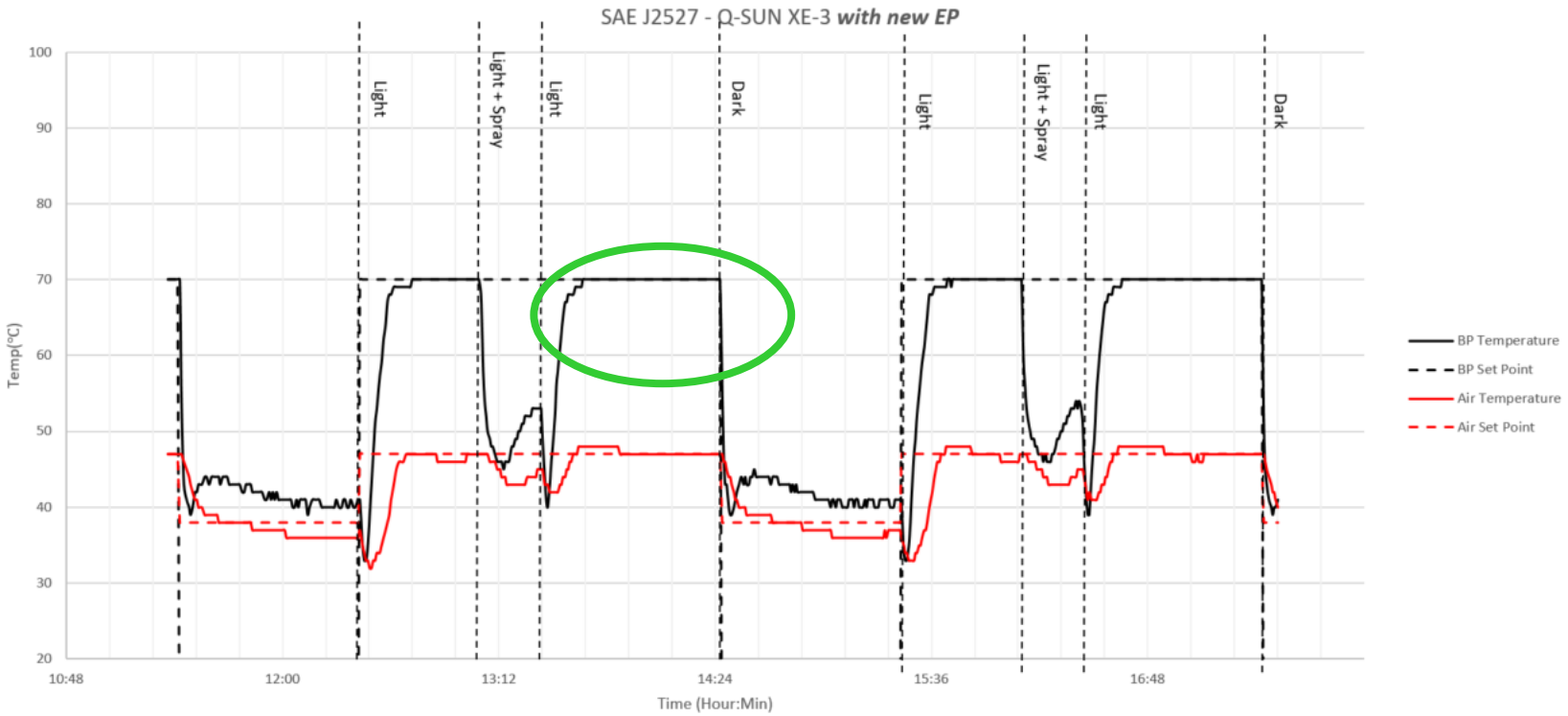
SAE J2527 in alternative tester



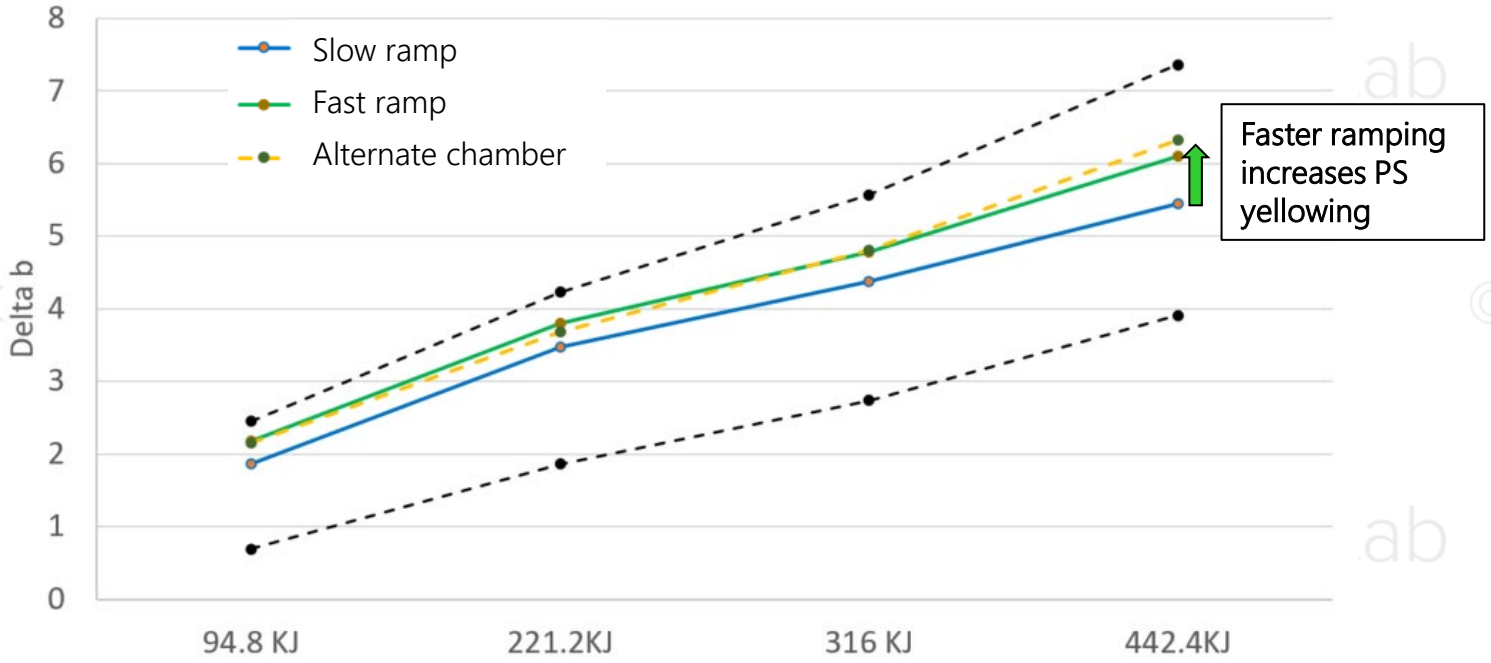
SAE J2527 in Q-SUN Xe-3: *Slow Temperature Increase*



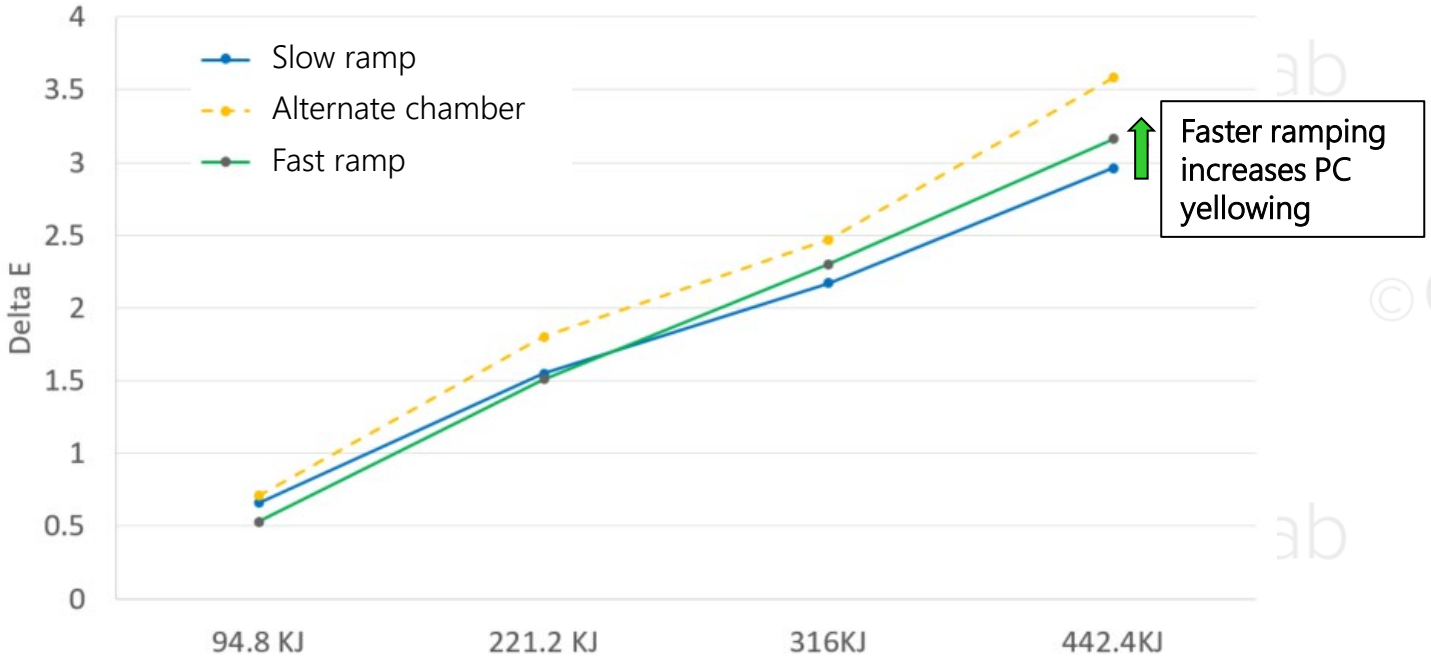
SAE J2527 in Q-SUN Xe-3: *Fast temperature increase*



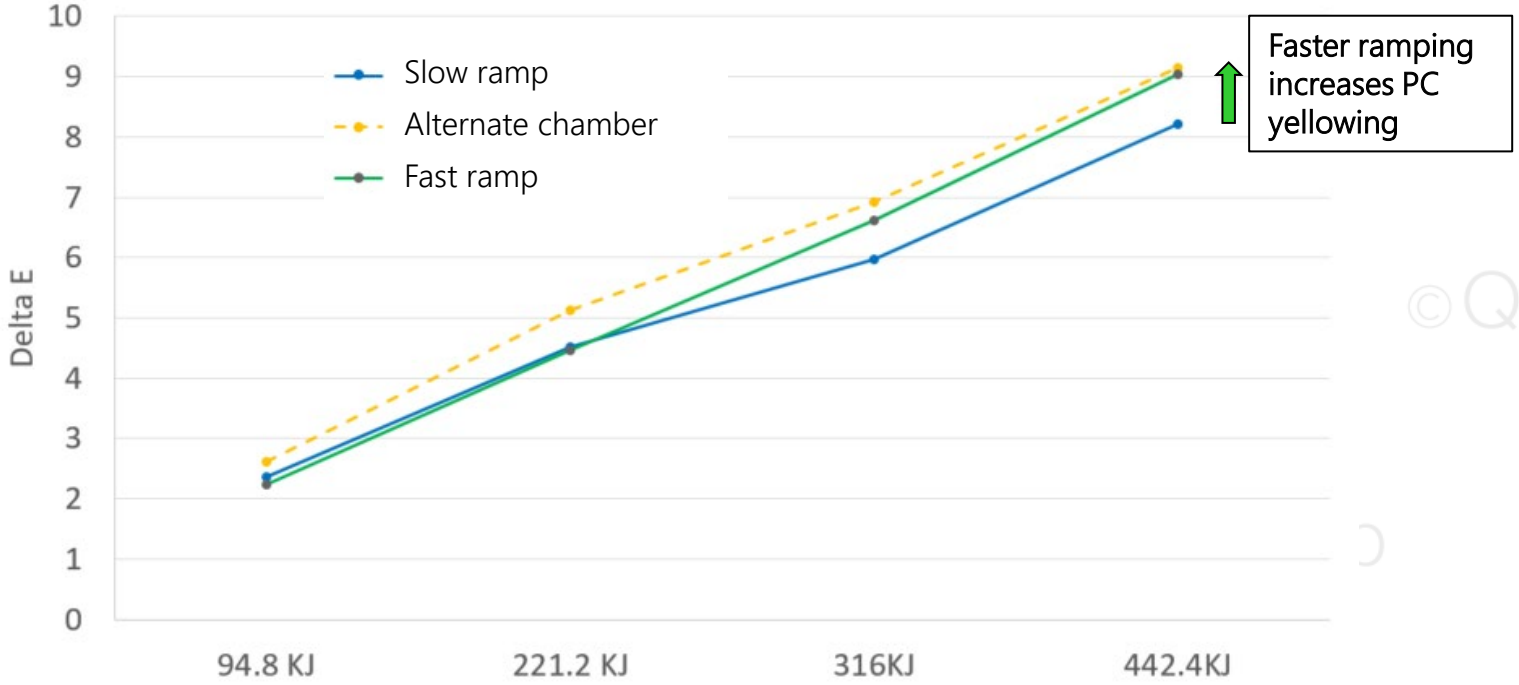
Delta b (yellowing) - PS, SAE J2527



Delta E (color change) - PC, SAE J2527

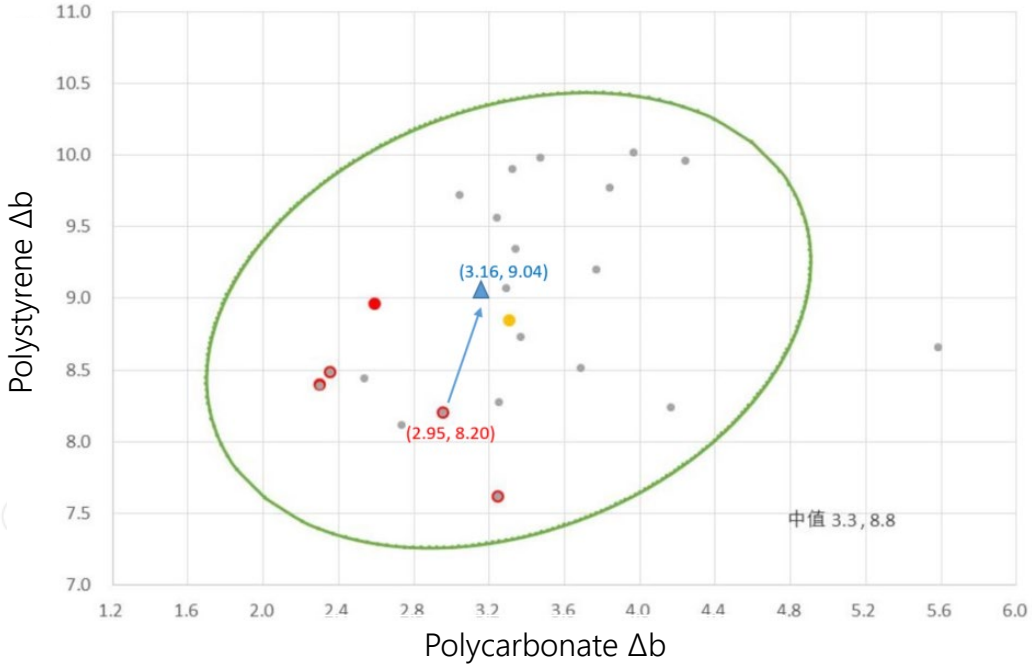


Delta E (color change) - GPPS, SAE J2527



Conclusions: Fast BPT ramp affects results

- More color change for these three transparent materials using a faster BPT ramp
- Red dots are default ramp
- Blue dot is faster ramp



Conclusions

- UV Fluorescent testing
  - BP for flat, conducting metal specimens
  - Insulated BP for flat, insulating plastic specimens
  - Insulated BP for **any** specimens tested in 3D boxes
  - UV fluorescent IBP matches performance of Black Standard
- Xenon arc
  - BP for metals
  - Insulated BP for plastics
- Transition times
  - Not specified in any weathering test standards
  - May influence severity of test results

Thank you for your time!

Questions?

info@q-lab.com

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