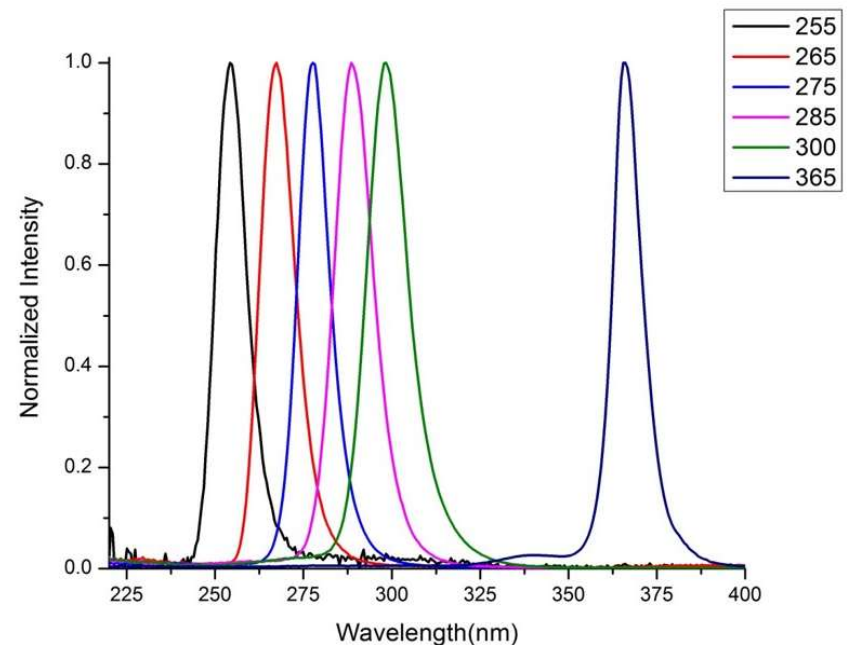


Collimated Beams – What are they used for?

- Applications include
 - **UV Dose response for organisms**
 - Photopolymerization of materials
 - Wavelength effect studies
 - Fluorescent slides



Collimated Beams and UV Dose

$$\text{UV DOSE} = \text{INTENSITY} \times \text{RESIDENCE TIME}$$



How much UV light is being “dosed” into a reactor or onto a sample

How much energy the light source (*collimated beam*) is providing



The length of exposure time to the energy

UV Dose is expressed in:

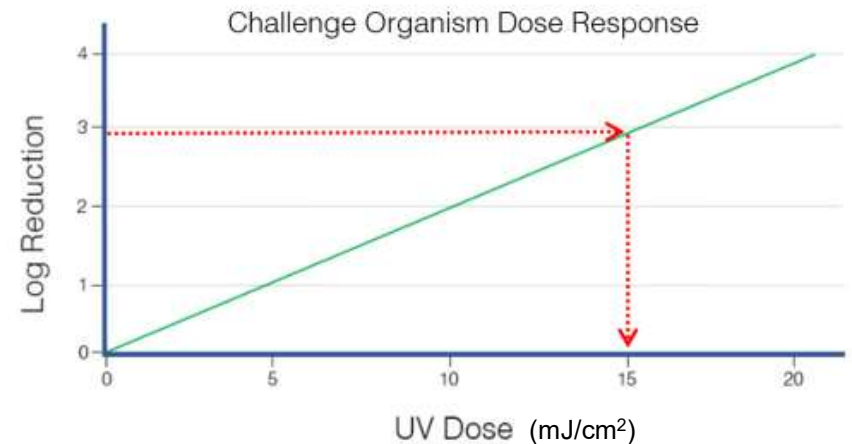
- $\mu\text{Wsec}/\text{cm}^2$ (Microwatt seconds/ cm^2)
- mWsec/cm^2 (Milliwatt seconds/ cm^2)
- **mJ/cm^2 (Millijoules/ cm^2)**

UV Dose

- Design Requirement for UV are stated in terms of “Dose”
- UV Dose = UV Intensity (mW/cm^2) x Exposure Time (seconds)

Dose Response Curve Determination

- Place a sample in a petri dish
 - Know the concentration of the challenge organism
- Exposing the sample to collimated UV light for a predetermined amount of time
 - Measure the intensity of the UV light so you can calculate UV Dose
 - $UV\ Dose = 0.5mW/cm^2 * 30sec = 15(mW*sec)/cm^2 = 15mJ/cm^2$
- Measuring the concentration of the challenge organism before and after exposure
 - The different in concentration is used to determine the log inactivation, or percentage reduction, of organisms from a certain UV Dose
 - 1 log reduction = 90%
 - 2 log reduction = 99%
 - 3 log reduction = 99.9%
- Plot data a Dose Response Curve (green line)
- Use curve for future reference
 - Can be used to size a larger UV system (red lines)
 - Prevents the same testing being duplicated

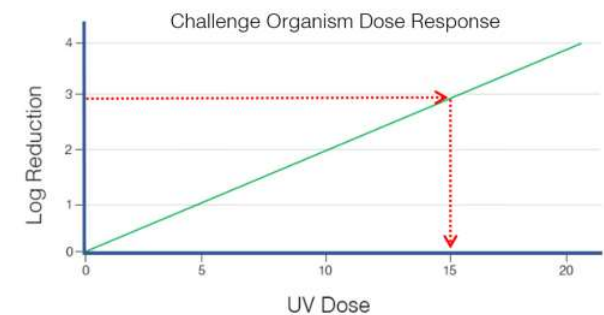


What are Dose Response Curves Used for?

Average UV Dose Required for Inactivation (mJ/cm²)

| Pathogen | 1-Log | 2-Log | 3-Log | 4-Log |
|---------------------------------------|-----------|------------|-----------|-------------|
| <i>Cryptosporidium parvum</i> oocysts | 1.3 | 2.5 | 4.3 | 5.7 |
| <i>Giardia lamblia</i> cysts | 0.3 | 0.7 | 1.3 | 1.7 |
| <i>Vibrio cholerae</i> | 0.8 | 1.4 | 2.2 | 2.9 |
| <i>Shigella dysenteriae</i> | 0.5 | 1.2 | 2 | 3 |
| <i>Escherichia coli</i> O 157:H7 | 1.5 | 2.8 | 4.1 | 5.6 |
| <i>Salmonella typhi</i> | 1.8 - 2.7 | 4.1 - 4.8 | 5.5 - 6.4 | 7.1 - 8.2 |
| <i>Shigella sonnei</i> | 3.2 | 4.9 | 6.5 | 8.2 |
| <i>Salmonella enteritidis</i> | 5 | 7 | 9 | 10 |
| <i>Hepatitis A virus</i> | 4.1 - 5.5 | 8.2 - 13.7 | 12.3 - 22 | 16.4 - 29.6 |
| <i>Poliovirus Type 1</i> | 4.1 - 6 | 8.7 - 14 | 14.2 - 23 | 21.5 - 30 |
| <i>Coxsackie B5 virus</i> | 6.9 | 13.7 | 20.6 | 30 |
| <i>Rotavirus SA 11</i> | 7.1 - 9.1 | 14.8 - 19 | 23 - 25 | 36 |

Dose response curves are a critical input when determining UV system sizing for various water treatment applications



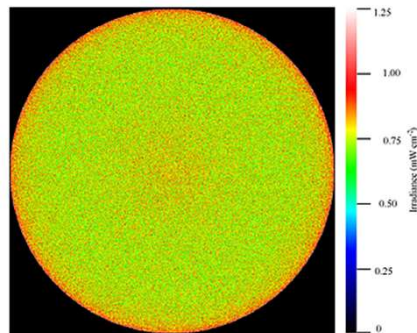
Source: Haji Malayeri, A.; Mohseni, M.; Cairns, B.; and Bolton, J. R. 2016 Fluence (UV Dose) Required to Achieve Incremental Log Inactivation of Bacteria, Protozoa, Viruses and Algae, IUVA News, 18(3): 4-6 + supp. tables.

UV Dose is Important Because Each Organism Will Respond Differently to UV. UV Systems are Typically Sized Based on the Organism that is Most Resistant to UV (e.g. Viruses)

Petri Factor – Why it Matters

- The Petri Factor is the measure of intensity across a sample
 - The higher the number, the less variation there is across the area
- The PearlBeam has a Petri Factor greater than 0.9
 - Means the highest possible fluctuation in treatment across the surface is 10%
 - 0.9 is the research standard, and the PBM surpasses it
- Homemade Collimated Beams typically have very low Petri Factors
 - Hot spotting during testing
- PearlBeam can uniformly irradiate petri dishes up to 60mm in size

Intensity Distribution



Typical 285nm Irradiance at the end of the collimating tube

PearlBeam

| Model Number* | Wavelength (nm) | Irradiance** (mW/cm ²) |
|---------------|-----------------|---------------------------------------|
| S255 | 255 | 0.05 |
| S285 | 285 | 0.7 |
| D255/285 | 255 & 285 | 0.05 & 0.7 |
| T255/265/285 | 255, 265, & 285 | 0.05, 0.3, & 0.7 |
| T265/285/300 | 265, 285, & 300 | 0.3, 0.7, & 0.7 |
| T285/300/365 | 285, 300, & 365 | 0.7, 0.7, & 13 |

*Custom PearlBeams are available. Please contact us for details

**Irradiance is measured at the bottom of the collimating tube.