Light Stability Testing of Home and Personal Care Products

Q-Lab Corporation

Click here to view the morning presentation.

Click here to view the afternoon presentation.

Q-Lab Corporation

- Founded in 1956
- Specialize in material durability testing equipment and services

Westlake, Ohio
Headquarters &
Instrument Division

Bolton, England
Q-Lab Europe

Shanghai, China
Q-Lab China

Saarbrücken Germany,
Q-Lab Germany

Q-Lab Outdoor Weathering Sites

What We Will Talk About

- Weathering Testing vs. Light Stability
- Common Light Spectra
- Natural Exposures
- Accelerated Testing
  - Xenon Arc Testing
  - Fluorescent UV Testing
- ICH Guidelines
- Best Practices and Practical Considerations

Weathering Testing

- Combination of sunlight, heat, and moisture
- Temperatures simulate realistic hot outdoor conditions
- Moisture (water spray or condensation) usually included

Light Stability Testing

- Simulation of sunlight or indoor lighting

- No moisture* or elevated temperatures
- Test temperatures often simulate typical indoor environment

*May control RH to reduce variability

Which Should I Use?

If you're not sure how your material will perform, and want to test it for every environment,

Run a Weathering Test

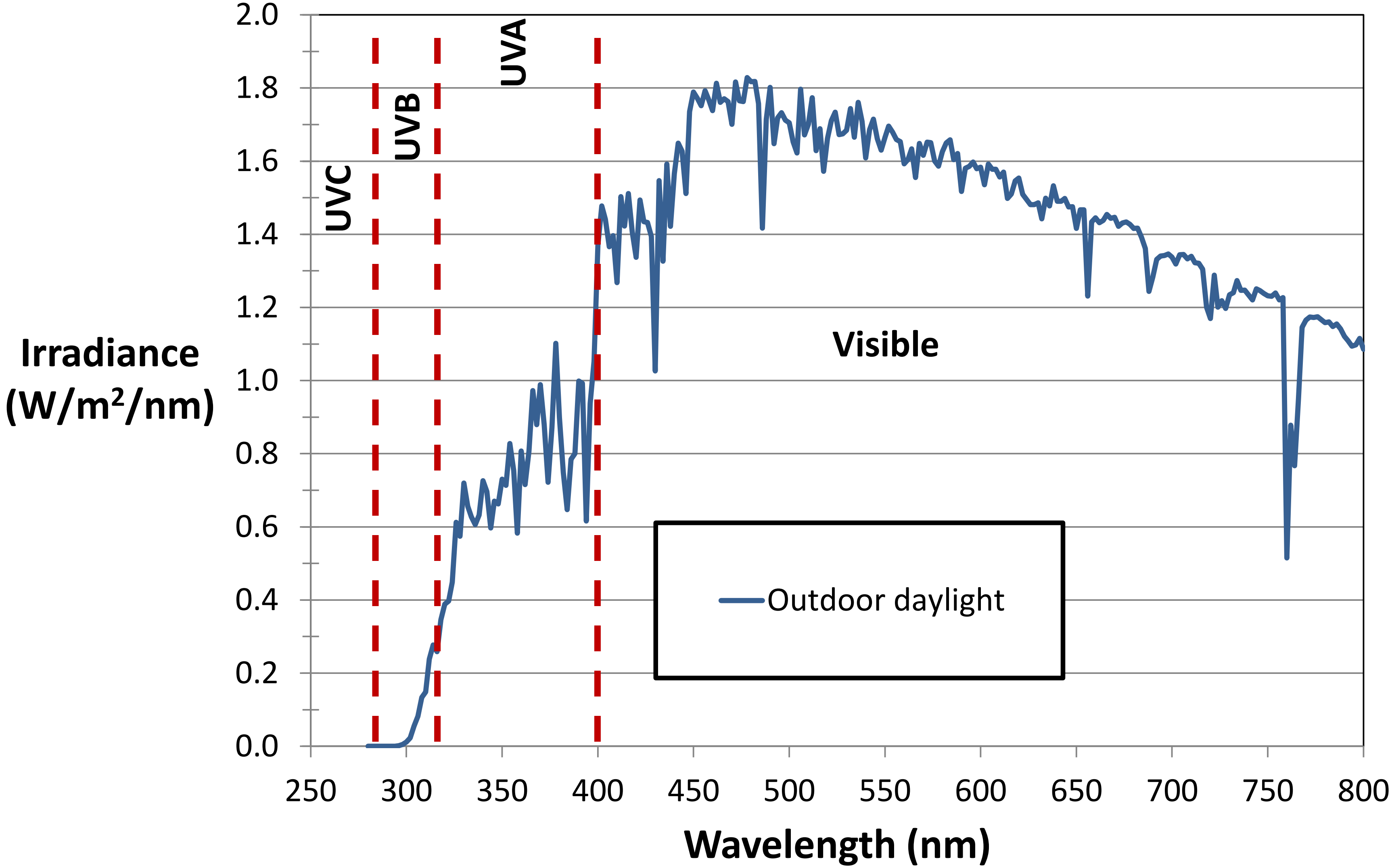
If your material only needs to perform in a controlled environment, or you are only interested in the effect of light on your product,

Run a Light Stability Test

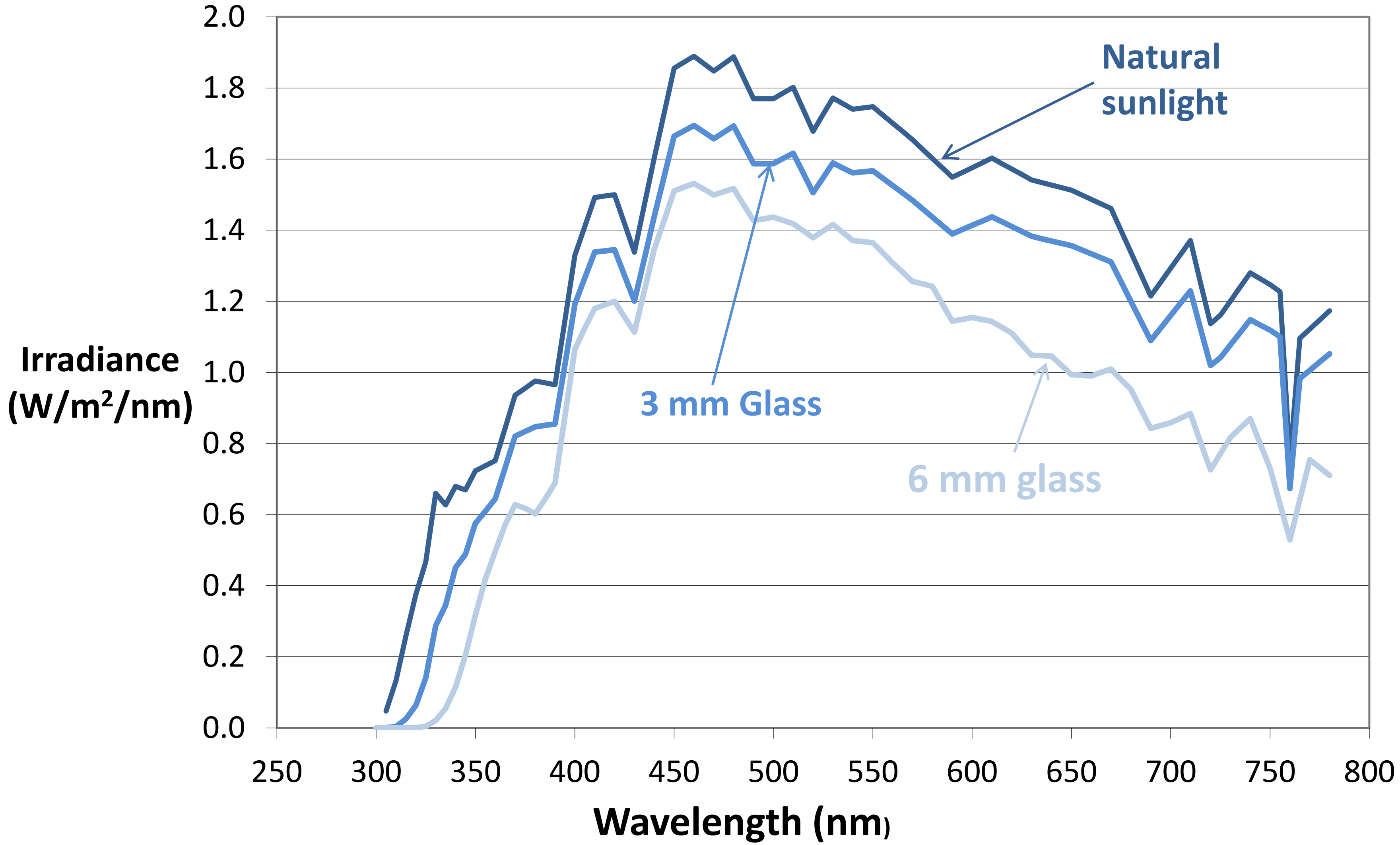
Common Light Spectra

- Sunlight
  - Direct
  - Through Window Glass
- Commercial Lighting
- Home Lighting

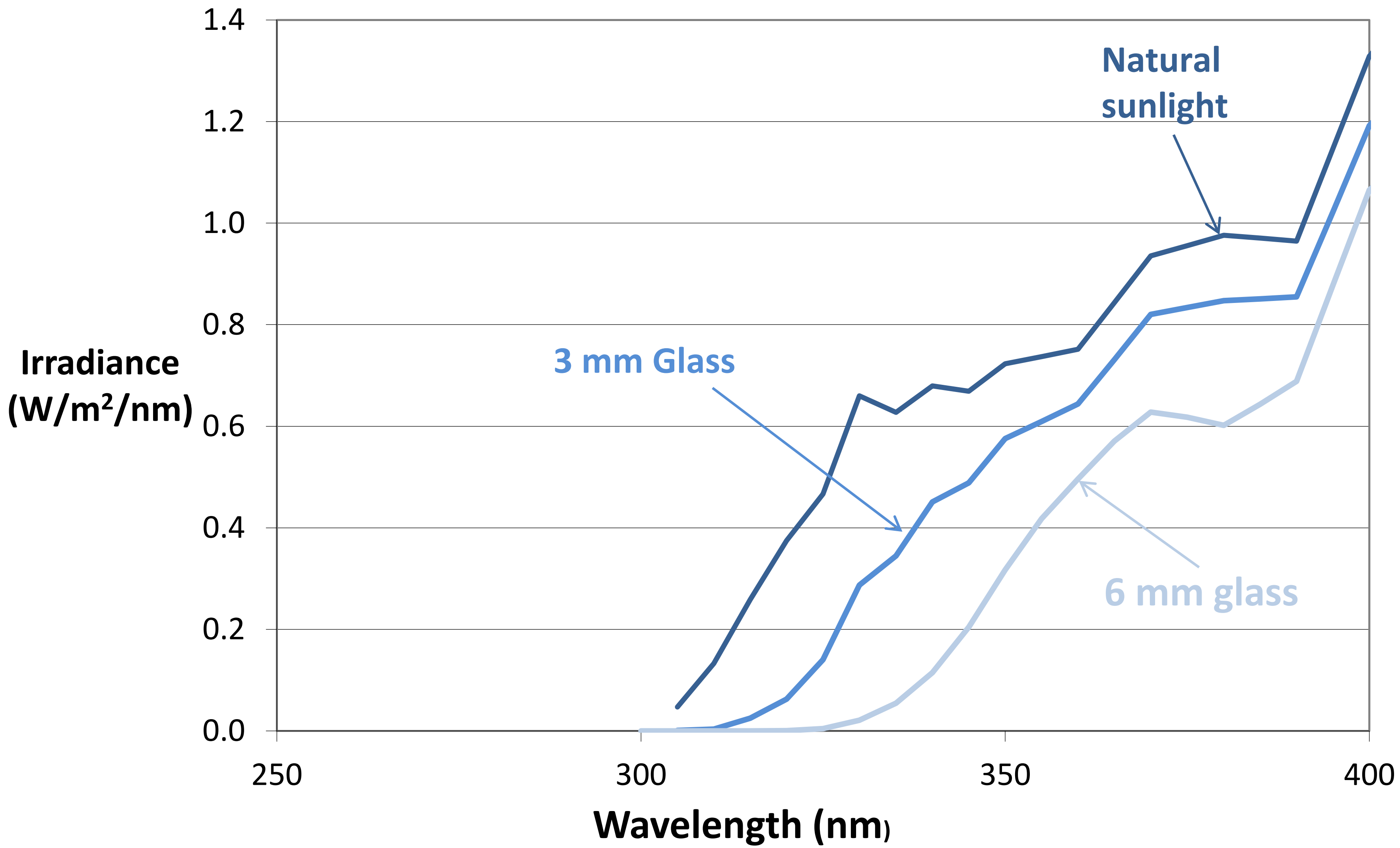
Summer Sunlight Spectrum



Sunlight through Window Glass

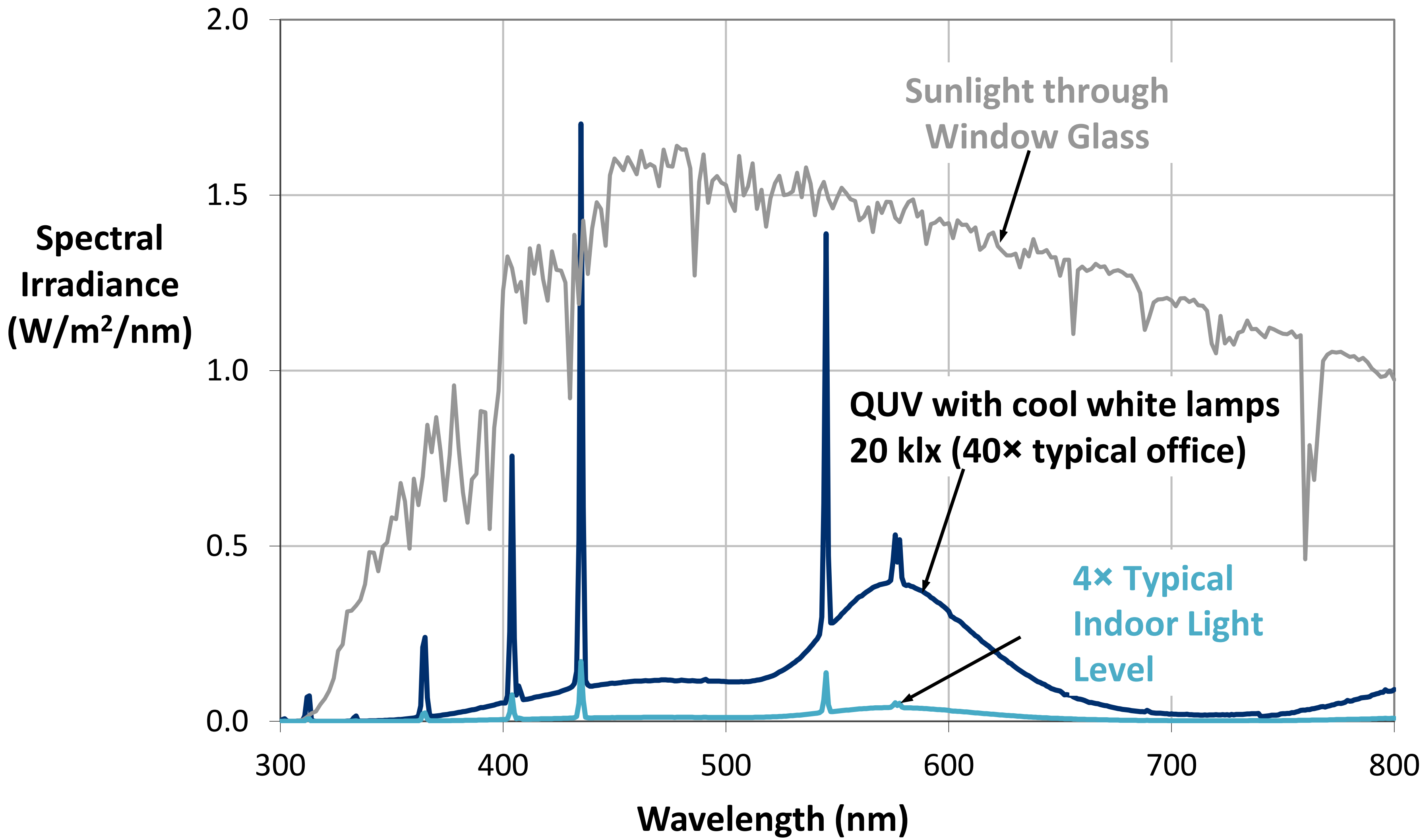


Sunlight through Window Glass

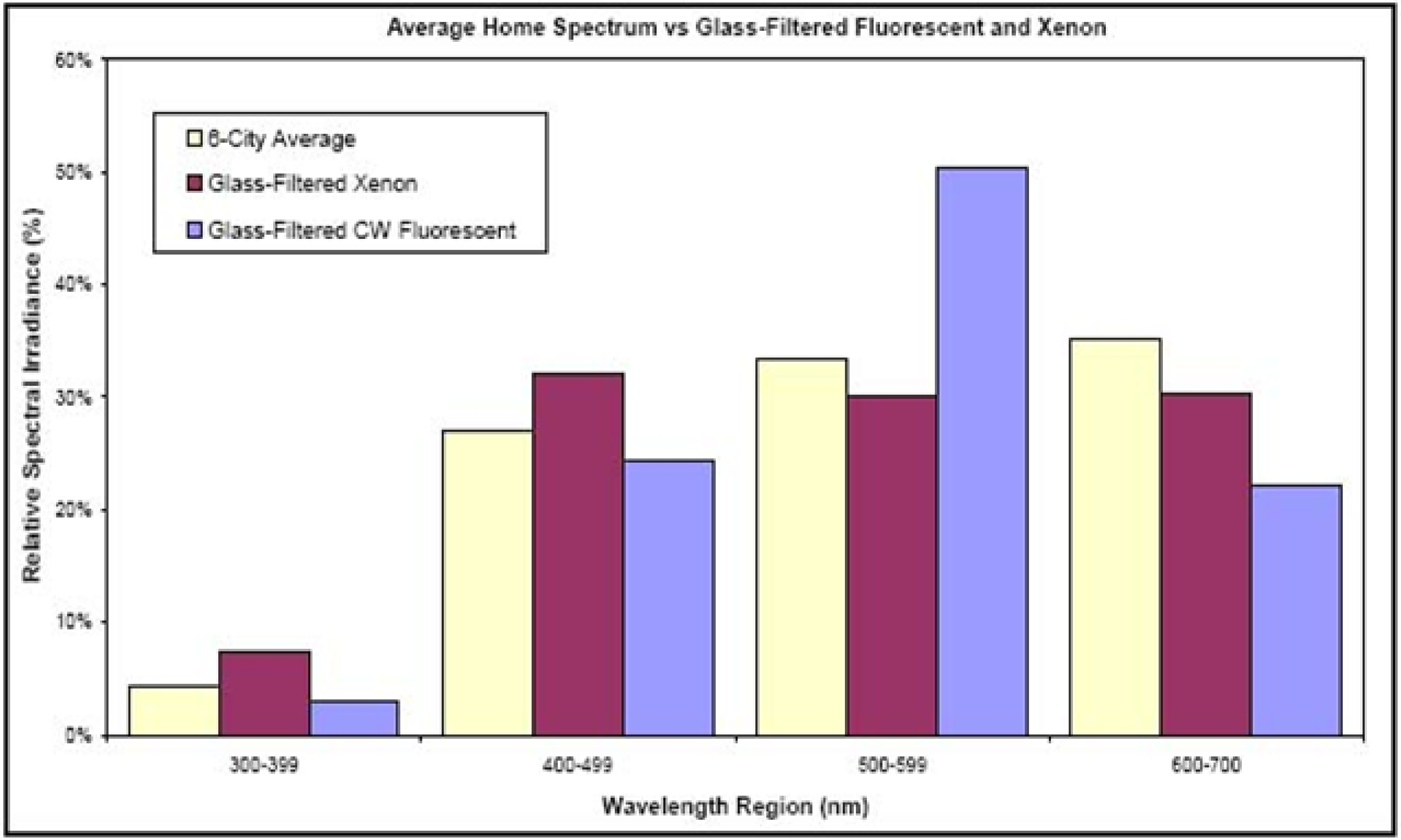


Interior Lighting

Commercial Indoor Lighting



Average Home Lighting



Even Though It Is Only 5% of Sunlight...

UV Light Causes Most Photodegradation!

Natural Exposures

Natural Exposures

In order to find out how your material will last in its service environment…

Put it in the service environment!

Natural Exposures

Benchmark Commercial Sites

South Florida, Arizona Desert

- Inexpensive
- Reliable
- Extreme environments create acceleration

At your own facility

- "Scientific Window Sill Testing"
  - Convenient
  - Easy to make frequent observations
- DIY Exposures

Natural Exposures

For many Fast Moving Consumer Goods (FMCGs), natural exposure testing at benchmark sites is very cost effective and can give you excellent data in a short amount of time

Accelerated Exposures

FMCGs can be tested for light stability in even shorted periods of time with accelerated testing, usually with xenon arc or fluorescent UV testers

Xenon Arc Testers

Xe-3-HC

Xe-1-BC

Q-SUN Xenon Test Chamber

Benefits of Xenon Arc Testing

- Realistic simulation of longwave UV and visible portion of sunlight
- Optical filters can simulate different kinds of glass
- Relative Humidity Control

Optical Filters

Daylight Filters

(exterior exposures)

Window Glass

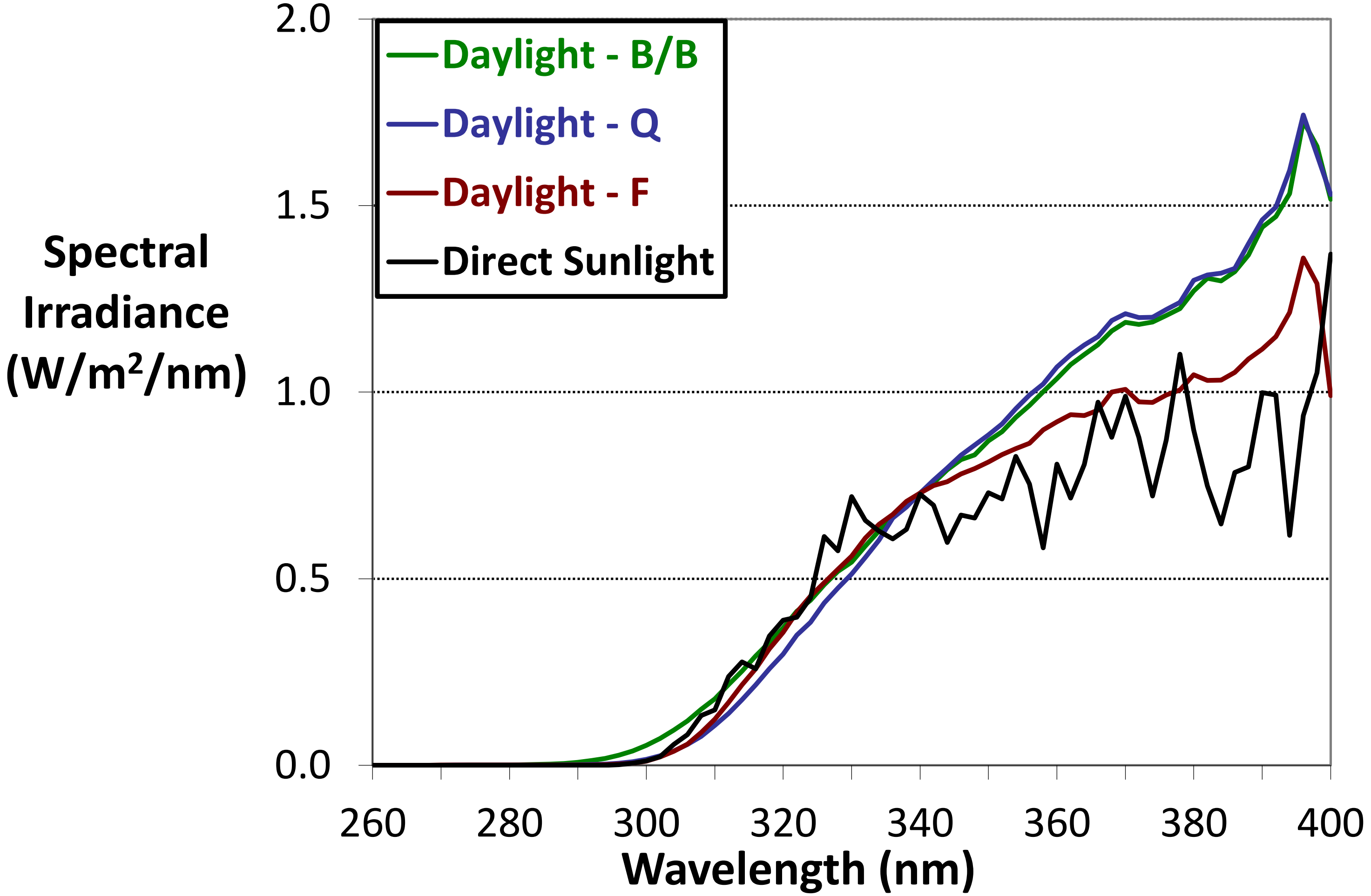
(indoor exposures, textiles, inks, etc.)

Extended UV

(automotive, aerospace, etc.)

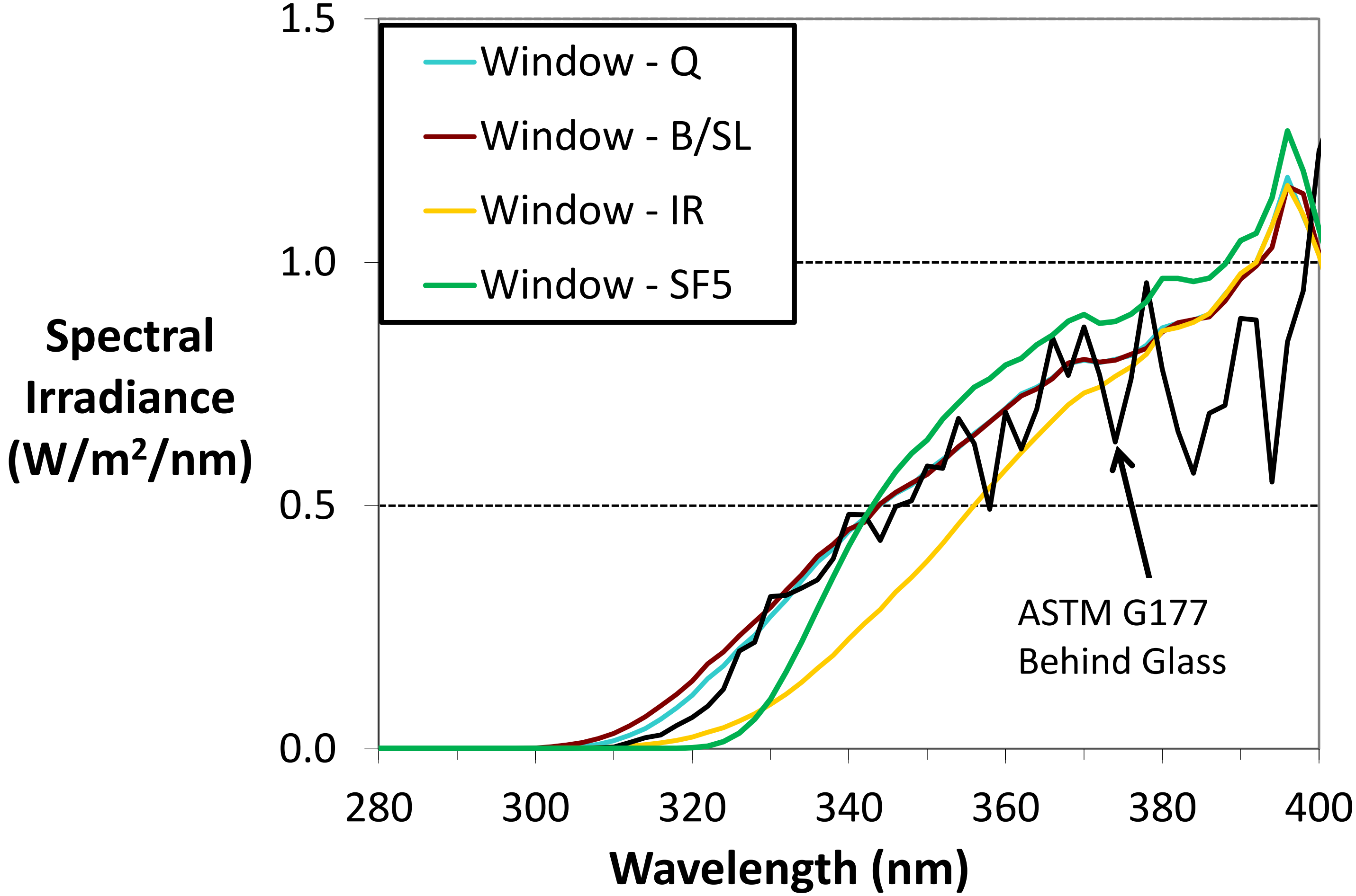
Xenon Arc with Daylight Filters

UV spectrum



Xenon Arc with Window Filters

UV Spectrum



Irradiance Control

- Narrow Band
  - 340 nm
  - 420 nm
- Total UV (300-400 nm) Wide Band
- Global (300-800 nm) – not recommended
  - Shorter wavelengths cause more photodegradation
  - Lamp aging can cause more than 50% reduction in critical UV wavelengths

Irradiance Control Point Conversion

Example: **Window B/SL** Filter

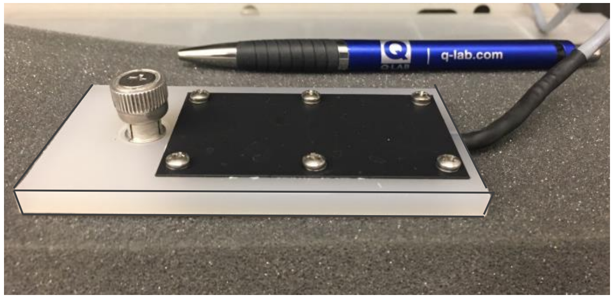
Control Point	Irradiance
340 nm	0.35 $W/m^2/nm$
420 nm	0.79 $W/m^2/nm$
TUV (300-400 nm)	40 W/m^2

These conversion factors only apply for this particular filter

Temperature Control

- Black panel
  - Hotter than ambient in sunlight
  - Not necessarily same as specimen temperature
  - Exists for test repeatability and reproducibility
- Chamber air
  - Controlled somewhat independently
  - More relevant for some applications
- Chiller System
  - Removes heat to allow normal indoor temperatures inside xenon arc test chamber

Black Panel 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

** White Panel versions of the above are available but far less commonly used*

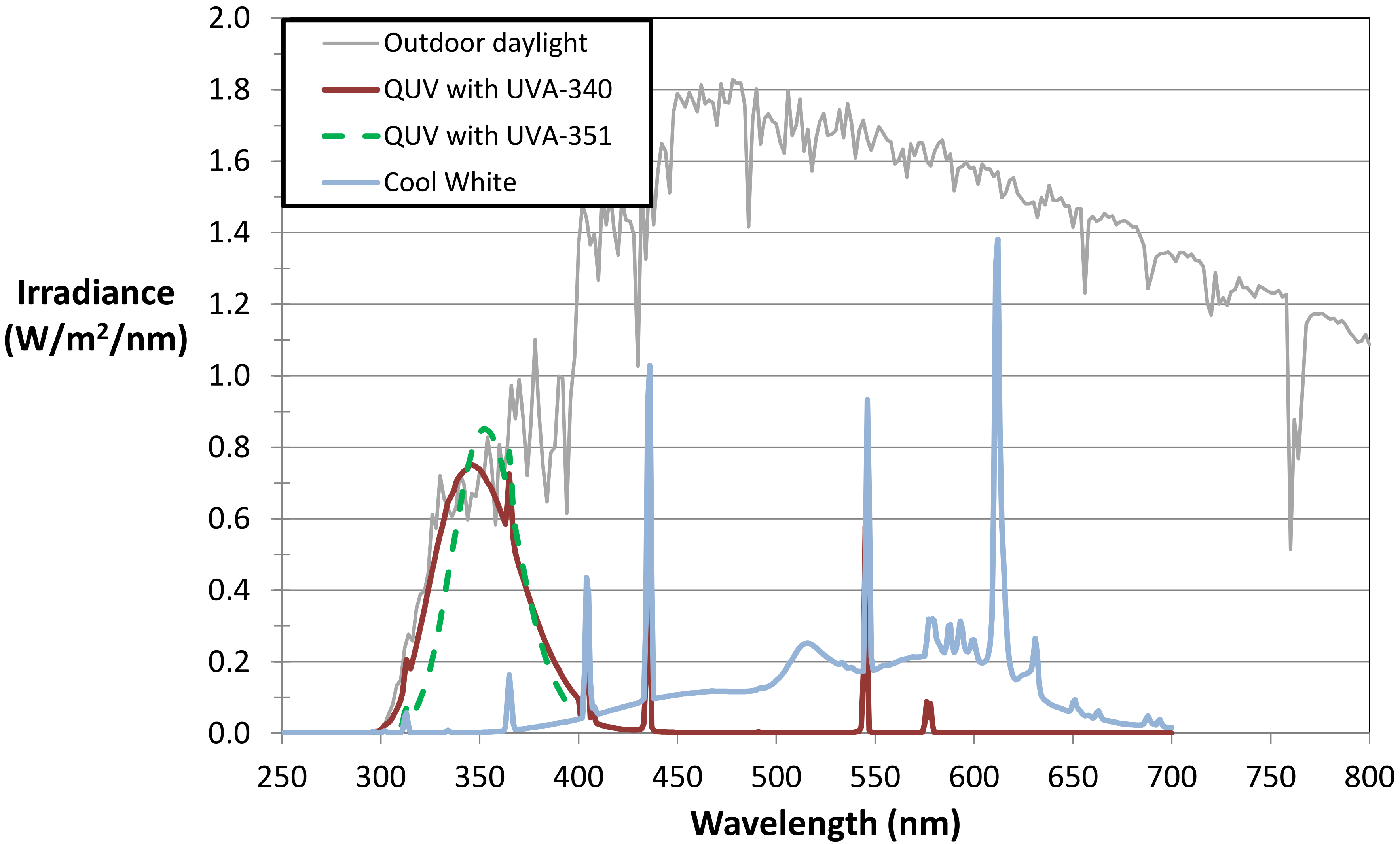
Fluorescent UV Testing

QUV/se Weathering Testing and QUV/cw Light Stability Testing Chamber

Benefits of Fluorescent UV Testing

- Lower-cost solution
- Highly repeatable and reproducible spectrum
- Cool White lamps are an excellent reproduction of commercial lighting
- Very easy to use

Fluorescent UV Light Spectra



ICH Guidelines

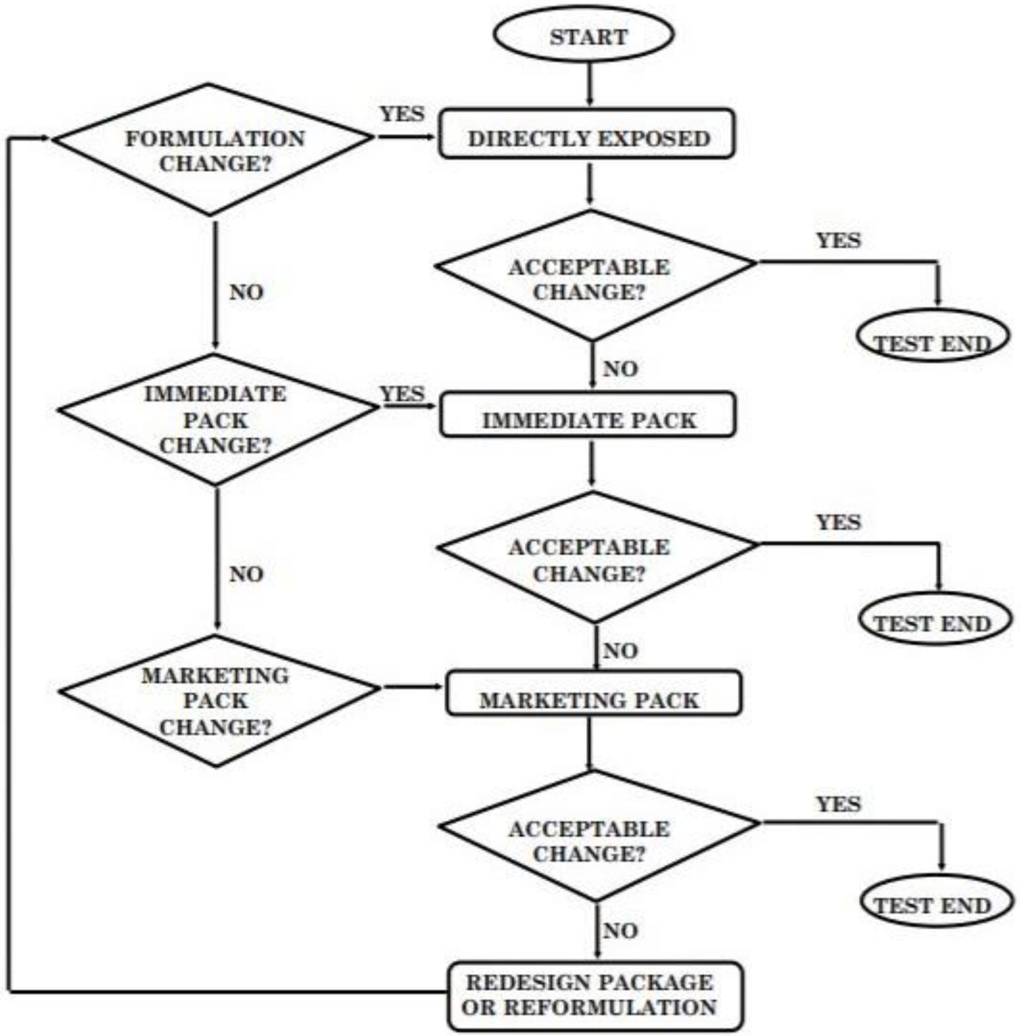
International Conference on Harmonization: Guidelines

for the Photostability Testing of New Drug Substances and Products

ICH Guidelines

- Joint effort of U.S., European, Japanese regulatory agencies
- New products and drug substances should not exhibit “unacceptable change” when exposed to light
- Two exposure options are available

ICH Guidelines Flowchart



ICH Guidelines

Two Exposure Options

1. D65/ID65 light source*
   - "artificial daylight fluorescent lamp combining visible and ultraviolet outputs, xenon, or metal halide lamp"
   - Wavelengths below 320 nm may be filtered

2. Cool white fluorescent and "near ultraviolet lamp"

** ICH Guidelines cite ISO 10977 on photographic films and prints, which is withdrawn and replaced by ISO 18909. They refer to CIE 15, Recommendations on Colorimetry.*
CIE 85 Solar Spectral Irradiance would have been a better choice for lightstability tests.

ICH Guidelines
Radiant Exposure

Exposures are based on UV ***radiant*** *dosage* and ***illuminance**** *dosage*

**Illuminance is a measure of visible light that takes irradiance dosage and applies the human photopic response curve*

ICH Guidelines
Radiant Exposure Criteria

Two exposure values must be reached:

1. 1.2 million lux-hours (per m^2) *minimum (*visible light by definition*)*

2. 200 Watt-hours UV (per m^2) *minimum*

– These do not correspond specifically to either the D65 or ID65 reference light source

– *No single light source can meet the visible light exposure conditions without significant "over-exposure" of the UV portion*
– *"Over-exposure" is perfectly acceptable*

Value 1: Calculating Lux-hours

Irradiance (W/m^2) at each wavelength

×

Photopic Response (lumens/W) at wavelength

=

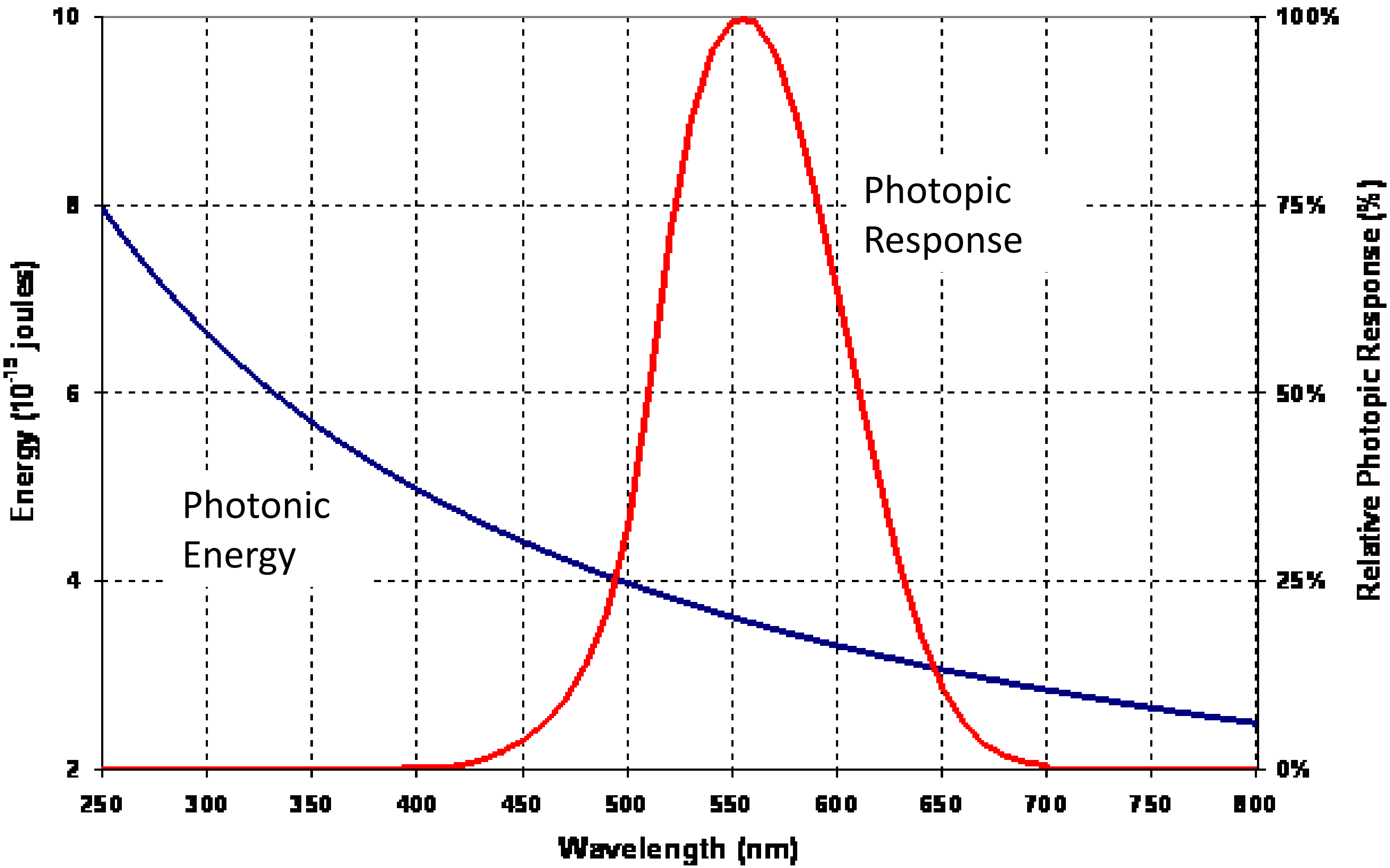
Illuminance ($lumens/m^2$) or lux

Example:

Wavelength (nm)	*Photopic Response (lumens/W)*		*Irradiance (W/m^2)*		*Illuminance ($lumens/m^2$)(lux)*
555	**683.00**	×	**0.33**	=	**227.2**

Now, sum up the value at each wavelength and multiply this number by exposure time in hours

Photopic Response & Photonic Energy

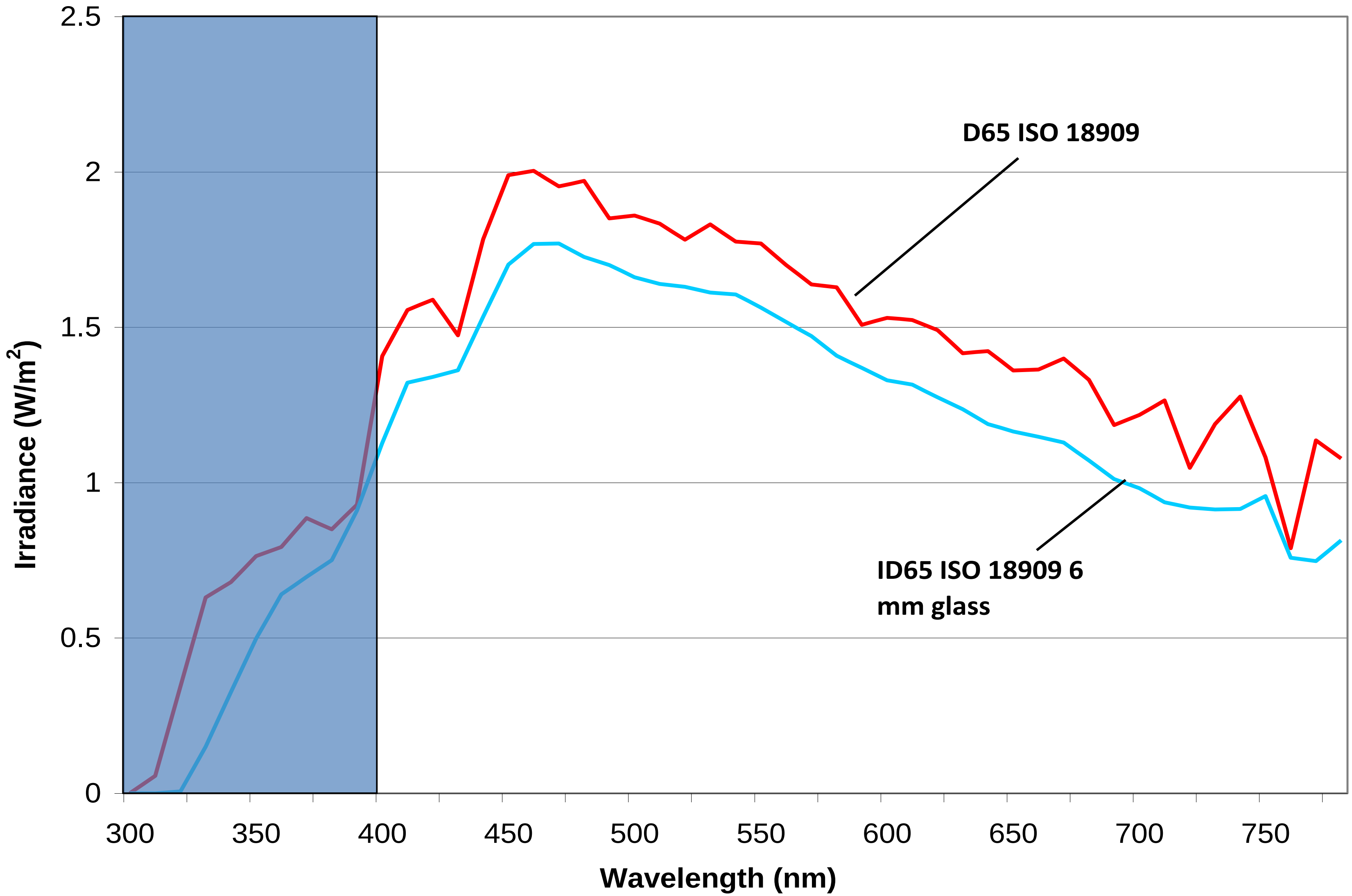


Value 2: Calculating TUV Watt-hours

- SPD data gives you irradiance (W/m^2) at each wavelength
- Sum irradiance at wavelengths 300-400 nm (Total UltraViolet or "TUV")
- Multiply this number by exposure time measured in hours

$40\ W/m^2 \times 10$ hours = 400 W-hours/m^2

Total UV Exposure (TUV, 300-400nm)



ICH Guidelines

Temperature

Temperature is not specified, however …

- Thermal degradation should be evaluated separately in heat aging tests, not during lightfastness testing. Therefore, testing at normal room temperature ranges is desirable
- Room temperature testing requires chilling the air circulated through the chamber

ICH Guidelines
Performing Option 1

- Q-SUN Xe-1BC
- Window – Q Filter (ID65 3 mm glass spectrum
- 420 nm irradiance control point, 1.10 W/m^2/nm
- Chamber Air temperature control, 25 °C

ICH Guidelines
Option 1

Test duration

- Run test for 13.1 hours
- 650 Watt-hours UV (225% more UV than required)
- 1.2 million lux-hours

To reduce the UV exposure, run in two parts

– Part 1: Run until 200 W-hr/m^2 TUV exposure, using Window-Q Filters

– Part 2: Add a UV Blocking filter, recalibrate, and run to achieve 1.2 million Lux-hours (no additional TUV)

Irradiance & Test Time

Option 1, Q-SUN with Window-Q

Irradiance @ 420 nm	Hours	Lux-hours	TUV Dosage (Watt-hr/m^2)
0.50 W/m^2	28.9	1.2 million	647
0.60 W/m^2	24.1		
0.70 W/m^2	20.7		
0.80 W/m^2	18.1		
0.90 W/m^2	16.1		
1.00 W/m^2	14.5		
1.10 W/m^2	13.1		

Multiple pathways to reach the specified exposure criteria

ICH Guidelines
Option 2

Step 1: QUV with cool white lamps

Set Point: 20,000 lux

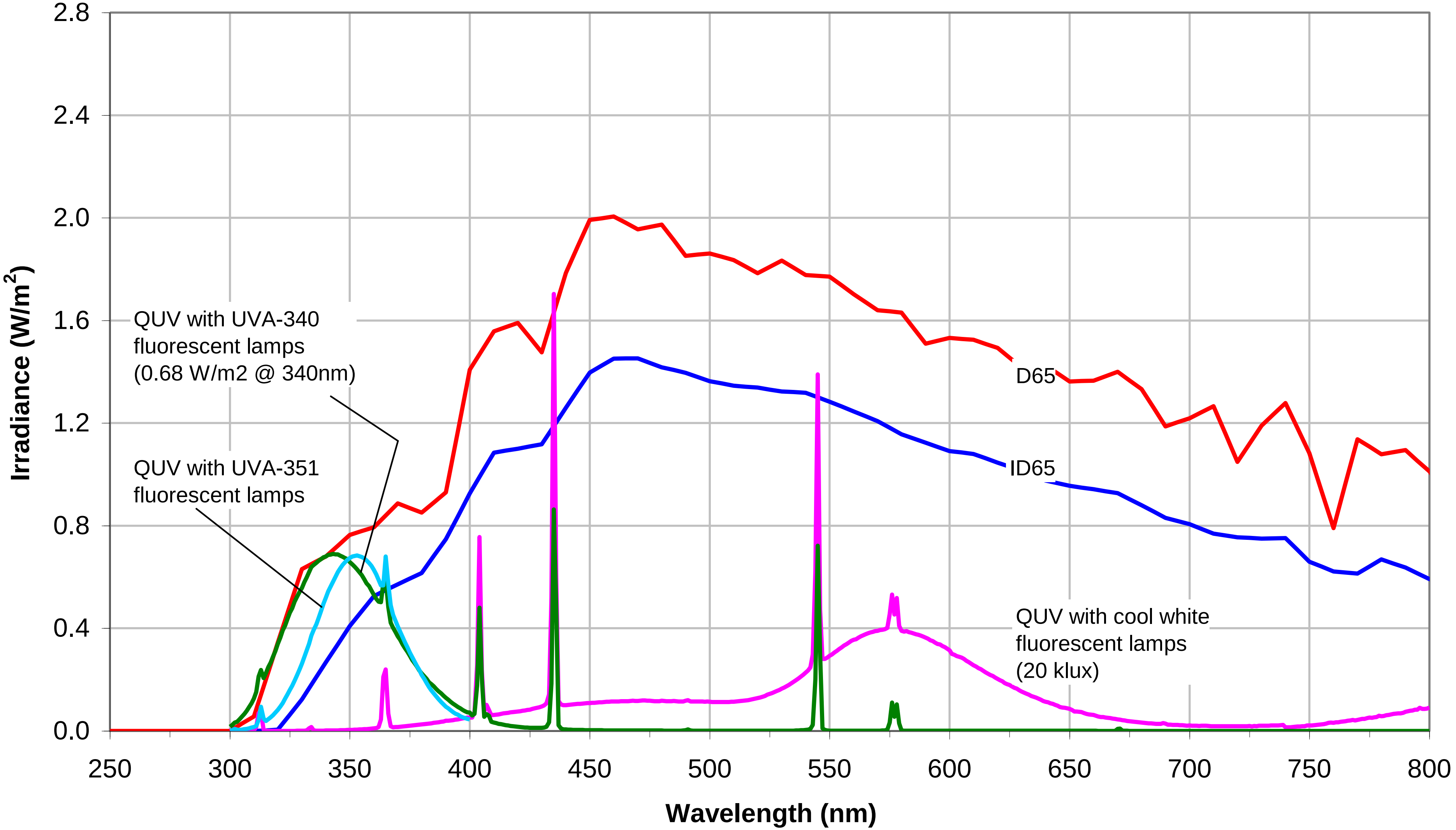
Time: 60 hours

Step 2: QUV with UVA-351 lamps

Set Point: 0.55 $W/m^2/nm$ @ 340 nm

Time: 4 hours

QUV Light Spectra and ICH Guidelines



Best Practices and Practical Considerations in Light Stability Testing

Best Practices And Practical Considerations

1. **Perform natural exposures**
   - Necessary for understanding accelerated results
   - Does lab test correctly rank material performance?

Miami outdoor exposures

Best Practices And Practical Considerations

2. **Test until failure** (forced degradation)

- Required for drug products
  - Identify impurities resulting from photodegradation
  - Determine degradation pathways
- Necessary for developing rank order performance

Best Practices And Practical Considerations

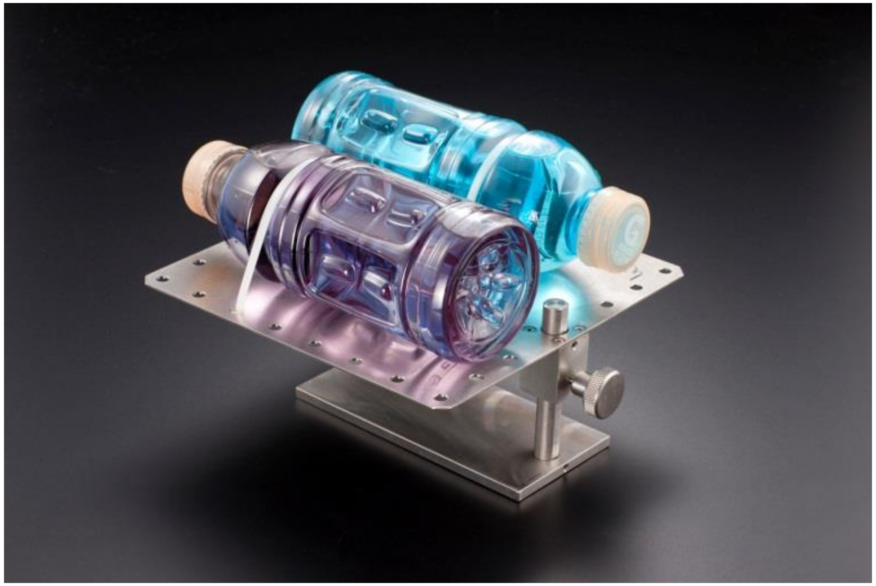
3. **Expose a control with your test specimen**
   - Use Control Material of Known Durability
     - Outdoor performance
     - Lab performance
   - Similar Composition to Test Material
   - Similar Degradation Mode to Test Material

Benefits of a Control

- Compare performance of control to a known material
- Allows confidence in lab exposure
- Assure that laboratory tester is operating properly

Best Practices And Practical Considerations

4. Test your product "In the package" in order to simulate the actual service environment.



Whole Product Testing

Q-SUN Xe-3

Q-SUN Xe-1

Best Practices And Practical Considerations

5. Use realistic temperatures to prevent unrealistic failures

Testing with a chiller system allows for higher irradiance while maintaining cool temperatures

Q-SUN Specimen Capacity

Q-SUN Xe-3HC

3200 cm^2

Q-SUN Xe-1BC

1100 cm^2

Correlation

5. Use realistic temperatures to prevent unrealistic failures

Testing with a chiller system allows for higher irradiance while maintaining cool temperatures

Questions?