

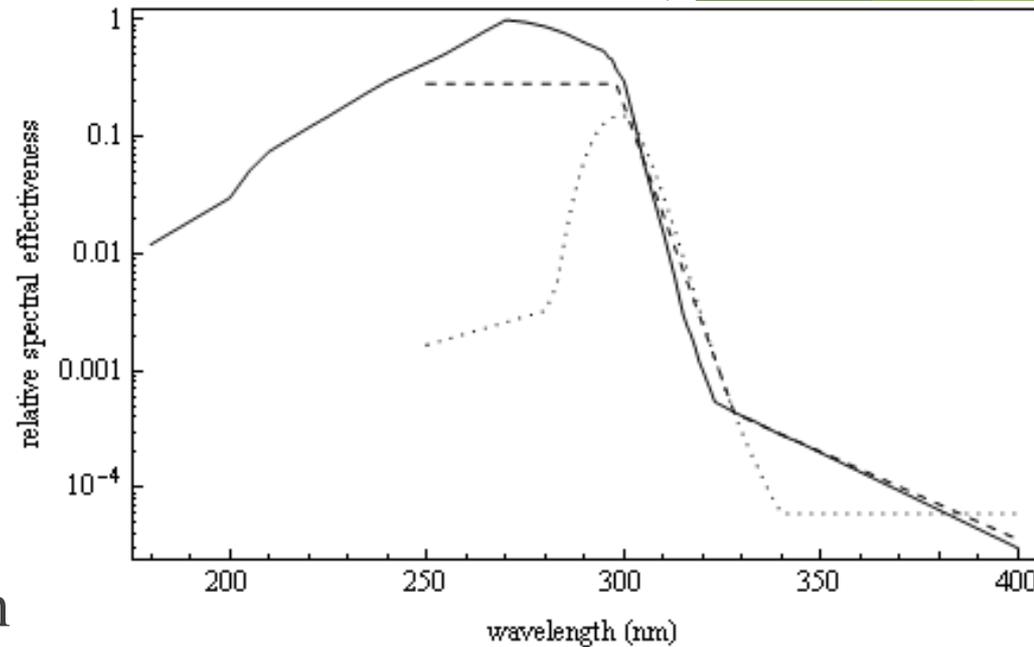
UV-C Measurement Problems for Lamp Safety Assessments

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UV Action Spectra Applied in Risk Analyses for Eye and Skin

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- ▶ 3 UV Action spectra—different at $\lambda < 300$ nm:
 - ▶ ACGIH/ICNIRP UV $S(\lambda)$ hazard function, applied in CIE lamp safety standard S009
 - ▶ CIE standardized erythematous A.S. applied in UV index
 - ▶ CIE standardized A.S. for photocarcinogenesis—note low value at 254 nm (UVGI)



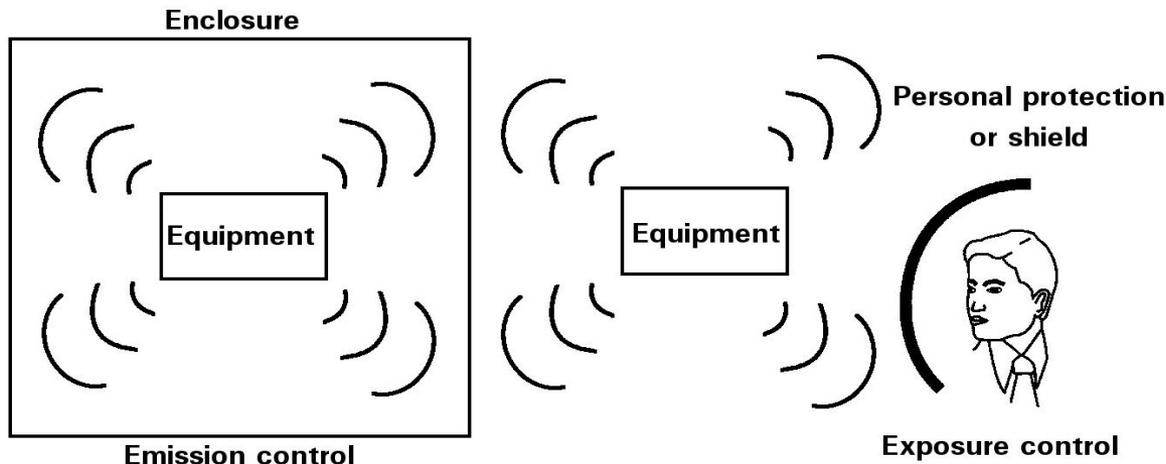
Important to recognize that all biological A.S. relate at $\lambda \sim 300$ nm

How are Risk-Group Emission Limits Based upon Exposure Limits

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- ▶ The accessible emission limits (AELs) for Product Safety Standards are derived from exposure limits
 - ▶ Based upon reasonably foreseeable worst-case exposures
 - ▶ Example: Lamp Safety Risk Groups (RGs)
 - ▶ The challenges are: at what distances, for how long an exposure? - 500 lux for GLS

AELs developed by product experts, and tested by technicians

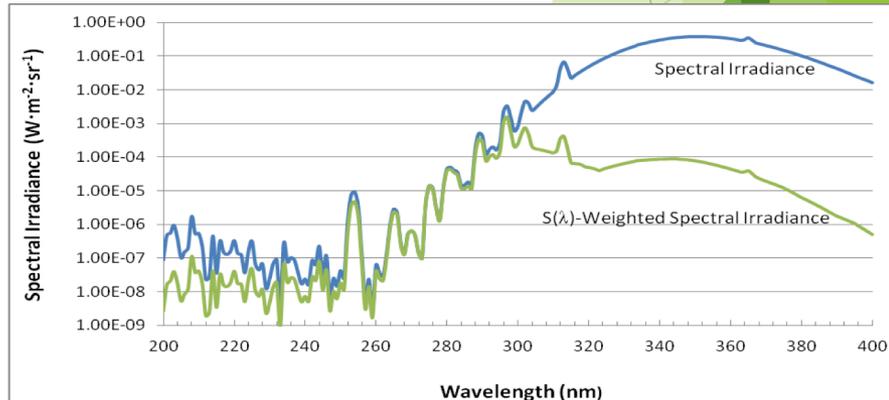
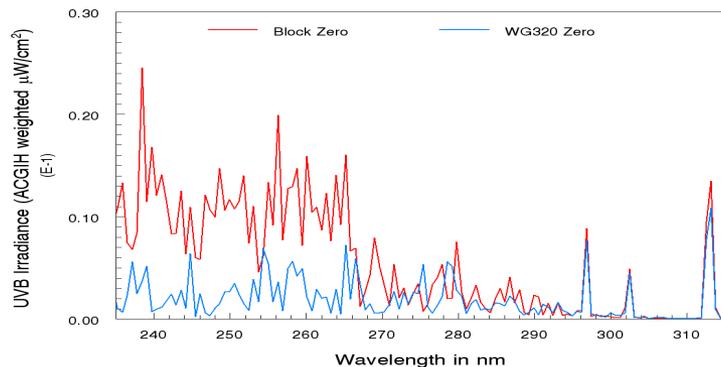


Occupational and Environmental Health Specialists apply ELs

Origin of the 20-cm Reference Measurement Distance (UV issue)

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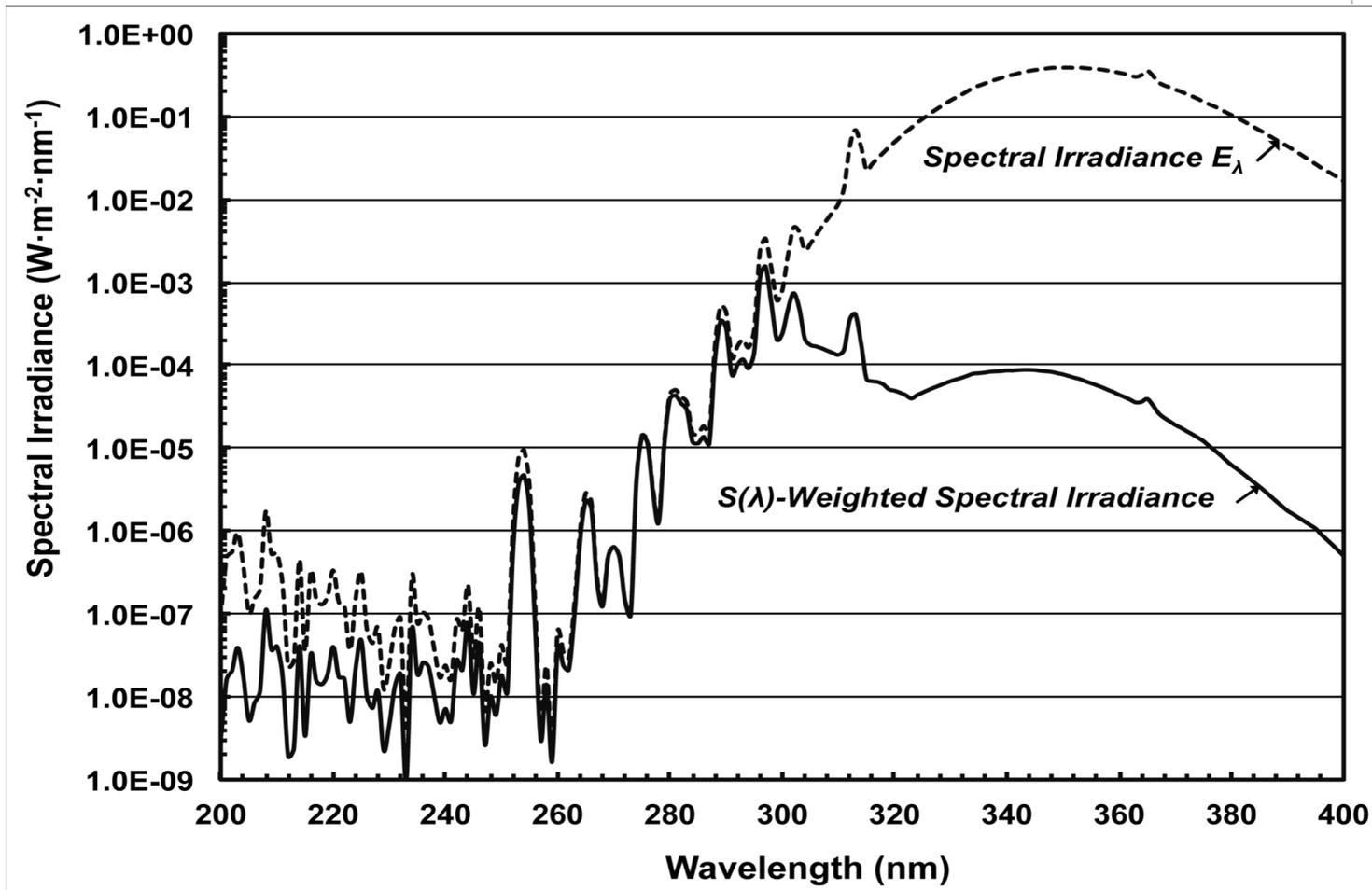
- ▶ The most challenging AEL spectroradiometric measurement was: $E_{\text{UV-effective}}$ where stray light and noise produced a large uncertainty
- ▶ Also, the closest reasonable facial distance to observe a lamp momentarily for RG-3.- not RG-1!



Cooled PMT - Norwegian Test

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Double-grating instrument with low stray-light appears to solve the problem, but larger bandwidth was used.



What is the Problem!??

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The Problem - Erroneous Conclusion of an actual UV Photobiological Hazard on the basis of Measurements during Testing

- ▶ A lamp product fails the RG-1 or Exempt requirements of the standards for photobiological safety of lamps:
 - ▶ IESNA/ANSI RP27-2 or
 - ▶ IEC60825-1/CIE-S-009).
- ▶ A 1-nm resolution needed because of $S(\lambda)$
- ▶ Error generally attributed to noise or stray light recorded at levels that place the lamp in a higher risk category.

What are we trying to Measure?

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- ▶ The “Exempt” emission level is $0.1 \mu\text{W}\cdot\text{cm}^{-2}$ in the UV-C and this low level requires a noise level below $1 \text{ nW}\cdot\text{cm}^{-2}\cdot\text{nm}^{-1}$ when one considers an integration over 100 nm (e.g., from 200 nm to 300 nm).
- ▶ Measuring the trace levels of UV-C ($\lambda < 280 \text{ nm}$) and UV-B (280 - 315 nm) emitted from most lamps pose special challenges in any case -
 - ▶ particularly if the lamp emits strongly in the UV-A (315-400 nm), e.g., a “black-light” fluorescent

“Gold Standard” - Spectroradiometer Employing a Double-monochromator

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- ▶ Double-monochromator represents the gold-standard for trace UV emission measurements.
- ▶ Exempt Risk Group (RG) or even RG-1 (very low risk) emission limits require $<10^{-9} \text{ W}\cdot\text{cm}^{-2}\cdot\text{nm}^{-1}$ noise level for good spectral resolution.
- ▶ Recognizing the 254-nm line over noise can be an indicator
- ▶ Repeated scans frequently help
- ▶ Cooled P.M.T will help

Are there other approaches?

Noise floor - Check it out!

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- ▶ Could we revise standards to permit a limiting of UV-C spectral irradiance measurements only to wavelengths above 250 nm to reduce uncertainty when the lamp envelope is known.
- ▶ Knowledge of the lamp envelope could permit one to exclude wavelengths below 290 nm.
- ▶ Important to make test technicians more familiar with the problem and recognize false readings.
- ▶ Move to final digital readout of weighted sum compounds the problems

Can We Use a Check-Test with a UV safety meter?

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- ▶ Check using a broad-band UV safety meter or even small, single-grating instruments can give clues as whether noise is the issue.
 - ▶ Still a big challenge from stray light from intense, longer-wavelength emissions.
 - ▶ Use of blocking filters and pass-band filters can improve the measurement check considerably.
 - ▶ Higher level of uncertainty generally exists with the use of the broad-band instrument or single-grating instrument



Simple Instruments may suffice

– The “Uncertainty Budget:”

Issue in Standards - Meeting a Limit:

