

# Temperature Control in Accelerated Laboratory Weathering Testing of Plastics

## 塑料在实验室加速老化测试中的温度控制

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# Introduction

- Weathering testing is used widely to evaluate service environment performance of durable materials

耐候测试被广泛应用去评估材料在服役环境中的表现

- **Outdoor testing:** natural and accelerated outdoor exposures

户外曝晒：自然和加速户外曝晒

- **Accelerated testing:** UV fluorescent and xenon arc

加速老化测试：紫外和氙灯

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

乙烯基墙板协会做的户外和实验室加速研究是耐候测试的一个很好的例子

# Weathering Testing of Vinyl Siding 乙烯基壁板

- Co-extruded building cladding material 共挤建筑覆层材料
  - 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<sup>2</sup> used per year  
在北美, 最常见的住宅外墙覆层材料每年大约使用2000万平方米

- **Homeowners want to have a guarantee of long-term durability – weathering testing can help**  
户主希望有长期的耐候性-老化测试可以帮助解决



# Weathering Testing of Vinyl 乙烯基的耐候测试

## VSI Outdoor test program 乙烯基户外测试项目

- Large-scale, long-term study  
大规模，长期的研究
- Outdoor data collection ongoing since 1984  
从1984年开始一直在收集户外的数据
- New tests started every 5 years;  
thousands of specimens and replicates tested  
新的测试每5年开始，成千上万的样品
- Long-term material degradation mechanisms are now well understood  
材料长期老化机制很好地被理解



# Weathering Testing of Vinyl 乙烯基的耐候测试

## Service Life Certification 寿命认证

- Accurate service life estimate based on 2-year outdoor testing  
基于2年的户外测试得到准确的寿命评估
  - Look for color change <1 after two years of exposure  
看是否2年曝晒色差小于1
  - Indicates a high probability of color change <4 after 25 years  
预测25年之后大概率色差小于4
- 2-year outdoor certification program  
2年的户外认证项目
  - Administered by ISO 17025-accredited, independent 3rd party  
由ISO 17025认证的独立第三方管理
  - Exposures in FL, AZ, OH  
在佛罗里达，亚利桑那和俄亥俄州曝晒
  - Tests performed in accordance with ASTM test standards  
按照ASTM测试标准进行测试
  - Receive a VSI stamp, gives credibility to a **25-year warranty**  
收到VSI印章，给予25年信誉的保证

# Weathering Testing of Vinyl 乙烯基的耐候测试

## Accelerated Weathering 加速老化

- **Question:** can accelerated testing correlate to 2-year outdoor testing and shorten qualification timing?  
问题：加速老化测试是否可以与2年的户外曝晒相关并且缩短认证时间？
- **Approach:** Six rounds of accelerated testing conducted by multiple labs –UV fluorescent and xenon  
方法：六轮实验在不同的实验室进行- 紫外和氙灯
- **Unique Fluorescent UV cycle** provided best correlation for PVC siding material  
荧光紫外提供了最好的相关性对于PVC材料
  - Hot condensation best for accelerating realistic moisture attack  
冷凝最好地加速了现实地潮湿侵袭
  - Example of where the less expensive, simpler technology is superior  
低测试成本，简单地测试技术
- UV fluorescent test not adopted for certification program, but used by members for product development  
荧光紫外测试不作为认证项目，但是作为材料开发之用



# 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!***

***最独特的因素是测试的温度!***

# Temperature in Accelerated Weathering Testing

## 加速老化测试中的温度加速

- Specimen **temperature** is discussed less frequently than **light** spectrum and **water**, but is critical when testing polymeric materials like vinyl  
样品温度的讨论少于光谱和水，但对于聚合物材料测试很重要
  - Photochemical degradation can be strongly temperature-dependent  
温度影响光致反应
  - Plastics can soften or melt if subjected to excessive temperatures  
温度过高会导致塑料软化或者融化
- Accelerated test temperature usually controlled with a black panel (BP) thermometer  
通常使用黑板温度计来控制加速老化测试



# Black Panel (BP) Temperature Control

## 黑板温度控制

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

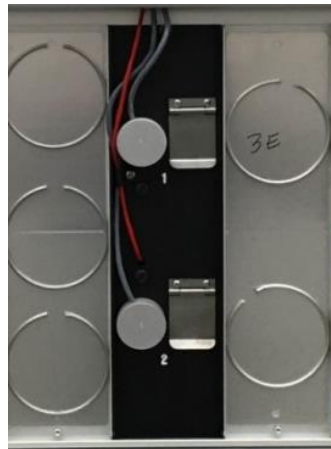
黑板温度模拟样品温度，和空气温度不一样

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

黑板温度规范了样品经受的环境，和实验室温度没关系

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

黑板温度不一定是样品的温度，也不是样品可能到达的最高温度

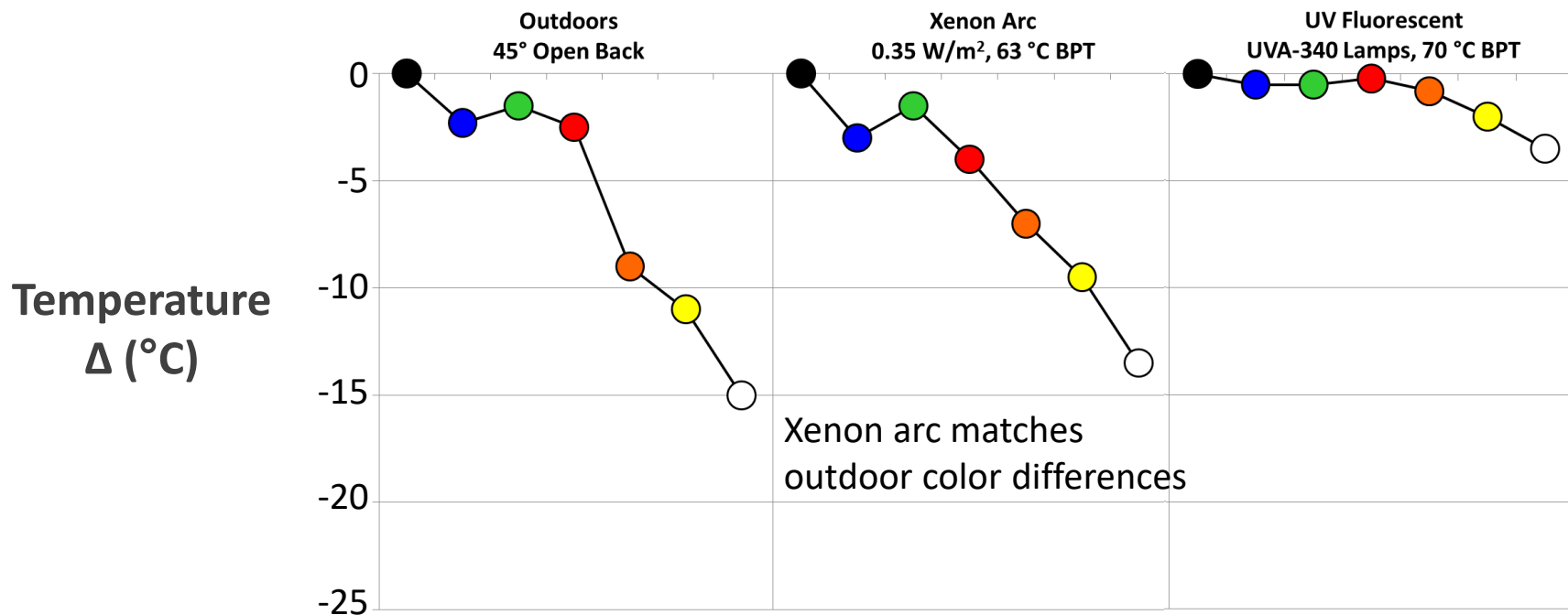


Fluorescent UV  
BP sensor

Xenon arc BP and IBP sensors



# Temperature in accelerated weathering testers



- Specimens in xenon testers absorb visible and IR light, increasing their temperature  
氙灯箱内样品吸收可见光和红外, 使他们的温度升高
- UV fluorescent testers do not generate much radiant heat for specimens  
紫外老化箱不产生很多辐射热

# Specimen Temperature Testing Goals

- Observe differences in temperatures during accelerated weathering testing with **xenon arc and fluorescent UV**

氙灯老化和紫外老化测试中观察不同的温度表征

- Black panel and chamber air temperature

黑板和空气温度

- Specimen temperatures

样品温度

- Evaluate temperature differences between plastic and metal specimens, black panels, and chamber air

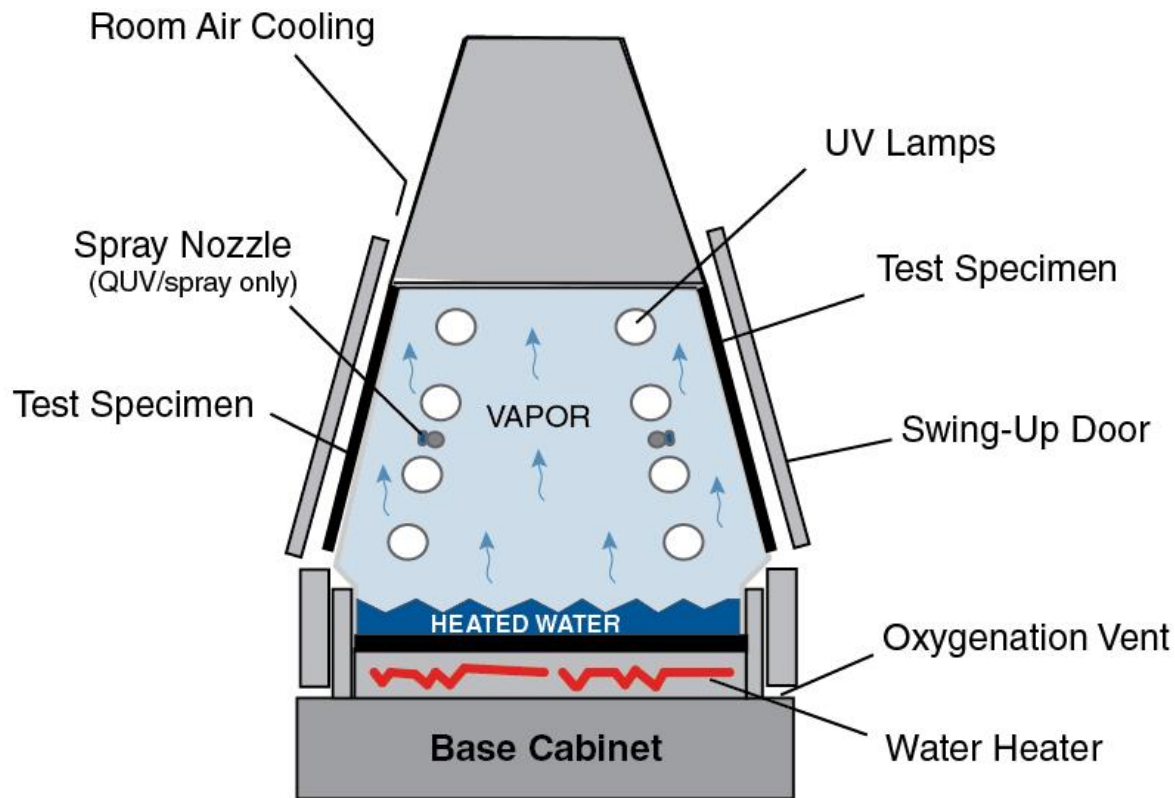
塑料和金属样品间温度，黑板和箱体空气温度间的不同

- Understand how to control temperature differences between test configurations
- 理解不同测试间如何控制温度变化

# Specimen Temperatures: Fluorescent UV

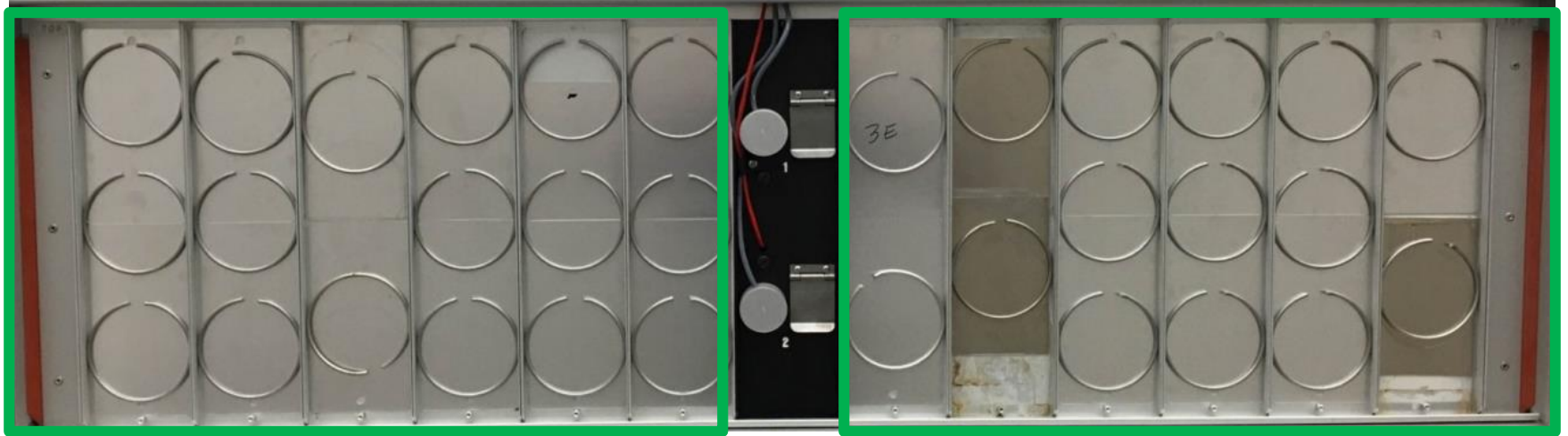


# Fluorescent UV tester schematic



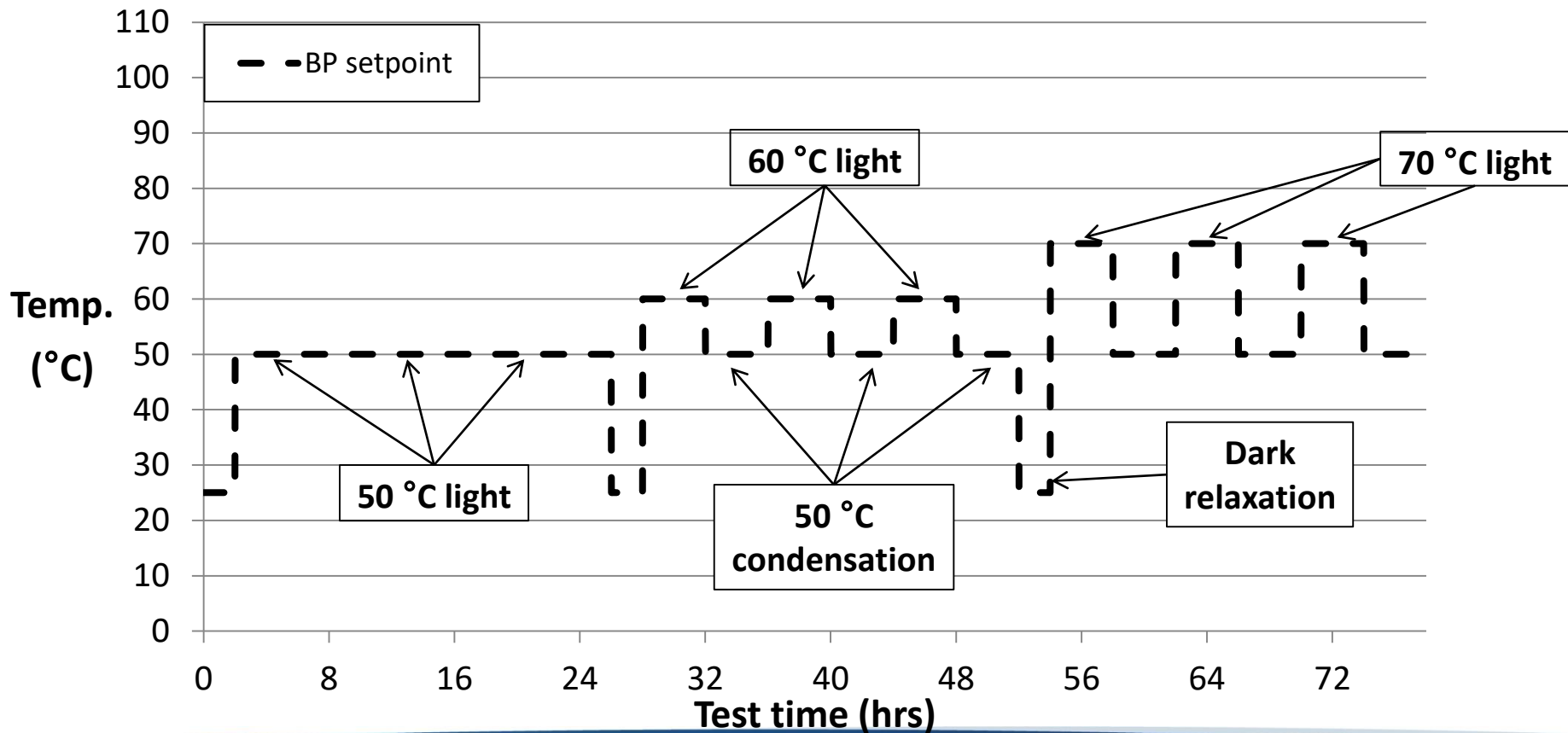
# Fluorescent UV testing

## Standard “2D” Specimen mounting

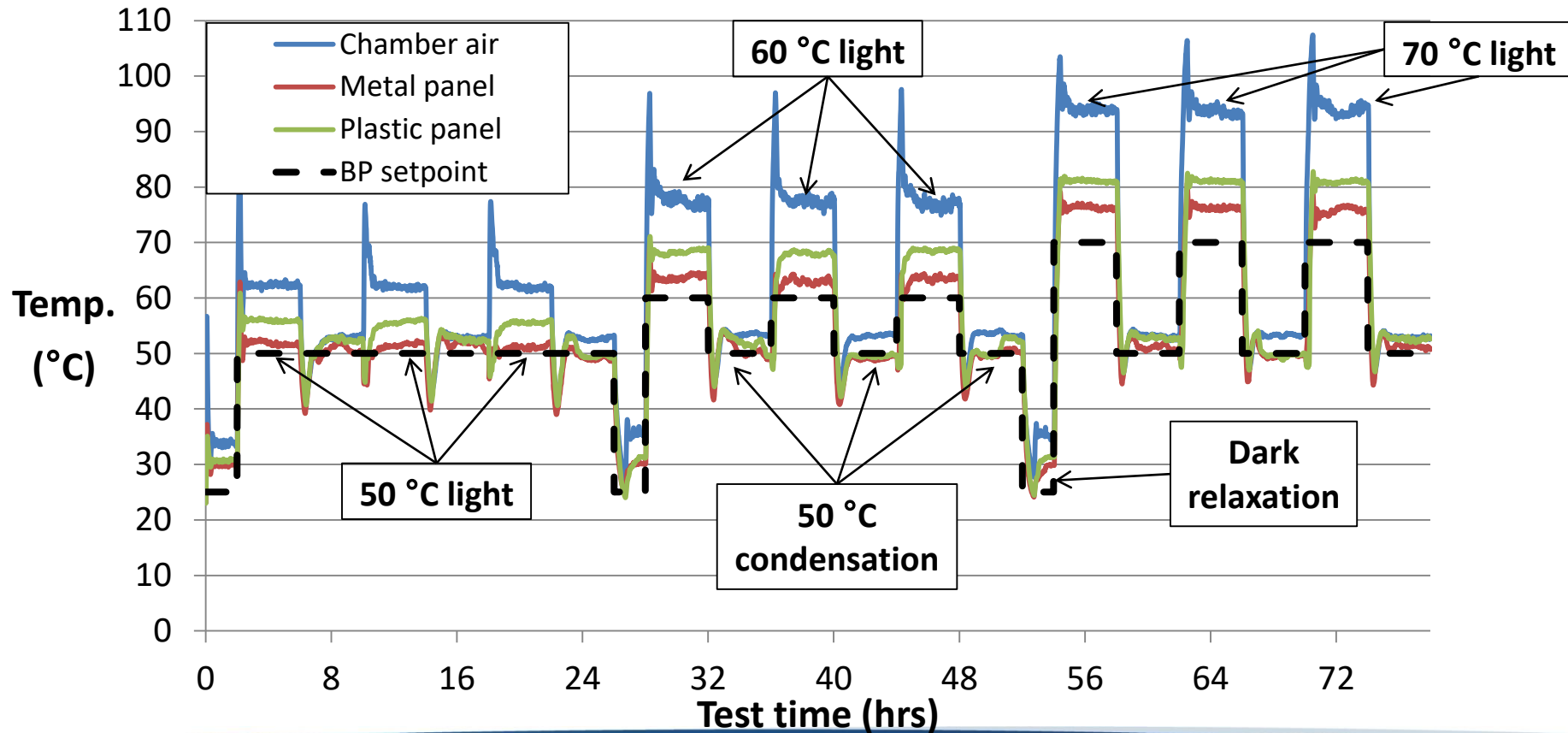


- Typical mounting for flat panels in a fluorescent UV tester 典型的平整样品
- Front two “quadrants” are shown

# Fluorescent UV Experimental Test Cycle

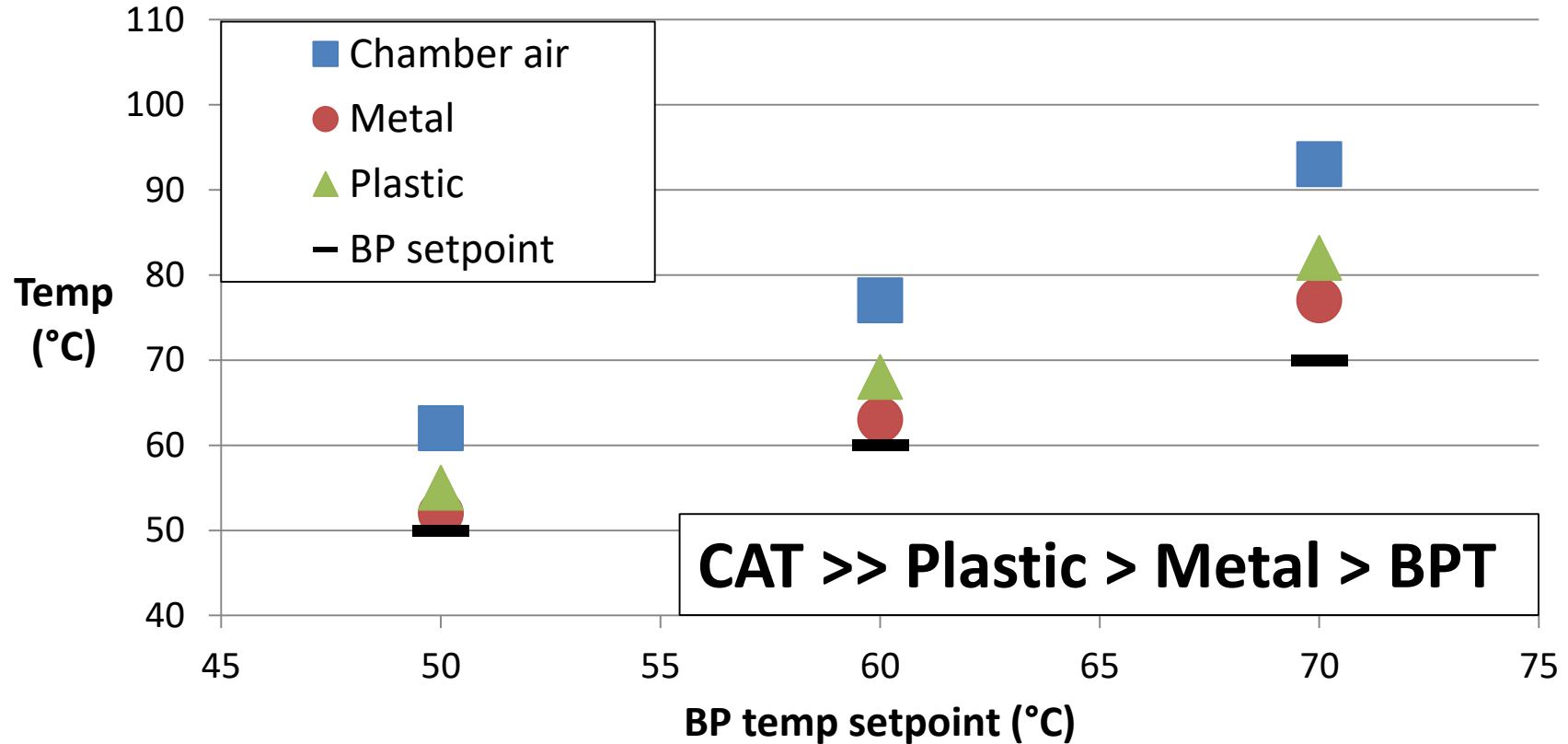


# Fluorescent UV Experimental Results



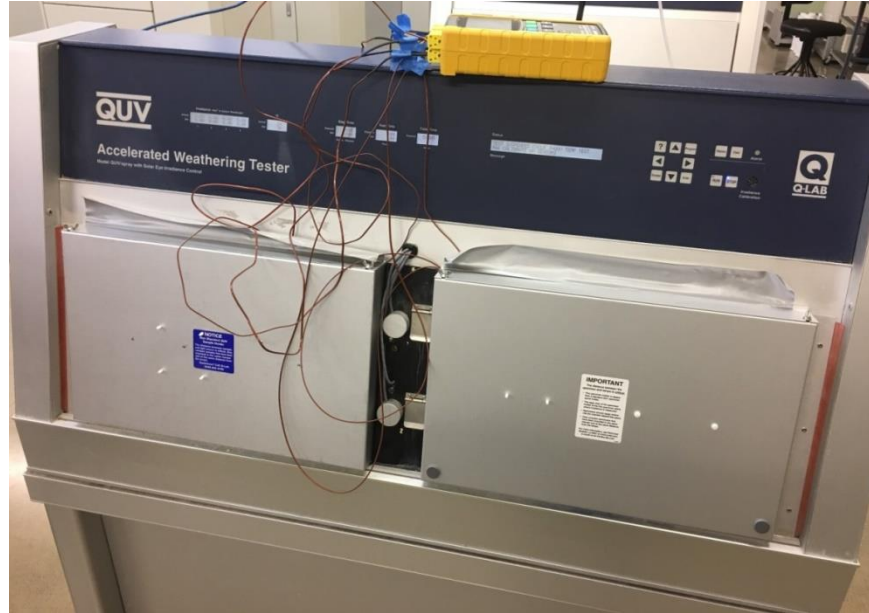


# Fluorescent UV Test Cycle: Simplified View



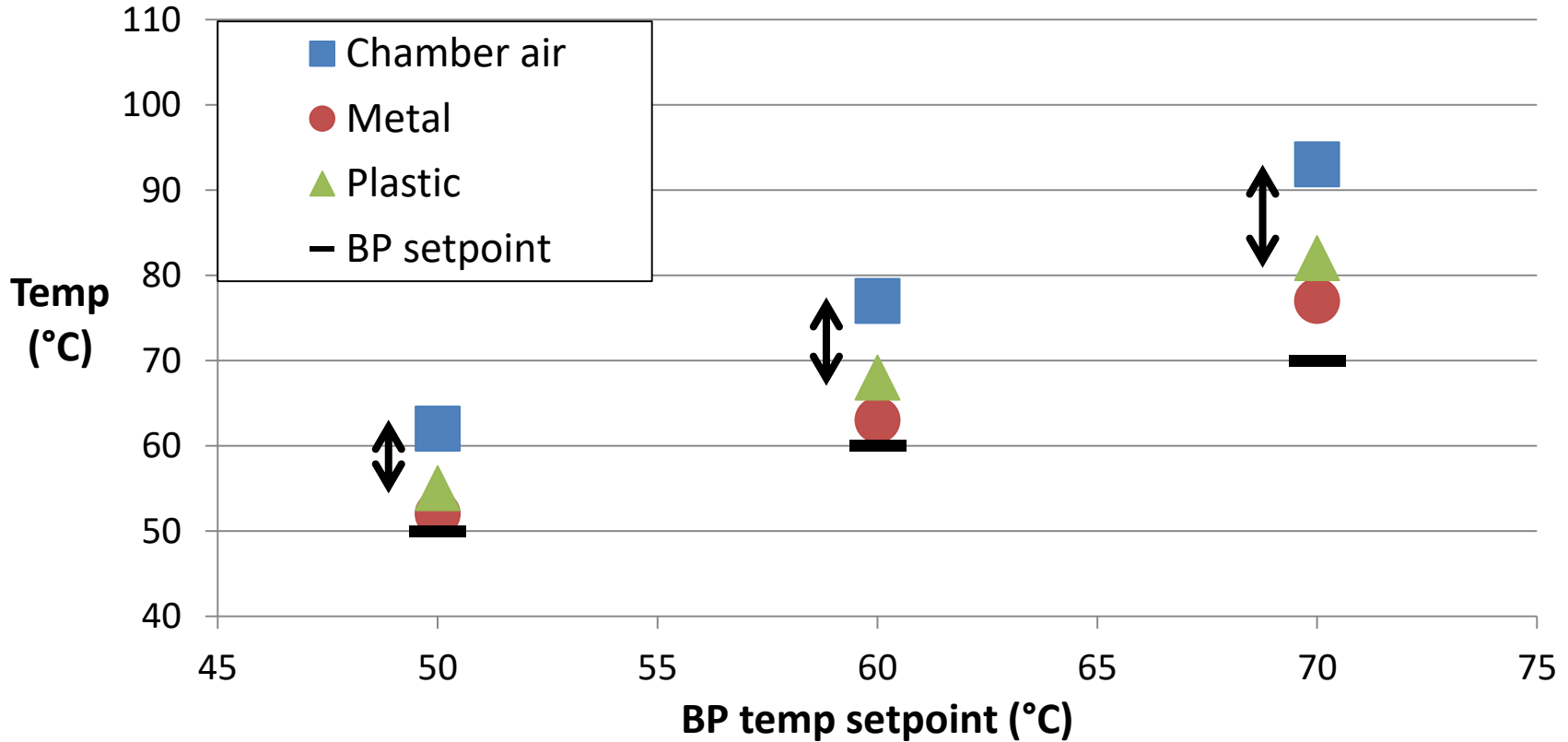
# Fluorescent UV testing

## “3D” Specimen mounting

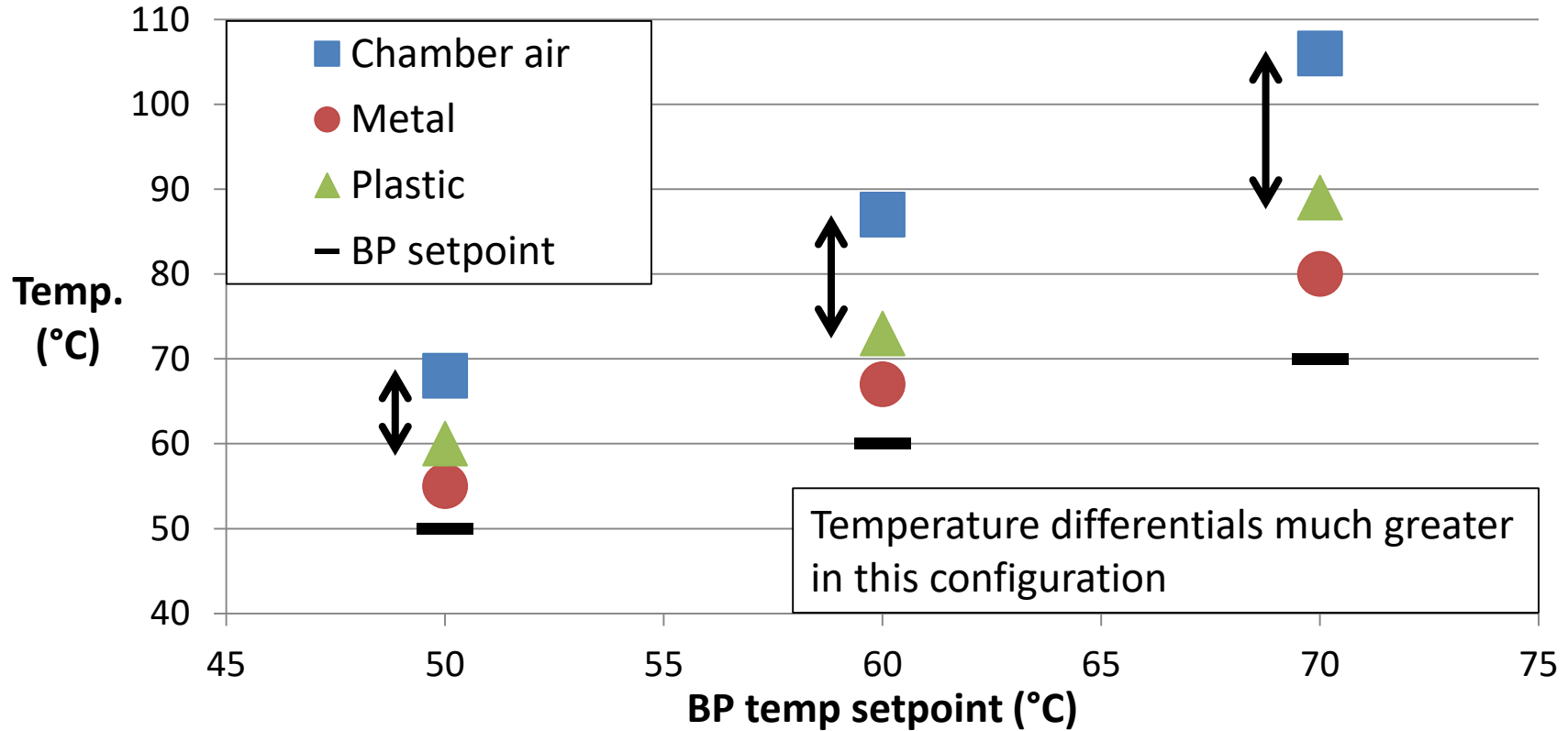


Quadrant boxes allow weathering of three-dimensional specimens

# Test Cycle: 2D results (reminder)

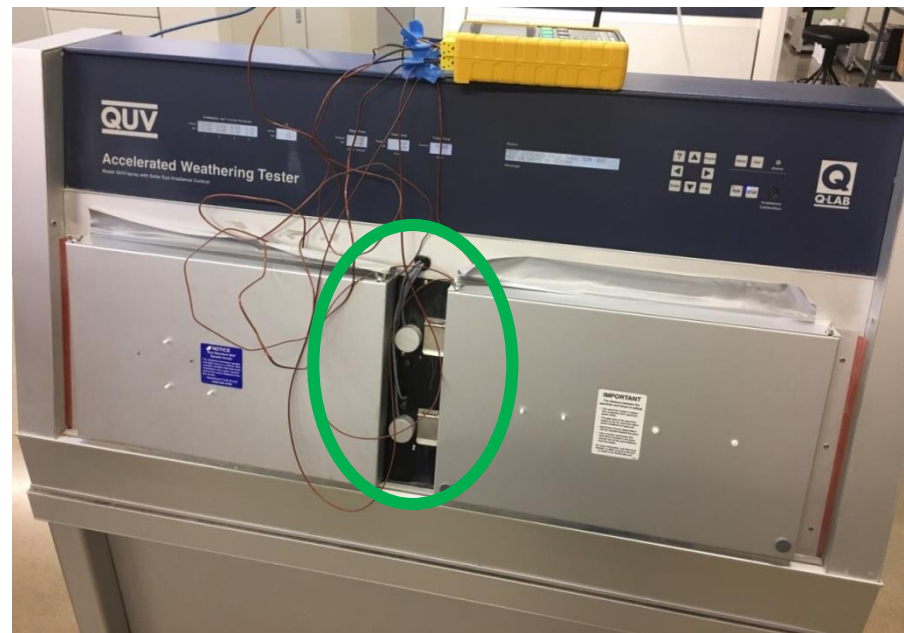


# Specimen temperatures: 3D configuration



# Why the temperature differences? 为什么产生这样的温度差异？

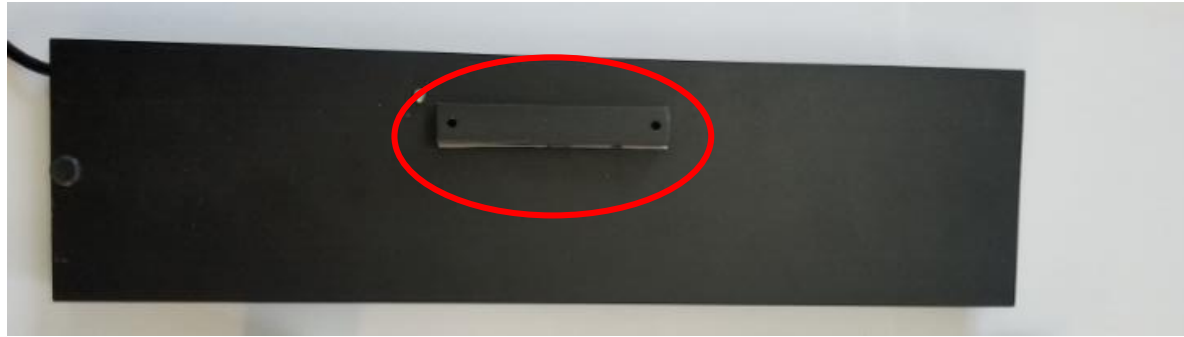
- Black panel was not insulated from laboratory air by a door  
黑板温度计与实验室空气直接接触
- Lab air cools the BP, which increases heater output, increasing specimen and chamber temperatures  
实验室冷空气给黑板降温，使得加热器输出变大，提高了样品和箱体内空气温度
- Specimen temperature control is **critical** for polymeric materials – need to control weathering testing properly  
塑料材料的样品温度控制很重要 – 需要正确控制老化测试



## 3D configuration with Insulation

### 使用绝缘技术测试三维样品

- Adding an insulating door brings chamber air and specimen temperatures in a three-dimensional configuration right in line with standard specimen mounting  
增加绝缘的箱门使得箱体空气温度和样品温度和标准的样品安装方式一致
- What if we took it a step further, and used an insulated black panel?  
我们可否使用黑标温度计/绝缘黑板温度计？



# Specimen Temperatures in Standard Configuration w/ IBP

## 使用黑标温度计时样品的温度

### 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

## 使用绝缘技术测试三维样品

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

样品温度可以被很好地控制在紫外老化箱里，如果样品正确安装

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

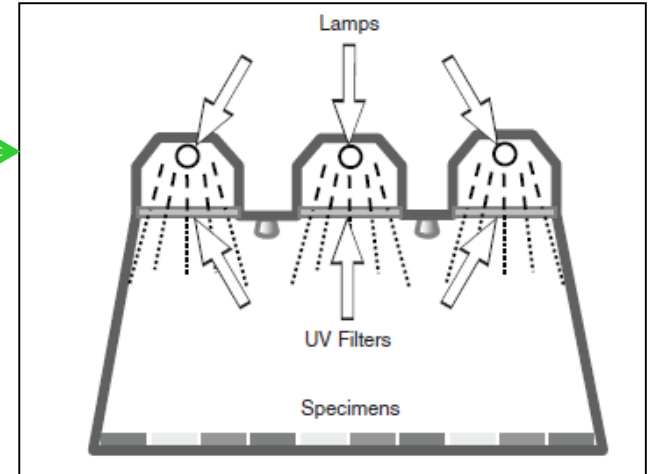
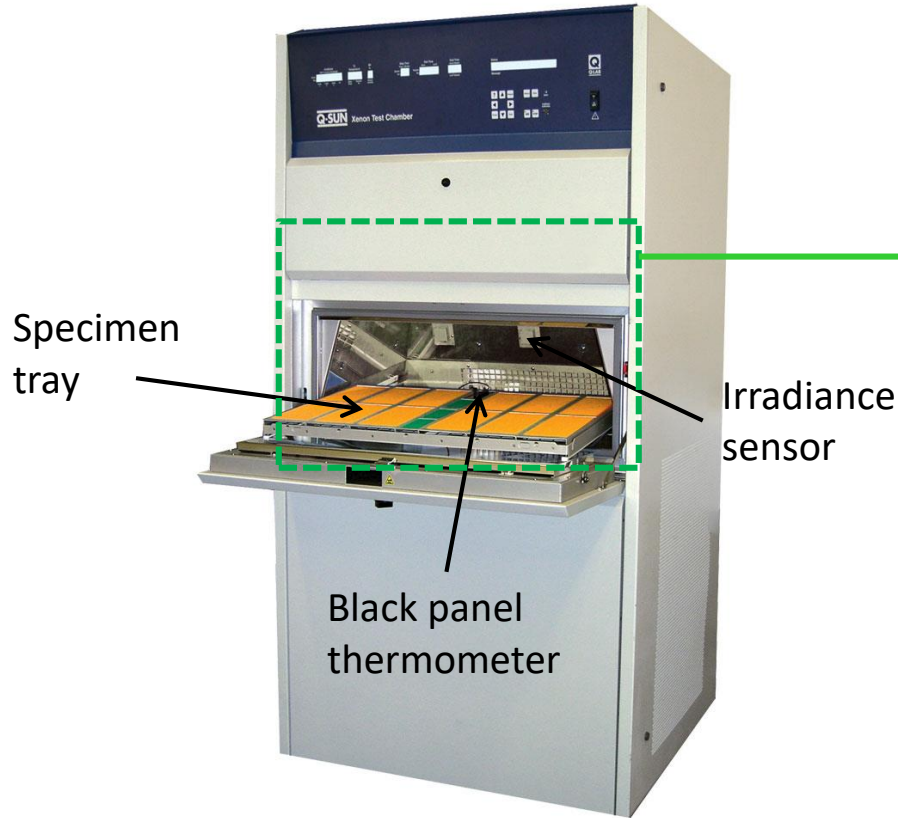
在光老化测试中理解黑板和箱体空气温度很关键！



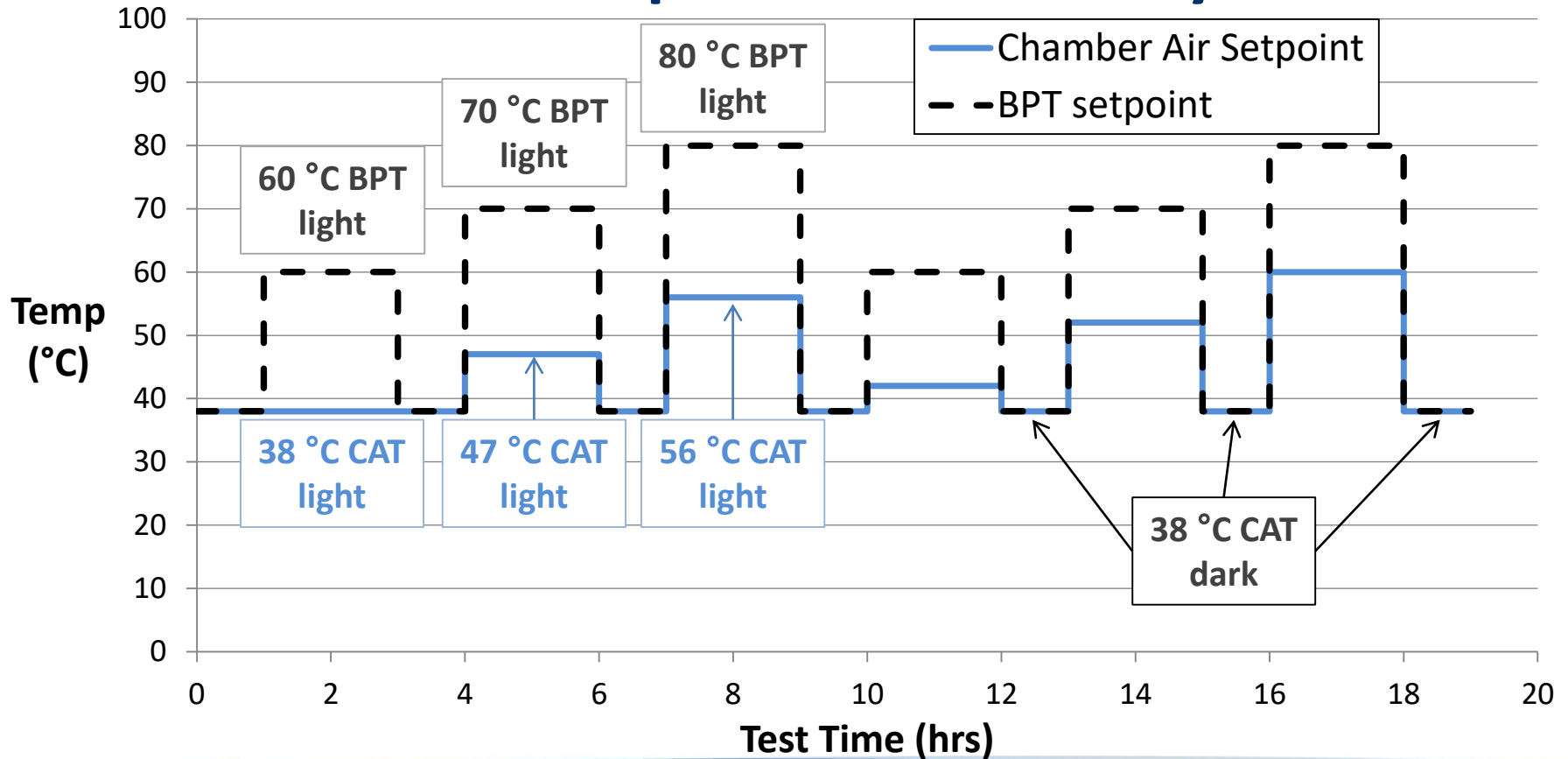
# Specimen Temperatures: Xenon arc



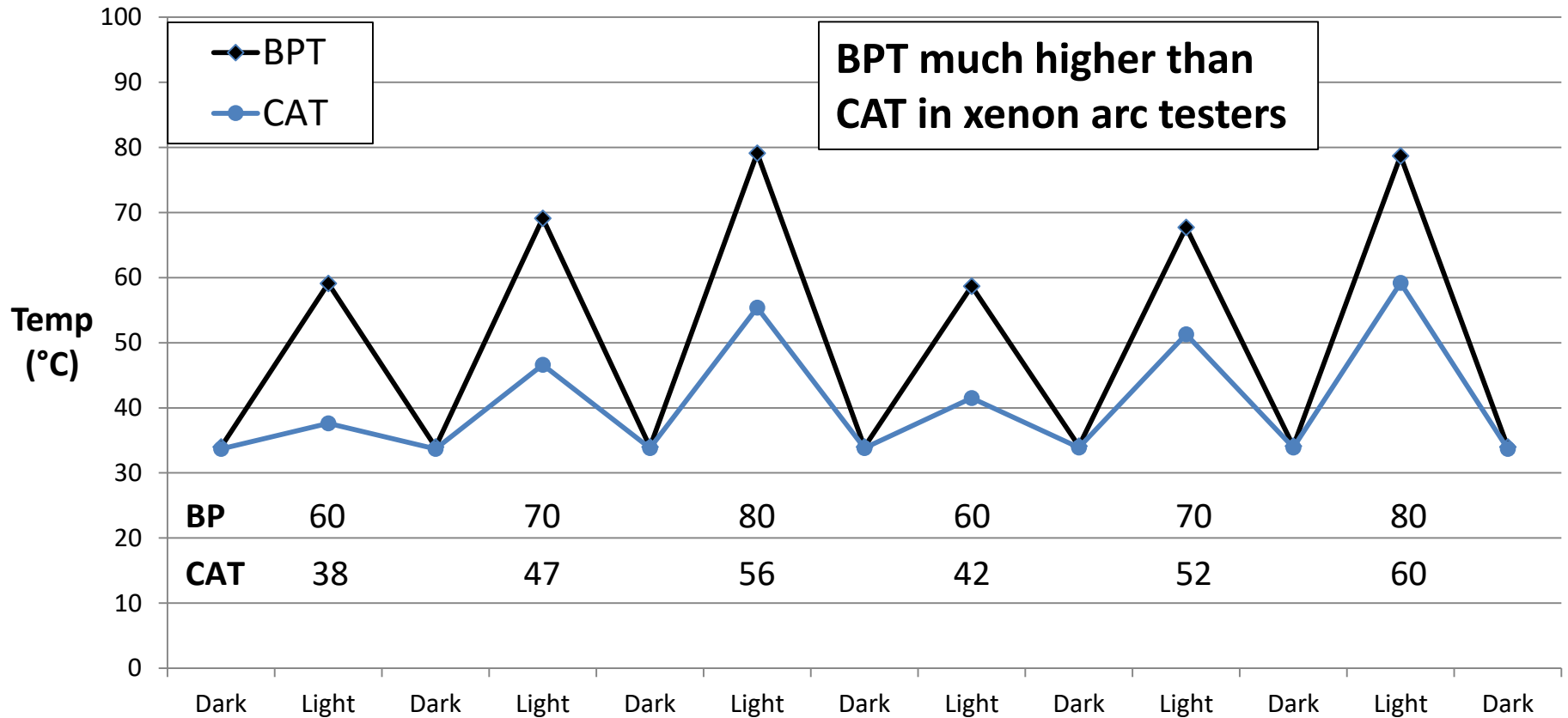
# Xenon arc tester schematic



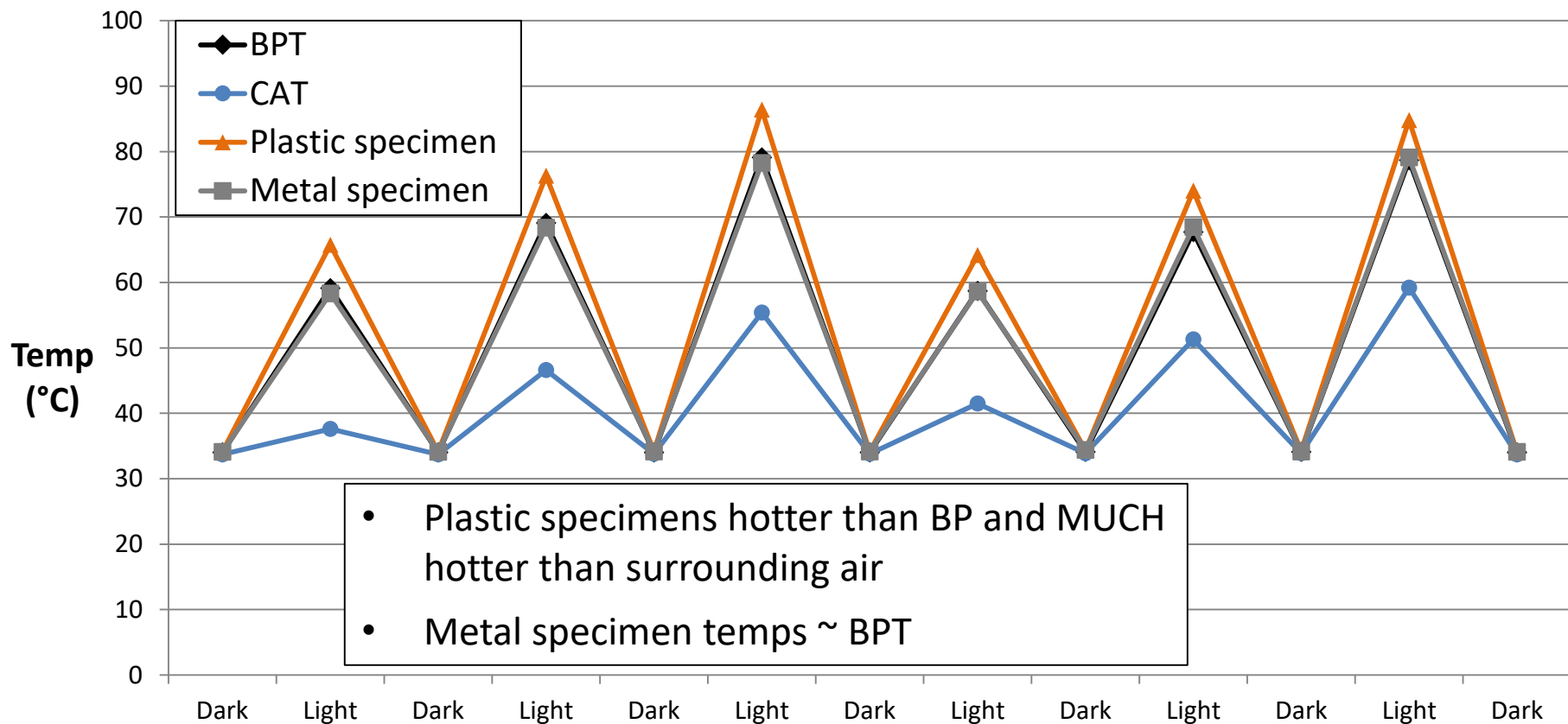
# Xenon Arc Experimental Test Cycle



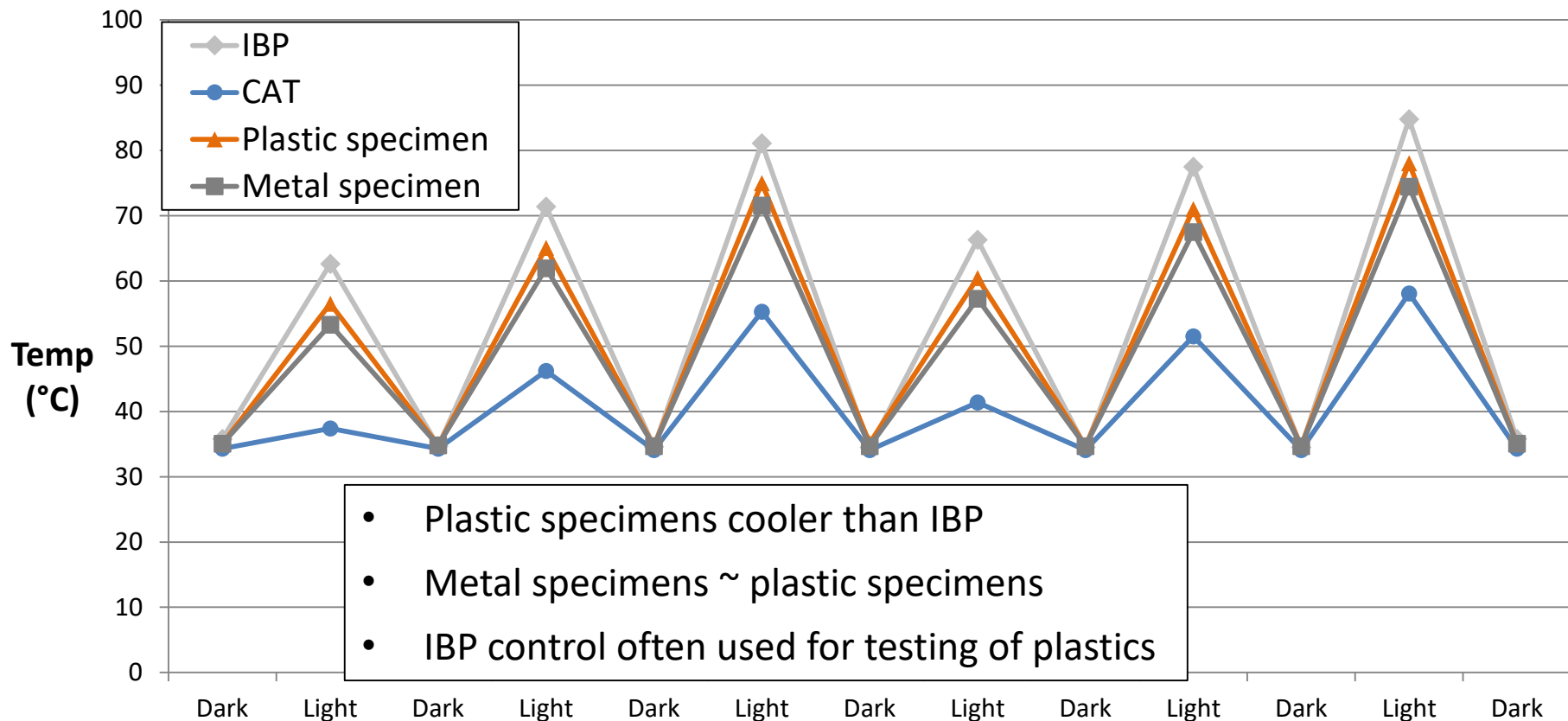
# Xenon Arc Test Cycle: Simplified View



# Xenon Arc: Specimen Temperatures w/ BP control



# Xenon Arc: Specimen Temperatures w/IBP control



# Conclusions

- **Fluorescent UV 荧光紫外**

- Chamber air and specimen temperatures exceed black panel temperature – UV testers do not generate radiant heat

箱体空气和样品温度超过黑板温度 – 紫外老化箱不产生辐射热

- Polymer reach much higher temperatures than chamber air temp and metal test specimens  
塑料本身温度比箱体温度和金属温度要高得多
- Specimens can be 10-20 °C hotter than nominal test setpoints without proper test control.  
样品温度可以比机器设定的温度高10-20摄氏度，如果没有正确安装

- **Xenon arc 氙灯**

- Black panel temperatures exceed chamber air temperatures due to radiant heat  
黑板温度比箱体空气温度高因为辐射
- Plastic specimens slightly hotter than BP temp but slightly lower than IBP temp  
塑料的温度比黑板温度高，但是稍低于黑标温度

# Conclusions

- **Specimen temperature** is a critical factor to both understand and control in xenon and fluorescent UV weathering testing of plastics  
在氙灯和紫外箱中控制塑料本身的温度很重要
- **Black panel temperature** doesn't tell the whole story!  
黑板温度不代表样品最高温度
- **3D testing** in fluorescent UV testers offers flexibility but can complicate specimen temperature control  
紫外老化箱中可以安装三维样品，但是样品温度控制很关键
- **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.  
在老化测试中理解样品温度 – 特别是三维样品安装，可以提供更可靠真实的实验数据，避免损坏对温度敏感的物品





# Thank you for your attention!

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