Temperature Control in Accelerated Laboratory Weathering Testing of Plastics

Bill Tobin – Senior Technical Marketing Specialist
Dave Duecker – Technical Marketing Specialist
Sean Fowler – Senior Technical Director
Andy Francis – Marketing Director

Click here to view the presentation.

Housekeeping

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

- Our ongoing webinar series can be found at: q-lab.com/webinarseries
- Our archived webinars are hosted at: q-lab.com/webinars
- 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 Temperature Control in Accelerated Laboratory Weathering Testing of Plastics 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.

We consistently hold seminars and webinars about weathering, corrosion, standards and more. The best way to keep up with news and events is by following us on Facebook, Twitter and LinkedIn.

Introduction

- Weathering testing is used widely to evaluate service environment performance of durable materials
  - **Outdoor testing:** natural and accelerated outdoor exposures
  - **Accelerated testing**: UV fluorescent and xenon arc

- A great example of weathering testing is the long-term **outdoor** and **accelerated** study conducted by the **Vinyl Siding Institute (VSI)**

Weathering Testing of Vinyl Siding

- Co-extruded building cladding material
  - Mostly Polyvinyl Chloride (PVC)
  - Top layer (capstock) is durable and UV-stabilized

- Most common residential exterior cladding material in US & Canada – about 20 million m^2 used per year

- **Homeowners want to have a guarantee of long-term durability – weathering testing can help**

Weathering Testing of Vinyl

VSI Outdoor test program

- Large-scale, long-term study
- Outdoor data collection ongoing since 1984
- New tests started every 5 years; thousands of specimens and replicates tested
- Long-term material degradation mechanisms are now well understood

Weathering Testing of Vinyl

Service Life Certification

- Accurate service life estimate based on 2-year outdoor testing
  - Look for color change <1 after two years of exposure
  - Indicates a high probability of color change <4 after 25 years
- 2-year outdoor certification program
  - Administered by ISO 17025-accredited, independent 3rd party
  - Exposures in FL, AZ, OH
  - Tests performed in accordance with ASTM test standards
  - Receive a VSI stamp, gives credibility to a **25-year warranty**

Weathering Testing of Vinyl

Accelerated Weathering

- **Question**: can accelerated testing correlate to 2-year outdoor testing and shorten qualification timing?
- **Approach:** Six rounds of accelerated testing conducted by multiple labs –UV fluorescent and xenon
- Unique **Fluorescent UV** cycle provided best correlation for PVC siding material
  - Hot condensation best for accelerating realistic moisture attack
  - Example of where the less expensive, simpler technology is superior
- UV fluorescent test not adopted for certification program, but used by members for product development

VSI Accelerated cycle

Step 1: Condensation, 55 °C, 12:00
Step 2: UV, 50 °C, 12:00

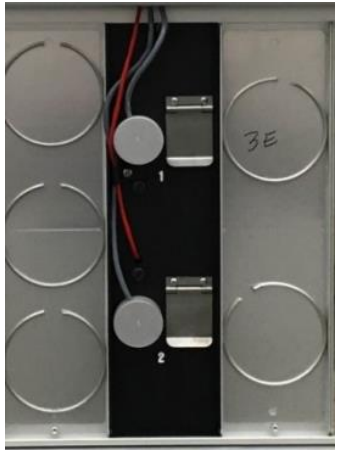
Most Unique factor is the temperature of the test!

Temperature in Accelerated Weathering Testing

- Specimen **temperature** is discussed less frequently than **light** spectrum and **water**, but is critical when testing polymeric materials like vinyl
  - Photochemical degradation can be strongly temperature-dependent
  - Plastics can soften or melt if subjected to excessive temperatures
- Accelerated test temperature usually controlled with a black panel (BP) thermometer

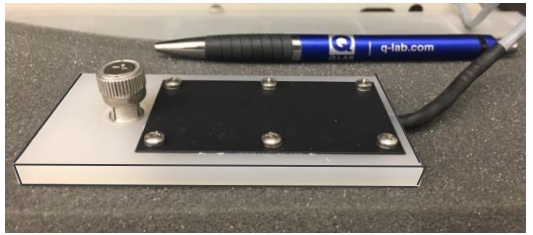
Black Panel (BP) Temperature Control

- 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!**

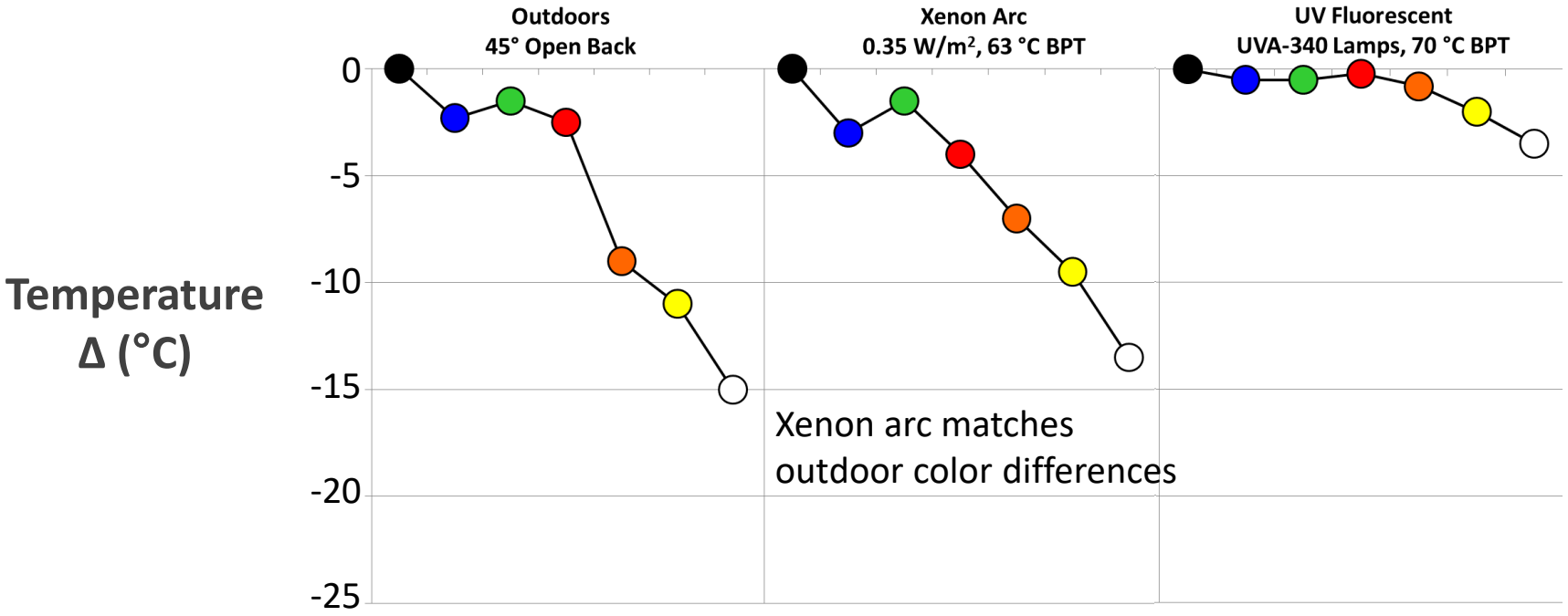


Fluorescent UV BP sensor

Xenon arc BP and IBP sensors



Temperature in accelerated weathering testers



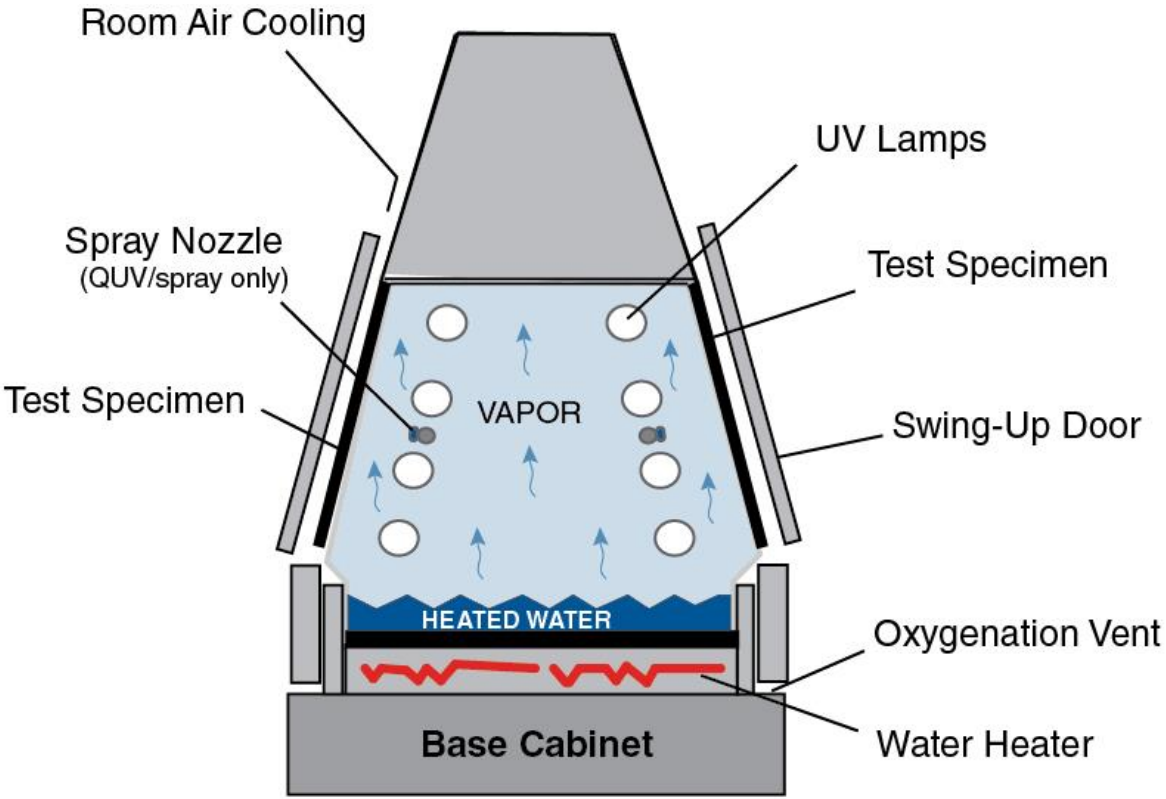
- Specimens in xenon testers absorb visible and IR light, increasing their temperature
- UV fluorescent testers do not generate much radiant heat for specimens

Specimen Temperature Testing Goals

- Observe differences in temperatures during accelerated weathering testing with **xenon arc** and **fluorescent UV**
  - Black panel and chamber air temperature
  - Specimen temperatures
- Evaluate temperature differences between plastic and metal specimens, black panels, and chamber air
- Understand how to control temperature differences between test configurations

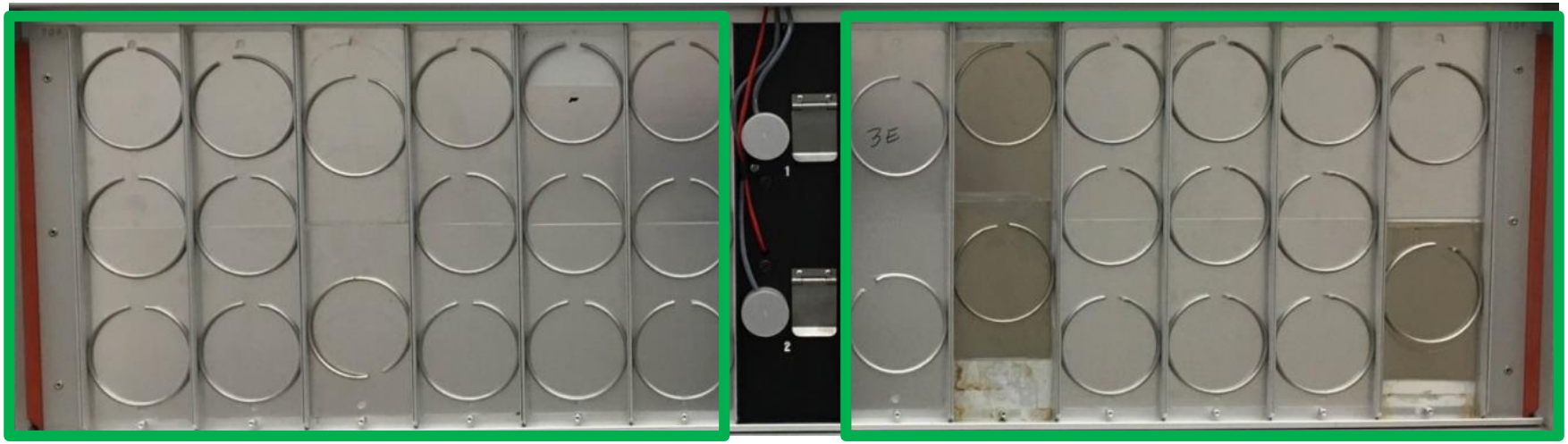
Specimen Temperatures: Fluorescent UV

Fluorescent UV tester schematic



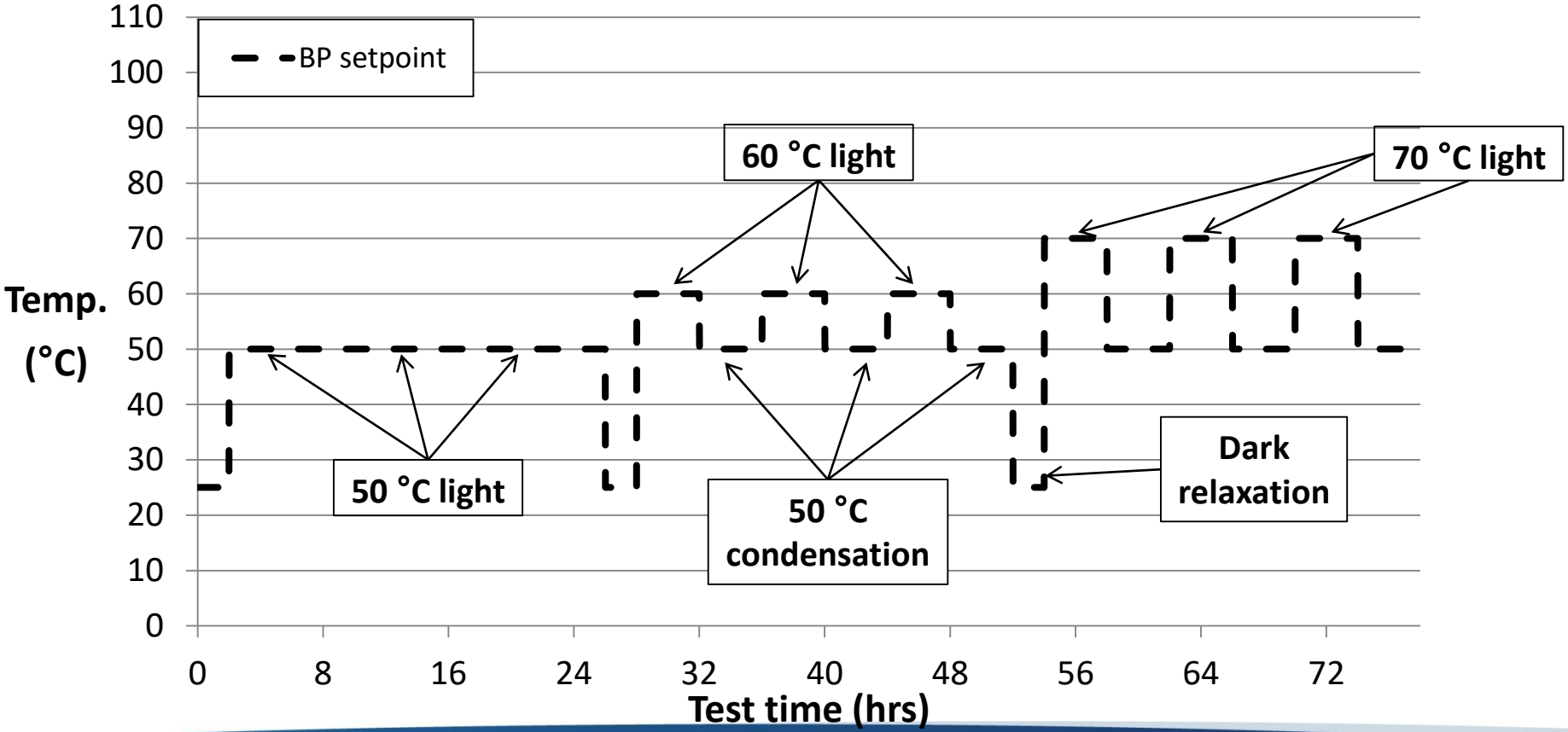
Fluorescent UV testing

Standard “2D” Specimen mounting

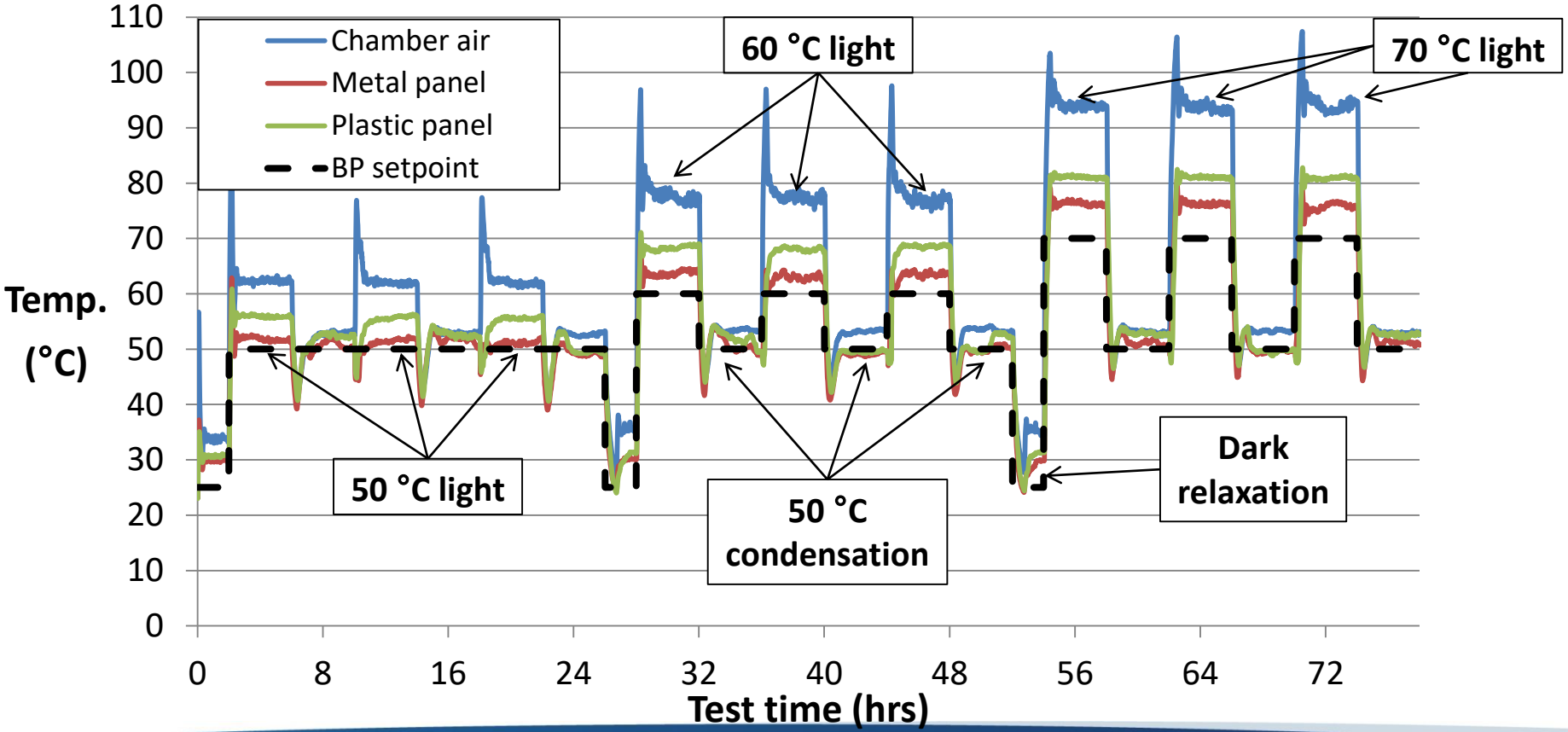


- Typical mounting for flat panels in a fluorescent UV tester
- Front two “quadrants” are shown

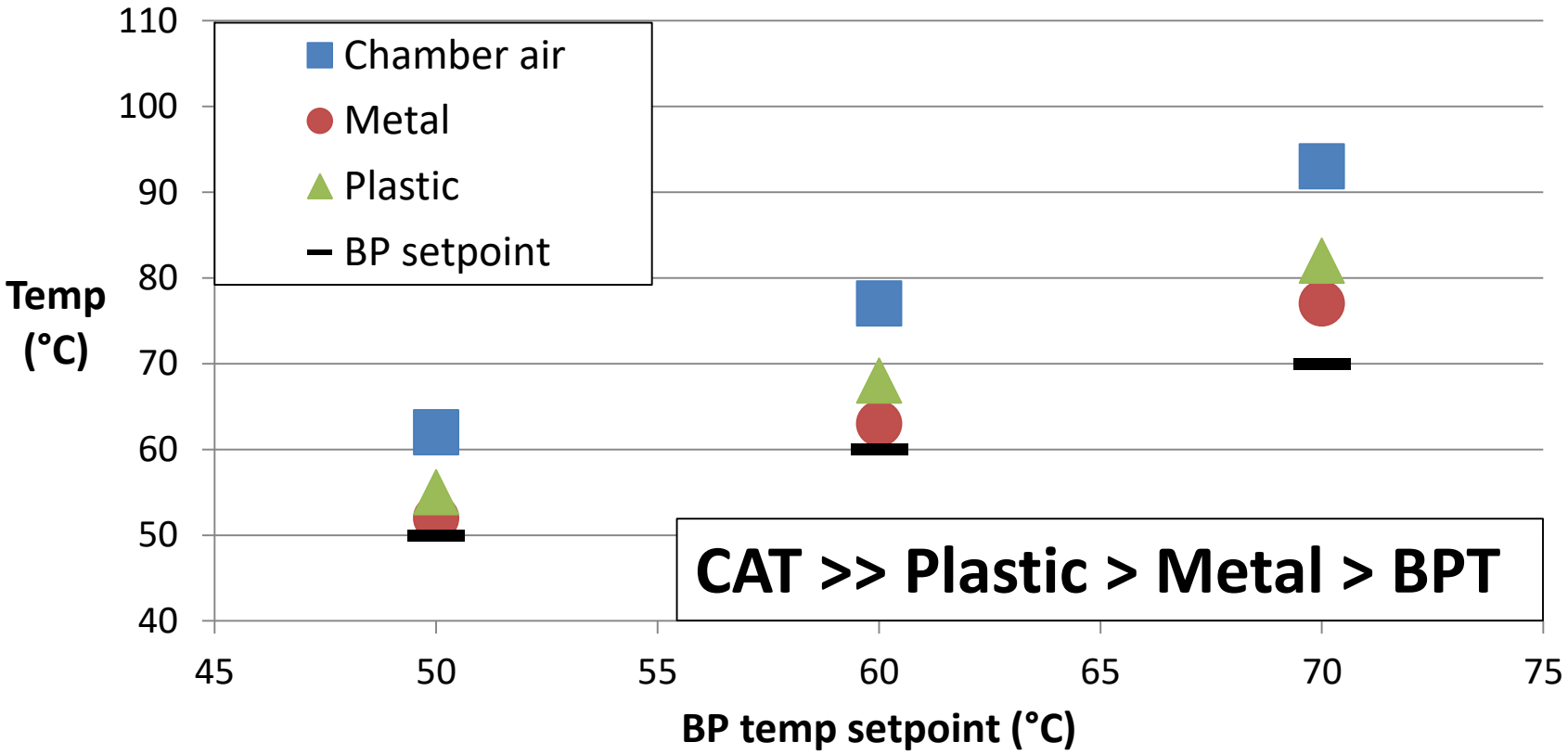
Fluorescent UV Experimental Test Cycle



Fluorescent UV Experimental Results



Fluorescent UV Test Cycle: Simplified View

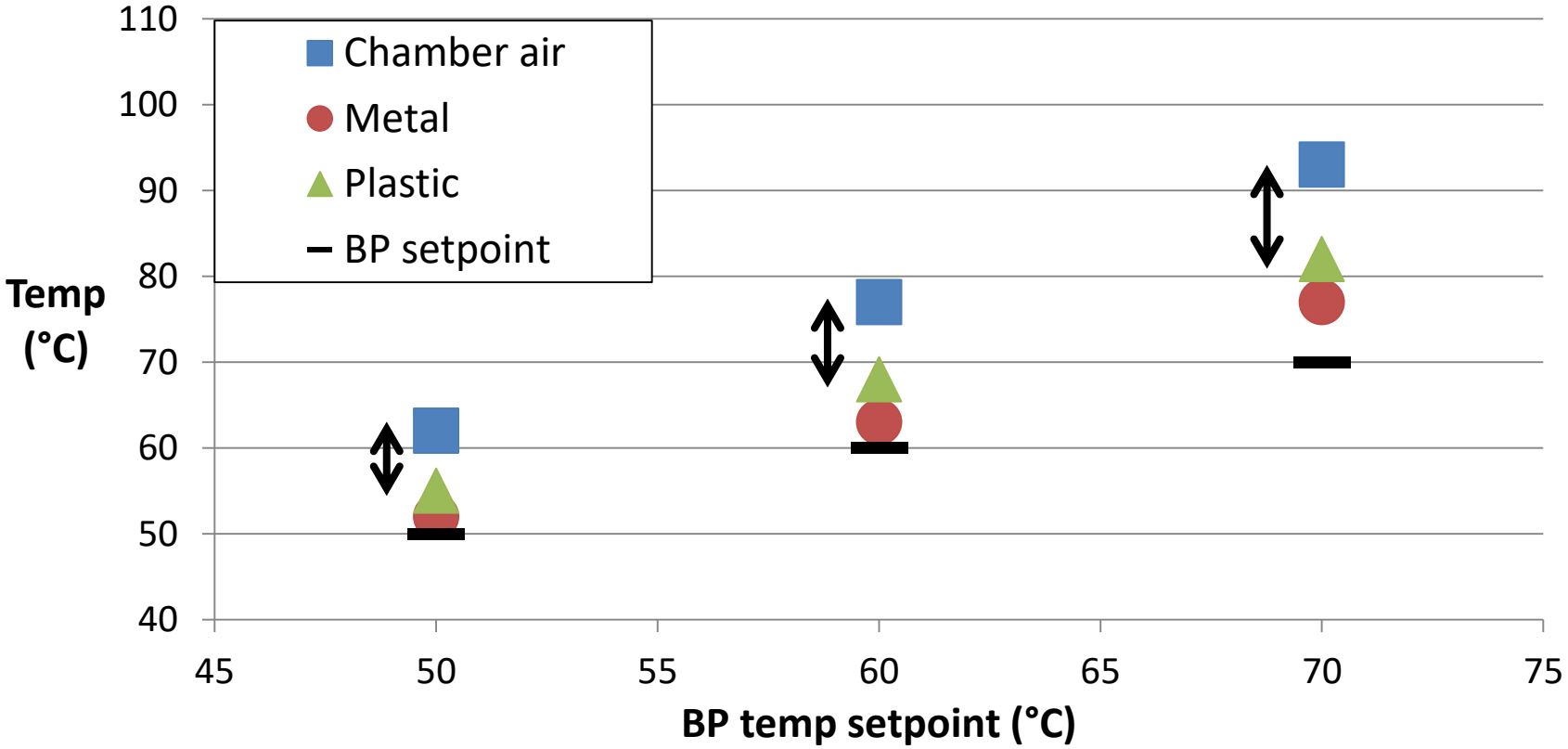


Fluorescent UV testing

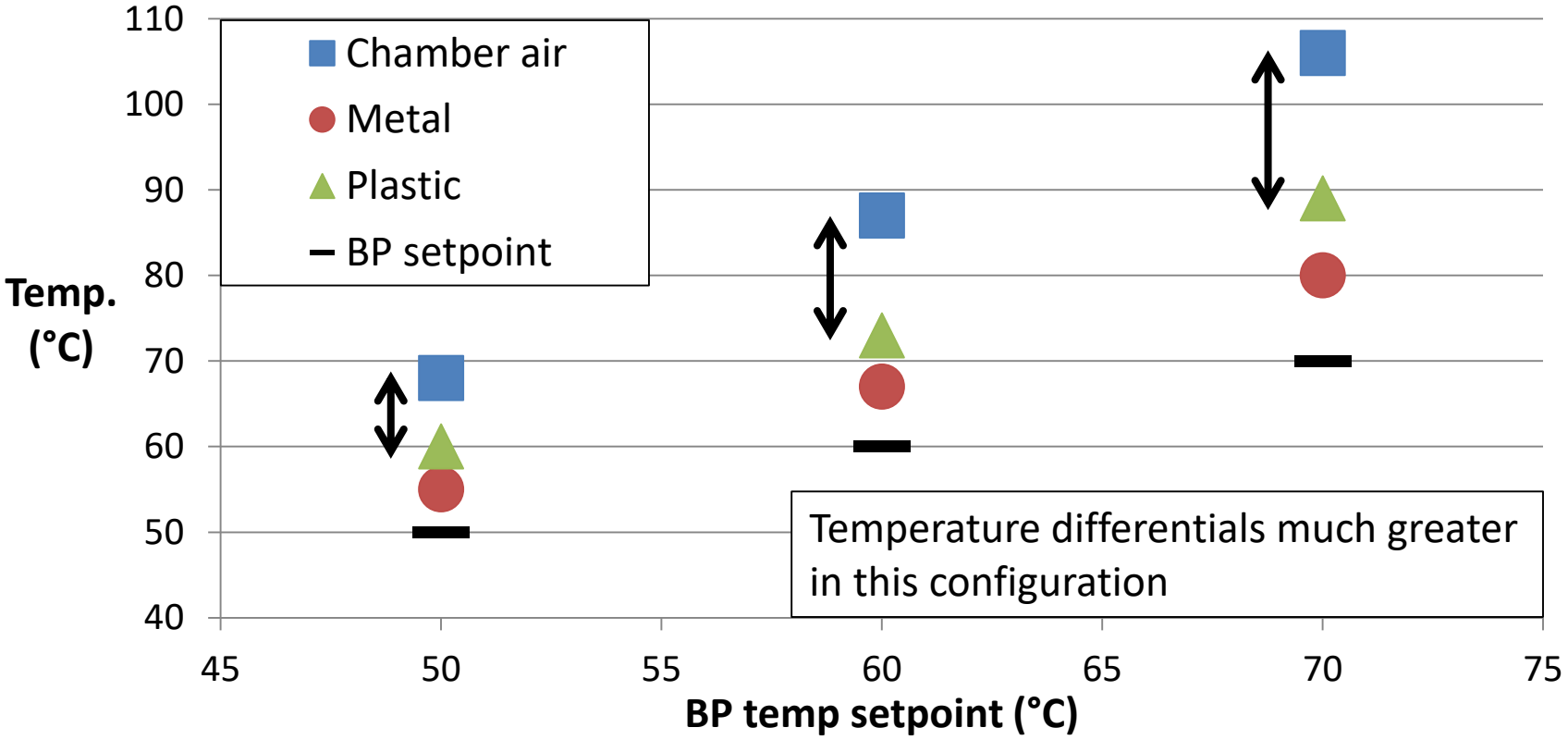
“3D” Specimen mounting

Quadrant boxes allow weathering of three-dimensional specimens

Test Cycle: 2D results (reminder)

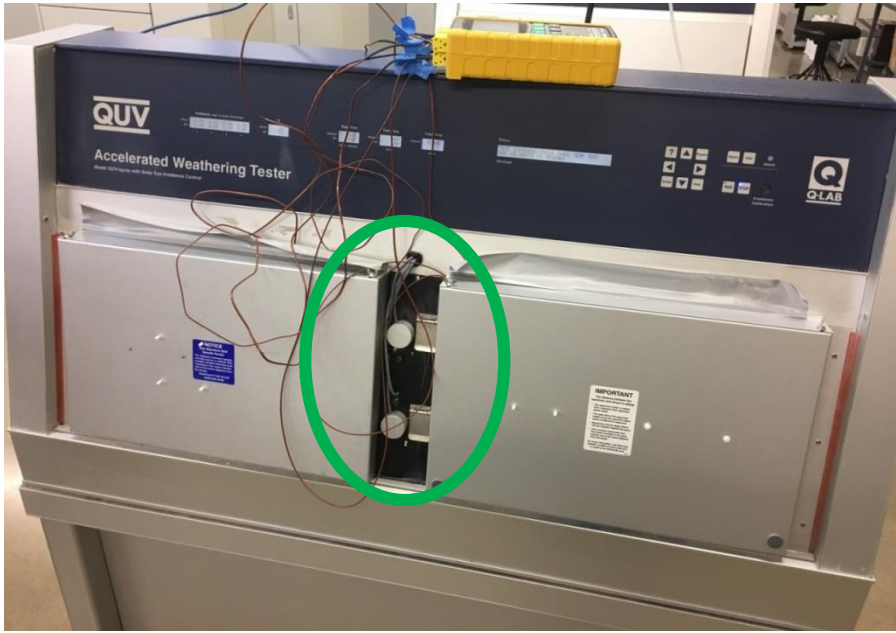


Specimen temperatures: 3D configuration



Why the temperature differences?

- Black panel was not insulated from laboratory air by a door
- Lab air cools the BP, which increases heater output, increasing specimen and chamber temperatures
- Specimen temperature control is **critical** for polymeric materials – need to control weathering testing properly



3D configuration with Insulation

- Adding an insulating door brings chamber air and specimen temperatures in a three-dimensional configuration right in line with standard specimen mounting

- What if we took it a step further, and used an insulated black panel?

Specimen Temperatures in Standard Configuration w/ IBP

Chamber temp – 70 C Setpoint

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

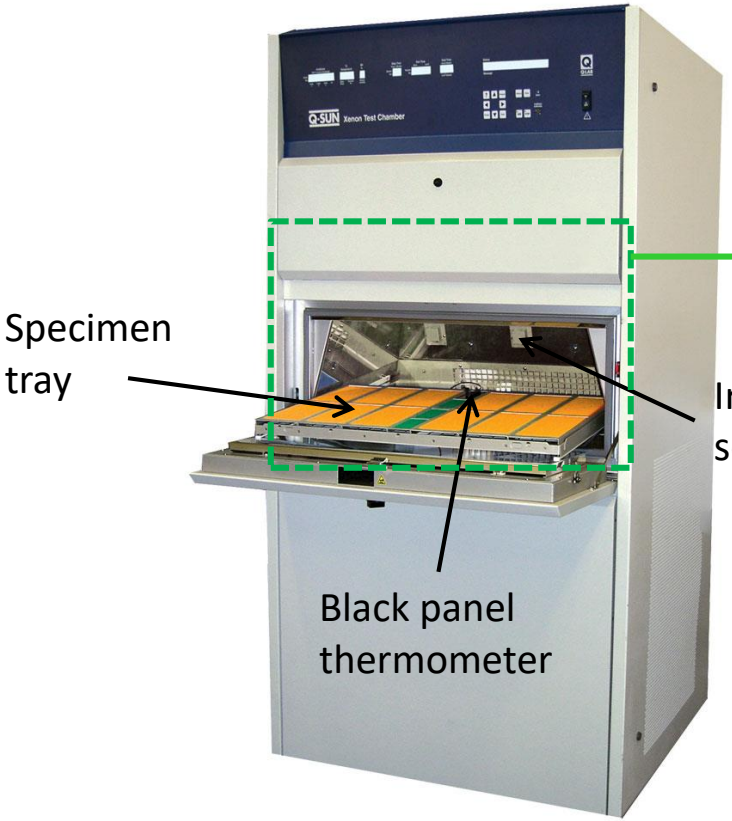
3D configuration with Insulation

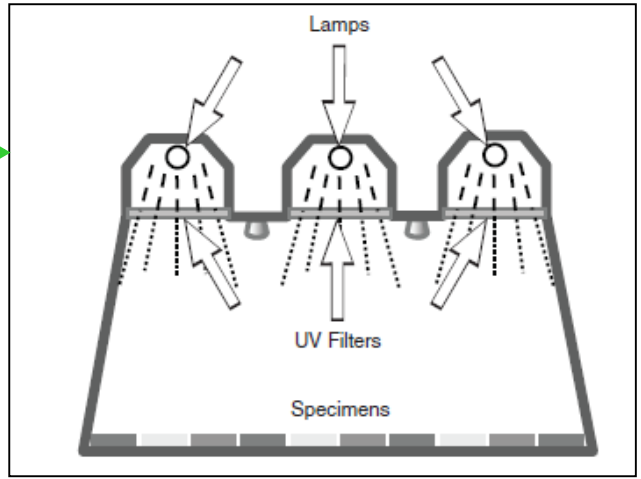
- Specimen temperatures can be very well-controlled in fluorescent UV if proper mounting and setup are performed

- **It's critical to understand differences between BP and CA temperatures in any weathering test!**

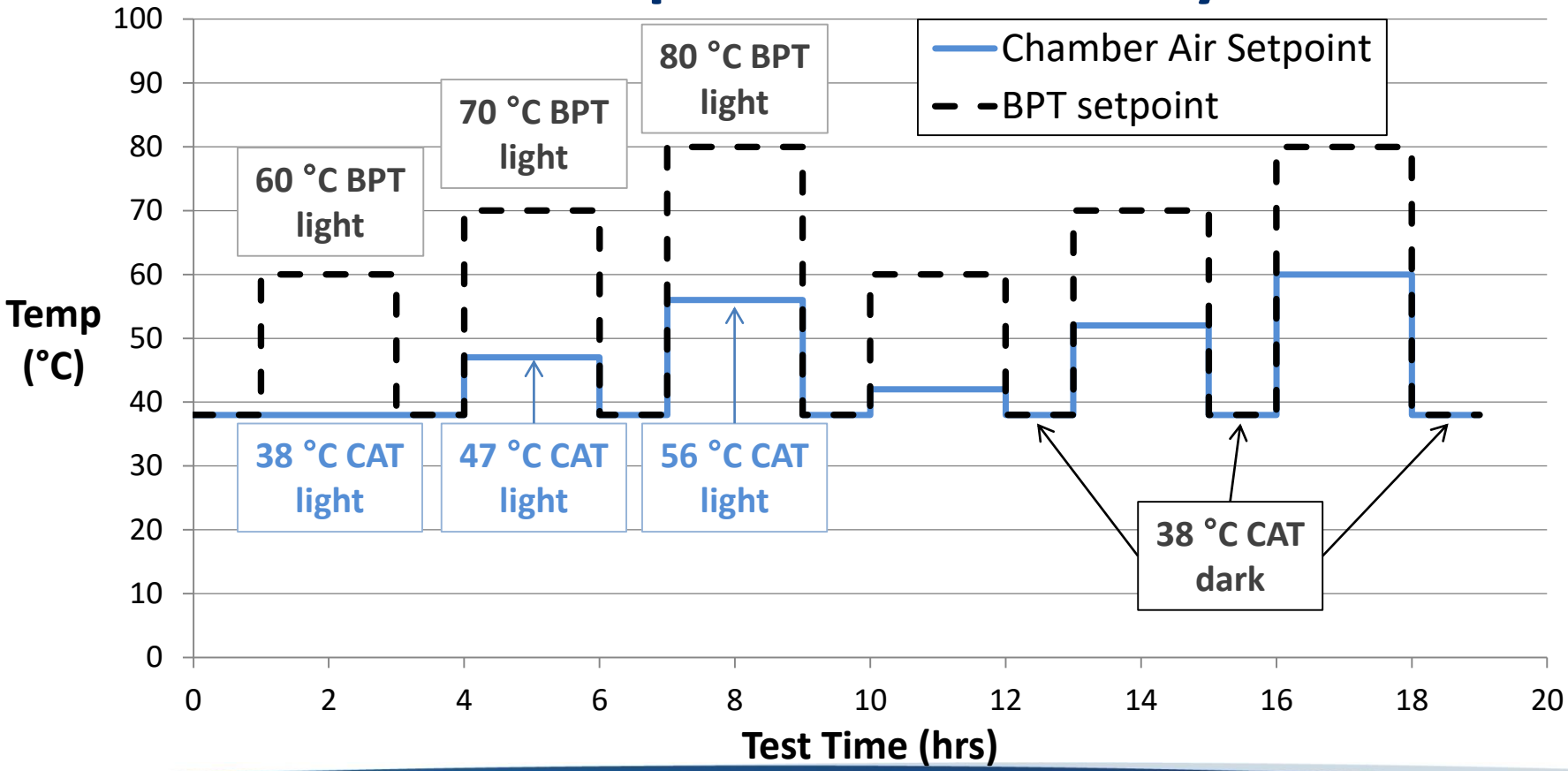
Specimen Temperatures: Xenon arc

Xenon arc tester schematic

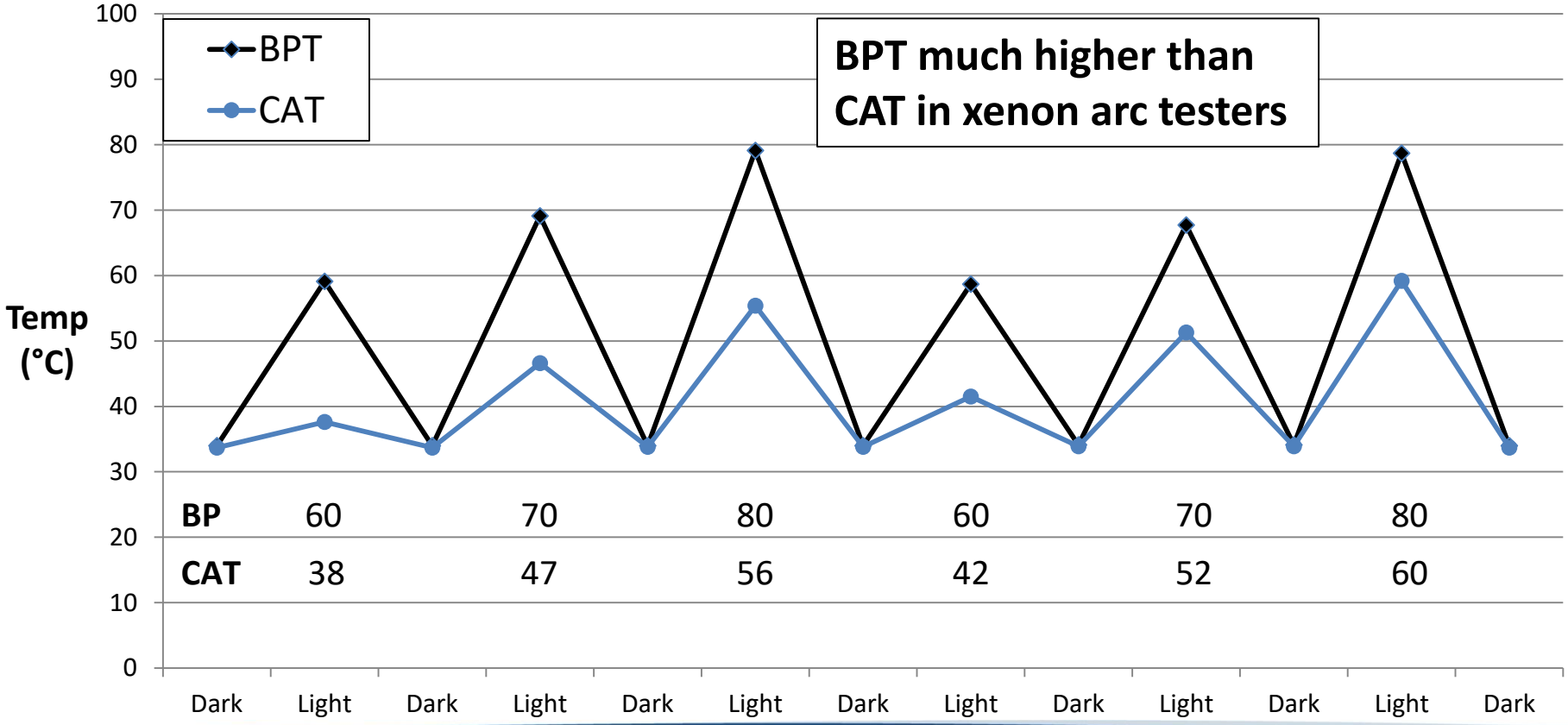




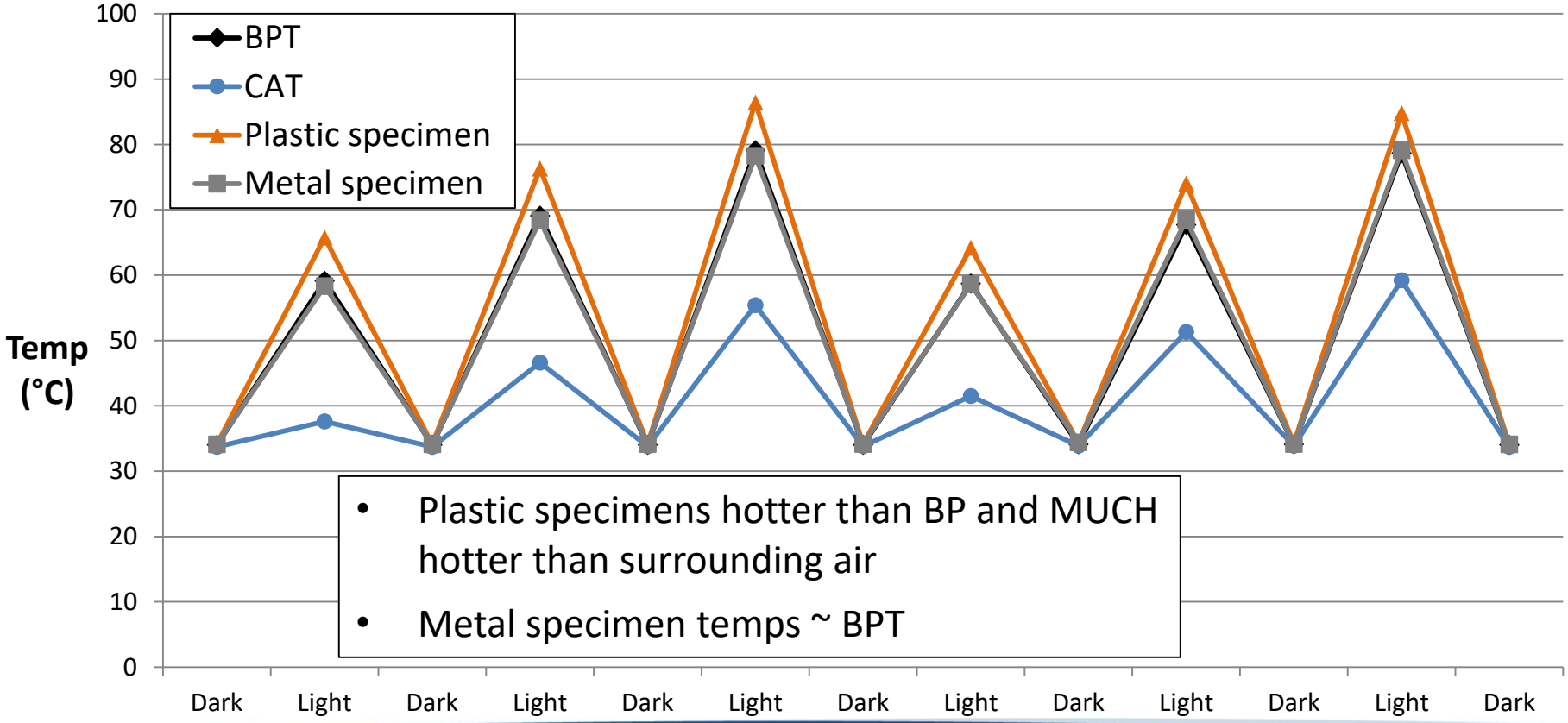
Xenon Arc Experimental Test Cycle



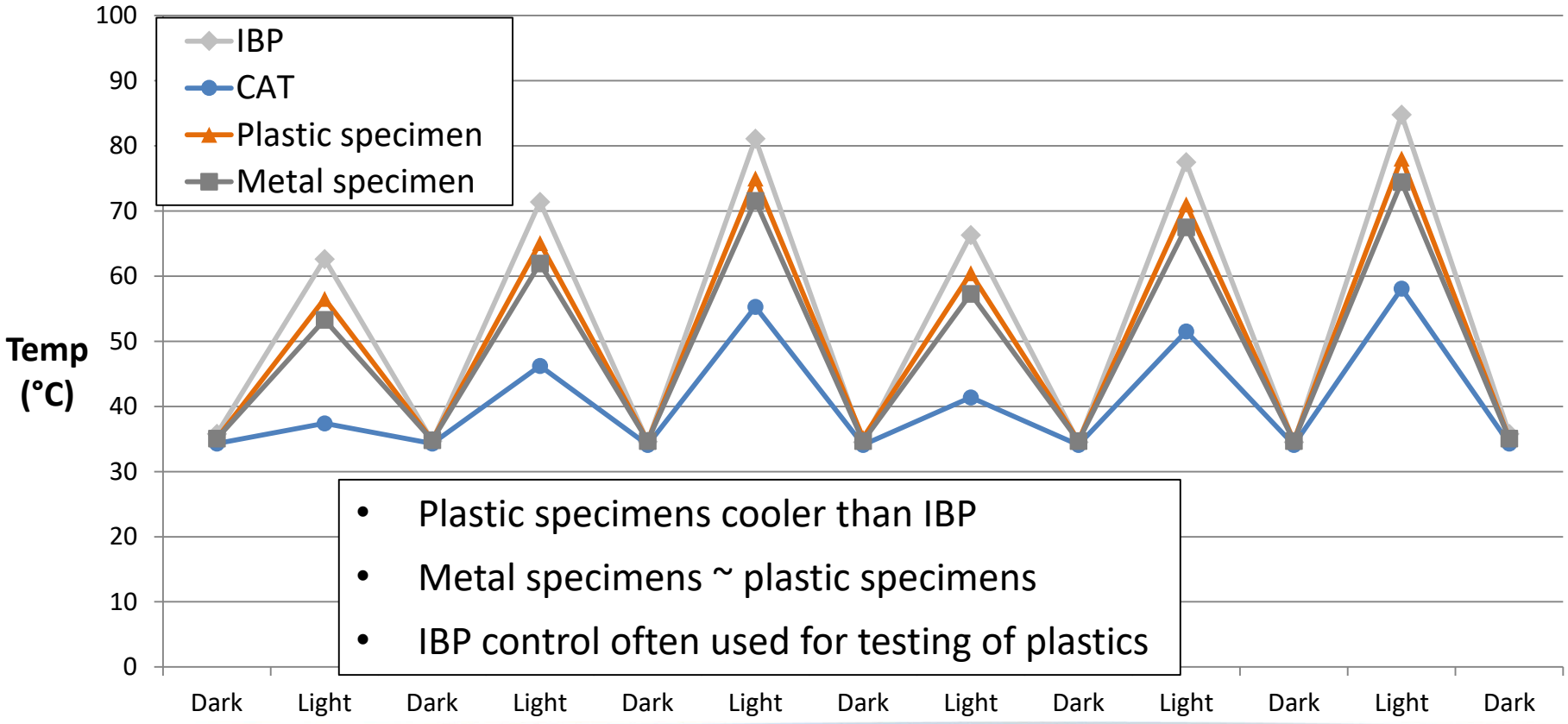
Xenon Arc Test Cycle: Simplified View



Xenon Arc: Specimen Temperatures w/ BP control



Xenon Arc: Specimen Temperatures w/IBP control



Conclusions

- **Fluorescent UV**
  - Chamber air and specimen temperatures exceed black panel temperature – UV testers do not generate radiant heat
  - Polymer reach much higher temperatures than chamber air temp and metal test specimens
  - Specimens can be 10-20 °C hotter than nominal test setpoints without proper test control.
- **Xenon arc**
  - Black panel temperatures exceed chamber air temperatures due to radiant heat
  - Plastic specimens slightly hotter than BP temp but slightly lower than IBP temp

Conclusions

- **Specimen temperature** is a critical factor to both understand and control in xenon and fluorescent UV weathering testing of plastics
- Black panel temperature doesn't tell the whole story!
- 3D testing in fluorescent UV testers offers flexibility but can complicate specimen temperature control
- Understanding specimen temperatures in accelerated weathering tests – especially with 3D mounting - can help provide more reliable and realistic test results and avoid damaging sensitive test materials.

Thank you for your attention!

For further questions, contact
info@q-lab.com